Visual detection of Infra-Red for troubleshooting Fiber Optic devices

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Summary

Fiber Optic Communication happens in the Infra-Red zone of the spectrum which makes its detection impossible with just the naked eye.

To detect these Infra-Red signals while troubleshooting Fiber Optic devices, an inherent flaw in the characteristic of CMOS Image sensors in the digital cameras of mobile phones was used to isolate and repair the defect in the motherboard of a Truck Interface Module of Scorpion Data Acquisition System.

Multiple other problems related to Fiber Optic devices were resolved as well using the cost effective technique.

Introduction

Onshore Seismic Data Acquisition in ONGC has come a long way since the days of acquisition with just 24 channels in the late 1950s to 15000 channels in the present day. To cope up with this huge amount of data, data transmission technology has adopted Fiber Optic transmission instead of older copper cables for cross line transmission as the former offers multitude of benefits over the latter.

But a few times new technologies bring new set of problems. Fiber optic communication usually occurs in the infra-red region of the spectrum around the wavelengths of 850nm, 1300nm and 1550 nm. The visual spectrum, i.e. the light that we can see, falls between the wavelengths of around 400nm to 700nm.

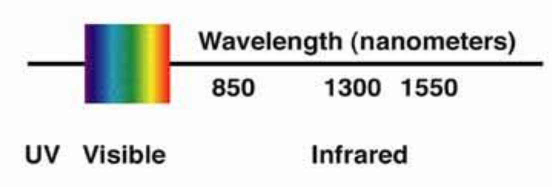

Figure 1: Wavelengths used for Fiber Optics compared to Visual Spectrum. (Courtesy – www.thefoa.org)

These particular wavelengths are used because they provide the least amount of attenuation, which is a must for long distance communication.

This limitation creates a particular problem in troubleshooting fiber optic devices used in the modern day seismic data acquisition systems as it doesn’t provide any visual indication in case of malfunction.

This paper goes on to show how the properties of CMOS Image sensors of smart phones or any digital camera can be used to visually detect the Infra-red signals.

Theory

To understand how a CMOS Image sensor detects Infra-red radiations, we will first have to understand that how these image sensors work.

The main sensor of any digital camera contains tiny photosites for each pixel which records the intensity of light following on it. Each photosite is a photo-sensitive transducer which converts the light into electrical signal in proportion to the intensity of light falling on it. To generate a colored image different photosites with filters of wavelengths specific to Red, Green and Blue are arranged in Bayer Pattern.

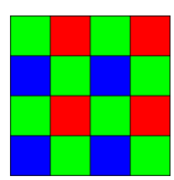

Figure 2 Bayer Pattern (Courtesy – www.wikimedia.org)

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The arrangement is made in such a way that it mimics human eye and also facilitates even and uniform distribution of light. As with the human eye, 50% weightage is given to green color and 25% to each red and blue.

These photosites use band-pass filters attuned to specific wavelengths to differentiate between these colors. Generally the following wavelengths are used to segregate between different colors:

Color	Wavelength
Red	700 nm
Green	546 nm
Blue	435 nm

Ideally the filters are expected to let through just the above mentioned wavelengths, but practically it allows through a few signals of wavelengths beyond 700nm as well because implementing a perfect filter is practically impossible.

The actual spectral response of a digital camera sensor can be seen in the following picture.

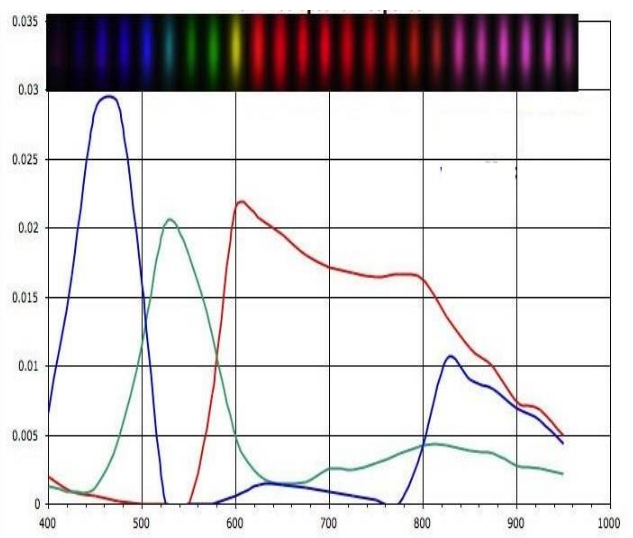

Figure 3 Spectral Response of a digital Image Sensor (Courtesy – www.maxmax.com)

As can be seen from the Figure 3, the photosites, although slightly attenuated, do allow the wavelengths beyond 700 nm to pass through.

