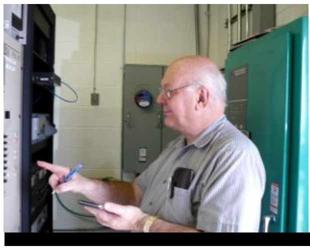


The

Broadcasters' Desktop Resource

www.theBDR.net ... *edited by Barry Mishkind – the Eclectic Engineer*

The Maintenance Shift

Testing Your Solid-State Rectifiers

By Gary Minker

[June 2010] With the fast-paced marvels of digital technology installed in virtually every device around us today, the solid-state rectifier is still the primary source which makes virtually all things go, and any decent technician must have a good working familiarity with them. Gary Minker shows how to test and diagnose some of the common problems that can arise in your power supplies.

In a world where direct current reigns supreme, power supply designs have evolved from brute force to switching bridges, and filters now provide high frequency, low-ripple modes – modern rectification of the alternating current from the primary line supply gives a new meaning to the old term "constant voltage."

Experienced technicians may vaguely remember their experiences with the forerunners of today's silicon rectifier devices. Glowing in the dark, hot cathode tube and mercury vapor type devices introduced many to the world of direct current. Lengthy warm-up times made instant use impossible. Filament driven rectifiers required undesirable (by today's standards) operating characteristics to insure proper operation. Vibration and extremes of cold wreaked havoc on these devices among other constraints.

Any failure to follow the proper care and feeding of these devices no doubt meant early failure, X-ray radiation, and replacement. Though still in limited use today, these early devices have lead the way to Selenium, Germanium, and finally the modern p/n junction and the silicon controlled rectifiers of today.

TEST OR REPLACE?

Consumer level products often must yield to the economic pressures which dictate a throwaway style of replacement parts and entire assemblies – repair is warranted only under the most unusual of circumstances. While typically generic in specification, these silicons are readily kept on hand in just such a situation.

Of course, test bed time and diagnostic interpretation can be costly. Testing a suspect defective silicon and subsequent reinstallation or replacement falls under economic guidelines. Timely decisions can usually be made to continue testing or to simply "shotgun" the circuit with on hand parts - this decision often influenced by the lack of sufficient parts to effectively "shotgun" the circuit.

This leads back to the pressing need to efficiently and most importantly, accurately diagnose a problem and its suspect defective devices, so that only the defective devices may be replaced with parts on hand. In applications where effective, accurate testing and diagnosis of the suspect components is required, there are many avenues of support. This includes professional and industrial grades of technology which mandate the sophisticated testing and repair due equipment of this caliber.

Eventually you will find yourself troubleshooting a piece of gear where you will need to know if the solid-state rectifiers are working correctly. Testing does not have to be rocket science; some basic equipment and common sense is all you need for most situations. Indeed, as we shall see, while digital and analog meters are helpful, the old Lissajou trace still reigns supreme.

PASS OR FAIL?

After the big box has blown the breaker off the wall for the N^{th} time, and the situation has become painfully obvious that the power supply problem must be effectively diagnosed, the suspect silicons may be more easily examined if at your earlier convenience you have developed a set of look up charts, tables and Lissajou traces outlining the assorted devices incorporated into your equipment. This preventive maintenance exercise will give the technician a greater level of understanding in normal operation of a device while allowing him to remove the suspect components and examine them based on these previously developed charts and photographs of the curve traces of the junctions within the device.

These charts or graphs should contain these parameters:

1. Forward breakdown voltage
2. Expected normal milliampere flow at a given forward voltage (both above breakdown and below breakdown)
3. Expected normal reverse bias milliamperage (below peak inverse voltage - PIV) yes, some diode stacks do have a resistive reverse flow.
4. Reference Lissajous traces of junction activity at repeatable parameters (curve traces).
5. Forward bias resistance or diode function test readings (Ohms voltage drop).
6. Reverse bias resistance readings (Ohms) (yes, they are different).
7. Capacitance measurements of device in forward and reverse bias.

