

To all our customers

Regarding the change of names mentioned in the document, such as Mitsubishi Electric and Mitsubishi XX, to Renesas Technology Corp.

The semiconductor operations of Hitachi and Mitsubishi Electric were transferred to Renesas Technology Corporation on April 1st 2003. These operations include microcomputer, logic, analog and discrete devices, and memory chips other than DRAMs (flash memory, SRAMs etc.) Accordingly, although Mitsubishi Electric, Mitsubishi Electric Corporation, Mitsubishi Semiconductors, and other Mitsubishi brand names are mentioned in the document, these names have in fact all been changed to Renesas Technology Corp. Thank you for your understanding. Except for our corporate trademark, logo and corporate statement, no changes whatsoever have been made to the contents of the document, and these changes do not constitute any alteration to the contents of the document itself.

Note : Mitsubishi Electric will continue the business operations of high frequency & optical devices and power devices.

Renesas Technology Corp.
Customer Support Dept.
April 1, 2003

DESCRIPTION

The 7630 group is a single chip 8-bit microcomputer designed with CMOS silicon gate technology.

Being equipped with a CAN (Controller Area Network) module circuit, the microcomputer is suited to drive automotive equipments. The CAN module complies with CAN specification version 2.0, part B and allows priority-based message management.

In addition to the microcomputers simple instruction set, the ROM, RAM and I/O addresses are placed in the same memory map to enable easy programming.

The built-in ROM is available as mask ROM or One Time PROM. For development purposes, emulator- and EPROM-type microcomputers are available as well.

FEATURES

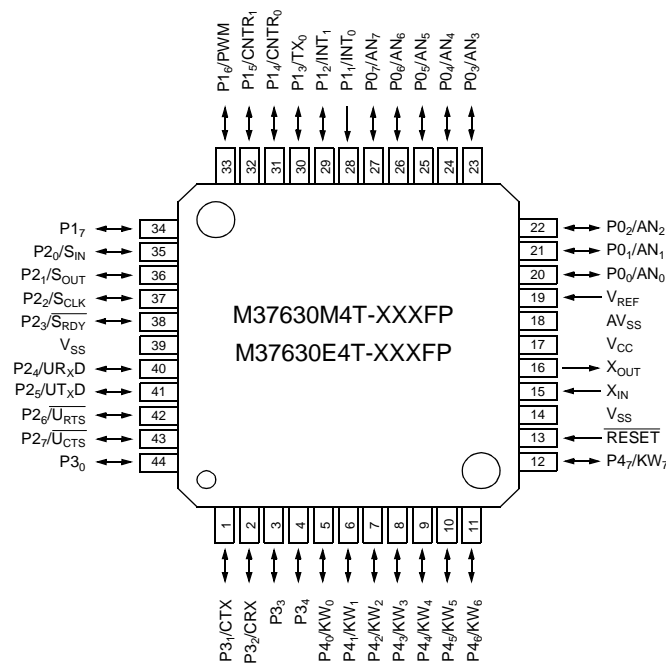
- Basic machine-language instructions 71
- Minimum instruction execution time
(at 10 MHz oscillation frequency) 0.2 μs
- Memory size
ROM 16252 bytes (M37630M4T-XXXFP)
RAM 512 bytes (M37630M4T-XXXFP)
- I/O ports
Programmable I/O ports 35
Input 1

- Interrupts 24 sources, 24 vectors
- Timers
16-bit Timers 2 channels
8-bit Timers 3 channels
- Serial I/Os
Clock synchronous 1 channel
UART 1 channel
- CAN module
(CAN specification version 2.0, part B) 1 channel
- A-D converter 8-bits x 8 channels
- Watchdog timer 1
- Clock Generating Circuit 1
Built-in with internal feedback resistor
- Power source voltage
(at 10 MHz oscillation frequency) 4.0 to 5.5 V
- Power dissipation
In high-speed mode 55 mW
(at 8 MHz oscillation frequency, at 5 V power source voltage)
- Operating temperature range -40 to 85 °C
- Package 44QFP (44P6N-A)

APPLICATION

Automotive controls

PIN CONFIGURATION (TOP VIEW)



**Package type: 44P6N-A
 44-pin plastic molded QFP**

Fig. 1 Pin configuration of M37630M4T-XXXFP

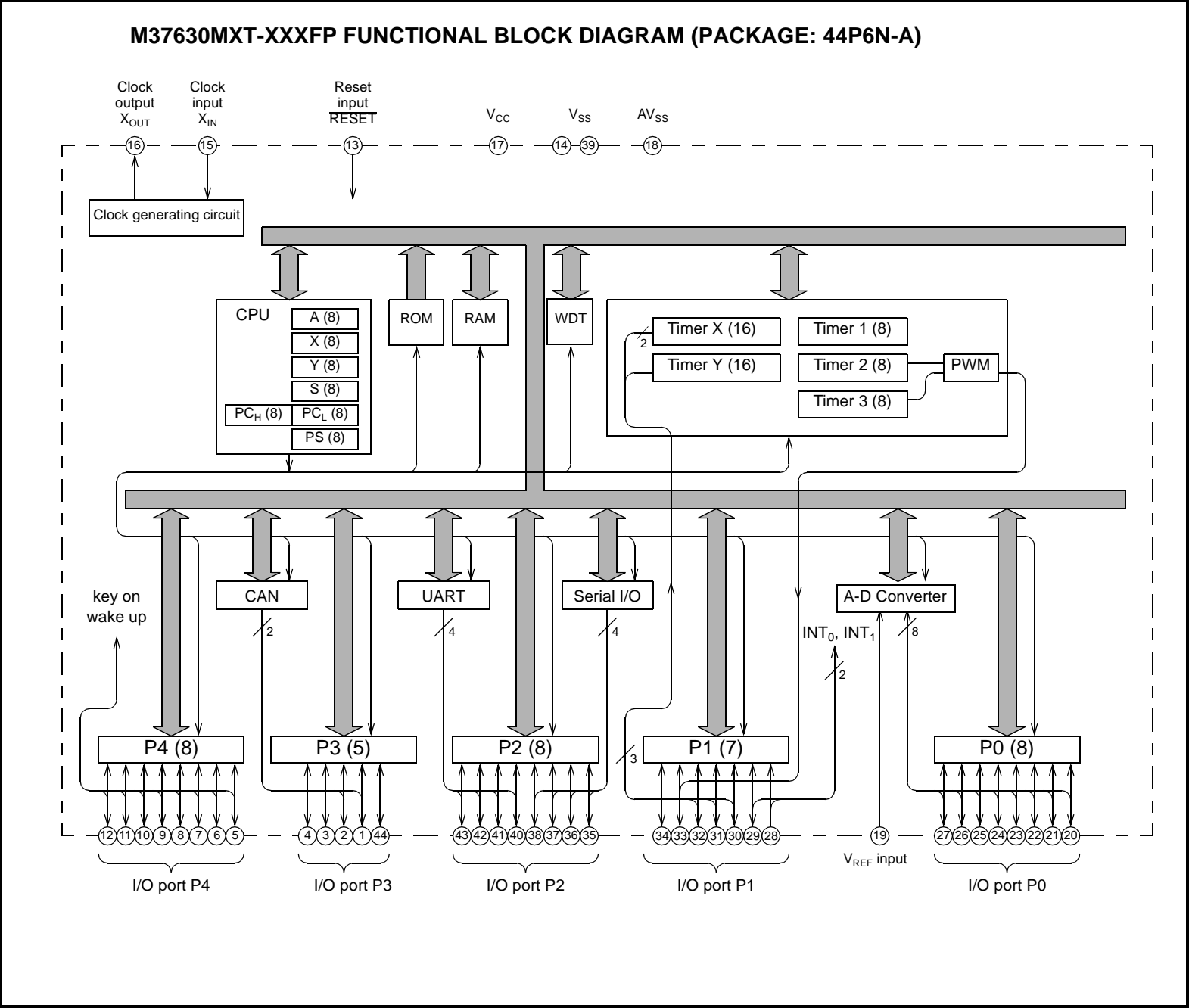


Fig. 2 Functional block diagram

PIN DESCRIPTION

Table 1: Pin description

Pin	Name	Input/Output	Description	
V _{CC} , V _{SS}	Power source voltage		Power supply pins; apply 4.0 to 5.5 V to V _{CC} and 0 V to V _{SS}	
AV _{SS}	Analog power source voltage		Ground pin for A-D converter. Connect to V _{SS}	
$\overline{\text{RESET}}$	Reset input	Input	Reset pin. This pin must be kept at "L" level for more than 2 μ s, to enter the reset state. If the crystal or ceramic resonator requires more time to stabilize, extend the "L" level period.	
X _{IN}	Clock input	Input	Input and output pins of the internal clock generating circuit. Connect a ceramic or quartz-crystal resonator between the X _{IN} and X _{OUT} pins. When an external clock source is used, connect it to X _{IN} and leave X _{OUT} open.	
X _{OUT}	Clock output	Output		
V _{REF}	Reference voltage input	Input	Reference voltage input pin for A-D converter	
P0 ₀ /AN ₀ — P0 ₇ /AN ₇	I/O port P0	I/O	CMOS I/O ports or analog input ports	
P1 ₁ /INT ₀	I/O port P1	Input	CMOS input port or external interrupt input port. The active edge (rising or falling) of external interrupts can be selected. This pin will be used as V _{PP} pin during PROM programming of One Time PROM Versions.	
P1 ₂ /INT ₁			CMOS I/O port or external interrupt input port. The active edge (rising or falling) of external interrupts can be selected.	
P1 ₃ /TX ₀			CMOS I/O port or input pin used in the bi-phase counter mode	
P1 ₄ /CNTR ₀		I/O	CMOS I/O port or timer X input pin used for the event counter, pulse width measurement and bi-phase counter mode	
P1 ₅ /CNTR ₁			CMOS I/O port or timer Y input pin used for the event counter, pulse width and pulse period measurement mode	
P1 ₆ /PWM			CMOS I/O port or PWM output pin used in the PWM mode of timers 2 and 3	
P1 ₇			CMOS I/O port	
P2 ₀ /S _{IN} P2 ₁ /S _{OUT} P2 ₂ /S _{CLK} P2 ₃ /S _{RDY}	I/O port P2	I/O	CMOS I/O ports or clock synchronous serial I/O pins	
P2 ₄ /UR _X D P2 ₅ /UT _X D P2 ₆ /U _{RTS} P2 ₇ /U _{CTS}				CMOS I/O ports or asynchronous serial I/O pins
P3 ₀	I/O port P3	I/O	CMOS I/O port	
P3 ₁ /CTX				CMOS I/O port or CAN transmit data pin
P3 ₂ /CRX				CMOS I/O port or CAN receive data pin
P3 ₃ —P3 ₄				CMOS I/O port
P4 ₀ /KW ₀ — P4 ₇ /KW ₇	I/O port P4	I/O	CMOS I/O ports. These ports can be used for key-on wake-up when configured as inputs.	

PART NUMBERING

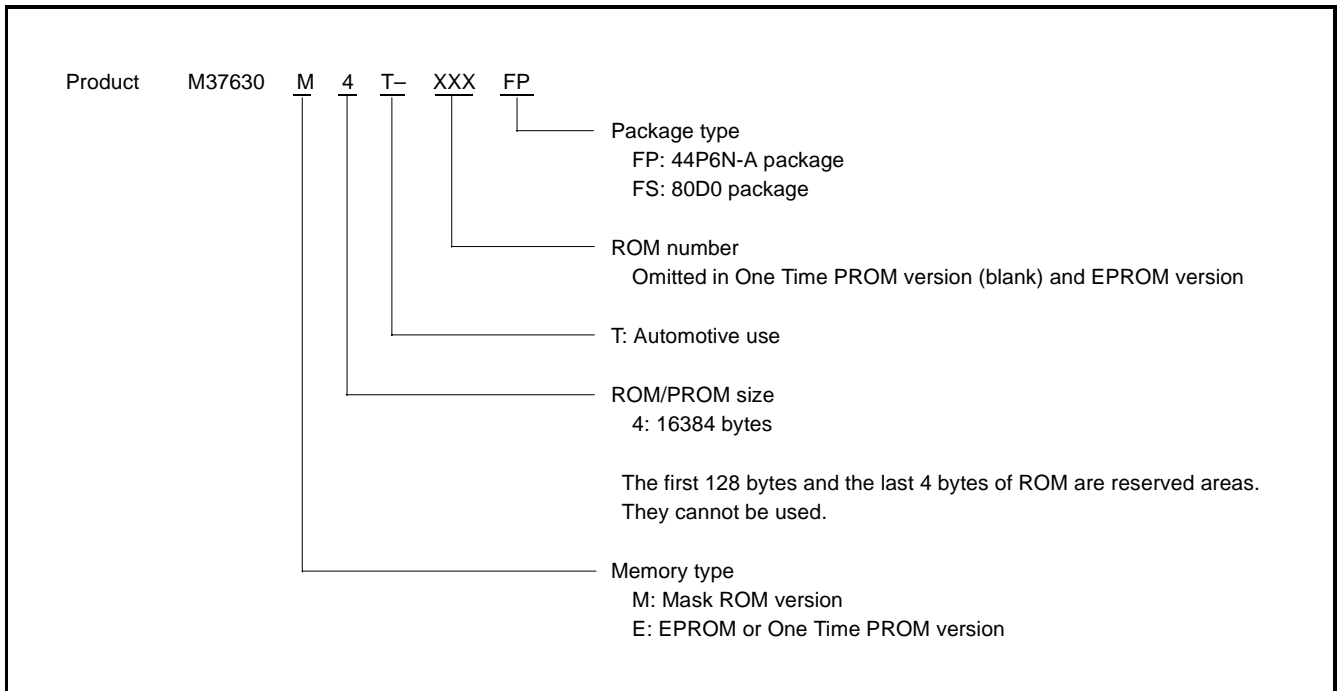


Fig. 3 Part numbering

GROUP EXPANSION

Mitsubishi plans to expand the 7630 group as follows:

Memory Type

Support mask ROM, One Time PROM and EPROM versions.

Memory Size

ROM/PROM size 16 Kbytes
RAM size. 512 bytes

Package

44P6N-A0.8mm-pitch plastic molded QFP
80D00.8mm-pitch ceramic LCC (EPROM version)

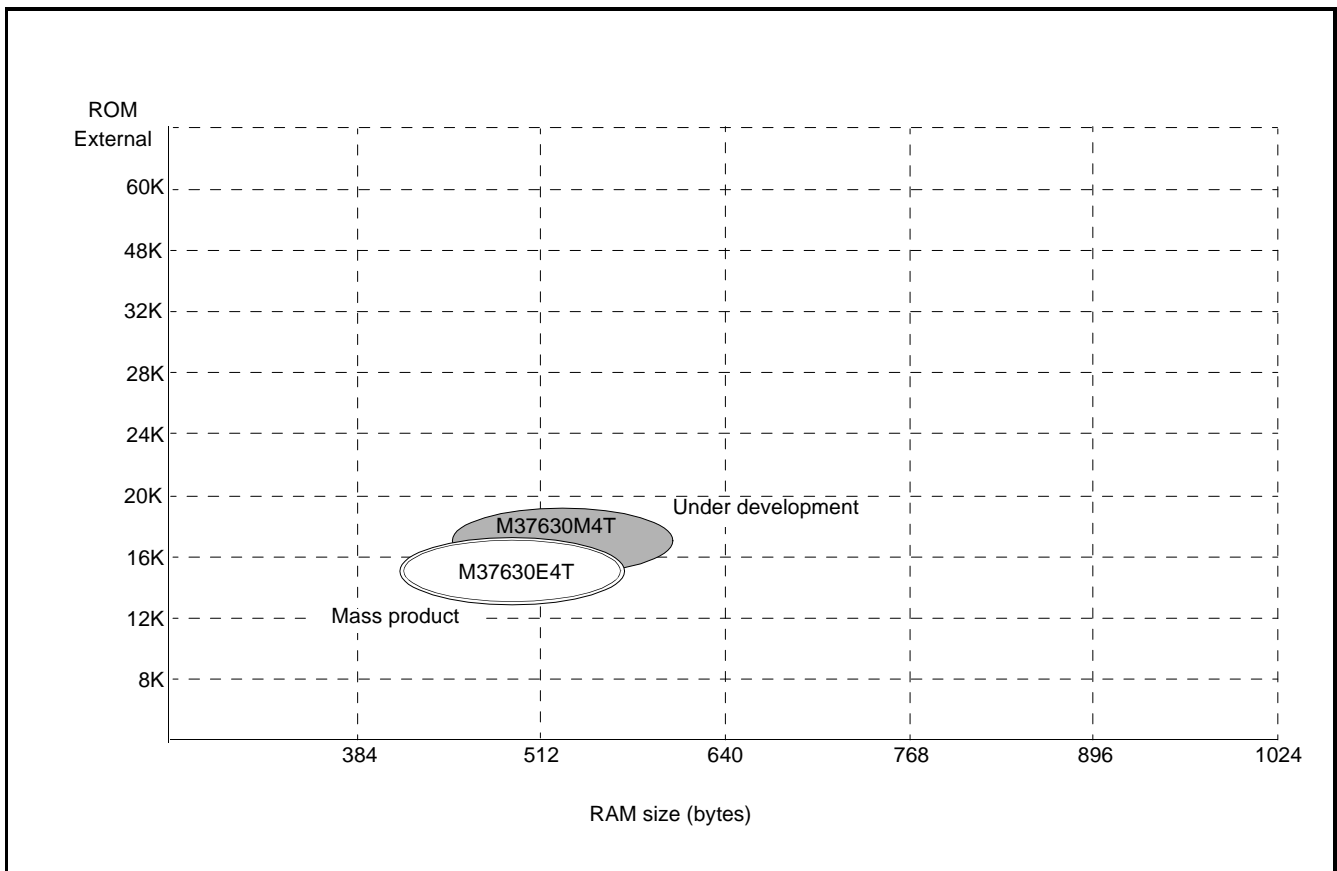


Fig. 4 Memory expansion plan

Currently supported products are listed below:

Table 2: List of supported products

As of March 1998

Product	(P)ROM size (bytes) ROM size for User ()	RAM size (bytes)	Package	Remarks
M37630M4T-XXXFP	16384 (16252)	512	44P6N-A	Mask ROM version
M37630E4T-XXXFP				One Time PROM version
M37630E4FP				One Time PROM version (blank)
M37630E4FS			80D0	EPROM version

FUNCTIONAL DESCRIPTION

Central Processing Unit (CPU)

The core of 7630 group microcomputers is the 7600 series CPU. This core is based on the standard instruction set of 740 series; however the performance is improved by allowing to execute the same instructions as that of the 740 series in less cycles. Refer to the 7600 Series Software Manual for details of the instruction set.

CPU Mode Register CPUM

The CPU mode register contains the stack page selection bit and internal system clock selection bit. The CPU mode register is allocated to address 0000₁₆.

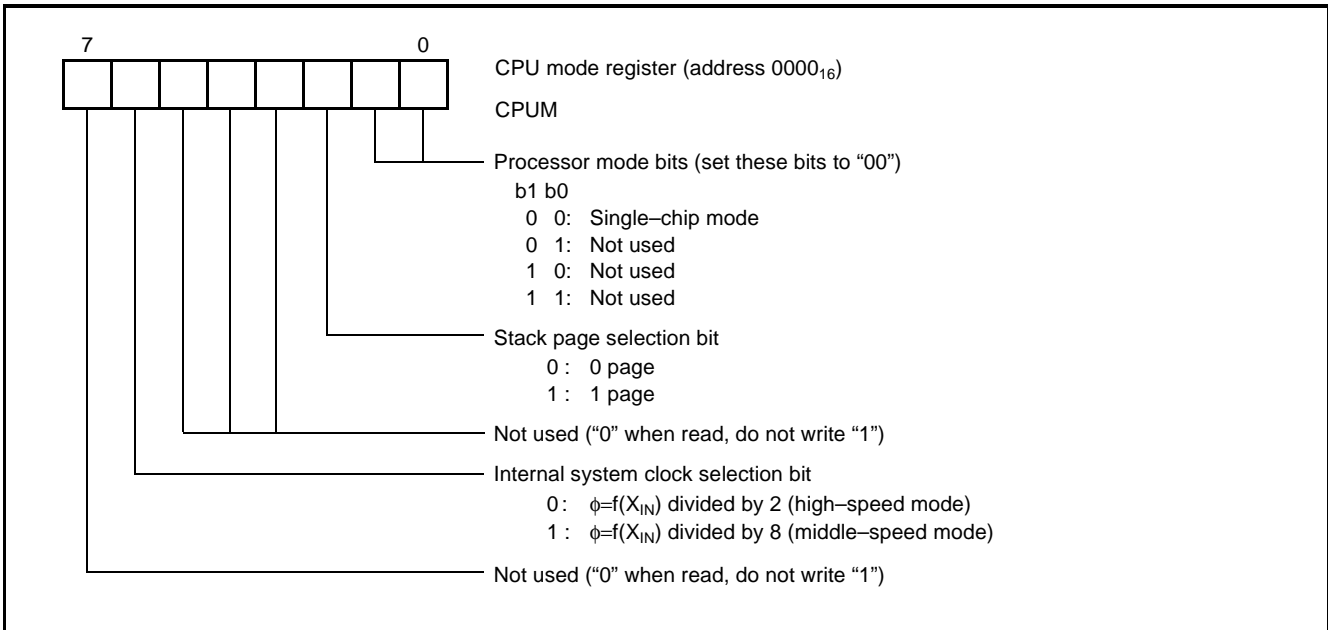


Fig. 5 Structure of CPU mode register

MEMORY

Special Function Register (SFR) Area

The special function register (SFR) area contains the registers relating to functions such as I/O ports and timers.

RAM

RAM is used for data storage and for stack area of subroutine calls and interrupts.

ROM

ROM is used for storing user's program code as well as the interrupt vector area.

Interrupt Vector Area

The interrupt vector area is for storing jump destination addresses used at reset or when an interrupt is generated.

Zero Page

This area can be accessed most efficiently by means of the zero page addressing mode.

Special Page

This area can be accessed most efficiently by means of the special page addressing mode.

