# Utility Metering Solutions

MICROCHIP

## Complete Utility Metering Solutions


www.microchip.com/meter

# Design Innovation in Energy, Gas, Water and Heat Meters

The metering market is currently facing many challenges. Government regulations, competitive forces, technology innovations and end customer expectations are fueling unprecedented changes in this rapidly-evolving market. Innovation in the latest meter designs are being driven by a number of factors including the migration from mechanical meters to smart meters, the need to provide advanced intelligence and two-way communications in smart meters and the demands of tomorrow's smart grids.

Having a "smart" partner who can help you keep up with the latest trends and allow you to react quickly to new developments will be the key to your success in designing for the metering market. Microchip understands the design challenges facing meter designers. Our solutions are used in millions of meters worldwide, helping to increase meter accuracy and reliability while lowering total system cost. We provide products and technical support to assist you with developing engaging energy management solutions for use by end customers over their home area networks. Microchip wants to be a partner in your success rather than just a vendor.

Microchip offers a complete portfolio of 8-, 16- and 32-bit microcontrollers, 16-bit digital signal controllers, energy measurement integrated circuits (ICs), analog components, Flash memory and serial EEPROMs. Our devices allow you to:

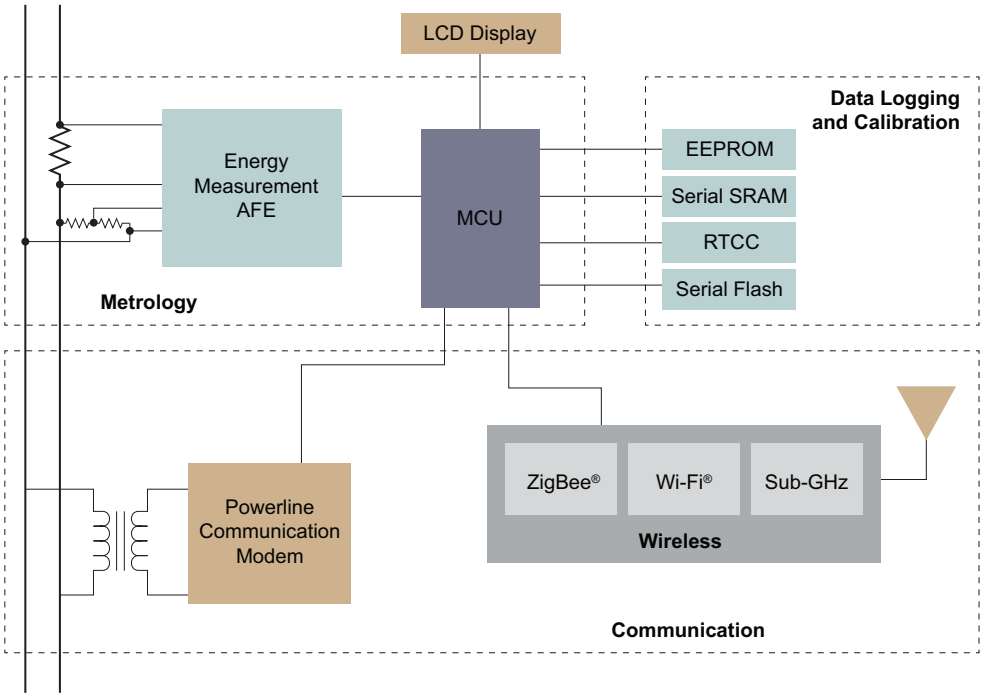
- Directly drive inexpensive LED and LCD displays
- Add wireless communication for automated meter reading
- Implement anti-tampering techniques
- Manage low-power design with nanoWatt XLP technology
- Integrate real time clock for advanced billing schemes
- Improve accuracy and simplify meter calibration
- Easily integrate touch sensing functionality into your designs with mTouch® sensing solutions

Our free MPLAB® X Integrated Design Environment provides a single platform for product development which shortens the time it takes to complete new designs or to modify existing designs to meet regional needs.

Our Metering Design Center features complete access to all of Microchip's metering application notes, software libraries, reference designs and other technical documentation to help you get your products to market quickly and efficiently.

Microchip's global 24/7 technical support team, regional training centers and our local application teams are here to help you meet your customers' expectations and schedules. We are committed to being part of your success.

## Basic Smart Meter



# Utility Metering Solutions

## Energy Measurement ICs

The devices in the MCP391X family are highly accurate energy measurement analog front ends with up to eight channels for single-phase and three-phase metering. When paired with a PIC® microcontroller, the MCP391X offers you a complete, flexible and highly accurate solution for energy measurement in utility metering and power monitoring applications.

The MCP391X devices feature simultaneous sampling 16/24-bit delta-sigma A/D converters, internal voltage reference and Programmable Gain Amplifiers (PGA). With up to 94.5 dB SINAD and –107 dB THD performance this family allows for the highest accuracy designs enabling 0.1% active power measurement error over a 10,000:1 dynamic range. Additional innovations include a unique 2-wire serial interface that reduces expensive isolation requirements. For more information, visit www.microchip.com/energymetering.

## Microcontrollers and Digital Signal Controllers

Microchip's flexible microcontroller (MCU) and digital signal controller (DSC) platform, along with the common MPLAB X Integrated Development Environment (IDE), can enable a wide range of utility metering solutions. Our broad portfolio of 8-/16-/32-bit MCUs and DSCs lowers total system cost by enabling the appropriate level of integration to match utility metering system requirements. Features include display functions, real-time clock and calendar, temperature sensing with the Charge Time Measurement Unit (CTMU) and eXtreme Low Power (XLP) performance to extend battery life. Our unique approach allows for easy migration across the entire MCU and DSC portfolio, giving you the flexibility to adapt or change your design to meet local system requirements. Utility metering solutions with free energy calculation firmware range from a single-chip design with the PIC18F87J72 which offers ease of use and smaller board space to a two-chip solution using our Energy Measurement ICs with any MCU or DSC.

