INFORMATION TECHNOLOGY SESSION

AUTOMATION OF ELECTRICAL STRESS TESTING FOR ELECTRONIC COMPONENTS USING LABVIEW SOFTWARE ENVIRONMENT

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Abstract:

This document describes the implementation of the LabVIEW software platform in automating the reliability testing of electronic components subjected to critical electrical disturbances in certain military products.

Most of the products used in military technologies have very sensitive electronic parts which must be tested in various operational conditions. In this paper, tests related to the electronics in a product called the *Proximity sensor vPS-M23* will be checked under many conditions required by relevant standardizations.

The applicable testing procedures have been performed in order to ascertain any unexpected reactions of the electronics used in the proximity sensor when exposed to various credible or other stressing electrical stimuli and to determine the level of electrical ruggedness of the safety system.

The core contribution of this work is in generating the results and determining pass or fall criteria related to the tests, such as measuring voltage rise and fall as well as short - term power drop-outs. By using DAQmx drivers and specific algorithms for precise time - sequence management, an automated system for testing' performance was developed in order to ensure high test repeatability and minimize human error compared to the manual methods.

The results demonstrate that the LabVIEW implementation significantly accelerates the component characterization process, providing precise insights into the dynamic response of systems under stress, which is crucial for quality assurance in modern military electronic components and also eliminates human error during testing of the products.

Keywords:

Electrical Stress, LabVIEW, Proximity Sensor, Testing.

INTRODUCTION

LabVIEW is a graphical programming platform used by engineers and scientists for data acquisition, instrument control, and industrial automation. As confirmed in [1], LabVIEW uses dataflow programming, where the flow of data through the nodes on the block diagram determines the execution order of the virtual instruments and functions.

In this paper, a LabVIEW-developed program will be used for checking the test criteria on the military product called the proximity sensor. In order to ascertain the distance to the terrain, as well as its own velocity, the proximity sensor relies on radar and advanced signal processing,

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while facilitating the selection of the desired height of detonation of a weapon above the target. In order to prove its safety and functionality, the device is exposed to different electrical stress tests according to defined military-based standards. [2], [3]

This electrical stress test evaluates the effect of various stressing electrical stimuli on applicable electronics of the proximity sensor. In an operating environment, applicable devices may be subjected to irregular power sources and component failures that result in voltage rises and falls and power drop-outs, and other faults that could degrade the system's safety. The test plan, which includes the LabVIEW interface, will specify the tests, levels and pass/fail criteria.

Automation of test performance through the LabVIEW software has several advantages over performing the tests manually due to the following reasons:

1. Precision of timing and repeatability
- **Manual test problem**: during manual work, the operator starts the switch, or operates the potentiometer by himself, which makes achieving the same start and stop times or rise and fall times of various electrical stimuli virtually impossible; and
- **LabVIEW advantage**: the software controls transients in microseconds. Every test, regardless of the number of repetitions, will be performed identically, which makes the test scientifically valid.

2. Eliminating human error in readings
- **Manual test problem**: the engineer must look at the oscilloscope and stopwatch at the same time and note the results; and
- **LabVIEW advantage**: the software takes the data directly from the DAQ card, calculates and stores them.

3. Many parameters synchronisation
- **Manual test problem**: It is very hard to track the effect of a power drop-out on the temperature of the component; and
- **LabVIEW advantage**: In the same iteration, the software can read 10 different sensors. The relation between the electrical stress and physical behaviour of the component could be defined.

4. Data post processing
- **Manual test problem**: after measurements are completed, an engineer must transfer all data to Excel or another program and make diagrams and calculations; and
- **LabVIEW advantage**: the software generates the results and diagrams automatically.

5. Safety
- **Manual test problem**: during an electrical stress test, there is a risk of sparkling, capacitor exploding, or isolation breach which can be dangerous for an engineer near the equipment; and
- **LabVIEW advantage:** using the software, the engineer can perform the test far from the test table, at a safe distance.

