

# Electrical Systems

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This guide is intended to assist Heartland Owners in understanding the electrical system in their RV.

## Important Notices

### Who created this document?

This document has been created by Heartland Owners independently of the Heartland RV Company, and is posted to the Heartland Owners Forum as a service to the owner community.

### Errors and Omissions

Because the authors are Heartland owners, not engineers or service technicians, it's possible that this document could contain errors or omissions. Readers are advised to also review the manufacturers' product documentation for more complete information and guidance.

### Additional Resources

The [heartlandowners.org](http://heartlandowners.org) website has a collection of owner-written user guides, including information on water systems, heating and cooling, winterizing, residential refrigerator, water heater and other topics. This information is available at <http://manuals.heartlandowners.org/?man=User%20Guides>.

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# Electrical Systems

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## Overview

There are three electrical systems in your RV:

- The 120V AC system which generally uses either shore power provided by a campground pedestal or generator power.
- The 12V DC system which uses battery power, in conjunction with the output of a power converter when there is also a source of 120V AC power.
- The 12V DC system powering brakes, tail lights, brake lights, turn signals and marker lights. This system is powered by the tow vehicle.

While generally independent, there are points of interconnection between systems.

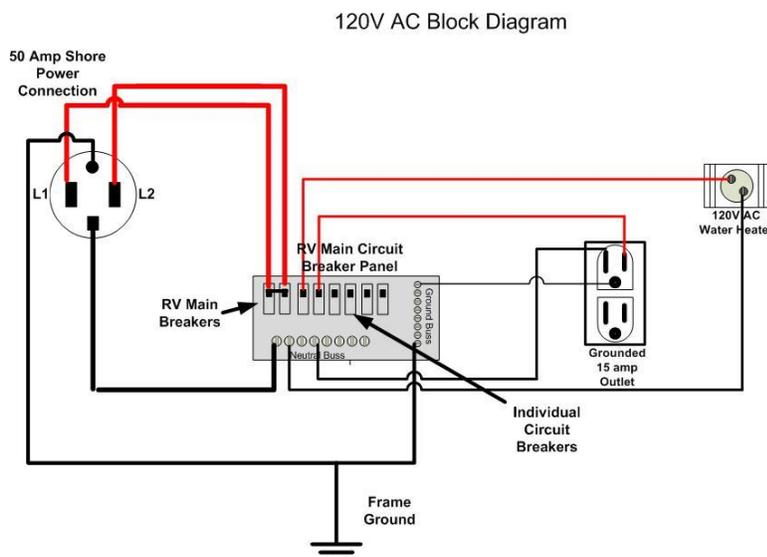
Version 2 of this guide includes a description of the Solar Option offering by Heartland on 2020 Landmark 365 units. While a number of owners have installed solar panels to augment the operation of their RV electrical systems, owner solar power owner installations vary considerably and are not covered in this guide. Inverters, apart from the small one dedicated to the residential refrigerator, are also not covered except for the one included in the Landmark 365 Solar Option.

Drawings and photos used are examples based on how Heartland built a particular RV at a particular time. Your trailer may differ from what's shown, but the content here should help you get a better understanding of the specifics of your trailer.

## 120V AC

### General Layout of 120V AC Power System

Power flows from the campground power pedestal, to the main circuit breaker panel. The main breaker(s) in the panel distribute power to the individual, or branch circuits. Each branch circuit



breaker supplies power to one or more 120V AC appliances or outlets. The circuit breakers also provide protection against overloads that can be caused by exposed wires, short circuits or malfunctioning equipment. Below is a simplified diagram showing 2 branch circuits. Note the hot, neutral and ground wire connections in the diagram.

## Power Connections

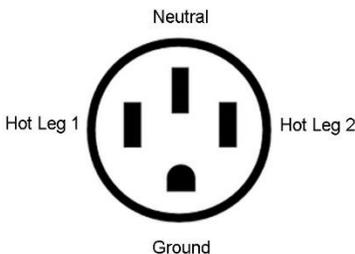
### Campground Pedestals

Newer campground power pedestals generally provide three receptacles that can provide power to the RV. A 50 amp, a 30 amp, and a 15 (or 20 if GFCI) amp receptacle. If your RV has 50 amp service, you would usually want to plug into the 50 amp receptacle as it provides the most power to run electrical devices in your RV. But using an adapter, you could plug into the 30 amp receptacle. You could even plug into the 15 amp receptacle, but you wouldn't be able to power very much in the RV.

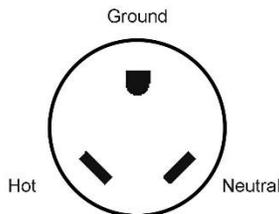
Some older campgrounds may only have a 30 amp receptacle.

### Various Types of Receptacles and Plugs

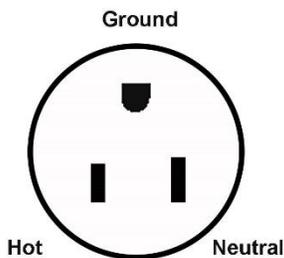
#### *NEMA 14-50R Receptacle*



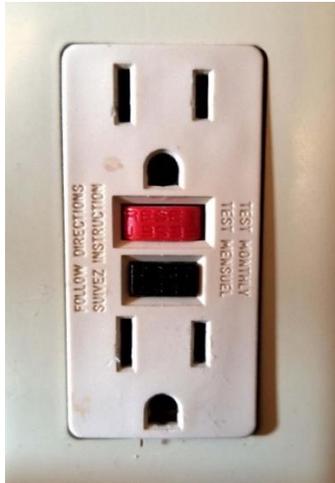
The NEMA 14-50R receptacle has two hot legs, each providing 50 amps at 120V, for a total of 12,000 watts of power to operate appliances.



The NEMA TT-30R receptacle has one hot leg, providing 30 amps at 120V, for a total of 3,600 watts of power to operate appliances.



The NEMA 5-15R receptacle has one hot leg, providing 15 amps at 120V, for a total of 1,800 watts of power to operate appliances. A 20 amp GFCI version of this outlet would provide 2,400 watts of power. A GFCI outlet has Test and Reset buttons on the front of the receptacle.



Ground Fault Circuit Interrupt (GFCI) outlets are designed to protect you from hazardous electrical shocks. The GFCI outlet is the first outlet in a string of outlets, all on the same branch circuit from one of the circuit breakers in your main panel. On RVs, it's usually located in the bathroom. The outlet compares the power going from the hot wire, to the power coming back on the neutral wire. If there's a difference, to protect you from a shock, the outlet cuts power to its own sockets, and to any other downstream outlets on the same branch circuit. GFCI protection is typically used for outlets that might be exposed to water. This includes outlets in the bathroom or kitchen area, the Universal Docking Center (UDC), if the RV has one, and other exterior outlets that could be exposed to water.

If you experience a power loss on several outlets, particularly the ones mentioned, you should try the reset button on the GFCI outlet to see if that restores power. Of course, if you have a wet outlet, the GFCI may immediately trip after you reset it. So you may need to investigate all of the outlets mentioned.

### **Dedicated 20 Amp 120V AC Plug**



Larger coaches have Power Converters that may have peak period demand in excess of 15 amps. The circuit breaker, wiring and receptacle will be rated for 20 amps at 120V AC. The plug on the Power Converter's power cord uses a dedicated 20 amp plug that only fits a 20 amp outlet.

Notice that one of the flat prongs is rotated 90 degrees. This prevents plugging the Power Converter into a 15 amp receptacle, or into an extension cord. Normally this doesn't matter, but in the event of an electrical failure in the coach, where there is no power to the 20 amp receptacle, this prevents use of alternative power sources. In such an event, to keep your battery charged, you would need a battery charger plugged into an external power source.

## Adapters

Various types of adapters are commonly available online or at RV Dealerships.



If your trailer has a 50 amp power cord, and you visit a park that has only 30 amp receptacles, you'll need an adapter that adapts your 4 prong power cord to the 3 prong receptacle. Inside the adapter, the single hot wire coming from the 30 amp receptacle is tied to each of the hot legs in your 4 prong 50 amp plug. In that way, power flows through both legs of your power cord and is available to all devices in your RV.



If your trailer has a 30 amp power cord, you may on occasion find yourself at a park that has only 50 amp 4 prong receptacles. In that case you would need an adapter with 4 male prongs on one end and 3 female connections on the other end. On this type of adapter, hot leg 1 from the pedestal would be tied to the hot leg on the 30 amp end. Hot leg 2 of the pedestal would go unused.

## Shore Power Cord

The shore power cord for your trailer matches the internal power capability. If your trailer is wired for 50 amp service, it comes with a 50 amp shore power cord. The cord will have 4 conductors: hot leg 1, hot leg 2, neutral, and ground.

If your trailer has 30 amp service, it comes with a 30 amp shore power cord. The cord will have 3 conductors: hot, neutral, ground.

A detachable power cord, 50 or 30 amp, uses a matching twist-lock connector at the trailer end.

## Cord Reel

Some coaches come with the shore power cord permanently attached by way of a powered cord reel. The cord reel has a 12V DC motor powered by the coach battery so that external power is not needed to wind up the power cord. The shore power cord wires are connected to terminals on the end of the spool assembly.



### **Neutral and Ground Connections**

Power to your appliances originates on the hot wire, goes through the appliance that's energized, and returns on the Neutral wire. Providing power on the hot wire is not sufficient to run the appliance as the Neutral wire completes the circuit.

The ground wire is a safety device. In case of an appliance defect, short circuit, or other circumstance where electrical power might "leak", posing a safety hazard, the ground wire provides a safe return for the power to avoid it passing through your body. Electricity will seek the path of least resistance. A high quality ground connection offers less resistance than a human body so that leaking power can pass harmlessly to the earth.

On the RV, neutral and ground wires are kept separate. The ground wires on various devices in the RV are connected to a ground buss bar which in turn is connected by a wire to the frame of the RV. The ground buss bar or the frame of the RV is also connected to the ground wire in the shore power cord. If because of a defect, power ever reaches the frame of the RV, it safely flows back to the pedestal through the shore power cord's ground wire.

Behind the scenes in the campground, neutral and ground are tied together and connected to an earth ground; a conductive post that goes several feet into the earth.

### **Hot Skin – You Get a Shock When Touching the Body or Frame of the RV**

A Hot Skin condition can be extremely dangerous. If you ever feel electric current, even just a slight tingle, you should immediately unplug from shore power until the cause can be found and the problem resolved.

In general, you may have two problems contributing to a Hot Skin condition. First, something in the RV is probably leaking voltage to ground. Second, the ground connection back to earth ground is probably defective. The leaking voltage, not finding an easy path to earth ground, will pass through your body when you provide the ground. In a wet environment, this can be fatal.

One approach to identifying the source of the voltage leak is to turn off the circuit breakers in the main circuit breaker panel, one at a time. Do this while someone outside the coach monitors the Hot Skin using a non-contact voltage tester. Most hardware stores carry them. Get the \$20 model.

You'll also want to carefully check the ground connections on your power cords, adapters, and extension cords. A damaged ground pin will compromise safety.

You can read more about this condition at the [No Shock Zone website](#).

### **Can I Use Both the 50 amp and 30 amp Receptacles at the Same Time?**

Without knowing the power structure of the campground pedestal, you should not attempt this. A pedestal would typically have a 50 or perhaps a 60 amp power source from the campground's main power distribution panel. The wiring from the campground main to the pedestal may only be rated for 50 or perhaps 60 amps. In the campground's main power system, there may also be a 50 or 60 amp circuit breaker limiting power to the pedestal.

If you plug the trailer into the 50 amp receptacle and run several air conditioners along with other devices in the RV, you may be using most of the power that's available to the pedestal. Adding separate appliances to the 30 amp receptacle could overload the wiring to the pedestal, or trip the circuit breaker back at the campground's main power distribution panel.

## Generator

### Onan 5500

Luxury models and toy haulers generally are available with the option of an on-board generator. The factory installs a propane powered Onan 5500 generator that supplies approximately 5500 watts of power. On Toy Haulers, generators are also usually an Onan 5500 watt model, but may be a gasoline powered model. Onan 5500 generators are also available in diesel models.

### Generator Prep

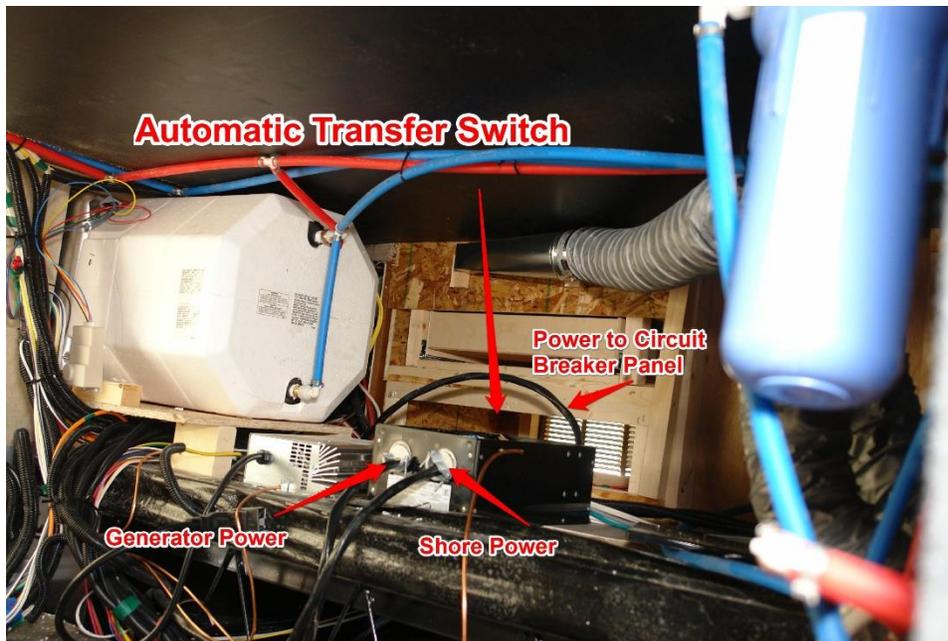
A pre-requisite for ordering a generator from the factory, or installing an on-board generator locally, is Generator Prep. This will include an automatic transfer switch to which both shore power and the generator are connected. Junction boxes and wiring for the generator connection are also installed.

