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zilog
Embedded in Life
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Z8FS040

ZMOTION™ Detection and Control Family Featuring PIR Technology

Product Specification

PS028511-0112

ZMOTION™

www.zilog.com

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Revision History

Each instance in the revision history table reflects a change to this document from its previous revision. For more details, refer to the corresponding pages or appropriate links provided in the table below.

Date	Revision Level	Description	Page
Dec 2011	11	Updated to include two new Nicera lenses in the Lens and PIR Sensor Selector.	40
Jan 2011	10	Modifications to some lens/sensor descriptions in Lens Selection Guide.	55
Jan 2011	09	Updated to include two new Nicera lenses in the Lens and PIR Sensor Selector.	40
Jan 2011	08	Updated to correct part number on title page.	i
Nov 2010	07	Updated to comply with accepted Zilog style.	All
Nov 2010	06	Updated to new Zilog/IXYS logo.	All
Oct 2010	05	Replaced all instances of *ePIR* with *advanced passive infrared*.	All
Sep 2010	04	Fixed formatting and pagination issues.	All
Sep 2010	03	Replaced Zilog logos, ePIR with ZMOTION, and Zdots with Module.	All
Oct 2008	02	Updated the Related Documents section (changed 88-pin SOIC to 28-pin SOIC for Z8FS040AHJ20SG). Removed references to GP and General Purpose.	42, all
Oct 2008	01	Original issue.	All

Table of Contents

Revision History iii
List of Figures vi
List of Tables vii
Overview 1
Features 1
Z8FS040 MCU Block Diagram 3
MCU Part Selection Guide and Reference 4
Pin Configurations 5
Signal Descriptions 7
Memory Map 9
RAM Memory Map (Register Files) 10
Peripherals 11
Peripheral Availability 11
Pin Availability 16
Hardware Connection Requirements 18
Zilog's PIR Technology and API 19
Standard API Register Set 20
Advanced API Register Set 31
Packaging 39
Ordering Information 39
Ordering Example 41
Related Documents 42
Appendix A. Application Schematics 43
8-Pin Z8FS040xSB20EG MCU 43
20-Pin Z8FS040xHH20EG 44
Single Pyroelectric Sensors 44
Dual Pyroelectric Sensors 45
28-Pin Z8FS040xHJ20EG 46
Single Pyroelectric Sensor 46
Dual Pyroelectric Sensors 48
Appendix B. PIR Engine Initialization and Control 49
Appendix C. Software Support Files and Project Configuration 53
ZDSII Project Settings 53
Appendix D. Lens Selection Guide 55
Customer Support 57

List of Figures

Figure 1. Z8FS040 MCU Block Diagram 3
Figure 2. 8-Pin SOIC Package Diagram – Z8FS040xSB20EG 5
Figure 3. 20-Pin SSOP Package Diagram – Z8FS040xHH20EG 5
Figure 4. 28-Pin SSOP Package Diagram – Z8FS040xHJ20EG 6
Figure 5. Z8FS040 MCU Program Memory Map 9
Figure 6. Z8FS040 MCU RAM Memory Map 10
Figure 7. Required Circuit Connections for the Z8FS040xSB20EG(8-Pin) Motion Detection MCU 44
Figure 8. Required Circuit Connections for the Z8FS040xHH20EG (20-Pin) Motion Detection MCU in Single Pyro Mode 45
Figure 9. Required Circuit Connections for the Z8FS040xHH20EG (20-Pin) Motion Detection MCU in Dual Pyro Mode 46
Figure 10. Required Circuit Connections for the Z8FS040xHJ20EG (28-Pin) Motion Detection MCU in Single Pyro Mode 47
Figure 11. Required Circuit Connections for the Z8FS040xHJ20EG (28-Pin) Motion Detection MCU in Dual Pyro Mode 48
Figure 12. Application Flow Diagram: Normal Scan Rate 51
Figure 13. Application Flow Diagram: Low Scan Rate 52

