HELPFUL HINTS FOR ASSEMBLING YOUR BATTERY ANALYZER

Before beginning assembly, please note the following key points, which we think will facilitate your board assembly and calibration.

Viewing the top of the PC board:

- The identification of R1 and R3 trimmer pots will be hidden when the parts are mounted on the board, so make a note (or mark on the board) to avoid confusion later when calibrating.
- Note that S1 can been eliminated and was not included in your parts kit. Jim has developed an easier method of calibration utilizing a variable voltage power supply (more on this later). Referring to the schematic, you will see Figures 1 and 2 showing jumper wires to be installed instead of the switch. For those of you who would prefer to install the SPDT switch as described in the QST article, it can be purchased at Radio Shack, P/N 275-625.
- If you are using an Altoids tin as your enclosure, start by place the PC board in the bottom and mark the four corner holes for later mounting. It is important to do this before mounting parts on the board to achieve accurate mounting point location. Be sure to allow sufficient room for installing the DC Power Connector later. More on mounting the board follows below.

General assembly hints and suggestions:

- Insert and solder the passive components to the board. Parts should solder easily with no cleaning (alcohol, etc) necessary. Save the resistor lead cutoffs for jumper wires.
- Insert and solder D1, D2, and LM339N.
- The LEDs need a little special consideration. Note that the longer lead of the two indicates the anode….which connects to the 1K ohm resistor. The board trace is easily visible, so double check your installation. The distance from the board to the top of each LED is important….actually it is more important to have all four of the LEDs the same height off the board for proper viewing. (Note: Don't confuse the orange and yellow LEDs!) Our suggestion is ½" (or slightly more) from the board to top of each LED. Solder the red LED in place first, then line-up the remaining 3 to match. The board height from the bottom of the tin will be adjustable for later fine-tuning of the LED display.

Working with the Altoids tin….

- Working with light gauge metal can be tricky and when drilling holes special care must be taken. I used a tongue depressor to provide support behind each hole as it was drilled.
- Before installing the PC board, drill/file the hole for the male DC Power Connector. First, mark the hole location with a fine point awl or ice pick….you don't want your drill bit to "wander"! Then drill a pilot hole with your smallest bit, followed by a 3/8" bit. Since the mounting hole is not simply "round" it will be necessary to do final shaping with a small triangular file. Don't mount the connector at this point….let's decide how we want to mount the PC board first.
- The PC board can be mounted in one of two ways: Four holes can be drilled through the bottom of the tin, or flat head screws can be soldered to the inside bottom of the tin. I used the former; Jim used the latter….and we each think our way was the best. If you decide to drill holes, use a 9/64" bit and 4-40 x 3/4 round or oval head mounting hardware. If you decide to use the

"solder" method, use 4-40 x 5/8" flat head hardware. Using steel wool, rough up the inside of the tin in the approximate positions of the four flat-head screws; do the same to the screw heads as well. Tin both screws and their tin locations using a high-heat solder iron or soldering gun; then heat the two and fuse together. If necessary (guaranteed!) a screw can be repositioned to align the stud and PC board hole by reapplying heart. Finally, the height of the PC board is determined by the position of the 2 or 3 nuts on each support screw.

- Perhaps the most challenging part of the project is positioning, marking, and drilling the four holes in the enclosure lid for the LEDs to "poke" through. Some of you may have ideas to share with the group…don't be shy! What follows is Jim's method, which worked quite well: Mount the PC board on the four studs such that the hinge-side LED just makes contact with the lid as the lid approaches the closed position. Place a drop of Whiteout® (or something similar) on the tip of the LED and close the lid to the point of contact….the first hole to be drilled will be marked on the inside of the lid. Using the method described above for drilling holes, proceed and drill a hole using a (final) bit size of 1/8 inch. The three remaining holes can be drilled one at a time in the same fashion, or you can make a template that will be based on the correct position of the first LED.

Board test….

