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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	40MHz
Connectivity	LINbus, SCI
Peripherals	LVD, POR, PWM, WDT
Number of I/O	12
Program Memory Size	4KB (4K x 8)
Program Memory Type	FLASH
EEPROM Size	-
RAM Size	256 x 8
Voltage - Supply (Vcc/Vdd)	4.5V ~ 5.5V
Data Converters	A/D 8x10b
Oscillator Type	Internal
Operating Temperature	-40°C ~ 85°C (TA)
Mounting Type	Surface Mount
Package / Case	16-TSSOP (0.173", 4.40mm Width)
Supplier Device Package	16-TSSOP
Purchase URL	https://www.e-xfl.com/product-detail/nxp-semiconductors/s9s08sc4e0ctgr

Chapter 2

Pins and Connections

This section describes signals that connect to package pins. It includes pinout diagrams, recommended system connections, and detailed discussions of signals.

2.1 Device Pin Assignment

The following figure shows the pin assignments for the MC9S08SC4 device.

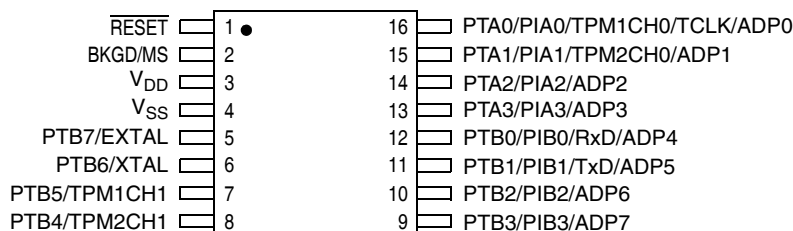


Table 2-1. Pin Function Priority

Pin Number	Priority				
	← Lowest Highest →				
16-pin	Port Pin	Alt 1	Alt 2	Alt 3	Alt 4
1					RESET
2				BKGD	MS
3					V _{DD}
4					V _{SS}
5	PTB7		EXTAL		
6	PTB6		XTAL		
7	PTB5	TPM1CH1			
8	PTB4	TPM2CH1			
9	PTB3	PIB3			ADP7
10	PTB2	PIB2			ADP6
11	PTB1	PIB1	TxD		ADP5

Table 2-1. Pin Function Priority (continued)

Pin Number	Priority				
	<div style="display: flex; justify-content: space-between; align-items: center;"> ← Lowest Highest → </div>				
16-pin	Port Pin	Alt 1	Alt 2	Alt 3	Alt 4
12	PTB0	PIB0	RxD		ADP4
13	PTA3	PIA3			ADP3
14	PTA2	PIA2			ADP2
15	PTA1	PIA1	TPM2CH0		ADP1
16	PTA0	PIA0	TPM1CH0	TCLK	ADP0

Chapter 3

Electrical Characteristics

3.1 Introduction

This section contains electrical and timing specifications for the MC9S08SC4 Series of microcontrollers available at the time of publication.

3.2 Parameter Classification

The electrical parameters shown in this supplement are guaranteed by various methods. To give the customer a better understanding the following classification is used and the parameters are tagged accordingly in the tables where appropriate:

Table 3-1. Parameter Classifications

P	Those parameters are guaranteed during production testing on each individual device.
C	Those parameters are achieved by the design characterization by measuring a statistically relevant sample size across process variations.
T	Those parameters are achieved by design characterization on a small sample size from typical devices under typical conditions unless otherwise noted. All values shown in the typical column are within this category.
D	Those parameters are derived mainly from simulations.

NOTE

The classification is shown in the column labeled “C” in the parameter tables where appropriate.

3.3 Absolute Maximum Ratings

Absolute maximum ratings are stress ratings only, and functional operation at the maxima is not guaranteed. Stress beyond the limits specified in [Table 3-2](#) may affect device reliability or cause permanent damage to the device. For functional operating conditions, refer to the remaining tables in this section.

This device contains circuitry protecting against damage due to high static voltage or electrical fields; however, it is advised that normal precautions be taken to avoid application of any voltages higher than maximum-rated voltages to this high-impedance circuit. Reliability of operation is enhanced if unused inputs are tied to an appropriate logic voltage level (for instance, either V_{SS} or V_{DD}) or the programmable pull-up resistor associated with the pin is enabled.

- 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:

$$T_J = T_A + (P_D \times \theta_{JA}) \quad \text{Eqn. 3-1}$$

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

$$P_D = K \div (T_J + 273^\circ\text{C}) \quad \text{Eqn. 3-2}$$

Solving Equation 3-1 and Equation 3-2 for K gives:

$$K = P_D \times (T_A + 273^\circ\text{C}) + \theta_{JA} \times (P_D)^2 \quad \text{Eqn. 3-3}$$

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 3-1 and Equation 3-2 iteratively for any value of T_A .

