Operating Manual for the CurveBug

Guide to Usage and Theory of Operation

11/11/25

Introduction

The CurveBug debugging hardware is a simple but effective tool to help find faults in modern, arbitrarily complex circuit boards. This manual provides an in-depth guide to the use and theory of operation of the CurveBug, ensuring users can maximize its potential.

As a design engineer, I was once tasked with helping my company's technicians as they were trying to find root cause to product failures. In this case, the firm assembling the PCAs were not up to the task of consistently building our product. Merely claiming that the failures were due to poor workmanship was not a strong enough argument. We had to find root cause of the failure on quite a number of units. Our technicians best tool at the time was a microscope. They would laboriously examine the boards to find the workmanship issues. This really wasn't getting the job done… the faults were just too random. I got pulled into the issue. I really didn't want to debug hundreds of boards. What was needed was a tool to find faults quickly without extensive knowledge of the inner workings of the product.

Faults on a circuit board have relatively few causes. Bad assembly can result in open solder joints or solder bridges. Or, in extreme cases, missing, mis-aligned or wrong parts. Field failures are generally a result of over-stresses electrical or thermal. Corrosion or physical breakage are pretty obvious to examination. All of these leave measurable traces on the circuit board. A time-honored technique is to use a curve tracer on an un-powered board to hunt for anomalies. But these are expensive beasts, fussy to operate and easily liable to damage the circuit if mis-used. An idea emerged to make a simple and safe debugger based on the curve tracing concept.

Overview of the CurveBug

Modern circuit boards are predominantly using CMOS circuitry. In nearly all cases CMOS chips have diodes on all their pins that provide a conducting path to the ground for any stimulus that goes below -0.6V. A negative potential applied to most any node on a circuit board will see some amount of current flow. A multimeter's diode checker can be used to get some idea of a circuit node's characteristic by applying the positive lead to the board's ground and the negative lead to the nod. By itself, this multimeter measurement is quite helpful in comparing a known good board and a faulty one. If you simultaneously probe the voltage/current relationship (curve) of good versus bad, you get even more insight into any differences between two circuits. In many cases you may have multiple identical circuits in the same product. For example, a stereo amplifier with one channel faulty can be compared to the other. Data bus lines should likewise match.

The CurveBug will drive a weak signal onto the tested devices. In standard mode this doesn't exceed 700uA, and in weak mode 30uA. The CurveBug common is connected directly to the controlling PC's ground. ESD hazards to the tested devices are thus mitigated. Do remember to only test devices that are unpowered.

The CurveBug's data is displayed on the screen of a Windows PC by the provided software. All source for that software resides at https://github.com/rbep/CurveBug An alternative set of software has been written in Python that is claimed to run on Linux, Mac and others. If you want to go down that path, the software is available at https://github.com/SaxonRah/PyCurveBug.

Using the CurveBug

Setup and Installation

To begin using CurveBug, follow these steps:

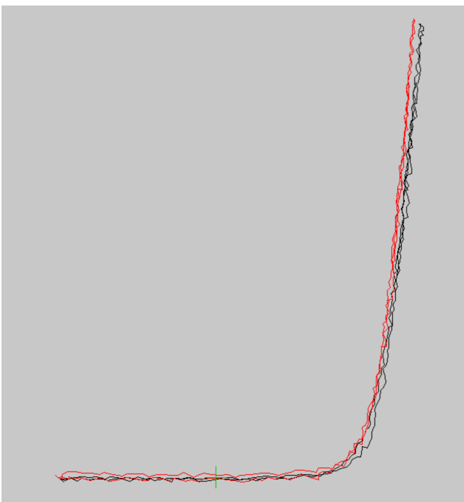
- Install the software on your PC (Windows 10 or 11). Just run the installation package "CurveBugInstaller.msi". This is available from the Vintagetek website at: https://vintagetek.org/curvebug/
- Connect CurveBug to your PC's USB port. It needs a USB-C cable. Your PC will generally give off it's hardware-connected sounds.
- Run the CurveBug software. You'll see the version numbers of the PC software, the CurveBug hardware and CurveBug firmware. The serial number of the hardware is also displayed. If the PC software can't connect to the hardware you'll be warned.
- Go find 4 appropriate banana-plug test leads. Two banana to clip lead and two banana to probe cables. This should illustrate the idea.

