Ultracapacitors Help P21 To Provide Fuel Cell-Based Backup Power For Telecoms

Introduction

P21 develops, produces, and sells fuel cell based backup systems. They are used in base station networks where conventional batteries often operate at their technical limits. With its patented, hydrogen-powered PEM fuel cells, P21 is the leading supplier of fuel cell power for use in the telecommunications industry: as backup solutions, primary supply in combination with renewable energies, energy saving systems with unattended remote control operation

While fuel cells are an excellent technology for backup power, they take a few seconds to come online and provide full power. P21 therefore needed to select an energy storage technology to provide short-term "bridge" power to cover this gap. It chose ultracapacitors from Maxwell Technologies, as these provided a number of advantages over batteries for this application.

Requirements for backup power in telecoms

For many mission-critical installations, backup power generation equipment is essential to ensure continuous operation. The telecoms industry, in particular, needs to ensure that its mobile phone base stations have power at all times, and are able to keep functioning even if there is an interruption to the grid electricity supply.

Traditionally, the technology chosen for back up power was batteries. More recently, fuel cells have been used for base station power backup. PEM (Proton Exchange Membrane) fuel cells are today highly-efficient energy conversion devices that can operate continuously for as long as hydrogen is available. They are environmentally benign and can provide a reliable source of back-up power for many applications. They provide high reliability and savings in cost, space and weight, and can withstand harsh conditions of high temperatures and humidity. P21 fuel cell systems have advanced control and online monitoring features, to ensure they are safe in operation.

Fuel cells have proven reliable in practice, with over 1 billion hours of operation over 10 years in back-up power applications. Based on a 10-15 year useful life a fuel cell based solution can be around 30% less expensive than a battery backup solution.

However, a typical P21 fuel cell has a start up time of about 5 seconds to achieve full power. This means that a short-term source of bridge power is still required to ensure continuous operation.
While batteries have often been used with fuel cells to provide this bridge power, they have a number of disadvantages, including relatively short lifetime, regular maintenance requirements, and poor performance in extreme temperatures. For

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long-lasting, reliable applications this means there is a higher maintenance cost, and concerns about reliability.

Ultracaps in backup power solution

P21 decided to investigate other energy storage solutions that could be used instead of batteries. They chose ultracapacitors, which are an excellent match to work with fuel cells. With low ESR and high charge storage capacity, ultracapacitors can ramp up large currents with minimal change in voltage, creating a short-term buffering response to peak power demands. They smoothly deliver power through transient interruptions. This permits the fuel cell to maintain its quiescent operating point without inefficiency. This combination results in an energy rich, reliable, maintenance free solution that is also very environmentally friendly.

"Ultracapacitors were selected because of their reliability, load/duty cycle stability and because they are maintenance free," said Dieter Braechtken, CEO of P21 GmbH. Maxwell's ultracapacitors have a lifetime of typically over a million cycles, making them well-suited to this application.

Ultracapacitors have another advantage over batteries that makes them suited to support fuel cells in backup applications. A fuel cell's output varies with load. A battery's output is fairly fixed, and will affect the fuel cell's performance. An ultracapacitor, however, has no fixed operating voltage, and therefore can operate directly across the output of the fuel cell, directly into the power electronics.

Ultracapacitor technology and benefits

Also known as supercapacitors or Electrochemical Double Layer Capacitors (ELDC), ultracapacitors are not a new component, but the technology has advanced dramatically in the last 5-10 years.

The beneficial characteristics of ultracapacitors are made possible by their composition and construction. Their activated carbon electrode has a specific surface area of 2000m^2/g with a charge separation of 10 Angstrom or less, giving them a very high capacitance. High conductivity electrolytes, a proprietary electrode manufacturing techniques and an advanced cell design allow ultra-low internal resistance and thus highest power density products. The energy storage mechanism is highly reversible, with no chemical bonds being made or broken, leading to a cycle life of over 1 million cycles with minimal degradation. The operating temperature domain is between –40degC and +65degC, or even higher for short durations.

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Figure 1: Maxwell BMOD0058 and BPAK0058 ultracapacitor modules for bridge power applications

With the maturation of the ultracapacitor industry, ultracapacitors are highly competitive with, and in many cases superior to, older bridge technologies. They offer the functionality, life cycle costs, and reliability necessary to make mission-critical power backup systems successful. Since the ultracapacitor is used strictly as a bridge, its high power density is well suited to supply high power for short periods up to 30 seconds. A battery is more typically sized to deliver power over longer periods, making them larger than necessary in case of bridge power applications. If a battery is sized for the actual short duration required, it may have difficulty supplying the necessary power.

