Robotic Testing of Next-Generation Fuses

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NI Product(s) Used:
LabVIEW 2015
cDAQ-9136 | CompactDAQ Controller, 1.91 GHz Quad-Core Atom, 4-Slot
NI-9375 | 24v, 16-Channel Digital Output Module
NI-9219 (2) | Universal Analog Input, 24-bit, 100 S/s/ch, 4-Channel
NI-9475 | 8-Channel, 60 V, 1 µs Sourcing Digital Output Module
VB-8012 (4) | VirtualBench All-In-One Instrument
NI ISM-7412E (2) | Nema 23 Integrated Ethernet Stepper
TSM-12 Touch Screen Monitor, LED

Industry:
Electronics and Semiconductor

Application Area:
Research Production Test.

The Challenge
Create an adaptable motion based test system capable of resistance testing multiple thin-film safety fuses for a medical device in order to drastically reduce long test-times incurred by manually checking sheets of hundreds of fuses with a hand-held digital multi-meter.

The Solution
Combining the ruggedness of the embedded cDAQ-9136 and NI Ethernet Steppers with commercially available off-the-shelf motion stages, DSA was able to create a modular and adaptable thin-film fuse tester that could easily be adapted for changing fuse panel layouts.

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.

Our customer needed to validate the resistance values of thin-film fuses manufactured to their specifications. Their vendor was using a known production method but with the fuses being constructed of material not typically utilized in the production method the process was still in flux and being fine-tuned. The customer was testing all the fuses manually with a hand-held DMM, this process was tedious and also error prone due to the manual data entry procedure. There were three-hundred ninety-six fuses per sheet in the initial layout of the sheets used to manufacture the fuses, with about fifty sheets per batch being created. Having to test nearly twenty thousand of fuses per batch run while the manufacturing process was being adjusted was manually tedious and inefficient.

An additional challenge we faced when designing this system was the customers knowledge that the fuse layout patterns would be changing over time after the first commissioning of the system. DSA knew only that the sheets would all have to fit within an eighteen by twenty four inch area – due to manufacturing constraints. Downstream manufacturing would dictate the final spacing of the fuses on the sheets. Therefor the system had to be adaptable enough to accept different layout parameters for the motion control and also be relatively easy to change-over with regards to the test probe end effector.

Move that Bed-of-Nails!

The system created leverages NI Ethernet Stepper Motors that have built-in controllers. This allowed the control module to be simplified as no complicated motion profiles or true-coordinated motion were needed by the system. This eliminated the need for costly motion systems consisting of separate controller cards and high-power motor drive systems. The all-in-one solution with built-in NI SoftMotion VIs sped up development time as time was not needed to learn or write third-party motion control drivers. The availability of industry standard sized motors allowed DSA to source stages that met our precision requirements and reduce lead-times as the stages were a standard part stocked by Velmex.

A small block non-conducting material was used to house spring-pins typically utilized in bed-of-nails testers. The system was designed to move the end effector into place using an X-Y gantry and then use a pneumatic cylinder to push the test pins into place onto the fuses and then perform 4-wire resistance measurements and log the data to file using the TDMS file format. The two dimensional spacing of the fuses on the sheets is loaded from a configuration file to allow for adaptation to new fuse spacing as the project progressed. Initially this system was to be a research and development tool and would only be responsible for testing the resistance of the fuses.

The initial system with only four test positions being tested took the testing of a single sheet from around thirty minutes (optimally at 5 second per fuse to read 396 fuses and write down the fuse information) plus whatever time needed to transcribe the data into the spreadsheets down to only <u>two minutes per sheet with the data already recorded on the customer's server</u>. This was a huge gain in through-put for the customer.

The 4-wire test method for the resistance measurements assured that cable lengths and quick-disconnects in-line with the readings would be taken into account and would not affect the fuse test results. The ability to leverage the C-Series footprint with the NI 9219 cards allowed the cabinet size to be minimized due to the smaller footprint than stand-alone bench test models, or even NI's own PXI based DMM cards. The signal density of the 9219 with 4 channels per card capable of performing 4-wire resistance measurement was also found to be exceptional when compared to alternative systems.

