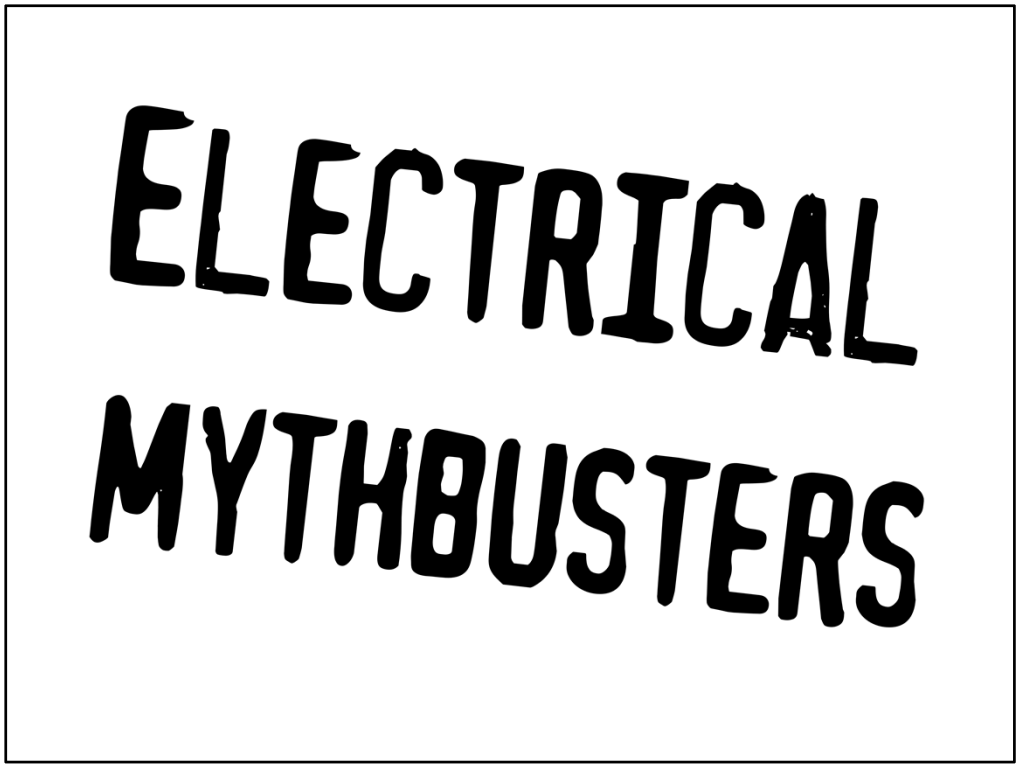


I gave this presentation at the Roadtrek International Chapter rally held in Branson Missouri in the spring of 2013. Several people asked if I would post the presentation. By themselves the slides may not make sense, so I've added notes for each slide.

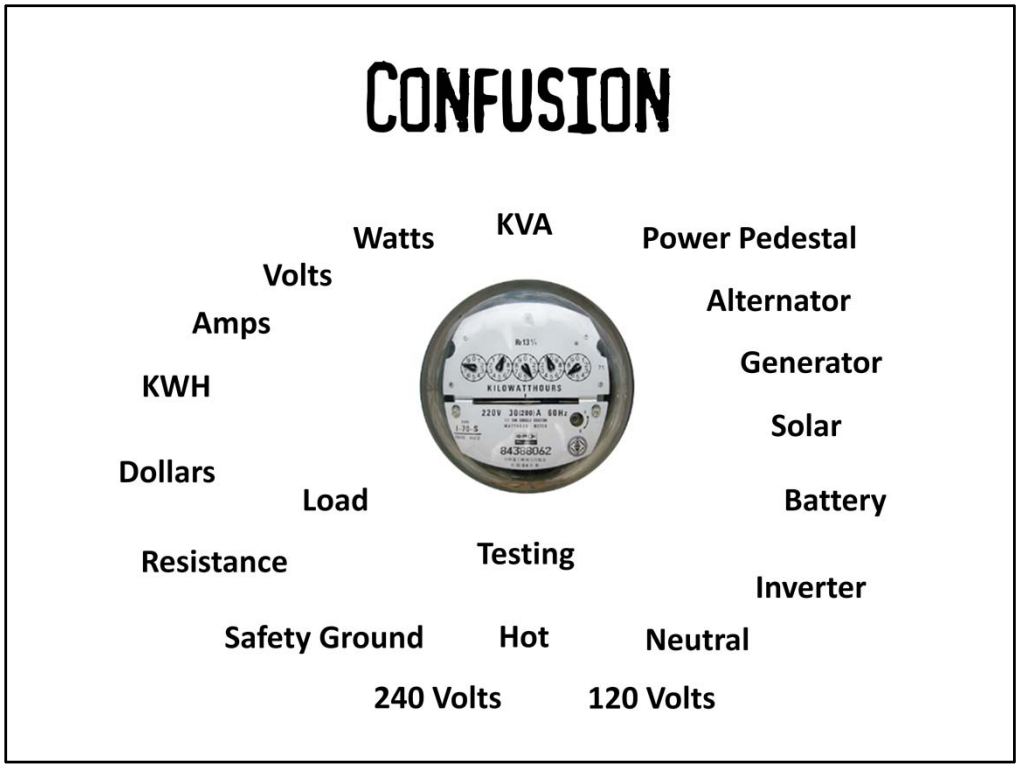
I've made a few minor changes in the slides for clarity.