2. TEST SETUP AND SYSTEM DESIGN

The electronics of the units under test (UUT) comprise several PCBs which provide: selection of the unit’s operational parameters, execution of the system's mission algorithm and the radar functionality of the device, communication with other elements in the fuzing system, as well as providing the unit circuitry with multiple voltage levels needed for proper operation.

The test item electronics are production representative hardware. The UUTs contain no energetic materials by design. A sample of the UUT is shown in Figure 1. [4]

Throughout the tests performed, the test point which is being constantly monitored via an oscilloscope is the voltage on the output line which carries the information on the proximity of the target for the purposes of initiation of detonation. The test point is selected as the only output line of the sensor which influences the safety of the system. [4]

Test setup is shown in Figure 2.

The equipment used for this testing is as follows: [5], [6]
- Tektronix MSO 2024 Mixed Signal Oscilloscope;
- Fluke 116 True RMS Multimeter;
- Agilent 3631A DC Power supply;
- PC running NI LabView Application developed for this testing;
- vFI-M24 Initiator electronics (for enabling safety features MP1 and MP2); and
- Capsule sensitivity box connected to NI DAQ 6001 USB Multifunction I/O Device.

A PC running the NI LabView Application is used to perform the LabVIEW algorithm. It makes a calculation of the timing for stress tests and sends digital/analogue commands via USB.

The Interface and acquisition device (NI DAQ 6001 USB) is the “heart” of the system. It transfers digital commands from the software into physical signals.

The DC Supply provides a stable voltage which is being "stressed".

The oscilloscope graphs the monitored voltage levels and is key to the verification of the results. It visualises the input voltage rise/fall, generated through LabVIEW and the appropriate hardware, as well as the output signal levels in real time.

The initiator represents a device providing signals of environmentally influenced safety features to the fuzing system elements which require them. One of such signals is provided upon the release of the weapon from the carrying platform and another when an appropriate drop is confirmed. These signals are used in the real working conditions' of the weapon which is equipped with the proximity sensor. [7]

The vCST Capsule Sensitivity Box is a specialized module for testing the sensitivity of the sensor. It serves as an interface between the power supply and the sensor itself, allowing for the precise application of electrical stress.

Block diagram of the capsule sensitivity box (vCST Box) is given in Figure 3.

In Figure 3, we can see a diagram of the developed vCST module which allows precise modulation of the electrical load. By using the amplifier OPA548, the system is able to achieve high linearity in generating the voltage rise/fall profile.

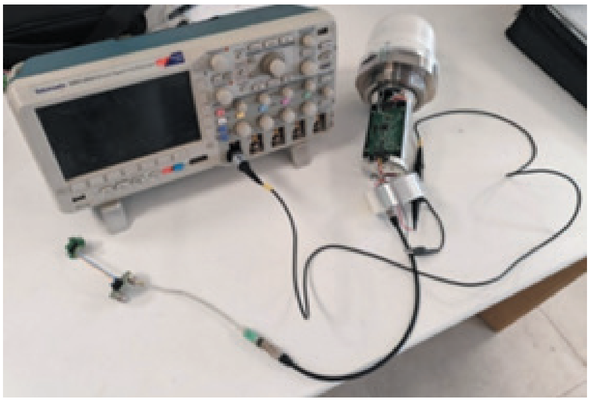

Figure 1. Unit under test (UUT)