3.5 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 used 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 specified otherwise in the device specification.

Table 3-4. 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 3-5. 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 $T_A = 125^\circ\text{C}$	I_{LAT}	± 100	—	mA

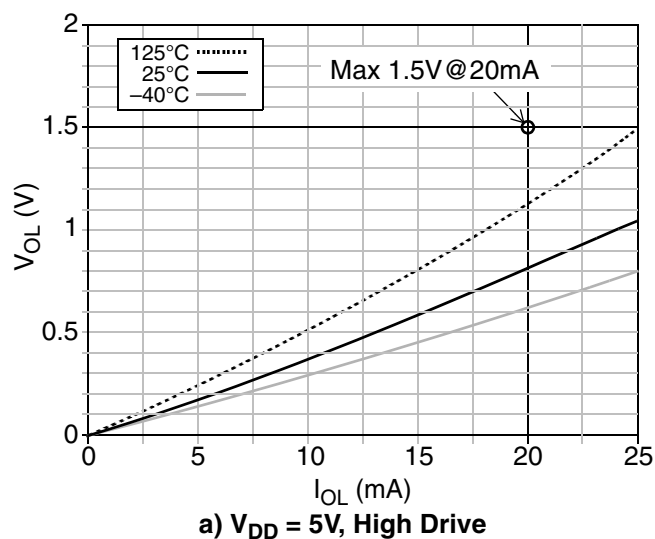
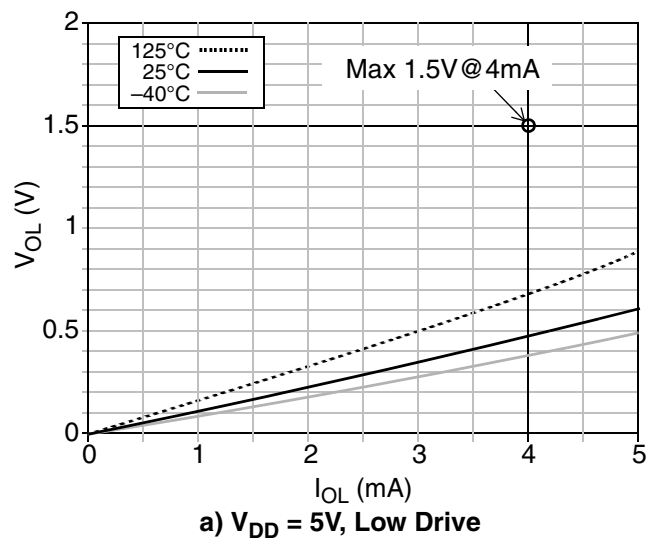
¹ Parameter is achieved by design characterization on a small sample size from typical devices under typical conditions unless otherwise noted.

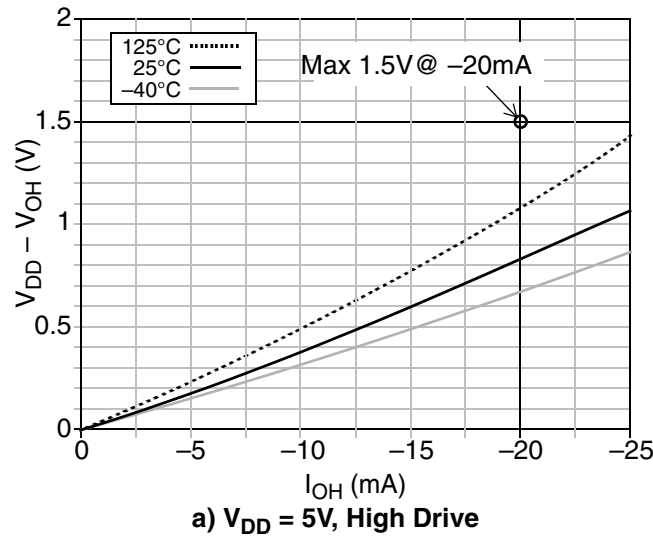
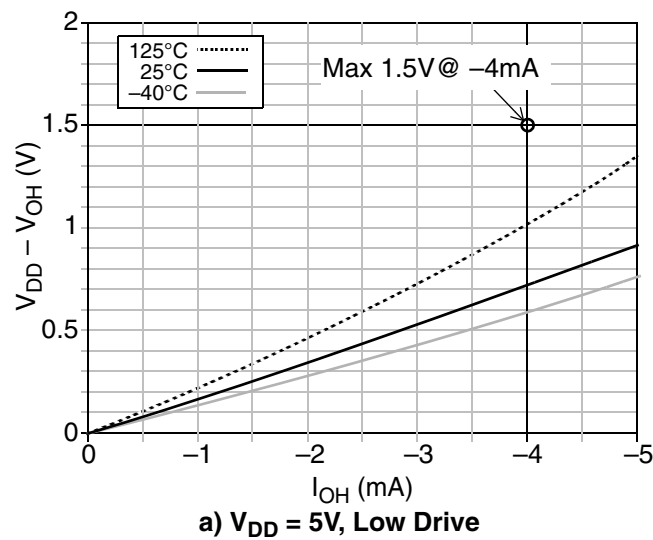
3.6 DC Characteristics