#### *Automatic Transfer Switch*

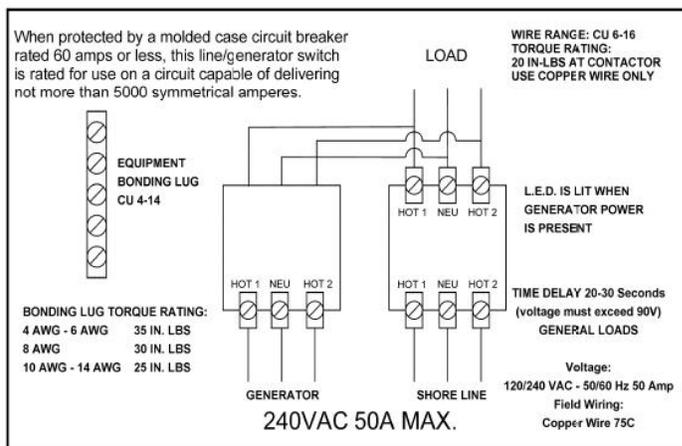
The purpose of the transfer switch is to ensure that only one power source can be used at a time, and for safety reasons, to ensure that generator power cannot be back-fed through the shore power cord into the park electrical system.

The transfer switch prioritizes generator power. Any time generator power is sensed, the transfer switch will default to use generator power, even if shore power is also available.

The transfer switch is usually located behind the rear wall of the pass through basement storage. Note that this transfer switch is separate from the transfer switch used to power a residential refrigerator.



The transfer switch wiring diagram below, is also on the inside of the top cover of the switch.



**WARNING:** The current flowing through the transfer switch is potentially lethal. Disconnect from shore power before opening the cover or working on the switch.

### Installation of an on-board Onan Generator

At the factory, the generator is usually placed in the coach before the lower front wall is installed, so installation is much simpler. Local installation can be done, but will generally require more labor.

### Generator Circuit Breakers

Onan generators have two circuit breakers on the front of the generator. These may each be 30 amp, or one may be a 30 amp and the other a 20 amp. The wiring from each of these breakers goes to the hot leg 1 and hot leg 2 of the automatic transfer switch, and from there to the coach's main circuit breaker panel.

5500 Watts is typically enough power to run 2 air conditioners, along with other appliances in the RV. It is possible however, to turn on enough devices to overload the generator. In that case, one of the generator's circuit breakers will trip. At that point, inside the coach, half of the breakers in the coach's

main circuit breaker panel will receive no power. Some devices in the coach will continue running because they get power from the other generator circuit breaker.

### **Installing an On-Board Onan Generator Larger than the Factory Installs**

If installing an on-board Onan generator locally, rather than from the factory, it's possible to install an Onan generator larger than 5500 watts. A 6500 watt generator, for example, would allow you to run more 120V AC devices at the same time. Three air conditioners for example.

### **Using a Larger Generator on a Landmark 365 or Toy Hauler**

On Landmark 365, or on toy haulers with the [Precision Circuits, Inc.](#) Power Control System, the programming is set for a 5500 watt generator. If you exceed 5500 watts of power by turning more devices on, it will still shed loads to manage to the 5500 power level, even though you have more power available. To change the programming, you would have to contact [Precision Circuits, Inc.](#) directly to arrange re-programming of the unit.

### **Fuel Consumption**

According to Onan Spec Sheets, the gasoline powered Onan 5500 generator will consume between .3 and .9 gallons per hour, depending on load (how much power is being used). The propane generator will consume between .4 and 1.1 gallons per hour depending on load.

In a toy hauler, the fuel station(s) may store enough gasoline to run the generator for an extended period while boon docking.

On coaches with propane generators, the on board two propane tanks will each have 7-9 gallons of propane, providing a much more limited run time for the generator. 40 lb. propane tanks contain about 9 gallons. Running one air conditioner on the generator from 6 PM to 8 AM could use up most or all of one 40 lb. propane tank. For boon docking with a propane generator, extra care would have to be taken to manage propane usage.

### **Maintenance**

Onan propane generators need to be exercised monthly and have the oil and filter changed annually. Gasoline generators require the same, but in addition, the fuel must be managed carefully to avoid it going stale. A fuel stabilizer is generally a good idea.

### **No power from Generator**

If the generator is running, but there's no power to the coach, the first thing to check is the two circuit breakers on the front of the generator.

### **Portable Generators**

An alternative to the on-board generator is to purchase a portable generator. Depending on which appliances you wish to run while on generator power, you might purchase a 2,000 or 3,000 watt generator, or perhaps a linked pair of 2,000 watt generators that work together. A pair of 2,000 watt generators can be easier to manage from a weight and storage standpoint, than a 3,000 watt generator.

### *Connecting a Portable Generator*

2,000-3,000 watt portable generators will usually have a 30 amp receptacle. Using an adapter, you should be able to plug the trailer's shore power cord into the adapter. Everything in the trailer will be supplied with power, but of course you'll have to manage power consumption so as to not overload the generator.

### *Inverter Generator*

Inverter Generators provide "clean" power that is needed by sensitive electronic devices. Less expensive "contractor" type generators may work, but may not be suitable depending on which appliances and devices you plan to run on generator power.

### *Neutral-Ground Bonding*

Portable generators often have separate neutral and ground wiring inside the generator. In order to power the trailer, particularly if you have an Electrical Management System installed, you may have to "bond" the generator's neutral and ground wiring. You can read more about this on the [No Shock Zone website](#).

## **120V AC Power Distribution, Control and Safeguards**

### **RV Main Circuit Breaker Panel**

The main circuit breaker panel in the coach takes the incoming shore power, or generator power, and routes power to each of the individual branch circuits. In the picture below, the two leftmost breakers are the coach main breakers. Each one receives 50 amps at 120V AC from the hot leg 1 and hot leg 2 of the shore power connection. The two mains are physically tied together so as to trip together even if only one breaker is overloaded.



Each individual branch circuit breaker gets power from one or the other of the main 50s. The 1<sup>st</sup>, 3<sup>rd</sup>, 5<sup>th</sup>, 7<sup>th</sup>, 9<sup>th</sup>, 11<sup>th</sup>, 13<sup>th</sup>, and 15<sup>th</sup> branch circuit breakers get power from the left-hand main 50. The 2<sup>nd</sup>, 4<sup>th</sup>, 6<sup>th</sup>, 8<sup>th</sup>, 10<sup>th</sup>, 12<sup>th</sup>, 14<sup>th</sup>, and 16<sup>th</sup> branch circuit breakers get power from the right-hand main 50.

Recently, an owner has reported finding a different power distribution arrangement, where the 1<sup>st</sup> and 2<sup>nd</sup> breakers receive power from the left-hand main 50, and the 3<sup>rd</sup> and 4<sup>th</sup> breakers from the right-hand main 50, and so on. It is possible Heartland may have changed vendors and is now using this different arrangement on some coaches.

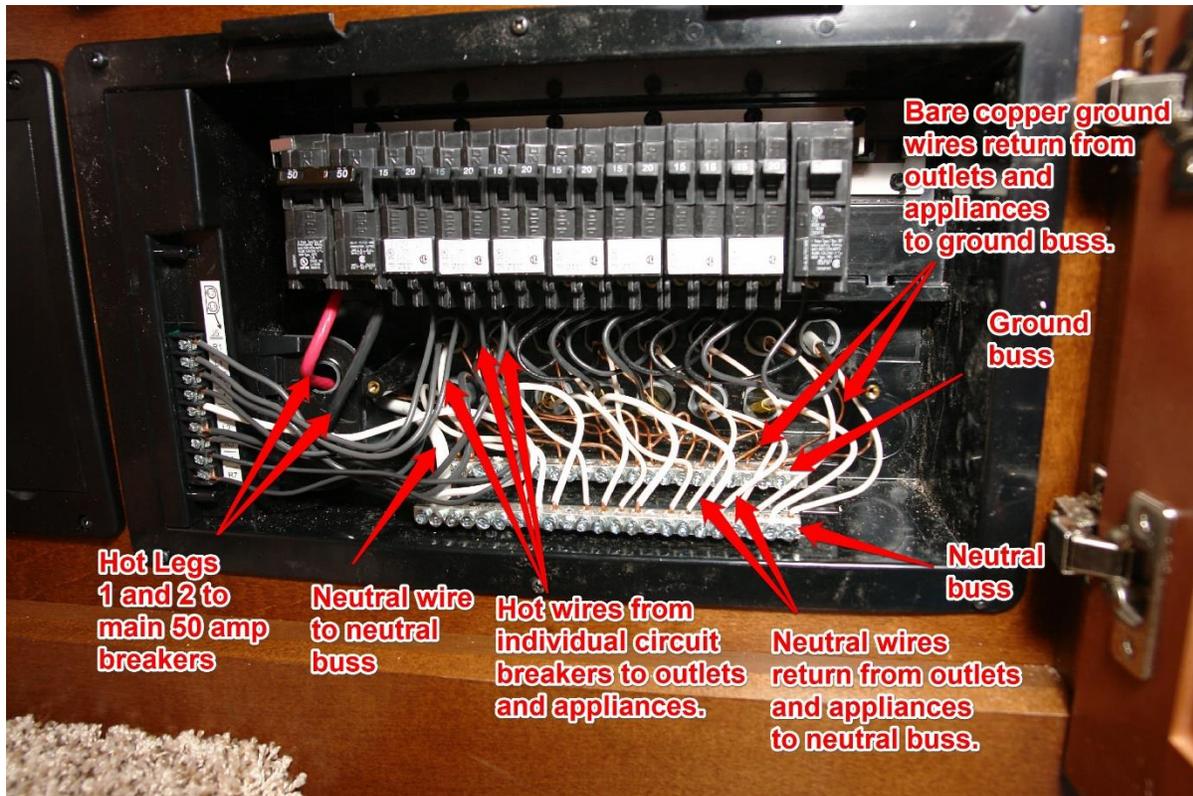
Since the main 50s are tied together, if one or the other trips, they both shut off, cutting power to all of the branch circuits. No 120V appliances or outlets will have power.

On some coaches, the 50 amp main breakers are in the center of the panel. The branch circuit breakers on the left are powered by hot leg 1 and on the right by hot leg 2.

However, if power on either hot leg 1 or hot leg 2 is interrupted before the main 50s, half of the branch circuits will be working and the other half will not have power. So, if the even numbered branch circuits are dead, you know that power on hot leg 2 has been interrupted before the mains.

Most of the branch circuit breakers are 15 amps. A few are likely to be 20 amps. On larger rigs, the Power Converter usually requires a 20 amp circuit breaker. Microwave/Convection ovens usually also require 20 amp circuit breakers. Note that the wires associated with 20 amp circuit breakers will be slightly thicker than those going to 15 amp circuit breakers. If replacing a branch circuit breaker, be sure to replace the breaker with one that has the same rating. Replacing a 15 amp circuit breaker with a 20 amp breaker could lead to overheating of wires and create a fire hazard.

### *Circuit Breaker Connections*



### **Precision Circuits, Inc. Power Control System**

Landmark 365 and some toy haulers with 3 air conditioners come with a [Precision Circuits, Inc.](#) Power Control System that manages power consumption. The control panel inside the coach looks like this on a Landmark 365. The version used on toy haulers may not have the multi-line display screen.



With 3 air conditioners running, if other 120V appliances are in use, you may exceed available power. The Power Control System is programmed to shed loads so that short-term situations requiring extra power are managed without tripping breakers.

LOAD SHED TABLE																	
Relay #	Relay Type	Relay Voltage	Relay Connector	Line Assoc	Load Name (12 Characters Max)						Shed Order (1-7)						
Relay 1	120VAC 1	120VAC	J5-1,2	1	W	A	T	E	R	H	E	A	T	E	R	1	
Relay 2	Air Cond 1	12VDC	J4-3,4,5	2	F	R	O	N	T	A	/	C				3	
Relay 3	120VAC 2	120VAC	J5-3,4	1	M	I	C	R	O	W	A	V	E			7	
Relay 4	Air Cond 2	12VDC	J4-8,9,10	1	M	I	D		A	/	C					5	
Relay 5	120VAC 3	120VAC	J5-6,7	2	W	A	S	H	E	R	/	D	R	Y	E	R	4
Relay 6	Air Cond 3	12VDC	J4-6,11,12	1	R	E	A	R		A	/	C				2	
Relay 7	120VAC 4	120VAC	J5-8,9	2	F	I	R	E	P	L	A	C	E			6	

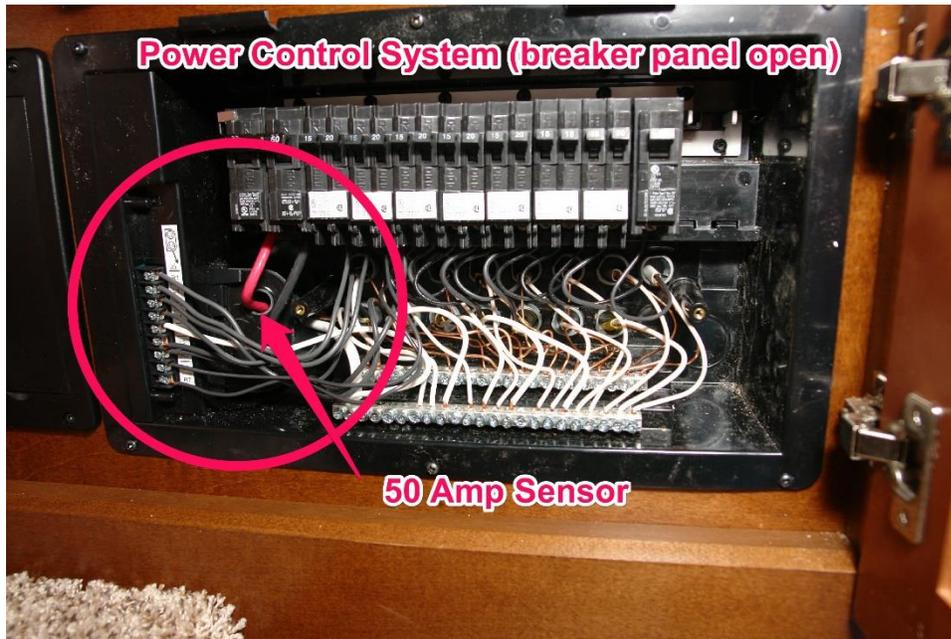
For example, if you are running 3 air conditioners, have the water heater running on 120V AC, start the microwave oven, and your residential refrigerator's compressor starts, the demand for power from all of these devices could exceed the available power. In that case, the [Precision Circuits, Inc.](#) Power Control System will automatically cut power to selected devices to prevent an overload that would trip circuit breakers. When the temporary demand is reduced, the devices that were turned off will resume operation automatically.

Power to the electric heating element in the water heater is likely to be shed first in order to manage power. The rear air conditioner's compressor is likely to be turned off next, when demand exceeds available power. In the case of air conditioners, while the compressor may be turned off, the fans will continue to run, circulating cool air. The compressor is turned off by activating the air conditioner's freeze sensor circuit, simulating an ice buildup.

