Use and Application Notes:
New Design: Features Extended Accuracy in the Low Amperage Range to Measure Stall Currents

As a result of my involvement in "Command Control" Systems for 19 years, it became apparent that model railroaders needed a simple to use, accurate tool to measure volts and amps for their Railroads. The advent of DCC with its unconventional waveform further amplified the need. I conveyed the concept and format to Larry Maier, a model railroader, and electrical engineer who is also a vital contributor to our DCC development efforts. His resulting design speaks for itself. Jim Scorse from NCE Corp. also made some great suggestions.

The maximum DCC and DC voltage is approximately 28 volts (covers the complete specified NMRA voltage range). The maximum DCC and DC current is approximately 10 amps. The maximum AC voltage is about 20 volts while the maximum AC current is about 7.5 amps. AC signals have a higher ratio of the maximum signal value to the RMS signal value than does the DCC and DC signal. These values may vary slightly from unit to unit due to component tolerances. The accuracy is between 2%-3% of reading. Two status indicator LEDs indicate either DCC or AC voltage. Both LEDs on means DC voltage is present. When measuring DCC and AC voltages and current, any polarity will work. When measuring DC voltage, proper polarity is necessary. If you attempt to measure a DC voltage and there is no readout, simply reverse the connection polarity and you will get the proper readout. Units with battery or an external DC power supply will display DC voltage and current irrespective of polarity.

Version IV RRampMeterHP is same as III but designed for large scale high voltage and current applications with the following specs: DCC: 33.8 V and 26.6 A (peak); AC: 24 V and 18-20 A; DC: 33.8 V and 26.6 A (peak). The RRampMeter will show a 10-40 mA (0.01-0.04 A) reading with no load or current draw. This is normal electronic noise and is not reflected in actual amperage readings under loads.

Owners of the RRampMeter Version (1) can upgrade to V (2) or (3) as follows:

Kits contain all parts necessary to upgrade.

V1 to V2 Upgrade Kit $39.95

V1 to V3 Upgrade Kit $49.95

To install the battery connector (see Fig. 4), solder the red or the positive lead of the battery connector at the J3 location to the hole with the square pad. Solder the black wire to the hole with the round pad. Solder these connections to the back side of the board so that the battery connector will fit in the enclosure. To install the switch (see Fig. 4), desolder the jumper, and solder the switch into the three holes marked S1 on the top side of the board.

Amperage must be measured in series by connecting the left set of contacts or clip leads to the input power supply or power source while the right set of contacts or clip leads are connected to the load or isolated track section where current is to be measured (Fig 1). The RRampMeter may be connected in the reverse direction without damage, but the display will show the current used by the RRampMeter in addition to the load current (about 0.03 to 0.04 for no load) (Fig 4). The voltage display also will not account for any voltage drop in the RRampMeter itself.

Voltage can be measured from the left or right set of contacts or clip leads. If measuring voltage only, then either end of the RRampMeter may be used accurately.

We do not recommend soldering directly to the buss bars that connect the adjustable contacts as this may interfere with the operation of the adjustable contacts (Fig 2).

For Panel or Fascia mounting, Version (1) can be used. You will have to cut out holes in your fascia for the LEDs and the Indicator Lights. Four mounting holes are provided on the circuit board for mounting. You can also use Version (2) and mount the enclosure cover to your Fascia if you prefer a dressier appearance (Fig 3). For mounting templates see, Figures 6 and 7.

The RRampMeter is designed to read true RMS voltage and current. The RMS values are proportional to the power being supplied to the layout. An average reading meter (most inexpensive meters found in electronic stores, hardware stores, etc.) WILL NOT agree with the RRampMeter. The RRampMeter is displaying the correct values.

Some DC power supplies use pulsed power for low speed. The RRampMeter will read this signal at its correct RMS value, but will display the AC PRESENT light. Once the supply transitions to full DC, the RRampMeter will continue to display the correct values, but the DCC PRESENT and AC PRESENT lights will both be out.

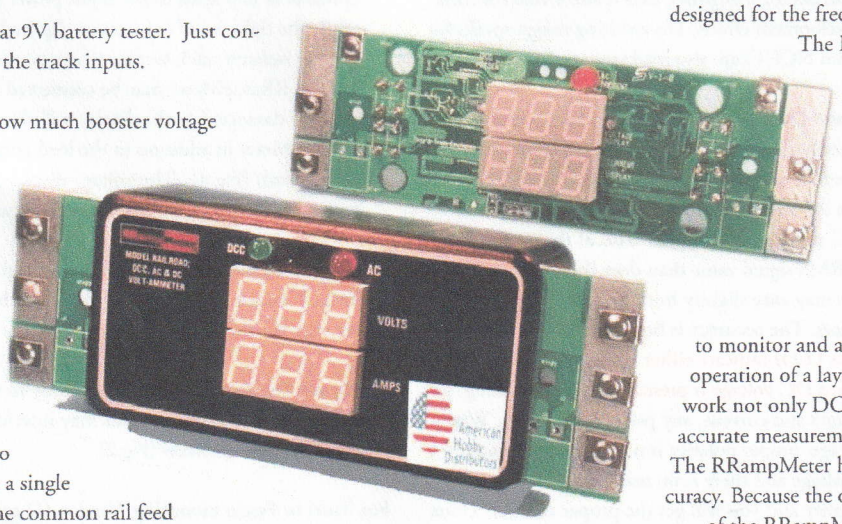
When using a battery, the RRampMeter will not show 0.00 volts with no signal connected. This is because the open contacts on the input actually pick up some voltage from the surroundings (power lines, DCC on the tracks, etc.). In addition, the circuitry used cannot quite reach 0.00. The RRampMeter is calibrated to read correctly above several tenths of a volt.