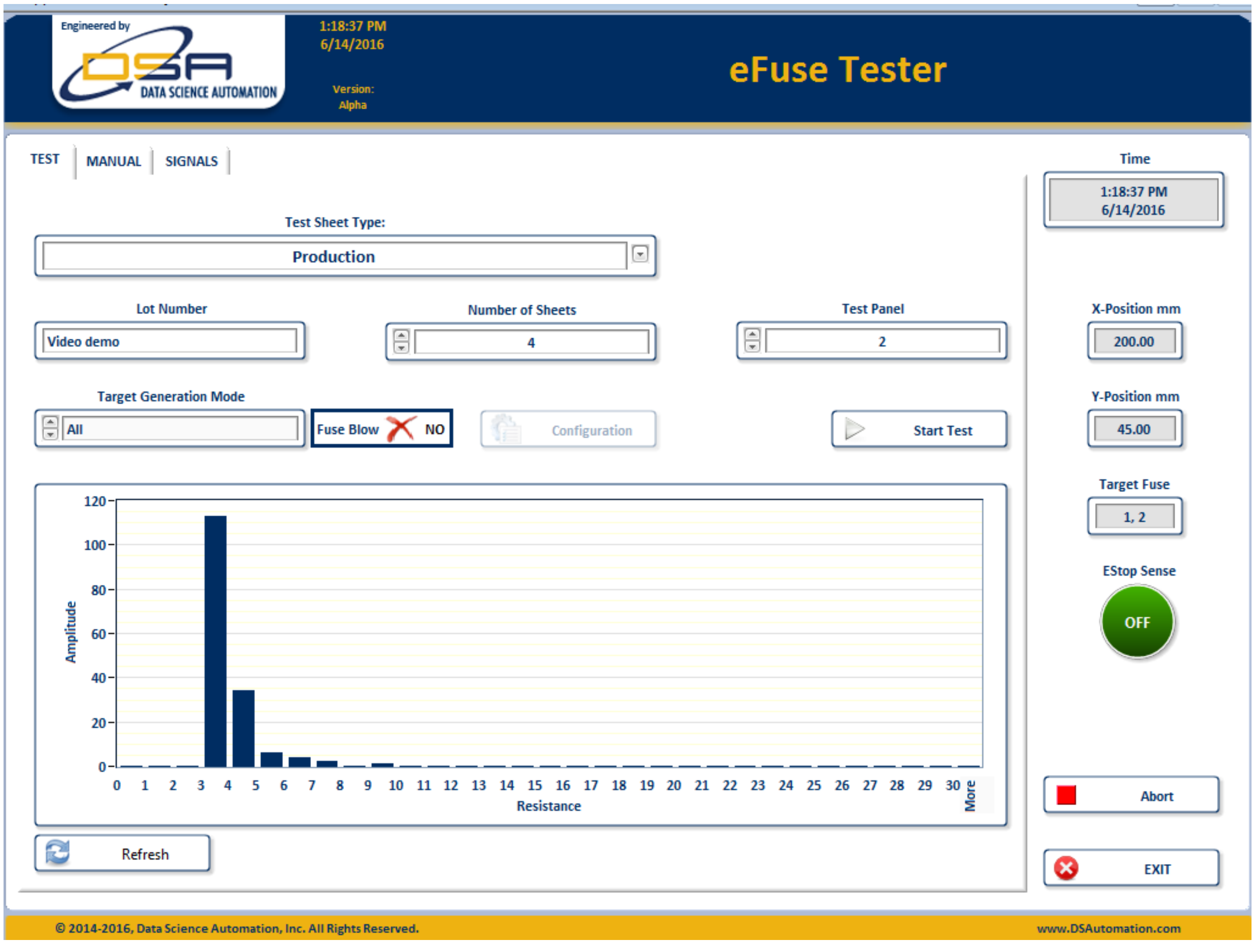

Figure 1 Fuse resistances, binned by value to show variance of production.
All higher values, and open circuits, are collected in the last bin

