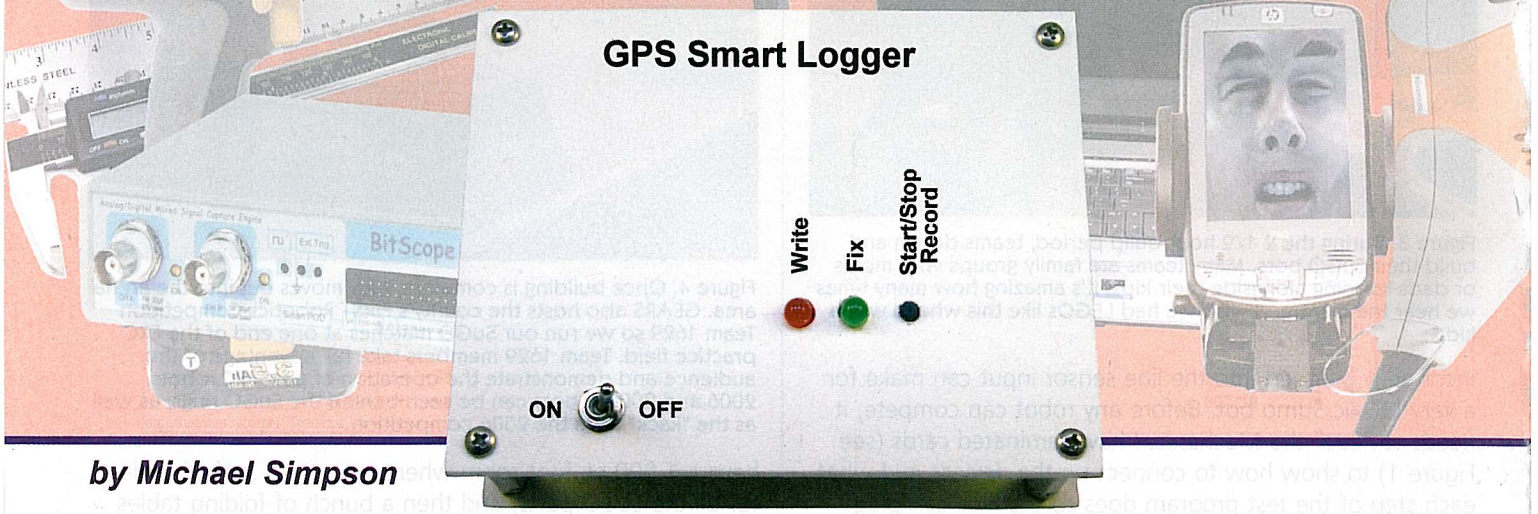
Build a GPS SMART LOGGER



by Michael Simpson

I recently did a GPS series covering various GPS modules and their interfaces. A project that I have had in mind for a while was a small GPS Smart Logger. I call it a smart logger because in addition to the GPS data, you can log various other telemetry. You can also set the conditions and type of GPS data that gets logged.

When I started this project, I came up with the following requirements:

- Self-contained operation
- Able to operate on battery for 24 hours
- Able to detect low battery levels
- Log data must be written to SD memory card
- WAAS support
- Single button operation
- LED indicators
- 3.3V operation
- Ability to log additional data
- Must cost under $150 to build

I call this a smart logger because you have the ability to choose what does and does not get written to the SD memory card. You can also use one of the many analog-to-digital (A/D) lines on the DiosPro to log additional data.

I chose to operate the smart logger at 3.3V for a couple of reasons. First, both the SD card and the GPS module operate at that voltage. Second, the lower the operating voltage, the more run-time for a set of batteries.

The DiosPro microcontroller chip that I have chosen to use in this project will operate at 3.3V just as easily as it will at 5V. The DiosPro also supports an LVD library that is capable of detecting a low voltage drop. This is important to prevent log file corruption when the battery dies.

The wiring diagram for the project is shown in Schematic 1. I have used a couple of techniques to make hookup easier. Notice that the two LEDs are connected to two ports each. Ports 0 and 2 are held low, so this provides a ground for the LEDs. While this uses a port on the DiosPro, it does make the connection of the LEDs much simpler, as you will see later.

Another shortcut I have taken is to tie both leads on the record button to ports 6 and 7. The DiosPro has the ability to hold ports 0-7 high with a weak internal resistor. Port 6 is held low so that when the record button is pressed, this forces port 7 low, as well.

The EM 408 GPS connection is straightforward. I have simply connected it to the onboard UART. Notice how the Enable lead is also tied to VCC. This needs to be done in order for the GPS module to operate.

The SD memory card interface utilizes the Dios MMC library and is forced to use I/O ports 10, 11, and 12. The CS (Card Select) is configurable and can be set to any port. In this case, I have used port 13.

