



# Interfacing a Pressure Sensor with the Z8 Encore! XP<sup>®</sup> MCU

AN019502-1207

## Abstract

This Application Note describes an interface between Motorola's integrated silicon pressure sensor and Zilog's Z8 Encore! XP<sup>®</sup> microcontroller unit (MCU). The voltage output from the sensor is converted into a digital format using the Direct Memory Access (DMA)/Analog-to-Digital Converter (ADC) peripheral of the Z8 Encore! XP MCU. The output from the sensor is obtained at pre-set time intervals and up on conversion to the digital format, the data is stored. The data is displayed in a HyperTerminal application at regular time intervals via the UART port of the MCU.

The source code associated with this Application Note is in the AN0195-SC01.zip file available for download at [www.zilog.com](http://www.zilog.com).

## Z8 Encore! XP Flash Microcontrollers

Zilog's Z8 Encore! XP products are based on the new eZ8 CPU and introduce Flash memory to Zilog's extensive line of 8-bit MCUs. Flash memory in-circuit programming capability allows for faster development time and program changes in the field. The high-performance register-to-register based architecture of the eZ8 core maintains backward compatibility with Zilog's popular Z8<sup>®</sup> MCU.

Z8 Encore! XP MCUs combine a 20 MHz core with Flash memory, linear-register SRAM, and an extensive array of on-chip peripherals. These peripherals make the Z8 Encore! XP MCU suitable for a variety of applications including motor control, security systems, home appliances, personal electronic devices, and sensors.

## Discussion

Pressure is defined as the force exerted per unit area and is expressed in several different units. The SI unit for pressure is Newton per meter square (N/m<sup>2</sup>), and is also known as Pascal (Pa). Other commonly used units are pounds per square inch (psi), bar (100,000 Pa), millibar (100 Pa), Torr, and Atmosphere (atm). For more information about these units of measurement, see [Appendix A—Glossary](#) on page 4.

Pressure sensors are sensitive to various ranges of pressure and the output from a pressure sensor is proportional to the pressure to which it is subjected. Pressure sensors find their use in several fields, in particular the automotive electronics.

The pressure sensor utilized for the interface application described in this document outputs a voltage between 0.2 V to 4.8 V, which represents pressure from 15 kPa to 115 kPa. The formula to calculate pressure from voltage is:

$$V_{OUT} = V_S (P * 0.01059 - 0.1518) \pm (\text{Pressure Error} * \text{Temperature Factor} * 0.01059 * V_S)$$

where:

$V_S$  = Supply voltage (5.1 V  $\pm$  0.25 V<sub>DC</sub>)

P = Pressure

Pressure Error =  $\pm$  1.5 kPa (max)

Temperature factor = 3 for  $-40$  °C to  $+125$  °C, and 1 for  $0$  °C to  $85$  °C.

## The Motorola Pressure Sensor

The MPXA4100A6U device from Motorola is a surface-mount, micro-machined, signal-conditioned silicon pressure sensor. It is designed primarily as a Manifold Absolute Pressure (MAP) sensor for engine control. The sensor is temperature compensated over  $-40\text{ }^{\circ}\text{C}$  to  $+125\text{ }^{\circ}\text{C}$  and ranges from 15 kPa to 115 kPa (2.2 psi to 16.7 psi). The sensor is best used between 20 kPa to 105 kPa because the pressure reading is linear within this range.

The Motorola MPXA4100A6U pressure sensor measures absolute pressure (relative to vacuum). For further details about this device, refer to Motorola datasheet available at: [http://e-www.motorola.com/files/sensors/doc/data\\_sheet/MPX4100A.pdf](http://e-www.motorola.com/files/sensors/doc/data_sheet/MPX4100A.pdf).

## Developing the Z8 Encore! XP Pressure Sensor Interface

This section contains the hardware architecture and the software implementation of the pressure sensor interface.

### Hardware Architecture

The pressure sensor is powered by the conventional 5 V supply that fits into the supply voltage range of  $5.1\text{ V} \pm 0.25\text{ V}$ . The sensor output is attenuated by half so that it is scaled to the input range of the Z8 Encore! XP MCU's ADC. No additional hardware is required. The schematic provided in [Appendix B—Schematics](#) on page 5 displays the connection details between the pressure sensor, the Z8 Encore! XP Development Board pins, and the PC.

