

OPTIREG™ PMIC TLF4D985QKV01R1

Multi-rail power management IC for systems up to ASIL D



[Order now](#)



[Technical documents](#)



[Simulation](#)



[Family overview](#)



[Support](#)



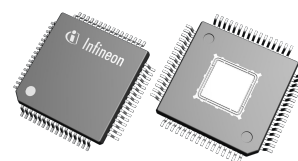
RoHS



ISO 26262
compliant

Features

- AEC-Q100 Grade 0 for high temperature mission profiles
- Wide input voltage range 3.8 V to 60 V
- 5.0 V, 30 mA low drop voltage regulator for standby supply
- 5.5 V, 4.0 V, 10 A pre-regulator
- 7 A multiphase synchronous buck converter for microcontroller supply, configurable from 0.7 V to 1.1 V in 12.5 mV steps
- 3.3 V, 1.2 A buck post-regulator for high-speed communication interface
- 5.0 V, 600 mA low drop regulator for microcontroller IO supply
- 5.0 V, 600 mA low drop regulator for low speed communication supply
- 5.0 V $\pm 1\%$, 150 mA voltage reference for ADC supply
- Control circuit for external MOSFETs for safety switch and reverse battery
- Voltage monitoring with reset and interrupt functions, built-in self-test
- Input voltage monitoring with overvoltage shutdown
- Two safe state control outputs, configurable functional watchdog and window watchdog
- Internal state machine with support for CPU and system virtualization
- 32 bit SPI with CRC
- ISO 26262 Safety Element out of Context (SEooC) for safety requirements up to ASIL D
- Infineon automotive quality
- Green Product (RoHS compliant)



Potential applications

- Car powertrain and transmission applications: inverter, engine management
- Truck applications, CAV applications
- Sensor fusion
- Domain controller, zone controller
- Connected gateway

Product validation

Qualified for automotive applications with higher temperature requirements. Product validation according to AEC-Q100, Grade 0.

Description

Description

The OPTIREG™ PMIC TLF4D985QKV01R1 is a highly efficient Functional Safety PMIC (Power management integrated circuit).

Type	Package	Marking (Line 1 / Line 2)
TLF4D985QKV01R1	PG-LQFP-64	TLF4D985 V01R1

Table of contents

	Features	1
	Potential applications	1
	Product validation	1
	Description	2
	Table of contents	3
1	Block diagram	11
2	Pin configuration	12
2.1	Pin assignment	12
2.2	Pin definitions and functions	12
3	General product characteristics	16
3.1	Absolute maximum ratings	16
3.2	Functional range	19
3.2.1	Functional range description	19
3.2.2	Electrical characteristics functional range	19
3.3	Thermal resistance	21
4	DCDC Switching frequency generation and clock synchronization	22
4.1	Functional description	22
4.1.1	EMC features	23
5	Power supply function	24
5.1	BUCK PREREG (buck pre-regulator)	24
5.1.1	Functional description BUCK PREREG	24
5.1.2	Electrical characteristics BUCK PREREG	25
5.2	BUCK CORE (buck core regulator)	28
5.2.1	Functional description BUCK CORE	29
5.2.2	Electrical characteristics BUCK CORE	30
5.3	BUCK IF (interface regulator)	35
5.3.1	Functional description BUCK IF	36
5.3.2	Electrical characteristics BUCK IF	37
5.4	BOOST (boost regulator)	40
5.4.1	Functional description BOOST	41
5.4.2	Electrical characteristics BOOST	42
5.5	Communication LDO (QCO)	43
5.5.1	Functional description communication LDO (QCO)	44
5.5.2	Electrical characteristics communication LDO (QCO)	44
5.6	Reference LDO (QVR)	45
5.6.1	Functional description reference LDO (QVR)	45
5.6.2	Electrical characteristics reference LDO (QVR)	46

Table of contents

5.7	MCU-LDO (QUC)	46
5.7.1	Functional description MCU-LDO (QUC)	47
5.7.2	Electrical characteristics MCU-LDO (QUC)	47
5.8	Standby LDO (QST)	48
5.8.1	Functional descriptions standby LDO (QST)	48
5.8.2	Electrical characteristics standby LDO (QST)	49
5.9	Active discharge	50
6	Safety switch (SSW)	51
6.1	Functional description safety switch (SSW)	51
6.2	Electrical characteristics safety switch (SSW)	52
7	Wakeup functions	54
7.1	Introduction	54
7.2	Enable (ENA)	54
7.2.1	Functional description enable (ENA)	55
7.2.2	Electrical characteristics enable (ENA)	55
7.3	Wake (WAK)	56
7.3.1	Functional description wake (WAK)	56
7.3.2	Electrical characteristics wake (WAK)	57
7.4	Wake-up timer (WUT)	57
7.4.1	Functional description wake-up timer (WUT)	57
7.4.2	Electrical characteristic wake-up timer	58
7.5	Wake-up via SPI frame	58
8	Hardware configuration (HWCFG)	59
8.1	Functional description	59
9	State machine (FSM)	61
9.1	Functional description state machine (FSM)	61
9.1.1	Description of the states	62
9.1.1.1	POWERDOWN state	62
9.1.1.2	INIT state	63
9.1.1.3	NORMAL state	65
9.1.1.4	WAKE state	66
9.1.1.5	REDUCED OPERATION state	68
9.1.1.6	FAILSAFE state	69
9.1.1.7	SLEEP state	70
9.1.1.8	STANDBY state	72
9.1.2	INIT timer function	73
9.1.3	State transition	76
9.1.3.1	State transition table	76
9.1.3.2	Programmable transition delay time	78
9.1.3.3	Automated wake-up from FAILSAFE	79
9.1.4	Power sequencing	79

Table of contents

9.1.4.1	Power up sequence schema A	80
9.1.4.2	Power up sequence schema B	81
9.1.4.3	Power down sequencing	82
9.2	Electrical characteristics state machine (FSM)	84
10	Monitoring functions	103
10.1	Watchdog functions (WD)	103
10.1.1	Introduction watchdog functions (WD)	103
10.1.2	Window watchdog (WWD)	104
10.1.2.1	Functional description window watchdog (WWD)	104
10.1.2.1.1	Valid triggering of the window watchdog	104
10.1.2.1.2	Invalid triggering due to missing trigger during open window	105
10.1.2.1.3	Invalid triggering due to trigger during closed window	106
10.1.2.1.4	Watchdog startup behavior (enable and reset)	107
10.1.2.1.5	Windows watchdog error counter	108
10.1.2.1.6	Timing constraints and behavior after configuring the watchdog	108
10.1.2.2	Electrical characteristics window watchdog (WWD)	109
10.1.3	Functional watchdog (FWD)	110
10.1.3.1	Functional description functional watchdog (FWD)	110
10.1.3.1.1	Functional watchdog service	110
10.1.3.1.2	Functional watchdog error counter overflow	116
10.2	Error monitoring (ERR MON)	117
10.2.1	Introduction	117
10.2.2	Functional description error monitoring (ERR MON)	118
10.2.2.1	Error monitoring initialization	118
10.2.2.2	Error monitoring configuration	119
10.2.2.3	Error monitoring recovery timers	121
10.2.2.4	Invalid error toggling	121
10.2.3	Electrical characteristics error monitoring (ERR MON)	123
10.3	Voltage monitoring	124
10.3.1	Introduction	124
10.3.2	Battery voltage monitoring	125
10.3.3	Internal voltage monitoring	125
10.3.4	Electrical characteristics monitoring functions	128
10.3.5	Ext. monitoring channels (VMON)	131
10.3.5.1	Functional description ext. monitoring channels (VMON)	132
10.3.5.2	Electrical characteristics ext. monitoring channels (VMON)	133
10.4	Overcurrent and overtemperature monitoring	134
10.4.1	Introduction	134
10.4.2	Functional description overtemperature monitoring	136
10.4.3	Functional description current monitoring	136
10.4.4	Electrical characteristics overtemperature monitoring	137
10.5	Safe state control (SSOx)	137

Table of contents

10.5.1	Introduction	137
10.5.2	Functional descriptions shutdown path (SSOx)	138
10.5.2.1	Delay times and reaction on detected faults	138
10.5.3	Electrical characteristics shutdown path (SSOx)	140
10.6	Reaction on faults	140
10.6.1	Reaction on detected fault	140
10.7	Analog built-in self test (ABIST)	156
10.7.1	Analog built-in self test (ABIST) - overview	156
10.7.2	ABIST - comparators only	157
10.7.3	ABIST - full path	157
10.7.4	ABIST - configuration and execution	159
10.7.5	ABIST - testing the secondary shutdown path logic	159
11	Interrupt function (INT)	161
11.1	Introduction	161
11.2	Interrupt activation	162
11.3	Interrupt deactivation	162
11.4	Electrical characteristics interrupt (INT)	165
12	Reset function (RESOUT)	166
12.1	Functional description reset function (RESOUT)	166
12.1.1	Introduction	166
12.1.2	Application Reset (REDUCED OPERATION ENABLE)	168
12.1.2.1	Activation	168
12.1.3	System Reset	170
12.1.3.1	Activation	170
12.1.3.2	Hard and Soft reset	171
12.2	Electrical characteristics reset function (RESOUT)	173
13	Microcontroller programming support (MPS)	174
14	SPI	175
14.1	Functional description SPI	175
14.1.1	SPI data transfer	176
14.1.2	SPI frame format	176
14.1.2.1	SPI transfer	176
14.1.2.2	SPI service	177
14.1.2.3	SPI read service	177
14.1.2.4	SPI write service	178
14.1.2.5	CRC field	178
14.1.2.5.1	CRC microcontroller handling	179
14.1.2.5.2	CRC device handling	180
14.1.2.6	Status field	182
14.1.2.6.1	Last frame OK (LFOK)	182
14.1.2.7	Error mechanism	183

Table of contents

14.1.2.8	SPI response with MPS ON	183
14.2	Electrical characteristics SPI	184
15	Reset classes	186
15.1	R0 - Reset class	186
15.2	R1 - Reset class	186
15.3	R2 - Reset class	186
15.4	R3 - Reset class	186
15.5	R3_C1 - Reset class	186
15.6	R3_C2 - Reset class	187
16	Collection registers, error reporting and clearance of bitfields	188
16.1	Error reporting generating an interrupt	188
16.2	Error reporting causing a move to INIT or REDUCED OPERATION	195
16.3	Error reporting causing a move to FAILSAFE	198
16.4	Status reporting - Miscellaneous registers	203
17	Protected registers - Protected write and reflected status registers	204
17.1	Unlock/lock sequence	204
18	Registers description	205
18.1	Registers overview - OTHERSR2 (ascending offset address)	205
18.2	Registers overview - ERR (ascending offset address)	206
18.3	Registers overview - OTHERSR0 (ascending offset address)	206
18.4	Registers overview - OTHERSR1 (ascending offset address)	206
18.5	Registers overview - WATCHDOG (ascending offset address)	207
18.6	Register overview - MISC (ascending offset address)	208
18.7	Registers overview - DEVICEID (ascending offset address)	209
18.8	Device configuration 4 *R2)	210
18.9	Reduced operation reflected status configuration 2 register - *R2)	212
18.10	Protection configuration register - *R2)	213
18.11	Device reflected status configuration Register *R2)	214
18.12	Wake up timer LSB Value (*R2)	216
18.13	Wake up timer MSB Value (*R2)	217
18.14	Wakeup status flags for Application 1 *R2)	218
18.15	Wakeup status flags for Application 2 *R2)	219
18.16	INIT and REDUCED OPERATION Error Status flags for Application 1 *R2)	220
18.17	INIT and REDUCED OPERATION Error Status flags for Application 2 *R2)	222
18.18	Interrupt flags for Application 1 that trigger INT1 *R2)	224
18.19	Interrupt flags for Application 2 that trigger INT2 *R2)	226
18.20	System status flags for Application 1 that trigger INT1 *R2)	228
18.21	System status flags for Application 2 that trigger INT2 *R2)	230
18.22	SPI failure status flags that triggers INT1 *R2)	232
18.23	SPI status flags for Application 2 that trigger INT2 *R2)	233
18.24	Monitor status flags register 2 for Application 1 *R2)	234

Table of contents

18.25	Monitor status flags register 2 for Application 2 *R2)	236
18.26	Over temperature warning and over current status flags *R2)	238
18.27	Over temperature warning /Over current status flags for Application 2 *R2)	240
18.28	Voltage monitor status *R2)	242
18.29	Device status register *R2)	244
18.30	DC-DC switching frequency change *R2)	246
18.31	DC-DC Frequency spread-spectrum control register *R2)	248
18.32	ABIST control 0 *R2)	250
18.33	ABIST control 1 *R2)	251
18.34	ABIST select 0 *R2)	252
18.35	ABIST select 1 *R2)	254
18.36	ABIST select 2 *R2)	256
18.37	Global testmode *R2)	258
18.38	Reduced operation reflected status configuration 1 register - *R2)	259
18.39	ERR0 protection write configuration register *R2)	261
18.40	ERR0 reflected status configuration register *R3)	262
18.41	ERR1 protection write configuration register *R2)	263
18.42	ERR1 reflected status configuration register *R3_C1)	264
18.43	ERR2 protection write configuration register *R2)	265
18.44	ERR2 reflected status configuration register *R3_C2)	266
18.45	Device configuration 1 register *R0)	267
18.46	Device protected write configuration 2 register *R0)	269
18.47	Device reflected status configuration 2 register *R0)	270
18.48	System failure status register for application 1 *R1)	271
18.49	System failure status flags for application 2 *R1)	273
18.50	Short to ground status register for application 1 *R1)	275
18.51	Short to ground status register for application 2 *R1)	277
18.52	Overvoltage status register for application 1 *R1)	279
18.53	Overvoltage status register for application 2 *R1)	281
18.54	Internal supply status register for application 1 *R1)	283
18.55	Internal supply status register for application 2 *R1)	284
18.56	Over temperature status register for application 1 *R1)	285
18.57	Over temperature status register for application 2 *R1)	286
18.58	Protection status *R1)	287
18.59	Reduced operation protected write configuration 1 register - *R1)	288
18.60	Reduced operation protected write configuration 2 register - *R1)	290
18.61	Device protected write configuration 3 register *R1)	291
18.62	Watchdog 1 protected write configuration 0 register *R2)	293
18.63	Watchdog 1 reflected status configuration 0 register - *R3_C1	294
18.64	Watchdog 1 protected write configuration 1 register *R2)	295
18.65	Watchdog 1 reflected status configuration 1 register- *R3_C1	296
18.66	Functional watchdog 1 protected write heart beat timer period configuration register - *R2)	297

Table of contents

18.67	Functional watchdog 1 reflected status heart beat timer period configuration register *R3_C1	298
18.68	Window watchdog 1 protected write closed window configuration register - *R2)	299
18.69	Window watchdog 1 reflected status closed window configuration register *R3_C1)	300
18.70	Window watchdog 1 protected write open window configuration register - *R2)	301
18.71	Window watchdog 1 reflected status open window configuration register - *R3_C1)	302
18.72	Window watchdog 1 trigger- *R2)	303
18.73	Functional watchdog 1 response register - *R2)	304
18.74	Functional watchdog 1 response register with synchronization of the heartbeat timer - *R2)	305
18.75	Functional watchdog 1 status register - *R3_C1)	306
18.76	Window watchdog 1 error counter status register - *R3_C1)	307
18.77	Watchdog 2 protected write configuration 0 register - *R2)	308
18.78	Watchdog 2 reflected status configuration 0 register- *R3_C2)	309
18.79	Watchdog 2 protected write configuration 1 - *R2)	310
18.80	Watchdog 2 reflected status configuration 1 register - *R3_C2)	311
18.81	Functional watchdog 2 protected write heart beat timer period configuration register - *R2)	312
18.82	Functional watchdog 2 reflected status heart beat timer period configuration register *R3_C2)	313
18.83	Window watchdog 2 protected write closed window configuration register - *R2)	314
18.84	Window watchdog 2 reflected status closed window configuration register *R3_C2)	315
18.85	Window watchdog 2 protected write open window configuration register - *R2)	316
18.86	Window watchdog 2 reflected status open window configuration register *R3_C2)	317
18.87	Window watchdog 2 service - *R2)	318
18.88	Functional watchdog 2 response register - *R2)	319
18.89	Functional watchdog 2 response register with synchronization - *R2)	320
18.90	Functional watchdog 2 status register - *R3_C2)	321
18.91	Window watchdog 2 status register - *R3_C2)	322
18.92	Safety switch diagnostics, *R1)	323
18.93	BUCK CORE protected write voltage selection register *R1)	324
18.94	BUCK CORE reflected status voltage selection register *R2)	325
18.95	Buck core voltage selection stat, *R2)	326
18.96	Buck core voltage selection monitors stat, *R2)	327
18.97	Wake Up Timer value after exiting from STANDBY or SLEEP (lower 16 bits)	328
18.98	Wake Up Timer value after exiting from STANDBY or SLEEP (upper 8 bits)	329
18.99	Chip product identifier	330
18.100	Chip product version and revision	331
18.101	Manufacturer ID	332
19	Application information	333
19.1	Application diagram	333
19.2	BOM recommendation	334
20	Package information	341
21	Revision history	342



Table of contents

Disclaimer 343

2 Pin configuration

2 Pin configuration

2.1 Pin assignment

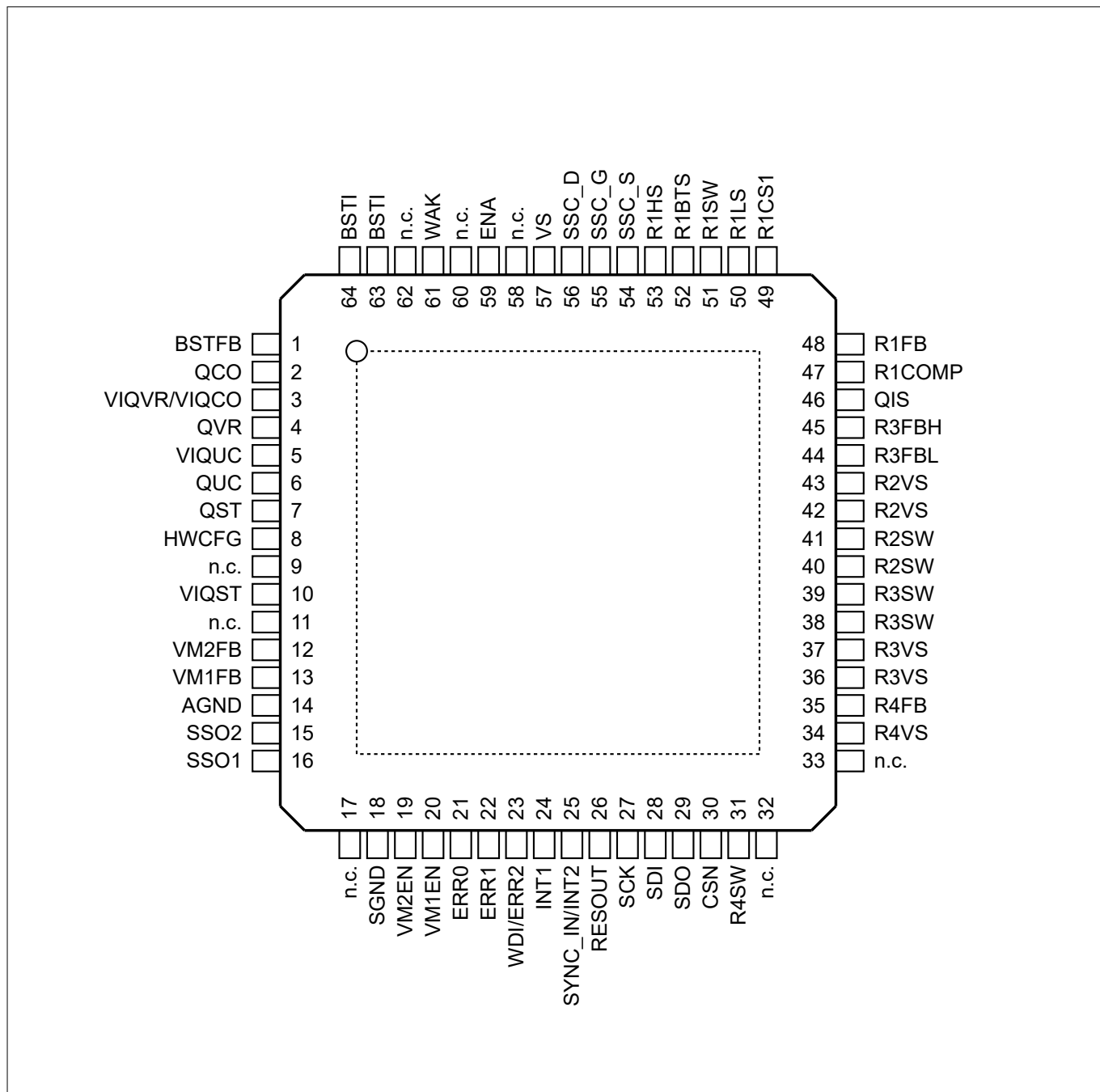


Figure 2 Pin assignment PG-LQFP-64 package

2.2 Pin definitions and functions

Table 1 Pin definitions and functions

Pin	Name	Type	Function
(table continues...)			

2 Pin configuration

Table 1 (continued) Pin definitions and functions

1	BSTFB	AI	Boost voltage feedback (connect to R1FB if BOOST not used)
2	QCO	SO	Communication supply voltage
3	VIQVR - VIQCO	SI	Input voltage for voltage reference regulator (QVR) and communication supply regulator (QCO)
4	QVR	SO	ADC reference supply voltage
5	VIQUC	SI	Input voltage for microcontroller IO regulator
6	QUC	SO	Microcontroller IO supply voltage
7	QST	SO	Standby regulator output voltage
8	HWCFG	AO	Hardware configuration setting
9	n.c.	–	Not connected - do not connect to any potential and leave floating
10	VIQST	SI	Input voltage for standby regulator and internal peripherals
11	n.c.	–	Not connected - do not connect to any potential and leave floating
12	VM2FB	AI	Feedback for external voltage monitoring 2
13	VM1FB	AI	Feedback for external voltage monitoring 1
14	AGND	GND	Analog ground connection
15	SSO2	AO	Safe state control output 2
16	SSO1	AO	Safe state control output 1
17	n.c.	–	Not connected - do not connect to any potential and leave floating
18	SGND	GND	Safety ground connection (ground for safety corner SSO1 and SSO2)
19	VM2EN	DIO	Enable for external voltage monitoring 2
20	VM1EN	DIO	Enable for external voltage monitoring 1
21	ERR0	DI	Error monitoring 0 input
22	ERR1	DI	Error monitoring 1 input
23	WDI/ ERR2	DI	Watchdog input/ Error monitoring 2 input WDI option is the default function If REDUCED OPERATION is enabled the integrator must ensure to use the functionality correctly and exclusively use WDI/ERR2 for either one of the watchdogs or ERR2
24	INT1	DO	Interrupt 1 output
25	SYNC_IN/ INT2	DIO	Synchronization input/ Interrupt 2 output
26	RESOUT	DO	Reset output
27	SCK	DI	SPI clock input
28	SDI	DI	SPI data input
29	SDO	DO	SPI data output

(table continues...)

2 Pin configuration

Table 1 (continued) Pin definitions and functions

30	CSN	DI	SPI chip select input
31	R4SW	AO	Switching node buck interface
32	n.c.	–	Not connected - do not connect to any potential and leave floating
33	n.c.	–	Not connected - do not connect to any potential and leave floating
34	R4VS	SI	Input voltage buck interface
35	R4FB	AI	Feedback voltage buck interface regulator
36	R3VS	SI	Input voltage buck core regulator
37	R3VS	SI	Input voltage buck core regulator
38	R3SW	AO	Switching node buck core
39	R3SW	AO	Switching node buck core
40	R2SW	AO	Switching node buck core
41	R2SW	AO	Switching node buck core
42	R2VS	SI	Input voltage buck core regulator
43	R2VS	SI	Input voltage buck core regulator
44	R3FBL	AI	Feedback BUCKCORE regulator: Remote ground GND
45	R3FBH	AI	Feedback buck core regulator
46	QIS	SO	Buffer capacitor for internal supply
47	R1COMP	AO	Buck pre-regulator compensation
48	R1FB	AI	Feedback voltage buck pre-regulator
49	R1CS1	AI	Current feedback shunt positive
50	R1LS	AO	Gate external low side FET for buck pre-regulator
51	R1SW	AI	Switch node pre-regulator
52	R1BTS	SI	Bootstrap input voltage
53	R1HS	AO	Gate external high side FET for buck pre-regulator
54	SSC_S	AI	Safety switch source (If the safety switch is not used, connect to the input of PREREG)
55	SSC_G	AO	Safety switch gate (If the safety switch is not used, connect to the input of PREREG)
56	SSC_D	SI	Safety switch drain (If the safety switch is not used, connect to GND)
57	VS	SI	Main supply voltage
58	n.c.	–	Not connected - do not connect to any potential and leave floating
59	ENA	AI	Enable - edge sensitive
60	n.c.	–	Not connected - do not connect to any potential and leave floating
61	WAK	AI	Wake - level sensitive

(table continues...)

2 Pin configuration

Table 1 (continued) Pin definitions and functions

62	n.c.	–	Not connected - do not connect to any potential and leave floating
63	BSTI	AO	Switch node boost regulator (connect to GND if BOOST not used)
64	BSTI	AO	Switch node boost regulator (connect to GND if BOOST not used)
–	Exposed pad	–	Connect the exposed pad to GND. It is recommended to connect the exposed pad to a heat sink.

Notes:

AI: Analog input

AO: Analog output

AIO: Analog input output

SI: Supply input

SO: Supply output

DI: Digital input

DO: Digital output

DIO: Digital input output

3 General product characteristics

3 General product characteristics

- Note:**
- Stresses above the ones listed here may cause permanent damage to the device. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.
 - Integrated protection functions are designed to prevent IC destruction under fault conditions described in the datasheet. Fault conditions are considered as outside the normal operating range. Protection functions are not designed for continuous repetitive operation.

3.1 Absolute maximum ratings

Table 2 Absolute maximum ratings

$T_j = -40^{\circ}\text{C}$ to $+175^{\circ}\text{C}$, all voltages with respect to ground, positive current flowing into pin (unless otherwise specified)

1)

Parameter	Symbol	Values			Unit	Note or condition	P-Number
		Min.	Typ.	Max.			
Pins							
Input voltage for standby regulator QST	V _{VIQST}	-0.3	–	60	V	–	DS-1661
Safety switch drain	V _{SSC_D}	-0.3	–	60	V	–	DS-1662
Safety switch gate	V _{SSC_G}	-0.3	–	60	V	–	DS-1663
Safety switch source	V _{SSC_S}	-0.3	–	60	V	–	DS-1664
Main supply voltage	V _{VS}	-0.3	–	60	V	–	DS-1665
Enable	V _{ENA}	-0.3	–	60	V	–	DS-1666
Wake	V _{WAK}	-0.3	–	60	V	–	DS-1667
Switch node BUCK PREREG	V _{R1SW}	-2	–	60	V	–	DS-1668
Bootstrap input voltage	V _{R1BTS}	-0.3	–	60	V	–	DS-1669
Gate external high-side FET for BUCK PREREG	V _{R1HS}	-0.3	–	60	V	–	DS-1670
Switch node BOOST regulator	V _{BSTI}	-0.3	–	7	V	–	DS-1671
Current feedback shunt positive	V _{R1CS1}	-0.3	–	7	V	–	DS-1672
Feedback voltage BUCK PREREG	V _{R1FB}	-0.3	–	7	V	–	DS-1673
Input voltage BUCK IF regulator	V _{R4VS}	-0.3	–	7	V	–	DS-1674
Feedback for BUCK IF regulator	V _{R4FB}	-0.3	–	7	V	–	DS-1675
Input voltage BUCK CORE 2 regulator	V _{R3VS}	-0.3	–	7	V	–	DS-1676

(table continues...)

3 General product characteristics

Table 2 (continued) Absolute maximum ratings

$T_j = -40^{\circ}\text{C}$ to $+175^{\circ}\text{C}$, all voltages with respect to ground, positive current flowing into pin (unless otherwise specified)

1)

Parameter	Symbol	Values			Unit	Note or condition	P-Number
		Min.	Typ.	Max.			
Switch node BUCK CORE 2 regulator	V_{R3SW}	-0.3	–	7	V	–	DS-1677
Switch node BUCK CORE 1 regulator	V_{R2SW}	-0.3	–	7	V	–	DS-1678
Input voltage BUCK CORE 1 regulator	V_{R2VS}	-0.3	–	7	V	–	DS-1679
Compensation	V_{R1COMP}	-0.3	–	7	V	–	DS-1680
Buffer capacitor for internal supply	V_{QIS}	-0.3	–	7	V	–	DS-1681
Feedback BUCK CORE 2 regulator	V_{R3FBH}	-0.3	–	7	V	–	DS-1682
Switch node BUCK IF regulator	V_{R4SW}	-0.3	–	7	V	–	DS-1683
SPI chip select input	V_{CSN}	-0.3	–	6	V	–	DS-1684
Feedback for external voltage monitoring 2	V_{VM2FB}	-0.3	–	60	V	–	DS-1685
Feedback for external voltage monitoring 1	V_{VM1FB}	-0.3	–	6	V	–	DS-1686
SPI data output	V_{SDO}	-0.3	–	6	V	–	DS-1687
SPI data input	V_{SDI}	-0.3	–	6	V	–	DS-1688
SPI clock input	V_{SCK}	-0.3	–	6	V	–	DS-1689
Hardware configuration setting	V_{HWCFG}	-0.3	–	60	V	–	DS-1690
Output voltage for standby regulator QST	V_{QST}	-0.3	–	6	V	Max value increases to 7 V if QUC is OFF and QST is ON	DS-1691
Microcontroller IO supply voltage	V_{QUC}	-0.3	–	6	V	–	DS-1692
Input voltage for microcontroller IO regulator	V_{VIQUC}	-0.3	–	7	V	–	DS-1693
ADC reference supply voltage	V_{QVR}	-0.3	–	6	V	–	DS-1694
Input voltage reference and communication regulator	V_{VIQVR-} V_{IQCO}	-0.3	–	7	V	–	DS-1695
Communication supply voltage	V_{QCO}	-0.3	–	6	V	–	DS-1696

(table continues...)

3 General product characteristics

Table 2 (continued) Absolute maximum ratings

$T_j = -40^{\circ}\text{C}$ to $+175^{\circ}\text{C}$, all voltages with respect to ground, positive current flowing into pin (unless otherwise specified)

¹⁾

Parameter	Symbol	Values			Unit	Note or condition	P-Number
		Min.	Typ.	Max.			
Boost voltage feedback	V_{BSTFB}	-0.3	–	7	V	–	DS-1697
Safe state control output 1	V_{SSO1}	-0.3	–	60	V	–	DS-1698
Safe state control output 2	V_{SSO2}	-0.3	–	60	V	–	DS-1699
Reset output	V_{RESOUT}	-0.3	–	6	V	–	DS-1700
Synchronization input / interrupt output 2	$V_{\text{SYNC_IN/INT2}}$	-0.3	–	6	V	–	DS-1701
Interrupt output 1	V_{INT1}	-0.3	–	6	V	–	DS-1702
Watchdog input / error input 2	$V_{\text{WDI/ERR2}}$	-0.3	–	6	V	–	DS-1703
Error input 0	V_{ERR0}	-0.3	–	6	V	–	DS-1704
Error input 1	V_{ERR1}	-0.3	–	6	V	–	DS-1705
Enable for external voltage monitoring 1	V_{VM1EN}	-0.3	–	6	V	–	DS-1706
Enable for external voltage monitoring 2	V_{VM2EN}	-0.3	–	6	V	–	DS-1707
Safety ground connection	V_{SGND}	-0.3	–	0.3	V	AGND, SGND and EP are internally connected	DS-1708
Power ground - exposed pad	V_{EP}	-0.3	–	0.3	V	AGND, SGND and EP are internally connected	DS-1709
Analog ground connection	V_{AGND}	-0.3	–	0.3	V	AGND, SGND and EP are internally connected	DS-1710
Connection to buck core ground	V_{R3FBL}	-0.3	–	0.3	V	Respect to AGND	DS-1711
Gate external low-side FET for BUCK PREREG	V_{R1LS}	-0.3	–	7	V	Respect to AGND	DS-1712

ESD robustness

ESD voltage HBM parameter	$V_{\text{ESD_HBM}}$	-2	–	2	kV	²⁾ HBM	DS-1732
ESD robustness not corner pins (CDM)	$V_{\text{ESD_CDM}}$	-500	–	500	V	³⁾ CDM	DS-1733
ESD robustness corner pins (CDM)	$V_{\text{ESD_CDM_Corner}}$	- 750	–	750	V	³⁾ CDM	DS-1734

Differential parameters

Differential voltage between R1BTS - R1SW	$\Delta V_{\text{R1BTS-R1SW}}$	-0.3	–	7	V	$\Delta V_{\text{R1BTS-R1SW}} = V_{\text{R1BTS}} - V_{\text{R1SW}}$	DS-2060
---	--------------------------------	------	---	---	---	---	---------

(table continues...)

3 General product characteristics

Table 2 (continued) Absolute maximum ratings

$T_j = -40^{\circ}\text{C}$ to $+175^{\circ}\text{C}$, all voltages with respect to ground, positive current flowing into pin (unless otherwise specified)

1)

Parameter	Symbol	Values			Unit	Note or condition	P-Number
		Min.	Typ.	Max.			
Differential voltage between R1HS- R1SW	$\Delta V_{R1HS-R1SW}$	-0.3	–	7	V	$\Delta V_{R1HS-R1SW} = V_{R1HS} - V_{R1SW}$	DS-2061
Differential voltage between SSC_G - SSC_S	$\Delta V_{SSC_G-SSC_S}$	-0.3	–	7	V	$\Delta V_{SSC_G-SSC_S_max} = V_{SSC_G} - V_{SSC_S}$	DS-2062

1) Not subject to production test, specified by design.

2) Human Body Model (HBM) according to JEDEC HBM Human Body Model ANSI/ESDA/JEDEC JS001 (1.5 kΩ, 100 pF).

3) Charged Device Model (CDM) according to ESDA STM5.3.1 or ANSI/ESD S.5.3.1.

3.2 Functional range

3.2.1 Functional range description

Note: *Within the functional or operating range, the device operates as described in the circuit description. The electrical characteristics are specified within the conditions given in the Electrical Characteristics table.*

3.2.2 Electrical characteristics functional range

Table 3 Functional range

$V_{VS} = 6.0\text{ V}$ to 36 V , $T_j = -40^{\circ}\text{C}$ to $+175^{\circ}\text{C}$, all voltages with respect to ground, positive current flowing into pin (unless otherwise specified)

Parameter	Symbol	Values			Unit	Note or condition	P-Number
		Min.	Typ.	Max.			
Supply voltage for normal operation of internal blocks with BOOST	V_S	3.8	–	36	V	For $V_{VS} < 6\text{ V}$, max temp is 105°C ; Same voltage applied to VS and VIQST pins; Device must already be operating 1)	DS-2143
Supply voltage for normal operation of internal blocks without BOOST	V_S	6	–	36	V	Same voltage applied to VS and VIQST pins 1)	DS-1932

(table continues...)

3 General product characteristics

Table 3 (continued) Functional range

$V_{VS} = 6.0 \text{ V to } 36 \text{ V}$, $T_j = -40^\circ\text{C to } +175^\circ\text{C}$, all voltages with respect to ground, positive current flowing into pin (unless otherwise specified)

Parameter	Symbol	Values			Unit	Note or condition	P-Number
		Min.	Typ.	Max.			
Device start-up time	$t_{\text{start_up}}$	–	–	11	ms	From first battery connection to release of microcontroller reset RESOUT; Default reset delay time $t_{RD} = 2\text{ms}$; $V_{SSC_S} < 1\text{V}$ at startup; Capacitance at SSC_S pin = $1\mu\text{F}[\text{Max}]$ 1)	DS-2084
Supply voltage range, load dump	V_{VS_LD}			V_{VS_OV}	V	Load dump condition, device transitions to FAILSAFE mode if severe overvoltage is detected on VS pin; Same voltage applied to VS and VIQST pins; 1)	DS-2132
PREREG input voltage with boost	V_{SSC_S}	3.8	–	36	V	For $V_{SSC_S} \leq 6.5 \text{ V}$: $T_j = -40^\circ\text{C to } 25^\circ\text{C}$; BOOST max load: 650 mA; PREREG max load: 3.5 A (including BOOST load); $dV_{SSC_S}/dt \leq 8 \text{ V/ms}$; PREREG efficiency $\geq 88\%$ 1)	DS-2070
PREREG input voltage with boost, high temp	V_{SSC_S}	4.3	–	36	V	For $V_{SSC_S} \leq 6.5 \text{ V}$: $T_j = -40^\circ\text{C to } 105^\circ\text{C}$; BOOST max load: 650 mA; PREREG max load: 3.5 A (including BOOST load); $dV_{SSC_S}/dt \leq 8 \text{ V/ms}$; PREREG efficiency $\geq 88\%$ 1)	DS-2158
PREREG input voltage without boost	$V_{SSC_S_PREREG_noBOOST}$	6.6	–	36	V	$V_{SSC_S} > 6.6\text{V}$ needed for startup without boost; 1)	DS-2157

(table continues...)

3 General product characteristics

Table 3 (continued) Functional range

$V_{VS} = 6.0 \text{ V to } 36 \text{ V}$, $T_j = -40^\circ\text{C to } +175^\circ\text{C}$, all voltages with respect to ground, positive current flowing into pin (unless otherwise specified)

Parameter	Symbol	Values			Unit	Note or condition	P-Number
		Min.	Typ.	Max.			
Temperatures							
Junction temperature	T_j	-40	–	175	°C	Continuous operation; ¹⁾	DS-1931
Storage temperature	T_{stg}	-55	–	175	°C	¹⁾	DS-2069

¹⁾ Not subject to production test, specified by design

3.3 Thermal resistance

Table 4 Thermal resistance

$V_{VS} = 6.0 \text{ V to } 40 \text{ V}$, $T_j = -40^\circ\text{C to } +175^\circ\text{C}$, all voltages with respect to ground, positive current flowing into pin (unless otherwise specified)

Parameter	Symbol	Values			Unit	Note or condition	P-Number
		Min.	Typ.	Max.			
Junction to case	R_{thJC}	–	4.8	–	K/W	Fixed temperature for bottom ¹⁾	DS-2018
Junction to top	R_{thJTop}	–	16.9	–	K/W	Fixed temperature for top side ¹⁾	DS-2020
Junction to ambient - 2s2p	R_{thJA_2s2p}	–	24.4	–	K/W	JEDEC 2s2p PCB ^{1) 2)}	DS-2022
Junction to ambient - 2s4p	R_{thJA_2s4p}	–	19.3	–	K/W	2s4p PCB ^{1) 3)}	DS-2024

¹⁾ Not subject to production test, specified by design

²⁾ Specified R_{thJA} value is according to JEDEC JESD51-2,-5,-7 at natural convection on FR4 2s2p board; the product (chip and package) was simulated on a $76.2 \times 114.3 \times 1.5 \text{ mm}^3$ board with two outside signal Cu traces ($2 \times 70 \mu\text{m}$) and two inner copper layers ($2 \times 35 \mu\text{m}$). Where applicable, a thermal via array next to the package contacted the first inner copper layer.

³⁾ Specified R_{thJA} value is according to internal application board at a natural convection on FR4 2s4p board; the product (chip and package) was simulated on a $74.2 \times 74.2 \times 1.688 \text{ mm}^3$ board with two outside copper layers ($2 \times 53 \mu\text{m}$) and four inner copper layers ($4 \times 33 \mu\text{m Cu}$). Thermal via array contacted the second and third inner copper layer.

4 DCDC Switching frequency generation and clock synchronization

4 DCDC Switching frequency generation and clock synchronization

Table 5 Electrical characteristics DCDC Switching frequency generation and clock synchronization

$V_{DS} = 6.0 \text{ V to } 36 \text{ V}$, $T_j = -40^\circ\text{C to } +175^\circ\text{C}$, all voltages with respect to ground, positive current flowing into pin (unless otherwise specified)

Parameter	Symbol	Values			Unit	Note or condition	P-Number
		Min.	Typ.	Max.			
DCDC switching frequency default	f_{DCDC}	$2.2 + f_{\text{DCDC_acc}}[\text{MIN}]$	2.2	$2.2 + f_{\text{DCDC_acc}}[\text{MAX}]$	MHz	–	DS-1719
DCDC switching frequency accuracy	$f_{\text{DCDC_acc}}$	-10	–	+10	%	–	DS-1720

4.1 Functional description

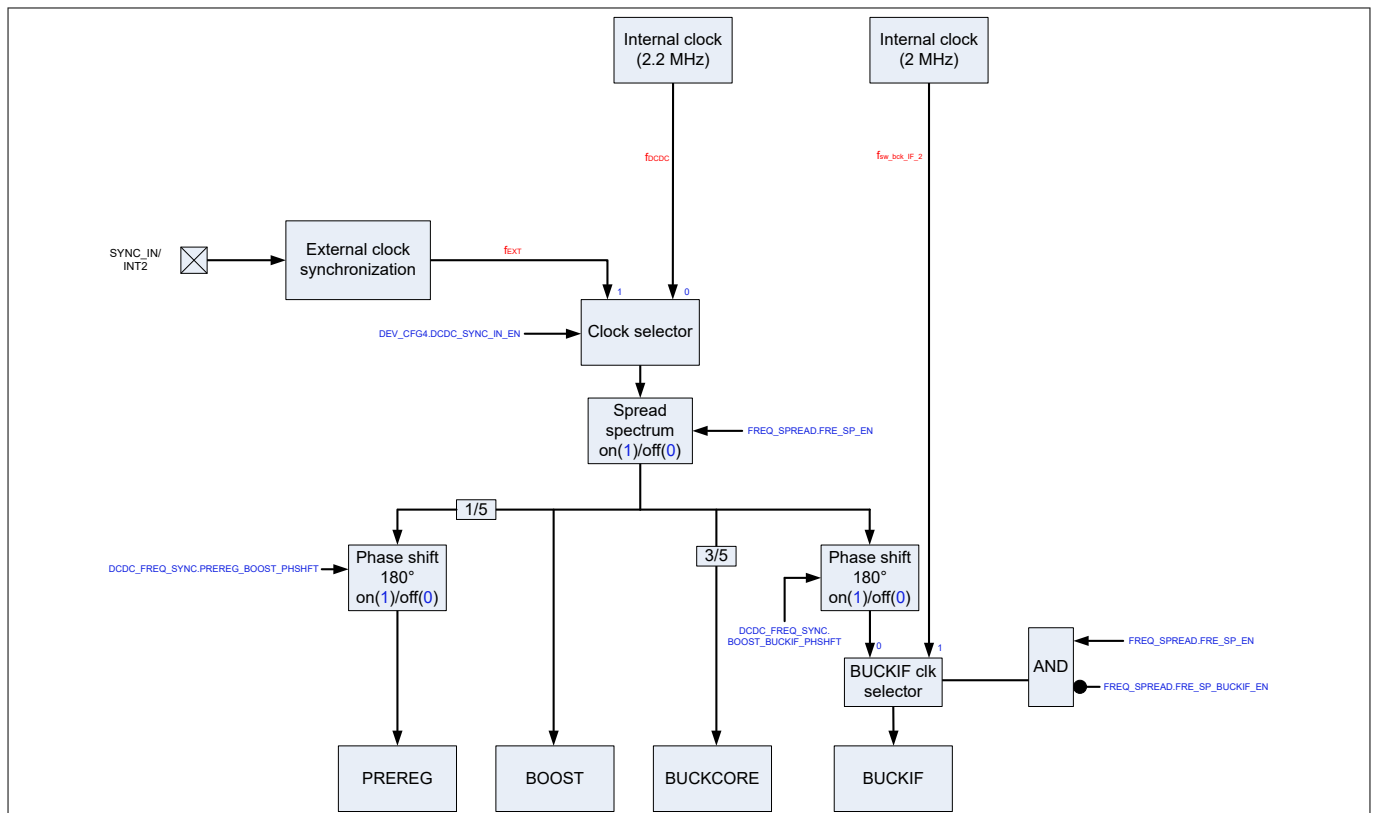


Figure 3 DCDC clock generation and clock manager

The switching frequencies for the different integrated DCDC converters are generated by an integrated clock generator or an external synchronization frequency signal.

The main switching frequency (f_{DCDC}) is adjustable via SPI bitfield **DCDC_FREQ_SYNC.DCDC_FREQSEL**, in the range of 1.8 MHz to 2.4 MHz with 100 kHz step resolution.

External clock synchronization

4 DCDC Switching frequency generation and clock synchronization

The device provides an external synchronization of the DC-DC switching frequency f_{DCDC} to an external clock source within the range 1.6 MHz to 2.6 MHz at the SYNC_IN/INT2 pin, to improve the EMC/EMI performance and reduce the cross-talk to the loads.

Synchronization can be enabled or disabled via SPI bit DEV_CFG4.DCDC_SYNC_IN_EN, default is disabled (DEV_CFG4.DCDC_SYNC_IN_EN = 0).

The device handles a change of 100 kHz in the external clock source frequency with a settling time of 50 μs on the switching frequency.

4.1.1 EMC features

Spread spectrum

The device incorporates spread-spectrum modulation to improve EMC/EMI performance. The spread spectrum modulation is applied to the main clock source, hence affects all power converters.

The spread spectrum modulation is disabled by default and can be enabled via SPI bit **FREQ_SPREAD.FRE_SP_EN**.

After enabling the spread spectrum (**FREQ_SPREAD.FRE_SP_EN = 1**), the device allows to configure the spread spectrum functionality to be applied also to the Buck IF regulator via SPI bit **FREQ_SPREAD.FRE_SP_BUCKIF_EN**.

The configuration of the spread spectrum modulation method, modulation frequency and amplitude can be selected via SPI register **FREQ_SPREAD**.

Phase shift

To further improve the EMC performance, the device allows to configure phase relationship between BUCK PREREG and BOOST regulator and between BUCK IF and BOOST regulator via SPI:

- The device enables 180° phase shift between BOOST and BUCK IF if SPI **DCDC_FREQ_SYNC.BOOST_BUCKIF_PHSFT** is set to 1.
- The device enables 180° phase shift between BOOST and PREREG if SPI **DCDC_FREQ_SYNC.PREREG_BOOST_PHSFT** is set to 1.

Slew rate control

Device also provides configurability of switching slew rate for all power converters via SPI register **DCDC_FREQ_SYNC**

5 Power supply function

5 Power supply function

5.1 BUCK PREREG (buck pre-regulator)

5.1.1 Functional description BUCK PREREG

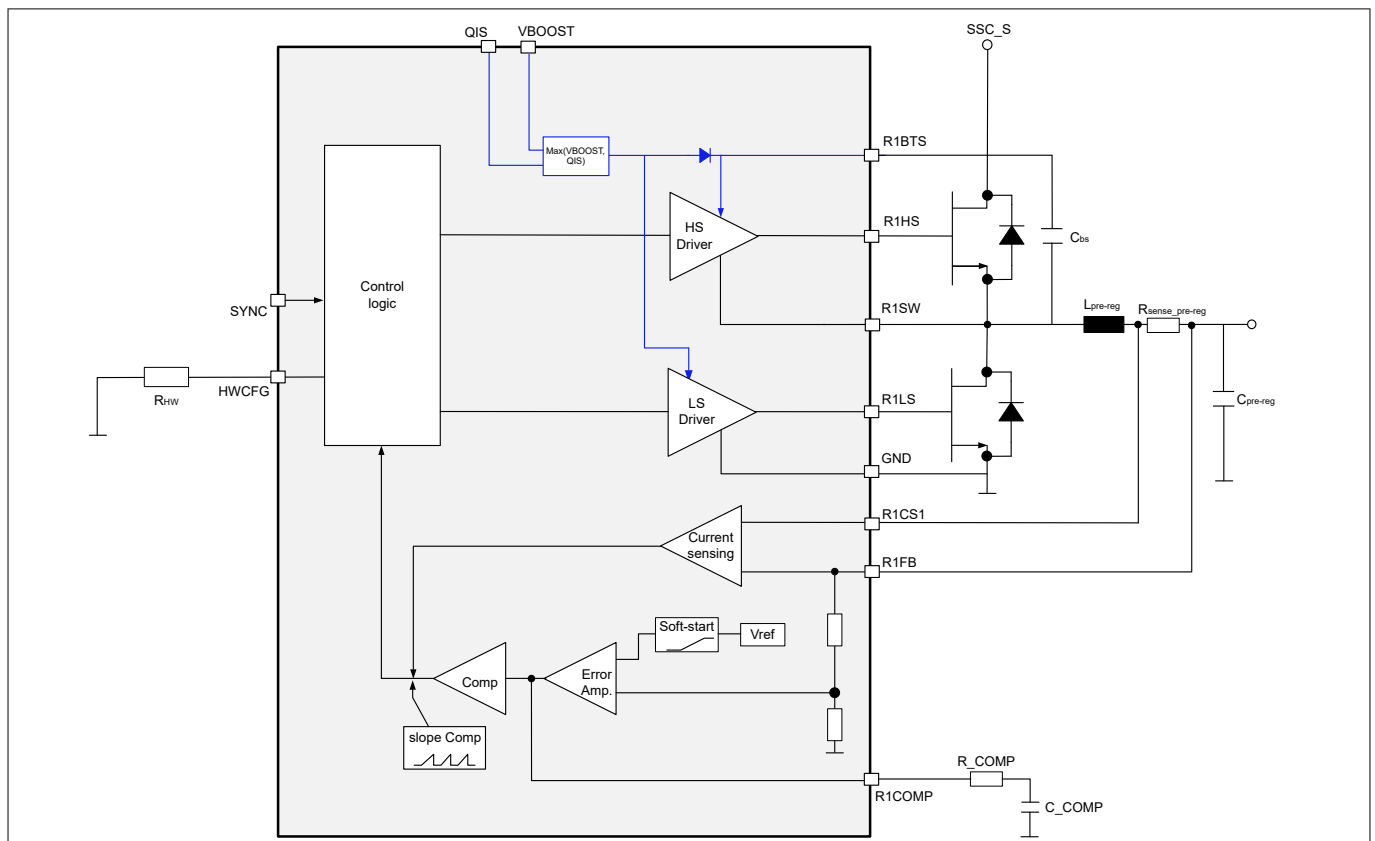


Figure 4 Block diagram PREREG

The pre-regulator is a synchronous buck controller with two external power switches (NMOS, enhanced type) to supply internal circuitry, buck, boost, LDOs and other external loads.

The pre-regulator converts the input voltage at pin SSC_S to an output voltage V_{R1FB} with I_{bck_prereg} output current.

The output voltage of the pre-regulator is configurable by hardware.

Depending on the value of the external resistor on pin HWCFG, the output voltage $V_{R1FB} = V_{R1FB_4V0}$ or $V_{R1FB} = V_{R1FB_5V5}$.

The pre-regulator operates in PWM mode with peak current control and outer voltage control loop.

The output current is sensed via an external shunt resistor (R_{sense}) in series with the inductor and the maximum current capability is defined by the external components (NMOS gate charge, inductor, shunt resistor), the gate driver current capability and the switching frequency. An overcurrent detection is implemented to protect the external MOSFETs. If an overcurrent is detected after the HS minimum TON time, the HS is turned OFF and will be turned ON again at the next rising edge of the switching clock. The overcurrent induces a duty cycle reduction that could lead to the output voltage gradually dropping.

The BUCK PREREG operates with external compensation for external component-references according to the table given below:

5 Power supply function

Table 6 External filter component buck pre-regulator

1)

Parameter	Symbol	Values			Unit	Note or condition	P-Number
		Min.	Typ.	Max.			
External inductor	L_{PR}	-20 %	6.8	20%	μH	–	DS-1890
External inductor series resistance	$DCRL_{PR}$	–	8	10	mΩ	Max value to guarantee the efficiency	DS-1891
External capacitor	C_{PR}	-20 %	66	20%	μF	–	DS-1892
External capacitor series resistance	R_{C_PR}	–	10	20	mΩ	Max value to guarantee the efficiency and the stability	DS-1893
External bootstrap capacitor	C_{R1BTS}	-20 %	100	20%	nF	–	DS-1894
External bootstrap capacitor resistance	R_{C_R1BTS}	–	50	–	mΩ	–	DS-1895
External sense resistor	R_{sense}	-1%	10	+1%	mΩ	For 10 A current capability	DS-1896
External sense resistor	R_{sense}	-1%	20	+1%	mΩ	For 5 A current capability	DS-1897
External compensation capacitor	C_{comp}	-20 %	1.5	+20 %	nF	For 5 A current capability	DS-1898
External compensation capacitor	C_{comp}	-20 %	2.7	+20 %	nF	For 10 A current capability	DS-1899
External compensation resistance	R_{comp}	-1%	25	+1%	kΩ	For 5 A current capability	DS-1900
External compensation resistance	R_{comp}	-1%	12	+1%	kΩ	For 10 A current capability	DS-1901

1) Not subject to production test

5.1.2 Electrical characteristics BUCK PREREG

Table 7 Electrical characteristics BUCK PREREG

$V_{VS} = 6.0 \text{ V to } 36 \text{ V}$, $T_j = -40^\circ\text{C to } +175^\circ\text{C}$, all voltages with respect to ground, positive current flowing into pin (unless otherwise specified)

Parameter	Symbol	Values			Unit	Note or condition	P-Number
		Min.	Typ.	Max.			
4.0 V output voltage	V_{R1FB_4V0}	3.6	4	4.4	V	$V_{SSC_S} \geq 5.5 \text{ V}$; $dI/dt \leq 390 \text{ A/ms}$; Output voltage is set to 4 V by HWCFG	DS-1407

(table continues...)

5 Power supply function

Table 7 (continued) Electrical characteristics BUCK PREREG

$V_{VS} = 6.0 \text{ V to } 36 \text{ V}$, $T_j = -40^\circ\text{C to } +175^\circ\text{C}$, all voltages with respect to ground, positive current flowing into pin (unless otherwise specified)

Parameter	Symbol	Values			Unit	Note or condition	P-Number
		Min.	Typ.	Max.			
4.0 V output voltage accuracy	$V_{R1FB_4V0_acc}$	3.88	–	4.08	V	Static; $V_{SSC_S} \geq 5.5 \text{ V}$	DS-2151
5.5 V output voltage	V_{R1FB_5V5}	4.95	5.5	6.05	V	$V_{SSC_S} \geq 6.5 \text{ V}$; $dI/dt \leq 390 \text{ A/ms}$; Output voltage is set to 5V5 by HWCFG	DS-2154
5.5 V output voltage accuracy	$V_{R1FB_5V5_acc}$	5.34	–	5.61	V	Static; $V_{SSC_S} \geq 6.5 \text{ V}$	DS-2152
Maximum output current	I_{bck_prereg}	5	–	10	A	Max = 10 A with $R_{sense} = 10 \text{ m}\Omega$; Max = 5 A with $R_{sense} = 20 \text{ m}\Omega$; $I_{bck_prereg} < 5 \text{ A}$ if $V_{SSC_S} \leq 8 \text{ V}$	DS-2155
Sense input current high side	I_{R1CS1}			100	μA	$V_{SSC_S} > 3.6 \text{ V}$; $I_{bck_prereg} = 0$ 1)	DS-1410
Sense input current low-side	I_{R1FB}			100	μA	$V_{SSC_S} > 3.6 \text{ V}$; $I_{bck_prereg} = 0$ 1)	DS-1411
Overcurrent peak detection threshold	$V_{shunt_R1FB_OC}$	120	150	180	mV	Overcurrent case not including R_{sense} tolerance	DS-1412
Switching frequency	$f_{sw_bck_prereg}$	$f_{DCDC} [\text{MIN}] / 5$	$f_{DCDC} / 5$	$f_{DCDC} [\text{MAX}] / 5$	MHz	$f_{sw_bck_prereg} = f_{DCDC} / 5$	DS-1413
Soft-start time	$t_{ss_bck_pre_reg}$	–	400	715	μs	Voltage at pin V_{R1FB} ramps up from 10% to 90% of V_{R1FB}	DS-1414
Maximum duty cycle	$D_{max_bck_prereg}$			98	%		DS-1415
High-side peak sourcing current	I_{R1HS_SRC}	200 * X	–	850 * X	mA	$V_{R1HS} - V_{R1SW}$ from 1 V to 4 V $V_{QIS} = 5.5 \text{ V}$ I_{R1HS_SRC} is programmable by SPI in $DCDC_FREQ_SYNC.PREREG_DRIVER_CONFIG$; x:1,2/3,1/3; Default value: 1; 1)	DS-2087

(table continues...)

5 Power supply function

Table 7 (continued) Electrical characteristics BUCK PREREG

$V_{VS} = 6.0 \text{ V to } 36 \text{ V}$, $T_j = -40^\circ\text{C to } +175^\circ\text{C}$, all voltages with respect to ground, positive current flowing into pin (unless otherwise specified)

Parameter	Symbol	Values			Unit	Note or condition	P-Number
		Min.	Typ.	Max.			
High-side peak sinking current	I_{R1HS_SNK}	200 * X		850 * X	mA	$V_{R1HS} - V_{R1SW}$ from 4 V to 1 V; $V_{QIS} = 5.5 \text{ V}$ I_{R1HS_SNK} is programmable by SPI in DCDC_FREQ_SYNC.PREREG_DRIVER_CONFIG; x:1,2/3,1/3; Default value: 1; 1)	DS-2088
Low-side peak sourcing current	I_{R1LS_SRC}	200 * X	-	850 * X	mA	V_{R1LS} from 1 V to 4 V; $V_{QIS} = 5.5 \text{ V}$; I_{R1LS_SRC} is programmable by SPI in DCDC_FREQ_SYNC.PREREG_DRIVER_CONFIG; x:1,2/3,1/3; Default value: 1; 1)	DS-2089
Low-side peak sinking current	I_{R1LS_SNK}	200 * X		850 * X	mA	V_{R1LS} from 4 V to 1 V; $V_{QIS} = 5.5 \text{ V}$ I_{R1LS_SNK} is programmable by SPI in DCDC_FREQ_SYNC.PREREG_DRIVER_CONFIG; x:1,2/3,1/3; Default value: 1; 1)	DS-2090
Low-side high level gate output voltage vs. source	ΔV_{R1LS}	3.5	4.5	6	V	$\Delta V_{R1LS} = V_{R1LS} - V_{GND}$; $V_{VS} = V_{VIQST} > 6 \text{ V}$ 1)	DS-1514
High-side high level gate output voltage vs. source	$\Delta V_{HS_R1HS_R1SW}$	3.5	4.5	6	V	$\Delta V_{HS_R1HS_R1SW} = V_{R1HS} - V_{R1SW}$; $V_{VS} = V_{VQST} > 6 \text{ V}$ 1)	DS-1515
High-side gate rise time	t_{R1HS_r}	23	-	55	ns	V_{R1HS} from 10% to 90%; $C_{R1HS} = 3 \text{ nF}$ 1)	DS-1516
High-side gate fall time	t_{R1HS_f}	24	-	51	ns	V_{R1HS} from 90% to 10%; $C_{R1HS} = 3 \text{ nF}$ 1)	DS-1517

(table continues...)

5 Power supply function

Table 7 (continued) Electrical characteristics BUCK PREREG

$V_{VS} = 6.0 \text{ V to } 36 \text{ V}$, $T_j = -40^\circ\text{C to } +175^\circ\text{C}$, all voltages with respect to ground, positive current flowing into pin (unless otherwise specified)

Parameter	Symbol	Values			Unit	Note or condition	P-Number
		Min.	Typ.	Max.			
Low-side gate rise time	t_{R1LS_r}	23	–	55	ns	V_{R1LS} from 10% to 90%; $C_{R1LS} = 3 \text{ nF}$ ¹⁾	DS-1518
Low-side gate fall time	t_{R1LS_f}	24	–	51	ns	V_{R1LS} from 90% to 10%; $C_{R1LS} = 3 \text{ nF}$ ¹⁾	DS-1519

¹⁾ Not subject to production test, specified by design

5.2 BUCK CORE (buck core regulator)

5 Power supply function

5.2.1 Functional description BUCK CORE

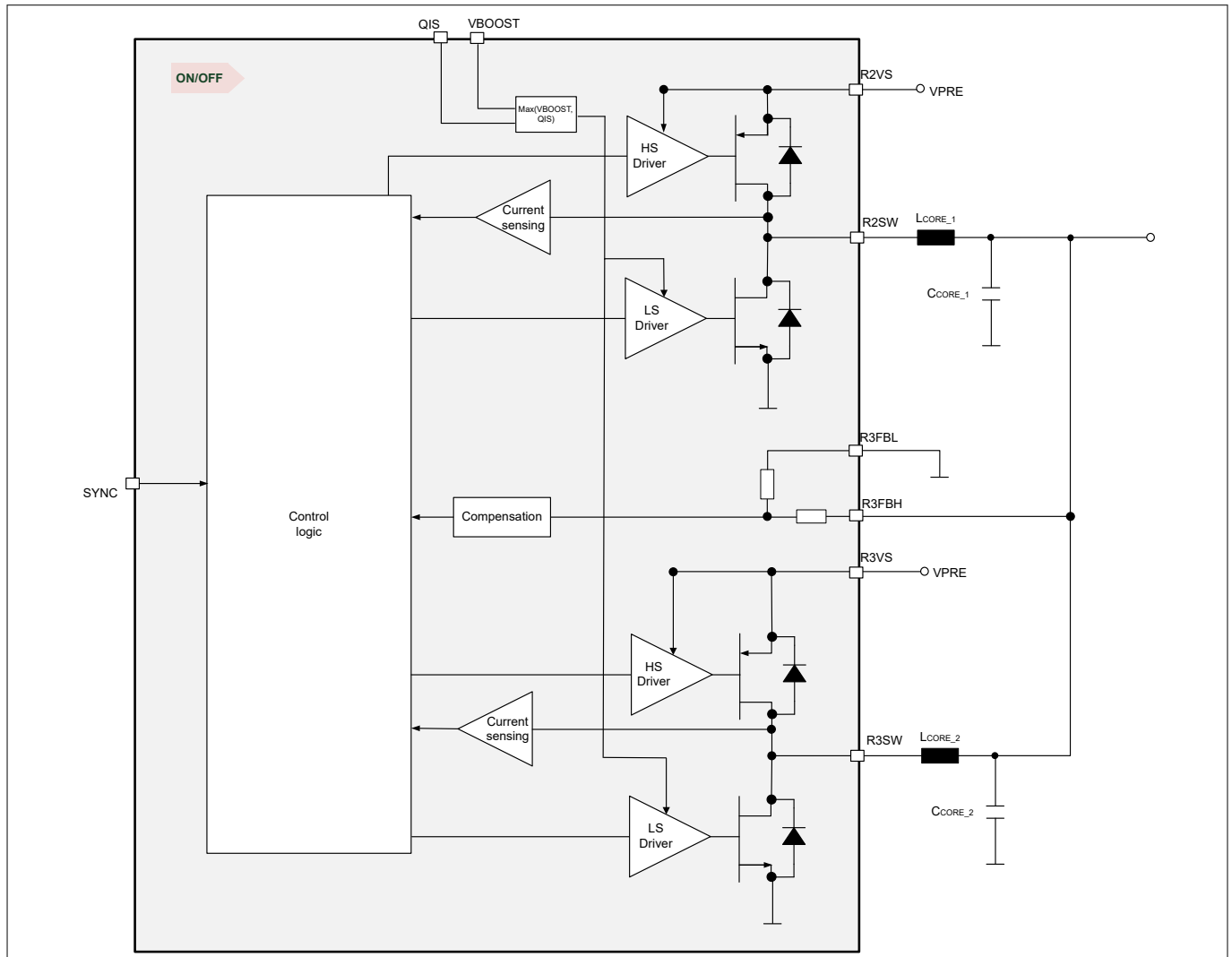


Figure 5 Block diagram BUCK CORE regulator

The device provides a dual phases buck regulator, which generates an output voltage between V_{R3FBH} and V_{R3FBL} with I_{bck_core} output current to supply the microcontroller core.

The default output voltage of the buck core can be read in the SPI register bitfield **VCORESTAT.VOUT**.

The output voltage of the buck core can be adjusted via SPI register bitfield **BUCK_CORE_PW_VSEL.VSEL**.

The device provides voltage scaling based on the request from the SPI interface in the range of V_{R3FBH_rg} with the unit step of V_{R3FBH_step} . When starting up or recovering from a R1 reset class event (see [Reset classes](#)) the regulator starts up with its default value of 1.025 V.

Further default OTP (One Time Programmable) values are available as default options:

0.7 V, 0.8 V, 0.9 V, 0.95 V, 0.9625 V, 0.975 V, 0.9875 V, 1.0 V, 1.0125 V, 1.025 V, 1.0375 V, 1.05 V, 1.15 V

Note: The reset value of the respective registers for configuring the output voltage of BUCKCORE (BUCK_CORE_PW_VSEL, BUCK_CORE_RS_VSEL, VCORESTAT, VCOREMONSTAT) does not correspond with the value a user will read upon the device's start-up or recovering from reset event. During the start-up, this register is overwritten with the pre-set default value.

The undervoltage and overvoltage monitoring thresholds of the buck core are adjusted according to the chosen regulator set point during static voltage scaling.

An overcurrent protection of maximum $I_{OC_bck_core}$ in cycle-by-cycle limitation mode is implemented.

5 Power supply function

The buck core regulator is implemented with an overload protection in the low-side MOSFET with $I_{OL_bck_core}$ limit in source-drain direction.

The buck core regulator operates with internal compensation for external component-references according to the table given below:

Table 8 External filter component (BOM) buck core regulator

1)

Parameter	Symbol	Values			Unit	Note or condition	P-Number
		Min.	Typ.	Max.			
External inductor 1	$L_{buck_core_1}$	-20 %	1	20%	μH	–	DS-1902
External inductor series resistance 1	$DCR_{L_buck_core_1}$	–	30	37	mΩ	–	DS-1903
External inductor 2	$L_{buck_core_2}$	-20 %	1	20%	μH	–	DS-1904
External inductor series resistance 2	$DCR_{L_buck_core_2}$	–	30	37	mΩ	–	DS-1905
External capacitor 1	$C_{buck_core_1}$	-20 %	47	20%	μF	–	DS-1906
External capacitor series resistance 1	$ESR_{C_buck_core_1}$	–	–	5	mΩ	–	DS-1907
External capacitor 2	$C_{buck_core_2}$	-20 %	47	20%	μF	–	DS-1908
External capacitor series resistance 2	$ESR_{C_buck_core_2}$	–	–	5	mΩ	–	DS-1909

1) Not subject to production test

5.2.2 Electrical characteristics BUCK CORE

Table 9 Electrical characteristics BUCK CORE

$V_{VS} = 6.0\text{ V to }36\text{ V}$, $T_j = -40^\circ\text{C to }+175^\circ\text{C}$, all voltages with respect to ground, positive current flowing into pin (unless otherwise specified)

Parameter	Symbol	Values			Unit	Note or condition	P-Number
		Min.	Typ.	Max.			
Input voltage	V_{R*VS}	V_{R1FB_4V0}	–	V_{R1FB_5V5}	V	$V_{R*VS} = V_{R2VS} = V_{R3VS}$	DS-1418
Default output voltage	V_{R3FBH}	–	1.025	–	V	–	DS-2085
Maximum output current	$I_{bck_core_ph}$	–	–	3.5	A	Per phase	DS-1421

(table continues...)

5 Power supply function

Table 9 (continued) Electrical characteristics BUCK CORE

$V_{VS} = 6.0 \text{ V to } 36 \text{ V}$, $T_j = -40^\circ\text{C to } +175^\circ\text{C}$, all voltages with respect to ground, positive current flowing into pin (unless otherwise specified)

Parameter	Symbol	Values			Unit	Note or condition	P-Number
		Min.	Typ.	Max.			
Minimum output current	$I_{\text{bck_core_min}}$	1	–	–	mA	¹⁾	DS-1428
Overcurrent limitation	$I_{\text{OC_bck_core_ph}}$	4.3	–	5.3	A	Per phase	DS-1423
Overload limitation	$I_{\text{OL_bck_core_ph}}$	4.3	–	5.3	A	Per phase	DS-1529
Static voltage range	$V_{\text{R3FBH_rg}}$	0.7	–	1.1	V	$V_{\text{R3FBH_rg}}$ is programmable (6 bits) between 0.7V and 1.1V via SPI with a default value V_{R3FBH} From 0.7V to 0.8875V: $V_{\text{R2VS}} = V_{\text{R3VS}} = V_{\text{R1FB_4V0}}$	DS-1419
Static voltage steps	$V_{\text{R3FBH_step}}$	–	12.5	–	mV	–	DS-1530
Switching frequency	$f_{\text{sw_bck_core}}$	$(f_{\text{DCD}} [\text{MHz}] / 5) \times 3$	$(f_{\text{DCD}} [\text{MHz}] / 5) \times 3$	$(f_{\text{DCD}} [\text{MHz}] / 5) \times 3$	MHz	–	DS-1531
Static tolerance including ripple	$dV_{\text{R3FBH_stat}}$	-2	–	+2	%	Under static output load.	DS-1420
Response time for static voltage scaling	$T_{\text{R_TO_SVS}}$	$0.9 \times T_{\text{R_TO_SVS}} [\text{typ}]$	$20 + 50 \times ((V_{\text{R3FBH_end}} - V_{\text{R3FBH_start}}) / dV_{\text{R3FBH_step}}) + 20$	$1.1 \times T_{\text{R_TO_SVS}} [\text{typ}]$	us	$V_{\text{R3FBH_end}}$ is the target V_{R3FBH} output voltage; $V_{\text{R3FBH_start}}$ is the starting V_{R3FBH} output voltage; $I_{\text{bck_core}} \geq 200 \text{ mA}$ to guarantee the BUCK_CORE response time for static voltage scaling ¹⁾	DS-1422

(table continues...)

5 Power supply function

Table 9 (continued) Electrical characteristics BUCK CORE

$V_{VS} = 6.0 \text{ V to } 36 \text{ V}$, $T_j = -40^\circ\text{C to } +175^\circ\text{C}$, all voltages with respect to ground, positive current flowing into pin (unless otherwise specified)

Parameter	Symbol	Values			Unit	Note or condition	P-Number
		Min.	Typ.	Max.			
Peak efficiency	$P_{\text{eff_bck_core}}$	83	87	–	%	50% of max load ($I_{\text{bck_core}}/2$) including typical external components and excluding board parasitics at RT ¹⁾	DS-1424
Soft-start time	$t_{\text{ss_bck_core}}$	–	0.5	–	ms	Voltage at pin V_{R3FBH} ramps up from 10% to 90% of V_{R3FBH}	DS-1425
Load step response for high load	$dV_{\text{R3FBH_HL}}$	-0.04 * V_{R3FBH}	–	0.04 * V_{R3FBH}	mV	(1) $0.7 \text{ V} \leq V_{\text{R3FBH}} \leq 0.9 \text{ V}$; $V_{\text{R2VS}} = V_{\text{R3VS}} = 4 \text{ V}$; (2) $0.9 \text{ V} < V_{\text{R3FBH}} \leq 1.1 \text{ V}$; $V_{\text{R2VS}} = V_{\text{R3VS}} = 5.5 \text{ V}$ or $V_{\text{R2VS}} = V_{\text{R3VS}} = 4 \text{ V}$; $dI_{\text{bck_core}} < 1200 \text{ mA}$; $100 \text{ mA} \leq I_{\text{bck_core}} \leq 5000 \text{ mA}$; load step rise/fall time = 100 ns; $t_{\text{settling}} = 10 \mu\text{s}$ $dI_{\text{bck_core}} > -1200 \text{ mA}$; $2100 \text{ mA} \leq I_{\text{bck_core}} \leq 7000 \text{ mA}$; load step rise/fall time = 100 ns; $t_{\text{settling}} = 10 \mu\text{s}$ series resistance 10mOhm between R3FBH and load (VDD supply pin MCU); series resistance 5 mΩ between R3FBL and load ground (supply ground pin of MCU); Including static output voltage accuracy ¹⁾	DS-2147

(table continues...)

5 Power supply function

Table 9 (continued) Electrical characteristics BUCK CORE

$V_{VS} = 6.0 \text{ V to } 36 \text{ V}$, $T_j = -40^\circ\text{C to } +175^\circ\text{C}$, all voltages with respect to ground, positive current flowing into pin (unless otherwise specified)

Parameter	Symbol	Values			Unit	Note or condition	P-Number
		Min.	Typ.	Max.			
Load step response for medium load	dV_{R3FBH_ML}	-0.03 $5 \cdot V_{R3FBH}$	–	0.03 $5 \cdot V_{R3FBH}$	mV	(1) $0.7 \leq V_{R3FBH} \leq 0.9$; $V_{R3VS} = 4\text{V}$ (2) $0.9 < V_{R3FBH} \leq 1.1\text{V}$; $V_{R3VS} = 5.5\text{V}$ or $V_{R3VS} = 4\text{V}$ $dI_{buck_core} < 500\text{mA}$; $100\text{mA} \leq I_{bck_core} \leq 6500\text{mA}$; load step rise/fall time = 100ns ; $t_{settling} = 10\mu\text{s}$ $dI_{buck_core} > -500\text{mA}$; $600\text{mA} \leq I_{bck_core} \leq 7000\text{mA}$; load step rise/fall time = 100ns ; $t_{settling} = 10\mu\text{s}$ series resistance $10\text{m}\Omega$ between $R3FBH$ and load (VDD supply pin MCU); series resistance $5\text{m}\Omega$ between $R3FBL$ and load ground (supply ground pin of MCU); Including static output voltage accuracy ¹⁾	DS-2148
Line step response	dV_{R3FBH_line}	-0.01 $5 \cdot V_{R3FBH}$	–	0.01 $5 \cdot V_{R3FBH}$	mV	(1) Maximum load: $dV/dT = 50 \text{ V/ms}$; step on $V_{R2VS} = V_{R3VS}$ from 3.6 V to 4.4 V if $V_{R1FB} = V_{R1FB_4V0}$; $100 \text{ mA} \leq I_{bck_core} \leq 7000 \text{ mA}$ (2) Maximum load: $dV/dT = 50 \text{ V/ms}$; step on $V_{R2VS} = V_{R3VS}$ from 4.95 V to 6.05 V if $V_{R1FB} = V_{R1FB_5V5}$; $100 \text{ mA} \leq I_{bck_core} \leq 7000 \text{ mA}$ ¹⁾	DS-1429
Internal pull-down resistor	R_{R3FBH_PD}	2.5	–	8.5	Ω	$V_{R3FBH} = 1 \text{ V}$	DS-1532
BUCKCORE high side on-resistance (4V0)	$R_{DS(on)_HS_BUCKCORE_4V0}$	–	67	118	$\text{m}\Omega$	$V_{R1FB} = V_{R1FB_4V0}$ ¹⁾	DS-2053
BUCKCORE high side on-resistance (5V5)	$R_{DS(on)_HS_BUCKCORE_5V5}$	–	58	101	$\text{m}\Omega$	$V_{R1FB} = V_{R1FB_5V5}$	DS-2063
BUCKCORE low side on-resistance	$R_{DS(on)_LS_BUCKCORE}$	–	33	63	$\text{m}\Omega$	–	DS-2146

(table continues...)

5 Power supply function

Table 9 (continued) Electrical characteristics BUCK CORE

$V_{VS} = 6.0 \text{ V to } 36 \text{ V}$, $T_j = -40^\circ\text{C to } +175^\circ\text{C}$, all voltages with respect to ground, positive current flowing into pin (unless otherwise specified)

Parameter	Symbol	Values			Unit	Note or condition	P-Number
		Min.	Typ.	Max.			
Switching output slew rate	$SR_{bck_core_5V5}$	4.2	–	6.3	V/ns	$V_{R2VS} = V_{R3VS} = 5.5 \text{ V}$ $SR_{bck_core_5V5} = 0.8 * V_{R2VS} / \text{trise}$, where trise is the rise time measured between 10% and 90%. DCDC_FREQ_SYNC.BUCKCORE_DRIVER_CONFIG = 00 _b 1)	DS-2094
Switching output slew rate	$SR_{bck_core_5V5}$	2.8		5.9	V/ns	$V_{R2VS} = V_{R3VS} = 5.5 \text{ V}$ $SR_{bck_core_5V5} = 0.8 * V_{R2VS} / \text{trise}$, where trise is the rise time measured between 10% and 90%. DCDC_FREQ_SYNC.BUCKCORE_DRIVER_CONFIG = 01 _b 1)	DS-2099
Switching output slew rate	$SR_{bck_core_5V5}$	1.1	–	3.6	V/ns	$V_{R2VS} = V_{R3VS} = 5.5 \text{ V}$ $SR_{bck_core_5V5} = 0.8 * V_{R2VS} / \text{trise}$, where trise is the rise time measured between 10% and 90%. DCDC_FREQ_SYNC.BUCKCORE_DRIVER_CONFIG = 10 _b 1)	DS-2098
Switching output slew rate	$SR_{bck_core_4V}$	2.8	–	4.9	V/ns	$V_{R2VS} = V_{R3VS} = 4 \text{ V}$ $SR_{bck_core_4V} = 0.8 * V_{R2VS} / \text{trise}$, where trise is the rise time measured between 10% and 90% DCDC_FREQ_SYNC.BUCKCORE_DRIVER_CONFIG = 00 _b 1)	DS-2097

(table continues...)

5 Power supply function

Table 9 (continued) Electrical characteristics BUCK CORE

$V_{VS} = 6.0 \text{ V}$ to 36 V , $T_j = -40^\circ\text{C}$ to $+175^\circ\text{C}$, all voltages with respect to ground, positive current flowing into pin (unless otherwise specified)

Parameter	Symbol	Values			Unit	Note or condition	P-Number
		Min.	Typ.	Max.			
Switching output slew rate	$SR_{\text{bck_core_4V}}$	1		4.4	V/ns	$V_{R2VS} = V_{R3VS} = 4 \text{ V}$ $SR_{\text{bck_core_4V}} = 0.8 * V_{R2VS} / \text{trise}$, where trise is the rise time measured between 10% and 90% DCDC_FREQ_SYNC.BUCKCORE_DRIVER_CONFIG = 01 _b 1)	DS-2096
Switching output slew rate	$SR_{\text{bck_core_4V}}$	0.38	–	1.3	V/ns	$V_{R2VS} = V_{R3VS} = 4 \text{ V}$ $SR_{\text{bck_core_4V}} = 0.8 * V_{R2VS} / \text{trise}$, where trise is the rise time measured between 10% and 90% DCDC_FREQ_SYNC.BUCKCORE_DRIVER_CONFIG = 10 _b 1)	DS-2095

1) Not subject to production test, specified by design

5.3 BUCK IF (interface regulator)

5 Power supply function

5.3.1 Functional description BUCK IF

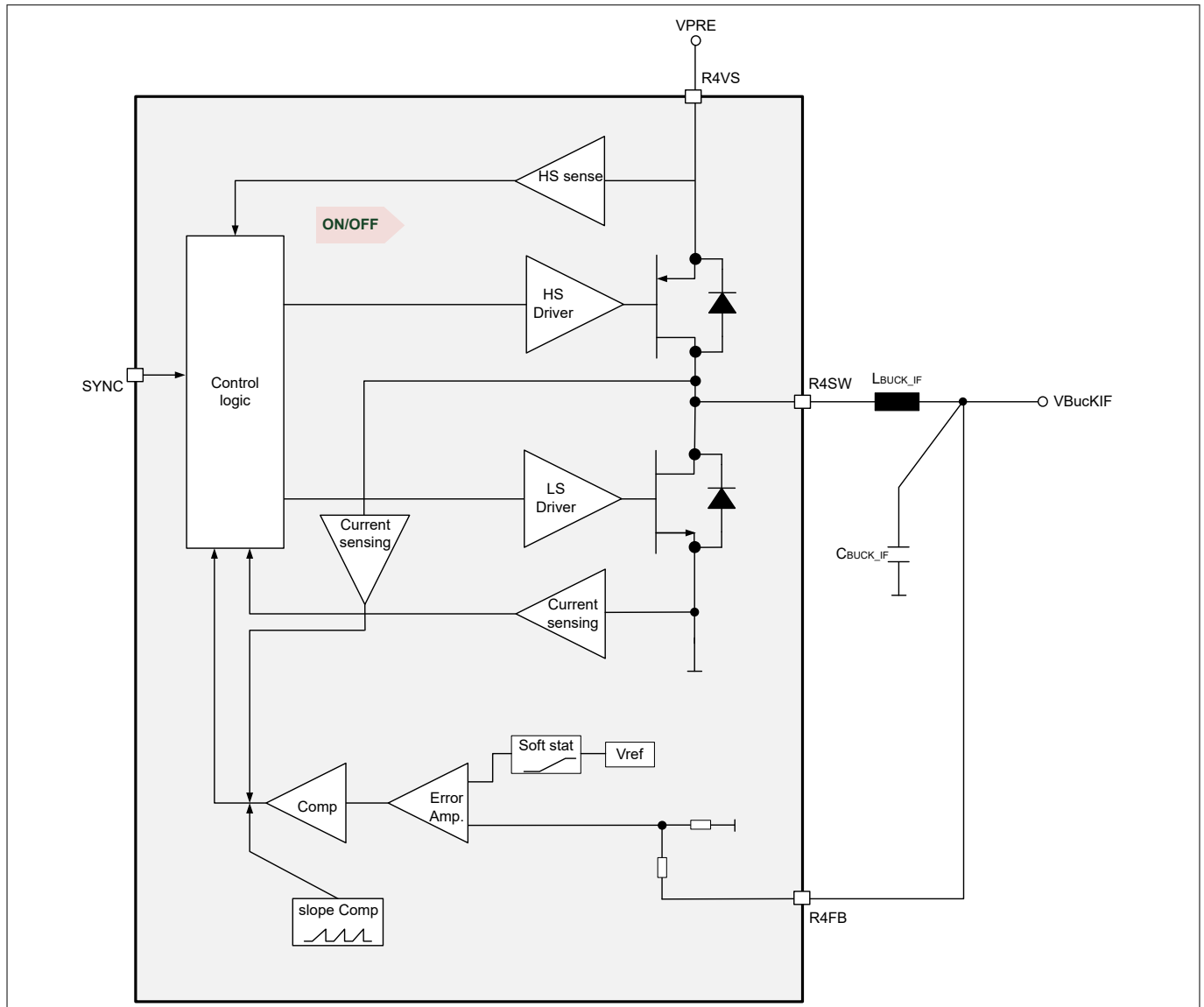


Figure 6 Block diagram BUCKIF

The device provides buck interface regulator which steps down the PREREG output voltage VPRE to an output voltage V_{BUCKIF} with I_{bck_if} output current at pin R4FB.

Note: This voltage can be used to supply the high speed interfaces.

The BUCK IF regulator is implemented with an overcurrent protection of maximum $I_{OC_bck_if}$ in cycle-by-cycle limitation mode.

The BUCK IF regulator is implemented with an overload protection in the low-side MOSFET with $I_{OL_bck_if}$ limit in source-drain direction.

The device provides an auto detection during start-up if the BUCK IF regulator is used within the application. If not used the pins of BUCKIF must be connected according to the following configuration:

- R4VS: connect to GND
- R4FB: leave open
- R4SW: leave open

5 Power supply function

Note: *BUCK IF is excluded from the power sequencing if not used.*

The BUCK IF regulator operates with internal compensation for external component-references according to the table given below:

Table 10 External filter component (BOM) BUCK IF

1)

Parameter	Symbol	Values			Unit	Note or condition	P-Number
		Min.	Typ.	Max.			
External inductor	$L_{\text{BUCK_IF}}$	-20 %	2.2	20%	μH	–	DS-1910
External inductor series resistance	$D_{\text{CRL_BUCK_IF}}$		20	80	mΩ	Max value to guarantee the efficiency	DS-1911
External capacitor	$C_{\text{BUCK_IF}}$	25	47	(+20 %)	μF	–	DS-1912
External capacitor series resistance	$ESR_{\text{C_BUCK_IF}}$		8	15	mΩ	Max value to guarantee the efficiency	DS-1913

1) Not subject to production test

5.3.2 Electrical characteristics BUCK IF

Table 11 Electrical characteristics BUCK IF

$V_{\text{VS}} = 6.0 \text{ V to } 36 \text{ V}$, $T_j = -40^\circ\text{C to } +175^\circ\text{C}$, all voltages with respect to ground, positive current flowing into pin (unless otherwise specified)

Parameter	Symbol	Values			Unit	Note or condition	P-Number
		Min.	Typ.	Max.			
Input voltage	V_{R4VS}	$V_{\text{R1FB_4V0}}$	–	$V_{\text{R1FB_5V5}}$	V	–	DS-1431
Output voltage excluding ripple	V_{R4FB}	3.23 4	3.3	3.36 6	V	Static output voltage excluding ripple minimum load: $I_{\text{bck_if}} \geq 20\text{mA}$ 1)	DS-1432
Maximum output current	$I_{\text{bck_if}}$	–	–	1.2	A	1)	DS-1434
Minimum output current	$I_{\text{buck_if_min}}$	200	–	–	μA	1)	DS-2042
Overcurrent limitation	$I_{\text{OC_bck_if}}$	1.5	–	2.6	A	–	DS-1435
Peak efficiency	$P_{\text{eff_bck_if}}$	80	88	–	%	$I_{\text{buck_if}}$ from 0.2 A up to 1 A, including typical external components at RT 1)	DS-1436

(table continues...)

5 Power supply function

Table 11 (continued) Electrical characteristics BUCK IF

$V_{VS} = 6.0 \text{ V to } 36 \text{ V}$, $T_j = -40^\circ\text{C to } +175^\circ\text{C}$, all voltages with respect to ground, positive current flowing into pin (unless otherwise specified)

Parameter	Symbol	Values			Unit	Note or condition	P-Number
		Min.	Typ.	Max.			
Switching frequency	$f_{\text{sw_bck_IF}}$	f_{DCDC} [MIN]	f_{DCDC}	f_{DCDC} [MAX]	MHz	–	DS-1523
Switching frequency 2	$f_{\text{sw_bck_IF}_2}$	0.9 * $f_{\text{sw_bck_IF}_2}[\text{typ}]$	2	1.1 * $f_{\text{sw_bck_IF}_2}[\text{typ}]$	MHz	Only applicable if: FREQ_SPREAD.FRE_SP_EN = 1 AND FREQ_SPREAD.FRE_SP_BUCKIF_EN = 0	DS-2050
Soft-start time	$t_{\text{ss_bck_if}}$	–	430	800	μs	Voltage at pin V_{R4FB} ramps up from 10% to 90% of V_{R4FB} $5 \text{ mA} < I_{\text{R4FB}} < 500 \text{ mA}$	DS-2167
Load step response	$\Delta V_{\text{R4FB_load}}$	-82	–	82	mV	$\Delta I_{\text{bck_if}} < 500 \text{ mA}$; $20 \text{ mA} \leq I_{\text{bck_if}} \leq 500 \text{ mA}$; load step rise/fall time = 100 ns; $\Delta I_{\text{bck_if}} > -500 \text{ mA}$; $520 \text{ mA} \leq I_{\text{bck_if}} \leq 1000 \text{ mA}$; load step rise/fall time = 100 ns 1)	DS-1438
Load step response max dynamic range	$\Delta V_{\text{R4FB_mdr_load}}$	-116	–	116	mV	$\Delta I_{\text{bck_if}} > -700 \text{ mA}$; $I_{\text{bck_if}} = 1000 \text{ mA}$; load step rise/fall time = 100 ns; $t_{\text{settling}} = 10 \mu\text{s}$ 1)	DS-1440
Line step response	$\Delta V_{\text{R4FB_line}}$	-116	–	116	mV	Step on V_{R4VS} from 3.88 V to 3.66 V in 10 μs and from 3.66 V to 3.88 V in 10 μs if $V_{\text{R1FB}} = V_{\text{R1FB_4V0}}$; Step on V_{R4VS} from 5.61 V to 5.97 V in 10 μs and from 5.97 V to 5.61 V in 10 μs if $V_{\text{R1FB}} = V_{\text{R1FB_5V5}}$; $20 \text{ mA} \leq I_{\text{bck_if}} \leq 1000 \text{ mA}$	DS-1442
Overload limitation	$I_{\text{OL bck if}}$	1.5	–	2.1	A	–	DS-1522
Internal pull-down resistor	$R_{\text{R4FB_PD}}$	3.2	–	21	Ω	–	DS-1524
BUCKIF high side on-resistance (4V0)	$R_{\text{DS(on)_HS_BUCKIF_4V0}}$	–	214	372	mΩ	$V_{\text{R1FB}} = V_{\text{R1FB_4V0}}$ 1)	DS-2055

(table continues...)

5 Power supply function

Table 11 (continued) Electrical characteristics BUCK IF

$V_{VS} = 6.0 \text{ V to } 36 \text{ V}$, $T_j = -40^\circ\text{C to } +175^\circ\text{C}$, all voltages with respect to ground, positive current flowing into pin (unless otherwise specified)

Parameter	Symbol	Values			Unit	Note or condition	P-Number
		Min.	Typ.	Max.			
BUCKIF high side on-resistance (5V5)	$R_{DS(on)_HS_BUCKIF_5V5}$	–	181	309	mΩ	$V_{R1FB} = V_{R1FB_5V5}$	DS-2065
BUCKIF low side on-resistance (4V0)	$R_{DS(on)_LS_BUCKIF_4V0}$	–	92	158	mΩ	$V_{R1FB} = V_{R1FB_4V0}$ 1)	DS-2056
BUCKIF low side on-resistance (5V5)	$R_{DS(on)_LS_BUCKIF_5V5}$	–	82	139	mΩ	$R_{DS(on)_HS_BUCKIF_5V5}$	DS-2066
Switching output slew rate	$SR_{bck_if_5V5}$	1.8	–	3.5	V/ns	$V_{R4VS} = 5.5 \text{ V}$ $SR_{bck_if_5V5} = 0.8 * V_{R4VS} / \text{trise}$, where trise is the rise time measured between 10% and 90% DCDC_FREQ_SYNC.BUCKIF_D RIVER_CONFIG = 00 _b 1)	DS-2100
Switching output slew rate	$SR_{bck_if_5V5}$	1.8	–	3.5	V/ns	$V_{R4VS} = 5.5 \text{ V}$ $SR_{bck_if_5V5} = 0.8 * V_{R4VS} / \text{trise}$, where trise is the rise time measured between 10% and 90% DCDC_FREQ_SYNC.BUCKIF_D RIVER_CONFIG = 01 _b 1)	DS-2101
Switching output slew rate	$SR_{bck_if_5V5}$	1.8	–	3.5	V/ns	$V_{R4VS} = 5.5 \text{ V}$ $SR_{bck_if_5V5} = 0.8 * V_{R4VS} / \text{trise}$, where trise is the rise time measured between 10% and 90% DCDC_FREQ_SYNC.BUCKIF_D RIVER_CONFIG = 10 _b 1)	DS-2102

(table continues...)

