Zeus a network tester for Utilities

the Path to Excellence

Zeus is a tester designed to install and maintain the communications in the power industry. It supports legacy and new generation interfaces in order to verify Ethernet / IP, PTP, SyncE, ToD, IRIG-B, T1 / E1, C37.94, RS-232, G703 and check protocols such as GOOSE, SV or MMS. Therefore you will get a perfect vision and control of your infrastructures improving protection and data acquisition.

Communications needs

Power Utilities usually have three networks (a) the corporate one based on Ethernet / IP; (b) the WAN based on TDM, MPLS, C37.94, T1/E1; and (c) the operational consisting of a combination of IP, RS-232, IRIG-B and the new IEC 61850 protocols.

Step-by-step proprietary architectures are being replaced by standards relaying on optical Ethernet, so there is a clear need for tools that can manage both old and new interfaces. This is Zeus, a tester capable of verifying, activating and troubleshooting all kinds of communications infrastructures including those that were installed in recent decades and the latest that will be installed in the coming years. All together are transforming substations into a more flexible, robust and scalable systems thanks to the integration and interconnectivity of different manufacturers using fibers and unified protocols.

GOOSE, SV, MMS

Zeus has a set of programmable filters to capture live data traffic at wire-speed. You can now analyze GOOSE, SV, MMS and other protocols to decode and save them in PCAP format or calculate propagation delay from local or remote substations.

"View, Verify, Maintain your communication resources"

About Synchronization

Power Utility companies have strict timing requirements that Zeus can test and adjust by means of advanced features that allow to measure and emulate PTP, IRIG-B, 1PPS, ToD, T1/E1. The internal oscillator of the tester can be OCXO or Rubidium depending on the accuracy you need or more particularly if you need to operate in hold-over mode.

Protection

A uninterrupted supply of energy requires protection functions to ensure the reliable operation of the power system. With Zeus you will fully test C37.94 systems measuring frequency, events, one way delay, and all kind of events.

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Zeus at the Substation

Networks deployed by Utilities have special requirements that include synchronization, delay measurements, protocol analysis and event detection in order to assure a quality service without interruptions.

