Test Sequencer for Handheld Consumer Electronics

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NI Product(s) Used:

- LabVIEW 2015
- USB-6351
- A NI cDAQ 9178 Chassis containing:
  - Two NI 9482 Relay modules
  - NI 9239 Isolated Analog Input module to measure floating battery voltages
  - NI 9234 IEPE Analog Input module
- NI GPIB-USB-HS

Industry:
Electronics and Semiconductor

Application Area:
Consumer Electronics Test

The Challenge
To test a handheld consumer product for LED, Bluetooth, vibration motor, and analog output functionality as it comes off a manufacturing line in less than 2.5 minutes.

The Solution
We combined several cDAQ components and a USB DAQ board with NI-controlled external USB-connected hardware to interact with the Device Under Test (DUT), simulate the expected signals, and test all aspects of its function.

Introduction
For 25 years, Data Science Automation® (DSA) has been a premier automation systems integrator, leveraging commercial off-the-shelf tools in the design and implementation of custom-engineered, complete, and highly-adaptive solutions in laboratory automation, embedded/new product development, manufacturing and test automation. The company provides an extensive array of automation engineering, programming, consulting & training services to dramatically improve research, manufacturing, government & business operations. DSA is fast and methodical, staffed with exceptional, multi-disciplinary, NI Certified professionals that consistently apply CSIA-certified best practices to deliver the lowest total cost of ownership.

DSA was selected by our customer as an outgrowth of the Research and Development project we had performed with this same product. They were pleased with our responsiveness and speed with which we could solve their engineering challenges, and continued with us into the manufacturing test. As a small start-up company with limited resources, they also appreciated the electrical and mechanical engineering expertise we could bring to bear on the development of the text fixture.

The task at hand is to test a small handheld device as it comes off the manufacturing line. DSA developed three different fixtures for this customer for different stages of manufacture, but this paper will focus on the first, wherein the assembled circuit board is tested for several aspects of functionality. The Device Under Test (DUT) expects interactions with several outside entities:

1) The user presses buttons, observes LEDs, feels a vibration motor, and uses an analog voltage output from the device.

2) A charging station applies an AC signal to recharge the batteries in the DUT.

3) A programming unit downloads new software onto the device during later manufacturing steps.

4) A Bluetooth system on the DUT interacts with the user's cellphone to communicate usage records to an app.

Each interaction must be tested on each manufactured board to avoid further processing of bad boards and assure customer satisfaction. To be cost effective, the test should take less than 150 seconds, and produce a Test Report of all results.

To meet these challenges, we assembled a number of hardware elements to interact with different aspects of the DUT:

- A NI USB-6351 Series Multifunction DAQ board to measure analog and digital voltages
- A NI cDAQ 9178 Chassis to hold cDAQ modules including:
  - Two NI 9482 Relay modules to connect and disconnect the battery charger, and to mimic the user pressing buttons on the device.
  - A NI 9239 Isolated Analog Input module to measure floating battery voltages
  - A NI 9234 IEPE Analog Input module to power and measure a piezoelectric vibration measurement sensor.
- NI GPIB-USB-HS to communicate with a Keithley 2303 Battery Simulator
- A Microchip RN4020 Bluetooth module to test the DUT's communication protocol
- A Microchip PICkit3 programming module
- A Feasa LED Analyzer for automated check of LED intensity and color.

LabVIEW makes programming National Instruments hardware easy, and the ability of LabVIEW to interact with multiple third party hardware modules really simplified the programming process. The streamlined process assisted in the need for Agile development, as each iteration of the test stand refined the customers needs. As each test requirement was defined, modular components were created and checked with an eye towards flexibility.

Programming the DUT with the MicroChip PICkit 3

The first module used PICkit 3 programmer to download bitfiles to the device under test, and had to allow different programs to run on the system for separate tests. To meet the PICkit's expectations of power plug and unplug for programming, we synchronized the programming module with the NI relay module, which could control the application of the charging current for the circuit, and the programming wires to the PICkit module, which allowed the DUT to be tested without any charge loss through the programmer. While functional, the start-up and shutdown of the PICkit 3's program through the command prompt proved to be a significant time sink. This time issue was solved through allowing LabVIEW to send commands to an already-opened command window, removing the start-up and shutdown time. Mapping ASCII values onto keystrokes (including the shift key for many special characters) was a challenge, but straightforward. This modification cut perhaps 30% off the full testing time of each device, and showing another level of interactivity that LabVIEW mediated.

Measuring battery charging with a Keithley 2303

One set of tested behaviors revolved around whether the device reacted properly to different states on an onboard rechargeable battery. The battery's state is determined by its voltage, so the test system used DIP switches to remove the DUT's battery from the circuit and replace it with an externally supplied voltage from a high speed Keithley 2303, which is designed to adjust as quickly as possible to most closely simulate a real battery's behavior. The high speed of the 2303 required precise wiring, to make sure the source and signal wires did not have any lag to create oscillations in the voltage.

