Application Note

Z8 Encore! XP® Based CO Detector Reference Design

AN022502-0608

Abstract

Carbon monoxide (CO) is a by-product of fossil fuel combustion. It is an invisible gas and has no smell or taste. When this gas enters human lungs during breathing, it kills by displacing oxygen in the bloodstream. Therefore, considerable effort is being applied to the development and use of various systems to monitor human habitats with the objective of detecting and reporting unacceptable concentration of this deadly gas. CO detectors are developed to detect and report when the concentration of CO is unacceptable, which is usually greater than 60 parts per million (ppm).

The current generation of CO detectors mainly consists of infrared (IR) or electrochemical-cell sensors. IR sensors are based on measurement of the absorption of infrared light in the frequency bands characteristic of CO. An IR sensor needs an IR transmitting source and a receiver to detect a CO gas signature.

Electrochemical-cell sensors are considered to be inherently more robust than any other CO detector and they are based on the oxidization of the CO inside the cell. Detectors with electrochemical cells react with the sampled air. This results either in a voltage or current variation to the detector circuitry depending on the design of the particular CO detector.

This Application Note describes the operation and advantages of an electrochemical CO sensor solution, which consists Zilog's Z8 Encore! XP® advanced microcontroller unit (MCU) and the Sixth Sense ECO-Sure® (2e) CO sensor.

Z8 Encore! XP Series Flash Microcontrollers

The main features of Z8 Encore! XP Series of devices include:

- Zilog's 20 MHz eZ8™ CPU core.

  The high-performance register-to-register based architecture of the eZ8 core maintains backward compatibility with Zilog's popular Z8® MCU.
- Introduce Flash Memory to Zilog's extensive line of 8-bit microcontrollers.

  The Flash Memory in-circuit programming capability allows for faster development time and program changes in the field.
- Linear-register SRAM.
- An extensive array of on-chip peripherals.
- Up to 8 KB of Flash Program Memory.
- 1 KB register RAM.
- An on-chip temperature sensor allows temperature measurement over a range of –40 ºC to +105 ºC.
- Two enhanced 16-bit timer blocks featuring PWM and Capture and Compare capabilities.
- An on-chip Internal Precision Oscillator (5 MHz/32 kHz) can be used as a trimmable clock source requiring no external components.
- 128 Bytes of Non-volatile Data Storage (NVDS) memory where individual bytes can be written or read.

- The full-duplex UART, in addition to providing serial communications and IrDA encoding and decoding capability, also supports multi-drop address processing in hardware.

The rich set of on-chip peripherals make the Z8 Encore! XP® MCUs suitable for various applications including motor control, security systems, home appliances, personal electronic devices, and sensors.

Discussion

The unique array of advanced on-chip integrated hardware in Z8 Encore! XP provides a complete CO detector solution, minimizes the board space, and requires a very few external components. This section discusses the hardware architecture and firmware implementation of the electrochemical cell CO detector solution.

Hardware and Software Implementation

The solution implements continuous monitoring of the CO level to ensure a high degree of reliability. Peripherals integrated in the Z8 Encore! XP MCU, with functionality specific to this task, include:

- **Transimpedance Amplifier** — A transimpedance amplifier, which measures the current variations produced by the ECO-Sure® (2e) CO sensor. The measured values are translated into voltages and are fed to the integrated Sigma-Delta Analog-to-Digital Converter (ADC).
- **Sigma-Delta ADC** — An enhanced Sigma-Delta ADC, which converts the voltage associated with the CO level, which is measured in parts per million (ppm) into digital data. The output value of the ADC is then processed by the CPU, based on the firmware algorithms, in order to determine if the maximum preset CO ppm level has been reached.
- **On-chip Timer** — An on-chip timer, (Timer 0), which provides all timing and reset functions while the on-chip Flash and the non-volatile memory caters to all user configurable parameters.
- **High Current Integrated Led Driver Module** — A high current integrated led driver module, which provides direct coupling of the MCU to the LED(s) without the requirement for additional external components.
- **Power Management Routine** — A power management routine using the SLEEP mode and Watchdog Timer (WDT) option working together to conserve power consumption.

