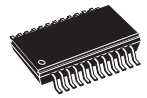
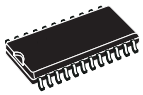
STP16CPPS05

Low voltage 16-bit constant current LED sink driver with auto power-saving

Datasheet - production data



QSOP-24



SO-24

TSSOP24

TSSOP24
(exposed pad)

Features

- Low voltage power supply down to 3 V
- 16 constant current output channels
- Adjustable output current through external resistor
- Serial data IN/parallel data OUT
- Auto power-saving
- 3.3 V MCU-driving capability
- Output current: 3 to 40 mA
- 30 MHz clock frequency
- Available in high thermal efficiency TSSOP exposed pad
- ESD protection: 2 kV HBM, 200 V MM

Description

The STP16CPPS05 is a monolithic, low voltage, low current power 16-bit shift register designed for LED panel displays. The device features a 16-bit serial-in, parallel-out shift register that feeds a 16-bit D-type storage register. In the output stage, sixteen regulated current sources are designed to provide 3 to 40 mA of constant current to drive the LEDs.

The STP16CPPS05 output current can be adjusted through an external resistor to control the light intensity of the LEDs.
LED brightness is adjustable from 0% to 100% via the $\overline{OE}$ pin.

The auto power-shutdown and auto power-ON feature allows the device to save power with no external intervention.

The STP16CPPS05 guarantees a 20 V output driving capability, allowing users to connect more LEDs in series. The high 30 MHz clock frequency makes the device suitable for high data rate transmission. The 3.3 V supply is well suited for applications which interface a 3.3 V MCU. Compared to a standard TSSOP package, the TSSOP with exposed pad increases heat dissipation capability by a factor of 2.5.

Table 1. Device summary

Order codes	Package	Packaging
STP16CPPS05MTR	SO-24	1000 parts per reel
STP16CPPS05TTR	TSSOP24	2500 parts per reel
STP16CPPS05XTTR	TSSOP24 exposed pad	2500 parts per reel
STP16CPPS05PTR	QSOP-24	2500 parts per reel

Contents

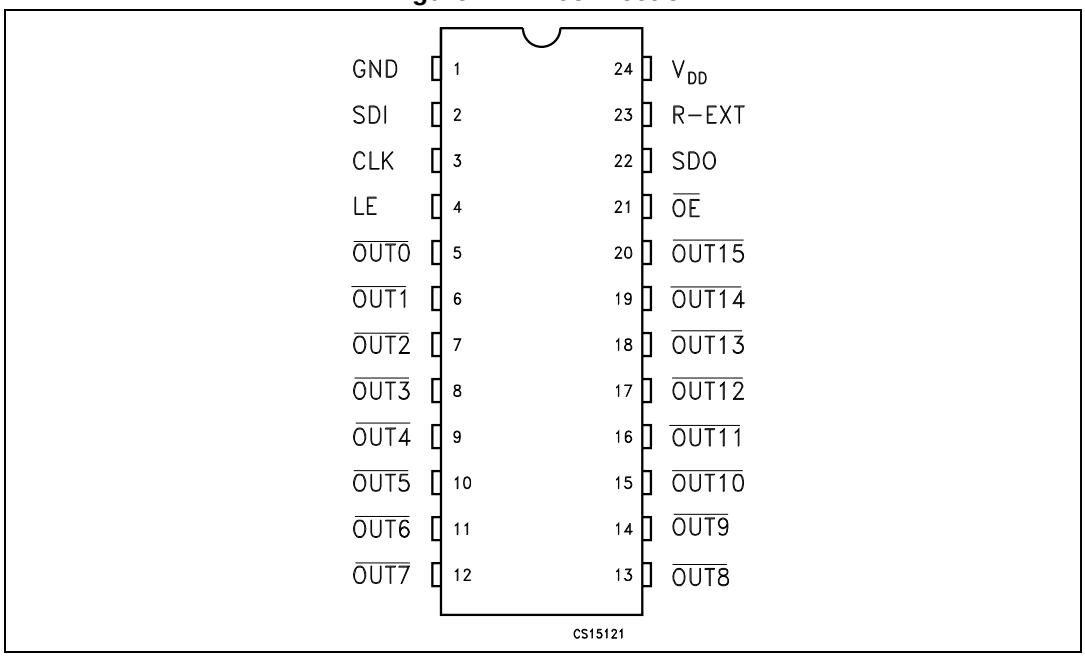
1 Summary description

Table 2. Typical current accuracy

Output voltage	Current accuracy		Output current	V_{DD}	Temperature
	Between bits	Between ICs			
≥ 1.3 V	± 1%	± 2%	5 to 40 mA	3.3 V to 5 V	25 °C

1.1 Pin connection and description

Figure 1. Pin connection



Note: The exposed pad should be electrically connected to a metal land electrically isolated or connected to ground.

Table 3. Pin description

Pin n°	Symbol	Name and function
1	GND	Ground terminal
2	SDI	Serial data input terminal
3	CLK	Clock input terminal
4	LE	Latch input terminal - detect mode 1 (see operation principle)
5-20	OUT 0-15	Output terminal
21	OE	Input terminal of output enable (active low) - detect mode 1 (see operation principle)
22	SDO	Serial data out terminal
23	R-EXT	Input terminal for an external resistor for constant current programming
24	V_{DD}	Supply voltage terminal

2 Electrical ratings

2.1 Absolute maximum ratings

Stressing the device above the ratings listed in the “absolute maximum ratings” table may cause permanent damage to the device. These are stress ratings only and operation of the device at these or any other condition above those indicated in the operating sections of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

Table 4. Absolute maximum ratings

Symbol	Parameter	Value	Unit
V_{DD}	Supply voltage	0 to 7	V
V_O	Output voltage	-0.5 to 20	V
I_O	Output current	50	mA
V_I	Input voltage	-0.4 to V_{DD}	V
I_{GND}	GND terminal current	800	mA
f_{CLK}	Clock frequency	50	MHz
T_J	Junction temperature range (1)	-40 to +170	°C

1. Such absolute value is based on the thermal shutdown protection.

2.2 Thermal data

Table 5. Thermal data

Symbol	Parameter		Value	Unit
T_A	Operating free-air temperature range		-40 to +125	°C
$T_{J\text{-}OPR}$	Operating thermal junction temperature range		-40 to +150	°C
T_{STG}	Storage temperature range		-55 to +150	°C
R_{thJA}	Thermal resistance junction-ambient (1)	SO-24	42.7	°C/W
		TSSOP24	55	°C/W
		TSSOP24(2) Exposed Pad	37.5	°C/W
		QSOP-24	55	°C/W

1. According with JEDEC standard 51-7B
2. The exposed pad should be soldered directly to the PCB to obtain the thermal benefits.

2.3 Recommended operating conditions

Table 6. Recommended operating conditions

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
V_{DD}	Supply voltage		3.0		5.5	V
V_O	Output voltage				20	V
I_O	Output current	OUTn	3		40	mA
I_{OH}	Output current	SERIAL-OUT			+1	mA
I_{OL}	Output current	SERIAL-OUT			-1	mA
V_{IH}	Input voltage		0.7 V_{DD}		V_{DD}	V
V_{IL}	Input voltage		-0.3		0.3 V_{DD}	V
t_{wLAT}	LE pulse width	V_{DD} = 3.0 V to 5.0 V	20			ns
t_{wCLK}	CLK pulse width		10			ns
t_{wEN}	$\overline{OE}$ pulse width		100			ns
$t_{SETUP(D)}$	Setup time for DATA		8			ns
$t_{HOLD(D)}$	Hold time for DATA		5			ns
$t_{SETUP(L)}$	Setup time for LATCH		8			ns
f_{CLK}	Clock frequency	Cascade operation (1)			30	MHz

1. If the device is connected in cascade, it may not be possible achieve the maximum data transfer. Please consider the timings carefully.

3 Electrical characteristics

V_{DD} = 3.3 V to 5 V, T_A = 25 °C, unless otherwise specified.

