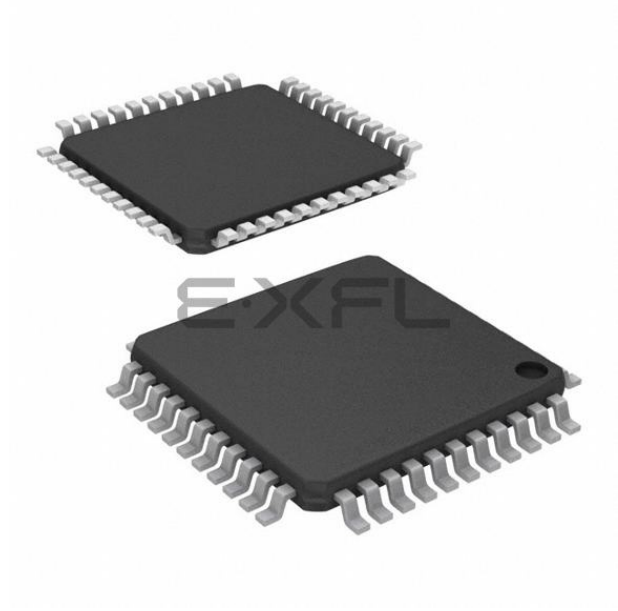

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Applications of "Embedded - Microcontrollers"

Details	
Product Status	Active
Core Processor	56800E
Core Size	16-Bit
Speed	60MHz
Connectivity	CANbus, I²C, LINbus, SCI, SPI
Peripherals	LVD, POR, PWM, WDT
Number of I/O	35
Program Memory Size	48KB (24K x 16)
Program Memory Type	FLASH
EEPROM Size	-
RAM Size	3K x 16
Voltage - Supply (Vcc/Vdd)	3V ~ 3.6V
Data Converters	A/D 8x12b; D/A 1x12b
Oscillator Type	Internal
Operating Temperature	-40°C ~ 105°C (TA)
Mounting Type	Surface Mount
Package / Case	44-LQFP
Supplier Device Package	44-LQFP (10x10)
Purchase URL	https://www.e-xfl.com/product-detail/nxp-semiconductors/mc56f8245vld

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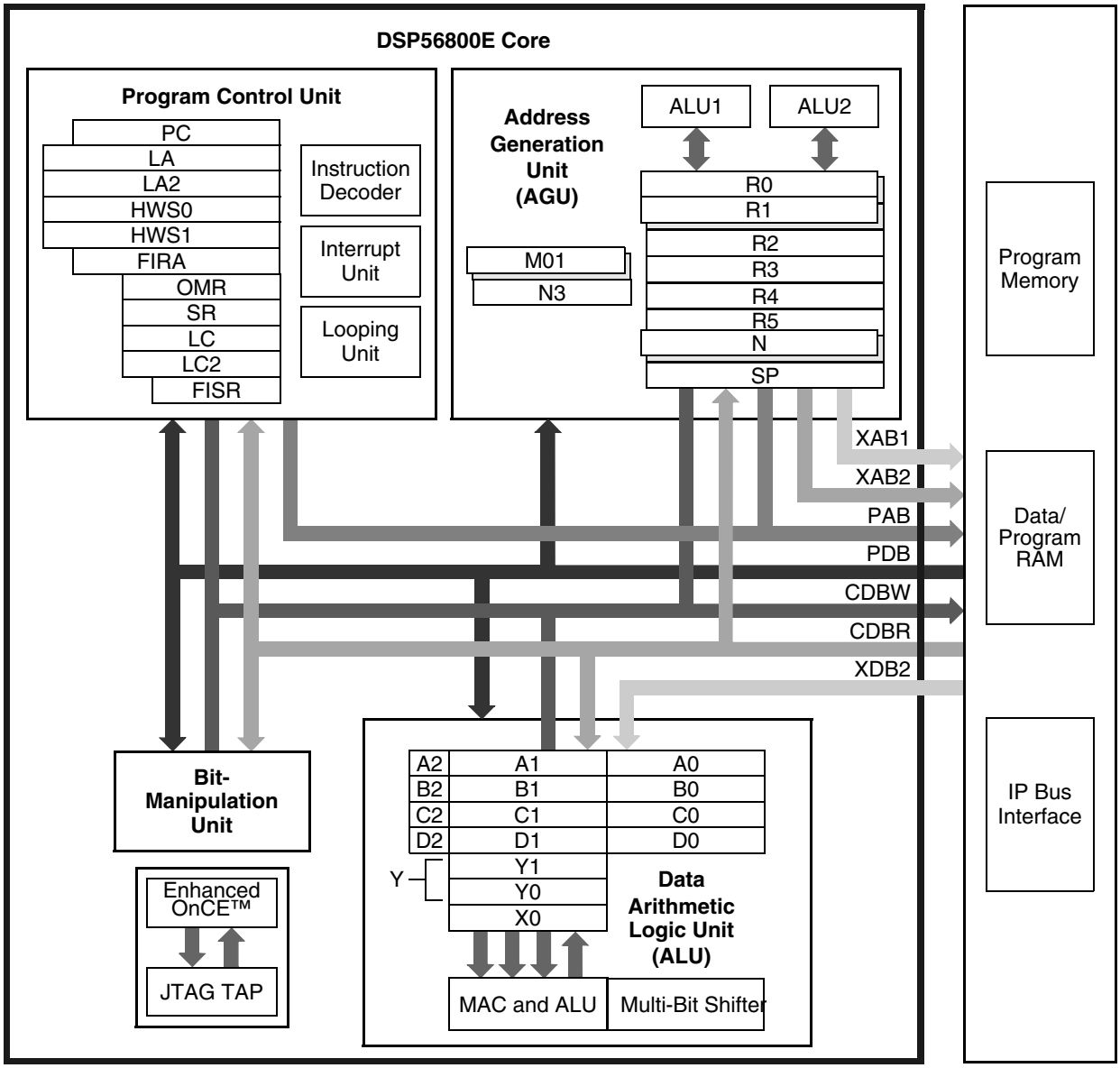


Figure 1. 56800E Core Block Diagram

Figure 2 shows the peripherals and control blocks connected to the IP bus bridge. Refer to the system integration module (SIM) section in the device's reference manual for information about which signals are multiplexed with those of other peripherals.

Table 5. MC56F825x/MC56F824x Signal and Package Information (continued)

Signal Name	44 LQFP	48 LQFP	64 LQFP	Type	State During Reset	Signal Description
GPIOA2 *(ANA2& VREFHA& CMPA_M1)*	10	11	15	Input/ Output Input	Input, internal pullup enabled	Port A GPIO — This GPIO pin can be individually programmed as an input or output pin. ANA2 and VREFHA and CMPA_M1 — Analog input to channel 2 of ADCA and analog references high of ADCA and negative input 1 of analog comparator A. When used as an analog input, the signal goes to ANA2 and VREFHA and CMPA_M1. ADC control register configures this input as ANA2 or VREFHA. After reset, the default state is GPIOA2.
GPIOA3 *(ANA3& VREFLA& CMPA_M2)*	11	12	16	Input/ Output Input	Input, internal pullup enabled	Port A GPIO — This GPIO pin can be individually programmed as an input or output pin. ANA3 and VREFLA and CMPA_M2 — Analog input to channel 3 of ADCA and analog references low of ADCA and negative input 2 of analog comparator A. When used as an analog input, the signal goes to ANA3 and VREFLA and CMPA_M2. ADC control register configures this input as ANA3 or VREFLA. After reset, the default state is GPIOA3.
GPIOA4 *(ANA4)*		8	12	Input/ Output Input	Input, internal pullup enabled	Port A GPIO — This GPIO pin can be individually programmed as an input or output pin. ANA4 — Analog input to channel 4 of ADCA. After reset, the default state is GPIOA4.
GPIOA5 *(ANA5)*			11	Input/ Output Input	Input, internal pullup enabled	Port A GPIO — This GPIO pin can be individually programmed as an input or output pin. ANA5 — Analog input to channel 5 of ADCA. After reset, the default state is GPIOA5.
GPIOA6 *(ANA6)*			10	Input/ Output Input	Input, internal pullup enabled	Port A GPIO — This GPIO pin can be individually programmed as an input or output pin. ANA6 — Analog input to channel 5 of ADCA. After reset, the default state is GPIOA6.
GPIOA7 *(ANA7)*			9	Input/ Output Input	Input, internal pullup enabled	Port A GPIO — This GPIO pin can be individually programmed as an input or output pin. ANA7 — Analog input to channel 7 of ADCA. After reset, the default state is GPIOA7.

