Hybrid power: the buoy has it

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Datawell has introduced a triple source, hybrid power option for the Waverider buoy. The power module combines solar cells, Boostcap capacitors and primary batteries. This innovative approach to energy storage effectively eliminates power budget considerations as a factor in determining operational maintenance schedules while surmounting the vulnerabilities and complexities associated with traditional rechargeable battery usage.

Since its introduction in 1968, the Waverider (WR) buoy has been recognised as a standard wave data acquisition tool. Throughout its lifetime the Waverider has used primary cells as its power source. In the early days there were no reliable alternatives and design considerations focused on achieving the lowest possible power consumption requirements.

Continuous improvements in electronics have resulted today in a specified power consumption of less than 0.35 watts for a Directional Waverider (DWR) continuously measuring and transmitting wave data. Using primary cells, the 0.9-metre diameter Directional Waverider has an operational life of three years between battery changes and the 0.7-metre version achieves in excess of one year.

To date, the incorporation of solar panels with accompanying rechargeable batteries has not been considered to be a viable option due to the increased vulnerability, complexity and costs associated with such modules.

Concept

However, the advantages of solar power are obvious. In sunny climates, solar energy can power a buoy for years without the need to ever change a single battery. In most regions however, while there is an abundance of solar energy during the summer months, the winter season normally provides insufficient recharging capacity.

This seasonal consideration has a major effect on the design of most solar systems for buoys with regards to both solar panels and batteries. The solar panels need to acquire as much energy as possible during low sunshine periods and the rechargeable batteries require sufficient capacity to carry forward the abundant summer energy into the winter period. This generally results in a large, cumbersome and expensive array.

Datawell has taken a different approach. This is to optimise the solar energy system for the summer time, via the introduction of solid state energy storage modules, and rely mainly on standard primary cells during the winter period. By adopting this hybrid concept the solar panel assembly can be kept small and only a minor amount of energy needs to be stored in order to cover the hours of darkness. The advantages are obvious:

- The solar panel can be kept small and positioned in a mechanically safe place.
- The energy storage medium needs to only bridge circa twelve hours a day and can thus be based on maintenance free solid state capacitors.

Figure 1 shows in more detail how the hybrid system works. There are three major components that set the Waverider “hybrid power module” apart from a primary cell powered buoy - the solar generator, the storage module and the electronic power switch. The latter is used to automatically switch between solar power and battery power in order to save as much battery power as possible. The buoy electronics keep track of the energy used from the primary cells. This infor-
The recent introduction of Boostcap capacitors opened the door for the hybrid power option. These devices offer a capacity of hundreds of farads (2.5 volts) within a 60-gram cell. Around these Boostcaps, Datawell has designed a hybrid energy system that combines the reliability and ease of primary cells with the lifetime generation offered by a solar system. Just a few of these maintenance free cells are needed to satisfy the low power consumption requirements of the efficient Waverider electronics for a 12-hour period.

The hybrid energy system consists of three major components:

- A dedicated solar panel array supplying energy to the buoy. It has a peak power equal to 1.5 times the energy consumption of the standard Directional Waverider using HF transmission.
- A set of Boostcap capacitors storing, and supplying when needed, the surplus solar energy. The capacity equals the energy used by a Directional Waverider with HF transmission during 12 hours of operation.
- Primary cells for one year of operation of a Directional Waverider with HF transmission.

This hybrid energy module is available for fitting to any current Waverider buoy - DWR/DWR-G/WR-SG - with any type of data link - HF/GSM/Argos/Orbcomm - both in 0.7-metre and in 0.9-metre diameter versions.

The idea is to use the primary cells when needed, from day one or during the darker periods of the year, and to use solar energy whenever available. The advantages are obvious; the buoy is always ready for use and the finite energy content of the primary cells is extended to a point where it is no longer a limiting factor for maintenance scheduling.