i Test & Monitoring points

1 - GOOSE delay
2 - C37.94
3 - E1/T1
4 - GbE
5 - MMS
6 - GNSS
7 - 1PPS
8 - Eth/IP
9 - MPLS
A - PTP
B - NTP
C - GOOSE
D - PTP wander
E - RS-232
F - SyncE
G - Codir (G703)
H - SV capture
I - GOOSE capture
J - One Way Delay
k - 100BASE-T
L - IRIG-B
M - MbE
N - Round Trip Delay
O - PTP Power / Telecom
Q - GOOSE offset
R - PTP wander
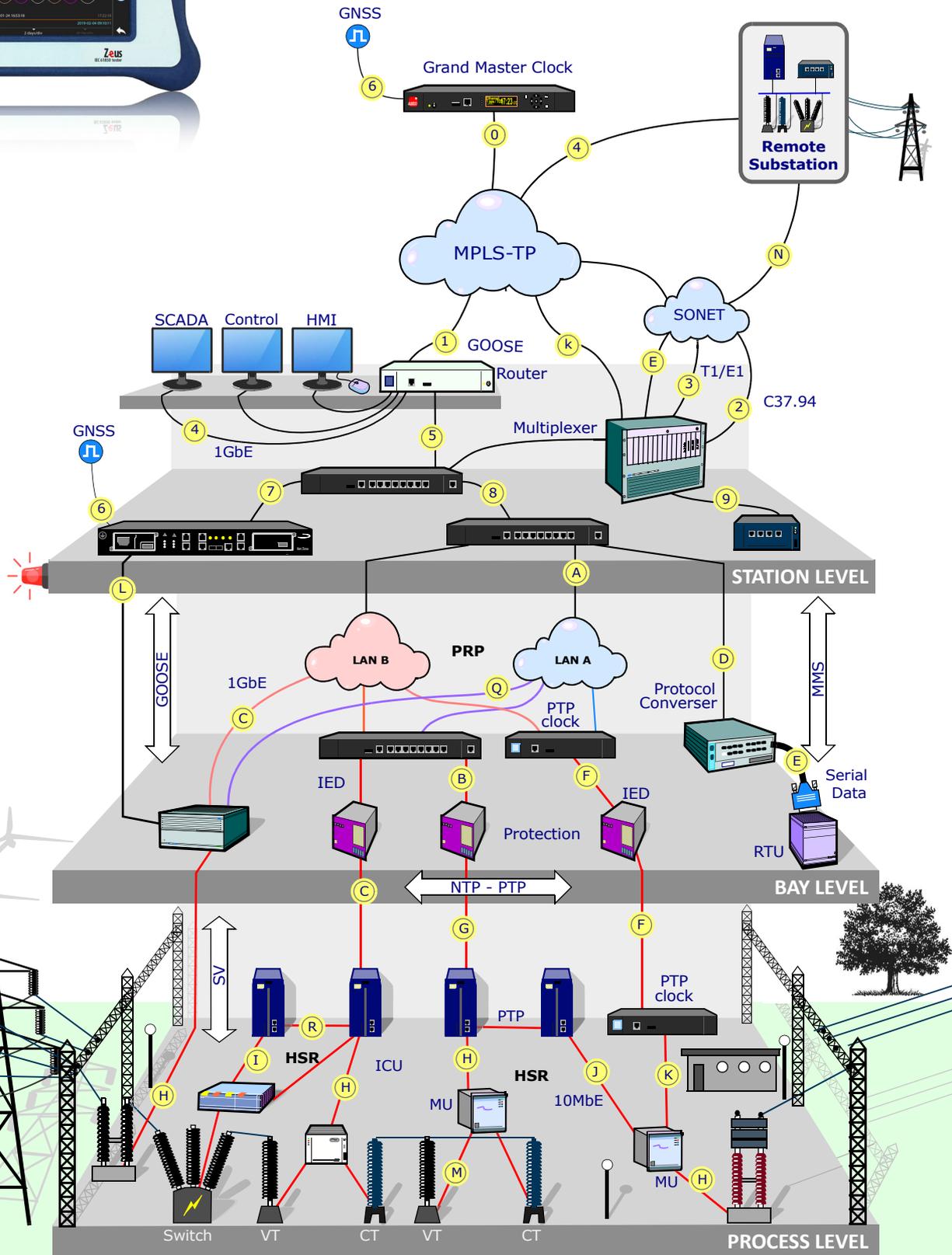
Zeus provides deep insights to design, install, maintain, troubleshoot and commission communications, the foundation of the Smart Grid.

Type	Message	Protocol	Layer	BWidth	Max. Delay	Priority	Bus	Model	Application
1A	Trip	GOOSE	L2 - Multicast	Low	< 3 to 10ms	High	Process	Publisher	Protection
1B	Other	GOOSE	L2 - Multicast	Low	< 20 to 100ms	High	Process	Publisher	Control
2	Medium Speed	MMS	L3 - IP/TCP	Low	< 100 ms	Medium Low	Process & Station	Client/Server	SCADA
3	Low Speed	MMS	L3 - IP/TCP	Low	< 500 ms	Medium Low	Process & Station	Client/Server	SCADA data collection
4	Raw Data	SV	L2 - Multicast	High	< 3 to 10ms	High	Process	Publisher	Analysis, Protection
5	File Transfer	MMS	IP/TCP/FTP	Medium	< 1000 ms	Low	Process & Station	Client/Server	Management, data
6	Timing	PTP	L2 - PTP	Low	Protection < 0,1 to 3ms Transformers ±1 to ±25us	Medium High	Process & Station	Unidirectional	Synchrophasors, IED
7	Command	MMS	L3 - IP	Low	< 500 ms	Medium Low	Station	Client/Server	SCADA, configuration

Table 1. *IEC-61850 protocols to synchronize, measure, exchange data, command and protect the grid that can be verified with Zeus.*

The Smart Grid

The electricity distribution scheme barely changed during the first 100 years. However, with the arrival of new technologies the Smart Grid concept emerged in order to increase the efficiency, robustness and quality of the electricity provision.

