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OPTICAL TECHNOLOGIES, COMMUNICATIONS APPLICATIONS, AND INDUSTRY ANALYSIS WORLDWIDE PennWell® MARCH 2009

TECHNOLOGY

Passive PICs are key elements in 40- and 100-Gbps systems

by ANTHONY TICKNOR and G. FERRIS LIPSCOMB, Neophotonics

Silica-on-silicon-based planar demodulators are ideal for both coherent and differential 40- and 100-Gbps DWDM applications; the technology enables such devices to meet stringent polarization requirements and provides a platform for hybrid integration.

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TECHNOLOGY

Internally compensated digital VOA modules improve cost

by XINZHONG WANG and YAO LI, Alliance Fiber Optic Products Inc.

The increased deployment of ROADM technology calls for more modular, digitally interfaced subsystems, such as the electrically controlled variable optical attenuator (VOA). With more standardized digital control formats and the availability of sub-$100 VOAs such as the iC-VOA, a new generation of VOA modules can lead to more dynamic control of optical networks.

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APPLICATIONS

Improving test reliability and throughput for multiport components

by ANETTE ZIMMERMANN, Agilent Technologies

The use of high-speed measurement data acquisition, fast data transfer for post-processing, and a high dynamic range—combined with a multiport adapter that enables connection of individual fibers of a multichannel component—provides end users with increased throughput and operational efficiency.

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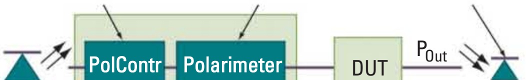

INDUSTRY

Our 2008 Top 5 companies are prepared for 2009

by STEPHEN HARDY and MEGHAN FULLER HANNA

Lightwave's editorial staff once again ranks the Top 5 companies in the components/subsystems and systems spaces. Amid economic uncertainty, this year's list features several shakeups, including a new name at the top of the component vendor heap. And the solvency (or lack thereof) of a certain systems vendor has our editors musing about the future of the optical systems landscape.

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Technology

Advances in research, development, engineering, and standards

Internally compensated digital VOA modules improve cost

By Xinzhong Wang and Yao Li

OVERVIEW

The need to increase integration and standardize interfaces pertains to a variety of modules, including variable optical attenuators (VOAs). New technology can make a modular, digital VOA device design possible.

Lightwave communications applications are evolving rapidly toward increased agility and flexibility. The emerging era requires deployment of reconfigurable optical add/drop multiplexing (ROADM) nodes using more standard-interfaced components. This trend pressures traditional optical component manufacturers to increase integration and create, for example, more modular variable optical attenuator (VOA) modules that can offer interchangeable digital interface capabilities directly.

To a large extent, active optical component makers forged this path earlier, transforming themselves from providers of analog lasers to producers of a variety of digitally controlled transmitters in SFP, XFP, and other standardized form factors. One key advantage of such integration toward industry-standardized modules is that it allows multisource agreements (MSAs) to be established to help sustain competition among various supporting technologies and thus promote continuous cost-improvement efforts into the future.

Although this trend has not been fully established in markets other than transmitters, it is possible that for components such as electrically controlled VOAs, the push for a modular and digitally interfaced product can result in breakthrough cost improvements and enhanced manufacturing freedom.

VOA requirements

In today's VOA marketplace, various devices offer distinctive features in optical, electrical, and environmental performances and requirements. Each class has its own unique form factors as well. One common attribute among all is that they require analog electrical signals to drive voltage, current, or both. Yet one device design, highly favored by one system integrator, may prove to be too costly to implement for another due to the need to redesign a printed circuit board (PCB) to power the VOA engine.

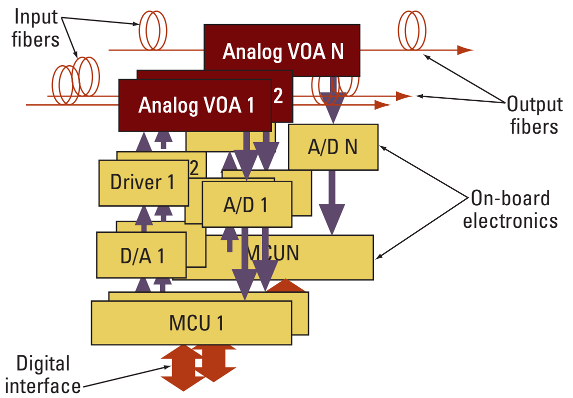

FIGURE 1. This diagram of a multi-channel digital VOA module architecture shows that, in addition to analog VOA devices, some basic electronics and micro-controllers are used to help bridge the digital interface.

