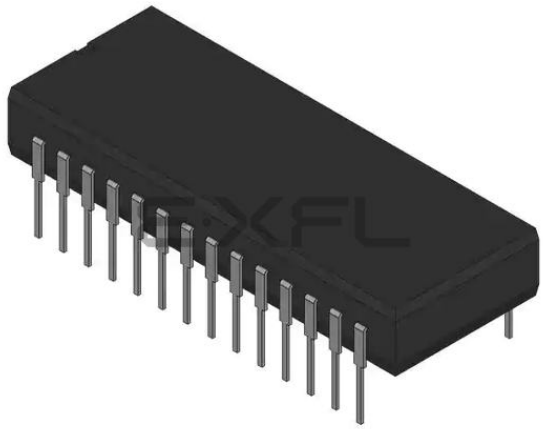

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"Embedded - Microcontrollers" refer to small, integrated circuits designed to perform specific tasks within larger systems. These microcontrollers are essentially compact computers on a single chip, containing a processor core, memory, and programmable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

Applications of "Embedded - Microcontrollers"

Details	
Product Status	Active
Core Processor	S08
Core Size	8-Bit
Speed	51.34MHz
Connectivity	I²C, LINbus, SCI, SPI
Peripherals	LVD, POR, PWM, WDT
Number of I/O	22
Program Memory Size	12KB (12K x 8)
Program Memory Type	FLASH
EEPROM Size	-
RAM Size	512 x 8
Voltage - Supply (Vcc/Vdd)	2.7V ~ 5.5V
Data Converters	A/D 13x12b; D/A 3x5b
Oscillator Type	Internal
Operating Temperature	-40°C ~ 105°C (TA)
Mounting Type	Surface Mount
Package / Case	28-SOIC (0.295", 7.50mm Width)
Supplier Device Package	28-SOIC
Purchase URL	https://www.e-xfl.com/pro/item?MUrl=&PartUrl=mc9s08mp12vwl

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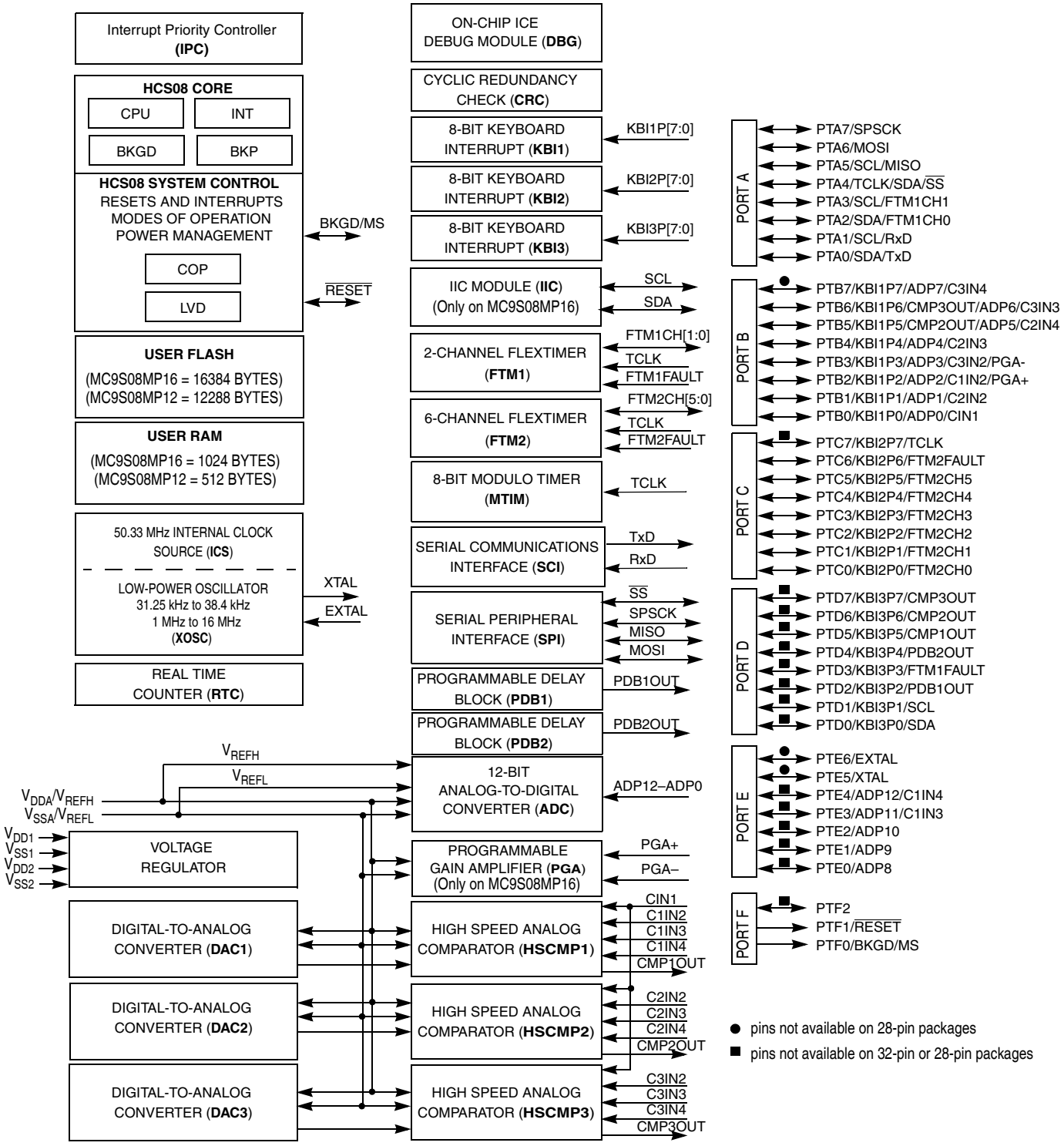
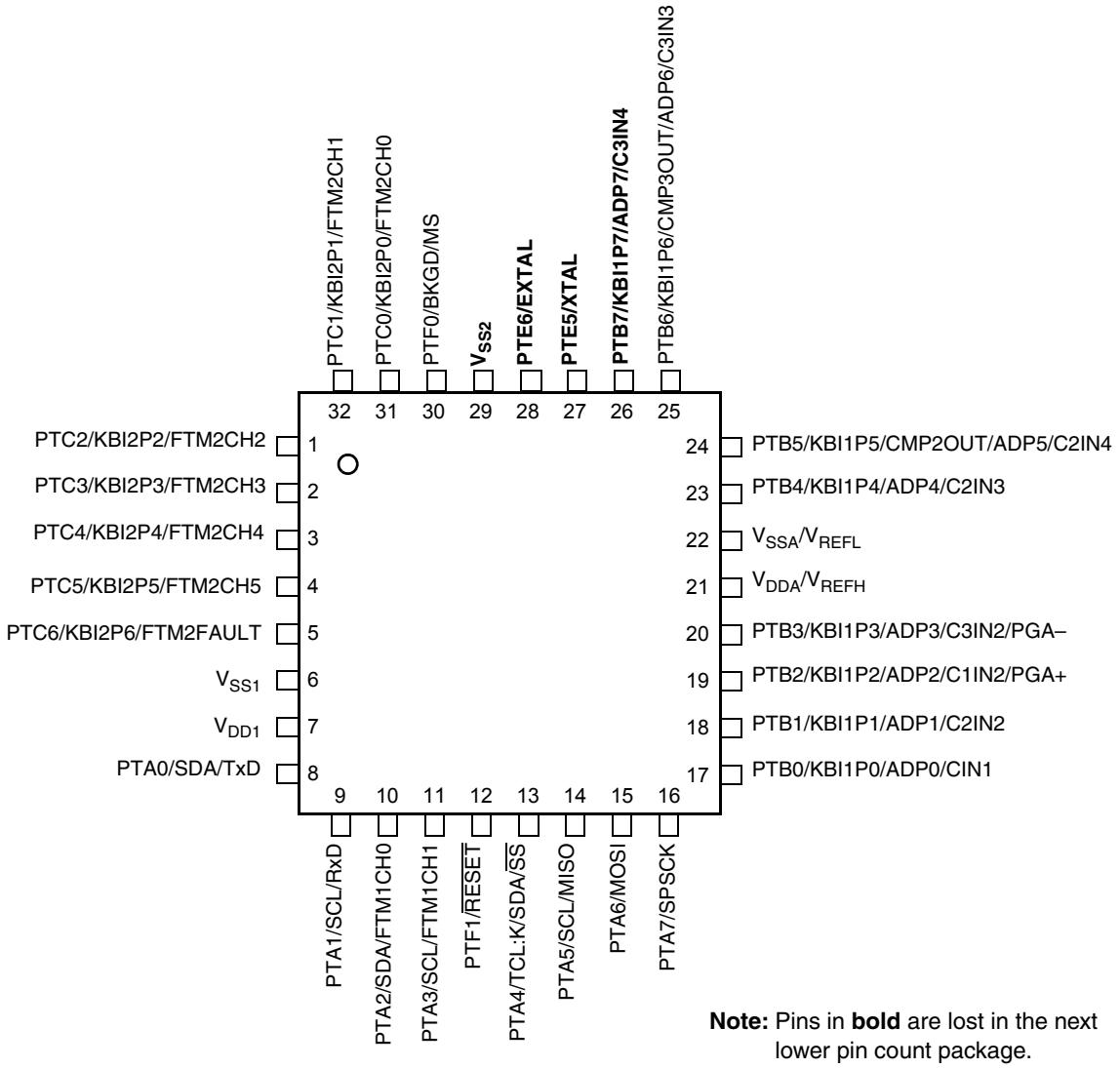


