



# Perseverance Tracks Down Some Odd Problems

## PN Junction = Photodetector

Recently, I added a swing-arm incandescent light to my workbench. There is nothing like a little extra illumination to aid in tracking down circuit bugs, or so I thought.

One day I was looking at a high-voltage power supply that I had been working on earlier. The supply bucks up the voltage from a 9 V battery to about 400 V and is regulated by feedback through Zener diodes. It had been working perfectly and now it exhibited a strange "hand effect." As I moved my hand in the vicinity of the circuit, the voltage would vary between full voltage and a hundred volts or so. I had certainly seen the hand effect come into play with antenna tuners and regenerative receivers, but a power supply — what was going on here?

I thumped and tapped every component, resoldered connections and even replaced the transistor in the feedback path. No change. I decided to give up for the day when I switched off the desk light and the voltage shot back up to 400 V! Light on, light off, light on, light off... it only took a few minutes to eventually cast a shadow on the Zener diodes and isolate the problem.

The Zeners are glass encapsulated, and in this particular circuit they are only passing a microamp or less. Light hitting the reverse-biased PN junction lowered the effective series resistance (photo conduction), which increased the feedback and reduced the power supply output voltage.

When photons impinge upon the hole/electron pairs along the PN junction, it causes them to separate. The resulting ionization creates a net *current* proportional to the illumination.<sup>1</sup>

Figure 1 shows a simple test setup that demonstrates the effect. If you are using an auto-ranging digital multimeter (DMM), set it to a fixed range (either a high-megohm or a low voltage range with a  $10\text{ M}\Omega$  input impedance). When the Zener is *not illuminated*, the indicated resistance will be very high and the voltage will be close to zero.

<sup>1</sup>Reference Data for Radio Engineers, Howard W. Sams, 6th ed, 1975, Ch 19: Semiconductors and Transistors, p 19-6.

*Illuminating* the Zener should cause the displayed resistance to drop to a megohm or less and the displayed voltage to increase to  $-300\text{ mV}$  or more. I obtained similar results for both a 1N4762 (82 V Zener) and a 1N966B (16 V Zener) that I happened to have available.

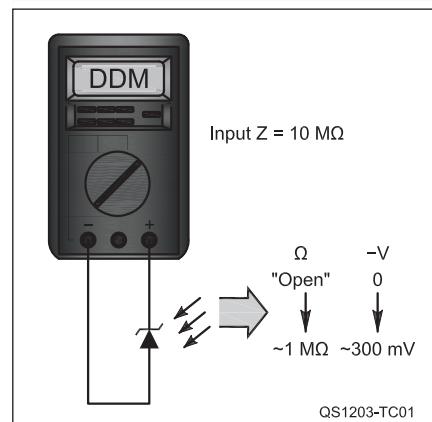
Note that the illuminated Zener diode PN junction is a current source, not a voltage source. So, the roughly  $300\text{ mV}$  displayed by a  $10\text{ M}\Omega$  input impedance DMM is the result of the junction generating  $30\text{ nA}$ .

This effect is not limited to glass encapsulated diodes. Transistors housed in metal cans may have a glass seal that can admit light, possibly resulting in spurious operation. I tested a 2N2102 bipolar transistor in a TO-39 metal case with the circuit shown in Figure 2. With no light, the meter read near zero; exposing the base to a 100 W bulb several inches away caused the reading to increase to roughly  $200\text{ mV}$ . The base of the TO-39 is all metal except where the base and collector leads exit through glass seals roughly  $1/16$  inch in diameter. — 73, Barry Shackleford, W6YE, ARRL Technical Advisor, [w6ye@arrl.net](mailto:w6ye@arrl.net)

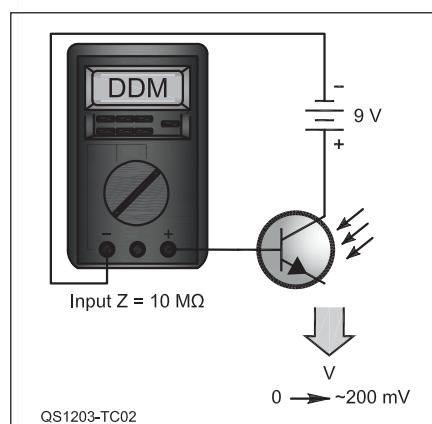
## A Ham Radio Detective Story (Finding an ODD RFI Source)

Starting around the holiday season of 2010/11 I experienced a puzzling problem at my station. I began to receive reports that there was some extraneous noise on my transmitted audio signal. Sometimes the noise would disappear when I switched from my homebrewed headset adapter (May 2009 *QST*) to the stock hand microphone for my ICOM IC-706 Mk II G.<sup>2</sup> Sometimes it would vanish completely for a few days, only to reappear, usually at some inopportune time like the start of a net. Since I was usually the net control station, this caused me plenty of aggravation and embarrassment.

With lots of helpful suggestions from my fellow hams, I began to try to track down the source of the noise. Initially, I did not believe it could be a problem with the headset adapter, since I had been using that design successfully for several years. I found some problems with the extra fan I had mounted on the heat sink of my IC-706, so I removed the fan and the noise disappeared. My satisfaction was short lived because a few days later, the noise came back. Someone suggested that it might be the tuner control cable or the



**Figure 1** — Simple test setup to illustrate vulnerability of glass-encapsulated Zener diodes to ambient light. Dim light will show an open circuit and close to 0 V, while the light from a 100 W bulb several inches away can drive the indicated resistance to less than a megohm and an indicated voltage to more than  $-300\text{ mV}$ .



**Figure 2** — A 2N2102 bipolar transistor housed in a TO-39 metal case shows sensitivity to light entering through glass seals around the base and emitter leads. In dim light the meter read near 0 V, while light from a 100 W bulb several inches away increased the reading to roughly  $200\text{ mV}$ . Note that the input impedance of the digital multimeter will affect the magnitude of the reading.

<sup>2</sup>Geoff Haines, N1GY, "A Cell Phone Headset Adapter for Amateur Radio," *QST*, May 2009, p 40.

AH-4 tuner (remotely mounted on the base of my flagpole vertical antenna. I had the AH-4 checked by a professional technician (Steve Senft, KG4LJB), and it came back with a clean bill of health. I checked the control cable for shorts or broken wires, but that was fine. What now?

I sent the IC-706 out to Steve as well, and he tuned the radio up so every possible parameter was within the factory specs. The noise continued. Then I realized that I had installed a new LCD flat screen TV and the set top box almost right next to my radio stack. The TV and set top box were banished to the far side of the room. The noise then pulled a vanishing act for a few days before returning.

The only thing that kept my radio station on the air was the fact that the stock hand mic did not seem to have the problem. Being used to my featherweight cellular headset, using the hand mic for nets was a real chore. I realized that the hand mic probably had a lot more circuitry devoted to filtering than my headset adapter did, but I was still doubtful that the problem was internal to the adapter. I have been using this same adapter for several years with universal reports of great audio and clear signals.

At the end of June 2011, the “rainy season” commenced here in Florida. Rainy season is kind of unique to central Florida. Each afternoon, the sea breeze from the West coast meets the sea breeze from the East coast of the peninsula. This causes afternoon thunderstorms, which are epic. Fortunately, they tend to be brief.

At this time our house began to suffer from

power outages. Each time the power went out, both the main 150 A breaker inside the power distribution panel and the 150 A breaker outside, under the electric meter would trip. Also the 50 A breaker for the air conditioning would trip. After they were reset, everything would be normal until the next outage, which might be days away or mere hours. This always seemed to coincide with rainfall. No

other circuit breakers were affected. My son-in-law, who is a pretty good journeyman electrician, came over and we decided that the main breaker out on the pole under the meter might be age-weakened since it had been there since the mid 1970s. He replaced it, and I found out just how expensive big circuit breakers can be.

