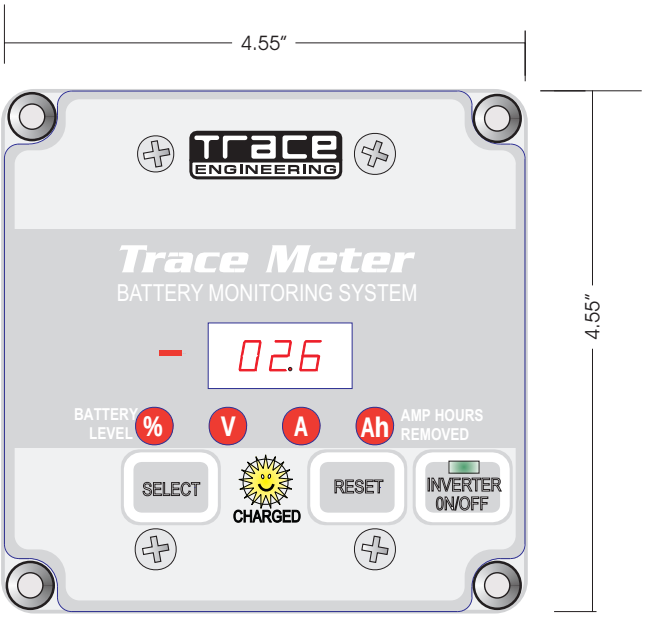
Trace Meter

Battery Status Monitor



INTRODUCING THE TRACE BATTERY STATUS MONITOR

The Trace Meter battery status monitor features six data-monitoring functions and three indicators including:

- State of Charge/Amp-hour content: full or percent of capacity
- State of Charge/Voltage: real-time voltage level, historical high & low system voltage
- Amps: real-time amps, total charging amps, total load amps
- Amp-hours removed
- Days since fully charged
- Cumulative amp-hours
- Recharge indicator
- Low voltage indicator
- Full charge indicator

The Trace Meter works with 12-volt, 24-volt, and 48-volt battery systems (optional TM48 shunt board required for 48-volt systems).

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www.traceengineering.com
Part Number 3507 Rev B,
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BASIC OPERATING FUNCTIONS

The Trace Meter enables you to monitor battery state-of-charge, voltage, amps, and amp-hours used. You can configure the reporting functions of the Trace Meter to your specific application by setting the fully-charged criteria, battery capacity, charging efficiency, low-battery warning conditions, and recharge reminder. You can monitor any DC energy supply from zero to 65 volts, track energy consumption and estimate remaining battery life. In addition, you can turn your Trace inverter (if equipped) On or Off remotely.

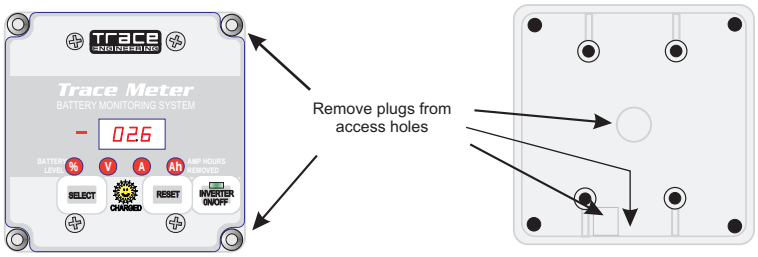
MOUNTING AND INSTALLATION

Your Trace Meter package (Part Number TM500) includes this manual, a 50-foot communications cord, one Deltec™ 500-amp/50-millivolt shunt (P/N TM500NS does not include a shunt), a 12/24-volt shunt board equipped with an in-line two-amp fuse (order Trace part number TM48 for 48-volt systems), and a molded plastic mounting enclosure.

Mount the Trace meter in the enclosure provided or in a standard double-gang plastic electrical box. You can surface-mount the Trace Meter on a control panel, or flush-mount it by creating a rectangular opening 3 7/8“ wide by 3 1/4“ high to allow clearance for the circuit board. Allow at least two inches clearance behind the meter for attaching the cabling. Be sure to mount the Trace Meter in a clean, dry environment.

The Trace Meter faceplate with the plastic mounting enclosure is designed to allow you to choose how to mount the meter. Remove the four screws on the faceplate and remove the meter from its enclosure. Decide upon the mounting location and type: flush or surface.

For a flush mount, cut a rectangular opening 3 7/8” wide by 3 1/4” high in the surface in which you are going to mount the meter. Carefully remove the recessed dimples at each corner of the faceplate. Use an Exacto knife or razor knife to remove the center of each screw plug. Ensure adequate clearance behind the meter for cables. Install your communications cable and (if used) your remote control cable and mount in the surface you have selected. Attach with appropriate length wood or sheet metal screws.