Please be aware that some things have no "exact" answer and opinions vary. Also not all situations are the same.

If you find an error, or have issue with any of this, please let me know and I will review the material and we will get it right!

Happy Treking!

John Slaughter
John.e.slaughter@gmail.com



There is a lot of confusion about the electrical systems in our Roadtreks and it's no wonder, they are complicated. However there are some things which everyone needs to understand and avoid some of the common problems and hazzards.

Safety needs to be the highest priority with protection of equipment and property as a secondary concern.

Keep in mind that the reason we have our machines is to actually "use" them. Being so overly cautions that we can't enjoy the machine is not a good strategy.

To help make some of this clearer I'm going to try and use an analogy using money in the bank and rates of pay.

VOLTAGE AND CURRENT

The voltage is the critical factor. ***<u>False</u>***

- **Knowing the voltage is only ½ the story, you need to know the current as well.**
- **It takes voltage, current and *time* to do useful work!**
- **For example; a 100 watt bulb At 120Volts AC pulls 0.83 amps.**
- **A 18 watt bulb which operates at 12 volts DC, pulls 1.5 amps.**

Before we get to money, I want to clear up some confusion about voltage. We hear a lot of discussion about voltage, but it's vital to remember that it takes both voltage and current to do useful work. It's normally easy to measure voltage and a bit more difficult to measure current, but to really understand what's happening you need to know both.

High voltage and or high current does not necessarily imply high power. We do need to be concerned about high voltages which can kill via electric shock, but high currents can create other hazards.

The ordinary 100 watt 120 volt bulb requires about 0.83 amps where the little 18 watt bulbs found on many of our rigs requires almost twice as much current, but at a much lower voltage.

If you have voltage and current, then work is being done and often that work is mostly "heat."

Don't worry too much about DC and AC voltage for the moment. AC or alternating current has the advantage that it's easily transformed from one voltage to another so it can be transmitted over long distances. DC or direct current is naturally created by batteries and solar panels and it's a bit more difficult to transform to another voltage.

ANALOGY

We all understand money!
So I will I will try to explain some of these concepts in terms of money.

As I said before we all understand money and my hope is to make some of these concepts more understandable by relating them to everyday monetary themes.

ENERGY AND POWER

- ***Energy*** **is like money,** ***No it is money!***
- **You pay money for energy and we measure it in Kilo-Watt-Hours --- KWH**
- **1 KWH costs about 10¢.**
- ***Power*** **is like your rate of pay or how much the mechanic charges per hour to fix your car. More hours, more money.**
- **Remember the 100 watt light bulb? Well the rate is 100 watts and in one hour you will have spent 1¢.**

We buy electricity in **kilo-watt-hours** and this is a unit of energy. For purposes of this discussion, we will use a cost of 10 cents per kilo-watt-hour or **KWH**.

We can store energy in a battery, buy it as needed from the utility, transform solar energy into electricity or convert gasoline into electrical energy. Liquid gasoline is a convenient way to store a large amount of energy.

The "rate" at which we buy, make or store energy is **power** and this is expressed in **watts**. Much like our rate of pay might be $10 per hour. After 10 hours of working we could deposit our $100 into the bank. (Not including taxes, but more about that later.) Likewise if we earned $20 per hour we would only have to work 5 hours to earn the same amount.

The 100 watt light bulb consumes energy at a rate of 1 cent / hour. So in 10 hours it would consume 10 cents or 1000 watt-hours worth of electricity. If the cost per 1000 watt-hours is 10 cents, then we would have spent our energy at the rate of 1 cent per hour. Ten hours at this rate would cost 10 cents.

Technically the energy is not consumed, it is transformed from one form into another. So the energy used to light the lamp is converted into light and heat.

Voltage and Current

- ***Energy*** **is power delivered over time: Watts × Hours.**
- **100 watts delivered for 10 hours is 1000 watt-hours.**
  10¢! A 1¢ per hour rate!
- **The product of the voltage and current determines the power being delivered.**
  So watt-hours = Volts × Amps × hours
- **A Watt-hour is too small, so we divide by 1000 to get Kilowatt-hours or KWH.**

Time is really important, you can have a high **rate** or **power**, but if you use for a short period of time, the energy cost is low. Making coffee requires a large amount of power, but a small amount of energy. A coffee maker might require 1000 watts, but only runs for 6 minutes. The rate is 10 cents per hour, but for 1/10 of an hour. So the cost is only 1 cent.

A 100 watt bulb running for 10 hours is only a 1 cent per hour rate, but the long run time makes it much more expensive in terms of energy. 10 cents!

Energy Limits

- **Your bank may limit the rate at which you can withdraw money each day!**
- **In the case of our "banks" the numbers are**
  - **30 amp 36¢ / hour (3600 watts)**
  - **15 amp 18¢ / hour (1800 watts)**
  - **Onan 28¢ /hour (2800 watts)**
  - **Trip-Lite Inverter 7.5¢ / hour (750 watts)**
  - **Batteries … 6¢ to 10¢ / hour (600-1000 watts)**

Remember **energy** is measured in kilo-watt-hours or **KWH**.

We often get confused about how many things we can run at one time. Using the "money" analogy you can see that some energy sources may have plenty of money (**energy**) in the bank, but the rate of pay (**watts**), may be limited. So a 30 amp connection will let you run more things simultaneously than a 15 amp connection. The bank balance (**energy**) may be "large" but in this case the rate is the limiting factor.

