Chipsmall Limited consists of a professional team with an average of over 10 year of expertise in the distribution of electronic components. Based in Hongkong, we have already established firm and mutual-benefit business relationships with customers from,Europe,America and south Asia,supplying obsolete and hard-to-find components to meet their specific needs.

With the principle of “Quality Parts,Customers Priority,Honest Operation,and Considerate Service”,our business mainly focus on the distribution of electronic components. Line cards we deal with include Microchip,ALPS,ROHM,Xilinx,Pulse,ON,Everlight and Freescale. Main products comprise IC,Modules,Potentiometer,IC Socket,Relay,Connector.Our parts cover such applications as commercial,industrial, and automotives areas.

We are looking forward to setting up business relationship with you and hope to provide you with the best service and solution. Let us make a better world for our industry!


## Contact us

Tel: +86-755-8981 8866 Fax: +86-755-8427 6832
Email & Skype: info@chipsmall.com Web: www.chipsmall.com
Address: A1208, Overseas Decoration Building, #122 Zhenhua RD., Futian, Shenzhen, China

zilog
Embedded in Life
An IXYS Company

# Z8FS021

# ZMOTION™ Intrusion Detection

## Product Specification

PS028804-1011

ZMOTION™


www.zilog.com

**Warning:** DO NOT USE THIS PRODUCT IN LIFE SUPPORT SYSTEMS.

## LIFE SUPPORT POLICY

ZILOG'S PRODUCTS ARE NOT AUTHORIZED FOR USE AS CRITICAL COMPONENTS IN LIFE SUPPORT DEVICES OR SYSTEMS WITHOUT THE EXPRESS PRIOR WRITTEN APPROVAL OF THE PRESIDENT AND GENERAL COUNSEL OF ZILOG CORPORATION.

### As used herein

Life support devices or systems are devices which (a) are intended for surgical implant into the body, or (b) support or sustain life and whose failure to perform when properly used in accordance with instructions for use provided in the labeling can be reasonably expected to result in a significant injury to the user. A critical component is any component in a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system or to affect its safety or effectiveness.

### Document Disclaimer

 Information in this publication concerning the devices, applications, or technology described is intended to suggest possible uses and may be superseded. ZILOG, INC. DOES NOT ASSUME LIABILITY FOR OR PROVIDE A REPRESENTATION OF ACCURACY OF THE INFORMATION, DEVICES, OR TECHNOLOGY DESCRIBED IN THIS DOCUMENT. ZILOG ALSO DOES NOT ASSUME LIABILITY FOR INTELLECTUAL PROPERTY INFRINGEMENT RELATED IN ANY MANNER TO USE OF INFORMATION, DEVICES, OR TECHNOLOGY DESCRIBED HEREIN OR OTHERWISE. The information contained within this document has been verified according to the general principles of electrical and mechanical engineering.

ZMOTION and Z8 Encore! XP are trademarks or registered trademarks of Zilog, Inc. (An IXYS Company). All other product or service names are the property of their respective owners.

# Revision History

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

| Date | Revision Level | Description | Page Number |
|---|---|---|---|
| Oct 2011 | 04 | Corrected error in ePIR_SC1 description, Table 9; modified Packaging section. | 29, 46 |
| Jul 2011 | 03 | Corrections to ePIR_SC1, ePIR_Process_Rate and ePIR_Signal_DC registers | 29, 40, 44 |
| Apr 2011 | 02 | Corrections to PIR Noise Sensitivity Level Register and PIR Transient Sensitivity Level Register. | 42 |
| Feb 2011 | 01 | Original issue. | All |

# Table of Contents

# List of Figures

# List of Tables

# Overview

The ZMOTION Intrusion Detection device is an integrated and flexible solution for Passive Infrared (PIR)-based motion detection applications. The ZMOTION family includes a series of high-performance microcontrollers with integrated motion-detection algorithms and a selection of lenses and PIR sensors to fit a wide range of intrusion detection and security applications. Zilog's ZMOTION Intrusion Detection Solution provides a dramatic improvement in both sensitivity and stability over traditional security-related motion detection designs with integrated functions such as White Light detection and Pet Immunity. As a result, it is the ideal solution for security applications in which intrusion detection capability is vital.