The RRampMeter will measure voltages down to approximately 7.00 volts without using the 9V battery option. For DCC, this is more than adequate. To measure lower voltages, the battery option must be used. If the battery is connected, one position of the switch will turn the RRampMeter on using the battery. The other position will disconnect the battery and allow the RRampMeter to be powered from the input voltage. Either position may be used with the battery connected.

If the RRampMeter is operated at currents in excess of 5 amps on a continuous basis, then it must be mounted in such a way as to allow free air circulation for cooling.

The RRampMeter is a great 9V battery tester. Just connect the battery across the track inputs.

You may be surprised at how much booster voltage is lost in track feeders, long stretches of track, and control switches. The RRampMeter is telling the truth.



The RRampMeter will work with common rail systems. If you want to measure the current in a single track block, connect the common rail feed to J1-1 (J4-1 or J6) and the remaining side of the booster to J1-2 (J4-2 or J7). A single output connection may be run from J2-1 (J5-2 or J9) to the desired block. If you want to measure the TOTAL current on the common rail feed, connect the common rail to J1-2 (J4-2 or J7) and the remaining side of the booster to J1-1 (J4-1 or J6). The common rail is then connected to J2-1 (J5-2 or J9).

We have tried the RRampMeter in conjunction with the programming track with mixed results. In some cases, the current drawn by the RRampMeter to operate itself may be sufficient to upset the programming sequence. If you want to operate the RRampMeter with the programming track, it may be necessary to use the battery option.

If you plan to use the RRampMeter without the case in a situation where it will be handled, it may be wise to glue Y1 and C1 (located on the back of the board) to the printed wiring board to prevent an accidental component removal. We find that a touch of "Crazy Glue" or equivalent is ideal for this purpose.

J4 and J5 are optional and sized for a two terminal header for use with a connector. The DigiKey part number is ED1817-ND. The mating plug is DigiKey part number ED1717-ND. You may also solder wires directly to these holes for a permanent installation.

If you are installing the RRampMeter as a permanent fascia display, a piece of red clear plastic or lighting gel in front of the display will improve the contrast.

Why the RRampMeter

Maintaining and analyzing the electrical system of a layout requires accurate measurements of the voltage and amps. When DC was used a standard meter was all that was needed for these measurements. With DCC use of a standard meter most of the time will not give you an accurate measurement. Tests have show that meters not designed to read the DCC wave forms can be off by as much as ±50%. Even meters that are "true RMS" may not be designed for the frequency range of DCC. The RRampMeter was designed to fill the need for a highly accurate DCC meter to measure of both voltage and amps. The RRampMeter is designed as a flexible tool to monitor and analyze the electrical operation of a layout. It is designed to work not only DCC power but to make accurate measurements of AC and DC. The RRampMeter has an amazing 2% accuracy. Because the original 10 amp range of the RRampMeter was not adequate for large scales a 20 amp version was added to the line.

Available Models

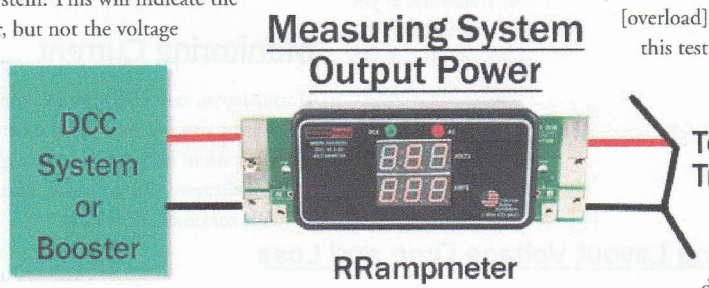
A total of four models of the RRampMeter are available. There are three models are available in the 10 amp range and one for large scale with a 20 amp range. The standard meter is rated at up to near 10 amps and up to 23 volts DCC or DC and 6 amp at up to 16 volts on AC. The new Version VI RRampMeter for large scale trains have a capacity of up to about 20 amps. The three basic models are [A] a bare module design for panel mounting, [B] mounted in a plastic case and [C] mounted in a plastic case with the option of battery power. All of the meters are powered by the input voltage. The voltage must be greater than 7 volts to operate. Versions III and IV have a 9V battery connection to operate the meter when the input voltage is less than 7 Volts. The meter can be used either as a portable meter or mounted permanently in a panel. Screw terminals are supplied with the meter that can be soldered to the back side of the meter's circuit board.

RRampMeter Circuit Modules

Version I
Bare RRampMeter Module; 7-28 V, 10 A (DCC)
Version II
RRampMeter with enclosure and clip leads; 7-28 V, 10 A (DCC)
Version III
RRampMeter with enclosure, clip leads and 9 V battery backup; 0-23 V, 10 A (DCC)
Version IV
RRampMeter with enclosure, clip leads and 9 V battery backup; 0-23 V, 20 A (DCC)

Panel Meter

A meter mounted near the system or booster will let you monitoring the power supplied to the layout. This will let you can determine how well your system or booster is regulating voltage under load. You can also measure just how close you are to the maximum power limit of the booster or system. This will indicate the operation of the system/booster, but not the voltage drop of the wiring and rails of the layout.

