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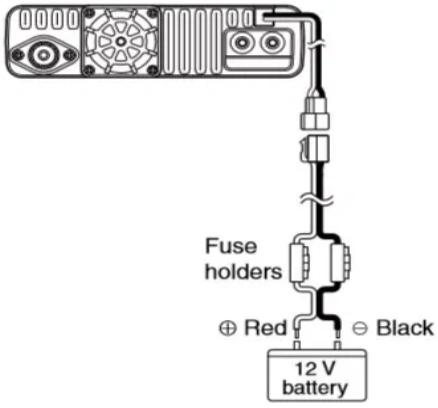
Mobile DC Power: One Fuse or Two?

8 March 2020 | by Bob KØNR | Share | Tweet | Leave a Comment (6)

[My apologies. I fumble-fingered WordPress and published a draft version of this article that was incomplete. This is the corrected version.]

Sometime during the 20th Century, I learned that fuses (or circuit breakers) are used in electrical circuits to prevent catastrophic failure. Fuses open in response to an electrical fault that causes excessive current to flow. The job of the fuse is to minimize the damage and keep things from catching on fire. When I started installing amateur transceivers into vehicles, I learned that you should connect wires directly to the car battery (or darn close) and you should fuse both the positive and negative power leads. I was surprised by the need for two fuses, but there are technical arguments for it. Besides, the transceiver manufacturers recommend it in their manuals. (See figure below.)

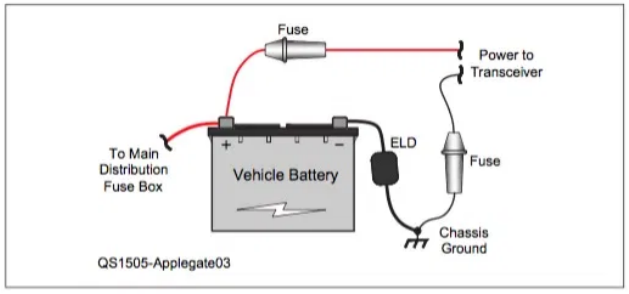


DC power connection as shown in the manual for an ICOM amateur radio transceiver (IC-2730).

I am focusing this discussion on a typical 2m/70cm FM transceiver installation – that is what I have the most experience with and that is the most common ham mobile installation. Such a radio typically draws ~10 A on transmit, so the DC power is usually fused with something like a 15 A (or 20 A) fuse. Keep in mind that a 15 A fuse is not going to protect delicate circuitry but might stop more serious damage or fire.

Connect To The Battery?

Alan/K0BG has an excellent website that provides guidance on mobile radio installations. He points out that modern vehicles usually have an Electrical Load Detector (ELD) inserted into the negative lead of the battery, so that the vehicle control systems can monitor the state of the battery. It is important to connect your radio on the "other side" of the ELD, near where it connects to the vehicle chassis. Oh, and never use the existing vehicle wiring to power your radio (especially not the 12 V accessory plug).



The negative power lead for a transceiver power should be connected to the chassis side of the ELD. Figure: k0bg.com website.

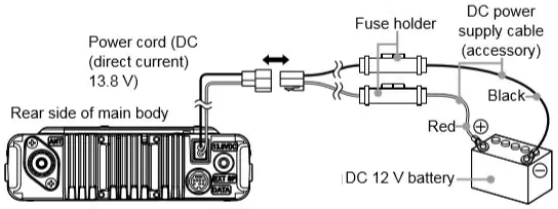
One Fuse or Two Controversy

Recently, I became aware of controversy with regard to proper fusing. Some people are questioning the practice of fusing both DC power leads, while others are vigorously defending it.

For example, there is a lively eham.net discussion here. Ed/W1RFI provides some useful insight on the ARRL forum. Alan/K0BG covers the topic of DC power on his wiring and grounding page. Tom/W8JI argues for the one fuse approach on his website.

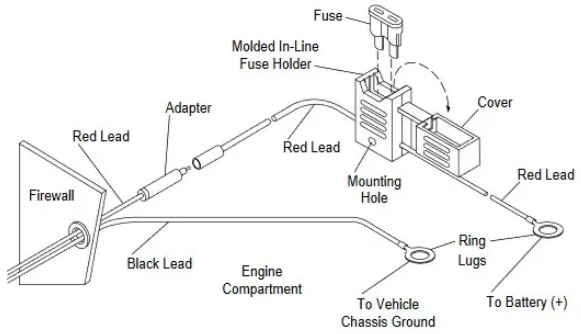
What Do The Manufacturers Say?

