# Test&Measurement in Power Utilities

*Installation and Maintenances of Digital communications: Ethernet, IP, GOOSE, SV, PTP, NTP, PRP, IRIG-B, Serial, C37.94...*

ALBEDO Telecom

*the Path to Excellence*

# ALBEDO a **Global** manufacurer of **Testers** & **Timing** appliances


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# ABSTRACT



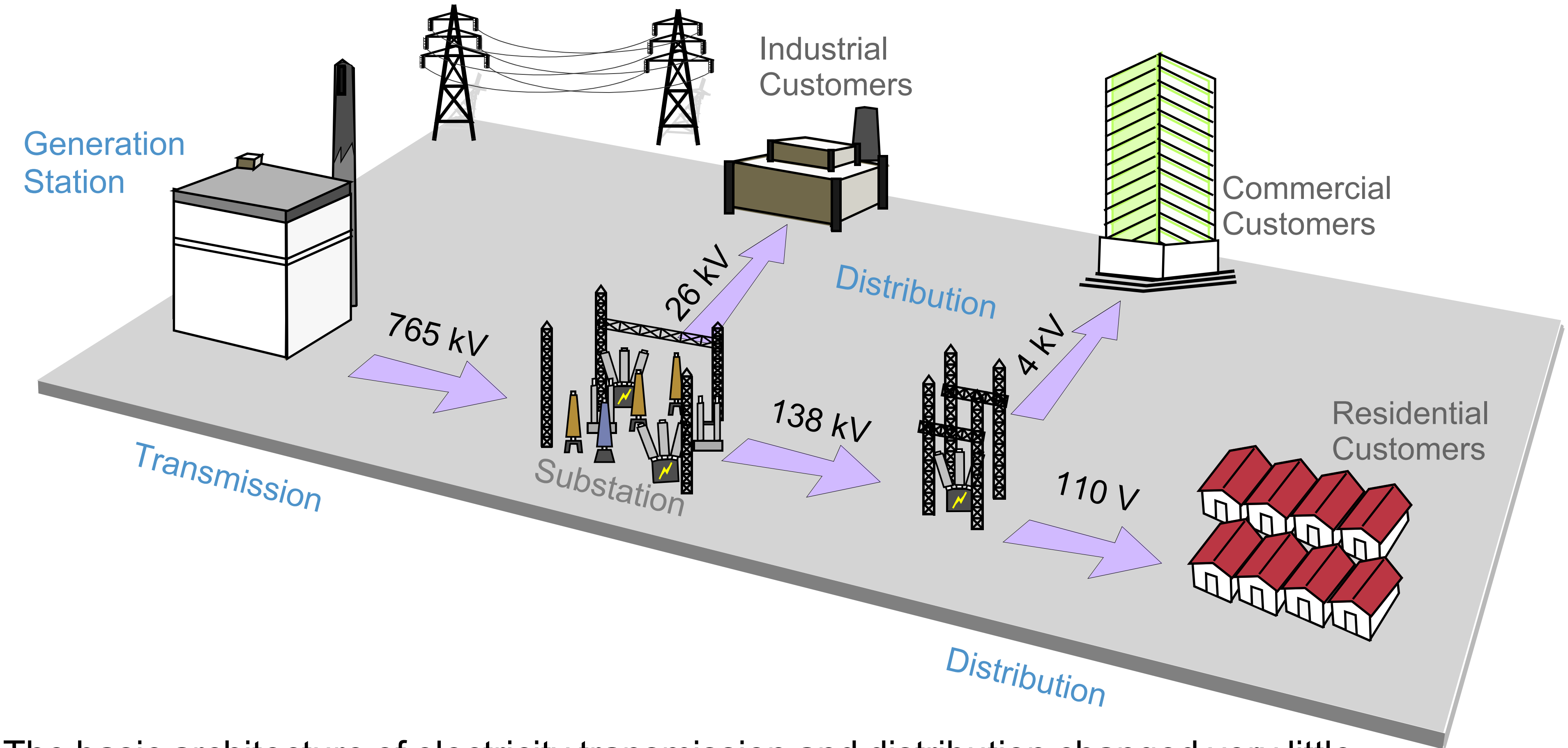
As result of the convergence process in the **Power Grid,** a new standard was released, the **IEC 61850**, that defines a set of Ethernet-based protocols. The objective is to facilitate the interoperability, ease of configuration, long term stability, and reliability to replace wire communications.

This presentation is how to facilitate the interoperability, configuration, long term stability and reliability of the new digital communications including the MPLS backbone and the protocols and interfaces of the substations.

# The **Power** Grid

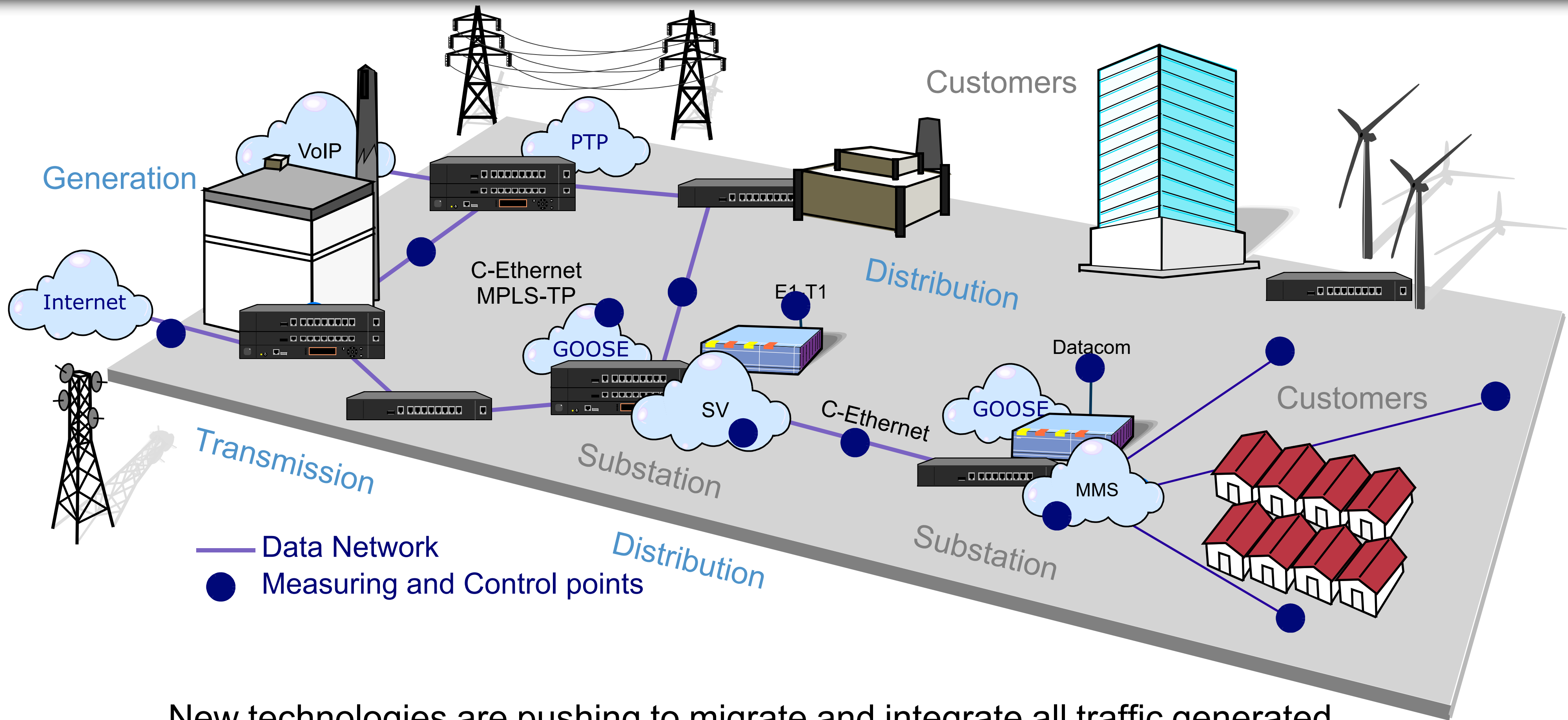







The basic architecture of electricity transmission and distribution changed very little during the first 100 years. However, in recent decades, the concept of **Smart Grid** emerged thanks to the massive use of digital technologies to increase efficiency, resilience and quality of the service.

