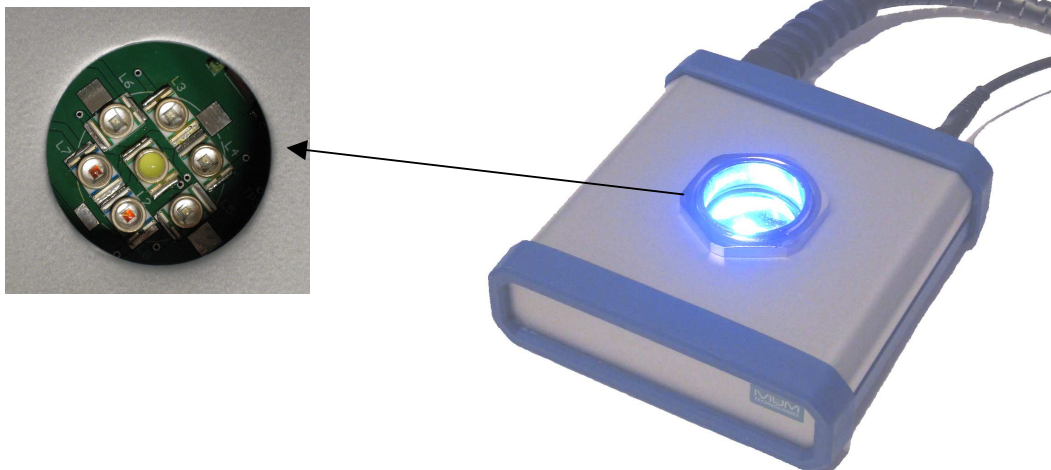


IVIUM MODULIGHT MODULE: Product Note



The ModuLight-module is a programmable light source that has been specifically designed to investigate photo-electrical devices, such as solar cells. The module will operate in combination with all Ivium potentiostats, through the peripheral I/O-port.

The ModuLight wavelength can be set programmatically from 465-635 nm in 7 steps. The light intensity can be modulated using the sinewave generator of the potentiostat, from 10 μ Hz to 2 MHz. Using the extensive Solar cell applications that are included in the Ivium software, it is thus possible to fully characterize a solar cell. The functionality includes E/I curves as function of the light intensity, IMVS/IMPS, and solar cell modelling resulting in all characteristic values of the studied object.

Modulight specifications

Mode	Color	Wavelength	Luminous Flux	Radiant Flux
1	White	425-660 nm	57 lm	N.A.
2	Royal Blue	465 nm	10 lm	255 mW
3	Blue	475 nm	19 lm	278 mW
4	Cyan	510 nm	45 lm	78 mW
5	Green	535 nm	52 lm	91 mW
6	Amber	595 nm	42 lm	82 mW
7	Red	635 nm	40 lm	260 mW

Light intensity	can be modulated with the FRAoutput of the build-in sinewave generator of the IviumStat/CompactStat from 10 μ Hz to 2 MHz.
Bias resolution	16 bit, 0.0015%
Wavelength	set programmatically 465-635 nm in 7 steps
Dynamic flux	0 - 57 lm
Luminous flux	0 - 278 mW
Bandwidth	0 => 2 MHz
power requirements	external adapter: 100-240 V, 45-65Hz at DC-connector: 5 V, 1A
Size	w x d x h = 12 x 13 x 2.5 cm
Weight	0.5 kg
Interfacing/connectivity	HD37, connects to the potentiostat peripheral port
Use	only i.c.w. Ivium potentiostats

Functionality

The ModuLight module is a programmable light source that has been designed to investigate photo-electrical devices, such as solar cells. Its light intensity can be modulated with the IviumStat/CompactStat. The wavelength can be set programmatically from 465-635 nm in 7 steps, with a maximum light intensity of 60 lm.

Installation

Connect The ModuLight module directly to the DB37 peripheral port via the 37 pin Male connector. Then insert the 5V DC plug into the back of the ModuLight. Plug the adapter into the mains power. The ModuLight is now ready for use. It is controlled via the IviumSoft software.

Operation

The ModuLight module is fully controlled by the IviumSoft software. The wavelength mode is controlled by the digital outputs, and the intensity is controlled by the analog output (16 bits resolution). Additionally, the light intensity can be modulated with the FRAoutput of the build-in sinewave generator from 10uHz to 2MHz.