In operation, we could measure both sourcing and sinking of current to the 2303. This allowed testing of two modes at the same time, the usage of battery power during both standard and alarm conditions, as well as proper function of the charging circuit as it sourced current to the simulator.

LED Verification with Feasa LED Analyzer

For proper user experience testing, we needed to make sure the LEDs were lit in the correct order, and the correct color. Asking for Operator response on this function would have dramatically slopwed testing, so automating the test with third party hardware from Feasa was a plug and play solution whose LabVIEW drivers worked right out of the box. Individual optical fibers placed in proximity to each LED under test simplified the physical integration of the optical sensor with the DUT. One call to the driver returned both the raw RGB values as well as processed values for hue, saturation, and intensity. Hue and intensity turned out to be the most distinguishing characteristics for the tests required by our customer.

Communicating with a Microchip RN4020 Bluetooth Module

Testing the Bluetooth capabilities of the DUT was a layered challenge. The DUT only expected to communicate with the Bluetooth App when plugged into the charging station, so we had to make sure the charging environment was simulated, while making the Bluetooth connection in the least amount of time. LabVIEW's VISA library enabled correct control and COM port assignment, so that the communication was able to predictably connect in the test fixture. Having a team of Certified Architects, and Instructors led to a familiarity with all of the LabVIEW connectivity products that enabled development and debugging of this module to proceed efficiently.

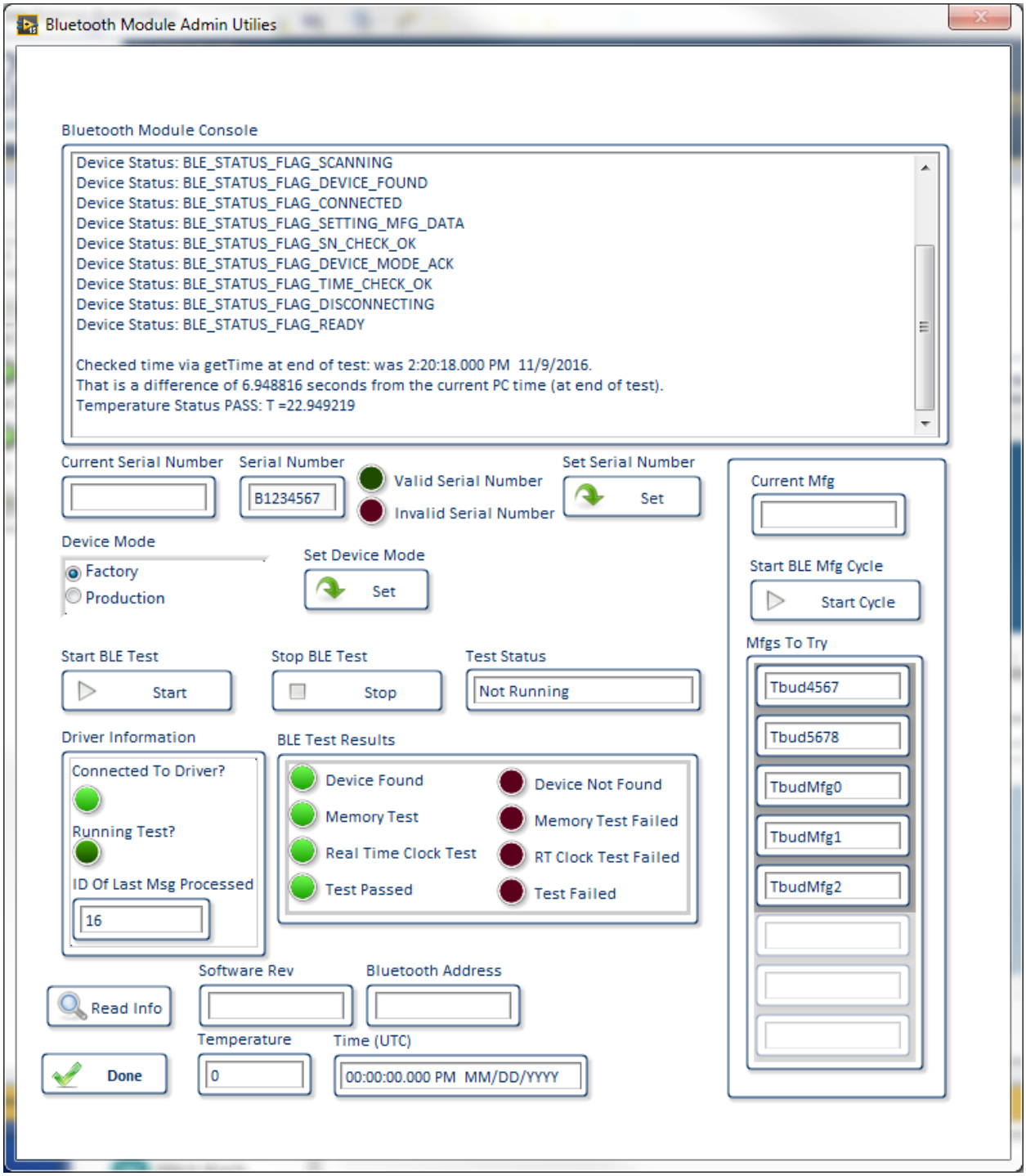

Figure 1 - Bluetooth communication screen, with messaging and test results per DUT

