CMOS 8-Bit Microcontroller

TMP88CK48N, TMP88CM48N
TMP88CK48F, TMP88CM48F

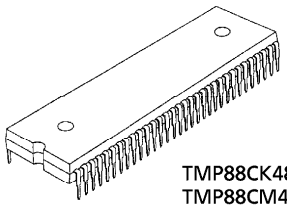
TMP88CK48N, TMP88CM48N, TMP88CK48F, and TMP88CM48F, are high-speed and high-function 8-bit single-chip microcomputers whose built-in features include large-capacity RAM, multi-function timer/counter, and 10-bit AD converter, serial interface (UART/I2C bus). They are equipped with 3 phase brushless DC sensorless/sensor motor control, and AC motor inverter control.

Part No.	ROM	RAM	Package	OTP MCU
TMP88CK48N	24 Kbytes	1 Kbytes	P-SDIP64-750-1.78	TMP88PS49N
TMP88CK48F			P-QFP64-1420-1.00A	TMP88PS49F
TMP88CM48N	32 Kbytes		P-SDIP64-750-1.78	TMP88PS49N
TMP88CM48F			P-QFP64-1420-1.00A	TMP88PS49F

Features

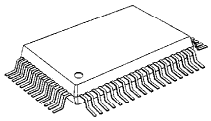
- ◆8-bit single-chip microcomputer TLCS-870/X series microcomputer
- ◆Interrupt sources: 24 (6 external, 18 Internal)
- ◆I/O ports: 56 pins
  - Large-current output: 8 pins (typ. 20 mA), LED direct drive
- ◆16-bit timer/counter: 2 channels
  - Timer, event counter, programmable pulse generator (PPG) output, pulse width measurement, external trigger timer, window mode
- ◆8-bit Timer/Counter: 2 channels
  - Timer, event counter, capture (pulse width/duty measurement), pulse width modulation (PWM) output, programmable divider output (PDO) mode
- ◆Time base timer (interrupt frequency: 1 to 16384 Hz)
- ◆Watchdog timer
- ◆Divider output function (frequency: 1 to 8 kHz)
- ◆Programmable motor driver (PMD): 1 channel
  - Rotor position: minimum resolution of 250 ns for detecting rotor position
  - Motor control timer, timer capture function
  - Overload protection function
    DC overload protection function
    AC overload protection function (Can halt counter in 3-phase PWM output circuit)
  - Protection circuit for malfunction (urgent halt)
  - Automatic direction change, automatic position detection start
- ◆High-speed PWM output: 1 channel
  - Cycle: 32 kHz, 64 kHz, 128 kHz
  - Resolution: 8-bit, 7-bit, 6-bit mode selectable

P-SDIP64-750-1.78



TMP88CK48N
TMP88CM48N
TMP88PS49N

P-QFP64-1420-1.00A



TMP88CK48F
TMP88CM48F
TMP88PS49F

980910EBP1

◆Serial interface
- 8-bit SIO/I2C bus
- Universal asynchronous receiver transmitter (UART)

◆10-bit successive approximation type AD converter
- Analog input: 16 channels
- Conversion time: 11.5 μs / 46 μs (at 16 MHz operation)

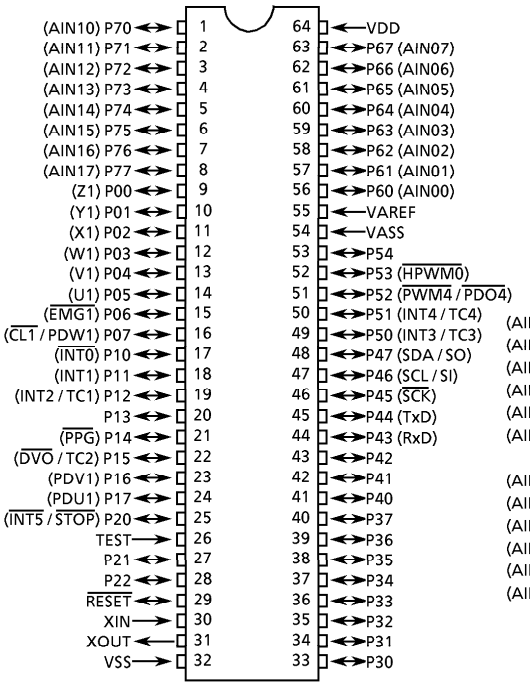
◆Low power dissipation operation (2 modes)
- STOP mode:Stops oscillation (battery or capacitor backup). Port output hold or high impedance selectable
- IDLE mode:Stops CPU but continues operation of peripheral hardware. Released by interrupt (restarts CPU)

