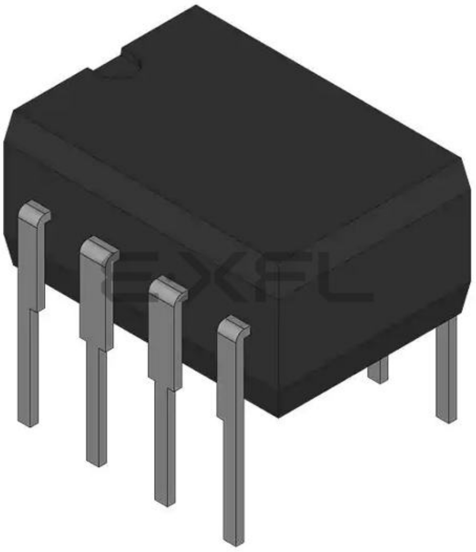
Freescale Semiconductor - MC908QT2ACPE Datasheet



What is "Embedded - Microcontrollers"?

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

Applications of "Embedded - Microcontrollers"

Details	
Product Status	Obsolete
Core Processor	HC08
Core Size	8-Bit
Speed	8MHz
Connectivity	-
Peripherals	LVD, POR, PWM
Number of I/O	5
Program Memory Size	1.5KB (1.5K x 8)
Program Memory Type	FLASH
EEPROM Size	-
RAM Size	128 x 8
Voltage - Supply (Vcc/Vdd)	2.7V ~ 5.5V
Data Converters	A/D 6x10b
Oscillator Type	Internal
Operating Temperature	-40°C ~ 85°C (TA)
Mounting Type	Through Hole
Package / Case	8-DIP (0.300", 7.62mm)
Supplier Device Package	8-PDIP
Purchase URL	https://www.e-xfl.com/pro/item?MUrl=&PartUrl=mc908qt2acpe

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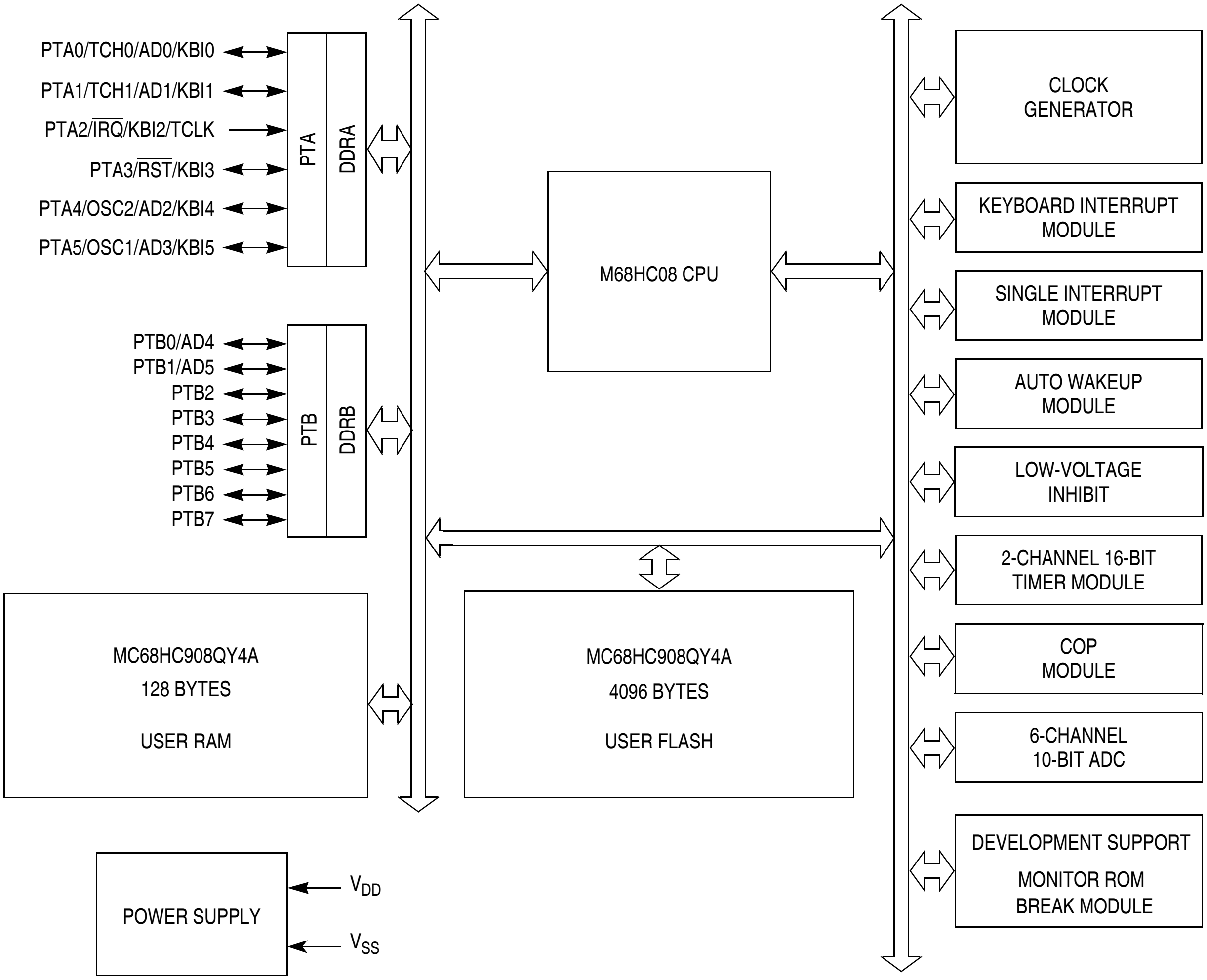
1.3 MCU Block Diagram

Figure 1-1 shows the structure of the MC68HC908QY4A.



$\overline{\text{RST}}$, $\overline{\text{IRQ}}$: Pins have internal pull up device
All port pins have programmable pull up device
PTA[0:5]: Higher current sink and source capability
PTB[0:7]: Not available on 8-pin devices

Figure 1-1. Block Diagram

Chapter 3
Analog-to-Digital Converter (ADC10) Module

3.1 Introduction

This section describes the 10-bit successive approximation analog-to-digital converter (ADC10).

The ADC10 module shares its pins with general-purpose input/output (I/O) port pins. See Figure 3-1 for port location of these shared pins. The ADC10 on this MCU uses V_{DD} and V_{SS} as its supply and reference pins. This MCU uses BUSCLKX4 as its alternate clock source for the ADC. This MCU does not have a hardware conversion trigger.