Construction

You will need the following components in order to

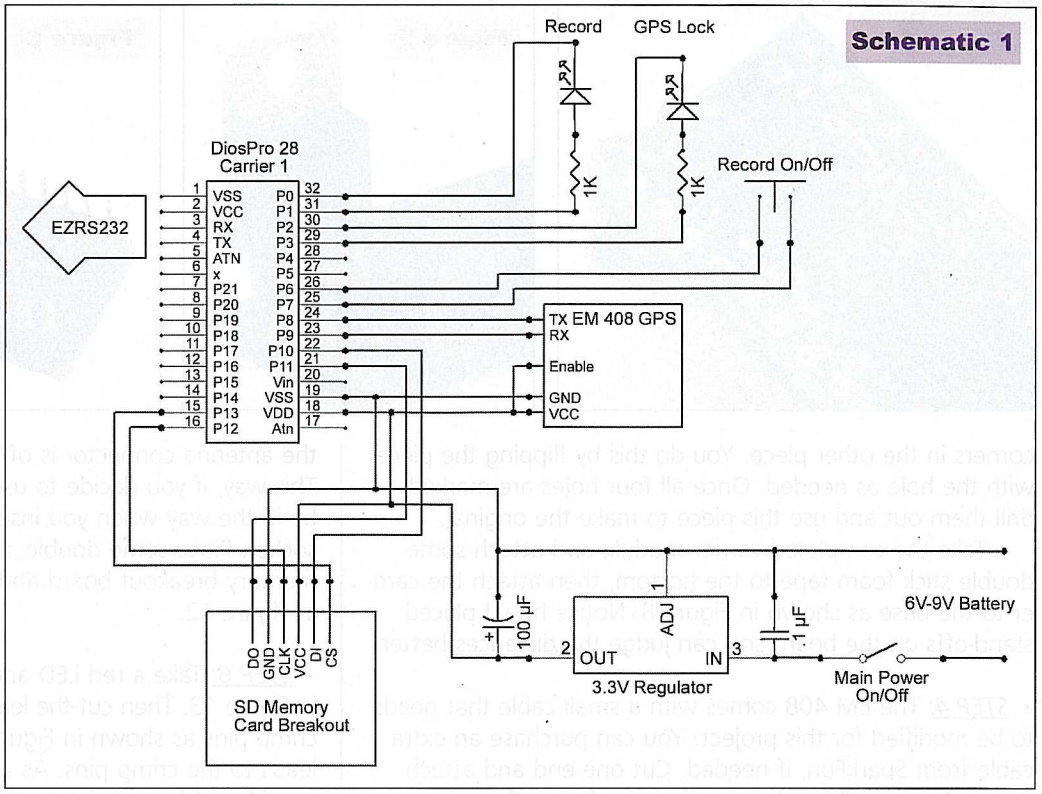
complete this project. Please refer to the parts list later in the article for part numbers.

Major Functional Components:

- DiosPro 28 chip
- Dios Carrier 1
- EM 408 GPS
- SD breakout board
- EZRS232 (needed for Programming the DiosPro)
- SD memory card

Additional Components:

- Pushbutton
- Twored LEDs
- Two green LEDs
- 100 µF capacitor
- On/off switch
- Jumpers
- Battery holder
- Battery connector clip
- Two 1K resistors
- 36-Pin female header
- 40-Pin male header
- Two 4.5" x 3.5" pieces ofpPlastic
- 3.3V regulator
- Four #4 x 1" stand-offs (F-F)
- Female crimp pins
- Eight #4 x 1/2" machine screws
- Eight #4 hex nuts
- Double stick foam tape



You will also need a copy of the Dios compiler. This compiler is free and can be found on the KronosRobotics website at **www.kronosrobotics.com**.

• *STEP 1:* The first thing you need to do is to build the Dios Carrier 1. Build it according to the included instructions but hold off attaching the two included 16-pin headers as shown in Figure 2. The carrier comes with a 10 µF capacitor and this is plenty for the circuit; however, you may want to replace it with a 100 µF capacitor. This will keep the insertion of the memory card from resetting the DiosPro chip. A 100 µF capacitor won't fit on the board, so you will have to bend the pins and insert it at an angle.

• *STEP 2:* The project requires a 3.3V regulator to power the circuit. The most compact way to do this is to attach it directly to the Dios Carrier 1 board. Take the regulator and insert pins 1 and 2 into the board as shown in Figure 3. From the underside of the board, bend pin 1 on the regulator and solder it in place as shown in Figure 4. Be sure to solder at both the entry pad and the pad located at the tip of the pin. Now gently twist the regulator and insert the remaining pin into the hole shown in Figure 5. With the regulator attached, you can now attach the two 16-pin headers on the top of the board as shown in Figure 6. Take an additional two pin header and attach it to the position marked J2.

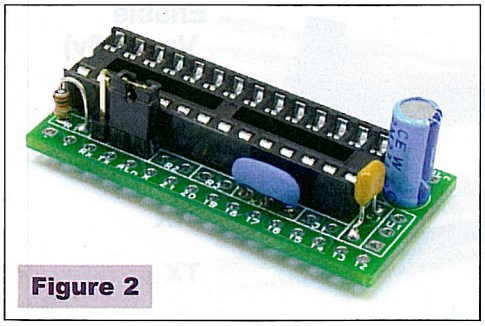


Figure 2

• *STEP 3:* You will need to cut two pieces of plastic like the ones shown in Figure 7. I used compressed PVC cut to 4.5" x 3.5". The bulk of the size of the project is devoted to the batteries used to power the device. I am using a six AA cell pack to power my unit. If you want to use a small 9V-like battery, this would allow you to create a much smaller enclosure. The trade-off, however, would be less run-time.