From the long-term view of all system integrators, a potentially MSA-capable digitally controlled VOA module would be ideal. To promote the long-term viability of a common footprint/interface design, it would help if various enabling technologies can support it and compete at the same time.

Next-generation VOA modules must accommodate a set of commonly shared optical and electrical performance specifications. Extremes in requirements for response time, power consumption, and form factors should remain niche and be generally excluded for the broader market's common requirements.

Based on our survey of various system integration applications and available technological options, a typical *N*-channel digital VOA module

Table 1. A list of generic requirements for digital VOA modules

Parameter	Unit	Specification	Remark
Wavelength range	nm	1520-1570	C-Band typical, but the larger the better
Attenuation range	dB	1 – 20	"Bright" or "dark" state possibility
Polarization-dependent loss	dB	<0.25	Performance should be proportional to attenuation setting limited by the maximum specification value
Wavelength-dependent loss	dB	<0.4	
Temperature-dependent loss	dB	<0.8	
Setting accuracy/repeatability	dB	<0.15	
Tuning speed	msec	<300	Between any two attenuation points
Peak power consumption/channel	mW	<500	
Control requirement (digital)	N/A	I2C, RS-232, USB	Typically for array up to eight channels
Module cost per channel	$	<100	Including enclosures and electronics

architecture is depicted in Figure 1. A set of basic requirements that balance among most application needs is presented in Table 1. Included in the requirements is also a nominal target cost per VOA channel (even in single-channel modules) that can actualize and motivate its wider application and adoption in the future.

VOA technologies

To support a digital and modular integration approach, several common device technologies can be considered:

- electro-optic (E-O)
- micro-opto-mechanical system (MOMS)
- micro-electro-mechanical system (MEMS).

The E-O technologies have the advantage of no moving parts and possess very high attenuation tuning speed. Some of them in the planar waveguide circuit (PLC) forms are multichannel oriented with small device form factors. However, these PLC-based devices are often less competitive in some optical performance characteristics such as polarization-dependent loss (PDL), wavelength-dependent loss (WDL), and temperature-dependent loss (TDL). While the technology can address larger array VOA applications with cost reaching below $100/channel, for smaller channel counts they are less cost competitive and do not offer common drive requirements as devices.

The technologies supporting MOMS VOA modules have the longest field exposure. This type of device's actuation speed is typically slower and it is bulkier in packaging. But these devices are very reliable and can serve applications where speed, power consumption, device dimension, and thus large-channel-count array integration are not among the most important considerations. However, many MOMS VOA devices are not cost competitive due to use of more expensive and hard-to-manufacture special optical components, such as variable neutral density (ND) filters.

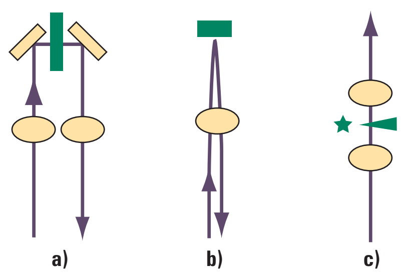

FIGURE 2. Schematic of (a) a traditional MOMS VOA; (b) a MEMS VOA, and (c) an iC-VOA as digital VOA module candidate technologies. Components marked in green are key to the implementation of the attenuating functionality.

Last but not least, MEMS technology is a special class that distinguished itself from MOMS for its unique device characteristics associated with semiconductor fabrication processes. Although possessing moving parts, the small scale of a MEMS VOA chipset enables fast response time at a much smaller power dissipation level than a MOMS-based device.

MEMS VOAs have significantly penetrated the market over the last 10 years. Some may recall that during the last telecom bubble, headlines proclaimed the near availability of sub-$100 MEMS VOA devices, owing to the many desirable characteristics that MEMS manufacturing platforms uniquely possessed. Various optical MEMS foundry services were set up and so were many MEMS VOA assembly lines.

However, history proved that the sub-$100 VOA cost milestone was tough to achieve. Among the problems in improving the cost-reduction curve for MEMS was packaging manufacturing yield. Many heavily promoted advantages associated with the performance excellence and uniformity at the MEMS chip level could not overcome the dominant manual assembly processes that led to an overall lower yield at the final product level.

