AN1013

Gas and Water Metering with the PIC16F91X Family

Author: *Joseph Julicher*
John Charais
Microchip Technology Inc.

INTRODUCTION

Electronic utility meters are an important step towards automating the utility metering process. Automated utility meters allow many new features that help reduce the cost of utilities to customers and reduce the cost of delivering utilities to the utility provider.

TYPES OF UTILITY METERS

The primary utilities metered are electricity, water and gas. Water and Gas are measured with very similar systems while electric meters are very unique.

Electric Meters

Electric meters measure the power consumbed at a customers site. This type of meter is very easy to convert into an electronic version using an MCP3905 single-phase power metering IC.

Gas and Water Meters

Gas and water meters are based upon a mechanical flow meter. There are many types of flow meters, but the most common type for gas is a positive displacement flow meter. In this type of meter, a known volume of gas is accumulated and then released to the customer. Each time the volume of gas is released, a shaft rotates. The rotating shaft is attached to a meter movement to indicate the number of rotations or the total volume sold to the customer. Water flow meters are typically flow rate systems. The water flow impinges upon an impeller, causing rotation. The rotating impeller is attached to a magnet. A second magnet inside the meter movement couples to the first magnet by virtue of the magnetic fields. As the fluid motion causes the first magnet to turn, the second magnet also turns and the rotations are counted by the meter mechanism (see Figure 1).

By using a magnetically coupled system, the wetted portion of the meter can be kept clean, while the meter portion of the system can be converted to any type of sensor or display without affecting the measured fluid.

READING FLUID FLOW

Because the water flow meter uses a spinning magnet to indicate flow rate, we must use a magnetic sensor or a spinning magnet to couple the flow meter. For this application, we decided to eliminate all moving parts in the display by using Hall effect switches to detect when the spinning magnet makes one revolution. By using two Hall effect switches, it is possible to determine which direction the water is flowing and to take an appropriate action. When using two switches, the digital outputs will sequence through the following four states as the magnets rotate (see Table 1).

TABLE 1:

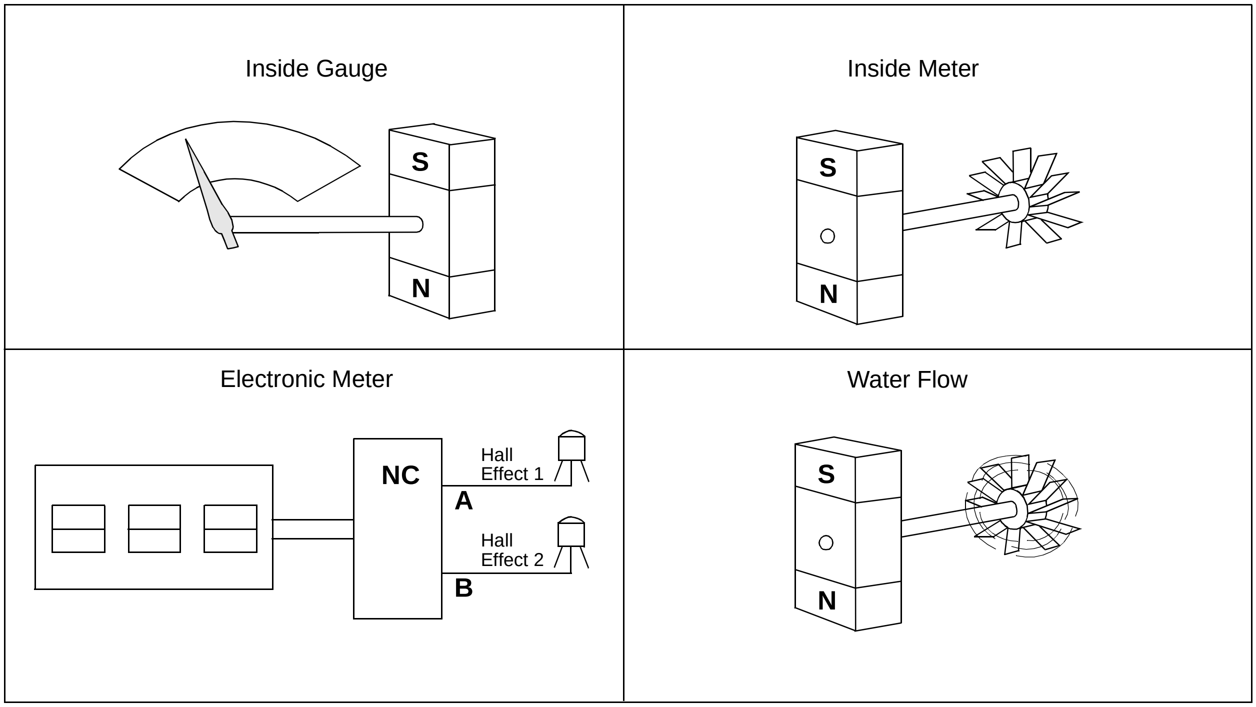
Switch States	Meaning
`00`	The magnet is not near the switches.
`01`	The magnet has reached the first switch.
`11`	The magnet is between the two switches.
`10`	The magnet has reached the second switch.
`00`	The magnet has moved past the switches.