3.2 Features

Features of the ADC10 module include:

- Linear successive approximation algorithm with 10-bit resolution
- Output formatted in 10- or 8-bit right-justified format
- Single or continuous conversion (automatic power-down in single conversion mode)
- Configurable sample time and conversion speed (to save power)
- Conversion complete flag and interrupt
- Input clock selectable from up to three sources
- Operation in wait and stop modes for lower noise operation
- Selectable asynchronous hardware conversion trigger

3.3 Functional Description

The ADC10 uses successive approximation to convert the input sample taken from ADVIN to a digital representation. The approximation is taken and then rounded to the nearest 10- or 8-bit value to provide greater accuracy and to provide a more robust mechanism for achieving the ideal code-transition voltage.

Figure 3-2 shows a block diagram of the ADC10

For proper conversion, the voltage on ADVIN must fall between V_{REFH} and V_{REFL}. If ADVIN is equal to or exceeds V_{REFH}, the converter circuit converts the signal to $3FF for a 10-bit representation or $FF for a 8-bit representation. If ADVIN is equal to or less than V_{REFL}, the converter circuit converts it to $000. Input voltages between V_{REFH} and V_{REFL} are straight-line linear conversions.

NOTE

Input voltage must not exceed the analog supply voltages.

clocks are too fast, then the clock must be divided to the appropriate frequency. This divider is specified by the ADIV[1:0] bits and can be divide-by 1, 2, 4, or 8.

3.3.2 Input Select and Pin Control

Only one analog input may be used for conversion at any given time. The channel select bits in ADSCR are used to select the input signal for conversion.

3.3.3 Conversion Control

Conversions can be performed in either 10-bit mode or 8-bit mode as determined by the MODE bits. Conversions can be initiated by either a software or hardware trigger. In addition, the ADC10 module can be configured for low power operation, long sample time, and continuous conversion.

3.3.3.1 Initiating Conversions

A conversion is initiated:

- Following a write to ADSCR (with ADCH bits not all 1s) if software triggered operation is selected.
- Following a hardware trigger event if hardware triggered operation is selected.
- Following the transfer of the result to the data registers when continuous conversion is enabled.

If continuous conversions are enabled a new conversion is automatically initiated after the completion of the current conversion. In software triggered operation, continuous conversions begin after ADSCR is written and continue until aborted. In hardware triggered operation, continuous conversions begin after a hardware trigger event and continue until aborted.

3.3.3.2 Completing Conversions

A conversion is completed when the result of the conversion is transferred into the data result registers, ADRH and ADRL. This is indicated by the setting of the COCO bit. An interrupt is generated if AIEN is high at the time that COCO is set.

A blocking mechanism prevents a new result from overwriting previous data in ADRH and ADRL if the previous data is in the process of being read while in 10-bit mode (ADRH has been read but ADRL has not). In this case the data transfer is blocked, COCO is not set, and the new result is lost. When a data transfer is blocked, another conversion is initiated regardless of the state of ADCO (single or continuous conversions enabled). If single conversions are enabled, this could result in several discarded conversions and excess power consumption. To avoid this issue, the data registers must not be read after initiating a single conversion until the conversion completes.

3.3.3.3 Aborting Conversions

Any conversion in progress will be aborted when:

- A write to ADSCR occurs (the current conversion will be aborted and a new conversion will be initiated, if ADCH are not all 1s).
- A write to ADCLK occurs.
- The MCU is reset.
- The MCU enters stop mode with ACLK not enabled.

When a conversion is aborted, the contents of the data registers, ADRH and ADRL, are not altered but continue to be the values transferred after the completion of the last successful conversion. In the case that the conversion was aborted by a reset, ADRH and ADRL return to their reset states.

3.3.4 Sources of Error

Several sources of error exist for ADC conversions. These are discussed in the following sections.

3.3.4.1 Sampling Error

For proper conversions, the input must be sampled long enough to achieve the proper accuracy. Given the maximum input resistance of approximately 15 kΩ and input capacitance of approximately 10 pF, sampling to within
1/4LSB (at 10-bit resolution) can be achieved within the minimum sample window (3.5 cycles / 2 MHz maximum ADCK frequency) provided the resistance of the external analog source (R_{AS}) is kept below 10 kΩ. Higher source resistances or higher-accuracy sampling is possible by setting ADLSMP (to increase the sample window to 23.5 cycles) or decreasing ADCK frequency to increase sample time.

3.3.4.2 Pin Leakage Error

Leakage on the I/O pins can cause conversion error if the external analog source resistance (R_{AS}) is high. If this error cannot be tolerated by the application, keep R_{AS} lower than V_{ADVIN} / (4096*I_{Leak}) for less than 1/4LSB leakage error (at 10-bit resolution).

3.3.4.3 Noise-Induced Errors

System noise which occurs during the sample or conversion process can affect the accuracy of the conversion. The ADC10 accuracy numbers are guaranteed as specified only if the following conditions are met:

- There is a 0.1μF low-ESR capacitor from V_{REFH} to V_{REFL} (if available).
- There is a 0.1μF low-ESR capacitor from V_{DDA} to V_{SSA} (if available).
- If inductive isolation is used from the primary supply, an additional 1μF capacitor is placed from V_{DDA} to V_{SSA} (if available).
- V_{SSA} and V_{REFL} (if available) is connected to V_{SS} at a quiet point in the ground plane.
- The MCU is placed in wait mode immediately after initiating the conversion (next instruction after write to ADSCR).
- There is no I/O switching, input or output, on the MCU during the conversion.

There are some situations where external system activity causes radiated or conducted noise emissions or excessive V_{DD} noise is coupled into the ADC10. In these cases, or when the MCU cannot be placed in wait or I/O activity cannot be halted, the following recommendations may reduce the effect of noise on the accuracy:

- Place a 0.01 μF capacitor on the selected input channel to V_{REFL} or V_{SSA} (if available). This will improve noise issues but will affect sample rate based on the external analog source resistance.
- Operate the ADC10 in stop mode by setting ACLKEN, selecting the channel in ADSCR, and executing a STOP instruction. This will reduce V_{DD} noise but will increase effective conversion time due to stop recovery.
- Average the input by converting the output many times in succession and dividing the sum of the results. Four samples are required to eliminate the effect of a 1LSB, one-time error.
- Reduce the effect of synchronous noise by operating off the asynchronous clock (ACLKEN=1) and averaging. Noise that is synchronous to the ADCK cannot be averaged out.

break, the bit cannot change during the break state as long as BCFE is cleared. After the break, doing the second step clears the status bit.