5 Power supply function

Table 11 (continued) Electrical characteristics BUCK IF

$V_{VS} = 6.0 \text{ V}$ to 36 V , $T_j = -40^\circ\text{C}$ to $+175^\circ\text{C}$, all voltages with respect to ground, positive current flowing into pin (unless otherwise specified)

Parameter	Symbol	Values			Unit	Note or condition	P-Number
		Min.	Typ.	Max.			
Switching output slew rate	$SR_{bck_if_4V}$	1.3	–	2.6	V/ns	$V_{R4VS} = 4V$ $SR_{bck_if_4V} = 0.8 * V_{R4VS} / \text{trise}$, where trise is the rise time measured between 10% and 90% DCDC_FREQ_SYNC.BUCKIF_D RIVER_CONFIG = 00 _b 1)	DS-2103
Switching output slew rate	$SR_{bck_if_4V}$	1.3	–	2.6	V/ns	$V_{R4VS} = 4V$ $SR_{bck_if_4V} = 0.8 * V_{R4VS} / \text{trise}$, where trise is the rise time measured between 10% and 90% DCDC_FREQ_SYNC.BUCKIF_D RIVER_CONFIG = 01 _b 1)	DS-2104
Switching output slew rate	$SR_{bck_if_4V}$	1.1	–	2.1	V/ns	$V_{R4VS} = 4V$ $SR_{bck_if_4V} = 0.8 * V_{R4VS} / \text{trise}$, where trise is the rise time measured between 10% and 90% DCDC_FREQ_SYNC.BUCKIF_D RIVER_CONFIG = 10 _b 1)	DS-2105

1) Not subject to production test, specified by design

5.4 BOOST (boost regulator)

5 Power supply function

Table 12 (continued) **External filter component BOOST**

1)

Parameter	Symbol	Values			Unit	Note or condition	P-Number
		Min.	Typ.	Max.			
External capacitor series resistance	$ESR_{C_{bst}}$	–	10	20	mΩ	–	DS-1917
External Schottky diode forward voltage	$V_{D_{bst}}$	–	0.4	0.52	V	@ $I_{D_{boost}} = 1$ A	DS-1951

1) Not subject to production test

5.4.2 Electrical characteristics BOOST

Table 13 **Electrical characteristics BOOST**

$V_{VS} = 6.0$ V to 36 V, $T_j = -40^\circ\text{C}$ to $+175^\circ\text{C}$, all voltages with respect to ground, positive current flowing into pin (unless otherwise specified)

Parameter	Symbol	Values			Unit	Note or condition	P-Number
		Min.	Typ.	Max.			
Input voltage	V_{in_boost}	2.7	–	5.61	V	1)	DS-2150
Output voltage	V_{BSTFB}	5.63	5.8	5.97	V	$I_{LOAD_BOOST} < 1$ A: $3.9\text{ V} \leq V_{R1FB_4V0} \leq 4.1\text{ V}$, $5.33\text{ V} \leq V_{R1FB_5V5} \leq 5.61\text{ V}$; $I_{LOAD_BOOST} < 0.650$ A; $2.59\text{ V} \leq V_{R1FB} \leq 2.71\text{ V}$	DS-1447
Load current	I_{LOAD_BOOST}	–	–	1	A	Total load (internal and external load)	DS-1509
Switching frequency	f_{sw_bst}	f_{DCDC} [MIN]	f_{DCDC}	f_{DCDC} [MAX]	MHz	–	DS-1526
Overcurrent limitation	I_{OC_BSTI}	3.5	4	4.5	A	–	DS-1448
Efficiency	P_{eff_bst}	81	85	–	%	Including typical BOM; @27°C; $150\text{ mA} \leq I_{LOAD_BOOST} \leq 950\text{ mA}$ 1)	DS-1449
Soft-start time	t_{ss_boost}	–	650	1000	μs	Voltage at pin V_{BSTFB} ramps up from 10% to 90% of V_{BSTFB}	DS-1450
Pull-down resistor	R_{BSTFB_PD}	12	–	76	Ω	–	DS-1527
BOOST low side on-resistance	$R_{DS(on)_LS_BOOST}$	–	114	221	mΩ	–	DS-2057

(table continues...)

5 Power supply function

Table 13 (continued) Electrical characteristics BOOST

$V_{VS} = 6.0 \text{ V to } 36 \text{ V}$, $T_j = -40^\circ\text{C to } +175^\circ\text{C}$, all voltages with respect to ground, positive current flowing into pin (unless otherwise specified)

Parameter	Symbol	Values			Unit	Note or condition	P-Number
		Min.	Typ.	Max.			
Switching output slew rate	SR_{bst}	0.50		2.2	V/ns	$SR_{bst} = 0.8 \cdot V_{BSTI} / t_{fall}$, where t_{fall} is the fall time measured between 10% and 90%. $100\text{mA} < I_{bst} < 1\text{A}$ DCDC_FREQ_SYNC.BOOST_D RIVER_CONFIG = 00 _b 1)	DS-2091
Switching output slew rate	SR_{bst}	0.4		1.5	V/ns	$S_{R_bst} = 0.8 \cdot V_{BSTI} / t_{fall}$, where t_{fall} is the fall time measured between 10% and 90%. $100\text{mA} < I_{bst} < 1\text{A}$ DCDC_FREQ_SYNC.BOOST_D RIVER_CONFIG = 01 _b 1)	DS-2092
Switching output slew rate	SR_{bst}	0.15		0.8	V/ns	$S_{R_bst} = 0.8 \cdot V_{BSTI} / t_{fall}$, where t_{fall} is the fall time measured between 10% and 90%. $100\text{mA} < I_{bst} < 1\text{A}$ DCDC_FREQ_SYNC.BOOST_D RIVER_CONFIG = 10 _b 1)	DS-2093

1) Not subject to production test, specified by design

5.5 Communication LDO (QCO)

5 Power supply function

5.5.1 Functional description communication LDO (QCO)

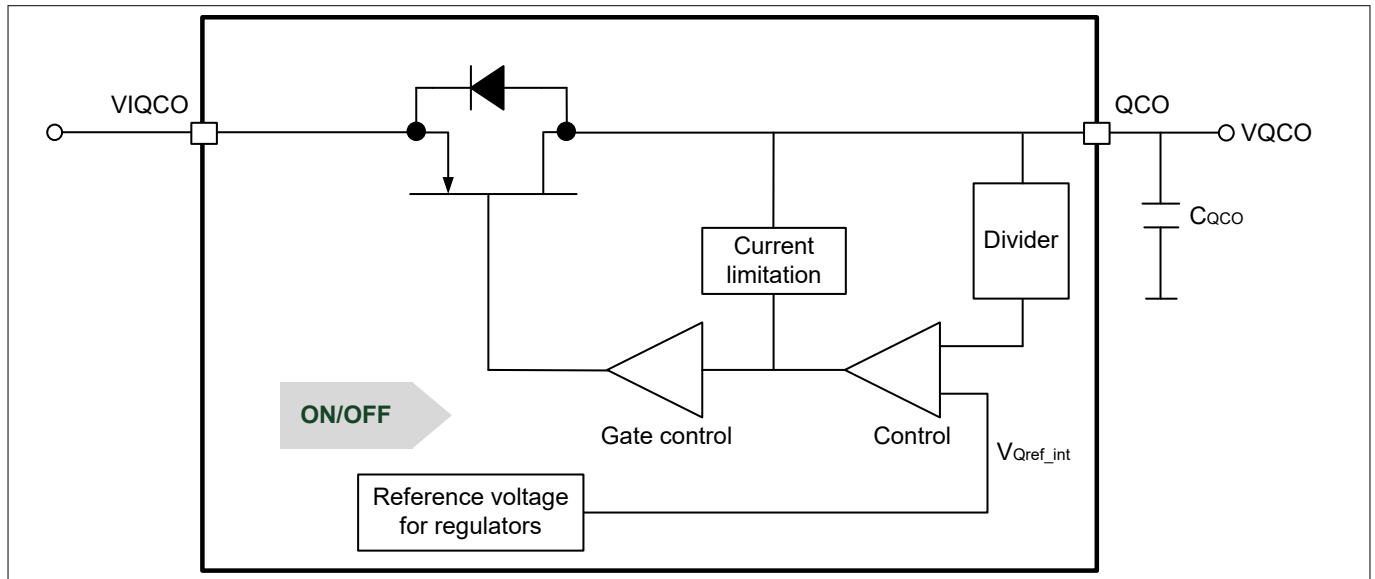


Figure 8 Block diagram LDO-QCO

The device provides a low-dropout-regulator LDO-QCO which generates a regulated output voltage V_{QCO} with I_{QCO} output current to supply the microcontroller. The regulator is supplied from the boost regulator output. As a configuration option, the regulator can also be supplied directly from the pre-regulator output.

The stability of the control loop depends on the load current, the characteristics of the output capacitor and the chip junction temperature. A stable operation is ensured by the output capacitance chosen according to the specified electrical characteristics table below (capacitance value C_{QCO} and equivalent series resistance $ESR_{C_{QCO}}$). The output capacitance is either one capacitor or a set of capacitors following the capacitance range as a whole.

Note: This voltage can be used to supply the communication device, e.g. CAN transceiver.

To protect the communication supply from overstress the current limitation limits the output current I_{QCO} to the specified limit I_{QCO_max} .

5.5.2 Electrical characteristics communication LDO (QCO)

Table 14 Electrical characteristics communication LDO (QCO)

$V_{VS} = 6.0\text{ V to }36\text{ V}$, $T_j = -40^\circ\text{C to }+175^\circ\text{C}$, all voltages with respect to ground, positive current flowing into pin (unless otherwise specified)

Parameter	Symbol	Values			Unit	Note or condition	P-Number
		Min.	Typ.	Max.			
Output voltage	V_{QCO}	4.9	5	5.1	V	$0\text{ mA} < I_{QCO} < 600\text{ mA}$	DS-1453
Output current	I_{QCO}	0	–	600	mA	–	DS-1454
Output current limitation	I_{QCO_max}	650	–	1100	mA	–	DS-1455

(table continues...)

5 Power supply function

Table 14 (continued) Electrical characteristics communication LDO (QCO)

$V_{VS} = 6.0 \text{ V to } 36 \text{ V}$, $T_j = -40^\circ\text{C to } +175^\circ\text{C}$, all voltages with respect to ground, positive current flowing into pin (unless otherwise specified)

Parameter	Symbol	Values			Unit	Note or condition	P-Number
		Min.	Typ.	Max.			
Drop voltage	V_{dr_QCO}	–	–	500	mV	$I_{QCO} < 600 \text{ mA}$	DS-1456
Power supply ripple rejection	$PSRR_{QCO}$	26	–	–	dB	$V_{VIQVR_VIQCO} = 5.8\text{V}$ with 100mVpp at 2.2 MHz and $I_{load} \leq I_{QCO}$ $ESR_{C_QCO} \leq 50\text{m}\Omega$ ¹⁾	DS-1457
Load regulation	ΔV_{QCO}	–	40	70	mV	$100 \mu\text{A} < I_{QCO} < 600 \text{ mA}$	DS-1458
Output capacitor	C_{QCO}	1	–	47	μF	¹⁾	DS-1459
Output capacitor equivalent series resistance	ESR_{C_QCO}	–	–	100	$\text{m}\Omega$	¹⁾	DS-1460
Soft-start time	t_{ss_QCO}	–	290	500	μs	Voltage at pin QCO ramps up from 10% to 90% of V_{QCO} ; $-60 \text{ mA} < I_{QCO} < -5 \text{ mA}$; $C_{QCO} = 4.7 \mu\text{F}$	DS-2046

1) Not subject to production test, specified by design

5.6 Reference LDO (QVR)

5.6.1 Functional description reference LDO (QVR)

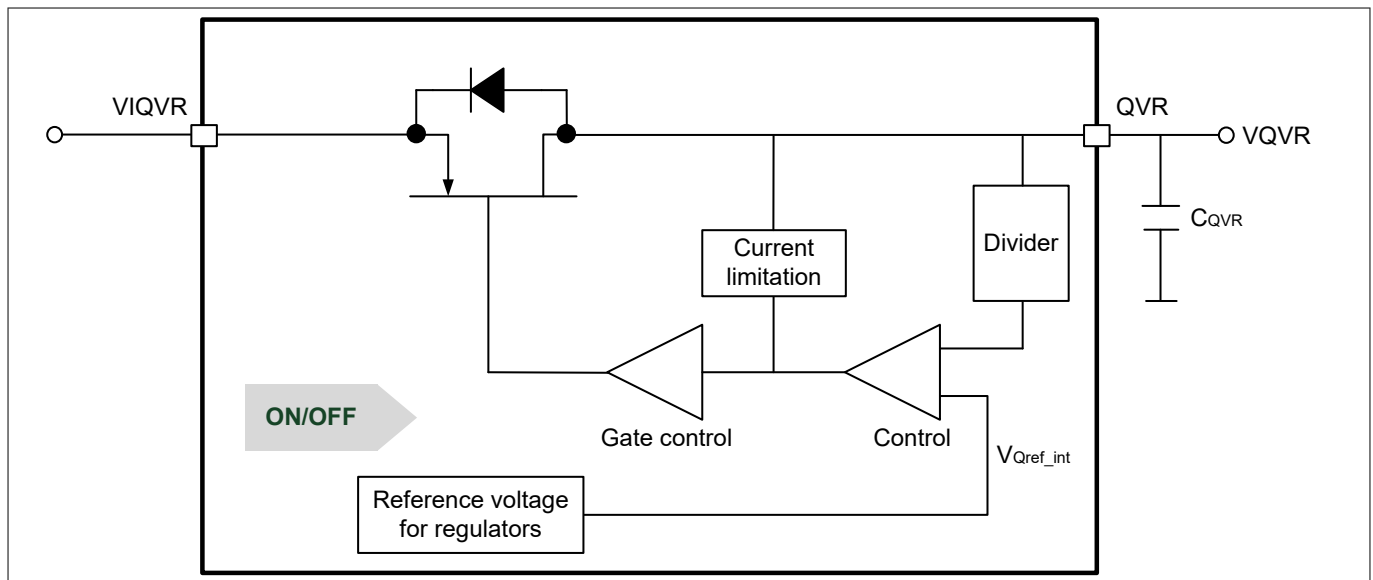


Figure 9 Block diagram LDO-QVR

5 Power supply function

The device provides a low dropout regulator LDO-VREF which generates a regulated output voltage V_{QVR} with I_{QVR} output current to supply the microcontroller. The regulator is supplied from the boost regulator output. As a configuration option, the regulator can also be supplied directly from the pre-regulator output.

The stability of the control loop depends on the load current, the characteristics of the output capacitor and the chip junction temperature. A stable operation is ensured by the output capacitance chosen according to the specified electrical characteristics table below (capacitance value C_{VREF} and equivalent series resistance ESR_{C_QVR}). The output capacitance is either one capacitor or a set of capacitors following as a whole the capacitance range.

Note: This voltage can be used as reference voltage for the ADC in the microcontroller.

To protect the communication supply from overstress the current limitation limits the output current I_{QVR} to the specified limit I_{QVR_max} .

The status of OC fault can be read via register and can be cleared on write command via SPI once the OC fault is expired.

5.6.2 Electrical characteristics reference LDO (QVR)

Table 15 Electrical characteristics reference LDO (QVR)

$V_{VS} = 6.0\text{ V to }36\text{ V}$, $T_j = -40^\circ\text{C to }+175^\circ\text{C}$, all voltages with respect to ground, positive current flowing into pin (unless otherwise specified)

Parameter	Symbol	Values			Unit	Note or condition	P-Number
		Min.	Typ.	Max.			
Output voltage	V_{QVR}	4.95	5	5.05	V	$0\text{ mA} < I_{QVR} < 150\text{ mA}$	DS-1462
Output current	I_{QVR}	0	–	150	mA	–	DS-1463
Output current limitation	I_{QVR_max}	170	–	345	mA	–	DS-1464
Drop voltage	V_{dr_QVR}	–	–	400	mV	$I_{QVR} < 150\text{ mA}$	DS-1465
Load regulation	ΔV_{QVR}	–	4.5	9	mV	$100\text{ }\mu\text{A} < I_{QVR} < 150\text{ mA}$	DS-1466
Power supply ripple rejection	$PSRR_{QVR}$	26	–	–	dB	$V_{I_{QVR_VIQCO}} = 5.8\text{V}$ with 100mVpp at 2.2 MHz and $I_{load} \leq I_{QVR}$ $ESR_{C_QVR} \leq 50\text{m}\Omega$ ¹⁾	DS-1467
Output capacitor	C_{QVR}	1	–	10	μF	¹⁾	DS-1468
Output capacitor equivalent series resistance	ESR_{C_QVR}	–	–	100	m Ω	¹⁾	DS-1469
Soft-start time	t_{ss_QVR}	–	280	520	μs	Voltage at pin QVR ramps up from 10% to 90% of V_{QVR} ; $-15\text{ mA} < I_{QVR} < -5\text{ mA}$; $C_{QVR} = 4.7\text{ }\mu\text{F}$	DS-2048

¹⁾ Not subject to production test, specified by design

5.7 MCU-LDO (QUC)

5 Power supply function

5.7.1 Functional description MCU-LDO (QUC)

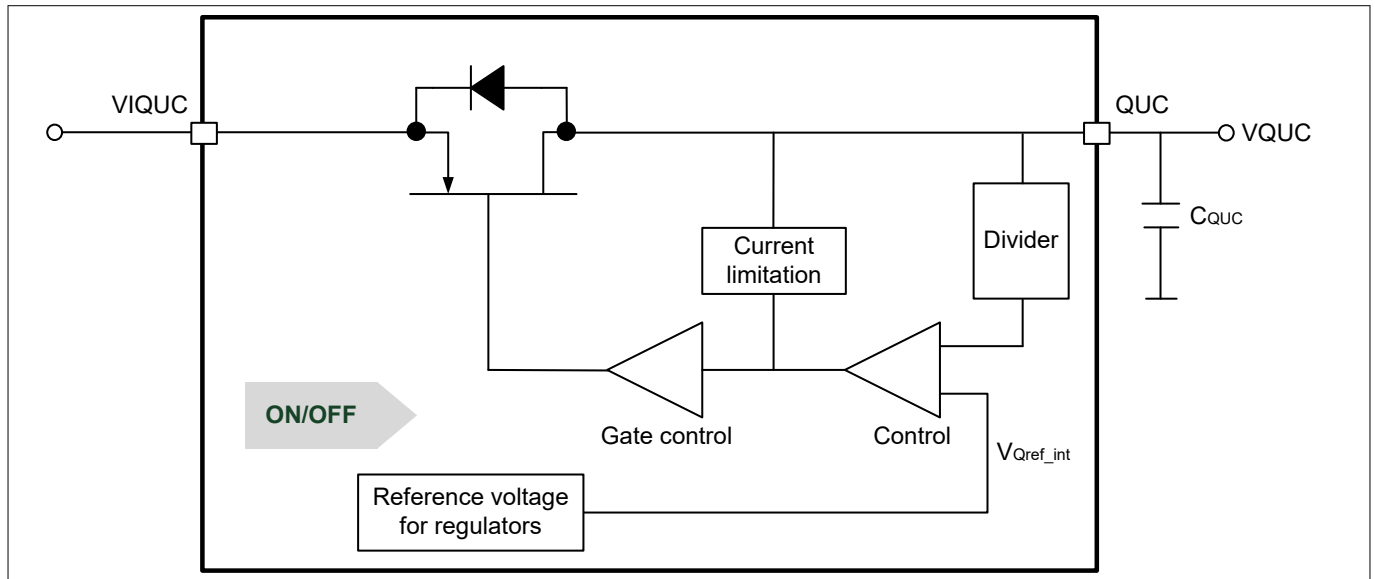


Figure 10 Block diagram LDO-QUC

The device provides a low drop out regulator LDO-QUC which generates a regulated output voltage V_{QUC} with I_{QUC} output current to supply the microcontroller. The regulator is supplied from the boost regulator output. As a configuration option, the regulator can also be supplied directly from the pre-regulator output.

The stability of the control loop depends on the load current, the characteristics of the output capacitor and the chip junction temperature. A stable operation is ensured by the output capacitance chosen according to the specified electrical characteristics table below (capacitance value C_{QUC} and equivalent series resistance $ESR_{C_{QUC}}$). The output capacitance is either one capacitor or a set of capacitors following the capacitance range as a whole.

To protect the QUC supply from overstress the current limitation limits the output current I_{QUC} to the specified limit I_{QUC_max} .

Note: When the current, sunk from the output pin QUC, is limited, the output voltage V_{QUC} will decrease.

5.7.2 Electrical characteristics MCU-LDO (QUC)

Table 16 Electrical characteristics MCU-LDO (QUC)

$V_{VS} = 6.0\text{ V to }36\text{ V}$, $T_j = -40^\circ\text{C to }+175^\circ\text{C}$, all voltages with respect to ground, positive current flowing into pin (unless otherwise specified)

Parameter	Symbol	Values			Unit	Note or condition	P-Number
		Min.	Typ.	Max.			
Output voltage	V_{QUC}	4.9	5	5.1	V	$0\text{ mA} < I_{QUC} < 600\text{ mA}$	DS-1471
Output current	I_{QUC}	0	–	600	mA	–	DS-1473
Output current limitation	I_{QUC_max}	650	–	1100	mA	–	DS-1474
Drop voltage	ΔV_{QUC}	–	–	450	mV	$I_{QUC} < 600\text{ mA}$	DS-1475
Load regulation	ΔV_{QUC_load}	–	45	81	mV	$100\text{ }\mu\text{A} < I_{QUC} < 600\text{ mA}$	DS-1477

(table continues...)

5 Power supply function

Table 16 (continued) Electrical characteristics MCU-LDO (QUC)

$V_{VS} = 6.0 \text{ V to } 36 \text{ V}$, $T_j = -40^\circ\text{C to } +175^\circ\text{C}$, all voltages with respect to ground, positive current flowing into pin (unless otherwise specified)

Parameter	Symbol	Values			Unit	Note or condition	P-Number
		Min.	Typ.	Max.			
Output capacitor	C_{QUC}	2.2	4.7	22	μF	1)	DS-1479
Output capacitor equivalent series resistance	$ESR_{C_{QUC}}$	–	–	100	$\text{m}\Omega$	1)	DS-1480
Power supply ripple rejection	$PSRR_{QUC}$	26	–	–	dB	$V_{I_{QUC}} = 5.8 \text{ V}$ with 100 mVpp at 2.2 MHz and $I_{load} \leq I_{QUC}$ $ESR_{C_{QUC}} \leq 50 \text{ m}\Omega$ 1)	DS-1481
Soft-start time	t_{ss_QUC}	–	290	500	μs	Voltage at pin QUC ramps up from 10% to 90% of V_{QUC} ; $-60 \text{ mA} < I_{QUC} < -5 \text{ mA}$; $C_{QUC} = 4.7 \mu\text{F}$ 1)	DS-2047

1) Not subject to production test, specified by design

5.8 Standby LDO (QST)

5.8.1 Functional descriptions standby LDO (QST)

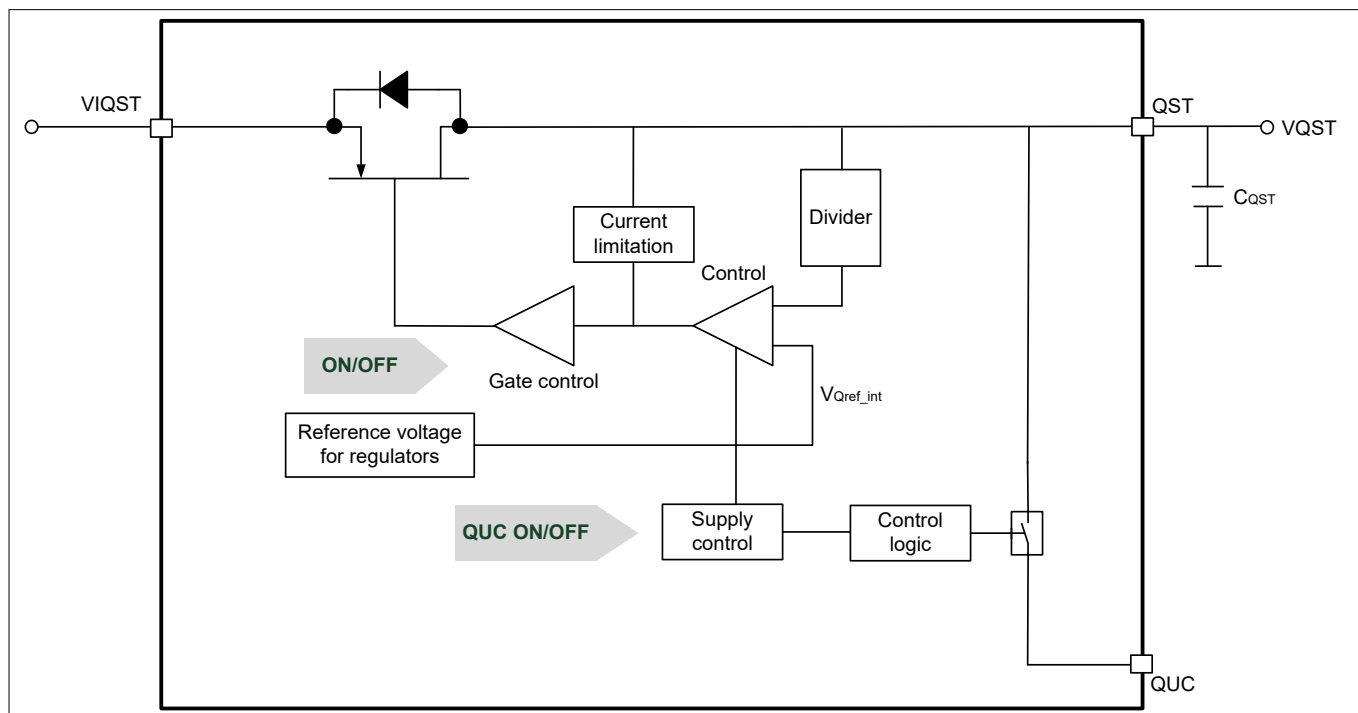


Figure 11 Block diagram LDO QST

5 Power supply function

The device provides a linear low dropout regulator LDO-QST which generated a regulated output voltage V_{QST} with I_{QST} output current.

The output voltage V_{QST} at pin QST is generated from the input voltage V_{IQST} after starting up the device. In case LDO-QUC is enabled, the output voltage V_{QST} is supplied from the input voltage V_{QUC} at pin QUC to optimize the supply topology for higher efficiency.

The stability of the control loop depends on the load current, the characteristics of the output capacitor and the chip junction temperature. A stable operation is ensured by the output capacitance chosen according to the specified electrical characteristics table below (capacitance value C_{QST} and equivalent series resistance $ESR_{C_{QST}}$). The output capacitance is either one capacitor or a set of capacitors following as a whole the capacitance range.

The QST regulator can be enabled or disabled by protected SPI communication.

To protect the standby supply from overstress the current limitation limits the output current I_{QST} to the specified limit I_{QST_max} .

The status of OC fault can be read via register and can be cleared on write command via SPI once the OC fault is expired.

Note: When the current sunk from the output pin QST is limited, the output voltage V_{QST} will decrease.

5.8.2 Electrical characteristics standby LDO (QST)

Table 17 Electrical characteristics standby LDO (QST)

$V_{VS} = 6.0\text{ V to }36\text{ V}$, $T_j = -40^\circ\text{C to }+175^\circ\text{C}$, all voltages with respect to ground, positive current flowing into pin (unless otherwise specified)

Parameter	Symbol	Values			Unit	Note or condition	P-Number
		Min.	Typ.	Max.			
Output voltage	V_{QST}	4.8	5	5.2	V	0 mA < I_{QST} < 30 mA static; 5.6 V < V_{VIQST} < 40 V	DS-1486
Output current	I_{QST}	0	–	30	mA	QUC OFF	DS-1498
Output current limitation	I_{QST_max}	40	60	90	mA	QUC OFF	DS-1488
Soft-start time	t_{ss_QST}	–	255	–	μs	Voltage at pin QST ramps up from 10% to 90% of V_{QST} ; -5 mA < I_{QST} < -1 mA; $C_{QUC} = 4.7\text{ μF}$	DS-1497
Transient line regulation 1	$\Delta V_{QST_tr_line1}$	–	–	70	mV	$I_{QST} < 30\text{ mA}$; V_{IQST} from 10 V to 14 V voltage step in $\Delta t = 30\text{ μs}$; QUC OFF	DS-1490
Transient line regulation 2	$\Delta V_{QST_tr_line2}$	–	–	140	mV	$I_{QST} < 30\text{ mA}$; V_{IQST} from 6 V to 14 V voltage step in $\Delta t = 500\text{ μs}$; QUC OFF	DS-1491

(table continues...)

5 Power supply function

Table 17 (continued) Electrical characteristics standby LDO (QST)

$V_{VS} = 6.0 \text{ V to } 36 \text{ V}$, $T_j = -40^\circ\text{C to } +175^\circ\text{C}$, all voltages with respect to ground, positive current flowing into pin (unless otherwise specified)

Parameter	Symbol	Values			Unit	Note or condition	P-Number
		Min.	Typ.	Max.			
Load regulation	ΔV_{QST_load}	–	25	40	mV	$100 \mu\text{A} < I_{QST} < 15 \text{ mA}$; QUC OFF	DS-1492
Power supply ripple rejection	$PSRR_{QST}$	30	–	–	dB	$V_{batt} = 13.5 \text{ V}$, 100 mVpp, ESR $\leq 50 \text{ m}\Omega$, $f = 100 \text{ Hz}$ and $f = 100 \text{ kHz}$ ¹⁾	DS-1496
Output capacitor	C_{QST}	0.47	–	10	μF	¹⁾	DS-1494
Output capacitor equivalent series resistance	ESR_{C_QST}	–	–	200	$\text{m}\Omega$	¹⁾	DS-1495
Drop voltage RT	ΔV_{QST_RT}	–	–	380	mV	$I_{QST} < 30 \text{ mA}$; at $T_j = 27^\circ\text{C}$	DS-1721
Drop voltage HT	ΔV_{QST_HT}	–	–	600	mV	$I_{QST} < 30 \text{ mA}$; at $T_j = 155^\circ\text{C}$	DS-1489
Dropout voltage when QUC ON	ΔV_{QUC_QST}	–	–	300	mV	$I_{QST} = 30 \text{ mA}$	DS-2003

1) Not subject to production test, specified by design

5.9 Active discharge

Each of the output rails generated by one of the device's regulators, incorporate an active discharge function. This discharge function consists of an internal pull-down resistor. Whenever a regulator is disabled via SPI or switched off due to reaction on detected faults (this also includes state transitions into FAILSAFE), the discharge path is activated and discharges the corresponding output rail. Except for Boost regulator, this discharge feature remains also active while being in SLEEP or STANDBY state if a regulator is not used during this time.

6 Safety switch (SSW)

6 Safety switch (SSW)

6.1 Functional description safety switch (SSW)

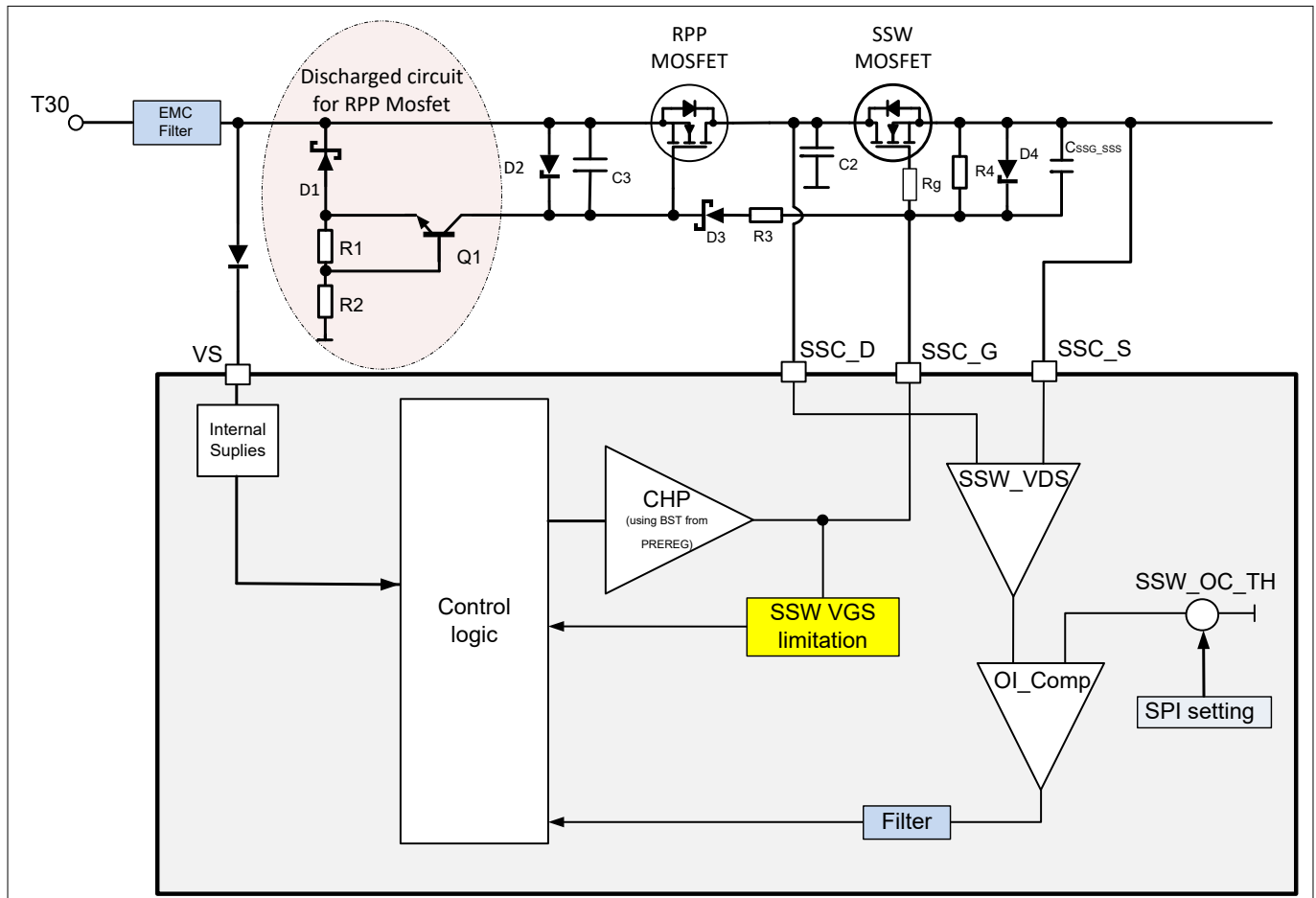


Figure 12 Block diagram SSW & RPP

The device provides a driver to control the external n-channel power MOSFETs (the reverse polarity protection (RPP) MOSFET and the safety switch (SSW) MOSFET).

The gate of both MOSFETs is connected to SSC_G.

The activation of the external power MOSFET is driven according to the failure reaction table and the operation mode.

In case of reverse battery, the Gate of the RPP MOSFET is discharged through the external circuitry.

The source of the SSW MOSFET is connected to pin SSC_S and the drain is connected to SSC_D pin.

The driver circuit includes an over current detection on the SSW MOSFET (Sensing the voltage drop between source and drain).

The threshold for the over current detection is programmable via SPI register bitfield **DEV_PW_CFG2.SSW_OC_TH**.

The overcurrent is detected if the drain source voltage exceeds the detection threshold (SSW_{OC_TH}) for a time longer than the over current detection time (t_{fil_OC}).

The device autodetects at start-up the usage of the input side safety switch protection MOSFET and store the autodetection result into a status register. If the safety switch is not used the corresponding pins must be connected according to the following configuration:

- SSC_D: connect to GND

6 Safety switch (SSW)

- SSC_G: connect to input of PREREG
- SSC_S: connect to input of PREREG

6.2 Electrical characteristics safety switch (SSW)

Table 18 Electrical characteristics safety switch

$V_{VS} = 6.0\text{ V to }36\text{ V}$, $T_j = -40^\circ\text{C to }+175^\circ\text{C}$, all voltages with respect to ground, positive current flowing into pin (unless otherwise specified)

Parameter	Symbol	Values			Unit	Note or condition	P-Number
		Min.	Typ.	Max.			
High level gate output voltage vs. source	ΔV_{SSG_SSS}	4	4.5	–	V	$\Delta V_{SSG_SSS} = V_{SSC_G} - V_{SSC_S}$; $C_{BTS} > 20 \times C_{SSG_SSS}$; BUCK PREREG in CCM; $I_{bck_prereg} \geq 1\text{ A}$ ¹⁾	DS-1500
[SSW] High level Gate output voltage vs. Source (light load)	ΔV_{SSG_SSS}	3.4	4.5	–	V	$\Delta V_{SSG_SSS} = V_{SSC_G} - V_{SSC_S}$; $C_{BTS} > 20 \times C_{SSG_SSS}$; BUCK PREREG in CCM; $I_{bck_prereg} < 1\text{ A}$ ¹⁾	DS-2041
Gate rise time	$t_{SSC_G_r}$	–	–	320	μs	ΔV_{SSG_SSS} from 0 V to 4 V $V_{VS} > V_{VS}[\text{MIN}]$ $C_{SSG_SSS} = 3\text{ nF}$ From R1SW rising edge ¹⁾	DS-1501
Gate fall time	$t_{SSC_G_f}$	–	–	3	μs	$\Delta V_{SSG_SSS} = V_{SSC_G} - V_{SSC_S}$; ΔV_{SSG_SSS} from 4.0V to 0.7V $C_{SSG_SSS} = 1\text{ nF}$ $V_{VS} > V_{VS}[\text{MIN}]$ ¹⁾	DS-2141
Over current detection threshold for SSW	SSW_{OC_TH}	x * 0.63	x	x * 1.73	V	SSW_{OC_TH} is programmable by SPI; x: 0.755 V, 0.944 V, 1.04 V, 1.22 V; Default value: 0.755V; $V_{SSC_D} \geq 5\text{V}$, for x: 0.755V $V_{SSC_D} \geq 6.5\text{V}$, for x: 0.944V, 1.04V, 1.22V $V_{VS} > V_{VS}[\text{MIN}]$	DS-2136
Filter time for over current detection	t_{fil_OC}	–	60	–	ns	$V_{VS} > V_{VS}[\text{MIN}]$ ¹⁾	DS-1947

(table continues...)

6 Safety switch (SSW)

Table 18 (continued) Electrical characteristics safety switch

$V_{VS} = 6.0\text{ V to }36\text{ V}$, $T_j = -40^\circ\text{C to }+175^\circ\text{C}$, all voltages with respect to ground, positive current flowing into pin (unless otherwise specified)

Parameter	Symbol	Values			Unit	Note or condition	P-Number
		Min.	Typ.	Max.			
SSW over current detection and reaction time	$t_{SSW_OC_SD}$	-	500	-	ns	V_{SSG_SSS} is off $V_{VS} > V_{VS}[MIN]$ ¹⁾	DS-1948

1) Not subject to production test, specified by design

7 Wakeup functions

7 Wakeup functions

7.1 Introduction

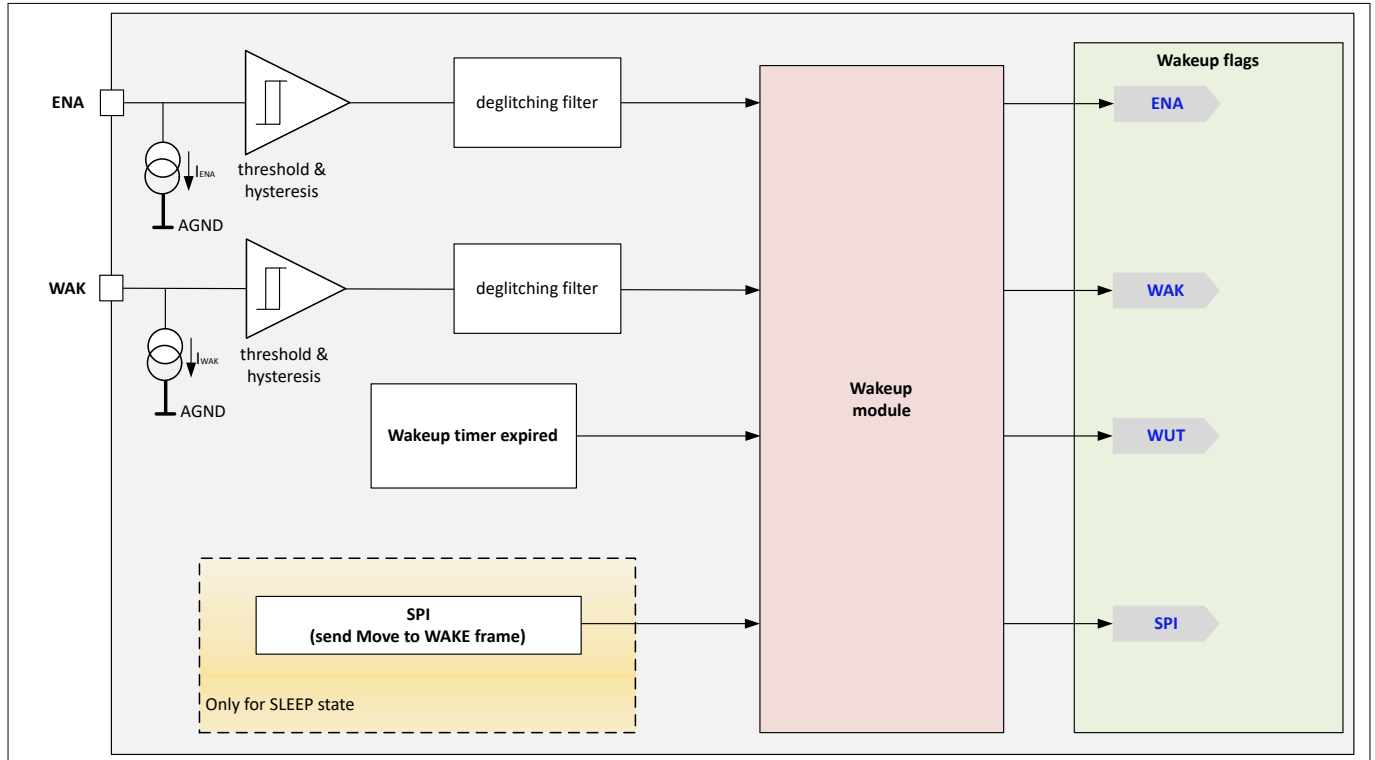


Figure 13 Functional block diagram wakeup functions

The module provides the following wakeup sources:

- ENA pin (edge sensitive input)
- WAK pin (level sensitive input)
- Internal wakeup timer (WUT)
- SPI

To determine which wake-up event caused the device to start-up, the registers **WAKE_STAT_APP1/2** store the following wakeup events:

- ENA
- WAK
- WUT
- SPI

Any wakeup event may trigger a state transition and an interrupt event, see [Chapter 9](#) and [interrupt \[AutoNumbering\]](#).

The ENA wakeup signal is typically a signal from the vehicle ignition switch. The WAK wakeup signal is typically a signal from a transceiver.

7.2 Enable (ENA)

7 Wakeup functions

7.2.1 Functional description enable (ENA)

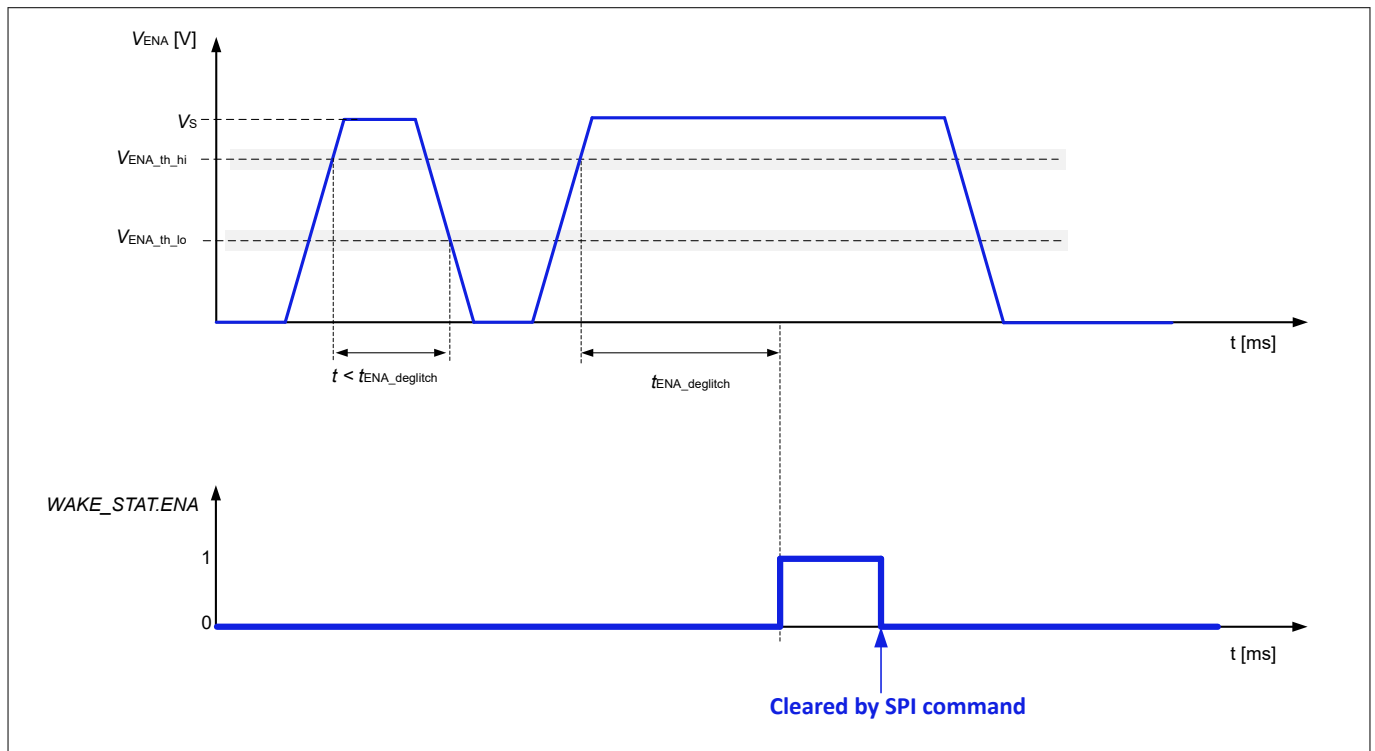


Figure 14 Enable (ENA) signal diagram

The ENA pin is edge sensitive.

Rising edge detection

If the voltage at the ENA pin exceeds the threshold $V_{ENA_th_lo}$ and it also exceeds the threshold $V_{ENA_th_hi}$ for longer than the deglitch filter time $t_{ENA_deglitch}$, then the device detects a rising edge.

ENA bit setting

The device sets the **WAKE_STAT_APPx.ENA** bit if an FSM state transition is caused by a rising edge detection at the ENA pin.

The **WAKE_STAT_APPx.ENA** bit can be cleared via SPI, independently of the voltage level at the ENA pin.

7.2.2 Electrical characteristics enable (ENA)

Table 19 Electrical characteristics enable (ENA)

$V_{VS} = 6.0\text{ V to }36\text{ V}$, $T_j = -40^\circ\text{C to }+175^\circ\text{C}$, all voltages with respect to ground, positive current flowing into pin (unless otherwise specified)

Parameter	Symbol	Values			Unit	Note or condition	P-Number
		Min.	Typ.	Max.			
ENA threshold "high" voltage	$V_{ENA_th_hi}$	1.3	1.65	2.0	V	V_{ENA} increasing; $V_S \geq 6\text{ V}$	DS-1971
ENA threshold "low" voltage	$V_{ENA_th_lo}$	1	1.2	1.4	V	V_{ENA} decreasing; $V_S \geq 6\text{ V}$	DS-1972

(table continues...)

7 Wakeup functions

Table 19 (continued) Electrical characteristics enable (ENA)

$V_{VS} = 6.0 \text{ V}$ to 36 V , $T_j = -40^\circ\text{C}$ to $+175^\circ\text{C}$, all voltages with respect to ground, positive current flowing into pin (unless otherwise specified)

Parameter	Symbol	Values			Unit	Note or condition	P-Number
		Min.	Typ.	Max.			
ENA deglitch filter time	$t_{\text{ENA_deglitch}}$	20	30	40	μs	$V_S \geq 6 \text{ V}$	DS-1973
ENA pin "high" input current	$I_{\text{ENA_hi}}$	–	–	5	μA	$V_{\text{ENA}} \geq 2 \text{ V}$	DS-1974
ENA pin "low" input current	$I_{\text{ENA_lo}}$	–	0.1	2	μA	$V_{\text{ENA}} \leq 1 \text{ V}$	DS-1975
ENA threshold hysteresis	$V_{\text{ENA_HYST}}$	200	400	550	mV	$V_S \geq 6 \text{ V}$	DS-1976

7.3 Wake (WAK)

7.3.1 Functional description wake (WAK)

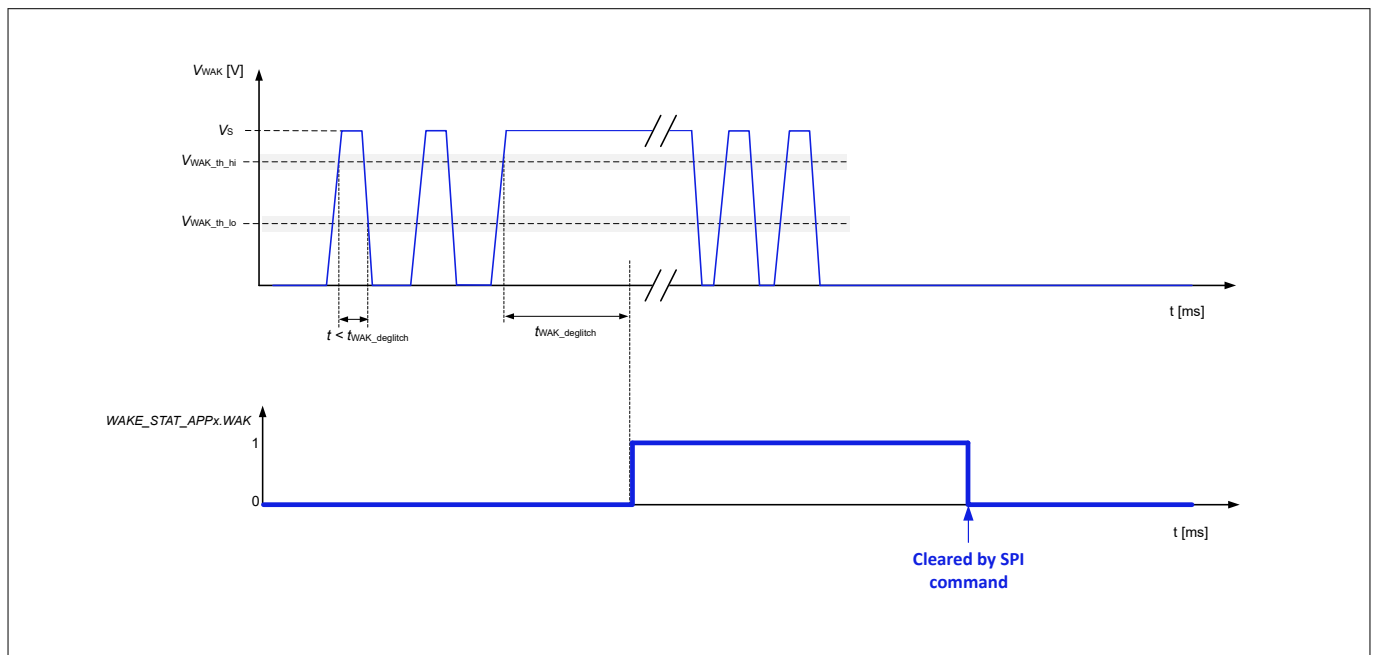


Figure 15 Wake(WAK) signal diagram

The WAK pin is level sensitive.

Level definition

If the voltage level at the WAK pin is below the threshold $V_{\text{WAK_th_lo}}$ for longer than the deglitch filter time $t_{\text{WAK_deglitch}}$, then it detects a valid "low" signal.

If the voltage level at the WAK pin is above the threshold $V_{\text{WAK_th_hi}}$ for longer than the deglitch filter time $t_{\text{WAK_deglitch}}$, then it detects a valid "high" signal.

WAK bit setting

The device sets an **WAKE_STAT_APPx.WAK** bit if a wake-up is caused by a valid "high" level detection at the WAK pin

The **WAKE_STAT_APPx.WAK** bit can be cleared via SPI.

7 Wakeup functions

7.3.2 Electrical characteristics wake (WAK)

Table 20 Electrical characteristics wake (WAK)

$V_{VS} = 6.0 \text{ V to } 36 \text{ V}$, $T_j = -40^\circ\text{C to } +175^\circ\text{C}$, all voltages with respect to ground, positive current flowing into pin (unless otherwise specified)

Parameter	Symbol	Values			Unit	Note or condition	P-Number
		Min.	Typ.	Max.			
WAK threshold "high" voltage	$V_{WAK_th_hi}$	1.3	1.65	2.0	V	V_{WAK} increasing; $V_S \geq 6 \text{ V}$	DS-1977
WAK threshold "low" voltage	$V_{WAK_th_lo}$	1.0	1.2	1.4	V	V_{WAK} decreasing; $V_S \geq 6 \text{ V}$	DS-1978
WAK deglitch filter time	$t_{WAK_deglit_ch}$	20	30	40	μs	$V_S \geq 6 \text{ V}$	DS-1979
WAK pin "high" input current	I_{WAK_hi}	–	–	5	μA	$V_{WAK} \geq 2 \text{ V}$	DS-1980
WAK pin "low" input current	I_{WAK_lo}	–	0.1	2	μA	$V_{WAK} \leq 1 \text{ V}$	DS-1981
WAK threshold hysteresis	V_{WAK_HYST}	200	400	550	mV	$V_S \geq 6 \text{ V}$	DS-1982

7.4 Wake-up timer (WUT)

7.4.1 Functional description wake-up timer (WUT)

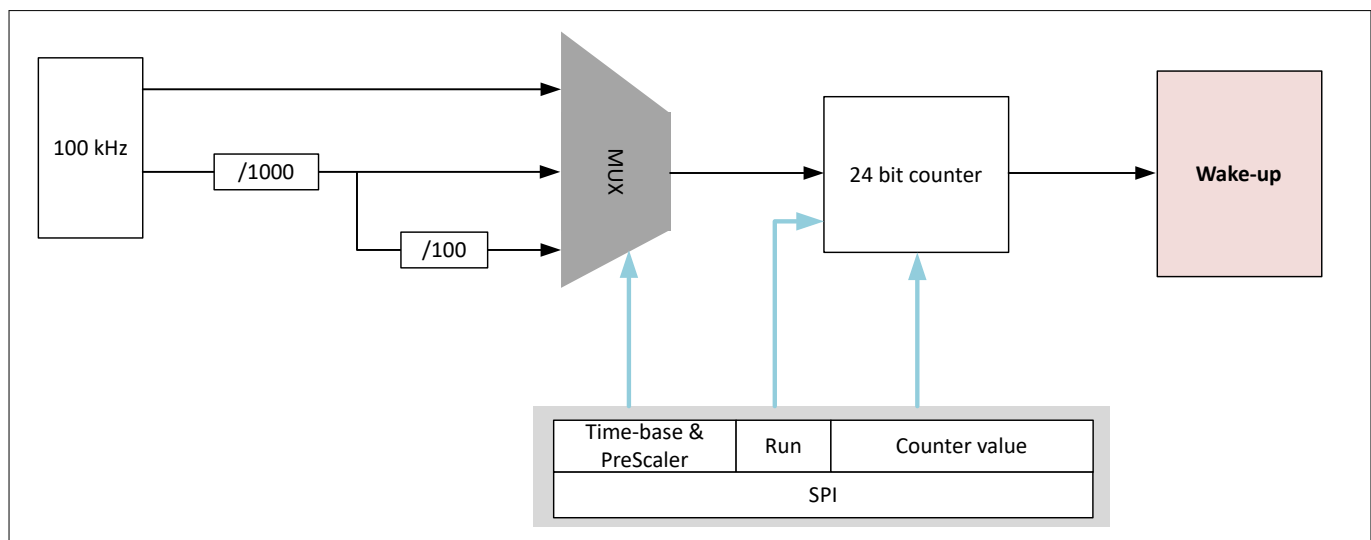


Figure 16 Functional block diagram wake-up timer

Wake-up timer configuration

The wake-up timer value can be configured via SPI in the 24-bit wide wake-up timer registers **WUT_CFG0** and **WUT_CFG1** and the time base can be configured via **DEV_CFG4** register.

The wake-up timer is a 24-bit counter, which operates at a selectable clock frequency of 100 kHz, 1 kHz, 100 Hz or 1 Hz (timebase).

7 Wakeup functions

Table 21 Wake-up timer configuration

Timebase		Clock	Timer resolution	Timer range (timebase resolution × timer value)
WUT_CYC	WUT_PRESC			
0	0	100 kHz	10 µs	10 µs to 168 s
0	1	1 kHz	1 ms	1 ms to 4.6 h
1	0	100Hz	10 ms	10 ms to 1.9 days
1	1	1 Hz	1 s	1 s to 194 days

The device allows enabling and disabling the wake-up timer via **DEV_CFG4.WUT_EN**.

Wake-up timer start and stop

On entering STANDBY state or SLEEP state with DEV_CFG4.WUT_EN=1, the counter is loaded with the value of the wake-up timer register and starts decrementing.

The device stops the timer under any of the following conditions:

- The wake-up timer expires
- The device exits SLEEP state or STANDBY state. The remaining timer value can be read back via SPI in order to evaluate the theoretical time left and the corresponding time elapsed (**WUT_STAT0.TIMVALL**, **WUT_STAT1.TIMVALH**, **WUT_STAT1.PRESC**, **WUT_STAT1.CYC**)

Wake-up timer bit

If the wake-up timer expires, the device sets the wake-up timer bit **WAKE_STAT_APPx.WUT = 1**.

The WUT bit can be cleared via SPI.

7.4.2 Electrical characteristic wake-up timer

Table 22 Electrical characteristic wake-up timer

$V_{VS} = 6.0\text{ V to }36\text{ V}$, $T_j = -40^\circ\text{C to }+175^\circ\text{C}$, all voltages with respect to ground, positive current flowing into pin (unless otherwise specified)

Parameter	Symbol	Values			Unit	Note or condition	P-Number
		Min.	Typ.	Max.			
Wake-up timer accuracy	d_{acc_WUT}	-10	–	10	%	–	DS-2059

7.5 Wake-up via SPI frame

A wake-up via SPI is only available if the device is in SLEEP state and BUCKCORE and QUC are enabled. Only then the device can be woken up by sending a state transition request to WAKE state by writing **DEV_PW_CFG3.FSM_STATEREQ = WAKE** accordingly. Writing any other register that is not involved in a state transition request does not result in a wake-up of the device.

8 Hardware configuration (HWCFG)

8 Hardware configuration (HWCFG)

Table 23 Electrical characteristics hardware configuration resistor

$V_{VS} = 6.0\text{ V to }36\text{ V}$, $T_j = -40^\circ\text{C to }+175^\circ\text{C}$, all voltages with respect to ground, positive current flowing into pin (unless otherwise specified)

Parameter	Symbol	Values			Unit	Note or condition	P-Number
		Min.	Typ.	Max.			
External resistor accuracy	R_{HWCFG_ac}	-5	-	+5	%	1)	DS-2017

1) Not subject to production test, specified by design

8.1 Functional description

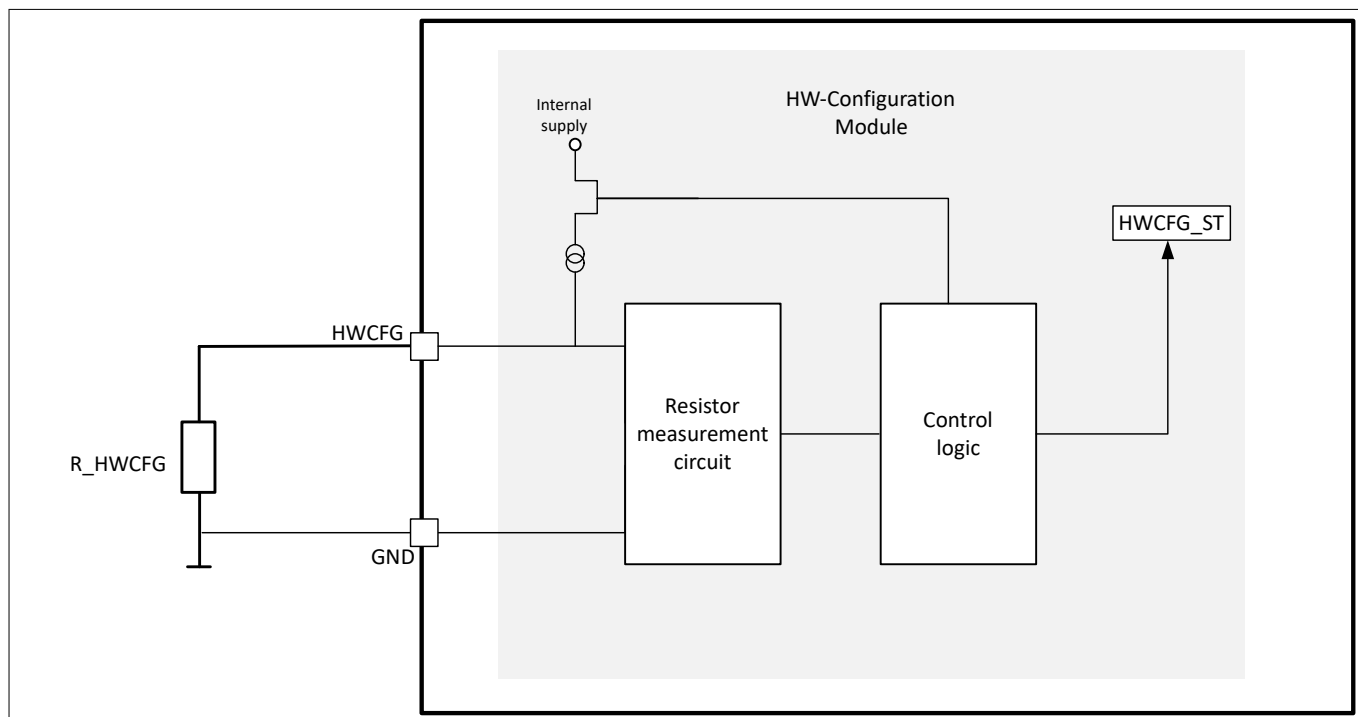


Figure 17 Hardware configuration blockdiagramm

The device provides a hardware configuration module. The external resistor (R_{HWCFG}) connected on pin (HWCFG) is used to:

- Define the start-up sequence of the internal regulators
- Define the pre-regulator output voltage
- Define the default value of the reset delay time
- Activate the MPS mode

According to the table below.

8 Hardware configuration (HWCFG)

Table 24 **Hardware configuration (HWCFG)**

HWCFG resistor setting kΩ, 5% tolerance	RESOUT start-up delay	Pre-regulator output voltage (V_{PRE})	Start-up sequence of the regulator	MPS mode activation	SPI bits readout DEV_CFG1.HWC FG_STAT
	2 ms/10 ms (TBD)	4V/5V5	Schema (A)/ Schema (B)	ON/OFF	
< 1.0 or GND	10 ms	4V	A	OFF	0000
2.2	2 ms	4V	A	OFF	0001
3.3	2 ms	4V	B	OFF	0010
4.7	10 ms	4V	B	OFF	0011
6.8	2 ms	5V5	A	OFF	0100
10	10 ms	5V5	A	OFF	0101
15	2 ms	5V5	B	OFF	0110
22	2 ms	5V5	B	ON	1001
33	2 ms	5V5	A	ON	1010
47	10 ms	4V	B	ON	1011
68	2 ms	4V	B	ON	1100
100	2 ms	4V	A	ON	1101
150	10 ms	4V	A	ON	1110
> 200 or open	10 ms	4V	A	OFF	1111

After starting up the device, microcontroller can verify the selected setting by reading the SPI status register **DEV_CFG1.HWCFG_STAT** where the HWCFG resistor value is stored

9 State machine (FSM)

9 State machine (FSM)

9.1 Functional description state machine (FSM)

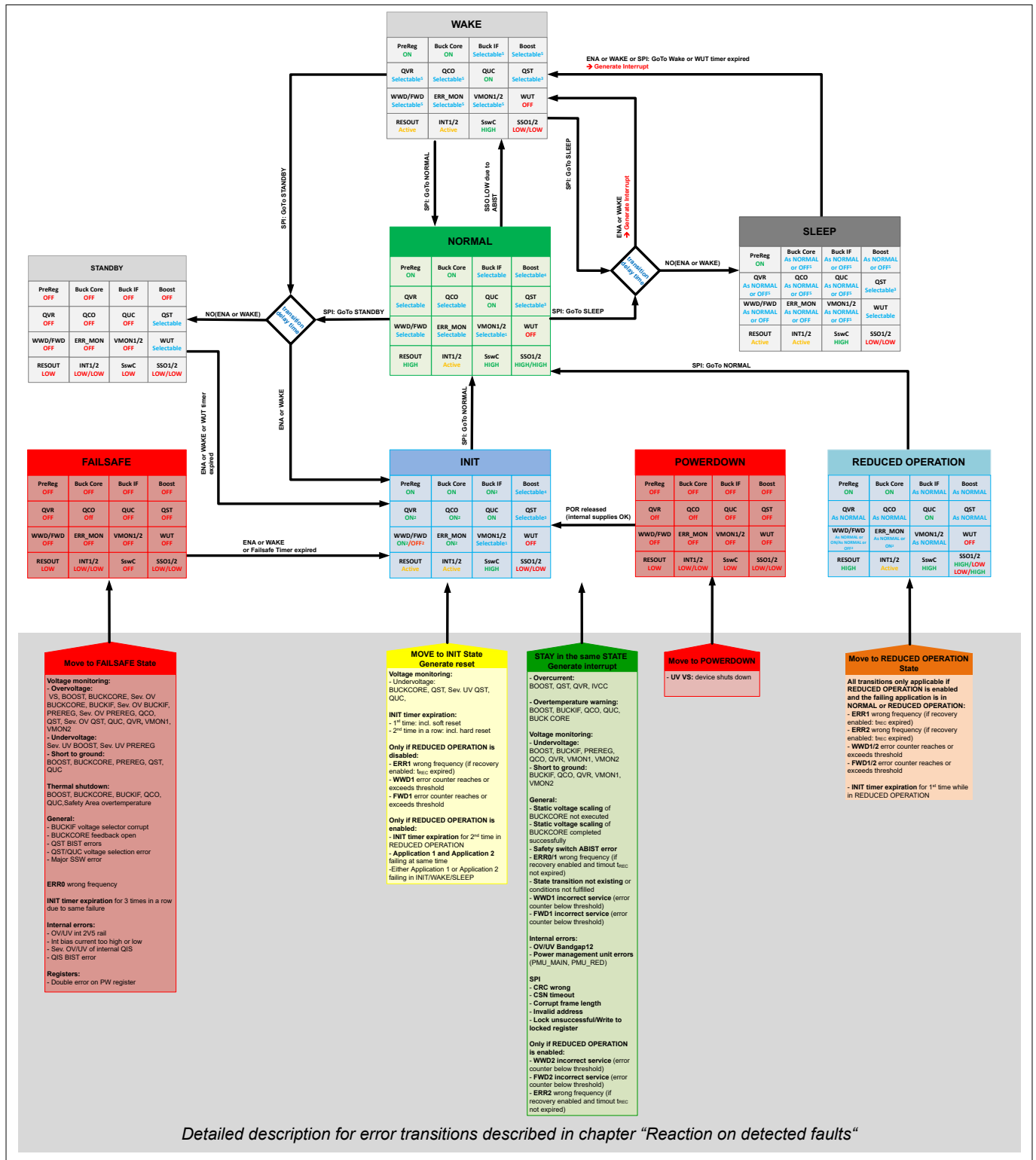


Figure 18 State machine flow diagram

(1): Selectable function during the start-up via VMxEN; can be switched off via SPI. Restarts on entering INIT

9 State machine (FSM)

(2): Switched ON or OFF at entering the INIT or the REDUCED OPERATION state, then configurable via SPI.

(3): QST supply is on or off, can be configured by SPI when QST_MODE is configured as USER_MODE else QST is on independently of QST_EN when QST_MODE is configured as PMIC_MODE (Default)

(4): Selectable with start-up autodetect only if VPREREG=5V5 nominal. Otherwise it is ON

(5): WD: Can be configured to remain active in SLEEP; all other modules have to be disabled within the same SPI frame that contains the move to SLEEP command; Upon wake-up the modules are restored to the states as they were before the move to SLEEP

9.1.1 Description of the states

The device provides the following states:

- INITIALIZATION states:
 - INIT
 - WAKE
- OPERATIONAL state:
 - NORMAL
- LOW QUIESCENT states:
 - SLEEP
 - STANDBY
- ERROR states
 - FAILSAFE
 - REDUCED OPERATION

9.1.1.1 POWERDOWN state

The POWERDOWN state represents the unpowered condition of the device. The voltage at VS pin is not available.

POWERDOWN			
PreReg OFF	Buck Core OFF	Buck IF OFF	Boost OFF
QVR Off	QCO Off	QUC OFF	QST OFF
WWD/FWD OFF	ERR_MON OFF	VMON1/2 OFF	WUT OFF
RESOUT LOW	INT1/2 LOW/LOW	SswC LOW	SSO1/2 LOW/LOW

Figure 19 POWERDOWN state

9 State machine (FSM)

Table 25 POWERDOWN state

Part/Function	Value	Description
PreReg	OFF	Pre-regulator is off
Buck Core	OFF	Core supply is off
Buck IF	OFF	Buck regulator for interface supply is off
Boost	OFF	Boost regulator is off
QVR	OFF	Voltage reference is off
QCO	OFF	Communication supply is off
QUC	OFF	Microcontroller supply is off
QST	OFF	Standby supply is off
WWD/FWD	OFF	Watchdog is off
ERR_MON	OFF	Error monitoring function ERR MON is off
VMON1/2	OFF	External voltage monitoring VMON1/2 is off
WUT	OFF	Wake up timer (WUT) is off
RESOUT	LOW	RESOUT output is low
INT1/2	LOW	Interrupt outputs are low
SswC	LOW	External safety switch is off
SSO1/2	LOW	Safe state outputs are low

9.1.1.2 INIT state

In INIT state the device starts up its internal supplies, as well as the external voltage rails as configured. Upon every entry RESOUT will be pulled low for t_{RD_2ms}/t_{RD_10ms} or to its configured value and released again after the power-up sequence was executed. If rails are still at their nominal voltage upon entry, they are skipped in the power-up sequence. Internal checks are being performed and the device waits for [successful initialization](#) by the microcontroller before the INIT timer t_{INIT} expires.

9 State machine (FSM)

INIT			
PreReg ON	Buck Core ON	Buck IF ON ²	Boost Selectable ⁴
QVR ON ²	QCO ON ²	QUC ON	QST Selectable ³
WWD/FWD ON ² /OFF ²	ERR_MON ON ²	VMON1/2 Selectable ¹	WUT OFF
RESOUT Active	INT1/2 Active	SswC HIGH	SSO1/2 LOW/LOW

Figure 20 INIT state

Table 26 INIT state

Part/Function	Value	Description
PreReg	ON	Pre-regulator is on
Buck Core	ON	Core supply is on
Buck IF	ON	Buck regulator for interface supply is on, if automated use-detection identified the usage; then configurable via SPI
Boost	Selectable	Boost regulator is selectable with start-up autodetect only if $V_{OUT_PreReg} = 5V5$ nominal otherwise, it is on.
QVR	ON	Voltage reference is on; then configurable via SPI
QCO	ON	Communication supply is on; then configurable via SPI
QUC	ON	Microcontroller supply is on
QST	Selectable	Standby supply is selectable when QST_MODE is configured as USER_MODE otherwise, it is on when QST_MODE is configured as PMIC_MODE (default)
WWD	ON	Window watchdog is on; then configurable via SPI
FWD	OFF	Functional Watchdog is off; then configurable via SPI
ERR_MON	ON	Error monitoring function ERR MON is on; then configurable via SPI
VMON1/2	Selectable	External voltage monitoring VMON1/2 is on, if automated use-detection identified the usage; can be switched off by SPI
WUT	OFF	Wake-up timer (WUT) is off
RESOUT	Active	RESOUT output released ("high") after power-up sequence has finished and reset delay time has expired

(table continues...)

9 State machine (FSM)

Table 26 (continued) INIT state

Part/Function	Value	Description
INT1/2	Active	Interrupt outputs are active (INT2 only active if "REDUCED OPERATION" is enabled)
SswC	High	External safety switch is on
SSO1/2	LOW	Safe state outputs are low

Note:

The Move to NORMAL SPI command is not executed:

- 900µs after move to INIT because of execution of auto detection
- Until all enabled voltage rails are in regulation (above UV threshold). Note: all regulators are switched on again at move to INIT (if disabled before)

In general the application is not exposed to this limitation due to RESOUT at low level but with the following exceptions:

- with low tRD values (<1ms)
- in case MPS is ON (the RESOUT stays high for WDs/ERRs monitoring faults and therefore the application can be exposed to such limitation).

9.1.1.3 NORMAL state

Device has a NORMAL state and the only state where safe state outputs (SSO1/2) are high.

Note: In this state the device is supplying the microcontroller and the peripheral blocks in the application.

NORMAL			
PreReg ON	Buck Core ON	Buck IF Selectable	Boost Selectable ⁴
QVR Selectable	QCO Selectable	QUC ON	QST Selectable ³
WWD/FWD Selectable	ERR_MON Selectable	VMON1/2 Selectable ¹	WUT OFF
RESOUT HIGH	INT1/2 Active	SswC HIGH	SSO1/2 HIGH/HIGH

Figure 21 NORMAL state

9 State machine (FSM)

Table 27 **NORMAL state**

Part/Function	Value	Description
PreReg	ON	Pre-regulator is on
Buck Core	ON	Core supply is on
Buck IF	Selectable	Buck regulator for interface supply can be switched on or off, if it has been detected via automated use detection during start-up
Boost	Selectable	Boost regulator is selectable with start-up autodetect only if $V_{R1FB} = 5V5$ nominal. Otherwise it is on
QVR	Selectable	Voltage reference can be selected by SPI to be on or off
QCO	Selectable	Communication supply can be selected by SPI to be on or off
QUC	ON	Microcontroller supply is on
QST	Selectable	Standby supply is selectable when QST_MODE is configured as USER_MODE otherwise, it is on when QST_MODE is configured as PMIC_MODE (default)
WWD/FWD	Selectable	Watchdog can be selected by SPI to be on or off
ERR_MON	Selectable	Error monitoring function ERR MON can be selected by SPI to be on or off
VMON1/2	Selectable	External voltage monitoring VMON1/2 is on, if automated use-detection identified the usage; can be switched off by SPI
WUT	OFF	Wake-up timer (WUT) is off
RESOUT	High	RESOUT output is high
INT1/2	Active	Interrupt outputs are active (INT2 only active if "REDUCED OPERATION" is enabled)
SswC	High	External safety switch is on
SSO1/2	High/High	Safe state outputs are high

9.1.1.4 WAKE state

When the device enters WAKE from SLEEP, the modules are restored to the states as they were before the move to SLEEP. If in SLEEP RESOUT was low, in WAKE state the device waits for successful initialization by the microcontroller before the INIT timer tINIT expires.

9 State machine (FSM)

WAKE			
PreReg ON	Buck Core ON	Buck IF Selectable ⁵	Boost Selectable ⁵
QVR Selectable ⁵	QCO Selectable ⁵	QUC ON	QST Selectable ³
WWD/FWD Selectable ⁵	ERR_MON Selectable ⁵	VMON1/2 Selectable ⁵	WUT OFF
RESOUT Active	INT1/2 Active	SswC HIGH	SSO1/2 LOW/LOW

Figure 22 WAKE state

Table 28 WAKE state

Part/Function	Value	Description
PreReg	ON	Pre-regulator is on
Buck Core	ON	Core supply is on
Buck IF	Selectable	Buck regulator for interface supply is configurable, if it has been detected via automated use detection during start-up
Boost	Selectable	Boost regulator is configurable with start-up autodetect only if VR1FB = 5V5 nominal otherwise, it is on
QVR	Selectable	Voltage reference is configurable via SPI
QCO	Selectable	Communication supply is configurable via SPI
QUC	ON	Microcontroller supply is on
QST	Selectable	Standby supply is selectable when QST_MODE is configured as USER_MODE otherwise, it is on when QST_MODE is configured as PMIC_MODE (default)
WWD/FWD	Selectable	Watchdog is configurable via SPI
ERR_MON	Selectable	Error monitoring function ERR MON is configurable via SPI
VMON1/2	Selectable	External voltage monitoring VMON1/2 is on, if automated use-detection identified the usage; can be switched off by SPI
WUT	OFF	Wake-up timer (WUT) is off
RESOUT	Active	RESOUT output is active
INT1/2	Active	Interrupt outputs are active
SswC	HIGH	External safety switch is on
SSO1/2	LOW	Safe state outputs are low

9 State machine (FSM)

9.1.1.5 REDUCED OPERATION state

The device provides a REDUCED OPERATION state to allow severe safety reactions only on sub-parts of the application, when the device is either in NORMAL state or REDUCED OPERATION state itself. In addition, a [successful initialization](#) by the microcontroller must be done before the INIT timer t_{INIT} expires. If REDUCED OPERATION is enabled (**REDOP_RS_CFG1.EN = 1**) the device shows a differentiated reaction to specific events. In particular an additional Application Reset function is introduced. This Application Reset differs in its configurable pulse width compared to a normal reset and it is issued at the outputs INT1/2 accordingly (**REDOP_RS_CFG2.REDOP_RESOUT_APP1_DUR**, **REDOP_RS_CFG2.REDOP_RESOUT_APP2_DUR**). By enabling this state ERR2 and WD2 are automatically enabled, too. Events that are detected at ERR1 or WD1 are reported with an Application Reset at INT1 and events that are detected at ERR2 and WD2 are reported with an Application Reset at INT2. In addition a normal interrupt is issued at INT1 if ERR2 or WD2 report an error and vice versa at INT2 if ERR1 or WD1 report an error. This cross application notification however can be disabled by using the configuration in **REDOP_RS_CFG1.INT1_DIS** and **REDOP_RS_CFG1.INT2_DIS**. For further information on initialization in REDUCED OPERATION, failure reaction, interrupt generation and Application Reset the following chapter provide more details:

- [INIT timer function](#)
- [Reaction on faults](#)
- [Interrupt function \(INT\)](#)
- [Application Reset \(REDUCED OPERATION ENABLE\)](#)

REDUCED OPERATION			
PreReg ON	Buck Core ON	Buck IF As NORMAL	Boost As NORMAL
QVR As NORMAL	QCO As NORMAL	QUC ON	QST As NORMAL
WWD/FWD As NORMAL or ON/As NORMAL or OFF²	ERR_MON As NORMAL or ON²	VMON1/2 As NORMAL	WUT OFF
RESOUT HIGH	INT1/2 Active	SswC HIGH	SSO1/2 HIGH/LOW LOW/HIGH

Figure 23 REDUCED OPERATION state

Table 29 REDUCED OPERATION state

Part/Function	Value	Description
PreReg	ON	Pre-regulator is on
Buck Core	ON	Core supply is on
Buck IF	As NORMAL	Buck regulator for interface supply has same configuration as in NORMAL state
Boost	As NORMAL	Boost regulator has the same configuration as in NORMAL
QVR	As NORMAL	Voltage reference has same configuration as in NORMAL state
QCO	As NORMAL	Communication supply has same configuration as in NORMAL state

(table continues...)

9 State machine (FSM)

Table 29 (continued) **REDUCED OPERATION state**

Part/Function	Value	Description
QUC	ON	Microcontroller supply is on
QST	As NORMAL	Standby supply has same configuration as in NORMAL state
WWD	Failing application: ON Configuration registers reset Non failing application: As NORMAL	Failing application: Configuration registers reset and remains ON. Waits for trigger and/or configuration via SPI. Non failing application: Keeps configuration as for NORMAL state and needs to be serviced as in NORMAL state.
FWD	Failing application: OFF Configuration registers reset Non failing application: As NORMAL	Failing application: Configuration registers reset and OFF. Non failing application: Keeps configuration and stays ON as in NORMAL. Trigger must be done accordingly.
ERR_MON	Failing application: ON Configuration registers reset Non failing application: As NORMAL	Failing application: Configuration registers reset and remains ON. Waits for correct ERR pin signal and/or configuration via SPI. Non failing application: Keeps configuration as for NORMAL state and needs to be serviced as in NORMAL state.
VMON1/2	As NORMAL	External voltage monitoring VMON1/2 have same configuration as in NORMAL state
WUT	OFF	Wake-up timer (WUT) is off
RESOUT	High	RESOUT output is high
INT1/2	Active	Interrupt outputs are active
SswC	High	External safety switch is on
SSO1/2	High/Low or Low/High	Safe state outputs are low or high depending on the failing cluster/application

Note: While being in REDUCED OPERATION state it must be ensured by the integrator, that except for triggering the watchdog and reconfiguring the application specific monitoring ERR1/2 or WD1/2, no other configuration of the device is being made, like disabling or enabling voltage rails. This could interfere with the internal monitoring of the device and cause incorrect error reporting while being in REDUCED OPERATION. In addition it must be mentioned, that upon the release of the related INTx, the corresponding WWDx and ERRx function is re-enabled, whereas the FWD is disabled.

9.1.1.6 FAILSAFE state

In FAILSAFE state all generated voltage rails are being switched off.
The failsafe timer is started when entering the FAILSAFE state.

9 State machine (FSM)

FAILSAFE			
PreReg OFF	Buck Core OFF	Buck IF OFF	Boost OFF
QVR OFF	QCO OFF	QUC OFF	QST OFF
WWD/FWD OFF	ERR_MON OFF	VMON1/2 OFF	WUT OFF
RESOUT LOW	INT1/2 LOW/LOW	SswC OFF	SSO1/2 LOW/LOW

Figure 24 FAILSAFE state

Table 30 FAILSAFE state

Part/Function	Value	Description
PreReg	OFF	Pre-regulator is off
Buck Core	OFF	Core supply is off
Buck IF	OFF	Buck regulator for interface supply is off
Boost	OFF	Boost regulator is off
QVR	OFF	Voltage reference is off
QCO	OFF	Communication supply is off
QUC	OFF	Microcontroller supply is off
QST	OFF	Standby supply is off
WWD/FWD	OFF	Watchdog is off
ERR_MON	OFF	Error monitoring function ERR MON block is off
VMON1/2	OFF	External voltage monitoring VMON1/2 are off
WUT	OFF	Wake-up timer (WUT) is off
RESOUT	LOW	RESOUT output is low
INT1/2	LOW	Interrupt outputs are low
SswC	LOW	External safety switch is off
SSO1/2	LOW	Safe state outputs are low

9.1.1.7 SLEEP state

For minimized operation constraints in the application the device can be moved into a SLEEP state which provides a configuration to only operate selected modules of the device. This enables a state for reduced function sets while consuming less energy in the application compared to the NORMAL state.

9 State machine (FSM)

SLEEP			
PreReg ON	Buck Core As NORMAL or OFF ⁵	Buck IF As NORMAL or OFF ⁵	Boost As NORMAL or OFF ⁵
QVR As NORMAL or OFF ⁵	QCO As NORMAL or OFF ⁵	QUC As NORMAL or OFF ⁵	QST Selectable ³
WWD/FWD As NORMAL or OFF	ERR_MON As NORMAL or OFF	VMON1/2 As NORMAL or OFF ⁵	WUT Selectable
RESOUT Active	INT1/2 Active	SswC HIGH	SSO1/2 LOW/LOW

Figure 25 SLEEP state

Table 31 SLEEP state

Part/Function	Value	Description
PreReg	ON	Pre-regulator is on
Buck Core	As NORMAL or OFF	Buck core regulator has same configuration as in NORMAL state or is off if configured
Buck IF	As NORMAL or OFF	Buck regulator for interface supply has same configuration as in NORMAL state or is off if configured
Boost	As NORMAL or OFF	Boost regulator has same configuration as in NORMAL state or is off if configured
QVR	As NORMAL or OFF	Voltage reference has same configuration as in NORMAL state or is off if configured
QCO	As NORMAL or OFF	Communication supply has same configuration as in NORMAL state or is off if configured
QUC	As NORMAL or OFF	Microcontroller supply has same configuration as in NORMAL state or is off if configured
QST	Selectable	Standby supply is selectable when QST_MODE is configured as USER_MODE otherwise, it is on when QST_MODE is configured as PMIC_MODE (default)
WWD/FWD	As NORMAL or OFF	Watchdog has same configuration as in NORMAL state or is off if configured
ERR_MON	As NORMAL or OFF	Error monitoring function ERR MON has same configuration as in NORMAL state or is off if configured
VMON1/2	As NORMAL or OFF	External voltage monitoring VMON1/2 have same configuration as in NORMAL state or they are off if configured

(table continues...)

9 State machine (FSM)

Table 31 (continued) **SLEEP state**

Part/Function	Value	Description
WUT	Selectable	Wake-up timer (WUT) is selectable to be on or off
RESOUT	Active	RESOUT output is active (LOW if either BUCKCORE or QUC are OFF)
INT1/2	Active	Interrupt outputs are active (LOW if QUC is OFF)
SswC	HIGH	External safety switch is on
SSO1/2	LOW	SSO1 and SSO2 are low

Note: While being in SLEEP state it must be ensured by the integrator, that except for servicing the watchdog no other configuration of the device is being made, like disabling or enabling voltage rails or changing the configuration of WD1/2 or ERR1/2. This could interfere with the internal monitoring of the device and cause incorrect error reporting while being in SLEEP.

9.1.1.8 STANDBY state

The STANDBY state represents the low current mode of the device.

STANDBY			
PreReg OFF	Buck Core OFF	Buck IF OFF	Boost OFF
QVR OFF	QCO OFF	QUC OFF	QST Selectable
WWD/FWD OFF	ERR_MON OFF	VMON1/2 OFF	WUT Selectable
RESOUT LOW	INT1/2 LOW/LOW	SswC LOW	SSO1/2 LOW/LOW

Figure 26 STANDBY state

Table 32 STANDBY state

Part/Function	Value	Description
PreReg	OFF	Pre-regulator is off
Buck Core	OFF	Core supply is off
Buck IF	OFF	Buck regulator for interface supply is off
Boost	OFF	Boost regulator is off
QVR	OFF	Voltage reference is off
QCO	OFF	Communication supply is off

(table continues...)

9 State machine (FSM)

Table 32 (continued) **STANDBY state**

Part/Function	Value	Description
QUC	OFF	Microcontroller supply is off
QST	Selectable	Standby supply is on or off, can be configurable by SPI
WWD/FWD	OFF	Watchdog interface is off
ERR_MON	OFF	Error monitoring block is off
VMON1/2	OFF	Monitoring blocks are off
WUT	Selectable	Wake block is selected to be on or off
RESOUT	LOW	Control reset output is low
INT1/2	LOW	Interrupt outputs are low
SswC	LOW	External safety switch is off
SSO1/2	LOW	Safe state outputs are low

Note: Lowest quiescent current can only be reached if WUT and QST are both OFF. This allows the device to switch off all internal voltage rails that are not required.

9.1.2 INIT timer function

The INIT timer provides an extended time window for the microcontroller to properly start-up and synchronize itself with the PMIC. Upon release of the reset output elementary supervision functions have be established or disabled before t_{INIT} expires. The following paragraphs refine the general operation of the INIT timer.

Start INIT timer

- The INIT timer starts on the rising edge of the application reset pulse of the corresponding INT1/2 pin if the device is in REDUCED OPERATION state.
- The INIT timer starts on the rising edge of RESOUT pin if the device is in INIT or in WAKE state.

STOP INIT timer

The device stops the INIT timer and resets its expiration counter if all of the following conditions are fulfilled:

- WD1/2 is properly triggered or is disabled via SPI, see [Watchdog functions](#).
- ERRMON0/1/2 signal is applied correctly or is disabled via SPI, see [Error monitoring](#)

INIT TIMER FAULT

The device detects an INIT_TIMER_FAULT if the INIT timer is not successfully stopped before it expires.

Note: WD2 and ERR2 only need to be initialized if REDUCED OPERATION is enabled (**REDOP_RS_CFG1.EN = 1**).