Generally, you should follow the advice of the manufacturer on any equipment installation, so I took a look at a few owner's manuals. Most (or all?) of the manuals for the amateur gear show the two fuse method. See the ICOM example below. (Note that they don't show the presence of the ELD.)



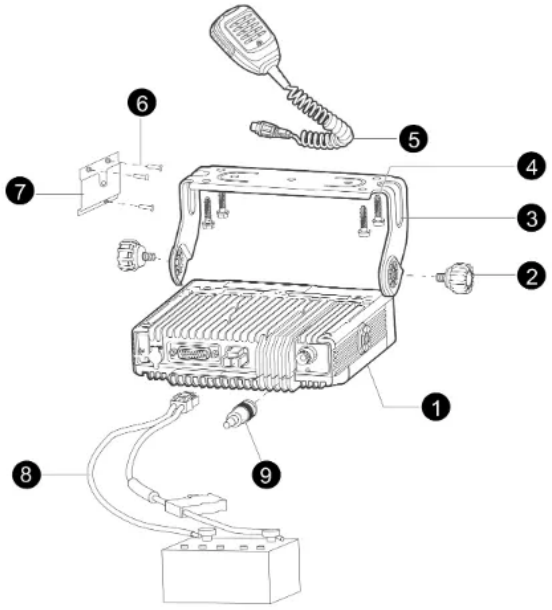
DC power wiring diagram for a Yaesu amateur radio.

I also took a look at some commercial land mobile radio manuals. Motorola shows the single fuse approach.



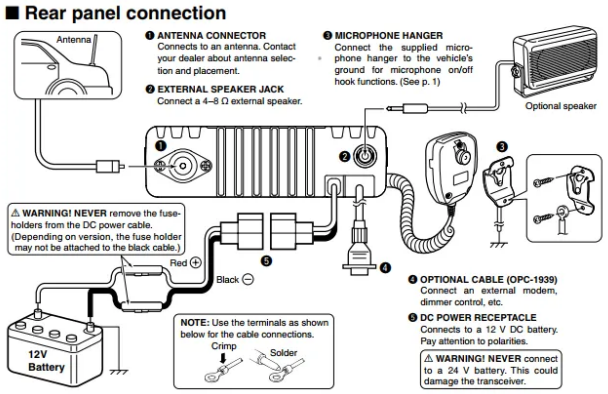
DC power wiring diagram from a Motorola land mobile manual (CM200- 300).

Hytera also shows a single fuse in its land mobile manuals.



DC wiring diagram from a Hytera land mobile manual.

ICOM makes both amateur and commercial land mobile gear, so I wondered what they recommend for their land mobile product line. Ha, funny thing, they show two fuses, with a comment that says, "Depending on version, the fuse holder may not be attached to the black cable." Well, isn't that special?

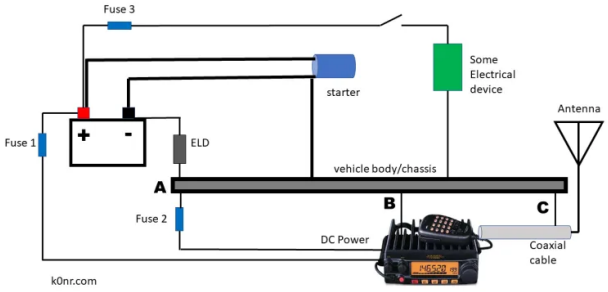


ICOM land mobile transceiver wiring diagram shows two fuses but says the negative one may not be there. (IC-F5021 manual)

So is the two-fuse thing some kind of ancient amateur radio practice and the land mobile industry has gone a different path? Sometimes industries adopt "standard" approaches and then forget why with time.

Some Circuit Analysis

After reading through all of the arguments, I tried to distill them down to their essence. I created a wiring diagram that may help explain the concepts. Or maybe not. An automobile is a complex electrical and electronic system, so any practical diagram risks oversimplifying the situation. But here's my best shot at it.