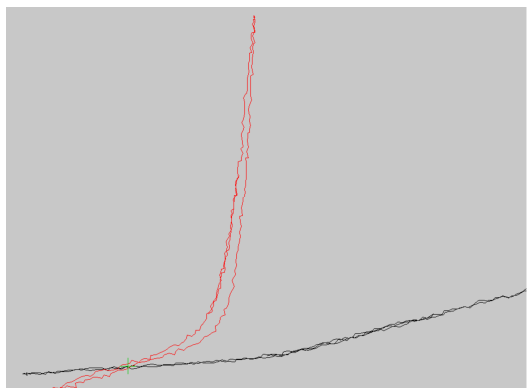
Connecting to the tested Device(s)

Important: Make sure that your tested device is un-powered. The CurveBug is not intended to attach to devices that could put power into it. Furthermore, your controlling PC can be spoilt by current passing from the device through the CurveBug into your PC's USB port.

With the banana-to-clip cables connect the grounds of the tested devices to the center jack of the CurveBug. If in doubt about the location of a ground on the tested devices, look for metal shields or the metallic shell of a connector.

With the two probes touch corresponding circuit nodes on the two tested devices. You'll see something like these (the left is a good match, the right is suspect).





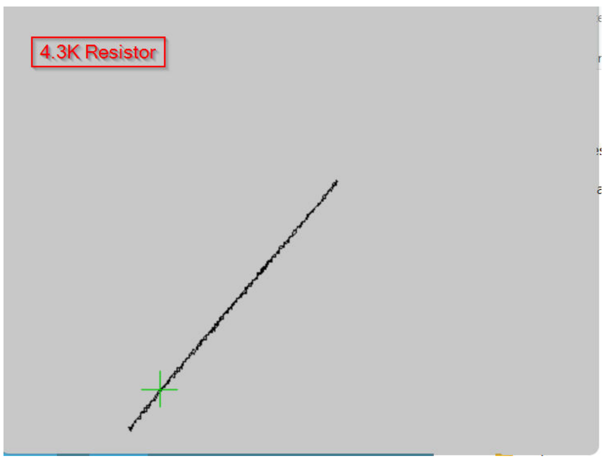
If the black and red curves correspond closely, then more probing is needed to locate the anomaly. Once you see something like the curve set on the right, then you're on to something.

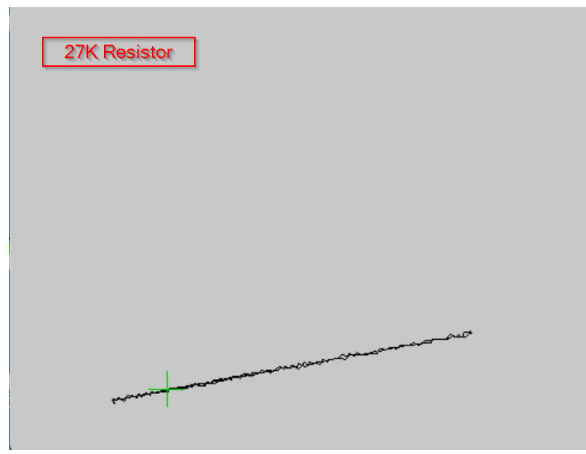
Interpreting the curves

First, the graphs are reversed left-to-right and up-to-down. Leftward on the graph is increasingly negative voltage. Up is increasingly negative current. It just looks better.

