INSTALLER'S INSTRUCTIONS FOR
TRI-METRIC ™
Battery system monitor, Models TM-2030-RV and TM-2030-A

revised January28, 2016

IMPORTANT: The wiring installation for this meter, especially the shunt installation must be performed by someone knowledgeable in proper wiring, electrical practices, and safety. If you do not have this knowledge please have someone install it who does, or at least get some competent help to supervise the installation.

To install:

1. **Please read or scan two pages of introductory information in section A.**
2. **Consult drawings Figure 1 and 2 (pages 7-8).**
3. **Follow step by step installation instructions in section B.**
4. **Program the two most important parameters into meter (section C1).**

Contents

Limited warranty. Meter is warranted for 4 years against any manufacturing defects. Any meter not meeting the specification or performance description will be replaced or repaired within four years of purchase, provided it has not been subject to abuse or misapplication, and provided the defective unit is shipped to us if we request it. Contact your dealer or us before shipping.

BOGART ENGINEERING Inc
19020 Two Bar Road
Boulder Creek, CA 95006
(831) 338-0616
www.bogartengineering.com

A: What you may need to know before installing the TriMetric meter.

Review this (briefly) before installing.

The TriMetric is usually located in the living area **where people using the power can readily observe it. It is usually located less than 100 ft from batteries.** For greater distances refer to section B2 for details**.** If the optional SC-2030 Solar charger is also to be used, the charger is typically located near the batteries where it can be completely controlled from the TriMetric TM-2030.

The TM-2030 measures volts, amps, watts, percent full on your "main" system. In addition, it will monitor *voltage only* on a second battery having a common negative connection, which could be the engine starting battery.

Permissible battery voltage: This meter is suitable for battery systems with nominal voltage from 8 to 65 volts. *It should not be connected to systems which will ever exceed 65 volts.*

You may choose three different operating levels from simplest to more complex: The meter comes initially programmed at the lowest Operating Level: L1 which will furnish the most important data. There are also levels "L2" or "L3" which add more functionality, but with more complexity. For new users, begin with L1, and after becoming familiar with the meter advance to L2 or L3 later at any time. L4 adds (only) a more stringent requirement for what is considered to be "charged," intended mainly when using the optional SC-2030 solar charger. These levels are described in the TriMetric User's Instructions.

Lightning considerations: The meter has been designed with good protection against lightning.

It is possible to wire the TriMetric so it reads *only* total solar input current, or only total load current (and amp-hours): In this case refer to our web site: BogartEngineering, SUPPORT/APPLICATION NOTES" entitled : Using TriMetric for measuring only wind or solar charging source.

Serial data output is available for all real time data— This is a data access method for techies. See application note on the Bogart Engineering web site under SUPPORT/APPLICATION NOTES entitled : TM-2025-TM-2030 Technical Information on Serial Data Output

Mounting the meter: There are two versions of the TM2030 which differ only in their size, front label colors and whether the meter includes its own enclosure.

The TM-2030 RV model comes in a white, surface mount enclosure (3 x 4-1/4 x 1-1/4 inch deep). It can be mounted to a wall with screws at the top and bottom flanges.

The **TM-2030 A can be mounted** in many standard "double gang" electrical boxes available in hardware stores.

For detailed drawings, see **application** notes on the **Bogart Engineering** web site under **SUPPORT/APPLICATION NOTES**: "**Mounting Drawings** for .TM-2020/TM2030."

A shunt (an accurate, very low resistance power resistor) must be wired into your battery system as described in section B of these instructions, shown on the wiring diagram page 8. The "amps" shown on the meter measures whatever current passes through this shunt—so it must be wired in series with the wire which carries the current to be measured. **The shunt is almost always installed between the negative terminal of the battery and all the loads and charging sources** (see Figure 1 on page 7.) It is located near the batteries, since the high current carrying wires must be kept short. The TriMetric meter measures the current ("amps") by measuring the very small voltage drop across this shunt. The voltage drop across the shunt is very small—with the 500A/50mV shunt it is equivalent to only a 2 foot additional length of 0000 gauge cable in series with your main wiring.

