Medical Application Solutions

MICROCHIP

Solutions for Medical Applications

www.microchip.com/medical

Enabling New Technologies in Medical Applications

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Lead (Pb)-Free Packaging

Microchip has converted from tin-lead (SnPb)-plated product packaging to lead (Pb)-free product packaging across the entire portfolio of PIC® microcontrollers, dsPIC® digital signal controllers, serial EEPROMs, stand-alone analog and other devices. This enables our customers to achieve compliance with new regulations around the world such as the European Union Restrictions on Hazardous Substances in Electrical and Electronic Equipment (RoHS) directive.

Enabling Medical Devices

The evolutionary paths of medicine and electronics are linked, with electronic innovation enabling new medical devices, while medical innovation demands new capabilities from electronics. At the same time, market forces are driving changes in electronic medical devices. New classes of implanted devices call for lower power and smaller size. Connectivity is becoming a standard feature. More and more devices are intended for use by people who don't have specialized training.

Microchip provides solutions to medical device designers for these and other challenges of this changing market. Our broad portfolio of analog devices, microcontrollers and non-volatile EEPROM memories are enabling new medical devices to keep ahead of market trends.

In addition, recognizing that medical designers need more than just leading silicon devices, Microchip has established a reputation for our comprehensive set of world-class, easy-to-use, low cost application development tools. Whether the task is analog design, software development, in-circuit emulation or system level evaluation, Microchip's tools make the job easier.

In 2003, Microchip achieved a significant milestone when the Company's quality system was certified to the International Organization for Standards/Technical Specification (ISO/TS)-16949:2002. Microchip was one of the first semiconductor manufacturers in the world to achieve this distinction, demonstrating the important role of quality in our corporate culture.

Hundreds of leading medical device manufacturers have realized the benefits of partnering with Microchip to take their next generation designs from the drawing board to market. We are committed to providing value-added solutions that drive innovation and enable our customers to succeed.

Application Design Centers

Please visit one of our on-line design centers for complete technical resources including circuit diagrams, application notes, web seminars, development tools, recommended products and device samples.

www.microchip.com/designcenters

- Medical Solutions
- Human Interface
- Motor Control
- Intelligent Power Supply
- Lighting
- Wired & Wireless Connectivity
- Mechatronics
- Low Power

Microchip for Medical Applications

With hundreds of medical device manufacturers using our microcontrollers, memories and analog devices, Microchip is an established and dependable supplier to the medical market. Our customers count on us to bring them embedded control solutions for everything from implanted cardioverters to disposable pregnancy testers. Our unique advantages make us an ideal partner for your next medical device design.

Dependable Delivery and Quality

Microchip's culture embraces quality at every level. The company's quality systems and operations are periodically examined by independent outside auditors, to verify conformance to the stringent standards of the International Standards Organization (ISO). A documented change control process and a history of long product lifetimes offer uncommon stability to makers of medical devices. In addition, a robust capability for tracing device manufacturing history supports the requirements of the medical market.

Faster Time to Market

PIC Microcontrollers achieve low-risk product development by providing seamless program size expansion. Pin compatibility facilitates drop-in replacements of package types as well as variations of reprogrammable (Flash) and one-time programmable (OTP) program memories without having to completely re-write code. This seamless migration path allows medical device designers to reuse verified code and a proven printed circuit board layout, potentially reducing the burden of regulatory compliance.

Lower Total System Cost

A broad product portfolio allows Microchip to offer medical device designers an appropriate integration of both analog and digital peripherals, ranging from simple digital to sophisticated analog modules, in addition to versatile stand-alone analog ICs. This breadth of options minimizes component count and thereby lowers total system cost while increasing reliability. At the same time, the flexibility of Microchip's large and diverse portfolio of parts allows engineers to optimize their designs for size and function, enabling smaller and more efficient medical devices.

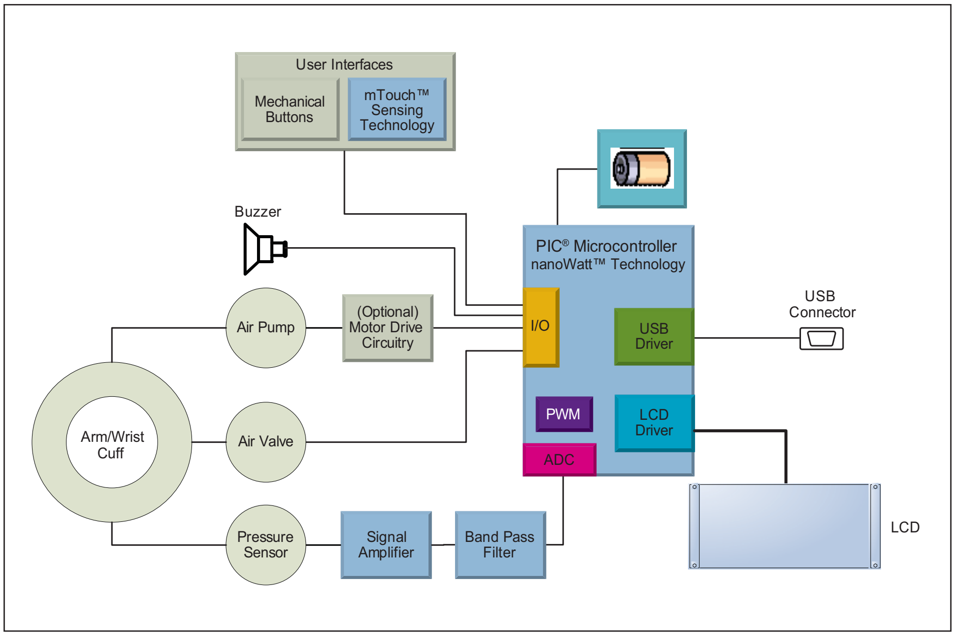
Global Support

In addition to hundreds of dedicated field applications engineers located in more than 50 sales offices, Microchip's 24/7 global technical support line offers technical support resources any time help is needed. Medical device designers can also take advantage of technical seminars from Microchip Regional Training Centers, standard code libraries, reference designs and application notes. These resources support the needs of a large base of customers who produce a wide range of medical devices.

Blood Pressure Meter

A sphygmomanometer or blood pressure meter measures the pressure of the blood in the arteries. Blood pressure is an important indication of a person's cardiovascular health. It is most often measured by inflating a flexible cuff that surrounds the arm in the area of the brachial artery. The cuff is inflated to a pressure sufficient to prevent the flow of blood through the artery. As the pressure is gradually released, the blood flow through the artery resumes. The pressure at which the flow first resumes is recorded as the systolic pressure. The restricted flow can be detected by the distinctive sound it makes when heard through a stethoscope. As the cuff pressure continues to drop, the sound eventually vanishes when the blood flow is no longer restricted. This point is recorded as the diastolic pressure.

Blood Pressure Meter



In a modern electronic blood pressure meter, all of these functions are performed automatically. The cuff inflation and deflation are handled by a small air compressor driven by an electric motor, along with a solenoid controlled valve. The motor and valve can both be easily controlled by a microcontroller using general-purpose input/output ports. The pressure in the cuff is measured by a pressure sensor, which can also detect the blood sounds. Amplification for the low amplitude signal by the blood flow can be provided by a low power precision operational amplifier, like Microchip's MCP6031. After amplification, the signal can be read by analog to digital converter, which generates the digital data used to calculate the pressure. The algorithm used to transform the sensor data into a pressure reading will depend on the specific sensor used, and the location of the cuff (arm, wrist, finger, etc). Once the systolic and diastolic pressures are determined, they are displayed, typically on an LCD. With on-board LCD drive, as well as integrated analog to digital conversion capability, Microchip's 8-bit microcontrollers such as the PIC16F91X family are an excellent fit for blood pressure meters. Because trends and changes in blood pressure are more important than a single measurement, many meters also include built-in memory for storing results, allowing the user to identify a potential issue, or monitor the results of a treatment regimen. Microchip's versatile EEPROM devices offer non-volatile storage options from 128 bits to 1 Mbit. This functionality is further strengthened in devices that are enabled with communications capability, allowing them to send data to a PC for storage and analysis.

Suitable Devices

- PIC16F91X
- PIC16F193X
- PIC18F14K50
- PIC18F46J50
- PIC18F87J90
- MCP6V01
- MCP603X
- TC1017
- MCP1702

References

Application Notes

AN246	Driving the Analog Inputs of a SAR A/D Converter
AN699	Anti-Aliasing, Analog Filters for Data Acquisition Systems
AN781	Solving Sensor Offset Problems
AN842	Differential ADC Biasing Techniques, Tips and Tricks
AN990	Analog Sensor Conditioning Circuits
AN1101	Introduction to Capacitive Sensing
AN1152	Achieving Higher ADC Resolution Using Oversampling
TB077	Advantages of Microchip's Cascaded Op Amps

Additional application notes available at:
www.microchip.com/appnotes

Product Highlights

Microcontroller Family Highlights

PIC16F9XX Low-Power Features

- Standby Current:
  – <100 nA @ 2.0V, (typ.)
- Operating Current:
  – 11 μA @ 32 kHz, 2.0V, (typ.)
  – 220 μA @ 4 MHz, 2.0V, (typ.)
- Watchdog Timer Current:
  – 1 μA @ 2.0V, (typ.)

