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OPTOELECTRONICS ATE ON A PCI PLATFORM

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ATE Needs

Automated testing is essential for controlling optoelectronic component costs and ensuring their reliability. Active fiberoptic components and modules have continued to evolve, even during the current market downturn for telecommunications equipment. This evolution has resulted in more complex modules that support self-configuring networks, an essential feature for continued growth of fiberoptic telecommunications.

Light-current-voltage (LIV) testing is an essential part of fiberoptic communications system manufacturing, during which DC characteristics of laser diodes are obtained at various stages of production. These tests are required for wafer level testing on VCSELs (vertical cavity surface emitting lasers), bar stage testing of edge emitters, and finished product testing of laser diode modules.

The latest modules, such as tunable laser diodes and multi-wavelength Raman pump modules, require more source and measurement channels in production test systems in order to maintain or improve throughput. This is particularly true of modules used in DWDM (Dense Wavelength Division Multiplexed) systems, which require evaluation of several parameters over many different wavelengths. A large number of channels are now required to characterize active components in these modules, and for simultaneous testing of multiple components. Furthermore, the high channel count is accompanied by a need for precision, real-time measurements that go beyond the capabilities of many existing test solutions. New test systems are needed that are more compact, provide a better price/performance ratio, lower operating costs, and help increase yields.

Automated LIV test systems that address these needs are now appearing. Most of these solutions are designed for PC-controlled testing; some can be easily scaled for different levels of automation. This is important, as success depends on matching automated test systems to the current state of production, and having the flexibility to change along with manufacturing needs. Such features also provide an attractive cost of ownership and fast payback, which is important when manufacturing components with a relative short production life before they are redesigned and test requirements changed.

Rack-and-Stack Instruments

Most LIV test systems use a rack-and-stack design comprised of many different source and measurement instruments. The rack-and-stack approach reflects the industry's relatively low level of automation up to this point. Even with multiple instruments, these rack-and-stack systems often lack the throughput to meet current manufacturing needs because of individual instrument attributes.

A common problem with multiple instrument systems is a tangle of cable connections, so noise has often been a limiting factor in measurement precision and speed. In addition, the relatively slow GPIB interface that is standard in most rack-and-stack systems reduces throughput even more. Systems that use several different instruments also require complex trigger schemes and trigger controller hardware. High channel counts are often achieved with electrical switch matrices that add additional complexity in programming and cabling.

Using PCI for Modular, Scalable ATE

The challenge to automated test equipment (ATE) designers is to retain all the required features and functions while reducing complexity and size in a tightly integrated, modular system. Often, VXI or PXI platforms are considered, but cost may be a sticking point. An alternate approach is a PCI chassis and backplane that allows fast data transfers across the PCI bus and a great deal of flexibility to add functions via PCI plug-in modules. Fast microprocessors are available for control under the Windows® operating system (OS), with all its familiarity and compatibility with industry standard test development and execution environments. Furthermore, the open PCI architecture facilitates development of modules with application specific features, such as optical and functional testing.

In addition to a fast microprocessor, ATE system require high speed source-measure functions that apply biases and source a DC voltage or current to the device under test (DUT), followed by a precision measurement of its response. A wide range of output current is often required—up to 1A or more for multi-wavelength Raman pump modules, high output transmitter modules, and EDFA pump lasers. To reduce the overall test time, source-measure settling time must be minimized. Having source-measure instruments plugged into the ATE's PCI backplane is a major improvement over externally cabled instruments; a snarl of cables introduces excessive capacitance, inductance, and settling time.

Often, these and other optoelectronic DUTs are tested in a multi-head test cell (Figure 1) that asynchronously executes tests on demand for each device. In some systems, a component handling robot moves DUTs to and from the test sockets. As soon as the robot informs the cell controller that a new DUT is in position, the controller initiates the tests. Implementation of the test sequence should be independent of test hardware dedicated to other DUT sockets. This allows the robot to service other sockets while instrumentation completes tests at a different location on the test fixture.