For surface mounting, remove one or both of the access plugs in the bottom of the molded plastic enclosure, and mount the enclosure on the surface of your choice by inserting a wood or sheet metal screw in each of the holes in each corner of the enclosure. Then install the meter in the enclosure, being careful not to over tighten the screws. Alternatively, remove the center plug in the back of the enclosure, mount the enclosure on the surface, attach the appropriate communication cables, and re-install the meter in the enclosure.

For flush mounting in new construction, install a standard double-gang plastic box (do not use a metal box) on a stud in the usual manner, discard the molded plastic enclosure provided and install the meter in the double-gang box after attaching the appropriate communications cables.

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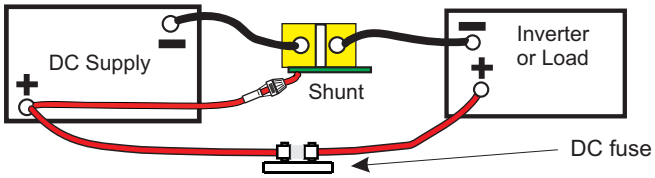
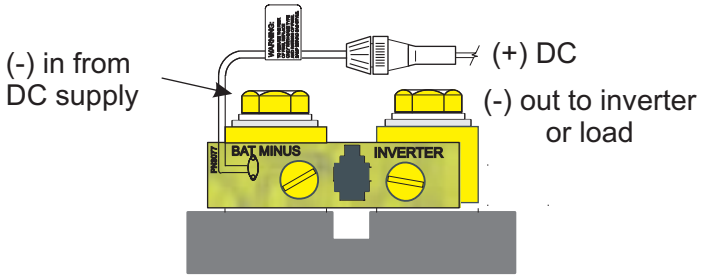
Hookup Procedure

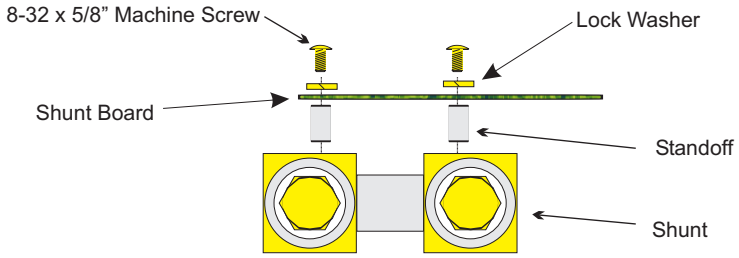
Mount the Deltec™ shunt on or near the battery box near the negative (-) battery terminal or DC supply. The shunt is installed in the negative DC supply circuit. Disconnect the negative battery cable at the battery or battery bank and attach it to the side of the shunt labeled 'Inverter'. Install a short cable of the same gauge from the negative (-) battery terminal to the side of the shunt labeled 'Bat Minus.'



Remove the fuse from the fuse holder in the black (+) DC wire and attach the wire terminal to a positive (+) battery terminal or DC supply. Insert the shunt communications cable into the RJ6 connector on the shunt board. If desired, you can extend this cable up to 100 feet. Replace the fuse in the fuse holder.



To order a Trace Meter without the shunt, use part number TM500NS. This kit includes a shunt board, two 8-32 x 5/8" machine screws, and two spacers (standoffs). Attach the shunt board to your shunt by first removing the two screws, flat washers, and lock washers that came with your shunt. Replace the screws with the screws provided in the shunt kit. Place a lock washer on the machine screws, then insert into the shunt board. Place a spacer over each of the screws, and attach to the side of the shunt as shown in the illustration below.



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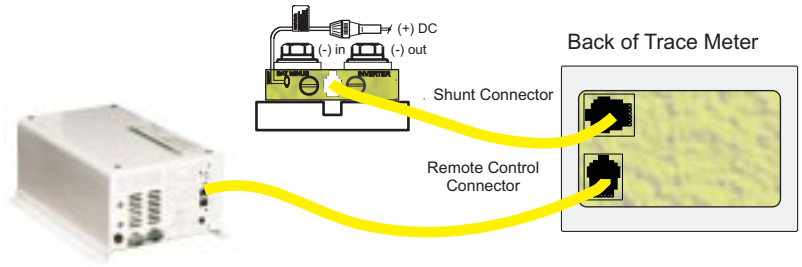
To complete the installation, insert the shunt communications cable into the RJ6 telephone-type connector on the back of the Trace Meter printed circuit board (PCB). There are two RJ6 connectors on the back of the PCB. The one near the top left of the board is the shunt connector. The one on the lower left of the PCB is the remote control connector. Do not confuse these two connectors. Irreversible damage to the PCB will result if the shunt communications cable is connected to the remote control connector or vice-versa.



