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What is "[Embedded - Microcontrollers](#)"?

"[Embedded - Microcontrollers](#)" refer to small, integrated circuits designed to perform specific tasks within larger systems. These microcontrollers are essentially compact computers on a single chip, containing a processor core, memory, and programmable input/output peripherals. They are called "embedded" because they are embedded within electronic devices to control various functions, rather than serving as standalone computers. Microcontrollers are crucial in modern electronics, providing the intelligence and control needed for a wide range of applications.

Applications of "[Embedded - Microcontrollers](#)"

Details

Product Status	Obsolete
Core Processor	F ² MC-16FX
Core Size	16-Bit
Speed	32MHz
Connectivity	LINbus, SCI, UART/USART
Peripherals	DMA, LVD, POR, PWM, WDT
Number of I/O	37
Program Memory Size	64KB (64K x 8)
Program Memory Type	FLASH
EEPROM Size	-
RAM Size	4K x 8
Voltage - Supply (Vcc/Vdd)	2.7V ~ 5.5V
Data Converters	A/D 16x8/10b
Oscillator Type	Internal
Operating Temperature	-40°C ~ 125°C (TA)
Mounting Type	Surface Mount
Package / Case	48-LQFP
Supplier Device Package	48-LQFP (7x7)
Purchase URL	https://www.e-xfl.com/product-detail/infineon-technologies/mb96f612abpmc-gs-101uje1

- LIN functionality working either as master or slave LIN device
- Extended support for LIN-Protocol to reduce interrupt load

A/D Converter

- SAR-type
- 8/10-bit resolution
- Signals interrupt on conversion end, single conversion mode, continuous conversion mode, stop conversion mode, activation by software, external trigger, reload timers and PPGs
- Range Comparator Function

Source Clock Timers

- Three independent clock timers (23-bit RC clock timer, 23-bit Main clock timer, 17-bit Sub clock timer)

Hardware Watchdog Timer

- Hardware watchdog timer is active after reset
- Window function of Watchdog Timer is used to select the lower window limit of the watchdog interval

Reload Timers

- 16-bit wide
- Prescaler with $1/2^1$, $1/2^2$, $1/2^3$, $1/2^4$, $1/2^5$, $1/2^6$ of peripheral clock frequency
- Event count function

Free-Running Timers

- Signals an interrupt on overflow, supports timer clear upon match with Output Compare (0, 4)
- Prescaler with 1, $1/2^1$, $1/2^2$, $1/2^3$, $1/2^4$, $1/2^5$, $1/2^6$, $1/2^7$, $1/2^8$ of peripheral clock frequency

Input Capture Units

- 16-bit wide
- Signals an interrupt upon external event
- Rising edge, Falling edge or Both (rising & falling) edges sensitive

Output Compare Units

- 16-bit wide
- Signals an interrupt when a match with Free-running Timer occurs
- A pair of compare registers can be used to generate an output signal

Programmable Pulse Generator

- 16-bit down counter, cycle and duty setting registers
- Can be used as 2 × 8-bit PPG
- Interrupt at trigger, counter borrow and/or duty match
- PWM operation and one-shot operation

- Internal prescaler allows 1, 1/4, 1/16, 1/64 of peripheral clock as counter clock or of selected Reload timer underflow as clock input
- Can be triggered by software or reload timer
- Can trigger ADC conversion
- Timing point capture

Quadrature Position/Revolution Counter (QPRC)

- Up/down count mode, Phase difference count mode, Count mode with direction
- 16-bit position counter
- 16-bit revolution counter
- Two 16-bit compare registers with interrupt
- Detection edge of the three external event input pins AIN, BIN and ZIN is configurable

Real Time Clock

- Operational on main oscillation (4MHz), sub oscillation (32kHz) or RC oscillation (100kHz/2MHz)
- Capable to correct oscillation deviation of Sub clock or RC oscillator clock (clock calibration)
- Read/write accessible second/minute/hour registers
- Can signal interrupts every half second/second/minute/hour/day
- Internal clock divider and prescaler provide exact 1s clock

External Interrupts

- Edge or Level sensitive
- Interrupt mask bit per channel
- Each available CAN channel RX has an external interrupt for wake-up
- Selected USART channels SIN have an external interrupt for wake-up

Non Maskable Interrupt

- Disabled after reset, can be enabled by Boot-ROM depending on ROM configuration block
- Once enabled, can not be disabled other than by reset
- High or Low level sensitive
- Pin shared with external interrupt 0

I/O Ports

- Most of the external pins can be used as general purpose I/O
- All push-pull outputs
- Bit-wise programmable as input/output or peripheral signal
- Bit-wise programmable input enable
- One input level per GPIO-pin (either Automotive or CMOS hysteresis)
- Bit-wise programmable pull-up resistor

Built-in On Chip Debugger (OCD)

- One-wire debug tool interface
- Break function:
 - Hardware break: 6 points (shared with code event)
 - Software break: 4096 points
- Event function
 - Code event: 6 points (shared with hardware break)
 - Data event: 6 points
 - Event sequencer: 2 levels + reset
- Execution time measurement function
- Trace function: 42 branches
- Security function