Table 5. MC56F825x/MC56F824x Signal and Package Information (continued)

Signal Name	44 LQFP	48 LQFP	64 LQFP	Type	State During Reset	Signal Description
GPIOB0 *(ANB0& CMPB_P2)*	15	17	24	Input/ Output Input	Input, internal pullup enabled	Port B GPIO — This GPIO pin can be individually programmed as an input or output pin. ANB0 and CMPB_P2 — Analog input to channel 0 of ADCB and positive input 2 of analog comparator B. When used as an analog input, the signal goes to ANB0 and CMPB_P2. After reset, the default state is GPIOB0.
GPIOB1 *(ANB1& CMPB_M0)*	16	18	25	Input/ Output Input	Input, internal pullup enabled	Port B GPIO — This GPIO pin can be individually programmed as an input or output pin. ANB1 and CMPB_M0— Analog input to channel 1 of ADCB and negative input 0 of analog comparator B. When used as an analog input, the signal goes to ANB1 and CMPB_M0. After reset, the default state is GPIOB1.
GPIOB2 *(ANB2& VREFHB& CMPC_P2)*	18	20	27	Input/ Output Input	Input, internal pullup enabled	Port B GPIO — This GPIO pin can be individually programmed as an input or output pin. ANB2 and VREFHB and CMPC_P2 — Analog input to channel 2 of ADCB and analog references high of ADCB and positive input 2 of analog comparator C. When used as an analog input, the signal goes to ANB2 and VREFHB and CMPC_P2. ADC control register configures this input as ANB2 or VREFHB. After reset, the default state is GPIOB2.
GPIOB3 *(ANB3& VREFLB& CMPC_M0)*	19	21	28	Input/ Output Input	Input, internal pullup enabled	Port B GPIO — This GPIO pin can be individually programmed as an input or output pin. ANB3 and VREFLB and CMPC_M0 — Analog input to channel 3 of ADCB and analog references low of ADCB and negative input 0 of analog comparator C. When used as an analog input, the signal goes to ANB3 and VREFLB and MPC_M0. ADC control register configures this input as ANB3 or VREFLB. After reset, the default state is GPIOB3.

Table 11. 56F8245/56 Data Memory Map[1]

Begin/End Address	Memory Allocation
X:0xFF FFFF X:0xFF FF00	EOnCE 256 locations allocated
X:0xFF FEFF X:0x01 0000	RESERVED
X:0x00 FFFF X:0x00 F000	On-Chip Peripherals 4096 locations allocated
X:0x00 EFFF X:0x00 8C00	RESERVED
X:0x00 8BFF X:0x00 8000	On-Chip Data RAM Alias
X:0x00 7FFF X:0x00 0C00	RESERVED
X:0x00 0BFF X:0x00 0000	On-Chip Data RAM 6 KB[2]

1 All addresses are 16-bit word addresses.

2 This RAM is shared with program space starting at P: 0x00 8000. See Figure 8.

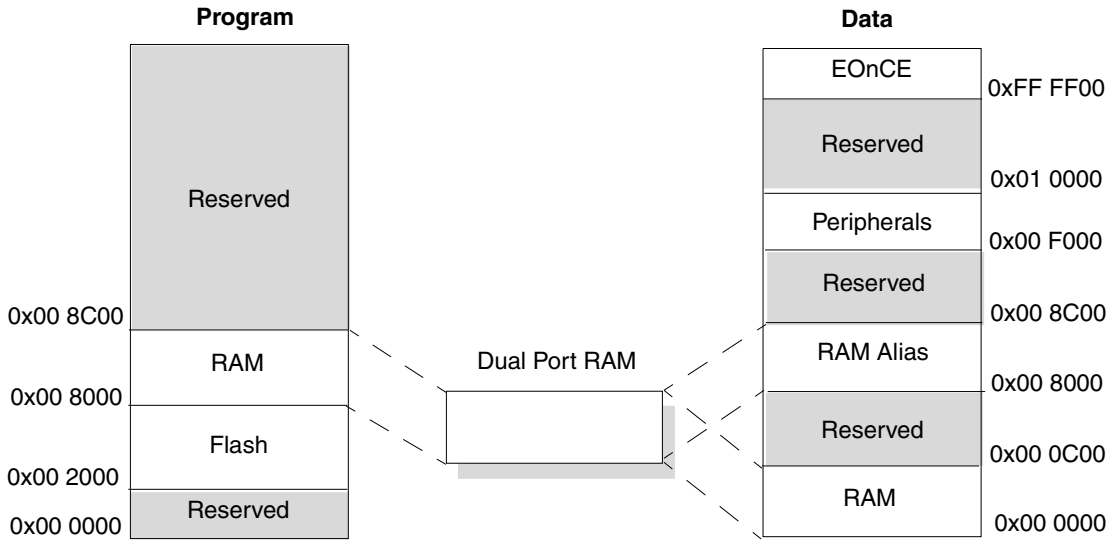


Figure 8. 56F8245/46 Dual Port RAM Map

4.4 Interrupt Vector Table and Reset Vector

The location of the vector table is determined by the vector base address register (VBA). The value in this register is used as the upper 14 bits of the interrupt vector VAB[20:0]. The lower seven bits are determined based on the highest priority interrupt and are then appended to VBA before presenting the full VAB to the core. Refer to the device's reference manual for details.

The reset startup addresses of 56F824x and 56F825x are different.

- The 56F825x's startup address is located at 0x00 0000. The reset value of VBA is reset to a value of 0x0000 that corresponds to the address 0x00 0000.

- The 56F824x's startup address is located at 0x00 2000. The reset value of VBA is reset to a value of 0x0020 that corresponds to the address 0x00 2000.

By default, the chip reset address and COP reset address correspond to vector 0 and 1 of the interrupt vector table. In these instances, the first two locations in the vector table must contain branch or JMP instructions. All other entries must contain JSR instructions.

Table 48 on page 85 provides the MC56F825x/MC56F824x's interrupt table contents and interrupt priority structure.

4.5 Peripheral Memory-Mapped Registers

The locations of on-chip peripheral registers are part of the data memory map on the 56800E series. These locations may be accessed with the same addressing modes used for ordinary data memory. However, all peripheral registers should be read or written using word accesses only.

Table 12 summarizes the base addresses for the set of peripherals on the MC56F825x/MC56F824x devices. Peripherals are listed in order of the base address.