Place four small 1/8" holes in each corner about 1/8" from both edges. A trick I use to place the holes all in the same place in each corner is to drill one hole in one piece. Then use that hole to mark each of the

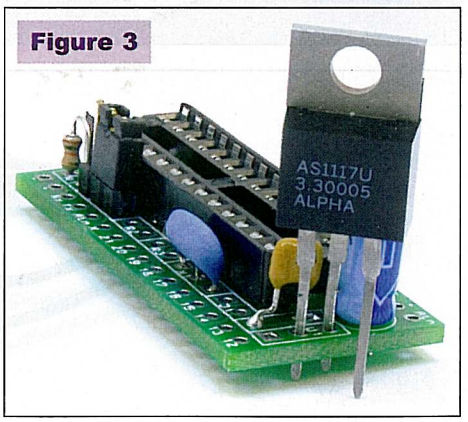


Figure 3

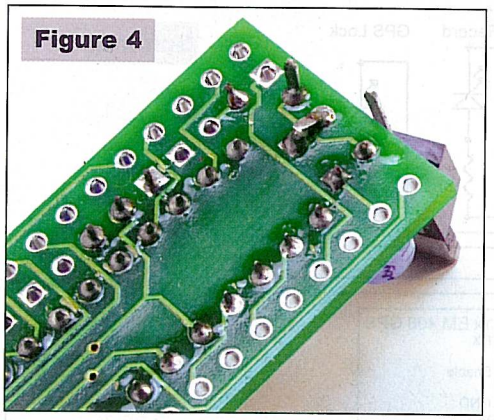


Figure 4

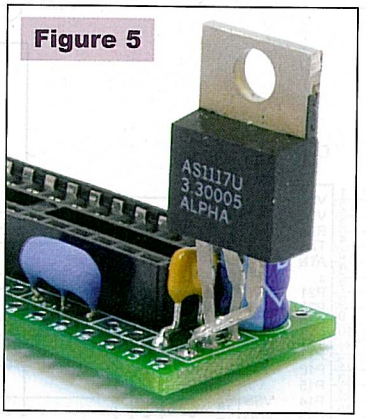


Figure 5

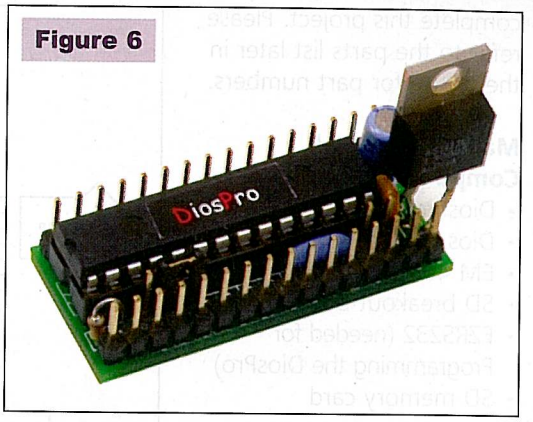


Figure 6

corners in the other piece. You do this by flipping the piece with the hole as needed. Once all four holes are marked, drill them out and use this piece to make the original.

Take the completed carrier module and attach some double stick foam tape to the bottom, then attach the carrier to the base as shown in Figure 8. Notice how I placed stand-offs on the board so I can judge the distances better.

• *STEP 4:* The EM 408 comes with a small cable that needs to be modified for this project. You can purchase an extra cable from SparkFun, if needed. Cut one end and attach the leads to small headers as shown in Figure 9.

• *STEP 5:* Take the SD memory breakout board and attach a five-pin header into the first five pads shown in Figure 10. Take a few pieces of double stick foam tape and attach them to the memory board as shown in Figure 11. Now take the EM 408 and attach it to the memory board as shown in Figure 11. Make sure the antenna connector is off to one side of the card slot. This way, if you decide to use an external antenna it won't be in the way when you insert the memory card into its socket. Place some double stick tape on the bottom of the memory breakout board and attach it to the base as shown in Figure 12.

• *STEP 6:* Take a red LED and attach a 1K resistor as shown in Figure 13. Then cut the leads so that they can slip into the crimp pins as shown in Figure 14. You can also solder the leads to the crimp pins. As an option, you may connect a small bit of heat shrink to the leads as shown in Figure 15. Repeat the step with the green LED. If you don't want to use the crimp pins, you can use a two-pin female header instead.

• *STEP 7:* Attach two crimp pins to a pushbutton as shown in Figure 16. You can also use a female header. The actual connection technique depends upon the type of button that you use. As before, you can cover the leads with heat shrink.