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

Table 3-6. DC Characteristics

Num	C	Characteristic	Symbol	Condition	Min	Typ ¹	Max	Unit
4	—	Operating voltage	V_{DD}	—	4.5	—	5.5	V
5	C	Output high voltage All I/O pins, low-drive strength	V_{OH}	5 V, $I_{\text{Load}} = -4$ mA	$V_{\text{DD}} - 1.5$	—	—	V
	P			5 V, $I_{\text{Load}} = -2$ mA	$V_{\text{DD}} - 0.8$	—	—	
	C			5 V, $I_{\text{Load}} = -20$ mA	$V_{\text{DD}} - 1.5$	—	—	
	P			5 V, $I_{\text{Load}} = -10$ mA	$V_{\text{DD}} - 0.8$	—	—	
6	C	Output high current Max total I_{OH} for all ports	I_{OHT}	$V_{\text{OUT}} < V_{\text{DD}}$	0	—	-100	mA
7	C	Output low voltage All I/O pins, low-drive strength	V_{OL}	5 V, $I_{\text{Load}} = 4$ mA	—	—	1.5	V
	P			5 V, $I_{\text{Load}} = 2$ mA	—	—	0.8	
	C			5 V, $I_{\text{Load}} = 20$ mA	—	—	1.5	
	P			5 V, $I_{\text{Load}} = 10$ mA	—	—	0.8	
8	C	Output low current Max total I_{OL} for all ports	I_{OLT}	$V_{\text{OUT}} > V_{\text{SS}}$	0	—	100	mA
9	P	Input high voltage; all digital inputs	V_{IH}	5V	$0.65 \times V_{\text{DD}}$	—	—	V
10	P	Input low voltage; all digital inputs	V_{IL}	5V	—	—	$0.35 \times V_{\text{DD}}$	V
11	C	Input hysteresis	V_{hys}	—	$0.06 \times V_{\text{DD}}$	—	—	V
12	P	Input leakage current (per pin)	$ I_{\text{In}} $	$V_{\text{In}} = V_{\text{DD}}$ or V_{SS}	—	0.1	1	μA
13	P	Hi-Z (off-state) leakage current (per pin)	$ I_{\text{OZ}} $	$V_{\text{In}} = V_{\text{DD}}$ or V_{SS}	—	0.1	1	μA
		input/output port pins		$V_{\text{In}} = V_{\text{DD}}$ or V_{SS}	—	0.2	2	μA
		PTB6/XTAL, RESET		$V_{\text{In}} = V_{\text{DD}}$ or V_{SS}	—	0.2	2	μA
14	P	Pull-up or Pull-down ² resistors; when enabled I/O pins	$R_{\text{PU}}, R_{\text{PD}}$	—	17	37	52	$\text{k}\Omega$
	C		R_{PU}		17	37	52	$\text{k}\Omega$

Figure 3-1. Typical V_{OL} vs I_{OL} , High Drive StrengthFigure 3-2. Typical V_{OL} vs I_{OL} , Low Drive Strength

Figure 3-3. Typical $V_{DD} - V_{OH}$ vs I_{OH} , High Drive StrengthFigure 3-4. Typical $V_{DD} - V_{OH}$ vs I_{OH} , Low Drive Strength

3.7 Supply Current Characteristics

This section includes information about power supply current in various operating modes.