## Analog and Interface Devices

From devices for measuring temperature and signals to power management and infrared interfaces, Microchip provides a wide portfolio of analog and interface components that are well suited for metering applications. Low-power and precise operational amplifiers enable signal acquisition for accurate measurements of current, voltage, temperature or flow. Our family of digital temperature sensors provides accurate measurements to compensate for temperature drifts in meter components. Infrared interface devices provide a platform of products for developing a robust communication method for data gathering at meter locations. For more information, visit www.microchip.com/analog.

## Memory Products

For reliable data and code storage, Microchip offers a broad range of memory devices, which include SRAM, EEPROM and Flash. Supporting a variety of densities that can operate over wide voltage and temperature ranges in very small packages, these devices can meet the requirements of any metering application.

SPI-compatible Serial SRAM devices support unlimited endurance and fast Write times. If non-volatile memory is needed, our very high-endurance Serial EEPROMs offer the highest Erase/Write cycle endurance in the industry. These devices are available with I²C™, SPI or Microwire serial interfaces to support any microcontroller serial port that has been selected.

For applications with higher-density memory requirements, our SuperFlash® SPI, SQI® and Parallel Flash products are ideal solutions. In designs that require a boot loader, SPI Flash can be used to store the boot code, making it available for download into shadow memory upon power-up. For applications that require execute-in-place, the higher bandwidth SQI Flash and Parallel Flash have this same capability. SuperFlash products are cost-effective non-volatile memory data storage solutions, offering industry-leading features along with fixed and fast program/erase times, ultra-low power consumption, high-endurance and excellent reliability. For more information visit www.microchip.com/memory.

# Utility Metering Solutions

### Real-Time Clock/Calendar (RTCC)

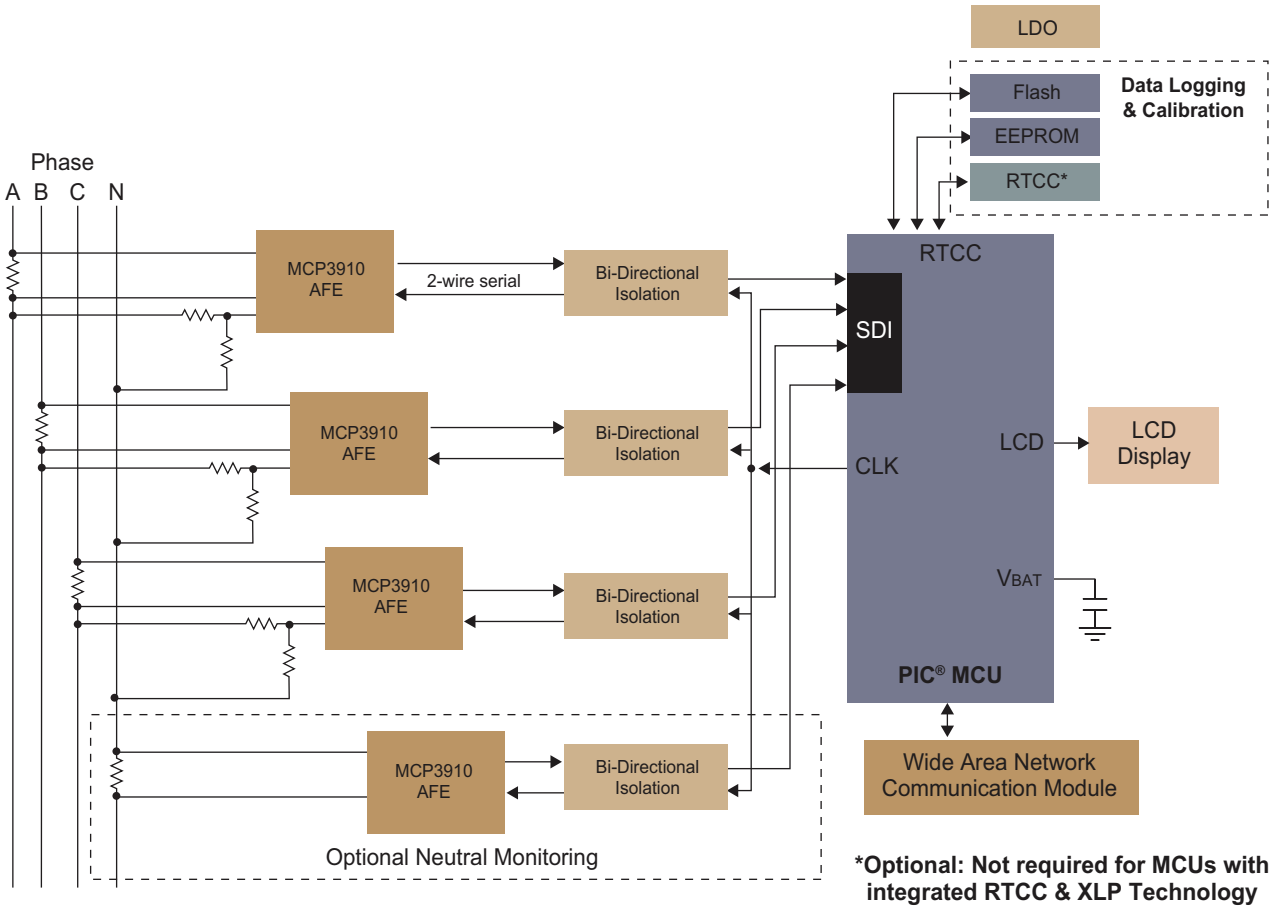
For low-cost and accurate timekeeping, the MCP794XX and MCP795XX families of Real-Time Clocks have a usable amount of non-volatile SRAM, EEPROM and a battery switchover circuit for backup power. This family has a digital trimming circuit with a wide adjustment range to compensate for crystal frequency drift that can occur over temperature. In the event of a power failure, the RTCC has a power-fail timestamp that can log the time that main power was lost and the time that it was restored. A Unique ID with a MAC Address is also included in protected memory to provide a unique identifier when communicating over wired or wireless interfaces. For more information visit www.microchip.com/clock.

