Wall Industries, Inc.

Wall Industries SMPS and Microcontrollers

Introduction

Wall Industries' commitment to the latest technologies is evident in its recent announcement to add microcontrollers to their already advanced designs. The purpose of this white paper is to educate Wall's customers of the uses and capabilities on modern microcontrollers when used in power electronics products. We will start by describing what exactly a microcontroller is; what some of its capabilities are; site some examples of microcontroller uses in power electronics; and, finally, the functions of the microcontroller. Wall Industries' TP Wide Input Range Isolated Converter will be examined as an example.

Microcontrollers

Microcontrollers are programmable devices that can perform digital processing and replace analog circuitry. Unlike PC microprocessors, micro-controllers are mostly self-contained in that they require no external parts such as memory or oscillators. Their relatively low-cost and numerous internal peripherals make them ideal to replace analog circuitry in power supplies. Furthermore, once the microcontroller is embedded in the design, new capabilities and flexibilities can be realized. Also, due to continuous performance improvements, some microcontrollers now can be used in applications that once required high-end digital signal processors (DSP's).

Practical Uses in Power Supplies

There are many practical uses of microcontrollers in power supplies. The uses range from mimicking existing analog circuitry to adding never -before-available features to the power supply. The simplest use is in replacing supervisory control circuits. For example, the micro can control the behavior of the power supply during start-up - including when to begin synchronous rectification to prevent back-bias glitches. The micro can monitor the enable pin and react appropriately particularly when the pin is used after fault conditions or during start-up. Handling these corner conditions can add costs to a power supply without a microcontroller. With respect to fault conditions, microcontrollers are particularly agile at handling the various protection requirements of a modern power supplies (e.g. resettable latch, limited hiccup, combination faults).

Microcontrollers can also get involved in the feedback control mechanisms of the power supply. While it would require a very fast microcontroller for a typical converter to have complete digital control, there are many hybrid options that make much more sense. For example, the analog PWM can be digitally controlled inside the microcontroller. This would allow the PWM to be easily shut down when required, its frequency be digitally controlled (even modulated for noise reduction pusposes), or give fault information directly to the controller firmware. Other alternates to complete digital control include control element tuning and hybrid control where the slower outer voltage loop is digital but the fast inner current loop is still analog.

While microcontrollers can replace existing analog circuitry, they can also add some functions to a power supply that have normally been reserved for higher end systems due to cost considerations. Now with powerful in-expensive microcontrollers available, even the simplest converters can get advanced digital capabilities like communication and logging. These improvements are allowing computer systems to communicate with its power systems and gather information and control behavior. It is even possible now to log into a power supply to check its statistics.

Indirect Advantages

The advantage of adding microcontrollers to our products goes beyond the new capabilities that microcontrollers will now facilitate. While new features are important, solving issues associated with traditional design methods are critical. Adding microcontrollers can have several indirect advantages including cost, reliability, and flexibility.

Direct costs can be reduced because many analog components such as window detectors, comparators and latches can be replaced with a single microcontroller. Integrating many components into one increases reliability, but also saves board space. This extra board space can be used to save costs by producing a smaller product. It can also be used to improve the performance of the power supply by increasing current carrying copper or the size of the magnetics.

Since the software is flexible, a single design can accommodate several part types saving money. For example, one hardware design can handle positive or negative enable logic, latching or hiccup behavior. Custom behavior can be added with no added manufacturing costs.

Having a programmable micro also allows us to quickly meet changing customer requirements. Before using microcontrollers, a small change in a timing specification or recovery behavior would require a change in the bill of materials, PCB change or even a new design. Now many of the changes can be handled with only a firmware update. These changes are quicker, cheaper and can be performed on existing hardware either in the factory or sometimes in the customer's box.

Types and Capabilities

While there are many semiconductor manufacturers of microcontrollers (e.g. Atmel, Cypress Microsystems, Freescale Semiconductors, Texas Instruments), in the interest of brevity, we will focus now only on Microchip's PIC micro-controller line (www.microchip.com). The extensive PIC line microcontrollers can be roughly divided into three groups: basic, advanced and high-end. As the microcontroller capabilities increase and cost decreases each year, what functions are included in each of these categories changes. The following is a current snapshot.

One example shown in Figure 1 is a microcontroller in the basic category, the PIC10 series.

