



CASE STUDY

Radar Failure at 12,000 Feet Not Optional

Ani Dimusheva, Power Standards Lab

High above the Fryingpan Valley in Colorado looms Red Table Mountain, a massive 18-mile long sandstone ridge protruding sharply from the valley below. The mountain top is accessible by a 4-wheel drive vehicle just two months of the year, a bumpy ride up a single lane road so rough it can wear out the wheels of an army jeep in a single trip. The rest of the year, the only way to the top is by helicopter. Here, at the clear altitude of 12,000 feet, FAA maintains a radar site for guiding aircraft over the Continental Divide. It is arguably one of the worst locations for a radar failure to happen.

Most radar sites are operated on commercial power, and are backed up by a generator with a Power Conditioning System (PCS). The PCS supports the Critical Radar Loads during power bumps, power spikes, voltage sags and transitions from commercial to engine-generated power. The static switch and the PCS unit have to make the transition in less than 4 milliseconds to ensure uninterrupted function of the beacon, radio transmitters and other radar equipment. The PCS at the Red Table Mountain site had a frustrating problem: PCS batteries were supposed to last up to 4 years, but they only lasted a year to year and a half. The frequent replacement of the



FAA Radar Station at 12,000 feet, Red Table Mountain, Colorado.



Jerry Taylor, a support engineer for the FAA Western Service Area, arrives on Red Table Mountain by helicopter to help staff solve the frequent switching puzzle.

batteries was costly and time-consuming. The site personnel suspected that the PCS unit was going to batteries frequently, without the engine sensing a power failure. It was not clear why this would be happening, so they requested assistance in identifying the problem.

The person sent to solve the puzzle was Jerry Taylor, an engineering technician with the FAA's Western Service Area Technical Support Center in Denver. Taylor had worked as a resident engineer for a number of years, installing Power Systems all over the United States, including Alaska and Guam. He was often called to assist facilities in solving critical electrical issues.

Before heading to Red Table, Taylor had asked for two PQubes to be delivered to the station. The PQube is a tiny but highly accurate instrument for monitoring and recording power quality. Taylor knew it had the unique ability to automatically email all data, including waveform captures, to anyone anywhere. It could also email daily,

weekly, and monthly reports about critical power parameters, including digital and analog data. Taylor had not used the PQube before but a colleague at the FAA Training Academy in Oklahoma City had recommended the instrument. Engineers there used the PQube to verify 4 millisecond static switch transfers, which other instruments could not always capture. The colleague described the PQube as a



A typical PQube installation: PQube unit (middle) with a power supply module (right) and a combined current/ethernet module (left).