Table 7. Electrical characteristics

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
V_{IH}	Input voltage high level		0.7 V_{DD}		V_{DD}	V
V_{IL}	Input voltage low level		GND		0.3 V_{DD}	V
I_{OH}	Output leakage current	V_{OH} = 20 V			1	µA
V_{OL}	Output voltage (serial-OUT)	I_{OL} = 1 mA			0.4	V
V_{OH}	Output voltage (serial-OUT)	I_{OH} = -1 mA	V_{DD}-0.4V			V
I_{OL1}	Output current	V_O = 0.3 V, R_{ext} = 4 kΩ	4.75	5	5.25	mA
I_{OL2}		V_O = 0.3 V, R_{ext} = 1 kΩ	19	20	21	
I_{OL3}		V_O = 1.3 V, R_{ext} = 497 Ω	38	40	42	
ΔI_{OL1}	Output current error between bit (All output ON)	V_O = 0.3 V, I_O = 5 mA R_{EXT} = 4 kΩ		± 1	± 5	%
ΔI_{OL2}		V_O = 0.3 V, I_O = 20 mA R_{EXT} = 980 Ω		± 0.5	± 3	
ΔI_{OL3}		V_O = 1.3 V, I_O = 40 mA R_{EXT} = 490 Ω		± 0.5	± 3	
$R_{SIN(up)}$	Pull-up resistor		150	300	600	kΩ
$R_{SIN(down)}$	Pull-down resistor		100	200	400	kΩ
$I_{DD(OFF1)}$	Supply current (OFF)	R_{EXT} = 1 kΩ, I_{OUT} = 20 mA, OUT 0 to 15 = OFF		5.4	7.5	mA
$I_{DD(OFF2)}$		R_{EXT} = 497 Ω, I_{OUT} = 40 mA OUT 0 to 15 = OFF		8.0	9.5	
$I_{DD(ON1)}$	Supply current (ON)	R_{EXT} = 1 kΩ, I_{OUT} = 20 mA, OUT 0 to 15 = ON		5.5	7.5	
$I_{DD(ON2)}$		R_{EXT} = 497 Ω, I_{OUT} = 40 mA OUT 0 to 15 = ON		8.1	9.5	
$I_{DD(SH)}$	Shut-down current all latched data = L	VDD = 3.3V		160	200	µA
		VDD = 5V		190	240	µA
Thermal	Thermal protection			170		°C

V_{DD} = 3.3 V to 5 V, T_A = 25 °C, unless otherwise specified.

Table 8. Switching characteristics

Symbol	Parameter	Test conditions		Min	Typ	Max	Unit
t_{PLH1}	Propagation delay time, CLK-OUTn, LE = H, $\overline{OE}$ = L	$V_{IH} = V_{DD}$ V_{IL} = GND I_O = 20 mA R_{EXT} = 1 KΩ C_L = 10 pF V_L = 3.0 V R_L = 60 Ω	V_{DD} = 3.3 V		53.5	86.5	ns
			V_{DD} = 5 V		32	46.5	
t_{PLH2}	Propagation delay time, LE-OUTn, $\overline{OE}$ = L		V_{DD} = 3.3 V		48	75.5	ns
			V_{DD} = 5 V		30	43	
t_{PLH3}	Propagation delay time, $\overline{OE}$-OUTn, LE = H		V_{DD} = 3.3 V		71.5	118	ns
			V_{DD} = 5 V		43	62	
t_{PLH}	Propagation delay time, CLK-SDO		V_{DD} = 3.3 V	15	21	31	ns
			V_{DD} = 5 V	11	15	21	
t_{PHL1}	Propagation delay time, CLK-OUTn, LE = H, $\overline{OE}$ = L		V_{DD} = 3.3 V		27.5	39	ns
			V_{DD} = 5 V		22	30.5	
t_{PHL2}	Propagation delay time, LE-OUTn, $\overline{OE}$ = L		V_{DD} = 3.3 V		11.5	17.5	ns
			V_{DD} = 5 V		8	11.5	
t_{PHL3}	Propagation delay time, $\overline{OE}$-OUTn, LE = H		V_{DD} = 3.3 V		24	33.5	ns
			V_{DD} = 5 V		21	28.5	
t_{PHL}	Propagation delay time, CLK-SDO		V_{DD} = 3.3 V	17.5	24	36	ns
			V_{DD} = 5 V	12.5	17	25	
t_{ON}	Output rise time 10~90% of voltage waveform		V_{DD} = 3.3 V		29	54	ns
			V_{DD} = 5 V		10	17	
t_{OFF}	Output fall time 90~10% of voltage waveform		V_{DD} = 3.3 V		4.5	6	ns
			V_{DD} = 5 V		3.5	5	
t_r	CLK rise time (1)					5000	ns
t_f	CLK fall time (1)					5000	ns