While fully automated assembly lines might have solved such assembly issues over the long term, the industry's capital limitations over the past decade would not allow component manufacturers to justify the level of investment required. In fact, without the huge volume that only the semiconductor industry can create, it may not be possible to justify the high costs of a new assembly line featuring state-of-the-art equipment and automated batch processing for the VOA

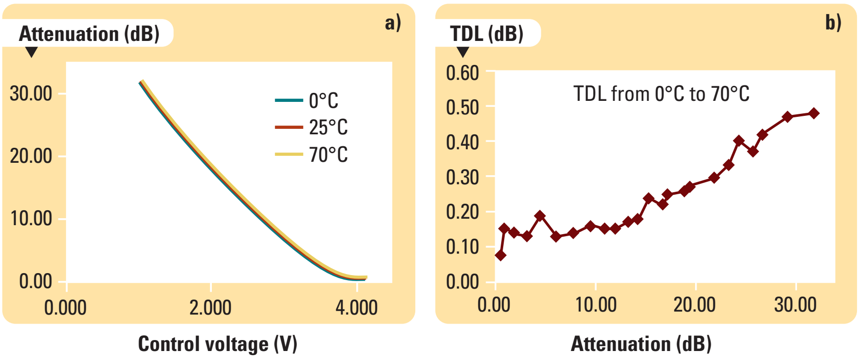

FIGURE 3. (a) Attenuation curves of an iC-VOA module at 0°C, 25°C, and 70°C; (b) TDL of the iC-VOA defined as the attenuation maximum differences among the three operating temperatures.

application. The industry must adjust to a supply model where a more modest product volume will demand new, low-cost component technologies that require lower initial capital investment and low-cost labor support, among other considerations.

Interestingly, migration to a more standard integrated digital VOA module may also pave the way for lower total cost per channel on an industry-wide basis, based on the industry served—i.e., moderate volume, high-performance optical communications. Higher performance at lower cost per channel is a win-win for system designers. And potentially standardizing the interface enables a wider supplier base over time to please manufacturing and procurement.

A path toward standardization

To achieve the required high manufacturing yield and low component cost—without high up-front investment or requiring consumer semiconductor volumes—requires thinking about what's "in the box." The key enabling technologies for a sustainable sub-$100 digital VOA module design might come from the innovative use of various existing, low-cost, reliable optical elements that other industries have developed and matured over recent years. Integration and packaging of commoditized components derived from these technologies must fit low-cost manual assembly platforms. Once these two most important conditions are satisfied, use of these commodity components, some of which are being manufactured in volumes exceeding 100 million pieces per year, will contribute to high manufacturing yields and propel future continuous cost-cutting initiatives as well.

Figure 2 shows a simplistic view of several technologies that can serve digital VOA module needs. These include a traditional MOMS VOA, the popular MEMS VOA, and a newer MOMS VOA featured in an internally compensated VOA (iC-VOA) module. The iC-VOA combines some of the better characteristics from traditional MOMS and MEMS technologies, and adds performance enhancements through an internal compensation scheme that uniquely fits MOMS packaging dimensions and digital module integration requirements.

For example, what makes the MEMS VOA so sensitive to the environment (thus causing yield loss due to degrading TDL, WDL, and PDL performance) is a weakness in the MEMS's beam blocking actuation stability. The iC-VOA solves this issue with a patent-pending internal compensation technique using low-cost digital control electronics that a digital VOA module requires as well, thereby leveraging a synergy of requirements.

iC-VOA technology is low in cost due to its inherent use of commodity-volume optical elements from well-developed industries outside of telecom. It also avoids the use of an improper mix of semiconductor fab-yielded chipsets with a very high degree of sensitivity. However, at the digital module level, MEMS or E-O technologies can also satisfy the footprint and interface requirements. This compatibility increases competition and innovation from all technologies and enables multiple component sources—even if some are lower cost at the outset.

A typical iC-VOA engine's attenuation scans in the range of 0.5 to 30 dB are plotted in Figure 3 in three temperatures, 0°C, 25°C, and 70°C. Figure 3a shows the three attenuation curves.

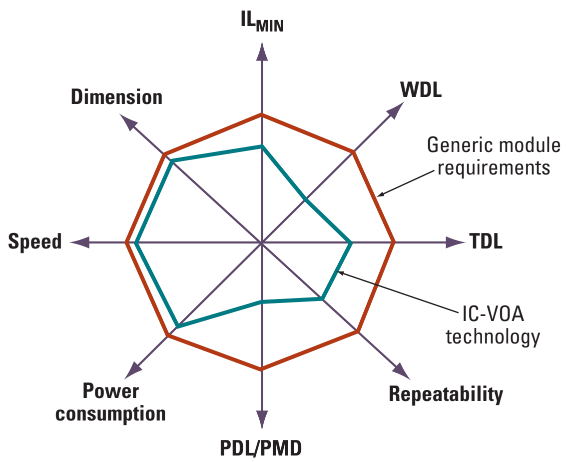

FIGURE 4. An 8D spider graph defining a set of the eight most important performance requirements a digital VOA module should meet. Shown also in the same plot is the competitive position of the iC-VOA technology within these attributes.