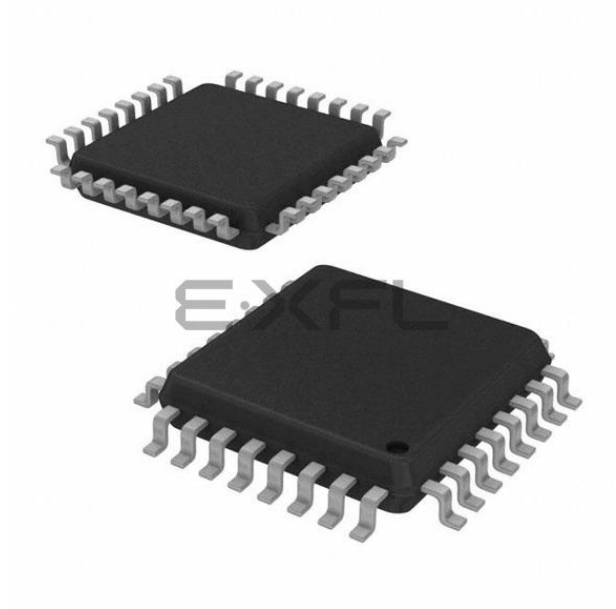

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Program Memory Type	FLASH
EEPROM Size	-
RAM Size	2K x 8
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Data Converters	A/D 10x12b
Oscillator Type	External
Operating Temperature	-40°C ~ 125°C (TA)
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Package / Case	32-LQFP
Supplier Device Package	32-LQFP (7x7)
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Revision History

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The following revision history table summarizes changes contained in this document.

Revision Number	Revision Date	Description of Changes
1	6/2006	Advance Information version for alpha samples customers
2	9/2007	Product Launch. Removed the 64-pin QFN package. Changed from standard to extended mode for MSCAN registers in register summary. Corrected Block diagrams for SCI. Updated the latest Temp Sensor information. Made FTSTMOD reserved. Updated device to use the ADC 12-bit module. Revised the MCG module. Updated the TPM block module to version 3. Added the TPM block module version 2 as an appendix for devices using 3M05C (or earlier) mask sets. Heavily revised the Electricals appendix.
3	6/2008	Sustaining Update. Incorporated PS Issues # 2765, 3177, 3236, 3292, 3301, 3311, 3312, 3326, 3335, 3345, 3382, 2795, 3382 and 3386 PLL Jitter Spec update. Also, added internal reference clock trim adjustment statement to Features page. Updated the TPM module to the latest version. Adjusted values in Table A-13 Control Timing row 2 and in Table A-6 DC Characteristics row 24 so that it references 5.0 V instead of 3.0 V.

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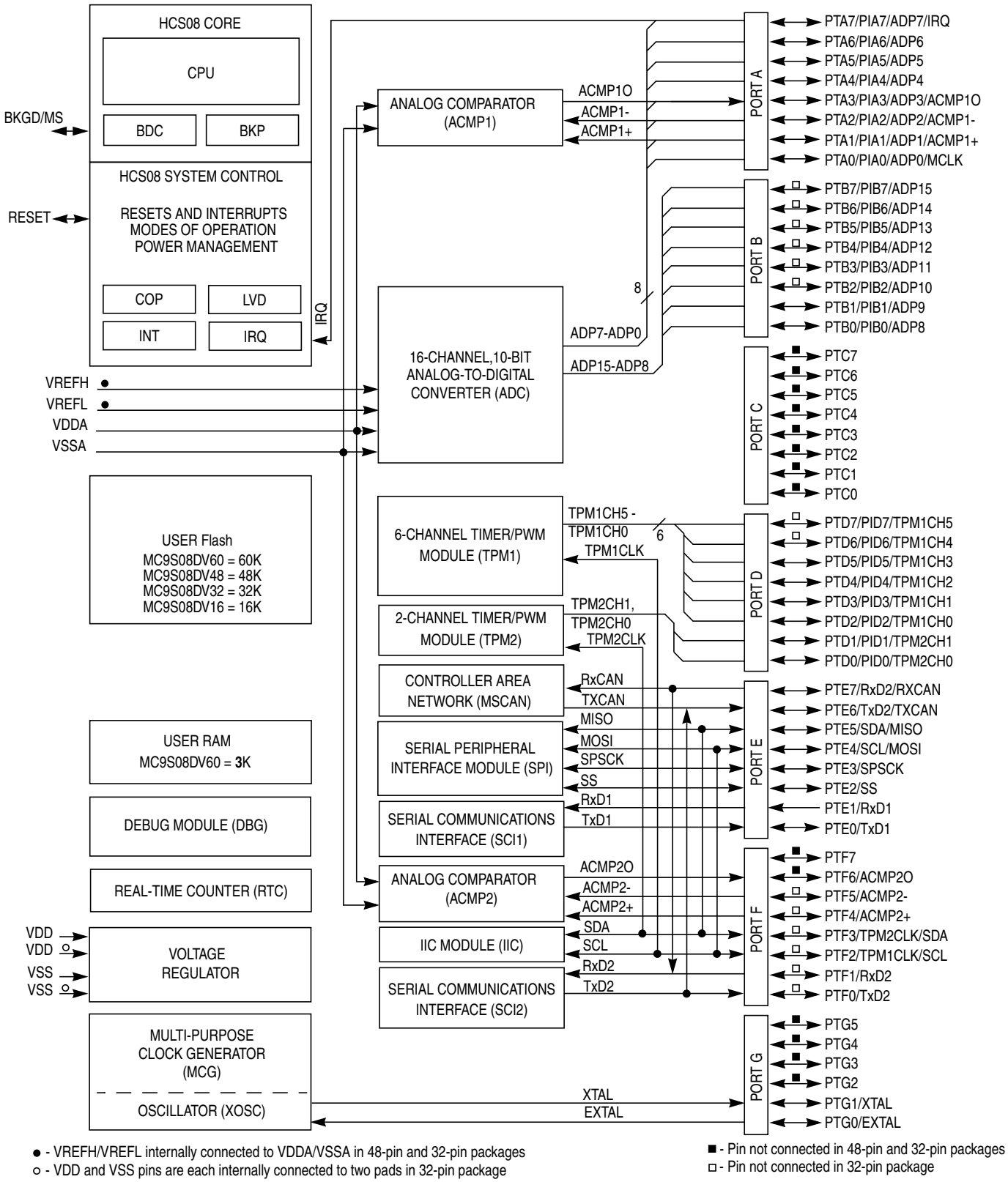
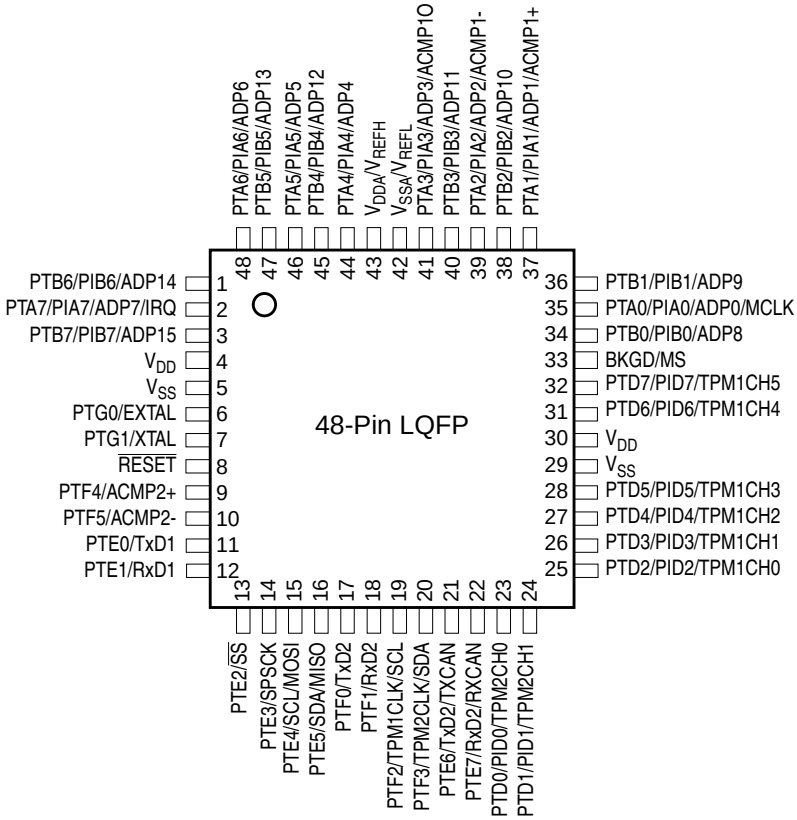