Microcontroller Family Products

Device	Flash (words/bytes)	Program Memory	Data Memory		10-bit A/D (ch)	LCD (segment drivers)	CCP	Timers 8/16-bit
		SRAM (bytes)	EEPROM (bytes)	I/O				
PIC16F913	4K/7K	256	256	24	5	16(1)	1	2/1
PIC16F914	4K/7K	256	256	35	8	24	2	2/1
PIC16F916	8K/14K	352	256	24	5	16(1)	1	2/1
PIC16F917	8K/14K	352	256	35	8	24	2	2/1
PIC16F946	8K/14K	336	256	53	8	42	2	2/1

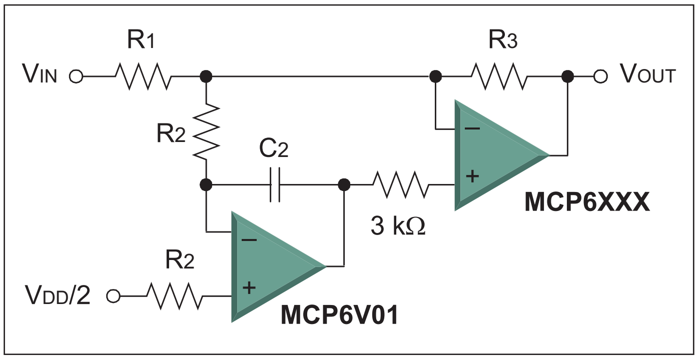
Note 1: COM3 and SEG15 share the same physical pin on the PIC16F913/916, therefore SEG15 is not available when using 1/4 multiplex displays.

Analog Family Highlights

MCP73831/2 Op Amp Features

- High DC Precision:
  – V_{OS} Drift: ±50 nV/°C (max.)
  – V_{OS}: ±2 μV (max.)
  – A_{OL}: 130 dB (min.)
  – PSRR: 130 dB (min.)
  – CMRR: 130 dB (min.)
  – E_{ni}: 2.5 μV_{P-P} (typ.), f = 0.1 Hz to 10 Hz
  – E_{ni}: 0.79 μV_{P-P} (typ.), f = 0.01 Hz to 1 Hz
- Low Power and Supply Voltages:
  – I_Q: 300 μA/amplifier (typ.)
  – Wide Supply Voltage Range: 1.8V to 5.5V
- Easy to Use:
  – Rail-to-Rail Input/Output
  – Gain Bandwidth Product: 1.3 MHz (typ.)
  – Unity Gain Stable
  – Available in Single and Dual
  – Single with Chip Select ($\overline{CS}$): MCP6V03
- Extended Temperature Range: -40°C to +125°C

Offset Voltage Correction for Power Driver



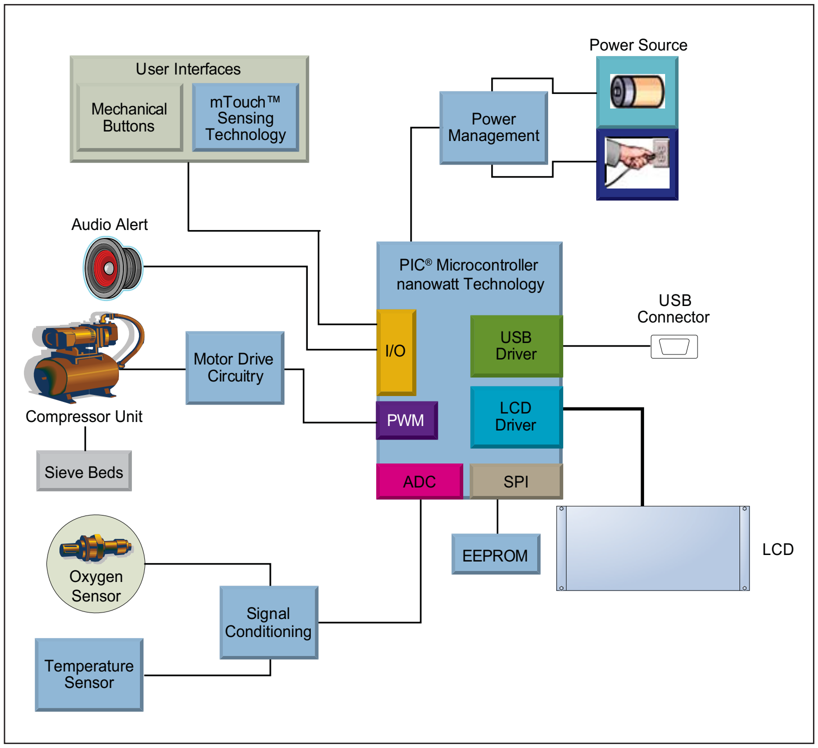
Oxygen Concentrator

An Oxygen Concentrator produces a supply of air with increased oxygen content. It can be used to replace liquid oxygen or pressurized oxygen tanks for people who require oxygen-enriched air. Oxygen concentrators work by removing the nitrogen which normally accounts for approximately 78 percent of the volume of ambient air. In most oxygen concentrators, the nitrogen is adsorbed by a molecular sieve made from a class of aluminosilicate materials called zeolites. The zeolite is contained in one or more airtight cylinders called sieve beds. In each sieve bed, nitrogen is adsorbed under pressure, allowing the oxygen and trace gasses to pass through. The nitrogen is vented to the air when the pressure is relieved. A highly efficient oxygen concentrator can deliver oxygen which is approximately 95 percent pure.

The compressor that moves air into the oxygen concentrator and generates the pressure in the sieve beds is driven by an electric motor, making efficient motor control an important part of oxygen concentrator design. Microchip's high performance 16 bit dsPIC30F family of digital signal controllers offer powerful dedicated peripherals to simplify control various types of motors. For example, the dsPIC30F4011 includes six channels of motor control pulse width modulation (PWM) control featuring dead time control to enable robust and cost-effective control of brushless DC motors. The versatile PWM controller can also synchronize with the integrated Analog-to-Digital Converter on the dsPIC30F4011, to simplify commutation feedback and system design.

Efficient operation of an oxygen concentrator requires careful coordination between the component sections of the device. Pressure must be monitored in each of the sieve beds, in the product oxygen tank and at the intake and output manifolds. Product oxygen purity is continuously monitored, along with flow rate. Sensors track system operating parameters, such as temperature and battery voltage in the case of portable oxygen concentrators. Supporting all of these sensors requires a sophisticated analog signal processing capability. Microchip's digital signal controllers feature 10-bit and 12-bit Analog-to-Digital converters, to accommodate a diverse range of sensors. In addition, Microchip's broad line of analog components allows designers to incorporate pre-conversion analog signal processing into oxygen concentrators and other medical devices that rely on sensors. For example, the MCP6S26 Programmable Gain Amplifier (PGA) has six channels of low noise amplification with rail-to-rail input and output capability. The MCP6S26 can be controlled by an MCU via SPI bus, for maximum flexibility.

Oxygen Concentrator



Suitable Devices

- dsPIC30FXXX
- PIC18F67XX
- PIC18FXX31
- MCP6S26
- MCP60X
- TC126X
- 25XX

References

Application Notes

AN594	Using the CCP Module
AN695	Interfacing Pressure Sensors to Microchip Analog Peripherals
AN957	Sensored BLDC Motor Control Using dsPIC30F2010
AN1012	PIC16HV785: Programmable Lithium and Nickel Battery Charger
AN1083	Sensorless BLDC Control With Back-EMF Filtering

Additional application notes available at:
www.microchip.com/appnotes

Product Highlights

Microcontroller Family Highlights

PIC18FXX31 MCU Family Features

14-Bit Power Control PWM Module

- Up to 4 Channels with Complementary Outputs
- Edge or Center-Aligned Operation
- Flexible Dead-Band Generator
- Hardware Fault Protection Inputs
- Simultaneous Update of Duty Cycle and Period:
  - Flexible Special Event Trigger output

Motion Feedback Module

- Three Independent Input Capture Channels:
  - Flexible operating modes for period and pulse-width measurement
  - Special Hall sensor interface module
  - Special Event Trigger output to other modules
- Quadrature Encoder Interface:
  - 2-phase inputs and one index input from encoder
  - High and low position tracking with direction status and change of direction interrupt
  - Velocity measurement

Peripheral Highlights

- High-Current Sink/Source 25 mA/25 mA
- Three External Interrupts
- Two Capture/Compare/PWM (CCP) modules:
  - Capture is 16-bit, max. resolution 6.25 ns ($T_{CY}/16$)
  - Compare is 16-bit, max. resolution 100 ns (T_{CY})
  - PWM output: PWM resolution is 1 to 10 bits
- Enhanced USART module:
  - Supports RS-485, RS-232 and LIN 1.2
  - Auto-wake-up on Start bit
  - Auto-Baud Detect
- RS-232 Operation using Internal Oscillator Block (no external crystal required)

Memory Product Highlights

25XX SPI Serial EEPROM Family

Memory Size	Speed	Package
1K-4K	10 MHz	P, MS, SN, ST, MC, OT
16K-64K	10 MHz	P, MS, SN, ST
128K-256K	10 MHz	P, MS, SN, ST, MF
512K-1 Mbit	20 MHz	P, SM, MF

