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FEATURE ARTICLE

Brian Millier

Quad Bench Power Supply

The need for a bevy of equipment for building and testing presents a problem: how to deliver an adequate power supply while keeping workbench clutter to a minimum. Brian decided to tackle this classic engineering conundrum with a small, low-capacity quad bench power supply.

I hate to admit it, but my electronics bench is not a pretty sight, at least in the midst of a project anyway. Of course, I'm always in the middle of some project that, more often than not, contains two or three different projects in various stages of completion. To make matters worse, most of my projects involve microchips, which have to be programmed. Because I use ISP flash memory MCUs exclusively, it makes sense to locate a computer on my construction bench to facilitate programming and testing. To save space, I initially used my laptop's parallel port for MCU programming. It was only a matter of time before I popped the laptop's printer port by connecting it to a prototype circuit with errors on it.

Fixing my laptop's printer port would have involved replacing its main board, which is an expensive proposition. Therefore, I switched over to a desktop computer (with a $20 ISA printer port board) for programming and testing purposes. The desktop, however, took up much more room on my bench.

You can't do without lots of testing equipment, all of which takes up more bench space. Amongst my test equipment, I have several bench power supplies, which are unfortunately large because I built them with surplus power supply assemblies taken from older, unused equipment. This seemed like a good candidate for miniaturization.

At about the same time, I read a fine article by Robert Lacoste describing a high-power tracking lab power supply ("A Tracking Lab Power Supply," *Circuit Cellar* 139). Although I liked many of Robert's clever design ideas, most of my recent projects seemed to need only modest amounts of power. Therefore, I decided to design my own low-capacity bench supply that would be compact enough to fit in a small case. In this article, I'll describe that power supply.

MY WISH LIST

Even though I mentioned that my recent project's power demands were fairly modest, I frequently needed three or more discrete voltage levels. This meant lugging out a couple of different bench supplies and wiring all of them to the circuit I was building. If the circuit required all of the power supplies to cycle on and off simultaneously, the above arrangement was extremely inconvenient. In any event, it took up too much space on my bench.

I decided that I wanted to have four discrete voltage sources available. One power supply would be ground referenced. Two additional power supplies would be floating power supplies. Each of these would have the provision to switch either the positive or negative terminal to the nega-

Photo 1—*The ground-referenced power supply PCB also contains the SIMM100 MCU daughterboard. The IsoLoop isolators, being SMD components, are mounted on the bottom of the PCB and aren't in view.*

tive (ground) terminal of the ground-referenced supply, allowing for positive or negative output voltage. Alternately, these supplies could be left floating with respect to ground by leaving the aforementioned switch in the center position.

This arrangement allows for one positive and two positive, negative or floating voltage outputs. To round off the complement, I added Condor's commercial 5-V, 3-A linear power supply module, which I had on hand in my junk box. Table 1 shows the capabilities of the four power supplies.

I wanted to provide the metering of voltage and current for the three variable power supplies. The simultaneous voltage and current measurement of three completely independent power supplies seemed to indicate the need for six digital panel meters. Indeed, this is the path that Robert Lacoste used in his tracking lab supply.

I had used many of these DPM modules before, so I was aware of the fact that the modules require their negative measurement terminal to float with respect to the DPM's own power supply. I solved this problem in the past by providing the DPM module with its own independent power source. Robert solved it by designing a differential drive circuit for the DPM. Either solution, when multiplied by six, is not trivial. Add to this the fact that high-quality DPMs cost about $40 in Canada, and you'll see why I started to consider a different solution.

I decided to incorporate an MCU into the design to replace the six DPMs as well as six 10-turn potentiometers, which are also becoming expensive. In place of $240 worth of DPMs, I used three inexpensive dual 12-bit ADCs, an MCU, and an inexpensive LCD panel. The $100 worth of 10-turn potentiometers was replaced with three dual digital potentiometers and two inexpensive rotary encoders.

Using a microcontroller-based circuit basically allows you to control the bench supply with a computer for free. I have to admit that I decided to add the commercial 5-V supply module at the last minute; therefore, I didn't allow for the voltage or current monitoring of this particular supply.

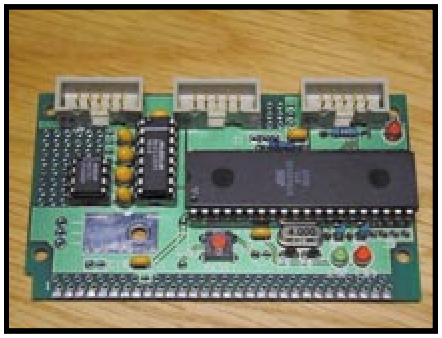

Photo 2—*I used a Lawicel SIMM100 module for the microcontroller and associated circuitry.*

THE ANALOG CORE

Although there certainly is a digital component to this project, the basic power supply core is a standard analog series-pass regulator design. I borrowed a bit of this design from Robert's lab supply circuit.

Basically, all three power supplies share the same design. The ground-referenced power supply provides less voltage and more current than the floating supplies. Thus, it uses a different transformer than the two floating supplies. The ground-referenced supply's digital circuitry (for control of the digital potentiometer and ADC) can be connected directly to the MCU port lines. The two floating supplies, in addition to the different power transformer, also need isolation circuitry to connect to the MCU.

