Bringing Mobile Phone Coverage to Rural Areas With a Green, Off-Grid Energy Solution

Diverse Energy's PowerCube replaces diesel generators with fuel cell technology that takes industrial gas and converts it into electricity with zero local carbon emissions.

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– Dr. Mike Rendall, Diverse Energy Ltd

The Challenge:
Developing a green, off-grid energy solution to power mobile phone base stations in rural Africa.

The Solution:
Using NI CompactRIO hardware and NI LabVIEW software to control and monitor ammonia cracking to deliver regulated DC electrical power that produces only clean water and nitrogen as by-products. This new PowerCube system provides a clean and reliable electrical supply to rural areas of Africa, and, as a result, enables mobile phone coverage to become more stable and far-reaching.

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Introduction

According to a report by the United Nations, mobile phone adoption in Africa rose more than 500 percent between 2003 and 2008 and can be expected to continue rising exponentially. As such, mobile phones are revolutionising economies in Africa, the world's second largest continent.

However, a mobile phone is of little use without adequate signal coverage. To create a mobile phone signal coverage area, you need a base station, which in turn needs a sizeable and reliable electricity supply. The geographical coverage area produced by a single base station is limited, so a country requires a distributed network of base stations to provide adequate mobile phone signal coverage, which in turn requires a distributed and maintainable supply of electricity. The current energy grid in Africa is anything but distributed or reliable and rural areas suffer the

worst conditions. In the relatively few locations where the grid is available, it is often only powered on for a few hours a day and is not dependable during that short time.
Diesel generators have been suggested to fix this problem, but that is far from an ideal solution. Diesel generators are noisy and inefficient when run at part loads. They also require regular maintenance in the form of oil changes every 300 hours due to their moving parts. On top of that, they simply are not an environmentally friendly solution because they emit particulate soot and sulphur into the local atmosphere. Another problem is that diesel generators and their local fuel stores are highly resalable, which makes them prime targets for theft, especially in remote and unguarded areas.

Diverse Energy's solution replaces the diesel generator with fuel cell technology, which takes industrial gas and converts it into electricity with zero local carbon emissions. The industrial gas used in the current product is ammonia, a widely used and distributed gas for refrigeration and pharmaceuticals. Ammonia is also used in substantial quantities to generate fertilisers for agriculture. To turn ammonia into electricity, one must tap ammonia from a bulk supply, reform the ammonia into hydrogen and nitrogen, separate the hydrogen from the mixed gas stream, and pass the pure hydrogen stream to a fuel cell to produce electricity and pure water. In Diverse Energy's PowerCube, NI CompactRIO controls and monitors the entire process.

Useful By-Products

Diverse Energy's PowerCube not only does away with environmentally harmful waste, but also produces useful byproducts. The PowerCube's main byproduct is pure, deionised water, and one unit can produce up to 50 litres per day. In areas where pure, sanitised drinking water is scarce, this is especially helpful.

For all small companies, time to market is a key driver in a business model. If you take too long, you may miss the golden opportunity. The LabVIEW graphical programming environment helps with rapid development and deployment. If we had undertaken the same programming challenges in a text-based language, we wouldn't be anywhere near where we are now in the development cycle. LabVIEW helps engineers and scientists make rapid changes to code to test and analyse different operating modes. Conventional programming requires a number of coding specialists to support the development team, thus increasing headcount and costs.

We initially developed a 'mark 1' PowerCube that was built around NI Compact FieldPoint. When we realised that CompactRIO could incorporate faster processing as well as global control and communication, we decided to change platforms. The CompactRIO platform also incorporates an accessible field-programmable gate array (FGPA) built directly into the backplane of the chassis. Using the LabVIEW graphical interface, we programmed the FPGA to enhance the functionality of the standard I/O, including the production of custom PWM and sine output signals. By embedding this functionality in the FPGA, we offloaded processing from the controller, thereby freeing up the controller to complete other tasks. This also reduced the amount of custom hardware, which had a substantial impact on lowering cost and construction time.

Due to the inherent scalability of LabVIEW, we reused as much as 80 percent of our code when changing our hardware platform from Compact FieldPoint to CompactRIO, saving a significant

amount of development time and cost. It took around eight months to develop and test the mark 1 PowerCube, but only two weeks to move the project over to the CompactRIO platform, including writing a bespoke FPGA image.

Rather than let the Compact FieldPoint systems collect dust, we retasked them to control three independent test stations to test fuel cell modules. By linking Compact FieldPoint to a database, any updates to the code intended for deployment onto the PowerCube are reflected by the test stations on the very next run. In this way, the tests run on the fuel cells remained absolutely relevant as the design of the final product evolved, all with minimal coding time or effort.

The Future

We currently have five PowerCubes running in Africa, with a further five in the United Kingdom that are ready to be shipped. LabVIEW and the CompactRIO platform are perfect for development and field trial use. The ability to easily monitor real-time data and rapidly apply code modifications is an obvious benefit when developing new systems.

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