QRP

Low Power Operation

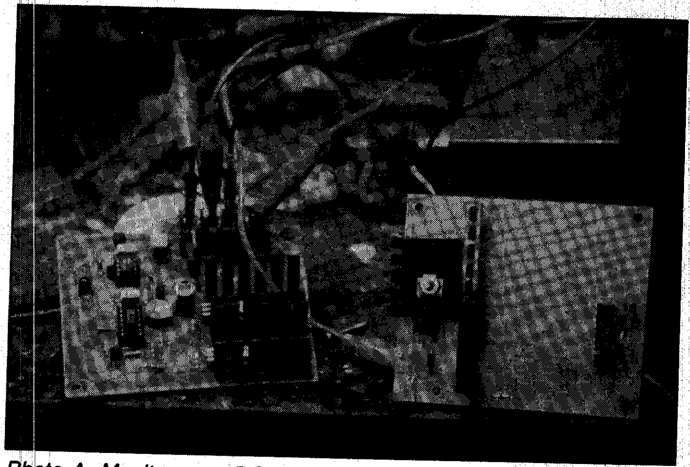

Photo A. Monitor your DC supply with this LED expanded voltmeter circuit (shown on the right).

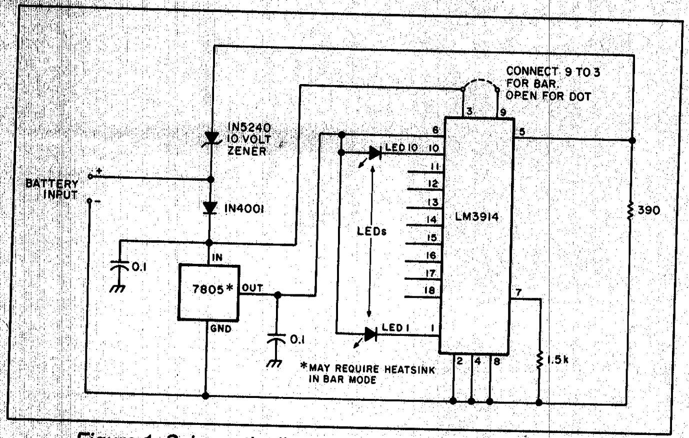

Figure 1. Schematic diagram of the expanded voltmeter.

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LED Expanded Voltmeter

Can you stand just one more expanded voltmeter? I sure hope so, as this is an easy project to put together and operate. In fact, there is not one single adjustment to be made. What makes this expanded voltmeter special is the 10-segment LED readout. All this magic is carried out by an LM3914 dot/bar display driver IC.

Unlike other chips used today, the LM3914 does only one thing, and that is to light up 10 LEDs in bar mode, or one of 10 LEDs in the dot mode, in response to an input voltage. The LM3914 contains a voltage divider and 10 comparators that turn on in sequence as the input voltage rises. There's also a 1.2 volt reference voltage source inside the LM3914. The LM3914 comes in an 18-pin dual in-line package. Figure 1 contains a simplified version of the circuit of the LM3914. You could build your own version of the LM3914 using LM339 comparators to get a 10-LED bar display, but I don't see any reason why. The LM3914 goes for about $3 at most electronic supply houses.

How It Works

The expanded voltmeter takes advantage of the external reference pins of the LM3914. You can use either the built-in 1.2 volt reference or supply a reference voltage to pin #6 (Rhi) of the LM3914. Pin #4 (Rlow) is the ground return for the divider chain. This is exactly what we're going to do when we build the voltmeter.

The reference voltage we'll feed to the LM3914 comes from a 7805 1-amp regulator. This regulator will also source the LEDs. The +5 volts is placed on pin #6 of the LM3914. The low end of the divider chain is pin 4 and it's grounded. Pin 6 is +5 volts, pin 4 is ground, so we have established 5 volts across the divider. The LM3914 then divides this 5 volts into 10 equal steps, each one 0.5 volts DC. This establishes the full-scale voltage (0–5) of the meter.

The battery voltage is fed to a zener diode. In this case, it's a 1N5240, a 10 volt zener diode. This zener diode subtracts 10 volts from our incoming voltage feed from the battery. The 390 ohm resistor connected in series to the zener diode continually draws current through the zener diode and makes the voltage drop stable. The value of this resistor is not critical. You can use almost any value from 220 ohms up to 1,000 ohms. Use something close if you don't have the 390 ohm resistor in the junk box.

