CMOS 8-Bit Microcontroller TMP88CU74F

The TMP88CU74 are the high speed and high performance 8-bit single chip microcomputers. These MCU contain 8-bit AD conversion inputs and a VFT (Vacuum Fluorescent Tube) driver on a chip.

Product No.	ROM	RAM	Package	OTP MCU
TMP88CU74F	96 Kbytes + 256 bytes	2 Kbytes	P-QFP80-1420-0.80B	TMP88PU74F

Features

8-bit single chip microcomputer TLCS-870/X Series

Instruction execution time: $0.32 \ \mu s$ (at $12.5 \ MHz$), $122 \ \mu s$ (at $32.768 \ kHz$)

842 basic instructions

General-purpose register: 16 banks

15 interrupt sources (External: 6, Internal: 9)

- All sources have independent latches each
- Edge-selectable external interrupts with noise reject
- High-speed task switching by register bank changeover

Input/Output ports (71 pins)

16-bit timer/counters: 2 channels

- TC1: Timer, Eventcounter, PPG (Programable Pulse Generator) output, Pulse width measurement, External trigger timer, Window modes.
- TC2: Timer, Eventcounter, Window modes.

8-bit timer/counters: 2 channels

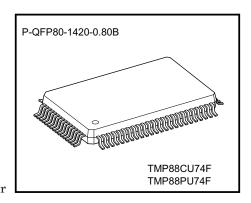
- TC3: Timer, Eventcounter, Capture (Pulse width/duty measurment)
- TC4: Timer, PWM output, PDO (Programmable Divider Output) mode

000707EBP1

The information contained herein is subject to change without notice.



Purchase of TOSHIBA I²C components conveys a license under the Philips I²C Patent Rights to use these components in an I²C system, provided that the system conforms to the I²C Standard Specification as defined by Philips.



[•] For a discussion of how the reliability of microcontrollers can be predicted, please refer to Section 1.3 of the chapter entitled Quality and Reliability Assurance / Handling Precautions.

TOSHIBA is continually working to improve the quality and reliability of its products. Nevertheless, semiconductor devices in general
can malfunction or fail due to their inherent electrical sensitivity and vulnerability to physical stress. It is the responsibility of the buyer,
when utilizing TOSHIBA products, to comply with the standards of safety in making a safe design for the entire system, and to avoid
situations in which a malfunction or failure of such TOSHIBA products could cause loss of human life, bodily injury or damage to
property.

property. In developing your designs, please ensure that TOSHIBA products are used within specified operating ranges as set forth in the most recent TOSHIBA products specifications. Also, please keep in mind the precautions and conditions set forth in the "Handling Guide for Semiconductor Devices," or "TOSHIBA Semiconductor Reliability Handbock" etc..

The TOSHIBA products listed in this document are intended for usage in general electronics applications (computer, personal equipment, office equipment, measuring equipment, industrial robotics, domestic appliances, etc.). These TOSHIBA products are neither intended nor warranted for usage in equipment that requires extraordinarily high quality and/or reliability or a malfunction or failure of which may cause loss of human life or bodily injury ("Unintended Usage"). Unintended Usage include atomic energy control instruments, airplane or spaceship instruments, transportation instruments, traffic signal instruments, combustion control instruments, medical instruments, all types of safety devices, etc.. Unintended Usage of TOSHIBA products listed in this document shall be made at the customer's own risk.

[•] The products described in this document are subject to the foreign exchange and foreign trade laws.

The information contained herein is presented only as a guide for the applications of our products. No responsibility is assumed by TOSHIBA CORPORATION for any infringements of intellectual property or other rights of the third parties which may result from its use. No license is granted by implication or otherwise under any intellectual property or other rights of TOSHIBA CORPORATION or others.