TRACE METER INDICATORS AND CONTROLS

The Trace Meter features a large three-digit LED display, four red mode indicators, one yellow full-charge indicator, one green Inverter On/Off indicator, and three pressure-sensitive pushbuttons. The LED screen displays alpha-numeric messages with resolution to 0.00. A negative value (-) indicator is positioned just to the left of the screen.

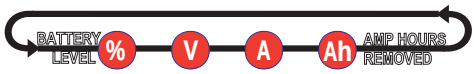
The Select button is used to switch between meters and modes. The four LEDs beneath the screen light to indicate the operating mode: battery state-of-charge; volts, amps, and amp-hours.

A Reset button is provided to change the user-defined parameters and to reset the fully-charged 'Happy Sun' indicator located between the Select and the Reset buttons.

A third button (labeled Inverter On/Off) enables you to turn your inverter On or Off remotely if your system includes a Trace inverter/charger equipped with an RC4 or RC8 remote control jack. The "Inverter On/Off" button duplicates the operation of the RC8 remote control if you connect a remote control cable between the Trace Meter and your inverter. Remote control cables are available in 10, 25, 50, and 100 foot lengths. Order Trace part number TC/XX according to the length desired. See the RC8 Owner's Manual (included with the TC/XX cable) for remote control operating instructions.

Basic Meters

To select a meter display, press and release the Select button until the desired mode indicator lights. There are four mode indicators:



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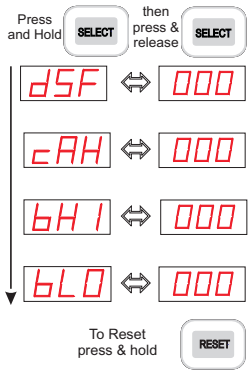
- **% (Percent State of Charge)** When this indicator is lighted, the LED screen will display the battery state-of-charge based upon the amp-hour capacity. Range is LO setting(<27.5%), 30% to 90% in 5% increments, and 'FULL' when over 92.5% of capacity.
- **V (Volts)** When this indicator is lighted, the LED screen will display the real time voltage from 08.0 to 35.0 volts (12 and 24 volt system) with ±0.1 volt accuracy or 16.0 to 69.9 volts (48 volt system) with and ±0.2 volt accuracy.
- **A (Amps)** When selected, the LED screen will display the real-time charge current or load current in amps. The range is from ± 0.1 to ± 999 amps, with a speed of response of one second. Accuracy is ±1.5%.
- **AH (Amp Hours)** This meter displays the total amp-hours removed from the DC source since the last reset. Range is from 0.00 to ±167,000 amp-hours. When the decimal point flashes, multiply the reading by 1000. (111. = 111,000). Automatically resets to zero about one minute after the Charge LED remains on (stops flashing).

Power Saving Mode

Pressing the Select button until the display goes blank puts the Trace Meter in power saving mode. None of the red mode indicators are lighted when the meter is in power-saving mode. In this mode, the meter consumes approximately 18mA (milliamps). Maximum power consumption in any mode is 32mA.

Data Monitors

There are several additional data displays that are accessed by pressing and holding the Select button until "dSF" is displayed on the LED. Then press and release the Select button to scroll through the data displays. The data types will alternate with the data values. When the "bLO' data value has been displayed, another press of the Select button will display the basic meters again. The data monitors are listed below in the order in which they appear on the display.



- **dSF (Days Since Full)** This meter shows the number of days since the battery was fully charged. The range is from 0.00 to 655. The value resets to zero when the battery is recharged. (Charged LED flashes)
- **cAH (Cumulative Amp Hours)** This meter measures the cumulative amp-hours removed. Use it as a battery life indicator. Its range is from 00.0 to 999,000. Multiply the reading by1000 when the decimal point flashes on and off. The cumulative amp-hours are retained in memory even if the meter is disconnected.
- **bHI (High Battery Voltage)** Displays highest battery voltage. Use to determine if an over-charge event has occurred. Resets to current battery voltage when theTrace Meter is disconnected and reconnected.
- **bLO (Low Battery Voltage)** Displays lowest battery voltage Use to detect over-discharge. Resets to zero when the Trace Meter is disconnected, then reconnected.