Application

Standard in electrochemistry, the impedance is determined using the current and potential directly from the potentiostat/galvanostat. However, for Ivium potentiostats it is possible to use the instrument as standalone FRA in combination with other equipment. Additionally, other reference signals can be selected for variations from the classical electrochemical impedance techniques, such as combinations with optical or hydrodynamic impedance.

In the IviumSoft at the impedance techniques, a parameter is available in advanced mode: "MeasConfig".

In standard setting, the impedance is defined as Y/X, which is normally E/I. When other (external) signals are used for X/Y, the meaning of the plotted impedance might be different from the classical interpretation. The software will always display the data as if it were E/I, the user is responsible for any conversions.

MeasConfig	X	Y
standard	I stat	E stat
INT_ac I	ac intern	E stat
INT_ac E	I stat	ac intern
EXT_ac EI	X periph.	Y periph.
EXT_ac I	X periph.	E stat
EXT_ac E	I stat	Y periph.

Example 1: Solarcell IMPS1

The IviumStat/CompactStat AC-OUT port is used to drive the intensity of a light source, and the ac-photocurrent from the solar cell is to be recorded with reference to the incident light: "impedance" = Light /photo-Current.

The instrument is set to "Impedance Constant E", and the MeasConfig parameter to "INT_ac E". With this parameter-setting, the internal applied ac signal is used as Y, which is the light-intensity here, instead of the cell-potential.

Note that the potentiostat potential may be set to shortcut conditions (E=0), but it may also be operated at other potentials, such as maximum power point.

Example 2: Solarcell IMVS

The IviumStat/CompactStat AC-OUT port is used to drive the intensity of a light source, and the ac-photopotential from the solar cell is to be recorded with reference to the incident light: "impedance" = photopotential / Light.

The instrument is set to "Impedance Constant I", and the MeasConfig parameter to "INT_ac I". With this parameter-setting, the internal applied ac signal is used as X, which is the light-intensity here, instead of the cell-current.

Note that the galvanostat current may be set to OCP conditions (I=0), but it may also be operated at other currents, such as maximum power point.