Time base timer

Divider output function

Watchdog timer

• Interrupt source/reset output (programmable)

8-bit serial interface: 1 channel

- With 8 bytes transmit/receive data buffer
- Internal/External serial clock, and 4/8-bit mode

Serial bus interface

• 8-bit SIO/I²C bus mode

8-bit successive approximate type AD converter with sample and hold

• Analog inputs: 12 channels conversion time: 23 µs at 8 MHz (High-speed conversion mode),

59 µs at 12.5 MHz (Low-speed conversion mode)

Vacuum fluorescent tube driver (Automatic display)

- High breakdown voltage ports (Max 40 $\rm V \times 37$ bits)
- Programmable grid scan output

Dual clock operation

• Single/Dual-clock mode (selection)

Five power saving operating modes

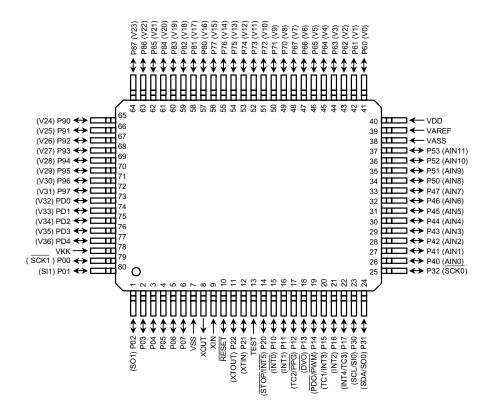
- STOP mode: Oscillation stops. Battery/Capacitor back-up. Release by stop pin input.
- SLOW mode: Low power consumption operation using low-frequency clock.
- IDLE1 mode: CPU stops, and Peripherals operate using high-frequency clock. Release by interrupts.
- IDLE2 mode: CPU stops, and Peripherals operate using high-and low-frequency clock. Release by interrupts.
- SLEEP mode: CPU stops, and Peripherals operate using low-frequency clock. Release by interrupts.

Wide operating voltage: 2.7 to 5.5 V at 32.8 kHz, 4.5 to 5.5 V at 12.5 MHz/32.8 kHz

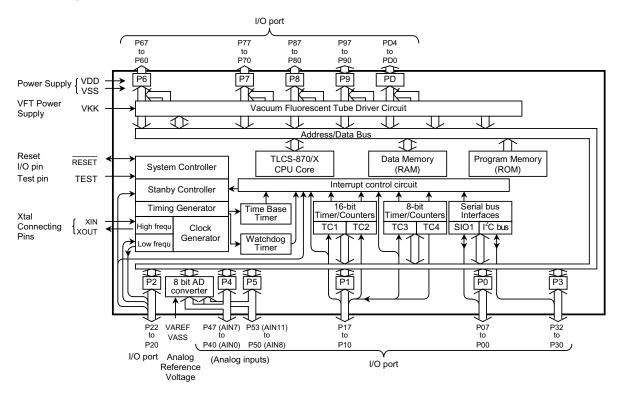
Emulation Pod: BM88CU74F0A

Pin Assignments (Top View)

P-QFP80-1420-0.80B



Block Diagram



Pin Functions (1/2)