The main circuit breaker panel in the coach is somewhat different where the Power Control System is used. As shown below, there is a Current Sensing Cup through which the main power cable passes. There are also some relays used to cut power to the devices being shed.

When connected to 50 amp shore power, the Power Control System detects that there are two hot legs, each providing 120V AC. The system is able to differentiate two hot legs that have a phase difference (50 amp service) from two hot legs that are in phase (30 amp service). When running on generator power, the

signal to the generator hour meter is detected by the Power Control System, letting it know that power is coming from the on-board generator, assumed to be supplying a total of 45 amps. If the system doesn't detect 50 amp service, or a generator, it assumes 30 amp service is available. Note that when plugged into a 15 or 20 amp receptacle, you must manually set the Power Control System to the lesser value or it will not work as intended.



Note that in the picture above, L1, the red wire to the left-hand main 50 amp breaker, is routed through the top PCS sensor. PCS documentation stresses that L1 MUST be routed through the bottom sensor for correct operation of the PCS system. But PCS has not offered any explanation of what might happen if routed incorrectly, as shown in the above photo. The correct routing is pictured below.



## Electrical Management System (Surge Protector)

In our sticks and bricks homes, we're all used to having reliable power. In most areas of North America, it's rare to have significant power surges. Brownouts may occur, where voltage levels are temporarily reduced to manage excess demand during a heat wave, or in some locations during extreme cold weather. Conditions such as reverse polarity or open neutrals are exceptional in residential situations.

However, in RVs, many of these situations are commonplace. Loose connections inside power pedestals are not all that uncommon. In older parks, it's quite common during a hot summer day for everyone to turn on one or two air conditioners, exceeding the power capacity of the park. If as a result, voltage to your coach drops below 105V AC, you could have equipment stop working and even be damaged. Loose neutral wires can create serious over-voltage situations on one of your power legs, damaging electronic equipment. Thunderstorms can damage the equipment in your coach even without a direct lightning strike.

While RVers usually worry about power surges, low voltage conditions are much more common. Loose or open neutral connections are probably more common as well.

While all protective devices are usually referred to as Surge Protectors, there are actually two classes of products. There are relatively inexpensive surge protectors. These protect only against power surges. There is a more expensive class of product called an Electrical Management System, often referred to as a surge protector. This more expensive product not only protects against power surges, but also protects against other damaging conditions such as low voltage, high voltage, open or partially open neutral, reverse polarity, and sometimes other conditions.

An Electrical Management System (EMS) will typically cut power to the coach if a dangerous condition is detected. They also typically have a 2 minute startup delay before passing power to the coach, to prevent damage to air conditioners where a momentary power outage occurs. Some air conditioners have built in protection. Some do not, so this is a useful feature.

### *What to Do if You Plug Into the Campground Pedestal and the EMS Doesn't Turn Power On*

As many of us have found, it's not all that uncommon to plug into the pedestal and get an error condition where the EMS won't supply power to the coach. In some cases, it may work for a little while, but then cut power. It may in some cases cut power repeatedly, restarting after the 2 minute startup delay.

In all of these cases, the EMS is detecting a problem that could result in damage to your coach. Campground maintenance workers will often advise you that this is a problem with the EMS being over sensitive and they will suggest bypassing it. You should ask for the problem in the pedestal to be corrected, or for the park to move you to another site. Keep in mind that campgrounds generally will not accept blame for damage to your coach and it can be very difficult to prove that the damage was caused by their power system.

### *Portable EMS Units versus In-line Units*

EMS devices come in two types. There are portable units that are plugged into the pedestal. Your shore power cord is then plugged into the EMS. There are also in-line units that are hard wired into your

electrical wiring and therefore don't require any action on your part to get the benefit from them. In-line units may come with a remote display that can be mounted in a location where you can note the incoming voltage and any error codes.

In-line units require installation somewhere prior to the main circuit breaker panel. If you have Generator Prep with an automatic transfer switch, the question arises of whether to install the EMS before or after the transfer switch. One advantage of installing it after the transfer switch (between transfer switch and main circuit breaker panel), is that the EMS would protect against a failure inside the transfer switch; a partially open neutral connection for example. While not terribly common, this type of problem does occur.

A portable EMS requires no installation, but takes a few extra seconds while setting up at a campground, and again when leaving. In addition, it's a good idea to secure the EMS with a cable lock or other security device to prevent it from "walking away". While the portable device won't protect against transfer switch failures, or a failure at the shore power cord connection to the trailer or powered cord reel, they do protect against the most commonly experienced problems.

The two main suppliers of EMS devices are Progressive Industries and Southwire (marketed under their TRC brand). Function and pricing are similar. Progressive has offered a lifetime warranty for a number of years. Southwire has recently matched this.

When shopping for an EMS, be sure to check the types of protection offered, to ensure the device you get has a full set of protections.

### *Hughes AutoFormer*

Given that the most common electrical problem an RV is likely to run into is low voltage, the Hughes AutoFormer can be an attractive way to protect your coach. In cases where voltage at the power pedestal drops to an unsafe level (below 105V), the AutoFormer will automatically boost power by up to 10%. So if local power drops to 96V, which could cause damage to your RV, the AutoFormer is capable of keeping the power to the RV at 105V. The newer units also have surge and spike protection. They don't have the full set of protections offered by Progressive and Southwire devices, but will keep you powered up in cases where Progressive and Southwire will shut off power to protect the coach. Some RVers use an AutoFormer in addition to an EMS. Note that some RV Parks may not permit use of an AutoFormer device.

## **Appliance Connections**

### **Water Heater 120V AC Connections**

Most RV water heaters supplied by Heartland have the capability to run on either 120V AC or propane, where a few models may use propane only. The 120V AC used to energize the heating element may connect to the water heater in any of several arrangements. The 120V AC power is typically on its own branch circuit, protected by its own circuit breaker in your main circuit breaker panel. At the water heater, there is usually a junction box on the front inside corner of the unit, where the 120V AC wiring, and perhaps 12V DC control wiring, makes a connection to the water heater.

In between the branch circuit breaker and the junction box on the water heater there will always be a switch with which you activate the electric heating element. Heartland has used several approaches to switch the heating element on and off.

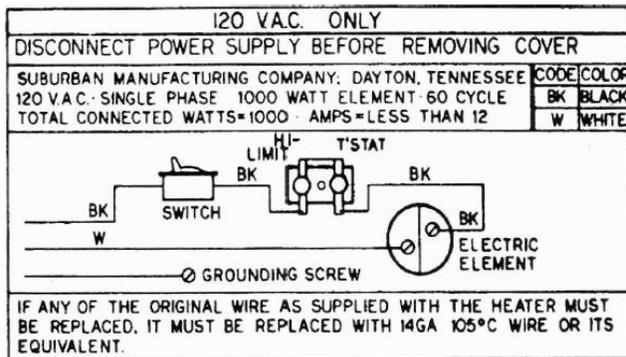
Atwood water heaters usually have a 12V DC relay in the junction box that's attached to the water heater. That relay acts as a remote switching device and is controlled by a 12V DC switch in your control panel. The wires from the circuit breaker panel go to the relay in the junction box.

Beginning on units built in June 2017, Suburban water heaters use the same approach as Atwood. There is a 12V DC relay in the junction box attached to the water heater. And there is a 12V DC switch in the control panel.

Prior to June 2017, several different approaches were used to connect and switch 120V AC power for Suburban water heaters. On 2011 builds, for example, the 120V AC went from the circuit breaker directly to a wall-type 120V AC switch in the control panel, and from there to the junction box on the water heater. At some later date, the 120V AC went to a relay located behind the control panel, and from there to the junction box on the water heater. The relay was operated by a 12V DC switch in the control panel. On some Landmark 365 units built between late 2016 and June 2017, the KIB Multi-Plex Control Panel operated an electronic switch on the KIB relay control board, which in turn operated a 12V DC relay in a separate junction box located near the KIB system. 120V AC from the circuit breaker was routed to that junction box, through the relay, and on to the junction box on the water heater.

## Water Heater Internal Wiring

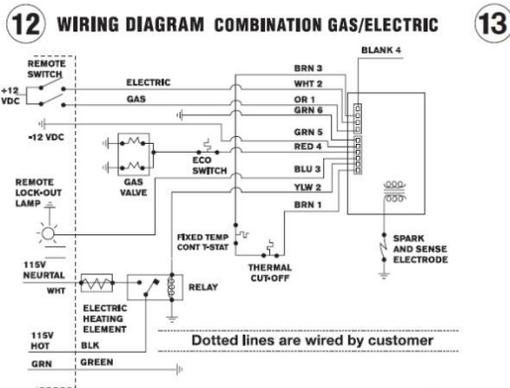
### *Suburban Water Heater*



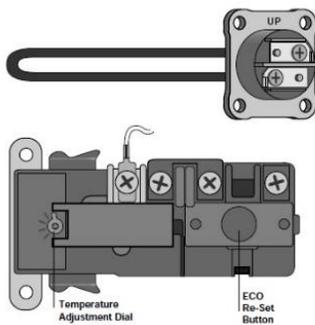
The electric heating element on Suburban water heaters is independent of the propane system. The control board is not involved in the 120V AC operation. The switch shown in the drawing is a secondary power switch located in the bottom left corner on the outside of the water heater, under the exterior cover.

### *Atwood Water Heater*

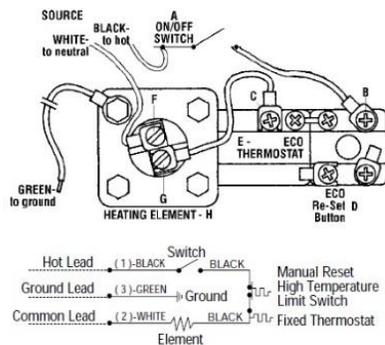
The Atwood water heater control board operates a relay that closes the 120V AC power circuit to the electric heating element. Also, note that the thermostat and emergency cut off (ECO) are common to both 120V AC and propane operation. As a result, an Atwood water heater needs a good 12V DC supply to the control board in order to use the 120V AC heating element.



**BOLT-IN Heating Element, Thermostat & ECO**



**110VAC Trouble-Shooting Wiring Schematic**



**KIB Multi-Plex Control Panel**



Landmark 365 units built starting in late 2016 include the KIB Multi-Plex Control Panel. Most devices controlled by the KIB panel run on 12V DC, but it may also control the 120V AC electric heating element of the water heater, as described above, the 120V AC ceiling fan, and the tank heating pads that are part of the YETI option. A junction box located near the KIB system contains 12V DC relays that switch the 120V AC power to the water heater, ceiling fan and tank heating pads. Power from the circuit breakers goes to that junction box, through the relays, and on to each of the devices being controlled.

On 2020 Landmark 365 units, the KIB system was upgraded to use a touchscreen tablet in place of a physical control panel.



In addition, heating and cooling controls were added to the KIB system, replacing traditional thermostats located throughout the coach. A Bluetooth interface allows owners to use a free smart phone app (iOS or Android) to also control lights and other devices while inside, or near the coach.

More information is included in the [KIB Multi-Plex Control System V2](#) document.

### *KIB Wiring Block Diagram*

The appendix contains a block diagram that illustrates how the various components in the KIB system are connected. For more detailed information about the KIB System, consult the [KIB Multi-Plex Control System user guide](#).

### **Junction Boxes**

Junction boxes are used in various locations throughout the trailer where wires are joined. The wires are typically held together by a wire nut. One benefit of a junction box is to make the wire connections accessible if maintenance is needed. They may also provide some protection in the event a wire nut comes off, exposing the hot wire.

Junction boxes are typically located under the living room slides. During construction, slide rooms are prewired for 120V AC, 12V DC, and TV circuits. Because slide rooms move, special “stranded” 120V AC wire is used in the portion of the wiring that connects the slide room to the Romex-style 120V AC wire that comes from the main circuit breaker panel. The wire from the breaker panel is routed through the underbelly, and then through the frame. The two wire types are joined together in the metal junction boxes on the outer RV frame, below the slide rooms.

If your trailer came with Generator Prep, there will be a junction box in the front compartment where the wires from the Automatic Transfer Switch terminate. When the generator is installed, the wires from the generator output are joined to the transfer switch wires inside the junction box.

A junction box will also be located on the front inside corner of the water heater, providing a connection point for 120V AC and 12V DC wiring.

If your RV has a residential refrigerator, you’ll likely find another junction box in the front compartment, where the output of the refrigerator’s transfer switch is joined to the wiring that goes to the refrigerator’s 120V AC outlet.

Trailers with the V1 KIB Multi-Plex Control System will have a junction box near the KIB system where 120V AC connections may be made to power the ceiling fan, YETI tank heating pads, and in some cases, the water heater.

### *Outlet Failures in a Slide Room*

If a group of outlets in a slide room all stop working, after checking the main circuit breaker panel, look under the slides for the junction box. It's a good idea to use a non-contact voltage tester on the junction box before touching it, in case the box is energized by a loose wire. Non-contact voltage testers are available at most hardware stores for about \$20. Skip the \$10 variety as they don't work as well.

### **Switched Outlet**

One exterior outlet, usually at the front of the trailer on the door side, is controlled by a switch in the control panel. Traditionally, this outlet is energized by a switch so that outside lights can be turned on and off from inside the coach. With the advent of 12V DC LED light strips commonly mounted outside, the switched outlet is less commonly used, but still offers the same functionality.

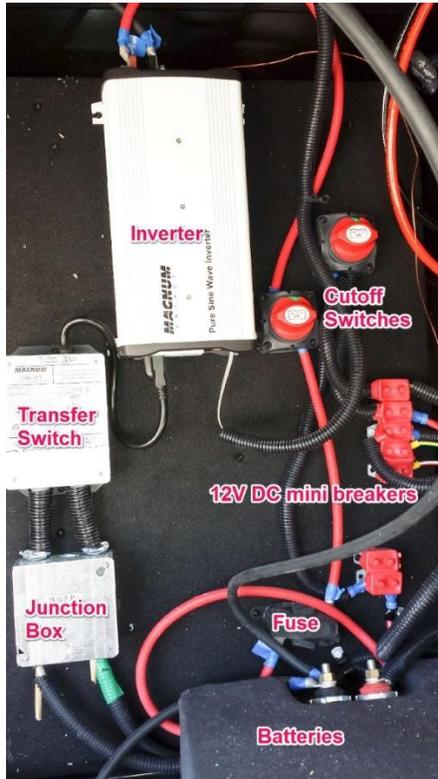
### **Residential Refrigerator Power**

Residential refrigerators are the same type of refrigerator found in a sticks and bricks home. Unlike a traditional RV gas absorption refrigerator, which can run on either 120V AC or propane, the residential refrigerator runs on 120V AC only.

