LIVE LINE INSTALLATION OF AERIAL FIBER OPTICS – A RETROFIT SOLUTION FOR ELECTRICAL HIGH VOLTAGE TRANSMISSION CORRIDORS

Protection, control and automation of operations in a real time environment - now becoming a critical requirement for power systems

Various communications medium were deployed in the past for SCADA systems and distribution automation like Power Line Carrier (PLC), copper cable, microwaves etc.

Advantages of Optical Fibers:
1) High bandwidth,
2) Immunity to EMI and lightning strikes,
3) Freedom from earth potential differential between different sites.

Fiber Optic system affords limitless potential to T&D utilities to provide:
1) Interactive communication to customers.
2) Improved, more reliable and faster communication with higher bandwidth afforded by fiber optics allow new functions to improve system restoration by immediate detection of outages, fault location and system isolation.

With proper engineering purely optical integrated network can be installed where optical communication backbone is integrated with optical sensing and monitoring of parameters like voltage & current in real time

SUPREME IN COLLABORATION WITH GROUP COMPANIES
WEB SPIDERS AND NETWINGS INFOTECH OFFER COMPLETE END-TO-END SOLUTION
OPTICAL FIBERS

- An optical fiber is a glass or plastic fiber that carries light along its length without much attenuation or loss.

- The glass used to make Optical Fibers is pure.

- The repeater distances on long haul routes for optical fibers varies from 50 to 150 km.
Why Optical Fibers?

In today’s world where the spectrum of signals being communicated (viz. voice data, graphics, video, images etc.) is increasing continuously as also the fact that communication need is getting more & more real-time, bandwidth of the communication medium is becoming more and more critical.

Earlier copper wires were used for telephonic and telegraphic communication. But soon demand increased, beyond the capacity and capability of copper wires as the data transport got added to voice communication. Then came coaxial copper cables, VHF and UHF Radios, Satellite but demand still outstripped the supply.

Then optical Fibers enables large amount of communication bandwidth economically and easily available to everyone.

For example 50,000 voice / data circuit copper cable is massive in size and very expensive, while a single Optical Fiber, the diameter of human hair, can carry 5,00,000 circuits of voice and data. This capacity is increasing day by day as supporting electronics is developing. In itself the capacity of Optical Fibers is limitless.
IMPORTANT CONSIDERATIONS FOR RETROFITTING OF OPGW & ADSS ON POWER LINE

- Where durability is very important consideration, OPGW is the most common type of overhead fiber optic cable as it has the longest life expectancy of any fibre optic type cable.

- The proportion of aluminum alloy and aluminium clad wires are designed to achieve required tensile strength and sag characteristics as well as conduction of fault currents and lightning currents without damage.

- ADSS is more commonly used to retrofit communication capability to a line where de-energisation of power line is not feasible.

- However, ease of live line installation of ADSS is to be balanced by two important considerations as –
  - Possibility of ADSS cable sheath damage due to exposure to electric field
  - Lower life expectancy of ADSS vis-a-vis OPGW

- Maximum voltage for optical wires in phase conductors should be limited to 132 kV. In this type of cable, a critical design aspect is transition from line voltage to ground these cables are susceptible to failure due to uncontrolled electrical field gradient and dry band arcing resulting from build-up of particulate pollution.

- Fiber optic cable sag should co-ordinated with the phase conductor sag to prevent mid span flash-over.

- Maximum rated design tension should ensure that zero strain limit of optical fibres in not exceeded.

- Suitable vibration damping to damp aeolin vibrations and to reduce galloping motion so that motions are kept within acceptable limits.
IMPORTANT CONSIDERATIONS FOR RETROFITTING OF OPGW & ADSS ON POWER LINE

• Optical fibers are vulnerable to attenuation due to mechanical strain and moisture. Design of the cable has to factor in the required safeguards to avoid mechanical strain and moisture.

• Environmental consideration like corrosion sensitivity of a location; wind and ice loads on cable are factors to be considered in design.

• Factors that may influence the interaction of the hardware with cable interface are as follows:
  • Excessive contact pressure by clamping hardware may cause the maximum acceptable crushing limits of the cable to be exceeded.
  • Contact between dissimilar materials may cause excessive corrosion in some environments. It is therefore recommended that hardware and other accessories connected electrically and mechanically to the cable are compatible for the cable being used.
  • Corona from the tips of armor rods can erode that sheath of ADSS. If the ends of the armor rods are not aligned so that they all terminate at the same location along the cable length, then the sheath can be burnt by corona at protruding armor rod tips.
IMPORTANT CONSIDERATIONS FOR RETROFITTING OF OPGW & ADSS ON POWER LINE

- Wind loading on long spans may cause tension augmentation in OPGW and ADSS beyond acceptable limits. It is advisable to have special cable for long span application to ensure that cable is able withstand higher tensile stresses as also ensure zero optical fiber strain.