Table 3-7. Supply Current Characteristics

Num	C	Parameter	Symbol	V _{DD} (V)	Typ ¹	Max ²	Unit
1	C	Run supply current ³ measured at (CPU clock = 4 MHz, f _{BUS} = 2 MHz)	RI _{DD}	5	1.9	2.4	mA
2	P	Run supply current ³ measured at (CPU clock = 16 MHz, f _{BUS} = 8 MHz)	RI _{DD}	5	4.6	5.6	mA
3	C	Run supply current ⁴ measured at (CPU clock = 32 MHz, f _{BUS} = 16 MHz)	RI _{DD}	5	7.8	8.9	mA
4	C	–40 °C (C & M suffix)	S3I _{DD}	5	0.71	—	μA
	P	Stop3 mode 25 °C (All parts)			0.93	—	
	C ⁵	supply current 85 °C (C suffix only)			4	11	
	C ⁵	105 °C (V suffix only)			9	30	
	P ⁵	125 °C (M suffix only)			28	60	
5	C	–40 °C (C & M suffix)	S2I _{DD}	5	0.70	—	μA
	P	Stop2 mode 25 °C (All parts)			0.89	—	
	C ⁵	supply current 85 °C (C suffix only)			3	8	
	C ⁵	105 °C (V suffix only)			6	22	
	P ⁵	125 °C (M suffix only)			17	41	
6	C	LVD adder to stop3 (LVDE = LVDSE = 1)	S3I _{DDLVD}	5	110	165	μA
7	C	Adder to stop3 for oscillator enabled ⁶ (EREFSTEN = 1)	S3I _{DDOSC}	5	5	8	μA

¹ Typical values are based on characterization data at 25 °C. See Figure 3-5 through Figure 3-7 for typical curves across voltage/temperature.

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 FBE, 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 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.

⁶ Values given under the following conditions: low range operation (RANGE = 0) with a 32.768 kHz crystal and low power mode (HGO = 0).

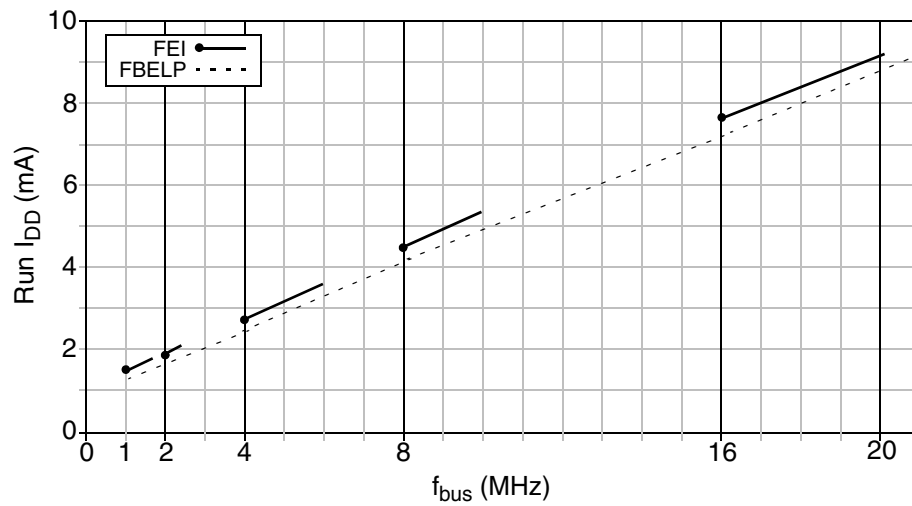
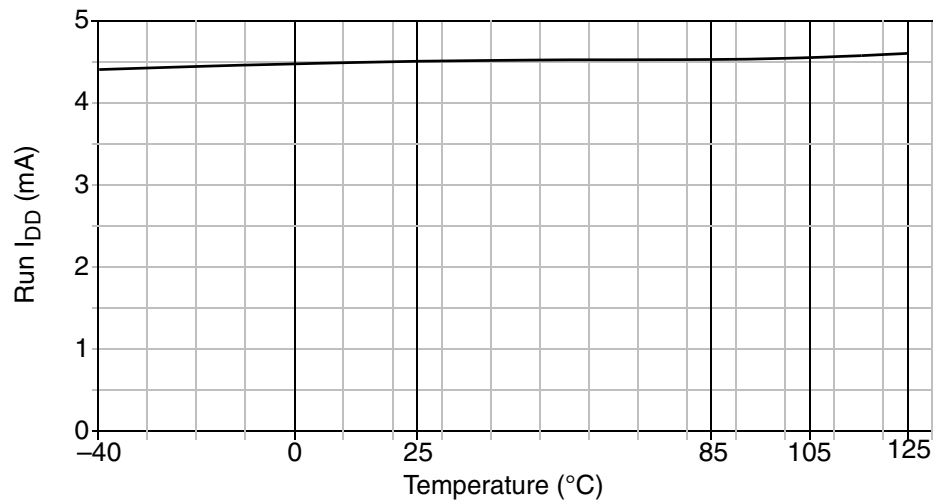


Figure 3-5. Typical Run I_{DD} vs. Bus Frequency (V_{DD} = 5V)



Note: ICS is configured to FEI.