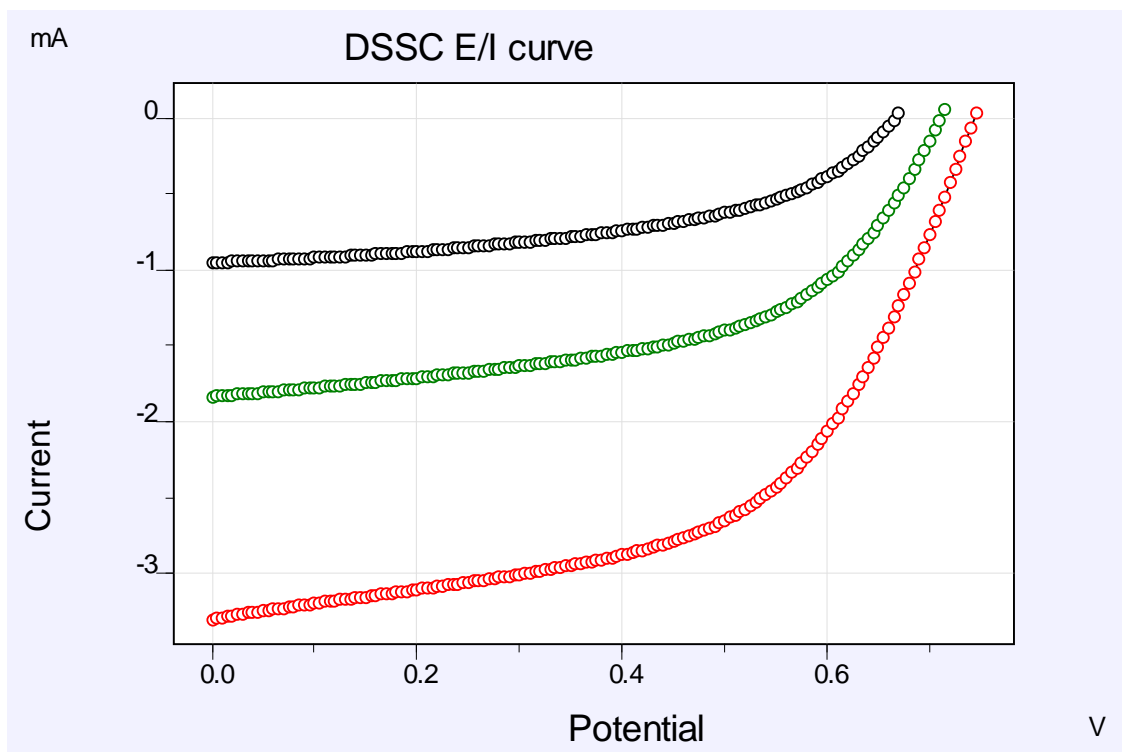
Experimental example

Experiments were conducted with a 1cm^2 Dye Sensitized SolarCell (DSSC). The solarcell was connected to an Ivium CompactStat, with WE/S to the positive pole, and CE/RE to the negative pole. (a negative current means that the solarcell is producing power).

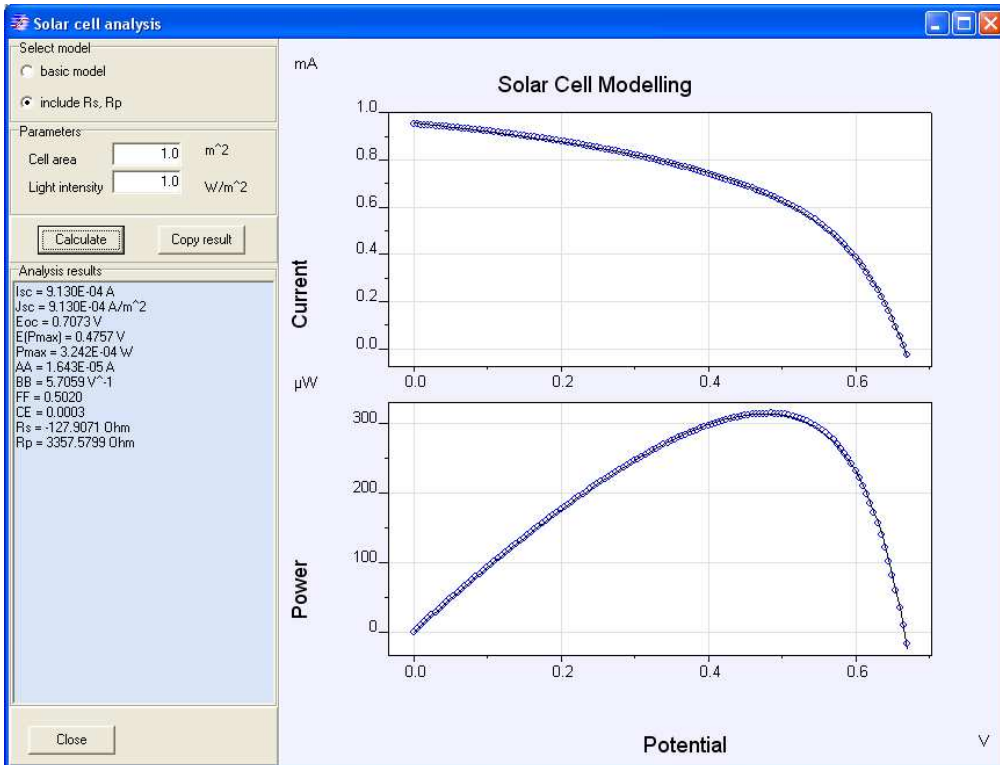
As lightsource, we took the Ivium ModuLight module using the 635nm setting, connected to the CompactStat peripheral port with AnalogOut1 and ACout.

The DC LSV scans were done by first setting the illumination level with AnalogOut1, and thereafter performing a scan. The DC experiments with pulsed light were done with Mixed Mode, setting the Anout1 parameter of the 2nd level to the desired light intensity.