### Software Implementation

The software initializes the ADC peripheral to be used in conjunction with the DMA peripheral. Although only one channel is required for the basic operation of the pressure sensor interface, the ADC peripheral is used in the DMA mode so that for sophisticated applications additional ADC channels may be utilized. An example of using an additional channel would be to determine the temperature of the

pressure sensor and apply the temperature compensation factor. However, if your application is limited to a single ADC channel, it is more efficient to use the ADC peripheral without the DMA peripheral.

For the pressure sensor interface described in this Application Note, the temperature is assumed to be room temperature ( $25\text{ }^{\circ}\text{C}$ ) for which the temperature factor is unity.

The general structure of the sensor interface is straightforward. The tasks performed by the software are listed below:

- The Z8 Encore! XP DMA<sup>1</sup> is enabled to read the sensor output after a pre-set time interval (5 ms).
- The DMA triggers the ADC data conversion.
- As soon as the converted data is available, the DMA generates an interrupt.
- The interrupt handler stores the converted data and disables the DMA; after 5 ms, the DMA is re-enabled.
- The pressure reading is displayed in the HyperTerminal application via UART0 every 30 s.

For further details, see the flowcharts in [Appendix C—Flowcharts](#) on page 6.

The pressure sensor interface was tested at atmospheric pressure. To test at atmospheric pressure, the sensor and microcontroller hardware must be connected, according to the schematic displayed in [Figure 1](#) on page 5, before power-up. The pressure sensor input was open to the atmosphere. The resulting pressure reading displayed on the HyperTerminal console was one atmosphere.

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<sup>1</sup>The Application Note titled *Using Z8 Encore!<sup>®</sup> MCU for DMA-ADC Implementation (AN0132)* describes how to use the Z8 Encore! DMA-ADC peripheral. This document is available for download at [www.zilog.com](http://www.zilog.com).

For thorough testing across the entire range of the pressure sensor, a source of known variable pressure is required.

## Summary

This Application Note demonstrates the capability of Zilog's Z8 Encore! XP Flash MCUs with their built-in DMA-ADC peripheral to interface with a pressure sensor and output a reading to the HyperTerminal application.

## References

The documents associated with Z8 Encore!, Z8 Encore XP, and Motorola products are listed below.

- Z8 Encore!<sup>®</sup> Flash Microcontroller Development Kit User Manual (UM0146)
- Z8 Encore! XP<sup>®</sup> 64K Series Flash Microcontroller Development Kit User Manual (UM0151)
- Z8 Encore! XP<sup>®</sup> F0822 Series Flash Microcontrollers Development Kit User Manual (UM0150)
- Z8 Encore! XP<sup>®</sup> 64K Series Flash Microcontrollers Product Specification (PS0199)
- eZ8 CPU Core User Manual (UM0128)
- Zilog Developer Studio II—Z8 Encore! User Manual (UM0130)
- Data sheet available at [http://e-www.motorola.com/files/sensors/doc/data\\_sheet/MPX4100A.pdf](http://e-www.motorola.com/files/sensors/doc/data_sheet/MPX4100A.pdf)

## Appendix A—Glossary

Definitions for terms and abbreviations used in this Application Note that are not commonly used are listed in [Table 1](#).

**Table 1. Glossary of Terms**

<b>Term/Abbreviation</b>	<b>Definition/Expansion</b>
Pascal (Pa)	The SI unit of pressure.
psi	Pounds per square inch
torr	Based on the original Torricelli barometer design. A pressure that causes the Mercury (Hg) column to rise by 1 millimeter is called 1 torr (also known as 1 mm Hg).
Atmosphere (atm)	Normal atmospheric pressure is defined as 1 atmosphere. 1 atm = 14.6956 psi = 760 torr.
bar	The bar nearly identical to the atmosphere unit. 1 bar = 750.062 torr = 0.9869 atm = 100,000 Pa.
Millibar (mb or mbar)	There are 1,000 millibars in one bar. This unit is used by meteorologists who find it easier to refer to atmospheric pressures without using decimals. 1 millibar = 0.001 bar = 0.750 torr = 100 Pa.
SI	International System of Units.