3.7 I/O Signals

The ADC10 module shares its pins with general-purpose input/output (I/O) port pins. See Figure 3-1 for port location of these shared pins. The ADC10 on this MCU uses V_{DD} and V_{SS} as its supply and reference pins. This MCU does not have an external trigger source.

3.7.1 ADC10 Analog Power Pin (V_{DDA})

The ADC10 analog portion uses V_{DDA} as its power pin. In some packages, V_{DDA} is connected internally to V_{DD}. If externally available, connect the V_{DDA} pin to the same voltage potential as V_{DD}. External filtering may be necessary to ensure clean V_{DDA} for good results.

NOTE

If externally available, route V_{DDA} carefully for maximum noise immunity and place bypass capacitors as near as possible to the package.

3.7.2 ADC10 Analog Ground Pin (V_{SSA})

The ADC10 analog portion uses V_{SSA} as its ground pin. In some packages, V_{SSA} is connected internally to V_{SS}. If externally available, connect the V_{SSA} pin to the same voltage potential as V_{SS}.

In cases where separate power supplies are used for analog and digital power, the ground connection between these supplies should be at the V_{SSA} pin. This should be the only ground connection between these supplies if possible. The V_{SSA} pin makes a good single point ground location.

3.7.3 ADC10 Voltage Reference High Pin (V_{REFH})

V_{REFH} is the power supply for setting the high-reference voltage for the converter. In some packages, V_{REFH} is connected internally to V_{DDA}. If externally available, V_{REFH} may be connected to the same potential as V_{DDA}, or may be driven by an external source that is between the minimum V_{DDA} spec and the V_{DDA} potential (V_{REFH} must never exceed V_{DDA}).

NOTE

Route V_{REFH} carefully for maximum noise immunity and place bypass capacitors as near as possible to the package.

AC current in the form of current spikes required to supply charge to the capacitor array at each successive approximation step is drawn through the V_{REFH} and V_{REFL} loop. The best external component to meet this current demand is a 0.1 μF capacitor with good high frequency characteristics. This capacitor is connected between V_{REFH} and V_{REFL} and must be placed as close as possible to the package pins. Resistance in the path is not recommended because the current will cause a voltage drop which could result in conversion errors. Inductance in this path must be minimum (parasitic only).

3.7.4 ADC10 Voltage Reference Low Pin (V_{REFL})

V_{REFL} is the power supply for setting the low-reference voltage for the converter. In some packages, V_{REFL} is connected internally to V_{SSA}. If externally available, connect the V_{REFL} pin to the same voltage potential as V_{SSA}. There will be a brief current associated with V_{REFL} when the sampling capacitor is

If the bus frequency is less than the ADCK frequency, precise sample time for continuous conversions cannot be guaranteed in short-sample mode (ADLSMP = 0). If the bus frequency is less than 1/11th of the ADCK frequency, precise sample time for continuous conversions cannot be guaranteed in long-sample mode (ADLSMP = 1).

When clear, the ADC10 will perform a single conversion (single conversion mode) each time ADSCR is written (assuming the ADCH[4:0] bits do not decode all 1s).
1 = Continuous conversion following a write to ADSCR
0 = One conversion following a write to ADSCR

ADCH[4:0] — Channel Select Bits
The ADCH[4:0] bits form a 5-bit field that is used to select one of the input channels. The input channels are detailed in Table 3-2. The successive approximation converter subsystem is turned off when the channel select bits are all set to 1. This feature allows explicit disabling of the ADC10 and isolation of the input channel from the I/O pad. Terminating continuous conversion mode this way will prevent an additional, single conversion from being performed. It is not necessary to set the channel select bits to all 1s to place the ADC10 in a low-power state, however, because the module is automatically placed in a low-power state when a conversion completes.

Table 3-2. Input Channel Select

ADCH4	ADCH3	ADCH2	ADCH1	ADCH0	Input Select[1]
0	0	0	0	0	AD0
0	0	0	0	1	AD1
0	0	0	1	0	AD2
0	0	0	1	1	AD3
0	0	1	0	0	AD4
0	0	1	0	1	AD5
0	0	1	1	0	Unused
Continuing through					Unused
1	1	0	0	1	Unused
1	1	0	1	0	BANDGAP REF[2]
1	1	0	1	1	Reserved
1	1	1	0	0	Reserved
1	1	1	0	1	V_{REFH}
1	1	1	1	0	V_{REFL}
1	1	1	1	1	Low-power state

1. If any unused or reserved channels are selected, the resulting conversion will be unknown.
2. Requires LVI to be powered (LVIPWRD =0, in CONFIG1)

3.8.2 ADC10 Result High Register (ADRH)

This register holds the MSBs of the result and is updated each time a conversion completes. All other bits read as 0s. Reading ADRH prevents the ADC10 from transferring subsequent conversion results into the result registers until ADRL is read. If ADRL is not read until the after next conversion is completed, then the intermediate conversion result will be lost. In 8-bit mode, this register contains no interlocking with ADRL.

4.6.2 Keyboard Status and Control Register

The keyboard status and control register (KBSCR):

- Flags keyboard/auto wakeup interrupt requests
- Acknowledges keyboard/auto wakeup interrupt requests
- Masks keyboard/auto wakeup interrupt requests

	Bit 7	6	5	4	3	2	1	Bit 0
Read:	0	0	0	0	KEYF	0	IMASKK	MODEK
Write:	▨	▨	▨	▨	▨	ACKK		
Reset:	0	0	0	0	0	0	0	0

▨ = Unimplemented

Figure 4-3. Keyboard Status and Control Register (KBSCR)

Bits 7–4 — Not used

These read-only bits always read as 0s.

KEYF — Keyboard Flag Bit

This read-only bit is set when a keyboard interrupt is pending on port A or auto wakeup. Reset clears the KEYF bit.

1 = Keyboard/auto wakeup interrupt pending
0 = No keyboard/auto wakeup interrupt pending

ACKK — Keyboard Acknowledge Bit

Writing a 1 to this write-only bit clears the keyboard/auto wakeup interrupt request on port A and auto wakeup logic. ACKK always reads as 0. Reset clears ACKK.

IMASKK— Keyboard Interrupt Mask Bit

Writing a 1 to this read/write bit prevents the output of the keyboard interrupt mask from generating interrupt requests on port A or auto wakeup. Reset clears the IMASKK bit.

1 = Keyboard/auto wakeup interrupt requests masked
0 = Keyboard/auto wakeup interrupt requests not masked

NOTE

MODEK is not used in conjuction with the auto wakeup feature. To see a description of this bit, see 9.8.1 Keyboard Status and Control Register (KBSCR).