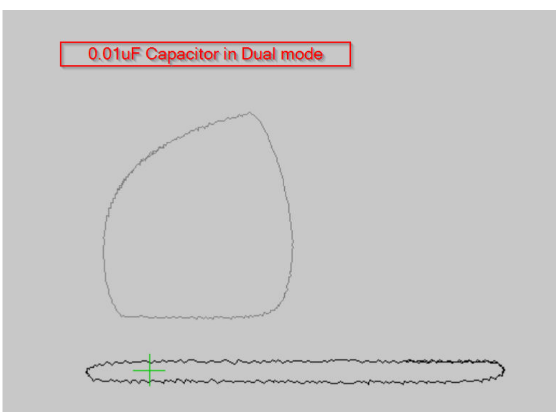
The green cross hair in the lower left represents the origin, zero volts, zero amps. Thus a horizontal line through the origin is an open circuit, a vertical is a low impedance or short to ground.

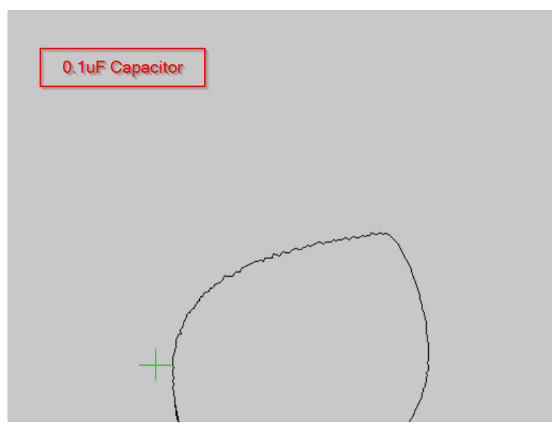
Resistors result in a diagonal line through the origin.





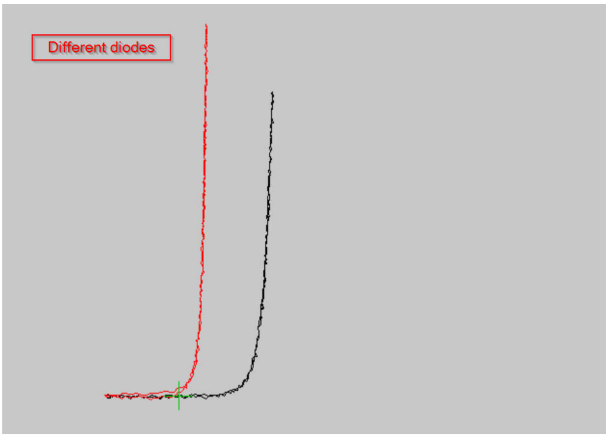
Capacitance results in an opening up of the curves. Here are some curves from capacitors



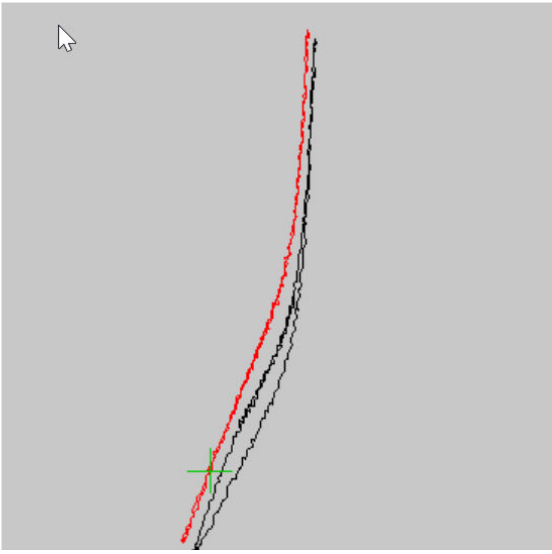


As you move the cursor over the graphs, you are shown the voltage and current corresponding to the cursor position. If the cursor is off the graph surface, the number of completed scans is displayed. As this is primarily a heuristic device, the accuracy of the readings can be off by a few percent. In dual mode, the cursor measurement are of the primary graph.

Implicit diodes abound in CMOS circuits Here are a couple of different diodes. The red curve is a 1amp rated diode (1N4004) and the black is a signal diode (1N4148).



In circuit you get combinations of these characteristics. Here are a couple of samples:



Additional controls

The PC keyboard lets you access a few options to your scan.

