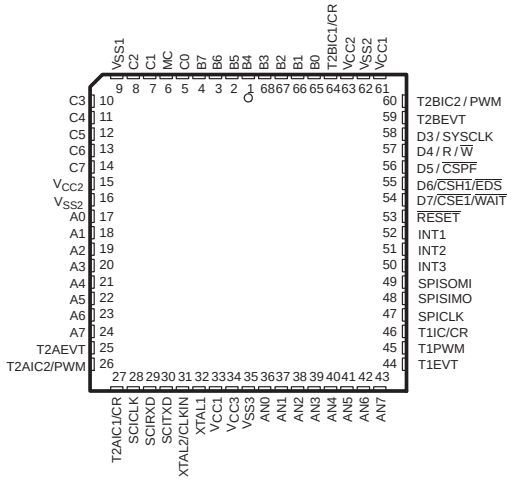
SPNS033C – SEPTEMBER 1995 – REVISED FEBRUARY 1997

- **CMOS/EEPROM/EPROM Technologies on a Single Device**
  - **Mask-ROM Devices for High-Volume Production**
  - **One-Time-Programmable (OTP) EPROM Devices for Low-Volume Production**
  - **Reprogrammable EPROM Devices for Prototyping Purposes**
- **Internal System Memory Configurations**
  - **On-Chip Program Memory Versions**
    - **ROM: 24K, 32K, or 48K Bytes**
    - **EPROM: 32K or 48K Bytes**
  - **Data EEPROM: 256 Bytes**
  - **Static RAM: 1K or 3.5K Bytes**
  - **External Memory/Peripheral Wait States**
  - **Precoded External Chip-Select Outputs in Microcomputer Mode**
- **Flexible Operating Features**
  - **Low-Power Modes: STANDBY and HALT**
  - **Commercial, Industrial, and Automotive Temperature Ranges**
  - **Clock Options**
    - **Divide-by-4 (0.5 MHz – 5 MHz SYSCLK)**
    - **Divide-by-1 (2 MHz – 5 MHz SYSCLK) PLL**
  - **Supply Voltage (V_{CC}): 5 V ± 10%**
- **Eight-Channel 8-Bit Analog-to-Digital Converter 1 (ADC1)**
- **Three 16-Bit General Purpose Timers**
  - **Software Configurable as Three 16-Bit Event Counters, or Three 16-Bit Pulse Accumulators, or Five 16-Bit Input Capture Functions, or Six Compare Registers, or Three Self-Contained PWM Functions**
  - **One Timer Has an 8-Bit Prescaler, Providing a 24-Bit Real-Time Timer**
- **On-Chip 24-Bit Watchdog Timer**
  - **EPROM/OTP: Standard Watchdog**
  - **Mask-ROM Devices: Hard Watchdog, Simple Counter, or Standard Watchdog**
- **Serial Communications Interface (SCI1)**
  - **Asynchronous and Isosynchronous† Modes**
  - **Full Duplex, Double-Buffered RX and TX**
  - **Two Multiprocessor Communication Formats**

FN/FZ PACKAGE
(TOP VIEW)



- **Serial Peripheral Interface (SPI)**
  - **Variable-Length High-Speed Shift Register**
  - **Synchronous Master/Slave Operation**
- **Flexible Interrupt Handling**
  - **Two S/W Programmable Interrupt Levels**
  - **Global- and Individual-Interrupt Masking**
  - **Programmable Rising- or Falling-Edge Detect**
- **TMS370 Series Compatibility**
  - **Register-to-Register Architecture**
  - **256 General-Purpose Registers**
  - **14 Powerful Addressing Modes**
  - **Instructions Upwardly Compatible With All TMS370 Devices**
- **CMOS/Package/TTL-Compatible I/O Pins**
  - **46 Bidirectional Pins, 9 Input Pins**
  - **68-Pin Plastic and Ceramic Leaded Chip Carrier Packages**
  - **All Peripheral Function Pins Are Software Configurable for Digital I/O**
- **Workstation/PC-Based Development System**
  - **C Compiler and C Source Debugger**
  - **Real-Time In-Circuit Emulation**
  - **Extensive Breakpoint/Trace Capability**
  - **Software Performance Analysis**
  - **Multi-Window User Interface**
  - **Microcontroller Programmer**

† Isosynchronous = Isochronous

Pin Descriptions

PIN			I/O†	DESCRIPTION‡
NAME	ALTERNATE FUNCTION	PLCC (68)		
A0 A1 A2 A3 A4 A5 A6 A7	DATA0 DATA1 DATA2 DATA3 DATA4 DATA5 DATA6 DATA7	17 18 19 20 21 22 23 24	I/O	Single-chip mode: Port A is a general-purpose bidirectional I/O port. Expansion mode: Port A can be individually programmed as the external bidirectional data bus (DATA0–DATA7).
B0 B1 B2 B3 B4 B5 B6 B7	ADDR0 ADDR1 ADDR2 ADDR3 ADDR4 ADDR5 ADDR6 ADDR7	65 66 67 68 1 2 3 4	I/O	Single-chip mode: Port B is a general-purpose bidirectional I/O port. Expansion mode: Port B can be individually programmed as the low-order address output bus (ADDR0–ADDR7).
C0 C1 C2 C3 C4 C5 C6 C7	ADDR8 ADDR9 ADDR10 ADDR11 ADDR12 ADDR13 ADDR14 ADDR15	5 7 8 10 11 12 13 14	I/O	Single-chip mode: Port C is a general-purpose bidirectional I/O port. Expansion mode: Port C can be individually programmed as the high-order address output bus (ADDR8–ADDR15).
INT1 INT2 INT3	NMI — —	52 51 50	I I/O I/O	External (nonmaskable or maskable) interrupt/general-purpose input pin External maskable interrupt input/general-purpose bidirectional pin External maskable interrupt input/general-purpose bidirectional pin
AN0 AN1 AN2 AN3 AN4 AN5 AN6 AN7	E0 E1 E2 E3 E4 E5 E6 E7	36 37 38 39 40 41 42 43	I	ADC1 analog input (AN0–AN7) or positive reference pins (AN1–AN7) Port E can be programmed individually as general-purpose input pins if not used as ADC1 analog input or positive reference input.
V_{CC3} V_{SS3}		34 35		ADC1 positive-supply voltage and optional positive-reference input pin ADC1 ground reference input pin
$\overline{\text{RESET}}$		53	I/O	System reset bidirectional pin. $\overline{\text{RESET}}$, as an input, initializes the microcontroller; as open-drain output, $\overline{\text{RESET}}$ indicates an internal failure was detected by the watchdog or oscillator fault circuit.
MC		6	I	Mode control (MC) pin. MC enables EEPROM write-protection override (WPO) mode, also EPROM V_{PP}.
XTAL2/CLKIN XTAL1		31 32	I O	Internal oscillator crystal input / external clock source input Internal oscillator output for crystal
V_{CC1}		33, 61		Positive supply voltage
V_{CC2}		15, 63		Positive supply voltage

† I = input, O = output

‡ Ports A, B, C, and D can be configured only as general-purpose I/O pins. Also, port D3 can be configured as SYSCLK.

Pin Descriptions (Continued)

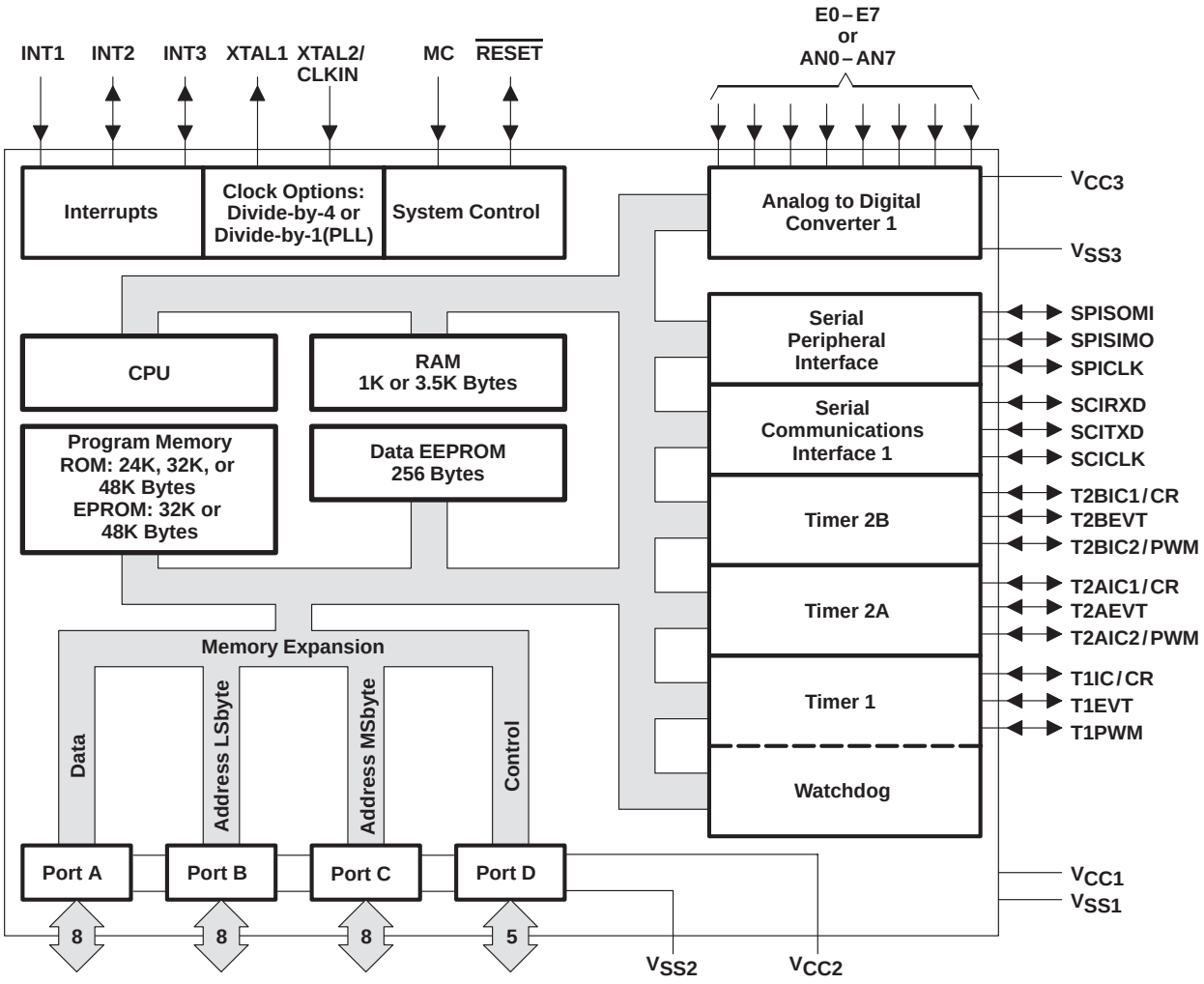
PIN				I/O†	DESCRIPTION‡
NAME	ALTERNATE FUNCTION		PLCC (68)		
V_{SS1}			9		Ground reference for digital logic
V_{SS2}			16,62		Ground reference for digital I/O logic
	FUNCTION			I/O	Single-chip mode: Port D is a general-purpose bidirectional I/O port. Each of the port D pins can be configured individually as a general-purpose I/O pin, primary memory control signal (function A), or secondary memory control signal (function B). All chip selects are independent and can be used for memory-bank switching. See Table 1 for function A memory accesses.
	A	B			
D3	SYSCLK	SYSCLK	58		I/O pin A, B: Internal clock signal is 1/1 (PLL) or 1/4 XTAL2/CLKIN frequency
D4	R/$\overline{W}$	R/$\overline{W}$	57		I/O pin A, B: Read/write output pin
D5	$\overline{CSPF}$	—	56		I/O pin A: Chip select peripheral output for peripheral file goes low during memory accesses I/O pin B: Reserved
D6	$\overline{CSH1}$	$\overline{EDS}$	55		I/O pin A: Chip select half output 1 goes low during memory accesses I/O pin B: External data strobe output goes low during memory accesses from external memory and has the same timings as the five chip selects.
D7	$\overline{CSE1}$	$\overline{WAIT}$	54		I/O pin A: Chip select eighth output goes low during memory accesses. I/O pin B: Wait-input pin extends bus signals.
SCITXD	SCIIO1		30	I/O	SCI transmit data output pin/general-purpose bidirectional pin§
SCIRXD	SCIIO2		29		SCI receive data input pin/general-purpose bidirectional pin
SCICLK	SCIIO3		28		SCI bidirectional serial clock pin/general-purpose bidirectional pin
T1IC/CR	T1IO1		46	I/O	Timer1 input capture/counter reset input pin/general-purpose bidirectional pin
T1PWM	T1IO2		45		Timer1 pulse width modulation (PWM) output pin/general-purpose bidirectional pin
T1EVT	T1IO3		44		Timer1 external event input pin/general-purpose bidirectional pin
T2AIC1/CR	T2AIO1		27	I/O	Timer2A input capture 1/counter-reset input pin/general-purpose bidirectional pin
T2AIC2/PWM	T2AIO2		26		Timer2A input capture 2/PWM output pin/general-purpose bidirectional pin
T2AEVT	T2AIO3		25		Timer2A external event input pin/general-purpose bidirectional pin
T2BIC1/CR	T2BIO1		64	I/O	Timer2B input capture 1/counter-reset input pin/general-purpose bidirectional pin
T2BIC2/PWM	T2BIO2		60		Timer2B input capture 2/PWM output pin/general-purpose bidirectional pin
T2BEVT	T2BIO3		59		Timer2B external event input pin/general-purpose bidirectional pin
SPISOMI	SPIIO1		49	I/O	SPI slave output pin, master input pin/general-purpose bidirectional pin
SPISIMO	SPIIO2		48		SPI slave input pin, master output pin/general-purpose bidirectional pin
SPICLK	SPIIO3		47		SPI bidirectional serial clock pin/general-purpose bidirectional pin

† I = input, O = output
‡ Ports A, B, C, and D can be configured only as general-purpose I/O pins. Port D3 also can be configured as SYSCLK.
§ The three-pin configuration SCI is referred to as SCI1.

Table 1. Function A Memory-Access Locations for ‘x6x Devices

FUNCTION A	’X67	‘X68	‘X69
$\overline{CSE1}$	A000h – BFFFh (8K bytes)	A000h – BFFFh (8K bytes)	E000h – EFFFh (4K bytes)
$\overline{CSH1}$	C000h – FFFFh (16K bytes)	C000h – FFFFh (16K bytes)	F000h – FFFFh (4K bytes)
$\overline{CSPF}$	10C0h – 10FFh (64 bytes)	10C0h – 10FFh (64 bytes)	10C0h – 10FFh (64 bytes)

functional block diagram



description

The TMS370C067, TMS370C068, TMS370C069, TMS370C768, TMS370C769, SE370C768, and SE370C769 devices are members of the TMS370 family of single-chip 8-bit microcontrollers. Unless otherwise noted, the term TMS370Cx6x refers to these devices. The TMS370 family provides cost-effective real-time control through integration of advanced peripheral function modules and various on-chip memory configurations.

The TMS370Cx6x family of devices is implemented using high-performance silicon-gate CMOS EPROM and EEPROM technologies. The low-operating power, wide-operating temperature range, and noise immunity of CMOS technology, coupled with the high performance and extensive on-chip peripheral functions, make the TMS370Cx6x devices attractive in system designs for automotive electronics, industrial motor control, computer peripheral control, telecommunications, and consumer application.

All TMS370Cx6x devices contain the following on-chip peripheral modules:

- 8-channel, 8-bit analog-to-digital converter 1 (ADC1)
- Serial communications interface 1 (SCI1)
- Serial peripheral interface (SPI)

description (continued)

- One 24-bit general-purpose watchdog timer
- Three 16-bit general-purpose timers (one with an 8-bit prescaler)

Table 2 provides a memory configuration overview of the TMS370Cx6x devices.

Table 2. Memory Configurations

DEVICE	PROGRAM MEMORY (BYTES)		OFF-CHIP MEMORY EXP. (BYTES)	DATA MEMORY (BYTES)		OPERATING MODES		PACKAGES 68-PIN PLCC/CLCC
	ROM	EPROM		RAM	EEPROM	μC†	μP†	
TMS370C067A	24K	—	24K	1K	256	√	√	FN – PLCC
TMS370C068A	32K	—	24K	1K	256	√	√	FN – PLCC
TMS370C069A	48K‡	—	8K	3.5K	256	√	√	FN – PLCC
TMS370C768A	—	32K	24K	1K	256	√	√	FN – PLCC
TMS370C769A	—	48K‡	8K	3.5K	256	√	√	FN – PLCC
SE370C768A§	—	32K	24K	1K	256	√	√	FZ – CLCC
SE370C769A§	—	48K‡	8K	3.5K	256	√	√	FZ – CLCC

† μC – Microcomputer mode
μP – Microprocessor mode
‡ 'x69 can only operate up to 3 MHz SYSCLK.
§ System evaluators and development tools are for use only in a prototype environment, and their reliability has not been characterized.

The suffix letter (A) appended to the device names shown in the device column of Table 2 indicates the configuration of the device. ROM or EPROM devices have different configurations as indicated in Table 3. ROM devices with the suffix letter A are configured through a programmable contact during manufacture.

Table 3. Suffix Letter Configuration

DEVICE¶	WATCHDOG TIMER	CLOCK	LOW-POWER MODE
EPROM A	Standard	Divide-by-4 (Standard oscillator)	Enabled
ROM A	Standard	Divide-by-4 or Divide-by-1 (PLL)	Enabled or disabled
	Hard		
	Simple		

¶ Refer to the "device numbering conventions" section for device nomenclature and the "device part numbers" section for ordering.

The mask-programmable ROM in the associated TMS370C06x devices is replaced in the TMS370C76x with 32K or 48K bytes of EPROM while all the other available memory and on-chip peripherals are identical. One-time-programmable (OTP) (TMS370C768 and TMS370C769) and reprogrammable devices (SE370C768 and SE370C769) are available.

TMS370C768 and TMS370C769 are OTP devices that are available in plastic packages. This microcomputer is effective to use for immediate production updates for other members of the TMS370Cx6x family or for low-volume production runs when the mask charge or cycle time for low-cost mask-ROM devices is not practical.

The SE370C768 and SE370C769 have windowed ceramic packages to allow reprogramming of the program EPROM memory during the development/prototyping phase of design. The SE370C768 and SE370C769 devices allow quick updates to breadboards and prototype systems while iterating initial designs.

description (continued)

The TMS370Cx6x family provides two low-power modes (STANDBY and HALT) for applications where low-power consumption is critical. Both modes stop all central processing unit (CPU) activity (i.e., no instructions are executed). In the STANDBY mode, the internal oscillator and the general-purpose timer remain active. In the HALT mode, all device activity is stopped. The device retains all RAM data and peripheral configuration bits throughout both low-power modes.

The TMS370Cx6x features advanced register-to-register architecture that allows direct arithmetic and logical operations without requiring an accumulator (for example, ADD R24, R47; add the contents of register 24 to the contents of register 47 and store the result in register 47). The TMS370Cx6x family is fully instruction-set compatible, allowing easy transition between members of the TMS370 8-bit microcontroller family.

The SPI and the two operational modes of the SCI1 allow three methods of serial communications. The SCI1 allows standard RS-232-C communications interface between other common data transmission equipment, while the SPI gives high-speed communications between simpler shift-register type devices, such as display drivers, ADC1, phase-locked loop (PLL), I/O expansion, or other microcontrollers in the system.

For large memory applications, the TMS370Cx6x family provides an external bus with non-multiplexed address and data. Precoded memory chip-select outputs can be enabled, which allows minimum-chip-count system implementations. Wait-state support facilitates performance matching among the CPU, external memory, and the peripherals. All pins associated with memory expansion interface are individually software configurable for general purpose digital input/output (I/O) pins when operating in the microcomputer mode.

The TMS370Cx6x family provides the system designer with an economical, efficient solution to real-time control applications. The TMS370 family compact development tool (CDT™) solves the challenge of efficiently developing the software and hardware required to design the TMS370Cx6x into an ever-increasing number of complex applications. The application source code can be written in assembly and C language, and the output code can be generated by the linker. The TMS370 family CDT development tool can communicate through a standard RS-232-C interface with an existing personal computer. This allows the use of the personal computer editors and software utilities already familiar to the designer. The TMS370 family CDT emphasizes extensive use of menus and screen windowing so that a system designer with minimal training can begin developing software. Precise real-time in-circuit emulation and extensive symbolic debug and analysis tools ensure efficient software and hardware implementation as well as reduced time-to-market cycle.

The TMS370Cx6x family together with the TMS370 family CDT370, starter kit, software tools, the SE370C76x reprogrammable devices, comprehensive product documentation, and customer support provide a complete solution to the needs of the system designer.

modes

The TMS370Cx6x has four operating modes, two basic modes with each mode having two memory configurations. The basic operating modes are the microcomputer and microprocessor modes, which are selected by the voltage level applied to the dedicated MC pin two cycles before $\overline{\text{RESET}}$ goes inactive. The two memory configurations then are selected through software programming of the internal system configuration registers. The four operating modes are the microcomputer single chip, microcomputer with external expansion, microprocessor without internal program memory, and microprocessor with internal program memory. These modes are described in the following list.

- Microcomputer single chip mode:
  - Operates as a self-contained microcomputer with all memory and peripherals on-chip
  - Maximizes the general-purpose I/O capability for real-time control applications
- Microcomputer with external expansion mode:
  - Supports bus expansion to external memory or peripherals, while all on-chip memory (RAM, ROM, EPROM, and data EEPROM) remains active
  - Configures digital I/O ports (ports A, B, C, and D) through software, under control of the associated port control, to become external memory as follows:
    - Port A: 8-bit data memory
    - Port B and Port C: 16-bit address memory
    - Port D: 5-bit control memory (pin not used as function A or B can be configured as I/O)
  - Utilizes the pins available (not used for address, data, or control memory) as general-purpose input/output by programming them individually
  - Lowers the system cost by not requiring an external address/data latch (address memory and data memory are nonmultiplexed)
  - Reduces external interface decode logic by using the precoded chip select outputs that provide direct memory/peripheral chip select or chip enable functions
  - Function A maps up to 24K bytes of external memory into the address space by using $\overline{\text{CSE1}}$ and $\overline{\text{CSH1}}$ as memory-bank selects under software control.
  - Function B maps up to 24K bytes of external memory into the address space by using $\overline{\text{EDS}}$ under software control.
- Microprocessor without internal program memory mode:
  - Ports A, B, C, and D (these ports are not programmable) become the address, data, and control buses for interface to external memory and peripherals.
  - On-chip RAM and data EEPROM remain active, while the on-chip ROM or EPROM is disabled.
  - Program area and the reset, interrupt, and trap vectors are located in off-chip memory locations.
- Microprocessor with internal program memory mode:
  - Configured as the microprocessor without internal program memory mode with respect to the external bus interface
  - Application program in external memory enables the internal program ROM or EPROM to be active in the system. (Writing a zero to the MEMORY DISABLED control bit (SCCR1.2) of the SCCR1 control register accomplishes this.)

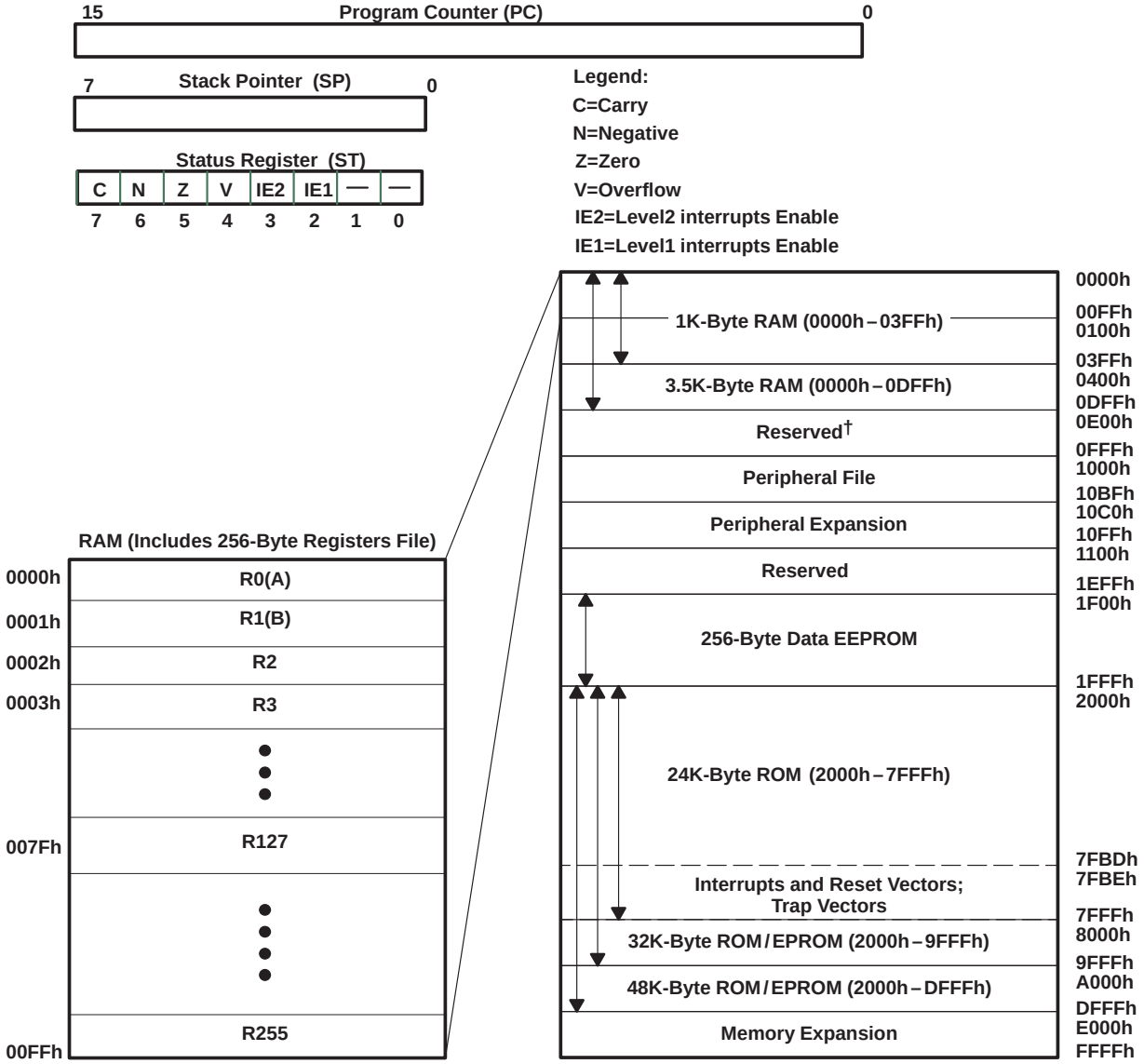
memory/peripheral wait operation

The TMS370Cx6x enhances interface flexibility by providing $\overline{\text{WAIT}}$-state support, decoupling the cycle time of the CPU from the read/write access of the external memory or peripherals. External devices can extend the read/write accesses indefinitely by placing an active low on the $\overline{\text{WAIT}}$ input pin. The CPU continues to wait as long as $\overline{\text{WAIT}}$ remains active.