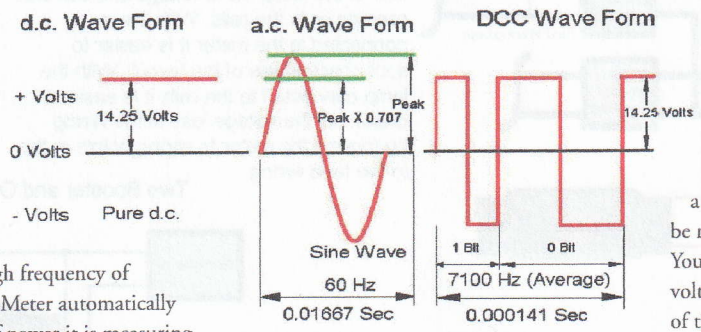


Track Voltage

Voltage is read by connecting to the two terminals on the left side of the meter. The end of the circuit board has an area that allows you to put the meter directly on the rails to measure the voltage. In order to measure amps, the current must flow through the meter by connecting a load to the two terminals on the right side of the meter.

True "RMS"

Most common meters can read both AC and DC, but can not accurately read DCC power. In order to accurately read DCC power a "true RMS" meter, like the RRampMeter is needed. This is due to the shape and frequency of the DCC signal. Even many "true RMS" are not designed for the high frequency of the DCC wave form. The RRampMeter automatically detects and switches to the type of power it is measuring. Two status indicator LEDs indicate either DCC or AC voltage. Both LEDs on means DC voltage is present.

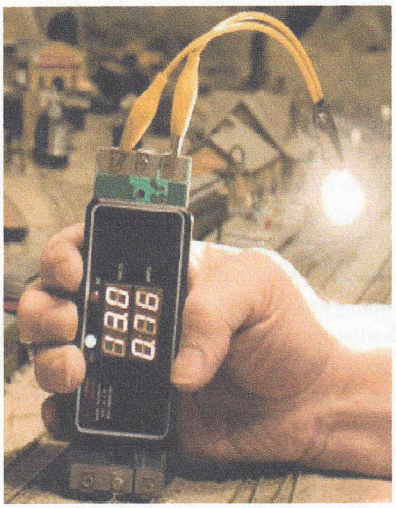


The meter automatically senses and switches the type of power. Only a "true RMS" meter can accurately measure DCC voltage and current.

Layout Voltage Loss

When the rail voltage to a decoder drops the train speed can also drop along with lights dimming. There are many places in the path from the booster to the decoder where voltage can be lost. The voltage from the booster or system may have a small drop as more current is drawn. The wiring from the booster to the rail will also lose some voltage. Devices like circuit breakers and block detector can add to the voltage loss. Nickle Silver rail is not as good a conductor electricity as copper wire and can be a significant part of the voltage loss. Rail joiners can also cause a loss in voltage. To determine the layout voltage loss the voltage must be measured at the rails when current is flowing. Without a current flow there is little to no voltage loss. It is almost impossible to get a good stable voltage reading using a train running as a current load. The best way to measure the loss is with some type of steady load. An automotive lamp turns out to be a good device to use as a steady load. They are cheap and easily available. A couple of pieces of wire with clips can be soldered the lamp. (See photo) Depending on your scale and booster rating one of the following automotive lamps should work. The #912 draws about 1 amp the #1141 about 1.5 amps and the #1156 about 2.25 amps. (Due to the low cold resistance of a lamp, the 1156 lamp can cause low powered systems like the Zephyr to shut down [overload]. The 912 should be OK for this test.) Choose a lamp that is near the maximum current used in a block, not the current used by the layout.

The first test should be to determine the voltage loss of the system or booster. [A] Measure the output voltage of the booster at a point close to the booster with no trains running. If you have an RRampMeter connected as a panel meter close to the booster this reading should work. [B] Next connect the load to the rails load (lamp) to the rails with the meter still next to the booster. The difference between the two readings will give you the voltage loss of the booster at this current. [C] Read the voltage at the rails with out a load. [D] Read the voltage at the rails with the load. The lamp can be connected the terminals of the RRampMeter so a number of reading can be made in the same block. You may be surprised at the voltage loss at different points of the same block. This can be due to the poor conductivity of Nickle Silver rail. Poor connections of rail joiners is another thing to look for. Wire that is under size is also a cause of voltage loss. When making measurements of loss across things like rail joiners and connections the voltage is so low that the RRampMeter with the battery option



Checking voltage drop with an RRampMeter. Auto lamp used as a load.

make be needed. It is best to keep the voltage loss due to wiring and rails under 1 volt. More than a couple of volts can cause slowing of locomotives and in extreme cases even cause the decoder to drop out. There is a wire chart that shows the length of wire for a ½ Volt drop due to wire resistance. The chart shows the voltage drop for 1, 2, 5 and 10 Amps. This is a chart for one way resistance. If you wire out to the rails and back (double the length), this chart becomes a 1 Volt chart.

Which Size Wire?