The ZMOTION Intrusion Detection Solution, based on Zilog's Z8FS021 MCU, combines the programmability and rich peripheral set of our Z8 Encore! XP family of In-Circuit Programmable Flash MCUs with built-in motion detection software algorithms to provide the functions necessary for PIR motion detection applications. These algorithms comprise the PIR Engine and run in the background while control and status of the Engine is accessed through a software Application Programmer Interface (API). These APIs allow designers to create their own application-specific software while taking advantage of Zilog's ZMOTION Motion Detection Technology. Additional API settings are provided to match PIR Engine operation to each lens and pyroelectric sensor combination.

The Flash in-circuit programming capability of the Z8FS021 MCU allows for faster development time, more flexible manufacturing and firmware changes in the field.

As with all of Zilog's ZMOTION products, the ZMOTION Intrusion Detection MCU provides optimized configuration parameters for each lens/sensor combination to ensure the best possible performance while significantly reducing development risk and minimizing time to market.

## ZMOTION Intrusion Detection Features

- Software-based Motion Detection (PIR) Engine controlled and monitored via 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
- Sensitivity control, range control and directionality detection
- Accurate frequency discrimination and programmable pet immunity
- No temperature compensation required
- White light detection using status LED reduces system cost (eliminates CDS photocell)
- White Light Anti-Jam feature and programmable sensitivity to support a wide range of LED and light pipe configurations

- Programmable transient and noise detection

## Z8FS021 MCU Features

- High-performance eZ8® CPU core
- 2 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 single-ended channels or 3 differential channels 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
- Low power modes

# Z8FS021 MCU Block Diagram

Figure 1 displays a block diagram of the Z8FS021 MCU.