Programmable automatic wait-state generation also is provided by the TMS370Cx6x on-chip bus controller. Following a hardware reset, the TMS370Cx6x is configured to add one wait state to all external bus transactions and memory and peripheral accesses, thus making every external access a minimum of three system clock cycles. The designer can disable the automatic wait-state generation if the AUTOWAIT DISABLE bit in SCCR1 is set to 1. Also, all accesses to the upper four frames of the peripheral file can be extended independently to four system clock cycles if the PF AUTO WAIT bit in SCCR0 is set to one. Programmable wait states can be used in conjunction with the external $\overline{\text{WAIT}}$ pin. In applications where the external device read/write access can interface with the TMS370Cx6x CPU using one wait state, the automatic wait-state generation can eliminate external $\overline{\text{WAIT}}$ interface logic, lowering system cost.

CPU

The CPU used on TMS370Cx6x devices is the high-performance 8-bit TMS370 CPU module. The ’x6x implements an efficient register-to-register architecture that eliminates the conventional accumulator bottleneck. The complete ’x6x instruction set is summarized in Table 22. Figure 1 illustrates the CPU registers and memory blocks.



† Reserved means the address space is reserved for future expansion.

Figure 1. Programmer’s Model

CPU (continued)

The ’x6x CPU architecture provides the following components:

- CPU registers:
  - A stack pointer that points to the last entry in the memory stack
  - A status register that monitors the operation of the instructions and contains the global-interrupt-enable bits
  - A program counter (PC) that points to the memory location of the next instruction to be executed
- A memory map that includes :
  - 1K- or 3.5K-byte general-purpose RAM that can be used for data-memory storage, program instructions, general-purpose register, or the stack (can be located only in the first 256 bytes)
  - A peripheral file that provides access to all internal peripheral modules, system-wide control functions, and EEPROM/EPROM programming control
  - 256-byte EEPROM module that provides in-circuit programmability and data retention in power-off conditions
  - 24K-, 32K-, or 48K-byte ROM or 32K-, or 48K-byte EPROM program memory

stack pointer (SP)

The SP is an 8-bit CPU register. The stack operates as a last-in, first-out, read/write memory. The stack is used typically to store the return address on subroutine calls as well as the status-register contents during interrupt sequences.

The SP points to the last entry or to the top of the stack. The SP increments automatically before data is pushed onto the stack and decrements after data is popped from the stack. The stack can be located only in the first 256 bytes of the on-chip RAM memory.

status register (ST)

The ST monitors the operation of the instructions and contains the global-interrupt-enable bits. The ST includes four status bits (condition flags) and two interrupt-enable bits:

- The four status bits indicate the outcome of the previous instruction; conditional instructions (for example, the conditional-jump instructions) use these status bits to determine program flow.
- The two interrupt-enable bits control the two interrupt levels.

The ST register, status bit notation, and status bit definitions are shown in Table 4.

Table 4. Status Registers

7	6	5	4	3	2	1	0
C	N	Z	V	IE2	IE1	Reserved	Reserved
RW-0	RW-0	RW-0	RW-0	RW-0	RW-0		

R = read, W = write, 0 = value after reset

CPU (continued)

program counter (PC)

The contents of the PC point to the memory location of the next instruction to be executed. The PC consists of two 8-bit registers in the CPU: the program counter high (PCH) and program counter low (PCL). These registers contain the most-significant byte (MSbyte) and least-significant byte (LSbyte) of a 16-bit address.

The contents of the reset vector (7FFEh, 7FFFh) are loaded into the program counter during reset. The PCH (MSbyte of the PC) is loaded with the contents of memory location 7FFEh, and the PCL (LSbyte of the PC) is loaded with the contents of memory location 7FFFh. Figure 2 shows this operation using an example value of 6000h as the contents of memory locations 7FFEh and 7FFFh (reset vector).

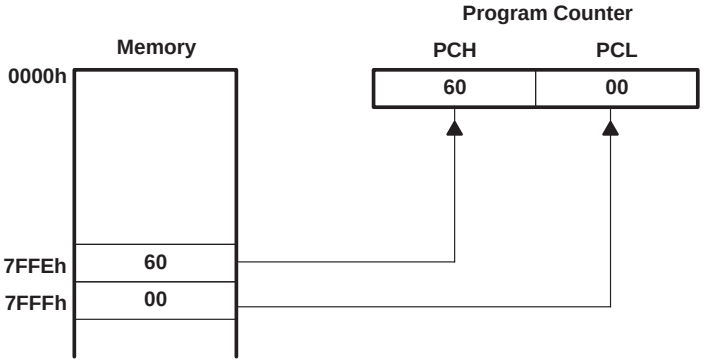


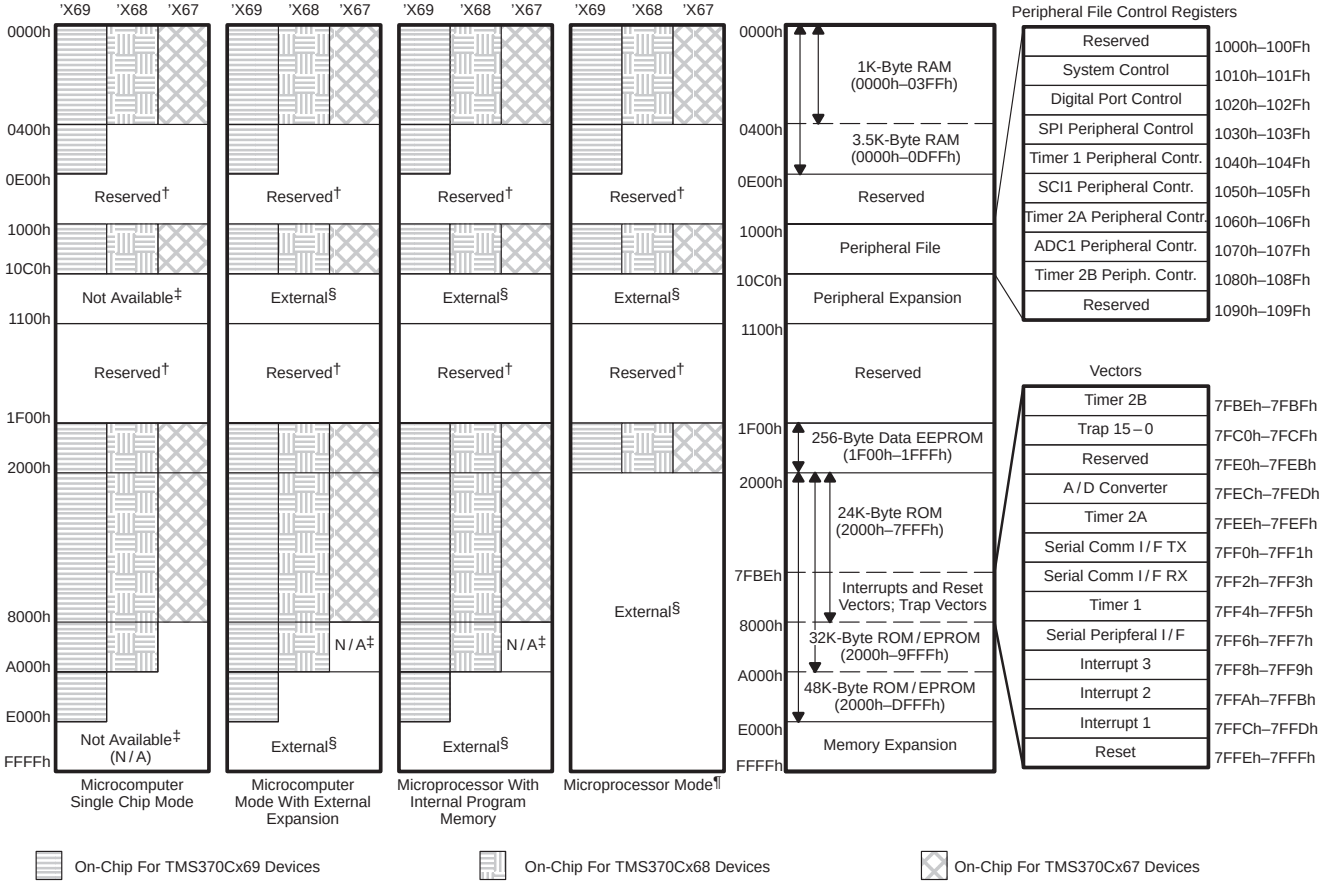
Figure 2. Program Counter After Reset

memory map

The TMS370Cx6x architecture is based on the Von Neuman architecture, where the program memory and data memory share a common address space. All peripheral input/output is memory mapped in this same common address space. In the expansion mode, external memory peripherals are also memory-mapped into this common address. As shown in Figure 3, the TMS370Cx6x provides a 16 bit-address range to access internal or external RAM, ROM, data EEPROM, EPROM input/output pins, peripheral functions, and system-interrupt vectors.

The peripheral file contains all input/output port control, on- and off-chip peripheral status and control, EPROM, EEPROM programming, and system-wide control functions. The peripheral file consists of 256 contiguous addresses located from 1000h to 10FFh. The 256 contiguous addresses are logically divided into 16 peripheral file frames of 16 bytes each. Each on-chip peripheral is assigned to a separate frame through which peripheral control and data information is passed. The TMS370Cx6x has its on-chip peripherals and system control assigned to peripheral file frames 1 through 8, addresses 1010h through 108Fh.

memory map (continued)



† Reserved = the address space is reserved for future expansion.
‡ Not available (N/A) = address space is unavailable in the mode illustrated.
§ Precoded chip select outputs available on external expansion bus.
¶ Microprocessor mode is designed for ROM-less devices. ROM and EPROM devices also can be used in this mode, but all on-chip memory is ignored.

Figure 3. TMS370Cx6x Memory Map

RAM/register file (RF)

Locations within RAM address space can serve as either register file or general-purpose read/write memory, program memory, or stack instructions. The TMS370Cx67 and TMS370Cx68 devices contain 1K bytes of internal RAM, mapped beginning at location 0000h and continuing through location 03FFh, which is shown in Table 5 along with 'x69 devices.

Table 5. RAM Memory Map

	'x67 and 'x68	'x69
RAM Size	1K Bytes	3.5K Bytes
Memory Mapped	0000h – 03FFh	0000h – 0DFFh

The first 256 bytes of RAM (0000h – 00FFh) are register files, R0 through R255 (see Figure 1). The first two registers, R0 and R1, are also called register A and B, respectively. Some instructions implicitly use register A or B; for example, the instruction LDSP (load SP) assumes that the value to be loaded into the stack pointer is contained in register B. Registers A and B are the only registers cleared on reset.

peripheral file (PF)

The TMS370Cx6x control registers contain all the registers necessary to operate the system and peripheral modules on the device. The instruction set includes some instructions that access the PF directly. These instructions designate the register by the number of the PF relative to 1000h, preceded by P0 for a hexadecimal designator or by P for a decimal designator. For example, the system control register 0 (SCCR0) is located at address 1010h; its peripheral file hexadecimal designator is P010, and its decimal designator is P16. Table 6 lists the TMS370Cx6x peripheral files.

Table 6. TMS370Cx6x Peripheral File Address Map

ADDRESS RANGE	PERIPHERAL FILE DESIGNATOR	DESCRIPTION
1000h–100Fh	P000–P00F	Reserved for factory test
1010h–101Fh	P010–P01F	System and EEPROM/EPROM control registers
1020h–102Fh	P020–P02F	Digital I/O port control registers
1030h–103Fh	P030–P03F	Serial peripheral interface registers
1040h–104Fh	P040–P04F	Timer 1 registers
1050h–105Fh	P050–P05F	Serial communication interface 1 registers
1060h–106Fh	P060–P06F	Timer 2A registers
1070h–107Fh	P070–P07F	Analog-to-digital converter 1 registers
1080h–108Fh	P080–P08F	Timer 2B registers
1090h–10BFh	P090–P0BF	Reserved
10C0h–10FFh	P0C0–P0FF	External peripheral control

data EEPROM

The TMS370Cx6x devices contain 256 bytes of data EEPROM, and the memory is mapped beginning at location 1F00h and continuing through location 1FFFh.

Writing to the data EEPROM module is controlled by the data-EEPROM control register (DEECTL) and the write-protection register (WPR). Programming algorithm examples are available in the *TMS370 Family User's Guide* (literature number SPNU127) or the *TMS370 Data Manual* (SPNS014B). The data EEPROM features include the following:

- Programming:
  - Bit, byte, and block write/erase modes

data EEPROM (continued)

- Internal charge pump circuitry. No external EEPROM programming voltage supply is needed.
- Control register: Data EEPROM programming is controlled by the data EEPROM control register (DEECTL) located in the PF frame beginning at location P01A.
- In-circuit programming capability: There is no need to remove the device to program it.

- Write-protection: Writes to the data EEPROM are disabled during the following conditions:
  - Reset: All programming of the data EEPROM module is halted.
  - Write protection active: there is one write-protect bit per 32-byte EEPROM block.
  - Low-power mode operation
- Write protection can be overridden by applying 12 V to MC.

Table 7 shows the memory map of the control registers.

Table 7. Data EEPROM and Program EPROM Control Registers Memory Map

ADDRESS	SYMBOL	NAME†
P014	EPCTLH	Program EPROM control register – high array
P015–P016		Reserved
P017	INT1	External interrupt 1 control register
P018	INT2	External interrupt 2 control register
P019	INT3	External interrupt 3 control register
P01A	DEECTL	Data EEPROM control register
P01B		Reserved
P01C	EPCTLM	Program EPROM control register – middle array
P01D		Reserved
P01E	EPCTLL	Program EPROM control register – low array

† For the 24K- and 32K-byte EPROM device, the program memory is controlled by P01C and P01E; for the 48K-byte EPROM device, the program memory is controlled by P014, P01C, and P01E.

program EPROM

The ‘370C767 program EPROM consists of 24K bytes that are made up of one 16K-byte array and one 8K-byte array of EPROM; the 16K-byte array is located at address locations 2000h through 5FFFh, and the 8K-byte array is located at address locations 6000h through 7FFFh. The ‘370C768 program EPROM consists of 32K bytes that are made up of two 16K-byte arrays of EPROM; the first 16K-byte array is located at address locations 2000h through 5FFFh, and the second 16K-byte array is located at address locations 6000h through 9FFFh. The ’370C769 program EPROM consists of 48K bytes that are made up of three 16K-byte arrays of EPROM; the first 16K-byte array is located at address locations 2000h through 5FFFh, the second 16K-byte array is located at address locations 6000h through 9FFFh, the third 16K-byte array is located at address locations A000h through DFFFh as shown in Table 8.

program EPROM (continued)

Table 8. EPROM Memory Map

	’767		’768		’769		
EPROM size	24K Bytes		32K Bytes		48K Bytes		
Memory mapped	16K 2000h–5FFFh	8K 6000h–7FFFh	First 16K 2000h–5FFFh	Second 16K 6000h–9FFFh	First 16K 2000h–5FFFh	Second 16K 6000h–9FFFh	Third 16K A000h–DFFFh
Contol registers	EPCTLL P01E	EPCTLM P01C	EPCTLL P01E	EPCTLM P01C	EPCTLL P01E	EPCTLM P01C	EPCTLH P014

The EPROM memory map in Table 8 expresses the following:

- For the 24K-byte EPROM, the 16K-byte array is controlled by EPCTLL register, located at 101Eh (P01E); the 8K-byte array is controlled by EPCTLM register, located at 101Ch (P01C).
- For the 32K-byte EPROM, the first 16-byte array is controlled by EPCTLL register, located at 101Eh (P01E); the second 16K-byte array is controlled by EPCTLM register, located at 101Ch (P01C).
- For the 48K-bytes EPROM, the first 16K-byte array is controlled by EPCTLL register, located at 101Eh (P01E); the second 16K-byte array is controlled by EPCTLM register, located at 101Ch (P01C); the third 16K-byte array is controlled by EPCTLH register, located at 1014h (P014).

Reading the program-EPROM modules is identical to reading other internal memory. During programming, the EPROM is controlled by the EPCTL. The program EPROM modules’ features include:

- Programming
  - In-circuit programming capability if V_{PP} is applied to MC
  - Control register: Program EPROM programming is controlled by the program EPROM control registers (EPCTLL, EPCTLM, and EPCTLH) located in the PF frame as shown in Table 7.
  - Programming one EPROM module while executing the other
- Write protection: Writes to the program EPROM are disabled under the following conditions:
  - Reset: All programming to the EPROM module is halted.
  - Low-power modes
  - 13 V not applied to MC

program ROM

The program ROM consists of 24K, 32K or 48K bytes of mask-programmable ROM. The program ROM is used for permanent storage of data or instructions. Programming of the mask ROM is performed at the time of device fabrication. Table 9 shows the program ROM memory map.

Table 9. ROM Memory Map†

	‘067	’068	‘069
ROM Size	24K Bytes	32K Bytes	48K Bytes
Memory Mapped	2000h – 7FFFh	2000h – 9FFFh	2000h – DFFFh

† Memory addresses 7FE0h through 7FEBh are reserved for Texas Instruments Incorporated. Memory addresses 7FBEh through 7FBFh and 7FECh through 7FFFh are reserved for interrupts and reset vectors. Trap vectors, used with TRAP0 through TRAP15 instructions, are located at addresses 7FC0h and 7FCFh.

system reset

The system-reset operation ensures an orderly start-up sequence for the TMS370Cx6x CPU-based device. There are up to three different actions that can cause a system reset to the device. Two of these actions are internally generated, while one ($\overline{\text{RESET}}$) is controlled externally. These actions are as follows:

- Watchdog (WD) timer. A watchdog-generated reset occurs if an improper value is written to the WD key register, or if the re-initialization does not occur before the watchdog timer timeout . See the *TMS370 Family User's Guide* (literature number SPNU127) or the *TMS370 Family Data Manual* (literature number SPNS014B) for more information.
- Oscillator reset. Reset occurs when the oscillator operates outside the recommended operating range. See the *TMS370 Family User's Guide* (literature number SPNU127) or the *TMS370 Family Data Manual* (literature number SPNS014B) for more information.
- External $\overline{\text{RESET}}$ Pin. A low level signal can trigger an external reset. To ensure a reset, the external signal should be held low for one SYSCLK cycle. Signals of less than one SYSCLK can generate a reset. See the *TMS370 Family User's Guide* (literature number SPNU127) or the *TMS370 Family Data Manual* (literature number SPNS014B) for more information.

Once a reset source is activated, the external $\overline{\text{RESET}}$ pin is driven (active) low for a minimum of eight SYSCLK cycles. This allows the 'x6x device to reset external system components. Additionally, if a cold start (V_{CC} is off for several hundred milliseconds) condition or oscillator failure occurs or $\overline{\text{RESET}}$ pin is held low, then the reset logic holds the device in a reset state for as long as these actions are active.

After a reset, the program can check the oscillator fault flag (OSC FLT FLAG, SCCR0.4), the cold start flag (COLD START, SCCR0.7) and the watchdog reset (WD OVRFL INT FLAG, T1CTL2.5) to determine the source of the reset. A reset does not clear these flags. Table 10 lists the reset sources.

Table 10. Reset Sources

REGISTER	ADDRESS	PF	BIT NO.	CONTROL BIT	SOURCE OF RESET
SCCR0	1010h	P010	7	COLD START	Cold (power-up)
SCCR0	1010h	P010	4	OSC FLT FLAG	Oscillator out of range
T1CTL2	104Ah	P04A	5	WD OVRFL INT FLAG	Watchdog timer timeout

Once a reset is activated, the following sequence of events occurs:

1. The CPU registers are initialized: ST = 00h, SP = 01h (reset state).
2. Registers A and B are initialized to 00h (no other RAM is changed).
3. The contents of the LSbyte of the reset vector (07FFh) are read and stored in the PCL.
4. The contents of the MSbyte of the reset vector (07FEh) are read and stored in the PCH.
5. Program execution begins with an opcode fetch from the address pointed to by the PC.

The reset sequence takes 20 SYSCLK cycles from the time the reset pulse is released until the first opcode fetch. During a reset, RAM contents (except for registers A and B) remain unchanged, and the module control register bits are initialized to their reset state. During $\overline{\text{RESET}}$, the two basic operating modes which are the microcomputer and microprocessor modes can be selected by applying the desired voltage level to the dedicated MC pin two cycles before $\overline{\text{RESET}}$ goes inactive. See the mode section for operating modes description.

interrupts

The TMS370 family software programmable interrupt structure permits flexible on-chip and external interrupt configurations to meet real-time interrupt-driven application requirements. The hardware interrupt structure incorporates two priority levels as shown in Figure 4. Interrupt level 1 has a higher priority than interrupt level 2. The two priority levels can be independently masked by the global-interrupt mask bits (IE1 and IE2) of the status register.

Each system interrupt is independently configured to either the high- or low-priority chain by the application program during system initialization. Within each interrupt chain, the interrupt priority is fixed by the position of the system interrupt. However, since each system interrupt is selectively configured on either the high-or-low priority interrupt chain, the application program can elevate any system interrupt to the highest priority. Arbitration between the two priority levels is performed within the CPU. Arbitration within each of the priority chains is performed within the peripheral modules to support interrupt expansion for future modules. Pending interrupts are serviced upon completion of current instruction execution, depending on their interrupt mask and priority conditions.

The TMS370Cx6x has ten hardware system interrupts (plus $\overline{\text{RESET}}$) as shown in Table 11. Each system interrupt has a dedicated vector located in program memory through which control is passed to the interrupt service routines. A system interrupt can have multiple interrupt sources (e.g., SCI RXINT has two interrupt sources). All of the interrupt sources are individually maskable by local interrupt-enable control bits in the associated PF. Each interrupt source FLAG bit is individually readable for software polling or to determine which interrupt source generated the associated system interrupt. Interrupt control block diagram is illustrated in Figure 4.

interrupts (continued)

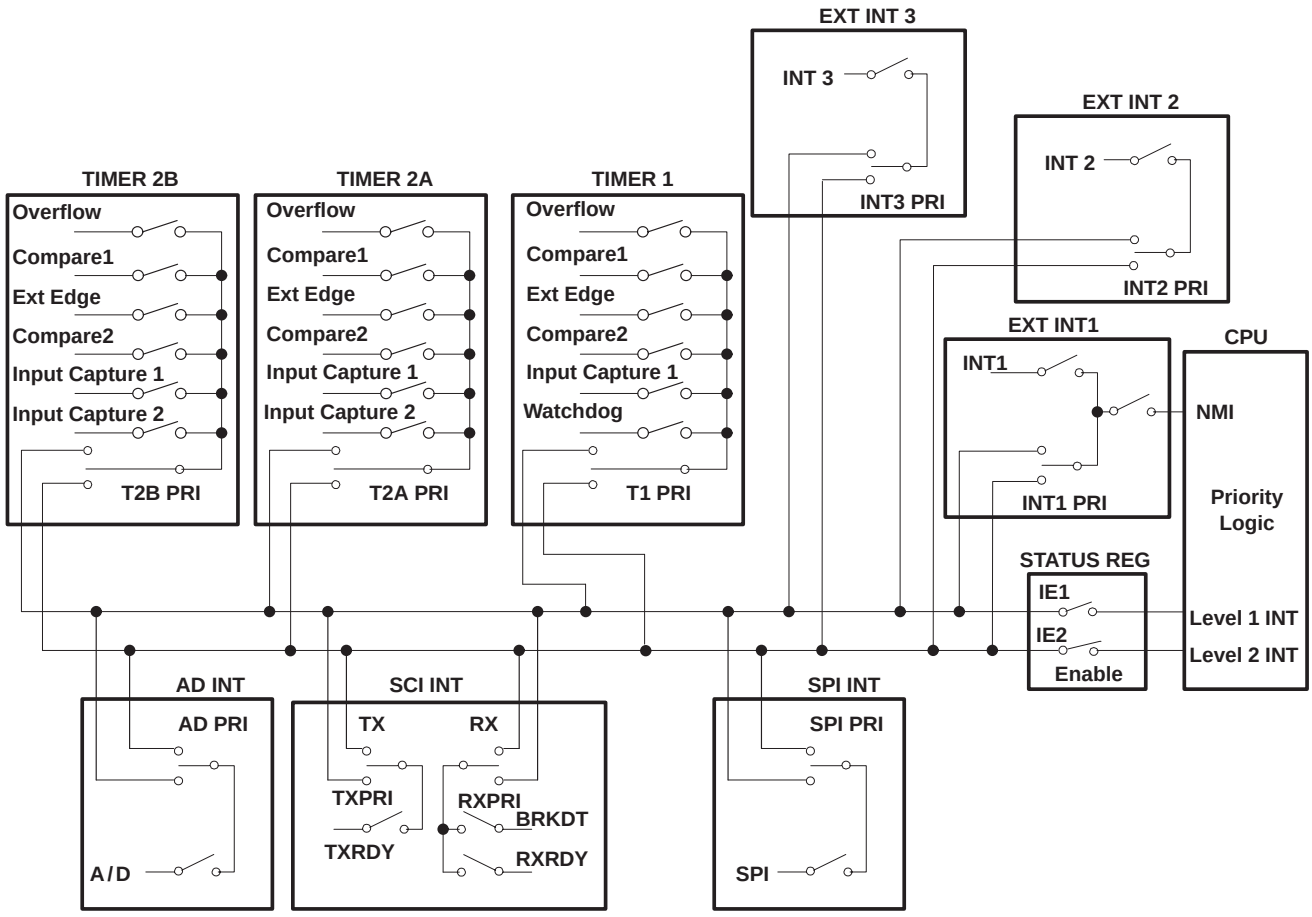


Figure 4. Interrupt Control

Seven of the system interrupts are generated by on-chip peripheral functions, and three external interrupts are supported. Software configuration of the external interrupts is performed through the INT1, INT2, and INT3 control registers in PF frame 1. Each external interrupt is individually software configurable for input polarity (rising or falling edge) for ease of system interface. External interrupt INT1 is software configurable as either a maskable or non-maskable interrupt. When INT1 is configured as nonmaskable, it cannot be masked by the individual- or global-enable-mask bits. Recall that the INT1 NMI bit is protected during non-privileged operation and therefore should be configured during the initialization sequence following reset. To maximize pin flexibility, external interrupts INT2 and INT3 can be software configured as general-purpose input/output pins if the interrupt function is not required (INT1 can be similarly configured as an input pin). Table 11 shows the interrupt-vector sources, corresponding addresses, and hardware priorities.

interrupts (continued)

Table 11. Hardware-System Interrupts

INTERRUPT SOURCE	INTERRUPT FLAG	SYSTEM INTERRUPT	VECTOR ADDRESS	PRIORITY†
External $\overline{\text{RESET}}$ Watchdog overflow Oscillator fault detect	COLD START WD OVRFL INT FLAG OSC FLT FLAG	$\overline{\text{RESET}}$‡	7FFEh, 7FFFh	1
External INT1	INT1 FLAG	INT1‡	7FFCh, 7FFDh	2
External INT2	INT2 FLAG	INT2‡	7FFAh, 7FFBh	3
External INT3	INT3 FLAG	INT3‡	7FF8h, 7FF9h	4
SPI RX/TX complete	SPI INT FLAG	SPIINT	7FF6h, 7FF7h	5
Timer 1 overflow Timer 1 compare 1 Timer 1 compare 2 Timer 1 external edge Timer 1 input capture 1 Watchdog overflow	T1 OVRFL INT FLAG T1C1 INT FLAG T1C2 INT FLAG T1EDGE INT FLAG T1IC1 INT FLAG WD OVRFL INT FLAG	T1INT§	7FF4h, 7FF5h	6
SCI RX data register full SCI RX break detect	RXRDY FLAG BRKDT FLAG	RXINT‡	7FF2h,7FF3h	7
SCI TX data register empty	TXRDY FLAG	TXINT	7FF0h, 7FF1h	8
Timer 2A overflow Timer 2A compare 1 Timer 2A compare 2 Timer 2A external edge Timer 2A input capture 1 Timer 2A input capture 2	T2A OVRFL INT FLAG T2AC1 INT FLAG T2AC2 INT FLAG T2AEDGE INT FLAG T2AIC1 INT FLAG T2AIC2 INT FLAG	T2AINT	7FEEh, 7FEFh	9
ADC1 conversion complete	AD INT FLAG	ADINT	7FECh, 7FEDh	10
Timer 2B overflow Timer 2B compare 1 Timer 2B compare 2 Timer 2B external edge Timer 2B input capture 1 Timer 2B input capture 2	T2B OVRFL INT FLAG T2BC1 INT FLAG T2BC2 INT FLAG T2BEDGE INT FLAG T2BIC1 INT FLAG T2BIC2 INT FLAG	T2BINT	7FBEh, 7FBFh	11

† Relative priority within an interrupt level
‡ Release microcontroller from STANDBY and HALT low-power modes
§ Release microcontroller from STANDBY low-power mode

privileged operation and EEPROM write-protection override

The TMS370Cx6x family has significant flexibility to enable the designer to software-configure the system and peripherals to meet the requirements of a broad variety of applications. The nonprivileged mode of operation ensures the integrity of the system configuration, once it is defined for an application. Following a hardware reset, the TMS370Cx6x operates in the privileged mode, where all peripheral file registers have unrestricted read/write access, and the application program configures the system during the initialization sequence following reset. As the last step of system initialization, the PRIVILEGE DISABLE bit (SCCR2.0) should be set to 1 to enter the nonprivileged mode, disabling write operations to specific configuration control bits within the peripheral file. Table 12 lists the system configuration bits that are write-protected during the nonprivileged mode and must be configured by software prior to exiting the privileged mode.

privileged operation and EEPROM write-protection override (continued)

Table 12. Privileged Bits

REGISTER†		CONTROL BIT
NAME	LOCATION	
SCCRO	P010.5 P010.6	PF AUTOWAIT OSC POWER
SCCR1	P011.2 P011.4	MEMORY DISABLE AUTOWAIT DISABLE
SCCR2	P012.0 P012.1 P012.3 P012.4 P012.6 P012.7	PRIVILEGE DISABLE INT1 NMI CPU STEST BUS STEST PWRDWN/IDLE HALT/STANDBY
SPIPRI	P03F.5 P03F.6 P03F.7	SPI ESPEN SPI PRIORITY SPI STEST
SCIPRI	P05F.4 P05F.5 P05F.6 P05F.7	SCI ESPEN SCIRX PRIORITY SCITX PRIORITY SCI STEST
T1PRI	P04F.6 P04F.7	T1 PRIORITY T1 STEST
T2APRI	P06F.6 P06F.7	T2A PRIORITY T2A STEST
ADPRI	P07F.5 P07F.6 P07F.7	AD ESPEN AD PRIORITY AD STEST
T2BPRI	P08F.6 P08F.7	T2B PRIORITY T2B STEST

† The privileged bits are shown in a bold typeface in Table 14.

