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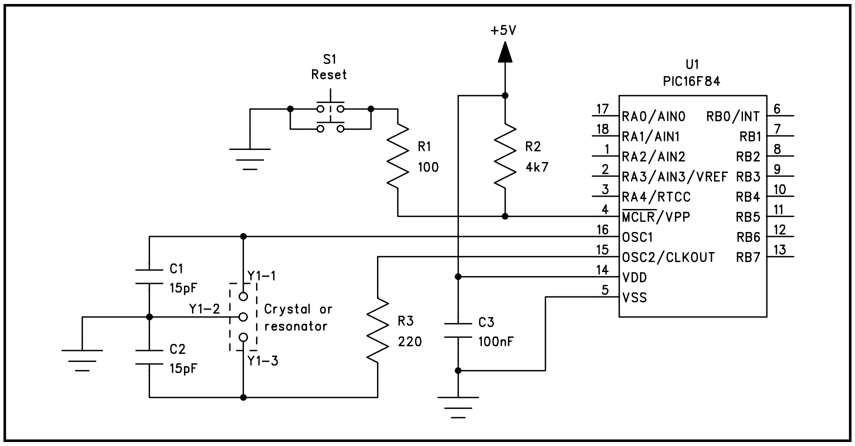
Beginner Project 1

Basic Crystal Oscillator Circuit

The function of an oscillator circuit is to provide an accurate and stable periodic clock signal to a microcontroller. The frequency of this clock signal can range from a few kilohertz to tens of megahertz and determines how quickly the microcontroller executes its instructions.

Most microcontrollers include a clock driver circuit which is designed to drive a quartz crystal into oscillation. The clock driver circuitry built into the PICmicro family is very flexible and allows for four different clocking options: clock signal supplied from another oscillator, an R-C clock (based on a resistor-capacitor charging time constant), a ceramic resonator, or a crystal oscillator.

An R-C clock circuit is the simplest but does not provide accurate timing since both resistor and capacitor values can vary greatly with temperature. Crystal oscillator and ceramic resonator-based clock circuits provide the most stable and accurate timebases, and require only a few extra parts than a simple R-C oscillator (see the schematic diagram, above).



This schematic diagram illustrates both the clock oscillator and reset circuits.

The clock circuit consists of capacitors C1 and C2, a quartz crystal or ceramic resonator Y1, and a series resistor, R3. The values of capacitors C1 and C2 is determined by both the clock speed at which you intend to run the PICmicro, and by the selection of a quartz crystal or a ceramic resonator as the clock source. Use the table as a guide to select the appropriate capacitors.

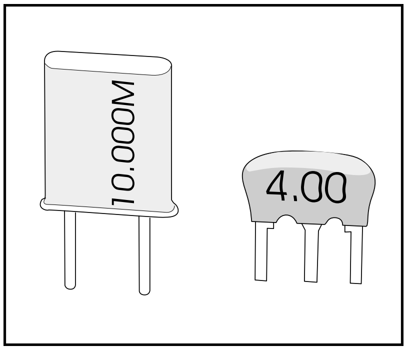
When the capacitance of C1 or C2 is shown as a range of values, select a higher capacitance for lower frequencies of operation, and a lower capacitance for higher clock frequencies. For example, when using the XT oscillator mode with a 100 kHz quartz crystal, select a value of C1 close to 30 pF and a value of C2 close to 300 pF for the best performance.

Oscillator Type	Frequency Range	C1	C2
XT - Resonator	1 - 4 MHz	20-330 pF	20-330 pF
HS - Resonator	8 MHz	20-200 pF	20-200 pF
LP - Crystal	32 - 200 kHz	15 pF	15 pF
XT - Crystal	100 kHz - 1 MHz	15-30 pF	15-300pF
HS - Crystal	2 - 20 MHz	15 pF	15 pF

LP is low power mode, XT is a regular oscillator, and HS is high speed mode.