PIC18F2331/2431/4331/4431 Microcontroller Family Products

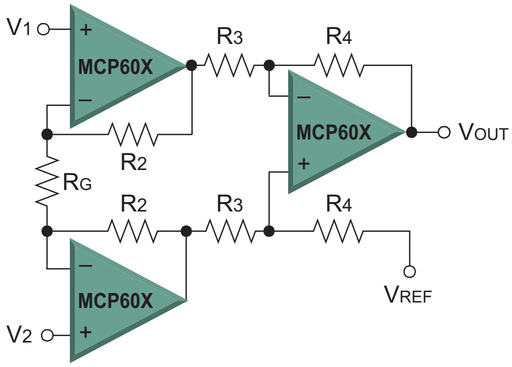
Device	Program Memory		Data Memory		I/O	10-bit A/D (ch)	CCP	SSP		EUSART	Quadrature Encoder	14-Bit PWM (ch)	Timers 8/16-bit
	Flash (bytes)	# Single-Word Instructions	SRAM (bytes)	EEPROM (bytes)				SPI	Slave I²C™				
PIC18F2331	8192	4096	768	256	24	5	2	Y	Y	Y	Y	6	1/3
PIC18F2431	16384	8192	768	256	24	5	2	Y	Y	Y	Y	6	1/3
PIC18F4331	8192	4096	768	256	36	9	2	Y	Y	Y	Y	8	1/3
PIC18F4431	16384	8192	768	256	36	9	2	Y	Y	Y	Y	8	1/3

Analog Family Highlights

MCP601/1R/2/3/4 Op Amp Family Features

- Single-Supply: 2.7V to 6.0V
- Rail-to-Rail Output
- Input Range Includes Ground
- Gain Bandwidth Product: 2.8 MHz (typ.)
- Unity-Gain Stable
- Low Quiescent Current: 230 µA/amplifier (typ.)
- Chip Select ($\overline{CS}$): MCP603 only
- Temperature Ranges:
  - Industrial: -40°C to +85°C
  - Extended: -40°C to +125°C
- Available in Single, Dual and Quad

Three Op Amp Instrumentation Amplifier

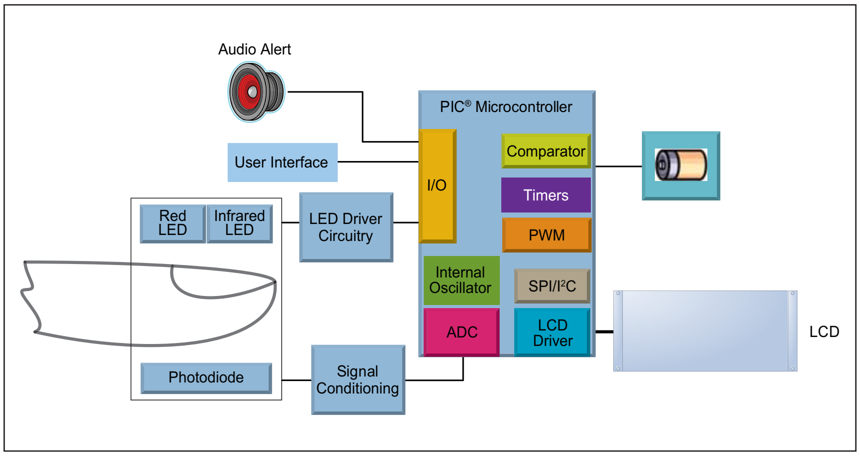


$$V_{OUT} = (V_1 - V_2)\left(1 + \frac{2R_2}{R_G}\right)\left(\frac{R_4}{R_3}\right) + V_{REF}$$

Pulse Oximeter

A pulse oximeter measures the amount of oxygen in a patient's blood by sensing the amount of light absorbed by the blood in capillaries under the skin. In a typical device, a sensing probe is attached to the patient's finger with a spring-loaded clip or an adhesive band. On one side of the probe is a pair of Light-Emitting Diodes (LEDs), and on the other side is a photodiode. One of the LEDs produces red light, and the other produces infrared light. Pulse oximetry depends on the optical characteristics of hemoglobin, the blood protein that carries oxygen. When hemoglobin is more highly oxygenated, it becomes more transmissive to red light and more absorptive to infrared light. When hemoglobin contains little oxygen, it becomes relatively more transmissive to infrared, and more absorptive to red light. This property means that by measuring the ratio of red light to infrared light passing through the patient's finger, the probe can produce a signal proportional to the amount of oxygen in the blood. In addition, the surge of blood on each heartbeat generates a signal representative of the patient's pulse rate.

Pulse Oximeter



Since the output of the photodiode is a low amplitude current, some signal conditioning must be applied before it can be used. Microchip's MCP6V01 auto-zeroed op amp is an ideal choice for use in a resistor-feedback transimpedance amplifier configuration. This configuration is also used in other bioelectric sensing applications. The resulting output voltage is read by an analog-to-digital converter on a PIC microcontroller such as the PIC24FJ family of MCUs. The PIC MCU calculates the ratio of red light to infrared light, and determines the corresponding oxygen saturation level using a lookup table. This value is then sent via serial communications link to a data acquisition system, or, in the care of a stand-alone pulse oximeter, displayed for the user.

Suitable Devices

– PIC24FJXXXGA Family
– MCP6V01
– MCP600X
– MCP604X
– MCP1702
– MCP73832

References

Application Notes

AN513	Analog to Digital Conversion
AN737	Using Digital Potentiometers to Design Low Pass Adjustable Filters
AN784	Buck Configuration High-Power LED Driver
AN951	Amplifying High-Impedance Sensors & Photodiode Example
AN1047	Buck-Boost LED Driver Using the PIC16F785 MCU
AN1080	Understanding Digital Potentiometers Resistors Variation
AN1138	A Digital Constant Current Power LED Driver
DG3	Signal Chain Design Guide

Additional application notes available at:
www.microchip.com/appnotes

Product Highlights

Microcontroller Family Highlights

PIC24FJ64GA004 Family Features

- Operating Voltage Range of 2.0V to 3.6V
- 5.5V Tolerant Input (digital pins only)
- High-Current Sink/Source (18 mA/18 mA) on all I/O PIns
- Flash Program Memory:
  - 10,000 erase/write
  - 20-year data retention minimum
- Power Management modes:
  - Sleep, Idle, Doze and Alternate Clock modes
  - Operating current 650 µA/MIPS typical at 2.0V
  - Sleep current 150 nA typical at 2.0V
- Fail-Safe Clock Monitor Operation:
  - Detects clock failure and switches to on-chip, low-power RC oscillator
- On-Chip, 2.5V Regulator with Tracking mode
- Power-on Reset (POR), Power-up Timer (PWRT) and Oscillator Start-up Timer (OST)
- Flexible Watchdog Timer (WDT) with On-Chip, Low-Power RC Oscillator for Reliable Operation
- In-Circuit Serial Programming™ (ICSP™) and In-Circuit Debug (ICD) via 2 Pins
- JTAG Boundary Scan and Programming Support

PIC24FJXXGA00X Product Family

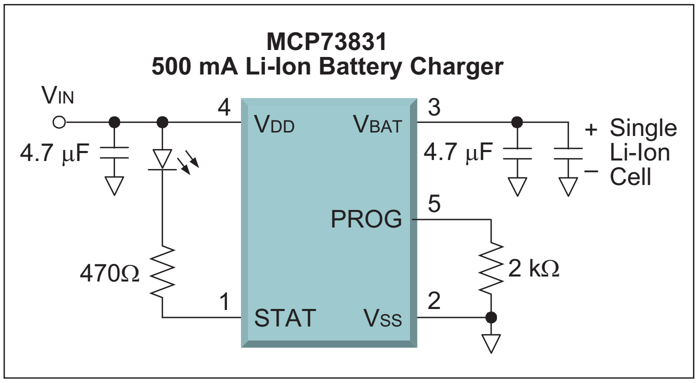
PIC24FJ Device	Pins	Program Memory (bytes)	SRAM (bytes)	Remappable Peripherals						I2C™	10-Bit A/D (ch)	Comparators	PMP/PSP	JTAG
				Remappable Pins	Timers 16-Bit	Capture Input	Compare/PWM Output	UART w/ IrDA®	SPI					
PIC24FJ16GA002	28	16K	4K	16	5	5	5	2	2	2	10	2	Y	Y
PIC24FJ32GA002	28	32K	8K	16	5	5	5	2	2	2	10	2	Y	Y
PIC24FJ48GA002	28	48K	8K	16	5	5	5	2	2	2	10	2	Y	Y
PIC24FJ64GA002	28	64K	8K	16	5	5	5	2	2	2	10	2	Y	Y
PIC24FJ16GA004	44	16K	4K	26	5	5	5	2	2	2	13	2	Y	Y
PIC24FJ32GA004	44	32K	8K	26	5	5	5	2	2	2	13	2	Y	Y
PIC24FJ48GA004	44	48K	8K	26	5	5	5	2	2	2	13	2	Y	Y
PIC24FJ64GA004	44	64K	8K	26	5	5	5	2	2	2	13	2	Y	Y

Analog Family Highlights

MCP73831/2 Features

- Linear Charge Management Controller:
  - Integrated Pass Transistor
  - Integrated Current Sense
  - Reverse Discharge Protection
- High Accuracy Preset Voltage Regulation: + 0.75%
- Four Voltage Regulation Options:
  - 4.20V, 4.35V, 4.40V, 4.50V
- Programmable Charge Current: 15 mA to 500 mA
- Selectable Preconditioning:
  - 10%, 20%, 40% or Disable
- Selectable End-of-Charge Control:
  - 5%, 7.5%, 10% or 20%
- Charge Status Output
  - Tri-State Output - MCP73831
  - Open-Drain Output - MCP73832
- Automatic Power-Down
- Thermal Regulation
- Temperature Range: -40°C to +85°C
- Packaging:
  - 8-lead, 2 mm x 3 mm DFN
  - 5-lead, SOT-23

Typical Application



Continuous Positive Airway Pressure (CPAP)