To reset the data monitor values to zero (or present value) press and hold the Reset button for about 5 seconds (the data monitor value will flash On and Off three times, and then update).

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Reminders and Other Indicators

The Trace Meter features a programmable recharge reminder, low-voltage indicator, and a charged indicator.

Recharge Reminder You can configure the Ah lamp to flash at a specified interval following recharge as a reminder that it is time to charge the batteries. The range is from one to 99 days, or you can turn it Off. When the number of days since the last charge exceeds the specified value, the Ah LED will flash until reset. The specified value will be retained until the Trace Meter is disconnected.

To configure this reminder, press and hold the Select button until the dSF message is displayed, then release. Then press and release the Select and Reset button simultaneously. Then press the Reset button until the desired value is displayed. Press the Select button to accept the value. Recharging the batteries synchronizes the State-of-Charge and the Amp Hour meters.

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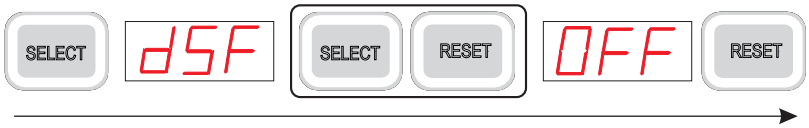

Low Voltage Indicator You can specify a voltage between 10 and 35 volts (10 and 64.9 volts for 48 volt systems) to activate the low voltage alarm. When battery voltage falls below this setting, the Voltage indicator will flash about once every four seconds.

To configure this alarm, press and hold the Select button until the dSF message is displayed, then release. Then press and release the Select button until the bL0 message is displayed. Then press and release the Select and Reset button simultaneously. Press the Reset button until the desired voltage is displayed. Accept the value by pressing the Select button.

Charged Indicator The yellow LED behind the 'Happy Sun' symbol between the Reset and the Select buttons can be programmed to flash every four seconds when specified charging criteria are met. You can specify voltage alone, voltage and current, or voltage and time. When the fully-charged criteria is satisfied for 30 seconds, the Charged LED will flash. The Charged LED will stop flashing (remains On) and the amp-hours will reset to zero when the amps go negative (battery discharging) continuously for one minute. To reset the Charge LED, press the Reset button while the **%, V, or A** LED is on.

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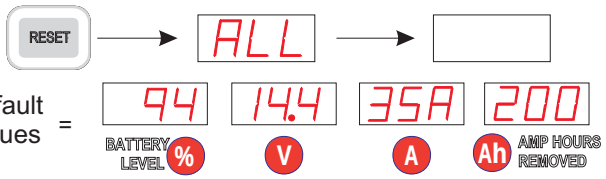
SETUP

The TraceMeter is factory-configured for monitoring a 12-volt DC system. You can configure the Trace Meter for your specific application.

Reset to Factory Default Values

You can reset program values instantly by pressing and holding the Reset button when the Trace Meter is in Power Saving mode. A flashing 'ALL' message will be displayed on the LED. Hold the Reset button until the 'ALL' message stops flashing and the screen becomes blank. The factory default values are shown below.



Low Voltage Indicator = 11.2

Recharge Reminder = OFF

Setting Parameters

To set individual configuration values, press the Select button until the mode indicator for the mode you want to change is lighted. Press the Select and the Reset button simultaneously. Release both buttons when the LED screen begins to flash. Press and release the Reset button to scroll through the selections slowly. Press and hold the Reset button to scroll through the selections rapidly. When the value you want is displayed, press the Select button to select it.

Charge Efficiency: Because batteries are storage devices that are not 100% efficient, more energy is required to charge them than can be removed from them. Some energy is lost in the form of heat and gassing. An efficiency factor of 94% to 98% is typical of lead-acid batteries. This means, for example, that if you charge a lead-acid battery for five hours @ 20 amps per hour for a total of 100 amp-hours, approximately 2% to 6% of charge will be lost to heat and gassing. Therefore the amp-hour capacity of the battery will increase by only 94 to 98 amp-hours. The default setting is 94%. If you have new lead-acid batteries, set this efficiency factor to 96%. Older batteries will be less efficient. This setting effects the Percent State-of-Charge meter.

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Setting the efficiency factor: If you do not know what efficiency factor to use, if you have lead-acid batteries start with 94%. If you find that after discharging and recharging your batteries that the amp-hours reading is somewhat below 000 (negative) when the Charged LED flashes (charge settings reached), then increase the efficiency factor. If you find that the numbers are substantially going above zero before the "charged" LED flashes, decrease the efficiency factor. Typically, try to adjust the efficiency so that when the "charged" LED flashes the amp-hour number is slightly positive.

