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C37.94 - Installation & Maintenance

1. INTRODUCTION

Power utility companies have to protect high voltage lines monitoring them constantly. This supervision requires the transmission of information between the power substations in order to ensure correct operation while controlling every single alarm and failure. Legacy telecom networks where interconnected with metallic wires, the problem is that this environment is characterized by a high level of electromagnetic fields that may disturb BNC and any copper wires.

To avoid this perturbations it is recommended the use of optical links at the physical layer -instead of the traditional metallic cables- to solve the above mentioned issues following the IEEE C37.94 standard that defines the rules to interconnect tele-protection and multiplexer devices of different manufacturers using optical fiber.

Figure 1 *Protection of high voltage power lines is a fundamental task of power utility companies to deliver a secure and uninterrupted supply of electricity.*

2. PROTECTION OF HIGH VOLTAGE POWER LINES

Authorities use a tele-protection scheme to enable substations to communicate with one another to selectively isolate faults on high voltage lines, transformers, reactors and other important elements of the electrical plants. This functionality requires the continuos exchange of critical data in order to assure correct operation. In order to warranty the operation the telecom network should always be in perfect conditions in terms of availability, performance, quality and delays.

Initially these networks were electrical, then the 56–64 kbps channels became vulnerable to electromagnetic and radio interferences (EMI/RFI), signal ground loops, and ground potential rise because were based on metallic conductive media. Obviously this is not good for the reliability of the protections protocols. The substation environment is usually characterized by a high level of electromagnetic fields caused by high voltages and currents in power lines.

Moreover, during fault conditions electromagnetic perturbations may rise significantly and disturb those communications channels based on copper wires. The reliability of the communications link interconnecting the protection relays is critical and must be resilient to the effects encountered in high voltage areas such as high frequency induction and ground potential rise.