1. In order to achieve high cascade data transfer, please consider tr/tf timings carefully.

4 Equivalent circuit and outputs

Figure 2. $\overline{OE}$ terminal

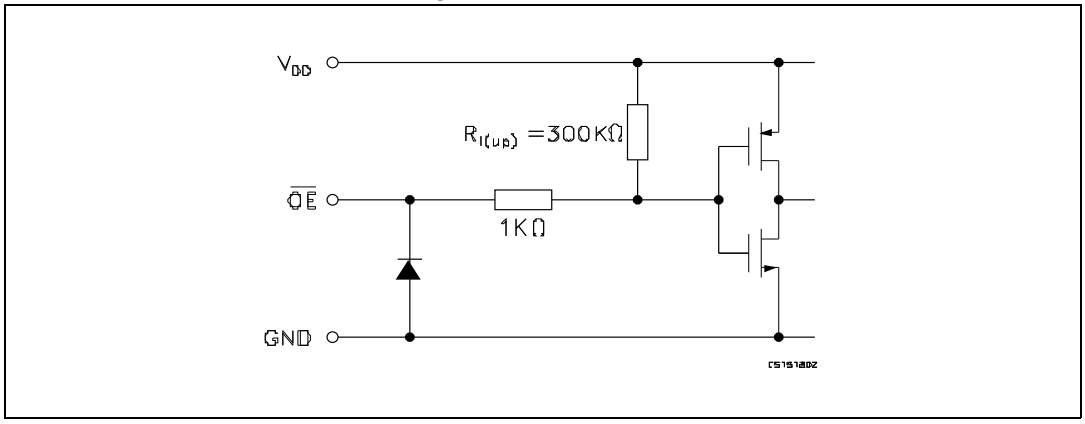


Figure 3. LE terminal

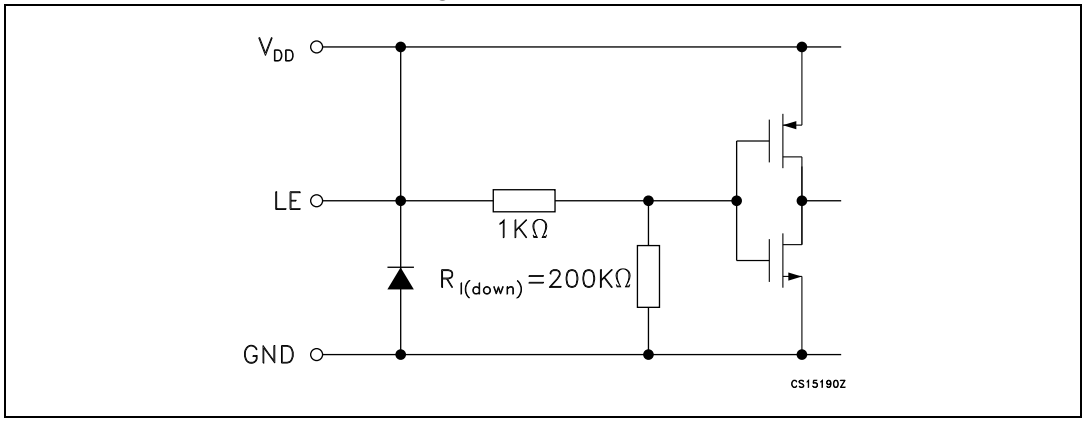


Figure 4. CLK, SDI terminal

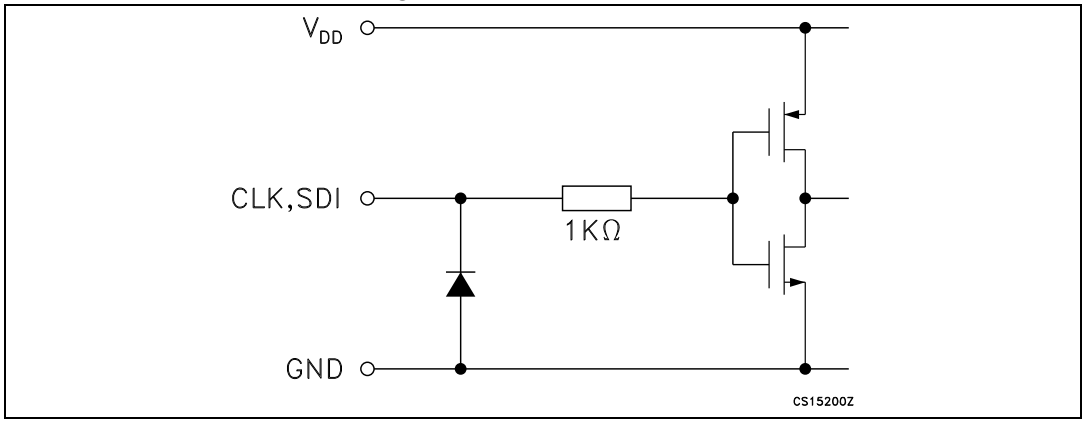


Figure 5. SDO terminal

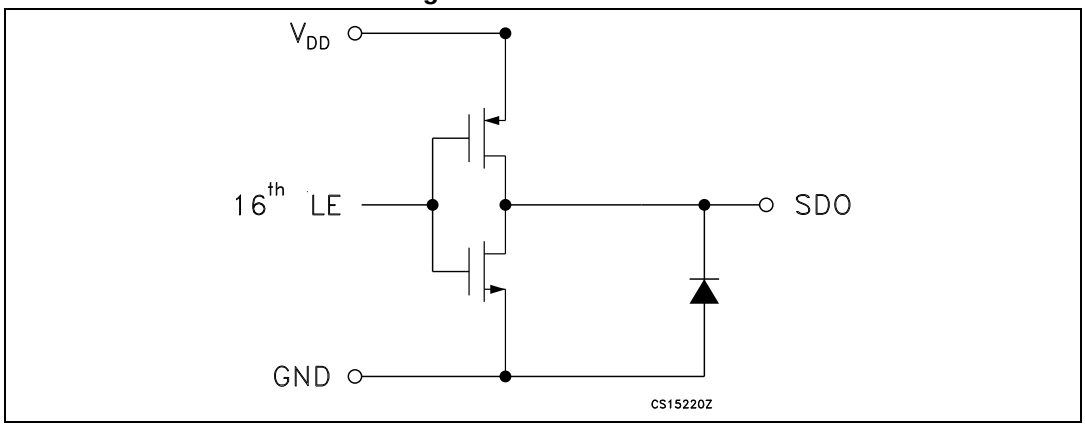
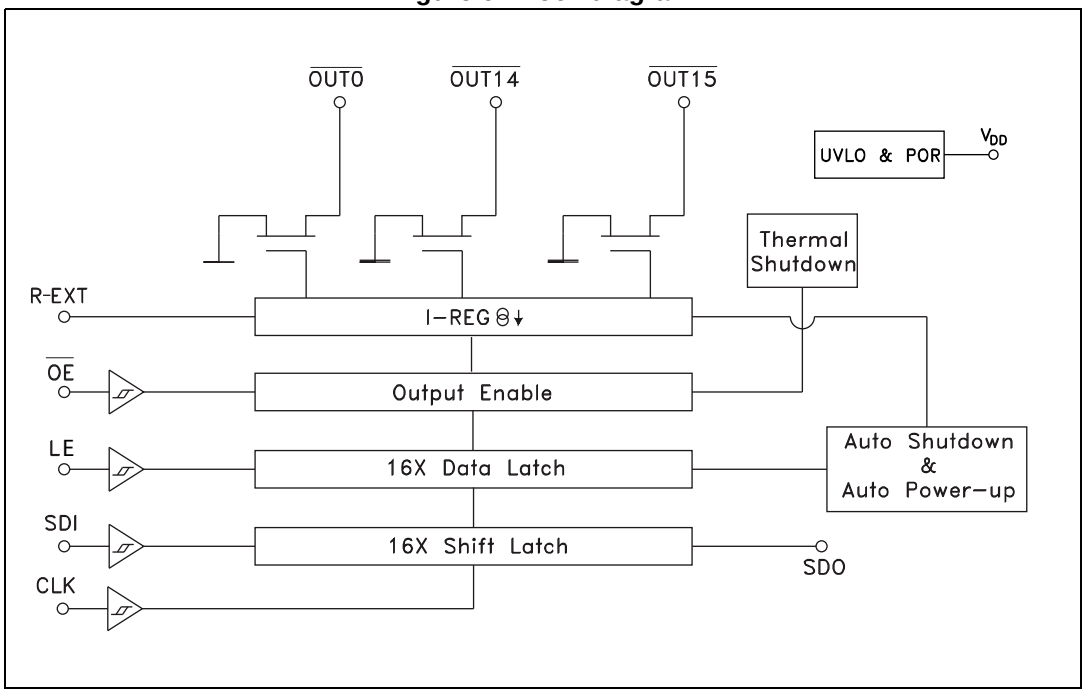


Figure 6. Block diagram



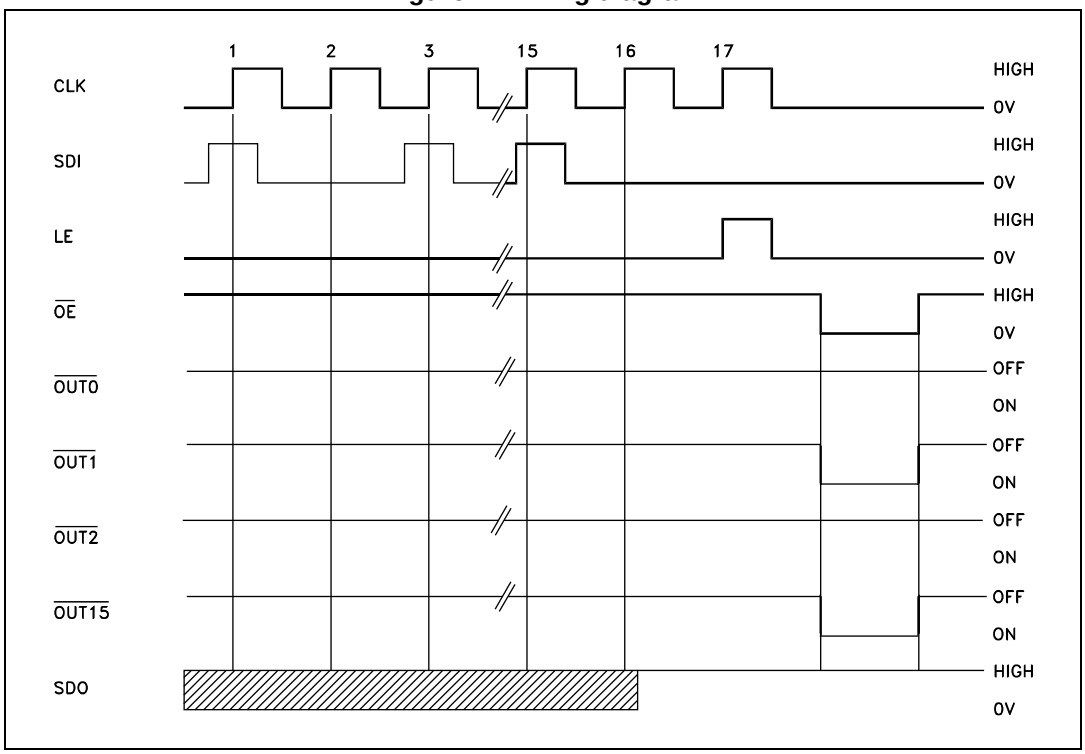
5 Timing diagrams

Table 9. Truth table

CLOCK	LE	$\overline{OE}$	SERIAL-IN	$\overline{OUT0}$ ..... $\overline{OUT7}$ ..... $\overline{OUT15}$	SDO
⎍	H	L	Dn	Dn ..... Dn - 7 ..... Dn -15	Dn - 15
⎍	L	L	Dn + 1	No change	Dn - 14
⎍	H	L	Dn + 2	Dn + 2 ..... Dn - 5 ..... Dn -13	Dn - 13
⎎	X	L	Dn + 3	Dn + 2 ..... Dn - 5 ..... Dn -13	Dn - 13
⎎	X	H	Dn + 3	OFF	Dn - 13

Note: OUTn = ON when Dn = H OUTn = OFF when Dn = L

Figure 7. Timing diagram



Note: 1 Latch and output enable terminals are level-sensitive and are not synchronized with rising or falling edge of CLK signal.