Flash Memory

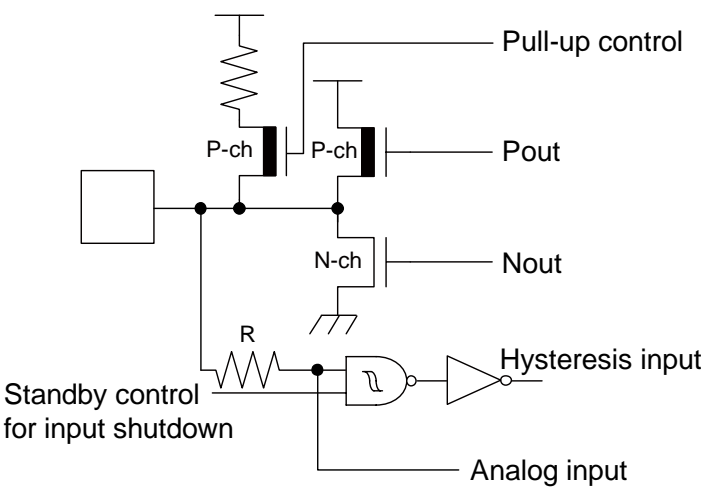
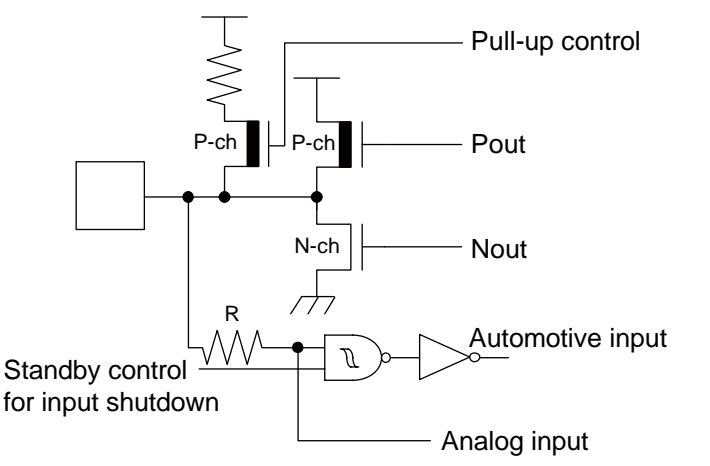
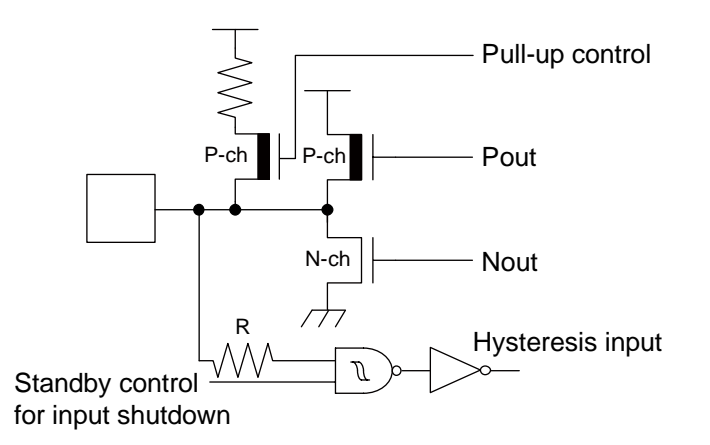
- Dual operation flash allowing reading of one Flash bank while programming or erasing the other bank
- Command sequencer for automatic execution of programming algorithm and for supporting DMA for programming of the Flash Memory
- Supports automatic programming, Embedded Algorithm
- Write/Erase/Erase-Suspend/Resume commands
- A flag indicating completion of the automatic algorithm
- Erase can be performed on each sector individually
- Sector protection
- Flash Security feature to protect the content of the Flash
- Low voltage detection during Flash erase or write

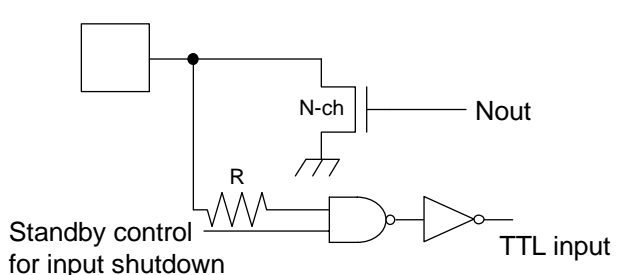
4. Pin Description

Pin Name	Feature	Description
ADTG_R	ADC	Relocated A/D converter trigger input pin
AINn	QPRC	Quadrature Position/Revolution Counter Unit n input pin
ANn	ADC	A/D converter channel n input pin
AVcc	Supply	Analog circuits power supply pin
AVRH	ADC	A/D converter high reference voltage input pin
AVss	Supply	Analog circuits power supply pin
BINn	QPRC	Quadrature Position/Revolution Counter Unit n input pin
C	Voltage regulator	Internally regulated power supply stabilization capacitor pin
CKOTn	Clock Output function	Clock Output function n output pin
CKOTn_R	Clock Output function	Relocated Clock Output function n output pin
CKOTXn	Clock Output function	Clock Output function n inverted output pin
DEBUG I/F	OCD	On Chip Debugger input/output pin
INn	ICU	Input Capture Unit n input pin
INTn	External Interrupt	External Interrupt n input pin
INTn_R	External Interrupt	Relocated External Interrupt n input pin
INTn_R1	External Interrupt	Relocated External Interrupt n input pin
MD	Core	Input pin for specifying the operating mode
NMI	External Interrupt	Non-Maskable Interrupt input pin
OUTn	OCU	Output Compare Unit n waveform output pin
OUTn_R	OCU	Relocated Output Compare Unit n waveform output pin
Pnn_m	GPIO	General purpose I/O pin
PPGn	PPG	Programmable Pulse Generator n output pin (16bit/8bit)
PPGn_B	PPG	Programmable Pulse Generator n output pin (16bit/8bit)
RSTX	Core	Reset input pin
RXn	CAN	CAN interface n RX input pin
SCKn	USART	USART n serial clock input/output pin
SCKn_R	USART	Relocated USART n serial clock input/output pin
SINn	USART	USART n serial data input pin
SINn_R	USART	Relocated USART n serial data input pin
SOTn	USART	USART n serial data output pin
SOTn_R	USART	Relocated USART n serial data output pin
TINn	Reload Timer	Reload Timer n event input pin
TOTn	Reload Timer	Reload Timer n output pin
TTGn	PPG	Programmable Pulse Generator n trigger input pin
TXn	CAN	CAN interface n TX output pin
V _{cc}	Supply	Power supply pin
V _{ss}	Supply	Power supply pin
X0	Clock	Oscillator input pin
X0A	Clock	Subclock Oscillator input pin
X1	Clock	Oscillator output pin
X1A	Clock	Subclock Oscillator output pin

Pin No.	I/O Circuit Type*	Pin Name
33	C	RSTX
34	A	X1
35	A	X0
36	Supply	Vss
37	Supply	Vcc
38	F	C
39	H	P02_5 / BIN0 / IN1 / TTG1 / ADTG_R
40	K	P03_0 / AIN1 / IN4 / TTG4 / TTG12 / AN24
41	K	P03_1 / BIN1 / IN5 / TTG5 / TTG13 / AN25
42	M	P03_2 / INT10_R / RX2
43	H	P03_3 / TX2
44	K	P03_6 / ZIN1 / OUT6 / AN30
45	K	P03_7 / OUT7 / AN31
46	K	P06_0 / AN0 / PPG0
47	K	P06_1 / AN1 / PPG1
48	Supply	AVcc

*: See [I/O Circuit Type](#) for details on the I/O circuit types.

