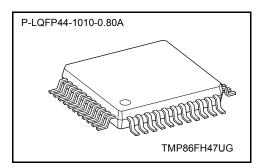
CMOS 8-Bit Microcontroller TMP86FH47UG

The TMP86FH47 is a high-speed, high-performance 8-bit microcomputer built around the TLCS-870/C Series core with built-in 16-Kbyte flash memory and it is pin compatible with its mask ROM version, the TMP86C845/847/H47. Writing programs in the built-in flash memory enables this microcomputer to perform the same operations as the TMP86C847/H47. About TMP86C845, please refer to "Difference between TMP86C845 and TMP86Cx47". The built-in flash memory can be rewritten on board (without removing it from the PCB) by a built-in boot program.

Product No.	Flash Memory	RAM	Package
TMP86FH47UG	16384×8 bits	512×8 bits	P-LQFP44-1010-0.80A

Feautures

- 8-bit single chip microcomputer TLCS-870/C series
- Instruction execution time: 0.25 µs (at 16 MHz)
 122 µs (at 32.768 kHz)
- 132 types and 731 basic instructions
- 18 interrupt sources (External: 6, Internal: 12)
- Input/output ports (35 pins)
- 8-bit timer counter: 2 ch
 - Timer, PWM, PPG, PDO, Event counter modes
- Time base timer
- Watchdog timer
 - Interrupt sources/reset output (Programmable)
- Serial interface
 - 8-bit SIO: 1 ch
 - 8-bit UART: 1 ch



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- 10-bit successive approximation type AD converter
 - Analog input: 8 ch
- 16-bit timer counter: 1 ch
 - Timer, event counter, pulse width measurment, programmable pulse generator (PPG), external-triggered timer, window modes
- ♦ Key-on wakeup: 4 ch
- Dual clock operation

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- Single/dual-clock mode
- Nine power saving operating modes

STOP mode: Oscillation stops. Battery/capacitor backup. Port output hold/high-impedance.

- SLOW 1, 2 mode: Low power consumption operation using low-frequency clock (32.768 kHz)
- IDLE 0 mode: CPU stops, and peripherals operate using high-frequency clock of timebase-timer. Release by INTTBT interrupt.
- IDLE 1 mode: CPU stops, and peripherals operate using high-frequency clock. Release by interrupts.
- IDLE 2 mode: CPU stops, and peripherals operate using high and low frequency clock. Release by interrupts.
- SLEEP 0 mode: CPU stops, and peripherals operate using low-frequency clock of timebase-timer. Release by INTTBT interrupt.
- SLEEP 1 mode: CPU stops, and peripherals operate using low-frequency clock. Release by interrupts.
- SLEEP 2 mode: CPU stops, and peripherals operate using high and low frequency clock. Release by interrupts.
- Wide operating voltage: 4.5 to 5.5 V at 16 MHz/32.768 kHz
 2.7 to 5.5 V at 8 MHz/32.768 kHz
 - Note: The operating voltage, the operating temperature and the operating current are different between TMP86FH47 and TMP86C845/847/H47. About details, please refer to electrical characteristics of each products.