Notes: When PTF1 is configured as RESET, pin becomes bi-directional with output being open-drain drive containing an internal pull-up device.
When PTF0 is configured as BKGD, pin becomes bi-directional.
V_{DD2} pad is tied internally on 32-pin and 28-pin packages,
V_{SS2} pad is tied internally on 28-pin packages

Figure 1. MC9S08MP16 Series Block Diagram



Note: Pins in **bold** are lost in the next lower pin count package.

Figure 3. MC9S08MP16 Series in 32-Pin LQFP Package

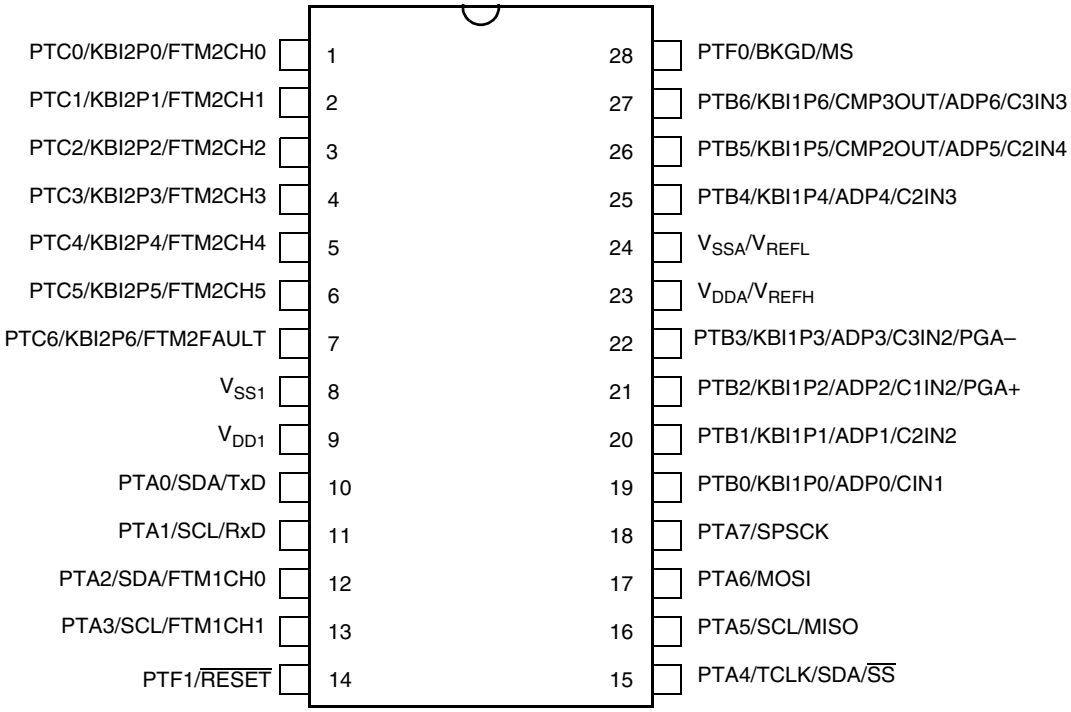


Figure 4. MC9S08MP16 Series in 28-Pin SOIC Package

Table 1. Pin Availability by Package Pin-Count (continued)

Pin Number			<-- Lowest **Priority** --> Highest				
48	**32 LQFP**	**28**	**Port Pin**	**Alt 1**	**Alt 2**	**Alt3**	**Alt4**
35	—	—	PTE4		ADP12[6]	C1IN4[6]	
36	23	25	PTB4	KBI1P4		ADP4[6]	C2IN3[6]
37	24	26	PTB5	KBI1P5	CMP2OUT[2]	ADP5[6]	C2IN4[6]
38	25	27	PTB6	KBI1P6	CMP3OUT[3]	ADP6[6]	C3IN3[6]
39	26	—	PTB7	KBI1P7		ADP7[6]	C3IN4[6]
40	27	—	PTE5	XTAL			
41	28	—	PTE6	EXTAL			
42	29	—					V_{SS2}
43	—	—					V_{DD2}
44	30	28	PTF0	BKGD	MS		
45	31	1	PTC0	KBI2P0	FTM2CH0		
46	32	2	PTC1	KBI2P1	FTM2CH1		
47	1	3	PTC2	KBI2P2	FTM2CH2		
48	2	4	PTC3	KBI2P3	FTM2CH3		

1 TCLK pin can be repositioned using TCLKPS in SOPT2. Default reset location is PTC7.

2 HSCMP2 output CMP2OUT can be repositioned using the CMP2OPS in the SOPT2 register. Default reset location is PTD6.

3 HSCMP3 output CMP3OUT can be repositioned using the CMP3OPS in the SOPT2 register. Default reset location is PTD7.

4 Pin is open drain with an internal pullup that is always enabled. Pin does not contain a clamp diode to V_{DD} and should not be driven above V_{DD}. The voltage measured on the internally pulled up $\overline{\text{RESET}}$ will not be pulled to V_{DD}. The internal gates connected to this pin are pulled to V_{DD}.

5 IIC pins SDA and SCL can be repositioned using IICPS in SOPT2. Default reset locations are PTD0 and PTD1.

6 If ADC, HSCMP, or PGA is enabling a shared analog input pin, each has access to the pin.

2 Electrical Characteristics

2.1 Introduction

This section contains electrical and timing specifications for the MC9S08MP16 Series of microcontrollers available at the time of publication.

2.4 Thermal Characteristics

This section provides information about operating temperature range, power dissipation, and package thermal resistance. Power dissipation on I/O pins is usually small compared to the power dissipation in on-chip logic and voltage regulator circuits, and it is user-determined rather than being controlled by the MCU design. To take $P_{I/O}$ into account in power calculations, determine the difference between actual pin voltage and V_{SS} or V_{DD} and multiply by the pin current for each I/O pin. Except in cases of unusually high pin current (heavy loads), the difference between pin voltage and V_{SS} or V_{DD} will be very small.