If the INIT timer elapses **once** in INIT state, the device:

- generates an INIT_TIMER_FAULT,
- activates a soft reset
- stores the fault
- resets registers belonging to the reset class R3
- moves to INIT state, see [state machine](#)

If the INIT timer elapses **twice** in INIT state, the device

- generates an INIT_TIMER_FAULT
- activates a hard reset
- stores the fault

9 State machine (FSM)

- resets registers belonging to the reset class R3
- performs configured power-down sequence
- restarts configured power sequence
- moves to INIT state, see [state machine](#)

If the INIT timer elapses **a third time** in INIT state, the device

- stores the fault
- resets registers belonging to the reset class R2
- moves to FAILSAFE state, see [state machine](#)

If the INIT timer elapses **once** in REDUCED OPERATION state, the device:

- generates an INIT_TIMER_FAULT
- activates a new application reset corresponding to the application that has failed
- sets the bit **INIT_ERR_APPx.REDOP_RES1**

If the INIT timer elapses **twice** in REDUCED OPERATION state, the device

- generates an INIT_TIMER_FAULT,
- activates a soft reset
- sets the error bit **INIT_ERR_APPx.REDOP_RES2**
- moves to INIT state, see [state machine](#)

If the INIT timer elapses **once** in WAKE state, the device

- generates an INIT_TIMER_FAULT,
- activates a soft reset
- stores the fault
- resets registers belonging to the reset class R3
- moves to INIT state, see [state machine](#)

Note: *The first expiration in WAKE already counts as first as if it had happened in INIT.*

9 State machine (FSM)

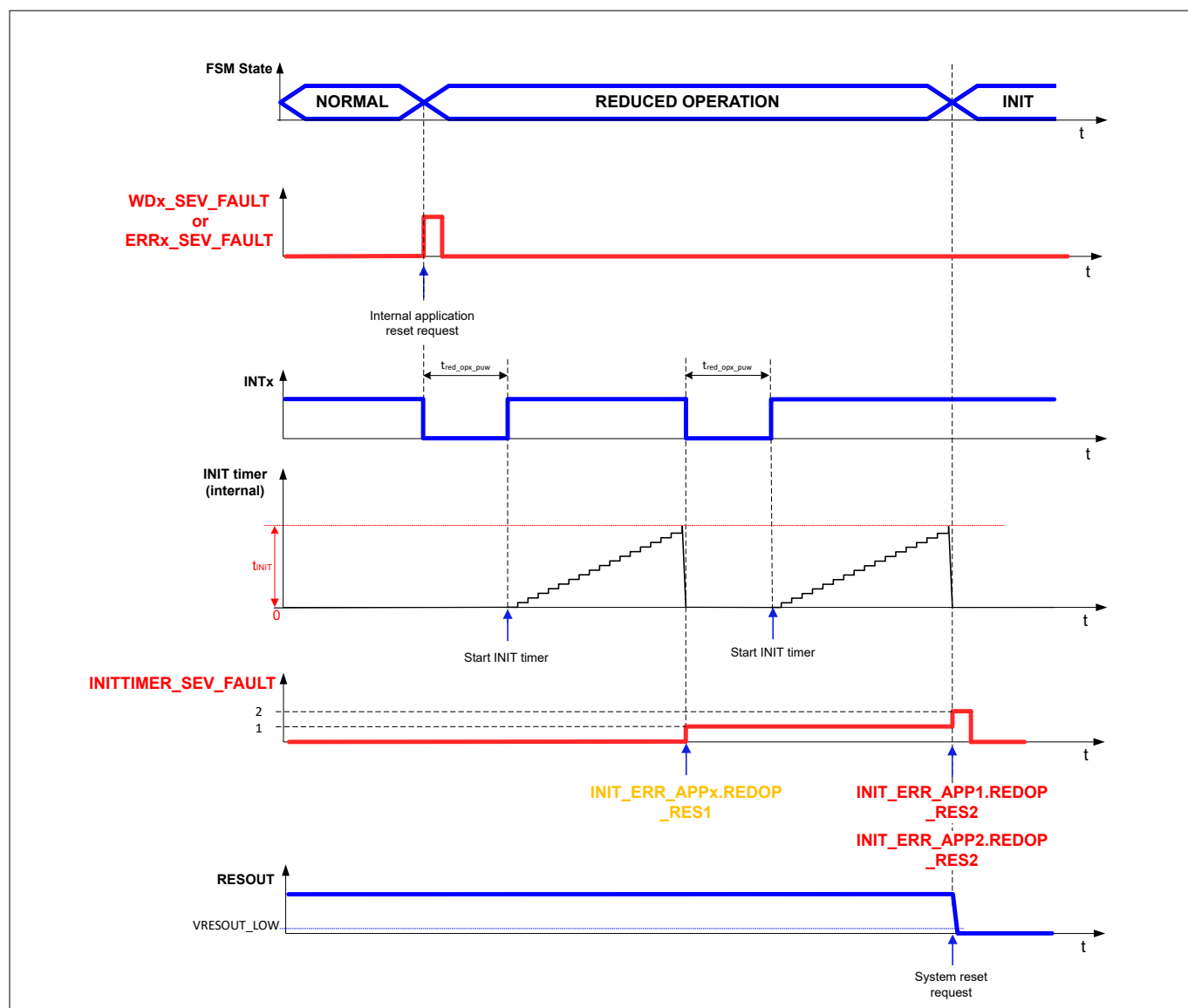


Figure 27 Signal diagram system reset activation in REDUCED OPERATION state

x = 1, 2

9 State machine (FSM)

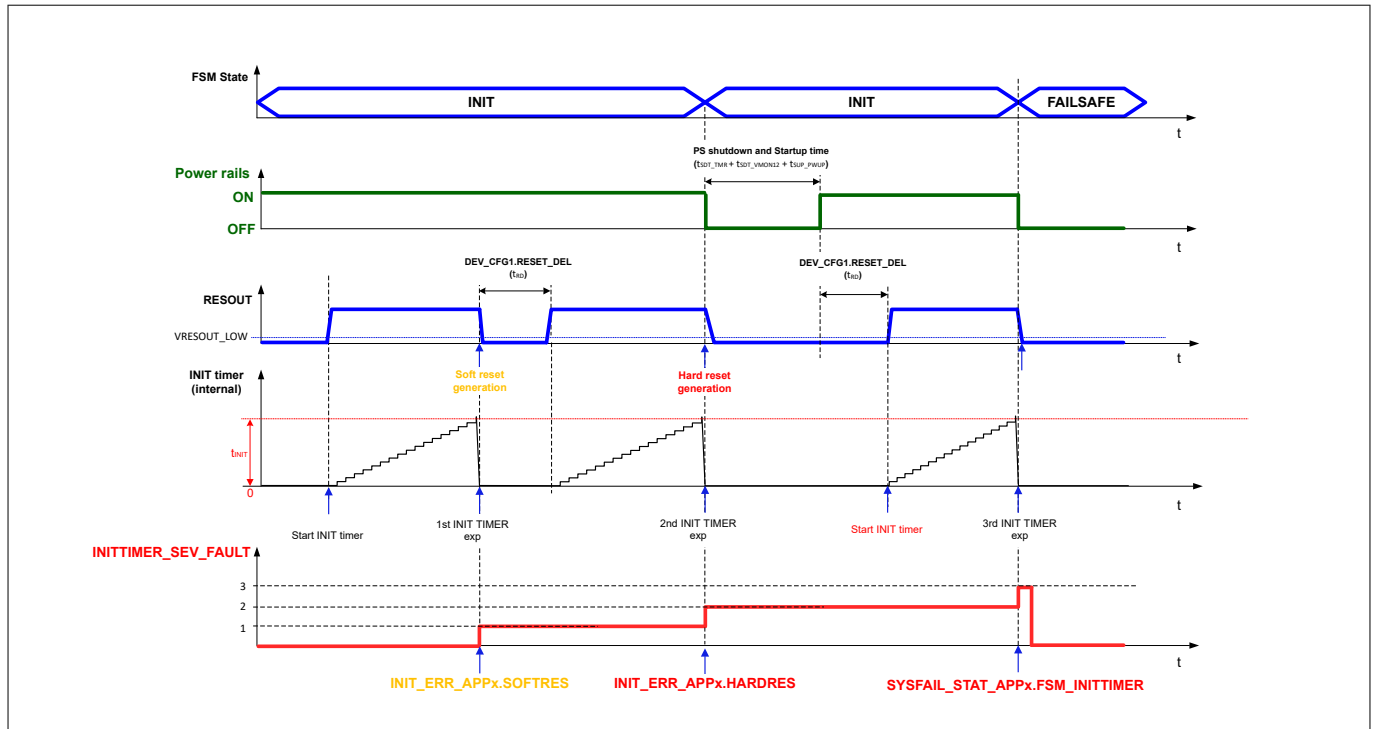


Figure 28 Signal diagram system shutdown due to 3xINIT timer elapse in INIT state

x = 1, 2

9.1.3 State transition

A state transition is requested by writing the bitfield **DEV_PW_CFG3.FSM_STATEREQ**. Made changes will take effect upon successful completion of the SPI communication and locking the protected write registers again. This happens upon release of CSN after **PROT_CFG.KEY** has been written with the lock key. If a state transition originated in NORMAL is requested, the release of CSN after writing the lock key also marks the moment when the outputs SSOx will be pulled low. Possible configured delay times between SSO1 and SSO2 will still be respected.

If a state request is received while the device executes a power-up or power-down sequence, the state transition is rejected and the bit **SYS_STAT_APP1.FSM_NOOP** is set while at the same time an interrupt is issued (if REDUCED OPERATION is enabled, also **SYS_STAT_APP2.FSM_NOOP** is set). The same reaction also takes place if a state transition is requested which is not listed in the state transition table (invalid state transition request). If a valid state transition is requested while already being in a transition delay into SLEEP or STANDBY, the current delay will be aborted and a transition takes place as if ENA or WAK signal would have been detected instead. Transitions from one state into itself are allowed.

In case a WAK, ENA takes places after the delay time has expired, the already started power-down sequence will be finished and a wake-up takes place directly afterwards.

(x = 1,2)

9.1.3.1 State transition table

Old State	New state	Conditions	Comments
POWERDOWN	INIT	Internal POR (internal supplies OK)	The configured power sequencing is applied, see Hardware configuration (HWCFG)

9 State machine (FSM)

INIT	NORMAL	(SPI command: Move to NORMAL) AND (Disable or successful service within t_{INIT} : - WWD1/2 - FWD1/2 - ERR0/1/2 pin monitoring)	–
NORMAL	SLEEP	(SPI command: Move to SLEEP) AND (No ENA) AND (No WAK)	- If a move to SLEEP is unsuccessful an interrupt is issued and the device moves into WAKE - The configured power sequencing is applied, see Hardware configuration (HWCFG)
NORMAL	STANDBY	(SPI command: Move to STANDBY) AND (No ENA) AND (No WAK)	- If a move to STANDBY is unsuccessful an interrupt is issued and the device moves into INIT - The configured power sequencing is applied, see Hardware configuration (HWCFG)
SLEEP	WAKE	ENA OR WAK OR WUT timer expired OR (SPI command: Move to WAKE)	- Upon wake-up from SLEEP an interrupt is issued, if QUC was on in SLEEP - The wake-up information is stored - Restores regulator configuration as it has been before entering SLEEP, following the power-up sequence and skipping the respective regulators, see Hardware configuration (HWCFG)
WAKE	NORMAL	(SPI command: Move to NORMAL) AND (Disable or successful service within t_{INIT} : - WWD1/2 - FWD1/2 - ERR0/1/2 pin monitoring)	–

9 State machine (FSM)

WAKE	SLEEP	(SPI command: Move to SLEEP) AND (No ENA) AND (No WAK)	- If a move to SLEEP is unsuccessful an interrupt is issued and the device moves into WAKE - The configured power sequencing is applied, see Hardware configuration (HWCFG)
WAKE	STANDBY	(SPI command: Move to STANDBY) AND (No ENA) AND (No WAK)	- If a move to STANDBY is unsuccessful an interrupt is issued and the device moves into INIT - The configured power sequencing is applied, see Hardware configuration (HWCFG)
STANDBY	INIT	ENA OR WAK OR WUT timer expired	The configured power sequencing is applied
FAILSAFE	INIT	ENA OR WAK OR Failsafe Timer expired	- The automated wake-up from FAILSAFE upon expiration of the failsafe timer only works if FAILSAFE has not been entered three times consecutively caused by the same failure - The configured power sequencing is applied
REDUCED OPERATION	NORMAL	(SPI command: Move to NORMAL) AND (Disable or successful service within t_{INIT} : - WWD1/2 - FWD1/2 - ERR0/1/2 pin monitoring)	–

Note: When requesting a state transition into SLEEP or STANDBY, all configurations of the destination state must be done before sending the state transition request.

9.1.3.2 Programmable transition delay time

For the transitions from NORMAL to SLEEP, from NORMAL to STANDBY, from WAKE to SLEEP and from WAKE to STANDBY a configurable transition delay time exists. Once one of the mentioned state transitions have been requested by the microcontroller, the transition takes place after the expiration of the transition delay time

9 State machine (FSM)

t_{TR_DEL} . The transition is unsuccessful and moves to INIT or WAKE respectively, if a state request is received within the transition delay time.

The configuration is done in **DEV_CFG4.FSM_TRDEL**.

9.1.3.3 Automated wake-up from FAILSAFE

Upon entering FAILSAFE the device remains in it for $t_{FAILSAFE_min}^*$. Afterwards it runs an automated restart attempt unless FAILSAFE was entered 3 times consecutively caused by the same error source, in which case the device remains in FAILSAFE and waits for ENA or WAK to run another restart attempt. In case it is unsuccessful, the device follows the same sequence as above.

*) If an overtemperature event was the cause for entering FAILSAFE the device remains in it for t_{TSD_min} .

9.1.4 Power sequencing

BUCK PREREG and QST are the first regulators to ramp up when the internal power on reset (POR) was released. However QST output voltage level has no impact on the power sequencing and is not gating for other rails to start up. Also the UV events for a regulator is masked until the output has exceeded its undervoltage threshold.

If a regulator does not succeed to establish a voltage above its undervoltage threshold before t_{StG} expires, one of the following scenarios apply:

1. Move to FAILSAFE:
 - BUCK PREREG
 - BOOST (if usage detected)
 - QUC
 - BUCK CORE
 - QST
2. Skips the start-up of the respective regulator and disables it. Issues an interrupt according to the reaction on detected faults for short to GND detection in [Reaction on faults](#) (non-blocking for power sequence)
 - BUCK IF (if usage detected)
 - VMON1 (if usage detected)
 - QVR
 - QCO
 - VMON2 (if usage detected)

The initial reset release (RESOUT going "high") after a power-up sequence has taken place, occurs when QUC, QST and BUCKCORE have surpassed their undervoltage thresholds. Further details for the reset function see [Reset function \(RESOUT\)](#)

PREREG starts switching after the input voltage at the pins VS and VIQST is above $V_{PWD_TH_H}$ and the time t_{SUP_PWUP} has passed.

9 State machine (FSM)

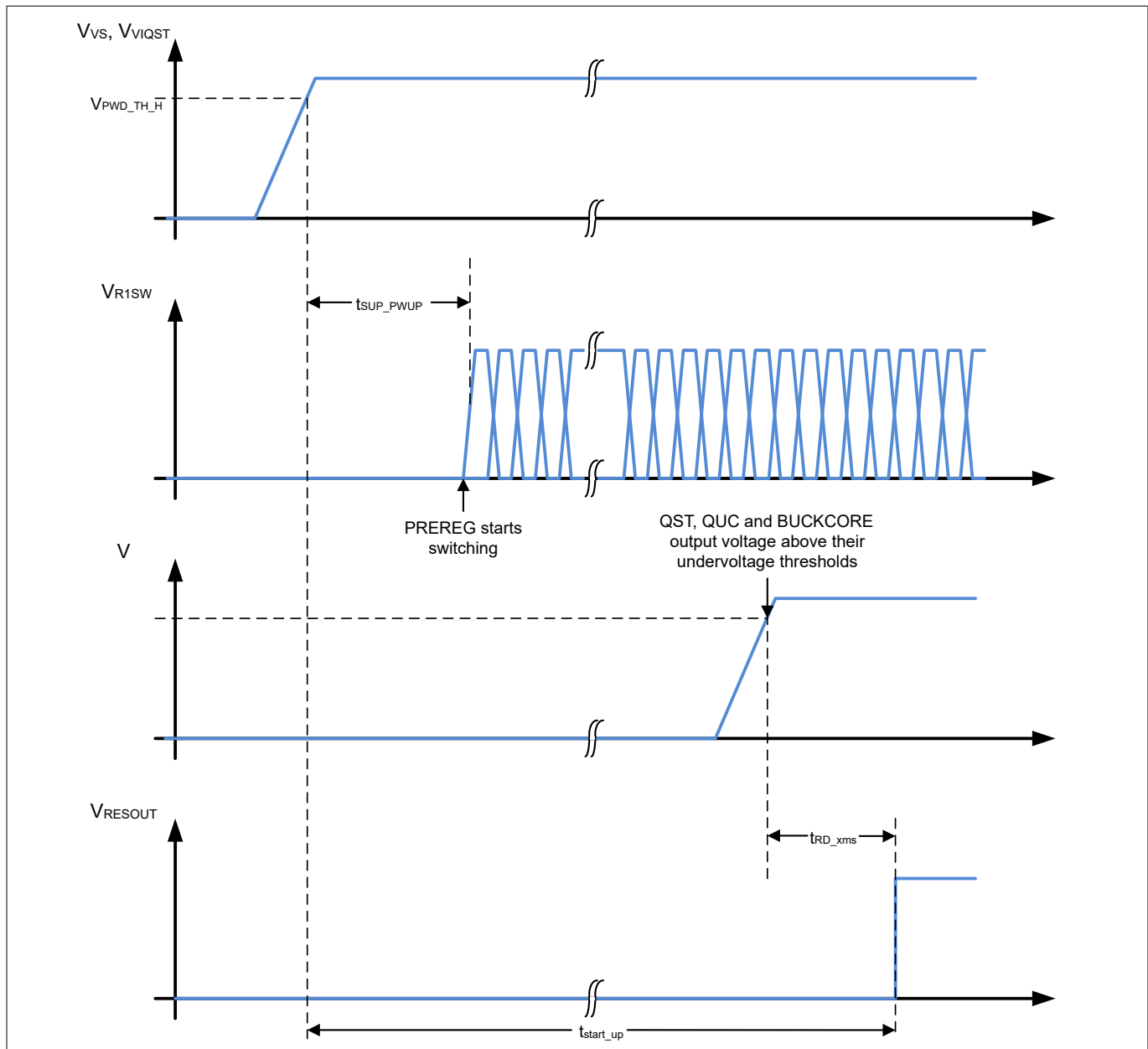


Figure 29 System start-up timings

If a state transition request is placed while the device performs a power-down or power-up sequence the following points apply:

- The command is ignored
- An interrupt is triggered
- The fault is stored in a dedicated register

The device provides status information for static configurations (active regulators) via register status flags in DEV_STAT.

9.1.4.1 Power up sequence schema A

The hardware configuration (HWCFG) determines the start up sequence to be either schema A or schema B.

If the power up sequence schema A is selected, the sequence as described below is executed. Thereby the next voltage rail is only ramped up if the previous output voltage rail has exceeded its undervoltage threshold. QST starts up independently from the other voltage regulators and is not a precondition for another regulator.

9 State machine (FSM)

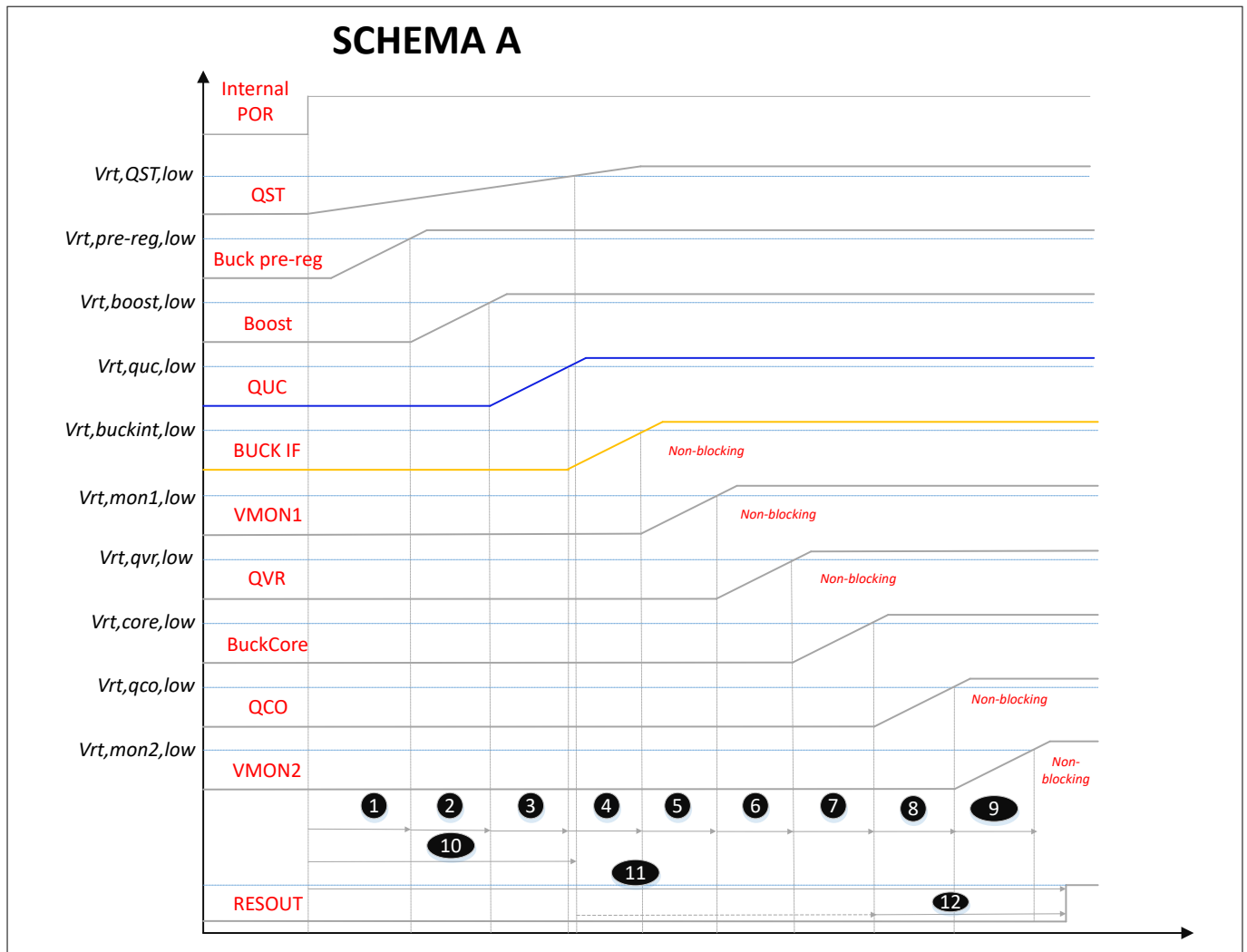


Figure 30 Power-up sequencing schema A

- 1 -> PREREG starts up
- 2 -> BOOST starts up (only if autodetected)
- 3 -> QUC starts up
- 4 -> BUCKIF starts up (only if autodetected during first power up sequence)
- 5 -> VMON1 starts up (only if autodetected during first power up sequence)
- 6 -> QVR starts up
- 7 -> BUCK CORE starts up
- 8 -> QCO starts up
- 9 -> VMON2 starts up (only if autodetected during first power up sequence)
- 10 -> QST starts up
- 11 -> Duration of complete start-up: t_{start_up}
- 12 -> RESOUT delay time (further information in [Reset function \(RESOUT\)](#))

9.1.4.2 Power up sequence schema B

If the power up sequence schema B is selected, the sequence as described below is executed. Thereby the next voltage rail is only ramped up if the previous output voltage rail has exceeded its undervoltage threshold. QST starts up independently from the other voltage regulators and is not a precondition for another regulator.

9 State machine (FSM)

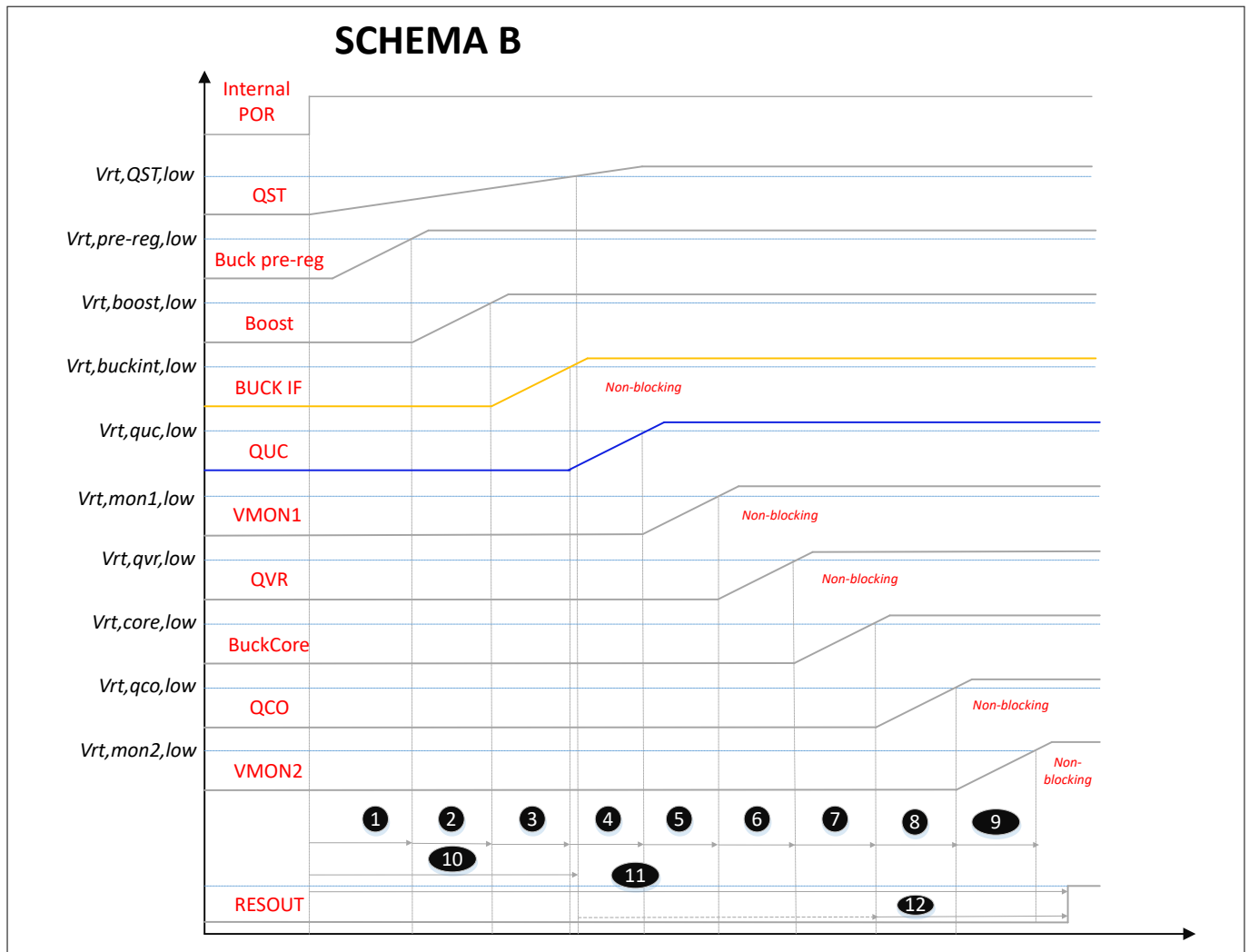


Figure 31 Power sequencing schema B

- 1 -> PREREG starts up
- 2 -> BOOST starts up (only if autotected)
- 3 -> BUCKIF starts up (only if autotected during first power up sequence)
- 4 -> QUC starts up
- 5 -> VMON1 starts up (only if autotected during first power up sequence)
- 6 -> QVR starts up
- 7 -> BUCK CORE starts up
- 8 -> QCO starts up
- 9 -> VMON2 (only if autotected during first power up sequence)
- 10 -> QST starts up
- 11 -> Duration of complete start-up: $t_{\text{start_up}}$
- 12 -> RESOUT delay time (further information in [Reset function \(RESOUT\)](#))

9.1.4.3 Power down sequencing

The device disables the output voltage rail(s) following the corresponding power down sequences if it transitions into STANDBY or SLEEP. When transitioning into SLEEP the sequence will leave out the rails and the associated delays, that are configured to stay on.

9 State machine (FSM)

If power up sequence schema A was selected

- 1.** disable VMON2
- 2.** wait for t_{SDT_VMON12}
- 3.** disable QCO
- 4.** wait for t_{SDT_TMR}
- 5.** disable BUCK CORE
- 6.** wait for t_{SDT_TMR}
- 7.** disable QVR
- 8.** wait for t_{SDT_TMR}
- 9.** disable VMON1
- 10.** wait for t_{SDT_VMON12}
- 11.** disable BUCK IF
- 12.** wait for t_{SDT_TMR}
- 13.** disable QUC
- 14.** wait for t_{SDT_TMR}
- 15.** disable BOOST
- 16.** wait for t_{SDT_TMR}
- 17.** disable BUCK PREREG
- 18.** wait for t_{SDT_TMR}

If power up sequence schema B was selected

- 1.** disable VMON2
- 2.** wait for t_{SDT_VMON12}
- 3.** disable QCO
- 4.** wait for t_{SDT_TMR}
- 5.** disable BUCK CORE
- 6.** wait for t_{SDT_TMR}
- 7.** disable QVR
- 8.** wait for t_{SDT_TMR}
- 9.** disable VMON1
- 10.** wait for t_{SDT_VMON12}
- 11.** disable QUC
- 12.** wait for t_{SDT_TMR}
- 13.** disable BUCK IF
- 14.** wait for t_{SDT_TMR}
- 15.** disable BOOST
- 16.** wait for t_{SDT_TMR}
- 17.** disable BUCK PREREG
- 18.** wait for t_{SDT_TMR}

The device disables the output voltage rail(s) following the corresponding power down sequencing.

9 State machine (FSM)

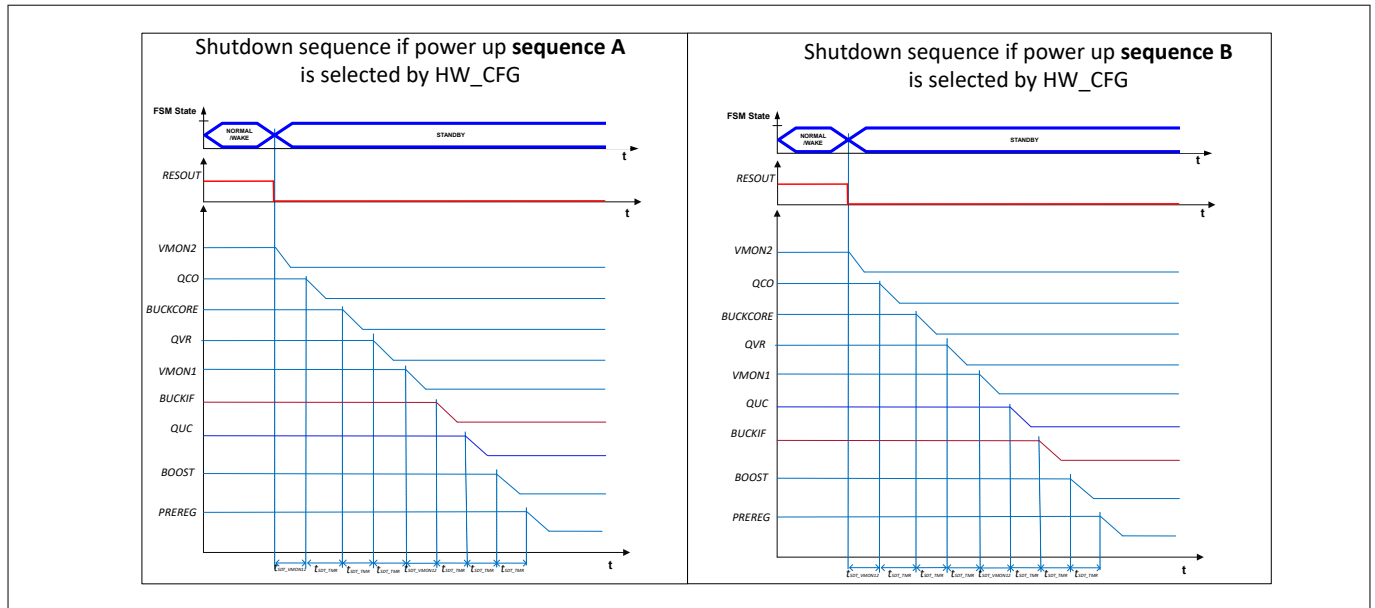


Figure 32 Power down sequencing

Note: The parameter t_{SDT_TMR} and t_{SDT_VMON12} represent an internal delay and is not gated by external conditions.

9.2 Electrical characteristics state machine (FSM)

Table 33 Electrical characteristics state machine (FSM)

$V_{VS} = 6.0 \text{ V to } 36 \text{ V}$, $T_j = -40^\circ\text{C to } +175^\circ\text{C}$, all voltages with respect to ground, positive current flowing into pin (unless otherwise specified)¹⁾

Parameter	Symbol	Values			Unit	Note or condition	P-Number
		Min.	Typ.	Max.			
Supplies start-up time	t_{SUP_PWUP}	–	4	6	ms	V_{VS} and $V_{VIQST} \geq V_{PWD_TH_H}$ (V_S and V_{IQST} pins assumed to be connected together externally) $V_{SSC_S} < 1\text{V}$ at startup - Max. Capacitance at SSC_S pin is 1uF	DS-2083
Power up threshold	$V_{PWD_TH_H}$	–	–	6	V	V_{VS} increasing	DS-2156
Power down threshold low	$V_{PWD_TH_L}$	2.5	–	5.5	V	V_{VS} decreasing BOOST not used	DS-1555
System shutdown time	t_{SDT}	–	–	15	ms	–	DS-1536
Thermal shutdown time	t_{TSD_min}	0.9	1	1.1	s	–	DS-1548

(table continues...)

9 State machine (FSM)

Table 33 (continued) Electrical characteristics state machine (FSM)

$V_{VS} = 6.0 \text{ V to } 36 \text{ V}$, $T_j = -40^\circ\text{C to } +175^\circ\text{C}$, all voltages with respect to ground, positive current flowing into pin (unless otherwise specified)¹⁾

Parameter	Symbol	Values			Unit	Note or condition	P-Number
		Min.	Typ.	Max.			
Internal voltage rails shutdown delay	t_{SDT_TMR}	$0.9 \cdot t_{SDT_TMR}$	t_{SDT_TMR}	$1.1 \cdot t_{SDT_TMR}$	μs	t_{SDT_TMR} : Programmable via SPI in DEV_CFG4.FSM_SDT_TMR	DS-1936
VMON1/2 shutdown time	t_{SDT_VMON12}	$0.9 \cdot t_{SDT_VMON12}$	t_{SDT_VMON12}	$1.1 \cdot t_{SDT_VMON12}$	μs	t_{SDT_VMON12} : Programmable via SPI in DEV_CFG4.FSM_SDT_VMON12	DS-1937
Short to ground detection time for internal regulators except QST	t_{STG}	0.9	1	1.1	ms	–	DS-1538
Short to ground detection time for QST regulator	t_{STG_QST}	1.8	2	2.2	ms	–	DS-1537
FAILSAFE time	$t_{FAILSAFE_min}$	18	20	22	ms	–	DS-1547
INIT timer	t_{INIT}	540	600	660	ms	–	DS-1549
Low power state transition time	t_{TR_DEL}	100	–	1600	μs	t_{TR_DEL} is programmable between 100 μs and 1.6 ms via SPI The default value is set to 900 μs	DS-1503
Accuracy for low power state transition time	$t_{TR_DEL_ACC}$	-20	–	20	%	–	DS-1550
State transition time	t_{TR}	–	–	200	μs	–	DS-1551
State transition time to Initialization state	t_{TR_INIT}	–	–	3	ms	Transition from STANDBY/ FAILSAFE to INIT state: Measured from rising edge of ENA/WAKE to R1SW rising edge; Move to INIT faults: Measured from RESOUT falling edge to QVR enable or R1SW rising edge	DS-1552

(table continues...)

9 State machine (FSM)

Table 33 (continued) Electrical characteristics state machine (FSM)

$V_{VS} = 6.0 \text{ V to } 36 \text{ V}$, $T_j = -40^\circ\text{C to } +175^\circ\text{C}$, all voltages with respect to ground, positive current flowing into pin (unless otherwise specified)¹⁾

Parameter	Symbol	Values			Unit	Note or condition	P-Number
		Min.	Typ.	Max.			
Current consumption							
SLEEP state current consumption	I_{q_SLEEP}	–	12.9	20	mA	Current consumptions are measured from V_S(T30) without load current applied to post regulators: • BUCK PREREG, QUC, BUCK IF, QCO and QST are enabled • BUCK CORE and QVR are switched off; • BOOST is not populated; • $V_{R1FB} = V_{R1FB_5V5}$; • $f_{DCDC} = 2.2 \text{ MHz}$; • VMON1 and VMON2 are disabled; • Error pin monitoring and all watchdog channels are disabled; • wakeup timer is disabled; • $V_{VS}/V_{VIQST} = 13.5 \text{ V}$; • MOSFET IPG20N06S2L-35A for SSW, MOSFET IPG20N06S4L-26A for PREREG Half-bridge • BUCK CORE Load = 1mA, BUCK IF Load = 200uA • $T_j \leq 85^{\circ}\text{C}$	DS-2128

(table continues...)

9 State machine (FSM)

Table 33 (continued) Electrical characteristics state machine (FSM)

$V_{VS} = 6.0 \text{ V to } 36 \text{ V}$, $T_j = -40^\circ\text{C to } +175^\circ\text{C}$, all voltages with respect to ground, positive current flowing into pin (unless otherwise specified)¹⁾

Parameter	Symbol	Values			Unit	Note or condition	P-Number
		Min.	Typ.	Max.			
SLEEP state current consumption	I_{q_SLEEP}	–	7.9	12.3	mA	Current consumptions are measured from $V_{S(T30)}$: • BUCK PREREG enabled • BOOST, BUCK CORE, QUC, BUCK IF, QCO and QST and QVR are switched off; • $V_{R1FB} = V_{R1FB_4V}$; • $f_{DCDC} = 2.2 \text{ MHz}$; • VMON1 and VMON2 are disabled; • Error pin monitoring and all watchdog channels are disabled; • wakeup timer is disabled; • $V_{VS}/V_{VIQST} = 13.5 \text{ V}$; • MOSFET IPG20N06S2L-35A for SSW, MOSFET IPG20N06S4L-26A for PREREG Half-bridge • BUCK CORE Load = 1mA, BUCK IF Load = 200uA • $T_j \leq 85^\circ\text{C}$	DS-2107

(table continues...)

9 State machine (FSM)

Table 33 (continued) **Electrical characteristics state machine (FSM)**

$V_{VS} = 6.0 \text{ V to } 36 \text{ V}$, $T_j = -40^\circ\text{C to } +175^\circ\text{C}$, all voltages with respect to ground, positive current flowing into pin (unless otherwise specified)¹⁾

Parameter	Symbol	Values			Unit	Note or condition	P-Number
		Min.	Typ.	Max.			
SLEEP state current consumption	I_{q_SLEEP}	–	6	9.3	mA	Current consumptions are measured from $V_{S(T30)}$: • BUCK PREREG and BOOST are enabled • BUCK CORE, QUC, BUCK IF, QCO and QST and QVR are switched off; • $V_{R1FB} = V_{R1FB_4V}$; • $f_{DCDC} = 2.2 \text{ MHz}$; • VMON1 and VMON2 are disabled; • Error pin monitoring and all watchdog channels are disabled; • wakeup timer is disabled; • $V_{VS}/V_{VIQST} = 13.5 \text{ V}$; • MOSFET IPG20N06S2L-35A for SSW, MOSFET IPG20N06S4L-26A for PREREG Half-bridge • BUCK CORE Load = 1mA, BUCK IF Load = 200uA • $T_j \leq 85^\circ\text{C}$	DS-2109

(table continues...)

9 State machine (FSM)

Table 33 (continued) Electrical characteristics state machine (FSM)

$V_{VS} = 6.0\text{ V to }36\text{ V}$, $T_j = -40^\circ\text{C to }+175^\circ\text{C}$, all voltages with respect to ground, positive current flowing into pin (unless otherwise specified)¹⁾

Parameter	Symbol	Values			Unit	Note or condition	P-Number
		Min.	Typ.	Max.			
SLEEP state current consumption	I_{q_SLEEP}	–	6.9	10.7	mA	Current consumptions are measured from $V_{S(T30)}$: • BUCK PREREG, BOOST and QUC are enabled • BUCK CORE, BUCK IF, QCO and QST and QVR are switched off; • $V_{R1FB} = V_{R1FB_4V}$; • $f_{DCDC} = 2.2\text{ MHz}$; • VMON1 and VMON2 are disabled; • Error pin monitoring and all watchdog channels are disabled; • wakeup timer is disabled; • $V_{VS}/V_{VIQST} = 13.5\text{ V}$; • MOSFET IPG20N06S2L-35A for SSW, MOSFET IPG20N06S4L-26A for PREREG Half-bridge • BUCK CORE Load = 1mA, BUCK IF Load = 200uA • $T_j \leq 85^\circ\text{C}$	DS-2111

(table continues...)

9 State machine (FSM)

Table 33 (continued) Electrical characteristics state machine (FSM)

$V_{VS} = 6.0 \text{ V to } 36 \text{ V}$, $T_j = -40^\circ\text{C to } +175^\circ\text{C}$, all voltages with respect to ground, positive current flowing into pin (unless otherwise specified)¹⁾

Parameter	Symbol	Values			Unit	Note or condition	P-Number
		Min.	Typ.	Max.			
SLEEP state current consumption	I_{q_SLEEP}	–	10.4	16.2	mA	Current consumptions are measured from $V_{S(T30)}$: • BUCK PREREG, BOOST, BUCK IF and QUC are enabled • BUCK CORE, QCO, QST and QVR are switched off; • $V_{R1FB} = V_{R1FB_4V}$; • $f_{DCDC} = 2.2 \text{ MHz}$; • VMON1 and VMON2 are disabled; • Error pin monitoring and all watchdog channels are disabled; • wakeup timer is disabled; • $V_{VS}/V_{VIQST} = 13.5 \text{ V}$; • MOSFET IPG20N06S2L-35A for SSW, MOSFET IPG20N06S4L-26A for PREREG Half-bridge • BUCK CORE Load = 1mA, BUCK IF Load = 200uA • $T_j \leq 85^\circ\text{C}$	DS-2113

(table continues...)

9 State machine (FSM)

Table 33 (continued) Electrical characteristics state machine (FSM)

$V_{VS} = 6.0 \text{ V to } 36 \text{ V}$, $T_j = -40^\circ\text{C to } +175^\circ\text{C}$, all voltages with respect to ground, positive current flowing into pin (unless otherwise specified)¹⁾

Parameter	Symbol	Values			Unit	Note or condition	P-Number
		Min.	Typ.	Max.			
SLEEP state current consumption	I_{q_SLEEP}	–	11.4	17.7	mA	Current consumptions are measured from $V_{S(T30)}$: • BUCK PREREG, BOOST, BUCK IF, QVR and QUC are enabled • BUCK CORE, QCO, QST are switched off; • $V_{R1FB} = V_{R1FB_4V}$; • $f_{DCDC} = 2.2 \text{ MHz}$; • VMON1 and VMON2 are disabled; • Error pin monitoring and all watchdog channels are disabled; • wakeup timer is disabled; • $V_{VS}/V_{VIQST} = 13.5 \text{ V}$; • MOSFET IPG20N06S2L-35A for SSW, MOSFET IPG20N06S4L-26A for PREREG Half-bridge • BUCK CORE Load = 1mA, BUCK IF Load = 200uA • $T_j \leq 85^\circ\text{C}$	DS-2115

(table continues...)

9 State machine (FSM)

Table 33 (continued) Electrical characteristics state machine (FSM)

$V_{VS} = 6.0 \text{ V to } 36 \text{ V}$, $T_j = -40^\circ\text{C to } +175^\circ\text{C}$, all voltages with respect to ground, positive current flowing into pin (unless otherwise specified)¹⁾

Parameter	Symbol	Values			Unit	Note or condition	P-Number
		Min.	Typ.	Max.			
SLEEP state current consumption	I_{q_SLEEP}	–	12.9	20	mA	Current consumptions are measured from $V_{S(T30)}$: • BUCK PREREG, BOOST, BUCK IF, QVR, BUCK CORE, QCO and QUC are enabled • QST is switched off; • $V_{R1FB} = V_{R1FB_4V}$; • $f_{DCDC} = 2.2 \text{ MHz}$; • VMON1 and VMON2 are disabled; • Error pin monitoring and all watchdog channels are disabled; • wakeup timer is disabled; • $V_{VS}/V_{VIQST} = 13.5 \text{ V}$; • MOSFET IPG20N06S2L-35A for SSW, MOSFET IPG20N06S4L-26A for PREREG Half-bridge • BUCK CORE Load = 1mA, BUCK IF Load = 200uA • $T_j \leq 85^\circ\text{C}$	DS-2117

(table continues...)

9 State machine (FSM)

Table 33 (continued) Electrical characteristics state machine (FSM)

$V_{VS} = 6.0\text{ V to }36\text{ V}$, $T_j = -40^\circ\text{C to }+175^\circ\text{C}$, all voltages with respect to ground, positive current flowing into pin (unless otherwise specified)¹⁾

Parameter	Symbol	Values			Unit	Note or condition	P-Number
		Min.	Typ.	Max.			
SLEEP state current consumption	I_{q_SLEEP}	–	6	9.3	mA	Current consumptions are measured from $V_{-S}(T30)$: • BUCK PREREG is enabled • BUCK IF, QVR, BUCK CORE, QCO, QUC and QST are switched off; • BOOST is not populated; • $V_{R1FB} = V_{R1FB_5V5}$; • $f_{DCDC} = 2.2\text{ MHz}$; • VMON1 and VMON2 are disabled; • Error pin monitoring and all watchdog channels are disabled; • wakeup timer is disabled; • $V_{VS}/V_{VIQST} = 13.5\text{ V}$; • MOSFET IPG20N06S2L-35A for SSW, MOSFET IPG20N06S4L-26A for PREREG Half-bridge • BUCK CORE Load = 1mA, BUCK IF Load = 200uA • $T_j \leq 85^\circ\text{C}$	DS-2119

(table continues...)

9 State machine (FSM)

Table 33 (continued) Electrical characteristics state machine (FSM)

$V_{VS} = 6.0 \text{ V to } 36 \text{ V}$, $T_j = -40^\circ\text{C to } +175^\circ\text{C}$, all voltages with respect to ground, positive current flowing into pin (unless otherwise specified)¹⁾

Parameter	Symbol	Values			Unit	Note or condition	P-Number
		Min.	Typ.	Max.			
SLEEP state current consumption	I_{q_SLEEP}	–	6.1	9.5	mA	Current consumptions are measured from $V_{S(T30)}$: • BUCK PREREG and QUC are enabled • BUCK IF, QVR, BUCK CORE, QCO and QST are switched off; • BOOST is not populated; • $V_{R1FB} = V_{R1FB_5V5}$; • $f_{DCDC} = 2.2 \text{ MHz}$; • VMON1 and VMON2 are disabled; • Error pin monitoring and all watchdog channels are disabled; • wakeup timer is disabled; • $V_{VS}/V_{VIQST} = 13.5 \text{ V}$; • MOSFET IPG20N06S2L-35A for SSW, MOSFET IPG20N06S4L-26A for PREREG Half-bridge • BUCK CORE Load = 1mA, BUCK IF Load = 200uA • $T_j \leq 85^\circ\text{C}$	DS-2121

(table continues...)

9 State machine (FSM)

Table 33 (continued) **Electrical characteristics state machine (FSM)**

$V_{VS} = 6.0 \text{ V to } 36 \text{ V}$, $T_j = -40^\circ\text{C to } +175^\circ\text{C}$, all voltages with respect to ground, positive current flowing into pin (unless otherwise specified)¹⁾

Parameter	Symbol	Values			Unit	Note or condition	P-Number
		Min.	Typ.	Max.			
SLEEP state current consumption	I_{q_SLEEP}	–	13.4	20.8	mA	Current consumptions are measured from $V_{S(T30)}$: • BUCK PREREG, BUCK IF and QUC are enabled • QVR, BUCK CORE, QCO and QST are switched off; • BOOST is not populated; • $V_{R1FB} = V_{R1FB_5V5}$; • $f_{DCDC} = 2.2 \text{ MHz}$; • VMON1 and VMON2 are disabled; • Error pin monitoring and all watchdog channels are disabled; • wakeup timer is disabled; • $V_{VS}/V_{VIQST} = 13.5 \text{ V}$; • MOSFET IPG20N06S2L-35A for SSW, MOSFET IPG20N06S4L-26A for PREREG Half-bridge • BUCK CORE Load = 1mA, BUCK IF Load = 200uA • $T_j \leq 85^\circ\text{C}$	DS-2123

(table continues...)

9 State machine (FSM)

Table 33 (continued) Electrical characteristics state machine (FSM)

$V_{VS} = 6.0 \text{ V to } 36 \text{ V}$, $T_j = -40^\circ\text{C to } +175^\circ\text{C}$, all voltages with respect to ground, positive current flowing into pin (unless otherwise specified)¹⁾

Parameter	Symbol	Values			Unit	Note or condition	P-Number
		Min.	Typ.	Max.			
SLEEP state current consumption	I_{q_SLEEP}	–	14	21.7	mA	Current consumptions are measured from $V_{S(T30)}$: • BUCK PREREG, BUCK IF, QVR and QUC are enabled • BUCK CORE, QCO and QST are switched off; • BOOST is not populated; • $V_{R1FB} = V_{R1FB_5V5}$; • $f_{DCDC} = 2.2 \text{ MHz}$; • VMON1 and VMON2 are disabled; • Error pin monitoring and all watchdog channels are disabled; • wakeup timer is disabled; • $V_{VS}/V_{VIQST} = 13.5 \text{ V}$; • MOSFET IPG20N06S2L-35A for SSW, MOSFET IPG20N06S4L-26A for PREREG Half-bridge • BUCK CORE Load = 1mA, BUCK IF Load = 200uA • $T_j \leq 85^\circ\text{C}$	DS-2125

(table continues...)

9 State machine (FSM)

Table 33 (continued) **Electrical characteristics state machine (FSM)**

$V_{VS} = 6.0 \text{ V to } 36 \text{ V}$, $T_j = -40^\circ\text{C to } +175^\circ\text{C}$, all voltages with respect to ground, positive current flowing into pin (unless otherwise specified)¹⁾

Parameter	Symbol	Values			Unit	Note or condition	P-Number
		Min.	Typ.	Max.			
SLEEP state current consumption	I_{q_SLEEP}	–	15.2	23.6	mA	Current consumptions are measured from $V_{S(T30)}$: • BUCK PREREG, BUCK IF, QVR, BUCK CORE, QCO and QUC are enabled • QST is switched off; • BOOST is not populated; • $V_{R1FB} = V_{R1FB_5V5}$; • $f_{DCDC} = 2.2 \text{ MHz}$; • VMON1 and VMON2 are disabled; • Error pin monitoring and all watchdog channels are disabled; • wakeup timer is disabled; • $V_{VS}/V_{VIQST} = 13.5 \text{ V}$; • MOSFET IPG20N06S2L-35A for SSW, MOSFET IPG20N06S4L-26A for PREREG Half-bridge • BUCK CORE Load = 1mA, BUCK IF Load = 200uA • $T_j \leq 85^\circ\text{C}$	DS-2127

(table continues...)

9 State machine (FSM)

Table 33 (continued) Electrical characteristics state machine (FSM)

$V_{VS} = 6.0 \text{ V to } 36 \text{ V}$, $T_j = -40^\circ\text{C to } +175^\circ\text{C}$, all voltages with respect to ground, positive current flowing into pin (unless otherwise specified)¹⁾

Parameter	Symbol	Values			Unit	Note or condition	P-Number
		Min.	Typ.	Max.			
STANDBY state current consumption	$I_{q_STANDBY\ OFF}$	–	20	24	μA	Current consumptions are measured from $V_{S(T30)}$: - All output voltage rails (BUCK PREREG, BUCK CORE, BUCK IF, BOOST, QUC, QVR, QST, QCO) are switched off - VMON1 and VMON2 are disabled - Error pin monitoring and all watchdog channels are disabled - Wakeup timer is disabled - Pin ENA and pin WAK are monitored for wakeup events $10 \text{ V} \leq V_{VS}/V_{VIQST} \leq 28 \text{ V}$ $T_j \leq 85^\circ\text{C}$ - Quiescent current also depending on the leakage of diode D3	DS-2079

(table continues...)

9 State machine (FSM)

Table 33 (continued) **Electrical characteristics state machine (FSM)**

$V_{VS} = 6.0 \text{ V to } 36 \text{ V}$, $T_j = -40^\circ\text{C to } +175^\circ\text{C}$, all voltages with respect to ground, positive current flowing into pin (unless otherwise specified)¹⁾

Parameter	Symbol	Values			Unit	Note or condition	P-Number
		Min.	Typ.	Max.			
STANDBY state current consumption with QST ON	$I_{q_STANDBY_ON}$	–	54	70	μA	Current consumptions are measured from $V_{S(T30)}$: - QST is switched ON - All output voltage rails (BUCK PREREG, BUCK CORE, BUCK IF, BOOST, QUC, QVR, QCO) are switched off - ERRx pin monitoring, WWD and FWD are disabled - VMON1 and VMON2 are disabled - Wakeup timer is disabled - Pin ENA and pin WAK are monitored for wakeup events $10 \text{ V} \leq V_{VS}/V_{VIQST} \leq 28 \text{ V}$ $T_j \leq 85^\circ\text{C}$ - Quiescent current also depending on the leakage of diode D3	DS-1544

(table continues...)

9 State machine (FSM)

Table 33 (continued) **Electrical characteristics state machine (FSM)**

$V_{VS} = 6.0 \text{ V to } 36 \text{ V}$, $T_j = -40^\circ\text{C to } +175^\circ\text{C}$, all voltages with respect to ground, positive current flowing into pin (unless otherwise specified)¹⁾

Parameter	Symbol	Values			Unit	Note or condition	P-Number
		Min.	Typ.	Max.			
STANDBY state current consumption with WUT ON	$I_{q_WUT_ON}$	–	–	50	μA	Current consumptions are measured from $V_{S(T30)}$: - QST is switched OFF - All output voltage rails (BUCK PREREG, BUCK CORE, BUCK IF, BOOST, QUC, QVR, QCO) are switched off - ERRx pin monitoring, WWD and FWD are disabled - VMON1 and VMON2 are disabled - Wakeup timer is enabled - Pin ENA and pin WAK are monitored for wakeup events $10 \text{ V} \leq V_{VS}/V_{VIQST} \leq 28 \text{ V}$ $T_j \leq 85^\circ\text{C}$ - Quiescent current also depending on the leakage of diode D3	DS-2052

(table continues...)

9 State machine (FSM)

Table 33 (continued) Electrical characteristics state machine (FSM)

$V_{VS} = 6.0 \text{ V to } 36 \text{ V}$, $T_j = -40^\circ\text{C to } +175^\circ\text{C}$, all voltages with respect to ground, positive current flowing into pin (unless otherwise specified)¹⁾

Parameter	Symbol	Values			Unit	Note or condition	P-Number
		Min.	Typ.	Max.			
STANDBY state current consumption with QST and WUT ON	$I_{q_STANDBY_WUT_ON}$	–	–	70	μA	Current consumptions are measured from $V_{S(T30)}$: - QST is switched ON - All output voltage rails (BUCK PREREG, BUCK CORE, BUCK IF, BOOST, QUC, QVR, QCO) are switched off - ERRx pin monitoring, WWD and FWD are disabled - VMON1 and VMON2 are disabled - Wakeup timer is enabled - Pin ENA and pin WAK are monitored for wakeup events $10 \text{ V} \leq V_{VS}/V_{VIQST} \leq 28 \text{ V}$ $T_j \leq 85^\circ\text{C}$ - Quiescent current also depending on the leakage of diode D3	DS-2051
Operational state current consumption	$I_{q_Operational}$	–	20	30	mA	Current consumptions are measured from $V_{S(T30)}$ without load current applied to post regulators: - All output voltage rails (BUCK PREREG, BUCK CORE, BUCK IF, BOOST, QUC, QTS, QVR, QCO) are switched on - ERRx pin monitoring, WWD and FWD are disabled - VMON1 and VMON2 are disabled - Wakeup timer is disabled $f_{DCDC} = 2.2 \text{ MHz}$ $10 \text{ V} \leq V_{VS}/V_{VIQST} \leq 28 \text{ V}$ $T_j \leq 85^\circ\text{C}$	DS-2080

(table continues...)

9 State machine (FSM)

Table 33 (continued) Electrical characteristics state machine (FSM)

$V_{VS} = 6.0 \text{ V to } 36 \text{ V}$, $T_j = -40^\circ\text{C to } +175^\circ\text{C}$, all voltages with respect to ground, positive current flowing into pin (unless otherwise specified)¹⁾

Parameter	Symbol	Values			Unit	Note or condition	P-Number
		Min.	Typ.	Max.			
FAILSAFE state current consumption	$I_{q_FAILSAFE}$	–	120	200	μA	Current consumptions are measured from $V_{S(T30)}$: - All output voltage rails (BUCK PREREG, BUCK CORE, BUCK IF, BOOST, QUC, QVR, QST, QCO) are switched off - ERRx pin monitoring, WWD and FWD are disabled - VMON1 and VMON2 are disabled - Wakeup timer is disabled - Pin ENA and pin WAK are monitored for wakeup events $10 \text{ V} \leq V_{VS}/V_{VIQST} \leq 18 \text{ V}$ $T_j \leq 40^\circ\text{C}$ $t_{FAILSAFE} > t_{FAILSAFE_min}$ - Quiescent current also depending on the leakage of diode D3	DS-1546

1) Not subject to production test, specified by design

10 Monitoring functions

10 Monitoring functions

10.1 Watchdog functions (WD)

10.1.1 Introduction watchdog functions (WD)

The purpose of a watchdog is to provide a monitoring mechanism for the application microcontroller by means of temporal and logical program sequence monitoring. A watchdog may detect defective MCU program sequence, where individual program elements (e.g. software modules, subprograms, or commands) are processed in the wrong sequence or period of time, or if the clock of the processor is faulty.

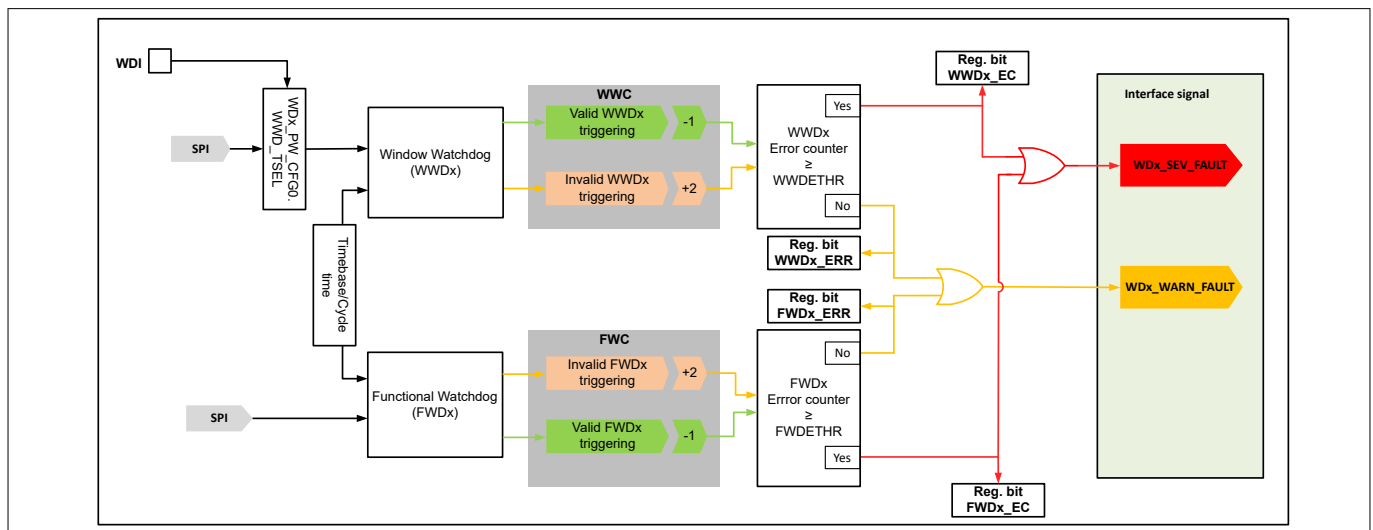


Figure 33 Functional block diagram watchdog functions

(x = 1; 2)

The device incorporates two independent watchdog instances(WD). Each of them consisting of one window watchdog module (WWD) and one functional watchdog module (FWD):

- WD1: Consisting of WWD1 and FWD1
- WD2: Consisting of WWD2 and FWD2

Note: Watchdog instance 2 can only be used if REDUCED OPERATION is enabled (**REDOP_RS_CFG1.EN = 1**).

The watchdog modules differentiate between the following services:

- "Valid WWDx triggering" or "Invalid WWDx triggering"
- "Valid FWDx triggering" or "Invalid FWDx triggering"

Each WWD module and each FWD module has its own error counters assigned and monitors the watchdog triggers. This allows an operation of a WWD and FWD in parallel. A WWDx shares the same time base with its corresponding FWDx.

The basic time base configuration is done with the register bit WDX_PW_CFG0.CYC. For shortening the time base even further an additional divider by 10 can be enabled which results in a time base as depicted:

$$\text{time base} = \frac{WDX_RS_CFG0.CYC}{WDX_RS_CFG1.CYC_DIV} \text{ (interpreted value)}$$

Equation 1

Configuration

10 Monitoring functions

Each watchdog module can be activated and deactivated independently in the register bits **WDx_PW_CFG0.WWD_EN** and **WDx_PW_CFG0.FWD_EN**.

Automatic deactivation of the watchdogs on entering SLEEP state can be configured in the register bits **WDx_PW_CFG1.SLP_EN**.

10.1.2 Window watchdog (WWD)

10.1.2.1 Functional description window watchdog (WWD)

The window watchdogs (WWDx) can be configured in **WDx_PW_CFG0.WWD_TSEL** to be triggered by one of the following events:

- Falling edge at the digital input pin WDI
- Writing WWD1_TRIG.TRIG via SPI. In order to trigger the watchdog:
 - Read the last internal service value (**WWDx_TRIG.TRIG_STAT**) received via SPI
 - Write the inverted value of the (**WWDx_TRIG.TRIG_STAT**) to the **WWDx_TRIG.TRIG** bitfield

If the trigger event occurs during the open window period (OW), then the device detects a **"valid WWDx triggering"**. The open window is closed immediately and the closed window starts.

If no trigger event occurs during the open window period or if the trigger event occurs during the closed window period (CW), then the device detects an **"invalid WWDx triggering"**.

The duration of the open window t_{OW} and the closed window t_{CW} can be calculated with the following formulas:

$$t_{OW} = (\text{WWDx_PW_OW_CFG.OW} + 1) \times 50 \times \text{time base}$$

Equation 2

$$t_{CW} = (\text{WWDx_PW_CW_CFG.CW} + 1) \times 50 \times \text{time base}$$

Equation 3

The duration of the closed window of the window watchdog is also configurable to be set to 0. If this setting is used (**WWDx_PW_CW_CFG.CW_DIS** = 1), a successful trigger within the open window will immediately initialize a new open window again.

10.1.2.1.1 Valid triggering of the window watchdog

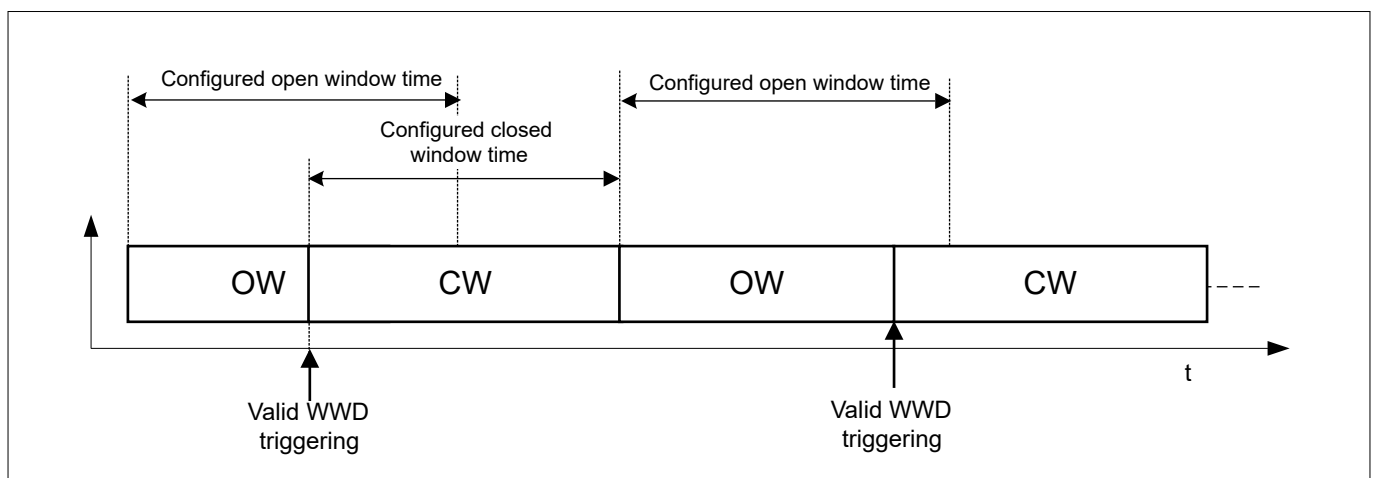


Figure 34 Valid triggering of the window watchdog

10 Monitoring functions

Initially the window watchdog starts with an open window. If successfully triggered, the open window closes immediately and a closed window is started. After the closed window was active for the configured time, an open window is started again. After reconfiguration the window watchdog starts with the configured open window and its corresponding error counter is reset.

10.1.2.1.2 Invalid triggering due to missing trigger during open window

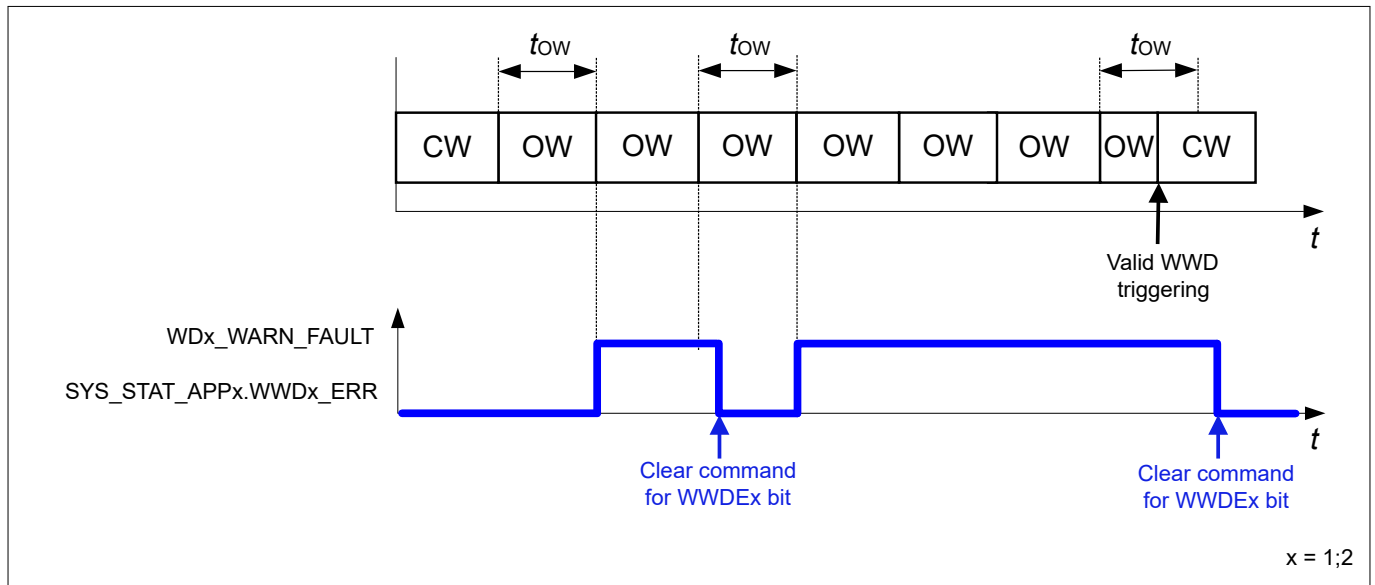


Figure 35 Invalid service due to missing trigger during open window assuming error counter remains smaller than threshold

If the open window expires without any trigger, then the watchdog starts a new timing sequence with an open window and the device performs the following actions:

1. Increment the corresponding error counter value by 2, see [Chapter 10.1.2.1.5](#)
2. If the error counter remains below the configured threshold:
 - then:
 - Generate a watchdog warning fault WDx_WARN_FAULT
 - Set the corresponding error bit $SYS_STAT_APPx.WWDx_ERR$, which can be cleared via SPI
 - else:
 - Generate a watchdog severe fault WDx_SEV_FAULT

($x = 1; 2$)

10 Monitoring functions

10.1.2.1.3 Invalid triggering due to trigger during closed window

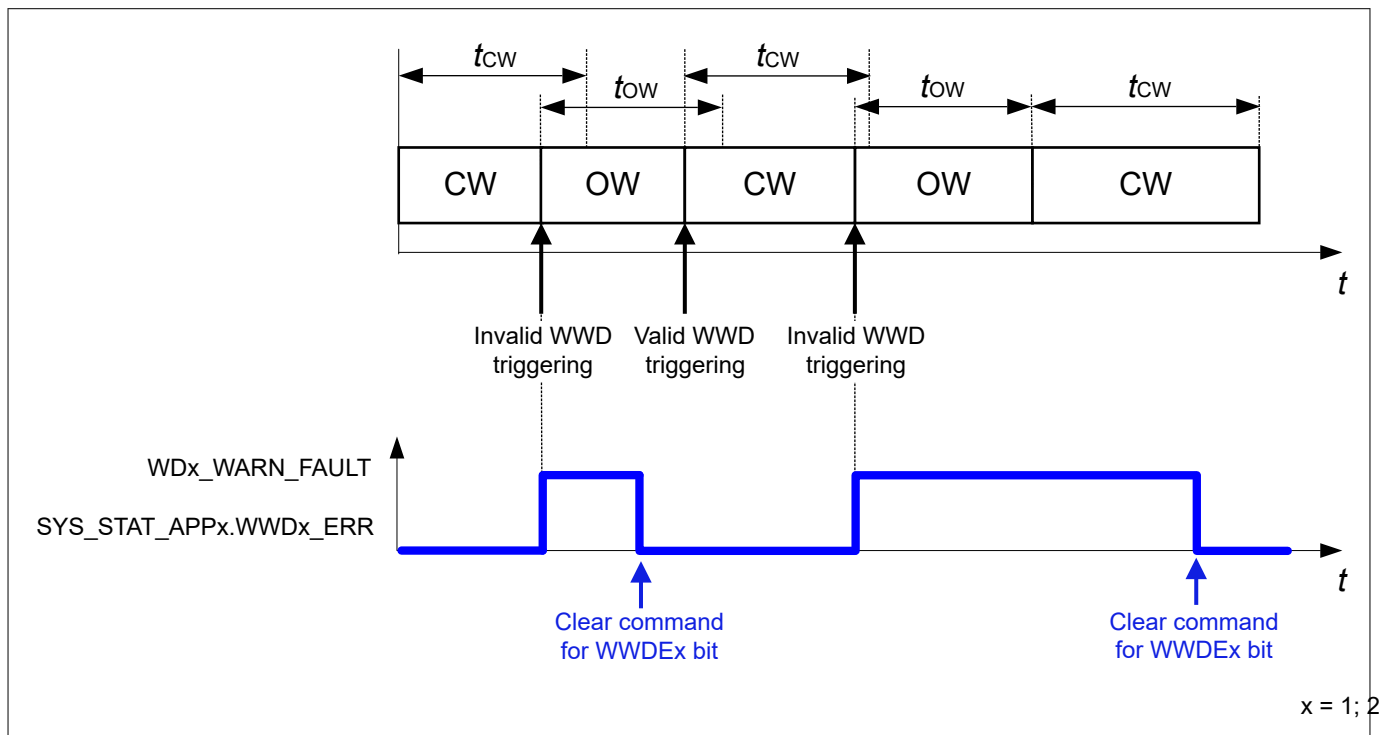


Figure 36 Invalid triggering due to trigger during closed window assuming error counter remains smaller than threshold

If the watchdog is triggered during the closed window, then it starts a new watchdog timing sequence with an open window and the device performs the following actions:

1. Increment the corresponding error counter value by 2, see [Chapter 10.1.2.1.5](#)
2. If the error counter remains below the configured threshold:
 - then:
 - Generate a watchdog warning fault **WDX_WARN_FAULT**
 - Set the corresponding error bit **SYS_STAT_APPx.WWDx_ERR**, which can be cleared via SPI
 - else:
 - Generate a watchdog severe fault **WDX_SEV_FAULT**

(x = 1; 2)

10 Monitoring functions

10.1.2.1.4 Watchdog startup behavior (enable and reset)

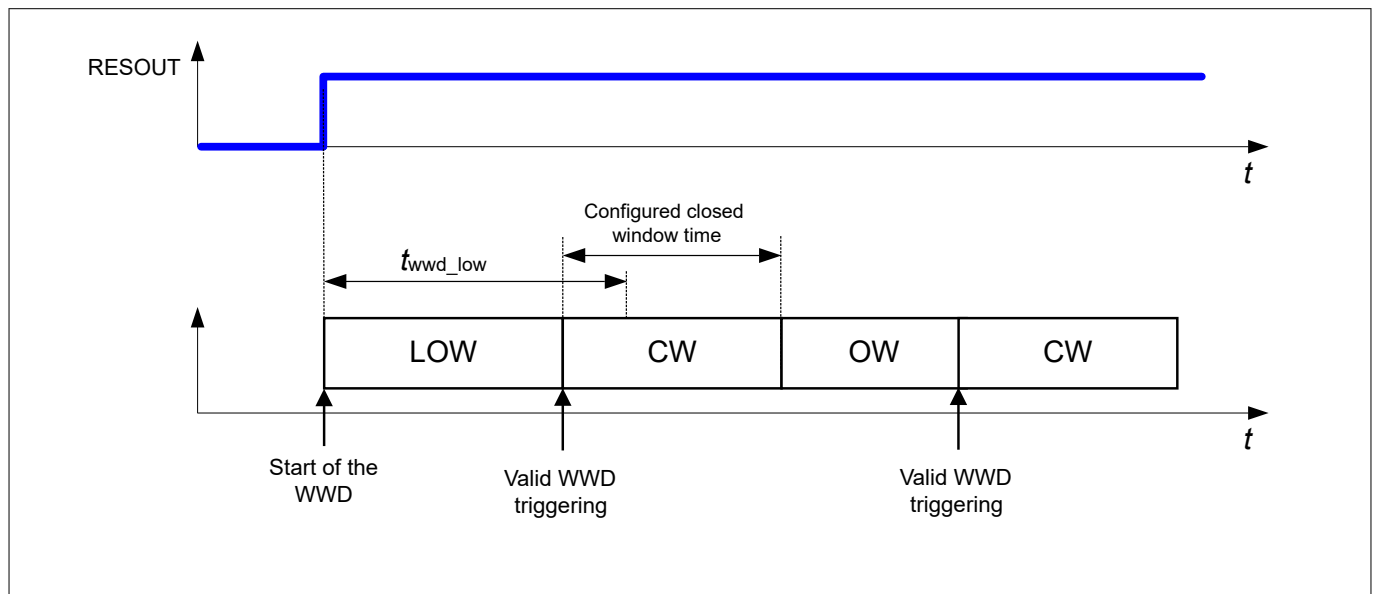


Figure 37 Watchdog initialization phase

Whenever INIT state is entered and RESOUT was released (pin RESOUT goes "high"), the watchdog is enabled and starts the first watchdog timing window sequence with a long open window. The long open window time $t_{\text{WDD_LOW}}$ matches the INIT timer duration t_{INIT} . If a valid trigger is provided within $t_{\text{WDD_LOW}}$ the WWD starts operating as described in this chapter, else the watchdog long open window expires together with the INIT timer and an INIT_TIMER_FAULT is generated.

10 Monitoring functions

10.1.2.1.5 Windows watchdog error counter

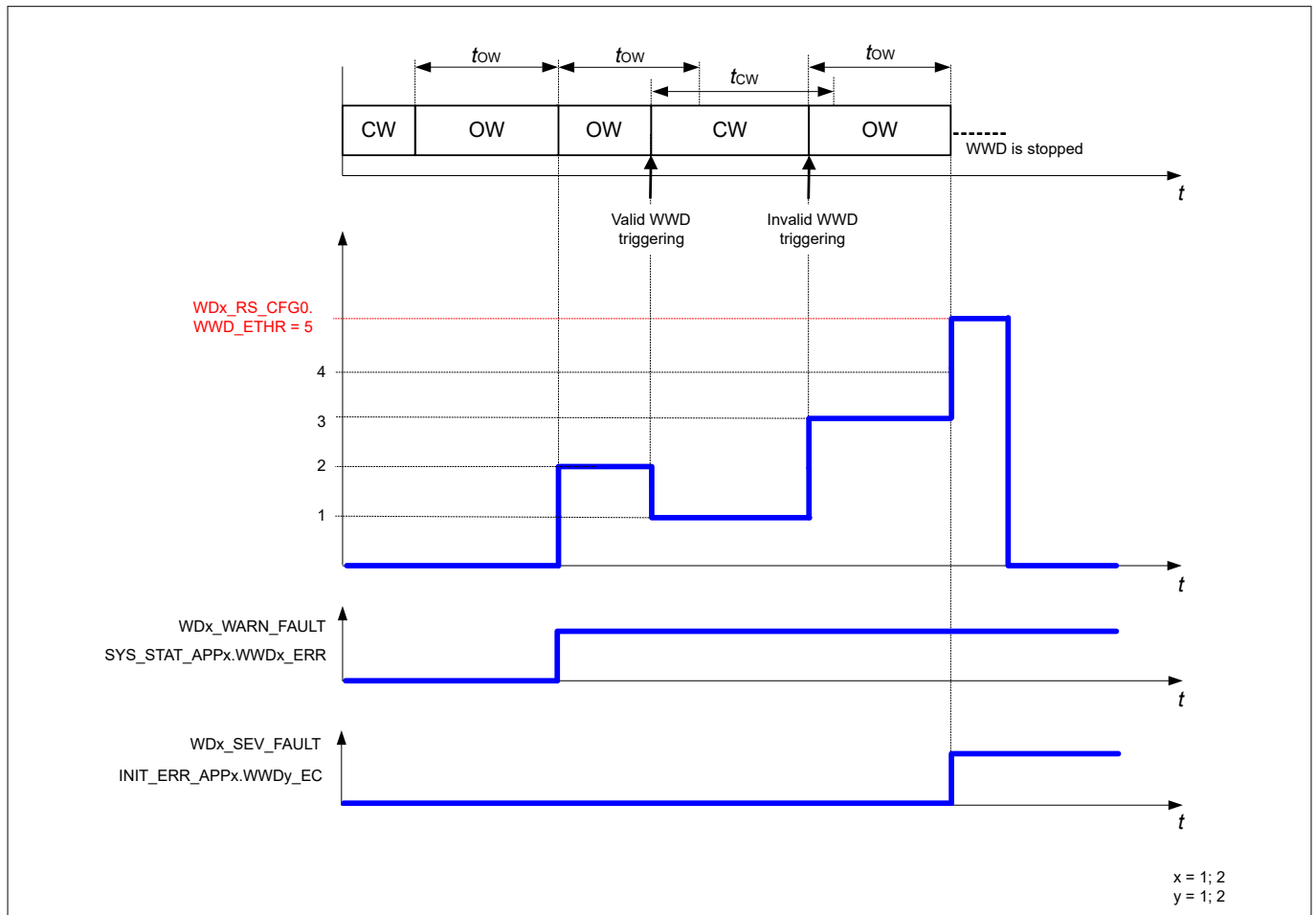


Figure 38 Window watchdog error counter

If the device detects an invalid triggering, it increments the value of **WWDx_ECNT_STAT.ECNT** by 2.

If the device detects a valid triggering, it decrements **WWDx_ECNT_STAT.ECNT** by 1.

If the value of the ECNT bitfield reaches the value of the configured WWD error counter threshold **WDDx_RS_CFG0.WWD_ETHR**, the device performs the following actions:

- Generate a watchdog severe fault **WDDx_SEV_FAULT**
- Set the corresponding error bit **INIT_ERR_APPx.WWDy_EC**, which can be cleared via SPI
- Clear the error counter

10.1.2.1.6 Timing constraints and behavior after configuring the watchdog

After configuring the watchdog and before first service there is a timing constraint, which needs to be respected. New configurations of the watchdog, such as open/closed window time, made by the microcontroller can take up to $t_{\text{config_delay_wd}}$ before they become active.. Because the watchdog configuration registers belong to the protected registers, an unlock and lock command must be sent. Only upon successfully receiving the lock command changes, made to the watchdog configuration, are mirrored to the corresponding reflected status registers and hereby made available for the PMICs modules. Hence the lock command marks the start of the timing before a first trigger can be received via SPI and applied to the new configuration. This timing limitation does however not apply to a trigger via WDI pin, since the combination of sample time $t_{\text{WDI_spl}}$ and filter criteria will always be longer than $t_{\text{config_delay_wd}}$.

10 Monitoring functions

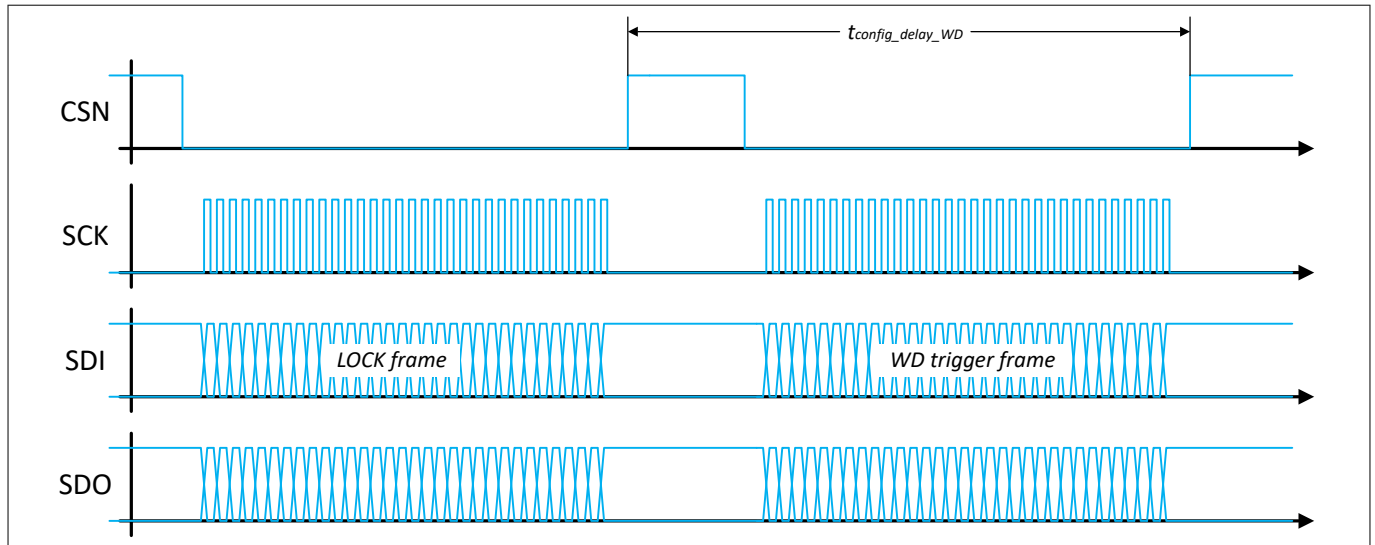


Figure 39 Watchdog trigger delay after configuration of watchdog module

10.1.2.2 Electrical characteristics window watchdog (WWD)

Table 34 Electrical characteristics window watchdog (WWD)

$V_{VS} = 6.0 \text{ V to } 36 \text{ V}$, $T_j = -40^\circ\text{C to } +175^\circ\text{C}$, all voltages with respect to ground, positive current flowing into pin (unless otherwise specified)

Parameter	Symbol	Values			Unit	Note or condition	P-Number
		Min.	Typ.	Max.			
Cycle time	$t_{\text{wwd_cycle_0}}$	90	100	110	μs	Selectable via SPI	DS-1660
Cycle time, default	$t_{\text{wwd_cycle_1}}$	900	1000	1100	μs	Selectable via SPI	DS-1659
Long open window time	$t_{\text{wwd_low}}$	540	600	660	ms	Used for the initial WWD activation, or after each WWD restart due to recovery from a fault condition	DS-1653
WDI sample time	$t_{\text{WDI_spl}}$	45	50	55	μs	²⁾ ¹⁾	DS-2166
WD configuration-trigger delay	$t_{\text{config_delay_wd}}$	–	–	22	μs	²⁾	DS-2068

1) Since ERR2 and WDI share the same pin, they also share the electrical characteristic for voltage levels, hysteresis and current specification. Therefore it is being referred to table

[Electrical characteristics error monitoring \(ERR MON\) \[EC-Table-P\]](#)

2) Not subject to production test, specified by design

10 Monitoring functions

10.1.3 Functional watchdog (FWD)

10.1.3.1 Functional description functional watchdog (FWD)

The functional watchdog (FWD, also called question/answer watchdog) generates a question taken from a table and starts the heartbeat counter from zero. To trigger the functional watchdog correctly, the correct response bytes to each question must be written to an answer register, in a specific order, within the heartbeat period.

The heartbeat timer increments until it reaches its configured heart beat timer period. This period is configured via the register **FWDx_PW_HBTP_CFG.HBTP**. The length of the period follows the following formula for the heart beat timer:

$$\text{heartbeat time} = (\text{FWDx_RS_HBTP_CFG.HBTP} + 1) \times 50 \times \text{time base} \quad (\text{interpreted value})$$

Equation 4

10.1.3.1.1 Functional watchdog service

Upon enabling or reconfiguration of the FWD its corresponding HBT starts running. It waits for 4 bytes being written to FWDx_RSP.RSP or FWDx_RSP_SYNC.RSP_SYNC consecutively. The response bytes have to match the question which is read from FWDx_STAT.QUEST. If all bytes are written correctly before the HBT expires, the service was successful, which decrements the error counter and starts a new sequence with the next question in FWDx_STAT.QUEST. After having received the 4th response byte, the received byte is checked for correctness. If the response was incorrect and the last byte was written to FWDx_RSP_SYNC.RSP_SYNC the error counter of FWDx is incremented. Also, if the HBT expires the corresponding error counter is incremented. Status register FWDx_STAT is reset upon reconfiguration of the FWD.

10 Monitoring functions

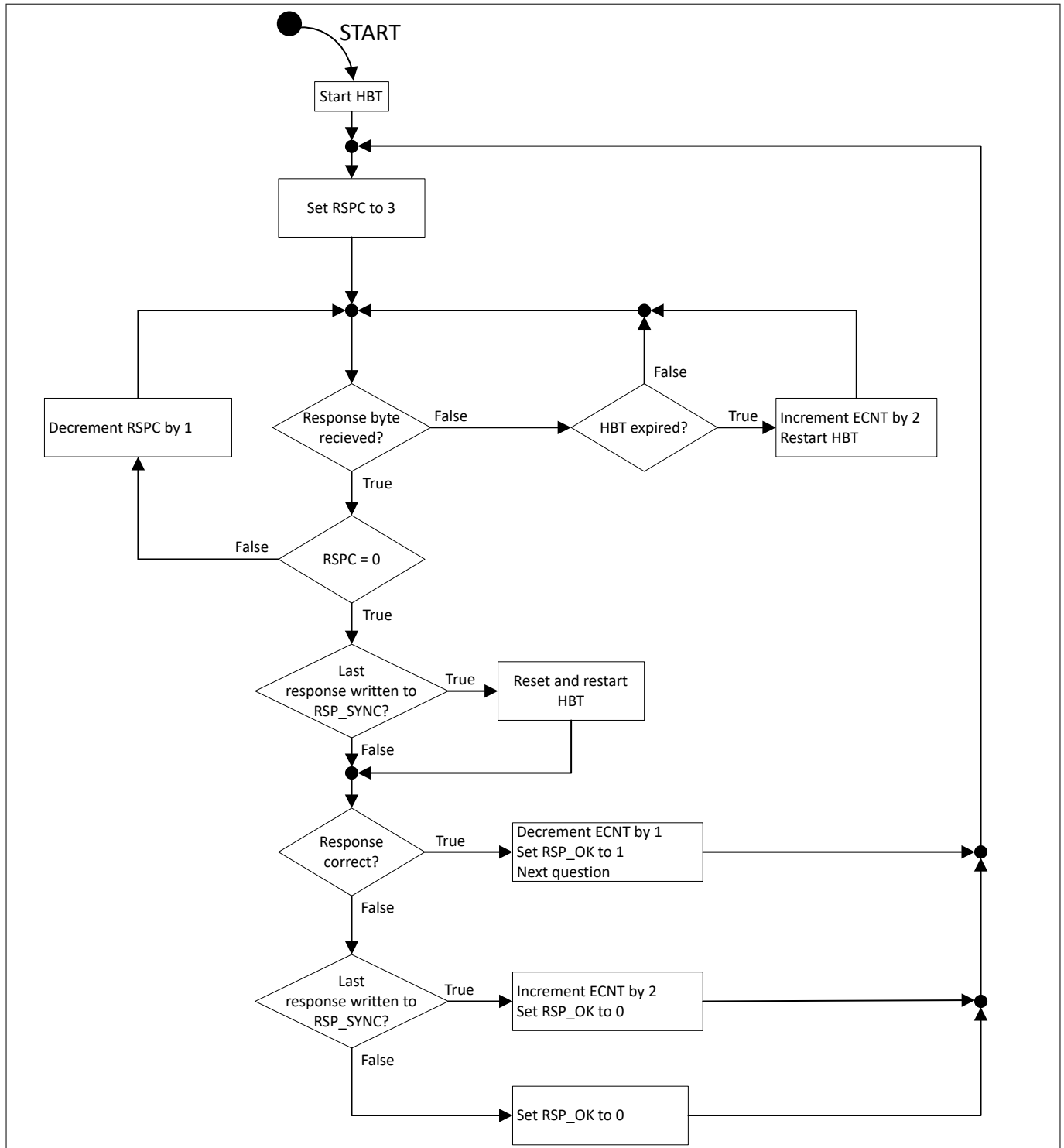


Figure 40 FWD flow chart

Valid triggering of the functional watchdog

The question consists of 4 bits, the corresponding answer consists of four consecutive response bytes.

The answer to each question in the register **FWDx_STAT.QUEST** needs to be written to the response register **FWDx_RSP.RSP** or **FWDx_RSP_SYNC.RSP_SYNC**.

10 Monitoring functions

Table 35 **Functional watchdog questions and responses**

QUEST[3:0]	RESP3	RESP2	RESP1	RESP0
0	FF	0F	F0	00
1	B0	40	BF	4F
2	E9	19	E6	16
3	A6	56	A9	59
4	75	85	7A	8A
5	3A	CA	35	C5
6	63	93	6C	9C
7	2C	DC	23	D3
8	D2	22	DD	2D
9	9D	6D	92	62
A	C4	34	CB	3B
B	8B	7B	84	74
C	58	A8	57	A7
D	17	E7	18	E8
E	4E	BE	41	B1
F	01	F1	0E	FE

If all of the following conditions are fulfilled for a question, the FWD is triggered correctly (valid trigger):

- The four response bytes are in the correct order from RESP3 to RESP0
- All four responses are correctly written to the response registers

To reset the heartbeat counter, the last response (RESP0) must be written to the synchronization response register **FWDx_RSP_SYNC.RSP_SYNC**.