# The Power Grid **Network**

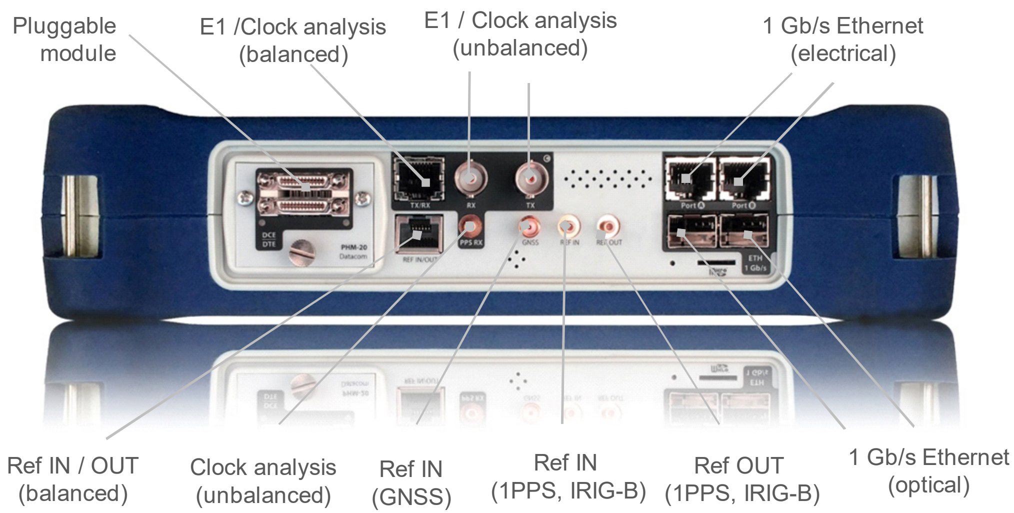



New technologies are pushing to migrate and integrate all traffic generated over Ethernet but assuming the installed base:

- Carrier-Ethernet, MPLS and MPLS-TP at the backbone
- IEC 61850 protocols at the Substations
- Legacy support including T1 / E1, Serial Data, IRIG-B, etc

# xGenius / Zeus handheld Test Platform







- Light, battery powered, “self-contained”
- 8” touch screen, advanced plots
- Built-in Rubidium or OCXO
- PTP, NTP and background traffic emulation
- GOOSE and SV latency analysis
- Integrated GNSS receiver, IRIG-B, 1PPS and frequency clock references
- Time-stamped capture based on GNSS or IRIG-B clock references
- Supports legacy interfaces: G.703 E1, 64 kb/s co-directional, analog (E&M), IEEE C37.94...

# Pluggable Hardware Modules

**Serial Data**


**C37.94**


**G.703**


**VF**


To provide enhanced interfaces to satisfy all the demand

- Customizable and Hot Swapable interfaces:
- Datacom / Serial communications
- IEEE C37.94 dual port
- VF / Analog  Port
- Codirectional and Contradirectional - G703
- Additional E1 / T1 balanced port

# Areas of Application




- **Who**:
  Power Utilities engineers, IED designers, Manufacturers
- **Where**:
  Utilities WAN, Power Substation, optical and electrical buses
- **What**:
  Synchronization, Protocols, Ethernet, Teleprotection,
- **When**:
  Acceptance, Installation, Commissioning and Maintenance

# What is a **Substation**?



Located in between Generation and Consumers Substations manage key functions:

1. **Transforms**: Converting High to Lower Voltages
2. **Distribution**: Splitting power lines for sending the energy to the consumers
3. **Operation**: Configuring and supervising the electric system to the correct values
4. **Protection:** Detecting events and Isolating power elements and lines when faults occur
5. **Interconnection**: Linking circuits of varying voltages and different lines at the same voltage



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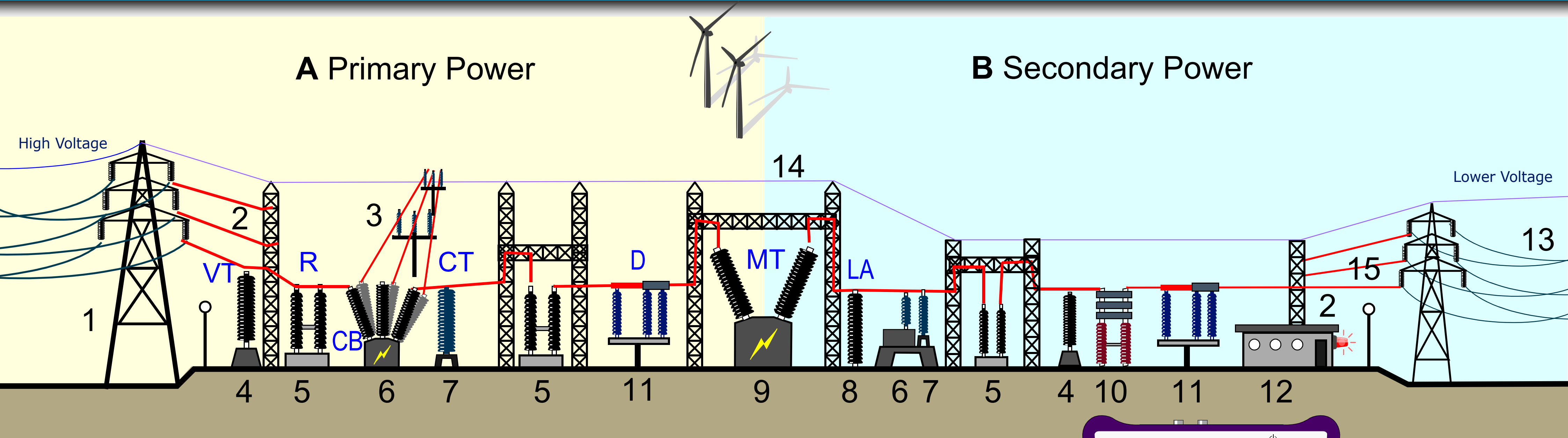
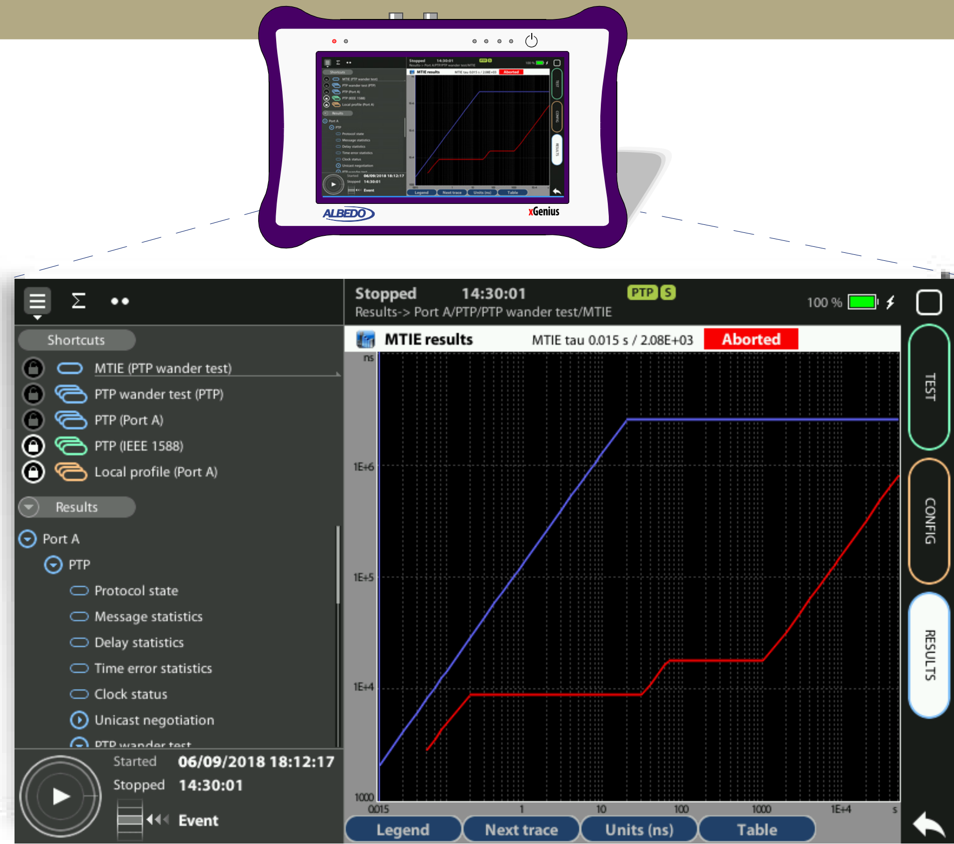
# Components & **Systems** in a Substation




1.Primary Power (PP), 2.Feeder, 3. Busbar, 4.Voltage Transformer (VT), 5.Relay (R), 6.Circuit Breaker (CB), 7.Current Transformer (CT), 8.Lightning Arrester (LA), 9.Main Transformer (MT), 10. Capacitors (C), 11.Disconnector, 12.Control Shelter, 13.Secondary Lines, 14. Ground, 15. Overhead Lines




The **Primary Power** manages the high voltages lines coming from Generation while the secondary the lower voltages distributed to customer.