TriMetric maximum current capability: The TriMetric meter itself will measure current (amps) properly up to 999 amps with a 500A/50 mV shunt. With the 100A/100 mV shunt the meter measurements will be OK up to 300 amps. However, **at these currents the shunt is going to get too hot**. The typical 500A/50mV shunt will be OK up to 420 amps. The typical 100A/100A shunt will be OK up to 70 amps maximum. These are charging or discharging amps values, NOT amp hour numbers.

MORE SHUNT INFORMATION

There are two choices of shunt, depending on your system size: the 500A/50mV or 100A/100mV size. Most systems will use the 500 amp-50 mV shunt. This gives an "ampere" resolution as low as 0.1 amp and will read to a steady 430 amps before the shunt overheats. For smaller systems (with 12V systems with inverter 800 watts or less) you could use a 100A/100mV shunt It has the advantage that you can read currents as low as 0.01 amp, however has the 70 amp maximum amp limitation noted above. The correct shunt must be programmed as described in section C2 on page 6

Technical note: It is only the shunt *ratio* between amps to mV. which is important to the meter--so, for example, a 200 amp-200 mV. shunt can, from the meter's point of view, be considered equivalent to the 100 amp-100 mV shunt. The implication, when a shunt is rated at "100 amps-100 mV." is that it may safely carry *up to* 100 amps maximum--however in many cases so-called "100 amp" shunts will not carry this much without overheating. For more information see application note on the **Bogart Engineering** web site under **SUPPORT/APPLICATION NOTES** entitled: **Shunt Info**.

B. How to Install METER and SHUNT

B.1. Preliminary

- **IMPORTANT: A qualified person familiar with safe electrical practices and the local electrical code should install this meter--particularly when installing the shunt. Accidentally shorting the battery with a tool or other metal such as a finger ring can result in severe burns from an arc. Mistakes in wiring could seriously damage your electrical system.**
- **Refer to wiring drawing on last page--please read all notes.**
- **To prevent damage to meter, do not install into a battery system that has a voltage that will rise above 65 volts. It is designed for a maximum "nominal" 48 volt battery system.**
- **A (1Amp, fast-blow) fuse shown** located *near the battery* for each battery in the wiring diagram will protect the wire and the meter even if you accidentally miswire to the terminal block.. If not provided with your meter, such "in line" fuses are available at Radio Shack and other electrical supply stores.

B.2:For installation you will need:

- **One shunt (usually 500A/50mV size).** This is the sensor that measures the "amps"**.**
- **"shunt to battery cable:"** Prepare or obtain from an electrical supply or auto store a **"shunt-battery cable"** (about 6 inches to several feet long as needed,) with diameter at least as large as the largest cable going to the negative battery connection. The cable size must be large enough to accommodate the maximum system charging or discharge amps from the battery. It should have suitable bolt lugs at each end. One end will connect to one large bolt on the shunt—the other end to the battery negative post. See Figure 1 on page 7.
- **Small, 4 or 5 wire cable long enough to connect from meter to battery system—with one or two 1Amp fuseholders:** Virtually any multi conductor cable available in a hardware or electrical supply house will be OK, including CAT5. Or 4 or 5 individual wires may be used. Required wire size shown next paragraph. (Five wires if two batteries are being measured.) **The wire used for the + connection of both the main (and secondary battery if used) should each have a 1A fuse at the battery end** to protect against a short in the wire.

  Minimum size wire for distances shown: #26 gauge: 45 feet. #24 gauge: 70 feet. #22 gauge: 110 feet. #20 gauge: 180 feet. #18 gauge: 300 feet.