- It will be easier to test the board (initially) outside of the tin enclosure. ~~But note that the system ground for the board is divided into two parts (newbie screw-up…. go ahead, fire me). When installed, the ground plain is completed via the four corners being screwed to the bottom of the enclosure. To compensate for the board being outside the enclosure, a test clip connecting corner 1 and corner 2 will be necessary (see board picture) to complete the system ground.~~ *(this issue has been resolved)*

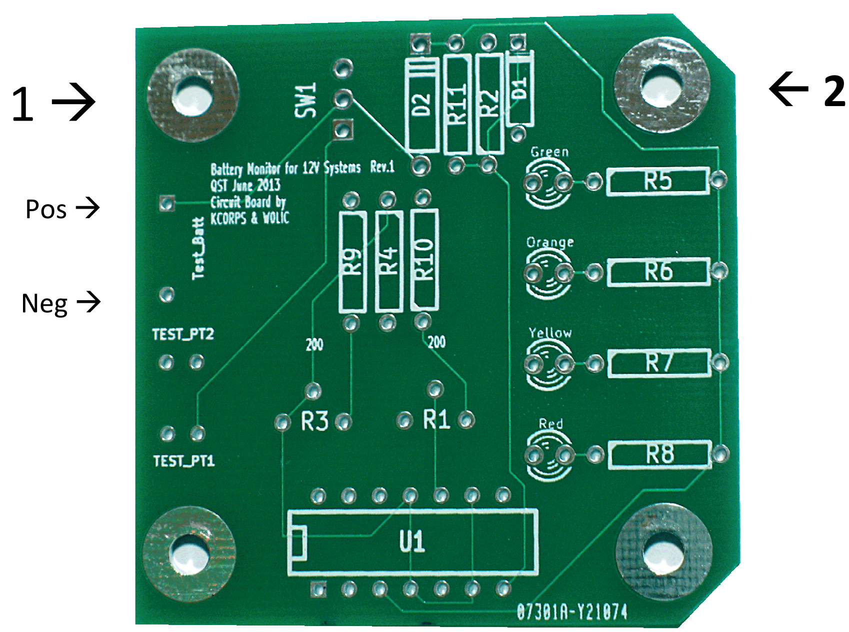


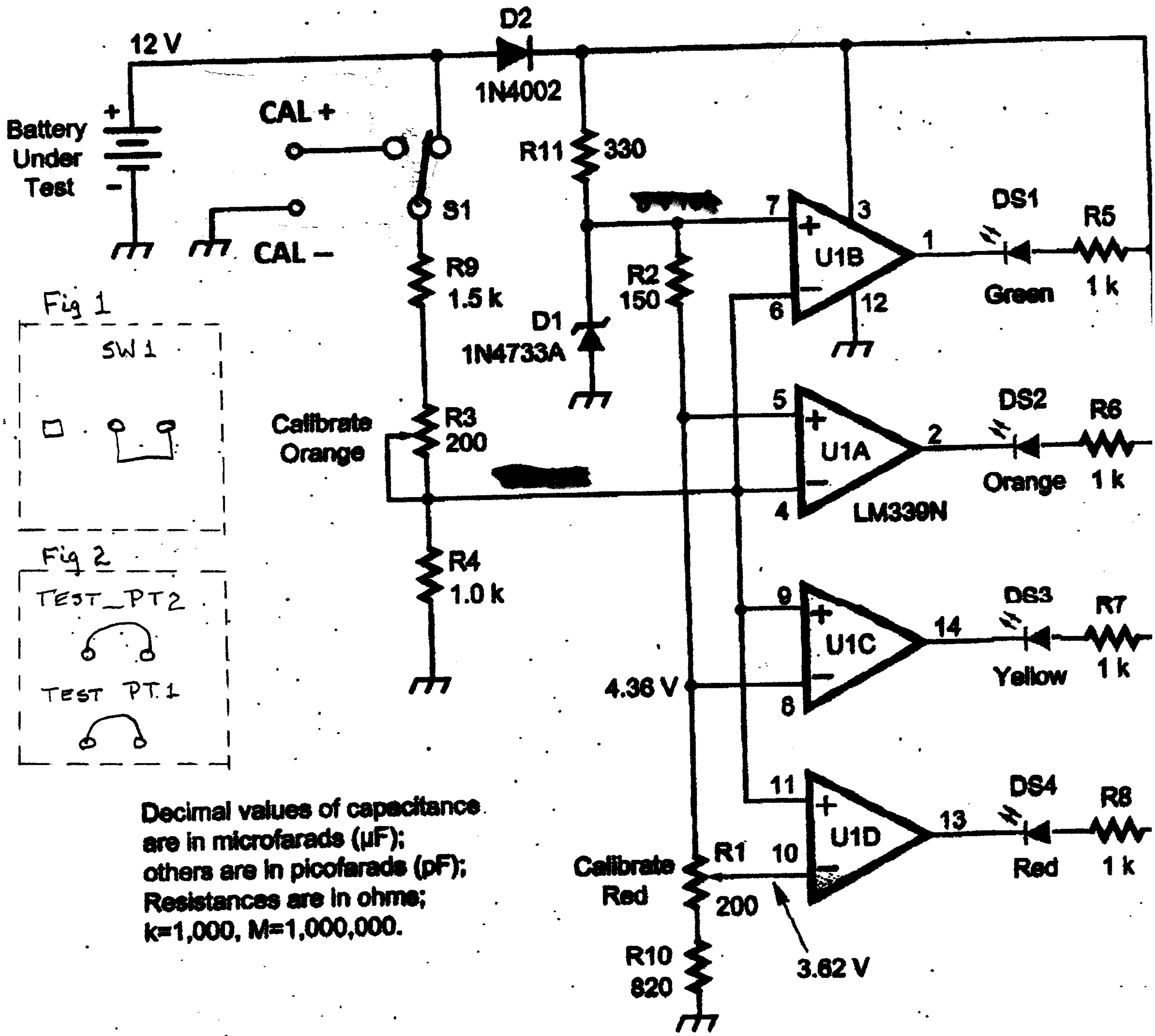
Figure 1 Printed Circuit Board for A Battery Monitor for 12V Systems, QST June 2013

