Reference Design

ZMOTION Intrusion Motion Detector

RD000103-0814

Abstract

This reference design demonstrates how to use Zilog's ZMOTION Intrusion Motion Detection solution in a PIR-based intrusion motion detector. It also shows how to implement additional functions such as anti-mask and power supply supervisory features.

The ZMOTION Intrusion Motion Detection (ZIRD) device provides an integrated and flexible solution for Passive Infrared (PIR)-based security/intrusion motion detection applications. It includes the Z8FS021 ZMOTION Intrusion MCU combined with a selection of lenses to fit a range of intrusion motion detection applications.

The Z8FS021 ZMOTION Intrusion MCU comes preprogrammed with motion detection software algorithms that comprise the ZMOTION Engine. These software algorithms run in the background while control and status of the Engine is accessed through a software Application Programmer Interface (API). Optimized API settings are provided to match Engine operation to each of the lens and pyroelectric sensor combinations provided.

Note: The source code file associated with this reference design, RD0001-SC01.zip, is available for download on zilog.com. This source code has been tested with version 5.0.0 of ZDS II for Z8 Encore!-powered MCUs. Subsequent releases of ZDS II may require you to modify the code supplied with this reference design.

Features

The key features of this reference design include:

- Complete Intrusion Motion Detection design supporting three lens types:
  - WA 1.2 GI 12 V4: 18 meter, wide angle (installed)
  - LR 1.2 GI 12 V3: 30 meter, corridor
  - VB 1.2 GI V1: 15 meter, vertical barrier
- White light immunity > 12,000 LUX
- Uses low-cost RE200B dual-element pyroelectric sensor
- Automatic temperature compensation
- 12 kg/30 kg selectable pet immunity
- Selectable NORMAL and PULSE modes
- Auto LED
- Anti-mask demonstration
- Power supply supervisory

- Independently verified to meet EN-50131 EMC susceptibility requirements

Key features of the ZMOTION Intrusion Motion Detection device are shown Figures 1 and 2.

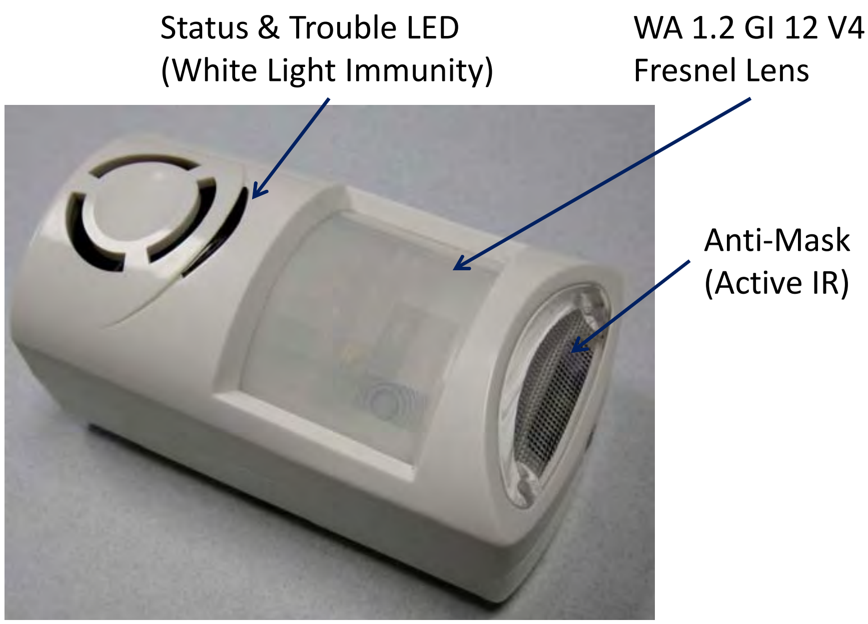

Figure 1. ZIRD Motion Detector

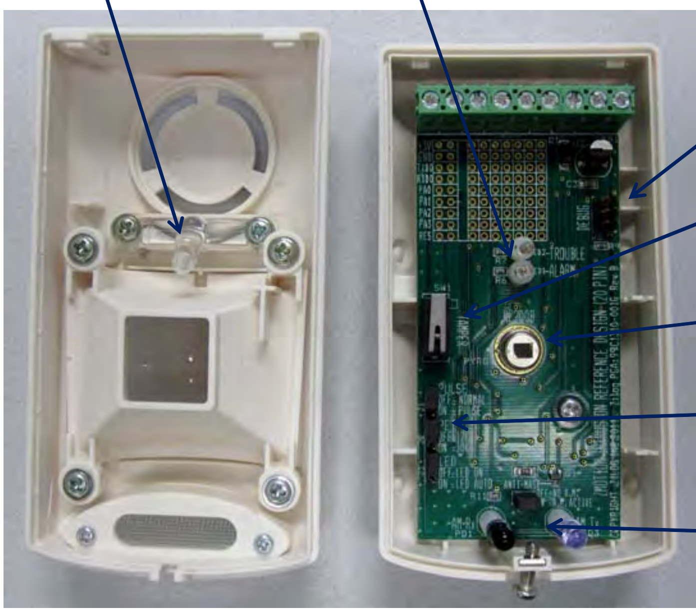

Figure 2. ZIRD Motion Detector Inside

Discussion

Passive Infrared (PIR)-based motion detectors have been prevalent in the security and intrusion industries for many years and have become key components of any home or commercial security system. In spite of this popularity, the traditional design architecture and its inherent limitations have not significantly changed since their inception. The ZMOTION Intrusion Detection Solution employs a new architecture that delivers a dramatic improvement in both sensitivity and stability over the traditional security-related motion detection designs.

Traditional Design Architecture

Traditional motion detector designs, such as that shown in Figure 3, uses a pyroelectric sensing element combined with a Fresnel or similar type lens to direct the infrared energy emitted from the target as it moves across the detection area. As this focused energy moves across the sensing elements of the pyroelectric sensor, it generates a voltage with a frequency component ranging from 0.1 Hz to 10 Hz. The amplitude of this signal is relative to the difference in temperature between the target and its surrounding environment (ambient temperature) and is typically in the range of 1 mVP-P to 2 mVP-P. It also contains a large high-frequency noise component and a DC offset of 400 mV to 1,800 mV that will change with temperature and aging, and can even vary between devices.

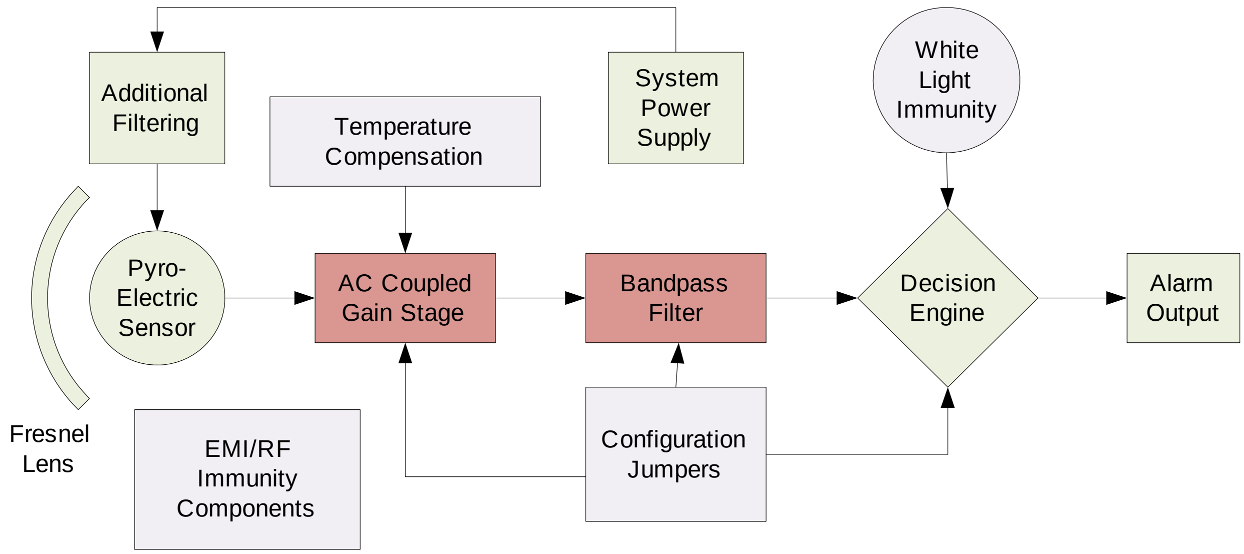

Figure 3. Traditional Design Architecture

To create a signal that is usable by either discrete components or a microcontroller, the output signal from the sensor is typically followed by an AC-coupled gain stage (~72 db) combined with a bandpass filter, which reduces the high-frequency noise content and strips the DC offset. The decision stage is responsible for extracting the signature of human motion from the resulting signal. The most common approaches are *rate of rise* and *time above an amplitude*. The *time above an amplitude* method can be implemented with a simple window comparator in which the two signal inputs are phase-delayed from each other. However, there are several drawbacks to these two methods, the most significant of which is their susceptibility to false detections. As a result, these approaches are commonly used in low-cost motion detectors.

More commonly, motion detectors intended for intrusion applications use a microcontroller to perform the decision analysis. A microcontroller can combine multiple detection methods to produce a more stable motion detector. However, incorporating an MCU into the design still does not address the root issues causing false detections: high gain circuit elements and an extremely-modified sensor signal. By filtering the signal, useful information that is sometimes critical to making a reliable decision is removed. Because of the low-frequency filtering required by the traditional architecture, signal discontinuities caused by external electrical factors (mainly EMI, ESD) can create a signature that is indiscernible from valid motion, thereby creating false alarms. The high gain stage simply compounds the problem and increases its susceptibility.

White Light Immunity ensures that the infrared energy generated by a strong light source such as car headlights shining onto the detector through a window do not generate false alarms. Typically, an ambient light sensor is used to detect the condition and disable any generated alarm output. Pulse Count is a “feature” that also helps reduce false alarms by requiring more than one detected motion event within a certain time period before an actual alarm is generated. This requirement helps to eliminate false alarms generated by HVAC systems turning ON and OFF, or furniture warming and cooling, but again, it does not address the root cause.

ZMOTION Design Architecture

With the ZMOTION Intrusion Detection Solution (see Figure 4), the pyroelectric sensor is interfaced directly to the Z8FS021 MCU without any AC coupling, gain or filtering. This arrangement allows the MCU to work with the true, unmodified signal and see the real time effects caused by shifts in DC offset, transients and other non-motion-based signal changes. No temperature compensation is required, and the Status LED is used as the sensor for white light immunity, resulting in a lower component count design.

The ZMOTION Intrusion Reference Design is based on this architecture, and is described more fully in the pages that follow.