In the case of "batteries" in addition to a limit on the rate of pay (**watts**), we have a limited bank (**energy**) balance! We also may suffer an additional penalty for rapid withdraws and the bank balance falls faster than normal. A progressive "tax" if you will.

More "tax" may be imposed for converting the battery voltage from 12 volts DC to 120 volts AC or vice versa.

How Much Energy

Device	Power Watts	¢ / hr rate	Hrs/Day typical	KWH/Day	¢ / day
Coffee Pot	1025	10	6 min	0.103	1
Hair Dryer	1600	16	10 min	0.270	2.7
Microwave	1300	13	15 min	0.325	3.3
Toaster Oven	1500	15	10 min	0.250	2.5
A/C / Space heater	1400	14	8 hrs	11.2	112
Computer/TV	50	0.5	2 hrs	0.100	1
Cell Phone Charger	<5	0.05	8 hrs	< 0.040	<0.4
Exhaust Fan Hi	18	0.18	8 hrs	0.216	2.2
4 Lights (18w each)	72	0.72	10 hrs	0.720	7.2
4 LED (1w each)	4	0.04	10 hrs	0.040	0.4

Too much load for inverter

This chart lists some of the common devices we use, the power required, cost per hour, typical time per day, the number of kilo-watt-hours and the cost for the energy.

You may notice that for most of the things we use are either very high power (**watts**) or not so much. For most of us the high power devices are really beyond what the inverter can deliver even for a short period of time. This is because of the rate-of-pay limitation of the battery and the inverter. In the case of the coffee pot, the "bank balance" (**KWH**) is adequate, but the rate of pay (**watts**) limitation makes it really tough on the battery.

Most noticeably the traditional incandescent lights many of us have in our rigs consume a large amount of energy if run for many hours. Notice how much more energy the lights require than the coffee pot. On the other hand the A/C or Space heater have high rates and usually run for many hours in a given day. Notice how little energy the LED lights require compared to the incandescent lights while providing the same amount of light.

BATTERIES

- **The two batteries in most Roadtreks will store about 2 Kilowatt-hours. About 20¢ worth of electricity.**
- **You don't want to run the battery flat, so 50% is about 1KWH worth of electricity. About 10 ¢ from the utility. A 100 watt bulb for 10 hours!**

- **So you only have 10¢ to spend without recharging.**
- **You can pull energy at the rate of 6¢ to 10¢ per hour for a very short period of time. (Extra charge!)**

Batteries store energy and as they get older they will store less and less. Eventually they will have to be replaced. The above figures assume fresh "healthy" batteries.

It's very important to remember that our "deep cycle" batteries are not designed to deliver large amounts of energy in a short period of time like a automotive starter battery. Excessive demands will shorten battery life and reduce the amount of energy you can use on each charge.

In the case of the coffee pot example, the total energy is about 0.100 **KWH** or 1 cent. This is only about 10% of the battery capacity, but the rate of 1000 watts is really beyond what the two batteries can deliver efficiently.

Not all units have the same batteries and some have more capacity than others. So the actual energy storage will vary. Some have only one battery and this will ½ the capacity. Remember, older batteries won't store as much energy as new batteries.

How Much Energy

Device	Power Watts	¢ / hr rate	Hrs/Day	KWH/Day	¢/day	% of Battery
Coffee Pot	1025	10	6 min	0.103	1	10%
Hair Dryer	1600	16	10 min	0.270	2.7	27%
Microwave	1300	13	15 min	0.325	3.3	33%
Toaster Oven	1500	15	10 min	0.250	2.5	25%
A/C / Heater	1400	14	8 hrs	11.2	112	1120%
Computer/TV	50	0.5	2 hrs	0.100	1	10%
Phone Charger	<5	0.05	8 hrs	< 0.040	<0.4	< 4%
Exhaust Fan Hi	18	0.18	8 hrs	0.216	2.2	22%
4 Lights (18w)	72	0.72	10 hrs	0.720	7.2	72%
4 LED (1w each)	4	0.04	10 hrs	0.040	0.4	4%

Too much load for inverter

On this chart I've added a column; "% of Battery." Note that for most of the high power items even though they don't consume all the energy, the rates are really beyond the capacity of the inverter / battery combination.

Notice how much total energy four conventional incandescent bulbs consume. The computer or TV for a few hours is tiny in comparison. Actually in practice, most computers and TVs consume even less power.

LED lights are a huge improvement over incandescent bulbs. If you want to boondock, invest in LED lights!

For most of us, when we boondock, lights and the exhaust fan are the must have loads. The computer or the TV can be "managed."

GENERATOR

- **A gallon of gasoline burned in your 2.8KW Onan at full power will produce about 6.7 KWH in a little over two hours.**
- **It can make about 28¢ worth of 10¢ per KWH electricity every hour! (Costs a lot more in gas!)**
- **Running a light load like a TV mostly burns gasoline and makes noise. Use the inverter!**

It is amazing how much energy is contained in one gallon of gasoline. A single gallon of gas weighs only 6 pounds yet contains a lot of energy. Compared to the useful 1 KWH in our batteries, the generator can turn that gallon of gasoline into 6.7KWH. This is even more amazing when you consider that the generator is only at best about 20% efficient. Most the energy in the gasoline is converted into heat.

