Micromega Corporation

Application Note 34

Measuring Water Level with the MPXM2010GS Pressure Sensor

This application note shows an example of using the A/D input on the uM-FPU V3 floating point coprocessor to measure water depth using an MPXM2010GS pressure sensor. The concepts discussed can be used in a variety of applications requiring the measurement of a liquid level. This particular application measures the water level of a lake or river.

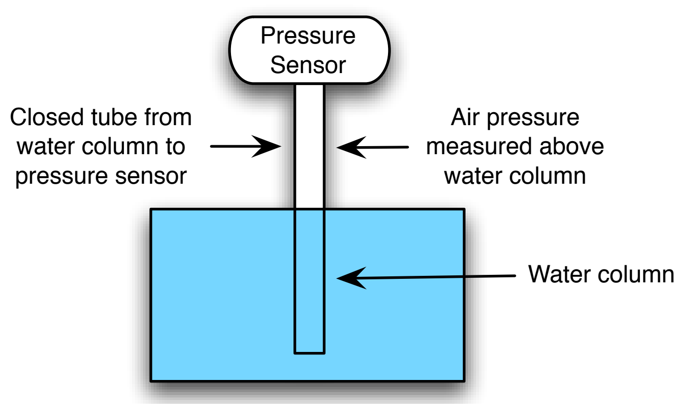
Background

Measuring the water level of lakes and rivers can be useful for both scientific and recreational purposes. This application note describes a water level station located at the source of the St. Lawrence River, as it leaves Lake Ontario, one of the largest lakes in the world. The water level at this location varies greatly over the course of a single season, due to natural causes and changing flow rates at hydroelectric dams located downstream. This system is designed to measure changes in water level of up to one meter (~39.37 inches).

Overview

The measurement technique uses the air pressure in a closed tube above a column of water to determine the water level. The following diagram shows the basic components of the measuring system. As the water level in the column changes, the air pressure in the closed tube above the column will change proportionally. By measuring the air pressure, the water level can be determined.

Figure 1
Pressure Measurement Setup



The MPXM series of pressure sensors from Freescale Semiconductor are silicon piezoresistive sensors, with on-chip temperature compensation. They provide a highly accurate and linear voltage output, directly proportional to the applied pressure. This application measures water levels from 0 to 100 cm. The static pressure of water is approximately one kiloPascal (kPa) per 10 cm of water, so the pressure range is 0 to 10 kPa, which corresponds to the range of the MPXM2010GS pressure sensor.

Measurement Apparatus

A water column is mounted under a dock as shown in Figure 2a and 2b, and connected with 1/8 inch flexible tubing to the MPXM2010GS sensor port as shown in Figure 2c.

Figure 2a
Water measurement column located under dock.

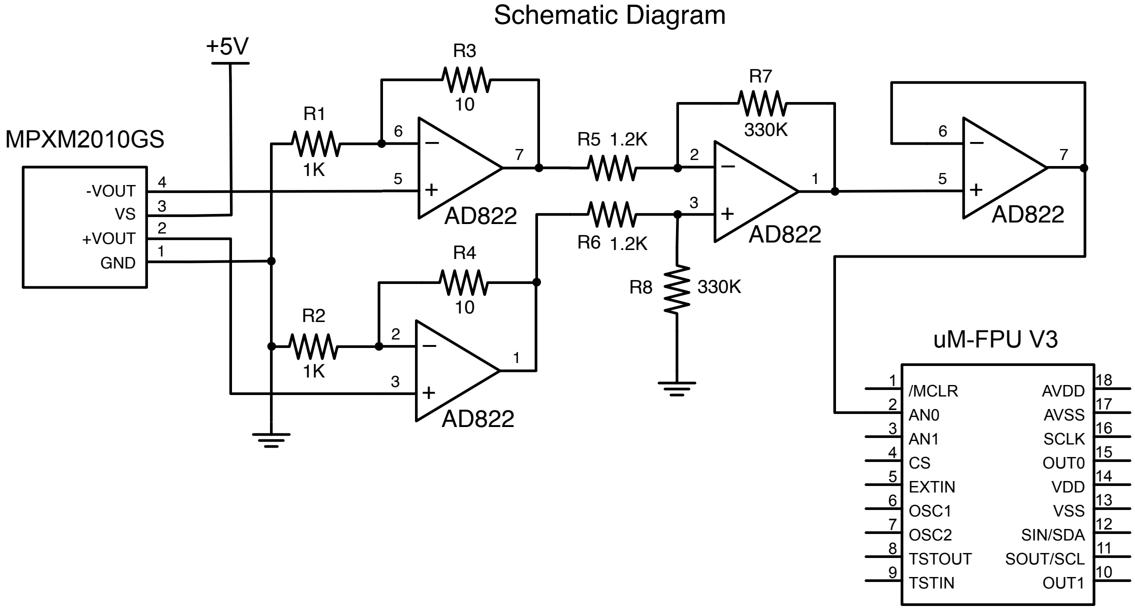
Figure 2b
Water measurement column with tube leading to pressure sensor.

