ENERGY HARVESTING PREDICTION TOOL

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WHAT IS ENERGY HARVESTING?

Energy Harvesting is the process of **collecting energy from the environment**, usually on a small scale, to power electronic devices [1]. By generating energy from the environment – using **photovoltaic (PV) cells**, **thermoelectric generators (TEGs)**, or other technologies – the need for batteries or wired power is removed. Batteries require replacing, which can be costly or impractical, and it may not be feasible to run wires to sensors.

THE PROBLEM

The power available from an energy harvester is usually low and can **vary considerably**. Therefore, before a particular method is chosen (i.e. which chemistry of PV cell, or whether to use PV or thermoelectric generators) **data must be gathered** about the environment in which the device will be situated.

OUR SOLUTION

We created a **modular data logger** which records environmental data from pluggable sensor modules over time. Analysis software then uses this data to **predict the power available** from a real energy harvesting device. PV and TEG sensor modules were developed, and new modules can be added in the future.

DATA LOGGER

WIRELESS CONTROL

The unit is **controlled via Bluetooth**, and logging parameters can be set wirelessly. This means fewer holes in the case where water could enter, as well as providing the option for a future extension to allow it to be controlled using a smartphone.

BATTERY POWER

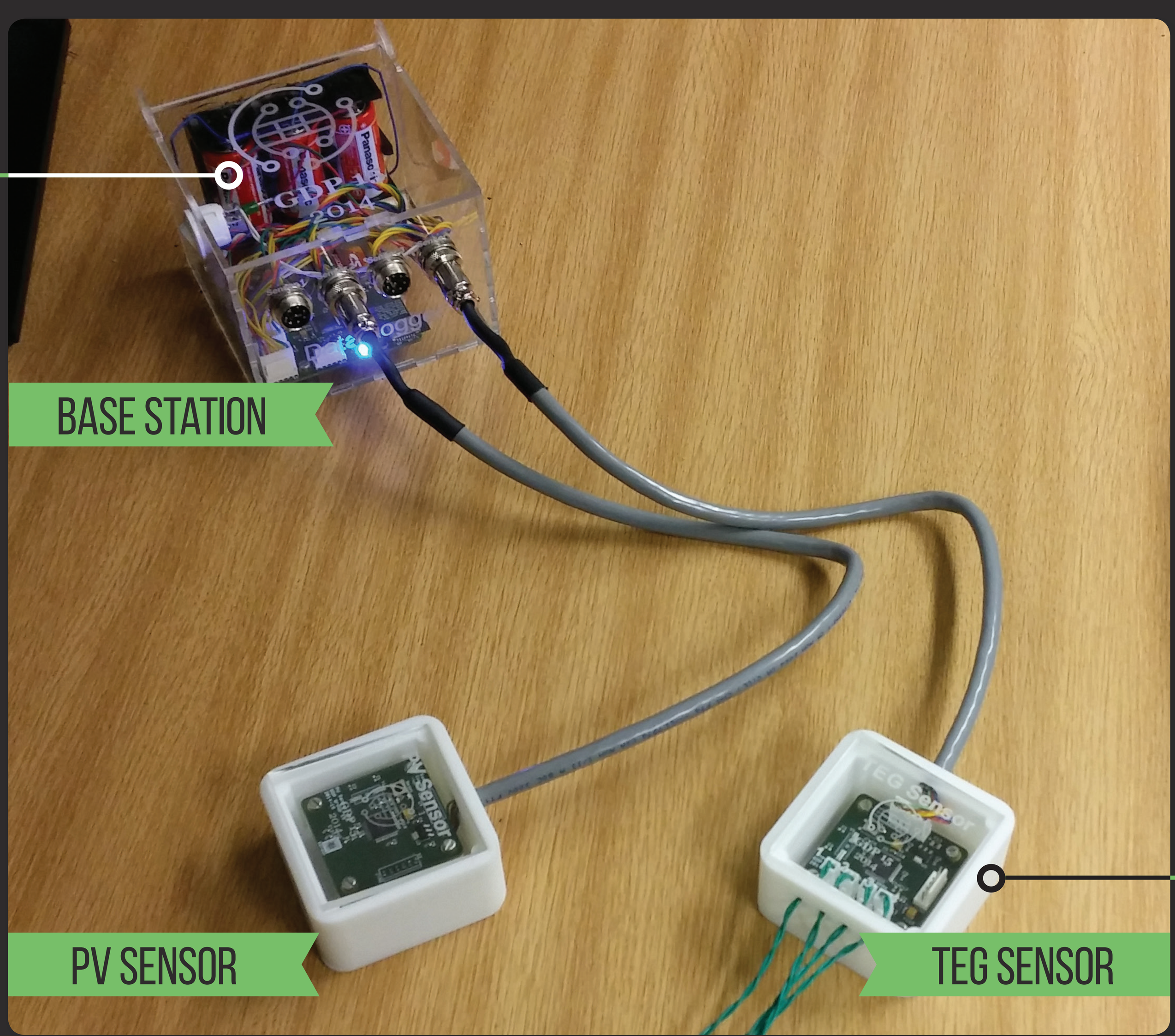
The device is battery powered so it can be used at locations where mains power is not available. Depending on the configuration, the device's batteries can last **longer than a week**.