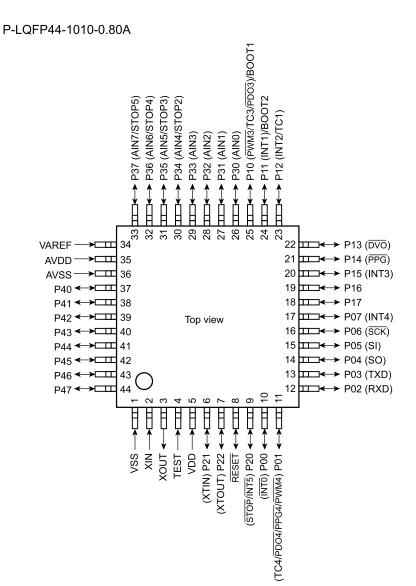
			TMP86Cx47U						
		TMP86C847U	TMP86CH47U	TMP86CM47U	TMP86C845U				
ROM (Byte	e)	8 K	16 K	32 K	8 K				
RAM (Byte	:)	512	512	1 K	256				
I/O			35		35				
Package (B	Body size)		QFP44 (10 × 10 mm)		QFP44 (10 × 10 mm)				
Min instruc	tion		0.25 μs (at 16 MHz)		0.5 μs (at 8 MHz)				
Supply vol	1.8 to 5.5 V at 4.2 MHz/32.768 kHz Supply voltage 2.7 to 5.5 V at 8.0 MHz/32.768 kHz 4.5 to 5.5 V at 16 MHz/32.768 kHz		58 kHz	2.7 to 5.5 V at 8.0 MHz/ 32.768 kHz					
16-bit time	r/counter		1 ch		-				
8-bit timer/	counter	2 ch		2 ch					
Time base	timer		1 ch		1 ch		1 ch		1 ch
Watchdog	timer		1 ch		1 ch				
AD conver	ter		8 ch		8 ch				
Serial I/O		Clocked synchronous: 1 ch, UART: 1 ch			Clocked synchronous: 1 ch				
Key on wa	wakeup 4 ch		4 ch		-				
Warm-up c	ounter		6		4				
1/0	Hysteresis input				Port2, P00, P05, P06, P07, P10, P11, P12, P15 pin				
Circuitry	CMOS input		P3, P4 port	Port3, Port4, P01, P02, P03, P04, P13, P14, P16, P17 pin					
	RESET	Watchdog timer,	Adress trap, System c	lock reset output	Input only				
Operation	Temp.		–40 to 85°C		−40 to 85°C				

Difference Between TMP86C845 and TMP86Cx47

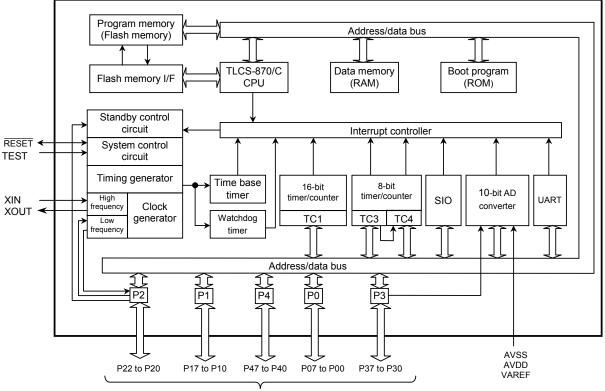
are difference points between TMP86C845 and TMP86Cx47.

Please refer to "Input/Output Circutry" of TMP86C847/H47/M47 and TMP86C845 for details.

Pin Assignments (Top view)



Block Diagram



I/O ports

Pin Function

The TMP86FH47 has MCU mode and serial PROM mode.

(1) MCU mode

In the MCU mode, the TMP86FH47 is a pin compatible with the TMP86C845/847/H47 (Make sure to fix the TEST pin to low level).

(2) Serial PROM mode

The serial PROM mode is set by fixing TEST pin, P10 and P11 at "high" respectively when $\overline{\text{RESET}}$ pin is fixed "low".

After release of reset, the built-in BOOT ROM program is activated and the built-in flash memory is rewritten by serial I/F (UART).

Pin Name (Serial PROM mode)	Input/ Output	Functions	Pin Name (MCU mode)			
BOOT1/RXD	Input/Input	Fix "High" during reset. This pin is used as RXD pin after releasing reset.	P10			
BOOT2/TXD	Input/Output	Fix "High" during reset. This pin is used as TXD pin after releasing reset.	P11			
TEST	Input	Fix to "High".				
RESET	I/O	Reset signal input or an internal error reset out	put.			
VDD, AVDD	Power supply	5 V				
VSS, AVSS, VAREF	Fower suppry	0 V				
P07 to P00, P17 to P12, P22 to P20, P37 to P30, P47 to P40		Fix to "Low" or "High".				
XIN	Input	Colf application with recorder (2 MHz, 4 MHz, 9 MHz, 16 MHz)				
XOUT	Output	Self oscillation with resonator (2 MHz, 4 MHz, 8 MHz, 16 MHz)				

Operation

This section describes the functions and basic operational blocks of TMP86FH47.

The TMP86FH47 has flash memory in place of the mask ROM which is included in the TMP86C845/847/H47. The configuration and function are the same as the TMP86C847/H47. For TMP86C845, however, some functions have been partially changed or deleted. For the functions of TMP86FH47 in details, see the section of TMP86C845/847/H47.