Pin Name	Input/Output		Function			
P07 to P03	I/O	Two 8-bit programmable input/output				
P02 (SO1)	I/O (Output)	ports (tri-state).	SIO1 Serial data Output			
P01 (SI1)	I/O (Input)	Each bit of these ports can be	SIO1 Serial data Input			
P00 (SCK1)	I/O (I/O)	individually configured as an input or	SIO1 Serial clock input/output			
P17 (INT4/TC3)		an output under software control.	External interrupt 4 input or			
· · · ·		During reset, all bits are configured	Timer Counter 3 input			
P16 (INT2)	I/O (Input)	as inputs. When used as a PPG output or a	External interrupt 2 input			
P15 (INT3/TC1)		divider output, the output latch must	External interrupt 3 input or Timer Counter 1 input			
P14 (PDO / PWM)	I/O (Output)	be set to "1".	PWM output or programmable divider output			
P13 (DVO)	I/O (Output)		Divider output			
P12 (TC2/ PPG)	I/O (I/O)		Timer counter input 2 or programmable pulse generator output			
P11 (INT1)			External interrupt input 1			
P10 (INT0)	I/O (Input)		External interrupt input 0			
P22 (XTOUT)	I/O (Output)	3-bit input/output port with latch.	Resonator connecting pins (32.8 kHz).			
P21 (XTIN)		When used as an input port, a resonator connecting pin, an	For inputting external clock, XTIN is used and XTOUT is opened.			
P20 (INT5 / STOP)	I/O (Input)	external interrupt input, or a STOP mode release input, the output latch must be set to "1".	External interrupt input 5 or STOP mode release signal input			
P32 (SCK0)	I/O (Input)	3-bit programmable input/output port (tri-state/programmable open drain). Each bit of the port can be individully configured as an input or an output	SIO0 clock input/output			
P31 (SDA/SO0)	I/O (I/O/Output)	under software control. When used as a serial interface output, the output latch must be set	I ² C bus data input/output or SIO0 data output			
P30 (SCL/SI0)	I/O (I/O/Input)	to "1".	I ² C bus clock input/output or SIO0 data input			
P47 (AIN7) to P40 (AIN0)	I/O (Input)	8/4-bit programmable input/output port (tri-state). Each bit of the port can be				
P53 (AIN13) to P50 (AIN8)	I/O (Input)	individually configured as an input or output under software control. When used as an analog input set to input mode.	AD converter analog inputs			
P67 (V7) to P60 (V0)		8-bit high breakdown voltage output				
P77 (V15) to P70 (V8)		ports with the latch.				
P87 (V23) to P80 (V16)		When used as an vacuum				
P97 (V31) to P90 (V24)		fluorescent tube driver output, the				
1 57 (V51) to F 90 (V24)	I/O (Output)	output latch must be cleared to "0".	VTF output			
PD4(V36) to PD0 (V32)		5-bit high breakdown voltage output ports with the latch. When used as an vacuum fluorescent tube driver output, the				
		latch must be cleared to "0".				

Pin Functions (2/2)

Pin Name	Input/Output	Function
XIN, XOUT	Input/Output	Resonator connecting pins for high-frequency clock. For inputting external clock, XIN is used an XOUT is opened.
RESET	Input/Output	Reset signal input or watchdog timer output/address-reset output/system clock reset output.
TEST	Input	Test pin for out-going teset. Be tied to low.
VDD, VSS		+5 V, 0 V (GND)
VKK	Power Supply	Vacuum fluore scent tube driver voltage pin.
VAREF, VASS		Analog reference voltage input (High, Low)

Operational Description

1. CPU Core Functions

The CPU core consists of a CPU, a system clock controller, an interrupt controller, and a watchdog timer.

This section provides a description of the CPU core, the program memory (ROM), the data memory (RAM), and the reset circuit.

1.1 Memory Address Map

TLCS-870/X Series, the memory is organized 4 address spaces (ROM, RAM, SFR, and DBR). Figure 1.1.1 shows the memory address maps of the TMP88CU74. It uses a memory mapped I/O system, and all I/O registers are mapped in the SFR/DBR address spaces. There are 16 banks of general-purpose registers.

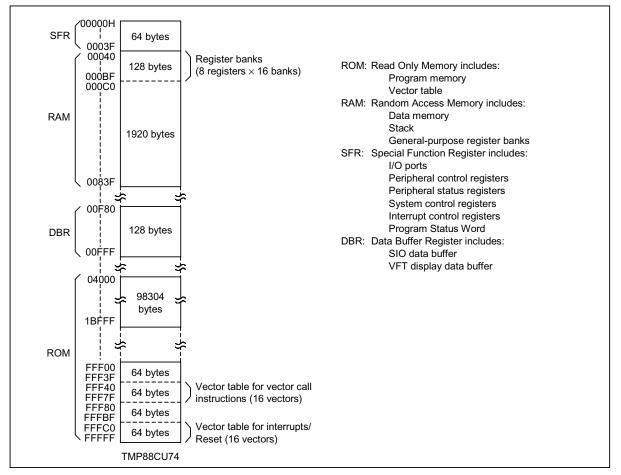


Figure 1.1.1 Memory Address Maps

1.2 Program Memory (ROM)

The TMP88CU74 has a 96 Kbytes (addresses 04000H to 1BFFFH) and 256 bytes (addresses FFF00H to FFFFFH) of program memory (mask programmed ROM). Figure 1.1.1 shown in Memory address maps.