While plugged into shore power, as with all other 120V appliances in the coach, the refrigerator is also receiving power. However, while towing, or boon docking, or in the event of a local power failure, the refrigerator needs another source of 120V AC power.

When the factory builds a coach with a residential refrigerator, several additional electrical components are added to provide 120V AC power when shore power is not available. A second battery is added, along with an inverter that converts 12V DC from the batteries into 120V AC for the refrigerator. The output of the inverter is routed to a dedicated automatic transfer switch (separate from the transfer switch that is part of generator prep) which is used to supply either shore power or inverter power to the refrigerator. If the transfer switch detects shore power, it uses shore power. In the absence of shore power, it uses the power from the batteries, by way of the inverter.

### *Residential Refrigerator Power Source Components*



Power from the batteries goes through a fuse that protects the batteries, through a separate cutoff switch (a few early builds may have used a single cutoff switch), and on to the inverter. The inverter has two outlets. The transfer switch is plugged into one of the inverter outlets. The transfer switch also gets shore power from a circuit breaker in the main circuit breaker panel. The output of the transfer switch is then routed to the refrigerator's power receptacle. This component layout will be different on Landmark 365 units with the factory-installed Solar Option.

### *Residential Refrigerator Wiring Block Diagram*

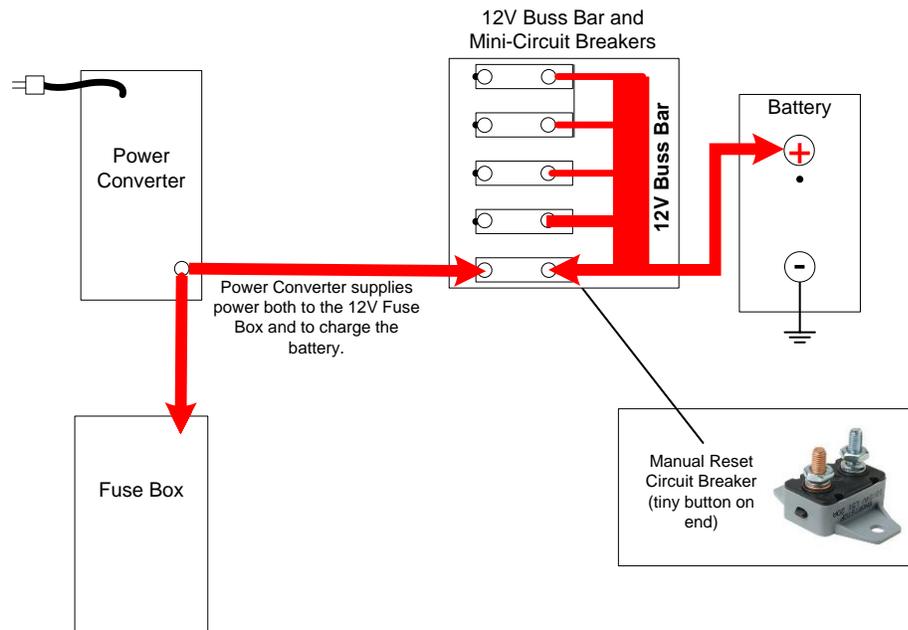
The appendix contains a block diagram that illustrates how these various refrigerator power components are typically connected. Note that on some toy haulers, Heartland may have routed the refrigerator's transfer switch output to a receptacle near the refrigerator to allow operation of other devices.

More information can be found in our owner-written [Residential Refrigerator Guide](#).

## 12V DC

Lights, water heater, furnace, landing gear and leveling systems, slide rooms, and the traditional RV gas absorption refrigerator may need to be operated when no 120V AC shore power is available. All of these appliances and lights can be operated on 12V DC power supplied by the on-board battery.

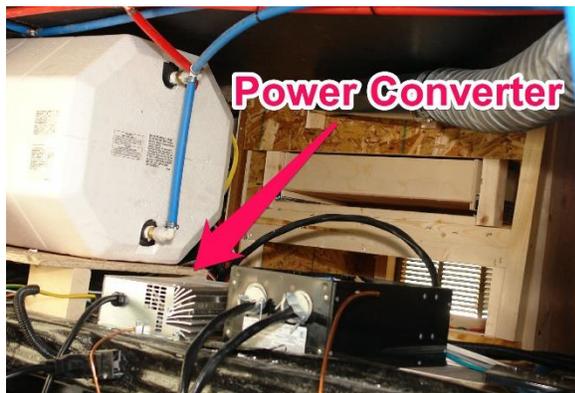
### Block Diagram of Main 12V DC Power Flow (Simplified)



Note that the junction of power wires to the Power Converter and Fuse Box may be located at either the Power Converter, or at the Fuse Box.

The major components of the 12V DC Power System include the Power Converter, Fuse Box, Buss Bar with Mini-Circuit Breakers, and Battery. Some coaches come with a Battery Cutoff Switch as standard equipment. On others it's left to the owner to have one installed if desired. If present, the Battery Cutoff switch is located between battery and 12V Buss Bar and Mini-Circuit breakers.

### Power Converter



In order to keep the battery charged, your RV comes with a Power Converter that converts 120V AC shore power into 12V DC. The output of the Power Converter is routed to the main fuse box inside the coach, to supply power to lights, furnace, and other 12V DC devices, and also to the battery to keep it charged.

The Power Converter is usually located behind the rear wall of the pass through basement storage.

On larger coaches, the Power Converter is rated for 80 amps output at 12V DC, which allows it to supply enough power for the furnace, propane operation of the water heater, propane operation of a gas absorption refrigerator, bathroom fan, and other low amperage 12V DC devices. On smaller coaches, the Power Converter may have a lower output.

The Power Converter has several voltage levels used to maintain the battery under different circumstances without over-charging it or boiling off excessive amounts of water from the battery. It also has several on-board automotive type blade fuses that protect the circuitry from damage in the event that the coach battery is installed with positive and negative cables reversed.

## Fuse Box

Low amperage devices, typically rated between 5 and 20 amps, are usually powered through the fuse box. An individual automotive type blade fuse protects against short circuits or equipment malfunctions. When the device on a given circuit tries to use more power than the rating of the fuse, the metal conductor inside the fuse melts, opening the circuit. This protects against overheated wiring or other damage to the coach.

Most of the fuses will be rated for 15 amps at 12V DC. One or two may be rated for 20 amps. One or two might be rated at 10 amps or even 5 amps. Fuse ratings are matched to the wire size on each circuit and to the power demand of the devices on that circuit.

Keeping a spare fuse kit on hand, with a selection of amperage ratings, is a good idea. Sometimes a fuse will blow without any obvious problem, and replacing it with a new fuse of the same value corrects the problem.

### What if a Fuse Blows and the New Fuse Blows Immediately or Within a Short Time

Repetitive blown fuses on the same circuit usually indicate there's a short circuit somewhere in the wiring or at the device being powered. The cause needs to be identified and corrected.

As an example, suppose the overhead lights in one slideout stop working. You replace the fuse for that circuit and they work. But as you continue your travels, at the next stop, you find the lights are once again out and the fuse is once again blown. As you investigate, you determine that the fuse blows as the slideout is retracted. With symptoms like this, you would probably want to look under the slide to find where the wiring to the lights enters the slide room. You may find that the insulation has been worn through and the hot wire is intermittently contacting a ground when the slideout is retracted.

On some coaches, the fuse boxes have LED bulbs adjacent to each fuse. When you turn on a light or other device, and it doesn't operate, you may find one of the LEDs in the fuse box illuminated. This is a feature to help you quickly locate a blown fuse. The LED provides a low-current alternative path when the circuit is completed by turning the switch ON. If the switch is not ON, the LED will not illuminate, even if the fuse is blown.

**WARNING:** Never try to resolve a blown fuse problem by substituting a higher rated fuse. Doing so would defeat the safety features that protect your coach from a fire started by overheated wiring.

**NOTE:** Devices using LEDs, such as the Television Signal Booster, may appear to be working even when their fuse is blown. The LED in the fuse box passes enough power to illuminate a downstream small LED such as found on the Signal Booster. Where you have LED lights in your coach, even with a blown fuse, you may find they emit a little bit of light, passed through the LED in the fuse box. If LED lights are very dim, it's an indication of a possible blown fuse.

### Fuse Box Ground Connections

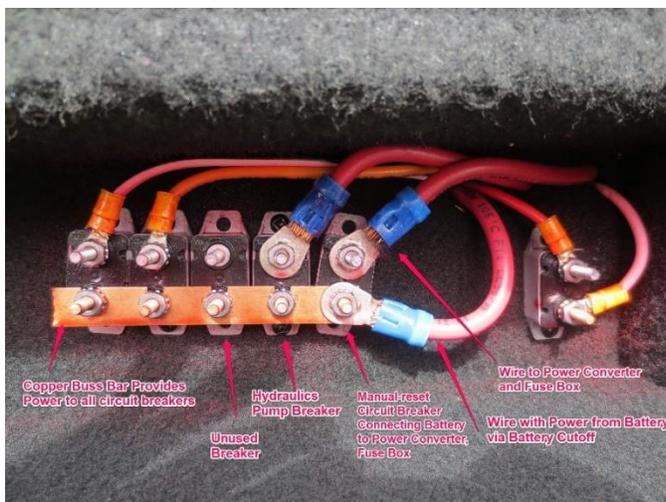
If you examine the back side of the fuse box, you would find that there is a row of wire connections on one side of each fuse. These are the wires that go to the devices being powered through the fuses. The other side is a power buss that receives 12V DC by way of a thick red wire from the Power Converter. You'd also find a ground buss bar where the ground wires for each circuit are attached. There is a thick black wire that connects the ground buss to frame ground.

### Buss Bar and 12V DC Mini Circuit Breakers

Some devices on the coach use more 12V power than others. The hydraulic pump, electrically powered slideouts, and stabilizers are examples of devices that typically require more than 20 amps to operate. With higher current devices like these, Heartland uses a 12V DC mini-circuit breaker instead of a fuse. If the circuit briefly uses more power than the rating of the breaker, the breaker trips, but once reset, continues to operate normally. With one exception, the mini-circuit breakers are the type that automatically reset after a few seconds. Of course, if the wiring is shorted, the breaker will continually trip and reset and trip and reset. A group of these breakers are arranged together, sharing power by way of a copper bar connected to each breaker.

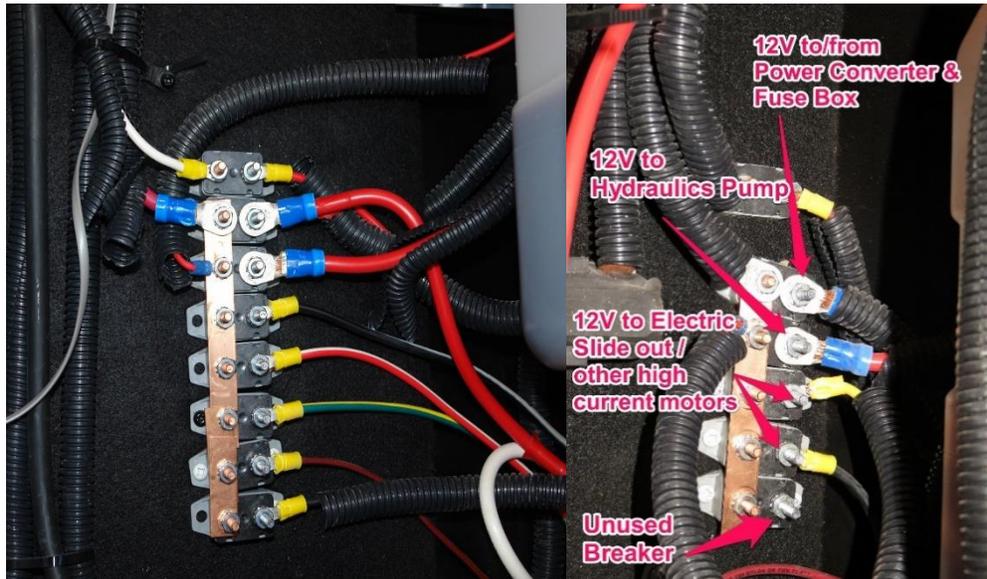
The layout of these buss bars varies by coach, depending on what devices are installed. They always consist of 1) a group of 12V DC mini-circuit breakers, 2) a copper bar connecting those breakers, and 3) red rubber boots covering each breaker. They are located within a short distance from the coach battery.

The positive cable from the battery connects to one breaker, on the side with the copper bar that connects all



the breakers. The copper bar shares the power across all breakers. On the other side of the breakers, the connected device is attached.

Breaker ratings may vary from 20 amp to 50 amp. Lower amperage breakers have thinner wires attached. The 50 amp breakers have thick wires attached. Typically, the thick wires go to the Power Converter and to the hydraulic pump.



### Manual Reset 12V DC Circuit Breaker

The one breaker that is a manual reset type sits in between the Power Converter and the battery. If for any reason this breaker trips, you'll need to manually reset it. The breaker has a teeny-tiny reset button on one end. It's often asked why this one breaker is a manual reset type. While the answer is not definitively known, one possibility is that the circuit it protects is different from the others.



All of the automatic reset breakers are on circuits where you would be operating a switch to energize the circuit. If something were to go wrong, you would let go of the switch and the circuit would be de-energized. But with the Power Converter/Battery circuit, power flows when the coach is unattended. If something were to go wrong on that circuit, you would not necessarily be present to de-energize the circuit. Having a manual reset takes care of the problem in your absence.

### Symptoms of a Tripped Manual Reset Breaker

The classic symptom is that you unplug from shore power and all the interior lights go out. This happens because the wiring path from the battery was interrupted when the mini-circuit breaker tripped.

### Hydraulic Slideout Starts and Stops

Another symptom is low battery voltage when operating slideouts or landing gear. With the manual reset mini-circuit breaker tripped, the path from Power Converter to battery has been interrupted and the battery will not be getting recharged. And because no power from the Power Converter gets to the buss bar, the high current devices like the hydraulic pump are totally dependent on power from the battery. As the battery discharges, its ability to provide sufficient power to the hydraulic pump is diminished. One failure symptom is that the low voltage causes the pump to draw more amps than the rating of its mini-

circuit breaker. As a result, the slideout moves a little. Stops. After a few seconds moves a little more. Stops again. The same thing can happen with the auto-leveling system because it uses the same hydraulic pump as the slideouts. Note that once an auto-reset breaker starts tripping, it may never operate as well as a new breaker and you may continue to have start/stop problems even after the battery is recharged. If that happens, you should replace the breaker.