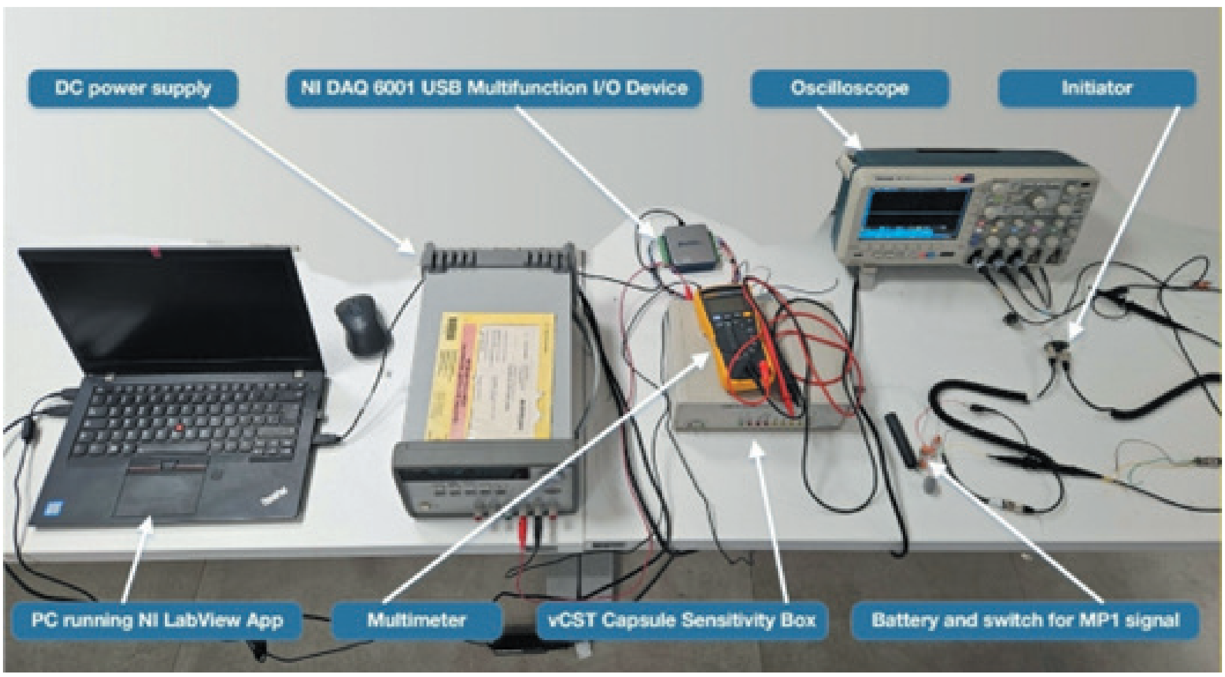

Figure 2. Experimental setup for Electrical Stress Characterization

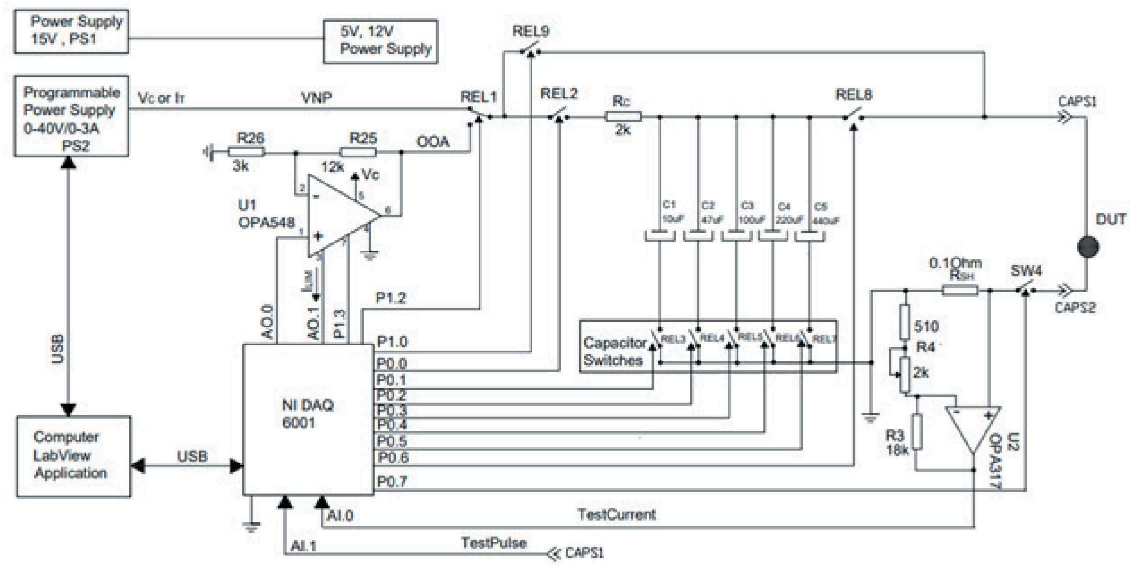

Figure 3. Block diagram of capsule sensitivity box

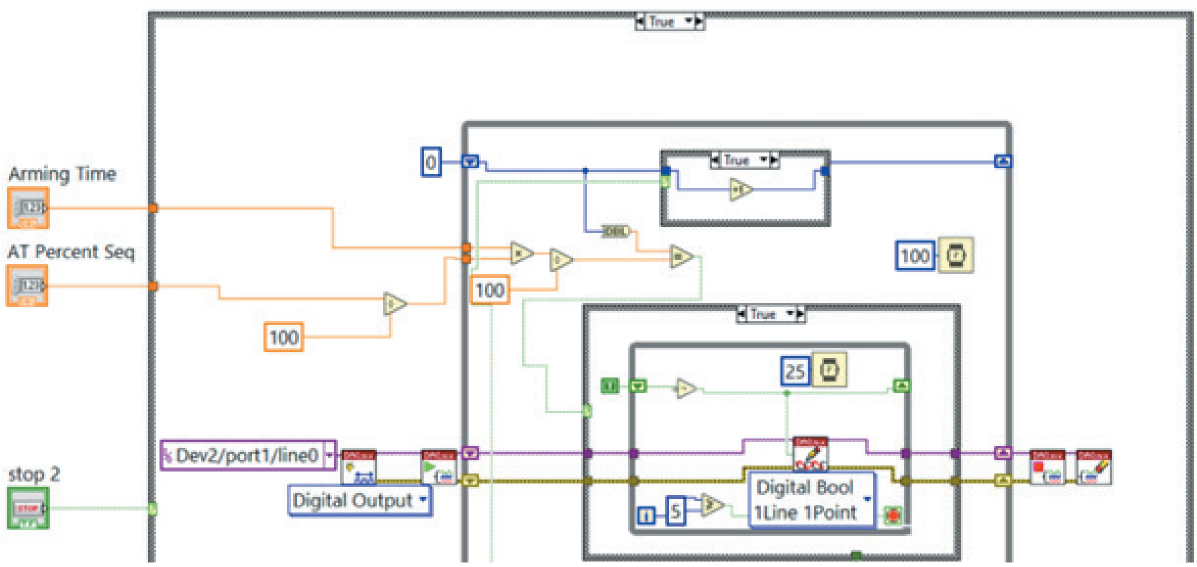

Figure 4. Part of LabVIEW block diagram

3. LABVIEW IMPLEMENTATION THROUGH THE TESTS AND RESULTS

Part of the block diagram for the LabVIEW developed software [8] is shown in Figure 4.

As shown in Figure 4, the software developed in the LabVIEW environment is used for generating time sequences of electrical stress. The algorithm allows for defining the total test duration (Arming time) and the precise moment of voltage fall or power dropout, expressed as a percentage of the sequence. The implemented logic through DAQmx drivers, that directly address the digital outputs of the NI DAQ 6001 card, enables high repeatability of the tests with time resolution measured in milliseconds. [8], [9]

3.1. VOLTAGE RISE/FALL TEST MODULE WITH RESULTS

For the purpose of conducting these tests, a LabView application was developed [10], so that the vCST Box can provide an output voltage rise/fall an order of magnitude slower than normal and a decay over a period of 1 sec or 100 sec (Ramp down with 1 s and 100 s fall time) as seen in Figure 5. [11]

The testing procedure, as per [3] includes the following steps:

- Apply all power supplies with a ramp rate of one order of magnitude slower than nominal;
- Apply normal power to the UUT from all supplies. Allow all supplies to decay from the nominal supply voltage to zero voltage over periods of 1 second and 100 seconds;
- Apply normal power to the UUT from all supplies. Allow the UUT to arm normally; and
- Allow all supplies to decay from the nominal supply voltage to zero voltage over periods of 1 second and 100 seconds.

