Photovoltaic Principles and Applications - PV75-100

The Feedback Photovoltaic Principles trainer is a bench-top instrument which teaches the fundamental principles of photovoltaic energy. The course content is relevant to engineering undergraduates complementing theoretical studies on renewable energy and would also serve as a basis for project work.

The photovoltaic effect is a method of energy generation that converts solar radiation into an electrical current by means of semiconductors that are arranged into solar cells. This method of generating electrical energy has seen rapid expansion in recent years as the global pursuit of renewable power generation gains momentum.

There is a range of experiments that the student can conduct that are based on Feedback's Espial Courseware which delivers course content, virtual instrumentation and relevant background theory.

Features

- **Enables automatic plotting of cell IV curves**
- **Light source simulates solar illumination**
- **Suitable for undergraduate study and projects**
- **Espial software featuring virtual instrumentation**
- **Series and parallel connection methods compared**
- **Removable project board allowing further study**

The instrument consists of a light source which acts as a solar simulator that allows photovoltaic (PV) cells to be illuminated at light levels comparable with direct sunlight using very high brightness LED modules. This provides a safe, temperature controlled environment for working at high levels of illumination.

Cells are fitted to a PV carrier board which allows them to be positioned in the light box at variable positions beneath the light source. By patching connections on the applications board, the student can investigate the performance of different series and parallel electrical combinations of the cells.

A shading vane allows selective and progressive shading of either the front or rear pair of PV panels and the effects on generated power observed. The PV carrier is fitted with thermistors and light sensors that enable the temperature and illumination of the panels to be monitored and controlled.

A student Applications console enables an electronic load to be applied to the cells under test and allows voltage and current measurements to be performed by the virtual instrumentation in the PC-based Espial software. This process can be automated to give a family of curves at different levels of illumination, for a given cell.

The console also allows the study and experimentation of power conversion and energy storage and has a removable project board, allowing specific areas of study. The instrument is furnished with a project board featuring d.c.- d.c. converters employing boost and buck topologies. Further boards are available from Feedback Instruments.

Subject Areas

1. Open Circuit Voltage and Short Circuit current Cells in series and parallel. The student selects different combinations of cell connection in order to understand how the electrical performance varies with different connection methods.

2. Maximum Power Point with resistive load at constant illumination. The effect of changing the load resistance is observed using the Espial on-screen instrumentation. The experiment shows the student how maximum power can be transferred to the load, by optimizing the load resistance.

3. Maximum Power Point with varying illumination and plotting of MPP curve. The experiment shows the student how maximum power can be transferred to the load, by optimizing the load resistance for different operating conditions.

4. Effects of temperature on cell output. The software allows output voltage versus cell temperature to be plotted to teach the student the relationship between these two parameters.

5. Effects of shading and physical layout. The student is able to assess the effect on output by shading areas of the cells which simulates cloud cover or building shading of a PV array.

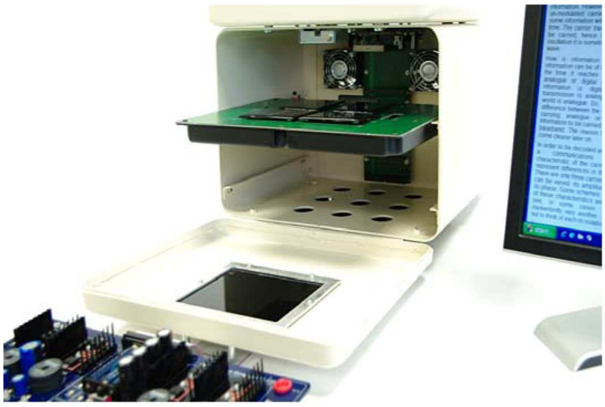
6. Bypass diodes. Introduction of the concept of using bypass diodes to reduce shading losses. This allows the student to experiment with connecting diodes to mitigate shading conditions.

7. Solar Day Simulator. The software can be used to alter the angle of the PV module and modulate the level of solar intensity to simulate the reduced values of irradiance experienced either side of the solar noon towards dawn and dusk.

PV Principles

Espial Software. The student is guided through the principles of photovoltaic energy by following a series of practical assignments which are supported by a comprehensive reference section. The student interacts with hardware using a pc and the applications board.

Electronic Load. This is a software controlled load that is applied to the output of the PV array which allows the maximum power point to be maintained by the Espial software. By tracking the output voltage, the load can be adjusted to ensure the optimal performance of the array.



PV carrier board inserted into the light source

Applications Console. This features a mimic diagram and patch cords that allow the student make connections between the cells and the load. These define whether the PV cells are connected in series or parallel and allow energy produced by the PV array to be measured.