Figure 4 Infra-red signal seen through a mobile phone camera

In Fig.4 the 850 nm range infra-red signal can be seen as violet color, on the right side of the picture, as compared to black, on the left side, when no signal is present. It can also be confirmed with the spectral response curve in the Figure 3. As the colors blue and red are more dominant at the wavelength of 850 nm, it results in the output of the combination of two, i.e. magenta.

It should be noted that it can differ from camera to camera depending on the type of filter used for the photosites of the Image sensors. Some cameras may also use IR cut-off filter which eliminates any signal with wavelength over 700nm. So, not all digital cameras may be used to detect IR as visible light.

Example

Scorpion System, a seismic data acquisition system manufactured by INOVA Geophysical, and in use at various work centers at Oil and Natural Gas Corporation Ltd., has the real time capacity of 30000 active channels. This huge channel capacity warrants the use of Fiber Optic to transmit the data across different receiver lines and ultimately to the acquisition unit. The backbone of this system is the field Fiber Optic Cables and the Truck Interface Module (TIM). Together they are responsible for the transmission and electrical to optical conversion of the data and vice versa.

In fact the bandwidth requirement is so huge that to acquire real time seismic data, multiple interface has to be used as one Fiber optic interface port can only support up to around 6000 channels at the data rate of 2ms. For this particular reason, Truck Interface

Module (TIM) is equipped with 4 interface ports. Truck Interface Module acts as an interface between ground electronics and Central Recording System of Scorpion Data Acquisition System. The data from the ground units is transmitted through fiber optic cables to one of the ports in the TIM.

Figure 5 Front (Left) and Top (Right) View of TIM

Each port of the TIM has two optical/electrical transceivers. These transceivers are responsible for both, optical to electrical and electrical to optical conversions. After conversion the data is sent to the Acquisition System.

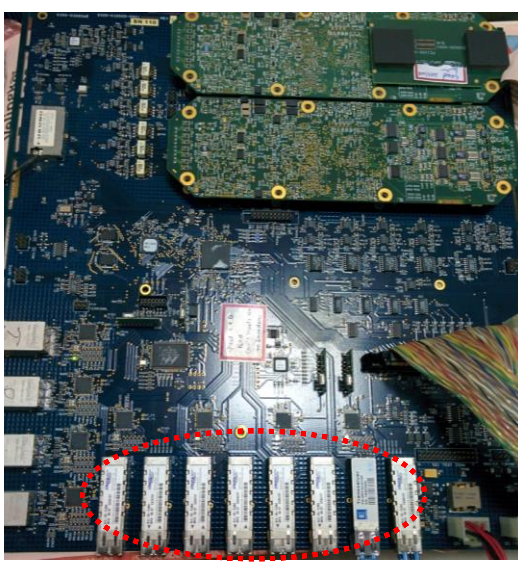

Figure 6 Electrical/Optical Transceivers

A failure in any of the ports results in instant reduction in number of usable channels by 6000. One port each in two of the Truck Interface Module were found to be not working resulting in an overall reduction of capacity by 12000 channels.

By the above mentioned method, a problem in one of the transceivers, working in the 1300 nm range, was identified.

Figure 7 Faulty Transceiver

The problem in both the TIMs got resolved upon replacing the transceivers with new ones.

Result

In the above example, Regional Electronics Laboratory, Geophysical Services, ONGC Vadodara, was able to repair the complex motherboard of the TIM to full functionality and revive the lost capacity of 12000 channels by using the above mentioned method.

Conclusions

The example mentioned in the paper displays the applicability of the use of digital camera Image sensors of mobile phones in the troubleshooting of fiber optic devices in modern day geophysical data acquisition systems.

The same principle can be applied in other fields as well which are dealing with Fiber Optic devices working in the infra-red range to obtain a cost effective solution while troubleshooting them.

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