# Agilent
# Automotive Power Window Regulator Testing

Application Note

Agilent Technologies

## Abstract

Automotive power window regulator tests require the use of accurate data acquisition devices, as they cover a wide range of parameters such as window movement, acceleration of the window movement in both directions, maximum range of movement, torque exerted at the start, the end stall torque, and motor load characteristics. This document provides an overview of how the Agilent U2351A Series USB-based data acquisition (DAQ) device can be used for automotive power window regulator testing by mounting suitable sensors on the power window to measure the various parameters.


## Introduction

Today's power window systems have stringent customer requirements and they also must adhere to various safety regulations. A list of typical customer's requirements is shown below.

### Typical Test Requirements

- The window should completely close/open in approximately 5 seconds. This implies that the motor should not be in the ON state after the window completely closes/opens.
- The window should start moving in less than 1 second after the command is issued.
- The window must stop after it is in the fully open or fully closed position; i.e., the motor should be turned OFF as a fail-safe protection.
- The window should be able to detect an obstruction that exerts a force of more than 50 N.
- If an obstruction is detected, the window should lower itself by 10 cm.
- The measurements include the motor load current, the acceleration of window movement in both directions, the displacement of the window under different conditions, and the initial force detected when encountering an obstacle.
- Software is required for setting up the test scenarios with data-logging and post-analysis capability. Also needed are plots to analyze the variation of several parameters over time, for which a software based approach is definitely required.
- A total of 6 analog channels and 10 digital input/output channels are required for testing.

With the necessary sensors, all the above requirements can be fulfilled using a programmable logic controller (PLC) based system. Displacement sensors, either linear variable differential transducer (LVDT) or optical, are placed along the length of the window at distances of 10 cm each, which will allow the detection of window displacement and acceleration (care is needed to ensure that the sensors are not damaged by the window movement). Software automation systems used to run the test sequences must be incorporated with software timers in order to determine the time taken for a particular test event or to measure the duration of certain test events.

These PLC-based systems usually are able to perform only a single test on one power window at a time. Multiple tests usually require multiple setups and multiple software test sequences. Moreover, each test sequence requires a separate result plot: voltage vs. time, current vs. time, displacement vs. time, and so forth. This application note describes an affordable, reliable solution that is capable of running multiple tests in the same test setup and combining multiple result plots on a single screen, as compared to a traditional PLC-based system.

## A New Approach

A typical test setup for a single power window requires five channels to monitor the movement of the window, a software-based timer to calculate the time it takes for the window to move from one monitored point to another, a current transducer to measure the armature current drawn by the motor, and a force transducer to detect obstacles.

The Agilent U2351A Series USB-based DAQ device is ideally suited for such a testing environment. The U2351A has 16 analog channels and can achieve a maximum sampling rate of 250 kSa/sec. This results in a sampling rate of more than 40 kSa/sec per channel on six channels, the number of analog channels required for this application. As a result, the U2351A can perform all required measurements with increased accuracy and speed at a relatively lower cost (compared to PLC-based solutions).

Adding more channels enables simultaneous testing of multiple power window systems. Along with the U2351A, Agilent's VEE Pro test and automation software makes data logging and report generation possible by giving you the flexibility to display several plots on one screen or save them to a single file.

The Agilent VEE Pro software, with its built-in MATLAB signal-processing tool box, is capable of computing the acceleration of the window and is also capable of managing the various result plots versus time that are required for data analysis.

## Test Scenarios

### Test Scenario 1: Single Input Command

In this scenario, we measure the time taken by the window to fully open/close once the command is given. Here the commands are given individually at the passenger and driver sides and a plot of window position vs. time is plotted for each window. The plot using Agilent VEE Pro appears as shown below (Figure 1). The armature current is also monitored vs. time (through a current transducer) to make sure that under no conditions will the motor draw current for more than five seconds.