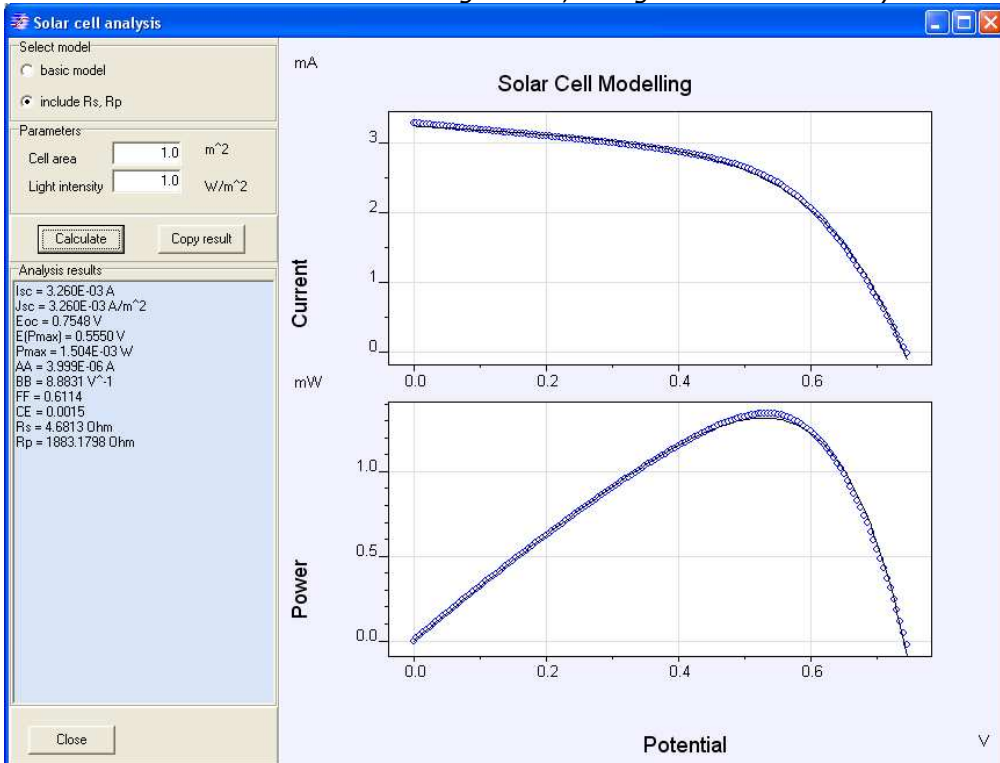
The EIS scans were done by first setting the Bias-illumination level with AnalogOut1, and thereafter performing an EIS scan with "MeasConfig" parameter to "Int_AC_E" for potentiostatic scans and "Int_AC_I" for galvanostatic scans. The applied frequency range was 10kHz to 0.1Hz.



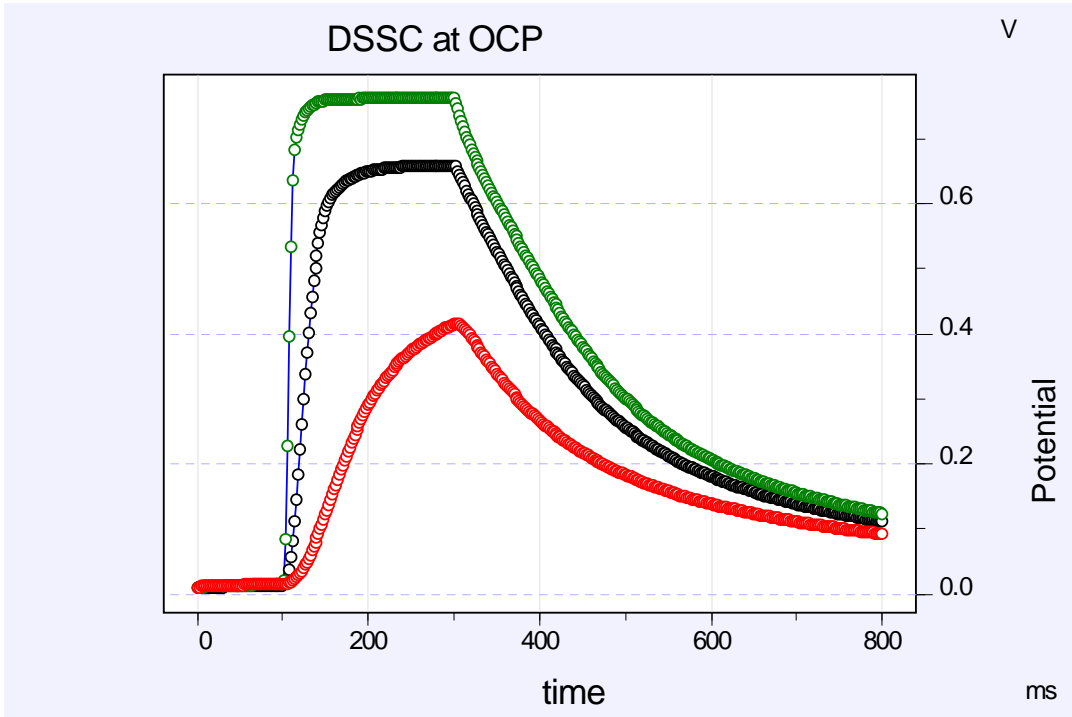
E/I curves for DSSC at various light intensities: 15lm, 30lm, 60lm



