

Hybrid composite cable for power transmission, critical signaling & telecom applications

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Abstract

Need of telecommunication industries of power transmission along with data transmission is increasing, which felt the need to explore the innovative product category called Hybrid Cable. Hybrid aerial, underground cable is very innovative and versatile cabling solution with in built power transmission required for network equipments with OFC cables. Hybrid Composite Cable is need of a day, firstly to support for power transmission for always ON (Interrupt free) telecom needs.



Keywords

Quad cable, optical fiber, signaling, conductor, power transmission

1. Introduction

Hybrid aerial, underground cable is very innovative and versatile cabling solution with in built power transmission required for network equipments with OFC cables. Hybrid Composite Cable is need of a day, firstly to support for power transmission for always ON (Interrupt free) telecom needs. The telecom network elements & terminations are powered with help of this copper pair. Secondly, the copper pair also used for critical signaling needs for railway signaling & fiber optic element for telecom application. In this paper we described the hybrid cable of Quad & OFC for railway signaling and communication. Conventionally railway use quad cables for communication as well as signaling. Due to change in technology & increase in applications of communications for data transmission optical fiber cables have now become backbone of communication. Customer / Passenger expectations are increased for communications during traveling. On other hand railways are forced to provide services with lower investments. Railways have no choice to select only one communication media due to application & limitations of each media. New hybrid cable design is made such that it reduces cost of installation & total cost of two separable cables. The copper conductors & types of fiber cable reinforcement & protection are provided based on requirement of the field.

In this paper we describe the hybrid cable of Quad & OFC for railway signaling and communication. This cable is also helpful to power the remote equipments from the station generator. We conducted optical & electrical tests to validate the performance of cable. Test results & applications are summarized in this paper.

Quad cables are having metallic conductor copper as guided media for signaling blocks between two stations. Metallic media can be used for signaling or power up equipments in the network. Railway signaling block is active element it requires power as well as operation signal. Replacing quad with OFC is more expensive to maintain separate power supply at each block/signal or emergency telephone on other hand to meet communication bandwidth requirement. Quad cable is not sufficient. It is mandatory to maintain two separate cables in railway signaling & communication. Installing these two separate cables is more expensive than cost of cables.

2. Cable Construction

The cable includes an optical fiber enclosed within loose tubes & quad of copper conductor. Optical fibers in the loose tube can be either ribbonized or loose. Four conductors of copper are bundled to form a quad. Quad & loose tubes are S-Z stranded over the central strength member for easy access of any sub group either optical fiber or quad.

Polyethylene inner sheath is extruded over this core. Quad cables application is along railway track, which includes voltage on the cable. This effect is minimized by screening. Aluminium wires are helically wrapped over inner sheath for minimizing screening effect. Inner sheath of polyethylene is extruded over aluminium wires. Above this inner sheath longitudinal steel tape is applied for rodent protection, which helps in direct burial application.

RipCORDs are applied under sheath steel tape & sheath for easy removal of outer layers jointing of cables. Outer HDPE rugged sheath extruded over steel tape for weather resistance of cable & cable covering. Construction diagram is as shown in figure 1.

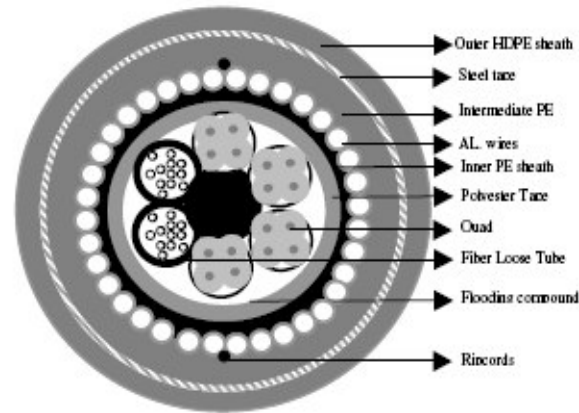


Figure 1. Cross section view of composite cable

3. Applications of Hybrid Cable

Uninterrupted communication & online status of railways becomes need of passenger throughout the journey. This can be achieved by mobile towers throughout railway route connected by OFC. One tower can cover range of approx. 4 Km. One signaling block & emergency telephone is located at approx. 2 Km. Hybrid quad cable serves purpose of both signaling & communication.

Quads are used to connect emergency phones in line. Optical fiber connects mobile tower to nearest exchange. Hybrid cable helps in railway safety. Locking of signal or miss signaling happens due to damage of quad which is difficult to detect on line. Such damage to hybrid cable can be easily communicated to nearest station due to fiber break signal at equipment. Use of hybrid cable along railway track is shown in the figure 2.