Figure 1 is the schematic for the ground-referenced supply. As you can see, a 24VCT PCB-mounted transformer provides all four necessary voltage sources. A full wave rectifier comprised of D4, D5, and C5 provides the 16 V that's regulated down to the actual power supply output. Diodes D6, R10, C8, and Zener diode D7 provide the negative power supply needed by the op-amps.

A UA7805 regulator is used to drop the 16-V supply down to the 5 V needed for the digital potentiometer and ADC. Finally, an independent 5-V power supply for the MCU is provided by D3, C4, and U4, another UA7805 three-terminal regulator. Because I eventually added a 5-V, 3-A commercial power supply to the unit, I think it would have made more sense to run the MCU from that supply instead.

The series-pass element is an IRL520 power MOSFET that's driven by U1, which is configured as a unity-gain buffer. I had the IRL520 devices on hand, but I suspect that NPN Darlington transistors could have been used in their place with the advantage of a lower base drive voltage requirement.

Voltage regulation is performed by comparing a portion of the power supply output voltage with the B-section output of the digital potentiometer U6. A TL082, U3-B acts as a comparator for this purpose. The full-scale output of the digital potentiometer is 5 V, and the power supply output voltage is scaled down to this level by R5 and the potentiometer R10. Without any initialization from the MCU, the digital potentiometer presets itself to half scale, or 2.5 V at power-up. When testing this power supply, prior to connecting it to the MCU, potentiometer R10 is adjusted to provide an output voltage of 6.4 V at power-up. This gives a resolution of 50 mV per step of the digital potentiometer.

Current limiting is provided by comparator U3A and the A section of the digital potentiometer. Current monitor IC U2, which you'll learn more about later, provides a voltage that's proportional to the output current. Basically, comparator U3A compares a voltage proportional to current draw, with the current limit set point value programmed into the digital potentiometer, and throttles back the drive to the pass regulator when necessary.

The two sections of the TL082, acting as comparators, have their outputs connected to buffer U1's input via diodes D1 and D2. In combination with R1, these components provide a NOR function. To be precise, if either comparator's output goes low, the drive to the pass regulator (provided by R1) will be reduced until the over-voltage/current condition ceases.

Apart from the digital potentiometers replacing mechanical ones, this circuit is somewhat similar to that used by Robert in his lab power supply. You'll learn more about how I used the high-side current monitor circuit a little later.

Although Robert didn't mention any instability problems in his article, I experienced them myself as I was building this circuit. I found it necessary to use 0.01 capacitors (C2, C3) for feedback compensation on both comparators in order to eliminate RF oscillation on the power supply output under varying load conditions. I thought I could eliminate buffer U1 in my design because of the low current requirements of the MOSFET pass element; however, the diode NOR circuit seemed to produce RF oscillations on the power supply's output without this buffer in place.

The final part of the circuit is the metering portion. In place of the DPMs, I used a Microchip MCP3202, which is a dual 12-bit ADC. This ADC is inexpensive (it costs less than $3) and doesn't need an external reference. The fact that it uses an SPI interface really simplifies the isolation circuitry needed in the floating supplies.

Even though the MCP3202 can operate from 2.7 to 5.5 V, I chose to operate it from 5 V, because that regulated voltage was easy to provide with a UA7805. The disadvantage to this power supply voltage was that the ADC's full-scale input is also 5 V. Though the power supply's output voltage is scaled down to this range for the regulation circuitry, the current-monitoring circuitry converts current to a somewhat lower voltage. Despite the fact that the actual scaling differs between the floating and non-floating power supplies, the net result is that current resolution is only about 9 bits. This current resolution was sufficient for my purposes, however.

The MCP42010 dual digital potentiometer has a neat feature: it contains a Serial Out terminal. Using this feature, you can daisy-chain these devices and load many of them simultaneously, using only three control lines—CS, SCK, and SI (with the daisy-chained devices being fed from the previous device's SO line).

Although I needed only one dual potentiometer for each power supply, I used this feature to daisy-chain the MC3202 ADC device to the digital potentiometer, thereby eliminating one—the CS control line—for the nonessential ground-referenced supply. For the floating supplies, it allowed me to provide all of the necessary isolation in one device package, which was beneficial.