Solar panel construction

The solar panel array converts the captured sunlight into electrical energy. Due to the low power consumption of the Waverider only a small solar panel is required. The array comprises a flat circle of five-centimetre squared solar cells on top of the stainless steel hatch-cover and is protected by a layer of polycarbonate. This rugged construction, fully integrated within the original spherical design of the hull, makes the panel extremely robust. Using only 16 of these small cells, the array generates a peak power of 15 times the continuous power consumption of a Directional Waverider (specified at air mass 0).

During even reasonably short deployments, surface-floating buoys such as the Waverider cannot avoid suffering from marine growth, salt crystals, bird deposits and physical knocks. Shadows cast by the antennae and fixings will also intrude between the sun and the solar cells. Therefore, a novel cell configuration has been used to deal with these situations.

Usually a solar panel array consists of many small solar cells connected in series. When a shadow blocks light to an individual cell or a cell is damaged, the chain is broken and the whole section stops producing energy (see Figure 2A). The solar panel array on the Waverider overcomes this potential problem by linking the solar cells in a matrix (see Figure 2B). When any one cell is blocked, current can still flow through the neighbouring cells in the matrix. In the unlikely case that a complete row in the matrix is blocked, no more current would flow but the probability of this happening is minimised by placing the individual cells of a row as remote as possible from each other.

A by-product of this novel approach is that the design of antennae and hatch-cover handles is not compromised by the solar panels. This ensures that the existing excellent transmission specifications and time proven ease of handling of the hatch-cover features are retained.

Boostcap capacitors

The pivotal innovative feature of the hybrid Waverider is the Boostcap capacitor. An array of these specialised, ultra-high capacity capacitors is used to store surplus solar energy during the day. A normal power supply capacitor typically has a capacity of 0.0047 farads. Boostcaps are available in capacities up to 2600 farads. That is half a million times more than a normal power supply capacitor.

Although Boostcaps do not come anywhere near the storage capacity of lead-acid batteries, the extremely efficient, low-power consumption electronic design of the Waverider ensures that enough energy can be stored to power the Waverider through the night. The main operational advantage of the Boostcap is its robustness - it is a completely maintenance-free component and can be charged and discharged millions of times. This makes the Boostcap ideally suitable for applications at sea.

First experimental results

The purpose of the hybrid power system is to reduce primary battery drainage. A typical result of this strategy can be seen in Figure 3. This data set is from a hybrid powered Waverider in Dutch waters (52oN latitude) during a sunny week in April.

It can be seen that the solar panel produced up to 4.5 times the required power in this spring week. The excess energy was stored in the Boostcap capacitors and used during the night. Sometimes the Boostcaps had expired before the sun rose again and sometimes, on fruitful days, the Boostcaps were full before the sun went down and surplus energy was dispersed. All in all, the Directional Waverider operated during this week for 82 per cent of the time on solar energy and four per cent of the generated solar energy was dispersed.

During winter times the percentage of solar energy in the total power consumption budget is less favourable, as can be seen in Figure 4. The graph spans a period from November until April (i.e., winter and spring). Based on this graph it is estimated that the solar panel array will supply circa 30 per cent of the energy consumption of the Directional Waverider during the darkest half of winter.
the year. During the rest of the year this figure will rise to 80 per cent. From these numbers, it is safe to say that, on average, battery drainage will be halved and, thus, battery life will be doubled.

This doubling of the lifetime of the primary cells is what would be expected in regions with a pronounced difference between summer and winter. In regions with a more constant supply of sunshine (between the tropics) the lifetime of the primary cells will increase to an even greater extent.

**Conclusion**

In conclusion, the Datawell hybrid energy power system, developed for the (Directional) Waverider, combines the reliability of primary cells with the environmental and financial benefits of solar energy. The design makes no compromises in the important area of buoy design either with respect to vulnerability or functionality of the hatch, hatch cover and antennae. The design is suited for use in all climates and provides a “ready for action” buoy at all times. By at least doubling the lifetime of the primary cells, battery life no longer determines the service interval for the buoy.