4.6.3 Keyboard Interrupt Enable Register

The keyboard interrupt enable register (KBIER) enables or disables the auto wakeup to operate as a keyboard/auto wakeup interrupt input.

	Bit 7	6	5	4	3	2	1	Bit 0
Read:	0	AWUIE	KBIE5	KBIE4	KBIE3	KBIE2	KBIE1	KBIE0
Write:	▨							
Reset:	0	0	0	0	0	0	0	0

▨ = Unimplemented

Figure 4-4. Keyboard Interrupt Enable Register (KBIER)

LVIPWRD — LVI Power Disable Bit

LVIPWRD disables the LVI module.

1 = LVI module power disabled
0 = LVI module power enabled

LVITRIP — LVI Trip Point Selection Bit

LVITRIP selects the voltage operating mode of the LVI module. The voltage mode selected for the LVI should match the operating V_{DD} for the LVI's voltage trip points for each of the modes.

1 = LVI operates for a 5-V protection
0 = LVI operates for a 3-V protection

NOTE

The LVITRIP bit is cleared by a power-on reset (POR) only. Other resets will leave this bit unaffected.

SSREC — Short Stop Recovery Bit

SSREC enables the CPU to exit stop mode with a delay of 32 BUSCLKX4 cycles instead of a 4096 BUSCLKX4 cycle delay.

1 = Stop mode recovery after 32 BUSCLKX4 cycles
0 = Stop mode recovery after 4096 BUSCLKX4 cycles

NOTE

Exiting stop mode by an LVI reset will result in the long stop recovery.

When using the LVI during normal operation but disabling during stop mode, the LVI will have an enable time of t_{EN}. The system stabilization time for power-on reset and long stop recovery (both 4096 BUSCLKX4 cycles) gives a delay longer than the LVI enable time for these startup scenarios. There is no period where the MCU is not protected from a low-power condition. However, when using the short stop recovery configuration option, the 32 BUSCLKX4 delay must be greater than the LVI's turn on time to avoid a period in startup where the LVI is not protecting the MCU.

STOP — STOP Instruction Enable Bit

STOP enables the STOP instruction.

1 = STOP instruction enabled
0 = STOP instruction treated as illegal opcode

COPD — COP Disable Bit

COPD disables the COP module.