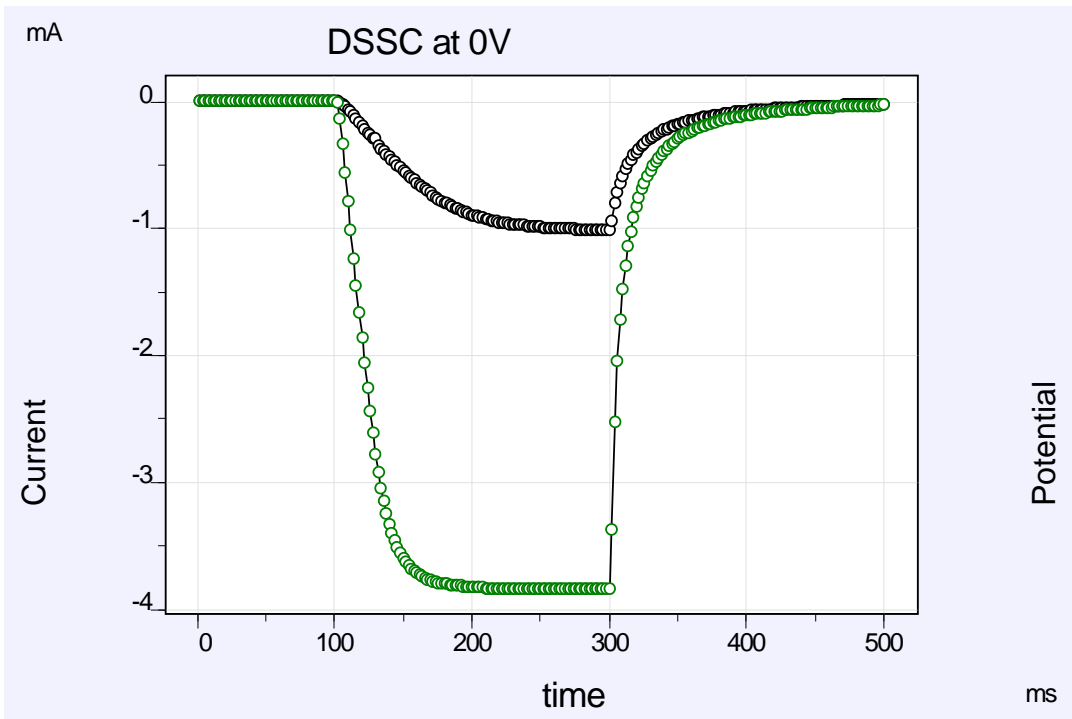
Screenshot of the solarcell modeling circuit, using the 15lm intensity curve