If the state goes in the other direction, it means that the water has begun to backup. This indicates one of three things:

1. The system is installed incorrectly
2. The anti-siphon system has broken
3. The meter has been tampered with

It is also possible that some bouncing between adjacent states will occur. This is normal when the water has been turned off and the flow goes to zero.

FIGURE 1: ELECTRONIC METER



DATA DISPLAY

Electronic displays come in a large variety of types but the most appropriate type for a low-power meter application is a LCD segment type display. Typically, these displays are custom built for the application they will be used in. For a demonstration unit, the cost of custom LCD glass was not appropriate, so an 8-digit, 7-segment display was found in the form of a Varitronix VIM-838 display. This display is available with pins to connect to the PCB which makes prototype units easier to construct. Driving this display requires a LCD controller device. Fortunately, Microchip Technology offers a wide variety of LCD controller equipped PICmicro® microcontrollers.

ADVANCED FEATURES

Thinking of the future, this application was equipped with a radio transmitter to allow the meter data to be sent wirelessly to a nearby data collection device. Generally, the data collection devices are in a passing vehicle, so a wireless method to start the transmission is required. A radio receiver was added to accomplish the wake-up function. There are many simple RF solutions on the market. When building any RF transmission system, care must be taken to ensure that emitted power and frequency are within the regulated limits for the region the transmitter will be operating.

MICROCONTROLLER CHOICE

For this application, the PIC16F917 was chosen from Microchip's new low-cost LCD family of devices (see Table 2):

- It can drive the number of segments in the chosen LCD glass
- It is low cost
- There are enough I/O pins left for the application and communications
- There is sufficient program space to handle the entire application

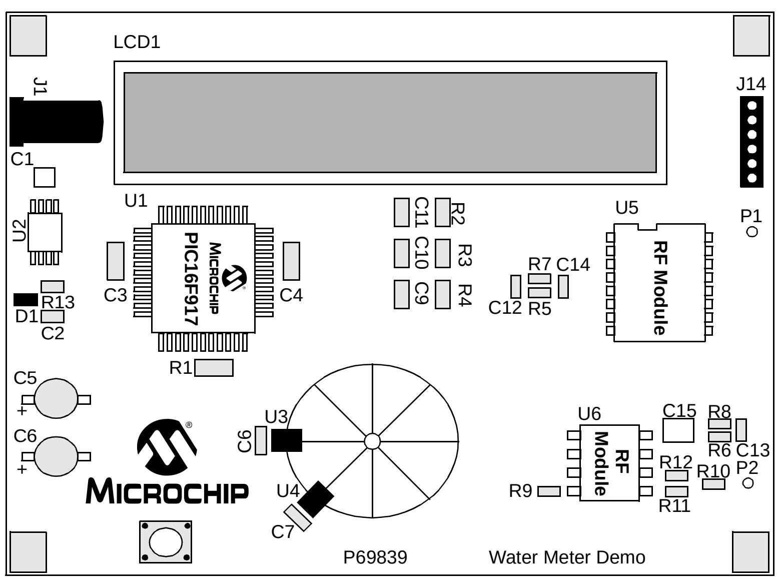
Other advantages of using the PIC16F917 is the possibility to add additional advanced features in the application, such as:

- Automatic contrast control with the internal comparators
- Low-voltage operation to allow a simple battery backup for off-line operation
- Internal nonvolatile memory (EEPROM) to back-up meter readings during power failures
- Variable clock speed to reduce power consumption between meter calculations
- In-circuit debugging allows debugging the code in the final circuit with the final device
- In-circuit programming simplifies programming of surface mount devices

TABLE 2:

Device	Program Memory	Data Memory		I/O	10-bit A/D (ch)	LCD (segment drivers)	CCP	Timer 8/16-bit
	Flash (words/ bytes)	SRAM (bytes)	EEPROM (bytes)					
PIC16F913	4K/7K	256	256	24	5	16	1	2/1
PIC16F914	4K/7K	256	256	35	8	24	2	2/1
PIC16F916	8K/14K	352	256	24	5	16	1	2/1
PIC16F917	8K/14K	352	256	35	8	24	2	2/1

FIGURE 2: BOARD LAYOUT



PUTTING THE HARDWARE TOGETHER

With the basic design decisions made, the next step is to assemble the building blocks into a working system.

