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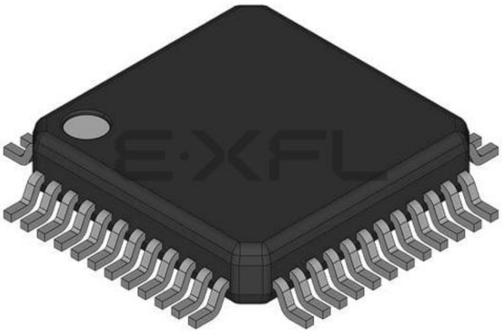
Freescale Semiconductor - MC9S08DN60MLF Datasheet



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Applications of "Embedded - Microcontrollers"

Details	
Product Status	Active
Core Processor	S08
Core Size	8-Bit
Speed	40MHz
Connectivity	I²C, LINbus, SCI, SPI
Peripherals	LVD, POR, PWM, WDT
Number of I/O	39
Program Memory Size	60KB (60K x 8)
Program Memory Type	FLASH
EEPROM Size	2K x 8
RAM Size	2K x 8
Voltage - Supply (Vcc/Vdd)	2.7V ~ 5.5V
Data Converters	A/D 16x12b
Oscillator Type	External
Operating Temperature	-40°C ~ 125°C (TA)
Mounting Type	Surface Mount
Package / Case	48-LQFP
Supplier Device Package	48-LQFP (7x7)
Purchase URL	https://www.e-xfl.com/pro/item?MUrl=&PartUrl=mc9s08dn60mlf

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Section Number **Title** **Page**

Chapter 12
Serial Peripheral Interface (S08SPIV3)

Background commands are of two types:

- Non-intrusive commands, defined as commands that can be issued while the user program is running. Non-intrusive commands can be issued through the BKGD/MS pin while the MCU is in run mode; non-intrusive commands can also be executed when the MCU is in the active background mode. Non-intrusive commands include:
  - Memory access commands
  - Memory-access-with-status commands
  - BDC register access commands
  - The BACKGROUND command
- Active background commands, which can only be executed while the MCU is in active background mode. Active background commands include commands to:
  - Read or write CPU registers
  - Trace one user program instruction at a time
  - Leave active background mode to return to the user application program (GO)

The active background mode is used to program a bootloader or user application program into the Flash program memory before the MCU is operated in run mode for the first time. When the MC9S08DN60 Series is shipped from the Freescale Semiconductor factory, the Flash program memory is erased by default unless specifically noted so there is no program that could be executed in run mode until the Flash memory is initially programmed. The active background mode can also be used to erase and reprogram the Flash memory after it has been previously programmed.

For additional information about the active background mode, refer to the Development Support chapter.

3.5 Wait Mode

Wait mode is entered by executing a WAIT instruction. Upon execution of the WAIT instruction, the CPU enters a low-power state in which it is not clocked. The I bit in CCR is cleared when the CPU enters the wait mode, enabling interrupts. When an interrupt request occurs, the CPU exits the wait mode and resumes processing, beginning with the stacking operations leading to the interrupt service routine.

While the MCU is in wait mode, there are some restrictions on which background debug commands can be used. Only the BACKGROUND command and memory-access-with-status commands are available when the MCU is in wait mode. The memory-access-with-status commands do not allow memory access, but they report an error indicating that the MCU is in either stop or wait mode. The BACKGROUND command can be used to wake the MCU from wait mode and enter active background mode.

Table 4-6. FCDIV Register Field Descriptions

Field	Description
7 DIVLD	**Divisor Loaded Status Flag** — When set, this read-only status flag indicates that the FCDIV register has been written since reset. Reset clears this bit and the first write to this register causes this bit to become set regardless of the data written. 0 FCDIV has not been written since reset; erase and program operations disabled for Flash and EEPROM. 1 FCDIV has been written since reset; erase and program operations enabled for Flash and EEPROM.
6 PRDIV8	**Prescale (Divide) Flash and EEPROM Clock by 8** (This bit is write once.) 0 Clock input to the Flash and EEPROM clock divider is the bus rate clock. 1 Clock input to the Flash and EEPROM clock divider is the bus rate clock divided by 8.
5:0 DIV	**Divisor for Flash and EEPROM Clock Divider** — These bits are write once. The Flash and EEPROM clock divider divides the bus rate clock (or the bus rate clock divided by 8 if PRDIV8 = 1) by the value in the 6-bit DIV field plus one. The resulting frequency of the internal Flash and EEPROM clock must fall within the range of 200 kHz to 150 kHz for proper Flash and EEPROM operations. Program/Erase timing pulses are one cycle of this internal Flash and EEPROM clock which corresponds to a range of 5 µs to 6.7 µs. The automated programming logic uses an integer number of these pulses to complete an erase or program operation. See Equation 4-1 and Equation 4-2.

$$\text{if PRDIV8} = 0 — f_{FCLK} = f_{Bus} \div (DIV + 1) \qquad \textit{Eqn. 4-1}$$

$$\text{if PRDIV8} = 1 — f_{FCLK} = f_{Bus} \div (8 \times (DIV + 1)) \qquad \textit{Eqn. 4-2}$$

Table 4-7 shows the appropriate values for PRDIV8 and DIV for selected bus frequencies.

Table 4-7. Flash and EEPROM Clock Divider Settings

f_{Bus}	PRDIV8 (Binary)	DIV (Decimal)	f_{FCLK}	Program/Erase Timing Pulse (5 µs Min, 6.7 µs Max)
20 MHz	1	12	192.3 kHz	5.2 µs
10 MHz	0	49	200 kHz	5 µs
8 MHz	0	39	200 kHz	5 µs
4 MHz	0	19	200 kHz	5 µs
2 MHz	0	9	200 kHz	5 µs
1 MHz	0	4	200 kHz	5 µs
200 kHz	0	0	200 kHz	5 µs
150 kHz	0	0	150 kHz	6.7 µs

4.5.11.2 Flash and EEPROM Options Register (FOPT and NVOPT)

During reset, the contents of the nonvolatile location NVOPT are copied from Flash into FOPT. To change the value in this register, erase and reprogram the NVOPT location in Flash memory as usual and then issue a new MCU reset.