Zeus is powerful and self-contained tool ideal for engineers to set up, troubleshoot and maintain all Digital Communications deployed in Substations.

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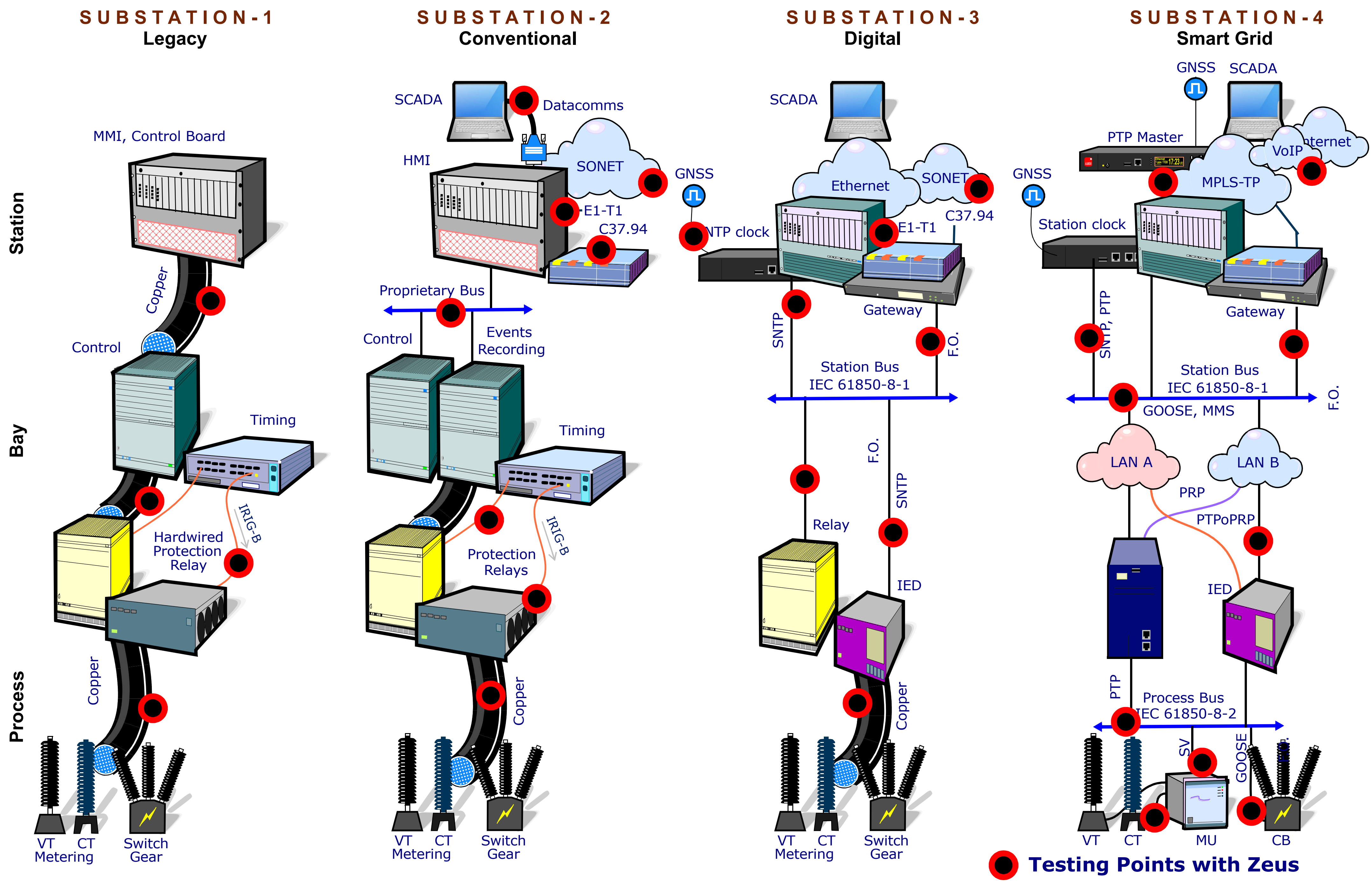
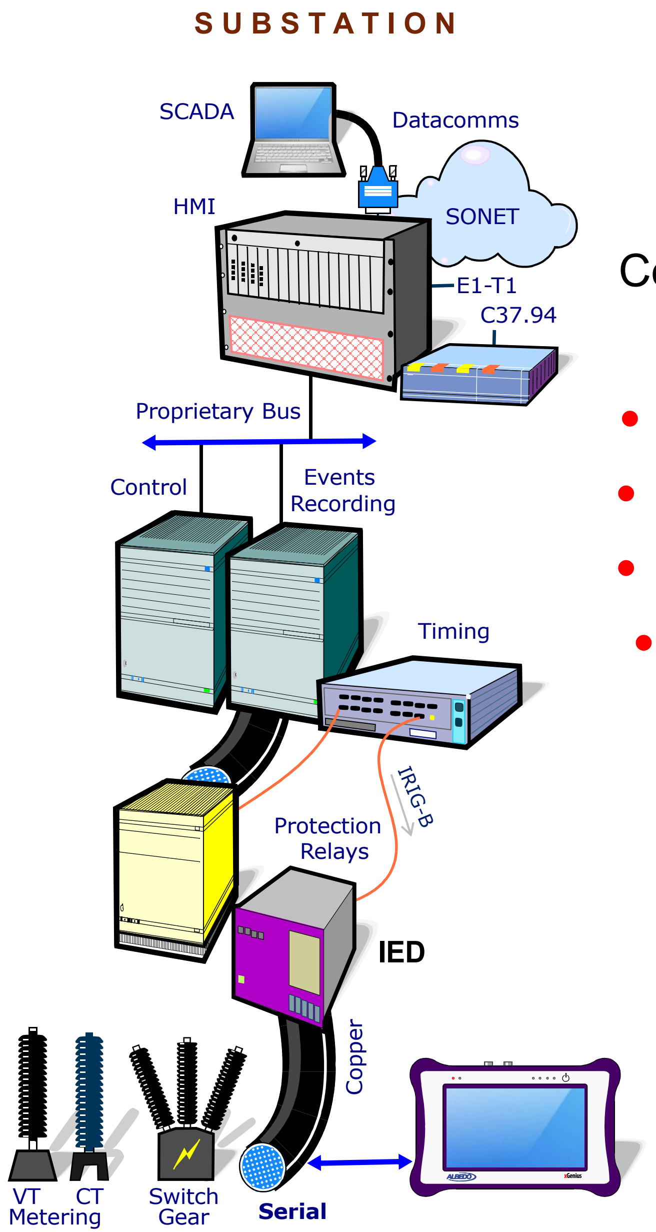
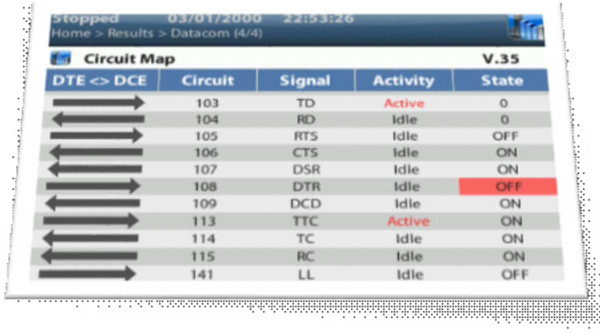
# Type Substation **and testing points**





# Conventional Susbtations: **Serial copper test**



Stopped 03/01/2000 22:53:26
Home > Results > Datacom (4/4)