On the other hand, the generator is noisy and very inefficient without a large load. It takes a lot of gasoline just to keep the generator running.

Running the microwave or the air conditioner are good applications for the generator when you can't plug in.

Running a TV or computer is not a good application for the generator. Recharging the batteries is not so clear. The Trip-Lite can charge at 45 amps, but running the vehicle engine can charge at an even higher rate. You might find that running the vehicle engine works quite well and makes a lot less noise.

Deeply discharged batteries will not charge very rapidly. It's best not to deeply discharge your batteries because it shortens the useful life.

TRIPP-LITE INVERTER

- **Maximum of 750 watts continuous. 7.5¢ / hour!**
- **Requires 73 amps to produce full 750 watt output.**
- **Boost mode 1125 watts, 100 + amps. Very tough on the battery.**
- **You could run the vehicle engine to "buck up" the available DC power.**

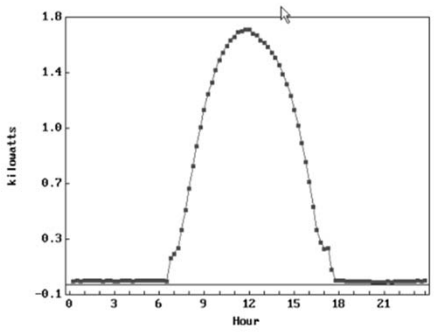
The full 750 watts requires a lot of current, about 73 amps. This is actually quite hard on the batteries. Running in the Boost mode is clearly beyond the battery design limit. Running the vehicle while using the inverter can help.

The inverter is really good for running smaller loads like your computer and your TV.

It might not be obvious, but charging your phone using a 12 volt charger uses much less energy, than using the inverter to run a wall charger. Most of our machines have 12 volt receptacles which draw from the house batteries rather than the vehicle battery. While the phone charger is not much of a load for the vehicle battery, be aware that you are drawing from that battery when you use the vehicle cigarette lighter receptacle.

Solar Panel

- **A very large, 250 watt solar panel on a sunny day will produce about 1KWH or about 10 ¢ per day. The actual output is *highly variable*. So at best, the rate is 2.5¢ per hour and usually a lot less.**



Solar is great, the energy is free. Unfortunately you only get large amounts of energy when the sun is shining. Yes you will get some energy even in low light, but much less than in full sun.

The chart is for a typical 2KW array in full sun over a 24 hour period. You can see that the output drops dramatically.

This panel is “properly” tilted towards the sun. In most RV installations, the panels are flat against the roof. This reduces the effective “aperture” of the panels.

Not all panels are created equal and some will work better than others. The differences are not huge!

Solar Panel

- **Many RV panels are on the order of 100 watts. So about 0.4 KWH on a good day. About 4¢ worth of electricity. The rate would be about 1¢ / hour in full sun.**
- **You need "room" in the battery to store the energy. If the battery is already charged, the energy is lost. You usually need the energy at night. These means that your battery capacity must be able to bridge days of low solar output.**

A lot of RVs have panels on the order 100 watts. This is enough to keep a battery charged when not in use, but it won't help with really heavy loads.

Unfortunately the only place you can put "excess" energy from the panels is into your battery. If it's already charged, then the extra energy does not help you later in the evening when you want to use it.

The energy from a solar panel varies and you need a charge controller which compensates for this variation and maximizes the transfer to energy to your batteries. Not all charge controller are created equal!

I've never had a report on a "dashboard panel" which worked very well.

IMPONDERABLE QUESTION

- **Why are automotive electrical systems designed to work at 12 volts and not at a much higher voltage?**

It would seem that higher voltages would really be better. It is true that the battery would have to have more cells, but that's not the reason.

ANSWER

- **Low voltage electric lights are much more durable and can tolerate vibration much better than high voltage lights because the filaments are made of thicker wire which is shorter in total length.**
- **A 60 watt 120 volt lamp has an uncoiled filament length of 22.8 inches with a wire diameter of only 0.0018 inches.**

Thomas Edison did not “invent” incandescent lighting, he invented a way to make a high voltage low power electric lamp.

High voltages are essential to moving energy from the power station to the point of use. So Edison made electric incandescent lighting “practical.”

Inconvenient Facts

- **Rapid discharge of your battery will result in less energy available! At a 600 watt rate, a quarter of the capacity is lost. So your 10¢ is reduced to 7.5¢.**
- **With the generator and the inverter, the opposite is true, it's more efficient at maximum output and has very low efficiency with a small load.**
- **You can't "force feed" a battery, it takes time to recharge. High charge rates are inefficient and can damage the battery.**

We'd like to operate as if we were plugged into shore power when parked. Unfortunately we must make compromises.

The generator makes a lot of noise and while capable of running heavy loads is limited by the available fuel.

Batteries have low energy density are heavy and expensive. Finding room for additional batteries is difficult and usually takes away from valuable storage space.

YOU CANNOT RUN ON BATTERIES VERY LONG

False: **With two good batteries and some careful planning, you can go for several days on the batteries alone.**

- **Run only the devices you need, running every light in the rig will run down the battery much faster than just one or two.**
- **LED lights are much more efficient than incandescent bulbs.**

Just like the fresh water tank, we've all learned not to run the water needlessly. The same thing is true of the battery. It can be done!

Older batteries won't work as well as newer batteries.