Change Change Change

The customer and their fuse vendor decided that the automated test machine provided them with enough new information and the through put was fast enough, and could be made faster, that the test machine would be used as part of the fuse production process to perform 100% test coverage of all fuses to make sure that no out-of-specification fuses made it into the downstream manufacturing process. Additionally they wanted to adapt the system to have the capability to test the fuse blow capability to verify with spot checks that the power level required to blow a fuse was within specification. They also desired more pins to be added to the system since we proved out the technology in the initial release. This would speed the tests up further. As they had finalized the layout and a new end effector head was needed to accommodate the new spacing this was an optimal time to upgrade the system.

Due to the planning of the system from the outset to be adaptable the changes required to the system were minimal with regards to adding the new channels for resistance testing. Adding in the fuse blow testing required additional switching hardware to connect power supplies to the system. The system was to supply short power bursts of ~300 ms to verify proper circuit operation. DSA researched commercial off-the-shelf power supplies vs the channel density needed for the system of testing 8 fuses at once (maximum).

We chose the NI VirtualBench 8012 for its dual channel power supply output and ease of integration with LabVIEW and immediate availability and lower overall integration costs to our customer. The NI 9475 module was utilized to provide the high-speed switching to control the power going to the fuse and assure the 300 millisecond signal duration. The NI 9375 Digital Input/Output module was utilized to monitor system feedback on the Z-stage position as well as controlling new DPDT relays used to switch the end-effector pins from being connected to the 9219 modules to the VB 8012 units for the fuse blow testing. If fuse-blow was selected the test system would perform the resistance testing first, then switch to the power supply and blow the fuses, then switch to performing another 4-wire resistance measurement to verify the fuses were then open and performed properly.

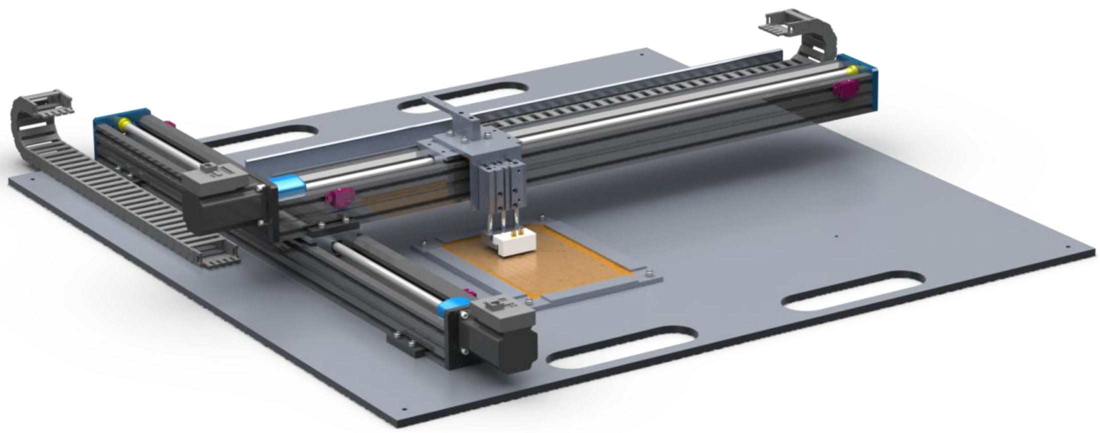

Figure 2 Mechanical movement and end effector design.

Conclusion

The final iteration of the machine utilized 8 channels of either 4-wire resistance measurements or 8 channels of fuse-blow power routing capability with complete sheet test times running around a minute. The ease-of-use of the system and the confidence in the test results the customer gained through hands-on utilization led to changes in the planned production methods, removing the need to add in-line product testing to detect bad fuses before assembly into the end product.

Contact Information.

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