2 When LE terminal is low level, the latch circuit holds previous set of data.

3 When LE terminal is high level, the latch circuit refreshes new set of data from SDI chain.

4 When $\overline{OE}$ terminal is at low level, the output terminals Out 0 to Out 15 respond to data in the latch circuits, either '1' for ON or '0' for OFF.

5 When $\overline{OE}$ terminal is at high level, all output terminals are switched OFF.

Table 10. Enable IO: shutdown truth table

CLOCK	LE	SDI_0 ..... SDI_7 ..... SDI_{15}	SH	Auto Power-up	OUTn
⎍	H	All = L	Active	Not active (1)	OFF
⎍	L	No change	No change	No change	No change
⎍	H	One or more = H	Not active	Active	X (2)

1. At power-up, the device starts in shutdown mode.
2. Undefined.

Figure 8. Clock, serial-in, serial-out

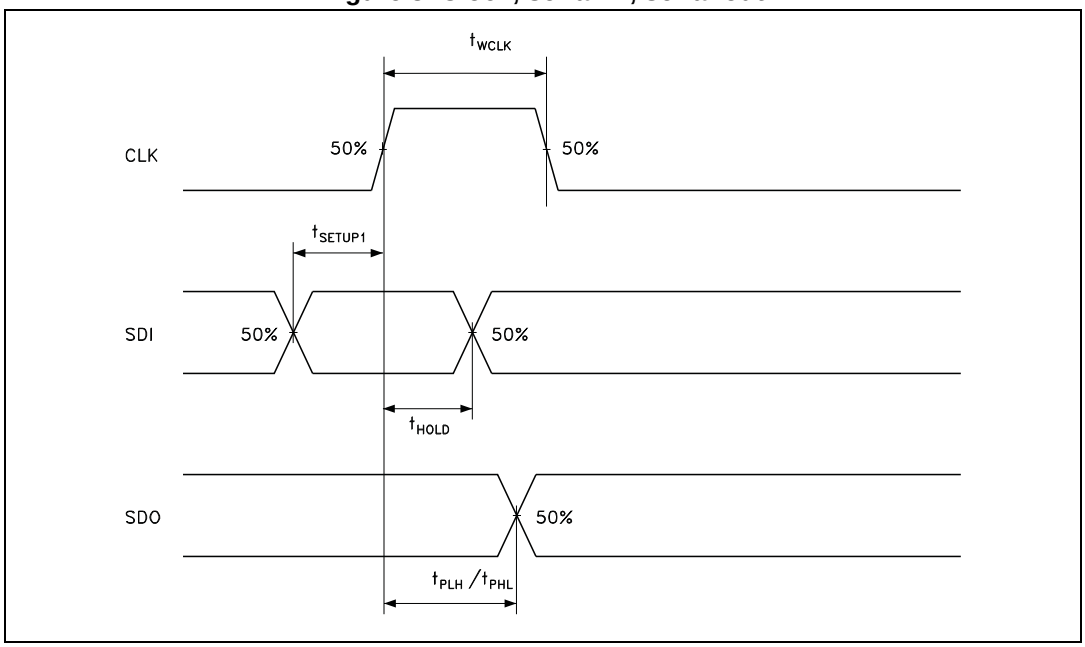


Figure 9. Clock, serial-in, latch, enable, outputs

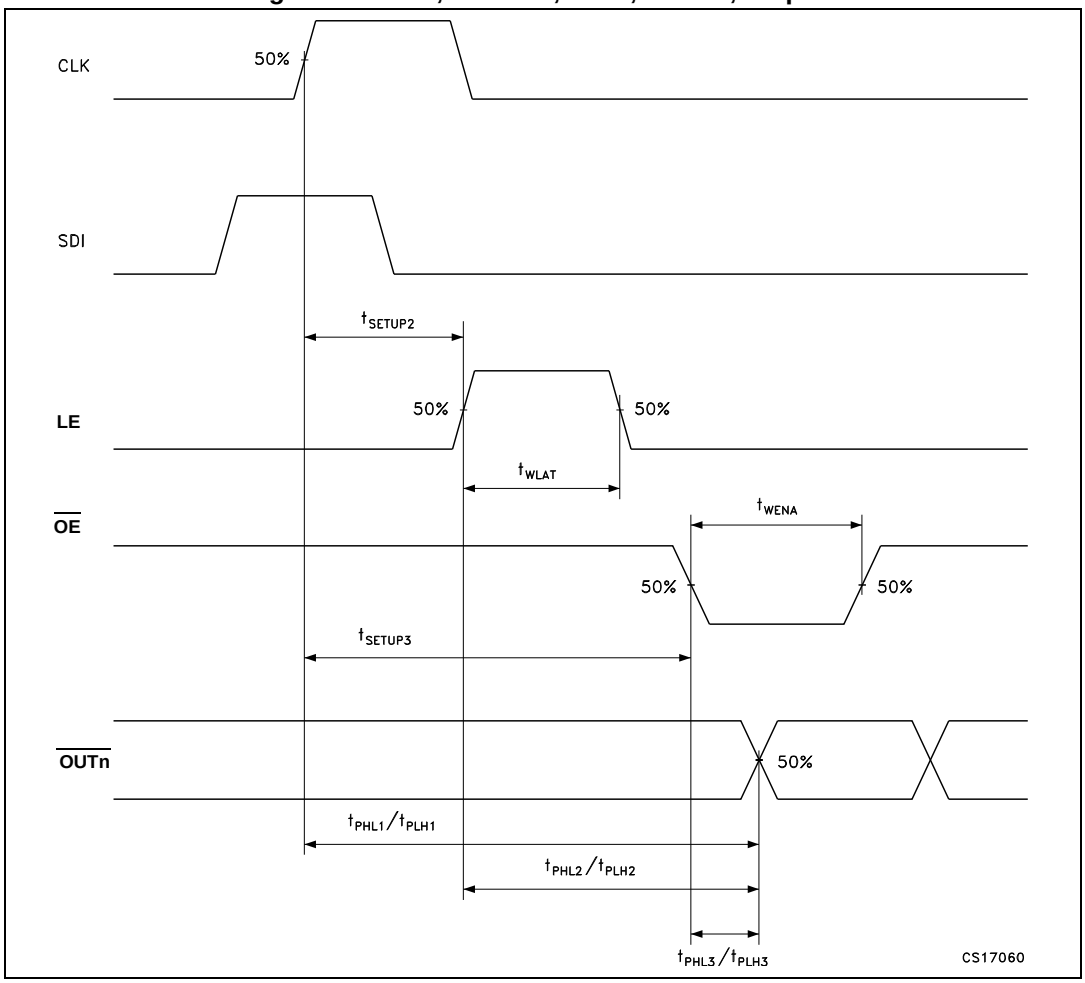
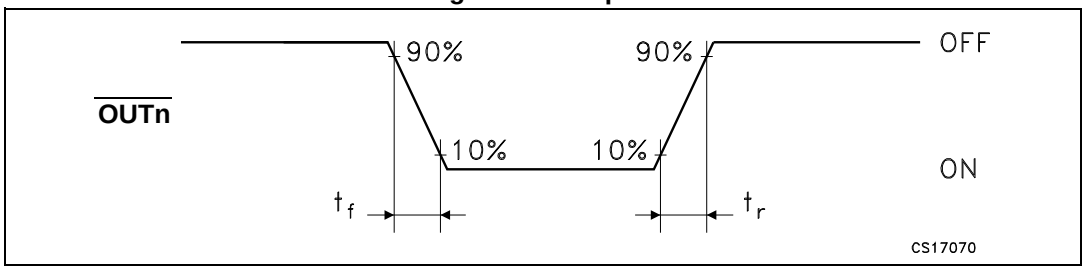