One has to "manage" the limited energy.

YOU CANNOT RUN ON BATTERIES VERY LONG

- **The refrigerator running on DC will deplete the battery rapidly. Use the DC mode only for travel. When parked, run the refrigerator on propane.**
- **The inverter consumes power even when idle, use it sparingly. Turn off when not needed.**

The refrigerator 12 volt mode will produce very little cooling when running on battery. You are better off to use propane or just let it "coast." If you don't open the door and have a reasonable amount of food in the frig, it will stay cold for several hours even if it's not running.

It is interesting to note, that when running the refrigerator while driving the performance of the refrigerator is much better because of the higher voltage.

Many people have ruined batteries simply by leaving the inverter switch on when not in use. Recent Roadtreks will drain the battery when the inverter is on, even if the battery switch is off.

Never run the battery flat for any reason.

When in storage, you must manage the batteries either by periodic use of the vehicle or keep it plugged into shore power. Older vehicles won't maintain the vehicle battery by leaving it plugged into shore power, but they will maintain the RV batteries. You may need to have the battery switch on for this to work depending on the model and year.

Determine what you need to do to preserve your batteries and implement the plan.

YOU CANNOT RUN ON BATTERIES VERY LONG

- **Running the vehicle engine will usually charge faster than the generator, particularly on older Roadtreks.**
- **A solar panel can help, but it probably not as well as you think. On a good day, a 100 watt panel can replace 4¢ worth of the 10¢ you can store in the batteries.**

- **A solar panel is a great solution for keeping batteries charged while in storage if you can't plug in.**

An added benefit of running the vehicle engine instead of the generator is that you won't run afoul of generator restrictions in a campground.

Solar panels are fine, but they won't work miracles. Be sure you understand the benefits. It's essential to invest in LED lights before even considering solar. Once you have LED's you may find that you don't need solar!

Maintaining the batteries in storage requires that you verify that everything is working properly. Don't assume that all is well!

YOU CANNOT RUN ON BATTERIES VERY LONG

- **Pay attention to the battery condition and "top" off the batteries as needed by running the vehicle engine or generator.**
- **Every charge cycle reduces the life of a battery. Don't deeply discharge, unless it's "worth" the cost.**

Letting a battery run down is the most common cause of early failure.

You can "estimate" your usage and manage the battery. Measuring the state of charge with an accurate voltmeter works, but you must allow the batteries to "rest" before making the measurement.

Remember that the generator may not charge the battery very fast, particularly on older Roadtreks. Running the vehicle engine may be a better startegy.

Many people are terrified that they will “blowup” their rigs by plugging into bad power.

In practice this rarely happens, but it’s best to be aware and take some simple precautions.

Park Power

This is an example of a very old pedestal. Notice the burned receptacle and the lack of a disconnect or circuit breaker.

Park Power

Another old pedestal. This one has the old style “Edison” fuses. I suspect the fuses had been bypassed. This thing must be 50 years or more old.

Park Power

- **If the park is neat and well kept, it's a good sign!**
- **Look for poor workmanship, shoddy construction and exposed wires. It won't have passed inspection if it looks shoddy.**
- **Loose fitting receptacles. These can get hot and create voltage drops under load. Feel the case of the plug when under load, it can be a little warm, but if it's hot, you have a problem. Burned spots on the receptacle is a strong hint of possible trouble!**

There is no reason to suspect that the majority of parks have poor systems. Most are fine, but use your eyes first.

Park Power

- **A 15, 20 or 30 Amp receptacle without an associated breaker *might* be a substandard installation. You might want to avoid heavy loads.**
- **A very full park on a very hot day. The system could be operating beyond it's design limit, look out!**
- **Even if the voltage is fine initially, check it under load in your vehicle with a big load. It will drop a little, but if excessive, look out. Most things will run okay on 110 volts, but don't go lower.**

Checking the performance of the system under load is key.

If the voltage does not sag excessively, then you are probably okay.

This does not mean that you should overload a 15 amp circuit!

Park Power

- **The Air Conditioner is the most at risk appliance due to low voltage. If the voltage is low, below 110 volts with the AC running, don't use the AC. It's much harder to start and the motor will run hotter. Normal voltage should be between 114 to 126 volts.**
- **Measure the voltage under load inside the rig, not at the pedestal. You want to include the voltage drop in the cable and connection.**
- **If you are plugged into a 15 amp or 20 amp receptacle, you *must* limit the load to one high power device.**

Listen and be aware of how your AC unit sounds normally. If it starts to struggle, it's time to disconnect!

Just because you "can" operate the AC and microwave at the same time does not mean that you are not "stressing" the system beyond it's design limit. Don't cheat, if you are plugged into a 15 or 20 amp circuit, limit your usage to one high power device at a time. It might work, but you are asking for trouble.

Don't depend on a breaker tripping, it might run for hours while "cooking" wires and connections.

A circuit breaker is an "inexpensive" device which is not all that precise. It works off of heat, the higher the load, the more heat. It takes time for a small overload to generate enough heat to trip the breaker.

Park Wiring

Look out for the following:

- **More than one RV owner has had a receptacle installed at home and the electrician, unfamiliar with RV plugs will wire the receptacle incorrectly for 240 volts. Don't assume it's correct, check before using.**

- **Temporary power can be incorrect. This happened at one of the big FMCA RV rallies. Be vary wary of temporary power! Always Check!**

If you are the "first" to use a connection, you might be the one to "find" the mistake.