Figure 1-1. MC9S08DV60 Block Diagram



V_{REFH} and V_{REFL} are internally connected to V_{DDA} and V_{SSA}, respectively.

Figure 2-2. 48-Pin LQFP

NOTE

To avoid extra current drain from floating input pins, the reset initialization routine in the application program should either enable on-chip pull-up devices or change the direction of unused or non-bonded pins to outputs so they do not float.

Table 4-2. Direct-Page Register Summary (Sheet 3 of 3)

Address	Register Name	Bit 7	6	5	4	3	2	1	Bit 0
0x0050	**SPIC1**	SPIE	SPE	SPTIE	MSTR	CPOL	CPHA	SSOE	LSBFE
0x0051	**SPIC2**	0	0	0	MODFEN	BIDIROE	0	SPISWAI	SPC0
0x0052	**SPIBR**	0	SPPR2	SPPR1	SPPR0	0	SPR2	SPR1	SPR0
0x0053	**SPIS**	SPRF	0	SPTEF	MODF	0	0	0	0
0x0054	Reserved	0	0	0	0	0	0	0	0
0x0055	**SPID**	Bit 7	6	5	4	3	2	1	Bit 0
0x0056– 0x0057	Reserved	— —	— —	— —	— —	— —	— —	— —	— —
0x0058	**IICA**	AD7	AD6	AD5	AD4	AD3	AD2	AD1	0
0x0059	**IICF**	MULT		ICR					
0x005A	**IICC1**	IICEN	IICIE	MST	TX	TXAK	RSTA	0	0
0x005B	**IICS**	TCF	IAAS	BUSY	ARBL	0	SRW	IICIF	RXAK
0x005C	**IICD**	DATA							
0x005D	**IICC2**	GCAEN	ADEXT	0	0	0	AD10	AD9	AD8
0x005E– 0x005F	Reserved	— —	— —	— —	— —	— —	— —	— —	— —
0x0060	**TPM2SC**	TOF	TOIE	CPWMS	CLKSB	CLKSA	PS2	PS1	PS0
0x0061	**TPM2CNTH**	Bit 15	14	13	12	11	10	9	Bit 8
0x0062	**TPM2CNTL**	Bit 7	6	5	4	3	2	1	Bit 0
0x0063	**TPM2MODH**	Bit 15	14	13	12	11	10	9	Bit 8
0x0064	**TPM2MODL**	Bit 7	6	5	4	3	2	1	Bit 0
0x0065	**TPM2C0SC**	CH0F	CH0IE	MS0B	MS0A	ELS0B	ELS0A	0	0
0x0066	**TPM2C0VH**	Bit 15	14	13	12	11	10	9	Bit 8
0x0067	**TPM2C0VL**	Bit 7	6	5	4	3	2	1	Bit 0
0x0068	**TPM2C1SC**	CH1F	CH1IE	MS1B	MS1A	ELS1B	ELS1A	0	0
0x0069	**TPM2C1VH**	Bit 15	14	13	12	11	10	9	Bit 8
0x006A	**TPM2C1VL**	Bit 7	6	5	4	3	2	1	Bit 0
0x006B	Reserved	—	—	—	—	—	—	—	—
0x006C	**RTCSC**	RTIF	RTCLKS		RTIE	RTCPS			
0x006D	**RTCCNT**	RTCCNT							
0x006E	**RTCMOD**	RTCMOD							
0x006F	Reserved	—	—	—	—	—	—	—	—
0x0070– 0x007F	Reserved	— —	— —	— —	— —	— —	— —	— —	— —

High-page registers, shown in Table 4-3, are accessed much less often than other I/O and control registers so they have been located outside the direct addressable memory space, starting at 0x1800.

Table 4-10. Security States[1]

SEC[1:0]	Description
0:0	secure
0:1	secure
1:0	unsecured
1:1	secure

1 SEC changes to 1:0 after successful backdoor key entry or a successful blank check of Flash.

4.5.10.3 Flash Configuration Register (FCNFG)

	7	6	5	4	3	2	1	0
R	0	Reserved	KEYACC	Reserved[1]	0	0	0	1
W								
Reset	0	0	0	1	0	0	0	1

= Unimplemented or Reserved

Figure 4-7. Flash Configuration Register (FCNFG)

1 User must write a 1 to this bit. Failing to do so may result in unexpected behavior.

Table 4-11. FCNFG Register Field Descriptions

Field	Description
5 KEYACC	**Enable Writing of Access Key** — This bit enables writing of the backdoor comparison key. For more detailed information about the backdoor key mechanism, refer to Section 4.5.9, “Security.” 0 Writes to 0xFFB0–0xFFB7 are interpreted as the start of a Flash programming or erase command. 1 Writes to NVBACKKEY (0xFFB0–0xFFB7) are interpreted as comparison key writes.