Wiring diagram for radio transceiver installation, including some major vehicle components. (click to enlarge)

The center of the diagram shows the body/chassis of the vehicle which is connected to the negative lead of the battery, through the ELD. The transceiver is directly connected to the + terminal of the battery (via Fuse 1) and the chassis side of the ELD (via Fuse 2). The engine starter is connected to the battery with heavy cables and is also connected to the body/chassis. While there are a large number of other electrical devices in a modern vehicle, only one is shown here as an example (with a switch and fuse).

The circuit shows the antenna connected to the radio with a coaxial cable. The shield of that cable is almost always grounded to the vehicle chassis at the antenna. (Magnetic mount antennas are one exception and I am sure there are others.) I can say that every mobile installation I've ever done had the coaxial cable connected to the chassis. This is an important point because it provides a chassis connection for the transceiver at point **C** (whether you wanted it or not). There may be other ways that a transceiver is connected to chassis (point **B**), including the mounting bracket, external speaker, microphone or other accessories.

Arguments For and Against

The **argument for** fusing the negative lead is to protect against return current from other devices that find its way back to the battery through the transceiver's negative power lead. For example, the starter could have a fault in its negative cable, causing the current to flow through the chassis to the transceiver and back to the battery. The starter current can be hundreds of amperes which would likely overload the radio wire which is sized for 15 amperes. The fuse will open and protect the negative lead (and maybe the radio, to some extent).

The **argument against** fusing the negative lead is that if the fuse opens up, it could cause problems. Suppose Fuse 2 opens up due to some transient condition. If the transceiver is completely isolated, Fuse 2 would remove power from the transceiver. However, the return path at the antenna coax (point **C**) will most likely allow the radio to continue functioning using the coax as the negative return. Typically, this is RG-58 or similar cable, which is not intended to carry significant DC current and may fry under the load. If the current is coming from a fault in the starter wiring (big current), this is going to be a bad day for your mobile.

My Conclusions

I think both arguments have merit but choosing one fuse or two requires estimating which problem is most likely and judging the overall impact of the fault. The negative lead fuse can do only one thing well: protect the negative lead. It *might* provide some protection to the transceiver but there are a lot of sensitive circuits inside the radio that will get destroyed with 15 A flowing. Again, the connection at point **C** means that the radio will be connected to chassis and current can flow.

If Fuse 2 is eliminated it allows for the flow of high currents through the negative lead of the transceiver. This is not desirable but is it better or worse than the current flowing through the coax shield? Probably better. If a high current device (the starter) has a wiring failure that dumps large currents into the chassis, it may find a number of return paths. Lots of current is going to flow somewhere and potentially cause damage, *with or without a negative lead fuse*.

I will note that bonding the transceiver to the vehicle chassis has some benefit (point **B** in the diagram). You may or may not have this connection depending on how you mounted the radio. This electrical connection can shunt any currents away from the coaxial cable, hopefully doing less damage that way.

What am I going to do? My future mobile installations will have only one fuse in the positive lead. I'll also bond the radio body to the vehicle chassis, with a hefty, low-resistance connection.

My existing mobile installations all have two fuses. I won't be changing them out because the risk of inducing a problem with the negative lead fuse is rather low. I don't see the negative lead fuse as a big risk. If you choose to follow the amateur radio manufacturer's two fuse recommendation, I understand.

A Request

The amateur radio equipment manufacturers need to give this issue a fresh look. At a minimum, the presence of ELD's needs to be addressed and the common recommendation of wiring directly to the battery is obsolete. But the one-fuse-or-two issue should also get a careful look by the manufacturer's engineering teams.

That's my analysis. What do you think?
(Runs and ducks for cover.)

Note: This article is my technical opinion but my attorney says to tell you that you are responsible if you destroy your vehicle while wiring up your transceiver.

The post Mobile DC Power: One Fuse or Two? appeared first on The KØNR Radio Site.

Bob Witte, KØNR, is a regular contributor to AmateurRadio.com and writes from Colorado, USA. Contact him at bob@k0nr.com.

6 Responses to "Mobile DC Power: One Fuse or Two?"

- *Larry Nixon:*
  9 March 2020 at 01:16 UTC

  Thanks for the article. I have a mobile installation to get to once it warms up. Was not aware of the ELD in vehicles.