Figure 3-6. Typical Run I_{DD} vs. Temperature (V_{DD} = 5V; f_{bus} = 8MHz)

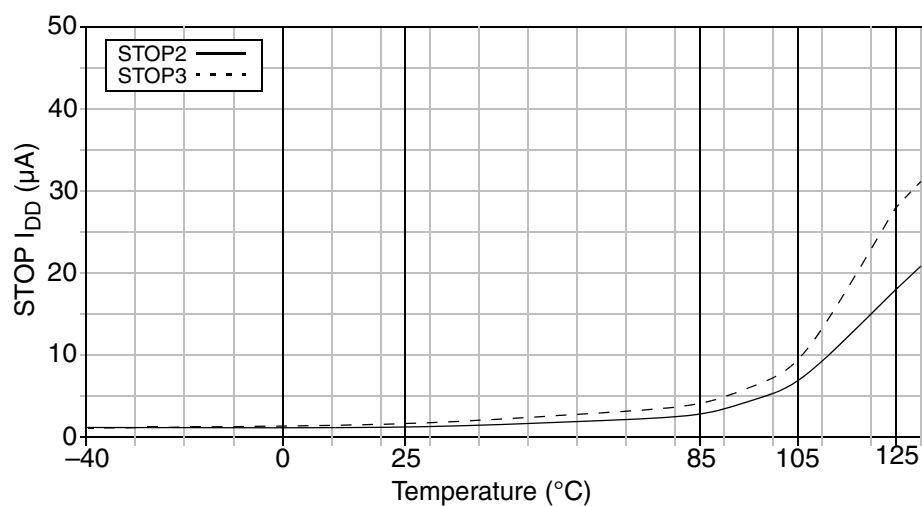


Figure 3-7. Typical Stop I_{DD} vs. Temperature ($V_{DD} = 5V$)

3.8 External Oscillator (XOSC) Characteristics

NOTE

The MC9S08SC4 series supports a narrower low frequency external reference range than the standard ICS specification. All references to range "31.25 kHz to 39.0625 kHz" in this section should be limited to "32.0 kHz to 38.4 kHz".

Table 3-11. ADC Characteristics

Characteristic	Conditions	C	Symb	Min	Typ ¹	Max	Unit	Comment
Quantization Error	10 bit mode	D	E_Q	—	—	± 0.5	LSB	—
	8 bit mode			—	—	± 0.5		
Input Leakage Error	10 bit mode	D	E_{IL}	—	± 0.2	± 2.5	LSB	Pad leakage ² * R_{AS}
	8 bit mode			—	± 0.1	± 1		
Temp Sensor Slope	–40°C– 25°C	D	m	—	3.266	—	mV/°C	—
	25°C– 125°C			—	3.638	—		
Temp Sensor Voltage	25°C	D	V_{TEMP2} 5	—	1.396	—	V	—

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

² Based on input pad leakage current. Refer to pad electricals.

3.11 AC Characteristics

This section describes AC timing characteristics for each peripheral system.

3.11.1 Control Timing

Table 3-12. Control Timing

Num	C	Rating	Symbol	Min	Typ ¹	Max	Unit
1	D	Bus frequency ($t_{cyc} = 1/f_{Bus}$)	f_{Bus}	dc	—	20	MHz
2	P	Internal low power oscillator period	t_{LPO}	700	975	1500	μs
3	D	External reset pulse width ²	t_{extrst}	100	—	—	ns
4	D	Reset low drive ³	t_{rstdrv}	$66 \times t_{cyc}$	—	—	ns
5	D	Pin interrupt pulse width Asynchronous path ² Synchronous path ⁴	t_{ILIH}, t_{IHIL}	100 $1.5 \times t_{cyc}$	—	—	ns
6	C	Port rise and fall time — Low output drive ($PTxDS = 0$) (load = 50 pF) ⁵ Slew rate control disabled ($PTxSE = 0$) Slew rate control enabled ($PTxSE = 1$)	t_{Rise}, t_{Fall}	— —	40 75	— —	ns
		Port rise and fall time — High output drive ($PTxDS = 1$) (load = 50 pF) ⁶ Slew rate control disabled ($PTxSE = 0$) Slew rate control enabled ($PTxSE = 1$)	t_{Rise}, t_{Fall}	— —	11 35	— —	ns

¹ Typical values are based on characterization data at $V_{DD} = 5.0V$, 25°C unless otherwise stated.