◆Operating voltage: 4.5 to 5.5 V at 16 MHz operation

◆Emulation pod: BM88CM49N0A

Pin Assignments

P-SDIP64-750-1.78



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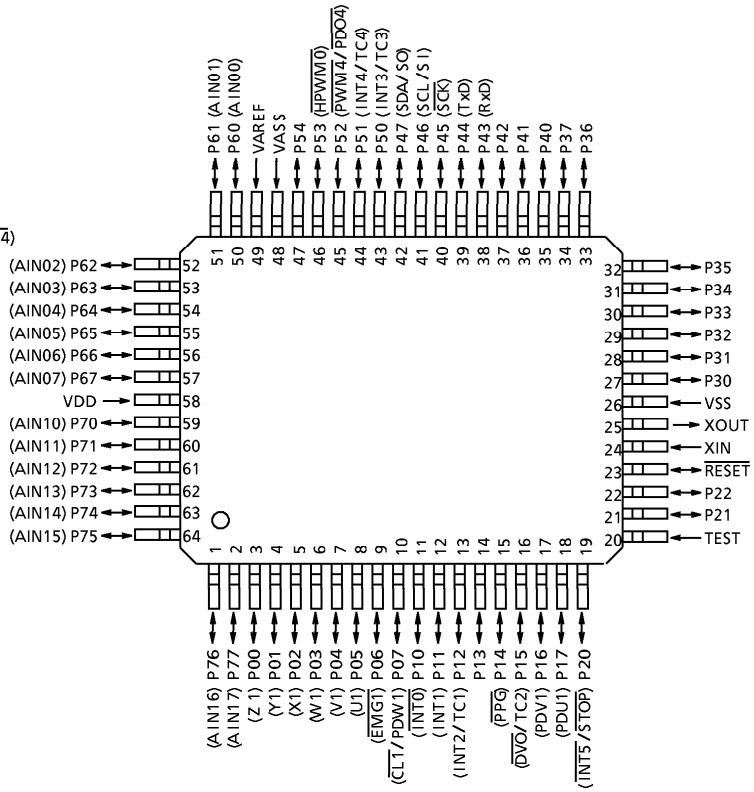
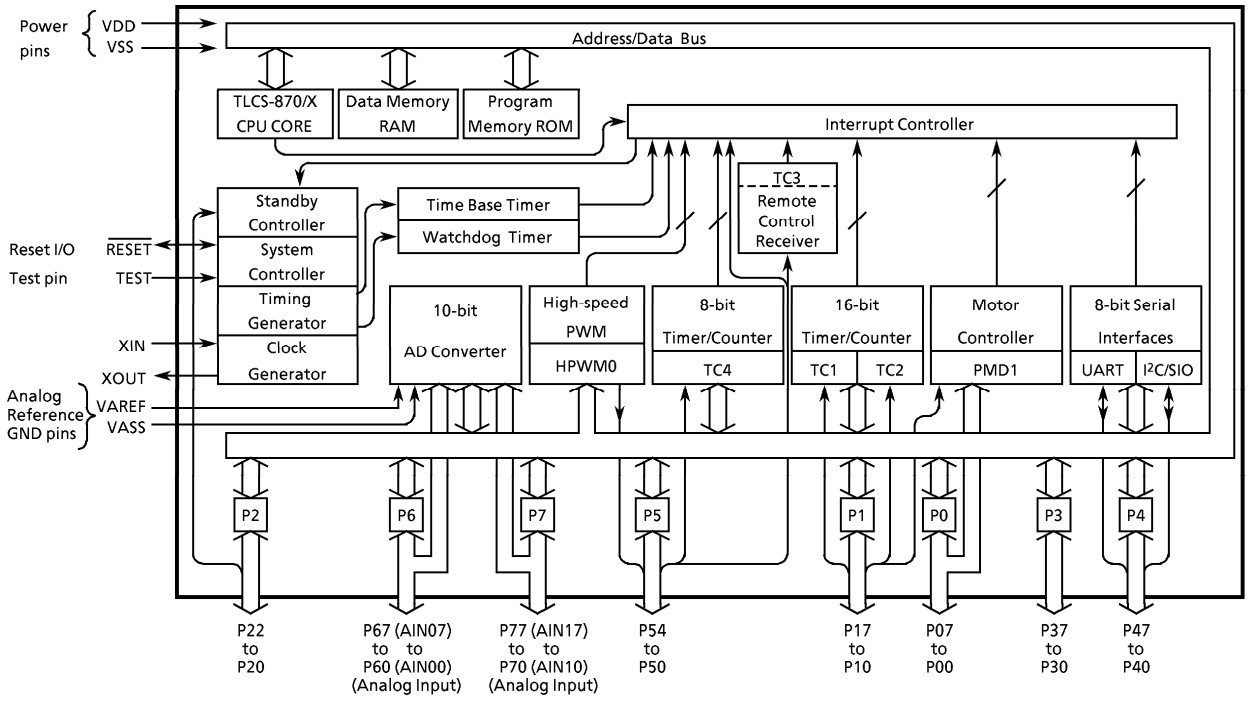


