Freescale Semiconductor
Data Sheet: Technical Data

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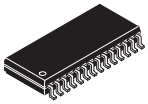
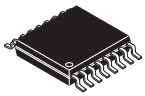
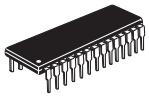
Rev. 3, 4/2009

MC9S08SE8


28-Pin SOIC
Case 751F


16-Pin TSSOP
Case 948F-01


28-Pin PDIP
Case 710-02

MC9S08SE8 Series

Covers: MC9S08SE8 MC9S08SE4

Features:

- 8-Bit HCS08 Central Processor Unit (CPU)
  - 20 MHz HCS08 CPU (central processor unit)
  - 10 MHz internal bus frequency
  - HC08 instruction set with added BGND
  - Support for up to 32 interrupt/reset sources
- On-Chip Memory
  - Up to 8 KB of on-chip in-circuit programmable flash memory with block protection and security options
  - Up to 512 bytes of on-chip RAM
- Power-Saving Modes
  - Wait plus two stops
- Clock Source Options
  - Oscillator (XOSC) — Loop-control Pierce oscillator; crystal or ceramic resonator range of 31.25 kHz to 38.4 kHz or 1 MHz to 16 MHz
  - Internal Clock Source (ICS) — Internal clock source module containing a frequency-locked-loop (FLL) controlled by internal or external reference; precision trimming of internal reference allows 0.2% resolution and 2% deviation over temperature and voltage; supports bus frequencies from 1 MHz to 10 MHz.
- System Protection
  - Optional computer operating properly (COP) reset with option to run from independent 1 kHz internal clock source or the bus clock
  - Low voltage detection
  - Illegal opcode detection with reset
  - Illegal address detection with reset
- Development Support
  - Single-wire background debug interface
  - Breakpoint capability to allow single breakpoint setting during in-circuit debugging
- Peripherals
  - **SCI** — Full duplex non-return to zero (NRZ); LIN master extended break generation; LIN slave extended break detection; wakeup on active edge
  - **ADC —** 10-channel, 10-bit resolution; 2.5 µs conversion time; automatic compare function; 1.7 mV/°C temperature sensor; internal bandgap reference channel; runs in stop3
  - **TPMx** — One 2-channel (TPM1) and one 1-channel (TPM2) 16-bit timer/pulse-width modulator (TPM) modules; selectable input capture, output compare, and edge-aligned PWM capability on each channel; timer module may be configured for buffered, centered PWM (CPWM) on all channels
  - **KBI** — 8-pin keyboard interrupt module
  - **RTC** — Real-time counter with binary- or decimal-based prescaler
- Input/Output
  - Software selectable pullups on ports when used as inputs
  - Software selectable slew rate control on ports when used as outputs
  - Software selectable drive strength on ports when used as outputs
  - Master reset pin and power-on reset (POR)
  - Internal pullup on $\overline{\text{RESET}}$, IRQ, and BKGD/MS pins to reduce customer system cost
- Package Options
  - 28-pin PDIP
  - 28-pin SOIC
  - 16-pin TSSOP

This document contains information on a product under development. Freescale reserves the right to change or discontinue this product without notice.

Table of Contents

Revision History

To provide the most up-to-date information, the revision 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	Date	Description of Changes
1	10/8/2008	Initial public released.
2	1/16/2009	In Table 8, added the Max. of $S2I_{DD}$ and $S3I_{DD}$ in 0–105 °C; changed the Max. of $S2I_{DD}$ and $S3I_{DD}$ in 0–85 °C; changed the typical of $S2I_{DD}$ and $S3I_{DD}$; changed the $S23I_{DDRTI}$ to P.
3	4/7/2009	Added $\|I_{OZTOT}\|$ in the Table 7. Changed V_{DDAD} to V_{DDA}, V_{SSAD} to V_{SSA}. Updated Table 9, Table 10, Table 11, and Table 12. Updated Figure 13 and Figure 14.

Related Documentation

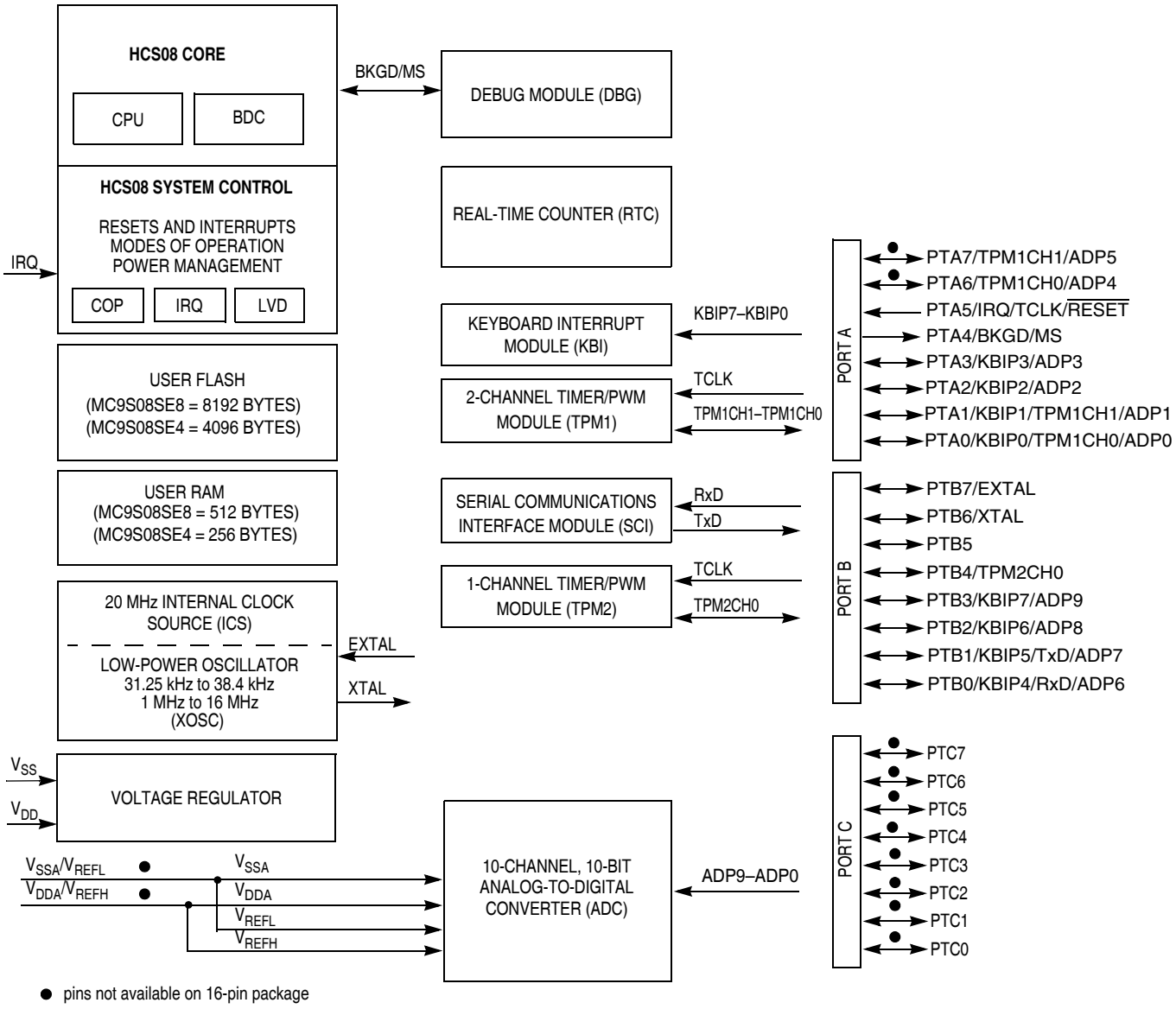
Find the most current versions of all documents at: http://www.freescale.com

Reference Manual (MC9S08SE8RM)

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

1 MCU Block Diagram

The block diagram, Figure 1, shows the structure of the MC9S08SE8 series MCUs.



● pins not available on 16-pin package

Notes:

When PTA4 is configured as BKGD, pin is bi-directional.

For the 16-pin package: V_{SSA}/V_{REFL} and V_{DDA}/V_{REFH} are double bonded to V_{SS} and V_{DD} respectively.

Figure 1. MC9S08SE8 Series Block Diagram

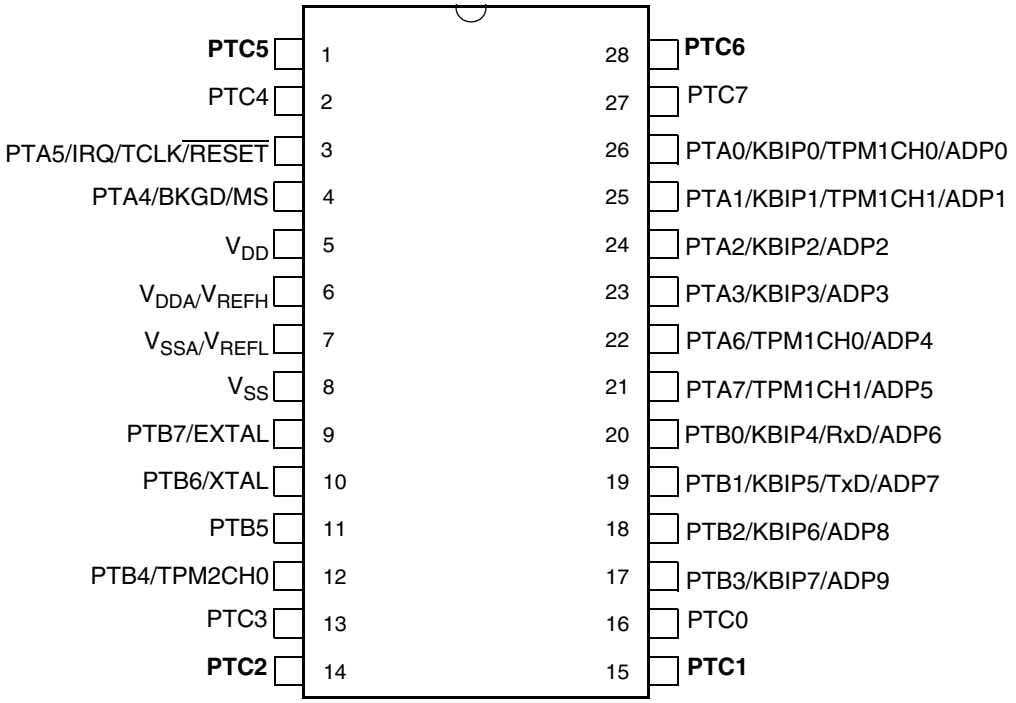
2 Pin Assignments

This chapter shows the pin assignments in the packages available for the MC9S08SE8 series.