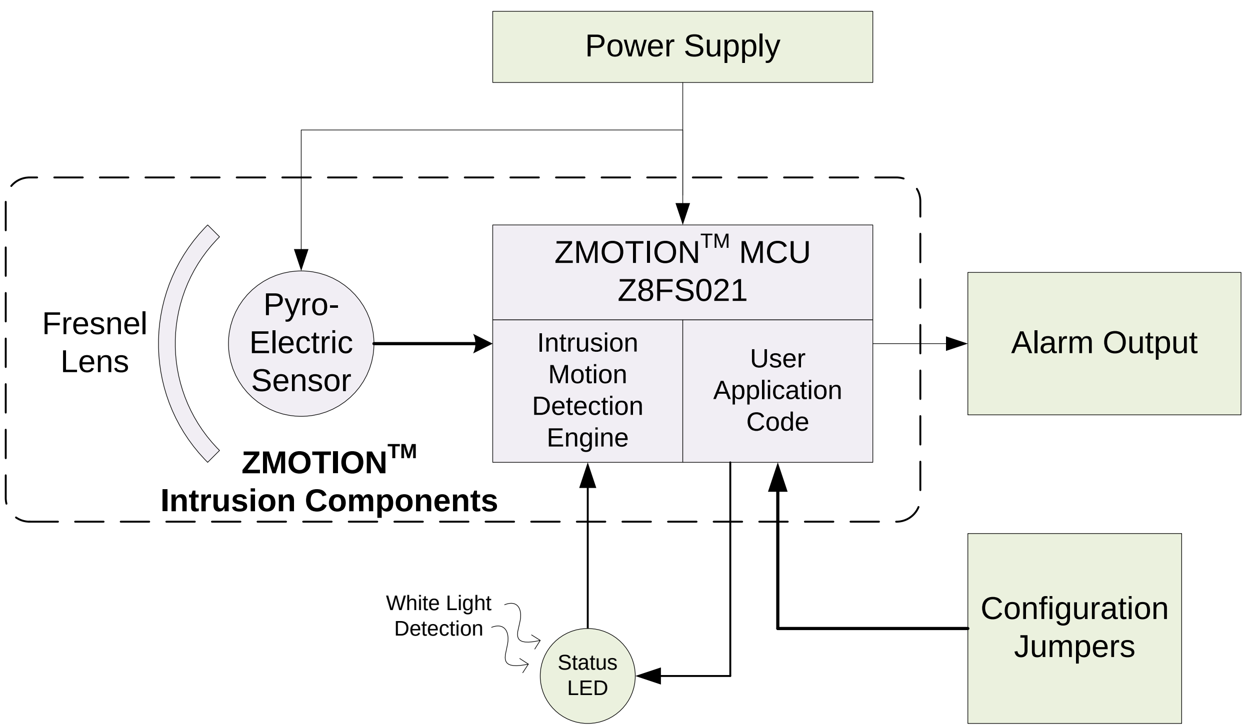

Figure 4. ZMOTION Design Architecture

Theory of Operation

The ZMOTION Intrusion Motion Detection Solution is based on the Z8FS021 ZMOTION Intrusion MCU, which includes the ZMOTION motion detection algorithms preprogrammed in Flash memory. 2KB is available for application code. The motion detection software runs from the ADC end of the conversion interrupt and provides status to the application via the API registers. See the [ZMOTION Intrusion Detection Product Specification (PS0288)] for more information about these API registers.

The block diagram in Figure 5 shows all peripherals included with the Z8FS021 MCU that are available to the application.

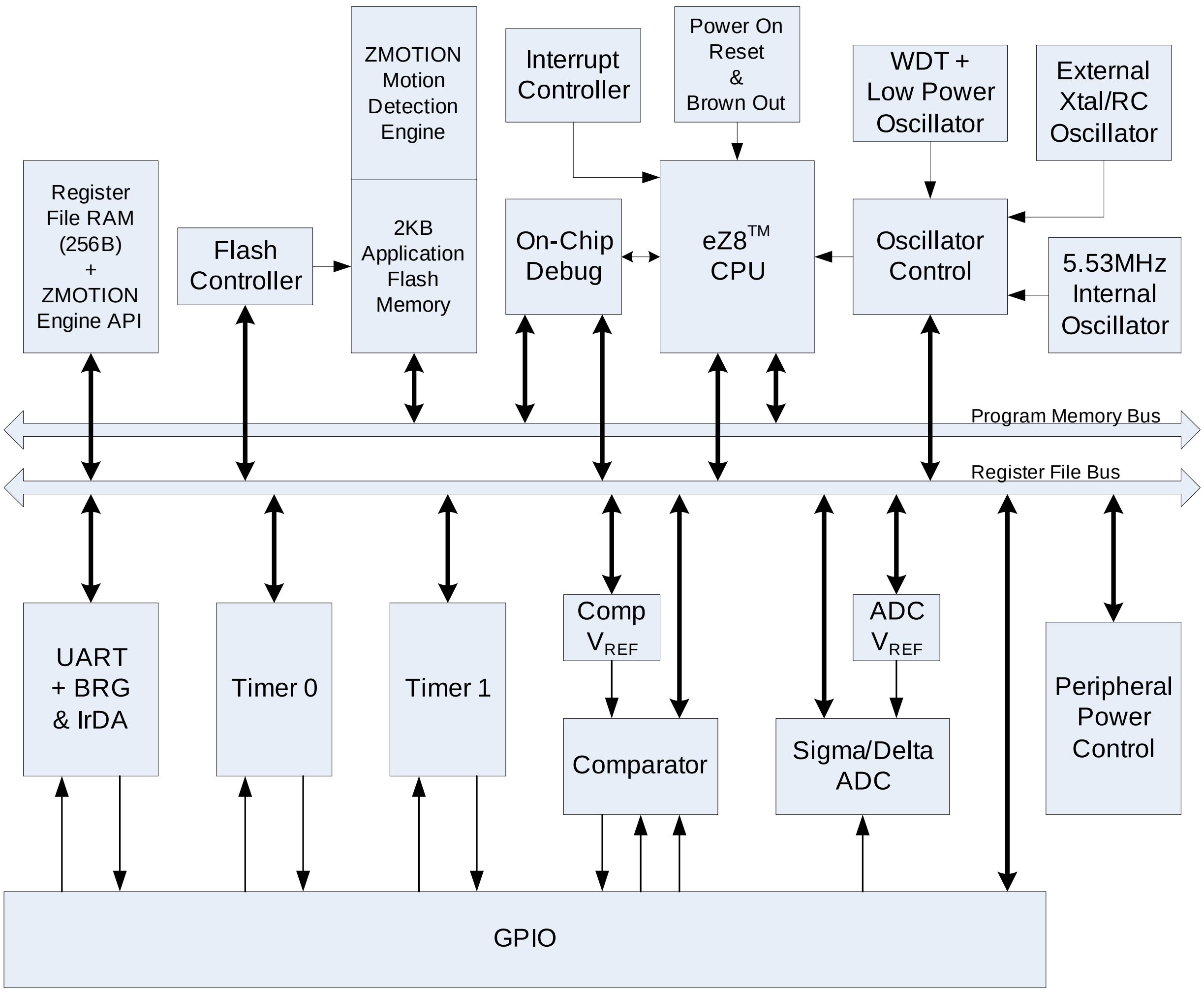

Figure 5. Z8FS021 MCU Block Diagram

The motion detection algorithms take advantage of the on-chip sigma/delta ADC, operated in differential mode. The pyroelectric sensor is connected directly to the positive ADC input, with the 1V $ADCV_{REF}$ connected to the negative input of the ADC. This arrangement creates a ±1V range for the pyroelectric sensor input. Although specified for 10-bit accuracy, the Sigma/Delta ADC has a 16-bit result register of which one bit is used for overflow indication and another bit for sign. The ZMOTION Engine oversamples and averages the pyroelectric sensor signal input, providing 15 bits of resolution. Because the software algorithms of the ZMOTION Engine are interested in changes and rates of changes in the pyroelectric sensor signal, absolute accuracy is not necessary. By over-sampling and averaging, constructed sample values have a ±16,384 count range which provides a usable resolution of 61 µV/count.

Hardware Architecture

The ZMOTION Intrusion Reference Design (ZIRD) is based on the 20-pin Z8FS021 ZMOTION Intrusion MCU. All functions related to the operation of the detector are handled by the MCU, with the exception of the case tamper which is implemented with a simple lever switch that opens when the front cover is removed.

Referring to Figure 6, all external connections to the detector are made through the nine-position Terminal Block. A Clare CPC1017 Solid State Relay provides the Form-A contacts for the Trouble and Alarm outputs. A Clare CPC1117 Solid Sate Relay is used to provide the contacts for the Form-B Alarm output.

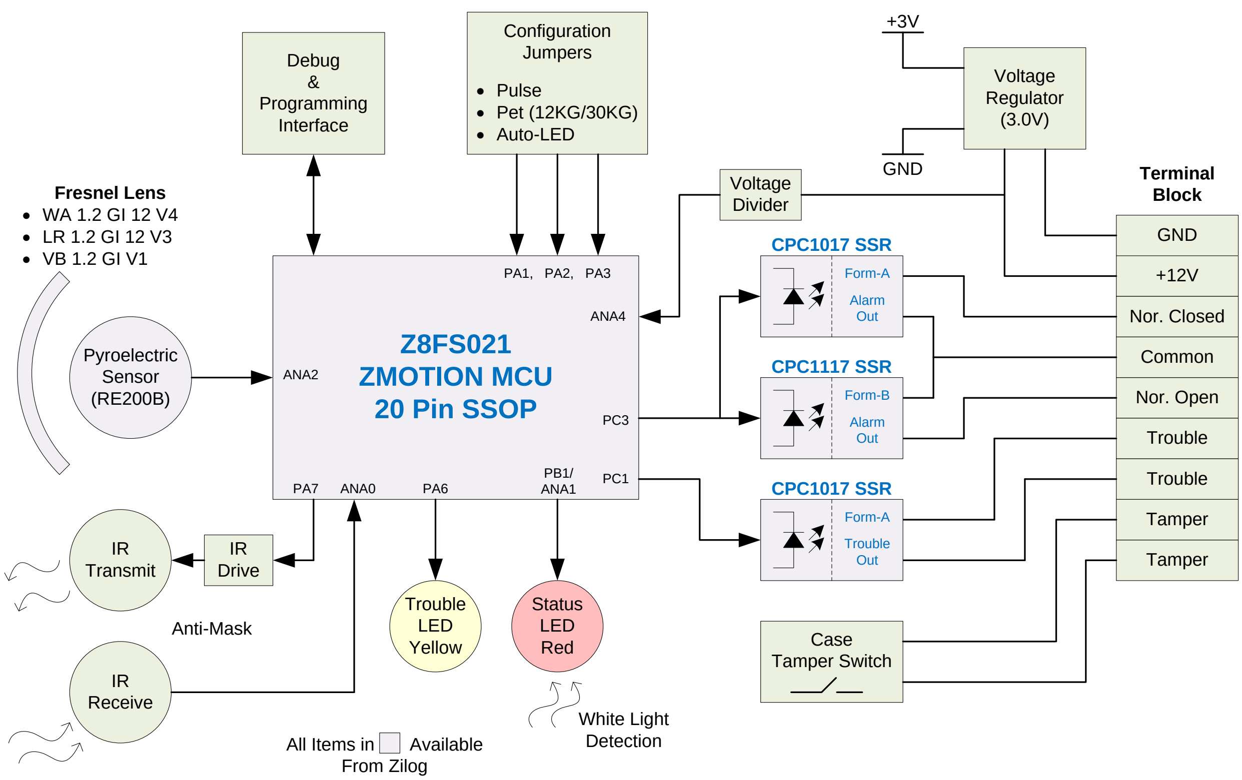

Figure 6. ZIRD Block Diagram

The plastic enclosure is designed to support standard 1.2-inch focal length flat Fresnel lenses available from Zilog and other suppliers. The reference design ships with the WA 1.2 GI 12 V4 18-meter wide angle lens installed.

The PCB is a 2-layer FR4 material using 1-oz. copper with gold plating. A small prototype area is provided, with unused port pins routed for additional functions.

I/O Map

A map listing the Input/Output functions of the ZMOTION MCU is shown in Table 1. Not shown in the table are the unused I/O pins, which are routed to the prototype area.