Table 12. Data Memory Peripheral Base Address Map Summary

Peripheral	Prefix	Base Address
Quad Timer A	TMRA	X:0x00 F000
Quad Timer B	TMRB	X:0x00 F040
Analog-to-Digital Converter	ADC	X:0x00 F080
Interrupt Controller	INTC	X:0x00 F0C0
System Integration Module	SIM	X:0x00 F0E0
Crossbar module	XBAR	X:0x00 F100
Computer Operating Properly module	COP	X:0x00 F110
On-Chip Clock Synthesis module	OCCS	X:0x00 F120
Power Supervisor	PS	X:0x00 F130
GPIO Port A	GPIOA	X:0x00 F140
GPIO Port B	GPIOB	X:0x00 F150
GPIO Port C	GPIOC	X:0x00 F160
GPIO Port D	GPIOD	X:0x00 F170
GPIO Port E	GPIOE	X:0x00 F180
GPIO Port F	GPIOF	X:0x00 F190
12-bit Digital-to-Analog Converter	DAC	X:0x00 F1A0
Analog Comparator A	CMPA	X:0x00 F1B0
Analog Comparator B	CMPB	X:0x00 F1C0
Analog Comparator C	CMPC	X:0x00 F1D0
Queued Serial Communication Interface 0	QSCI0	X:0x00 F1E0
Queued Serial Communication Interface 1	QSCI1	X:0x00 F1F0
Queued Serial Peripheral Interface	QSPI	X:0x00 F200
Inter-Integrated Circuit 0	I^2C0	X:0x00 F210
Inter-Integrated Circuit 1	I^2C1	X:0x00 F220

Table 13. EOnCE Memory Map

Address	Register Abbreviation	Register Name
X:0xFF FF91–X:0xFF FF90	OBMSK (32 bits)	Breakpoint Unit Mask Register 2
X:0xFF FF8F		Reserved
X:0xFF FF8E	OBCNTR	EOnCE Breakpoint Unit Counter
X:0xFF FF8D		Reserved
X:0xFF FF8C		Reserved
X:0xFF FF8B		Reserved
X:0xFF FF8A	OESCR	External Signal Control Register
X:0xFF FF89 –X:0xFF FF00		Reserved

5 General System Control Information

5.1 Overview

This section discusses power pins, reset sources, interrupt sources, clock sources, the system integration module (SIM), ADC synchronization, and JTAG/EOnCE interfaces.

5.2 Power Pins

V_{DD}, V_{SS} and V_{DDA}, V_{SSA} are the primary power supply pins for the device. The voltage source supplies power to all on-chip peripherals, I/O buffer circuitry, and internal voltage regulators. The device has multiple internal voltages to provide regulated lower-voltage sources for the peripherals, core, memory, and on-chip relaxation oscillators.

Typically, at least two separate capacitors are across the power pins to bypass the glitches and provide bulk charge storage. In this case, a bulk electrolytic or tantalum capacitor, such as a 10 µF tantalum capacitor, should provide bulk charge storage for the overall system, and a 0.1 µF ceramic bypass capacitor should be located as near to the device power pins as is practical to suppress high-frequency noise. Each pin must have a bypass capacitor for optimal noise suppression.

V_{DDA} and V_{SSA} are the analog power supply pins for the device. This voltage source supplies power to the ADC, PGA, and CMP modules. A 0.1 µF ceramic bypass capacitor should be located as near to the device V_{DDA} and V_{SSA} pins as is practical to suppress high-frequency noise. V_{DDA} and V_{SSA} are also the voltage reference high and voltage reference low inputs, respectively, for the ADC module.

5.3 Reset

Resetting the device provides a way to start processing from a known set of initial conditions. During reset, most control and status registers are forced to initial values, and the program counter is loaded from the reset vector. On-chip peripheral modules are disabled and I/O pins are initially configured at the reset status shown in Table 5 on page 18.

The MC56F825x/MC56F824x has the following sources for reset:

- Power-on reset (POR)
- Partial power-down reset (PPD)
- Low-voltage detect (LVD)
- External pin reset (EXTR)
- Computer operating properly loss of reference reset (COP_LOR)
- Computer operating properly time-out reset (COP_CPU)

- Software reset (SWR)

Each of these sources has an associated bit in the reset status register (RSTAT) in the system integration module (SIM).

The external pin reset function is shared with a GPIO port A7 on the $\overline{\text{RESET}}$/GPIOA7 pin. The reset function is enabled following any reset of the device. Bit 7 of the GPIOA_PER register must be cleared to use this pin as a GPIO port pin. When the pin is enabled as the $\overline{\text{RESET}}$ pin, an internal pullup device is automatically enabled.

5.4 On-chip Clock Synthesis

The on-chip clock synthesis (OCCS) module allows designers using an internal relaxation oscillator, an external crystal, or an external clock to run 56F8000 family devices at user-selectable frequencies up to 60 MHz.

The features of OCCS module include:

- Ability to power down the internal relaxation oscillator or crystal oscillator
- Ability to put the internal relaxation oscillator into standby mode
- Ability to power down the PLL
- Provides a 2x system clock that operates at two times the system clock to the timer and SCI modules
- Safety shutdown feature if the PLL reference clock is lost
- Ability to be driven from an external clock source

The clock generation module provides the programming interface for the PLL, internal relaxation oscillator, and crystal oscillator. It also provides a postscaler to divide clock frequency down by 1, 2, 4, 8, 16, 32, 64, 128, or 256 before feeding it to the SIM. The SIM is responsible for further dividing these frequencies by 2, which ensures a 50% duty cycle in the system clock output. For details, refer to the OCCS section of the device's reference manual.

5.4.1 Internal Clock Source

When an external frequency source or crystal is not used, an internal relaxation oscillator can supply the reference frequency. It is optimized for accuracy and programmability while providing several power-saving configurations that accommodate different operating conditions. The internal relaxation oscillator has little temperature and voltage variability. To optimize power, the internal relaxation oscillator supports a run state (8 MHz), standby state (400 kHz), and a power-down state.

During a boot or reset sequence, the relaxation oscillator is enabled by default (the PRECS bit in the PLLCR word is set to 0). Application code can then also switch to the external clock source and power down the internal oscillator, if desired. If a changeover between internal and external clock sources is required at power-on, ensure that the clock source is not switched until the desired external clock source is enabled and stable.

To compensate for variances in the device manufacturing process, the accuracy of the relaxation oscillator can be incrementally adjusted to within + 0.078% of 8 MHz by trimming an internal capacitor. Bits 0–9 of the oscillator control (OSCTL) register allow you to set an additional offset (trim) to this preset value to increase or decrease capacitance. Each unit added or subtracted changes the output frequency by about 0.078% of 8 MHz, allowing incremental adjustment until the desired frequency accuracy is achieved.

The center frequency of the internal oscillator is calibrated at the factory to 8 MHz, and the TRIM value is stored in the flash information block and loaded to the HFM IFR option register 0 at reset. When using the relaxation oscillator, the boot code should read the HFM IFR option register 0 and set this value as OSCTL TRIM. For further information, refer to the device's reference manual.

5.4.2 Crystal Oscillator/Ceramic Resonator

The internal crystal oscillator circuit is designed to interface with a parallel-resonant crystal resonator in the frequency range, specified for the external crystal, of 4 MHz to 16 MHz. A ceramic resonator can be substituted for the 4 MHz to 16 MHz range. When used to supply a source to the internal PLL, the recommended crystal/resonator is in the 8 MHz to 16 MHz range to optimize PLL performance. Oscillator circuits appear in Figure 9 and Figure 10. Follow the crystal supplier's recommendations

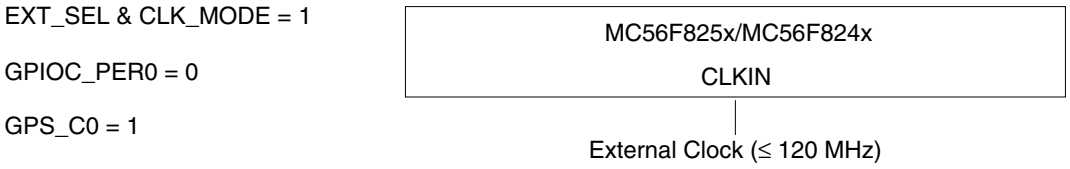


Figure 11. Connecting an External Clock Signal Using GPIO

5.5 Interrupt Controller

The MC56F825x/MC56F824x interrupt controller (INTC) module arbitrates the various interrupt requests (IRQs). When an interrupt of sufficient priority exists, the INTC signals to the 56800E core and provides the address to which to jump to service the interrupt.