  For long runs over 100 feet our website has an application note describing how to use Cat 5 cable for going up to 350 feet. See the **Bogart Engineering** web site under **SUPPORT/APPLICATION NOTES** entitled: **Using CAT5 cable up o 350 ft. for TriMetric**.
- **Suitable wrench or tools for connecting the large cables to battery and shunt**
- **Very small screwdriver for connecting wires to terminal block on the back of the TM-2030.**
- **Small Phillips screwdriver for removing front panel of meter**
- **Medium screwdriver for connecting wires to shunt**
- **For TM-2030-RV only: A drill for making a small hole to allow wires to enter the meter box**
- **For TM-2030-A only: A "double gang" electrical box of suitable size to accommodate the meter panel.**

B.3: Eight steps to install shunt and meter:

Steps 1-3: Install Shunt
Steps 4-6: Connect wires from meter to shunt and batteries.
Step 7: Check of wiring.
Step 8: Install two program values for your system

STEP 1:Turn off main breaker to battery. **Check figure 1 on page 7 to see how the shunt will be connected when you complete step 3.** Remove **EVERY wire and EVERY cable** connected to the **negative** side of your battery system. After you have accomplished this step you will be left with one or more dangling cables that will be reconnected to the shunt in STEP 2. **A common error is to leave one or more still connected**.

If your system has one battery, **or if you have two (or more) batteries in series**, then before step 2 you will have one negative pole (on one battery) that should be **completely bare, disconnected** from **any** (current carrying) wires or cables, such as chassis ground.

If your system has four 6V batteries in series-parallel, or **two 12V batteries in parallel**, then on the negative side of the battery system you will then have **only one** cable connecting two negative poles from two different batteries connected together. Before step 2, there must be **no other wires** going to

inverters, grounds, solar controllers or ANYTHING ELSE connected to **the negative side of the battery system except for one** cable that connects the two battery negative poles together.

We emphasize this because quite often people **make the mistake of leaving chassis ground, or one or more other device still connected to the negative side of the battery system—**which will result in the wrong battery "amps" being read on the TriMetric.

STEP 2: Reconnect all the cables you took off in STEP 1 to either of the two large bolts on the shunt. All such cables must be connected to one side of the shunt—leaving the other bolt empty for step 3. This doesn't mean that they have to go directly to the bolt itself—but must connect electrically to this side of the shunt. Arrange the shunt so the two small "Kelvin" screws on the side or top of shunt are accessible for connecting later (Step 5).

STEP 3: Obtain "shunt to battery cable" referred to in B2 above. See diagram page 7, Figure 1B, "After cable installation".

Connect one end of cable to the now empty large bolt on the shunt.

Connect the other end of cable to the now bare battery negative battery connection provided in STEP1.

PREPARE FOR STEPS 4-6: Connecting wires from meter to battery and shunt. Refer to the wiring diagram on the last page of these instructions to see how the wires connect from the meter to the battery system. Every system will require a minimum of four wires shown as G1, G2, SIG +B1 shown in table below. If you also wish to also monitor the voltage (only) of a secondary battery you will also need to connect a fifth wire from the positive post of this battery to meter as shown in wiring diagram.

The terminal block on the TriMetric circuit board accommodates wire size from 16 to 26 AWG. Use a cable with different colored wires to reduce the probability of wiring errors. **On the chart below write the colors for each wire**. It has suggested colors if your cable uses these colors—Note that G1 and G2 **may** be the same color, as they both join together at the Kelvin screw on the shunt.

The +B1 terminal must be connected to the + terminal of the *main* battery set. We suggest connecting directly to the + battery terminals so that the meter will operate even if a main breaker is turned off. The +B2 wire is only used if you wish to measure the voltage only of a second battery.

Ignore this paragraph unless twisted pair wires in a cable are used: Twisted pair wires are not necessary unless you run the wires very close to other high current carrying wires for 10 feet or more. **However if used,** the wires labeled "G2" and "SIG" should be run with one twisted pair, and if another pair is used, "G1" and "+B1" may be run in an another pair, although twisted pair here will not give any benefit. Clearly establish which wires in the cable are "paired" together. This often requires stripping quite a bit of insulation to see which pairs are twisted together. Then choose one twisted pair for G2 and SIG (the ones for which twisted pair is helpful), and record the wire colors for that pair below in the chart. You may want to use a piece of tape at each end of the cable to tie these two together, to clearly mark the pair. Then you can also choose a pair for G1 and +B1 and record their colors on the chart above, and an extra wire for +B2, if used.