If we use a 12 volt battery, the LM3914 "sees" only 2 volts. The 2 volts are then applied to the input of the LM3914 and, when compared to the 5 volt reference, the chip will then light up four LEDs (in the bar mode). Remember, each LED is worth 0.5 volts, so 2 volts equal four LEDs. By using the zener diode, we have expanded the range of the meter to read 10 volts, no LED on, to 15 volts, or all LEDs illuminated.

The 1.5k resistor on pin #7 of the LM3914 is used to control the amount of current flowing though the LEDs. Since we're feeding the LEDs' anodes from the 7805, we can adjust the value of the 1.5k resistor to suite your liking. Lower the value and the LEDs will get brighter; raise the value and they'll be dimmer. The brighter the LEDs, the more current we'll be demanding from the battery we're trying to measure. If you don't happen to have a 1.5k resistor in your junk box, a 2.2k works very well.

We could have sourced the LEDs directly from the Vcc line, but that would have really put stress on the LM3914. They're kind of expensive chips to be cooking, so stick with the 7805.

To keep the electronic expanded voltmeter from going up in smoke if you connect it to the battery backwards, a simple 1N4001 diode is used. If you hook the meter up backward nothing bad will happen; in fact, nothing will happen at all.

Another feature of the LM3914 and of this project is the ability of the LM3914 to display either a moving dot (one LED at a time) or bar mode (many LEDs at one time). Pin 9 selects either one. When pin 9 is connected to Vcc, we have bar mode. If pin 9 is left floating, dot mode. We should connect pin 9 to pin 11 when using dot mode, but I have not had any trouble just leaving the pin float.

Construction Tips

Because of the number of components used, a small piece of perfboard could be used for construction. However, a lot of mistakes can be made when connecting the LEDs to the LM3914. A ready-made PC board is available from Far Circuits, 18N640 Field Court, Dundee, IL 60118, for $8 plus $1.50 for shipping. A complete set of parts, including the PC board, LM3914, LED strip and the 7805 may be purchased for $19.95 plus $1.50 shipping from me.

Watch the Vcc and ground pins as they are different from many ICs you may be used to using. The Vcc pin is #3 and the ground pin is #2. Remember, the LM3914 comes in an 18-pin DIP package. As the LM3914 is kind of expensive, it would be a good idea to get a socket for it.

The PC board has been laid out to accept a 10-LED strip. This makes a really nice display as all the LEDs are straight and of equal intensity. This strip is available from Mouser Electronics (part number is 351-2011). Of course, you don't have to use the LED strip as regular LEDs may be used. If you go this route, check each LED for brightness before you solder it in the PC board. I mounted the LED strip by inserting a 0.625" long nylon spacer on

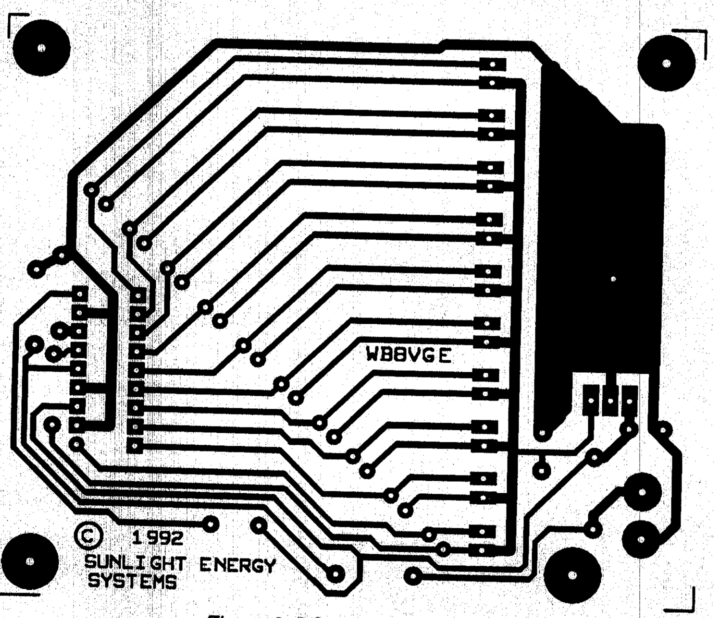

Figure 2. PC board foil pattern.

the first and last LED. This provides support and keeps the LED strip from bending. If you don't use the LED strip, you could use nylon spacers on each LED as well to keep them all upright. It might be a tight fit with all 10 spacers under the LEDs.

