Curve Tracer

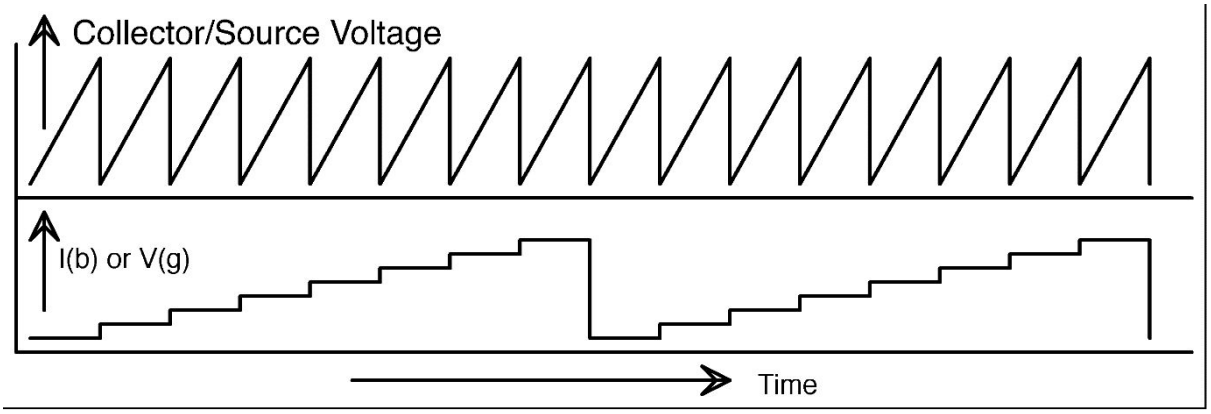
Introduction

A semiconductor curve tracer is a piece of electronic test equipment that is used to analyze the DC characteristic curves of discrete semiconductor devices such as diodes, transistors, and MOSFETs. Current-Voltage Characteristic Curves of electrical devices or components consist of a set of graphical curves which are used to define its operation within an electrical circuit. Apart from pedagogic purpose, curve tracers find an important application in Parametric Characterization of semiconductors, detecting defective components, quality control and component matching. It contains various waveform generators to stimulate the device under test (DUT) and thus, trace their current or voltage values on a single plot, independent of time. The concept of semiconductor curve tracer was implemented using a counter, a Digital to Analog converter and a difference amplifier with additional circuitry as a very low cost yet a reliable solution.

Description

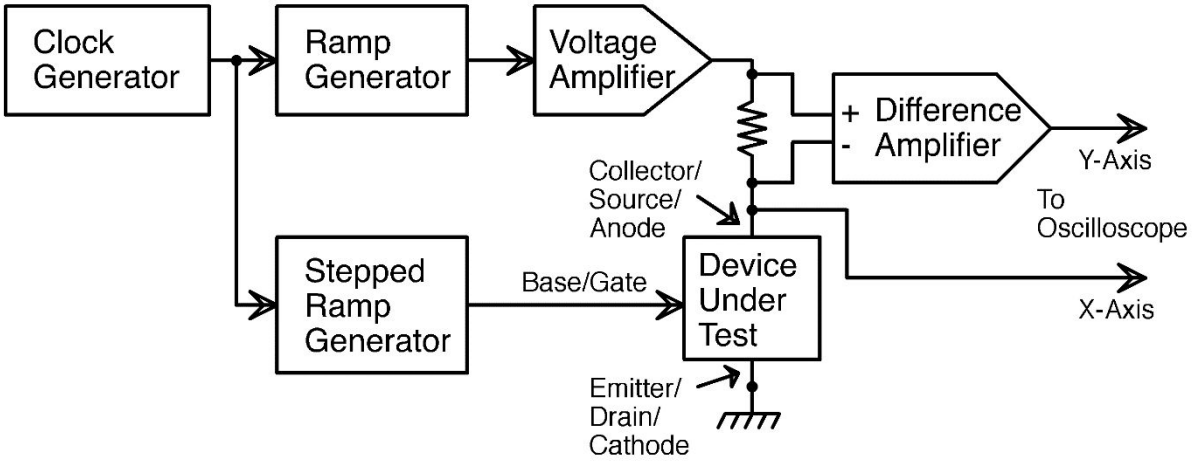
The figure shows the transfer characteristics of a two terminal and a three terminal device. From the figure we can deduce that for two terminal device we need to vary the input supply voltage and measure the corresponding current flowing through the device whereas for three terminal device we have to vary input collector supply for different base current and measure the corresponding collector current flowing through three terminal device.