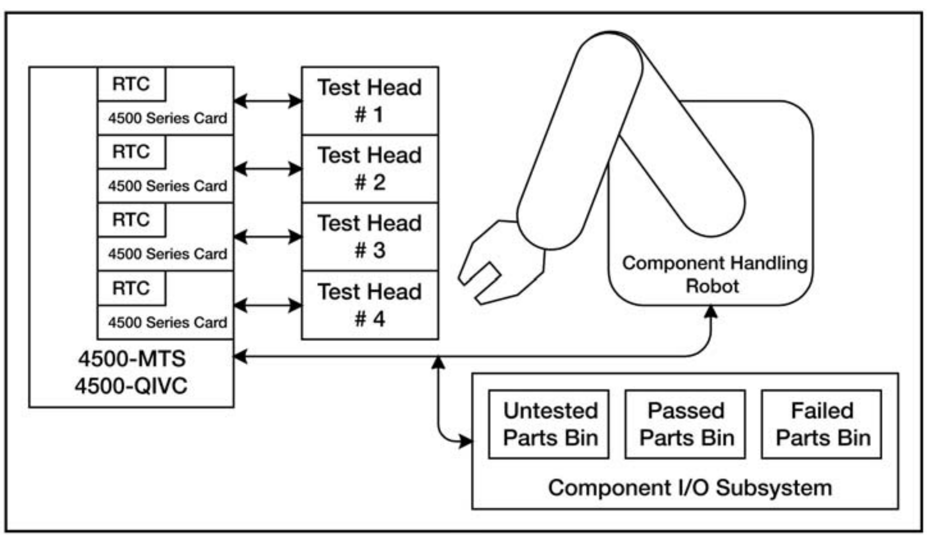

Figure 1. Real-time controller cards make true asynchronous concurrent testing a reality. While the RTCs execute tests, other test system resources are free to command the component I/O and robotic handling subsystems.

All this presupposes real-time control and efficient algorithms in the ATE system, which allow offloading many test functions from a PC-based cell controller. In particular, the ATE should be capable of executing concurrent (parallel) tests on different groups of source-measure channels for different devices. Then, with application specific test sequences stored in ATE memory, such as those for laser diode LIV testing, traffic on the external data bus is kept to a minimum. Only instrument readings need to be transmitted from the ATE to the cell controller, which can take place when the controller's processor isn't required for other functions. If the ATE system and cell controller use a 100BaseT fast Ethernet connection, large data sets can be transferred in a fraction of the time required when using a conventional instrument bus, such as GPIB.

Beyond the Basics

Many of the features described above are basic requirements for a fast, accurate, and cost-effective ATE system that will be used in production. However, there are several features that can be added or expanded on to further enhance system performance.

Instrument-Grade PCI Chassis. Many optoelectronic tests require low noise, high current sourcing and precision, high speed measurements. This dictates a well-controlled environment with stable temperatures. An ATX (Intel ATX Standard) power supply system, typical of the power supply in a benchtop PC, can't supply instrument-grade power to a large number of source circuits. Furthermore, power supply cooling in an ATX standard system is also used for overall system cooling. For high quality source-measure capability, dedicated low noise power must be distributed to all the PCI slots. Additionally, those slots should be cooled with a separate forced air system to ensure that source/measure circuits are temperature stabilized for repeatability and accuracy.

Modularity/Scalability Characteristics. Rapid change is a classic problem in the optoelectronics industry, making equipment modification and reuse an economic necessity. While rack-and-stack instruments allow a good deal of flexibility, manufacturers shouldn't have to give up the speed, accuracy, and ease of use that an integrated ATE system can bring to the party. Building an ATE system around the open architecture of a PCI platform, with plug-in card modularity, makes it easy to modify and expand the system as needed. Standard PCI cards can be used in conjunction with the ATE's specialized cards to create a complete high throughput test system within a single chassis. Thus, high channel density and expanded functionality is gained within a small footprint—critical features for space-starved manufacturing facilities.

Hardware Trigger Bus. Real-time sequencing of multiple source-measure channels can be coordinated through the use of a hardware trigger bus. Coupled with distributed real-time controllers, an inter-module trigger bus makes it possible for groups of channels spanning multiple PCI modules to act in concert as though controlled by a single real-time test engine. This concept also provides a mechanism for multiple groups of channels to execute asynchronously and independently. Thus, a trigger bus consisting of several trigger lines allows a number of groups of source-measure channels to execute different tests on different DUTs with complete autonomy. This is fundamental for efficient multi-head test system operation.