	CONNECTION	WIRE COLOR
supplies - power to meter →	G1	(black?)
amp sense (twisted pair if used) →	G2	(black?)
	SIG	(white?)
supplies + power to meter →	+B1	(red?)
measures 2nd battery voltage (optional) →	+B2	

STEP 4: Connect wires at battery/shunt end: Using chart above for wire colors:

a. First connect both the **G1** and **G2** wires to the Kelvin "load side" terminal (on the shunt *farthest* from the minus battery terminal lead,) as also shown in Figure 2. These two wires must join together *only* right at this terminal.

b. Then connect the **SIG** wire to the *other* Kelvin "battery side" terminal (*closest* to the minus battery connection.)

c. Connect the wire for the **+B1** connection to one side of the one amp fuse holder. Don't yet put in the fuse.

d. A wire from the other side of the fuse holder must connect to the + terminal of the *main* battery set. We suggest connecting it directly to the + battery terminals so that the meter will operate even if a main breaker is turned off.

e. Then, if you are measuring a secondary battery use a second fuse to connect the secondary battery + terminal to its **+B2** wire.

STEP 5: Connecting wires to meter: Check that the fuse holders installed in STEP 4B still have their fuses removed.

TM-2030-RV only: Take the meter out of its box by removing 4 screws. Drill a hole in the plastic box in a desired location and size to allow the cable or wires to enter the box. Thread the wires through the hole.

TM-2030-A only: The panel can mount in a suitably sized "double gang" electrical box that is mounted 90 degrees from its usual orientation on the wall. Thread the wires through a suitable hole in the box.

The meter circuit board has a 5 pin terminal block on the rear. The five connections are labeled: G1, G2, SIG and +B1 and +B2. Strip insulation off each wire 1/4 inch or so.

STEP 6: Use a small screwdriver to loosen the screws on the connector and insert each wire in a separate connector hole using the chart above and/or wiring diagram (Figure 2) to determine which wire goes to which terminal, and tighten each screw to hold the wires securely, taking care that there is no danger of shorts between the wires.

Make a final check of the wiring. Install meter in box and finally insert the 1A fuse(s) in the battery fuse holder(s). Digits should light up on the meter**. If fuse blows, wiring is probably wrong: before replacing fuse:** carefully check that **B1+** wire from battery and fuse goes to proper "B1+" terminal on the meter**.** (See wiring, Figure 2)

If you installed the more common 500A/50mV shunt, proceed to next step 7. If you used the 100A/100mV shunt, see section C2 below: "How to program your meter for the 100A/100mV shunt"

STEP 7: Here's how to check that you've probably wired you meter and shunt properly:

1. Push "SELECT" to illuminate the front panel light: B1 VOLTS. The battery volts should display.

2. Push SELECT to show AMPS. Turn <u>all</u> charging sources and all loads off, with the inverter <u>completely</u> off (not even in "standby"). The meter "amps" display should show near 0. (0.0 to 0.1 amps if using the 500A/50mV shunt. If using the 100A/100mV shunt minus 0.03-0.05 amps which is the current used by the TM2030 itself)

3. Turn on a known load of over 20 watts. (One or more lights, for example,.) This should cause the "AMPS" reading to become more <u>negative.</u> The "amp" value should be about equal to the watts divided by 12 for a 12V system plus a little more for the inverter power. (20÷12 = 1.8 amps) Divide by 24 for a 24V system.

4. Check AMPS charging from every charging source. As you turn each charging source on (solar, alternator, battery charger, etc) be sure that for each source the amps become more <u>positive</u> by about the amount you would expect from that source.

