Increase Automotive ECU Test Throughput

Application Note 1505

Description

The automobile electrical system is poorly regulated and subject to frequent dips and overshoots. Voltage can range from 11 to 15 volts under normal conditions and from 8 to 24 volts under transient starting and running conditions. As a result, voltage margin testing is a necessary part of testing Engine Control Units (ECUs) to verify proper operation and tolerance for extreme bias voltage conditions.

Problem

Every second of test time counts in the competitive automotive electronics marketplace. Testing at multiple bias voltage levels is a necessary, but time consuming part of ECU testing. Most system DC sources available require significant time to change and settle to a new output setting, adding several seconds to the overall test time.

Solution

Agilent Technologies N6700 Modular Power System and N6752A power supply module incorporate features that reduce ECU test time and enhance testing, including:

- The N6752A 50 V, 10 A, 100 W autoranging power supply module features active down programming for fast output downward transitions regardless of load.
- Less than 1 millisecond command processing time reduces test time.
- Less than 4 milliseconds output response time reduces test time.
- Identical modules can be paralleled and operated as a virtual single output for greater output current and power, for testing higher power ECUs.
- Up to four modules fit in the 1-U high mainframe, saving test system space.

DC Power Input	Communication Interface
$V_{Battery}$	CAN bus
Static Analog Inputs	**Static Digital Drive Ouputs**
$V_{Battery}$ sense	Fuel pump
Engine temperature	Check engine light
Air temperature	A/C cutout relay
Manifold Absolute Pressure (MAP)	Fan relay
Mass air flow rate	EGR solenoid
Exhaust oxygen (Lambda)	Purge canister solenoid
Throttle position	Diagnostics code readout
Dynamic Analog Inputs	**Dynamic Digital Driver Outputs**
Engine knock	Fuel injectors
	Ignition coils
Static Digital (or Switched) Inputs	**Static Analog Outputs**
Ignition switch: off, acc., on, crank	Regulated voltages or currents for sensors
Acc. on/off; A/C, heater, brake, lights	
Throttle idle position	
Diagnostic mode	
Dynamic Digital (or Pulsed) Inputs	**Dynamic Analog Outputs**
Vehicle speed	Idle speed control servo
Camshaft/engine speed	
Camshaft/engine position	

Figure 1. ECU Inputs and Outputs

ECU Input and Output Characteristics

An ECU takes a myriad of signals monitoring the vehicle and its environment. In turn it manages and controls the engine and ancillary equipment for optimum operation. Figure 1 summarizes the many input and output signals of a typical ECU.

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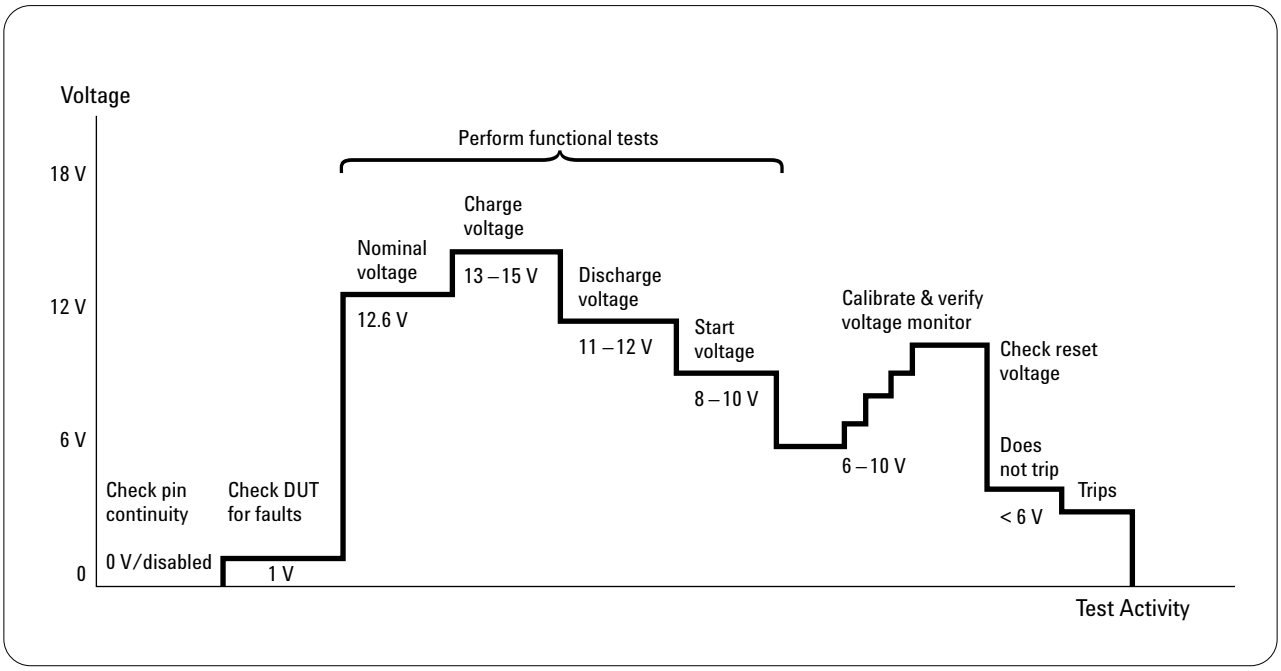

Figure 2. Key Bias Voltage Levels

In ECU functional test, appropriate test system resources emulate the various input signals in a controlled manner and load and check the outputs for correct response. It is readily apparent based on the number of inputs and outputs that test system resources for ECU test is quite extensive.