### Wired Communications for Smart Grid

Power line repeaters collect data from power meters using wired communications such as RS-485 and Power Line Carrier (PLC) technology. This data is transmitted to concentrators for processing and subsequent transmission to utility companies using power line modems (PLM) and Ethernet, as well as other technologies. The dsPIC® Digital Signal Controller (DSC) general purpose family is well-suited for low-cost energy meters, offering a fast and efficient CPU, DMA channels and small package footprints. The PIC32MZ and PIC32MX family have the performance needed to process automated meter reading data as well as a rich set of connectivity features including UARTs, ADCs, SPIs, high-speed USB, CAN, Ethernet, $I^2C$, EBI and SQI. For more information visit www.microchip.com/PIC32.

### Polyphase Shunt Meter with the MCP3910 Analog Front-End

Resistive shunts are inexpensive, small, highly linear and immune to magnetic influences when compared to alternative current sensing solutions, such as current transformers and Rogowski coils. However, they lack the electrical isolation needed in polyphase systems, thus requiring isolaters at an additional cost. The MCP3918 and MCP3910 2-wire serial interfaces greatly reduce system cost by halving isolation requirements, needing only a single bidirectional isolator per phase for polyphase shunt-based meter designs.



# Utility Metering Solutions

### Wireless Communications for Smart Grid

The meter is evolving with Smart Grid initiatives to become the hub of communication from the home to the utility provider. Enabling communication within the grid is key to presenting, monitoring and controlling usage of precious energy resources. Microchip provides development platforms to enable wireless communication of ZigBee® networks including the Smart Energy Profile, Wi-Fi® Connectivity and Sub-GHz AMI solutions. See all of Microchip's wireless solutions at www.microchip.com/wireless.

### Complete Technical Resources for Metering Designs

Engineering resources are often limited, which makes access to existing application reference designs and technical documentation critical in reducing time to market. Microchip's Utility Meter Design Center at www.microchip.com/meter offers material that will walk you through all of the building blocks and considerations necessary to create a utility metering design. The design center also features complete access to all of Microchip's metering application notes, reference designs and other technical documentation to help you get your products to market quickly and efficiently.

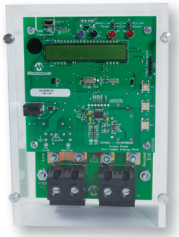
### Development Systems

Low-cost and easy-to-learn development tools can save you time, money and engineering resources. Microchip offers a number of development boards and evaluation kits to demonstrate the capabilities of its silicon solutions for utility metering and power monitoring applications.

# Utility Metering Development Systems

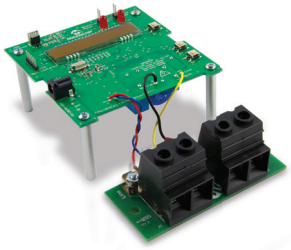
## Single-Phase Meter Reference Designs

### MCP3911 and PIC18F85K90 Anti-Tamper Meter Reference Design (ARD00385)



This fully functional IEC Class 0.5 compliant single-phase meter has enhanced capabilities, such as battery backup, RTC and anti-tamper features. The PIC18F85K90 MCU drives the LCD and communicates via UART with the MCP2200, offering an isolated USB connection for calibration and access to power calculations. The system calculates active energy, active power, RMS current, RMS voltage, reactive energy, reactive power, apparent power and other typical power quantities.

### PIC18F87J72 Single Phase Energy Meter Reference Design (ARD00280)

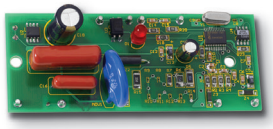


This is a fully functional single phase meter featuring the PIC18F87J72 MCU with Analog Front End. This low-cost design uses a shunt for the current sensor. The PIC18F87J72 drives the LCD and includes both an isolated USB and non-isolated RS232 interface for calibration and access to power calculations. The system calculates active/reactive energy, forward/reverse energy, active/reactive/apparent power and RMS current/voltage.

# Utility Metering Development Systems

## Single-Phase Meter Reference Designs (Continued)

### MCP3905A Energy Meter Reference Design (MCP3905RD-PM1)



This low-cost energy meter board acts as a stand-alone energy meter or as the analog front-end design for LCD microcontroller-based meters. The MCP3905A design is specified with an energy measurement error of 0.1% typical across 1:500 dynamic range. The board is compliant with EMC requirements per energy metering standards IEC62053 and legacy IEC61036, IEC1046 and IEC687.

### MCP39F501 Metering and Power Monitoring Demonstration Board (ARD00455)

The MCP39F501 Demonstration Board is a fully functional, single-phase power monitor. This low-cost design does not use any transformers and requires few external components. The device calculates active power, reactive power, RMS current, RMS voltage, power factor, line frequency, other typical power quantities and programmable event notifications.

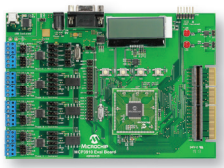
## 3-Phase Meter Reference Designs

### MCP3909/dsPIC33F Advanced 3-Phase Energy Meter Reference Design (MCP3909RD-3PH3)

This fully functional energy meter reference design has many advanced features such as harmonic analysis, per phase distortion information, sag detection, four quadrant energy measurement, and active and reactive power calculation. It uses Microchip's 16-bit DSC dsPIC33FJ64GP206. This reference design takes advantage of the dsPIC33F by performing all calculations in the DSP engine. All output quantities are calculated in the frequency domain yielding a large number of outputs for a variety of meter designs.

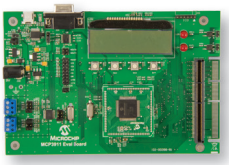
## Development Tools and Evaluation Boards

### MCP3910 ADC Evaluation Board for 16-bit MCUs (ADM00425)



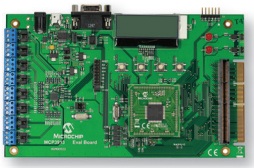
The MCP3910 ADC Evaluation Board provides the opportunity to evaluate the performance of the MCP3910 dual-channel ADCs in a multiple device, isolated system. It comes with four MCP3910s, three of which are isolated and operate in 2-wire Serial Interface mode. It also provides a development platform for 16-bit PIC microcontroller-based applications, using existing 100-pin PIM systems, compatible with the Explorer 16 and other PIC MCU demonstration boards.

