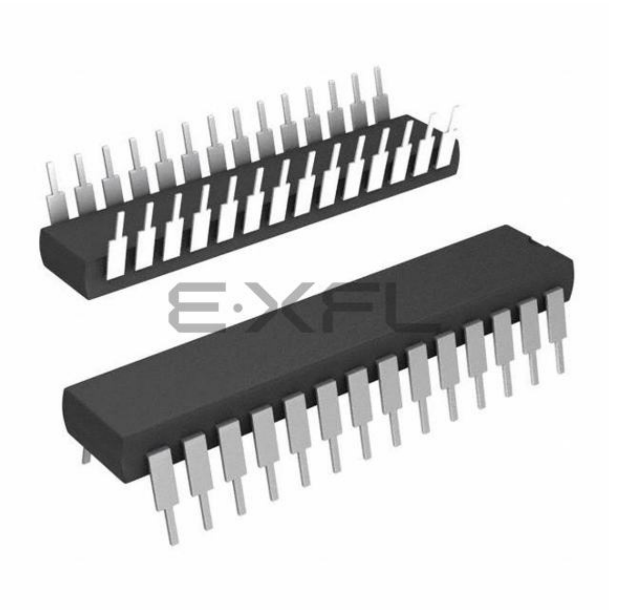

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What is "Embedded - Microcontrollers"?

"Embedded - Microcontrollers" refer to small, integrated circuits designed to perform specific tasks within larger systems. These microcontrollers are essentially compact computers on a single chip, containing a processor core, memory, and programmable input/output peripherals. They are called "embedded" because they are embedded within electronic devices to control various functions, rather than serving as standalone computers. Microcontrollers are crucial in modern electronics, providing the intelligence and control needed for a wide range of applications.

Applications of "Embedded - Microcontrollers"

Details	
Product Status	Active
Core Processor	PIC
Core Size	8-Bit
Speed	20MHz
Connectivity	I²C, SPI, UART/USART
Peripherals	Brown-out Detect/Reset, POR, PWM, WDT
Number of I/O	22
Program Memory Size	7KB (4K x 14)
Program Memory Type	OTP
EEPROM Size	-
RAM Size	192 x 8
Voltage - Supply (Vcc/Vdd)	4V ~ 5.5V
Data Converters	-
Oscillator Type	External
Operating Temperature	0°C ~ 70°C (TA)
Mounting Type	Through Hole
Package / Case	28-DIP (0.300", 7.62mm)
Supplier Device Package	28-SPDIP
Purchase URL	https://www.e-xfl.com/product-detail/microchip-technology/pic16c63a-20-sp

Tips 'n Tricks
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Application Notes:

AN512, "I*mplementing Ohmmeter/Temperature Sensor*"

AN611, "*Resistance and Capacitance Meter Using a PIC16C622*"

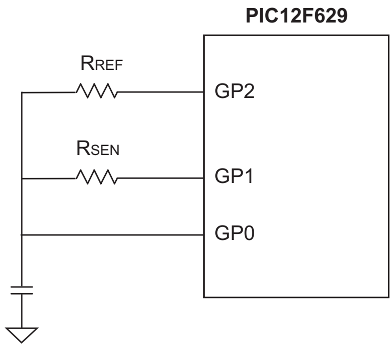
Here is the schematic and software flow for using a reference resistor to improve the accuracy of an analog sensor reading. The reference resistor (R_{REF}) and sensor (R_{SEN}) are assigned an I/O and share a common capacitor. GP0 is used to discharge the capacitor and represents the capacitor voltage.

Through software, a timer is used to measure when GP0 switches from a '0' to a '1' for the sensor and reference measurements. Any difference measured between the reference measurement and its calibrated measurement is used to adjust the sensor reading, resulting in a more accurate measurement.

The comparator and comparator reference on the PIC12F629/675 can be used instead of a port pin for a more accurate measurement. Polypropylene capacitors are very stable and beneficial in this type of application.

1. Set GP1 and GP2 to inputs, and GP0 to a low output to discharge C
2. Set GP0 to an input and GP1 to a high output
3. Measure tR_{SEN} (GP0 changes to 1)
4. Repeat step 1
5. Set GP0 to an input and GP2 to a high output
6. Measure tR_{REF} (GP0 changes to 1)
7. Use film polypropylene capacitor
8. $R_{TH} = x\ R_{REF} \dfrac{tR_{SEN}}{tR_{REF}}$

Figure 13-2



Other alternatives: voltage comparator in the PIC12F6XX to measure capacitor voltage on GP0.

Tip #13.2 Reading a Sensor With Higher Accuracy – Charge Balancing Method

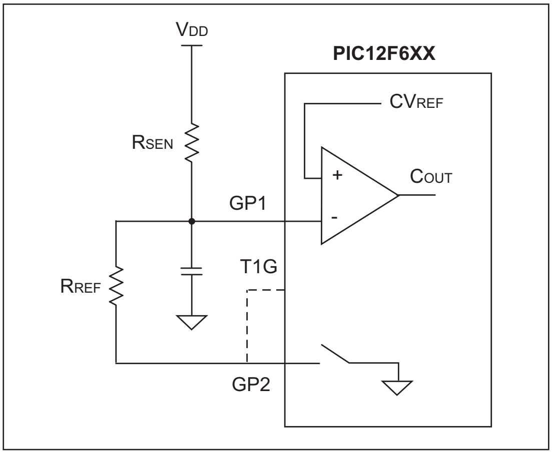
1. Sensor charges a capacitor
2. Reference resistor discharges the capacitor
3. Modulate reference resistor to maintain constant average charge in the capacitor
4. Use comparator to determine modulation

To improve resolution beyond 10 or 12 bits, a technique called "Charge Balancing" can be used. The basic concept is for the MCU to maintain a constant voltage on a capacitor by either allowing the charge to build through a sensor or discharge through a reference resistor. A timer is used to sample the capacitor voltage on regular intervals until a predetermined number of samples are counted. By counting the number of times the capacitor voltage is over an arbitrary threshold, the sensor voltage is determined.