Distributed Real-time Controllers. A conventional modular/scalable test system typically relies on a single embedded PC to coordinate all test functions and sequences. This architecture limits throughput and timing, which are dictated by the PC and OS. These limitations include sequential execution and OS latency. For example, Windows in well known to be temporally unpredictable. During a test sequence, the timing between source and measure operations must be predictable to ensure precise, repeatable measurements. Another limitation of using a single CPU is that only one operation can be executed at a time. As a result, it's not possible to perform true parallel tests and gain the high throughput this produces.

Several problems can be overcome by incorporating multiple distributed controllers among the source-measure channels, with each controller running a real-time operating system (RTOS). Real-time controllers running an RTOS don't suffer from temporal unpredictability. Several real-time controllers can work in concert using the hardware trigger bus to execute high throughput parallel tests. As an additional benefit, the real-time controllers can be programmed to share resources via the hardware trigger bus. This technique allows channel groups to take advantage of resources allocated to different real-time controllers.

Real-time Management Software. To take advantage of a flexible hardware platform with built-in PC and distributed real-time controllers, embedded software must be developed from a deep understanding of the optoelectronic manufacturer's test environment. In particular, the software requires sophisticated features that can control several dozen channels of real-time source-measure capability. In addition to the customary device drivers, software features should include a *real-time manager* to coordinate the complex functions in a multi-head test system. A principal task of the real-time manager is to track which individual channels are assigned to specified channel groups, and prevent conflicts between groups. The real-time manager is also used for programming the complex trigger model to ensure proper test sequencing during real-time execution. This software should also help a test engineer quickly develop code for concurrent testing of multiple DUTs without having to do a detailed analysis of trigger interactions and resource allocations.

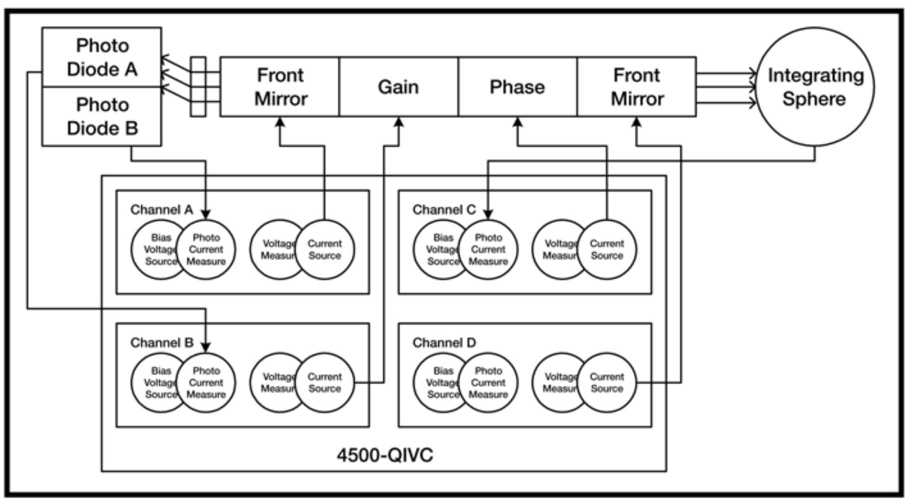

Figure 2. ATE system for testing four-section tunable laser diode modules. Current source cards control injection currents. Three of the four current measurement channels record photocurrents—two are for wavelength measurement, and one for recording optical output power. This testing generates from 250,000 to 1,500,000 LIV measurements. Essential ATE requirements are high channel count, multiple A/D converters, and fast transfer of large data sets to the PC controller.

A tightly integrated system of this type (Figure 2) provides a platform for creating a variety of automated test solutions for I-V characterization of electronic devices. Such a system can be used to test products as diverse as laser diodes, RFICs, carbon nanotube arrays, bioassay chips, and multichemical sensor arrays, as well as for DNA "lab-on-a-chip" testing.

About the Author

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