### MCP3911 ADC Evaluation Board for 16-bit MCUs (ADM00398)



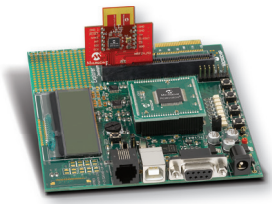
This evaluation board for 16-bit MCU systems provides the ability to evaluate the performance of the MCP3911 dual-channel ADC. It also provides a development platform for 16-bit PIC MCU-based applications, using existing 100-pin PIM systems compatible with the Explorer 16 and other PIC MCU demo boards.

### MCP3913/14 ADC Evaluation Boards for 16-bit MCUs (ADM00522/ADM00523)



The MCP3913 and MCP3914 ADC Evaluation Boards for 16-bit MCU systems allow you to evaluate the performance of the MCP3913 six channel sigma-delta ADC or MCP3914 eight-channel sigma-delta ADC. It also provides a development platform for 16-bit PIC MCU-based applications, using existing 100-pin PIM systems compatible with the Explorer 16 and other MCU demonstrations boards.

### Explorer 16 Development Board (DM240001/ DM240002) and MRF24J40MA PICtail™ Plus Daughter Board (AC164134-1)



This board offers an economical way to evaluate Microchip's 16- and 32-bit microcontrollers and dsPIC33F DSC Families. It allows you to create IEEE 802.15.4™/ ZigBee and IEEE 802.11™/ Wi-Fi wireless communication applications by adding wireless PICtail daughter cards to the Explorer 16 using the associated software protocol stack.

# Product Specifications

## Energy Measurement AFE

| Device | Resolution | SINAD | ADC Channels | Typical Voltage Reference Drift (ppm/°C) | Output Type | Analog $V_{DD}$ (V) | Digital $V_{DD}$ (V) | Features |
|---|---|---|---|---|---|---|---|---|
| MCP3918 | 24-bit | 93.5 dB | 1 | 9 | SPI/2-wire | 2.7 to 3.6 | 2.7 to 3.6 | Phase compensation, programmable data rate up to 125 ksps, 16-bit CRC |
| MCP3910 | 24-bit | 93.5 dB | 2 | 9 | SPI/2-wire | 2.7 to 3.6 | 2.7 to 3.6 | Phase compensation, programmable data rate up to 125 ksps, 16-bit CRC |
| MCP3911 | 24-bit | 94.5 dB | 2 | 7 | SPI | 2.7 to 3.6 | 2.7 to 3.6 | Phase compensation, programmable data rate up to 125 ksps |
| MCP3913 | 24-bit | 94.5 dB | 6 | 9 | SPI | 2.7 to 3.6 | 2.7 to 3.6 | Phase compensation, programmable data rate up to 125 ksps, 16-bit CRC |
| MCP3914 | 24-bit | 94.5 dB | 8 | 9 | SPI | 2.7 to 3.6 | 2.7 to 3.6 | Phase compensation, programmable data rate up to 125 ksps, 16-bit CRC |

## Energy Measurement ICs

| Device | Dynamic Range | Measurement Error | ADC Channels | Typical Voltage Reference Drift (ppm/°C) | Output Type | Analog $V_{DD}$ (V) | Digital $V_{DD}$ (V) | Features |
|---|---|---|---|---|---|---|---|---|
| MCP3905A | 500:1 | 0.1% | 2 | 15 | Active power pulse | 4.5 to 5.5 | 4.5 to 5.5 | Active power calculation |
| MCP3906A | 1000:1 | 0.1% | 2 | 15 | Active power pulse | 4.5 to 5.5 | 4.5 to 5.5 | Active power calculation |
| MCP3909 | 1000:1 | 0.1% | 2 | 15 | Active power pulse, SPI | 4.5 to 5.5 | 4.5 to 5.5 | Active power calculation |
| MCP39F501 | 4000:1 | 0.1% | 2 | 10 | UART | 2.7 to 3.6 | 2.7 to 3.6 | Active, reactive and apparent power, RMS current and voltage, power factor, line frequency |

## Recommended 8-bit PIC® Microcontrollers

| Device | MIPS | ADC Bits | Flash | RAM | LCD | UART | RTCC | Temp. Sensing | DMA | Power Down/RTCC* Current* (µA) |
|---|---|---|---|---|---|---|---|---|---|---|
| PIC18F87J72 | 12 | 16 and 12 | 64–128 | 4 | 4 × 33 | 2 | RTCC | CTMU | – | 3.6/1.6 |
| PIC18F67K90 | 16 | 12 | 32–128 | 2–4 | 4 × 33 | 2 | RTCC | CTMU | – | 0.06/1.1 |
| PIC18F67J93 | 12 | 12 | 64–128 | 4 | 4 × 33 | 2 | RTCC | CTMU | – | 3.6/1.6 |
| PIC18F67J90 | 12 | 10 | 64–128 | 4 | 4 × 33 | 2 | RTCC | CTMU | – | 3.6/1.6 |
| PIC18F65J90 | 12 | 10 | 8–32 | 1–2 | 4 × 33 | 2 | Timer 1 | – | – | 3.5/9 |
| PIC18F87K90 | 16 | 12 | 32–128 | 2–4 | 4 × 33 | 2 | RTCC | CTMU | – | 0.06/1.1 |
| PIC18F89J93 | 12 | 12 | 64–128 | 4 | 4 × 33 | 2 | RTCC | CTMU | – | 3.6/1.6 |
| PIC18F87J90 | 12 | 10 | 64–128 | 4 | 4 × 33 | 2 | RTCC | CTMU | – | 3.6/1.6 |
| PIC18F85J90 | 12 | 10 | 8–32 | 1–2 | 4 × 33 | 2 | Timer 1 | – | – | 3.5/9 |
| PIC18F67K22 | 16 | 12 | 62–128 | 2–4 | – | 2 | RTCC | CTMU | – | 0.06/1.1 |
| PIC18F67J11 | 12 | 12 | 64–128 | 4 | – | 2 | Timer 1 | – | – | 3.6/21 |
| PIC18F65J11 | 12 | 10 | 8–32 | 1-2 | – | 2 | Timer 1 | – | – | 3.5/9 |