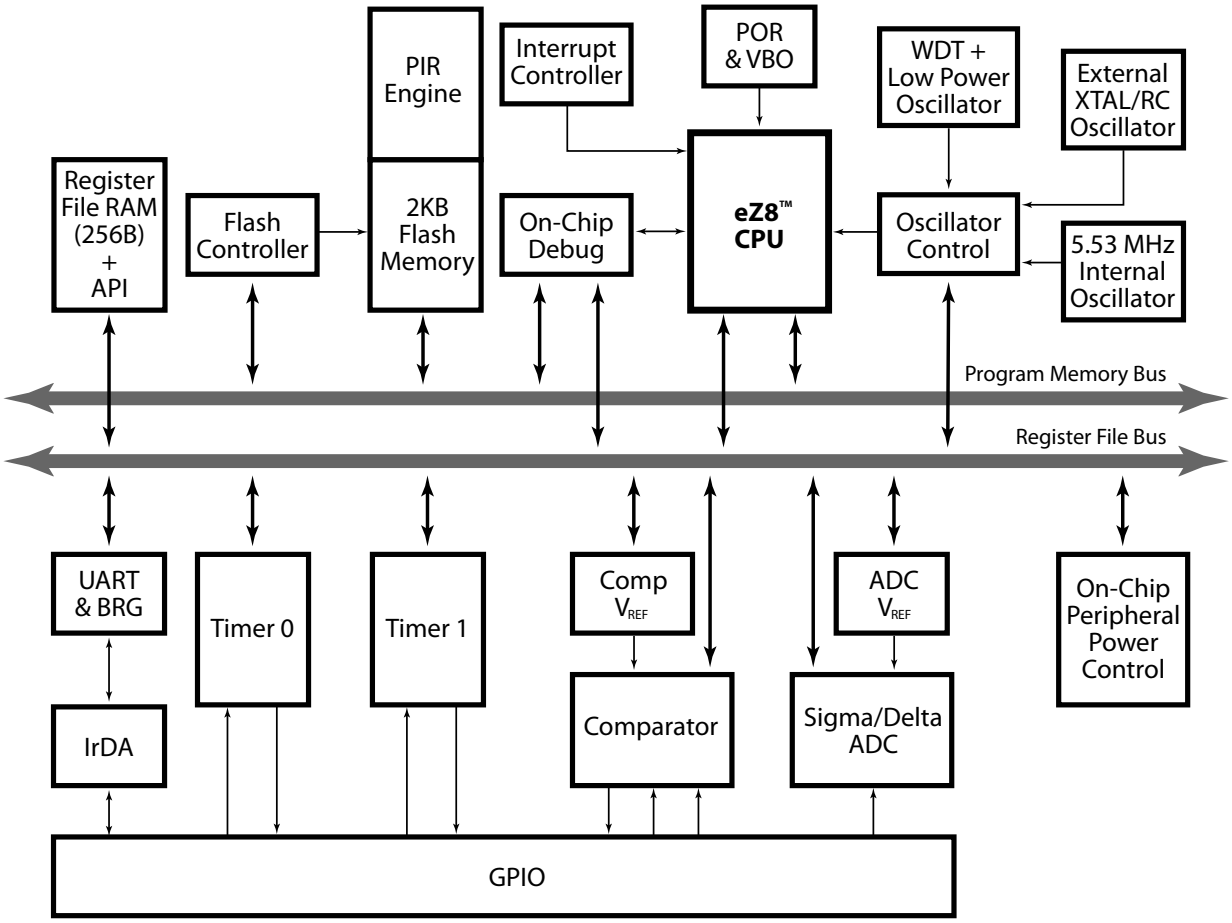


**Figure 1. Z8FS021 MCU Block Diagram**

# MCU Part Selection Guide

Table 1 displays the basic features and package styles available for each device within the Z8FS021 ZMOTION Intrusion Detection MCU devices. Select the package type that is most suitable to your application based on required General Purpose I/Os and ADC channels. The table suggests references to the pin configuration diagrams for the peripheral functions available on each I/O pin.

See the Ordering Information section on page 47 for a list of all ZMOTION Intrusion Detection part numbers.

**Table 1. Z8FS021 ZMOTION Intrusion Detection MCU Part Selection Guide**

| ZMOTION MCU Part Number | Z8 Encore! XP Base Part Number | Flash Memory | GPIO | ADC Channels | Package | Pin Configuration Diagram |
|---|---|---|---|---|---|---|
| Z8FS021xSB20EG | Z8F082ASB020EG | 2KB | 5 | 3 | 8-pin SOIC | Figure 2 |
| Z8FS021xHH20EG | Z8F082AHH020EG | 2KB | 16 | 4 | 20-pin SSOP | Figure 3 |
| Z8FS021xHJ20EG | Z8F082AHJ020EG | 2KB | 22 | 6 | 28-pin SSOP | Figure 4 |

Note: x = PIR Engine Revision Identifier (see Table 4 on page 23.)

# Pin Configuration

The Z8FS021 MCU is available in a variety of package styles and pin configurations. This chapter describes the signals and available pin configurations for each of the package styles. For information about the physical package specifications, see the Packaging section on page 46.

Figures 2 through 4 display the pin configurations of all the packages available for the ZMOTION MCU Series. For a description of the signals, see Tables 6 through 8 on pages 24 through 26.

At reset, all port pins are set to GPIO input state except /RESET/DE0/T1OUT (8-pin) which is configured to /RESET, PA0/T0IN/T0OUT/XIN/DBG (8-pin), which is configured to DBG and RESET/PD0 (20- and 28-pin) which are configured to /RESET.