The write-protect override (WPO) mode provides an external hardware method of overriding the write-protection registers of data EEPROM on the TMS370Cx6x.The WPO mode is entered by applying a 12-V input to MC after $\overline{\text{RESET}}$ input goes high (logic 1). The high voltage on MC during the WPO mode is not the programming voltage for the data EEPROM or program EPROM. All EEPROM programming voltages are generated on-chip. The WPO mode provides hardware system-level capability to modify the content of the data EEPROM while the device remains in the application but only while requiring a 12-V external input on the MC pin (normally not available in the end application except in a service or diagnostic environment).

low-power and IDLE modes

The TMS370Cx6x devices have two low-power modes (STANDBY and HALT) and an IDLE mode. For mask-ROM devices, low-power modes can be disabled permanently through a programmable contact at the time when the mask is manufactured.

The STANDBY and HALT low-power modes significantly reduce power consumption by reducing or stopping the activity of the various on-chip peripherals when processing is not required. Each of the low-power modes is entered by executing the IDLE instruction when the PWRDWN/IDLE bit in SCCR2 has been set to 1. The HALT/STANDBY bit in SCCR2 controls which low-power mode is entered.

low-power and IDLE modes (continued)

In the STANDBY mode (HALT/STANDBY = 0), all CPU activity and most peripheral module activity is stopped; however, the oscillator, internal clocks, timer 1, and the receive start-bit detection circuit of the serial communications interface remain active. System processing is suspended until a qualified interrupt (hardware $\overline{\text{RESET}}$, external interrupt on INT1, INT2, INT3, timer 1 interrupt, or low level on the receive pin of the serial communications interface) is detected.

In the HALT mode (HALT/STANDBY = 1), the TMS370Cx6x is placed in its lowest power-consumption mode. The oscillator and internal clocks are stopped, causing all internal activity to be halted. System activity is suspended until a qualified interrupt (hardware $\overline{\text{RESET}}$, external interrupt on the INT1, INT2, INT3, or low level on the receive pin of the serial communications interface) is detected. The low-power mode selection bits are summarized in Table 13.

Table 13. Low-Power/Idle Control Bits

POWER-DOWN CONTROL BITS		MODE SELECTED
PWRDWN/IDLE (SCCR2.6)	HALT/STANDBY (SCCR2.7)	
1	0	STANDBY
1	1	HALT
0	X	IDLE

X = don't care

When low-power modes are disabled through a programmable contact in the mask-ROM devices, writing to the SCCR2.6–7 bits is ignored. In addition, if an idle instruction executes when low-power modes are disabled through a programmable contact, the device always enters the IDLE mode.

To provide a method of always exiting low-power modes for mask-ROM devices, INT1 is automatically enabled as a nonmaskable interrupt (NMI) during low-power modes when the hard watchdog mode is selected. This means that the NMI always is generated, regardless of the interrupt-enable flags.

The following information is preserved throughout both the STANDBY and HALT modes: RAM (register file), CPU registers (stack pointer, program counter, and status register), I/O pin direction and output data, and status registers of all on-chip peripheral functions. Since all CPU instruction processing is stopped during the STANDBY and HALT modes, the clocking of the watchdog timer is inhibited.

clock modules

The 'x6x family provides two clock options which are referred to as divide-by-1 (PLL) and divide-by-4 (standard oscillator). Both the divide-by-1 and divide-by-4 options are configurable during the manufacturing process of a TMS370 microcontroller. The 'x6x ROM-masked devices offer both options to meet system engineering requirements. Only one of the two clock options is allowed on each ROM device. An EPROM has only the divide-by-1.

The divide-by-1 clock module option provides the capability for reduced electromagnetic interference (EMI) with no added cost.

The divide-by-1 provides a 1-to-1 match between the external resonator frequency and the internal system clock (SYSCLK) frequency. The divide-by-4 produces a SYSCLK which is one-fourth the frequency of the external resonator. Inside the divide-by-1 module, the frequency of the external resonator is multiplied by four. The clock module then divides the resulting signal by four to provide the four-phased internal system clock signals. The resulting SYSCLK is equal to the resonator frequency. The frequencies are formulated as follows:

clock modules (continued)

$$\text{Divide-by-4 option : SYSCLK} = \frac{\text{external resonator frequency}}{4} = \frac{\text{CLKIN}}{4}$$

$$\text{Divide-by-1 option : SYSCLK} = \frac{\text{external resonator frequency} \times 4}{4} = \text{CLKIN}$$

The main advantage of choosing a divide-by-1 oscillator is the improved EMI performance. The harmonics of low-speed resonators extend through less of the emissions spectrum than the harmonics of faster resonators. The divide-by-1 provides the capability of reducing the resonator speed by four times, and this results in a steeper decay of emissions produced by the oscillator.

system configuration registers

Table 14 contains system configuration and control functions and registers for controlling EEPROM programming. The privileged bits are shown in bold typeface and shaded.

Table 14. Peripheral File Frame 1: System Configuration Registers

PF	BIT 7	BIT 6	BIT 5	BIT 4	BIT 3	BIT 2	BIT 1	BIT 0	REG
P010	COLD START	**OSC POWER**	**PF AUTO WAIT**	OSC FLT FLAG	MC PIN WPO	MC PIN DATA	—	µP/µC MODE	SCCR0
P011	—	—	—	**AUTOWAIT DISABLE**	—	**MEMORY DISABLE**	—	—	SCCR1
P012	**HALT/ STANDBY**	**PWRDWN/ IDLE**	—	**BUS STEST**	**CPU STEST**	—	**INT1 NMI**	**PRIVILEGE DISABLE**	SCCR2
P013	Reserved								
P014	BUSY	VPPS	—	—	—	—	W0	EXE	EPCTLH
P015 to P016	Reserved								
P017	INT1 FLAG	INT1 PIN DATA	—	—	—	INT1 POLARITY	INT1 PRIORITY	INT1 ENABLE	INT1
P018	INT2 FLAG	INT2 PIN DATA	—	INT2 DATA DIR	INT2 DATA OUT	INT2 POLARITY	INT2 PRIORITY	INT2 ENABLE	INT2
P019	INT3 FLAG	INT3 PIN DATA	—	INT3 DATA DIR	INT3 DATA OUT	INT3 POLARITY	INT3 PRIORITY	INT3 ENABLE	INT3
P01A	BUSY	—	—	—	—	AP	W1W0	EXE	DEECTL
P01B	Reserved								
P01C	BUSY	VPPS	—	—	—	—	W0	EXE	EPCTLM
P01D	Reserved								
P01E	BUSY	VPPS	—	—	—	—	W0	EXE	EPCTLL
P01F	Reserved								

digital port control

Peripheral file frame 2 contains the digital I/O pin configuration and control registers. Table 15 lists the specific addresses, registers, and control bits within this peripheral file frame.

Table 15. Peripheral File Frame 2: Digital Port Control Registers

PF	BIT 7	BIT 6	BIT 5	BIT 4	BIT 3	BIT 2	BIT 1	BIT 0	REG
P020	Reserved								APORT1
P021	Port A Control Register 2								APORT2
P022	Port A Data								ADATA
P023	Port A Direction								ADIR
P024	Reserved								BPORT1
P025	Port B Control Register 2								BPORT2
P026	Port B Data								BDATA
P027	Port B Direction								BDIR
P028	Reserved								CPORT1
P029	Port C Control Register 2								CPORT2
P02A	Port C Data								CDATA
P02B	Port C Direction								CDIR
P02C	Port D Control Register 1					—	—	—	DPORT1
P02D	Port D Control Register 2†					—	—	—	DPORT2
P02E	Port D Data					—	—	—	DDATA
P02F	Port D Direction					—	—	—	DDIR

† To configure pin D3 as SYSCLK, set port D control register 2 = 08h.

Table 16. Port Configuration Register Setup

PORT	PIN	INPUT	OUTPUT	FUNCTION A	FUNCTION B (μP MODE)
		XPORT1 = 0‡ XPORT2 = 0 XDATA = y XDIR = 0	XPORT1 = 0‡ XPORT2 = 0 XDATA = q XDIR = 1	XPORT1 = 0‡ XPORT2 = 1 XDATA = x XDIR = x	XPORT1 = 1‡ XPORT2 = 1 XDATA = x XDIR = x
A	0–7	Data In y	Data Out q	Data Bus	Reserved
B	0–7	Data In y	Data Out q	Low ADDR	Reserved
C	0–7	Data In y	Data Out q	Hi ADDR	Reserved
D	3 4 5 6 7	Data In y	Data Out q	SYSCLK R/$\overline{W}$ $\overline{CSPF}$ $\overline{CSH1}$ $\overline{CSE1}$	SYSCLK R/$\overline{W}$ — $\overline{EDS}$ $\overline{WAIT}$
XPORT1 = 1 XPORT2 =0 XDATA = x XDIR = x			Not defined		

‡ DPORT only

timer 1 module

The programmable timer 1 (T1) module of the TMS370Cx6x provides the designer with the enhanced timer resources required to perform real-time system control. The T1 module contains the general-purpose timer and the watchdog (WD) timer. The two independent 16-bit timers (T1 and WD) allow program selection of input clock sources (real-time, external-event, or pulse-accumulate) with multiple 16-bit registers (input-capture and compare) for special timer function control. The T1 module includes three external device pins that can be used for multiple counter functions (operation mode dependent) or used as general-purpose I/O pins. The T1 module is shown in Figure 5.

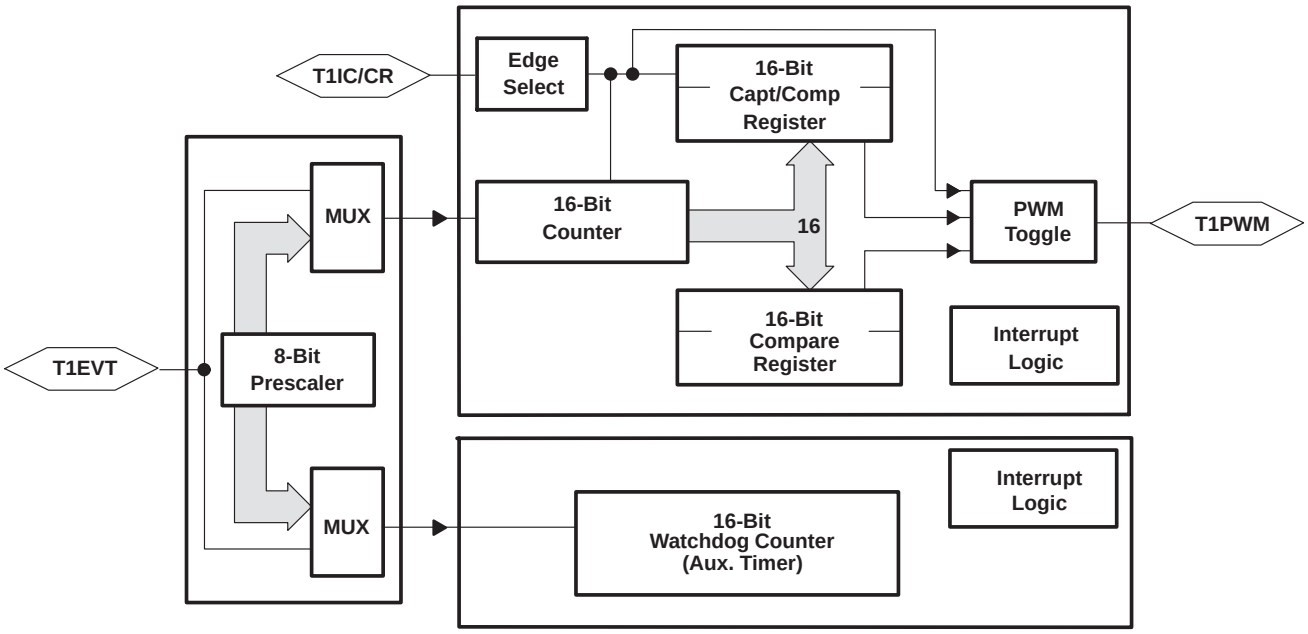


Figure 5. Timer 1 Block Diagram

- Three T1 I/O pins
  - T1IC/CR: Timer 1 input capture/counter reset input pin, or general-purpose bidirectional I/O pin
  - T1PWM: Timer 1 pulse-width-modulation (PWM) output pin, or general-purpose bidirectional I/O pin
  - T1EVT: Timer 1 event input pin, or general-purpose bidirectional I/O pin
- Two operation modes:
  - Dual–compare mode: Provides PWM signal
  - Capture/compare mode: Provides input capture pin
- One 16-bit general-purpose resettable counter
- One 16-bit compare register with associated compare logic
- One 16-bit capture/compare register, which, depending on the mode of operation, operates as either capture or compare register
- One 16-bit watchdog counter can be used as an event counter, a pulse accumulator, or an interval timer if watchdog feature is not needed.
- Prescaler/clock sources that determine one of eight clock sources for general-purpose timer

timer 1 module (continued)

- Selectable edge-detection circuitry that, depending on the mode of operation, senses active transitions on the input capture pins (T1IC/CR)
- Interrupts that can be generated on the occurrence of:
  - A capture
  - A compare equal
  - A counter overflow
  - An external edge detection
- Sixteen T1 module control registers: Located in the PF frame beginning at address P040

timer 1 module (continued)

Table 17 shows the T1 module control register memory map.

Table 17. Timer 1 Module Register Memory Map

PF	BIT 7	BIT 6	BIT 5	BIT 4	BIT 3	BIT 2	BIT 1	BIT 0	REG
	Modes: Dual-Compare and Capture/Compare								
P040	Bit 15			T1 Counter MSbyte				Bit 8	T1CNTR
P041	Bit 7			T1 Counter LSbyte				Bit 0	
P042	Bit 15			Compare Register MSbyte				Bit 8	T1C
P043	Bit 7			Compare Register LSbyte				Bit 0	
P044	Bit 15			Capture/Compare Register MSbyte				Bit 8	T1CC
P045	Bit 7			Capture/Compare Register LSbyte				Bit 0	
P046	Bit 15			Watchdog Counter MSbyte				Bit 8	WDCNTR
P047	Bit 7			Watchdog Counter LSbyte				Bit 0	
P048	Bit 15			Watchdog Reset Key				Bit 0	WDRST
P049	WD OVRFL TAP SEL†	WD INPUT SELECT2†	WD INPUT SELECT1†	WD INPUT SELECT0†	—	T1 INPUT SELECT2	T1 INPUT SELECT1	T1 INPUT SELECT0	T1CTL1
P04A	WD OVRFL RST ENA†	WD OVRFL INT ENA	WD OVRFL INT FLAG	T1 OVRFL INT ENA	T1 OVRFL INT FLAG	—	—	T1 SW RESET	T1CTL2
	Mode: Dual-Compare								
P04B	T1EDGE INT FLAG	T1C2 INT FLAG	T1C1 INT FLAG	—	—	T1EDGE INT ENA	T1C2 INT ENA	T1C1 INT ENA	T1CTL3
P04C	T1 MODE = 0	T1C1 OUT ENA	T1C2 OUT ENA	T1C1 RST ENA	T1CR OUT ENA	T1EDGE POLARITY	T1CR RST ENA	T1EDGE DET ENA	T1CTL4
	Mode: Capture/Compare								
P04B	T1EDGE INT FLAG	—	T1C1 INT FLAG	—	—	T1EDGE INT ENA	—	T1C1 INT ENA	T1CTL3
P04C	T1 MODE = 1	T1C1 OUT ENA	—	T1C1 RST ENA	—	T1EDGE POLARITY	—	T1EDGE DET ENA	T1CTL4
	Modes: Dual-Compare and Capture/Compare								
P04D	—	—	—	—	T1EVT DATA IN	T1EVT DATA OUT	T1EVT FUNCTION	T1EVT DATA DIR	T1PC1
P04E	T1PWM DATA IN	T1PWM DATA OUT	T1PWM FUNCTION	T1PWM DATA DIR	T1IC/CR DATA IN	T1IC/CR DATA OUT	T1IC/CR FUNCTION	T1IC/CR DATA DIR	T1PC2
P04F	**T1 STEST**	**T1 PRIORITY**	—	—	—	—	—	—	T1PRI

† Once the WD OVRFL RST ENA bit is set, these bits cannot be changed until a reset; this applies only to the standard watchdog and to simple counter. In the hard watchdog, these bits can be modified at any time; the WD INPUT SELECT2 bits are ignored.

timer 1 module (continued)

The timer 1 capture/compare mode block diagram is illustrated in Figure 6. The annotations in Figure 6 identify the register and the bit(s) in the peripheral frame. For example, the actual address of T1CTL2.0 is 104Ah, bit 0, in the T1CTL2 register.

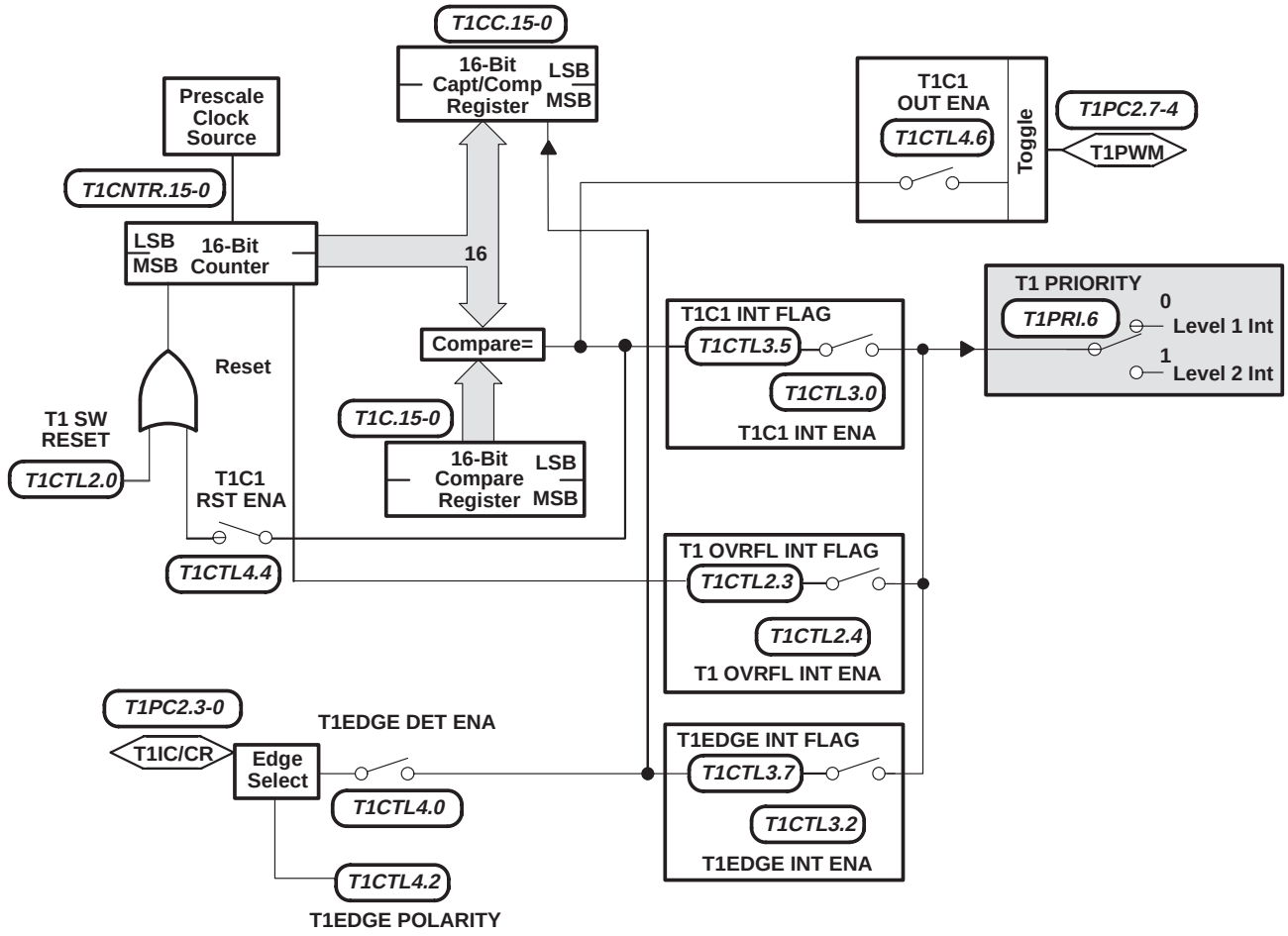


Figure 6. Capture/Compare Mode

timer 1 module (continued)

The timer 1 dual-compare mode block diagram is illustrated in Figure 7. The annotations in Figure 7 identify the register and the bit(s) in the peripheral frame. For example, the actual address of T1CTL2.0 is 104Ah, bit 0, in the T1CTL2 register.

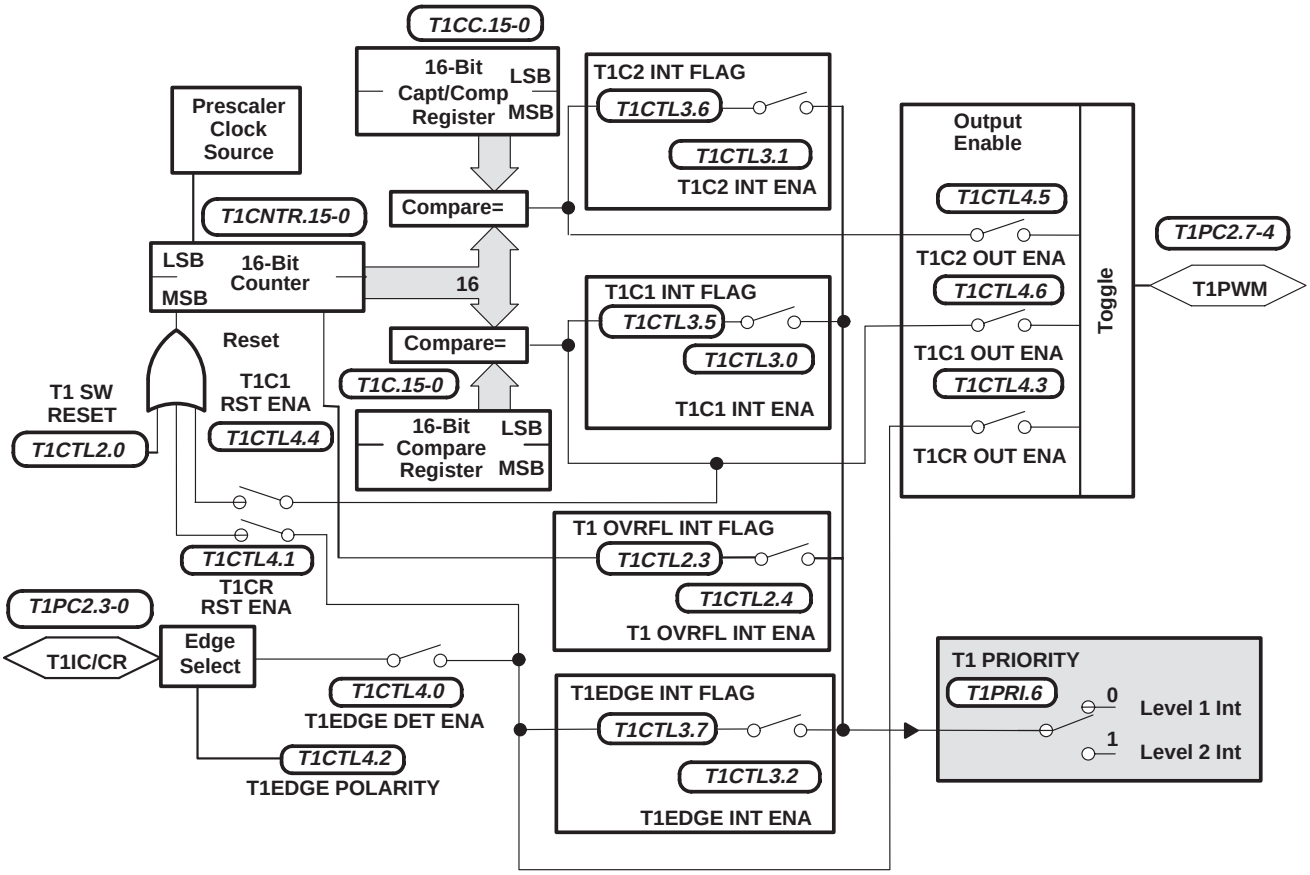


Figure 7. Dual-Compare Mode

timer 1 module (continued)

The TMS370Cx6x device includes a 24-bit watchdog (WD) timer, contained in the T1 module, which can be software programmed as an event counter, pulse accumulator, or interval timer if the watchdog function is not desired. The WD function is to monitor software and hardware operation and to implement a system reset when the WD counter is not serviced properly (WD counter overflow or WD counter is reinitialized by an incorrect value). The WD can be configured as one of three mask options: standard watchdog, hard watchdog, or simple counter.