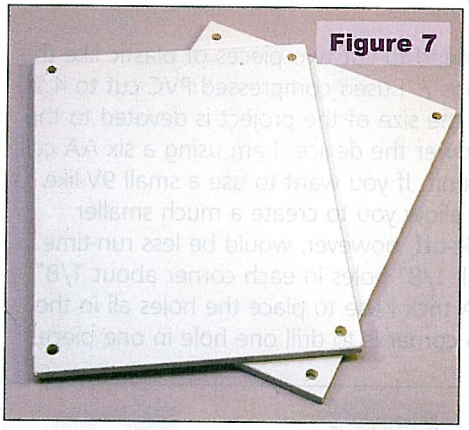


Figure 7

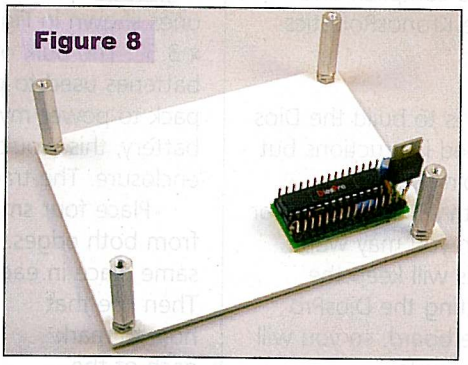


Figure 8

• *STEP 8:* Attach the red LED to ports 0 and 1 as shown in Figure 17. Make sure the flat side of the LED is connected to port 0. Attach the green LED to ports 2 and 3. Make sure the flat side of the LED is attached to port 2. Attach the button to ports 6 and 7 as shown in Figure 17.

• *STEP 9:* You need to build a battery connector assembly. This connector will work with the six-cell battery

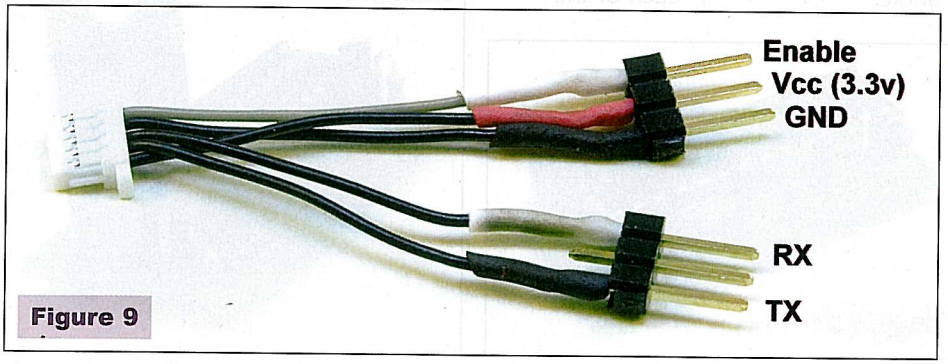


Figure 9

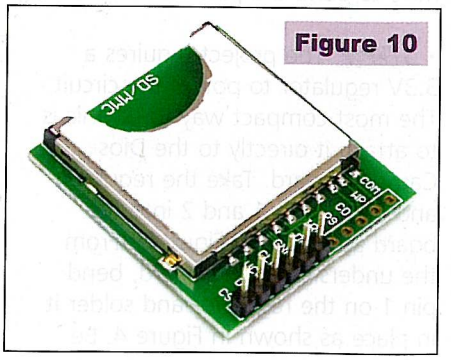


Figure 10

holder, as well as a nine-volt battery. Take the battery clip and attach the ends to a small two-pin female header as shown in Figure 18. Cut the red lead at about 3.5 inches from the clip. Strip and solder each red lead to a small toggle switch as shown in Figure 18. Attach the cable assembly to the carrier board as shown in Figure 19. Make sure the black lead faces the capacitor.

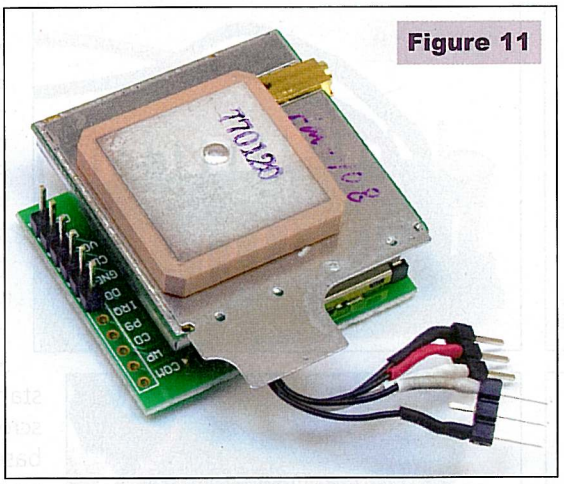


Figure 11

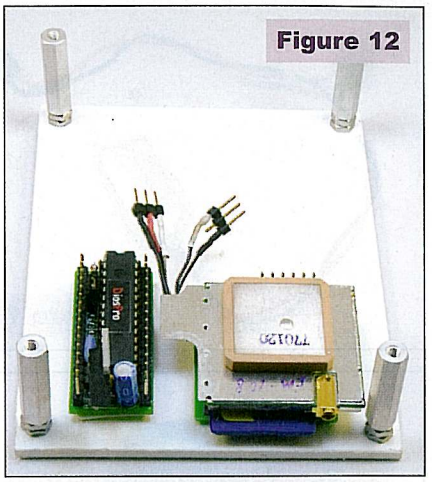


Figure 12

• *STEP 10:* At this point, you can perform an LED test. Before you can do that, you need to build the EZRS232 driver. The EZRS232 driver comes with a male header so you have two choices. The first is to install a five-pin female header in place of the included male header as shown in Figure 20. Another option is to create a female-to-female connector by attaching two five-pin female headers together and using this as an adapter.