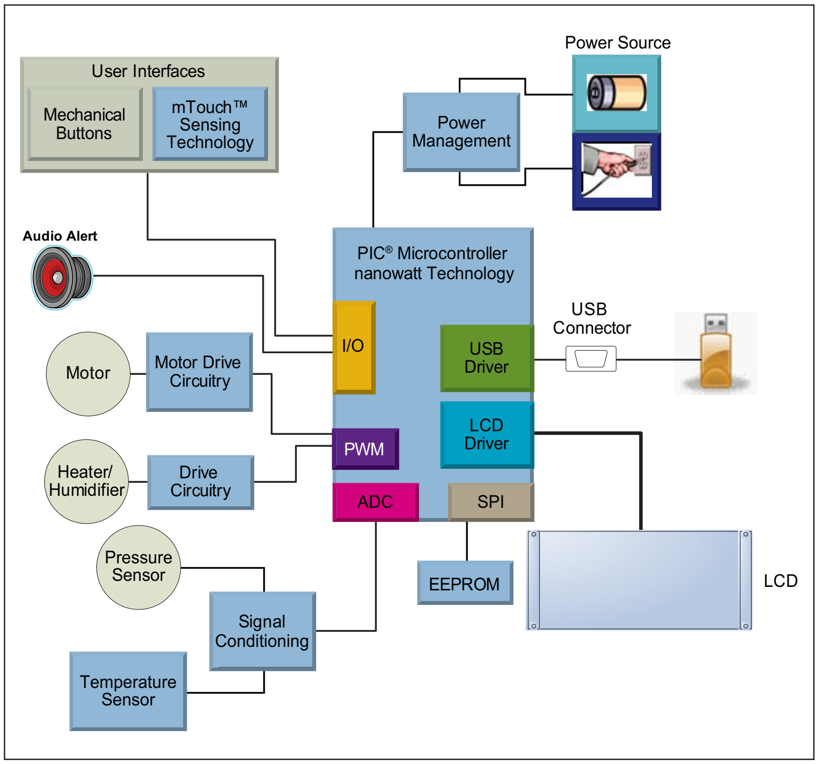
Continuous positive airway pressure (CPAP) machines deliver therapy for obstructive sleep apnea (OSA). People who suffer from OSA experience a collapse of the airway during sleep, which prevents normal breathing. As a result, they partially awaken many times per night, leading to sleep deprivation and associated health issues, including daytime tiredness. By providing air at a dynamically controlled pressure, a CPCP machine keeps the airway open, allowing a normal sleep pattern.

Essentially an air pump, every CPAP machine includes a motor to drive a fan which pressurizes the air. Each system calls for a unique optimization of system parameters such as noise, response time, air volume, power consumption, size and cost. To meet their objectives, system designers use various types of motors, all of which can be controlled with Microchip's flexible integrated motor control peripherals.

Microchip's PIC Microcontrollers for motor control include the powerful dsPIC33 family of Digital Signal Controllers. With 40 MIPS performance and DSP capability, designers can use the dsPIC33 family to implement their choice of control strategies, including sensorless BLDC control. To reduce design time and risk, Microchip offers a portfolio of free and low-cost code examples, software libraries and development tools specifically for motor control. The versatile dsPIC33 family has flash program memory sizes ranging from 12K to 256K, in packages from 20 pins to 100 pins, to cover a broad range of application options. Cost sensitive designs can easily migrate to Microchip's PIC24F microcontroller family for system cost reduction.

Besides logic circuitry, CPAP machines also use a number of sensors to gather physical data during operation. Pressure sensors monitor the pressure of the air being delivered, along with the patient's breathing. Pressure sensor data is conditioned with analog circuitry and routed to the analog to digital converter on the microcontroller. Likewise, air temperature and humidity can be measured and adjusted, to make the therapy more comfortable for the patient. Microchip's full range of operational amplifiers allow designers to condition analog data before converting it to digital for processing. In addition, our temperature sensors provide an accurate, precise and easy to use thermal measurement solution.

Continuous Positive Airway Pressure (CPAP)



Suitable Devices

– PIC24F/HXXX
– dsPIC33FJXXX
– MCP600X
– MCP97XX
– 24XX
– 25XX

References

Application Notes

AN594 Using the CCP Module
AN695 Interfacing Pressure Sensors to Microchip Analog Peripherals
AN866 Designing Operational Amplifier Oscillator Circuits For Sensor Applications
AN898 Determining MOSFET Driver Needs for Motor Drive Applications
AN901 Using the dsPIC30F and dsPIC33F DSCs for Sensorless BLDC control
AN981 Interfacing a MCP9700 Analog Output Temperature Sensor to a PIC® Microcontroller
AN990 Analog Sensor Conditioning Circuits
AN1083 Sensorless BLDC Control with Back EMF Filtering

Additional application notes available at:
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Product Highlights

Microcontroller Family Highlights

dsPIC33FJ32MC302/304, dsPIC33FJ64MCX02/X04 and dsPIC33FJ128MCX02/X04 Controller Families

Device	Pins	Program Flash Memory (Kbyte)	RAM (Kbyte)(1)	Remappable Peripheral										RTCC	I2C™	CRC Generator	10-bit/12-bit ADC (Channels)	6-pin 16-bit DAC	Analog Comparator (2 Channels/Voltage Regulator)	8-bit Parallel Master Port (Address Lines)	I/O Pins	Packages
				Remappable Pins	16-bit Timer(2)	Input Capture	Output Compare Standard PWM	Motor Control PWM (Channels)(3)	Quadrature Encoder Interface	UART	SPI	ECAN™	External Interrupts(4)									
dsPIC33FJ128MC804	44	128	16	26	5	4	4	1	2	2	2	1	3	1	1	1	9	1	1/1	11	35	QFN, TQFP
dsPIC33FJ128MC802	28	128	16	16	5	4	4	1	2	2	2	1	3	1	1	1	6	0	1/0	2	21	SDIP, SOIC QFN-S
dsPIC33FJ128MC204	44	128	8	26	5	4	4	1	2	2	2	0	3	1	1	1	9	0	1/1	11	35	QFN, TQFP
dsPIC33FJ128MC202	28	128	8	16	5	4	4	1	2	2	2	0	3	1	1	1	6	0	1/0	2	21	SDIP, SOIC QFN-S
dsPIC33FJ64MC804	44	64	16	26	5	4	4	1	2	2	2	1	3	1	1	1	9	1	1/1	11	35	QFN, TQFP
dsPIC33FJ64MC802	28	64	16	16	5	4	4	1	2	2	2	1	3	1	1	1	6	0	1/0	2	21	SDIP, SOIC QFN-S
dsPIC33FJ64MC204	44	64	8	26	5	4	4	1	2	2	2	0	3	1	1	1	9	0	1/1	11	35	QFN, TQFP
dsPIC33FJ64MC202	28	64	8	16	5	4	4	1	2	2	2	0	3	1	1	1	6	0	1/0	2	21	SDIP, SOIC QFN-S
dsPIC33FJ32MC304	44	32	4	26	5	4	4	1	2	2	2	0	3	1	1	1	9	0	1/1	11	35	QFN, TQFP
dsPIC33FJ32MC302	28	32	4	16	5	4	4	1	2	2	2	0	3	1	1	1	6	0	1/0	2	21	SDIP, SOIC QFN-S

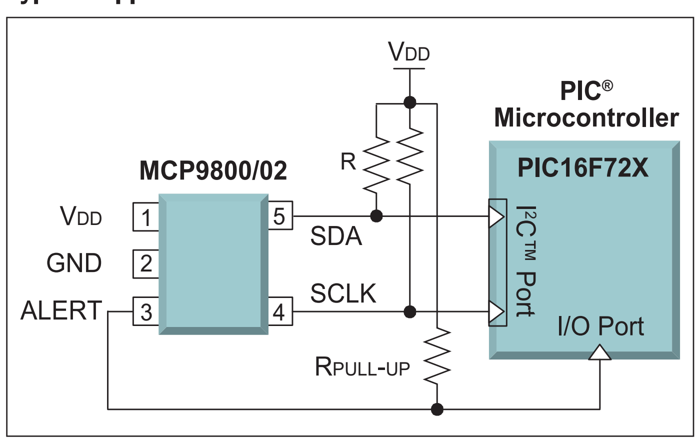
Note 1: RAM size is inclusive of 2 Kbytes of DMA RAM for all devices except dsPIC33FJ32GP302/304, which include 1 Kbyte of DMA RAM.
2: Only four out of five timers are remappable.
3: Only PWM fault pins are remappable.
4: Only two out of three interrupts are remappable.