Addresses FFF00H to FFFFFH in the program memory can also be used for special purposes.

Electrical Characteristics

Parameter	Symbol	Pins	Ratings	Unit
Supply Voltage	V _{DD}		-0.3 to 6.5	
Input Voltage	VIN		-0.3 to V _{DD} + 0.3	V
Output Voltage	V _{OUT1}	P2, P3 (at open-drain)	-0.3 to V _{DD} + 0.3	v
Output Voltage	V _{OUT2}	P6, P7, P8, P9, PD	$V_{DD} - 40$ to $V_{DD} + 0.3$	
Output Current	I _{OUT1}	P0, P1, P2, P3, P4, P5 Ports	3.2	
(Per 1 pin)	I _{OUT2}	P6, P7, P8, P9, PD Ports	-25	
	ΣI_{OUT1}	P0, P1, P3, P4, P5 Ports	-40	mA
Output Current (Total)	ΣI_{OUT2}	P0, P1, P2, P3, P4, P5 Ports	120	
	ΣΙ _{ΟUT3}	P6, P7, P8, P9, PD Ports	-160	
Power Dissipation [Topr = 25°C]	PD (Note 2)		1200	mW
Soldering Temperature (time)	Tsld		260 (10 s)	
Storage Temperature Ts			-55 to + 125	°C
Operating Temperature	Topr		-30 to + 70	

Absolute Maximum Ratings $(V_{SS} = 0 V)$

Note 1: 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.

Note 2: Power Dissipation (PD); For PD, it is necessary to decrease 14.3 mw/°C.

Parameter	Symbol	Pins		Conditions	3	Min	Max	Unit
			fc =	NORMAL1,	2 modes	4.5		
			12.5 MHz	IDLE1, 2	modes	4.5		
Supply Voltage	V _{DD}		fs =	SLOW	modes	0.7	5.5	
			32.768 KHz	SLEEP	modes	2.7		
				STOP	modes	2.0		
	V _{IH1}	Except hysteresis input	$\lambda = \lambda E \lambda$		$V_{DD} imes 0.70$	V _{DD}	V	
Input High Voltage	V _{IH2}	Hysteresis input	V _{DD} ≥4.5 V				$V_{\text{DD}} \times 0.75$	
	V _{IH3}		$V_{DD} < 4.5 V$		$V_{\text{DD}} \times 0.90$			
	V _{IL1}	Except hysteresis input			,	V _{DD} ×	$V_{DD} imes 0.30$	
Input Low Voltage	V _{IL2}	Hysteresis input		V _{DD} ≥ 4.5 V		0	$V_{DD} imes 0.25$	
	V _{IL3}		V _{DD} < 4.5 V			$V_{DD} imes 0.10$		
		XIN, XOUT	V _{DD} = 4.5 to 5.5 V (Note 2)		8	12.5	MHz	
Clock Frequency	fc	XTIN, XTOUT	V _{DD} = 2.7 to 5.5 V		30.0	34.0	kHz	

Recommended Operating Conditions $(V_{SS} = 0 \text{ V}, \text{ Topr} = -30 \text{ to } 70^{\circ}\text{C})$

Note 1: 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. Note 2: Clock frequency fc: Supply voltage range is specified in NORMAL 1/2 mode and IDLE 1/2 mode.

How to Calculate Power Consumption.

With the TMP88CU74, a pull-down resistor ($R_K = 80 \text{ k}\Omega \text{ typ.}$) can be built into a VFT driver using mask option (port by port). The share of VFT driver loss (VFT driver output loss + pull-down resistor (R_K) loss) in power consumption Pmax is high. When using a fluorescent display tube with a large number of segments, the maximum power consumption PD must not be exceeded.

