White Paper

Fibre Optic Technologies for Satellite Communication and Broadcast Industries

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Abstract

The satellite communications and broadcast industries are going through significant change both in terms of market consolidation and growing bandwidth demands. These changes are to support the migration toward multi-media service platforms. This convergence is presenting problems for existing installed equipment and the solutions often involve using new fibre optic based technologies.

Introduction

Over the last few years the broadcast and telecommunications Industries have become much more closely linked. Convergence, the process by which the same content can be transmitted over different mediums, has meant that the world of telecommunications and television are growing ever closer, particularly in the area of digital interactive services. It is therefore becoming possible for the consumer to access a variety of digital services over terrestrial broadcast, satellite, cable or even new higher bandwidth telephony products, which allow broadcast content over the telephone network.

Behind the point of consumer content delivery there is a common backbone that both broadcasters and telecommunication providers utilise, which is the global satellite infrastructure. It is therefore no surprise that to cope with the backhaul demands caused by convergence the satellite communications industry is going through significant change. This change has manifested itself in terms of market consolidation and growing bandwidth demands to support the migration toward multi-media service platforms. Once separately operated ground based systems such IF & L-band, UHF & VHF, CATV & DVB are now being merged together.

Most satellite operators are implementing development plans to existing teleport sites and earth ground station facilities to accommodate this industry growth and global expansion needs. It is during site upgrades that operational and quality of service (QoS) issues with the traditional payload transmission fabric have been encountered. This is driving an industry shift to fibre optic based systems for teleport infrastructure.

Broadcast media generation and transmission processes are also being enhanced using new fibre optic based technologies. The demand on these applications is caused by the continuous need to handle greater bandwidth, fuelled by the growth of High Definition (HD) services. Equipment in this sector is also desired with reduced size, footprint and weight.

This paper will discuss and present fibre optic based technical options to existing methods used in both the satellite and broadcast sectors. Firstly, the paper begins by explaining the concept of carrying Radio Frequency (RF) signals over fibre, the concept that enables the fibre optic technologies for broadcast and satellite.

RF Transmission over Fibre

Transmission of RF signals over fibre (RoF) is an established technology. The continued fall in the price of electro-optical converters over the last ten years has led to RoF becoming a competitive transmission platform. This has attracted the attention of satellite network installers and broadcast equipment integrators. There are numerous benefits of using optical fibre based solutions, some of which are listed below.

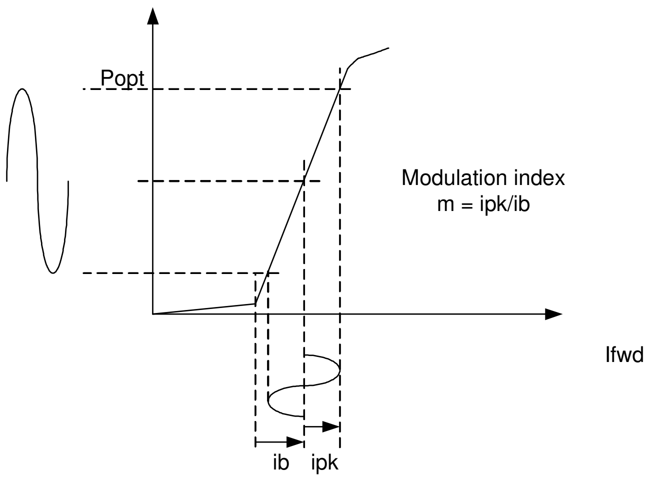
- Extensive bandwidth
- Low attenuation making it effectively transparent
- Immunity to EMI and RFI
- Highly reliable and low maintenance
- Install and forget technology
- Future proof connectivity platform
- Flat frequency response