10 Monitoring functions

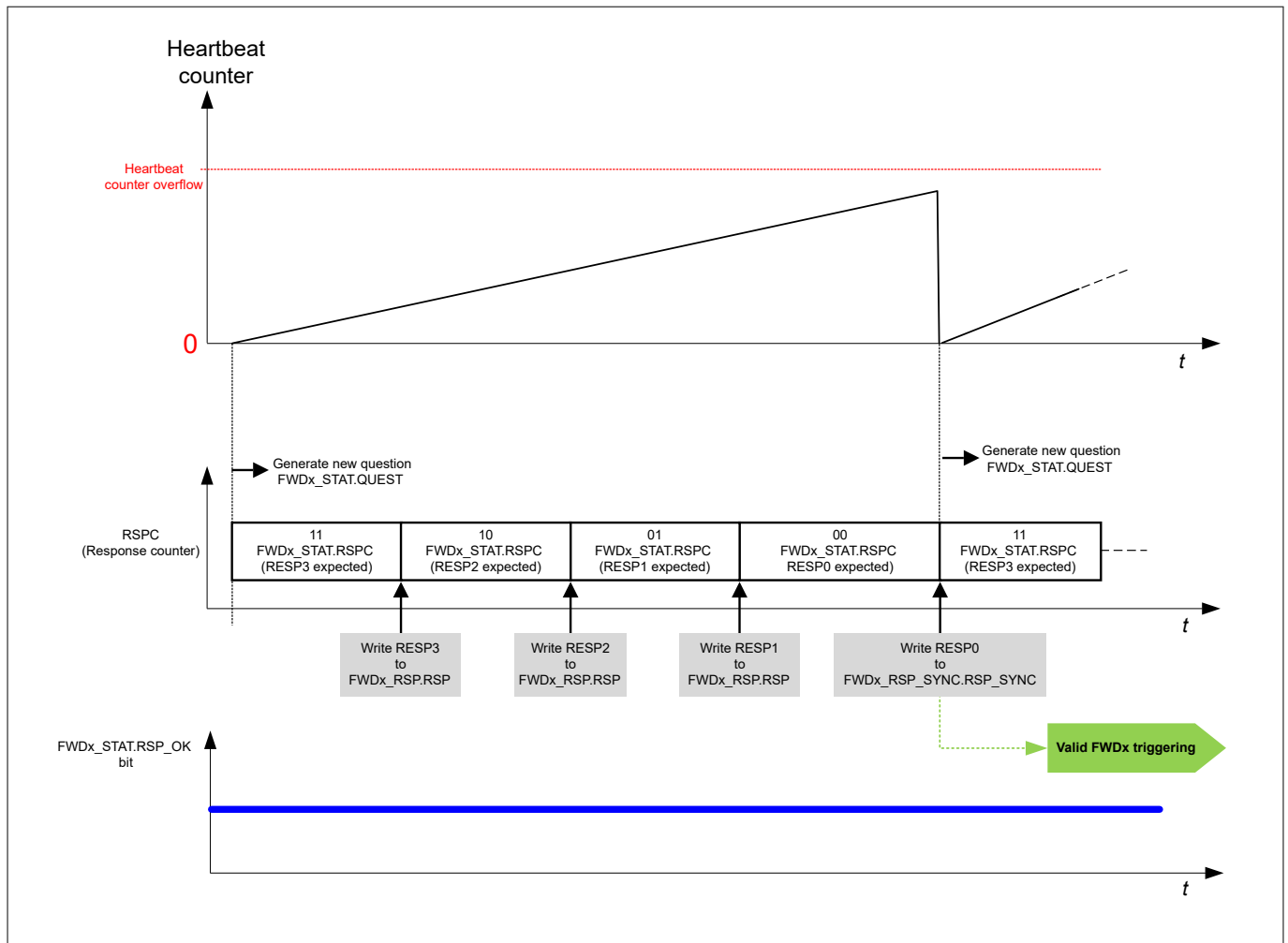


Figure 41 Example FWD: Possible valid triggering

Upon detection of a valid triggering, the device performs the following actions:

- Generate a new question
- Resets the response counter RSPC to 3
- Decrements the corresponding error counter value by 1 if not already at 0, see [Chapter 10.1.2.1.5](#)
- Sets the corresponding status bit of the response bytes **FWDx_STAT.RSP_OK** to 1
- If the last byte has been written to **FWDx_RSP_SYNC.RSP_SYNC** also the HBT periode is reset and restarted

Invalid triggering of the functional watchdog

If any of the following conditions is fulfilled, the FWD is triggered incorrectly (invalid trigger):

- Wrong order or content of the four response bytes
- Heartbeat period expires (heartbeat counter overflow)

Upon detection of an invalid trigger, the device performs the following actions:

- HBT expiration:
 - Increment error counter **FWDx_STAT.ECNT** by 2, see [Chapter 10.1.3.1.2](#)
 - Reset and restart HBT
- If the 4th byte was written to **FWDx_RSP_SYNC.RSP_SYNC**:
 - Reset and restart HBT

10 Monitoring functions

- Set the status bit **FWDx_STAT.RSP_OK** to 0
- Increment the error counter **FWDx_STAT.ECNT** by 2, see [Chapter 10.1.3.1.2](#)
- If the 4th byte was written to **FWDx_RSP.RSP**:
 - Set the status bit **FWDx_STAT.RSP_OK** to 0
- If error counter **FWDx_STAT.ECNT** was incremented (see [Reaction on faults](#)):
 - Generate a watchdog warning fault **WDx_WARN_FAULT** if error counter is still below configured error threshold, see [Chapter 9](#)
 - Sets the corresponding error bit **SYS_STAT_APPx.FWDx_ERR**, which can be cleared via SPI

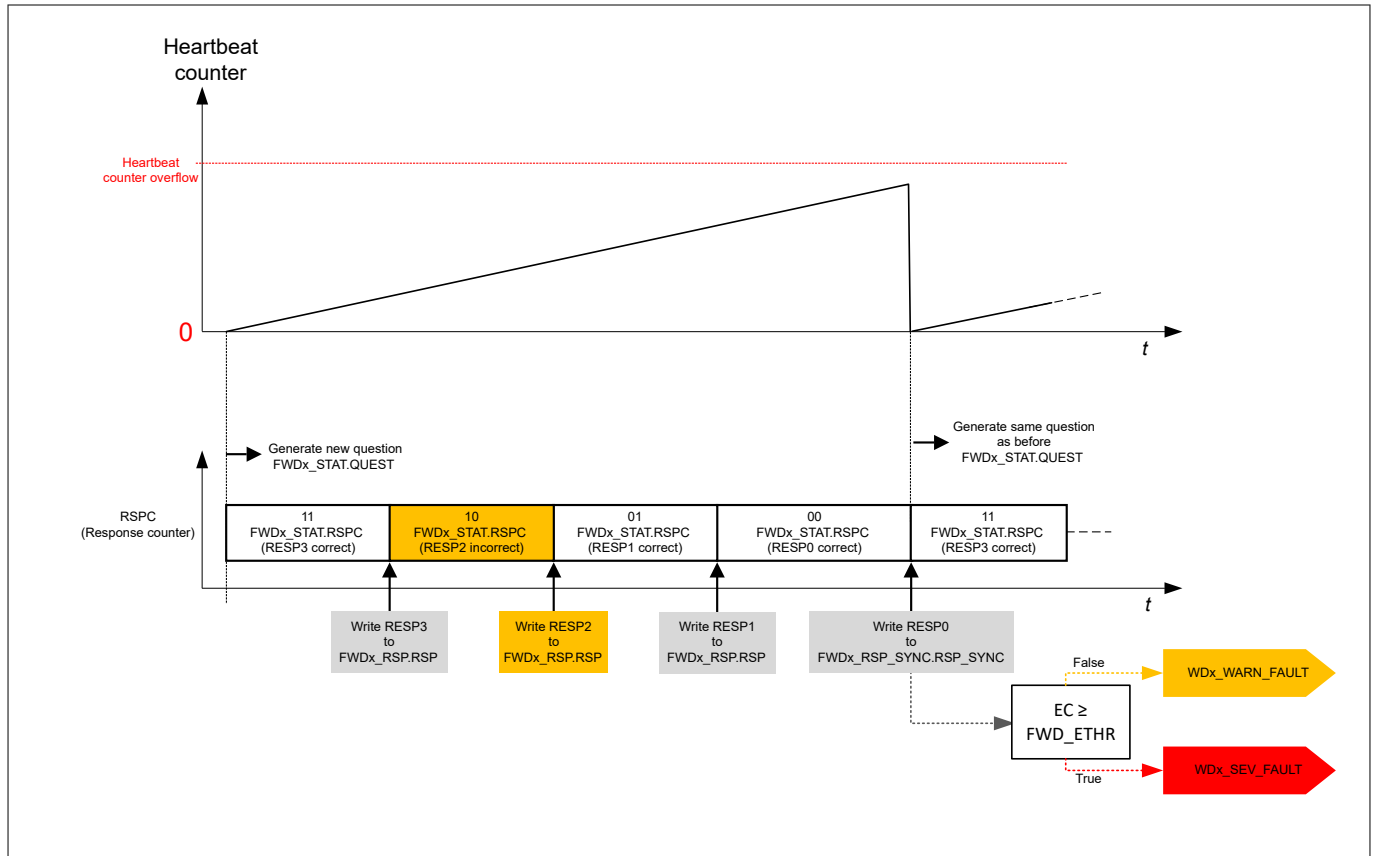


Figure 42 FWD: Wrong response (RESP2) timing diagram

(x = 1, 2)

10 Monitoring functions

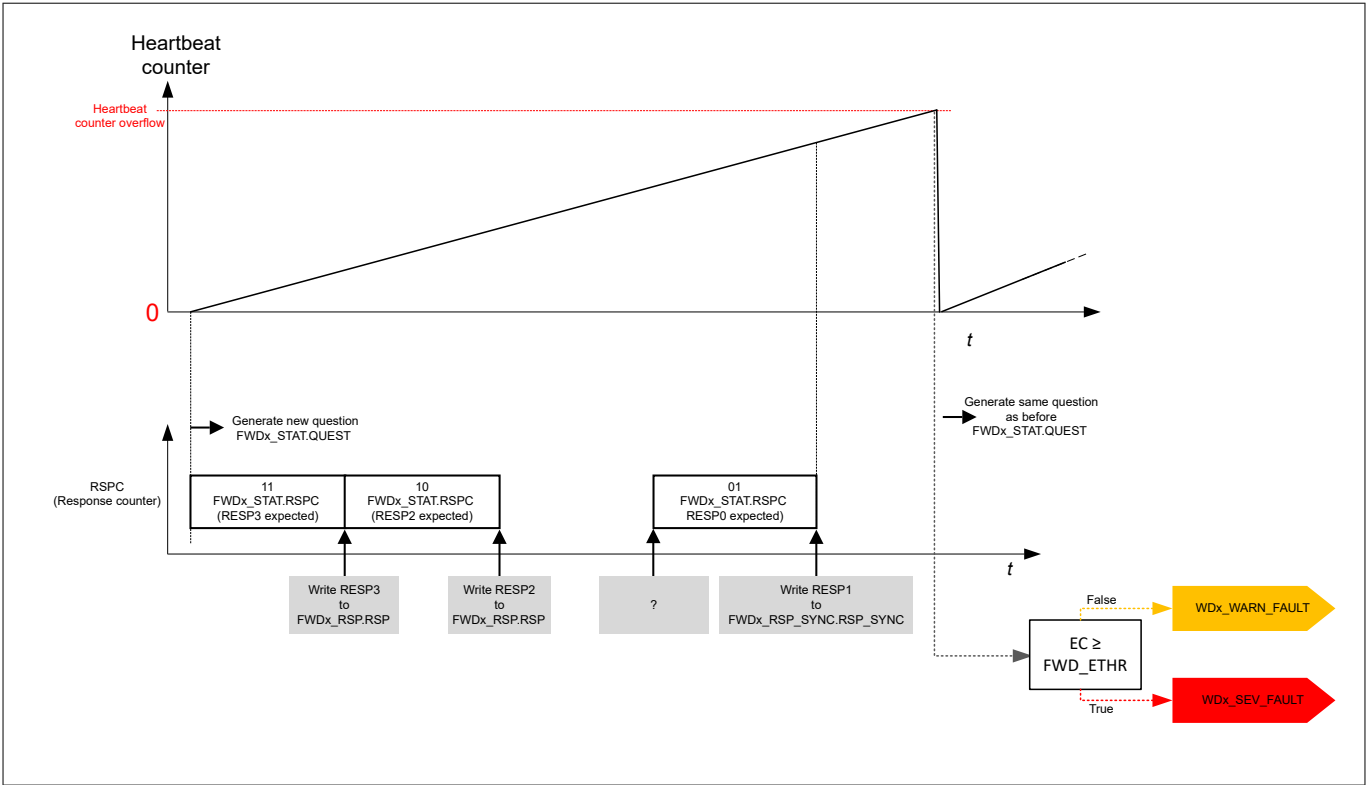


Figure 43 Missing response timing diagram

(x = 1, 2)

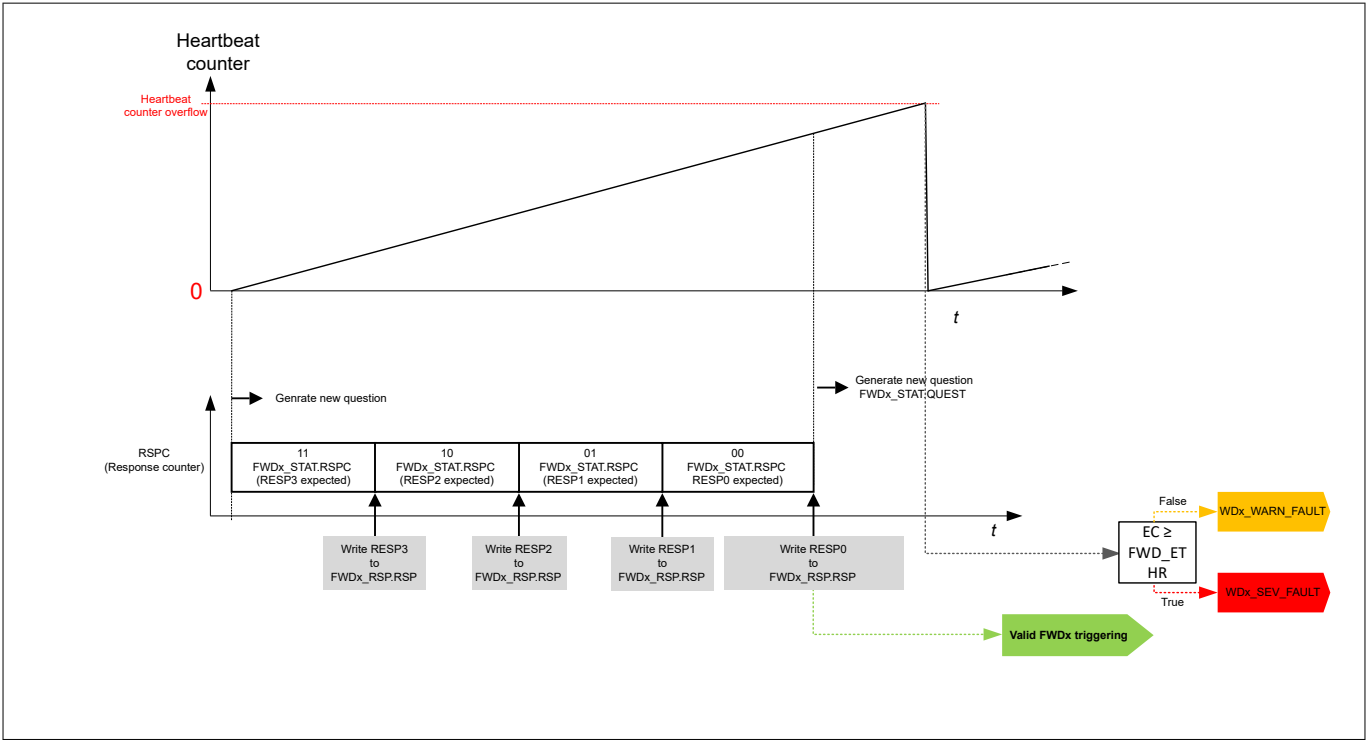


Figure 44 Missing synchronization timing diagram

(x = 1, 2)

10 Monitoring functions

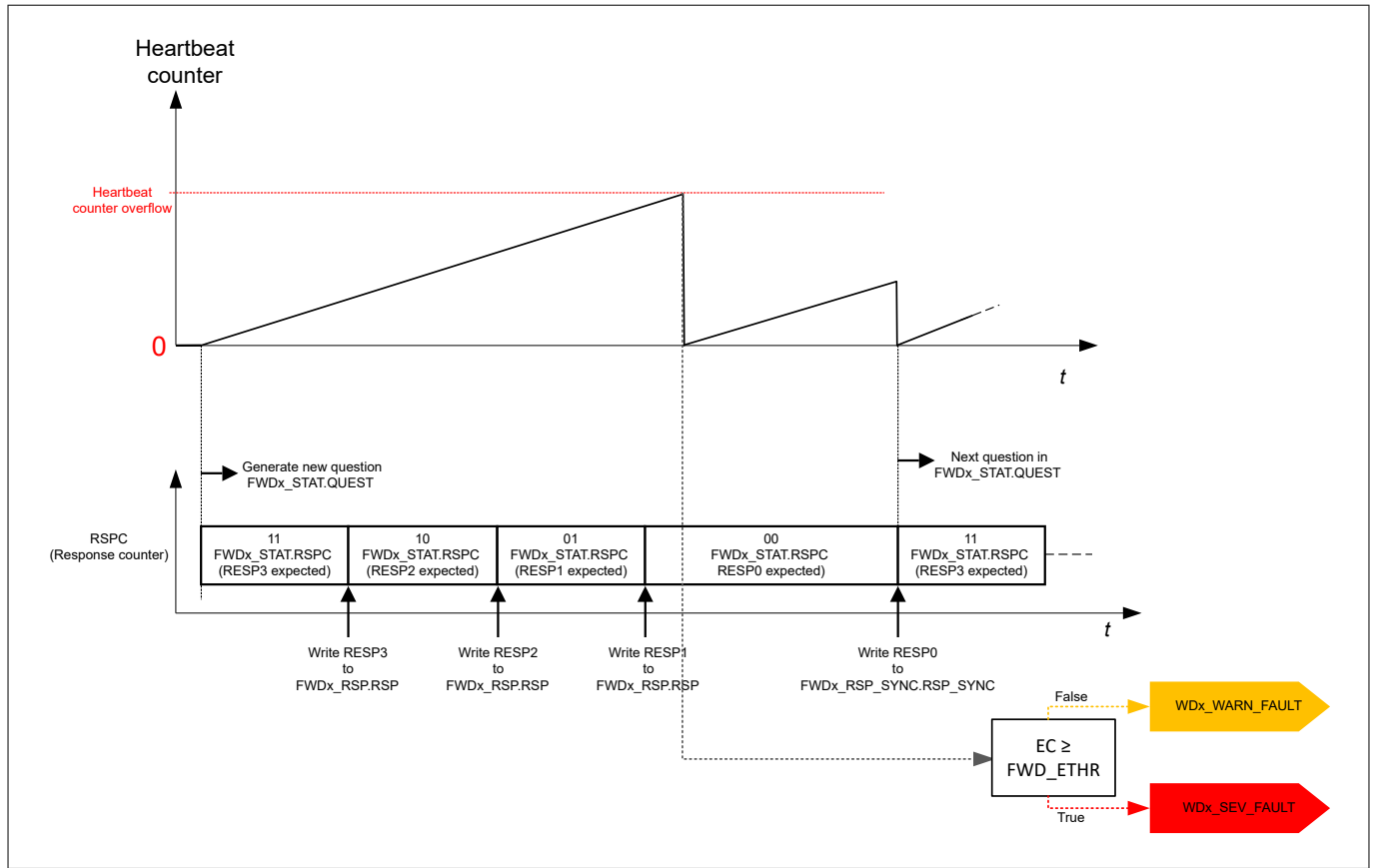


Figure 45 Heartbeat counter overflow

(x = 1, 2)

10.1.3.1.2 Functional watchdog error counter overflow

If the device detects valid FWDx triggering, then it decrements the value of the ECNT bitfield in the **FWDx_STAT** register by 1 if greater than 0.

If the device detects invalid FWDx triggering, then it increments the value of the ECNT bitfield in the **FWDx_STAT** register by 2.

If the value of the ECNT bitfield reaches or exceeds the value of the configured FWD error counter threshold **WDx_PW_CFG1.FWD_ETHR**, the device performs the following actions (see [Reaction on faults](#)):

- Generate a watchdog severe fault **WDx_SEV_FAULT**, see [Chapter 9](#)
- Set the corresponding failure bit (register **INIT_ERR_APPx.FWDy_EC**), which can be cleared via SPI
- Clear the FWD error counter

10 Monitoring functions

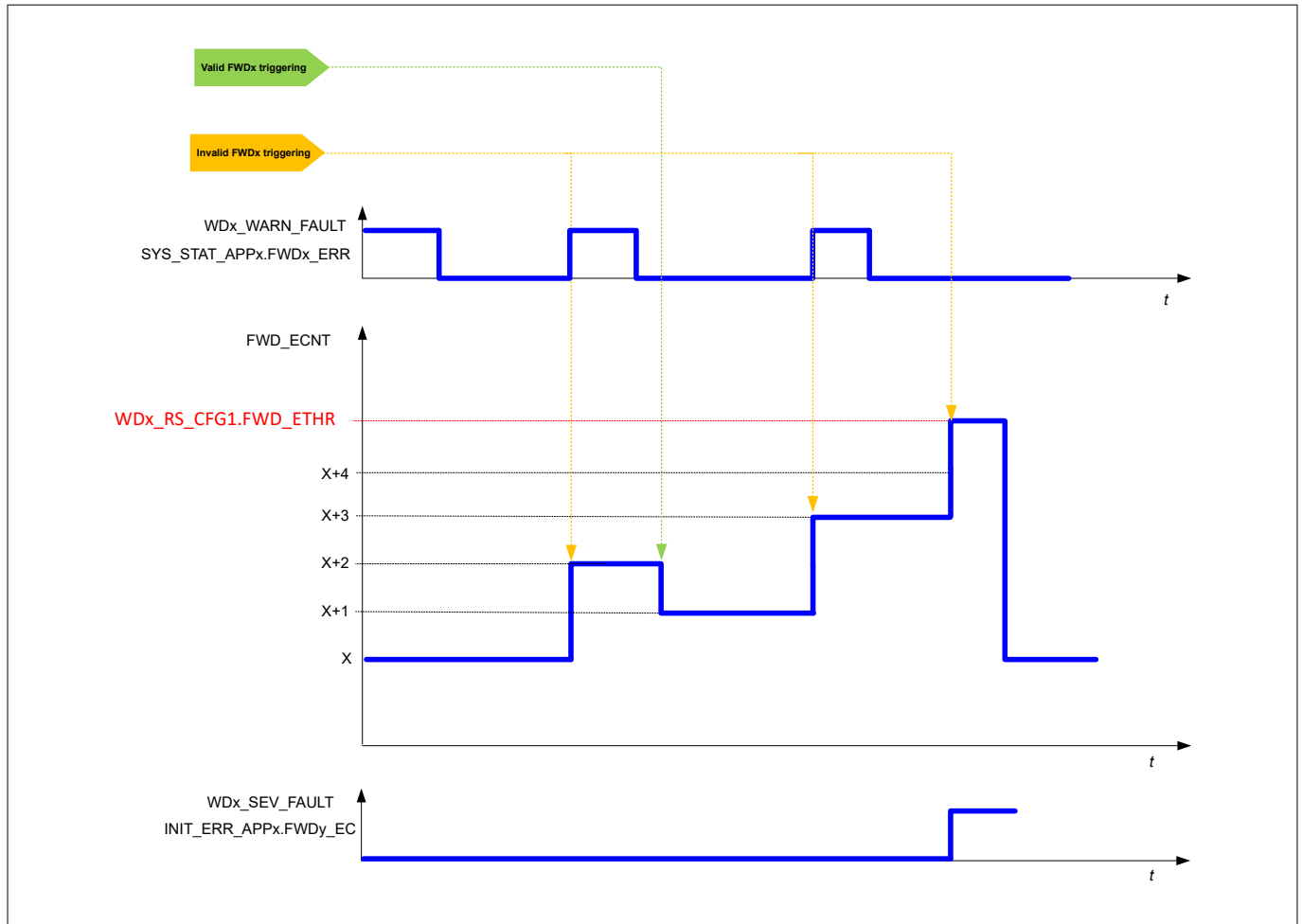


Figure 46 Error counter (ECNT) overflow timing diagram

(x = 1, 2)

(y = 1, 2)

10.2 Error monitoring (ERR MON)

10.2.1 Introduction

The error monitoring (ERR MON) function is a safety mechanism that supervises the safety management unit (SMU) of the application's microcontroller. There are three independent ERRx inputs. If one of the error monitors detects a signal frequency at its input which is outside of the valid frequency range, the device reacts accordingly (see [Reaction on faults](#)).

(x=0, 1, 2)

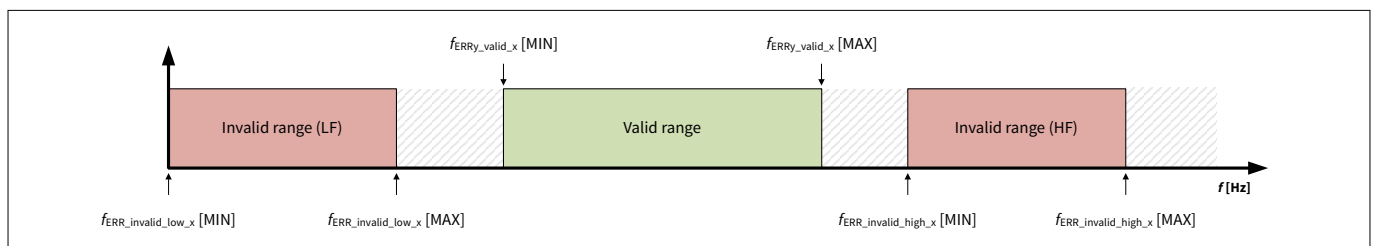


Figure 47 Toggling frequency signal applied on ERRy monitoring inputs

(x = LF; HF)

10 Monitoring functions

(y = 0; 1; 2)

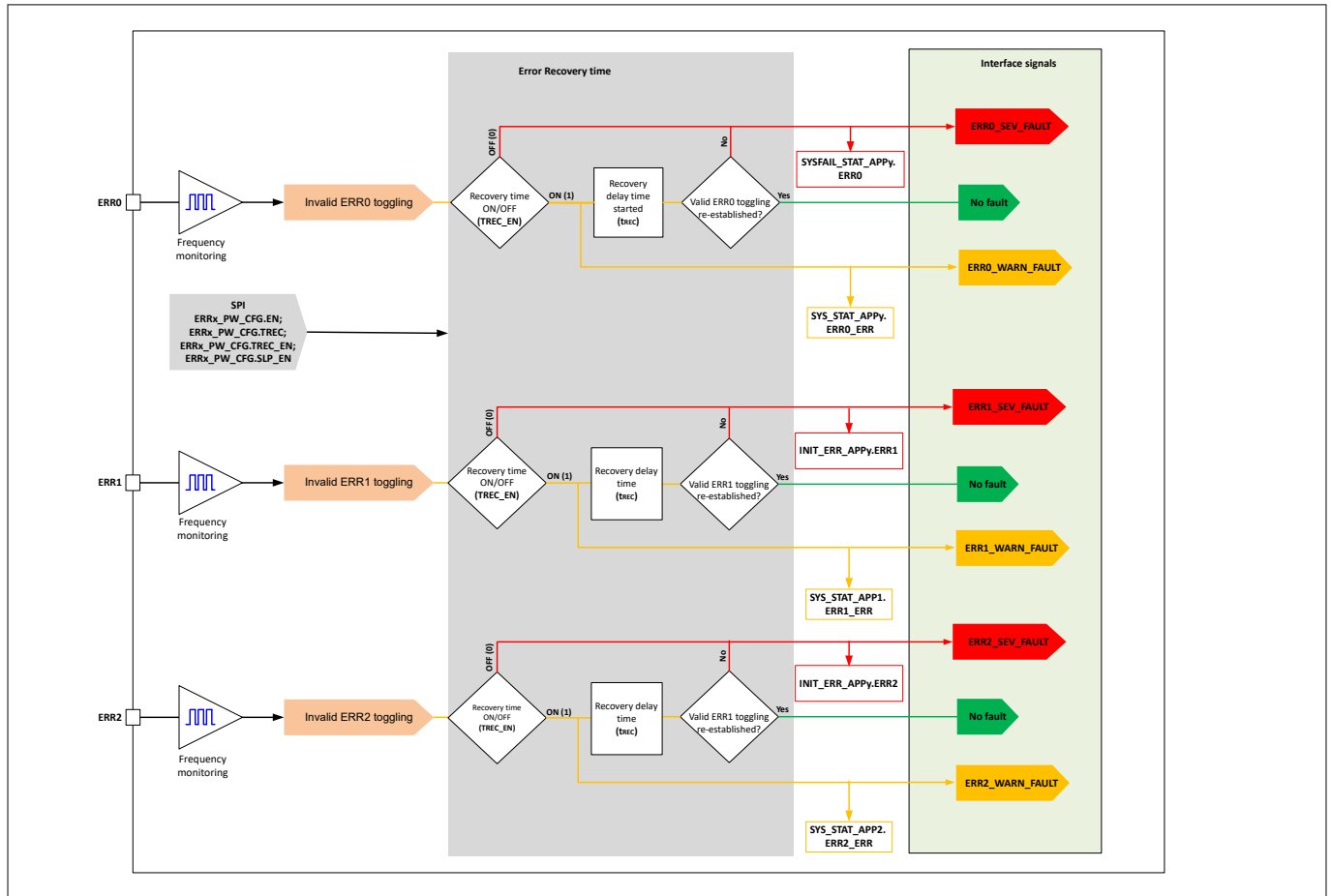


Figure 48 Functional block diagram error monitoring functions

(x = 1, 2, 3; y = 1, 2)

The device provides the following error monitoring channels:

- ERR MON0 for the ERR0 pin
- ERR MON1 for the ERR1 pin
- ERR MON2 for the ERR2 pin

10.2.2 Functional description error monitoring (ERR MON)

10.2.2.1 Error monitoring initialization

The error monitoring module can be properly triggered either using a low or a high frequency:

- Valid input signal frequency low ($f_{\text{ERRx_valid_LOW}}$)
- Valid input signal frequency high ($f_{\text{ERRx_valid_HIGH}}$)

Upon applying the error monitoring signal at ERRx, the device ignores the first six edges of the signal to allow stabilization of the external signal. Next the device automatically detects the frequency range among the allowed ranges. If no correct frequency range can be detected, it reacts accordingly (see [Reaction on faults](#)). While operating, the ERRx module continuously monitors the applied signal. This procedure is always executed whenever the ERRx module experiences a reset condition and reinitialization is required. Reset conditions are:

- RESOUT showed a reset
- Starting from POWERDOWN
- Recovering from FAILSAFE, STANDBY or SLEEP with QUC or BUCKCORE disabled
- Exiting form SLEEP with **ERRx_RS_CFG.EN** = 1 and **ERRx_RS_CFG.SLP_EN** = 0

10 Monitoring functions

(x = 0; 1; 2)

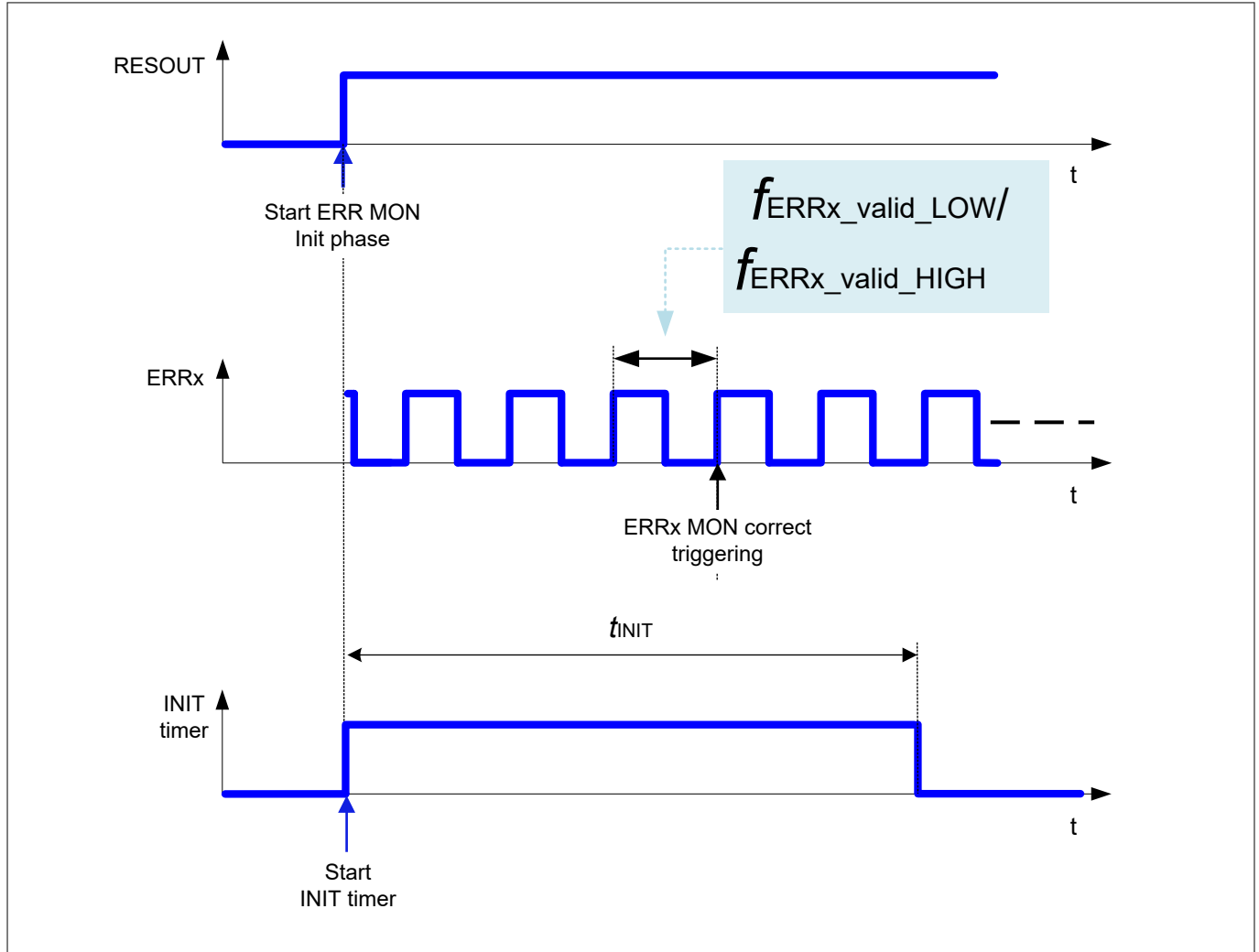


Figure 49 Error monitoring correct triggering

(x = 0; 1; 2)

10.2.2.2 Error monitoring configuration

Each error monitoring channel can be activated or deactivated independently in the register bit **ERRx_PW_CFG.EN**.

On reactivating the error monitoring channel via SPI, the device starts the reactivation timeout after reenabling $t_{ERR_to_ren}$. When the device detects an edge on the ERRx pin, it stops $t_{ERR_to_ren}$. If $t_{ERR_to_ren}$ expires without detecting an edge, a severe fault is thrown.

10 Monitoring functions

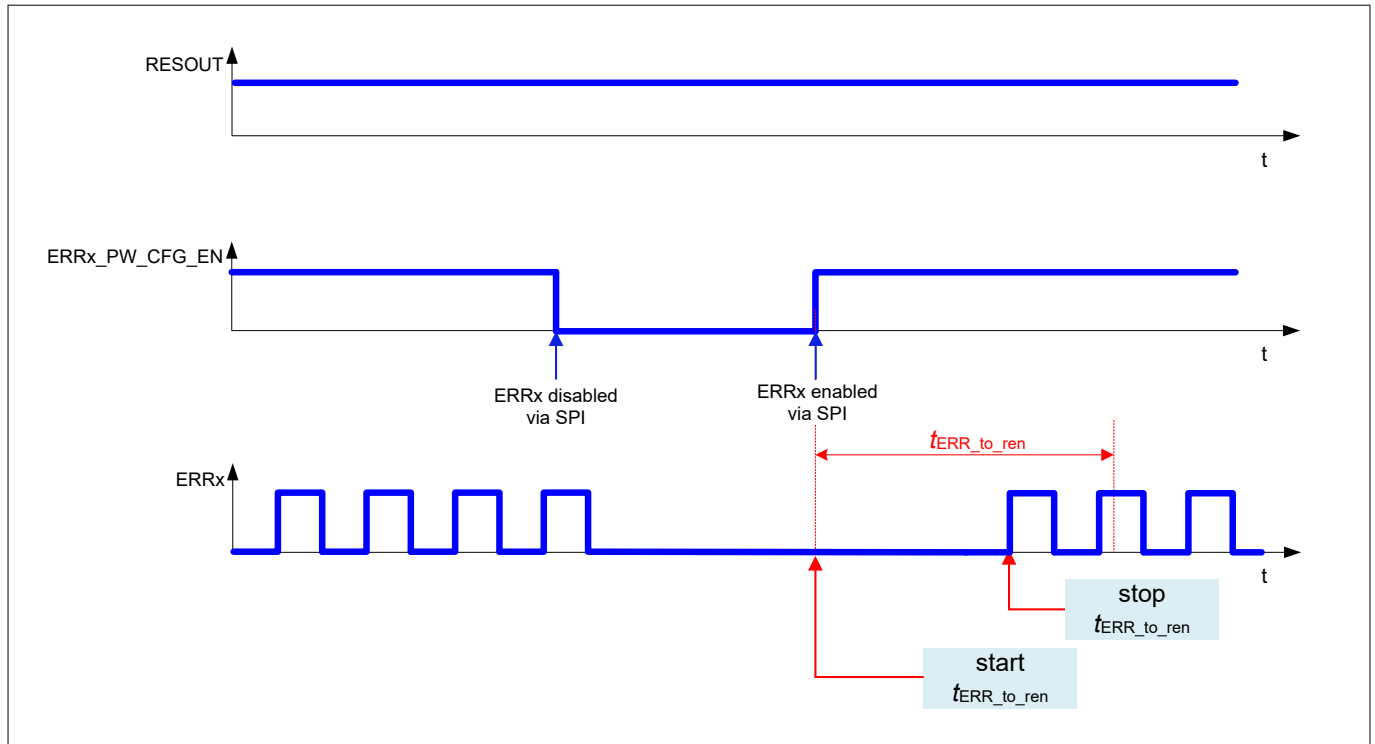


Figure 50 ERRx reactivation timeout

(x = 0; 1; 2)

The error monitoring channels can be enabled and disabled independently from each other by writing the respective **ERRx_PW_CFG.EN** bit. In addition each error monitoring channel can be configured to remain active while being in SLEEP state with the respective bit **ERRx_PW_CFG.SLP_EN**. If the error monitoring has not been configured to remain active while being in SLEEP state and it has already been running before entering SLEEP state, the function will re-enable upon transition into WAKE state and starts the reactivation timeout t_{ERR_to} . This provides an additional time budget to apply an error monitoring signal again or disable the function. If no error monitoring is applied within t_{ERR_to} an **ERRx_SEV_FAULT** is issued (see [Interrupt function \(INT\)](#) and [Reset function \(RESOUT\)](#)). The ERR timeout is a global timer and is only stopped, if either all ERRx channels are disabled or all enabled ERRx channels are properly serviced within t_{ERR_to} .

Note: ERR2 can only be used if REDUCED OPERATION is enabled (**REDOP_RS_CFG1.EN = 1**).

10 Monitoring functions

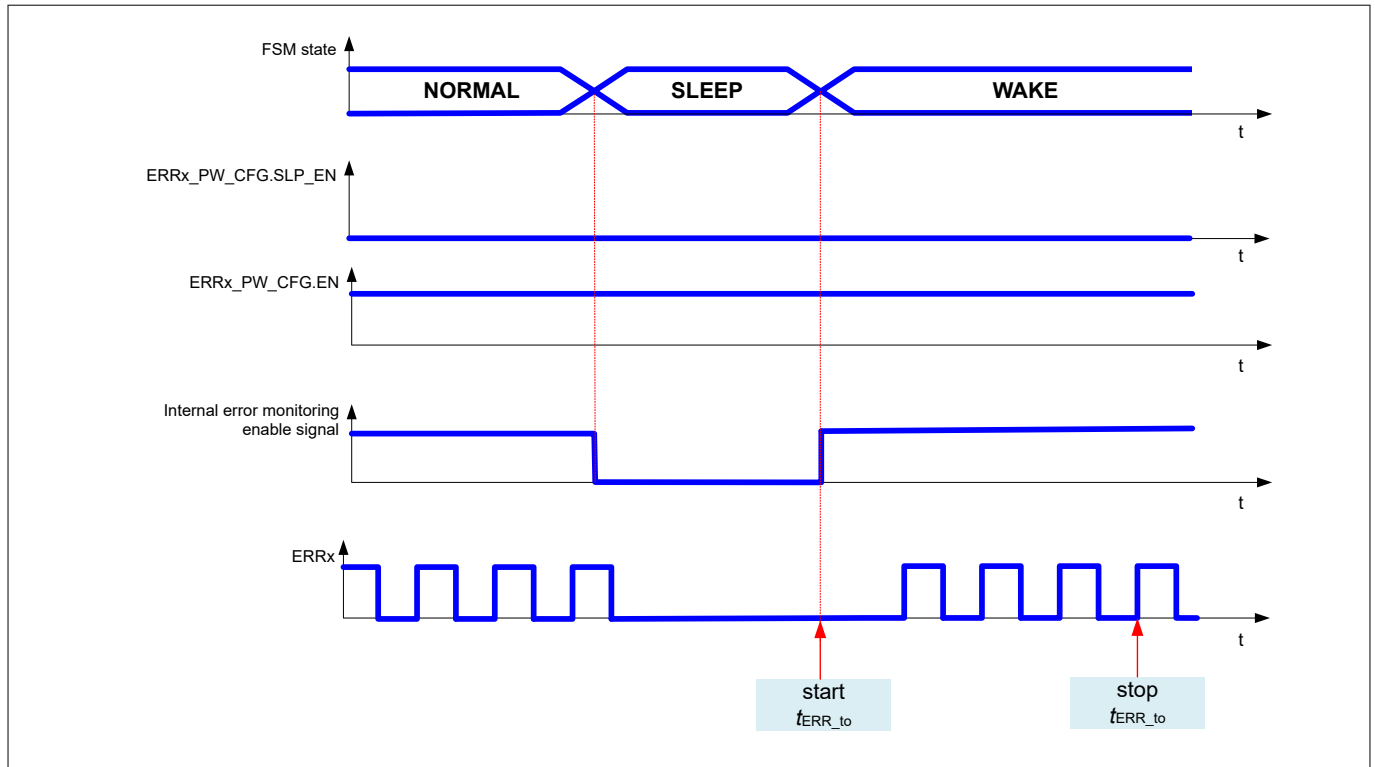


Figure 51 ERRx reactivation timeout from SLEEP state

(x = 0; 1; 2;
y = 1; 2)

10.2.2.3 Error monitoring recovery timers

Each error monitoring channel provides a recovery timer. On detection of an invalid ERRx toggling signal period, the corresponding recovery timer grants the application some time to recover and to resume valid error frequency generation.

The recovery timer of each error monitoring channel can be activated or deactivated independently in the register bit **ERRx_PW_CFG.TREC_EN**.

For an activated recovery timer, the duration of the recovery time t_{REC} can be configured in the bitfield **ERRx_PW_CFG.TREC**.

10.2.2.4 Invalid error toggling

If any of the following conditions is fulfilled, then the device detects "invalid ERRx toggling":

- The ERR signal stops toggling and remains "low" or "high"
- The ERR signal starts toggling with a too high frequency ($f_{ERR_invalid_high_x}$)
- The ERR signal starts toggling with a too low frequency ($f_{ERR_invalid_low_x}$)

(x = LF; HF)

Recovery time disabled

On detection of an invalid ERRx triggering, the device performs the following actions:

- Generate an error monitoring severe fault **ERRx_SEV_FAULT**, see [Reaction on faults](#)
- Set the corresponding failure bit (**SYSFAIL_STAT_APPy.ERR0**, **INIT_ERR_APPy.ERRx**)

Recovery time enabled

On detection of invalid ERRx triggering, the device performs the following actions:

- Generate an error monitoring warning fault **ERRx_WARN_FAULT**, see [Reaction on faults](#)
- Set the corresponding failure bits (**SYS_STAT_APPy.ERRx_ERR**), which can be cleared via SPI

10 Monitoring functions

- Start the recovery timer
- If correct signal has been re-established before t_{REC} has expired, timer is stopped and no further actions take place
- Generate an error monitoring severe fault $ERR_x_SEV_FAULT$ after the recovery time t_{REC} has expired and no valid error signal has been re-established in time, see [Reaction on faults](#)
- Set the corresponding failure bit (**SYSFAIL_STAT_APPy.ERR0, INIT_ERR_APPy.ERRx**), which can be cleared via SPI

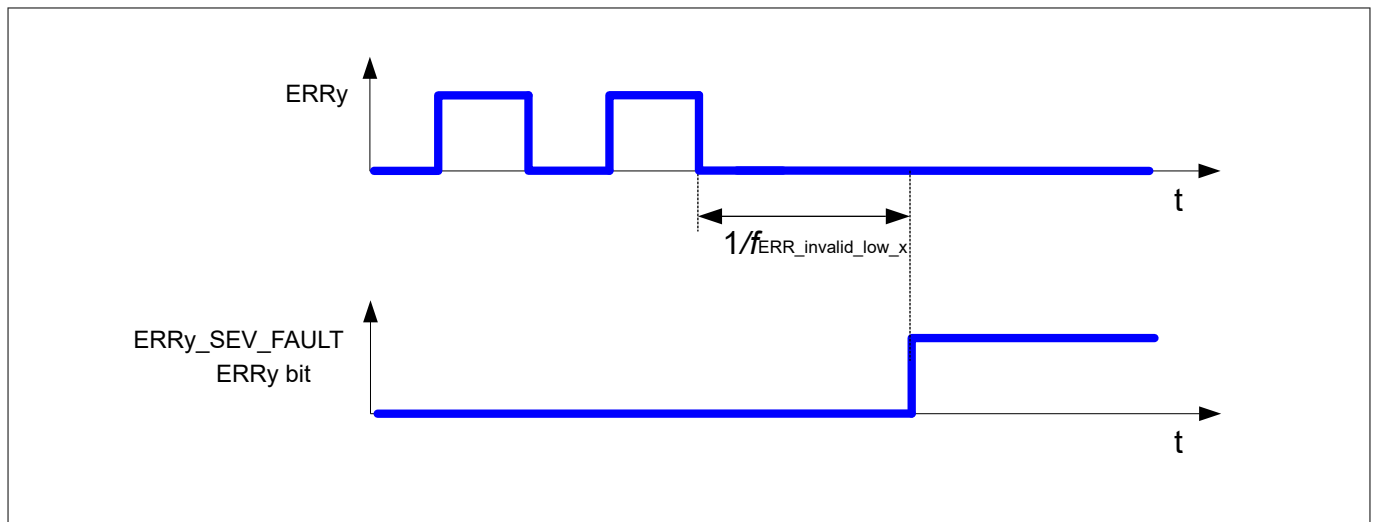


Figure 52 **ERR_y capture with too low frequency or stops toggling (recovery time disabled)**

($x = LF; HF$)

($y = 0; 1; 2$)

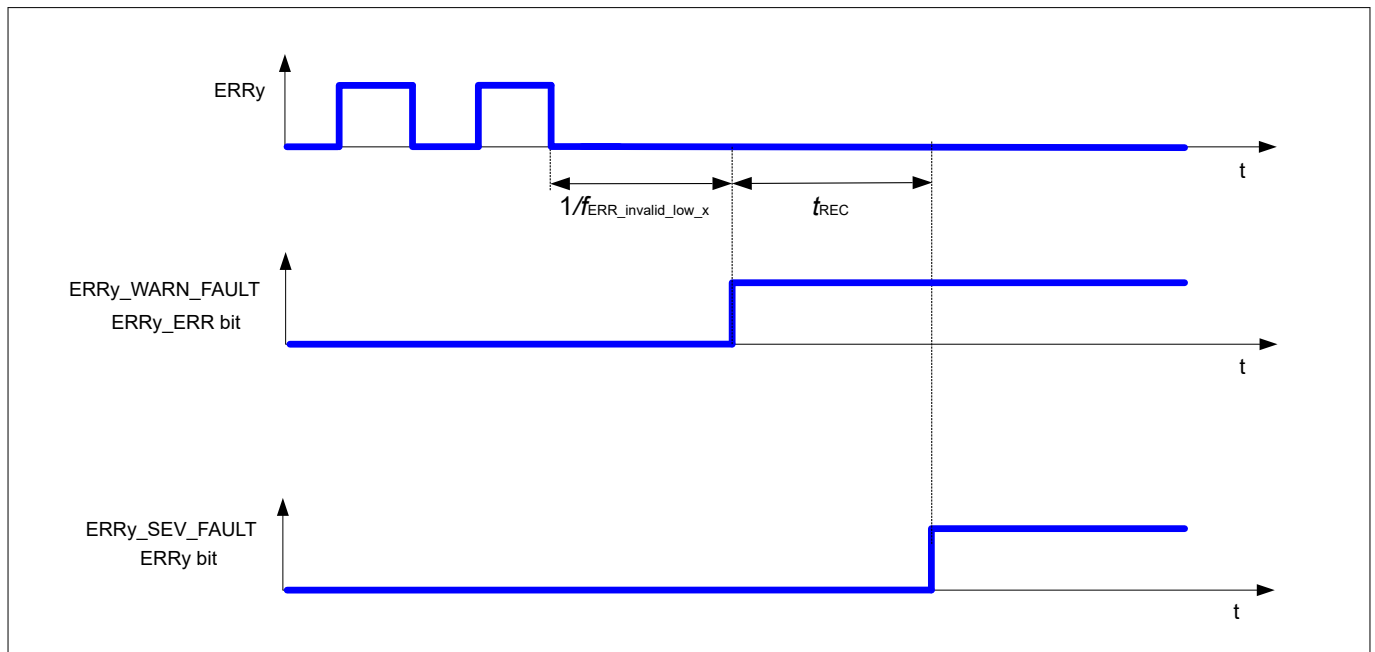


Figure 53 **ERR_y capture with too low frequency or stops toggling (recovery time enabled)**

($x = LF; HF$)

($y = 0; 1; 2$)

10 Monitoring functions

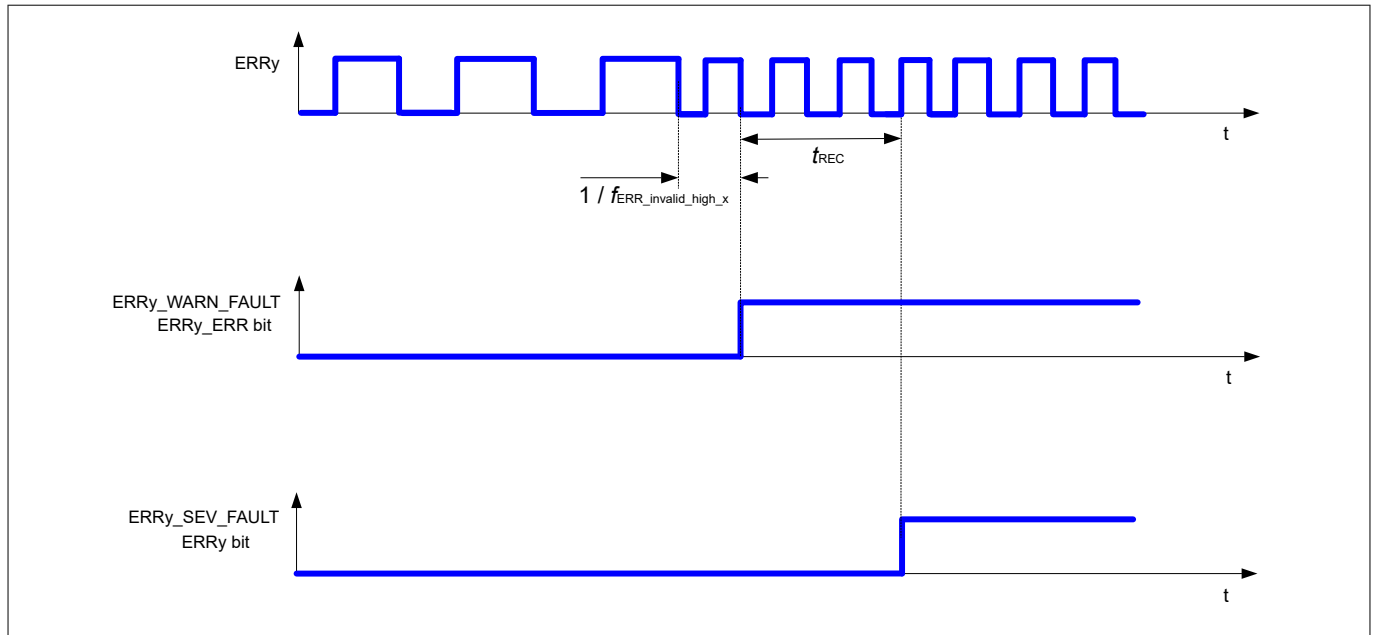


Figure 54 ERRy capture with too high frequency (recovery time enabled)

(x = LF; HF)

(y = 0; 1; 2)

10.2.3 Electrical characteristics error monitoring (ERR MON)

Table 36 Electrical characteristics error monitoring (ERR MON)

$V_{VS} = 6.0\text{ V to }36\text{ V}$, $T_j = -40^\circ\text{C to }+175^\circ\text{C}$, all voltages with respect to ground, positive current flowing into pin (unless otherwise specified)

Parameter	Symbol	Values			Unit	Note or condition	P-Number
		Min.	Typ.	Max.			
ERRx pin valid "high" voltage	V_{ERRx_HIG} H	3.15	–	V_{QUC}	V	V_{ERRx} increasing; $V_{QUC} \geq V_{QUC}[\text{Min.}]$	DS-1623
ERRx pin valid "low" voltage	V_{ERRx_LOW}	0	–	0.8	V	V_{ERRx} decreasing	DS-1625
ERRx pin hysteresis	V_{ERRx_HYS} T	–	300	–	mV	$V_{QUC} = V_{QUC}[\text{Typ.}]$	DS-1626
ERRx pin pull-down current	I_{ERRx}	–	135	330	μA	$V_{ERRx} = V_{QUC}$	DS-1628
ERRx pin input capacitance	C_{ERRx}	–	4	15	pF	¹⁾	DS-1629
Valid ERRx input signal frequency low	$f_{ERRx_valid_LOW}$	10	–	45	kHz	–	DS-1630
Valid ERRx input signal frequency high	$f_{ERRx_valid_HIGH}$	1000	–	2000	kHz	–	DS-1631
ERRx invalid input signal - too low frequency LF	$f_{ERR_invalid_low_LF}$	0	–	5	kHz	¹⁾	DS-1632
ERRx invalid input signal - too high frequency LF	$f_{ERR_invalid_high_LF}$	96.2	–	1000 0	kHz	¹⁾	DS-1633

(table continues...)

10 Monitoring functions

Table 36 (continued) Electrical characteristics error monitoring (ERR MON)

$V_{VS} = 6.0 \text{ V to } 36 \text{ V}$, $T_j = -40^\circ\text{C to } +175^\circ\text{C}$, all voltages with respect to ground, positive current flowing into pin (unless otherwise specified)

Parameter	Symbol	Values			Unit	Note or condition	P-Number
		Min.	Typ.	Max.			
ERRx invalid input signal - too low frequency HF	$f_{ERR_invalid_low_HF}$	0	–	0.5	MHz	¹⁾	DS-1634
ERRx invalid input signal - too high frequency HF	$f_{ERR_invalid_high_HF}$	4	–	10	MHz	¹⁾	DS-1635
Reactivation timeout	t_{ERR_to}	9	–	11	ms	After SLEEP with RESOUT=1 and ERRx_RS_CFG.EN=1 and ERRx_RS_CFG.SLP_EN=0 ¹⁾	DS-1636
Reactivation timeout after reenabling	$t_{ERR_to_ren}$	90	100	110	µs	After reenabling via SPI ¹⁾	DS-1637
ERRx recovery time	t_{REC}	$0.9 \cdot t$	t	$1.1 \cdot t$	ms	t configurable to be 1 ms, 2.5 ms, 5 ms, 10 ms; Configuration done via SPI ¹⁾	DS-1998

¹⁾ Not subject to production test, specified by design

10.3 Voltage monitoring

10.3.1 Introduction

The voltage monitoring (VMON) function is a safety mechanism that supervises the internal and external supply rails. If the monitoring voltage rail is outside of the defined operational range, then the device reacts accordingly.

The voltage monitoring module provides following voltage monitoring channels:

- The Battery voltage monitoring
- The internal voltage monitoring for each internal regulator or supply rail
- Two external voltage monitoring channels

The voltage monitoring for the corresponding voltage rail is active whenever the regulator is enabled.

Only when a regulator is being ramped up, an undervoltage is ignored until the output voltage is within the monitoring range defined by his undervoltage and overvoltage thresholds.

A short to ground detection remains active while being ramped up.

The device integrates also internal voltage supplies and bias currents necessary to operate all functions, including regulators, monitoring and digital logic. These internal supplies are monitored to ensure proper device functionality.

The following internal supplies are monitored in the device:

- internal supply voltages
- bias currents
- bandgap to bandgap variation

Note: These voltages and current sources are not directly available externally to the device

10 Monitoring functions

10.3.2 Battery voltage monitoring

The voltage on Vs pin is monitored to protect the device for unexpected overvoltage.

If the voltage (V_{VS}) on Vs pin exceeds the overvoltage threshold V_{VS_OV} , the device performs the following actions:

- Generate an VBAT monitoring severe fault VBAT_SEV_FAULT, see [Chapter 9](#)
- Set the corresponding failure bit INTSUP_STAT_APPx.VBAT_OV, which can be cleared via SPI.

10.3.3 Internal voltage monitoring

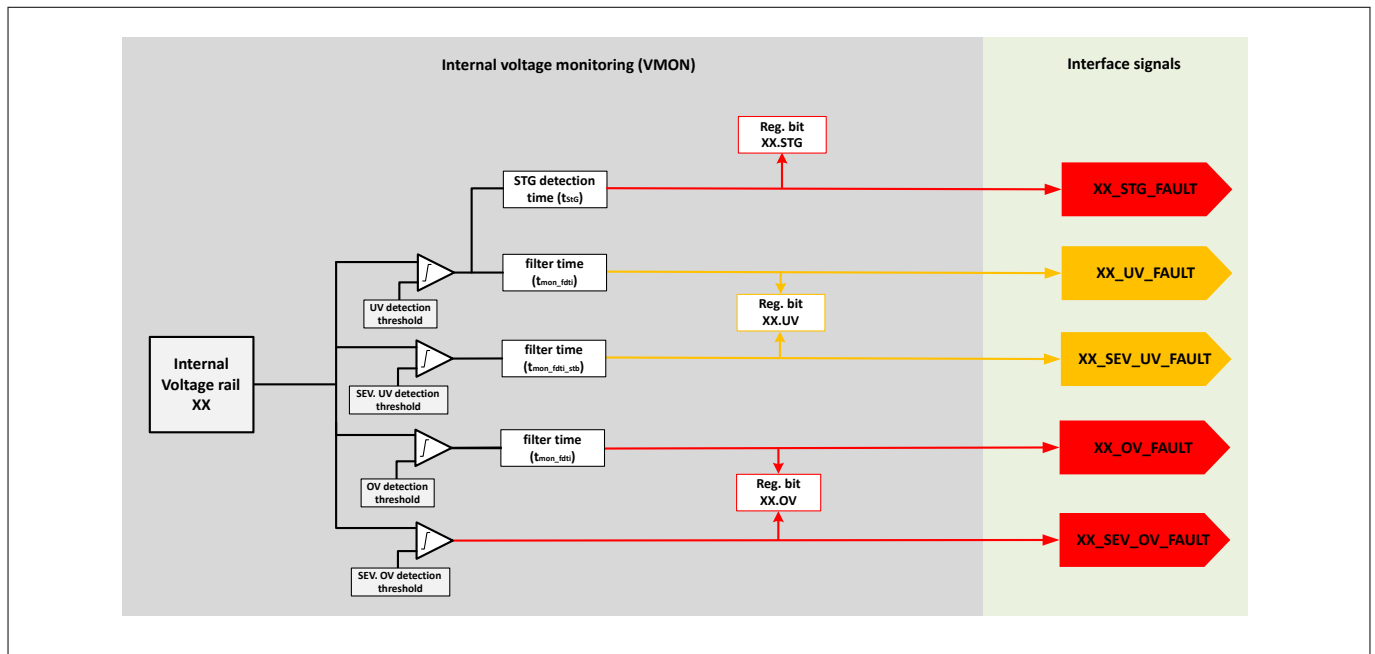


Figure 55 Functional block diagram internal voltage monitoring

The table below shows the corresponding monitoring type for each regulator rail (XX)

Monitoring rail (XX)	severe OV detection	OV detection	UV detection	severe UV Detection	Short to Ground
BUCK PREREG	X	X	X	x (BOOST not used) *	X
BUCKIF	X	X	X		X
BUCKCORE	X	X	X		X
BOOST		X	X	x (BOOST used) *	X
QUC		X	X		X
QCO		X	X		X
QVR		X	X		X
QST	X	X	X		X
QST (STANDBY)	X			X	X
Int. Supply	X	X	X		X
BG12		X	X		

* Severe undervoltage monitoring is performed at BSTFB pin with following cases:

10 Monitoring functions

- If BOOST is mounted and switched on, it is considered as BOOST severe undervoltage and it is indicated in the SPI bitfield STG_STAT_APPx.BOOST
- If BOOST is not mounted or switched off in Sleep state, it is considered as BUCK PREREG severe undervoltage and is indicated in the SPI bitfield STG_STAT_APPx.PREREG

Overvoltage detection:

If the output voltage of internal supply rail XX exceeds the defined overvoltage threshold V_{XX_OV} for a timer longer than the monitoring reaction time of t_{mon_fdti} , the device performs the following actions:

- Generate an internal overvoltage fault XX_OV_FAULT (see [Reaction on detected fault](#))
- Set the corresponding failure bits (register **OV_STAT_APPx.XX**), which can only be cleared via SPI after the voltage returns to normal operation range.

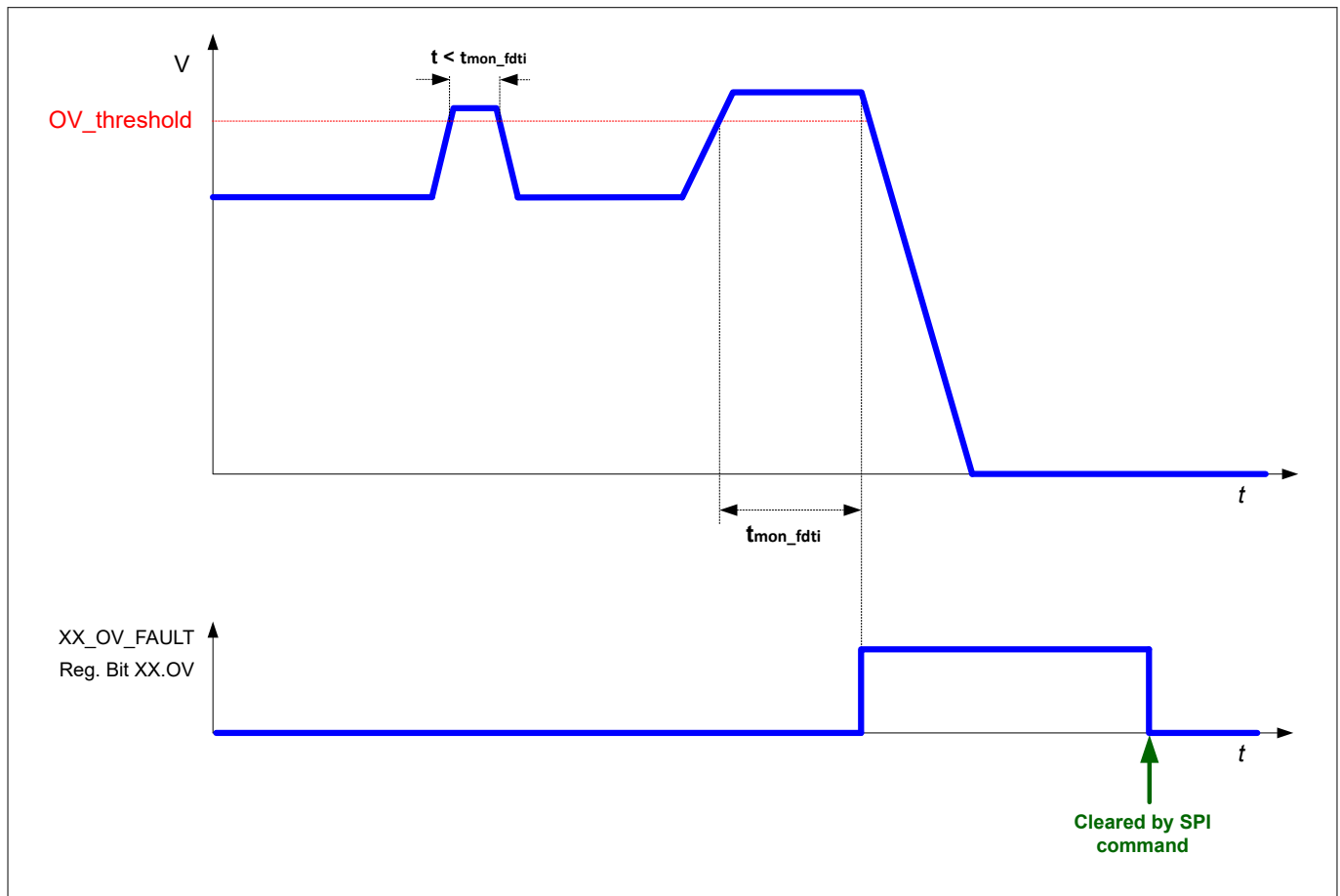


Figure 56 Timing diagram overvoltage detection

Severe overvoltage detection:

If the output voltage of internal supply rail XX rapidly increases and reach the severe overvoltage threshold $V_{XX_SEV_OV}$,

the device immediately switches off the correspondent regulator. In general the severe overvoltage reaction is the same as for the overvoltage detection with the difference, that the threshold is set higher compared to the overvoltage and the filter time is not applied.

10 Monitoring functions

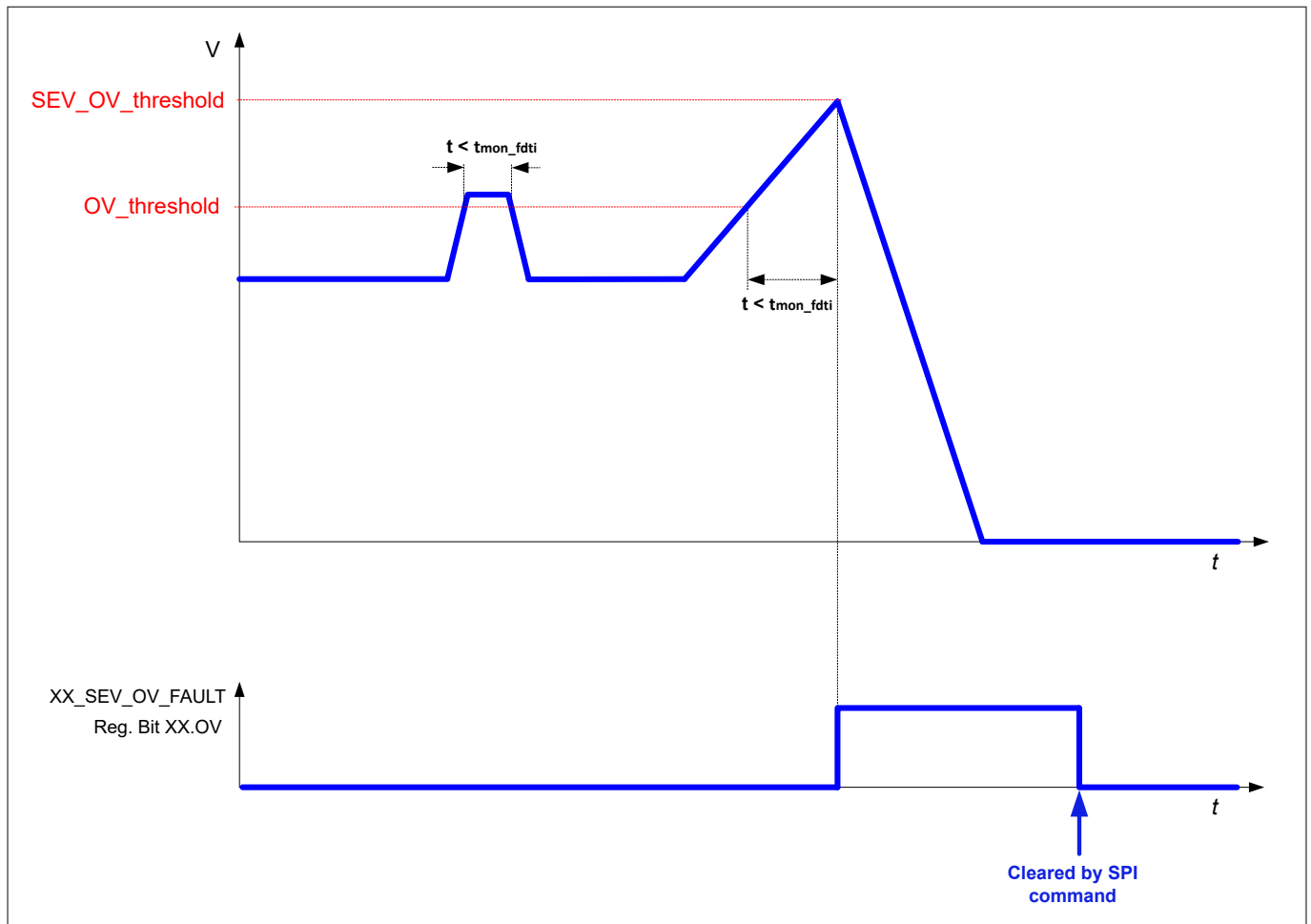


Figure 57 Timing diagram severe overvoltage detection

If the device enters STANDBY state and the output voltage of the standby regulator (QST) drops below the severe undervoltage threshold $V_{QST_SEV_UV}$ for a timer longer than the monitoring reaction time in standby $t_{mon_fdti_stb}$,

the device performs the following actions:

- Generate an internal undervoltage fault QST_SEV_UV_FAULT (see [Reaction on detected fault](#))
- Set the corresponding failure bits (register **UV_STAT_APPx.XX**), which can only be cleared via SPI after the voltage returns to normal operation range.

Short to Ground detection:

If the output voltage of the internal supply rail XX drops below the defined undervoltage threshold V_{XX_UV} for a timer longer than the short to ground detection time of t_{STG} ,

the device performs the following actions:

- Generate an internal short to ground fault XX_STG_FAULT, see [Chapter 9](#)
- Set the corresponding failure bit (register **STG_STAT_APPx.XX**), which can only be cleared via SPI after the voltage returns to normal operation range.

The device detects a short to ground (StG) on the BOOST regulator switched node, if the voltage at pin V_{BSTI} does not recover above the threshold V_{BSTI_UV} between the switching cycles.

The device detects an short to ground (StG) at pin QST if the voltage V_{QST} drops below the undervoltage threshold V_{QST_UV} for a timer longer than the QST short to ground detection time t_{STG_QST} .

10 Monitoring functions

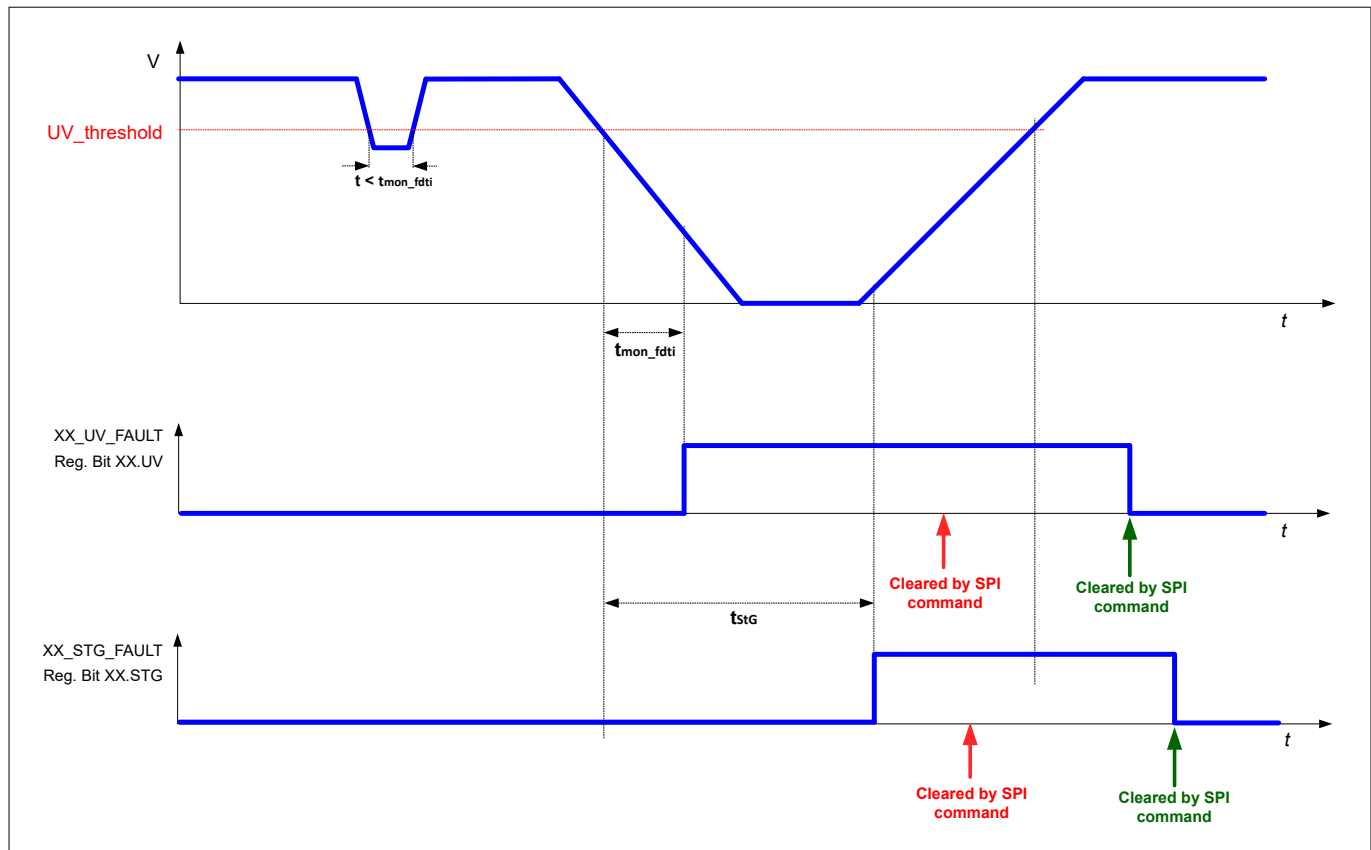


Figure 58 Timing diagram UV and STG detection

10.3.4 Electrical characteristics monitoring functions

Table 37 Electrical characteristics monitoring functions

$V_{VS} = 6.0\text{ V to }36\text{ V}$, $T_j = -40^\circ\text{C to }+175^\circ\text{C}$, all voltages with respect to ground, positive current flowing into pin (unless otherwise specified)

Parameter	Symbol	Values			Unit	Note or condition	P- Number
		Min.	Typ.	Max.			
Overvoltage monitoring							
Vbat overvoltage shutdown threshold	V _{VS_OV}	49	52	55	V	–	DS-1355
Severe overvoltage threshold Pre-reg	V _{R1FB_SEV_OV}	6.66	6.8	6.94	V	–	DS-1356
5V5 overvoltage threshold Pre-reg	V _{R1FB_5V5_OV}	6.15	6.3	6.43	V	–	DS-1357
4V0 overvoltage threshold Pre-reg	V _{R1FB_4V0_OV}	5.10	5.2	5.3	V	–	DS-1358

(table continues...)

10 Monitoring functions

Table 37 (continued) Electrical characteristics monitoring functions

$V_{VS} = 6.0 \text{ V to } 36 \text{ V}$, $T_j = -40^\circ\text{C to } +175^\circ\text{C}$, all voltages with respect to ground, positive current flowing into pin (unless otherwise specified)

Parameter	Symbol	Values			Unit	Note or condition	P-Number
		Min.	Typ.	Max.			
Severe overvoltage threshold BUCK CORE	$V_{R3FB_sev_OV}$	y * 1.19	–	y * 1.56	V	y: Configured nominal BUCKCORE output voltage; $y = 0.7 + x \cdot 12.5 \text{ mV}$; x: 0,1,...32 (register value); $y = 1.15 \text{ V}$ for x = 33	DS-2043
Overvoltage threshold BUCK CORE	V_{R3FBH_OV}	y * 1.06 8	y * 1.09	y * 1.11 2	V	y: Configured nominal BUCKCORE output voltage; $y = 0.7 + x \cdot 12.5 \text{ mV}$; x: 0,1,...32 (register value BUCK_CORE_PW_VSEL); $y = 1.15 \text{ V}$ for x = 33	DS-1359
Overvoltage hysteresis BUCK CORE	$V_{R3FBH_OV_HYS}$	5	15	25	mV	–	DS-1360
Severe overvoltage threshold BUCK IF	$V_{R4FB_SEV_OV}$	4.21	4.3	4.39	V	–	DS-1361
Overvoltage threshold BUCK IF	V_{R4FB_OV}	3.49	3.56	3.63	V	–	DS-1363
Overvoltage threshold BOOST	V_{BSTFB_OV}	6.37	6.5	6.63	V	–	DS-1365
Overvoltage hysteresis BOOST	$V_{BSTFB_OV_HYS}$	35	–	115	mV	–	DS-1366
Overvoltage threshold QUC	V_{QUC_OV}	5.3	5.4	5.5	V	–	DS-1367
Overvoltage hysteresis QUC	$V_{QUC_OV_HYS}$	34	–	102	mV	–	DS-1368
Overvoltage threshold QCO	V_{QCO_OV}	5.3	5.4	5.5	V	–	DS-1371
Overvoltage hysteresis QCO	$V_{QCO_OV_HYS}$	25	–	102	mV	–	DS-2153
Severe overvoltage threshold QST	$V_{QST_SEV_OV}$	5.95	6.25	6.5	V	–	DS-1373
Overvoltage threshold QST	V_{QST_OV}	5.3	5.4	5.5	V	–	DS-1374
Overvoltage hysteresis QST	$V_{QST_OV_HYS}$	34	–	102	mV	–	DS-1377
Overvoltage threshold QVR	V_{QVR_OV}	5.24	5.35	5.46	V	–	DS-1378
Overvoltage hysteresis QVR	$V_{QVR_OV_HYS}$	30	–	100	mV	–	DS-1379

(table continues...)

10 Monitoring functions

Table 37 (continued) Electrical characteristics monitoring functions

$V_{VS} = 6.0 \text{ V to } 36 \text{ V}$, $T_j = -40^\circ\text{C to } +175^\circ\text{C}$, all voltages with respect to ground, positive current flowing into pin (unless otherwise specified)

Parameter	Symbol	Values			Unit	Note or condition	P- Number
		Min.	Typ.	Max.			
Undervoltage monitoring							
Undervoltage threshold Pre-reg	V_{R1FB_UV}	2.59	2.65	2.71	V	–	DS-1380
Undervoltage hysteresis Pre-reg	$V_{R1FB_UV_HYS}$	15	–	50	mV	–	DS-1381
Undervoltage threshold BUCK CORE	V_{R3FBH_UV}	y * 0.89 1	y * 0.91	y * 0.92 9	V	y: Configured nominal BUCKCORE output voltage; y = 0.7 + x*12.5 mV; x: 0,1,...32 (register value BUCK_CORE_PW_VSEL); y = 1.15 V for x = 33	DS-1382
Undervoltage hysteresis BUCK CORE	$V_{R3FBH_UV_HYS}$	3	15	25	mV	–	DS-1383
Undervoltage threshold BUCK IF	V_{R4FB_UV}	2.9	2.97	3.03 6	V	–	DS-1385
Undervoltage hysteresis BUCK IF	$V_{R4FB_UV_HYS}$	15	–	55	mV	–	DS-1387
Undervoltage threshold BOOST	V_{BSTFB_UV}	4.9	5	5.10	V	–	DS-1388
Severe undervoltage threshold BOOST	$V_{BSTFB_SE_V_UV}$	1.96	2	2.04	V	If BOOST is not used, it is interpreted as BUCK PREREG severe undervoltage threshold	DS-2161
Undervoltage hysteresis BOOST	$V_{BSTFB_UV_HYS}$	30	–	90	mV	–	DS-1389
Boost short to ground threshold	V_{BSTI_UV}	1.84	2.0	2.16	V	V_{BSTI} decreasing	DS-1955
Boost short to ground threshold hysteresis	$V_{BSTI_UV_HYS}$	13 ¹⁾	25	37	mV	V_{BSTI} increasing	DS-1956
Undervoltage threshold QCO	V_{QCO_UV}	4.5	4.6	4.7	V	–	DS-1390
Undervoltage hysteresis QCO	$V_{QCO_UV_HYS}$	25	–	80	mV	–	DS-1391
Undervoltage threshold QUC	V_{QUC_UV}	4.4	4.5	4.6	V	–	DS-1392

(table continues...)

10 Monitoring functions

Table 37 (continued) Electrical characteristics monitoring functions

$V_{VS} = 6.0\text{ V}$ to 36 V , $T_j = -40^\circ\text{C}$ to $+175^\circ\text{C}$, all voltages with respect to ground, positive current flowing into pin (unless otherwise specified)

Parameter	Symbol	Values			Unit	Note or condition	P-Number
		Min.	Typ.	Max.			
Undervoltage hysteresis QUC	$V_{QUC_UV_HYS}$	25	–	80	mV	–	DS-1393
Undervoltage threshold QVR	V_{QVR_UV}	4.5	4.6	4.7	V	–	DS-1396
Undervoltage hysteresis QVR	$V_{QVR_UV_HYS}$	25	–	80	mV	–	DS-1397
Undervoltage threshold QST	V_{QST_UV}	4.3	4.4	4.5	V	–	DS-1398
Undervoltage hysteresis QST	$V_{QST_UV_HYS}$	25	–	80	mV	–	DS-1400
Severe undervoltage threshold QST	$V_{QST_SEV_UV}$	2.6	2.72	2.78	V	–	DS-2007
Internal Supply undervoltage threshold	$V_{int_sup_U}$	4.4	4.5	4.6	V	V_{QIS} decreasing	DS-1966
Internal Supply overvoltage threshold	$V_{int_sup_O}$	6.37	6.5	6.63	V	V_{QIS} increasing	DS-2008
Voltage monitoring fault detection time	t_{mon_fdti}	6		12	μs	–	DS-2001
Voltage monitoring fault detection time standby	$t_{mon_fdti_s_tb}$	8		50	μs	–	DS-2002

1) Not subject to production test, specified by design

10.3.5 Ext. monitoring channels (VMON)

10 Monitoring functions

10.3.5.1 Functional description ext. monitoring channels (VMON)

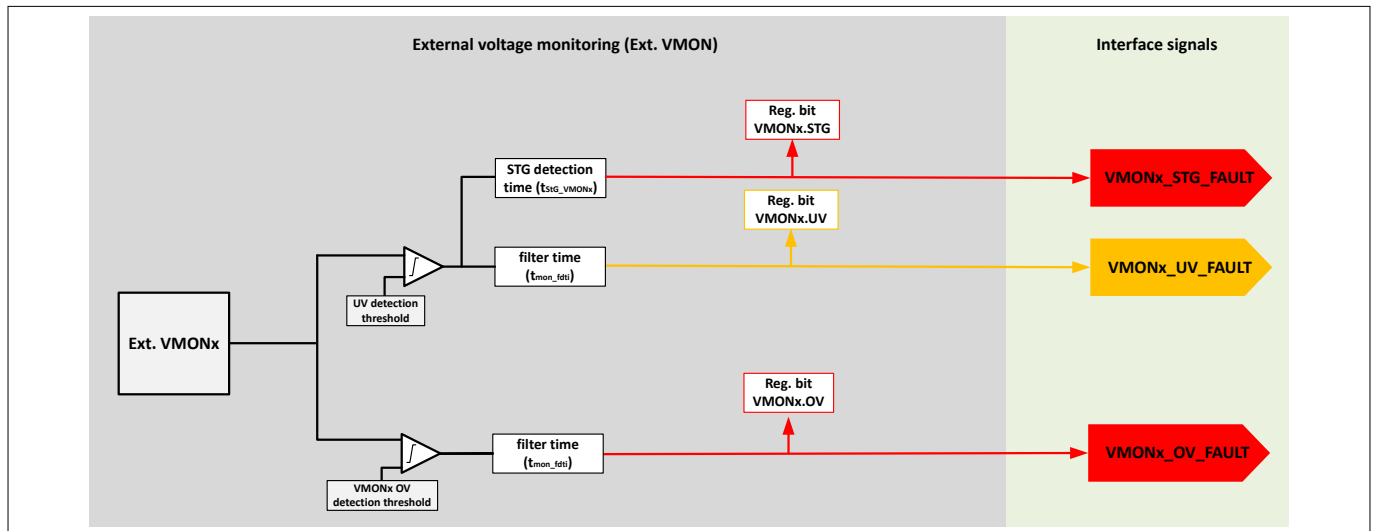


Figure 59 Functional block diagram external voltage monitoring

The device includes two channels (VMON1 or VMON2), each consists of two pins VMxFB and VMxEN. The external voltage rail is compared against a predefined threshold on the pins VM1FB and VM2FB. An external resistor divider must be used to scale the voltage that shall be monitored to the mid point of the monitoring window (typ: 0.8 V). The pins VM1EN and VM2EN are outputs to the corresponding monitoring inputs VM1FB and VM2FB. They provide a high level V_{VMxEN_H} if the automatic use detection during start-up detects the usage of the channel or, after that, if they are disabled and re-enabled via SPI. They can be used to enable and embed an external voltage regulator into the start-up and shut-down sequence of the device.

When a signal exceeds the thresholds for a duration longer than the fault detection time t_{mon_fdti} , an undervoltage or an overvoltage event is generated.

During start-up, the device detects if the external monitoring channels VMON1 or VMON2 are used within the application. If the respective external voltage monitor shall not be used in the application, the pin VMxEN must be connected to ground in order to enable the device to reliably determine whether a voltage monitor is used. For this case VMxFB can be left open. If an external voltage monitoring channel is used, VMxEN must be connected to the external regulator's enable pin. This properly integrates the start-up of the voltage rail into the start-up sequence.

Note: VMON1 and VMON2 are excluded from the power sequencing if not used.

The device detects a short to ground (StG) at one of the external monitoring channels, if the output voltage at pin V_{VMxFB} stays below the undervoltage threshold V_{MONx_UV} for a time longer than the short to ground detection time t_{STG_VMONx} .

The short to ground detection times for each external monitoring channel t_{STG_VMONx} is programmable via SPI register Bitfield **DEV_PW_CFG2.VMONx_STG_TIME**

(x = 1; 2)

10 Monitoring functions

10.3.5.2 Electrical characteristics ext. monitoring channels (VMON)

Table 38 Electrical characteristics ext. monitoring channels (VMON)

$V_{VS} = 6.0 \text{ V to } 36 \text{ V}$, $T_j = -40^\circ\text{C to } +175^\circ\text{C}$, all voltages with respect to ground, positive current flowing into pin (unless otherwise specified)

Parameter	Symbol	Values			Unit	Note or condition	P-Number
		Min.	Typ.	Max.			
Output voltage high level (x=1 or 2)	V_{VMxEN_H}	3.15	–	–	V	$V_{QUC} \geq V_{QUC}[\text{Min}]$; $I_{VMxEN} = -7 \text{ mA}$	DS-1655
Output voltage low level (X = 1 or 2)	V_{VMxEN_L}	–	–	0.7	V	$I_{VMxEN} = 5 \text{ mA}$	DS-1657
Short to ground detection time for VMON1	t_{STG_VMON1}	1		6	ms	t_{STG_VMON1} is programmable between 1ms, 2ms, 4ms and 6ms via SPI with a default value of 6ms	DS-1942
accuracy of the short to ground detection time for VMON1	$t_{STG_VMON1_acc}$	$t_{STG_VMON1}^-$ (10 % * t_{STG_VMON1})	t_{STG_VMON1}	$t_{STG_VMON1}^+$ (10 % * t_{STG_VMON1})	ms		DS-1943
Short to ground detection time for VMON2	t_{STG_VMON2}	1		6	ms	t_{STG_VMON2} is programmable between 1 ms, 2 ms, 4 ms and 6 ms via SPI with a default value of 6 ms	DS-1939
Accuracy of the short to ground detection time for VMON2	$t_{STG_VMON2_acc}$	$t_{STG_VMON2}^-$ (10 % * t_{STG_VMON2})	t_{STG_VMON2}	$t_{STG_VMON2}^+$ (10 % * t_{STG_VMON2})	ms		DS-1938
VMON1 overvoltage threshold	$V_{mon_MON1_OV}$	858	872	886	mV	V_{VM1FB} increasing	DS-1957
VMON1 overvoltage hysteresis	$V_{mon_MON1_OV_HYS}$	5 ¹⁾		15	mV	V_{VM1FB} decreasing	DS-1958
VMON1 undervoltage threshold	$V_{mon_MON1_UV}$	716	728	740	mV	V_{VM1FB} decreasing	DS-1959
VMON1 undervoltage hysteresis	$V_{mon_MON1_UV_HYS}$	5 ¹⁾		15	mV	V_{VM1FB} increasing	DS-1960

(table continues...)

10 Monitoring functions

Table 38 (continued) Electrical characteristics ext. monitoring channels (VMON)

$V_{VS} = 6.0 \text{ V to } 36 \text{ V}$, $T_j = -40^\circ\text{C to } +175^\circ\text{C}$, all voltages with respect to ground, positive current flowing into pin (unless otherwise specified)

Parameter	Symbol	Values			Unit	Note or condition	P-Number
		Min.	Typ.	Max.			
VMON2 overvoltage threshold	$V_{\text{mon_MON}2_OV}$	858	872	895	mV	V_{VM2FB} increasing	DS-1961
VMON2 overvoltage hysteresis	$V_{\text{mon_MON}2_OV_HYS}$	5 ¹⁾		15	mV	V_{VM2FB} decreasing	DS-2009
VMON2 undervoltage threshold	$V_{\text{mon_MON}2_UV}$	716	728	750	mV	V_{VM2FB} decreasing	DS-2010
VMON2 undervoltage hysteresis	$V_{\text{mon_MON}2_UV_HYS}$	5 ¹⁾		15	mV	V_{VM2FB} increasing	DS-2011

1) Not subject to production test, specified by design

10.4 Overcurrent and overtemperature monitoring

10.4.1 Introduction

The overtemperature or overcurrent monitoring function protects the device for transient overtemperature (e.g. load dump or short circuit).

Overtemperature monitoring

The device provides an overtemperature monitoring sensor for the safety area and for all post regulators except the Standby (QST) and the reference (QVR) regulator.