- While retrofitting OPGW, to ensure electrical and mechanical matching of ground wire and OPGW should have similar diameters and aluminum to steel ratios.

- Pole strength should be checked while retrofitting ADSS to ensure that poles have adequate strength to meet additional loads.
Fiber optic cable functions as a "light guide," guiding the light introduced at one end of the cable through to the other end. The light source can either be a light-emitting diode (LED) or a laser. The light source is pulsed on and off at the transmitting (TX) end, and a light-sensitive receiver (Rx) on the other end of the cable converts the pulses back into the digital ones and zeros of the original signal.
ADVANTAGES OF OPTICAL FIBERS

- Very High Data Transmission Capability.
- Low Attenuation (Levels<0.2 Db/Km)
- Small In Diameter And Light Weight
- Low Cost As Compared To Copper
- Greater Safety And Immunity From Emi & Rfi, Moisture & Corrosion
- Flexible And Easy To Install In Tight Conduits & Ducts
- ZERO RESALE VALUE (So Theft Is Less)
- It Is Dielectric In Nature So Can Be Laid In Electrically Sensitive Surroundings
- Difficult To Tap Fibers, So Secure
- No Cross Talk And Disturbances
LIMITATION IN USING OF OPTICAL FIBERS...

- Fiber optic cable connectors and the equipment needed to install and test them are still more expensive than their copper counterparts.
- Optical Fiber require a careful handling.
- Communication is not totally in optical domain, so electrical to light energy conversion and vice versa device is needed.
- Tapping is not easy. Specialized equipment is needed to tap a fiber.
- Optical fiber splicing is a specialized technique and needs expertly trained manpower.
Characteristics of Optical Fiber

- Thin Diameter
- Light Weight
- Easy Bending
- Noise Immunity
- Low Loss
- Wide Bandwidth

Advantage of Optical Fiber

- Space Use
- Easy Multi-Fiber Cabling
- Easy Installation
- Interference
- Long Repeatless Range
- Large Capacity Transmission Line
APPLICATIONS OF OPTICAL FIBERS...

- LONG DISTANCE COMMUNICATION BACKBONE
- INTER-EXCHANGE JUNCTIONS
- VIDEO TRANSMISSION
- BROADBAND SERVICES
- COMPUTER DATA COMMUNICATION (LAN, WAN, MAN etc.)
- HIGH EMI AREAS
- MILITARY APPLICATION
- NON-COMMUNICATION APPLICATIONS (sensors, fiber lasers etc.)
- PROTECTION OF PHASE CONDUCTORS FROM LIGHTNING STRIKES AND TO LIMIT FAULT CURRENT
- COMMUNICATION MEDIUM FOR SCADA NETWORKS
## COMPARISON WITH OTHER MEDIA / TECHNOLOGIES