4.5.10.4 Flash Protection Register (FPROT and NVPROT)

The FPROT register defines which Flash and EEPROM sectors are protected against program and erase operations.

During the reset sequence, the FPROT register is loaded from the nonvolatile location NVPROT. To change the protection that will be loaded during the reset sequence, the sector containing NVPROT must be unprotected and erased, then NVPROT can be reprogrammed.

FPROT bits are readable at any time and writable as long as the size of the protected region is being increased. Any write to FPROT that attempts to decrease the size of the protected memory will be ignored.

Trying to alter data in any protected area will result in a protection violation error and the FPVIOL flag will be set in the FSTAT register. Mass erase is not possible if any one of the sectors is protected.

6.5.2.3 Port B Pull Enable Register (PTBPE)

	7	6	5	4	3	2	1	0
R W	PTBPE7	PTBPE6	PTBPE5	PTBPE4	PTBPE3	PTBPE2	PTBPE1	PTBPE0
Reset:	0	0	0	0	0	0	0	0

Figure 6-13. Internal Pull Enable for Port B Register (PTBPE)

Table 6-11. PTBPE Register Field Descriptions

Field	Description
7:0 PTBPE[7:0]	**Internal Pull Enable for Port B Bits** — Each of these control bits determines if the internal pull-up or pull-down device is enabled for the associated PTB pin. For port B pins that are configured as outputs, these bits have no effect and the internal pull devices are disabled. 0 Internal pull-up/pull-down device disabled for port B bit n. 1 Internal pull-up/pull-down device enabled for port B bit n.

NOTE

Pull-down devices only apply when using pin interrupt functions, when corresponding edge select and pin select functions are configured.

6.5.2.4 Port B Slew Rate Enable Register (PTBSE)

	7	6	5	4	3	2	1	0
R W	PTBSE7	PTBSE6	PTBSE5	PTBSE4	PTBSE3	PTBSE2	PTBSE1	PTBSE0
Reset:	0	0	0	0	0	0	0	0

Figure 6-14. Slew Rate Enable for Port B Register (PTBSE)

Table 6-12. PTBSE Register Field Descriptions

Field	Description
7:0 PTBSE[7:0]	**Output Slew Rate Enable for Port B Bits** — Each of these control bits determines if the output slew rate control is enabled for the associated PTB pin. For port B pins that are configured as inputs, these bits have no effect. 0 Output slew rate control disabled for port B bit n. 1 Output slew rate control enabled for port B bit n.

Note: Slew rate reset default values may differ between engineering samples and final production parts. Always initialize slew rate control to the desired value to ensure correct operation.

7.2 Programmer's Model and CPU Registers

Figure 7-1 shows the five CPU registers. CPU registers are not part of the memory map.

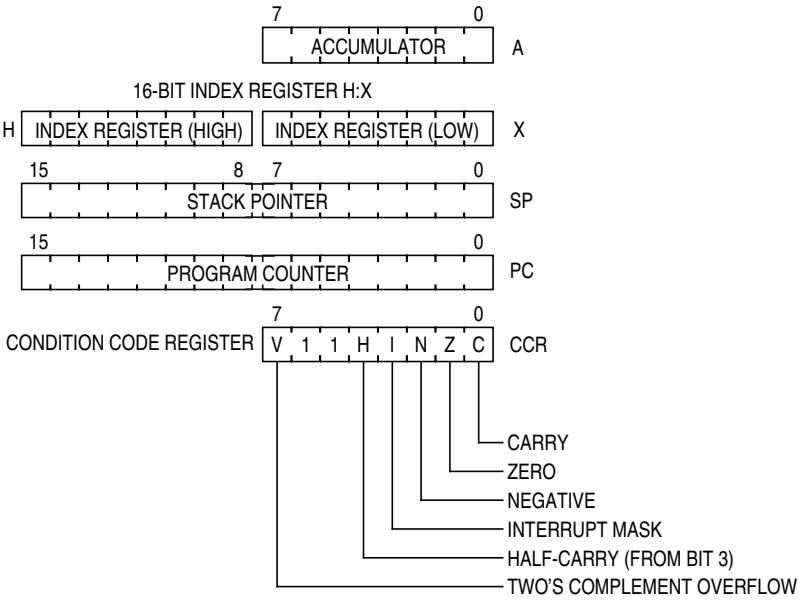


Figure 7-1. CPU Registers

7.2.1 Accumulator (A)

The A accumulator is a general-purpose 8-bit register. One operand input to the arithmetic logic unit (ALU) is connected to the accumulator and the ALU results are often stored into the A accumulator after arithmetic and logical operations. The accumulator can be loaded from memory using various addressing modes to specify the address where the loaded data comes from, or the contents of A can be stored to memory using various addressing modes to specify the address where data from A will be stored.

Reset has no effect on the contents of the A accumulator.

7.2.2 Index Register (H:X)

This 16-bit register is actually two separate 8-bit registers (H and X), which often work together as a 16-bit address pointer where H holds the upper byte of an address and X holds the lower byte of the address. All indexed addressing mode instructions use the full 16-bit value in H:X as an index reference pointer; however, for compatibility with the earlier M68HC05 Family, some instructions operate only on the low-order 8-bit half (X).

Many instructions treat X as a second general-purpose 8-bit register that can be used to hold 8-bit data values. X can be cleared, incremented, decremented, complemented, negated, shifted, or rotated. Transfer instructions allow data to be transferred from A or transferred to A where arithmetic and logical operations can then be performed.

For compatibility with the earlier M68HC05 Family, H is forced to 0x00 during reset. Reset has no effect on the contents of X.

interrupt service routine, this would allow nesting of interrupts (which is not recommended because it leads to programs that are difficult to debug and maintain).

For compatibility with the earlier M68HC05 MCUs, the high-order half of the H:X index register pair (H) is not saved on the stack as part of the interrupt sequence. The user must use a PSHH instruction at the beginning of the service routine to save H and then use a PULH instruction just before the RTI that ends the interrupt service routine. It is not necessary to save H if you are certain that the interrupt service routine does not use any instructions or auto-increment addressing modes that might change the value of H.