- Standard watchdog configuration (see Figure 8) – for ’76xA EPROM and mask-ROM devices
  - Watchdog mode
    - Ten different WD overflow rates ranging from 6.55 ms to 3.35 s at 5-MHz SYSCLK
    - A WD reset key (WDRST) register is used to clear the watchdog counter (WDCNTR) when a correct value is written.
    - Generates a system reset if an incorrect value is written to the watchdog reset key or if the counter overflows
    - A watchdog overflow flag (WD OVRFL INT FLAG) bit that indicates whether the WD timer initiated a system reset
  - Non-watchdog mode
    - Watchdog timer can be configured as an event counter, pulse accumulator, or an interval timer.

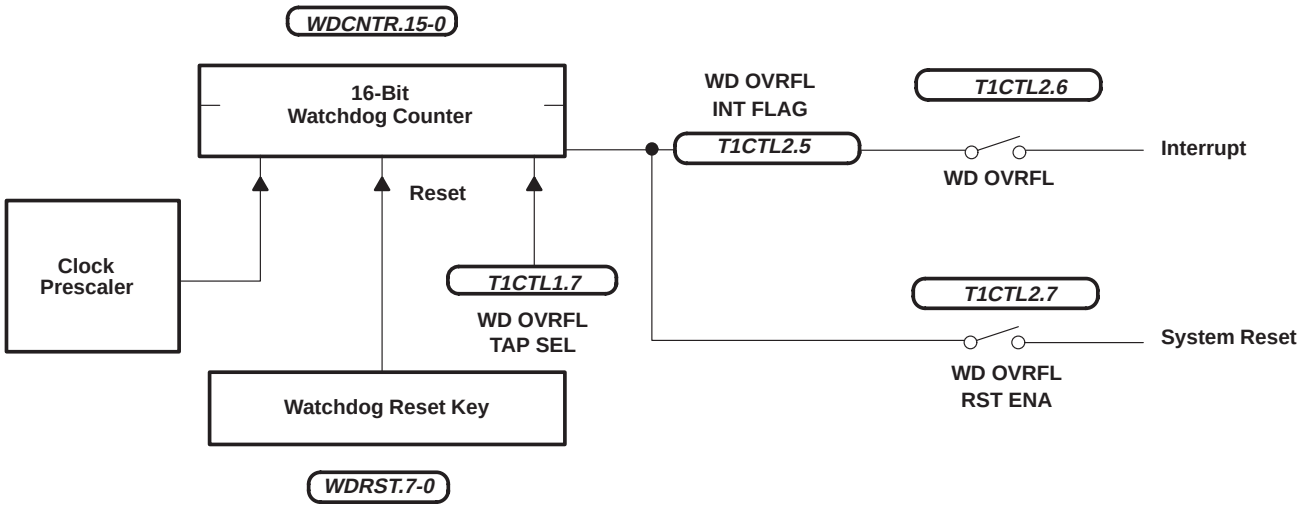


Figure 8. Standard Watchdog

timer 1 module (continued)

- Hard watchdog configuration (see Figure 9) – for mask-ROM devices
  - Eight different WD overflow rates ranging from 26.2 ms to 3.35 s at 5-MHz SYSCLK
  - A WD reset key (WDRST) register is used to clear the watchdog counter (WDCNTR) when a correct value is written.
  - Generates a system reset if an incorrect value is written to the watchdog reset key or if the counter overflows
  - Automatic activation of the WD timer upon power-up reset
  - INT1 is enabled as nonmaskable interrupt during low-power modes
  - A watchdog overflow flag (WD OVRFL INT FLAG) bit that indicates whether the WD timer initiated a system reset

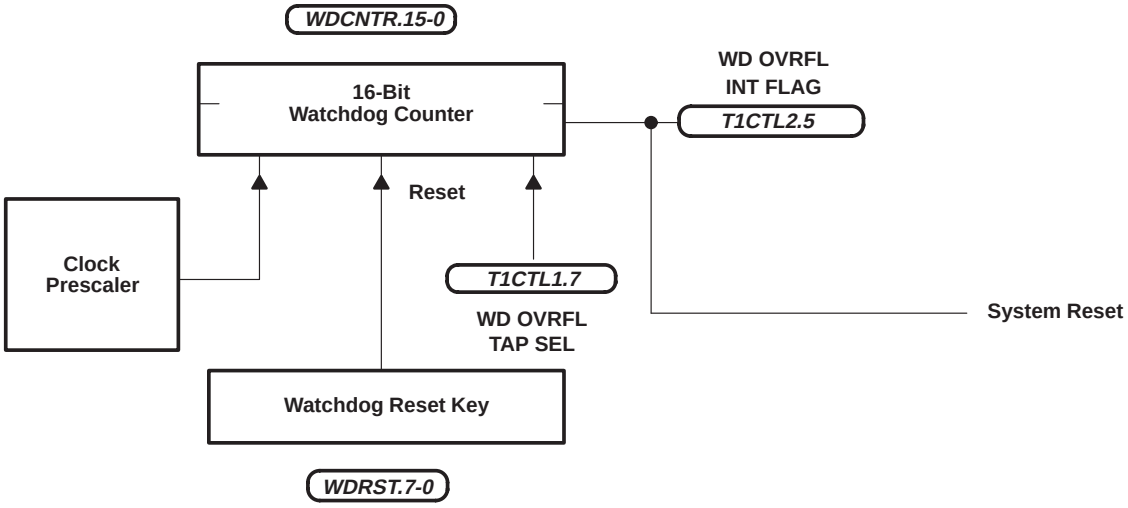


Figure 9. Hard Watchdog

timer 1 module (continued)

- Simple-counter configuration (see Figure 10) – for mask-ROM devices only
  - Simple counter can be configured as an event counter, pulse accumulator, or an interval timer

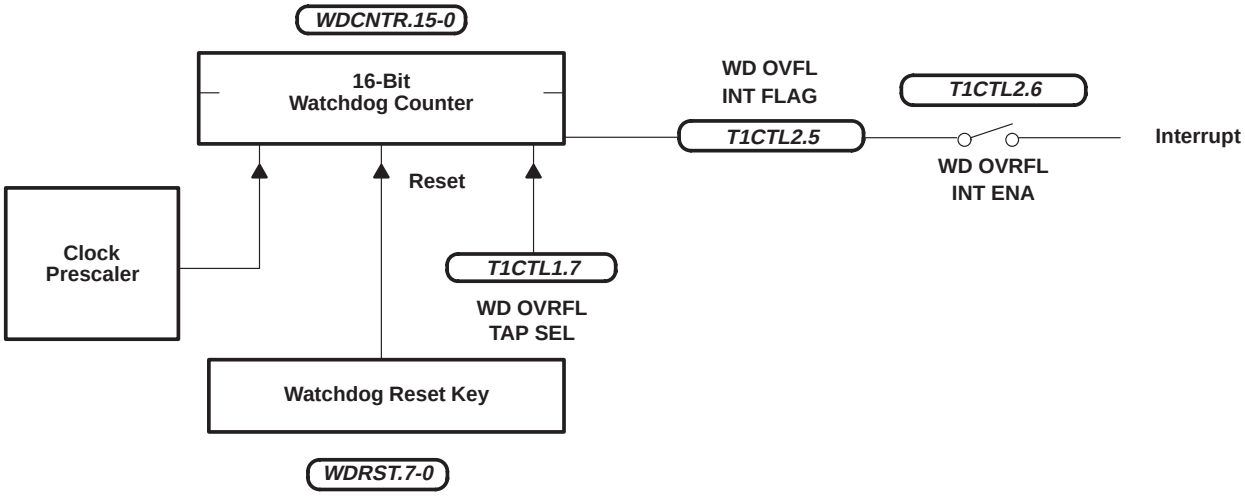


Figure 10. Simple Counter

timer 2n modules (T2A and T2B)

The TMS370Cx6x device includes two 16-bit general-purpose timer 2 modules (T2A and T2B). The T2A or T2B are referred to as T2n throughout this section. The T2n module contains a 16-bit resettable counter, 16-bit compare register with associated compare logic, 16-bit capture register, and a 16-bit register that functions as a capture register in one mode and as a compare register in the other mode. The T2n module adds additional timers that provide event counts, input captures, and compare functions. The T2n module includes three external-device pins that can be dedicated as timer functions or used as general-purpose I/O pins. The T2n module is shown in Figure 11.

timer 2n modules (T2A and T2B) (continued)

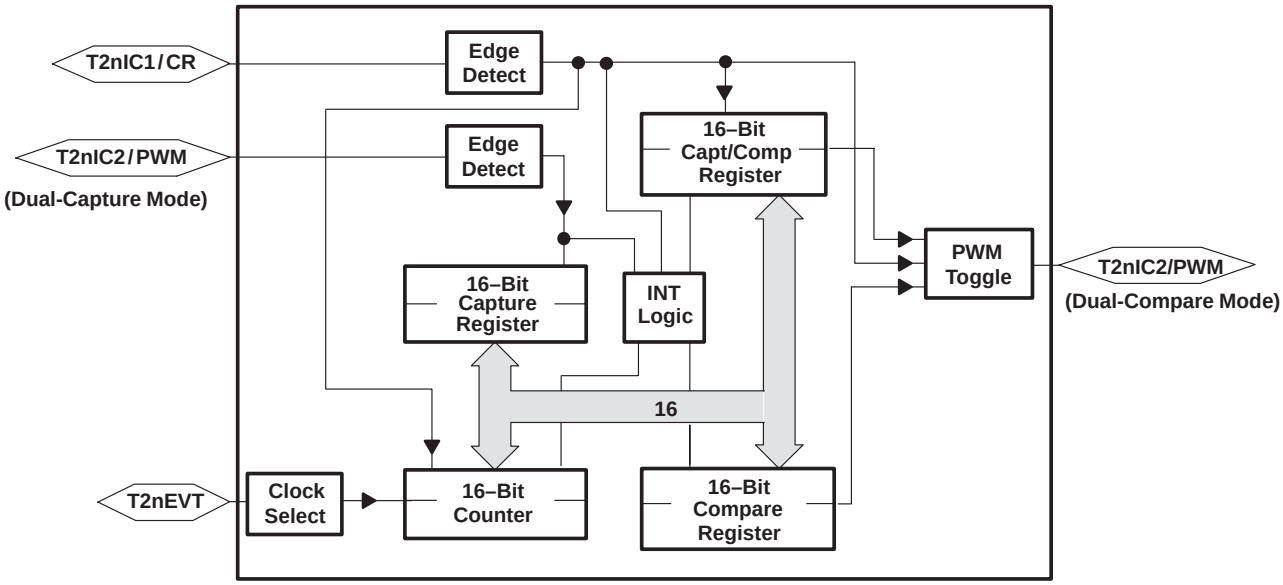


Figure 11. Timer 2n Block Diagram

The T2n module features include the following:

- Three T2A I/O pins
  - T2nIC1/CR: Timer 2n input capture 1/counter-reset input pin, or general-purpose bidirectional I/O pin
  - T2nIC2/PWM: Timer 2n input capture 2/pulse-width-modulation (PWM) output pin, or general-purpose bidirectional I/O pin
  - T2nEVT: Timer 2n event-input pin, or general-purpose bidirection I/O pin
- Two operation modes:
  - Dual-compare mode: Provides PWM signal
  - Dual-capture mode: Provides input-capture pin
- One 16-bit general-purpose resettable counter
- One 16-bit compare register with associated compare logic
- One 16-bit capture register with associated capture logic
- One 16-bit capture/compare register, which, depending on the mode of operation, operates as either capture or compare registers
- T2n clock sources can be any of the following:
  - System clock
  - No clock (the counter is stopped)
  - External clock synchronized to the system clock (event counter)
  - System clock while external input is high (pulse accumulation)

timer 2n modules (T2A and T2B) (continued)

- Selectable edge-detection circuitry that, depending on the mode of operation, senses active transitions on the input-capture pins (T2nIC1/CR)
- Interrupts that can be generated on the occurrence of:
  - A compare equal for dedicated-compare register
  - A compare equal for capture-compare register
  - A counter overflow
  - An external edge 1 detection
  - An external edge 2 detection
- Fourteen control registers for each Timer 2 module: Located in the PF frame beginning at address P060 and P080 for T2A and T2B, respectively.

The timer 2n module control registers are illustrated in Table 18.

Table 18. Timer 2n Module Register Memory Map

PF	PF	BIT 7	BIT 6	BIT 5	BIT 4	BIT 3	BIT 2	BIT 1	BIT 0	REG
		Modes: Dual-Compare and Dual-Capture								
P060	P080	Bit 15			T2n Counter MSbyte				Bit 8	T2nCNTR
P061	P081	Bit 7			T2n Counter LSbyte				Bit 0	
P062	P082	Bit 15			Compare Register MSbyte				Bit 8	T2nC
P063	P083	Bit 7			Compare Register LSbyte				Bit 0	
P064	P084	Bit 15			Capture/Compare Register MSbyte				Bit 8	T2nCC
P065	P085	Bit 7			Capture/Compare Register LSbyte				Bit 0	
P066	P086	Bit 15			Capture Register 2 MSbyte				Bit 8	T2nIC
P067	P087	Bit 7			Capture Register 2 LSbyte				Bit 0	
P06A	P08A	—	—	—	T2n OVRFL INT ENA	T2n OVRFL INT FLAG	T2n INPUT SELECT1	T2n INPUT SELECT0	T2n SW RESET	T2nCTL1
		Mode: Dual-Compare								
P06B	P08B	T2nEDGE1 INT FLAG	T2nC2 INT FLAG	T2nC1 INT FLAG	—	—	T2nEDGE1 INT ENA	T2nC2 INT ENA	T2nC1 INT ENA	T2nCTL2
P06C	P08C	T2n MODE = 0	T2nC1 OUT ENA	T2nC2 OUT ENA	T2nC1 RST ENA	T2nEDGE1 OUT ENA	T2nEDGE1 POLARITY	T2nEDGE1 RST ENA	T2nEDGE1 DET ENA	T2nCTL3
		Mode: Dual-Capture								
P06B	P08B	T2nEDGE1 INT FLAG	T2nEDGE2 INT FLAG	T2nC1 INT FLAG	—	—	T2nEDGE1 INT ENA	T2nEDGE2 INT ENA	T2nC1 INT ENA	T2nCTL2
P06C	P08C	T2n MODE = 1	—	—	T2nC1 RST ENA	T2nEDGE2 POLARITY	T2nEDGE1 POLARITY	T2nEDGE2 DET ENA	T2nEDGE1 DET ENA	T2nCTL3
		Modes: Dual-Compare and Dual-Capture								
P06D	P08D	—	—	—	—	T2nEVT DATA IN	T2nEVT DATA OUT	T2nEVT FUNCTION	T2nEVT DATA DIR	T2nPC1
P06E	P08E	T2nIC2 / PWM DATA IN	T2nIC2 / PWM DATA OUT	T2nIC2 / PWM FUNCTION	T2nIC2 / PWM DATA DIR	T2nIC1/CR DATA IN	T2nIC1/CR DATA OUT	T2nIC1/CR FUNCTION	T2nIC1/CR DATA DIR	T2nPC2
P06F	P08F	**T2n STEST**	**T2n PRIORITY**	—	—	—	—	—	—	T2nPRI

timer 2n modules (T2A and T2B) (continued)

The timer 2n dual-compare mode block diagram is illustrated in Figure 12. The annotations on the diagram identify the register and the bit(s) in the peripheral frame. For example, the actual address of T2nCTL2.0 is 106Bh (n = A) or 108Bh (n = B), bit 0, in the T2nCTL2 register.

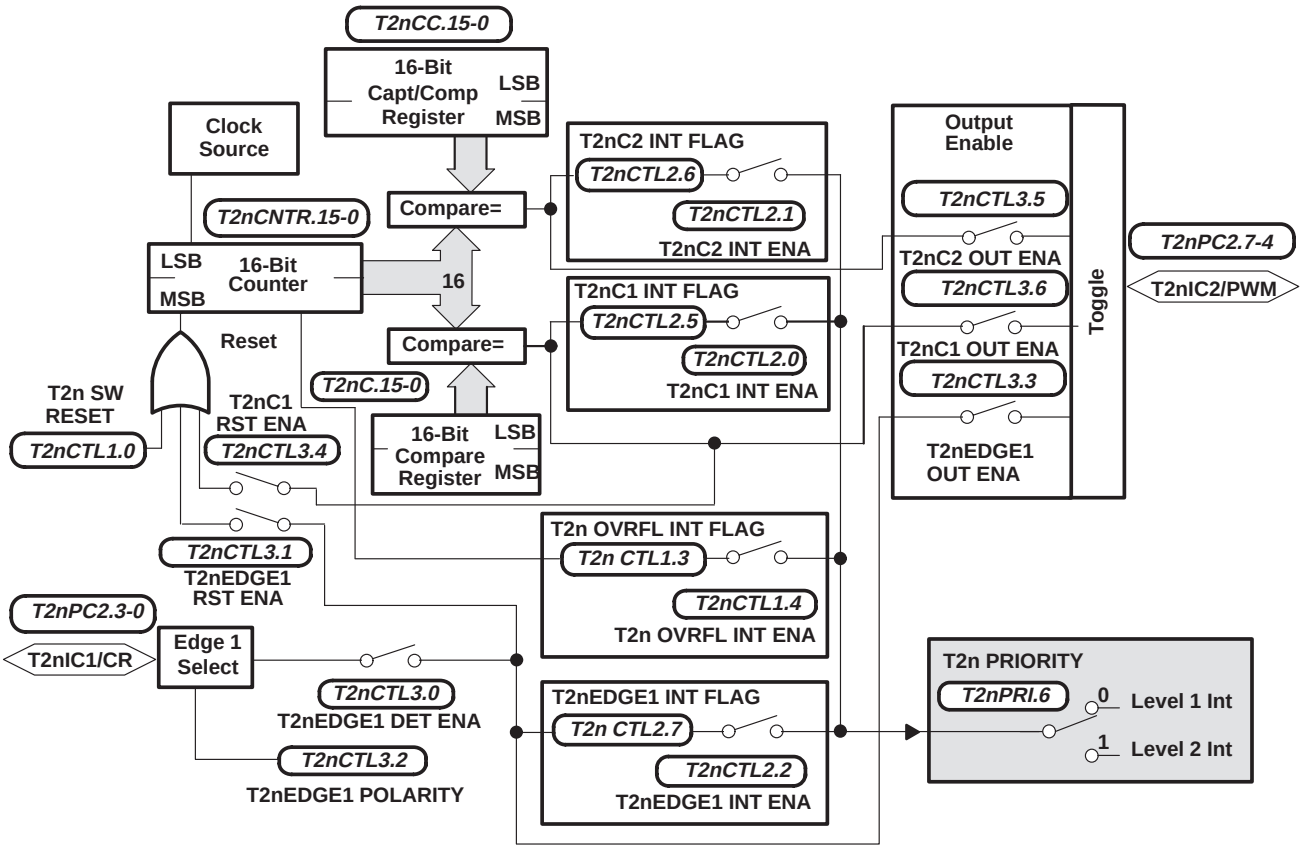


Figure 12. Dual-Compare Mode

timer 2n modules (T2A and T2B) (continued)

The timer 2n dual-capture mode block diagram is illustrated in Figure 13. The annotations on the diagram identify the register and the bit(s) in the peripheral frame. For example, the actual address of T2nCTL2.0 is 106Bh (n = A) or 108Bh (n = B), bit 0, in the T2nCTL2 register.

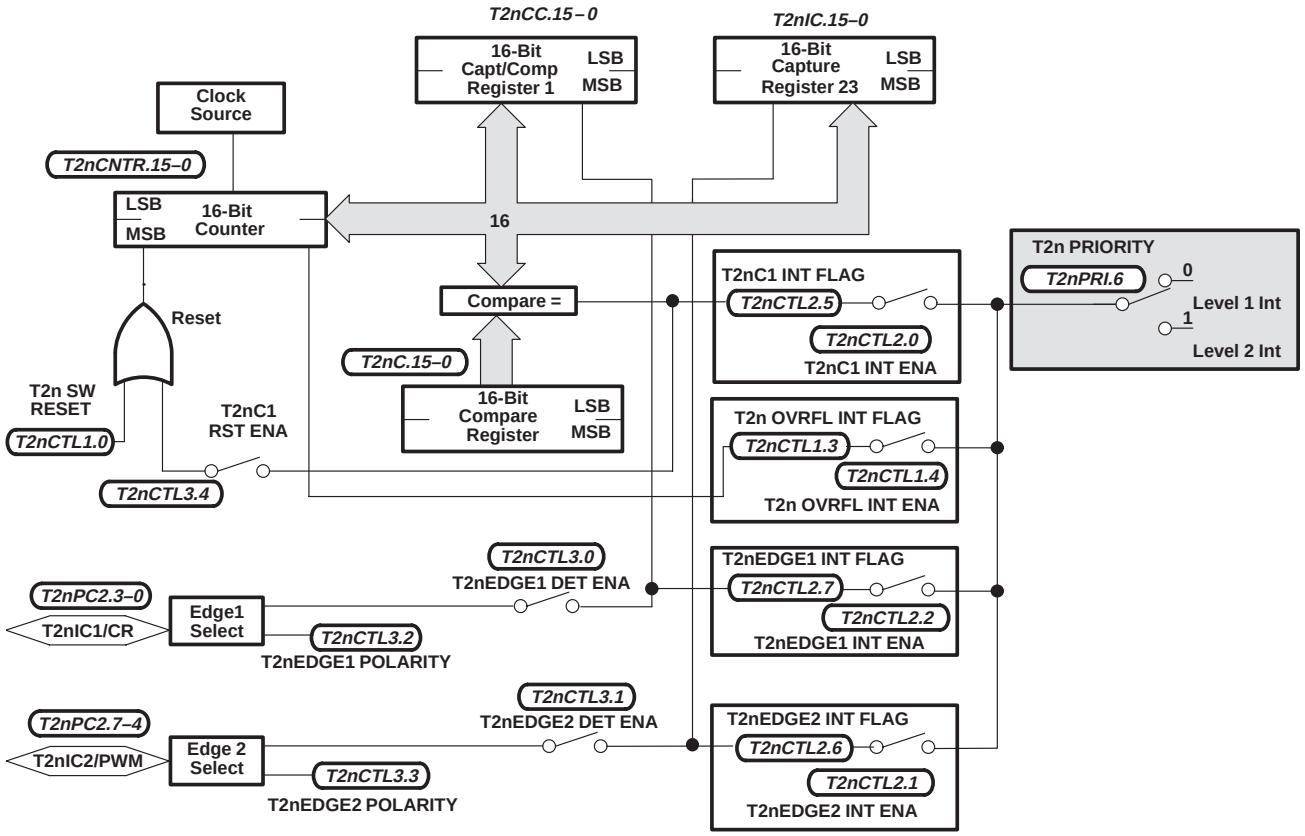


Figure 13. Dual-Capture Mode

serial peripheral interface (SPI) module

The SPI is a high-speed, synchronous, serial I/O port that allows a serial bit stream of programmed length (1 to 8 bits) to be shifted into and out of the device at a programmable bit-transfer rate.The SPI is used normally for communications between the microcontroller and external peripherals or another microcontroller. Typical applications include external I/O or peripheral expansion using devices such as shift registers, display drivers, and analog-to-digital (A/D) converters. The master/slave operation of the SPI supports multi-device communications. The SPI module features include the following:

- Three external pins:
  - SPISOMI: SPI slave output/master input pin or general-purpose bidirectional I/O pin
  - SPISIMO: SPI slave input/master output pin or general-purpose bidirectional I/O pin
  - SPICLK: SPI serial-clock pin or general-purpose bidirectional I/O pin
- Two operational modes: master and slave
- Baud rate: Eight different programmable rates
  - Maximum baud rate in master mode: 2.5M bps at 5-MHz SYSCLK

    $$\text{SPI BAUD RATE} = \frac{\text{SYSCLK}}{2 \times 2^{b}}$$

    where b = bit rate in SPICCR.5-3 (range 0–7)
  - Maximum baud rate in slave mode: 625K bps at 5-MHz SYSCLK

    For maximum slave SPI BAUD RATE < SYSCLK/8
- Data-word format: one to eight data bits
- Simultaneous receiver and transmitter operation (transmit function can be disabled in software)
- Transmitter and receiver operations are accomplished through either interrupt-driven or polled algorithms.
- Seven SPI module-control registers: located in control register frame beginning at address P030h

serial peripheral interface (SPI) module (continued)

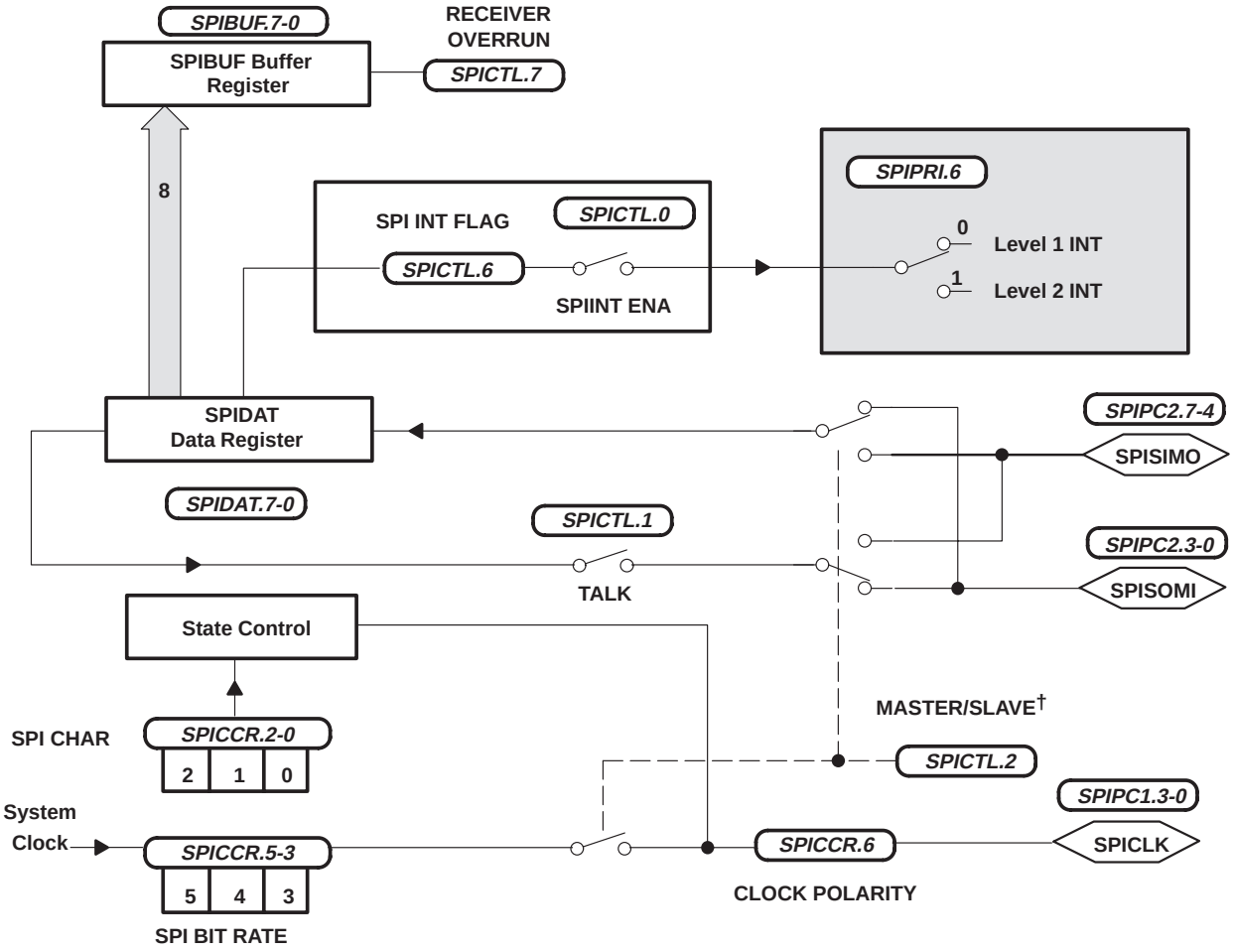
The SPI module control registers are illustrated in Table 19.