Figure 1 on page 3 displays the block diagram of the CO detector solution. The LED indicator indicates the status of the detector. When the CO level is higher than the maximum level defined, the red status LED flashes and a voice annunciator is activated. These warning signals run continuously as long as the detected CO level remains higher than the maximum preset value.

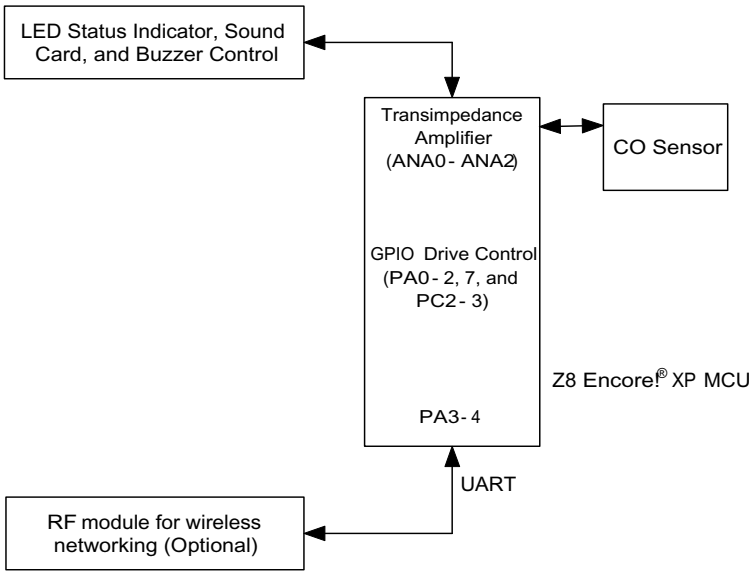

Figure 1. Block Diagram of the CO Detector

Figure 2 displays the picture of the CO detector. The circuit is powered by three AA batteries and has provision for a smoke detector. The details of this smoke detector and the software associated with it are not covered in this application note. This software is provided for completeness.

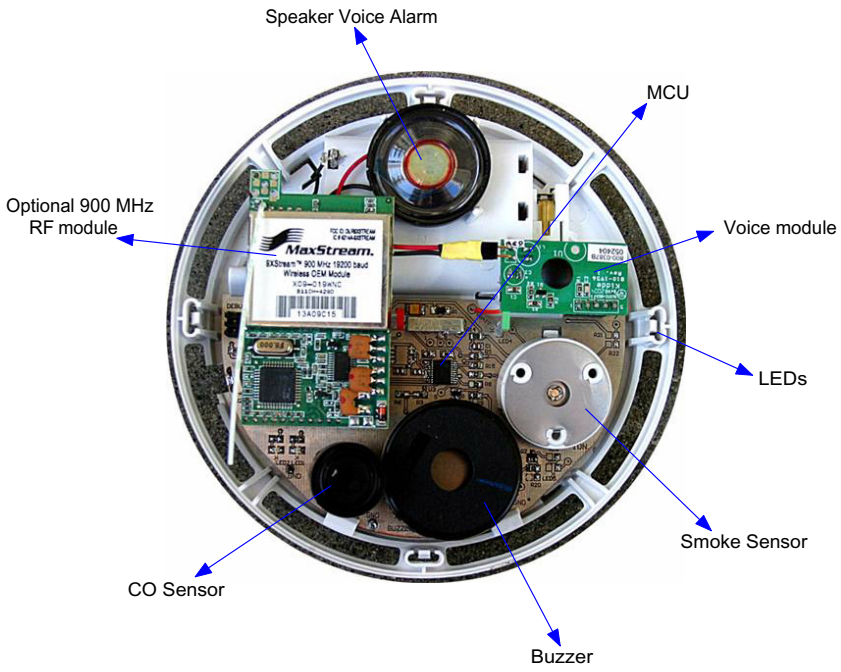

Figure 2. CO Detector

The optional MaxStream 900 MHz RF module is aimed at wireless networking and monitoring applications. The operation of the RF module is not covered in this application note and will be added to a future revision.