Analog Family Highlights

MCP9800/1/2/3 Temperature Sensor Features

- Temperature-to-Digital Converter
- Accuracy with 12-bit Resolution:
  - ±0.5°C (typ.) at +25°C
  - ±1°C (max.) from -10°C to +85°C
  - ±2°C (max.) from -10°C to +125°C
  - ±3°C (max.) from -55°C to +125°C
- User-selectable Resolution: 9-12 bit
- Operating Voltage Range: 2.7V to 5.5V
- 2-wire Interface: I2C™/SMBus Compatible
- Operating Current: 200 μA (typ.)
- Shutdown Current: 1 μA (max.)
- Power-saving One-shot Temperature Measurement
- Available Packages: SOT-23-5, MSOP-8, SOIC-8

Typical Application

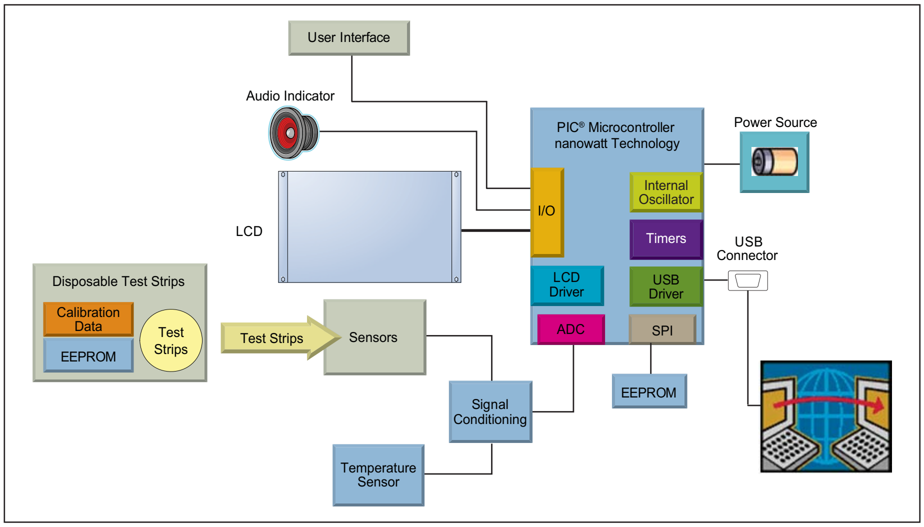


Glucometer

Glucometers are used to determine the concentration of glucose in a patient's blood. Glucose concentration is an important quantity for the management of diabetes.

Glucose measurements can be taken in several ways, including optical or electrochemical methods. In electrochemical meters, a disposable biocatalyst test strip is used to measure the glucose content of a small blood sample obtained by sticking a finger with a lancing device. When the sample is applied to the test strip, the resulting catalytic reaction generates a current. The chemically generated current is converted to a voltage and amplified by an operational amplifier. The operational amplifier's output is scaled to a range that can be measured by the PIC microcontrollers' embedded analog-to-digital converter (ADC). Since the chemical reaction of the test strip is temperature-sensitive, ambient temperature measurement is often used to improve the accuracy of the system. The temperature can be measured using one of Microchip's low cost temperature sensor ICs.

Glucometer



Many consumer devices have the ability to log the test results for later download to a PC for analysis by the user and/or the user's doctor. Data logging requires the use of non-volatile flash memory. PIC microcontrollers are offered with a variety of memory options ranging from 1K to 256K, and can be easily programmed on the board during assembly, or by the system itself, either during manufacturing or in the field. Because small size is an important design criterion for glucometers, Microchip's UNI/O™ family of single wire EEPROMs is a perfect fit for these devices. With UNI/O, designers can add non-volatile memory in the smallest possible space, and using only one wire to communicate to the MCU.

For applications that require higher-resolution ADCs, system designers will find that the MCP3421 family offers an outstanding solution. This family features 18-bit resolution and ultra-low power consumption. The device also offers the ability to trade current consumption, resolution, and sample rate allowing the design optimization.

As with any battery powered device current consumption is critical. Since a glucose meter is only used a few times a day, it is important to have the lowest current possible when the meter is in inactive "sleep" mode. While active power consumption is an important consideration, the ability to shut down is even more useful in this type of application. The MCP604X family of operational amplifiers will typically draw current in the 600 nA range when active and less than 20 pA in shutdown mode, enabling designers to meet their battery life objectives.

Suitable Devices

- PIC16F946
- PIC18FJ90
- PIC24FJXXX Family
- MCP3421
- MCP604X
- MCP7383X
- 11AAXX
- 25XX/24XX

References

Application Notes

AN552	Low Power Real-Time Clock
AN587	Interfacing PIC MCUs to an LCD Module
AN658	LCD Fundamentals Using PIC16C92X
AN693	Understand A/D Converter Performance Specification
AN703	Using the MCP320X 12-Bit Serial A/D Converter with Microchip PIC® MCU Devices
AN867	Temperature Sensing With a Programmable Gain Amplifier
AN947	Power Management in Portable Applications: Charging Lithium-Ion/Lithium-Polymer Batteries
AN971	USB Port-Powered Li-Ion/Li-Polymer Battery Charging
AN990	Analog Sensor Conditioning Circuits - An Overview
AN1070	Driving Liquid Crystal Displays with the PIC16F913/914/916/917/946
AN1177	Op Amp Precision Design: DC Errors
AN1182	Fonts in the Microchip Graphics Library
AN1188	Interfacing Mid-Range PIC MCUs with UNI/O® Bus-Compatible Serial EEPROMs
DG3	Signal Chain Design Guide

Additional application notes available at:
www.microchip.com/appnotes

Product Highlights

Microcontroller Family Highlights

PIC18F87J90 Family Features

LCD Driver and Keypad Interface Features

- Direct LCD Panel Drive Capability:
  – Can drive LCD panel while in Sleep mode
- Up to 48 Segments and 192 Pixels, Software Selectable
- Programmable LCD Timing module:
  – Multiple LCD timing sources available
  – Up to four commons: static, 1/2, 1/3 or 1/4 multiplex
  – Static, 1/2 or 1/3 bias configuration
- On-Chip LCD Boost Voltage Regulator for Contrast Control
- Charge Time Measurement Unit (CTMU) for Capacitive Touch Sensing
- ADC for Resistive Touch Sensing

Low Power Features

- Power-Managed modes:
  – Run: CPU On, Peripherals On
  – Idle: CPU Off, Peripherals On
  – Sleep: CPU Off, Peripherals Off
- Two-Speed Oscillator Start-up

PIC18F87J90 Family Products

Device	Flash Program Memory (Bytes)	SRAM Data Memory (Bytes)	I/O	LCD (Pixels)	Timers 8/16-Bit	CCP	MSSP		EUSART AUSART	10-Bit A/D (Channels)	Comparators	BOR/LVD	RTCC	CTMU
							SPI	Master I²C™						
PIC18F66J90	64K	3,923	51	132	1/3	2	Yes	Yes	1/1	12	2	Yes	Yes	Yes
PIC18F67J90	128K	3,923	51	132	1/3	2	Yes	Yes	1/1	12	2	Yes	Yes	Yes
PIC18F86J90	64K	3,923	67	192	1/3	2	Yes	Yes	1/1	12	2	Yes	Yes	Yes
PIC18F87J90	128K	3,923	67	192	1/3	2	Yes	Yes	1/1	12	2	Yes	Yes	Yes

Memory Product Highlights

UNI/O® Serial EEPROM Family Features

- Single I/O, UNI/O Serial Interface Bus
- Low-Power CMOS Technology
  – 1 mA active current (typ.)
  – 1 µA standby current (max.) (I-temp)
- Schmitt Trigger Inputs for Noise Suppression
- Output Slope Control to Eliminate Ground Bounce
- 100 kbps Max. Bit Rate – Equivalent to 100 kHz Clock Frequency
- Self-Timed Write Cycle (including Auto-Erase)
- Page-Write Buffer for up to 16 Bytes
- Block Write Protection
  – Protect none, 1/4, 1/2 or all of array
- Built-in Write Protection
  – Power-on/off data protection circuitry
  – Write enable latch
- High Reliability
  – Endurance: 1,000,000 erase/write cycles
  – Data retention: > 200 years
  – ESD protection: > 4,000V
- 3-lead SOT-23 Package
- 8-lead PDIP, SOIC, MSOP, TDFN Packages

11AAXXX Family Products

Part Number	Density (bits)	Organization	Vcc Range	Page Size (Bytes)	Temp. Ranges	Packages
11AA010	1K	128 x 8	1.8-5.5V	16	I	P, SN, MS, MN, TT
11AA020	2K	256 x 8	1.8-5.5V	16	I	P, SN, MS, MN, TT
11AA040	4K	512 x 8	1.8-5.5V	16	I	P, SN, MS, MN, TT
11AA080	8K	1,024 x 8	1.8-5.5V	16	I	P, SN, MS, MN, TT
11AA160	16K	2,048 x 8	1.8-5.5V	16	I	P, SN, MS, MN, TT

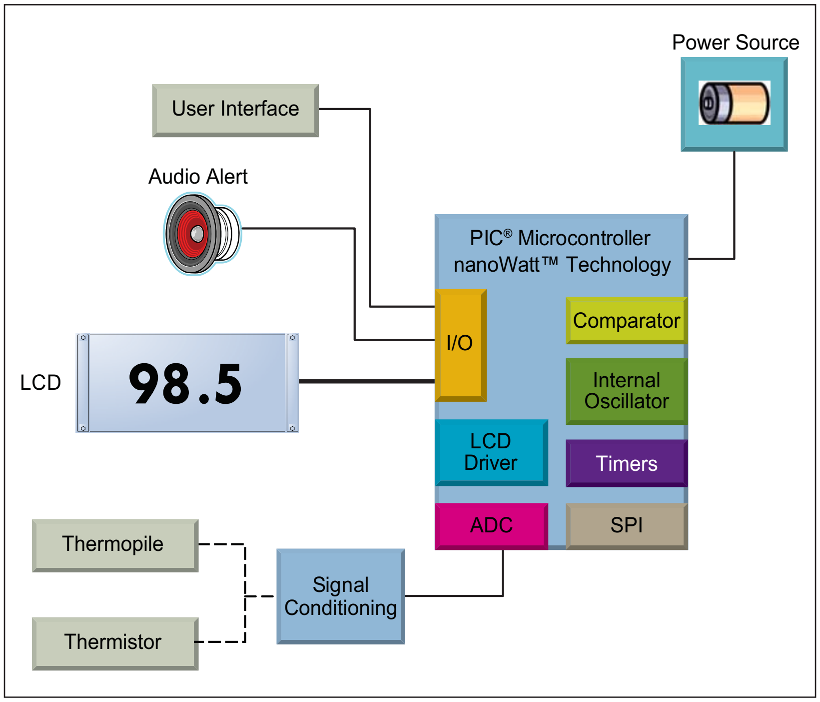
Digital Thermometer

Once made almost exclusively from mercury filled glass tubes, thermometers are rapidly evolving into electronic devices. Market demand for greater safety, speed and precision are driving the adoption of the digital thermometer. A variety of sensor technologies are used to create thermometers that measure body temperature in different ways. Oral, axillary, aural, temporal and other thermometers all start with a temperature sensor connected to an Analog to Digital Converter (ADC). Microchip's families of flexible microcontrollers include devices with 8-bit, 10-bit and 12-bit integrated ADCs. For amplification and analog signal conditioning before digital conversion, Microchip offers a wide range of analog components, including ultra low power operational amplifiers.