Table 4. Thermal Characteristics

Num	C	Rating	Symbol	Consumer & Industrial	Automotive	Unit
1	—	Operating temperature range (packaged)	T_A	–40 to 105	–40 to 125	°C
2	D	Maximum junction temperature	T_J	115	135	°C
3	D	Thermal resistance [1,2] single-layer board				
		48-pin LQFP	θ_{JA}	80	80	°C/W
		32-pin LQFP		85	—	
		28-pin SOIC		71	—	
4	D	Thermal resistance [1,2] four-layer board				
		48-pin LQFP	θ_{JA}	56	56	°C/W
		32-pin LQFP		57	—	
		28-pin SOIC		48	—	

1 Junction temperature is a function of die size, on-chip power dissipation, package thermal resistance, mounting site (board) temperature, ambient temperature, air flow, power dissipation of other components on the board, and board thermal resistance.

2 Junction-to-ambient natural convection

The average chip-junction temperature (T_J) in °C can be obtained from:

$$T_J = T_A + (P_D \times \theta_{JA}) \qquad \textit{Eqn. 1}$$

where:

T_A = Ambient temperature, °C
θ_{JA} = Package thermal resistance, junction-to-ambient, °C/W
$P_D = P_{int} + P_{I/O}$
$P_{int} = I_{DD} \times V_{DD}$, Watts — chip internal power
$P_{I/O}$ = Power dissipation on input and output pins — user determined

For most applications, $P_{I/O} << P_{int}$ and can be neglected. An approximate relationship between P_D and T_J (if $P_{I/O}$ is neglected) is:

$$P_D = K \div (T_J + 273°C) \qquad \textit{Eqn. 2}$$

Solving Equation 1 and Equation 2 for K gives:

$$K = P_D \times (T_A + 273°C) + \theta_{JA} \times (P_D)^2 \qquad \textit{Eqn. 3}$$

where K is a constant pertaining to the particular part. K can be determined from equation 3 by measuring P_D (at equilibrium) for a known T_A. Using this value of K, the values of P_D and T_J can be obtained by solving Equation 1 and Equation 2 iteratively for any value of T_A.

2.5 ESD Protection and Latch-Up Immunity

Although damage from electrostatic discharge (ESD) is much less common on these devices than on early CMOS circuits, normal handling precautions should be taken to avoid exposure to static discharge. Qualification tests are performed to ensure that these devices can withstand exposure to reasonable levels of static without suffering any permanent damage.

All ESD testing is in conformity with AEC-Q100 Stress Test Qualification for Automotive Grade Integrated Circuits. During the device qualification, ESD stresses were performed for the human body model (HBM) and the charge device model (CDM).

A device is defined as a failure if after exposure to ESD pulses the device no longer meets the device specification. Complete DC parametric and functional testing is performed per the applicable device specification at room temperature followed by hot temperature, unless instructed otherwise in the device specification.

Table 5. ESD and Latch-up Test Conditions

Model	Description	Symbol	Value	Unit
Human Body	Series resistance	R1	1500	Ω
	Storage capacitance	C	100	pF
	Number of pulses per pin	—	3	
Latch-up	Minimum input voltage limit		– 2.5	V
	Maximum input voltage limit		7.5	V

Table 6. ESD and Latch-Up Protection Characteristics

No.	Rating[1]	Symbol	Min	Max	Unit
1	Human body model (HBM)	V_{HBM}	± 2000	—	V
2	Charge device model (CDM)	V_{CDM}	± 500	—	V
3	Latch-up current at T_A = 125°C	I_{LAT}	± 100	—	mA

1 Parameter is achieved by design characterization on a small sample size from typical devices under typical conditions unless otherwise noted.

2.6 DC Characteristics

This section includes information about power supply requirements and I/O pin characteristics.

Table 7. DC Characteristics

Num	C	Characteristic	Symbol	Condition	Min	Typ[1]	Max	Unit
1	—	Operating Voltage	V_{DD}		2.7	—	5.5	V
2	—	Analog Supply voltage delta to V_{DD} (V_{DD} – V_{DDA})[(2)]	ΔV_{DDA}		—	0	±100	mV
3	—	Analog Ground voltage delta to V_{SS} (V_{SS} – V_{SSA})[(2)]	ΔV_{SSA}		—	0	±100	mV

Table 7. DC Characteristics (continued)

Num	C	Characteristic	Symbol	Condition	Min	Typ[1]	Max	Unit
4	C	All I/O pins (except PTF1/$\overline{\text{RESET}}$)	V_{OH}	5 V, I_{Load} = –4 mA	V_{DD} – 1.5	—	—	V
	P	low-drive strength		5 V, I_{Load} = –2 mA	V_{DD} – 0.8	—	—	
	C	Output high		3 V, I_{Load} = –1 mA	V_{DD} – 0.8	—	—	
	C	voltage		5 V, I_{Load} = –20 mA	V_{DD} – 1.5	—	—	
	P	high-drive strength		5 V, I_{Load} = –10 mA	V_{DD} – 0.8	—	—	
	C			3 V, I_{Load} = –5 mA	V_{DD} – 0.8	—	—	
5	D	Output high current — Max total I_{OH} for all ports	I_{OHT}	$V_{OUT} < V_{DD}$	0	—	–100	mA
6	C	All I/O pins	V_{OL}	5 V, I_{Load} = 4 mA	—	—	1.5	V
	P	(except PTF1/$\overline{\text{RESET}}$)		5 V, I_{Load} = 2 mA	—	—	0.8	
	C	low-drive strength		3 V, I_{Load} = 1 mA	—	—	0.8	
	C	All I/O pins		5 V, I_{Load} = 20 mA	—	—	1.5	
	P	Output low (Except PTF1/$\overline{\text{RESET}}$)		5 V, I_{Load} = 10 mA	—	—	0.8	
	C	voltage high-drive strength		3 V, I_{Load} = 5 mA	—	—	0.8	
7	C	PTF1/$\overline{\text{RESET}}$		5 V, I_{Load} = 3.2 mA	—	—	1.5	
8	P			5 V, I_{Load} = 1.6 mA	—	—	0.8	
9	C			3 V, I_{Load} = 0.8 mA	—	—	0.8	
10	D	Output low current — Max total I_{OL} for all ports	I_{OLT}	$V_{OUT} > V_{SS}$	0	—	100	mA
11	P	Input high voltage; all digital inputs	V_{IH}	5V	0.65 x V_{DD}	—	—	V
	C			3V	0.7 x V_{DD}	—	—	
12	P	Input low voltage; all digital inputs	V_{IL}	5V	—	—	0.35 x V_{DD}	V
	C			3V	—	—	0.35 x V_{DD}	
13	C	Input hysteresis	V_{hys}		0.06 x V_{DD}			V
14	P	Input leakage current (per pin)	$\lvert I_{In} \rvert$	$V_{In} = V_{DD}$ or V_{SS}	—	—	1	µA
15	P	Hi-Z (off-state) leakage current (per pin)						
		input/output port pins	$\lvert I_{OZ} \rvert$	$V_{In} = V_{DD}$ or V_{SS}	—	—	1	µA
		PTF1/$\overline{\text{RESET}}$, PTE5/XTAL pins		$V_{In} = V_{DD}$ or V_{SS}	—	—	2	µA
16	P	Pullup or Pulldown[3] resistors; when enabled — I/O pins	R_{PU},R_{PD}		17	37	52	kΩ
	C	PTF1/$\overline{\text{RESET}}$[4]	R_{PU}		17	37	52	kΩ
17	D	DC injection current [5, 6, 7, 8] — Single pin limit	I_{IC}	$V_{IN} > V_{DD}$	0	—	2	mA
				$V_{IN} < V_{SS}$	0	—	–0.2	mA
		Total MCU limit, includes sum of all stressed pins		$V_{IN} > V_{DD}$	0	—	25	mA
				$V_{IN} < V_{SS}$	0	—	–5	mA

Table 7. DC Characteristics (continued)