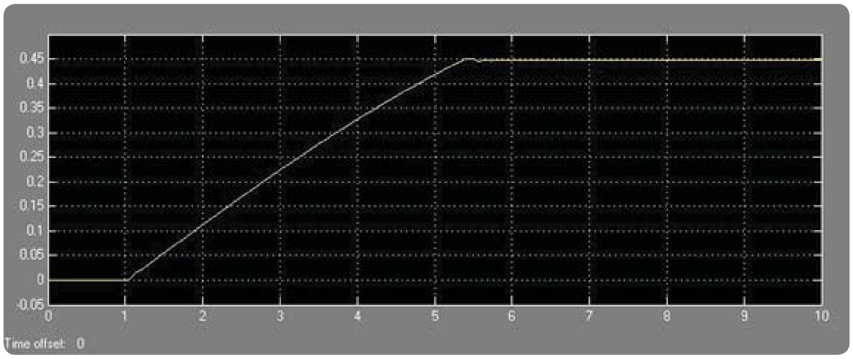


**Figure 1.** Window position vs. time

The plot above is obtained by sampling and plotting the LVDT outputs obtained from the motions of each window over several instants of time. From the plot, we observe that the motor movement is initiated in approximately one second, which is within the test requirements.

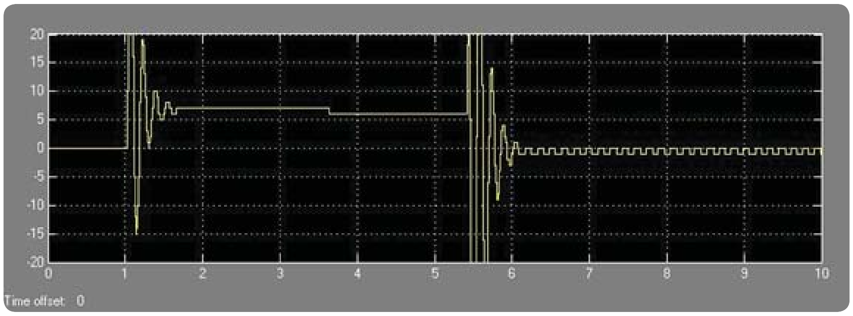


**Figure 2.** Armature current vs. time

The current transducer gives a voltage output proportional to the measured current. The actual measured current can be plotted using the Agilent VEE Pro with built-in MATLAB functionality, as shown in Figure 2. Correlating the plots in Figure 1 and Figure 2, we can observe that the window movement is in sync with the motor and the armature draws no current after approximately 5.7 seconds, which is when the window motion stops.

## Test Scenario 2: Varying Input Commands

In this scenario, we determine window position vs. time for changing commands such as up-down-up or up-stop-up. The response time for the window can be obtained by observing the plot shown below.

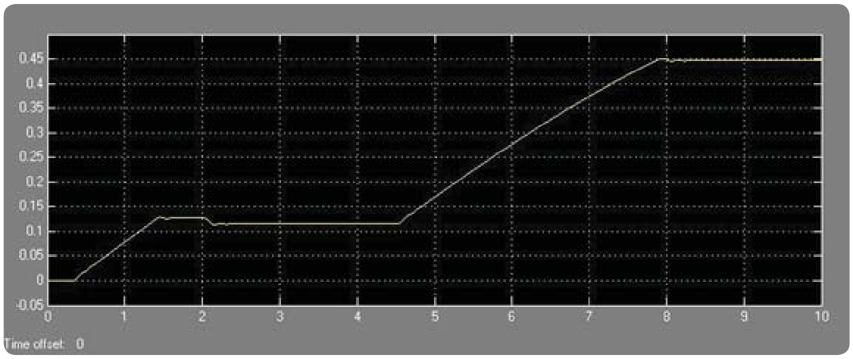


**Figure 3.** Window position vs. time for varying input commands

The digital input sequences for commands must also be observed, which is again made possible by reading the digital input lines and plotting them using Agilent VEE Pro.