1. Operating Mode

The TMP86FH47 has MCU mode and serial PROM mode.

1.1 MCU Mode

The MCU mode is set by fixing the TEST pin to the low level.

In the MCU mode, the operation is the same as the TMP86C845/847/H47 (TEST pin cannot be used open because it has no built-in pull-down resistor).

1.1.1 Program memory

The TMP86FH47 has a 16-K byte built-in flash memory (addresses C000H to FFFFH in the MCU mode).

When using TMP86FH47 for evaluation of TMP86C845/847/H47, the program is written by the serial PROM mode.

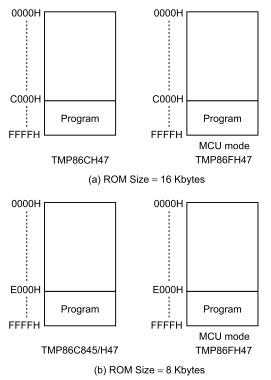


Figure 1.1.1 Program Memory Area

Note: The area that is not in use should be set data to FFH.

2. Serial PROM Mode

2.1 Outline

The TMP86FH47 has a 2-Kbyte BOOT ROM for programming to flash memory. This BOOT ROM is a mask ROM that contains a program to write the flash memory on-board. The BOOT ROM is available in a serial PROM mode and it is controlled by TEST pin and RESET pin and 2 I/O pins, and is communicated with UART. There are four operation modes in a serial PROM mode: flash memory writing mode, RAM loader mode, flash memory SUM output mode and product discrimination code output mode. Operating area of serial PROM mode differs from that of MCU mode. The operating area of serial PROM mode shows in Table 2.1.1.

Parameter	Symbol	Min	Min Max	
Operating voltage	V _{DD}	4.5	5.5	V
High frequency	fc	2, 4,	MHz	
Temperature	Topr	25	°C	

Table 2.1.1	Operating Area of Serial PROM Mode
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2.2 Memory Mapping

The BOOT ROM is mapped in address F800H to FFFFH. The BOOT ROM can't be accessed in MCU mode. The Figure 2.2.1 shows a memory mapping.

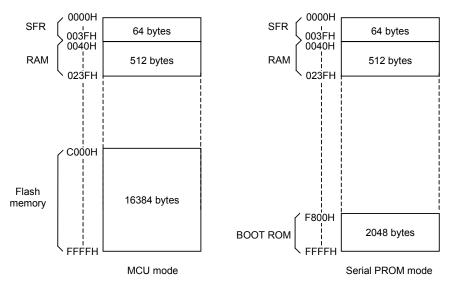


Figure 2.2.1 Memory Address Maps

Electrical Characteristics

Absolute Maximum Ratings	$(V_{SS} = 0 V)$
/ boolate maximan ratinge	(135 - 1)

Parameter	Symbol	Pins	Rating	Unit	
Supply voltage	V _{DD}		-0.3 to 5.5		
Input voltage	V _{IN}		-0.3 to V _{DD} + 0.3	V	
Output voltage	V _{OUT}		-0.3 to V _{DD} + 0.3		
	I _{OUT1} I _{OH}	P1, P3, P4 ports	-1.8		
Output current (Per 1 pin)	I _{OUT2} I _{OL}	P1, P3 ports	3.2		
	I _{OUT3} I _{OL}	P0, P2, P4 ports	30	mA	
Output ourrent (Total)	ΣI_{OUT1}	P1, P3 ports	60		
Output current (Total)	ΣI_{OUT2}	P0, P2, P4 ports	80		
Power dissipation [Topr = 70°C]	PD		250	mW	
Soldering temperature (time)	Tsld		260 (10 s)		
Storage temperature	Tstg		-55 to 125	°C	
Operating tomporature	Toor		-40 to 70 (MCU mode)		
Operating temperature	Topr		20 to 30 (Serial PROM mode)		

Note: The absolute maximum ratings are rated values which must not be exceeded during operation, even for an instant. Any one of the ratings must not be exceeded. If any absolute maximum rating is exceeded, a device may break down or its performance may be degraded, causing it to catch fire or explode resulting in injury to the user. Thus, when designing products which include this device, ensure that no absolute maximum rating value will ever be exceeded.