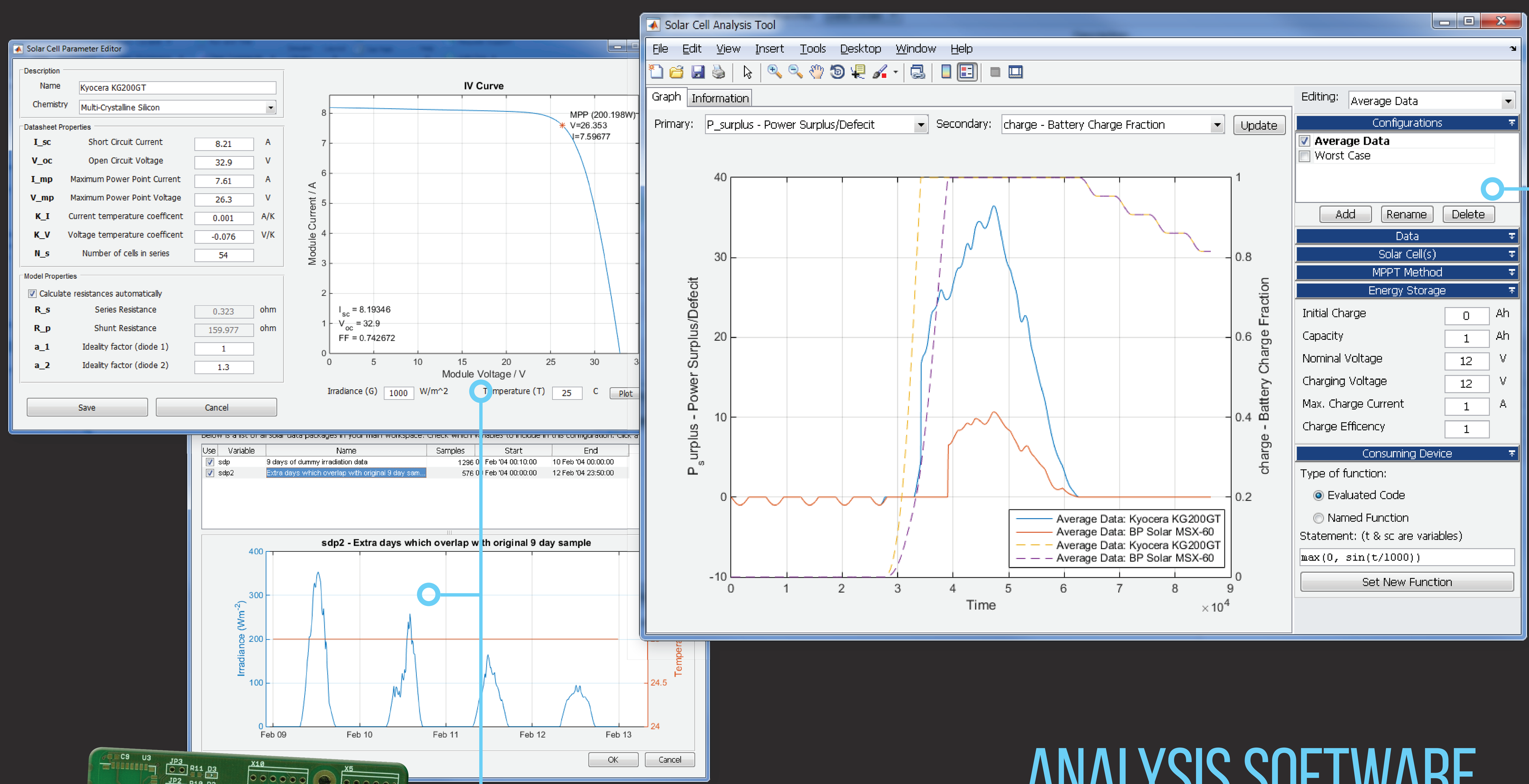
Battery power is regulated in the base unit and each of the sensor modules to reduce the effect of interference picked up on the interconnecting cables.

