



# Power Considerations

Getting Started - Power Considerations

In this presentation we will examine the different Power considerations that should be taken into account when designing with Microchip's PICmicro<sup>®</sup> microcontrollers (MCUs).



# Power Considerations

- **Topics**

- Connections
- Operating Range
- Regulation
- Decoupling Capacitors
- Board Layout Concerns
- Current Consumption
- SLEEP Mode
- Power-On Reset

Getting Started - Power Considerations

In order to operate, the PICmicro MCU requires a source of power. This tutorial describes some basic power concerns when working with PICmicro MCUs. You will learn which pins are used for power and ground connections, operating voltage range, power supply regulation, decoupling capacitors, board layout issues, current consumption, SLEEP mode and Power-On Reset requirements. This presentation is intended to give you a brief overview of issues relating to PICmicro MCU power requirements, rather than being a comprehensive guide to power supply implementation.



## Power Considerations

- Power connections for PICmicro<sup>®</sup> MCUs
  - VSS
    - Commonly referred to as common, ground, or 0 volts
  - VDD
    - Positive voltage with respect to VSS
    - Typically +5 volts
    - Can range from +2 to +5.5 volts depending upon application and device.

Getting Started - Power Considerations

On every PICmicro MCU there is at least one VSS pin and at least one VDD pin that need to be properly connected in order to power the microcontroller.

The name VSS comes from the voltage applied to the source of an N channel FET device. On an N channel device the source will be at a lower voltage potential than the drain. Generally VSS is referred to as common or ground.

The name VDD, refers to the voltage applied to the drain of an N channel device. On an N channel device the drain is at a higher voltage potential than the source. In the same manner, VDD is at a higher voltage potential than VSS. Typically VDD is +5 Volts greater potential than VSS. On PICmicro MCUs, the allowed voltage applied to VDD with respect to VSS can range from +2.0V to +5.5 Volts. Refer to the individual device datasheets for specific operating Voltage ranges.



## Power Considerations

- Multiple VSS and VDD pins
  - All VDD and VSS pins must be connected for proper operation.

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Many PICmicro MCUs have more than one VSS or VDD pin. This is common on devices with higher pin counts. These pins are generally connected internally but through a finite impedance. To insure proper operation, all VSS and VDD pins need to be properly connected externally.



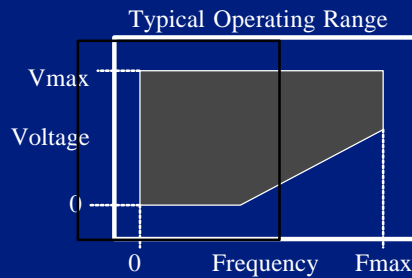
## Power Considerations

- AVSS and AVDD
  - Ground and power connections dedicated to analog sections
  - All AVSS and AVDD pins must be properly connected for proper operation.
  - Provided to allow quieter source for more accurate analog operations.

Getting Started - Power Considerations

Some PICmicro MCUs feature analog VSS and analog VDD as separate ground and power connections dedicated to the analog sections of the device. Separating the digital from the analog power and ground can reduce noise in the analog sections of the microcontroller. Reducing the noise to the analog sections will typically allow for more accurate A/D conversions. Analog VSS and analog VDD must be properly connected and must typically be within 0.3 volts of VSS and VDD respectively, for proper operation.

- Operating Voltage Range
  - Range is specified in Electrical Characteristics section of the Datasheets
  - Varies depending upon part and operating frequency



The operating voltage range is specified in the datasheet for the specific device. The actual range will vary depending upon the part number and the operating frequency. Generally, higher frequency operation requires a higher operating voltage.



## Power Considerations

- Low Voltage Versions
  - Designated by LC or LF
  - Same datasheet as C and F versions
  - Tested for lower voltage and current requirements at typically lower operating frequencies

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Typically PICmicro MCUs are intended to run at a VDD of 4.5 to 5.5 Volts. Low power versions of these are available that will operate off of a VDD as low as 2.0 Volts. These low voltage parts are designated by an LC in the part number rather than a C, or an LF rather than an F. They are fundamentally the same as their standard counterparts but have been tested for operation at lower operating voltages. The low voltage devices are in the same datasheet as the standard devices. The differences for the devices are described in the Electrical Characteristics section of the datasheet.



## Power Considerations

- Power Supply
  - Bulk Capacitance
    - Low noise
  - Voltage Regulator
    - Low noise
    - Good stability
  - Battery Power
    - Low noise
    - Voltage declines during discharge

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Bulk capacitance on a rectified AC signal can reduce noise on VDD but will not guarantee a stable voltage level. Use of a power supply regulator will reduce the noise and also increase the stability of VDD. This will prevent moderate changes in the incoming voltage from damaging the device due to excessive voltage on VDD. In addition, regulation of VDD will insure more stable logic levels. In order to obtain consistent results when using any analog peripherals, power supply regulation is a requirement. A battery power source is generally low in noise but will decline in voltage level as it discharges. The designer must take this into account as a design consideration. No matter what power supply type is used, the possible voltage range of the power supply must be within the allowed voltage range of the PICmicro MCU.