Recommended Operating Condition

1) MCU mode ($V_{SS} = 0$ V, Topr = -40 to 70°C)

Parameter	Symbol	Pins	C	ondition	Min	Max	Unit	
			NORMAL1, 2 mode		4.5			
			fc = 16 MHz	IDLE0, 1, 2 mode	4.5			
Supply voltage V _{DD}	V _{DD}		fc = 8 MHz	NORMAL1, 2 mode		5.5		
				IDLE0, 1, 2 mode	2.7			
				STOP mode				
	V _{IH1}	Except hysteresis input	$V_{DD} \ge 4.5 V$ $V_{DD} < 4.5 V$		$V_{DD} \times 0.70$			V
Input high level	V _{IH2}	Hysteresis input			$V_{DD} imes 0.75$	V _{DD}		
	V _{IH3}				$V_{DD} imes 0.90$			
	V _{IL1}	Except hysteresis input	V _{DD} ≥ 4.5 V			$V_{DD} \times 0.30$		
Input low level	V _{IL2}	Hysteresis input	vDD		0	$V_{DD} imes 0.25$		
	V _{IL3}		V _{DD} < 4.5 V			$V_{DD} \times 0.10$		
	fc			V _{DD} = 4.5 to 5.5 V		16.0	MHz	
Clock frequency		XIN, XOUT	V _{DD} = 2.7 to 5.5 V		1.0	8.0		
	fs	XTIN, XTOUT			30.0	34.0	kHz	

2) Serial PROM mode ($V_{SS} = 0 \text{ V}$, Topr = 20 to 30°C)

Parameter	Symbol	Pins	Condition	Min	Max	Unit
Supply voltage	V _{DD}		fc = 2 MHz, 4 MHz, 8 MHz, 16 MHz	4.5	5.5	
Input high lovel	V _{IH1}	Except hysteresis input	V _{DD} = 4.5 to 5.5 V	$V_{DD} \times 0.70$	V _{DD}	
Input high level V _{IH2}	V _{IH2}	Hysteresis input	VDD - 4.5 10 5.5 V	$V_{DD} \times 0.75$	v DD	V
Input low level	V _{IL1}	Except hysteresis input	V _{DD} = 4.5 to 5.5 V	0	$V_{DD} imes 0.30$	
V _{IL}	V _{IL2}	Hysteresis input	VDD - 4.5 10 5.5 V	0	$V_{DD} imes 0.25$	
Clock frequency	fc	XIN, XOUT	$V_{DD} = 4.5$ to 5.5 V	2.0, 4.0, 8.0, 16		MHz

Note: The recommended operating conditions for a device are operating conditions under which it can be guaranteed that the device will operate as specified. If the device is used under operating conditions other than the recommended operating conditions (Supply voltage, operating temperature range, specified AC/DC values etc.), malfunction may occur. Thus, when designing products which include this device, ensure that the recommended operating conditions for the device are always adhered to.

Parameter	Symbol	Pins	Condi	tion	Min	Тур.	Max	Unit
Hysteresis voltage	V _{HS}	Hysteresis input			-	0.9	-	V
	I _{IN1}	TEST						
Input current	I _{IN2}	Sink open drain, tri-state	$V_{DD} = 5.5 \text{ V}, \text{V}_{\text{IN}} = 8$	5.5/0 V	-	-	±2	μA
	I _{IN3}	RESET, STOP						
Input resistance	R _{IN2}	RESET pull up			100	200	450	kΩ
Output leakage	I _{LO1}	Sink open drain	$V_{DD} = 5.5 \text{ V}, \text{ V}_{OUT} =$	= 5.5 V	-	-	2	μA
current	I _{LO2}	Tri-state	$V_{DD} = 5.5 \text{ V}, \text{ V}_{OUT} =$	= 5.5/0 V	-	-	±2	μι
Output high voltage	V _{OH}	Tri-state	$V_{DD} = 4.5 \text{ V}, I_{OH} = -$	-0.7 mA	4.1	-	-	
Output low voltage	V _{OL}	Except XOUT, P0, P2 and P4 ports	$V_{DD} = 4.5 \text{ V}, \text{ I}_{OL} = 1$	$V_{DD} = 4.5 \text{ V}, I_{OL} = 1.6 \text{ mA}$		-	0.4	V
Output low current	I _{OL}	High current port (P0, P2, P4 port)	$V_{DD} = 4.5 \text{ V}, \text{ V}_{OL} =$	1.0 V	-	20	-	
Supply current in NORMAL 1, 2 mode			V _{DD} = 5.5 V		-	8.0	12.5	mA
Supply current in IDLE1, 2 mode			V _{IN} = 5.3 V/0.2 V fc = 16 MHz		-	6.0	9.0	ma
Supply current in IDLE0 mode			fs = 32.768 kHz		-	4.5	9.0	
Supply current in].			When a program operates on flash memory	-	300	600	
SLOW1 mode	I _{DD}		V _{DD} = 3.0 V V _{IN} = 2.8 V/0.2 V	When a program operates on RAM	-	8.0	27	
Supply current in SLEEP1 mode			fs = 32.768 kHz		-	7.0	25	μA
Supply current in SLEEP0 mode]				-	6.0	24	
Supply current in STOP mode			V _{DD} = 5.0 V V _{IN} = 5.3 V/0.2 V		_	0.5	10	