Initial Electrical Test…

- Solder wires to the two Test_Bat connection points as marked on the PC board. Connect a 12V battery (observing correct polarity… see photo above) to the test leads, If any of the four LEDs lights, board assembly is probably been done successfully and congratulations are in order!

Final Test and Calibration…

- This can best be accomplished using a variable voltage power supply, and a simple voltmeter (Harbor Freight™, etc.) and should be done once final assembly is complete. A variable voltage supply will be on-hand at the next club meeting for final calibration. For those of you with a variable voltage supply at home, connect your supply to the battery test leads and set the voltage points (using R1 and R3) as described in the attached QST article.



Decimal values of capacitance are in microfarads (µF); others are in picofarads (pF); Resistances are in ohms; k=1,000, M=1,000,000.

Schematic diagram and parts list for battery voltage monitor.

D1 — 5.1 V Zener diode (or use 78L05, see text).
D2 — 1N4002 silicon diode.
DS1 — Green LED.
DS2 — Orange LED.
DS3 — Yellow LED.
DS4 — Red LED.
J1-J2 — Test pin jacks.
(ON BOARD LABLED CAL + and CAL –)

R1, R3 — 200 Ω potentiometer.
R2 — 150 Ω, ¼ W resistor.
R4-R8 — 1 kΩ, ¼ W resistor.
R9 — 1.5 kΩ, ¼ W resistor.
R10 — 820 Ω, ¼ W resistor.
R11 — 330 Ω, ¼ W resistor.
S1 — SPDT miniature toggle switch.
U1 — LM339N quad comparator IC.

BATTERY ANALYZER PARTS LIST

SCHEMATIC ID	DESCRIPTION	QTY	MOUSER P/N	COMMENTS
U1A-D	LM339N COMPARATOR	1	512-LM339N	
DS1	GREEN LED	1	630-HLMP-1503	
DS2	ORANGE LED	1	630-HLMP-K401	
DS3	YELLOW LED	1	630-HLMP-1401	
DS4	RED LED	1	630-HLMP-1301	
R1, R3	200 OHM TRIMMER POT	2	858-25PR200LF	MAY BE O/S *
R2	150 OHM, 1/4 WATT	1	791-RC1/4-151JB	MAY BE O/S **
R4 - R8	1K OHM, 1/4 WATT	5	791-RC1/4-102JB	
R9	1.5K OHM, 1/4 WATT	1	588-OD152JE	
R10	820 OHM, 1/4 WATT	1	588-OD821JE	
R11	330 OHM, 1/4 WATT	1	271-330-RC	
D2	1N4002 DIODE	1	512-1N4002	
D1	5.1V ZENER DIODE	1	512-1N4733ATR	
	DC POWER CORD	1	172-7443-B-E	
	DC FEMALE POWER PANEL MOUNT CON'TOR	1	16PJ222	
	ALLIGATOR CLIPS OR SIMILAR	2	NOT PROVIDED	

ESTIMATED COST OF ABOVE PARTS: $13.00

* CONSIDER DIGI-KEY P/N 987-1594-5-ND
** CONSIDER DIGI-KEY P/N CF14JT150RCT-ND

E:\BAT ANA PL

A Battery Monitor for 12 V Systems

Keep track of the status of those storage batteries for ARRL Field Day.