Type	Circuit	Remarks
I		<ul style="list-style-type: none"> ■ CMOS level output ■ ($I_{OL} = 4\text{mA}$, $I_{OH} = -4\text{mA}$) ■ CMOS hysteresis input with input shutdown function ■ Programmable pull-up resistor ■ Analog input
K		<ul style="list-style-type: none"> ■ CMOS level output ■ ($I_{OL} = 4\text{mA}$, $I_{OH} = -4\text{mA}$) ■ Automotive input with input shutdown function ■ Programmable pull-up resistor ■ Analog input
M		<ul style="list-style-type: none"> ■ CMOS level output ■ ($I_{OL} = 4\text{mA}$, $I_{OH} = -4\text{mA}$) ■ CMOS hysteresis input with input shutdown function ■ Programmable pull-up resistor

Type	Circuit	Remarks
O	 <p>Standby control for input shutdown</p> <p>Nout</p> <p>TTL input</p>	<ul style="list-style-type: none"> ■ Open-drain I/O ■ Output 25mA, $V_{cc} = 2.7V$ ■ TTL input

9. User ROM Memory Map for Flash Devices

		CY96F612	CY96F613	CY96F615	
CPU mode address	Flash memory mode address	Flash size 32.5KB + 32KB	Flash size 64.5KB + 32KB	Flash size 128.5KB + 32KB	
FF:FFFF _H	3F:FFFF _H	SA39 - 32KB			Bank A of Flash A
FF:8000 _H	3F:8000 _H		SA39 - 64KB	SA39 - 64KB	
FF:7FFF _H	3F:7FFF _H				
FF:0000 _H	3F:0000 _H				
FE:FFFF _H	3E:FFFF _H			SA38 - 64KB	
FE:0000 _H	3E:0000 _H				Bank B of Flash A
FD:FFFF _H					
		Reserved	Reserved	Reserved	
DF:A000 _H					Bank A of Flash A
DF:9FFF _H	1F:9FFF _H	SA4 - 8KB	SA4 - 8KB	SA4 - 8KB	
DF:8000 _H	1F:8000 _H				
DF:7FFF _H	1F:7FFF _H	SA3 - 8KB	SA3 - 8KB	SA3 - 8KB	
DF:6000 _H	1F:6000 _H				
DF:5FFF _H	1F:5FFF _H	SA2 - 8KB	SA2 - 8KB	SA2 - 8KB	Bank A of Flash A
DF:4000 _H	1F:4000 _H				
DF:3FFF _H	1F:3FFF _H	SA1 - 8KB	SA1 - 8KB	SA1 - 8KB	
DF:2000 _H	1F:2000 _H				
DF:1FFF _H	1F:1FFF _H	SAS - 512B*	SAS - 512B*	SAS - 512B*	
DF:0000 _H	1F:0000 _H				Bank A of Flash A
DE:FFFF _H		Reserved	Reserved	Reserved	
DE:0000 _H					

*: Physical address area of SAS-512B is from DF:0000_H to DF:01FF_H.

Others (from DF:0200_H to DF:1FFF_H) is mirror area of SAS-512B.

Sector SAS contains the ROM configuration block RCBA at CPU address DF:0000_H -DF:01FF_H.

SAS can not be used for E²PROM emulation.

10. Serial Programming Communication Interface

USART pins for Flash serial programming (MD = 0, DEBUG I/F = 0, Serial Communication mode)

CY96610		
Pin Number	USART Number	Normal Function
7	USART2	SIN2
8		SOT2
9		SCK2
20	USART7	SIN7_R
19		SOT7_R
18		SCK7_R
22	USART8	SIN8_R
21		SOT8_R
23		SCK8_R

12. Handling Precautions

Any semiconductor devices have inherently a certain rate of failure. The possibility of failure is greatly affected by the conditions in which they are used (circuit conditions, environmental conditions, etc.). This page describes precautions that must be observed to minimize the chance of failure and to obtain higher reliability from your Cypress semiconductor devices.

12.1 Precautions for Product Design

This section describes precautions when designing electronic equipment using semiconductor devices.

■ Absolute Maximum Ratings

Semiconductor devices can be permanently damaged by application of stress (voltage, current, temperature, etc.) in excess of certain established limits, called absolute maximum ratings. Do not exceed these ratings.

■ Recommended Operating Conditions

Recommended operating conditions are normal operating ranges for the semiconductor device. All the device's electrical characteristics are warranted when operated within these ranges.

Always use semiconductor devices within the recommended operating conditions. Operation outside these ranges may adversely affect reliability and could result in device failure.

No warranty is made with respect to uses, operating conditions, or combinations not represented on the data sheet. Users considering application outside the listed conditions are advised to contact their sales representative beforehand.

■ Processing and Protection of Pins

These precautions must be followed when handling the pins which connect semiconductor devices to power supply and input/output functions.

1. Preventing Over-Voltage and Over-Current Conditions

Exposure to voltage or current levels in excess of maximum ratings at any pin is likely to cause deterioration within the device, and in extreme cases leads to permanent damage of the device. Try to prevent such overvoltage or over-current conditions at the design stage.

2. Protection of Output Pins

Shorting of output pins to supply pins or other output pins, or connection to large capacitance can cause large current flows. Such conditions if present for extended periods of time can damage the device. Therefore, avoid this type of connection.

3. Handling of Unused Input Pins

Unconnected input pins with very high impedance levels can adversely affect stability of operation. Such pins should be connected through an appropriate resistance to a power supply pin or ground pin.

■ Latch-up

Semiconductor devices are constructed by the formation of P-type and N-type areas on a substrate. When subjected to abnormally high voltages, internal parasitic PNPN junctions (called thyristor structures) may be formed, causing large current levels in excess of several hundred mA to flow continuously at the power supply pin. This condition is called latch-up.