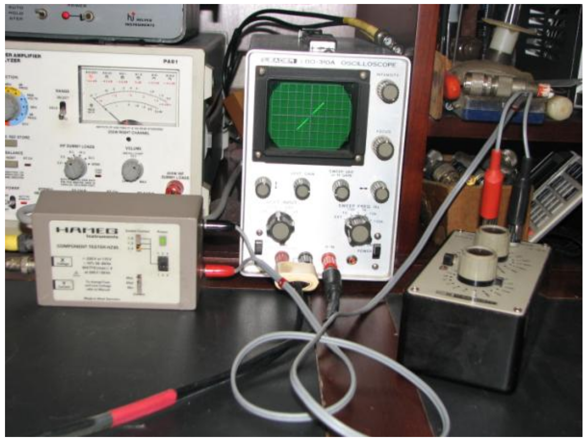
It is important to remember that in-circuit testing of these devices is seldom reliable. Many of these tests are "bias polarity" sensitive and will not give a valid or reliable reading if performed in-circuit.

Each class of device will respond differently to these suggested graph and chart references. While all diodes will respond to the forward breakdown test, some require special test jigs or higher voltage equipment. All diodes will exhibit predictable forward milliamperage flow at a given voltage, though some require test equipment capable of generating hundreds of Volts.

Each device will exhibit a predictable milliamperage flow in a reverse bias condition as long as the PIV is not exceeded. Great care must be observed where zener or regulating silicons are in use. These devices will not conform to the usual p/n junction testing rules.

Optical (Lissajou) comparison of a junction's activity is often the best diagnostic aid. The behavioral characteristics of a junction are easily and completely observed at varying voltage and amperage ranges when displayed on a CRT or LCD screen.

The subtle curve changes that may be glaringly obvious when displayed as an optical anomaly on an otherwise linear curve would probably go undetected when tested by any other analog means, such as an Ohm meter.



A typical test setup

Zener devices are best tested via a curve trace/Lissajous unit, and suitable capacitor leakage test meter. The "diode test" function incorporated into many of the more modern digital meters will give a very accurate indication of the actual voltage conduction point of the junction under test for non-stacked units. This reading should be repeatable from device to device. In the case where a device under test deviates from this norm, a red flag should wave vigorously.

With the incredibly high resistance readings possible with modern test equipment, this category pays particular attention to resistor-equalized, stacked device arrays. In most cases the reverse bias milli-amperage and Ohmic readings will give the proper look up chart data for these devices under test.

However in these resistor-equalized cases this is an important indication of an open equalizing resistor which will certainly cause an almost immediate subsequent failure in the stack, and in the same diode position. Capacitance measurements will provide reliable and repeatable references in resistively unequalized high voltage devices in both bias polarities. These forward and reverse readings would be distinctly different.

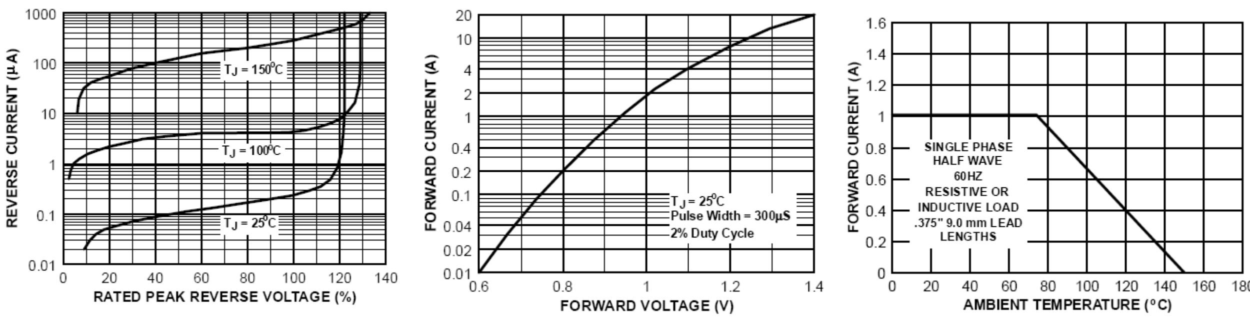
A stacked diode assembly

Equally important to these look-up charts and tests is a visual inspection. All too often the engrossed technician will overlook the obvious when trying to examine a defective circuit or diode stack.

Under test conditions, depending on the type of capacitance tester, lower voltage devices will display a shorted condition indication when tested in one or the other bias mode. Only one repeatable capacitance reading will be provided. As you go along, you will see each type of diode device will have an anatomy of its own which can be easily used to identify good and bad components.