- ² This is the shortest pulse that is guaranteed to be recognized as a reset pin request. Shorter pulses are not guaranteed to override reset requests from internal sources. Refer to [Figure 3-9](#).
- ³ When any reset is initiated, internal circuitry drives the reset pin low for about 66 cycles of t_{CYC} . After POR reset the bus clock frequency changes to the untrimmed DCO frequency ($f_{reset} = (f_{dco_ut})/4$) because TRIM is reset to 0x80 and FTRIM is reset to 0, and there is an extra divide-by-two because BDIV is reset to 0:1. After other resets trim stays at the pre-reset value.
- ⁴ This is the minimum pulse width that is guaranteed to pass through the pin synchronization circuitry. Shorter pulses may or may not be recognized. In stop mode, the synchronizer is bypassed so shorter pulses can be recognized in that case.
- ⁵ Timing is shown with respect to 20% V_{DD} and 80% V_{DD} levels. Temperature range -40°C to 125°C .

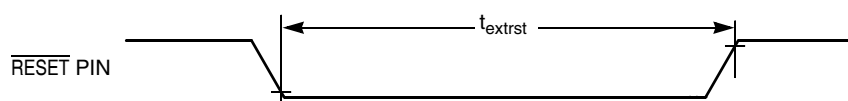


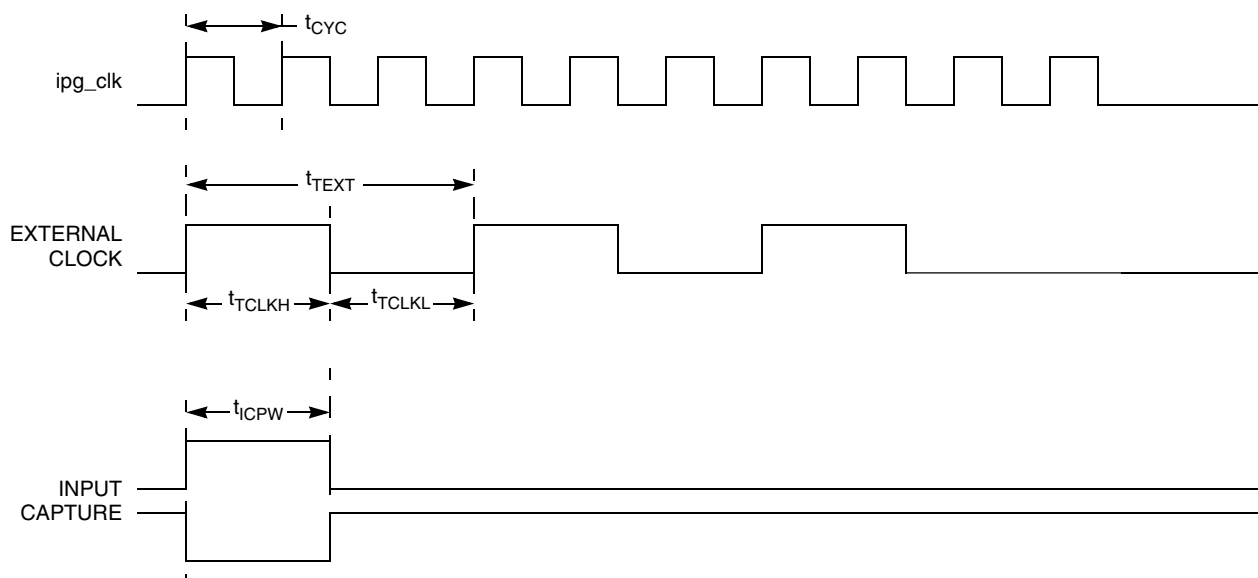
Figure 3-9. Reset Timing

3.11.2 TPM Module Timing

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

Table 3-13. TPM Input Timing

Num	C	Rating	Symbol	Min	Max	Unit
1	—	External clock frequency	f_{TEXT}	dc	$1/4 f_{op}$	MHz
2	—	External clock period	t_{TEXT}	4	—	t_{CYC}
3	—	External clock high time	t_{TCLKH}	1.5	—	t_{CYC}
4	—	External clock low time	t_{TCLKL}	1.5	—	t_{CYC}
5	—	Input capture pulse width	f_{ICPW}	1.5	—	t_{CYC}



3.12 Flash Specifications

This section provides details about program/erase times and program-erase endurance for the FLASH memory.

Program and erase operations do not require any special power sources other than the normal V_{DD} supply. For more detailed information about program/erase operations, see the Memory section.