Block Diagram



Pin Function

Pin Name	I/O	Function	
P07 ($\overline{CL1}$/PDW1)	I/O (Input)	8-bit programmable I/O port (tri state) Input or output specifiable in units of bits. When using pins for motor control circuit, set accordingly using P0CR, then MDCR to 1.	Overload protection input 1/motor control circuit W1-phase position detection input
P06 ($\overline{EMG1}$)			Motor control circuit malfunction detection input 1
P05 (U1)	I/O (Output)		Motor control circuit U1-/V1-/W1-phase output
P04 (V1)			
P03 (W1)			
P02 (X1)	I/O (Output)		Motor control circuit X1-/ Y1-/Z1-phase output
P01 (Y1)			
P00 (Z1)			
P17 (PDU1)	I/O (Input)	8-bit programmable I/O port (tri state) Input or output specifiable units of bits. When using pins for motor control circuit, timer/counter input, or external interrupt input, set them to input mode. When using pins for PPG output, divider output, or PWM output/PDO output, set them to output mode.	Motor control circuit U1-phase position detection input
P16 (PDV1)			Motor control circuit V1-phase position detection input
P15 ($\overline{DVO}$/TC2)	II/O (Output/Input)		Divider output or Timer/Counter 2 input
P14 ($\overline{PPG}$)	I/O (Output)		Programmable pulse generator output
P13			—
P12 (INT2/TC1)	I/O (Input)		External interrupt input 2 or Timer/Counter 1 input
P11 (INT1)			External interrupt input 1
P10 ($\overline{INT0}$)			External interrupt input 0
P22	I/O	3-bit I/O port When using pins for input port, external interrupt input, or STOP mode release input, set output latches to 1.	—
P21			—
P20 ($\overline{INT5}$/$\overline{STOP}$)	I/O (Input)		External interrupt input 5 or STOP mode release signal input
P37	I/O (Output)	8-bit I/O port (large-current output) When using pins for motor control circuit input, set output latches to 1, then MDCR2 to 1.	—
P36			
P35			
P34			
P33			
P32			
P31			
P30			
P47 (SDA/SO)	I/O (I/O/Output)	8-bit I/O port When using pins for motor control circuit input, UART/I2C/SIO, set output latches to 1.	I2C/SIO I/O
P46 (SCL/SI)	I/O (I/O/Input)		
P45 ($\overline{SCK}$)	I/O (I/O)		
P44 (TxD)	I/O (Input)		UART data input
P43 (RxD)	I/O (Output)		UART data output
P42	I/O		—
P41			
P40			
P54	I/O	5-bit input/output port with latch. When using pins for input port, HPWM output, PWM output/PDO output, external interrupt input, or timer/counter input, set output latches to 1.	—
P53 ($\overline{HPWM0}$)	I/O (Output)		high-speed PWM output
P52 ($\overline{PWM4}$/$\overline{PDO4}$)			8-BIT PWM output 4 or, 8-bit programmable divider output 4
P51 (INT4/TC4)	I/O (Input)		External interrupt 4 input or timer / counter 4 input
P50 (INT3/TC3)			External interrupt 3 input or timer / counter 3 input