Table 19. SPI Module Control Register Memory Map

PF	BIT 7	BIT 6	BIT 5	BIT 4	BIT 3	BIT 2	BIT 1	BIT 0	REG
P030	SPI SW RESET	CLOCK POLARITY	SPI BIT RATE2	SPI BIT RATE1	SPI BIT RATE0	SPI CHAR2	SPI CHAR1	SPI CHAR0	SPICCR
P031	RECEIVER OVERRUN	SPI INT FLAG	—	—	—	MASTER/ SLAVE	TALK	SPI INT ENA	SPICTL
P032 to P036	Reserved								
P037	RCVD7	RCVD6	RCVD5	RCVD4	RCVD3	RCVD2	RCVD1	RCVD0	SPIBUF
P038	Reserved								
P039	SDAT7	SDAT6	SDAT5	SDAT4	SDAT3	SDAT2	SDAT1	SDAT0	SPIDAT
P03A to P03C	Reserved								
P03D	—	—	—	—	SPICLK DATA IN	SPICLK DATA OUT	SPICLK FUNCTION	SPICLK DATA DIR	SPIPC1
P03E	SPISIMO DATA IN	SPISIMO DATA OUT	SPISIMO FUNCTION	SPISIMO DATA DIR	SPISOMI DATA IN	SPISOMI DATA OUT	SPISOMI FUNCTION	SPISOMI DATA DIR	SPIPC2
P03F	**SPI STEST**	**SPI PRIORITY**	**SPI ESPEN**	—	—	—	—	—	SPIPRI

serial peripheral interface (SPI) module (continued)

The SPI block diagram is illustrated in Figure 14.



† The diagram is shown in slave mode.

Figure 14. SPI Block Diagram

serial communications interface 1 (SCI1) module

The TMS370x6x devices include a serial communications interface (SCI1) module. The SCI1 module supports digital communications between the TMS370 devices and other asynchronous peripherals and uses the standard non-return-to-zero (NRZ) format. The SCI1's receiver and transmitter are double buffered, and each has its own separate enable and interrupt bits. Both can be operated independently or simultaneously in the full-duplex mode. To ensure data integrity, the SCI1 checks received data for break detection, parity, overrun, and framing errors. The speed of bit rate (baud) is programmable to over 65,000 different speeds through a 16-bit baud-select register.

serial communications interface 1 (SCI1) module (continued)

Features of the SCI1 module include:

- Three external pins:
  - SCITXD: SCI transmit output pin or general-purpose bidirectional I/O pin
  - SCIRXD: SCI receive input pin or general-purpose bidirectional I/O pin
  - SCICLK: SCI bidirectional serial clock pin, or general-purpose bidirectional I/O pin
- Two communications modes: asynchronous and isosynchronous†
- Baud rate: 64K different programmable rates
  - Asynchronous mode: 3 bps to 156K bps at 5-MHz SYSCLK

$$\text{ASYNCHRONOUS BAUD} = \frac{\text{SYSCLK}}{(\text{BAUD REG} + 1) \times 32}$$

  - Isosynchronous mode: 39 bps to 2.5M bps at 5-MHz SYSCLK

$$\text{ISOSYNCHRONOUS BAUD} = \frac{\text{SYSCLK}}{(\text{BAUD REG} + 1) \times 2}$$

- Data-word format
  - One start bit
  - Data-word length programmable from one to eight bits
  - Optional even/odd/no parity bit
  - One or two stop bits
- Four error-detection flags: parity, overrun, framing, and break detection
- Two wake-up multiprocessor modes: Idle-line and address bit
- Half or full-duplex operation
- Double-buffered receive and transmit functions
- Interrupt driven or polled algorithms with status flags accomplish transmitter and receiver operations.
  - Transmitter: TXRDY flag (transmitter buffer register is ready to receive another character) and TX EMPTY flag (transmitter shift register is empty)
  - Receiver: RXRDY flag (receive buffer register ready to receive another character), BRKDT flag (break condition occurred), and RX ERROR monitoring four interrupt conditions
  - Separate enable bits for transmitter and receiver interrupts
  - NRZ (non-return-to-zero) format
- Eleven SCI1 module control registers are located in control register frame beginning at address P050h.

† Isosynchronous = Isochronous

serial communications interface 1 (SCI1) module (continued)

The SCI1 module control registers are illustrated in Table 20.

Table 20. SCI1 Module Control Register Memory Map

PF	BIT 7	BIT 6	BIT 5	BIT 4	BIT 3	BIT 2	BIT 1	BIT 0	REG
P050	STOP BITS	EVEN/ODD PARITY	PARITY ENABLE	ASYNC/ ISOSYNC	ADDRESS/ IDLE WUP	SCI CHAR2	SCI CHAR1	SCI CHAR0	SCICCR
P051	—	—	SCI SW RESET	CLOCK	TXWAKE	SLEEP	TXENA	RXENA	SCICTL
P052	BAUDF (MSB)	BAUDE	BAUDD	BAUDC	BAUDB	BAUDA	BAUD9	BAUD8	BAUD MSB
P053	BAUD7	BAUD6	BAUD5	BAUD4	BAUD3	BAUD2	BAUD1	BAUD0 (LSB)	BAUD LSB
P054	TXRDY	TX EMPTY	—	—	—	—	—	SCI TX INT ENA	TXCTL
P055	RX ERROR	RXRDY	BRKDT	FE	OE	PE	RXWAKE	SCI RX INT ENA	RXCTL
P056	Reserved								
P057	RXDT7	RXDT6	RXDT5	RXDT4	RXDT3	RXDT2	RXDT1	RXDT0	RXBUF
P058	Reserved								
P059	TXDT7	TXDT6	TXDT5	TXDT4	TXDT3	TXDT2	TXDT1	TXDT0	TXBUF
P05A P05B P05C	Reserved								
P05D	—	—	—	—	SCICLK DATA IN	SCICLK DATA OUT	SCICLK FUNCTION	SCICLK DATA DIR	SCIPC1
P05E	SCITXD DATA IN	SCITXD DATA OUT	SCITXD FUNCTION	SCITXD DATA DIR	SCIRXD DATA IN	SCIRXD DATA OUT	SCIRXD FUNCTION	SCIRXD DATA DIR	SCIPC2
P05F	**SCI STEST**	**SCITX PRIORITY**	**SCIRX PRIORITY**	**SCI ESPEN**	—	—	—	—	SCIPRI

The SCI1 module block diagram is illustrated in Figure 15.

serial communications interface 1 (SCI1) module (continued)

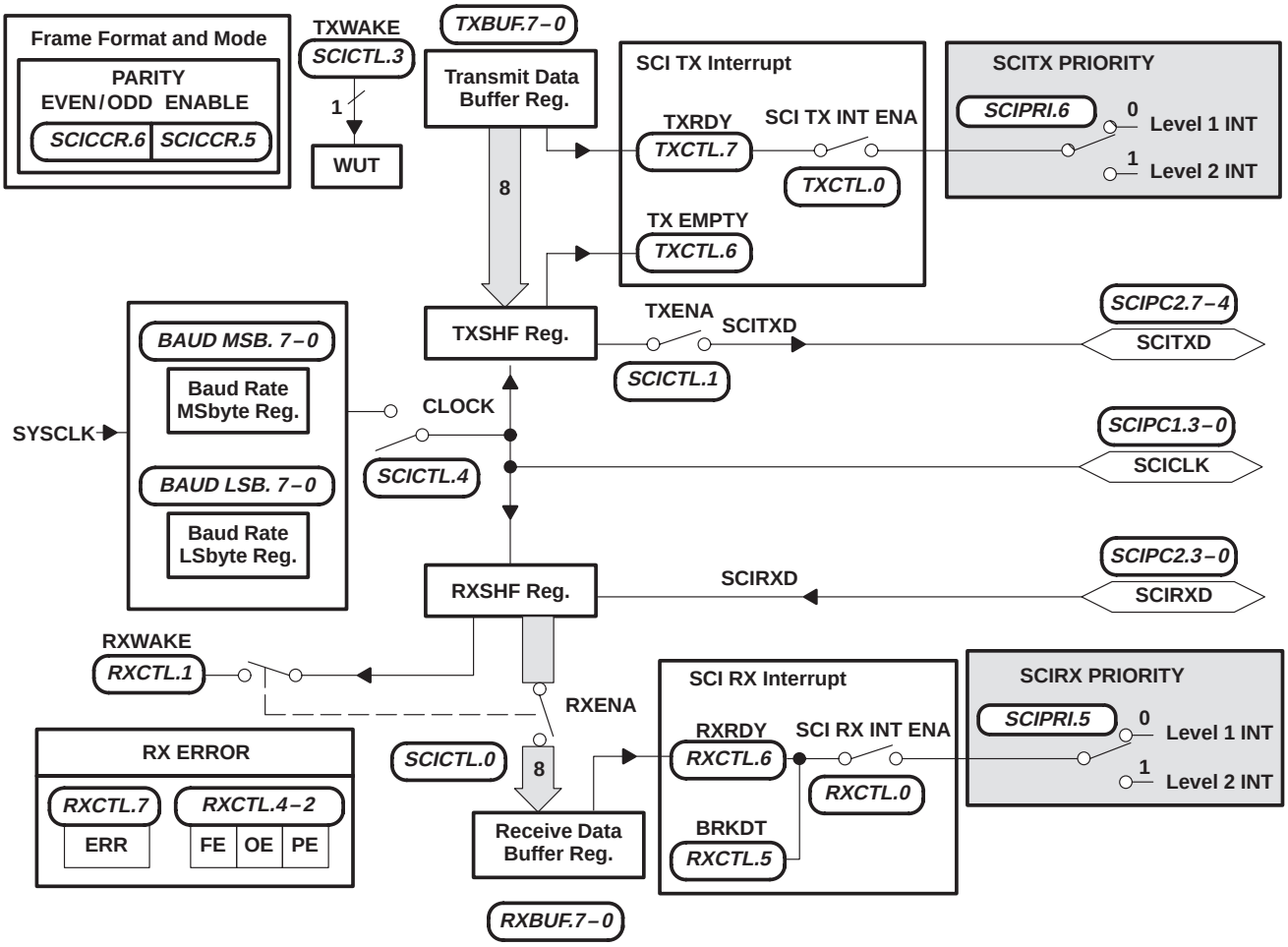


Figure 15. SCI1 Block Diagram

analog-to-digital converter 1 (ADC1) module

The analog-to-digital (ADC1) converter module is an 8-bit, successive approximation converter with internal sample-and-hold circuitry. The module has eight multiplexed analog input channels that allow the processor to convert the voltage levels from up to eight different sources. The ADC1 module features include the following:

- Minimum conversion time: 32.8 µs at 5-MHz SYSCLK
- Ten external pins:
  - Eight analog input channels (AN0–AN7), any of which can be software configured as digital inputs (E0–E7) if not needed as analog channels
  - AN1–AN7 also can be configured as positive-input voltage reference.
  - V_{CC3}: ADC1 module high-voltage reference input
  - V_{SS3}: ADC1 module low-voltage reference input

analog-to-digital converter 1 (ADC1) module (continued)

- The ADDATA register, which contains the digital result of the last ADC1 conversion
- ADC1 operations can be accomplished through either interrupt driven or polled algorithms.
- Six ADC1 module control registers are located in the control register frame beginning at address 1070h.

The ADC1 module control registers are illustrated in Table 21.

Table 21. ADC1 Module Control Register Memory Map

PF	BIT 7	BIT 6	BIT 5	BIT 4	BIT 3	BIT 2	BIT 1	BIT 0	REG
P070	CONVERT START	SAMPLE START	REF VOLT SELECT2	REF VOLT SELECT1	REF VOLT SELECT0	AD INPUT SELECT2	AD INPUT SELECT1	AD INPUT SELECT0	ADCTL
P071	—	—	—	—	—	AD READY	AD INT FLAG	AD INT ENA	ADSTAT
P072	A-to-D Conversion Data Register								ADDATA
P073 to P07C	Reserved								
P07D	Port E Data Input Register								ADIN
P07E	Port E Input Enable Register								ADENA
P07F	**AD STEST**	**AD PRIORITY**	**AD ESPEN**	—	—	—	—	—	ADPRI

analog-to-digital converter 1 (ADC1) module (continued)

The ADC1 module block diagram is illustrated in Figure 16.

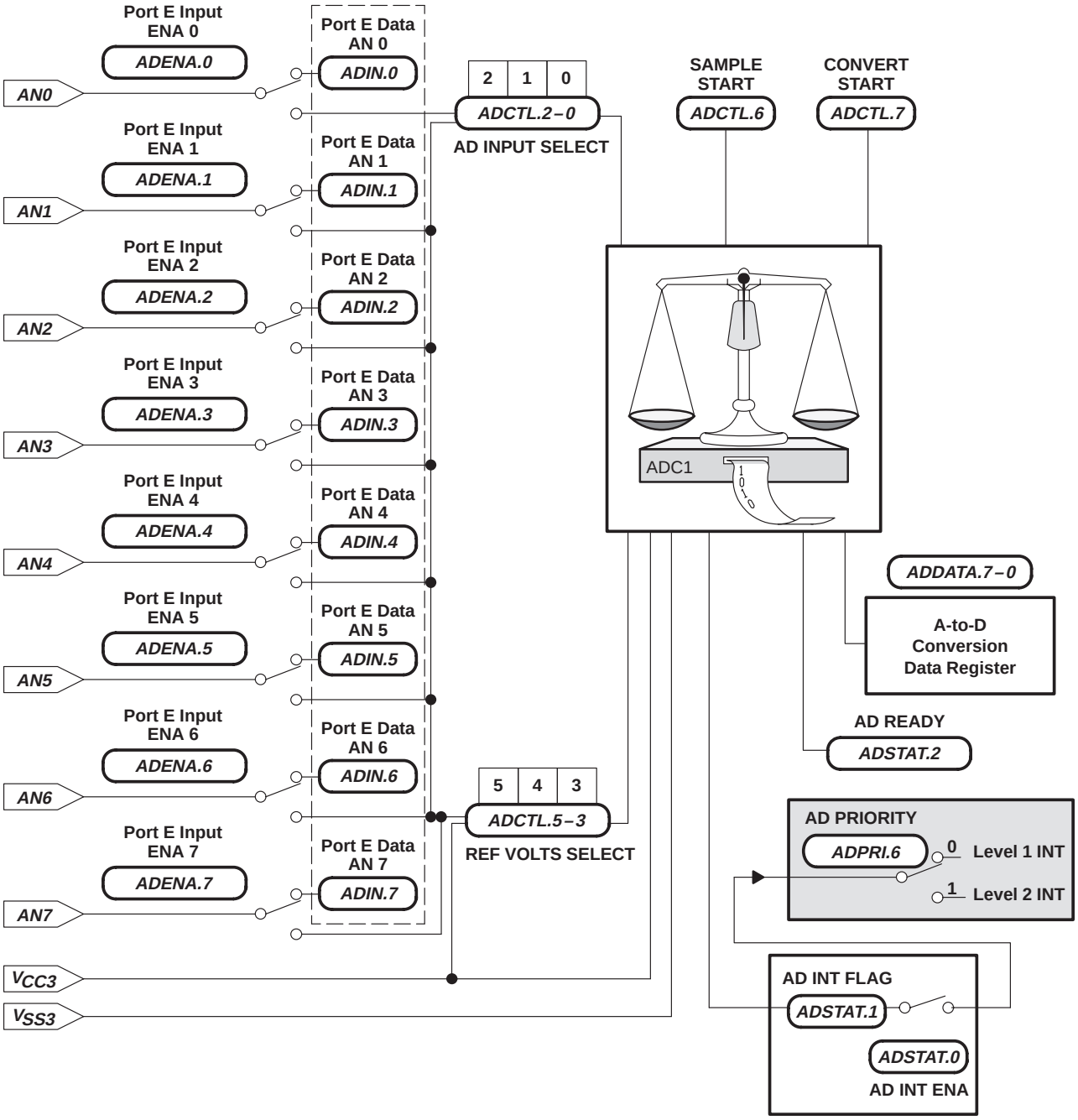


Figure 16. ADC1 Block Diagram

instruction set overview

Table 22 provides an opcode-to-instruction cross-reference of all 73 instructions and 274 opcodes of the ‘370Cx6x instruction set. The numbers at the top of this table represent the most significant nibble of the opcode while the numbers at the left side of the table represent the least significant nibble. The instruction of these two opcode nibbles contains the mnemonic, operands, and byte/cycle particular to that opcode.

For example, the opcode B5h points to the CLR A instruction. This instruction contains one byte and executes in eight SYSCLK cycles.

Table 22. TMS370 Family Opcode/Instruction Map†

LSN \ MSN	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
0	JMP #ra 2/7							INCW #ra,Rd 3/11	MOV Ps,A 2/8			CLRC / TST A 1/9	MOV A,B 1/9	MOV A,Rd 2/7	TRAP 15 1/14	LDST n 2/6
1	JN ra 2/5		MOV A,Pd 2/8			MOV B,Pd 2/8		MOV Rs,Pd 3/10		MOV Ps,B 2/7				MOV B,Rd 2/7	TRAP 14 1/14	MOV #ra[SP],A 2/7
2	JZ ra 2/5	MOV Rs,A 2/7	MOV #n,A 2/6	MOV Rs,B 2/7	MOV Rs,Rd 3/9	MOV #n,B 2/6	MOV B,A 1/8	MOV #n,Rd 3/8			MOV Ps,Rd 3/10	DEC A 1/8	DEC B 1/8	DEC Rd 2/6	TRAP 13 1/14	MOV A,*ra[SP] 2/7
3	JC ra 2/5	AND Rs,A 2/7	AND #n,A 2/6	AND Rs,B 2/7	AND Rs,Rd 3/9	AND #n,B 2/6	AND B,A 1/8	AND #n,Rd 3/8	AND A,Pd 2/9	AND B,Pd 2/9	AND #n,Pd 3/10	INC A 1/8	INC B 1/8	INC Rd 2/6	TRAP 12 1/14	CMP *n[SP],A 2/8
4	JP ra 2/5	OR Rs,A 2/7	OR #n,A 2/6	OR Rs,B 2/7	OR Rs,Rd 3/9	OR #n,B 2/6	OR B,A 1/8	OR #n,Rd 3/8	OR A,Pd 2/9	OR B,Pd 2/9	OR #n,Pd 3/10	INV A 1/8	INV B 1/8	INV Rd 2/6	TRAP 11 1/14	extend inst,2 opcodes
5	JPZ ra 2/5	XOR Rs,A 2/7	XOR #n,A 2/6	XOR Rs,B 2/7	XOR Rs,Rd 3/9	XOR #n,B 2/6	XOR B,A 1/8	XOR #n,Rd 3/8	XOR A,Pd 2/9	XOR B,Pd 2/9	XOR #n,Pd 3/10	CLR A 1/8	CLR B 1/8	CLR Rn 2/6	TRAP 10 1/14	
6	JNZ ra 2/5	BTJO Rs,A,ra 3/9	BTJO #n,A,ra 3/8	BTJO Rs,B,ra 3/9	BTJO Rs,Rd,ra 4/11	BTJO #n,B,ra 3/8	BTJO B,A,ra 2/10	BTJO #n,Rd,ra 4/10	BTJO A,Pd,ra 3/11	BTJO B,Pd,ra 3/10	BTJO #n,Pd,ra 4/11	XCHB A 1/10	XCHB A / TST B 1/10	XCHB Rn 2/8	TRAP 9 1/14	IDLE 1/6
7	JNC ra 2/5	BTJZ Rs.,A,ra 3/9	BTJZ #n,A,ra 3/8	BTJZ Rs,B,ra 3/9	BTJZ Rs,Rd,ra 4/11	BTJZ #n,B,ra 3/8	BTJZ B,A,ra 2/10	BTJZ #n,Rd,ra 4/10	BTJZ A,Pd,ra 3/10	BTJZ B,Pd,ra 3/10	BTJZ #n,Pd,ra 4/11	SWAP A 1/11	SWAP B 1/11	SWAP Rn 2/9	TRAP 8 1/14	MOV #n,Pd 3/10
8	JV ra 2/5	ADD Rs,A 2/7	ADD #n,A 2/6	ADD Rs,B 2/7	ADD Rs,Rd 3/9	ADD #n,B 2/6	ADD B,A 1/8	ADD #n,Rd 3/8	MOVW #16,Rd 4/13	MOVW Rs,Rd 3/12	MOVW #16[B],Rpd 4/15	PUSH A 1/9	PUSH B 1/9	PUSH Rd 2/7	TRAP 7 1/14	SETC 1/7
9	JL ra 2/5	ADC Rs,A 2/7	ADC #n,A 2/6	ADC Rs,B 2/7	ADC Rs,Rd 3/9	ADC #n,B 2/6	ADC B,A 1/8	ADC #n,Rd 3/8	JMPL lab 3/9	JMPL *Rp 2/8	JMPL *lab[B] 3/11	POP A 1/9	POP B 1/9	POP Rd 2/7	TRAP 6 1/14	RTS 1/9
A	JLE ra 2/5	SUB Rs,A 2/7	SUB #n,A 2/6	SUB Rs,B 2/7	SUB Rs,Rd 3/9	SUB #n,B 2/6	SUB B,A 1/8	SUB #n,Rd 3/8	MOV & lab,A 3/10	MOV *Rp,A 2/9	MOV *lab[B],A 3/12	DJNZ A,#ra 2/10	DJNZ B,#ra 2/10	DJNZ Rd,#ra 3/8	TRAP 5 1/14	RTI 1/12
B	JHS ra 2/5	SBB Rs,A 2/7	SBB #n,A 2/6	SBB Rs,B 2/7	SBB Rs,Rd 3/9	SBB #n,B 2/6	SBB B,A 1/8	SBB #n,Rd 3/8	MOV A, & lab 3/10	MOV A, *Rp 2/9	MOV A,*lab[B] 3/12	COMPL A 1/8	COMPL B 1/8	COMPL Rd 2/6	TRAP 4 1/14	PUSH ST 1/8

† All conditional jumps (opcodes 01–0F), BTJO, BTJZ, and DJNZ instructions use two additional cycles if the branch is taken. The BTJO, BTJZ, and DJNZ instructions have a relative address as the last operand.

Table 22. TMS370 Family Opcode/Instruction Map† (Continued)

LSN \ MSN	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
C	JNV ra 2/5	MPY Rs,A 2/46	MPY #n,A 2/45	MPY Rs,B 2/46	MPY Rs,Rd 3/48	MPY #n,B 2/45	MPY B,A 1/47	MPY #n,Rs 3/47	BR lab 3/9	BR *Rp 2/8	BR *lab[B] 3/11	RR A 1/8	RR B 1/8	RR Rd 2/6	TRAP 3 1/14	POP ST 1/8
D	JGE ra 2/5	CMP Rs,A 2/7	CMP #n,A 2/6	CMP Rs,B 2/7	CMP Rs,Rd 3/9	CMP #n,B 2/6	CMP B,A 1/8	CMP #n,Rd 3/8	CMP & lab,A 3/11	CMP *Rp,A 2/10	CMP *lab[B],A 3/13	RRC A 1/8	RRC B 1/8	RRC Rd 2/6	TRAP 2 1/14	LDSP 1/7
E	JG ra 2/5	DAC Rs,A 2/9	DAC #n,A 2/8	DAC Rs,B 2/9	DAC Rs,Rd 3/11	DAC #n,B 2/8	DAC B,A 1/10	DAC #n,Rd 3/10	CALL lab 3/13	CALL *Rp 2/12	CALL *lab[B] 3/15	RL A 1/8	RL B 1/8	RL Rd 2/6	TRAP 1 1/14	STSP 1/8
F	JLO ra 2/5	DSB Rs,A 2/9	DSB #n,A 2/8	DSB Rs,B 2/9	DSB Rs,Rd 3/11	DSB #n,B 2/8	DSB B,A 1/10	DSB #n,Rd 3/10	CALLR lab 3/15	CALLR *Rp 2/14	CALLR *lab[B] 3/17	RLC A 1/8	RLC B 1/8	RLC Rd 2/6	TRAP 0 1/14	NOP 1/7

Second byte of two-byte instructions (F4xx):			
	F4	8	MOVW *n[Rn] 4/15
			DIV Rn.A 3/14-63
	F4	9	JMPL *n[Rn] 4/16
	F4	A	MOV *n[Rn],A 4/17
	F4	B	MOV A,*n[Rn] 4/16
	F4	C	BR *n[Rn] 4/16
	F4	D	CMP *n[Rn],A 4/18
	F4	E	CALL *n[Rn] 4/20
	F4	F	CALLR *n[Rn] 4/22

Legend:
* = Indirect addressing operand prefix
& = Direct addressing operand prefix
# = immediate operand
#16 = immediate 16-bit number
lab = 16-label
n = immediate 8-bit number
Pd = Peripheral register containing destination type
Pn = Peripheral register
Ps = Peripheral register containing source byte
ra = Relative address
Rd = Register containing destination type
Rn = Register file
Rp = Register pair
Rpd = Destination register pair
Rps = Source Register pair
Rs = Register containing source byte

† All conditional jumps (opcodes 01–0F), BTJO, BTJZ, and DJNZ instructions use two additional cycles if the branch is taken. The BTJO, BTJZ, and DJNZ instructions have a relative address as the last operand.

development system support

The TMS370 family development support tools include an assembler, a C compiler, a linker, compact development tool, and an EEPROM/UVEPROM programmer.