- Flexible and light weight
- Simple installation

The Electro-Optical (E/O) Conversion Process

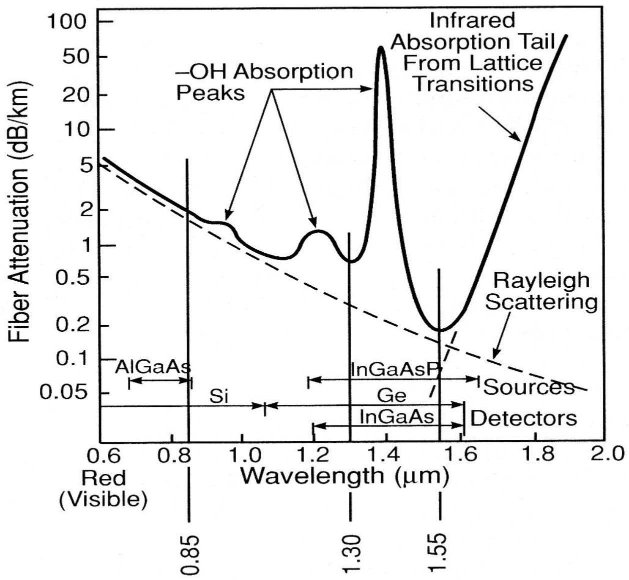
Optical Transmitter: At the heart of the module that converts RF signals to light is a laser diode. The basic principle is direct modulation of the incoming RF signal onto the output of the laser diode. An example of the intensity output from a typical laser diode is shown in Figure 1. The RF input signal directly modulates the laser diode bias current about the optimal DC working point, sometimes referred to as the quiescent point, which is typically 40mA. Modulation gains range from 0.02 to 0.2mW/mA and a monitor photodiode maintains the stability of the fixed operating point of the laser. For high performance (low noise and high dynamic range) Distributed Feedback (DFB) semiconductor lasers are used, although for less demanding lower cost applications Fabry-Perot (FP) lasers can be utilised.

Figure 1
Laser diode analogue response



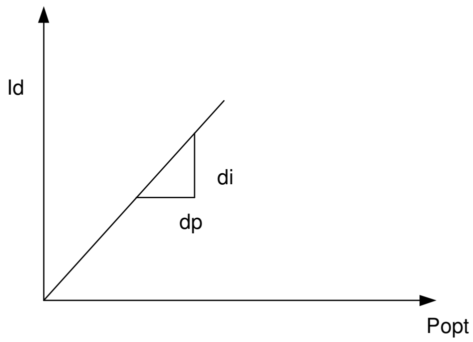
Optical Fibre: The optical fibre is the transport medium for the signal and therefore an important part of the systems required for maintaining high signal integrity. Light emitted from the transmitter is coupled into a single mode optical fibre for cross-site transmission to the receiver location. Corning SMF28 single mode fibre is typically installed to transmit RF traffic at either 1310nm or 1550nm laser wavelengths, where the optical attenuation is 0.4dB/km and 0.25dB/km respectively. Figure 2 shows the optical transmission spectrum for typical signal mode fibre. Optical cable is factory terminated with industry standard FC/APC connectors. An 8° angled facet fibre end-face ensures minimal return loss of 60dB.

Figure 2
Optical Fibre Transmission Spectrum



Optical Receiver: Light emitted from the transmitter emerges from the single mode optical fibre at a receiver location and is coupled into the receiver module using FC/APC connectors. Inside the receiver module a high speed PIN photodiode performs an O/E conversion operation, to deliver an RF electrical signal output. The behaviour of a typical photodiode is represented by the response curve, shown in Figure 3, yielding typically 0.9A/W.

Figure 3
PIN photodiode response

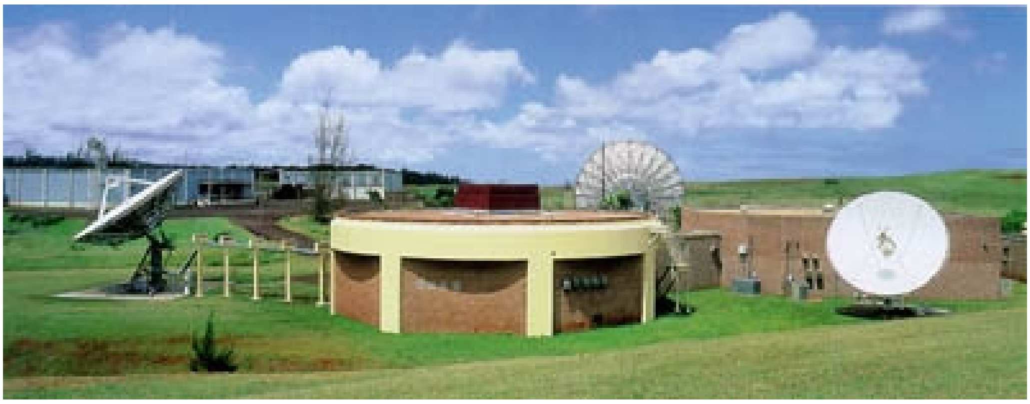


Design Rules
When defining an overall RF power budget consideration must take into account that absolute RF losses (due to optical losses in the fibre and connectors) equates to twice the optical loss in dB.