Mert Nellis, W0UFO

Being able to monitor a battery in use during operation or while charging can be useful to make sure everything is working as it should. After all, you don't want a power interruption to spoil your Field Day fun. While there are several commercially available monitors, this one is an easy, do it yourself project. You might be able to make it from parts that are in your junk box. I find it useful for monitoring charging with my solar panel.[1]

The schematic in Figure 1 shows that the LM339 quad comparator is the main component. It needs a 5 V reference and four LEDs to indicate four different voltage levels from the battery that is being monitored.

Operation

The idea is to have an orange LED come on if the battery voltage is above a middle operating range. If during charging it goes higher to its full charge voltage, a green LED lights along with the orange. If the battery voltage goes below the middle range, the above two LEDs are extinguished and a yellow LED comes on. If the discharge continues till the voltage reaches the bottom of safe battery usage, then the red LED lights up. Even if you don't use different color LEDs, the position of the lights (with labels, perhaps) can give the message.

Circuit Details

The unit is powered by the battery being tested, so no other supply is needed. The internal 5 V reference can be provided by either a 78L05 IC or a 5.1 V Zener diode. The schematic shows the Zener but R11 and D1 can be replaced by a 78L05 and the usual bypass capacitors if desired. The 5.1 V also supplies the comparator, so it will continue to function as long as the battery has even a small fraction of its charge.

Note that a switch is provided to remove the sense lead from the operating battery and connect it to a test point so that a separate variable calibration voltage can be applied to test the comparator. A series diode (D2) is used to protect the circuit if the polarity is accidentally reversed when connecting to a battery.

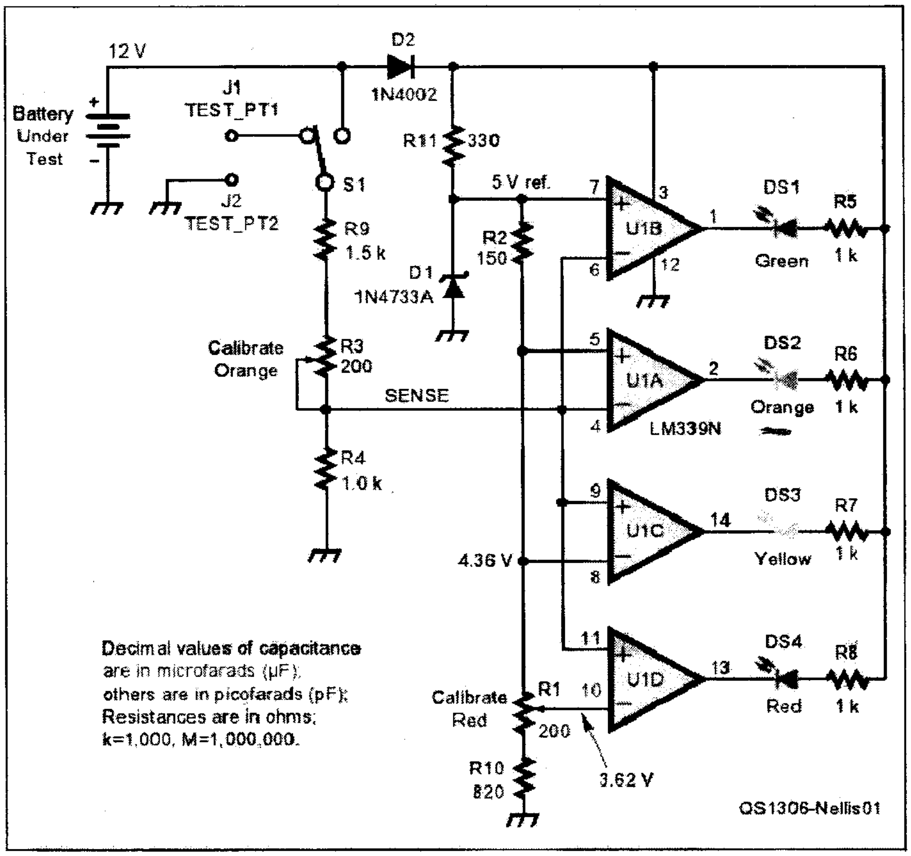


Figure 1 — Schematic diagram and parts list for battery voltage monitor.