Series resistor R3 is required for some types of crystals in HS or XT mode. Including R3 with crystals that do not require a series resistor will not degrade the performance of the oscillator circuit. A low value of resistance, up to a few hundred ohms, will keep the clock driver circuit in the PICmicro from overdriving the crystal.

Selecting the Components



A typical crystal (left) and resonator.

Quartz crystals and ceramic resonators are similar, but have some physical differences. As shown in the diagram, quartz crystals are typically mounted in a hermetically sealed metal case with two wire leads protruding from the bottom. Sometimes crystals may have a third ground lead soldered or welded to the top of the metal can. Grounding the pin on the metal can helps to both stabilize the crystal, lessening the impact of mechanical shock, as well as reduces RF emissions.

Select a quartz crystal specified as a microprocessor crystal, rather than a tuning crystal for a radio. Typically, these are stocked in common frequencies by most large electronic distributors.

Ceramic resonators are usually produced in the form of molded or dipped parts with two or three wire leads. The center wire, if present, connects to the circuit ground.

Both quartz crystals and ceramic resonators are non-polarized electronic devices and can be installed in the oscillator circuit in either orientation.

Lastly, the type of resistor and capacitors chosen for the circuit are not critical. Any ceramic or monolithic capacitor of the suggested value should work, as should any typical ¼ watt metal or carbon film resistor.

Building the Oscillator

A few general precautions should be observed when building the oscillator circuit. Since the clock oscillator is typically the source of the fastest signals, and potentially, the major source of RF emissions in a circuit, good design practice dictates that all clock circuit signal lengths should be kept as short as possible. A good, low impedance ground return wire from capacitors C1 and C2 to the circuit ground is also necessary.

Some PICmicros, like the PIC16C711, use the pins adjacent to the clock oscillator circuit as analog inputs. For accurate analog-to-digital conversion it is especially important to minimize the length of any clock oscillator signal wires running in parallel with the analog input lines. Ideally, separate the analog signal lines from any digital signals by using a ground wire as a shield between all analog and digital wiring.

Programming the Clock

Before you download your program into a PICmicro, you must select the appropriate clock oscillator fuse settings. These settings tell the PICmicro which of the four clock oscillator options to use. The oscillator fuse settings are most commonly set by the downloading software, but some assemblers allow you to specify the oscillator type in your source code. Make sure that you know how to select the oscillator before programming your microcontroller.

The Reset Circuit

A real reset circuit is not necessary in order for a PICmicro to function in a circuit. The only component required to run a PICmicro, other than those parts that make up the oscillator circuit, is a pull-up resistor connected to the MCLR/Vpp pin. In the schematic diagram, R2 functions as the pullup resistor. If you omit the pull-up resistor, your PICmicro will remain in reset (clear) mode on power-up, and will not execute its program.

Resistor R1 and pushbutton switch S1 make up an actual reset circuit. When S1 is pressed, it completes a low impedance connection from the MCLR/Vpp pin to ground, forcing the PICmicro into reset (clear) mode. Resistor R1 is optional, and is used to limit the current on the MCLR/Vpp pin to prevent a condition called latch-up—in which the input circuit of a CMOS chip can become 'stuck'. Electrostatic discard (ESD) from a person touching the reset switch could potentially cause latch-up.

S1 is not two pushbutton switches as the schematic seems to indicate. We use a small pcb-mounted pushbutton switch with four legs in our circuits—that's why the one in the schematic is shown with four circles attached to wires.

There is one last part in the basic oscillator and reset circuit. Capacitor C3 is a decoupling capacitor which forms part of the power supply circuit.

The Power Supply

An electronic circuit is only as stable as its power supply. Capacitor C3 is a decoupling capacitor which is used to reduce ringing and ground-bounce on the power supply lines. In other words, C3 works to clean up any voltage fluctuations at the power supply pins of the PICmicro. To be most effective, it is important to mount C3 as close to the PICmicro power supply pin (Vdd) as possible.

