Two-Wire Current-Voltage Analyzer Basics

The NI ELVIS Two-Wire Current-Voltage Analyzer is a stand-alone, software-based instrument that is a basic two-wire IV curve tracer. It can measure four quadrant IV signals within ±10 V and ±40 mA. Place the device under test between DUT+ and DUT–

⚠ **Caution** For these measurements, DUT– is a virtual ground input and should not be subjected to a DC offset because it might blow the protection fuse.

With the Two-Wire Current-Voltage Analyzer it is possible to effortlessly plot current-voltage static characteristics for the following two terminal devices: (a) Rectifier Diodes, (b) Zener diodes, (c) Photodiodes, (c) Photovoltaic cells, (d) LEDs, (e) LASER diodes or (f) Phototransistors. Additionally, the Two-Wire Current-Voltage Analyzer can be used in conjunction with the Variable Power Supply (VPS) to plot the output IV static characteristics of J-FET and MOSFET transistors.

MOSFET Basics

A MOSFET is a natural voltage-controlled switch. A high gate voltage turns on the MOSFET channel, allowing current to flow between drain and source, thereby turning a load, which can be a LED, a speaker, a fan or some other device. The amount of current the MOSFET can provide depends on the transistor physical properties such as width, length, oxide thickness, etc., the gate voltage, and the load.

Each transistor has four terminals: drain (D), source (S), gate (G), and body (B). Note that the body is also called substrate or bulk and is usually internally tied to the source terminal in discrete components, unless otherwise explicitly stated in the datasheet. For this lab the MOSFETs that will be used are: 2N7000, BS170 & BS250. Look up the corresponding datasheets and identify the transistor terminals.

Diode Configuration IV curve

On the data sheet, the threshold voltage is defined to be the gate to source voltage value (V_{GS}) at which the drain current (I_D) is 1 μA when the transistor is biased at saturation. The datasheets can use the notation $V_{GS(Th)}$ or V_{Tn}. for the threshold voltage.

The threshold voltage of a MOSFET can be obtained by plotting the IV curve of the device when connected in the diode configuration. In this setup the transistor is forced to work in saturation by connecting the drain and gate together. The threshold voltage can then be determined from the voltage at which current equals a set threshold, i.e. 1 μA.

To obtain the IV Curves proceed as follows:

- Using the correct data sheet as a guide, identify the drain, gate, and source terminals of the NMOS or PMOS transistor.
- Power off ELVIS II board.
- Connect the gate and drain to DUT+ and the Source and Body to DUT-.
- Power on the ELVIS and open the 2-wire Current-Voltage Analyzer.
- Configure the two-wire current-voltage analyzer for the following voltage sweep:

NMOS: 0V start voltage, +3V stop voltage and 0.05V increments
PMOS: -3V start voltage, 0V stop voltage and 0.05V increments

- Using the cursors check the voltage value at the point where Id = 1uA. Does this value of V_T fall within the range specified on the data sheet?

I_D vs V_{DS} for several values of V_{GS}

In order to trace I_D as a function of V_{DS} for several values of V_{GS} one must use the VPS in conjunction with the two-wire current-voltage analyzer. Remember that the saturation current will vary depending on the V_{GS} used for testing. For testing proceed as follows:

- Make sure the ELVIS II power is turned off.
- Connect the gate to the VPS+ for NMOS or VPS- for PMOS.
- Connect the drain to DUT+.
- Connect the source/body to DUT-.

⚠ **Caution** The DUT- is at a virtual ground, so the source is at approximately ground. Do NOT connect DUT- to ground, as it will interfere with the analyzer's measurements.

- Open the 2-Wire Current Voltage Analyzer and Variable Power Supply
- Set the VPS to +1.9V for the NMOS or -3.0V for the PMOS. Then click Run.
- Prepare the 2-wire analyzer using the following voltage sweep settings:
  NMOS: 0V start voltage, +2V stop voltage and 0.05V increments
  PMOS: -2V start voltage, 0V stop voltage and 0.05V increments
- Power on the ELVIS II board.
- Click the Run button on the 2-Wire Current-Voltage Analyzer Panel.
- Repeat this process 2 more times changing the VPS to the following values:
  NMOS: -2.0V and -2.1V
  PMOS: -3.1V and -3.2V

A sample curve is shown below: