Wireless Condition Monitoring

Extending Battery Life Using Thermal Energy Harvesters

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BENTLY NEVADA* WIRELESS SIGNAL INPUT MODULE (WSIM) WITH EXTERNAL POWER MODULE BASE, CABLE, AND PERPETUA POWER PUCK** POWER SOURCE

One of the main benefits of our wireless condition monitoring system is that the processed signals are sent to the data acquisition unit via radio transmission, rather than through physical field wiring that requires costly conduit to protect the signal cables. When powered by internal batteries, our wSIM and Repeater modules are not required to be located near sources of ac power. This allows for broad flexibility in selecting mounting locations at an industrial site. However, the very batteries that allow our wireless modules to be so flexible eventually become depleted and need to be replaced. This is why we developed the External Power Module.

An External Power Module (Reference 1) contains the same kind of lithium thionyl chloride batteries that our normal battery packs do. However, it also incorporates a connector for accepting direct current input from any source capable of providing 5 vdc at 0.5 mA. If the output of the external power source drops below this value for any reason, the internal battery pack automatically takes over, performing its duty the same as a normal battery pack that doesn't have the external power option. As long as the external power source is carrying the load, the internal battery simply serves as a standby source of power, and its life is extended to the full limits of its normal "shelf-life."

We have evaluated several possible sources of external power over the past few years, with mixed results. Recently, however, we had some very satisfactory results with a thermal energy harvester called the Perpetua Power Puck. At the heart of any thermoelectric generator – including the Power Puck – is a device that generates electrical energy when it is subjected to differential temperature.

Ordinary thermocouples are familiar examples of this principle, relying on the Seebeck Effect for their operation. Whenever two dissimilar materials are connected in two places, with one junction in a warmer location and the other junction in a cooler location, an electrical potential, or voltage is developed between them. When the circuit is completed through a load, useful current flows. Modern thermal energy harvesters, such as the Power Puck, add onboard electronics to regulate the supplied voltage for added stability.

The Power Puck design includes an integral magnet that allows the base to be securely attached to any hot (magnetic) surface. The fins on the top of the unit use natural convection with ambient air to provide the cool junction needed for operation.

Engineering Field Trials

For the field trial described here, we selected a natural gas fired multi-technology power generation facility with peak generating capacity of just over1000 MW. The newest units at the site use combined-cycle technology, incorporating heavy-duty gas turbines with Heat Recovery Steam Generators (HRSGs) and steam turbines. The site also includes simple-cycle dual-fueled gas turbine peakers and older-technology gas-fired steam plants.

The wide range of plant equipment provided ample opportunity to test the Power Puck modules on a variety of different hot equipment surfaces, a few of which are shown here (Figures 1 through 3). Most of the selected surfaces provided adequate differential temperature (delta-T) for the Power Puck to fully supply a wSIM for the entire evaluation period. One of the surfaces that we tested was too cool to provide the required delta-T, yet it still contributed a significant amount of power to the wSIM and extended the life of the battery. The results of this interesting test are included in Figure 4.

FIGURE 1: Warm Gland Seal Condenser support structure, with magnetically-mounted Power Puck and the thermocouple being used to monitor surface temperature for data collection. The temperature signal was processed and transmitted by the wSIM that the Power Puck was energizing.

FIGURE 3: Hot Boiler Feedwater Pump (foreground). Again, the surface temperature sensor used for engineering data collection is visible in this photo, next to the Power Puck. The air-cooled pump drive motor is at the left side of this photo, and the wSIM is just outside the field of view at the top.

FIGURE 2: Hot Boiler Feedwater Line. In this example, the wSIM was hanging upside down from the overhead structure and the Power Puck was attached on top of the piping tee at the bottom of the photo.

Test Results

Our results were very positive. In multiple trials, we verified that if the temperature difference between the hot surface and ambient air is 20 °C or more, the Power Puck will reliably power the attached wireless device continuously, and will not require the internal batteries to expend any of their stored energy. One of the more interesting tests used a Lube Oil Pump as the heat source (test data in Figure 4). This test showed that the Power Puck will actually provide power for a significant fraction of the time even if the delta-T is significantly less than 20 °C. In fact, the delta-T only exceeded this value once (red circle) during the five-day time period shown here.

Test Conclusions

Power Puck modules met our expectations, and operated reliably in a hot, dry, high-desert environment. Installation of the modules with the integral magnet was simple and took very little time, once a suitable warm surface was located. With a differential temperature of 20 °C or more, a Power Puck will reliably power a wSIM or Repeater module.

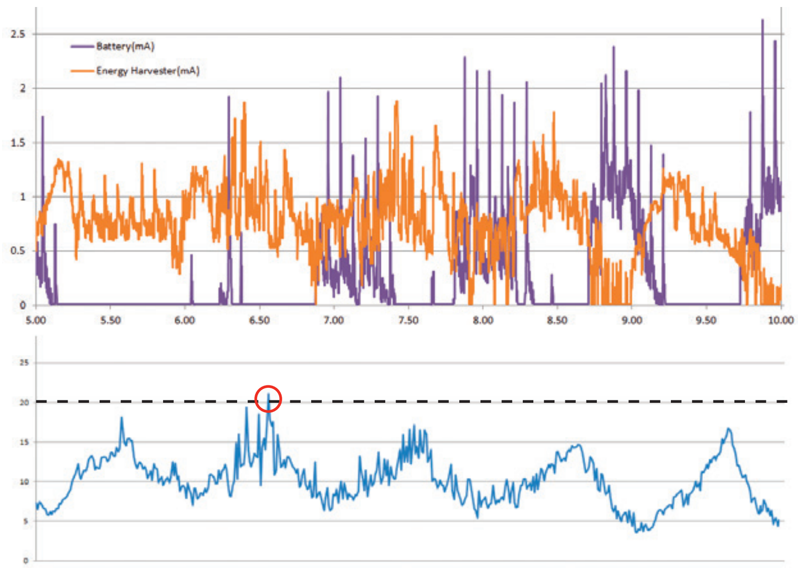

FIGURE 4: Five days of data for the Lube Oil Pump test. The upper plot shows wSIM internal battery current in purple, and Power Puck current in orange. The lower plot shows differential temperature in Celsius, with the 20 degree value indicated by the dashed line. Purple spikes in the upper plot represent brief periods when the External Power Module battery pack powered the wSIM.

Power Puck Benefits & Features Summary (Reference 2)

- Reduces the need to buy and install replacement batteries
- Reduces environmental impact from recycling expended batteries
- Enables more frequent collection, processing and transmission of data
- Meet IP67 requirements, and are RoHS compliant
- No moving parts, maintenance-free – thermoelectric generators are known for long-life operation – typically more than 20 years

What's Next?

At the time of this writing, we are working on including Perpetua's Power Puck thermal energy harvester in our wireless accessories. Our website will include this external power source when it is available. **http://www.ge-mcs.com/en/bently-nevada-monitoring/wireless-surveillance-scanning/essential-insight.html**

References

1. Specifications and Ordering Information, Part Number 185301-01. "Essential Insight.mesh – Wireless Condition Monitoring External Power Module datasheet, **http://www.ge-mcs.com/download/monitoring/185301_CDA_000.pdf**

2. Power Puck information is available at the Perpetua website, **http://www.perpetuapower.com**