The interrupt controller contains registers that allow each of the 66 interrupt sources to be set to one of three priority levels (excluding certain interrupt sources that have fixed priority) or to be disabled. Next, all interrupt requests of a given level are priority encoded to determine the lowest numeric value of the active interrupt requests for that level. Within a given priority level, the lowest vector number is the highest priority, and the highest vector number is the lowest priority.

Any two interrupt sources can be assigned to faster interrupts. Fast interrupts are described in the *DSP56800E Reference Manual*. The interrupt controller recognizes fast interrupts before the core does.

A fast interrupt is defined by:

1. Setting the priority of the interrupt as level 2 with the appropriate field in the Interrupt Priority Register (IPR) registers
2. Setting the Fast Interrupt Match (FIM*n*) register to the appropriate vector number
3. Setting the Fast Interrupt Vector Address Low (FIVAL*n)* and Fast Interrupt Vector Address High (FIVAH*n)* registers with the address of the code for the fast interrupt

When an interrupt occurs, its vector number is compared with the FIM0 and FIM1 register values. If a match occurs, and it is a level 2 interrupt, the INTC handles it as a Fast Interrupt. The INTC takes the vector address from the appropriate FIVAL*n* and FIVAH*n* registers, instead of generating an address that is an offset from the VBA.

The core then fetches the instruction from the indicated vector address instead of jumping to the vector table. If the instruction is not a JSR, the core starts its fast interrupt handling. Refer to section 9.3.3.3 of *DSP56800E 16-Bit Core Reference Manual* for details.

Table 48 on page 85 provides the MC56F825x/MC56F824x's interrupt table contents and interrupt priority structure.

5.6 System Integration Module (SIM)

The SIM module consists of the glue logic that ties together the system-on-a-chip. It controls distribution of resets and clocks and provides a number of control features, including pin muxing control, inter-module connection control (such as connecting comparator output to eFlexPWM fault input), individual peripheral enabling/disabling, clock rate control for quad timers and SCIs, enabling peripheral operation in stop mode, and port configuration overwrite protection. For more information, refer to the device's reference manual.

The SIM is responsible for the following functions:

- Chip reset sequencing
- Core and peripheral clock control and distribution
- Stop/wait mode control
- System status control
- Registers containing the JTAG ID of the chip
- Controls for programmable peripheral and GPIO connections

- Peripheral clocks for Quad Timers and SCIs with a high-speed (2x) option
- Power-saving clock gating for peripherals
- Controls for enabling/disabling functions of large regulator standby mode with write protection capability
- Allowing selected peripherals to run in stop mode to generate stop recovery interrupts
- Controls for programmable peripheral and GPIO connections
- Software chip reset
- I/O short address base location control
- Peripheral protection control to provide runaway code protection for safety-critical applications
- Controls for output of internal clock sources to CLKO pin
- Four general-purpose software control registers that are reset only at power-on
- Peripheral stop mode clocking control

5.7 Inter-Module Connections

The operations between on-chip peripherals can be synchronized or cascaded through internal module connections to support particular applications. Examples include synchronization between ADC sampling and PWM waveform generation for a power conversion application, and synchronization between timer pulse outputs and DAC waveform generation for a printer application. The user can program the internal Crossbar Switch or Comparator input multiplexes to connect one on-chip peripheral's outputs to other peripherals' inputs.

5.7.1 Comparator Connections

The MC56F825x/MC56F824x includes three high-speed comparators. Each comparator input has a 4-to-1 input mux, allowing it to sample a variety of analog sources. Some of these inputs share package pins with the on-chip ADCs; see Table 5 on page 18.

Each comparator is paired with a dedicated, programmable, 5-bit on-chip voltage reference DAC (VREF_DAC). Optionally, an on-chip 12-bit DAC can be internally fed to each comparator's positive input 1 (CMPn_P1) or negative input 3 (CMPn_M3). In addition, all three comparators' positive input 3 (CMPn_P3) can be connected together to package pin CMP_REF. Other inputs can be routed to package pins when the corresponding pin is configured for peripheral mode in the GPIO module.

Table 16. Crossbar Output Signal Assignments (continued)

XBAR_OUTn	Output to	Function
XBAR_OUT7	ADCB	ADCB Trigger
XBAR_OUT8	DAC	12-bit DAC SYNC_IN
XBAR_OUT9	CMPA	Comparator A Window/Sample
XBAR_OUT10	CMPB	Comparator B Window/Sample
XBAR_OUT11	CMPC	Comparator C Window/Sample
XBAR_OUT12	PWM0 EXTA	eFlexPWM submodule 0 Alternate Control signal
XBAR_OUT13	PWM1 EXTA	eFlexPWM submodule 1 Alternate Control signal
XBAR_OUT14	PWM2 EXTA	eFlexPWM submodule 2 Alternate Control signal
XBAR_OUT15	PWM3 EXTA	eFlexPWM submodule 3 Alternate Control signal
XBAR_OUT16	PWM0 EXT_SYNC	eFlexPWM submodule 0 External Synchronization signal
XBAR_OUT17	PWM1 EXT_SYNC	eFlexPWM submodule 1 External Synchronization signal
XBAR_OUT18	PWM2 EXT_SYNC	eFlexPWM submodule 2 External Synchronization signal
XBAR_OUT19	PWM3 EXT_SYNC	eFlexPWM submodule 3 External Synchronization signal
XBAR_OUT20	PWM EXT_CLK	eFlexPWM External Clock signal
XBAR_OUT21	PWM FAULT0	eFlexPWM Module FAULT0
XBAR_OUT22	PWM FAULT1	eFlexPWM Module FAULT1
XBAR_OUT23	PWM FAULT2	eFlexPWM Module FAULT2
XBAR_OUT24	PWM FAULT3	eFlexPWM Module FAULT3
XBAR_OUT25	PWM FORCE	eFlexPWM External Output Force signal
XBAR_OUT26	TB0	Quad Timer B0 Input when SIM_GPS3[12] is set
XBAR_OUT27	TB1	Quad Timer B1 Input when SIM_GPS3[13] is set
XBAR_OUT28	TB2	Quad Timer B2 Input when SIM_GPS3[14] is set
XBAR_OUT29	TB3	Quad Timer B3 Input when SIM_GPS3[15] is set

5.7.3 Interconnection of PWM Module and ADC Module

In addition to how PWM0_EXTA, PWM1_EXTA, PWM2_EXTA, and PWM3_EXTA connect to crossbar outputs, the ADC conversion high/low limit compare results of sample0, sample1, and sample2 are used to drive PWM0_EXTB, PWM1_EXTB, and PWM2_EXTB, respectively. PWM3_EXTB is permanently tied to GND.

State of PWM0_EXTB:

- If the ADC conversion result in SAMPLE0 is greater than the value programmed into the high limit register 0, PWM0_EXTB is driven low.
- If the ADC conversion result in SAMPLE0 is less than the value programmed into the low limit register 0, PWM0_EXTB is driven high.

State of PWM1_EXTB:

- If the ADC conversion result in SAMPLE1 is greater than the value programmed into the high limit register 1, PWM1_EXTB is driven low.