- SPACEBAR – Cycle between 4.5Kohm excitation, the weaker 100Kohm and alternating between the two.
- P – Pause scanning. Hit any key to resume.
- S – Single channel. Black trace only. Useful for writing the manual.

Caveats

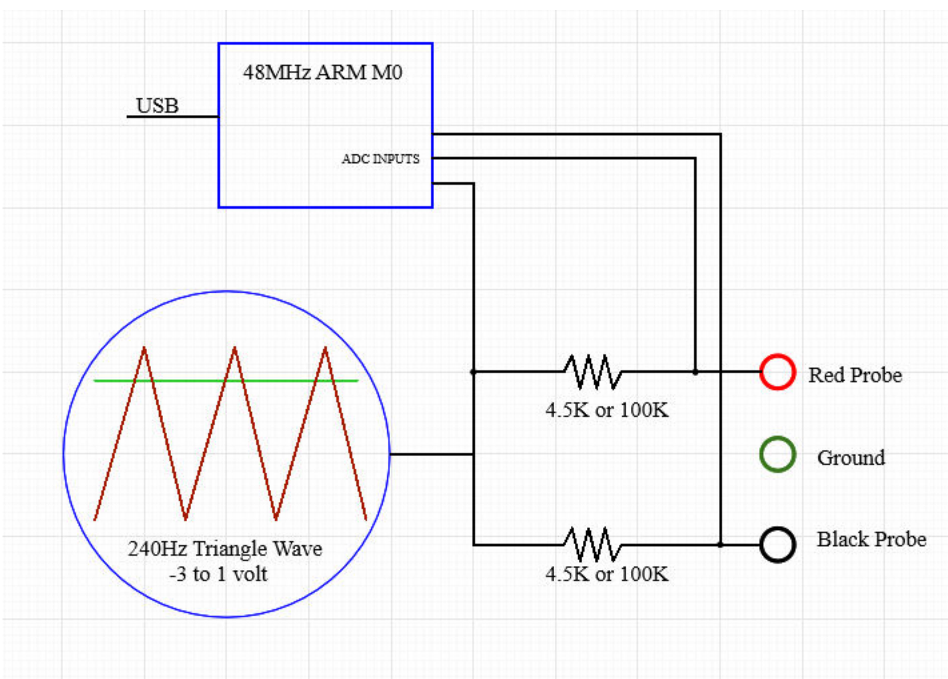
If there has been a part substitution or a significant shift in the fabrication of semiconductor parts, then you may see differences that aren't important.

Theory of Operation

Core Principles

A 240Hz triangle wave is generated that oscillates between -3 and +1 volts. This is applied to the tested circuit through selectable 4.5Kohm or 100Kohm resistors. The voltage across the resistors is used to determine the current. The drive voltage and currents are then digitized in an ARM MCU and the data is captured and sent to the controlling PC at its request for a scan. Every scan consists of 1008 samples or 336 graph points for each of the two channels. The scan is asynchronous to the un-interrupted operation of the oscillator.

As diode curves are typically shown in a positive-is-conducting style, the PC software inverts the X and Y axis to make the curves more familiar.



Specifications

Circuit excitation: 240Hz triangle wave, ranging from -3V to +1V

Current setting resistance: 4.5Kohm in high range, 100Kohm in low range

Power input: 5V from USB @ 18mA

Sampling: 336 sets of 12 bit data of one common voltage and two current channels per scan

Embedded Microcontroller: ARM M0 @ 48MHz

Troubleshooting

There are USB cables that are only for charging devices. These cables will not allow data transfer between PC and Curvebug. You may wish to test your cable's ability to connect a known good device, e.g. a cell-phone, to see if your USB cable provides data and power connections.

Units prior to serial# 107 will not be powered when connected to a USB-C port on your computer. You must use a USB-A port on your PC. Or USB-C to USB-A adapter, followed by a USB-A to USB-C cable.

One annoyance is that most voltmeter banana-to-probe cables are designed for maximum safety in voltmeter applications. To use these, you have to cut off the plastic sleeve that hides the banana plug.

Conclusion

We certainly hope that the CurveBug is a useful addition to your electronics diagnostic toolbox.