DC Characteristics $(V_{SS} = 0 \text{ V}, \text{ Topr} = -40 \text{ to } 70^{\circ}\text{C})$

Note 1: Typical values show those at Topr = 25°C, V_{DD} = 5 V.

Note 2: Input current (I $_{\text{IN3}}$); The current through pull-up resistor is not included.

Note 3: I_{DD} does not include I_{REF} current.

(V_{SS} = 0 V, 4.5 V \leq V_{DD} \leq 5.5 V, Topr = -40 to 70°C)

Parameter	Symbol	Condition	Min	Тур.	Max	Unit
Analog reference voltage	V _{AREF}		A _{VDD} - 1.0	-	A _{VDD}	
Power supply voltage of analog control circuit	A _{VDD}			V _{DD}		v
Analog reference voltage range (Note 4)	ΔV_{AREF}		3.5	-	-	
Analog input voltage	V _{AIN}		V _{SS}	-	V _{AREF}	
Power supply current of analog reference voltage	I _{REF}	$V_{DD} = A_{VDD} = V_{AREF} = 5.5 V$ $V_{SS} = A_{VSS} = 0.0 V$	-	0.6	1.0	mA
Non linearity error		$V_{DD} = A_{VDD} = 5.0 V$	-	-	±2	
Zero point error		$V_{SS} = A_{VSS} = 0.0 V$	-	-	±2	LSB
Full scale error			-	-	±2	LOB
Total error		V _{AREF} = 5.0 V	-	-	±2	

(V_{SS} = 0 V, 2.7 V \leq V_{DD} < 4.5 V, Topr = -40 to 70 $^{\circ}C$)

Parameter	Symbol	Condition	Min	Тур.	Max	Unit
Analog reference voltage	V _{AREF}		A _{VDD} - 1.0	-	A _{VDD}	
Power supply voltage of analog control circuit	A _{VDD}			V _{DD}		V
Analog reference voltage range (Note 4)	ΔV_{AREF}		2.5	-	-	v
Analog input voltage	V _{AIN}		V _{SS}	-	V _{AREF}	
Power supply current of analog reference voltage	I _{REF}	$V_{DD} = A_{VDD} = V_{AREF} = 4.5V$ $V_{SS} = A_{VSS} = 0.0 V$	-	0.5	0.8	mA
Non linearity error		$V_{DD} = A_{VDD} = 2.7 V$	-	-	±2	
Zero point error		$V_{SS} = 0.0 V$	-	-	±2	LSB
Full scale error		V _{SS} = 0.0 V V _{AREF} = 2.7 V	-	-	±2	LOD
Total error		$v_{AREF} = 2.7 v$	_	-	±2	

- Note 1: The total error includes all errors except a quantization error, and is defined as a maximum deviation from the ideal conversion line.
- Note 2: Conversion time is different in recommended value by power supply voltage. About conversion time, please refer to "10-Bit AD Converter".
- Note 3: Please use input voltage to AIN input pin in limit of $V_{AREF} V_{SS}$. When voltage of range outside is input, conversion value becomes unsettled and gives affect to other channel conversion value.
- Note 4: Analog reference voltage range: $\Delta V_{AREF} = V_{AREF} V_{SS}$
- Note 5: The A_{VDD} pin should be fixed on the V_{DD} level even though AD converter is not used.