The software interrupt (SWI) instruction is like a hardware interrupt except that it is not masked by the global I bit in the CCR and it is associated with an instruction opcode within the program so it is not asynchronous to program execution.

7.4.3 Wait Mode Operation

The WAIT instruction enables interrupts by clearing the I bit in the CCR. It then halts the clocks to the CPU to reduce overall power consumption while the CPU is waiting for the interrupt or reset event that will wake the CPU from wait mode. When an interrupt or reset event occurs, the CPU clocks will resume and the interrupt or reset event will be processed normally.

If a serial BACKGROUND command is issued to the MCU through the background debug interface while the CPU is in wait mode, CPU clocks will resume and the CPU will enter active background mode where other serial background commands can be processed. This ensures that a host development system can still gain access to a target MCU even if it is in wait mode.

7.4.4 Stop Mode Operation

Usually, all system clocks, including the crystal oscillator (when used), are halted during stop mode to minimize power consumption. In such systems, external circuitry is needed to control the time spent in stop mode and to issue a signal to wake up the target MCU when it is time to resume processing. Unlike the earlier M68HC05 and M68HC08 MCUs, the HCS08 can be configured to keep a minimum set of clocks running in stop mode. This optionally allows an internal periodic signal to wake the target MCU from stop mode.

When a host debug system is connected to the background debug pin (BKGD) and the ENBDM control bit has been set by a serial command through the background interface (or because the MCU was reset into active background mode), the oscillator is forced to remain active when the MCU enters stop mode. In this case, if a serial BACKGROUND command is issued to the MCU through the background debug interface while the CPU is in stop mode, CPU clocks will resume and the CPU will enter active background mode where other serial background commands can be processed. This ensures that a host development system can still gain access to a target MCU even if it is in stop mode.

Recovery from stop mode depends on the particular HCS08 and whether the oscillator was stopped in stop mode. Refer to the Modes of Operation chapter for more details.

8.3.4 MCG Status and Control Register (MCGSC)

	7	6	5	4	3	2	1	0
R	LOLS	LOCK	PLLST	IREFST	CLKST		OSCINIT	FTRIM
W								
POR:	0	0	0	1	0	0	0	0
Reset:	0	0	0	1	0	0	0	U

Figure 8-6. MCG Status and Control Register (MCGSC)

Table 8-4. MCG Status and Control Register Field Descriptions

Field	Description
7 LOLS	**Loss of Lock Status** — This bit is a sticky indication of lock status for the FLL or PLL. LOLS is set when lock detection is enabled and after acquiring lock, the FLL or PLL output frequency has fallen outside the lock exit frequency tolerance, D_{unl}. LOLIE determines whether an interrupt request is made when set. LOLS is cleared by reset or by writing a logic 1 to LOLS when LOLS is set. Writing a logic 0 to LOLS has no effect. 0 FLL or PLL has not lost lock since LOLS was last cleared. 1 FLL or PLL has lost lock since LOLS was last cleared.
6 LOCK	**Lock Status** — Indicates whether the FLL or PLL has acquired lock. Lock detection is disabled when both the FLL and PLL are disabled. If the lock status bit is set then changing the value of any of the following bits IREFS, PLLS, RDIV[2:0], TRIM[7:0] (if in FEI or FBI modes), or VDIV[3:0] (if in PBE or PEE modes), will cause the lock status bit to clear and stay cleared until the FLL or PLL has reacquired lock. Stop mode entry will also cause the lock status bit to clear and stay cleared until the FLL or PLL has reacquired lock. Entry into BLPI or BLPE mode will also cause the lock status bit to clear and stay cleared until the MCG has exited these modes and the FLL or PLL has reacquired lock. 0 FLL or PLL is currently unlocked. 1 FLL or PLL is currently locked.
5 PLLST	**PLL Select Status** — The PLLST bit indicates the current source for the PLLS clock. The PLLST bit does not update immediately after a write to the PLLS bit due to internal synchronization between clock domains. 0 Source of PLLS clock is FLL clock. 1 Source of PLLS clock is PLL clock.
4 IREFST	**Internal Reference Status** — The IREFST bit indicates the current source for the reference clock. The IREFST bit does not update immediately after a write to the IREFS bit due to internal synchronization between clock domains. 0 Source of reference clock is external reference clock (oscillator or external clock source as determined by the EREFS bit in the MCGC2 register). 1 Source of reference clock is internal reference clock.
3:2 CLKST	**Clock Mode Status** — The CLKST bits indicate the current clock mode. The CLKST bits do not update immediately after a write to the CLKS bits due to internal synchronization between clock domains. 00 Encoding 0 — Output of FLL is selected. 01 Encoding 1 — Internal reference clock is selected. 10 Encoding 2 — External reference clock is selected. 11 Encoding 3 — Output of PLL is selected.

11.4.2 10-bit Address

For 10-bit addressing, 0x11110 is used for the first 5 bits of the first address byte. Various combinations of read/write formats are possible within a transfer that includes 10-bit addressing.

11.4.2.1 Master-Transmitter Addresses a Slave-Receiver

The transfer direction is not changed (see Table 11-9). When a 10-bit address follows a start condition, each slave compares the first seven bits of the first byte of the slave address (11110XX) with its own address and tests whether the eighth bit (R/$\overline{W}$ direction bit) is 0. More than one device can find a match and generate an acknowledge (A1). Then, each slave that finds a match compares the eight bits of the second byte of the slave address with its own address. Only one slave finds a match and generates an acknowledge (A2). The matching slave remains addressed by the master until it receives a stop condition (P) or a repeated start condition (Sr) followed by a different slave address.

S	Slave Address 1st 7 bits 11110 + AD10 + AD9	R/W 0	A1	Slave Address 2nd byte AD[8:1]	A2	Data	A	...	Data	A/A	P

Table 11-9. Master-Transmitter Addresses Slave-Receiver with a 10-bit Address

After the master-transmitter has sent the first byte of the 10-bit address, the slave-receiver sees an IIC interrupt. Software must ensure the contents of IICD are ignored and not treated as valid data for this interrupt.