Table 4-14. FSTAT Register Field Descriptions (continued)

Field	Description
4 FACCERR	**Access Error Flag** — FACCERR is set automatically when the proper command sequence is not obeyed exactly (the erroneous command is ignored), if a program or erase operation is attempted before the FCDIV register has been initialized, or if the MCU enters stop while a command was in progress. For a more detailed discussion of the exact actions that are considered access errors, see Section 4.5.6, "Access Errors." FACCERR is cleared by writing a 1 to FACCERR. Writing a 0 to FACCERR has no meaning or effect. 0 No access error. 1 An access error has occurred.
2 FBLANK	**Verified as All Blank (erased) Flag** — FBLANK is set automatically at the conclusion of a blank check command if the entire Flash or EEPROM array was verified to be erased. FBLANK is cleared by clearing FCBEF to write a new valid command. Writing to FBLANK has no meaning or effect. 0 After a blank check command is completed and FCCF = 1, FBLANK = 0 indicates the Flash or EEPROM array is not completely erased. 1 After a blank check command is completed and FCCF = 1, FBLANK = 1 indicates the Flash or EEPROM array is completely erased (all 0xFFFF).

4.5.11.6 Flash and EEPROM Command Register (FCMD)

Only six command codes are recognized in normal user modes, as shown in Table 4-15. All other command codes are illegal and generate an access error. Refer to Section 4.5.3, "Program and Erase Command Execution," for a detailed discussion of Flash and EEPROM programming and erase operations.

	7	6	5	4	3	2	1	0
R	0	0	0	0	0	0	0	0
W	FCMD							
Reset	0	0	0	0	0	0	0	0

Figure 4-10. Flash and EEPROM Command Register (FCMD)

Table 4-15. Flash and EEPROM Commands

Command	FCMD	Equate File Label
Blank check	0x05	mBlank
Byte program	0x20	mByteProg
Burst program	0x25	mBurstProg
Sector erase	0x40	mSectorErase
Mass erase	0x41	mMassErase
Sector erase abort	0x47	mEraseAbort

It is not necessary to perform a blank check command after a mass erase operation. Only blank check is required as part of the security unlocking mechanism.

6.5.6 Port F Registers

Port F is controlled by the registers listed below.

6.5.6.1 Port F Data Register (PTFD)

	7	6	5	4	3	2	1	0
R W	PTFD7	PTFD6	PTFD5	PTFD4	PTFD3	PTFD2	PTFD1	PTFD0
Reset:	0	0	0	0	0	0	0	0

Figure 6-37. Port F Data Register (PTFD)

Table 6-35. PTFD Register Field Descriptions

Field	Description
7:0 PTFD[7:0]	**Port F Data Register Bits** — For port F pins that are inputs, reads return the logic level on the pin. For port F pins that are configured as outputs, reads return the last value written to this register. Writes are latched into all bits of this register. For port F pins that are configured as outputs, the logic level is driven out the corresponding MCU pin. Reset forces PTFD to all 0s, but these 0s are not driven out the corresponding pins because reset also configures all port pins as high-impedance inputs with pull-ups disabled.

6.5.6.2 Port F Data Direction Register (PTFDD)

	7	6	5	4	3	2	1	0
R W	PTFDD7	PTFDD6	PTFDD5	PTFDD4	PTFDD3	PTFDD2	PTFDD1	PTFDD0
Reset:	0	0	0	0	0	0	0	0

Figure 6-38. Port F Data Direction Register (PTFDD)

Table 6-36. PTFDD Register Field Descriptions

Field	Description
7:0 PTFDD[7:0]	**Data Direction for Port F Bits** — These read/write bits control the direction of port F pins and what is read for PTFD reads. 0 Input (output driver disabled) and reads return the pin value. 1 Output driver enabled for port F bit n and PTFD reads return the contents of PTFDn.

8.3.3 MCG Trim Register (MCGTRM)

	7	6	5	4	3	2	1	0
R W	TRIM							
POR:	1	0	0	0	0	0	0	0
Reset:	U	U	U	U	U	U	U	U

Figure 8-5. MCG Trim Register (MCGTRM)

Table 8-3. MCG Trim Register Field Descriptions

Field	Description
7:0 TRIM	MCG **Trim Setting** — Controls the internal reference clock frequency by controlling the internal reference clock period. The TRIM bits are binary weighted (i.e., bit 1 will adjust twice as much as bit 0). Increasing the binary value in TRIM will increase the period, and decreasing the value will decrease the period. An additional fine trim bit is available in MCGSC as the FTRIM bit. If a TRIM[7:0] value stored in nonvolatile memory is to be used, it's the user's responsibility to copy that value from the nonvolatile memory location to this register.

  c) MCGC1 = 0xB8 (%10111000)
    - CLKS (bits 7 and 6) set to %10 in order to select external reference clock as system clock source
    - RDIV (bits 5-3) set to %111, or divide-by-128 because 4 MHz / 128 = 31.25 kHz which is in the 31.25 kHz to 39.0625 kHz range required by the FLL
    - IREFS (bit 2) cleared to 0, selecting the external reference clock

  d) Loop until IREFST (bit 4) in MCGSC is 0, indicating the external reference is the current source for the reference clock

  e) Loop until CLKST (bits 3 and 2) in MCGSC are %10, indicating that the external reference clock is selected to feed MCGOUT