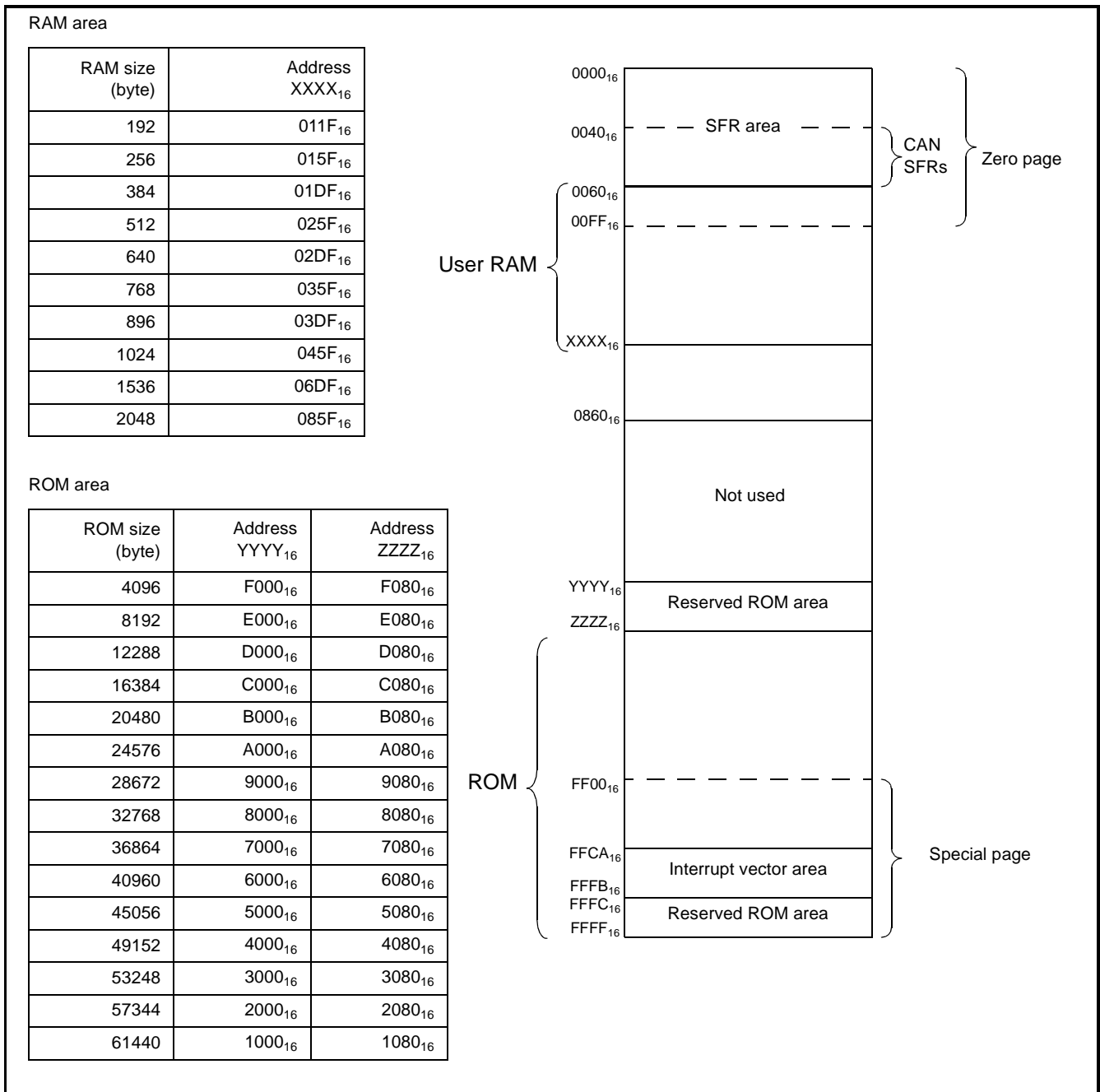


Fig. 6 Memory map diagram

SPECIAL FUNCTION REGISTERS (SFR)

0000 ₁₆	CPU mode register	CPUM	0030 ₁₆	CAN transmit control register	CTRM
0001 ₁₆	Not used		0031 ₁₆	CAN bus timing control register 1	CBTCON1
0002 ₁₆	Interrupt request register A	IREQA	0032 ₁₆	CAN bus timing control register 2	CBTCON2
0003 ₁₆	Interrupt request register B	IREQB	0033 ₁₆	CAN acceptance code register 0	CAC0
0004 ₁₆	Interrupt request register C	IREQC	0034 ₁₆	CAN acceptance code register 1	CAC1
0005 ₁₆	Interrupt control register A	ICONA	0035 ₁₆	CAN acceptance code register 2	CAC2
0006 ₁₆	Interrupt control register B	ICONB	0036 ₁₆	CAN acceptance code register 3	CAC3
0007 ₁₆	Interrupt control register C	ICONC	0037 ₁₆	CAN acceptance code register 4	CAC4
0008 ₁₆	Port P0 register	P0	0038 ₁₆	CAN acceptance mask register 0	CAM0
0009 ₁₆	Port P0 direction register	P0D	0039 ₁₆	CAN acceptance mask register 1	CAM1
000A ₁₆	Port P1 register	P1	003A ₁₆	CAN acceptance mask register 2	CAM2
000B ₁₆	Port P1 direction register	P1D	003B ₁₆	CAN acceptance mask register 3	CAM3
000C ₁₆	Port P2 register	P2	003C ₁₆	CAN acceptance mask register 4	CAM4
000D ₁₆	Port P2 direction register	P2D	003D ₁₆	CAN receive control register	CREC
000E ₁₆	Port P3 register	P3	003E ₁₆	CAN transmit abort register	CABORT
000F ₁₆	Port P3 direction register	P3D	003F ₁₆	Reserved	
0010 ₁₆	Port P4 register	P4	0040 ₁₆	CAN transmit buffer register 0	CTB0
0011 ₁₆	Port P4 direction register	P4D	0041 ₁₆	CAN transmit buffer register 1	CTB1
0012 ₁₆	Serial I/O shift register	SIO	0042 ₁₆	CAN transmit buffer register 2	CTB2
0013 ₁₆	Serial I/O control register	SIOCON	0043 ₁₆	CAN transmit buffer register 3	CTB3
0014 ₁₆	A-D conversion register	AD	0044 ₁₆	CAN transmit buffer register 4	CTB4
0015 ₁₆	A-D control register	ADCON	0045 ₁₆	CAN transmit buffer register 5	CTB5
0016 ₁₆	Timer 1	T1	0046 ₁₆	CAN transmit buffer register 6	CTB6
0017 ₁₆	Timer 2	T2	0047 ₁₆	CAN transmit buffer register 7	CTB7
0018 ₁₆	Timer 3	T3	0048 ₁₆	CAN transmit buffer register 8	CTB8
0019 ₁₆	Timer 123 mode register	T123M	0049 ₁₆	CAN transmit buffer register 9	CTB9
001A ₁₆	Timer XL	TXL	004A ₁₆	CAN transmit buffer register A	CTBA
001B ₁₆	Timer XH	TXH	004B ₁₆	CAN transmit buffer register B	CTBB
001C ₁₆	Timer YL	TYL	004C ₁₆	CAN transmit buffer register C	CTBC
001D ₁₆	Timer YH	TYH	004D ₁₆	CAN transmit buffer register D	CTBD
001E ₁₆	Timer X mode register	TXM	004E ₁₆	Reserved	
001F ₁₆	Timer Y mode register	TYM	004F ₁₆	Reserved	
0020 ₁₆	UART mode register	UMOD	0050 ₁₆	CAN receive buffer register 0	CRB0
0021 ₁₆	UART baud rate generator	UBRG	0051 ₁₆	CAN receive buffer register 1	CRB1
0022 ₁₆	UART control register	UCON	0052 ₁₆	CAN receive buffer register 2	CRB2
0023 ₁₆	UART status register	USTS	0053 ₁₆	CAN receive buffer register 3	CRB3
0024 ₁₆	UART transmit buffer register 1	UTBR1	0054 ₁₆	CAN receive buffer register 4	CRB4
0025 ₁₆	UART transmit buffer register 2	UTBR2	0055 ₁₆	CAN receive buffer register 5	CRB5
0026 ₁₆	UART receive buffer register 1	URBR1	0056 ₁₆	CAN receive buffer register 6	CRB6
0027 ₁₆	UART receive buffer register 2	URBR2	0057 ₁₆	CAN receive buffer register 7	CRB7
0028 ₁₆	Port P0 pull-up control register	PUP0	0058 ₁₆	CAN receive buffer register 8	CRB8
0029 ₁₆	Port P1 pull-up control register	PUP1	0059 ₁₆	CAN receive buffer register 9	CRB9
002A ₁₆	Port P2 pull-up control register	PUP2	005A ₁₆	CAN receive buffer register A	CRBA
002B ₁₆	Port P3 pull-up control register	PUP3	005B ₁₆	CAN receive buffer register B	CRBB
002C ₁₆	Port P4 pull-up/down control register	PUP4	005C ₁₆	CAN receive buffer register C	CRBC
002D ₁₆	Interrupt polarity selection register	IPOL	005D ₁₆	CAN receive buffer register D	CRBD
002E ₁₆	Watchdog timer register	WDT	005E ₁₆	Reserved	
002F ₁₆	Polarity control register	PCON	005F ₁₆	Reserved	

Fig. 7 Memory map of special register (SFR)

I/O PORTS

The 7630 group has 35 programmable I/O pins and one input pin arranged in five I/O ports (ports P0 to P4). The I/O ports are controlled by the corresponding port registers and port direction registers; each I/O pin can be controlled separately.

When data is read from a port configured as an output port, the port latch's contents are read instead of the port level. A port configured

as an input port becomes floating and its level can be read. Data written to this port will affect the port latch only; the port remains floating.

Refer to Structure of port- and port direction registers, Structure of port I/Os (1) and Structure of port I/Os (2).

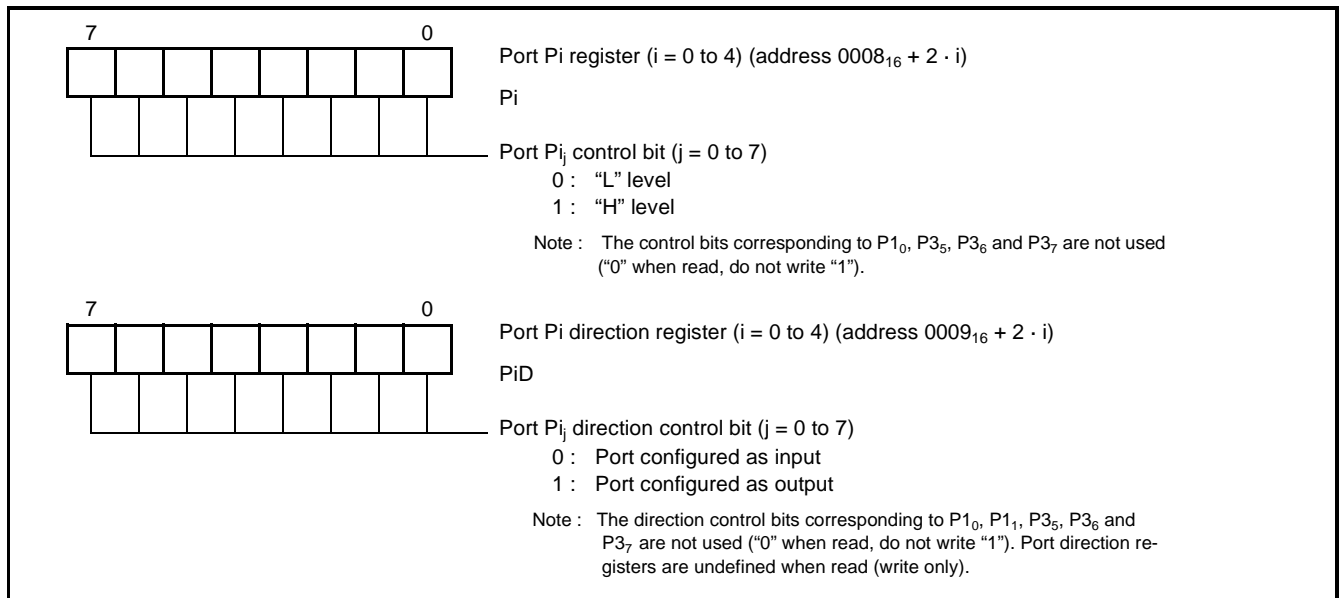


Fig. 8 Structure of port- and port direction registers

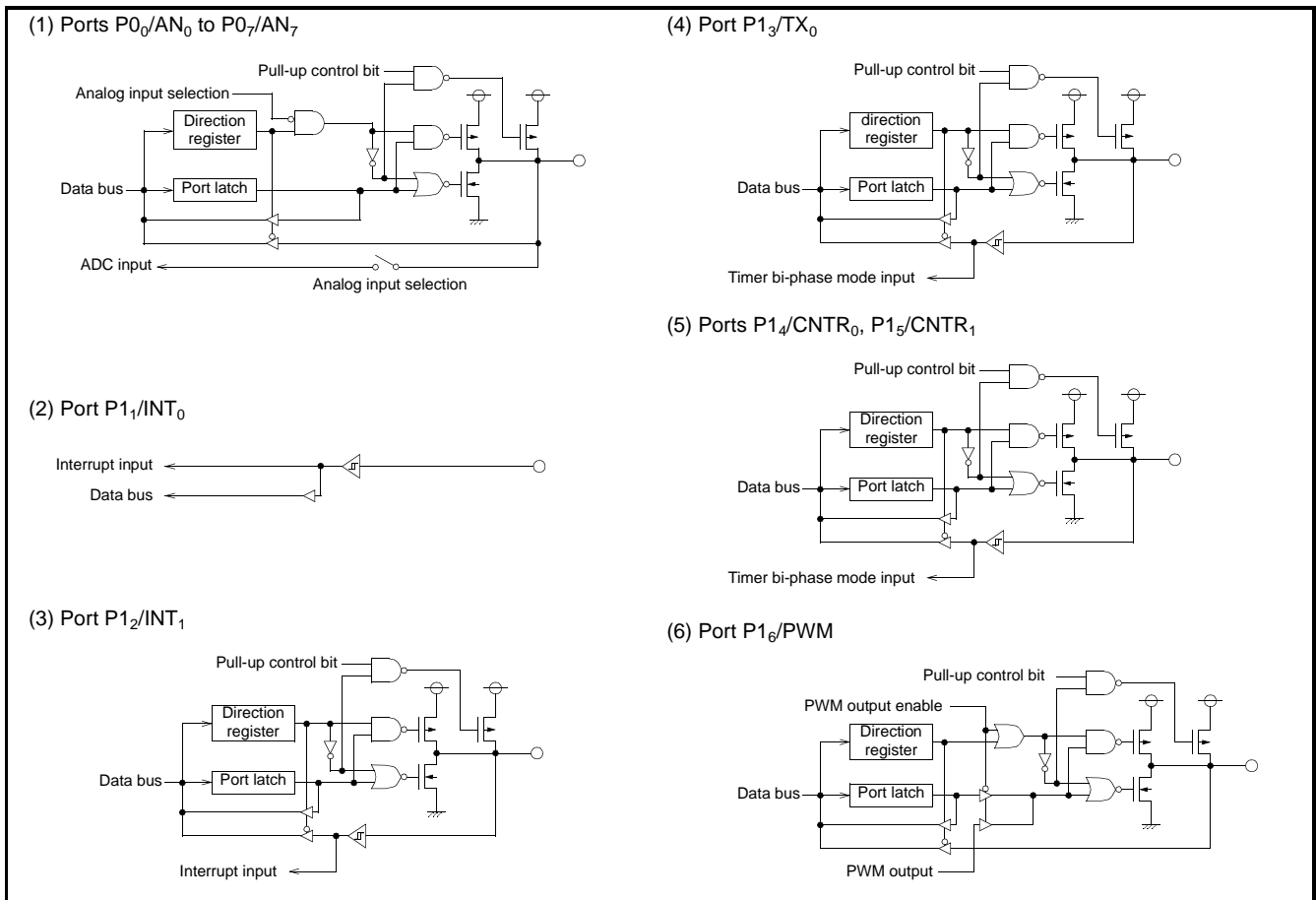


Fig. 9 Structure of port I/Os (1)

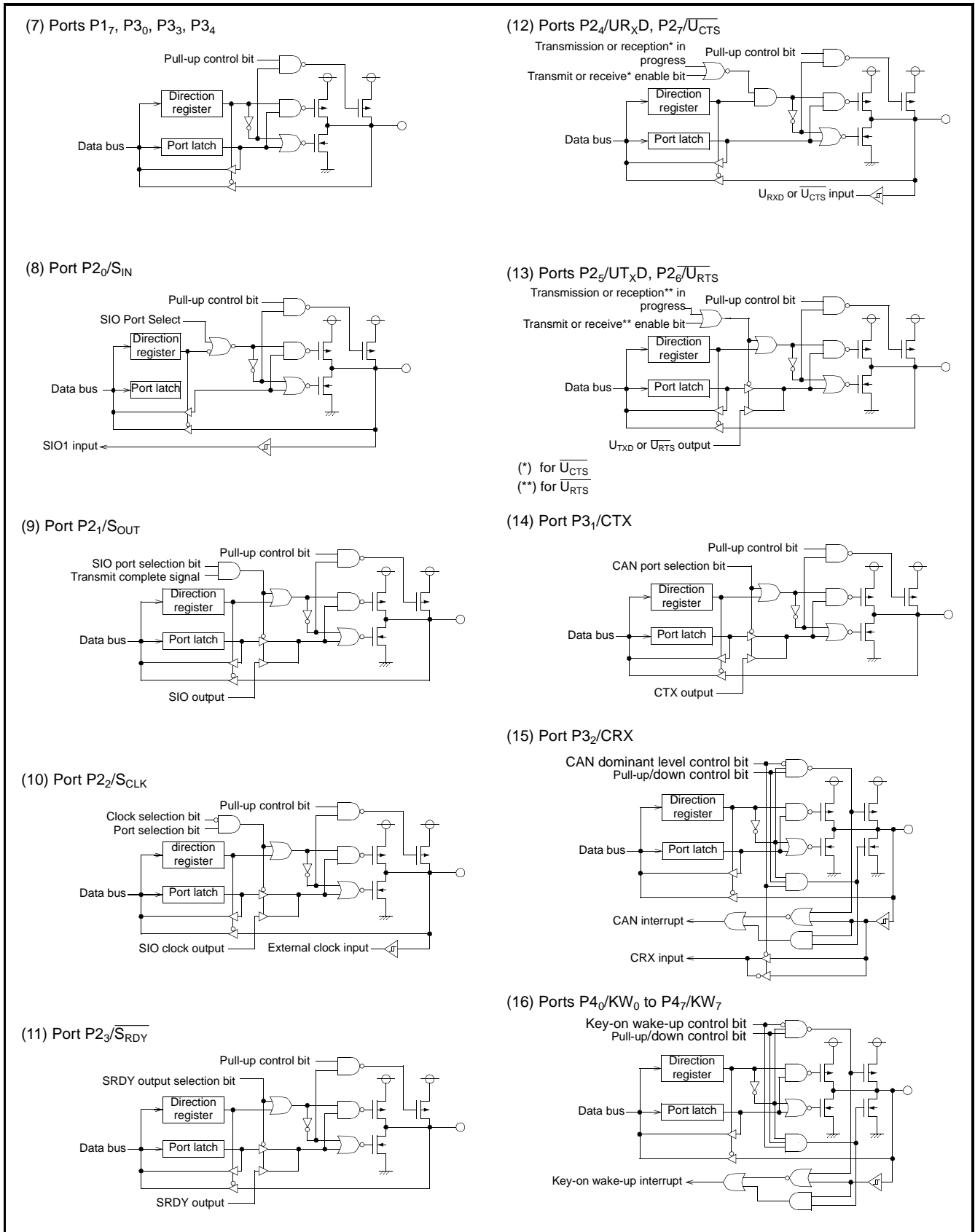


Fig. 10 Structure of port I/Os (2)

Port Pull-up/pull-down Function

Each pin of ports P0 to P4 except P₁ is equipped with a programmable pull-up transistor. P₃₂/CRX and P₄₀/KW₀ to P₄₇/KW₇ are equipped with programmable pull-down transistors as well. The pull-up function of P0 to P3 can be controlled by the corresponding

port pull-up control registers (see Structure of port pull-up/down control registers). The pull-up/down function of ports P₃₂ and P4 can be controlled by the corresponding port pull-up/pull-down registers together with the polarity control register (see Structure of polarity control register).

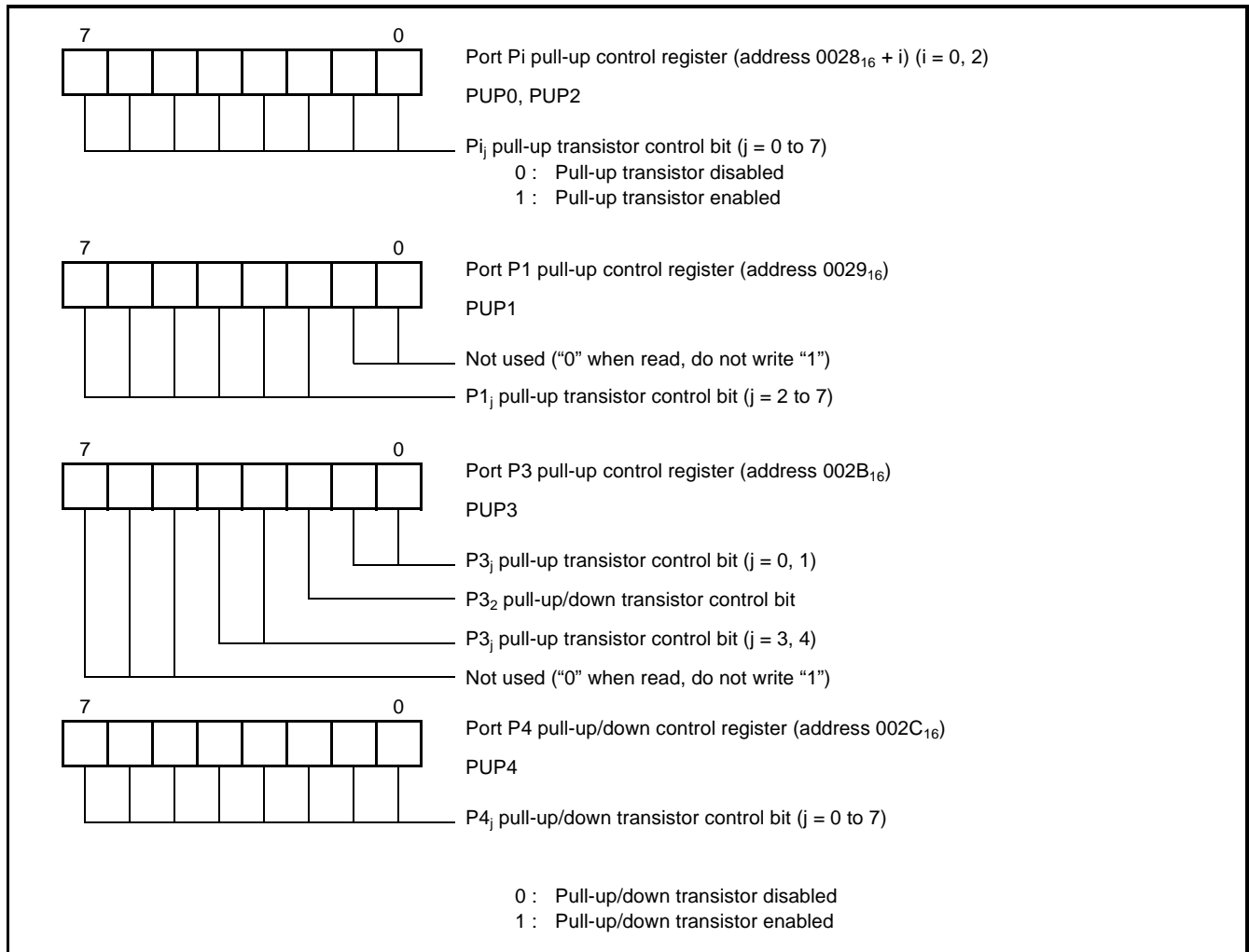


Fig. 11 Structure of port pull-up/down control registers

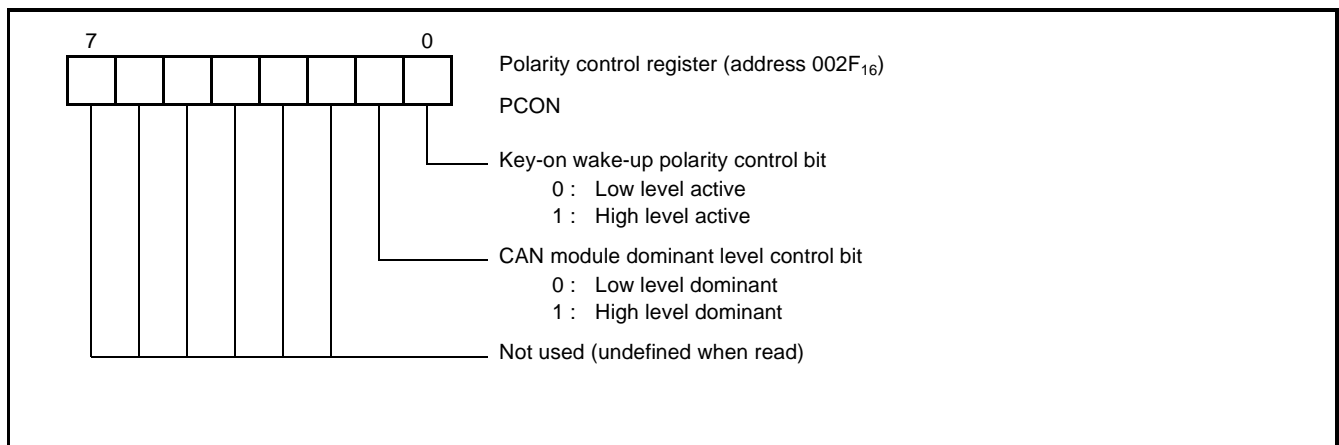


Fig. 12 Structure of polarity control register

Port Overvoltage Application

When configured as input ports, P1 to P4 may be subjected to overvoltage ($V_I > V_{CC}$) if the input current to the applicable port is limited to the specified values (see "Table 8:"). Use a serial resistor of appropriate size to limit the input current. To estimate the resistor value, assume the port voltage to be V_{CC} at overvoltage condition.