Figure 13

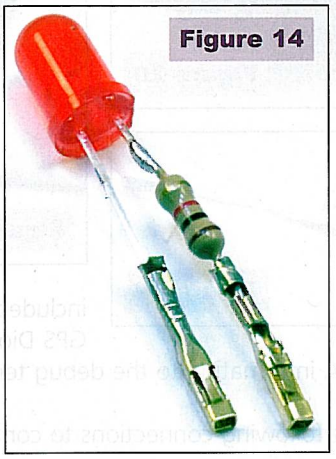


Figure 14


Figure 15

• *STEP 11:* Attach the battery to the battery clip and the LEDs should begin to light. This is because each DiosPro chip comes preprogrammed with a test program. Attach the EZRS232 to the Dios Carrier as shown in Figure 21, then connect the nine-pin cable to your PC and start up the Dios compiler. Load and program the included file called DiosLEDtest.txt into the Dios. The two LEDs should blink and then stop when the button is pressed.

• *STEP 12:* I will be using some small female-to-female jumpers to connect the memory card and GPS module to the Dios carrier. These can be purchased from Schmartboard at **www.schmartboard.com/index.asp?a=11&id=42**.

We need to create a couple of split power connectors. In order to do this, take three of the jumpers and cut them in half. Then connect three of the pieces to create the split jumper shown in Figure 22. You will need to make two of these jumpers.

• *STEP 13:* Take one of the split jumpers and connect one end to the J1 pin 2 as shown in Figure 23. Then connect one of the other ends to the GPS GND lead (black). Connect the last end to the memory board pin 5 (GND).

With the second split jumper, connect one end to the J1 pin 1 as shown in Figure 23. Then connect the other ends to the GPS VCC and Enable leads (white and red).

• *STEP 14:* Take a single 5" jumper and connect it to the VCC pin (marked +)-on the carrier and the VCC lead on the memory board (pin 3) as shown in Figure 24.

• *STEP 15:* For the following connections, you need to refer to Schematic 1 and the Dios Carrier 1 manual to help you find the pin location.

Connect a jumper between the GPS TX lead (black) to the carrier port 8. Next, connect the GPS RX lead (white) to the carrier port 9.

At this point, you can test the GPS. Apply power to the Dios and attach the RS-232 driver. Load and program the Dios with the file called DiosEM408test.txt that I have


