Application Note

Interfacing an Accelerometer with Z8 Encore! XP® MCU

AN019402–1207

Abstract

This application note describes an interface between Motorola's MMA3201D acceleration sensor and DMA–ADC peripheral block of Z8F642x series of devices from Zilog's Z8 Encore! XP® family of microcontrollers.

Note: *The source code file associated with this application note,* `AN0194-SC01.zip`*, is available for download at* www.zilog.com.

Family Overview

Z8 Encore! XP® Flash Microcontrollers

Zilog's Z8 Encore! XP products are based on the new Zilog's eZ8™ CPU and introduce Flash memory to Zilog's extensive line of 8-bit microcontrollers. Flash memory in-circuit programming capability allows 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® MCU.

Featuring Zilog's eZ8 CPU, the Z8 Encore! XP microcontrollers combine a 20 MHz core with Flash memory, linear-register SRAM, and an extensive array of on-chip peripherals. These peripherals make Z8 Encore! XP MCU suitable for various applications including motor control, security systems, home appliances, personal electronic devices, and sensors.

Discussion

Acceleration is defined as the rate of change of velocity and is expressed in units of meters per seconds squared (m/s^2). For example, the gravitational acceleration near the surface of Earth is 9.8 m/s^2. The mass of a body freely falling under the influence of Earth's gravitational field experiences this acceleration. In effect, for every second of flight, the Earth's gravitational velocity increases by 9.8 m/s. This rate of acceleration is defined as 1g, which is used as the unit of measurement for acceleration.

Below equation is an example to measure the Earth's gravitational velocity:

$$1\,g = 9.8\ m/s^2 = 9.8\ m/s/s = 0.0098\ km/s/s = 35.28\ kph/s = 22.05\ mph/s$$

where, kph is kilometers per hour and mph is miles per hour.

From this equation, and under a gravitational pull/force of 1 g, the unit of mass of a free-falling body increases its velocity at the rate of 35.28 kph or 22.05 mph for every second of its flight.
For example, a Formula 1 race car can accelerate from 0 kph to 100 kph in 2.85 seconds at an acceleration rate of 34.48 kph/s (21.05 mph/s), or about 0.95 g. A passenger car can accelerate from 0 mph to 60 mph in about 7.5 seconds, which is 8 mph/s or 0.047 g.

An accelerometer is a device used for measuring the acceleration of, or for detecting and measuring, vibrations. Accelerometers provide outputs that indicate the accelerations to which the accelerometers are subjected.

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These devices are used in several fields of industry for vibration and impact monitoring. A *low-g* accelerometer device is used to study the one-dimensional motion of a car (real or toy), elevator, pendulum bob, or amusement park ride.

Motorola's Acceleration Sensor

The MMA3201D acceleration sensor from Motorola consists of a signal conditioner, a 4-pole low pass filter, and a filter compensation unit. The zero offset, full-scale span is set by the factory and requires no external device or field calibration. The sensor also features full system self-test capability and a ±40 g range. The MMA3201D application sensor includes the following features:

- Integral signal conditioning
- Linear output
- Ratiometric performance
- 4th order bessel filter preserves pulse shape integrity
- Calibrated self-test
- Low voltage detect, clock monitor, and eprom parity check status
- Transducer hermetically sealed at wafer level for superior reliability
- Robust design, high shocks survivability

An acceleration sensor's basic sensing mechanism is capacitive displacement sensing. For more details on the Motorola's application sensor, see References on page 4.

Figure 1 on page 3 displays a simplified accelerometer functional block diagram. For physical details on connecting an accelerometer to the Z8F642x device's DMA–ADC peripheral, see Appendix B—Schematic Diagrams on page 6.

Developing a Z8 Encore! XP® Based Accelerometer Application

The following section discusses the hardware interface and software implementation of Z8 Encore! XP based accelerometer application.

Hardware Architecture

The MMA3201D acceleration sensor features two outputs. Each output senses acceleration in the X and Y directions and is connected to an ADC channel (ADC channels 0 and 1 at port pins PB0 and PB1, respectively) on the Z8F642x device. Actual acceleration values are computed using the digital output of these two ADC channels. Acceleration in the X and Y directions is displayed separately on the HyperTerminal in units of g.

The sensor output is offset-nulled and full-scale-calibrated in the factory. The output varies from 0 to V_{DD} as the acceleration changes from -40 g to +40 g. The sensor output is $V_{DD} \div 2$ when there is no acceleration (zero acceleration). The sensor operates at 5 V V_{DD}; therefore its output corresponds to 2.5 V at zero acceleration. The ADC reference voltage (V_{REF}) is set to 2.5 V. The 0 V to 5 V range of the sensor output is then required to be reduced to a range of 0 V to 2.5 V. This 50% attenuation is achieved by using a resistor divider arrangement that is externally connected. For other values of V_{REF}, corresponding attenuation must be provided. A bypass capacitor is added to the divider network to filter high-frequency noise. Apart from this component, no additional hardware is required for the interface.