■ Surface Mount Type

Surface mount packaging has longer and thinner leads than lead-insertion packaging, and therefore leads are more easily deformed or bent. The use of packages with higher pin counts and narrower pin pitch results in increased susceptibility to open connections caused by deformed pins, or shorting due to solder bridges.

You must use appropriate mounting techniques. Cypress recommends the solder reflow method, and has established a ranking of mounting conditions for each product. Users are advised to mount packages in accordance with Cypress ranking of recommended conditions.

■ Lead-Free Packaging

CAUTION:

When ball grid array (BGA) packages with Sn-Ag-Cu balls are mounted using Sn-Pb eutectic soldering, junction strength may be reduced under some conditions of use.

■ Storage of Semiconductor Devices

Because plastic chip packages are formed from plastic resins, exposure to natural environmental conditions will cause absorption of moisture. During mounting, the application of heat to a package that has absorbed moisture can cause surfaces to peel, reducing moisture resistance and causing packages to crack. To prevent, do the following:

1. Avoid exposure to rapid temperature changes, which cause moisture to condense inside the product. Store products in locations where temperature changes are slight.
2. Use dry boxes for product storage. Products should be stored below 70% relative humidity, and at temperatures between 5°C and 30°C. When you open Dry Package that recommends humidity 40% to 70% relative humidity.
3. When necessary, Cypress packages semiconductor devices in highly moisture-resistant aluminum laminate bags, with a silica gel desiccant. Devices should be sealed in their aluminum laminate bags for storage.
4. Avoid storing packages where they are exposed to corrosive gases or high levels of dust.

■ Baking

Packages that have absorbed moisture may be de-moisturized by baking (heat drying). Follow the Cypress recommended conditions for baking.

Condition: 125°C/24 h

■ Static Electricity

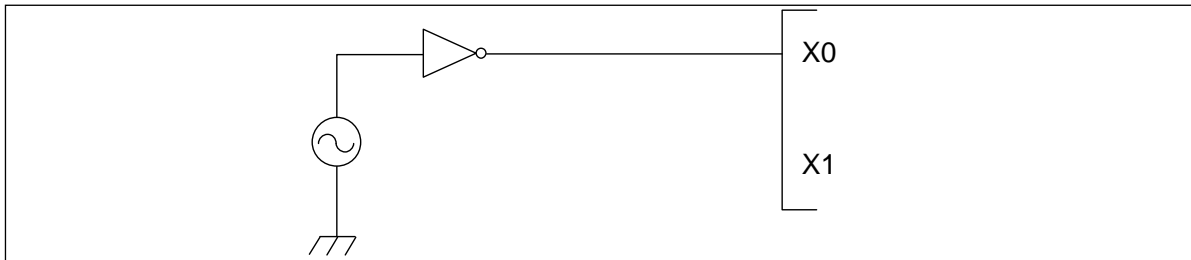
Because semiconductor devices are particularly susceptible to damage by static electricity, you must take the following precautions:

1. Maintain relative humidity in the working environment between 40% and 70%. Use of an apparatus for ion generation may be needed to remove electricity.
2. Electrically ground all conveyors, solder vessels, soldering irons and peripheral equipment.
3. Eliminate static body electricity by the use of rings or bracelets connected to ground through high resistance (on the level of 1 MΩ). Wearing of conductive clothing and shoes, use of conductive floor mats and other measures to minimize shock loads is recommended.
4. Ground all fixtures and instruments, or protect with anti-static measures.
5. Avoid the use of styro foam or other highly static-prone materials for storage of completed board assemblies.

AC Characteristics for detailed modes and frequency limits. Single and opposite phase external clocks must be connected as follows:

13.3.1 Single Phase External Clock for Main Oscillator

When using a single phase external clock for the Main oscillator, X0 pin must be driven and X1 pin left open. And supply 1.8V power to the external clock.

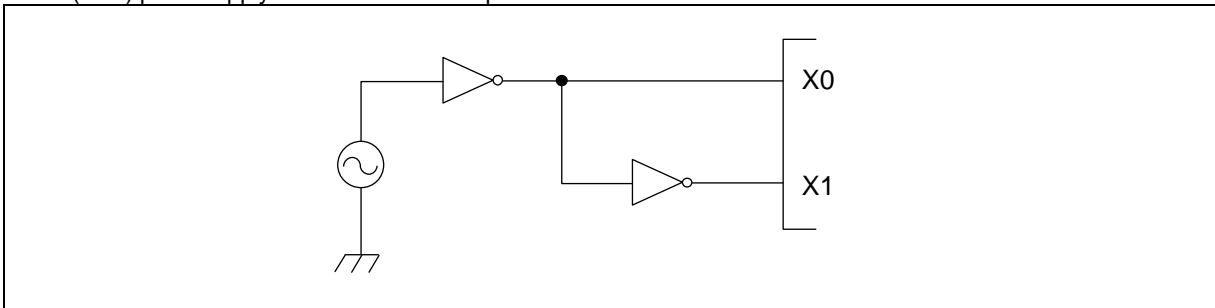


13.3.2 Single Phase External Clock for Sub Oscillator

When using a single phase external clock for the Sub oscillator, "External clock mode" must be selected and X0A/P04_0 pin must be driven. X1A/P04_1 pin can be configured as GPIO.

13.3.3 Opposite Phase External Clock

When using an opposite phase external clock, X1 (X1A) pins must be supplied with a clock signal which has the opposite phase to the X0 (X0A) pins. Supply level on X0 and X1 pins must be 1.8V.



13.4 Notes on PLL Clock Mode Operation

If the microcontroller is operated with PLL clock mode and no external oscillator is operating or no external clock is supplied, the microcontroller attempts to work with the free oscillating PLL. Performance of this operation, however, cannot be guaranteed.

13.5 Power Supply Pins (Vcc/Vss)

It is required that all V_{CC}-level as well as all V_{SS}-level power supply pins are at the same potential. If there is more than one V_{CC} or V_{SS} level, the device may operate incorrectly or be damaged even within the guaranteed operating range.