List of Tables

Table 1. Z8FS040 MCU Package Availability 4
Table 2. PIR Technology Revision Identifiers 4
Table 3. Z8FS040 MCU Signal Descriptions 7
Table 4. Peripheral Availability 11
Table 5. PIR Engine Standard API Registers 20
Table 6. PIR Engine Enable Register (ePIR_Enable) 21
Table 7. PIR Software Enable Patterns 21
Table 8. PIR Sensitivity Register (ePIR_Sensitivity) 22
Table 9. PIR Status/Control Register 0 (ePIR_SC0) 23
Table 10. PIR Status/Control Register 1 (ePIR_SC1) 25
Table 11. PIR Status/Control Register 2 (ePIR_SC2) 27
Table 12. PIR Status/Control Register 3 (ePIR_SC3), 28-Pin SSOP 27
Table 13. PIR Status/Control Register 3 (ePIR_SC3), 20-Pin SSOP 28
Table 14. PIR Status/Control Register 3 (ePIR_SC3), 8-Pin SOIC 28
Table 15. PIR ADC Result Value (ePIR_ADC_Result) 30
Table 16. PIR Version (ePIR_Version) 30
Table 17. PIR Engine Advanced Registers 31
Table 18. PIR Advanced Status/Control Register 0 (ePIR_ASC0) 32
Table 19. PIR Advanced Status/Control Register 2 (ePIR_ASC2) 33
Table 20. PIR Process Rate (ePIR_Process_Rate) 34
Table 21. PIR Sample Size Register (ePIR_Sample_Size) 35
Table 22. PIR Debounce Time Register (ePIR_Debounce) 35
Table 23. PIR Debounce Batch Size Register (ePIR_Debounce_Batch) 36
Table 24. PIR Transient Sensitivity Level (ePIR_Transient_Sense) 36
Table 25. Noise Sensitivity as determined by Window Size 37
Table 26. PIR Noise Sensitivity Level (ePIR_Noise_Sense) 37
Table 27. PIR Signal (ePIR_Signal) 38
Table 28. PIR DC Signal Level (ePIR_Signal_DC) 38
Table 29. Part Number Designations 39
Table 30. Positions 1–4 39
Table 31. Positions 5–8: MCU and MCU Package Selector* 40
Table 32. Positions 9–12: Lens and PIR Sensor Selector 40
Table 33. Position 13 40

Table 34. PIR Sensor Information 41
Table 35. ZMOTION Lens and Pyroelectric Sensor Selection Guide 55

Overview

Zilog's ZMOTION Detection and Control Family of products provides an integrated and flexible solution for motion detection applications based on Passive Infrared (PIR) technology, including a high-performance ZMOTION microcontroller with integrated motion detection algorithms and a selection of lenses and PIR sensors to fit a wide range of application requirements. Optimized configuration parameters for the MCU are provided for each lens/sensor combination to ensure the best possible performance while significantly reducing development risk and minimizing time to market.

Depending upon your application requirements, the ZMOTION Detection and Control Family offers a broad range of solutions, from a simple combination of the Z8FS040 MCU and an API to a full set of pyros and lenses that are bundled with the Z8FS040 MCU. The ZMOTION MCU is also packaged as a complete motion detection solution, the ZMOTION Module.

Zilog's Z8FS040 MCU combines the programmability and rich peripheral set of Zilog's Z8 Encore! XP® Flash MCUs with built-in motion detection software algorithms to provide the functions necessary for PIR motion detection applications. These motion detection algorithms comprise Zilog's PIR technology and run in the background while control and status of the PIR Engine is accessed through a software API. As a result, the designer can create application-specific software while taking advantage of Zilog's ZMOTION Motion Detection Technology.

API settings are provided to match the Engine operation to each of the lens and pyroelectric sensor combinations provided.

The Flash in-circuit programming capability of the Z8FS040 allows for faster development time, more flexible manufacturing and firmware changes in the field.

Zilog's PIR motion detection technology provides a dramatic improvement in both sensitivity and stability over traditional designs and is scalable to many market segments including Lighting Control, HVAC, Access Control, Vending, Display, Proximity, Power Management, Occupancy Sensing and many others.

Features

Key features of the Z8FS040 MCU include:

- High performance eZ8® CPU core
- 4 KB in-circuit programmable Flash available for application code
- Single-pin debug with unlimited breakpoints
- Flexible clocking scheme

- Internal precision oscillator running at 5.53 MHz
- External oscillator operating up to 20 MHz
- Sigma Delta ADC
- Up to 6 channels single-ended or 3 channels differential available
- On-chip analog comparator with independent programmable reference voltage
- Full-duplex UART with dedicated BRG
- Two 16-bit timers with input capture, output compare, and PWM capability (11 modes total)
- Watchdog timer (WDT) with dedicated internal oscillator
- Up to 20 vectored interrupts
- 6 to 25 I/O pins depending upon package
- 2.7 V to 3.6 V operating voltage with extended operating temperature range –40°C to +105°C
- Zilog's PIR technology controlled and monitored through software API registers
- Select from an assortment of lenses and pyroelectric sensors to best fit your application
- API settings provided for each lens and pyroelectric sensor combination
- Directly supports 1 or 2 pyroelectric sensors
- Sensitivity control, range control and directional detection
- Extended detection modes for occupancy sensing
- Low power modes

Z8FS040 MCU Block Diagram

Figure 1 displays a block diagram of the Z8FS040 MCU.