To protect against short circuits, I added a Raychem PolySwitch RXE075 resettable fuse, which limits short-circuit current to 750 mA. I did this

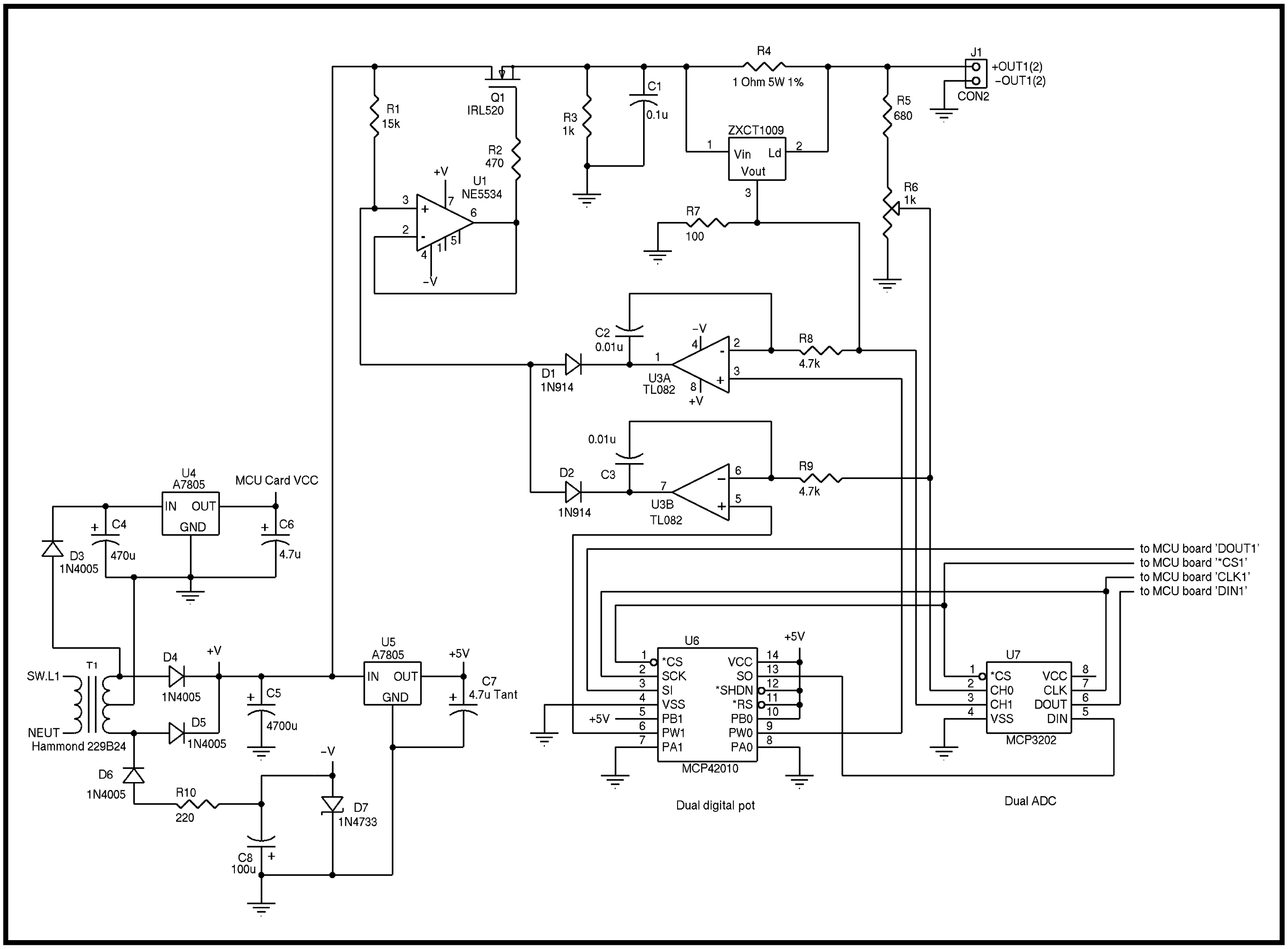

Figure 1—*The ground-referenced power supply includes an independent 5-V supply to run the microcontroller module.*

because the Zetex high-side current monitors need at least 2.5 V to operate properly. A direct short circuit would not provide this, and the current-limiting action would not work. The PolySwitch fuses more than function: they act as fuses and provide enough voltage drop during short-circuit conditions to allow the Zetex current monitors to operate.

Supply number	Voltage range	Current capacity	Notes
1	2.5–8 V	500 mA	Ground-referenced
2	2.5–15 V	300 mA	Bipolar or floating
3	2.5–15 V	300 mA	Bipolar or floating
4	5 V	3 A	Fixed logic supply, commercial module

Table 1—*As you can see, there are four power supplies. I've included all of the information you need to understand their capabilities.*

Although it isn't obvious from the schematic, I designed this power supply's PCB to include a 30-pin SIMM connector. The MCU module is a daughterboard on this PCB. Also, the two isolation chips that interface the MCU to the two floating power supplies are contained on this PCB. Photo 1 depicts the PCB and the backside of the MCU module. I'll describe both the MCU module and the isolation circuits later.

SEE IF IT FLOATS

I've explained in detail the ground-referenced power supply. There are only a few differences between it and the two floating power supplies; however, I've provided Figure 2 to show you these differences.

Where the ground-referenced supply was meant to provide 8 V at about 500 mA, the floating supplies were meant to provide higher voltages for powering analog circuits such as op-amps. I wanted at least a 15-V output, but a current capacity of 300 mA was deemed sufficient for my needs. I substituted a 34-V transformer for T1. It's the same size as the 24-V device used in the ground-referenced supply, which was handy because all three power supplies share a similar PCB layout.