The comparator and comparator voltage reference (CV_{REF}) on the PIC12F629/675 are ideal for this application.

1. GP1 average voltage = CV_{REF}
2. Time base as sampling rate
3. At the end of each time base period:
   - If GP1 > CV_{REF}, then GP2 Output Low
   - If GP1 < CV_{REF}, then GP2 Input mode
4. Accumulate the GP2 lows over many samples
5. Number of samples determines resolution
6. Number of GP2 lows determine effective duty cycle of R_{REF}

Figure 13-3



TIP #16 Optimizing Destinations

- Destination bit determines W for F for result
- Look at data movement and restructure

Example 16-1

Example: A + B → A

```
MOVF    A,W
ADDWF   B,W
MOVWF   A
```

3 instructions

```
MOVF    B,W
ADDWF   A,F
```

2 instructions

Careful use of the destination bits in instructions can save program memory. Here, register A and register B are summed and the result is put into the A register. A destination option is available for logic and arithmetic operations. In the first example, the result of the ADDWF instruction is placed in the working register. A MOVWF instruction is used to move the result from the working register to register A. In the second example, the ADDWF instruction uses the destination bit to place the result into the A register, saving an instruction.

TIP #17 Conditional Bit Set/Clear

- To move single bit of data from REGA to REGB
- Precondition REGB bit
- Test REGA bit and fix REGB if necessary

Example 17-1

```
BTFSS  REGA,2
BCF    REGB,5
BTFSC  REGA,2
BSF    REGB,5
```

4 instructions

```
BCF    REGB,5
BTFSC  REGA,2
BSF    REGB,5
```

3 instructions

One technique for moving one bit from the REGA register to REGB is to perform bit tests. In the first example, the bit in REGA is tested using a BTFSS instruction. If the bit is clear, the BCF instruction is executed and clears the REGB bit, and if the bit is set, the instruction is skipped.The second bit test determines if the bit is set, and if so, will execute the BSF and set the REGB bit, otherwise the instruction is skipped. This sequence requires four instructions.

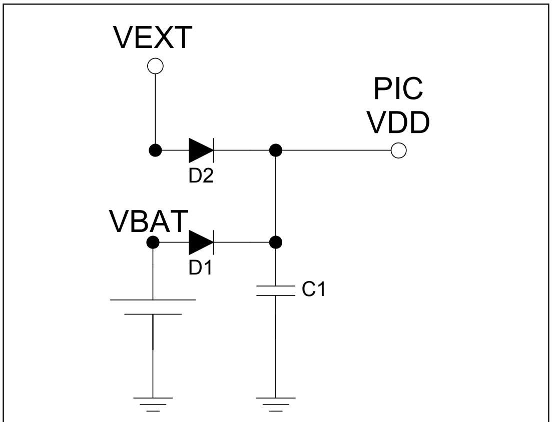
A more efficient technique is to assume the bit in REGA is clear, and clear the REGB bit, and test if the REGA bit is clear. If so, the assumption was correct and the BSF instruction is skipped, otherwise the REGB bit is set. The sequence in the second example uses three instructions because one bit test was not needed.

One important point is that the second example will create a two-cycle glitch if REGB is a port outputting a high. This is caused by the BCF and BTFSC instructions that will be executed regardless of the bit value in REGA.

TIP #7 Battery Backup for PIC MCUs

For an application that can operate from either an external supply or a battery backup, it is necessary to be able to switch from one to the other without user intervention. This can be accomplished with battery backup ICs, but it is also possible to implement with a simple diode OR circuit, shown in Figure 7-1. Diode D1 prevents current from flowing into the battery from VEXT when the external power is supplied. D2 prevents current from flowing into any external components from the battery if VEXT is removed. As long as the external source is present and higher voltage than the battery, no current from the battery will be used. When VEXT is removed and the voltage drops below VBAT, the battery will start powering the MCU. Low forward voltage Schottky diodes can be used in order to minimize the voltage dropout from the diodes. Additionally, inputs can be referenced to VEXT and VBAT in order to monitor the voltage levels of the battery and the external supply. This allows the micro to enter lower power modes when the supply is removed or the battery is running low. In order to avoid glitches on V_{DD} caused by the diode turn-on delay when switching supplies, ensure enough decoupling capacitance is used on V_{DD} (C1).

Figure 7-1:



Dynamic Operation Tips n’ Tricks

The following tips and tricks apply to methods of improving the dynamic operating current consumption of an application. This allows an application to get processing done quicker which enables it to sleep more and will help reduce the current consumed while processing.

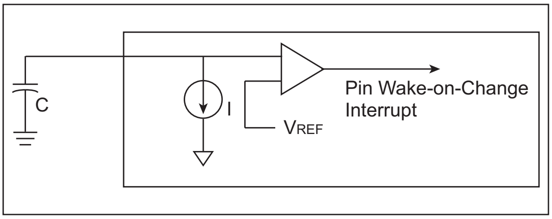
TIP #8 Enhanced PIC16 Mid-Range Core

The Enhanced PIC16 mid-range core has a few features to assist in low power. New instructions allow many applications to execute in less time. This allows the application to spend more time asleep and less time processing and can provide considerable power savings. It is important not to overlook these new instructions when designing with devices that contain the new core. The Timer1 oscillator and WDT have also been improved, now meeting nanoWatt XLP requirements and drawing much less current than in previous devices.