2. Then, FBE must transition either directly to PBE mode or first through BLPE mode and then to PBE mode:
   a) BLPE: If a transition through BLPE mode is desired, first set LP (bit 3) in MCGC2 to 1.
   b) BLPE/PBE: MCGC1 = 0x90 (%10010000)
      - RDIV (bits 5-3) set to %010, or divide-by-4 because 4 MHz / 4 = 1 MHz which is in the 1 MHz to 2 MHz range required by the PLL. In BLPE mode, the configuration of the RDIV does not matter because both the FLL and PLL are disabled. Changing them only sets up the the dividers for PLL usage in PBE mode
   c) BLPE/PBE: MCGC3 = 0x44 (%01000100)
      - PLLS (bit 6) set to 1, selects the PLL. In BLPE mode, changing this bit only prepares the MCG for PLL usage in PBE mode
      - VDIV (bits 3-0) set to %0100, or multiply-by-16 because 1 MHz reference * 16 = 16 MHz. In BLPE mode, the configuration of the VDIV bits does not matter because the PLL is disabled. Changing them only sets up the multiply value for PLL usage in PBE mode
   d) BLPE: If transitioning through BLPE mode, clear LP (bit 3) in MCGC2 to 0 here to switch to PBE mode
   e) PBE: Loop until PLLST (bit 5) in MCGSC is set, indicating that the current source for the PLLS clock is the PLL
   f) PBE: Then loop until LOCK (bit 6) in MCGSC is set, indicating that the PLL has acquired lock

3. Last, PBE mode transitions into PEE mode:
   a) MCGC1 = 0x10 (%00010000)
      - CLKS (bits7 and 6) in MCGSC1 set to %00 in order to select the output of the PLL as the system clock source
   b) Loop until CLKST (bits 3 and 2) in MCGSC are %11, indicating that the PLL output is selected to feed MCGOUT in the current clock mode
      - Now, With an RDIV of divide-by-4, a BDIV of divide-by-1, and a VDIV of multiply-by-16, MCGOUT = [(4 MHz / 4) * 16] / 1 = 16 MHz, and the bus frequency is MCGOUT / 2, or 8 MHz

8.5.3 Calibrating the Internal Reference Clock (IRC)

The IRC is calibrated by writing to the MCGTRM register first, then using the FTRIM bit to “fine tune” the frequency. We will refer to this total 9-bit value as the trim value, ranging from 0x000 to 0x1FF, where the FTRIM bit is the LSB.

The trim value after a POR is always 0x100 (MCGTRM = 0x80 and FTRIM = 0). Writing a larger value will decrease the frequency and smaller values will increase the frequency. The trim value is linear with the period, except that slight variations in wafer fab processing produce slight non-linearities between trim value and period. These non-linearities are why an iterative trimming approach to search for the best trim value is recommended. In Example #5: Internal Reference Clock Trim this approach will be demonstrated.

After a trim value has been found for a device, this value can be stored in FLASH memory to save the value. If power is removed from the device, the IRC can easily be re-trimmed by copying the saved value from FLASH to the MCG registers. Freescale identifies recommended FLASH locations for storing the trim value for each MCU. Consult the memory map in the data sheet for these locations. On devices that are factory trimmed, the factory trim value will be stored in these locations.

8.5.3.1 Example #5: Internal Reference Clock Trim

For applications that require a tight frequency tolerance, a trimming procedure is provided that will allow a very accurate internal clock source. This section outlines one example of trimming the internal oscillator. Many other possible trimming procedures are valid and can be used.

In the example below, the MCG trim will be calibrated for the 9-bit MCGTRM and FTRIM collective value. This value will be referred to as TRMVAL.

10.2.1 Analog Power (V_{DDAD})

The ADC analog portion uses V_{DDAD} as its power connection. In some packages, V_{DDAD} is connected internally to V_{DD}. If externally available, connect the V_{DDAD} pin to the same voltage potential as V_{DD}. External filtering may be necessary to ensure clean V_{DDAD} for good results.

10.2.2 Analog Ground (V_{SSAD})

The ADC analog portion uses V_{SSAD} as its ground connection. In some packages, V_{SSAD} is connected internally to V_{SS}. If externally available, connect the V_{SSAD} pin to the same voltage potential as V_{SS}.

10.2.3 Voltage Reference High (V_{REFH})

V_{REFH} is the high reference voltage for the converter. In some packages, V_{REFH} is connected internally to V_{DDAD}. If externally available, V_{REFH} may be connected to the same potential as V_{DDAD} or may be driven by an external source between the minimum V_{DDAD} spec and the V_{DDAD} potential (V_{REFH} must never exceed V_{DDAD}).

10.2.4 Voltage Reference Low (V_{REFL})

V_{REFL} is the low-reference voltage for the converter. In some packages, V_{REFL} is connected internally to V_{SSAD}. If externally available, connect the V_{REFL} pin to the same voltage potential as V_{SSAD}.

10.2.5 Analog Channel Inputs (ADx)

The ADC module supports up to 28 separate analog inputs. An input is selected for conversion through the ADCH channel select bits.

10.3 Register Definition

These memory-mapped registers control and monitor operation of the ADC:

- Status and control register, ADCSC1
- Status and control register, ADCSC2
- Data result registers, ADCRH and ADCRL
- Compare value registers, ADCCVH and ADCCVL
- Configuration register, ADCCFG
- Pin control registers, APCTL1, APCTL2, APCTL3

10.3.1 Status and Control Register 1 (ADCSC1)

This section describes the function of the ADC status and control register (ADCSC1). Writing ADCSC1 aborts the current conversion and initiates a new conversion (if the ADCH bits are equal to a value other than all 1s).

10.6.1.3 Analog Input Pins

The external analog inputs are typically shared with digital I/O pins on MCU devices. The pin I/O control is disabled by setting the appropriate control bit in one of the pin control registers. Conversions can be performed on inputs without the associated pin control register bit set. It is recommended that the pin control register bit always be set when using a pin as an analog input. This avoids problems with contention because the output buffer is in its high impedance state and the pullup is disabled. Also, the input buffer draws DC current when its input is not at V_{DD} or V_{SS}. Setting the pin control register bits for all pins used as analog inputs should be done to achieve lowest operating current.

Empirical data shows that capacitors on the analog inputs improve performance in the presence of noise or when the source impedance is high. Use of 0.01 μF capacitors with good high-frequency characteristics is sufficient. These capacitors are not necessary in all cases, but when used they must be placed as near as possible to the package pins and be referenced to V_{SSA}.