Power consumption Pmax = operating power consumption + normal output port loss + VFT driver loss

Where,

- 1. Operating power consumption: $V_{DD} \times I_{DD}$
- 2. Normal power consumption: $\Sigma I_{OUT2} \times 0.4$
- 3. VFT driver loss: VFT driver output loss + pull-down resistor (RK) loss

Example:

When Ta = 10 to 50°C and a fluorescent display tube with segment output = 3 mA, digit output = 15 mA, Vxx = -25 V is used.

Operating conditions: $V_{DD} = 5 V \pm 10\%$, fc = 12.5 MHz, VFT dimmer time (DIM) = (14/16) × tseg:

Power consumption Pmax = (1) + (2) + (3)

Where, segments pin = X grid pin = Y, Y = 2

- 1. Operating power consumption: $V_{DD} \times I_{DD} = 5.5 \text{ V} \times 20 \text{ mA} = 110 \text{ mW}$
- 2. Normal output port loss: IOUT2 \times 0.4 V = 120 mA \times 0.4 V = 48 mW

3. VFT driver loss: segment pin = $3 \text{ mA} \times 2 \text{ V} \times \text{number of segments} X = 6 \text{ mW} \times X \times \text{number of grids} Y$

digit pin =	15 mA \times 2 V \times 14/16 (DIM) = 52.5 mW
$R_K loss =$	$(5.5+25~\text{V})^2\!/50~\text{k}\Omega\times(\text{number of segments X}+\text{number of}$
	digits Y) = $18.605 \text{ mW} \times (\text{X} + 2)$

Therefore, Pmax = 110 mW + 48 mW + 6 mW × X + 52.5 mW + 18.605 mW × (X + 2) = 253.71 mW + 24.605 X

Maximum power consumption PD when $Ta = 50^{\circ}C$ is determined by the following equation:

 $\begin{array}{ll} P_{\rm D} &> {\rm Pmax} \\ 842.5 \ {\rm mW} &> 253.71 + 24.605 \ {\rm X} \\ 23.9 &> {\rm X} \end{array}$

Thus, a fluorescent display tube with less than 23 segments can be used. If a fluorescent display tube with 23 segments or more is used, either a pull-down resistor must be attached externally, or the number of segments to be lit must be kept to less than 23 by software.

Parameter	Symbol	Pins	Conditions	Min	Тур.	Max	Unit
Hysteresis Voltage	V _{HS}	Hysteresis input			0.9	_	V
	I _{IN1}	TEST					
Input Current	I _{IN2}	Open drain ports, Tri-state ports	V _{DD} = 5.5 V V _{IN} = 5.5 V/0 V		_	±2	μA
	I _{IN3}	RESET, STOP					
Input Resistance	R _{IN3}	RESET		100	220	450	kΩ
Pull-down Resistance	R _K	Source open drain ports	$V_{DD} = 5.5 \text{ V}, V_{KK} = -30 \text{ V}$	50	80	110	K22
	I _{LO1}	Sink open drain ports	$V_{DD} = 5.5 \text{ V}, V_{OUT} = 5.5 \text{ V}$	_	—	2	
Output Leakage	I _{LO2}	Source open drain ports	$V_{DD} = 5.5 \text{ V}, V_{OUT} = -32 \text{ V}$	_		-2	
Current	I _{LO3}	Tri-state ports	V _{DD} = 5.5 V, V _{OUT} = 5.5 V/0 V	V,		2	μΑ
Output High Voltage	V _{OH2}	Tri-state ports	$V_{DD} = 4.5 V_1 I_{OH} = -0.7 mA$	4.1		_	V
Output Low Voltage	V _{OL}	Except XOUT	$V_{DD} = 4.5 \text{ V}, I_{OL} = 1.6 \text{ mA}$	_		0.4	v
Output High current	I _{OH}	P6, P7, P8, P9, PD Port	$V_{DD} = 4.5 \text{ V}, V_{OH} = 2.4 \text{ V}$		-20		
Supply Current in NORMAL 1, 2 modes			V _{DD} = 5.5 V V _{IN} = 5.3 V/0.2 V	_	18	26	mA
Supply Current in IDLE 1, 2 modes			fc = 12.5 MHz fs = 32.768 kHz	_	5.5	8.5	
Supply Current in SLOW mode	I _{DD}		$V_{DD} = 3.0 V$	_	30	60	
Supply Current in SLEEP mode			V _{IN} = 2.8 V/0.2 V fs = 32.768 kHz	_	15	30	μΑ
Supply Current in STOP mode			V _{DD} = 5.5 V V _{IN} = 5.3 V/0.2 V	_	0.5	10	