Table 1. Pin Availability by Package Pin-Count

Pin Number (Package)		<-- Lowest **Priority** --> Highest			
28 (SOIC/PDIP)	**16 (TSSOP)**	**Port Pin**	**Alt 1**	**Alt 2**	**Alt 3**
1	—	PTC5			
2	—	PTC4			
3	1	PTA5	IRQ	TCLK	$\overline{\text{RESET}}$
4	2	PTA4		BKGD	MS
5	3				V_{DD}
6	—			V_{DDA}	V_{REFH}
7	—			V_{SSA}	V_{REFL}
8	4				V_{SS}
9	5	PTB7	EXTAL		
10	6	PTB6	XTAL		
11	7	PTB5			
12	8	PTB4		TPM2CH0	
13	—	PTC3			
14	—	PTC2			
15	—	PTC1			
16	—	PTC0			
17	9	PTB3	KBIP7		ADP9
18	10	PTB2	KBIP6		ADP8
19	11	PTB1	KBIP5	TxD	ADP7
20	12	PTB0	KBIP4	RxD	ADP6
21	—	PTA7		TPM1CH1[1]	ADP5
22	—	PTA6		TPM1CH0[1]	ADP4
23	13	PTA3	KBIP3		ADP3
24	14	PTA2	KBIP2		ADP2
25	15	PTA1	KBIP1	TPM1CH1[1]	ADP1
26	16	PTA0	KBIP0	TPM1CH0[1]	ADP0
27	—	PTC7			
28	—	PTC6			

[1] TPM1 pins can be remapped to PTA7, PTA6 and PTA1,PTA0



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

Figure 2. MC9S08SE8 Series in 28-Pin PDIP/SOIC Package

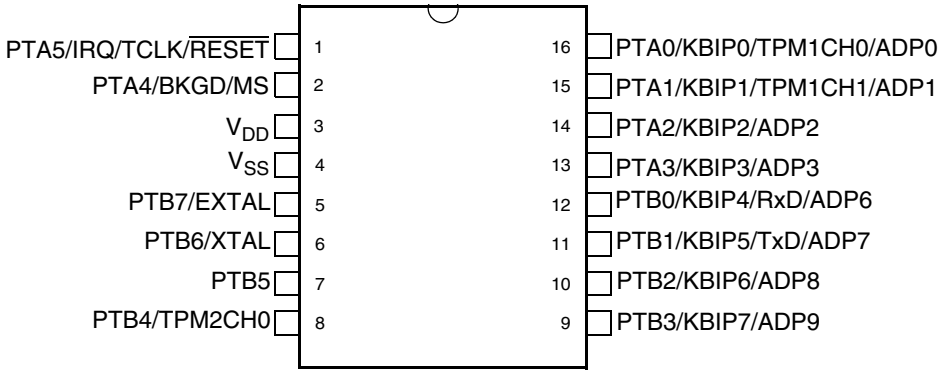


Figure 3. MC9S08SE8 in 16-Pin TSSOP Package

3 Electrical Characteristics

This chapter contains electrical and timing specifications.

3.1 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 2. 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.

3.2 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 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.

Table 3. Absolute Maximum Ratings

Rating	Symbol	Value	Unit
Supply voltage	V_{DD}	–0.3 to 5.8	V
Maximum current into V_{DD}	I_{DD}	120	mA
Digital input voltage	V_{In}	–0.3 to V_{DD} + 0.3	V
Instantaneous maximum current Single pin limit (applies to all port pins)[1, 2, 3]	I_D	±25	mA
Storage temperature range	T_{stg}	–55 to 150	°C

1 Input must be current limited to the value specified. To determine the value of the required current-limiting resistor, calculate resistance values for positive (V_{DD}) and negative (V_{SS}) clamp voltages, then use the larger of the two resistance values.

2 All functional non-supply pins are internally clamped to V_{SS} and V_{DD}.

3 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 the clock rate is very low (which would reduce overall power consumption).

3.3 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

Rating		Symbol	Value	Unit
Operating temperature range (packaged) C V M		T_A	T_L to T_H –40 to 85 –40 to 105 –40 to 125	°C
Maximum junction temperature		T_{JM}	135	°C
Thermal resistance single-layer board	28-pin SOIC	θ_{JA}	70	°C/W
	28-pin PDIP		68	
	16-pin TSSOP		129	
Thermal resistance four-layer board	28-pin SOIC		48	°C/W
	28-pin PDIP		49	
	16-pin TSSOP		85	

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

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

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:

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

Solving Equation 1 and Equation 2 for K gives:

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

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.

3.4 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.

During the device qualification ESD stresses were performed for the human body model (HBM), the machine model (MM) 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 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	—
Machine	Series resistance	R1	0	Ω
	Storage capacitance	C	200	pF
	Number of pulses per pin	—	3	—

Table 5. ESD and Latch-up Test Conditions (continued)

Model	Description	Symbol	Value	Unit
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	Machine model (MM)	V_{MM}	±200	—	V
3	Charge device model (CDM)	V_{CDM}	±500	—	V
4	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.

3.5 DC Characteristics

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

Table 7. DC Characteristics

Num	C	Parameter	Symbol	Min	Typical[1]	Max	Unit
1	—	Operating voltage	—	2.7	—	5.5	V
2	P	Output high voltage — Low drive (PTxDSn = 0) 5 V, I_{Load} = –2 mA 3 V, I_{Load} = –0.6 mA 5 V, I_{Load} = –0.4 mA 3 V, I_{Load} = –0.24 mA	V_{OH}	 V_{DD} – 1.5 V_{DD} – 1.5 V_{DD} – 0.8 V_{DD} – 0.8	 — — — —	 — — — —	V
		Output high voltage — High drive (PTxDSn = 1) 5 V, I_{Load} = –10 mA 3 V, I_{Load} = –3 mA 5 V, I_{Load} = –2 mA 3 V, I_{Load} = –0.4 mA		 V_{DD} – 1.5 V_{DD} – 1.5 V_{DD} – 0.8 V_{DD} – 0.8	 — — — —	 — — — —	
3	P	Output low voltage — Low drive (PTxDSn = 0) 5 V, I_{Load} = 2 mA 3 V, I_{Load} = 0.6 mA 5 V, I_{Load} = 0.4 mA 3 V, I_{Load} = 0.24 mA	V_{OL}	 1.5 1.5 0.8 0.8	 — — — —	 — — — —	V
		Output low voltage — High drive (PTxDSn = 1) 5 V, I_{Load} = 10 mA 3 V, I_{Load} = 3 mA 5 V, I_{Load} = 2 mA 3 V, I_{Load} = 0.4 mA		 1.5 1.5 0.8 0.8	 — — — —	 — — — —	
4	P	Output high current — Max total I_{OH} for all ports 5 V 3 V	I_{OHT}	 — —	 — —	 100 60	mA

Table 7. DC Characteristics (continued)

Num	C	Parameter	Symbol	Min	Typical[1]	Max	Unit
5	P	Output low current — Max total I_{OL} for all ports 5 V 3 V	I_{OLT}	— —	— —	100 60	mA
6	P	Input high voltage; all digital inputs	V_{IH}	$0.65 \times V_{DD}$	—	—	V
7	P	Input low voltage; all digital inputs	V_{IL}	—	—	$0.35 \times V_{DD}$	V
8	P	Input hysteresis; all digital inputs	V_{hys}	$0.06 \times V_{DD}$	—	—	mV
9	C	Input leakage current; input only pins[2]	$\lvert I_{In} \rvert$	—	0.1	1	μA
10	P	High impedance (off-state) leakage current[2]	$\lvert I_{OZ} \rvert$	—	0.1	1	μA
11	C	Total leakage combined for all inputs and Hi-Z pins — All input only and I/O[2]	$\lvert I_{OZTOT} \rvert$	—	—	2	μA
12	P	Internal pullup resistors[3]	R_{PU}	20	45	65	kΩ
13	P	Internal pulldown resistors[4]	R_{PD}	20	45	65	kΩ
14	D	DC injection current [5, 6, 7] $V_{IN} < V_{SS}$, $V_{IN} > V_{DD}$ Single pin limit Total MCU limit, includes sum of all stressed pins	I_{IC}	 –0.2 –5	 — —	 0.2 5	mA
15	C	Input capacitance; all non-supply pins	C_{In}	—	—	8	pF
16	C	RAM retention voltage	V_{RAM}	0.6	1.0	—	V
17	P	POR re-arm voltage[8]	V_{POR}	0.9	1.4	2.0	V
18	D	POR re-arm time	t_{POR}	10	—	—	μs
19	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
20	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
21	C	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
22	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
23	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
24	C	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

Table 7. DC Characteristics (continued)

Num	C	Parameter	Symbol	Min	Typical[1]	Max	Unit
25	T	Low-voltage inhibit reset/recover hysteresis 5 V 3 V	V_{hys}	— —	100 60	— —	mV
26	P	Bandgap voltage reference[9]	V_{BG}	1.18	1.20	1.21	V

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

2 Measured with $V_{In} = V_{DD}$ or V_{SS}.

3 Measured with $V_{In} = V_{SS}$.

4 Measured with $V_{In} = V_{DD}$.

5 All functional non-supply pins are internally clamped to V_{SS} and V_{DD}.

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 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).

8 Maximum is highest voltage that POR is guaranteed.

9 Factory trimmed at V_{DD} = 5.0 V, Temp = 25 °C.

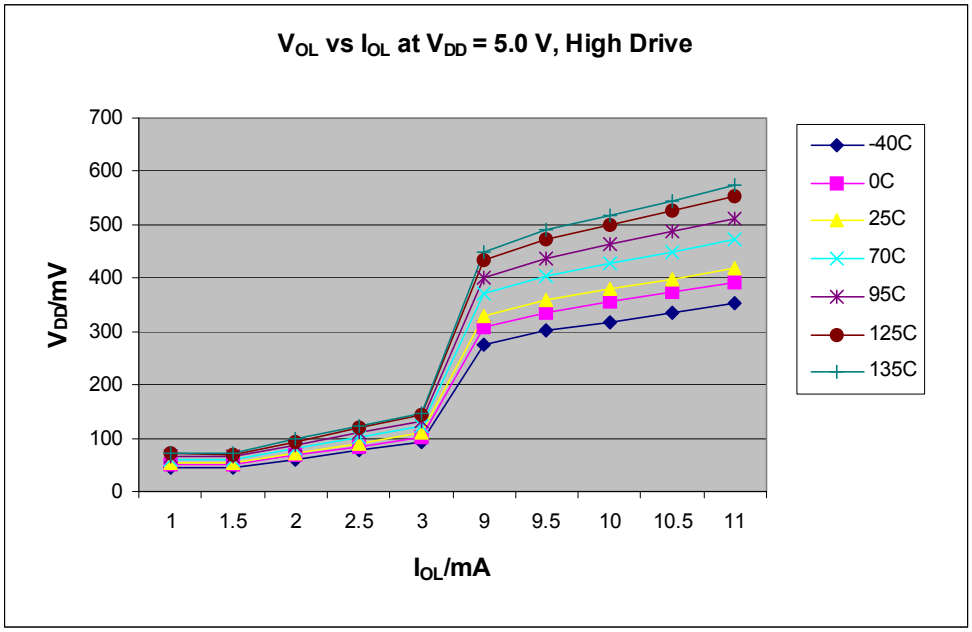


Figure 4. Typical V_{OL} vs. I_{OL} for High Drive Enabled Pad (V_{DD} = 5 V)

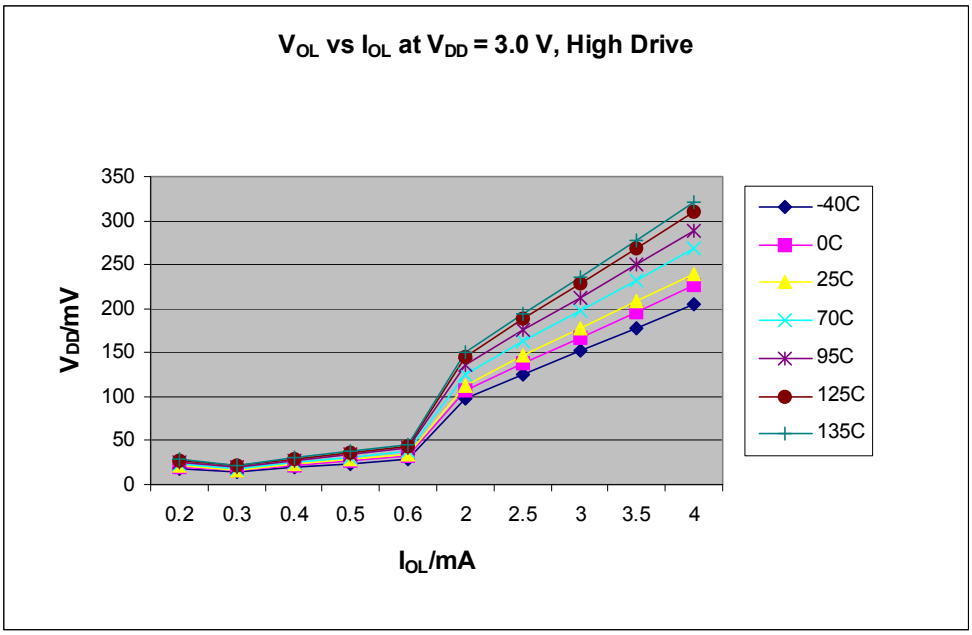


Figure 5. Typical V_{OL} vs. I_{OL} for High Drive Enabled Pad (V_{DD} = 3 V)