V_{CC} and V_{SS} pins must be connected to the device from the power supply with lowest possible impedance.

The smoothing capacitor at V_{CC} pin must use the one of a capacity value that is larger than C_s.

Besides this, as a measure against power supply noise, it is required to connect a bypass capacitor of about 0.1μF between V_{CC} and V_{SS} pins as close as possible to V_{CC} and V_{SS} pins.

13.6 Crystal Oscillator and ceramic resonator Circuit

Noise at X0, X1 pins or X0A, X1A pins might cause abnormal operation. It is required to provide bypass capacitors with shortest possible distance to X0, X1 pins and X0A, X1A pins, crystal oscillator (or ceramic resonator) and ground lines, and, to the utmost effort, that the lines of oscillation circuit do not cross the lines of other circuits.

It is highly recommended to provide a printed circuit board art work surrounding X0, X1 pins and X0A, X1A pins with a ground area for stabilizing the operation.

It is highly recommended to evaluate the quartz/MCU or resonator/MCU system at the quartz or resonator manufacturer, especially when using low-Q resonators at higher frequencies.

13.7 Turn on Sequence of Power Supply to A/D Converter and Analog Inputs

It is required to turn the A/D converter power supply (AV_{CC} , $AVRH$) and analog inputs (ANn) on after turning the digital power supply (V_{CC}) on.

It is also required to turn the digital power off after turning the A/D converter supply and analog inputs off. In this case, $AVRH$ must not exceed AV_{CC} . Input voltage for ports shared with analog input ports also must not exceed AV_{CC} (turning the analog and digital power supplies simultaneously on or off is acceptable).

13.8 Pin Handling when Not Using the A/D Converter

If the A/D converter is not used, the power supply pins for A/D converter should be connected such as $AV_{CC} = V_{CC}$, $AV_{SS} = AVRH = V_{SS}$.

13.9 Notes on Power-on

To prevent malfunction of the internal voltage regulator, supply voltage profile while turning the power supply on should be slower than 50 μ s from 0.2V to 2.7V.

13.10 Stabilization of Power Supply Voltage

If the power supply voltage varies acutely even within the operation safety range of the V_{CC} power supply voltage, a malfunction may occur. The V_{CC} power supply voltage must therefore be stabilized. As stabilization guidelines, the power supply voltage must be stabilized in such a way that V_{CC} ripple fluctuations (peak to peak value) in the commercial frequencies (50Hz to 60Hz) fall within 10% of the standard V_{CC} power supply voltage and the transient fluctuation rate becomes 0.1V/ μ s or less in instantaneous fluctuation for power supply switching.

13.11 Serial Communication

There is a possibility to receive wrong data due to noise or other causes on the serial communication.

Therefore, design a printed circuit board so as to avoid noise.

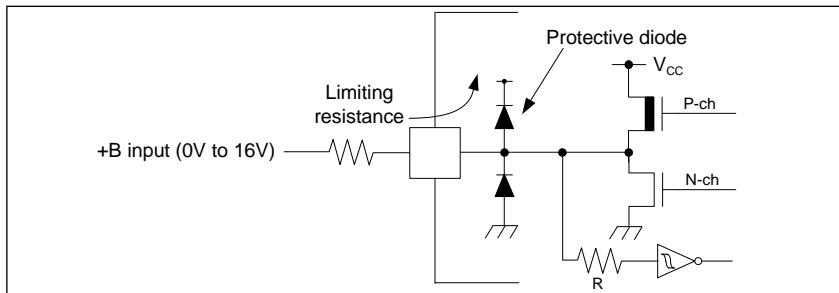
Consider receiving of wrong data when designing the system. For example apply a checksum and retransmit the data if an error occurs.

13.12 Mode Pin (MD)

Connect the mode pin directly to V_{CC} or V_{SS} pin. To prevent the device unintentionally entering test mode due to noise, lay out the printed circuit board so as to minimize the distance from the mode pin to V_{CC} or V_{SS} pin and provide a low-impedance connection.

- Note that when the microcontroller drive current is low, such as in the power saving modes, the +B input potential may pass through the protective diode and increase the potential at the VCC pin, and this may affect other devices.
- Note that if a +B signal is input when the microcontroller power supply is off (not fixed at 0V), the power supply is provided from the pins, so that incomplete operation may result.
- Note that if the +B input is applied during power-on, the power supply is provided from the pins and the resulting supply voltage may not be sufficient to operate the Power reset.
- The DEBUG I/F pin has only a protective diode against VSS. Hence it is only permitted to input a negative clamping current (4mA). For protection against positive input voltages, use an external clamping diode which limits the input voltage to maximum 6.0V.

Sample recommended circuits:



[5]: The maximum permitted power dissipation depends on the ambient temperature, the air flow velocity and the thermal conductance of the package on the PCB.

The actual power dissipation depends on the customer application and can be calculated as follows:

$$P_D = P_{IO} + P_{INT}$$

$$P_{IO} = \sum (V_{OL} \times I_{OL} + V_{OH} \times I_{OH}) \text{ (I/O load power dissipation, sum is performed on all I/O ports)}$$

$$P_{INT} = V_{CC} \times (I_{CC} + I_A) \text{ (internal power dissipation)}$$

I_{CC} is the total core current consumption into V_{CC} as described in the "DC characteristics" and depends on the selected operation mode and clock frequency and the usage of functions like Flash programming.

I_A is the analog current consumption into AV_{CC} .

[6]: Worst case value for a package mounted on single layer PCB at specified T_A without air flow.

[7]: Write/erase to a large sector in flash memory is warranted with $T_A \leq +105^\circ\text{C}$.

WARNING:

Semiconductor devices can be permanently damaged by application of stress (voltage, current, temperature, etc.) in excess of absolute maximum ratings. Do not exceed these ratings.

