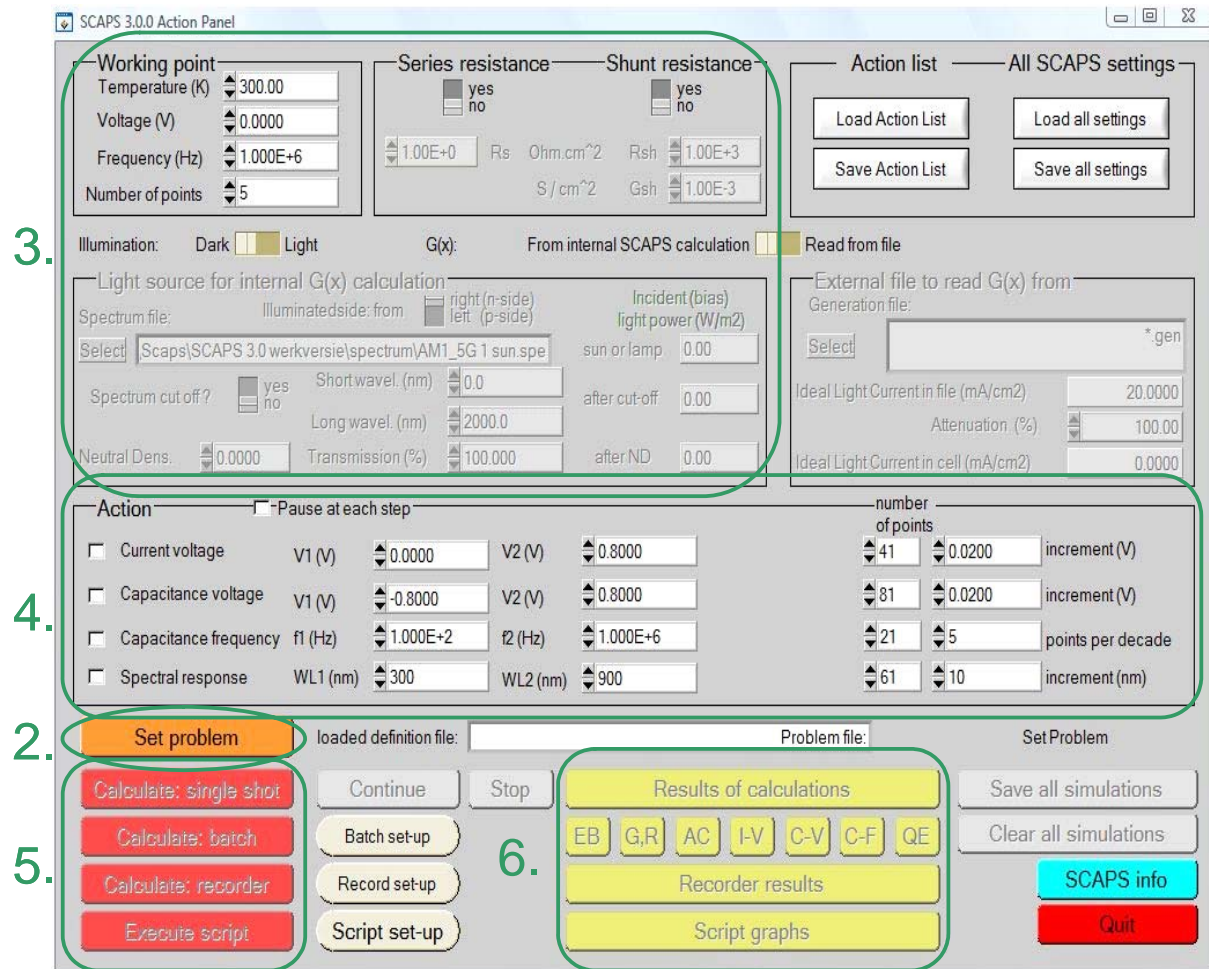


Getting started with SCAPS

SCAPS (a Solar Cell Capacitance Simulator) is a simulation program developed at ELIS, University of Gent. The presentation here is based on version 3.0, March 2010.