For more information on slideouts or landing gear starting and stopping, refer to our owner-written [Hydraulic Slide Starts and Stops](#) user guide.

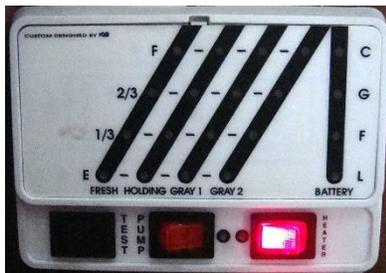
## Battery

Traditionally, RVs are delivered to buyers with a single 12V DC deep cycle battery. Deep cycle batteries are designed to supply constant power over a long period of time, but can also supply bursts of power at higher amperage levels. Car and truck batteries are designed to supply bursts of power for shorter intervals.

Trailers with residential refrigerators need more than one battery because when being towed, or during an overnight stay without shore power, the residential refrigerator requires extra power.

RVers who boon dock may install additional batteries to meet their power needs.

### Reading the Battery Power Level



RVs come with a test panel to read battery and holding tank levels. Press the button to see how many lights turn on for the battery level. When on shore power, the reading will be 4 lights, reflecting the output of the Power Converter, which is usually between 13.2 and 13.6V DC. When not on shore power, a fully charged battery will supply about 12.6V DC, which will illuminate 3, and possibly 4 lights.



On Landmark 365 units with the KIB Multi-Plex system, the upper right of the Convenience Control Panel has a Systems Monitor which displays tank levels and battery levels. Press once to display tank levels and a 2<sup>nd</sup> time to display battery level. Again, if on shore power, the battery level will actually be the output level of the Power Converter. The arrangement of the battery level display is a bit different on newer KIB installations.

### Battery Maintenance

Deep cycle batteries need to be checked monthly to ensure they have water covering the plates inside the battery. Carefully remove the caps on top of the battery and verify that the water level is above the top of the plates. Add distilled water as necessary. When checking water level, also check that the battery cables are tightly attached and that the terminals are free of corrosion.

**WARNING:** Batteries contain acid that can irritate and damage skin and if splashed in your eyes, can cause blindness. Avoid spilling or splashing the battery contents. Immediately rinse off any acid that contacts you and seek medical attention if necessary.

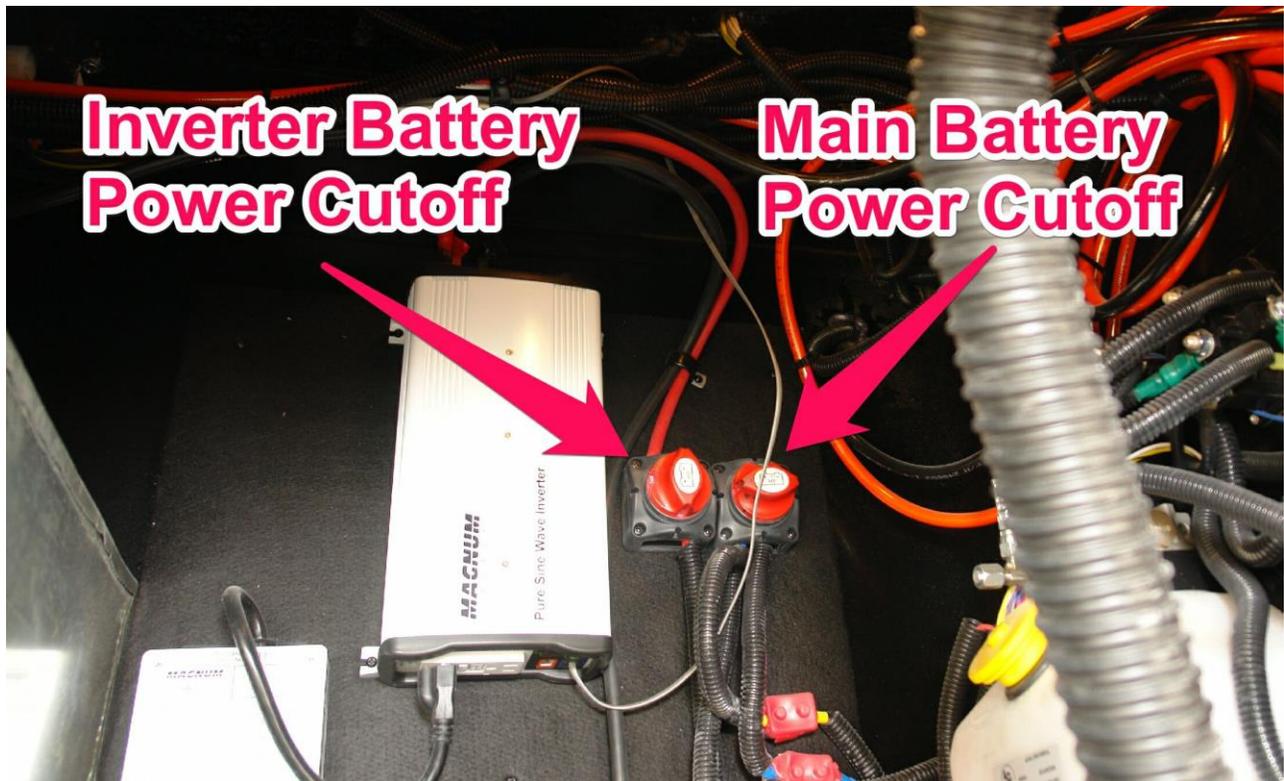
Battery fumes are combustible. Do not smoke or use open flame near the battery.

### Operating Without a Battery

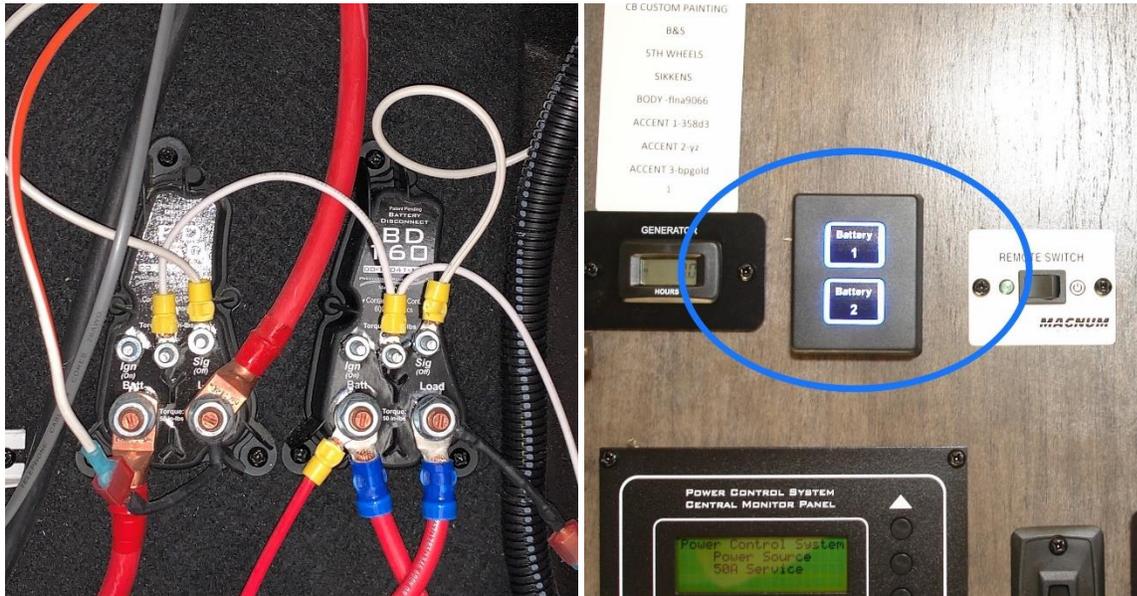
The Power Converter supplies enough power to run your interior 12V DC lights and 12V DC appliances. If you ever have to replace the battery, you can remove it, take it to the store for disposal, and install a new battery on your return. The Power Converter will keep things running. But you may not be able to operate slideouts or the landing gear/Level-Up system, or other devices powered from the 12V Buss Bar and Mini-Circuit Breakers. The Power Converter is designed for a constant power output and would have difficulty supplying the bursts of high amperage required by devices powered from the Buss Bar.

### Battery Cutoff Switches or Relays

Some trailers come with a factory installed battery cutoff switch, located near the battery. The switch interrupts power from the positive terminal of the battery, to the buss bar. In trailers with a residential refrigerator, there will usually be two cutoff switches. One is for power going to the components powering the residential refrigerator, and the other is for power to all other 12V DC devices.



On 2020 Landmark 365 and some other units, the manual battery cutoff switches have been replaced by relays and remote switches located in the control panel.



The control panel switches labeled Battery 1 and Battery 2 each control one of the relays in the front compartment. Contrary to the labels, each relay receives power from both batteries. So one of the switches will operate the cutoff relay affecting power to the residential refrigerator (and possibly other fixtures), and the other will cut off power to the rest of the RV. The switches are illuminated when ON. A single press of the button will turn the respective relay ON or OFF.

**NOTE: When turning power OFF by pressing one or both Battery buttons, the light inside the switch will stay ON for 30-60 seconds. If while waiting for the light to go out you press the button a second time, the relay in the front compartment will change state, turning power back ON.**

## Appliances that Require 12V DC

Generally speaking, any appliance that works without shore power requires 12V DC. This includes the water heater, furnace, traditional gas absorption refrigerator, awnings, bathroom fan, Fantastic Fan, water pump, interior and exterior lights, TV signal booster, propane detector, stabilizers, landing gear, Level-Up system, awnings, and in some cases the radio.

Some of these appliances may need a combination of 120V AC and 12V DC in order to operate. Some gas absorption refrigerators are an example of this. Without 12V DC power, the control board on the refrigerator may not operate, even if you have 120V AC going to the refrigerator. Atwood water heaters also need 12V DC for the control board, even when using 120V AC to the heating element. While the air conditioner runs on 120V AC, the thermostat requires 12V DC in order to turn on the air conditioner. So a

complete loss of 12V DC power will cause multiple appliances to stop operating, even when on shore power.

### **Low Voltage Issues**

Various appliances have differing minimum voltage requirements in order to function.

#### *Furnace*

In the case of the furnace, the battery must supply enough power for the blower motor to achieve 75% of normal speed, which triggers the furnace sail switch. There also needs to be enough power to open the gas valve and to energize the direct spark ignition. As voltage drops below 12V DC, the furnace will become intermittent and eventually stop working until power is restored to normal. After three failed ignition attempts, the furnace will go into a safety lockout condition. The thermostat must be cycled OFF and back ON to clear the lockout.

#### *Hydraulics*

The hydraulics pump puts a heavy demand on the battery for a relatively short period of time. As battery voltage drops, there may not be enough power to extend or retract the slides or landing gear. And, as voltage drops, amperage goes up which may cause the 12V DC mini-circuit breaker to trip and automatically reset after a few seconds. The results in a start/stop operation of the slides and landing gear which is described in our [Hydraulic Slideout Starts and Stops](#) user guide. This can cause the circuit breaker to weaken, leading to failure symptoms even after recharging the battery.

#### *Generator Start*

The on-board Onan Generator also places a very heavy demand on the battery. As the battery voltage drops, eventually there won't be enough power to start the generator. You may be able to resolve the situation by connecting the trailer to your tow vehicle and running the engine on high idle for 30 minutes. That may give you enough battery charge to start the generator. After that, running the generator will recharge the battery if nothing else is malfunctioning.

#### *KIB Multi-Plex Control System*

The KIB Multi-Plex Control System needs 12V DC to operate optimally, but may operate with DC voltage as low as 7 volts. In the absence of 12V DC, all lights and any 12V DC devices controlled by the KIB system will be out of service. In addition, the 120V water heater operation will fail, as will the 120V ceiling fan, as well as the YETI tank heating pads. These three devices are powered through relays operated by the KIB relay control boards. On 2020 and later Landmark builds, the Air Conditioning and Furnace will also be inoperative without 12V DC power. In the absence of 12V DC to operate the KIB system, nothing it controls will work. Because the KIB Convenience Control Panel is used to start the generator, that function is also compromised in the absence of 12V DC. However, it may still be possible to start the generator from the generator's front panel controls.

### **Furnace Wiring**

When the thermostat calls for heat, 12V DC is sent to the furnace, going through the Limit Switch, to the Sail Switch and on to the Control Board. Power is also applied to the Blower Motor. When the Blower

Motor gets up to about 75% of its operating speed, the Sail Switch closes, providing power to the Control Board, which in turn applies power to the Gas Valve and Direct Spark Ignition.

A wiring diagram for the Suburban SF42 Furnace is included in the appendix.

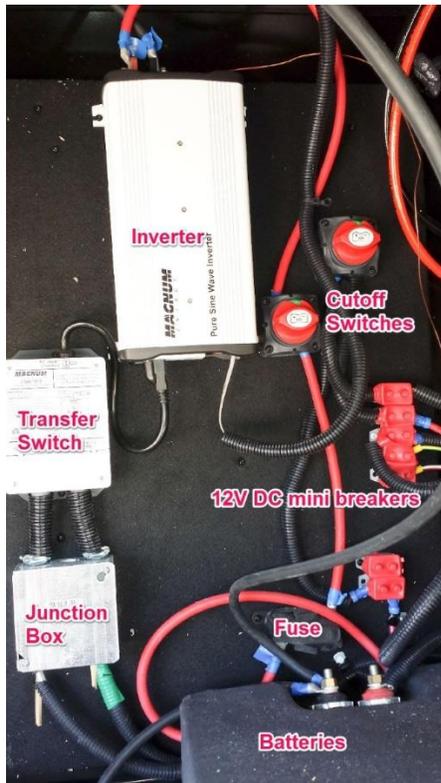
## Residential Refrigerator Power

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### *Residential Refrigerator Power Source Components*



Power from the batteries goes through a fuse that protects the batteries, through a separate cutoff switch (a few early builds may have used a single cutoff switch), and on to the inverter. The inverter has two outlets. The transfer switch is plugged into one of the inverter outlets. The transfer switch also gets shore power from a circuit breaker in the main circuit breaker panel. The output of the transfer switch is then routed to the refrigerator's power receptacle.

Note that on Landmark 365 models with the factory-installed Solar Option, the equipment and layout will be different.

### *Residential Refrigerator Wiring Block Diagram*

The appendix contains a block diagram that illustrates how these various refrigerator power components are typically connected. Note that on some toy haulers, Heartland may have routed the refrigerator's transfer switch output to a receptacle near the refrigerator to allow operation of other devices.

More information can be found in our owner-written [Residential Refrigerator Guide](#).