Key Bias Voltage Levels in Automotive Electrical Systems

Depending on the operating state of the vehicle, certain voltage levels are commonly encountered in an automotive electrical system. These levels become key voltages for ECU test, as illustrated in Figure 2. Some relevant tests at key voltages include:

- Continuity between multiple ground, power and high current driver pins is checked with the power supply set to zero or disabled.
- Shorts or other unexpected faults can be checked by applying a very low voltage and measuring the resultant current.
- Various functional tests are run from a low level of around 8 volts, representing starting, up to high level of around 15 volts, representing full charging conditions.
- The ECU voltage monitor circuit, if included, is calibrated or verified, typically by applying two end-point operating voltages at minimum.
- The ECU low voltage reset level is verified by checking its minimum “must not trip” and maximum “must trip” thresholds.

In all, an ECU may be subjected to up to 20 bias voltage level changes during test.

Power Supply Output Response Time

A few steps occur when changing a power supply output voltage setting to a new value, as depicted in Figure 3. These steps all take a finite amount of time.

Once a command is received by the power supply-it must process it; this is its command processing time. The power supply's output then responds and changes to the new setting. The time it takes to reach its final value, within a certain settling band, is its output response time. A 1% settling band is suitable for ECU test.

Table 1 compares the command processing and output response times of many typical programmable power supplies to the N6700 and N6752A. The exceptional speed characteristics are a result of being designed for high throughput test applications.

It is especially important to take note of down programming output response time. Many power supplies depend upon the actual loading of the DUT to bring the voltage down. Under light loading conditions it can take a second or more for some power supplies without down programmers to reach their final value. The N6752A power supply module incorporates an internal down programmer for fast down programming, independent of the load. Both fast up and down programming speed is important in ECU testing.

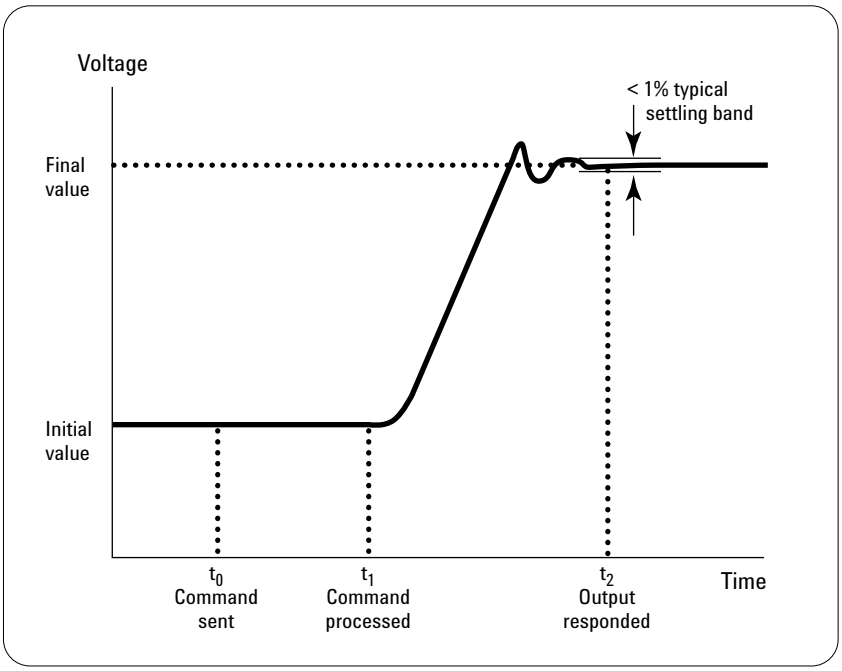

Figure 3. Power Supply Command Processing and Output Response

Parameter	Agilent N6700A/N6752A	Typical System DC Sources
Command Processing Time	< 1 millisecond	20 to 50 milliseconds
Output Response Time	≤ 4 milliseconds to 50 mV	50 to 500 milliseconds to <1%

Table 1: Command Processing and Output Response Times

Throughput Improvement Using Agilent Technologies N6700 Modular Power System and N6752A Power Supply Module

The test time reduction achieved by switching to the N6700 and N6752A from a slower power supply is a product of the command processing and output response time improvement and the number of output voltage transitions. A 200-millisecond time improvement and 15 output transitions yields a 3 second test time reduction. For an ECU having a 20 second test time, this translates to a 15% improvement in throughput. Such an improvement is highly valued by ECU manufacturers, greatly reducing their cost of test and providing immediate benefit.

Related Applications

- Automotive Electronic Control Modules (ECMs)
- Automotive Body Electronics
- Automotive Telematics

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