Pin Name	Input/Output	Function	
P67 (AIN07) to P60 (AIN00)	I/O (Input)	8-bit programmable I/O port (tri state) Input or output specifiable in units of bits. When using pins for analog input, set to input mode using P6CR and ADCCR.	AD converter analog input
P77 (AIN17) to P70 (AIN10)	I/O (Input)	8-bit programmable I/O port (tri state) Input or output specifiable in units of bits. When using pins for analog input, set to input mode using P7CR and ADCCR.	AD converter analog input
XIN, XOUT	Input, Output	High-frequency oscillator connecting pins. For external clock input, input to XIN and leave XOUT open.	
$\overline{\text{RESET}}$	I/O	Reset signal input, watchdog timer output, address trap reset output, system clock reset output	
TEST	Input	Shipment test pin, fix to "L" level.	
VDD, VSS	Power Supply	+ 5 V, 0 V (GND)	
VAREF, VASS		Analog reference voltage for AD conversion. Reference GND.	

Operation

1. CPU Core Functions

The CPU core consists of the CPU, system clock control circuit, and interrupt control circuit. This chapter describes the CPU core, program memory, data memory and the reset circuit.

1.1 Memory Address Map

The TMP88CK48/M48 memory consists of four blocks: ROM, RAM, special function registers (SFR) and Data buffer registers (DBR). They are all mapped to a 1 Mbyte address space. Figure 1-1 shows the TMP88CK48/M48 memory address map. There are 16 general-purpose registers mapped to the RAM address space.