Depending on the type and location of the sensor, the measured temperature may have to be corrected to derive an accurate representation of the user's core temperature. After the sensor output has been amplified and digitized, it is processed by the microcontroller according to an appropriate algorithm. Microchip's world-class development tools, including the MPLAB Integrated Development Environment, simplify the software development process. Code writing and debugging, software simulation, hardware emulation and device programming are all done within a single user interface, making MPLAB exceptionally easy to learn and use. MPLAB is available as a free download from microchip.com.

Once the temperature is calculated, the result needs to be displayed to the user. The display technology most used in digital thermometers is the segmented LCD. Microchip's popular MCU families all include devices with built-in LCD drive capability, enabling low cost, reduced parts count and smaller size for stand-alone units. Thermometers are also often included in remote reading telemetry systems. In these systems, a patient's temperature is transmitted wirelessly to another location. Microchip's wireless chips and modules, such as the MRF24J40 provide a cost-effective low-risk option to add wireless capability to any sensing system.

Digital Thermometer



Suitable Devices

- PIC16F68X
- PIC16F91X
- PIC18F87J90
- PIC16F/LF72X
- MCP125X
- MCP970X
- MCP1727

References

Application Notes

AN587	Interfacing PIC MCUs to an LCD Module
AN658	LCD Fundamentals Using PIC16C92X
AN679	Temperature sensing Technologies
AN685	Thermistors in Single Supply Temperature Sensing Circuits
AN688	Layout Tips for 12-Bit A/D Converter Application
AN693	Understanding A/D Converter Performance Specifications
AN781	Solving Sensor Offset Problem
AN897	Thermistor Temperature Sensing with MCP6S2X PGA

Additional application notes available at:
www.microchip.com/appnotes

Product Highlights

Microcontroller Family Highlights

PIC16F72X/PIC16LF72X Family Features

- Precision Internal Oscillator:
  - 16 MHz or 500 kHz operation
  - Factory calibrated to ±1%, (typ.)
  - Software tunable
  - Software selectable ÷1, ÷2, ÷4 or ÷8 divider
- Power-Saving Sleep mode
- Industrial and Extended Temperature Range
- Power-on Reset (POR)
- Power-up Timer (PWRT) and Oscillator Start-up Timer (OST)
- Brown-out Reset (BOR):
  - Selectable between two trip points
  - Disable in Sleep option
- Multiplexed Master Clear with Pull-up/Input Pin
- Programmable Code Protection
- High-Endurance Flash Cell:
  - 1,000 write Flash endurance (typ.)
  - Flash retention: > 40 years
- Wide Operating Voltage Range:
  - 1.8V-5.5V (PIC16F72X)
  - 1.8V-3.6V (PIC16LF72X)
- CSM (Capacitive Sensing Module)

Low-Power Features

- Standby Current:
  - 60 nA @ 2.0V (typ.)
- Operating Current:
  - 7.0 µA @ 32 kHz, 2.0V (typ.)
  - 110 µA @ 1 MHz, 2.0V (typ.)
- Low-Power Watchdog Timer Current:
  - 0.5 µA @ 1.8V (typ.)

PIC16F72X/PIC16LF72X Microcontroller Family Products

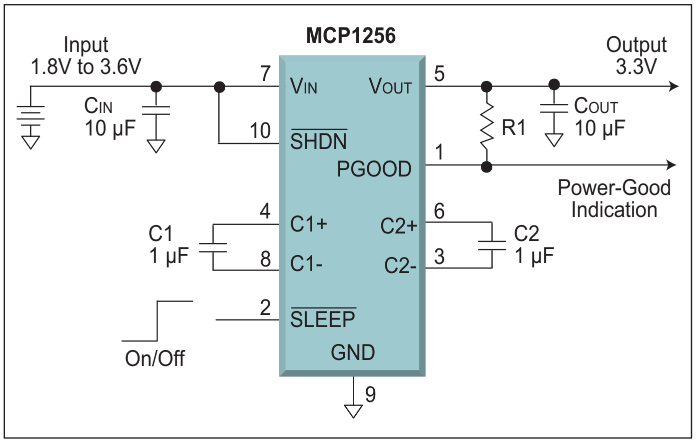
Device	Program Memory Flash (words)	SRAM (bytes)	I/Os	Interrupts	8-bit A/D (ch)	AUSART	CCP	Timers 8/16-bit
PIC16F722/PIC16LF722	2048	128	25	12	11	Yes	2	2/1
PIC16F723/PIC16LF723	4096	192	25	12	11	Yes	2	2/1
PIC16F724/PIC16LF724	4096	192	36	12	14	Yes	2	2/1
PIC16F726/PIC16LF726	8192	368	25	12	11	Yes	2	2/1
PIC16F727/PIC16LF727	8192	368	36	12	14	Yes	2	2/1

Analog Family Highlights

MCP1256/7/8/9 Charge Pump Features

- Inductorless 1.5x, 2x Boost DC/DC Converter
- Output Voltage: 3.3V
- High Output Voltage Accuracy:
  - ±3.0% (V_{OUT} Fixed)
- Output Current Up To 100 mA
- 20m V_{PP} Output Voltage Ripple
- Thermal Shutdown and Short Circuit Protection
- Uses Small Ceramic Capacitors
- Switching Frequency: 650 kHz
- Low-Power Sleep Mode: MCP1256/7
- Bypass Mode: MCP1258/9
- Low-Power Shutdown Mode: 0.1 µA (typ.)
- Shutdown Input Compatible with 1.8V Logic
- V_{IN} Range: 1.8V to 3.6V
- Soft-Start Circuitry to Minimize Inrush Current
- Temperature Range: -40°C to +125°C
- Packaging:
  - 10-pin, 3 mm x 3 mm DFN
  - 10-pin, MSOP

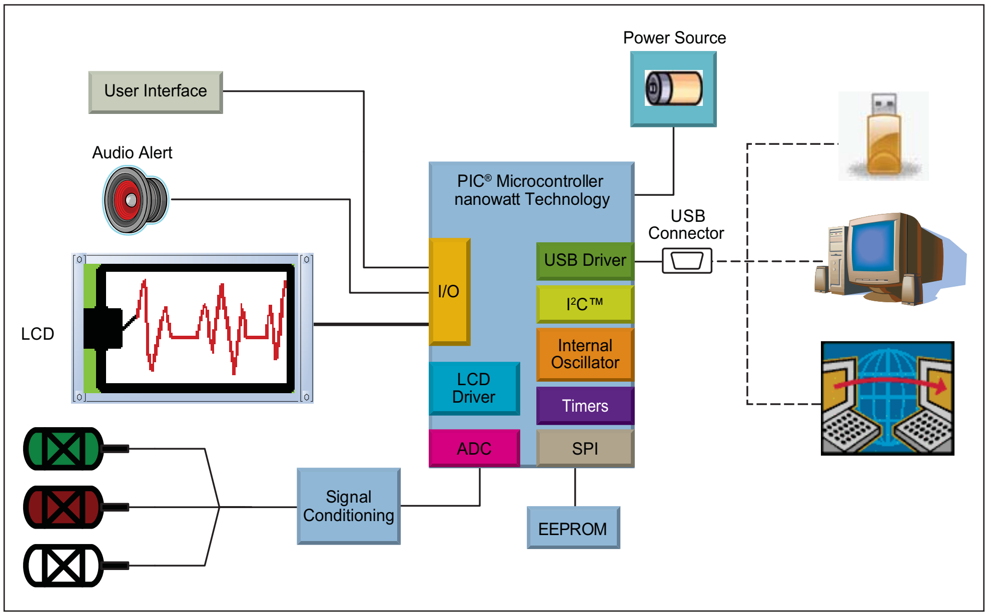
Typical Application with Power-Good Indication



ECG/EKG

An Electrocardiogram (ECG) is used to monitor the electrical activity of the heart. The ECG acquires the heart's signals via electrodes placed on the skin. The electrodes sense the voltage potentials at several points of the body. Depending on the type of system, and the analysis to be done on the signals, the most popular configurations are 3-wire, 5-wire and 10 wire connections to the body. The voltages present on the skin are in the range of 0.1 mV to 3.0 mV. Since the signals of interest are very small, the elimination of common mode noise is a challenging part of designing and ECG system. Microchip's low noise operational amplifiers, such as the MCP606, can be used to extract the cardiac signal from the noise, and provide amplification. Once the signal is properly conditioned, it can be read by an analog to digital converter (ADC), so that it can be analyzed by an MCU.