14.3 DC Characteristics

14.3.1 Current Rating

($V_{CC} = AV_{CC} = 2.7V$ to $5.5V$, $V_{SS} = AV_{SS} = 0V$, $T_A = -40^{\circ}C$ to $+125^{\circ}C$)

Parameter	Symbol	Pin Name	Conditions	Value			Unit	Remarks
				Min	Typ	Max		
Power supply current in Run modes ^[1]	I _{CCPLL}	V _{CC}	PLL Run mode with CLKS1/2 = CLKB = CLKP1/2 = 32MHz Flash 0 wait (CLKRC and CLKSC stopped)	-	25	-	mA	T _A = +25°C
				-	-	34	mA	T _A = +105°C
				-	-	35	mA	T _A = +125°C
	I _{CCMAIN}		Main Run mode with CLKS1/2 = CLKB = CLKP1/2 = 4MHz Flash 0 wait (CLKPLL, CLKSC and CLKRC stopped)	-	3.5	-	mA	T _A = +25°C
				-	-	7.5	mA	T _A = +105°C
				-	-	8.5	mA	T _A = +125°C
	I _{CCRCH}		RC Run mode with CLKS1/2 = CLKB = CLKP1/2 = CLKRC = 2MHz Flash 0 wait (CLKMC, CLKPLL and CLKSC stopped)	-	1.7	-	mA	T _A = +25°C
				-	-	5.5	mA	T _A = +105°C
				-	-	6.5	mA	T _A = +125°C
	I _{CCRCL}		RC Run mode with CLKS1/2 = CLKB = CLKP1/2 = CLKRC = 100kHz Flash 0 wait (CLKMC, CLKPLL and CLKSC stopped)	-	0.15	-	mA	T _A = +25°C
				-	-	3.2	mA	T _A = +105°C
				-	-	4.2	mA	T _A = +125°C
	I _{CCSUB}		Sub Run mode with CLKS1/2 = CLKB = CLKP1/2 = 32kHz Flash 0 wait (CLKMC, CLKPLL and CLKRC stopped)	-	0.1	-	mA	T _A = +25°C
				-	-	3	mA	T _A = +105°C
				-	-	4	mA	T _A = +125°C

14.3.2 Pin Characteristics
 $(V_{CC} = AV_{CC} = 2.7V \text{ to } 5.5V, V_{SS} = AV_{SS} = 0V, T_A = -40^{\circ}C \text{ to } +125^{\circ}C)$

Parameter	Symbol	Pin Name	Conditions	Value			Unit	Remarks
				Min	Typ	Max		
"H" level input voltage	V_{IH}	Port inputs Pnn_m	-	$V_{CC} \times 0.7$	-	$V_{CC} + 0.3$	V	CMOS Hysteresis input
			-	$V_{CC} \times 0.8$	-	$V_{CC} + 0.3$	V	AUTOMOTIVE Hysteresis input
	V_{IHx0S}	X0	External clock in "Fast Clock Input mode"	$V_D \times 0.8$	-	V_D	V	$V_D = 1.8V \pm 0.15V$
	V_{IHx0AS}	X0A	External clock in "Oscillation mode"	$V_{CC} \times 0.8$	-	$V_{CC} + 0.3$	V	
	V_{IHR}	RSTX	-	$V_{CC} \times 0.8$	-	$V_{CC} + 0.3$	V	CMOS Hysteresis input
	V_{IHM}	MD	-	$V_{CC} - 0.3$	-	$V_{CC} + 0.3$	V	CMOS Hysteresis input
"L" level input voltage	V_{IL}	Port inputs Pnn_m	-	$V_{SS} - 0.3$	-	$V_{CC} \times 0.3$	V	CMOS Hysteresis input
			-	$V_{SS} - 0.3$	-	$V_{CC} \times 0.5$	V	AUTOMOTIVE Hysteresis input
	V_{ILx0S}	X0	External clock in "Fast Clock Input mode"	V_{SS}	-	$V_D \times 0.2$	V	$V_D = 1.8V \pm 0.15V$
	V_{ILx0AS}	X0A	External clock in "Oscillation mode"	$V_{SS} - 0.3$	-	$V_{CC} \times 0.2$	V	
	V_{ILR}	RSTX	-	$V_{SS} - 0.3$	-	$V_{CC} \times 0.2$	V	CMOS Hysteresis input
	V_{ILM}	MD	-	$V_{SS} - 0.3$	-	$V_{SS} + 0.3$	V	CMOS Hysteresis input
"H" level output voltage	V_{OH4}	4mA type	$4.5V \leq V_{CC} \leq 5.5V$ $I_{OH} = -4mA$	$V_{CC} - 0.5$	-	V_{CC}	V	
			$2.7V \leq V_{CC} < 4.5V$ $I_{OH} = -1.5mA$					
"L" level output voltage	V_{OL4}	4mA type	$4.5V \leq V_{CC} \leq 5.5V$ $I_{OL} = +4mA$	-	-	0.4	V	
			$2.7V \leq V_{CC} < 4.5V$ $I_{OL} = +1.7mA$					
	V_{OLD}	DEBUG I/F	$V_{CC} = 2.7V$ $I_{OL} = +25mA$	0	-	0.25	V	
Input leak current	I_{IL}	Pnn_m	$V_{SS} < V_I < V_{CC}$ $AV_{SS} < V_I < AV_{CC}$, AVRH	-1	-	+1	μA	
Pull-up resistance value	R_{PU}	Pnn_m	$V_{CC} = 5.0V \pm 10\%$	25	50	100	k Ω	
Input capacitance	C_{IN}	Other than C, Vcc, Vss, AVcc, AVss, AVRH	-	-	5	15	pF	

14.4.3 Built-in RC Oscillation Characteristics

($V_{CC} = AV_{CC} = 2.7V$ to $5.5V$, $V_{SS} = AV_{SS} = 0V$, $T_A = -40^{\circ}C$ to $+125^{\circ}C$)

Parameter	Symbol	Value			Unit	Remarks
		Min	Typ	Max		
Clock frequency	f_{RC}	50	100	200	kHz	When using slow frequency of RC oscillator
		1	2	4	MHz	When using fast frequency of RC oscillator
RC clock stabilization time	t_{RCSTAB}	80	160	320	μs	When using slow frequency of RC oscillator (16 RC clock cycles)
		64	128	256	μs	When using fast frequency of RC oscillator (256 RC clock cycles)