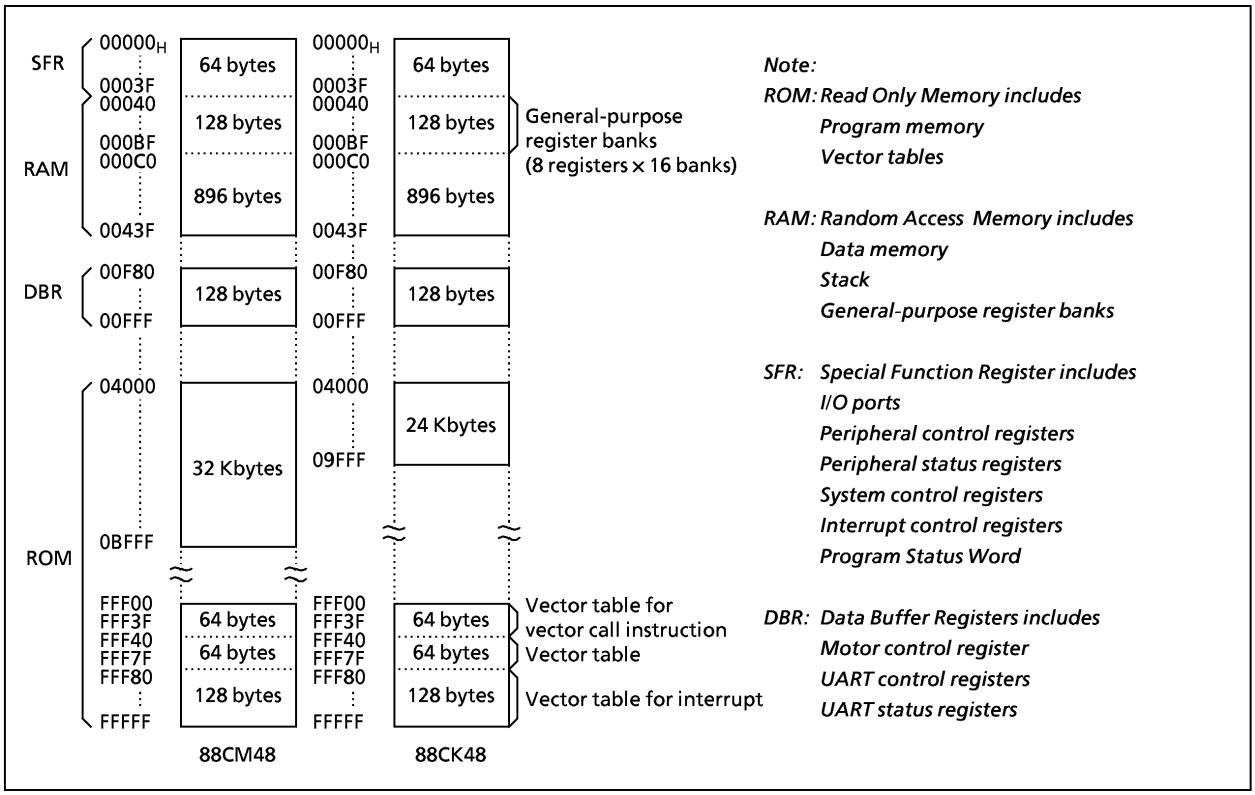


Figure 1-1. Memory Address Maps

Electrical Characteristics

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

Parameter	Symbol	Pins	Ratings	Unit
Supply Voltage	V_{DD}		– 0.3 to 6.5	V
Input Voltage	V_{IN}		– 0.3 to V_{DD} + 0.3	V
Output Voltage	V_{OUT1}	Port P21, P22, $\overline{RESET}$, Tri-state port	– 0.3 to V_{DD} + 0.3	V
	V_{OUT2}	Port P20, Sink open drain port	– 0.3 to 5.5	V
Output Current	I_{OUT1}	Ports P1, P2, P4, P5, P6, P7	3.2	mA
	I_{OUT2}	Port P0	20	
	I_{OUT3}	Port P3	30	
Output Current	ΣI_{OUT1}	Ports P1, P2, P4, P5, P6, P7	120	mA
	ΣI_{OUT2}	Port P0	60	
	ΣI_{OUT3}	Port P3	120	
Power Dissipation [Topr = 70°C]	PD	TMP88CK48N/TMP88CM48N	600	mW
		TMP88CK48F/TMP88CM48F	350	
Soldering Temperature (time)	Tsld		260 (10 s)	°C
Storage Temperature	Tstg		– 55 to 125	°C
Operating Temperature	Topr		– 40 to 85	°C

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 Opeating Conditions (V_{SS} = 0 V, Topr = – 40 to 85°C)

Parameter	Symbol	Pins	Conditions		Min	Max	Unit
Supply Voltage	V_{DD}		fc = 16 MHz	NORMAL mode	4.5	5.5	V
				IDLE mode			
				STOP mode			
Input High Voltage	V_{IH1}	Except hysteresis input	$V_{DD} \geqq 4.5$ V		$V_{DD} \times 0.70$	V_{DD}	V
	V_{IH2}	Hysteresis input			$V_{DD} \times 0.75$		
	V_{IH3}		$V_{DD} < 4.5$ V		$V_{DD} \times 0.90$		
Input Low Voltage	V_{IL1}	Except hysteresis input	$V_{DD} \geqq 4.5$ V		0	$V_{DD} \times 0.30$	V
	V_{IL2}	Hysteresis input				$V_{DD} \times 0.25$	
	V_{IL3}		$V_{DD} < 4.5$ V			$V_{DD} \times 0.10$	
Clock Frequency	fc	XIN, XOUT	V_{DD} = 4.5 to 5.5 V		8.0	16.0	MHz

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: The condition of supply voltage range is the value in NORMAL and IDLE modes.