7.8 Power-On Reset, Low Voltage Detection Specification

Table 25. Power-On Reset and Low-Voltage Detection Parameters

Characteristic	Symbol	Min	Typ	Max	Unit
Low-Voltage Interrupt for 3.3 V supply[1]	V_{LVI27}	2.6	2.7	2.8	V
Low-Voltage Interrupt for 2.5 V supply[2]	V_{LVI21}	—	2.18	—	V
Low-Voltage Interrupt Recovery Hysteresis	V_{EIH}	—	50	—	mV
Power-On Reset Threshold[3]	POR	2.6	2.7	2.8	V
Brown-Out Reset Threshold[4]	BOR	—	1.8	1.9	V

1 When V_{DD} drops below LVI27, an interrupt is generated.
2 When V_{DD} drops below LVI21, an interrupt is generated.
3 While power is ramping up, this signal remains active for as long as the internal 2.5 V is below 2.18 V or the 3.3 V V_{DD} voltage is below 2.7 V, no matter how long the ramp-up rate is. The internally regulated voltage is typically 100 mV less than V_{DD} during ramp-up until 2.5 V is reached, at which time it self-regulates.
4 Brown-Out Reset occurs whenever the internally regulated 2.5 V digital supply drops below 1.8 V.

7.9 Voltage Regulator Specifications

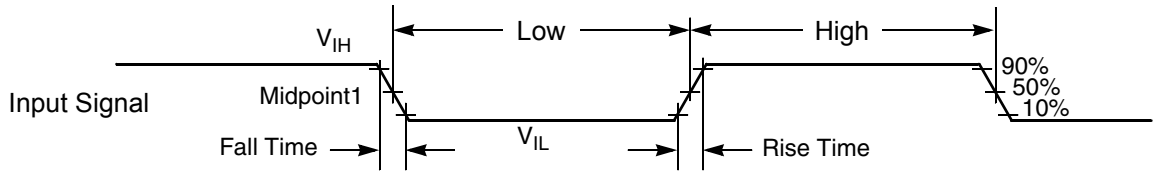
The MC56F825x/MC56F824x has two on-chip regulators. One supplies the PLL, crystal oscillator, NanoEdge placement PWM, and relaxation oscillator. It has no external pins and therefore has no external characteristics that must be guaranteed (other than proper operation of the device). The second regulator supplies approximately 2.5 V to the MC56F825x/MC56F824x's core logic. For proper operation, this regulator requires an external capacitor of 2.2 µF or greater. Ceramic and tantalum capacitors tend to provide better performance tolerances. The output voltage can be measured directly on the V_{CAP} pin. The specifications for this regulator appear in Table 26.

Table 26. Regulator Parameters

Characteristic	Symbol	Min	Typical	Max	Unit
Short Circuit Current	I_{SS}	—	900	1300	mA
Short Circuit Tolerance (V_{CAP} shorted to ground)	T_{RSC}	—	—	30	minutes

7.10 AC Electrical Characteristics

Tests are conducted using the input levels specified in Table 23. Unless otherwise specified, propagation delays are measured from the 50% to the 50% point, and rise and fall times are measured between the 10% and 90% points, as shown in Figure 15.



The midpoint is $V_{IL} + (V_{IH} - V_{IL})/2$.

Figure 15. Input Signal Measurement References

Figure 16 shows the definitions of the following signal states:

- Active state, when a bus or signal is driven, and enters a low impedance state
- Tri-stated, when a bus or signal is placed in a high impedance state
- Data Valid state, when a signal level has reached V_{OL} or V_{OH}
- Data Invalid state, when a signal level is in transition between V_{OL} and V_{OH}

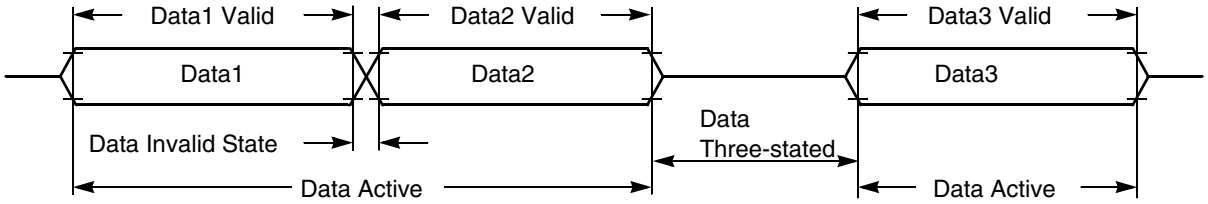


Figure 16. Signal States

7.11 Enhanced Flex PWM Characteristics

Table 27. Enhanced Flex PWM Timing Parameters

Characteristic	Symbol	Min	Typ	Max	Unit
NanoEdge Placement (NEP) step size[1 2 3]	—	—	521	—	ps
Delay for fault input activating to PWM output deactivated	—	1	—		ns

1 Required: IP bus clock is between 50 MHz and ~60 Mhz in NanoEdge Placement mode.

2 NanoEdge Placement step size is a function of clock frequency only. Temperature and voltage variations do not affect NanoEdge Placement step size.

3 In NanoEdge Placement mode, the minimum pulse edge-to-edge cannot be less than 4 PWM clock cycles.

7.12 Flash Memory Characteristics

Table 28. Flash Timing Parameters

Characteristic	Symbol	Min	Typ	Max	Unit
Program time[1]	tprog	20	—	40	µs
Erase time [2]	terase	20	—	—	ms
Mass erase time	tme	100	—	—	ms

1 Additional overhead is part of the programming sequence. Refer to the device's reference manual for details.

2 Specifies page erase time. There are 1024 bytes per page in the program flash memory.

7.13 External Clock Operation Timing

Table 29. External Clock Operation Timing Requirements[1]

Characteristic	Symbol	Min	Typ	Max	Unit
Frequency of operation (external clock driver)[2]	f_{osc}	—	—	120	MHz
Clock pulse width[3]	t_{PW}	6.25	—	—	ns

7.15 External Crystal or Resonator Requirement

Table 31. Crystal or Resonator Requirement

Characteristic	Symbol	Min	Typ	Max	Unit
Frequency of operation	f_{XOSC}	4	8	16	MHz

7.16 Relaxation Oscillator Timing

Table 32. Relaxation Oscillator Timing

Characteristic	Symbol	Minimum	Typical	Maximum	Unit
Relaxation oscillator output frequency[1] Normal Mode Standby Mode	f_{op}	—	 8.05 400	—	 MHz kHz
Relaxation oscillator stabilization time[2]	t_{roscs}	—	1	3	ms
Cycle-to-cycle jitter. This is measured on the CLKO signal (programmed prescaler_clock) over 264 clocks[3]	$t_{jitterrosc}$	—	400	—	ps
Variation over temperature –40°C to 150°C[4]		—	+1.5 to –1.5	+3.0 to –3.0	%
Variation over temperature 0°C to 105°C[4]		—	0 to +1	+2.0 to –2.0	%