Figure 10. Outputs



6 Typical characteristics

Figure 11. Output current vs. R-EXT resistor

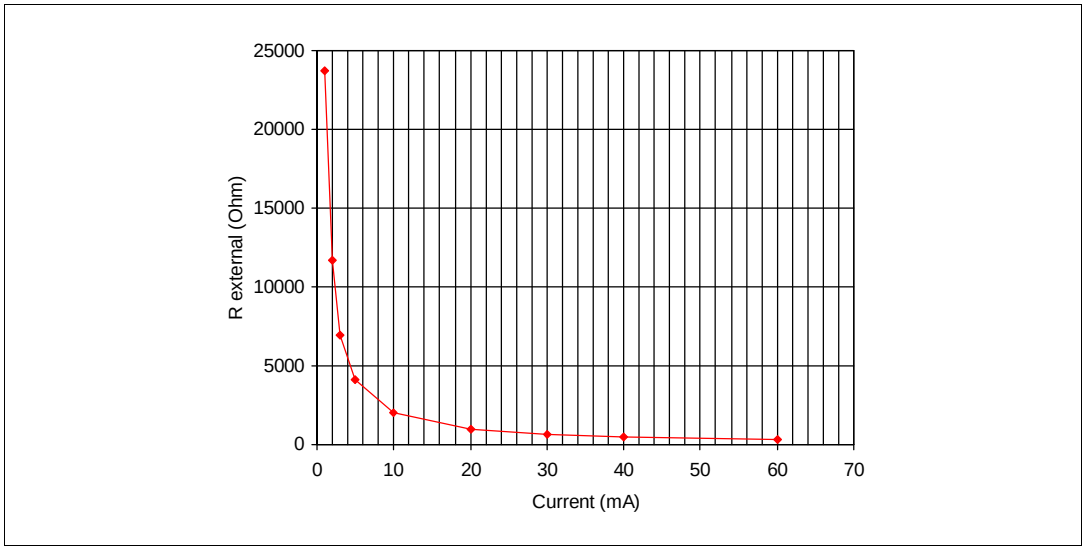


Table 11. Output current vs. R-EXT resistor

R-EXT (Ω)	Output current (mA)
23700	1
11730	2
6930	3
4090	5
2025	10
1000	20
667	30
497	40
331	60

Conditions:
Temperature = 25 °C, V_{DD} = 3.3 V; 5.0 V, I_{SET} = 3 mA; 5 mA; 10 mA; 20 mA; 50 mA; 60 mA.

Figure 12. I_{SET} vs. dropout voltage (V_{drop})

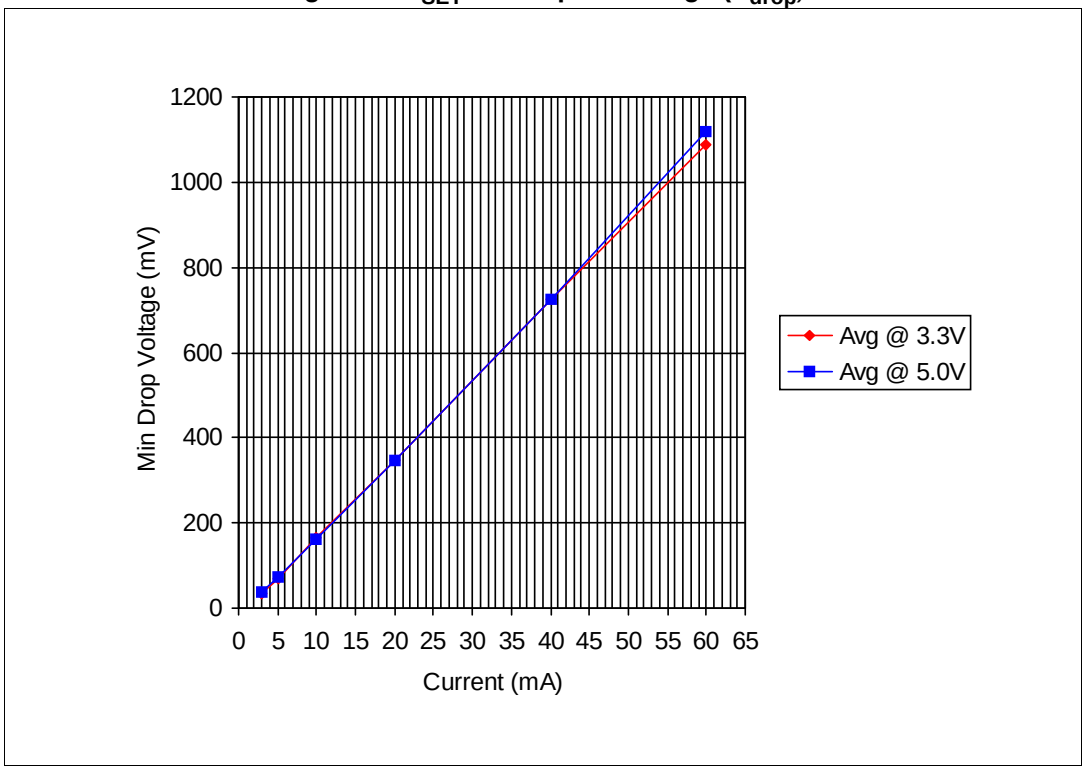


Table 12. I_{SET} vs. dropout voltage (V_{drop})

Iout (mA)	Avg (mV) @ 3.3 V	Avg (mV)@ 5.0 V
3	36	37
5	71	72
10	163	163
20	346	347
40	724	726
60	1080	1110

T_A = 25 °C, Vdd = 3.3 V; 5 V

Figure 13. Output current vs. ± ΔI_{OL}(%)