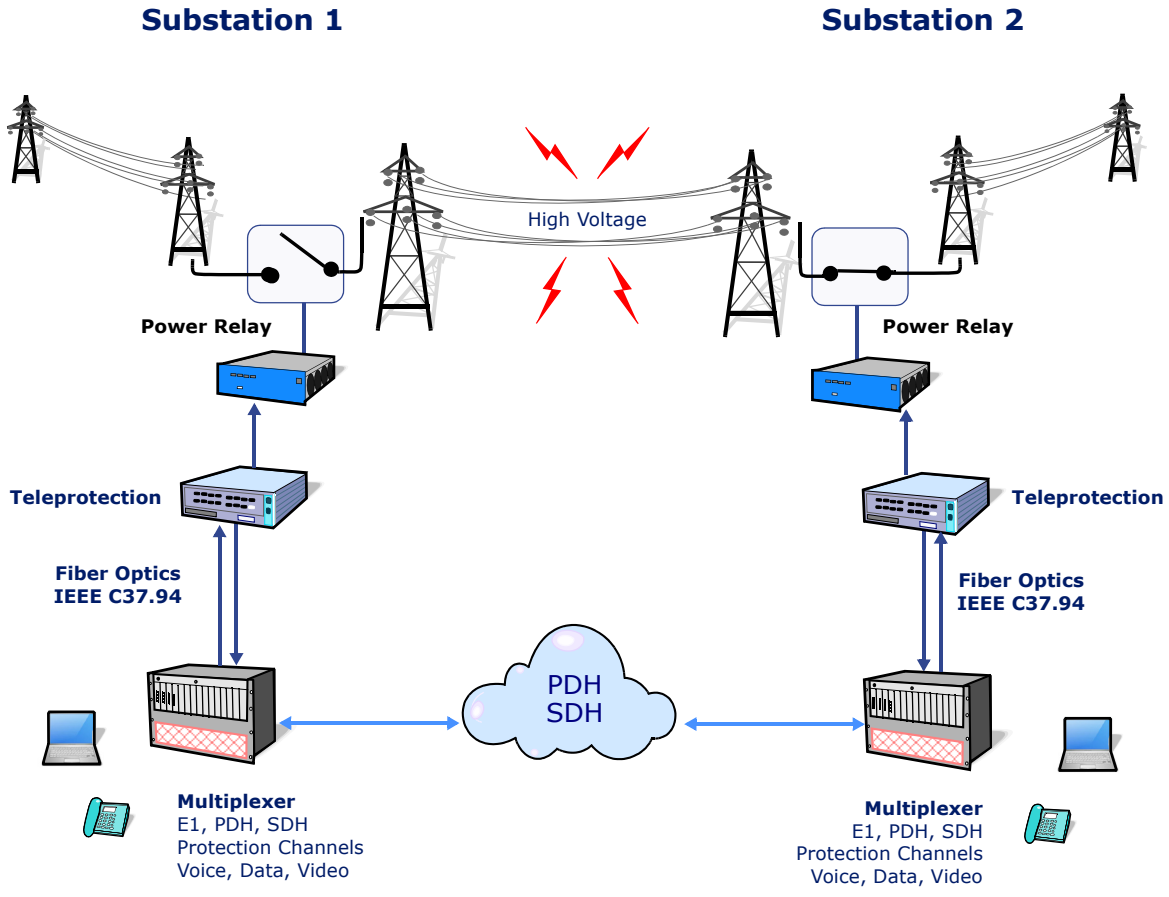

Figure 2 *Teleprotection architecture using C37.94 in normal operation.*

This is the reason why the industry moved to optical fibers to connect the different items of the installed in the substations. Fiber optics do not need ground and are immune to the interferences caused by electrical noise therefore eliminates a lot of the errors that electrical connections do suffer. In other words, it is convenient the use of fully optical links from power relays to Multiplexers as the IEEE C37.94 standard defines.

The protection scheme is able to be upgraded to a more sophisticated architecture using fault tolerant networks. Then instead of using direct relay connection and dedicated fibres redundant network are able to make the protection procedures process more reliable increasing the availability critical data interchanges.

3. THE IEEE C37.94 STANDARD

Teleprotection systems must isolate faults very quickly to preventing damage to the network and power outages. Then the IEEE committee defined the C37.94 as a programmable n x 64 kbps (n=1...12) multimode optical fibre interface to provide transparent communications between teleprotection relays and multiplexers for distances of up to 2 km. Later on the industry adopted monomode optical fibre too in order to reach longer distances.

The standard defines the protection and communications equipment inside a substation using optical fibers, the method for clock recovery, the jitter tolerances allowed in the signals, the physical connection method, and the actions the protection equipment must follow when any kind of network anomalies and faults occur. C37.94 has already implemented by many protection relay manufacturers including ABB, SEL, RFL, RAD and others. Teleprotection equipment use to offer a choice of transmission interfaces including the IEEE C37.94 compliant optical fiber interface for transmission over fiber pairs, and G.703, 64Kbps co-directional and E1 interfaces.

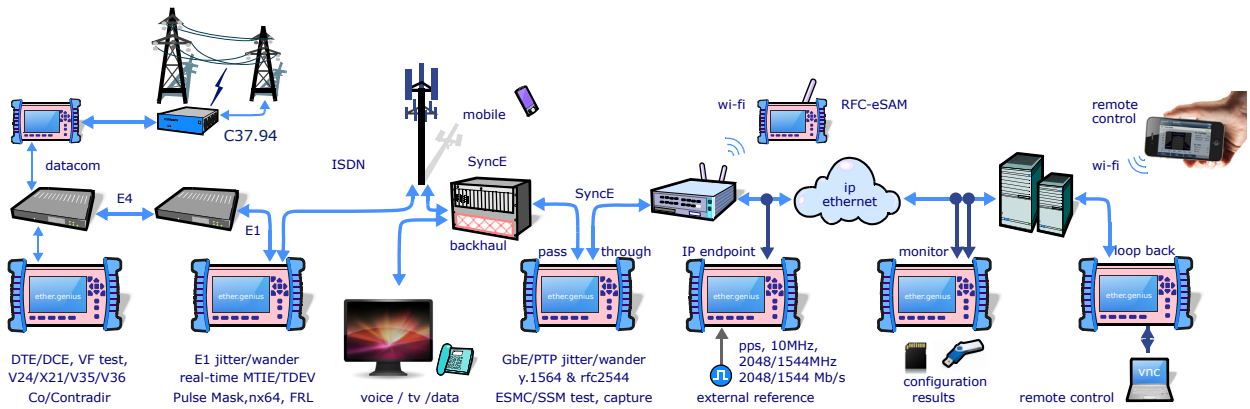

Figure 3 ***Ether.Genius*** *is a multi technology tester equipped with all the features to install and troubleshoot C37.94 teleprotection systems and Gigabit Ethernet, SyncE, PTP, E1 and Datacom services.*