Ah ***Amp Hours:*** Set your system's amp-hour capacity using the Setup menu under this mode. Determine your system's capacity and select it. The amp-hour capacity is often listed on the battery. If not, contact the dealer or manufacturer. This parameter is adjustable from 10 to 2550 amp-hours. A decimal indicates a value of 1000 or over. It is better to rate your system's capacity conservatively in order to avoid excessively discharging your system.

Setting the battery capacity: The battery capacity setting should be adjusted to a value that is equal to or lower than the actual capacity. When a number that is lower than the actual capacity is used, the "%" battery state-of-charge will allow a more conservative use of the batteries and often the stated capacity numbers for batteries tend to be optimistic. Also note what temperature your battery capacity is rated, the amp-hour capacity of batteries will decrease at lower than rated temperatures. If batteries are connected in series, the capacity of the series string is equal to the value of the least capacity battery in the series.

Setup for the Charged Indicator

Use the settings described below to program the Charged indicator. Choose between voltage, voltage and current, or voltage and time as the criteria for activating the Charged indicator. A good rule of thumb - use voltage/amperage criteria unless the peak amps from your charging source is less than your fully charged current setting (battery capacity divided by 20 - C/20).

V **Voltage Criterion**: To specify the full-charge voltage value, first press and release the Select button until the voltage (V) indicator is lighted, then press the Reset button while holding the Select button down. The screen will blink and display the present voltage setting. Press the Reset button to select the desired full-charge voltage. Press the Select button to accept the value. The range is from 10 to 64.9 volts. When the fully-charged criteria are satisfied, the 'Happy Sun' LED will flash. For 48-volt systems, set the full-charge criterion above 35 volts, else the display value will be ½ of the actual voltage. For a 12-volt, liquid lead-acid battery bank, 14.3 to 14.8 volts is an appropriate full-charge voltage. For a 24-volt system, double the voltage set point. For a 48-volt system, quadruple the setpoint. For other battery types, refer to manufacturers recommendations.

A

Voltage Alone: To specify voltage as the sole criterion, set the fully-charged voltage value first and then turn the amps criterion Off. Press Select to select the amps (A) indicator and enter the Setup menu by pressing the Reset button while holding the Select button down. The LED display will flash on and off displaying the present amps criterion value. Press the Reset button until 'OFF' is displayed, then press the Select button to accept the value.

A

Voltage and Current: To specify both voltage and current as the criteria, first set the voltage criterion, then set the current (amps) criterion. Press Select to select the amps (A) indicator and enter the Setup menu by pressing the Reset button while holding the Select button down. Press Reset until an "A" is displayed on the LED following a numeric value. Continue to press Reset until the desired value is displayed. Press Select to accept the value and exit the Setup menu. The range is from one to 99 amps.

As batteries are charged, battery voltage increases and charging current decreases. When battery voltage equals or exceeds the voltage criterion, and charging current is equal or is less than the amps criterion, the 'Happy Sun' indicator will flash once at about two second intervals to indicate the batteries are fully charged. When there are DC loads on the batteries, the current requirements of these loads can keep the charge rate from falling low enough to reach the amps criterion value. Set the current criterion higher if significant DC loads are anticipated during charging. To determine the appropriate fully-charged current setting for your installation, divide battery capacity by 20 (C/20). For example: Given an 880 amphour capacity, divide 880 by 20 for a current setpoint of 44 amps.

A

Voltage and Time: To specify voltage and time, select the amps indicator and press Reset while holding Select to enter the Setup menu. The LED display will flash. Press the Reset button until the LED displays an "H" following a value. Continue to press the Reset button until the desire value (in hours or tenths of hours) is reached. Press Select to accept the value and exit the Setup menu. The range is from 0.2 H to 2. H (12 minutes to two hours). When the current remains positive and the voltage exceeds the fully-charged voltage criterion for a period longer than the time criterion, the 'Happy Sun' indicator will light and flash about once every four seconds. If the current goes negative, the time will reset to zero; the indicator will not light until a new time period elapses.