Notes:

- Subjecting ports to overvoltage may effect the supply voltage. Assure to keep V_{CC} and V_{SS} within the target limits.
- Avoid to subject ports to overvoltage causing V_{CC} to rise above 5.5 V.
- The overvoltage condition causing input current flowing through the internal port protection circuits has a negative effect on the ports noise immunity. Therefore, careful and intense testing of the target system's noise immunity is required. Refer to the "countermeasures against noise" of the corresponding users manual.
- Port P0 must not be subjected to overvoltage conditions.

INTERRUPTS

There are 24 interrupts: 6 external, 17 internal, and 1 software.

Interrupt Control

Each interrupt except the BRK instruction interrupt has both an interrupt request bit and an interrupt enable bit, and is controlled by the interrupt disable flag. An interrupt occurs when the corresponding interrupt request and enable bits are "1" and the interrupt disable flag is "0". Interrupt enable bits can be cleared or set by software. Interrupt request bits can be cleared by software but cannot be set by software. The BRK instruction interrupt and reset cannot be disabled with any flag or bit. The I flag disables all interrupts except the BRK instruction interrupt and reset. If several interrupt requests occur at the same time, the interrupt with the highest priority is accepted first.

Interrupt Operation

Upon acceptance of an interrupt, the following operations are automatically performed.

1. The processing being executed is stopped.
2. The contents of the program counter and processor status register are automatically pushed onto the stack.
3. Concurrently with the push operation, the interrupt jump destination address is read from the vector table into the program counter.
4. The interrupt disable flag is set and the corresponding interrupt request bit is cleared.

Notes on use

When the active edge of an external interrupt (INT₀, INT₁, CNTR₀, CNTR₁, CWKU or KOI) is changed, the corresponding interrupt request bit may also be set. Therefore, take the following sequence.

- (1) Disable the external interrupt which is selected.
- (2) Change the active edge in interrupt edge selection register.
(in the case of CNTR₀: Timer X mode register; in the case of CNTR₁: Timer Y mode register)
- (3) Clear the interrupt request bit to "0".
- (4) Enable the external interrupt which is selected.

Table 3: Interrupt vector addresses and priority

Interrupt source	Priority	Vector Address (Note 1)		Interrupt Request Generating Conditions	Remarks
		High	Low		
Reset (Note 2)	1	FFFB ₁₆	FFFA ₁₆	At Reset	Non-maskable
Watchdog timer	2	FFF9 ₁₆	FFF8 ₁₆	At Watchdog timer underflow	Non-maskable
INT0	3	FFF7 ₁₆	FFF6 ₁₆	At detection of either rising or falling edge of INT ₀ interrupt	External Interrupt (active edge selectable)
INT1	4	FFF5 ₁₆	FFF4 ₁₆	At detection of either rising or falling edge of INT ₁ interrupt	External Interrupt (active edge selectable)
CAN successful transmit	5	FFF3 ₁₆	FFF2 ₁₆	At CAN module successful transmission of message	Valid when CAN module is activated and request transmit
CAN successful receive	6	FFF1 ₁₆	FFF0 ₁₆	At CAN module successful reception of message	Valid when CAN module is activated
CAN overrun	7	FFEF ₁₆	FFEE ₁₆	If CAN module receives message when receive buffers are full.	Valid when CAN module is activated
CAN error passive	8	FFED ₁₆	FFEC ₁₆	When CAN module enters into error passive state	Valid when CAN module is active
CAN error bus off	9	FFEB ₁₆	FFEA ₁₆	When CAN module enters into bus off state	Valid when CAN module is active
CAN wake up	10	FFE9 ₁₆	FFE8 ₁₆	When CAN module wakes up via CAN bus	
Timer X	11	FFE7 ₁₆	FFE6 ₁₆	At Timer X underflow or overflow	
Timer Y	12	FFE5 ₁₆	FFE4 ₁₆	At Timer Y underflow	
Timer 1	13	FFE3 ₁₆	FFE2 ₁₆	At Timer 1 underflow	
Timer 2	14	FFE1 ₁₆	FFE0 ₁₆	At Timer 2 underflow	
Timer 3	15	FFDF ₁₆	FFDE ₁₆	At Timer 3 underflow	
CNTR0	16	FFDD ₁₆	FFDC ₁₆	At detection of either rising or falling edge in CNTR ₀ input	External Interrupt (active edge selectable)
CNTR1	17	FFDB ₁₆	FFDA ₁₆	At detection of either rising or falling edge in CNTR ₁ input	External Interrupt (active edge selectable)
UART receive	18	FFD9 ₁₆	FFD8 ₁₆	At completion of UART receive	Valid when UART is selected
UART transmit	19	FFD7 ₁₆	FFD6 ₁₆	At completion of UART transmit	Valid when UART is selected
UART transmit buffer empty	20	FFD5 ₁₆	FFD4 ₁₆	At UART transmit buffer empty	Valid when UART is selected
UART receive error	21	FFD3 ₁₆	FFD2 ₁₆	When UART reception error occurs.	Valid when UART is selected
Serial I/O	22	FFD1 ₁₆	FFD0 ₁₆	At completion of serial I/O data transmit and receive	Valid when serial I/O is selected
A-D conversion	23	FFCF ₁₆	FFCE ₁₆	At completion of A-D conversion	
Key-on wake-up	24	FFCD ₁₆	FFCC ₁₆	At detection of either rising or falling edge of P4 input	External Interrupt (active edge selectable)
BRK instruction	25	FFCB ₁₆	FFCA ₁₆	At BRK instruction execution	Non-maskable

Notes 1: Vector addresses contain interrupt jump destination address

2: Reset function in the same way as an interrupt with the highest priority

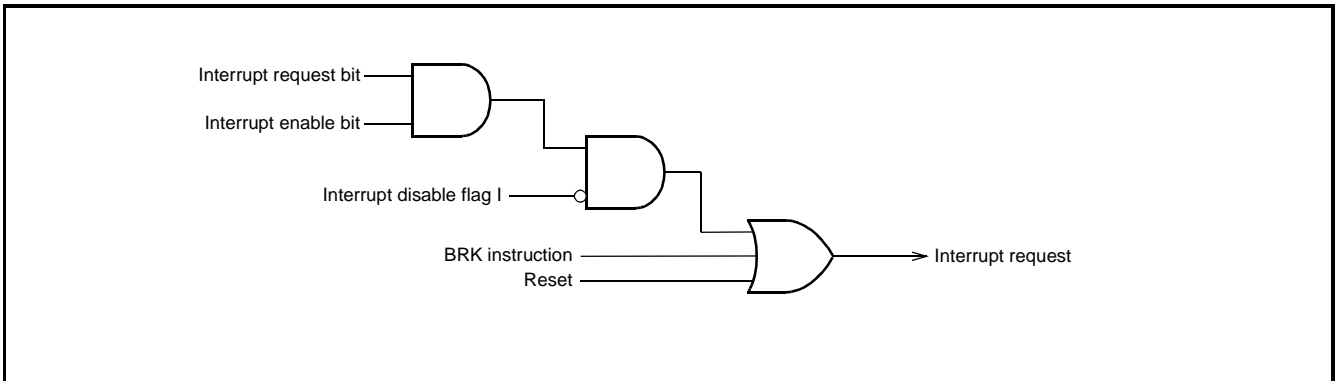


Fig. 13 Interrupt control

For the external interrupts INT0 and INT1, the active edge causing the interrupt request can be selected by the INT0 and INT1 interrupt edge selection bits of the interrupt polarity selection register (IPOL); please refer to Fig. 14 below.

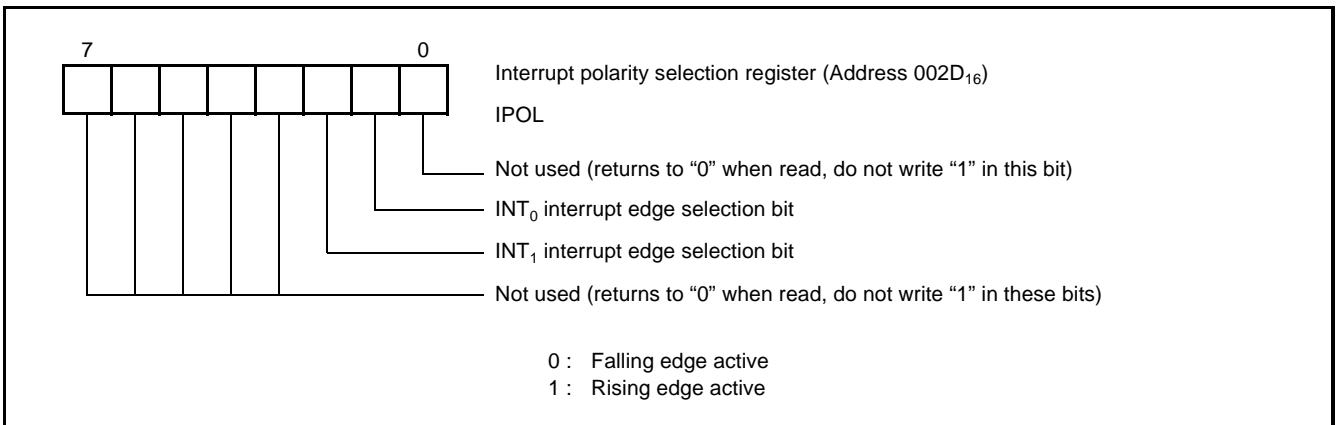


Fig. 14 Structure of interrupt polarity selection register

SINGLE-CHIP 8-BIT CMOS MICROCOMPUTER

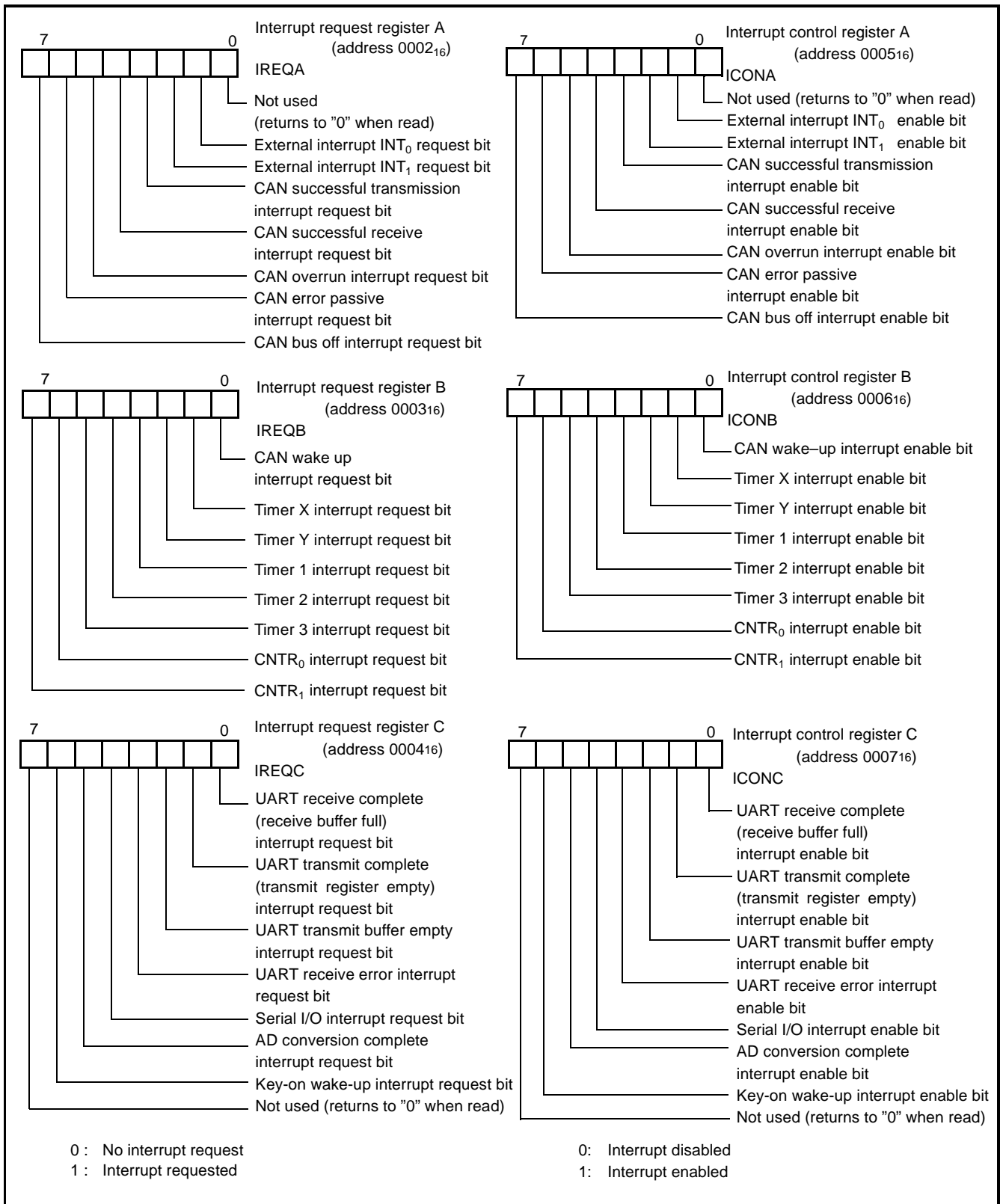


Fig. 15 Structure of interrupt request and control registers A, B and C

KEY-ON WAKE-UP

"Key-on wake-up" is one way of returning from a power-down state caused by the STP or WIT instruction. Any terminal of port P4 can be used to generate the key-on wake-up interrupt request. The active polarity can be selected by the key-on wake-up polarity con-

trol bit of PCON (see Fig. 12). If any pin of port P4 has the selected active level applied, the key-on wake-up interrupt request will be set to "1". Please refer to Fig. 16.

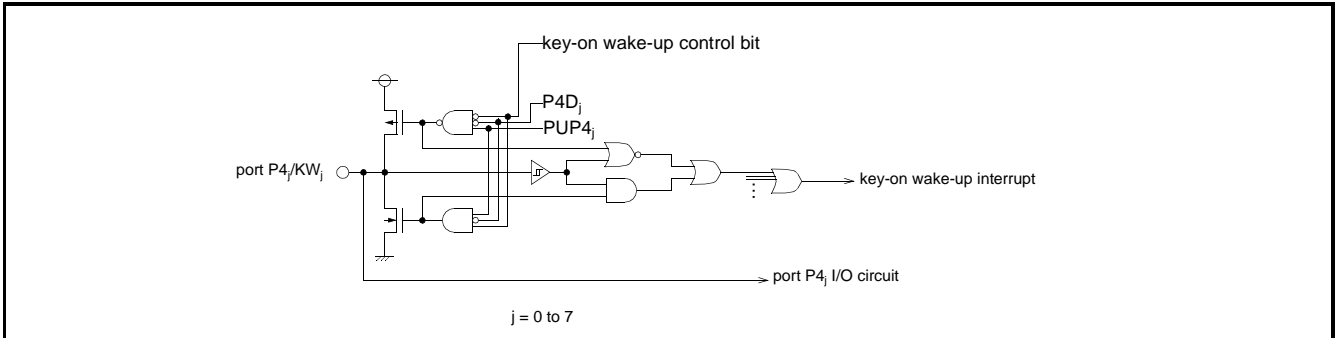


Fig. 16 Block diagram of key-on wake-up circuit

TIMERS

The 7630 group has five timers: two 16-bit timers and three 8-bit timers. All these timers will be described in detail below.

16-bit Timers

Timers X and Y are 16-bit timers with multiple operating modes. Please refer to Fig. 17.

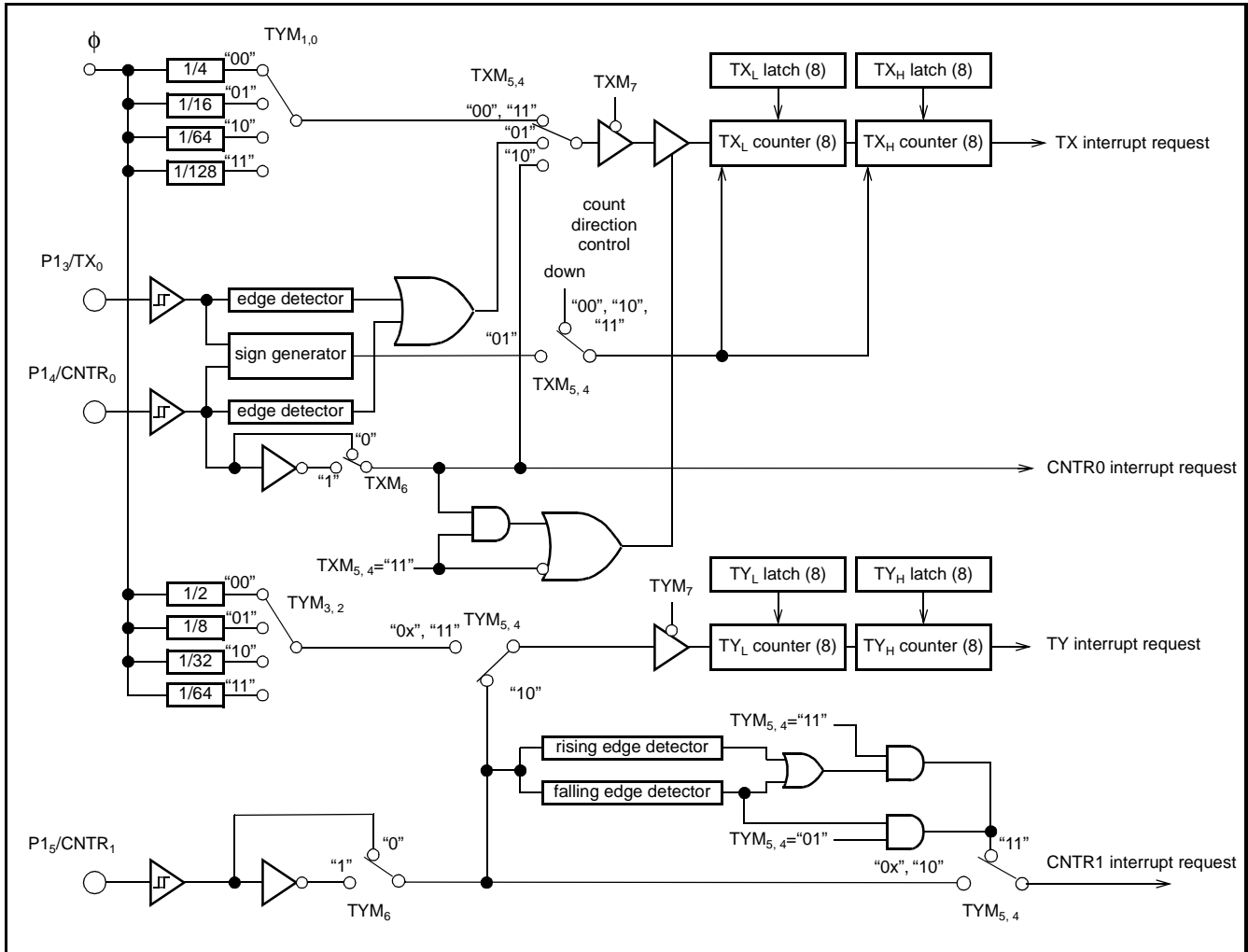


Fig. 17 Block diagram of timers X and Y (φ is internal system clock)

Timer X

Timer X is a 16-bit timer with a 16-bit reload latch supporting the following operating modes:

- (1) Timer mode
- (2) Bi-phase counter mode
- (3) Event counter mode
- (4) Pulse width measurement mode

These modes can be selected by the timer X mode register (TXM). In the timer- and pulse width measurement mode, the timer's count source can be selected by the timer X count source selection bits of the timer Y mode register (TYM). Please refer to the Figures below for the TXM and TYM bit assignment.

On read or write access to timer X, note that the high-order and low-order bytes must be accessed in the specific order.

Write method

When writing to the timer X, write the low-order byte first. The data written is stored in a temporary register which is assigned to the

same address as TX_L. Next, write the high-order byte. When this is finished, the data is placed in the timer X high-order reload latch and the low-order byte is transferred from its temporary register to the timer X low-order reload latch. Depending on the timer X write control bit, the latch contents are reloaded to the timer immediately (write control bit = "0") or on the next timer underflow (write control bit = "1").

Read method

When reading the timer X, read the high-order byte first. This causes the timer X high- and low-order bytes to be transferred to temporary registers being assigned to the same addresses as TX_H and TX_L. Next, read the low-order byte which is read from the temporary register. This method assures the correct timer value can be read during the timer count operation.

Timer X count stop control

Regardless of the actual operating mode, timer X can be stopped by setting the timer X count stop bit (bit 7 of the timer X mode register) to "1".