- *Bill KI7HYI:*
  9 March 2020 at 20:25 UTC

  The schematic associated with "Wiring diagram for radio transceiver installation, includin" was half way out of the frame, FWIW.
  I spent a couple of years, in between my broadcast engineering gigs, doing 2-way radio work, and none of the commercial radios that I worked on ever had any kind of protection on either of the ground leads. This was back in the days when there was a control head in the cab and a radio box in the truck or rear of the vehicle. There was a ground lead on the control head and another ground lead on the radio box. Both of the ground leads went to vehicle chassis, and the one on the radio box never went back to the battery, due to the lesser voltage drop through the chassis.

- *Lowell NE4EB:*
  10 March 2020 at 01:10 UTC

  The Ham Writer Standards Manual really should preclude using the words "fuse" and "protecting circuits, radios, electronic devices", etc. in the same sentence.

  Fuses are to stop wiring that is carrying excess current from starting fires.

  I would never connect a radio negative lead to the battery negative post in a vehicle. Use the same point the battery negative is bonded to the vehicle chassis if you feel you must route the ground back into the engine compartment. But far more often the ground was bonded to the chassis withing a few feet of the the main radio unit.

  One of my jobs at a Motorola MSS for over a decade was training our installers in power and signal wiring tie points. These type of connections for primary power were not negotiable.

- *Paul Montgomery, K8SFC:*
  14 March 2020 at 16:49 UTC

  I am retired now, but I was an avionics tech for 33 years at a major commercial airline. Before that I worked at a regional carrier as a shop tech and aircraft "R&E" (radio and electrical) tech. Before that I worked as an avionics installer at an FBO (fixed-base operator), installing all manner of electronic gee-gaws in private aircraft, including communications and navigation systems. In all that time, I never saw a fused ground or chassis connection. All of the equipment chassis were bonded together and connected directly to the airframe, usually with copper braid of at least 1/2″ width, without benefit of a fuse or circuit breaker. The "hot" DC connection typically went to a circuit breaker which was connected to a buss. This buss was typically connected to an "avionics master" breaker switch which went to +28 or +14VDC, depending on the system. In commercial aircraft, control heads are mounted in the cockpit and the "R/T" units are remotely installed in racks in the avionics bay under the cockpit floor. The "R/T" chassis are all bonded together behind the racks and connected to the airframe as directly as is practical. I could be wrong, of course, but I wonder if the second fuse so typically seen in amateur transceivers might be for the accomodation of positive-ground vehicles like White Freightliners or MGs.

- *Paul Montgomery, K8SFC:*
  14 March 2020 at 17:23 UTC

  I should clarify two things… I installed a CB radio in a White Freightliner back in the '70's, and I found out the hard way that this particular truck was positive ground. This was a long time ago, and I should say that perhaps these vehicles are no longer positive-ground. Also, I mentioned MGs… many if not most English cars; Jaguar's, etc., were positive ground back in the 50's and 60's. I'm old and not at all up-to-date on what modern English automobile designers are up to. Hopefully everyone has switched over to negative ground by now! Also I mentioned "R/T" units… for those who may be unfamiliar, this means "Receiver/Transmitter" units, which are typically remotely located. The operating frequency, audio levels and so-forth are controlled with a small box located in the cockpit for operator access. This is the same concept as used with most commercial radio systems as previously mentioned.

- *Moe K2JDM:*
  15 March 2020 at 01:19 UTC

  Finally an article that actually explains WHY you should use 2 fuses. I have worked as a mechanic years ago, and you would be surprised what people think is acceptable for wiring a radio (Am, or FM, or a combo, or Ham equipment).

  I worked on a pickup truck where the driver used one fuse on the positive side of his AM/FM/cassette radio going to the battery, and used a chassis ground point for the negative side. He kept frying out his radio, and claimed it was a "factory defect". After the third replacement, my boss asked me to check it all out. I found the problem. He had a starter cable that was chaffed and contacting other wires at times, and apparently it WAS trying to draw from the battery. It didn't do much good to his radio. He paid for the work I did, but it got correctly fixed, also using 2 fuses.

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- **Matt W1MST, *Managing Editor***
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