Figure 16

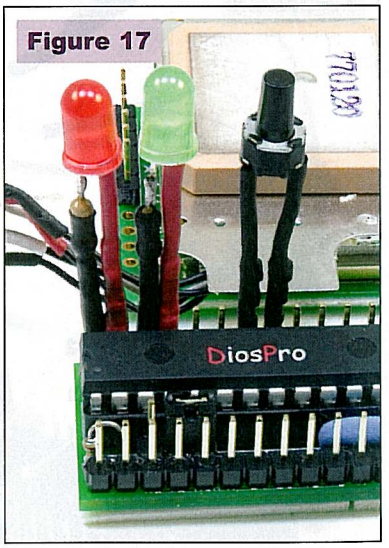


Figure 17

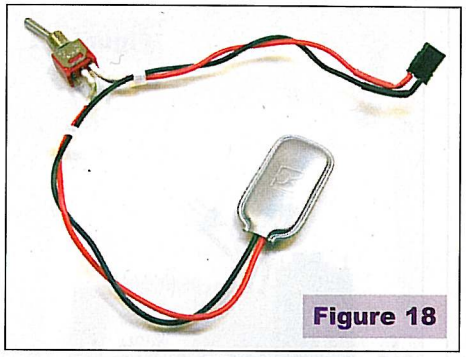


Figure 18

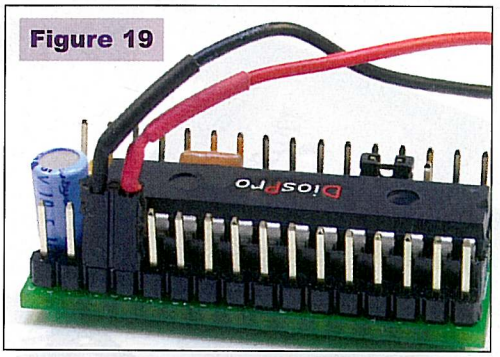


Figure 19

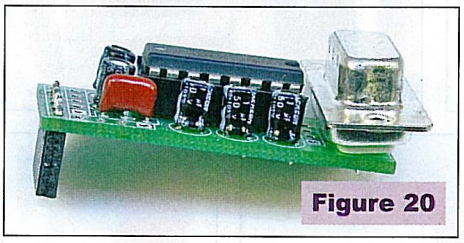


Figure 20

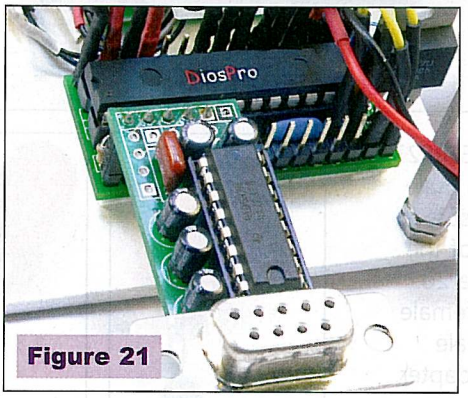


Figure 21

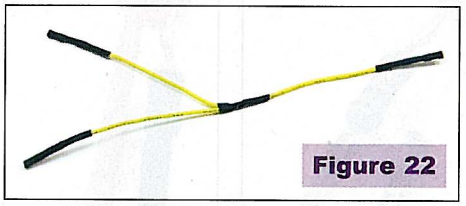


Figure 22

included. The GPS Dios should start to display NEMA information to the debug terminal.

• *STEP 16:* Make the following connections to complete the hookup:

- Connect the memory card pin 1 (CS) to the carrier port 13.
- Connect the memory card pin 2 (DI) to the carrier port 10.
- Connect the memory card pin 4 (CLK) to the carrier port 12.
- Connect the memory card pin 6 (DO) to the carrier port 11.

Now insert an SD memory card into the memory card breakout board and apply power. Then plug the EZRS232 driver into the carrier and load the program file called DiosLogEM408.txt. This is the main logger program.

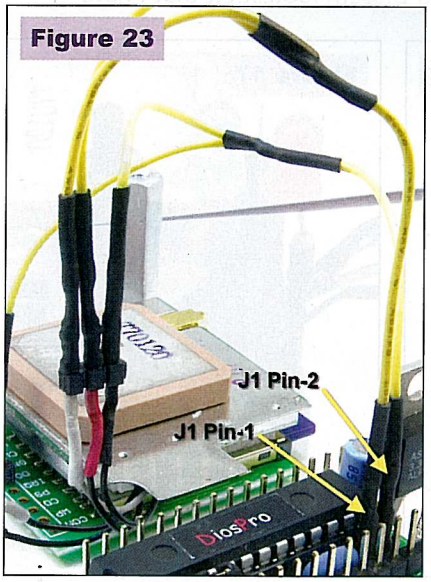


Figure 23

If the memory card is working properly, you should se a message that looks something like this:

Memory Card Initialized
Volume Type=FAT16
Partition starts at sector 0.101
Reserved sectors 7
Each cluster has 8 sectors
Number of fat tables 2
Each FAT has 244 sectors
Root has 512 entries or 16384 bytes. 32 sectors
Fat1=0.109
Fat2=0.353
Root=0.597
Data=0.629
Memory Card Initialized

• *STEP 17:* In order to attach the stand-offs, insert a 1/2" machine screw through a hole in the bottom base, then attach two nuts to the screw and finally the 1" stand-off (as shown back in Figures 8 and 12). This configuration will make the six-cell battery holder fit tightly inside the enclosure. If you use another kind of battery, you will need to adjust accordingly.

• *STEP 18:* In order to attach the top base, you will need to line up the LEDs and buttons to create some holes. There are a couple of ways to do this. One way is to cut out a piece of tracing paper that is the same size as the base and place it over the LEDs, then mark the LED and button positions. Before drilling the holes, add an extra 1/8" between the two LEDs.

For the LEDs, I drilled 5/32" holes. The button will depend on what is used. If you use a button that mounts to the top base, then you can attach wires to the leads and route them to ports 6 and 7. In this case, the button can be placed in several locations.

You will also need to drill a hole for the power switch. The actual diameter will depend on the switch you use.

Attach the base to the stand-offs with four 1/2" machine screws as shown in Figure 25. You will probably have to bend the leads on the LEDs in order for them to fit properly. This is normal, and if you used heat shrink as insulation, should not present a problem.

Smart Logger Operation

When power is applied to the smart logger, it will test the memory card for a file called LOGDATA2.txt. If it is not found, a 20 meg file will be created. This is just a place holder file and will be truncated as necessary when collecting data.

Startup Indicators

- Red LED blinks four times and stops — Smart Logger is ready and in run mode.
- Red and green LEDs alternate a one second blink — Memory card failure.
- Red LED does nothing — Battery dead.
- Red LED blinks four times then green LED flashes

fast — Battery low.

Fix Indicator

- Green LED alternates on and off every second or so — Smart Logger is ready and in run mode with no Fix.
- Green LED flickers on with one quick blink — GPS has a SPS mode 1 Fix.
- Green LED flickers on with two quick blinks — GPS has a DGPS or WAAS mode 2 Fix.
- Green LED flickers very fast constantly — Indicates battery level has dropped too low for operation.
- Green LED fails to light at all — Battery dead.

