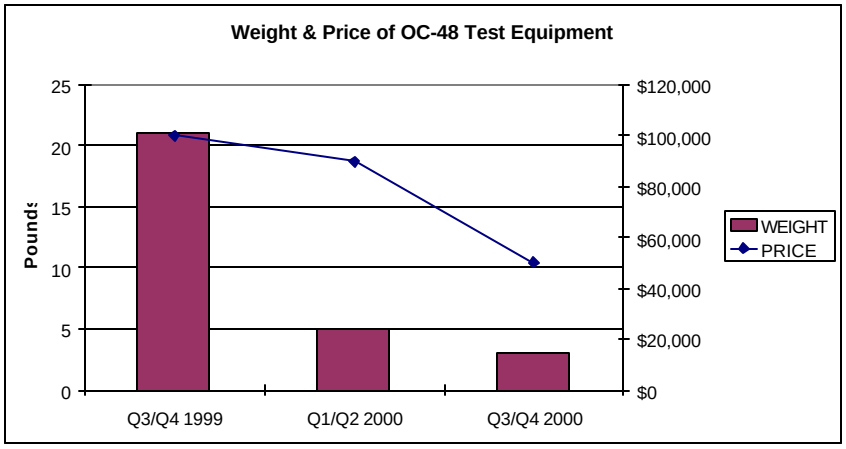
The SunSet OCx: Enabling Technologies Converge to Deliver the World's First *True* OC-48 Handheld Test Set

Introduction

Only by searching the globe for the latest high-tech components and applying design techniques perfected by years of shrinking the size of test equipment could one create a three pound OC-48 test set that fits in your hand. This paper will explore how several enabling technologies were combined in the Sunrise Telecom SunSet OC-48 OCx to shrink its size and weight, while also reducing its cost. The graph below shows the drop in average weight and price of OC-48 test equipment versus the six-month period of the product's introduction.



Fortunately for the telecommunications industry, this culmination of advanced technologies has occurred just in time to meet an increased demand for service and the transition to a competitive marketplace. The key enabling technologies discussed in this paper are *OC-48 optical transceiver modules, color displays, high capacity re-configurable hardware, and high volume miniature cooling fans*. First, the market context is introduced to give a perspective on what is driving the demand for this product.

OCx Market Context: World's Telecommunications Networks in Transition

Fueled by an unprecedented increase in demand and a shift from voice traffic to data traffic, the world's telecommunications networks are in the midst of a major transition. Service providers are scrambling to satisfy bandwidth demand, while at the same time

differentiate themselves in the new competitive environment that was created by the Telecommunications Act of 1996 and continued deregulation internationally. In this market, it is little wonder that a tremendous amount of fiber optic cable being installed, 70 million kilometers worldwide in 1999 growing to *95 million kilometers in 2000*.[1] More importantly, the data rate on that fiber is substantially higher. From 2000 to 2001, the percentage of optical circuits being turned up at the higher 2.5 Gbs OC-48 rate is estimated to increase from just 26% to over 50%.[2] These two factors are driving the need for field test equipment capable of handling the higher 2.5 Gbs data rate. Despite reports in the late 1990s of SONET's demise, spending on metro SONET equipment is expected to grow at a CAGR of 20% well into the 00s.[3] Spending for metro SONET will be more than double that of all emerging technologies combined, according to market forecasts. The competitive telecommunications market also requires test tools that are economical enough to be placed in the hands of those field professionals who are working with fiber networks daily.

The OCx heritage: A thumbnail sketch of the SunSet product line.