If you use individual LEDs, you might want to add some color to the project. The lower voltage LED could be red, some yellow or green in the middle, and red LEDs at the top two positions.

The PC board allows you to install the LEDs either vertically or on a slant. Don't install two rows of LEDs! Doing so will french fry the LM3914.

Install a small heat sink to the 7805 regulator if you use the voltmeter in the moving bar mode. You won't need to heat-sink the regulator if you set the mode to moving dot as only one LED will be on at a time.

Assembly is easy. Stuff the PC board and check out your work. If you want the moving bar display, solder a resistor lead in the two PC holes marked "mode." For the moving dot display, don't use the jumper.

Check over your work before adding juice to the circuit. There's nothing to adjust or set up. Use a variable power supply to test out the voltmeter to verify operation before you connect the meter to a battery. As you raise the voltage, the LEDs will light up (depending on what mode you have the display in). If you have the display in the moving bar mode, at 15 VDC all the LEDs should be illuminate. At 10.5 volts, all the LEDs should be dark.

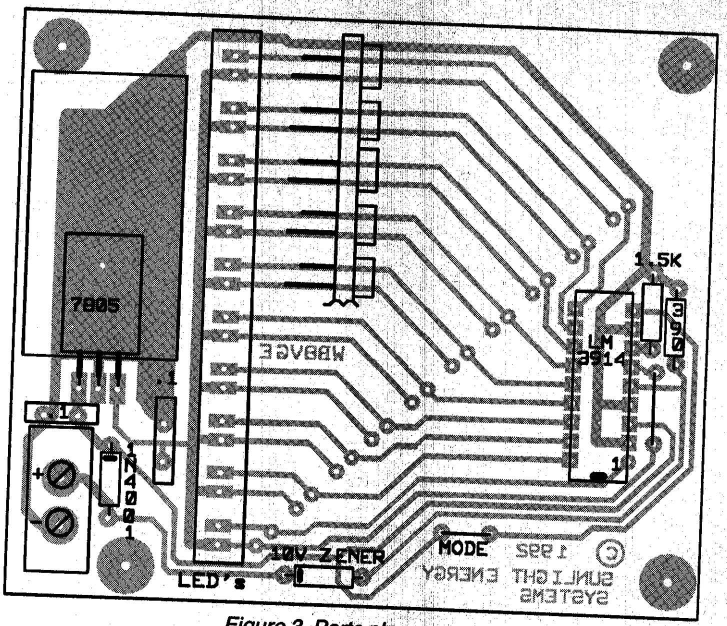

Figure 3. Parts placement.

That's it! But before you button the meter up, you'll have to add some type of scale. I for one can't remember what LED should be glowing at any one time.

Install the meter in a small plastic box. A paper scale was laid out and placed on the front of the box. This method seems to work quite well. Nothing fancy, but it gets the idea across. Start with the bottom LED at 10.5 volts (at 10 volts, all the LEDs are off) and the top (or tenth LED) at 15.5 volts.

If you have the display set as a moving bar, total current for all the meter will be around 130 mA. Moving dot display requires 30 mA. In the moving bar mode, I would not want to leave the meter connected to a small battery very long. This expanded voltmeter would be a great accessory to a variable power supply on your work bench. RVers, as well as mobile operators, might find it useful.

Field Day QRPers can keep an eye on their batteries. You'll find this expanded voltmeter a valuable part of your tool box. 73

CIRCUITS

Number 19 on your Feedback card

Great Ideas From Our Readers

Crystal Matching and Activity Tester

Hams still use crystals for many purposes: VXOs in QRP gear; in matched frequency sets for IF ladder and lattice filters; local oscillator injection to product detectors; as "quick and dirty" RF sources for experimentation, and many other uses. Many different crystals available as surplus are quite inexpensive, and there are a number of crystals residing near the bottom of a number of junk boxes, many of which can be put to use.