TIP #22 Ultra Low-Power Wake-Up Peripheral

Newer devices have a modification to PORTA that creates an Ultra Low-Power Wake-Up (ULPWU) peripheral. A small current sink and a comparator have been added that allows an external capacitor to be used as a wake-up timer. This feature provides a low-power periodic wake-up source which is dependent on the discharge time of the external RC circuit.

Figure 22-1: Ultra Low-Power Wake-Up Peripheral



If the accuracy of the Watchdog Timer is not required, this peripheral can save a lot of current.

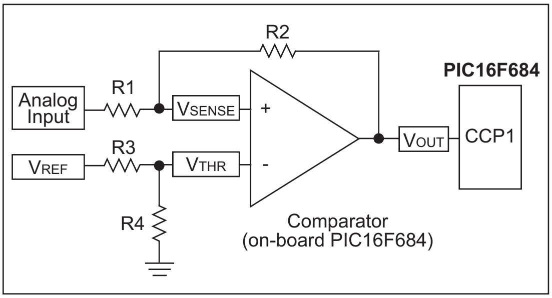
Visit the low power design center at: www.microchip.com/lowpower for additional design resources.

TIP #6 Measuring the Period of an Analog Signal

Microcontrollers with on-board Analog Comparator module(s), in addition to a CCP (or ECCP) module, can easily be configured to measure the period of an analog signal.

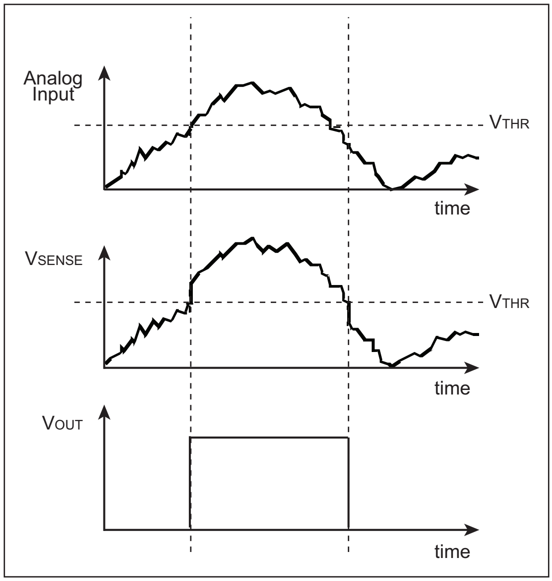
Figure 6-1 shows an example circuit using the peripherals of the PIC16F684.

Figure 6-1: Circuit



R3 and R4 set the threshold voltage for the comparator. When the analog input reaches the threshold voltage, V_{OUT} will toggle from low to high. R1 and R2 provide hysteresis to insure that small changes in the analog input won't cause jitter in the circuit. Figure 6-2 demonstrates the effect of hysteresis on the input. Look specifically at what V_{SENSE} does when the analog input reaches the threshold voltage.

Figure 6-2: Signal Comparison



The CCP module, configured in Capture mode, can time the length between the rising edges of the comparator output (V_{OUT}.) This is the period of the analog input, provided the analog signal reaches V_{THR} during every period.

COMPARE TIPS ‘N TRICKS

In Compare mode, the 16-bit CCPRx register value is constantly compared against the TMR1 register pair values. When a match occurs, the CCPx pin is:

- Driven high
- Driven low
- Remains unchanged, or
- Toggles based on the module’s configuration

The action on the pin is determined by control bits CCPxM3:CCPxM0 (CCPxCON<3:0>). A CCP interrupt is generated when a match occurs.

Special Event Trigger

Timer1 is normally not cleared during a CCP interrupt when the CCP module is configured in Compare mode. The only exception to this is when the CCP module is configured in Special Event Trigger mode. In this mode, when Timer1 and CCPRx are equal, the CCPx interrupt is generated, Timer1 is cleared, and an A/D conversion is started (if the A/D module is enabled.)

“Why Would I Use Compare Mode?”

Compare mode works much like the timer function on a stopwatch. In the case of a stopwatch, a predetermined time is loaded into the watch and it counts down from that time until zero is reached.

Compare works in the same way with one exception – it counts from zero to the predetermined time. This mode is useful for generating specific actions at precise intervals. A timer could be used to perform the same functionality, however, it would mean preloading the timer each time. Compare mode also has the added benefit of automatically altering the state of the CCPx pin based on the way the module is set up.

TIP #12 Making an Op Amp Out of a Comparator

When interfacing to a sensor, some gain is typically required to match the full range of the sensor to the full range of an ADC. Usually this is done with an operational amplifier, however, in cost sensitive applications, an additional active component may exceed the budget. This tip shows how an on-chip comparator can be used as an op amp like gain stage for slow sensor signals. Both an inverting and non-inverting topology are shown (see Figure 12-1 and Figure 12-2).