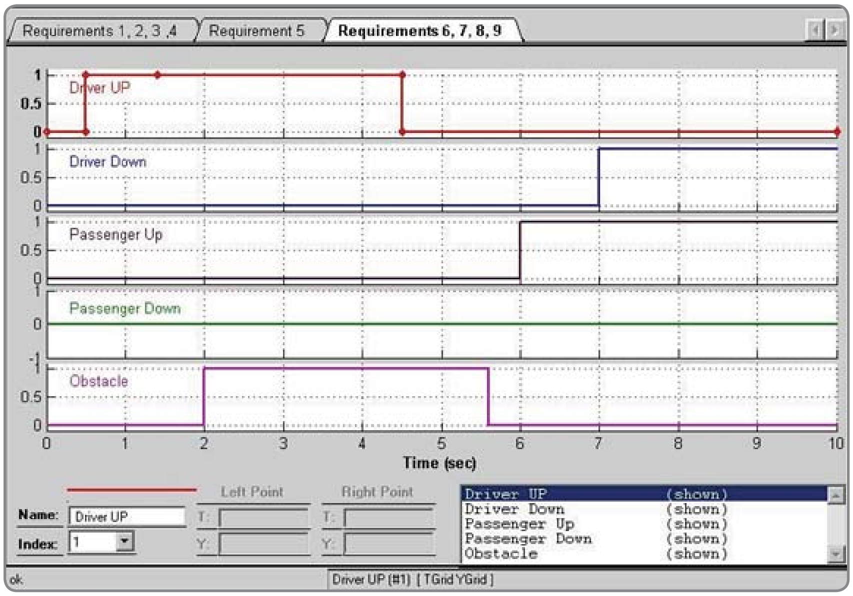


**Figure 4.** Plotting the input sequences

## Test Scenario 3: Obstruction Detection

This scenario involves obstruction detection and measurement of force applied on the obstruction vs. time. A force sensor detects an obstruction that exerts a force of 50 N or more. The 0 – 10 V output of this sensor is monitored using Agilent VEE Pro. Window displacement is also measured once an obstruction is detected (force application is simulated).

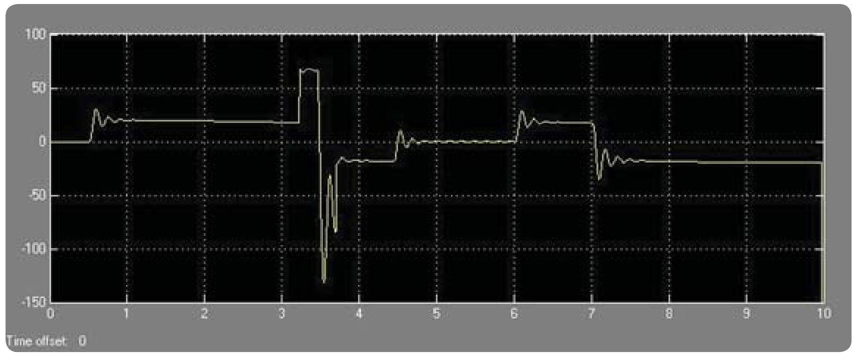


**Figure 5.** Applied force vs. time  for obstruction detection test

We can observe that the window moves down by approximately 10 cm when an obstruction is detected. This positional information is obtained by measuring the LVDT output.