Automation

Today power resources are connected telematically from generation plants and substations to the customers. At the beginning it was through SONET links and more recently using Ethernet/IP or MPLS-TP networks in order to satisfy all requirements to provide full control, security and resilience of the utility services.

However, automation goes beyond the traditional SCADA as new technologies aims to add capabilities that will improve the operation control and efficiency and this is the real foundation of the Smart Power Grid.

Synchronization

In substation automation many resources require accurate synchronization ranging from microseconds to milliseconds:

• Applications that use SV / GOOSE and need to minimize latency.
• Data acquisition at IED, RTU and MU.
• SCADA and the MMS protocol.

• Line protection schemes.
• Events recording.
• Synchro-phasors deployed across the WAN to monitor the power grid.

Zeus has a complete set of features for timcommissioning by means of measurements, analysis and protocol emulations of PTP, IRIG-B, GPS, SyncE, T1/E1, 1PPS.

Resilience

A flexible and robust network is core of intelligent substations that are capable of guaranteeing the control and operation of mission-critical applications. Therefore, it is important to have advanced instruments to verify, measure and adjust each protocol according to the strict requirements defined by IEC 61850 regarding interconnectivity, latency, symmetry and redundancy (see Table 1).

An additional challenge is how to design reliable and redundant, while cost effective, networks capable of recovering data flows quickly after a failure to support applications that do not tolerate even a millisec-

ond of network interruption without severely affecting operations that eventually could cause blackouts and even put endangered the safety of company's employees. Consequently, an acceptance procedure is a must to verify the conditions of all mission critical systems and protections deployed across the power grid.
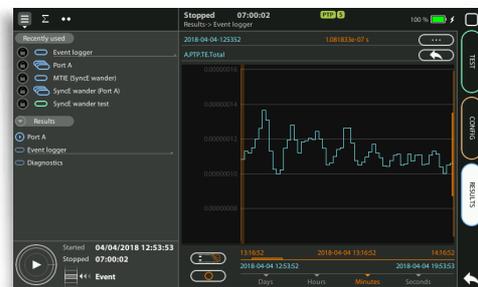
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APPLICATIONS

• Communications design, acceptance and commissioning
• IED acceptance and interconnectivity
• Certify migration to IP
• PTP, IRIG-B synchronization impairments and testing
• Check Teleprotection
• Verify Delay Asymmetry
• Asses Network Security
• Data Interception Analysis

KEY FEATURES

• GOOSE, SV, MMS protocol capture and save in PCAP
• GOOSE and SV time offset and propagation delay
• IRIG-B / ToD / 1PPS support
• Compact and Autonomous
• One-Way-Delay with GPS in all interfaces
• PTP wander analys&genera
• TE calculation
• C37.94 full test & emulation
• T1/E1 comprehensive test
• MPLS/TP support
• Codirectional G703
• Optical / electrical interfaces
• BER, Delay, Defects
• No Delay, Zero Packet Loss

BENEFITS

• Easy IEC-61850 migration
• Predefined substation tests
• Ethernet / IP verification
• Risk-less traffic control
• Field tester with batteries

Ethernet / IP	
Interfaces	• 2xSFP: 1000BASE-SX, 1000BASE-LX, 1000BASE-ZX, 1000BASE-BX, 100BASE-FX, 100BASE-TX • 2xRJ45: 1000BASE-T, 100BASE-T, 10BASE-T, PoE detection/ transparency • Autonegotiation: Bit rate at 10, 100 and 1000 Mbit/s, Disable and direct set up
Generation (8 streams)	• Traffic generation and analysis features up to 1 Gb/s, equivalent to 1.5 millions of frames, if frame size is set to 64 bytes • VLAN: Single VLAN support, Q-in-Q stacking, VID, DEI, S-VLAN, C-VLAN, and Priority codepoint • Bandwidth Profile: Constant, in bit/s and frames/s, Periodic Burst, in high/low traffic, Ramp, in high/low traffic, Random
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) • 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 (per stream & port)	• Twisted Cable: MDI/MDI-X status, Open, Cable Length Test, Short, Polarities, Pair Skew. PoE: voltage and current • Frame Delay (FTD) Y.1563: Min/Max/Med/Mean; Delay Variation (FDV) RFC1889: Frame Loss (FLR) Y.1563, RFC 5236 • Availability: SES and Y.1563 PEU; BER: Count, seconds with errors, Pattern losses, pattern loss seconds
Performance tests	• 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 • RFC 6349: active/passive modes, MTU/MSS/BB configuration, Round-Trip Time, Window Sweep, Transfer Time, TCP efficiency, Buffer delay
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