WIRING THE GLASS

In this system, the LCD display will require thirty of the I/O pins of the microcontroller. Six of these pins have fixed functions, so the first step is to connect the commons (COM<0-2>) and the LCD voltages (VLCD<0-3>). The glass chosen has only three commons. Looking up three common glass connections in the data sheet provides the first section of the schematic. Another look at the devices reveals that there are only 23 available segment pins and 23 segment pins are required. Attach all the segments from the glass to the PIC® microcontroller.

ADDING THE HALL EFFECT SWITCHES

The Hall effect switches simply need two available input pins and two pull-up resistors, this is because they are open-drain output. Looking at the pins on the left of the PICmicro device shows that the choices are:

1. RA6 and RA7 (OSC1 and OSC2)
2. RD0
3. RD1
4. RD2

The remaining tasks for the application are communications and detecting when the power fails. Simply because it keeps the Hall effect switches together, RA6 and RA7 will be chosen for the Hall effect inputs.

RF COMMUNICATIONS

The RF communications is being handled by a pair of RF modules. The transmitter accepts an input from a digital output and produces RF energy. The receiver receives the RF energy and produces a digital signal. There are three choices left for pins. For this application, attaching the transmitter to RD0 will save a few instructions in the serial transmit software. This is because we can load the carry flag with the next bit and rotate the bit into RD0 with one instruction. If we attach the receiver to RD2, it will allow the software to use the CCP module to capture the data pulses, making the software a little easier.

POWER FAIL DETECTION

The power fail detection is a simple input from the voltage regulator. A diode/capacitor combination (D1, C5/C6) will keep the voltage available to the application for a few milliseconds to provide a graceful power-down. The most important task during the power-down is to save the current water usage to the EEPROM. The voltage on RD1 comes before D1 allowing the voltage, at RD1, to drop faster than V_{DD}. If RD1 ever goes low, the firmware will know that the power has been removed and it must save its data.

WHAT IS LEFT?

The last major step is providing a connection for programming and debugging. A 6-pin connector will allow an MPLAB® ICD 2 or other programmer to be attached during development. Because the ICD requires the use of RB6 and RB7, there will be an affect on the LCD. Fortunately, this affect is temporary and will not damage the glass. Before the LCD code is finished, it will be tested without the ICD attached to verify that the software is correctly using the RB6 and RB7 segments.

SCHEMATIC

The complete schematic for this application is located in **Appendix A: Schematic**.

