

Re: Multimeter damaged when powered from regulated power supply.

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Source: <http://sci.tech-archive.net/Archive/sci.electronics.basics/2006-02/msg00226.html>

- *From:* "Chris" <cfoley1064@xxxxxxxxxx>
 - *Date:* 5 Feb 2006 10:23:55 -0800
-

Geogle wrote:

Thanks much for the enlightening reply Chris.

It will be really helpful if you could give few more clarifications about the reply.

Chris wrote:

Geogle wrote:

Thanks to all help with ascii schematic, here are the figures again. In the DMM, I assume that HV probe is protected with respect to the Probe GND. But GND itself is not protected from the supply gnd. So adding the zener/filter cap must be good enough to protect the whole thing. Caution has to be taken to see that the >> entire thing is treated as a live circuit. In that way the battery thing may be more dangerous thing because changing the battery means, in case you forget to disconnect the probe you are in danger. (Just a thought!).

First Picture:

```
. DANGER HIGHVOLTAGE
.
.----- .-----
. L || 9V || Probe HV
.-----
. |||
```

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```
. ||| 7107 Mtr |  
. MAINS | 9 V |||  
. | Supply |||  
. ||||  
. || 0 | Probe GND  
. -----|-----  
. N -----' '-----'
```

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Second Picture:

```
. DANGER HIGHVOLTAGE  
. .  
. ----- .  
. L || 9V || Probe HV  
. -----  
. ||||  
. ||| 7107 Mtr |  
. MAINS | 9 V |||  
. | Supply |||  
. ||||  
. || 0 | Probe GND  
. -----|-----|-----|-----  
. N -----' | '-----'  
. ||  
. | Elec. Cap |  
. | \ |  
. |-----|]-----|  
. | / ]+ |  
. ||  
. ||  
. ----->Z-----|
```

Zener

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Third Picture:

```
. Equivalent Circuit.  
. .  
. .  
. L  
. -----||  
. ||  
. | Leakage Cap | Leakage Cap
```

Re: Multimeter damaged when powered from regulated power supply.