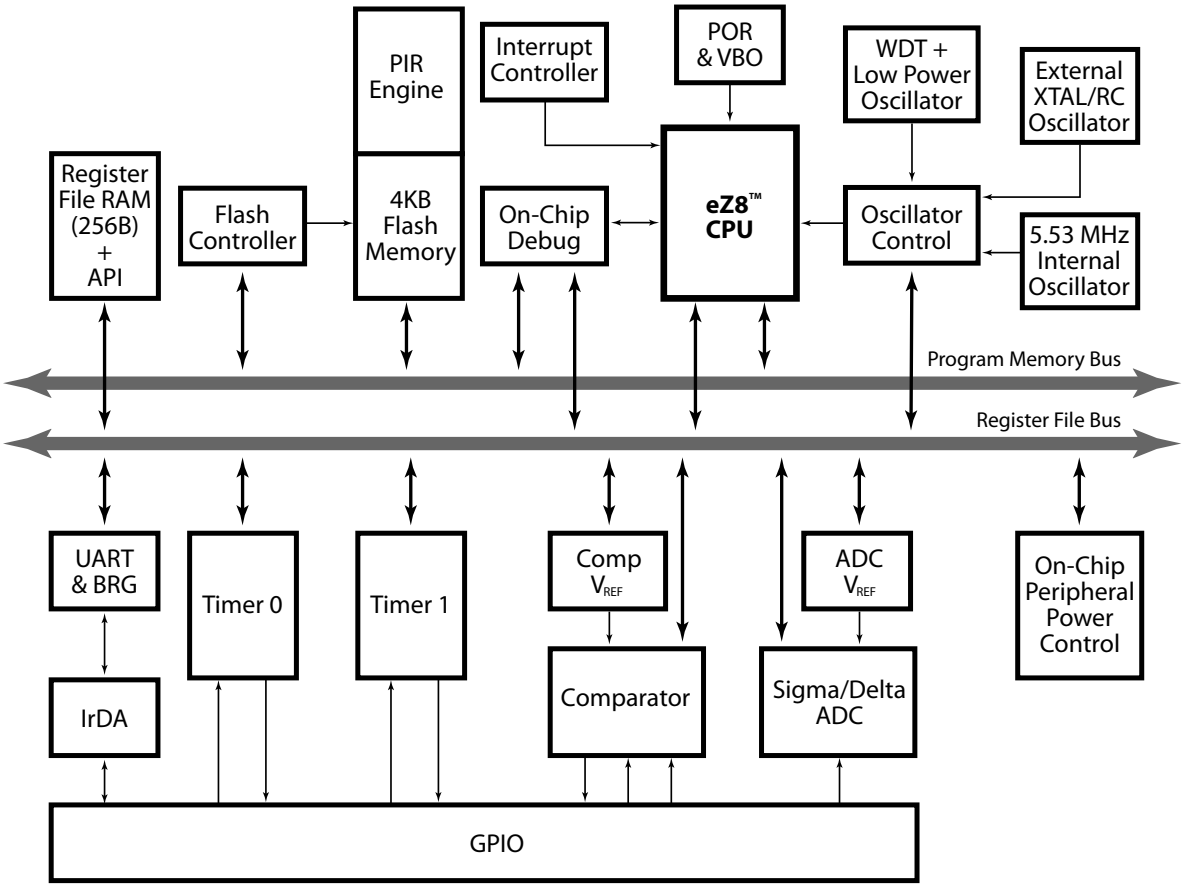

Figure 1. Z8FS040 MCU Block Diagram

MCU Part Selection Guide and Reference

The ZMOTION MCU is packaged in three forms to suit differing application requirements, as follows:

The ZMOTION Dedicated Silicon and Optimized Software Solution. A general-purpose MCU with motion detection software and API stack.

The ZMOTION Module. A complete modular system with a lens and pyroelectric sensor for out-of-the-box development.

The ZMOTION Detection and Control Bundled Solution. A package that combines the ZMOTION MCU with an assortment of lenses and pyros.

Table 1 lists these three packages by part number, while Table 2 indicates changes since the initial release of the MCU. To determine the appropriate ZMOTION product for your application by part number, see the Ordering Information section on page 39 of this document.

Table 1. Z8FS040 MCU Package Availability

ZMOTION MCU Part Number	Z8 Encore XP Base Part Number	Flash Memory	GPIO	ADC Channels	Package
Z8FS040*x*SB20EG	Z8F082ASB020EG	4 KB	5	3	8-pin SOIC
Z8FS040*x*HH20EG	Z8F082AHH020EG	4 KB	16	4	20-pin SSOP
Z8FS040*x*HJ20EG	Z8F082AHJ020EG	4 KB	22	6	28-pin SSOP

Note: *x* = PIR Technology Revision Identifier (see Table 2).

Table 2. PIR Technology Revision Identifiers

Version	Part Number Engine Revision Identifier	Description
1.00	A	Initial release for ZEPIR0AAS01SBCG, 8-pin version only.
2.00	B	ZMOTION MCU Series release features improved detection/stability, added range; low power, extended detection, dual pyro capability; advanced API features. Revised Z8FS040*x* part numbering schema.

Please refer to the base part number in the Z8 Encore! XP F082A Series Product Specification (PS0228) for all MCU functions, features and specifications not covered in this document.

Pin Configurations

Zilog's Z8FS040 products are available in 8-pin SOIC and 20- and 28-pin SSOP package configurations, as shown in Figures 2 through 4. This chapter describes the signals and available pin configurations for each of these package types. For a description of the signals, see Tables 6 through 8 starting on page 21. For physical package specification information, see the Packaging section on page 39.