<table>
<thead>
<tr>
<th>Sl.No.</th>
<th>Particular</th>
<th>Coaxial</th>
<th>Microwave</th>
<th>Satellite</th>
<th>Optical Fiber</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Engg. system required</td>
<td>Simple</td>
<td>Detail</td>
<td>Detail</td>
<td>Simple</td>
</tr>
<tr>
<td>2</td>
<td>Reliability of data Network</td>
<td>Highly reliable</td>
<td>Frequent maintenance requirement</td>
<td>Stringent maintenance for reliability</td>
<td>Most reliable</td>
</tr>
<tr>
<td>3</td>
<td>Capacity</td>
<td>Upto 10,800 channels (60MHz) per pair of cable core</td>
<td>Maximum of 1800 channels in analogue version and 1920 channels digital version per RF channel possible</td>
<td>1332 Channels/transponder</td>
<td>On the pair system of 1 GB/s system feasible now (About 20,000 channel)</td>
</tr>
<tr>
<td>4</td>
<td>Noise performance</td>
<td>Upto less than 1 PW/ km</td>
<td>Noise/ km is higher</td>
<td>Same as for M/W</td>
<td>BER* (Bit error ratio) is very satisfactory (upto 10)</td>
</tr>
<tr>
<td>5</td>
<td>Links for wayside stations</td>
<td>Very easily possible to drop/ insert channels on main system or use interstice system</td>
<td>Limited use to drop/ insert sub-base band facilities</td>
<td>Wide coverage</td>
<td>one pair can be marked for this purpose</td>
</tr>
<tr>
<td>6</td>
<td>Cost</td>
<td>Very Costly</td>
<td>Cheaper</td>
<td>Costlier than CXL system</td>
<td>Cheapest for higher no of channels</td>
</tr>
<tr>
<td>7</td>
<td>Time for completion</td>
<td>More time consuming specially in difficult terrain</td>
<td>Lesser</td>
<td>Least</td>
<td>Easier than that of coaxial cables</td>
</tr>
<tr>
<td>8</td>
<td>Effect of Electro magnetic and electrostatic induction</td>
<td>Maximum protection arrangement have to be made</td>
<td>Not required</td>
<td>Not required</td>
<td>Not required</td>
</tr>
<tr>
<td>9</td>
<td>Repeater Spacing for wide band system</td>
<td>4km for L/T 2km for S/T</td>
<td>About 40 Kms</td>
<td>1/3rd Globe 40-45 kms</td>
<td></td>
</tr>
</tbody>
</table>

*BER (Bit Error Ratio) : It is the ratio of the number of bits, elements, characters or blocks incorrectly received to the total no of bits, elements, characters or blocks sent during the specified time internal.*
VARIOUS TYPES OF OPTICAL FIBER CABLES

- OPGW Cable
- ADSS type Optical Fiber Cable
- Self-Support AERIAL Cable
- OFPC : OPTICAL FIBRE PHASE CABLE
- LASHED type Optical Fiber Cable
- UNDERGROUND / BURIED type of Cables
- DUCT Type Optical Fiber Cable
Type of Aerial Fiber Optics

- OPGW, Optical ground wire
- Wrap – on phase or ground wire
- Lash – on phase or ground wire
- MASS, Metallic self supporting
- ADSS, All dielectric self supporting
- OPPC, Optical Phase conductor
OPGW

WHAT?
Optical fiber ground wire

WHERE?
1. On transmission lines at the top of the towers
2. On new transmission lines or existing lines

FUNCTIONS :-
OPGW can perform both the function of ground wire and telecommunication.

PROPERTIES :-
1. It can be designed to achieve the desired tensile strength and sag characteristics.
2. It can also be used for conducting fault currents and lightning currents without damage.
Optical fiber parameter and performance
# Specimen specification of OPGW & OPUG

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mode field diameter:</td>
<td>8 to 9.5 μm at 1310 nm</td>
</tr>
<tr>
<td></td>
<td>9 to 11.5 μm at 1550 nm</td>
</tr>
<tr>
<td>Sheath (cladding) diameter:</td>
<td>125 μm, ±2</td>
</tr>
<tr>
<td>Concentricity error:</td>
<td>Less than 0.7 μm</td>
</tr>
<tr>
<td>Mode field non-circularity:</td>
<td>Less than 6%</td>
</tr>
<tr>
<td>Cladding non-circularity:</td>
<td>Less than 2%</td>
</tr>
<tr>
<td>Cut-off wavelength:</td>
<td>1250 nm, following ITU-T G.652</td>
</tr>
<tr>
<td>Attenuation coefficient</td>
<td>&lt;0.35 dB/km at 1310 nm</td>
</tr>
<tr>
<td></td>
<td>&lt;0.25 dB/km at 1550 nm</td>
</tr>
<tr>
<td>Parameter of dispersion:</td>
<td>&lt;3.5 ps/nm x km at 1310 nm</td>
</tr>
<tr>
<td></td>
<td>&lt;18 ps/nm x km at 1550 nm</td>
</tr>
<tr>
<td>Layer-stranded:</td>
<td>..........</td>
</tr>
<tr>
<td>Rated temperature:</td>
<td>-20°C to 80°C</td>
</tr>
<tr>
<td>PE sheath, color:</td>
<td>Black</td>
</tr>
</tbody>
</table>
## Marking of cores and fibers

<table>
<thead>
<tr>
<th>Marking Type</th>
<th>Marking Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fiber marking</td>
<td>Red, green, blue, yellow, white, gray, brown, violet</td>
</tr>
<tr>
<td>Core marking</td>
<td>Pilot wire red, others are yellow</td>
</tr>
<tr>
<td>Dummy elements</td>
<td>Natural</td>
</tr>
</tbody>
</table>
Fiber coating

- The optical fiber are coated with tight outer UV-hardened acrylate (type of polymer) protective coating; diameter 250µm ± 15µm.
- Coatings are mechanically easily removable over a length up to 50 mm for the purpose of cleaning.
- To reduce losses optical fibers are not to generate H₂ gas.
- All coatings/colors are compatible with fusion splicers utilizing the light inject detect (LID).