Sunrise Telecom pioneered the handheld test set in 1991 with the introduction of the SunSet T1. Initial market research revealed a real need for a lightweight, battery powered, yet powerful field test-tool. A test set was needed that could be taken from the CO to the B-box, from the top of a pole to a manhole. A typical field test situation requires that one hand be free for such duties as connecting patch cords or operating transmission equipment. Consequently, the test set had to be easily held in one hand. In addition, since test sessions typically lasted anywhere from ten minutes to an hour, the test set had to be lightweight. Just as important, a field test set had to be economically priced to permit wide distribution. After the SunSet T1 was established in the marketplace, field technicians began to ask for advanced features, such as ISDN PRI and GR-303 protocol analysis. The next generation SunSet, the T10, was introduced so that the field technician had a single test set that could easily go back and forth between the physical layer and the upper layers of the telecommunications protocol stack. Adding protocol analysis and other advanced options such as VF dialing analysis became an important market differentiator for the SunSet product line.

Introduction of the SunSet OCx

Field technicians really appreciated the flexibility and increased productivity that their SunSets offered. So in 1999, Sunrise Telecom extended the capabilities of the SunSet line to include SONET optical network testing at 52 Mbs, 155 Mbs and 622 Mbs with the introduction of the SunSet OCx. Within a year, over 1000 OCxs had been deployed to the field. Now the capability of the OCx has been expanded to include 2.5 Gbs SONET testing with the newest member of the SunSet OCx family. At only three pounds, the OCx is small and light enough that it can be comfortably held in one hand for extended periods. The second hand is free to plug in patch cords, operate the set, jot down notes,

[1] Source: Corning Inc. Corning, New York, USA.
[2] The Gartner Group Inc., "Network Processors Finally Ready for Prime Time."
[3] Pioneer Consulting, "Optical Edge Networks: Market Opportunities for Integrated Optical Network Solutions in Metro Networks,"

or make a phone call back to headquarters. While few SunSet OCxs will be taken up a pole or into a manhole, the convenience, portability and economy of the OCx appeals to today's field professional who travels from site to site or just up and down flights of stairs all day. With the OC-48 data rate finding its ways into the access portion of the network, there is a real need for a true handheld at 2.5 Gbs. In keeping with the SunSet tradition, the OCx goes beyond the physical layer. Today's layer 2/3 protocol analysis requirement is primarily ATM, which is a popular option for the OCx.

Four Enabling technologies

The next paragraphs explore four key technologies that have made the OC-48 version of the OCx possible. These technologies range from optics and semiconductors to liquid crystal displays and electro-mechanics.

2.5 Gbs Optical Transceiver Modules The OCx uses optical transceivers at 2.5Gbs to interface with an optical network. These small yet economical units convert an optical signal to an electrical signal, which is then processed and analyzed by the OCx. In just five years, the size of 2.5Gbs optical transceiver units has shrunk from 15 square inches to only one square inch. Prices have also dropped dramatically from the original price in 1995 of over $10,000**.**

To achieve such improvement in size and cost, optical transceiver vendors have taken advantage of advances in three areas: new Emitter Coupled Logic (ECL) high speed chip sets, increased sensitivity of Avalanche Photo Diodes (APD) for the detectors, and advances in Fabry Perot and Distributed Feed Back (DFB) lasers. In addition, the new components can be packed closer together since they produce much less noise than their larger, discrete predecessors.

The OCx also takes advantage of increased functionality available in today's optical transceiver modules. Optical power monitoring is available directly from the module, obviating specific optical components and circuitry for this function.

Color LCD Displays The display requirements for field test equipment are some of the toughest around: a wide range of ambient lighting condition, extremes of hot and cold, low power consumption, and durability, to name a few. A plethora of battery powered consumer products have driven the display industry to produce today's high performance displays. For the OCx product, the primary criteria is that the display be visible in both full sunlight and darkness, across the specified operating temperature range. For the first time, color LCD displays have come on the market that have been optimized to meet this requirement.

The display technology utilized in the OCx is referred to as Supertwist Nematic Transflective Color, or STN TFC. This technology works by reflecting external light in bright ambient light conditions. The display is brighter because the light passing through the display is not reduced by the transistor structures that other technologies have. A Cold Fluorescent Light (CLF) is installed as a backlight for low light conditions. Then an

exclusive mirror technology provides optimum reflectivity, whether in sunlight or office light, and results in an 80% reduction in power consumption over conventional LCD displays. The operating temperature range is –20C to +70C, more than enough for most outdoor situations.