Appendix B—Schematic Diagrams on page 6 displays the connection details between the acceleration sensor and the Z8F642x device of the Z8 Encore! XP family of microcontrollers.

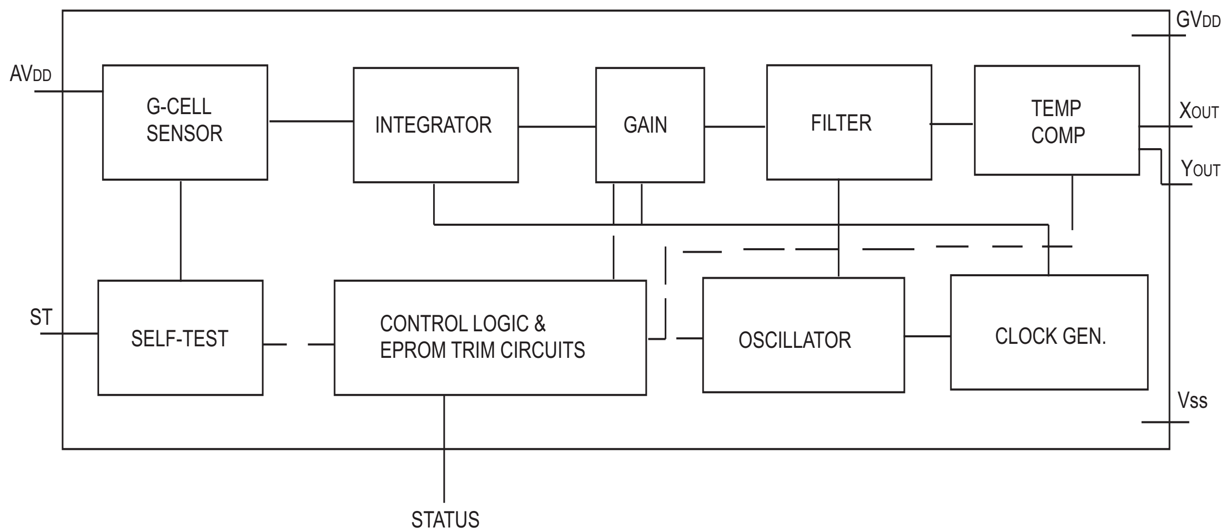

Figure 1. Simplified Accelerometer Functional Block Diagram

> **Note:** *Follow the PCB guidelines provided by the manufacturer.*

Software Implementation

The software initializes the Analog-to-Digital Converter (ADC) to be used in conjunction with the Direct Memory Access (DMA) function. Two ADC channels are required for the basic operation of reading the acceleration in the X and Y directions. No error compensation or calibration routine is required. The use of DMA makes the process of reading the ADC outputs from the two channels simple and efficient.

After the ADC completes its conversion, the DMA transfers the digital data to preinitialized locations in RAM. The main routine reads the digital data from these locations during program execution.

Follow the steps below to measure acceleration using the Z8F642x MCU (see Appendix C—Flowcharts on page 7):

1. A reading is continuously performed at every fixed interval. For the accelerometer application described in this document , this interval is selected, as 5 ms for reading the accelerometer output and 30 seconds for displaying it through the UART0 port in the HyperTerminal application.
2. After a predetermined time interval of 5 ms, the DMA is enabled to read the sensor output.
3. When data is available, the DMA triggers the ADC data conversion and generates an interrupt.
4. The interrupt service routine (ISR) for this interrupt stores the data and disables the DMA.

5. The DMA is enabled again after a time interval of 5 ms.
6. After another predetermined time interval of 30 seconds, the current accelerometer readings for both X and Y directions are displayed in the HyperTerminal application connected to the UART0 port (see flowcharts in Appendix C—Flowcharts on page 7).
7. This process is repeated at the intervals discussed above. These time intervals can be set as per the application requirements.

Note: *The sensor takes 2 ms to stabilize its output; therefore, you must set the sensor read time interval to more than 2 ms. In this application, it is set to 5 ms.*

Testing

As the sensor range is very high (±40 g), the circuit was fully tested using the sensor's self-test feature. This mechanism allows you to test the functionality of both the mechanical and electronic sections. Details on this self-test feature is available in Motorola's acceleration sensor data sheet (see References).

Equipment Used

The following equipments are used for testing:

- Z8F642x Development Kit
- PC with the HyperTerminal application set to 9600 baud, 8 bits, no parity, 1 stop bit

Procedure

Follow the steps below to test the accelerometer sensor application:

1. Connect the accelerometer as shown in Appendix B—Schematic Diagrams on page 6.
2. Trigger the self-test logic input of the accelerometer.
3. Wait for the sensor reading to stabilize.
4. Measure the acceleration outputs in both the X and Y directions. The result is displayed in the HyperTerminal application.