1 = COP module disabled
0 = COP module enabled

Table 7-2. Opcode Map

	Bit Manipulation		Branch	Read-Modify-Write						Control		Register/Memory							
	DIR	DIR	REL	DIR	INH	INH	IX1	SP1	IX	INH	INH	IMM	DIR	EXT	IX2	SP2	IX1	SP1	IX
MSB / LSB	0	1	2	3	4	5	6	9E6	7	8	9	A	B	C	D	9ED	E	9EE	F
0	5 BRSET0 3 DIR	4 BSET0 2 DIR	3 BRA 2 REL	4 NEG 2 DIR	1 NEGA 1 INH	1 NEGX 1 INH	4 NEG 2 IX1	5 NEG 3 SP1	3 NEG 1 IX	7 RTI 1 INH	3 BGE 2 REL	2 SUB 2 IMM	3 SUB 2 DIR	4 SUB 3 EXT	4 SUB 3 IX2	5 SUB 4 SP2	3 SUB 2 IX1	4 SUB 3 SP1	2 SUB 1 IX
1	5 BRCLR0 3 DIR	4 BCLR0 2 DIR	3 BRN 2 REL	5 CBEQ 3 DIR	4 CBEQA 3 IMM	4 CBEQX 3 IMM	5 CBEQ 3 IX1+	6 CBEQ 4 SP1	4 CBEQ 2 IX+	4 RTS 1 INH	3 BLT 2 REL	2 CMP 2 IMM	3 CMP 2 DIR	4 CMP 3 EXT	4 CMP 3 IX2	5 CMP 4 SP2	3 CMP 2 IX1	4 CMP 3 SP1	2 CMP 1 IX
2	5 BRSET1 3 DIR	4 BSET1 2 DIR	3 BHI 2 REL		5 MUL 1 INH	7 DIV 1 INH	3 NSA 1 INH		2 DAA 1 INH		3 BGT 2 REL	2 SBC 2 IMM	3 SBC 2 DIR	4 SBC 3 EXT	4 SBC 3 IX2	5 SBC 4 SP2	3 SBC 2 IX1	4 SBC 3 SP1	2 SBC 1 IX
3	5 BRCLR1 3 DIR	4 BCLR1 2 DIR	3 BLS 2 REL	4 COM 2 DIR	1 COMA 1 INH	1 COMX 1 INH	4 COM 2 IX1	5 COM 3 SP1	3 COM 1 IX	9 SWI 1 INH	3 BLE 2 REL	2 CPX 2 IMM	3 CPX 2 DIR	4 CPX 3 EXT	4 CPX 3 IX2	5 CPX 4 SP2	3 CPX 2 IX1	4 CPX 3 SP1	2 CPX 1 IX
4	5 BRSET2 3 DIR	4 BSET2 2 DIR	3 BCC 2 REL	4 LSR 2 DIR	1 LSRA 1 INH	1 LSRX 1 INH	4 LSR 2 IX1	5 LSR 3 SP1	3 LSR 1 IX	2 TAP 1 INH	2 TXS 1 INH	2 AND 2 IMM	3 AND 2 DIR	4 AND 3 EXT	4 AND 3 IX2	5 AND 4 SP2	3 AND 2 IX1	4 AND 3 SP1	2 AND 1 IX
5	5 BRCLR2 3 DIR	4 BCLR2 2 DIR	3 BCS 2 REL	4 STHX 2 DIR	3 LDHX 3 IMM	4 LDHX 2 DIR	3 CPHX 3 IMM		4 CPHX 2 DIR	1 TPA 1 INH	2 TSX 1 INH	2 BIT 2 IMM	3 BIT 2 DIR	4 BIT 3 EXT	4 BIT 3 IX2	5 BIT 4 SP2	3 BIT 2 IX1	4 BIT 3 SP1	2 BIT 1 IX
6	5 BRSET3 3 DIR	4 BSET3 2 DIR	3 BNE 2 REL	4 ROR 2 DIR	1 RORA 1 INH	1 RORX 1 INH	4 ROR 2 IX1	5 ROR 3 SP1	3 ROR 1 IX	2 PULA 1 INH		2 LDA 2 IMM	3 LDA 2 DIR	4 LDA 3 EXT	4 LDA 3 IX2	5 LDA 4 SP2	3 LDA 2 IX1	4 LDA 3 SP1	2 LDA 1 IX
7	5 BRCLR3 3 DIR	4 BCLR3 2 DIR	3 BEQ 2 REL	4 ASR 2 DIR	1 ASRA 1 INH	1 ASRX 1 INH	4 ASR 2 IX1	5 ASR 3 SP1	3 ASR 1 IX	2 PSHA 1 INH	1 TAX 1 INH	2 AIS 2 IMM	3 STA 2 DIR	4 STA 3 EXT	4 STA 3 IX2	5 STA 4 SP2	3 STA 2 IX1	4 STA 3 SP1	2 STA 1 IX
8	5 BRSET4 3 DIR	4 BSET4 2 DIR	3 BHCC 2 REL	4 LSL 2 DIR	1 LSLA 1 INH	1 LSLX 1 INH	4 LSL 2 IX1	5 LSL 3 SP1	3 LSL 1 IX	2 PULX 1 INH	1 CLC 1 INH	2 EOR 2 IMM	3 EOR 2 DIR	4 EOR 3 EXT	4 EOR 3 IX2	5 EOR 4 SP2	3 EOR 2 IX1	4 EOR 3 SP1	2 EOR 1 IX
9	5 BRCLR4 3 DIR	4 BCLR4 2 DIR	3 BHCS 2 REL	4 ROL 2 DIR	1 ROLA 1 INH	1 ROLX 1 INH	4 ROL 2 IX1	5 ROL 3 SP1	3 ROL 1 IX	2 PSHX 1 INH	1 SEC 1 INH	2 ADC 2 IMM	3 ADC 2 DIR	4 ADC 3 EXT	4 ADC 3 IX2	5 ADC 4 SP2	3 ADC 2 IX1	4 ADC 3 SP1	2 ADC 1 IX
A	5 BRSET5 3 DIR	4 BSET5 2 DIR	3 BPL 2 REL	4 DEC 2 DIR	1 DECA 1 INH	1 DECX 1 INH	4 DEC 2 IX1	5 DEC 3 SP1	3 DEC 1 IX	2 PULH 1 INH	2 CLI 1 INH	2 ORA 2 IMM	3 ORA 2 DIR	4 ORA 3 EXT	4 ORA 3 IX2	5 ORA 4 SP2	3 ORA 2 IX1	4 ORA 3 SP1	2 ORA 1 IX
B	5 BRCLR5 3 DIR	4 BCLR5 2 DIR	3 BMI 2 REL	5 DBNZ 3 DIR	3 DBNZA 2 INH	3 DBNZX 2 INH	5 DBNZ 3 IX1	6 DBNZ 4 SP1	4 DBNZ 2 IX	2 PSHH 1 INH	2 SEI 1 INH	2 ADD 2 IMM	3 ADD 2 DIR	4 ADD 3 EXT	4 ADD 3 IX2	5 ADD 4 SP2	3 ADD 2 IX1	4 ADD 3 SP1	2 ADD 1 IX
C	5 BRSET6 3 DIR	4 BSET6 2 DIR	3 BMC 2 REL	4 INC 2 DIR	1 INCA 1 INH	1 INCX 1 INH	4 INC 2 IX1	5 INC 3 SP1	3 INC 1 IX	1 CLRH 1 INH	1 RSP 1 INH		2 JMP 2 DIR	3 JMP 3 EXT	4 JMP 3 IX2		3 JMP 2 IX1		2 JMP 1 IX
D	5 BRCLR6 3 DIR	4 BCLR6 2 DIR	3 BMS 2 REL	3 TST 2 DIR	1 TSTA 1 INH	1 TSTX 1 INH	3 TST 2 IX1	4 TST 3 SP1	2 TST 1 IX		1 NOP 1 INH	4 BSR 2 REL	4 JSR 2 DIR	5 JSR 3 EXT	6 JSR 3 IX2		5 JSR 2 IX1		4 JSR 1 IX
E	5 BRSET7 3 DIR	4 BSET7 2 DIR	3 BIL 2 REL		5 MOV 3 DD	4 MOV 2 DIX+	4 MOV 3 IMD		4 MOV 2 IX+D	1 STOP 1 INH	*	2 LDX 2 IMM	3 LDX 2 DIR	4 LDX 3 EXT	4 LDX 3 IX2	5 LDX 4 SP2	3 LDX 2 IX1	4 LDX 3 SP1	2 LDX 1 IX
F	5 BRCLR7 3 DIR	4 BCLR7 2 DIR	3 BIH 2 REL	3 CLR 2 DIR	1 CLRA 1 INH	1 CLRX 1 INH	3 CLR 2 IX1	4 CLR 3 SP1	2 CLR 1 IX	1 WAIT 1 INH	1 TXA 1 INH	2 AIX 2 IMM	3 STX 2 DIR	4 STX 3 EXT	4 STX 3 IX2	5 STX 4 SP2	3 STX 2 IX1	4 STX 3 SP1	2 STX 1 IX

INH	Inherent
IMM	Immediate
DIR	Direct
EXT	Extended
DD	Direct-Direct
IX+D	Indexed-Direct
REL	Relative
IX	Indexed, No Offset
IX1	Indexed, 8-Bit Offset
IX2	Indexed, 16-Bit Offset
IMD	Immediate-Direct
DIX+	Direct-Indexed
SP1	Stack Pointer, 8-Bit Offset
SP2	Stack Pointer, 16-Bit Offset
IX+	Indexed, No Offset with Post Increment
IX1+	Indexed, 1-Byte Offset with Post Increment

*Pre-byte for stack pointer indexed instructions

	MSB / LSB	0	High Byte of Opcode in Hexadecimal
Low Byte of Opcode in Hexadecimal	0	5 BRSET0 3 DIR	Cycles Opcode Mnemonic Number of Bytes / Addressing Mode

Chapter 10
Low-Voltage Inhibit (LVI)

10.1 Introduction

The low-voltage inhibit (LVI) module is provided as a system protection mechanism to prevent the MCU from operating below a certain operating supply voltage level. The module has several configuration options to allow functionality to be tailored to different system level demands.

The configuration registers (see Chapter 5 Configuration Register (CONFIG)) contain control bits for this module.

10.2 Features

Features of the LVI module include:

- Programmable LVI reset
- Selectable LVI trip voltage
- Programmable stop mode operation

10.3 Functional Description

Figure 10-1 shows the structure of the LVI module. LVISTOP, LVIPWRD, LVITRIP, and LVIRSTD are user selectable options found in the configuration register.