Num	C	Characteristic	Symbol	Condition	Min	Typ[1]	Max	Unit
13	C	Input Capacitance, all pins	C_{In}		—	—	8	pF
14	C	RAM retention voltage	V_{RAM}		—	0.6	1.0	V
15	C	POR re-arm voltage[9]	V_{POR}		0.9	1.4	2.0	V
16	D	POR re-arm time	t_{POR}		10	—	—	µs
17	P	Low-voltage detection threshold — high range V_{DD} falling V_{DD} rising	V_{LVD1}		 3.9 4.0	 4.0 4.1	 4.1 4.2	V
18	P	Low-voltage detection threshold — low range V_{DD} falling V_{DD} rising	V_{LVD0}		 2.48 2.54	 2.56 2.62	 2.64 2.70	V
19	P	Low-voltage warning threshold — high range 1 V_{DD} falling V_{DD} rising	V_{LVW3}		 4.5 4.6	 4.6 4.7	 4.7 4.8	V
20	P	Low-voltage warning threshold — high range 0 V_{DD} falling V_{DD} rising	V_{LVW2}		 4.2 4.3	 4.3 4.4	 4.4 4.5	V
21	P	Low-voltage warning threshold low range 1 V_{DD} falling V_{DD} rising	V_{LVW1}		 2.84 2.90	 2.92 2.98	 3.00 3.06	V
22	P	Low-voltage warning threshold — low range 0 V_{DD} falling V_{DD} rising	V_{LVW0}		 2.66 2.72	 2.74 2.80	 2.82 2.88	V
23	T	Low-voltage inhibit reset/recover hysteresis	V_{hys}	5 V	—	100	—	mV
				3 V	—	60	—	
24	P	Bandgap voltage reference at 25°C[10]	V_{BG}		1.18	1.202	1.21	V
25	P	Bandgap voltage reference across temperature range[10]			1.17	—	1.22	V

1 Typical values are measured at 25°C. Characterized, not tested

2 DC potential difference.

3 When keyboard interrupt is configured to detect rising edges, pulldown resistors are used in place of pullup resistors.

4 The specified resistor value is the actual value internal to the device. The pullup value may measure higher when measured externally on the pin.

5 Power supply must maintain regulation within operating V_{DD} range during instantaneous and operating maximum current conditions. If positive injection current ($V_{In} > V_{DD}$) is greater than I_{DD}, the injection current may flow out of V_{DD} and could result in external power supply going out of regulation. Ensure external V_{DD} load will shunt current greater than maximum injection current. This will be the greatest risk when the MCU is not consuming power. Examples are: if no system clock is present, or if clock rate is very low (which would reduce overall power consumption).

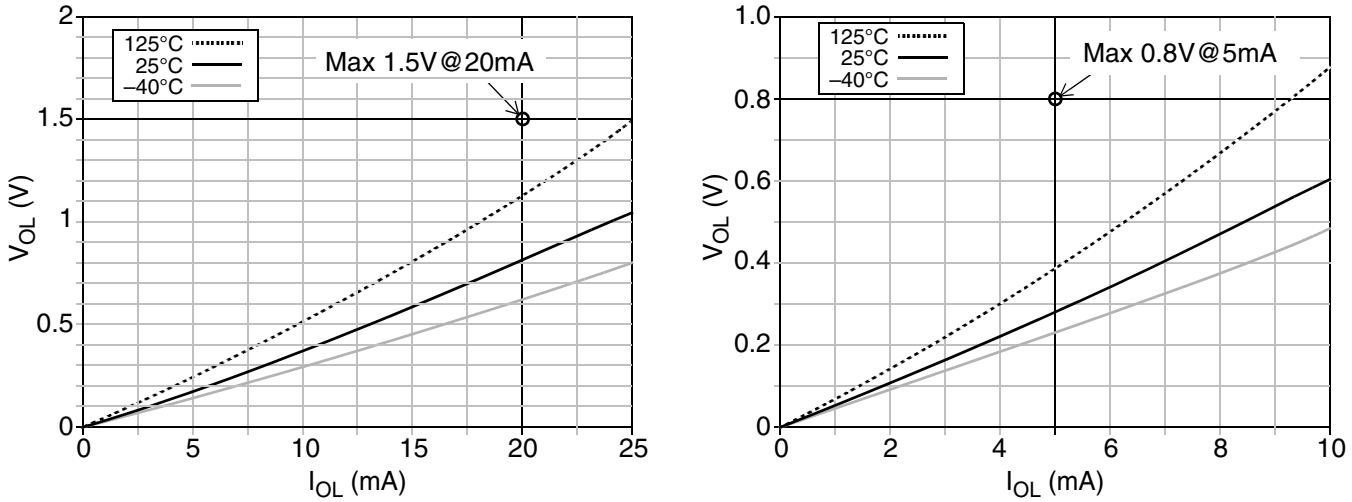
6 Input must be current limited to the value specified. To determine the value of the required current-limiting resistor, calculate resistance values for positive and negative clamp voltages, then use the larger of the two values.

7 All functional non-supply pins except PTF1/$\overline{\text{RESET}}$ are internally clamped to V_{SS} and V_{DD}.

8 The PTF1/$\overline{\text{RESET}}$ pin does not have a clamp diode to V_{DD}. Do not drive this pin above V_{DD}.

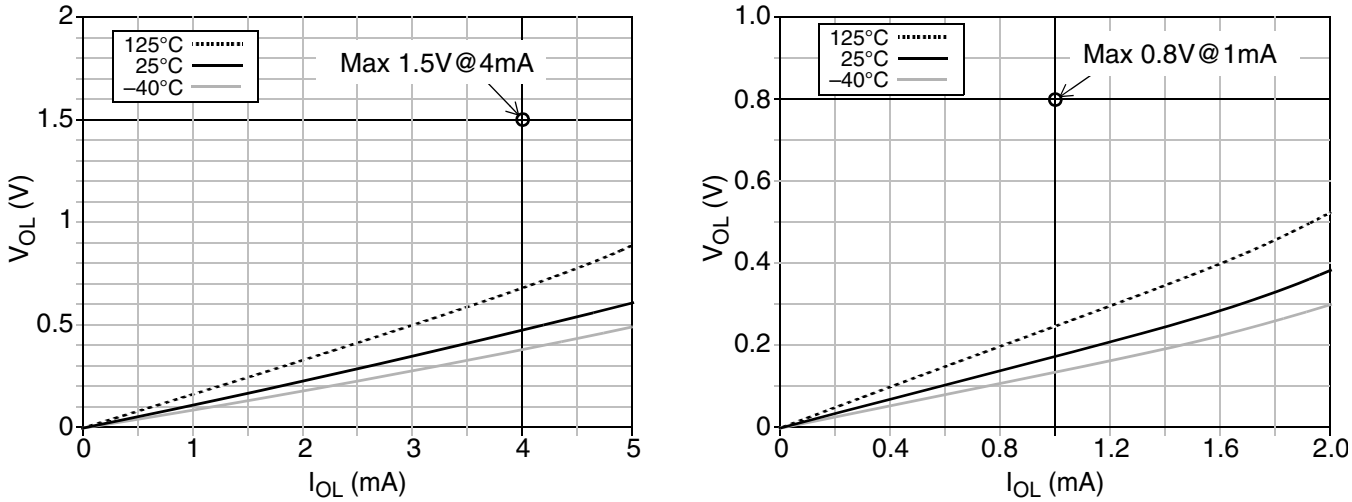
9 Maximum is highest voltage that POR is guaranteed.

10 Factory trimmed at V_{DD} = 5.0 V



a) V_{DD} = 5V, High Drive **b) V_{DD} = 3V, High Drive**

Figure 5. Typical V_{OL} vs I_{OL}, High Drive Strength (except PTF1/RESET)



a) V_{DD} = 5V, Low Drive **b) V_{DD} = 3V, Low Drive**

Figure 6. Typical V_{OL} vs I_{OL}, Low Drive Strength (except PTF1/RESET)

Table 8. Supply Current Characteristics (continued)

Num	C	Parameter	Symbol	V_{DD} (V)	Typ[1]	Max[2]	Unit
10	C	LVD adder to stop3 (LVDE = LVDSE = 1)	$S3I_{DDLVD}$	5	110	180	µA
				3	90	160	µA
11	C	Adder to stop3 for oscillator enabled[8] (EREFSTEN =1)	$S3I_{DDOSC}$	5,3	5	8	µA

1 Typical values are based on characterization data at 25°C. See Figure 9 through Figure 14 for typical curves across temperature and voltage.