Table 1. ZIRD: Z8FS021 I/O Map

Pin #	Pin Name	Type	Function	Comments
4	V_{DD}	V_{DD}	Power	3.0V
7	V_{SS}	V_{SS}	Ground	
15	DBG	Digital I/O	Debug	Requires 10K PU
14	Reset (PD0)	Digital I/O	Reset	1µF + 10K PU + Proto
20	ANA0 (PB0)	Analog I/P	Anti-Mask Detector	—
1	ANA1 (PB1)	Analog I/P & Digital O/P	RED Status LED White Light Immunity	—
2	ANA2 (PB2)	Analog I/P	Pyro Signal (ANA2)	—
3	ANA3 (PB3)	Analog I/P	Pyro 1V Ref (ANA3)	Tie to V_{REF}
16	ANA4 / CIN+ (PC0)	Analog Comparator	12VDC Power Monitor	Trouble @ 8V
17	PC1	Digital LED (3mA) O/P	Trouble Output for Pyro, AM, +12V faults	LED drive (no resistor)
18	V_{REF} (PC2)	Analog O/P	V_{REF} Output	Tie to ANA3
11	TXD0 (PA5)	Digital O/P	UART Tx for Development	Prototype Area
10	RXD0 (PA4)	Digital I/P	UART RX for Development	Prototype Area
5	PA0	Digital I/P (Internal Pull Up)	Unused	Prototype Area
6	PA1	Digital I/P (Internal Pull Up)	Jumper 1 (Pulse)	Prototype Area
8	PA2	Digital I/P (Internal Pull Up)	Jumper 2 (Pet Immunity)	Prototype Area
9	PA3	Digital I/P (Internal Pull Up)	Jumper 3 (Auto LED)	Prototype Area
12	PA6	Digital O/P	Yellow Trouble LED for Pyro, AM, +12V faults	—
13	PA7/T1OUT	Digital O/P	Anti-Mask Transmit	Alternate method: Use T1 for PWM
19	PC3	Digital LED (3mA) O/P	Alarm Out Form "C" Output (CPC1017/1117)	LED drive (no resistor)

White Light Immunity

In the White Light Immunity circuit (see Figure 7), the Status LED (LED 1) is used to detect White Light events. When light shines on an LED, it generates a small voltage which the ZMOTION Engine can measure. When enabled, the ZMOTION Engine periodically configures PB1/ANA1 to an analog input and performs the necessary ADC conversion, after which it is returned to a general purpose output. When a significant shift is detected (change in voltage input – not absolute level), the ZMOTION Engine will automatically compensate its detection algorithms for the accompanying DC shift from the pyroelectric sensor signal.

LED 1 is mounted on the PCB with a light pipe to focus the light in and out of the detector just above the lens. In other designs, it would be possible to place the LED behind the lens; however, the lens should not have any white light filtering.

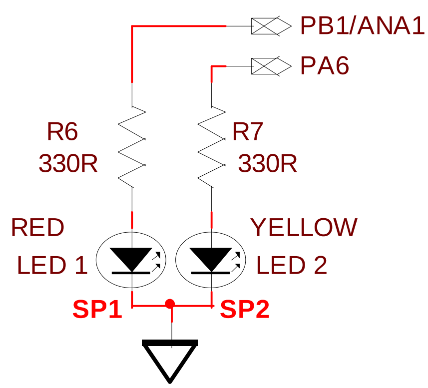

Figure 7. White Light Immunity and Status LED Circuit

Most high-efficiency LEDs are suitable for White Light functions, but there are certain requirements for the placement of the LED used in the system.

- Do not place the LED behind any white light filtering material. If it is behind a lens or a light pipe, such material should be transparent to white light. A lens with white light filtering is neither required nor advised for a detector based on ZMOTION technology.
- The LED should be placed near the pyroelectric sensor such that any light shining on the LED also shines on the pyroelectric sensor. It is important that the PIR sensor and the LED receive the light at the same time.
- The voltage generated by the LED is dependent on the amount of light reaching the LED through the light pipe and the specifications of the LED itself. To accommodate for different designs and LEDs, the ZMOTION Engine API includes a register that controls white light detection sensitivity.
- Most high-efficiency LEDs in red, yellow or green with a forward voltage drop less than 2V @ 2mA are well suited for white light detection.

Anti-Mask

An *anti-mask* is a feature that can detect if something has been placed in front of the detector, thereby blocking its ability to detect motion. For example, if a piece of paper is placed in front of the detector, thereby covering the lens, it would not be able to sense motion in the room. When this condition is detected, the yellow LED is turned ON and the Trouble relay is activated.

In the anti-mask circuit (see Figure 8), the infrared LED transmitter (LED 3) is driven through FET Q1 when PA7 of the MCU is driven High. An infrared photodiode (PD1) is connected to ANA0 and used to sense the IR energy level.

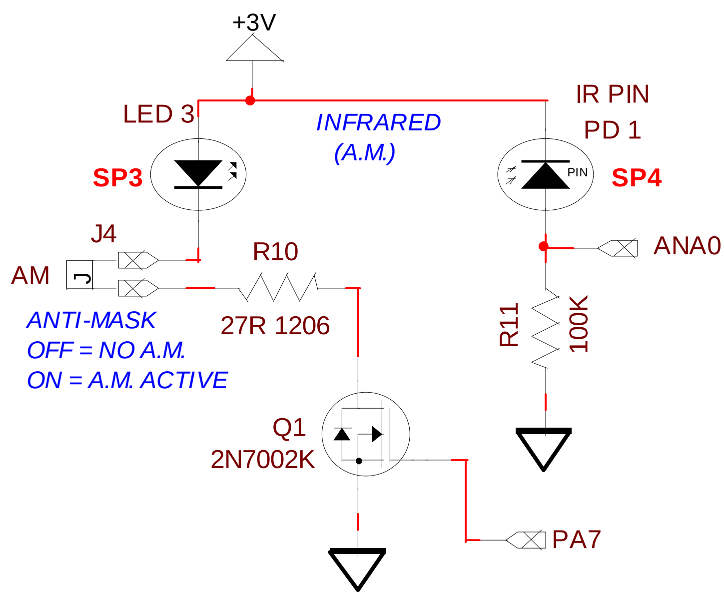

Figure 8. Anti-Mask Circuit

In the following description, please refer to the source code file, RD0001-SC01.zip, which has been provided with this reference design. The software performs the Anti-Mask check every 200ms. The function is controlled by the `cAntiMaskPhase` variable and is incremented in the 100ms timer interrupt.

When `cAntiMaskPhase` = 1, the IR LED is turned OFF and a baseline energy level is measured from the photodiode via ANA0. This level will be compared to the IR level measured when the IR LED is turned ON. Normally (when nothing is positioned in front of the detector), the second measurement will be slightly higher than the baseline. However, if something is placed in front of the detector, the second measurement will be much higher. The baseline measurement is multiplied by a value determined experimentally that accounts for the small increase expected when the IR LED is turned ON and nothing is in front of the detector. However, because the output/gain of the IR photodiode is nonlinear, a table lookup is used to determine a multiplier value. The multiplier value is based on the measured value from the photodiode (see `ANTIMASK_MULTIPLIER_TABLE` in `main.h`).

Table values are scaled by 16 to preserve accuracy without using a floating point. This compensated value is saved as the baseline (`lObjectLevel`) when no additional IR stimulus is present.

When `cAntiMaskPhase` = 3, the IR LED is turned ON and the IR energy level is measured again. If nothing is in front of the detector, this value should be below the `lObjectLevel` compensated baseline value. This function is debounced and, if still above the compensated baseline, the Trouble Relay is activated.

Power Supply and Supervisory

Referring to Figure 9, the system power supply is implemented with an LP2950 3.0V linear regulator. All circuit components operate from the single supply. The input to the regulator comes from the terminal block, which is connected to the alarm panel power supply. The voltage range is nominally 9V to 14V and is typically supplied from a sealed lead acid battery. The LP2950 supports an input voltage up to 30V. The SMAJ18CA TVS diode and blocking diode D3 protect the regulator from overvoltage and reverse voltage conditions, respectively. The 2.2µF input and output decoupling capacitors are surface-mount ceramic devices.

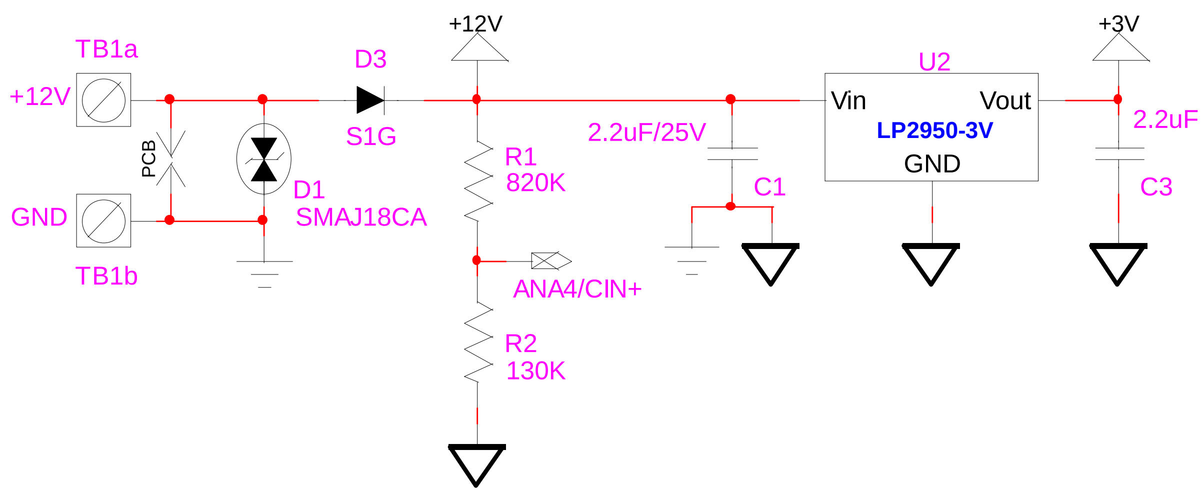

Figure 9. Power Supply & Supervisory Circuit

The power supply input is monitored by the MCU via resistor divider R1/R2; it generates a Trouble event when it drops below a preset level. This value can be modified by changing the `LOW_AUX` definition in `main.h`. The default value of 1900 corresponds to 8.5V through the following relationship:

LOW_AUX=(4095 – DC_OFFSET) * [R2/(R1+R2) * V_LOW] / 2V

where:

- V_LOW is the low supply voltage level to be detected
- 4095 is the full scale signed count of the ADC

- 2V is the ADC reference voltage
- DC_OFFSET is the measured ADC DC offset error

Outputs: Alarm, Trouble, Tamper, Protection

Referring to Figure 10, the Alarm and Trouble outputs are implemented with Clare solid state relays. These surface-mount devices use Clare's OptoMOS architecture, provide 1500VRMS circuit isolation and operate from 1mA of LED current. The CPC1017N is a miniature single pole, normally open (Form-A) device, while the CPC1117N is a miniature single pole, normally closed (Form-B) device.

For the Alarm output, SSR1 (CPC1017N) and SSR2 (CPC1117N) are connected in series and driven by the MCU's PC3 port pin. This pin is configured in constant current mode, supplying 3mA without the requirement for a limiting resistor. The serial connection of the SSRs provides a Form-C output (one normally open and one normally closed) with the COM terminal common to both outputs.

SSR3 (CPC1017N) provides the Form-A Trouble output driven by the MCU's PC1 port pin programmed in constant current mode (3mA).

All outputs are protected by SMAJ18CA TVS diodes. The SSR outputs are further protected from ESD by 10Ω series resistors.

The tamper detection is implemented mechanically with a lever switch that opens when the detector's cover is removed. This condition is not monitored by the MCU.