1 Output frequency after factory trim.

2 This is the time required from standby to normal mode transition.

3 J_A is required to meet QSCI requirements.

4 See Figure 18.

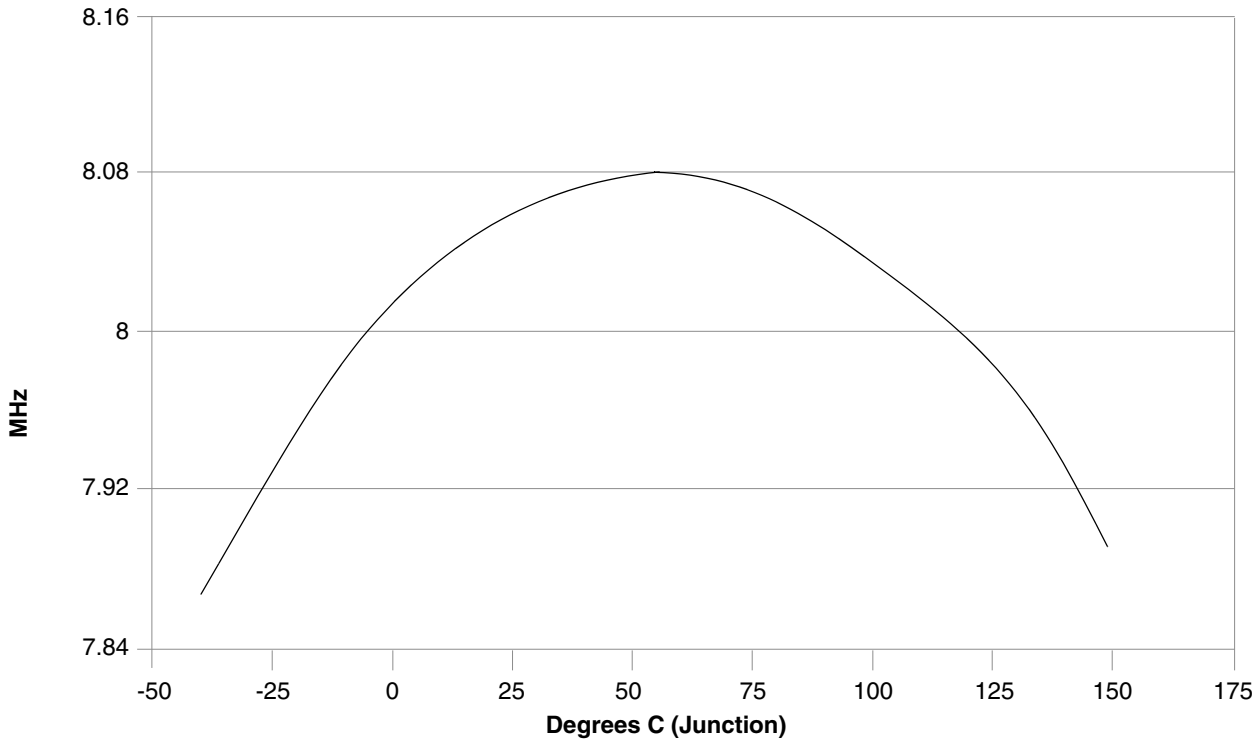


Figure 18. Relaxation Oscillator Temperature Variation (Typical) After Trim

B, the internal [state-dependent] component, reflects the supply current required by certain on-chip resources only when those resources are in use. These resources include RAM, flash memory, and the ADCs.

C, the internal [dynamic] component, is classic $C*V^2*F$ CMOS power dissipation corresponding to the 56800E core and standard cell logic.

D, the external [dynamic] component, reflects power dissipated on-chip as a result of capacitive loading on the external pins of the chip. This component is also commonly described as $C*V^2*F$, although simulations on two of the I/O cell types used on the 56800E reveal that the power-versus-load curve does have a non-zero Y-intercept.

Table 45. I/O Loading Coefficients at 10 MHz

	Intercept	Slope
8 mA drive	1.3	0.11 mW/pF
4 mA drive	1.15 mW	0.11 mW/pF

Power due to capacitive loading on output pins is (first order) a function of the capacitive load and frequency at which the outputs change. Table 45 provides coefficients for calculating power dissipated in the I/O cells as a function of capacitive load. In these cases, Equation 2 applies.

$$TotalPower = \Sigma((Intercept + Slope*C_{load})*frequency/10\ MHz) \qquad Eqn.\ 2$$

where:

— Summation is performed over all output pins with capacitive loads.

— Total power is expressed in mW.

— C_{load} is expressed in pF.

Because of the low duty cycle on most device pins, power dissipation due to capacitive loads was found to be fairly low when averaged over a period of time.

E, the external [static] component, reflects the effects of placing resistive loads on the outputs of the device. Total all V^2/R or IV to arrive at the resistive load contribution to power. Assume V = 0.5 for the purposes of these rough calculations. For instance, if there is a total of nine PWM outputs driving 10 mA into LEDs, then P = 8*0.5*0.01 = 40 mW.

In previous discussions, power consumption due to parasites associated with pure input pins is ignored and assumed to be negligible.

8 Design Considerations

8.1 Thermal Design Considerations

An estimation of the chip junction temperature, T_J, can be obtained from Equation 3.

$$T_J = T_A + (R_{\theta JA} \times P_D) \qquad Eqn.\ 3$$

where:

T_A = Ambient temperature for the package (^oC)

$R_{\theta JA}$ = Junction-to-ambient thermal resistance ($^oC/W$)

P_D = Power dissipation in the package (W)

The junction-to-ambient thermal resistance is an industry-standard value that provides a quick and easy estimation of thermal performance. Unfortunately, there are two values in common usage: the value determined on a single-layer board and the value obtained on a board with two planes. For packages such as the PBGA, these values can be different by a factor of two. Which

value is closer to the application depends on the power dissipated by other components on the board. The value obtained on a single layer board is appropriate for the tightly packed printed circuit board. The value obtained on the board with the internal planes is usually appropriate if the board has low-power dissipation and the components are well separated.

When a heat sink is used, the thermal resistance is expressed as the sum of a junction-to-case thermal resistance and a case-to-ambient thermal resistance.

$$R_{\theta JA} = R_{\theta JC} + R_{\theta CA} \qquad \textit{Eqn. 4}$$

where:

$R_{\theta JA}$ = Package junction-to-ambient thermal resistance (°C/W)

$R_{\theta JC}$ = Package junction-to-case thermal resistance (°C/W)

$R_{\theta CA}$ = Package case-to-ambient thermal resistance (°C/W)

$R_{\theta JC}$ is device related and cannot be adjusted. You control the thermal environment to change the case to ambient thermal resistance, $R_{\theta CA}$. For instance, you can change the size of the heat sink, the air flow around the device, the interface material, the mounting arrangement on printed circuit board, or the thermal dissipation on the printed circuit board surrounding the device.

To determine the junction temperature of the device in the application when heat sinks are not used, the thermal characterization parameter (Ψ_{JT}) can be used to determine the junction temperature with a measurement of the temperature at the top center of the package case. Refer to Equation 5.

$$T_J = T_T + (\Psi_{JT} \times P_D) \qquad \textit{Eqn. 5}$$

where:

T_T = Thermocouple temperature on top of package (^oC)

Ψ_{JT} = Thermal characterization parameter ($^oC/W$)

P_D = Power dissipation in package (W)

The thermal characterization parameter is measured per JESD51–2 specification using a 40-gauge type T thermocouple epoxied to the top center of the package case. The thermocouple should be positioned so that the thermocouple junction rests on the package. A small amount of epoxy is placed over the thermocouple junction and over about 1 mm of wire extending from the junction. The thermocouple wire is placed flat against the package case to avoid measurement errors caused by cooling effects of the thermocouple wire.

When heat sink is used, the junction temperature is determined from a thermocouple inserted at the interface between the case of the package and the interface material. A clearance slot or hole is normally required in the heat sink. Minimizing the size of the clearance is important to minimize the change in thermal performance caused by removing part of the thermal interface to the heat sink. Because of the experimental difficulties with this technique, many engineers measure the heat sink temperature and then back-calculate the case temperature using a separate measurement of the thermal resistance of the interface. From this case temperature, the junction temperature is determined from the junction-to-case thermal resistance.