Park Wiring

- **A missing safety ground is by far the most dangerous fault.**
- **If the safety ground is missing, just touching the frame of the RV could result in a shock which could kill.**
- **The little 3 light testers will identify a missing ground. It won't tell you how good the connections are, but likely if it's there it's okay.**

Safety equipment is in place to protect you in the event of a failure. If the safety system is not present then you have lost that line of defense.

Much like wearing a seat belt, you might be fine until you have an accident, then it will be very important.

The little testers will not detect every problem, but they will identify most of them.

Park Wiring

More MISWIRED configurations

- **A reversed neutral and hot wire; happens occasionally, you probably won't notice unless you check, but you should not use such a circuit.**
- **A properly wired connection is the first level of protection from shock, the second level is the safety ground. The little 3 light testers will reliably detect this condition.**
- **The combination of a reversed neutral and a missing ground is a potentially deadly fault.**

This occurs sometimes, but because people check, most RV parks will find out about the problem and get it fixed.

It's particularly important in an RV, because the RV is made of metal and the unit is "insulated" from the ground. Should the "body" of your RV become charged and the conditions are right, just touching the body of the vehicle could be fatal.

PARK WIRING

Connection between Safety Ground and Neutral

- **The safety ground and neutral must not be connected together inside your rig for proper protection against faulty wiring.**
- **Plugging into a park with a reversed hot and neutral will create a short circuit in the safety ground which will either trip the breaker or burn a wire.**
- **If you find that you trip a breaker when plugging into some parks, you may need to correct a fault in your rig.**

Many people don't understand this requirement and are not concerned. If you have experienced a breaker tripping immediately when plugging in, then it's likely that you have such a fault. Don't delay, get it fixed.

Inside the 120 volt panel you will find both a "ground" bus and a "neutral" bus. The neutral bus will be "insulated" from the metal box while the "ground" bus is solidly connected to the box and the frame of the rig.

The neutral bus is "isolated" to insure that the current running loads will flow through the neutral wire and not the ground wire. The ground wire is the "seat belt" and only sees current in a fault condition.

Note that when the breaker trips with a reversed neutral and hot, it's an indication of a problem with both the park ***and*** your rig.

TEST EQUIPMENT

Three Light Circuit Tester

Use with a 15 to 30 amp adapter.
You want to check the circuit you will be using!

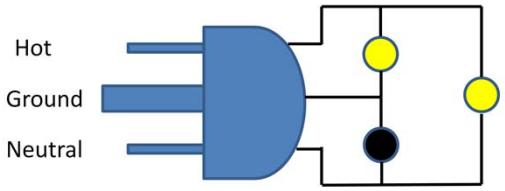
This is a very simple but effective device. Be sure and use it with the 15 to 30 amp adapter.

Some of these “testers” have a “button” used to test GFCI or ground fault circuit Interrupters. When pushed it allows a small amount of current to flow between the hot and the ground and this should trip a GFCI if plugged into such a circuit.

I’ve never seen a 30 amp GFCI in an RV park. I don’t think any of the current codes require this device on the 30AMP circuit.

TEST EQUIPMENT

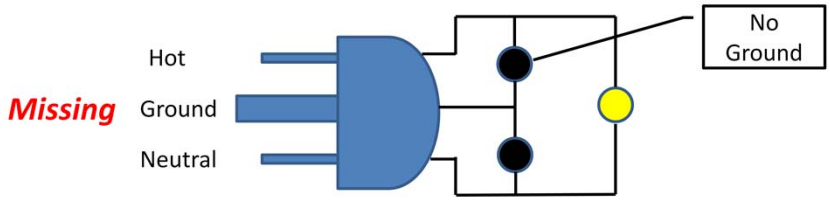
How does the little 3 light tester actually work?
It has 3 neon lamps which are connected as shown.



Normal Operation
The Ground and Neutral are connected together at the main panel, but no where else.

The bulb between the neutral and ground is usually “red” since it should never be on in a normal situation.