STEP 8 FINAL STEP: program two important program values for your system. This is necessary to make the "% full" display work correctly::

1. Hold the SELECT button down, and when "P1" appears in the display, release the button. If you miss it, just hold it down again until you succeed. The display will show the "Charged voltage setting", alternating with "P1"
2. Momentarily push BOTH SELECT and RESET at the same time—to get the three green lights on the meter to flash on and off. Now you can change the number.
3. For a 12V system enter 14.3 volts. For a 24V system enter 28.6 volts or 48V system 57.2. Push the RESET button to make the number go up. To make numbers go DOWN you must go all the way to 65.0—then it will jump to 10.0 and go up again.
4. Next Push SELECT a few times to show "P3." This will display "battery capacity."
5. As before, momentarily push both SELECT and RESET—three green lights will flash. Enter your "battery capacity" in amp hours. **If you do not know what your "battery capacity" is, see below "How to determine battery system capacity.** As before, the RESET button will increase the numbers. Note that the display can't show above 999, so above this you will see a flashing decimal point. The flashing decimal point means "multiply the number by 1000." . To

go down in this display, you will need to go all the way up to 9.99, (9990 amp hours) then down to 10.

These numbers cause the Percent Full to reset to "100%" every time the battery is fully charged. This occurs when the voltage exceeds the P1 value and the charging amps are less than P2 (expressed as a percent) times P3 (amp hours.) Refer to TM-2030 Users manual, Section 6.2 for a comprehensive description of what these do.

****

C1. How to determine program item P3: "battery system capacity" This is a number in "amp hours" that indicates how much charge your batteries hold when they are fully charged. For "deep cycle" batteries this number is specified by the battery manufacturer. Find the "capacity" in amp hours from the manufacturer. If several different values of "capacity" are given, you can use the "20 hour discharge" value. If you have only one battery then use that value in P3: It is more usual to have more than one battery connected together as shown in Figure 1: Batteries A and B are connected "**in series**". String A-B is then connected "**in parallel**" with string C and D.

When combining batteries here's how to calculate total amp hours:

When you put identical type batteries in <u>series</u> the amp hour of the series string is the <u>same</u> as the amp hour rating of each single battery in the string. (Add the voltage of each for total volts.)

When you put them in <u>parallel</u> then you <u>add</u> the amp hours of each string or battery. (Total volts are SAME as each.)

When you have batteries that are both in series and in parallel, first compute the amp hour of EACH series string. Then add those together for as many series string as you have to get the total value. Put this value in the "battery system capacity" (P3) in Table 1 on page 7. **Values over 1000 amp hours will appear with flashing decimal point: e.g. 1.02 (decimal point flashing) means 1020 Amp hours.**

C2. How to program your meter for the 100A/100mV shunt. If you are using the 100A/100mV shunt you must program the TM-2030 for this—otherwise the "amps" values will show as ten times higher than they should. Follow these steps:

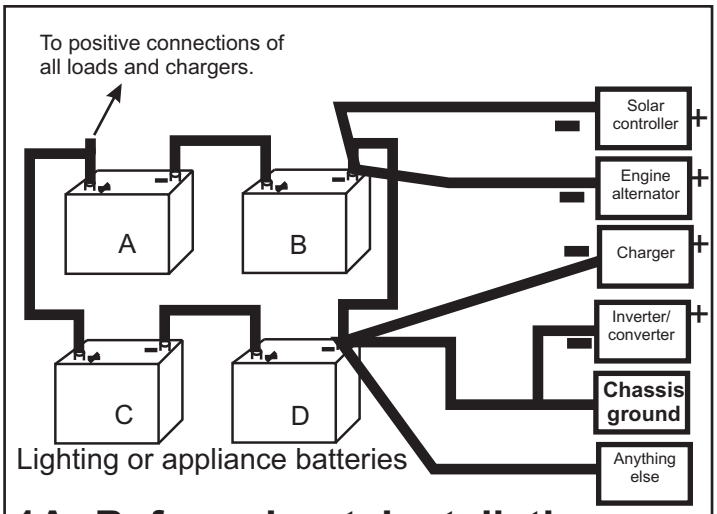
1. Hold SELECT switch until "P1" comes into display. Then release SELECT. If you miss the P1, hold SELECT again .and it will come back around.
2. Push SELECT about 6 times to show "P7".
3. Push SELECT and RESET both momentarily together—and release: 3 green lights should flash.
4. Push RESET a few times to change the display to "L3."
5. Push SELECT several times until display shows "P11" It will probably show "Sh.H".
6. Push SELECT and RESET both momentarily together—and release: 3 green lights should flash.
7. Push RESET once to change display to "Sh.L"
8. Push SELECT a number of times and you will be back to the normal display. Continue with step 7 above.