8.2 Electrical Design Considerations

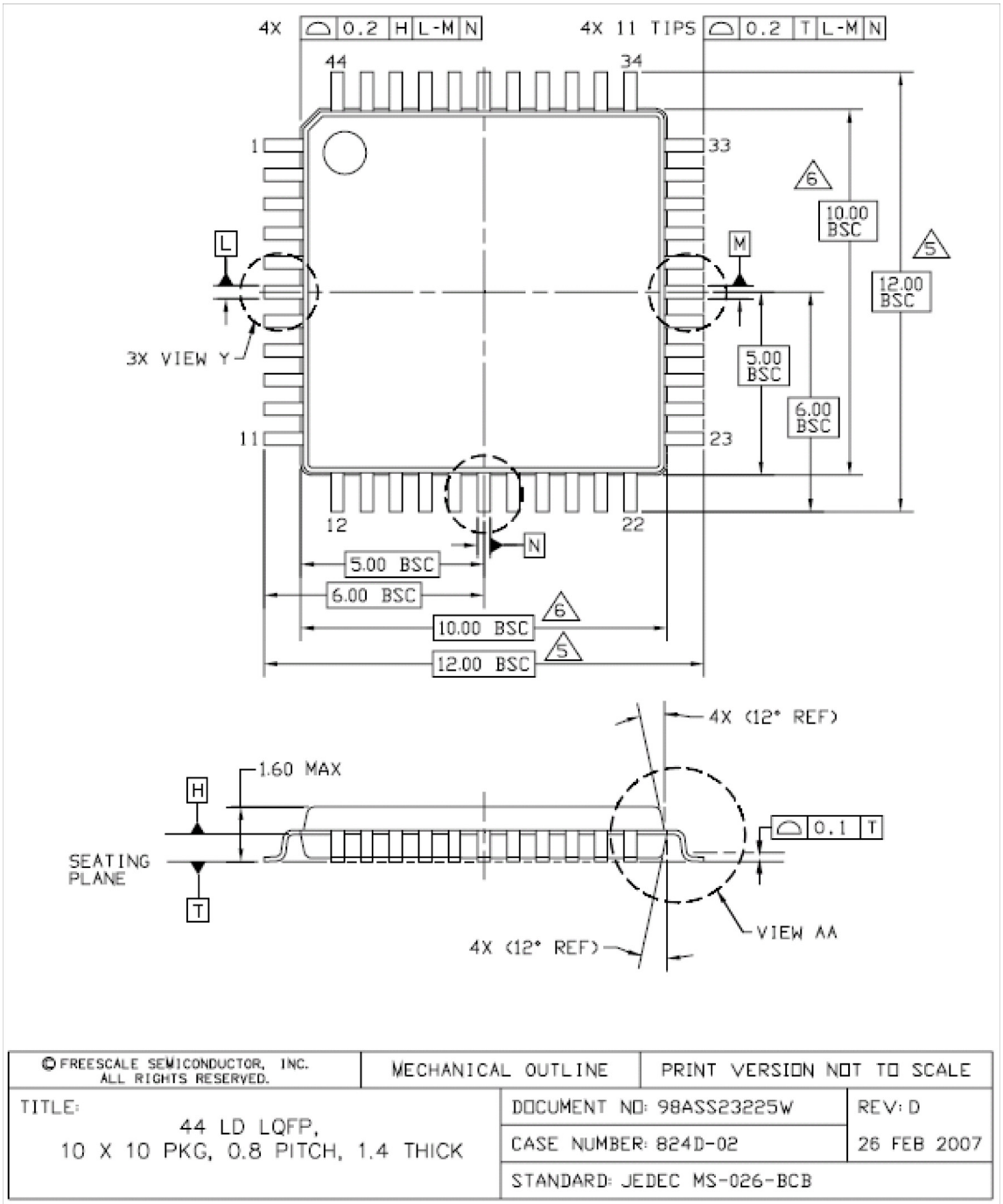
CAUTION

This device contains protective circuitry to guard against damage due to high static voltage or electrical fields. However, take normal precautions 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 voltage level.

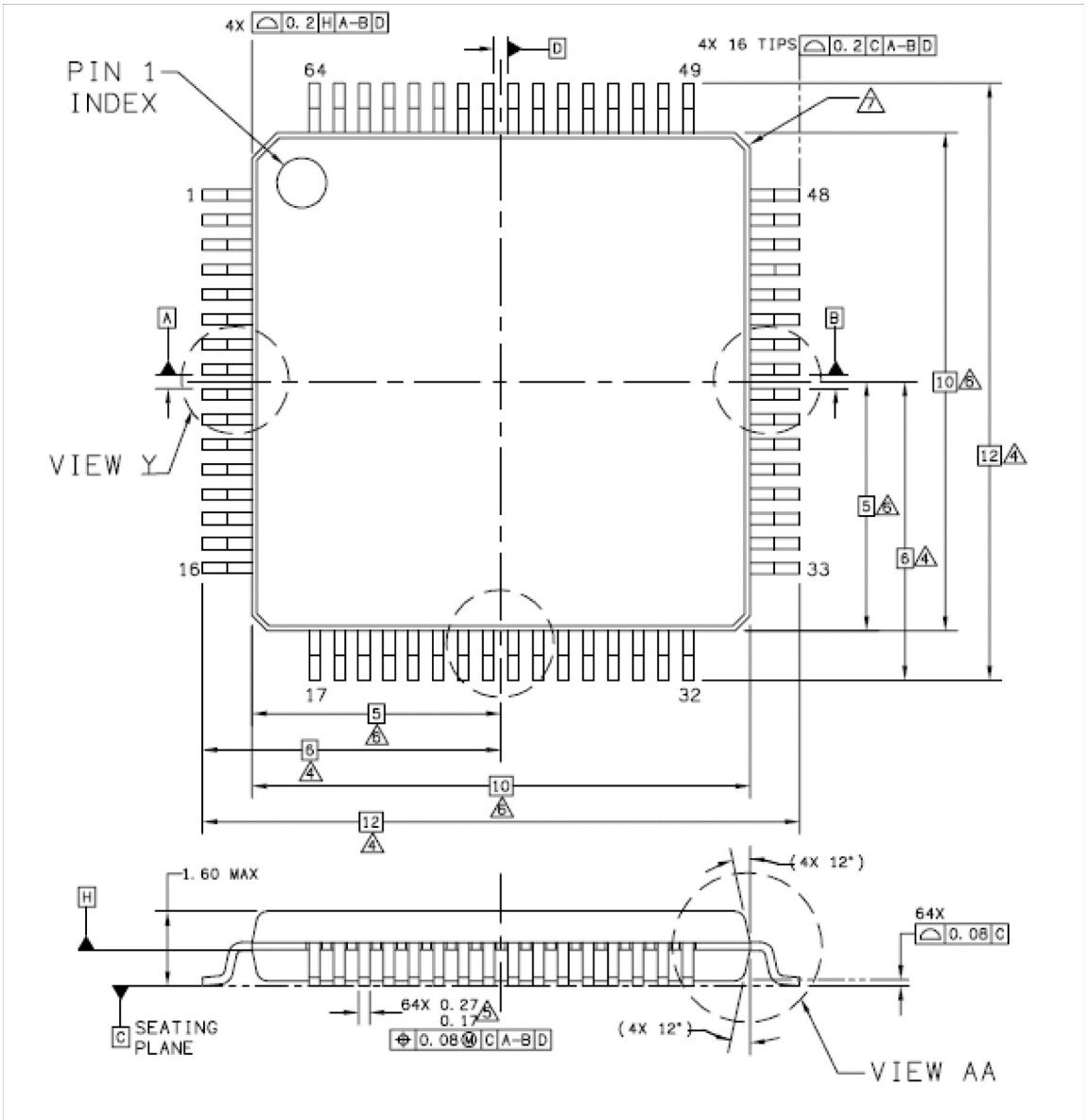
10 Package Mechanical Outline Drawings

To ensure you have the latest version of a package drawing, go to www.freescale.com and perform a keyword search for the drawing's document number (shown in the following sections for each package).