The floating supplies need not include the 5-V regulated MCU power supply that was part of the ground-referenced supply. The value of the output voltage-scaling network is different from the ground-referenced supply. In this case, potentiometer R10 is set to produce 12.8 V at power-up. This gives a resolution of 100 mV per digital potentiometer step.

The only remaining difference has to do with the value of the current monitor-scaling resistor R6. I increased the value of this resistor from 100 to 220 Ω to scale the lower current capacity of this supply into a voltage that's compatible with both the 5-V referenced ADC and digital potentiometer.

THE ZETEX ZXCT1009

You can monitor the current drawn from the power supplies in two ways. Both methods involve inserting an accurate low-value resistor in series with the power supply output, and then measuring the voltage drop across that resistor. A measure of the current drawn then will be equal to the voltage drop/resistor value. If that resistor is placed in series with the negative output terminal of the power supply, the resulting voltage drop will be referenced to the power supply's common terminal. This makes it easy to measure with an ADC (or DPM) that is powered by, and referenced to, the power supply's common terminal.

The downside of this method is that whatever voltage is dropped across, this current sense resistor is lost (i.e., the load gets a little less voltage than the power supply thinks it is providing, and you see an inflated reading on the voltage meter).

Alternately, you can place the current-monitoring resistor in series with the positive output terminal of the power supply. Then, the voltage feedback network of the pass regulator can be wired to follow this resistor, eliminating the lost voltage problem that I described earlier.

This method, however, introduces the main problem associated with the measuring of a small current-sense voltage riding on a large common-mode voltage: the power supply voltage itself. You can minimize this problem by using a high-quality instrumentation amplifier and precision-matched resistors, but they are somewhat costly. This second approach is called high-side monitoring.

In his lab supply project, Robert devised a clever circuit to compensate for the lost voltage problem that plagued the first method I described. In my design, I chose to go with the second approach—high-side monitoring.

I came to this decision after discovering a clever IC made by Zetex called a high-side current monitor. The ZXCT1009 is a three-pin device in an SOT23 package that converts the voltage dropped across a high-side current sense resistor into a current. This current is sent through a resistor to the power supply's common terminal, providing an easy-to-measure voltage proportional to the current draw.

The problems of measuring the low sense voltage riding on the high power supply common-mode voltage are addressed inside the ZXCT1009; therefore, you don't have to worry too much about this. Because the device costs roughly $1, it certainly beats designing in an instrumentation amplifier to perform this task.

However, the ZXCT1009 isn't a universal solution to the current-sensing problem. It requires an input voltage of 2.5 V or greater, so you can't easily monitor current if you want to run your power supply at voltages less than this. The maximum input voltage it can withstand is 20 V without additional circuitry. Neither limitation was a deal breaker for me, so I incorporated one of these devices in each power supply. My biggest concern was holding the tiny device steady while I soldered it to the PCB!

You may want to consult the Zetex datasheet for more information, but the only other detail I'll mention is that the device produces 10 mA for every 1 V dropped across the current sense resistor. I had 1-Ω, 1% 5-W resistors in my junk box, so that's what I used for the current-sense resistors in all three supplies. This didn't waste too much of the power supply's voltage capability.

The lower-current floating supplies used a 220-Ω resistor to convert ZXCT1009's output current into a voltage. The higher-current, ground-referenced supply has a fitted 100-Ω resistor, and the MCU's software performs the math that's necessary to convert the ADC's output into the correct current reading on the meter.

AN IDEAL ISOLATOR

After spending years servicing and designing electronics devices, I have to say that I'm as impressed with some of the amazing things that were done with vacuum tube circuits back in the old days, as I am with some of the modern, miniature ICs that are available today.

For this project, though, I pampered myself with state-of-the-art devices rather than depending on clever, but more involved, circuits using conventional devices. I've already described the Zetex current monitor, which is one example of this. I continued with this trend in choosing the isolation technique for the floating power supplies.

The digital control and monitoring signals for the two floating supplies have to be electrically isolated from the ground-referenced MCU circuit. Thanks to the clever design of Microchip's SPI digital potentiometer and SPI ADC, each power supply needed only four control signals: three outputs from the MCU and one input.

My first inclination was to use optoisolator chips. I had just finished another project using optoisolators to interface the same Microchip SPI ADCs. In that project, meeting the ADC's SPI timing considerations given the rather slow response of the optoisolators was a bit tricky, although possible.

Luckily, Jeff Bachiochi had just written a column about isolation in which he outlined a novel line of isolators made by Nonvolatile Electronics ("You're Not Alone—Dealing with Isolation," *Circuit Cellar* 142). Rather than using an optical method to achieve galvanic isolation, these isolators use magnetism. Although pulse transformers have been around for ages and can perform isolation using magnetism, they are comparatively bulky, expensive, and don't pass DC levels.