2 Max values in this column apply for the full operating temperature range of the device unless otherwise noted.

3 All modules except ADC active, ICS configured for FBELP, and does not include any dc loads on port pins

4 All modules except ADC active, ICS configured for FEI, and does not include any dc loads on port pins

5 All modules except ADC active, ICS configured for FEI, and does not include any dc loads on port pins

6 Stop currents are tested in production for 25°C on all parts. Tests at other temperatures depend upon the part number suffix and maturity of the product. Freescale may eliminate a test insertion at a particular temperature from the production test flow once sufficient data has been collected and is approved.

7 Most customers are expected to find that auto-wakeup from stop2 or stop3 can be used instead of the higher current wait mode.

8 Values given under the following conditions: low range operation (RANGE = 0) with a 32.768kHz crystal and low power mode (HGO = 0).

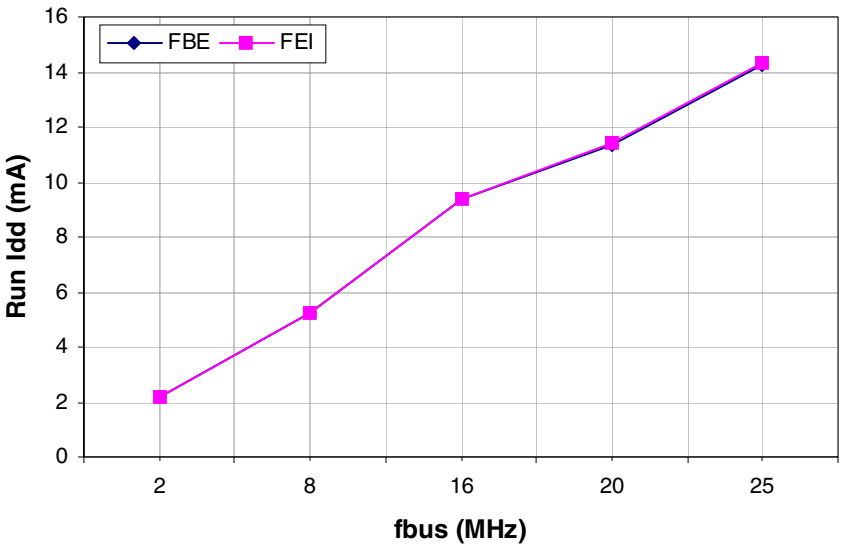


Figure 9. Typical Run I_{DD} vs. Bus Frequency (V_{DD} = 5V)

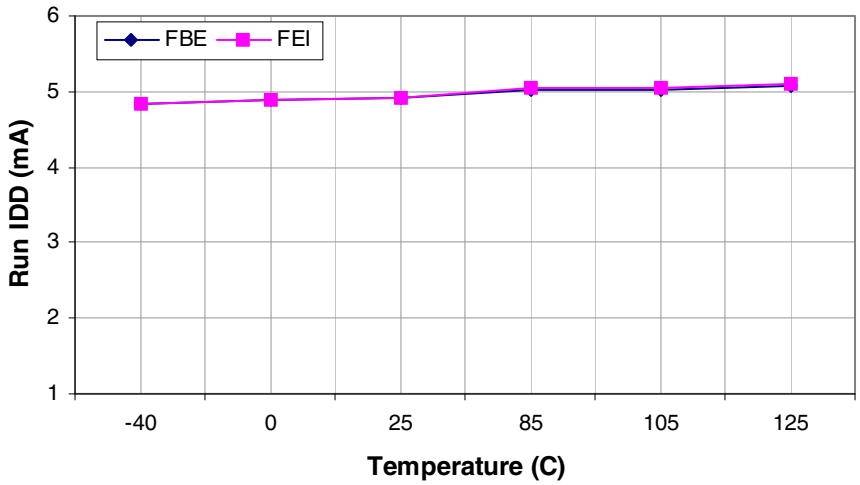


Figure 12. Typical Run I_{DD} vs. Temperature (V_{DD} = 3V, f_{bus} = 8MHz)

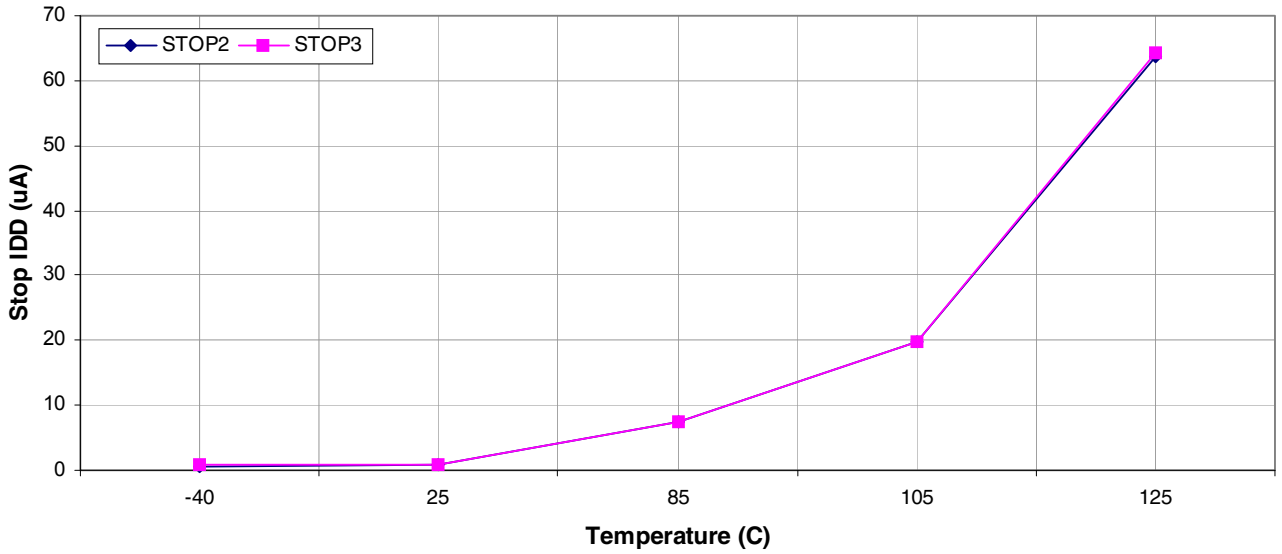


Figure 13. Typical Stop I_{DD} vs. Temperature (V_{DD} = 5V)

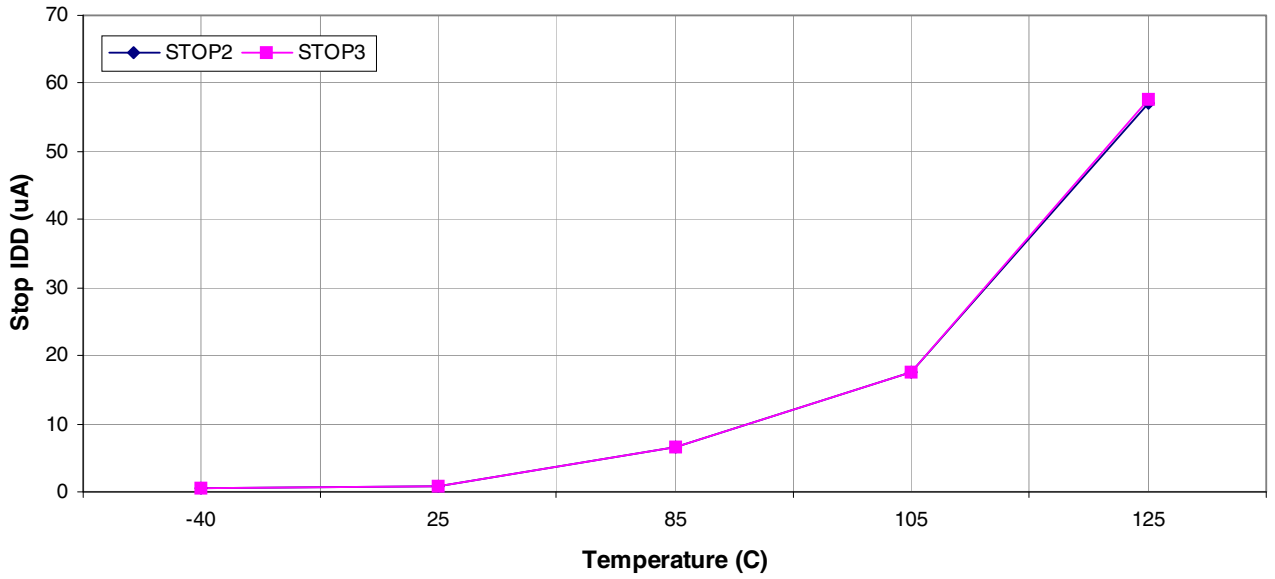


Figure 14. Typical Stop I_{DD} vs. Temperature (V_{DD} = 3V)