You can set the maximum CO level at which the alarm is needed using the following statement, which is available in the `CO_detector_demo.h` header file in the `AN0225-SC01.zip` file.

```
#define coLevelMax 0 // assigned
20 PPM
```

For testing purposes, the parameter is set to 0.

The CO level is sampled every five seconds using the `Timer 0` interrupt routine. The five seconds interval is chosen to achieve the critical real time monitoring while minimizing the possibility of false triggering.

The power management option in the software conserves the battery life by putting the Z8 Encore! XP® to SLEEP mode after the CO level sample.

If the CO level is below the preset maximum CO level (`coLevelMax`), the Z8 Encore! XP® goes to sleep mode while the WDT initiates a reset after 30 seconds to wake up the MCU and sample again. This process continues as long as the CO level is within the preset maximum level. If the CO level reaches the maximum preset CO level, the MCU does not go to the SLEEP mode and continues to alarm.

The power management routine resumes if the sampled CO level is below the preset maximum CO level.

A high CO level triggers the buzzer. In addition, there is a sound card for the voice annunciator. This is controlled by PA0, PA1, and PA2 port pins, which generates a recorded message once a high CO level is detected.

Table 1 provides the PA0 – PA2 inputs and the voice output.

Table 1. PA0 - PA2 Inputs and Voice Output

PA2	PA1	PA0	Voice Output
1	0	1	Fire! Fire!
0	0	1	Warning! Carbon Monoxide
0	1	1	Low Battery

Testing the Application

This section provides details of the equipment and the procedure to calibrate and test the CO detector application.

Hardware Required

The test setup consists of the following hardware:

- CO Detector Solution Board
- Three AA batteries

Software Required

The software required for testing the CO detector application include:

- ZDS II – Z8 Encore!® v4.9.5 or later (included with the development kit)
- CO detector source code files (`AN00225-SC01.zip` is available for download at www.zilog.com)

Procedure

Follow the steps below to test the Z8 Encore! XP-based CO detector application:

1. Download the source code `AN00225-SC01.zip` from www.zilog.com to an appropriate location on your PC.

2. Insert three AA batteries in the battery case of the CO Detector Board.
3. Launch Zilog ZDS II - Z8 Encore!® v4.9.5 or later.
4. Set the default level for maximum CO level in the header file `CO_detector_demo.h` file as mentioned earlier.
5. Build the files in the project available from `AN0225-SC01.zip` and download the code to the CO detector board.
6. Press the **Reset** button on the board to initiate program execution.

If `coLevelMax` (in the `CO_detector_demo.h` file) is set to 0 for validating the functionality of the CO detector and the sound card, voice-recorded messages are activated on reset followed by brief activation of the buzzer. The green status LED blinks to indicate the activation of CO sensing. The intermittent blinking continues during normal operation.

Summary

This Application Note demonstrates a compact CO and smoke detector unit using the 20-pin Z8 Encore! XP® microcontroller. This unit runs on three AA size batteries and has a blinking LED indicator to indicate that the detector is active.

A voice annunciator along with an LED, and a buzzer are provided as indicators of CO or smoke detection. All this has been made possible in a compact unit due to the fact that this unit uses a lot of on-chip peripherals of Z8 Encore! XP such as transimpedance amplifier, ADC, and timer.

This application can be extended for using the RF module to modify the settings or monitor the status remotely. The provision to use the on-chip temperature sensor is for future development.

Appendix A—Flowcharts

Figure 3 displays the flowchart for the main CO detector routine.