## Power Considerations

- Decoupling Capacitors
  - Provide low impedance for high frequency pulses
  - Reduce noise radiated on power traces
  - Place close to each power pin
  - 0.1uF ceramic generally acceptable

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Because of the high frequency power demands of a microcontroller, it is recommended that bypass capacitors be placed at the VDD and AVDD pins. These bypass capacitors provide a low impedance path to ground for the high frequency current demands of the microcontroller. This will also reduce the amount of noise radiated by the power traces. Ideally, a ceramic bypass capacitor of about 0.1uF is placed as close as practically possible to each power pin on the microcontroller



## Power Considerations

- Ground and Power traces
  - Ideally use a power and ground plane
  - If this is not possible
    - Make traces as wide as practically possible
    - Route power and ground together
    - Don't create a loop with power and ground traces

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Even though the current draw of a microcontroller is typically low, the short term current demands can be much higher. Ideally the power and ground are complete planes of copper. If a multi-layer board is not possible, make the power and ground tracks as wide as is practically possible. Use of a FILL feature after routing all traces can increase the width of power and ground traces to use all available space. It is also best to route power and ground together and not in a large loop around the board perimeter. Routing traces in a loop around the board can increase the boards susceptibility to external fields as well as increase the generation of them. One of the best methods for power and ground routing is a star configuration where the center of the star is the main source of power.



## Power Considerations

- Operating Current
  - Higher frequency, higher current
  - Higher voltage, higher current
  - Variation over temperature

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The current consumed by an operating PICmicro MCU varies with the frequency of operation and the power supply voltage. The higher the frequency of operation, the more current the PICmicro MCU will consume. In addition, the higher the power supply voltage the more current will be consumed. The operating current specifications for a device can be found in the DC Characteristics section of the device datasheet.

The current consumed will also vary over temperature, but this relationship is non-linear. If current consumption is a critical design requirement, it should be tested over the temperature range of the application.



## Power Considerations

- SLEEP Mode
  - Lowest current consumption mode
  - Code not being executed during SLEEP
  - For lowest current consumption configure pins
    - as inputs and connect to VSS or VDD
    - or as outputs and leave unconnected
  - Power down specification does not include any current sourced or sunk by I/O pins

Getting Started - Power Considerations

To conserve power, the PICmicro MCU can be put into a SLEEP mode. This is especially useful in battery powered applications. In this mode, the oscillator circuit is turned off and the device stops executing code. In order to obtain the lowest possible current consumption in SLEEP mode, all unused I/O pins should either be configured as inputs and connected to VDD or VSS, or configured as outputs and left unterminated. The power down current specification does not include current sourced or sunk by any I/O pins. In addition, modules such as the Watchdog timer and the Brown-Out Detection circuitry will increase the amount of current draw. The power down current specifications and the increases due to enabling Brown-Out Detection or Watchdog timer circuitry are given in the DC Characteristics section of the device datasheet.



## Power Considerations

- SLEEP Mode
  - Sources of wake up from sleep
    - Watchdog timer timeout
    - Some interrupts
  - Wake up latency
    - If crystal oscillator 1024 cycles counted before wake up

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A number of conditions can wake the device from SLEEP. These include Watchdog timer timeout, and some interrupts. After waking from SLEEP mode, the oscillator will be re-enabled and if it is in RC oscillator mode, the device will begin executing code. If a crystal oscillator is used, 1024 clock cycles will be counted before the code begins executing.



## Power Considerations

- Power-On Reset
  - Initializes most SFRs
  - Must meet minimum VDD level
  - Must meet minimum VDD rise rate

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The PICmicro device will generate an internal Power-On Reset pulse if the level and rise rate of VDD meet or exceed the specified rise rate. The minimum rise time specification is given in the DC Characteristics section of the datasheet. The Power-On Reset pulse will initialize most special function registers to known values. There are a number of registers that are not initialized by other resets but are initialized by a Power-On Reset. For this reason it is important to meet the minimum rise rate specifications to insure a valid Power-On Reset pulse. If this is not possible, then an external reset circuit on the MCLR pin will help, but will not be able to duplicate the performance of the internal Power-On Reset circuitry. The initialized states of the special function registers are described in the Special Function register section of the data sheet.



## Power Considerations

**For further information on  
Power considerations, please refer to  
the specific device datasheets.**

Getting Started - Power Considerations

This concludes the brief examination of PICmicro MCU Power considerations.

Additional information on this topic can be found in the following literature available in pdf format on the Website:

*Mid-Range Family Reference Manual* (<http://www.microchip.com/14010/helper.htm>)

*AN522 "Power-up Considerations"* (<http://www.microchip.com/14010/helper.htm>)

*AN607 "Power-up Trouble Shooting"* (<http://www.microchip.com/14010/helper.htm>)

For additional information, please see the datasheet for the specific device being used. Datasheets, Application Notes, Seminar and Workshop schedules, and other helpful information can be found on the Microchip Website.



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