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[1] M. Nellis, W0UFO, "Characterizing Solar Panels for Amateur Radio Applications," *QST*, Feb 2012, pp 33-34.

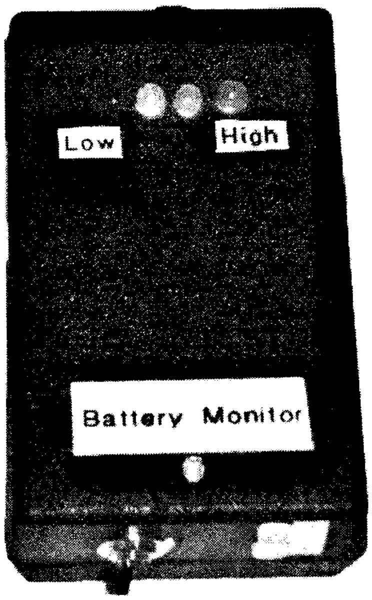


Figure 2 — Front panel of the battery monitor.

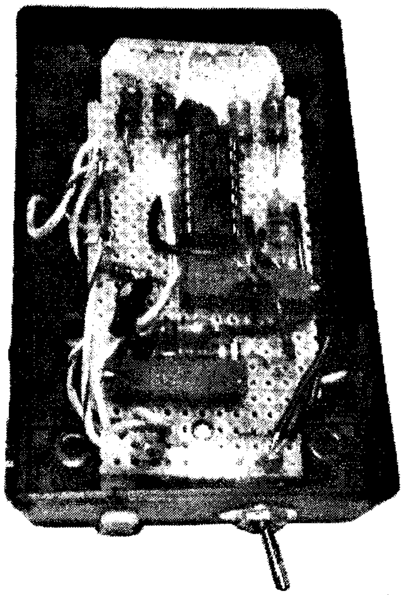


Figure 3 — Inside view of the battery monitor. The use of perforated project board is optional.

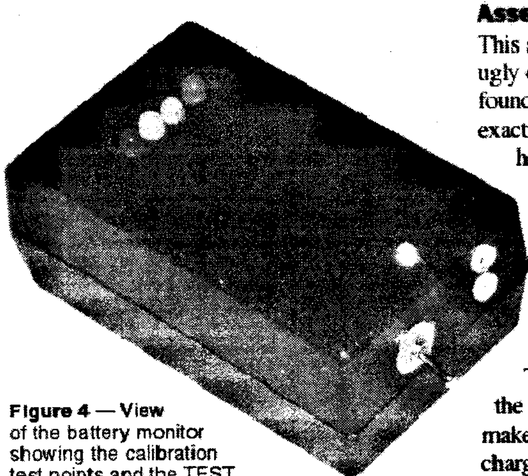


Figure 4 — View of the battery monitor showing the calibration test points and the TEST switch.

Assembly

This small circuit can be assembled using ugly construction or on a prototype board. I found the prototype board to be useful. The exact layout will depend on the parts you have available. I put mine in a small plastic case, but use whatever will work for you. All circuits operate at dc, so layout isn't particularly important. Figures 2 through 4 will give you some ideas of how mine is laid out.

Calibration

The voltage sense input is switched from the battery input to a separate test point to make it easier to calibrate. To calibrate, a full charge voltage of about 13.8 V from a sealed lead acid battery can be connected to the test point input and R3 adjusted until the orange LED just lights along with the green LED. The mid-range point at which the top end LEDs (orange and green) go out is already set by the voltage divider string R1, R2 and R10 to be about 12 V. The red LED for the battery low charge point is set by adjusting R1 for red to come on (probably near 10 V).