PQube Events					
Date	Time	Type	Magnitude	Duration in Seconds	Files
2011/04/14	T 12:00:00.005	Snapshot	N/A	N/A	File List
2011/04/15	T 12:00:00.011	Snapshot	N/A	N/A	File List
2011/04/16	T 12:00:00.011	Snapshot	N/A	N/A	File List
2011/04/17	T 12:00:00.015	Snapshot	N/A	N/A	File List
2011/04/17	T 22:32:15.433	Voltage Sag	56.88%	0.200	File List
2011/04/17	T 22:32:15.840	Waveshape Change	N/A	N/A	File List
2011/04/17	T 22:32:19.048	Waveshape Change	N/A	N/A	File List
2011/04/18	T 03:57:43.927	Voltage Sag	89.22%	0.008	File List
2011/04/18	T 12:00:00.002	Snapshot	N/A	N/A	File List
2011/04/19	T 04:58:58.964	Voltage Sag	66.12%	0.219	File List
2011/04/19	T 04:59:02.925	Waveshape Change	N/A	N/A	File List
2011/04/19	T 07:56:43.428	Voltage Sag	89.07%	0.025	File List
2011/04/19	T 07:56:47.171	Voltage Sag	87.33%	0.078	File List
2011/04/19	T 07:56:51.455	Voltage Sag	86.07%	0.211	File List
2011/04/19	T 07:56:57.539	Voltage Sag	87.16%	0.220	File List
2011/04/19	T 12:00:00.006	Snapshot	N/A	N/A	File List
2011/04/19	T 14:44:27.926	Voltage Sag	74.67%	0.036	File List
2011/04/19	T 14:44:30.991	Voltage Sag	72.64%	0.275	File List
2011/04/19	T 14:49:03.962	Voltage Sag	72.49%	0.069	File List
2011/04/19	T 15:02:04.175	Voltage Sag	75.66%	0.061	File List
2011/04/19	T 15:02:17.706	Voltage Sag	81.76%	0.042	File List
2011/04/19	T 15:02:20.406	Voltage Sag	81.58%	0.092	File List
2011/04/19	T 15:02:27.547	Voltage Sag	81.39%	0.225	File List
2011/04/19	T 15:12:00.180	Voltage Sag	82.28%	0.050	File List
2011/04/19	T 17:33:31.464	Voltage Sag	71.74%	0.033	File List
2011/04/19	T 17:33:31.699	Waveshape Change	N/A	N/A	File List
2011/04/20	T 12:00:00.010	Snapshot	N/A	N/A	File List
2011/04/21	T 12:00:00.004	Snapshot	N/A	N/A	File List
2011/04/21	T 14:45:10.485	Voltage Sag	74.87%	0.044	File List
2011/04/22	T 01:09:09.833	Voltage Sag	59.03%	0.200	File List
2011/04/22	T 12:00:00.007	Snapshot	N/A	N/A	File List
2011/04/23	T 12:00:00.010	Snapshot	N/A	N/A	File List
2011/04/24	T 12:00:00.011	Snapshot	N/A	N/A	File List
2011/04/25	T 12:00:00.016	Snapshot	N/A	N/A	File List
2011/04/25	T 14:57:54.525	Voltage Sag	33.16%	0.208	File List
2011/04/25	T 14:57:54.827	Waveshape Change	N/A	N/A	File List
2011/04/25	T 14:57:58.050	Voltage Sag	32.86%	0.308	File List
2011/04/25	T 14:58:01.658	Voltage Sag	33.06%	0.225	File List
2011/04/25	T 14:58:12.175	Voltage Sag	32.79%	0.408	File List
2011/04/25	T 14:58:22.883	Voltage Sag	32.74%	0.399	File List
2011/04/25	T 15:53:38.756	Voltage Sag	32.69%	0.408	File List
2011/04/26	T 12:00:00.018	Snapshot	N/A	N/A	File List
2011/04/27	T 00:30:07.902	Voltage Sag	65.20%	0.192	File List
2011/04/27	T 00:30:11.409	Waveshape Change	N/A	N/A	File List
2011/04/27	T 12:00:00.007	Snapshot	N/A	N/A	File List

Fig. 1. HTM summary of data from the PQube at Red Table Mountain.

plug-and-play device that requires minimal setup—just input power and a few CTs to begin monitoring and recording the system’s voltage and current. Unlike the bulky and expensive portable testing equipment technicians typically brought with them to test for problems, the PQube seemed like the perfect instrument to send to Red Table. Technicians could have several for the price of their regular testing equipment, and could receive the data right away and anywhere.

Taylor’s intention was to leave the two PQubes at the site to collect data on the commercial incoming power, the transfer time to the engine generator during power failure, the time the generator was on, the quality of generator power, the transfer back to commercial power, the PCS input and output power, and the transfer times of the PCS. Two PQubes could do all that, and provide the digital, analog and waveform data in real time. By leaving them connected to the equipment over a period of time, Taylor hoped to gather enough information to see if any events or patterns appeared—something he couldn’t do with a portable analyzer in a day.

When he arrived, Taylor found that just one PQube had been sent, so he installed it on the PCS input. He also connected two temperature/humidity probes that had been purchased with the unit because he felt the room might be too hot for the PCS and batteries. He installed one probe in the PCS room and one in an adjacent room, using an extension cable. As soon as it was hooked up, the PQube began monitoring and recording power data. Taylor returned to his duty station.