For proper conversion, the input voltage must fall between V_{REFH} and V_{REFL}. If the input is equal to or exceeds V_{REFH}, the converter circuit converts the signal to 0xFFF (full scale 12-bit representation), 0x3FF (full scale 10-bit representation) or 0xFF (full scale 8-bit representation). If the input is equal to or less than V_{REFL}, the converter circuit converts it to 0x000. Input voltages between V_{REFH} and V_{REFL} are straight-line linear conversions. There is a brief current associated with V_{REFL} when the sampling capacitor is charging. The input is sampled for 3.5 cycles of the ADCK source when ADLSMP is low, or 23.5 cycles when ADLSMP is high.

For minimal loss of accuracy due to current injection, pins adjacent to the analog input pins should not be transitioning during conversions.

10.6.2 Sources of Error

Several sources of error exist for A/D conversions. These are discussed in the following sections.

10.6.2.1 Sampling Error

For proper conversions, the input must be sampled long enough to achieve the proper accuracy. Given the maximum input resistance of approximately 7kΩ and input capacitance of approximately 5.5 pF, sampling to within 1/4LSB (at 12-bit resolution) can be achieved within the minimum sample window (3.5 cycles @ 8 MHz maximum ADCK frequency) provided the resistance of the external analog source (R_{AS}) is kept below 2 kΩ.

Higher source resistances or higher-accuracy sampling is possible by setting ADLSMP (to increase the sample window to 23.5 cycles) or decreasing ADCK frequency to increase sample time.

10.6.2.2 Pin Leakage Error

Leakage on the I/O pins can cause conversion error if the external analog source resistance (R_{AS}) is high. If this error cannot be tolerated by the application, keep R_{AS} lower than $V_{DDAD} / (2^N * I_{LEAK})$ for less than 1/4LSB leakage error (N = 8 in 8-bit, 10 in 10-bit or 12 in 12-bit mode).

11.4.3 General Call Address

General calls can be requested in 7-bit address or 10-bit address. If the GCAEN bit is set, the IIC matches the general call address as well as its own slave address. When the IIC responds to a general call, it acts as a slave-receiver and the IAAS bit is set after the address cycle. Software must read the IICD register after the first byte transfer to determine whether the address matches is its own slave address or a general call. If the value is 00, the match is a general call. If the GCAEN bit is clear, the IIC ignores any data supplied from a general call address by not issuing an acknowledgement.

11.5 Resets

The IIC is disabled after reset. The IIC cannot cause an MCU reset.

11.6 Interrupts

The IIC generates a single interrupt.

An interrupt from the IIC is generated when any of the events in Table 11-11 occur, provided the IICIE bit is set. The interrupt is driven by bit IICIF (of the IIC status register) and masked with bit IICIE (of the IIC control register). The IICIF bit must be cleared by software by writing a 1 to it in the interrupt routine. You can determine the interrupt type by reading the status register.

Table 11-11. Interrupt Summary

Interrupt Source	Status	Flag	Local Enable
Complete 1-byte transfer	TCF	IICIF	IICIE
Match of received calling address	IAAS	IICIF	IICIE
Arbitration Lost	ARBL	IICIF	IICIE

11.6.1 Byte Transfer Interrupt

The TCF (transfer complete flag) bit is set at the falling edge of the ninth clock to indicate the completion of byte transfer.

11.6.2 Address Detect Interrupt

When the calling address matches the programmed slave address (IIC address register) or when the GCAEN bit is set and a general call is received, the IAAS bit in the status register is set. The CPU is interrupted, provided the IICIE is set. The CPU must check the SRW bit and set its Tx mode accordingly.

11.6.3 Arbitration Lost Interrupt

The IIC is a true multi-master bus that allows more than one master to be connected on it. If two or more masters try to control the bus at the same time, the relative priority of the contending masters is determined by a data arbitration procedure. The IIC module asserts this interrupt when it loses the data arbitration process and the ARBL bit in the status register is set.

Table 12-7. SPIS Register Field Descriptions

Field	Description
7 SPRF	**SPI Read Buffer Full Flag** — SPRF is set at the completion of an SPI transfer to indicate that received data may be read from the SPI data register (SPID). SPRF is cleared by reading SPRF while it is set, then reading the SPI data register. 0 No data available in the receive data buffer 1 Data available in the receive data buffer
5 SPTEF	**SPI Transmit Buffer Empty Flag** — This bit is set when there is room in the transmit data buffer. It is cleared by reading SPIS with SPTEF set, followed by writing a data value to the transmit buffer at SPID. SPIS must be read with SPTEF = 1 before writing data to SPID or the SPID write will be ignored. SPTEF generates an SPTEF CPU interrupt request if the SPTIE bit in the SPIC1 is also set. SPTEF is automatically set when a data byte transfers from the transmit buffer into the transmit shift register. For an idle SPI (no data in the transmit buffer or the shift register and no transfer in progress), data written to SPID is transferred to the shifter almost immediately so SPTEF is set within two bus cycles allowing a second 8-bit data value to be queued into the transmit buffer. After completion of the transfer of the value in the shift register, the queued value from the transmit buffer will automatically move to the shifter and SPTEF will be set to indicate there is room for new data in the transmit buffer. If no new data is waiting in the transmit buffer, SPTEF simply remains set and no data moves from the buffer to the shifter. 0 SPI transmit buffer not empty 1 SPI transmit buffer empty
4 MODF	**Master Mode Fault Flag** — MODF is set if the SPI is configured as a master and the slave select input goes low, indicating some other SPI device is also configured as a master. The $\overline{SS}$ pin acts as a mode fault error input only when MSTR = 1, MODFEN = 1, and SSOE = 0; otherwise, MODF will never be set. MODF is cleared by reading MODF while it is 1, then writing to SPI control register 1 (SPIC1). 0 No mode fault error 1 Mode fault error detected

12.4.5 SPI Data Register (SPID)

	7	6	5	4	3	2	1	0
R W	Bit 7	6	5	4	3	2	1	Bit 0
Reset	0	0	0	0	0	0	0	0

Figure 12-9. SPI Data Register (SPID)

Reads of this register return the data read from the receive data buffer. Writes to this register write data to the transmit data buffer. When the SPI is configured as a master, writing data to the transmit data buffer initiates an SPI transfer.

