Title

LBNL Open Power Data

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Abstract

The dataset stored at `https://powerdata-explore.lbl.gov` is a set of power measurements and annotations, and an interface for exploring and downloading that data. The power measurements are collected by micro-phasor measurement units (μPMUs) [Powa, VMCMA14] and PQube3 power quality meters [Powb] manufactured by Power Standards Laboratory in Alameda, CA and located at Lawrence Berkeley National Laboratory, as well as other sites. This white paper describes the datasets, how to view and download the data and associated metadata.

The PQube3 power quality meters [Powb] and PQube3 "micro-phasor measurement units" or "micro-PMUs" or "μPMUs" [Powa, VMCMA14] that we use measure the three-phase voltage and current phasor at 512 samples per cycle, 60 cycles per second. The PQube3s output data via a ModbusTCP interface at 2 Hz, and, when a trigger condition is initiated, can output at the full 512 samples/cycles, 60 cycles per second. The μPMUs also measure phase angle, and output synchrophasor data at 120 Hz. Both the PQube3 and μPMUs are designed to be positioned at different points over the distribution grid. These μPMUs enables analytics that are similar to the use of PMUs at the transmission level, but at a higher sampling rate and precision. Both the PQube3 abd μPMUs were developed by Power Standards Laboratory of Alameda, CA – the μPMUs were developed as part of an ARPA-E-funded project.

Sensors	Power Standards Lab PQube3 Power Quality Meter and PQube3 Micro Phasor Measurement Unit
Data Location	`https://powerdata-explore.lbl.gov`
Data Type	Current, voltage, and phase angle for single phase or all three phases, depending on sensor location
Sensor Measurement Frequency	512 Samples/Cycle, 60 Cycles/Second
Sensor Output Frequency	120 Hz
Resolution	0.001° for voltage and current phase angles, 2 PPM resolution for voltage and current magnitude
Interfaces	Web visualization; JSON and CSV download; and Python API

The data located at `https://powerdata-explore.lbl.gov` is collected by PQube3s and μPMUs installed and used initially for a variety of purposes. Some of that data was collected originally for the aforementioned ARPA-E project, and has also been collected by E. Stewart, et al., as part of the *Open-μPMU* dataset [SLR16]. Other data in `https://powerdata-explore.lbl.gov` has been collected as part of a DOE Cybersecurity for Energy Delivery Systems (CEDS) project that seeks to study the use of μPMUs to detect cyber attacks against the power distribution grid [JSP+16, JSR+17c, JSR+17b, JSR+17a]. Other projects have also used `https://powerdata-explore.lbl.gov` to store and analyze data for additional purposes. For example, the PQube3s and μPMUs monitoring high-performance computing systems were initially installed to examine the ability to perform "side-channel attacks" on the HPC systems — that is, to use power data to infer what types of computational activities are taking place on that HPC system.

The data located at `https://powerdata-explore.lbl.gov` can be visualized via a web front-end, downloaded in multiple formats, including CSV and JSON, both raw and with downsampling; and also accessed via a Elasticsearch and Cassandra-based APIs.

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S. Peisert was the Principal Investigator of the sponsored research projects that created the data framework located at `https://powerdata-explore.lbl.gov` and installed the power sensors in LBNL Buildings 50 and 59.

R. Gentz substantially debugged and enhanced the sensor data acquisition portion of the data framework, implemented much of the RabbitMQ functionality and the Grafana interface, and conceived of the much of the user interaction with the framework both by the visual front-end and the API.

J. Boverhof significantly influenced the two-database (Elastic and Cassandra) design currently the data framework, performed a substantial amount of the system administration for the back end, and provides ongoing assistance and maintenance of the project.

C. McParland conceived of the original design of the sensor data acquisition from the PSL μPMU sensors, early versions of the database architecture and the messaging processes, and implemented much of the early code.

S. Engle provided substantial feedback on the interface and visualization pieces of the project, developed the project's web site landing page, and implemented one of the versions of the

A. Elbashandy implemented an early version of the front-end for the data framework.

D. Gunter provided useful feedback on the architecture of the system.

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