2.8 External Oscillator (XOSC) Characteristics

Table 9. Oscillator Electrical Specifications

Num	C	Rating	Symbol	Min	Typ[1]	Max	Unit
1	C	Oscillator crystal or resonator (EREFS = 1, ERCLKEN = 1)					
		Low range (RANGE = 0)	f_{lo}	32	—	38.4	kHz
		High range (RANGE = 1) FEE[2] or FBE[3] mode	f_{hi}	1	—	16	MHz
		High range (RANGE = 1, HGO = 1) FBELP mode	f_{hi-hgo}	1	—	16	MHz
		High range (RANGE = 1, HGO = 0) FBELP mode	f_{hi-lp}	1	—	8	MHz
2	—	Load capacitors	C_1, C_2	See crystal or resonator manufacturer's recommendation.			
3	—	Feedback resistor					
		Low range (32 kHz to 100 kHz)	R_F	—	10	—	MΩ
		High range (1 MHz to 16 MHz)		—	1	—	
4	—	Series resistor					
		Low range, low gain (RANGE = 0, HGO = 0)	R_S	—	0	—	kΩ
		Low range, high gain (RANGE = 0, HGO = 1)		—	100	—	
		High range, low gain (RANGE = 1, HGO = 0)		—	0	—	
		High range, high gain (RANGE = 1, HGO = 1)					
		≥ 8 MHz		—	0	0	
		4 MHz		—	0	10	
		1 MHz		—	0	20	

Table 9. Oscillator Electrical Specifications (continued)

Num	C	Rating	Symbol	Min	Typ[1]	Max	Unit
5	T	Crystal start-up time [4] Low range, low gain (RANGE = 0, HGO = 0) Low range, high gain (RANGE = 0, HGO = 1) High range, low gain (RANGE = 1, HGO = 0)[5] High range, high gain (RANGE = 1, HGO = 1)[4]	 $t_{CSTL-LP}$ $t_{CSTL-HGO}$ $t_{CSTH-LP}$ $t_{CSTH-HGO}$	 — — — —	 200 400 5 20	 — — — —	ms
6	T	Square wave input clock frequency (EREFS = 0, ERCLKEN = 1) FEE mode [2] FBE mode [3] FBELP mode	f_{extal}	 0.03125 0 0	 — — —	 51.34 51.34 51.34	 MHz MHz MHz

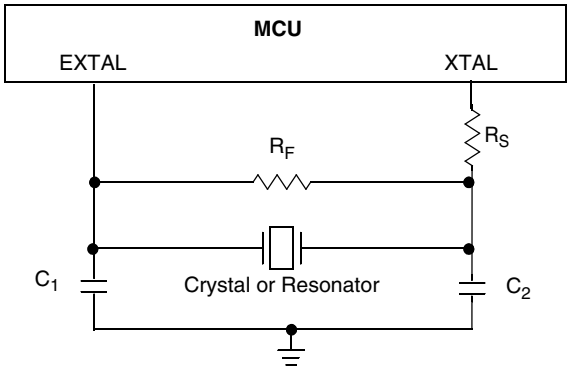
1 Typical data was characterized at 5.0 V, 25°C or is recommended value.

2 The input clock source must be divided using RDIV to within the range of 31.25 kHz to 39.0625 kHz.

3 The input clock source must be divided using RDIV to less than or equal to 39.0625 kHz.

4 This parameter is characterized and not tested on each device. Proper PC board layout procedures must be followed to achieve specifications.

5 4 MHz crystal



2.9 Internal Clock Source (ICS) Characteristics

Table 10. ICS Frequency Specifications

Num	C	Characteristic	Symbol	Min	Typ[1]	Max	Unit
1a	P	Average internal reference frequency — factory trimmed (consumer- and industrial-qualified devices) at V_{DD} = 5 V and temperature = 25°C	f_{int_t}	—	32.768	—	kHz
1b	P	Average internal reference frequency — factory trimmed (automotive-qualified devices) at V_{DD} = 5 V and temperature = 25°C	f_{int_t}	—	31.25	—	kHz
2	P	Internal reference frequency — user trimmed	f_{int_t}	31.25	—	39.06	kHz
3	T	Internal reference start-up time	t_{irefst}	—	60	100	µs

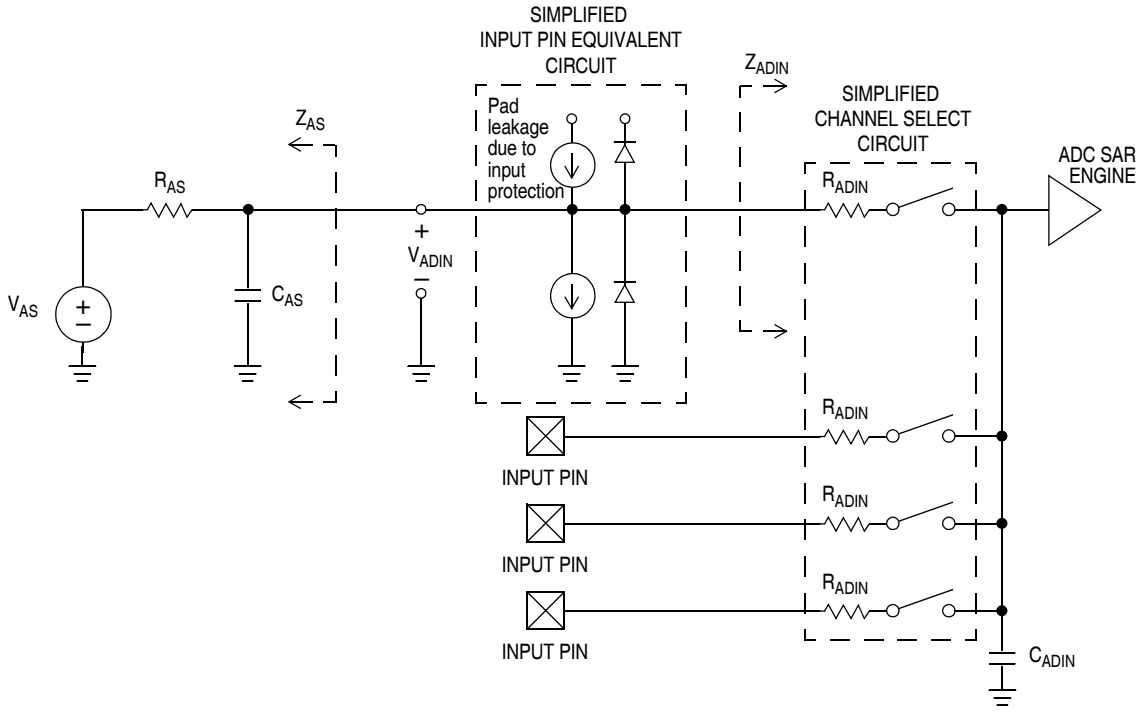


Figure 16. ADC Input Impedance Equivalency Diagram

Table 12. 12-bit ADC Characteristics (V_{REFH} = V_{DDAD}, V_{REFL} = V_{SSAD})