- Assembler/linker (Part No. TMDS3740850–02 for PC)
  - Provides extensive macro capability
  - Allows high-speed operation
  - Includes format conversion utilities for popular formats
- ANSI C Compiler (Part No. TMDS3740855–02 for PC, Part No. TMDS3740555–09 for HP700™, Sun-3™ or Sun-4™)
  - Generates assembly code for the TMS370 that can be inspected easily
  - Improves code execution speed and reduces code size with optional optimizer pass
  - Enables the user to directly reference the TMS370 port registers by using a naming convention
  - Provides flexibility in specifying the storage for data objects
  - Interfaces C functions and assembly functions easily
  - Includes assembler and linker
- CDT370 (compact development tool) Timer real-time in-circuit emulation
  - Base (Part No. EDSCDT37T – for PC, requires cable)
    - Cable for 68-pin PLCC (Part No. EDSTRG68PLCC)
  - Provides EEPROM and EPROM programming support
  - Allows inspection and modification of memory locations
  - Uploads/downloads program and data memory
  - Executes programs and software routines
  - Includes 1024 samples trace buffer
  - Includes single-step executable instructions
  - Uses software breakpoints to halt program execution at selected address
- Microcontroller programmer
  - Base (Part No. TMDS3760500A – for PC, requires programmer head)
    - Single unit head for 68-pin PLCC (Part No. TMDS3780510A)
  - PC-based, window/function-key-oriented user interface for ease of use and rapid learning environment
- Starter Kit (Part No. TMDS37000 – for PC)
  - Includes TMS370 Assembler diskette and documentation
  - Includes TMS370 Simulator
  - Includes programming adapter board and programming software
  - Not included – to be supplied by the user:

HP700 is a trademark of Hewlett-Packard Company.
Sun-3 and Sun-4 are trademarks of Sun Microsystems, Inc.

development system support (continued)

- + 5 V power supply
- ZIF sockets
- 9-pin RS232 cable

device numbering conventions

Figure 17 illustrates the numbering and symbol nomenclature for the TMS370Cx6x family.

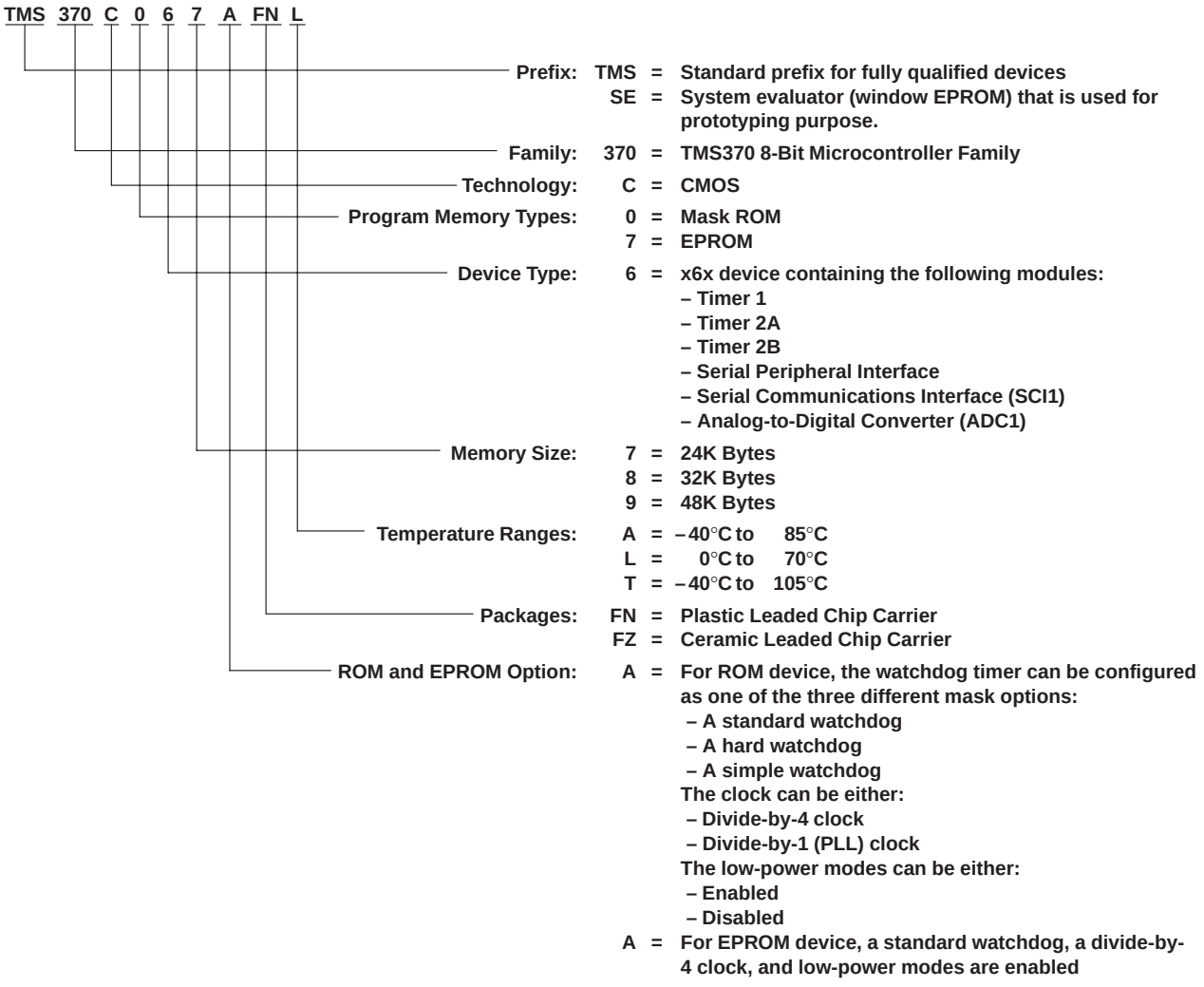


Figure 17. TMS370Cx6x Family Nomenclature

device part numbers

Table 23 lists all the ‘x6x devices available. The device part number nomenclature is designed to assist ordering. Upon ordering, the customer must specify not only the device part number, but also the clock and watchdog timer options desired. Remember that each device can have only one of the possible three watchdog timer options and one of the two clock options. The options to be specified pertain solely to orders involving ROM devices.

Table 23. Device Part Numbers

DEVICE PART NUMBERS FOR 68 PINS
TMS370C067AFNA TMS370C067AFNL TMS370C067AFNT
TMS370C068AFNA TMS370C068AFNL TMS370C068AFNT
TMS370C069AFNA TMS370C069AFNL TMS370C069AFNT
TMS370C768AFNT
TMS370C769AFNT
SE370C768AFZT† SE370C769AFZT†

† System evaluators are for use only in prototype environment and their reliability has not been characterized.

new code release form

Figure 18 shows a sample of the new code release form.

NEW CODE RELEASE FORM
TEXAS INSTRUMENTS
TMS370 MICROCONTROLLER PRODUCTS

DATE: _____

To release a new customer algorithm to TI incorporated into a TMS370 family microcontroller, complete this form and submit with the following information:

1. A ROM description in object form on Floppy Disk, Modem XFR, or EPROM (Verification file will be returned via same media)
2. An attached specification if not using TI standard specification as incorporated in TI's applicable device data book.

Company Name: _____
Street Address: _____
Street Address: _____
City: _____ State _____ Zip _____

Customer Part Number: _____
Customer Application: _____

TMS370 Device: _____

TI Customer ROM Number: _____
(provided by Texas Instruments)

OSCILLATOR FREQUENCY

	MIN	TYP	MAX
[] External Drive (CLKIN)	_____	_____	_____
[] Crystal	_____	_____	_____
[] Ceramic Resonator	_____	_____	_____

[] Supply Voltage MIN: _____ MAX: _____
(std range: 4.5V to 5.5V)

TEMPERATURE RANGE
[] 'L': 0° to 70°C (standard)
[] 'A': –40° to 85°C
[] 'T': –40° to 105°C

SYMBOLIZATION
[] TI standard symbolization
[] TI standard w/customer part number
[] Customer symbolization
(per attached spec, subject to approval)

Contact Mr./Ms.: _____
Phone: (_____)_____ Ext.: _____

Customer Purchase Order Number: _____

Customer Print Number *Yes:____ # _____
No: ____ (Std. spec to be followed)
*If Yes: Customer must provide "print" to TI w/NCRF for approval before ROM code processing starts.

CONTACT OPTIONS FOR THE 'A' VERSION TMS370 MICROCONTROLLERS

Low Power Modes	Watchdog counter	Clock Type
[] Enabled	[] Standard	[] Standard (/4)
[] Disabled	[] Hard Enabled	[] PLL (/1)
	[] Simple Counter	

NOTE:
Non 'A' version ROM devices of the TMS370 microcontrollers will have the "Low-power modes Enabled", "Divide-by-4" Clock, and "Standard" Watchdog options. See the *TMS370 Family User's Guide* (literature number SPNU127) or the *TMS370 Family Data Manual* (literature number SPNS014B).

PACKAGE TYPE
[] 'N' 28-pin PDIP
[] "FN" 28-pin PLCC
[] "N" 40-pin PDIP
[] "NJ" 40-pin PSDIP (formerly known as N2)
[] "FN" 44-pin PLCC
[] "FN" 68-pin PLCC
[] "NM" 64-pin PSDIP

BUS EXPANSION
[] YES [] NO

NON-STANDARD SPECIFICATIONS:
ALL NON-STANDARDS SPECIFICATIONS MUST BE APPROVED BY THE TI ENGINEERING STAFF: If the customer requires expedited production material (i.e., product which must be started in process prior to prototype approval and full production release) and non-standard spec issues are not resolved to the satisfaction of both the customer and TI in time for a scheduled shipment, the specification parameters in question will be processed/tested to the standard TI spec. Any such devices which are shipped without conformance to a mutually approved spec, will be identified by a 'P' in the symbolization preceding the TI part number.

RELEASE AUTHORIZATION:
This document, including any referenced attachments, is and will be the controlling document for all orders placed for this TI custom device. Any changes must be in writing and mutually agreed to by both the customer and TI. The prototype cycletime commences when this document is signed off and the verification code is approved by the customer.

1. Customer: _____ Date: _____

2. TI: Field Sales: _____
Marketing: _____
Prod. Eng.: _____
Proto. Release: _____

Figure 18. Sample New Code Release Form

Table 24 is a collection of all the peripheral file frames using the ’Cx6x, (provided for a quick reference).

Table 24. Peripheral File Frame Compilation

PF	BIT 7	BIT 6	BIT 5	BIT 4	BIT 3	BIT 2	BIT 1	BIT 0	REG
	System Configuration Registers								
P010	COLD START	**OSC POWER**	**PF AUTO WAIT**	OSC FLT FLAG	MC PIN WPO	MC PIN DATA	—	µP/µC MODE	SCCR0
P011		—	—	**AUTOWAIT DISABLE**	—	**MEMORY DISABLE**	—	—	SCCR1
P012	**HALT/ STANDBY**	**PWRDWN/ IDLE**	—	**BUS STEST**	**CPU STEST**	—	**INT1 NMI**	**PRIVILEGE DISABLE**	SCCR2
P013	Reserved								
P014	BUSY	VPPS	—	—	—	—	W0	EXE	EPCTLH
P015 to P016	Reserved								
P017	INT1 FLAG	INT1 PIN DATA	—	—	—	INT1 POLARITY	INT1 PRIORITY	INT1 ENABLE	INT1
P018	INT2 FLAG	INT2 PIN DATA	—	INT2 DATA DIR	INT2 DATA OUT	INT2 POLARITY	INT2 PRIORITY	INT2 ENABLE	INT2
P019	INT3 FLAG	INT3 PIN DATA	—	INT3 DATA DIR	INT3 DATA OUT	INT3 POLARITY	INT3 PRIORITY	INT3 ENABLE	INT3
P01A	BUSY	—	—	—	—	AP	W1W0	EXE	DEECTL
P01B	Reserved								
P01C	BUSY	VPPS	—	—	—	—	W0	EXE	EPCTLM
P01D	Reserved								
P01E	BUSY	VPPS	—	—	—	—	W0	EXE	EPCTLL
P01F	Reserved								
	Digital Port Control Registers								
P020	Reserved								APORT1
P021	Port A Control Register 2								APORT2
P022	Port A Data								ADATA
P023	Port A Direction								ADIR
P024	Reserved								BPORT1
P025	Port B Control Register 2								BPORT2
P026	Port B Data								BDATA
P027	Port B Direction								BDIR
P028	Reserved								CPORT1
P029	Port C Control Register 2								CPORT2
P02A	Port C Data								CDATA
P02B	Port C Direction								CDIR
P02C	Port D Control Register 1					—	—	—	DPORT1
P02D	Port D Control Register 2†					—	—	—	DPORT2
P02E	Port D Data					—	—	—	DDATA
P02F	Port D Direction					—	—	—	DDIR

† To configure pin D3 as SYSCLK, set port D control register 2 = 08h.

Table 24. Peripheral File Frame Compilation (Continued)

PF	BIT 7	BIT 6	BIT 5	BIT 4	BIT 3	BIT 2	BIT 1	BIT 0	REG
	SPI Module Control Memory Map								
P030	SPI SW RESET	CLOCK POLARITY	SPI BIT RATE2	SPI BIT RATE1	SPI BIT RATE0	SPI CHAR2	SPI CHAR1	SPI CHAR0	SPICCR
P031	RECEIVER OVERRUN	SPI INT FLAG	—	—	—	MASTER/ SLAVE	TALK	SPI INT ENA	SPICTL
P032 to P036	Reserved								
P037	RCVD7	RCVD6	RCVD5	RCVD4	RCVD3	RCVD2	RCVD1	RCVD0	SPIBUF
P038	Reserved								
P039	SDAT7	SDAT6	SDAT5	SDAT4	SDAT3	SDAT2	SDAT1	SDAT0	SPIDAT
P03A to P03C	Reserved								
P03D	—	—	—	—	SPICLK DATA IN	SPICLK DATA OUT	SPICLK FUNCTION	SPICLK DATA DIR	SPIPC1
P03E	SPISIMO DATA IN	SPISIMO DATA OUT	SPISIMO FUNCTION	SPISIMO DATA DIR	SPISOMI DATA IN	SPISOMI DATA OUT	SPISOMI FUNCTION	SPISOMI DATA DIR	SPIPC2
P03F	**SPI STEST**	**SPI PRIORITY**	**SPI ESPEN**	—	—	—	—	—	SPIPRI
	Timer 1 Module Register Memory Map								
	Modes: Dual-Compare and Capture/Compare								
P040	Bit 15	T1 Counter MSbyte						Bit 8	T1CNTR
P041	Bit 7	T1 Counter LSbyte						Bit 0	
P042	Bit 15	Compare Register MSbyte						Bit 8	T1C
P043	Bit 7	Compare Register LSbyte						Bit 0	
P044	Bit 15	Capture/Compare Register MSbyte						Bit 8	T1CC
P045	Bit 7	Capture/Compare Register LSbyte						Bit 0	
P046	Bit 15	Watchdog Counter MSbyte						Bit 8	WDCNTR
P047	Bit 7	Watchdog Counter LSbyte						Bit 0	
P048	Bit 15	Watchdog Reset Key						Bit 0	WDRST
P049	WD OVRFL TAP SEL†	WD INPUT SELECT2†	WD INPUT SELECT1†	WD INPUT SELECT0†	—	T1 INPUT SELECT2	T1 INPUT SELECT1	T1 INPUT SELECT0	T1CTL1
P04A	WD OVRFL RST ENA†	WD OVRFL INT ENA	WD OVRFL INT FLAG	T1 OVRFL INT ENA	T1 OVRFL INT FLAG	—	—	T1 SW RESET	T1CTL2
	Mode: Dual-Compare								
P04B	T1EDGE INT FLAG	T1C2 INT FLAG	T1C1 INT FLAG	—	—	T1EDGE INT ENA	T1C2 INT ENA	T1C1 INT ENA	T1CTL3
P04C	T1 MODE = 0	T1C1 OUT ENA	T1C2 OUT ENA	T1C1 RST ENA	T1CR OUT ENA	T1EDGE POLARITY	T1CR RST ENA	T1EDGE DET ENA	T1CTL4
	Mode: Capture/Compare								
P04B	T1EDGE INT FLAG	—	T1C1 INT FLAG	—	—	T1EDGE INT ENA	—	T1C1 INT ENA	T1CTL3

† Once the WD OVRFL RST ENA bit is set, these bits cannot be changed until a reset; this applies only to the standard watchdog and to simple counter. In the hard watchdog, these bits can be modified at any time; the WD INPUT SELECT2 bits are ignored.

Table 24. Peripheral File Frame Compilation (Continued)

PF	BIT 7	BIT 6	BIT 5	BIT 4	BIT 3	BIT 2	BIT 1	BIT 0	REG
	Modes: Dual-Compare and Capture/Compare								
P04C	T1 MODE = 1	T1C1 OUT ENA	—	T1C1 RST ENA	—	T1EDGE POLARITY	—	T1EDGE DET ENA	T1CTL4
P04D	—	—	—	—	T1EVT DATA IN	T1EVT DATA OUT	T1EVT FUNCTION	T1EVT DATA DIR	T1PC1
P04E	T1PWM DATA IN	T1PWM DATA OUT	T1PWM FUNCTION	T1PWM DATA DIR	T1IC/CR DATA IN	T1IC/CR DATA OUT	T1IC/CR FUNCTION	T1IC/CR DATA DIR	T1PC2
P04F	**T1 STEST**	**T1 PRIORITY**	—	—	—	—	—	—	T1PRI
	Serial Communications Interface 1 Memory Map								
P050	STOP BITS	EVEN/ODD PARITY	PARITY ENABLE	ASYNC/ ISOSYNC	ADDRESS/ IDLE WUP	SCI CHAR2	SCI CHAR1	SCI CHAR0	SCICCR
P051	—	—	SCI SW RESET	CLOCK	TXWAKE	SLEEP	TXENA	RXENA	SCICTL
P052	BAUDF (MSB)	BAUDE	BAUDD	BAUDC	BAUDB	BAUDA	BAUD9	BAUD8	BAUD MSB
P053	BAUD7	BAUD6	BAUD5	BAUD4	BAUD3	BAUD2	BAUD1	BAUD0 (LSB)	BAUD LSB
P054	TXRDY	TX EMPTY	—	—	—	—	—	SCI TX INT ENA	TXCTL
P055	RX ERROR	RXRDY	BRKDT	FE	OE	PE	RXWAKE	SCI RX INT ENA	RXCTL
P056	Reserved								
P057	RXDT7	RXDT6	RXDT5	RXDT4	RXDT3	RXDT2	RXDT1	RXDT0	RXBUF
P058	Reserved								
P059	TXDT7	TXDT6	TXDT5	TXDT4	TXDT3	TXDT2	TXDT1	TXDT0	TXBUF
P05A P05B P05C	Reserved								
P05D	—	—	—	—	SCICLK DATA IN	SCICLK DATA OUT	SCICLK FUNCTION	SCICLK DATA DIR	SCIPC1
P05E	SCITXD DATA IN	SCITXD DATA OUT	SCITXD FUNCTION	SCITXD DATA DIR	SCIRXD DATA IN	SCIRXD DATA OUT	SCIRXD FUNCTION	SCIRXD DATA DIR	SCIPC2
P05F	**SCI STEST**	**SCITX PRIORITY**	**SCIRX PRIORITY**	**SCI ESPEN**	—	—	—	—	SCIPRI
	Timer 2A Control Registers Memory Map								
	Modes: Dual-Compare and Dual-Capture								
P060	Bit 15	T2A Counter MSbyte						Bit 8	T2ACNTR
P061	Bit 7	T2A Counter LSbyte						Bit 0	
P062	Bit 15	Compare Register MSbyte						Bit 8	T2AC
P063	Bit 7	Compare Register LSbyte						Bit 0	
P064	Bit 15	Capture/Compare Register MSbyte						Bit 8	T2ACC
P065	Bit 7	Capture/Compare Register LSbyte						Bit 0	
P066	Bit 15	Capture Register 2 MSbyte						Bit 8	T2AIC
P067	Bit 7	Capture Register 2 LSbyte						Bit 0	
P06A	—	—	—	T2A OVRFL INT ENA	T2A OVRFL INT FLAG	T2A INPUT SELECT1	T2A INPUT SELECT0	T2A SW RESET	T2ACTL1

Table 24. Peripheral File Frame Compilation (Continued)

PF	BIT 7	BIT 6	BIT 5	BIT 4	BIT 3	BIT 2	BIT 1	BIT 0	REG
	Mode: Dual-Compare								
P06B	T2AEDGE1 INT FLAG	T2AC2 INT FLAG	T2AC1 INT FLAG	—	—	T2AEDGE1 INT ENA	T2AC2 INT ENA	T2AC1 INT ENA	T2ACTL2
P06C	T2A MODE = 0	T2AC1 OUT ENA	T2AC2 OUT ENA	T2AC1 RST ENA	T2AEDGE1 OUT ENA	T2AEDGE1 POLARITY	T2AEDGE1 RST ENA	T2AEDGE1 DET ENA	T2ACTL3
	Mode: Dual-Capture								
P06B	T2AEDGE1 INT FLAG	T2AEDGE2 INT FLAG	T2AC1 INT FLAG	—	—	T2AEDGE1 INT ENA	T2AEDGE2 INT ENA	T2AC1 INT ENA	T2ACTL2
P06C	T2A MODE = 1	—	—	T2AC1 RST ENA	T2AEDGE2 POLARITY	T2AEDGE1 POLARITY	T2AEDGE2 DET ENA	T2AEDGE1 DET ENA	T2ACTL3
	Modes: Dual-Compare and Dual-Capture								
P06D	—	—	—	—	T2AEVT DATA IN	T2AEVT DATA OUT	T2AEVT FUNCTION	T2AEVT DATA DIR	T2APC1
P06E	T2AIC2/PWM DATA IN	T2AIC2/PWM DATA OUT	T2AIC2/PWM FUNCTION	T2AIC2/PWM DATA DIR	T2AIC1/CR DATA IN	T2AIC1/CR DATA OUT	T2AIC1/CR FUNCTION	T2AIC1/CR DATA DIR	T2APC2
P06F	**T2A STEST**	**T2A PRIORITY**	—	—	—	—	—	—	T2APRI
	Analog-To-Digital Converter 1 Control Registers								
P070	CONVERT START	SAMPLE START	REF VOLT SELECT2	REF VOLT SELECT1	REF VOLT SELECT0	AD INPUT SELECT2	AD INPUT SELECT1	AD INPUT SELECT0	ADCTL
P071	—	—	—	—	—	AD READY	AD INT FLAG	AD INT ENA	ADSTAT
P072	A-to-D Conversion Data Register								ADDATA
P073 to P07C	Reserved								
P07D	Port E Data Input Register								ADIN
P07E	Port E Input Enable Register								ADENA
P07F	**AD STEST**	**AD PRIORITY**	**AD ESPEN**	—	—	—	—	—	ADPRI
	Timer 2B Control Registers Memory Map								
	Modes: Dual-Compare and Dual-Capture								
P080	BIT 15	T2B Counter MSbyte						BIT 8	T2BCNTR
P081	BIT 7	T2B Counter LSbyte						BIT 0	
P082	BIT 15	Compare Register MSbyte						BIT 8	T2BC
P083	BIT 7	Compare Register LSbyte						BIT 0	
P084	BIT 15	Capture/Compare Register MSbyte						BIT 8	T2BCC
P085	BIT 7	Capture/Compare Register LSbyte						BIT 0	
P086	BIT 15	Capture Register 2 MSbyte						BIT 8	T2BIC
P087	BIT 7	Capture Register 2 LSbyte						BIT 0	
P08A	—	—	—	T2B OVRFL INT ENA	T2B OVRFL INT FLAG	T2B INPUT SELECT1	T2B INPUT SELECT0	T2B SW RESET	T2BCTL1

Table 24. Peripheral File Frame Compilation (Continued)

PF	BIT 7	BIT 6	BIT 5	BIT 4	BIT 3	BIT 2	BIT 1	BIT 0	REG
	Mode: Dual-Compare								
P08B	T2BEDGE1 INT FLAG	T2BC2 INT FLAG	T2BC1 INT FLAG	—	—	T2BEDGE1 INT ENA	T2BC2 INT ENA	T2BC1 INT ENA	T2BCTL2
P08C	T2B MODE = 0	T2BC1 OUT ENA	T2BC2 OUT ENA	T2BC1 RST ENA	T2BEDGE1 OUT ENA	T2BEDGE1 POLARITY	T2BEDGE1 RST ENA	T2BEDGE1 DET ENA	T2BCTL3
	Mode: Dual-Capture								
P08B	T2BEDGE1 INT FLAG	T2BEDGE2 INT FLAG	T2BC1 INT FLAG	—	—	T2BEDGE1 INT ENA	T2BEDGE2 INT ENA	T2BC1 INT ENA	T2BCTL2
P08C	T2B MODE = 1	—	—	T2BC1 RST ENA	T2BEDGE2 POLARITY	T2BEDGE1 POLARITY	T2BEDGE2 DET ENA	T2BEDGE1 DET ENA	T2BCTL3
	Modes: Dual-Compare and Dual-Capture								
P08D	—	—	—	—	T2BEVT DATA IN	T2BEVT DATA OUT	T2BEVT FUNCTION	T2BEVT DATA DIR	T2BPC1
P08E	T2BIC2/PWM DATA IN	T2BIC2/PWM DATA OUT	T2BIC2/PWM FUNCTION	T2BIC2/PWM DATA DIR	T2BIC1/CR DATA IN	T2BIC1/CR DATA OUT	T2BIC1/CR FUNCTION	T2BIC1/CR DATA DIR	T2BPC2
P08F	**T2B STEST**	**T2B PRIORITY**	—	—	—	—	—	—	T2BPRI

absolute maximum ratings over operating free-air temperature range (unless otherwise noted)†