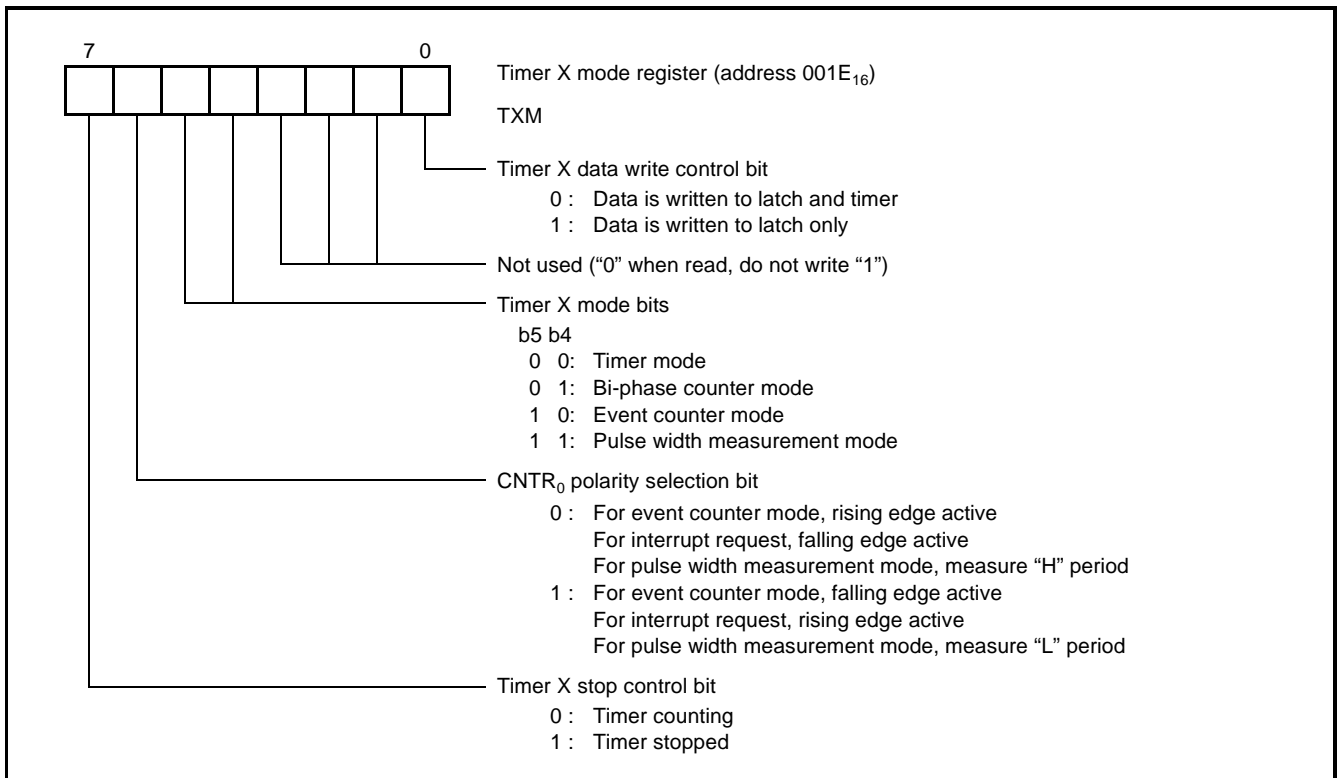


Fig. 18 Structure of Timer X mode register

Timer Y

Timer Y is a 16 bit timer with a 16-bit reload latch supporting the following operating modes:

- (1) Timer mode
- (3) Event counter mode
- (5) Pulse period measurement mode
- (6) H/L pulse width measurement mode

These modes can be selected by the timer Y mode register (TYM). In the timer, pulse period- and pulse width measurement modes' the timer's count source can be selected by the timer Y count source selection bits. Please refer to Fig. 19.

On read or write access to timer Y, note that the high-order and low-order bytes must be accessed in a specific order.

Write method

When writing to timer Y, write the low-order byte first. The data written is stored in a temporary register which is assigned to the same

address as TY_L. Next, write the high-order byte. When this is finished, the data is placed in the timer Y high-order reload latch and the low-order byte is transferred from its temporary register to the timer Y low-order reload latch.

Read method

When reading the timer Y, read the high-order byte first. This causes the timer Y high- and low-order bytes to be transferred to temporary registers being assigned to the same addresses as TY_H and TY_L. Next, read the low-order byte which is read from the temporary register. This method assures the correct timer value can be read during timer count operation.

Timer Y count stop control

Regardless of the actual operating mode, timer Y can be stopped by setting the timer Y count stop bit (bit 7 of the timer Y mode register) to "1".

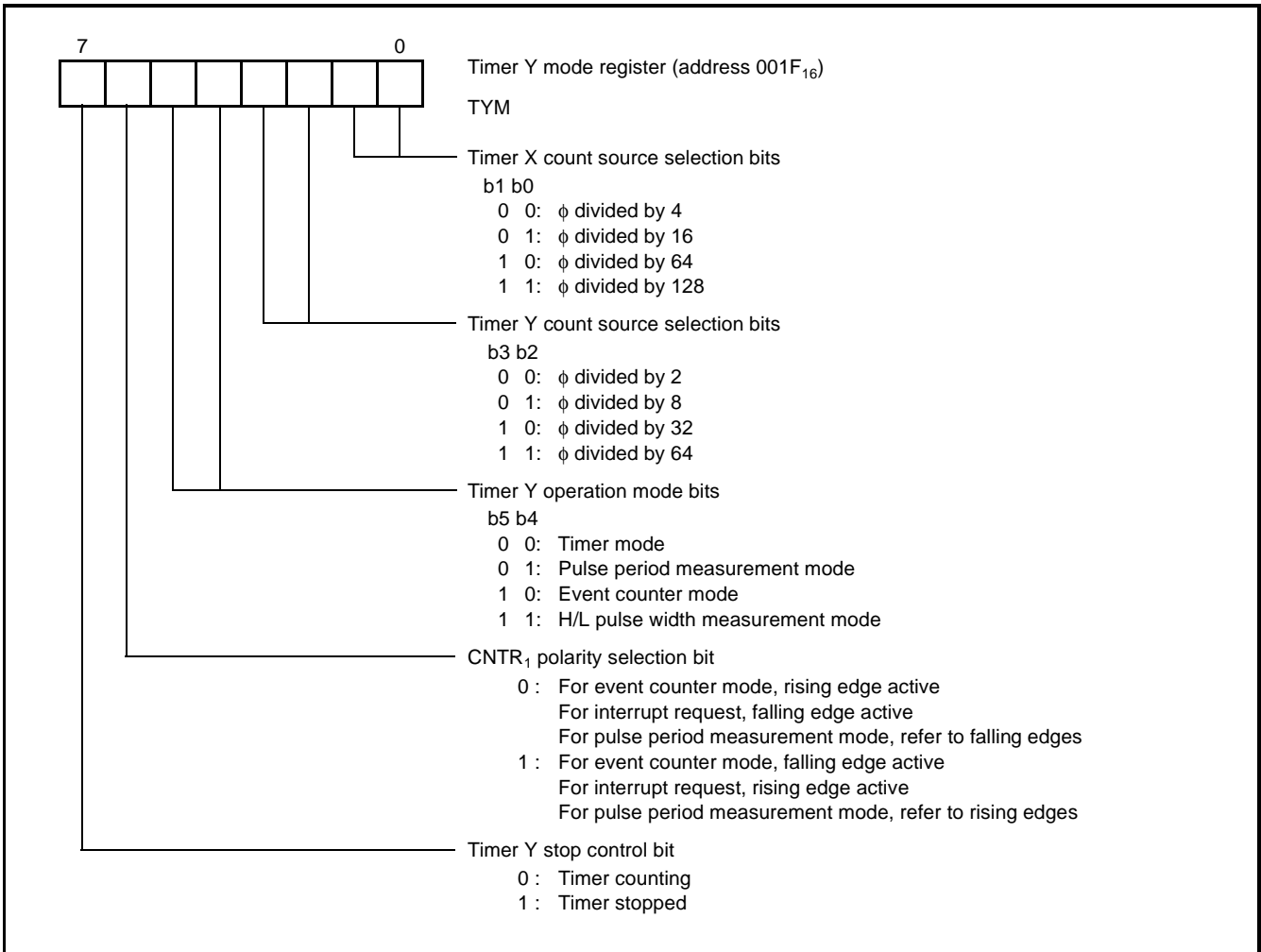


Fig. 19 Structure of timer Y mode register (ϕ is internal system clock)

Operating Modes

(1) Timer mode

This mode is available with timer X and timer Y.

- Count source
The count source for timer X and Y is the output of the corresponding clock divider. The division ratio can be selected by the timer Y mode register.
- Operation
Both timers X and Y are down counters. On a timer underflow, the corresponding timer interrupt request bit will be set to "1", the contents of the corresponding timer latches will be reloaded to the counters and counting continues.

(2) Bi-phase counter mode (quadruplicate)

This mode is available with timer X only.

- Count source
The count sources are P1₄/CNTR₀ and the P1₃/TX₀ pins.
- Operation
Timer X will count both rising and falling edges on both input pins (see above). Refer to Timer X bi-phase counter mode operation for the timing chart of the bi-phase counter mode.

The count direction is determined by the edge polarity and level of count source inputs and may change during the count operation. Refer to the table below.

Table 4: Timer X count direction in Bi-phase counter mode

P1 ₃ /TX ₀	P1 ₄ /CNTR ₀	Count direction
↑ Edge	L	Up
	H	Down
↓ Edge	L	Down
	H	Up
L	↑ Edge	Down
H		Up
L	↓ Edge	Up
H		Down

On a timer over- or underflow, the corresponding interrupt request bit will be set to "1" and counting continues.

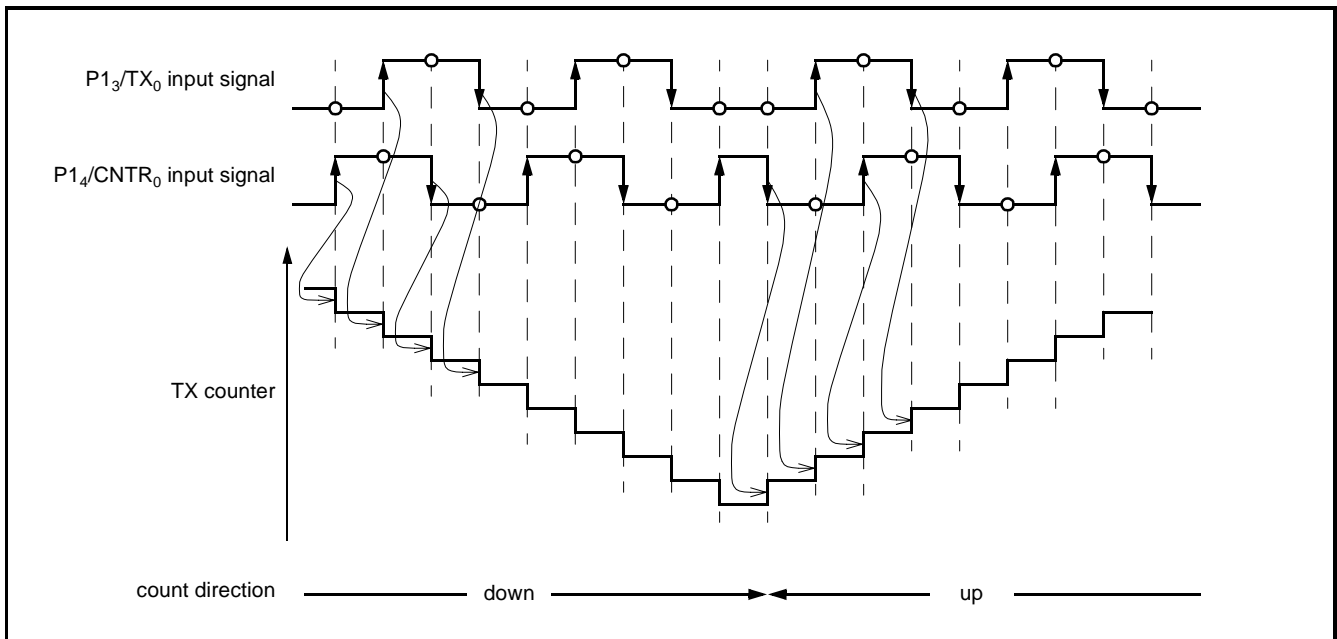


Fig. 20 Timer X bi-phase counter mode operation

(3) Event counter mode

This mode is available with timer X and timer Y.

- Count source
The count source for timer X is the input signal to the $P1_4/CNTR_0$ pin and for timer Y the input signal to $P1_5/CNTR_1$ pin.
- Operation
The timer counts down. On a timer underflow, the corresponding timer interrupt request bit will be set to "1", the contents of the corresponding timer latches will be reloaded to the counters and counting continues. The active edge used for counting can be selected by the polarity selection bit of the corresponding pin $P1_4/CNTR_0$ or $P1_5/CNTR_1$. These bits are part of TXM (Structure of Timer X mode register) and TYM (Structure of timer Y mode register (f is internal system clock)) registers.

(4) Pulse width measurement mode

This mode is available with timer X only.

- Count source
The count source is the output of timer X clock divider. The division ratio can be selected by the timer Y mode register.
- Operation
The timer counts down while the input signal level on $P1_4/CNTR_0$ matches the active polarity selected by the $CNTR_0$ polarity selection bit of TXM (Structure of Timer X mode register). On a timer underflow, the timer X interrupt request bit will be set to "1", the contents of the timer latches are reloaded to the counters and counting continues. When the input level changes from active polarity (as selected), the $CNTR_0$ interrupt request bit will be set to "1". The measurement result may be obtained by reading timer X during interrupt service.

(5) Pulse period measurement mode

This mode is available with timer Y only.

- Count source
The count source is the output of timer Y clock divider.

- Operation
The active edge of input signal to be measured can be selected by $CNTR_1$ polarity selection bit (Fig. 18). When this bit is set to "0", the time between two consecutive falling edges of the signal input to $P1_5/CNTR_1$ pin will be measured, when the polarity bit is set to "1", the time between two consecutive rising edges will be measured.
The timer counts down. On detection of an active edge of input signal, the contents of the TY counters will be transferred to temporary registers assigned to the same addresses as TY. At the same time, the contents of TY latches will be reloaded to the counters and counting continues. The active edge of input signal also causes the $CNTR_1$ interrupt request bit to be set to "1". The measurement result may be obtained by reading timer Y during interrupt service.

(6) H/L pulse width measurement mode

This mode is available with timer Y only.

- Count source
The count source is the output of the timer Y's clock divider.
- Operation
This mode measures both the "H" and "L" periods of a signal input to $P1_5/CNTR_1$ pin continuously. On detection of any edge (rising or falling) of input signal to $P1_5/CNTR_1$ pin, the contents of timer Y counters are stored to temporary registers which are assigned to the same addresses as timer Y. At the same time, the contents of timer Y latches are reloaded to the counters and counting continues. The detection of an edge causes the $CNTR_1$ interrupt request bit to be set to "1" as well. The result of measurement may be obtained by reading timer Y during interrupt service. This read access will address the temporary registers. On a timer underflow, the timer Y interrupt request bit will be set to "1", the contents of timer Y latches will be transferred to the counters and counting continues.

TIMER 1, TIMER 2, TIMER 3

Timers 1 to 3 are 8-bit timers with 8-bit reload latches and one common pre-divider. Timer 1 can operate in the timer mode only,

whereas timers 2 and 3 can be used to generate a PWM output signal timing as well. Timers 1 to 3 are down count timers. See Fig. 21.

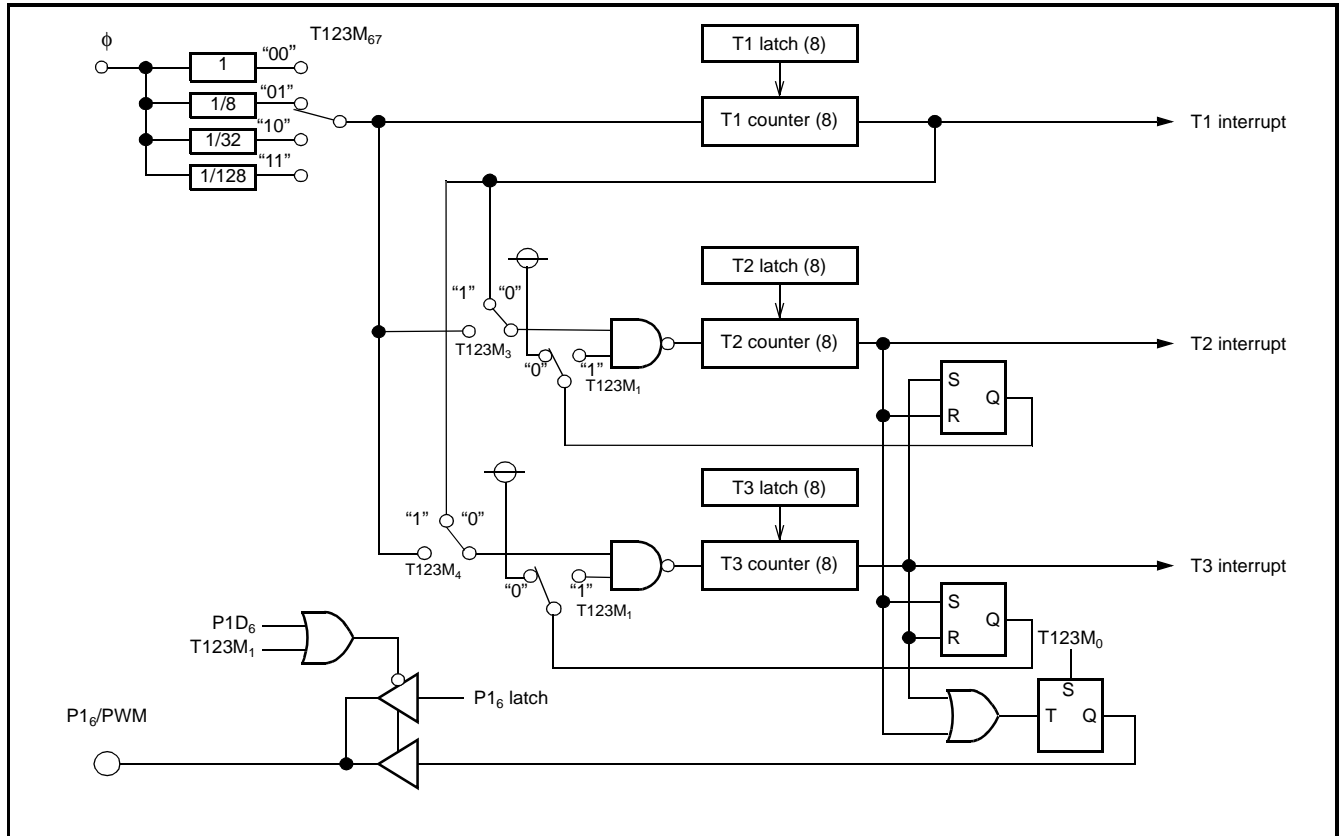


Fig. 21 Block diagram of timers 1 to 3 (ϕ is internal system clock)

Timer 1

The count source of timer 1 is the output of timer 123 pre-divider. The division ratio of the pre-divider can be selected by the pre-divider division ratio bits of timer 123 mode register (T123M). Refer to Timer 123 mode register configuration (f is internal system clock). On a timer 1 underflow, the timer 1 interrupt request bit will be set to "1".

Writing to timer 1 initializes the latch and counter.

Timers 2 and 3

The count source of timers 2 and 3 can be either the output of the timer 123 pre-divider or the timer 1 underflow. The count source can

be selected by the timer count source selection bits of timer 123 mode register (T123M).

Writing to timer 2 register affects the reload latch only or both of the reload latch and counter depending on the timer 2 write control bit of T123M. When the timer write control bit is set to "0", both latch and counter will be initialized simultaneously; when set to "1" only the reload latch will be initialized, on an underflow, the counter will be set to the modified reload value. Writing to timer 3 initializes latch and counter both.

Timer 2 or 3 underflow causes the timer 2 or 3 interrupt request bit to be set to "1".

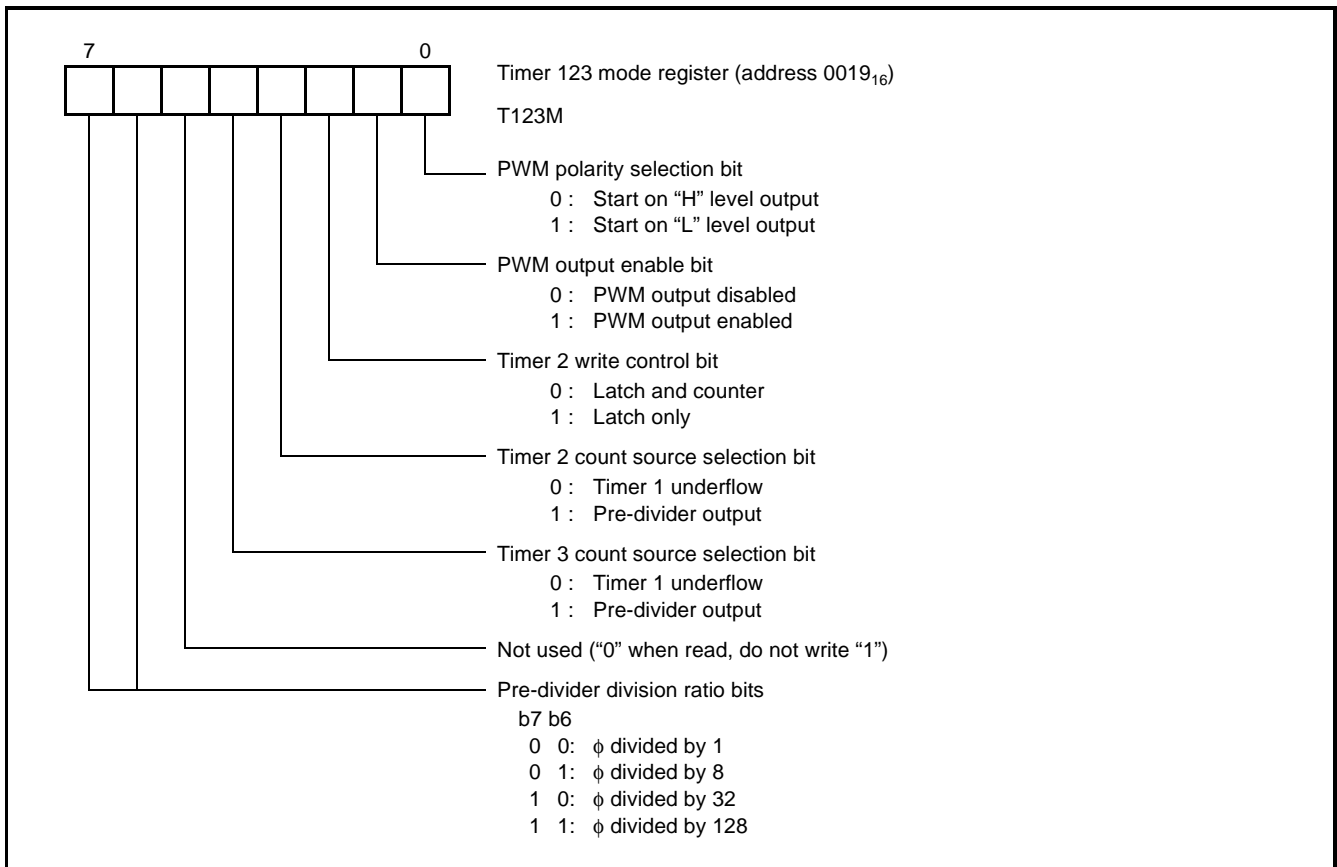


Fig. 22 Timer 123 mode register configuration (ϕ is internal system clock)

Operating Modes

(1) Timer Mode

This mode is available with timers 1 to 3.

- Count source
For timer 1, the count source is the output of the corresponding pre-divider. For timers 2 and 3, the count source can be separately selected to be either the pre-divider output or timer 1 underflow.
- Operation
The timer counts down. On a timer underflow, the corresponding timer interrupt request bit will be set to "1", the contents of the corresponding timer latch will be reloaded to the counter and counting continues.

(2) PWM Mode

This mode is available with timer 2 and 3.

- Count source
The count source can be separately selected to be either the pre-divider output or timer 1 underflow.
- Operation
When the PWM-mode is enabled, timer 2 starts counting. As soon as timer 2 underflows, timer 2 stops and timer 3 starts counting. If bit 0 is set, timer 2 determines the low duration and the initial output level is low. Timer 3 determines the high duration. If bit 0 is zero timer 2 determines the high duration and the initial output level is high. In this case timer 3 determines the low duration.