Data should not be written to the transmit data buffer unless the SPI transmit buffer empty flag (SPTEF) is set, indicating there is room in the transmit buffer to queue a new transmit byte.

Data may be read from SPID any time after SPRF is set and before another transfer is finished. Failure to read the data out of the receive data buffer before a new transfer ends causes a receive overrun condition and the data from the new transfer is lost.

Table 13-6. SCI1S2 Field Descriptions (continued)

Field	Description
1 LBKDE	**LIN Break Detection Enable**— LBKDE is used to select a longer break character detection length. While LBKDE is set, framing error (FE) and receive data register full (RDRF) flags are prevented from setting. 0 Break character is detected at length of 10 bit times (11 if M = 1). 1 Break character is detected at length of 11 bit times (12 if M = 1).
0 RAF	**Receiver Active Flag** — RAF is set when the SCI receiver detects the beginning of a valid start bit, and RAF is cleared automatically when the receiver detects an idle line. This status flag can be used to check whether an SCI character is being received before instructing the MCU to go to stop mode. 0 SCI receiver idle waiting for a start bit. 1 SCI receiver active (RxD input not idle).

[1] Setting RXINV inverts the RxD input for all cases: data bits, start and stop bits, break, and idle.

When using an internal oscillator in a LIN system, it is necessary to raise the break detection threshold by one bit time. Under the worst case timing conditions allowed in LIN, it is possible that a 0x00 data character can appear to be 10.26 bit times long at a slave which is running 14% faster than the master. This would trigger normal break detection circuitry which is designed to detect a 10 bit break symbol. When the LBKDE bit is set, framing errors are inhibited and the break detection threshold changes from 10 bits to 11 bits, preventing false detection of a 0x00 data character as a LIN break symbol.

13.2.6 SCI Control Register 3 (SCI1C3)

	7	6	5	4	3	2	1	0
R	R8	T8	TXDIR	TXINV	ORIE	NEIE	FEIE	PEIE
W	▨							
Reset	0	0	0	0	0	0	0	0

▨ = Unimplemented or Reserved

Figure 13-10. SCI Control Register 3 (SCI1C3)

Table 13-7. SCI1C3 Field Descriptions

Field	Description
7 R8	**Ninth Data Bit for Receiver** — When the SCI is configured for 9-bit data (M = 1), R8 can be thought of as a ninth receive data bit to the left of the MSB of the buffered data in the SCI1D register. When reading 9-bit data, read R8 before reading SCI1D because reading SCI1D completes automatic flag clearing sequences which could allow R8 and SCI1D to be overwritten with new data.
6 T8	**Ninth Data Bit for Transmitter** — When the SCI is configured for 9-bit data (M = 1), T8 may be thought of as a ninth transmit data bit to the left of the MSB of the data in the SCI1D register. When writing 9-bit data, the entire 9-bit value is transferred to the SCI shift register after SCI1D is written so T8 should be written (if it needs to change from its previous value) before SCI1D is written. If T8 does not need to change in the new value (such as when it is used to generate mark or space parity), it need not be written each time SCI1D is written.
5 TXDIR	**TxD Pin Direction in Single-Wire Mode** — When the SCI is configured for single-wire half-duplex operation (LOOPS = RSRC = 1), this bit determines the direction of data at the TxD pin. 0 TxD pin is an input in single-wire mode. 1 TxD pin is an output in single-wire mode.

	7	6	5	4	3	2	1	0
R	Bit 7	6	5	4	3	2	1	Bit 0
W	Any write to TPMxCNTL clears the 16-bit counter							
Reset	0	0	0	0	0	0	0	0

Figure 15-9. TPM Counter Register Low (TPMxCNTL)

When BDM is active, the timer counter is frozen (this is the value that will be read by user); the coherency mechanism is frozen such that the buffer latches remain in the state they were in when the BDM became active, even if one or both counter halves are read while BDM is active. This assures that if the user was in the middle of reading a 16-bit register when BDM became active, it will read the appropriate value from the other half of the 16-bit value after returning to normal execution.

In BDM mode, writing any value to TPMxSC, TPMxCNTH or TPMxCNTL registers resets the read coherency mechanism of the TPMxCNTH:L registers, regardless of the data involved in the write.

15.3.3 TPM Counter Modulo Registers (TPMxMODH:TPMxMODL)

The read/write TPM modulo registers contain the modulo value for the TPM counter. After the TPM counter reaches the modulo value, the TPM counter resumes counting from 0x0000 at the next clock, and the overflow flag (TOF) becomes set. Writing to TPMxMODH or TPMxMODL inhibits the TOF bit and overflow interrupts until the other byte is written. Reset sets the TPM counter modulo registers to 0x0000 which results in a free running timer counter (modulo disabled).

Writing to either byte (TPMxMODH or TPMxMODL) latches the value into a buffer and the registers are updated with the value of their write buffer according to the value of CLKSB:CLKSA bits, so:

- If (CLKSB:CLKSA = 0:0), then the registers are updated when the second byte is written
- If (CLKSB:CLKSA not = 0:0), then the registers are updated after both bytes were written, and the TPM counter changes from (TPMxMODH:TPMxMODL - 1) to (TPMxMODH:TPMxMODL). If the TPM counter is a free-running counter, the update is made when the TPM counter changes from 0xFFFE to 0xFFFF

The latching mechanism may be manually reset by writing to the TPMxSC address (whether BDM is active or not).

When BDM is active, the coherency mechanism is frozen (unless reset by writing to TPMxSC register) such that the buffer latches remain in the state they were in when the BDM became active, even if one or both halves of the modulo register are written while BDM is active. Any write to the modulo registers bypasses the buffer latches and directly writes to the modulo register while BDM is active.