Figure 12-1: Non-Inverting Amplifier

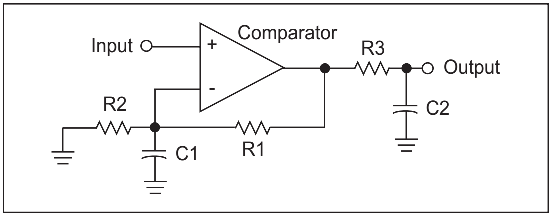
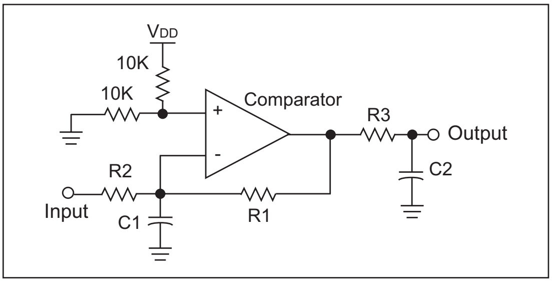


Figure 12-2: Inverting Amplifier



To design a non-inverting amplifier, choose resistors R1 and R2 using the Gain formula for an op amp non-inverting amplifier (see Equation 12-1).

Equation 12-1

$$Gain = \frac{R1 + R2}{R2}$$

Once the gain has been determined, values for R3 and C2 can be determined. R3 and C2 form a low-pass filter on the output of the amplifier. The corner frequency of the low pass should be 2 to 3 times the maximum frequency of the signal being amplified to prevent attenuation of the signal, and R3 should be kept small to minimize the output impedance of the amplifier. Equation 12-2 shows the relationship between R3, C2 and the corner frequency of the low pass filter.

Equation 12-2

$$F_{CORNER} = \frac{1}{2 * \quad * R3 * C2}$$

A value for C1 can then be determined using Equation 12-3. The corner frequency should be the same as Equation 12-3.

Equation 12-3

$$F_{CORNER} = \frac{1}{2 * \quad * (R1 \parallel R2) * C2}$$

To design an inverting amp, choose resistors R1 and R2 using the Gain formula for an op amp inverting amplifier (see Equation 12-4).

Equation 12-4

$$Gain = \frac{R_1}{R_2}$$

Then choose values for the resistor divider formed by R4 and R5. Finally choose C1 and C2 as shown in the non-inverting amplifier design.

Example:

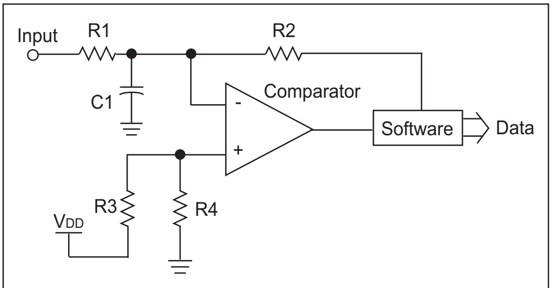
- For C2 will set the corner F
- Gain = 6.156, R1 = R3 = 19.8k
- R2 = 3.84k, C1 = .047 µF, F_{CORNER} = 171 Hz
- C2 = .22 µF

TIP #14 Delta-Sigma ADC

This tip describes the creation of a hardware/software-based Delta-Sigma ADC. A Delta-Sigma ADC is based on a Delta-Sigma modulator composed of an integrator, a comparator, a clock sampler and a 1-bit DAC output. In this example, the integrator is formed by R1 and C1. The comparator is an on-chip voltage comparator. The clock sampler is implemented in software and the 1-bit DAC output is a single I/O pin. The DAC output feeds back into the integrator through R2.

Resistors R3 and R4 form a $V_{DD}/2$ reference for the circuit (see Figure 14-1).

Figure 14-1: Delta-Sigma Modulator



In operation, the feedback output from the software is a time sampled copy of the comparator output. In normal operation, the modulator output generates a PWM signal which is inversely proportional to the input voltage. As the input voltage increases, the PWM signal will drop in duty cycle to compensate. As the input decreases, the duty cycle rises.

To perform an A-to-D conversion, the duty cycle must be integrated over time, digitally, to integrate the duty cycle to a binary value. The software starts two counters. The first counts the total number of samples in the conversion and the second counts the number of samples that were low. The ratio of the two counts is equal to the ratio of the input voltage over V_{DD}.

> **Note:** This assumes that R1 and R2 are equal and R3 is equal to R4. If R1 and R2 are not equal, then the input voltage is also scaled by the ratio of R2 over R1, and R3 must still be equal to R4.

For a more complete description of the operation of a Delta-Sigma ADC and example firmware, see Application Note AN700 "*Make A Delta-Sigma Converter Using a Microcontroller's Analog Comparator Module*."

Example:

- R3 = R4 = 10 kHz
- R1 = R2 = 5.1k
- C1 = 1000 pF

Figure 3-1: 4 and 5 Wire Stepper Motors

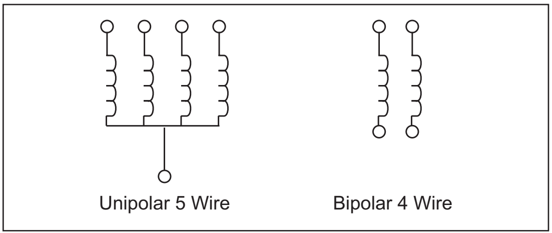


Figure 3-2: 6 and 8 Wire Stepper Motors

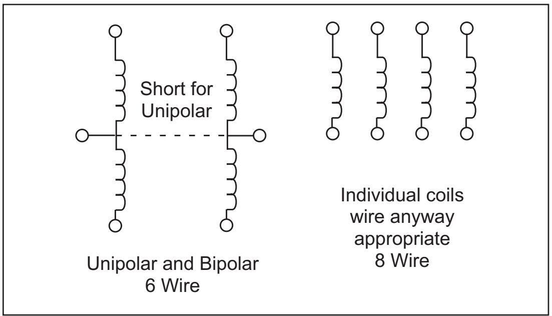
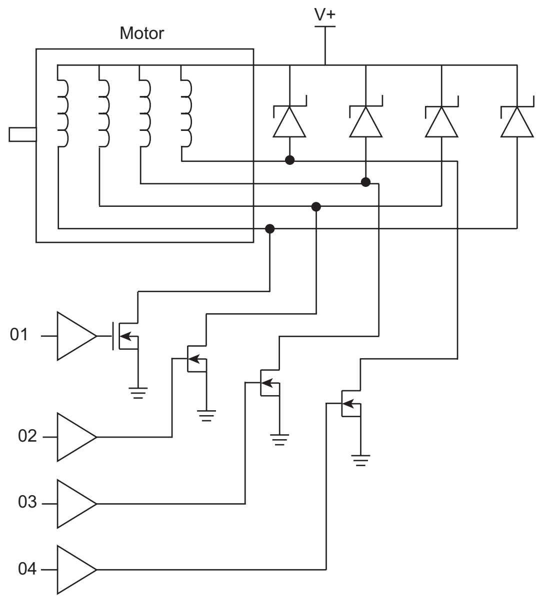
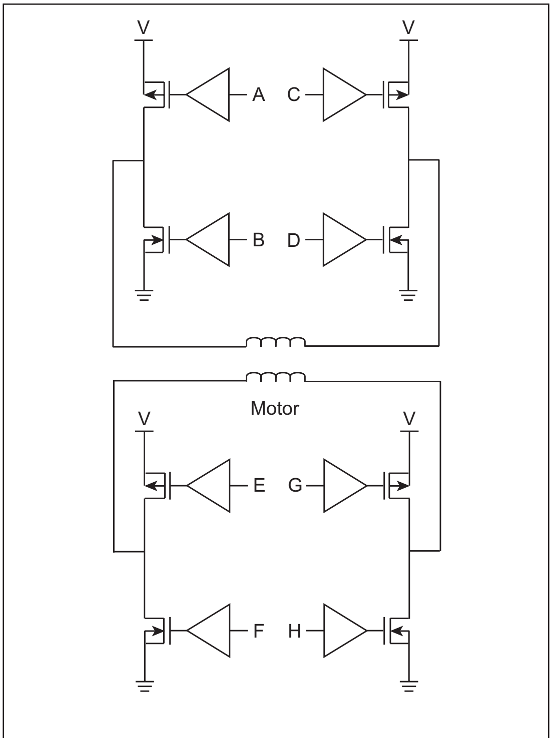


Figure 3-3: Unipolar Motor (4 Low Side Switches)



01-04 are outputs from a PIC® MCU or dsPIC® DSC.

Figure 3-4: Bipolar Motor (4 Half-Bridges)



A-H are digital outputs from a PIC® MCU or dsPIC® DSC.

TIP #5 Writing a PWM Value to the the CCP Registers With a Mid-Range PIC® Microcontroller

The two PWM LSb’s are located in the CCPCON register of the CCP. This can make changing the PWM period frustrating for a developer. Example 5-1 through Example 5-3 show three macros written for the mid-range product family that can be used to set the PWM period. The first macro takes a 16-bit value and uses the 10 MSb’s to set the PWM period. The second macro takes a 16-bit value and uses the 10 LSb’s to set the PWM period. The last macro takes 8 bits and sets the PWM period. This assumes that the CCP is configured for no more than 8 bits.

Example 5-1: Left Justified 16-Bit Macro

```
pwm_tmp    equ xxx  ;this variable must be
                    ;allocated someplace
setPeriod  macro a  ;a is 2 SFR’s in
                    ;Low:High arrangement
                    ;the 10 MSb’s are the
                    ;desired PWM value
 RRF       a,w      ;This macro will
                    ;change w
 MOVWF     pwm_tmp
 RRF       pwm_tmp,w
 ANDLW     0x30
 IORLW     0x0F
 MOVWF     CCP1CON
 MOVF      a+1,w
 MOVWF     CCPR1L
```

Example 5-2: Right Justified 16-Bit Macro

```
pwm_tmp    equ xxx  ;this variable must be
                    ;allocated someplace
setPeriod  macro a  ;a is 2 bytes in
                    ;Low:High arrangement
                    ;the 10 LSb’s are the
                    ;desired PWM value
 SWAPF     a,w      ;This macro will
                    ;change w
 ANDLW     0x30
 IORLW     0x0F
 MOVWF     CCP1CON
 RLF       a,w
 IORLW     0x0F
 MOVWF     pwm_tmp
 RRF       pwm_tmp,f
 RRF       pwm_tmp,w
 MOVWF     CCPR1L
```

Example 5-3: 8-Bit Macro

```
pwm_tmp    equ xxx  ;this variable must be
                    ;allocated someplace
setPeriod  macro a  ;a is 1 SFR
 SWAPF     a,w      ;This macro will
                    ;change w
 ANDLW     0x30
 IORLW     0x0F
 MOVWF     CCP1CON
 RRF       a,w
 MOVWF     pwm_tmp
 RRF       pwm_tmp,w
 MOVWF     CCPR1L
```