Note: Be sure to configure the P1₆/PWM pin as an output port before using PWM mode.

SERIAL I/Os

The serial I/O section of 7630 group consists of one clock synchronous and one asynchronous (UART) interface.

Clock Synchronous Serial I/O (SIO)

The clock synchronous interface allows full duplex communication based on 8 bit word length. The transfer clock can be selected from an internal or external clock. When an internal clock is selected, a programmable clock divider allows eight different transmission

speeds. Refer to Block diagram of clock synchronous I/O (ϕ is internal system clock). The operation of the clock synchronous serial I/O can be configured by the serial I/O control register SIOCON; refer to Fig. 25.

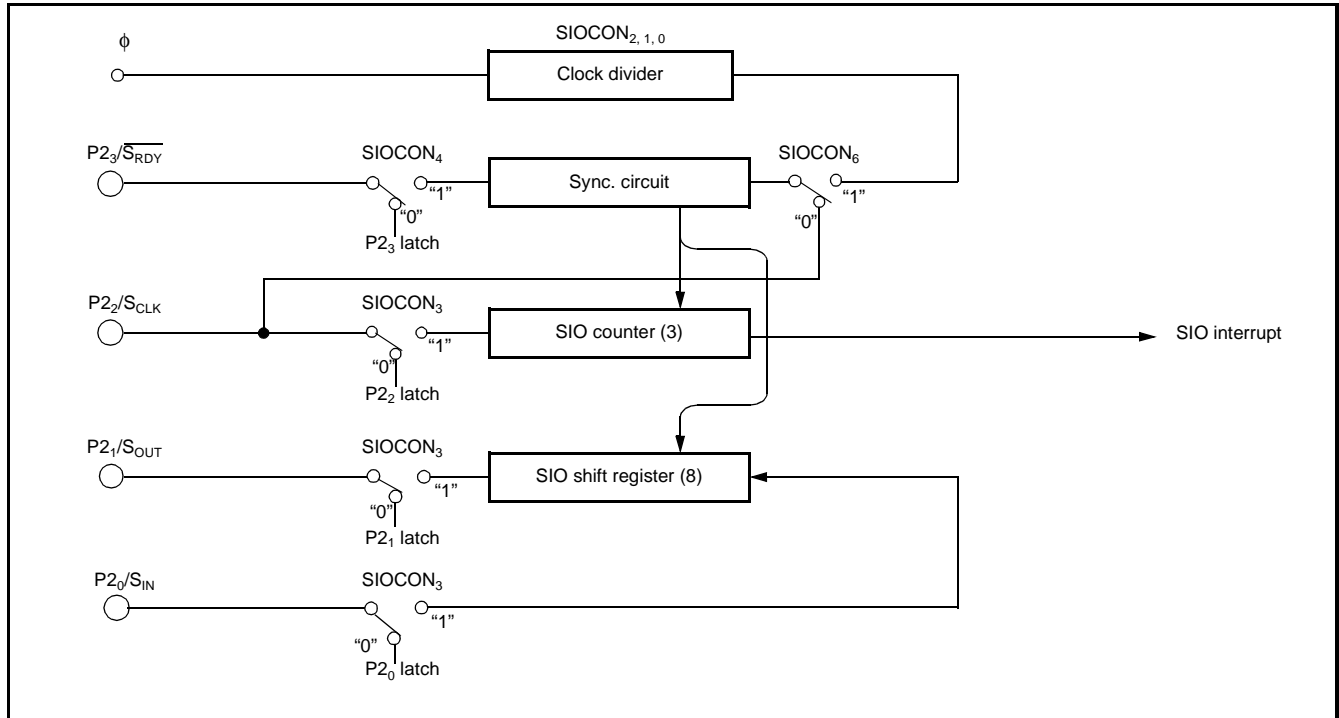


Fig. 23 Block diagram of clock synchronous I/O (ϕ is internal system clock)

(1) Clock synchronous serial I/O operation

Either an internal or external transfer clock can be selected by bit 6 of SIOCON. The internal clock divider can be programmed by bits 0 to 2 of SIOCON. Bit 3 of SIOCON determines whether the double function pins P2₀ to P2₂ will act as I/O ports or serve as SIO pins. Bit 4 of SIOCON allows the same selection for pin P2₃.

When an internal transfer clock is selected, transmission can be triggered by writing data to the SIO shift register (SIO, address

0012₁₆). After an 8-bit transmission has been completed, the S_{OUT} pin will change to high impedance and the SIO interrupt request bit will be set to "1".

When an external transfer clock is selected, the SIO interrupt request bit will be set to "1" after 8 cycles but the contents of the SIO shift register continue to be shifted while the transfer clock is being input. Therefore, the clock needs to be controlled externally; the S_{OUT} pin will not change to high impedance automatically.

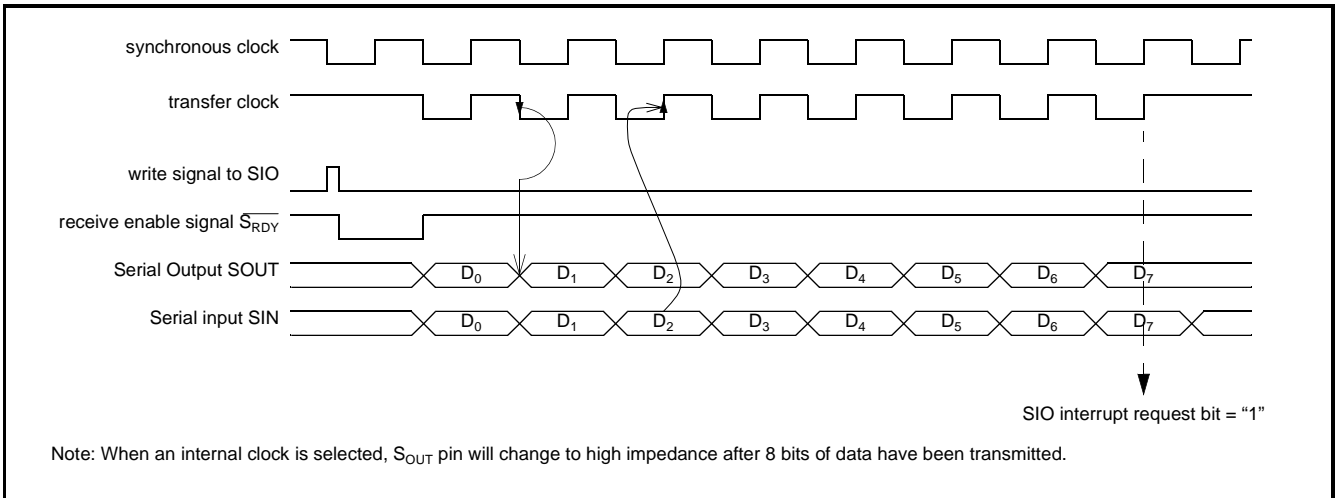


Fig. 24 Timing of clock synchronous SIO function (LSB first selected)

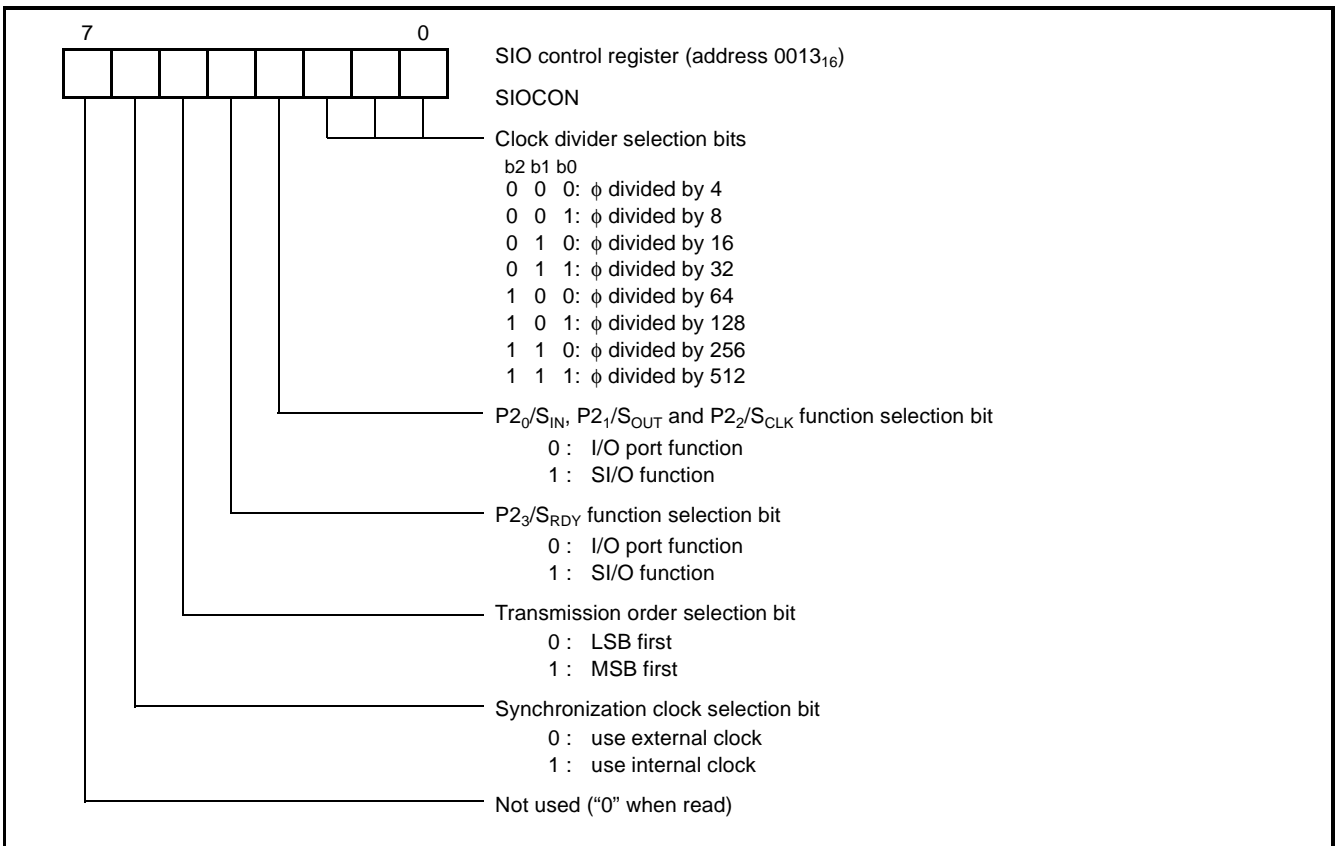


Fig. 25 Structure of serial I/O control register (ϕ is internal system clock)

Clock Asynchronous Serial I/O (UART)

The UART is a full duplex asynchronous transmit/receive unit. The built-in clock divider and baud rate generator enable a broad range of transmission speeds. Please refer to Block diagram of UART.

(1) Description

The transmit and receive shift registers have a buffer (consisting of high and low order byte) each. Since the shift registers cannot be

written to or read from directly, transmit data is written to the transmit buffer and receive data is read from the receive buffer. A transmit or receive operation will be triggered by the transmit enable bit and receive enable bit of the UART control register UCON (see Structure of UART control register). The double function terminals P2₅/UT_xD, P2₆/URT_S and P2₄/UR_xD, P2₇/UCT_S will be switched to serve as UART pins automatically.

(2) Baud rate selection

The baud rate of transmission and reception is determined by the setting of the prescaler and the contents of the UART baud rate generator register. It is calculated by: where p is the division ratio of

$$b = \frac{\phi}{16 \cdot p \cdot (n + 1)}$$

the prescaler and n is the content of UART baud rate generator register. The prescaler's division ratio can be selected by the UART mode register (see below).

UART mode register (UMOD, Structure of UART mode register)

The UART mode register allows to select the transmission and reception format with the following options:

- word length: 7, 8 or 9 bits
- parity: none, odd or even
- stop bits: 1 or 2

It allows to select the prescaler's division ratio as well.

UART baud rate generator (UBRG)

This 8 bit register allows to select the baud rate of the UART (see above). Set this register to the desired value before enabling reception or transmission.

UART control register (UCON, Structure of UART control register)

The UART control register consists of four control bits (bit 0 to bit 3) which allow to control reception and transmission.

UART status register (USTS, Structure of UART status register)

The read-only UART status register consists of 7 bits (bit 0 to bit 6) which indicate the operating status of the UART function and various errors.

(3) Handshaking signals

When used as transmitter the UART will recognize the clear-to-send signal via $P2_7/\overline{UCTS}$ terminal for handshaking. When used as receiver it will issue a request-to-send signal through $P2_6/\overline{URTS}$ pin.

Clear-to-send input

When used as a transmitter (transmit enable bit set to "1"), the UART starts transmission after recognizing "L" level on $P2_7/\overline{UCTS}$. After started the UART will continue to transmit regardless of the actual level of $P2_7/\overline{UCTS}$ or status of the transmit enable bit.

Request-to-send output

The UART controls the $P2_6/\overline{URTS}$ output according to the following conditions.

Table 5: Output control conditions

Condition	$P2_6/\overline{URTS}$
Receive enable bit is set to "1"	"L"
Reception completed during receive enable bit set to "1"	
Start bit (falling edge) detected	"H"
Receive enable bit is set to "0" before reception started	
Hardware reset	
Receive initialization bit is set to "1"	

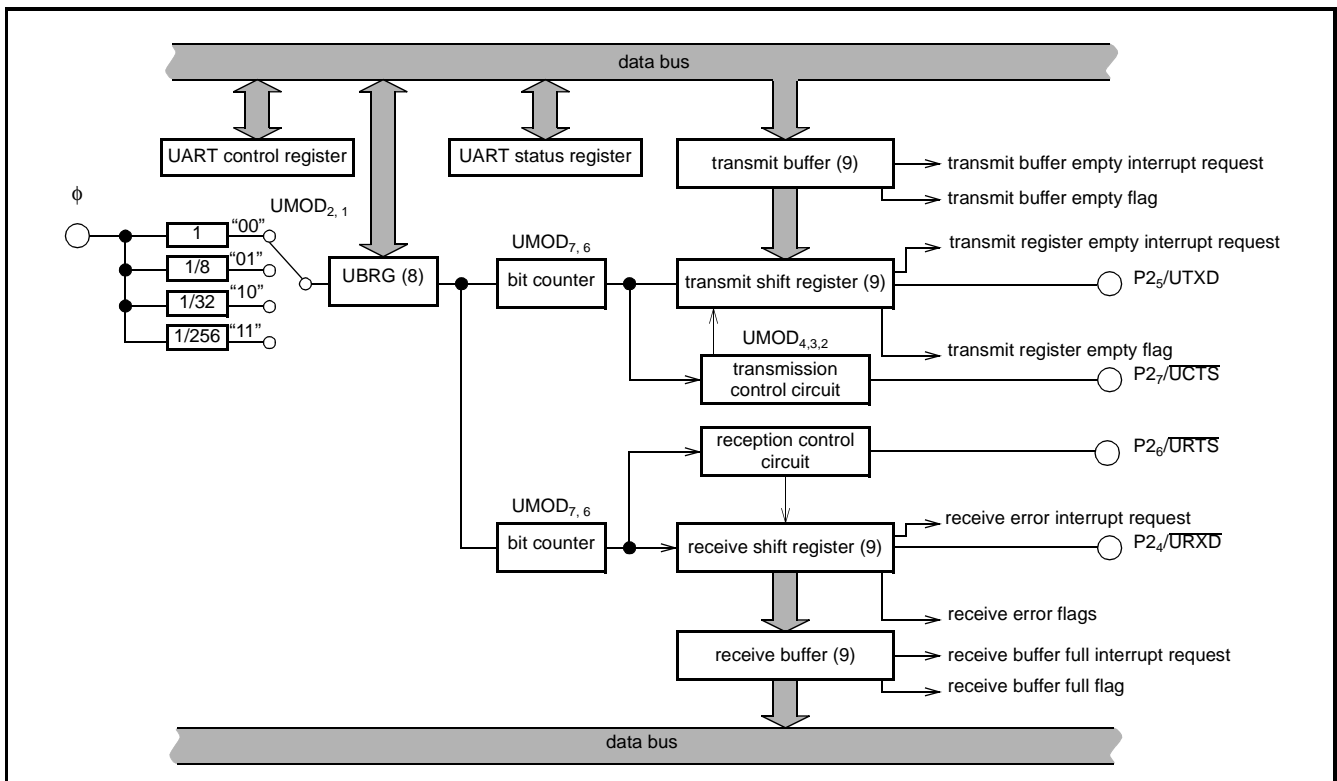


Fig. 26 Block diagram of UART

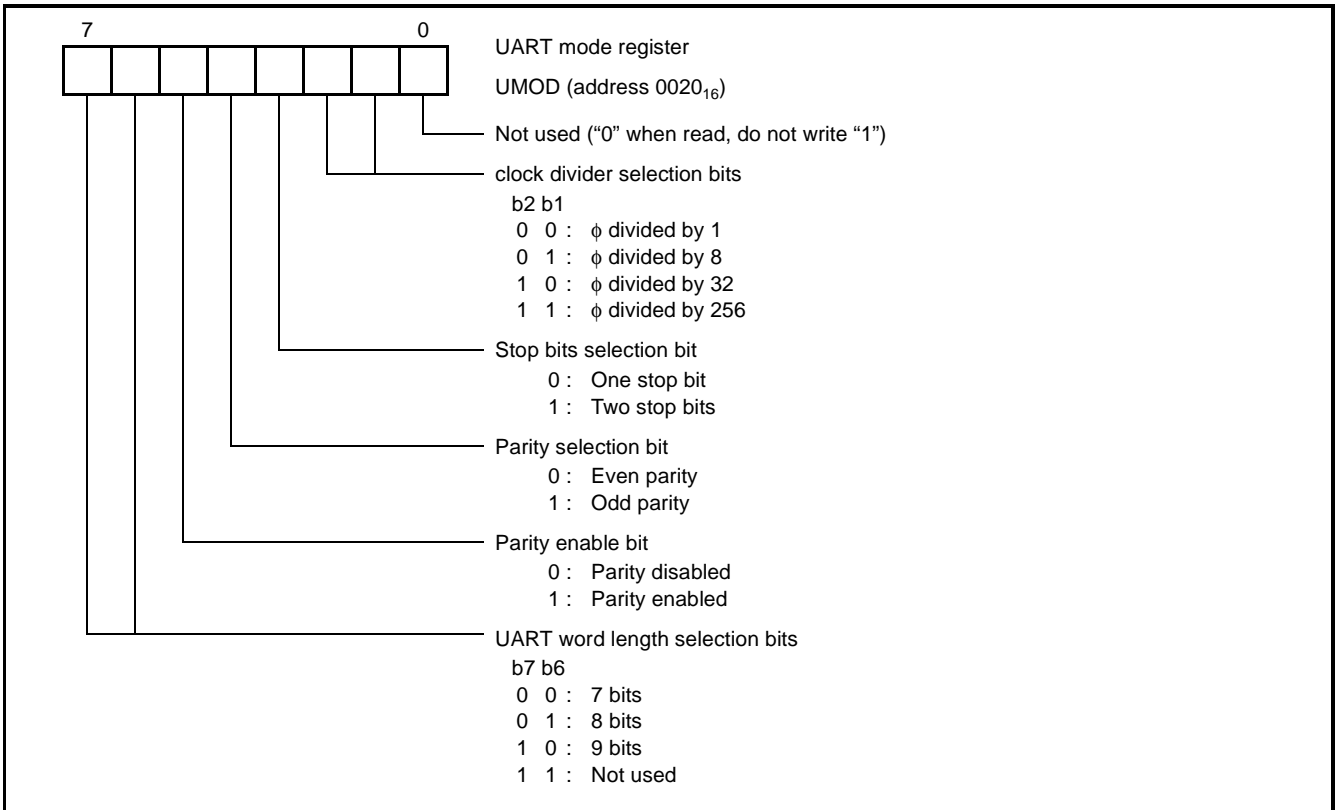


Fig. 27 Structure of UART mode register

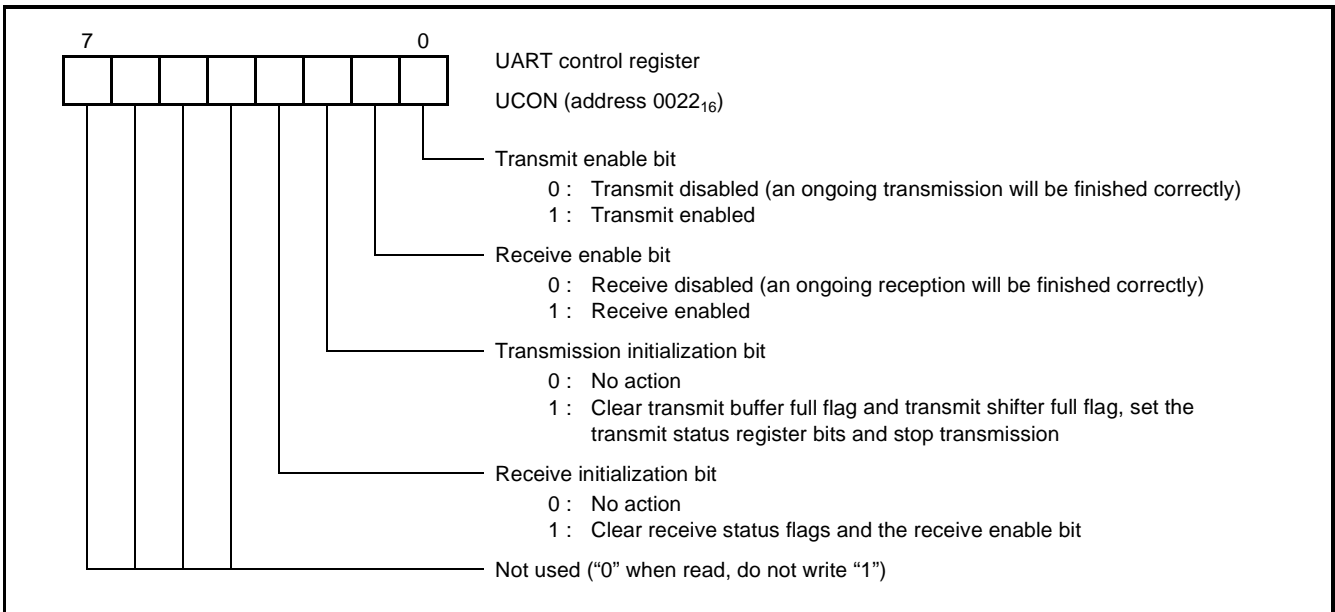


Fig. 28 Structure of UART control register

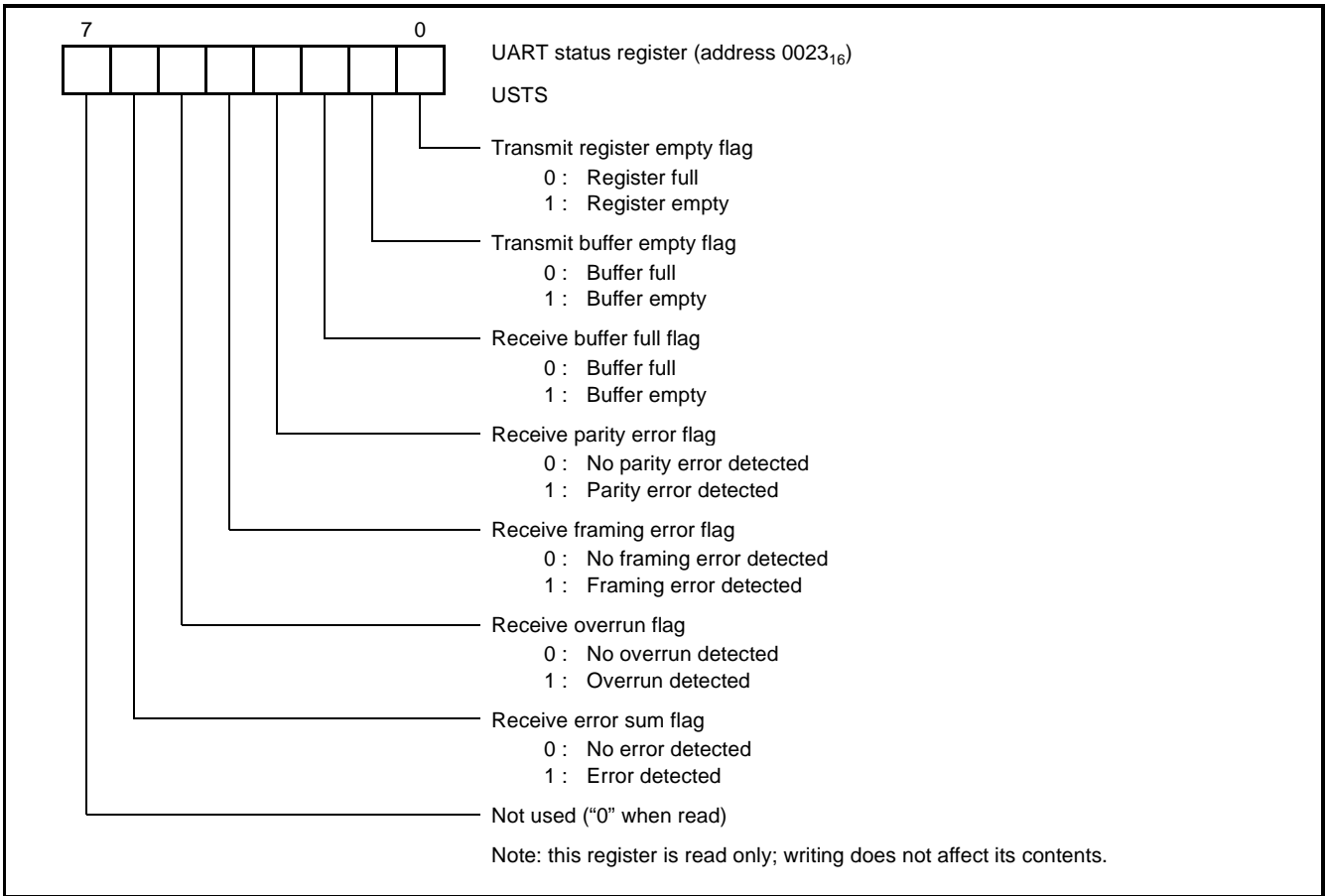


Fig. 29 Structure of UART status register

CAN MODULE

The CAN (Controller Area Network) interface of the 7630 group complies with the 2.0B specification, enabling reception and transmission of frames with either 11- or 29- bit identifier length. Refer to Fig. 31 for a block diagram of the CAN interface.