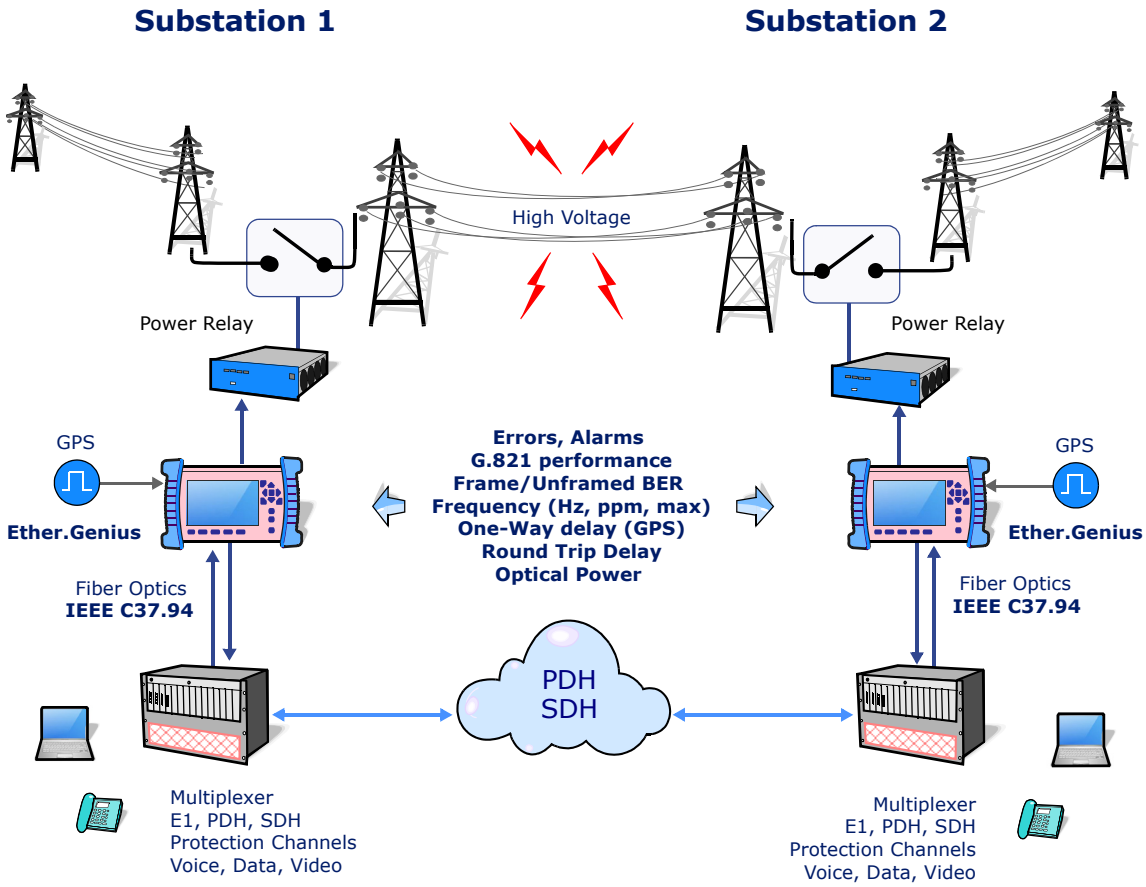

Figure 4 *Teleprotection system installation and maintenance with ALBEDO Ether.Genius.*

4. ALBEDO ETHER.GENIUS AND C37.94

Ether.Genius provides a fully integrated test set to verify protection systems using C37.94 interfaces to be connected to the unit. This is a real handheld multi technology tester that can operate up to 24h hours on batteries and can also verify networks ans services based on Gigabit Ethernet (GbE), Synchronous Ethernet (SyncE), E1, Datacom, Precision Time Protocol (PTP, IEEE 1588v2), Jitter/Wander, One-way-delay using GPS, Round trip delay and Optical Power measurements.

Field engineers can use Ether.Genius to turn up a new C37.94 deployments, or to troubleshoot teleprotection relays and multiplexer by means features such as bit error rate testing (BERT), events monitoring, one-way-delay measurements using GPS, round trip delays and optical power measurement to facilitate engineers to install and maintain any protection system to automatically and to prevent outages in a power substations.

Ethernet Testing	
Interfaces	• Dual RJ-45 port for electrical connection 10/100/1000BASE-T; PoE detection and PoE transparency • 2 x SFPs ports: 10BASE-T, 100BASE-TX, 100BASE-FX, 1000BASE-T, 1000BASE-SX, 1000BASE-LX, 1000BASE-ZX and 1000BASE-BX • Autonegotiation: Bit rate at 10, 100, and 1000 Mbit/s, Disable autonegotiation and direct set up • EtherType II (DIX v.2), IEEE 802.3, IEEE 802.1Q, IEEE 802.1ad; IEEE 802.2–LLC1, IEEE 802.3–SNAP; IPv4 (RFC791), IPv6 RFC2460)
Generation (8 streams)	• MAC address: Source / Destination, Default / User defined, Single / Range • VLAN: Single VLAN support, Q-in-Q stacking, VID, DEI, S-VLAN, C-VLAN, and Priority codepoint • Type / Length: Generation/Analysis, Jumbo frames with MTU up to 10 kB • Bandwidth Profile: Constant, in bit/s and frames/s, Periodic Burst, in high/low traffic, Ramp, in high/low traffic, Poisson • Loopback: L1to L4 layers, filtering conditions, broadcast and ICMP frames control • Single, burst, rate, random, FCS error insertion in pass-through mode • Unframed Layer 1 (IEEE 802.3-2008 Annex 36A): High, Low, Mixed Frequency Test, Long, Short (NCITS TR-25-1999): RPAT, JJTPAT, SPAT • Framed Layer 2-4 BERT; PRBS: 2e11-1, 2e15-1, 2e20-1, 2e23-1, 2e31-1 and inverted, All 1, all 0, ud. (32 bits), SLA Payload Y.1731 • RTD and VF tone generation
Filters for Statistics (up to 8 simultaneously)	• Ethernet Selection: MAC address, Type/Length, C-VID, S-VID, CoS and Priority with selection mask • IPv4 and IPv6 Selection: address, protocol, DSCP, Flow (v6): single value or range. UDP Selection: port: single value or range
Traffic Statistics	• Top 16 talkers: Sour/Dest MAC / IPv4 / IPv6 addresses, VID (VLAN), C-VID (Q_in_Q), S-VID (MPLS) • Ethernet Frame Counts (RFC 2819): VLAN, Q-in-Q, Priority, Control, Pause, BPDUs • Tx/Rx Uni-Multi-Broadcast, Errors, Undersized, Oversized, Fragments, Jabbers, Runts, (Late) Collisions, Sizes, MPLS stack length • Bandwidth Statistics: (in bit/s, frame/s,%) Rate, Max, Min, Aver, Occupancy, Unicast, Multicast, Broadcast • IPv4 & IPv6 counts: (in bit/s, frame/s,%) Unicast, Multicast, Broadcast, Errors, TCP, UDP, ICMP
Results	• Twisted Cable: MDI/MDI-X status, Open, Cable Length Test, Short, Polarities, Pair Skew. PoE: voltage and current • SFP: Presence current interface, Vendor, Part number, Optical power (over compatible SFP) • Frame Delay (FTD) Y.1563: Min/Max/Med/Mean; Delay Variation (FDV) RFC1889: Peak; Jitter Curr/Max/Min/Mean • Frame Loss (FLR) Y.1563, Duplicated: Out-of-Order packets (RFC 5236) • Availability: SES and Y.1563 PEU; BER: Count, seconds with errors, Pattern losses, pattern loss seconds
RFC-2544 & Y.1564	• RFC 2544: Throughput, Latency, Frame Loss, Back-to-back, Recovery • eSAM: test up to 8 non-color or 4 color aware services. Configuration: CIR, EIR, max. throughput for each service • Tests (CIR, EIR and policing) with FTD, FDV, FLR and availability • Performance test with FTD, FDV, FLR and availability results for all services
ICMP	• RFC 792: IP ping / Traceroute, Generation of ICMP echo request: Dest. IP address, Packet length, Generation interval • Analysis of ICMP echo reply: Round trip time, Lost packets, Time-To-Live Exceeded, Port unreachable

SyncE and PTP testing	
Synchronous Ethernet	• Interfaces: 100/1000BASE-T by RJ45; 1000BASE-SX, 1000BASE-LX, 1000BASE-ZX and 1000BASE-BX by SFP both for all operation modes • Clock Ref.: recovered; internal (better than ±2.0 ppm or ±0.2 ppm); external (10 MHz, 2048/1544 Mb/s, 2048/1544 MHz, 1 pps) • Line Analysis: frequency (MHz), offset (ppm), drift (ppm/s) [clause 10]; Offset Generation: ±125 ppm (0.001 ppm) as per ITU-T O.174 • Wander generation [ITU-T O.174 section 8.4] and MTIE / TDEV measurement [ITU-T O.172 clause 10] • SyncE Generation / Decoding ESMC and SSM [ITU-T G.8264]
PTP / IEEE 1588(v2)	• Precision Time Protocol (PTP): Master & Grandmaster id., Priority 1-2, Class, Accuracy, Variance, Time source • PTP over UDP encapsulation, PTP Generation / Analysis / Emulation; hardware-assisted Decoding; End-point and Through modes • Counts: Sync Inter Arrival Delay (IAD) Avg/Curr; Packet Total Delay (PTD): Std Dev/Range; Packet Delay Variation (PDV): Cur/Max/Avg • Frequency offset between the master and the local clock (ppm)

E1 & Datacom testing	
Interfaces	• Port A: Coaxial Pair Impedance: 75 Ohm BNC unbalanced and 120 Ohm RJ-45 balanced • Port B: Symmetrical Pair Impedance 120 Ohm RJ-45 balanced • Coaxial Pair Impedance: 75 Ohm BNC unbalanced. Analogue voice frequency audio port • Additional balanced secondary E1 port 0 to -6dB, nominal and PMP -20dB • Bit Rate: 2048 Kbit/s ± 3ppm. Codes: HDB3 / AMI • Clock Source: Internal Timing: 2.048 MHz ± 25000 ppm; External Timing; Recovery from Rx Timing (Loop Timing)
BERT	• Unframed. PCM31: FAS / FAS+CRC4. PCM30: FAS+CAS / FAS+CRC • Standard, non-standard PRBS, and user patterns. Transmit Error Rate • Force Single Error: Bit, Frame, CRC, and BPV (Bipolar Violation); Alarms, Errors Count; G.826, G.821, and M.2100
Datacom	• Smart Serial 26p DTE / DCE ports. DTE, DCE emulation and monitor • V.11/X.24, V.24/V.28, V.24/V.35, V.24/V.11 (V.36/RS449), EIA530 and EIA-530A. Codirectional according G.703 • Rate: 50, 60 bit/s, 1.2, 2.4, 4.8, 8, 9.6, 16, 19.2, 32, 48, 72, 128, 144, 192, 1544 kbit/ Nx56 kbit/s; Nx64 kbit/s, up to 10 Mbit/s
Jitter & Wander	• Overpass O.172: Jitter level, tolerance, transfer and Event detection. 100% digital based generation and analyzer • Wander Generation and Measurements (TIE, MTIE, TDEV). Wander results from 20 to 100 000s
Pulse Mask	• Meets ITU G.703: PASS / FAIL function with Persistent Graphic Display scope • Nominal 2.37V for Coaxial Pair 75 Ohm, Nominal 3.00V for Symmetrical Pair 120 Ohm
C37.94	• Test Rate: N x 64 kbit/s; Frame/Unframed BER; ITU-T G.821: ES, SES, UAS, DM. Results with pass / fail indications • Frequency (Hz), Deviation (ppm), Max deviation; Round Trip Delay (ms), One-way Delay synchronised with GPS • Defects: LOC, AIS, LOF, RDI, LSS, All 0, All 1; Anomalies: FAS, TSE, Slip • Optical Power Meter

Ergonomics	
Hand-held Instrument	• Display 480 x 272 TFT, Soft LEDS, 223x144x65 mm, IP rating 54; Weight: 1.2 kg USB and Ethernet ports, Serial Port RS-232C • Rechargeable Batteries continuous working up to 10 hours; Operating 0ºC ~ 50º C Storage -20ºC ~ 70ºC; Humidity 5% ~ 95%

ALBEDO Telecom

ALBEDO Telecom designs, manufactures, and delivers solutions that enable Telecom organizations of all sizes to test, measure, troubleshoot, monitor, and migrate mission critical networks and multiplay applications.

On local segments and across distributed networks, ALBEDO enable Organizations, Installers, Operators, Service Providers and Suppliers to quickly check the health of Network Architectures, Service Agreements (SLA), IP Quality (QoS), or fix any issue.

Your Business Partner

Results. ALBEDO Telecom helps the industry to make the most of the investment on infrastructure.

Expertise. ALBEDO Telecom engineers and consultants provide industry leading knowledge in hand-held TAPs and WAN emulators, IPTV, VoIP, Carrier-Ethernet, Synchronization, Jitter, Wander, SyncE, PTP, E1, and Datacom to address customers unique needs.

Integration. ALBEDO Telecom integrates disparate telecom technologies and applications, facilitating new business efficiencies.

Agility. ALBEDO Telecom increases the ability of customers to respond quickly to new market opportunities and requirements.

Coverage. ALBEDO Telecom offers solutions that facilitates the migration and the roll-out to new architectures.

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aims

+ UNDERSTAND causes of telecom interoperability issues
+ EXPERIENCE the best quality in unified networking
+ ASSESS different hardware, firmware, and software solutions
+ LEARN from experts by means of professional services and consultancy