The 20 to 18 gauge wire should be used only for Z and N scales. This size can be used for short track feeders in larger scales. The 16 gauge works for most small layouts with short runs. The 14 to 12 gauge for larger layouts in most scales. The 8 to 10 should be reserved for older O scale and G scale layouts. This larger size wire becomes a bit cumbersome to work with.

Stranded wire can be used anywhere, but solid should only be used where it will not be flexed or moved.

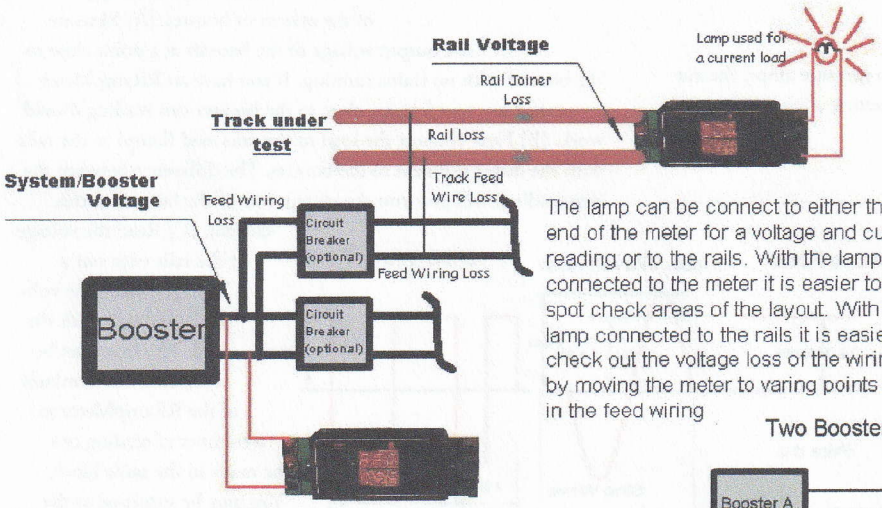
Voltage loss for ½ Volt for different currents and wire size.

Wire Size	1A	2A	5A	10A
8	796	398	159	80
10	501	250	100	50
12	314	157	63	31
14	198	99	40	20
16	124	62	25	12
18	78	39	16	8
20	50	25	10	5

Monitoring Current

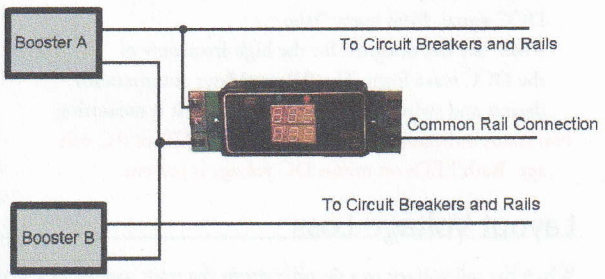
If your layout uses common rail wiring and you have more than one booster you can monitor the current from both boosters. Run the common of both booster through the meter and this will get you an indication of total layout current. NOTE this will only work with common rail wiring.

Measuring Layout Voltage Drop and Loss



The lamp can be connect to either the end of the meter for a voltage and current reading or to the rails. With the lamp connected to the meter it is easier to spot check areas of the layout. With the lamp connected to the rails it is easier to check out the voltage loss of the wiring by moving the meter to varing points in the in the feed wiring

