Keysight Technologies
How an Effort to Save Patient Lives Infected a Company's Bottom Line

Application Brief

The Challenge

It is no secret that health care costs are growing quickly. For example, U.S. health care inflation exceeded the general U.S. inflation rate in every year from 2005 through 2015 except 2009.[1] An ironic fact is that some of the cost is associated with infections picked up in healthcare facilities. The U.S. Center for Disease Control (CDC) says, "On any given day, about one in 25 hospital patients has at least one healthcare-associated infection."[2]

Fortunately, reducing healthcare associated infections (HAIs) is not particularly difficult or expensive. According to The Society for Healthcare Epidemiology of America, the importance of proper hand hygiene was known as far back as 1847, and hand hygiene is a very basic step one can take to reduce the risk of HAIs. The CDC puts it very succinctly: "hand hygiene saves lives."[3]

Saving Lives with Electronics

With the goals of saving lives and reducing costs by reducing HAIs, a company we'll call ACME (not its real name), introduced an automatic hand sanitizer dispenser for hospitals (we'll call it the ACME-1). Like many hand sanitizers, the ACME-1 would automatically detect the presence of hands and squirt out a specific amount of sanitizer. Unlike many other sanitizers, the ACME-1 would also use an RF transceiver to communicate wirelessly with the hospital's network to record usage. In this way, the hospital could check usage in various floors and departments to ensure sufficient use and reduce the rate of infections. This is important to hospitals, as it often costs the hospital (not the patient or insurance company) money to care for HAIs.

The ACME R&D team designed their detection and broadcast circuit and measured the current consumption using a standard oscilloscope and digital multimeter (DMM). Everything appeared to go smoothly. The cell used to power the dispenser was thought of as "set and forget," meaning that it would last for the expected life of the ACME-1 (five to ten years, even in the demanding environment of a hospital.)

Good News and Bad News

Customer orders were brisk, and there were smiles all around as the ACME-1 production line rolled into action. A year later, however, many of the units had dead batteries. The usage data showed that the usage in the hospitals with failed units was right around the expected level. There had to be something wrong with either the way the product was built and installed, the way the product lifetime calculations were made, or the way the current drain was measured.

Progress Toward a Solution

Careful examination of returned units showed no problems with the manufacturing process; the units appeared to be properly built and passed functional tests once a new battery was installed. A few visits to different hospitals showed that the units were generally installed in an appropriate manner. ACME's statisticians checked and double-checked the product lifetime calculations; the results affirmed the correctness of the original five to ten year estimates.

Finally, a product validation engineer realized that the current drain measurements had been limited by the shunt resistors in the DMM they used to characterize the performance. The resistance of the DMM was being added in series with the resistance of the ACME-1, creating a voltage drop ("burden voltage") that artificially limited the current output. This burden voltage led to a smaller current usage value that in turn produced the incorrect, longer lifetime projection.

At this point, the customer decided to try the Keysight N6705B DC Power Analyzer with an N6781A source-measure unit (SMU) module. The SMU has no burden voltage, so it showed the correct (larger) peak current of approximately 100 µA. However, the 100-µA peak current was significantly shorter (in time) than the 10-µA peak current measured on the original test equipment, so the overall power consumption was about the same as the original estimate.

The Final Puzzle Piece

Although the total power consumed was not much different between the two methods, the SMU's reporting of the correct peak current provided the key clue. The reason the batteries were failing was passivation of the battery (lithium chloride buildup on the lithium anode) caused by the high current demand. This caused the battery voltage to drop very low—much more quickly than expected—even though the total energy/power delivered by the cell was not very high. A quick examination of the battery's data sheet confirmed that the battery had markedly different output voltage curves over time for different current loads, and the current demand of the ACME-1 was so high that it exceeded the battery's specification.

Painful Costs and a Way to Avoid Them

Unfortunately, the joy of finding the issue's cause was quickly tempered as the ACME accountants began to figure out how much the solution would cost. The company would either have to modify their equipment with a new battery type or add a series resistor to match the shunt in the DMM! In either case, the cost was enormous—even to simply change the cell, a technician had to fly from ACME to the hospital, stay for a week, install the modification in a few hundred dispensers, and then either fly back or fly on to the next unhappy customer. Beyond the parts, labor, and travel costs, the reputation cost and lost business made the entire problem very painful for the company.

Of course, ACME never revealed the total cost of the incident, but it was clearly far beyond the cost of the DC power analyzer, SMU, and application software that they happily ordered to prevent similar mistakes from ever happening again. By using the seamless ranging and zero burden voltage of the N6705B with the N6781A SMU to power and measure their devices, engineers can accurately measure current consumption and ensure accurate lifetime predictions for their battery-powered devices.

References

[1] https://www.forbes.com/sites/mikepatton/2015/06/29/u-s-health-care-costs-rise-faster-than-inflation/

[2] https://www.cdc.gov/hai/surveillance/index.html

[3] https://shea-online.org/images/briefings/060508_Brennan_Briefing_Slides.pdf