### **Precision Circuits, Inc. Power Control Systems 12V DC Interaction**

Landmark 365 and some toy haulers use the [Precision Circuits, Inc.](#) Power Control System to manage 120V AC power loads. Some of the controls in the PCS system may require 12V DC in order to function correctly. There may be some cases where absence of 12V DC could prevent a 120V AC appliance from operating.

### **Welcome Back Light**

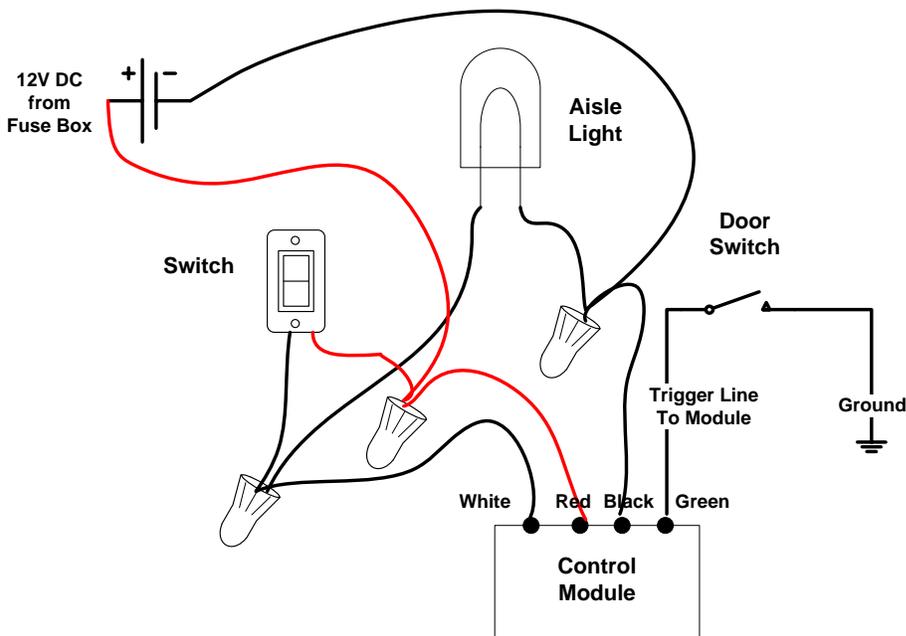
Some model years of the Landmark and some Bighorn and Big Country coaches have a feature called the Welcome Back Light. There is a ceiling light just inside the entry door that can be turned on either with a switch, or if the switch is left off, by opening the entry door. When activated by the entry door, the light stays on from 30 seconds to three minutes, until a control circuit cuts power to the light. When the light is switched on manually, the Welcome Back feature is disabled.

A KIB DTM904-2 control module located within a few feet of the door, usually in the basement, is connected to 12V DC power, and to ground by way of a magnetically activated switch in the door frame.

When the door is opened, the switch closes, providing a ground path to the control module. The module then supplies 12V DC to the ceiling light.

Note that if the ceiling light fixture has an on-board switch, it must be on. Conversely, to disable the Welcome Back Feature, turn the on-board switch to the off position. On some builds, there may be no switch for the Welcome Back Light.

### Welcome Back Light Feature Block Diagram

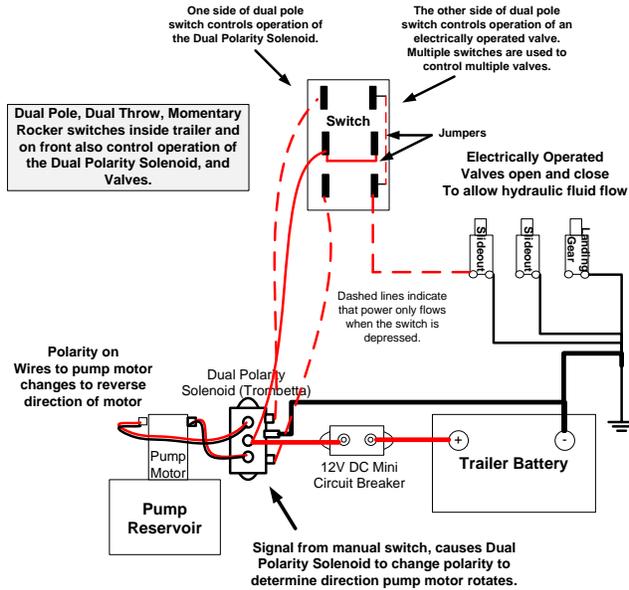


### Lippert Hydraulic System – Level-Up and Slideouts

The appendix contains a block diagram illustrating wiring for a typical Level-Up system. Power from the battery flows through a 12V DC mini-circuit breaker on (or connected to) the buss bar. Heavy gauge wiring runs from the circuit breaker to the Dual Polarity Solenoid (Trombetta) attached to the hydraulic pump motor. The Dual Polarity Solenoid has two contactors, similar to a relay, that switch power to the pump motor via control voltage from either a switch on the front of the RV, or from the Level-Up control panel, or from slideout switches inside the trailer. The switches energize one of the contactors on the Dual Polarity Solenoid, depending on which way the switch is depressed. Reversing the switch operation energizes the other contactor. Pump motor direction of rotation is determined by which contactor is energized. The switch also opens and closes an electrically operated valve that allows hydraulic fluid to flow when open, blocking fluid flow when closed. The polarity of the 12V DC coming out of the switch is reversed as the switch position is reversed. The appendix also contains a diagram of typical switch wiring.

The Level-Up Controller sends signals to the Dual Polarity Solenoid and to the various electrically-controlled Valves to raise and lower the landing jacks as it levels the trailer.

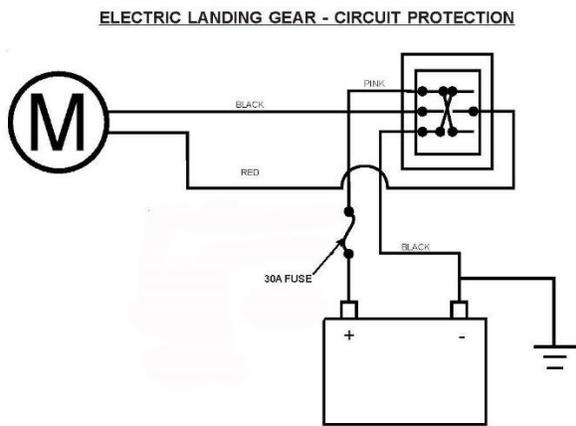
## Hydraulic Landing Gear and Slideout Wiring



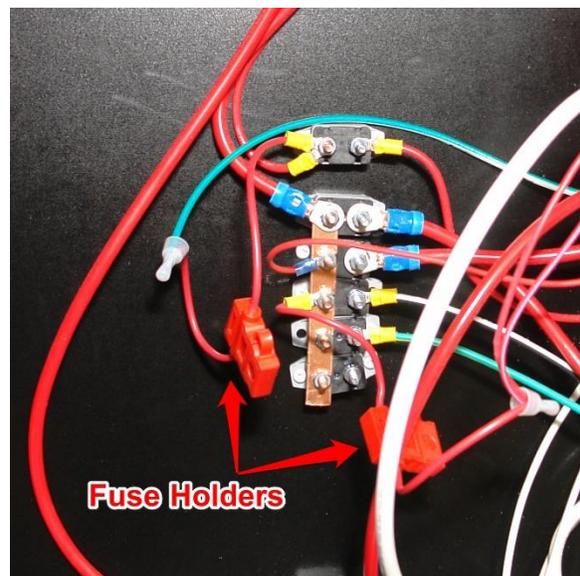
Hydraulic landing gear, not part of the Level-Up system, are extended and retracted by the hydraulic pump. The same pump extends and retracts hydraulic slideouts. A switch on the front of the trailer operates one of the contactors on the Dual Polarity Solenoid (Trombetta), powering the motor to rotate in one direction or the other, depending on which way the switch is depressed. The switch also energizes the electrically-controlled valve that allows hydraulic fluid to flow to and from the landing gear.

## Electric Landing Gear

Some trailers are equipped with front landing gear operated by an electric motor, where the circuit is protected by a 30 amp fuse. If the landing gear are retracted all the way, the motor may draw more than 30 amps, blowing the fuse. It's a good idea to mark the landing gear so you know when to release the switch, before the fuse blows. Another approach would be to replace the 30 amp fuse with a 30 amp mini-circuit breaker. Fuses may be located in-line in a wire bundle, or in a fuse holder such as shown below.



The Lippert Components, Inc. Electric Landing Gear Switch and Harness is supplied stock with a 30A inline fuse on the power lead to the switch.

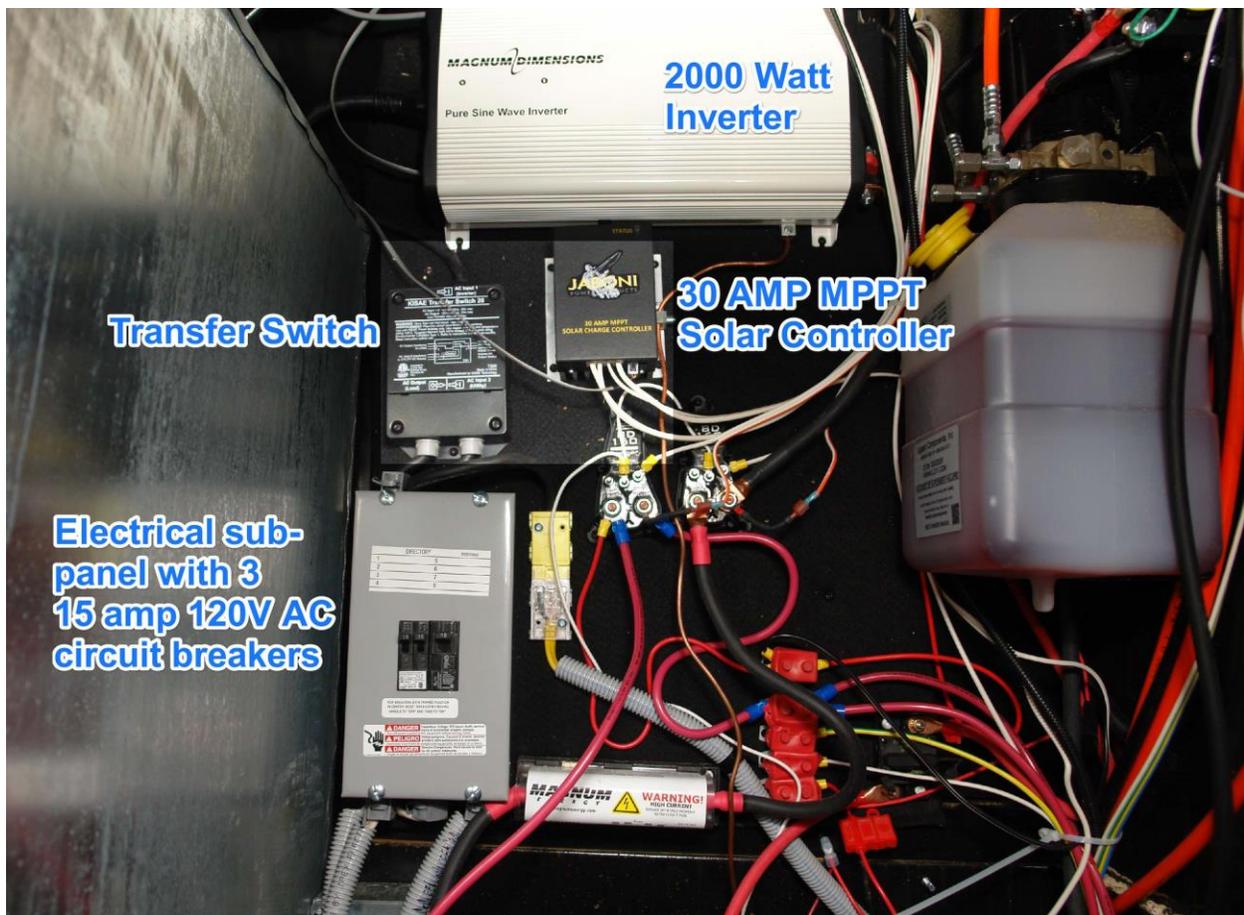


## Solar Power Pre-wiring

Some recently built trailers include pre-wiring to enable easier connection of solar panel kits or components. On some trailers, there is a connector on the front of the trailer with wiring that goes to the battery compartment. This enables plugging in a self-contained portable solar panel kit with controller. On other trailers, there may be wiring from the roof to the interior so that solar panels can be installed on the roof and a controller installed inside the trailer.

## 2020 Landmark 365 Factory-Installed Solar Option

2020 Landmark 365 coaches may be ordered with the solar option. The option includes one 300 watt solar panel installed on the roof, a 30 amp MPPT Controller to charge the batteries, a total of four batteries (instead of the standard two batteries), and an electrical sub-panel in the front compartment with three 120V AC circuit breakers.



The 300 watt solar panel on the roof sends approximately 36 volts to the Solar Controller in the front compartment. The Controller regulates the power down to approximately 13-14.4V DC to charge the batteries. When charged sufficiently, the batteries supply enough power to run the Inverter. The 2000 watt Inverter changes the 12V DC battery power into 120V AC power that goes to one input on the Transfer Switch. The other input on the Transfer Switch comes from a 30 amp circuit breaker in the main circuit breaker panel inside the coach. When shore power or generator power is available, the Transfer Switch

uses the 120V power from the main circuit breaker panel. So when shore power or generator power is available, the Transfer Switch does not use any power from the batteries.

Note that the output of the Solar Panel and Controller does not directly feed to the Inverter. They charge the batteries. The 2000 watt capacity of the inverter determines what devices can be powered based on how many watts of power they draw. The amount of power stored in the batteries determines how long the inverter will be able to supply power to the devices being used.

The Electrical sub-panel has three 120V AC circuit breakers that provide power to the residential refrigerator, the living room entertainment center outlets (TV, satellite, DVD, etc.), and the outlets on each side of the bed (for CPAP or other devices).

It's possible to add a second solar panel to the roof. If accompanied by an additional two batteries (total of six), the power stored in the batteries can be increased in order to provide for longer runtime on the devices powered by the Electrical sub-panel. At the time of this writing, Heartland does not sell the second panel as an option when ordering the RV. It would have to be purchased and installed separately. The 30 Amp Controller will work with either one or two 300 watt solar panels. Generally speaking, installing an additional panel without additional batteries will likely not provide much if any benefit. The first panel should fully charge the 4 battery array. Once the batteries are fully charged, additional output from the second panel won't charge them to a higher level.

## 12V DC from Tow Vehicle

The umbilical connection between tow vehicle and trailer provides 12V DC power to the brakes, brake lights, stop lights, turn signals and running lights. On some recently built trailers, Heartland has added wiring to support installation of a backup camera.