One key challenge with batteries is the difficulty in measuring their state of charge and their state of health. The charge of an ultracapacitor, however, is measured solely by its voltage. The measurement of the capacitors charge and internal resistance allows to determine the state of health. A simple and direct monitoring of the energy storage system is thus guaranteed. Additionally, since ultracapacitors operate on a different principle than batteries, the ultracapacitor is capable of sitting on a charge voltage for extended periods without any loss of capacity, unlike a battery.

Furthermore, cycle depth isn't an issue, so ultracapacitors can be micro-cycled (cycled less than 5% of their total energy) or full-cycled (cycled greater than 80% of their total energy) with the same long life.

Ultracapacitors are inherently reliable because of their composition and construction. There are no mechanical moving parts as in a flywheel, eliminating all maintenance. Combined with the wide temperature range, long life, and flexible voltage range, ultracapacitors provide an extremely reliable solution for bridge power.

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P21's Premion T system

P21's Premion T fuel cell products, which incorporate ultracapacitors and fuel cells, have been developed specifically for the needs of the telecoms industry. Compared with conventional batteries they guarantee completely flexible backup times, are substantially more cost-efficient and reliable, significantly lower maintenance efforts and longer life and are much more environmentally friendly because of the use of hydrogen to generate electricity. The fuel cell systems also reduce energy costs due to reduced air conditioning requirements, and total cost savings of more than 30% can be achieved over the whole lifecycle.

For UPS applications in telecoms, Figure 2 shows a typical backup system with battery, while the layout of a backup system including Premion T is shown in Figure 3.

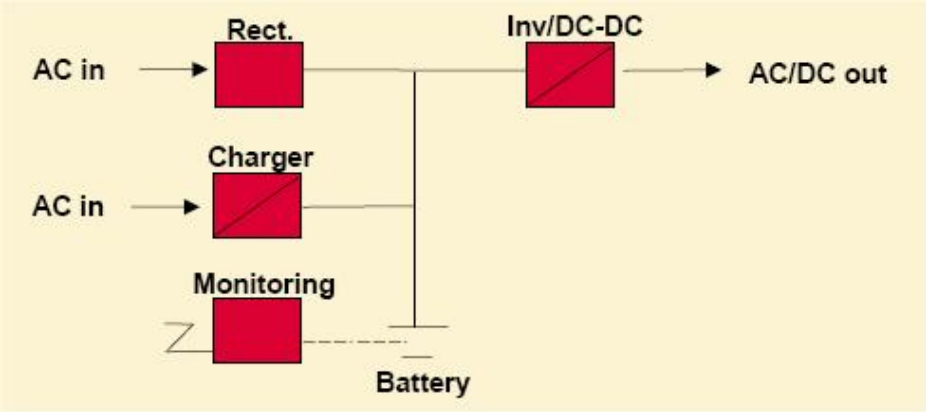

Figure 2: layout of a typical backup system with battery

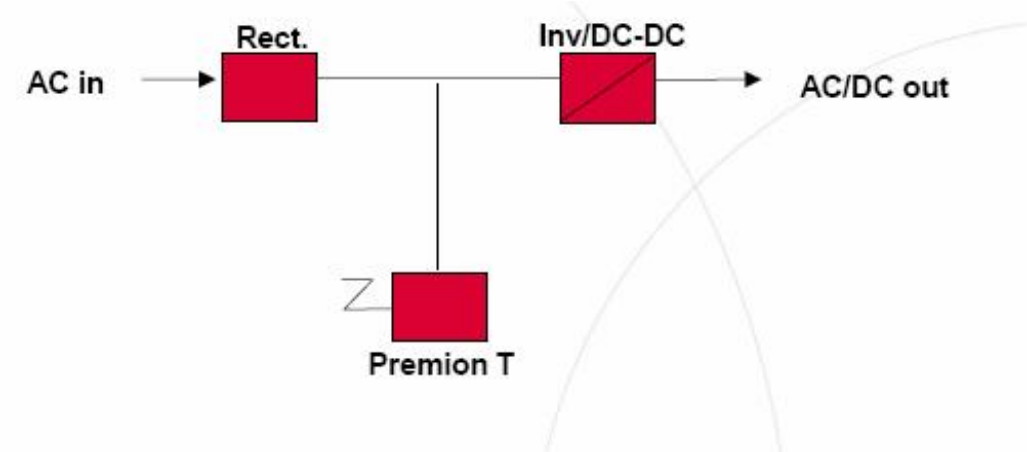

Figure 3: layout of a typical backup system with Premion T fuel cell system

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The Premion T system is housed in a 19" rack and weighs 93kg. It delivers 3kW output power. It is extremely reliable, and thus ensures the high availability of the systems it is protecting. Typical lifetime in backup systems is 10-15 years.