AC Characteristics $(V_{SS} = 0 \text{ V}, V_{DD} = 4.5 \text{ to } 5.5 \text{ V}, \text{ Topr} = -40 \text{ to } 70^{\circ}\text{C})$

Parameter	Symbol	Condition	Min	Тур.	Max	Unit
Machine cycle time	tcy	NORMAL1, 2 mode	0.25	-	4	μs
		IDLE1, 2 mode	0.25			
		SLOW1, 2 mode	117.6	-	133.3	
		SLEEP1, 2 mode	117.0			
High level clock pulse width	twcH	For external clock operation (XIN	-	31.25	-	ns
Low level clock pulse width	twcL	input), fc = 16 MHz				
High level clock pulse width	twcH	For external clock operation (XTIN	-	15.26	-	μS
Low level clock pulse width	twcL	input), fs = 32.768 kHz				

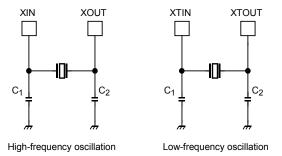
(V_{SS} = 0 V, V_{DD} = 2.7 to 4.5 V, Topr = -40 to 70° C)

Parameter	Symbol	Condition	Min	Тур.	Max	Unit
Machine cycle time	tcy	NORMAL1, 2 mode	0.5	-	4	μs
		IDLE1, 2 mode	0.5			
		SLOW1, 2 mode	117.6	-	133.3	
		SLEEP1, 2 mode	117.0			
High level clock pulse width	twcH	For external clock operation (XIN	-	62.5	-	ns
Low level clock pulse width	twcL	input), fc = 8 MHz				
High level clock pulse width	twcH	For external clock operation (XTIN	-	15.26	-	μS
Low level clock pulse width	twcL	input), fs = 32.768 kHz				

Deremeter	Oscillator	Oscillation	Recommened Oscillator		Recommended Constant		
Parameter	Oscillator	Frequency			C ₁	C ₂	
		16 MHz	MURATA	CSA16.00MXZ040	10 pF	10 pF	
		8 MHz	MURATA	CSA8.00MTZ	30 pF	30 pF	
	Ceramic Resonator			CST8.00MTW	30 pF (built-in)	30 pF (built-in)	
		4.19 MHz	MURATA	CSA4.19MG	30 pF	30 pF	
				CST4.19MGW	30 pF (built-in)	30 pF (built-in)	
Low-frequency	Crystal Oscillator	32.768 kHz	SII	VT-200	6 pF	6 pF	
Oscillation	Crystal Oscillator	32.700 KHZ	311	V 1-200	0 PF	0 PF	

Recommended Oscillating Conditions-2 $(V_{SS} = 0 \text{ V}, V_{DD} = 2.7 \text{ to } 5.5 \text{ V}, \text{ Topr} = -40 \text{ to } 70^{\circ}\text{C})$

Parameter Oscillator		Oscillation Becom		manad Oppillator	Recommended Constant		
Parameter	Oscillator	Frequency	, Recommened Oscillator		C ₁	C ₂	
High-frequency Ceramic Oscillation Resonator		8 MHz	MURATA	CSA8.00MTZ	30 pF	30 pF	
	Ceramic			CST8.00MTW	30 pF (built-in)	30 pF (built-in)	
	Resonator	4.19 MHz	MURATA	CSA4.19MG	30 pF	30 pF	
		4.19 MHZ		CST4.19MGW	30 pF (built-in)	30 pF (built-in)	



- Note 1: When using the device (Oscillator) in places exposed to high electric fields such as cathoderay tubes, we recommend electrically shielding the package in order to maintain normal operating condition.
- Note 2: To ensure stable oscillation, the resonator position, load capacitance, etc. must be appropriate. Because there factors are greatly affected by board patterns, please be sure to evaluate operation on the board on which the device will actually be mounted.
- Note 3: The product numbers and specifications of the resonators by Murata Manufacturing Co., Ltd. are subject to change. For up-to-date information, please refer to the following URL: http://www.murata.co.jp/search/index.html