Crystals vary in activity and many crystals, especially those in FT-241 and FT-243 holders, tend to age, and both frequency and activity are subject to change over time. Even if they have quit entirely they can be taken apart and washed in alcohol and replaced in their holders. Modern crystals in hermetically sealed metal cases seldom age much and rarely quit operating unless a mechanical shock has broken an internal connection.

This simple circuit allows rapid testing of crystal activity—if the crystal is good, the LED lights. The connector allows monitoring of crystal frequency with a frequency counter, making selection of matched frequency crystals for IF filters a simple matter. Crystals of frequencies from below 1 MHz to over 13 MHz will oscillate readily in this circuit. Crystals oscillate in their series mode, slightly higher in frequency than that marked on the holders.

One-half of a 7400 2-input quad NAND gate TTL chip is connected as an oscillator and is followed by an NPN transistor switch. RF from the oscillator is rectified by a pair of germanium diodes (silicon will also work), filtered, and the resulting DC voltage applied to the gate of the transistor, which causes it to conduct. Collector current then illuminates the LED to indicate that the crystal is oscillating.

A crystal of normal activity will cause the LED to light brightly. If crystal activity is low the LED will be less bright, and the crystal most likely should not be used. If a crystal will not oscillate, the LED will remain dark.

If a very accurate indication of crystal activity is required, the diodes and filter can be fed through a potentiometer into a microammeter to ground. This replaces the transistor switch and LED. The pot will set the meter indication at a reference point on the meter scale with an active crystal in the circuit. Additional crystals will produce a meter indication higher or lower than that established with the first crystal, thus showing they are more or less active oscillators. This is rarely of major importance. The simple GO-NO GO indication with the LED will suffice in most instances.

Depending on the type of holders used for the crystals you have, one or more suitable crystal sockets can be paralleled for ease of use in testing.

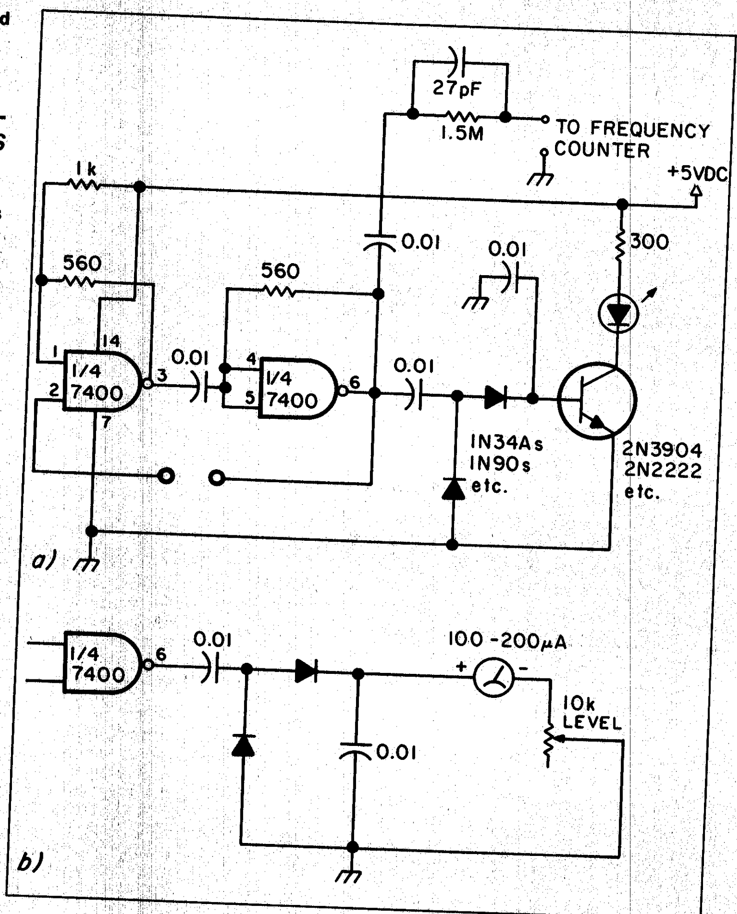

Figure 1a and 1b.

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