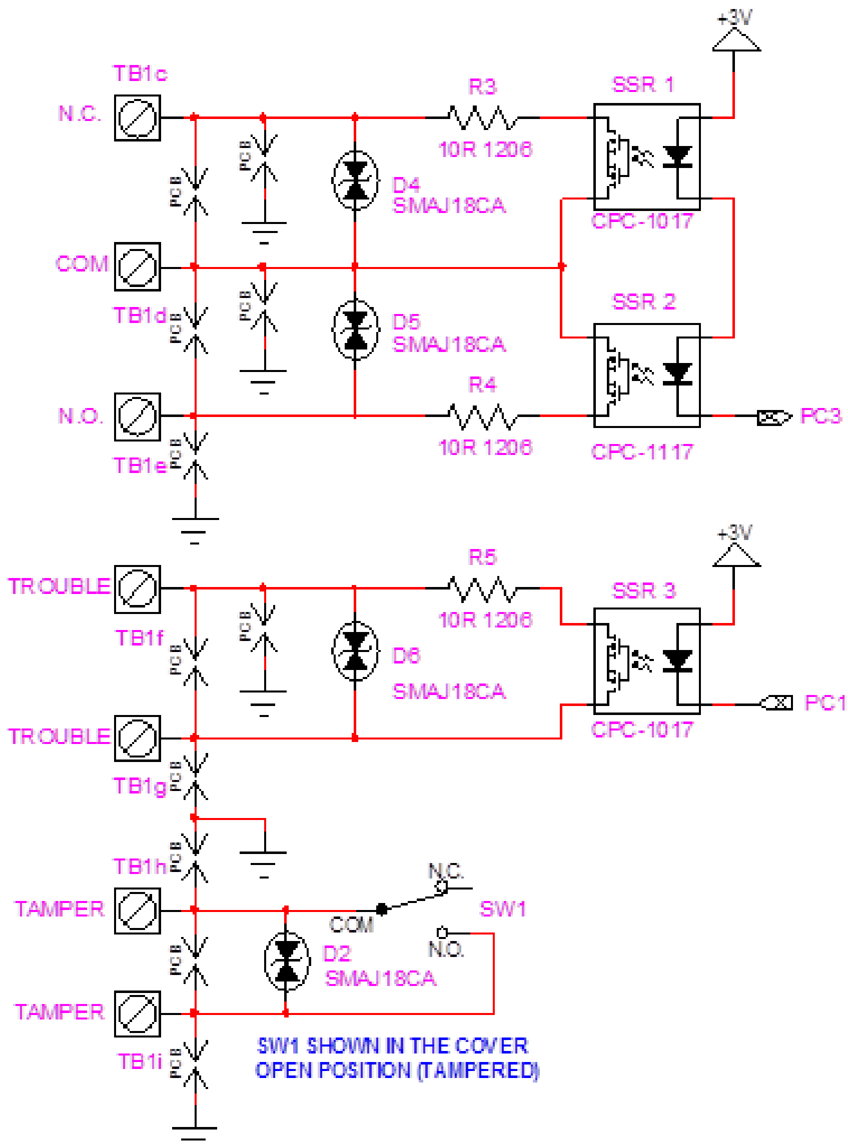

Figure 10. Alarm, Trouble & Tamper Outputs

Pulse Mode

The Fresnel lens breaks up the detection area into zones. As a target moves through these zones, the focused IR energy moves across the elements of the pyroelectric sensor to create a signal that rises and falls with the target motion. PULSE Mode selects the number of signal transitions required to produce an alarm output.

In ONE PULSE Mode (SC1_2_PULSE_ENABLED bit in ePIR_SC1 = 0), the ZMOTION engine will search the pyroelectric sensor signal for either a single rising slope or a single falling slope. The frequency response of this slope detection is controlled by the SC1_FREQUENCY_RESPONSE bits in the ePIR_SC1 Register (a value of `0x0` requires a fast frequency change for the slope detection, and a value of `0xF` will allow a slow frequency slope to be detected). The minimum level of required signal change is controlled by the value in the ePIR_SC2_RANGE_CONTROL Register, and the amplitude of the slope change is determined by the ePIR_SENSITIVITY Register. These conditions must be met (debounced) for the time period set in the ePIR_DEBOUNCE_TIME Register before a motion event is generated by setting the SC0_MOTION_DETECTED bit in ePIR_SC0.

In TWO PULSE Mode (SC1_2_PULSE_ENABLED bit in ePIR_SC1 = 1), the motion event is generated when two separate slope detections in opposing directions, following the same criteria required for ONE PULSE Mode, are detected within a total fixed time window of four seconds.

Note: Because of the beam patterns associated with the LR 1.2 GI 12 V3 and VB 1.2 GI V1 lenses, Zilog does not recommend using TWO PULSE Mode with these lenses.

Pet Immunity

Pet detection/immunity takes advantage of the difference in frequency/amplitude signal types generated between smaller horizontal targets and larger more vertical targets. Larger vertical targets, such as humans, tend to generate higher frequencies and amplitudes than smaller, more horizontal targets such as dogs and cats as they move through the beam pattern. This difference can place a significant dependence on the specific lens being used. For example, a lens with evenly spaced beams is better suited for pet detection than a lens with varying beam sizes, because the latter will produce an uneven signal frequency even though the target is moving with uniform motion. The WA 1.2 GI 12 V4 lens is well suited for pet immunity, while the LR 1.2 GI 12 V3 and VB 1.2 GI V1 lenses do not have an appropriate beam pattern and are not recommended for use in applications requiring pet immunity.

There are two settings supported by the ZMOTION Intrusion Reference Design: PET15 and PET30. PET15 is the “normal” setting and is capable of rejecting pets in the sub-15kg range. With this setting, very small pets/targets are ignored without any special settings for the ZMOTION Engine, because the amplitude and frequency they generate are small enough that no motion event is generated (no slope change is debounced; see the Pulse Mode section above).

PET30 Mode modifies four conditions used to detect motion: Frequency Response, Minimum Threshold, Debounce Time and Lock Level. When PET30 is selected, the Frequency Response is slowed down so a higher frequency signal is required to initiate signal amplitude debouncing. The minimum amplitude threshold before debouncing starts is increased, and the time for the motion conditions to be debounced is decreased. The fourth condition modified to support PET30 Mode is the Lock Level (ASC2_LOCK_LEVEL programmed in the ePIR_ASC2 Register). This value works in combination with the ePIR_SENSITIVTY and ePIR_SC2_RANGE_CONTROL values to affect signal debouncing.

After a motion event has been debounced, the minimum threshold is temporarily locked according to the ASC2_LOCK_LEVEL setting for the duration of the debouncing time. This lock ensures that a small change in slope direction does *not* restart the debouncing process.

In either TWO PULSE or PET30 modes, the extended detection system (`SC0_EXTENDED` bits in ePIR_SC0) that handles very fast and very slow motion must be disabled (set to 0). Additionally, the Extended Debounce Register (`ePIR_Ext_Debounce`) should be set to 250, and the Extended Time-Out (`ePIR_ExtTimeout`) should be set to 1.

Auto LED

In normal operation, the Status LED on a motion detector should *not* illuminate when motion is detected. However, when performing a Walk Test, the Status LED is a convenient visual confirmation of detected motion. The Red Status LED on the ZMOTION Intrusion Reference Design operates in one of two modes as selected by the LED Jumper: LED ON and LED-AUTO.

In LED ON mode, the Status LED is turned ON when motion is detected.

In LED-AUTO (Auto LED) mode, the LED normally remains OFF when motion is detected. By shining a bright light (such as a flashlight) on the Status LED for about two seconds (causing the ZMOTION Engine to detect a white light event), WALK TEST Mode is enabled for five minutes (defined as WALK_TEST_TIME in `main.h`). After five minutes, WALK TEST Mode is disabled, and the Status LED remains OFF when motion is detected. The AUTO_LED_RETRIGGER defined in `main.h` allows this time to be retriggered each time motion is detected (it requires five minutes without detecting motion to exit WALK TEST Mode).

In LED-AUTO mode, the White Light status bit (ASC0_WHITE_LIGHT_DETECTED) in the ePIR_ASC0 Register is checked as part of the main execution loop when the jumper settings are updated. If a white light event is detected, the `iWalkTestTime` variable is initialized to WALK_TEST_TIME. This value is checked before turning ON the Status LED when motion is detected.

Other methods can be used to enable WALK TEST Mode, such as requiring a certain number of white light events within a certain amount of time, but these methods shall remain open to the imagination of the designer.

Software Architecture

The project included with the reference design is called `ZIRD_1.00.zdsproj`. It is built using ZDS II version 5.0.0 and can be downloaded from the Zilog website.

The `ZIRD_1.00.zdsproj` project file contains standard ZDS II support files, standard ZMOTION support files and custom application files. Each of these files is briefly described in this section.

Source Files

main.c. A custom application source code file that implements all major functions of the software.

ePIR_API.c. A standard ZMOTION support file required for all ZMOTION projects. This file reserves space in RAM for ZMOTION API registers and defines the API register names.

startupePIR.asm. A standard ZMOTION support file required for all ZMOTION projects. This file provides all necessary environment initializations after reset. It replaces the standard `startups.asm` or `startupl.asm` file.

Header Files

ePIR_API.h. A standard ZMOTION support file required for all ZMOTION projects. This file provides bit definitions for all API registers.

main.h. A custom application file containing project definitions and defaults for `main.c`.

eZ8.h. A standard ZDS II support file that brings in all other ZDS II MCU-specific support files.

ZIRD_API_INIT_09.h. A modified standard ZMOTION API configuration file for the WA 1.2 GI 12 V4 lens with RE200B pyroelectric sensor.

ZIRD_API_INIT_10.h. A modified standard ZMOTION API configuration file for the LR 1.2 GI 12 V3 lens with RE200B pyroelectric sensor.

ZIRD_API_INIT_11.h. A modified standard ZMOTION API configuration file for the VB 1.2 GI V1 lens with RE200B pyroelectric sensor.

Project Configurations

Separate ZDS II project configurations are defined for each of the three supported lens types. These three configurations are:

- Release_WA_1.2_Lens
- Release_VB_1.2_Lens
- Release_LR_1.2_Lens

To rebuild the project for a specific lens, select the appropriate project configuration and then select **Rebuild All** from the **Build** menu.

The application consists of a main loop and two interrupt sources: ADC and Timer 0. Halt mode is used in the main loop, causing it to be executed once after either interrupt. The ADC interrupt passes control to the ZMOTION Engine, which performs all motion detection processing, updates the API, and then returns to the calling function. The ADC is run in continuous mode; therefore this interrupt occurs once every 256 system clocks (about once every 46.2 µs). The Timer 0 interrupt runs once every 100 ms and controls all software timers used in the main loop. It also sets the required one-second time base bit in the API and updates the status of the LEDs.

The flow chart in Figure 11 shows a high-level code flow for the ZMOTION Intrusion Reference Design.