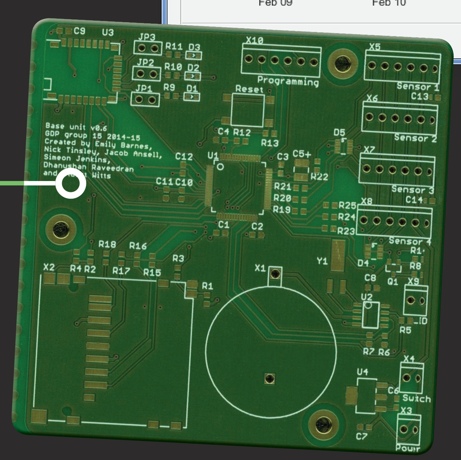
EXTENSIBLE DESIGN

The modular design of the data logger allows any combination of sensor modules to be plugged in to the base unit. Up to **four** can be plugged in at once.

This could, for example, allow two PV modules to be tested in different orientations, or two different types of module to be tested at once.







PCB DESIGN

The circuit was designed and major subsystems were prototyped. Printed circuit boards were then manufactured which gave a platform for the embedded software.

LOGGING PROCESS

The sampling rate is controlled by the base station, which sends sampling requests to connected sensors over the SPI interface. They respond with their data. As the device captures data it records it onto an **SD card**.

ANALYSIS SOFTWARE

INPUTS

The modelling software requires input of solar cell details and environmental information collected by the data logger. Using this it can produce an accurate prediction of the amount of the power produced by the energy harvesting device over that time period. Time periods can even be averaged to get an idea of a typical day.

SIMULATION/COMPARISON

Unlimited **combinations** of data sets, PV cells/TEGs, and consumption power profiles can be added and compared within the software. **Battery sources** that can be charged and drained can be modelled as part of the system, so that the user can accurately product how well their device functions when powered by an energy harvester.

PHOTOVOLTAIC

The PV cell uses an equivalent **two-diode circuit model** with parameters **automatically** determined from those on a cell datasheet, using a reliable and accurate method [2]. Adjustments are made to the model for chemistry and irradiance.