The programmer's interface to the CAN module is formed by three status/control registers (Fig. 32, Fig. 33, Fig. 34), two bus timing control registers (Fig. 35 Fig. 36), several registers for acceptance filtering (Fig. 37), the transmit and receive buffer registers (Fig. 38) and one dominant level control bit (Fig. 22).

Baud Rate Selection

A programmable clock prescaler is used to derive the CAN module's basic clock from the internal system clock frequency (ϕ). Bit 0 to bit 3 of the CAN bus timing control register represent the prescaler allowing a division ratio from 1 to 1/16 to be selected. So the CAN module basic clock frequency f_{CANB} can be calculated as follows:

$$f_{CANB} = \frac{\phi}{p + 1}$$

where p is the value of the prescaler (selectable from 1 to 15). The effective baud rate of the CAN bus communication depends on the CAN bus timing control parameters and will be explained below.

CAN Bus Timing Control

Each bit-time consists of four different segments (see Fig. 30):

- Synchronization segment (SS),
- Propagation time segment (PTS),
- Phase buffer segment 1 (PBS1) and
- Phase buffer segment 2 (PBS2).

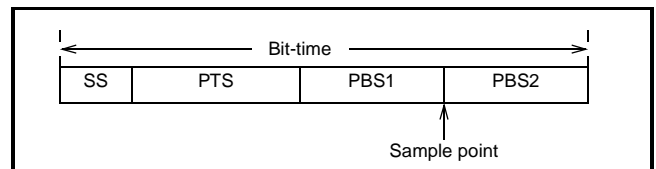


Fig. 30 Bit time of CAN module

The first of these segments is of fixed length (one Time Quantum) and the latter three can be programmed to be 1 to 8 Time Quanta by the CAN bus timing control register 1 and 2 (see Fig. 35 and Fig. 36). The whole bit-time has to consist of minimum 8 and maximum 25 Time Quanta. The duration of one Time Quantum is the cycle time of f_{CANB} . For example, assuming $\phi = 5$ MHz, $p = 0$, one Time Quantum will be 200 ns long. This allows the maximum transmission rate of 625 kb/s to be reached (assuming 8 Time Quanta per bit-time).

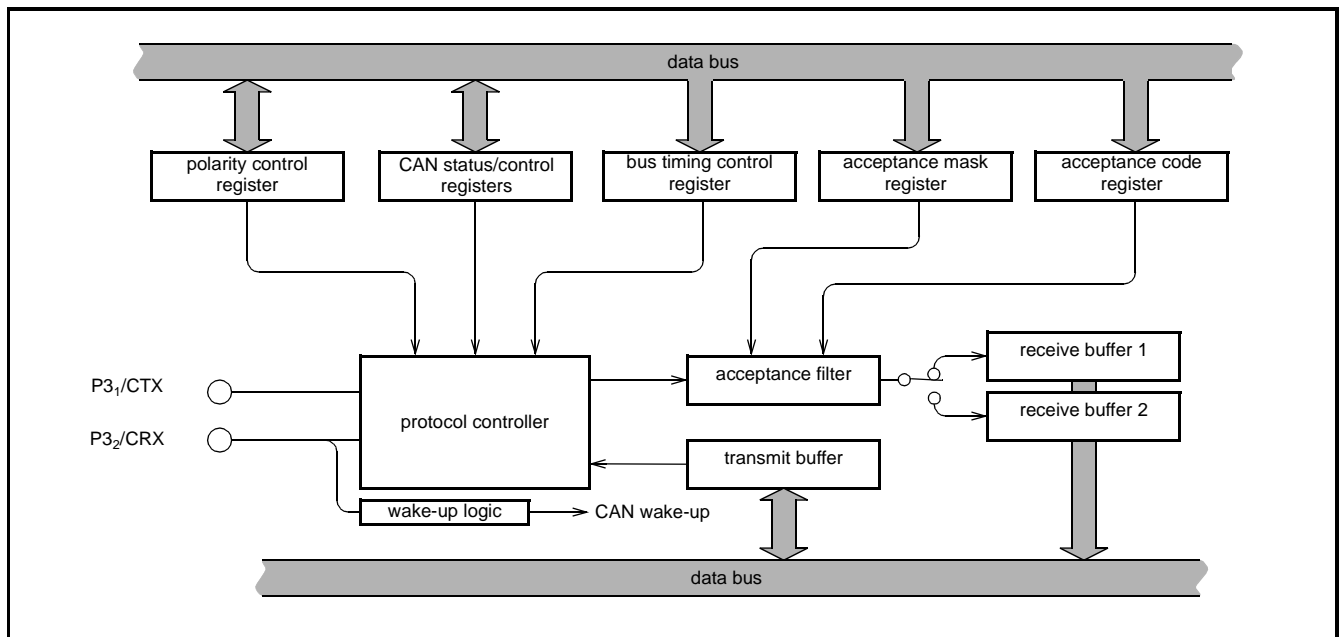


Fig. 31 Block diagram of CAN module

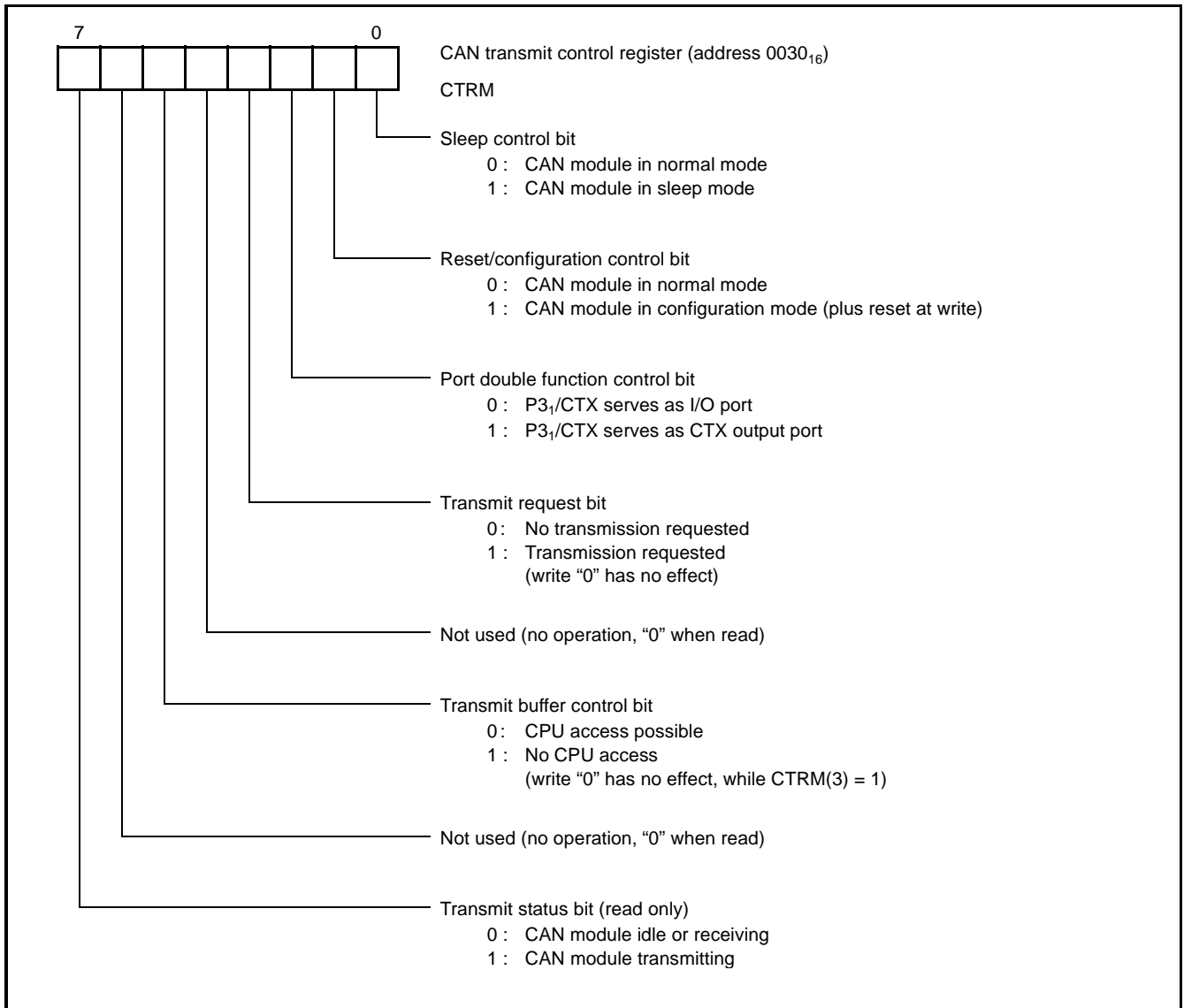


Fig. 32 Structure of CAN transmit control register

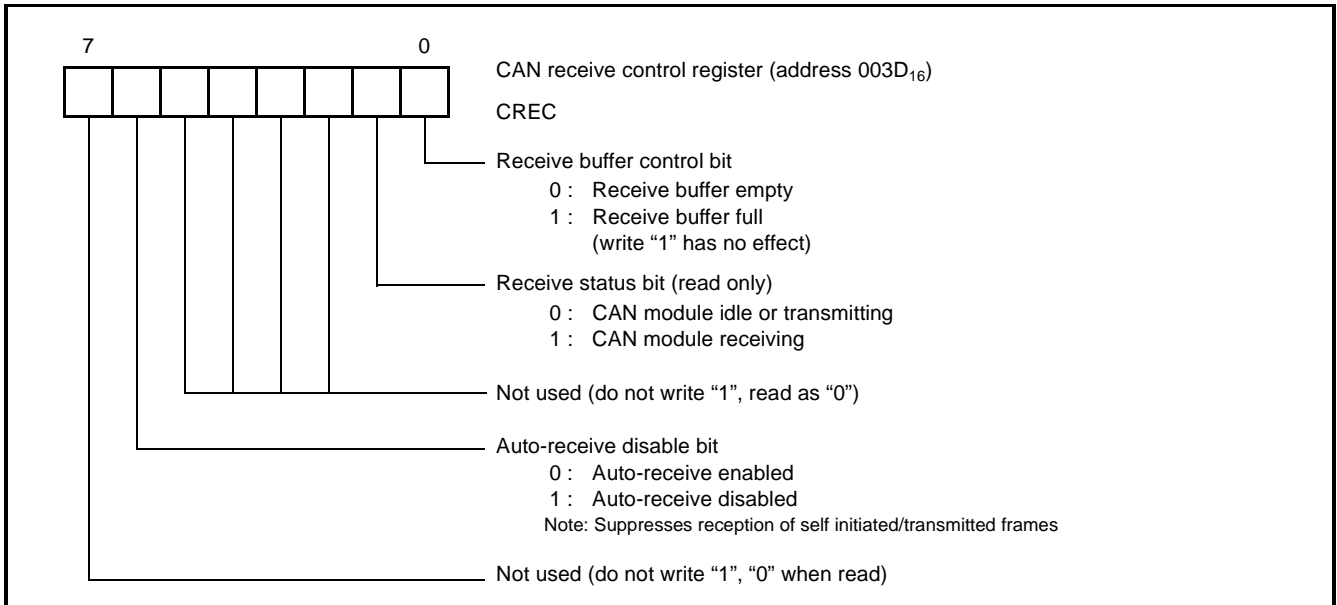


Fig. 33 Structure of CAN receive control register

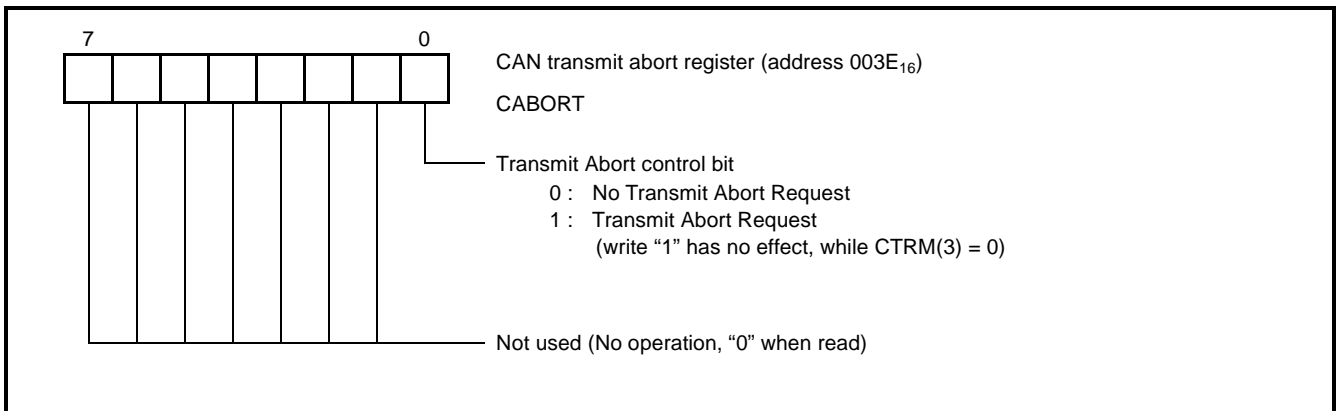


Fig. 34 Structure of CAN transmit abort register

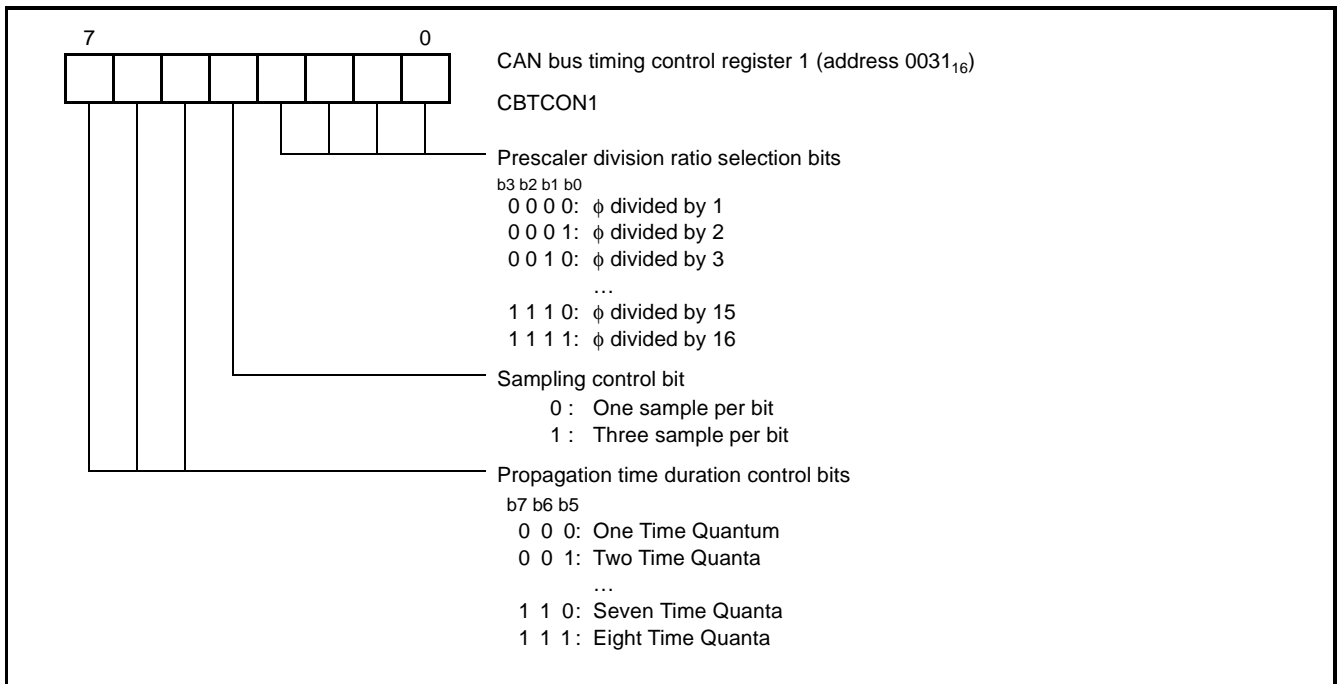


Fig. 35 Structure of CAN bus timing control register 1

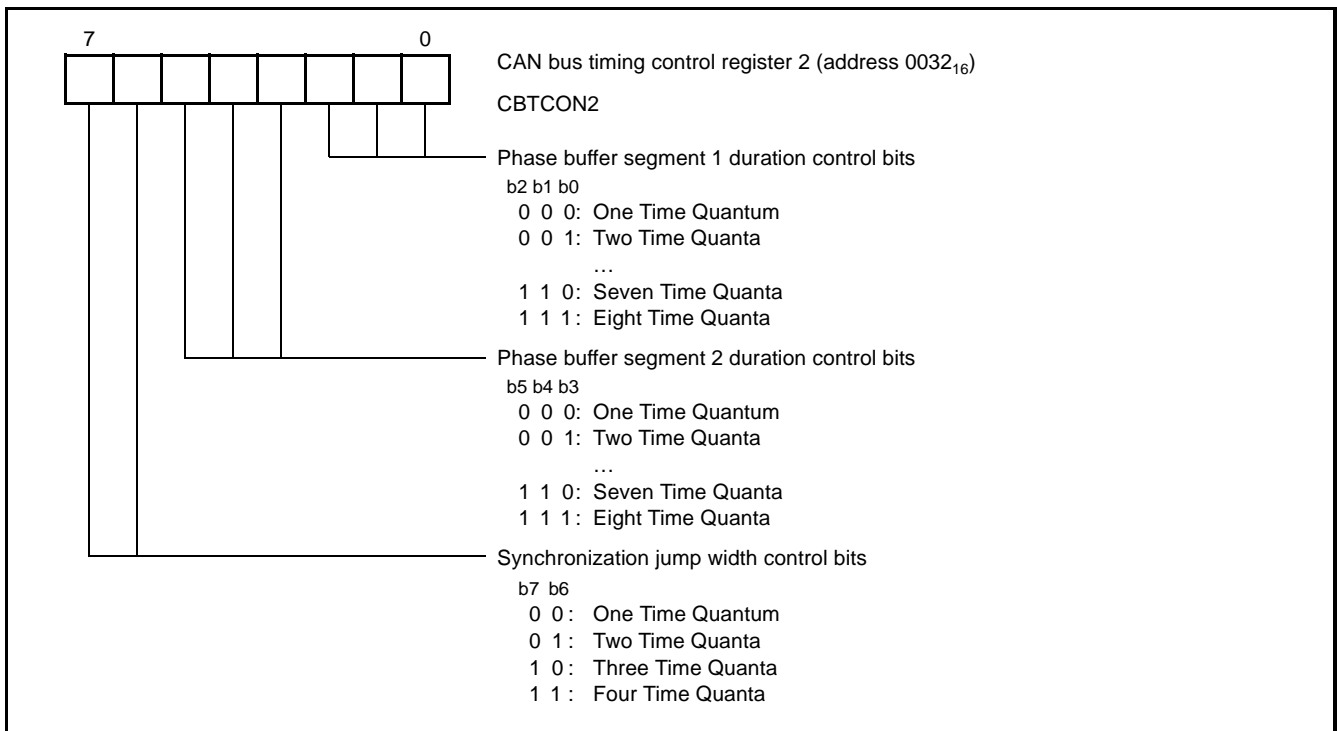


Fig. 36 Structure of CAN bus timing control register 2

SINGLE-CHIP 8-BIT CMOS MICROCOMPUTER

	name	7									0	address
Acceptance code registers:	CAC0	Not used	Not used	Not used	CSID ₁₀	CSID ₉	CSID ₈	CSID ₇	CSID ₆		0033 ₁₆	
	CAC1	CSID ₅	CSID ₄	CSID ₃	CSID ₂	CSID ₁	CSID ₀	Not used	Not used		0034 ₁₆	
	CAC2	Not used	Not used	Not used	Not used	CEID ₁₇	CEID ₁₆	CEID ₁₅	CEID ₁₄		0035 ₁₆	
	CAC3	CEID ₁₃	CEID ₁₂	CEID ₁₁	CEID ₁₀	CEID ₉	CEID ₈	CEID ₇	CEID ₆		0036 ₁₆	
	CAC4	CEID ₅	CEID ₄	CEID ₃	CEID ₂	CEID ₁	CEID ₀	Not used	Not used		0037 ₁₆	
Select the bit pattern of identifiers which allows to pass acceptance filtering.												
Acceptance mask registers:	CAM0	Not used	Not used	Not used	MSID ₁₀	MSID ₉	MSID ₈	MSID ₇	MSID ₆		0038 ₁₆	
	CAM1	MSID ₅	MSID ₄	MSID ₃	MSID ₂	MSID ₁	MSID ₀	Not used	Not used		0039 ₁₆	
	CAM2	Not used	Not used	Not used	Not used	MEID ₁₇	MEID ₁₆	MEID ₁₅	MEID ₁₄		003A ₁₆	
	CAM3	MEID ₁₃	MEID ₁₂	MEID ₁₁	MEID ₁₀	MEID ₉	MEID ₈	MEID ₇	MEID ₆		003B ₁₆	
	CAM4	MEID ₅	MEID ₄	MEID ₃	MEID ₂	MEID ₁	MEID ₀	Not used	Not used		003C ₁₆	
0 : Mask identifier bit (do not care) 1 : Compare identifier bit with acceptance code register bit (Not used: write to "0")												

Fig. 37 Structure of CAN mask and code registers

	name	7									0	offset
	CTB0, CRB0	Not used	Not used	Not used	SID ₁₀	SID ₉	SID ₈	SID ₇	SID ₆		0000 ₁₆	
	CTB1, CRB1	SID ₅	SID ₄	SID ₃	SID ₂	SID ₁	SID ₀	RTR/SRR	IDE		0001 ₁₆	
	CTB2, CRB2	Not used	Not used	Not used	Not used	EID ₁₇	EID ₁₆	EID ₁₅	EID ₁₄		0002 ₁₆	
	CTB3, CRB3	EID ₁₃	EID ₁₂	EID ₁₁	EID ₁₀	EID ₉	EID ₈	EID ₇	EID ₆		0003 ₁₆	
	CTB4, CRB4	EID ₅	EID ₄	EID ₃	EID ₂	EID ₁	EID ₀	RTR	r1		0004 ₁₆	
	CTB5, CRB5	Not used	Not used	Not used	r ₀	DLC ₃	DLC ₂	DLC ₁	DLC ₀		0005 ₁₆	
	CTB6, CRB6	data byte 0									0006 ₁₆	
	CTB7, CRB7	data byte 1									0007 ₁₆	
	CTB8, CRB8	data byte 2									0008 ₁₆	
	CTB9, CRB9	data byte 3									0009 ₁₆	
	CTBA, CRBA	data byte 4									000A ₁₆	
	CTBB, CRBB	data byte 5									000B ₁₆	
	CTBC, CRBC	data byte 6									000C ₁₆	
	CTBD, CRBD	data byte 7									000D ₁₆	
Calculate the actual address as follows: TxD buffer address = 0040 ₁₆ + offset RxD buffer address = 0050 ₁₆ + offset (Not used: write to "0")												

Fig. 38 Structure of CAN transmission and reception buffer registers

Note 1: All CAN related SFRs must not be written in "CAN sleep" mode.