ECG/EKG



Originally, ECG systems were intended to do little more than display the heart's electrical activity. These devices allowed a cardiologist to observe and interpret the operation of the heart. Newer systems include the capability to do various amounts of autonomous signal analysis, to reduce the burden on the doctor who is using the system. In addition to real-time ECG display and analysis, there are also portable data recording systems, for monitoring cardiac electrical activity over extended periods of time. These are essentially ECG systems, but instead of displaying the electrical waveforms, the captured data is stored for later analysis. The latest ECG systems are portable, and even handheld, creating an entirely new market space. Finally, ECG capability is being embedded into other devices, such as Automated External Defibrillators, and heart rate monitors, to enhance their capabilities.

Microchip's broad range of PIC microcontrollers can cover this entire spectrum of capabilities with the industry's best migration strategy. From small, ultra low power PIC18 devices for portable recording systems to 70 MIPS 32-bit PIC32 devices for high demand signal analysis algorithms, Microchip has the appropriate device for the job. For portable systems that include connectivity to a PC, the PIC24FJ256GB family integrates USB connectivity and numerous memory size and package options, along with low power consumption.

Suitable Devices

- PIC24FJXXXGB Family
- MCP125X
- MCP603X
- MCP62X2
- TC1017
- 25AAXXX

References

Application Notes

AN582	Low-Power Real Clock
AN699	Anti-Aliasing, Analog Filters for Data Acquisition Systems
AN852	Implementing FIR and IIR Digital Filters Using PIC18 Microcontrollers
AN1003	USB Mass Storage Using a PIC® MCU
AN1066	MiWi™ Wireless Networking Protocol Stack
AN1132	How to Use Widgets in Microchip Graphics Library
AN1182	Fonts in the Microchip Graphics Library
DG8	Battery Power Design Guide

Additional application notes available at:
www.microchip.com/appnotes

Product Highlights

Microcontroller Family Highlights

PIC24FJXXGBXXXX Family Features

Power Management

- On-Chip 2.5V Voltage Regulator
- Switch between Clock Sources in Real Time
- Idle, Sleep and Doze modes with Fast Wake-up and Two-Speed Start-up
- Run mode: 1 mA/MIPS, 2.0V (typ.)
- Sleep mode Current Down to 100 nA (typ.)
- Standby Current with 32 kHz Oscillator: 2.5 µA, 2.0V (typ.)

High-Performance CPU

- Modified Harvard Architecture
- Up to 16 MIPS Operation at 32 MHz
- 8 MHz Internal Oscillator
- 17-Bit x 17-Bit Single-Cycle Hardware Multiplier
- 32-Bit by 16-Bit Hardware Divider
- 16 x 16-Bit Working Register Array
- C Compiler Optimized Instruction Set Architecture with Flexible Addressing modes
- Linear Program Memory Addressing, Up to 12 Mbytes
- Linear Data Memory Addressing, Up to 64 Kbytes
- Two Address Generation Units for Separate Read and Write Addressing of Data Memory

PIC24FJ256GB110 Microcontroller Family

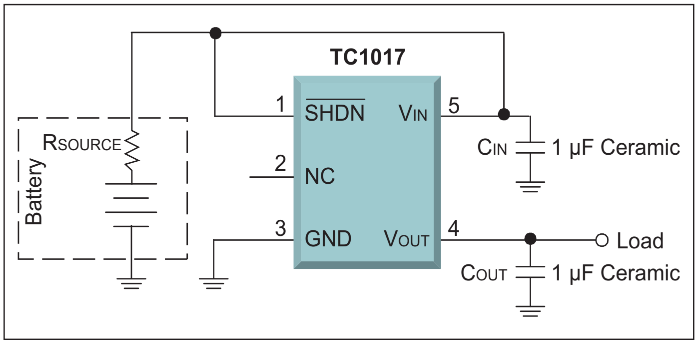
Device	Pins	Program Memory (bytes)	SRAM (bytes)	Remappable Peripherals							10-Bit A/D (ch)	Comparators	PMP/PSP	JTAG	CTMU	USB-OTG
				Remappable Pins	Timers 16-Bit	Capture Input	Compare/PWM Output	UART w/IrDA®	SPI	I2C™						
PIC24FJ64GB106	64	64K	16K	29	5	9	9	4	3	3	16	3	Y	Y	Y	Y
PIC24FJ128GB106	64	128K	16K	29	5	9	9	4	3	3	16	3	Y	Y	Y	Y
PIC24FJ192GB106	64	192K	16K	29	5	9	9	4	3	3	16	3	Y	Y	Y	Y
PIC24FJ256GB106	64	256K	16K	29	5	9	9	4	3	3	16	3	Y	Y	Y	Y
PIC24FJ64GB108	80	64K	16K	40	5	9	9	4	3	3	16	3	Y	Y	Y	Y
PIC24FJ128GB108	80	128K	16K	40	5	9	9	4	3	3	16	3	Y	Y	Y	Y
PIC24FJ192GB108	80	192K	16K	40	5	9	9	4	3	3	16	3	Y	Y	Y	Y
PIC24FJ256GB108	80	256K	16K	40	5	9	9	4	3	3	16	3	Y	Y	Y	Y
PIC24FJ64GB110	100	64K	16K	44	5	9	9	4	3	3	16	3	Y	Y	Y	Y
PIC24FJ128GB110	100	128K	16K	44	5	9	9	4	3	3	16	3	Y	Y	Y	Y
PIC24FJ192GB110	100	192K	16K	44	5	9	9	4	3	3	16	3	Y	Y	Y	Y
PIC24FJ256GB110	100	256K	16K	44	5	9	9	4	3	3	16	3	Y	Y	Y	Y

Analog Family Highlights

TC1017 LDO Linear Regulator Features

- Space-saving 5-Pin SC-70 and SOT-23 Packages
- Extremely Low Operating Current for Longer Battery Life: 53 µA (typ.)
- Very Low Dropout Voltage
- Rated 150 mA Output Current
- Requires Only 1 µF Ceramic Output Capacitance
- High Output Voltage Accuracy: ±0.5% (typ.)
- 10 µs (typ.) Wake-Up Time from $\overline{\text{SHDN}}$
- Power-Saving Shutdown Mode: 0.05 µA (typ.)
- Overcurrent and Overtemperature Protection
- Pin-Compatible Upgrade for Bipolar Regulators

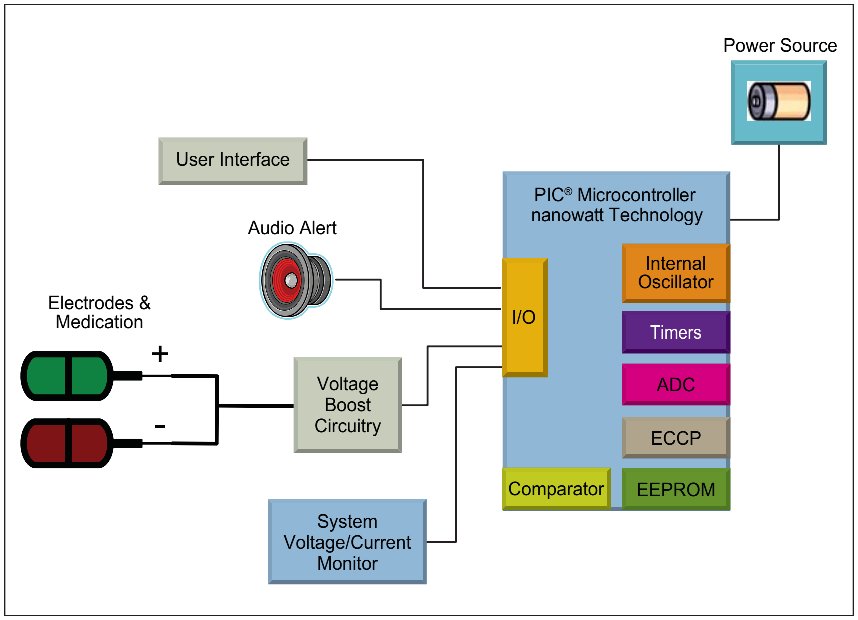
Typical Application



Iontophresis

An Iontophoresis device applies a small electric current to enhance the transport of charged compounds through the skin. If the charged compound is a pharmaceutical formulation, then the iontophoresis device becomes a drug delivery device. Early applications of iontophoresis include treatment of hyperhidrosis and the administration of transdermal anti-inflammatory drugs. Newer devices are being developed to deliver an expanding list of medications for conditions ranging from dermal anesthesia and pain management to headaches and other neurological disorders. Iontophoresis devices can vary in physical implementation from large console-based systems to miniature self-adhesive patch devices that are applied to the skin by the user. It is also possible to employ reverse iontophoresis as a non-invasive means to obtain fluid samples to test for presence or concentration of certain molecules.

Iontophresis



In electrical terms, an iontophoresis device is essentially a constant current power supply, with performance characteristics that have been selected to optimize delivery of the particular compound to be administered. In practice, the current and voltage to be applied will depend upon the drug used, the site of application, and the desired dosage. Microchip's PIC microcontrollers can be used to realize the cost effective embedded voltage regulation required in an iontophoresis device. For example, the PIC16F690 has an Enhanced Capture/Compare/PWM peripheral that simplifies the design of the type of boost regulation circuit which is often used in iontophoresis devices. The integrated 10-bit Analog-to-Digital converter on the PIC16F690 can be used to monitor the applied voltage, providing closed-loop control. On-board non-volatile EEPROM memory provides for storage of usage-specific calibration parameters, dosage history, compliance monitoring or other data. Microchip's large selection of PIC MCUs makes it easy to select a device with the right feature set for any application.