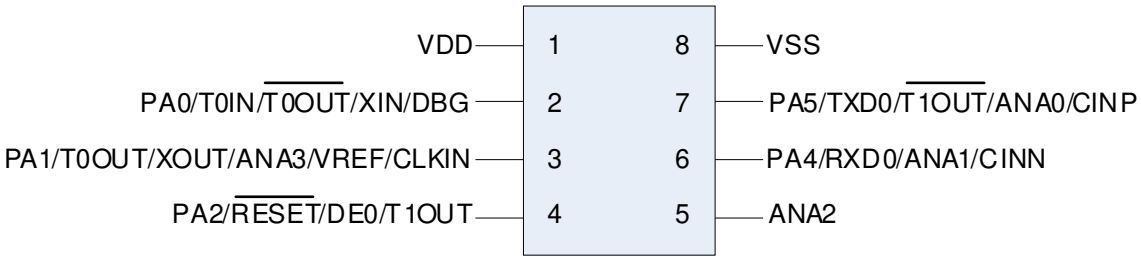


**Figure 2. 8-Pin SOIC Package Diagram – Z8FS021xSB20EG**

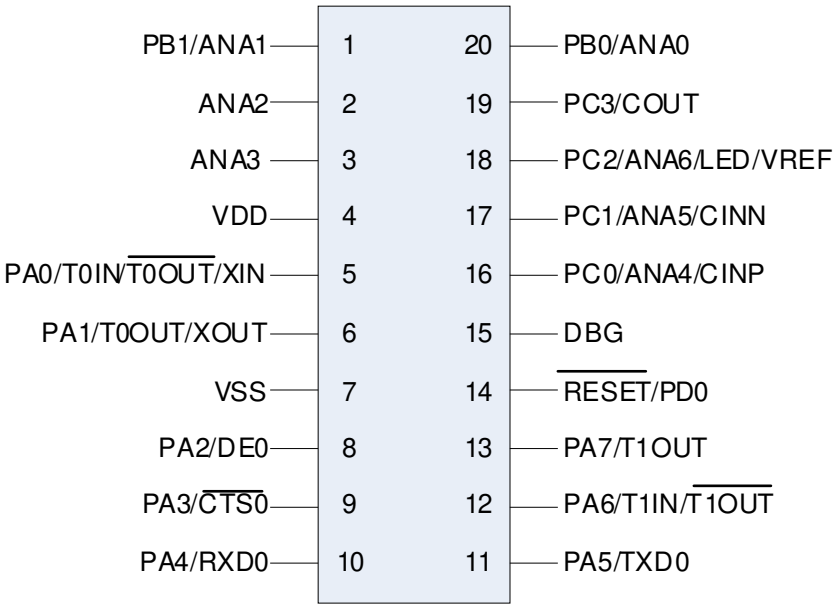


**Figure 3. 20-Pin SSOP Package Diagram – Z8FS021xHH20EG**

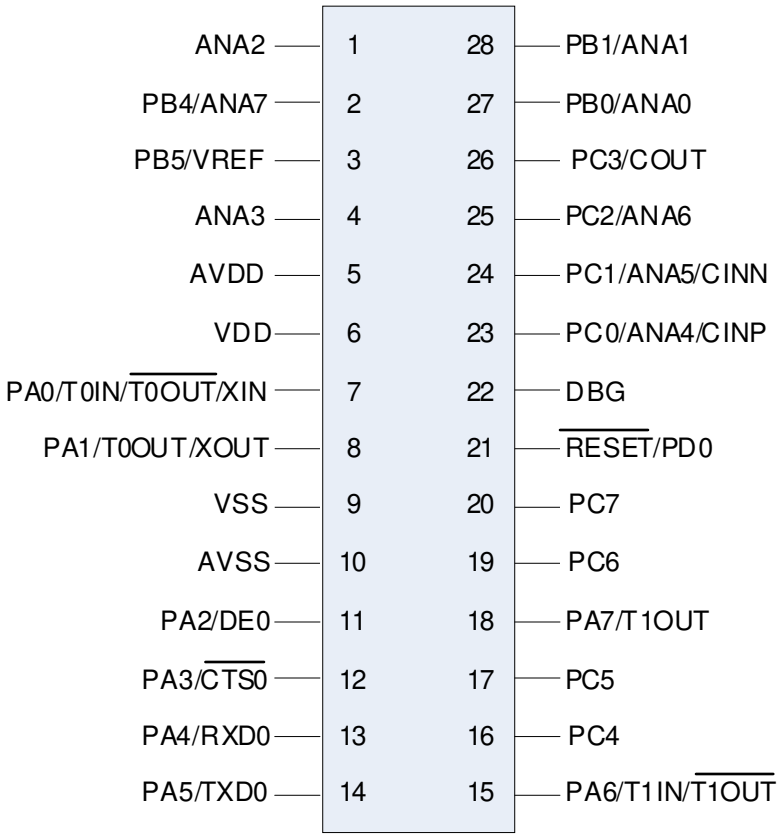


**Figure 4. 28-Pin SSOP Package Pin-Out, Z8FS021xHJ20EG**

# Signal Descriptions

Table 2 describes the Z8FS021 MCU signals. Signal availability is package dependent. See the Pin Configuration section on page 5 for signal availability multiplexing.