D.C. Characteristics

(V_{SS} = 0 V, Topr = – 40 to 85°C)

Parameter	Symbol	Pins	Conditions	Min	Typ.	Max	Unit
Hysteresis Voltage	V_{HS}	Hysteresis inputs		–	0.9	–	V
Input Current	I_{IN1}	TEST	V_{DD} = 5.5 V V_{IN} = 5.5 V/0 V	–	–	± 2	μA
	I_{IN2}	Sink open drain, Tri-state ports					
	I_{IN3}	$\overline{RESET}$, $\overline{STOP}$					
Input Resistor (*)	R_{IN}	TEST with pull-down		20	70	170	kΩ
		$\overline{RESET}$		90	220	510	
Output Leakage Current	I_{OL}	Sink open drain, Tri-state ports	V_{DD} = 5.5 V, V_{OUT} = 5.5 V/0 V	–	–	± 2	μA
Output High Voltage	V_{OH}	Tri-state ports	V_{DD} = 4.5 V, I_{OH} = – 0.7 mA	4.1	–	–	V
Output Low Current	I_{OL1}	Except XOUT, Ports P0, P3.	V_{DD} = 4.5 V, V_{OL} = 0.4 V	–	1.6	–	mA
	I_{OL2}	Port P0	V_{DD} = 4.5 V, V_{OL} = 1.0 V	6	10	–	
	I_{OL3}	Port P3		–	20	–	
Supply Current in NORMAL Mode			V_{DD} = 5.5 V V_{IN} = 5.3 V/0.2 V fc = 16.0 MHz	–	20	32	mA
Supply Current in IDLE Mode				–	10	16	mA
Supply Current in STOP Mode			V_{DD} = 5.5 V V_{IN} = 5.3 V/0.2 V	–	0.5	20	μA

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

Note 2: Input Current I_{IN1}, I_{IN3}; The current through registor is not included, when the input resistor (pull-up or pull-down) is contained.

Note 3: IDD except I_{REF}.

AD Conversion Characteristics

(Topr = – 40 to 85°C)

Parameter	Symbol	Conditions	Min	Typ.	Max			Unit
					ADCDR1	ADCDR2		
						ACK = 0	ACK = 1	
Analog Reference Voltage	V_{AREF}	V_{AREF} – V_{ASS} ≧ 3.5 V	V_{DD} – 1.0	—	V_{DD}			V
	V_{ASS}		V_{SS}	—	1.0			
Analog Input Voltage	V_{AIN}		V_{ASS}	—	V_{AREF}			V
Analog Supply Current	I_{REF}	V_{AREF} = 5.5 V, V_{ASS} = 0.0 V	—	0.5	1.0			mA
Non-Linearity Error		V_{DD} = 5.0 V, V_{SS} = 0.0 V V_{AREF} = 5.000 V V_{ASS} = 0.000 V	—	—	± 1	± 3	± 2	LSB
Zero Point Error			—	—	± 1	± 3	± 2	
Full Scale Error			—	—	± 1	± 3	± 2	
Total Error			—	—	± 2	± 6	± 4	

Note 1: ADCDR1: 8-bit AD conversion result (1LSB = ΔV_{AREF}/256)
ADCDR2: 10-bit AD conversion result (1LSB = ΔV_{AREF}/1024)

Note 2: Total error includes all errors except quantization error.

A.C. Characteristics

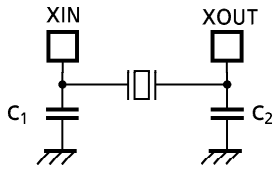
(V_{SS} = 0 V, V_{DD} = 4.5 to 5.5 V, Topr = – 40 to 85°C)

Parameter	Symbol	Conditions	Min	Typ.	Max	Unit
Machine Cycle Time	tcy	NORMAL mode	0.25	–	0.5	μs
		IDLE mode				
High Level Clock Pulse Width	t_{WCH}	For external clock operation (XIN input)	31.25	–	62.5	ns
Low Level Clock Pulse Width	t_{WCL}					

Recommended Oscillating Conditions

(V_{SS} = 0 V, V_{DD} = 4.5 to 5.5 V, Topr = – 40 to 85°C)

Parameter	Oscillator	Oscillation Frequency	Recommended Oscillator	Recommended Constant	
				C_1	C_2
High-frequency Oscillation	Ceramic Resonator	16 MHz	MURATA CSA16.00MXZ	5 pF	5 pF
			MURATA CST16.00MXW	built-in 5 pF	built-in 5 pF



High-frequency Oscillation

Note: An electrical shield by metal shield 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.