Table 3-14. FLASH Characteristics

Num	C	Characteristic	Symbol	Min	Typical	Max	Unit
1	—	Supply voltage for program/erase	$V_{prog/erase}$	4.5	—	5.5	V
2	—	Supply voltage for read operation	V_{Read}	4.5	—	5.5	V
3	—	Internal FCLK frequency ¹	f_{FCLK}	150	—	200	kHz
4	—	Internal FCLK period ($1/f_{FCLK}$)	t_{Fcyc}	5	—	6.67	μs
5	—	Byte program time (random location) ²	t_{prog}	9			t_{Fcyc}
6	—	Byte program time (burst mode) ²	t_{Burst}	4			t_{Fcyc}
7	—	Page erase time ²	t_{Page}	4000			t_{Fcyc}
8	—	Mass erase time ²	t_{Mass}	20,000			t_{Fcyc}
9	C	Program/erase endurance ³ T_L to T_H = $-40^{\circ}C$ to $+125^{\circ}C$ $T = 25^{\circ}C$	n_{FLPE}	10,000 —	— 100,000	— —	cycles
10	C	Data retention ⁴	t_{D_ret}	15	100	—	years

¹ The frequency of this clock is controlled by a software setting.

² These values are hardware state machine controlled. User code does not need to count cycles. This information supplied for calculating approximate time to program and erase.

³ Typical endurance for FLASH is based on the intrinsic bit cell performance. For additional information on how Freescale defines typical endurance, please refer to Engineering Bulletin EB619/D, Typical Endurance for Nonvolatile Memory.

⁴ Typical data retention values are based on intrinsic capability of the technology measured at high temperature and de-rated to $25^{\circ}C$ using the Arrhenius equation. For additional information on how Freescale defines typical data retention, please refer to Engineering Bulletin EB618/D, Typical Data Retention for Nonvolatile Memory.

3.13 EMC Performance

Electromagnetic compatibility (EMC) performance is highly dependant on the environment in which the MCU resides. Board design and layout, circuit topology choices, location and characteristics of external components as well as MCU software operation all play a significant role in EMC performance. The system designer should consult Freescale applications notes such as AN2321, AN1050, AN1263, AN2764, and AN1259 for advice and guidance specifically targeted at optimizing EMC performance.

3.13.1 Radiated Emissions

Microcontroller radiated RF emissions are measured from 150 kHz to 1 GHz using the TEM/GTEM Cell method in accordance with the IEC 61967-2 and SAE J1752/3 standards. The measurement is performed with the microcontroller installed on a custom EMC evaluation board while running specialized EMC test software. The radiated emissions from the microcontroller are measured in a TEM cell in two package orientations (North and East).

The maximum radiated RF emissions of the tested configuration in all orientations are less than or equal to the reported emissions levels.

Table 3-15. Radiated Emissions, Electric Field

Parameter	Symbol	Conditions	Frequency	f_{osc}/f_{bus}	Level ¹ (Max)	Unit
Radiated emissions, electric field	V_{RE_TEM}	$V_{DD} = 5\text{ V}$ $T_A = +25^\circ\text{C}$ package type 16-TSSOP	0.15 – 50 MHz	4 MHz crystal 8 MHz bus	–7	dB μ V
			50 – 150 MHz		–11	
			150 – 500 MHz		–11	
			500 – 1000 MHz		–10	
			IEC Level		N	—
			SAE Level		1	—

¹ Data based on qualification test results.

Chapter 4

Ordering Information and Mechanical Drawings

4.1 Ordering Information

This section contains ordering information for MC9S08SC4 device.