11.4.2.2 Master-Receiver Addresses a Slave-Transmitter

The transfer direction is changed after the second R/$\overline{W}$ bit (see Table 11-10). Up to and including acknowledge bit A2, the procedure is the same as that described for a master-transmitter addressing a slave-receiver. After the repeated start condition (Sr), a matching slave remembers that it was addressed before. This slave then checks whether the first seven bits of the first byte of the slave address following Sr are the same as they were after the start condition (S) and tests whether the eighth (R/$\overline{W}$) bit is 1. If there is a match, the slave considers that it has been addressed as a transmitter and generates acknowledge A3. The slave-transmitter remains addressed until it receives a stop condition (P) or a repeated start condition (Sr) followed by a different slave address.

After a repeated start condition (Sr), all other slave devices also compare the first seven bits of the first byte of the slave address with their own addresses and test the eighth (R/$\overline{W}$) bit. However, none of them are addressed because R/$\overline{W}$ = 1 (for 10-bit devices) or the 11110XX slave address (for 7-bit devices) does not match.

S	Slave Address 1st 7 bits 11110 + AD10 + AD9	R/W 0	A1	Slave Address 2nd byte AD[8:1]	A2	Sr	Slave Address 1st 7 bits 11110 + AD10 + AD9	R/W 1	A3	Data	A	...	Data	A	P

Table 11-10. Master-Receiver Addresses a Slave-Transmitter with a 10-bit Address

After the master-receiver has sent the first byte of the 10-bit address, the slave-transmitter sees an IIC interrupt. Software must ensure the contents of IICD are ignored and not treated as valid data for this interrupt.

12.1.3 Block Diagram

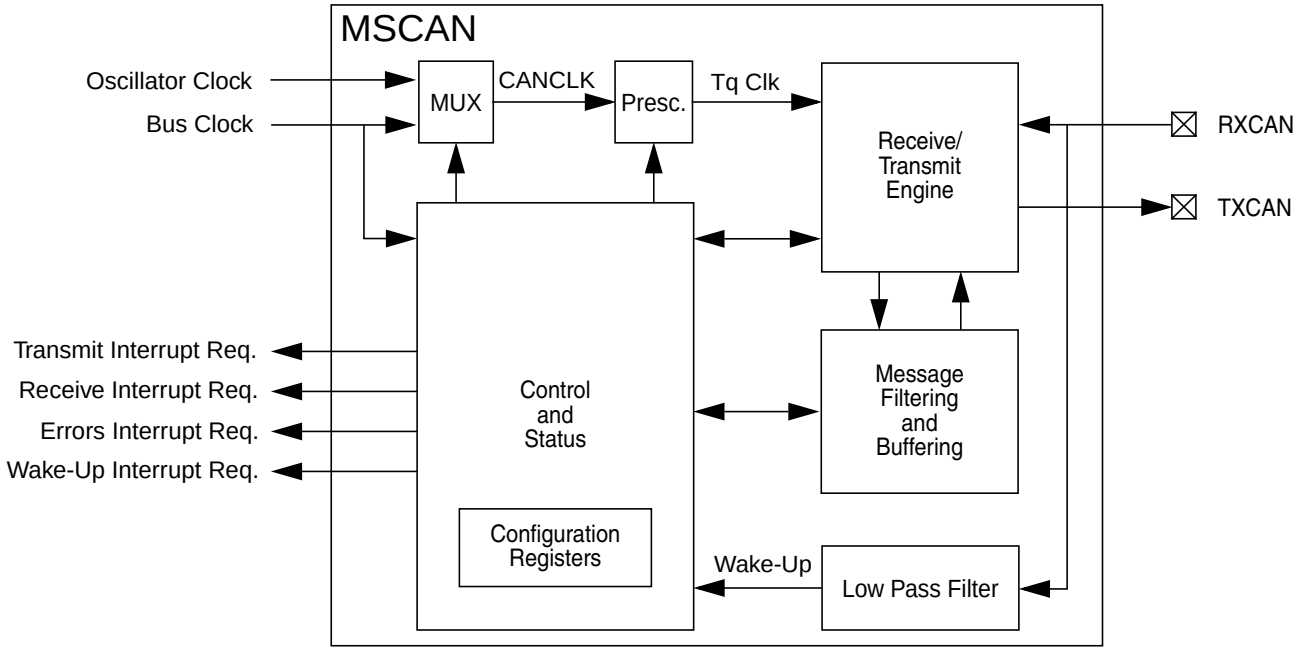


Figure 12-2. MSCAN Block Diagram

12.2 External Signal Description

The MSCAN uses two external pins:

12.2.1 RXCAN — CAN Receiver Input Pin

RXCAN is the MSCAN receiver input pin.

12.2.2 TXCAN — CAN Transmitter Output Pin

TXCAN is the MSCAN transmitter output pin. The TXCAN output pin represents the logic level on the CAN bus:

0 = Dominant state
1 = Recessive state

12.2.3 CAN System

A typical CAN system with MSCAN is shown in Figure 12-3. Each CAN node is connected physically to the CAN bus lines through a transceiver device. The transceiver is capable of driving the large current needed for the CAN bus and has current protection against defective CAN or defective nodes.

Register Name		Bit 7	6	5	4	3	2	1	Bit0
IDR0	R W	ID28	ID27	ID26	ID25	ID24	ID23	ID22	ID21
IDR1	R W	ID20	ID19	ID18	SRR(1)	IDE(1)	ID17	ID16	ID15
IDR2	R W	ID14	ID13	ID12	ID11	ID10	ID9	ID8	ID7
IDR3	R W	ID6	ID5	ID4	ID3	ID2	ID1	ID0	RTR2
DSR0	R W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
DSR1	R W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
DSR2	R W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
DSR3	R W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
DSR4	R W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
DSR5	R W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
DSR6	R W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
DSR7	R W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
DLR	R W					DLC3	DLC2	DLC1	DLC0

= Unused, always read 'x'

Figure 12-23. Receive/Transmit Message Buffer — Extended Identifier Mapping

1 SRR and IDE are both 1s.

2 The position of RTR differs between extended and standard indentifier mapping.

Read: For transmit buffers, anytime when TXEx flag is set (see Section 12.3.6, "MSCAN Transmitter Flag Register (CANTFLG)") and the corresponding transmit buffer is selected in CANTBSEL (see

The most common uses of the SPI system include connecting simple shift registers for adding input or output ports or connecting small peripheral devices such as serial A/D or D/A converters. Although Figure 13-2 shows a system where data is exchanged between two MCUs, many practical systems involve simpler connections where data is unidirectionally transferred from the master MCU to a slave or from a slave to the master MCU.

