

•••Ground Fault Interrupters

The “Hows” and “Whys” of Ground Fault Interrupters

There seems to be a huge amount of misunderstanding about how ground fault interrupters work. A very pretty web site was recently referenced in one discussion that contained several nicely drawn diagrams. All completely wrong. This article is designed to explain in layman’s terms how a GFI works.

Photo 1 is a photo of the insides of a Lutron Catalog No. 632-6899-W, Spec

in the hot and neutral legs. There are some sense electronics that rectify the output of the longitudinal transformer and generates a trip signal when the current exceeds a designated amount. There is a trip coil that opens the main contacts. There are the main contacts that interrupt the current. (Note: I drew only one contact for simplicity. Most GFIs interrupt both the hot and

The middle portion of Figure 1 shows the condition when a fault to ground exists, say someone touching a hot wire. Current flows in through the hot lead but then it splits. Some flows through the load (if the load is turned on) and some flows through our hapless victim to ground. (Note: Ground can be either the green wire or earth ground or any other ground. The function of the GFI

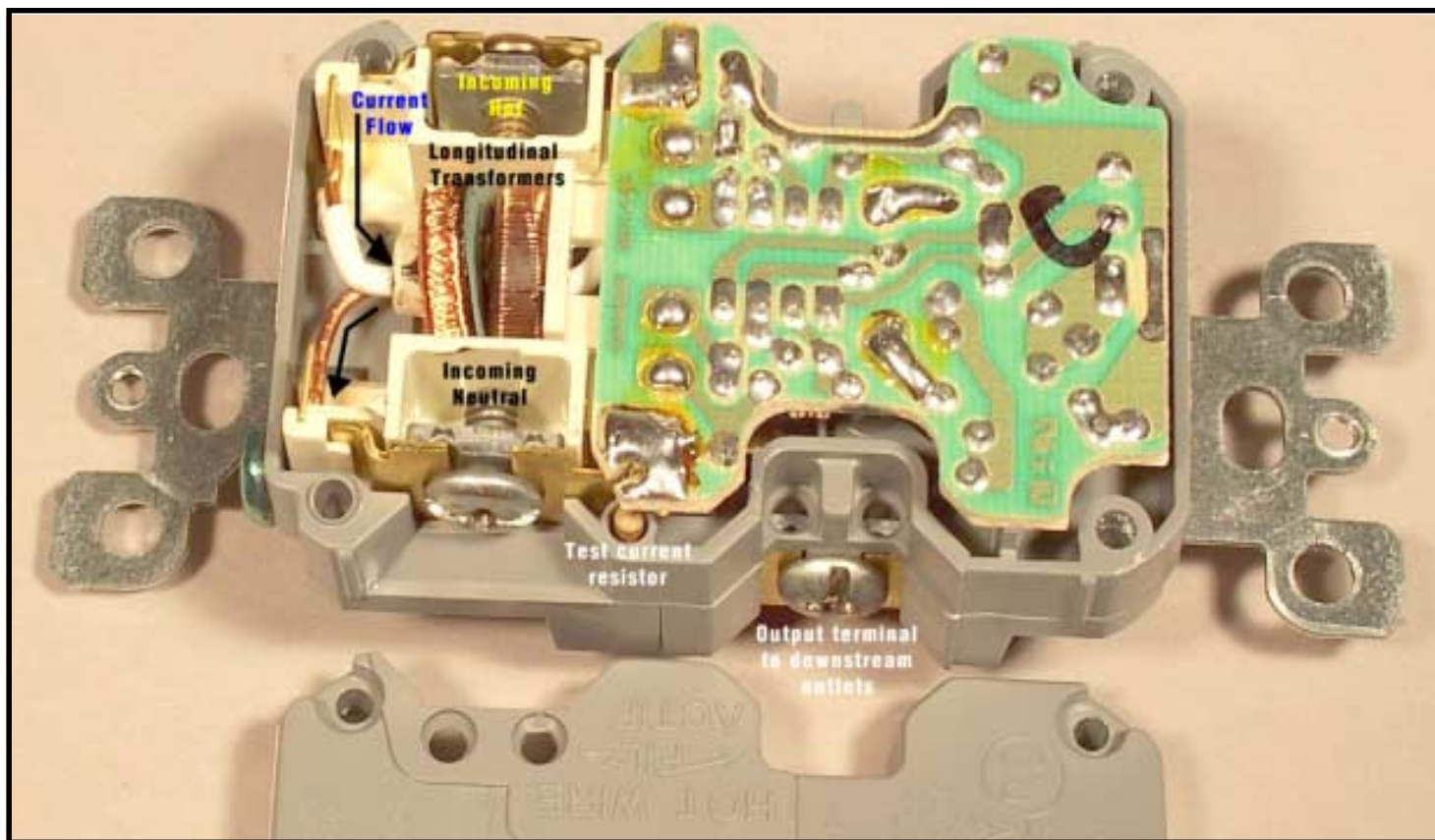


Photo 1

Grade GFI as one might buy at Home Depot, Lowe’s or similar outlet. It is designed to protect not only loads plugged into it but also loads connected to the output terminals. This type of protector can protect all outlets on a branch and is known more specifically as a GFCI or Ground Fault Circuit Interrupter.

Figure 1 shows a block diagram of a GFI. There are several major parts. There is a longitudinal transformer that detects imbalance in the flow of current

neutral for extra safety in case the polarity gets reversed.) And there is the test button that introduces an actual fault current to the interrupter to test its function. These parts are labeled both on Photo 1 and on Figure 1.

At the top of Figure 1, one can see how the GFI works under normal condition. Equal current flows to the load through the hot lead and returns through the neutral lead. There is no current flow either in the ground lead or to earth.