Supply voltage range‡, V_{CC1}, V_{CC2}, V_{CC3} (see Note 1) . . . . . –0.6 V to 7 V
Input voltage range, All pins except MC . . . . . –0.6 V to 7 V
MC . . . . . –0.6 V to 14 V
Input clamp current, I_{IK} ($V_I < 0$ or $V_I > V_{CC1}$) . . . . . ±20 mA
Output clamp current, I_{OK} ($V_O < 0$ or $V_O > V_{CC1}$) . . . . . ±20 mA
Continuous output current per buffer, I_O (V_O = 0 to V_{CC1})(see Note 1) . . . . . ±10 mA
Maximum I_{CC} current . . . . . 170 mA
Maximum I_{SS} current . . . . . – 170 mA
Continuous power dissipation . . . . . 1 W
Operating free-air temperature range, T_A: L version . . . . . 0°C to 70°C
A version . . . . . – 40°C to 85°C
T version . . . . . – 40°C to 105°C
Storage temperature range, T_{stg} . . . . . –65°C to 150°C

† Stresses beyond those listed under “absolute maximum ratings” may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under “recommended operating conditions” is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

‡ $V_{CC1} = V_{CC}$

NOTE 1: Electrical characteristics are specified with all output buffers loaded with the specified I_O current. Exceeding the specified I_O current in any buffer can affect the levels on other buffers.

recommended operating conditions

			MIN	NOM	MAX	UNIT
V_{CC1}	Supply voltage (see Note 2)		4.5	5	5.5	V
	RAM data-retention supply voltage (see Note 3)		3		5.5	
V_{CC2}	Digital I/O supply voltage (see Note 2)		4.5	5	5.5	V
V_{CC3}	Analog supply voltage (see Note 2)		4.5	5	5.5	
V_{SS2}	Digital I/O supply ground		– 0.3	0	0.3	V
V_{SS3}	Analog supply ground		– 0.3	0	0.3	V
V_{IL}	Low-level input voltage	All pins except MC	V_{SS1}		0.8	V
		MC, normal operation	V_{SS1}		0.3	V
V_{IH}	High-level input voltage	All pins except MC, XTAL2/CLKIN, and $\overline{\text{RESET}}$	2		V_{CC1}	V
		MC (non-WPO mode)	$V_{CC1}-0.3$		$V_{CC1}+0.3$	
		XTAL2/CLKIN	$0.8\ V_{CC1}$		V_{CC1}	
		$\overline{\text{RESET}}$	$0.7\ V_{CC1}$		V_{CC1}	
V_{MC}	MC (mode control) voltage (see Note 4)	EEPROM write protect override (WPO)	11.7	12	13	V
		EPROM programming voltage (V_{PP})	13	13.2	13.5	
		Microprocessor	$V_{CC1}-0.3$		$V_{CC1}+0.3$	
		Microcomputer	V_{SS1}		0.3	
T_A	Operating free-air temperature	L version	0		70	°C
		A version	– 40		85	
		T version	– 40		105	

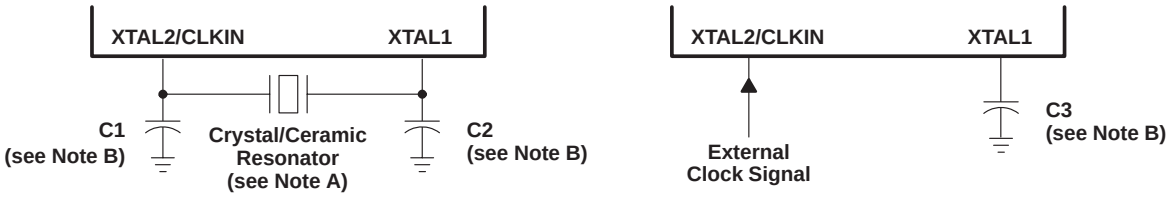
NOTES: 2. Unless otherwise noted, all voltage values are with respect to V_{SS1}.
3. $\overline{\text{RESET}}$ must be activated externally when V_{CC1} or SYSCLK is out of the recommended operating range.
4. The basic microcomputer and microprocessor operating modes are selected by the voltage level applied to the dedicated MC pin two system-clock cycles (t_c) before $\overline{\text{RESET}}$ goes inactive (high). The WPO mode can be selected anytime that a sufficient voltage is present on MC.

electrical characteristics over recommended operating free-air temperature range (unless otherwise noted)

PARAMETER			TEST CONDITIONS		MIN	TYP	MAX	UNIT
V_{OL}	Low-level output voltage		I_{OL} = 1.4 mA				0.4	V
V_{OH}	High-level output voltage		I_{OH} = –50 µA		$0.9V_{CC1}$			V
			I_{OH} = –2 mA		2.4			
I_I	Input current	MC	0 V < V_I ≤ 0.3 V				10	µA
			0.3 V < V_I < V_{CC1} – 0.3 V				50	
			V_{CC1}–0.3 V ≤ V_I ≤ V_{CC1}+0.3 V				10	
			V_{CC1} + 0.3 V < V_I ≤ 13 V				650	
			12 V ≤ V_I ≤ 13 V	(See Note 6)			50	mA
		I/O pins	0 V ≤ V_I ≤ V_{CC1}				± 10	µA
I_{OL}	Low-level output current		V_{OL} = 0.4 V		1.4			mA
I_{OH}	High-level output current		V_{OH} = 0.9 V_{CC1}		– 50			µA
			V_{OH} = 2.4 V		– 2			mA
I_{CC}	Supply current (operating mode) OSC POWER bit = 0 (see Note 9)	TMS370Cx67A TMS370Cx68A	SYSCLK = 5 MHz	See Notes 7 and 8		35	56	mA
		TMS370Cx67A TMS370Cx68A	SYSCLK = 3 MHz	See Notes 7 and 8		25	36	mA
		TMS370Cx69A	SYSCLK = 3 MHz	See Notes 5 and 7		46	55	mA
		TMS370Cx67A TMS370Cx68A	SYSCLK = 0.5 MHz	See Notes 7 and 8		13	18	mA
		TMS370Cx69A	SYSCLK = 0.5 MHz	See Notes 5 and 7		22	28	
	Supply current (STANDBY mode) OSC POWER bit = 0 (see Note 10)		SYSCLK = 5 MHz	See Notes 7 and 8		12	17	mA
			SYSCLK = 3 MHz	See Notes 7 and 8		8	11	
			SYSCLK = 0.5 MHz	See Notes 7 and 8		2.5	3.5	
	Supply current (STANDBY mode) OSC POWER bit = 1 (see Note 11)		SYSCLK = 3 MHz	See Notes 7 and 8		6	8.6	mA
			SYSCLK = 0.5 MHz	See Notes 7 and 8		2	3	
	Supply current (HALT mode)		XTAL2/CLKIN < 0.2 V	See Note 7		2	30	µA

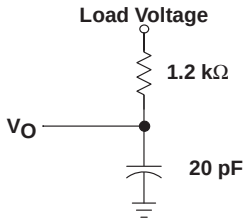
NOTES: 5. 'x69 operates up to 3 MHz SYSCLK. XTAL2/CLKIN is driven with an external square wave signal with 50% duty cycle and rise and fall times less than 10 ns.
6. Input current I_{PP} is a maximum of 50 mA only when programming EPROM.
7. Single chip mode, ports configured as inputs or outputs with no load. All inputs ≤ 0.2 V or ≥ V_{CC1} – 0.2V.
8. XTAL2/CLKIN is driven with an external square wave signal with 50% duty cycle and rise and fall times less than 10 ns. Current can be higher with a crystal oscillator. At 5 MHz SYSCLK, this extra current = 0.01 mA x (total load capacitance + crystal capacitance in pF).
9. Maximum operating current for TMS370Cx6x = 10 (SYSCLK) + 5.8 mA.
10. Maximum standby current for TMS370Cx6x = 3 (SYSCLK) + 2 mA. (OSC POWER bit = 0).
11. Maximum standby current for TMS370Cx6x = 2.24 (SYSCLK) + 1.9 mA. (OSC POWER bit = 1, only valid up to 3 MHz SYSCLK).

PARAMETER MEASUREMENT INFORMATION



NOTES: A. The crystal/ceramic resonator frequency is four times the reciprocal of the system clock period.
B. The values of C1 and C2 typically are 15 pF and the value of C3 is typically 50pF. See the manufacturer's recommendations for ceramic resonators.

Figure 19. Recommended Crystal/Clock Connections (See Note A)



Case 1: $V_O = V_{OH}$ = 2.4 V; Load Voltage = 0 V
Case 2: $V_O = V_{OL}$ = 0.4 V; Load Voltage = 2.1 V

NOTE A: All measurements are made with the pin loading as shown unless otherwise noted. All measurements are made with XTAL2/CLKIN driven by an external square wave signal with a 50% duty cycle and rise and fall times less than 10 ns unless otherwise stated.

Figure 20. Typical Output Load Circuit

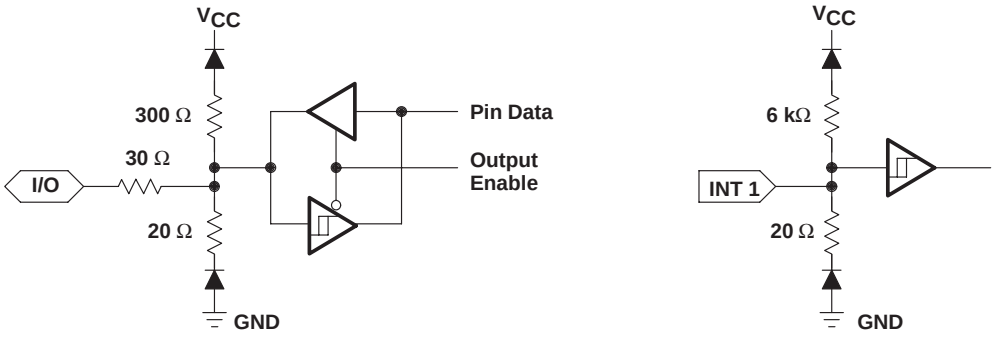


Figure 21. Typlcal Buffer Circuitry

PARAMETER MEASUREMENT INFORMATION

timing parameter symbology

Timing parameter symbols have been created in accordance with JEDEC Standard 100. In order to shorten the symbols, some of the pin names and other related terminology have been abbreviated as follows:

A	Address	RXD	SCIRXD
AR	Array	S	Slave mode
B	Byte	SC	SYSCLK
CI	XTAL2/CLKIN	SCC	SCICLK
D	Data	SIMO	SPISIMO
E	$\overline{\text{EDS}}$	SOMI	SPISOMI
FE	Final	SPC	SPICLK
IE	Initial	TXD	SCITXD
M	Master mode	W	Write
PGM	Program	WT	$\overline{\text{WAIT}}$
R	Read		

Lowercase subscripts and their meanings are:

c	cycle time (period)	r	rise time
d	delay time	su	setup time
f	fall time	v	valid time
h	hold time	w	pulse duration (width)

The following additional letters are used with these meanings:

H	High
L	Low
V	Valid
Z	High impedance

All timings are measured between high and low measurement points as indicated in Figure 22 and Figure 23.

Figure 22. XTAL2/CLKIN Measurement Points

Figure 23. General Measurement Points

external clocking requirements for clock divided by 4† (see Figure 24)

NO.	PARAMETER		MIN	MAX	UNIT
1	$t_{w(Cl)}$	Pulse duration, XTAL2/CLKIN (see Note 12)	20		ns
2	$t_{r(Cl)}$	Rise time, XTAL2/CLKIN		30	ns
3	$t_{f(Cl)}$	Fall time, XTAL2/CLKIN		30	ns
4	$t_{d(ClH-SCL)}$	Delay time, XTAL2/CLKIN rise to SYSCLK fall		100	ns
	CLKIN§	Crystal operating frequency	2	20	MHz
	SYSCLK¶	System clock‡	0.5	5	MHz

† For V_{IL} and V_{IH}, refer to recommended operating conditions table.
‡ SYSCLK = CLKIN/4
§ 'x69A operates up to 12 MHz CLKIN
¶ 'x69A operates up to 3 MHz SYSCLK
NOTE 12: This pulse can be either a high pulse, which extends from the earliest valid high to the final valid high in an XTAL2/CLKIN cycle, or a low pulse, which extends from the earliest valid low to the final valid low in an XTAL2/CLKIN cycle.

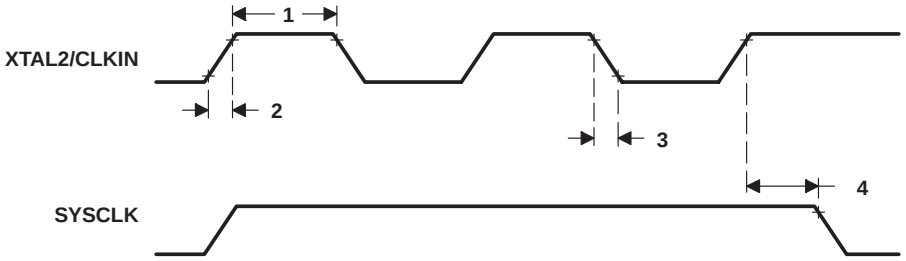


Figure 24. External Clock Divide-by-4

external clocking requirements for clock divided by 1 (PLL)† (see Figure 25)

NO.	PARAMETER		MIN	MAX	UNIT
1	$t_{w(Cl)}$	Pulse duration, XTAL2/CLKIN (see Note 12)	20		ns
2	$t_{r(Cl)}$	Rise time, XTAL2/CLKIN		30	ns
3	$t_{f(Cl)}$	Fall time, XTAL2/CLKIN		30	ns
4	$t_{d(ClH-SCH)}$	Delay time, XTAL2/CLKIN rise to SYSCLK rise		100	ns
	CLKIN#	Crystal operating frequency	2	5	MHz
	SYSCLK¶	System clock‖	2	5	MHz

† For V_{IL} and V_{IH}, refer to recommended operating conditions table.
¶ 'x69A operates up to 3 MHz SYSCLK
# 'x69A operates up to 3 MHz CLKIN (for divide-by-1 clock option)
‖ SYSCLK = CLKIN/1
NOTE 12: This pulse can be either a high pulse, which extends from the earliest valid high to the final valid high in an XTAL2/CLKIN cycle, or a low pulse, which extends from the earliest valid low to the final valid low in an XTAL2/CLKIN cycle.

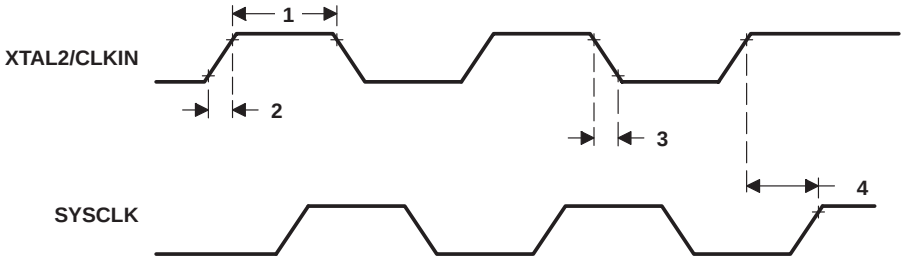


Figure 25. External Clock Divide-by-1

general purpose output signal switching time requirements (see Figure 26)

		MIN	NOM	MAX	UNIT
t_r	Rise time		30		ns
t_f	Fall time		30		ns

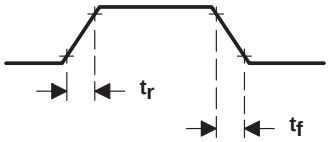


Figure 26. Signal Switching Timing

recommended EEPROM timing requirements for programming

		MIN	MAX	UNIT
$t_{w(PGM)B}$	Pulse duration, programming signal to ensure valid data is stored (byte mode)	10		ms
$t_{w(PGM)AR}$	Pulse duration, programming signal to ensure valid data is stored (array mode)	20		ms

recommended EPROM operating conditions for programming

			MIN	NOM	MAX	UNIT
V_{CC1}	Supply voltage		4.75	5.5	6	V
V_{PP}	Supply voltage at MC pin		13	13.2	13.5	V
I_{PP}	Supply current at MC pin during programming (V_{PP} = 13 V)			30	50	mA
SYSCLK	System clock	Divide-by-4	0.5		5	MHz
		Divide-by-1	2		5	

recommended EPROM timing requirements for programming

		MIN	NOM	MAX	UNIT
$t_{w(EPGM)}$	Pulse duration, programming signal (see Note 13)	0.40	0.50	3	ms

NOTE 13: Programming pulse is active when both EXE (EPCTL.0) and V_{PPS} (EPCTL.6) are set.

switching characteristics and timing requirements for external read and write† (see Figure 27 and Figure 28)

NO.	PARAMETER			MIN	MAX	UNIT
5	t_c	Cycle time, SYSCLK (system clock)	Divide-by-4 clock	200	2000	ns
			Divide-by-1 PLL	200	500	
6	$t_{w(SCL)}$	Pulse duration, SYSCLK low		$0.5t_c$–25	$0.5t_c$	ns
7	$t_{w(SCH)}$	Pulse duration, SYSCLK high		$0.5t_c$	$0.5t_c$+20	ns
8	$t_{d(SCL-A)}$	Delay time, SYSCLK low to address R/$\overline{W}$ and $\overline{OCF}$ valid			$0.25t_c$+75	ns
9	$t_{v(A)}$	Valid time, address to $\overline{EDS}$, $\overline{CSE1}$, $\overline{CSH1}$, and $\overline{CSPF}$ low		$0.5t_c$–90		ns
10	$t_{su(D)}$	Setup time, write data time to $\overline{EDS}$ high		$0.75t_c$–80‡		ns
11	$t_{h(EH-A)}$	Hold time, address, R/$\overline{W}$ and $\overline{OCF}$ from $\overline{EDS}$, $\overline{CSE1}$, $\overline{CSH1}$ and $\overline{CSPF}$ high		$0.5t_c$–60		ns
12	$t_{h(EH-D)W}$	Hold time, write data time from $\overline{EDS}$ high		$0.75t_c$+15		ns
13	$t_{d(DZ-EL)}$	Delay time, data bus high impedance to $\overline{EDS}$ low (read cycle)		$0.25t_c$–35		ns
14	$t_{d(EH-D)}$	Delay time, $\overline{EDS}$ high to data bus enable (read cycle)		$1.25t_c$–40		ns
15	$t_{d(EL-DV)R}$	Delay time, $\overline{EDS}$ low to read data valid			t_c–95‡	ns
16	$t_{h(EH-D)R}$	Hold time, read time from $\overline{EDS}$ high		0		ns
17	$t_{su(WT-SCH)}$	Setup time, $\overline{WAIT}$ time to SYSCLK high		$0.25t_c$+70§		ns
18	$t_{h(SCH-WT)}$	Hold time, $\overline{WAIT}$ time from SYSCLK high		0		ns
19	$t_{d(EL-WTV)}$	Delay time, $\overline{EDS}$ low to $\overline{WAIT}$ valid			$0.5t_c$–60	ns
20	t_w	Pulse duration, $\overline{EDS}$, $\overline{CSE1}$, $\overline{CSH1}$ and $\overline{CSPF}$ low		t_c–80‡	t_c+40‡	ns
21	$t_{d(AV-DV)R}$	Delay time, address valid to read data valid			$1.5t_c$–115‡	ns
22	$t_{d(AV-WTV)}$	Delay time, address valid to $\overline{WAIT}$ valid			t_c–115	ns
23	$t_{d(AV-EH)}$	Delay time, address valid to $\overline{EDS}$ high (end of write)		$1.5t_c$–85‡		ns

† t_c = system-clock cycle time = 1/SYSCLK

‡ If wait states, PFWait, or the autowait feature is used, add t_c to this value for each wait state invoked.

§ If the autowait feature is enabled, the $\overline{WAIT}$ input can assume a “don’t care” condition until the third cycle of the access. The $\overline{WAIT}$ signal must be synchronized with the high pulse of the SYSCLK signal while still conforming to the minimum set-up time.

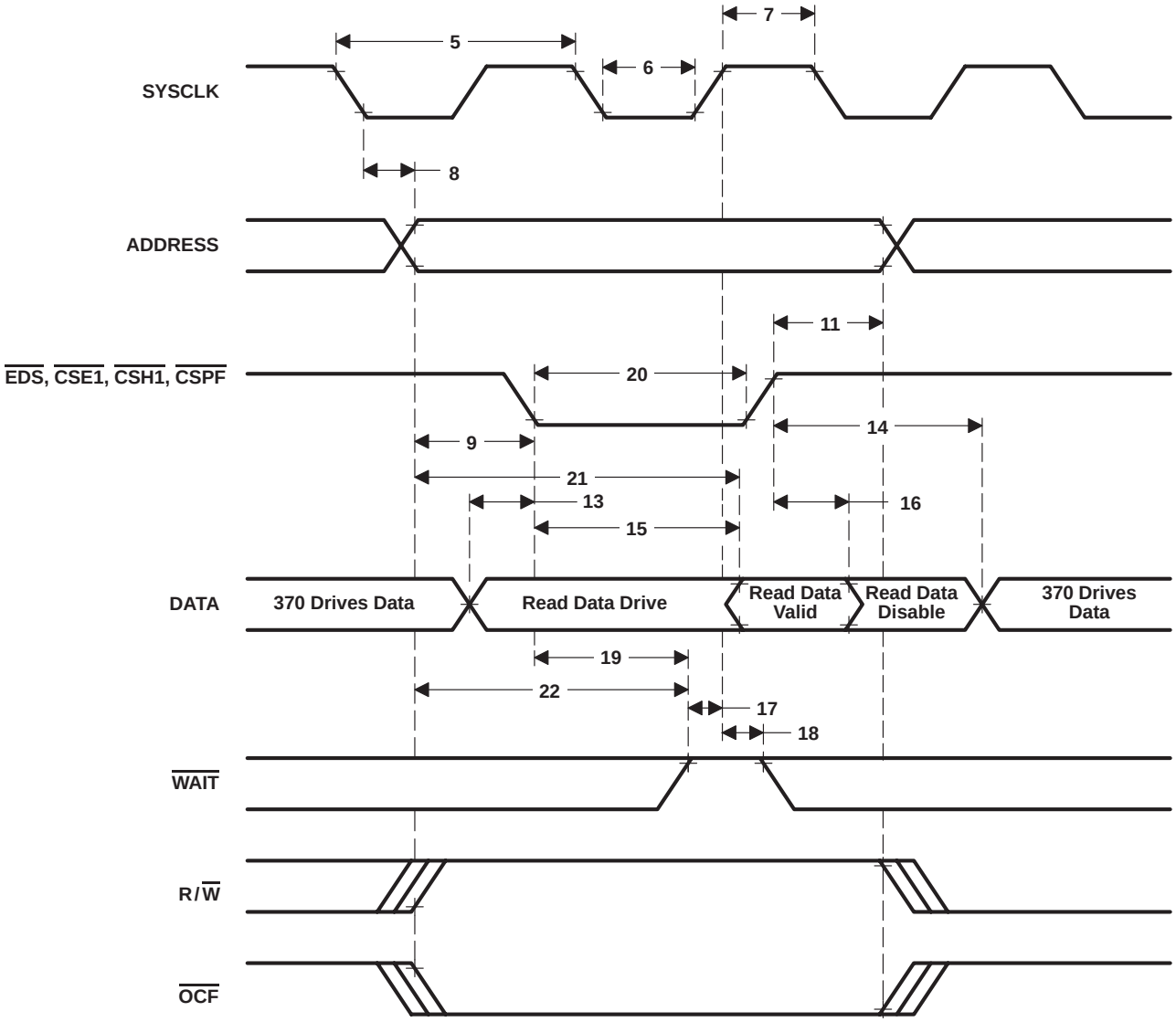


Figure 27. External-Read Timing

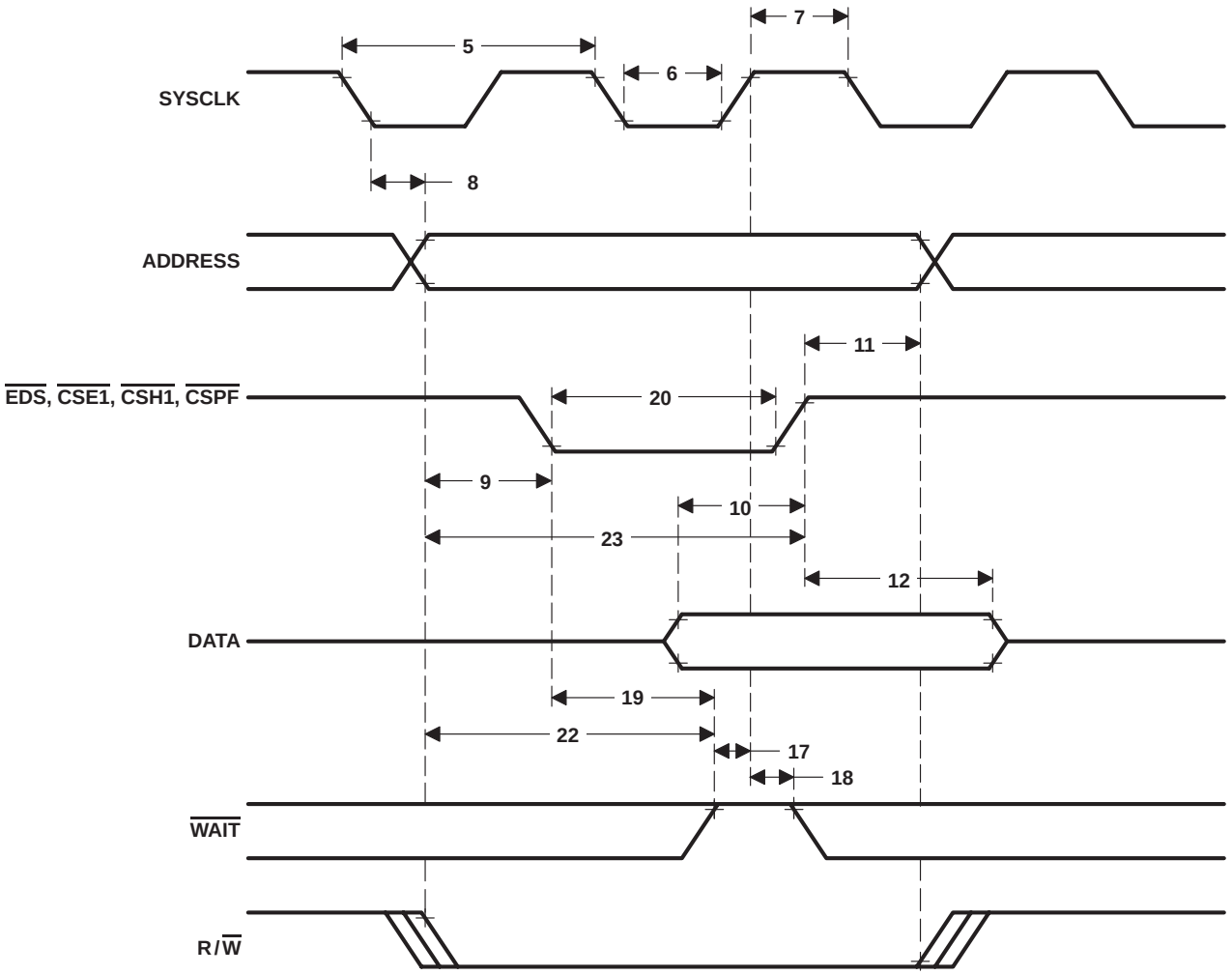


Figure 28. External-Write Timing

SCI1 isosynchronous-mode timing characteristics and requirements for internal clock (see Note 14 and Figure 29)