Record Indicator

- Solid Red LED — When record button is pressed, the LED will light solid red until the button is released. Press a second time to exit record mode.
- Red LED flashed quickly — Each time a NEMA GGA or RMC message is saved, the red LED will flash quickly.
- Red LED not flashing — Not in Record mode.

Each line of data is actually written to a buffer and when that buffer reaches a value of 512 bytes, it is saved to the SD memory card. When recording is stopped or the battery level drops too low, the buffer is also saved to the memory card.

It is not recommended that you remove the memory card while in record mode; you could corrupt the log file. Take the logger out of record mode first. You can stop and start the record mode at will. When restarted, it will append data to the end of the log file. Note that if power is removed, the logger will start back at the beginning of the file when power is restored.

How Well Does it Work?

On a freshly charged set of 2,000 mAh rechargeable batteries, I get about 20 hours of record time. This could probably be extended if the LEDs were turned off completely. By only recording the GGA and RMC messages, we can store about 39 hours of data in a single 20 meg file. Because of the way I set up the addtofile function, only 65,000 sectors can be written to the file on the SD memory card. This is about 33 meg. If you need to store more data, then you need to add more code to flush the current file and open up a second. Another option would be to modify the addtofile and setfilesize functions to handle a larger sector counter.

I have included a sample log file that I created using the Smart Logger and I have to say it worked perfectly. The logger is small enough to fit into most robots that would be using GPS and can be made even smaller if you remove the battery and power it from your robot's logic power source.

Going Further

If you look closely at the code in the DiosLogEM408.txt program, you can see that I have added my own NEMA messages. When a low battery is detected, a "$GPMSG,1,LowBat*7C" is sent to the log. The DiosPro has several unused digital and A/D ports so it would be possible to add additional data to the log file. This would enable you to actually record robot control telemetry, as well as sensor data.

The DiosPro supports a sleep mode so it is possible to log intermittent data. This would allow you to log days worth of data on a single charge.

While the Smart Logger was built for logging GPS and telemetry data for robotic applications, there's no reason you can't use it to log positional and speed data in your automobile.

SparkFun Data Logger

I would be remiss if I didn't mention the SparkFun data logger module. For those of you who want a pre-built data logger module, this may be what you are looking for. The GPS Logger v2.4 is a self-contained module. All you need to add is four to seven volts DC. The module has an EM406 GPS module installed on the top as shown in Figure 26. It supports up to a 1GB SD memory card which is inserted on the bottom as shown in Figure 27.

To power the module, I recommend a set of 2,000 mAh rechargeable batteries and a battery holder like the one shown in Figure 28. SparkFun also sells a battery holder with a two-pin connector that mates directly with this module. With this power source, you will get just under 12 hours of operation with a steady stream of data writing to the memory card. You will get a couple days of run time if you opt for an intermittent write of once every few minutes.

Once you insert a memory card and apply power, the module will create a default config file called GLOGCON.TXT as shown next. By default, the config file will be set to mode 1, which will log all data. By changing this to mode 1, you can set the time between logs, thus putting the module to sleep when it is not writing. Another setting you will want to change if you are in the US is the WAAS setting. By setting this to 1, the module's accuracy