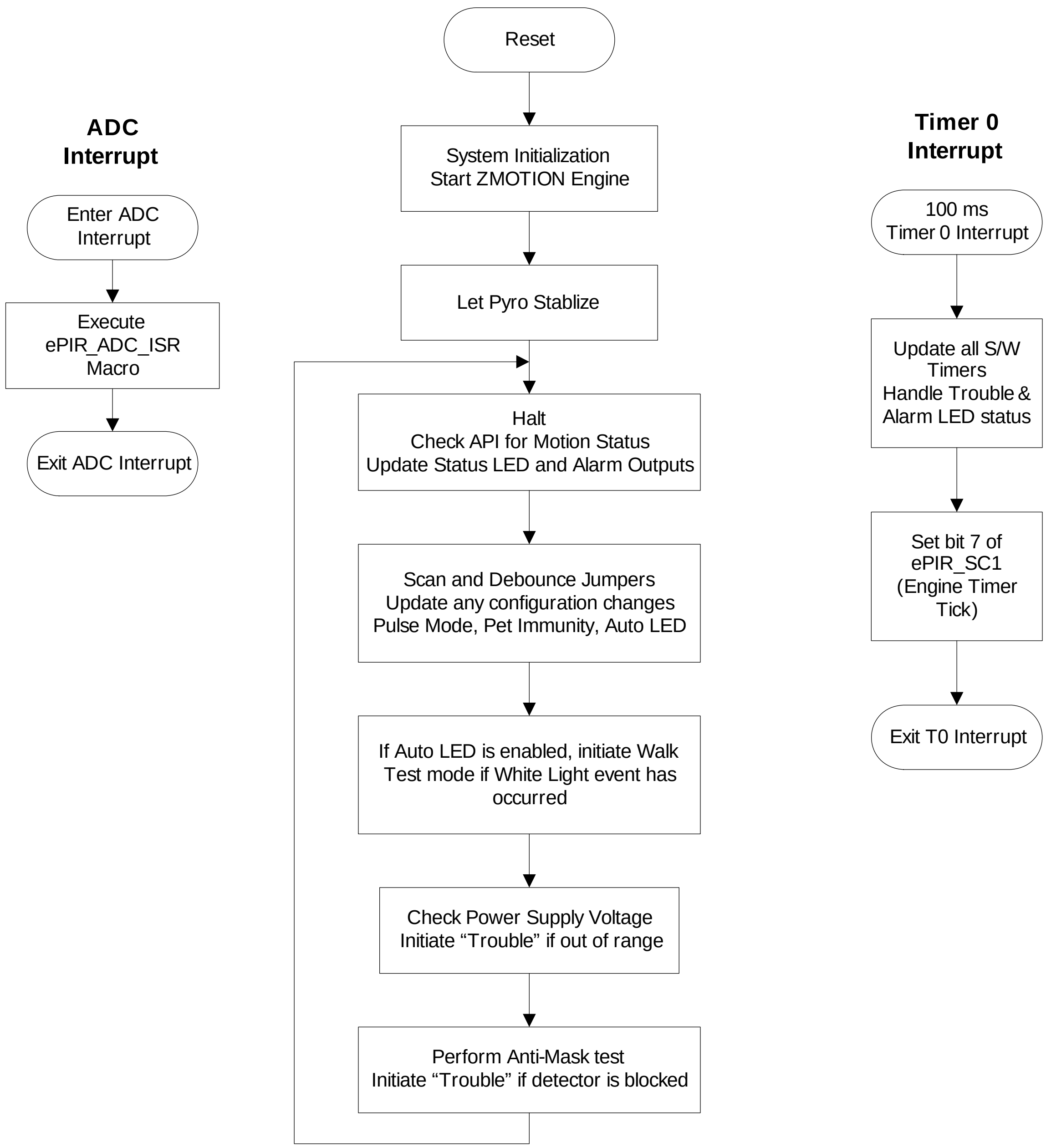

Figure 11. Software Flow: Top Level

The flow chart in Figure 12 shows a detailed flow of the main application loop.

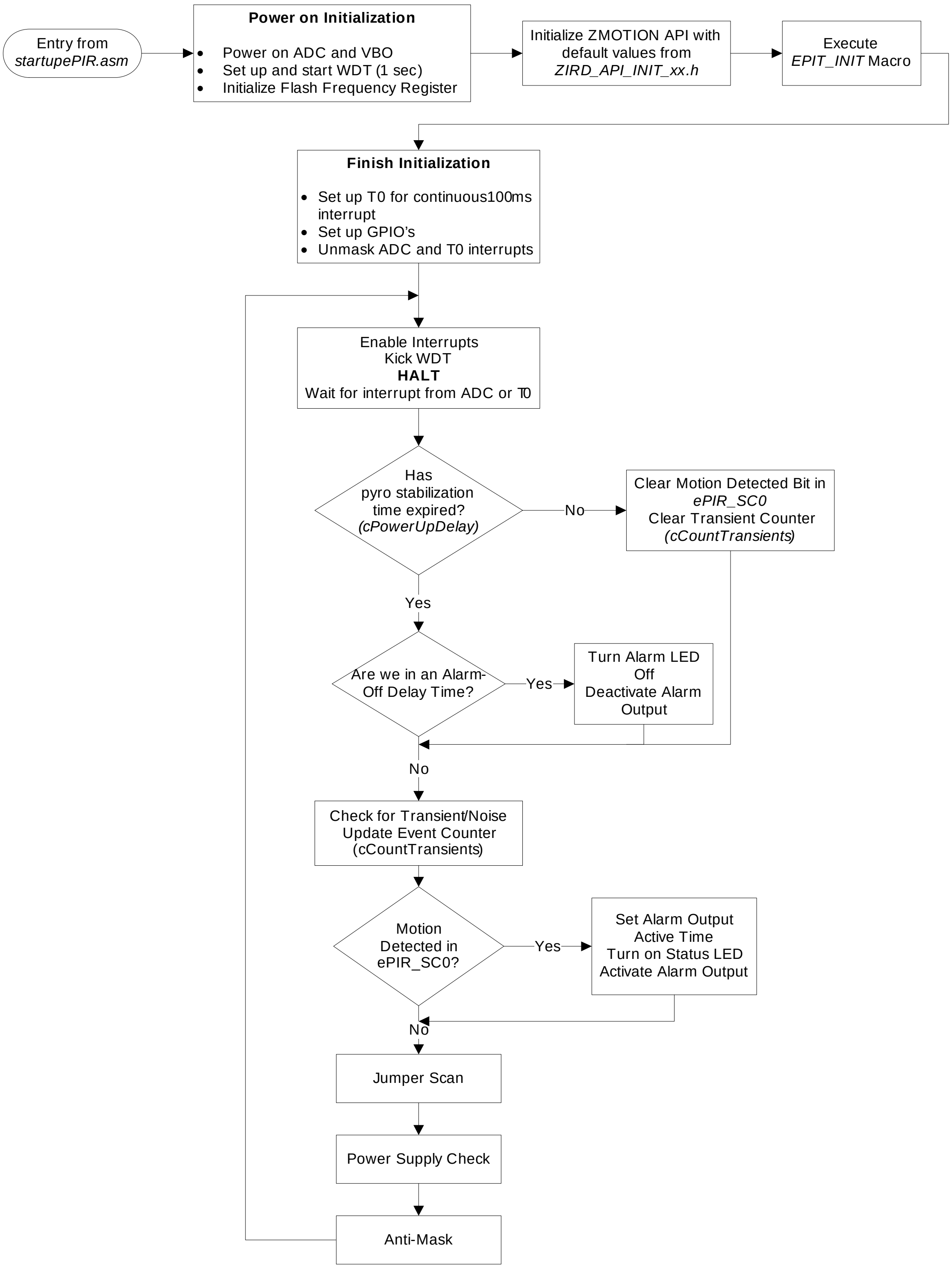

Figure 12. Software Flow: Main Application

The flow chart in Figure 13 shows a detailed flow of the power supply check loop.

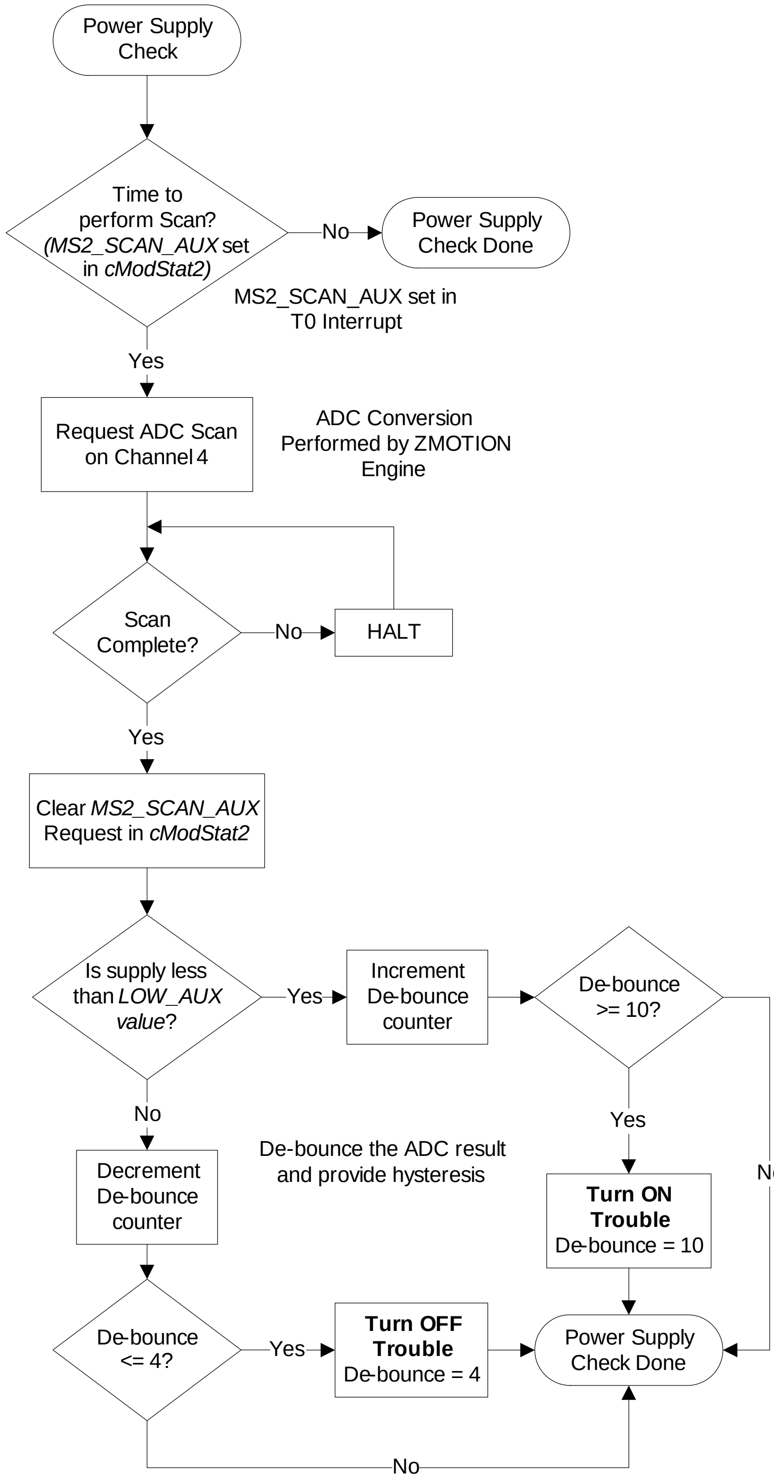

Figure 13. Software Flow: Power Supply Check

The flow chart in Figure 14 shows a detailed flow of the jumper scan loop.

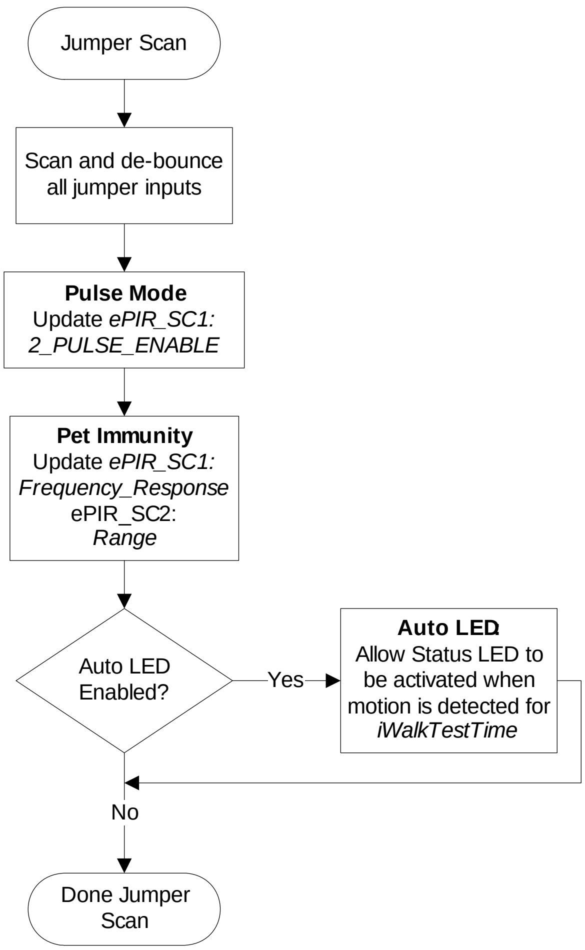

Figure 14. Software Flow: Jumper Scan

The flow chart in Figure 15 shows a detailed flow of the anti-mask loop.