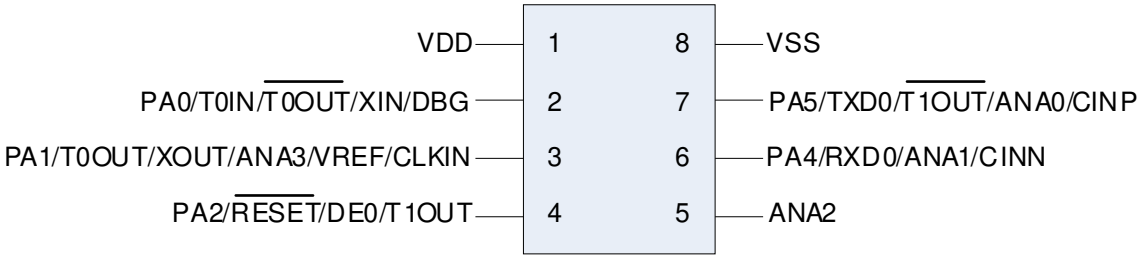

Figure 2. 8-Pin SOIC Package Diagram – Z8FS040xSB20EG

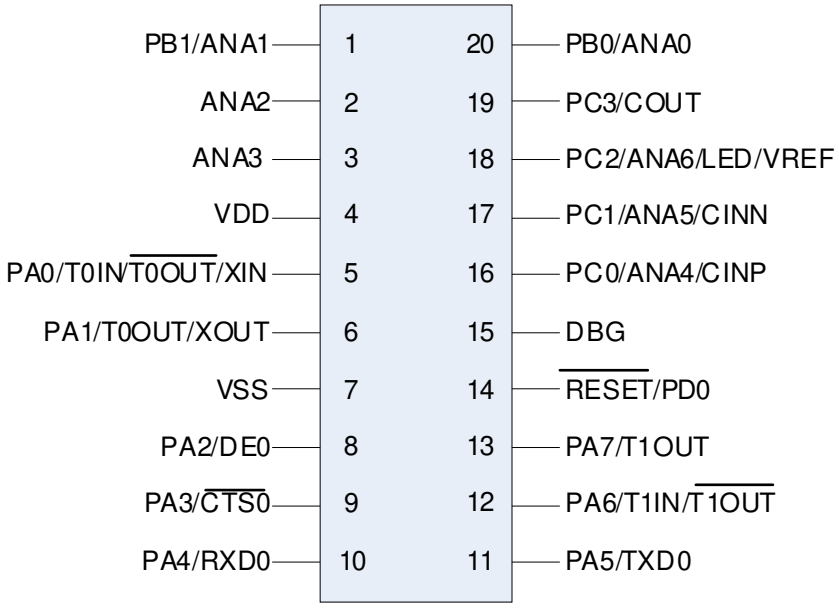

Figure 3. 20-Pin SSOP Package Diagram – Z8FS040xHH20EG

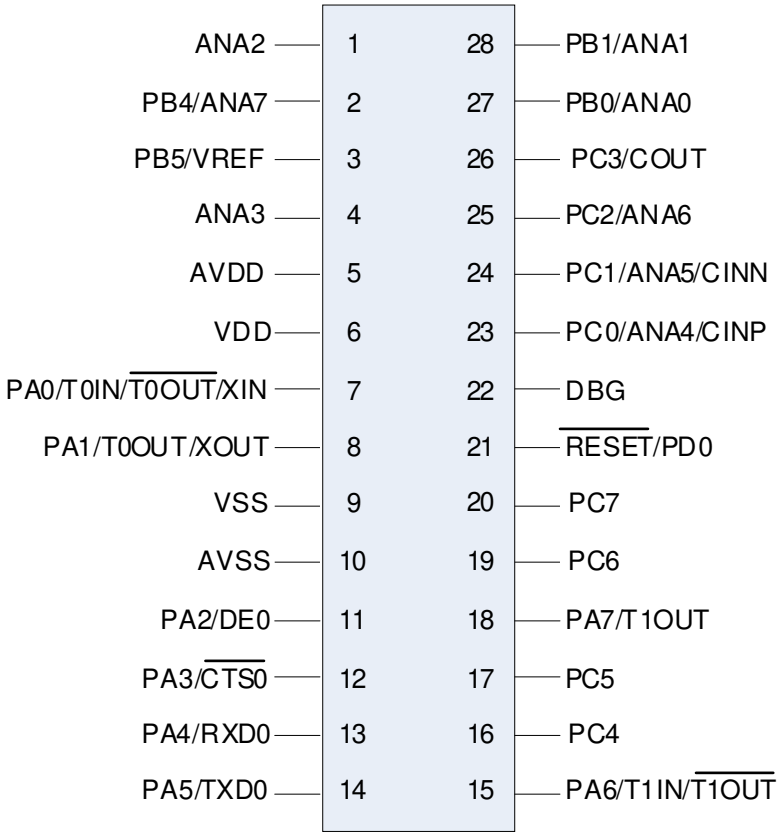

Figure 4. 28-Pin SSOP Package Diagram – Z8FS040xHJ20EG

Signal Descriptions

At reset, all port pins are set to the GPIO input state on the 8-pin SOIC package except for $\overline{\text{RESET}}$/DE0/$T1_{OUT}$, which is configured to $\overline{\text{RESET}}$, and PA0/$T0_{IN}$/$T0_{OUT}$/X_{IN}/DBG, which is configured to DBG. On the 20- and 28-pin SSOP packages, RESET/PD0 is configured to $\overline{\text{RESET}}$.

