Photovoltaics Lab at Ioffe Physical Technical Institute
“TECHNOEXAN” Ltd an innovation company of the Ioffe Institute

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MULTIFUNCTIONAL FLASH SOLAR SIMULATOR/TESTER

Tester function

At the PV Lab of the Ioffe Institute, a multifunctional flash solar simulator/tester has been developed able to cover several needs at the PV measurements of the cells and modules. It may be used as a cost-effective mean applied at I-V measurements of the 1-sun and concentrator cells, as well as the large area flat and concentrator modules. The only limitation is connected with life time of the photogenerated carriers in the PV devices under test: they should be based on materials with short enough life time, because I-V measurements are carried out in a pulse regime at light pulse duration of about 1 millisecond.

The most serious requirements to the simulator optical design must be satisfied at characterization of the large-area concentrator modules: 1 sun irradiation level with good spatial uniformity; proper spectral distribution; light beam divergence similar to that from the sun disc. Light from Xenon lamps passed through an aperture hole 20 mm in diameter and a large-area Fresnel lens 2000 mm in focal distance to form a collimated 0.5x0.5 m^2 flux. It is easy to change simulator configuration for characterizing the individual cells and large-area (1x2 m^2) flat modules under non-collimated light flux. A flat solar array may be placed far enough for realization of the 1-sun illumination conditions. In turn, in this simulator configuration the concentrator solar cells may be characterized as well at their placing much closer to flash lamps. Pulse shape is almost Π-like with flat part duration of 1 millisecond. Tester function of the instrument is ensured by measurement unit developed in a form of an active load. It covers voltage ranges from -3/+10V up to -20/+200V and current range up to 0÷20A. The developed simulator may be regarded as a modular unit for arrangement of the instruments with sufficiently increased “collimated” illumination areas: 0.5x1 m^2, or 1x1 m^2 (two, or four modular units would be mounted together). In the instrument versions with “non-collimated” light flux, the illumination areas is proportionally larger too.

Technical parameters (in configuration with one 0.5x0.5 m^2 collimating lens)

1. Output light power density corresponds to 1 sun AM 1.5D, or AM 0, spectra for triple-junction InGaP/GaAs/Ge solar cells with spectral matching corresponding to Class A.

2. Output aperture area of a collimating system……….…… ………0.5x0.5 m^2 (**modifications are possible on the customer’ requirements**).

3. Divergence of the rays passing through a light collimating system…… …..0.5 degree of arc.

4. Possibility to vary output power at the maximum of light pulse..…………… within +/-20%.

5. Reproducibility of light intensity from pulse to pulse…………………………. within +/-2%.

6. Non-uniformity of light distribution across the whole output aperture area…... within +/-4%.

7. Light pulse duration on an intensity plateau (at 2% accuracy)…………….. 1 millisecond.

8. The tester is supplied with DC light sources (high brightness light-emitting diodes) situated co-axially with flash lamps for pre-alignment of the concentrator systems under test.

9. Repetition rate of the light pulses corresponds to 1 pulse per 10÷15 seconds depending on lamp voltage.

10. The measurement unit of the tester is supplied with digital memory oscilloscope and electronic circuit for measurements of the output I-V curve in a module under test (current and voltage ranges to come to an agreement in accordance with output parameters of the modules produced by a customer).

11. Module position is vertical with front surface facing to the collimating lenses (**modifications are possible on the customer' requirements**).

Optical design

For correct CPV module characterization, light source must have an angular divergence similar to that of the sun (± 0.27º), and optical image like sun disc. To eliminate effect of chromatic aberration and non-uniform illumination in peripheral zones of the measurement plane, the focal distance of the 0.5x0.5 m2 lenses was chosen to be as long as 2 m. In Fig. 1, a picture of the Tester is shown (on the left) and possible arrangement of the light sources in a Tester configuration with larger aperture area (on the right). In Fig.2, a picture of the light source simulating sun disc image is given (on the left), as well as a profile of the flash light pulse with 1 millisecond flat part (on the right). Aperture areas as large as 1x1 m^2 and even more are possible.

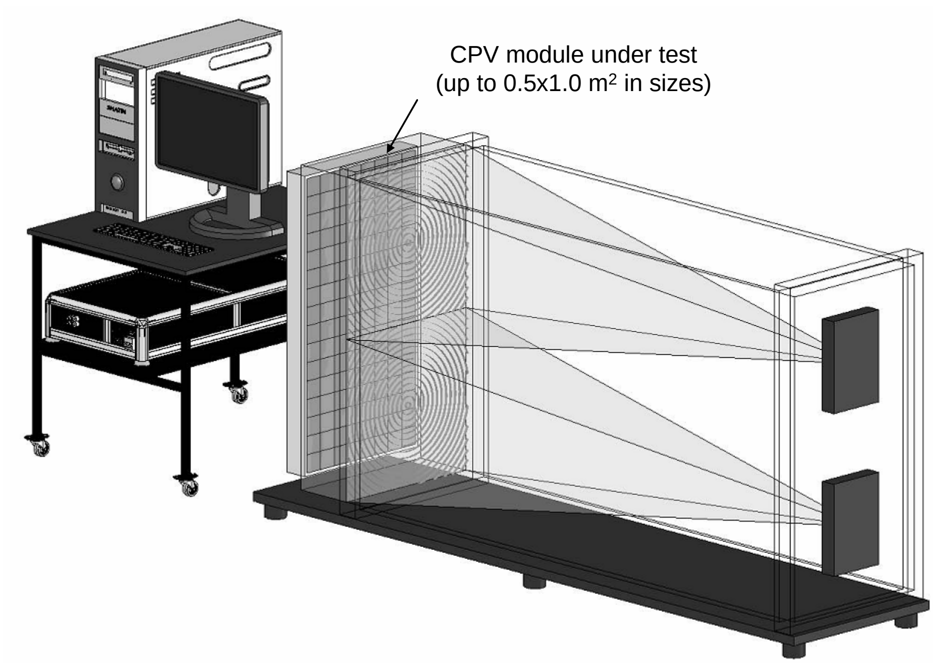

Fig. 1. A picture of the Tester is shown at characterization of a concentrator module of 0.5x0.5 m^2 aperture area (on the left), and possible arrangement of the light sources in a Tester configuration with larger aperture areas (on the right).