**Table 2. Z8FS021 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** | | |
| T0OUT/T1OUT | O | Timer Output 0–1. These signals are outputs from the timers. |
| T0OUT/T1OUT | O | Timer Complement Output 0–1. These signals are output from the timers in PWM Dual Output mode. |
| T0IN/T1IN | I | Timer Input 0–1. These signals are used as the capture, gating and counter inputs. |
| **Comparator** | | |
| CINP/CINN | I | Comparator Inputs. These signals are the positive and negative inputs to the comparator. |
| COUT | O | Comparator Output. |
| **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. |

**Table 2. Z8FS021 MCU Signal Descriptions (Continued)**

| Signal Mnemonic | I/O | Description |
|---|---|---|
| **Oscillators** | | |
| XIN | I | External Crystal Input. This pin is the input pin to the crystal oscillator. A crystal can be connected between it and the XOUT pin to form the oscillator. In addition, this pin is used with external RC networks or external clock drivers to provide the system clock. |
| XOUT | O | External Crystal Output. This pin is the output of the crystal oscillator. A crystal can be connected between it and the XIN pin to form the oscillator. |
| **Clock Input** | | |
| CLKIN | I | Clock Input Signal. This pin can 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. |

# Flash Memory Map

The Z8FS021 MCU is based on Zilog's Z8F082A device, which contains a total of 8KB Flash memory. Zilog's PIR technology is located in the 6KB address range 0800h–1FFFh, a code space that is locked and cannot be erased by the user or by the Zilog Debug Interface (ZDI) mass erase or page erase commands. The remaining 2 KB of this Flash memory space, in the address range 0000h–07FFh, is available for user application code.

A memory map of the Z8FS021 MCU's Flash code space is illustrated in Figure 5.

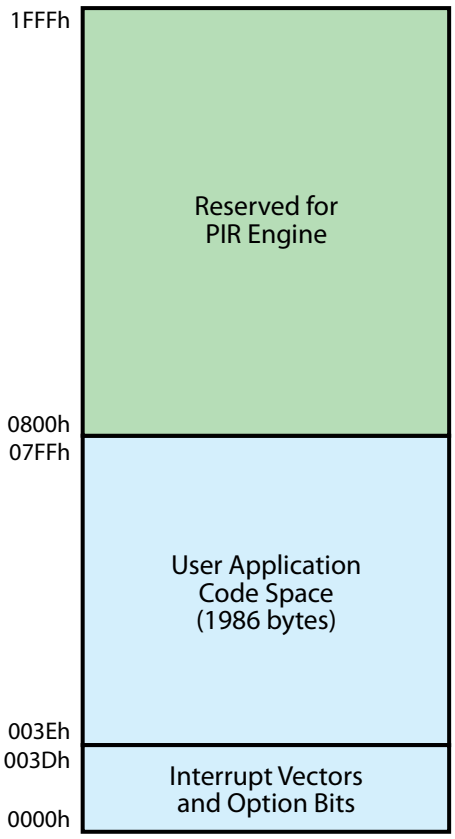


**Figure 5. Z8FS021 MCU Program Memory Map**

# RAM Memory Map

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.

The ZMOTION Motion Detection API is a series of registers located in the RAM memory space in the address range 0F0h–10Fh. It is through these memory locations that configuration and status are passed between the PIR Engine and the user application. Advanced API registers are located in the range 0F0h–0FFh. See the PIR Engine and API section on page 21 for details about these API registers and to set up the project memory environment.