As we can see, the upper image is showing the LabVIEW application control panel where we have defined Ramp Down data because this test is an example of voltage fall conditions:

- **Arming time (4000ms)**: The system will wait 4 seconds before the sequence reaches a certain critical point or initiates a certain action;
- **AT percentage (80%)**: This parameter requests the software to initiate a voltage drop after 80% of the arming time has passed; and
- **Ramp Down**: A profile with 1s is chosen which means that the voltage will fall linearly during 1 s period;

The lower image shows the results of the execution of this LabVIEW sequence:

- **Horizontal scale (200 ms per field)**: We can see that the voltage fall lasts 5 fields. Total duration is 5x200ms=1s. This confirms good Ramp Down command implementation on the hardware;
- **Vertical scale (2V per field)**: Voltage falls from cca 7.5V to the level of 0V; and
- **Linearity**: The voltage fall is linear without any oscillation.

3.2. POWER DROP – OUT TEST MODULE WITH RESULTS

For the purpose of conducting these tests, a LabView application is developed [10], so that, in conjunction with the vCST Box, an appropriate power supply waveform can be achieved (the power supply interrupted in 50ms cycles, consecutively 3 times at 50% duty cycle) as seen in Figure 6.

The testing procedure, as per [3] includes the following steps:

- Apply 3 consecutive cycles of a 50 ms drop-out condition at 50% duty cycle to one of the power sources. This drop-out of power shall occur **before** the enabling of any safety features;
- Apply 3 consecutive cycles of a 50 ms drop-out condition at 50% duty cycle to one of the power sources. This drop-out of power shall occur **after** the enabling of the first safety feature.

In the upper image we can see the parameters for the interruption of the power supply:

- **Arming time (4000ms)**: A phase of 4 seconds is used again;
- **AT percentage (80%)**: The interruption is activated at the same moment as in the previous test, after 3.2 s which allows for results comparison; and
- **Interruption time 50ms**: This is the standard time for power dropout tests for electronics.

The lower image shows the results of the execution of this LabVIEW sequence:

- **Horizontal scale (20 ms per field)**: The oscilloscope graph shows that the produced power supply signal is as required (in 3 consecutive cycles, it drops for 25 ms and is restored for 25 ms); and
- **Vertical scale (2V per field)**: Voltage falls from cca 7.5V to the level of 0V.

Using the software, we made it clear that the system is capable of producing periodic power drop-outs, as is visible in Figure 6. The interruptions produced do not show any bouncing (made by relay contacts), and there is no overshoot observed when the voltage is reinstated after a drop.