does **not** require the presence of a green wire.) Because there is more current flowing through the hot wire than through the neutral wire, current is introduced in the secondary of the longitudinal transformer. This current is proportional to the imbalance between the hot and neutral leads. The output of the longitudinal transformer is applied to the sense circuit, in the case of the Lutron, a printed circuit board. This circuitry rectifies the input, filters it and applies it to a comparator.

When the input from the longitudinal transformer becomes equivalent to 5 ma imbalance in current flow in the main leads, the comparator switches stage and generates a trip signal. This trip signal is applied to a coil that trips the main normally closed contacts. These contacts open and break the circuit to our stick man, saving his very thin heart! And his life.

Note that none of this functionality relies on the green wire. Indeed the green wire can be totally missing and the GFI will work just fine. This should be intuitive - one would not want the GFI to malfunction because the green wire is missing or cut - but there seems

like a real fault would. The amount of current is chosen to just trip the unit. In this particular case, the resistor is 14.75 kohm which at 120 volts produces a current of 8.2 ma. Since the GFI **must** trip at 5 ma per UL, this is a positive test of the device.

Spurious Trips

As good as the GFI is at protecting people, sometimes it becomes a great nuisance, causing spurious trips. In this section I examine some of the causes of spurious trips and what can be done about them.

Probably the most common source of spurious trips are electrical devices that have small leakage currents to

tected outlet.

In an RV, a common source of leakage current is the 12 volt converter, especially the switching type. These commonly have input RFI suppression to keep the high frequency energy off the incoming wiring. These filters typically leak several ma to ground as part of their normal function. Again, the only solution is to run the converter from a non-GFI circuit.

Another common source of trips is leakage in electric motor windings to ground. As the windings age and collect dirt, they become leaky and conduct current to ground. A motor can run for years while leaking a few ma of current.

