GMC Motorhome

Electrical System From The Top Down

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The electrical system of the GMC is fairly simple when considered as a system, but it's easy to get lost in the details. We work on those details, and sometimes miss an understanding of the system as a whole. The purpose of this article is to lay out the system as a whole so that GMC owners can see how the details fit into the big picture. This article lays out the electrical system of the GMC from the system perspective rather than from the device perspective. The devices are listed with respect to the systems they belong to. After the discussion of the GMC design for the system, I have included a section discussing one popular modification to that system, which replaces the isolator with a combiner. The application of a combiner is much easier to understand in the context of an overall understanding of the 12-volt electrical system.

A System of Systems

The GMC has two or three 12-volt electrical systems, plus a 120-volt AC electrical system. This article will address only the 12-volt systems. Each system includes a battery, a charging source, and devices that use power (i.e., the load). Sometimes, those systems are connected, and those connections cause the most confusion. Those systems are:

- Chassis electrical system, which runs the automotive stuff
- House electrical system, which runs the house stuff
- (For early coaches) Generator electrical system for starting and operating the generator

Chassis System

All coaches have a chassis electrical system that provides power to the devices used for driving the coach. That system includes:

- engine starting battery (which is up front on all coaches)
- the alternator (which is the charging source)
- chassis electrical loads.

House System

All coaches also have a house 12-volt electrical system that provides power to the 12-volt devices used while camping. That system includes:

- house battery or batteries
- converter (which is the charging source)
- house electrical loads.

Generator System

For early coaches, there is a third 12-volt system that is used to start and operate the generator. This includes:

- generator starting battery
- generator voltage regulator (which is the charging source)
- generator control system and ignition 12-volt loads.

The '73's and '74's put the engine and house batteries in the front, and used a separate battery for starting the Onan. Later coaches moved the house battery to the back (in a tray next to the Onan for 26-footers), and used it to start the Onan and run the house. Therefore, 1975 and newer coaches merge the generator 12-volt system with the house 12-volt system.

The systems connect to each other in two ways, as configured by GM. The first is that we can use the charging source in the chassis system to charge the battery in the house system. The device GM provided to do so is the *isolator*. It allows current to pass from the chassis system to the chassis battery, and separately to the house battery. All other current flows are prevented, so the batteries are not shared for doing work, but only for charging.

The other connection makes it possible to use both the chassis and house batteries to do work together, by connecting the 12-volt side of the chassis and house batteries. The device that does this is an electrically controlled switch called the *boost solenoid*. The solenoid is like a relay, and when you energize it, large switch contacts close allowing a high current flow.

Both or all three systems share a ground. The house system uses the aluminum body frame as a ground, while the chassis system uses the steel vehicle frame and engine block as a ground. All of these must be reliably connected together so that the grounding system is shared by all the 12-volt systems.

Loads: Things That Use 12-volt Power

The only activities in a typical coach that demand large 12V currents from the batteries are starting the engine and, to a lesser extent, starting the generator. It’s easiest to understand a system design in terms of requirements, though, so it's useful to identify loads and charging sources with respect to the above two or three systems. Knowing the load helps us to determine what wire sizes are needed, too.

Here are the current loads, and which battery and system they draw from:

1. Engine starting, which may draw 200 amps, or more. This comes primarily from the chassis battery as part of the chassis system, or through the boost solenoid from the house battery. Wire is sized by current requirements, and we need a fat wire between the engine battery and the starter motor to move hundreds of amps. Two-gauge wire is sufficient for this task, because the chassis battery and the starter are close together. For boosting from a late-coach house battery in the back, fatter wire may be needed because of the length of the wire.

2. Generator starting draws about 100 amps, or more in cold weather. This comes from the house battery and house system, or, in early coaches, from the generator’s own battery. Most generator manufacturers recommend #2 wire for starting connections, which are similar in size to the main engine starting cables.

3. Engine/chassis electrical devices, including the ignition system, fuel pump (if you use an electric one), air compressor, auxiliary vacuum pump (if you have one), headlights, running lights, clearance lights, marker lights, turn signals, brake lights, dashboard and cockpit lights, the dashboard cigarette lighter, heater and AC controls and blower, the dash radio, and dashboard instrumentation. The air compressor draws the most, at about 20 amps, but all the systems taken together will not usually exceed 50 amps. All these are fed by the engine battery, through the positive battery terminal on the firewall. GMC used a 10-

gauge wire to feed the main fuse block, which is where all the chassis loads except the starter are fused.