10 Monitoring functions

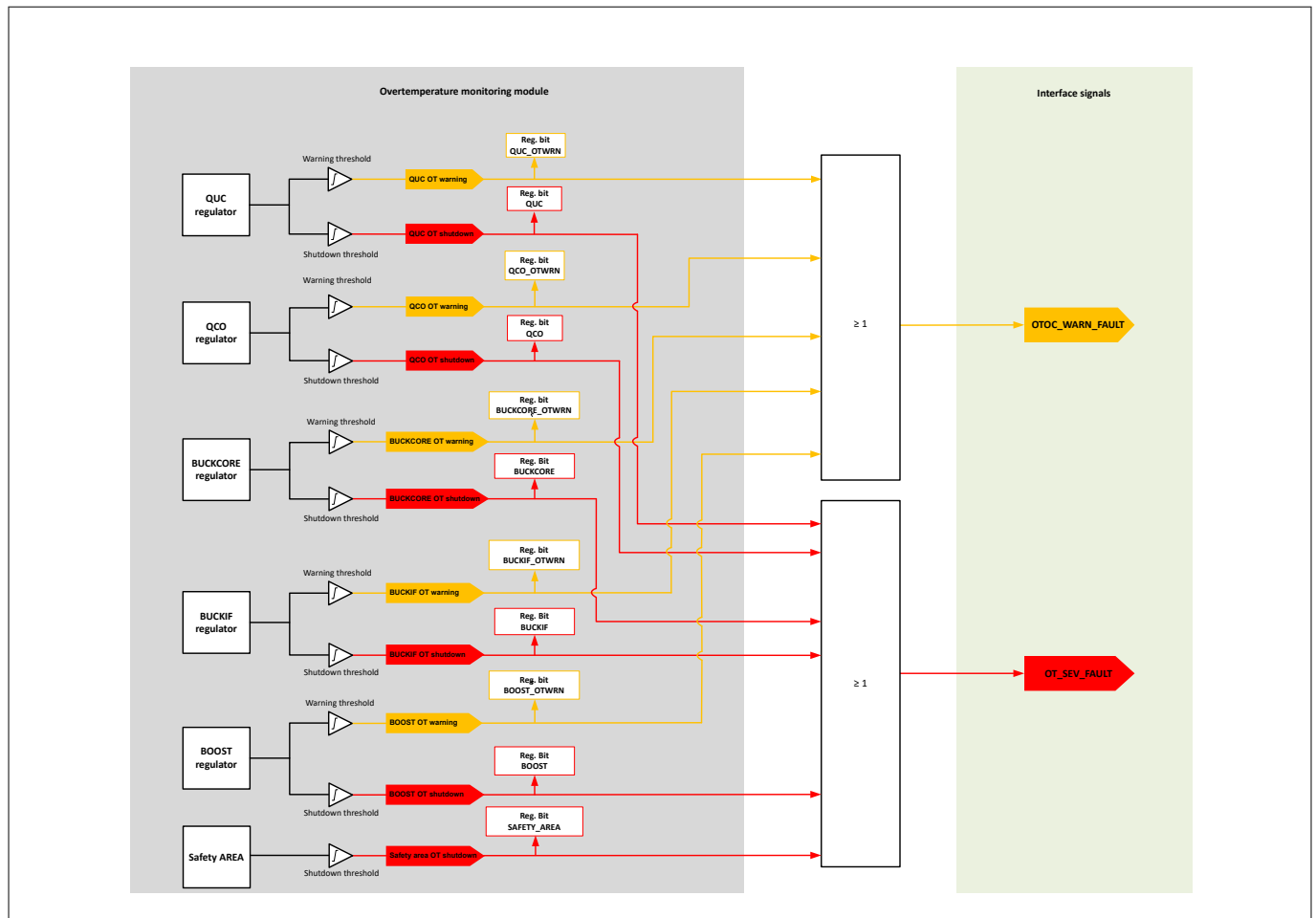


Figure 60 Functional block diagram overtemperature monitoring function

Overcurrent monitoring

The device provides overcurrent monitoring sensors for the boost regulator, the Standby regulator (QST), the internal supply (IVCC) and the reference voltage regulator (QVR).

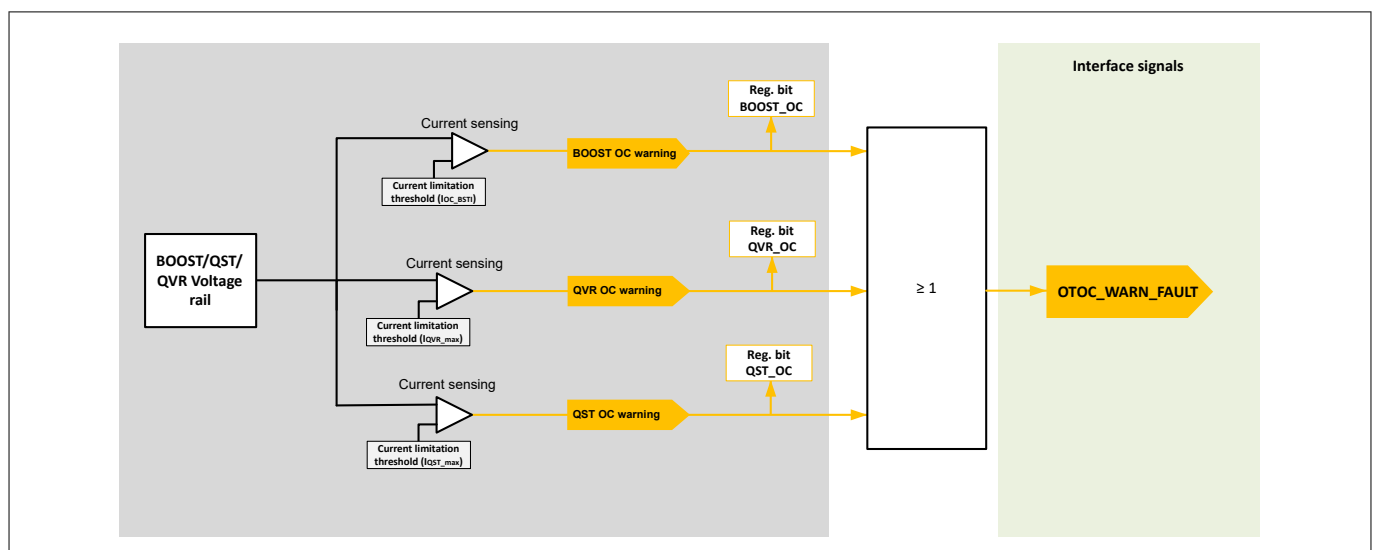


Figure 61 Functional block diagram overcurrent monitoring

10 Monitoring functions

10.4.2 Functional description overtemperature monitoring

Two overtemperature detection thresholds are implemented:

Overtemperature warning

If the temperature of the monitoring block exceeds the first threshold (overtemperature warning threshold (t_{PRE})), the device:

- sets the correspondent overtemperature warning bit, which can be cleared via SPI if the temperature drops below the warning threshold
- generates an overtemperature warning fault OTOC_WARN_FAULT, see [Chapter 9](#)

Overtemperature shutdown

If the temperature of the monitoring block continues to rise and exceeds the second threshold (overtemperature shutdown threshold (t_{OT})), the device:

- sets the correspondent overtemperature shutdown bit, which can be cleared via SPI if the temperature drops below the shutdown threshold
- generates an overtemperature severe fault OT_SEV_FAULT, see [Chapter 9](#)

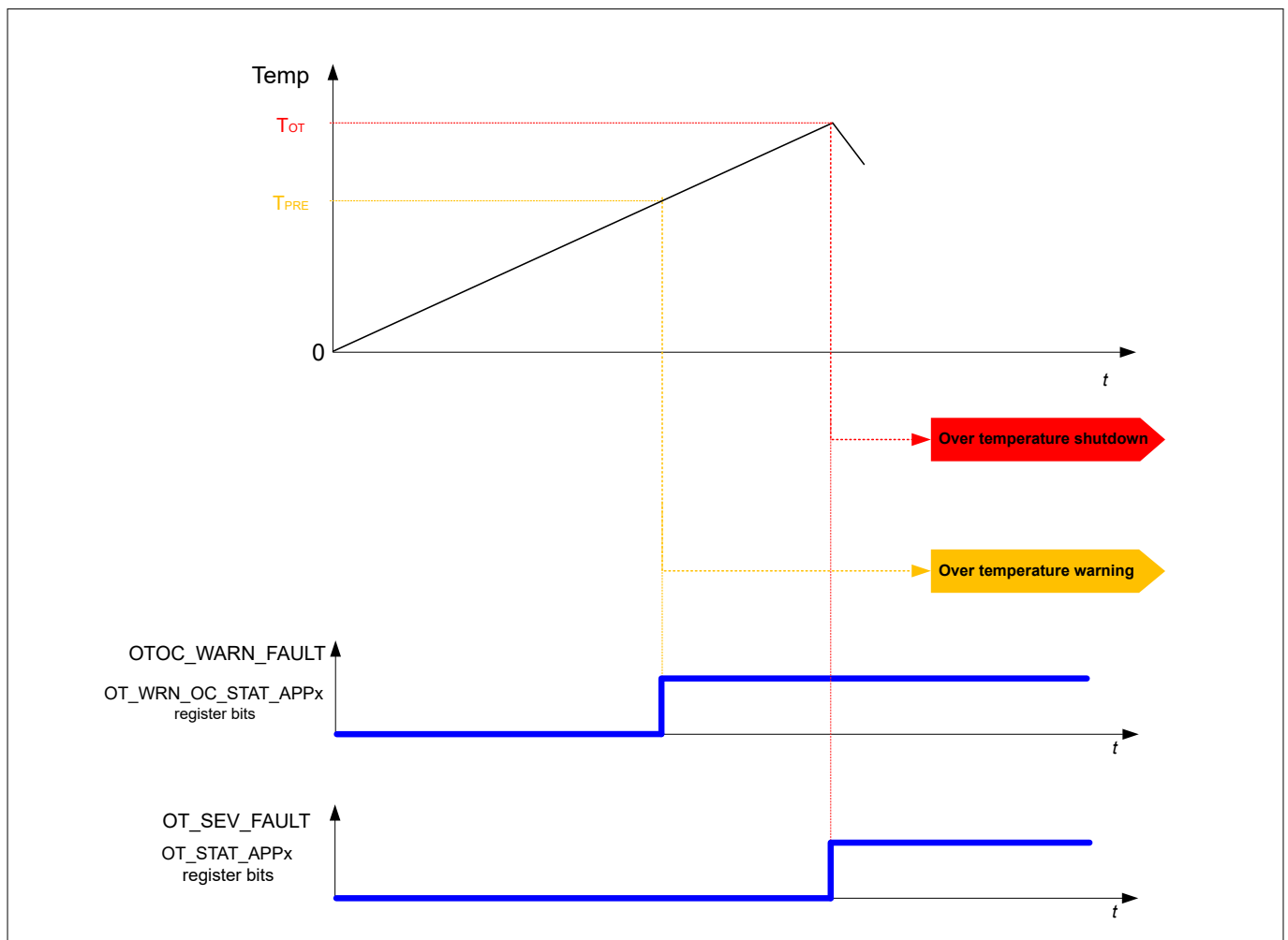


Figure 62 Signal diagram overtemperature monitoring

10.4.3 Functional description current monitoring

If the output current of the monitoring regulator reaches the overcurrent limitation threshold, the device:

10 Monitoring functions

- Sets the correspondent overcurrent warning bit, which can be cleared via SPI if the current drops below warning threshold
- Generates an overcurrent warning fault OTOC_WARN_FAULT, see [Chapter 9](#)
- The output voltage of the correspondent regulator starts to decrease immediately as consequence

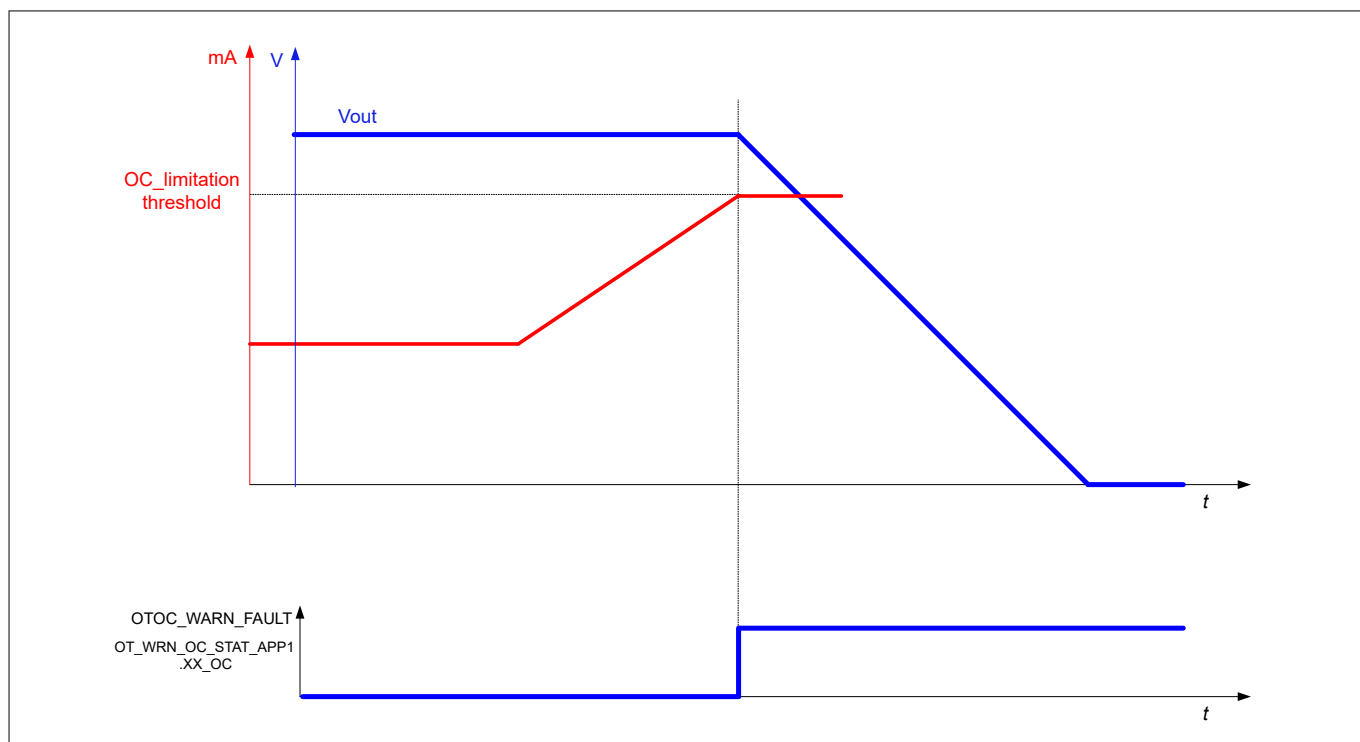


Figure 63 Signal diagram overcurrent monitoring

10.4.4 Electrical characteristics overtemperature monitoring

Table 39 Electrical characteristics overtemperature monitoring

$V_{VS} = 6.0 \text{ V to } 36 \text{ V}$, $T_j = -40^\circ\text{C to } +175^\circ\text{C}$, all voltages with respect to ground, positive current flowing into pin (unless otherwise specified)

Parameter	Symbol	Values			Unit	Note or condition	P-Number
		Min.	Typ.	Max.			
Overtemperature pre-warning threshold	T_{PRE}	136	146	156	$^\circ\text{C}$	T_j increasing ¹⁾	DS-1402
Overtemperature threshold	T_{OT}	177	187	197	$^\circ\text{C}$	T_j increasing ¹⁾	DS-1403

1) Not subject to production test, specified by design

10.5 Safe state control (SSOx)

10.5.1 Introduction

The Safe State Control module monitors the safety related signals and controls the safe state outputs. The following description summarizes the contributors to the Safe State Control function and the possibilities to adjust them.

10 Monitoring functions

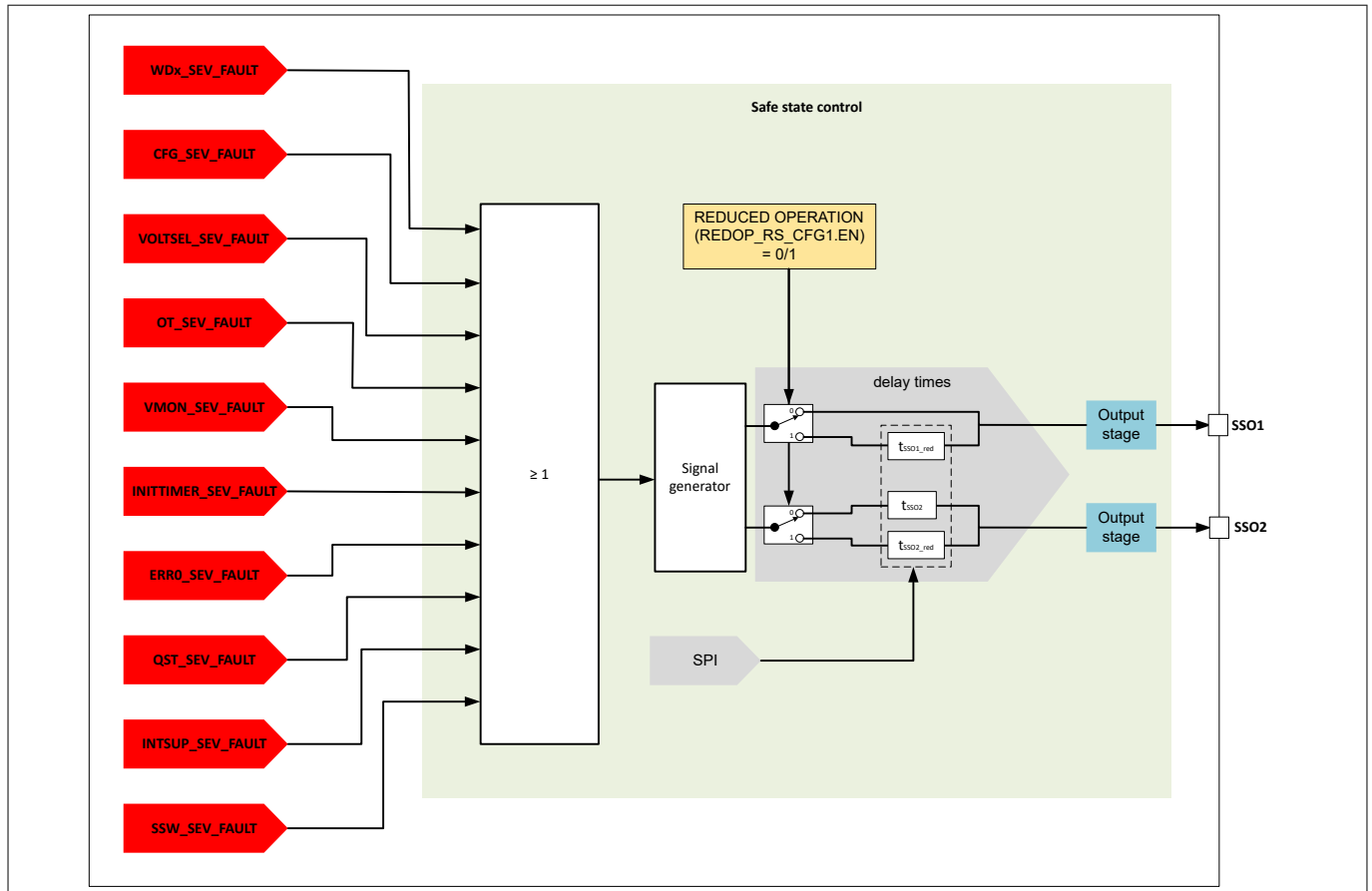


Figure 64 Functional block diagram safe state control

The safe state control module provides two safe state output control channels:

- The safe state control channel 1 which generates a safe state output signal on pin SSO1
- The safe state control channel 2 which generates a safe state output signal on pin SSO2

The safe state control module is designed to be independent of the device power supply parts by circuitry, signals, and layout.

10.5.2 Functional descriptions shutdown path (SSOx)

The device activates the shutdown path (SSOx output LOW) in any state but NORMAL. Respectively any fault or state transition command that causes the device to leave NORMAL state, results in SSO1 or SSO2 or both to be pulled low, depending on the fault. Also refer to [Reaction on detected fault](#).

10.5.2.1 Delay times and reaction on detected faults

The safe state control is implemented with optional delay time. these functions gives the application the possibility to generate two separate safe state output signals dependent on the application uses cases:

Single application use case:

Single application is activated by setting the register bit **REDOP_PW_CFG1.EN** to 0.

After detection of any severe fault, the device sets immediately the output signal on SSO1 pin to "low", while the output signal on SSO2 pin is pulled "low" after a delay time (t_{SSO2}).

The delay time (t_{SSO2}) can be configured in the register bitfield **REDOP_PW_CFG1.SSO1TOSSO2_DEL**.

10 Monitoring functions

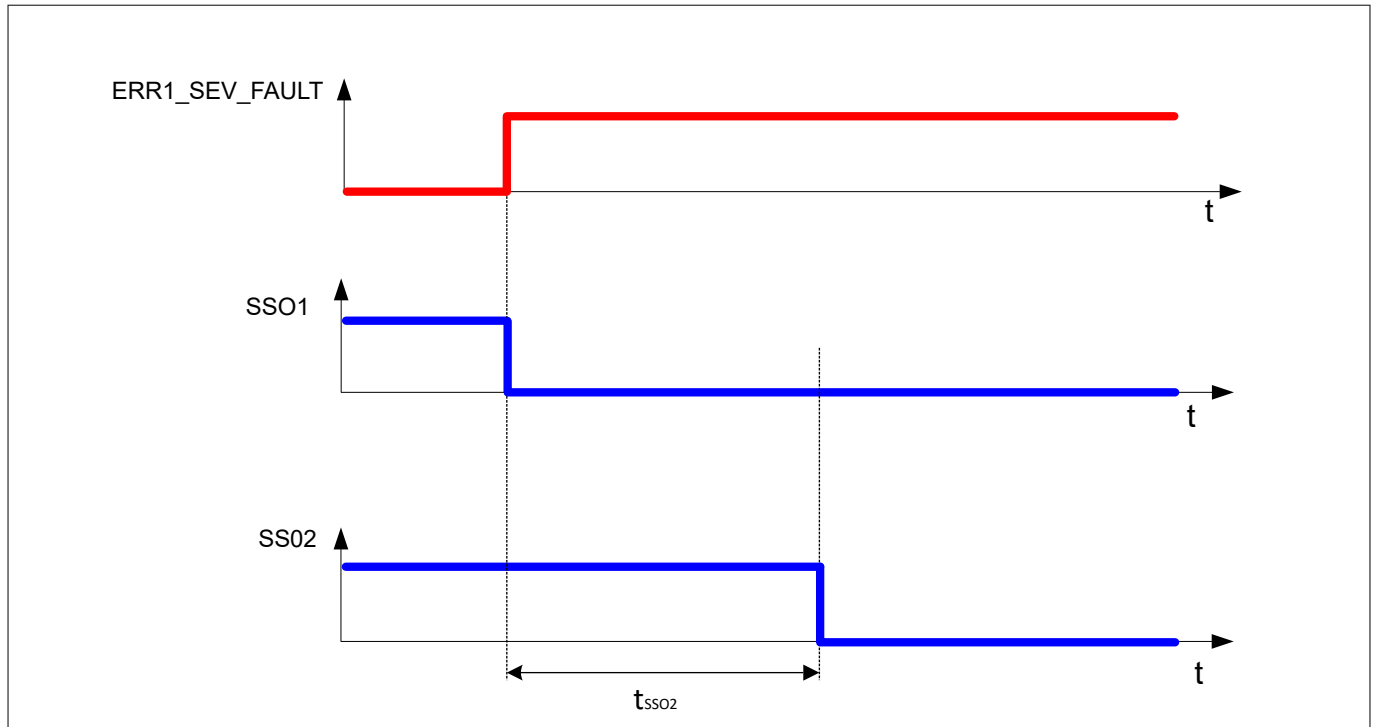


Figure 65 Flow diagram SSOx generation by single application use case, if ERR1 is the error source

(x = 1, 2)

Dual application use case:

Dual application is activated by setting the register bit **REDOP_PW_CFG1.EN** to 1.

The device sets the output signal on pin SSO1 or SSO2 "low" upon detection of any severe fault. In case the severe fault is originated in only one of the two applications, the related SSOx pin is set low. This activation can be delayed by configuring the delay times (t_{SSOx_red}) in the register bitfields **REDOP_PW_CFG1.SSOx_DEL**.

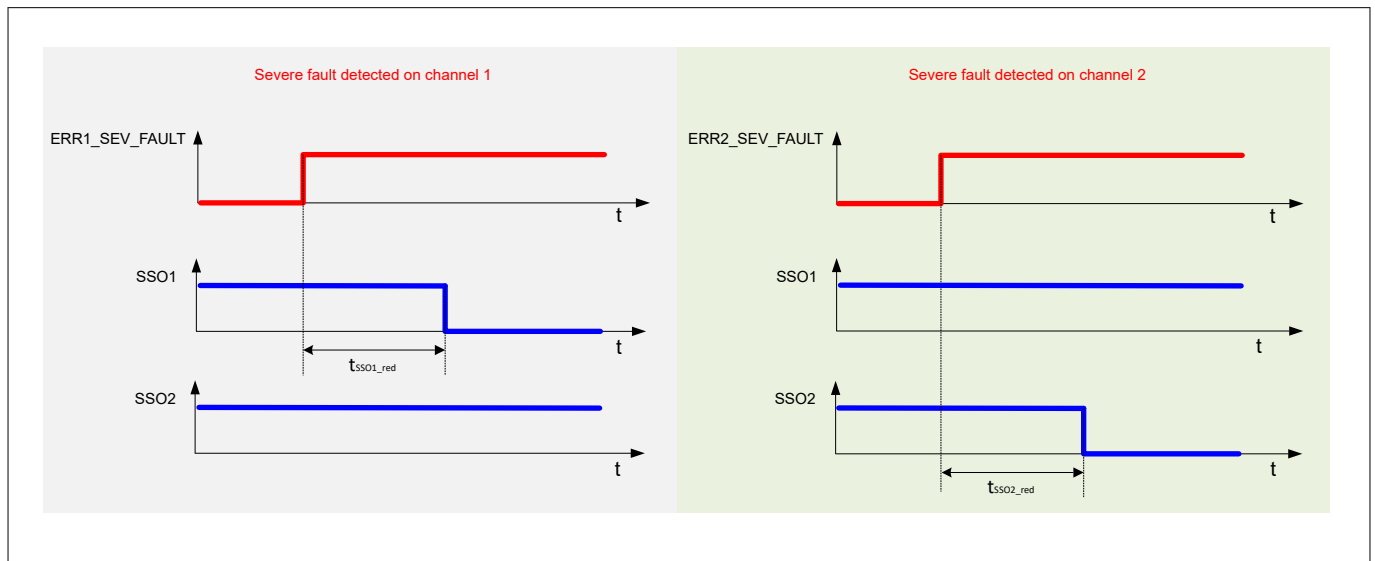


Figure 66 Flow diagram SSOx generation by dual application use case (**REDOP_PW_CFG1.EN** = 1)

Note: The delay time as described in the paragraphs above is only applied for faults that do not have a move to FAILSAFE as state transition. In other words if FAILSAFE is entered the delay times for SSO1/2 are not applied.

10 Monitoring functions

10.5.3 Electrical characteristics shutdown path (SSOx)

Table 40 Electrical characteristics shutdown path (SSOx)

$V_{VS} = 6.0 \text{ V to } 36 \text{ V}$, $T_j = -40^\circ\text{C to } +175^\circ\text{C}$, all voltages with respect to ground, positive current flowing into pin (unless otherwise specified)

Parameter	Symbol	Values			Unit	Note or condition	P-Number
		Min.	Typ.	Max.			
Output high level 1 mA	$V_{SSOx_HIG_H}$	3.6	4.8	V_{QUC}	V	$I_{SSOx} \geq -1 \text{ mA}$; $V_{QUC} = V_{QUC} [\text{Min}]$	DS-1612
[SSOx] Output high level 3.75 mA	$V_{SSOx_HIG_H_3mA}$	3.0	4.3	V_{QUC}	V	$I_{SSOx} \geq -3.75 \text{ mA}$; $V_{QUC} = V_{QUC} [\text{Min}]$	DS-1614
Pull-down resistor	R_{SSOx}	70	100	130	k Ω	–	DS-1616
Output low level	V_{SSOx_LO}	–	0	0.3	V	$R_{SSOx_PD_EXT} \leq 100 \text{ k}\Omega$; $I_{SSOx} \leq 1.2 \text{ mA}$; QUC active; $V_{QUC} \geq 2.9 \text{ V}$; $-40^\circ\text{C} \leq T_j \leq 175^\circ\text{C}$	DS-2081
SSO2 reaction delay time	t_{SSO2}	0	–	250	ms	Timebase accuracy is t_{SSC}	DS-1618
SSO1 reaction delay time for REDUCED OPERATION	t_{SSO1_red}	0	–	250	ms	Timebase accuracy is t_{SSC}	DS-1619
SSO2 reaction delay time for REDUCED OPERATION	t_{SSO2_red}	0	–	250	ms	Timebase accuracy is t_{SSC}	DS-1620
Timebase accuracy	t_{SSC}	-10	–	10	%		DS-1999

10.6 Reaction on faults

10.6.1 Reaction on detected fault

Table 41 Reaction on detected events of regulators

Module	Event description	REDUCED OPERATION ON/OFF	State transition	IO reaction	Register name	Bitfield name
Battery Monitoring	VS OV	any	Move to FAILSAFE	RESOUT, SSO1, SSO2 ²⁾	INTSUP_STAT_APP1	VBAT_OV
		on	Move to FAILSAFE	RESOUT, SSO1, SSO2 ²⁾	INTSUP_STAT_APP2	VBAT_OV
BOOST	BOOST OV	any	Move to FAILSAFE	RESOUT, SSO1, SSO2 ²⁾	OV_STAT_APP1	BOOST

(table continues...)

10 Monitoring functions

Table 41 (continued) Reaction on detected events of regulators

		on	Move to FAILSAFE	RESOUT, SSO1, SSO2 ²⁾	OV_STAT_APP 2	BOOST
	BOOST overcurrent	off	No transition	INT1	OT_WRN_OC_STAT_APP1	BOOST_OC
		on	No transition	INT1, INT2	OT_WRN_OC_STAT_APP1	BOOST_OC
		on	No transition	INT1, INT2	OT_WRN_OC_STAT_APP2	BOOST_OC
	BOOST overtemperature warning	off	No transition	INT1	OT_WRN_OC_STAT_APP1	BOOST_OT WRN
		on	No transition	INT1, INT2	OT_WRN_OC_STAT_APP1	BOOST_OT WRN
		on	No transition	INT1, INT2	OT_WRN_OC_STAT_APP2	BOOST_OT WRN
	BOOST short to ground or Severe undervoltage or undervoltage at BSTI pin	any	Move to FAILSAFE	RESOUT, SSO1, SSO2 ²⁾	STG_STAT_AP P1	BOOST
		on	Move to FAILSAFE	RESOUT, SSO1, SSO2 ²⁾	STG_STAT_AP P2	BOOST
	BOOST thermal shutdown	any	Move to FAILSAFE	RESOUT, SSO1, SSO2 ²⁾	OT_STAT_APP 1	BOOST
		on	Move to FAILSAFE	RESOUT, SSO1, SSO2 ²⁾	OT_STAT_APP 2	BOOST
	Undervoltage at BOOST	off	No transition	INT1	UV_STAT_APP 1	BOOST
		on	No transition	INT1, INT2	UV_STAT_APP 1	BOOST
		on	No transition	INT1, INT2	UV_STAT_APP 2	BOOST
BUCKCORE	BUCKCORE overtemperature warning	off	No transition	INT1	OT_WRN_OC_STAT_APP1	BUCKCORE_OTWRN
		on	No transition	INT1, INT2	OT_WRN_OC_STAT_APP1	BUCKCORE_OTWRN
		on	No transition	INT1, INT2	OT_WRN_OC_STAT_APP2	BUCKCORE_OTWRN
	BUCKCORE short to ground	any	Move to FAILSAFE	RESOUT, SSO1, SSO2 ²⁾	STG_STAT_AP P1	BUCKCORE
		on	Move to FAILSAFE	RESOUT, SSO1, SSO2 ²⁾	STG_STAT_AP P2	BUCKCORE

(table continues...)

10 Monitoring functions

Table 41 (continued) Reaction on detected events of regulators

	BUCKCORE thermal shutdown	any	Move to FAILSAFE	RESOUT, SSO1, SSO2 ²⁾	OT_STAT_APP 1	BUCKCORE
		on	Move to FAILSAFE	RESOUT, SSO1, SSO2 ²⁾	OT_STAT_APP 2	BUCKCORE
	BUCKCORE undervoltage	any	Move to INIT	RESOUT, SSO1, SSO2	UV_STAT_APP 1	BUCKCORE
		on	Move to INIT	RESOUT, SSO1, SSO2	UV_STAT_APP 1	BUCKCORE
	Feedback open	any	Move to FAILSAFE	RESOUT, SSO1, SSO2 ²⁾	OV_STAT_APP 1	BUCKCORE_FB_OPEN
		on	Move to FAILSAFE	RESOUT, SSO1, SSO2 ²⁾	OV_STAT_APP 2	BUCKCORE_FB_OPEN
	Severe overvoltage at BUCKCORE or BUCKCORE OV	any	Move to FAILSAFE	RESOUT, SSO1, SSO2 ²⁾	OV_STAT_APP 1	BUCKCORE
		on	Move to FAILSAFE	RESOUT, SSO1, SSO2 ²⁾	OV_STAT_APP 2	BUCKCORE
	Static voltage scaling completed successfully.	off	No transition	INT1	SYS_STAT_AP P1	BUCKCORE_SVS_OK
		on	No transition	INT1, INT2	SYS_STAT_AP P1	BUCKCORE_SVS_OK
		on	No transition	INT1, INT2	SYS_STAT_AP P2	BUCKCORE_SVS_OK
	Static voltage scaling not performed due to: - Device being not in INIT or NORMAL - BUCKCORE voltage set to 1.15 V - Invalid SPI value	off	No transition	INT1	SYS_STAT_AP P1	BUCKCORE_SVS_NOK
		on	No transition	INT1, INT2	SYS_STAT_AP P1	BUCKCORE_SVS_NOK
		on	No transition	INT1, INT2	SYS_STAT_AP P2	SBUCKCORE_SVS_NOK
	Voltage selection error. Core voltage might be corrupt.	any	Move to FAILSAFE	RESOUT, SSO1, SSO2 ²⁾	SYSFAIL_STAT_APP1	BUCK_CORE_VOLTSEL
		on	Move to FAILSAFE	RESOUT, SSO1, SSO2 ²⁾	SYSFAIL_STAT_APP2	BUCK_CORE_VOLTSEL
BUCKIF	BUCKIF overtemperature warning	off	No transition	INT1	OT_WRN_OC_STAT_APP1	BUCKIF_OT_WRN
		on	No transition	INT1, INT2	OT_WRN_OC_STAT_APP1	BUCKIF_OT_WRN

(table continues...)

10 Monitoring functions

Table 41 (continued) Reaction on detected events of regulators

		on	No transition	INT1, INT2	OT_WRN_OC_STAT_APP2	BUCKIF_OT WRN	
	BUCKIF thermal shutdown	any	Move to FAILSAFE	RESOUT, SSO1, SSO2 ²⁾	OT_STAT_APP 1	BUCKIF	
		on	Move to FAILSAFE	RESOUT, SSO1, SSO2 ²⁾	OT_STAT_APP 2	BUCKIF	
	Severe overvoltage at BUCKIF or BUCKIF OV	any	Move to FAILSAFE	RESOUT, SSO1, SSO2 ²⁾	OV_STAT_APP 1	BUCKIF	
		on	Move to FAILSAFE	RESOUT, SSO1, SSO2 ²⁾	OV_STAT_APP 2	BUCKIF	
	Undervoltage at BUCKIF	off	No transition	INT1	UV_STAT_APP 1	BUCKIF	
		on	No transition	INT1, INT2	UV_STAT_APP 1	BUCKIF	
		on	No transition	INT1, INT2	UV_STAT_APP 2	BUCKIF	
	Voltage selection error. 1.8 or 3.3 V might be corrupt and not correctly selected.	any	Move to FAILSAFE	RESOUT, SSO1, SSO2 ²⁾	SYSFAIL_STAT_APP1	BUCKIF_VOL TSEL	
		on	Move to FAILSAFE	RESOUT, SSO1, SSO2 ²⁾	SYSFAIL_STAT_APP2	BUCKIF_VOL TSEL	
	Short to ground at BUCKIF	off	No transition	INT1	STG_STAT_AP P1	BUCKIF	
		on	No transition	INT1, INT2	STG_STAT_AP P1	BUCKIF	
		on	No transition	INT1, INT2	STG_STAT_AP P2	BUCKIF	
	PREREG	PREREG short to ground	any	Move to FAILSAFE	RESOUT, SSO1, SSO2 ²⁾	STG_STAT_AP P1	PREREG
			on	Move to FAILSAFE	RESOUT, SSO1, SSO2 ²⁾	STG_STAT_AP P2	PREREG
Severe overvoltage at PREREG & PREREG OV		any	Move to FAILSAFE	RESOUT, SSO1, SSO2 ²⁾	OV_STAT_APP 1	PREREG	
		on	Move to FAILSAFE	RESOUT, SSO1, SSO2 ²⁾	OV_STAT_APP 2	PREREG	
Undervoltage at PREREG		off	No transition	INT1	UV_STAT_APP 1	PREREG	
		on	No transition	INT1, INT2	UV_STAT_APP 1	PREREG	
		on	No transition	INT1, INT2	UV_STAT_APP 2	PREREG	

(table continues...)

10 Monitoring functions

Table 41 (continued) Reaction on detected events of regulators

QCO	QCO OV	any	Move to FAILSAFE	RESOUT, SSO1, SSO2 ²⁾	OV_STAT_APP 1	QCO
		on	Move to FAILSAFE	RESOUT, SSO1, SSO2 ²⁾	OV_STAT_APP 2	QCO
	QCO overtemperature warning	off	No transition	INT1	OT_WRN_OC_STAT_APP1	QCO_OTWRN
		on	No transition	INT1, INT2	OT_WRN_OC_STAT_APP1	QCO_OTWRN
		on	No transition	INT1, INT2	OT_WRN_OC_STAT_APP2	QCO_OTWRN
	QCO thermal shutdown	any	Move to FAILSAFE	RESOUT, SSO1, SSO2 ²⁾	OT_STAT_APP 1	QCO
		on	Move to FAILSAFE	RESOUT, SSO1, SSO2 ²⁾	OT_STAT_APP 2	QCO
	Undervoltage at QCO	off	No transition	INT1	UV_STAT_APP 1	QCO
		on	No transition	INT1, INT2	UV_STAT_APP 1	QCO
		on	No transition	INT1, INT2	UV_STAT_APP 2	QCO
	Short to ground at QCO	off	No transition	INT1	STG_STAT_APP1	QCO
		on	No transition	INT1, INT2	STG_STAT_APP1	QCO
		on	No transition	INT1, INT2	STG_STAT_APP2	QCO
QST	QST OV	any	Move to FAILSAFE	RESOUT, SSO1, SSO2 ²⁾	OV_STAT_APP 1	QST
		on	Move to FAILSAFE	RESOUT, SSO1, SSO2 ²⁾	OV_STAT_APP 2	QST
	QST overcurrent	off	No transition	INT1	OT_WRN_OC_STAT_APP1	QST_OC
		on	No transition	INT1, INT2	OT_WRN_OC_STAT_APP1	QST_OC
		on	No transition	INT1, INT2	OT_WRN_OC_STAT_APP2	QST_OC
	QST undervoltage or Severe undervoltage	any	Move to INIT	RESOUT, SSO1, SSO2	UV_STAT_APP 1	QST
		on	Move to INIT	RESOUT, SSO1, SSO2	UV_STAT_APP 1	QST

(table continues...)

10 Monitoring functions

Table 41 (continued) Reaction on detected events of regulators

	QST short to ground	on	Move to FAILSAFE	RESOUT, SSO1, SSO2 ²⁾	STG_STAT_APP2	QST
	QST BIST errors, severe overvoltage	any	Move to FAILSAFE	RESOUT, SSO1, SSO2 ²⁾	SYSFAIL_STAT_APP1	QST
		on	Move to FAILSAFE	RESOUT, SSO1, SSO2 ²⁾	SYSFAIL_STAT_APP2	QST
	QST short to ground	any	Move to FAILSAFE	RESOUT, SSO1, SSO2 ²⁾	STG_STAT_APP1	QST
QST/QUC	Voltage selection error. 5 V or 3.3 V might be corrupt and not correctly selected.	any	Move to FAILSAFE	RESOUT, SSO1, SSO2 ²⁾	SYSFAIL_STAT_APP1	QST_QUC_V OLTSEL
		on	Move to FAILSAFE	RESOUT, SSO1, SSO2 ²⁾	SYSFAIL_STAT_APP2	QST_QUC_V OLTSEL
QUC	QUC OV	any	Move to FAILSAFE	RESOUT, SSO1, SSO2 ²⁾	OV_STAT_APP1	QUC
		on	Move to FAILSAFE	RESOUT, SSO1, SSO2 ²⁾	OV_STAT_APP2	QUC
	QUC overtemperature warning	off	No transition	INT1	OT_WRN_OC_STAT_APP1	QUC_OTWRN
		on	No transition	INT1, INT2	OT_WRN_OC_STAT_APP1	QUC_OTWRN
		on	No transition	INT1, INT2	OT_WRN_OC_STAT_APP2	QUC_OTWRN
	QUC short to ground	any	Move to FAILSAFE	RESOUT, SSO1, SSO2 ²⁾	STG_STAT_APP1	QUC
		on	Move to FAILSAFE	RESOUT, SSO1, SSO2 ²⁾	STG_STAT_APP2	QUC
	QUC thermal shutdown	any	Move to FAILSAFE	RESOUT, SSO1, SSO2 ²⁾	OT_STAT_APP1	QUC
		on	Move to FAILSAFE	RESOUT, SSO1, SSO2 ²⁾	OT_STAT_APP2	QUC
	QUC undervoltage	any	Move to INIT	RESOUT, SSO1, SSO2	UV_STAT_APP1	QUC
		on	Move to INIT	RESOUT, SSO1, SSO2	UV_STAT_APP1	QUC
QVR	QVR OV	any	Move to FAILSAFE	RESOUT, SSO1, SSO2 ²⁾	OV_STAT_APP1	QVR
		on	Move to FAILSAFE	RESOUT, SSO1, SSO2 ²⁾	OV_STAT_APP2	QVR
	QVR overcurrent	off	No transition	INT1	OT_WRN_OC_STAT_APP1	QVR_OC

(table continues...)

10 Monitoring functions

Table 41 (continued) Reaction on detected events of regulators

		on	No transition	INT1, INT2	OT_WRN_OC_STAT_APP1	QVR_OC
		on	No transition	INT1, INT2	OT_WRN_OC_STAT_APP2	QVR_OC
	Undervoltage at QVR	off	No transition	INT1	UV_STAT_APP 1	QVRUV
		on	No transition	INT1, INT2	UV_STAT_APP 1	QVRUV
		on	No transition	INT1, INT2	UV_STAT_APP 2	QVR
	QVR short to ground	off	No transition	INT1	STG_STAT_AP P1	QVR
		on	No transition	INT1, INT2	STG_STAT_AP P1	QVR
		on	No transition	INT1, INT2	STG_STAT_AP P2	QVR
VMON1	Undervoltage at VMON1	off	No transition	INT1	UV_STAT_APP 1	VMON1
		on	No transition	INT1, INT2	UV_STAT_APP 1	VMON1
		on	No transition	INT1, INT2	UV_STAT_APP 2	VMON1
	VMON1 OV	any	Move to FAILSAFE	RESOUT, SSO1, SSO2 ²⁾	OV_STAT_APP 1	VMON1
		on	Move to FAILSAFE	RESOUT, SSO1, SSO2 ²⁾	OV_STAT_APP 2	VMON1
	Short to ground at VMON1	off	No transition	INT1	STG_STAT_AP P1	VMON1
		on	No transition	INT1, INT2	STG_STAT_AP P1	VMON1
		on	No transition	INT1, INT2	STG_STAT_AP P2	VMON1
VMON2	Undervoltage at VMON2	off	No transition	INT1	UV_STAT_APP 1	VMON2
		on	No transition	INT1, INT2	UV_STAT_APP 1	VMON2
		on	No transition	INT1, INT2	UV_STAT_APP 2	VMON2
	VMON2 OV	any	Move to FAILSAFE	RESOUT, SSO1, SSO2 ²⁾	OV_STAT_APP 1	VMON2

(table continues...)

10 Monitoring functions

Table 41 (continued) **Reaction on detected events of regulators**

		on	Move to FAILSAFE	RESOUT, SSO1, SSO2 ²⁾	OV_STAT_APP2	VMON2
	Short to ground at VMON2	off	No transition	INT1	STG_STAT_APP1	VMON2
		on	No transition	INT1, INT2	STG_STAT_APP1	VMON2
		on	No transition	INT1, INT2	STG_STAT_APP2	VMON2

1) Only for move to INIT

2) Due to move to FAILSAFE also INTx will go low (QUC switched off in FAILSAFE)

(x = 1; 2)

Table 42 **Reaction on detected events of the system**

Module	Event description	REDUCED OPERATION ON/OFF	State transition	IO reaction	Register name	Bitfield name
SSW	Major error detected during SSW BIST or SSW was activated during normal operation	any	Move to FAILSAFE	RESOUT, SSO1, SSO2 ²⁾	SYSFAIL_STAT_APP1	PREREG_COSW
		on	Move to FAILSAFE	RESOUT, SSO1, SSO2 ²⁾	SYSFAIL_STAT_APP2	PREREG_COSW
ENA	ENA signal detected (only when waking up from FAILSAFE, STANDBY or SLEEP)	on	Move into WAKE if device is in SLEEP or within the transition into this state. Else no transition takes place.	INT1 ³⁾ , INT2 ³⁾	WAKE_STAT_APP1	ENA
		on	Move into WAKE if device is in SLEEP or within the transition into this state. Else no transition takes place.	INT1 ³⁾ , INT2 ³⁾	WAKE_STAT_APP2	ENA

(table continues...)

10 Monitoring functions

Table 42 (continued) Reaction on detected events of the system

		off	Move into WAKE or INIT if device is in STANDBY or SLEEP or within the transition into those states. Else no transition takes place.	INT1 ³⁾	WAKE_STAT_APP1	ENA
WAK	WAK signal detected (only when waking up from FAILSAFE, STANDBY or SLEEP)	on	Move into WAKE if device is in SLEEP or within the transition into this state. Else no transition takes place.	INT1 ³⁾ , INT2 ³⁾	WAKE_STAT_APP2	WAK
		on	Move into WAKE if device is in SLEEP or within the transition into this state. Else no transition takes place.	INT1 ³⁾ , INT2 ³⁾	WAKE_STAT_APP1	WAK
		off	Move into WAKE or INIT if device is in STANDBY or SLEEP or within the transition into those states. Else no transition takes place.	INT1 ³⁾	WAKE_STAT_APP1	WAK
WUT	Wake-up timer (WUT) expired and woke up the device (only when waking up from STANDBY or SLEEP)	on	Move into WAKE if device is in SLEEP. Else no transition takes place.	INT2	WAKE_STAT_APP2	WUT
		on	Move into WAKE if device is in SLEEP. Else no transition takes place.	INT1, INT2	WAKE_STAT_APP1	WUT

(table continues...)

10 Monitoring functions

Table 42 (continued) Reaction on detected events of the system

		off	Move into WAKE or INIT if device is in STANDBY or SLEEP. Else no transition takes place.	INT1	WAKE_STAT_APP1	WUT
ERR0	ERR0 monitoring error AND ERR0 recovery is enabled	on	No transition	INT1, INT2	SYS_STAT_APP2	ERR0_ERR
		on	No transition	INT1, INT2	SYS_STAT_APP1	ERR0_ERR
		off	No transition	INT1	SYS_STAT_APP1	ERR0_ERR
	FAILSAFE was entered after ERR0 reported invalid frequency (No recovery enabled or recovery expired)	any	Move to FAILSAFE	RESOUT, SSO1, SSO2 ²⁾	SYSFAIL_STAT_APP1	ERR0
		on	Move to FAILSAFE	RESOUT, SSO1, SSO2 ²⁾	SYSFAIL_STAT_APP2	ERR0
ERR1	ERR1 monitoring error AND ERR1 recovery is enabled (less than t_{REC})	any	No transition	INT1	SYS_STAT_APP1	ERR1_ERR
	ERR1 signal is outside of valid frequencies (if recovery enabled: longer than t_{REC} before being set)	off	Move to INIT	RESOUT, SSO1, SSO2	INIT_ERR_APP1	ERR1
		on	Move to REDUCED OPERATION	INT2 ⁴⁾	INIT_ERR_APP2	ERR1
		on	Move to REDUCED OPERATION	INT1 ⁶⁾ , SSO1	INIT_ERR_APP1	ERR1
ERR2	ERR2 monitoring error AND ERR2 recovery is enabled (less than t_{REC})	on	No transition	INT2	SYS_STAT_APP2	ERR2_ERR
	ERR2 signal is outside of valid frequencies (if recovery enabled: longer than t_{REC} before being set)	on	Move to REDUCED OPERATION	INT2 ⁶⁾ , SSO2	INIT_ERR_APP2	ERR2
		on	Move to REDUCED OPERATION	INT1 ⁴⁾	INIT_ERR_APP1	ERR2

(table continues...)

10 Monitoring functions

Table 42 (continued) Reaction on detected events of the system

FSM	FAILSAFE was entered because INIT timer expired a 3rd time in a row without successful initialization.	any	Move to FAILSAFE	RESOUT, SSO1, SSO2 ²⁾	SYSFAIL_ST AT_APP1	FSM_INITTIMER
		on	Move to FAILSAFE	RESOUT, SSO1, SSO2 ²⁾	SYSFAIL_ST AT_APP2	FSM_INITTIMER
	INIT timer expires 1st time Soft reset issued	off/on	Move to INIT	RESOUT, SSO1, SSO2	INIT_ERR_A PP1	SOFTRES
		on	Move to INIT	RESOUT, SSO1, SSO2	INIT_ERR_A PP2	SOFTRES
	INIT timer expires 2nd time in a row Hard reset issued	off/on	Move to INIT	RESOUT, SSO1, SSO2	INIT_ERR_A PP1	HARDRES
		on	Move to INIT	RESOUT, SSO1, SSO2	INIT_ERR_A PP2	HARDRES
	State transition into low power state (STANDBY or SLEEP) failed/ interrupted (e.g. by WAK or ENA)	off	Move into WAKE or INIT (depending on the transition)	INT1, RESOUT ¹⁾ , SSO1, SSO2	SYS_STAT_APP1	FSM_TRFAIL
	State transition into low power state (STANDBY or SLEEP) failed/ interrupted (e.g. by WAK or ENA)	on	Move into WAKE or INIT (depending on the transition)	INT1, INT2, RESOUT ¹⁾ , SSO1, SSO2	SYS_STAT_APP1	FSM_TRFAIL
		on	Move into WAKE or INIT (depending on the transition)	INT1, INT2, RESOUT ¹⁾ , SSO1, SSO2	SYS_STAT_APP2	FSM_TRFAIL
	State transition not existing or transition conditions not fulfilled.	off	No transition	INT1	SYS_STAT_APP1	FSM_NOOP
		on	No transition	INT1, INT2	SYS_STAT_APP1	FSM_NOOP
		on	No transition	INT1, INT2	SYS_STAT_APP2	FSM_NOOP
WWD1	WWD1 incorrectly triggered and error counter reaches or exceeds threshold	off	Move to INIT	RESOUT, SSO1, SSO2	INIT_ERR_A PP1	WWD1_EC
		on	Move to REDUCED OPERATION	INT2 ⁴⁾	INIT_ERR_A PP2	WWD1_EC
		on	Move to REDUCED OPERATION	INT1 ⁶⁾ , SSO1	INIT_ERR_A PP1	WWD1_EC

(table continues...)

10 Monitoring functions

Table 42 (continued) Reaction on detected events of the system

	WWD1 missed or incorrect service (error counter below threshold)	any	No transition	INT1	SYS_STAT_APP1	WWD1_ERR
WWD2	WWD2 incorrectly triggered and error counter reaches threshold	on	Move to REDUCED OPERATION	INT2 ⁶⁾ , SSO2	INIT_ERR_APP2	WWD2_EC
		on	Move to REDUCED OPERATION	INT1 ⁴⁾	INIT_ERR_APP1	WWD2_EC
	WWD2 missed or incorrect service (error counter below threshold)	on	No transition	INT2	SYS_STAT_APP2	WWD2_ERR
FWD1	FWD1 incorrectly triggered and error counter reaches threshold	off	Move to INIT	RESOUT, SSO1, SSO2	INIT_ERR_APP1	FWD1_EC
		on	Move to REDUCED OPERATION	INT2 ⁴⁾	INIT_ERR_APP2	FWD1_EC
		on	Move to REDUCED OPERATION	INT1 ⁶⁾ , SSO1	INIT_ERR_APP1	FWD1_EC
	FWD1 response missed or incorrectly triggered (error counter below threshold)	any	No transition	INT1	SYS_STAT_APP1	FWD1_ERR
FWD2	FWD2 response missed or incorrectly triggered (error counter below threshold)	on	No transition	INT2	SYS_STAT_APP2	FWD2_ERR
	FWD2 incorrectly triggered and error counter reaches threshold	on	Move to REDUCED OPERATION	INT2 ⁶⁾ , SSO2	INIT_ERR_APP2	FWD2_EC
		on	Move to REDUCED OPERATION	INT1 ⁴⁾	INIT_ERR_APP1	FWD2_EC
INT	Interrupt flags not cleared after t_{INTx_to}	any	No transition	-	IF1	INTMISS
		on	No transition	-	IF2	INTMISS

(table continues...)

10 Monitoring functions

Table 42 (continued) Reaction on detected events of the system

Internal Element	Internal 2V5 rail overvoltage	any	Move to FAILSAFE	RESOUT, SSO1, SSO2 ²⁾	OV_STAT_A PP1	INTSUP_VDD2V 5
		on	Move to FAILSAFE	RESOUT, SSO1, SSO2 ²⁾	OV_STAT_A PP2	INTSUP_VDD2V 5
	Internal 2V5 rail undervoltage	any	Move to FAILSAFE	RESOUT, SSO1, SSO2 ²⁾	UV_STAT_A PP1	INTSUP_VDD2V 5_UV
		on	Move to FAILSAFE	RESOUT, SSO1, SSO2 ²⁾	UV_STAT_A PP2	INTSUP_VDD2V 5_UV
	Internal bias current too high	any	Move to FAILSAFE	RESOUT, SSO1, SSO2 ²⁾	INTSUP_ST AT_APP1	BIAS_HI
		on	Move to FAILSAFE	RESOUT, SSO1, SSO2 ²⁾	INTSUP_ST AT_APP2	BIAS_HI
	Internal bias current too low	any	Move to FAILSAFE	RESOUT, SSO1, SSO2 ²⁾	INTSUP_ST AT_APP1	BIAS_LOW
		on	Move to FAILSAFE	RESOUT, SSO1, SSO2 ²⁾	INTSUP_ST AT_APP2	BIAS_LOW
	Internal error; Always needs to be read when waking up from FAILSAFE (IF register is not being set in FAILSAFE but INTSUP_STAT_AP Px can be set)	off	No transition	INT1	INTSUP_ST AT_APP1	BG12_OV
		off	No transition	INT1	INTSUP_ST AT_APP1	BG12_UV
		off	No transition	INT1	INTSUP_ST AT_APP1	PMU_MAIN
		off	No transition	INT1	INTSUP_ST AT_APP1	PMU_RED
		on	No transition	INT1, INT2	INTSUP_ST AT_APP1	BG12_OV
		on	No transition	INT1, INT2	INTSUP_ST AT_APP1	BG12_UV
		on	No transition	INT1, INT2	INTSUP_ST AT_APP1	PMU_MAIN
		on	No transition	INT1, INT2	INTSUP_ST AT_APP1	PMU_RED
		on	No transition	INT1, INT2	INTSUP_ST AT_APP2	BG12_OV

(table continues...)

10 Monitoring functions

Table 42 (continued) Reaction on detected events of the system

		on	No transition	INT1, INT2	INTSUP_ST AT_APP2	BG12_UV
		on	No transition	INT1, INT2	INTSUP_ST AT_APP2	PMU_MAIN
		on	No transition	INT1, INT2	INTSUP_ST AT_APP2	PMU_RED
	Internal IVCC overvoltage	any	Move to FAILSAFE	RESOUT, SSO1, SSO2 ²⁾	OV_STAT_A PP1	INTSUP_IVCC
		on	Move to FAILSAFE	RESOUT, SSO1, SSO2 ²⁾	OV_STAT_A PP2	INTSUP_IVCC
	Internal IVCC undervoltage or short to ground	any	Move to FAILSAFE	RESOUT, SSO1, SSO2 ²⁾	UV_STAT_A PP1	INTSUP_IVCC_ UV
		on	Move to FAILSAFE	RESOUT, SSO1, SSO2 ²⁾	UV_STAT_A PP2	INTSUP_IVCC_ UV
	Internal IVCC overcurrent	off	No transition	INT1	OT_WRN_O C_STAT_AP P1	IVCC_OC
		on	No transition	INT1, INT2	OT_WRN_O C_STAT_AP P1	IVCC_OC
		on	No transition	INT1, INT2	OT_WRN_O C_STAT_AP P2	IVCC_OC
	Interval IVCC BIST errors, severe overvoltage	any	Move to FAILSAFE	RESOUT, SSO1, SSO2 ²⁾	SYSFAIL_ST AT_APP1	INTSUP_IVCC
		on	Move to FAILSAFE	RESOUT, SSO1, SSO2 ²⁾	SYSFAIL_ST AT_APP2	INTSUP_IVCC
	Double Error detected on a protected register	any	Move to FAILSAFE	RESOUT, SSO1, SSO2 ²⁾	SYSFAIL_ST AT_APP1	CFGE
	Double Error detected on a protected register	on	Move to FAILSAFE	RESOUT, SSO1, SSO2 ²⁾	SYSFAIL_ST AT_APP2	CFGE
	Safety Area	Overtemperature of safety area	any	Move to FAILSAFE	RESOUT, SSO1, SSO2 ²⁾	OT_STAT_A PP1

(table continues...)

10 Monitoring functions

Table 42 (continued) Reaction on detected events of the system

		on	Move to FAILSAFE	RESOUT, SSO1, SSO2 ²⁾	OT_STAT_APP2	SAFETY_AREA
SPI	CRC wrong	off	No transition	INT1	SPI_FAIL_STAT_APP1	CRC
		on	No transition	INT1, INT2	SPI_FAIL_STAT_APP1	CRC
		on	No transition	INT1, INT2	SPI_FAIL_STAT_APP2	CRC
	CSN timeout after 2 ms	off	No transition	INT1	SPI_FAIL_STAT_APP1	CS_TO
		on	No transition	INT1, INT2	SPI_FAIL_STAT_APP1	CS_TO
		on	No transition	INT1, INT2	SPI_FAIL_STAT_APP2	CS_TO
	Frame length wrong	off	No transition	INT1	SPI_FAIL_STAT_APP1	FR_LEN
		on	No transition	INT1, INT2	SPI_FAIL_STAT_APP1	FR_LEN
		on	No transition	INT1, INT2	SPI_FAIL_STAT_APP2	FR_LEN
	Invalid address	off	No transition	INT1	SPI_FAIL_STAT_APP1	ADR
		on	No transition	INT1, INT2	SPI_FAIL_STAT_APP1	ADR
		on	No transition	INT1, INT2	SPI_FAIL_STAT_APP2	ADR
	Lock of protected registers was unsuccessful (will cause the registers to be locked again and made changes are ignored)	off	No transition	INT1	SPI_FAIL_STAT_APP1	LOCK
		on	No transition	INT1, INT2	SPI_FAIL_STAT_APP1	LOCK
		on	No transition	INT1, INT2	SPI_FAIL_STAT_APP2	LOCK
	SPI command woke up the device while in sleep	on	Move into WAKE if device is in SLEEP. Else no transition takes place.	INT1, INT2	WAKE_STAT_APP2	SPI

(table continues...)

10 Monitoring functions

Table 42 (continued) Reaction on detected events of the system

		on	Move into WAKE if device is in SLEEP. Else no transition takes place.	INT1, INT2	WAKE_STAT_APP1	SPI
		off	Move into WAKE if device is in SLEEP. Else no transition takes place.	INT1	WAKE_STAT_APP1	SPI
ABIST	ABIST finished execution	off	No transition	INT1	IF1	ABIST
		on	No transition	INT1, INT2	IF1	ABIST
		on	No transition	INT1, INT2	IF2	ABIST
	Any error that moves the device to FAILSAFE or INIT during an ABIST execution aborts the on-going ABIST and sets this bit.	any	No transition	RESOUT, SSO1, SSO2	SYSFAIL_STAT_APP1	ABIST
		on	No transition	RESOUT, SSO1, SSO2	SYSFAIL_STAT_APP2	ABIST
Application1	Application 1 was reason for entering REDUCED OPERATION	on	Move to REDUCED OPERATION	INT2 ⁴⁾	SYS_STAT_APP2	APP1_FAIL
	INIT timer expired a second time in RED. OP. due to application 1 not being able to reinitialize	on	Move to INIT	RESOUT, SSO2	INIT_ERR_APP1	REDOP_RES2
	INIT timer expired the first time in RED. OP. due to application 1 not being able to reinitialize	on	Move to REDUCED OPERATION	INT1	INIT_ERR_APP1	REDOP_RES1
Application2	Application 2 was reason for entering REDUCED OPERATION	on	Move to REDUCED OPERATION	INT1 ⁴⁾	SYS_STAT_APP1	APP2_FAIL

(table continues...)

10 Monitoring functions

Table 42 (continued) **Reaction on detected events of the system**

INIT timer expired a second time in RED. OP. due to application 2 not being able to reinitialize	on	Move to INIT	RESOUT, SSO1	INIT_ERR_A PP2	REDOP_RES2
INIT timer expired the first time in RED. OP. due to application 2 not being able to reinitialize	on	Move to REDUCED OPERATION	INT2	INIT_ERR_A PP2	REDOP_RES1

1) Only for move to INIT

2) Due to move to FAILSAFE also INTx will go low (QUC switched off in FAILSAFE)

3) Only if BUCKCORE and QUC are on

4) Configurable via SPI

5) Only if REDUCED OPERATION is enabled

6) Application reset

(x = 1; 2)

10.7 Analog built-in self test (ABIST)

10.7.1 Analog built-in self test (ABIST) - overview

The device contains an analog built in self-test function that can be triggered by the microcontroller. It serves the purpose to test the overvoltage and undervoltage comparators for the external and internal voltage rails, as well as the corresponding safety logic. By performing these tests, it can be ensured, that the monitoring works correctly and the warning and safety paths in the system are intact. The device differentiates between the following main configuration for the ABIST:

- Comparators Only (no deglitching)
- Full path including deglitching logic and interrupt generation (INTx)
- Full path including deglitching logic and secondary shutdown path (SSOx)

(x = 1;2)

The configuration for the mentioned tests is done in the registers:

- ABIST_CTRL0
- ABIST_SELECT0
- ABIST_SELECT1
- ABIST_SELECT2

In addition, the device allows specific analog tests, that affect the safety logic directly. For that the register

- ABIST_CTRL1

must be written accordingly.

10 Monitoring functions

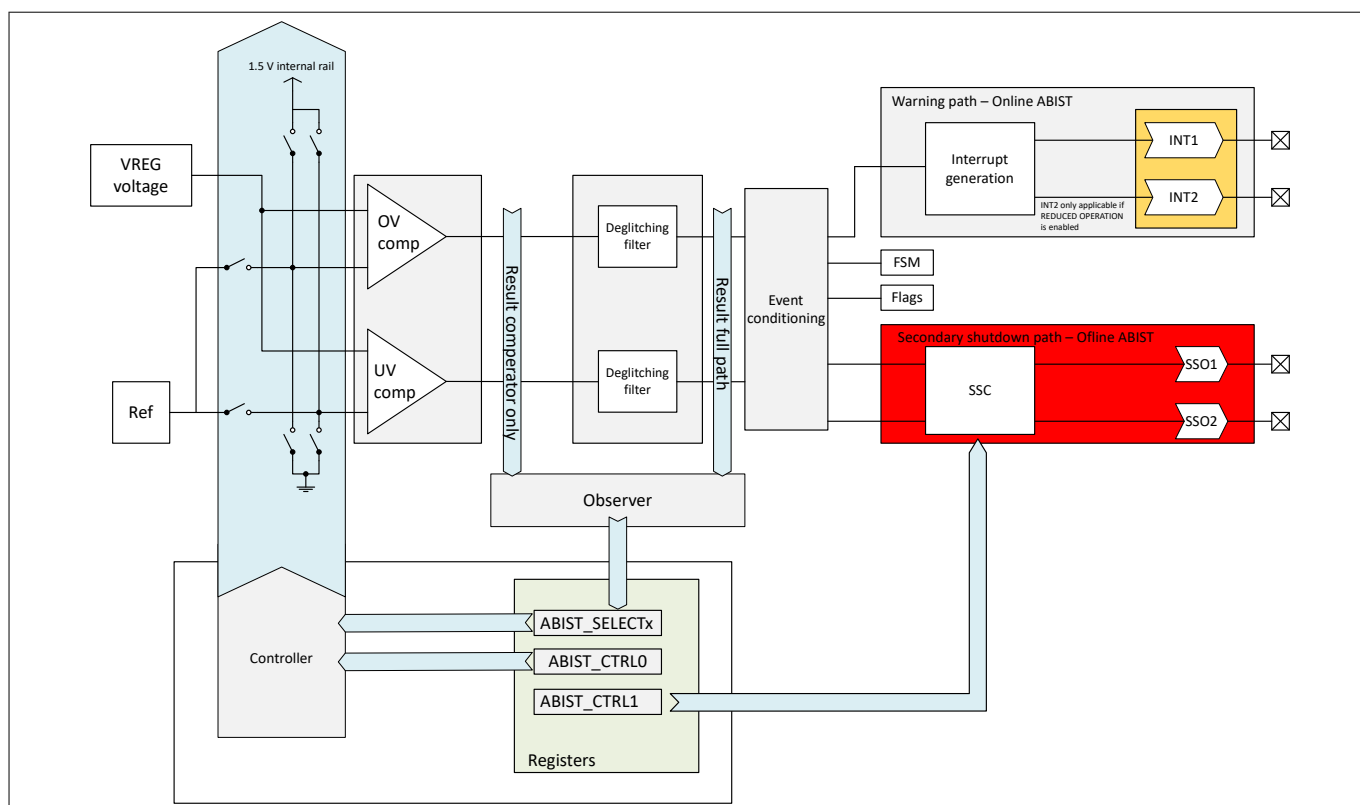


Figure 67 ABIST block diagram

10.7.2 ABIST - comparators only

The device provides the functionality to only test the comparators without the deglitching logic. During the test the overvoltage and undervoltage comparators are forced into error condition, by either connecting the reference input to ground or internal 1.5 V. This condition will only be applied for a time which does not exceed the deglitching logic filter time. Hence the remaining path (warning path, secondary shutdown path) is not tested any further.

10.7.3 ABIST - full path

The device provides the functionality to test the internal overvoltage and undervoltage comparators including the corresponding deglitching logic. This will consequently issue the respective full path as well (warning path, secondary shutdown path). When the full path to test to check SSO1/2 is started, the device must be in NORMAL state. For all other full path test executions the device can also be started in INIT or WAKE. Following the comparators are forced into error condition which is maintained for a time long enough to also trigger the deglitching logic. This will result in a corresponding event for the remaining path. If the test is started in NORMAL a state transition into WAKE will also occur (only for secondary shutdown path comparators, else no transition). Whether an interrupt at INT1/2 or a secondary shutdown path at SSO1/2 is issued, depends on the selection of the comparators, that has been made before the test was started. An overview of the corresponding comparator assignment can be found in the following table:

Table 43 ABIST - Comparator assignment to secondary shutdown path or warning path

Comparator	Secondary shutdown path	Interrupt
PREREG OV	X	
QST OV	X	
QUC OV	X	

(table continues...)

10 Monitoring functions

Table 43 (continued) ABIST - Comparator assignment to secondary shutdown path or warning path

BUCKCORE OV	x	
QCO OV	x	
QVR OV	x	
BUCKIF OV	x	
BOOST OV	x	
VMON1 OV	x	
VMON2 OV	x	
IVCC OV	x	
VDD2V5 OV	*	
PREREG SEVOV	*	
BUCKCORE SEVOV	*	
BUCKIF SEVOV	*	
R3FBL_OPEN	*	
PREREG UV		x
QST UV	x	
QUC UV	x	
BUCKCORE UV	x	
QCO UV		x
QVR UV		x
BUCKIF UV		x
BOOST UV		x
VMON1 UV		x
VMON2 UV		x
IVCC UV	x	
VDD2V5 UV	*	
BSTI UV	*	
BST_DEEP_UV	x	
VBAT OV	x	
BG12 UV		x
BG12 OV		x
BIASLOW	x	
BIASHI	x	
VDD1V5 UV	*	
VDD1V5 OV	*	

(table continues...)

10 Monitoring functions

Table 43 (continued) **ABIST - Comparator assignment to secondary shutdown path or warning path**

VDD5V0 UV	*	
VDD5V0 OV	*	

*) Comparators contribute to the secondary shutdown path but are not testable in full path by the ABIST.

Note: *An interrupt for a single test execution (only one comparator tested) will show two interrupts at the device. One for the comparator test and one for the completion of the test execution. If multiple comparators are tested only one interrupt for test completion will be issued. The SSO1/2 event, as well as the state transition into WAKE from NORMAL takes only place once for each test execution. Meaning, that if a test sequence is being run for the full path, only the first comparator will trigger the state transition and its corresponding full path reaction (secondary shutdown path). All others will simply test the deglitching logic and set the corresponding flags.*

Note: *To see the entire reaction chain for the full path, which includes the trigger of the INT pin or SSO1/2 pin (depending on the selected comparators) as well as the flagging of the respective error or status bits, it must be ensured by the integrator that all affected regulators that shall be tested are also enabled.*

10.7.4 ABIST - configuration and execution

To execute the ABIST the following selections and configurations must be made:

- ABIST_CTRL0:
 - START: Starts the ABIST
 - PATH: determines whether the full path or only the comparators are being tested
 - SINGLE: determines whether only a single comparator or an entire sequence (only the selected comparators in ABIST_SELECT0/1/2) is executed
 - INT: must be configured to select the test either for the warning path (interrupt related comparators) or the secondary shutdown path (SSO1/2 related comparators)
 - STATUS: indicates whether the ABIST has finished with or without errors
 - ALL: if set, all comparators in ABIST_SELECT0/1/2 are automatically selected and the test is executed with PATH = 0 and SINGLE = 0 except BSTI UV comparator
- ABIST_SELECT0/1/2: determines which comparators shall be tested during execution

Note: Integrator must ensure that the bit ABIST_SELECT1.BSTIUV is set to 0, especially before starting any ABIST operation in case an error in BSTI UV is reported

When the execution of the ABIST has finished:

1. An interrupt is issued
2. Check if ABIST_CTRL0.START = 0
3. ABIST without errors: ABIST_CTRL0.STATUS = 0x5
4. ABIST with errors: ABIST_CTRL0.STATUS = 0xA
5. Read ABIST_SELECT0/1/2:
 - 0: Comparator intact
 - 1: Comparator failed test

10.7.5 ABIST - testing the secondary shutdown path logic

In addition to the above described comparator tests, the device provides the option to directly force and hereby test the activation of the secondary shutdown path. This can be done for each SSO1/2 separately and is applied immediately once the register ABIST_CTRL1 is written.

The following tests can be applied by writing ABIST_CTRL1:

10 Monitoring functions

- OV_1V5_TRIG: forces an overvoltage at the internal 1.5 V supply of the secondary shutdown path logic
 - Expected result: SSO1/2 must be activated (pulled low)
- ABIST_CLK_EN: enables the internal clock signal for the SSOx reaction
 - Must be used in combination with the other bits in ABIST_CTRL1. For further references the Safety Manual provides more information.
- SS1_EN_BIST: interrupts the safety clock signal only for SS1
 - Expected result: SSO1 must be activated (pulled low)
- SS2_EN_BIST: interrupts the safety clock signal only for SS2
 - Expected result: SSO2 must be activated (pulled low)

11 Interrupt function (INT)

11 Interrupt function (INT)

11.1 Introduction

The interrupt module is used to inform the microcontroller that a system event has been detected by the device. It is a request to the microcontroller to perform a diagnostic of the device.

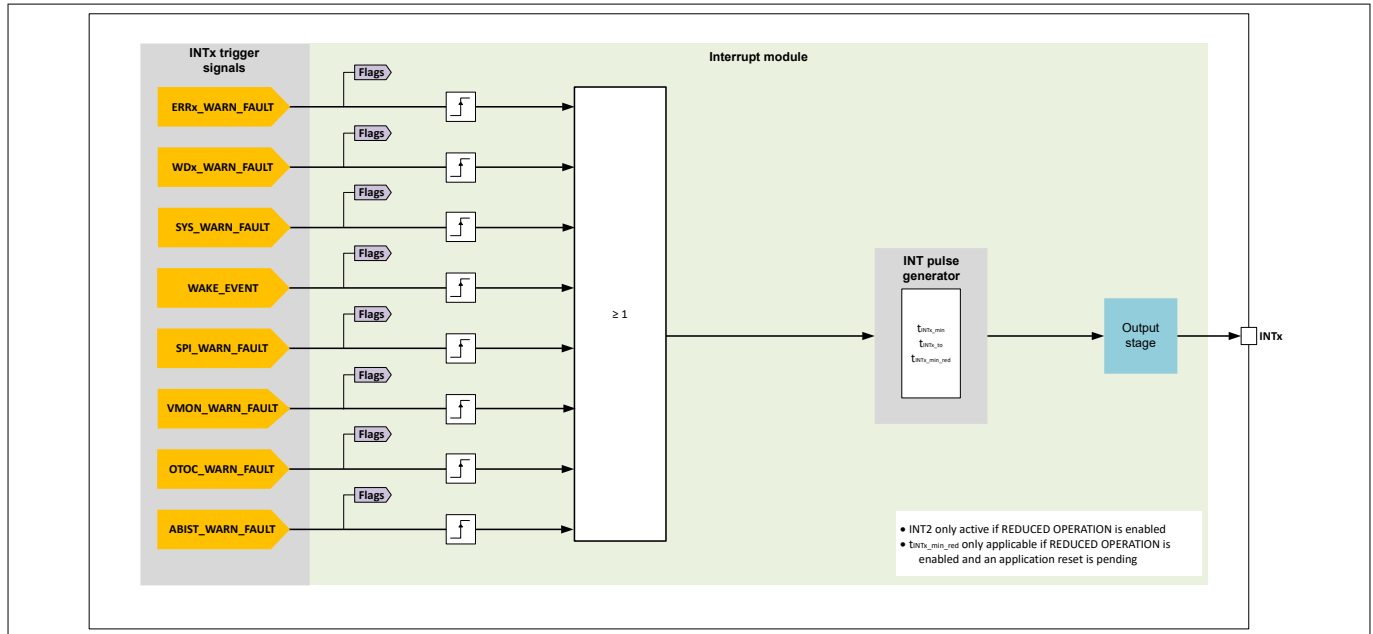


Figure 68 Functional block diagram Interrupt function

The interrupt module provides two interrupt channels.

General occurrences are reported on INT1. If REDUCED OPERATION is enabled, INT1 and INT2 are additionally activated for their application specific error cases (see [Reaction on faults](#)).

Each interrupt pin INTx (x = 1 or 2) is a push-pull stage.

The device can be configured for single application or dual application use cases.

Single Application use case (default configuration):

In this case, any interrupt-triggered signal detection activates the interrupt on the output pin INT1.

Dual Application use case:

Dual applications use case can be activated via SPI by setting the bit **REDOP_PW_CFG1.EN** to 1.

In this case (see [Reaction on faults](#)):

- The detection of the Interrupt-triggered signal on application 1 activates the interrupt on the output pin INT1
- The detection of the Interrupt-triggered signal on application 2 activates the interrupt on the output pin INT2
- The detection of general events is reported at both interrupt lines INT1 and INT2
- The detection of a severe fault (**WD1_SEV_FAULT** or **ERR1_SEV_FAULT**) on application 1 activates an interrupt on the application 2 if SPI bit **REDOP_RS_CFG1.INT2_DIS** is set to 0 (Condition: Device must be in NORMAL or REDUCED OPERATION state)
- The detection of a severe fault (**WD2_SEV_FAULT** or **ERR2_SEV_FAULT**) on application 2 activates an interrupt on the application 1 if SPI bit **REDOP_RS_CFG1.INT1_DIS** is set to 0 (Condition: Device must be in NORMAL or REDUCED OPERATION state)

11 Interrupt function (INT)

11.2 Interrupt activation

The default output value of the interrupt pin is logical high (no interrupt pending). The device activates an interrupt by setting the related interrupt pin to "low".

After the interrupt pin becomes inactive (Interrupt signal transition from "low" to "high"), a minimum active time t_{INTx_to} has to elapse before new interrupt requests can reactivate the pin. The t_{INTx_to} time starts with the next rising edge of the interrupt pin.

The occurrence of an interrupt is latched in a status register and can be read and cleared on a write command via SPI after removing the failure.

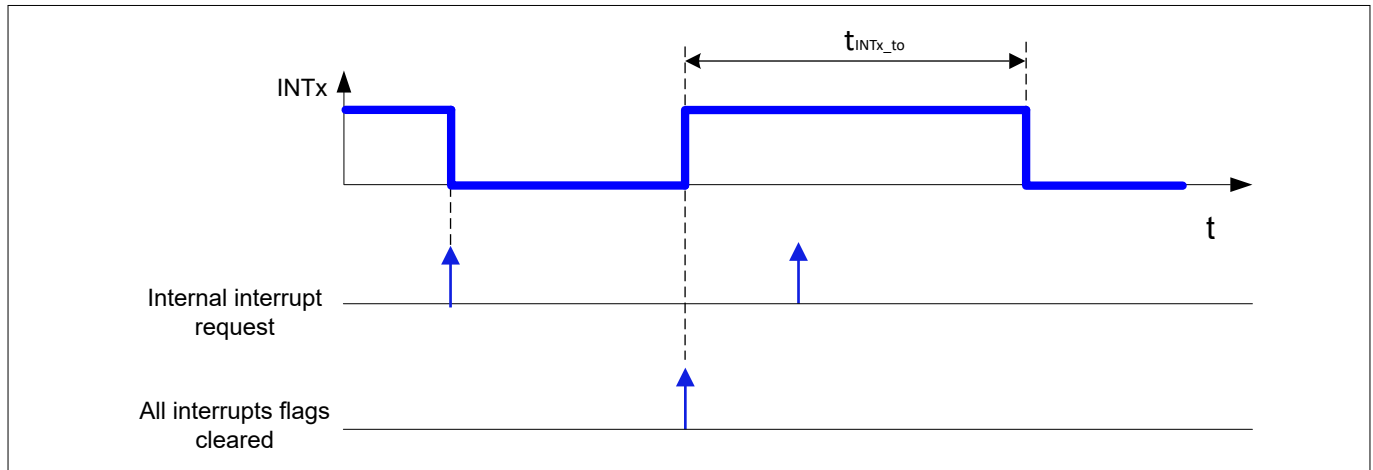


Figure 69 Activation of the interrupt pin INTx (set interrupt pin to logical low)

11.3 Interrupt deactivation

The interrupt will be deactivated and set to logical "high" under the following conditions:

- If all dedicated interrupt flags are cleared after the minimum interrupt pulse width t_{INTx_min} AND before t_{INTx_to} is expired (see figure [deactivating of interrupt by clearing all dedicated interrupt flags](#)).
- If t_{INTx_min} expires, and all interrupt flags have been cleared in time (see figure [deactivating of interrupt by the minimum pulse width if interrupt flags are cleared too early](#)).
- If $t_{INTx_min_red}$ expires and REDUCED OPERATION is enabled while an application reset is pending.
- If t_{INTx_to} expires and not all interrupt flags have been cleared in time (see figure [deactivating of interrupt by \$t_{INTx_to}\$ if interrupt flags cleared too late](#)). In this case a missing interrupt is detected, the bit **IFx.INTMISS** is set and can be clear via SPI.

(x=1,2)

11 Interrupt function (INT)

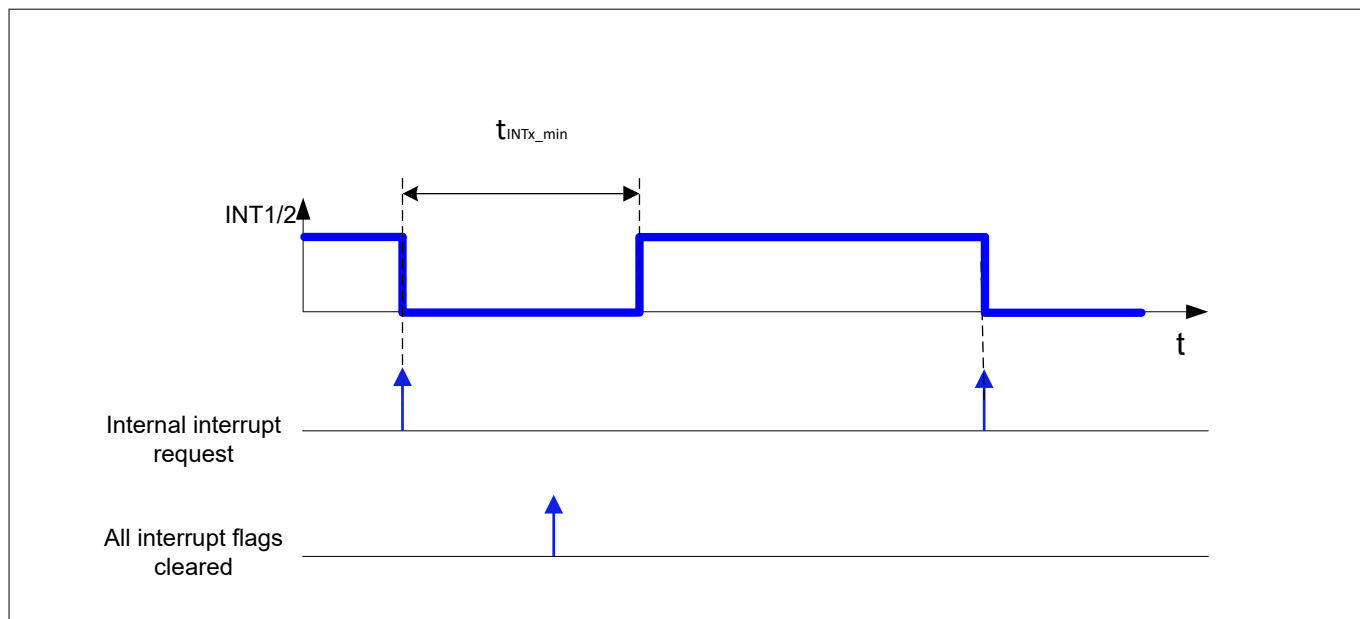


Figure 70 Deactivating of interrupt by the minimum pulse width if interrupt flags are cleared before expiration of t_{INTx_min}

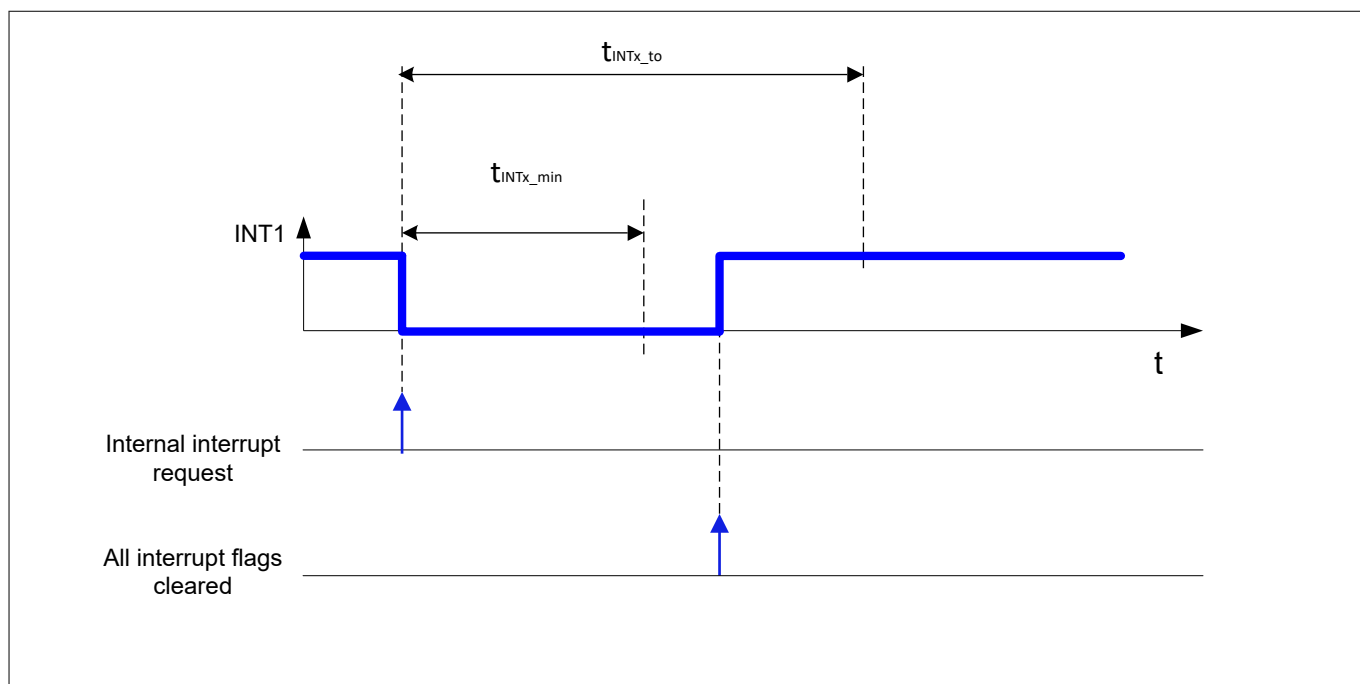


Figure 71 Deactivating of interrupt by clearing all dedicated interrupt flags

11 Interrupt function (INT)

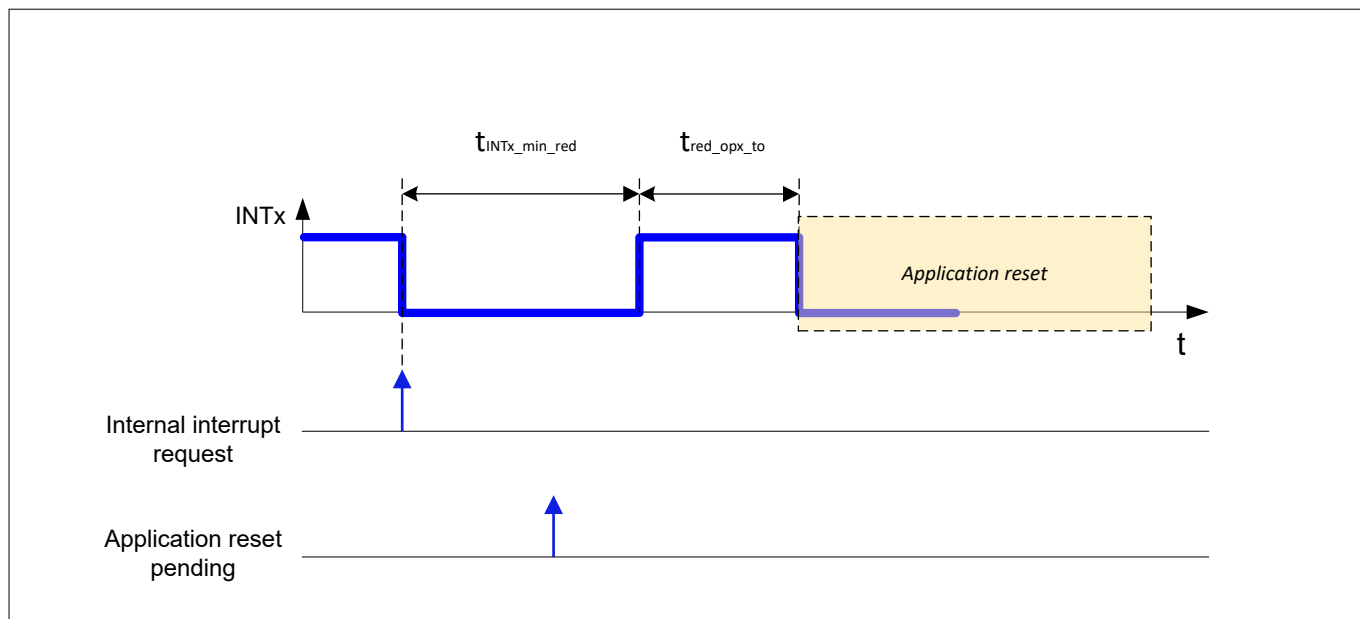


Figure 72 Deactivation of interrupt by pending application reset

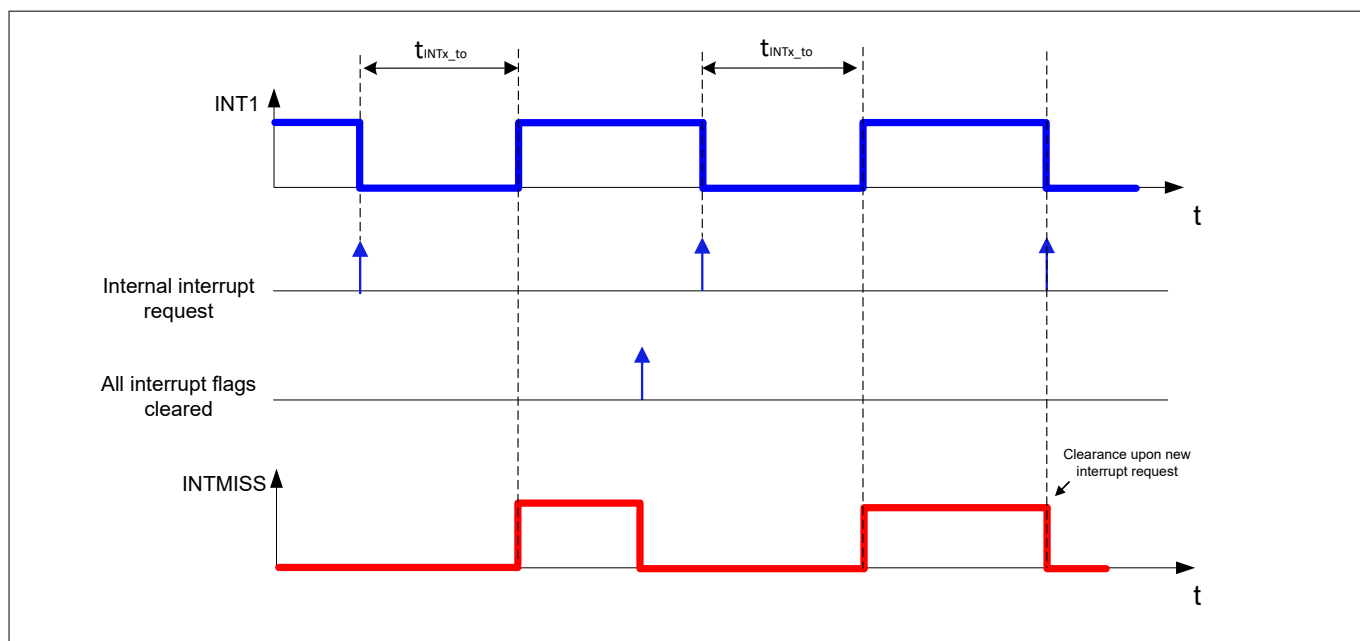


Figure 73 Missed interrupt (Deactivating of interrupt by timeout (t_{INTx_to}) if interrupt flags cleared too late)

11 Interrupt function (INT)

11.4 Electrical characteristics interrupt (INT)

Table 44 Electrical characteristics interrupt (INT)

$V_{VS} = 6.0 \text{ V to } 36 \text{ V}$, $T_j = -40^\circ\text{C to } +175^\circ\text{C}$, all voltages with respect to ground, positive current flowing into pin (unless otherwise specified)

Parameter	Symbol	Values			Unit	Note or condition	P-Number
		Min.	Typ.	Max.			
Output voltage high level	V_{INT_H}	3.15	–	–	V	$V_{QUC} \geq V_{QUC}[\text{Min}]$; $I_{INT} = -7 \text{ mA}$; Parameter applicable to INT1 and SYNC_IN/INT2	DS-1641
Output voltage low level	V_{INT_L}	–	–	0.7	V	$I_{INT} = 5.5 \text{ mA}$; Parameter applicable to INT1 and SYNC_IN/INT2	DS-1643
Pin output rise time	t_{INT_RISE}	–	–	25	ns	$C_{INT,load} = 50 \text{ pF}^{1)}$	DS-1644
Pin output fall time	t_{INT_FALL}	–	–	25	ns	$C_{INT,load} = 50 \text{ pF}^{1)}$	DS-1645
Minimum interrupt pulse width for single application use case	t_{INTx_min}	90	100	150	μs	¹⁾	DS-1646
Interrupt pulse timeout	t_{INTx_to}	270	300	350	μs	¹⁾	DS-1647
Minimum interrupt pulse width for dual application used case - application reset pending	$t_{INTx_min_red}$	50	55	60	μs	¹⁾	DS-1649

1) Not subject to production test, specified by design

12 Reset function (RESOUT)

12 Reset function (RESOUT)

12.1 Functional description reset function (RESOUT)

12.1.1 Introduction

The Reset module is used to reset a group of applications (Application Reset) or to reset the total system (System Reset) based on the configuration and the source of the reset. An application reset is only active if REDUCED OPERATION is enabled.