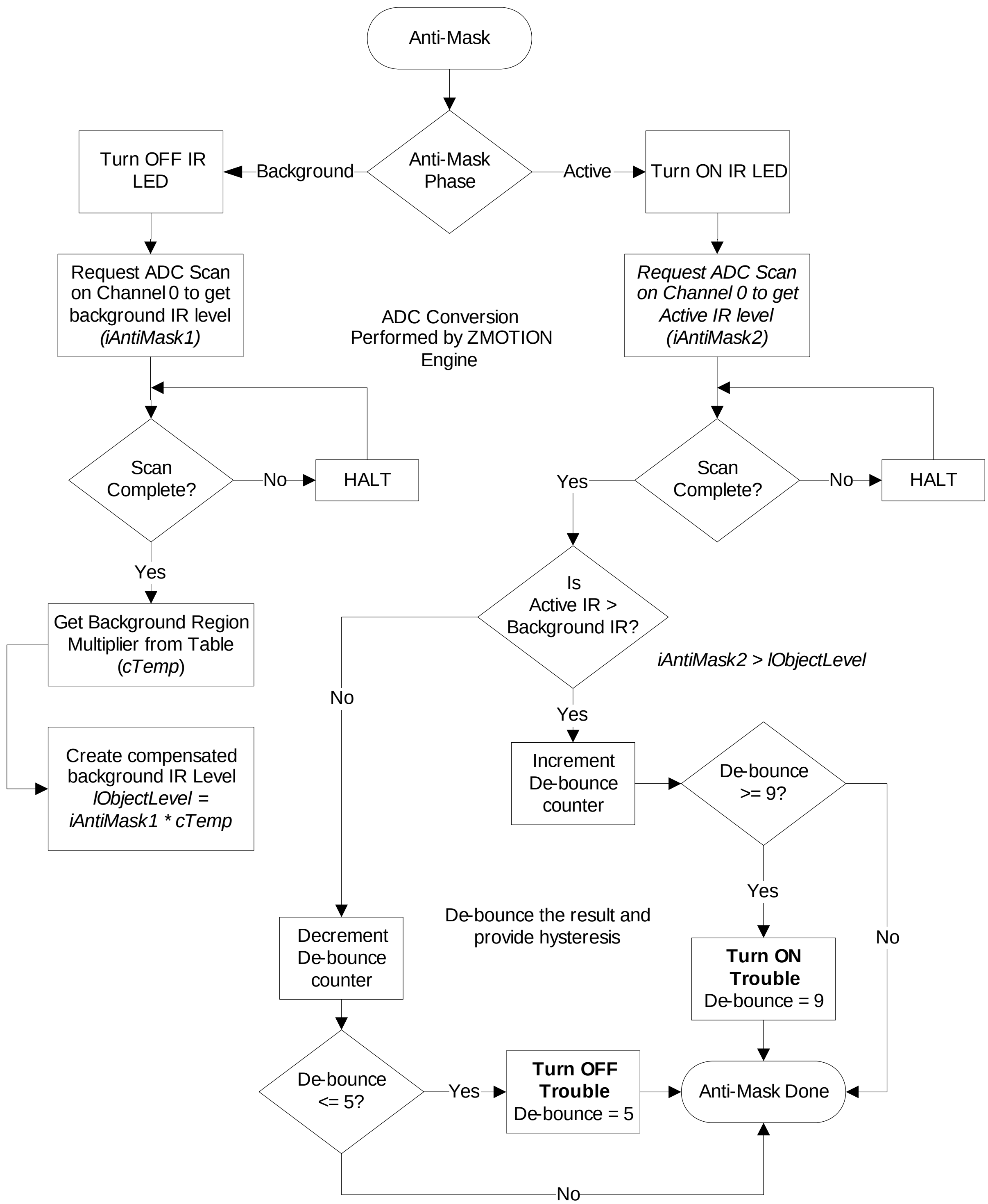

Figure 15. Software Flow: Anti-Mask

Installation and Operation

This section provides information about how to connect and operate the ZMOTION Intrusion Reference Design.

Connections

All connections to the detector are made through the Terminal Block, TB1 (see Figure 16) by removing the front cover, inserting the wire into the connector and securing it in place by tightening the screw. A wire channel is provided on the back of the detector so it may be mounted flush against a wall.

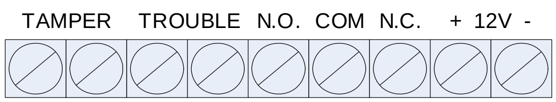

Figure 16. Terminal Block

Table 2. Terminal Block Signal Descriptions

Connection	Description	Comments
Tamper	Tamper switch – normally closed.	
Trouble	Trouble contacts – normally open.	
N.O.	Alarm contact – normally open.	Use with COM terminal.
COM	Common alarm terminal for N.O. and N.C.	
N.C.	Alarm contact – normally closed.	Use with COM terminal.
±12V	Detector DC supply voltage.	12V nominal.

Jumper Settings

Four jumpers are provided in Table 3 to select detector features.

Table 3. Jumper Settings

Jumper	Function	Installed	Removed
Pulse – J1	Pulse Mode. Number of detection pulses required to produce an alarm.	2 Pulse	1 Pulse
Pet – J2	Pet Immunity. Level of pet immunity provided. Values are approximate. Only valid with WA 1.2 GI 12 V4 lens.	30KG	12KG
LED – J3	Status LED Mode. Enables/disables the Status LED.	Auto-LED mode	Status LED ON when motion is detected
Anti-Mask - J4	Enables/disables Anti-Mask function.	Anti-Mask On	Anti-Mask Off

Testing

The following paragraphs provide information about how to test the various features of the ZMOTION Intrusion Reference Design. The key parameters of stability, area coverage (walk test) and EMC compliance were independently tested to ensure real-world viability of the design. The results of these tests are also provided.

Walk Test

To perform a basic walk test, supply 12V to the detector and ensure the LED Jumper is OFF (Status LED ON). When using the WA 1.2 GI 12 V4 lens, install the detector on a vertical surface at a height of 1.2m (6.8'). After power is applied, the detector will go through a warm-up period to allow the pyroelectric sensor to stabilize; this period will last about 45 seconds. During this time, the Status LED will flash. After this warm-up period is complete, the Status LED will turn OFF and only come ON again when motion is detected.

Anti-Mask

The Anti-Mask demonstration can be tested by first ensuring that the Anti-Mask Jumper (J4) is installed, then placing a piece of paper in front of the plastic lens on the bottom of the detector. The yellow Trouble light will illuminate and the Trouble output contact will be activated.

In a production version of a motion detector, the Anti-Mask elements would typically be placed closer to the Fresnel lens to ensure detection of anything blocking the lens.

Auto-LED

The Auto-LED feature can be tested by installing the LED Jumper (J3). Power is not required to be cycled. Normally, the Status LED will not illuminate when motion is detected. Shine a bright light (such as a flashlight) onto the light pipe on the outside of the case for about two seconds. The Status LED will now come ON when motion is detected. This WALK TEST Mode is automatically exited after 5 minutes.

Changing Lenses

This reference design ships preprogrammed to support the WA 1.2 GI 12 V4 lens. To operate the detector with one of the other two provided lenses (LR 1.2 GI 12 V3 and VB 1.2 GI V1), the software project must be rebuilt with the configuration that supports the specific lens (see the Project Configurations section on page 16). A USB Smart Cable (ZUSBSC00100ZACG; available separately) will also be required to program the MCU with the updated file.

The ZMOTION Intrusion Detection Development Kit (ZMOTIONS200ZCOG) includes all of the hardware and software required to modify this and other projects.

To change the lens on the ZMOTION Intrusion Reference Design, first remove the front cover from the detector by loosening the retaining screw at the bottom of the detector and lifting the front cover off from the bottom. Next, remove the four screws that hold the bezel in place, then remove the existing lens from the cover. See Figure 17.

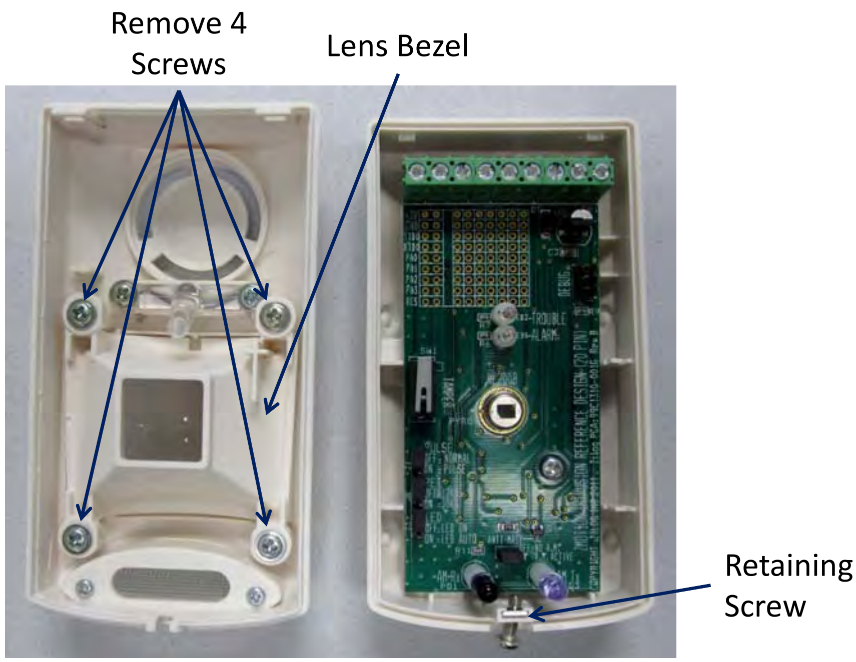

Figure 17. Changing ZIRD Lens

Place the new lens in the cover (ensure correct orientation), place the bezel over the top and reinstall the four screws to secure it in place. Reattach the cover to the base by inserting the top flange of the cover into the slot on the base, then moving the bottom into place.

Stability Test Results

Stability tests were performed in a large indoor open area for a period of 30 days. Six ZMOTION Intrusion Reference Design detectors were mounted at a height of 7 feet using the WA 1.2 GI 12 V4 lens such that it was exposed to 2 exterior concrete walls, two large windows and one interior wall. The floor was uncovered concrete and the ambient temperature was not controlled and varied from 15C to 30C.

Table 4. Stability Test Conditions

Room Dimensions	65' x 30'
Temperature variation	15C to 30C
Mounting	Vertical at 7'
Time period	30 days
Number of units	6

No false detections were recorded in this stability test.