Suitable Devices

– PIC16F193X
– PIC16F690
– PIC18FXX90
– MCP603X

References

Application Notes

AN812	Paralleling the TC1121 to Reduce Output Resistance for Driving Higher Load Current
AN1114	Switch Mode Power Supply Topologies
AN1138	A Digital Constant Current Power LED Driver
AN1177	Op Amp Precision Design: DC Errors
AN1211	Maximum Power Solar Converter

Additional application notes available at:
www.microchip.com/appnotes

Product Highlights

Microcontroller Family Highlights

PIC16F690 Family Features

- Precision Internal Oscillator:
  - Factory calibrated to ± 1%
  - Software selectable frequency range of 8 MHz to 32 kHz
  - Software tunable
  - Two-Speed Start-up mode
  - Crystal fail detect for critical applications
  - Clock mode switching during operation for power savings
- Power-Saving Sleep mode
- Wide Operating Voltage Range (2.0V-5.5V)
- Industrial and Extended Temperature Range
- Power-on Reset (POR)
- Power-up Timer (PWRTE) and Oscillator Start-up Timer (OST)
- Brown-out Reset (BOR) with Software Control Option
- Enhanced Low-Current Watchdog Timer (WDT) with On-Chip Oscillator (Software selectable nominal 268 Seconds with Full Prescaler) with Software Enable
- Multiplexed Master Clear/Input Pin
- Programmable Code Protection
- High Endurance Flash/EEPROM Cell:
  - 100,000 write Flash endurance
  - 1,000,000 write EEPROM endurance
  - Flash/Data EEPROM retention: > 40 years
- Enhanced USART Module:
  - Supports RS-485, RS-232 and LIN 2.0
  - Auto-Baud Detect
  - Auto-wake-up on Start bit

Low-Power Features

- Standby Current:
  - 50 nA @ 2.0V, (typ.)
- Operating Current:
  - 11 µA @ 32 kHz, 2.0V, (typ.)
  - 220 µA @ 4 MHz, 2.0V, (typ.)
- Watchdog Timer Current:
  - <1 µA @ 2.0V, (typ.)

PIC16F631/677/685/687/689/690 Microcontroller Family Products

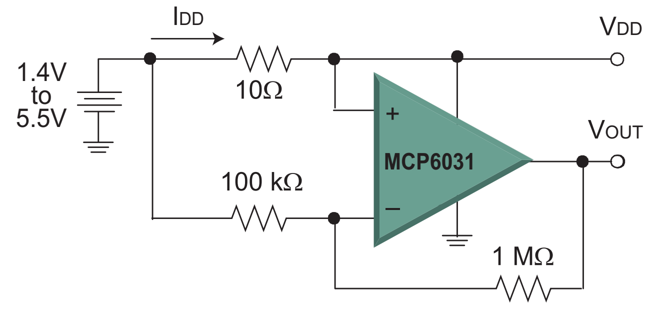
Device	Program Memory	Data Memory		I/O	10-bit A/D (ch)	Comparators	Timers 8/16-bit	SSP	ECCP+	EUSART
	Flash (bytes)	SRAM (bytes)	EEPROM (bytes)							
PIC16F631	1024	64	128	18	–	2	1/1	No	No	No
PIC16F677	2048	128	256	18	12	2	1/1	Yes	No	No
PIC16F685	4096	256	256	18	12	2	2/1	No	Yes	No
PIC16F687	2048	128	256	18	12	2	1/1	Yes	No	Yes
PIC16F689	4096	256	256	18	12	2	1/1	Yes	No	Yes
PIC16F690	4096	256	256	18	12	2	2/1	Yes	Yes	Yes

Analog Family Highlights

MCP6031/2/3/4 High Precision Op Amp Features

- Rail-to-Rail Input and Output
- Low Offset Voltage: ±150 µV (max.)
- Ultra Low Quiescent Current: 0.9 µA (typ.)
- Wide Power Supply Voltage: 1.8V to 5.5V
- Gain Bandwidth Product: 10 kHz (typ.)
- Unity Gain Stable
- Chip Select ($\overline{CS}$) capability: MCP6033
- Extended Temperature Range: -40°C to +125°C
- No Phase Reversal

Typical Application – High Side Battery Current Sensor



$$I_{DD} = \frac{V_{DD} - V_{OUT}}{(10\ V/V - (10\Omega)}$$

Connectivity in Medical Applications

Advances in technology will bring forth revolutionary changes to the medical health care field:

- Wireless sensors in the hospital that allow one caretaker to monitor multiple patients remotely.
- Doctors make diagnoses on patients who are in different continents via the internet.
- A system that provides the entire medical history of a person involved in an accident to the paramedics on scene while alerting the primary care physician and the emergency care center all with just the push of one button.

The need for real time information accessibility, remote location monitoring and diagnostics, and inter-network communication between medical devices come with many challenges. Performance, reliability and ease of implementation are all critical design parameters of networks that support multiple medical devices and sub-systems. In addition, ensuring the integrity of the data for seamless communication between the different protocols, both wired and wireless, adds another layer of complexity for the designer.

Microchip has a rich portfolio of connectivity products that include scalable integrated USB PIC microcontrollers, proprietary low cost wireless protocols (MiWi™), small embedded Ethernet controllers, ready to use ZigBee® stack, and microcontrollers with on-board enhanced CAN module. Microchip also offers numerous development tools, demonstration boards, and online reference notes to help the designer to shorten the design cycle and achieve faster time to market.

	Microcontroller	Stand Alone	Free Stack/ Library	Demo Board/Development Tool
USB	PIC18F1X50 PIC18F46J50 PIC24FJ256BB1 PIC32MX4XX		Yes	MPLAB® Starter Kit for PIC24F (DM24011) PIC24F USB Plug-In-Module (PIM) (MA240014) Low Pin Count USB Development Kit (DV164126)
Ethernet	PIC18F97J60	ENC28J60	Yes	PICDEM.net™ Development Board (DM163024)
Wireless		MRF24J40	Yes	PICDEM™ Z 2.4 GHz Development Kit (DM163027-4)
CAN	PIC18F4680 PIC24HJ256GP506 dsPIC33FJ64MC502	MCP2515 MCP2551	–	PICDEM CAN-LIN 2 Demo Board (DM163015)

PIC® Microcontrollers for Low Power

What is nanoWatt Technology?

Microchip developed a unique blend of process technology, design techniques and flexible power management features that give users the ability to design systems with extremely constrained power budgets. Very often, the limiting factor in low power operation of any MCU is static current consumption. Microchip developed its process technology and design methodologies to keep leakage current to a minimum.

Realizing that voltage is also a hurdle to reducing power consumption, Microchip has designed many of its nanoWatt Technology MCUs to be fully operable with supplies rated between 1.8V and 5.5V.

PIC MCUs with nanoWatt Technology support up to nine oscillator modes. These include:

- **Clock frequency can be switched on the fly**
  – Allowing no delay in code execution on transitions between external clocks and the internal oscillators.
- **Advantageous two-speed start-up feature**
  – Allows seamless transition by running from either of the internal oscillators while an external clock source stabilizes on start-up. After the external source has stabilized, the MCU automatically makes a clock switch, saving precious "up" time.
- **Configurable Idle, Sleep and Deep Sleep modes**
  – Let designers tailor current consumption levels and clocking options to fit any power budget.
- **Ultra Low Power Wake-up (ULPW) mode**
  – Reduces current draw during wake-up.

Microchip has developed the industry's most comprehensive power management technology spanning static low power, active power and fast wake-up. We call it nanoWatt Technology because it is made up of more than 30 features which allow you to manage all of the components of power including static, active and average power consumption.

Static low power features include Sleep currents as low as 100 nA, Real Time Clock currents of 1 µA, and low power system voltage monitors; ideal for battery powered applications. With the recently introduced nanoWatt XLP™ products, the Sleep current can be as low as 20 nA.

Low Power Safety

In addition to peripherals, products with nanoWatt XLP have system supervisory circuits specially designed for battery powered products.

- The Deep Sleep Brown-out Reset protects applications when batteries are depleted and changed, yet consumes a tiny 45 nA of current
- The Real-time Clock Calendar module on products with Deep Sleep can continue to run provide precise time for less than 500 nA
- Using a dedicated on-chip oscillator, the standard WDT and Deep Sleep WDT provide protection against system failure for less than 500 nA.

Benefits of nanoWatt XLP Technology:

- **Sleep currents down to 20 nA**
- **Brown-out Reset down to 45 nA**
- **Watch-dog Timer down to 400 nA**
- **Real-time Clock/Calendar down to 500 nA**

Application Examples

- Glucometer
- Blood Pressure Monitor
- Portable EKG
- Digital Thermometer
- Medication Reminder
- Medical ID Tag
- Portable Patient Monitor
- Nurse Paging Device
- Pulse Oximeter

Support

Microchip is committed to supporting its customers in developing products faster and more efficiently. We maintain a worldwide network of field applications engineers and technical support ready to provide product and system assistance. In addition, the following service areas are available at www.microchip.com:

- **Support** link provides a way to get questions answered fast: http://support.microchip.com
- **Sample** link offers evaluation samples of any Microchip device: http://sample.microchip.com
- **Forum** link provides access to knowledge base and peer help: http://forum.microchip.com
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