Sunrise Telecom works directly with the leading supplier of this technology in Japan. The displays are manufactured to Sunrise Telecom specifications, then individually inspected. In some cases, a display has even been custom designed to fit the SunSet format.

High capacity re-configurable hardware This is perhaps the most important enabling technology contained in the OC-48 OCx. The use of configurable hardware has been key to the success of the SunSet line from the early days. A Field Programmable Gate Array (FPGA) is re-configured by downloading a new program to it, depending on the particular task needed at the moment. From 1998 to 2000, the number of FPGA system gates has tripled from one million to three million. The engineers at Sunrise Telecom have taken full advantage of the larger FPGAs. For example, full SONET mappers/demappers and ISDN & GR-303 protocol decoders have been implemented. Capturing and decoding ATM cells on the fly at 2.5 Gbs would not be possible without the latest of FPGAs. Even rendering an ATM Segmentation Assembler Re-assembler (SAR) –a very sophisticated circuit needed for advanced ATM functions such as Switched Virtual Circuits– is not out of the question. By implementing these functions in an FPGA, the OCx has complete control over all aspects of the data stream, capabilities that are not possible with function-specific off-the-shelf hardware. Priced at hundreds of dollars, the latest FPGAs do not come cheap. However, the alternative is much more expensive, less flexible, and simply will not fit.

Aside from packing more circuitry into a small space economically, FPGAs afford customers one other significant advantage –field upgradability. This flexibility gained by FPGA technology means that the OCx is as close to future-proof as possible. The protocol du jour is ATM, but many other protocols are vying to take its place. MPLS, IP, or yet another protocol, possibly associated with DWDM and optical networking, may become the definitive protocol in the future. The Sunrise Telecom design team was very aware of these looming network changes when the choice of FPGA was made. Whichever protocols traverse the network in the future, the OCx is likely just a software upgrade away from being able to test it.

High Volume Miniature Cooling Fans As unlikely as it may seem, the latest advances in cooling fan technology are an OCx enabling technology. Continued demand for battery powered consumer products, such as the laptop used to write this paper, has been but one driving force behind miniature cooling fan technology. The latest breeds of fans process an incredible volume of air, are small, light weight, and quiet, while being surprisingly energy efficient. The impellers are computer designed to maximize airflow and minimize noise. On top of all these design constrains, the fans emit low levels of magnetic flux to prevent adverse effects on the display.

The fan used in an OCx requires one important characteristic that the fan in a laptop does not: operation during changes in orientation. Simply put, a laptop is seldom moved while the fan is running. The OCx, however, requires that the fan withstand constant changes in orientation during operation. As you probably recall from elementary physics, a rotating object will resist changes in the orientation of its axis. The angular momentum is proportional to the fan's rate of rotation, which incidentally is 6200 RPM. As the operator moves the test set, the fan's bearings experience more than normal stress. Sunrise Telecom has worked closely with the leading Japanese and Taiwanese fan manufacturers to ensure that the bearings can withstand such stress. Then to prove the fans in, a special jig was created for long term testing. Many sample fans were mounted on the jig, which allowed simulation of an OCx in operation. The result is a high performance, efficient, yet rugged fan that is capable of removing the heat generated by circuitry that is being clocked at 2.5 Gbs.

Conclusion

The original requirements for the SunSet T1 at 1.5 Mbs –that it can be held in one hand, for hours at a time, and is economical enough for wide distribution— are equally applicable to today's SunSet OCx at 2.5 Gbs. By combining the latest advances in several technologies, the engineering team at Sunrise Telecom has successfully delivered a product that advances SONET field testing to new limits in size reduction and test power.