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Other considerations: The type of charger (relay, taper, or three-stage) may also influence these criteria. A relay type charger charges up to a set voltage and shuts Off, using only voltage as the criterion. Adjust the voltage-only criterion slightly below your charger turn-off voltage and disable the other criteria. Taper chargers charge up to a specified voltage and shut off only when the current tapers down to a specific rate. For taper chargers (pulse-width-modulated), set your voltage criterion slightly below the charger's voltage and set the current criterion slightly below the charger's taper current setpoint. If your taper charger which charges up to a certain voltage then waits for a period of time to decide that the batteries are charged - then adjust the voltage setting to a level slightly below the charger's charge voltage and set the "time" setting to a period shorter than the charger's time period. Three-stage chargers maintain batteries at a 'float' voltage and a trickle current. Adjust the voltage criterion slightly below the charger's float voltage setting, and set the current criterion slightly below the float charge current.

Limited 2 Year Warranty

Trace Engineering Company warrants its power products against defects in materials and workmanship for a period of two (2) years from the date of purchase and extends this warranty to all purchasers or owners of the product during the warranty period. Trace does not warrant its products from any and all defects: (1) arising out of material or workmanship not provided by Trace Engineering, or (2) resulting from abnormal use of the product or use in violation of the instructions, or (3) in products repaired or serviced by other than Trace Engineering repair facilities, or (4) in components, parts, or products expressly warranted by another manufacturer. Trace Engineering agrees to supply all parts and labor or repair or replace defects covered by this warranty with parts or products of original or improved design, at its option, if the defective product is returned to any Trace Engineering authorized warranty repair facility or to the Trace Engineering factory in the original packaging, with all transportation costs and full insurance paid by the purchaser or owner.

All remedies and the measure of damages are limited to the above. Trace engineering shall in no event be liable for consequential, incidental, contingent or special damages, even if trace engineering has been advised of the possibility of such damages. Any and all other warranties expressed or implied arising by law, course of dealing, course of performance, usage of trade, or otherwise, including but not limited to implied warranties of merchantability and fitness for a particular purpose, are limited in duration to a period of two (2) years from the date of purchase. Some states do not allow limitations on how long an implied warranty lasts, or the exclusion of incidental or consequential damage. So the above limitations may not apply to you. This warranty gives you specific legal rights. You may also have other rights which vary from state to state.

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WarrantyProcedure

Complete the warranty card and mail it to Trace Engineering within ten (10) days from the date of purchase. Keep your bill of sale as proof of purchase, should any difficulties arise concerning the registration of the warranty card.

Warranty registration is tracked by model and serial numbers only, not by owner's name. Therefore, any correspondence or inquiries made to Trace Engineering must include the model and serial number of the product in question. Be sure to keep the model and serial numbers in a safe place for future reference.

Warranty service must be performed only at an authorized Trace Service Center, or at the Trace Engineering factory. Notify the repair facility before shipping to avoid the possibility of needless shipment.

UNAUTHORIZED SERVICE PERFORMED ON ANY TRACE PRODUCT WILL VOID THE EXISTING FACTORY WARRANTY ON THAT PRODUCT.

FACTORY SERVICE: If you wish your Trace Engineering product to be serviced at the factory, it must be shipped fully insured in the original packaging or equivalent; this warranty will not cover repairs on products damaged through improper packaging. If possible, avoid sending products through the mail.

Before returning any equipment to Trace Engineering, call our Warranty Coordinator and request an Return Merchandise Authorization (RMA) number. Be sure to have the serial number of the equipment handy.

Ship To:

Trace Engineering Company, Inc.
Attn: Service Department. RMA#
5916 195th NE
Arlington, WA 98223
Phone: (360) 435-8826
(Warranty Coordinator)

Be sure to include in the package:

- ☐ Complete return shipping address (PO Box numbers are not acceptable) and telephone number where you can be reached during work hours.
- ☐ A detailed description of any problems experienced, including the make and model numbers of any other equipment in the system, types and sizes of loads, operating environment, time of unit operation and temperature.
- ☐ A copy of your proof of purchase (purchase receipt).

Repaired products will be returned freight C.O.D. unless sufficient return shipment funds are included with the unit. Products sent to the factory from outside the U.S. MUST include return freight funds, and sender is fully responsible for all customs documents, duties, tariffs, and deposits.