A-D CONVERTER

The A-D converter uses the successive approximation method with 8 bit resolution. The functional blocks of the A-D converter are described below. Refer to Block diagram of A-D converter.

Comparison Voltage Generator

The comparison voltage generator divides the voltage between AV_{SS} and V_{REF} by 256, and outputs the divided voltage.

Channel Selector

The channel selector selects one of ports $P0_0/AN_0$ to $P0_7/AN_7$, and inputs its voltage to the comparator.

A-D conversion register AD

The A-D conversion register is a read-only register that stores the result of an A-D conversion. This register must not be read during an A-D conversion.

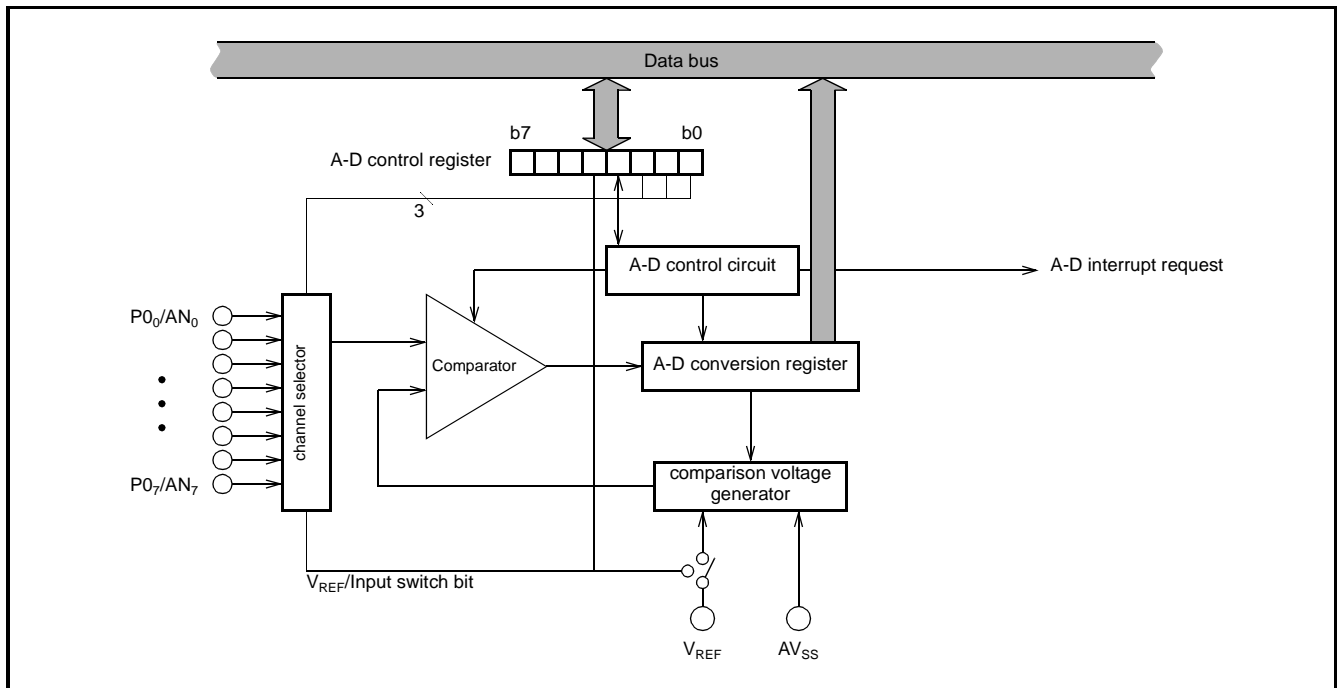


Fig. 39 Block diagram of A-D converter

A-D control register (Structure of A-D control register)

The A-D control register controls the A-D conversion process. Bits 0 to 2 select a specific analog input pin. Bit 3 signals the completion of an A-D conversion. The value of this bit remains "0" during an A-

D conversion, and changes to "1" when an A-D conversion ends. Writing "0" to this bit starts the A-D conversion. Bit 4 is the V_{REF} /Input switch bit.

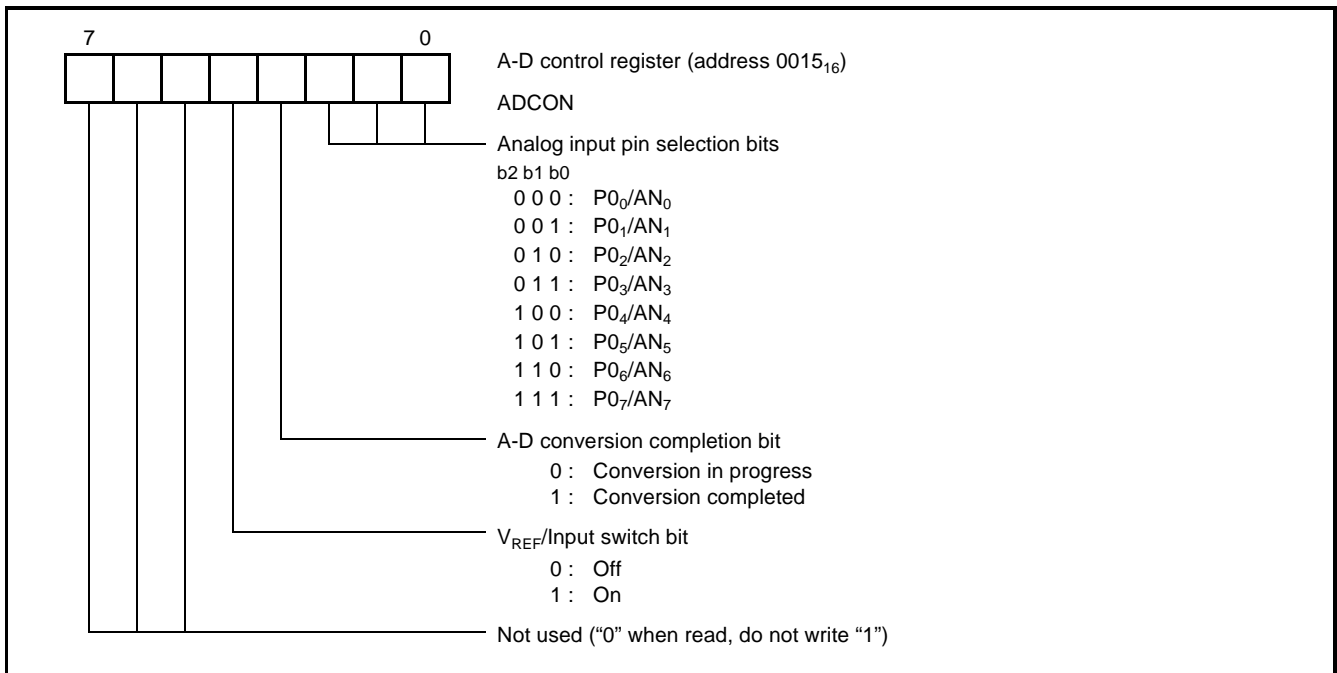


Fig. 40 Structure of A-D control register

A-D Converter Operation

The comparator and control circuit reference an analog input voltage with the reference voltage, then stores the result in the A-D conversion register. When an A-D conversion is complete, the control circuit sets the A-D conversion completion bit and the A-D inter-

rupt request bit to "1". The result of A-D conversion can be obtained from the A-D conversion register, AD (address 0014₁₆).

Note that the comparator is linked to a capacitor, so set $f(X_{IN})$ to 500 kHz or higher during A-D conversion.

WATCHDOG TIMER

The watchdog timer consists of two separate counters: one 7-bit counter (WD_H) and one 4-bit counter (WD_L). Cascading both counters or using the high-order counter allows only to select the time-out from either 524288 or 32768 cycles of the internal clock ϕ . Refer to Fig. 41 and Fig. 42. Both counters are addressed by the same watchdog timer register (WDT). When writing to this register, both counters will be set to the following default values:

- the high-order counter will be set to address 7F₁₆
- the low-order counter will be set to address F₁₆

regardless of the data written to the WDT register. Reading the watchdog timer register will return the corresponding control bit status, not the counter contents.

Once the WDT register is written to, the watchdog timer starts counting down and the watchdog timer interrupt is enabled. Once it is running, the watchdog timer cannot be disabled or stopped except by reset. On a watchdog timer underflow, a non-maskable watchdog timer interrupt will be requested.

To prevent the system being stopped by STP instruction, this instruction can be disabled by the STP instruction disable bit of WDT register. Once the STP instruction is disabled, it cannot be enabled again except by RESET.

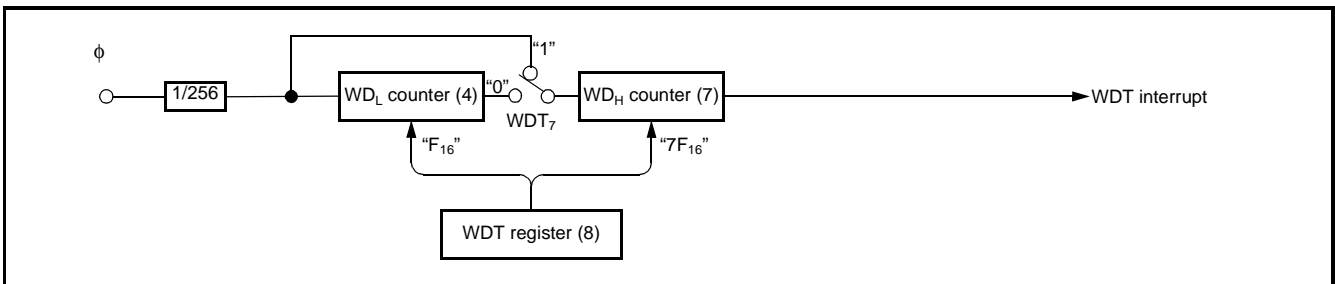


Fig. 41 Block diagram of watchdog timer

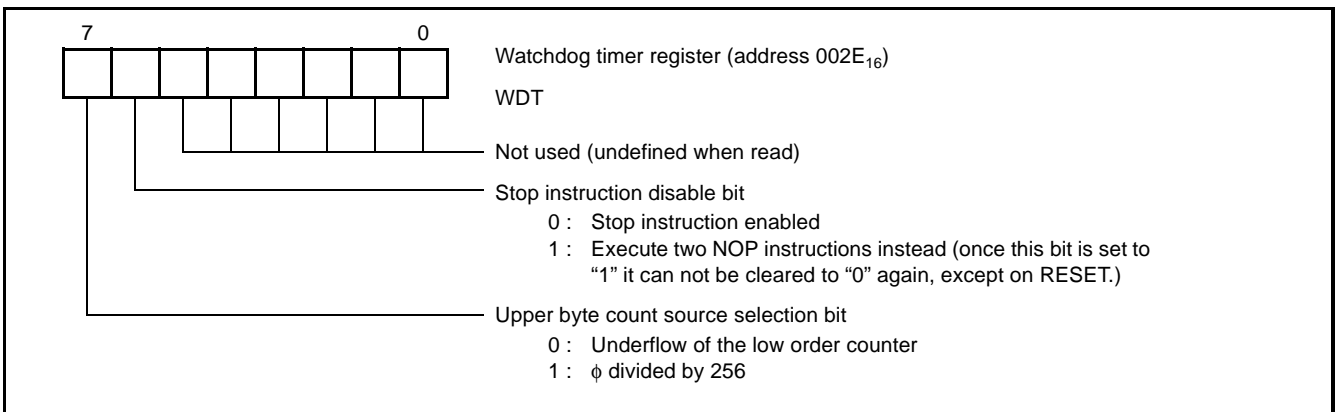


Fig. 42 Structure of watchdog timer register (ϕ is internal clock system)

RESET CIRCUIT

The 7630 group is reset according to the sequence shown in Fig. 44. It starts program execution from the address formed by the contents of the addresses $FFFB_{16}$ and $FFFA_{16}$, when the $\overline{\text{RESET}}$ pin is held at "L" level for more than $2 \mu\text{s}$ while the power supply voltage is

in the recommended operating condition and then returned to "H" level.

Refer to Fig. 43 for an example of the reset circuit.

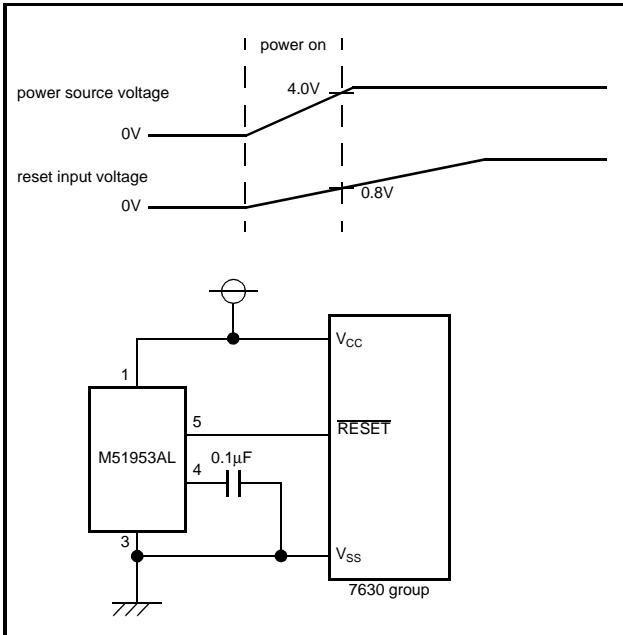


Fig. 43 Example of reset circuit

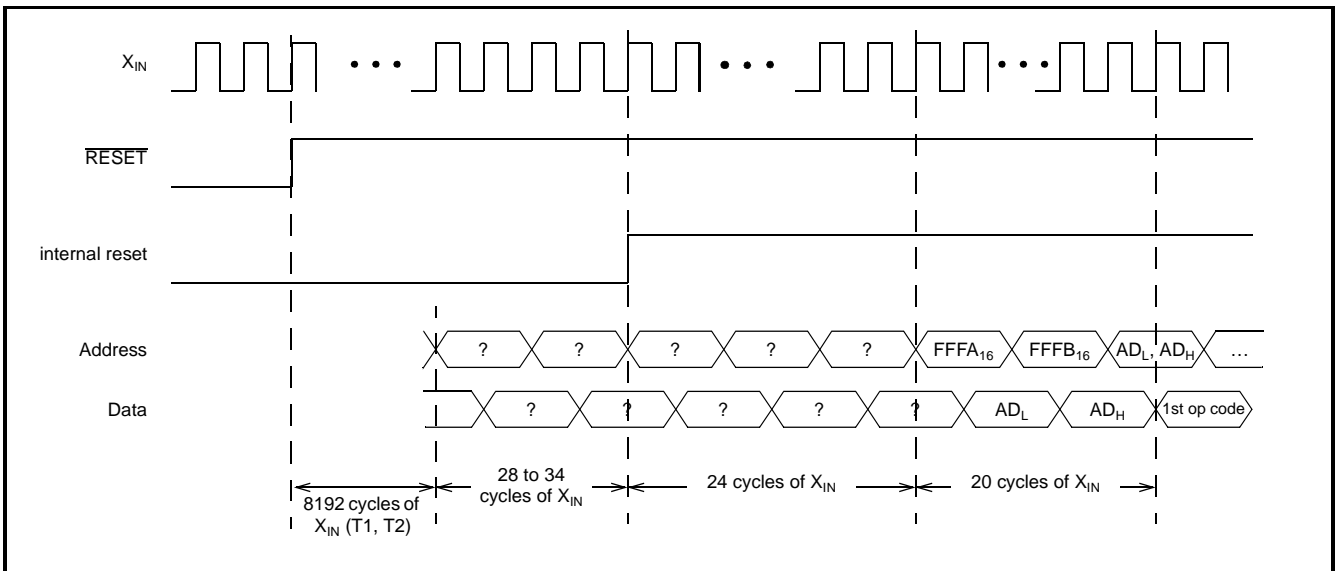


Fig. 44 Reset sequence

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Register	Address	Register contents	Register	Address	Register contents
CPU mode reg.	0000 ₁₆	48 ₁₆	Timer XH	001B ₁₆	FF ₁₆
Interrupt request reg. A	0002 ₁₆	00 ₁₆	Timer YL	001C ₁₆	FF ₁₆
Interrupt request reg. B	0003 ₁₆	00 ₁₆	Timer YH	001D ₁₆	FF ₁₆
Interrupt request reg. C	0004 ₁₆	00 ₁₆	Timer X mode reg.	001E ₁₆	00 ₁₆
Interrupt control reg. A	0005 ₁₆	00 ₁₆	Timer Y mode reg.	001F ₁₆	00 ₁₆
Interrupt control reg. B	0006 ₁₆	00 ₁₆	UART mode reg.	0020 ₁₆	00 ₁₀
Interrupt control reg. C	0007 ₁₆	00 ₁₆	UART control reg.	0022 ₁₆	00 ₁₆
Port P0 reg.	0008 ₁₆	00 ₁₆	UART status reg.	0023 ₁₆	07 ₁₀
Port P0 direction reg.	0009 ₁₆	00 ₁₆	Port P0 pull-up control reg.	0028 ₁₆	00 ₁₆
Port P1 reg.	000A ₁₆	00 ₁₆	Port P1 pull-up control reg.	0029 ₁₆	00 ₁₆
Port P1 direction reg.	000B ₁₆	00 ₁₆	Port P2 pull-up control reg.	002A ₁₆	00 ₁₆
Port P2 reg.	000C ₁₆	00 ₁₆	Port P3 pull-up control reg.	002B ₁₆	00 ₁₆
Port P2 direction reg.	000D ₁₆	00 ₁₆	Port P4 pull-up/down control reg.	002C ₁₆	00 ₁₆
Port P3 reg.	000E ₁₆	00 ₁₆	Interrupt polarity selection reg.	002D ₁₆	00 ₁₆
Port P3 direction reg.	000F ₁₆	00 ₁₆	Watchdog timer reg.	002E ₁₆	3F ₁₆
Port P4 reg.	0010 ₁₆	00 ₁₆	Polarity control reg.	002F ₁₆	00 ₁₆
Port P4 direction reg.	0011 ₁₆	00 ₁₆	CAN transmit control reg.	0030 ₁₆	02 ₁₆
Serial I/O control reg.	0013 ₁₆	00 ₁₆	CAN bus timing control reg. 1	0031 ₁₆	00 ₁₆
A-D control reg.	0015 ₁₆	08 ₁₆	CAN bus timing control reg. 2	0032 ₁₆	00 ₁₆
Timer 1	0016 ₁₆	FF ₁₆	CAN receive control reg.	003D ₁₆	00 ₁₆
Timer 2	0017 ₁₆	01 ₁₆	CAN transmit abort reg.	003E ₁₆	00 ₁₆
Timer 3	0018 ₁₆	FF ₁₆	Processor status reg.	(PS)	04 ₁₆
Timer 123 mode reg.	0019 ₁₆	40 ₁₆	Program counter (high-order byte)	(PCH)	contents of FFFB ₁₆
Timer XL	001A ₁₆	FF ₁₆	Program counter (low-order byte)	(PCL)	contents of FFFA ₁₆

Note: The contents of RAM and registers other than the above registers are undefined after reset; thus software initialization is required.

Fig. 45 Internal status of microcomputer after reset

CLOCK GENERATING CIRCUIT

The 7630 group is equipped with an internal clock generating circuit.

Please refer to Fig. 46 for a circuit example using a ceramic resonator or quartz crystal oscillator. For the capacitor values, refer to the manufacturers recommended parameters which depend on each oscillators characteristics. When using an external clock, input it to the X_{IN} pin and leave X_{OUT} open.

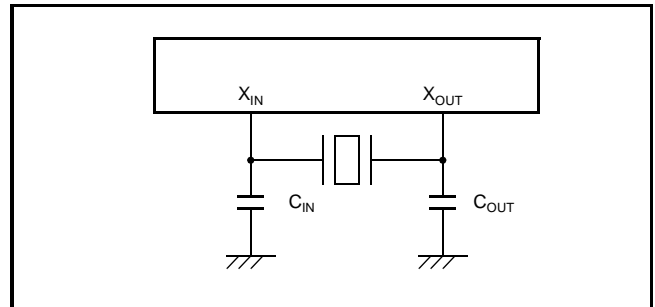


Fig. 46 Ceramic resonator circuit

Oscillation Control

The 7630 group has two low power modes: the stop and the wait mode.

Stop mode

The microcomputer enters the stop mode by executing the STP instruction. The oscillator stops with the internal clock ϕ at "H" level. Timers 1 and 2 will be cascaded and initialized by their reload latches contents. The count source for timer 1 will be set to $f(X_{IN})/16$.