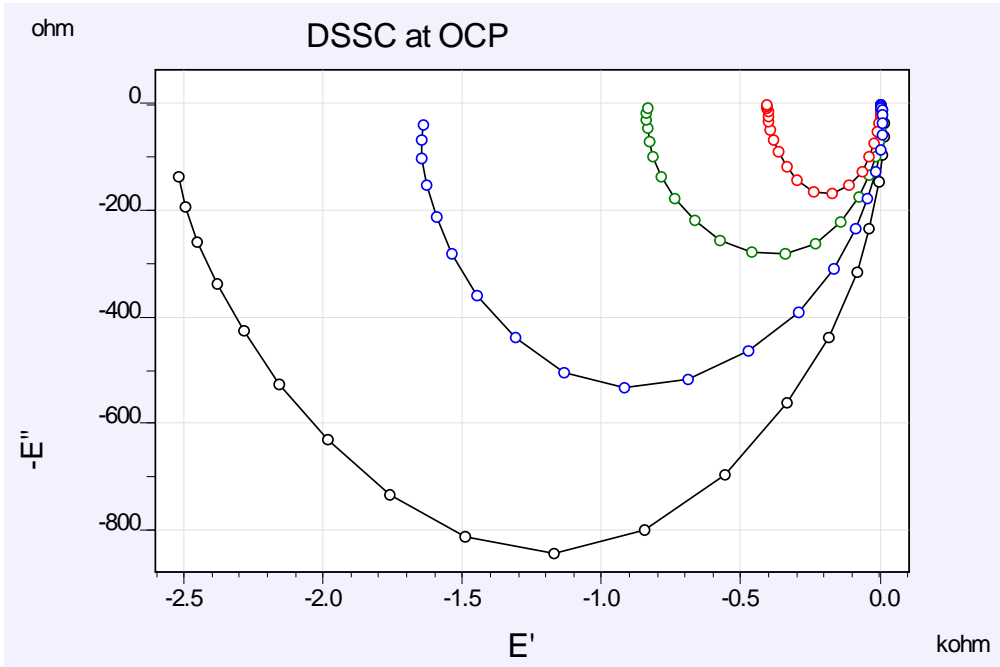
Screenshot of the solarcell modeling circuit, using the 60lm intensity curve



Open Cell Potential of DSSC for variable intensity light pulses



Current response of DSSC at Estat 0V, for variable intensity light pulses



IMVS photo-electric-impedance of a DSSC at OCP, at various light intensities, left to right: 15lm,18lm,23lm,30lm

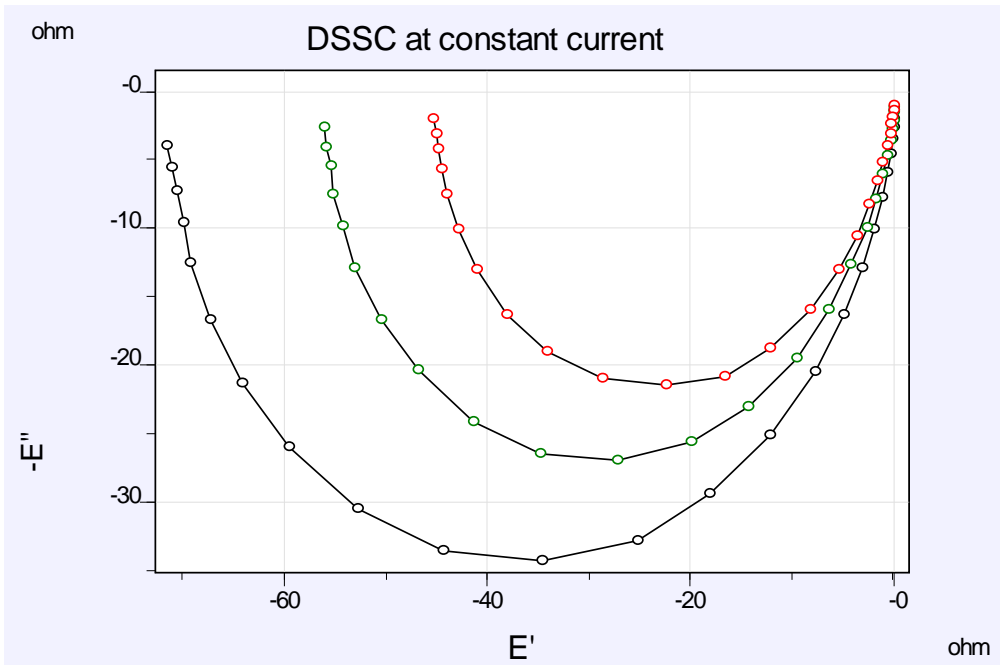


Photo-electric-impedance of a DSSC at various constant currents, 0.1Hz to 1kHz, at fixed light intensities of 60lm, left to right: 0mA (OCP), 1mA, 3 mA