The schematic diagram on the last page of this project sheet shows a simple regulator circuit that will produce a five volt output from any input voltage between approximately eight and twenty volts (it's shown with a 9V source attached).

U2 is a 7805 three-terminal voltage regulator IC. It works by actively maintaining a five volt output independent of the output current. The difference between the output voltage (5V) and the input voltage is converted to heat. The higher the input voltage, the hotter U2 will get. You may need to add a heat sink to U2 if you have a high input voltage, or a high output current.

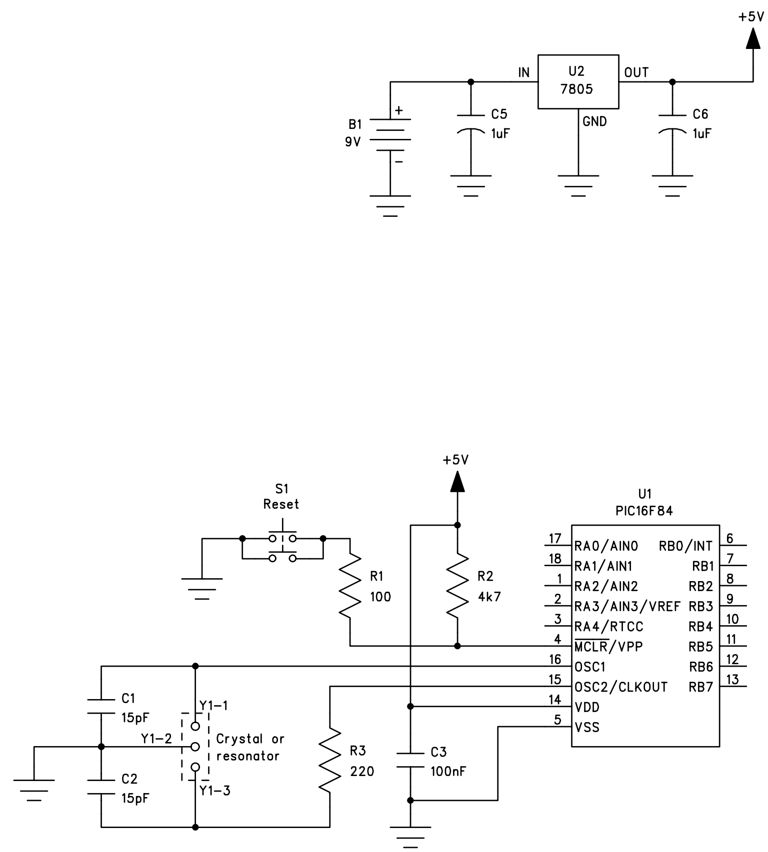
Capacitors C5 and C6 are input and output filter capacitors for the voltage regulator. C5 may not be necessary if a battery is used to power the circuit, and as long as the battery wires are kept short. Capacitor C6 is important as an output filter capacitor for the regulator.

If you wish to add other circuits to the voltage regulator, try to run a separate set of wires from your new circuit back to the +5V and ground common connections at C6. Remember to add a small decoupling capacitor, like C3, across the power supply leads of any active ICs in the circuits that you add.

Project Summary

This project sheet has examined the components necessary to support a PICmicro in a simple microcontroller circuit. Start with the clock oscillator design by determining the clock speed at which to run the PICmicro. The clock speed you choose may depend on the requirements of your application. Use the chart on the first page to select the components for the clock oscillator circuit. Next, determine if your circuit needs user reset capability. If not, simply use a pull-up resistor on the MCLR pin to get the PICmicro going when power is applied. Otherwise, add the reset pushbutton to the MCLR line. Last, make sure that your project has a regulated five volt DC source for trouble-free operation. Once you put all of the parts together, you'll have a basic PICmicro circuit ready to program.

Notes:



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