Table 3 describes the Z8FS040 Series signals.

Table 3. Z8FS040 MCU Signal Descriptions

Signal Mnemonic	I/O	Description
General-Purpose I/O Ports A–D		
PA[7:0]	I/O	Port A. These pins are used for general-purpose I/O.
PB[5:0]	I/O	Port B. These pins are used for general-purpose I/O.
PC[7:0]	I/O	Port C. These pins are used for general-purpose I/O.
PD[0]	O	Port D. This pin is used for general-purpose output only.
UART Controllers		
TXD0	O	Transmit Data. This signal is the transmit output from the UART and IrDA.
RXD0	I	Receive Data. This signal is the receive input for the UART and IrDA.
CTS0	I	Clear To Send. This signal is the flow control input for the UART.
DE	O	Driver Enable. This signal allows automatic control of external RS-485 drivers. It is approximately the inverse of the Transmit Empty (TXE) bit in the UART Status 0 Register. The DE signal can be used to ensure that the external RS-485 driver is enabled when data is transmitted by the UART.
Timers		
$T0_{OUT}$/$T1_{OUT}$	O	Timer Output 0–1. These signals are outputs from the timers.
$T0_{OUT}$/$T1_{OUT}$	O	Timer Complement Output 0–1. These signals are output from the timers in PWM DUAL OUTPUT Mode.
$T0_{IN}$/T1IN	I	Timer Input 0–1. These signals are used as the capture, gating and counter inputs.
Comparator		
C_{IN}P/C_{IN}N	I	Comparator Inputs. These signals are the positive and negative inputs to the comparator.
C_{OUT}	O	Comparator Output.

Table 3. Z8FS040 MCU Signal Descriptions (Continued)

Signal Mnemonic	I/O	Description
Analog		
ANA[7:0]	I	Analog Port. These signals are used as inputs to the analog-to-digital converter (ADC).
V_{REF}	I/O	Analog-to-digital converter reference voltage input, or buffered output for internal reference.
Oscillators		
X_{IN}	I	External Crystal Input. This is the input pin to the crystal oscillator. A crystal can be connected between it and the X_{OUT} pin to form the oscillator. In addition, this pin is used with external RC networks or external clock drivers to provide the system clock.
X_{OUT}	O	External Crystal Output. This pin is the output of the crystal oscillator. A crystal can be connected between it and the X_{IN} pin to form the oscillator.
Clock Input		
CLKIN	I	Clock Input Signal. This pin may be used to input a TTL-level signal to be used as the system clock.
LED Drivers		
LED	O	Direct LED drive capability. All port C pins have the capability to drive an LED without any other external components. These pins have programmable drive strengths set by the GPIO block.
On-Chip Debugger		
DBG	I/O	Debug. This signal is the control and data input and output to and from the On-Chip Debugger.
Caution:		The DBG pin is open-drain and requires a pull-up resistor to ensure proper operation.
Reset		
RESET	I/O	RESET. Generates a Reset when asserted (driven Low). Also serves as a reset indicator; the Z8 Encore! XP forces this pin low when in reset. This pin is open-drain and features an enabled internal pull-up resistor.
Power Supply		
V_{DD}	I	Digital Power Supply.
AV_{DD}	I	Analog Power Supply.
V_{SS}	I	Digital Ground.
AV_{SS}	I	Analog Ground.

Memory Map

The Z8FS040 MCU is based on Zilog's Z8F082A device, which contains a total of 8KB of Flash memory. Zilog's PIR technology is located in the 4KB address range 1000h to 1FFFh, a code space that is locked and cannot be erased by the user, by the Zilog Debug Interface (ZDI) mass or page erase commands. The remaining 4KB of this Flash memory space, in the address range 0000h to 0FFFh, is available for user application code.

A memory map of the Z8SF040 MCU is illustrated in Figure 5.

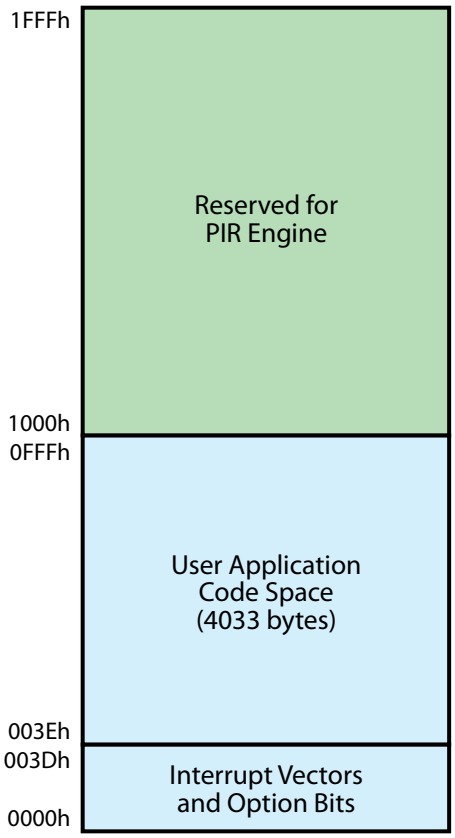

Figure 5. Z8FS040 MCU Program Memory Map

RAM Memory Map (Register Files)