12 Reset function (RESOUT)

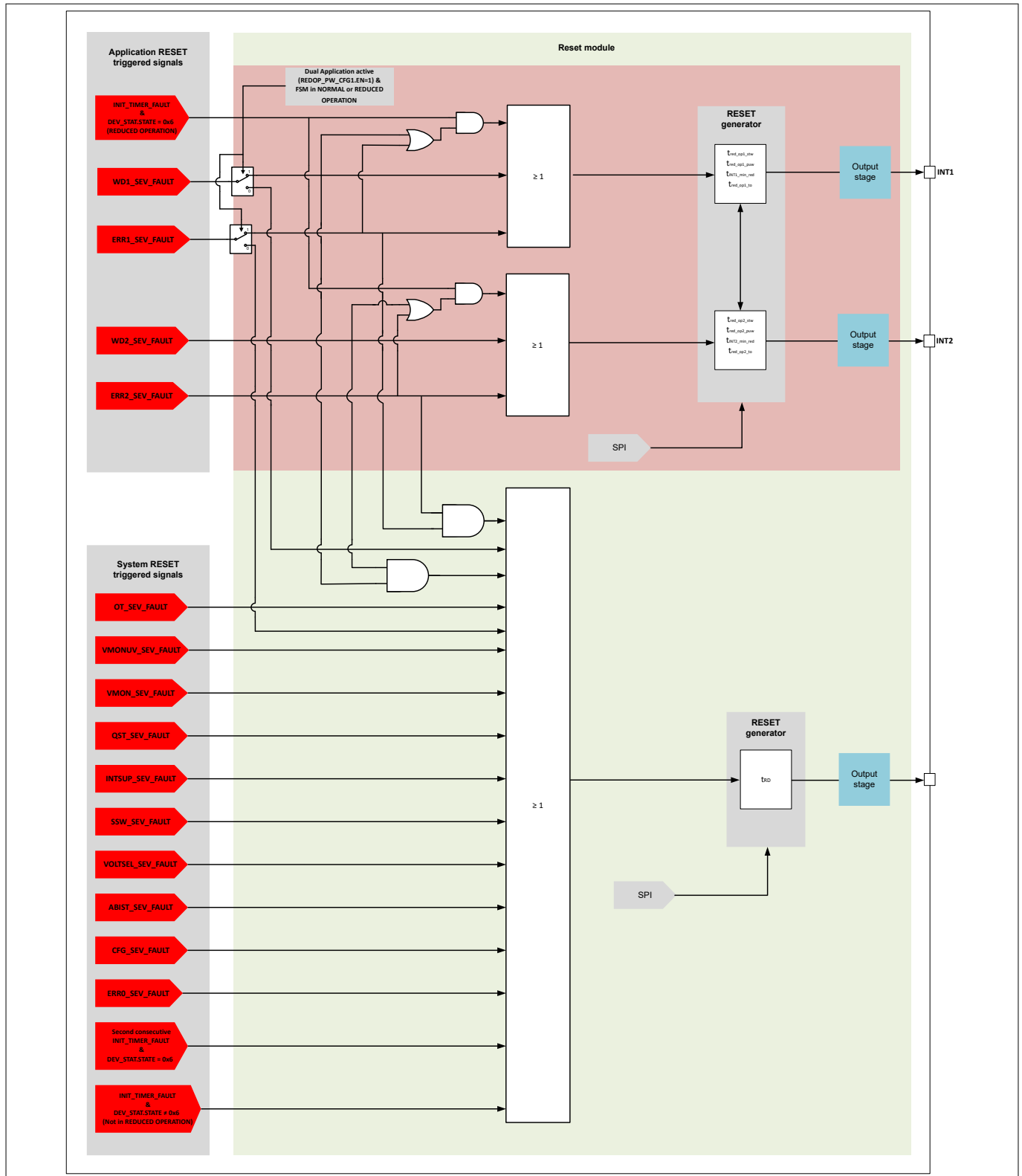


Figure 74 Functional block diagram reset function

The reset module provides following reset channels:

12 Reset function (RESOUT)

- Two channels for application reset. The application reset is activated on the output pins INTx (x = 1 or 2) if an application reset-triggered signal is detected on the related application (valid only for dual application use case (bit **REDOP_PW_CFG1.EN** = 1))
- One channel for system reset. The system reset is activated on the output pin RESOUT if:
 - a system reset-triggered signal is detected
 - an application reset-triggered signal is detected on both applications (valid only for dual application use case **REDOP_PW_CFG1.EN** = 1)

12.1.2 Application Reset (REDUCED OPERATION ENABLE)

12.1.2.1 Activation

The device activates an application reset by generating a "low" pulse on the related interrupt pin (INTx) if one of the following application-reset-triggered signals is detected on the corresponding application:

- A severe fault of the WD or ERRx monitoring(WDx_SEV_FAULT or ERRx_SEV_FAULT), see [application reset activation](#)
- The INIT timer elapses once (INIT_TIMER_FAULT) when the device is in REDUCED OPERATION state (SPI Bitfield **DEV_STAT.STATE** = 0x6), see [application reset activation INIT timer fault](#).

The duration of the pulse length ($t_{red_opx_puw}$) is configurable via SPI and can be calculated with following formula:

	Calculation	$t_{red_opx_stw}$	STEP
Pulse type 1 (default):	$t_{red_opx_puw} = STEP \times t_{red_opx_stw}$	10 μ s (TYP)	1 ... 8
Pulse type 2:	$t_{red_opx_puw} = STEP \times t_{red_opx_stw}$;	100 μ s (TYP)	1 ... 8

$t_{red_opx_stw}$ can be configured via SPI bit **REDOP_RS_CFG2.REDOP_RESOUT_APP_TB**, the default value is 10 μ s and STEP can be configured via SPI bit **REDOP_RS_CFG2.REDOP_RESOUT_APPx_DUR**.

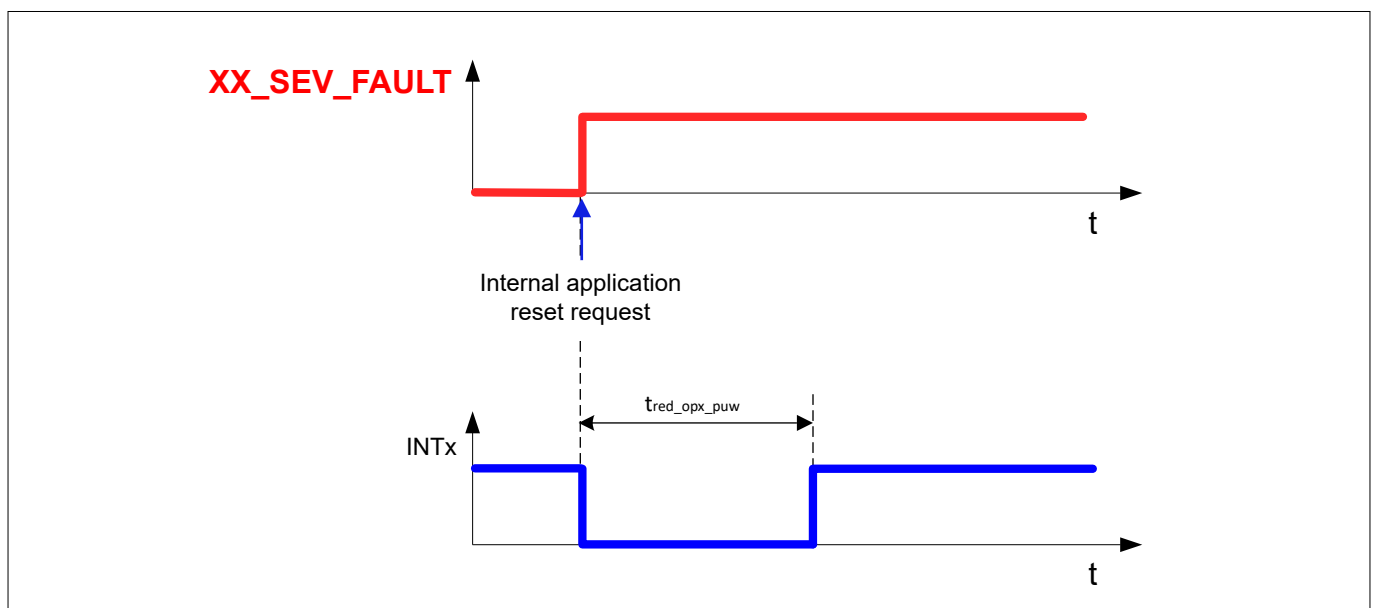


Figure 75 Activation of the application reset due to a severe fault

(xx: ERR1/2 or WD1/2 or INIT timer expiration in combination with one of the modules ERR1/2 or WD1/2)

12 Reset function (RESOUT)

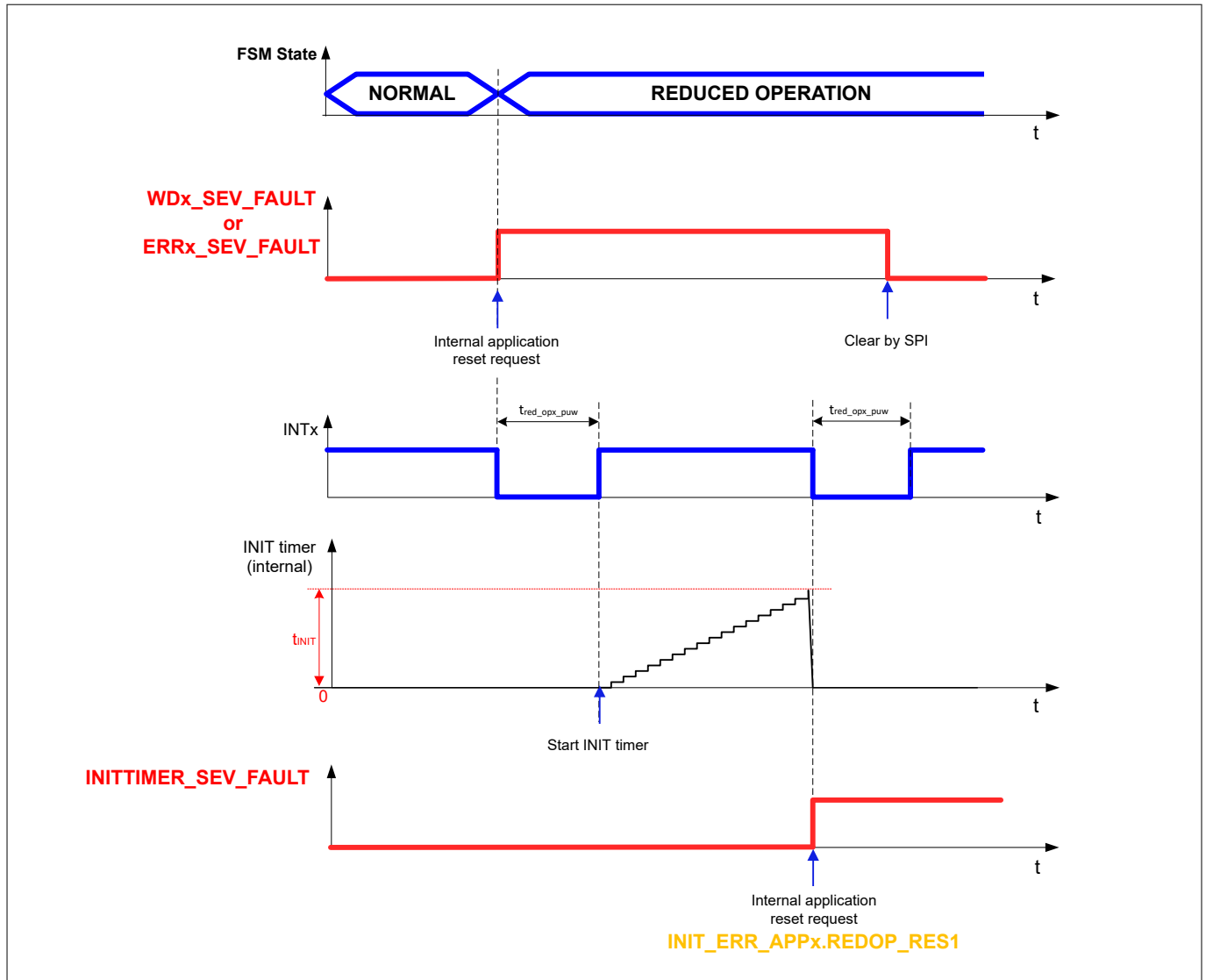


Figure 76 Activation of the application reset due to `INIT_TIMER_FAULT`

(x = 1; 2)

If the application reset is activated when the interrupt is active, the device sequentially:

1. Waits for the minimum interrupt pulse width $t_{INTx_min_red}$
2. Releases the interrupt line and waits for $t_{red_opx_to}$
3. Generates the interrupt pulse with its configurable width $t_{red_opx_puw}$

12 Reset function (RESOUT)

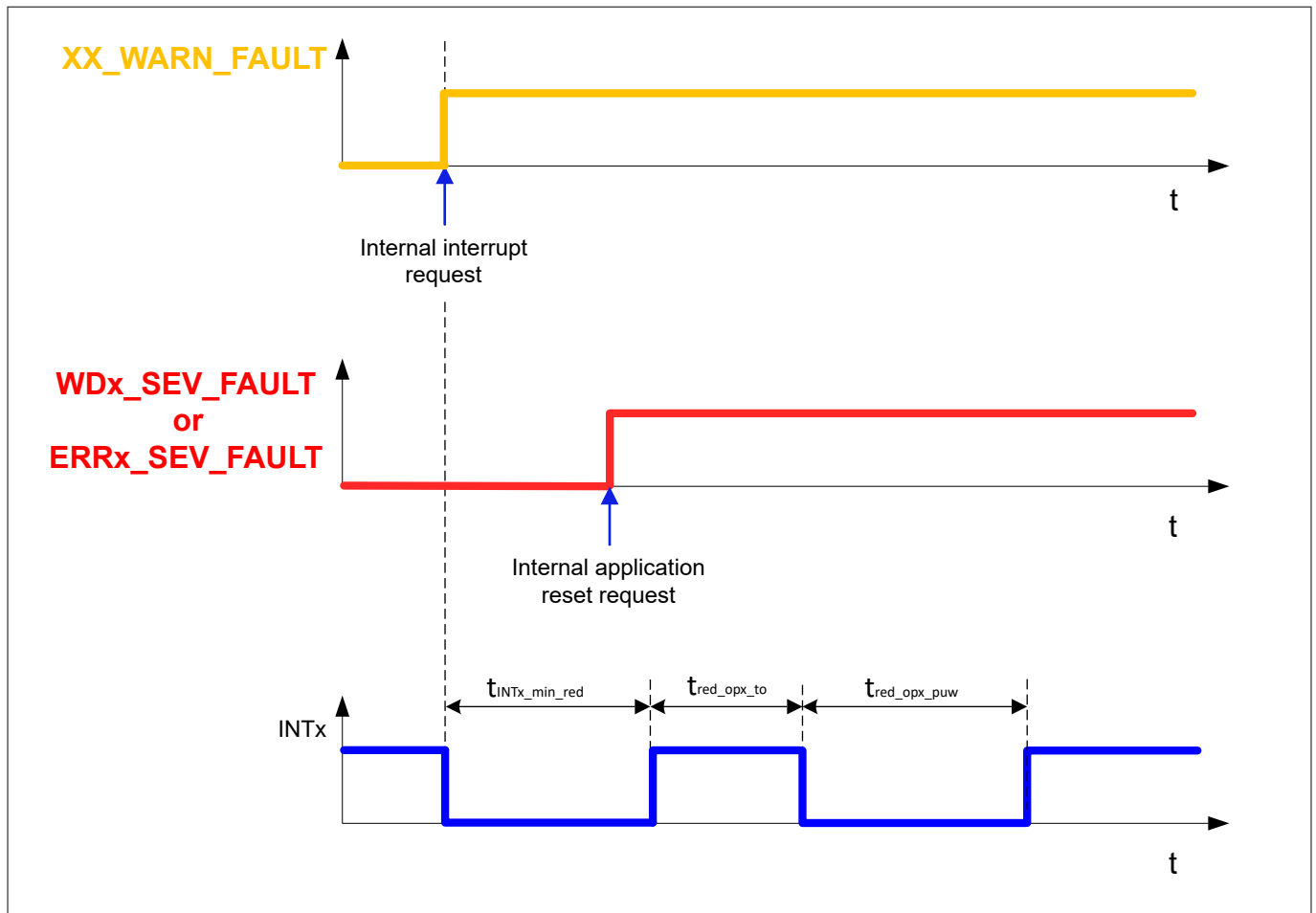


Figure 77 Application reset activation with interrupt active

If the INIT timer elapses **once** in REDUCED OPERATION state, the device:

- generates an INIT_TIMER_FAULT,
- activates a new application reset,
- sets the bit **INIT_ERR_APPx.REDOP_RES1**; which can be clear by SPI after removing the fault.
- remains in REDUCED OPERATION

If the INIT timer elapses **twice** in REDUCED OPERATION state, the device

- generates an INIT_TIMER_FAULT
- activates a system reset
- sets the error bits **INIT_ERR_APP1.REDOP_RES2** and **INIT_ERR_APP2.REDOP_RES2**; which can be clear by SPI after removing the fault.
- moves to INIT state, see [Chapter 9](#).

12.1.3 System Reset

12.1.3.1 Activation

The reset output pin RESOUT is an open drain structure. An internal pull up current (I_{RESOUT_PU}) is pulling the output towards V_{QUC} . As soon as a system reset condition occurs, the device triggers a reset by pulling pin RESOUT below V_{RESOUT_LOW} .

An additional external pull-up resistor can be connected between the RESOUT and V_{QUC} pins to speed up the low-to-high transition.

12 Reset function (RESOUT)

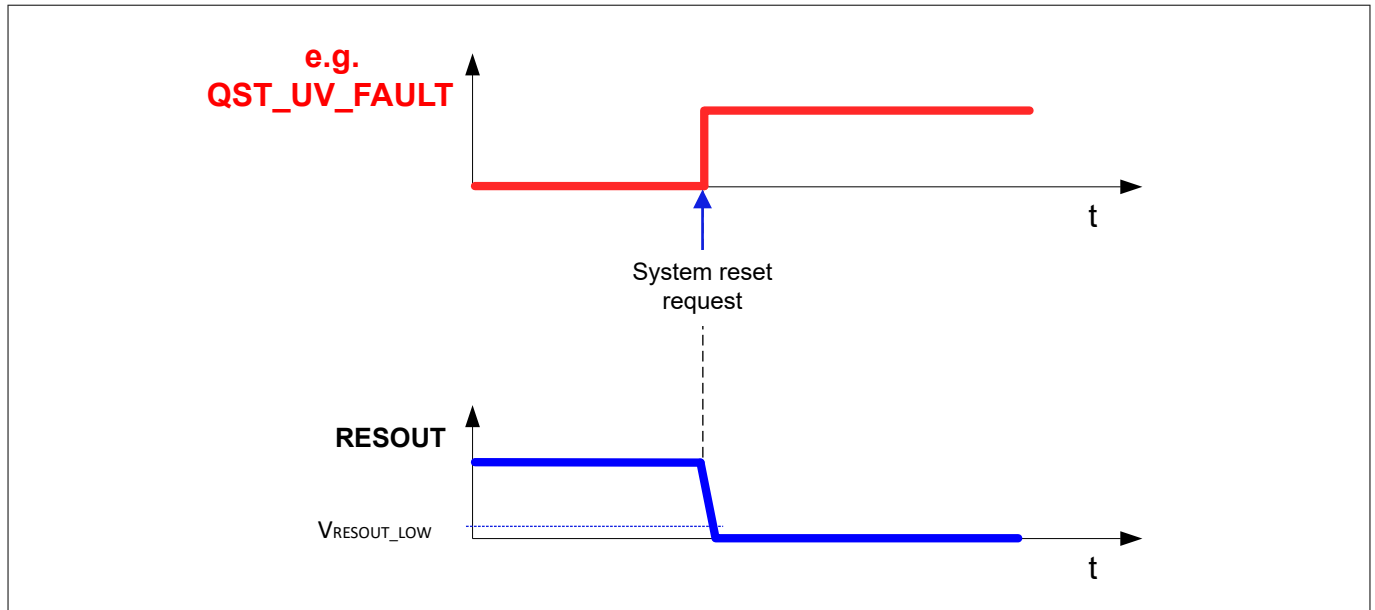


Figure 78 **Activation of a system reset**

12.1.3.2 **Hard and Soft reset**

Definition

Based on the detected system fault, the device generates a **"Soft Reset" (WARM RESET)** or a **"Hard Reset" (COLD RESET)** after entering INIT state, see [Chapter 9](#).

- It is called a **"Soft Reset"** if pin RESOUT goes below $V_{\text{RESOUT_LOW}}$, but the pre and post regulator output voltages are not switched off.
- It is called a **"Hard Reset"** if pin RESOUT goes below $V_{\text{RESOUT_LOW}}$, and all regulator output voltages are switched off.

If the INIT timer elapses **once** in INIT or in WAKE state, the device:

- activates a soft reset
- generates an INIT_TIMER_FAULT
- set the bit **INIT_ERR_APPx.SOFTRES**; which can be clear by SPI
- moves into INIT state, see [Chapter 9](#)

If the INIT timer elapses **second time** in a row in INIT state, the device

- activates a hard reset, all regulator output voltages are switched off
- generates INIT_TIMER_FAULT
- sets the error bit **INIT_ERR_APPx.HARDRES**; which can be clear by SPI after removing the fault
- moves into INIT state, see [Chapter 9](#)

12 Reset function (RESOUT)

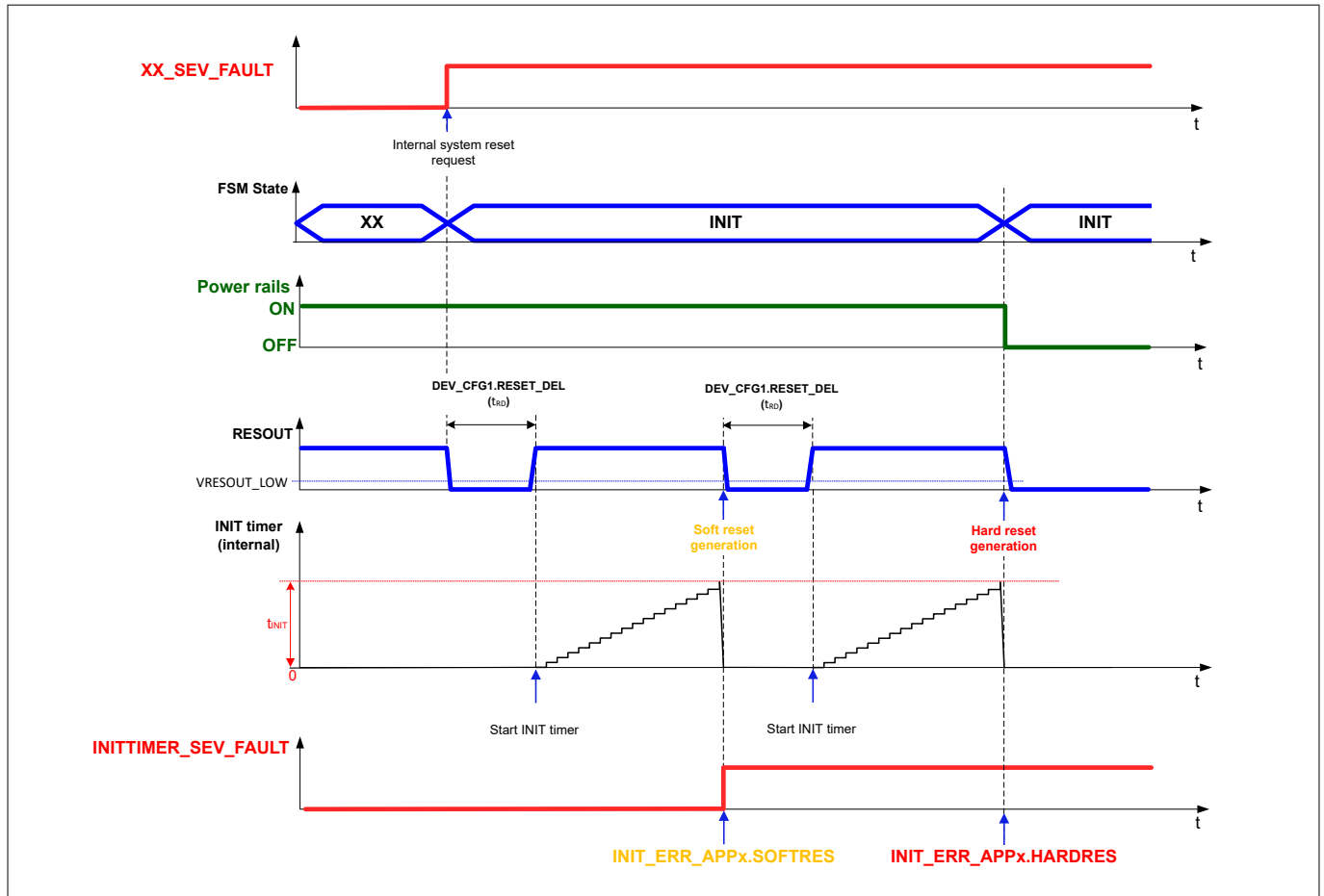


Figure 79 Signal diagram Soft and Hard reset activation

Reset release

After a soft reset generation, the device releases the reset by setting the output pin RESOUT "high" after the reset delay time (t_{RD}).

After a hard reset generation, the device waits for QST, QUC and BUCKCORE to reached their undervoltage threshold during the [power up sequencing schema A](#) or the [power up sequencing schema B](#). Only if this was successful, the device:

1. Waits for the reset delay time t_{RD}
2. Sets the output pin RESOUT "high"

Reset Delay time configuration

Upon starting up from POWERDOWN or STANDBY with WUT and QST disabled, the default value of the reset delay time can be set by hardware, see [HWCFG](#).

The configuration of the reset delay time t_{RD} is configurable during runtime in the register **DEV_CFG1.RESET_DEL**.

12 Reset function (RESOUT)

12.2 Electrical characteristics reset function (RESOUT)

Table 45 Electrical characteristics reset function (RESOUT)

$V_{VS} = 6.0 \text{ V to } 36 \text{ V}$, $T_j = -40^\circ\text{C to } +175^\circ\text{C}$, all voltages with respect to ground, positive current flowing into pin (unless otherwise specified)

Parameter	Symbol	Values			Unit	Note or condition	P-Number
		Min.	Typ.	Max.			
RESOUT start up delay time 2ms	t_{RD_2ms}	1.8	2	2.2	ms	RESOUT start up delay time is set to 2ms by HWCFG ¹⁾	DS-1539
RESOUT start up delay time 10ms	t_{RD_10ms}	9	10	11	ms	RESOUT start up delay time is set to 10ms by HWCFG ¹⁾	DS-1540
Pull-up current	I_{RESOUT_PU}	-180	-55	-15	μA	$V_{RESOUT} \leq 2.0 \text{ V}$	DS-2131
Low level	V_{RESOUT_LOW}	–	–	0.4	V	$V_{QUC} = V_{QUC} [\text{Typ}]$; $I_{RESOUT} = 3.5 \text{ mA}$	DS-1558
REDUCED OPERATION configurable reset step (default)	$t_{red_opx_stw}$	9	10	11	μs	Default configuration ¹⁾	DS-1648
REDUCED OPERATION reset timeout	$t_{red_opx_to}$	9	10	11	μs	¹⁾	DS-1650
Output fall time	t_{RESOUT_FALL}	–	–	25	ns	$C_{RESOUT,load} = 50 \text{ pF}$ ¹⁾	DS-1559

¹⁾ Not subject to production test, specified by design

13 Microcontroller programming support (MPS)

The device includes a Microcontroller Programming Support (MPS) function, during which the following events are masked:

- MCU reset events (RESOUT) due to ERR1/2 pin monitoring reactions
- MCU reset events (RESOUT) due to watchdog reactions
- MCU reset events (RESOUT) due to all INIT timers (including REDUCED OPERATION) expiration reactions (INIT timer is stopped or not started)
- Transition to FAILSAFE due to ERR0 pin monitoring reaction. In case ERR0 is triggered, the device will move to INIT state without generating a reset events

This allows for example a programming of the μ C without interruptions.

Note: *All other faults generates their respective response and other behaviors of the device remain the same.*

The MPS mode can be configured:

- Via hardware by setting the correspondent resistor value as describe in the [HWCFG](#) table
 - The MPS mode selection is refreshed only after a power cycle has been performed
- Via SPI command
 - MPS mode can be enable or disable in all FSM modes (**DEV_CFG1.MPS_EN**).

14 SPI

14 SPI

The Serial Peripheral Interface (SPI) is the communication link between the device and the microcontroller and supports multi-slave operation in full-duplex mode with 32 bit data access. The data transmission starts with the MSB. The clock polarity (CPOL) is 0 and the clock phase (CPHA) is 1.

The SPI uses 4 interface signals for synchronization and data transfer:

- CSN: SPI chip select (active low)
- SCK: SPI clock
- SDI: SPI data input
- SDO: SPI data output

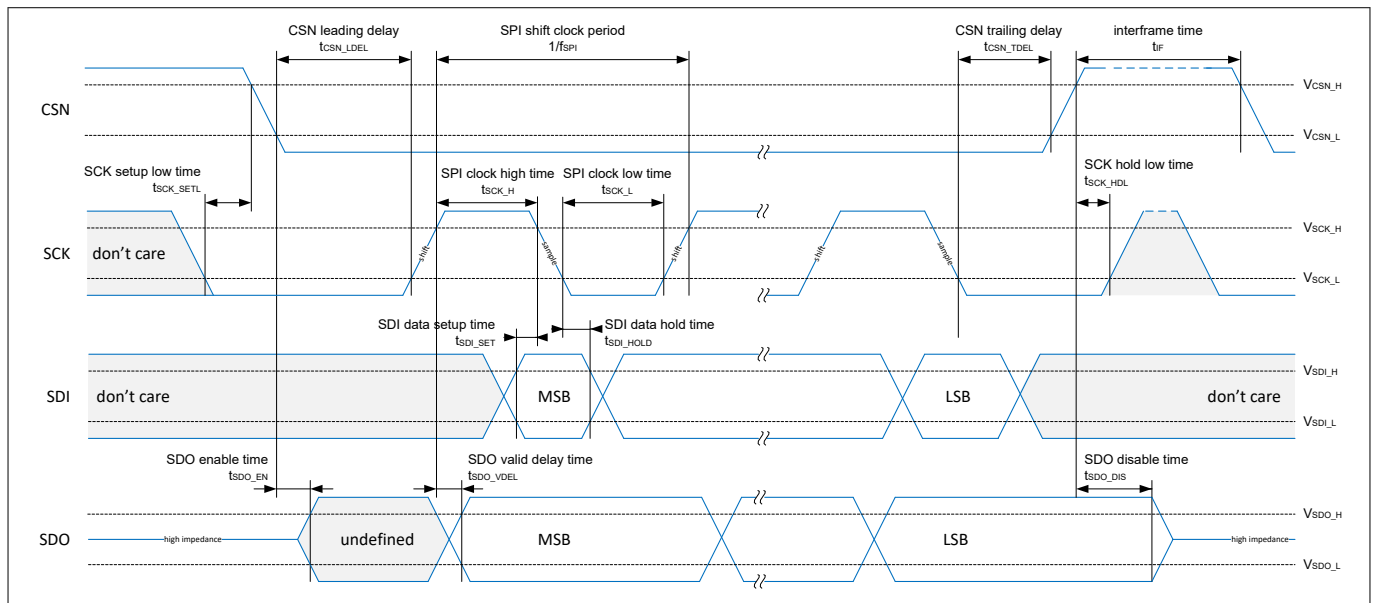


Figure 80 SPI signals

14.1 Functional description SPI

14 SPI

14.1.1 SPI data transfer

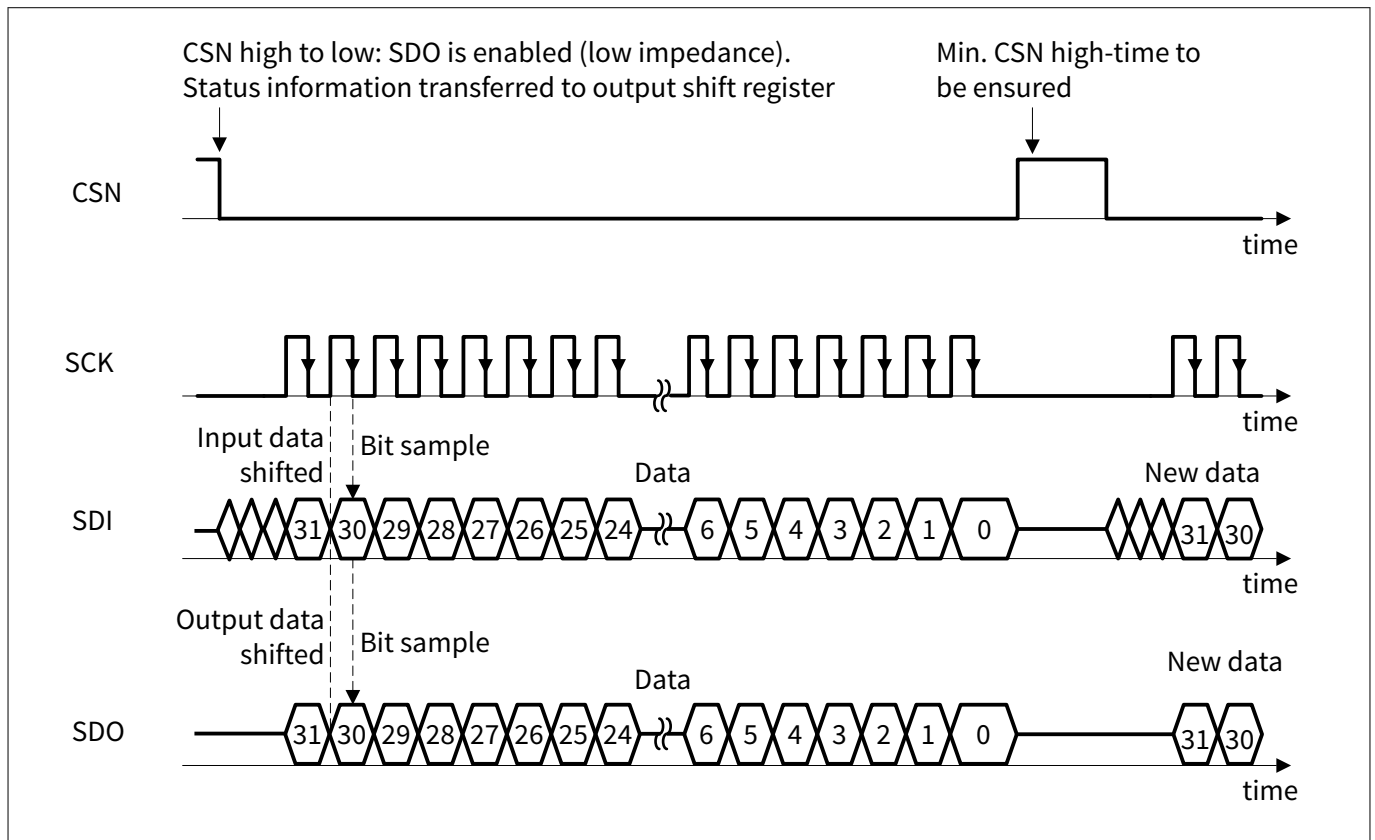


Figure 81 SPI data transfer

The SPI transfer begins when the device is selected by setting the CSN pin to "low". On every SCK rising edge data is shifted in on SDI (MSB first) and respectively shifted out on SDO (MSB first). The data on SDI is sampled on every falling edge of SCK. The SPI transfer is terminated by detecting a "high" signal at CSN. While CSN is at "high" level, SDO is set to high impedance.

The SPI does not support daisy chaining.

14.1.2 SPI frame format

The following section defines the SPI frame formats and defines the SPI service.

14.1.2.1 SPI transfer

An SPI transfer consists of the following frames:

- SDI frame
- SDO frame

After 32 shift clock cycles the device has received the SDI frame and the master (microcontroller) has received the SDO frame. [Figure 82](#) illustrates the structure of an SPI transfer.

14 SPI

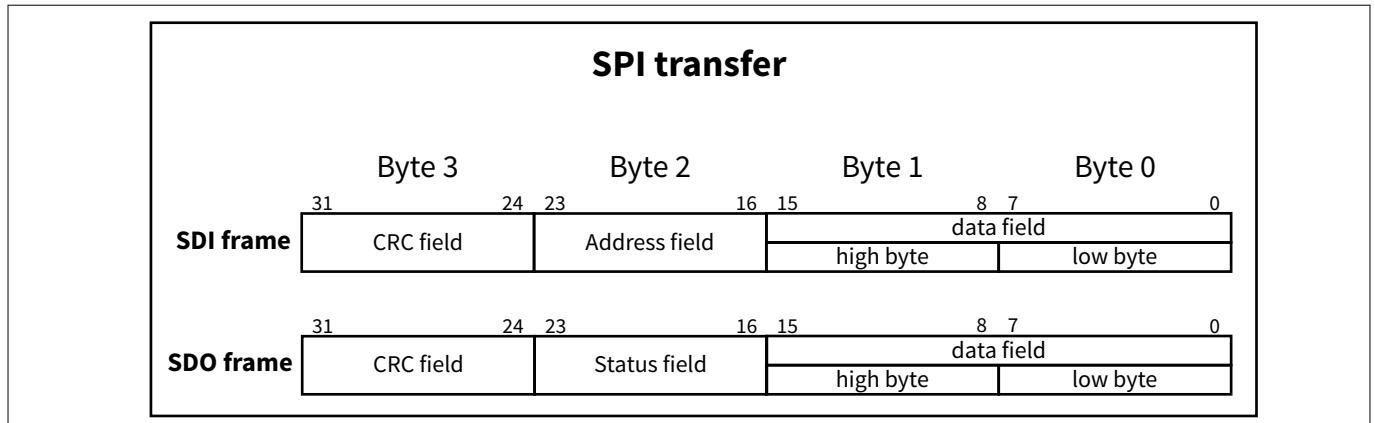


Figure 82 SPI transfer structure

14.1.2.2 SPI service

An SPI service can be a write service or a read service and consists of two SPI transfers. The first SPI transfer (request) contains the request information in the SDI frame which the master (microcontroller) sends to the device. The SDO frame of the first SPI transfer (request) contains the response information of the previous service and is not relevant for the current service. The second SPI transfer (response) contains the response information in the SDO frame. The SDI frame contains the request information of the next service and is not relevant for the current service. [Figure 83](#) shows the structure of the SPI service.

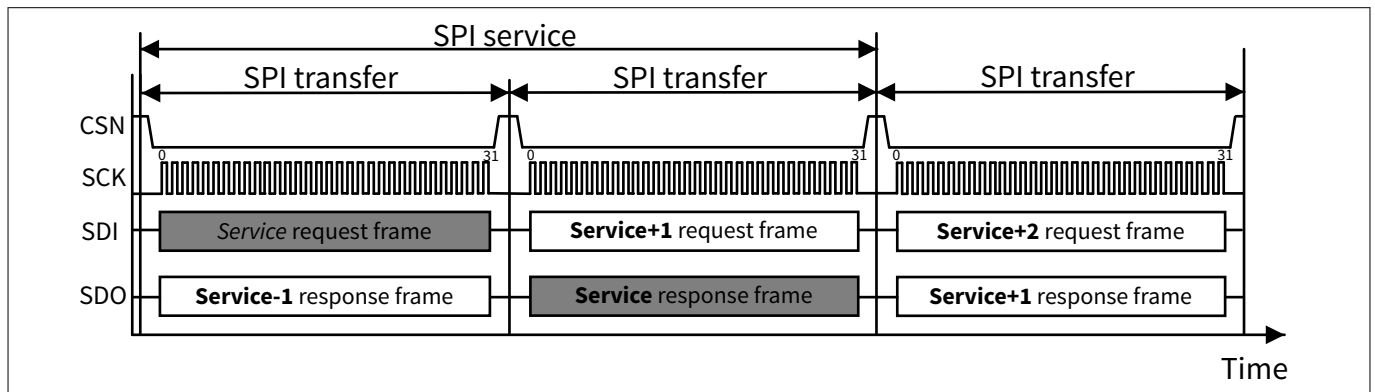


Figure 83 SPI service and transfer definition

14.1.2.3 SPI read service

A read service consists of two SPI transfers (request SPI transfer and response SPI transfer). [Figure 84](#) illustrates the structure of the read service.

Request SPI transfer SDI frame

- CRC field: The calculation process of the CRC value is described in [Chapter 14.1.2.5](#)
- Address field: The value of the address field must be FF_H , which defines a read service
- Data field: The data field contains the address of the register which shall be read

Response SPI transfer SDO frame

- CRC field: The calculation process of the CRC value is described in [Chapter 14.1.2.5](#)
- Status field: The status field is described in [Chapter 14.1.2.6](#)
- Data field: The data field contains the value of the register which was addressed in the request SPI transfer SDI frame

14 SPI

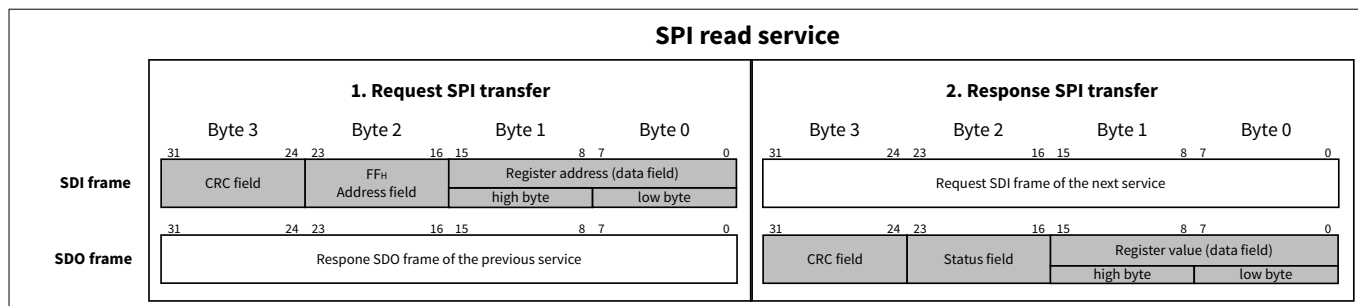


Figure 84 Structure of the read service

14.1.2.4 SPI write service

A write service consist of two SPI transfers (request SPI transfer and response SPI transfer). [Figure 85](#) illustrates the structure of the read service.

Request SPI transfer SDI frame

- CRC field: The calculation process of the CRC value is described in [Chapter 14.1.2.5](#)
- Address field: The address field contains the address to the register which shall be written
- Data field: The data field contains the value which shall be written to the register

Response SPI transfer SDO Frame

- CRC field: The calculation process of the CRC value is described in [Chapter 14.1.2.5](#)
- Status field: The status field is described in [Chapter 14.1.2.6](#)
- Data field: The data field contains the new value of the register after it was written

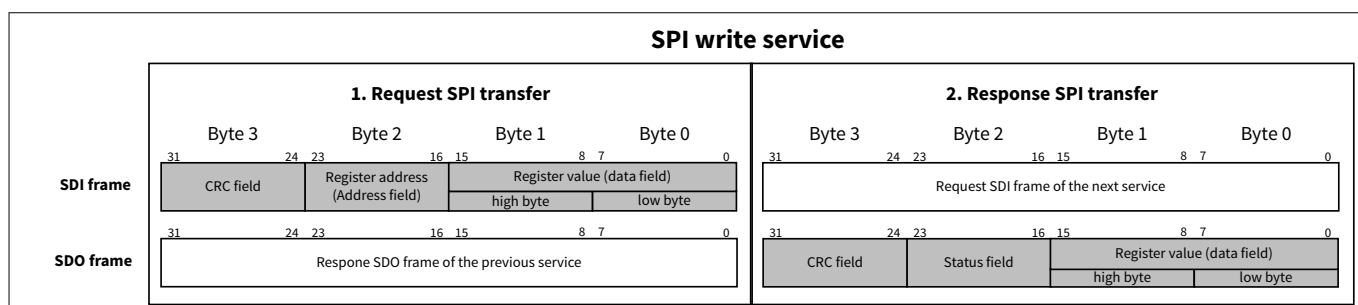


Figure 85 Structure of the SPI write service

14.1.2.5 CRC field

This chapter describes the CRC calculation from the point of view of the microcontroller and of the device. The CRC calculation uses the CRC8 of SAE J1850 standard.

14 SPI

The mathematical background for the CRC8 calculation and algorithm is described in the CRC AUTOSAR specification Version 4.3.1. The following C# example code explains the algorithm for calculating the CRC8.

```
Byte crc8(Byte[] data ,uint length) {
    Byte crc;
    uint i,bit;

    //Initial value must be 0xFF
    crc = 0xFF;
    for ( i=0 ; i<length ; i++ ) {
        crc ^= data[i];
        for ( bit=0 ; bit<8 ; bit++ ) {
            if ( (crc & 0x80)!=0 ) {
                crc <<= 1;
                crc ^= 0x1D; //Polynomial is 0x1D
            }
            else {
                crc <<= 1;
            }
        }
    }

    return (Byte)~crc;
}
```

The microcontroller calculates the CRC in the SDI frame (see [Chapter](#)) and must checks the CRC in the SDO frame (see [Chapter](#)).

The device calculates the CRC in the SDO frame (see [Chapter](#)) and must check the CRC in the SDI frame (see [Chapter](#)).

14.1.2.5.1 CRC microcontroller handling

CRC calculation

The CRC calculation includes the following SDI frame elements ([Figure 86](#)):

- Low byte of the data field
- High byte of the data field
- Address field

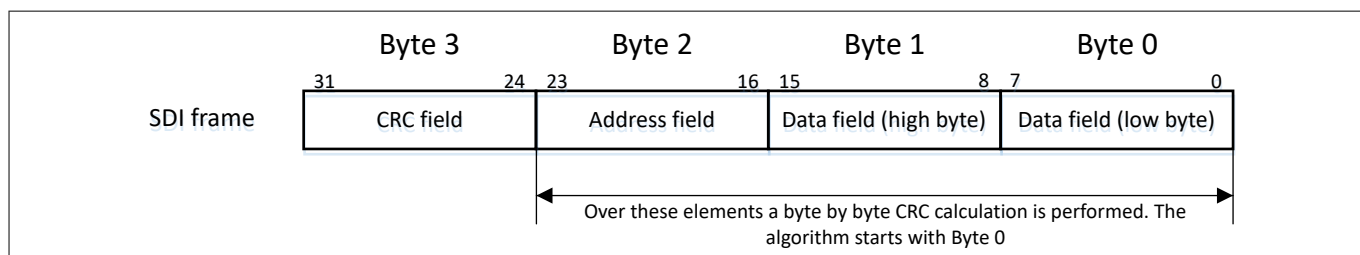


Figure 86 Byte order for SAE J1850 CRC calculation

To write to the register address 83_H the register value 01F2_H, the CRC algorithm (see [Chapter 14.1.2.5](#)) requires the following input parameters:

14 SPI

- Input bytefield parameter data: {F2_H, 01_H, 83_H}
- Input parameter length: 3

The result of the CRC calculation is 37_H. The SDI frame which must be sent from the microcontroller shows [Figure 87](#).

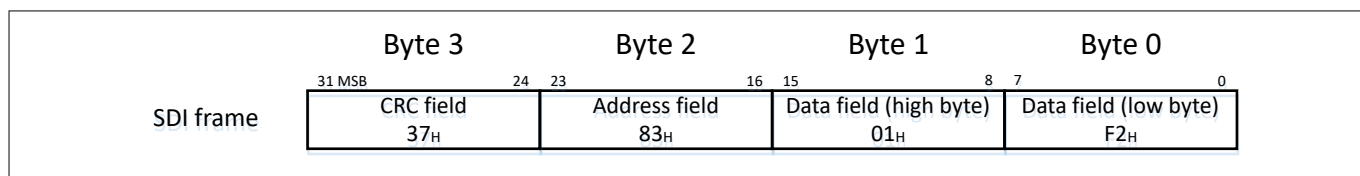


Figure 87 SDI frame example

CRC check

The CRC check includes the following SDO frame elements ([Figure 88](#)):

- Low byte of the data field
- High byte of the data field
- Status field
- CRC field

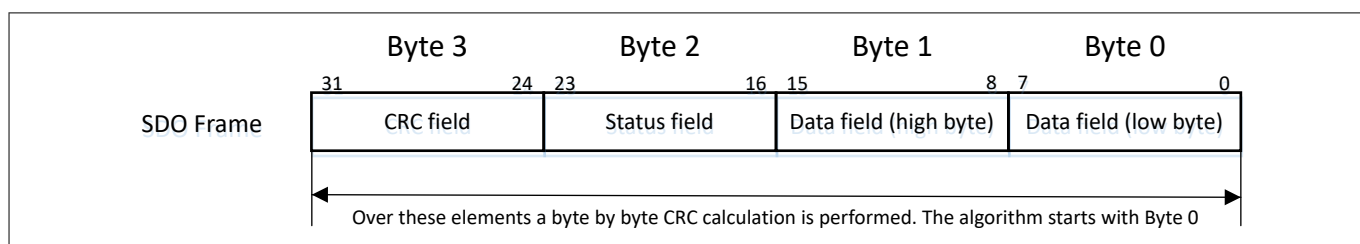


Figure 88 Byte order for SAE J1850 CRC check

Example:

If the microcontroller receives the frame in [Figure 89](#), then the CRC algorithm (see [Chapter 14.1.2.5](#)) requires the following input parameter:

- Input bytefield parameter data: {F2_H, 01_H, 83_H, 37_H}
- Input parameter length: 4

The result of the CRC check must always be 3B_H. Any other value means that the frame is corrupt. The value 3B_H is called magic number in the AUTOSAR CRC specification.

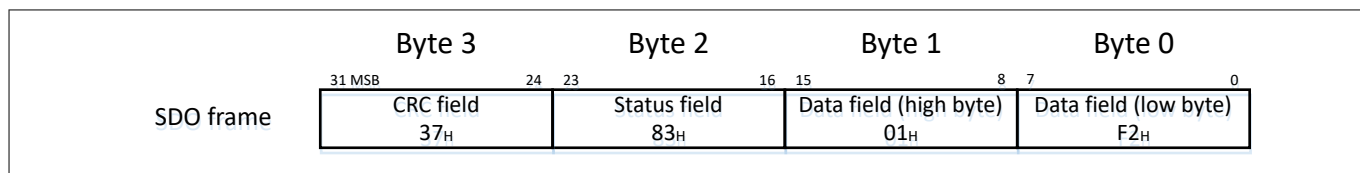


Figure 89 SDO frame example

14.1.2.5.2 CRC device handling

CRC calculation

The CRC calculation includes the following SDO frame elements ([Figure 90](#)):

- Low byte of the data field
- High byte of the data field
- Status field

14 SPI

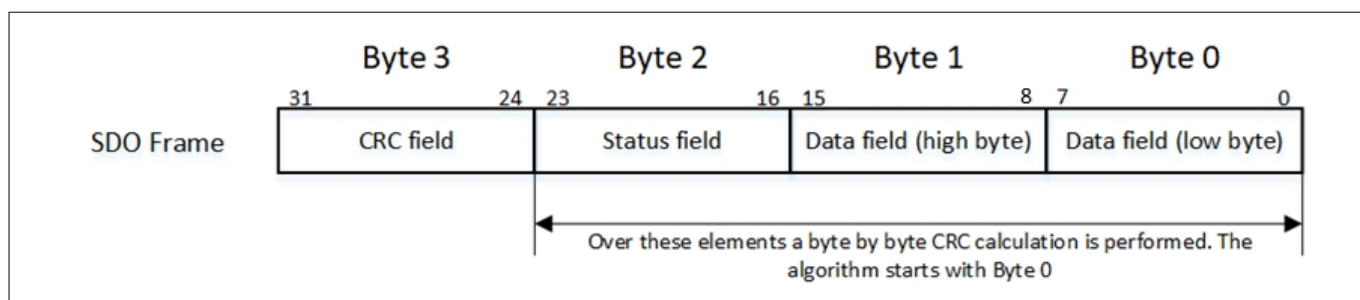


Figure 90 Byte order for SAE J1850 CRC calculation

If the status field has the value 83_H and the data field has the value $01F2_H$, the CRC algorithm (see [Chapter 14.1.2.5](#)) requires the following input parameters:

- Input bytefield parameter data: $\{F2_H, 01_H, 83_H\}$
- Input parameter length: 3

The result of the CRC calculation is 37_H .

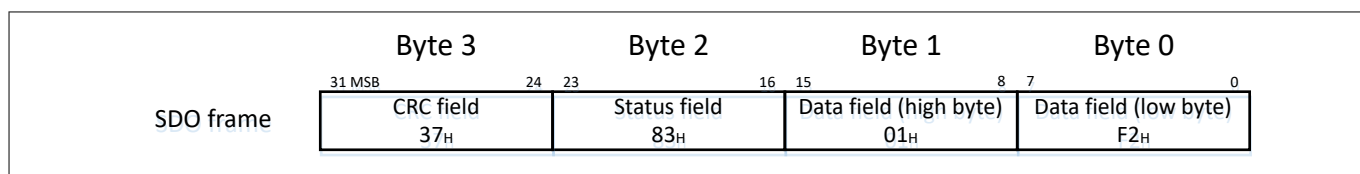


Figure 91 SDO frame example

CRC check

The CRC check includes the following SDI frame elements ([Figure 92](#)):

- Low byte of the data field
- High byte of the data field
- Address field
- CRC field

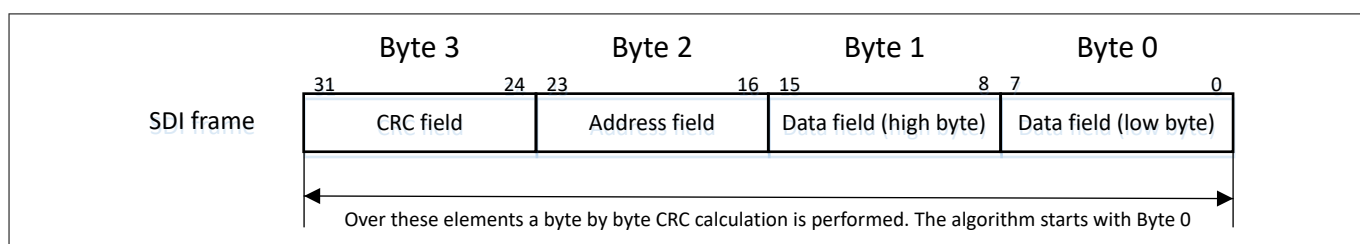


Figure 92 Byte order for SAE J1850 CRC calculation

Example:

If the device receives the frame in [Figure 93](#), then the CRC algorithm (see [Chapter 14.1.2.5](#)) requires the following input parameter:

- Input bytefield parameter data: $\{F2_H, 01_H, 83_H, 37_H\}$
- Input parameter length: 4

The result of the CRC check is always $3B_H$. A different value implies that the frame is corrupt. The value $3B_H$ is called magic number in the AUTOSAR CRC specification.

14 SPI

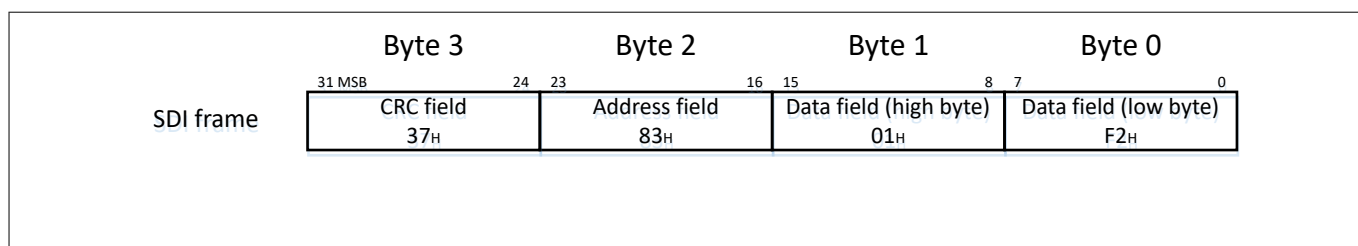


Figure 93 SDI frame example

14.1.2.6 Status field

Figure 94 shows the structure of the status field. The following chapters defines the functionality of the status field bits in detail.

BIT number in the SDI frame of a reponse command							
23	22	21	20	19	18	17	16
Res	LFOK	Can be defined by the product					

Figure 94 Structure of the status field

The device implements the following bit fields in the SDO frame status field bits 21 to 16:

Table 46 Device specific status field

Bit number referred to SDO frame	Bit number referred to status field	Function
[21]	[5]	INTMISS: Flag for interrupt not serviced in time t_{INTx_to}
[20]	[4]	MON: Flag for monitor interrupt (IF1.MON)
[19]	[3]	OTW: Flag for overtemperature warning interrupt (IF1.OTW)
[18]	[2]	CL2ERR: Flag for fault detected on WWD2, FWD2 or ERR2
[17]	[1]	CL1ERR: Flag for fault detected on WWD1, FWD1 or ERR1
[16]	[0]	ERRMISS: Flag for fault detected on any ERR[x]

Note:

The status flag only is updated upon arrival/request of the last frame.

14.1.2.6.1 Last frame OK (LFOK)

Table 47 Last frame OK

Encoding	Description
0 _b	Error encountered in the SDI frame of last request frame
1 _b	Read service or write service successfully executed

The error handling and the reason for an LFOK = 0 are described in [Chapter 14.1.2.7](#).

Note:

It is recommended to check the status of LFOK before processing SPI frame independent of INT

14 SPI

14.1.2.7 Error mechanism

In case a failure happens in the SPI communication (see Table 48), the LFOK bit is set to "0" (see Table 47). In this case the response SPI transfer contains an error code. Figure 95 shows the structure of the response SPI transfer.

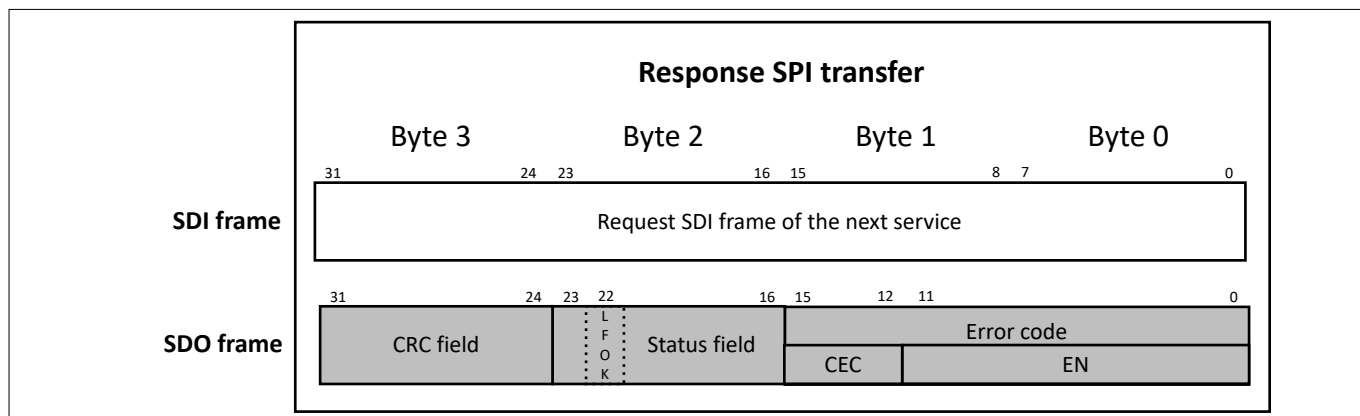


Figure 95 Error response SPI transfer

The error code consists of the following items:

- Communication error code (CEC)
- Error number (EN which is only used for internal usage)

Table 48 SPI communication failure

CEC	Description
0x0	reserved
0x1	Frame error detected - frame frame length invalid of previous SPI communication - frame ignored
0x2	CRC error detected - frame ignored
0x3	reserved
0x4	Access to none existing register (if SPI interframe is >5.2 us) If SPI interframe is <5.2 us an error frame of 0xF1000000 can be responded instead
0x5	reserved
0x6	reserved
0x7	Internal error while accessing a register

Note: In case a communication error code is received which is not listed, contact customer support, please.

14.1.2.8 SPI response with MPS ON

If MPS is enabled and MCU fails servicing ERRs/WDs, the device moves to INIT and performs the initialization sequence with RESOUT high.

Due to the initialization activity after the move to INIT event, there is a window of maximum 75µs, in which the SDO response needs longer (2.5 µs) to be available. If the SPI interframe space is shorter, the response on SDO has a 0xF1000000 error frame ("no data available") when the next SPI frame is transferred, even though the request is executed. Software can implement one out of the following countermeasures to avoid the error frame condition:

- Increase interframe space to 2.5 µs (typ.)

14 SPI

- Make SPI handler robust on receiving the error frame
- If there is a fault injection test on ERRs and WDs it is suggested to avoid SPI communication from the point of fault injection until 75µs after SSO1 decreases. Due to analog delays SSO1 decreases up to 30 µs after the actual move to INIT event.

14.2 Electrical characteristics SPI

Table 49 Electrical characteristics SPI

$V_{VS} = 6.0\text{ V to }36\text{ V}$, $T_j = -40^\circ\text{C to }+175^\circ\text{C}$, all voltages with respect to ground, positive current flowing into pin (unless otherwise specified)

Parameter	Symbol	Values			Unit	Note or condition	P- Number
		Min.	Typ.	Max.			
SPI timing							
SPI frequency	f_{SPI}	–	–	10	MHz	¹⁾	DS-1577
CSN leading delay	$t_{\text{CSN_LDEL}}$	200	–	–	ns	¹⁾	DS-2075
CSN trailing delay	$t_{\text{CSN_TDEL}}$	100	–	–	ns	¹⁾	DS-1579
Interframe time	t_{IF}	1	–	–	μs	CSN rising to CSN falling edge ¹⁾	DS-1580
SCK setup low time	$t_{\text{SCK_SETL}}$	100	–	–	ns	¹⁾	DS-1581
SCK clock high time	$t_{\text{SCK_H}}$	45	–	–	ns	¹⁾	DS-1582
SCK clock low time	$t_{\text{SCK_L}}$	45	–	–	ns	¹⁾	DS-1583
SCK hold low time	$t_{\text{SCK_HDL}}$	100	–	–	ns	¹⁾	DS-1584
SDI data setup time	$t_{\text{SDI_SET}}$	10	–	–	ns	¹⁾	DS-1585
SDI data hold time	$t_{\text{SDI_HOLD}}$	10	–	–	ns	¹⁾	DS-1586
SDO enable time	$t_{\text{SDO_EN}}$	–	–	50	ns	¹⁾	DS-1587
SDO valid delay time (high frequency)	$t_{\text{SDO_VDEL}}$	–	–	136	ns	$C_{\text{SDO,load}} = 50 \text{ pF}$; $f_{\text{SPI}} < 1 \text{ MHz}$ ¹⁾	DS-1588
SDO valid delay time (high frequency)	$t_{\text{SDO_VDEL}}$	–	–	36 + 0.1/ f_{SPI}	ns	$C_{\text{SDO,load}} = 50 \text{ pF}$; $1 \text{ MHz} \leq f_{\text{SPI}} \leq 10 \text{ MHz}$ ¹⁾	DS-1589
SDO disable time	$t_{\text{SDO_DIS}}$	–	–	100	ns	¹⁾	DS-1590
SPI input signal rise time (SDI, SCK, CSN)	$t_{\text{SPI,r}}$	–	–	100	ns	$f_{\text{SPI}} < 1 \text{ MHz}$; Parameter applicable to all SPI input pins SDI, SCK and CSN ¹⁾	DS-1591
SPI input signal rise time (SDI, SCK, CSN)	$t_{\text{SPI,r}}$	–	–	0.1/ f_{SPI}	ns	$1 \text{ MHz} \leq f_{\text{SPI}} \leq 10 \text{ MHz}$; Parameter applicable to all SPI input pins SDI, SCK and CSN ¹⁾	DS-1592
SPI input signal fall time (SDI, SCK, CSN)	$t_{\text{SPI,f}}$	–	–	100	ns	$f_{\text{SPI}} < 1 \text{ MHz}$; Parameter applicable to all SPI input pins SDI, SCK and CSN ¹⁾	DS-1593

(table continues...)

14 SPI

Table 49 (continued) Electrical characteristics SPI

$V_{VS} = 6.0 \text{ V to } 36 \text{ V}$, $T_j = -40^\circ\text{C to } +175^\circ\text{C}$, all voltages with respect to ground, positive current flowing into pin (unless otherwise specified)

Parameter	Symbol	Values			Unit	Note or condition	P-Number
		Min.	Typ.	Max.			
SPI input signal fall time (SDI, SCK, CSN)	$t_{\text{SPI},f}$	–	–	0.1/ f_{SPI}	ns	1 MHz $\leq f_{\text{SPI}} \leq$ 10 MHz; Parameter applicable to all SPI input pins SDI, SCK and CSN ¹⁾	DS-1594
SPI microcontroller interface							
SPI input voltage high level	V_{SPI_H}	3.15	–	V_{QUC}	V	V_{SPI} increasing; $V_{\text{QUC}} \geq V_{\text{QUC}}$ [Min]; Parameter applicable to all SPI input pins SDI, SCK and CSN	DS-1595
SPI input voltage low level	V_{SPI_L}	0	–	0.8	V	V_{SPI} decreasing; Parameter applicable to all SPI input pins SDI, SCK and CSN	DS-1597
SPI input voltage hysteresis	$V_{\text{SPI}_\text{HYS}}$	–	300	–	mV	$V_{\text{QUC}} = V_{\text{QUC}}$ [Typ]; Parameter applicable to all SPI input pins SDI, SCK and CSN	DS-1598
SPI input capacitance	C_{SPI}	–	4	15	pF	Parameter applicable to all SPI input pins SDI, SCK and CSN ¹⁾	DS-1600
CSN pull-up current	I_{CSN}	-180	-55	–	μA	$V_{\text{CSN}} \leq V_{\text{QUC}}$ [Typ] ¹⁾	DS-1601
SCK pull-down current	I_{SCK}	–	135	330	μA	$V_{\text{SCK}} \leq V_{\text{QUC}}$ [Typ] ¹⁾	DS-1602
SDI pull-down current	I_{SDI}	–	135	330	μA	$V_{\text{SDI}} = V_{\text{QUC}}$ ¹⁾	DS-1603
SDO output voltage high level	V_{SDO_H}	3.15	–	–	V	$V_{\text{QUC}} \geq V_{\text{QUC}}$ [Min]; $I_{\text{SDO}} = -7 \text{ mA}$ ¹⁾	DS-1604
SDO output voltage low level	V_{SDO_L}	–	–	0.7	V	$I_{\text{SDO}} = 5.5 \text{ mA}$ ¹⁾	DS-1606
SDO tristate capacitance	C_{SDO}	–	4	15	pF	¹⁾	DS-1607
SDO tristate leakage current	$I_{\text{SDO}_\text{leak}}$	-10	–	10	μA	¹⁾	DS-1608

1) Not subject to production test, specified by design

15 Reset classes

15 Reset classes

There are in total 6 reset classes. Each bitfield is assigned to one of these six reset classes and is reset to its reset value accordingly upon an occurrence of the events listed in the reset class. The reset classes are set up in a way so that the next higher reset class fully includes the lower reset class (for example: R3 contains R2, R2 contains R1,...).

15.1 R0 - Reset class

Bitfields assigned to reset class R0 are reset to their reset value upon occurrence of the following events:

- POR (power on reset, disconnect battery)
- STANDBY no WUT AND no QST active (entering STANDBY state without activating the wake-up timer nor using the standby voltage regulator QST)

15.2 R1 - Reset class

Bitfields assigned to reset class R1 are reset to their reset value upon occurrence of the following events:

- POR
- STANDBY no WUT AND no QST active
- STANDBY

15.3 R2 - Reset class

Bitfields assigned to reset class R2 are reset to their reset value upon occurrence of the following events:

- POR
- STANDBY no WUT AND no QST active
- STANDBY
- FAILSAFE

15.4 R3 - Reset class

Bitfields assigned to reset class R3 are reset to their reset value upon occurrence of the following events:

- POR
- STANDBY no WUT AND no QST active
- STANDBY
- FAILSAFE
- RESOUT pulled low
- INIT (entering INIT state)

15.5 R3_C1 - Reset class

Bitfields assigned to reset class R3_C1 are reset to their reset value upon occurrence of the following events:

- POR
- STANDBY no WUT AND no QST active
- STANDBY
- FAILSAFE
- RESOUT pulled low
- INIT
- REDUCED OPERATION (entering REDUCED OPERATION caused by a application 1 fault)

Registers and bitfields that belong to this reset class are:

- ERR1_RS_CFG

15 Reset classes

- WD1_RS_CFG0
- WD1_RS_CFG1
- FWD1_RS_HBTP_CFG
- WWD1_RS_CW_CFG
- WWD1_RS_OW_CFG
- FWD1_STAT
- WWD1_ECNT_STAT

15.6 R3_C2 - Reset class

Bitfields assigned to reset class R3_C2 are reset to their reset value upon occurrence of the following events:

- POR
- STANDBY no WUT AND no QST active
- STANDBY
- FAILSAFE
- RESOUT pulled low
- INIT
- REDUCED OPERATION (entering REDUCED OPERATION caused by a application 2 fault)

Registers and bitfields that belong to this reset class are:

- ERR2_RS_CFG
- WD2_RS_CFG0
- WD2_RS_CFG1
- FWD2_RS_HBTP_CFG
- WWD2_RS_CW_CFG
- WWD2_RS_OW_CFG
- FWD2_STAT
- WWD2_ECNT_STAT

16 Collection registers, error reporting and clearance of bitfields

The device provides error registers that are being set if respective error events occur (see [Reaction on faults](#)). To simplify the diagnosis procedure collection registers are implemented which bundle a group of error registers and only set one bit in the collection registers. By providing this piece of information it allows the integrator in a first step to only read the collection registers and follow the path of the error report, instead of always reading all error registers. The entire set up is available in a doubled up structure in case REDUCED OPERATION is enabled and two application threads access the information. If REDUCED OPERATION is not used, these doubled up registers are inactive and won't feedback any reliable result.

Failure and error bits are cleared by writing the respective bit with "1". Any other read and write access stays without effect.

In addition, the overview of the error reporting provides the assignment to the error classes used. In general, there is a distinction between a severe fault (xx_SEV_FAULT) and a warning fault (xx_WARN_FAULT).

Severe fault:

A severe fault is associated with a critical event in either the device or the system parameters monitored by the device, that could have caused the application to become unreliable and already is unreliable and must not be allowed to enter normal operation. Depending on the fault several recovery attempts such as a soft reset, a hard reset or a move to FAILSAFE will take place. In any case the signals SSO1/2 will be issued to indicate that the application cannot be assumed to be fully functional and must be brought into a safe state.

Warning fault:

A warning is associated with an event in either the device or the system parameters monitored by the device, which do not directly jeopardise the normal functionality of the application. A warning fault is indicated by issuing an interrupt. The application, however, remains in a normal functionality and no safe state is indicated via SSO1/2.

16.1 Error reporting generating an interrupt

Errors that trigger an interrupt (INT) are collected in the IFx register. Events that are bundled in this registers are listed in the following table.

Table 50 Errors generating an interrupt - Collection register: IF1

IF1 bitfield	Error register	Error class	Error bitfield	Description
SYSFAIL_ERR	SYS_STAT_APP1	ERRx_WARN_FAULT	ERR0_ERR	ERR0 monitoring error AND ERR0 recovery is enabled
			ERR1_ERR	ERR1 monitoring error AND ERR1 recovery is enabled
		WDx_WARN_FAULT	WWD1_ERR	WWD1 missed or incorrect service (error counter below threshold)
			FWD1_ERR	FWD1 response missed or incorrectly triggered (error counter below threshold)
		SYS_WARN_FAULT		

(table continues...)

16 Collection registers, error reporting and clearance of bitfields

Table 50 (continued) Errors generating an interrupt - Collection register: IF1

IF1 bitfield	Error register	Error class	Error bitfield	Description
			FSM_NOOP	State transition not existing or transition conditions not fulfilled.
			FSM_TRFAIL	State transition into low power state (STANDBY or SLEEP) failed/interrupted (e.g. by WAK or ENA)
			BUCKCORE_SVS_NO K	Static voltage scaling not performed due to: - Device being no in INIT or NORMAL - BUCKCORE voltage set to 1.15 V
			BUCKCORE_SVS_OK	Static voltage scaling completed successfully.
			APP2_FAIL	Application 2 was reason for entering REDUCED OPERATION
WUT_EVT	WAKE_STAT_APP1	WAKE_EVENT	ENA	ENA signal detected
			WAK	WAK signal detected
			WUT	Wake-up timer (WUT) expired and woke up the device
			SPI	SPI command woke up the device
SPI_FAIL	SPI_FAIL_STAT_APP1	SPI_WARN_FAULT	LOCK	Lock of protected registers was unsuccessful
			CRC	CRC wrong
			FR_LEN	Frame length wrong
			ADR	Invalid address
			CS_TO	CSN timeout after 2 ms
MON	STG_STAT_APP1	VMON_WARN_FAULT	BUCKIF	Short to ground at BUCKIF BUCKIF is switched off

(table continues...)

16 Collection registers, error reporting and clearance of bitfields

Table 50 (continued) Errors generating an interrupt - Collection register: IF1

IF1 bitfield	Error register	Error class	Error bitfield	Description
			QCO	Short to ground at QCO QCO is switched off
			QVR	Short to ground at QVR QVR is switched off
			VMON1	Short to ground at VMON1 VMON1 rail is disabled
			VMON2	Short to ground at VMON2 VMON2 rail is disabled
	UV_STAT_APP1		PREREG	Undervoltage at PREREG
	BOOST		Undervoltage at BOOST	
	QCO		Undervoltage at QCO	
	BUCKIF		Undervoltage at BUCKIF	
	QVRUV		Undervoltage at QVR	
	VMON1		Undervoltage at VMON1	
	VMON2		Undervoltage at VMON2	
	INTSUP_STAT_APP1		PMU_RED	Internal error; Always needs to be read when waking up from FAILSAFE (IF register is not being set in FAILSAFE but INTSUP_STAT_APPx could have been set)
			PMU_MAIN	Internal error; Always needs to be read when waking up from FAILSAFE (IF register is not being set in FAILSAFE but INTSUP_STAT_APPx could have been set)

(table continues...)

16 Collection registers, error reporting and clearance of bitfields

Table 50 (continued) Errors generating an interrupt - Collection register: IF1

IF1 bitfield	Error register	Error class	Error bitfield	Description
			BG12_OV	Internal error; Always needs to be read when waking up from FAILSAFE (IF register is not being set in FAILSAFE but INTSUP_STAT_APPx could have been set)
			BG12_UV	Internal error; Always needs to be read when waking up from FAILSAFE (IF register is not being set in FAILSAFE but INTSUP_STAT_APPx could have been set)
OT_WRN_OC_ERR	OT_WRN_OC_STAT_APP1	OTOC_WARN_FAULT	IVCC_OC	Internal error
			QST_OC	QST overcurrent
			BUCKCORE_OTWRN	BUCKCORE overtemperature warning
			BUCKIF_OTWRN	BUCKIF overtemperature warning
			BOOST_OTWRN	BOOST overtemperature warning
			BOOST_OC	BOOST overcurrent
			QUC_OTWRN	QUC overtemperature warning
			QCO_OTWRN	QCO overtemperature warning
			QVR_OC	QVR overcurrent
ABIST	-	ABIST_WARN_FAULT	-	ABIST finished execution
INTMISS	-	-	-	Interrupt flags not cleared after tINTx_to

(x = 1; 2)

If REDUCED OPERATION is enabled, also the following bits are set:

16 Collection registers, error reporting and clearance of bitfields

Table 51 Errors generating an interrupt - Reduced Operation - Collection register: IF2

IF2 bitfield	Error register	Error class	Error bitfield	Description
SYSFAIL_ERR	SYS_STAT_APP2	ERRx_WARN_FAULT	ERR0_ERR	ERR0 monitoring error
			ERR2_ERR	ERR2 monitoring error AND ERR2 recovery is enabled
		WDx_WARN_FAULT	WWD2_ERR	WWD2 missed or incorrect service (error counter below threshold)
			FWD2_ERR	FWD2 response missed or incorrectly triggered (error counter below threshold)
		SYS_WARN_FAULT	FSM_NOOP	State transition not existing or transition conditions not fulfilled.
			FSM_TRFAIL	State transition into low power state (STANDBY or SLEEP) failed/interrupted (e.g. by WAK or ENA)
			BUCKCORE_SVS_NO K	Static voltage scaling not performed due to: - Device being not in INIT or NORMAL - BUCKCORE voltage set to 1.15 V
			BUCKCORE_SVS_OK	Static voltage scaling completed successfully.
			APP1_FAIL	Cluster 1 was reason for entering REDUCED OPERATION
WUT_EVT	WAKE_STAT_APP2	WAKE_EVENT	ENA	ENA signal detected
			WAK	WAK signal detected
			WUT	Wake-up timer (WUT) expired and woke up the device

(table continues...)

16 Collection registers, error reporting and clearance of bitfields

Table 51 (continued) Errors generating an interrupt - Reduced Operation - Collection register: IF2

IF2 bitfield	Error register	Error class	Error bitfield	Description
			SPI	SPI command woke up the device
SPI_FAIL	SPI_FAIL_STAT_APP2	SPI_WARN_FAULT	LOCK	Lock of protected registers was unsuccessful
			CRC	CRC wrong
			FR_LEN	Frame length wrong
			ADR	Invalid address
			CS_TO	CSN timeout after 2 ms
MON	STG_STAT_APP2	VMON_WARN_FAULT	BUCKIF	Short to ground at BUCKIF BUCKIF is switched off
			QCO	Short to ground at QCO QCO is switched off
			QVR	Short to ground at QVR QVR is switched off
			VMON1	Short to ground at VMON1 VMON1 rail is disabled
			VMON2	Short to ground at VMON2 VMON2 rail is disabled
	UV_STAT_APP2	VMON_WARN_FAULT	PREREG	Undervoltage at PREREG
			BOOST	Undervoltage at BOOST
			QCO	Undervoltage at QCO
			BUCKIF	Undervoltage at BUCKIF
			QVR	Undervoltage at QVR
			VMON1	Undervoltage at VMON1
			VMON2	Undervoltage at VMON2

(table continues...)

16 Collection registers, error reporting and clearance of bitfields

Table 51 (continued) **Errors generating an interrupt - Reduced Operation - Collection register: IF2**

IF2 bitfield	Error register	Error class	Error bitfield	Description
	INTSUP_STAT_APP2		PMU_RED	Internal error; Always needs to be read when waking up from FAILSAFE (IF register is not being set in FAILSAFE but INTSUP_STAT_APPx could have been set)
			PMU_MAIN	Internal error; Always needs to be read when waking up from FAILSAFE (IF register is not being set in FAILSAFE but INTSUP_STAT_APPx could have been set)
			BG12_OV	Internal error; Always needs to be read when waking up from FAILSAFE (IF register is not being set in FAILSAFE but INTSUP_STAT_APPx could have been set)
			BG12_UV	Internal error; Always needs to be read when waking up from FAILSAFE (IF register is not being set in FAILSAFE but INTSUP_STAT_APPx could have been set)
OT_WRN_OC_ERR	OT_WRN_OC_STAT_APP2	OTOC_WARN_FAULT	IVCC_OC	Internal error
			QST_OC	QST overcurrent
			BUCKCORE_OTWRN	BUCKCORE overtemperature warning
			BUCKIF_OTWRN	BUCKIF overtemperature warning
			BOOST_OTWRN	BOOST overtemperature warning

(table continues...)

16 Collection registers, error reporting and clearance of bitfields

Table 51 (continued) **Errors generating an interrupt - Reduced Operation - Collection register: IF2**

IF2 bitfield	Error register	Error class	Error bitfield	Description
			BOOST_OC	BOOST overcurrent
			QUC_OTWRN	QUC overtemperature warning
			QCO_OTWRN	QCO overtemperature warning
			QVR_OTWRN	QVR overcurrent
ABIST	-	ABIST_WARN_FAULT	-	ABIST finished execution
INTMISS	-	-	-	Interrupt flags not cleared after tINTx_to

(x = 1; 2)

16.2 Error reporting causing a move to INIT or REDUCED OPERATION

Errors that trigger a move to INIT usually also trigger a reset (RESOUT) and are collected in the INIT_ERR_APPx register. Events that are bundled in this registers are listed in the following table. For MPS (see [Microcontroller programming support \(MPS\)](#)) enabled, some move to INITs do not issue an reset.

Table 52 **Errors causing a move to INIT - Collection register: INIT_ERR_APP1**

INIT_ERR_APP1 bitfield	Error class	Error register	Error bitfield	Description
VMONF	VMONUV_SEV_FAULT	UV_STAT_APP1	BUCKCORE	BUCKCORE undervoltage
			QUC	QUC undervoltage
			QST	QST undervoltage
WWD1_EC	WDx_SEV_FAULT	-	-	WWD1 incorrectly triggered and error counter reaches threshold
WWD2_EC		-	-	WWD2 incorrectly triggered and error counter reaches threshold
FWD1_EC		-	-	FWD1 incorrectly triggered and error counter reaches threshold

(table continues...)

16 Collection registers, error reporting and clearance of bitfields

Table 52 (continued) Errors causing a move to INIT - Collection register: INIT_ERR_APP1

INIT_ERR_APP1 bitfield	Error class	Error register	Error bitfield	Description
FWD2_EC		-	-	FWD2 incorrectly triggered and error counter reaches threshold
ERR1	ERRx_SEV_FAULT	-	-	ERR1 signal is outside of valid frequencies (if recovery enabled: longer than tREC before being set)
ERR2		-	-	ERR2 signal is outside of valid frequencies (if recovery enabled: longer than tREC before being set)
REDOP_RES1	INITTIMER_SEV_FAULT	-	-	INIT timer expired the first time in RED. OP. due to application 1 not being able to reinitialize
REDOP_RES2		-	-	INIT timer expired a second time in RED. OP.
SOFTRES		-	-	INIT timer expires 1st time → Soft reset issued
HARDRES		-	-	INIT timer expires 2nd time consecutively → Hard reset issued

(x = 1; 2)

If REDUCED OPERATION is enabled, also the following bits are set:

Table 53 Errors causing a move to INIT - Reduced Operation - Collection register: INIT_ERR_APP2

INIT_ERR_APP2 bitfield	Error class	Error register	Error bitfield	Description
VMONF	VMONUV_SEV_FAULT	UV_STAT_APP1	BUCKCORE	BUCKCORE undervoltage
			QUC	QUC undervoltage

(table continues...)

16 Collection registers, error reporting and clearance of bitfields

Table 53 (continued) **Errors causing a move to INIT - Reduced Operation - Collection register: INIT_ERR_APP2**

INIT_ERR_APP2 bitfield	Error class	Error register	Error bitfield	Description
			QST	QST undervoltage
WWD1_EC	WDx_SEV_FAULT	—	—	WWD1 incorrectly triggered and error counter reaches threshold
WWD2_EC		—	—	WWD2 incorrectly triggered and error counter reaches threshold
FWD1_EC		—	—	FWD1 incorrectly triggered and error counter reaches threshold
FWD2_EC		—	—	FWD2 incorrectly triggered and error counter reaches threshold
ERR1	ERRx_SEV_FAULT	—	—	ERR1 signal is outside of valid frequencies (if recovery enabled: longer than tREC before being set)
ERR2		—	—	ERR2 signal is outside of valid frequencies (if recovery enabled: longer than tREC before being set)
REDOP_RES1	INITTIMER_SEV_FAULT	—	—	INIT timer expired the first time in RED. OP. due to application 2 not being able to reinitialize
REDOP_RES2		—	—	INIT timer expired a second time in RED. OP.
SOFTRES		—	—	INIT timer expires 1st time → Soft reset issued

(table continues...)

16 Collection registers, error reporting and clearance of bitfields

Table 53 (continued) **Errors causing a move to INIT - Reduced Operation - Collection register: INIT_ERR_APP2**

INIT_ERR_APP2 bitfield	Error class	Error register	Error bitfield	Description
HARDRES		—	—	INIT timer expires 2nd time consecutively → Hard reset issued

(x = 1; 2)

16.3 Error reporting causing a move to FAILSAFE

Errors that trigger a move to FAILSAFE are collected in the register. Only exception is the bit ABIST. It is being set only, if during an ABIST execution an error occurs that moves the device into INIT or FAILSAFE and is by itself no trigger for a state transition.

Table 54 **Errors causing a move to FAILSAFE - Collection register: SYSFAIL_STAT_APP1**

SYSFAIL_STAT_APP1 bitfield	Error class	Error register	Error bitfield	Description
QST_QUC_VOLTSEL	VOLTSEL_SEV_FAULT	-	-	Voltage selection error. 5 V or 3.3 V might be corrupt and not correctly selected.
BUCKIF_VOLTSEL		-	-	Voltage selection error. 1.8 or 3.3 V might be corrupt and not correctly selected.
BUCK_CORE_VOLTSEL		-	-	Voltage selection error. Core voltage might be corrupt.
OT	OT_SEV_FAULT	OT_STAT_APP1	BUCKCORE	BUCKCORE thermal shutdown
			BUCKIF	BUCKIF thermal shutdown
			BOOST	BOOST thermal shutdown
			QUC	QUC thermal shutdown
			QCO	QCO thermal shutdown
			SAFETY_AREA	Overtemperature of safety area

(table continues...)

16 Collection registers, error reporting and clearance of bitfields

Table 54 (continued) **Errors causing a move to FAILSAFE - Collection register:**
SYSFAIL_STAT_APP1

SYSFAIL_STAT_APP1 bitfield	Error class	Error register	Error bitfield	Description
VMON	VMON_SEV_FAULT	STG_STAT_APP1	BUCKCORE	BUCKCORE short to ground
			BOOST	BOOST short to ground & Severe undervoltage
			QUC	QUC short to ground
			QST	QST short to ground
			PREREG	PREREG short to ground & Severe undervoltage
		OV_STAT_APP1	BUCKCORE	Severe overvoltage at BUCKCORE & BUCKCORE OV
			BUCKCORE_FB_OPEN	Feedback open
			PREREG	Severe overvoltage at PREREG & PREREG OV
			BUCKIF	Severe overvoltage at BUCKIF & BUCKIF OV
			BOOST	BOOST OV
			QUC	QUC OV
			QCO	QCO OV
			QVR	QVR OV
			QST	QST OV
			VMON1	VMON1 OV
			VMON2	VMON2 OV
			INTSUP_VDD2V5	Internal 2V5 rail overvoltage
			INTSUP_IVCC	Internal IVCC overvoltage
		UV_STAT_APP1	INTSUP_VDD2V5_UV	Internal 2V5 rail undervoltage
			INTSUP_IVCC_UV	Internal IVCC undervoltage

(table continues...)

16 Collection registers, error reporting and clearance of bitfields

Table 54 (continued) **Errors causing a move to FAILSAFE - Collection register:**
SYSFAIL_STAT_APP1

SYSFAIL_STAT_APP1 bitfield	Error class	Error register	Error bitfield	Description
		INTSUP_STAT_APP1	BIAS_HI	Internal bias current too high
			BIAS_LOW	Internal bias current too low
			VBAT_OV	VS OV
FSM_INITTIMER	INITTIMER_SEV_FAULT	-	-	FAILSAFE was entered because INIT timer expired a 3rd time without successful initialization.
ERR0	ERR0_SEV_FAULT	-	-	FAILSAFE was entered after ERR0 reported invalid frequency.
QST	QST_SEV_FAULT	-	-	Set for: QST BIST errors, severe overvoltage
INTSUP_IVCC	INTSUP_SEV_FAULT	-	-	Set for: QIS BIST errors, severe overvoltage
PREREG_COSW	SSW_SEV_FAULT	-	-	BIST major error SSC or SSW was activated during normal operation
CFGE	CFG_SEV_FAULT	-	-	Double Error detected on a protected register
ABIST	ABIST_SEV_FAULT	-	-	Any error that moves the device to FAILSAFE or INIT and is not part of the ABIST routine will abort the on-going ABIST and set this bit.

(x = 1; 2)

If REDUCED OPERATION is enabled, also the following bits are set:

16 Collection registers, error reporting and clearance of bitfields

Table 55 **Errors causing a move to FAILSAFE - Reduced Operation - Collection register:**
SYSFAIL_STAT_APP2

SYSFAIL_STAT_APP2 bitfield	Error class	Error register	Error bitfield	Description
QST_QUC_VOLTSEL	VOLTSEL_SEV_FAULT	-	-	Voltage selection error. 5 V or 3.3 V might be corrupt and not correctly selected.
BUCKIF_VOLTSEL		-	-	Voltage selection error. 1.8 V or 3.3 V might be corrupt and not correctly selected.
BUCK_CORE_VOLTSEL		-	-	Voltage selection error. Core voltage might be corrupt.
OT	OT_SEV_FAULT	OT_STAT_APP2	BUCKCORE	BUCKCORE thermal shutdown
			BUCKIF	BUCKIF thermal shutdown
			BOOST	BOOST thermal shutdown
			QUC	QUC thermal shutdown
			QCO	QCO thermal shutdown
			SAFETY_AREA	Overtemperature of safety area
VMON	VMON_SEV_FAULT	STG_STAT_APP2	BUCKCORE	BUCKCORE short to ground
			BOOST	BOOST short to ground & severe undervoltage
			QUC	QUC short to ground
			QST	QST short to ground
			PREREG	PREREG short to ground & severe undervoltage
		OV_STAT_APP2	BUCKCORE	Severe overvoltage at BUCKCORE & BUCKCORE OV

(table continues...)