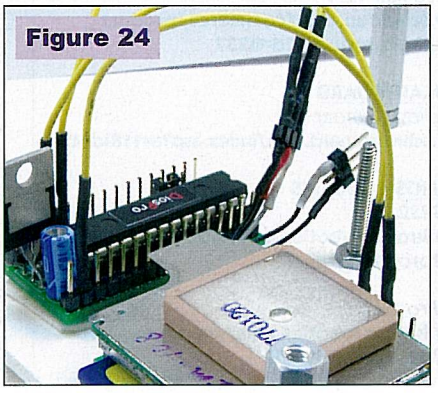


Figure 24

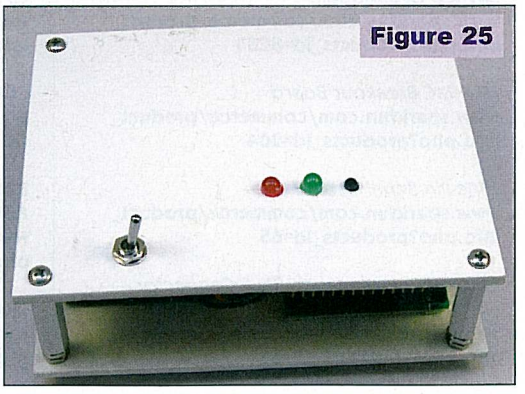


Figure 25

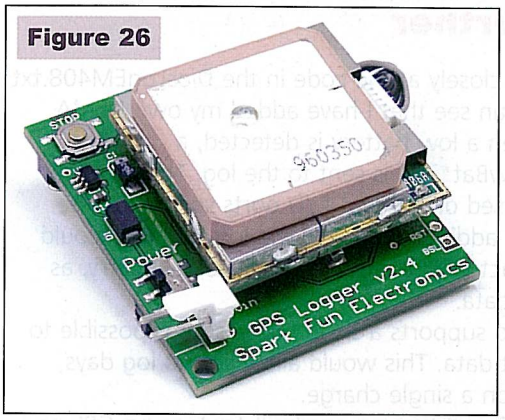


Figure 26

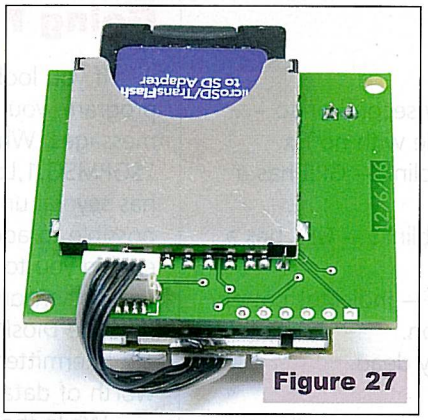


Figure 27

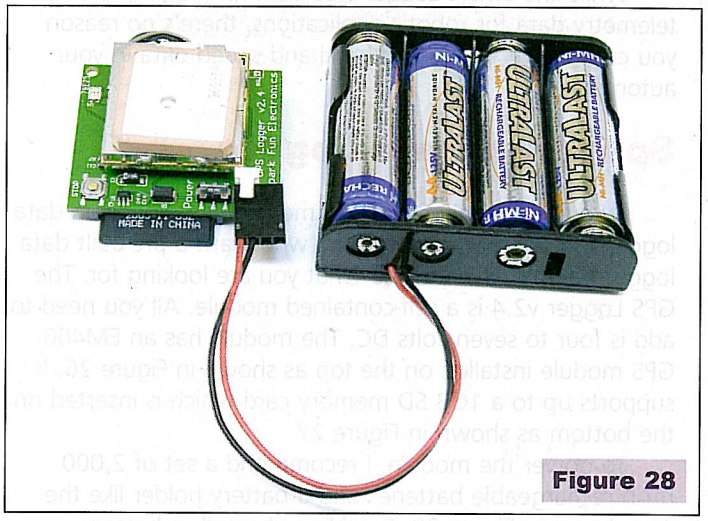


Figure 28

will be greatly increased.

Mode = 0
Log What = RMC;GGA;GSA
Time Between Logs = 00:10:00
Holdoff = 5
WAAS = 0
Max Time to Lock = 300

If you decide to use the SparkFun module, here are a few tips:

- The module does not monitor the battery so it's up to you to make sure you don't drain the batteries completely. If you do, you will probably corrupt the card and it will require reformatting. For long-term logging, you will want to use the intermittent write method mentioned previously.
- You need to hit the small button on the module to stop the logging operation. This can be a problem if you mount the module in any kind of enclosure. You can connect an external button to the two outside leads on the button. This way, you can route them to any location on your enclosure.
- To mount the module to an enclosure, place some double stick tape on the top of the GPS antenna and stick the module to the underside of the top of your enclosure.
- If the power connector gets in your way, try removing the connector completely and soldering a couple of wires to the bottom of the board.

Final Thoughts

All in all, the SparkFun data logger works pretty well and presents itself in a very small package. The output on the SD memory card is NEMA 0183 so you won't have any compatibility issues. If, however, you want total control over the output and the ability to log some of your own messages such as A/D, you will want to stick with the GPS Smart Logger. The cost is about the same for both systems.

Be sure to check for updates and downloads for this article at **www.kronosrobotics.com/Projects/GPSLOG.shtml**. SV

Parts List

The following is a breakdown of the sources for all the componets referenced in this project.

SPARKFUN ELECTRONICS

EM-408 GPS Module
www.sparkfun.com/commerce/product_info.php?products_id=8234

DF-MMC Breakout Board
www.sparkfun.com/commerce/product_info.php?products_id=204

Nine-Pin Serial Cable
www.sparkfun.com/commerce/product_info.php?products_id=65

External Antenna with SMA Connector (optional)
www.sparkfun.com/commerce/product_info.php?products_id=464

SMA to MMCX Adapter Cable (optional)
www.sparkfun.com/commerce/product_info.php?products_id=285

GPS Logger v2.4
www.sparkfun.com/commerce/product_info.php?products_id=8237

SCHMARTBOARD

5" Yellow Jumper
www.schmartboard.com/index.asp?a=11&id=42

KRONOS ROBOTICS

EZRS232
www.kronosrobotics.com/xcart/product.php?productid=16167

DiosPro 28 Chip
www.kronosrobotics.com/xcart/product.php?productid=16429

Dios Carrier 1
www.kronosrobotics.com/xcart/product.php?productid=16170

800 ma 3.3V Regulator
www.kronosrobotics.com/xcart/product.php?productid=16565

Six-Cell Battery Pack
www.kronosrobotics.com/xcart/product.php?productid=16321

36-Pin Female Header
www.kronosrobotics.com/xcart/product.php?productid=16291

Female Crimp Pins
www.kronosrobotics.com/xcart/product.php?productid=16261