LOOK-UP CHARTS AND GRAPHS

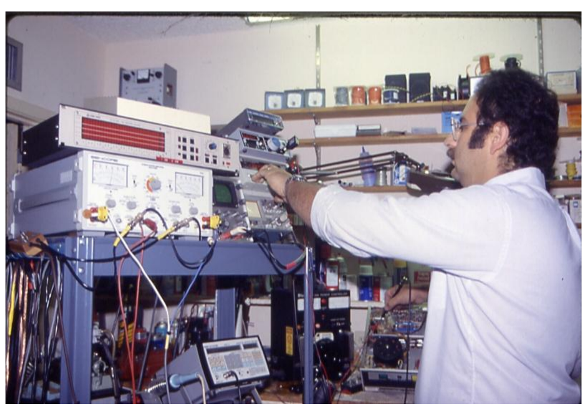
The following charts are given to demonstrate the predictable behavior of a typical silicon diode model 1N4001



CRASH CART

Time is of the essence may be an old adage but in the realm of efficient diagnosis it is all too true.

Nothing is slower than having to dig for each piece of test equipment. Even if it is just sitting on the shelf, having to hook it up, power it up, and integrate it with any other support device all takes time that you may not have to spare. In an active service environment where the broken equipment does not always come to you, you must more importantly go to the equipment. Enter: the Crash Cart.



The Crash Cart

This tremendously impressive display of gauche industrial blinking lights and numbers will typically save 45 minutes of setup time. And the integration of the required test instruments within the framework of the cart makes unusual and off the wall testing possible with very little reconfiguration.

A good example is to be able to easily test an SCR though disconnected and still mounted, while simultaneously watching the gate voltage on the scope and or digital meter. Not to mention you are monitoring the gate in reference to either anode or cathode. The apparent benefit of the well equipped crash cart is only too obvious.

For your review, the cart pictured, tailored to a combined audio and R.F. environment, is equipped with the following pieces of equipment and more.

- Dual-trace scope.
- Scope for curve trace function.
- Digital meter.
- Spectrum analyzer (audio).
- Mono/stereo multiple input RMS reading voltmeter/Watt meter (audio).
- Frequency counter.
- Audio frequency generator/digital dBm meter.
- Power line disturbance monitor audio distortion analyzer solder sucker soldering station SCR test adaptor capacitor/inductor test meter.
- Arc gap tester.
- Grid dip meter.
- Headphones.
- Vise.
- Test leads (customized for ease of test on in plant studios and equipment) impedance meter.
- As each situation dictates, other test instruments should be available.

ADAPTIVITY

In the test environment, adaptivity is the key to intuitive diagnostics. Before the age of measurement isolation systems, (voltage, current, pressure, infrared thermal sensing and, imaging) the test environment was predominantly referenced to ground. Those test fixtures and meters would only read a parameter referenced to ground.

Many of today's technicians have been engrained that this early basis for test is the most proper avenue of diagnosis. While this is very true in some respects, the adaptivity of today's new test instruments give a new twist to measurement techniques.

While a good ground is important for safety, new isolated input, and battery powered test meters allow the technician the freedom to measure or view a test point not referenced to ground but from one gated or stacked level to another, as long as the voltages are within reason. Silicon controlled rectifiers and industrial Triacs are the best example of junction devices that are triggered or "fire" in more than one mode. Isolated measurements of the elevated test points will often give the key to a trouble spot in these circuits. You can actually measure across the device and determine the voltage drop and other characteristics as compared to other brother devices.

Adaptations coming from circumstance motivated tests would include, directly reading the voltage drop across an active rectifier element, or hanging a battery powered, insulated scope across the same rectifier or other control silicon device, and actually observing the junction operate. Adaptive testing with the proper and safe test equipment will save much diagnostic time, especially where test equipment resources may be limited.

Now that you know the basics about what it takes to get ready to trouble shoot solid-state rectifiers, it is time to put all that to use. We will should you how in our next article, coming along shortly.

- - -

Gary Minker is president of Radio Works RF Consulting, in Lake Worth, Florida. He can be contacted at gary@radioworksrfconsulting.com or (561) 969-9245.

Want to know when the next part is published?
Take 30 seconds and sign up here!

Return to The BDR Menu