Figure 2c
Pressure sensor with tube coming from water measurement column.

Using the MPXM2010GS Pressure Sensor

When used with a 5V supply, the differential output from the MPXM2010GS ranges from 0 to 12.5 mV. An amplification circuit is used to convert the differential output to a ground-referenced, single-ended voltage suitable for the A/D converter on the uM-FPU V3 chip. The schematic diagram shown below provides a signal to the uM-FPU that spans the range from 0 to 5V.

Figure 1
Schematic Diagram



The op-amp circuit shown above is derived from the circuit presented in Freescale Semiconductor Application Note AN1950. A full description of the circuit is provided there. The first stage (10 ohm / 1K) produces a 0.005V offset to avoid some non-linear response at minimum pressures. The gain of the next stage is then calculated at 5V / (0.0125V + 0.005V). This works out to a gain of approximately 285.7, but using standard resistor values of 330K / 1.2K, the actual gain is set at 275.

uM-FPU V3 Program

Very little code is required on uM-FPU V3 to measure the water level. The A/D is initialized for manual triggering, two calibration points are entered during initial setup, then samples are simply interpolated from these values. The calibration points are taken with at water levels of 0 cm and 50 cm.

The following instruction initializes the A/D module for manual trigger and with a repeat count of 16. This means that when a manual trigger occurs, 16 consecutive samples are taken, and the average value is stored.

```
ADCMODE, 0x1F     ; manual trigger, repeat count = 16
```

The first calibration reading is taken with the water level at 0 cm. The value is stored as `C1`.

```
ADCTRIG           ; trigger A/D reading
SELECTA, C1       ; select C1 register
ADCLONG, 0        ; read A/D channel 0
LSET0             ; store value in C1
```

The second calibration reading is taken with the water level at 50 cm. the value is stored as `C2`.

```
ADCTRIG           ; trigger A/D reading
SELECTA, C2       ; select C2 register
ADCLONG, 0        ; read A/D channel 0
LSET0             ; store value in C2
```

A scaling value for interpolation is calculated as the ratio of 50 cm divided by the difference between `C2` and `C1`.

```
SELECTA, Scaler   ; select Scaler register
FSETI, 50         ; Scaler = 50
LEFT
LSET, C2          ; temp = float(C2 - C1)
LSUB, C1
FLOAT
RIGHT
FDIV0             ; Scaler = Scaler / temp
```

The main sampling loop, simply takes an A/D reading, subtracts the `C1` offset and multiplies by the `Scaler` value.

```
SELECTA, Sample   ; select Sample register
ADCLONG, 0        ; read A/D channel 0
LSET0             ; store value in Sample
LSUB, C1          ; Sample = float(Sample - C1)
FLOAT
FMUL, Scaler      ; Sample = Sample * Scaler
```

The result is displayed on an LCD, using the `FTOA` instruction to format the result.

Figure 3
Depth Readout

This application note shows how simple it is to use the A/D input on the uM-FPU V3 chip. There are many additional A/D features not shown in this example, including external triggers, timed triggers, and automatic scaling.

Further Information

See the Micromega website (http://www.micromegacorp.com) for additional information regarding the uM-FPU V3 floating point coprocessor, including:

uM-FPU V3 Datasheet
uM-FPU V3 Instruction Set

See the Freescale Semiconductor website (http://www.freescale.com) for additional information on the MPXM2010GS pressure sensor.

MPXM2010 Datasheet
AN1950 Water Level Monitoring