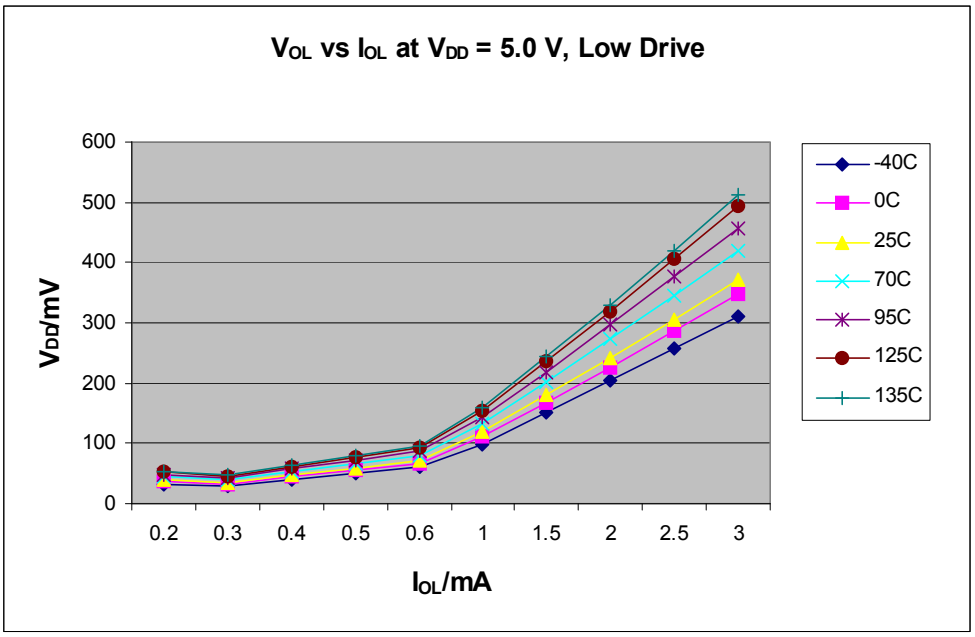


Figure 6. Typical V_{OL} vs. I_{OL} for Low Drive Enabled Pad (V_{DD} = 5 V)

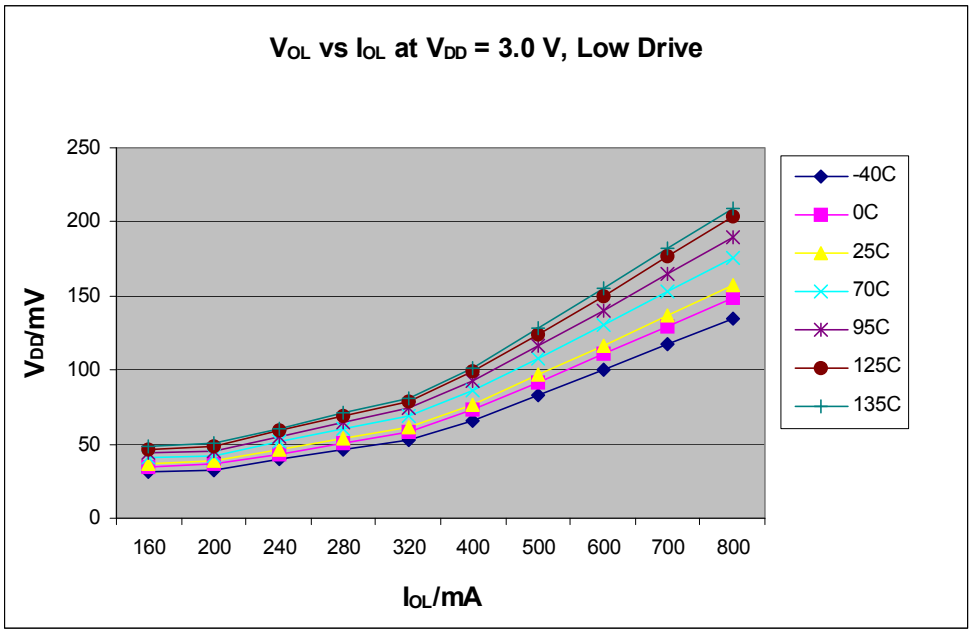


Figure 7. Typical V_{OL} vs. I_{OL} for Low Drive Enabled Pad (V_{DD} = 3 V)

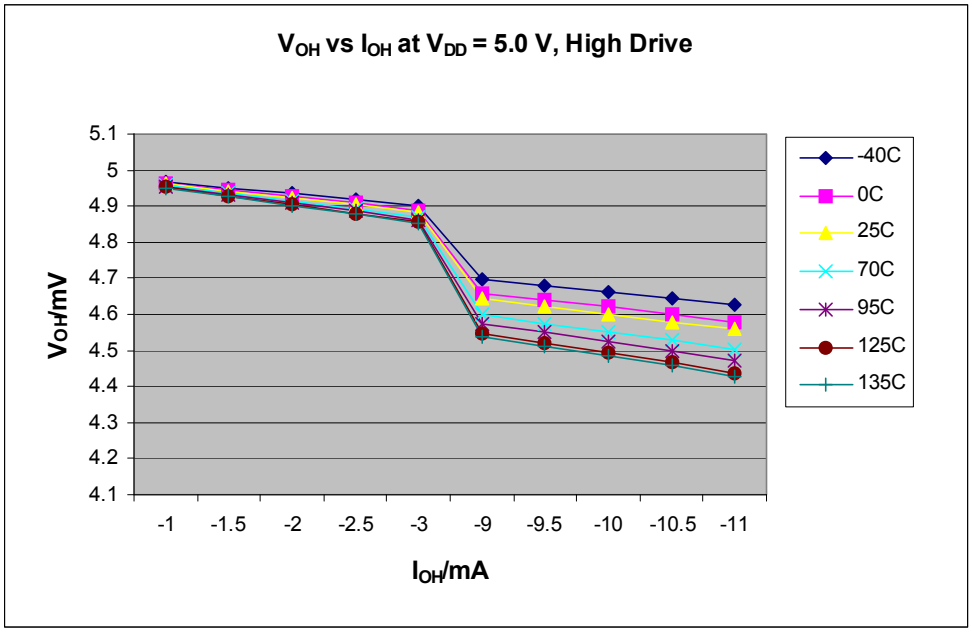


Figure 8. Typical V_{OH} vs. I_{OH} for High Drive Enabled Pad (V_{DD} = 5 V)

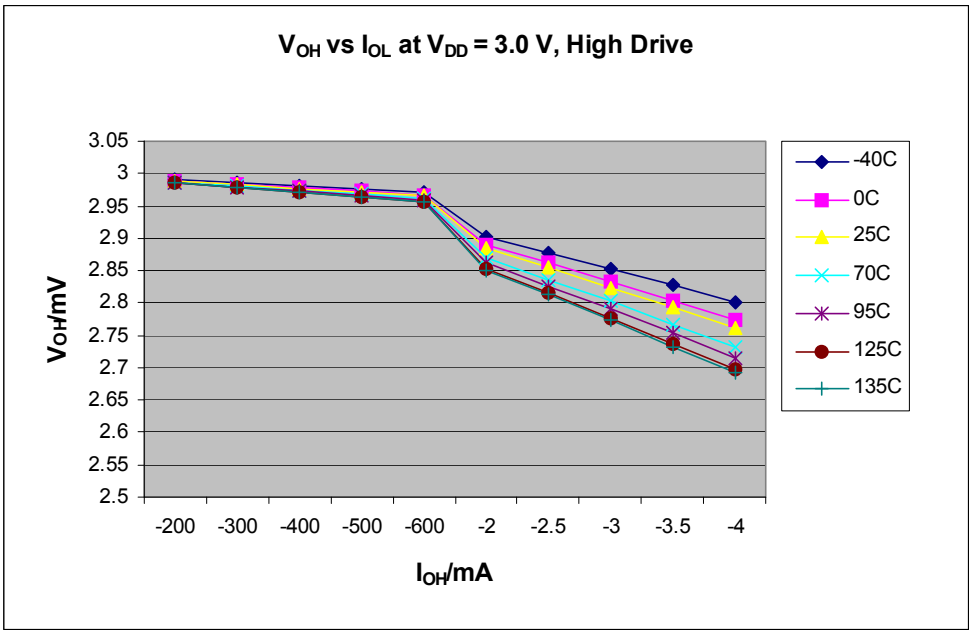


Figure 9. Typical V_{OH} vs. I_{OH} for High Drive Enabled Pad (V_{DD} = 3 V)

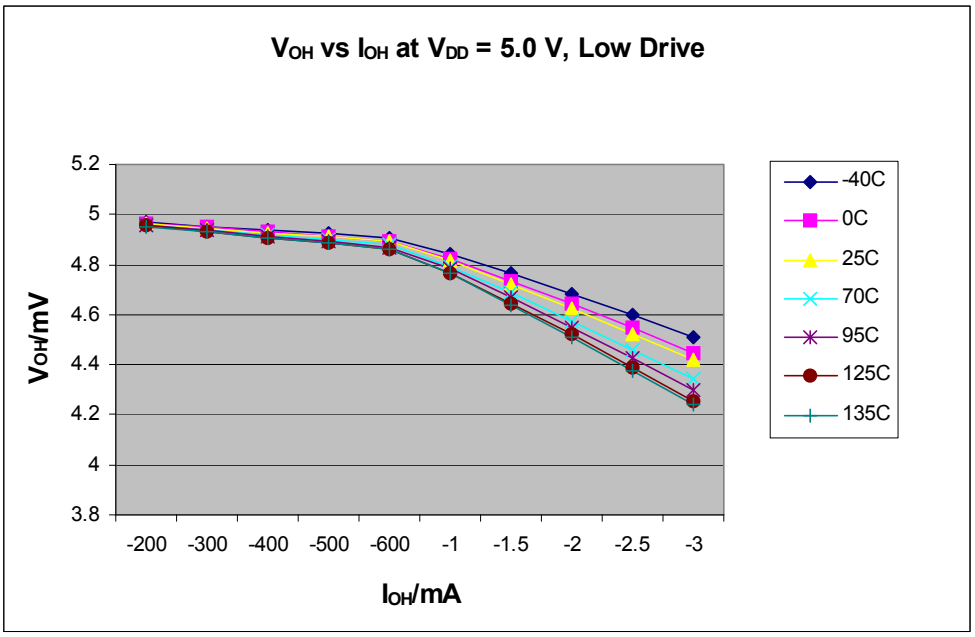


Figure 10. Typical V_{OH} vs. I_{OH} for Low Drive Enabled Pad (V_{DD} = 5 V)