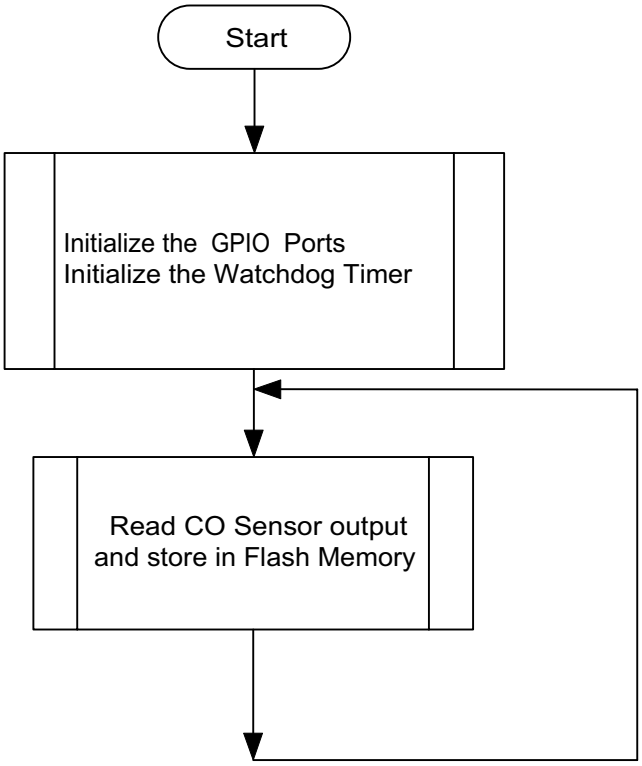

Figure 3. Main Routine of CO Detector

Figure 4 displays the flowchart for the Timer Interrupt routine of the CO detector.

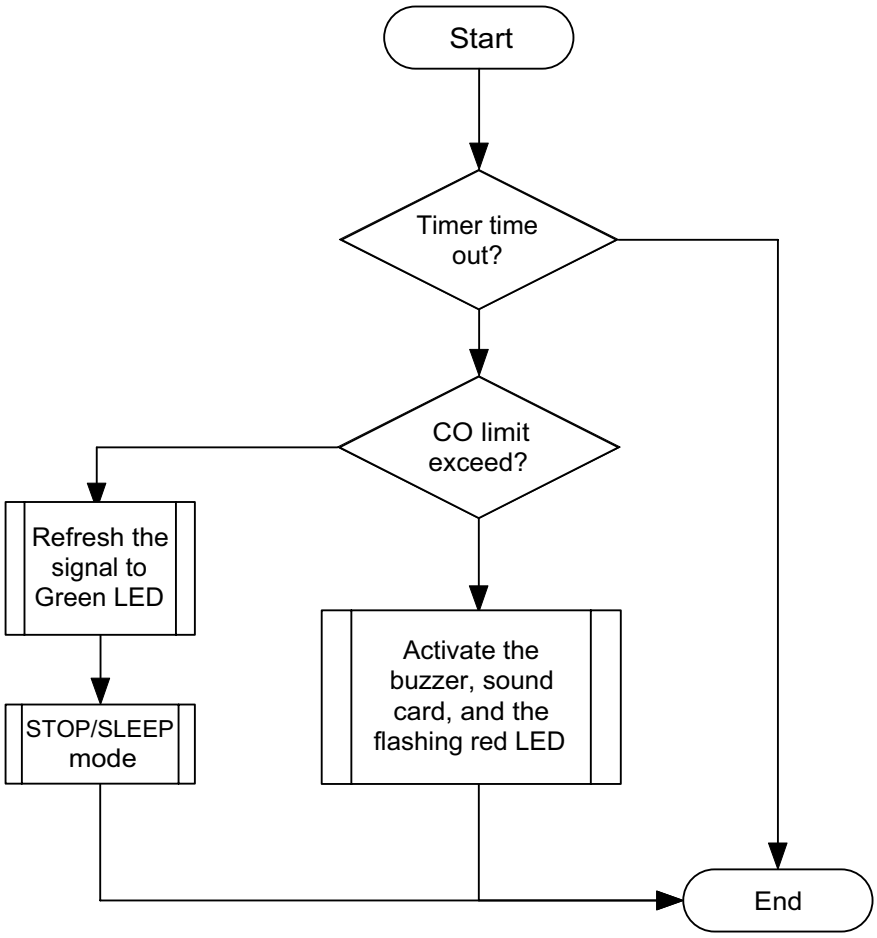

Figure 4. Timer Interrupt Routine

Appendix B—Schematic Diagram

Figure 5 displays the schematic diagram for the Z8 Encore! XP® based CO detector.