DC Characteristics	$(V_{SS} = 0 V,$	Topr = -30 to 70° C)
---------------------------	------------------	---------------------------------

Note 1: Typical values show those at Topr = 25° C, VDD = 5 V.

Note 2: Input Current IIN1,IIN3; The current through resistor is not included, when the input resistor (pull-up/pull-down) is contained.

AD Conversion Characteristics	$(V_{SS} = 0 \text{ V}, V_{DD} = 4.5 \text{ to } 5.5 \text{ V}, \text{ Topr} = -30 \text{ to } 70^{\circ}\text{C})$
-------------------------------	---

Parameter	Symbol	Conditions	Min	Тур.	Max	Unit
	VAREF		4.5	_	V _{DD}	
Analog Reference Voltage	VASS		V _{SS}			V
Analog Input Voltage	V _{AIN}		V _{ASS}	_	VAREF	
Analog Supply Current	I _{REF}	$V_{AREF} = 5.5 V, V_{ASS} = 0.0 V$		0.5	1.0	mA
Nonlinearity Error		X 50XX 00X	_	_	±1	
Zero Point Error		$V_{DD} = 5.0 \text{ V}, \text{ V}_{SS} = 0.0 \text{ V}$		_	±1	
Full Scale Error		V _{AREF} = 5.000 V V _{ASS} = 0.000 V			±1	LSB
Total Error				_	±2	

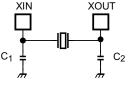
Note: Total errors includes all errors, except quantization error.

Parameter	Symbol	Conditions	Min	Тур.	Max	Unit
		In NORMAL1, 2 modes	0.32		10	
Machine Cycle Time	tov	In IDLE 1, 2 modes	0.32		10	
	tcy	In SLOW mode	117.6		133.3	μs
		In SLEEP mode	0.111			
High Level Clock Pulse Width	twch	For external clock operation	00 7 5			
Low Level Clock Pulse Width	twcL	(XIN input), fc = 12.5 MHz	33.75	_	_	ns
High Level Clock Pulse Width	twsH	For external clock operation	447			
Low Level Clock Pulse Width	t _{WSL}	(XTIN input), fs = 32.768 kHz	14.7	_	_	μs

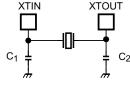
AC Characteristics $(V_{SS} = 0 \text{ V}, V_{DD} = 4.5 \text{ to } 5.5 \text{ V}, \text{ Topr} = -30 \text{ to } 70^{\circ}\text{C})$

Recommended Oscillating Conditions $(V_{SS} = 0 \text{ V}, V_{DD} = 4.5 \text{ to } 5.5 \text{ V}, \text{ Topr} = -30 \text{ to } 70^{\circ}\text{C})$

Parameter	Oscillator	Oscillation Frequency	Recomm	nended Oscillator	Recommended Constant	
					C ₁	C ₂
High-frequency Oscillation	Ceramic Resonator	12.5 MHz	Murata	CSA12.5MTZ	30 pF	30 pF
		8 MHz	Murata	CSA8.00MTZ	30 pF	30 pF
Oscillation	Crystal Oscillator	12.5 MHz	NDK	AT-51	10 pF	10 pF
Low-frequency Oscillation	Crystal Oscillator	32.768 kHz	NDK	MX-38T	15 pF	15 pF



(1) High-frequency Oscillation



(2) Low-frequency Oscillation

- Note 1: An electrical shield by metal shield plate on the surface of IC package should be recommendable in order to prevent the device from the high electric fieldstress applied from CRT (Cathode Ray Tube) for continuous reliable operation.
- Note 2: 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