Circuit Map V.35

| DTE <> DCE | Circuit | Signal | Activity | State |
|---|---|---|---|---|
| → | 103 | TD | Active | 0 |
| ← | 104 | RD | Idle | 0 |
| → | 105 | RTS | Idle | OFF |
| ← | 106 | CTS | Idle | ON |
| ← | 107 | DSR | Idle | ON |
| → | 108 | DTR | Idle | OFF |
| ← | 109 | DCD | Idle | ON |
| → | 113 | TTC | Active | ON |
| ← | 114 | TC | Idle | ON |
| ← | 115 | RC | Idle | ON |
| → | 141 | LL | Idle | OFF |

Convencional communications test:

- Based on Pluggable Hardware Module (
- RS-232, RS-422, V.35, V.36/RS-449, EIA-530/A
- Data, Stop, Parity, inter word gap
- DTE / DCE emulation, Full duplex monitor
- Event Insertion


# **IED** (Intelligent End Device)



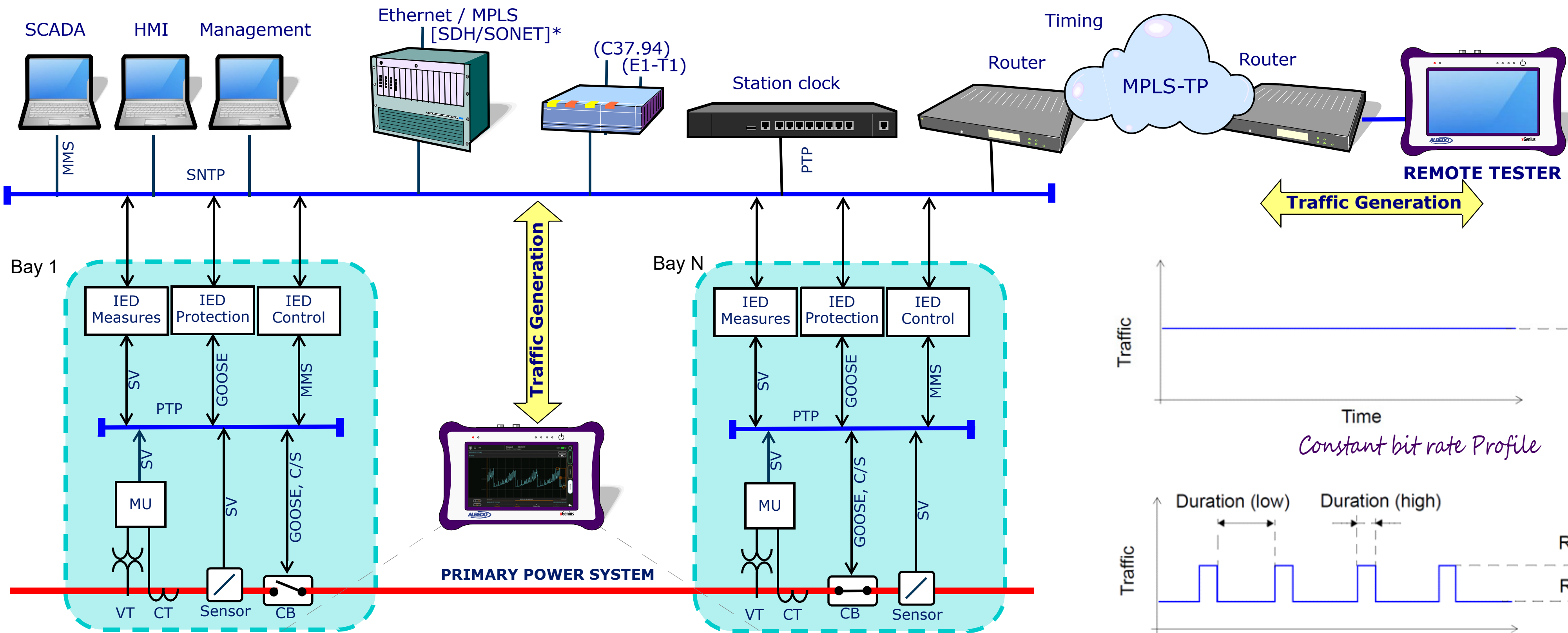

IEDs are a a key element in the substation and the result of the evolution of relays and other devices now equipped with microprocessor and advanced communications. There are several types of IED:

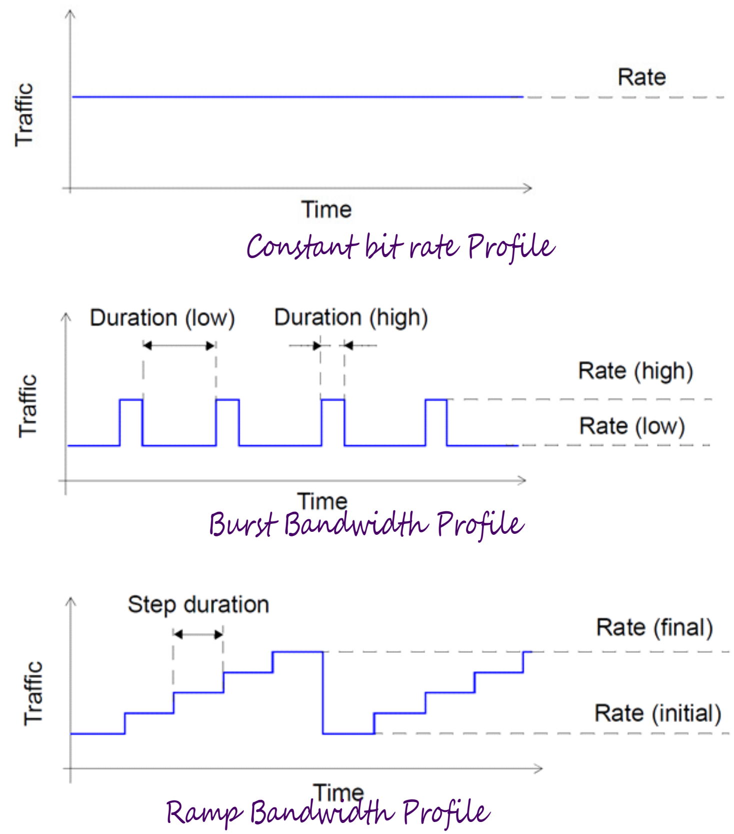
- **Protection Relays**: to protect lines, generators, motor, transformers, or feeders.
- **Bay Controllers**: to manage voltage regulators, logics in circuit breakers, event recording, etc.
- **Mergin Units** or **Metering Devices**: to data acquition and storage such as Voltage (V), Current (A), frequency (Hz), Power (MW), Energy (kWh), Harmonics (H), Temp (C), Tripping (t), etc.

IED can take decisions thanks to its capability to obtain and process information from the power grid. For instance in case of an event or a fault IEDs can automatically command circuit breakers to open or close for protection, IED can also reconfigure the network and provide service restoration in milliseconds.

Modern IEDs support IEC 61850 communication standards in order to assure vendor interoperability by means of universal protocols and data structures.