To help ensure this level of reliability, Premion T includes sophisticated monitoring software, error logging and remote maintenance capabilities. The monitoring software can be used to show the operation of the ultracapacitors. Firstly, Figure 4 shows Premion T on standby, with the ultracapacitors fully charged from network power, at voltage of 54V.

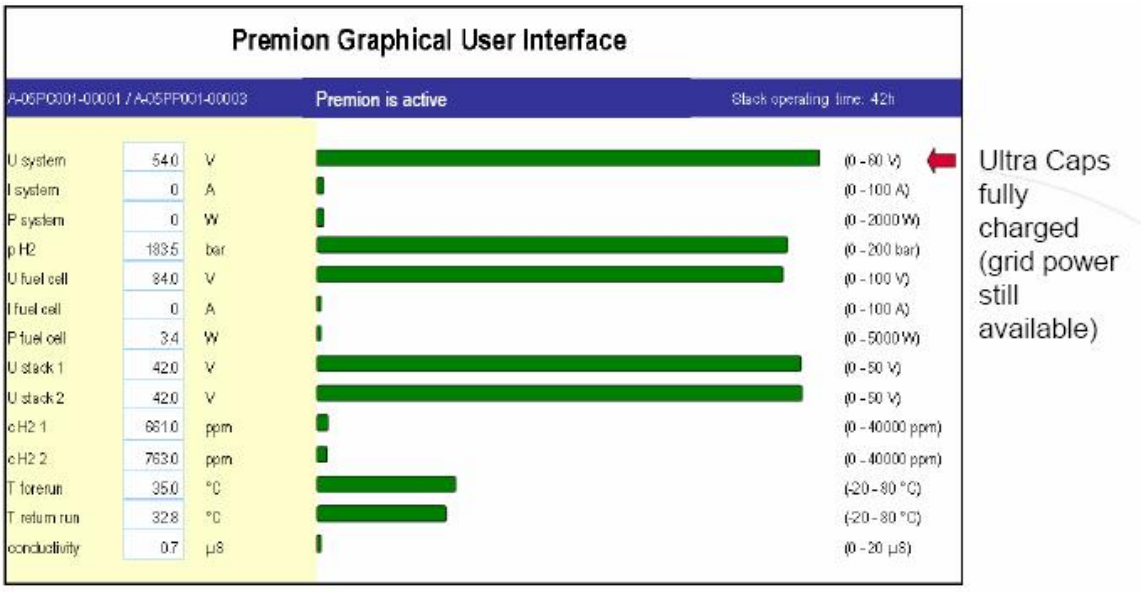

Figure 4: Premion T on standby

Then, Figure 5 shows what happens when the grid loses power and the Premion T starts to provide backup power. This is immediately after the grid power has gone down, and before the fuel cells are online. The ultracapacitors can be seen to deliver 1680W, maintaining system operation.

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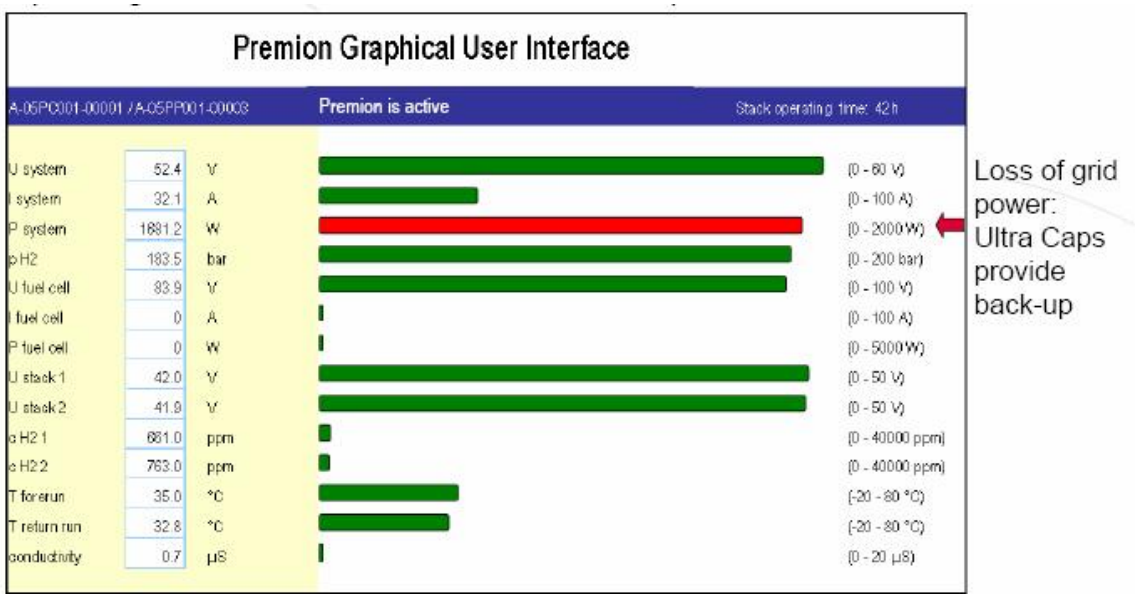

Figure 5: Ultracapacitors providing back-up power

Finally, Figure 6 shows the fuel cell system starting up and providing power for the system. The energy stored in the ultracapacitors has reduced, but the fuel cells are now able to recharge the ultracapacitors.