There is a total of 1 KB of RAM available on the base Z8F082A device. Some of this RAM (from 080h to 0EFh and from 190h to 3FFh) is used by Zilog's PIR technology. The remainder of the RAM, from 000h to 07Fh and from 110h to 18Fh (256 bytes) is available to the application. The MCU Control Registers are located at the top of memory, from F00h to FFFh, and are also available to the application. The area from 400h to EFFh contains no device memory. See Figure 6.

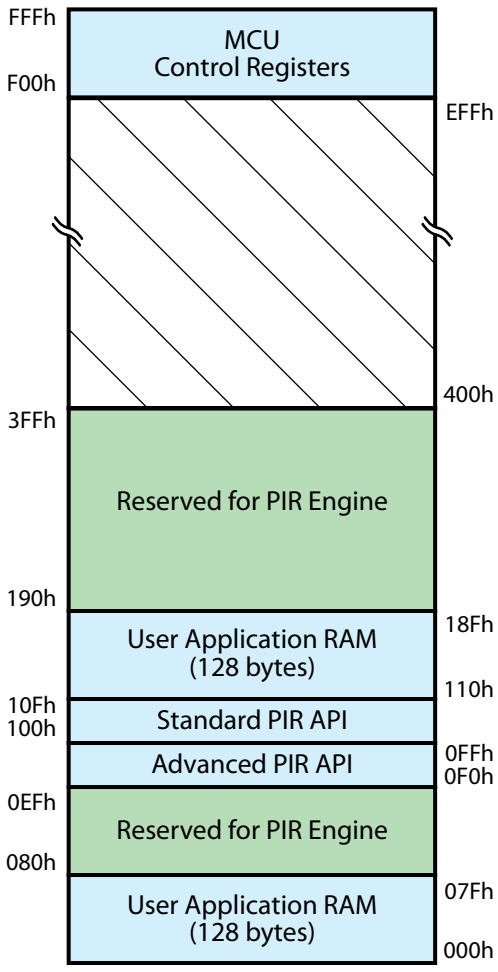

Figure 6. Z8FS040 MCU RAM Memory Map

The PIR Motion Detection API is a series of registers located in RAM memory space, from 0F0h to 10Fh. It is through these memory locations that configuration and status are passed between the PIR technology and the user application. Advanced API registers are

located in the address range 0F0h to 0FFh. See the Zilog's PIR Technology and API chapter on page 19 for details about the API registers and setting up the project memory environment.

Peripherals

The following sections describe the differences, changes, or limitations placed on any of the Z8FS040 peripherals or other functions from the base Z8F082A device. To learn more about the operation of each peripheral please refer to the appropriate section of the Z8 Encore! XP F082A Series Product Specification (PS0228).

Peripheral Availability

Table 4 shows how the Z8FS040 MCU peripherals are used by Zilog's PIR technology and how these peripherals differ from their counterparts on the base Z8F082A device. The peripherals used by the PIR technology should not be used by the application unless the engine is disabled through the PIR Engine Enable Register.

Table 4. Peripheral Availability

	Device		
	Z8FS040xSB20EG	**Z8FS040xHH20EG**	**Z8FS040xHJ20EG**
Base MCU Device	Z8F082ASB020EG	Z8F082AHH020EG	Z8F082AHJ020EG
Pins/Package	8 pin SOIC	20-Pin SSOP	28-Pin SSOP
ADC	ANA2 is used for PIR sensor input. ANA3 is used for a second sensor input in DUAL PYRO Mode.	ANA2 is used for PIR sensor input. ANA3 is connected to ANA6/V_{REF}. ANA3 is used for a second sensor input and ANA6 becomes available in DUAL PYRO Mode.	ANA2 is used for PIR sensor input. ANA3 is connected to V_{REF}. ANA3 is used for a second sensor in DUAL PYRO Mode
VREF	Internal V_{REF} used by the PIR engine and set to 1 V.	Internal V_{REF} used by the PIR engine and set to 1 V.	Internal V_{REF} used by the PIR engine and set to 1 V.
Timer 0	Available to application.	Available to application.	Available to application.
Timer 1	Available to application.	Available to application.	Available to application.