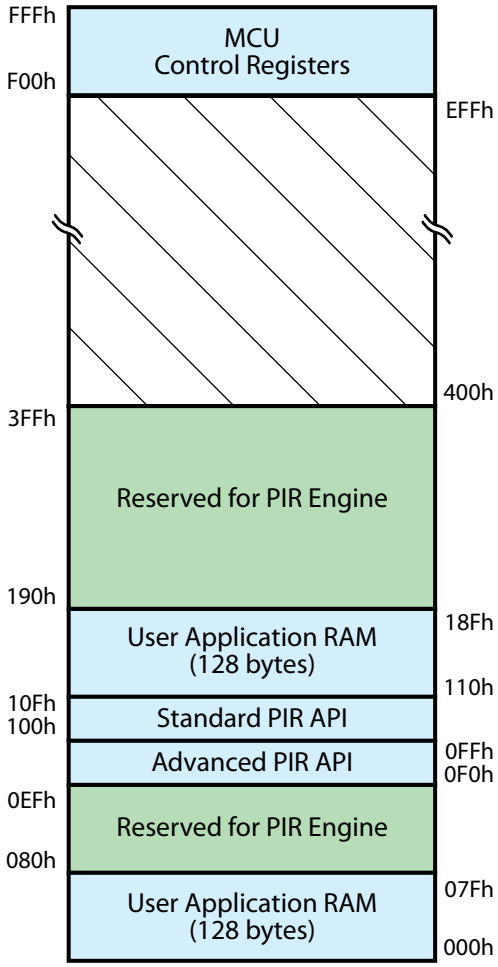


**Figure 6. Z8FS021 MCU RAM Memory Map**

# Peripherals

The following sections describe the differences, changes or limitations placed on any of the Z8FS021 peripherals or other functions from the base Z8F082A device. For more information 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 3 shows how the Z8FS021 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 Engine should not be used by the application unless the Engine is disabled through the PIR Engine Enable Register.

**Table 3. Peripheral Availability**

| | Device | | |
|---|---|---|---|
| | **Z8FS021xSB20EG** | **Z8FS021xHH20EG** | **Z8FS021xHJ20EG** |
| Base MCU Device | Z8F082ASB020EG | Z8F082AHH020EG | Z8F082AHJ020EG |
| Pins/Package | 8-pin SOIC | 20-pin SSOP | 28-pin SSOP |
| ADC | ANA1 is used for White Light Detection when enabled.<br>ANA2 is used for PIR sensor input.<br>ANA3 is used for a second sensor input in Dual Pyro Mode. | ANA1 is used for White Light Detection when enabled.<br>ANA2 is used for PIR sensor input.<br>ANA3 is connected to ANA6/$V_{REF}$.<br>ANA3 is used for a second sensor input and ANA6 becomes available in Dual Pyro Mode. | ANA1 is used for White Light Detection when enabled.<br>ANA2 is used for PIR sensor input.<br>ANA3 is connected to $V_{REF}$.<br>ANA3 is used for a second sensor in Dual Pyro Mode. |
| $V_{REF}$ | 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. |
| 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.<br>In dual pyro mode, PC2 becomes available. | PB2, PB3 & PB5 are used for PIR functions.<br>In dual pyro mode, PB5 becomes available. |

**Table 3. Peripheral Availability (Continued)**

| | | | |
|---|---|---|---|
| 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 a 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 – used for White Light detection |
| 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. Additionally, ANA3 and ANA6 are not available because 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 a second sensor input rather than being tied to $V_{REF}$; ANA6/$V_{REF}$ therefore becomes available. All other channels are available to the user application.

| ADC Channel | Available to Application |
|---|---|
| 0 | Yes |
| 1 | Yes – used for White Light detection |
| 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 because 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 $V_{REF}$; PB5 therefore becomes available. All other channels are available to the user application.

| ADC Channel | Available to Application |
|---|---|
| 0 | Yes |
| 1 | Yes – used for White Light detection |
| 2 | No |
| 3 | No |
| 4 | Yes |
| 5 | Yes |
| 6 | Yes |
| 7 | Yes |

## Timers

The Z8FS021 MCU offers two independent and identical 16-bit multi-function timers, Timer 0 and Timer 1; both are available to the user application.

| Timer 0 | |
|---|---|
| 8-Pin Device | T0OUT is not available in Dual Pyro Mode; it is 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 the PIR Engine; the WDT is available to the user application.

## Comparator

| | |
|---|---|
| 8-Pin Device | The external pin that carries COUT 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 COUT. |
| 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 | /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 is 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, because 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. The PIR Engine uses the value programmed into the Flash Frequency registers (FFREQ) to determine the required sample rate of the ADC and other functions. 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 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 the PIR Engine.

### 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 Z8FS021 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 Z8FS021 devices.

### Non-Volatile Data Storage

There is no dedicated non-volatile data storage on the Z8FS021 devices.

## Pin Availability

Although most pins on the ZMOTION MCU Series are available to the application, some pins are dedicated to supporting the functions of the PIR Engine. This section describes which pins are reserved and which are available to the application. The pins used by the PIR Engine 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. See Appendix A. Example Application Schematics on page 51 for more information.

| | |
|---|---|
| 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, COUT and T1IN) are not available for user applications.<br>In Dual Pyro Mode, in which the application uses 2 pyroelectric sensors, Pin 3 (ANA3) is used as an analog ADC input for a second sensor and is therefore not available for other functions (T0OUT/$V_{REF}$/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.<br>In Dual Pyro Mode (supporting 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/$V_{REF}$). |