Trace Meter Specifications

Function	Range	Accuracy
Battery Volts	8.0 - 35.0 volts	±0.1 volt
	16.0 - 70.0 volts	±0.2 volt
Battery Amps	0.1 to 999	±1.5% (+ least significant digit)

Battery Amps Resolution

12-volt	0.1 to 99.9 amps	0.1 amp
24-volt	100 to 999 amps	1.0 amp

Battery Level %

Low (<27.5%)	~2.5% accuracy
30-90%	in 5% increments
FULL (>92.5%)	

Current Draw

Power Saving mode	18mA max
All other modes	32mA max

Amp Hours

-0.00 to ±167,000 amp hours

Data Monitoring Functions

dSF-Days Since Full:	0.01 - 655 days
cAH-Cumulative AH Removed	0-999,000 in non-volatile memory
bHI-Battery HighVolts:	to 35.1 VDC resettable (12-24 volt DC) to 70.2 VDC (w/optional 48VDC adaptor)
bLO - Battery Low Volts:	08.0 volts, resettable (12-24 volt DC) 16.0-volts, resettable (w/48 volts DC adaptor)

Size: 4.55”H X 4.55”W X 1.725”D (11.56cm x 11.56cm x 4.38cm)

Shipping Weight: ~3 lbs (1.36 kg)

Mounting:

Surface	in molded plastic enclosure
Flush	in standard double-gang plastic outlet box
Flush	in panel or wall w/o box

LED Display: 3-digit, 7-segment Red LED with five additional indicators

LED indicators: State of Charge (SOC)/Battery Efficiency
Battery Voltage
Amps
Amphours Removed/ Battery Capacity
Recharge Reminder (adjustable)
Low Battery Voltage (adjustable)

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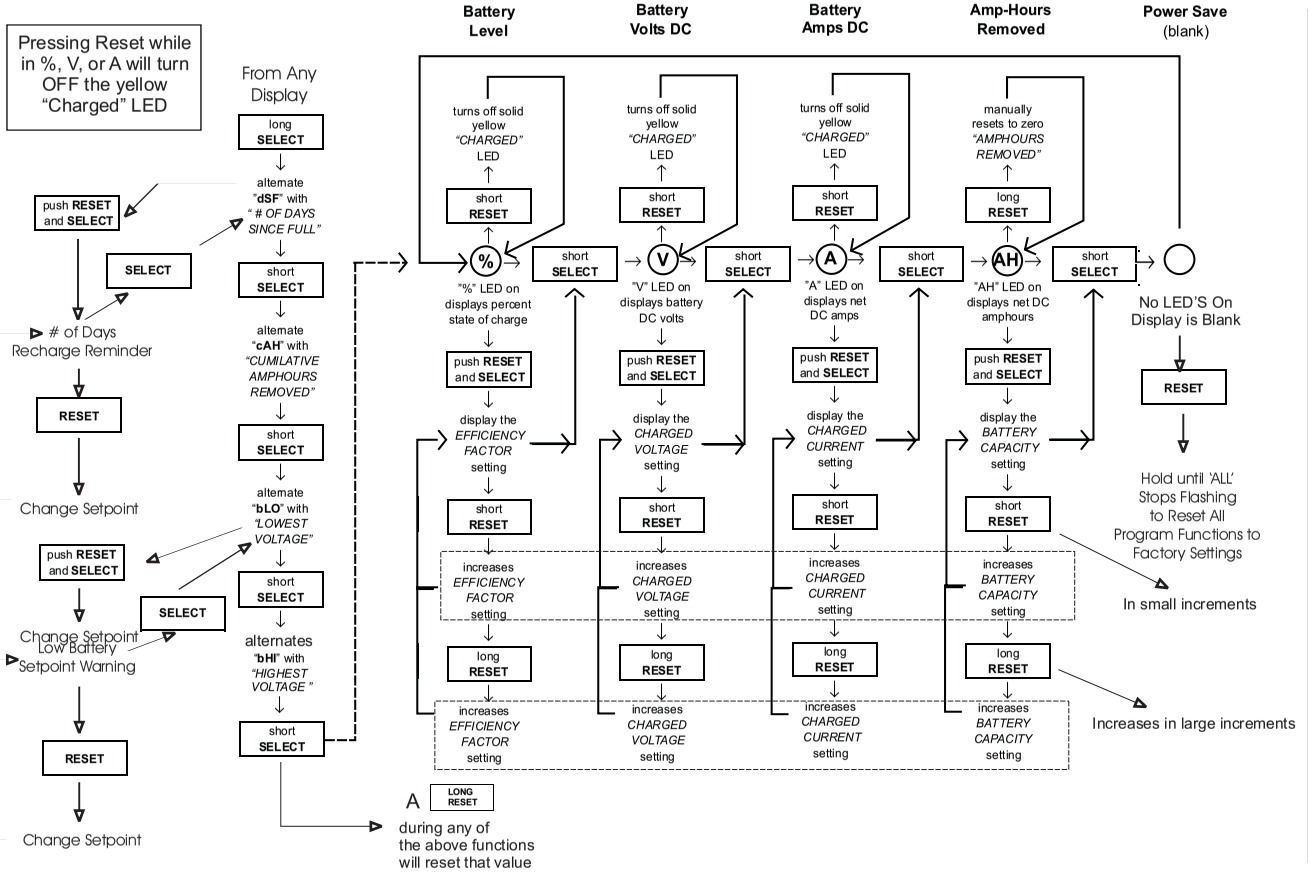

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TechNote 5: Battery Voltage and Current

Why does the voltage on a discharged battery measure the same as a fully charged battery, until loads are applied?