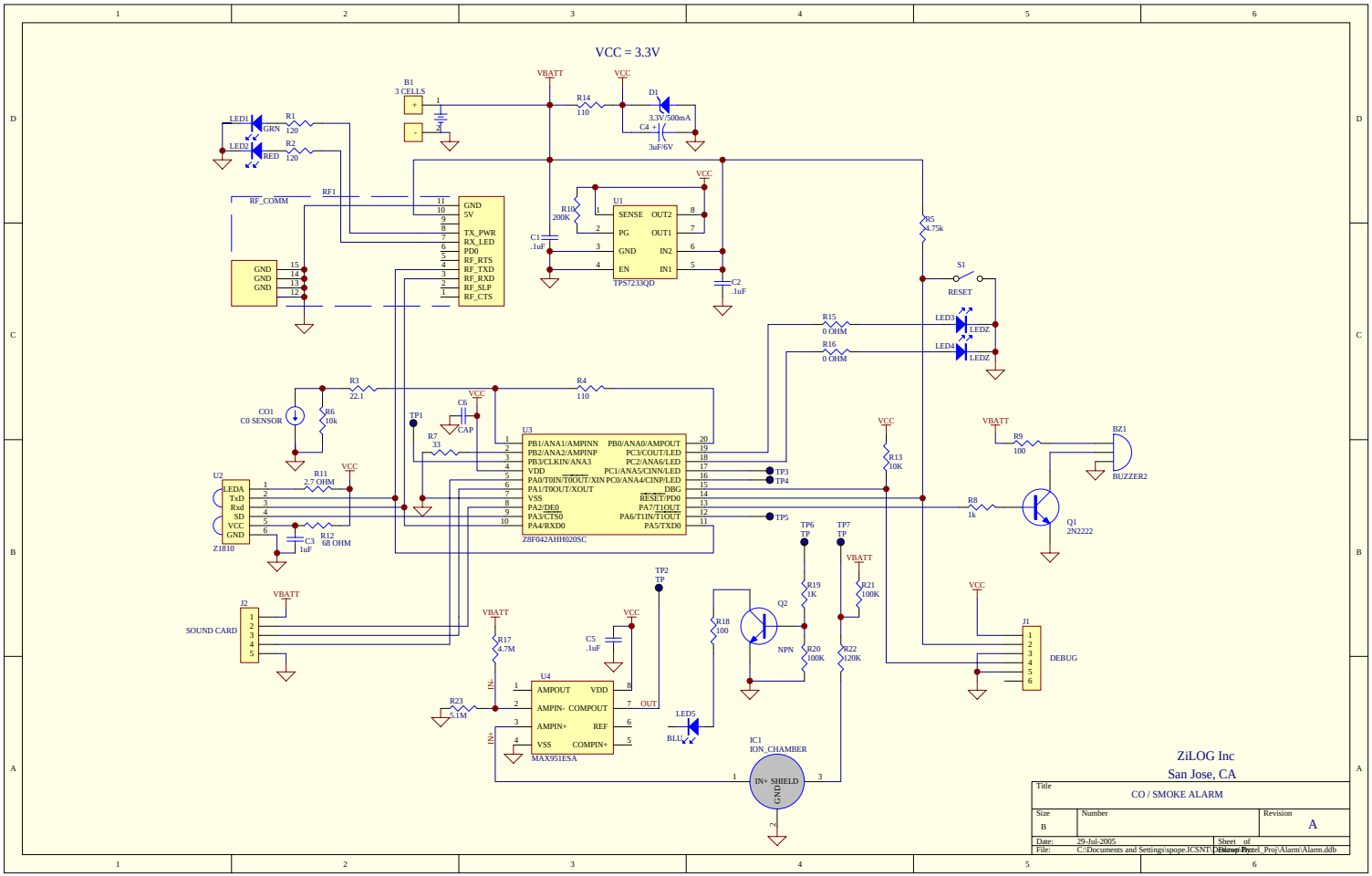

Figure 5. Schematic Diagram of CO Detector

Warning: DO NOT USE IN LIFE SUPPORT

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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.

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