# Ethernet **Traffic Generation** Test




Router latency when loaded with a ramp

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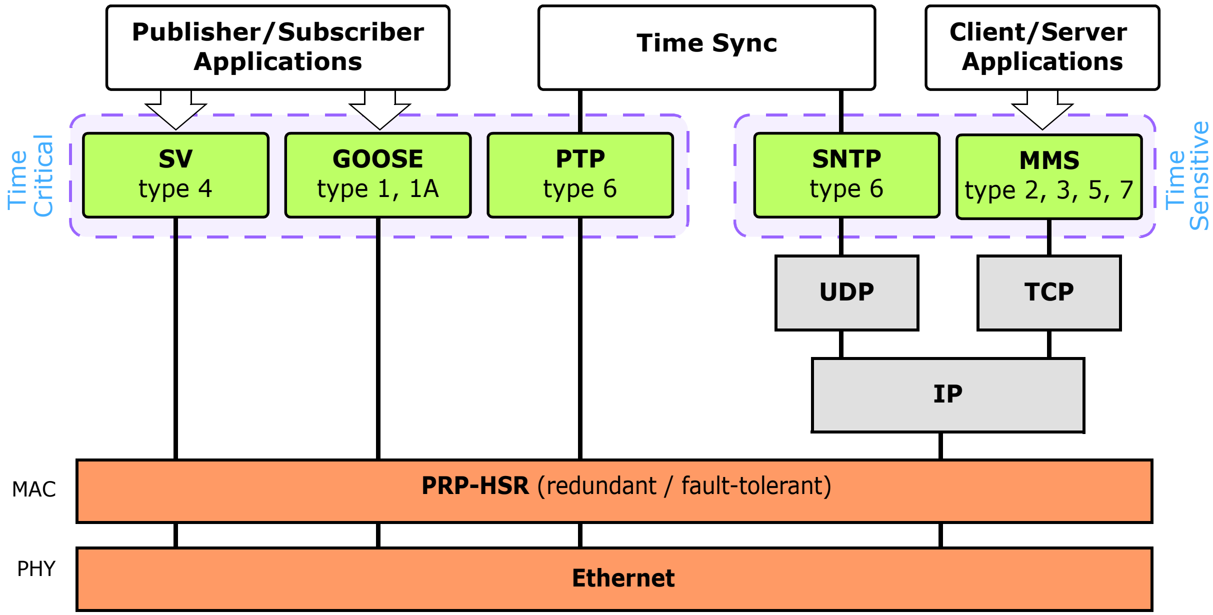
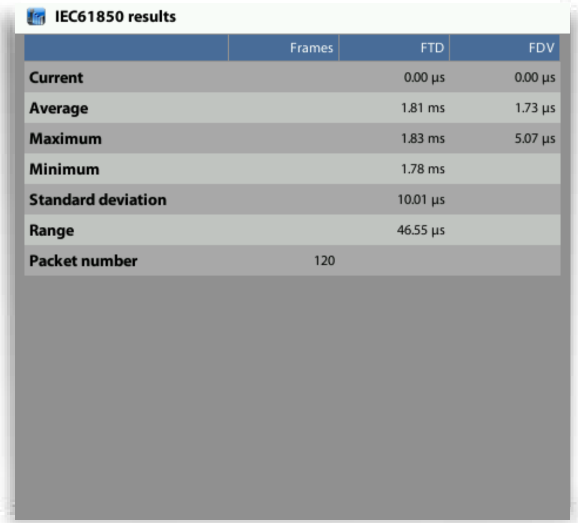
# The **IEC 61850** model and Zeus





IEC61850 results

| | Frames | FTD | FDV |
|---|---|---|---|
| Current | | 0.00 µs | 0.00 µs |
| Average | | 1.81 ms | 1.73 µs |
| Maximum | | 1.83 ms | 5.07 µs |
| Minimum | | 1.78 ms | |
| Standard deviation | | 10.01 µs | |
| Range | | 46.55 µs | |
| Packet number | 120 | | |

The IEC 61850 is a set of standards and technical reports to replace wire communications.

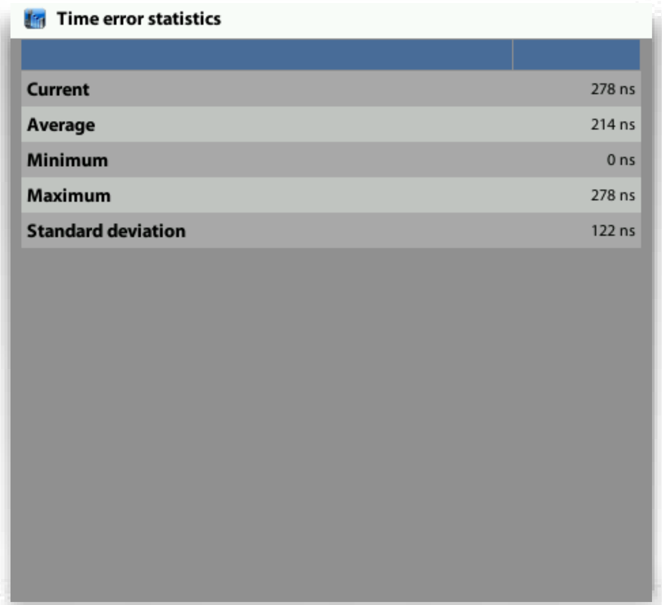
- **Ethernet-based Protocols**: Sampled Values (SV), Generic Object Oriented Substation Event (GOOSE), and Manufacturing Message Specification (MMS) that transport data and commands.
- **Time Synchronization**: Precision Time Protocol (PTP) and Simple Network Time Protocol (SNTP) that align in time the complete grid.
- **Lossless Architectures**: Parallel Redundancy Protocol (PRP) and High-availability Seamless Redundancy (HSR) that build a fault-tolerant network to a single point of failure.
- **Substation Configuration Language** (SCL) specified by IEC 61850 for the configuration of substation includes representation of modeled data to have a complete interoperability

# IEC 61850 protocols and Delay tests with Zeus



IEC-61850 protocols to synchronize, measure, exchange data, command and protect to be verified:.

| Type | Message | Protocol | Layer | BWidth | 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 |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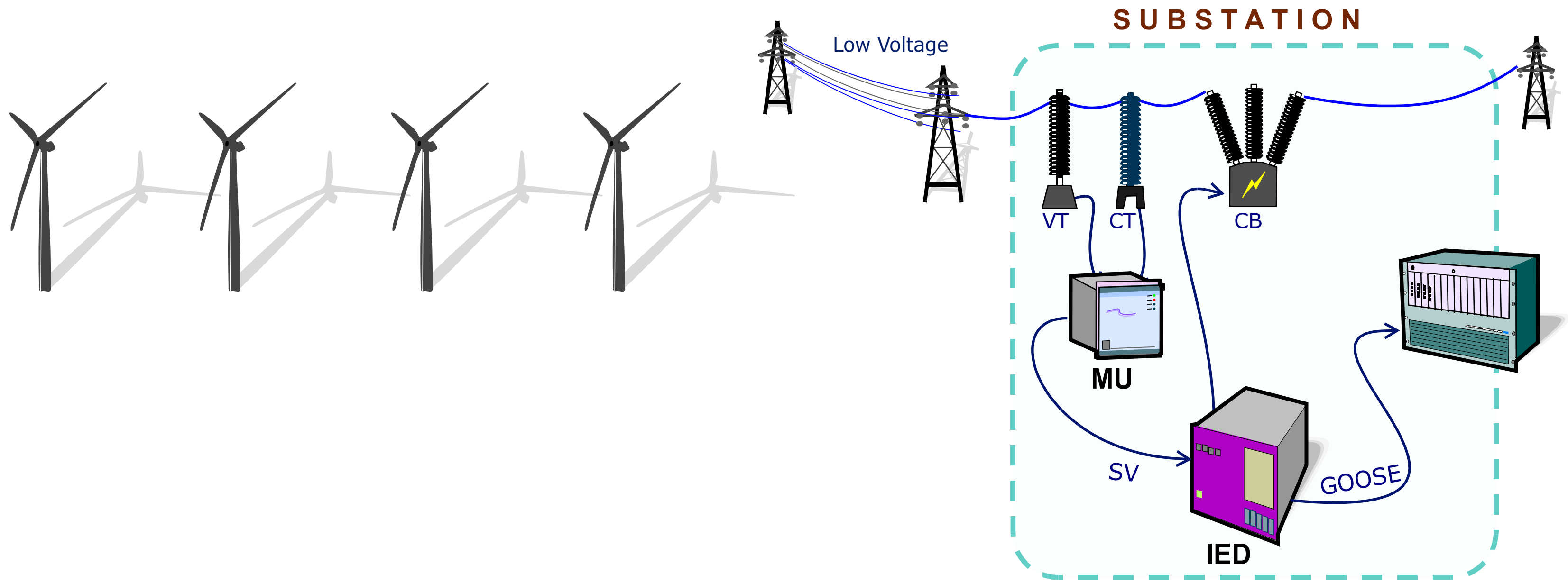
# **SV** (Sampled Values)





