Low-Cost Instrument Module
Adds ICT capability to Functional Test

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INTRODUCTION

Faced with shrinking budgets, Test Engineers are often forced to choose between ICT (In-Circuit Test) or Functional Test. Both test methods offer unique advantages as well as limitations. In the case of ICT, assembly related defects are quickly identified, but the process offers no assurances the device-under-test (DUT) will “function”. The Functional Test process validates the “functionality” of a DUT (after power is applied). However, a strategy that bypasses ICT and favors Functional Test alone is risky. A failure at Functional Test is usually very cryptic (i.e., DUT is DOA), which means a Test Tech could spend several hours troubleshooting (as opposed to ICT, where the defect could be located in about a 10th of a second).

So how do you decide (ICT or Functional Test)? Both can be expensive to build, but unfortunately your budget can only support one-or-the-other. After a careful review of the yield reports produced by the ICT, you discover (for similar products) the yields are very high. From that information you conclude the CM assembly process is reliable, so therefore a Functional Test system is perhaps justified. But you are still not 100% convinced (so you begin to wonder), *“what if there was a way to add an ICT capability to my Functional Test system”*? Well wonder no-more, Overton Instruments has invented the SF-MATE (an ‘8’ Channel “Short Circuit” Measurement Module).

OVERVIEW

The SF-MATE (*or Short-Finder*), is a unique test instrument that adds ICT capability to Functional Test equipment. Rather than spending thousands of dollars to test all nodes on a PCB, the SF-MATE limits the number of checks to those defined as “critical” test points. For example, during a typical assembly process, a PCB can receive inadvertent “shorts” in the power section. By verifying certain test points are “short free” (prior to applying power to the PCB), the SF-MATE can prevent damage to the DUT, adjoining test equipment and possible injury to the test Operator.

The SF-MATE has 8 input channels that are connected to a special Short-Sensor circuit. After a channel is selected, a constant current is supplied to the device-under-test and a voltage is measured that is proportional to the resistance. The Short-Sensor limits the current source to 1mA, and the open-circuit voltage is just 200mV (which is less than the nominal turn-on voltage for most PN junctions). When the input exceeds a certain level, the SF-MATE outputs a digital bit that indicates a short . Likewise, the SF-MATE can also be used to identify ‘open’ circuits as well (this can be useful to detect the position of mechanical switches or missing jumper plugs).

The SF-MATE can also function as a Relay Scanner. The 8 input channels are actually DPDT Form C relays (labeled K1 to K8), which are bussed together on the “normally-open” side and are connected to the Short -Sensor circuit (through relay K9). When relay K9 is active, the Relay Scanner can be used to route signals to external test equipment. A complete depiction of the various operating configurations for the SF-MATE is shown in Figure 1.

PROJECT EXAMPLE

In this example the SF-MATE is used as both a Short-Finder and a Relay Scanner. Figure 2, shows a PC-driven test system that performs a Functional Test. The DUT is a “hypothetical” electronic assembly that is used in a weather monitoring system. The DUT is capable of measuring wind speed and direction, rainfall, temperature humidity and wind chill. The DUT is also designed to operate from either a +12V or +24V power source. Once power is applied, the DUT can be commanded through a serial RS-232 Com port. Included in the test system is a PC Computer, a 7-Port USB Hub, a Programmable DMM & Power Supply, and ‘5’ Test Instrument Modules (SF-MATE, Check-MATE, Switch-MATE and the Pulse-MATE). The test system also includes a custom block of circuits that provide simulated weather sensors and passive loads. In the example, the test instruments are controlled by the PC (by issuing a series of ASCII commands via the USB interface).

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The test process is divided into '2' sections, DUT Power and Sensor test. During the DUT Power test, the SF-MATE is used to detect shorts (before power is applied), and is used to measure "key" voltages after power is applied. Table 1, lists the DUT test points which connect to the SF-MATE. Test Instrument Modules (COM-MATE, Check-MATE, Switch-MATE and the Pulse-MATE), are further described in Table 2.

DUT Power Test

To start the test sequence, the PC issues an 'SF_SS?' command to the SF-MATE, (which means all 8 channels are scanned for shorts). The scan cycle is performed is roughly 80msec. Once the scan is compete, the SF-MATE returns the results to the PC. The response is an 8-bit ASCII string (i.e., '<00000000>'), which represent 'short-status' for each channel. A logic '1' indicates a short-condition (msb = CH7, lsb = CH0). A short detected on channels CH0 thru CH5 are important because it indicates a serious fault lies within the power section of the DUT (and DUT power should not be applied). Assuming no shorts exist, the PC goes on to interpret the state of bit-6 'CH6'. The state of bit-6 will determine the Power Mode configuration for the DUT (a logic '0' is a +12V mode and a logic '1' is a +24V mode). The Power Mode is strapped (or hard-wired) one-way-or-the-other, during the assembly process. At this stage, the PC ignores bit-7 'CH7'.