To recap: when the battery is low both the low voltage red and yellow LEDs are on and, as the battery comes up, the red goes out, then the yellow goes out and the upper orange comes on and finally at full charge the green LED comes on along with the orange.

Polarity

The correct polarity must be observed when connecting the battery. A series diode, D2, is used to provide protection against reversed polarity connection to a battery but the circuit will work only with the correct polarity.

Amateur Extra class operator **Mert Nellis**, W0UFO, was first licensed as W9UFO in Nashwaulk, Minnesota, then as W8CNC in East Lansing, Virginia before he obtained his current call. He received a BSEE degree from Iowa State University, then an MSEE from Michigan State University and is a Registered Professional Engineer in Minnesota, working in magnetic and industrial control.

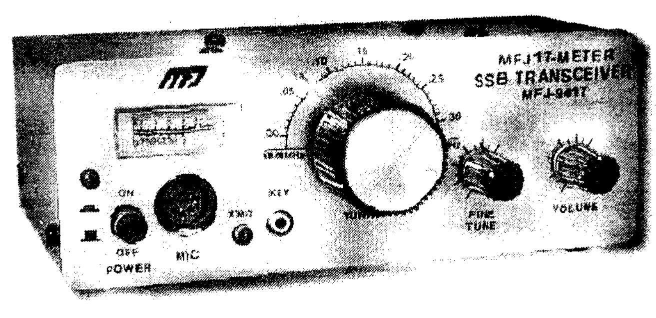
Mert enjoys low power operating, homebrewing gear and building kits. He is a member of ARRL, QRP-ARCI, FISTS, NAQCC, SKCC, SOC and is a life member of IEEE. He also enjoys hunting, fishing, private flying and gardening, as assistant to his wife the Master Gardener. You can reach Mert at 651 11th Ave NW, St Paul, MN 55112 or at **mertnellis@msn.com**.

For updates to this article, see the *QST* Feedback page at www.arrl.org/feedback.

New Products

MFJ Adventure Radios for 17 and 12 Meters

MFJ has added two new SSB transceivers to its Adventure Radio series. The MFJ-9717 covers 18.080-18.170 MHz and is rated for 12 W PEP on SSB. The MFJ-9412 covers 24.890-24.990 MHz and is rated for 20 W PEP. Both radios use a superhet receiver design with a 2.3 kHz crystal ladder filter. They have analog S meters and 500 mW audio output. On transmit, the transceivers use speech processing and have built-in low pass filters to suppress harmonics. A handheld dynamic microphone is included. They require a 13.8 V dc, 2 A power supply or an appropriately sized 12 V battery. Size (HWD): 2.5 × 6.5 × 6 inches. Price: MFJ-9417, $269.95; MFJ-9412, $289.95. For more information, to order, or for your nearest dealer, call 800-647-1800 or see www.mfjenterprises.com.



January 1966 issue of *QST*. That article had an error in it when published in 1966. The nomograph was off by a factor of 2.

In order to correct it later, my editor (Byron Goodman, W1DX, I believe) decided it was easier to edit the span in Figure 1 to be shown as ½ of the total span, rather than adjust the nomograph itself. That did correct the error, although it probably led to some of the ongoing confusion. Several ARRL editors have asked me questions about the drawing and nomograph over the years, probably when changes were being made to *The ARRL Antenna Book*. — *73, John Elengo, W1DQ (ex-K1AFR) 50 Surrey Dr, Cheshire, CT 06410*; **w1dq@arrl.net**

A Battery Monitor for 12 V Systems (June 2013)

Mert Nellis, WØUFO, outlined a neat little circuit for battery monitoring using the LM339N quad comparator IC. He makes no mention of what the total quiescent current drain of his circuit is, however. With two LEDs powered on when the circuit is active, along with the other parts, it looks to me like the quiescent current could be on the order of 50 mA or more. (This is assuming 0.8 mA for the LM339, 18 mA for the two LEDs, and 35 mA for the voltage reference Zener diode.)

So, in 24 hours the drain will be approximately 0.05 A × 24 H or 1.2 AH. In my opinion, that is too high a high price to pay to monitor a small gel battery, which may only have a capacity of 5 or 7 AH. In a few days the battery will be flat, just from monitoring.