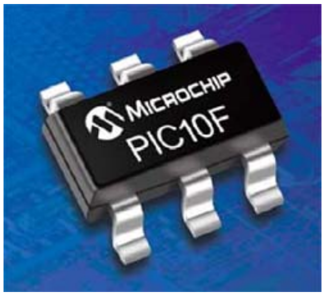

Figure 1 Example of Microcontroller in Basic Category

This small 6-pin SOT-23 device has many imbedded features that can easily replace some analog circuitry in a power supply. The microcontroller has a built-in RC clock for noise immunity, a watch -dog timer to guard against power glitch lock-ups, an internal comparator with reference and an analog to digital converter (ADC). This part is used in Wall's TP Wide Input Range Isolated Converter which we will discuss in the next section. Basic microcontrollers are usually small pin devices with an 8-bit core.

An example of a PIC microcontroller in advanced category is shown in Figure 2, the PIC 18 series.

Figure 2 Example of Microcontroller in Advanced Category

As the picture indicates, this microcontroller can give the power supply advanced communication capabilities such as a USB interface. Other examples of advanced microcontroller's communication features include other serial communication, I2C, SPI, and even Ethernet protocols like HTTP and SNMP. These advanced internal peripherals, larger memory, and pin count are what separate the advanced microcontrollers from the basic category.

Finally, high-end microcontrollers at Microchip include the 16 -bit dsPIC, shown in Figure 3, or the new 32-bit PIC32.

Figure 3 Example of Microcontroller in High-end Category

These powerful microcontrollers can perform the functions of a DSP, but at a fraction of the cost. Plus, since they are a microcontroller, using one of these devices required very few external parts. This is category that would be required for an all-digital control power supply. The advantages to all digital control depend on the application, but in some instances can give the power supply a performance edge under changing load conditions.

Case Study – TP Wide Input Range Isolated Supply

As a practical example of using a basic microcontroller in a power supply, consider Wall's new TP converter. The summary specifications for this industry standard half brick are:

- 18 – 75Vin
- Output voltages ranging from
- 1Vout to 24Vout
- High efficiency (>92%)
- Low assembley cost
- Industry compatible
    - Trim
    - Pin out
    - Height
    - Thermal design
    - Enable
    - Sensing
- 200W output power

A picture of the TP product with the microcontroller highlighted is shown in Figure 4.

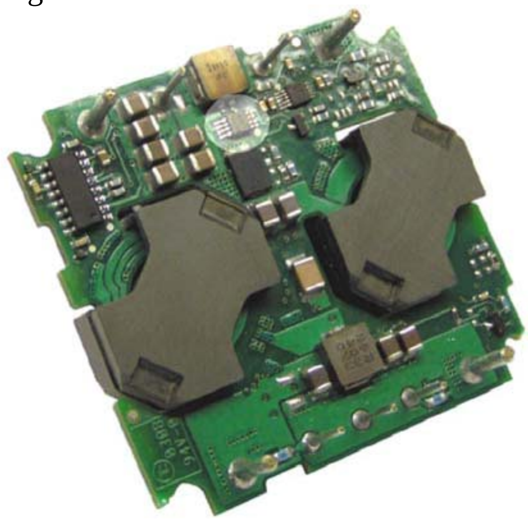

Figure 4 TP Half Brick with Microcontroller

To accomplish some of the basic supervisory controls, the product uses Microchip's 10F222 6-pin 8-bit micro-controller. The functions handled by the microcontroller are:

- Input Under Voltage Lockout
- Input Over Voltage Lockout
- Output Over Voltage Protection
- Over Temperature Protection
- Enable Pin Functionality

All these functions control whether the power supply is on or off. To control the converter, the microcontroller interfaces with the analog PWM integrated circuit. A block diagram of the microcontroller in this design is shown in Figure 5 and the usage of the six pins of the microcontroller shown in Table 1.

Of the six pins of the microcontroller, two are dedicated to power and ground. The remaining pins are fully configurable. In this application, during normal operation, three of the remaining pins are used as inputs (GP0, GP1, and GP3) and one is used as a digital output (GP2). To measure the input voltage and temperature, GP0 and GP1 use the Analog to Digital converter (ADC) inside the microcontroller. The enable pin of the converter is connected through some protection circuitry to the digital input pin (GP3).