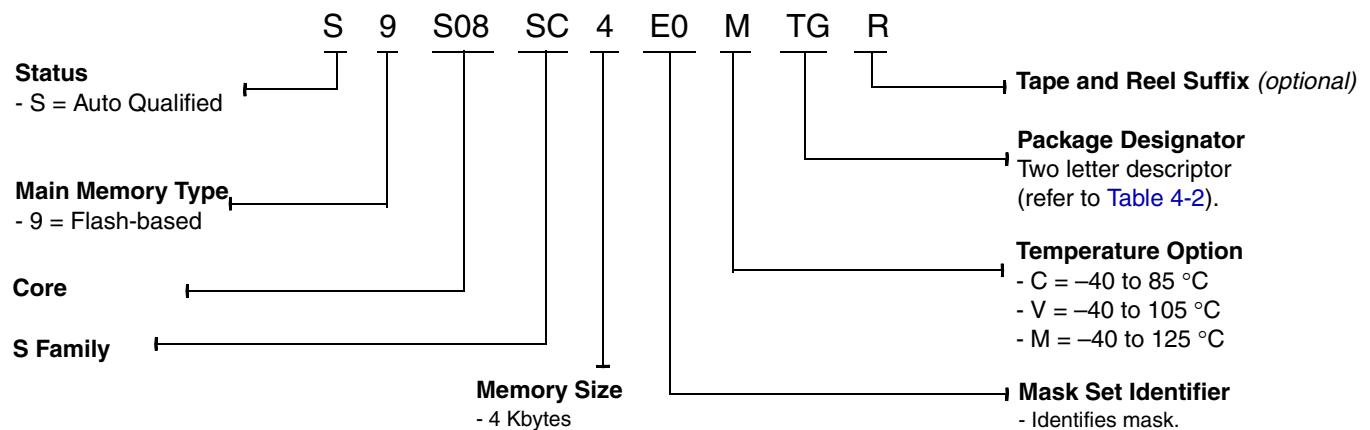
Table 4-1. Device Numbering System

Device Number ¹	Memory		Available Packages ²
	FLASH	RAM	
S9S08SC4E0MTG	4K	256	16 TSSOP

¹ See MC9S08SC4 Reference Manual for a complete description of modules included on each device.

² See [Table 4-2](#) for package information.

4.1.1 Device Numbering Scheme



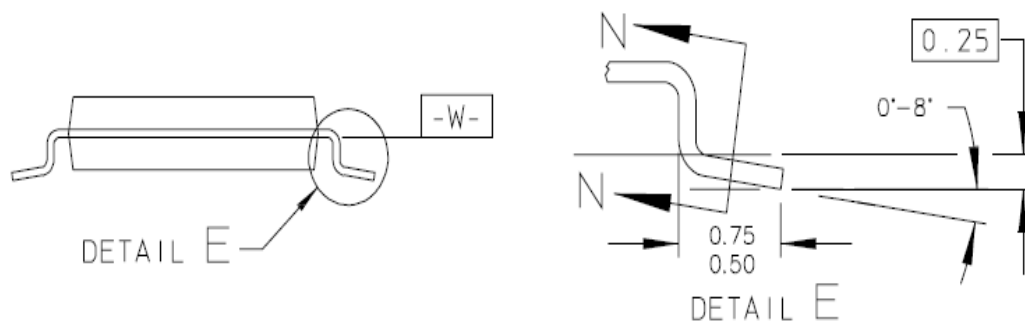
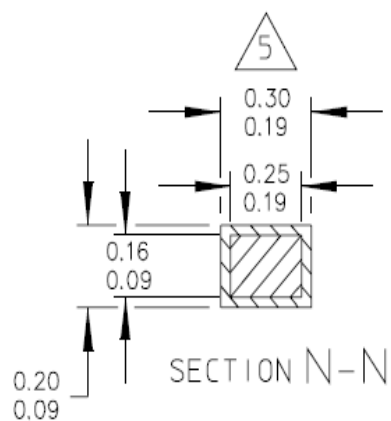
4.2 Package Information

Table 4-2. Package Information

Pin Count	Type	Designator	Case Number	Document No.
16	TSSOP	TG	948F-01	98ASH70247A

4.3 Mechanical Drawings

The following pages are mechanical drawings for the package described in [Table 4-2](#).



© FREESCALE SEMICONDUCTOR, INC. ALL RIGHTS RESERVED.	MECHANICAL OUTLINE	PRINT VERSION NOT TO SCALE
TITLE: 16 LD TSSOP, PITCH 0.65MM	DOCUMENT NO: 98ASH70247A	REV: B
	CASE NUMBER: 948F-01	19 MAY 2005
	STANDARD: JEDEC	

Chapter 5

Revision History

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

<http://freescale.com/>

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

Revision Number	Revision Date	Description of Changes
1	9/2008	<ul style="list-style-type: none"> Initial Release.
2	7/2009	<ul style="list-style-type: none"> Incorporated editing updates. Added C and V temperature ranges at page 1. Updated Section 3.10, "ADC Characteristics". Updated Table 3-3, Table 3-6, Table 3-7, Table 3-9, Table 3-12, Table 3-15 and Section 4.1.1, "Device Numbering Scheme". Added actual package mechanical drawings. Updated Figure 3-5, Figure 3-6. Removed Transient Susceptibility Section. Updated disclaimer page.
3	3/2010	<ul style="list-style-type: none"> Updated TSSOP-16 package diagram, clarified ICS deviation, SCI LIN features at page 1. Updated Table 3-6, Table 3-7, Table 3-9, Table 3-12, Table 4-1. Updated Figure 3-5 and Figure 3-7.
4	6/2010	<ul style="list-style-type: none"> Document changed from Advance Information to Technical Data Updated footnotes in Table 3-7 Updated Figure 3-5

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