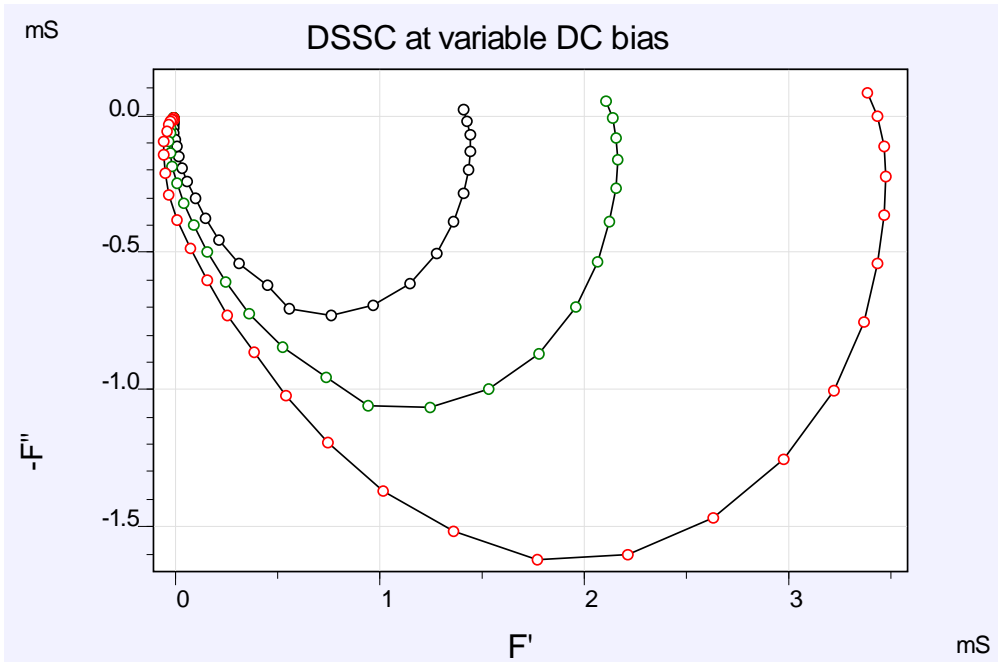


Photo-electric-admittance of DSSC at various DC bias, at fixed light intensity of 60lm, left to right: 0.7V, 0.6V, 0.0V(IMPS)

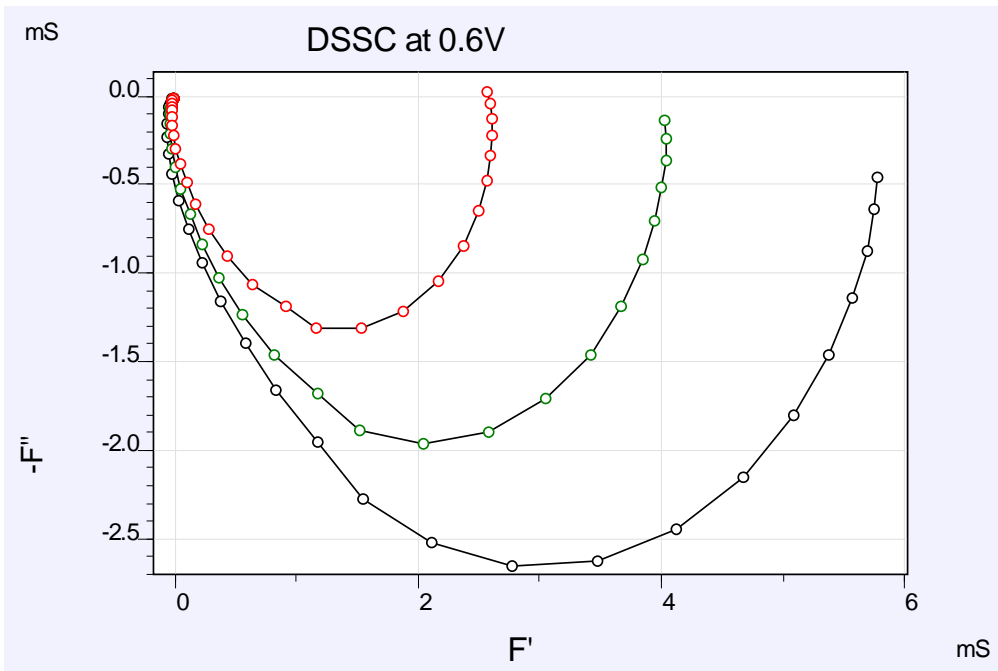


Photo-electric-admittance of DSSC at 600mV DC, at various light intensities, left to right: 15lm,30lm,60lm