Oscillation is restarted if an external interrupt is accepted or at reset. When using an external interrupt, the internal clock ϕ remains at "H" level until timer 2 underflows allowing a time-out until the

clock oscillation becomes stable. When using reset, a fixed time-out will be generated allowing oscillation to stabilize.

Wait mode

The microcomputer enters the wait mode by executing the WIT instruction. The internal clock ϕ stops at "H" level while the oscillator keeps running.

Recovery from wait mode can be done in the same way as from stop mode. However, the time-out period mentioned above is not required to return from wait-mode, thus no such time-out mechanism has been implemented.

Note: Set the interrupt enable bit of the interrupt source to be used to return from stop or wait mode to "1" before executing STP or WIT instruction.

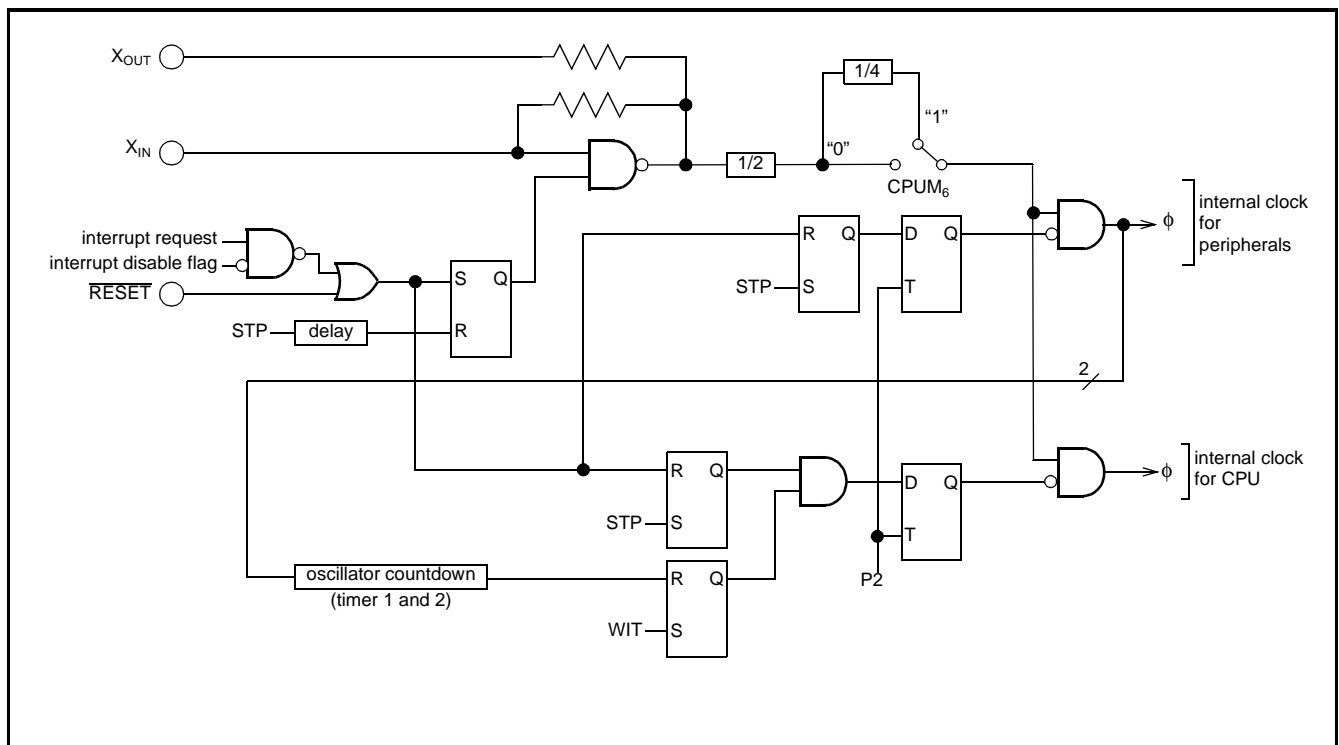


Fig. 47 Block diagram of clock generating circuit

DATA REQUIRED FOR MASK ORDERS

The following are necessary when ordering a mask ROM production:

- 1 Mask ROM Order Confirmation Form
- 2 Mask Specification Form
- 3 Contents of Mask ROM, in EPROM form (three identical copies)

PROM PROGRAMMING METHOD

The built-in PROM of the blank One Time PROM version and built-in EPROM version can be read or programmed with a general purpose PROM programmer using a special programming adapter. Set the address of PROM programmer to the user ROM area.

For the programming adapter type name, please refer to the following table:

Table 6: Programming adapter name

MCU type	Package	Programming adapter type
One Time PROM	44P6N-A	PCA7430
EPROM	80D0	PCA7431

The PROM of the blank One Time PROM version is not tested or screened in the assembly process and following processes. To ensure proper operation after programming, the procedure shown in Fig. 48 is recommended to verify programming.

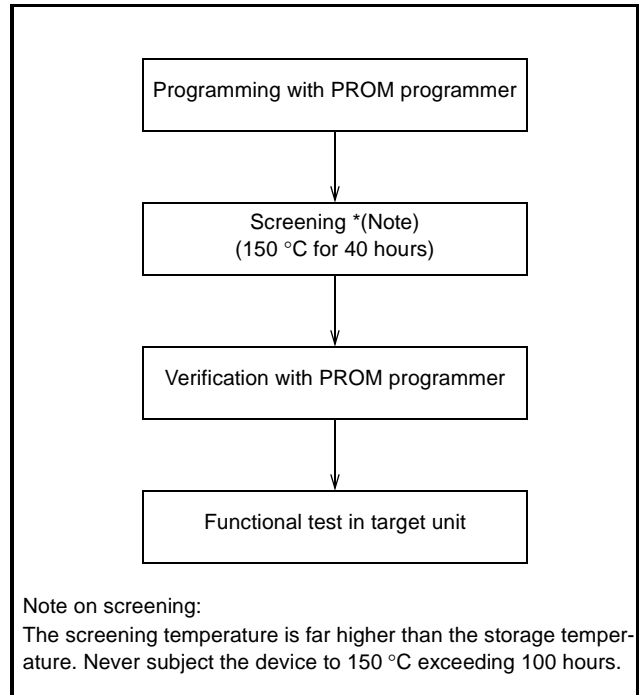


Fig. 48 Programming and testing of One Time PROM version

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Table 7: ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Conditions	Ratings	Unit
V_{CC}	Power source voltage		-0.3 to 7.0	V
V_I	Input voltage P0 ₀ —P0 ₇ , P1 ₁ —P1 ₇ , P2 ₀ —P2 ₇ , P3 ₀ —P3 ₄ , P4 ₀ —P4 ₇ , RESET, X _{IN}	All voltages with respect to V _{SS} and output transistors are "off".	-0.3 to V _{CC} + 0.3	V
V_O	Output voltage P0 ₀ —P0 ₇ , P1 ₂ —P1 ₇ , P2 ₀ —P2 ₇ , P3 ₀ —P3 ₄ , P4 ₀ —P4 ₇ , X _{OUT}		-0.3 to V _{CC} + 0.3	V
P_d	Power dissipation	T _a = 25 °C	500	mW
T_{opr}	Operating temperature		-40 to 85	°C
T_{stg}	Storage temperature		-60 to 150	°C

Table 8: RECOMMENDED OPERATING CONDITIONS

(V_{CC} = 4.0 to 5.5 V, V_{SS} = AV_{SS} = 0 V, T_a = -40 to 85 °C unless otherwise noted)

Symbol	Parameter	Limits			Unit
		min.	typ.	max.	
V_{CC}	Power source voltage	4.0	5.0	5.5	V
V_{SS}			0		V
V_{IH}	"H" Input voltage P0 ₀ —P0 ₇ , P1 ₁ —P1 ₇ , P2 ₀ —P2 ₇ , P3 ₀ —P3 ₄ , P4 ₀ —P4 ₇ , RESET, X _{IN}	0.8 · V _{CC}		V _{CC}	V
V_{IL}	"L" Input voltage P0 ₀ —P0 ₇ , P1 ₁ —P1 ₇ , P2 ₀ —P2 ₇ , P3 ₀ —P3 ₄ , P4 ₀ —P4 ₇ , RESET, X _{IN}	0		0.2 · V _{CC}	V
$\sum I_{OH} (peak)$	"H" sum peak output current P0 ₀ —P0 ₇ , P1 ₂ —P1 ₇ , P2 ₀ —P2 ₇ , P3 ₀ —P3 ₄ , P4 ₀ —P4 ₇			-80	mA
$\sum I_{OH} (avg)$	"H" sum average output current			-40	mA
$\sum I_{OL} (peak)$	"L" sum peak output current			80	mA
$\sum I_{OL} (avg)$	"L" sum average output current			40	mA
$I_{OH} (peak)$	"H" peak output current			-10	mA
$I_{OH} (avg)$	"H" average output current			-5	mA
$I_{OL} (peak)$	"L" peak output current			10	mA
$I_{OL} (avg)$	"L" average output current			5	mA
I_{IO}	input current at overvoltage condition (V _I > V _{CC}) P1 ₁ —P1 ₇ , P2 ₀ —P2 ₇ , P3 ₀ —P3 ₄ , P4 ₀ —P4 ₇			1	mA
$\sum I_{IO}$	total input current at overvoltage condition (V _I > V _{CC}) P1 ₁ —P1 ₇ , P2 ₀ —P2 ₇ , P3 ₀ —P3 ₄ , P4 ₀ —P4 ₇			16	mA
$f(CNTR)$	Timer input frequency (based on 50 % duty)	P1 ₄ /CNTR ₀ , P1 ₅ /CNTR ₁ (except bi-phase counter mode)		f(X _{IN})/16	MHz
		P1 ₃ /TX ₀ , P1 ₄ /CNTR ₀ (bi-phase counter mode)		f(X _{IN})/32	MHz
$f(X_{IN})$	Clock input oscillation frequency			10	MHz

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Table 9: ELECTRICAL CHARACTERISTICS

($V_{CC} = 4.0$ to 5.5 V, $V_{SS} = AV_{SS} = 0$ V, $T_a = -40$ to 85 °C unless otherwise noted)

Symbol	Parameter	Test conditions	Limits			Unit
			min.	typ.	max.	
V_{OH}	"H" output voltage P0 ₀ —P0 ₇ , P1 ₂ —P1 ₇ , P2 ₀ —P2 ₇ , P3 ₀ —P3 ₄ , P4 ₀ —P4 ₇	$I_{OH} = -5$ mA	$0.8 \cdot V_{CC}$			V
V_{OL}	"L" output voltage P0 ₀ —P0 ₇ , P1 ₂ —P1 ₇ , P2 ₀ —P2 ₇ , P3 ₀ —P3 ₄ , P4 ₀ —P4 ₇	$I_{OL} = 5$ mA			2.0	V
$V_{T+} - V_{T-}$	Hysteresis P1 ₁ /INT ₀ , P1 ₂ /INT ₁ , P1 ₃ /TX ₀ , P1 ₄ /CNTR ₀ , P1 ₅ /CNTR ₁ , P2 ₀ /S _{IN} , P2 ₂ /S _{CLK} , P2 ₆ /U _{RTS} , P2 ₇ /U _{CTS} , P3 ₂ /CRX, RESET			0.5		V
I_{IH}	"H" input current P0 ₀ —P0 ₇ , P1 ₁ —P1 ₇ , P2 ₀ —P2 ₇ , P3 ₀ —P3 ₄ , P4 ₀ —P4 ₇ , RESET	$V_i = V_{CC}$			5	μA
I_{IH}	"H" input current X _{IN}	$V_i = V_{CC}$		4		μA
I_{iL}	"L" input current P0 ₀ —P0 ₇ , P1 ₁ —P1 ₇ , P2 ₀ —P2 ₇ , P3 ₀ —P3 ₄ , P4 ₀ —P4 ₇ , RESET	$V_i = V_{SS}$			-5	μA
I_{iL}	"L" input current X _{IN}	$V_i = V_{SS}$		-4		μA
I_{IH}	"H" input current P3 ₂ , P4 ₀ —P4 ₇	$V_i = V_{CC}$ Pull-Down = 'On'	20		200	μA
I_{iL}	"L" input current P0 ₀ —P0 ₇ , P1 ₁ —P1 ₇ , P2 ₀ —P2 ₇ , P3 ₀ —P3 ₄ , P4 ₀ —P4 ₇ , RESET	$V_i = V_{SS}$ Pull-Up = 'On'	-200		-20	μA
V_{RAM}	RAM hold voltage	When clock stopped	2.0			V

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Symbol	Parameter	Test conditions	Limits			Unit
			min.	typ.	max.	
I _{CC}	Power source current	high speed mode, f(X _{IN}) = 8MHz, V _{CC} = 5V, output transistors off, CAN module running, ADC running		11.0	18.0	mA
		high speed mode, f(X _{IN}) = 8MHz, V _{CC} = 5V, output transistors off, CAN module stopped, ADC running		9.0	16.0	mA
		middle speed mode, f(X _{IN}) = 8MHz, V _{CC} = 5V, output transistors off, CAN module running, ADC running		6.0	11.0	mA
		middle speed mode, wait mode, f(X _{IN}) = 8MHz, V _{CC} = 5V, output transistors off, CAN module stopped, ADC stopped		2.0		mA
		stop mode, f(X _{IN}) = 0MHz, V _{CC} = 5V, T _a = 25°C		0.1	1.0	μA
		stop mode, f(X _{IN}) = 0MHz, V _{CC} = 5V, T _a = 85°C			10.0	μA

Table 10: A-D converter characteristics

(V_{CC} = 4.0 to 5.5 V, V_{SS} = AV_{SS} = 0 V, T_a = -40 to 85 °C, unless otherwise noted)

Symbol	Parameter	Test conditions	Limits			Unit
			min.	typ.	max.	
—	Resolution				8	Bit
—	Absolute accuracy			±1.0	±2.5	LSB
t _{CONV}	Conversion time	high-speed mode	106		108	t _C (X _{IN})
		middle-speed mode	424		432	t _C (X _{IN})
V _{REF}	Reference input voltage		2.0		V _{CC}	V
I _{REF}	Reference input current	V _{CC} = V _{REF} = 5.12 V		150	200	μA
R _{LADDER}	Ladder resistor value			35		kΩ
I _{IAN}	Analog input current	V _I = V _{SS} to V _{CC}		0.5	5.0	μA

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Table 11: Timing requirements

($V_{CC}=4.0$ to 5.5 V, $V_{SS}=AV_{SS}=0$ V, $T_a=-40$ to 85 °C unless otherwise noted)

Symbol	Parameter	Limits			Unit
		min.	typ.	max.	
$t_W(\text{RESET})$	Reset input "L" pulse width	2			μs
$t_C(X_{IN})$	External clock input cycle time	100			ns
$t_{WH}(X_{IN})$	External clock input "H" pulse width	37			ns
$t_{WL}(X_{IN})$	External clock input "L" pulse width	37			ns
$t_C(\text{CNTR})$	CNTR ₀ , CNTR ₁ input cycle time (except bi-phase counter mode)	1600			ns
	CNTR ₀ input cycle time (bi-phase counter mode)	2000			ns
$t_{WH}(\text{CNTR})$	CNTR ₀ , CNTR ₁ input "H" pulse width (except bi-phase counter mode)	800			ns
	CNTR ₀ input "H" pulse width (bi-phase counter mode)	1000			ns
$t_{WL}(\text{CNTR})$	CNTR ₀ , CNTR ₁ input "L" pulse width (except bi-phase counter mode)	800			ns
	CNTR ₀ input "L" pulse width (bi-phase counter mode)	1000			ns
$t_L(\text{CNTR}_0\text{-TX}_0)$	Lag of CNTR ₀ and TX ₀ input edges (bi-phase counter mode)	500			ns
$t_C(\text{TX}_0)$	TX ₀ input cycle time (bi-phase counter mode)	3200			ns
$t_{WH}(\text{TX}_0)$	TX ₀ input "H" pulse width (bi-phase counter mode)	1600			ns
$t_{WL}(\text{TX}_0)$	TX ₀ input "L" pulse width (bi-phase counter mode)	1600			ns
$t_{WH}(\text{INT})$	INT ₀ , INT ₁ input "H" pulse width	460			ns
$t_{WL}(\text{INT})$	INT ₀ , INT ₁ input "L" pulse width	460			ns
$t_C(\text{S}_{CLK})$	Serial I/O clock input cycle time	$8 \cdot t_C(X_{IN})$			ns
$t_{WH}(\text{S}_{CLK})$	Serial I/O clock input "H" pulse width	$4 \cdot t_C(X_{IN})$			ns
$t_{WL}(\text{S}_{CLK})$	Serial I/O clock input "L" pulse width	$4 \cdot t_C(X_{IN})$			ns
$t_{SU}(\text{S}_{IN}\text{-S}_{CLK})$	Serial I/O input setup time	200			ns
$t_H(\text{S}_{CLK}\text{-S}_{IN})$	Serial I/O input hold time	150			ns

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Table 12: Switching characteristics

($V_{CC} = 4.0$ to 5.5 V, $V_{SS} = AV_{SS} = 0$ V, $T_a = -40$ to 85 °C, unless otherwise noted)

Symbol	Parameter	Limits			Unit
		min.	typ.	max.	
$t_{WH}(S_{CLK})$	Serial I/O clock output "H" pulse width	$0.5 \cdot t_C(S_{CLK}) - 50$			ns
$t_{WL}(S_{CLK})$	Serial I/O clock output "L" pulse width	$0.5 \cdot t_C(S_{CLK}) - 50$			ns
$t_D(S_{CLK}-S_{OUT})$	Serial I/O output delay time			50	ns
$t_V(S_{CLK}-S_{OUT})$	Serial I/O output valid time	0		50	ns
$t_R(S_{CLK})$	Serial I/O clock output rise time			50	ns
$t_R(CMOS)$	CMOS output rise time		10	50	ns
$t_F(CMOS)$	CMOS output fall time		10	50	ns

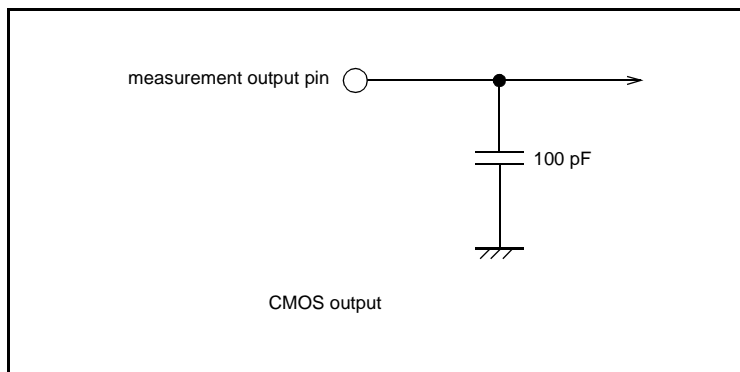


Fig. 49 Circuit for measuring output switching characteristics

TIMING DIAGRAM

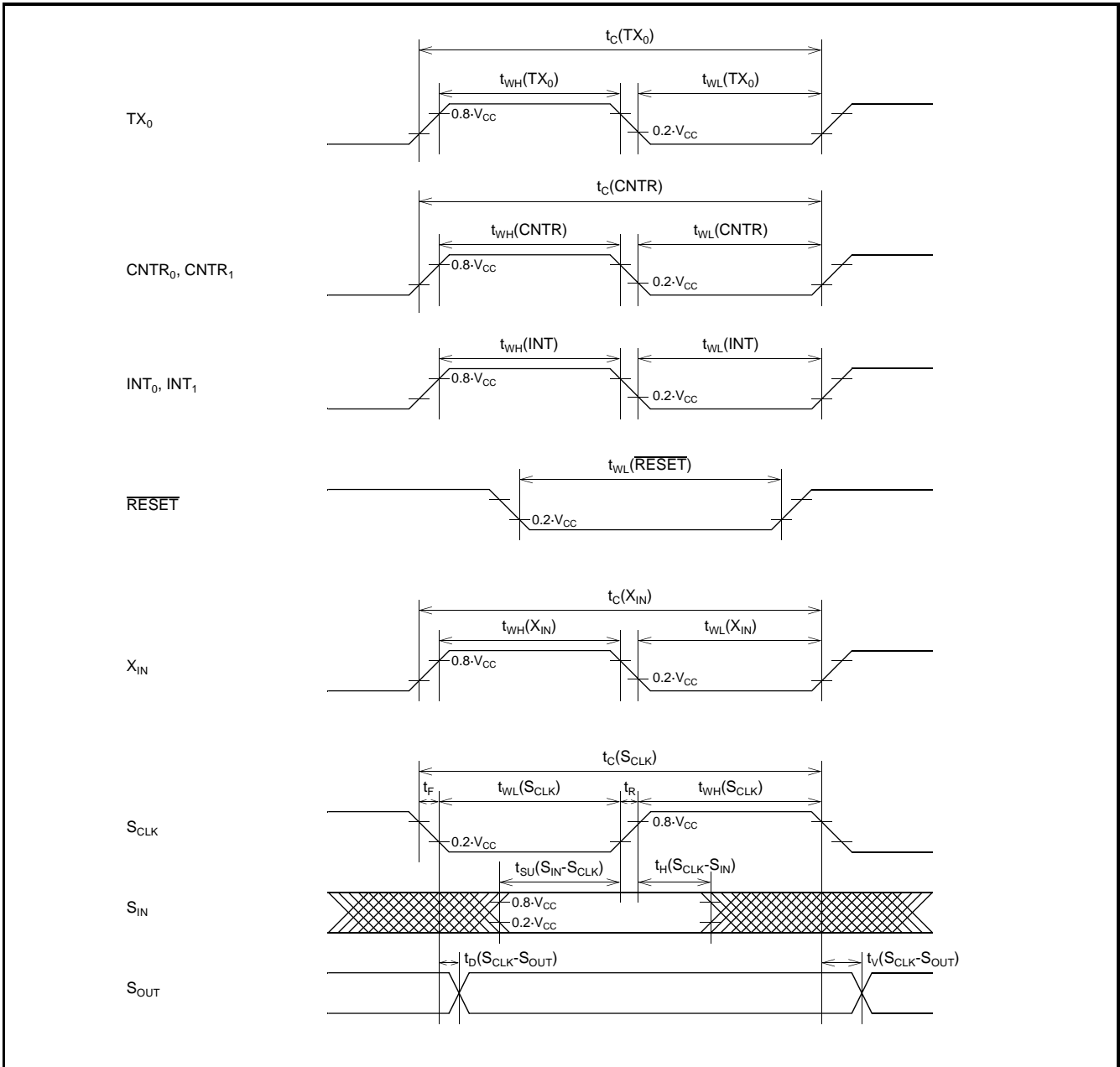


Fig. 50 Timing diagram

REVISION	DATE	Page		MODIFICATIONS
		New	Old	
1.1	10. 98			<p>“CAN controller” is replaced by “CAN module” in whole document.</p> <p>11 11 Schematics (8) and (11) are corrected.</p> <p>18 18 Replaced: “PUPD_j” with “PUP4_j”</p> <p>26 26 Replaced: “UT_XD” with “SOUT” Replaced: “UR_XD” with “SIN”</p> <p>38 38 Replaced: “FFFB_H” with “FFFB₁₆” Replaced: “FFFA_H” with “FFFA₁₆”</p> <p>41 Replaced: “44P6N” with “44P6N-A)</p>
(1.2)	13.01.99	43	43	Values changed:Iih(35, 113) to (20, 200) and Iil(-122, -70) to (-200, -20); typical values are removed.
		10	10	Schematic (1) is modified.
		35	35	Fig. 39 is modified.