Walk Test Results

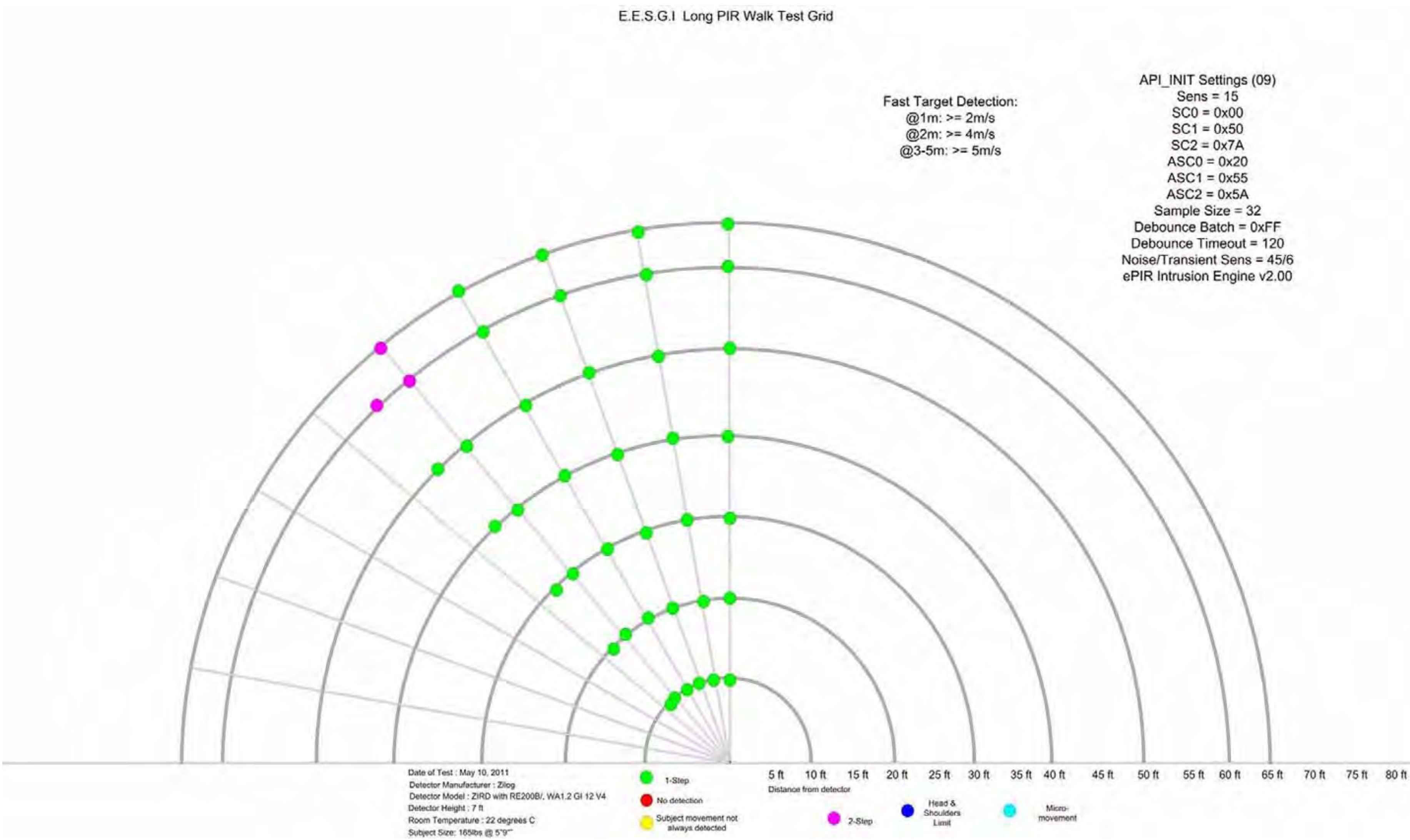

Figure 18. Walk Test Results for the WA 1.2 GI 12 V4 Lens

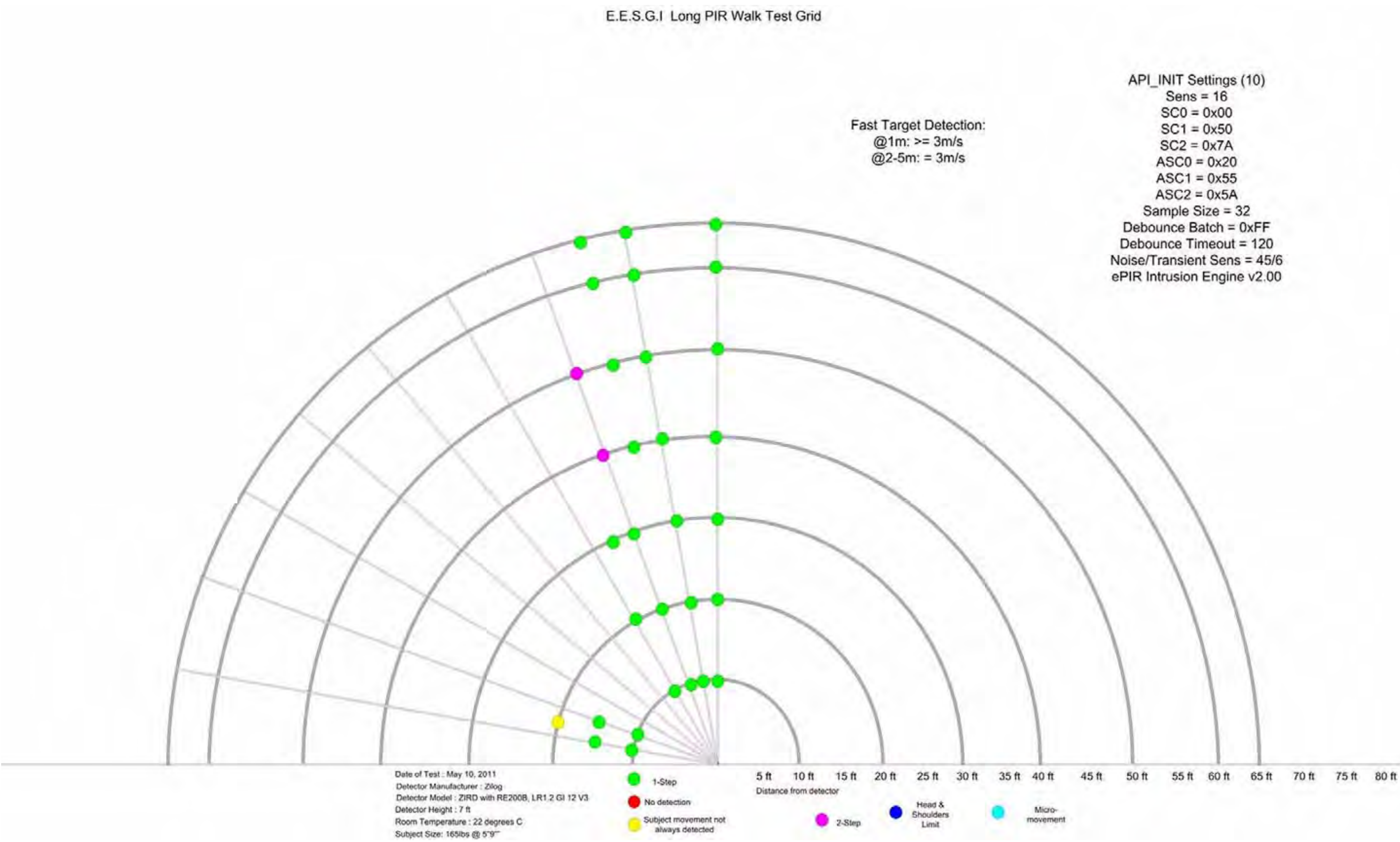

Figure 19. Walk Test Results for the LR 1.2 GI 12 V4 Lens

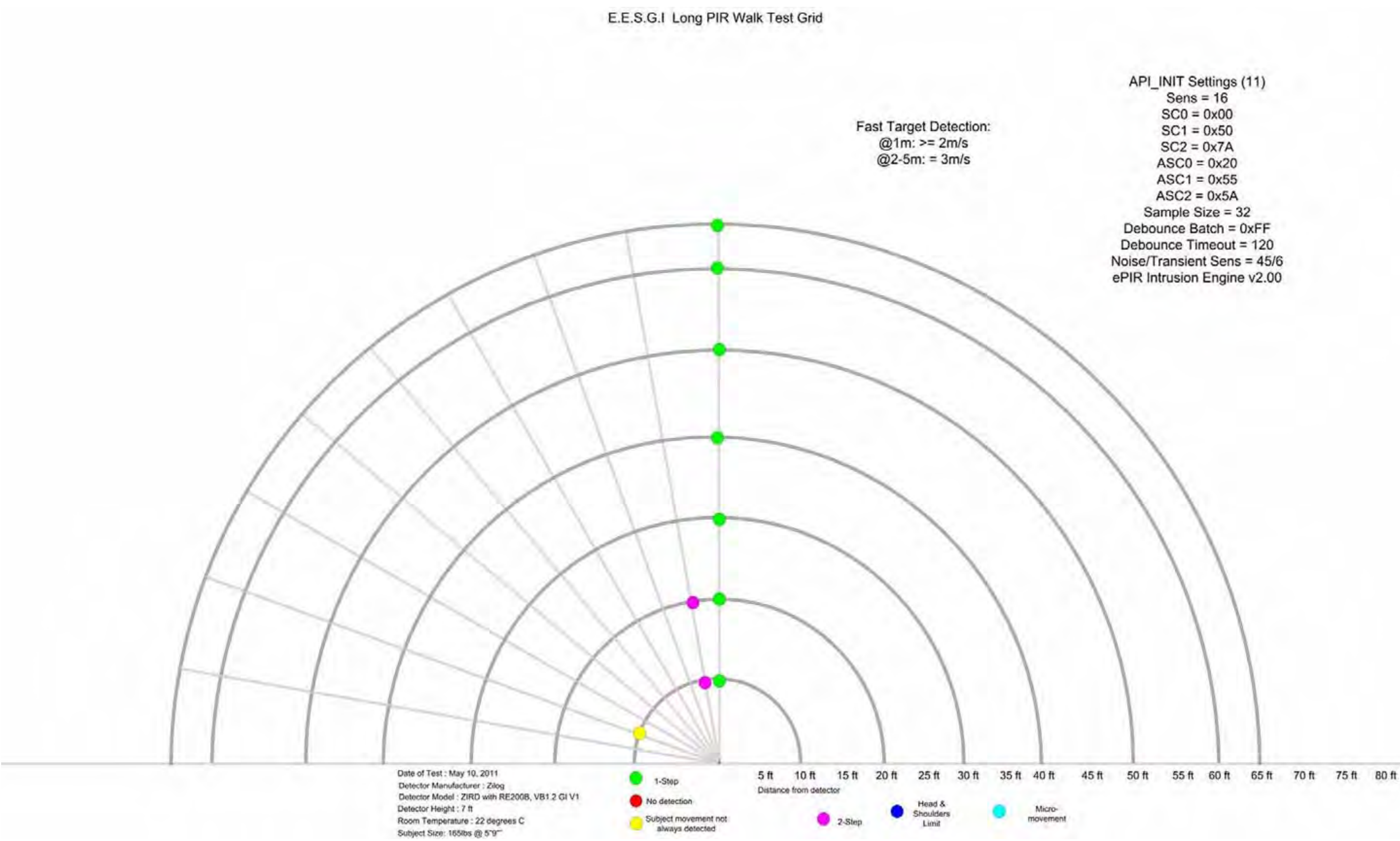

Figure 20. Walk Test Results for the VB 1.2 GI V1 Lens

EMC Test Results

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To Whom It May Concern:

This findings letter summarizes the RF Immunity tests conducted on the Zilog ZMOTION Intrusion Reference Design (ZIRD) unit for the standards, levels and conditions listed below.