The IsoLoop isolators, on the other hand, use GMR or giant magnetoresistive devices to sense the magnetic field change produced by an excitation coil, which is nearby but electrically isolated. The change in resistance of the magnetic thin film layer is used, along with other on-chip circuitry, to implement the isolation function of the device. The IsoLoop devices actually differentiate the input signal, and send only short magnetic pulses through their excitation coils during input signal transitions. The resulting resistance changes in the magnetic thin film layer—configured in a Wheatstone bridge—are measured,

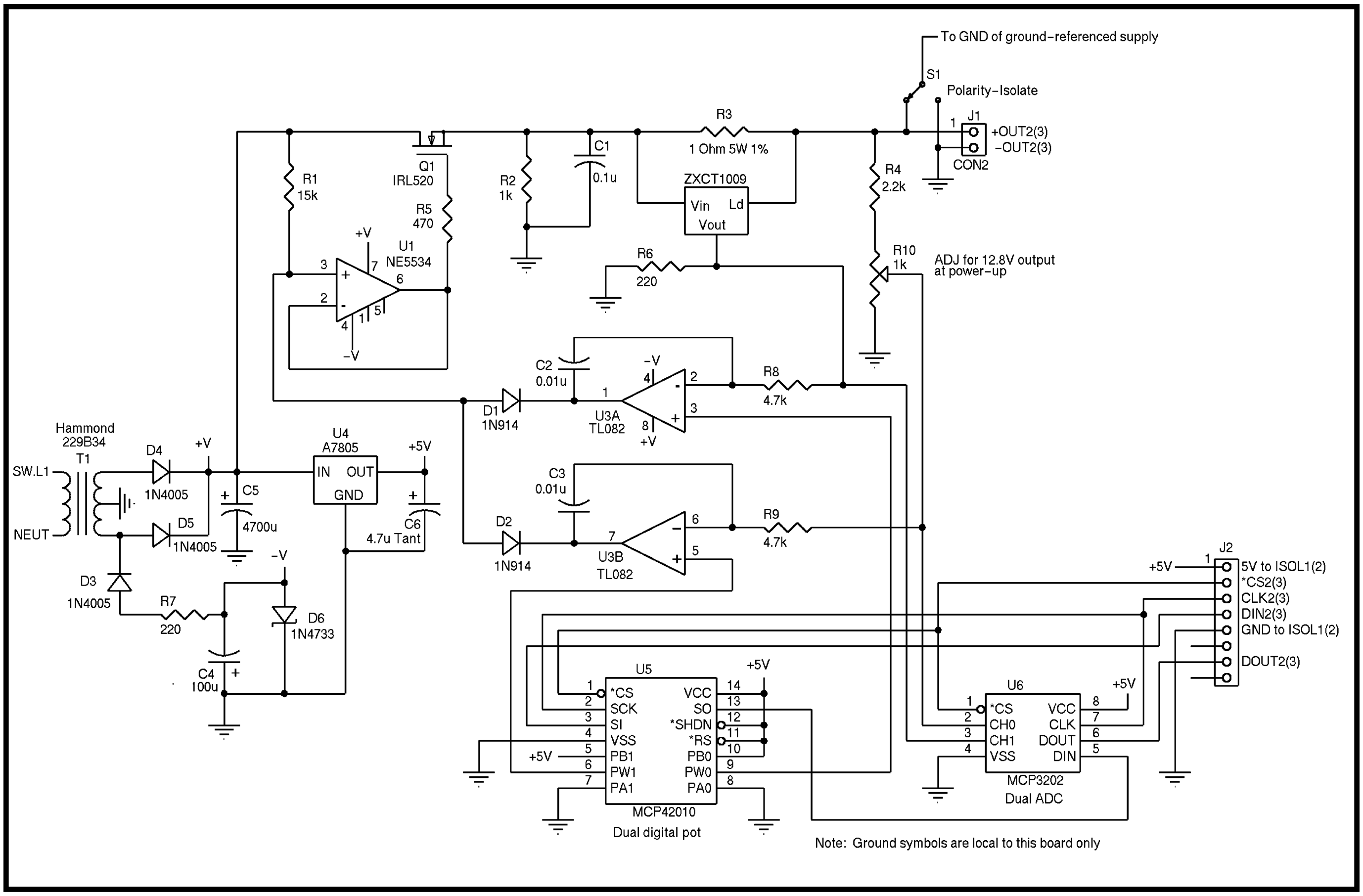

Figure 2—*The floating supplies are almost identical to Figure 1, but there are different component values. Note that the ground symbols in this figure are local to this board alone (i.e., they are not connected to ground on any other boards shown in the other figures).*

and the resulting output signal is actually the output of an on-chip latch device.

Don't be fooled by the use of the term "giant" in GMR; these devices are tiny. Typically, four isolators will fit into a 16-pin wide SOIC package. The wide package is needed, presumably, to allow the devices to withstand the 2500 V_{RMS} at which they are rated.

With regard to the packaging, I was impressed with NVE's decision to produce several different device configurations. They sell the normal quad devices with all four channels configured in the same direction (IL715); however, they also sell quad devices containing two channels in each direction (IL716). My favorite, the IL717, has three channels in one direction and the remainder going in the other direction. This configuration is perfect for SPI device isolation, which needs a Chip Select, Clock, and Data Out lines coming out from the MCU and a Data In line going back into the MCU.

