INCREASING TEST THROUGHPUT WITH BETTER INSTRUMENT COORDINATION

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The built-in intelligence and programmability of today's source-measure units can greatly improve test throughput.

Testing speed is important for all electronic components, but it is vital for low-price two- and three-terminal devices like diodes and transistors. Most types of diodes, for example, are tested for at least three basic DC parameters during final inspection: Forward Voltage (V_F), Breakdown Voltage (V_R), and Leakage Current (I_R). These tests must be accurate and quick.

Most of these tests require several instruments, such as a DMM, voltage source, and current source. However, using multiple instruments takes up more rack space than a system with all these functions in one unit. Three separate instruments also mean three sets of commands to learn, plus complicating system programming and maintenance. It also makes trigger timing more complex, increases triggering uncertainty, and increases the amount of bus traffic required, which hurts throughput.

The first part of the solution is to combine several functions in one instrument. A source-measure unit (SMU) combines a precision voltage source, a precision current source, a voltmeter, and an ammeter in one instrument, saving space and simplifying integration. The second part is to eliminate communication delays between the instruments and the control computer.

Using a GPIB (IEEE-488) link to deliver commands to control each step of a test has two drawbacks. First off, GPIB has considerable communications overhead. Secondly, there's generally a PC running Windows™ at the other end of the line, and Windows has unpredictable timing that it makes unsuitable for close synchronization of multiple instruments.

The solution is to let the instruments run themselves. Many of today's instruments have source memory list programming, and can run up to 100 complete test sequences without PC intervention. Each test can include source configurations, measurements, conditional branching, math functions, and pass/fail limit testing with binning capability. Some units can slow down more sensitive measurements and speed up others to optimize overall timing. The role of GPIB is then to download the test program before the test and upload the results to the PC afterwards, without interfering with the actual testing.

Instrument triggering

Figure 1 shows how a modern instrument (in this case an SMU) handles triggers. In the source-delay-measure (SDM) cycle the source is turned on, a programmable delay is executed, and then the measurement is performed. The user can trigger the beginning of each step, or the instrument can output a trigger after each one.

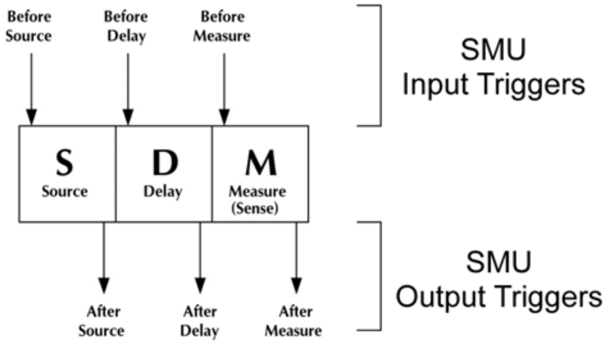

Figure 1. SMU trigger input/output configuration

Example: Testing diodes

Our first example involves one test instrument, a device handler, and a PC. The diodes arrive with unknown polarity, but the component handler can rotate them if necessary *(Figure 2)*.