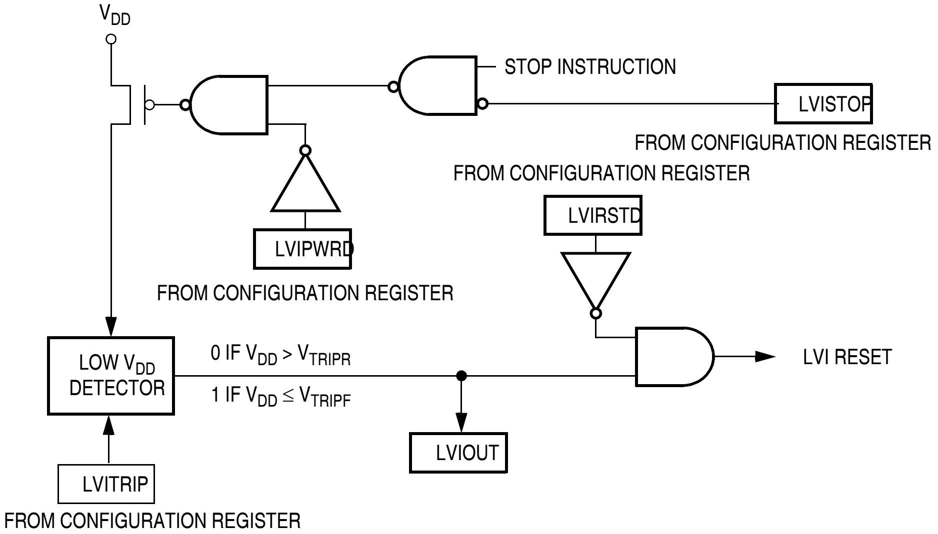
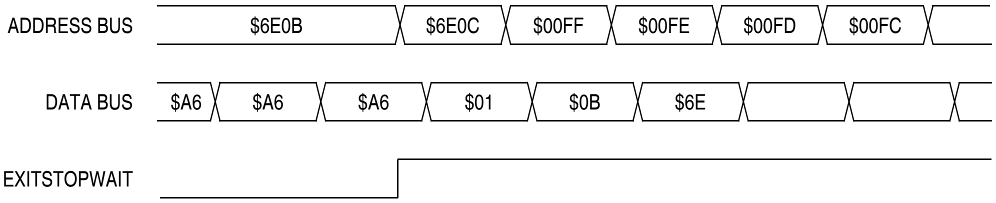


Figure 10-1. LVI Module Block Diagram

In wait mode, the CPU clocks are inactive. Refer to the wait mode subsection of each module to see if the module is active or inactive in wait mode. Some modules can be programmed to be active in wait mode.

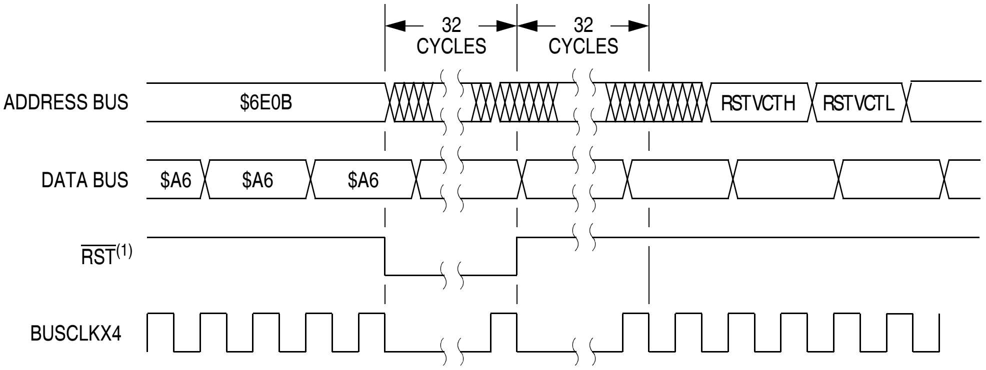
Wait mode can also be exited by a reset (or break in emulation mode). A break interrupt during wait mode sets the SIM break stop/wait bit, SBSW, in the break status register (BSR). If the COP disable bit, COPD, in the configuration register is 0, then the computer operating properly module (COP) is enabled and remains active in wait mode.

Figure 13-15 and Figure 13-16 show the timing for wait recovery.



NOTE: EXITSTOPWAIT = $\overline{\text{RST}}$ pin OR CPU interrupt

Figure 13-15. Wait Recovery from Interrupt



1. $\overline{\text{RST}}$ is only available if the RSTEN bit in the CONFIG1 register is set.

Figure 13-16. Wait Recovery from Internal Reset

13.7.2 Stop Mode

In stop mode, the SIM counter is reset and the system clocks are disabled. An interrupt request from a module can cause an exit from stop mode. Stacking for interrupts begins after the selected stop recovery time has elapsed. Reset or break also causes an exit from stop mode.

The SIM disables the oscillator signals (BUSCLKX2 and BUSCLKX4) in stop mode, stopping the CPU and peripherals. If OSCENINSTOP is set, BUSCLKX2 will remain running in STOP and can be used to run the AWU. Stop recovery time is selectable using the SSREC bit in the configuration register 1 (CONFIG1). If SSREC is set, stop recovery is reduced from the normal delay of 4096 BUSCLKX4 cycles down to 32. This is ideal for the internal oscillator, RC oscillator, and external oscillator options which do not require long start-up times from stop mode.

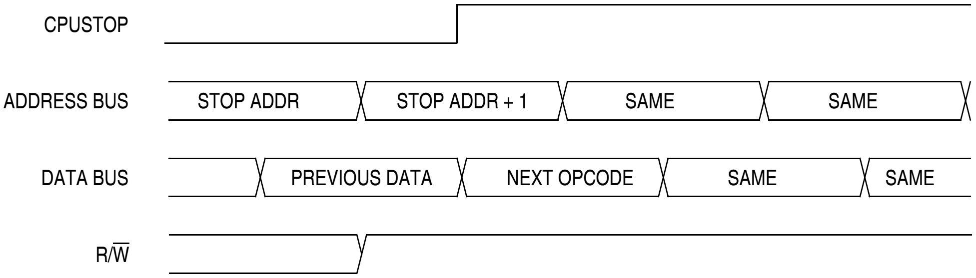
NOTE

External crystal applications should use the full stop recovery time by clearing the SSREC bit.

The SIM counter is held in reset from the execution of the STOP instruction until the beginning of stop recovery. It is then used to time the recovery period. Figure 13-17 shows stop mode entry timing and Figure 13-18 shows the stop mode recovery time from interrupt or break

NOTE

To minimize stop current, all pins configured as inputs should be driven to a logic 1 or logic 0.