	7	6	5	4	3	2	1	0
R W	Bit 15	14	13	12	11	10	9	Bit 8
Reset	0	0	0	0	0	0	0	0

Figure 15-10. TPM Counter Modulo Register High (TPMxMODH)

TPM counter changes from (TPMxMODH:L - 1) to (TPMxMODH:L). If the TPM counter is a free-running counter, then this update is made when the TPM counter changes from $FFFE to $FFFF. Instead, the TPM v2 makes this update after that the both bytes were written and when the TPM counter changes from TPMxMODH:L to $0000.

— Center-Aligned PWM (Section 15.4.2.4, “Center-Aligned PWM Mode)

In this mode and if (CLKSB:CLKSA not = 00), the TPM v3 updates the TPMxCnVH:L registers with the value of their write buffer after that the both bytes were written and when the TPM counter changes from (TPMxMODH:L - 1) to (TPMxMODH:L). If the TPM counter is a free-running counter, then this update is made when the TPM counter changes from $FFFE to $FFFF. Instead, the TPM v2 makes this update after that the both bytes were written and when the TPM counter changes from TPMxMODH:L to (TPMxMODH:L - 1).

5. Center-Aligned PWM (Section 15.4.2.4, “Center-Aligned PWM Mode)

— TPMxCnVH:L = TPMxMODH:L [SE110-TPM case 1]

In this case, the TPM v3 produces 100% duty cycle. Instead, the TPM v2 produces 0% duty cycle.

— TPMxCnVH:L = (TPMxMODH:L - 1) [SE110-TPM case 2]

In this case, the TPM v3 produces almost 100% duty cycle. Instead, the TPM v2 produces 0% duty cycle.

— TPMxCnVH:L is changed from 0x0000 to a non-zero value [SE110-TPM case 3 and 5]

In this case, the TPM v3 waits for the start of a new PWM period to begin using the new duty cycle setting. Instead, the TPM v2 changes the channel output at the middle of the current PWM period (when the count reaches 0x0000).

— TPMxCnVH:L is changed from a non-zero value to 0x0000 [SE110-TPM case 4]

In this case, the TPM v3 finishes the current PWM period using the old duty cycle setting. Instead, the TPM v2 finishes the current PWM period using the new duty cycle setting.

6. Write to TPMxMODH:L registers in BDM mode (Section 15.3.3, “TPM Counter Modulo Registers (TPMxMODH:TPMxMODL))

In the TPM v3 a write to TPMxSC register in BDM mode clears the write coherency mechanism of TPMxMODH:L registers. Instead, in the TPM v2 this coherency mechanism is not cleared when there is a write to TPMxSC register.

7. Update of EPWM signal when CLKSB:CLKSA = 00

In the TPM v3 if CLKSB:CLKSA = 00, then the EPWM signal in the channel output is not update (it is frozen while CLKSB:CLKSA = 00). Instead, in the TPM v2 the EPWM signal is updated at the next rising edge of bus clock after a write to TPMxCnSC register.

The Figure 0-1 and Figure 0-2 show when the EPWM signals generated by TPM v2 and TPM v3 after the reset (CLKSB:CLKSA = 00) and if there is a write to TPMxCnSC register.

16.3.6 Hardware Breakpoints

The BRKEN control bit in the DBGC register may be set to 1 to allow any of the trigger conditions described in Section 16.3.5, “Trigger Modes,” to be used to generate a hardware breakpoint request to the CPU. TAG in DBGC controls whether the breakpoint request will be treated as a tag-type breakpoint or a force-type breakpoint. A tag breakpoint causes the current opcode to be marked as it enters the instruction queue. If a tagged opcode reaches the end of the pipe, the CPU executes a BGND instruction to go to active background mode rather than executing the tagged opcode. A force-type breakpoint causes the CPU to finish the current instruction and then go to active background mode.

If the background mode has not been enabled (ENBDM = 1) by a serial WRITE_CONTROL command through the BKGD pin, the CPU will execute an SWI instruction instead of going to active background mode.

16.4 Register Definition

This section contains the descriptions of the BDC and DBG registers and control bits.

Refer to the high-page register summary in the device overview chapter of this data sheet for the absolute address assignments for all DBG registers. This section refers to registers and control bits only by their names. A Freescale-provided equate or header file is used to translate these names into the appropriate absolute addresses.

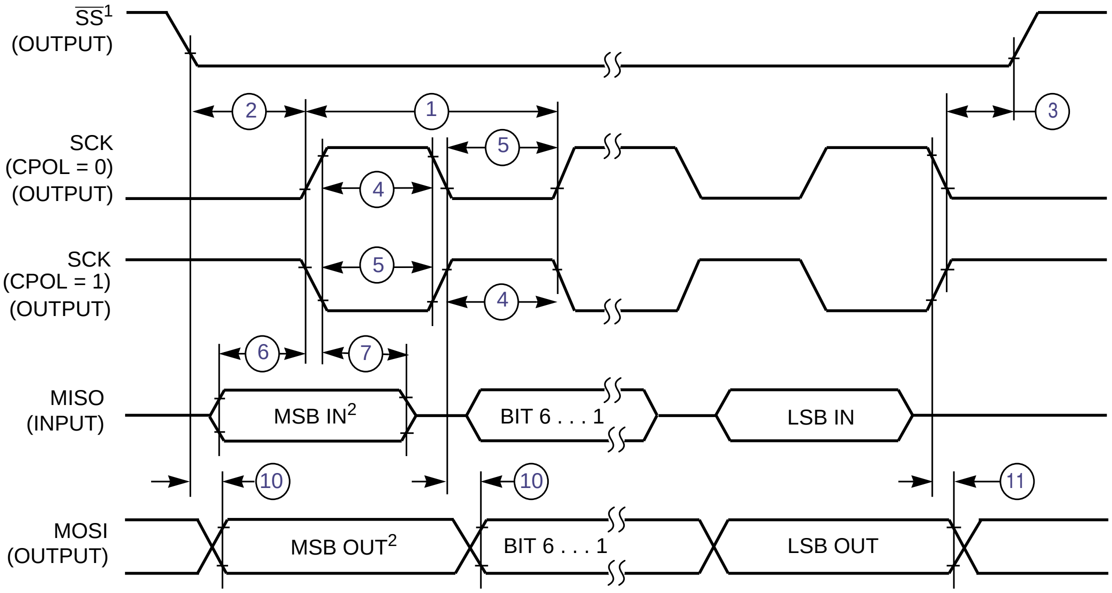
16.4.1 BDC Registers and Control Bits

The BDC has two registers:

- The BDC status and control register (BDCSCR) is an 8-bit register containing control and status bits for the background debug controller.
- The BDC breakpoint match register (BDCBKPT) holds a 16-bit breakpoint match address.