**Tubing/Buffering**

Acrylate: an acrylate is a type of polymer which could be refined as plastics generally, they are used for their transparency and resistance to breakage and elasticity.
Color coding of optical fibers

- Each fiber color coded in order to identify as specify in IEC 60304.
- Color coding are not degrade the optical cladding/core either mechanically or optically.
- It also helps to identify all optical fibers within each coded loose tube.
- The colors are permanent.
Aerial Fiber Optic Cables: Accessories required for different cable type & application

<table>
<thead>
<tr>
<th>Application</th>
<th>Cable Type</th>
<th>Products</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transmission line</td>
<td>OPGW</td>
<td>Helical dead ends and suspension sets, vibration damper, OPGW Downlead clamps for towers.</td>
</tr>
<tr>
<td>Transmission line</td>
<td>ADSS cables (dielectric)</td>
<td>Helical dead ends and suspension sets, vibration damper, Downlead clamps for towers.</td>
</tr>
<tr>
<td>Distribution line</td>
<td>ADSS cables (dielectric)</td>
<td>Wedge dead ends and articulated suspensions. Helical Deadends and suspension.</td>
</tr>
</tbody>
</table>
OPGW INSTALLATION
Overhead OPGW installation
DIFFERENT OPGW CONSTRUCTIONS

- Al-Clad stainless steel tube
- Stainless steel Tube
- Aluminum tube

Ground Wire

Optical Fibre & Gel
FRP
Loose Tube
Thermal Barrier
Al-tube
As Wire (23% IACS)

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Mechanical Suspensions - Single & Double
Sheath Stripper:

The Fiber Optic Sheath Stripper is designed to longitudinally score the tight structure fiber units within certain OPGW designs. A simple pull of the Sheath Stripper along the fiber unit ensures correct score depth allowing for easy removal of the overall unit sheath and access to the enclosed fibers.
Splice Enclosure

1. OPGW splice enclosure installs quickly and easily, without tapes or adhesives.
2. It provides protection for spliced fibers.
OPGW

Long spans

Dead End Arrangement

Suspension Arrangement

Vibration Dampen Arrangement

OPGW

Down Load Clamp OPGW
**DEAD-ENDING OF OPGW**

<table>
<thead>
<tr>
<th>With Multi Bolts Clamp</th>
<th><img src="helical-wire-arrangement.jpg" alt="Image" /></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Helical Wire Arrangement</strong></td>
<td>Helical wire arrangement shown below is the preferred option and recommended to customers by Supreme. This arrangement results in low unit compression stresses as total compression stress are distributed over long length. This system is ideal to prevent damage to sensitive fibers. In case of bolted type clamps, fiber may get damaged by concentrated clamping stresses.</td>
</tr>
<tr>
<td>With Helical Wires</td>
<td><img src="helical-wires-clamp.jpg" alt="Image" /></td>
</tr>
</tbody>
</table>
# DEAD-ENDING OF OPGW

<table>
<thead>
<tr>
<th>Dead-end Technology</th>
<th>Drawbacks</th>
<th>Advantages</th>
</tr>
</thead>
</table>
| ![Dead-end Technology](image1.png) | • Strain on the external layer wire  
• High production investment  
• Specific tooling required  
(dynamometric spanner)  
• Visual control is not possible after installation | • Can be dismantled  
• Easy and quick installation |
| ![Dead-end Technology](image2.png) | • Cannot be dismantled  
• Long installation time  
• Critical installation method  
• Specific tooling required (group-jack)  
• Highly qualified staff | • Guaranteed mechanical withstand |
| ![Dead-end Technology](image3.png) | • Limited mechanical withstand  
• High production investment | • Can be dismantled  
• Easy and quick installation |
| ![Dead-end Technology](image4.png) | • Can be dismantled  
• Easy and quick installation  
• Possible visual control of installation  
• Savings on cables and jointing boxes  
• Long experience on this technology  
• Process and testing technology  
• No special training tools required  
• This option is being offered by Supreme at present |