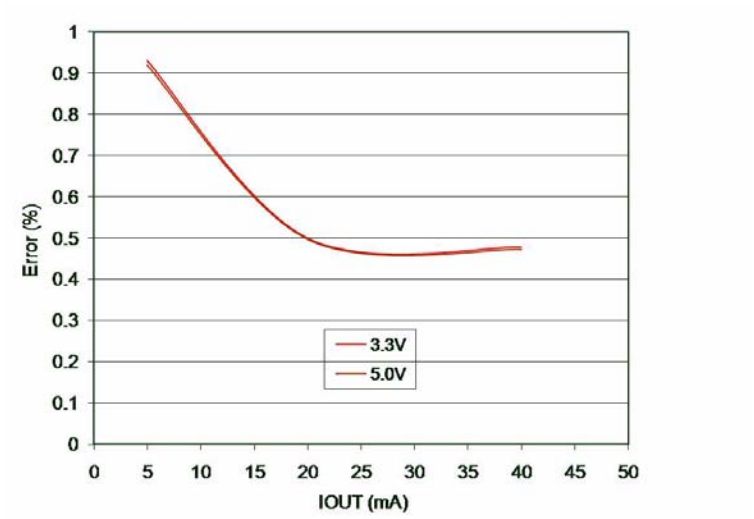


Figure 14. Idd ON/OFF

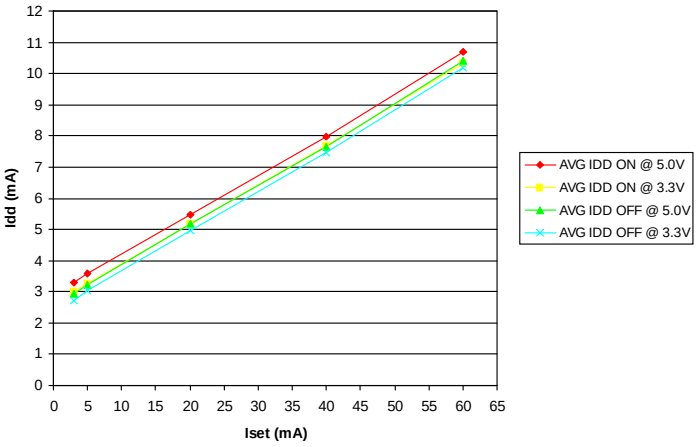
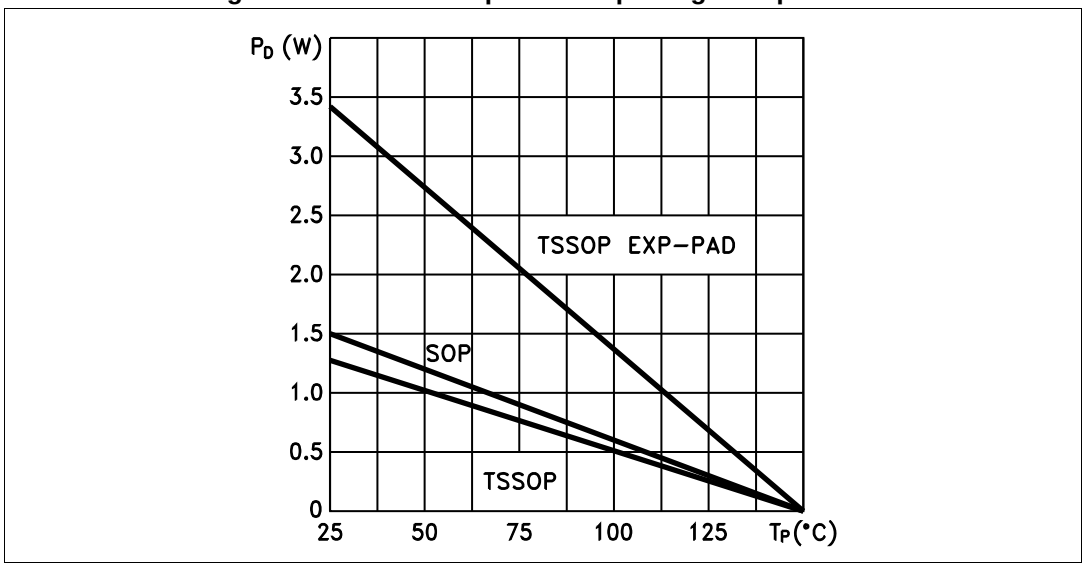


Figure 15. Power dissipation vs. package temperature



Note: The exposed pad should be soldered to the PCB to obtain the thermal benefits.

Figure 16. Turn ON output current characteristics (1)

Figure 17. Turn OFF output current characteristics (2)

Electrical conditions:
Vdd = 3.3 V, Vin = Vdd, Vled = 3.0 V, RL = 60 Ω, CL = 10 pF
Ch1 (Yellow) = $\overline{OE}$, Ch2 (Blue) = CLK, Ch3 (Purple) = VOUT, Ch4 (Green) = OUT

1. The reference level for the T_{ON} characteristics is 50% of $\overline{OE}$ signal and 90% of output current
2. The reference level for the T_{OFF} characteristics is 50% of $\overline{OE}$ signal and 10% of output current

6.1 Auto power-saving

The auto power-saving feature minimizes the quiescent current if no active data is detected on the latches and auto powers-up the device as the first active data is latched.

Figure 18. Auto power-saving feature

Electrical conditions: Temp. = 25 °C, Vdd = 3.3 V, Vin = Vdd, Vled = 3.0 V, RL = 60 Ω, CL = 10 pF
Ch1 (Yellow) = $\overline{OE}$, Ch2 (Blue) = CLK, Ch3 (Purple) = LE, Ch4 (Green) = idd
Idd consumption:
Idd (normal operation) = 4.2 mA
Idd (shut down condition) = 190 µA

Figure 19. First output ON after switching from auto power saving to normal operating condition

Electrical conditions: temp. = 25 °C, Vdd = 3.3 V, Vin = Vdd, Vled = 3.0 V, Iset = 20 mA
Ch1 (Yellow) = SDI, Ch2 (Blue) = CLK, Ch3 (Purple) = LE, Ch4 (Green) = first output ON

Note: When the device goes from AUTO power saving to normal operative condition, the first output that switch ON shows TON condition as seen in the plot above.

7 Package mechanical data

In order to meet environmental requirements, ST offers these devices in different grades of ECOPACK® packages, depending on their level of environmental compliance. ECOPACK® specifications, grade definitions and product status are available at: www.st.com. ECOPACK® is an ST trademark.

Figure 20. QSOP-24 package dimensions

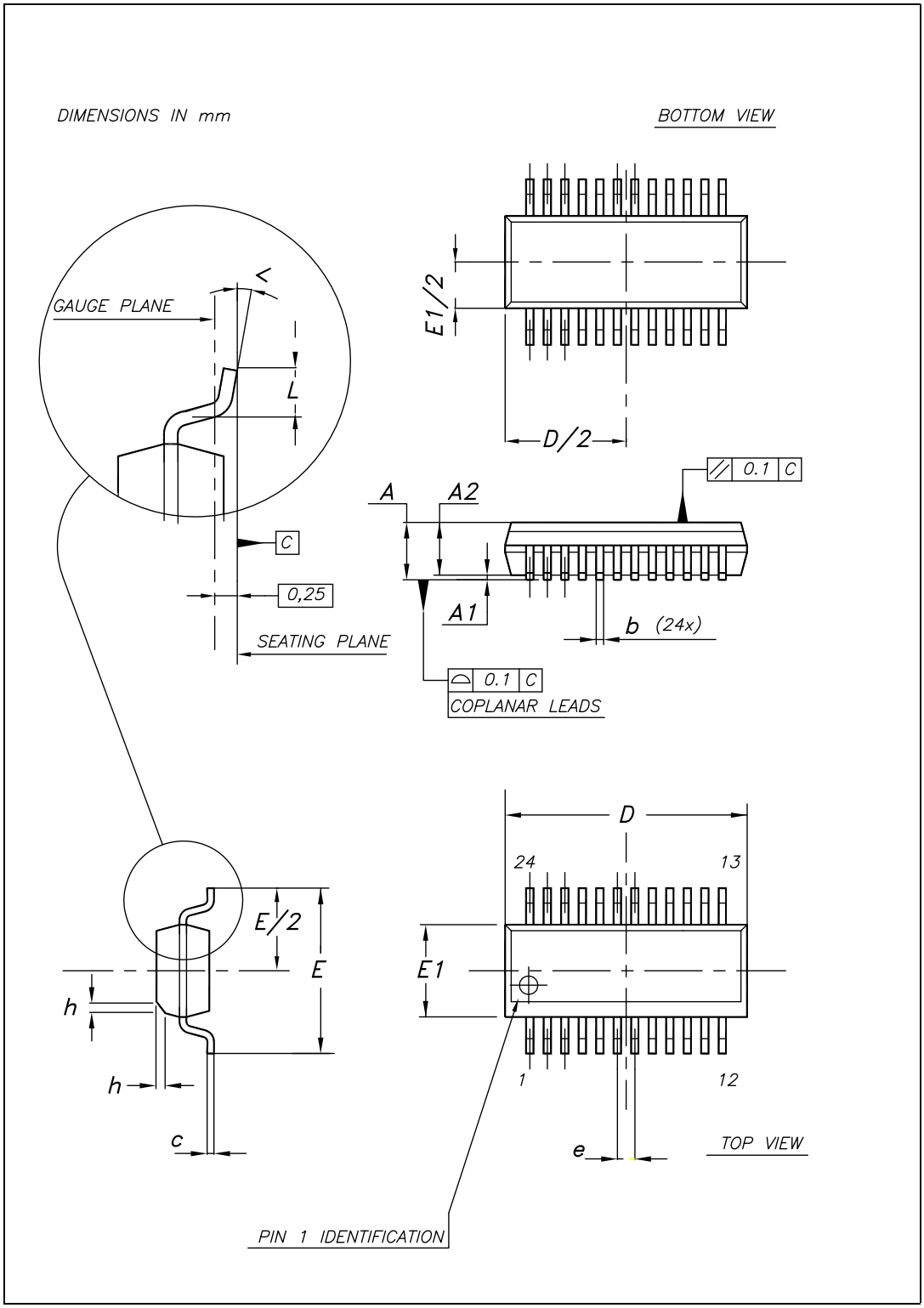


Table 13. QSOP-24 mechanical data

Dim.	mm.		
	Min	Typ	Max
A	1.54	1.62	1.73
A1	0.1	0.15	0.25
A2		1.47	
b	0.31	0.2	
c	0.254	0.17	
D	8.56	8.66	8.76
E	5.8	6	6.2
E1	3.8	3.91	4.01
e		0.635	
L	0.4	0.635	0.89
h	0.25	0.33	0.41
<	8°	0°	