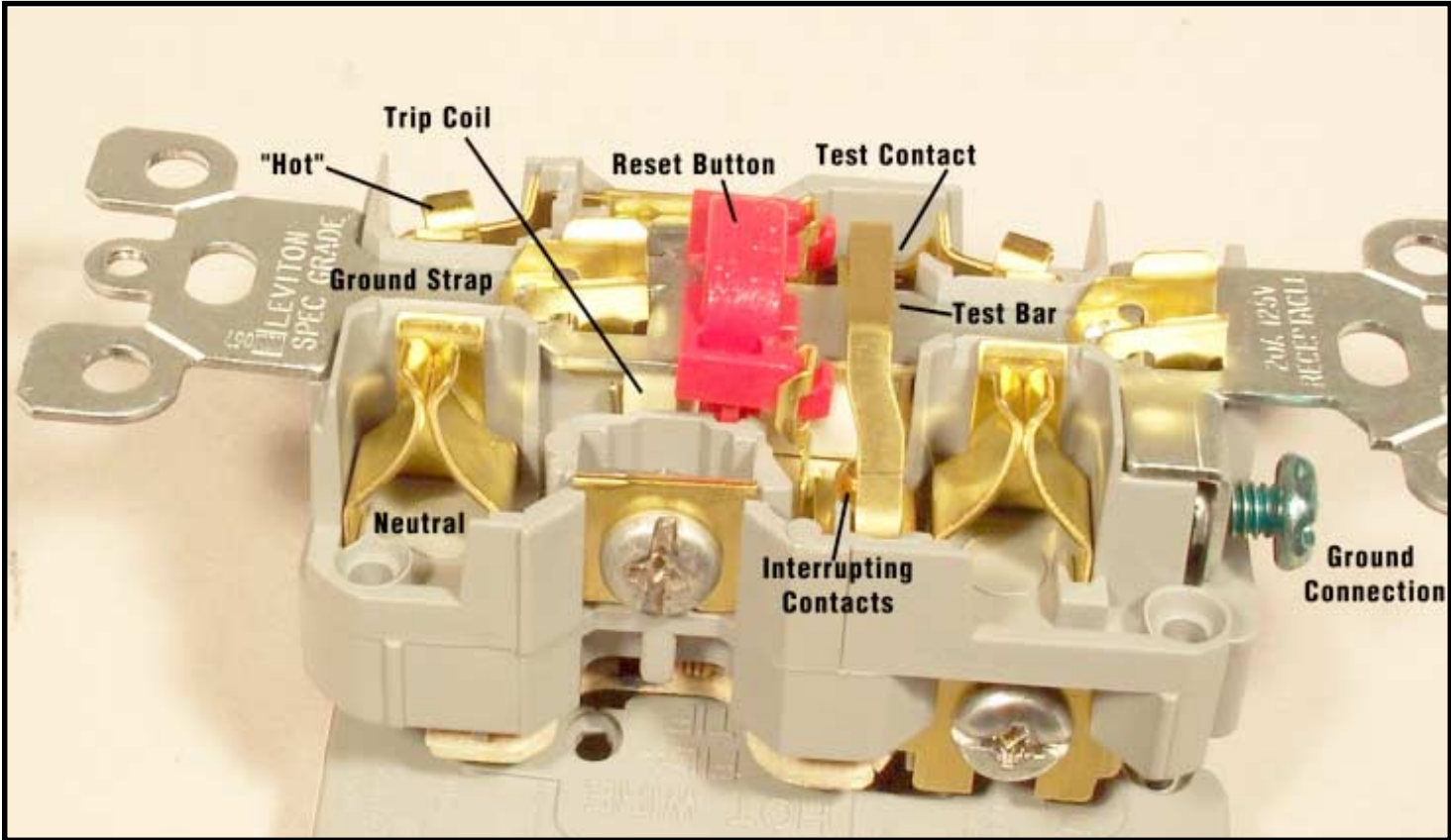


Photo 2

to be a popular misconception to the contrary.

The lower part of Figure 1 shows the GFI when the test button is pressed. This button shunts some current around the transformer and thus causes a trip if everything is working OK. When the button is pressed, a small amount of current is conducted around one leg of the conductors that pass through the longitudinal transformer. This causes an imbalance in the transformer just

ground. If the device has an input RFI filter, it is likely that there are capacitors connected from the hot and neutral leads to ground. If these capacitors are too large or if they become leaky, they can easily flow enough current to trip a GFI. Older test equipment is particularly bad about this, as are many types of commercial food service equipment. More on that later. The only solution in this case is to either replace the filter or operate the device on a non-GFI pro-

On an RV, the most common problem area is the rooftop AC unit. The blower fan is exposed to the elements and so can collect road grime and other contaminants on its windings. Again, the only solution is to run the offending motor on a non-GFI line. One must be sure the ground lead is intact because if the device containing the motor is not grounded, the case can have enough voltage on it to cause a jolt.

Food service equipment is particu-

larly pesky. The problem is that many of the heating elements are either exposed or are clad but with open ends. Moisture will impregnate the refractory insulation when the unit is off. When the unit is first powered up, there can be quite high leakage to ground. As the elements heat up, the moisture

by the hard-wired ground. The problem arises when such an appliance is corded and operated on a GFI protected circuit. The initial leakage will trip the GFI and never allow the unit to warm up enough to quit leaking. This used to drive me crazy with commercial coffee makers in my concession trailers when

case, the GFI is doing its job and the appliance should be repaired or discarded.