4. House electrical devices, including interior lights behind the cockpit, the refrigerator (if it has a 12-volt feature, though the control board of the refrigerator uses 12 volts, too, even if the cooler does not), the water pump, the macerator if you have one, the porch light, the furnace control and blower (the heat itself is made by burning propane), the fan in the roof vent, and various 12-volt accessories such as televisions, 12-volt portable fans, monitoring panels, and so on. The total draw for all these would not ever exceed about 20 or 25 amps except when you run your macerator while everything else is running. The macerator might draw as much as 20 amps, and the water pump might approach that, but only for a few seconds at a time and rarely at the same time. The furnace blower and roof fans will draw under 5 amps each. Typical lights draw about an amp each. Big-draw house devices, such as the refrigerator (unless yours has a 12VDC or propane mode which you are using at the time), the roof air conditioner, and the water heater, are run on 120-volt AC., which is a completely separate system. All the 12-volt house devices are fed by the house battery.

5. Generator electrical devices, including the ignition system, fuel pump, electric choke, and control board, all of which probably pull less than five amps. They are fed by the battery used to start the generator, whichever battery that is. The wiring in the Onan does not exceed 16 gauge except for the starter.

6. Included last because GMC didn't provide them, accessory inverters. Some people use inverters to power 120-volt AC devices from 12-volt sources while dry camping. The wire needed on the supply (12-volt) side depend on the capacity of the inverter. Remembering that volts times amps equals watts, a 1200-Watt inverter will draw 100 amps at 12 volts, plus whatever the inverter wastes making the conversion. It will also deplete most house batteries in a hurry. A 300-watt inverter, which is useful for charging camera batteries or powering a laptop computer, will draw 25 amps at 12 volts. That is within the power capabilities of a cigarette lighter receptacle, and usually the wire that comes with small inverters like this use 12-gauge wire. Again, the GMC is not equipped with accessory inverters from the factory, but many coach owners have installed them.

Those are the current loads, and they are properly fed by the batteries. The loads control the wire size needed between the battery and the loads. Next are the charging sources that keep the batteries from being depleted.

Charging Sources

Just as the wire from the battery to the load is sized by the current draw of the load, the wire from the charging source to the battery is sized by the capacity of the charging source. Those charging sources are:

1. Alternator. This charges the chassis battery, with a maximum charging current in practice of some large fraction of its nominal rating. GMC supplied 80-amp alternators and wired them to charge the battery using a 10-gauge wire. The alternator also charges the house battery through the isolator. Some owners have installed larger alternators without problem, but others replace the output wire with a larger gauge, such as 8-gauge or 6-gauge wire for a 100-amp alternator.

2. Converter. This charges the house battery, getting its energy from an AC source, either shore power or the generator. Most converters in GMC's are 40 or 55-amp models.

3. Generator charging circuit, which charges the generator battery at a current of 10 amps (in the case of the GM-supplied Onan). In later coaches that use the house battery to run the generator, this isn't used and really ought to be disconnected, because the house battery will be charged by the converter, which does a better job at it. Some aftermarket converters do not work well with the small charger output of the Onan generator. The Onan voltage regulator is the rectangular device with molded-in cooling fins on the back left of the generator, near the air cleaner; if it fails, it can

prevent the generator from continuing to run when the starter switch is released. It can be disabled merely by removing the wires plugged into it and taping them up.

System Separation and the Case for Combiners

In the original system, GM took a lot of care to keep these systems separate. The alternator was attached to the engine battery, the house battery was charged by the converter, and the Onan battery was charged by the Onan voltage regulator.

The isolator was one exception, where the alternator would charge the house battery, though as previously mentioned the isolator would prevent any other flow of electricity other than charging the house battery from the alternator. The boost solenoid was the other exception, making it possible for the engine and house 12-volt systems to be directly combined when both batteries are needed to do work, such as starting the engine on a cold morning when the chassis battery is depleted.

The problem with this approach is that not all batteries are necessarily charged when people think they should be. For example, when connected to shore power, the engine battery will not be charged unless the boost solenoid is engaged. The Onan starting battery (when provided, as with the early coaches) is not charged by anything except the Onan, which causes trouble for those who don't use the generator often.

Here are my requirements:

1. Charge *all* the batteries when
   a. the coach is plugged into shore power, OR
   b. the generator is running, OR
   c. the engine is running.

2. Drain only the house battery when dry camping with no generator, so that I can drain the house battery down to nothing, and still be able to start both the engine and the generator.

I achieved my requirements by installing a combiner between the engine and house 12-volt systems instead of the isolator. The combiner acts like a boost solenoid, except that it automatically combines the two systems when the voltage is high and separates them when the voltage is low. Chargers put out higher voltage than batteries, so when a charger is operating, the combiners join the separate circuits together. When no charger is operating, it keeps them separate.

