Life-Cycle Testing of Spring-Loaded Switches Using Motion, DAQ, and LabWindows/CVI

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The Challenge: Rigorous, flexible, automated life-cycle batch testing of AC and DC switches with varying voltage and current capacities.

The Solution: Developing a PC-based system using National Instruments ValueMotion Stepper and DAQ boards controlled by LabWindows/CVI.

Introduction
The primary reason for testing consumer products is customer satisfaction. Early failures on consumer products not only can damage product reputation with customers, but also can result in costly field returns for the manufacturer. These were two of the factors that led Black & Decker, Inc. to install a system to perform life-cycle testing on the trigger switches used in their power tools and other consumer products. They contracted with MicroCraft Corporation to develop a flexible PC-based system that uses National Instruments DAQ boards controlled by LabWindows/CVI.

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Specifically, Black & Decker was interested in the analysis of switches undergoing a process called “teasing.” Rick Sharpe at Black & Decker reported, “We have found that a major contributor to switch failures on power tools is a user practice we call ‘teasing.’ Teasing results when the operator relaxes the pressure on the trigger switch to the point where the switch contacts are barely making contact, forcing the full tool current through the edge of the switch contact. Trying to duplicate this failure mode using operators would require an excessive expenditure of technician time and, most importantly, would not provide the consistent data we require.”

Life-cycle testing of any type requires a robust test system. With a single test often taking several days, Black & Decker invests a lot of machine hours as well as man-hours testing each product. As a result, our challenge at MicroCraft was to develop a system that could withstand the rigors of continuous use and smoothly handle catastrophic events such as power outages with no loss of data and minimal interference with the test in progress. The system also needed to run several test stations independently to simultaneously test AC and DC switches with varying voltage and current characteristics.

Motion Control
The primary component of the Black & Decker switch test system is motion control. To test six switches simultaneously, we decided to use six Oriental Motor stepper motors controlled by two multiaxis ValueMotion PC-Step motor control boards from National Instruments. The boards control six stepper motors independently. Two National Instruments UMI motion interface modules provide the interconnection point between the motor control boards and the stepper motors.

We use a stepper motor to depress the switch from its off position to full-on position while current readings are made at both locations. Initially, we program the stepper motor to slowly release the trigger, in 0.003-inch steps, from its full-on position to the position where the software detects breakthrough current. At this breakthrough (or tease) point, full current is flowing through the tips of the switch contacts, which causes arcing.

To simulate the user’s finger vibrating under fatigue on the trigger switch, the stepper motor toggles forward and back around the tease point at a user-specified distance and frequency. The minimum tease distance of the system is 0.001 in.

Data Acquisition Hardware
One of the advantages of a PC-based system is the availability of plug-in data acquisition (DAQ) boards. We chose the National Instruments AT-MIO-64E-3 multipurpose...
SC-2070 termination breadboard to provide connections to the analog signals because it provides a cold-junction reference signal for the thermocouple input.

System Software
We chose National Instruments LabWindows/CVI as our software environment. With its special features, we could satisfy the requirements for a graphical user interface and yet maintain the speed necessary to test six switches simultaneously. The flexible LabWindows environment also made it easy to incorporate on-line help and a manual control mode. Using the manual control mode, Black & Decker engineers can use the system as a laboratory tool for characterizing new switches, in addition to its customary use as a test system. The system stores all test data points and test setup information to file in standard spreadsheet or SPC-compatible format. To simplify backups and data analysis, all files are accessible over Black & Decker’s network via a plug-in Ethernet board.

Summary
With the automated switch test system, Black & Decker can perform consistent, reliable testing on the large variety of switches used in their consumer products and can maintain standardized test data. Black & Decker has saved thousands of man-hours thanks to the speed, accuracy, and data storage capabilities of the National Instruments-based system. In addition, because of the inherent flexibility of the system, we easily added the manual mode—as a result, Black & Decker received a laboratory analysis tool as well as an automated life-cycle test system.

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