C3. Optional: Now or later you may wish to program P4, P5, P6. For information about these, see TM-2030 User's instructions, Table 2, page 6.

P4: Allows the main display to show "watts" instead of "amps"

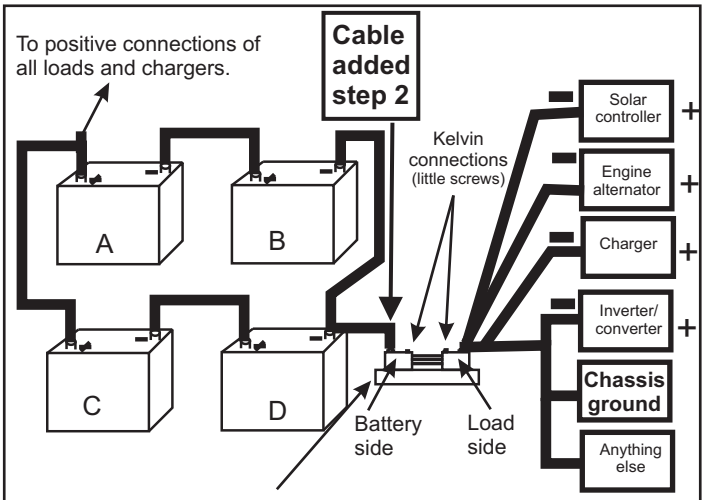
P5: Sets up meter to let you know when too many days have elapsed since last full charge for your batteries. Most useful for people that are continually using their batteries. Not as useful for people that only occasionally use batteries such as many RV'ers or weekend cabin users.

P6: Set up a timer to remind you to equalize your batteries at some set number of days.



1A: Before shunt installation

This won't be your exact situation--this example is unusually complicated. You will need to **first remove EVERY cable or wire that goes to the negative connection** on your battery system before installing the shunt. All of these will need to be reconnected to the right side of the shunt as shown in the right drawing.



1B: After shunt installation

O**ne end (either end) of the shunt must be connected only** to the negative side of battery or battery set .

ALL other cables/wires must connect to other side (right side-or load side- of shunt on drawing above). Including ground. Including solar charger negative. This is necessary for the meter to measure battery "amps" properly and also for the "Battery % full" display on your meter to work.

Figure 1: Shunt Installation

PROGRAM MODE NUMBER	PROGRAMMABLE DATA and ADJUSTMENT RANGE Complete instructions in TM-2030 User's Instructions, Section 5	Factory value Your value
P1	"CHARGED" setpoint voltage: **10.0** to **65.0**V	14.3
P2	"CHARGED" setpoint multiplier: **0.1** to **10 percent** or **OFF** "Charged setpoint amps" equals this % multiplied by value in P3	02
P3	"Battery Capacity" Amp-hours: **10** to **9,990** amp hours NOTE: Flashing decimal point means "multiply number by 1000"	400
P4	For primary display choose "watts" or "amps": **Pr** =watts **A** =amps (Secondary display will show the one not chosen.)	A
P5	Days before "time to recharge" reminder: **1** to **100** days or **OFF**	OFF
P6	Days before "time to equalize" reminder: **1** to **100** days or **OFF**	OFF
P7	Choose OPERATION LEVEL: **L1**, **L2**, **L3** or **L4**.	L1