13.1.2.2 SPI Module Block Diagram

Figure 13-3 is a block diagram of the SPI module. The central element of the SPI is the SPI shift register. Data is written to the double-buffered transmitter (write to SPID) and gets transferred to the SPI shift register at the start of a data transfer. After shifting in a byte of data, the data is transferred into the double-buffered receiver where it can be read (read from SPID). Pin multiplexing logic controls connections between MCU pins and the SPI module.

When the SPI is configured as a master, the clock output is routed to the SPSCK pin, the shifter output is routed to MOSI, and the shifter input is routed from the MISO pin.

When the SPI is configured as a slave, the SPSCK pin is routed to the clock input of the SPI, the shifter output is routed to MISO, and the shifter input is routed from the MOSI pin.

In the external SPI system, simply connect all SPSCK pins to each other, all MISO pins together, and all MOSI pins together. Peripheral devices often use slightly different names for these pins.

Writing 0 to TE does not immediately release the pin to be a general-purpose I/O pin. Any transmit activity that is in progress must first be completed. This includes data characters in progress, queued idle characters, and queued break characters.

14.3.2.1 Send Break and Queued Idle

The SBK control bit in SCIxC2 is used to send break characters which were originally used to gain the attention of old teletype receivers. Break characters are a full character time of logic 0 (10 bit times including the start and stop bits). A longer break of 13 bit times can be enabled by setting BRK13 = 1. Normally, a program would wait for TDRE to become set to indicate the last character of a message has moved to the transmit shifter, then write 1 and then write 0 to the SBK bit. This action queues a break character to be sent as soon as the shifter is available. If SBK is still 1 when the queued break moves into the shifter (synchronized to the baud rate clock), an additional break character is queued. If the receiving device is another Freescale Semiconductor SCI, the break characters will be received as 0s in all eight data bits and a framing error (FE = 1) occurs.

When idle-line wakeup is used, a full character time of idle (logic 1) is needed between messages to wake up any sleeping receivers. Normally, a program would wait for TDRE to become set to indicate the last character of a message has moved to the transmit shifter, then write 0 and then write 1 to the TE bit. This action queues an idle character to be sent as soon as the shifter is available. As long as the character in the shifter does not finish while TE = 0, the SCI transmitter never actually releases control of the TxD pin. If there is a possibility of the shifter finishing while TE = 0, set the general-purpose I/O controls so the pin that is shared with TxD is an output driving a logic 1. This ensures that the TxD line will look like a normal idle line even if the SCI loses control of the port pin between writing 0 and then 1 to TE.

The length of the break character is affected by the BRK13 and M bits as shown below.

Table 14-9. Break Character Length

BRK13	M	Break Character Length
0	0	10 bit times
0	1	11 bit times
1	0	13 bit times
1	1	14 bit times

14.3.3 Receiver Functional Description

In this section, the receiver block diagram (Figure 14-3) is used as a guide for the overall receiver functional description. Next, the data sampling technique used to reconstruct receiver data is described in more detail. Finally, two variations of the receiver wakeup function are explained.

The receiver input is inverted by setting RXINV = 1. The receiver is enabled by setting the RE bit in SCIxC2. Character frames consist of a start bit of logic 0, eight (or nine) data bits (LSB first), and a stop bit of logic 1. For information about 9-bit data mode, refer to Section 14.3.5.1, “8- and 9-Bit Data Modes.” For the remainder of this discussion, we assume the SCI is configured for normal 8-bit data mode.

After receiving the stop bit into the receive shifter, and provided the receive data register is not already full, the data character is transferred to the receive data register and the receive data register full (RDRF) status

Instead of hardware interrupts, software polling may be used to monitor the TDRE and TC status flags if the corresponding TIE or TCIE local interrupt masks are 0s.

When a program detects that the receive data register is full (RDRF = 1), it gets the data from the receive data register by reading SCIxD. The RDRF flag is cleared by reading SCIxS1 while RDRF = 1 and then reading SCIxD.

When polling is used, this sequence is naturally satisfied in the normal course of the user program. If hardware interrupts are used, SCIxS1 must be read in the interrupt service routine (ISR). Normally, this is done in the ISR anyway to check for receive errors, so the sequence is automatically satisfied.

The IDLE status flag includes logic that prevents it from getting set repeatedly when the RxD line remains idle for an extended period of time. IDLE is cleared by reading SCIxS1 while IDLE = 1 and then reading SCIxD. After IDLE has been cleared, it cannot become set again until the receiver has received at least one new character and has set RDRF.

If the associated error was detected in the received character that caused RDRF to be set, the error flags — noise flag (NF), framing error (FE), and parity error flag (PF) — get set at the same time as RDRF. These flags are not set in overrun cases.

If RDRF was already set when a new character is ready to be transferred from the receive shifter to the receive data buffer, the overrun (OR) flag gets set instead the data along with any associated NF, FE, or PF condition is lost.

At any time, an active edge on the RxD serial data input pin causes the RXEDGIF flag to set. The RXEDGIF flag is cleared by writing a “1” to it. This function does depend on the receiver being enabled (RE = 1).

14.3.5 Additional SCI Functions

The following sections describe additional SCI functions.

14.3.5.1 8- and 9-Bit Data Modes

The SCI system (transmitter and receiver) can be configured to operate in 9-bit data mode by setting the M control bit in SCIxC1. In 9-bit mode, there is a ninth data bit to the left of the MSB of the SCI data register. For the transmit data buffer, this bit is stored in T8 in SCIxC3. For the receiver, the ninth bit is held in R8 in SCIxC3.

For coherent writes to the transmit data buffer, write to the T8 bit before writing to SCIxD.

If the bit value to be transmitted as the ninth bit of a new character is the same as for the previous character, it is not necessary to write to T8 again. When data is transferred from the transmit data buffer to the transmit shifter, the value in T8 is copied at the same time data is transferred from SCIxD to the shifter.

9-bit data mode typically is used in conjunction with parity to allow eight bits of data plus the parity in the ninth bit. Or it is used with address-mark wakeup so the ninth data bit can serve as the wakeup bit. In custom protocols, the ninth bit can also serve as a software-controlled marker.