0. The basics

SCAPS is a Windows-oriented program, developed with LabWindows/CVI of National Instruments. We use here the LW/CVI terminology of a 'Panel' (names used in other softwares are: a window, a page, a pop-up...). SCAPS opens with the 'Action Panel'.



There are dedicated panels for the basic actions:

1. Run SCAPS .
2. Define the problem, thus the geometry, the materials, all properties of your solar cell
3. Indicate the circumstances in which you want to do the simulation, i.e. specify the working point
4. Indicate what you will calculate, i.e. which measurement you will simulate.
5. Start the calculation(s)
6. Display the simulated curves, ... (see section 6)

This is further explained below.



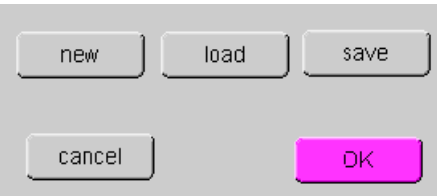
1. Run SCAPS:

Click the above pictogram on the Desktop, or double-click the file `c:\SCAPS210\scaps3000.exe` in the file manager. SCAPS opens with the Action Panel.

2. Define the problem:

Set problem

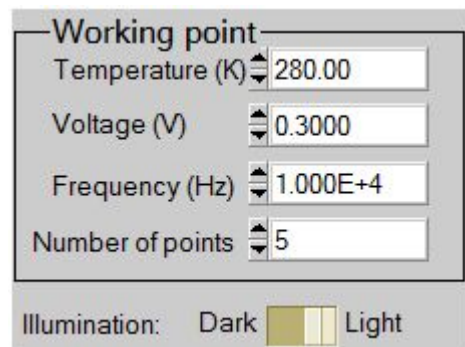
Click the button set problem in the action panel, and chose load in the lower right corner of the panel that opens. Select and open e.g. the file NUMOS CIGS baseline.def: that is the example problem file of the practicum session at the NUMOS workshop, Gent, 30 march 2007. This file is supposed to be in the folder `/scaps30/def`. If necessary, browse to find this file. In a later stage, you can alter all properties of the cell by clicking set problem in the action panel.



3. Define the working point

The working point specifies the parameters which are not varied in a measurement simulation, and which are relevant to that measurement. Thus:

- the temperature T : relevant for all measurements. Note: in SCAPS, only $N_C(T)$, $N_V(T)$, the thermal velocities, the thermal voltage kT and all their derivatives are the only variables which have an explicit temperature dependence; you must input for each T the corresponding materials parameters yourself.
- the voltage V : is discarded in I - V and C - V simulation. It is the dc-bias voltage in C - f simulation and in $QE(\lambda)$ simulation. SCAPS always starts at 0 V, and proceeds at the working point voltage in a number of steps that you also should specify.
- the frequency f : is discarded in I - V , $QE(\lambda)$ and C - f simulation. It is the frequency at which the C - V measurement is simulated.
- the illumination: is used for all measurements. For the $QE(\lambda)$ measurement, it determines the bias light conditions. The basis settings are: dark or light, choice of the illuminated side, choice of the spectrum. A one sun ($= 1000 \text{ W/m}^2$) illumination with the ‘air mass 1.5, global’ spectrum is the default, but you have a large choice of monochromatic light and spectra for your specialized simulations. If you have an optical simulator at your disposal you can immediately load a generation profile as well in stead of using a spectrum.



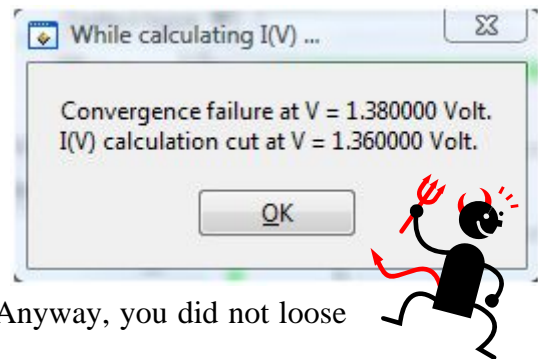
4. Select the measurement(s) to simulate

In the action-part of the Action Panel, you can select one or more of the following measurements to simulate: I - V , C - V , C - f and $QE(\lambda)$. Adjust if necessary the start and end values of the argument, and the number of steps. Initially, do one simulation at a time, and use

rather coarse steps: your computer and/or the SCAPS program might be less fast than you hope, or your problem could be really tough... A hint: in a $C-V$ simulation, the $I-V$ curve is calculated as well, no need then to specify it separately.