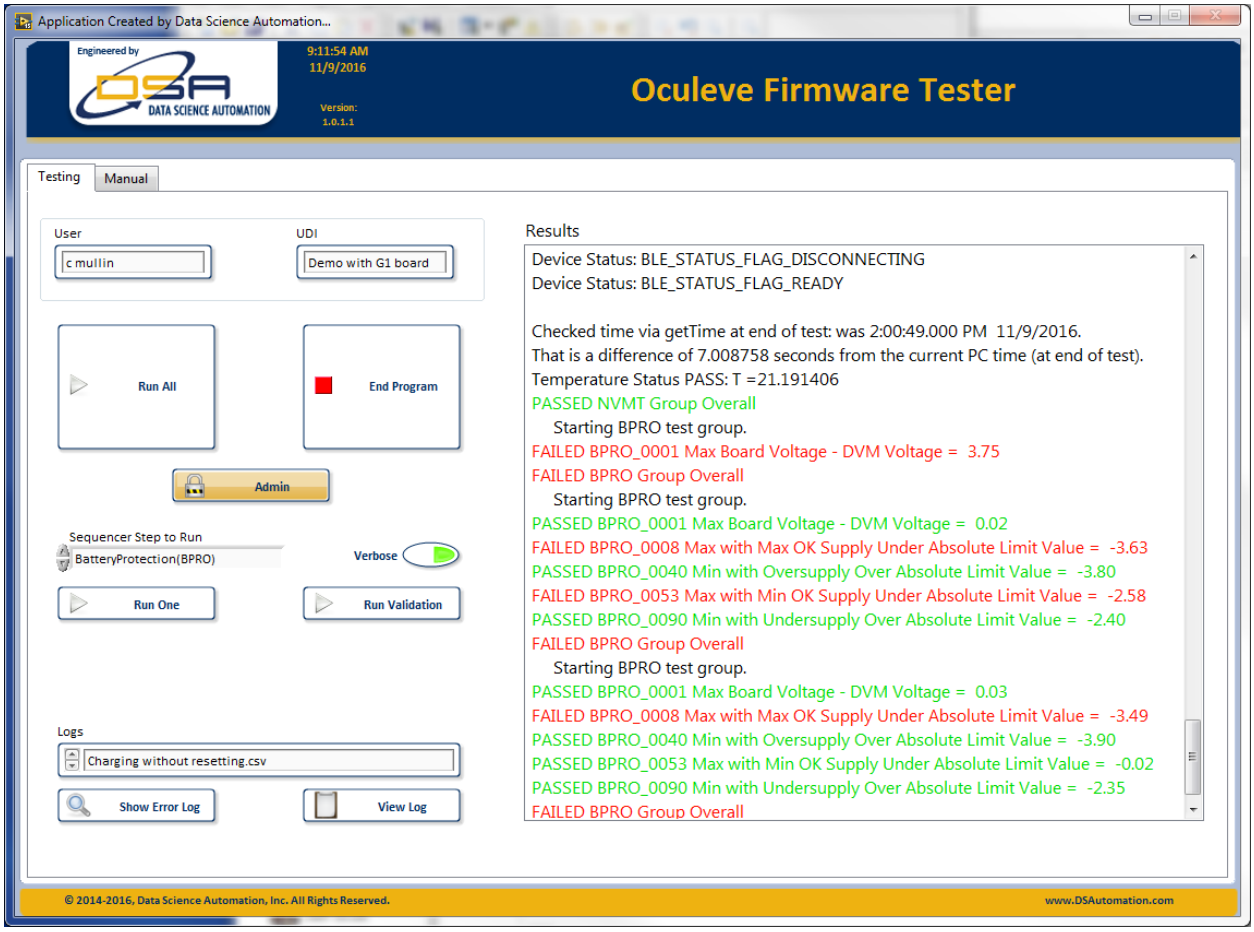

Figure 2 - Example test result with known-bad board, indicating passing and failing steps, arranged by test group.

Conclusion

With LabVIEW's intuitive programming interface and seamless GUI construction, overcoming the challenges listed above was manageable within tight timeline constraints. Automated testing of their boards now proceeds in the time scale desired, lowering testing cost, and increasing throughput on their system. We were able to reuse several of the test modules developed in the other tests mentioned, and our satisfied customer is getting ready to engage us for further projects because our reliable, robust software solutions provide the lowest total cost of ownership.

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