Two Booster and One Meter with Common Rail



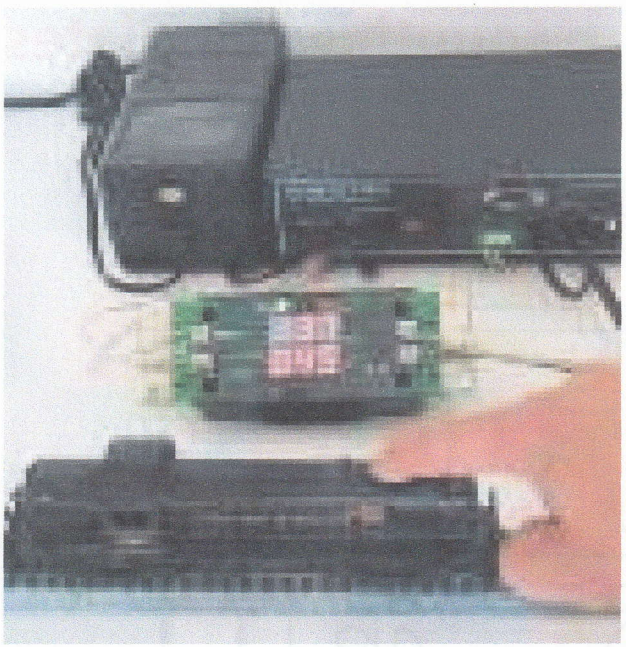


FIGURE 1

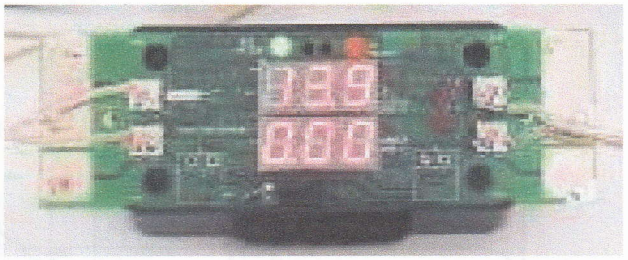


FIGURE 2

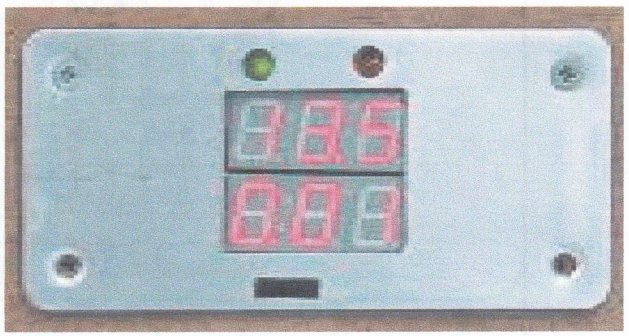
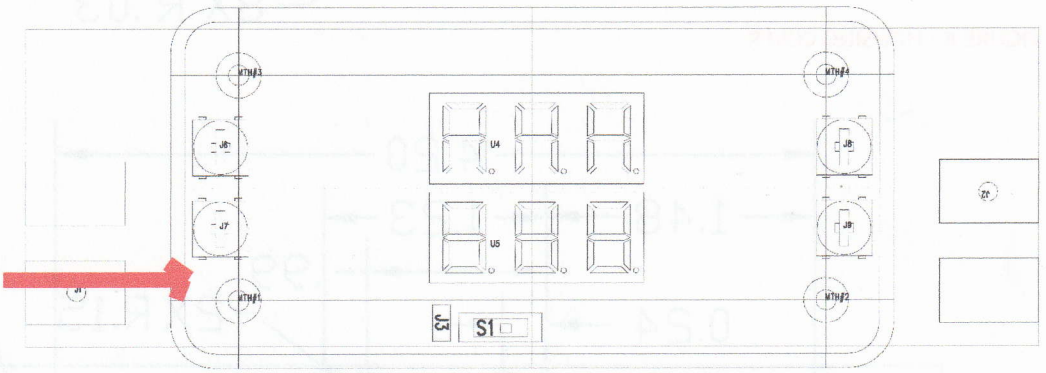


FIGURE 3

FIGURE 4 - ASSEMBLY TOP

Input/Output screw terminals, 4 supplied, can be soldered to 4 locations shown on front or back of circuit board. Only one or two legs of screw terminals need to be soldered. Also, for Input/Output connections you may solder directly to any one of the four holes at each screw terminal location on the circuit board if you choose not to use screw terminals.



J3 and S1, see page 1.

Reserved for future use.