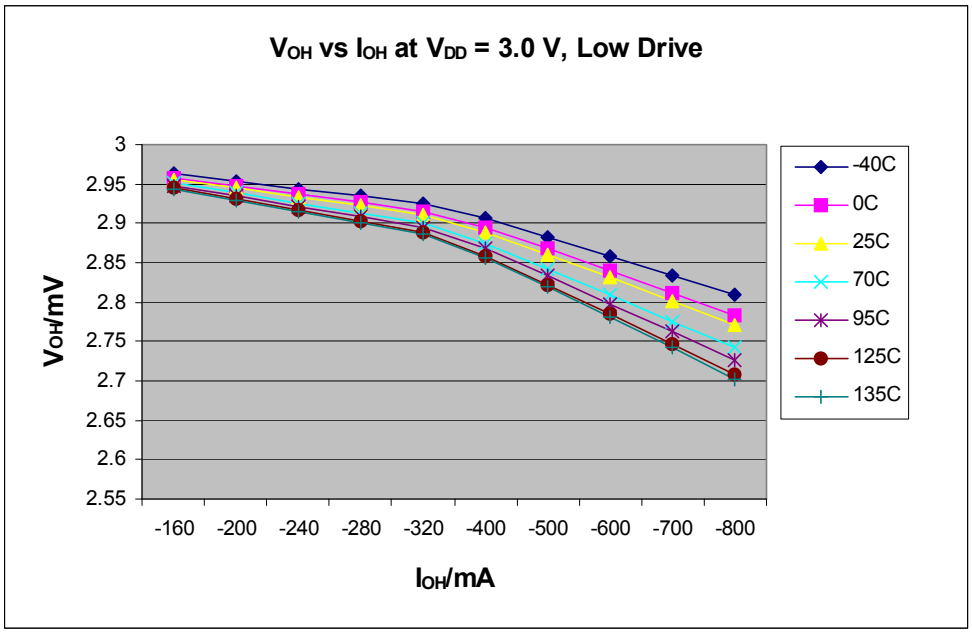


Figure 11. Typical V_{OH} vs. I_{OH} for Low Drive Enabled Pad (V_{DD} = 3 V)

3.6 Supply Current Characteristics

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

Table 8. Supply Current Characteristics

Num	C	Parameter	Symbol	V_{DD} (V)	Typical[1]	Max	Unit	Temp (°C)
1	C	Run supply current[2] measured at (CPU clock = 4 MHz, f_{Bus} = 2 MHz)	RI_{DD}	5	2.4	2.72	mA	–40 to 125
				3	2.18	2.26		
2	P	Run supply current[2] measured at (CPU clock = 20 MHz, f_{Bus} = 10 MHz)	RI_{DD}	5	6.35	7.29	mA	–40 to 125
				3	5.79	6.42		
3	P	Wait supply current[2] measured at f_{Bus} = 2 MHz	WI_{DD}	5	1.4	1.56	mA	–40 to 125
				3	1.36	1.53		
4	P	Stop2 mode supply current	$S2I_{DD}$	5	1.4	19 28 45.8	µA	–40 to 85 –40 to 105 –40 to 125
				3	1.3	15 22 37.2	µA	–40 to 85 –40 to 105 –40 to 125
5	P	Stop3 mode supply current	$S3I_{DD}$	5	1.61	23 43 76.1	µA	–40 to 85 –40 to 105 –40 to 125
				3	1.44	19 38 66.4	µA	–40 to 85 –40 to 105 –40 to 125
6	P	RTC adder to stop2 or stop3[3]	$S23I_{DDRTI}$	5	300	500 500	nA	–40 to 85 –40 to 125
				3	300	500 500	nA	–40 to 85 –40 to 125
7	C	LVD adder to stop3 (LVDE = LVDSE = 1)	$S3I_{DDLVD}$	5	122	180	µA	–40 to 125
				3	110	160	µA	–40 to 125
8	C	Adder to stop3 for oscillator enabled[4] (OSCSTEN =1)	$S3I_{DDOSC}$	5,3	5	8	µA	–40 to 125

1 Typical values are based on characterization data at 25 °C unless otherwise stated. See Figure 12 through Figure 13 for typical curves across voltage/temperature.

2 All modules except ADC active, ICS configured for FBE, and does not include any dc loads on port pins.

3 Most customers are expected to find that auto-wakeup from stop2 or stop3 can be used instead of the higher current wait mode. Wait mode typical is 220 µA at 5 V with f_{Bus} = 1 MHz.

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

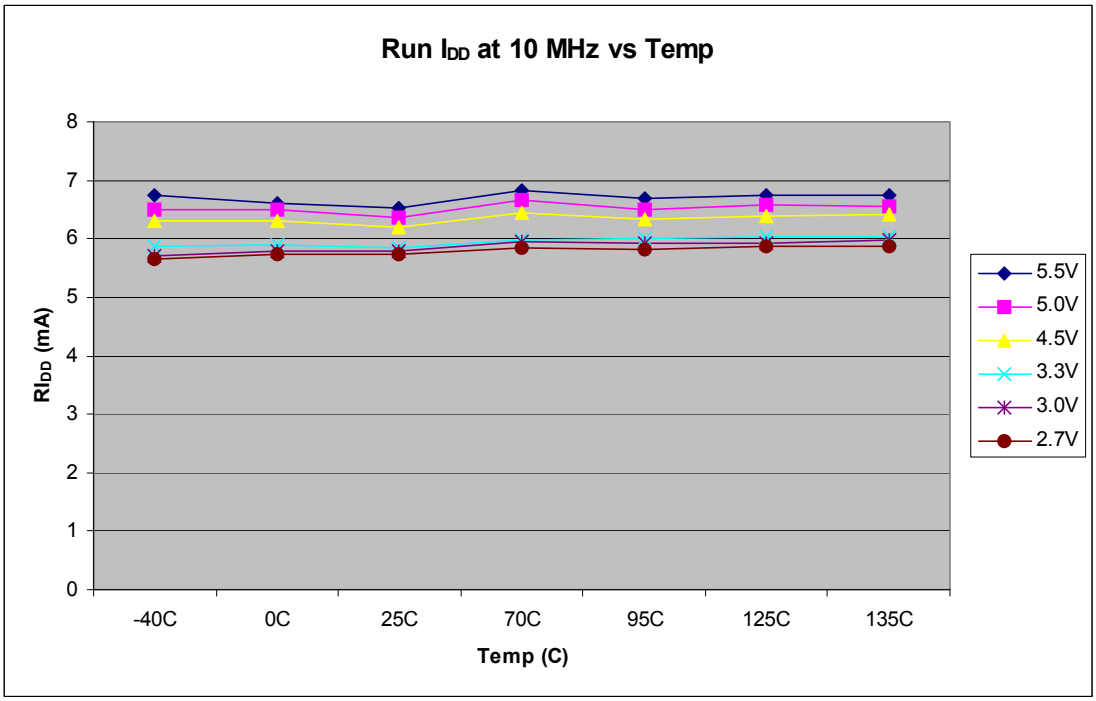


Figure 12. Typical Run I_{DD} Curves

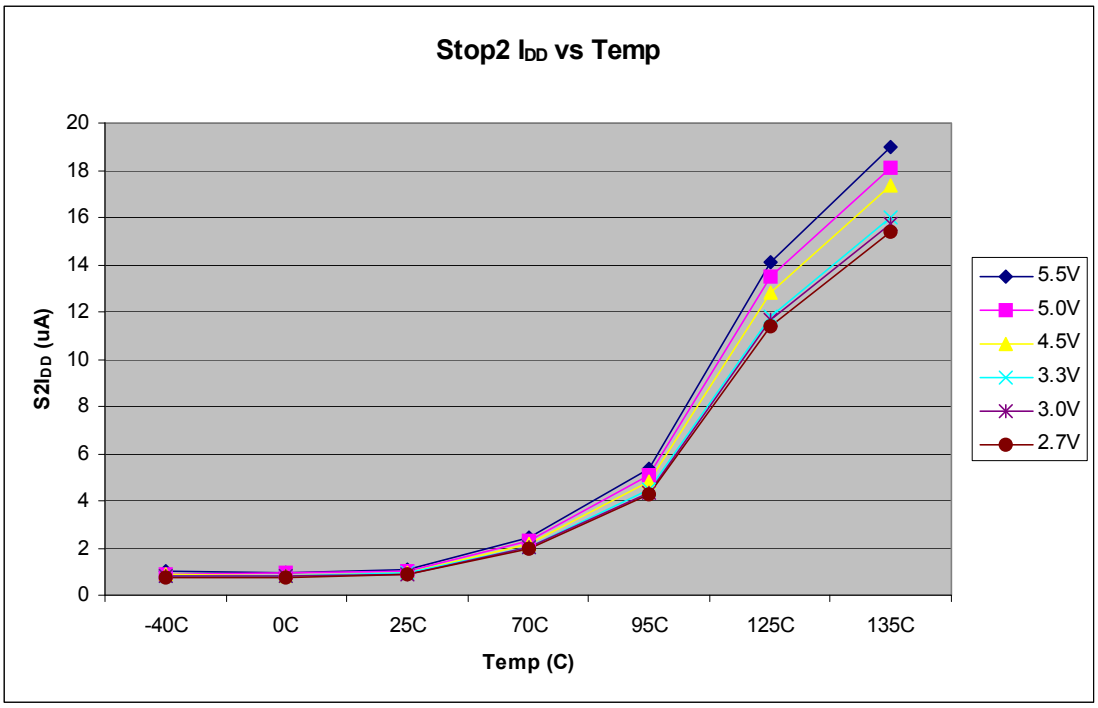


Figure 13. Typical Stop2 I_{DD} Curves

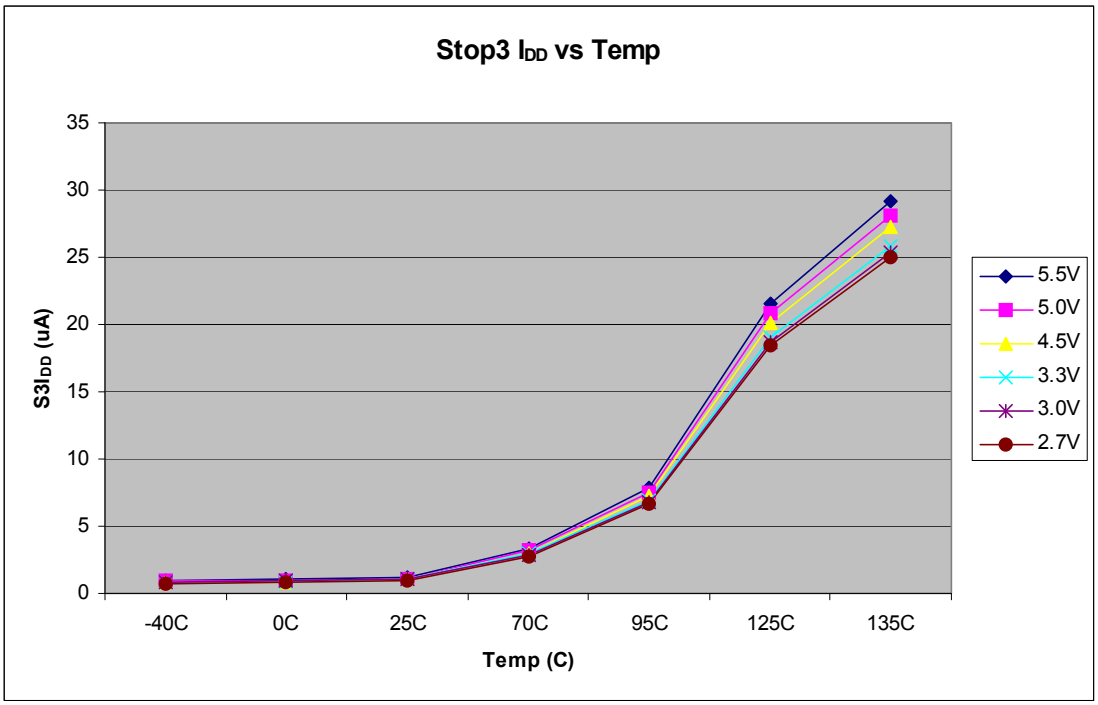


Figure 14. Typical Stop3 I_{DD} Curves

3.7 External Oscillator (XOSC) Characteristics

Table 9. XOSCVLP Specifications (Temperature Range = –40 to 125°C Ambient)