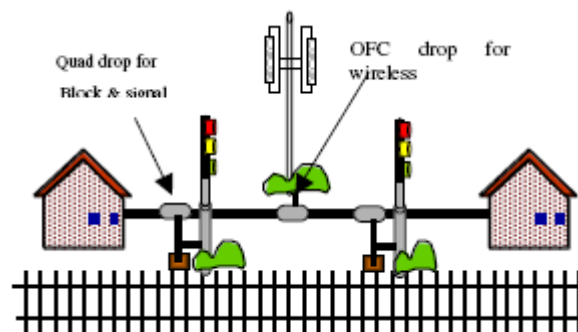


Figure 2. Use of Hybrid cable for communication, signaling and powering up equipments

3.1 Cable Economy

Hybrid cable is combination of two separate cables OFC & Quad. When both cables combined together cable diameter slightly increases but overall cost drastically decreases. Comparison for 10 Km railway track with separate OFC & Quad cable Vs Hybrid cable is shown in Table 1.

Table 1. % Cost comparison for 10 Km project

Description	Quad	OFC	Hybrid
Standard Length	0.5 Km	3 Km	2 Km
Number of joints required	20	03	11
Trenching & installation	10 Km	10 Km	10 Km
Gain using quad cable			
	OFC & Quad separate	Hybrid	Gain
Trenching & installation	20	10	50%
Jointing	23	11	6%
Cable cost	20 Km	10 Km	20%

Overall project cost is reduced by average 30 to 35%.

4. Cable Performance

Hybrid cable contains both metallic & non-metallic transmission media. Testing cables for both media as per their individual standards evaluate cable performance.

4.1 Optical Fiber Performance

Optical performance of the cable is evaluated by considering optical fibers as separate cables as separate cable independent of quad. Tested whole cable as per IEC standards for optical fiber cable.

4.1.1 Tensile Test

Cable is tested for fiber strain Vs. Load. Change in attenuation with respect to initial attenuation measured after completion of test. After test, cable is inspected physically. No damage is observed to the cable. Fiber strain Vs Load graph is shown in Figure 3 & test result summary in Table 2.

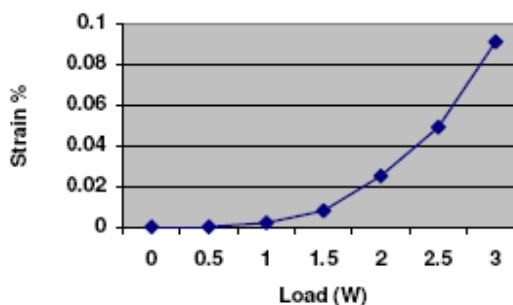


Figure 3. Strain % Vs Load W (W = weight of cable / Km)

Table 2. Summary report for Tensile Test

	1310 nm	1550 nm	Fiber Strain
Change	0.005 dB/Km	0.008 dB/Km	0.091%

4.1.2 Mechanical Tests

Cable is tested as per IEC standards for mechanical tests. Test results are summarized in the Table 3.

Table 3. Summary of Mechanical Test Report

Test	Specification	Test result
Compression test	IEC-60794-1-E3	Change in attenuation 0.007 dB/Km
Cable bend test	IEC-60794-1-E11	Change in attenuation 0.008 dB/Km
Impact test	IEC-60794-1-E4	Change in attenuation 0.005 dB/Km
Torsion test	IEC-60794-1-E7	Change in attenuation 0.01 dB/Km
Repeated bending	IEC-60794-1-E6	Change in attenuation 0.009 dB/Km

No physical damage was observed on the cable after completion of test.

4.1.3 Environmental Test

Cable is conditioned in walk-in type chamber for different temperatures. Temperature cycle is as shown in the Figure 4.

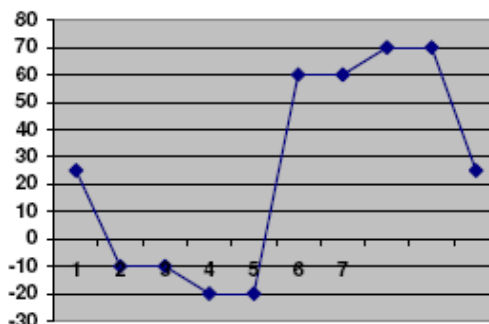


Figure 4. Temperature cycle set for environmental test performance

Attenuation readings are taken after condition of cable for 12 hours at each temperature. Change in loss is calculated with respect to the initial attenuation is as shown in Figure 5.

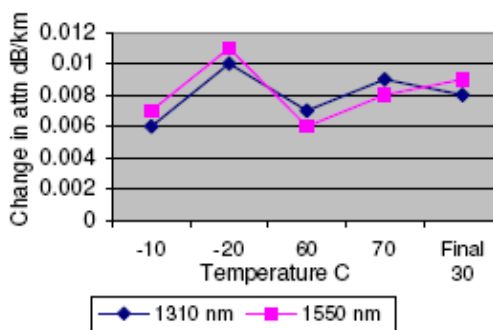


Figure 5. Change in attenuation during temperature cycle

4.2 Electrical Performance

For signaling electrical parameters are important in the hybrid cable. Quads are tested for electrical tests. Test results are summarized in the Table 4.