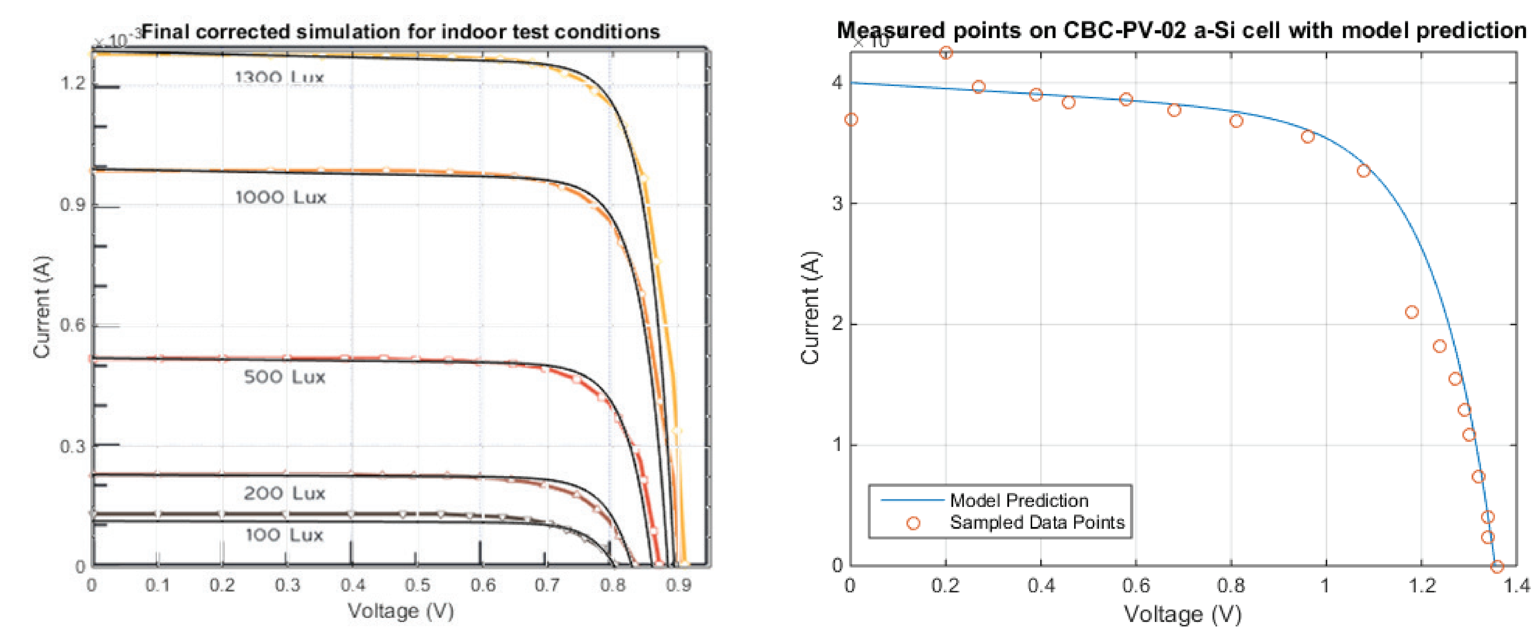
THERMOELECTRIC

The TEG model is simpler, with its main purpose to demonstrate the extensibility of the project. It uses a simple model that extrapolates a new curve from an initial one defined by input parameters, which is accurate at constant environmental conditions.

RESULTS & CONCLUSION

An accurate and reliable Bluetooth-enabled energy harvesting logger and prediction tool has been produced, including modules for photovoltaic and thermoelectric devices. It can be further extended to enable the evaluation of other types of energy harvesters, or to use alternative device models.

After collecting real data using the data logger and inputting it into the software model, it has been proven that the system produces a prediction of **within 1.4% accuracy** for an amorphous PV cell, and good agreement with a Gallium-Arsenide cell over a range of light intensities.



Left: *manufacturer tests (in colour) overlaid with our model predictions (in black)*
Right: *comparison of measured real-world data points to our model*

[1] J Donovan, *New Applications for Energy Harvesting* [Online]. Available: http://uk.mouser.com/applications/energy-harvesting-new-applications/ [Accessed 21 10 2014].
[2] K Ishaque et al, "Accurate MATLAB Simulink PV System Simulator Based on a Two-Diode Model" in *Journal of Power Electronics*, Vol.11 No.2, pp 179-187, 2011.

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