Num	C	Characteristic	Symbol	Min.	Typical[1]	Max.	Unit
1	C	Oscillator crystal or resonator (EREFS = 1, ERCLKEN = 1) Low range (RANGE = 0) High range (RANGE = 1), high gain (HGO = 1), FBELP mode High range (RANGE = 1), low power (HGO = 0), FBELP mode	 f_{lo} f_{hi} f_{hi}	 32 1 1	 — — —	 38.4 16 8	 kHz MHz MHz
2	D	Load capacitors Low range (RANGE=0), low power (HGO = 0) Other oscillator settings	C_1,C_2	See Note [2] See Note [3]			
3	D	Feedback resistor Low range, low power (RANGE = 0, HGO = 0)[2] Low range, high gain (RANGE = 0, HGO = 1) High range (RANGE = 1, HGO = X)	R_F	 — — —	 — 10 1	 — — —	MΩ
4	D	Series resistor — Low range, low power (RANGE = 0, HGO = 0)[2] Low range, high gain (RANGE = 0, HGO = 1) High range, low power (RANGE = 1, HGO = 0) High range, high gain (RANGE = 1, HGO = 1) ≥ 8 MHz 4 MHz 1 MHz	R_S	 — — — — — —	 — 100 0 0 0 0	 — — — 0 10 20	kΩ
5	C	Crystal start-up time[4] Low range, low power Low range, high gain High range, low power High range, high gain	 t_{CSTL} t_{CSTH} 	 — — — —	 600 400 5 15	 — — — —	ms
6	D	Square wave input clock frequency (EREFS = 0, ERCLKEN = 1) FEE mode FBE or FBELP mode	f_{extal}	 0.03125 0	 — —	 20 20	 MHz MHz

1 Data in Typical column was characterized at 3.0 V, 25 °C or is typical recommended value.

2 Load capacitors (C_1,C_2), feedback resistor (R_F) and series resistor (R_S) are incorporated internally when RANGE = HGO = 0.

3 See crystal or resonator manufacturer's recommendation.

4 Proper PC board layout procedures must be followed to achieve specifications.

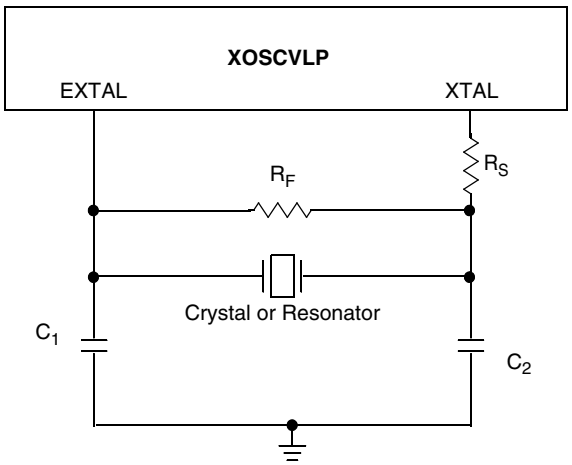


Figure 15. Typical Crystal or Resonator Circuit: High Range and Low Range/High Gain

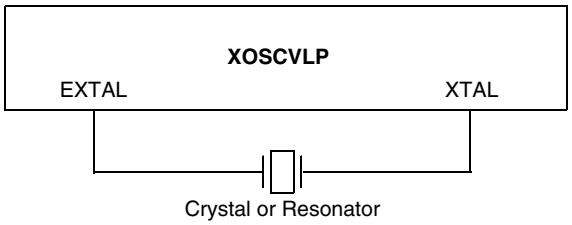


Figure 16. Typical Crystal or Resonator Circuit: Low Range/Low Power

3.8 Internal Clock Source (ICS) Characteristics

Table 10. ICS Frequency Specifications (Temperature Range = –40 to 85°C Ambient)

Num	C	Characteristic		Symbol	Min.	Typical[1]	Max.	Unit
1	P	Average internal reference frequency — factory trimmed at V_{DD} = 5 V and temperature = 25 °C		f_{int_t}	—	39.0625	—	kHz
2	P	Internal reference frequency — user trimmed		f_{int_ut}	31.25	—	39.06	kHz
3	T	Internal reference start-up time		t_{IRST}	—	60	100	µs
4	D	DCO output frequency range — trimmed[2]	Low range (DRS = 00)	f_{dco_t}	16	—	20	MHz
5	D	DCO output frequency[2] Reference = 32768 Hz and DMX32 = 1		f_{dco_DMX32}	—	59.77	—	MHz
6	C	Resolution of trimmed DCO output frequency at fixed voltage and temperature (using FTRIM)		$\Delta f_{dco\_res\_t}$	—	±0.1	±0.2	$\%f_{dco}$

Table 10. ICS Frequency Specifications (Temperature Range = –40 to 85°C Ambient) (continued)

Num	C	Characteristic	Symbol	Min.	Typical[1]	Max.	Unit
7	C	Resolution of trimmed DCO output frequency at fixed voltage and temperature (not using FTRIM)	$\Delta f_{dco\_res\_t}$	—	± 0.2	± 0.4	$\%f_{dco}$
8	C	Total deviation of DCO output from trimmed frequency[3] Over full voltage and temperature range Over fixed voltage and temperature range of 0 to 70 °C	Δf_{dco_t}	—	–1.0 to 0.5 ±0.5	± 2 ± 1	$\%f_{dco}$
10	C	FLL acquisition time[4]	$t_{Acquire}$	—	—	1	ms
11	C	Long term jitter of DCO output clock (averaged over 2-ms interval)[5]	C_{Jitter}	—	0.02	0.2	$\%f_{dco}$

1 Data in Typical column was characterized at 3.0 V, 25 °C or is typical recommended value.

2 The resulting bus clock frequency should not exceed the maximum specified bus clock frequency of the device.

3 This parameter is characterized and not tested on each device.

4 This specification applies to any time the FLL reference source or reference divider is changed, trim value changed or changing from FLL disabled (FBELP, FBILP) to FLL enabled (FEI, FEE, FBE, FBI). If a crystal/resonator is being used as the reference, this specification assumes it is already running.

5 Jitter is the average deviation from the programmed frequency measured over the specified interval at maximum f_{Bus}. Measurements are made with the device powered by filtered supplies and clocked by a stable external clock signal. Noise injected into the FLL circuitry via V_{DD} and V_{SS} and variation in crystal oscillator frequency increase the C_{Jitter} percentage for a given interval.

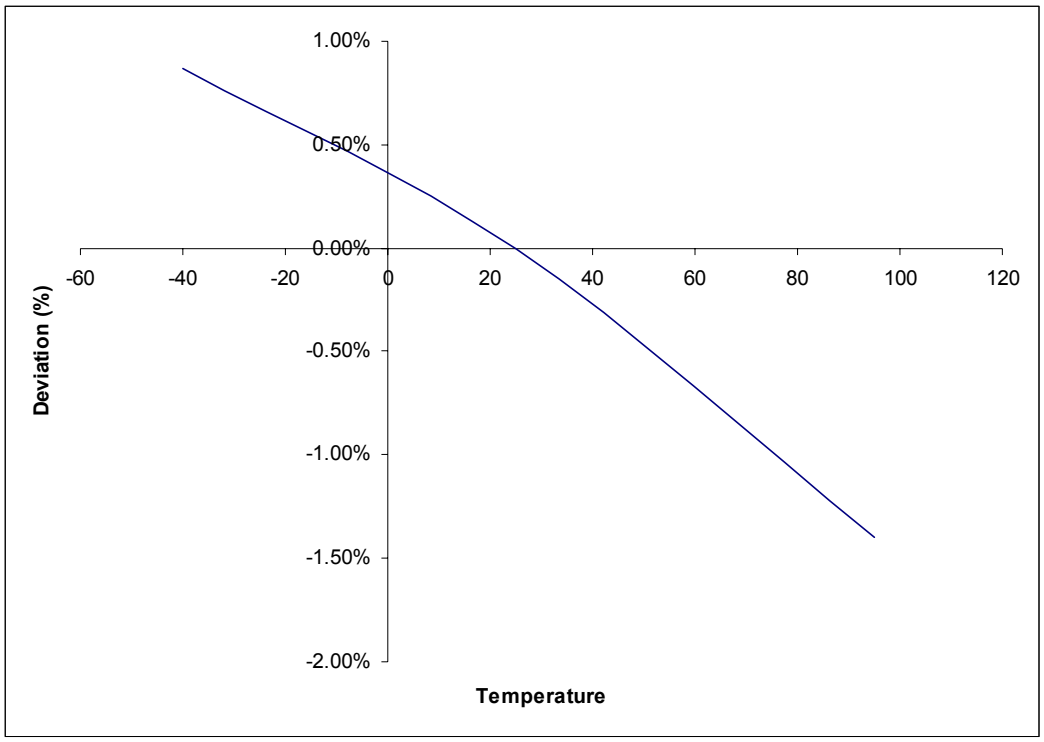


Figure 17. Deviation of DCO Output from Trimmed Frequency (20 MHz, 3.0 V)

3.9 ADC Characteristics

Table 11. 10-Bit ADC Operating Conditions

Characteristic	Conditions	Symb	Min	Typ[1]	Max	Unit	Comment
Supply voltage	Absolute	V_{DDA}	2.7	—	5.5	V	
	Delta to V_{DD} ($V_{DD} - V_{DDA}$)[2]	ΔV_{DDA}	–100	0	100	mV	
Ground voltage	Delta to V_{SS} ($V_{SS} - V_{SSA}$)[2]	ΔV_{SSA}	–100	0	100	mV	
Input voltage		V_{ADIN}	V_{REFL}	—	V_{REFH}	V	
Input capacitance		C_{ADIN}	—	4.5	5.5	pF	
Input resistance		R_{ADIN}	—	3	5	kΩ	
Analog source resistance	10-bit mode f_{ADCK} > 4MHz f_{ADCK} < 4MHz	R_{AS}	— —	— —	5 10	kΩ	External to MCU
	8-bit mode (all valid f_{ADCK})		—	—	10		
ADC conversion clock frequency	High speed (ADLPC = 0)	f_{ADCK}	0.4	—	8.0	MHz	
	Low power (ADLPC = 1)		0.4	—	4.0		