10.1 44-pin LQFP



10.3 64-pin LQFP



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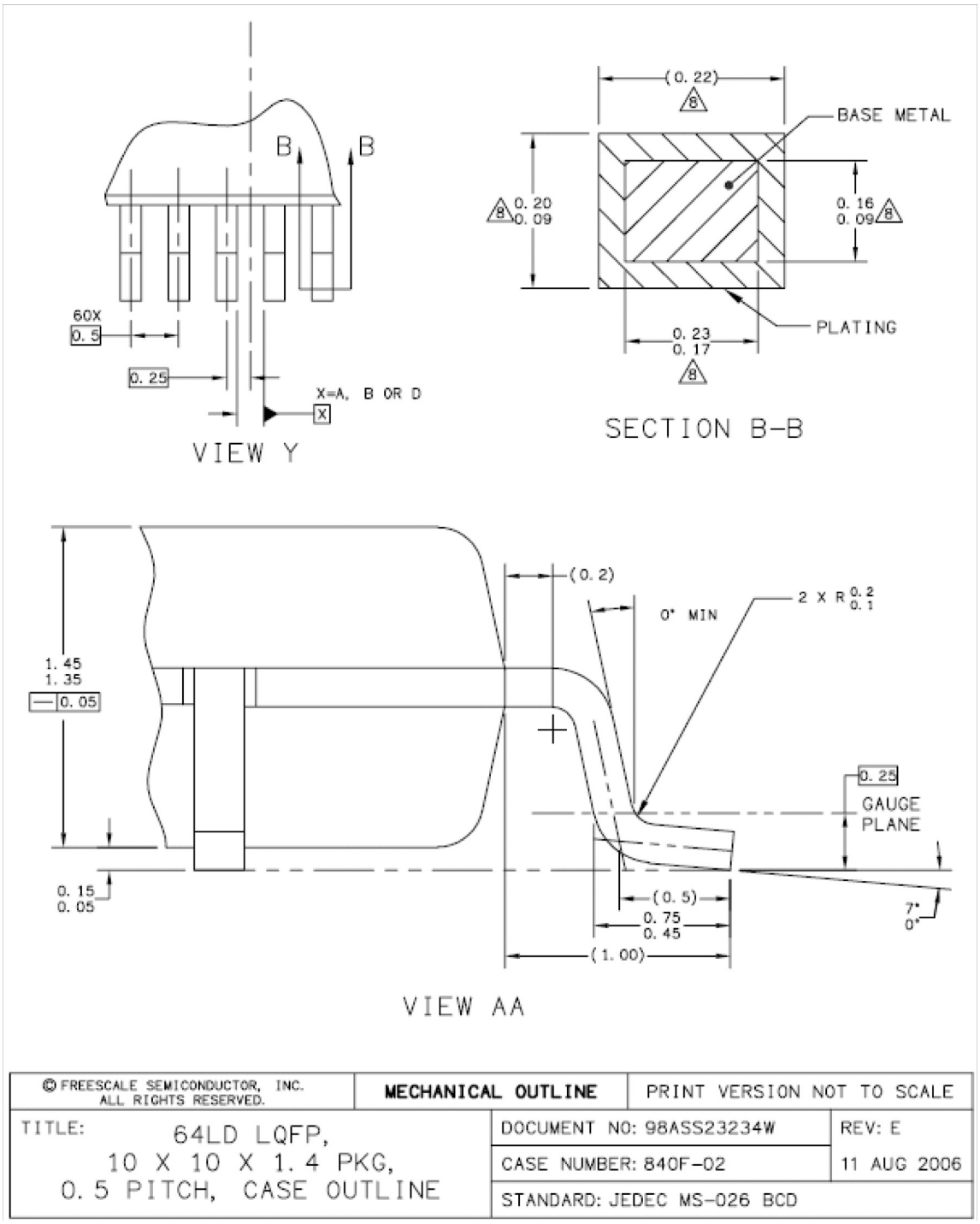
TITLE: 64LD LQFP, 10 X 10 X 1.4 PKG, 0.5 PITCH, CASE OUTLINE	DOCUMENT NO: 98ASS23234W	REV: E
	CASE NUMBER: 840F-02	11 AUG 2006
	STANDARD: JEDEC MS-026 BCD	



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TITLE: 64LD LQFP, 10 X 10 X 1.4 PKG, 0.5 PITCH, CASE OUTLINE	DOCUMENT NO: 98ASS23234W	REV: E
	CASE NUMBER: 840F-02	11 AUG 2006
	STANDARD: JEDEC MS-026 BCD	

Table 48. Interrupt Vector Table Contents[1] (continued)

Peripheral	Vector Number	Priority Level	Vector Base Address +	Interrupt Function
CAN	25	0 - 2	P:0x32	CAN Error Interrupt
CAN	26	0 - 2	P:0x34	CAN Wake-Up Interrupt
QSCI1	27	0 - 2	P:0x36	QSCI1 Receiver Overrun/Errors
QSCI1	28	0 - 2	P:0x38	QSCI1 Receiver Full
QSCI1	29	0 - 2	P:0x3A	QSCI1 Transmitter Idle
QSCI1	30	0 - 2	P:0x3C	QSCI1 Transmitter Empty
QSCI0	31	0 - 2	P:0x3E	QSCI0 Receiver Overrun/Errors
QSCI0	32	0 - 2	P:0x40	QSCI0 Receiver Full
QSCI0	33	0 - 2	P:0x42	QSCI0 Transmitter Idle
QSCI0	34	0 - 2	P:0x44	QSCI0 Transmitter Empty
QSPI	35	0 - 2	P:0x46	SPI Transmitter Empty
QSPI	36	0 - 2	P:0x48	SPI Receiver Full
I^2C1	37	0 - 2	P:0x4A	I^2C1 Interrupt
I^2C0	38	0 -2	P:0x4C	I^2C0 Interrupt
TMRA3	39	0 -2	P:0x4E	Quad Timer A, Channel 3 Interrupt
TMRA2	40	0 -2	P:0x50	Quad Timer A, Channel 2 Interrupt
TMRA1	41	0 -2	P:0x52	Quad Timer A, Channel 1 Interrupt
TMRA0	42	0 -2	P:0x54	Quad Timer A, Channel 0 Interrupt
eFlexPWM	43	0 -2	P:0x56	PWM Fault
eFlexPWM	44	0 -2	P:0x58	PWM Reload Error
eFlexPWM	45	0 -2	P:0x5A	PWM Sub-Module 3 Reload
eFlexPWM	46	0 -2	P:0x5C	PWM Sub-Module 3 input capture
eFlexPWM	47	0 -2	P:0x5E	PWM Sub-Module 3 Compare
eFlexPWM	48	0 -2	P:0x60	PWM Sub-Module 2 Reload
eFlexPWM	49	0 -2	P:0x62	PWM Sub-Module 2 Compare
eFlexPWM	50	0 -2	P:0x64	PWM Sub-Module 1 Reload
eFlexPWM	51	0 -2	P:0x66	PWM Sub-Module 1 Compare
eFlexPWM	52	0 -2	P:0x68	PWM Sub-Module 0 Reload
eFlexPWM	53	0 -2	P:0x6A	PWM Sub-Module 0Compare
FM	54	0 -2	P:0x6C	Flash Memory Access Error
FM	55	0 -2	P:0x6E	Flash Memory Programming Command Complete
FM	56	0 -2	P:0x70	Flash Memory Buffer Empty Request
CMPC	57	0 - 2	P:0x72	Comparator C Rising/Falling Flag
CMPB	58	0 - 2	P:0x74	Comparator B Rising/Falling Flag