Funny Noises

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The Power of Protection-

When Diodes Aren't Enough

Most QRP radios, including all of those made by OHR, include some sort of protection against the application of power with reversed polarity. It should be a given that a person qualified to hold an amateur radio license will have enough sense to connect plus to plus and minus to minus, but mistakes will happen and so we manufacturers and designers do what we can to protect against the inevitable operator malfunctions.

What we can do is to provide a diode for reverse-polarity protection, and an instruction to use the device with a power supply that is short-circuit protected and/or fused. Too often, though, our kit builders ignore the power supply constraints and rely on the built-in protection, which is very seldom adequate to prevent major problems when the power supply leads are reversed. After all, the purpose of the diode is to create a short circuit when polarity is reversed, and this short circuit will trigger the shutdown of the power supply or the blowing of the fuse. That's how it's *supposed* to work.

Other equipment (notably consumer electronic stuff) will survive reverse polarity or even backwards insertion of batteries. Why can't that be done with QRP transceivers?

First, there is a presumption that a licensed amateur radio will understand DC electricity and the possible problems of getting it wrong. Second, it's kind of like SWR protection– the cost of providing the protection is greater than the cost of replacing the parts that the circuit is designed to protect.

There are two ways to use a single diode to protect a rig against reverse polarity. The first is to put the diode in series with the power supply. This can be pretty effective, but there are a couple of traps, and a fatal flaw when it comes to QRP transmitters. A silicon diode has a forward voltage drop of about .7V. Most QRP transmitters have their finals biased at the supply voltage, and a .7V drop will result in a noticeable reduction in power output. Yes, the rig will operate quite happily on a 13.8V power supply, but put it on a 12V battery and you are looking at 11.3V. Deplete the battery and you could be working with voltages of 10-11V. A well-known "national brand" commercial transceiver had the problem of an unstable VFO with supply voltage under 11.2V (the rigs sounded like an early experiment in frequency-agile transmitters). Another problem is that since all of the current required to operate the rig goes through the diode, the diode must be capable of carrying the full current load (and then some) on a permanent basis, without overheating. If the diode overheats, it could go into first stage failure (see below) which is potentially dangerous– the rig will function normally, but it will be without reverse-polarity protection.

The more common way to use the diode is in parallel, that is, going from the hot side of the power supply connection to ground. As long as the polarity is correct, and the diode is healthy, there is no effect on the supply voltage and it is as if the diode weren't even there, until and unless polarity is reversed. When the polarity is reversed, the diode will conduct the power straight to ground, blowing the line fuse that the sensible operator installed in the power cord, or tripping the over-current protection in the power supply itself. But if you do not have a fuse in the power cord, and are connecting direct to, say, a car battery, if you reverse the polarity you are SOL (simply out of luck). The diode is intended to carry perhaps 1A, and in the car-battery scenario described above, you will be sending perhaps 100A through it. Second stage failure of a diode can be spectacular, but at least there will be no doubt about what happened.

When excessive current flows through a diode, it gets hot. Enough current, applied for long enough, will melt the silicon junction in the diode, resulting in a conductive pool of material. That's first stage failure. If the current source is removed immediately, the diode will look ok but it will no longer function as a diode. So if you catch a reversed polarity problem instantly, and correct the polarity, the diode will still act as a short circuit. Leave it long enough and the diode will probably go into second-stage failure, in which case the radio might work when polarity is corrected, but is no longer protected against reversed polarity.

In second-stage failure, with enough current for long enough, the little pool of melted silicon that used to be a junction will boil and vaporize, often exploding the body of the diode with enough heat to burn the body material. The diode itself ceases to exist, becoming an open circuit. If reversed polarity voltage is still applied when that happens, then the protection is gone completely and the wrong polarity is applied to the entire circuit. Many components can be damaged, and it will be a challenge to figure out which ones have failed (unless of course you deal with the problem on a regular basis, as we do at OHR).

There are several morals to this little story. First, never assume anything. Convention says that in a two-wire DC power cord, the positive wire is the one with the printing on it. For a couple years OHR used a power supply cord which was black, and the printing included a long stripe between groups of characters. You'd be surprised how many builders thought that the stripe was a long minus sign. We put a noticeable dent in the support load when we went to a red-black power supply. Above all, never assume that you yourself cannot make a simple mistake!

Second, you need to understand the nature of your power supply. Yes, if you are using a modern bench supply which has over-current protection, you're pretty well covered. But if you need to use a battery, you should be aware that the entire capacity of the battery can be dumped through a short-circuit in a heart-beat.

Last but not least, if the manufacturer of your equipment recommends using a fuse, do it!