Evolution of Ground Based SatCom Transmission Systems

In all teleports and satellite ground stations a method of inter-facility linking is needed to transport the RF payloads between the field-based antennae and equipment or control rooms. Figure 4 shows a typical ground station site with remote antenna and central control room. Transmission from satellites is received at the antenna in the higher frequency C, Ka and Ku bands. This is then down converted to the commonly used L band frequency range for handling the signals within the ground station. L band is chosen because much of the equipment is more cost effective when designed for this lower frequency. Historically, inter-facility linking has been performed using copper based coaxial cables which remains adequate in some installations where the distance between control and antenna location is short or data rates are low. However, site expansion necessitates the need to deploy longer inter-facility transmission links and deliver increasing bandwidth.

Figure 4
Satellite Ground Station Site (courtesy of BT Goonhilly).



In many locations site expansion has pushed conventional copper coax to its operational limit due to signal attenuation and degradation, which necessities the use of costly amplifiers. The subsequent rise in capital investment to expand sites and the compromised quality of service has created an opportunity for competing platforms

Fibre optic technologies have taken up this opportunity and a range of specifically designed, commercially available products offering cost effective inter-facility linking. Site engineers have been installing optical fibre for some years to fulfil long-term facility capacity requirements. Large scale multi site equipment installs have now reached widespread adoption in many leading satellite operators ground stations such as SES Astra, Intelsat, Arqiva, European Broadcasting Union and BT.

Enabling New Broadcast Systems

Fibre based technologies are being used in an increasing number of broadcast applications. One example is the use in outside broadcast (OB) situations, either live or recorded. The trend in OB locations is for wider coverage areas and an increasingly large number of coverage points to be linked. The industry has standardised on radio cameras for such operations, which allows more extensive coverage, but issues remain regarding the link between the OB control van and the remote receive points for the wireless cameras. These connections, often to multiple locations, have to handle a significant number of HD feeds from the cameras, which are operating in dual or quad diversity modes. These examples are beyond the limit of triax, which traditionally has been used in OB situations. Fibre based connections offer much higher performance signal transmission over tens of kilometres and are lighter and faster to deploy in temporary OB locations.

The benefits of using fibre in OB and other broadcast applications has been made possible by miniaturising the O/E transmitters and receivers discussed in the previous sections. These small form factor modules can be built into wireless camera receivers to convert the raw or down converted broadcast signal onto fibre for relay back to the OB control van. Such diversity based camera receiver units are available from several manufacturers and have been deployed in stadiums, race tracks and even golf courses as they steadily replace conventional triax solutions.

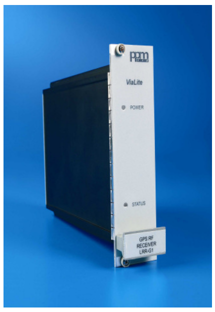
Specialist Fibre Optic Systems

RF design engineers at PPM have worked with major SatCom operators to develop an RF fibre optic transmission platform known as *ViaLite*. The basic *ViaLite* platform comprises an electro-optical (transmitter) converter, inter-facility optical cable, and optical-electrical (receiver) converter. The *ViaLite* platform is protocol transparent and comes in several format options. Modules can be housed in 19" 1U and 3U chassis hardware, or in standalone form factor, all shown in Figure 5 below. The fibre links are designed to operate over specific bandwidth regions such as L band or the DVB region. The total spectrum covered by the *ViaLite* range is 1MHz to 4.2MHz.

Figure 5
ViaLite Modules in (a) 19" 3U Rack Format, (b) 19" 1U Rack Format and (c) Standalone Format

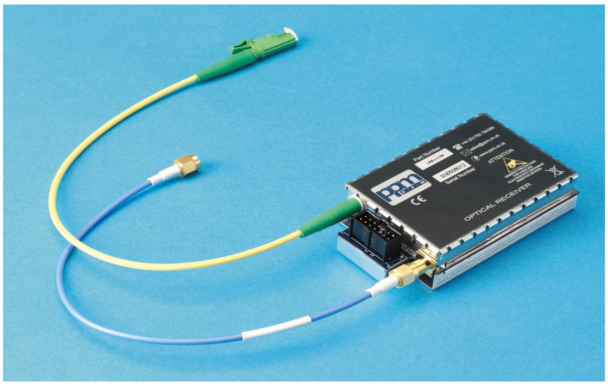
(a)


(b)


(c)


A small form factor variant is also available for the *ViaLite* products and will be of particular interest to the systems integrator or original equipment manufacturer in the Broadcast industry. An example of this module is shown in Figure 6 below.

Figure 6
Small Form Factor *ViaLite* Module



Conclusion

An explanation of the core concept of RF signal modulation within a fibre and how fibre systems function has been presented. Fibre optic technologies offer significant advantages over traditional copper based connections and this paper has introduced some of the satellite communication and broadcast applications that can take advantage of the benefits offered by fibre optic systems.