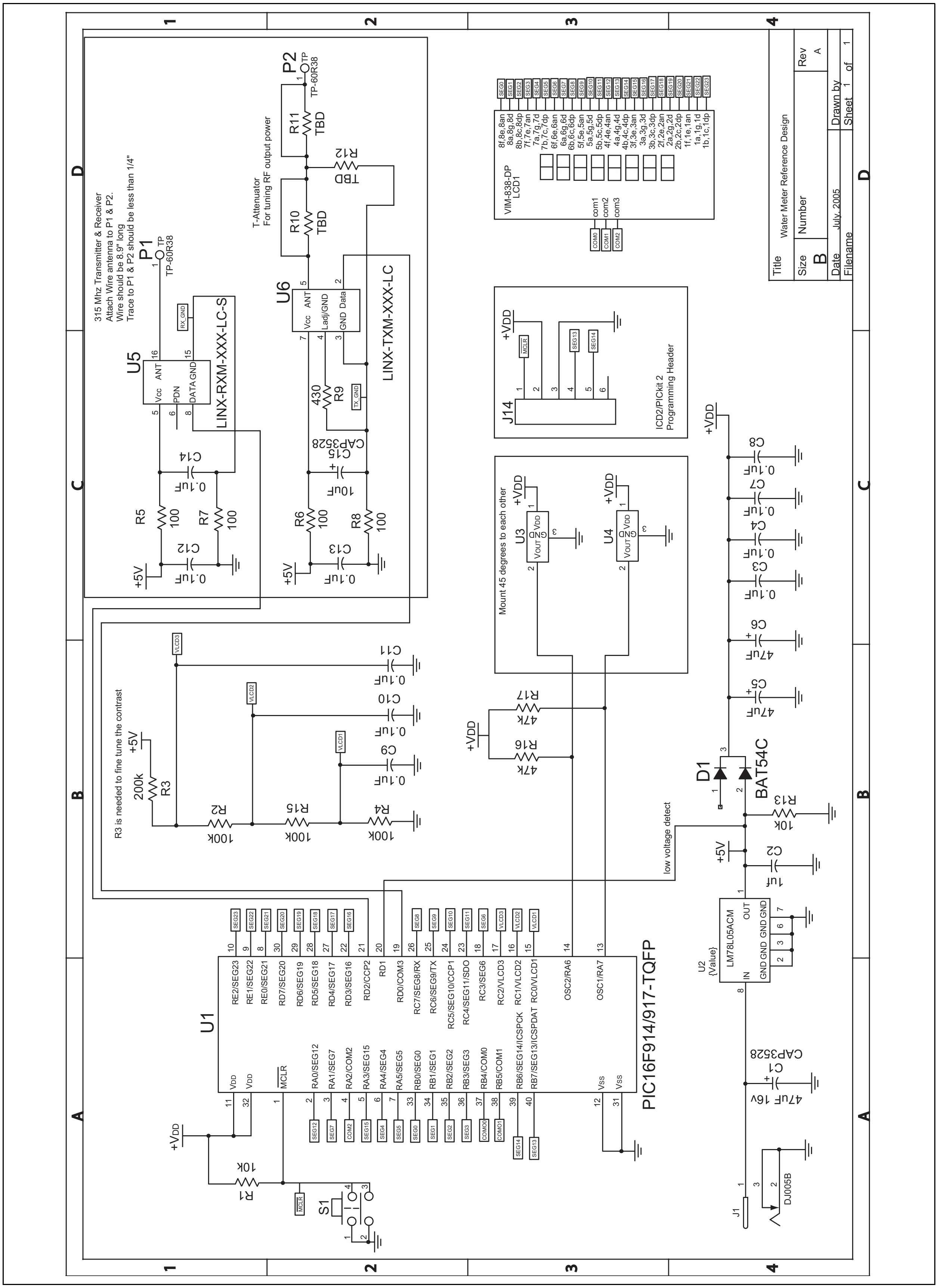
SOFTWARE DEVELOPMENT

The software for this application was developed in Assembly Language using the freely downloaded MPLAB development tools. Debugging the software was done simply by using the included simulator, and, after the board was completed, the in-circuit debugging features. Programming and the in-circuit debug were accomplished with the MPLAB ICD 2 device from Microchip Technology. The software is included, in a zip file, with this application note.

CONCLUSION

Implementing a basic electronic water meter is very easy with the PIC16F917. It is also a very cost-effective solution towards advanced metering features.

APPENDIX A: SCHEMATIC



NOTES:

Note the following details of the code protection feature on Microchip devices:

- Microchip products meet the specification contained in their particular Microchip Data Sheet.
- Microchip believes that its family of products is one of the most secure families of its kind on the market today, when used in the intended manner and under normal conditions.
- There are dishonest and possibly illegal methods used to breach the code protection feature. All of these methods, to our knowledge, require using the Microchip products in a manner outside the operating specifications contained in Microchip's Data Sheets. Most likely, the person doing so is engaged in theft of intellectual property.
- Microchip is willing to work with the customer who is concerned about the integrity of their code.
- Neither Microchip nor any other semiconductor manufacturer can guarantee the security of their code. Code protection does not mean that we are guaranteeing the product as "unbreakable."

Code protection is constantly evolving. We at Microchip are committed to continuously improving the code protection features of our products. Attempts to break Microchip's code protection feature may be a violation of the Digital Millennium Copyright Act. If such acts allow unauthorized access to your software or other copyrighted work, you may have a right to sue for relief under that Act.

Printed on recycled paper.

QUALITY MANAGEMENT SYSTEM
CERTIFIED BY DNV
ISO/TS 16949:2002

Microchip received ISO/TS-16949:2002 quality system certification for its worldwide headquarters, design and wafer fabrication facilities in Chandler and Tempe, Arizona and Mountain View, California in October 2003. The Company's quality system processes and procedures are for its PICmicro® 8-bit MCUs, KEELOQ® code hopping devices, Serial EEPROMs, microperipherals, nonvolatile memory and analog products. In addition, Microchip's quality system for the design and manufacture of development systems is ISO 9001:2000 certified.

WORLDWIDE SALES AND SERVICE

AMERICAS

Corporate Office
2355 West Chandler Blvd.
Chandler, AZ 85224-6199
Tel: 480-792-7200
Fax: 480-792-7277
Technical Support:
http://support.microchip.com
Web Address:
www.microchip.com

Atlanta
Alpharetta, GA
Tel: 770-640-0034
Fax: 770-640-0307

Boston
Westborough, MA
Tel: 774-760-0087
Fax: 774-760-0088

Chicago
Itasca, IL
Tel: 630-285-0071
Fax: 630-285-0075

Dallas
Addison, TX
Tel: 972-818-7423
Fax: 972-818-2924

Detroit
Farmington Hills, MI
Tel: 248-538-2250
Fax: 248-538-2260

Kokomo
Kokomo, IN
Tel: 765-864-8360
Fax: 765-864-8387

Los Angeles
Mission Viejo, CA
Tel: 949-462-9523
Fax: 949-462-9608

San Jose
Mountain View, CA
Tel: 650-215-1444
Fax: 650-961-0286

Toronto
Mississauga, Ontario,
Canada
Tel: 905-673-0699
Fax: 905-673-6509

ASIA/PACIFIC

Australia - Sydney
Tel: 61-2-9868-6733
Fax: 61-2-9868-6755

China - Beijing
Tel: 86-10-8528-2100
Fax: 86-10-8528-2104

China - Chengdu
Tel: 86-28-8676-6200
Fax: 86-28-8676-6599

China - Fuzhou
Tel: 86-591-8750-3506
Fax: 86-591-8750-3521

China - Hong Kong SAR
Tel: 852-2401-1200
Fax: 852-2401-3431

China - Qingdao
Tel: 86-532-8502-7355
Fax: 86-532-8502-7205

China - Shanghai
Tel: 86-21-5407-5533
Fax: 86-21-5407-5066

China - Shenyang
Tel: 86-24-2334-2829
Fax: 86-24-2334-2393

China - Shenzhen
Tel: 86-755-8203-2660
Fax: 86-755-8203-1760

China - Shunde
Tel: 86-757-2839-5507
Fax: 86-757-2839-5571

China - Wuhan
Tel: 86-27-5980-5300
Fax: 86-27-5980-5118

China - Xian
Tel: 86-29-8833-7250
Fax: 86-29-8833-7256

ASIA/PACIFIC

India - Bangalore
Tel: 91-80-2229-0061
Fax: 91-80-2229-0062

India - New Delhi
Tel: 91-11-5160-8631
Fax: 91-11-5160-8632

India - Pune
Tel: 91-20-2566-1512
Fax: 91-20-2566-1513

Japan - Yokohama
Tel: 81-45-471- 6166
Fax: 81-45-471-6122

Korea - Gumi
Tel: 82-54-473-4301
Fax: 82-54-473-4302

Korea - Seoul
Tel: 82-2-554-7200
Fax: 82-2-558-5932 or
82-2-558-5934

Malaysia - Penang
Tel: 60-4-646-8870
Fax: 60-4-646-5086

Philippines - Manila
Tel: 63-2-634-9065
Fax: 63-2-634-9069

Singapore
Tel: 65-6334-8870
Fax: 65-6334-8850

Taiwan - Hsin Chu
Tel: 886-3-572-9526
Fax: 886-3-572-6459

Taiwan - Kaohsiung
Tel: 886-7-536-4818
Fax: 886-7-536-4803

Taiwan - Taipei
Tel: 886-2-2500-6610
Fax: 886-2-2508-0102

Thailand - Bangkok
Tel: 66-2-694-1351
Fax: 66-2-694-1350

EUROPE

Austria - Wels
Tel: 43-7242-2244-399
Fax: 43-7242-2244-393

Denmark - Copenhagen
Tel: 45-4450-2828
Fax: 45-4485-2829

France - Paris
Tel: 33-1-69-53-63-20
Fax: 33-1-69-30-90-79

Germany - Munich
Tel: 49-89-627-144-0
Fax: 49-89-627-144-44

Italy - Milan
Tel: 39-0331-742611
Fax: 39-0331-466781

Netherlands - Drunen
Tel: 31-416-690399
Fax: 31-416-690340

Spain - Madrid
Tel: 34-91-708-08-90
Fax: 34-91-708-08-91

UK - Wokingham
Tel: 44-118-921-5869
Fax: 44-118-921-5820

10/31/05