TIP #1 Typical Ordering Considerations and Procedures for Custom Liquid Displays

1. Consider what useful information needs to be displayed on the custom LCD and the combination of alphanumeric and custom icons that will be necessary.
2. Understand the environment in which the LCD will be required to operate. Operating voltage and temperature can heavily influence the contrast of the LCD and potentially limit the type of LCD that can be used.
3. Determine the number of segments necessary to achieve the desired display on the LCD and reference the PIC Microcontroller LCD matrix for the appropriate LCD PIC microcontroller.
4. Create a sketch/mechanical print and written description of the custom LCD and understand the pinout of the LCD. (Pinout definition is best left to the glass manufacturer due to the constraints of routing the common and segment electrodes in two dimensions.)
5. Send the proposed LCD sketch and description for a written quotation to at least 3 vendors to determine pricing, scheduling and quality concerns.
   a) Take into account total NRE cost, price per unit, as well as any setup fees.
   b) Allow a minimum of two weeks for formal mechanical drawings and pin assignments and revised counter drawings.
6. Request a minimal initial prototype LCD build to ensure proper LCD development and ensure proper functionality within the target application.
   a) Allow typically 4-6 weeks for initial LCD prototype delivery upon final approval of mechanical drawings and pin assignments.
7. Upon receipt of prototype LCD, confirm functionality before giving final approval and beginning production of LCD.

> **Note:** Be sure to maintain good records by keeping copies of all materials transferred between both parties, such as initial sketches, drawings, pinouts, etc.

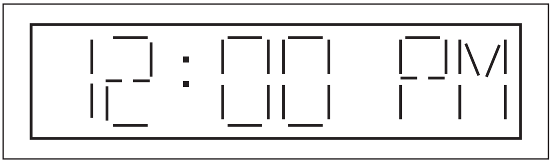
TIP #2 LCD PIC® MCU Segment/ Pixel Table

Table 2-1: Segment Matrix Table

Multiplex Commons	Maximum Number of Segments/Pixels					Bias
	PIC16F913/ 916	PIC16F914/ 917	PIC16F946	PIC18F6X90 (PIC18F6XJ90)	PIC18F8X90 (PIC18F8XJ90)	
Static (COM0)	15	24	42	32/ (33)	48	Static
1/2 (COM1: COM0)	30	48	84	64/ (66)	96	1/2 or 1/3
1/3 (COM2: COM0)	45	72	126	96/ (99)	144	1/2 or 1/3
1/4 (COM3: COM0)	60	96	168	128/ (132)	192	1/3

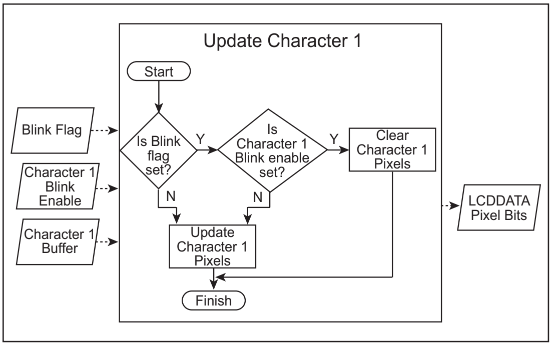
This Segment Matrix table shows that Microchip's 80-pin LCD devices can drive up to 4 commons and 48 segments (192 pixels), 64-pin devices can drive up to 33 segments (132 pixels), 40/44 pin devices can drive up to 24 segments (96 pixels) and 28-pin devices can drive 15 segments (60 segments).

Figure 11-1: Common Clock Application



Fortunately, blinking is quite easy to implement. There are many ways to implement a blinking effect in software. Any regular event can be used to update a blink period counter. A blink flag can be toggled each time the blink period elapses. Each character or display element that you want to blink can be assigned a corresponding blink enable flag. The flowchart for updating the display would look like:

Figure 11-2: Updating Display Flowchart



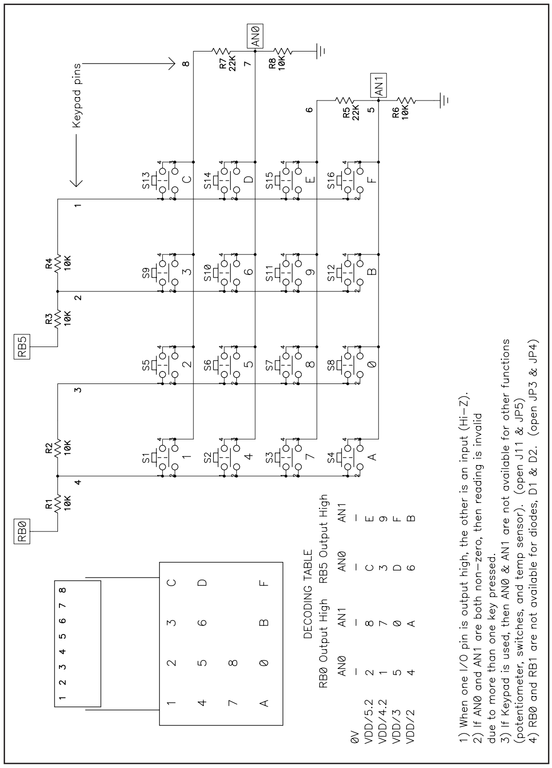
TIP #12 4 x 4 Keypad Interface that Conserves Pins for LCD Segment Drivers

A typical digital interface to a 4 x 4 keypad uses 8 digital I/O pins. But using eight pins as digital I/Os can take away from the number of segment driver pins available to interface to an LCD.

By using 2 digital I/O pins and 2 analog input pins, it is possible to add a 4 x 4 keypad to the PIC microcontroller without sacrificing any of its LCD segment driver pins.

The schematic for keypad hook-up is shown in Figure 12-1. This example uses the PIC18F8490, but the technique could be used on any of the LCD PIC MCUs.