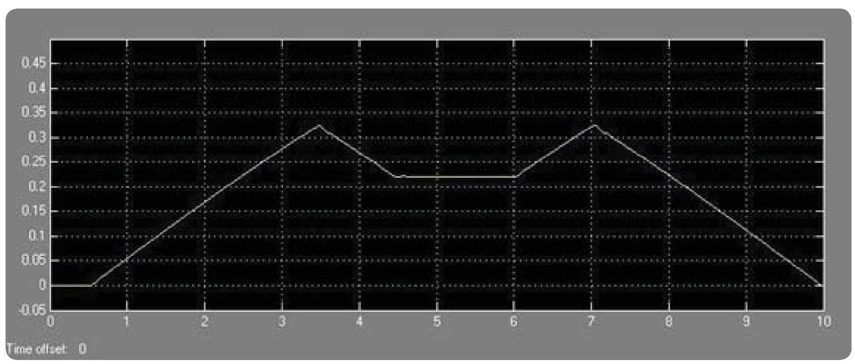


**Figure 6.** Window position vs. time for obstruction detection test

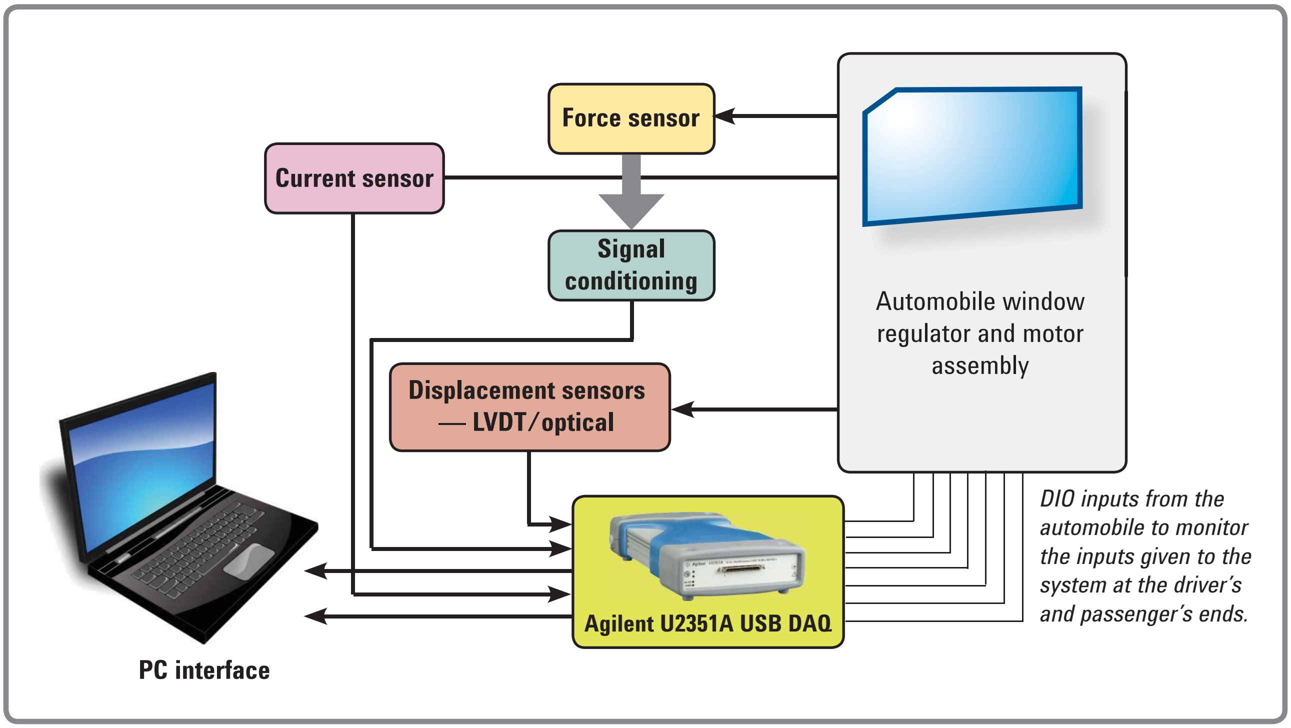


**Figure 7.** Application block diagram

## Advantages

- **Cost:** This solution has low start up cost per channel.
  - i. Software timers in Agilent's VEE Pro help reduce hardware costs.
  - ii. Analog output to power sensors minimize cost because external power supply is not required.
- **Scalability:** For faster measurement and analysis; the U2351A multifunction DAQ device with 16 analog channels allows multiple power window systems to be tested simultaneously with high-speed data acquisition.
- **Connectivity:** The U2351A multifunction DAQ device supports USB plug-and-play connectivity. Hi-speed USB-based data acquisition cards help to achieve faster data response.
- **Ease of Use:** Agilent's VEE Pro offers the following functionality.
  - i. Comprehensive and easy visualization of data are enabled by the plotting of one parameter against the other.
  - ii. Multiple different sensors with different response times can be triggered through the Agilent VEE Pro software and sequenced for efficient data logging and analysis.
  - iii. Faster tests can be performed by sequencing the tests in the Agilent VEE Pro software.
  - iv. Built-in Excel libraries allow easy report generation and are compatible with existing reporting tools.

## Conclusion

The Agilent U2351A USB-based DAQ system can provide you with a test solution that requires almost no change in your hardware configuration, but reduces your test times and programming times and thus reduces your overall costs. Complete automation through Agilent VEE Pro software provides the flexibility to develop custom systems at minimal costs and in less time. With such a configuration, this affordable, yet reliable solution can be easily used in the manufacturing enviroment.

For more information, please go to www.agilent.com/find/U2300A or call your nearest Agilent sales representatives.

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