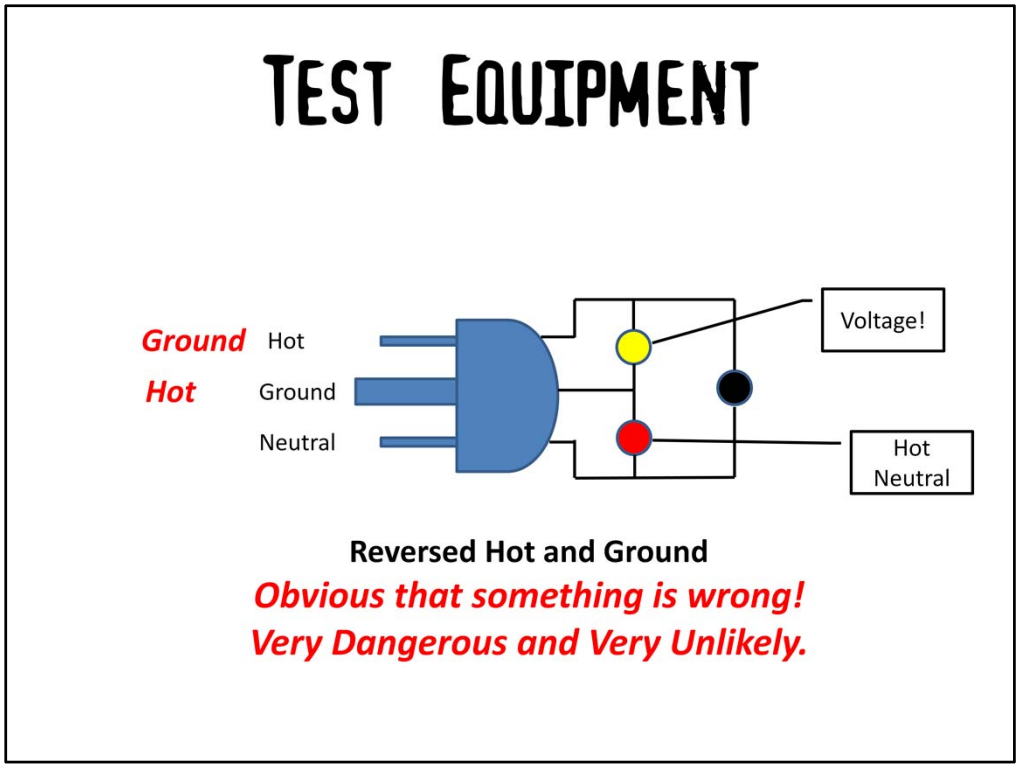
TEST EQUIPMENT



Missing or open Safety Ground
NO PROTECTION from a fault should the
Hot come in contact with a metal part you might touch.
You won't notice this unless you check!

This condition can only be seen if you check! Like a seat belt left unbuckled.

If the hot and neutral were reversed in addition to the missing ground, you would not detect the reversed hot and neutral condition which compounds the danger.



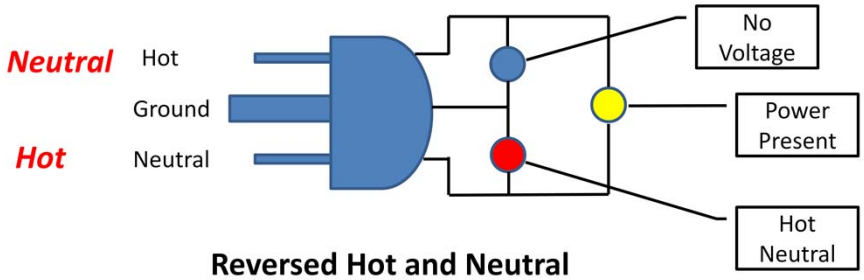
This is very unlikely to occur in an established park. A newly installed installation or temporary power is another story.

Be very cautious about new and temporary installations.

There have been reports of extension cords repaired incorrectly having this type of fault. Bottom line, if any part of the system is unproven, be sure and be aware of this potential problem.

Making simple repairs to an extension cord or other component can be deadly if done incorrectly. Be sure you understand what you are doing and "double-check" your work when done!

TEST EQUIPMENT



Reversed Hot and Neutral

The most common wiring mistake.
You won't notice this unless you check!
Can be dangerous to life and equipment

If you see this condition, don't use it.

TEST EQUIPMENT

Voltmeters

Note Expanded Scale
About $15
Very Easy to Use

Kill A Watt Measures Voltage, Current, Wattage, KWH and more. About $20. Get at Home Depot or Lowes.

The analog meter is fine for measuring voltage and is entirely adequate.

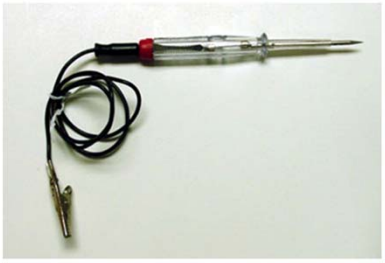
The Kill-A-Watt meter is not a lot more money and makes it possible to measure the actual load of various appliances.

The Kill-A-Watt will also tell you if your generator is running at the correct speed by reading out the frequency.

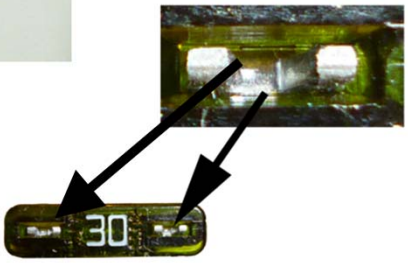
Inverters may give confusing readings on some voltmeters due to the modified sine wave output. Older electronics may not work correctly on an inverter and motorized devices may run hotter than normal.

TEST EQUIPMENT

12 volt test light



- **About $5**
- **Very versatile**
- **Easy to use.**
- **Check fuses easily in place.**
- **Only use on 12 volt circuits.**
- **Loads the circuit. (good!)**



You can use a DVM to make this kind of measurement, but the test light is a quicker and easier way to identify a bad fuse. Not having to pull the fuse out is worth the price!

This type of fuse have a little metal nub on each side, so you can make connections easily. Connect the clip lead to a grounded metal part and touch the probe to the nubs on the fuse. It should light on both sides. If it does not, the fuse is open. If it does not light at all, then you can't tell about the fuse. Check that the clip lead is connected to a grounded metal part.

Test Equipment

Advanced users only!
Digital Volt Ohm Meter DVM

- **$20 and up.**
- **Very versatile**
- **Difficult to use.**
- **Can be damaged easily.**
- **Readings can mislead!**
- **Does not "load" circuit**

The DVM is a great tool and you can use it in many situations. However unless you have a good understanding of it's limitations, you can easily misinterpret readings.