## Recommended 16-bit PIC® Microcontrollers and dsPIC® Digital Signal Controlls (DSCs)

| Device | MIPS | ADC Bits | Flash | RAM | LCD | UART | RTCC | Temp. Sensing | DMA | Power Down/ RTCC* Current* (µA) |
|---|---|---|---|---|---|---|---|---|---|---|
| PIC24FJ128GA310 | 16 | 12 | 64–128 | 8 | 8 × 60 | 4 | RTCC | CTMU | Yes | 0.04/0.4 |
| PIC24FJ128GA308 | 16 | 12 | 64–128 | 8 | 8 × 46 | 4 | RTCC | CTMU | Yes | 0.04/0.4 |
| PIC24FJ128GA306 | 16 | 12 | 64–128 | 8 | 8 × 30 | 4 | RTCC | CTMU | Yes | 0.04/0.4 |
| PIC24FJ128GC010 | 16 | 12/16 | 64–128 | 8 | 8 × 59 | 4 | RTCC | CTMU | Yes | 0.07/0.4 |
| PIC24FJ256GA110 | 16 | 10 | 128–256 | 16 | – | 4 | RTCC | CTMU | – | 4/3.5 |
| PIC24FJ128FA010 | 16 | 10 | 64–128 | 8 | – | 2 | RTCC | – | – | 27/8 |
| dsPIC33EP64GP506 | 60 | 12 | 64–512 | 8–48 | – | 2 | – | CTMU | Yes | 45/– |
| PIC24EP512GP206 | 60 | 12 | 64–512 | 8–48 | – | 2 | – | CTMU | Yes | 45/– |

# Product Specifications

## Recommended 32-bit PIC® Microcontrollers

| Device | MHz | ADC Bits | Flash | RAM | LCD | UART | RTCC | Temp. Sensing | DMA | Power Down/ RTCC* Current (µA) |
|---|---|---|---|---|---|---|---|---|---|---|
| **PIC32MX120F032D** | 50 | 10 | 32 | 8 | – | 2 | RTCC | CTMU | Yes | 44/23 |
| **PIC32MX120F032B** | 50 | 10 | 32 | 8 | – | 2 | RTCC | CTMU | Yes | 44/23 |
| **PIC32MX130F064D** | 40 | 10 | 64 | 16 | – | 2 | RTCC | CTMU | Yes | 44/23 |
| **PIC32MX130F064B** | 40 | 10 | 64 | 16 | – | 2 | RTCC | CTMU | Yes | 44/23 |
| **PIC32MX150F128D** | 50 | 10 | 128 | 32 | – | 2 | RTCC | CTMU | Yes | 44/23 |
| **PIC32MX150F128B** | 50 | 10 | 128 | 32 | – | 2 | RTCC | CTMU | Yes | 44/23 |
| **PIC32MX250F128D** | 50 | 10 | 128 | 32 | – | 2 | RTCC | CTMU | Yes | 44/23 |
| **PIC32MX270F256D** | 50 | 10 | 256 | 64 | – | 2 | RTCC | CTMU | Yes | 44/23 |
| **PIC32MX350F256** | 100 | 10 | 256 | 64 | – | 5 | RTCC | CTMU | Yes | 26/29 |
| **PIC32MX370F512** | 100 | 10 | 512 | 128 | – | 5 | RTCC | CTMU | Yes | 49/29 |
| **PIC32MX450F256** | 100 | 10 | 256 | 64 | – | 5 | RTCC | CTMU | Yes | 26/29 |
| **PIC32MX470F512** | 100 | 10 | 512 | 128 | – | 5 | RTCC | CTMU | Yes | 12/16 |
| **PIC32MX664F128** | 80 | 10 | 128 | 32 | – | 6 | RTCC | – | Yes | 20/23 |
| **PIC32MX675F256** | 80 | 10 | 256 | 64 | – | 6 | RTCC | – | Yes | 41/23 |
| **PIC32MX695F512** | 80 | 10 | 512 | 128 | – | 6 | RTCC | – | Yes | 41/23 |
| **PIC32MZ2048ECG100** | 200 | 10 | 2048 | 512 | – | 6 | RTCC | – | Yes | – |