Variation of collector/source voltage and base current is shown in figure.



Here collector source voltage varies in the form of steps increases the step value up to 256 steps and base current or gate voltage varies in the form of 8 steps. Thus for every base current we have 256 different values of collector supply voltage.

Block Diagram:



It is clearly inferred from the figure that ramp generator is used to produce varying collector supply voltage and stepped ramp generator is used to vary base current/ gate voltage for device under test.

Difference amplifier measure the current flowing across DUT and collector voltage is tapped from collector anode.

Clock Generator: Clock generator is used to generate clock for ramp generator and stepped ramp generator. It is made with the help of 555 astable multivibrator.

Ramp Generator: Ramp generator consists of 8 LSBs of 12 bit counter and R2R ladder. The counter counts till 256 steps and generate value in the form of binary value. R2R ladder converts corresponding digital value into analog value. Thus Ramp generator generates a ramp of 256 values between 0 and 5 volt.

Voltage amplifier: Voltage amplifier amplifies the generated ramp and thus map this ramp of 0-5 volt to 0-12 volt.

Stepped ramp generator: Stepped ramp generator consist of 3 HSBs of 12 bit counter and weighted R DAC. Thus this generates 8 steps of base currents and for every value of base current ramp generator generates a ramp of 256 values of collector supply voltage.

Differential Amplifier: Differential amplifier measures differential voltage across the resistor and thus current flowing across Device under test can be calculated.

Power Supply: As curve tracer have op amps which needs + 12 volt and -12 volt supply for their operation and digital circuitry such as multistable vibrator and counter requires +5 volt supply. So for the operation of curve tracer we need +12 volt, -12volt and +5 volt supply.

+5 volt is generated with the help of 7805 linear regulator which steps down the voltage from 12 volt to 5 volt.

-12 volt is generated with the help of charge pump circuit using 555 astable multivibrator.

Working:

Curves can be plotted on oscilloscope as well as on laptop using arduino.

Curve tracing with Oscilloscope:

1. Generally there are three modes of operations of oscilloscope: X-t mode, Y-t mode and X-Y mode. So for curve tracing we need to use oscilloscope in X-Y mode.
2. After putting the oscilloscope in X-Y mode we have to tap X axis voltage and Y-axis voltage. X axis voltage gives the collector voltage and Y axis corresponds to the collector current flowing across DUT.
3. Before plugging any device in curve tracer we will be able to see a single line on oscilloscope.
4. After this put your DUT in curve tracer according to the configurations written on it. All type of configurations are available in curve tracer whether it is a two terminal device or three terminal.
5. Now set the knob of sampling rate and thus you will be able to see the characteristics curve of any semiconductor device.

Curve Tracing with Arduino:

- First you have to tap X axis voltage and Y axis voltage with two analog pins. Set reference voltage of arduino as 1.1 volt.
- After this generate clock with arduino digital pin instead of generating clock with clock generator.
- This can be done by connecting CLK-RST to +5V.
- External clock should be applied to A-CLK pin with pulse at CTR-RST after every 255 readings to reset the counter.
- Tapped X and Y readings should be recorded with analogRead().
- After taking the reading, send another clock pulse and then record again.
- Readings can then be send serially to the computer.

Using GUI:

- Python based GUI can be used to receive data serially via COM port.
- Received data can then be plotted in real time via MatplotLib.
- Appropriate scaling of received data before plotting is required.

Appendix

List of Datasheets:

http://www.ti.com/lit/ds/symlink/ne555.pdf