Mounting Templates

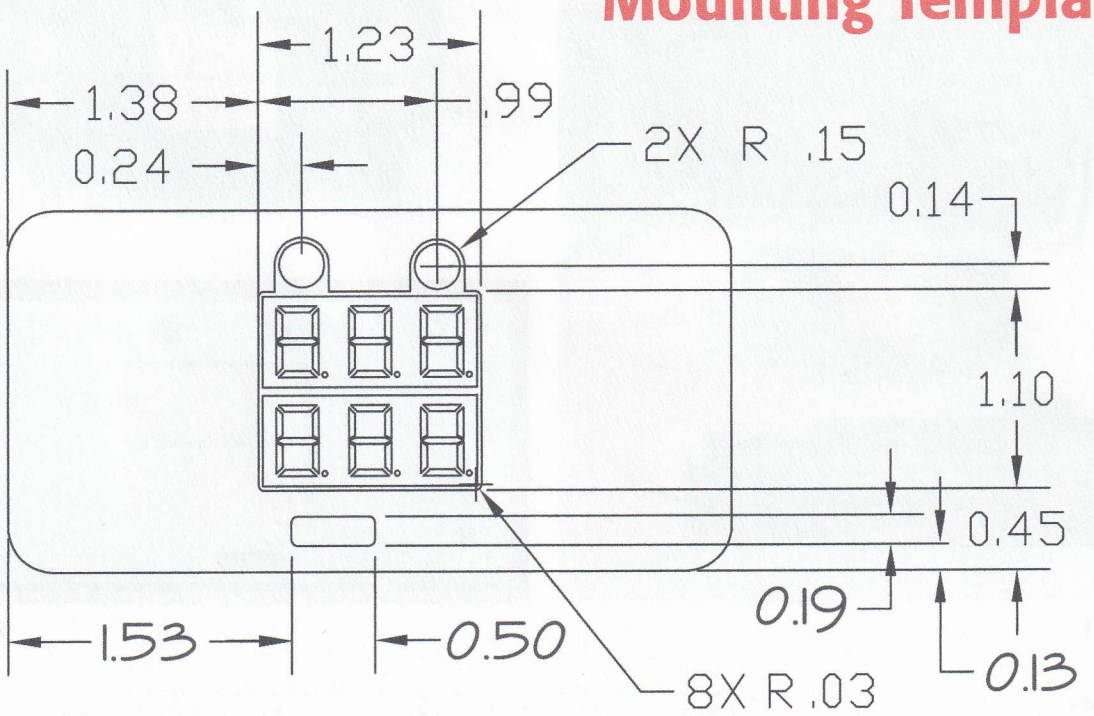


FIGURE 6 - HOUSING COVER

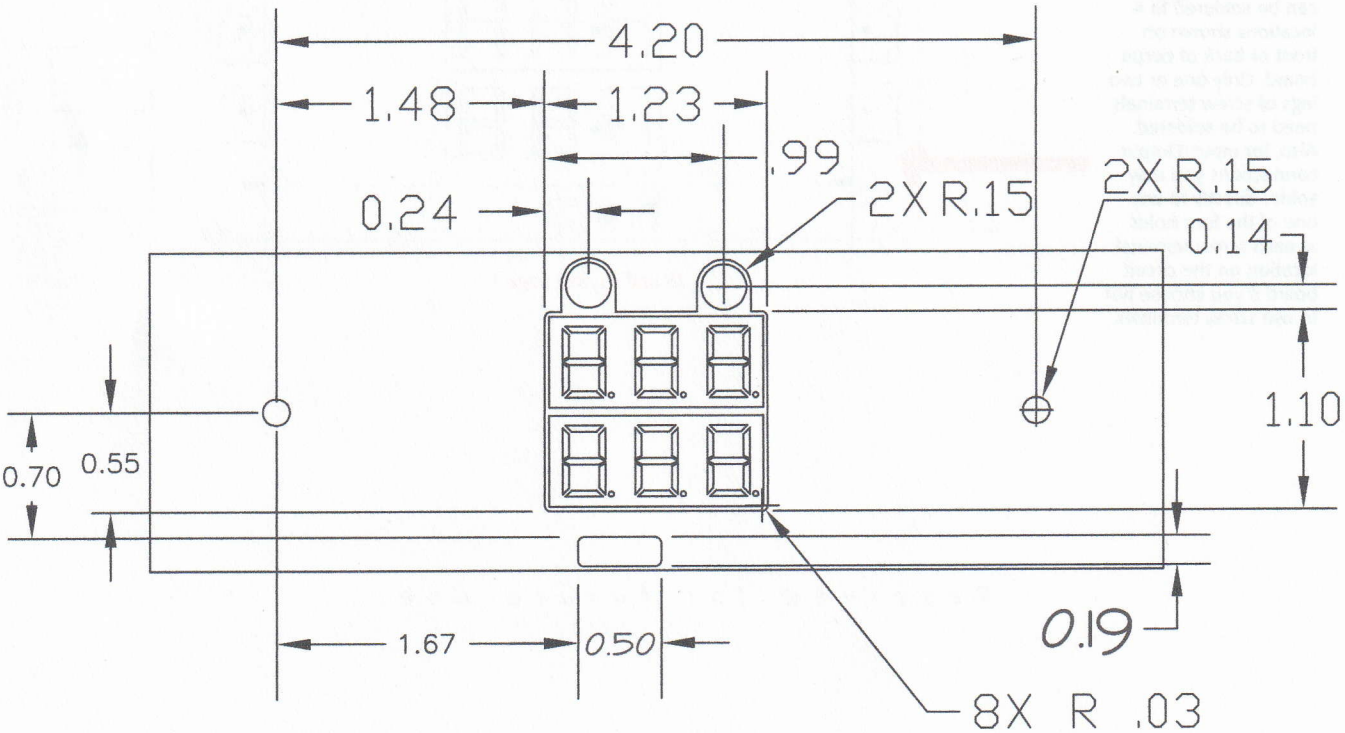


FIGURE 7 - PANEL CUTOUT

RRampMeter Application Notes

by Don Fiehmann

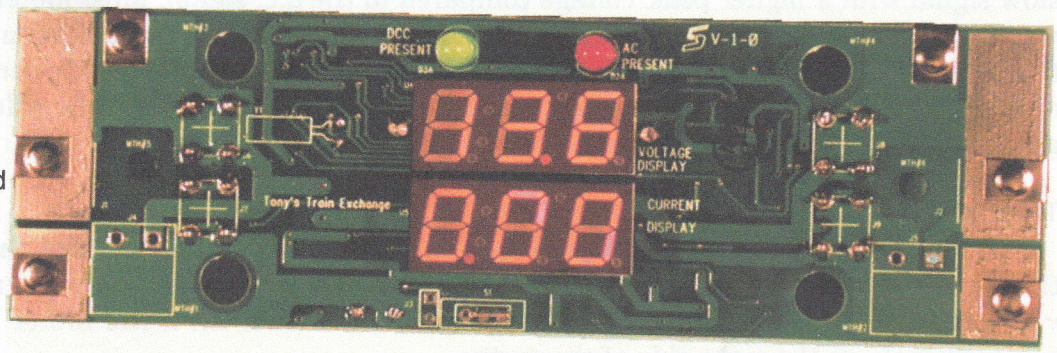
Meter shows the voltage at 13.4 volts and no current flow. LEDs at top show the type of power. Green LED indicates DCC Power.

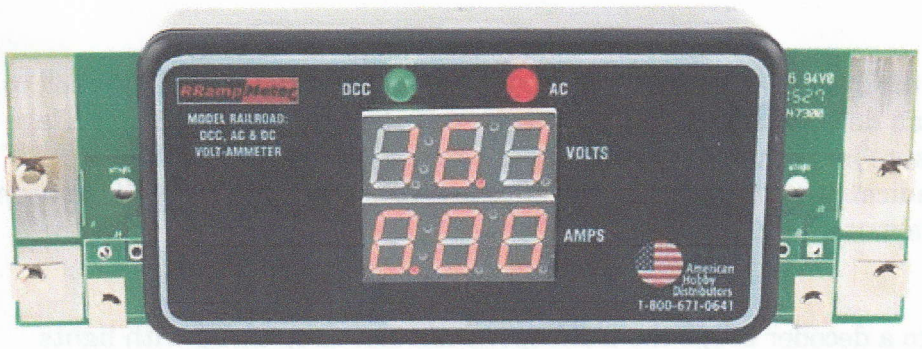
The RRampMeter is designed as a flexible tool to monitor and analyze the electrical operation of a layout. It is designed to work not only DCC power but also with ac and dc. Three models are available in two different current ranges. The standard meter is rated at up to 10 amps and up to 23 volts DCC or d.c. and 6 amp at up to 16 volts on a.c. There is a model unit for large scales has a capacity of up to about 20 amps.