Table 1 **PROGRAM DATA AVAILABLE IN OPERATION LEVEL L1.**

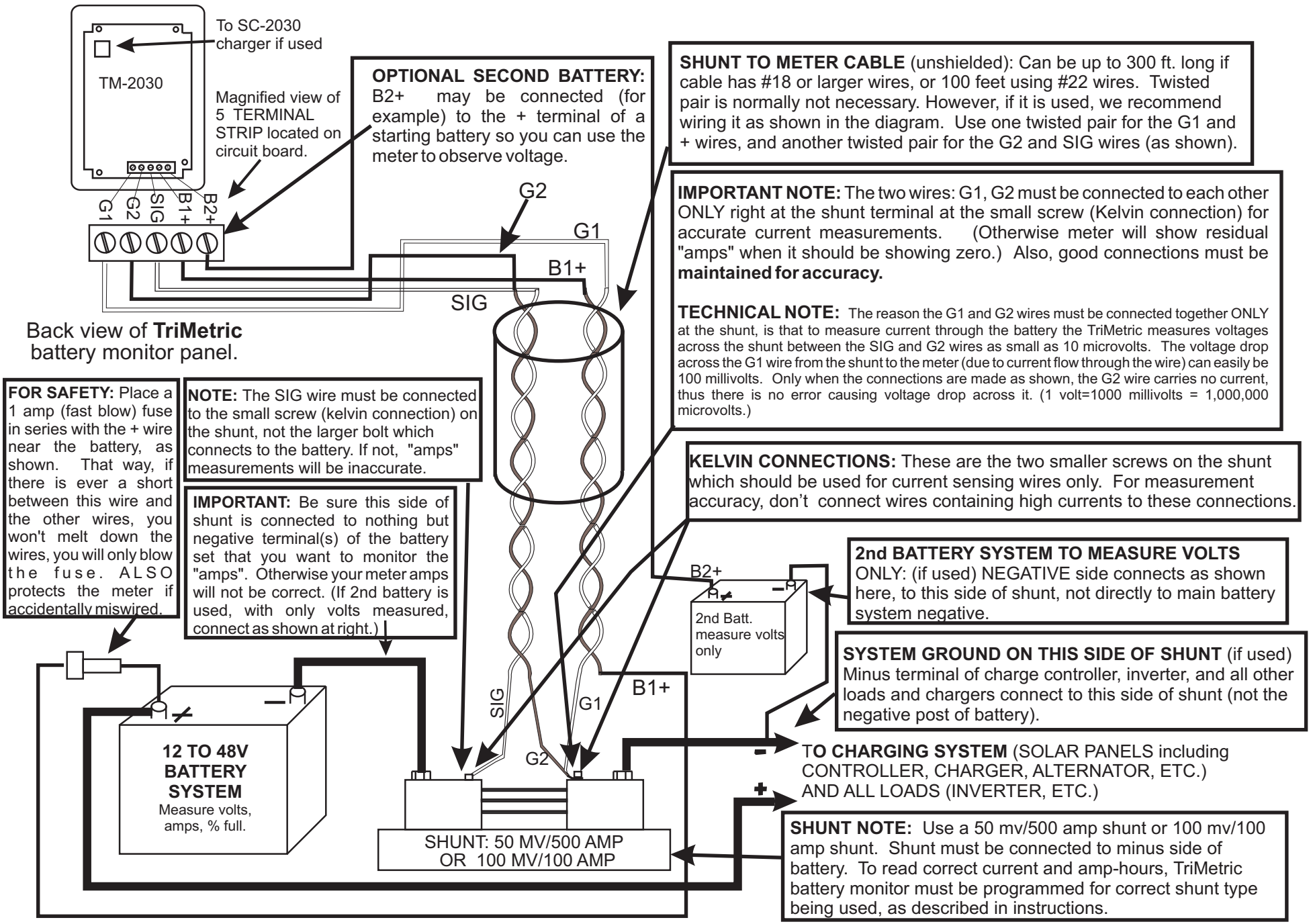


FIGURE 2: TM-2030 TriMetric Battery Monitor Connections | **3/20/14**