Because of the numerous sources of spurious trips in an RV, it is a bad idea to try to supply shore power from a GFI outlet. When the RV is occupied, the trips are little more than a nuisance. But if the RV is unoccupied, the trip can thaw the refrigerator or allow the unit to freeze. The NEC recognizes this and has an exception for RV-type 30 and 50 amp outlets.

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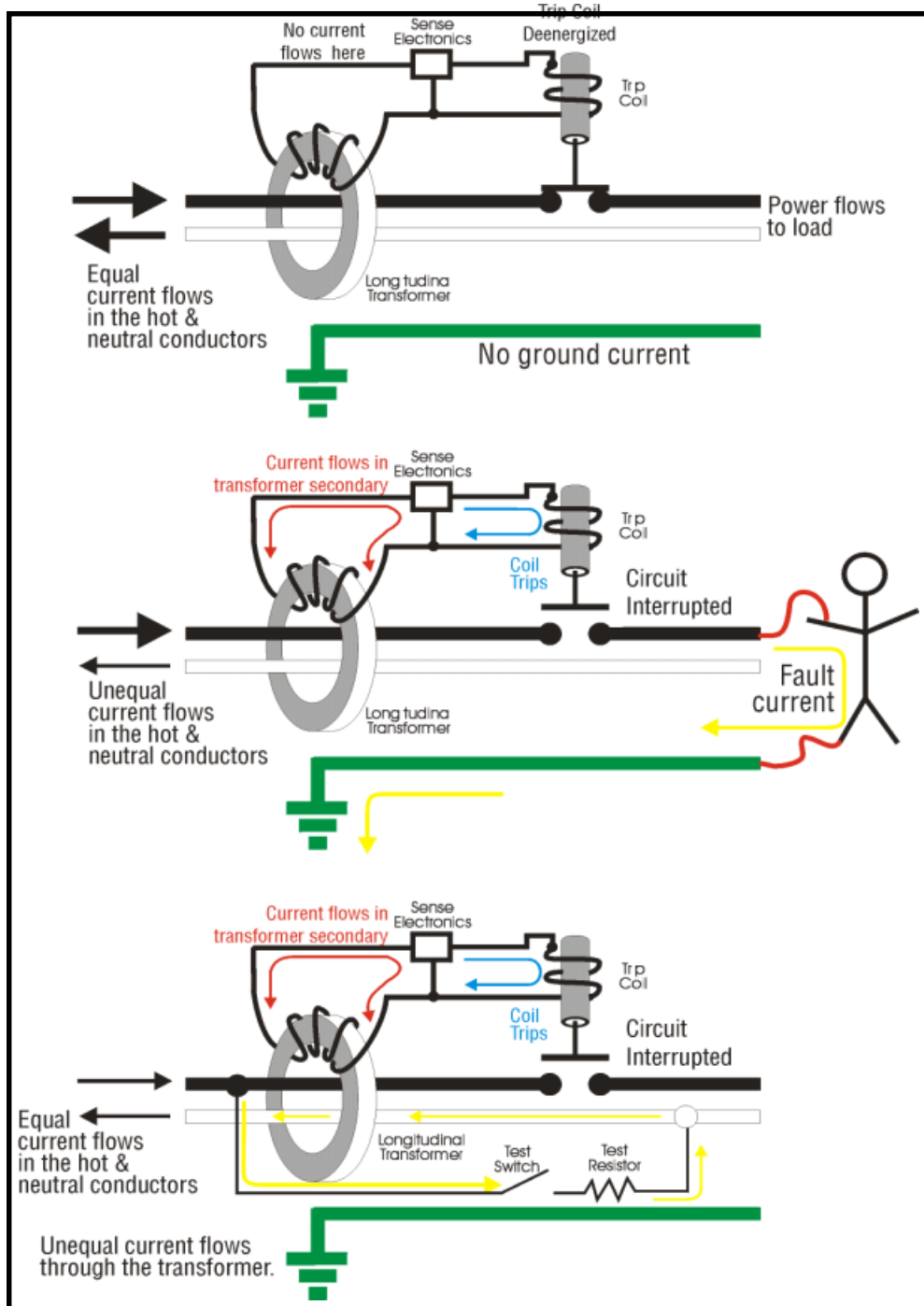


Figure 1

dries out and the leakage dissipates. Most of this equipment is designed to be hard-wired on a dedicated circuit where any leakage is normally conducted away

I tried to operate the trailer on GFI-protected shore power.

A final cause of GFI trips is an appliance suffering incipient failure. In this