Now, the PC is ready to apply DUT power (and validate the output and reference voltages). Based-on the Power Mode 'bit', the PC issues a series of commands to the Programmable Power Supply (to configure it for either +12 or +24 volt operation and set the current limit). Once power is applied, the PC queries the Power Supply to check the over-current alarm. If the alarm is not set, it's time to check the DUT voltages to verify they are within proper limits (the test points include +3.3V, +5V, ±12, 4.096Vref and 1.25Vref). First the PC issues a 'SF_ER1' command (which enables the 'external source' relay and places the SF-MATE into the Relay Scanner mode). Next the PC issues a series of commands to the Programmable DMM (to set the DC voltage range and measurement accuracy). Finally, the PC enters a program loop which includes the following steps:

(1) Select a channel 'SF_SR01' (which routes the CH0 test point to the DMM),
(2) Trigger the DMM to take a voltage measurement,
(3) Determine Pass or Fail and log the results,
(4) Repeat the cycle for channels CH1 thru CH3 (+5V & ±12).

Assuming the DMM is set for a nominal accuracy range (4.5 digits), this phase of the test could be completed in roughly 300msec per channel (or less than 2 seconds overall).

To complete the DUT Power test, a resistive load is placed on the output voltages to verify they remain within limits. However, an integral part of the test requires a communications link with the DUT via the RS-232 connection. To establish a dialog, the PC issues a 'CM_DC|ID?' command to the COM-MATE (which causes the DUT to respond with an ID message '<WeatherMonitorXJ7>'). After confirming the ID message, the PC enters a program loop which includes the following steps:

(1) Select Test Point 3.3V - CH0 (by sending command 'SF_SR01' to the SF-MATE),
(2) Select load #1 (by sending command 'SM_SR01' to the Switch-MATE),
(3) Trigger the DMM to take a voltage measurement
(4) Determine Pass/Fail & log the results,
(5) Query the DUT to measure load current (by sending command 'CM_DC|CR0?' to the COM-MATE),
(6) Determine Pass/Fail & log the results,
(7) Release load #1 (by sending command 'SM_SR00' to the Switch-MATE),
(8) Repeat the cycle for channels CH1 thru CH3 (+5V & ±12).

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DUT Sensor Test

As was described in the previous section, the DUT is a weather monitoring system that is capable of measuring wind speed and direction, rainfall, temperature, humidity and wind chill. The DUT measures weather conditions through a series of external sensors. The sensors are designed to produce an analog voltage. In the case of wind speed, the sensor is a tachometer (which produces a series of pulses, whose frequency matches the wind speed). In the test system shown Figure 1, the external sensors are replaced by a collection of custom interface circuits that are designed to "simulate" the sensors. The simulated sensors are controlled by the Check-MATE (see Table 2). To simulate wind speed, the Pulse-MATE is used (see Table 2).

The objective for the DUT Sensor Test is verify the DUT can accurately process analog data for each sensor input. This is accomplished by stimulating the DUT with a varying analog input, measure the corresponding output from the DUT, and evaluate the results to determine Pass/Fail.

Analog Data Acquisition

On the DUT, resides an Analog Multiplexer circuit (which allows any one of the sensors to be read by an ADC circuit). The ADC is used to convert the analog signal to a digital value (so the DUT can further manipulate). To perform the test sequence, the PC enters a program loop which includes following steps:

(1) The PC commands the Check-MATE to configure the 'sensor simulator' to mimic wind direction,
(2) The PC commands the DUT (via the COM port), to measure the wind direction,
(3) The DUT returns the measurement and the PC stores the result,
(4) The PC compares the DUT reading to a preset limit & determines Pass/Fail,
(5) The PC issues a 'SF_SR71' command (which routes the CH7 'Mux Out" test point to the DMM),
(6) The PC triggers the DMM to take a voltage measurement,
(7) The PC compares the DMM reading to the DUT reading & determines Pass/Fail,
(8) Repeat the cycle while simulating rainfall, temperature, humidity and wind chill.

Pulse Data Acquisition

The DUT measures wind speed by using an external "tachometer" sensor. To simulate the tachometer, the test system uses the Pulse-MATE. To perform the test sequence, the PC enters a program loop which includes following steps:

(1) The PC issues the Pulse-MATE a series commands (to set frequency, pulse-width and amplitude),
(2) The PC commands the DUT (via the COM port) to measure wind speed,
(3) The DUT returns the measurement,
(4) The PC compares the DUT reading to a preset limit & determines Pass/Fail,
(5) Repeat the cycle (by setting the frequency from 1 to 100Hz, in 1Hz increments)

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CONCLUSION

With the SF-MATE, Test Engineers can now afford to have the best of both worlds.   This APP NOTE provides a practical example of how critical features of ICT can be easily integrated into Functional Test equipment. The results are undisputed, using the SF-MATE in your next project will increase safety, reduce test-time, expand test-coverage and lower cost.

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Table 1. lists the DUT test points which connect to the SF-MATE

SF-MATE Channel	DUT Test Point	Description
CH0	+3.3Vdc	Power for 3.3V logic.
CH1	+5Vdc	Power for 5V logic
CH2	+12Vdc	Power for +12V analog circuits.
CH3	-12Vdc	Power for –12V analog circuits.
CH4	4.096Vref	Analog reference voltage, 4.096Vdc
CH5	1.25Vref	Analog reference voltage, 1.25Vdc
CH6	Power Mode	Power Mode configure the DUT for either +12Vdc or +24Vdc input power. No jumper = +12V operation. Jumper present = +24V operation.
CH7	Mux Out	The analog multiplexer output.

Figure 1. A complete depiction of the various operating configurations for the SF-MATE