Given the modest voltage isolation I needed for this supply, I could have used a quad optical isolator and wired up one section "backwards," so to speak, but the PCB layout would have been much less neat. In cases where input and output signals have to be isolated and substantial voltage isolation is required, the only way to achieve this—apart from using separate devices—is to use an appropriately configured device like those in this IsoLoop family.

I've actually saved the best part for last: these IsoLoop devices are fast! The IL700 family exhibits a 100-Mbps data rate. In addition, it has only 2-ns pulse width distortion and 10-ns pulse delay.

Unlike optoisolators, which require LED drive voltage/current and often don't provide logic-level output signals, the IsoLoop devices work directly with 3.3- or 5-V logic devices including MCUs. Although an optical isolator requires a steady drive current whenever its LED is turned on, the IsoLoop devices use only a short pulse of magnetism whenever the input signal changes state (even though a small but steady current is required for the detection and latching circuitry in the chip).

The IL717 that I used requires only a 2.5-mA power supply current on its input side, and 6 mA on its output side. This difference arises from the fact that the device has three channels in one direction and only one in the other.

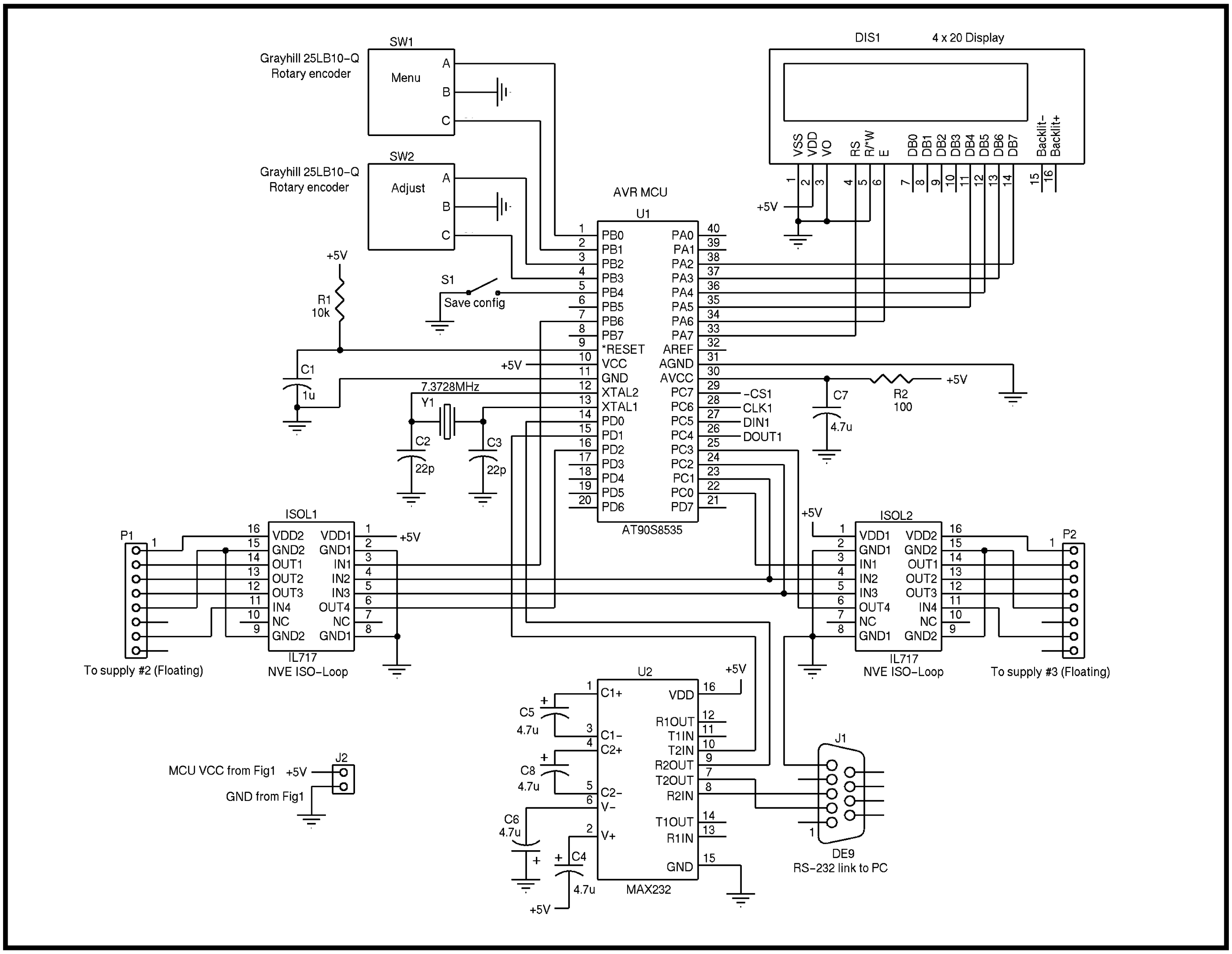

Figure 3—*Take a look at the MCU, IsoLoop isolators, and the user interface. Some of this circuitry is actually contained on the SIMM100 module.*