NOTE: Previous data can be operand data or the STOP opcode, depending on the last instruction.

Figure 13-17. Stop Mode Entry Timing

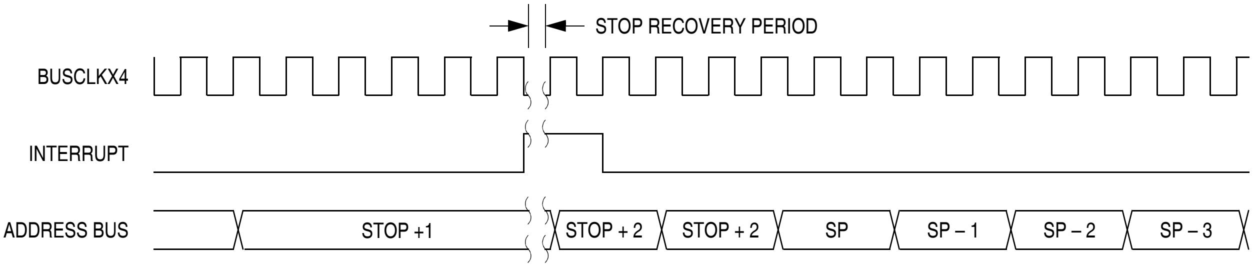


Figure 13-18. Stop Mode Recovery from Interrupt

13.8 SIM Registers

The SIM has two memory mapped registers.

13.8.1 SIM Reset Status Register

The SRSR register contains flags that show the source of the last reset. The status register will automatically clear after reading SRSR. A power-on reset sets the POR bit and clears all other bits in the register. All other reset sources set the individual flag bits but do not clear the register. More than one reset source can be flagged at any time depending on the conditions at the time of the internal or external reset. For example, the POR and LVI bit can both be set if the power supply has a slow rise time.

	Bit 7	6	5	4	3	2	1	Bit 0
Read:	POR	PIN	COP	ILOP	ILAD	MODRST	LVI	0
Write:	▨	▨	▨	▨	▨	▨	▨	▨
POR:	1	0	0	0	0	0	0	0

▨ = Unimplemented

Figure 13-19. SIM Reset Status Register (SRSR)

NOTE

If the reset vector is blank and monitor mode is entered, the chip will see an additional reset cycle after the initial power-on reset (POR). Once the reset vector has been programmed, the traditional method of applying a voltage, V_{TST}*, to IRQ must be used to enter monitor mode.*

If monitor mode was entered as a result of the reset vector being blank, the COP is always disabled regardless of the state of IRQ.

If the voltage applied to the IRQ is less than V_{TST}, the MCU will come out of reset in user mode. Internal circuitry monitors the reset vector fetches and will assert an internal reset if it detects that the reset vectors are erased ($FF). When the MCU comes out of reset, it is forced into monitor mode without requiring high voltage on the IRQ pin. Once out of reset, the monitor code is initially executing with the internal clock at its default frequency.

If IRQ is held high, all pins will default to regular input port functions except for PTA0 and PTA5 which will operate as a serial communication port and OSC1 input respectively (refer to Figure 15-11). That will allow the clock to be driven from an external source through OSC1 pin.

If IRQ is held low, all pins will default to regular input port function except for PTA0 which will operate as serial communication port. Refer to Figure 15-12.

Regardless of the state of the IRQ pin, it will not function as a port input pin in monitor mode. Bit 2 of the Port A data register will always read 0. The BIH and BIL instructions will behave as if the IRQ pin is enabled, regardless of the settings in the configuration register. See Chapter 5 Configuration Register (CONFIG).

The COP module is disabled in forced monitor mode. Any reset other than a power-on reset (POR) will automatically force the MCU to come back to the forced monitor mode.

15.3.1.3 Monitor Vectors

In monitor mode, the MCU uses different vectors for reset, SWI (software interrupt), and break interrupt than those for user mode. The alternate vectors are in the $FE page instead of the $FF page and allow code execution from the internal monitor firmware instead of user code.

NOTE

Exiting monitor mode after it has been initiated by having a blank reset vector requires a power-on reset (POR). Pulling RST (when RST pin available) low will not exit monitor mode in this situation.

Table 15-2 summarizes the differences between user mode and monitor mode regarding vectors.

Table 15-2. Mode Difference

Modes	Functions					
	Reset Vector High	Reset Vector Low	Break Vector High	Break Vector Low	SWI Vector High	SWI Vector Low
User	$FFFE	$FFFF	$FFFC	$FFFD	$FFFC	$FFFD
Monitor	$FEFE	$FEFF	$FEFC	$FEFD	$FEFC	$FEFD

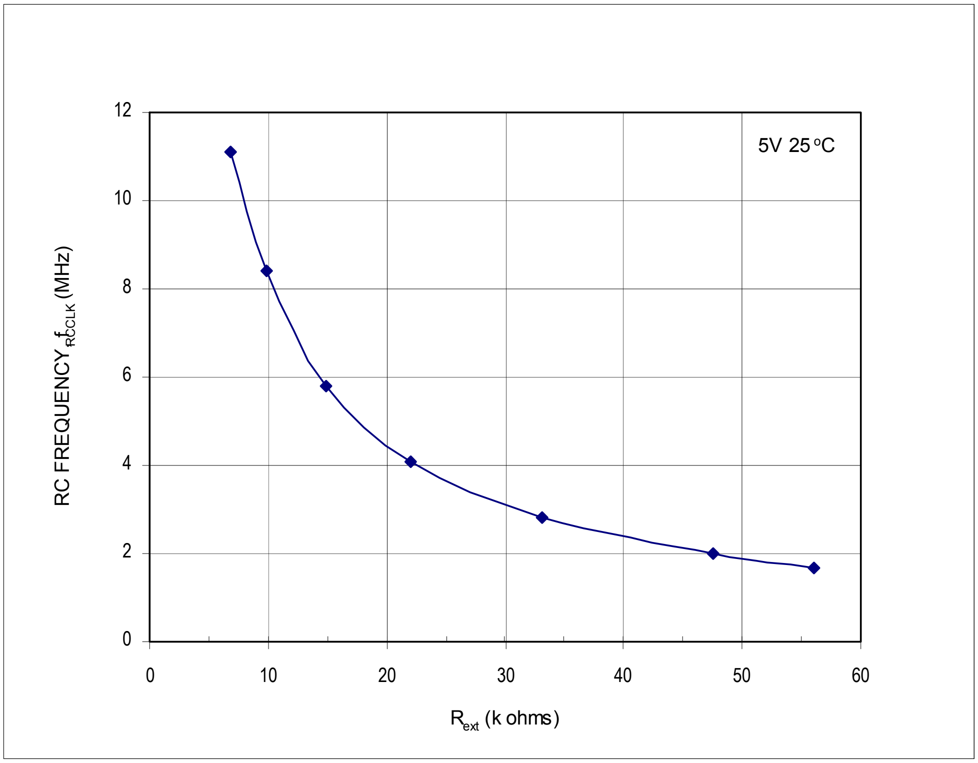


Figure 16-7. RC versus Frequency (5 Volts @ 25°C)