16 Collection registers, error reporting and clearance of bitfields

Table 55 (continued) **Errors causing a move to FAILSAFE - Reduced Operation - Collection register: SYSFAIL_STAT_APP2**

SYSFAIL_STAT_APP2 bitfield	Error class	Error register	Error bitfield	Description
			BUCKCORE_FB_OPEN	Feedback open
			PREREG	Severe overvoltage at PREREG & PREREG OV
			BUCKIF	Severe overvoltage at BUCKIF & BUCKIF OV
			BOOST	BOOST OV
			QUC	QUC OV
			QCO	QCO OV
			QVR	QVR OV
			QST	QST OV
			VMON1	VMON1 OV
			VMON2	VMON2 OV
			INTSUP_VDD2V5	Internal 2V5 rail overvoltage
			INTSUP_IVCC	Internal IVCC overvoltage
		UV_STAT_APP2	INTSUP_VDD2V5_UV	Internal 2V5 rail undervoltage
			INTSUP_IVCC_UV	Internal IVCC undervoltage
		INTSUP_STAT_APP2	BIAS_HI	Internal bias current too high
			BIAS_LOW	Internal bias current too low
			VBAT_OV	VS OV
FSM_INITTIMER	INITTIMER_SEV_FAULT	-	-	FAILSAFE was entered because INIT timer expired a 3rd time without successful initialization.
ERR0	ERR0_SEV_FAULT	-	-	FAILSAFE was entered after ERR0 reported invalid frequency.

(table continues...)

16 Collection registers, error reporting and clearance of bitfields

Table 55 (continued) **Errors causing a move to FAILSAFE - Reduced Operation - Collection register: SYSFAIL_STAT_APP2**

SYSFAIL_STAT_APP2 bitfield	Error class	Error register	Error bitfield	Description
QST	QST_SEV_FAULT	-	-	Set for: QST BIST errors, severe overvoltage
INTSUP_IVCC	INTSUP_SEV_FAULT	-	-	Set for: QIS BIST errors, severe overvoltage
PREREG_COSW	SSW_SEV_FAULT	-	-	BIST major error SSC or SSW was activated during normal operation
CFGE	CFG_SEV_FAULT	-	-	Double error detected on a protected register
ABIST	ABIST_SEV_FAULT	-	-	Any error that moves the device to FAILSAFE or INIT and is not part of the ABIST routine will abort the on-going ABIST and set this bit.

(x = 1; 2)

16.4 Status reporting - Miscellaneous registers

Device status information are collected in VMON_STAT and DEV_STAT.

	Status bitfield	Description
VMON_STAT	all	Indicates whether voltage regulators are within range or outside of it. If a regulator is switched off the bits read as 0.
DEV_STAT	all	Provides an overview of the devices general state (e.g. Enabled regulators, State, Autodetection)

17 Protected registers - Protected write and reflected status registers

The device contains protected registers to avoid unintentional access to safety related parameters. A protected register always consists of a pair of a configurable "protected write" register and its corresponding "reflected status" shadow register. These registers first need to be unlocked before new content can be written. New content must always be written to the protected write register. In order for new changes take effect, the registers have to be locked again. With the lock sequence new content is transferred to the reflected status registers.

Registers that belong to the class of protected registers are labeled as below in their names:

Protected write	<registername>_PW_<registername>
Reflected status	<registername>_RS_<registername>

17.1 Unlock/lock sequence

To unlock and lock protected register, the following steps must be executed:

1. Unlock registers: Write 0xB5CA to register **PROT_CFG.KEY**
2. Write changes to protected write registers
3. Lock registers: Write 0xD396 to register **PROT_CFG.KEY**

Before writing changes to protected write registers and checking whether changes took effect by reading reflected status registers, the current lock status of the protected registers can be read in **PROT_STAT.LOCK**. In addition the error bit SPI_FAIL_STAT_APP1.LOCK is set in case something went wrong during the unlock/lock sequence. In such case written values will not become effective and RS registers are not updated. If REDUCED OPERATION is enabled also SPI_FAIL_STAT_APP2.LOCK is set.

18 Registers description

18 Registers description

18.1 Registers overview - OTHERSR2 (ascending offset address)

Table 56 Registers overview - OTHERSR2 (ascending offset address)

Short name	Long name	Offset address	See
DEV_CFG4	Device configuration 4 *R2)	000 _H	210
REDOP_RS_CFG2	Reduced operation reflected status configuration 2 register - *R2)	001 _H	212
PROT_CFG	Protection configuration register - *R2)	002 _H	213
DEV_RS_CFG3	Device reflected status configuration Register *R2)	003 _H	214
WUT_CFG0	Wake up timer LSB Value (*R2)	004 _H	216
WUP_CFG1	Wake up timer MSB Value (*R2)	005 _H	217
WAKE_STAT_APP1	Wakeup status flags for Application 1 *R2)	006 _H	218
WAKE_STAT_APP2	Wakeup status flags for Application 2 *R2)	007 _H	219
INIT_ERR_APP1	INIT and REDUCED OPERATION Error Status flags for Application 1 *R2)	008 _H	220
INIT_ERR_APP2	INIT and REDUCED OPERATION Error Status flags for Application 2 *R2)	009 _H	222
IF1	Interrupt flags for Application 1 that trigger INT1 *R2)	00A _H	224
IF2	Interrupt flags for Application 2 that trigger INT2 *R2)	00B _H	226
SYS_STAT_APP1	System status flags for Application 1 that trigger INT1 *R2)	00C _H	228
SYS_STAT_APP2	System status flags for Application 2 that trigger INT2 *R2)	00D _H	230
SPI_FAIL_STAT_APP1	SPI failure status flags that triggers INT1 *R2)	00E _H	232
SPI_FAIL_STAT_APP2	SPI status flags for Application 2 that trigger INT2 *R2)	00F _H	233
UV_STAT_APP1	Monitor status flags register 2 for Application 1 *R2)	010 _H	234
UV_STAT_APP2	Monitor status flags register 2 for Application 2 *R2)	011 _H	236
OT_WRN_OC_STAT_APP1	Over temperature warning and over current status flags *R2)	012 _H	238
OT_WRN_OC_STAT_APP2	Over temperature warning /Over current status flags for Application 2 *R2)	013 _H	240
VMON_STAT	Voltage monitor status *R2)	014 _H	242
DEV_STAT	Device status register *R2)	015 _H	244
DCDC_FREQ_SYNC	DC-DC switching frequency change *R2)	016 _H	246
FREQ_SPREAD	DC-DC Frequency spread-spectrum control register *R2)	017 _H	248
ABIST_CTRL0	ABIST control 0 *R2)	018 _H	250
ABIST_CTRL1	ABIST control 1 *R2)	019 _H	251
ABIST_SELECT0	ABIST select 0 *R2)	01A _H	252
ABIST_SELECT1	ABIST select 1 *R2)	01B _H	254
ABIST_SELECT2	ABIST select 2 *R2)	01C _H	256

(table continues...)

18 Registers description

Table 56 (continued) Registers overview - OTHERSR2 (ascending offset address)

Short name	Long name	Offset address	See
GTM	Global testmode *R2)	01D _H	258
REDOP_RS_CFG1	Reduced operation reflected status configuration 1 register - *R2)	01E _H	259

18.2 Registers overview - ERR (ascending offset address)

Table 57 Registers overview - ERR (ascending offset address)

Short name	Long name	Offset address	See
ERR0_PW_CFG	ERR0 protection write configuration register *R2)	01F _H	261
ERR0_RS_CFG	ERR0 reflected status configuration register *R3)	020 _H	262
ERR1_PW_CFG	ERR1 protection write configuration register *R2)	021 _H	263
ERR1_RS_CFG	ERR1 reflected status configuration register *R3_C1)	022 _H	264
ERR2_PW_CFG	ERR2 protection write configuration register *R2)	023 _H	265
ERR2_RS_CFG	ERR2 reflected status configuration register *R3_C2)	024 _H	266

18.3 Registers overview - OTHERSR0 (ascending offset address)

Table 58 Registers overview - OTHERSR0 (ascending offset address)

Short name	Long name	Offset address	See
DEV_CFG1	Device configuration 1 register *R0)	025 _H	267
DEV_PW_CFG2	Device protected write configuration 2 register *R0)	026 _H	269
DEV_RS_CFG2	Device reflected status configuration 2 register *R0)	027 _H	270

18.4 Registers overview - OTHERSR1 (ascending offset address)

Table 59 Registers overview - OTHERSR1 (ascending offset address)

Short name	Long name	Offset address	See
SYSFAIL_STAT_APP1	System failure status register for application 1 *R1)	029 _H	271
SYSFAIL_STAT_APP2	System failure status flags for application 2 *R1)	02A _H	273
STG_STAT_APP1	Short to ground status register for application 1 *R1)	02B _H	275
STG_STAT_APP2	Short to ground status register for application 2 *R1)	02C _H	277
OV_STAT_APP1	Overvoltage status register for application 1 *R1)	02D _H	279
OV_STAT_APP2	Overvoltage status register for application 2 *R1)	02E _H	281
INTSUP_STAT_APP1	Internal supply status register for application 1 *R1)	02F _H	283
INTSUP_STAT_APP2	Internal supply status register for application 2 *R1)	030 _H	284

(table continues...)

18 Registers description

Table 59 (continued) Registers overview - OTHERSR1 (ascending offset address)

Short name	Long name	Offset address	See
OT_STAT_APP1	Over temperature status register for application 1 *R1)	031 _H	285
OT_STAT_APP2	Over temperature status register for application 2 *R1)	032 _H	286
PROT_STAT	Protection status *R1)	033 _H	287
REDOP_PW_CFG1	Reduced operation protected write configuration 1 register - *R1)	034 _H	288
REDOP_PW_CFG2	Reduced operation protected write configuration 2 register - *R1)	035 _H	290
DEV_PW_CFG3	Device protected write configuration 3 register *R1)	036 _H	291

18.5 Registers overview - WATCHDOG (ascending offset address)

Table 60 Registers overview - WATCHDOG (ascending offset address)

Short name	Long name	Offset address	See
WD1_PW_CFG0	Watchdog 1 protected write configuration 0 register *R2)	037 _H	293
WD1_RS_CFG0	Watchdog 1 reflected status configuration 0 register - *R3_C1	038 _H	294
WD1_PW_CFG1	Watchdog 1 protected write configuration 1 register *R2)	039 _H	295
WD1_RS_CFG1	Watchdog 1 reflected status configuration 1 register- *R3_C1	03A _H	296
FWD1_PW_HBTP_CFG	Functional watchdog 1 protected write heart beat timer period configuration register - *R2)	03B _H	297
FWD1_RS_HBTP_CFG	Functional watchdog 1 reflected status heart beat timer period configuration register *R3_C1	03C _H	298
WWD1_PW_CW_CFG	Window watchdog 1 protected write closed window configuration register - *R2)	03D _H	299
WWD1_RS_CW_CFG	Window watchdog 1 reflected status closed window configuration register *R3_C1)	03E _H	300
WWD1_PW_OW_CFG	Window watchdog 1 protected write open window configuration register - *R2)	03F _H	301
WWD1_RS_OW_CFG	Window watchdog 1 reflected status open window configuration register - *R3_C1)	040 _H	302
WWD1_TRIG	Window watchdog 1 trigger- *R2)	041 _H	303
FWD1_RSP	Functional watchdog 1 response register - *R2)	042 _H	304
FWD1_RSP_SYNC	Functional watchdog 1 response register with synchronization of the heartbeat timer - *R2)	043 _H	305
FWD1_STAT	Functional watchdog 1 status register - *R3_C1)	044 _H	306
WWD1_ECNT_STAT	Window watchdog 1 error counter status register - *R3_C1)	045 _H	307
WD2_PW_CFG0	Watchdog 2 protected write configuration 0 register - *R2)	046 _H	308
WD2_RS_CFG0	Watchdog 2 reflected status configuration 0 register- *R3_C2)	047 _H	309

(table continues...)

18 Registers description

Table 60 (continued) Registers overview - WATCHDOG (ascending offset address)

Short name	Long name	Offset address	See
WD2_PW_CFG1	Watchdog 2 protected write configuration 1 - *R2)	048 _H	310
WD2_RS_CFG1	Watchdog 2 reflected status configuration 1 register - *R3_C2)	049 _H	311
FWD2_PW_HBTP_CFG	Functional watchdog 2 protected write heart beat timer period configuration register - *R2)	04A _H	312
FWD2_RS_HBTP_CFG	Functional watchdog 2 reflected status heart beat timer period configuration register *R3_C2)	04B _H	313
WWD2_PW_CW_CFG	Window watchdog 2 protected write closed window configuration register - *R2)	04C _H	314
WWD2_RS_CW_CFG	Window watchdog 2 reflected status closed window configuration register *R3_C2)	04D _H	315
WWD2_PW_OW_CFG	Window watchdog 2 protected write open window configuration register - *R2)	04E _H	316
WWD2_RS_OW_CFG	Window watchdog 2 reflected status open window configuration register *R3_C2)	04F _H	317
WWD2_TRIG	Window watchdog 2 service - *R2)	050 _H	318
FWD2_RSP	Functional watchdog 2 response register - *R2)	051 _H	319
FWD2_RSP_SYNC	Functional watchdog 2 response register with synchronization - *R2)	052 _H	320
FWD2_STAT	Functional watchdog 2 status register - *R3_C2)	053 _H	321
WWD2_ECNT_STAT	Window watchdog 2 status register - *R3_C2)	054 _H	322

18.6 Register overview - MISC (ascending offset address)

Table 61 Register overview - MISC (ascending offset address)

Short name	Long name	Offset address	See
SSW_DIAG	Safety switch diagnostics, *R1)	055 _H	323
BUCK_CORE_PW_VSEL	BUCK CORE protected write voltage selection register *R1)	056 _H	324
BUCK_CORE_RS_VSEL	BUCK CORE reflected status voltage selection register *R2)	057 _H	325
VCORESTAT	Buck core voltage selection stat, *R2)	058 _H	326
VCOREMONSTAT	Buck core voltage selection monitors stat, *R2)	059 _H	327
WUT_STAT0	Wake Up Timer value after exiting from STANDBY or SLEEP (lower 16 bits)	05A _H	328
WUT_STAT1	Wake Up Timer value after exiting from STANDBY or SLEEP (upper 8 bits)	05B _H	329

18 Registers description

18.7 Registers overview - DEVICEID (ascending offset address)

Table 62 Registers overview - DEVICEID (ascending offset address)

Short name	Long name	Offset address	See
CHPID	Chip product identifier	1F0 _H	330
CHREV	Chip product version and revision	1F1 _H	331
MANID	Manufacturer ID	1F2 _H	332

18 Registers description

18.8 Device configuration 4 *R2)

DEV_CFG4

Device configuration 4 *R2)

Offset address: 000_H

Reset values see: [Table 63](#)

15	14	13	12	11	10	9	8
FSM_SDT_VMON12		Res				DCDC_SYN C_IN_EN	WUT_EN
rw		r				rw	rw
7	6	5	4	3	2	1	0
WUT_CYC	WUT_PRESC	FSM_SDT_TMR		FSM_TRDEL			
rw	rw	rw		rw			

Field	Bits	Type	Description
FSM_TRDEL	3:0	rw	Transition delay (TRDEL) into low power states (STANDBY, SLEEP) 0 _H 100 μs 1 _H 200 μs 2 _H 300 μs 3 _H 400 μs 4 _H 500 μs 5 _H 600 μs 6 _H 700 μs 7 _H 800 μs 8 _H 900 μs 9 _H 1000 μs A _H 1100 μs B _H 1200 μs C _H 1300 μs D _H 1400 μs E _H 1500 μs F _H 1600 μs
FSM_SDT_TMR	5:4	rw	Shut down timer (tSDT_TMR) for internal regulators of power down sequencing 00 _B 0 01 _B 500 μs 10 _B 1000 μs 11 _B 1500 μs
WUT_PRESC	6	rw	Wake up timer cycle period pre-scaler 0 _B Disabled 1 _B Enabled
WUT_CYC	7	rw	Wake timer cycle period 0 _B 10 μs 1 _B 10 ms

(table continues...)

18 Registers description

(continued)

Field	Bits	Type	Description
WUT_EN	8	rw	Wake timer enable 0 _B Disabled 1 _B Enabled
DCDC_SYNC_I N_EN	9	rw	Enable synchronization input (only applicable when REDUCED OPERATION is disabled, since it uses SYNC_IN pin shared with INT2) 0 _B Disable 1 _B Enable
FSM_SDT_VM ON12	15:14	rw	Shut down timer for VMON1 and VMON2 of power down sequencing 00 _B 0 μs 01 _B 500 μs 10 _B 1 ms 11 _B 1.5 ms

Table 63 Reset values of **DEV_CFG4**

Reset	Reset value	Note
	C038 _H	Reset class R2)

18 Registers description

18.9 Reduced operation reflected status configuration 2 register - *R2)

REDOP_RS_CFG2

Reduced operation reflected status configuration 2 register - *R2)

Offset address: 001_H

Reset values see: [Table 64](#)

15	14	13	12	11	10	9	8
REDOP_RESOUT_APP2_DUR			REDOP_RESOUT_APP1_DUR			REDOP_RESOUT_APP_TB	Res
r			r			r	r
7	6	5	4	3	2	1	0
Res							
r							

Field	Bits	Type	Description
REDOP_RESOUT_APP_TB	9	r	Partial reset timer step, selectable between 10 µs or 100 µs 0 _B 10 µs 1 _B 100 µs
REDOP_RESOUT_APP1_DUR	12:10	r	Application reset pulse duration duration for INT1 000 _B (0 + 1)*10 µs for REDOP_RESOUT_APP_TB = 0; ((0 + 1)*100 + 50) µs for REDOP_RESOUT_APP_TB = 1 ... 111 _B (7 + 1)*10 µs for REDOP_RESOUT_APP_TB = 0; ((7 + 1)*100 + 50) µs for REDOP_RESOUT_APP_TB = 1
REDOP_RESOUT_APP2_DUR	15:13	r	Application reset pulse duration duration for INT2 000 _B (0 + 1)*10 µs for REDOP_RESOUT_APP_TB = 0; ((0 + 1)*100 + 50) µs for REDOP_RESOUT_APP_TB = 1 ... 111 _B (7 + 1)*10 µs for REDOP_RESOUT_APP_TB = 0; ((7 + 1)*100 + 50) µs for REDOP_RESOUT_APP_TB = 1

Table 64 Reset values of [REDOP_RS_CFG2](#)

Reset	Reset value	Note
	0000 _H	Reset class R2)

18 Registers description

18.10 Protection configuration register - *R2)

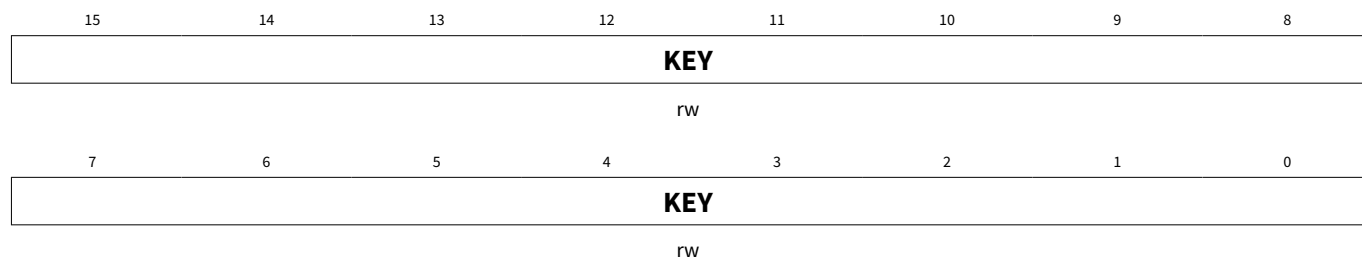
Controls UNLOCK/LOCK mechanism for password protected registers. UNLOCK allows to program registers, LOCK updates effective content of programmed ones. Any other value lead to LOCKed state, discarding pending changes if any.

PROT_CFG

Protection configuration register - *R2)

Offset address: 002_H

Reset values see: [Table 65](#)



Field	Bits	Type	Description
KEY	15:0	rw	KEY value B5CA _H Registers unlocked D396 _H Registers locked

Table 65 Reset values of **PROT_CFG**

Reset	Reset value	Note
	D396 _H	Reset class R2)

18 Registers description

18.11 Device reflected status configuration Register *R2)

DEV_RS_CFG3

Offset address: 003_H

Device reflected status configuration Register *R2)

Reset values see: [Table 66](#)

15	14	13	12	11	10	9	8
Res					VMON2_EN	VMON1_EN	BOOST_EN
r					r	r	r
7	6	5	4	3	2	1	0
BUCKINT_EN	QUC_EN	BUCKCORE_EN	QCO_EN	QVR_EN	FSM_STATEREQ		
r	r	r	r	r	r		

Field	Bits	Type	Description
FSM_STATEREQ	2:0	r	Request for device state transition. 000 _B NONE 001 _B INIT 010 _B NORMAL 011 _B SLEEP 100 _B STANDBY 101 _B WAKE 110 _B NONE 111 _B NONE
QVR_EN	3	r	Enable request for reference voltage. 0 _B Disabled 1 _B Enabled
QCO_EN	4	r	Enable request for communication LDO. 0 _B Disabled 1 _B Enabled
BUCKCORE_EN	5	r	Enable request for BUCKCORE 0 _B Disabled 1 _B Enabled
QUC_EN	6	r	Enable request for QUC 0 _B Disabled 1 _B Enabled
BUCKINT_EN	7	r	Enable request for BUCK interface 0 _B Disabled 1 _B Enabled
BOOST_EN	8	r	Enable request for Boost 0 _B Disabled 1 _B Enabled

(table continues...)

18 Registers description

(continued)

Field	Bits	Type	Description
VMON1_EN	9	r	Enable request for External Monitoring1 0 _B Disabled 1 _B Enabled
VMON2_EN	10	r	Enable request for External Monitoring2 0 _B Disabled 1 _B Enabled

Table 66 Reset values of **DEV_RS_CFG3**

Reset	Reset value	Note
	0000 _H	Reset class R2)

18 Registers description

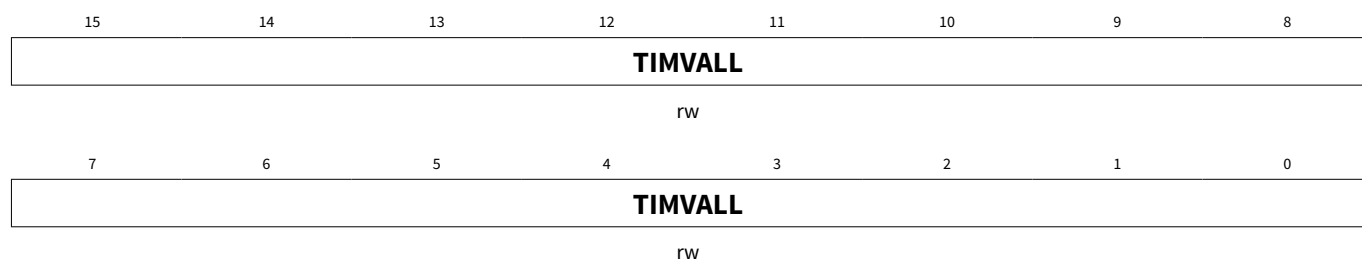
18.12 Wake up timer LSB Value (*R2)

WUT_CFG0

Offset address: 004_H

Wake up timer LSB Value [*R2)

Reset values see: [Table 67](#)



Field	Bits	Type	Description
TIMVALL	15:0	rw	Wake timer compare value, 16bit lsb

Table 67 Reset values of [WUT_CFG0](#)

Reset	Reset value	Note
	0000 _H	Reset class R2)

18 Registers description

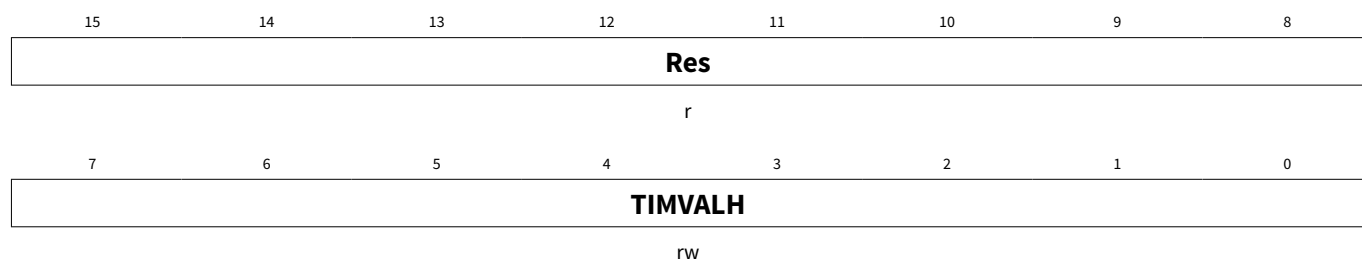
18.13 Wake up timer MSB Value (*R2)

WUP_CFG1

Offset address: 005_H

Wake up timer MSB Value [*R2]

Reset values see: [Table 68](#)



Field	Bits	Type	Description
TIMVALH	7:0	rw	Wake timer compare value (23:16) (msb)

Table 68 Reset values of [WUP_CFG1](#)

Reset	Reset value	Note
	0000 _H	Reset class R2)

18 Registers description

18.14 Wakeup status flags for Application 1 *R2)

WAKE_STAT_APP1

Wakeup status flags for Application 1 *R2)

Offset address: 006_H

Reset values see: [Table 69](#)

15	14	13	12	11	10	9	8
Res							
r							
7	6	5	4	3	2	1	0
Res		SPI		WUT	Res	ENA	WAK
r		rw1c		rw1c	r	rw1c	rw1c

Field	Bits	Type	Description
WAK	0	rw1c	Wakeup by WAK signal, bit is set if SLEEP, FAILSAFE or STANDBY state left because of WAK 0 _B No event detected 1 _B Event detected
ENA	1	rw1c	Wake by ENA signal, bit is set if SLEEP, FAILSAFE or STANDBY state left because of ENA 0 _B No event detected 1 _B Event detected
WUT	3	rw1c	Wakeup by wake timer 0 _B No event detected 1 _B Event detected
SPI	4	rw1c	Wakeup by SPI 0 _B No event detected 1 _B Event detected

Table 69 Reset values of [WAKE_STAT_APP1](#)

Reset	Reset value	Note
	0000 _H	Reset class R2)

18 Registers description

18.15 Wakeup status flags for Application 2 *R2)

WAKE_STAT_APP2

Wakeup status flags for Application 2 *R2)

Offset address: 007_H

Reset values see: [Table 70](#)

15	14	13	12	11	10	9	8
Res							
r							
7	6	5	4	3	2	1	0
Res		SPI		WUT		Res	
r		rw1c		rw1c		r	
						ENA	
						WAK	
						rw1c	

Field	Bits	Type	Description
WAK	0	rw1c	Wakeup by WAK signal, bit is set if SLEEP, FAILSAFE or STANDBY state left because of WAK 0 _B No event detected 1 _B Event detected
ENA	1	rw1c	Wake by ENA signal, bit is set if SLEEP, FAILSAFE or STANDBY state left because of ENA 0 _B No event detected 1 _B Event detected
WUT	3	rw1c	Wakeup by wake timer, bit will also be set if device leaves STANDBY state because of wakeup timer expired 0 _B No event detected 1 _B Event detected
SPI	4	rw1c	Wakeup by SPI from SLEEP state 0 _B No event detected 1 _B Event detected

Table 70 Reset values of [WAKE_STAT_APP2](#)

Reset	Reset value	Note
	0000 _H	Reset class R2)

18 Registers description

18.16 INIT and REDUCED OPERATION Error Status flags for Application 1 *R2)

INIT_ERR_APP1

INIT and REDUCED OPERATION Error Status flags for Application 1 *R2)

Offset address: 008_H

Reset values see: [Table 71](#)

15	14	13	12	11	10	9	8
HARDRES	SOFTRES	Res	REDOP_RE S2	REDOP_RE S1	Res		
rw1c	rw1c	r	rw1c	rw1c	r		
7	6	5	4	3	2	1	0
ERR2	ERR1	Res	FWD2_EC	FWD1_EC	WWD2_EC	WWD1_EC	VMONF
rw1c	rw1c	r	rw1c	rw1c	rw1c	rw1c	rw1c

Field	Bits	Type	Description
VMONF	0	rw1c	Voltage monitor failure which lead to INIT (see chapter: Collection registers) 0 _B No fault 1 _B Fault occurred
WWD1_EC	1	rw1c	Window watchdog1 error counter reached the error threshold 0 _B No fault 1 _B Fault occurred
WWD2_EC	2	rw1c	Window watchdog2 error counter reached the error threshold 0 _B No fault 1 _B Fault occurred
FWD1_EC	3	rw1c	Functional watchdog1 error counter reached the error threshold 0 _B No fault 1 _B Fault occurred
FWD2_EC	4	rw1c	Functional watchdog2 error counter reached the error threshold 0 _B No fault 1 _B Fault occurred
ERR1	6	rw1c	ERR1 failure 0 _B No fault 1 _B Fault occurred
ERR2	7	rw1c	ERR2 failure 0 _B No fault 1 _B Fault occurred
REDOP_RES1	10	rw1c	REDUCED OPERATION reset has been generated because REDUCED OPERATION timer expired once (same timer as INIT timer) 0 _B No fault 1 _B Fault occurred

(table continues...)

18 Registers description

(continued)

Field	Bits	Type	Description
REDOP_RES2	11	rw1c	REDUCED OPERATION reset has been generated because REDUCED OPERATION timer expired twice (same timer as INIT timer); Move to INIT is triggered 0 _B No fault 1 _B Fault occurred
SOFTRES	14	rw1c	Soft reset generated 0 _B No soft reset occurred 1 _B Soft reset occurred
HARDRES	15	rw1c	Hard reset generated because INIT timer expired twice 0 _B No hard reset occurred 1 _B Hard reset occurred

Table 71 Reset values of **INIT_ERR_APP1**

Reset	Reset value	Note
	0000 _H	Reset class R2)

18 Registers description

18.17 INIT and REDUCED OPERATION Error Status flags for Application 2 *R2)

INIT_ERR_APP2

INIT and REDUCED OPERATION Error Status flags for Application 2 *R2)

Offset address: 009_H

Reset values see: [Table 72](#)

15	14	13	12	11	10	9	8
HARDRES	SOFTRES	Res	REDOP_RE S2	REDOP_RE S1	Res		
rw1c	rw1c	r	rw1c	rw1c	r		
7	6	5	4	3	2	1	0
ERR2	ERR1	Res	FWD2_EC	FWD1_EC	WWD2_EC	WWD1_EC	VMONF
rw1c	rw1c	r	rw1c	rw1c	rw1c	rw1c	rw1c

Field	Bits	Type	Description
VMONF	0	rw1c	Voltage monitor failure which lead to INIT (see chapter: Collection registers) 0 _B No fault 1 _B Fault occurred
WWD1_EC	1	rw1c	Window watchdog1 error counter reached the error threshold 0 _B No fault 1 _B Fault occurred
WWD2_EC	2	rw1c	Window watchdog2 error counter reached the error threshold 0 _B No fault 1 _B Fault occurred
FWD1_EC	3	rw1c	Functional watchdog1 error counter reached the error threshold 0 _B No fault 1 _B Fault occurred
FWD2_EC	4	rw1c	Functional watchdog2 error counter reached the error threshold 0 _B No fault 1 _B Fault occurred
ERR1	6	rw1c	error1 monitor failure 0 _B No fault 1 _B Fault occurred
ERR2	7	rw1c	error2 monitor failure 0 _B No fault 1 _B Fault occurred
REDOP_RES1	10	rw1c	REDUCED OPERATION reset has been generated because REDUCED OPERATION timer expired once 0 _B No fault 1 _B Fault occurred

(table continues...)

18 Registers description

(continued)

Field	Bits	Type	Description
REDOP_RES2	11	rw1c	REDUCED OPERATION reset has been generated because REDUCED OPERATION timer expired twice 0 _B No fault 1 _B Fault occurred
SOFTRES	14	rw1c	Soft reset generated because the Init timer expired once 0 _B No soft reset occurred 1 _B Soft reset occurred
HARDRES	15	rw1c	Hard reset generated because Init timer expired twice 0 _B No hard reset occurred 1 _B Hard reset occurred

Table 72 Reset values of **INIT_ERR_APP2**

Reset	Reset value	Note
	0000 _H	Reset class R2)

18 Registers description

18.18 Interrupt flags for Application 1 that trigger INT1 *R2)

IF1 Offset address: 00A_H
Interrupt flags for Application 1 that trigger INT1 *R2) Reset values see: [Table 73](#)

15	14	13	12	11	10	9	8
Res							
r							
7	6	5	4	3	2	1	0
INTMISS	ABIST	Res	OT_WRN_OC_ERR	MON	SPI_FAIL	WUT_EVT	SYSFAIL_ERR
r	rw1c	r	rw1c	rw1c	rw1c	rw1c	rw1c

Field	Bits	Type	Description
SYSFAIL_ERR	0	rw1c	INT1 is triggered, because a system event has occurred (see chapter: Collection registers) 0 _B No interrupt 1 _B Interrupt occurred
WUT_EVT	1	rw1c	INT1 is triggered, because a wake up event has occurred (see chapter: Collection registers) 0 _B No interrupt 1 _B Interrupt occurred
SPI_FAIL	2	rw1c	INT1 is triggered, because a SPI_FAIL has occurred (see chapter: Collection registers) 0 _B No interrupt 1 _B Interrupt occurred
MON	3	rw1c	INT1 is triggered, because a monitoring event has occurred (see chapter: Collection registers) 0 _B No interrupt 1 _B Interrupt occurred
OT_WRN_OC_ERR	4	rw1c	INT1 is triggered, because a overtemperature warning or overcurrent has occurred (see chapter: Collection registers) 0 _B No interrupt 1 _B Interrupt occurred
ABIST	6	rw1c	Requested ABIST operation performed or interrupted. ABIST is not continued automatically. 0 _B No interrupt 1 _B Interrupt occurred
INTMISS	7	r	Interrupt INT1 has not been serviced within tINTTO time 0 _B No interrupt 1 _B Interrupt occurred

18 Registers description

Table 73 **Reset values of IF1**

Reset	Reset value	Note
	0000 _H	Reset class R2)

18 Registers description

18.19 Interrupt flags for Application 2 that trigger INT2 *R2)

IF2

Offset address: 00B_H

Interrupt flags for Application 2 that trigger INT2 *R2)

Reset values see: [Table 74](#)

15	14	13	12	11	10	9	8
Res							
r							
7	6	5	4	3	2	1	0
INTMISS	ABIST	Res	OT_WRN_OC_ERR	MON	SPI_FAIL	WUT_EVT	SYSFAIL_ERR
r	rw1c	r	rw1c	rw1c	rw1c	rw1c	rw1c

Field	Bits	Type	Description
SYSFAIL_ERR	0	rw1c	INT2 is triggered, because a system event has occurred (see chapter: Collection registers) 0 _B No interrupt 1 _B Interrupt occurred
WUT_EVT	1	rw1c	INT2 is triggered, because a wake up event has occurred (see chapter: Collection registers) 0 _B No interrupt 1 _B Interrupt occurred
SPI_FAIL	2	rw1c	INT2 is triggered, because a SPI_FAIL has occurred (see chapter: Collection registers) 0 _B No interrupt 1 _B Interrupt occurred
MON	3	rw1c	INT2 is triggered, because a monitoring event has occurred (see chapter: Collection registers) 0 _B No interrupt 1 _B Interrupt occurred
OT_WRN_OC_ERR	4	rw1c	INT2 is triggered, because a overtemperature warning or overcurrent has occurred (see chapter: Collection registers) 0 _B No interrupt 1 _B Interrupt occurred
ABIST	6	rw1c	Requested ABIST operation performed or interrupted. ABIST is not continued automatically. 0 _B No interrupt 1 _B Interrupt occurred
INTMISS	7	r	Interrupt INT2 has not been serviced within tINTTO time 0 _B No interrupt 1 _B Interrupt occurred

18 Registers description

Table 74 **Reset values of IF2**

Reset	Reset value	Note
	0000 _H	Reset class R2)

18 Registers description

18.20 System status flags for Application 1 that trigger INT1 *R2)

SYS_STAT_APP1

System status flags for Application 1 that trigger INT1 *R2)

Offset address: 00C_H

Reset values see: [Table 75](#)

15	14	13	12	11	10	9	8
Res						BUCKCORE _SVS_NOK	BUCKCORE _SVS_OK
r						rw1c	rw1c
7	6	5	4	3	2	1	0
APP2_FAIL	ERR1_ERR	ERR0_ERR	FSM_NOOP	FSM_TRFAI L	FWD1_ERR	WWD1_ERR	Res
rw1c	rw1c	rw1c	rw1c	rw1c	rw1c	rw1c	r

Field	Bits	Type	Description
WWD1_ERR	1	rw1c	Window watchdog 1 error interrupt flag. Service was incorrect or missed. 0 _B No event occurred 1 _B Event detected
FWD1_ERR	2	rw1c	Functional watchdog 1 error interrupt flag. Service was incorrect or missed. 0 _B No event occurred 1 _B Event occurred
FSM_TRFAIL	3	rw1c	Transition to low power state (STANDBY/SLEEP) failed 0 _B No occurrence 1 _B Transition unsuccessful
FSM_NOOP	4	rw1c	Requested state transition via DEVCTRL could not be performed because either path between current state and requested state does not exist (eg. INIT to SLEEP), or paths exists but pre-conditions are not satisfied (e.g. INIT to NORMAL, but WWD enabled and not serviced). 0 _B No occurrence 1 _B Transition was not executed
ERR0_ERR	5	rw1c	ERR0 error status flag 0 _B No occurrence 1 _B Invalid frequency - recovery time started
ERR1_ERR	6	rw1c	ERR1 error status flag 0 _B No occurrence 1 _B Invalid frequency - recovery time started
APP2_FAIL	7	rw1c	Application 2 entered REDUCED OPERATION 0 _B No occurrence 1 _B Application 2 fault occurred

(table continues...)

18 Registers description

(continued)

Field	Bits	Type	Description
BUCKCORE_SV S_OK	8	rw1c	BUCK CORE static voltage scaling procedure completed successfully. 0 _B Not completed 1 _B Completed successfully
BUCKCORE_SV S_NOK	9	rw1c	BUCK CORE static voltage scaling procedure was unsuccessful, because the device is not in state NORMAL or INIT or BUCKCORE output voltage is set to 1.15 V. 0 _B No occurrence 1 _B BUCK CORE voltage scaling was unsuccessful

Table 75 Reset values of **SYS_STAT_APP1**

Reset	Reset value	Note
	0000 _H	Reset class R2)

18 Registers description

18.21 System status flags for Application 2 that trigger INT2 *R2)

SYS_STAT_APP2

System status flags for Application 2 that trigger INT2 *R2)

Offset address: 00D_H

Reset values see: [Table 76](#)

15	14	13	12	11	10	9	8
Res						BUCKCORE _SVS_NOK	BUCKCORE _SVS_OK
r						rw1c	rw1c
7	6	5	4	3	2	1	0
APP1_FAIL	ERR2_ERR	ERR0_ERR	FSM_NOOP	FSM_TRFAI L	FWD2_ERR	WWD2_ERR	Res
rw1c	rw1c	rw1c	rw1c	rw1c	rw1c	rw1c	r

Field	Bits	Type	Description
WWD2_ERR	1	rw1c	Window watchdog 2 error interrupt flag. Service was incorrect or missed. 0 _B No event occurred 1 _B Event detected
FWD2_ERR	2	rw1c	Functional watchdog 1 error interrupt flag. Service was incorrect or missed. 0 _B No event detected 1 _B Event detected
FSM_TRFAIL	3	rw1c	Transition to low power state (STANDBY/SLEEP) failed 0 _B No occurrence 1 _B Transition unsuccessful
FSM_NOOP	4	rw1c	Requested state transition via DEVCTRL could not be performed because either path between current state and requested state does not exist (eg. INIT to SLEEP), or paths exists but pre-conditions are not satisfied (e.g. INIT to NORMAL, but WWD enabled and not serviced). 0 _B No occurrence 1 _B Transition was not executed
ERR0_ERR	5	rw1c	ERR0 error status flag 0 _B No occurrence 1 _B Invalid frequency - recovery time started
ERR2_ERR	6	rw1c	ERR2 error status flag 0 _B No occurrence 1 _B Invalid frequency - recovery time started
APP1_FAIL	7	rw1c	Application 1 entered REDUCED OPERATION 0 _B No occurrence 1 _B Application 1 fault occurred

(table continues...)

18 Registers description

(continued)

Field	Bits	Type	Description
BUCKCORE_SV S_OK	8	rw1c	BUCK CORE static voltage scaling procedure completed successfully. 0 _B Not completed 1 _B Completed successfully
BUCKCORE_SV S_NOK	9	rw1c	BUCK CORE static voltage scaling procedure was unsuccessful, because the device is not in state NORMAL or INIT or BUCKCORE output voltage is set to 1.15 V. 0 _B No occurrence 1 _B BUCK CORE voltage scaling was unsuccessful

Table 76 Reset values of **SYS_STAT_APP2**

Reset	Reset value	Note
	0000 _H	Reset class R2)

18 Registers description

18.22 SPI failure status flags that triggers INT1 *R2)

SPI_FAIL_STAT_APP1

SPI failure status flags that triggers INT1 *R2)

Offset address: 00E_H

Reset values see: [Table 77](#)

15	14	13	12	11	10	9	8
Res							
r							
7	6	5	4	3	2	1	0
Res		LOCK		CS_TO	ADR	FR_LEN	CRC
r		rw1c		rw1c	rw1c	rw1c	rw1c

Field	Bits	Type	Description
CRC	0	rw1c	CRC error in SPI frame 0 _B No error 1 _B CRC wrong
FR_LEN	1	rw1c	Invalid frame length, number of detected SPI clock cycles different than 32 0 _B Frame length ok 1 _B Frame length incorrect
ADR	2	rw1c	Invalid address in SPI frame 0 _B No occurrence 1 _B Address not existing
CS_TO	3	rw1c	Error in duration of SPI transaction, nCS low for more than 2 ms 0 _B No occurrence 1 _B CSN timeout
LOCK	4	rw1c	Error during LOCK/UNLOCK procedure or write attempts to locked registers 0 _B No occurrence 1 _B LOCK/UNLOCK sequence failed

Table 77 Reset values of **SPI_FAIL_STAT_APP1**

Reset	Reset value	Note
	0000 _H	Reset class R2)

18 Registers description

18.23 SPI status flags for Application 2 that trigger INT2 *R2)

SPI_FAIL_STAT_APP2

SPI status flags for Application 2 that trigger INT2 *R2)

Offset address: 00F_H

Reset values see: [Table 78](#)

15	14	13	12	11	10	9	8
Res							
r							
7	6	5	4	3	2	1	0
Res		LOCK		CS_TO	ADR	FR_LEN	CRC
r		rw1c		rw1c	rw1c	rw1c	rw1c

Field	Bits	Type	Description
CRC	0	rw1c	CRC error in SPI frame 0 _B No error 1 _B CRC wrong
FR_LEN	1	rw1c	Invalid frame length, number of detected SPI clock cycles different than 32 0 _B Frame length ok 1 _B Frame length incorrect
ADR	2	rw1c	Invalid address in SPI frame 0 _B No occurrence 1 _B Address not existing
CS_TO	3	rw1c	Error in duration of SPI transaction, nCS low for more than 2 ms 0 _B No occurrence 1 _B CSN timeout
LOCK	4	rw1c	Error during LOCK/UNLOCK procedure or write attempts to locked registers 0 _B No occurrence 1 _B LOCK/UNLOCK sequence failed

Table 78 Reset values of [SPI_FAIL_STAT_APP2](#)

Reset	Reset value	Note
	0000 _H	Reset class R2)

18 Registers description

18.24 Monitor status flags register 2 for Application 1 *R2)

UV_STAT_APP1

Monitor status flags register 2 for Application 1 *R2)

Offset address: 010_H

Reset values see: [Table 79](#)

15	14	13	12	11	10	9	8
Res				INTSUP_VD D2V5_UV	INTSUP_IV CC_UV	BUCKIF	VMON2
r				rw1c	rw1c	rw1c	rw1c
7	6	5	4	3	2	1	0
VMON1	BOOST	QVR	QCO	BUCKCORE	QST	QUC	PREREG
rw1c	rw1c	rw1c	rw1c	rw1c	rw1c	rw1c	rw1c

Field	Bits	Type	Description
PREREG	0	rw1c	Pre-regulator voltage under voltage status flag 0 _B No occurrence 1 _B Undervoltage occurred
QUC	1	rw1c	QUC under voltage status flag 0 _B No occurrence 1 _B Undervoltage occurred
QST	2	rw1c	QST under voltage status flag 0 _B No occurrence 1 _B Undervoltage occurred
BUCKCORE	3	rw1c	BUCKCORE under voltage status flag 0 _B No occurrence 1 _B Undervoltage occurred
QCO	4	rw1c	QCO under voltage status flag 0 _B No occurrence 1 _B Undervoltage occurred
QVR	5	rw1c	QVR under voltage status flag 0 _B No occurrence 1 _B Undervoltage occurred
BOOST	6	rw1c	BOOST under voltage status flag 0 _B No occurrence 1 _B Undervoltage occurred
VMON1	7	rw1c	VMON1 under voltage status flag 0 _B No occurrence 1 _B Undervoltage occurred
VMON2	8	rw1c	VMON2 under voltage status flag 0 _B No occurrence 1 _B Undervoltage occurred

(table continues...)

18 Registers description

(continued)

Field	Bits	Type	Description
BUCKIF	9	rw1c	BUCKIF under voltage status flag 0 _B No occurrence 1 _B Undervoltage occurred
INTSUP_IVCC_UV	10	rw1c	Internal supply IVCC under voltage status flag, *R1) 0 _B No occurrence 1 _B Undervoltage occurred
INTSUP_VDD2 V5_UV	11	rw1c	Internal supply VDD 2.5 V under voltage status flag, *R1) 0 _B No occurrence 1 _B Undervoltage occurred

Table 79 Reset values of **UV_STAT_APP1**

Reset	Reset value	Note
	0000 _H	Reset class R2)

18 Registers description

18.25 Monitor status flags register 2 for Application 2 *R2)

UV_STAT_APP2

Monitor status flags register 2 for Application 2 *R2)

Offset address:

011_H

Reset values see:

[Table 80](#)

15	14	13	12	11	10	9	8
Res				INTSUP_2V 5_UV	INTSUP_IV CC_UV	BUCKIF	VMON2
r				rw1c	rw1c	rw1c	rw1c
7	6	5	4	3	2	1	0
VMON1	BOOST	QVR	QCO	BUCKCORE	QST	QUC	PREREG
rw1c	rw1c	rw1c	rw1c	rw1c	rw1c	rw1c	rw1c

Field	Bits	Type	Description
PREREG	0	rw1c	Pre-regulator voltage under voltage status flag 0 _B No occurrence 1 _B Undervoltage occurred
QUC	1	rw1c	QUC under voltage status flag 0 _B No occurrence 1 _B Undervoltage occurred
QST	2	rw1c	QST under voltage status flag 0 _B No occurrence 1 _B Undervoltage occurred
BUCKCORE	3	rw1c	BUCKCORE under voltage status flag 0 _B No occurrence 1 _B Undervoltage occurred
QCO	4	rw1c	QCO under voltage status flag 0 _B No occurrence 1 _B Undervoltage occurred
QVR	5	rw1c	QVR under voltage status flag 0 _B No occurrence 1 _B Undervoltage occurred
BOOST	6	rw1c	Boost voltage under voltage status flag 0 _B No occurrence 1 _B Undervoltage occurred
VMON1	7	rw1c	VMON1 voltage under voltage status flag 0 _B No occurrence 1 _B Undervoltage occurrence
VMON2	8	rw1c	Mon2 voltage under voltage status flag 0 _B No occurrence 1 _B Undervoltage occurred

(table continues...)

18 Registers description

(continued)

Field	Bits	Type	Description
BUCKIF	9	rw1c	BUCKIF under voltage status flag 0 _B No occurrence 1 _B Undervoltage occurred
INTSUP_IVCC_UV	10	rw1c	IVCC voltage under voltage status flag *R1) 0 _B No occurrence 1 _B Undervoltage occurred
INTSUP_2V5_UV	11	rw1c	2V5 voltage under voltage status flag *R1) 0 _B No occurrence 1 _B Undervoltage occurred

Table 80 Reset values of **UV_STAT_APP2**

Reset	Reset value	Note
	0000 _H	Reset class R2)

18 Registers description

18.26 Over temperature warning and over current status flags *R2)

OT_WRN_OC_STAT_APP1

Over temperature warning and over current status flags *R2)

Offset address: 012_H

Reset values see: [Table 81](#)

15	14	13	12	11	10	9	8
Res							BOOST_OC
r							rw1c
7	6	5	4	3	2	1	0
IVCC_OC	QUC_OTWRN	BOOST_OTWRN	BUCKIF_OTWRN	BUCKCORE_OTWRN	QVR_OC	QCO_OTWRN	QST_OC
rw1c	rw1c	rw1c	rw1c	rw1c	rw1c	rw1c	rw1c

Field	Bits	Type	Description
QST_OC	0	rw1c	QST over current 0 _B No occurrence 1 _B Over current occurred
QCO_OTWRN	1	rw1c	QCO over temperature warning 0 _B No occurrence 1 _B Overtemperature warning
QVR_OC	2	rw1c	QVR over current 0 _B No occurrence 1 _B Over current occurred
BUCKCORE_OTWRN	3	rw1c	BUCKCORE overtemperature warning 0 _B No occurrence 1 _B Overtemperature warning
BUCKIF_OTWRN	4	rw1c	BUCKIF overtemperature warning 0 _B No occurrence 1 _B Overtemperature warning
BOOST_OTWRN	5	rw1c	BOOST overtemperature warning 0 _B No occurrence 1 _B Overtemperature warning
QUC_OTWRN	6	rw1c	QUC over temperature warning 0 _B No occurrence 1 _B Overtemperature warning
IVCC_OC	7	rw1c	IVCC over current warning 0 _B No occurrence 1 _B Over current occurred
BOOST_OC	8	rw1c	BOOST over current 0 _B No occurrence 1 _B Over current occurred

18 Registers description

Table 81 **Reset values of [OT_WRN_OC_STAT_APP1](#)**

Reset	Reset value	Note
	0000 _H	Reset class R2)

18 Registers description

18.27 Over temperature warning /Over current status flags for Application 2 *R2)

OT_WRN_OC_STAT_APP2

Over temperature warning /Over current status flags
for Application 2 *R2)

Offset address:

013_H

Reset values see:

[Table 82](#)

15	14	13	12	11	10	9	8
Res							BOOST_OC
r							rw1c
7	6	5	4	3	2	1	0
IVCC_OC	QUC_OTWRN	BOOST_OTWRN	BUCKIF_OTWRN	BUCKCORE_OTWRN	QVR_OC	QCO_OTWRN	QST_OC
rw1c	rw1c	rw1c	rw1c	rw1c	rw1c	rw1c	rw1c

Field	Bits	Type	Description
QST_OC	0	rw1c	QST over current 0 _B No occurrence 1 _B Over current occurred
QCO_OTWRN	1	rw1c	QCO over temperature warning 0 _B No occurrence 1 _B Overtemperature warning
QVR_OC	2	rw1c	QVR over current 0 _B No occurrence 1 _B Over current occurred
BUCKCORE_OTWRN	3	rw1c	BUCKCORE overtemperature warning 0 _B No occurrence 1 _B Overtemperature warning
BUCKIF_OTWRN	4	rw1c	BUCKIF overtemperature warning 0 _B No occurrence 1 _B Overtemperature warning
BOOST_OTWRN	5	rw1c	BOOST overtemperature warning 0 _B No occurrence 1 _B Overtemperature warning
QUC_OTWRN	6	rw1c	QUC over temperature warning 0 _B No occurrence 1 _B Overtemperature warning
IVCC_OC	7	rw1c	IVCC over current warning 0 _B No occurrence 1 _B Over current occurred
BOOST_OC	8	rw1c	BOOST over current 0 _B No occurrence 1 _B Over current occurred

18 Registers description

Table 82 **Reset values of [OT_WRN_OC_STAT_APP2](#)**

Reset	Reset value	Note
	0000 _H	Reset class R2)

18 Registers description

18.28 Voltage monitor status *R2)

VMON_STAT

Voltage monitor status *R2)

Offset address: 014_H

Reset values see: [Table 83](#)

15	14	13	12	11	10	9	8
Res					VMON2_ST	VMON1_ST	IVCC_ST
r					r	r	r
7	6	5	4	3	2	1	0
QUC_ST	PREREG_ST	BOOST_ST	BUCKINT_S T	QVR_ST	QCO_ST	BUCKCORE _ST	QST_ST
r	r	r	r	r	r	r	r

Field	Bits	Type	Description
QST_ST	0	r	Standby LDO voltage status 0 _B Voltage is out of range or not enabled 1 _B Voltage is OK
BUCKCORE_ST	1	r	Core voltage status 0 _B Voltage is out of range or not enabled 1 _B Voltage is OK
QCO_ST	2	r	Communication voltage status 0 _B Voltage is out of range or not enabled 1 _B Voltage is OK
QVR_ST	3	r	Reference voltage status 0 _B Voltage is out of range or not enabled 1 _B Voltage is OK
BUCKINT_ST	4	r	Buckint voltage status 0 _B Voltage is out of range or not enabled 1 _B Voltage is OK
BOOST_ST	5	r	Boost voltage status 0 _B Voltage is out of range or not enabled 1 _B Voltage is OK
PREREG_ST	6	r	Prereg voltage status 0 _B Voltage is out of range or not enabled 1 _B Voltage is OK
QUC_ST	7	r	QUC voltage status 0 _B Voltage is out of range or not enabled 1 _B Voltage is OK
IVCC_ST	8	r	IVCC voltage status 0 _B Voltage is out of range or not enabled 1 _B Voltage is OK

(table continues...)

18 Registers description

(continued)

Field	Bits	Type	Description
VMON1_ST	9	r	MON1 voltage status 0 _B Voltage is out of range or not enabled 1 _B Voltage is OK
VMON2_ST	10	r	MON2 voltage status 0 _B Voltage is out of range or not enabled 1 _B Voltage is OK

Table 83 **Reset values of VMON_STAT**

Reset	Reset value	Note
	0000 _H	Reset class R2)

18 Registers description

18.29 Device status register *R2)

DEV_STAT

Device status register *R2)

Offset address: 015_H

Reset values see: [Table 84](#)

15	14	13	12	11	10	9	8
VMON2_AUTO_DET	VMON1_AUTO_DET	BOOST_AUTO_DET	BUCKINT_AUTO_DET	SSW_AUTO_DET	VMON2_EN	VMON1_EN	BOOST_EN
r	r	r	r	r	r	r	r
7	6	5	4	3	2	1	0
BUCKIF_EN	QUC_EN	BUCKCORE_EN	QCO_EN	QVR_EN	STATE		
r	r	r	r	r	r		

Field	Bits	Type	Description
STATE	2:0	r	Current device state 000 _B reserved 001 _B INIT 010 _B NORMAL 011 _B SLEEP 100 _B STANDBY 101 _B WAKE 110 _B REDUCED_OPERATION 111 _B reserved
QVR_EN	3	r	QVR status 0 _B Disabled 1 _B Enabled
QCO_EN	4	r	QCO status 0 _B Disabled 1 _B Enabled
BUCKCORE_EN	5	r	BUCKCORE status 0 _B Disabled 1 _B Enabled
QUC_EN	6	r	QUC status 0 _B Disabled 1 _B Enabled
BUCKIF_EN	7	r	BUCKIF status 0 _B Disabled 1 _B Enabled
BOOST_EN	8	r	BOOST status 0 _B Disabled 1 _B Enabled

(table continues...)

18 Registers description

(continued)

Field	Bits	Type	Description
VMON1_EN	9	r	External voltage monitor channel 1 status 0 _B Disabled 1 _B Enabled
VMON2_EN	10	r	External voltage monitor channel 2 status 0 _B Disabled 1 _B Enabled
SSW_AUTO_DETECT	11	r	Safety switch auto detect 0 _B not detected 1 _B detected
BUCKINT_AUTO_DET	12	r	BUCKINT autodetection result: 0 not detected, 1 detected 0 _B not detected 1 _B detected
BOOST_AUTO_DET	13	r	BOOST autodetection result: 0 not detected, 1 detected 0 _B not detected 1 _B detected
VMON1_AUTO_DET	14	r	VMON1 autodetection result: 0 not detected, 1 detected 0 _B not detected 1 _B detected
VMON2_AUTO_DET	15	r	VMON2 autodetection result: 0 not detected, 1 detected 0 _B not detected 1 _B detected

Table 84 **Reset values of DEV_STAT**

Reset	Reset value	Note
	0000 _H	Reset class R2)

18 Registers description

18.30 DC-DC switching frequency change *R2)

DCDC_FREQ_SYNC

DC-DC switching frequency change *R2)

Offset address:

016_H

Reset values see:

[Table 85](#)

15	14	13	12	11	10	9	8
PREREG_BOOST_PHSHT	BOOST_BUCKIF_PHSHT	Res			BOOST_DRIVER_CONFIG	BUCKIF_DRIVER_CONFIG	
rw	rw	r			rw	rw	
7	6	5	4	3	2	1	0
BUCKIF_DRIVER_CONFIG	BUCKCORE_DRIVER_CONFIG	PREREG_DRIVER_CONFIG			DCDC_FREQSEL		
rw	rw	rw			rw		

Field	Bits	Type	Description
DCDC_FREQSEL	2:0	rw	DC-DC switching frequency (fDCDC) change 000 _B 1.8 MHz 001 _B 1.9 MHz 010 _B 2.0 MHz 011 _B 2.1 MHz 100 _B 2.2 MHz - default/center value 101 _B 2.3 MHz 110 _B 2.4 MHz 111 _B 2.4 MHz
PREREG_DRIVER_CONFIG	4:3	rw	Drive strength configuration for BUCK PREREG 00 _B Full strenght 01 _B 66% of full strength 10 _B 33% of full strength 11 _B RESERVED: Do not use, currently selects 33% strength
BUCKCORE_DRIVER_CONFIG	6:5	rw	Drive strength configuration for BUCK CORE 00 _B Full strenght 01 _B 50% of full strength 10 _B 25% of full strength 11 _B Do not use, currently selects 25% strength
BUCKIF_DRIVER_CONFIG	8:7	rw	Drive strength configuration for BUCK IF 00 _B Full strenght 01 _B 50% of full strength 10 _B 25% of full strength 11 _B RESERVED: Do not use, currently selects 25% strength

(table continues...)

18 Registers description

(continued)

Field	Bits	Type	Description
BOOST_DRIVE R_CONFIG	10:9	rw	Drive strength configuration for BOOST 00 _B Full strenght 01 _B 50% of full strength 10 _B 25% of full strength 11 _B RESERVED: Do not use, currently selects 25% strength
BOOST_BUCKI F_PHSFT	14	rw	180 degree phase shift between BOOST and BUCKIF 0 _B Disable phase shift 1 _B Enable phase shift
PREREG_BOO ST_PHSFT	15	rw	180 degree phase shift between BOOST and PREREG 0 _B Disable Phase Shift 1 _B Enable Phase Shift

Table 85 **Reset values of [DCDC_FREQ_SYNC](#)**

Reset	Reset value	Note
	0004 _H	Reset class R2)

18 Registers description

18.31 DC-DC Frequency spread-spectrum control register *R2)

FREQ_SPREAD

DC-DC Frequency spread-spectrum control register
 *R2)

Offset address: 017_H

Reset values see: [Table 86](#)

15	14	13	12	11	10	9	8
Res		FRE_SP_AMPLITUDE				FRE_SP_FSTEP	
r		rw				rw	
7	6	5	4	3	2	1	0
FRE_SP_TIMEBASE			FRE_SP_METH			FRE_SP_BUCK_IF_EN	FRE_SP_EN
rw			rw			rw	rw

Field	Bits	Type	Description
FRE_SP_EN	0	rw	Enable spread spectrum 0 _B Disabled 1 _B Enabled
FRE_SP_BUCK_IF_EN	1	rw	Enable spread spectrum for BUCKIF (ignored when FRE_SP_EN is 0) 0 _B Disabled 1 _B Enabled
FRE_SP_METH	4:2	rw	These bits define the method for vary the frequency spectrum 000 _B Triangle 001 _B Triangle with dithering 010 _B Triangle with pseudorandom period 011 _B Triangle with pseudorandom period and dithering 100 _B Triangle with pseudorandom half-period 101 _B Triangle with pseudorandom half-period and dithering 110 _B Triangle with pseudorandom ramp 111 _B Triangle with pseudorandom ramp and dithering
FRE_SP_TIMEBASE	7:5	rw	These bits define the timings for varying the frequency spectrum 000 _B Frequency changes every 3.5 us 001 _B Frequency changes every 7 us 010 _B Frequency changes every 10.5 us 011 _B Frequency changes every 14 us 100 _B Frequency changes every 17.5 us 101 _B Frequency changes every 21 us 110 _B Frequency changes every 24.5 us 111 _B Frequency changes every 28 us
FRE_SP_FSTEP	9:8	rw	These bits define the frequency step for varying the frequency spectrum 00 _B 0.625% variation 01 _B 1.25% variation 10 _B 2.5% variation 11 _B RESERVED: Do not use. Currently maps to 2.5% variation

(table continues...)

18 Registers description

(continued)

Field	Bits	Type	Description
FRE_SP_AMPLITUDE	13:10	rw	Defines the maximum width of the triangular ramp with respect to the center value 0 _H 12 frequency steps 1 _H 1 frequency step 2 _H 2 frequency steps 3 _H 3 frequency steps 4 _H 4 frequency steps 5 _H 5 frequency steps 6 _H 6 frequency steps 7 _H 7 frequency steps 8 _H 8 frequency steps 9 _H 9 frequency steps A _H 10 frequency steps B _H 11 frequency steps C _H 12 frequency steps D _H 13 frequency steps E _H 14 frequency steps F _H 15 frequency steps

Table 86 **Reset values of FREQ_SPREAD**

Reset	Reset value	Note
	0000 _H	Reset class R2)

18 Registers description

18.32 ABIST control 0 *R2)

ABIST_CTRL0

ABIST control 0 *R2)

Offset address: 018_H

Reset values see: [Table 87](#)

15	14	13	12	11	10	9	8
Res							ALL
r							rwh
7	6	5	4	3	2	1	0
STATUS				INT	SINGLE	PATH	START
r				rw	rw	rwh	rwh

Field	Bits	Type	Description
START	0	rwh	Start ABIST operation, the operation itself will be started. This bit is cleared after ABIST operation has been performed 0 _B Operation done or not started 1 _B Start operation
PATH	1	rwh	Select the path which should be covered by ABIST operation 0 _B Comparator only 1 _B Comparator and correspondig deglitching logic
SINGLE	2	rw	Select whether a single comparator shall be tested or all comparators in predefined sequence 0 _B Predefined sequence 1 _B Single comparator test
INT	3	rw	Selection for safe state related comparators or interrupt related comparators 0 _B Safe state related comparators 1 _B Interrupt related comparators
STATUS	7:4	r	ABIST global status information after requested operation has been performed, information shall only be considered valid, once START bit is cleared 5 _H Selected ABIST operation performed without errors A _H Selected ABIST operation performed with errors, check respective ABIST_SELECTx registers
ALL	8	rwh	When set to '1' all comparators are automatically selected. 0 _B Comparators executed as selected in ABIST_CTRL0 and ABIST_SELECT0/1/2 1 _B All comparators are tested with PATH = 0 and SINGLE = 0

Table 87 Reset values of **ABIST_CTRL0**

Reset	Reset value	Note
	0000 _H	Reset class R2)

18 Registers description

18.33 ABIST control 1 *R2)

ABIST_CTRL1

ABIST control 1 *R2)

Offset address: 019_H

Reset values see: [Table 88](#)

15	14	13	12	11	10	9	8
Res							
r							
7	6	5	4	3	2	1	0
Res			SS2_EN_BIST	SS1_EN_BIST	ABIST_CLK_EN	Res	OV_1V5_TRIG
r			rw	rw	rw	r	rw

Field	Bits	Type	Description
OV_1V5_TRIG	0	rw	Enable overvoltage trigger for protected 1.5 V comparator for analog safe state control 0 _B Disabled 1 _B Enabled
ABIST_CLK_EN	2	rw	Select ABIST clock to generate local 2 MHz clock 0 _B Disable 1 _B Enable
SS1_EN_BIST	3	rw	Enables ABIST for SS01. Requires ABIST_CTRL1.ABIST_CLK_EN=1 and ABIST_CTRL1.OV_1V5_TRIG=1 0 _B Disable 1 _B Enable
SS2_EN_BIST	4	rw	Enables ABIST for SS02. Requires ABIST_CTRL1.ABIST_CLK_EN=1 and ABIST_CTRL1.OV_1V5_TRIG=1 0 _B Disable 1 _B Enable

Table 88 Reset values of [ABIST_CTRL1](#)

Reset	Reset value	Note
	0000 _H	Reset class R2)

18 Registers description

18.34 ABIST select 0 *R2)

ABIST_SELECT0

ABIST select 0 *R2)

Offset address:

01A_H

Reset values see:

[Table 89](#)

15	14	13	12	11	10	9	8
R3FBL_OPE N	BUCKIF_SE VOV	BUCKCORE _SEVOV	PREREG_SE VOV	VDD2V5OV	IVCCOV	VMON2OV	VMON1OV
rwh	rwh	rwh	rwh	rwh	rwh	rwh	rwh
7	6	5	4	3	2	1	0
BOOSTOV	BUCKIFOV	QVROV	QCOOV	BUCKCORE OV	QSTOV	QUCOV	PREREGOV
rwh	rwh	rwh	rwh	rwh	rwh	rwh	rwh

Field	Bits	Type	Description
PREREGOV	0	rwh	Select Pre-regulator OV comparator for ABIST operation 0 _B Not selected 1 _B Selected; Bit will be cleared upon successful ABIST operation on comparator, bit will be set in case of ABIST fail for this comparator
QUCOV	1	rwh	Select uC LDO OV comparator for ABIST operation 0 _B Not selected 1 _B Selected; Bit will be cleared upon successful ABIST operation on comparator, bit will be set in case of ABIST fail for this comparator
QSTOV	2	rwh	Select Standby LDO OV comparator for ABIST operation 0 _B Not selected 1 _B Selected; Bit will be cleared upon successful ABIST operation on comparator, bit will be set in case of ABIST fail for this comparator
BUCKCOREOV	3	rwh	Select Core voltage OV comparator for ABIST operation 0 _B Not selected 1 _B Selected; Bit will be cleared upon successful ABIST operation on comparator, bit will be set in case of ABIST fail for this comparator
QCOOV	4	rwh	Select COM OV comparator for ABIST operation 0 _B Not selected 1 _B Selected; Bit will be cleared upon successful ABIST operation on comparator, bit will be set in case of ABIST fail for this comparator
QVROV	5	rwh	Select VREF OV comparator for ABIST operation 0 _B Not selected 1 _B Selected; Bit will be cleared upon successful ABIST operation on comparator, bit will be set in case of ABIST fail for this comparator
BUCKIFOV	6	rwh	Buck_int OV comparator for ABIST operation 0 _B Not selected 1 _B Selected; Bit will be cleared upon successful ABIST operation on comparator, bit will be set in case of ABIST fail for this comparator

(table continues...)

18 Registers description

(continued)

Field	Bits	Type	Description
BOOSTOV	7	rwh	BOOST OV comparator for ABIST operation 0 _B Not selected 1 _B Selected; Bit will be cleared upon successful ABIST operation on comparator, bit will be set in case of ABIST fail for this comparator
VMON1OV	8	rwh	VMON1 OV comparator for ABIST operation 0 _B Not selected 1 _B Selected; Bit will be cleared upon successful ABIST operation on comparator, bit will be set in case of ABIST fail for this comparator
VMON2OV	9	rwh	VMON2 OV comparator for ABIST operation 0 _B Not selected 1 _B Selected; Bit will be cleared upon successful ABIST operation on comparator, bit will be set in case of ABIST fail for this comparator
IVCCOV	10	rwh	IVCCOV comparator for ABIST operation 0 _B Not selected 1 _B Selected; Bit will be cleared upon successful ABIST operation on comparator, bit will be set in case of ABIST fail for this comparator
VDD2V5OV	11	rwh	VDD2V5 OV comparator for ABIST operation 0 _B Not selected 1 _B Selected; Bit will be cleared upon successful ABIST operation on comparator, bit will be set in case of ABIST fail for this comparator
PREREG_SEVO V	12	rwh	Select Pre-regulator Severe OV comparator for ABIST operation 0 _B Not selected 1 _B Selected; Bit will be cleared upon successful ABIST operation on comparator, bit will be set in case of ABIST fail for this comparator
BUCKCORE_SE VOV	13	rwh	Select BUCKCORE Severe OV comparator for ABIST operation 0 _B Not selected 1 _B Selected; Bit will be cleared upon successful ABIST operation on comparator, bit will be set in case of ABIST fail for this comparator
BUCKIF_SEVO V	14	rwh	Select BUCKINT Severe OV comparator for ABIST operation 0 _B Not selected 1 _B Selected; Bit will be cleared upon successful ABIST operation on comparator, bit will be set in case of ABIST fail for this comparator
R3FBL_OPEN	15	rwh	Select R3FBL comparator for ABIST operation 0 _B Not selected 1 _B Selected; Bit will be cleared upon successful ABIST operation on comparator, bit will be set in case of ABIST fail for this comparator

Table 89 Reset values of **ABIST_SELECT0**

Reset	Reset value	Note
	0000 _H	Reset class R2)

18 Registers description

18.35 ABIST select 1 *R2)

ABIST_SELECT1

ABIST select 1 *R2)

Offset address: 01B_H

Reset values see: [Table 90](#)

15	14	13	12	11	10	9	8
Res	BST_DEEP_UV	BSTIUUV	VDD2V5UV	IVCCUV	VMON2UV	VMON1UV	
r	rwh	rwh	rwh	rwh	rwh	rwh	rwh
7	6	5	4	3	2	1	0
BOOSTUV	BUCKINTUV	QVRUV	QCOUV	BUCKCORE UV	QSTUV	QUCUV	PREREGUV
rwh	rwh	rwh	rwh	rwh	rwh	rwh	rwh

Field	Bits	Type	Description
PREREGUV	0	rwh	Select pre regulator UV comparator for ABIST operation 0 _B Not selected 1 _B Selected; Bit will be cleared upon successful ABIST operation on comparator, bit will be set in case of ABIST fail for this comparator
QUCUV	1	rwh	Select uC UV comparator for ABIST operation 0 _B Not selected 1 _B Selected; Bit will be cleared upon successful ABIST operation on comparator, bit will be set in case of ABIST fail for this comparator
QSTUV	2	rwh	Select STBY UV comparator for ABIST operation 0 _B Not selected 1 _B Selected; Bit will be cleared upon successful ABIST operation on comparator, bit will be set in case of ABIST fail for this comparator
BUCKCOREUV	3	rwh	Select VCORE UV comparator for ABIST operation 0 _B Not selected 1 _B Selected; Bit will be cleared upon successful ABIST operation on comparator, bit will be set in case of ABIST fail for this comparator
QCOUV	4	rwh	Select COM UV comparator for ABIST operation 0 _B Not selected 1 _B Selected; Bit will be cleared upon successful ABIST operation on comparator, bit will be set in case of ABIST fail for this comparator
QVRUV	5	rwh	Select VREF UV comparator for ABIST operation 0 _B Not selected 1 _B Selected; Bit will be cleared upon successful ABIST operation on comparator, bit will be set in case of ABIST fail for this comparator
BUCKINTUV	6	rwh	Select Buck_int UV comparator for ABIST operation 0 _B Not selected 1 _B Selected; Bit will be cleared upon successful ABIST operation on comparator, bit will be set in case of ABIST fail for this comparator

(table continues...)

18 Registers description

(continued)

Field	Bits	Type	Description
BOOSTUV	7	rwh	Select Boost UV comparator for ABIST operation 0 _B Not selected 1 _B Selected; Bit will be cleared upon successful ABIST operation on comparator, bit will be set in case of ABIST fail for this comparator
VMON1UV	8	rwh	Select VMON1 UV comparator for ABIST operation 0 _B Not selected 1 _B Selected; Bit will be cleared upon successful ABIST operation on comparator, bit will be set in case of ABIST fail for this comparator
VMON2UV	9	rwh	Select VMON2 UV comparator for ABIST operation 0 _B Not selected 1 _B Selected; Bit will be cleared upon successful ABIST operation on comparator, bit will be set in case of ABIST fail for this comparator
IVCCUV	10	rwh	Select IVCC UV comparator for ABIST operation 0 _B Not selected 1 _B Selected; Bit will be cleared upon successful ABIST operation on comparator, bit will be set in case of ABIST fail for this comparator
VDD2V5UV	11	rwh	Select VDD2V5 UV comparator for ABIST operation 0 _B Not selected 1 _B Selected; Bit will be cleared upon successful ABIST operation on comparator, bit will be set in case of ABIST fail for this comparator
BSTIUV	12	rwh	BSTI UV comparator for ABIST operation 0 _B No error detected 1 _B Error detected (during internal checks)
BST_DEEP_UV	13	rwh	Select BST_DEEP_UV comparator for ABIST operation 0 _B Not selected 1 _B Selected; Bit will be cleared upon successful ABIST operation on comparator, bit will be set in case of ABIST fail for this comparator

Table 90 **Reset values of [ABIST_SELECT1](#)**

Reset	Reset value	Note
	0000 _H	Reset class R2)

18 Registers description

18.36 ABIST select 2 *R2)

ABIST_SELECT2

ABIST select 2 *R2)

Offset address:

01C_H

Reset values see:

[Table 91](#)

15	14	13	12	11	10	9	8
Res							VDD5V0OV
r							rwh
7	6	5	4	3	2	1	0
VDD5V0UV	VDD1V5OV	VDD1V5UV	BIASHI	BIASLOW	BG12OV	BG12UV	VBATOV
rwh	rwh	rwh	rwh	rwh	rwh	rwh	rwh

Field	Bits	Type	Description
VBATOV	0	rwh	Supply voltage VS1/2 is too high 0 _B Not selected 1 _B Selected; Bit will be cleared upon successful ABIST operation on comparator, bit will be set in case of ABIST fail for this comparator
BG12UV	1	rwh	Bandgap comparator UV condition 0 _B Not selected 1 _B Selected; Bit will be cleared upon successful ABIST operation on comparator, bit will be set in case of ABIST fail for this comparator
BG12OV	2	rwh	Bandgap comparator OV condition 0 _B Not selected 1 _B Selected; Bit will be cleared upon successful ABIST operation on comparator, bit will be set in case of ABIST fail for this comparator
BIASLOW	3	rwh	Bias current too low 0 _B Not selected 1 _B Selected; Bit will be cleared upon successful ABIST operation on comparator, bit will be set in case of ABIST fail for this comparator
BIASHI	4	rwh	Bias current too high 0 _B Not selected 1 _B Selected; Bit will be cleared upon successful ABIST operation on comparator, bit will be set in case of ABIST fail for this comparator
VDD1V5UV	5	rwh	Select internal 1.5 V domain undervoltage comparator 0 _B Comparator test not selected 1 _B Comparator test selected
VDD1V5OV	6	rwh	Select internal 1.5 V domain overvoltage comparator 0 _B Comparator test not selected 1 _B Comparator test selected
VDD5V0UV	7	rwh	Select internal 2.5 V domain undervoltage comparator 0 _B Comparator test not selected 1 _B Comparator test selected

(table continues...)

18 Registers description

(continued)

Field	Bits	Type	Description
VDD5V0OV	8	rwh	Select internal 2.5 V domain overvoltage comparator 0 _B Comparator test not selected 1 _B Comparator test selected

Table 91 Reset values of **ABIST_SELECT2**

Reset	Reset value	Note
	0000 _H	Reset class R2)

18 Registers description

18.37 Global testmode *R2)

GTM

Global testmode *R2)

Offset address:

01D_H

Reset values see:

[Table 92](#)

15	14	13	12	11	10	9	8
Res							
r							
7	6	5	4	3	2	1	0
Res						NTM	TM
r						r	r

Field	Bits	Type	Description
TM	0	r	Test mode status 0 _B Device is in normal mode 1 _B Device is in test mode
NTM	1	r	Test mode status inverted 0 _B Device is in test mode 1 _B Device is in normal mode

Table 92 Reset values of **GTM**

Reset	Reset value	Note
	0002 _H	Reset class R2)

18 Registers description

18.38 Reduced operation reflected status configuration 1 register - *R2)

REDOP_RS_CFG1

Reduced operation reflected status configuration 1 register - *R2)

Offset address: 01E_H

Reset values see: [Table 93](#)

15	14	13	12	11	10	9	8
Res	SSO1TOSSO2_DEL			Res		INT2_DIS	INT1_DIS
r	r			r		r	r
7	6	5	4	3	2	1	0
SSO2_DEL			SSO1_DEL			Res	EN
r			r			r	r

Field	Bits	Type	Description
EN	0	r	Enable reduced operation - *R3) 0 _B Disable 1 _B Enable
SSO1_DEL	4:2	r	Safe state output 1 delay (tSSO1_red) - only active if REDUCED OPERATION is enabled 000 _B 0 ms 001 _B 10 ms 010 _B 50 ms 011 _B 100 ms 100 _B 250 ms 101 _B Do not use. Maps to 0 ms ... 111 _B Do not use. Maps to 0 ms
SSO2_DEL	7:5	r	Safe state output 2 delay (tSSO2_red) - only active if REDUCED OPERATION is enabled 000 _B 0 ms 001 _B 10 ms 010 _B 50 ms 011 _B 100 ms 100 _B 250 ms 101 _B Do not use. Maps to 0 ms ... 111 _B Do not use. Maps to 0 ms
INT1_DIS	8	r	Disable generation of INT1 due to Cluster 2 entering REDUCED OPERATION 0 _B Allow generation of INT1 when application 2 enters REDUCED OPERATION 1 _B Disable generation of INT1 related to application 2 entering REDUCED OPERATION

(table continues...)

18 Registers description

(continued)

Field	Bits	Type	Description
INT2_DIS	9	r	Disable generation of INT2 due to Cluster 1 entering REDUCED OPERATION 0 _B Allow generation of INT2 when application 1 enters REDUCED OPERATION 1 _B Disable generation of INT2 related to application 1 entering REDUCED OPERATION
SSO1TOSSO2_DEL	14:12	r	Safe state output 2 delay to Safe state output 1 (tSSO2) when REDUCED OPERATION is disabled 000 _B 0 ms 001 _B 10 ms 010 _B 50 ms 011 _B 100 ms 100 _B 250 ms 101 _B Do not use. Maps to 0 ms ... 111 _B Do not use. Maps to 0 ms

Table 93 Reset values of **REDOP_RS_CFG1**

Reset	Reset value	Note
	0000 _H	Reset class R2)

18 Registers description

18.39 ERR0 protection write configuration register *R2)

ERR0_PW_CFG

Offset address: 01F_H

ERR0 protection write configuration register *R2)

Reset values see: [Table 94](#)

15	14	13	12	11	10	9	8
Res							
r							
7	6	5	4	3	2	1	0
Res		SLP_EN	EN	TREC_EN	TREC		
r		rw	rw	rw	rw		

Field	Bits	Type	Description
TREC	1:0	rw	ERR0 pin monitor recovery time 00 _B 1 ms 01 _B 2.5 ms 10 _B 5 ms 11 _B 10 ms
TREC_EN	2	rw	Enabling of recovery time functionality for ERR0 pin monitor 0 _B Disabled 1 _B Enabled
EN	3	rw	Enable ERR0 pin monitor 0 _B Disabled 1 _B Enabled
SLP_EN	4	rw	Enabling of ERR0 pin monitor functionality while the system is in SLEEP state 0 _B Disabled 1 _B Enabled

Table 94 Reset values of **ERR0_PW_CFG**

Reset	Reset value	Note
	0008 _H	Reset class R2)

18 Registers description

18.40 ERR0 reflected status configuration register *R3)

ERR0_RS_CFG

Offset address: 020_H

ERR0 reflected status configuration register *R3)

Reset values see: [Table 95](#)

15	14	13	12	11	10	9	8
Res							
r							
7	6	5	4	3	2	1	0
Res		SLP_EN		EN	TREC_EN	TREC	
r		r		r	r	r	

Field	Bits	Type	Description
TREC	1:0	r	ERR0 pin monitor recovery time 00 _B 1 ms 01 _B 2.5 ms 10 _B 5 ms 11 _B 10 ms
TREC_EN	2	r	Enabling of recovery time functionality for ERR0 pin monitor 0 _B Disabled 1 _B Enabled
EN	3	r	Enable ERR0 pin monitor 0 _B Disabled 1 _B Enabled
SLP_EN	4	r	Enabling of ERR0 pin monitor functionality while the system is in SLEEP state 0 _B Disabled 1 _B Enabled

Table 95 Reset values of [ERR0_RS_CFG](#)

Reset	Reset value	Note
	0008 _H	Reset class R3) C1

18 Registers description

18.41 ERR1 protection write configuration register *R2)

ERR1_PW_CFG

Offset address: 021_H

ERR1 protection write configuration register *R2)

Reset values see: [Table 96](#)

15	14	13	12	11	10	9	8
Res							
r							
7	6	5	4	3	2	1	0
Res		SLP_EN	EN	TREC_EN	TREC		
r		rw	rw	rw	rw		

Field	Bits	Type	Description
TREC	1:0	rw	ERR1 pin monitor recovery time 00 _B 1 ms 01 _B 2.5 ms 10 _B 5 ms 11 _B 10 ms
TREC_EN	2	rw	Enabling of recovery time functionality for ERR1 pin monitor 0 _B Disabled 1 _B Enabled
EN	3	rw	Enable ERR1 pin monitor 0 _B Disabled 1 _B Enabled
SLP_EN	4	rw	Enabling of ERR1 pin monitor functionality while the system is in SLEEP state 0 _B Disabled 1 _B Enabled

Table 96 Reset values of **ERR1_PW_CFG**

Reset	Reset value	Note
	0008 _H	Reset class R2)

18 Registers description

18.42 ERR1 reflected status configuration register *R3_C1)

ERR1_RS_CFG

Offset address: 022_H

ERR1 reflected status configuration register *R3_C1)

Reset values see: [Table 97](#)

15	14	13	12	11	10	9	8
Res							
r							
7	6	5	4	3	2	1	0
Res		SLP_EN		EN	TREC_EN	TREC	
r		r		r	r	r	

Field	Bits	Type	Description
TREC	1:0	r	ERR1 pin monitor recovery time 00 _B 1 ms 01 _B 2.5 ms 10 _B 5 ms 11 _B 10 ms
TREC_EN	2	r	Enabling of recovery time functionality for ERR1 pin monitor 0 _B Disabled 1 _B Enabled
EN	3	r	Enable ERR1 pin monitor 0 _B Disabled 1 _B Enabled
SLP_EN	4	r	Enabling of ERR1 pin monitor functionality while the system is in SLEEP state 0 _B Disabled 1 _B Enabled

Table 97 Reset values of **ERR1_RS_CFG**

Reset	Reset value	Note
	0008 _H	Reset class R3) C1

18 Registers description

18.43 ERR2 protection write configuration register *R2)

ERR2_PW_CFG

Offset address: 023_H

ERR2 protection write configuration register *R2)

Reset values see: [Table 98](#)

15	14	13	12	11	10	9	8
Res							
r							
7	6	5	4	3	2	1	0
Res		SLP_EN		EN	TREC_EN	TREC	
r		rw		rw	rw	rw	

Field	Bits	Type	Description
TREC	1:0	rw	ERR2 pin monitor recovery time 00 _B 1 ms 01 _B 2.5 ms 10 _B 5 ms 11 _B 10 ms
TREC_EN	2	rw	Enabling of recovery time functionality for ERR2 pin monitor 0 _B Disabled 1 _B Enabled
EN	3	rw	Enable ERR2 pin monitor This bit has only an effect if REDOP_RS_CFG1.EN is 1 0 _B Disabled 1 _B Enabled
SLP_EN	4	rw	Enabling of ERR2 pin monitor functionality while the system is in SLEEP state 0 _B Disabled 1 _B Enabled

Table 98 Reset values of [ERR2_PW_CFG](#)

Reset	Reset value	Note
	0008 _H	Reset class R2)

18 Registers description

18.44 ERR2 reflected status configuration register *R3_C2)

ERR2_RS_CFG

Offset address: 024_H

ERR2 reflected status configuration register *R3_C2)

Reset values see: [Table 99](#)

15	14	13	12	11	10	9	8
Res							
r							
7	6	5	4	3	2	1	0
Res		SLP_EN		EN	TREC_EN	TREC	
r		r		r	r	r	

Field	Bits	Type	Description
TREC	1:0	r	ERR2 pin monitor recovery time 00 _B 1 ms 01 _B 2.5 ms 10 _B 5 ms 11 _B 10 ms
TREC_EN	2	r	Enabling of recovery time functionality for ERR2 pin monitor 0 _B Disabled 1 _B Enabled
EN	3	r	Enable ERR2 pin monitor This bit has only an effect if REDOP_RS_CFG1.EN is 1 0 _B Disabled 1 _B Enabled
SLP_EN	4	r	Enabling of ERR2 pin monitor functionality while the system is in SLEEP state 0 _B Disabled 1 _B Enabled

Table 99 Reset values of [ERR2_RS_CFG](#)

Reset	Reset value	Note
	0008 _H	Reset class R3) C2

18 Registers description

18.45 Device configuration 1 register *R0)

DEV_CFG1

Device configuration 1 register *R0)

Offset address: 025_H

value: 0206_H

15	14	13	12	11	10	9	8
Res						ABIST_EN	Res
r						rw	r
7	6	5	4	3	2	1	0
HWCFG_STAT				MPS_EN	RESET_DEL		
r				rwh	rwh		

Field	Bits	Type	Description
RESET_DEL	2:0	rwh	Reset delay time (tRD); Starts upon QST, QUC and BUCKCORE are above their UV thresholds. 000 _B 200 μs 001 _B 400 μs 010 _B 800 μs 011 _B 1 ms 100 _B 2 ms 101 _B 4 ms 110 _B 10 ms 111 _B 20 ms
MPS_EN	3	rwh	Microcontroller programming support enable 0 _B Disabled 1 _B Enabled
HWCFG_STAT	7:4	r	This bit reflects the status of the hardware configuration pin 0 _H 1 kOhm 1 _H 2.2 kOhm 2 _H 3.3 kOhm 3 _H 4.7 kOhm 4 _H 6.8 kOhm 5 _H 10 kOhm 6 _H 15 kOhm 7 _H Reserved value 8 _H Reserved value 9 _H 22 kOhm A _H 33 kOhm B _H 47 kOhm C _H 68 kOhm D _H 100 kOhm E _H 150 kOhm F _H 200 kOhm

(table continues...)

18 Registers description

(continued)

Field	Bits	Type	Description
ABIST_EN	9	rw	Autostart of analog built in self test for voltage monitoring when waking up from FAILSAFE, STANDBY and POWERDOWN. 0 _B ABIST only executed when waking up from STANDBY (if WUT and QST are both OFF) or from POWERDOWN 1 _B ABIST executed when waking up from STANDBY or from POWERDOWN or from FAILSAFE

18 Registers description

18.46 Device protected write configuration 2 register *R0)

DEV_PW_CFG2

Offset address: 026_H

Device protected write configuration 2 register *R0)

value: F001_H

15	14	13	12	11	10	9	8
VMON2_STG_TIME		VMON1_STG_TIME		Res			
rw		rw		r			
7	6	5	4	3	2	1	0
Res				QST_MODE	SSW_OC_TH		QST_EN
r				rw	rw		rw

Field	Bits	Type	Description
QST_EN	0	rw	Activation of standby LDO 0 _B Disabled 1 _B Enabled
SSW_OC_TH	2:1	rw	Safety switch overcurrent detection threshold. 00 _B 0.755 V 01 _B 0.944 V 10 _B 1.04 V 11 _B 1.22 V
QST_MODE	3	rw	Selects between 2 different modes of controlling standby LDO via QSTEN 0 _B PMIC_MODE: QST is selectable only when the device is moving to STANDBY. QST is on in all other states, independently of QST_EN. 1 _B USER_MODE: QST supply on or off, can be configured by QST_EN
VMON1_STG_TIME	13:12	rw	Filter time to detect a short-to-ground on external voltage monitor channel 1 00 _B 1 ms 01 _B 2 ms 10 _B 4 ms 11 _B 6 ms
VMON2_STG_TIME	15:14	rw	Filter time to detect a short-to-ground on external voltage monitor channel 2 00 _B 1 ms 01 _B 2 ms 10 _B 4 ms 11 _B 6 ms

18 Registers description

18.47 Device reflected status configuration 2 register *R0)

DEV_RS_CFG2

Offset address: 027_H

Device reflected status configuration 2 register *R0)

value: F001_H

15	14	13	12	11	10	9	8
VMON2_STG_TIME		VMON1_STG_TIME		Res			
r		r		r			
7	6	5	4	3	2	1	0
Res				QST_MODE	SSW_OC_TH		QST_EN
r				r	r		r

Field	Bits	Type	Description
QST_EN	0	r	Activation of standby LDO 0 _B Disabled 1 _B Enabled
SSW_OC_TH	2:1	r	Safety switch overcurrent detection threshold. 00 _B 0.755 V 01 _B 0.944 V 10 _B 1.04 V 11 _B 1.22 V
QST_MODE	3	r	Selects between 2 different modes of controlling standby LDO via QSTEN 0 _B PMIC_MODE: QST is selectable only when the device is moving to STANDBY. QST is on in all other states, independently of QST_EN. 1 _B USER_MODE: QST supply on or off, can be configured by QST_EN
VMON1_STG_TIME	13:12	r	Time to detect a short-to-ground on external voltage monitor channel 1 00 _B 1 ms 01 _B 2 ms 10 _B 4 ms 11 _B 6 ms
VMON2_STG_TIME	15:14	r	Time to detect a short-to-ground on external voltage monitor channel 2 00 _B 1 ms 01 _B 2 ms 10 _B 4 ms 11 _B 6 ms

18 Registers description

18.48 System failure status register for application 1 *R1)

SYSFAIL_STAT_APP1

System failure status register for application 1 *R1)

Offset address: 029_H

Reset values see: [Table 100](#)

15	14	13	12	11	10	9	8
Res				ABIST	CFGE	PREREG_C OSW	INTSUP_IV CC
r				rw1c	rw1c	rw1c	rw1c
7	6	5	4	3	2	1	0
QST	ERR0	FSM_INITTI MER	VMON	OT	BUCK_COR E_VOLTSEL	BUCKIF_VO LTSEL	QST_QUC_ VOLTSEL
rw1c	rw1c	rw1c	rw1c	rw1c	rw1c	rw1c	rw1c

Field	Bits	Type	Description
QST_QUC_VOL TSEL	0	rw1c	QST and QUC voltage selection error. Nominal voltage of QST and QUC might be corrupt (3.3 V or 5 V). 0 _B No occurrence 1 _B Fault occurred
BUCKIF_VOLTS EL	1	rw1c	BUCK IF voltage selection error. Nominal voltage of BUCKIF might be corrupt (1.8 V or 3.3 V). 0 _B No occurrence 1 _B Fault occurred
BUCK_CORE_V OLTSEL	2	rw1c	BUCK CORE voltage selection error. Nominal voltage of BUCKCORE might be corrupt. 0 _B No occurrence 1 _B Fault occurred
OT	3	rw1c	Over temperature failure. (see chapter: Collection registers) 0 _B No fault 1 _B Fault occurred
VMON	4	rw1c	Voltage monitor failure (see chapter: Collection registers) 0 _B No fault 1 _B Fault occurred
FSM_INITTIME R	5	rw1c	Init timer failure due to the third INIT failure in row. The device moved to FAILSAFE state. 0 _B No fault 1 _B Fault occurred
ERR0	6	rw1c	ERR0 failure 0 _B No fault 1 _B Fault occurred
QST	7	rw1c	Standby LDO (QST) failure; Also set if BIST of QST returned an error 0 _B No fault 1 _B Fault occurred

(table continues...)