These registers are accessed with dedicated serial BDC commands and are not located in the memory space of the target MCU (so they do not have addresses and cannot be accessed by user programs).

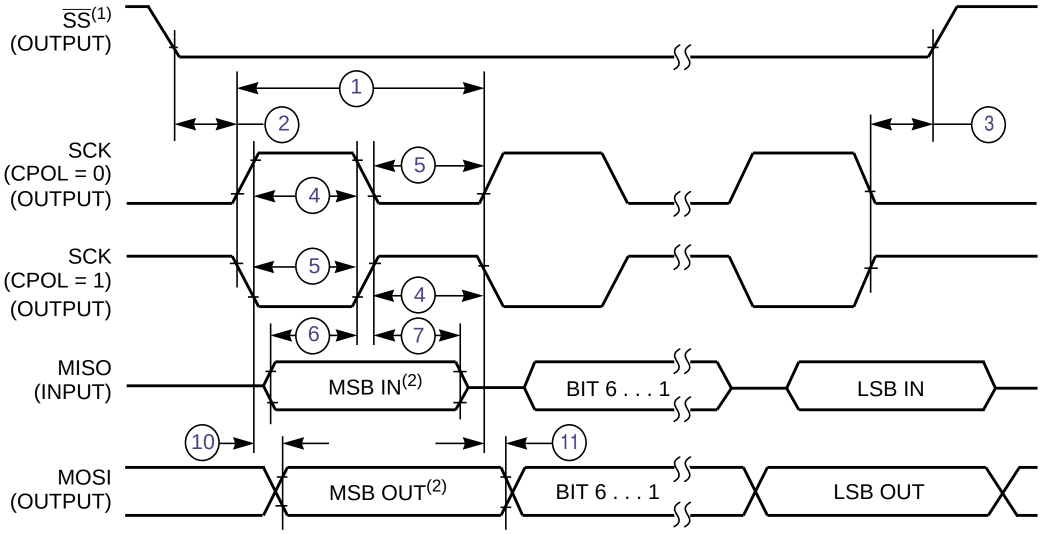
Some of the bits in the BDCSCR have write limitations; otherwise, these registers may be read or written at any time. For example, the ENBDM control bit may not be written while the MCU is in active background mode. (This prevents the ambiguous condition of the control bit forbidding active background mode while the MCU is already in active background mode.) Also, the four status bits (BDMACT, WS, WSF, and DVF) are read-only status indicators and can never be written by the WRITE_CONTROL serial BDC command. The clock switch (CLKSW) control bit may be read or written at any time.



NOTES:

1. SS output mode (MODFEN = 1, SSOE = 1).
2. LSBF = 0. For LSBF = 1, bit order is LSB, bit 1, ..., bit 6, MSB.

Figure A-7. SPI Master Timing (CPHA = 0)



NOTES:

1. SS output mode (MODFEN = 1, SSOE = 1).
2. LSBF = 0. For LSBF = 1, bit order is LSB, bit 1, ..., bit 6, MSB.

Figure A-8. SPI Master Timing (CPHA = 1)

All TPM channels are programmable independently as input capture, output compare, or buffered edge-aligned PWM channels.

B.1 External Signal Description

When any pin associated with the timer is configured as a timer input, a passive pullup can be enabled. After reset, the TPM modules are disabled and all pins default to general-purpose inputs with the passive pullups disabled.

B.1.1 External TPM Clock Sources

When control bits CLKSB:CLKSA in the timer status and control register are set to 1:1, the prescaler and consequently the 16-bit counter for TPMx are driven by an external clock source, TPMxCLK, connected to an I/O pin. A synchronizer is needed between the external clock and the rest of the TPM. This synchronizer is clocked by the bus clock so the frequency of the external source must be less than one-half the frequency of the bus rate clock. The upper frequency limit for this external clock source is specified to be one-fourth the bus frequency to conservatively accommodate duty cycle and phase-locked loop (PLL) or frequency-locked loop (FLL) frequency jitter effects.

On some devices the external clock input is shared with one of the TPM channels. When a TPM channel is shared as the external clock input, the associated TPM channel cannot use the pin. (The channel can still be used in output compare mode as a software timer.) Also, if one of the TPM channels is used as the external clock input, the corresponding ELSnB:ELSnA control bits must be set to 0:0 so the channel is not trying to use the same pin.

B.1.2 TPMxCHn — TPMx Channel n I/O Pins

Each TPM channel is associated with an I/O pin on the MCU. The function of this pin depends on the configuration of the channel. In some cases, no pin function is needed so the pin reverts to being controlled by general-purpose I/O controls. When a timer has control of a port pin, the port data and data direction registers do not affect the related pin(s). See the Pins and Connections chapter for additional information about shared pin functions.