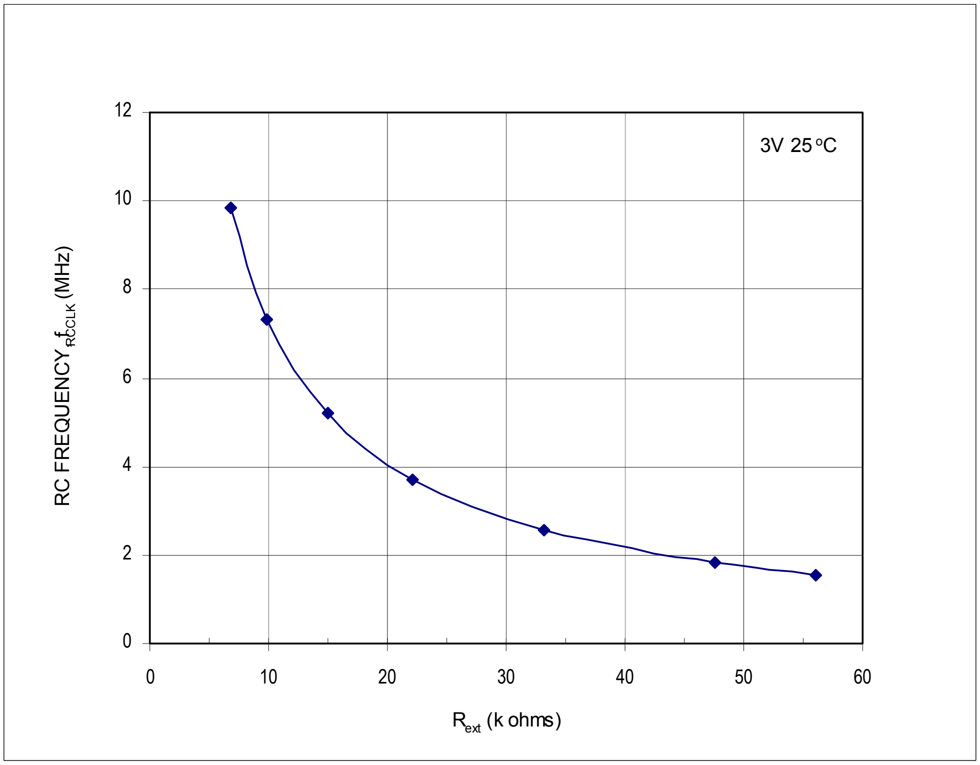


Figure 16-8. RC versus Frequency (3 Volts @ 25°C)

Characteristic	Conditions	Symbol	Min	Typ[1]	Max	Unit	Comment
Integral non-linearity	10-bit mode	INL	0	±0.5	—	LSB	
	8-bit mode		0	±0.3	—		
Zero-scale error	10-bit mode	E_{ZS}	0	±0.5	—	LSB	$V_{ADIN} = V_{SS}$
	8-bit mode		0	±0.3	—		
Full-scale error	10-bit mode	E_{FS}	0	±0.5	—	LSB	$V_{ADIN} = V_{DD}$
	8-bit mode		0	±0.3	—		
Quantization error	10-bit mode	E_Q	—	—	±0.5	LSB	8-bit mode is not truncated
	8-bit mode		—	—	±0.5		
Input leakage error	10-bit mode	E_{IL}	0	±0.2	±5	LSB	Pad leakage[5] * R_{AS}
	8-bit mode		0	±0.1	±1.2		
Bandgap voltage input[6]		V_{BG}	1.17	1.245	1.32	V	

1. Typical values assume V_{DD} = 5.0 V, temperature = 25•C, f_{ADCK} = 1.0 MHz unless otherwise stated. Typical values are for reference only and are not tested in production.
2. Incremental I_{DD} added to MCU mode current.
3. Values are based on characterization results, not tested in production.
4. Reference the ADC module specification for more information on calculating conversion times.
5. Based on typical input pad leakage current.
6. LVI must be enabled, (LVIPWRD = 0, in CONFIG1). Voltage input to ADCH4:0 = $1A, an ADC conversion on this channel allows user to determine supply voltage.

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A.2.5 Keyboard Interface Module (KBI) Functionality

The KBI module for the QYxA has the added capability of:

- Triggering a KBI interrupt on the rising or falling edge of an input while the QYx Classic has the capability of triggering on falling edges only.
  - A new register (Keyboard Interrupt Polarity Register) determines the polarity of KBI and the default state of this register configures the QYxA for triggering on falling edges to be compatible with QYx Classic.
  - The QYxA now has pull down resistors for the input pins that are configured for rising edge operation.

A.2.5.1 Registers Affected

	Bit 7	6	5	4	3	2	1	Bit 0
Read:	0	0	KBIP5	KBIP4	KBIP3	KBIP2	KBIP1	KBIP0
Write:	▨	▨						
Reset:	0	0	0	0	0	0	0	0

▨ = Unimplemented

Figure A-6. Keyboard Interrupt Polarity Register (KBIPR)

The KBIPR allows the selection of polarity, if any of these bits are set the corresponding interrupt pin will be configured for rising edge and a pulldown resistor will be added to the pin.

A.2.6 On-Chip Routine Enhancements

Enhancements have been made to the on-chip routines that are used for FLASH as EEPROM. Refer to AN2346 for information about using FLASH as EEPROM.

- A new mass erase routine requires a valid FLASH address loaded into the H:X register to perform an erase. This added step helps ensure that the erase routine is not inadvertently used to cause an unwanted erase. Also, on-chip FLASH programming routine ERARNGE variable CTRLBYT requires $00 for page erase and $40 for mass erase. The entire control byte must be set for proper operation.
- Separate routines will allow easy access to perform software SCI (Serial Communications Interface). For information on how to use on-chip FLASH programming routines refer to AN2635.
- Finally, there is improved security and robustness. The latest Monitor ROM implements updated security checks to make the program memory more secure.