14.4.4 Internal Clock Timing

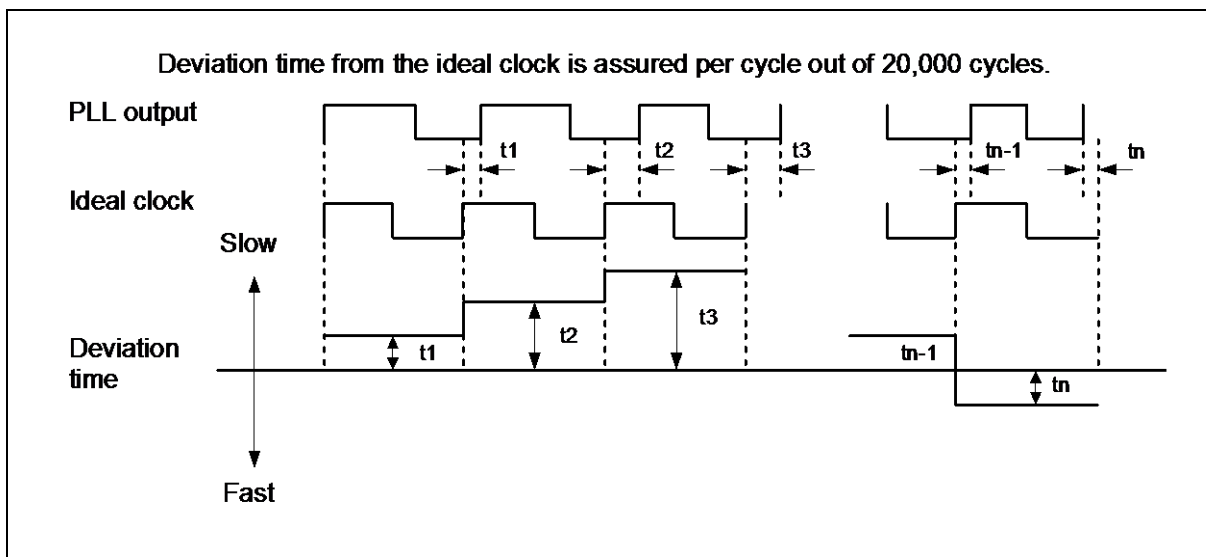
($V_{CC} = AV_{CC} = 2.7V$ to $5.5V$, $V_{SS} = AV_{SS} = 0V$, $T_A = -40^{\circ}C$ to $+125^{\circ}C$)

Parameter	Symbol	Value		Unit
		Min	Max	
Internal System clock frequency (CLKS1 and CLKS2)	f_{CLKS1}, f_{CLKS2}	-	54	MHz
Internal CPU clock frequency (CLKB), Internal peripheral clock frequency (CLKP1)	f_{CLKB}, f_{CLKP1}	-	32	MHz
Internal peripheral clock frequency (CLKP2)	f_{CLKP2}	-	32	MHz

14.4.5 Operating Conditions of PLL

($V_{CC} = AV_{CC} = 2.7V$ to $5.5V$, $V_{SS} = AV_{SS} = 0V$, $T_A = -40^{\circ}C$ to $+125^{\circ}C$)

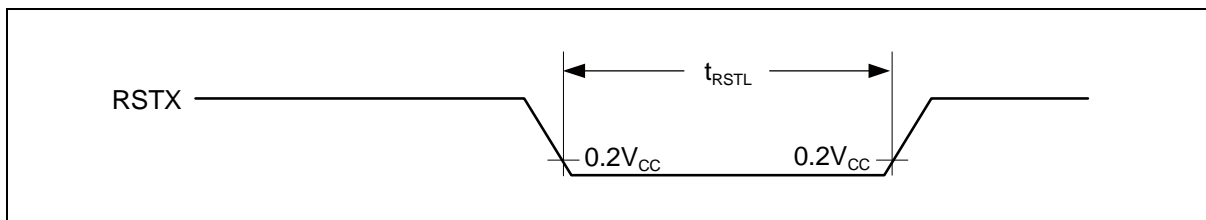
Parameter	Symbol	Value			Unit	Remarks
		Min	Typ	Max		
PLL oscillation stabilization wait time	t_{LOCK}	1	-	4	ms	For CLKMC = 4MHz
PLL input clock frequency	f_{PLLI}	4	-	8	MHz	
PLL oscillation clock frequency	f_{CLKVCO}	56	-	108	MHz	Permitted VCO output frequency of PLL (CLKVCO)
PLL phase jitter	t_{PSKEW}	-5	-	+5	ns	For CLKMC (PLL input clock) $\geq 4MHz$



14.4.6 Reset Input

($V_{CC} = AV_{CC} = 2.7V$ to $5.5V$, $V_{SS} = AV_{SS} = 0V$, $T_A = -40^{\circ}C$ to $+125^{\circ}C$)

Parameter	Symbol	Pin Name	Value		Unit
			Min	Max	
Reset input time	t_{RSTL}	RSTX	10	-	μs
Rejection of reset input time			1	-	μs



14.4.8 USART Timing

($V_{CC} = AV_{CC} = 2.7V$ to $5.5V$, $V_{SS} = AV_{SS} = 0V$, $T_A = -40^{\circ}C$ to $+125^{\circ}C$, $C_L = 50pF$)

Parameter	Symbol	Pin name	Conditions	$4.5V \leq V_{CC} < 5.5V$		$2.7V \leq V_{CC} < 4.5V$		Unit
				Min	Max	Min	Max	
Serial clock cycle time	t_{SCYC}	SCKn	Internal shift clock mode	$4t_{CLKP1}$	-	$4t_{CLKP1}$	-	ns
SCK ↓ → SOT delay time	t_{SLOVI}	SCKn, SOTn		- 20	+ 20	- 30	+ 30	ns
SOT → SCK ↑ delay time	t_{OVSHI}	SCKn, SOTn		$N \times t_{CLKP1} - 20^*$	-	$N \times t_{CLKP1} - 30^*$	-	ns
SIN → SCK ↑ setup time	t_{IVSHI}	SCKn, SINn		$t_{CLKP1} + 45$	-	$t_{CLKP1} + 55$	-	ns
SCK ↑ → SIN hold time	t_{SHIXI}	SCKn, SINn		0	-	0	-	ns
Serial clock "L" pulse width	t_{SLSH}	SCKn	External shift clock mode	$t_{CLKP1} + 10$	-	$t_{CLKP1} + 10$	-	ns
Serial clock "H" pulse width	t_{SHSL}	SCKn		$t_{CLKP1} + 10$	-	$t_{CLKP1} + 10$	-	ns
SCK ↓ → SOT delay time	t_{SLOVE}	SCKn, SOTn		-	$2t_{CLKP1} + 45$	-	$2t_{CLKP1} + 55$	ns
SIN → SCK ↑ setup time	t_{IVSHE}	SCKn, SINn		$t_{CLKP1}/2 + 10$	-	$t_{CLKP1}/2 + 10$	-	ns
SCK ↑ → SIN hold time	t_{SHIXE}	SCKn, SINn		$t_{CLKP1} + 10$	-	$t_{CLKP1} + 10$	-	ns
SCK fall time	t_F	SCKn		-	20	-	20	ns
SCK rise time	t_R	SCKn		-	20	-	20	ns