The umbilical connector also has a 12V DC connection to the trailer battery which helps charge the battery while towing. Although the current provided by the tow vehicle is much less than what is provided by the Power Converter built into the trailer, it will help restore a battery charge after an overnight stop with no shore power. It also helps supply battery power to run a residential refrigerator while towing.

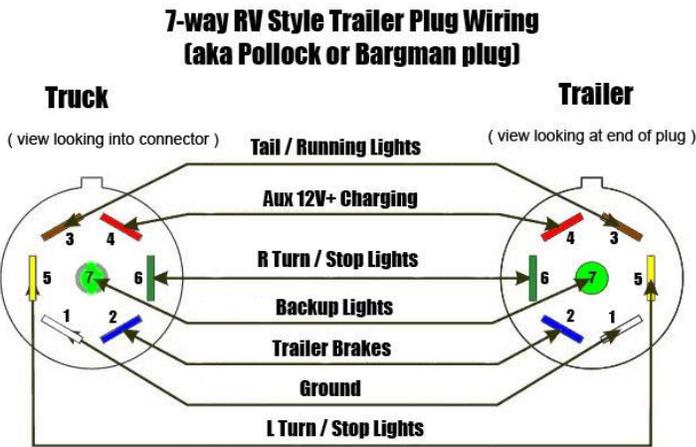
The 12V DC from the tow vehicle is generally not enough to operate any of the trailer's high current devices such as the hydraulics pump, or to start an on-board generator. But if the tow vehicle engine is run at high idle while connected to the trailer, it may be possible to recharge the trailer battery enough to operate those devices.

## 7 Pin Connector Wiring

The umbilical connection between truck and trailer is shown below from both the truck and trailer connector point of view. Note that wire colors may vary from what's shown here.

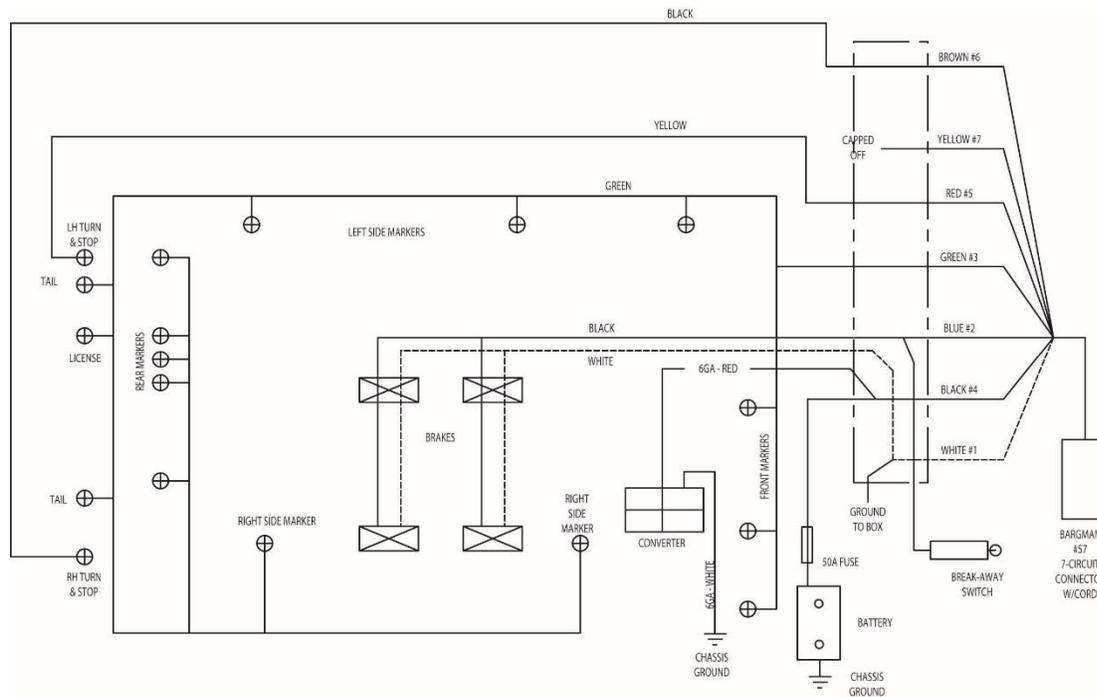
Some tow vehicles supply power to the 7 Pin Connector whether the ignition is on or off. If your trailer is connected to the tow vehicle while boon docking, you might be drawing down the batteries on your tow vehicle. Disconnecting the umbilical cord between truck and trailer will prevent this from happening.

Connections can become intermittent if the connectors corrode or are dirty, or if the prongs get bent.



## Trailer Brakes, Brake Lights, Stop Lights, Turn Signals and Running Lights

The block diagram shows the general case for how the wires from the 7 pin connector tie to the brakes, brake lights, stop lights, turn signals, and running lights. Wire colors may vary.



## Backup Camera Prewiring

On newer trailers, Heartland has been providing prewiring for a separately purchased backup camera that you can mount on the rear of the trailer, near the roof. Some backup cameras are designed with a fast refresh rate on the screen, allowing use for both backing the trailer, and also to observe traffic behind the trailer while towing. Other cameras are designed primarily for use while backing up. Their picture may refresh too slowly to provide a clear picture of traffic while towing.

From a wiring standpoint, most people would want continuous power going to the type of camera that lets you observe traffic. But for a camera that's only used when backing the trailer, most people might prefer a camera that is not powered continuously. The prewiring is for continuous power so that it supports either type of camera usage. If you have a camera used only for backup, you may want to add a switch to cut power to the camera when not in use. Some owners have installed a very inexpensive remote controlled switch like the [Logisys RM02 12V 15 Amp Relay Kit with Two Remote Controls](#).

Heartland has used two approaches to wiring. On some trailers, the backup camera prewiring is tied into the marker/running lights and is on when the marker/running lights are on. On others, there's a dedicated wire that runs the length of the trailer and may have an in-line fuse holder near the battery. You may have to add the fuse to the fuse holder.

### Emergency Breakaway Switch and Braking

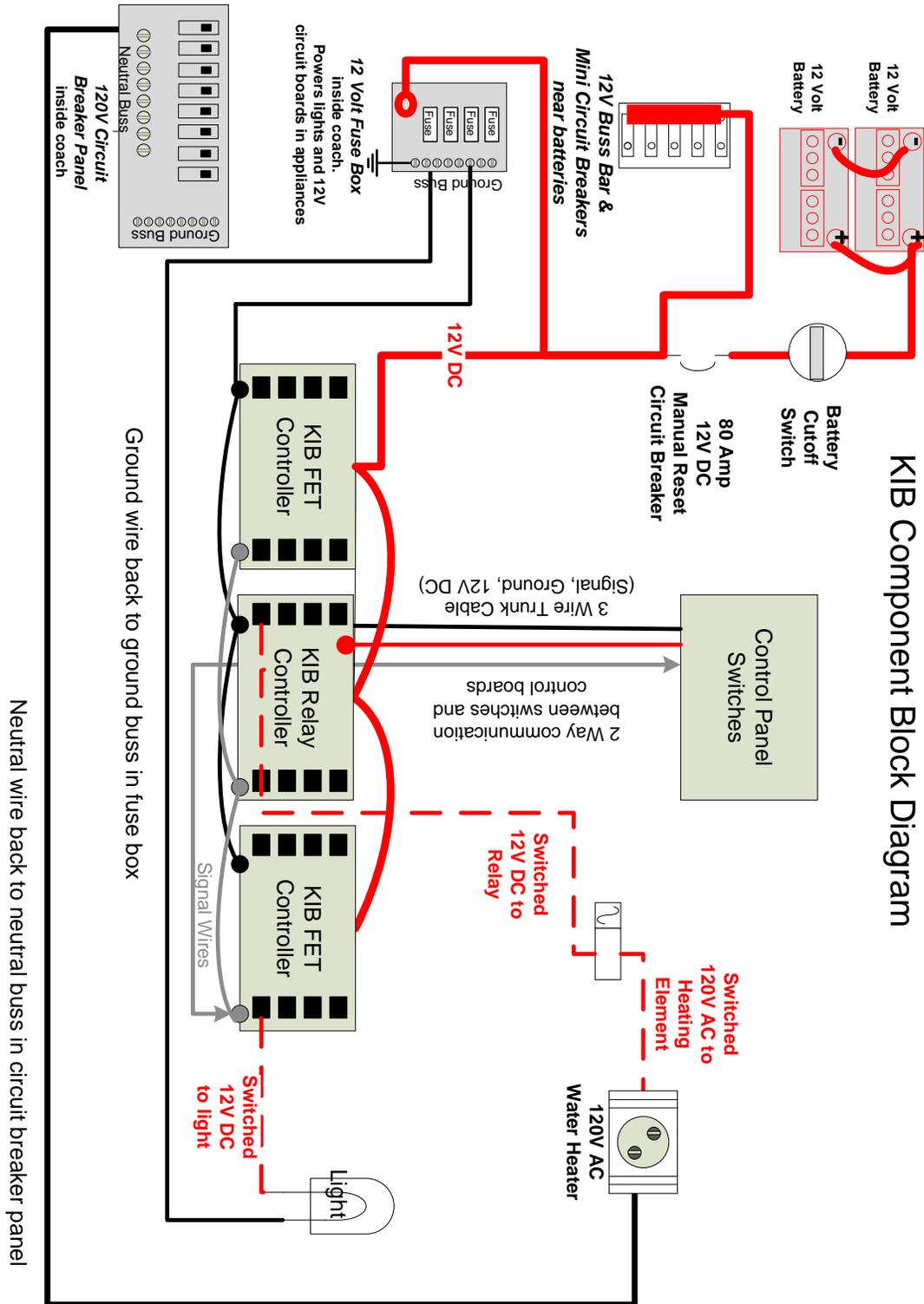
In addition to the umbilical cord connecting tow vehicle to trailer, there is a cable that must be attached to the truck. That cable goes to a switch on the trailer pin box, called the Emergency Breakaway Switch. If the trailer separates from the tow vehicle, the cable pulls out of the Emergency Breakaway Switch. At that point, power from the trailer battery flows through the switch to activate the trailer brakes. Be sure to position the cable so that it doesn't contact anything in the truck bed, and has enough slack for you to make sharp turns without inadvertently pulling the cable and energizing the trailer brakes.

**WARNING:** The trailer's battery must have a charge and be connected in order for the Emergency Breakaway system to function. Towing with a dead or missing battery could lead to a tragedy if the trailer were to separate from the tow vehicle.

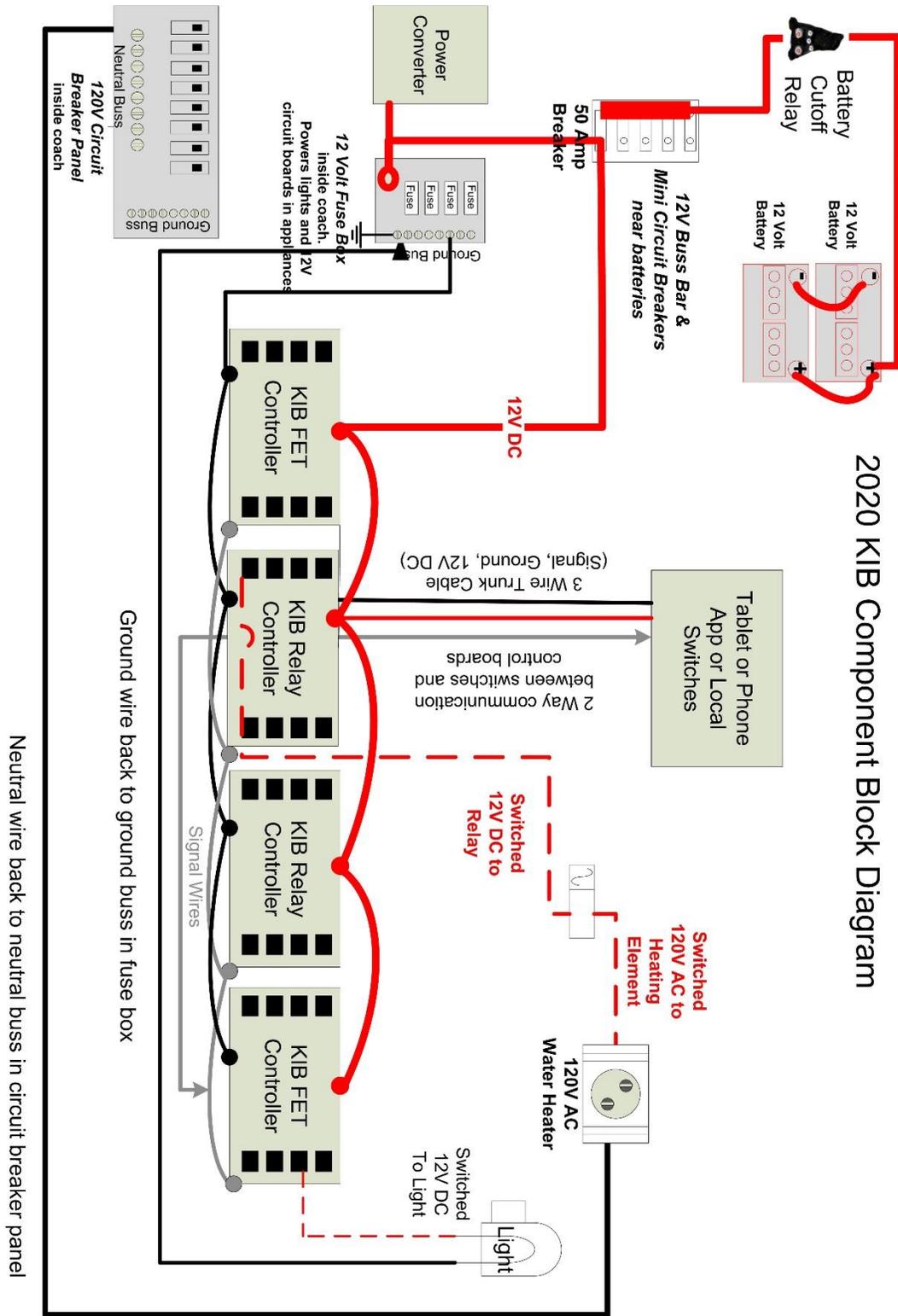
**CAUTION:** Never leave the Emergency Breakaway Switch activated for longer than a few minutes and no longer than absolutely necessary. While the switch is activated and the battery still has a charge, the trailer brakes will be applied continuously. The standard electric brakes use a magnet that's energized by the breakaway switch. After a few minutes of continuous use, the magnet will overheat and the brakes are likely to be damaged. In a worst case, the heat could affect the wheel grease and bearings. If you have hydraulic disc brakes, the pump, also not intended for continuous use, could be damaged after a few minutes if left energized.