*RTCC: Real-Time Clock and Calendar

## Recommended NOR Flash Memory

| Device | Bus | Density (bits) | Operating Voltage | Speed | Typical Program/ Erase Endurances | Supported Packages |
|---|---|---|---|---|---|---|
| **SST25VF512A/010A** | SPI | 512K to 1M | 2.7V to 3.6V | 33 MHz | 100K cycles | 8-SOIC, 8-TDFN-5, 8-XFBGA |
| **SST25VF020B/040B/080B** | SPI | 2M to 8M | 2.7V to 3.6V | 80 MHz | 100K cycles | 8-SOIC, 8-TDFN-5, 8/8/16-XFBGA |
| **SST26VF016B** | SQI® | 16M | 2.7V to 3.6V | 104 MHz | 100K cycles | 8-SOIC, 8-TDFN-5 |
| **SST26VF032B** | SQI | 32M | 2.7V to 3.6V | 104 MHz | 100K cycles | 8-SOIC, 8-TDFN-5 |
| **SST26VF064B** | SQI | 64M | 2.7V to 3.6V | 104 MHz | 100K cycles | 8-SOIC, 8-TDFN-5 |
| **SST25WF020A/040B/080B** | SPI | 512K to 8M | 1.65V to 1.95V | 75 MHz | 100K cycles | 8-SOIC, 8-TDFN-8 |
| **SST26WF032B** | SQI | 32M | 1.65V to 1.95V | 80 MHz | 100K cycles | 8-SOIC, 8-TDFN-5 |
| **SST39WF512/010/020/040** | ×8 Parallel | 512K to 4M | 2.7V to 3.6V | 55 ns, 70 ns | 100K cycles | 32-PLCC, 32-TSOP, 48-TFBGA, 34-WFBGA |
| **SST39VF200A/400A** | ×16 Parallel | 2M to 4M | 2.7V to 3.6V | 55 ns, 70 ns | 100K cycles | 48-TSOP, 48-TFBGA, 48-WFBGA, 48-XFLGA |
| **SST39VF801C/802C** | ×16 Parallel | 8M | 2.7V to 3.6V | 55 ns, 70 ns | 100K cycles | 48-TSOP, 48-TFBGA, 48-WFBGA |
| **SST39VF1601C/1602C** | ×16 Parallel | 16M | 2.7V to 3.6V | 70 ns | 100K cycles | 48-TSOP, 48-TFBGA |
| **SST39VF3201C/3202C** | ×16 Parallel | 32M | 2.7V to 3.6V | 70 ns | 100K cycles | 48-TSOP, 48-TFBGA |
| **SST38VF6401/2/3/4** | ×16 Parallel | 64M | 2.7V to 3.6V | 90 ns | 100K cycles | 48-TSOP, 48-TFBGA |
| **SST39WF400B/800B** | ×16 Parallel | 4M to 8M | 1.65V to 1.95V | 70 ns | 100K cycles | 48-TFBGA, 48-WFBGA, 48-XFLGA |
| **SST39WF1601/2** | ×16 Parallel | 16M | 1.65V to 1.95V | 70 ns | 100K cycles | 48-TFBGA, 48-WFBGA |

# Product Specifications

## Recommended Serial SRAM and EEPROM Memory

| Device | Memory Type | Bus | Density (bits) | Operating Voltage | Max Stanby Current (@5.5V, 85°C) | Max Clock Frequency | Typical E/W Endurance | Typical Meter Selection | Typical Packages in Meters |
|---|---|---|---|---|---|---|---|---|---|
| **93LC46B** | EEPROM | µwire | 1K | 1.8V to 5.5V | 1 µA | 3 MHz | > 1M cycles | Heat | 8-SN, 8-P |
| **24AA02** | EEPROM | I²C™ | 2K | 1.8V to 5.5V | 1 µA | 400 kHz | > 1M cycles | Gas, Water | 5-OT, 8-SN, 8-MS, 8-ST |
| **24AA024** | EEPROM | I²C | 2K | 1.8V to 5.5V | 1 µA | 400 kHz | > 1M cycles | Water | 8-SN, 8-MS, 8-ST |
| **93LC66B** | EEPROM | µwire | 4K | 2.5V to 5.5V | 1 µA | 3 MHz | > 1M cycles | Heat | 8-SN, 8-P |
| **24AA08** | EEPROM | I²C | 8K | 1.8V to 5.5V | 1 µA | 400 kHz | > 1M cycles | Electricity | 8-SN, 8-MS, 8-ST |
| **24AA16** | EEPROM | I²C | 16K | 1.8V to 5.5V | 1 µA | 400 kHz | > 1M cycles | Electricity | 8-SN, 8-MS, 8-ST |
| **24AA64** | EEPROM | I²C | 64K | 1.8V to 5.5V | 1 µA | 400 kHz | > 1M cycles | Electricity, Heat | 8-SN, 8-MS, 8-ST |
| **24AA128** | EEPROM | I²C | 128K | 1.8V to 5.5V | 1 µA | 1 MHz | > 1M cycles | Electricity, Gas | 8-SN, 8-MS, 8-ST |
| **24AA256** | EEPROM | I²C | 256K | 1.8V to 5.5V | 1 µA | 1 MHz | > 1M cycles | Electricity | 8-SN, 8-MS, 8-ST |
| **25AA256** | EEPROM | SPI | 256K | 1.8V to 5.5V | 1 µA | 10 Mhz | > 1M cycles | Electricity | 8-SN, 8-MS, 8-ST |
| **24AA512** | EEPROM | I²C | 512K | 1.8V to 5.5V | 1 µA | 1 MHz | > 1M cycles | Electricity, Water | 8-SN, 8-SM |
| **25AA512** | EEPROM | SPI | 512K | 1.8V to 5.5V | 10 µA | 20 MHz | > 1M cycles | Electricity | 8-SN, 8-SM |
| **24AA1025** | EEPROM | I²C | 1M | 1.8V to 5.5V | 5 µA | 1 MHz | > 1M cycles | Electricity, Water | 8-SN, 8-SM |
| **25AA1024** | EEPROM | SPI | 1M | 1.8V to 5.5V | 12 µA | 20 MHz | > 1M cycles | Electricity | 8-SM |
| **23K640** | SRAM | SPI | 64K | 2.7V to 5.5V | 4 µA | 20 MHz | ∞ | Electricity | 8-SN, 8-ST |
| **23K256** | SRAM | SPI | 256K | 2.7V to 5.5V | 4 µA | 20 MHz | ∞ | Electricity | 8-SN, 8-ST |
| **23LC512** | SRAM | SPI | 512K | 2.5V to 5.5V | 4 µA | 20 MHz | ∞ | Electricity | 8-SN, 8-ST |
| **23LC1024** | SRAM | SSPI | 1024K | 2.5V to 5.5V | 4 µA | 20 MHz | ∞ | Electricity | 8-SN, 8-ST |