Table 4. Peripheral Availability (Continued)

GP I/O	PA3/PA1 are multiplexed with ANA2/ANA3 and used for PIR sensor input (ANA2 for SINGLE PYRO Mode and ANA2/ANA3 for DUAL PYRO Mode).	PB2, PB3 & PC2 are used for PIR functions. In DUAL PYRO Mode, PC2 becomes available.	PB2, PB3 & PB5 are used for PIR functions. In DUAL PYRO Mode, PB5 becomes available.
Low Power Op Amp	Not Available	Not Available	Not Available
Comparator	Available to application.	Available to application.	Available to application.
UART	Available to application – No CTS.	Available to application.	Available to application.
Temperature Sensor	Not available.	Not Available.	Not Available.
LED Drive	—	Available to application.	Available to application.
WDT	Available to application.	Available to application.	Available to application.

The remainder of this section further describes the differences in application availability between the 8-pin, 20-pin and 28-pin peripheral sets.

Analog to Digital Signal Conversion

Zilog's PIR technology requires exclusive access to the ADC peripheral to detect motion. However, ADC conversions can be requested by the application via the API (PIR Status/ Control Register 3). If it is necessary for the user application to utilize the ADC peripheral directly, the PIR engine must first be disabled via the PIR Engine Enable Register in the API. Motion detection is not possible while the PIR engine is disabled. When the user application is finished with the ADC peripheral, it must reenable the PIR engine.

8-Pin Device. PA3 (ANA2) is reserved as the analog ADC input from the pyroelectric sensor. Therefore, ANA2 is not available for user applications. Additionally, ANA3 is used for second-sensor input in DUAL PYRO Mode. All other channels are available to the user application.

ADC Channel	Available to Application
0	Yes
1	Yes
2	No
3	Only in Single Pyro Mode

20-Pin Device. PB2 (ANA2) is reserved as the analog ADC input from the pyroelectric sensor. Therefore ANA2 is not available for user applications. Also, ANA3 and ANA6 are

not available since PB3 (ANA3) must be tied directly to PC2 (ANA6/V_{REF}). PC2 is configured as V_{REF} output by the PIR engine. In DUAL PYRO Mode, ANA3 is used for second sensor input rather than being tied to V_{REF}, and therefore ANA6/V_{REF} becomes available. All other channels are available to the user application.

ADC Channel	Available to Application
0	Yes
1	Yes
2	No
3	No
4	Yes
5	Yes
6	Only in DUAL PYRO Mode

28-Pin Device. PB2 (ANA2) is reserved as the analog ADC input from the pyroelectric sensor. Therefore ANA2 is not available for user applications. Also, ANA3 is not available since it is tied directly to PB5/V_{REF}. PB5 will be configured as V_{REF} output by the PIR engine. In DUAL PYRO Mode, ANA3 is used for a second sensor input rather than being tied to V_{REF}, and PB5 therefore becomes available. All other channels are available to the user application.

ADC Channel	Available to Application
0	Yes
1	Yes
2	No
3	No
4	Yes
5	Yes
6	Yes
7	Yes

Timers

There are two independent and identical 16-bit multifunction timers available; both Timer 0 and Timer 1 are available to the user application.

Timer 0	
8-Pin Device	$T0_{OUT}$ not available in DUAL PYRO Mode; configured as ANA3 to support a second sensor input. All other external Timer 0 functions are available for the user application.
20-Pin Device	All external Timer 0 functions are available for the user application.
28-Pin Device	All external Timer 0 functions are available for the user application.

Timer 1	
8-Pin Device	T1IN is configured as ANA2 to support the signal input from the pyroelectric sensor and is not available to the user application. All other Timer 1 functions are available.
20-Pin Device	All external Timer 1 functions are available for the user application.
28-Pin Device	All external Timer 1 functions are available for the user application.

Watchdog Timer

No changes or limitations are placed on WDT functions by Zilog's PIR technology; the WDT is available to the user application.

Comparator

8-Pin Device	The external pin that carries C_{OUT} is configured as ANA2 to support the signal input from the Pyroelectric sensor. However, the Comparator is still able to generate an interrupt internally without C_{OUT}.
20-Pin Device	All external Comparator functions are available for the user application.
28-Pin Device	All external Comparator functions are available for the user application.

UART

8-Pin Device	$\overline{\text{CTS0}}$ is configured as ANA2 to support the signal input from the Pyroelectric sensor. It is therefore not available to the user application. The UART is still able to function correctly without /CTS when CTSE in the U0CTL0 register set to 0.
20-Pin Device	All external UART functions are available for the user application.
28-Pin Device	All external UART functions are available for the user application.

Oscillator Control

All devices can be operated with the internal 5.54MHz IPO. For applications that require more processing power or a more accurate time base, an external crystal oscillator or ceramic resonator can be used.

When using the 8-pin device, external oscillator support is limited to SINGLE PYRO Mode only, since ANA3 (the ADC input for a second pyro sensor) is multiplexed with X_{OUT}. The 20- and 28-pin devices can be operated with an external oscillator in both SINGLE and DUAL PYRO modes.

Caution: Do not operate at frequencies lower than the IPO frequency while the PIR engine is enabled or motion detection performance will be degraded.

No other changes or limitations are placed on oscillator control functions by the PIR engine.