# Appendix

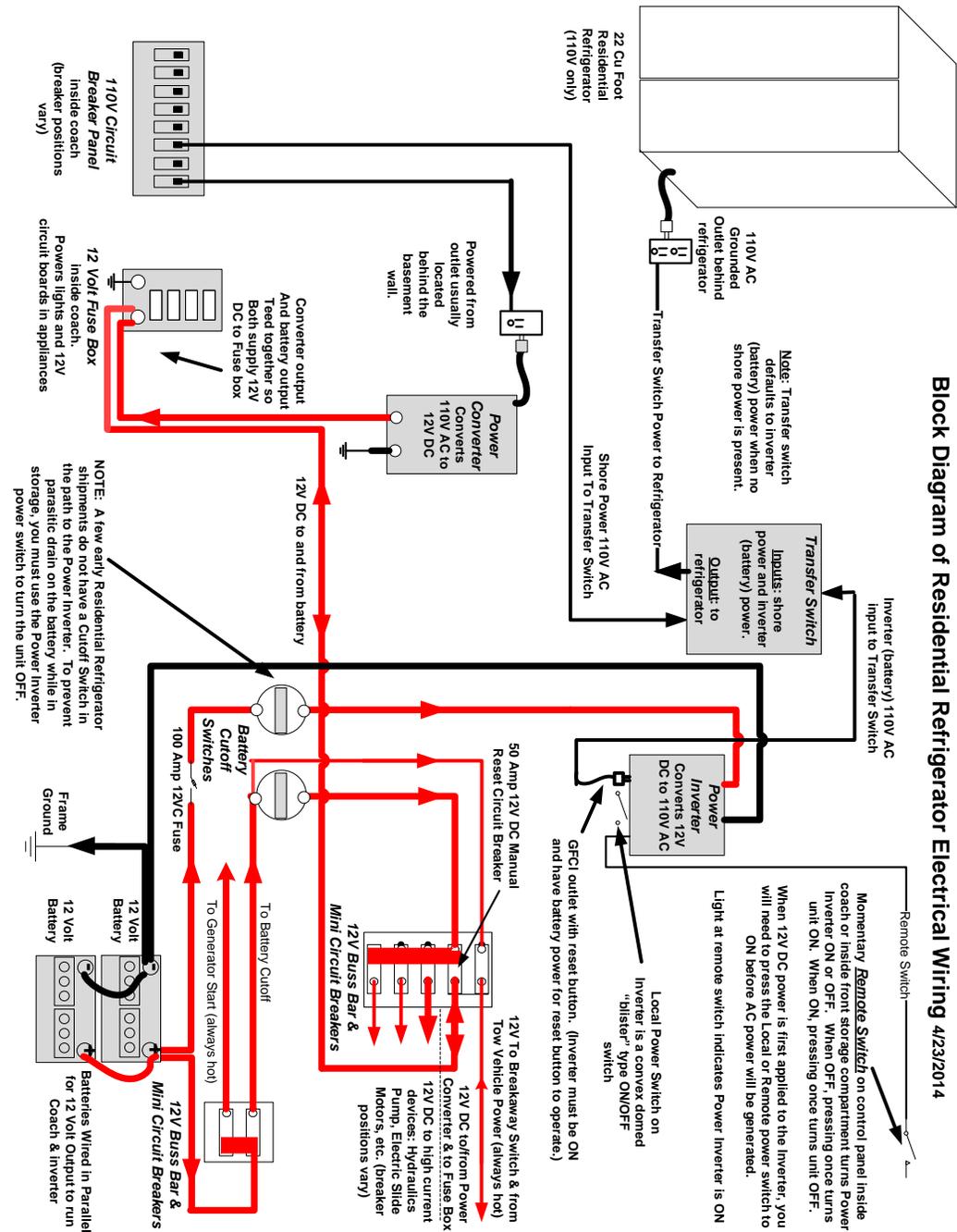
## KIB Multi-Plex Block Diagram V1



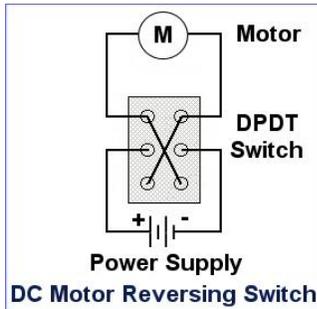
### KIB Multi-Plex Block Diagram V2 (2020)



# Residential Refrigerator Block Diagram



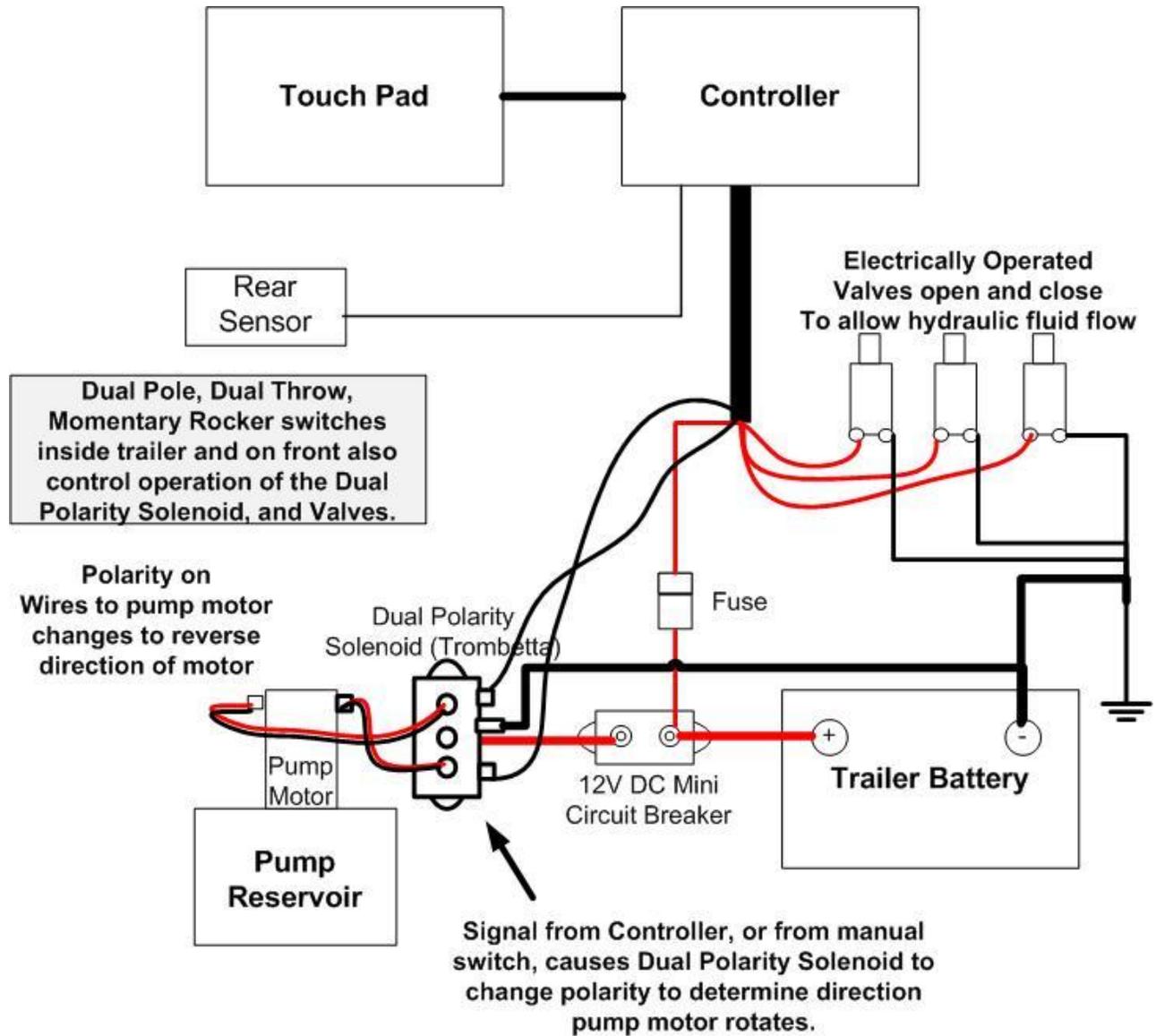
## Double Pole Double Throw (DPDT) Switch Wiring



Double Pole Double Throw (DPDT) switches may be used in several places in your coach. Slideout switches, front landing gear switch, and the stabilizer motor switch are usually this type. This type of switch is usually a momentary contact, rocker type switch that can be pushed one way to extend a slide, or landing gear, or stabilizers, and the other way to retract. Polarity of the voltage sent to the motor reverses when the position of the switch is reversed.

**NOTE:** When working on switches, typically a mounting plate needs to be removed from the wall on which the switch is mounted. Then the switch can be pulled away from the wall. Care should be taken to avoid pulling wires off the back of the switch. Before removing wires, use your smart phone to take a picture of the back of the switch, clearly showing where each wire goes. Without a clear picture, you could find it very difficult to get the wires back correctly.

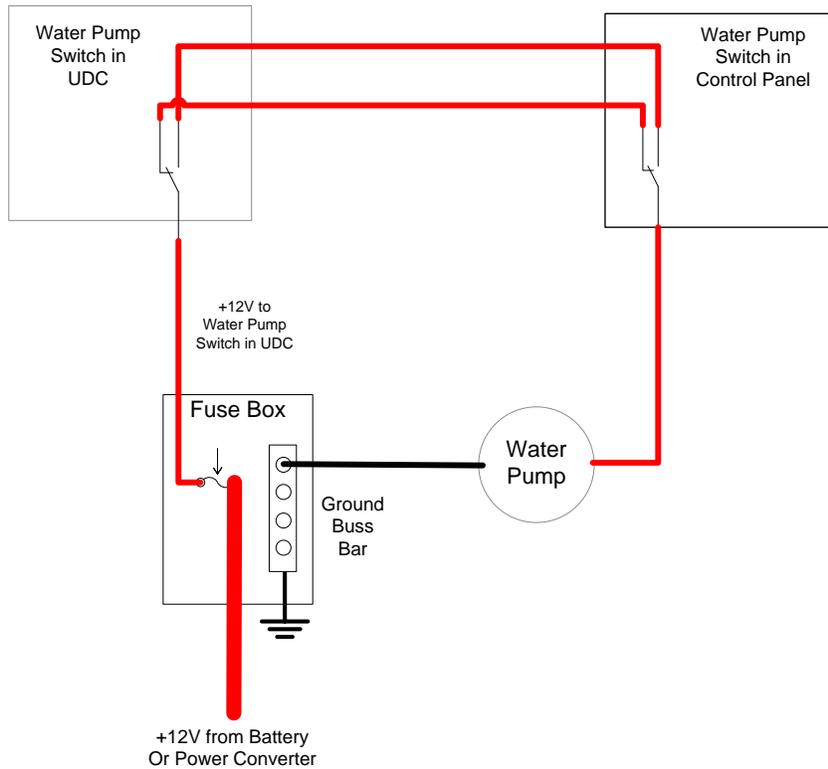
### Level-Up Block Diagram



### Water Pump 3-Way Switch Wiring

Beginning in 2012, on some larger coaches, Heartland introduced 3-way wiring to the water pump with one switch in the inside control panel and a 2<sup>nd</sup> switch in the Universal Docking Center (UDC).

On Landmark 365 units with the KIB Multi-Plex Control System, the UDC switch completes a ground signal to the KIB control board to signal that the water pump should be turned on.



## Suburban SF42 Furnace Wiring Diagram

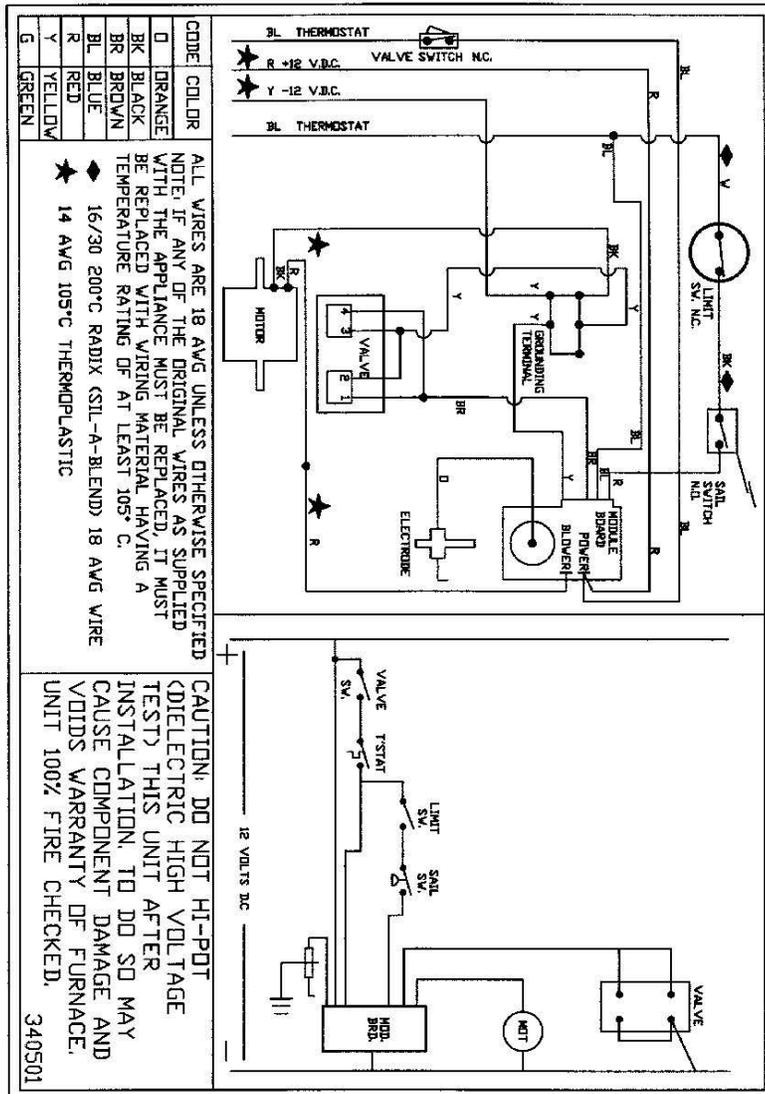


Figure 6

## Version History

03/30/2018 Initial Release

08/17/2020 V2 including KIB updates, Landmark 365 Solar Option, new Battery Cutoff Relays, and a number of minor updates and changes.