Notes:

- AC characteristic in CLK synchronized mode
- C_L is the load capacity value of pins when testing.
- Depending on the used machine clock frequency, the maximum possible baud rate can be limited by some parameters. These parameters are shown in "CY96600 series HARDWARE MANUAL".
- t_{CLKP1} indicates the peripheral clock 1 (CLKP1), Unit: ns
These characteristics only guarantee the same relocate port number.

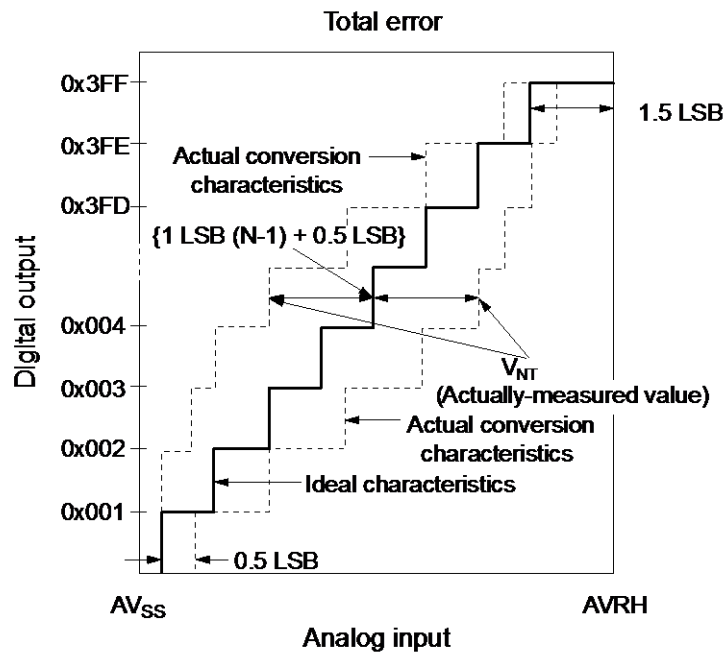
For example, the combination of SCKn and SOTn_R is not guaranteed.

*: Parameter N depends on t_{SCYC} and can be calculated as follows:

- If $t_{SCYC} = 2 \times k \times t_{CLKP1}$, then $N = k$, where k is an integer > 2
- If $t_{SCYC} = (2 \times k + 1) \times t_{CLKP1}$, then $N = k + 1$, where k is an integer > 1

Examples:

t_{SCYC}	N
$4 \times t_{CLKP1}$	2
$5 \times t_{CLKP1}$, $6 \times t_{CLKP1}$	3
$7 \times t_{CLKP1}$, $8 \times t_{CLKP1}$	4



$$1\text{LSB (Ideal value)} = \frac{AVRH - AVSS}{1024} \text{ [V]}$$

$$\text{Total error of digital output N} = \frac{V_{NT} - \{1\text{LSB} \times (N - 1) + 0.5\text{LSB}\}}{1\text{LSB}}$$

N : A/D converter digital output value.

V_{NT} : Voltage at which the digital output changes from $0x(N + 1)$ to $0xN$.

V_{OT} (Ideal value) = $AVSS + 0.5\text{LSB}$ [V]

V_{FST} (Ideal value) = $AVRH - 1.5\text{LSB}$ [V]

Page	Section	Change Results
52	■ELECTRICAL CHARACTERISTICS 7. Flash Memory Write/Erase Characteristics	Changed the Note While the Flash memory is written or erased, shutdown of the external power (V_{CC}) is prohibited. In the application system where the external power (V_{CC}) might be shut down while writing, be sure to turn the power off by using an external voltage detector. While the Flash memory is written or erased, shutdown of the external power (V_{CC}) is prohibited. In the application system where the external power (V_{CC}) might be shut down while writing or erasing, be sure to turn the power off by using a low voltage detection function.
56	■ORDERING INFORMATION	Deleted the Part number MCU with CAN controller MB96F612RBPMC-GTE2 MB96F613RBPMC-GTE2 MB96F615RBPMC-GTE2 MCU without CAN controller MB96F612ABPMC-GTE2 MB96F613ABPMC-GTE2 MB96F615ABPMC-GTE2
Revision 3.1		
-	-	Company name and layout design change
Rev.*B		
6, 8, 58, 59	1. Product Lineup 3. Pin Assignment 16. Ordering Information 17. Package Dimension	Package description modified to JEDEC description. FPT-48P-M26 → LQA048
58	16. Ordering Information	Added the following part number. MB96F612RBPMC-GS-UJE1, MB96F612RBPMC-GS-UJE2, MB96F613RBPMC-GS-UJE1, MB96F613RBPMC-GS-UJE2, MB96F615RBPMC-GS-UJE1, MB96F615RBPMC-GS-UJE2, MB96F612ABPMC-GS-UJE1, MB96F612ABPMC-GS-UJE2, MB96F613ABPMC-GS-UJE1, MB96F613ABPMC-GS-UJE2, MB96F615ABPMC-GS-UJE1, MB96F615ABPMC-GS-UJE2
Rev.*C		
58	16. Ordering Information	Deleted the Part number MCU without CAN controller MB96F615ABPMC-GS-UJE2
Rev.*D		
-	Marketing Part Numbers changed from an MB prefix to a CY prefix.	