18 Registers description

(continued)

Field	Bits	Type	Description
INTSUP_IVCC	8	rw1c	Internal supply IVCC failure; Also set if BIST of QIS returned an error 0 _B No fault 1 _B Fault occurred
PREREG_COS W	9	rw1c	Reports major faults detected during SSW BIST and overcurrent on SSW 0 _B No fault 1 _B Fault occurred
CFGE	10	rw1c	DED for Cluster1 config registers 0 _B Write 0 - no action 1 _B Event detected, write 1 to clear the flag
ABIST	11	rw1c	ABIST operation interrupted by move to INIT or move to FAILSAFE fault 0 _B No fault 1 _B Fault occurred

Table 100 Reset values of **SYSFAIL_STAT_APP1**

Reset	Reset value	Note
	0000 _H	Reset class R1)

18 Registers description

18.49 System failure status flags for application 2 *R1)

SYSFAIL_STAT_APP2

System failure status flags for application 2 *R1)

Offset address: 02A_H

Reset values see: [Table 101](#)

15	14	13	12	11	10	9	8
Res				ABIST	CFGE	PREREG_C OSW	INTSUP_IV CC
r				rw1c	rw1c	rw1c	rw1c
7	6	5	4	3	2	1	0
QST	ERR0	FSM_INITTI MER	VMON	OT	BUCK_COR E_VOLTSEL	BUCKIF_VO LTSEL	QST_QUC_ VOLTSEL
rw1c	rw1c	rw1c	rw1c	rw1c	rw1c	rw1c	rw1c

Field	Bits	Type	Description
QST_QUC_VOL TSEL	0	rw1c	QST and QUC voltage selection error. Nominal voltage of QST and QUC might be corrupt (3.3 V or 5 V). 0 _B No occurrence 1 _B Fault occurred
BUCKIF_VOLTS EL	1	rw1c	BUCK IF voltage selection error. Nominal voltage of BUCKIF might be corrupt (1.8 V or 3.3 V). 0 _B No occurrence 1 _B Fault occurred
BUCK_CORE_V OLTSEL	2	rw1c	BUCK CORE voltage selection error. Nominal voltage of BUCKCORE might be corrupt. 0 _B No occurrence 1 _B Fault occurred
OT	3	rw1c	Over temperature failure (see chapter: Collection registers) 0 _B No occurrence 1 _B Fault occurred
VMON	4	rw1c	Voltage monitor failure (see chapter: Collection registers) 0 _B No occurrence 1 _B Fault occurred
FSM_INITTIME R	5	rw1c	Init timer failure due to the third INIT failure in row. The device moved to FAILSAFE state. 0 _B No occurrence 1 _B Fault occurred
ERR0	6	rw1c	ERR0 failure 0 _B No occurrence 1 _B Fault occurred
QST	7	rw1c	Standby LDO (QST) failure 0 _B No occurrence 1 _B Fault occurred

(table continues...)

18 Registers description

(continued)

Field	Bits	Type	Description
INTSUP_IVCC	8	rw1c	Internal supply IVCC failure 0 _B No occurrence 1 _B Fault occurred
PREREG_COSW	9	rw1c	Reports severe faults detected during SSW BIST 0 _B No occurrence 1 _B Fault occurred
CFGE	10	rw1c	DED for Cluster 2 config registers 0 _B Write 0 - no action 1 _B Event detected, write 1 to clear the flag
ABIST	11	rw1c	ABIST operation interrupted by move to INIT or move to FAILSAFE fault 0 _B No occurrence 1 _B Fault occurred

Table 101 Reset values of [SYSFAIL_STAT_APP2](#)

Reset	Reset value	Note
	0000 _H	Reset class R1)

18 Registers description

18.50 Short to ground status register for application 1 *R1)

STG_STAT_APP1

Offset address:

02B_H

Short to ground status register for application 1 *R1)

Reset values see:

[Table 102](#)

15	14	13	12	11	10	9	8
Res						VMON2	VMON1
r						rw1c	rw1c
7	6	5	4	3	2	1	0
BOOST	BUCKIF	QVR	QCO	BUCKCORE	QST	QUC	PREREG
rw1c	rw1c	rw1c	rw1c	rw1c	rw1c	rw1c	rw1c

Field	Bits	Type	Description
PREREG	0	rw1c	Pre-regulator voltage short to ground status flag 0 _B No fault 1 _B Fault occurred
QUC	1	rw1c	MCU LDO short to ground status flag 0 _B No fault 1 _B Fault occurred
QST	2	rw1c	Standby LDO short to ground status flag 0 _B No fault 1 _B Fault occurred
BUCKCORE	3	rw1c	Buckcore voltage short to ground status flag 0 _B No fault 1 _B Fault occurred
QCO	4	rw1c	Communication LDO short to ground status flag 0 _B No fault 1 _B Fault occurred
QVR	5	rw1c	Reference LDO short to ground status flag 0 _B No fault 1 _B Fault occurred
BUCKIF	6	rw1c	Buck interface short to ground status flag 0 _B No fault 1 _B Fault occurred
BOOST	7	rw1c	Boost short to ground status flag 0 _B No fault 1 _B Event detected
VMON1	8	rw1c	VMON1 short to ground status flag 0 _B No fault 1 _B Fault occurred
VMON2	9	rw1c	VMON2 short to ground status flag 0 _B No fault 1 _B Fault occurred

18 Registers description

Table 102 **Reset values of [STG_STAT_APP1](#)**

Reset	Reset value	Note
	0000 _H	Reset class R1)

18 Registers description

18.51 Short to ground status register for application 2 *R1)

STG_STAT_APP2

Short to ground status register for application 2 *R1)

Offset address:

02C_H

Reset values see:

[Table 103](#)

15	14	13	12	11	10	9	8
Res						VMON2	VMON1
r						rw1c	rw1c
7	6	5	4	3	2	1	0
BOOST	BUCKIF	QVR	QCO	BUCKCORE	QST	QUC	PREREG
rw1c	rw1c	rw1c	rw1c	rw1c	rw1c	rw1c	rw1c

Field	Bits	Type	Description
PREREG	0	rw1c	Pre-regulator voltage short to ground status flag 0 _B No fault 1 _B Fault occurred
QUC	1	rw1c	MCU LDO short to ground status flag 0 _B No fault 1 _B Fault occurred
QST	2	rw1c	Standby LDO short to ground status flag 0 _B No fault 1 _B Fault occurred
BUCKCORE	3	rw1c	Buckcore voltage short to ground status flag 0 _B No fault 1 _B Fault occurred
QCO	4	rw1c	Communication LDO short to ground status flag 0 _B No fault 1 _B Fault occurred
QVR	5	rw1c	Voltage reference short to ground status flag 0 _B No fault 1 _B Fault occurred
BUCKIF	6	rw1c	Buckint short to ground status flag 0 _B No fault 1 _B Fault occurred
BOOST	7	rw1c	Boost short to ground status flag 0 _B No fault 1 _B Fault occurred
VMON1	8	rw1c	VMON1 short to ground status flag 0 _B No fault 1 _B Fault occurred
VMON2	9	rw1c	VMON2 short to ground status flag 0 _B No fault 1 _B Fault occurred

18 Registers description

Table 103 **Reset values of [STG_STAT_APP2](#)**

Reset	Reset value	Note
	0000 _H	Reset class R1)

18 Registers description

18.52 Overvoltage status register for application 1 *R1)

OV_STAT_APP1

Overvoltage status register for application 1 *R1)

Offset address:

02D_H

Reset values see:

[Table 104](#)

15	14	13	12	11	10	9	8
Res			BUCKCORE_FB_OPEN	INTSUP_VD D2V5	INTSUP_IV CC	BUCKIF	PREREG
r			rw1c	rw1c	rw1c	rw1c	rw1c
7	6	5	4	3	2	1	0
VMON2	VMON1	BOOST	QVR	QCO	BUCKCORE	QST	QUC
rw1c	rw1c	rw1c	rw1c	rw1c	rw1c	rw1c	rw1c

Field	Bits	Type	Description
QUC	0	rw1c	QUC over voltage status flag 0 _B No fault 1 _B Fault occurred
QST	1	rw1c	Standby LDO QST over voltage status flag 0 _B No fault 1 _B Fault occurred
BUCKCORE	2	rw1c	BUCKCORE over voltage status flag 0 _B No fault 1 _B Fault occurred
QCO	3	rw1c	QCO over voltage status flag 0 _B No fault 1 _B Fault occurred
QVR	4	rw1c	QVR over voltage status flag 0 _B No fault 1 _B Fault occurred
BOOST	5	rw1c	BOOST over voltage status flag 0 _B No fault 1 _B Fault occurred
VMON1	6	rw1c	External volatage monitor channel 1 over voltage status flag 0 _B No fault 1 _B Fault occurred
VMON2	7	rw1c	External volatage monitor channel 2 over voltage status flag 0 _B No fault 1 _B Fault occurred
PREREG	8	rw1c	Pre-regulator over voltage status flag 0 _B No fault 1 _B Fault occurred

(table continues...)

18 Registers description

(continued)

Field	Bits	Type	Description
BUCKIF	9	rw1c	Buck interface over voltage status flag 0 _B No fault 1 _B Fault occurred
INTSUP_IVCC	10	rw1c	Internal supply IVCC LDO over voltage status flag (Internal monitoring) 0 _B No fault 1 _B Fault occurred
INTSUP_VDD2 V5	11	rw1c	Internal supply VDD 2V5 LDO over voltage status flag (Internal monitoring) 0 _B No fault 1 _B Fault occurred
BUCKCORE_F B_OPEN	12	rw1c	BUCKCORE feedback open status flag 0 _B No fault 1 _B Fault occurred

Table 104 Reset values of **OV_STAT_APP1**

Reset	Reset value	Note
	0000 _H	Reset class R1)

18 Registers description

18.53 Overvoltage status register for application 2 *R1)

OV_STAT_APP2

Overvoltage status register for application 2 *R1)

Offset address:

02E_H

Reset values see:

[Table 105](#)

15	14	13	12	11	10	9	8
Res			BUCKCORE _GND_OPE N	VDD2V5OV	INTSUP_IV CC	BUCKIF	PREREG
r			rw1c	rw1c	rw1c	rw1c	rw1c
7	6	5	4	3	2	1	0
VMON2	VMON1	BOOST	QVR	QCO	BUCKCORE	QST	QUC
rw1c	rw1c	rw1c	rw1c	rw1c	rw1c	rw1c	rw1c

Field	Bits	Type	Description
QUC	0	rw1c	MCU LDO over voltage status flag 0 _B No fault 1 _B Fault occurred
QST	1	rw1c	Standby LDO QST over voltage status flag 0 _B No fault 1 _B Fault occurred
BUCKCORE	2	rw1c	BUCKCORE over voltage status flag 0 _B No fault 1 _B Fault occurred
QCO	3	rw1c	QCO over voltage status flag 0 _B No fault 1 _B Fault occurred
QVR	4	rw1c	QVR over voltage status flag 0 _B No fault 1 _B Fault occurred
BOOST	5	rw1c	BOOST over voltage status flag 0 _B No fault 1 _B Fault occurred
VMON1	6	rw1c	External volatage monitor channel 1 over voltage status flag 0 _B No fault 1 _B Fault occurred
VMON2	7	rw1c	External volatage monitor channel 2 over voltage status flag 0 _B No fault 1 _B Fault occurred
PREREG	8	rw1c	Pre-regulator over voltage status flag 0 _B No fault 1 _B Fault occurred

(table continues...)

18 Registers description

(continued)

Field	Bits	Type	Description
BUCKIF	9	rw1c	BUCKIF over voltage status flag 0 _B No fault 1 _B Fault occurred
INTSUP_IVCC	10	rw1c	Internal supply IVCC LDO over voltage status flag (Internal monitoring) 0 _B No fault 1 _B Fault occurred
VDD2V5OV	11	rw1c	Internal supply VDD 2V5 LDO over voltage status flag (Internal monitoring) 0 _B No fault 1 _B Fault occurred
BUCKCORE_G ND_OPEN	12	rw1c	Buckcore ground open status flag 0 _B No fault 1 _B Fault occurred

Table 105 Reset values of **OV_STAT_APP2**

Reset	Reset value	Note
	0000 _H	Reset class R1)

18 Registers description

18.54 Internal supply status register for application 1 *R1)

INTSUP_STAT_APP1

Offset address: 02F_H

Internal supply status register for application 1 *R1)

Reset values see: [Table 106](#)

15	14	13	12	11	10	9	8
Res							
r							
7	6	5	4	3	2	1	0
Res	PMU_RED	PMU_MAIN	BIAS_HI	BIAS_LOW	BG12_OV	BG12_UV	VBAT_OV
r	rw1c	rw1c	rw1c	rw1c	rw1c	rw1c	rw1c

Field	Bits	Type	Description
VBAT_OV	0	rw1c	Battery voltage supply (VS) over voltage 0 _B No fault 1 _B Fault occurred
BG12_UV	1	rw1c	Internal bandgap comparator detected UV condition (Internal monitoring) 0 _B No fault 1 _B Fault occurred
BG12_OV	2	rw1c	Internal bandgap comparator detected OV condition (Internal monitoring) 0 _B No fault 1 _B Fault occurred
BIAS_LOW	3	rw1c	Internal bias current too low (Internal monitoring) 0 _B No fault 1 _B Fault occurred
BIAS_HI	4	rw1c	Internal bias current too high (Internal monitoring) 0 _B No fault 1 _B Fault occurred
PMU_MAIN	5	rw1c	PMU main pass element fail (Internal monitoring) 0 _B No fault 1 _B Fault occurred
PMU_RED	6	rw1c	PMU redundant pass element fail (Internal monitoring) 0 _B No fault 1 _B Fault occurred

Table 106 Reset values of **INTSUP_STAT_APP1**

Reset	Reset value	Note
	0000 _H	Reset class R1)

18 Registers description

18.55 Internal supply status register for application 2 *R1)

INTSUP_STAT_APP2

Offset address: 030_H

Internal supply status register for application 2 *R1)

Reset values see: [Table 107](#)

15	14	13	12	11	10	9	8
Res							
r							
7	6	5	4	3	2	1	0
Res	PMU_RED	PMU_MAIN	BIAS_HI	BIAS_LOW	BG12_OV	BG12_UV	VBAT_OV
r	rw1c	rw1c	rw1c	rw1c	rw1c	rw1c	rw1c

Field	Bits	Type	Description
VBAT_OV	0	rw1c	Battery voltage supply (VS) over voltage 0 _B No fault 1 _B Fault occurred
BG12_UV	1	rw1c	Internal bandgap comparator detected UV condition (Internal monitoring) 0 _B No fault 1 _B Fault occurred
BG12_OV	2	rw1c	Internal bandgap comparator detected OV condition (Internal monitoring) 0 _B No fault 1 _B Fault occurred
BIAS_LOW	3	rw1c	Internal bias current too low (Internal monitoring) 0 _B No fault 1 _B Fault occurred
BIAS_HI	4	rw1c	Internal bias current too high (Internal monitoring) 0 _B No fault 1 _B Fault occurred
PMU_MAIN	5	rw1c	PMU main pass element fail (Internal monitoring) 0 _B No fault 1 _B Fault occurred
PMU_RED	6	rw1c	PMU redundant pass element fail (Internal monitoring) 0 _B No fault 1 _B Fault occurred

Table 107 Reset values of **INTSUP_STAT_APP2**

Reset	Reset value	Note
	0000 _H	Reset class R1)

18 Registers description

18.56 Over temperature status register for application 1 *R1)

OT_STAT_APP1

Offset address: 031_H

Over temperature status register for application 1 *R1)

Reset values see: [Table 108](#)

15	14	13	12	11	10	9	8
Res							
r							
7	6	5	4	3	2	1	0
Res	BOOST	BUCKIF	BUCKCORE	SAFETY_AR EA	QCO	QUC	
r	rw1c	rw1c	rw1c	rw1c	rw1c	rw1c	rw1c

Field	Bits	Type	Description
QUC	0	rw1c	QUC over temperature 0 _B No fault 1 _B Fault occurred
QCO	1	rw1c	QCO over temperature 0 _B No fault 1 _B Fault occurred
SAFETY_AREA	2	rw1c	Over temperature of Safety area temperature sensor 0 _B No fault 1 _B Fault occurred
BUCKCORE	3	rw1c	Buckcore over temperature 0 _B No fault 1 _B Fault occurred
BUCKIF	4	rw1c	BUCKIF over temperature 0 _B No fault 1 _B Fault occurred
BOOST	5	rw1c	BOOST over temperature 0 _B No fault 1 _B Fault occurred

Table 108 Reset values of **OT_STAT_APP1**

Reset	Reset value	Note
	0000 _H	Reset class R1)

18 Registers description

18.57 Over temperature status register for application 2 *R1)

OT_STAT_APP2

Offset address: 032_H

Over temperature status register for application 2 *R1)

Reset values see: [Table 109](#)

15	14	13	12	11	10	9	8
Res							
r							
7	6	5	4	3	2	1	0
Res	BOOST	BUCKIF	BUCKCORE	SAFETY_AR EA	QCO	QUC	
r	rw1c	rw1c	rw1c	rw1c	rw1c	rw1c	rw1c

Field	Bits	Type	Description
QUC	0	rw1c	QUC over temperature 0 _B No fault 1 _B Fault occurred
QCO	1	rw1c	QCO over temperature 0 _B No fault 1 _B Fault occurred
SAFETY_AREA	2	rw1c	Over temperature of Safety area temperature sensor 0 _B No fault 1 _B Fault occurred
BUCKCORE	3	rw1c	BUCKCORE over temperature 0 _B No fault 1 _B Fault occurred
BUCKIF	4	rw1c	BUCKIF over temperature 0 _B No fault 1 _B Fault occurred
BOOST	5	rw1c	BOOST over temperature 0 _B No fault 1 _B Fault occurred

Table 109 Reset values of **OT_STAT_APP2**

Reset	Reset value	Note
	0000 _H	Reset class R1)

18 Registers description

18.58 Protection status *R1)

PROT_STAT

Protection status *R1)

Offset address: 033_H

Reset values see: [Table 110](#)

15	14	13	12	11	10	9	8
Res							
r							
7	6	5	4	3	2	1	0
Res							LOCK
r							r

Field	Bits	Type	Description
LOCK	0	r	Protected register password status 0 _B Registers unlocked 1 _B Registers locked

Table 110 Reset values of **PROT_STAT**

Reset	Reset value	Note
	0001 _H	Reset class R1)

18 Registers description

18.59 Reduced operation protected write configuration 1 register - *R1)

This register contains configuration related to the reduce operation mode. All setting will be applied if reduce operation mode is enabled (EN = 1).

REDOP_PW_CFG1

Reduced operation protected write configuration 1 register - *R1)

Offset address: 034_H

Reset values see: [Table 111](#)

15	14	13	12	11	10	9	8
Res	SSO1TOSSO2_DEL			Res		INT2_DIS	INT1_DIS
r	rw			r		rw	rw
7	6	5	4	3	2	1	0
SSO2_DEL			SSO1_DEL			Res	EN
rw			rw			r	rw

Field	Bits	Type	Description
EN	0	rw	Enable reduced operation *R2) 0 _B Disabled 1 _B Enabled
SSO1_DEL	4:2	rw	Safe state output 1 delay (tSSO1_red) 000 _B 0 ms 001 _B 10 ms 010 _B 50 ms 011 _B 100 ms 100 _B 250 ms 101 _B Do not use. Maps to 0 ms ... 111 _B Do not use. Maps to 0 ms
SSO2_DEL	7:5	rw	Safe state output 2 delay (tSSO2_red) 000 _B 0 ms 001 _B 10 ms 010 _B 50 ms 011 _B 100 ms 100 _B 250 ms 101 _B Do not use. Maps to 0 ms ... 111 _B Do not use. Maps to 0 ms
INT1_DIS	8	rw	Disable generation of INT1 due to Cluster 2 entering REDUCED OPERATION 0 _B Allow generation of INT1 when Cluster 2 enters REDUCED OPERATION 1 _B Disable generation of INT1 related to Cluster 2 entering REDUCED OPERATION

(table continues...)

18 Registers description

(continued)

Field	Bits	Type	Description
INT2_DIS	9	rw	Disable generation of INT2 due to Cluster 1 entering REDUCED OPERATION 0 _B Allow generation of INT2 when Cluster 1 enters REDUCED OPERATION 1 _B Disable generation of INT2 related to Cluster 1 entering REDUCED OPERATION
SSO1TOSSO2_DEL	14:12	rw	Safe state output 2 delay to Safe state output 1 (tSSO2) when REDUCED OPERATION is disabled 000 _B 0 ms 001 _B 10 ms 010 _B 50 ms 011 _B 100 ms 100 _B 250 ms 101 _B Do not use. Maps to 0 ms ... 111 _B Do not use. Maps to 0 ms

Table 111 Reset values of **REDOP_PW_CFG1**

Reset	Reset value	Note
	0000 _H	Reset class R1)

18 Registers description

18.60 Reduced operation protected write configuration 2 register - *R1)

This register contains configuration related to the reduce operation mode. All setting will be applied if reduce operation mode is enabled (EN = 1).

REDOP_PW_CFG2

Reduced operation protected write configuration 2 register - *R1)

Offset address: 035_H

Reset values see: [Table 112](#)

15	14	13	12	11	10	9	8
REDOP_RESOUT_APP2_DUR			REDOP_RESOUT_APP1_DUR			REDOP_RESOUT_APP_TB	Res
rw			rw			rw	r
7	6	5	4	3	2	1	0
Res							
r							

Field	Bits	Type	Description
REDOP_RESOUT_APP_TB	9	rw	Reset timer time base for application reset pulse 0 _B 10 μs 1 _B 100 μs
REDOP_RESOUT_APP1_DUR	12:10	rw	Application reset pulse duration for INT1 000 _B (0 + 1)*10 μs for REDOP_RESOUT_APP_TB = 0; ((0 + 1)*100 + 50) μs for REDOP_RESOUT_APP_TB = 1 ... 111 _B (7 + 1)*10 μs for REDOP_RESOUT_APP_TB = 0; ((7 + 1)*100 + 50) μs for REDOP_RESOUT_APP_TB = 1
REDOP_RESOUT_APP2_DUR	15:13	rw	Application reset pulse duration for INT2 000 _B (0 + 1)*10 μs for REDOP_RESOUT_APP_TB = 0; ((0 + 1)*100 + 50) μs for REDOP_RESOUT_APP_TB = 1 ... 111 _B (7 + 1)*10 μs for REDOP_RESOUT_APP_TB = 0; ((7 + 1)*100 + 50) μs for REDOP_RESOUT_APP_TB = 1

Table 112 Reset values of [REDOP_PW_CFG2](#)

Reset	Reset value	Note
	0000 _H	Reset class R1)

18 Registers description

18.61 Device protected write configuration 3 register *R1)

DEV_PW_CFG3

Device protected write configuration 3 register *R1)

Offset address: 036_H

Reset values see: [Table 113](#)

15	14	13	12	11	10	9	8
Res					VMON2_EN	VMON1_EN	BOOST_EN
r					rw	rw	rw
7	6	5	4	3	2	1	0
BUCKIF_EN	QUCEN	BUCKCORE_EN	QCO_EN	QVR_EN	FSM_STATEREQ		
rw	rw	rw	rw	rw	rw		

Field	Bits	Type	Description
FSM_STATEREQ	2:0	rw	Request for device state transition. 000 _B NONE 001 _B INIT 010 _B NORMAL 011 _B SLEEP 100 _B STANDBY 101 _B WAKE 110 _B NONE 111 _B NONE
QVR_EN	3	rw	Enable request for reference voltage. 0 _B Disabled 1 _B Enabled
QCO_EN	4	rw	Enable request for communication LDO. 0 _B Disabled 1 _B Enabled
BUCKCORE_EN	5	rw	Enable request for BUCKCORE. 0 _B Disabled 1 _B Enabled
QUCEN	6	rw	Enable request for QUC. 0 _B Disabled 1 _B Enabled
BUCKIF_EN	7	rw	Enable request for Buck interface. 0 _B Disabled 1 _B Enabled
BOOST_EN	8	rw	Enable request for Boost. 0 _B Disabled 1 _B Enabled

(table continues...)

18 Registers description

(continued)

Field	Bits	Type	Description
VMON1_EN	9	rw	Enable request for external voltage monitoring channel 1. 0 _B Disabled 1 _B Enabled
VMON2_EN	10	rw	Enable request for external voltage monitoring channel 2. 0 _B Disabled 1 _B Enabled

Table 113 Reset values of **DEV_PW_CFG3**

Reset	Reset value	Note
	0000 _H	Reset class R1)

18 Registers description

18.62 Watchdog 1 protected write configuration 0 register *R2)

WD1_PW_CFG0

Offset address: 037_H

Watchdog 1 protected write configuration 0 register
 *R2)

Reset values see: [Table 114](#)

15	14	13	12	11	10	9	8
Res							
r							
7	6	5	4	3	2	1	0
WWD_ETHR				WWD_EN	FWD_EN	WWD_TSEL	CYC
rw				rw	rw	rw	rw

Field	Bits	Type	Description
CYC	0	rw	Watchdog 1 cycle time 0 _B 0.1 ms tick period 1 _B 1 ms tick period
WWD_TSEL	1	rw	Window watchdog (WWD1) trigger selection 0 _B External WDI input used as a WWD trigger 1 _B WWD is triggered by SPI
FWD_EN	2	rw	Functional watchdog (FWD1) enable 0 _B Disabled 1 _B Enabled
WWD_EN	3	rw	Window watchdog (WWD1) enable 0 _B Disabled 1 _B Enabled
WWD_ETHR	7:4	rw	Window watchdog error counter threshold.

Table 114 Reset values of **WD1_PW_CFG0**

Reset	Reset value	Note
	009B _H	Reset class R2)

18 Registers description

18.63 Watchdog 1 reflected status configuration 0 register - *R3_C1

WD1_RS_CFG0

Offset address: 038_H

Watchdog 1 reflected status configuration 0 register -
 *R3_C1

Reset values see: [Table 115](#)

15	14	13	12	11	10	9	8
Res							
r							
7	6	5	4	3	2	1	0
WWD_ETHR				WWD_EN	FWD_EN	WWD_TSEL	CYC
r				r	r	r	r

Field	Bits	Type	Description
CYC	0	r	Watchdog 1 cycle time 0 _B 0.1 ms tick period 1 _B 1 ms tick period
WWD_TSEL	1	r	Window watchdog (WWD1) trigger selection. 0 _B External WDI input used as a WWD trigger 1 _B WWD is triggered by SPI
FWD_EN	2	r	Functional watchdog enable (FWD1) 0 _B Disabled 1 _B Enabled
WWD_EN	3	r	Window watchdog enable (WWD1) 0 _B Disabled 1 _B Enabled
WWD_ETHR	7:4	r	Window watchdog error threshold.

Table 115 Reset values of [WD1_RS_CFG0](#)

Reset	Reset value	Note
	009B _H	Reset class R3) C1

18 Registers description

18.64 Watchdog 1 protected write configuration 1 register *R2)

WD1_PW_CFG1

Offset address: 039_H

Watchdog 1 protected write configuration 1 register
 *R2)

Reset values see: [Table 116](#)

15	14	13	12	11	10	9	8
Res							
r							
7	6	5	4	3	2	1	0
Res		CYC_DIV	SLP_EN	FWD_ETHR			
r		rw	rw	rw			

Field	Bits	Type	Description
FWD_ETHR	3:0	rw	Functional watchdog error threshold.
SLP_EN	4	rw	Watchdog1 is active in sleep state 0 _B Disabled 1 _B Enabled
CYC_DIV	5	rw	Apply an additional divider of 10 to the cycle time 0 _B Disabled 1 _B Enabled

Table 116 Reset values of [WD1_PW_CFG1](#)

Reset	Reset value	Note
	0009 _H	Reset class R2)

18 Registers description

18.65 Watchdog 1 reflected status configuration 1 register- *R3_C1

WD1_RS_CFG1

Offset address: 03A_H

Watchdog 1 reflected status configuration 1 register-
*R3_C1

Reset values see: [Table 117](#)

15	14	13	12	11	10	9	8
Res							
r							
7	6	5	4	3	2	1	0
Res	CYC_DIV	SLPEN	FWD_ETHR				
r	r	r	r				

Field	Bits	Type	Description
FWD_ETHR	3:0	r	Functional watchdog error threshold.
SLPEN	4	r	Watchdog1 is active in sleep state 0 _B Disabled 1 _B Enabled
CYC_DIV	5	r	Additional divider of 10 to the cycle time is applied 0 _B Disabled 1 _B Enabled

Table 117 Reset values of [WD1_RS_CFG1](#)

Reset	Reset value	Note
	0009 _H	Reset class R3) C1

18 Registers description

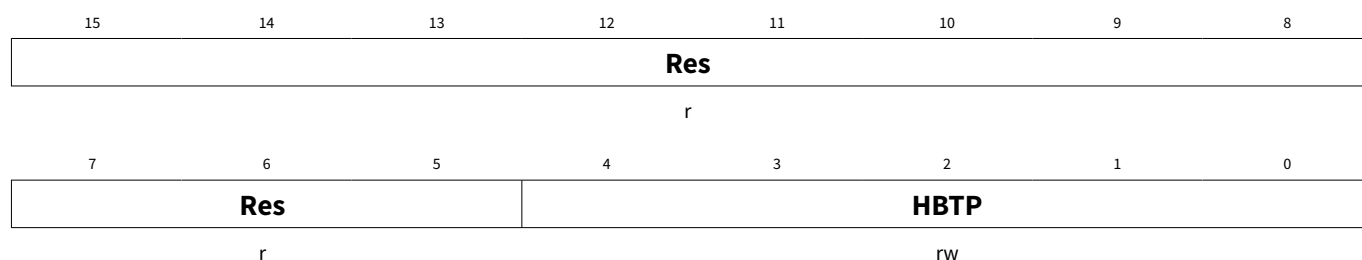
18.66 Functional watchdog 1 protected write heart beat timer period configuration register - *R2)

FWD1_PW_HBTP_CFG

Offset address: 03B_H

Functional watchdog 1 protected write heart beat timer period configuration register - *R2)

Reset values see: [Table 118](#)



Field	Bits	Type	Description
HBTP	4:0	rw	Functional watchdog 1 heartbeat timer period 00 _H (0 * 50 + 50) * time base ... 1F _H (31 * 50 + 50) * time base

Table 118 Reset values of [FWD1_PW_HBTP_CFG](#)

Reset	Reset value	Note
	000B _H	Reset class R2)

18 Registers description

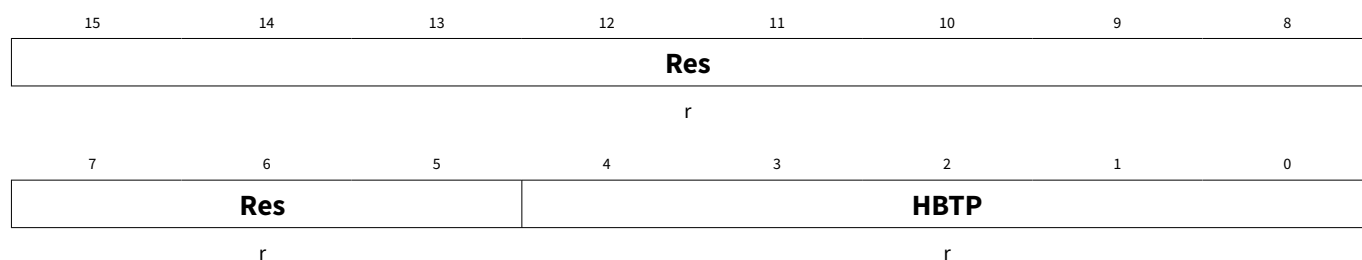
18.67 Functional watchdog 1 reflected status heart beat timer period configuration register *R3_C1

FWD1_RS_HBTP_CFG

Offset address: 03C_H

Functional watchdog 1 reflected status heart beat timer period configuration register *R3_C1

Reset values see: [Table 119](#)



Field	Bits	Type	Description
HBTP	4:0	r	Functional watchdog 1 heartbeat timer period 00 _H (0 * 50 + 50) * time base ... 1F _H (31 * 50 + 50) * time base

Table 119 Reset values of [FWD1_RS_HBTP_CFG](#)

Reset	Reset value	Note
	000B _H	Reset class R3) C1

18 Registers description

18.68 Window watchdog 1 protected write closed window configuration register - *R2)

WWD1_PW_CW_CFG

Window watchdog 1 protected write closed window configuration register - *R2)

Offset address: 03D_H

Reset values see: [Table 120](#)

15	14	13	12	11	10	9	8
CW_DIS		Res					
rw		r					
7	6	5	4	3	2	1	0
Res				CW			
r				rw			

Field	Bits	Type	Description
CW	4:0	rw	Closed window time 00 _H (0 * 50 + 50) * time base ... 1F _H (31 * 50 + 50) * time base
CW_DIS	15	rw	Disable the closed window (CW) of the window watchdog (WWD) 0 _B Closed window enabled 1 _B Closed window disabled

Table 120 Reset values of **WWD1_PW_CW_CFG**

Reset	Reset value	Note
	0006 _H	Reset class R2)

18 Registers description

18.69 Window watchdog 1 reflected status closed window configuration register *R3_C1)

WWD1_RS_CW_CFG

Offset address: 03E_H

Window watchdog 1 reflected status closed window configuration register *R3_C1)

Reset values see: [Table 121](#)

15	14	13	12	11	10	9	8
CW_DIS	Res						
r	r						
7	6	5	4	3	2	1	0
Res				CW			
r				r			

Field	Bits	Type	Description
CW	4:0	r	Closed window time 00 _H (0 * 50 + 50) * time base ... 1F _H (31 * 50 + 50) * time base
CW_DIS	15	r	Disable the closed window (CW) of the window watchdog (WWD) 0 _B Closed window enabled 1 _B Closed window disabled

Table 121 Reset values of [WWD1_RS_CW_CFG](#)

Reset	Reset value	Note
	0006 _H	Reset class R3) C1

18 Registers description

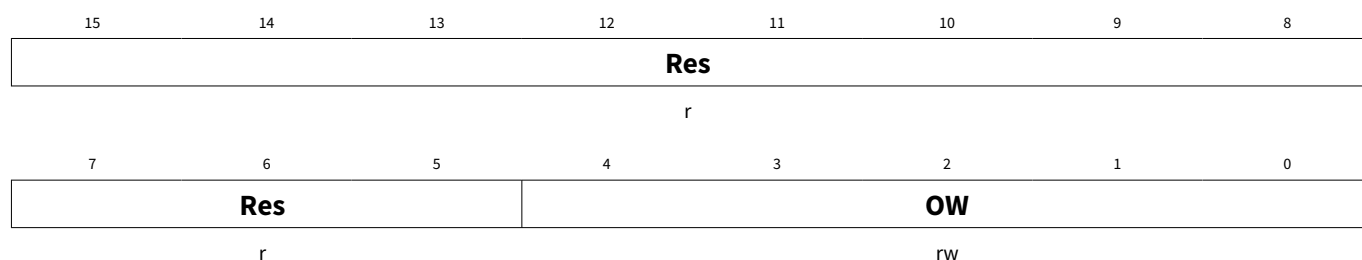
18.70 Window watchdog 1 protected write open window configuration register - *R2)

WWD1_PW_OW_CFG

Offset address: 03F_H

Window watchdog 1 protected write open window configuration register - *R2)

Reset values see: [Table 122](#)



Field	Bits	Type	Description
OW	4:0	rw	Open window time 00 _H (0 * 50 + 50) * time base ... 1F _H (31 * 50 + 50) * time base

Table 122 Reset values of [WWD1_PW_OW_CFG](#)

Reset	Reset value	Note
	000B _H	Reset class R2)

18 Registers description

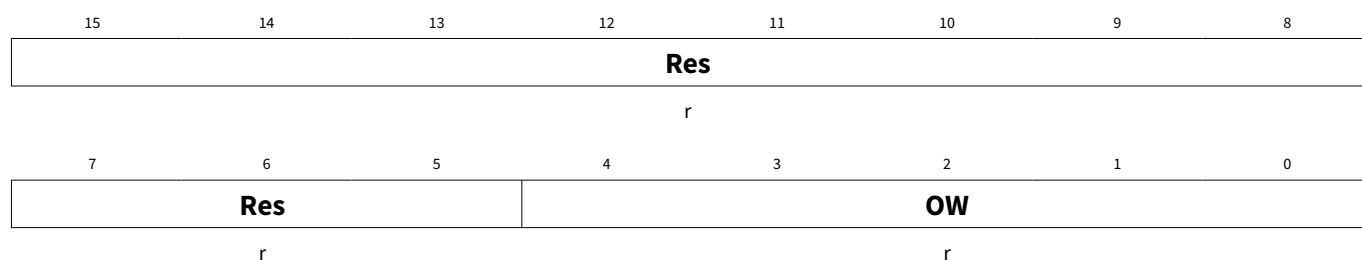
18.71 Window watchdog 1 reflected status open window configuration register - *R3_C1)

WWD1_RS_OW_CFG

Offset address: 040_H

Window watchdog 1 reflected status open window configuration register - *R3_C1)

Reset values see: [Table 123](#)



Field	Bits	Type	Description
OW	4:0	r	Open window time 00 _H (0 * 50 + 50) * time base ... 1F _H (31 * 50 + 50) * time base

Table 123 Reset values of [WWD1_RS_OW_CFG](#)

Reset	Reset value	Note
	000B _H	Reset class R3) C1

18 Registers description

18.72 Window watchdog 1 trigger- *R2)

WWD1_TRIG

Offset address: 041_H

Window watchdog 1 trigger- *R2)

Reset values see: [Table 124](#)

15	14	13	12	11	10	9	8
TRIG_STAT	Res						
r	r						
7	6	5	4	3	2	1	0
Res							TRIG
r							rw

Field	Bits	Type	Description
TRIG	0	rw	This bit triggers the window watchdog 1. For successful trigger, inverted value must be written.
TRIG_STAT	15	r	Last internal trigger value (TRIG bit) received via SPI.

Table 124 Reset values of **WWD1_TRIG**

Reset	Reset value	Note
	0000 _H	Reset class R2)

18 Registers description

18.73 Functional watchdog 1 response register - *R2)

FWD1_RSP

Offset address: 042_H

Functional watchdog 1 response register - *R2)

Reset values see: [Table 125](#)



Field	Bits	Type	Description
RSP	7:0	rw	Response byte

Table 125 Reset values of **FWD1_RSP**

Reset	Reset value	Note
	0000 _H	Reset class R2)

18 Registers description

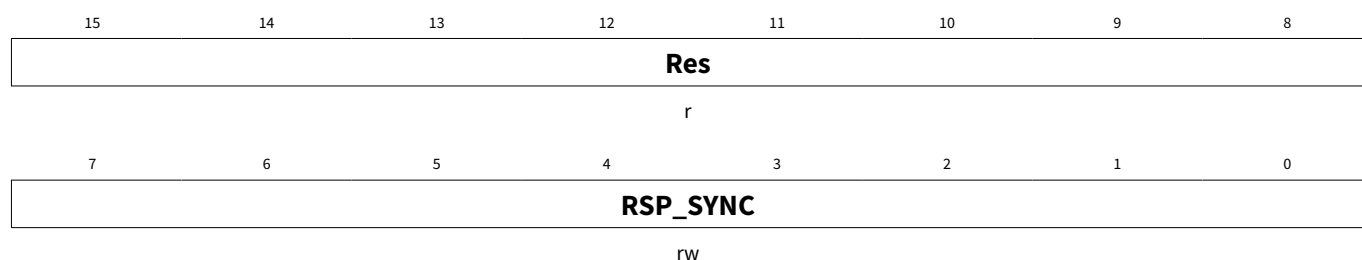
18.74 Functional watchdog 1 response register with synchronization of the heartbeat timer - *R2)

FWD1_RSP_SYNC

Functional watchdog 1 response register with synchronization of the heartbeat timer - *R2)

Offset address: 043_H

Reset values see: [Table 126](#)



Field	Bits	Type	Description
RSP_SYNC	7:0	rw	Functional watchdog response byte and heartbeat timer synchronization

Table 126 Reset values of [FWD1_RSP_SYNC](#)

Reset	Reset value	Note
	0000 _H	Reset class R2)

18 Registers description

18.75 Functional watchdog 1 status register - *R3_C1)

FWD1_STAT

Offset address: 044_H

Functional watchdog 1 status register - *R3_C1)

Reset values see: [Table 127](#)

15	14	13	12	11	10	9	8
Res						ECNT	
r						r	
7	6	5	4	3	2	1	0
ECNT	RSP_OK	RSPC		QUEST			
r	r	r		r			

Field	Bits	Type	Description
QUEST	3:0	r	Functional watchdog question. Represents the value of the question, that is currently being asked.
RSPC	5:4	r	Functional watchdog response counter value. Represents the response which is currently expected (RESP3/2/1/0).
RSP_OK	6	r	Functional watchdog response status 0 _B Response message is wrong 1 _B All received bytes in response message are correct
ECNT	10:7	r	Functional watchdog error counter value

Table 127 Reset values of [FWD1_STAT](#)

Reset	Reset value	Note
	0030 _H	Reset class R3) C1

18 Registers description

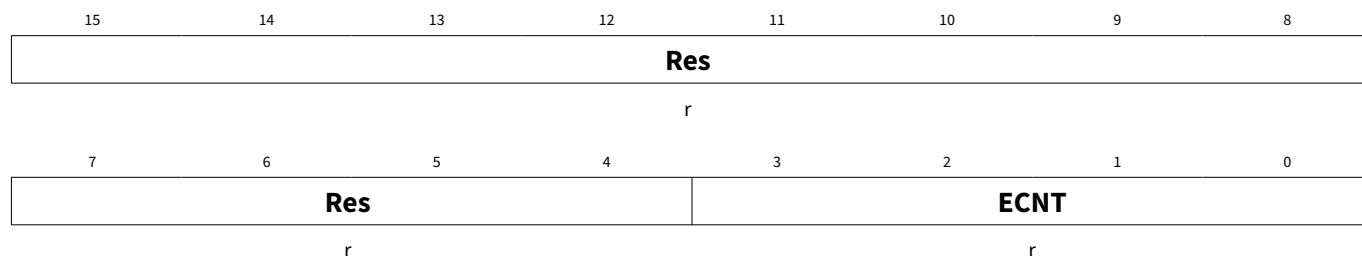
18.76 Window watchdog 1 error counter status register - *R3_C1)

WWD1_ECNT_STAT

Offset address: 045_H

Window watchdog 1 error counter status register -
 *R3_C1)

Reset values see: [Table 128](#)



Field	Bits	Type	Description
ECNT	3:0	r	Error counter value

Table 128 Reset values of [WWD1_ECNT_STAT](#)

Reset	Reset value	Note
	0000 _H	Reset class R3) C1

18 Registers description

18.77 Watchdog 2 protected write configuration 0 register - *R2)

WD2_PW_CFG0

Offset address: 046_H

Watchdog 2 protected write configuration 0 register - *R2)

Reset values see: [Table 129](#)

15	14	13	12	11	10	9	8
Res							
r							
7	6	5	4	3	2	1	0
WWD_ETHR				WWD_EN	FWD_EN	WWD_TSEL	CYC
rw				rw	rw	rw	rw

Field	Bits	Type	Description
CYC	0	rw	Watchdog 2 cycle time 0 _B 0.1 ms tick period 1 _B 1 ms tick period
WWD_TSEL	1	rw	Window watchdog (WWD2) trigger selection. 0 _B External WDI input used as a WWD trigger 1 _B WWD is triggered by SPI
FWD_EN	2	rw	Functional watchdog (FWD2) enable 0 _B Disabled 1 _B Enabled
WWD_EN	3	rw	Window watchdog (WWD2) enable 0 _B Disabled 1 _B Enabled
WWD_ETHR	7:4	rw	Window watchdog error threshold.

Table 129 Reset values of **WD2_PW_CFG0**

Reset	Reset value	Note
	009B _H	Reset class R2)

18 Registers description

18.78 Watchdog 2 reflected status configuration 0 register- *R3_C2)

WD2_RS_CFG0

Offset address: 047_H

Watchdog 2 reflected status configuration 0 register-
 *R3_C2)

Reset values see: [Table 130](#)

15	14	13	12	11	10	9	8
Res							
r							
7	6	5	4	3	2	1	0
WWD_ETHR				WWD_EN	FWD_EN	WWD_TSEL	CYC
r				r	r	r	r

Field	Bits	Type	Description
CYC	0	r	Watchdog 2 cycle time 0 _B 0.1 ms tick period 1 _B 1 ms tick period
WWD_TSEL	1	r	Window watchdog (WWD2) trigger selection. 0 _B External WDI input used as a WWD trigger 1 _B WWD is triggered by SPI write to WWDSCMD register
FWD_EN	2	r	Functional watchdog (FWD2) enable 0 _B Disabled 1 _B Enabled
WWD_EN	3	r	Window watchdog (WWD2) enable 0 _B Disabled 1 _B Enabled
WWD_ETHR	7:4	r	Window watchdog error threshold.

Table 130 Reset values of [WD2_RS_CFG0](#)

Reset	Reset value	Note
	009B _H	Reset class R3) C2

18 Registers description

18.79 Watchdog 2 protected write configuration 1 - *R2)

WD2_PW_CFG1

Offset address: 048_H

Watchdog 2 protected write configuration 1 - *R2)

Reset values see: [Table 131](#)

15	14	13	12	11	10	9	8
Res							
r							
7	6	5	4	3	2	1	0
Res		CYC_DIV	SLP_EN	FWD_ETHR			
r		rw	rw	rw			

Field	Bits	Type	Description
FWD_ETHR	3:0	rw	Functional watchdog error threshold.
SLP_EN	4	rw	Watchdog 2 is active in sleep state 0 _B Disabled 1 _B Enabled
CYC_DIV	5	rw	Apply an additional divider of 10 to the cycle time 0 _B Disabled 1 _B Enabled, additional divider

Table 131 Reset values of [WD2_PW_CFG1](#)

Reset	Reset value	Note
	0009 _H	Reset class R2)

18 Registers description

18.80 Watchdog 2 reflected status configuration 1 register - *R3_C2)

WD2_RS_CFG1

Offset address: 049_H

Watchdog 2 reflected status configuration 1 register - *R3_C2)

Reset values see: [Table 132](#)

15	14	13	12	11	10	9	8
Res							
r							
7	6	5	4	3	2	1	0
Res	CYC_DIV	SLP_EN	FWD_ETHR				
r	r	r	r				

Field	Bits	Type	Description
FWD_ETHR	3:0	r	Functional watchdog error threshold.
SLP_EN	4	r	Watchdog 2 is active in sleep state 0 _B Disabled 1 _B Enabled
CYC_DIV	5	r	Additional divider of 10 to the cycle time is applied 0 _B Disabled 1 _B Enabled

Table 132 Reset values of [WD2_RS_CFG1](#)

Reset	Reset value	Note
	0009 _H	Reset class R3) C2

18 Registers description

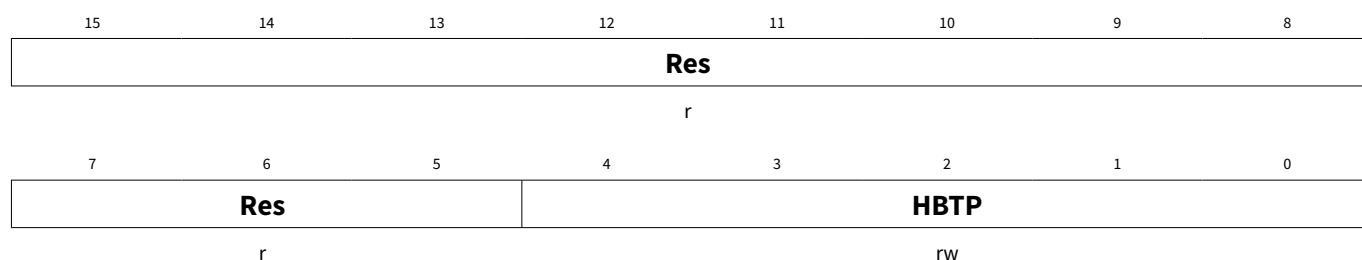
18.81 Functional watchdog 2 protected write heart beat timer period configuration register - *R2)

FWD2_PW_HBTP_CFG

Offset address: 04A_H

Functional watchdog 2 protected write heart beat timer period configuration register - *R2)

Reset values see: [Table 133](#)



Field	Bits	Type	Description
HBTP	4:0	rw	Functional watchdog 2 heartbeat timer period 00 _H (0 * 50 + 50) wd time base ... 1F _H (31 * 50 + 50) wd time base

Table 133 Reset values of [FWD2_PW_HBTP_CFG](#)

Reset	Reset value	Note
	000B _H	Reset class R2)

18 Registers description

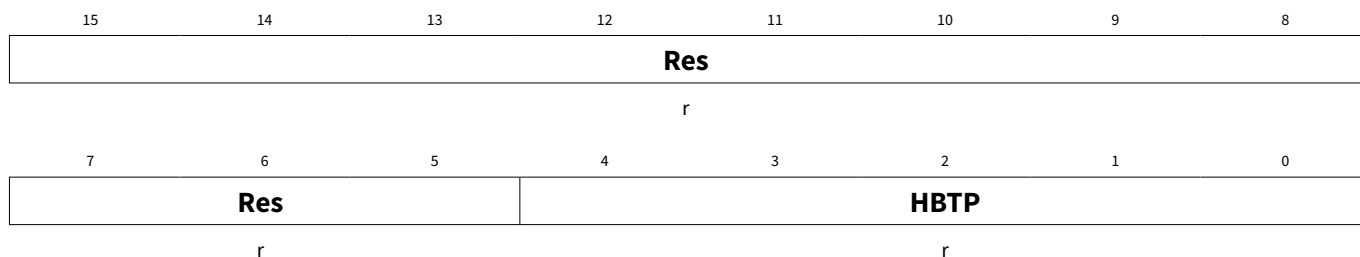
18.82 Functional watchdog 2 reflected status heart beat timer period configuration register *R3_C2)

FWD2_RS_HBTP_CFG

Offset address: 04B_H

Functional watchdog 2 reflected status heart beat timer period configuration register *R3_C2)

Reset values see: [Table 134](#)



Field	Bits	Type	Description
HBTP	4:0	r	Functional watchdog 2 heartbeat timer period 00 _H (0 * 50 + 50) wd time base ... 1F _H (31 * 50 + 50) wd time base

Table 134 Reset values of [FWD2_RS_HBTP_CFG](#)

Reset	Reset value	Note
	000B _H	Reset class R3) C2

18 Registers description

18.83 Window watchdog 2 protected write closed window configuration register - *R2)

WWD2_PW_CW_CFG

Window watchdog 2 protected write closed window configuration register - *R2)

Offset address: 04C_H

Reset values see: [Table 135](#)

15	14	13	12	11	10	9	8
CW_DIS		Res					
rw		r					
7	6	5	4	3	2	1	0
Res				CW			
r				rw			

Field	Bits	Type	Description
CW	4:0	rw	Closed window time 00 _H (0 * 50 + 50) wd time base ... 1F _H (31 * 50 + 50) wd time base
CW_DIS	15	rw	Disable the closed window (CW) of the window watchdog (WWD) 0 _B Closed window enabled 1 _B Closed window disabled

Table 135 Reset values of **WWD2_PW_CW_CFG**

Reset	Reset value	Note
	0006 _H	Reset class R2)

18 Registers description

18.84 Window watchdog 2 reflected status closed window configuration register *R3_C2)

WWD2_RS_CW_CFG

Offset address: 04D_H

Window watchdog 2 reflected status closed window configuration register *R3_C2)

Reset values see: [Table 136](#)

15	14	13	12	11	10	9	8
CW_DIS	Res						
r	r						
7	6	5	4	3	2	1	0
Res				CW			
r				r			

Field	Bits	Type	Description
CW	4:0	r	Closed window time 00 _H (0 * 50 + 50) wd time base ... 1F _H (31 * 50 + 50) wd time base
CW_DIS	15	r	Disable the closed window (CW) of the window watchdog (WWD) 0 _B Closed window enabled 1 _B Closed window disabled

Table 136 Reset values of [WWD2_RS_CW_CFG](#)

Reset	Reset value	Note
	0006 _H	Reset class R3) C2

18 Registers description

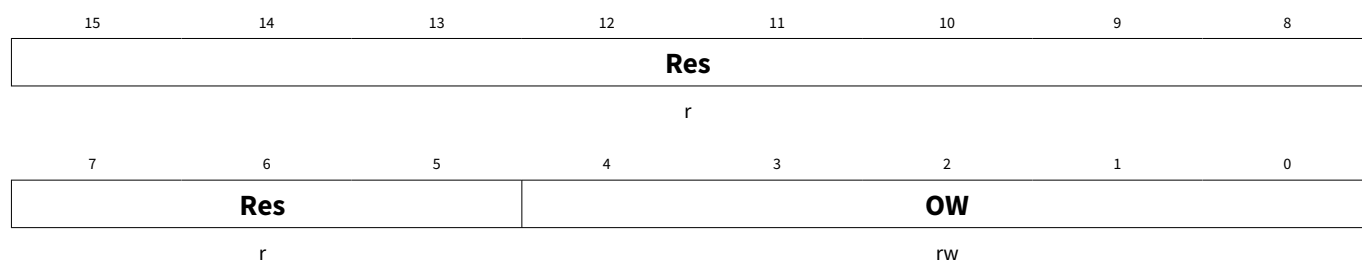
18.85 Window watchdog 2 protected write open window configuration register - *R2)

WWD2_PW_OW_CFG

Offset address: 04E_H

Window watchdog 2 protected write open window configuration register - *R2)

Reset values see: [Table 137](#)



Field	Bits	Type	Description
OW	4:0	rw	Open window time 00 _H (0 * 50 + 50) wd time base ... 1F _H (31 * 50 + 50) wd time base

Table 137 Reset values of [WWD2_PW_OW_CFG](#)

Reset	Reset value	Note
	000B _H	Reset class R2)

18 Registers description

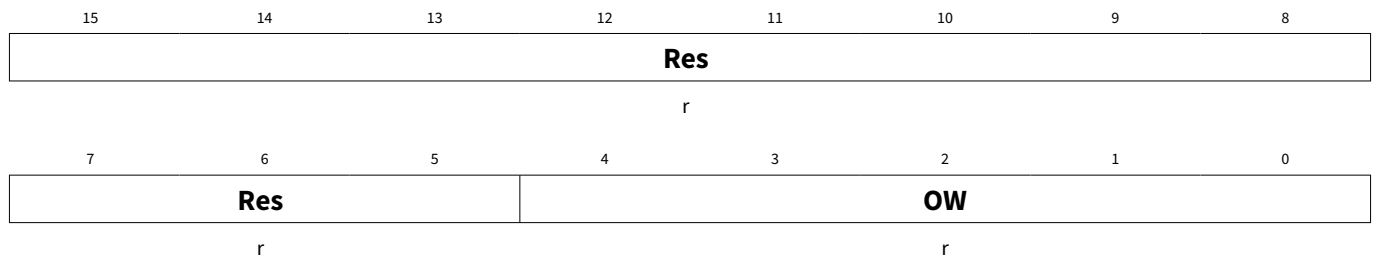
18.86 Window watchdog 2 reflected status open window configuration register *R3_C2)

WWD2_RS_OW_CFG

Offset address: 04F_H

Window watchdog 2 reflected status open window configuration register *R3_C2)

Reset values see: [Table 138](#)



Field	Bits	Type	Description
OW	4:0	r	Open window time 00 _H (0 * 50 + 50) wd time base ... 1F _H (31 * 50 + 50) wd time base

Table 138 Reset values of [WWD2_RS_OW_CFG](#)

Reset	Reset value	Note
	000B _H	Reset class R3) C2

18 Registers description

18.87 Window watchdog 2 service - *R2)

WWD2_TRIG

Offset address: 050_H

Window watchdog 2 service - *R2)

Reset values see: [Table 139](#)

15	14	13	12	11	10	9	8
TRIG_STAT	Res						
r	r						
7	6	5	4	3	2	1	0
Res							TRIG
r							rw

Field	Bits	Type	Description
TRIG	0	rw	This bit triggers the window watchdog 2. For successful trigger, inverted value must be written.
TRIG_STAT	15	r	Last internal service value (TRIG bit) received via SPI.

Table 139 Reset values of **WWD2_TRIG**

Reset	Reset value	Note
	0000 _H	Reset class R2)

18 Registers description

18.88 Functional watchdog 2 response register - *R2)

FWD2_RSP

Offset address: 051_H

Functional watchdog 2 response register - *R2)

Reset values see: [Table 140](#)



Field	Bits	Type	Description
RSP	7:0	rw	Response byte

Table 140 Reset values of **FWD2_RSP**

Reset	Reset value	Note
	0000 _H	Reset class R2)

18 Registers description

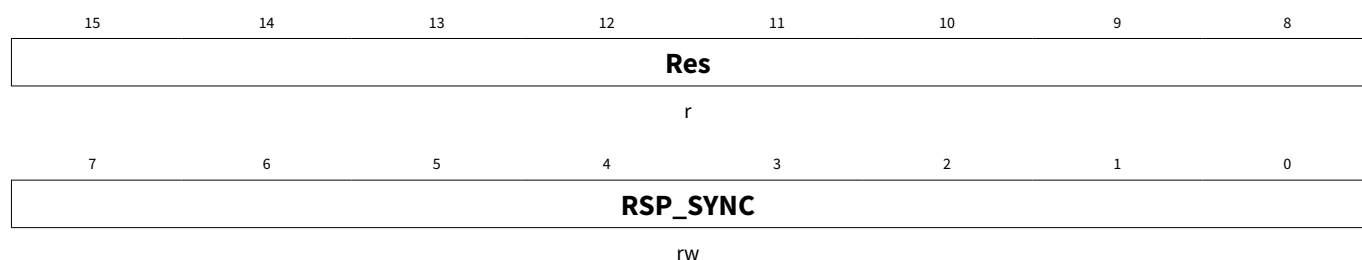
18.89 Functional watchdog 2 response register with synchronization - *R2)

FWD2_RSP_SYNC

Functional watchdog 2 response register with synchronization - *R2)

Offset address: 052_H

Reset values see: [Table 141](#)



Field	Bits	Type	Description
RSP_SYNC	7:0	rw	Functional watchdog response byte and heartbeat timer synchronization

Table 141 Reset values of [FWD2_RSP_SYNC](#)

Reset	Reset value	Note
	0000 _H	Reset class R2)

18 Registers description

18.90 Functional watchdog 2 status register - *R3_C2)

FWD2_STAT

Offset address: 053_H

Functional watchdog 2 status register - *R3_C2)

Reset values see: [Table 142](#)

15	14	13	12	11	10	9	8
Res						ECNT	
r						r	
7	6	5	4	3	2	1	0
ECNT	RSP_OK	RSPC		QUEST			
r	r	r		r			

Field	Bits	Type	Description
QUEST	3:0	r	Functional watchdog question
RSPC	5:4	r	Functional watchdog response counter value
RSP_OK	6	r	Functional watchdog response status 0 _B Response message is wrong 1 _B All received bytes in response message are correct
ECNT	10:7	r	Functional watchdog error counter value

Table 142 Reset values of [FWD2_STAT](#)

Reset	Reset value	Note
	0030 _H	Reset class R3) C2

18 Registers description

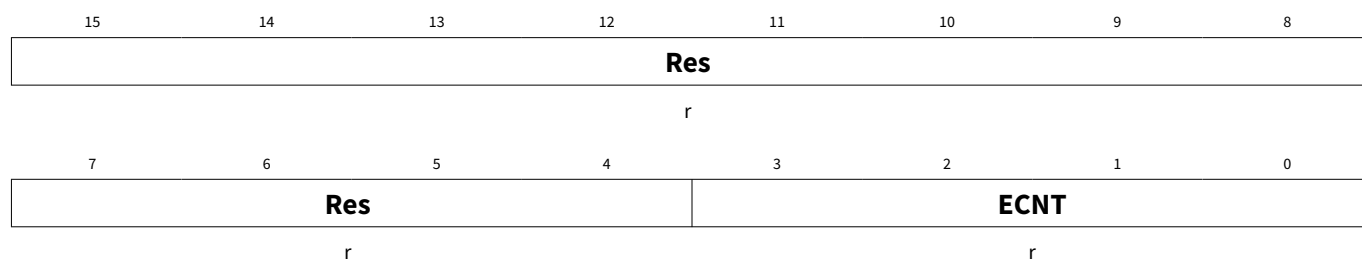
18.91 Window watchdog 2 status register - *R3_C2)

WWD2_ECNT_STAT

Offset address: 054_H

Window watchdog 2 status register - *R3_C2)

Reset values see: [Table 143](#)



Field	Bits	Type	Description
ECNT	3:0	r	Error counter value

Table 143 Reset values of [WWD2_ECNT_STAT](#)

Reset	Reset value	Note
	0000 _H	Reset class R3) C2

18 Registers description

18.92 Safety switch diagnostics, *R1)

SSW_DIAG

Safety switch diagnostics, *R1)

Offset address: 0055_H

Reset values see: [Table 144](#)

15	14	13	12	11	10	9	8
Res							
r							
7	6	5	4	3	2	1	0
Res		EBIST4		EBIST3	EBIST2	EBIST1	EBIST0
r		r		r	r	r	r

Field	Bits	Type	Description
EBIST0	0	r	Indicates if SSW is intact 0 _B No fault 1 _B SSW check not passed
EBIST1	1	r	Indicates if high side switch at PREREG is intact 0 _B No fault 1 _B HS switch of PREREG defect
EBIST2	2	r	Indicates if SSW gate can be discharged 0 _B No fault 1 _B SSW gate could not be discharged
EBIST3	3	r	Indicates if low side switch of PREREG is intact 0 _B No fault 1 _B LS switch of PREREG defect
EBIST4	4	r	Sanity check on SSW charge pump chain 0 _B No fault 1 _B Sanity check unsuccessful

Table 144 Reset values of **SSW_DIAG**

Reset	Reset value	Note
	0000 _H	Reset class R1)

18 Registers description

18.93 BUCK CORE protected write voltage selection register *R1)

BUCK_CORE_PW_VSEL

Offset address: 056_H

BUCK CORE protected write voltage selection register
 *R1)

Reset values see: [Table 145](#)

15	14	13	12	11	10	9	8
Res							
r							
7	6	5	4	3	2	1	0
Res		VSEL					
r		rw					

Field	Bits	Type	Description
VSEL	5:0	rw	Voltage selection (0.7 V to 1.1 V; 12.5 mV steps) 00 _H BUCKCORE output voltage: 0.7 V + 0*12.5 mV ... 20 _H BUCKCORE output voltage: 0.7 V + 32*12.5 mV others, reserved

Table 145 Reset values of **BUCK_CORE_PW_VSEL**

Reset	Reset value	Note
	0000 _H	

18 Registers description

18.94 BUCK CORE reflected status voltage selection register *R2)

BUCK_CORE_RS_VSEL

BUCK CORE reflected status voltage selection register
 *R2)

Offset address: 057_H

Reset values see: [Table 146](#)

15	14	13	12	11	10	9	8
Res							
r							
7	6	5	4	3	2	1	0
Res		VSEL					
r		r					

Field	Bits	Type	Description
VSEL	5:0	r	Voltage selection status register (0.7 V to 1.1 V; 12.5 mV steps) 00 _H BUCKCORE output voltage: 0.7 V + 0*12.5 mV ... 20 _H BUCKCORE output voltage: 0.7 V + 32*12.5 mV others, reserved

Table 146 Reset values of [BUCK_CORE_RS_VSEL](#)

Reset	Reset value	Note
	001A _H	Reset class R2)

18 Registers description

18.95 Buck core voltage selection stat, *R2)

VCORESTAT

Buck core voltage selection stat, *R2)

Offset address: 058_H

Reset values see: [Table 147](#)

15	14	13	12	11	10	9	8
Res							
r							
7	6	5	4	3	2	1	0
Res		VOUT					
r		r					

Field	Bits	Type	Description
VOUT	5:0	r	Current voltage out for buckcore, *R2) 00 _H BUCKCORE output voltage set to 0.7 V + 0*12.5 mV ... 20 _H BUCKCORE output voltage set to 0.7 V + 32*12.5 mV 21 _H BUCKCORE output voltage set to 1.15 V; Not allowed to be used for static voltage scaling! others, reserved

Table 147 Reset values of **VCORESTAT**

Reset	Reset value	Note
	0000 _H	Reset class R2)

18 Registers description

18.96 Buck core voltage selection monitors stat, *R2)

VCOREMONSTAT

Buck core voltage selection monitors stat, *R2)

Offset address: 059_H

Reset values see: [Table 148](#)

15	14	13	12	11	10	9	8
Res		OVTH					
r		r					
7	6	5	4	3	2	1	0
Res		UVTH					
r		r					

Field	Bits	Type	Description
UVTH	5:0	r	Under voltage thresholds for buckcore voltage selection, *R2) 00 _H BUCKCORE undervoltage threshold for VOUT = 0.7 V + 0*12.5 mV ... 20 _H BUCKCORE undervoltage threshold for VOUT = 0.7 V + 32*12.5 mV 21 _H BUCKCORE undervoltage threshold for VOUT = 1.15 V others, reserved
OVTH	13:8	r	Over voltage thresholds for buckcore voltage selection, *R2) 00 _H BUCKCORE overvoltage threshold for VOUT = 0.7 V + 0*12.5 mV ... 20 _H BUCKCORE overvoltage threshold for VOUT = 0.7 V + 32*12.5 mV 21 _H BUCKCORE overvoltage threshold for VOUT = 1.15 V others, reserved

Table 148 Reset values of **VCOREMONSTAT**

Reset	Reset value	Note
	0000 _H	Reset class R2)

18 Registers description

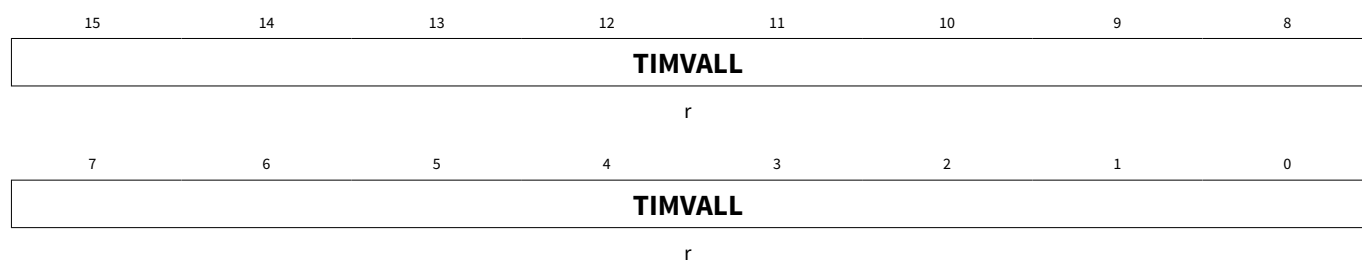
18.97 Wake Up Timer value after exiting from STANDBY or SLEEP (lower 16 bits)

WUT_STAT0

Wake Up Timer value after exiting from STANDBY or SLEEP [lower 16 bits)

Offset address: 05A_H

value: 0000_H



Field	Bits	Type	Description
TIMVALL	15:0	r	Lower 16 bit of wake-up timer value: LSB bit 0; MSB bit15

18 Registers description

18.98 Wake Up Timer value after exiting from STANDBY or SLEEP (upper 8 bits)

WUT_STAT1

Offset address: 05B_H

Wake Up Timer value after exiting from STANDBY or SLEEP [upper 8 bits)

value: 0000_H

15	14	13	12	11	10	9	8
CYC	PRESC	Res					
r	r	r					
7	6	5	4	3	2	1	0
TIMVALH							
r							

Field	Bits	Type	Description
TIMVALH	7:0	r	Higher 8 bits of wake-up timer value: LSB bit0; MSB bit 7
PRESC	14	r	0 _B Disabled 1 _B Enabled
CYC	15	r	0 _B 10 μs 1 _B 10 ms

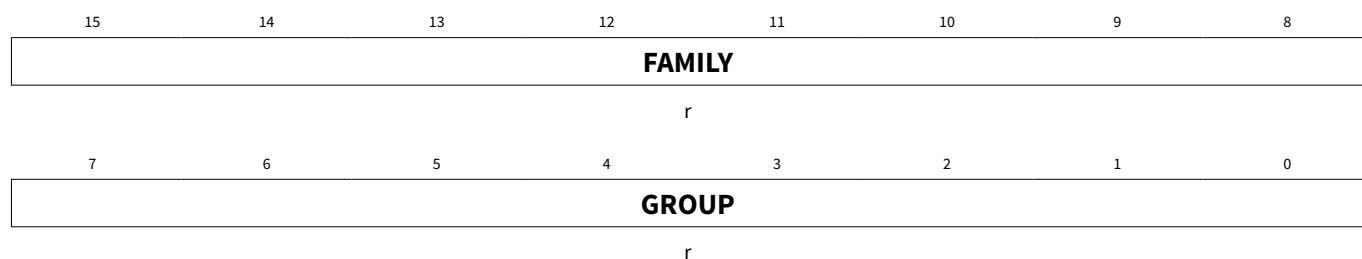
18 Registers description

18.99 Chip product identifier

CHPID

Chip product identifier

Offset address: 1F0_H
 value: 0201_H



Field	Bits	Type	Description
GROUP	7:0	r	Chip product group 01 _H GP_PMIC
FAMILY	15:8	r	Chip family 02 _H TLF4D985

18 Registers description

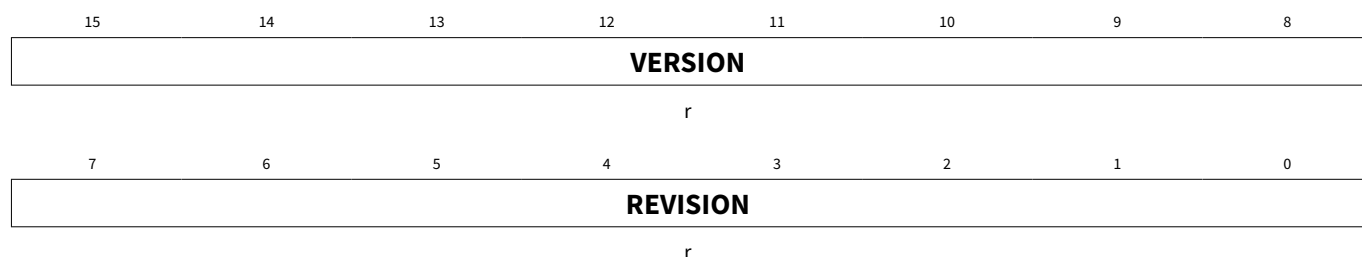
18.100 Chip product version and revision

CHREV

Chip product version and revision

Offset address: 1F1_H

value: 0003_H

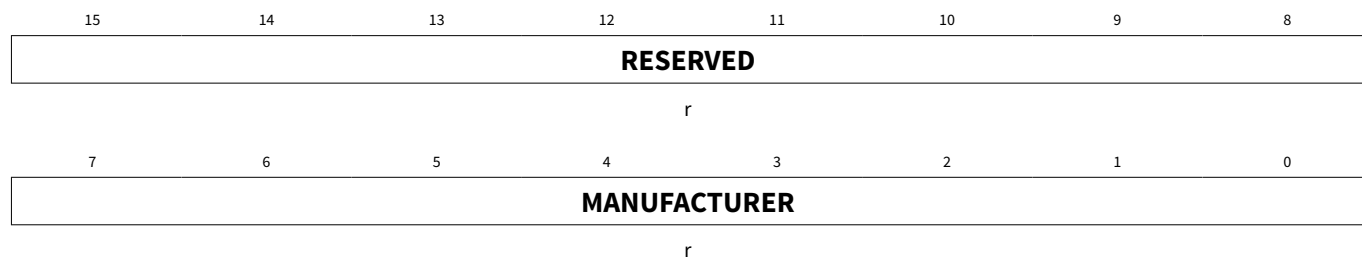


Field	Bits	Type	Description
REVISION	7:0	r	Chip revision 01 _H A11 02 _H A21 03 _H A31 (TLF4D985QxV0xR1)
VERSION	15:8	r	Chip product version 01 _H TLF4D985QxV01 02 _H TLF4D985QxV02 03 _H TLF4D985QxV03

18 Registers description

18.101 Manufacturer ID

MANID Offset address: 1F2_H
 Manufacturer ID value: 00C1_H



Field	Bits	Type	Description
MANUFACTURER	7:0	r	MANUFACTURER C1 _H Infineon technologies AG
RESERVED	15:8	r	RESERVED

19 Application information

19 Application information

19.1 Application diagram

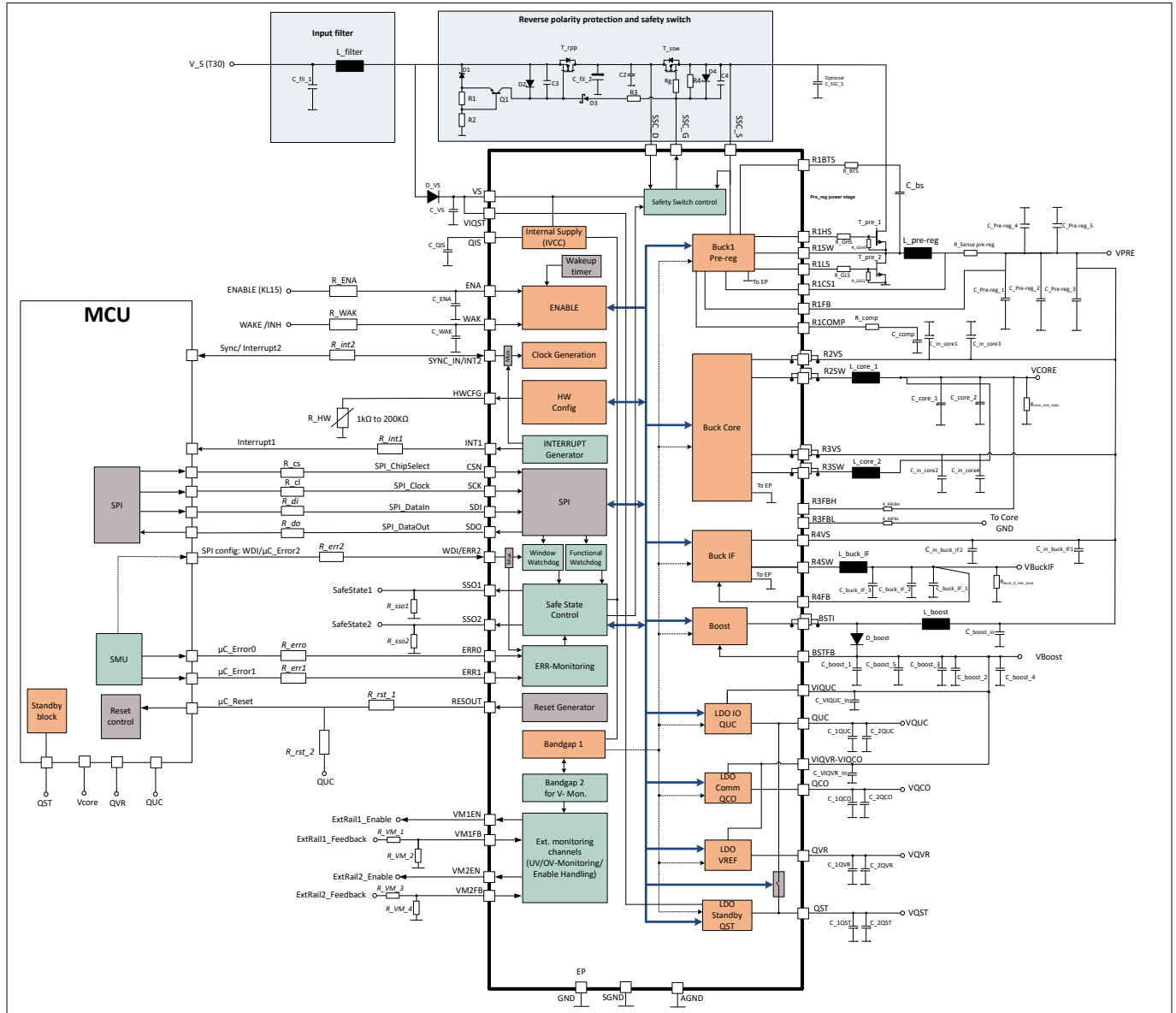


Figure 96 Application diagram

19 Application information

19.2 BOM recommendation

Table 149 BOM recommendation

Block	Symbol	Value	Description	Note
Input Filter	C_fil_1	10 µF	Surface mount ceramic capacitor	Max voltage depending on application (50 V for 12 V application and 100 V for 24 V application)
	C_fil_2	220 µF	Electrolytic capacitor	Max voltage depending on application (50 V for 12 V application and 100 V for 24 V application)
	L_filter	4.7 µH	Shielded filter Power Inductor	Inductor selection depending on EMC requirement
QIS & Input voltage	C_QIS	1 µF	Surface mount ceramic capacitor	–
	C_VS	4.7 µF	Surface mount ceramic capacitors	–
	D_VS	d_schottky	reverse polarity protection diode for low current path	–
Reverse battery protection (RPP) and safety switch (SSC)	C2	10 µF	Surface mount ceramic capacitor	Max voltage depending on application (50 V for 12 V application and 100 V for 24 V application)
	C3	1 nF	Surface mount ceramic capacitor	–
	C4	1 nF	Surface mount ceramic capacitor	–
	T_rpp	RPP + SSC MOSFET	N-Channel MOSFETs (logic level)	IPG20N06S2L-35A (dual MOSFET) or IAUZ40N06S5L050 (single) or similar
	T_ssw			
	D1	VBD = 60 V	Schottky diode to prevent current flowing via R1 and R2 in normal supply condition	–

(table continues...)

19 Application information

Table 149 (continued) BOM recommendation

Block	Symbol	Value	Description	Note
	D2	VZ = 10 V	Zener diode to protect gate of RPP MOSFET	–
	D3	VBD = 60 V	Schottky diode to prevent current bypassing RPP and SSW via R4 and R5 in normal supply condition	RB558VYM150FH
	D4	VZ = 6.2 V	Zener diode to protect the PMIC VGS driver	–
	Q1	nnp	Low leakage npn transistor, to discharge the RPP MOSFET when the battery voltage is below ground	Recommended low leakage at VCB = 40 V at hot
	R1	47 kΩ	Standard thick film chip resistor	–
	R2	47 kΩ	Standard thick film chip resistor	–
	R3	300 kΩ	Standard thick film chip resistor	–
	R4	300 kΩ	Standard thick film chip resistor	–
	Rg	10 Ω	Gate resistor for the control of the external safety switch	–
	C_SSC_S	1 μF (Max)	Surface mount ceramic capacitors	optional: To improve EMC performance. However dimension the capacitance to meet safety goals as it might have an effect on system's response to fault conditions.
PREREG	C_Pre_reg_1	3 × 22 μF	Surface mount ceramic capacitors	Nominal values of capacitances are recommended taking into account
	C_Pre_reg_2			

(table continues...)

19 Application information

Table 149 (continued) BOM recommendation

Block	Symbol	Value	Description	Note
	C_Pre_reg_3			all derating factors (voltage, temperature and aging)
	C_Pre_reg_4	1 μ F	Surface mount ceramic capacitor	–
	C_Pre_reg_5	100 nF	Surface mount ceramic capacitor	–
	L_pre_reg	6.8 μ H	Shielded power inductor	Select inductor according to the over current limitation
	T_pre_1	External MOSFETs	N-Channel MOSFETs (logic level)	IPG20N06S4L-26A (dual MOSFET) or IAUZ40N06S5L050 (single) or similar
	T_pre_2			IPG20N06S4L-26A (dual MOSFET) or IAUZ40N06S5L050 (single) or similar
	R_COMP	12 k Ω	Standard thick film chip resistor	For 10 A current capability
		25 k Ω	Standard thick film chip resistor	For 5 A current capability
	C_COMP	1.5 nF	Surface mount ceramic capacitor	For 5 A current capability
		2.7 nF	Surface mount ceramic capacitor	For 10 A current capability
	R_Sense_pre-reg	10 m Ω	Standard thick film chip resistor, tol. $\pm 1\%$	For 10 A current capability
		20 m Ω	Standard thick film chip resistor, tol. $\pm 1\%$	For 5 A current capability
	C_bs	100 nF	Surface mount ceramic capacitor	–
	R_BTS	–	Boot strap line resistance for limiting inrush currents	If EMC does not require it, set it to 0 Ω

(table continues...)

19 Application information

Table 149 (continued) BOM recommendation

Block	Symbol	Value	Description	Note
	R_GHS	–	Gate resistor for limiting gate currents	If EMC does not require it, set it to 0 Ω
	R_GSHS	–	–	optional: Only if use case assumption requires it for safety reasons
	R_GSLS	–	–	optional Only if use case assumption requires it for safety reasons
	R_GLS	–	Gate resistor for limiting gate currents	If EMC does not require it, set it to 0 Ω
BOOST	C_boost_in	100 nF	Surface mount ceramic capacitor	–
	C_boost_1	100 nF	Surface mount ceramic capacitor	–
	C_boost_2	1 μ F	Surface mount ceramic capacitor	–
	C_boost_3	10 μ F	Surface mount ceramic capacitor	–
	C_boost_4	100 nF	Surface mount ceramic capacitor	–
	C_boost_5	47 nF	Surface mount ceramic capacitor	–
	D_boost	d_schottky	Schottky Rectifier	MSS2P3 or similar
	L_boost	3.3 μ H	Shielded Power Inductor	Select inductance according to the over current limitation
BUCK CORE	C_in_core1	$2 \times 4.7 \mu$ F	Surface mount ceramic capacitors	–
	C_in_core2			
	C_in_core3	2×100 nF	Surface mount ceramic capacitors	–
	C_in_core4			
	C_core_1	$2 \times 47 \mu$ F	Surface mount ceramic capacitors	consider to use additional capacitance in case it is necessary.
	C_core_2			

(table continues...)

19 Application information

Table 149 (continued) BOM recommendation

Block	Symbol	Value	Description	Note
	L_core_1	1 μ H	Shielded power inductor	Select inductor according to the over current limitation
	L_core_2	1 μ H	Shielded power inductor	Select inductor according to the over current limitation
	R_core_min_load	–	–	Pick accordingly to fulfill Minimum output current - BUCK CORE
	R_R3FBH	10 - 100 Ω	–	optional: Only required if use case assumption requires it for safety reasons
	R_R3FBL	10 - 100 Ω	–	optional: Only required if use case assumption requires it for safety reasons
BUCK IF	C_in_buck_IF1	1 μ F	Surface mount ceramic capacitors	–
	C_in_buck_IF2	100 nF	Surface mount ceramic capacitors	–
	C_buck_IF_1	47 μ F	Surface mount ceramic capacitors	–
	C_buck_IF_2	1 μ F	Surface mount ceramic capacitor	–
	C_buck_IF_3	100 nF	Surface mount ceramic capacitor	–
	L_buck_IF	2.2 μ H	Shielded power inductor	Select inductor according to the over current limitation
	R_buck_if_min_load	–	–	Pick accordingly to fulfill Minimum output current - BUCK IF
LDO_Capacitors	C_1QCO	4.7 μ F	Surface mount ceramic capacitor	–

(table continues...)

19 Application information

Table 149 (continued) BOM recommendation

Block	Symbol	Value	Description	Note
	C_2QCO	–	Surface mount ceramic capacitor	Redundant setup might be required for safety context. Dimension according to EC table of QCO.
	C_1QST	4.7 μ F	Surface mount ceramic capacitor	–
	C_2QST	–	Surface mount ceramic capacitor	Redundant setup might be required for safety context. Dimension according to EC table of QST.
	C_1QUC	4.7 μ F	Surface mount ceramic capacitor	–
	C_2QUC	–	Surface mount ceramic capacitor	Redundant setup might be required for safety context. Dimension according to EC table of QUC.
	C_1QVR	4.7 μ F	Surface mount ceramic capacitor	–
	C_2QVR	–	Surface mount ceramic capacitor	Redundant setup might be required for safety context. Dimension according to EC table of QVR.
	C_IQUC_in	100 nF	Surface mount ceramic capacitor	optional
	C_IQVR_in	100 nF	Surface mount ceramic capacitor	optional
ENA/WAK	C_ENA	10 nF	Surface mount ceramic capacitor	optional
	C_WAK	10 nF	Surface mount ceramic capacitor	optional
	R_ENA	10 k Ω	Standard thick film chip resistor	optional
	R_WAK	10 k Ω	Standard thick film chip resistor	optional

19 Application information

Table 150 BOM deviation for output capacitances of switch mode power supplies

SMPS	Effective capacitance	Deviation
PREREG	$C_{PR}[typ]$	-40%
BUCKCORE	$C_{buck_core_1/2}[typ]$	-30%
BUCKIF	$C_{BUCK_IF}[typ]$	-40%
BOOST	$C_{bst}[typ]$	-40%

Note: When deviating to the values, as specified in the table above, for the output capacitances of the switch mode regulators, the dynamic performance as specified in the datasheet can be impacted and it would require a dedicated assessment of the behavior in the application's context.

20 Package information

20 Package information

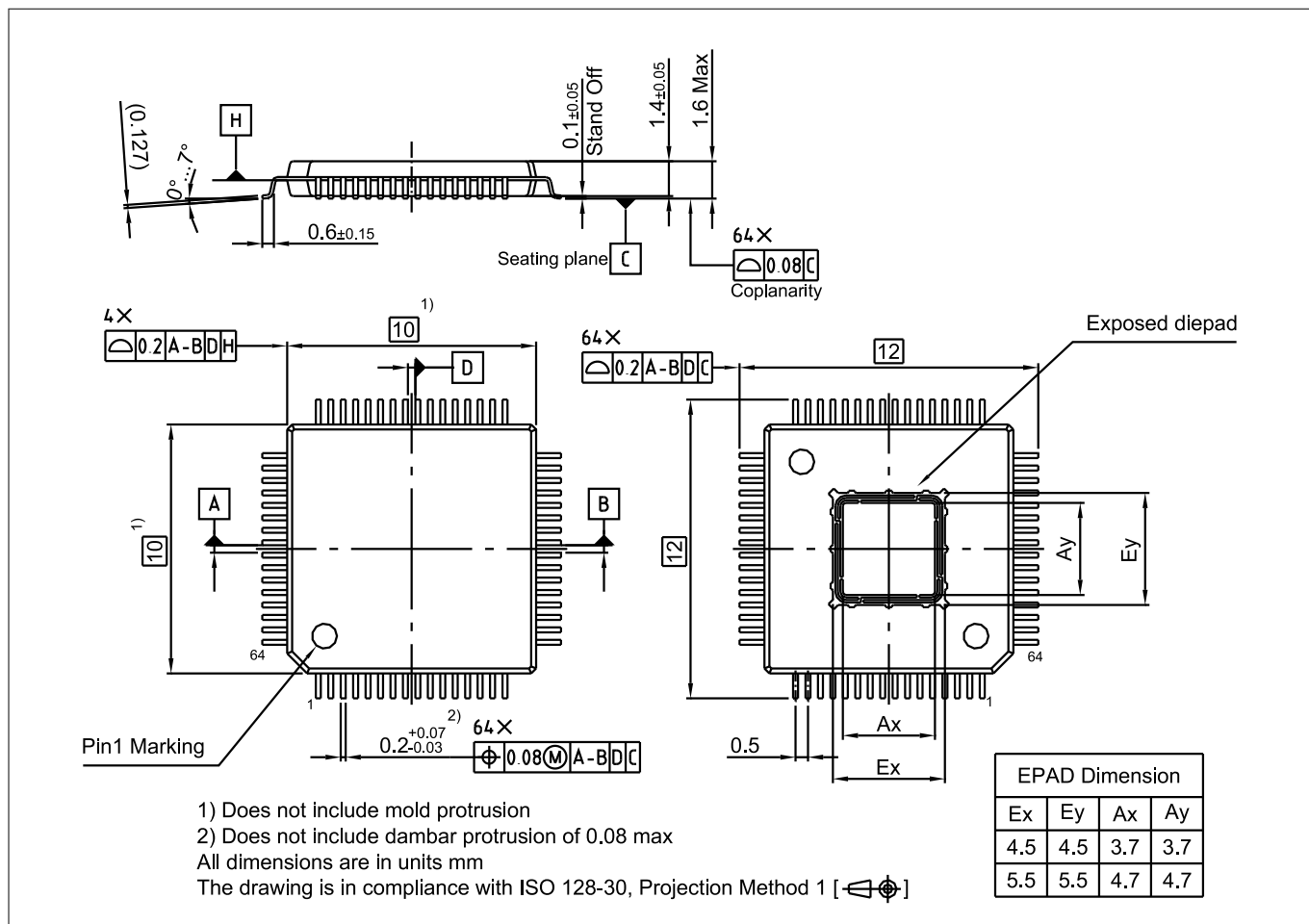


Figure 97 PG-LQFP-64¹⁾

Green Product (RoHS compliant)

To meet the world-wide customer requirements for environmentally friendly products and to be compliant with government regulations, the device is available as a Green Product. Green Products are RoHS compliant (Pb-free finish on leads and suitable for Pb-free soldering according to IPC/JEDEC J-STD-020).

Information on packages

For more information on packages, such as recommendations on assembly, refer to www.infineon.com/packages.

¹ Exposed pad dimensions [mm] for this product: E_x: 5.5, E_y: 5.5, A_x: 4.7, A_y: 4.7.

21 Revision history

21 Revision history

Revision	Date	Changes
1.00	2026-01-09	Datasheet created

Trademarks

All referenced product or service names and trademarks are the property of their respective owners.

Edition 2026-01-09

Published by

Infineon Technologies AG
81726 Munich, Germany

© 2026 Infineon Technologies AG
All Rights Reserved.

Do you have a question about any aspect of this document?

Email: erratum@infineon.com

Document reference

IFX-vgj1637772527721 Z8F80171965

Important notice

The information given in this document shall in no event be regarded as a guarantee of conditions or characteristics ("Beschaffenhheitsgarantie").

With respect to any examples, hints or any typical values stated herein and/or any information regarding the application of the product, Infineon Technologies hereby disclaims any and all warranties and liabilities of any kind, including without limitation warranties of non-infringement of intellectual property rights of any third party.

In addition, any information given in this document is subject to customer's compliance with its obligations stated in this document and any applicable legal requirements, norms and standards concerning customer's products and any use of the product of Infineon Technologies in customer's applications.

The data contained in this document is exclusively intended for technically trained staff. It is the responsibility of customer's technical departments to evaluate the suitability of the product for the intended application and the completeness of the product information given in this document with respect to such application.

Warnings

Due to technical requirements products may contain dangerous substances. For information on the types in question please contact your nearest Infineon Technologies office.

Except as otherwise explicitly approved by Infineon Technologies in a written document signed by authorized representatives of Infineon Technologies, Infineon Technologies' products may not be used in any applications where a failure of the product or any consequences of the use thereof can reasonably be expected to result in personal injury.