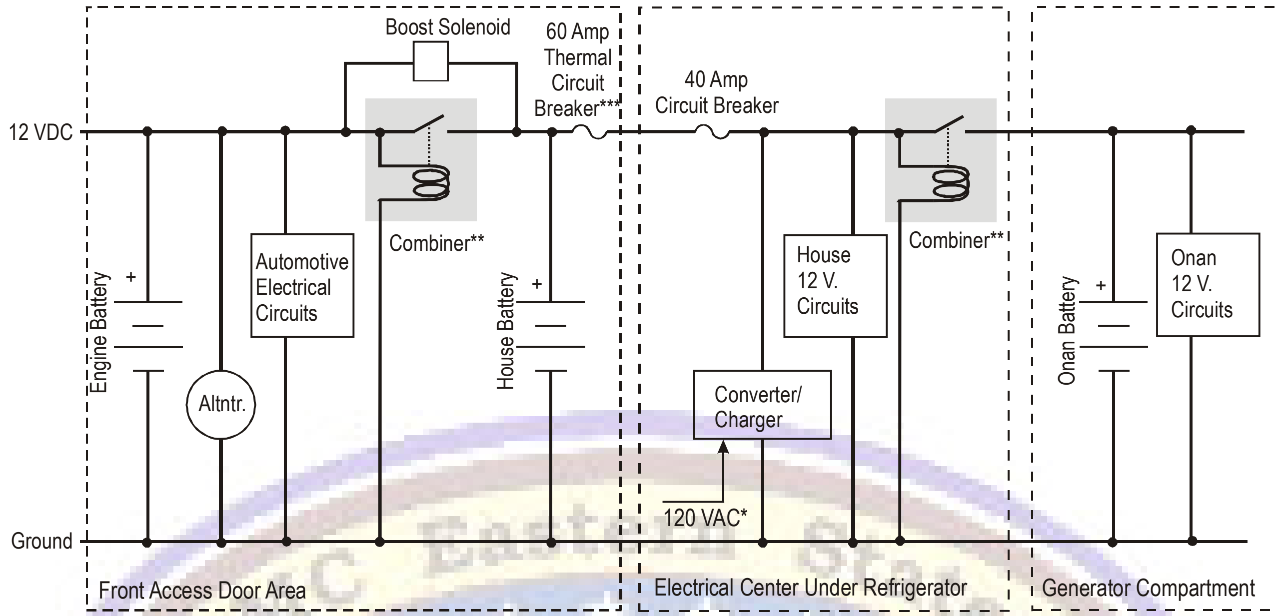
When I first bought my coach, I didn't realize that the generator battery was only charged by the generator, and I didn't run the generator enough to keep it properly charged. And the previous owner stranded himself in the months before I bought the coach because an owner previous to him had hard-wired the engine and house systems together using a marine battery switch and he ran them both down.

The system will now charge all batteries from any operating charging source, but it will deplete only the house battery when dry camping without the generator.

Using my approach, I left my house battery up front and don't need a large-gauge wire to the back. Because the only high-current load on the house battery is when it is recruited through the boost solenoid to help start the engine, the only large-gauge wire I needed runs between the house battery and the boost solenoid (on the house side, that is). The wire going back to the converter is 8 gauge - enough to carry the maximum 40-amp output of the converter. If I was starting the generator from the up-front house battery, I would need a large-gauge wire, but my early coach has its own generator starting battery adjacent to the generator. Because the starting batteries are close to the engines they are starting, however, the wiring between them only has to be fat enough to carry charging currents.

Figure 1 below shows a schematic of my system.

Some of the well-known renovators used a manual Perko-style battery switch instead of an automatic combiner, because the system is easy to control and understand. This is a valid choice. I chose the combiner because of the automatic operation.



*Only 12 VDC circuits are shown. 120VAC circuits are separate, and enter this diagram through Converter/Charger.

**Combiner closes circuit when voltage is 13.3 Volts or higher, with a delay in the circuit to prevent chatter. I used Yandina 50-Amp combiners. Combiner will be combined only when the converter/charger or alternator are running, but will be open during dry camping to prevent house circuits from discharging engine or Onan battery. Boost solenoid provides full starting current when starting engine with boost from house batteries (starting engine through 50-Amp combiner will limit starting boost to about 100 amps, and then only for a few seconds until combiner opens to protect itself).

***Circuit breakers are provided on each end of the wire going from the house battery to the house 12-volt power panel so that a short in that wire will protect the battery at the front and the converter and generator battery in the back.

Figure 1. Schematic of Early GMC battery, charger, and loads, using combiners.