Figure 12-1: Keypad Hook-up Schematic

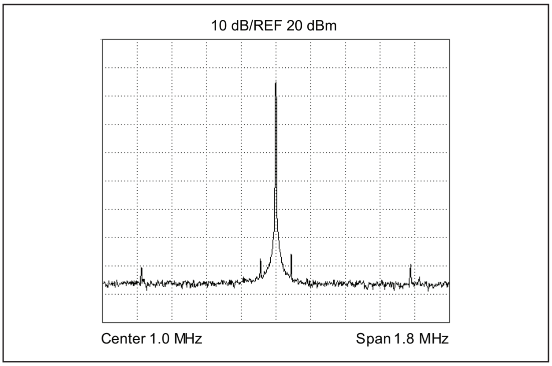


TIP #4 Creating a Dithered PWM Clock

In order to meet emissions requirements as mandated by the FCC and other regulatory organizations, the switching frequency of a power supply can be varied. Switching at a fixed frequency produces energy at that frequency. By varying the switching frequency, the energy is spread out over a wider range and the resulting magnitude of the emitted energy at each individual frequency is lower.

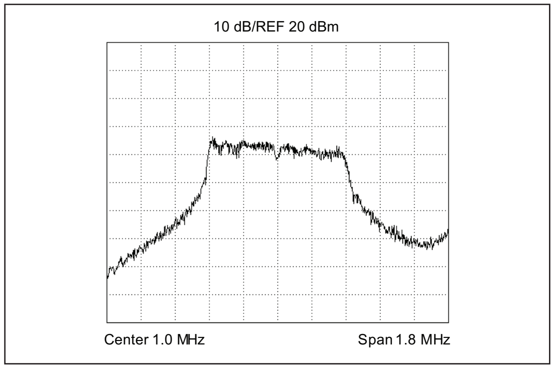
The PIC10F200 has an internal 4 MHz oscillator. A scaled version of oscillator can be output on a pin (Fosc/4). The scaled output is 1/4 of the oscillator frequency (1 MHz) and will always have a 50% duty cycle. Figure 4-1 shows a spectrum analyzer shot of the output of the Fosc/4 output.

Figure 4-1: Spectrum of Clock Output Before Dithering



The PIC10F200 provides an Oscillator Calibration (OSCCAL) register that is used to calibrate the frequency of the oscillator. By varying the value of the OSCCAL setting, the frequency of the clock output can be varied. A pseudo-random sequence was used to vary the OSCCAL setting, allowing frequencies from approximately 600 kHz to 1.2 MHz. The resulting spectrum is shown in Figure 4-2.

Figure 4-2: Spectrum of Clock Output After Dithering



By spreading the energy over a wider range of frequencies, a drop of more than 20 dB is achieved.

Example software is provided for the PIC10F200 that performs the pseudo-random sequence generation and loads the OSCCAL register.

TIP #8 Transformerless Power Supplies

When using a microcontroller in a line-powered application, such as the IR remote control actuated AC switch described in Tip #9, the cost of building a transformer-based AC/DC converter can be significant. However, there are transformerless alternatives which are described below.

Capacitive Transformerless Power Supply

Figure 8-1: Capacitive Power Supply

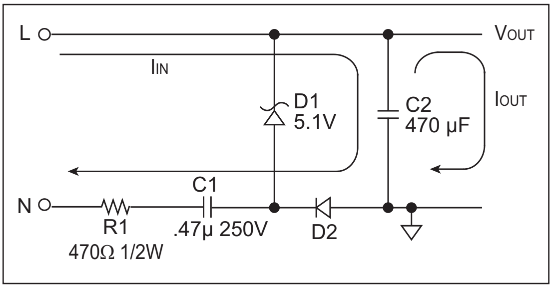


Figure 8-1 shows the basics for a capacitive power supply. The Zener diode is reverse-biased to create the desired voltage. The current drawn by the Zener is limited by R1 and the impedance of C1.

Advantages:

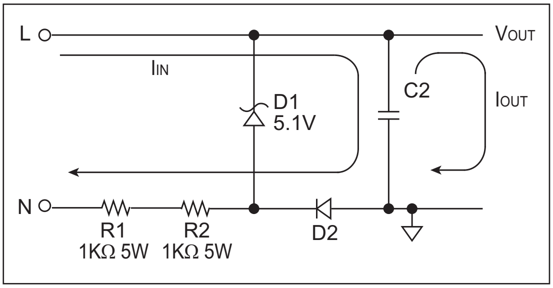
- Significantly smaller than a transformer-based power supply
- Lower cost than a transformer-based or switcher-based power supply
- Power supply is more efficient than a resistive transformerless power supply

Disadvantages:

- Not isolated from the AC line voltage which introduces safety issues
- Higher cost than a resistive power supply because X2 rated capacitors are required

Resistive Power Supply

Figure 8-2: Resistive Power Supply



The resistive power supply works in a similar manner to the capacitive power supply by using a reversed-biased Zener diode to produce the desired voltage. However, R1 is much larger and is the only current limiting element.

Advantages:

- Significantly smaller than a transformer-based power supply
- Lower cost than a transformer-based power supply
- Lower cost than a capacitive power supply

Disadvantages:

- Not isolated from the AC line voltage which introduces safety issues
- Power supply is less energy efficient than a capacitive power supply
- More energy is dissipated as heat in R1

More information on either of these solutions, including equations used for calculating circuit parameters, can be found in AN954, “*Transformerless Power Supplies: Resistive and Capacitive*” (DS00954) or in TB008, “*Transformerless Power Supply*” (DS91008).

TIP #20 Compensating Sensors Digitally

Many sensors and references tend to drift with temperature. For example, the MCP9700 specification states that its typical is ±0.5°C and its max error is ±4°C.