This did not solve the problem with the outages. Since the air conditioner seemed to be affected along with the main breakers, I called the company that installed the unit and also provides routine maintenance for it. They sent a technician the next day. He was doubtful about the AC causing the outages, because the unit checked out fine, but he agreed to run some tests on the power feed to the air conditioner. What he found amazed both of us.

Between the AC unit and the breaker on the distribution panel in the house is what is called a T-handle shut-off. This is installed on all AC units, at least here in Florida, so that the serviceperson does not have to have access to the house to service the unit. He or she just pulls the T-handle and power is

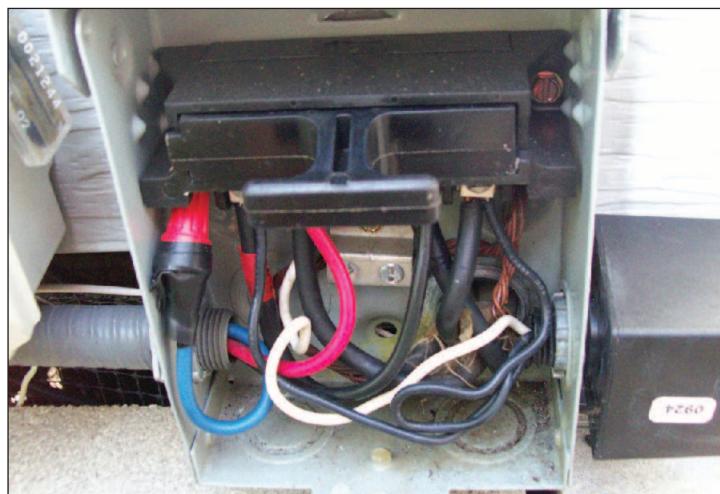
disconnected from the unit, making it safe to work on. Inside our T-handle box, there are also connections to a surge protector and a control box supplied by our electric utility that allows them to shut off our AC temporarily to avoid brown-outs during the summer. We get a slight discount for the flexibility this provides the utility.

The problem was that between a wire nut that had come loose and a ground wire from the 240 V cables that was too close to the neutral

and/or the hot wires in the same cable where it enters the shut-off box, fate had created a crude “spark-gap transmitter.” See Figure 3. When the weather turned damp, that slight arcing would turn into a full blown power short, and the breakers would trip. When the weather was less damp, the arcing simply created an RF generator that was then passed through the power distribution panel about 24 inches away from my radios.

The moral of this tale is self-evident. Do not ignore possible sources of interference just because they are not in the immediate vicinity of the radios. Before this episode, I never would have thought that an intermittent short circuit in the air conditioner power feed could cause all the problems it did. I would have expected the short to simply defy any attempt to turn the power back on. I also would not have thought to look outside of the house to solve a problem only noted on my radios for several months. These things can and do happen. Keep an open mind when trying to solve RFI problems.

With the “spark gap transmitter” permanently shut down, two problems instantly disappeared. We no longer suffer power outages that don’t affect anyone else in our neighborhood and my transmitted audio is now free of extraneous noise. Plus, I am again able to use my little cell-phone headset and run my nets in total comfort. Yippee! — 73, Geoff Haines, N1GY, 904 52<sup>nd</sup> Avenue Blvd W, Bradenton, FL 34207; [n1gy@arrl.net](mailto:n1gy@arrl.net)



**Figure 3** — Here is the T-handle shutoff that caused all the problems. The arcing was occurring between one of the large black wires (center right) and the bare ground wire just to the right of that. The wire nut had also fallen off the blue wire (center left) and it was intermittently grounding to the box. The red and blue wires are connected to the utility company’s control box. The blue wire is not connected to anything since it is apparently used for a different device, which we do not have.

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