C	Characteristic	Conditions	Symb	Min	Typ[1]	Max	Unit	Comment
T	Supply Current ADLPC=1 ADLSMP=1 ADCO=1		I_{DDA}	—	133	—	μA	
T	Supply Current ADLPC=1 ADLSMP=0 ADCO=1		I_{DDA}	—	218	—	μA	
T	Supply Current ADLPC=0 ADLSMP=1 ADCO=1		I_{DDA}	—	327	—	μA	
T	Supply Current ADLPC=0 ADLSMP=0 ADCO=1		I_{DDA}	—	0.582	—	mA	
P	ADC Asynchronous Clock Source	High Speed (ADLPC=0)	f_{ADACK}	2	3.3	5	MHz	t_{ADACK} = $1/f_{ADACK}$
		Low Power (ADLPC=1)		1.25	2	3.3		

Table 12. 12-bit ADC Characteristics (V_{REFH} = V_{DDAD}, V_{REFL} = V_{SSAD}) (continued)

C	Characteristic	Conditions	Symb	Min	Typ[1]	Max	Unit	Comment
D	Conversion Time (Including sample time)	Short Sample (ADLSMP=0)	t_{ADC}	—	20	—	ADCK cycles	See ADC chapter in the Reference Manual for conversion time variances
		Long Sample (ADLSMP=1)		—	40	—		
D	Sample Time	Short Sample (ADLSMP=0)	t_{ADS}	—	3.5	—	ADCK cycles	
		Long Sample (ADLSMP=1)		—	23.5	—		
T	Temp Sensor Slope	-40°C to 25°C	m	—	3.266	—	mV/°C	
		25°C to 125°C		—	3.638	—		
T	Temp Sensor Voltage	25°C	V_{TEMP25}	—	1.396	—	mV	
T	Total Unadjusted Error	12 bit mode	E_{TUE}	—	±3.0	±6.5	LSB[2]	Includes quantization
P		10 bit mode		—	±1	±2.5		
T		8 bit mode		—	±0.5	±1.0		
T	Differential Non-Linearity	12 bit mode	DNL	—	±1.75	±3.5	LSB[2]	
P		10 bit mode[3]		—	±0.5	±1.0		
T		8 bit mode[3]		—	±0.3	±0.5		
T	Integral Non-Linearity	12 bit mode	INL	—	±1.5	±4.5	LSB[2]	
P		10 bit mode		—	±0.5	±1.0		
T		8 bit mode		—	±0.3	±0.5		
T	Zero-Scale Error	12 bit mode	E_{ZS}	—	±1.5	0.0/ -3.0	LSB[2]	V_{ADIN} = V_{SSAD}
P		10 bit mode		—	±0.5	±1.5		
T		8 bit mode		—	±0.5	±0.5		
T	Full-Scale Error	12 bit mode	E_{FS}	—	±1.0	+1.75/ −1.25	LSB[2]	V_{ADIN} = V_{DDAD}
T		10 bit mode		—	±0.5	±1		
T		8 bit mode		—	±0.5	±0.5		
D	Quantization Error	12 bit mode	E_Q	—	-1 to 0	—	LSB[2]	
		10 bit mode		—	—	±0.5		
		8 bit mode		—	—	±0.5		
D	Input Leakage Error	12 bit mode	E_{IL}	—	±1	—	LSB[2]	Pad leakage[4] * R_{AS}
		10 bit mode		—	±0.2	±2.5		
		8 bit mode		—	±0.1	±1		

1 Typical values assume V_{DDAD} = 5.0V, Temp = 25°C, f_{ADCK}=1.0MHz unless otherwise stated. Typical values are for reference only and are not tested in production.

2 1 LSB = $(V_{REFH} - V_{REFL})/2^N$

3 Monotonicity and No-Missing-Codes guaranteed in 10 bit and 8 bit modes

4 Based on input pad leakage current. Refer to pad electricals.

Table 17. FTM Input Timing (continued)

No.	C	Function	Symbol	Min	Max	Unit
4	D	External clock low time	t_{clkl}	0.75	—	t_{cyc}
5	D	Input capture pulse width	t_{ICPW}	0.75	—	t_{cyc}

1 The maximum external clock frequency is limited to 10MHz due to input filter characteristics.

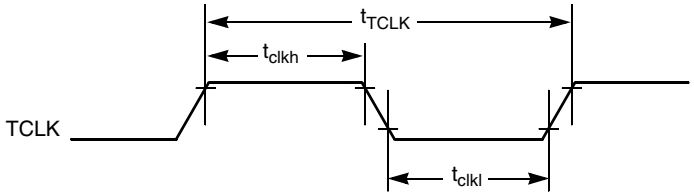


Figure 19. FTM External Clock

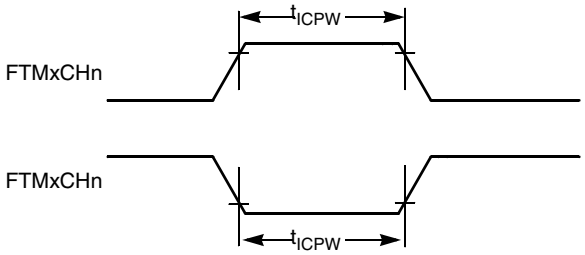


Figure 20. FTM Input Capture Pulse

2.14.3 MTIM Module Timing

Synchronizer circuits determine the fastest clock that can be used as the optional external clock source to the MTIM timer counter. These synchronizers operate from the current bus rate clock.

Table 18. MTIM Input Timing

No.	C	Function	Symbol	Min	Max	Unit
1	D	External clock frequency	f_{TCLK}	0	$f_{Bus}/4$	Hz
2	D	External clock period	t_{TCLK}	4	—	t_{cyc}
3	D	External clock high time	t_{clkh}	1.5	—	t_{cyc}
4	D	External clock low time	t_{clkl}	1.5	—	t_{cyc}

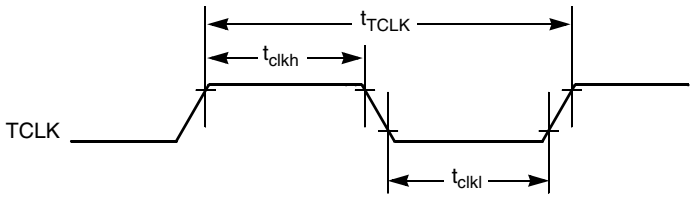


Figure 21. MTIM Timer External Clock

2.14.4 SPI

Table 19 and Figure 22 through Figure 25 describe the timing requirements for the SPI system.

Table 19. SPI Electrical Characteristics

Num[1]	C	Rating[2]	Symbol	Min	Max	Unit
1	D	Cycle time Master Slave	 t_{SCK} t_{SCK}	 2 4	 4096 —	 t_{cyc} t_{cyc}
2	D	Enable lead time Master Slave	 t_{Lead} t_{Lead}	 — 1/2	 1/2 —	 t_{SCK} t_{SCK}
3	D	Enable lag time Master Slave	 t_{Lag} t_{Lag}	 — 1/2	 1/2 —	 t_{SCK} t_{SCK}
4	D	Clock (SPSCK) high time Master and Slave	t_{SCKH}	1/2 t_{SCK} – 25	—	ns
5	D	Clock (SPSCK) low time Master and Slave	t_{SCKL}	1/2 t_{SCK} – 25	—	ns
6	D	Data setup time (inputs) Master Slave	 $t_{SI(M)}$ $t_{SI(S)}$	 30 30	 — —	 ns ns
7	D	Data hold time (inputs) Master Slave	 $t_{HI(M)}$ $t_{HI(S)}$	 30 30	 — —	 ns ns
8	D	Access time, slave[3]	t_A	0	40	ns
9	D	Disable time, slave[4]	t_{dis}	—	40	ns
10	D	Data setup time (outputs) Master Slave	 t_{SO} t_{SO}	 — —	 25 25	 ns ns
11	D	Data hold time (outputs) Master Slave	 t_{HO} t_{HO}	 –10 –10	 — —	 ns ns
12	D	Operating frequency Master (SPIFE=0) Slave (SPIFE=0) Master (SPIFE=1) Slave (SPIFE=1)	f_{op}	f_{Bus}/4096 dc f_{Bus}/4096 dc	8[5] f_{Bus}/4 5[6] 5[6]	MHz MHz MHz