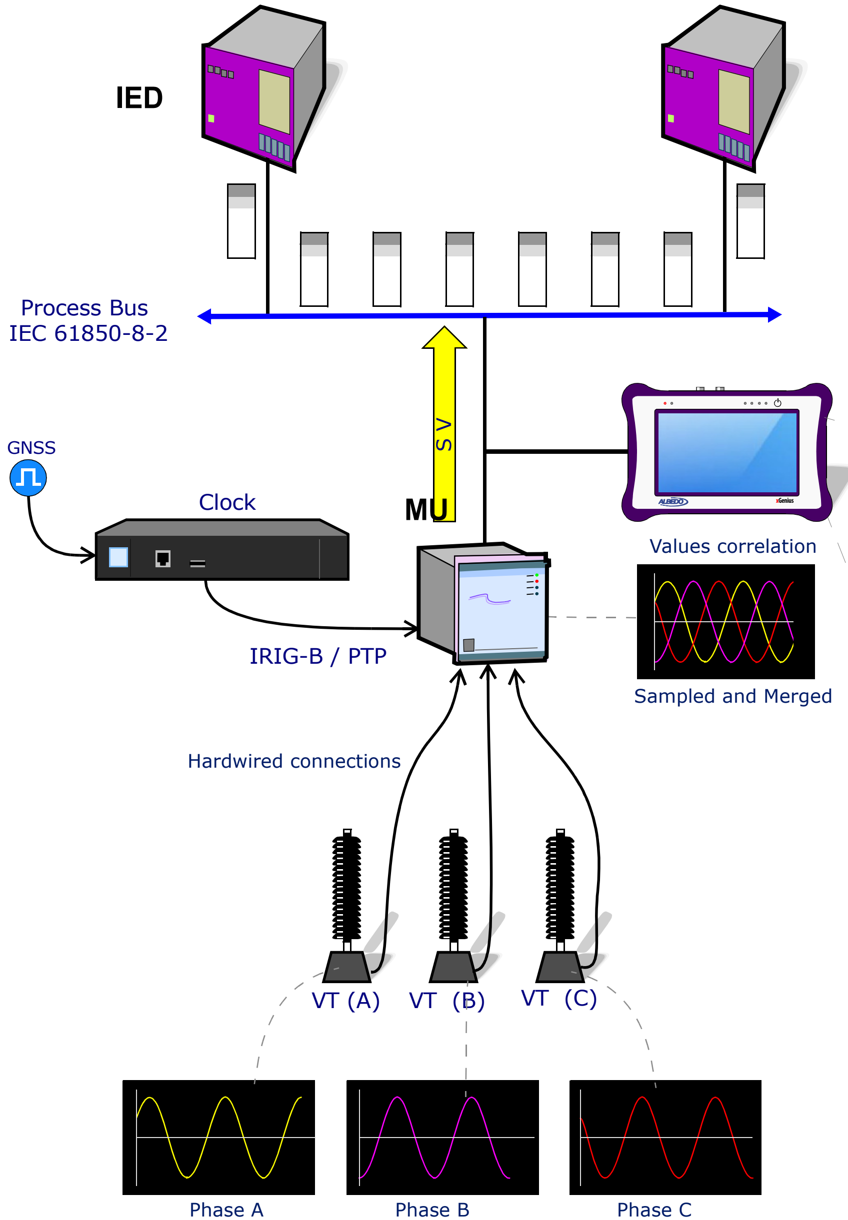



**Sampled Values** (SV) or **Sampled Measured Values** (SMV) is a protocol defined in IEC 61850-9-2 for the acquisition of raw data [8]. In particular, it facilitates the transfer of digitized samples of analog measurements. SV is time critical and can be streamed as unicast or multicast.

- SV are time critical messages, hence no acknowledgements are sent.
- SV is directly mapped, improving the time performance of data transfer. However, unlike in GOOSE, the same message is not retransmitted in SV.
- SV protocol continuously publishes data packets at a specific rate defined by the user.

# SV capture with Zeus at Merging Units (**MU**)






**Merging Units** (MU) digitize analog measurements taken by current and voltage transformers. Afterwards the MU publishes the data as Sampled Values (SV) in a stream at a predefined rate. is the protocol managed by hte MU for the acquisition and transfer of digitized samples of analog measurements such as Voltages and Intensity.

| | |
|---|---|
| State | Finished |
| Status | Idle |
| Packets stored | 130 |
| First capture at | 05/12/2019 15:31:37 |
| Last capture at | 05/12/2019 15:31:37 |
| Usage (%) | 0 |



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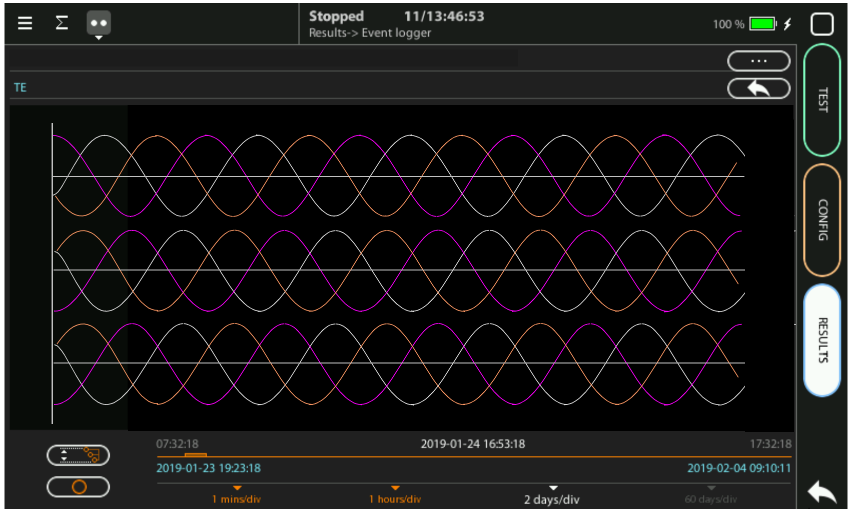
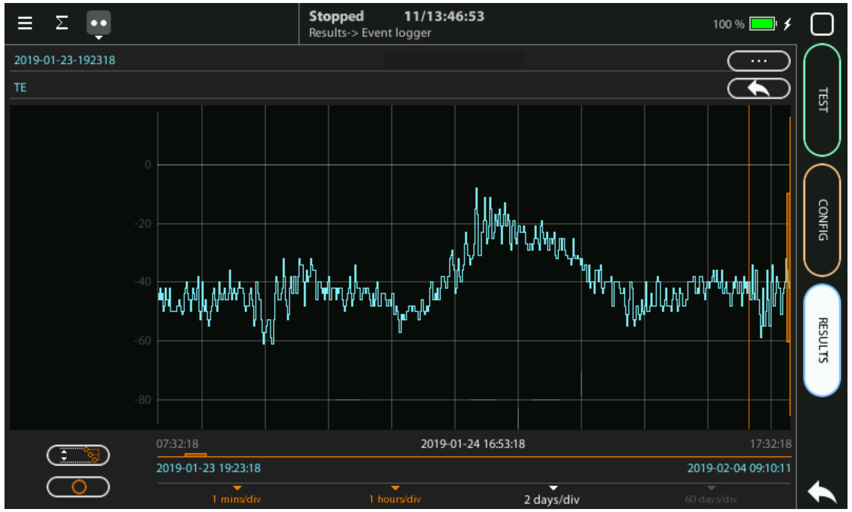
# SV (Sampled Values)



Voltage SV represented (FUTURE IMPLEMENTAION)