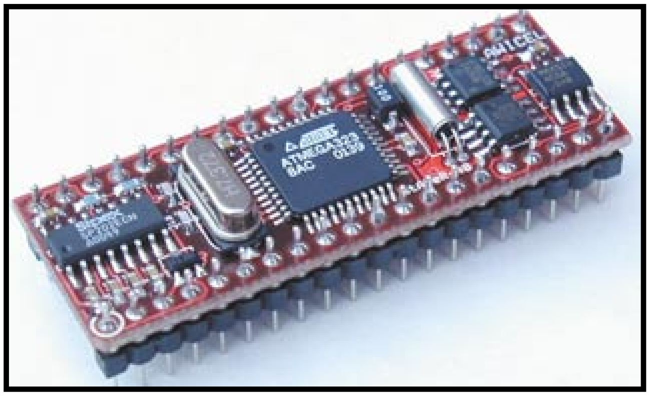

Photo 3—*Lawicel's new stAVeR40 module is a decent product. I might have used it in place of the SimmStick had it been available when I was designing my project.*

In my design, I did not have to give any more thought to the SPI timing on the floating channels than I did to the channel that wasn't isolated. Basically, what goes into the IL717 is what comes out the other side!

There are only two cautionary notes that I would add regarding these devices. First, IsoLoop devices transmit their signal across the isolation barrier only on signal transitions. The recovered signal on the other side of the barrier is then electrically latched. Practically, this means that the output of the devices is indeterminate until input transitions occur. For some applications, this means that an initialization routine must be performed to ensure that the device's outputs are in a known state after power-up.

The second cautionary note is just as important. Because the devices rely on sending a short magnetic pulse at each input transition, it is important to place at least a 47-nF ceramic decoupling capacitor between V_{DD} and ground on both input and output ports of the device. The capacitors should be placed close to the actual device pins.

I tried to share one capacitor between two IsoLoop devices on the common MCU port side of the two devices. This didn't work. There were random output errors on the device farthest away from the sole capacitor that disappeared completely when I followed directions!

MCU AND USER INTERFACE

As with every other project I've worked on in the last two years, I chose the Atmel AVR family for the MCU. In this case, I went with the AT90S8535 for a couple of reasons. I needed 23 I/O lines to handle the three SPI channels, LCD, rotary encoders, and RS-232. This ruled out the use of smaller AVR devices. I could've used the slightly less expensive AT90LS8515, but I wanted to allow for the possibility of adding a temperature-sensing meter/alarm option to the circuit. The '8535 has a 10-bit ADC function that's suitable for this purpose; the '8515 does not.

The '8535 MCU has 8 KB of ISP flash memory, which is just about right for the necessary firmware. It also contains 512 bytes of EEPROM. I used a small amount of the EEPROM to store default values for the three programmable power supplies. That is to say, the power supply will power up with the same settings that existed at the time its Save Configuration push button was last pressed.

To simplify construction, I decided to use a SIMM100 SimmStick module made by Lawicel. The SIMM100 is a 3.5″ × 2.0″ PCB containing the '8535, power supply regulator, reset function, RS-232 interface, ADC, ISP programming headers, and a 30-pin SimmStick-style bus. I've used this module for prototypes several times in the past, but this is the first time I've actually incorporated one into a finished project. Photo 2 is the manufacturer's picture of an assembled module. For this project, I populated a bare SIMM100 PCB with only the components that I actually needed.

The MCU port signals needed to operate the three SPI channels and interface the two rotary encoders come out through the 30-pin bus. As you now know, I designed the ground-referenced power supply PCB to include space to mount the SIMM100 module, as well as the IsoLoop isolators. The SIMM100 mounts at right angles to this PCB; it's hard-wired in place using 90° header pins. The floating power supplies share a virtually identical PCB layout apart from being smaller because of the lack of traces and circuitry associated with the SIMM100 bus and IsoLoop isolators.

The SIMM100 module has headers for the ISP programming cable and RS-232 port. I used its ADC header to run the LCD by reassigning six of the ADC port pins to general I/O pins.

Photo 4—*To the right of the output Johnson posts are the switches that set the polarity of the floating supplies—as well as the switch that disconnects all power supply outputs—while leaving the unit still powered up.*

When I buy in bulk, it's inevitable that by the time I use the last item in my stock, something better has taken its place. After contacting Lawicel to request a .jpg image of the SIMM100 for this article, I was introduced to the new line of AVR modules that the company is developing.

Rather than a SimmStick-based module, the new modules are 24- and 40-pin DIP modules that are meant to replace Basic Stamps. Instead of using PIC chips/serial EEPROM and a Basic Interpreter, they implement the most powerful members of Atmel's AVR family—the Mega chips.

Mega chips execute compiled code from fast internal flash memory and contain much more RAM and EEPROM than Stamps. Even though flash programming AVR-family chips is easy through SPI, using inexpensive printer port programming cables, these modules go one step further by incorporating RS-232 flash memory programming. This makes field updates a snap. Take a look at the new stAVeR40 module in Photo 3. I might have used this module instead of the SIMM100 had it existed when I started the project.

