Voltage Output Control, Device Communication and Data Collection

The following white paper reviews solutions used to make an IoT power supply monitoring and control device. It covers AC monitoring, output voltage control and operational feedback. It details techniques that created a dimmable, remotely operated lighting device capable of communicating with other devices in its network and being monitored for preventive maintenance.
Design Challenges

When designing a remotely operated and controlled power supply IoT device, working with AC power can be an obstacle. Implementing electrical isolation boundary technology allows the usage and monitoring of AC while simultaneously creating DC transformation space. That isolation also enables the on/off gateway and a TRIAC phase dimmer to vary the current.

Another issue with remote power supply IoT control is the distance between devices and the facilities center. In a smart network, communication among devices — and between devices and the controller — can be done through cellular, Wi-Fi or long-distance radios.

To ensure product maintenance, it is necessary to monitor the health of the input device along with the monitored system. Sensors and IoT monitoring devices — a term encompassing onboard circuitry that processes data, communicates with onboard sensors and provides connectivity to the onboard wireless devices — report readings, trigger outputs and make reports using a cloud-based network.

A final design challenge is to guarantee ongoing data collection and communication, even in the event of a power outage. Attaching a rechargeable onboard battery device, capable of running the monitor without the AC power source, covers that need.
Innovative Components

AC Monitoring, Switching, and Dimming

Isolation Boundaries

Isolation boundaries separate and quarantine voltages. They can be established through multiple means, including physical and optical. In this example, an electrical isolation boundary was used. It created a safety zone between the area of high voltage — the AC power input — and the area of where the intelligent monitoring, among other controls, rest. Voltage cannot pass across the boundary without going through a gateway. Switched AC is applied to the output source while transformed DC current can remain within its boundaries to power the device.

On/Off Switch

When dealing with a scenario where a device’s power status must be remotely switched — such as a lit sign — an intelligent monitoring device can be designed to work with an on/off gateway. The device receives a scheduled or an at-will command from a coordinated cloud platform. The device then relays it to the on/off gateway. The gateway opens the circuit, which switches the output off. The event platform can even receive third party information, such as what time the sun will set, and send a command that the circuit should be closed, turning the lights on.

TRIAC Phase Dimmer

Like with the on/off switch, the TRIAC phase dimmer receives commands from an intelligent monitoring device designed to receive independent or scheduled actions. In the dimming situation, a Field Programmable Gate Array (FPGA) monitors the frequency of the AC current using an isolated zero-cross detector. At the zero-cross pulse — or when the voltage hits zero along the y-axis — the FPGA indicates when the TRIAC phase dimmer
should turn on, to vary the AC output current. It switches the output voltage along a range of 128 steps each AC half-cycle. The FPGA maintains a delay between the zero-cross pulse notification and the dimmer’s activation, as a guard band, or margin, to mitigate zero-cross sensing error, and to guarantee sufficient voltage to turn on the TRIAC.

**On-board Battery**

Although the device will be configured to power itself using the main power supply, there may be times when the power will go out. In those situations, an onboard, rechargeable battery is necessary to continue operation of the device. The battery does not need to be a substantial provider as it will not power the output. However, it will provide enough power to continue collecting information about the power source and communicate data to be stored in the remote cloud platform.

**Communication**

**Cellular**

To ensure that your IoT device can communicate in remote areas, it should be equipped with cellular capability. Certifying it with a major provider will ensure it has access to a large cellular network. It’s also important to use an external antenna. This will enable better connectivity and access to service.

**Wi-Fi**

This service likewise requires adding in an extra antenna, though it may be internal. Using
Wi-Fi, such as any of the IEEE 802.11b/g/n, will ensure that data is transferred quickly to the cloud platform. Wi-Fi is less attractive on this type of device, however, due to often remote locations and poor service.

Long-Range Capability

Equipping the device with long range radios provides the device-device communication. With this addition, data can be sent to a central monitoring device and uploaded to the cloud, unburdening the cellular network.

Data Collection and Feedback

Environmental Sensors

For a power supply device such as this, it’s important to make sure the operational environment is appropriate. Place a temperature sensor within the IoT monitoring device. As it logs and records temperatures, it can trigger alerts in the connected platform if the temperature threshold is crossed. Likewise, a humidity sensor will trigger an alert if it registers a reading outside of the appropriate range.

Current Monitor

The same intelligent monitoring device that commands the dimmer contains the capability to monitor the feedback from the output destination. For example, in an illuminated sign, the output power required by the sign could be monitored. Multiple signs at a location could all be monitored by individual devices, yet connected to the cloud by a single IoT device. If one of those signs reports a current draw that is lower than the normal average current, it may mean the sign needs servicing. When the current monitor registers these discrepancies, it has the ability to return alerts to the cloud platform. In turn, that event could trigger an alarm for immediate maintenance to ensure the sign is operating correctly.

Cloud technology

One of the key tools for a remote IoT power supply device is its ability to connect with a cloud software application. The device can be proprietary or configurable to other options, depending on your device’s use. Its communication needs to be encrypted.
Wider Applications

The strengths of a remote power supply device with these design elements include its versatile application. Implementing an IoT power monitoring system would benefit anyone with many light-based outputs. Any “smart city” environment could employ this technology to save money, reduce consumption and prevent outages. Below are two applications of this technology.

City Centers

Imagine the overhead lamps, lit installations or streetlights illuminating your favorite walk home. If those lights go out, a walk instantly becomes less safe, which is one reason many developing cities have made smart operations a priority. Monitoring power supplied elements can be a hassle. Concerned citizens phone in reports or endless rounds are required to catch a broken light, a flickering sign or other power supply issue. Cities with new pedestrian areas and public parks require special maintenance due to the volume of people and the inaccessibility by vehicle.

With this kind of device, the aggregate feedback could be used to determine if lit street signs or overhead lamps had gone out. Streetlights could be turned on at low levels before gradually being brightened as sunlight fades. In the event of a power outage, onboard batteries would relay situational statistics as well as indicate if or when the device powers back on. Maintenance could be done more efficiently. The city’s overall power consumption could be lowered, especially in conjunction with the dimming schedule.
Amusement Parks

One of the more iconic elements of any amusement park experience is the lighting. The bright neon of the Walt Disney® logo and the flash-bulb border of "Welcome to Las Vegas" are famous throughout the world. Flashes and pulses accompany rides. Mock streetlamps recreate famous movie scenes. Safety kiosks light up less-traveled park places to keep everyone safe. Even background lighting makes the difference between an eerie canal and a manufactured river.

In an environment like an amusement park, power supply and consumption is a huge concern and a bigger cost. Imagine if an electrical team put individual devices on a few of their largest power consumers? Those signs could deliver data in motion for constant monitoring and optimization. Front gate signs would no longer deliver skewed messages if a single bulb, letter or strand lost power.