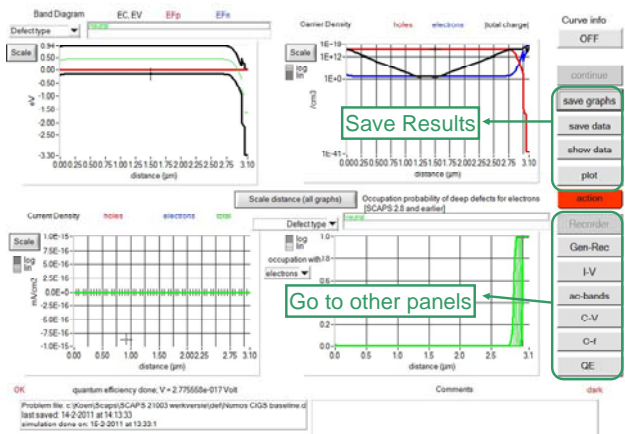
5. Start the calculation(s): Calculate: single shot

Click the button calculate: single shot in the action panel. The Energy Bands Panel opens, and the calculations start. At the bottom of the Panel, you see a status line, e.g. “iv from 0.000 to 0.800 Volt: V = 0.550 Volt”, showing you how the simulation proceeds. Meanwhile, SCAPS stands you a free movie how the conduction and valence bands, the Fermi levels and the whole caboodle are evolving. When you see the hated divergence message, you’re entitled to get into a bad mood, but don’t exaggerate. Anyway, you did not loose the $I-V$ points already calculated.



6. Display the simulated curves, ...

After the calculation(s), SCAPS switches to the Energy band panel (or the AC-band panel). You can now look at your ease to the band diagrams, carrier densities, current densities,... at the last bias point calculated (stop your calculations earlier, or use the pause button on the Action Panel if you want to look at an intermediate state at ease). You can output the results (buttons print, save graphs, show (then the numbers are shown on screen; cut & paste to e.g. Excel is possible), or save (then the numbers are saved to a file). You can switch to one of the specialized output Panels (if you have already simulated at least one corresponding measurement). We only show the example of the IV Panel.



7. ...e.g. the $I-V$ curves

The meaning of the plot, show or save buttons is as for the Energy Bands Panel. Again, you can switch to the other output panels (energy bands, ac, $C-V$, $C-f$ and QE , if already calculated), and to the Action Panel to do a new calculation, or to stop (important: you can only leave SCAPS from the Action panel!!). Several small remarks:

1. The color of the last calculated curve is indicated (tip: when the graph gets too crowded, go to the Action Panel and click clear all simulations to clear all graphs). The recombination curves are only shown for the last simulation. The color of the legend corresponds to the color of the curve (indicated as 1bis).
2. If Curve Info is switched ON and you click the cursor on a curve in a graph, a pop-up panel will appear which gives information about the graph, curve and the point which you clicked.

Cell definition	Type
Defect density	Property
All layers	layer
Defect 1	defect

Insert Above

Replace

Insert Below

Remove selected item

Clear entire list

determine the asked properties. This means the selected measurements on the action panel are ignored!

11. Further Reading...

The manual of *SCAPS* consists out of a (messy ☹) collection of Add-on manuals. However, most features of *SCAPS* are described there in a detailed way. It is strongly recommended to collect them in one folder and keep them close at hand whilst exploring the *SCAPS*. Most algorithms which are implemented have been reported in literature. An overview is given when clicking the *SCAPS info* button.

Good luck !

Koen Decock & Marc Burgelman, ELIS / UGent, March 2011.