The three models are (a) a bare module design for panel mounting, (b) mounted in a plastic case and (c) mounted in a plastic case with the option of battery power. All of the meters are powered by the input voltage as long as it is greater than 7 volts. The last unit can use a 9 volt battery to operate with input voltages of less than 7 volts.

The meter can be used either as a portable meter or mounted permanently. Screw terminals are supplied with the meter that can be soldered to the back side of the meter's circuit board.

This is the bare meter without a case. The meter can be mounted in a control panel or used as is.





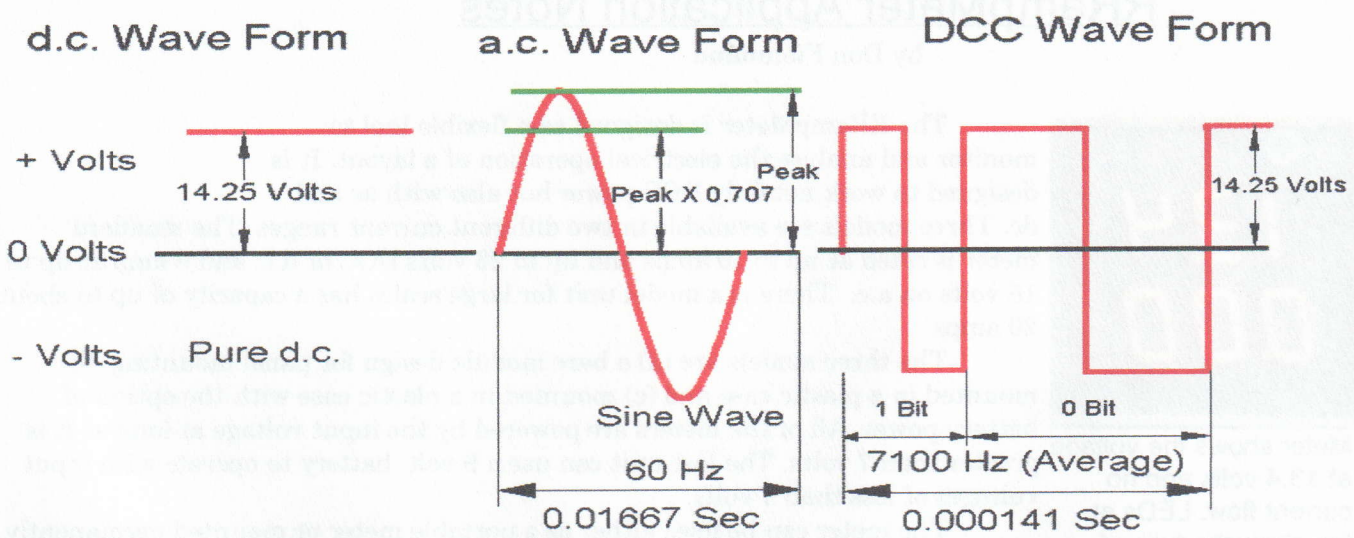
RRampMeter in a case. Battery power meter looks the same, but has a on/off switch below the display.

True "RMS"

Most common meters can read both ac and dc, but can not accurately read DCC power. In order to accurately read DCC power a "true RMS" meter, like the RRampMeter is needed. This is due to the shape and frequency of the DCC signal. The RRampMeter automatically detects and switches to the type of power it is measuring. Two LEDs indicate DCC or ac , no LED on indicates dc.

RMS is an abbreviation for Root Means Squared. It is a mathematical way of analyzing a distorted wave form.

The d.c. wave form is easy to read as it is a steady signal. The a.c. wave form is a relatively



The RRampMeter automatically sense and switches the type of power. Only a "true RMS" meter can accurately measure DCC voltage and current.

slow signal with a higher peak voltage compared to the d.c. signal. Most meters assume a sine wave at 60 Hz and simply take the peak voltage of the wave form and readout a value of 0.707 of the peak. DCC is a different type of signal. The signal is a much higher frequency can vary. In order for the meter to accurately read the DCC value it must compute the value of the voltage to get a true reading.

TRACK VOLTAGE

Voltage is read by connecting to the two terminals on the left side of the meter. The end of the circuit board has an area that allows you to put the meter directly on the rails to measure the voltage. In order to measure amps, the current must flow thru the meter by connecting to the two terminals on the right side of the meter.