B.2 Register Definition

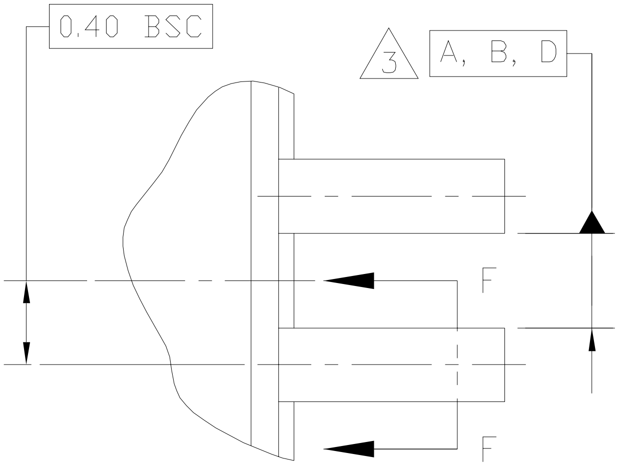
The TPM includes:

- An 8-bit status and control register (TPMxSC)
- A 16-bit counter (TPMxCNTH:TPMxCNTL)
- A 16-bit modulo register (TPMxMODH:TPMxMODL)

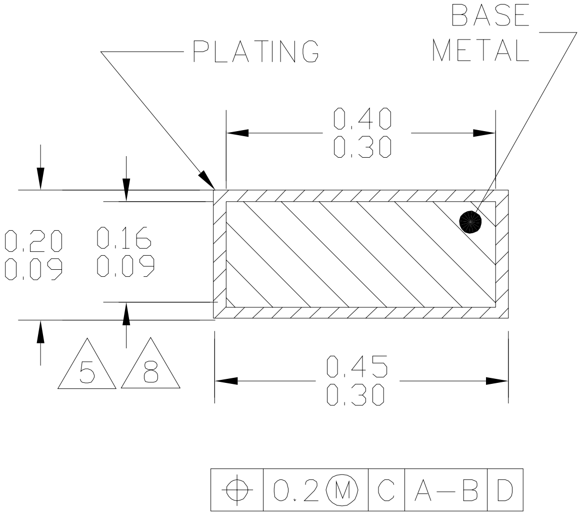
Each timer channel has:

- An 8-bit status and control register (TPMxCnSC)
- A 16-bit channel value register (TPMxCnVH:TPMxCnVL)

Refer to the direct-page register summary in the Memory chapter of this data sheet for the absolute address assignments for all TPM registers. This section refers to registers and control bits only by their names. A

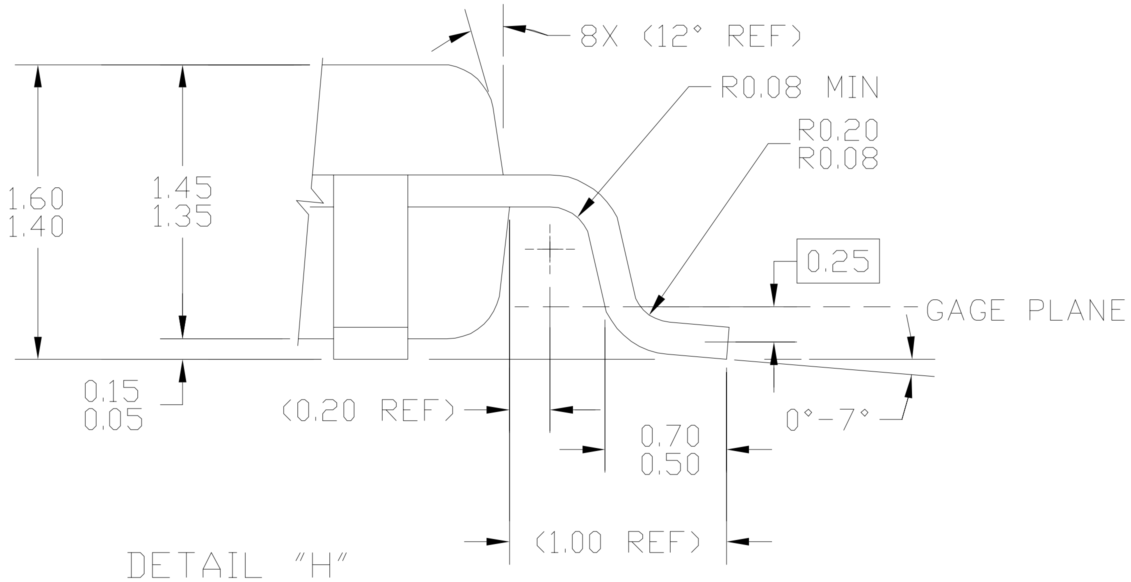


DETAIL G



SECTION F-F

ROTATED 90°CW
32 PLACES



DETAIL "H"

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TITLE: LOW PROFILE QUAD FLAT PACK (LQFP) 32 LEAD, 0.8 PITCH (7 X 7 X 1.4)	DOCUMENT NO: 98ASH70029A	REV: D
	CASE NUMBER: 873A-03	19 MAY 2005
	STANDARD: JEDEC MS-026 BBA	

NOTES:

1. DIMENSIONS ARE IN MILLIMETERS.

2. INTERPRET DIMENSIONS AND TOLERANCES PER ASME Y14.5−1994.

3. DATUMS A, B, AND D TO BE DETERMINED AT DATUM PLANE H.

4. DIMENSIONS TO BE DETERMINED AT SEATING PLANE DATUM C.

5. DIMENSION DOES NOT INCLUDE DAMBAR PROTRUSION. ALLOWABLE DAMBAR PROTRUSION SHALL NOT CAUSE THE LEAD WIDTH TO EXCEED THE MAXIMUM DIMENSION BY MORE THAN 0.08 MM. DAMBAR CANNOT BE LOCATED ON THE LOWER RADIUS OR THE FOOT. MINIMUM SPACE BETWEEN PROTRUSION AND ADJACENT LEAD OR PROTRUSION: 0.07 MM.

6. DIMENSIONS DO NOT INCLUDE MOLD PROTRUSION. ALLOWABLE PROTRUSION IS 0.25 MM PER SIDE. DIMENSIONS ARE MAXIMUM PLASTIC BODY SIZE DIMENSIONS INCLUDING MOLD MISMATCH.

7. EXACT SHAPE OF EACH CORNER IS OPTIONAL.

8. THESE DIMENSIONS APPLY TO THE FLAT SECTION OF THE LEAD BETWEEN 0.1 MM AND 0.25 MM FROM THE LEAD TIP.

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