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

2 DC potential difference.

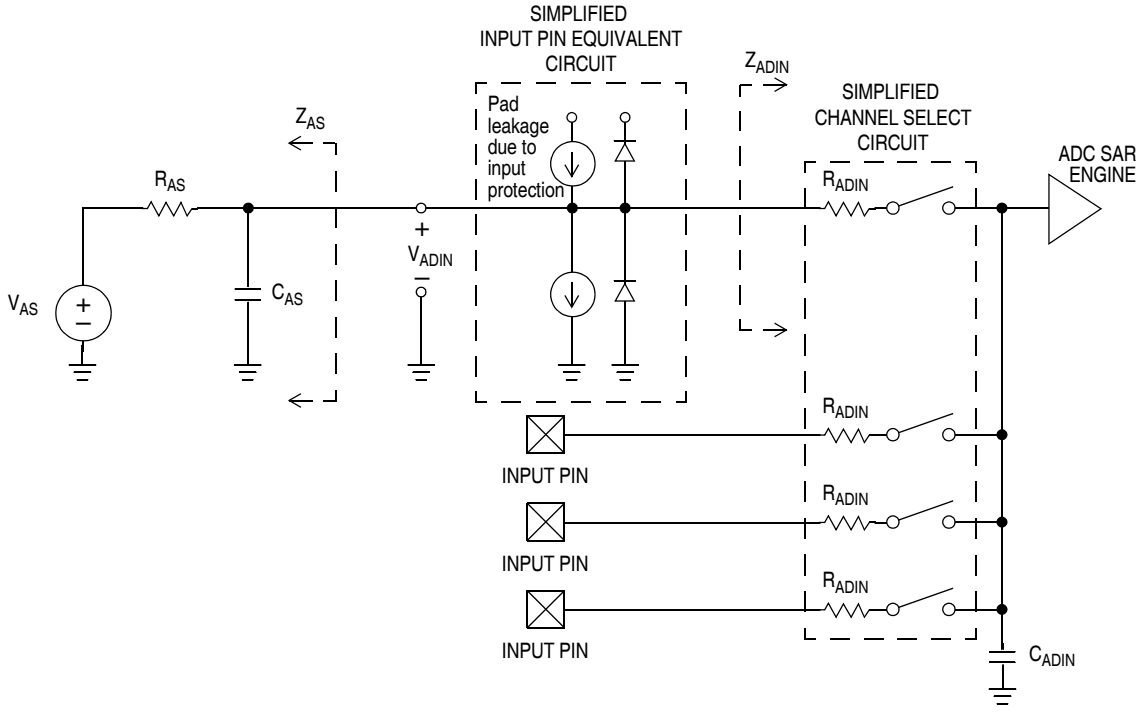


Figure 18. ADC Input Impedance Equivalency Diagram

Table 12. 10-Bit ADC Characteristics ($V_{REFH} = V_{DDA}$, $V_{REFL} = V_{SSA}$)

Characteristic	Conditions	C	Symb	Min	Typ[1]	Max	Unit	Comment
Supply Current ADLPC = 1 ADLSMP = 1 ADCO = 1		T	I_{DDA}	—	133	—	μA	
Supply Current ADLPC = 1 ADLSMP = 0 ADCO = 1		T	I_{DDA}	—	218	—	μA	
Supply Current ADLPC = 0 ADLSMP = 1 ADCO = 1		T	I_{DDA}	—	327	—	μA	
Supply Current ADLPC = 0 ADLSMP = 0 ADCO = 1		D	I_{DDA}	—	0.582	1	mA	
Supply Current	Stop, Reset, Module Off	D	I_{DDA}	—	0.011	1	μA	
ADC Asynchronous Clock Source	High Speed (ADLPC = 0)	D	f_{ADACK}	2	3.3	5	MHz	$t_{ADACK} = 1/f_{ADACK}$
	Low Power (ADLPC = 1)			1.25	2	3.3		
Conversion Time (Including sample time)	Short Sample (ADLSMP = 0)	D	t_{ADC}	—	20	—	ADCK cycles	See SE8 reference manual for conversion time variances
	Long Sample (ADLSMP = 1)			—	40	—		
Sample Time	Short Sample (ADLSMP = 0)	D	t_{ADS}	—	3.5	—	ADCK cycles	
	Long Sample (ADLSMP = 1)			—	23.5	—		
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_{TEMP25}	—	1.396	—	mV	
Characteristics for 28-pin packages only								
Total Unadjusted Error	10-bit mode	P	E_{TUE}	—	±1	±2.5	LSB[3]	Includes quantization
	8-bit mode	P		—	±0.5	±1.0		
Differential Non-Linearity	10-bit mode[2]	P	DNL	—	±0.5	±1.0	LSB[3]	
	8-bit mode[3]	P		—	±0.3	±0.5		
Integral Non-Linearity	10-bit mode	T	INL	—	±0.5	±1.0	LSB[3]	
	8-bit mode	T		—	±0.3	±0.5		

Table 12. 10-Bit ADC Characteristics ($V_{REFH} = V_{DDA}$, $V_{REFL} = V_{SSA}$) (continued)

Characteristic	Conditions	C	Symb	Min	Typ[1]	Max	Unit	Comment
Zero-Scale Error	10-bit mode	P	E_{ZS}	—	±0.5	±1.5	LSB[3]	$V_{ADIN} = V_{SSA}$
	8-bit mode	P		—	±0.5	±0.5		
Full-Scale Error	10-bit mode	T	E_{FS}	—	±0.5	±1	LSB[3]	$V_{ADIN} = V_{DDA}$
	8-bit mode	T		—	±0.5	±0.5		
Quantization Error	10-bit mode	D	E_Q	—	—	±0.5	LSB[3]	
	8-bit mode			—	—	±0.5		
Input Leakage Error	10-bit mode	D	E_{IL}	—	±0.2	±2.5	LSB[3]	Pad leakage[4] * R_{AS}
	8-bit mode			—	±0.1	±1		
Characteristics for 16-pin package only								
Total Unadjusted Error	10-bit mode	P	E_{TUE}	—	±1.5	±3.5	LSB[3]	Includes quantization
	8-bit mode	P		—	±0.7	±1.5		
Differential Non-Linearity	10-bit mode[3]	P	DNL	—	±0.5	±1.0	LSB[3]	
	8-bit mode[3]	P		—	±0.3	±0.5		
Integral Non-Linearity	10-bit mode	T	INL	—	±0.5	±1.0	LSB[3]	
	8-bit mode	T		—	±0.3	±0.5		
Zero-Scale Error	10-bit mode	P	E_{ZS}	—	±1.5	±2.1	LSB[3]	$V_{ADIN} = V_{SSA}$
	8-bit mode	P		—	±0.5	±0.7		
Full-Scale Error	10-bit mode	T	E_{FS}	—	±1	±1.5	LSB[3]	$V_{ADIN} = V_{DDA}$
	8-bit mode	T		—	±0.5	±0.5		
Quantization Error	10-bit mode	D	E_Q	—	—	±0.5	LSB[3]	
	8-bit mode			—	—	±0.5		
Input Leakage Error	10-bit mode	D	E_{IL}	—	±0.2	±2.5	LSB[3]	Pad leakage[4] * R_{AS}
	8-bit mode			—	±0.1	±1		

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

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

3 1 LSB = $(V_{REFH} - V_{REFL})/2^N$

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

3.10 AC Characteristics

This section describes ac timing characteristics for each peripheral system.

3.10.1 Control Timing

Table 13. Control Timing

Num	C	Rating	Symbol	Min	Typical[1]	Max	Unit
1	D	Bus frequency ($t_{cyc} = 1/f_{Bus}$)	f_{Bus}	DC	—	10	MHz
2	D	Internal low power oscillator period	t_{LPO}	700	—	1300	μs
3	D	External reset pulse width[2]	t_{extrst}	100	—	—	ns
4	D	Reset low drive[3]	t_{rstdrv}	$34 \times t_{cyc}$	—	—	ns
5	D	BKGD/MS setup time after issuing background debug force reset to enter user or BDM modes	t_{MSSU}	500	—	—	ns
6	D	BKGD/MS hold time after issuing background debug force reset to enter user or BDM modes[4]	t_{MSH}	100	—	—	μs
7	D	IRQ pulse width Asynchronous path[2] Synchronous path[5]	t_{ILIH}, t_{IHIL}	100 $1.5 \times t_{cyc}$	—	—	ns
8	D	Pin interrupt pulse width Asynchronous path[2] Synchronous path[5]	t_{ILIH}, t_{IHIL}	100 $1.5 \times t_{cyc}$	—	—	ns
9	C	Port rise and fall time — Low output drive (PTxDS = 0) (load = 50 pF)[6] 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) 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} = 5.0 V, 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.

3 When any reset is initiated, internal circuitry drives the reset pin (if enabled, RSTPE = 1) low for about 34 cycles of t_{cyc}.

4 To enter BDM mode following a POR, BKGD/MS should be held low during the power-up and for a hold time of t_{MSH} after V_{DD} rises above V_{LVD}.

5 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.

6 Timing is shown with respect to 20% V_{DD} and 80% V_{DD} levels. Temperature range –40 °C to 125 °C.

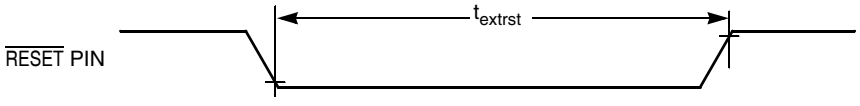


Figure 19. Reset Timing

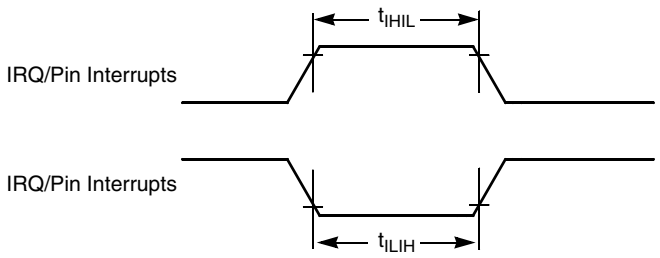


Figure 20. IRQ/Pin Interrupt Timing

3.10.2 TPM/MTIM 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 14. TPM Input Timing

Num	C	Rating	Symbol	Min	Max	Unit
1	D	External clock frequency	f_{TPMext}	DC	$f_{Bus}/4$	MHz
2	D	External clock period	t_{TPMext}	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}
5	D	Input capture pulse width	t_{ICPW}	1.5	—	t_{cyc}

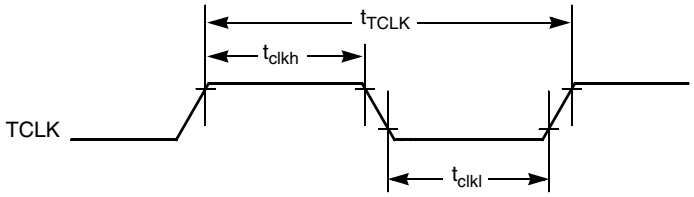


Figure 21. Timer External Clock

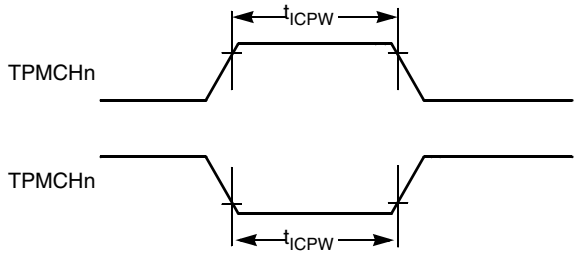


Figure 22. Timer Input Capture Pulse

3.11 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 in the reference manual.

Table 15. Flash Characteristics

Num	C	Characteristic	Symbol	Min	Typical	Max	Unit
1	D	Supply voltage for program/erase	$V_{prog/erase}$	2.7	—	5.5	V
2	D	Supply voltage for read operation	V_{Read}	2.7	—	5.5	V
3	D	Internal FCLK frequency[1]	f_{FCLK}	150	—	200	kHz
4	D	Internal FCLK period (1/FCLK)	t_{Fcyc}	5	—	6.67	μs
5	P	Byte program time (random location)[2]	t_{prog}	9			t_{Fcyc}
6	P	Byte program time (burst mode)[2]	t_{Burst}	4			t_{Fcyc}
7	P	Page erase time[2]	t_{Page}	4000			t_{Fcyc}
8	P	Mass erase time[2]	t_{Mass}	20,000			t_{Fcyc}
9	C	Program/erase endurance[3] T_L to T_H = –40 °C to 125 °C T = 25 °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.