I have a small solar-powered 12 V dc system with seven 50 AH gel batteries that power my ham shack lighting and all my rigs. I also have a standalone "kitchen ham shack," where a parallel pair of 7.5 AH gel batteries power a 440 MHz and 1.2 GHz rig. For these reasons, I have always been interested in a simple means of monitoring the battery bank(s).

One of the most important issues for any battery system monitor is the power burden placed on the battery system. This should be as small as possible. I have tried voltage monitoring kits that use the LM3914 dot/bar driver, such as Quality*Kits* Model FK939, but they have the same problem, which is excessive current drain. See **store.qkits.com/moreinfo.cfm/FK939**.

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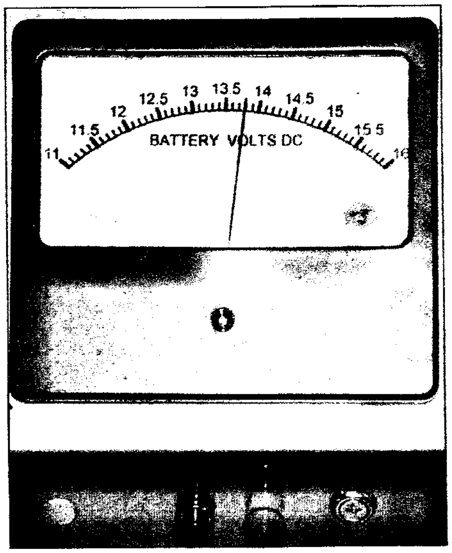

Figure 2 — A battery monitor meter with a customized scale added. The banana jacks on the front of the enclosure make it convenient to connect this monitor to any battery pack.

Another very well-thought-out kit is the BVM1 from **cirkits.com**. Here, the designer pulses the circuit on for a low duty cycle, resulting in an average drain of only 6 to 7 mA. I have one of these, and was able to reduce the average current drain to about 5 mA by extending the duty cycle.

When all is said and done, however, the simplest approach is to use a low cost 5 V dc analog panel meter with a series connected 11 V Zener diode, (such as a 1N5241B). This gives you an expanded scale voltmeter, with a range of 11 to 16 V.

Any suitable current meter in the range of 50 μA to 1 mA full scale can also be used, provided that you add an appropriate series resistor as well as the 11 V Zener diode to give you 16 V full scale.

I have used the excellent meter scale drawing program, *Meter*, by Jim Tonne, W4ENE, (**www.tonnesoftware.com**) many times to design and print a new meter scale. See Figures 2 and 3 for examples of the meter scales I am using. [*MeterBasic* is a program with a subset of the features available in *Meter*. It has been included on *The ARRL Handbook* CD-ROM for a number of years.[5] — *Ed.*]

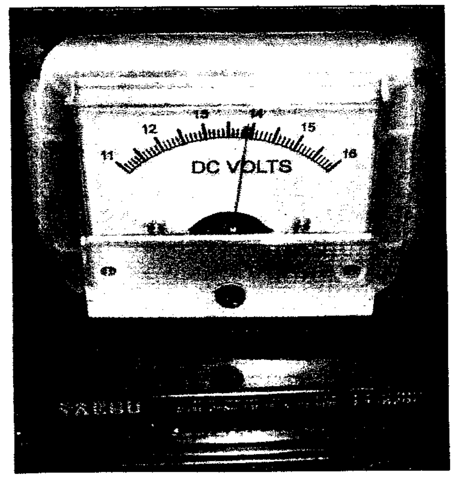

Figure 3 — This meter monitors the battery voltage in Don's "kitchen shack."

In my opinion, the analog expanded scale voltmeter beats any other means of battery voltage monitoring hands down. The current drain on the battery being monitored can be less than 1 mA. — *73, Don Dorward, VA3DDN, 1363 Brands Ct, Pickering, Ontario, Canada L1V2T2*; **ddorward@sympatico.ca**

[5]H. Ward Silver, NØAX, Ed., *The ARRL Handbook*, 2014 Edition (2013), ISBN: 978-1-62595-001-7; ARRL Publication Order No. 0007, $49.95. ARRL publications are available from your local ARRL dealer or from the ARRL Bookstore. Telephone toll free in the US: 888-277-5289, or call 860-594-0355, fax 860-594-0303; **www.arrl.org/shop**; **pubsales@arrl.org**.