The simple answer to this might go as follows: A battery creates electrical power by converting energy from a chemical reaction into electrical energy. As this reaction slows down the battery voltage will drop. In a lead acid battery the electrolytes conductivity (how well electrical current can flow through it) changes. The same current may be available but the rate of the reaction decreases, causing a voltage drop.

It is interesting to note that a charged 12 volt lead acid battery at rest (not powering loads and unused for a least 3 hours) will read about 12.6 volts. Hook up a load and the voltage will drop to about 11.9 volts.

Another way of looking at this is to use an analogy of a water pump (a battery is an electric pump). The pressure in PSI a pump delivers is like a battery's voltage. The volume of water in gallons/minute (GPM) is like electrical current. Let's look at a 12 PSI pump with no loads (the pump is running but the outflow valve is turned off). The pump will run and the internal pressure of the pump will build up to some point higher than 12 PSI. Once the valve is opened and the water is free to flow into the loads, the pressure will drop to the rated output pressure of 12 PSI, but only if the load is not too big. If the pump is designed to maintain 12 PSI at 15 GPM, and a load demanding 20 GPM is connected, the pump will not be able to keep up and the pressure will get sucked down to some lower PSI. If the load is then reduced or removed, the pump will catch up and return to it's rated 12 PSI pressure. If the pump has an infinite source of water such as a lake or the water utility (this is like the grid, no battery) the pump will never run out of pressure, and as long as the pump is operated at or below it's 15GPM level it will hold 12 PSI.

However, a pump that is connected to a water tank with a finite capacity, will start to lose the ability to hold pressure as the level of water in the tank drops. Think of siphoning water from a bucket, as the level of the water drops the volume of water exiting the siphon slows down.

When the tank is full it is capable of feeding more "pressure" to the pump inlet due to gravity, and the pump always has enough water available to maintain its rated pressure and volume. However, if the water tank gets low, the pump will not have enough water volume coming in to maintain 12 PSI at 15 GPM. If the loads are taken away from the pump by closing the valve on the outflow, even with low pressure in the tank the pump will eventually pump up to 12 PSI — it will just take it longer to get there. Then when the valve is opened the pump will sustain 12 PSI for a brief while, but since the tank is no longer feeding the pump as fast as needed the pressure will eventually drop. This analogy can be restated by replacing the pump with a battery, pressure with voltage, volume with amps, outflow valve with a switch, water with electricity, and the water tank with the battery electrolyte.

The level of the tank, could be thought of as the rate of the reaction taking place in the electrolyte. When the battery is fully charged the electrolyte has an excess of reactions taking place to feed the battery terminals. This tapers off with time as the electrolyte is spent, so maintaining voltage becomes near impossible. With no loads, the spent electrolyte will be capable of producing near rated voltage but only after a period of time has elapsed for enough reactions to take place to bring the voltage back up. Hopefully this scenario will help make clear why a battery measured at rest can show near its rated voltage but will not run a load.

Measuring Battery Condition with the Battery At Rest.

A good estimate of a battery's state of charge can be made by measuring the voltage across the battery terminals with the battery at rest (No energy input, no energy output) for at least three hours. These readings are best taken in the early morning, at or before sunrise, or in late evening. Take the reading while almost all loads are off and no charging sources are producing power. Connect a voltmeter across the positive and negative outputs of the battery or battery bank.

The following table will allow conversion of the readings obtained to an estimate of state of charge. The table is good for batteries at 77°F that have been at rest for 3 hours or more. If the batteries are at a lower temperature you can expect lower voltage readings.

Battery State of Charge Voltage Table

Percent of Full Charge	12 Volt DC System	24 Volt DC System	48 Volts DC System
100%	12.7	25.4	50.8
90%	12.6	25.2	50.4
80%	12.5	25	50
70%	12.3	24.6	49.2
60%	12.2	24.4	48.8
50%	12.1	24.2	48.4
40%	12.0	24	48
30%	11.8	23.6	47.2
20%	11.7	23.4	46.8
10%	11.6	23.2	46.4
0%	<=11.6	<=23.2	<=46.4

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