Results

The output of the self-test corresponds to an acceleration of 12 g, which is in compliance with Motorola's acceleration sensor data.

Summary

This application note describes how to interface an accelerometer with Zilog's Z8F642x device. The micromachined MMA3201D acceleration sensor from Motorola is used as an interface to complete a successful application.

References

Details on Z8 Encore! XP products discussed in this application note are available in the references listed below:

- eZ8™ CPU Core User Manual (UM0128)
- Z8 Encore!® Flash Microcontroller Development Kit User Manual (UM0146)
- Z8 Encore! XP® 64K Series Flash Microcontrollers Development Kit User Manual (UM0151)
- Using the Z8 Encore!® MCU for DMA–ADC Implementation (AN0132)
- Sensor—MMA3201 data sheet: http://www.motorola.com/files/sensors/doc/data_sheet/MMA3201.pdf

Appendix A—Glossary

Table 1 provides the definitions for terms and abbreviations used in this application note.

Table 1. Glossary

Term/Abbreviation	Definition
ADC	Analog-to-Digital Converter.
DMA	Direct Memory Access.
kph	Kilometers per hour, a measure of velocity.
m/s	Meters per second, an SI measure of velocity.
m/s^2	Meters per second squared, an SI measure of acceleration.
MMA	Micro Machined Accelerometer.
mph	Miles per hour, a popular measure of velocity.
SI	International system of units.

Appendix B—Schematic Diagrams

Figure 2 displays the schematic diagram for the Accelerometer interface described in this application note.

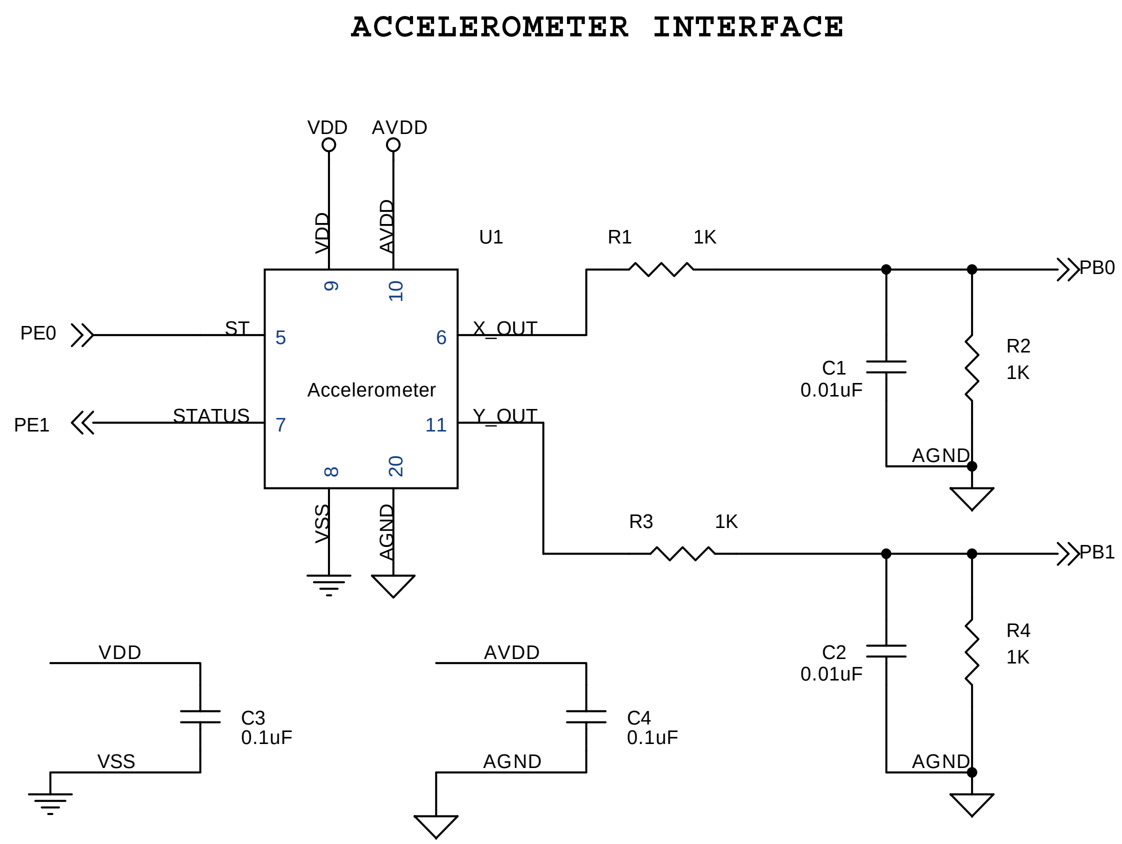

Figure 2. Schematic for Accelerometer Interface

Appendix C—Flowcharts

This appendix provides flowcharts which step through a number of functions required for the Z8 Encore! XP® accelerometer application.