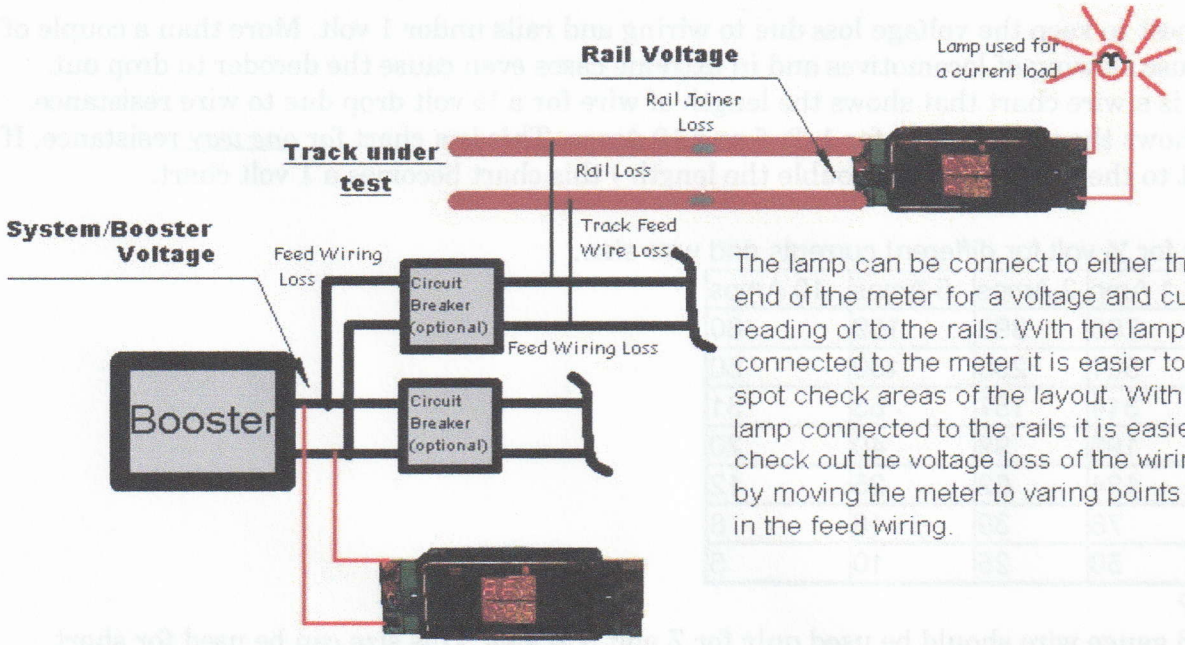
PANEL METER

A meter mounted near the system or booster will let you monitoring the power supplied to the layout. This will let you can determine how well your system or booster is regulating voltage under load. You can also measure just how close you are to the maximum power limit of the booster or system. This will indicate the operation of the system/booster, but not the voltage drop of the wiring and rails of the layout.

LAYOUT VOLTAGE LOSS

When the rail voltage to a decoder drops the train speed can also drop along with lights dimming. There are many places in the path from the booster to the decoder where voltage can be lost. The voltage from at the booster or system may have a small drop as more current is drawn. The wiring from the booster to the rail will also lose some voltage. Devices like circuit breakers and block detector can add to the voltage loss. Nickle Silver rail is not as good a conductor electricity as copper wire and can be a significant part of the voltage loss. Rail joiners can also cause a loss in voltage.

Measuring Layout Voltage Drop and Loss



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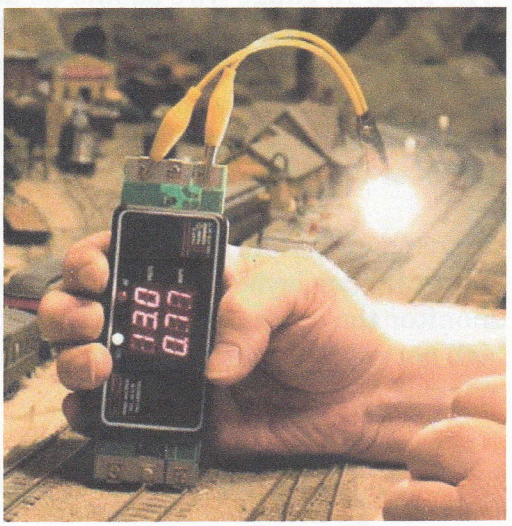

Lamp used as load

To determine the layout voltage loss the voltage must be measured at the rails when current is flowing. Without a current flow there is little to no voltage loss. It is almost impossible to get a good stable voltage reading using a train running as a current load. The best way to measure the loss is with some type of steady load. An automotive lamp turns out to be a good device to use as a steady load. They are cheap and easily available. A couple of pieces of wire with clips can be soldered the lamp. (See photo) Depending on your scale and booster rating one of the following should work. The #912 draws about 1 amp the #1141 about 1.5 amps and the #1156 about 2.25 amps. (Due to the low cold resistance of a lamp, the 1156 lamp can cause low powered systems like the Zephyr to shut down [overload]. The 912 should be OK for this test.) Choose a lamp that is near the maximum current used in a block, not the current used by the layout.

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that the RRampMeter with the battery option make be needed.

Wire Size

It is best to keep the voltage loss due to wiring and rails under 1 volt. More than a couple of volts can cause slowing of locomotives and in extreme cases even cause the decoder to drop out.

Here is a wire chart that shows the length of wire for a ½ volt drop due to wire resistance. The chart shows the voltage drop for 1, 2, 5 and 10 Amps. This is a chart for *one way* resistance. If you wire out to the rails and back (double the length) this chart becomes a 1 volt chart.

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Monitoring Current

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Two Booster and One Meter with Common Rail