Figure 21. TSSOP24 package dimensions

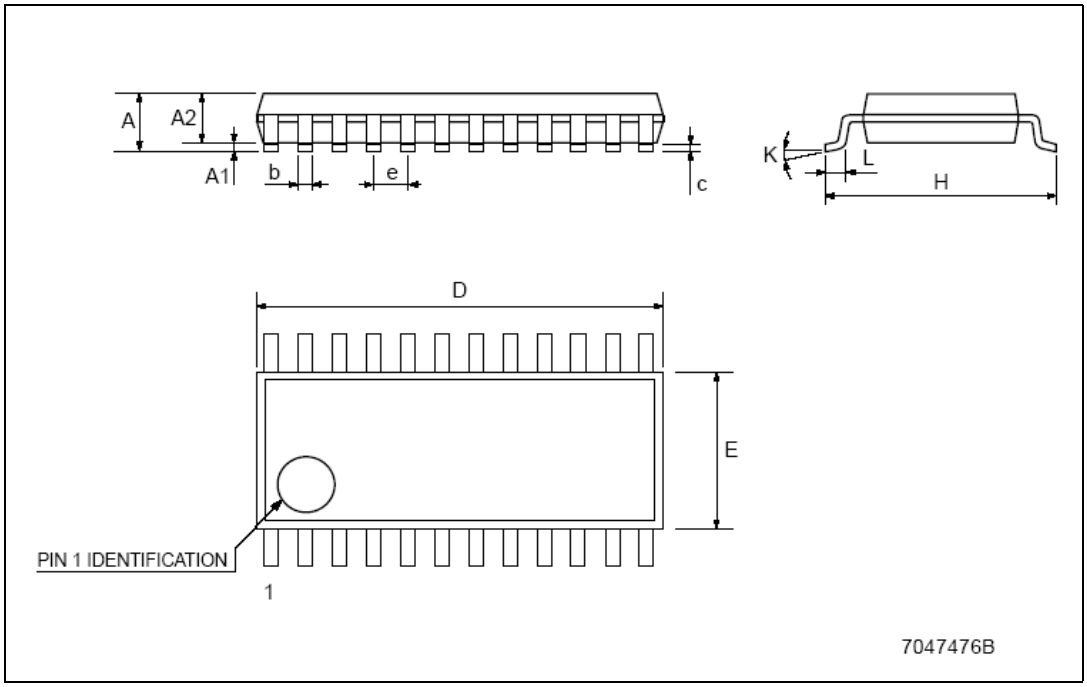


Table 14. TSSOP24 mechanical data

Dim.	mm		
	Min.	Typ.	Max.
A			1.1
A1	0.05		0.15
A2		0.9	
b	0.19		0.30
c	0.09		0.20
D	7.7		7.9
E	4.3		4.5
e		0.65 BSC	
H	6.25		6.5
K	0°		8°
L	0.50		0.70

Figure 22. SO-24 package dimensions

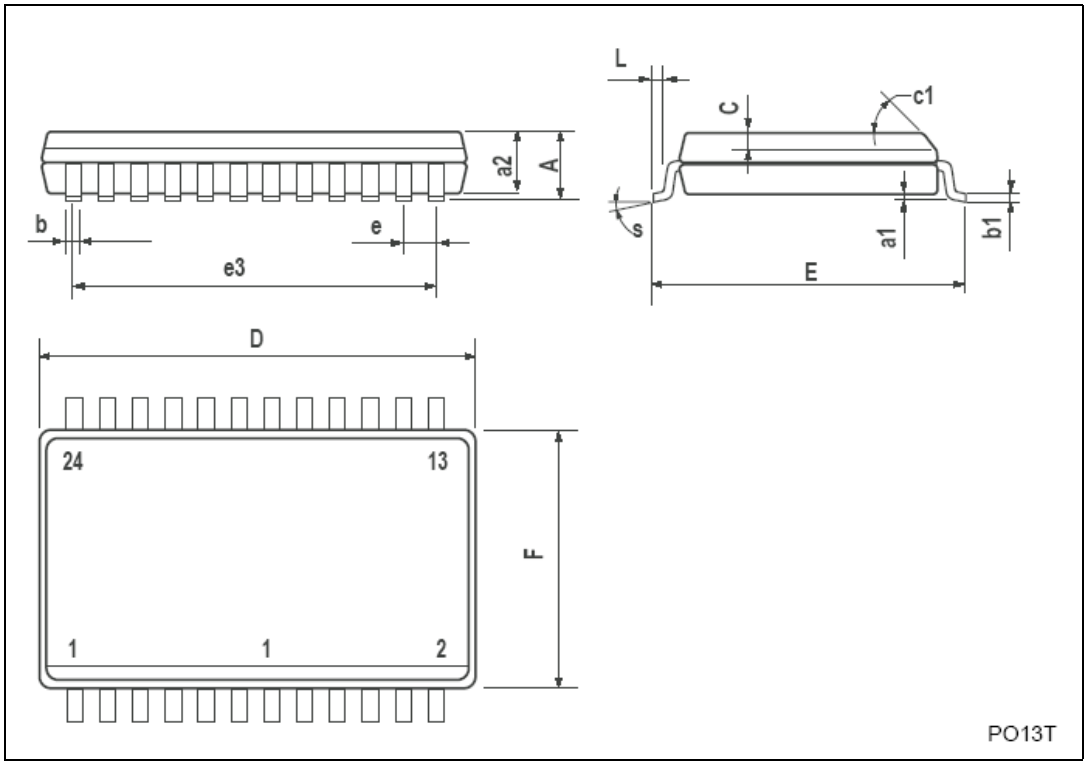


Table 15. SO-24 mechanical data

Dim.	mm.		
	Min	Typ	Max
A			2.65
a1	0.1		0.2
a2			2.45
b	0.35		0.49
b1	0.23		0.32
C		0.5	
c1	45°(typ.)		
D	15.20		15.60
E	10.00		10.65
e		1.27	
e3		13.97	
F	7.40		7.60
L	0.50		1.27
S	°(max.) 8		