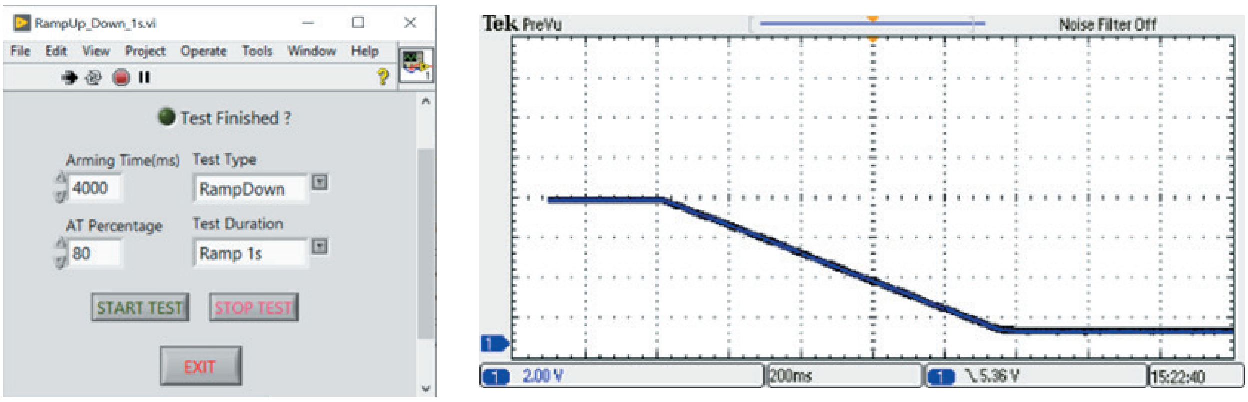

Figure 5. Voltage fall test input (left) with the results diagram (right)

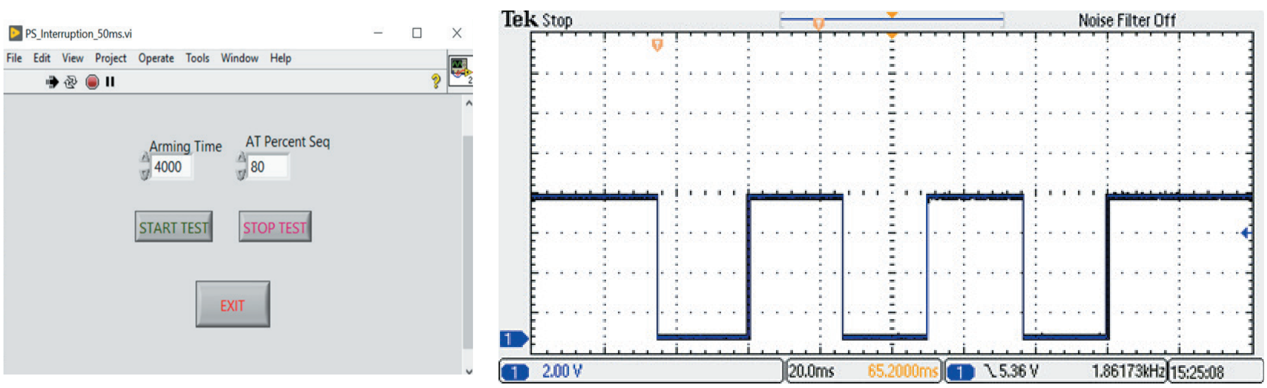

Figure 6. Power drop – out test inputs (left) with the results diagram (right)

4. CONCLUSION

In this paper, the development and implementation of an intelligent system for monitoring and testing of electrical stress on electronic components are presented. By using the LabVIEW platform, easy detection of critical interferences caused by input voltage drop/fall or power dropout is enabled. This platform can also be utilized to generate various other interfering stimuli, such as under/over voltage, brownouts, power cycling, floating inputs/outputs, transient ground loss, and more.

Experimental results in the form of diagrams prove that by the integration of software control, it is possible to check and track the detection of anomalies in real time which prevents physical damage to sensitive actuators and other parts. Long-term tracking of electrical stress allows the prediction of the lifetime of components which is crucial for systems with high request of safety. Data collected during testing allows further optimisation of components for real-time exploitation.

Unlike conventional methods, the developed software allows the user to define the slope (slew rate) with high resolution in voltage rise/fall tests, as well as the critical triggering moments in power dropout sequences. This ensures that each component tested is subjected to identical, standardized conditions, which is the basis for valid statistical sensitivity analysis.

Software integration with the NI DAQ 6001 card enabled simultaneous generation of control signals and acquisition of feedback. The software logic for peak and anomaly detection enables instant test validation, eliminating the need to manually check each individual oscilloscope trace.

To sum up, the software which is developed is not only a measuring instrument, it is also a tool for increasing the reliability. In this regard, this work can be a good base for implementing the algorithms of machine learning inside the LabVIEW environment in order to predict the failures before they manifest and damage the equipment.

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