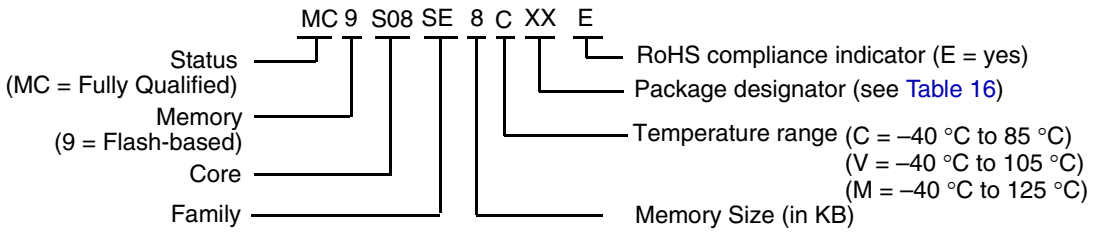
3 **Typical endurance for flash** was evaluated for this product family on the 9S12Dx64. For additional information on how Freescale defines typical endurance, please refer to Engineering Bulletin EB619/D, *Typical Endurance for Nonvolatile Memory.*

4 **Typical data retention** values are based on intrinsic capability of the technology measured at high temperature and de-rated to 25 °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.*

4 Ordering Information

This chapter contains ordering information for the device numbering system.

Example of the device numbering system:



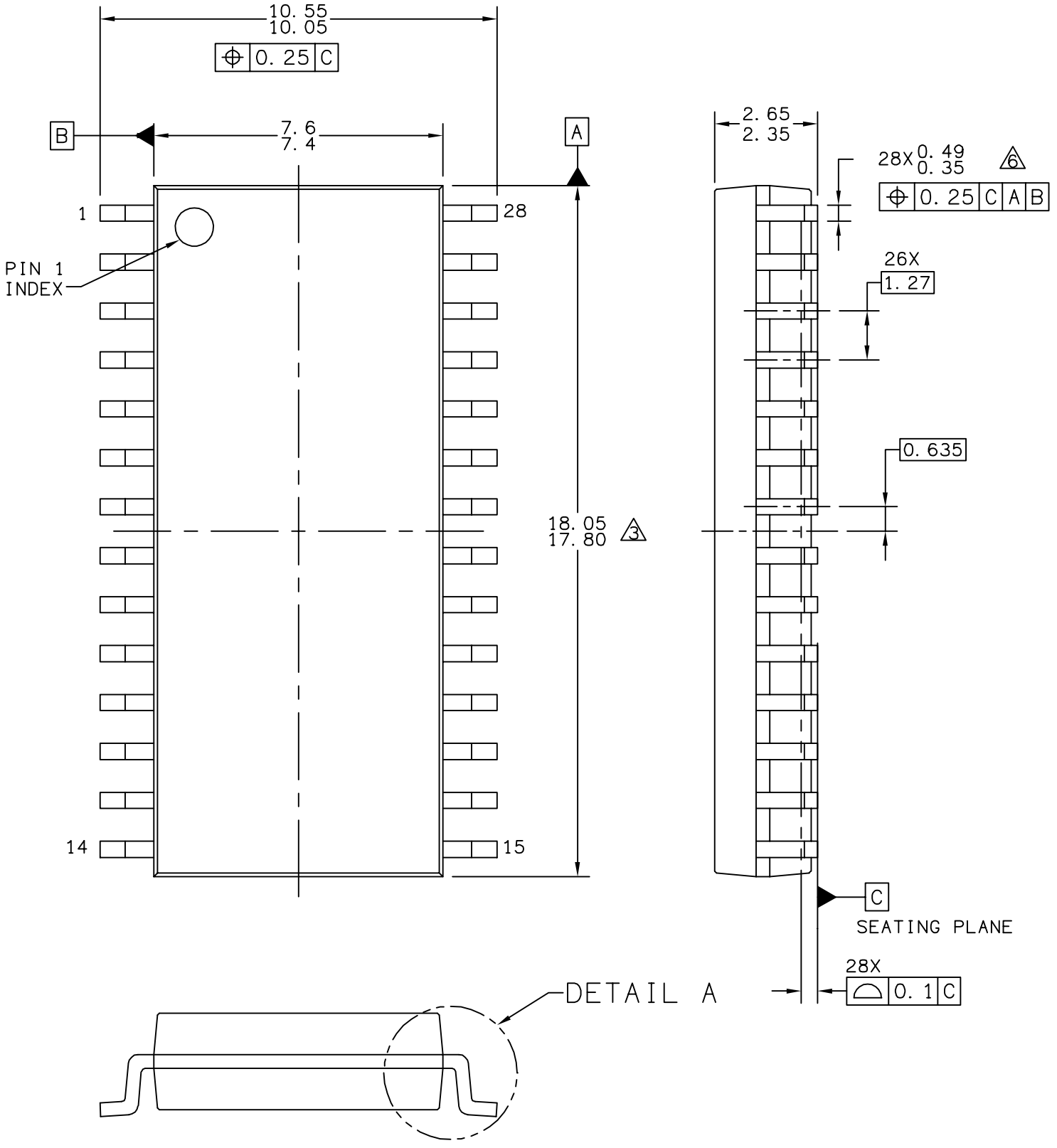
4.1 Package Information

Table 16. Package Descriptions

Pin Count	Package Type	Abbreviation	Designator	Case No.	Document No.
28	Plastic Dual In-line Pin	PDIP	RL	710	98ASB42390B
28	Small Outline Integrated Circuit	SOIC	WL	751F	98ASB42345B
16	Thin Shrink Small Outline Package	TSSOP	TG	948F	98ASH70247A

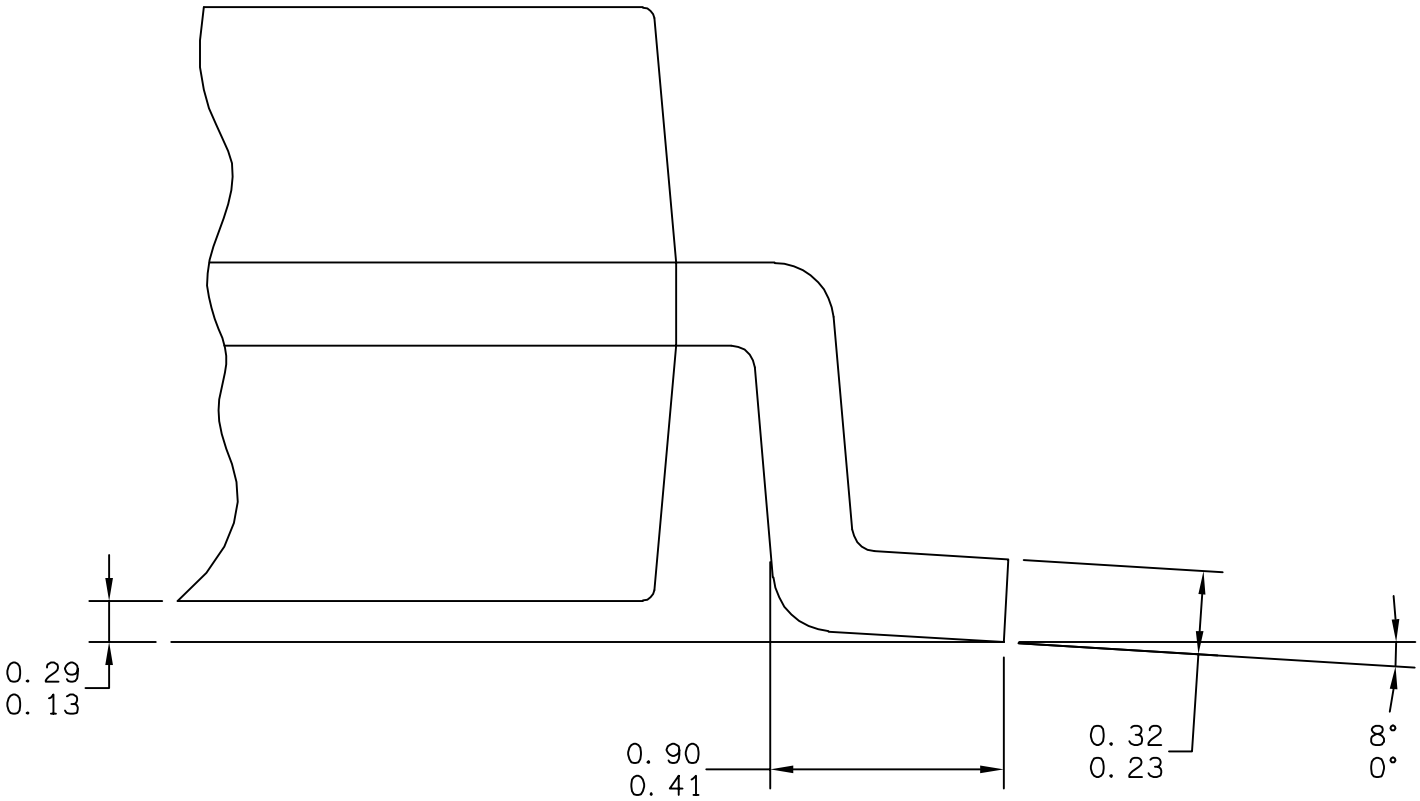
4.2 Mechanical Drawings

The following pages are mechanical drawings for the packages described in Table 16.



MECHANICAL OUTLINE	PRINT VERSION NOT TO SCALE

TITLE: SOIC, WIDE BODY, 28 LEAD CASEOUTLINE	DOCUMENT NO: 98ASB42345B	REV: G
	CASE NUMBER: 751F-05	10 MAR 2005
	STANDARD: MS-013AE	



MECHANICAL OUTLINE	PRINT VERSION NOT TO SCALE

TITLE: SOIC, WIDE BODY, 28 LEAD CASEOUTLINE	DOCUMENT NO: 98ASB42345B	REV: G
	CASE NUMBER: 751F-05	10 MAR 2005
	STANDARD: MS-013AE	

NOTES:

1. DIMENSIONS ARE IN MILLIMETERS.

2. DIMENSIONING AND TOLERANCING PER ASME Y14.5M–1994.

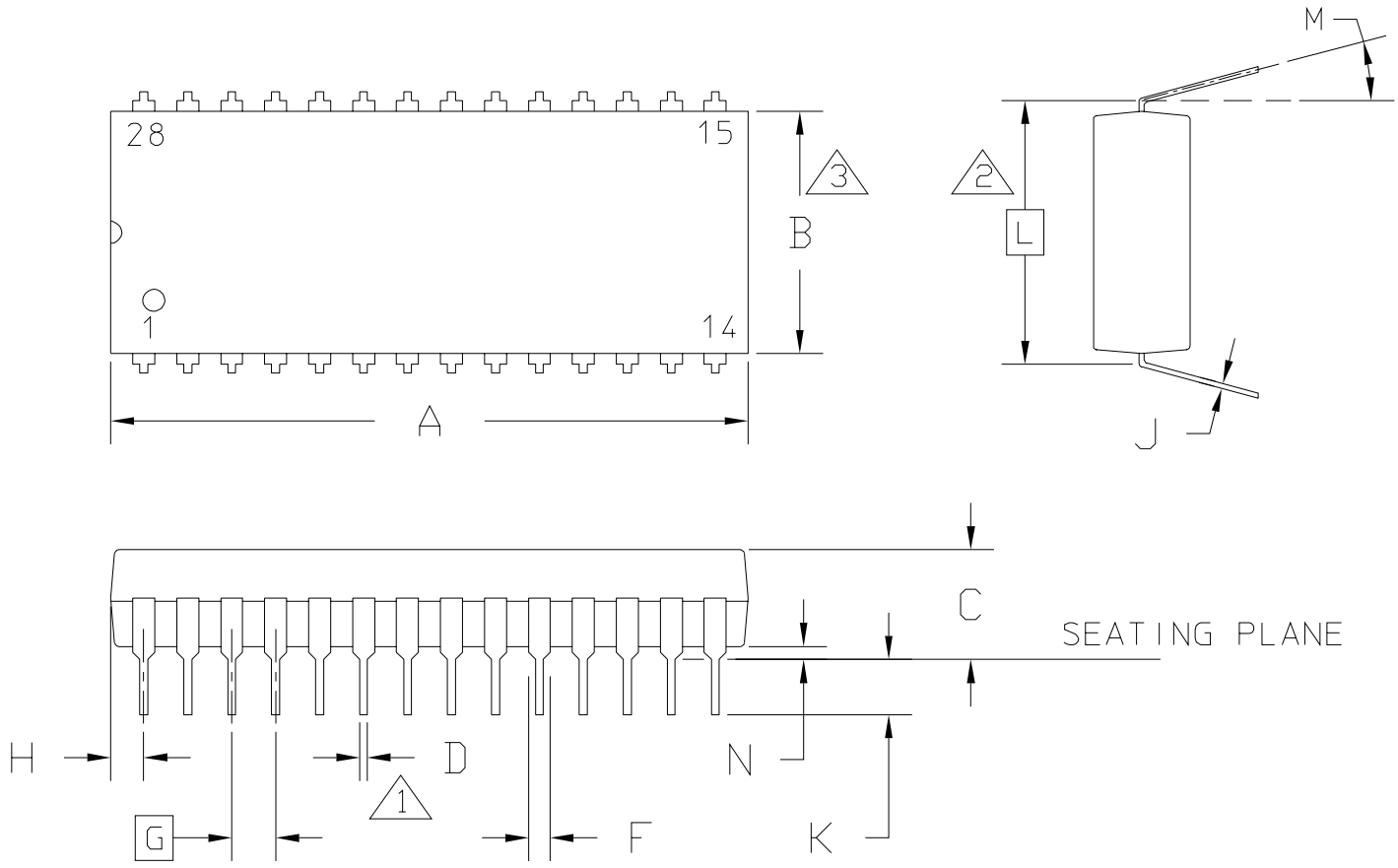
3. THIS DIMENSION DOES NOT INCLUDE MOLD PROTRUSION. MAXIMUM MOLD PROTRUSION 0.15 PER SIDE.