IEC 61850	
Timing	• Internal Oscillator: Rubidium or OCXO or default (<2.0 ppm) all disciplined to GNSS or alternative time references • Line Analysis: frequency (MHz), offset (ppm), drift (ppm/s) [clause 10]; Offset Generation: ±125 ppm (0.001 ppm) as per ITU-T O.174 • PTP wander analysis/generation [ITU-T O.174 section 8.4] and MTIE / TDEV measurement [ITU-T O.172 clause 10] • SyncE analysis/generation / Decoding ESMC and SSM [ITU-T G.8264]
IRIG-B	• IRIG-B00X, B12X, B13X, B14X, B15X, B22X unbalanced (REF IN/OUT port) • IRIG-B00X, B22X balanced (REF IN/OUT port)
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 • Two-way TE, max.|TE|on PTP. Low/High frequency TE, Constant/Dynamic TE components. Frequency offset master vs. local clock (ppm)
Packet Capture	Capture Filters • IEC 61850: GOOSE, SV, MMS preconfigured filters • Generic by 16-bit masks and user defined offset • Ethernet MAC address, Ethertype, VLAN-VID, VLAN-CoS, S-VLAN / C-VLAN • IPv6 / IPv4 Filters: Address, TCP, UDP, Telnet, FTP, DSCP field, single value and range Storage in PCAP format
GOOSE & SV protocols	• GOOSE & SV analysis as specified in IEC 61850-7-2, 61850-8-1 and 61850-9-2 • Protocol scan with GoCBName, GoID, DatSet (GOOSE) and svID population and selection of the active flow (SV) • GOOSE & SV frame count for the active flow and all flows • SV sample count and sampling rate measurement for the active flow. • GOOSE & SV Latency analysis: current, average, minimum, maximum, range and standard deviation computed over the active flow

T1 / E1 / Datacom / C37.94	
Interfaces	• Port A: Unbalanced (BNC) 75 Ω and balanced (RJ-45) 120 Ω; Balanced (Bantam) 100 Ω and balanced (RJ-48) 100 Ω • Port B: Balanced (RJ-45) 120 Ω Balanced (Bantam) 100 Ω (AT-1544 only) and balanced (RJ-48) 100 Ω • Port C: Unbalanced (BNC) 75 Ω Analogue voice frequency audio port • Additional balanced secondary T1, E1 port 0 to -6dB, nominal and PMP -20dB • 3xSMA+SMB: Clock Source: 1.544MHz, 2.048 MHz ± 25000 ppm; External Timing; Recovery from Rx Timing (Loop Timing)
BERT	• Unframed: 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 2.048 Mbit/s
Jitter & Wander	• Overpass 0.172: 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	• Pulse mask compliance: ANSI T1.102-1999, ITU-T G.703; PASS / FAIL function with Persistent Graphic Display scope
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 synchronized with GPS • Defects: LOC, AIS, LOF, RDI, LSS, All 0, All 1; Anomalies: FAS, TSE, Slip. Optical Power Meter

Ergonomics	
Hand-held Instrument	• Size: 260 x 160 x 63 mm, Weight: <2.0 kg, IP-54, Mouse, USB, Ethernet ports; SNMP / VNC support, Capacitive Touchscreen: 8 inch • Rechargeable Batteries continuous working up to 24 hs; Operating 0°C ~ 50° C Storage -20°C ~ 70°C

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