The user interface I settled on consisted of a common 4 × 20 LCD panel along with two rotary encoders. One encoder is used to scroll through the various power supply parameters, and the other adjusts the selected parameter. The cost of LCDs and rotary encoders is reasonable these days. Being able to eliminate the substantial cost of six DPMs and six 10-turn potentiometers was the main reason for choosing an MCU-based design in the first place. Photo 4 shows the front panel of the unit.

Inexpensive rotary encoders come in two basic flavors: quadrature encoded and 2-bit binary (Gray) coded. I've used the quadrature-encoded style in the past, but the ones I used for this project have a 2-bit output (with Gray coding). With only 2 bits, the encoder can represent only four different values, even though it has 32 detents per rotation. With this in mind, it's necessary for the firmware to constantly poll both encoders and keep track of the carry or borrow conditions that occur as the encoder moves beyond a four-position range. The main control loop in the firmware is executed every few milliseconds, so keeping an accurate track of the rotary encoder's position is accomplished readily.

The RS-232 port came as part of the SIMM100 module. Thinking about the future, I envision adding some firmware code to allow the bench supply to be remotely controlled by a host PC, and to allow for the data logging of the various voltages/currents over time.

I haven't provided you with a complete block diagram, but I did incorporate a few features that don't show up on the individual schematics. Previously, I mentioned adding an additional commercial 5-V, 3-A supply for logic circuits. I also added a 3PST switch, with one section in series with each supply's positive output, to allow all power supplies to be disconnected from the load during power-up.

A small DC computer-type fan was mounted on the top of the outer case for cooling purposes, because the pass-transistor heatsinks that I used were not too large.

Lastly, Figure 3 shows you how the '8535 MCU would typically be connected to the rest of the circuit. It doesn't show the exact wiring of the SIMM100 including the bus connections, because this detail isn't needed when constructing the circuit from scratch (i.e., if you're not using the SIMM100 module). The SIMM100 documentation will give you all of the necessary information regarding the header and bus connections on the module.

FIRMWARE

If you've read any of my more recent articles, then I'm going to sound like a broken record in this section. I used an MCS Electronics BASCOM-AVR compiler for this project (once again). The code did not have to run extremely fast, but floating-point and string operations were needed. Because there was plenty of flash memory available in the '8535, it made sense to program in Basic rather than using Assembly language.

Skipping over the unit's initialization procedure for now, the control loop in the program works basically as follows. Both encoders are checked to see if the user has moved them. If the Menu encoder is changed, nothing is done, apart from moving an arrow cursor amongst the various parameters that can be changed. If the Adjust encoder is moved, the appropriate routine is called to adjust the necessary power supply's voltage or current limit setting. This is accomplished by changing the value of the appropriate section of the digital potentiometer located on the proper supply PCB.

Because each supply's ADC is digitally cascaded with that supply's digital potentiometer, the routine that updates the digital potentiometers also reads the ADC all in one operation. For that reason, in the absence of any changes to the voltage or current-limit settings, each power supply is sent a control message at 0.5-s intervals to set its digital potentiometers and read the dual ADC. Constantly resetting the digital potentiometers at this interval is unnecessary, but periodically reading the ADCs is necessary to give you timely voltage/current readings.

The only remaining task in the control loop is to check the state of the Save Configuration push button. When it's pressed, a routine is called to save the current values of voltage and current limit, for all three power supplies, to data EEPROM.

At power-up, the data EEPROM is checked for a valid configuration saved from a previous use of the supply. If so, these voltage/current settings are stored in RAM variables, and the three supplies are initialized to these settings. In the absence of valid configuration readings, each power supply is set to half scale, and the current limit settings are preset to maximum.

WRAP UP

I'm looking forward to the convenience of using this multi-output yet compact power supply in my future projects. As with all projects, there were some compromises I made along the way.

I chose Microchip's dual 8-bit digital potentiometers for the voltage/current settings. Basically, I felt the 50-mV voltage-setting resolution (100 mV for floating supplies) was sufficient for my purposes. The resulting current-limit resolution of 20 mA (8 mA for floating supplies) also seemed reasonable; however, dual 12-bit SPI DACs are available, which would improve this resolution substantially. Maxim makes some nice serial DACs, but they come in such small packages that I can't handle or solder them to a PCB.

The existing version of the firmware uses 6800 of the total 8192 bytes of flash memory. This leaves sufficient room to add remote control via the RS-232 port in future. Because the firmware is written in BASIC, it's reasonably easy to go into the code and add additional features at a later date.

Although it was a bit of an overkill to use the ultra-fast NVE IsoLoop devices for this project, it made that part of the design rather easy. I'd like to thank NVE for quickly sending me a few samples to incorporate in my design. ◘

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PROJECT FILES

To download the firmware, go to ftp.circuitcellar.com/pub/Circuit_Cellar/2002/149/.

SOURCES

AT90S8535 Microcontroller
Atmel Corp.
(714) 282-8080
www.atmel.com

Power supply module
Condor D.C. Power Supplies, Inc.
(800) 235-5929
(805) 485-4565
www.condorpower.com

SIMM100, stAVRer modules
Lawicel HB
+46 (0) 451-59877
www.lawicel.com

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Nonvolatile Electronics, Inc.
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Raychem Corp.
www.raychem.com

ZXCT1009 Current monitor
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