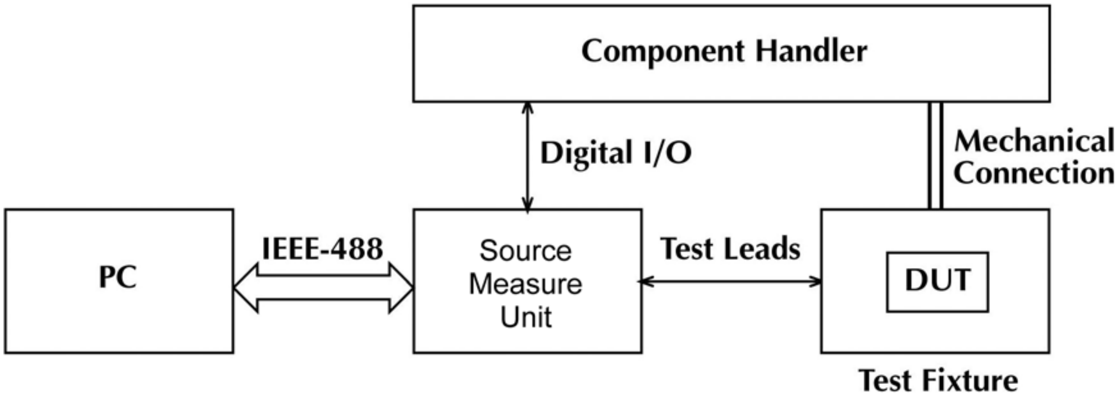

Figure 2. Diode testing setup with component handler

The test steps are as follows:

1. The operator tells the PC that a diode production lot is in place and ready for test.
2. The PC preconfigures the tests that the SMU will perform on each diode via GPIB.
3. The SMU waits for the Start of Test trigger from the handler.
4. When the first diode is in position, the handler sends a Start of Test trigger signal to the SMU, indicating the first diode is ready for testing.
5. The SMU executes a polarity test. If the diode is in forward polarity, the SMU proceeds with functional tests (Step 6). If it's reversed, a signal is sent to the handler to turn the device and return to step 4.
6. Once the diode is in forward polarity, the SMU runs diode functional tests in the order stored in source memory, makes pass/fail determinations, and saves data for each test.
7. The SMU sends an overall pass/fail code and End of Test signal to the handler and simultaneously sends test data to the PC via GPIB.
8. Steps 3–7 are repeated for the remainder of diodes in the lot.
9. The SMU returns to the idle state. The operator installs a new lot of diodes in the handler.
10. Steps 1–9 are repeated as required.

Note that the GPIB communication occurs only before and after the actual testing.

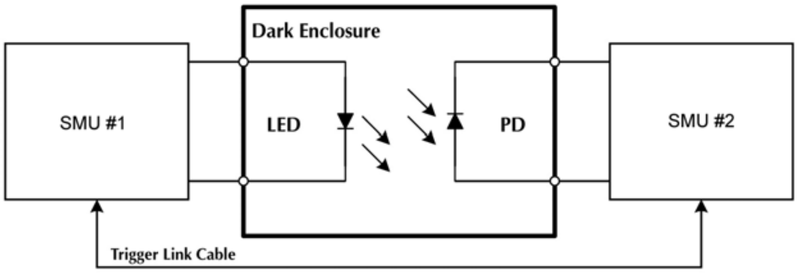

Figure 3. Basic LED/PD system configuration

Multiple with multiple SMUs

Figure 3 involves multiple instruments: testing an LED with a built-in photodetector (PD). SMU #1 supplies current to light the LED. SMU #2 provides a negative bias voltage to the PD and measures the resulting leakage current. Light from the LED increases this leakage current, and measurement of the current reveals the light-emitting capabilities of the LED. For the data to be useful, the voltage on the LED and the current on the PD must be measured at exactly the same time. Throughput is critical, so the dwell time of the source values are typically kept as short as possible. Figure 4 shows how the two instruments trigger each other. Similar methods can be used with more than two instruments.