Flash Memory

The control registers associated with Flash memory are all available to the application. Zilog's PIR technology uses the value programmed into the Flash Frequency registers (FFREQ) to determine its required sample timing. The Flash Frequency High (FFREQH) and Flash Frequency Low Byte (FFREQL) registers must be programmed prior to initializing the PIR engine. These two registers combine to form a 16-bit value, FFREQ. This value is also used by the PIR engine to calculate the required sample rate of the ADC and other functions. The 16-bit value for FFREQ is the System Clock Frequency in KHz and is calculated using the following equation.

```
FFREQ[15:0] = {FFREQH[7:0],FFREQL[7:0]} = (System Clock
Frequency)/1000
```

Interrupt Controller

No changes or limitations are placed on the interrupt controller functions by Zilog's PIR technology.

Temperature Sensor

The temperature sensor is not tested or calibrated (trim bits are not available). Therefore this peripheral is not available on any of the Z8FS040 devices.

Low-Power Operational Amplifier

The AMPINP signal is multiplexed with ANA2 which is used for the pyro sensor input. Therefore this peripheral is not available on any of the Z8FS040 devices.

Nonvolatile Data Storage

There is no dedicated nonvolatile data storage on the Z8FS040 devices.

Pin Availability

Although most pins on the ZMOTION MCU Series are available to the application, some pins are dedicated to supporting the PIR functions. The following section describes which pins are reserved and which are available to the application. The pins used by Zilog's PIR technology are automatically configured when the engine is initialized.

General-Purpose Input/Output

All of the General Purpose I/Os are available except for those used for the PIR circuit. To learn more, see the example application schematics in Appendix A. Application Schematics on page 43.

8-Pin Device	Pin 5 (ANA2) is reserved as the analog ADC input from the pyroelectric sensor. Any other functions multiplexed with Pin 5 (PA3/CTS0, C_{OUT} and T1IN) are not available for user applications. In DUAL PYRO Mode (the application uses 2 pyroelectric sensors), Pin 3 (ANA3) is used as an analog ADC input for second sensor and is therefore not available for other functions ($T0_{OUT}$/V_{REF}/CLKIN).
20-Pin Device	Pin 2 (ANA2) is reserved as the analog ADC input from the pyroelectric sensor. In SINGLE PYRO Mode, Pin 3 (ANA3) must be externally tied to V_{REF} on Pin 18 (PC2/ ANA6/LED/V_{REF}). PC2 will be configured as the V_{REF} output by the PIR engine when it is enabled. In DUAL PYRO Mode (which supports 2 pyroelectric sensors), Pin 3 (ANA3) is used for the second sensor. In this mode, the Pin 18 V_{REF} signal is not connected externally to any other ADC inputs and is therefore available to the application (PC2/ANA6/LED/ V_{REF}).
28-Pin Device	Pin 1 (ANA2) is reserved as the analog ADC input from the pyroelectric sensor. In SINGLE PYRO Mode, Pin 4 (ANA3) must be externally tied to V_{REF} on Pin 3 (PB5/V_{REF}). PB5 will be configured as V_{REF} output by the PIR engine when it is enabled. In DUAL PYRO Mode (which supports 2 pyroelectric sensors), Pin 4 (ANA3) is used for second sensor. In this mode, the Pin 3 V_{REF} signal is not connected externally to any other ADC inputs and is therefore available to the application (PB5/V_{REF}).

Hardware Connection Requirements

This section describes the required external hardware connection for the ZMOTION MCU Series.

Pins are automatically configured to their required function when the PIR engine is initialized via the EPIR_INIT macro.

See Appendix A. Application Schematics on page 43 for example schematic diagrams showing the required connections.

The device can be operated in SINGLE PYRO Mode to support one pyroelectric sensor, or DUAL PYRO Mode to support two pyroelectric sensors. Both of these modes can be operated in NORMAL or LOW SCAN RATE modes.

Depending on the application, there can be up to 3 connection requirements supporting these modes:

Pyroelectric Sensor (PIR Sensor). The signal from the PIR sensor is connected directly to the ANA2 input of the ADC. The ADC is configured for differential, buffered mode by Zilog's PIR technology. The sensor signal should be connected directly to the ADC input with no additional signal conditioning circuitry unless specified by the pyroelectric sensor manufacturer.

ADC V_{REF}. The on-chip V_{REF} is configured for 1 V nominal. The PIR Sensor signal is connected to the "+" differential input of the ADC (ANA2), and the V_{REF} signal is connected to the "–" differential input (ANA3). The 8 pin device has an internal connection from V_{REF} to ANA3 to support this configuration therefore no external hardware connection is required. The 20 and 28 pin devices require an external connection from the V_{REF} out signal to the ADC– (ANA3) input.

Pyroelectric Passive Infrared Sensor #2. In DUAL PYRO Mode, the ADC is still used in differential, buffered mode (the same as SINGLE PYRO Mode). The signal from the second PIR sensor is connected to ANA3. The V_{REF} signal is no longer connected to ANA3 ("–" ADC input). The fist PIR sensor is connected to the "+" ADC input (ANA2) as it is in SINGLE PYRO Mode. The V_{REF} signal is still used internally for the ADC, but the external pin is unused in DUAL PYRO Mode.