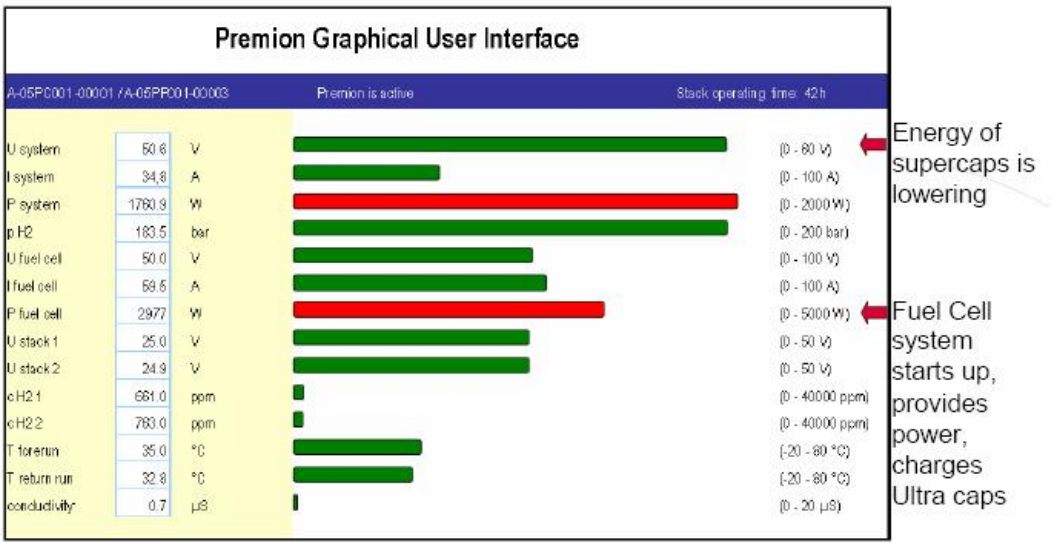

Figure 6: Fuel cells providing power

As well as ensuring continuous power during grid blackouts, the ultracapacitors also serve peak load requirements during fuel cell operation.

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Working with Maxwell Technologies

"The important factors that led us to choose Maxwell are the availability of the product, its quality and the availability of different packaging options, "said Dieter Braechtken. Maxwell's BOOSTCAP ultracapacitors can be solder-connected and thus easily integrated into P21's proprietary high-power electronic circuit boards.

The Premion project was started in 2002, and the first prototype was created by the end of the year. First shipments to customers were in 2003, and Maxwell's ultracapacitors have been proven to work successfully in P21's Premion products and prototypes in different product generations.

While the main focus of P21 is telecoms basestations, the Premion T has also proven to work well in different kinds of critical IT and communication applications, and the range of applications and product options is steadily being extended. "P21 is working to broaden the application range of the Premion T product and ramping up production," said Dieter Braechtken.

P21 has worked both directly with Maxwell, and with their German distributor Alfatec GmbH. "We have always been well-supported on the technical and commercial level. The response times were short and the information provided was helpful," said Dieter Braechtken.

Conclusions

Working with fuel cells, ultracapacitors are a valuable component for backup power applications, because they are reliable and maintenance-free, able to operate at extreme temperatures, and have a long operating lifetime.

P21 has designed an innovative backup power system for telecoms applications that takes full advantage of these features, and performs significantly better than battery-based alternatives.

"The ultracapacitors are an important feature to enable P21 to provide the benefits of our fuel cell systems to our customers," concluded Dieter Braechtken.

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Figure 7: Premion T system

About P21

P21 GmbH was founded in 2001 as a management buy-out from the Mannesmann/Vodafone group. The founders had one major goal that today has been realised: to develop fuel cell products that fulfil the highest requirements in the telecommunications and IT industries - and to considerably expand the technical capabilities in backup power supply.

An international consortium recognised the potential of this idea and provided P21 with the financial security it needed to grow. Today, P21 is a team of highly qualified experts with many years of experience in the industry. 35 employees from seven countries contribute their experience and expertise from all fields of fuel cell technology - from development to production and sales.

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