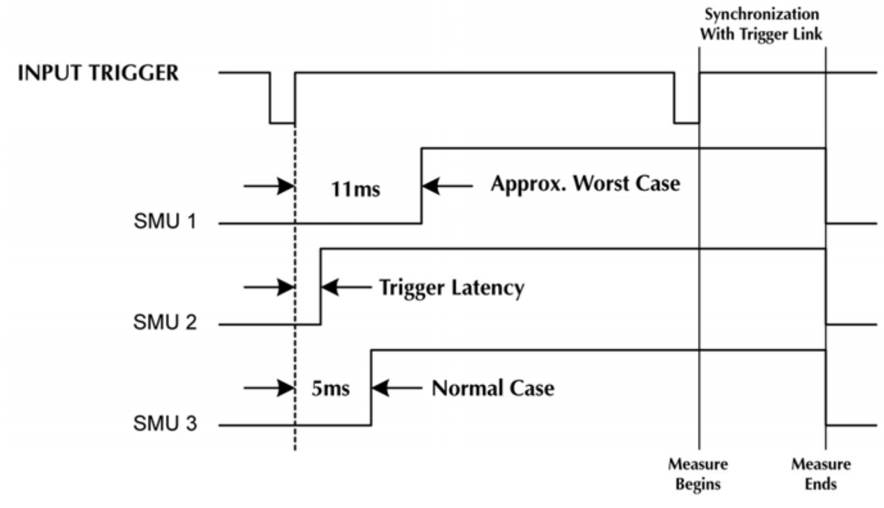

Figure 4. SDM triggers to synchronize two SMUs.

Using external trigger controllers

Testing devices such as transistors, DC-DC converters, LDO voltage regulators or LED/photodetector systems typically requires multiple instruments. Since it is desirable for both instruments to be preprogrammed (and thus avoid GPIB delays), all the instruments in the setup should operate synchronously. Unfortunately, their source memory recall and auto-ranging steps take an indeterminate amount of extra time (Table 1).

Table 1. Parameter change execution time.

Description	Approximate Execution Time (ms)
Changing current range	5
Changing voltage range	5
Switching from I source to V source*	11 (worst case)

* Switching source mode requires that the output be turned off and often requires changing both the voltage and current ranges.

In this case, or any time the triggering scheme required for a test system is too cumbersome or complex, we can use an external, dedicated trigger controller. Trigger control modules function as trigger routers, which issue and wait for triggers as programmed. They help greatly when a test system is built using equipment from different manufacturers or even products from the same manufacturer with different methods of triggering.

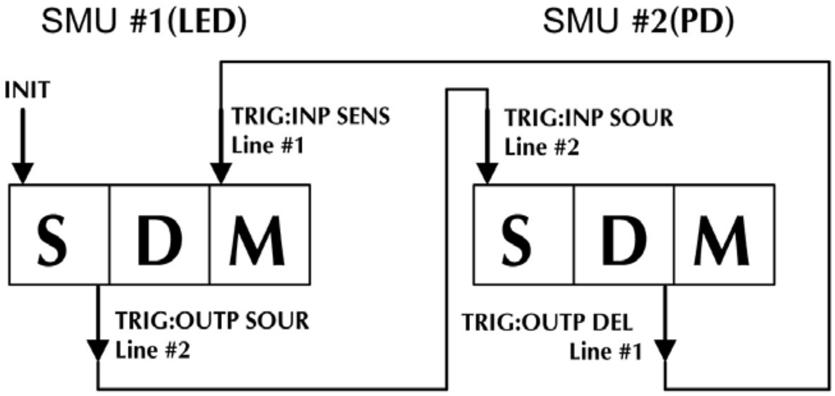

Figure 5. Effect of trigger synchronization

The process works like this (Figure 5):

1. The trigger controller sends a trigger to all instruments (source input).
2. A source memory location is recalled from memory.
3. The source output is enabled on all instruments.

4. Each instrument performs a user-defined delay.
5. Each instrument outputs a trigger to the controller once the delay operation is complete.
6. The trigger controller waits for a trigger output from each instrument (delay output).
7. The trigger controller outputs a trigger that is received by all instruments (measure input).
8. Each instrument begins the measurement operation.
9. Each instrument outputs a trigger to the controller once the measurement is complete.
10. The trigger controller waits for a trigger output from each instrument (measure output).
11. Go to Step 1 to begin the next test.

Conclusion

Test throughput can have a significant effect on profitability for manufacturers of semiconductor devices. Knowledgeable use of the programmability of today's multi-function instruments can go a long way toward reducing test costs and improving manufacturing productivity.

About the Author

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