PV Applications

The purpose of the PV Applications console is to teach the student about common uses of PV power and the type of devices which are found in PV renewable energy systems. Primarily these devices are concerned with converting electrical power from one form to another.

Maximum Power Point Tracking. This allows the load presented to the PV panel to be optimised for maximum power conversion. It can also be used to illustrate the principles of d.c./d.c. conversion – specifically boost and buck converters. When the console is in automatic mode, the Espial software can provide automatic continuous Maximum Power Point Tracking.

Energy Storage - Super Capacitors. Here a super capacitor is used to demonstrate energy storage when used in conjunction with PV arrays and power conversion.

Student Project Board - Power Conversion. A plug in board allows the student to work on specific subject areas related to PV technology and power conversion. The supplied board features several topologies of d.c. to d.c. converter. A blank board for student experimentation is also provided.

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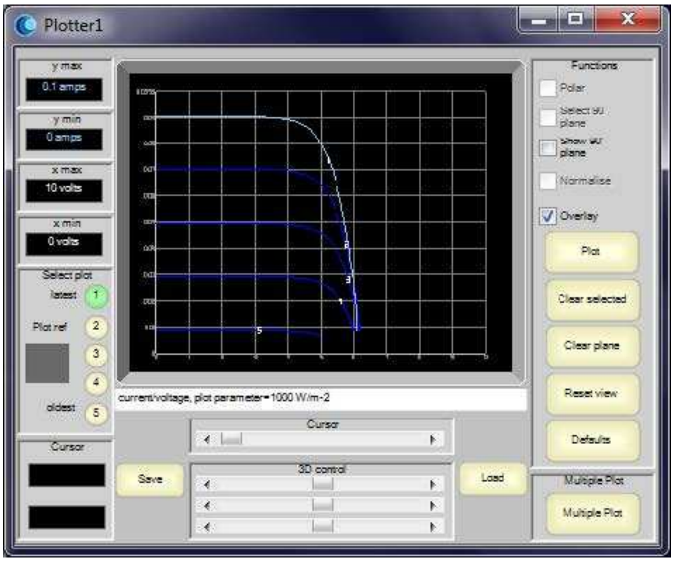


Screen showing the results of a current versus voltage plot of a PV cell.

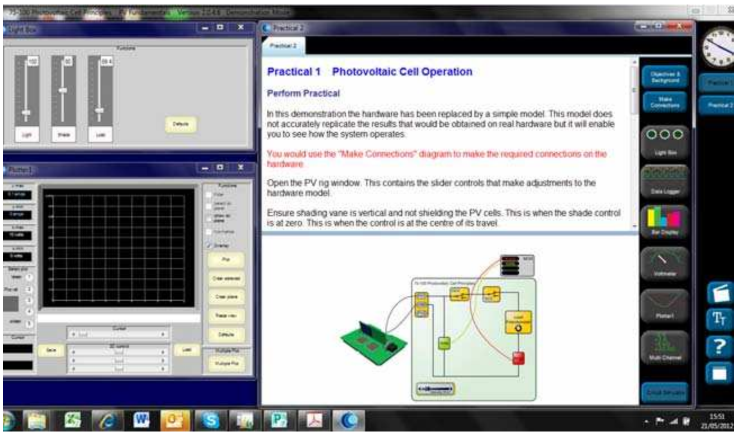
Espial Software

Feedback's Espial software provides a unique learning experience that encompasses virtual instrumentation, clear student instruction and a library of background material that supports the student through the assignments. The on-screen instructions prompt the student to configure the hardware for the practical assignments and then guide the student as they conduct the experiments.

By combining instruments within the Espial environment, this removes the need to have separate instruments that may clutter the working environment. Espial includes the following instruments: Oscilloscope, data-logger, frequency meter and function generator. Espial and Espial Tools are compatible with 32 and 64 bit versions of Windows XP, Vista, Windows 7 and Windows 8.

Features

- **On-screen instrumentation**
- **Supporting reference sections**
- **Step-by-step student instruction**
- **Configurable working environment**
- **Option available to author and edit assignments**
- **Results can be saved for future reference**



Product Specification

Supply voltage: 110 V a.c. 60 Hz or 230 V a.c. 50 Hz
Power consumption: 300W
AC connection: IEC type connector
Physical dimensions:
Light box: 317 mm (w) x 403 mm (h) x 270 mm (d)
Applications board: 410 mm (w) x 50 mm (h) x 270 mm (d)
PV carrier board: 297 mm (w) x 60 mm (h) x 222 mm (d)

northumbria UNIVERSITY

The product has been developed in conjunction with Northumbria University in the UK, which is conducting extensive research into renewable technologies and their applications. By concentrating on the fundamentals of the technology, a learning program has been devised with a team of University academics that enables the student to learn the principles of PV technology from experimentation and evaluation of their results.

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