Figure 3 displays the process to interface an acceleration sensor using Z8 Encore! XP MCU.

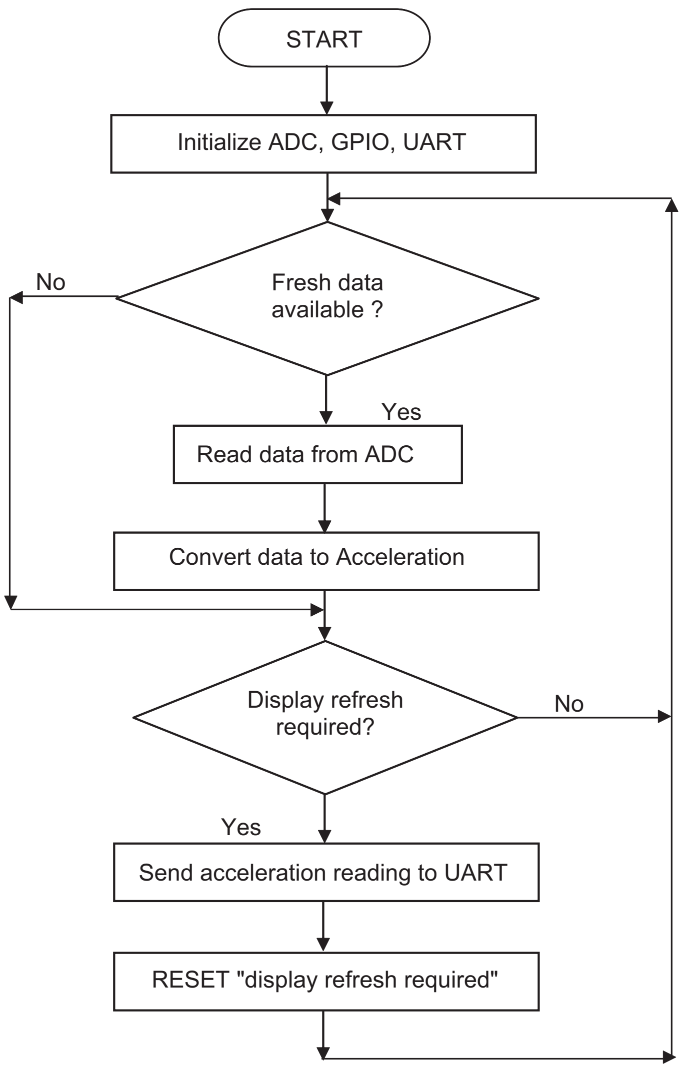

Figure 3. Flow of an Acceleration Sensor Interface Using Z8 Encore! XP MCU

Figure 4 and Figure 5 display the enabling and disabling of the DMA–ADC peripheral block with an ISR for the acceleration sensor interface application.

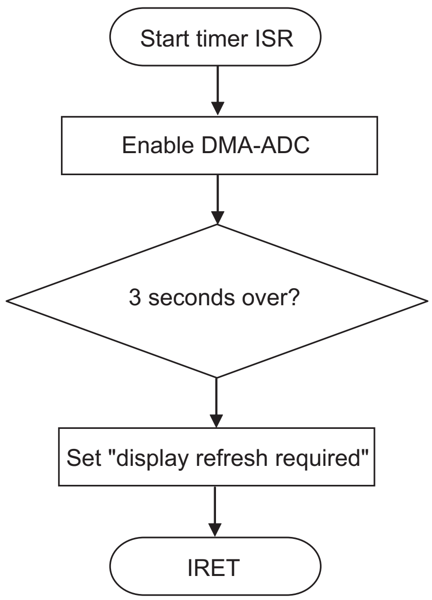

Figure 4. Enabling DMA–ADC Function with an ISR

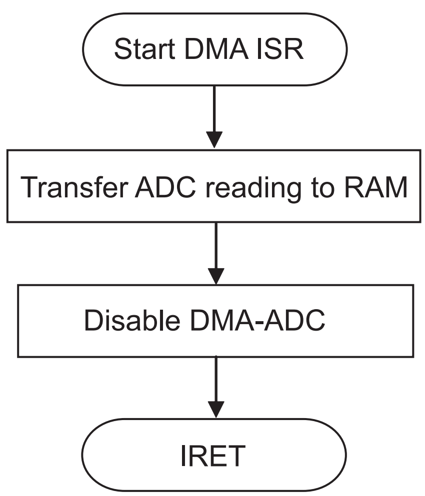

Figure 5. Disabling DMA–ADC Function with an ISR

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