Figure 23. TSSOP24 exposed pad dimensions

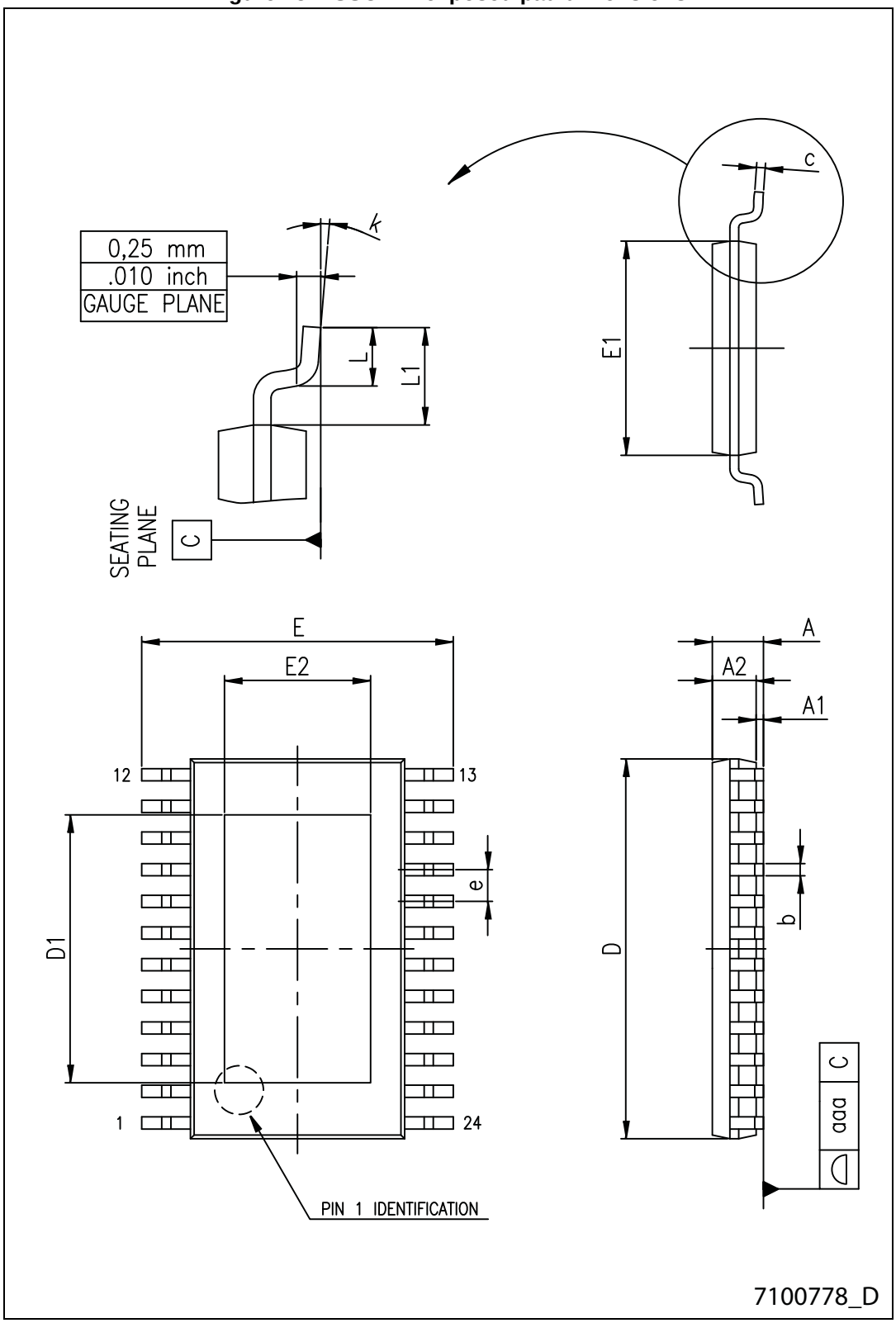


Table 16. TSSOP24 exposed pad mechanical data

Dim.	mm		
	Min.	Typ.	Max.
A			1.20
A1			0.15
A2	0.80	1.00	1.05
b	0.19		0.30
c	0.09		0.20
D	7.70	7.80	7.90
D1	4.80	5.00	5.2
E	6.20	6.40	6.60
E1	4.30	4.40	4.50
E2	3.00	3.20	3.40
e		0.65	
L	0.45	0.60	0.75
L1		1.00	
k	0		8
aaa			0.10

8 Packaging mechanical data

Figure 24. TSSOP24, TSSOP24 exposed pad and SO-24 reel dimensions

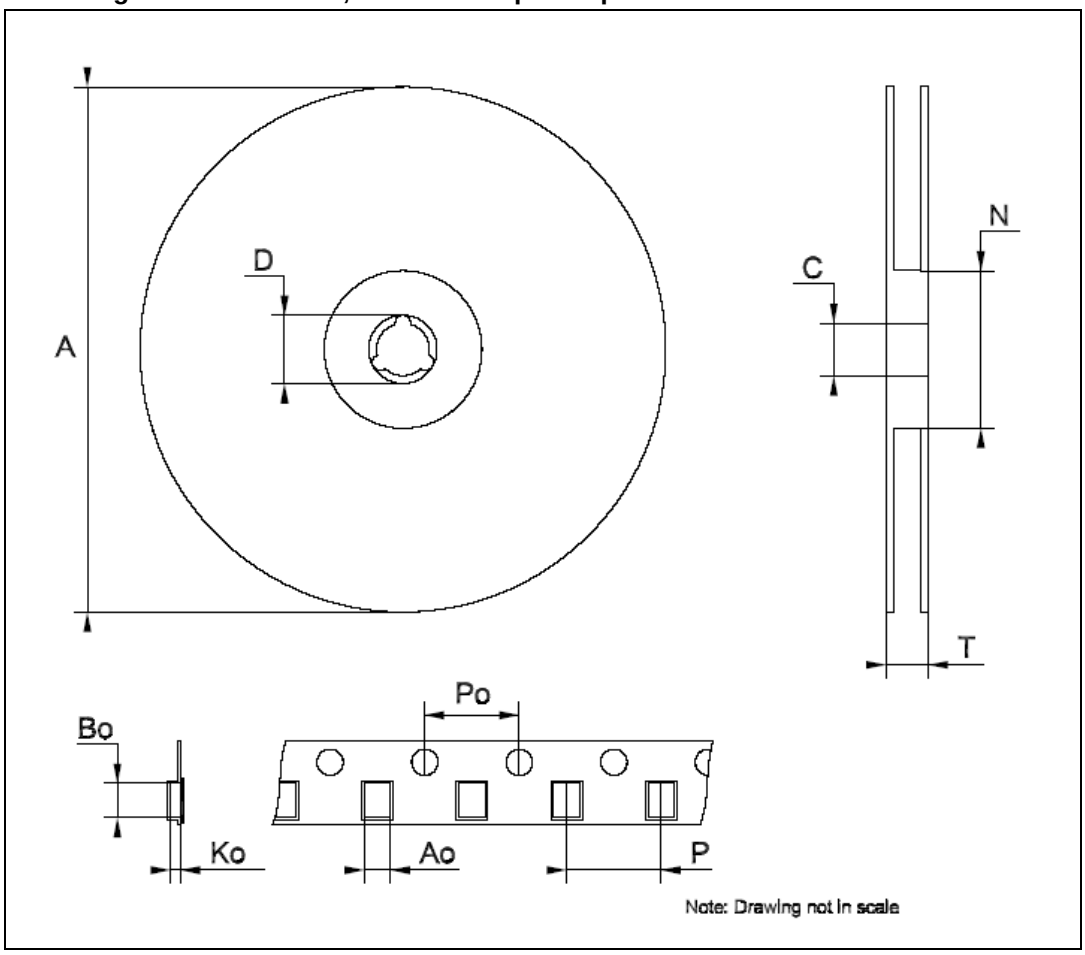


Table 17. TSSOP24 and TSSOP24 exposed pad tape and reel mechanical data

Dim.	mm		
	Min.	Typ.	Max.
A		-	330
C	12.8	-	13.2
D	20.2	-	
N	60	-	
T		-	22.4
Ao	6.8	-	7
Bo	8.2	-	8.4
Ko	1.7	-	1.9
Po	3.9	-	4.1
P	11.9	-	12.1

Table 18. SO-24 tape and reel mechanical data

Dim.	mm.		
	Min	Typ	Max
A		-	330
C	12.8	-	13.2
D	20.2	-	
N	60	-	
T		-	30.4
Ao	10.8	-	11.0
Bo	15.7	-	15.9
Ko	2.9	-	3.1
Po	3.9	-	4.1
P	11.9	-	12.1

9 Revision history

Table 19. Document revision history

Date	Revision	Changes
23-Oct-2009	1	Initial release.
16-Jun-2014	2	Updated *Section 7: Package mechanical data*. Added *Section 8: Packaging mechanical data*. Minor text changes.

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