Phase Time Error extracted from captured SV

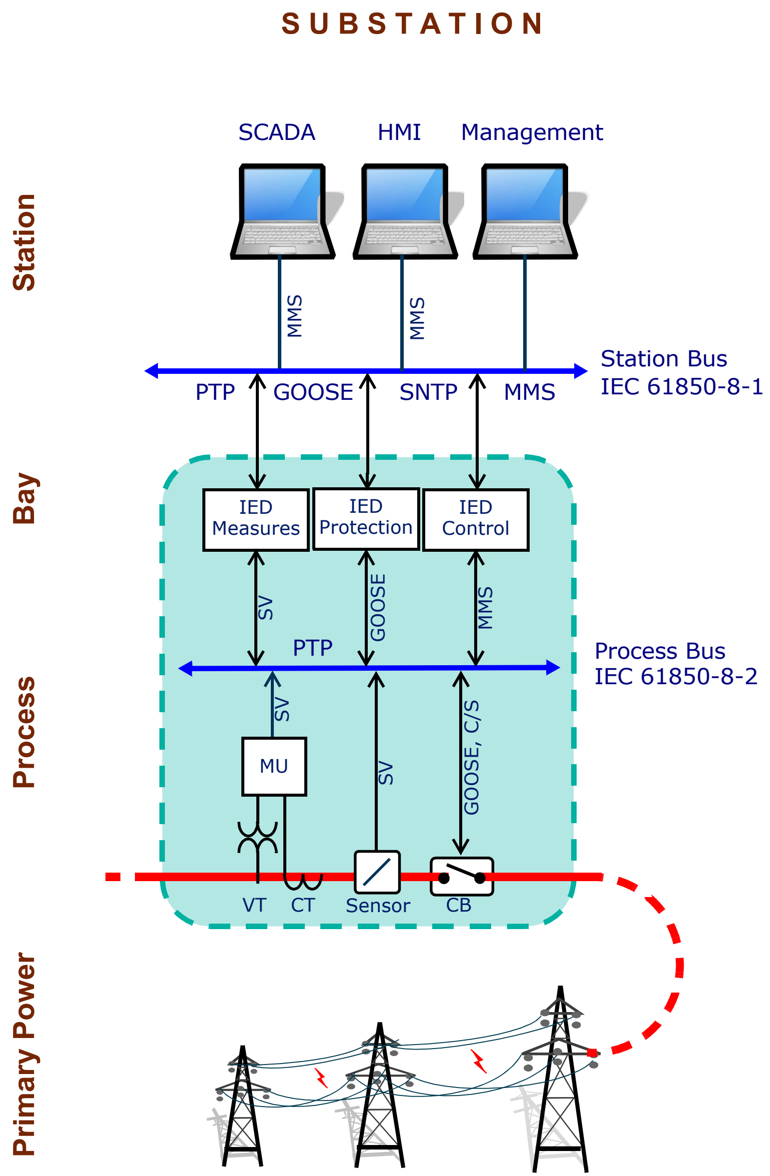



Zeus can scan and analyze the protocol SV that is used to transmit high speed streams of status, I/O signals and **values measured** by conventional or non-conventional current and voltage transformers.

- SV protocol scan with svID population and selection of the active flow
- SV frame count for the active flow and all flows
- Sample count and sampling rate measurement for the active flow
- Latency analysis: current, average, minimum, maximum, range and st. deviation
- Computed over the active flow

# GOOSE (Generic Object Oriented Substation Event)

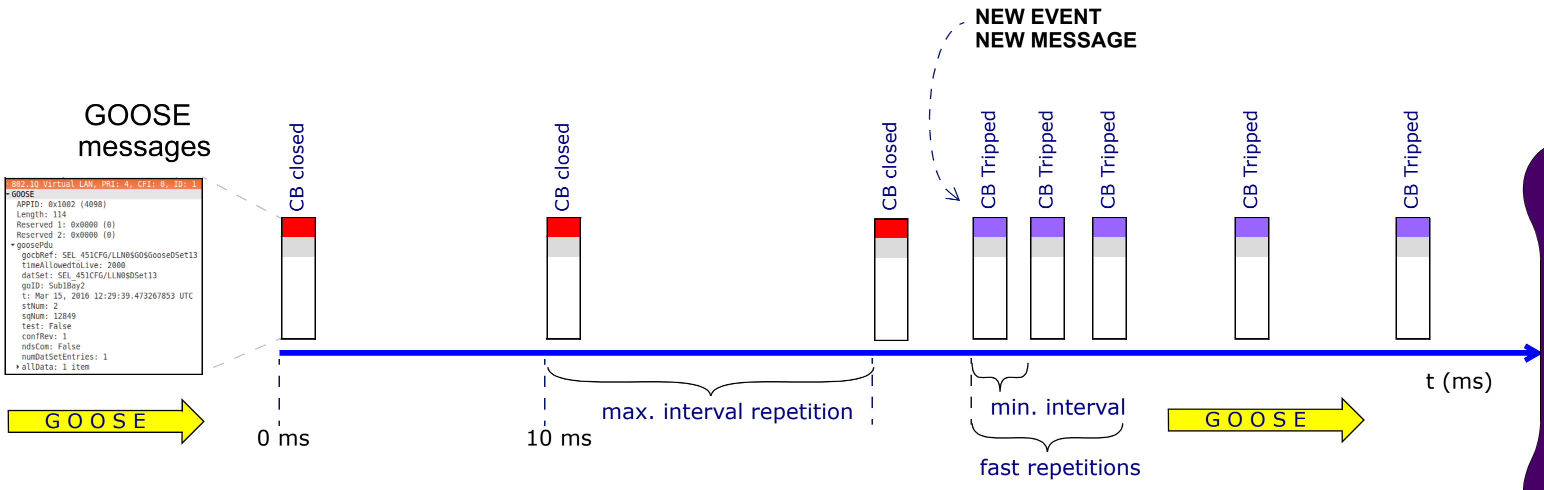


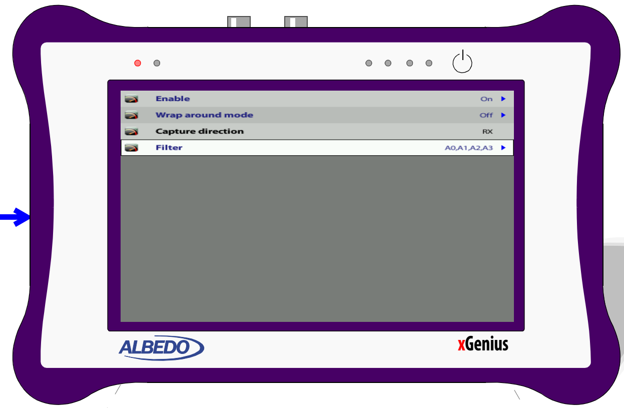


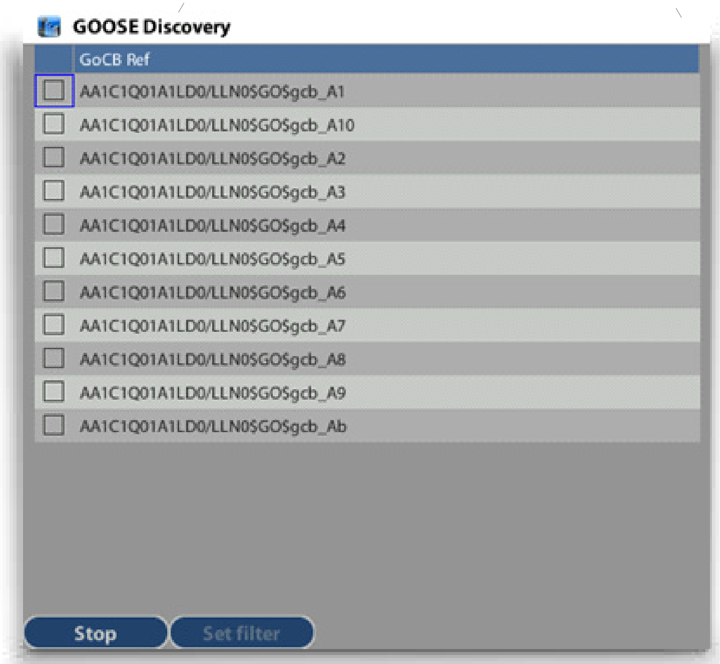

GOOSE is a messaging system used by IEDs and mission-critical applications to tell about substation substation events, such as commands, alarms, indications and measurements:

- Applications e.g. tripping of switchgear, starting of disturbance recorder, providing position indication for interlocking, and tele-protection.
- **L2 protocol**, GOOSE works in real-time ethernet context and used for fast / reliable distribution of data.
- **Publisher/Subscriber** method is used: *one* IED sends a message that can be read by *N* receivers. The reaction of each receiver depends on its functionality and configuration. For instance a message tells position of the Circuit Breaker (Open, Close, Intermediate)
- **No ACK** mechanism but messages are repeated cyclically during certain time, even if there are no changes. The idea to keep connected as a polling.
- **Simplifies wiring**, while the adoption of **fiber optic** unifies traffic reducing dramatically metallic cables.
- GOOSE is vendor **inter-operable** and **scalable.**