When the TPM is configured for center-aligned PWM (and ELSnB:ELSnA not = 0:0), the data direction for all channels in this TPM are overridden, the TPMxCHn pins are forced to be outputs controlled by the TPM, and the ELSnA bits control the polarity of each TPMxCHn output. If ELSnB:ELSnA=1:0, the corresponding TPMxCHn pin is cleared when the timer counter is counting up, and the channel value register matches the timer counter; the TPMxCHn pin is set when the timer counter is counting down, and the channel value register matches the timer counter. If ELSnA=1, the corresponding TPMxCHn pin is set when the timer counter is counting up and the channel value register matches the timer counter; the TPMxCHn pin is cleared when the timer counter is counting down and the channel value register matches the timer counter.

TPMxMODH:TPMxMODL = 0x0008
TPMxCnVH:TPMxCnVL = 0x0005

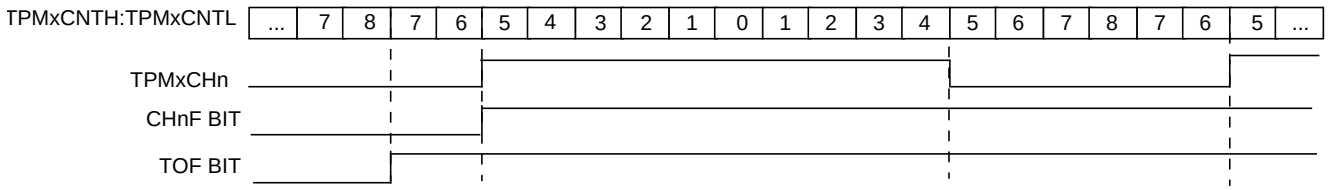


Figure 16-5. High-True Pulse of a Center-Aligned PWM

TPMxMODH:TPMxMODL = 0x0008
TPMxCnVH:TPMxCnVL = 0x0005

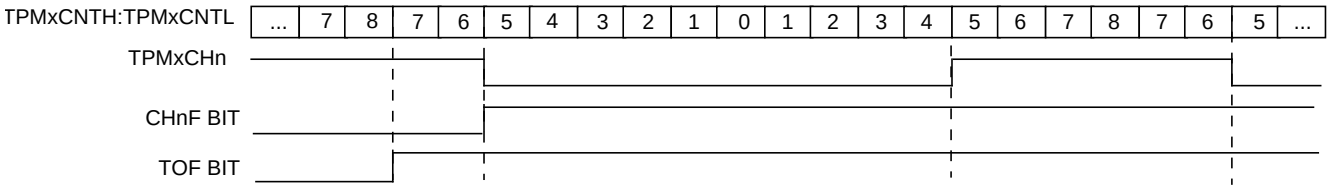


Figure 16-6. Low-True Pulse of a Center-Aligned PWM

Table 16-7. TPM Clock Source Selection

CLKSB:CLKSA	TPM Clock Source to Prescaler Input
00	No clock selected (TPM counter disabled)
01	Bus rate clock
10	Fixed system clock
11	External source

The bus rate clock is the main system bus clock for the MCU. This clock source requires no synchronization because it is the clock that is used for all internal MCU activities including operation of the CPU and buses.

In MCUs that have no PLL and FLL or the PLL and FLL are not engaged, the fixed system clock source is the same as the bus-rate-clock source, and it does not go through a synchronizer. When a PLL or FLL is present and engaged, a synchronizer is required between the crystal divided-by two clock source and the timer counter so counter transitions will be properly aligned to bus-clock transitions. A synchronizer will be used at chip level to synchronize the crystal-related source clock to the bus clock.

The external clock source may be connected to any TPM channel pin. This clock source always has to pass through a synchronizer to assure that counter transitions are properly aligned to bus clock transitions. The bus-rate clock drives the synchronizer; therefore, to meet Nyquist criteria even with jitter, the frequency of the external clock source must not be faster than the bus rate divided-by four. With ideal clocks the external clock can be as fast as bus clock divided by four.

When the external clock source shares the TPM channel pin, this pin should not be used for other channel timing functions. For example, it would be ambiguous to configure channel 0 for input capture when the TPM channel 0 pin was also being used as the timer external clock source. (It is the user's responsibility to avoid such settings.) The TPM channel could still be used in output compare mode for software timing functions (pin controls set not to affect the TPM channel pin).

16.4.1.2 Counter Overflow and Modulo Reset

An interrupt flag and enable are associated with the 16-bit main counter. The flag (TOF) is a software-accessible indication that the timer counter has overflowed. The enable signal selects between software polling (TOIE=0) where no hardware interrupt is generated, or interrupt-driven operation (TOIE=1) where a static hardware interrupt is generated whenever the TOF flag is equal to one.

The conditions causing TOF to become set depend on whether the TPM is configured for center-aligned PWM (CPWMS=1). In the simplest mode, there is no modulus limit and the TPM is not in CPWMS=1 mode. In this case, the 16-bit timer counter counts from 0x0000 through 0xFFFF and overflows to 0x0000 on the next counting clock. TOF becomes set at the transition from 0xFFFF to 0x0000. When a modulus limit is set, TOF becomes set at the transition from the value set in the modulus register to 0x0000. When the TPM is in center-aligned PWM mode (CPWMS=1), the TOF flag gets set as the counter changes direction at the end of the count value set in the modulus register (that is, at the transition from the value set in the modulus register to the next lower count value). This corresponds to the end of a PWM period (the 0x0000 count value corresponds to the center of a period).