## Appendix B—Schematics

Figure 1 displays the schematic diagram for the pressure sensor interface implementation.

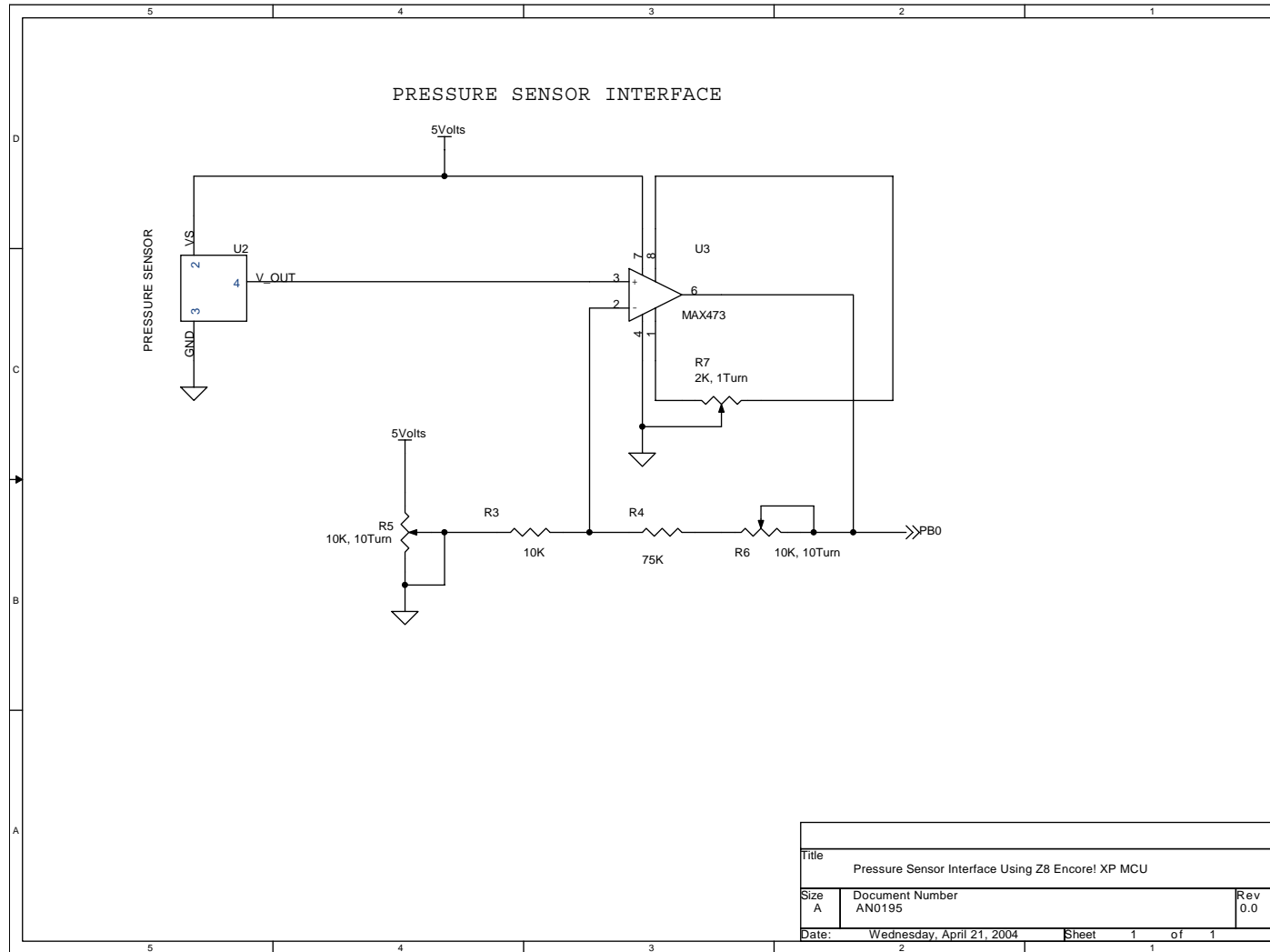
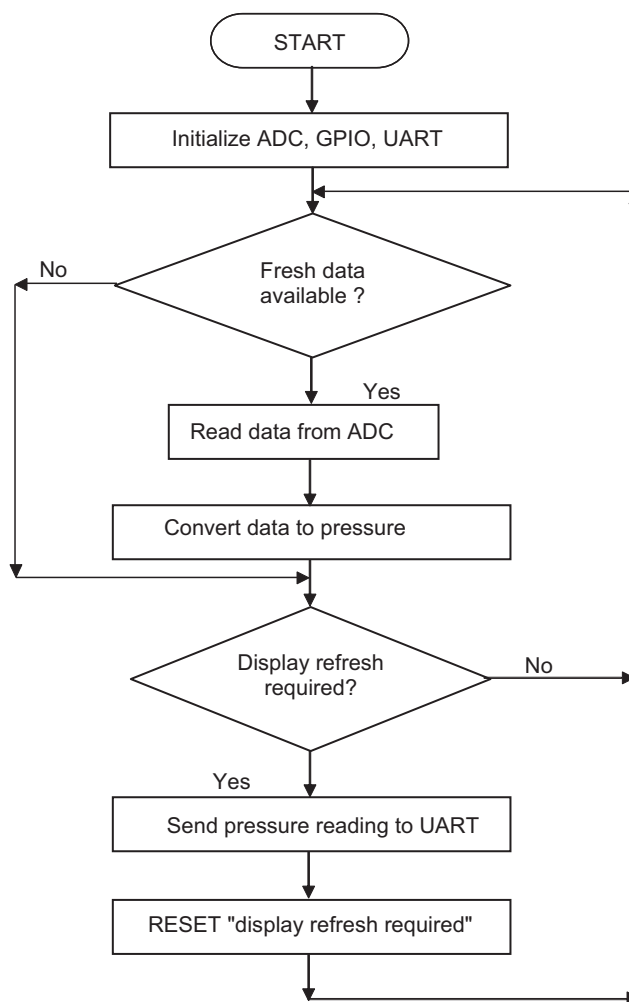