1 Refer to Figure 22 through Figure 25.

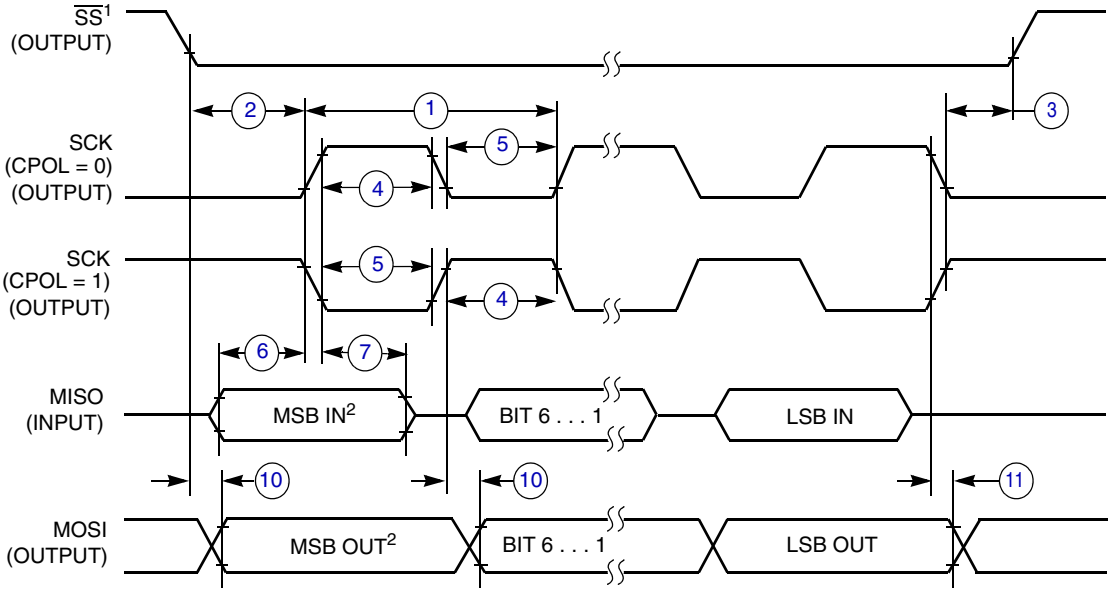
2 All timing is shown with respect to 20% V_{DD} and 70% V_{DD}, unless noted; 100 pF load on all SPI pins. All timing assumes slew rate control disabled and high drive strength enabled for SPI output pins.

3 Time to data active from high-impedance state.

4 Hold time to high-impedance state.

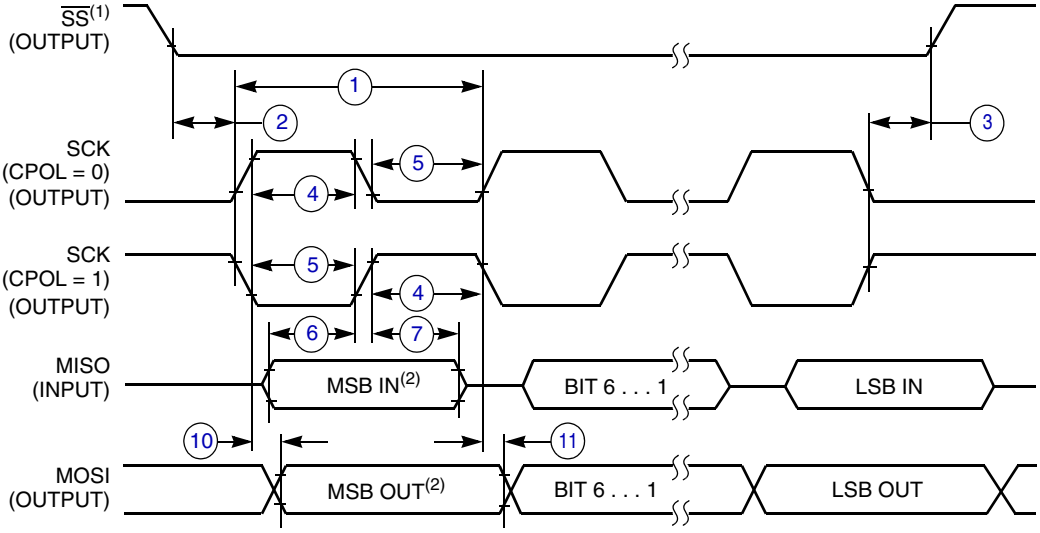
5 Maximum baud rate must be limited to 8 MHz.

6 Maximum baud rate must be limited to 5 MHz due to input filter characteristics.



NOTES:
1. $\overline{SS}$ output mode (MODFEN = 1, SSOE = 1).
2. LSBF = 0. For LSBF = 1, bit order is LSB, bit 1, ..., bit 6, MSB.

Figure 22. SPI Master Timing (CPHA = 0)

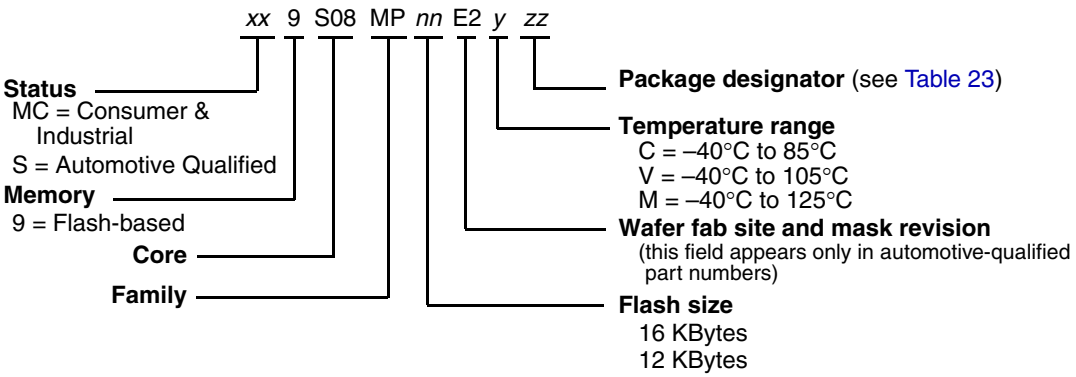


NOTES:
1. $\overline{SS}$ output mode (MODFEN = 1, SSOE = 1).
2. LSBF = 0. For LSBF = 1, bit order is LSB, bit 1, ..., bit 6, MSB.

Figure 23. SPI Master Timing (CPHA = 1)

3.1 Device Numbering Scheme

Example of the device numbering system:



4 Package Information

The latest package outline drawings are available on the product summary pages on our web site: http://www.freescale.com/8bit. The following table lists the document numbers per package. Use these numbers in the web page's keyword search engine to find the latest package outline drawings.

NOTE

The 32 LQFP and 28 SOIC are not qualified to meet automotive requirements.

Table 23. Package Descriptions

Pin Count	Package Type	Abbreviation	Designator	Case No.	Document No.
48	Low Quad Flat Pack	LQFP	LF	932-03	98ASH00962A
32	Low Quad Flat Pack	LQFP	LC	873A-03	98ASH70029A
28	Small Outline Integrated Circuit	SOIC	WL	751F-05	98ASB42345B

5 Related Documentation

Find the most current versions of all documents at http://www.freescale.com.

Reference Manual (MC9S08MP16RM)

Contains extensive product information including modes of operation, memory, resets and interrupts, register definition, port pins, CPU, and all module information.

6 Revision History

To provide the most up-to-date information, the revision of our documents on the World Wide Web are the most current. Your printed copy may be an earlier revision. To verify you have the latest information available, refer to:

http://www.freescale.com