# Xschem waveform Synthesis

This document provides a guide to synthes simulated current or voltage waveforms from the XSCHEM schematic editor using the pyVISA Python library. The waveforms are generated from data stored in a CSV file and can be synthesized with any compatible current or voltage source instrument. This guide demonstrates waveform synthesize from xschem using the Keithley 2450 Source Measure Unit (SMU).

~ Use launcher.sym to start the execution of your Python script. Launch the shell script *run_python.sh* from launcher.sym to run the Python script in the background, allowing **Xschem** to remain active during execution. To terminate or abort the trigger, use the Tcl script *stop_script.tcl*, which can also be launched via **launcher.sym**. This setup provides a convenient way to control both the start and stop of the arbitrary current or voltage wave generation.
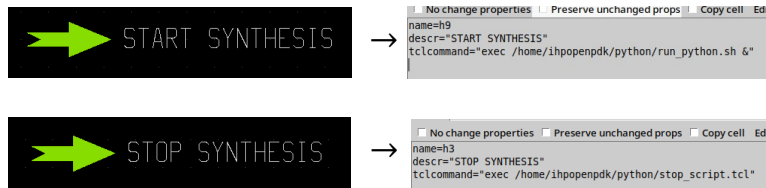
~ Sample NGSpice code to export simulation results to a CSV file is provided below.

```
name=Stimuli2
only_toplevel=true
value=
"
.lib /home/ihpopenpdk/asic_tools/pdk/IHP-Open-PDK/ihp-sg13g2/libs.tech/ngspice/models/cornerMOShv.lib mos_tt
.option savecurrents
.save all
.control
  set wr_vecnames *** Ensure ngspice includes vectors such as node voltages and current.
  set wr_singlescale *** Ensure that ngspice does not repeat time or frequency values in the output file .
  save all
  tran 0.05 50
  write test_23_csv.raw
  wrdata ~/current.csv @n.xm5.nsg13_hv_pmos[ids] ***write drain current (ids) of mosfet 5 to a csv file.
  set appendwrite
  op
  remzerovec
  write test_23_csv.raw
  save all
.endc"
```

~On the 2450 SMU, navigate to the **Menu Bar** and select **System Settings**. Under the **Command Set** section, choose **SCPI** for Python and pyVISA configuration.

~ Create and store a ***Source Configuration List*** that can includes settings such as voltage or current ranges, maximum limits, specific values and other relevant settings. Current or voltage values stored in a `.csv` file can be loaded into a Python array and incorporated into this S*ource Configuration List*. If needed, you can also define a ***Measure Configuration List*** to specify how measurements should be performed. Both configuration lists can then be used to generate arbitrary current or voltage waveforms

~ Configure **Timer 1** on the 2450 SMU to set the required time intervals for your source steps.

~ Build a **Trigger Model** to invoke the **Source Configuration List**. This will source the desired current or voltage values at each defined time step. The trigger model ensures that the SMU automatically applies each source setting in synchronization with the configured timer steps.