## Recommended Real-Time Clock/Calendar (RTCC) Products

| Device | Interface | Outputs | Digital Trim(1) (Adj/Range) | SRAM (Bytes) | EEPROM (kbits) | Protected EEPROM (bits) | Protected EEPROM contents | Minimum Voltage | Additional Features | Pins | Packages |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **MCP7940N** | I²C™ | 1 MFP (IRQ/CLK) | +1 ppm ±129 ppm | 64 | – | 0 | – | $V_{CC}$: 1.8V $V_{BAT}$: 1.3V | Battery Switchover, Power-Fail Timestamp | 8 | SOIC (SN), TTSOP (ST), MSOP (MS), TDFN (MNY) |
| **MCP79410** | I²C | 1 MFP (IRQ/CLK) | +1 ppm ±129 ppm | 64 | 1 | 64 | Blank ID | $V_{CC}$: 1.8V $V_{BAT}$: 1.3V | Battery Switchover, Power-Fail Timestamp | 8 | SOIC (SN), TTSOP (ST), MSOP (MS), TDFN (MNY) |
| **MCP79411** | I²C | 1 MFP (IRQ/CLK) | +1 ppm ±129 ppm | 64 | 1 | 64 | EUI-48 | $V_{CC}$: 1.8V $V_{BAT}$: 1.3V | Battery Switchover, Power-Fail Timestamp | 8 | SOIC (SN), TTSOP (ST), MSOP (MS), TDFN (MNY) |
| **MCP79412** | I²C | 1 MFP (IRQ/CLK) | +1 ppm ±129 ppm | 64 | 1 | 64 | EUI-64 | $V_{CC}$: 1.8V $V_{BAT}$: 1.3V | Battery Switchover, Power-Fail Timestamp | 8 | SOIC (SL), TSSOP (ST), MSOP (MS), TDFN (MNY) |
| **MCP79520** | SPI | 1 MFP (IRQ/CLK) | +1 ppm ±259 ppm | 64 | 2 | 128 | Blank ID | $V_{CC}$: 1.8V $V_{BAT}$: 1.3V | Battery Switchover, Power-Fail Timestamp | 10 | MDOP (MS), TDFN (MN) |
| **MCP795W20** | SPI | 1) CLK 2) IRQ 3) WDO RST | +1 ppm ±259 ppm | 64 | 2 | 128 | Blank ID | $V_{CC}$: 1.8V $V_{BAT}$: 1.3V | Battery Switchover, Power-Fail Timestamp, Watchdog, Events | 14 | SOIC (SL), TSSOP (ST) |

**Note 1:** 1 ppm is approximately 86 msec/day
**Note 2:** Unique ID is 64 bits (I²C) and 128 bits (SPI) of protected EEPROM.

# Product Specifications

## Recommended Analog and Interface Solutions

### Analog-to-Digital Converters

| Device | Resolution (bits) | Maximum Sampling Rate (samples/sec) | # of Input Channels | Interface | Supply Voltage Range (V) | Typical Supply Current (µA) | Typical INL | Temperature Range (°C) | Features |
|---|---|---|---|---|---|---|---|---|---|
| MCP3421/2/3/4 | 18 to 12 | 4 to 240 | 1/2/2/4 Diff | I²C™ | 2.7 to 5.5 | 155 | 10 ppm | –40 to +125 | PGA, VREF |
| MCP3425/6/7/8 | 16 to 12 | 15 to 240 | 1/2/2/4 Diff | I²C | 2.7 to 5.5 | 155 | 10 ppm | –40 to +125 | PGA, VREF |
| MCP3201/2/4/8 | 12 | 100k | 1/2/4/8 SE | SPI | 2.7 to 5.5 | 400 | ±1 LSB | –40 to +85 | – |

### Op Amps

| Device | Amplifiers Per Package | GBWP (kHz) | Iq/Amp Typical (µA) | Vos Max (µV) | Operating Voltage (V) |
|---|---|---|---|---|---|
| MCP644X | 1/2/4 | 9 | 0.45 | 4500 | 1.4–6.0 |
| MCP603X | 1/2/4 | 10 | 0.9 | 150 | 1.8–5.5 |
| MCP6V1X | 1/2/4 | 80 | 7.5 | 8 | 1.6–5.5 |
| MCP642X | 1/2/4 | 90 | 4.4 | 1000 | 1.8–5.5 |
| MCP6V3X | 1/2/4 | 300 | 23 | 8 | 1.8–5.5 |
| MCP640X | 1/2/4 | 1000 | 45 | 4500 | 1.8–6.0 |

### Temperature Sensors

| Device | Typical Accuracy (°C) | Maximum Accuracy @ 25°C (°C) | Maximum Temperature Range (°C) | Vcc Range (V) | Maximum Supply Current (µA) | Interface |
|---|---|---|---|---|---|---|
| MCP9800 | 0.5 | 1 | –55 to +155 | 2.7 to 5.5 | 400 | I²C |
| TCN75A | 0.5 | 1 | –55 to +125 | 2.7 to 5.5 | 400 | I²C |
| TC77 | 0.5 | 3 | –55 to +125 | 2.7 to 5.5 | 400 | SPI |

## Recommended Wireless Solutions

### IEEE 802.15.4 Transceivers/Modules

| Device | Pin Count | Freq. Range | Sensitivity | Power Output | RSSI | Tx Pwr | Rx Pwr | Clock | Sleep | MAC | MAC Feature | Encryption | Interface | Packages |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MRF24J40 | 40 | 2.405–2.48 | –95 | 0 | Yes | 23 | 19 | 20 MHz | Yes | Yes | CSMA-CA | AES128 | 4-wire SPI | 40-QFN |
| MRF24J40MA | 12 | 2.405–2.48 | –95 | 0 | Yes | 23 | 19 | 20 MHz | Yes | Yes | CSMA-CA | AES128 | 4-wire SPI | 12/Module |
| MRF24J40MD | 12 | 2.405–2.475 | –102 | 20 | Yes | 130 | 25 | 20 MHz | Yes | Yes | CSMA-CA | AES128 | 4-wire SPI | 12/Module |
| MRF24J40MC | 12 | 2.405–2.475 | –102 | 20 | Yes | 130 | 25 | 20 MHz | Yes | Yes | CSMA-CA | AES128 | 4-wire SPI | 12/Module |