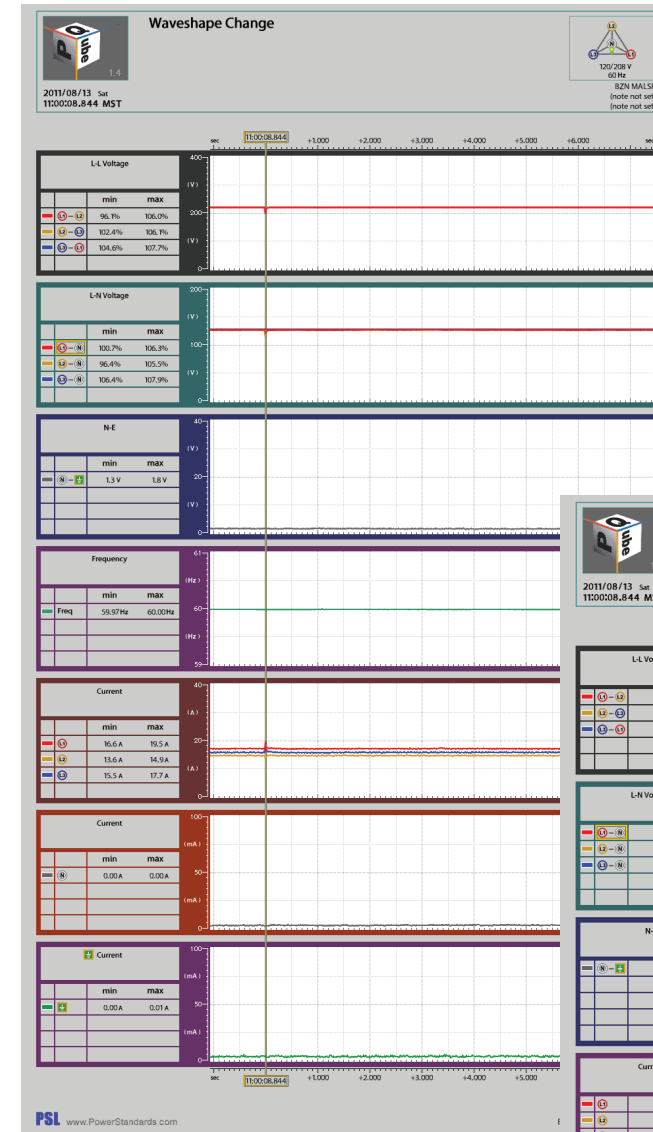


Fig. 2. Waveform and RMS “snapshots” of a waveshape change event like the one that caused the PCS unit at Red Table Mountain to switch.

Graphs like these, generated by the PQube directly, can be emailed as attachments and can be viewed in any picture viewer program—no special software is required.

Two weeks later, the site technicians forwarded to Taylor the data from the PQube’s SD card (.HTM summaries and .GIF and .CSV files he could open on any computer). The evidence was incontrovertible: In just two weeks, the PQube had detected and recorded 30 power quality events, noting the exact type, depth and duration of each event (Fig. 1). The PCS interpreted all of these deviations from normal voltage as power outages. The system switched from commercial to battery power every single

time, then switched back in a few seconds when it did not detect continuous outage. The PQube data revealed a second problem. To prevent the battery from freezing, employees were careful to keep the door of the PCS room shut all the time—raising temperature in the room above 100° Fahrenheit! Not only was the battery working overtime, it was working in an extremely overheated environment well above its maximum rating.

“What the PQube allows us to do is be proactive in how we deal with power problems. It’s like magic glasses: Suddenly you can see how much current you are drawing, what the voltage is doing, and see it as things are happening; the whole system becomes alive.”

— Jerry Taylor, FAA Support Engineer



The cost of a PQube (right) is a tiny fraction of the cost of a sophisticated backup system, and the knowledge and peace of mind it provides are absolutely priceless, says Taylor.

Taylor kept digging into the data. The shape of the waveform captured during the transfers alerted him to the possibility of bad capacitors in the PCS module—something the PCS manufacturer was quick to address.

Armed with the information from the PQube, the engineers at the site began to implement small but important changes to reduce wear on the PCS unit. They installed a filtering system to improve ride-through capability, and they tightened the timing of the transfer based on the voltage sag information from the PQube. They also called the utility company and asked it to address the voltage sags on its end. Finally, they installed an exhaust fan and a thermostat in the PCS room, to maintain optimal temperature and humidity. The Red Table technicians then followed up on Taylor's original intention and installed a second PQube permanently on the output side of the PCS. This allows them to compare input and

output data to make sure the PCS continues to function properly.

"The technicians do not want to give the PQubes back because they work so well and are so easy to use," says Taylor about his experience with taking PQubes around different sites. "I tell them next time they talk about buying an expensive monitor to instead buy ten PQubes so all the technicians have them."

"What the PQube allows us to do is be proactive in how we deal with power problems," he adds. "It's like magic glasses: Suddenly you can see how much current you are drawing, what the voltage is doing, and see it as things are happening; the whole system becomes alive."

Taylor can be reached at jerry.taylor@faa.gov. Ani Dimusheva is at ani@powerstandards.com. Learn more about the PQube at www.pqube.com.