During manufacturing, the micro-controller can be programmed with its firmware even after it has been installed on the board. This feature is called in-circuit programming. A special con-nector or test pads can be used for this function. Note that these in-circuit programming pins are not dedicated, and are used for normal functions during operation.

Conclusion

The TP converter is the first of many products we will be introducing that have been enhanced with micro-controllers. While the TP only utilizes a basic micro-controller, products with much more advanced features will soon be available.

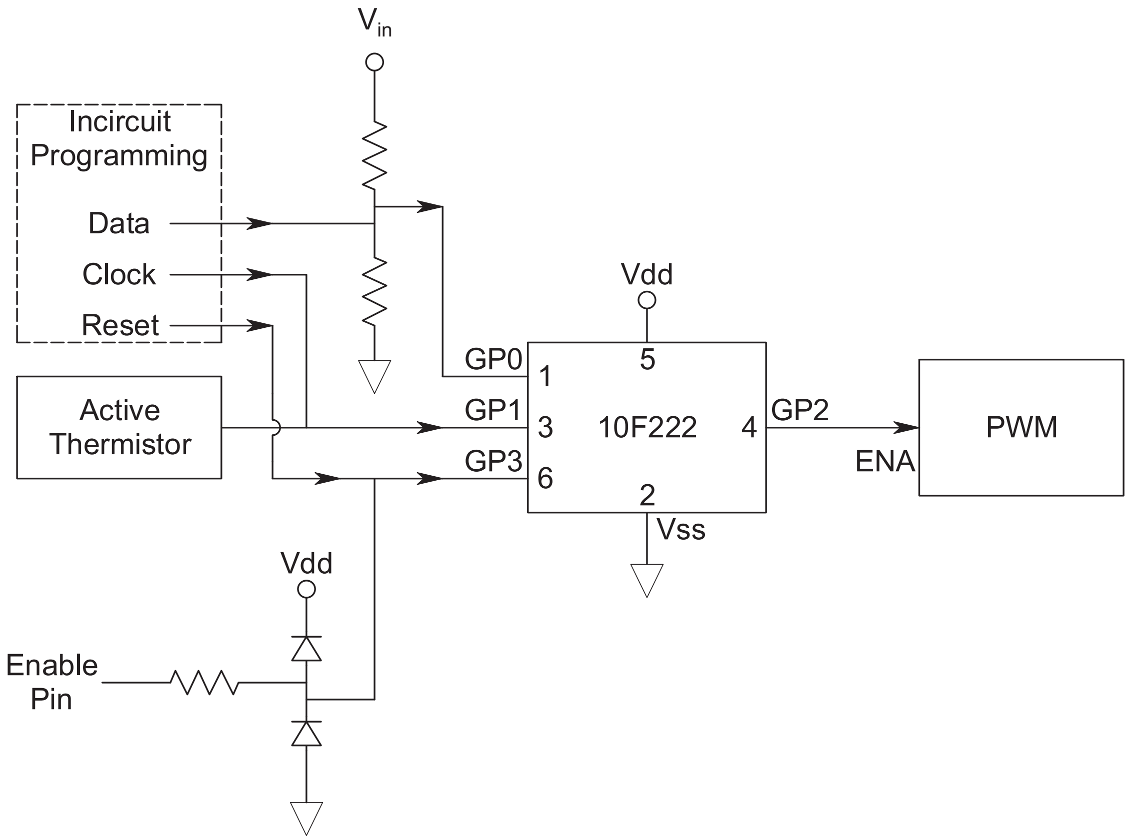

Table 1 Microcontroller Pins in TP Converter

Pin #	*Pin Name*	*Function(s)*	*Notes*
1	GP0	Measures Input Voltage	Voltage sampled using internal A/D
		Data in/out	Used for in-circuit programming
2	VSS	Ground	
3	GP1	Measures Temperature	Uses internal A/D to sample voltage of external active thermister IC. Uses internal A/D to sample voltage. Pin also used for in-circuit programming.
		Clock	Used for in-circuit programming
4	GP2	Power Supply On/Off	Pin is connected to the analog PWM enable pin
5	VDD	+5V Power	
6	GP3	Enable Pin Input	Signal is protected by external rail diodes before leaving converter. Pin also used for in-circuit programming.