4. 751F–01 THRU –04 OBSOLETE. NEW STANDARD: 751F–05

5. THIS DIMENSION DOES NOT INCLUDE DAM BAR PROTRUSION ALLOWABLE DAM BAR PROTRUSION SHALL BE 0.13 TOTAL IN EXCESS OF THIS DIMENSION AT MAXIMUM MATERIAL CONDITION.

MECHANICAL OUTLINE	PRINT VERSION NOT TO SCALE

TITLE: SOIC, WIDE BODY, 28 LEAD CASEOUTLINE	DOCUMENT NO: 98ASB42345B	REV: G
	CASE NUMBER: 751F–05	10 MAR 2005
	STANDARD: MS–013AE	



	MECHANICAL OUTLINE	PRINT VERSION NOT TO SCALE
TITLE: 28 LD PDIP	DOCUMENT NO: 98ASB42390B	REV: D
	CASE NUMBER: 710-02	24 MAY 2005
	STANDARD: NON-JEDEC	

NOTES:

1. POSITIONAL TOLERANCE OF LEADS, SHALL BE WITHIN 0.25 MM (0.010) AT MAXIMUM MATERIAL CONDITION, IN RELATION TO SEATING PLANE AND EACH OTHER.

2. DIMENSION TO CENTER OF LEADS WHEN FORMED PARALLEL.

3. DIMENSION DOES NOT INCLUDE MOLD FLASH.

4. 710-01 OBSOLETE, NEW STD 710-02.

5. CONTROLLING DIMENSION: INCH

DIM	INCH MIN	INCH MAX	MILLIMETER MIN	MILLIMETER MAX	DIM	INCH MIN	INCH MAX	MILLIMETER MIN	MILLIMETER MAX
A	1.435	1.465	36.45	37.21					
B	0.540	0.560	13.72	14.22					
C	0.155	0.200	3.94	5.08					
D	0.014	0.022	0.36	0.56					
F	0.040	0.060	1.02	1.52					
G	0.100 BSC		2.54 BSC						
H	0.065	0.085	1.65	2.16					
J	0.008	0.015	0.20	0.38					
K	0.115	0.135	2.92	3.43					
L	0.600 BSC		15.24 BSC						
M	0°	15°	0°	15°					
N	0.020	0.040	0.51	1.02					

MECHANICAL OUTLINE

PRINT VERSION NOT TO SCALE

TITLE:

28 LD PDIP

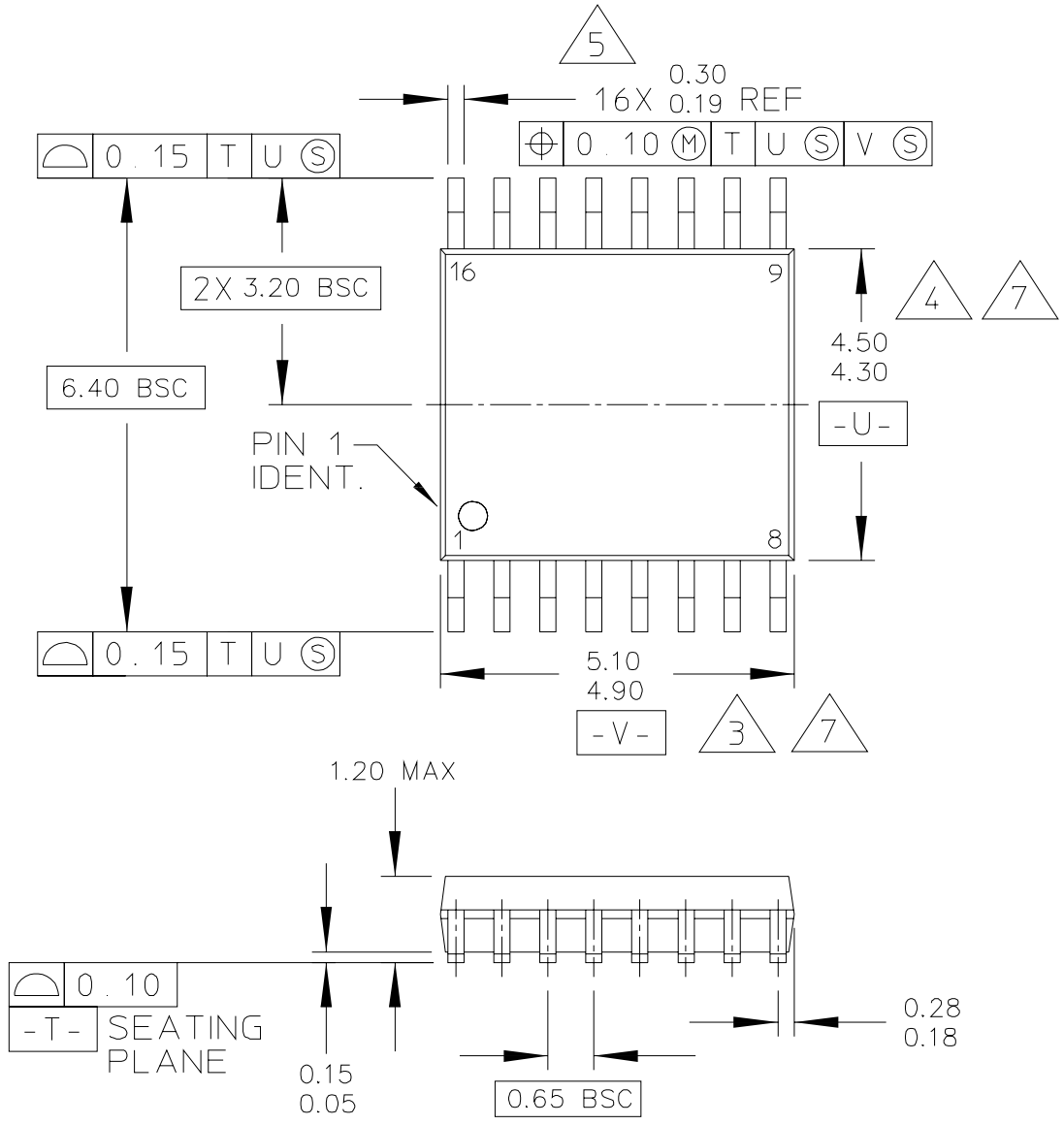
DOCUMENT NO: 98ASB42390B

REV: D

CASE NUMBER: 710-02

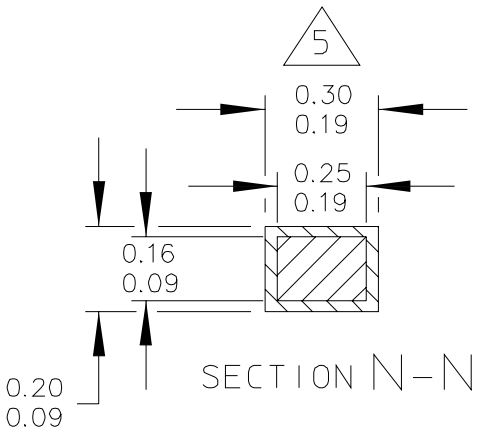
24 MAY 2005

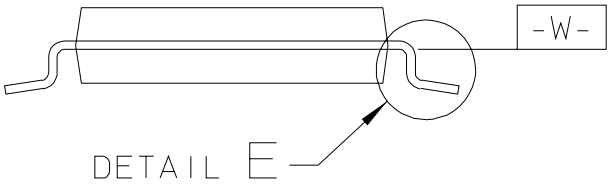
STANDARD: NON-JEDEC

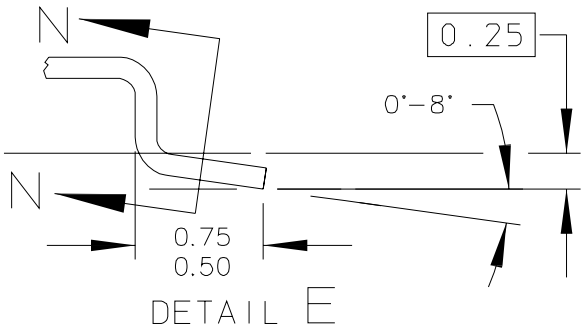


MECHANICAL OUTLINE	PRINT VERSION NOT TO SCALE

TITLE:	DOCUMENT NO: 98ASH70247A	REV: B
16 LD TSSOP, PITCH 0.65MM	CASE NUMBER: 948F-01	19 MAY 2005
	STANDARD: JEDEC	







MECHANICAL OUTLINE	PRINT VERSION NOT TO SCALE

TITLE:	DOCUMENT NO: 98ASH70247A	REV: B
16 LD TSSOP, PITCH 0.65MM	CASE NUMBER: 948F-01	19 MAY 2005
	STANDARD: JEDEC	

NOTES:

1. CONTROLLING DIMENSION: MILLIMETER
2. DIMENSIONS AND TOLERANCES PER ANSI Y14.5M-1982.
3. DIMENSION DOES NOT INCLUDE MOLD FLASH, PROTRUSIONS OR GATE BURRS. MOLD FLASH OR GATE BURRS SHALL NOT EXCEED 0.15 PER SIDE.
4. DIMENSION DOES NOT INCLUDE INTERLEAD FLASH OR PROTRUSION. INTERLEAD FLASH OR PROTRUSION SHALL NOT EXCEED 0.25 PER SIDE.
5. DIMENSION DOES NOT INCLUDE DAMBAR PROTRUSION. ALLOWABLE DAMBAR PROTRUSION SHALL BE 0.08 TOTAL IN EXCESS OF THE DIMENSION AT MAXIMUM MATERIAL CONDITION.
6. TERMINAL NUMBERS ARE SHOWN FOR REFERENCE ONLY.
7. DIMENSIONS ARE TO BE DETERMINED AT DATUM PLANE -W-.

MECHANICAL OUTLINE	PRINT VERSION NOT TO SCALE

TITLE:	DOCUMENT NO: 98ASH70247A	REV: B
16 LD TSSOP, PITCH 0.65MM	CASE NUMBER: 948F-01	19 MAY 2005
	STANDARD: JEDEC	

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