### Sub-GHz Transceivers/Modules

| Device | Pin Count | Freq. Range | Sensitivity | Power Output | RSSI | Tx Pwr | Rx Pwr | Clock | Sleep | Interface | Packages |
|---|---|---|---|---|---|---|---|---|---|---|---|
| MRF49XA | 16 | 433/868/915 | –110 | 7 | Yes | 15 mA @ 0 dBm | 11 | 10 MHz | Yes | 4-wire SPI | 16-TSSOP |
| MRF89XA | 32 | 868/915/950 | –113 | 12.5 | Yes | 25 mA @ 10 dBm | 3 | 12.8 MHz | Yes | 4-wire SPI | 32-TQFN |
| MRF89XAM8A | 12 | 868 MHz | –113 | 12.5 | Yes | 25 mA @ 10 dBm | 3 | 12.8 MHz | Yes | 4-wire SPI | 12/Module |
| MRF89XAM9A | 12 | 915 MHz | –113 | 12.5 | Yes | 25 mA @ 10 dBm | 3 | 12.8 MHz | Yes | 4-wire SPI | 12/Module |

### Bluetooth® Modules

| Device | Bluetooth® Spec | Frequency Range (GHz) | Sensitivity (dBm) | Power Output (Typ. dBm) | RSSI | Tx Pwr | Rx Pwr | Sleep Pwr | Interface | Packages |
|---|---|---|---|---|---|---|---|---|---|---|
| RN4020 | 4.1 BTLE | 2.4000–2.4835 | –92 | 7 | Yes | 16 mA @ 0 dBm | 16 mA | < 5 µA @ 3.0V | ASCII over UART | SMT Module |
| RN41 | 2.1 + EDR | 2.402–2.480 | –80 | 16 | Yes | 65 mA @ 15 dBm | 45 mA | 26 µA @ 3.3V | ASCII over UART | SMT Module |
| RN42 | 2.1 + EDR | 2.402–2.480 | –80 | 2 | Yes | 25 mA @ 2 dBm | 45 mA | 26 µA @ 3.3V | ASCII over UART | SMT Module |

### IEEE 802.11 Modules

| Device | Radio | Power Consumption | | | | | | Max. Power Output | Sustained Throughout | Host MCU |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Off* | Sleep** | PS | Rx | Tx | | | | |
| RN171 | 802.11 b/g | – | 4 µA | – | 30 mA | 120 mA (0 dBm) | 185 mA (+10 dBm) | +12 dBm | Up to 2.7 mbps | On module or any MCU |
| RN131G/RN131C | 802.11 b/g | – | 4 µA | – | 40 mA | 210 mA (+18 dBm) | | +18 dBm | Up to 2.7 mbps | On module or any MCU |
| MRF24WB0MA/MB | 802.11 b/g | 0.1 µA | – | 250 µA | 85 mA | 154 mA | | +10 dBm | Up to 1 mbps | PIC® MCU |
| MRF24WG0MA/MB | 802.11 b/g | 0.1 mA | – | 4 mA | 95 mA | 240 mA | | +18 dBm | Up to 5 mbps | PIC MCU |

*__Off:__ denoted as Hibernate state of MRF24WB0MA/MB. State information is not saved.
**__Sleep mode:__ device state saved, wake on input change and RTC active.

# Resources

## Application Notes and Tech Briefs

### Metering

| | |
|---|---|
| AN939 | Designing Energy Meters with the PIC16F873A |
| AN994 | IEC Compliant Active-Energy Meter Design Using the MCP3905/6 |
| AN1013 | Gas and Water Metering with the PIC16F91X Family |
| AB1426 | Design Tips for the MCP3911 |
| AN1300 | Designing with the MCP3901 Dual Channel Analog-to-Digital Converters |
| TB1092 | Designing Heat Meters Using PIC16F9XX Microcontrollers |
| AN1607 | PIC24FJ128GC010 Analog Design Guide |

### Communications

| | |
|---|---|
| AN833 | Microchip TCP/IP Stack Application Note |
| AN979 | Interfacing $I^2C$ Serial EEPROMs to PIC18 Devices |
| AN1255 | Microchip ZigBee PRO Feature Set Protocol Stack |

### Display

| | |
|---|---|
| AN234 | Hardware Techniques for PIC Microcontrollers |
| AN529 | Multiplexing LED Drive and 4 × 4 Keypad Sampling |
| AN557 | Four Channel Digital Voltmeter with Display and Keyboard |
| AN563 | Using PIC16C5X Microcontrollers as LCD Drivers |
| AN587 | Interfacing PIC Microcontrollers to an LCD Module |
| AN658 | LCD Fundamentals Using PIC16C92X Microcontrollers |
| TB029 | Complementary LED Drive |
| TB062 | High Power IR LED Driver Using the PIC16C781/782 |

### Temperature Sensing

| | |
|---|---|
| AN1333 | Use and Calibration of the Internal Temperature Indicator |
| TB3016 | Using the PIC MCU CTMU for Temperature Measurement |

### Security

| | |
|---|---|
| AN583 | Implementation of the Data Encryption Standard Using PIC17C42 |
| AN821 | Advanced Encryption Standard Using the PIC16XXX |
| AN953 | Data Encryption Routines for PIC18 Microcontrollers |

### Timekeeping

| | |
|---|---|
| AN582 | Low-Power Real-Time Clock |
| AN590 | A Clock Design Using the PIC16C54 for LED Displays and Switch Inputs |
| AN615 | Clock Design Using Low Power/Cost Techniques |
| AN649 | Yet Another Clock Featuring the PIC16C924 |
| AN1155 | Run-Time Calibration of Watch Crystals |
| AN1365 | Recommended Usage of Microchip's $I^2C$ Serial RTCC Devices |
| TB028 | Technique to Calculate Day of Week |

### Miscellaneous

| | |
|---|---|
| AN606 | Low-Power Design Using PIC Microcontrollers |
| AN828 | Measuring Temperature with the PIC16F84A Watchdog Timer |
| AN851 | A Flash Bootloader for PIC16 and PIC18 Devices |
| AN871 | Solving Thermal Measurement Problems Using the TC72 and TC77 Digital Silicon Temperature Sensors |
| AN913 | Interfacing the TC77 Thermal Sensor to a PIC Microcontroller |
| AN981 | Interfacing a MCP9700 Analog Temperature Sensor to a PIC MCU |
| ADN011 | Flexible Integrated Temp Sensors Lower System Costs |
| TB008 | Transformerless Power Supply Temperature Sensing |

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