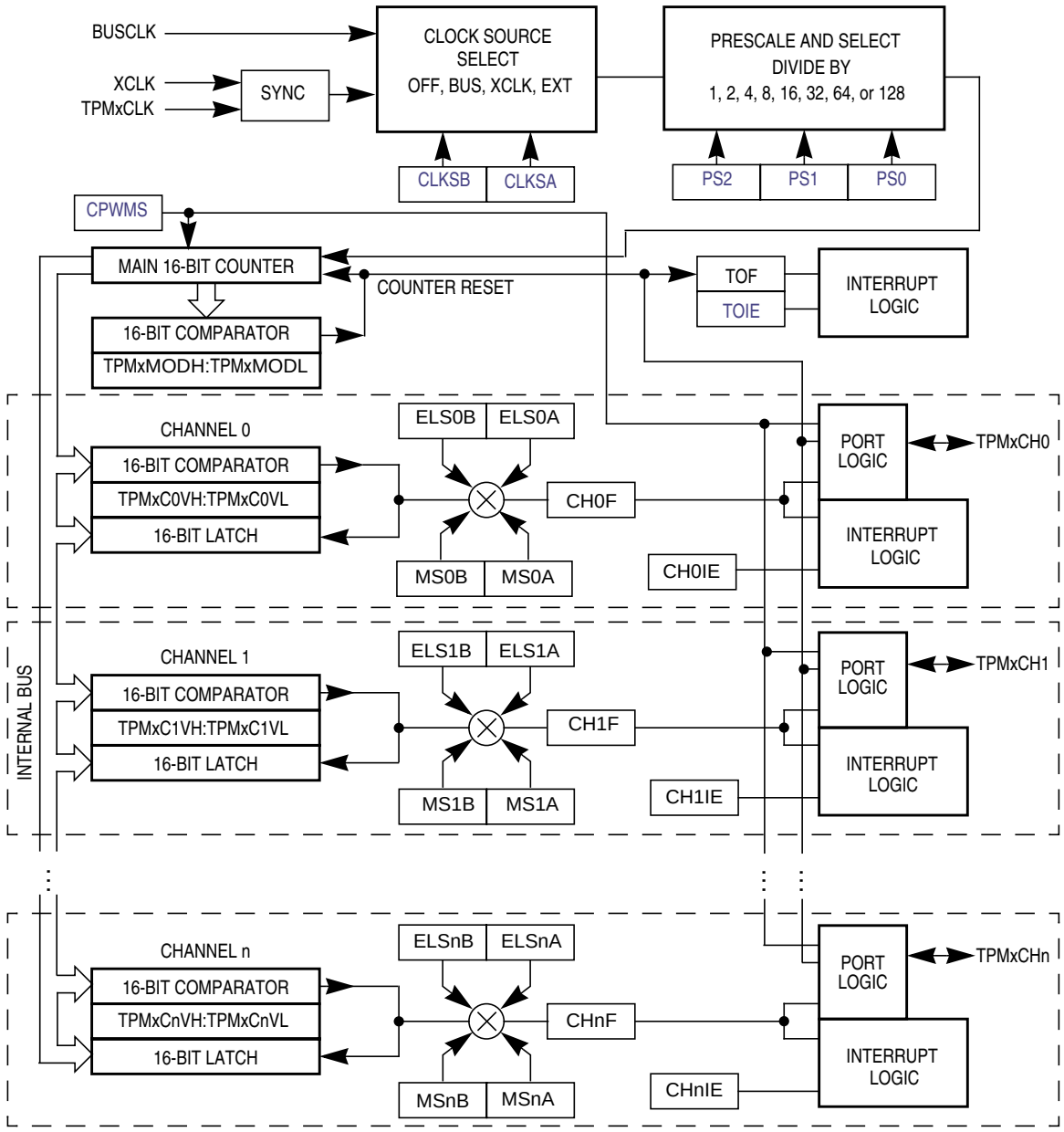


Figure B-1. TPM Block Diagram

The central component of the TPM is the 16-bit counter that can operate as a free-running counter, a modulo counter, or an up-/down-counter when the TPM is configured for center-aligned PWM. The TPM counter (when operating in normal up-counting mode) provides the timing reference for the input capture, output compare, and edge-aligned PWM functions. The timer counter modulo registers, TPMxMODH:TPMxMODL, control the modulo value of the counter. (The values 0x0000 or 0xFFFF effectively make the counter free running.) Software can read the counter value at any time without affecting the counting sequence. Any write to either byte of the TPMxCNT counter resets the counter regardless of the data value written.

An input capture event sets a flag bit (CHnF) that can optionally generate a CPU interrupt request.

B.3.2.2 Output Compare Mode

With the output compare function, the TPM can generate timed pulses with programmable position, polarity, duration, and frequency. When the counter reaches the value in the channel value registers of an output compare channel, the TPM can set, clear, or toggle the channel pin.

In output compare mode, values are transferred to the corresponding timer channel value registers only after both 8-bit bytes of a 16-bit register have been written. This coherency sequence can be manually reset by writing to the channel status/control register (TPMxCnSC).

An output compare event sets a flag bit (CHnF) that can optionally generate a CPU interrupt request.

B.3.2.3 Edge-Aligned PWM Mode

This type of PWM output uses the normal up-counting mode of the timer counter (CPWMS = 0) and can be used when other channels in the same TPM are configured for input capture or output compare functions. The period of this PWM signal is determined by the setting in the modulus register (TPMxMODH:TPMxMODL). The duty cycle is determined by the setting in the timer channel value register (TPMxCnVH:TPMxCnVL). The polarity of this PWM signal is determined by the setting in the ELSnA control bit. Duty cycle cases of 0 percent and 100 percent are possible.

As Figure B-10 shows, the output compare value in the TPM channel registers determines the pulse width (duty cycle) of the PWM signal. The time between the modulus overflow and the output compare is the pulse width. If ELSnA = 0, the counter overflow forces the PWM signal high and the output compare forces the PWM signal low. If ELSnA = 1, the counter overflow forces the PWM signal low and the output compare forces the PWM signal high.

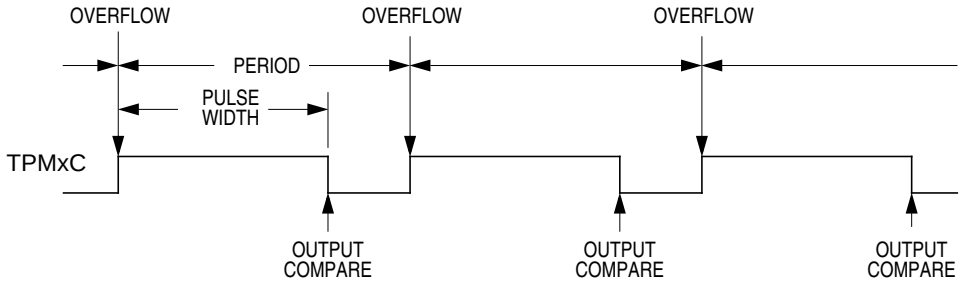


Figure B-10. PWM Period and Pulse Width (ELSnA = 0)

When the channel value register is set to 0x0000, the duty cycle is 0 percent. By setting the timer channel value register (TPMxCnVH:TPMxCnVL) to a value greater than the modulus setting, 100% duty cycle can be achieved. This implies that the modulus setting must be less than 0xFFFF to get 100% duty cycle.

Because the HCS08 is a family of 8-bit MCUs, the settings in the timer channel registers are buffered to ensure coherent 16-bit updates and to avoid unexpected PWM pulse widths. Writes to either register, TPMxCnVH or TPMxCnVL, write to buffer registers. In edge-PWM mode, values are transferred to the corresponding timer channel registers only after both 8-bit bytes of a 16-bit register have been written and