Figure 20-1: MCP9700 Accuracy

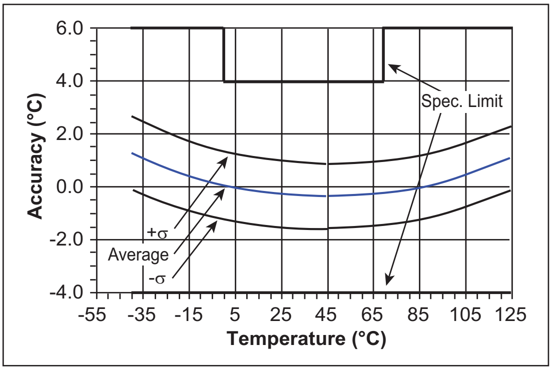


Figure 20-1 shows the accuracy of a 100 sample lot of MCP9700 temperature sensors. Despite the fact that the sensor’s error is nonlinear, a PIC microcontroller (MCU) can be used to compensate the sensor’s reading.

Polynomials can be fitted to the average error of the sensor. Each time a temperature reading is received, the PIC MCU can use the measured result and the error compensation polynomials to determine what the true temperature is.

Figure 20-2: MCP9700 Average Accuracy After Compensation

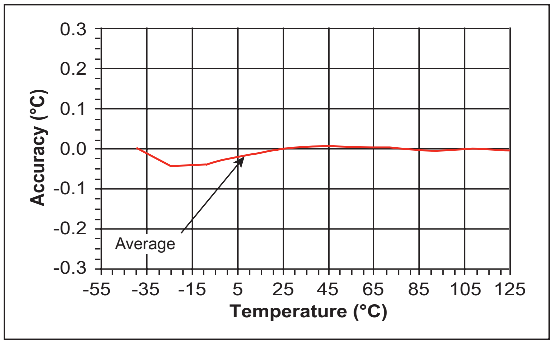


Figure 20-2 shows the average accuracy for the 100 sample lot of MCP9700 temperature sensors after compensation. The average error has been decreased over the full temperature range.

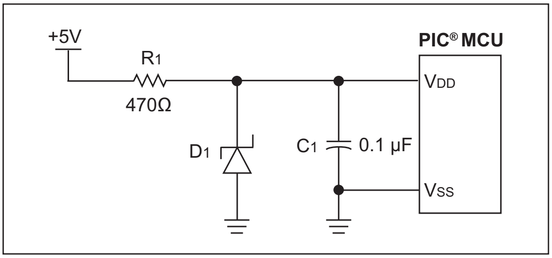
It is also possible to compensate for error from voltage references using this method.

For more information on compensating a temperature sensor digitally, refer to AN1001, “*IC Temperature Sensor Accuracy Compensation with a PIC Microcontroller*” (DS01001).

TIP #2 Low-Cost Alternative Power System Using a Zener Diode

Details a low-cost regulator alternative using a Zener diode.

Figure 2-1: Zener Supply



A simple, low-cost 3.3V regulator can be made out of a Zener diode and a resistor as shown in Figure 2-1. In many applications, this circuit can be a cost-effective alternative to using a LDO regulator. However, this regulator is more load sensitive than a LDO regulator. Additionally, it is less energy efficient, as power is always being dissipated in R1 and D1.

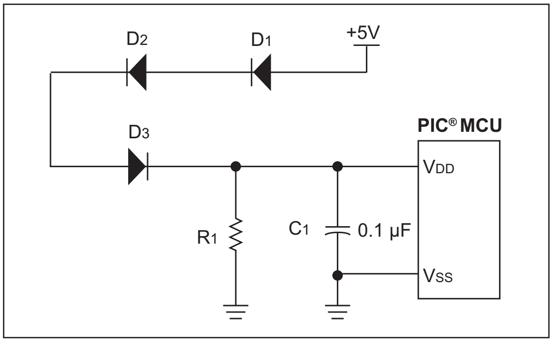
R1 limits the current to D1 and the PIC MCU so that V_{DD} stays within the allowable range. Because the reverse voltage across a Zener diode varies as the current through it changes, the value of R1 needs to be considered carefully.

R1 must be sized so that at maximum load, typically when the PIC MCU is running and is driving its outputs high, the voltage drop across R1 is low enough so that the PIC MCU has enough voltage to operate. Also, R1 must be sized so that at minimum load, typically when the PIC MCU is in Reset, that V_{DD} does not exceed either the Zener diode's power rating or the maximum V_{DD} for the PIC MCU.

TIP #3 Lower Cost Alternative Power System Using 3 Rectifier Diodes

Figure 3-1 details a lower cost regulator alternative using 3 rectifier diodes.

Figure 3-1: Diode Supply



We can also use the forward drop of a series of normal switching diodes to drop the voltage going into the PIC MCU. This can be even more cost-effective than the Zener diode regulator. The current draw from this design is typically less than a circuit using a Zener.

The number of diodes needed varies based on the forward voltage of the diode selected. The voltage drop across diodes D1-D3 is a function of the current through the diodes. R1 is present to keep the voltage at the PIC MCUs V_{DD} pin from exceeding the PIC MCUs maximum V_{DD} at minimum loads (typically when the PIC MCU is in Reset or sleeping). Depending on the other circuitry connected to V_{DD}, this resistor may have its value increased or possibly even eliminated entirely. Diodes D1-D3 must be selected so that at maximum load, typically when the PIC is running and is driving its outputs high, the voltage drop across D1-D3 is low enough to meet the PIC MCUs minimum V_{DD} requirements.

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