```
. -----.
. -----.
. ||
. ||
. ||
. GND || GND
. ||
. ||
. |+ |
. === z Zener
. /-\ A
. ||
. ||
. ||
. N ||
. ----- |.
```

On The assumption that HV Probe is already protected in DMM

Additional protection only for Probe GND with respect to Supply GND

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Hi, Geogle. Thing2 and Thing3 won't do the job -- you'll still damage your meter.

1) Your 9V power supply is not sufficiently isolated from the line unless you've got a transformer with electrostatic shield.

What is the likely values of (or the range) of the leakage cap the resistance that may come in series here ?

2) There is no direct meter internal connection between the 9V battery negative and the meter negative probe. You're just adding another problem by connecting the two with a cap and zener.

I checked the 7107 data sheet and one of the inputs are usually connected to the ref. voltage, and is at a voltage between 0 and +ve supply. How will the input circuit get damaged by the addition of a zener that prevents the input swinging below and above the normal supply ? (Remember the DMM is exclusively used for this purpose, and the live and neutral are connected carefully to the appropriate inputs.) Or for that matter what is the likely source for problem from

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addition of the cap ? (I guess the neutral, unless gets accidentally connected to live, is not going to take the input above or below the ref. voltage the input is having. Only the live is going to take the HV probe swing to the line voltage – Am I not correct ?)

3) Most cheapie meters can be damaged by applying line voltage to the probes with the battery disconnected, or with the battery power off. Since it takes anywhere between tenths of milliseconds and a few milliseconds for the input filter cap of your 9V supply to get charged up by the transformer, you're leaving yourself open to meter damage there, too.

I quite agree with this. In fact one of the problem is inputs getting powered before power filter caps reaching a suitable +ve voltage.

One likely solution is to add NiCad battery on the unregulated side through a diode and provide 30mA or so charging current from the unregulated input. That way the batteries are likely not going to be low – unless power goes off for a long time.

Other problem is surge in supply (not the case at HV probe side). Both are not handled by the suggestions I had.

One of life's ancient principles is that you may not always get what you pay for, but you always pay for what you get. Line-powered bench DMMs cost more than battery-operated handheld DMMs for a reason, and it's not just more accuracy.

If you open up a good benchtop DMM or look in the service manual, you'll see that quite a bit of care has been taken to provide good isolation between the line and the meter circuit power supply. You'll also note that most bench DMMs specify a maximum voltage between the probes and GND (usually between the negative probe and GND).

Many benchtop DMMs also have input circuitry that presents a high limiting input impedance when they're unpowered.

Let's look at this from a cost standpoint, which is where I think you're coming from. Using the Digi-Key catalog, I find that an Energizer 9V Industrial Alkaline battery will cost \$2.34 for 625mA-h at 9V. Six "D" Industrial Alkaline batteries in series will cost \$8.28 for 20,500 mA-h at 9V.

According to this measure, you'll replace the 9V batteries 32 times for each replacement of the 6 "D" batteries. Of course, the mA-h ratings

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for both are based on a 25mA load, and the mA–H ratings are for drawdown to 60% of nominal voltage. Both of these would favor the larger D battery, and I'm sure the actual replacement ratio will be somewhat lower than 32:1. The cost ratio, though, is only 3.5:1. 9V batteries are a relatively expensive way to run something. You'll easily save over 80% of the cost of running the meter by using 6 D batteries in series. If you've got an old 7107–based meter that uses a several mA, you'll be replacing batteries twice a year at worst. Most of your job is done easily.

To do this relatively safely, start by snapping a 9V battery clip with flying leads onto the 9V battery clip in the meter (note that red and black will now be bass–ackwards). Drill a small hole in the meter battery cover to allow the flying leads to be snaked through (you can later fill this hole with epoxy if you want to return the meter to regular service).

Purchase a thermoplastic (NOT metal!) project box bigger than the meter, and also purchase two 3–cell D battery holders. Mount the battery holders in the box, and drill a hole for the meter wires such that the wires will fit through when the meter is affixed to the box. I lined it up so the bottom of the meter was flush with the bottom of the project box, so it could be stood up on end for visibility. I also mounted a small stand on the bottom of the box to keep it from tipping over (the D batteries tended to make it a little top–heavy).

Now either use epoxy glue or ty–raps to affix the meter permanently to the project box. Install the 6 D batteries. Screw closed the cover on the project box. Turn the meter on. You're done.

I've been where you are now. This works.

And this setup with the meter and plastic project box is just as safe as the meter with the manufacturer–recommended 9V battery, if you know what you're doing with electricity. You wouldn't try to replace the enclosed battery on a meter while it's measuring line voltage either way, no matter what some might say. Other than that, it just looks kind of clunky.

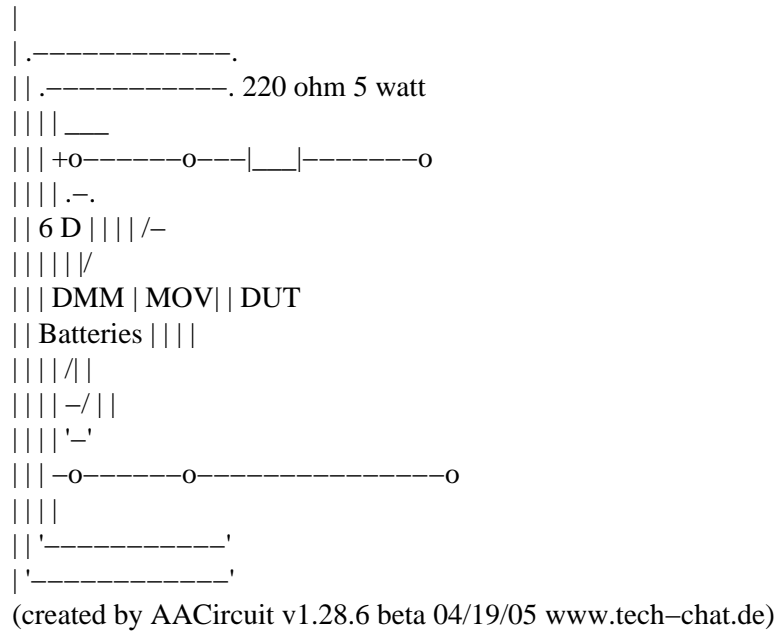
Standard legal/moral/ethical disclaimers apply. Affix a visible warning on the meter/plastic project box stating that hazardous voltages may be present inside, if you so choose, or if you're dealing with fresh grads who don't know which side of the soldering iron is hot.

And if you really want to work hard to protect your cheapie meter, use a series 220 ohm 3 watt wirewound in series with the red probe, and place a line voltage rated MOV between the red and black probes.

would a 220 ohm really give protection ? – won't the peak current

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exceed 0.5 amps, enough to damage the meter ?



Good luck
Chris

Thank again!!

Hi, Google. Very briefly:

1) Interwinding capacitance for a standard transformer (between primary and secondary) is usually in the range of 10 to 33pF. It's a lot less for some transformers, which advertise low capacitance. For 60Hz, that's a very high impedance, but when you turn on the switch or turn on power, the rate of rise of voltage is very high, so you can get enough charge squirted into the secondary to damage a CMOS chip like the 7107.

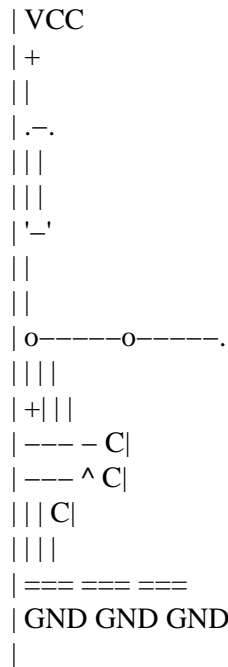
2) I'm just telling you what worked for me. The test stations I constructed were in operation for several years. By the time we gave up on trying to save money on 9V batteries, we had already smoked enough meters to pay for a lot of batteries. Of course, meters are a lot less expensive these days and alkaline 9V batteries are relatively more expensive. But we would have been better off just starting with our final solution, which was just going with 6 "D" alkaline batteries in a plastic box mounted to the back of the meter.

3) If you decide to go with your line-powered 9V supply, you can use a

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delay-on relay to ensure you've powered up first, like this:



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You can use a 5V DPDT relay, and choose your R and C values appropriately to have the DPDT relay connect the voltage to the leads only after meter power up. But I can tell you that reduced, but didn't solve the problem when we were doing it. We still had meters blow up, but they smoked when the relay closed rather than at power up. Remarkable waste of time.

Just out of curiosity -- what are you doing here? Cheapie DMMs drift, they only take readings once a second, and they are remarkably unresponsive to anything even approximating a real-time event, excepting $I * R$ voltage drops in the line from heavy loads. Also, you have to have somebody looking at them all the time.

Is it possible you have a DMM connected with RS-232 to a PC for automated data collection? If so, you definitely need optoisolation between the DMM RS-232 and the PC for any line voltage measurement. That will definitely fry your meter. But that's another story.

Good luck
Chris

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