Use it incorrectly and you can damage the meter.

This tool is for an advanced amateur or professional.

TEST EQUIPMENT

Advanced users only!
Combination Clamp Ammeter / DVM

- **$45 and up.**
- **Measures both DC and AC current.**
- **DVM functions**
- **Clamp current accuracy not great, but useful.**
- **Make sure you buy a AC/DC version.**

This instrument has the ability to measure current without breaking the circuit. You do have to access an individual wire to make a current measurement. Not all clamp meters can measure DC current.

This meter also has DVM functions as well.

Again a tool for an advanced amateur or professional.

An individual wire must pass though the jaws to measure current. For example if you clamp around both the wire connecting to a load and the associated return wire the currents will "cancel" and you won't get a reading. You can "multiply" the sensitivity by passing the current carrying wire through the jaws more than once. Twice, doubles the reading and three times triples the reading.

How To Test

- **Do a visual inspection.**
- **Plug in the 3 light circuit tester using a 15 to 30 amp adapter to check the 30 amp receptacle.**
- **Turn on 30 amp breaker.**
- **Proper lights on circuit tester?**
- **Turn off Breaker.**
- **All large 120 volt loads off in rig, AC in particular.**
- **Plug in power cord, nice tight fit?**
- **Turn on Breaker.**
- **Check voltage in rig.**
- **Turn on a load, electric heater, hair dryer**
- **Check voltage again in rig. (Still okay?)**
- **If you add more big loads, check voltage again.**

Check with tester first.

Big loads off in the rig.

Then connect!

Check voltage, first without a load and then with a big load.

If any doubt, monitor while in use.

ADAPTERS ARE SAFE TO USE

For the most part TRUE with some caveats.

- **The most common adapter is a 30 to 15/20 Amp**
- **Use at home or when 30 amp receptacle not available.**
- **You are limited to 1 high current appliance.**
- **Overload and you might damage the adapter or receptacle. Don't depend on the breaker!**
- **Connections should fit tightly.**
- **Watch for too hot to touch plugs!**

Some of these are cheaply made and get hot even with moderate loading. Get a good quality adapter.

ADAPTERS ARE SAFE TO USE

- **The 15 Amp to 30 Amp adapter is commonly used in conjunction with the little 3 light circuit tester.**
- **Used to connect to a 30 amp receptacle using a ordinary 15 to 20 amp plug.**
- **This might seem like a good way to use a light weight extension cord with a 30 amp receptacle.**
- **An extension cord rated for 30 amps with the 30 Amp plug and receptacle is a much better choice.**

You can use this with the 30 to 15 amp adapter and then use your 30 AMP extension cord as a 15 amp cord.

ADAPTERS ARE SAFE TO USE

- **Some of us have a 30 amp to 50 amp adapter. Now you are using a circuit with 50 Amp circuit protection with external wiring designed for 30 amp.**
- **Avoid this unless you have no choice. The load is limited only by your RV circuit breakers.**
- **Rarely it is necessary to use this adapter unless you are "doubling up."**

The 50 amp RV receptacle is actually two 50 amp 120 volt circuits and makes it possible to have 240 volt appliances in a "big rig."

This adapter taps one side of the 240 volt circuit to get a 120 volt circuit.

There is no benefit to using this adapter unless there is no 30 amp receptacle available or you are "doubling up."

ADAPTERS ARE SAFE TO USE

- **Never use a 2 to 3 wire adapter to connect your RV for any reason. That two wire extension cord you have lying around is not worth the risk.**

This is a really bad idea. Admit it, have you ever hooked up the little lead?

Cutting off the ground pin on a plug so you can use a two wire extension cord is equally bad.

Get and use the proper extension cord!

A Power Monitor Is the Solution

- **Automatically detects low / high voltage and most wiring errors.**
- **Be sure what you are buying is of high quality.**
- **They are usually quite expensive.**
- **The surge suppression feature is often a bit oversold.**

This is not a substitute for “thinking.” Use your eyes and evaluate the situation first!

Inconvenient Facts

- **Circuit breakers are not very precise. So a 30 amp circuit breaker operating with at a current of 40 amps might not trip for hours, if at all.**
- **Circuit breakers trip faster at high currents, so a short circuit will trip much more quickly than an overload.**
- **It's important not to "overload" a circuit because the circuit breaker might not trip before you have a fire or damage.**

Never "depend" on circuit breaker to "protect" you from an overloading a circuit.

They will trip quickly on a high current fault due to a failure, but may not trip on an overload.

Poor Connections Hurt!

This damage was due to loose connections on the neutral bus bar, it got hot and melted the wires! Not due to an overload!

Notice the burned plastic insulator under the neutral bar on the left. The neutral bar is isolated from the metal box.

The ground bus at the top is bolted to the metal box.

I was running a heater in the van when this happened and I was not around to smell the burned wires. This was caused by loose screws on the bus bar and the connections were not “tight.”

Fun Factoids

- **30 Gallons of gasoline turned into electrical energy works out to about 200 KWH.**
- **To store this much energy in lead acid storage batteries they would weigh more than 10,000 pounds.**
- **At 8 gallons per minute it takes 3 3/4 minutes to fill a 30 gallon tank. If it were electricity, the power rate would be 3,200,000 watts! $320 / hour rate! Of course the gas cost is $1,680 per hour at 8 gal / minute**