Table 4. Electrical characteristic test result

Electrical test	Specification	Results
High Voltage test	2 KV RMS AC Duration: 10 seconds	All conductors pass at 2 KV (rms) voltage
Insulation resistance	500 V DC Duration 1 minute Resistance > 5000 MΩ / Km	Insulation resistance measured value 11000 MΩ / Km
Conductor resistance test	Each Core: < 28 MΩ / Km Loop: < 56 Ω / Km	Measured value maximum 26.79 Ω / Km for core & 53.5 Ω / Km for loop
Mutual capacitance	For pair: Nominal 0.05 μF/ Km	Measured values Max: 51.38 nF Min: 48.75 nF Avg: 50.09 nF
Capacitance unbalance	Between Pairs In same Quad - 300 pF Adjacent Quad - 300 pF Any pair & earth - 1500 pF	Measured value Between Pairs In same Quad - 148 pF Adjacent Quad - 37 pF Any pair & earth - 1276 pF
Characteristic impedance	For 0.8 kHz Freq. 470 ± 15 % Ω For 5.0 kHz 195 ± 15 % Ω	Measured values 425 Ω @ 0.8 kHz 187 Ω @ 5.0 kHz
Far End Cross Talk	Measured at 150 kHz RMS value > 67.8 dB/Km Individual > 55.0 dB/Km	Measured Minimum individual value 58.70 dB/Km & RMS value is 68.9 dB/Km
Near End cross talk	Between Adjacent pairs > 55 dB	Measured minimum individual value 58.10 dB

Attenuation test	Measured at 150 KHz Max. 4.4 dB/Km	Measured maximum attenuation is 4.32 dB/Km
Reduction factor	For 50-450 V/Km Maximum 0.10	Measured value 0.08

Hybrid cable passes all electrical parameters. Required for signaling purpose.

5. Cable Accessories for Jointing

Hybrid cable is made up of both Quad & OFC cable. Joint closure is developed for jointing of both type of transmission media. Joint closure is waterproof & easy to handle. There is ample place for storage of loose tubes. There is add on facility for small transformers & other small accessories.

Joint closure contains IDE module for connecting Quad cables & splice trays for holding optical fibers as shown in Figure 6.

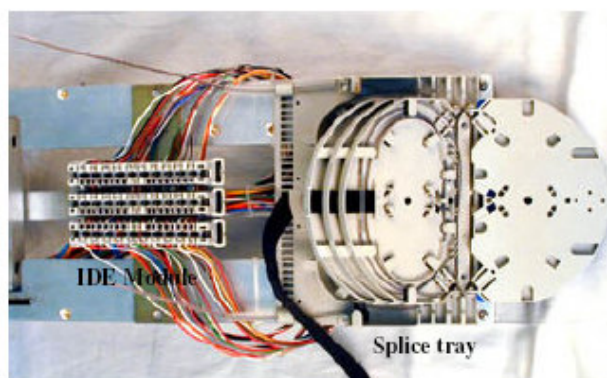


Figure 6. View of joint closure showing facility for connecting Quad & Optical fiber

During connectivity quad cables are required to drop at every 500 meter. As in such cases cutting fiber is not economic solution as well as link losses are going to increase. In this closure oval port is provided for mid span accessing of cable span. In mid span access loose tubes without cutting can be taken in the closure. Inside closure loose tube storage facility is available behind IDE module & splice trays.

Only required conductors can be cut & fix in IDE module where balance conductors having enough storage space in the closure.

Storage of loose tube & quad conductors are fixed in the back side of closure is shown in the Figure 7.

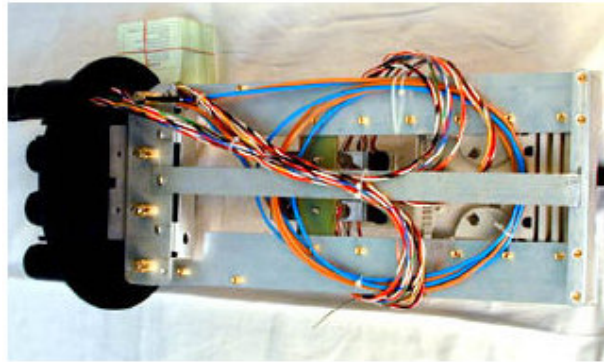


Figure 7. Storage of loose tubes & quad in the joint closure

Heat shrink sleeves are used to close the cable entry ports of the closure. This makes it air & watertight. Dome is closed by the hoop, which is easy for opening & closing closure repeatedly.

6. Conclusion

We developed hybrid cable for signaling, power transmission & telecommunication. As a part of accessory of the cable we developed joint closure having facility to terminate & join both transmission media. This cable is extensively tested as per standards. Cable meets all relevant standards. This cable is economical as it reduces cost of installation by 30 %. Hybrid cable is new generation cable in the field of communication.

7. Acknowledgements

The authors gratefully acknowledge the support by Mr. Anil Lagad for developing accessories & evaluating performance of this cable.

8. References

[1] Indian railway standard for Quad cable IRS: TC 30-05 Version 1

Fiber Optic Cable

Whitepaper



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