Standard	Level / Limits	Results
IEC/EN 61000-4-3 ➢ Based on guidance provided in EN 50131-2 and EN 50130-4	Radiated Immunity tested for 80 MHz to 2 GHz, ≥ 10 V/m AM Modulation (80% @ 1 kHz) PM Modulation (100%@ 1 Hz) Horizontal Polarization Vertical Polarization Multiple Axes Orientation including typical mounting condition (X Axis)	Passed All Criteria

In all cases the testing revealed the following:

- Immunity to False Alarms – No False Alarms Generated at Any Time
- Correct Functionality – Ability to Properly Detect Motion at All Times

All above mentioned tests were performed at Global EMC Labs on May 2nd & May 17th, 2011 by:

Sanjiv Vyas
EMC Engineer

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180 Brodie Dr, Unit 2
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Canada

Figure 21. RF Immunity Test Results from EMC

Summary

The ZMOTION Intrusion Reference Design demonstrates how to use Zilog's ZMOTION Intrusion Motion Detection solution in a PIR based intrusion motion detector design that meets and exceeds industry expectations. The stability and EMC tests show that how even a non-optimized board layout is capable of meeting the most stringent EN-50131 agency approvals. The flexibility of the Z8FS021 ZMOTION Intrusion MCU allows additional features such as anti-mask and power supply supervisory features to be added with minimal additional components.

The three lenses included with the reference design demonstrate the ease with which a full product family can be created based off the initial design - a different lens configuration file is all that is required.

Specifications

Table 5 shows the specifications of the ZMOTION Intrusion Reference Design. All values are typical.

Table 5. ZMOTION Intrusion Reference Design Specifications

Detection Method	Dual Element PIR
Power Input	8.5V to 18V
Current Consumption:	
• Standby with Anti-Mask On	16mA
• Standby with Anti-Mask Off	19mA
Detection Range:	
• WA 1.2 GI 12 V4	18 meters
• LR 1.2 GI 12 V3	30 meters
• VB 1.2 GI V1	15 meters
Walk Test/Auto-LED Time	5 minutes
Alarm Output Active Time	2 seconds
Alarm Output Type	Form-A/Form-B
Trouble Output Active Time	
Trouble Output Type	Form-A
Tamper Output Type	Form-B
Power On Warm up Time	45 seconds
White Light Immunity	>12,000 LUX
Pet Immunity	Selectable 12KG/30KG
Power Supply Supervisory Trip Level	8.5V
Dimensions (LxWxH)	6.4cm x 5.1cm x 12.7cm

Ordering Information

The ZMOTION Intrusion Motion Detector Reference Design can be purchased from the Zilog Store – simply click the Store Product ID listed in Table 6. To see a parts list for this product, see Appendix B on page 32.

Table 6. ZMOTION Intrusion Motion Detector Reference Design Ordering Information

Part Number	Description	Store Product ID
ZMOTIONS200ZRDG	ZMOTION Intrusion Motion Detector Reference Design	RD10005

Related Documentation

The documents associated with the ZMOTION Intrusion Detector and/or its base Z8FS021 MCU are listed in Table 7. Each of these documents can be obtained from the Zilog website by clicking the link associated with its document number.

Table 7. ZMOTION Intrusion Motion Detector Reference Design Documentation

Document Number	Description
RD0001-SC01	ZMOTION Intrusion Reference Design Source Code
PS0288	ZMOTION Intrusion Detection Product Specification
PS0228	Z8 Encore! XP F082A Series Product Specification
PS0286	ZMOTION Lens and Pyroelectric Sensor Product Specification
WP0017	ZMOTION: A New PIR Motion Detection Architecture White Paper
WP0018	ZMOTION Detection Lens and Pyro Sensor Configuration Guide
WP0019	ZMOTION Intrusion Reference Design Lab Findings Report

Appendix A. Schematic Diagram

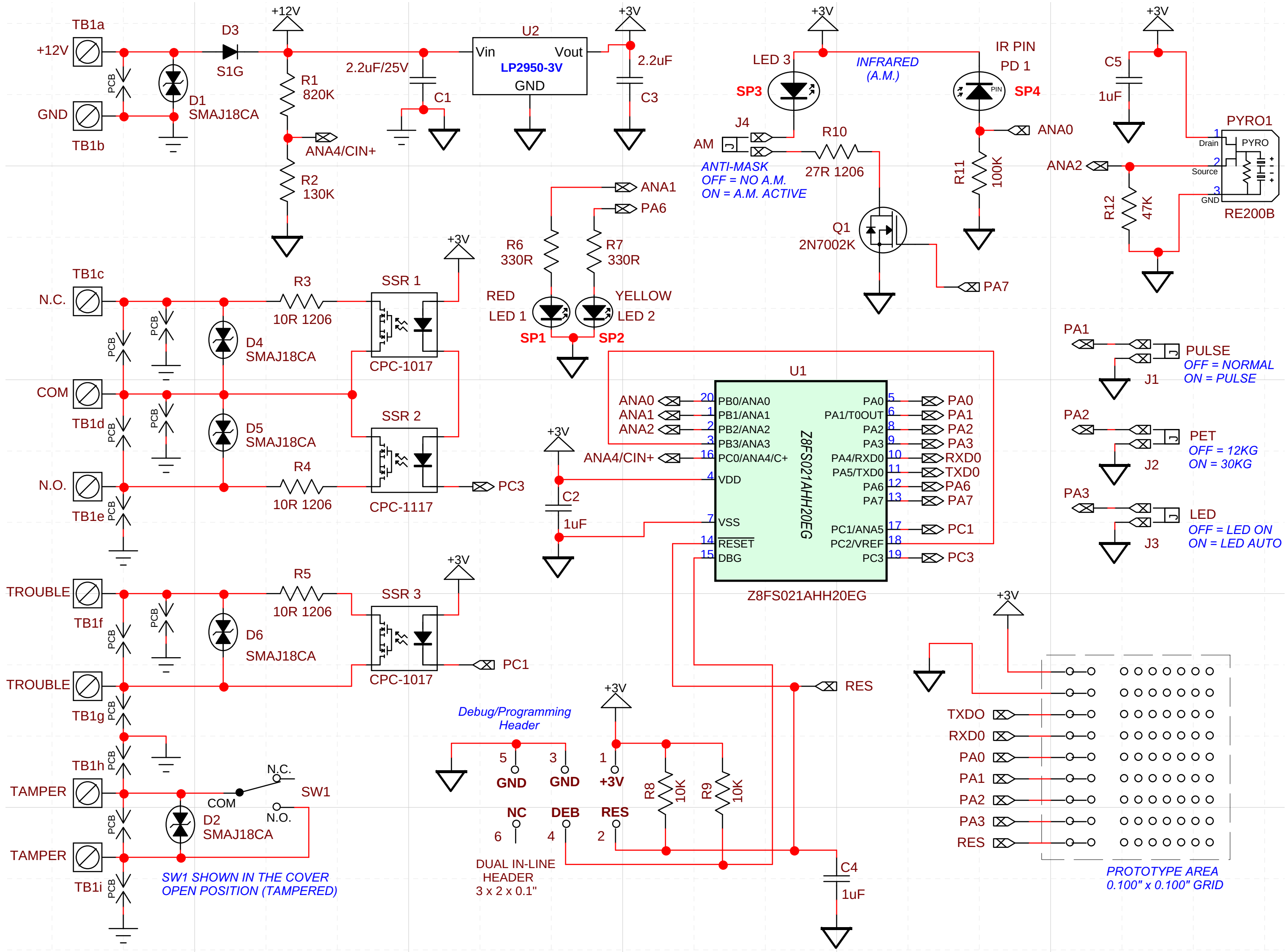

Figure 22. ZMOTION Intrusion Reference Design Schematic Diagram

Appendix B. Parts List

The parts required for building this ZMOTION Intrusion Motion Detector are listed in Table 8. The components shown in red are available from Zilog and Clare.

Table 8. ZMOTION Intrusion Reference Design PCB Parts List

#	Qty	Description	Reference	Manufacturer	Manufacturer's Part Number	PCB Footprint
1	3	CAP CER 1.0UF 25V X7R 10% 0805	C2, C4, C5	TDK	C2012X7R1E105K	0805
2	2	CAP CER 2.2UF 25V X7R 10% 0805	C1, C3	Murata	GRM21BR71E225KA73L	0805
3	5	DIODE TVS 18V 400W BI 5% SMD	D1, D2, D4, D5, D6	Bourns	SMAJ18CA	DO-214AC, SMA
4	1	DIODE GEN PURPOSE 400V 1A SMA	D3	Fairchild	S1G	DO-214AC, SMA
5	1	RES 820K OHM 1/10W 5% 0603 SMD	R1	Panasonic - ECG	ERJ-3GEYJ824V	0603
6	1	RES 130K OHM 1/10W 5% 0603 SMD	R2	Panasonic - ECG	ERJ-3GEYJ134V	0603
7	3	RES 10 OHM 1/4W 5% 1206 SMD	R3, R4, R5	Panasonic - ECG	ERJ-8GEYJ100V	1206
8	2	RES 330 OHM 1/10W 5% 0603 SMD	R6, R7	Panasonic - ECG	ERJ-3GEYJ331V	0603
9	2	RES 10K OHM 1/10W 5% 0603 SMD	R8, R9	Panasonic - ECG	ERJ-3GEYJ103V	0603
10	1	RES 27 OHM 1/4W 5% 1206 SMD	R10	Panasonic - ECG	ERJ-8GEYJ270V	1206
11	1	RES 100K OHM 1/10W 5% 0603 SMD	R11	Panasonic - ECG	ERJ-3GEYJ104V	0603
12	1	RES 47K OHM 1/10W 5% 0603 SMD	R12	Panasonic - ECG	ERJ-3GEYJ473V	0603
13	1	LED 623NM ROUND RED 3MM	LED 1	Optek	OVLBR4C7	T-1
14	1	LED 589NM ROUND YELLOW 3MM	LED 2	Optek	OVLBY4C7	T-1
15	1	IR LED 880NM ROUND 5MM	LED 3	OSRAM	SFH 484-2	T 1 3/4
16	1	PHOTODIODE 5MM PIN 890NM	PD 1	Optek	OP999	T 1 3/4
17	2	**RELAY OPTOMOS SP-NO**	**SSR 1 & 3**	**Clare**	**CPC1017NTR**	**4-ESOP**
18	1	**RELAY OPTOMOS SP-NC**	**SSR 2**	**Clare**	**CPC1117NTR**	**4-ESOP**
19	1	IC VREG 3V MICRPWR TO92-3	U2	National Semi	LP2950CZ-3.0	TO-92 (3 Pin)
20	1	**ZMOTION Intrusion MCU**	**U1**	**Zilog**	**Z8FS021AHH20EG**	**20-SSOP**
21	1	CONN HEADER 6POS .100 STR 15AU	DEBUG	FCI	67997-206HLF	2x3 0.100"
22	4	Jumper Header .100" x 2 - STRAIGHT	J1, J2, J3, J4	FCI	68001-202HLF	2x1 0.100"
23	4	JUMPER SHORTING GOLD 2x1	JS1, JS2, JS3, JS4	Sullins	SPC02SYAN	Jumper Cap 2x1
24	1	TERM BLOCK 9POS 5.0MM GREEN	TB1 (A-I)	Phoenix	1935239	9 x 5mm (0.197")
25	1	LEVER SWITCH PCB SPDT 3A 80GF	SW1	Omron	D2F-L	3x1 0.200"
26	1	MOSFET N-CH 60V 320MA SOT-23	Q1	ON Semi	2N7002KT1G	SOT-23-3
27	1	**Pyro RE200B Dual Element**	**PYRO1**	**Zilog/Nicera**	**RE200B**	**TO-5 x 3 Pin**
28	1	T-1 LED Spacer / Stand Off .200"	SP1, SP2	Keystone	7355	T-1 Spacer
29	1	T-1 3/4 LED Spacer / Stand Off .450"	SP3, SP4	Keystone	8330	T-1 3/4 Spacer
30	1	**18 Meter WA Lens**		**Zilog/Fresnel**	**WA 1.2 GI 12 V3**	
31	1	**30 Meter LR Lens**		**Zilog/Fresnel**	**LR 1.2 GI 12 V4**	
32	1	**15 Meter VB Lens**		**Zilog/Fresnel**	**WA 1.2 GI V1**	

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