Figure 1. Schematic of Pressure Sensor Interface

## Appendix C—Flowcharts

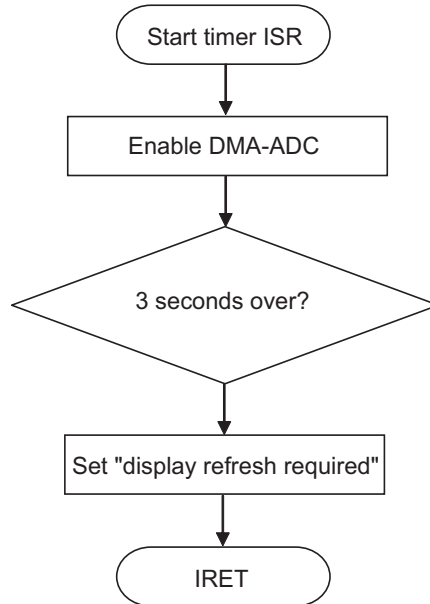
This appendix contains three flowcharts associated with the Z8 Encore! XP-based pressure sensor application described in this Application Note.

The flow of the main routine is displayed in [Figure 2](#).



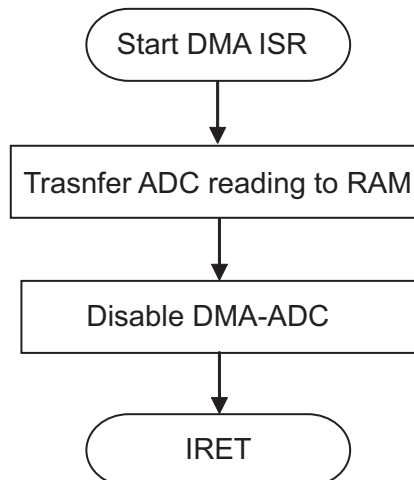
**Figure 2. The Main Routine**

The flow of the Timer Interrupt Service Routine (ISR) is displayed in [Figure 3](#).



**Figure 3. The Timer Interrupt Service Routine**

The flow of the DMA interrupt service routine is displayed in [Figure 4](#).



**Figure 4. The DMA Interrupt Service Routine**



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