NO.			MIN	MAX	UNIT
24	$t_{c(SCC)}$	Cycle time, SCICLK	$2t_c$	$131072t_c$	ns
25	$t_{w(SCCL)}$	Pulse duration, SCICLK low	$t_c - 45$	$0.5t_{c(SCC)}+45$	ns
26	$t_{w(SCCH)}$	Pulse duration, SCICLK high	$t_c - 45$	$0.5t_{c(SCC)}+45$	ns
27	$t_{d(SCCL-TXDV)}$	Delay time, SCITXD valid after SCICLK low	– 50	60	ns
28	$t_{v(SCCH-TXD)}$	Valid time, SCITXD data valid after SCICLK high	$t_{w(SCCH)} - 50$		ns
29	$t_{su(RXD-SCCH)}$	Setup time, SCIRXD to SCICLK high	$0.25\ t_c + 145$		ns
30	$t_{v(SCCH-RXD)}$	Valid time, SCIRXD data valid after SCICLK high	0		ns

NOTE 14: t_c = system-clock cycle time = 1/SYSCLK

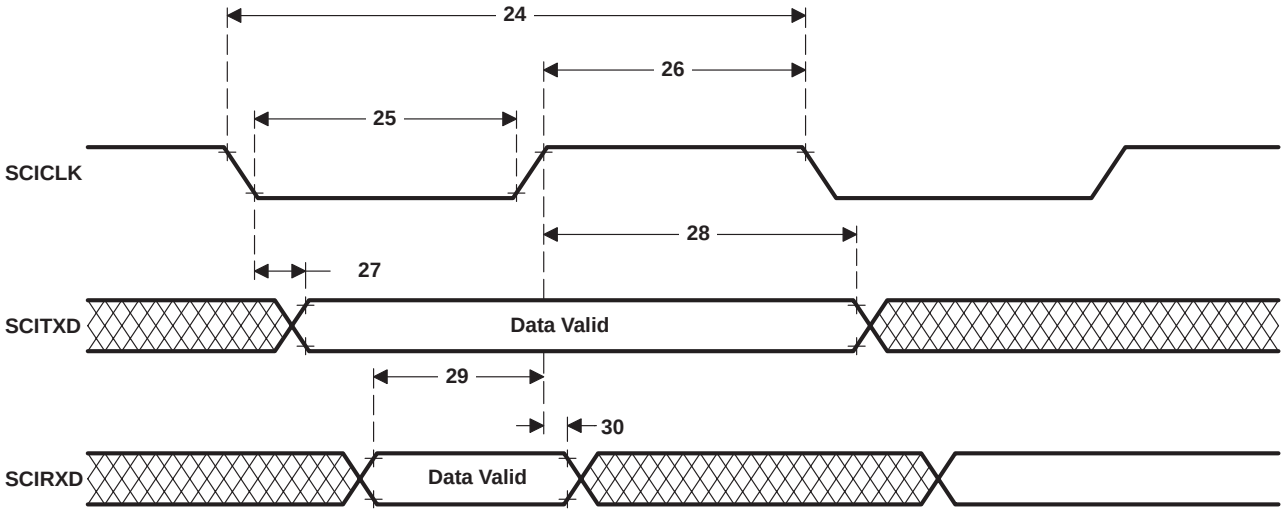


Figure 29. SCI1 Isosynchronous-Mode Timing for Internal Clock

SCI1 isosynchronous-mode timing characteristics and requirements for external clock (see Note 14 and Figure 30)

NO.			MIN	MAX	UNIT
31	$t_{c(SCC)}$	Cycle time, SCICLK	$10t_c$		ns
32	$t_{w(SCCL)}$	Pulse duration, SCICLK low	$4.25t_c + 120$		ns
33	$t_{w(SCCH)}$	Pulse duration, SCICLK high	$t_c + 120$		ns
34	$t_{d(SCCL-TXDV)}$	Delay time, SCITXD valid after SCICLK low		$4.25t_c + 145$	ns
35	$t_{v(SCCH-TXD)}$	Valid time, SCITXD data valid after SCICLK high	$t_{w(SCCH)}$		ns
36	$t_{su(SIMO-SCCH)}$	Setup time, SCIRXD to SCICLK high	40		ns
37	$t_{v(SCCH-RXD)}$	Valid time, SCIRXD data after SCICLK high	$2t_c$		ns

NOTE 14: t_c = system-clock cycle time = 1/SYSCLK

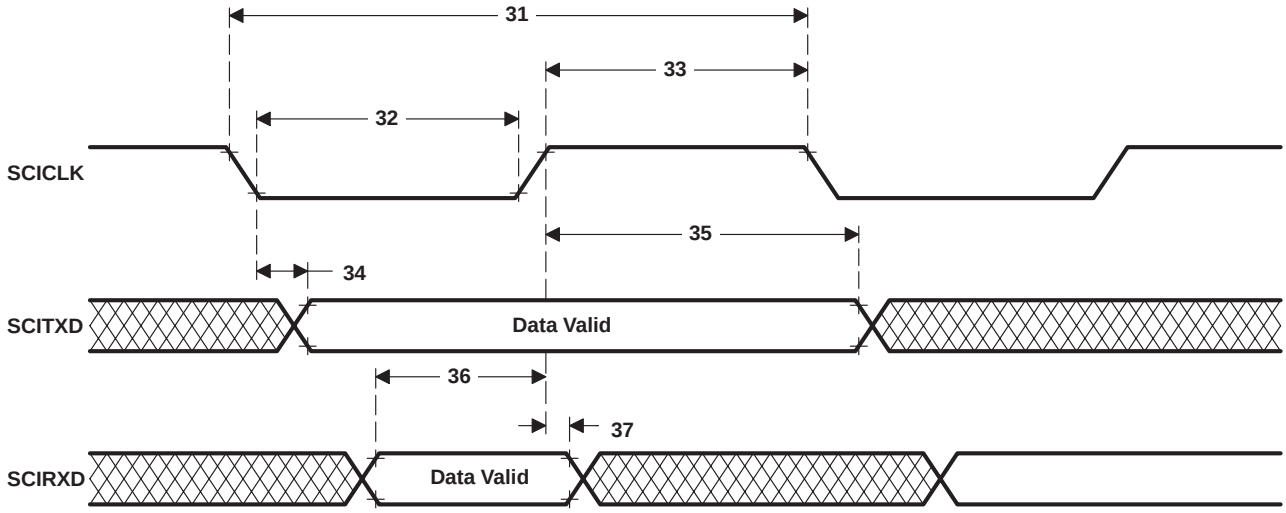
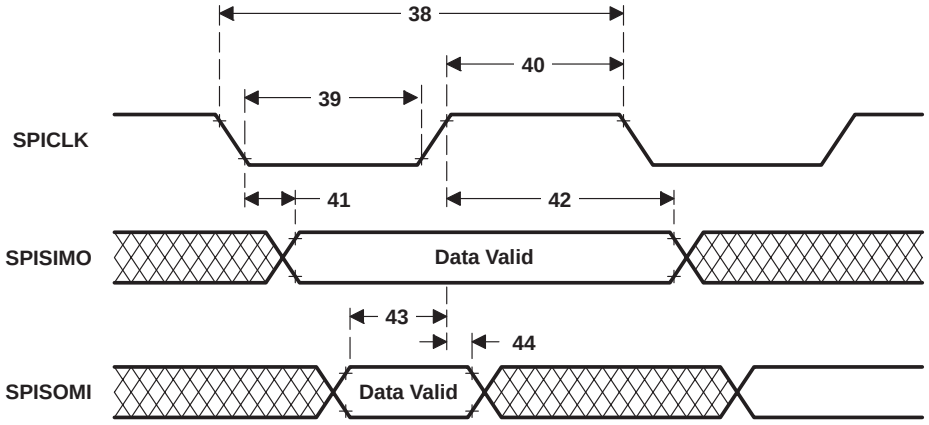


Figure 30. SCI1 Isosynchronous-Mode Timing for External Clock

SPI-master mode external timing characteristics and requirements (see Note 14 and Figure 31)

NO.			MIN	MAX	UNIT
38	$t_{c(SPC)M}$	Cycle time, SPICLK	$2t_c$	$256t_c$	ns
39	$t_{w(SPCL)M}$	Pulse duration, SPICLK low	$t_c - 45$	$0.5t_{c(SPC)}+45$	ns
40	$t_{w(SPCH)M}$	Pulse duration, SPICLK high	$t_c - 55$	$0.5t_{c(SPC)}+45$	ns
41	$t_{d(SPCL-SIMOV)M}$	Delay time, SPISIMO valid after SPICLK low (polarity = 1)	– 65	50	ns
42	$t_{v(SPCH-SIMO)M}$	Valid time, SPISIMO data valid after SPICLK high (polarity =1)	$t_{w(SPCH)} - 50$		ns
43	$t_{su(SOMI-SPCH)M}$	Setup time, SPISOMI to SPICLK high (polarity = 1)	$0.25\ t_c + 150$		ns
44	$t_{v(SPCH-SOMI)M}$	Valid time, SPISOMI data valid after SPICLK high (polarity = 1)	0		ns

NOTE 14: t_c = system-clock cycle time = 1/SYSCLK



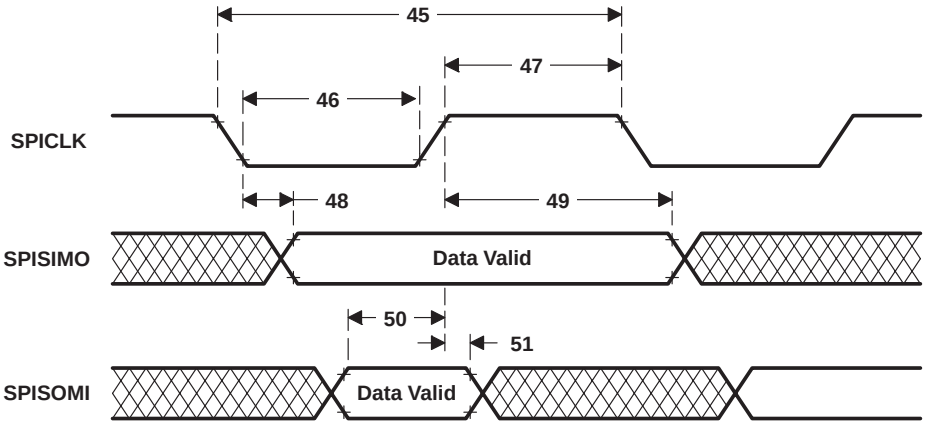
NOTE A: The diagram shows polarity = 1. SPICLK is inverted when polarity = 0.

Figure 31. SPI-Master External Timing

SPI-slave mode external timing characteristics and requirements (see Note 14 and Figure 32)

NO.			MIN	MAX	UNIT
45	$t_{c(SPC)S}$	Cycle time, SPICLK	$8t_c$		ns
46	$t_{w(SPCL)S}$	Pulse duration, SPICLK low	$4t_c - 45$	$0.5t_{c(SPC)S}+45$	ns
47	$t_{w(SPCH)S}$	Pulse duration, SPICLK high	$4t_c - 45$	$0.5t_{c(SPC)S}+45$	ns
48	$t_{d(SPCL-SOMIV)S}$	Delay time, SPISOMI valid after SPICLK low (polarity = 1)		$3.25t_c + 130$	ns
49	$t_{v(SPCH-SOMI)S}$	Valid time, SPISOMI data valid after SPICLK high (polarity =1)	$t_{w(SPCH)S}$		ns
50	$t_{su(SIMO-SPCH)S}$	Setup time, SPISIMO to SPICLK high (polarity = 1)	0		ns
51	$t_{v(SPCH-SIMO)S}$	Valid time, SPISIMO data after SPICLK high (polarity = 1)	$3t_c + 100$		ns

NOTE 14: t_c = system-clock cycle time = 1/SYSCLK



NOTE A: The diagram shows polarity = 1. SPICLK is inverted when polarity = 0.

Figure 32. SPI-Slave External Timing

analog-to-digital converter 1 (ADC1)

The ADC1 converter has a separate power bus for its analog circuitry. These pins are referred to as V_{CC3} and V_{SS3}. The purpose is to enhance ADC1 performance by preventing digital switching noise of the logic circuitry that can be present on V_{SS1} and V_{CC1} from coupling into the ADC1 analog stage. All ADC1 specifications are given with respect to V_{SS3} unless otherwise noted.

Resolution . . . . . 8-bits (256 values)
Monotonic . . . . . Yes
Output conversion mode . . . . . 00h to FFh (00 for VI ≤ V_{SS3} ≤; FF for VI ≤ V_{ref})
Conversion time (excluding sample time) . . . . . 164 t_c

recommended operating conditions

		MIN	NOM	MAX	UNIT
V_{CC3}	Analog supply voltage	4.5	5	5.5	V
		V_{CC1}–0.3		V_{CC1}+0.3	
V_{SS3}	Analog ground	V_{SS1}–0.3		V_{SS1}+0.3	V
V_{ref}	Non-V_{CC3} reference†	2.5	V_{CC3}	V_{CC3} + 0.1	V
	Analog input for conversion	V_{SS3}		V_{ref}	V

† V_{ref} must be stable, within ± 1/2 LSB of the required resolution, during the entire conversion time.

operating characteristics over recommended ranges operating conditions

PARAMETER				MIN	MAX	UNIT
	Absolute accuracy‡	V_{CC3} = 5.5 V	V_{rerf} = 5.1 V		±1.5	LSB
	Differential/integral linearity error‡§	V_{CC3} = 5.5 V	V_{rerf} = 5.1 V		±0.9	LSB
I_{CC3}	Analog supply current	Converting			2	mA
		Nonconverting			5	µA
I_I	Input current, AN0–AN7	0 V ≤ V_I ≤ 5.5 V			2	µA
	I_{ref} input charge current				1	mA
Z_{ref}	Source impedance of V_{ref}	SYSCLK ≤ 3 MHz			24	kΩ
		3 MHz < SYSCLK ≤ 5 MHz			10	kΩ

‡ Absolute resolution = 20 mV. At V_{ref} = 5 V, this is one LSB. As V_{ref} decreases, LSB size decreases. Therefore, the absolute accuracy and differential/integral linearity errors in terms of LSBs increase.
§ Excluding quantization error of 1/2 LSB

analog-to-digital converter 1 (ADC1) (continued)

The ADC1 module allows complete freedom in design of the sources for the analog inputs. The period of the sample time is user-defined so that the high-impedance can be accommodated without penalty to the low-impedance sources. The sample period begins when the SAMPLE START bit of the ADC1 control register (ADCTL.6) is set to 1. The end of the signal sample period occurs when the conversion bit (CONVERT START, ADCTL.7) is set to 1. After a hold time, the converter will reset the SAMPLE START and CONVERT START bits, signaling that a conversion has started and that the analog signal can be removed.

analog timing requirements

		MIN	MAX	UNIT
$t_{su(S)}$	Setup time, analog to sample command	0		ns
$t_{h(AN)}$	Hold time, analog input from start of conversion	$18t_c$		ns
$t_{w(S)}$	Pulse duration, sample time per kilohm of source impedance†	1		µs/kΩ

† The value given is valid for a signal with a source impedance > 1 kΩ. If the source impedance is < 1kΩ, use a minimum sampling time of 1µs.

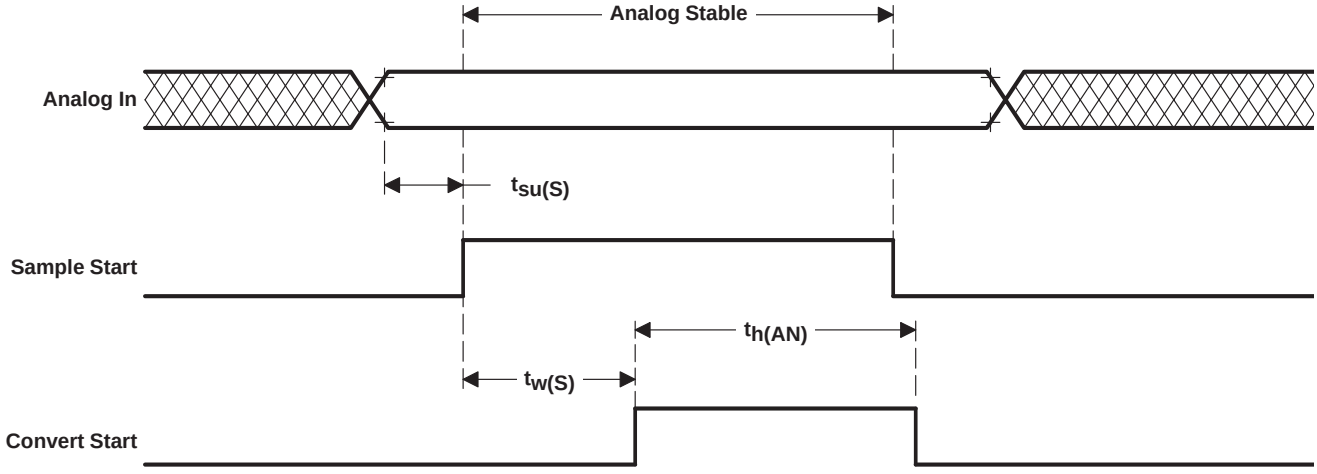


Figure 33. Analog Timing

Table 25 is designed to aid the user in referencing a device part number to a mechanical drawing. The table shows a cross-reference of the device part number to the TMS370 generic package name and the associated mechanical drawing by drawing number and name.

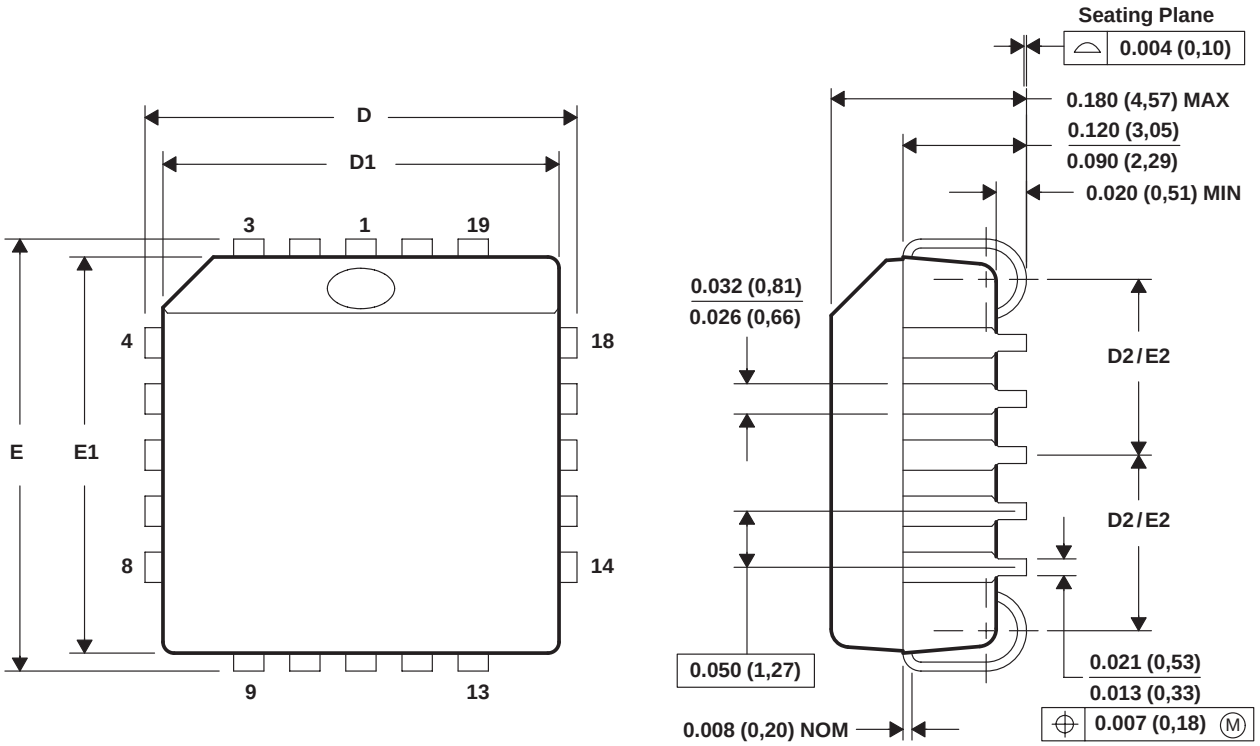
Table 25. TMS370Cx6x Family Package Type and Mechanical Cross-Reference

PKG TYPE (mil pin spacing)	TMS370 GENERIC NAME	PKG TYPE NO. AND MECHANICAL NAME	DEVICE PART NUMBERS
FN – 68 pin (50-mil pin spacing)	PLASTIC LEADED CHIP CARRIER (PLCC)	FN(S-PQCC-J**) PLASTIC J-LEADED CHIP CARRIER	TMS370C067AFNA TMS370C067AFNL TMS370C067AFNT TMS370C068AFNA TMS370C068AFNL TMS370C068AFNT TMS370C069AFNA TMS370C069AFNL TMS370C069AFNT TMS370C768AFNT TMS370C769AFNT
FZ – 68 pin (50-mil pin spacing)	CERAMIC LEADED CHIP CARRIER (CLCC)	FZ(S-CQCC-J**) J-LEADED CERAMIC CHIP CARRIER	SE370C768AFZT SE370C769AFZT

MECHANICAL DATA

FN (S-PQCC-J)** **PLASTIC J-LEADED CHIP CARRIER**

20 PIN SHOWN



NO. OF PINS **	D / E		D1 / E1		D2 / E2	
	MIN	MAX	MIN	MAX	MIN	MAX
20	0.385 (9,78)	0.395 (10,03)	0.350 (8,89)	0.356 (9,04)	0.141 (3,58)	0.169 (4,29)
28	0.485 (12,32)	0.495 (12,57)	0.450 (11,43)	0.456 (11,58)	0.191 (4,85)	0.219 (5,56)
44	0.685 (17,40)	0.695 (17,65)	0.650 (16,51)	0.656 (16,66)	0.291 (7,39)	0.319 (8,10)
52	0.785 (19,94)	0.795 (20,19)	0.750 (19,05)	0.756 (19,20)	0.341 (8,66)	0.369 (9,37)
68	0.985 (25,02)	0.995 (25,27)	0.950 (24,13)	0.958 (24,33)	0.441 (11,20)	0.469 (11,91)
84	1.185 (30,10)	1.195 (30,35)	1.150 (29,21)	1.158 (29,41)	0.541 (13,74)	0.569 (14,45)

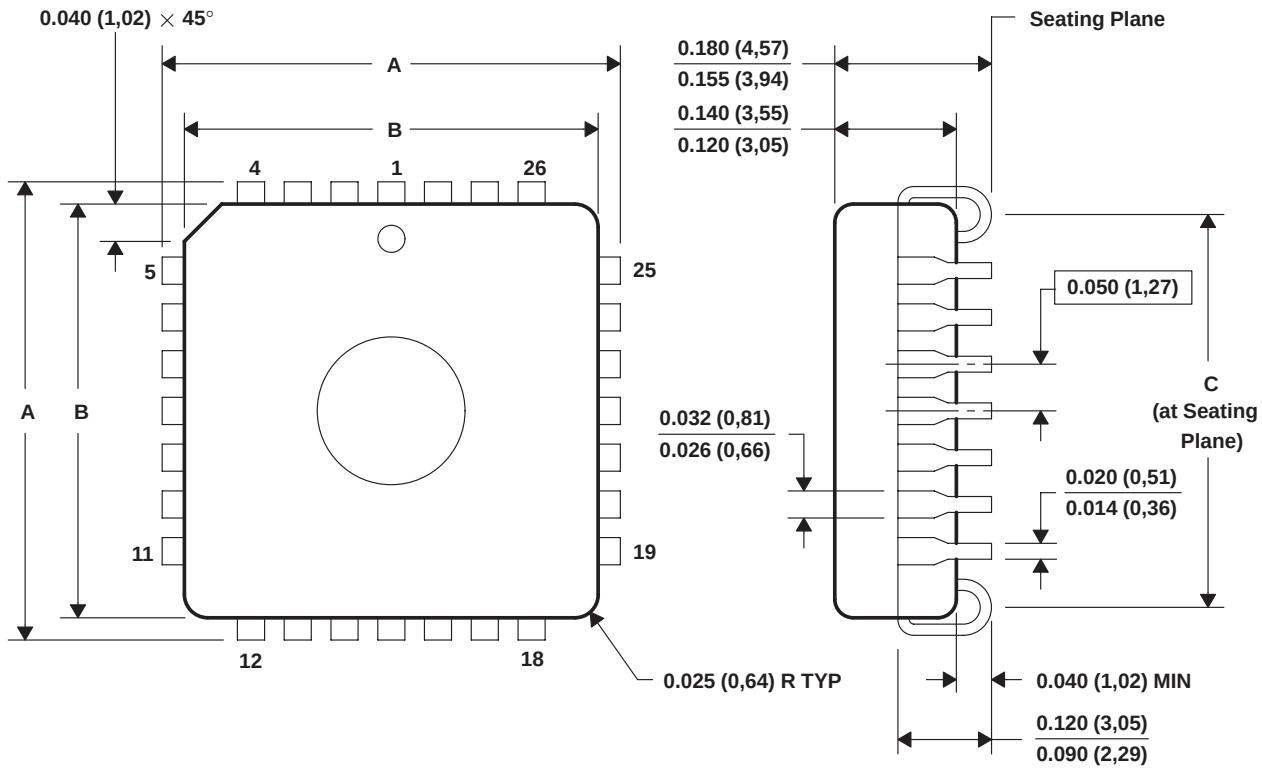
4040005 / B 03/95

NOTES: A. All linear dimensions are in inches (millimeters).
B. This drawing is subject to change without notice.
C. Falls within JEDEC MS-018

MECHANICAL DATA

FZ (S-CQCC-J)** **J-LEADED CERAMIC CHIP CARRIER**

28 LEAD SHOWN



JEDEC OUTLINE	NO. OF PINS**	A		B		C	
		MIN	MAX	MIN	MAX	MIN	MAX
MO-087AA	28	0.485 (12,32)	0.495 (12,57)	0.430 (10,92)	0.455 (11,56)	0.410 (10,41)	0.430 (10,92)
MO-087AB	44	0.685 (17,40)	0.695 (17,65)	0.630 (16,00)	0.655 (16,64)	0.610 (15,49)	0.630 (16,00)
MO-087AC	52	0.785 (19,94)	0.795 (20,19)	0.730 (18,54)	0.765 (19,43)	0.680 (17,28)	0.740 (18,79)
MO-087AD	68	0.985 (25,02)	0.995 (25,27)	0.930 (23,62)	0.955 (24,26)	0.910 (23,11)	0.930 (23,62)

4040219 / B 03/95

NOTES: A. All linear dimensions are in inches (millimeters).
B. This drawing is subject to change without notice.
C. This package can be hermetically sealed with a ceramic lid using glass frit.

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