# GOOSE protocol scan

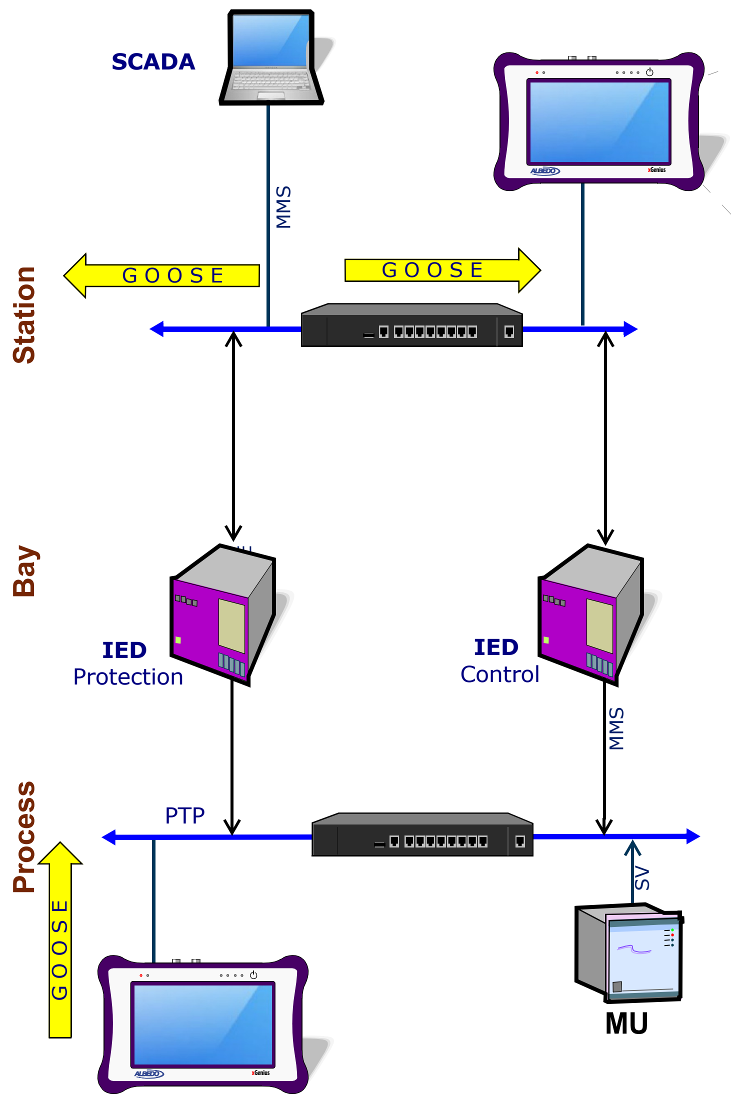


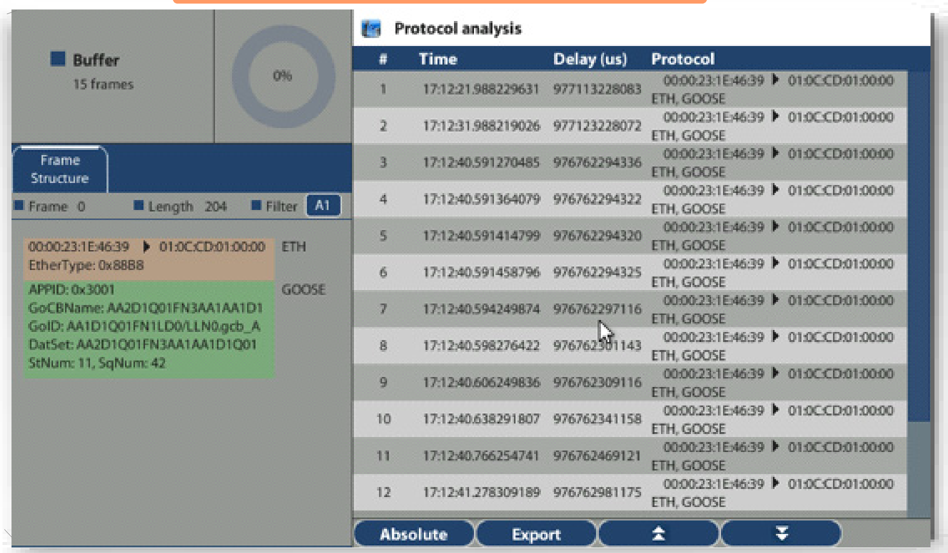




Since the GOOSE messages replace hard-wired signals used for protection and control applications IEC 61850 introduces mechanisms that ensure the delivery of the required information.

# Capture & Analysis of **GOOSE**




**GOOSE protocol analysis**

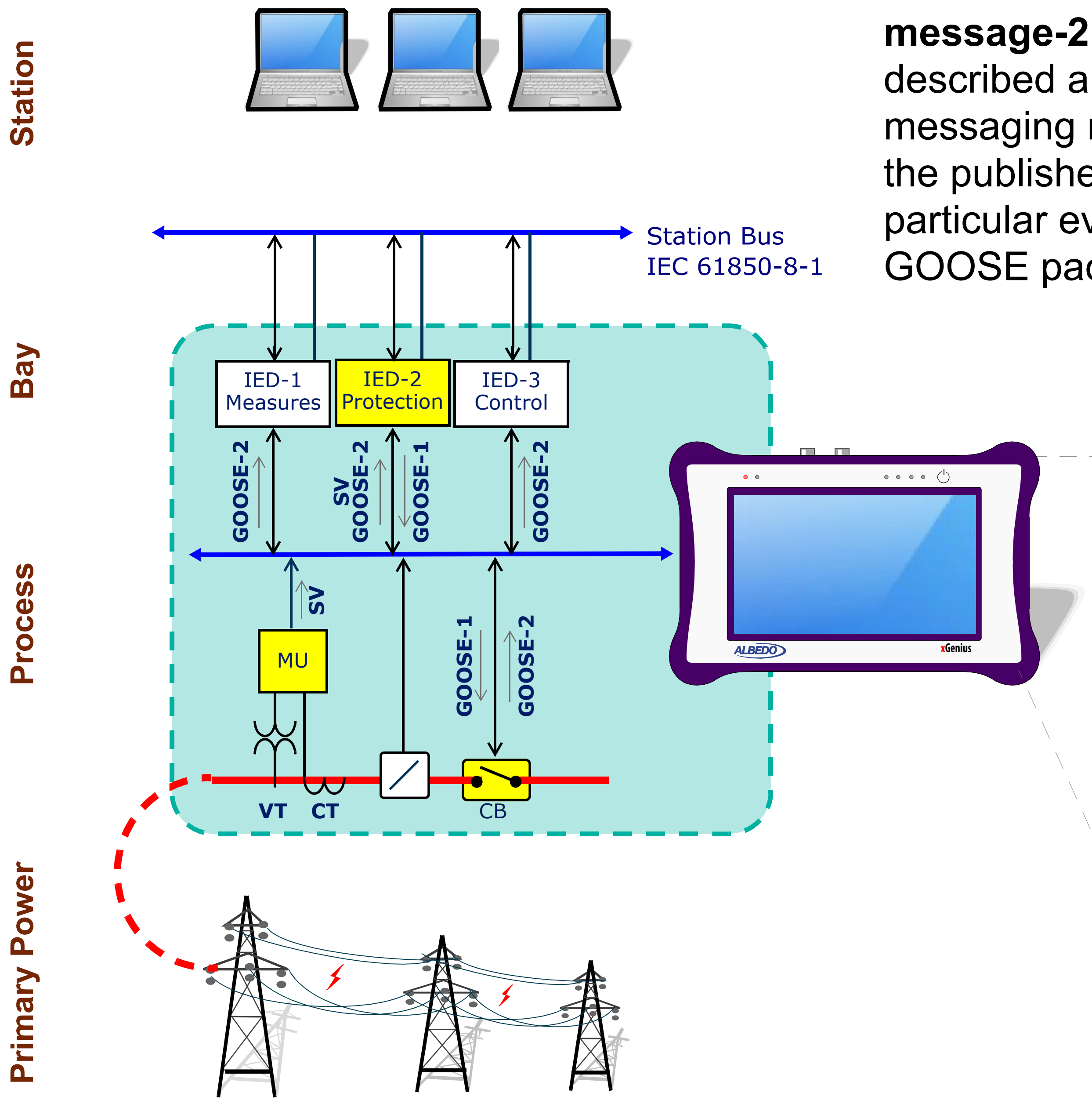



Zeus or xGenius connected at the Process or Station bus can;

- Decodes and analyzes GOOSE frames encoded
- GOOSE protocol scan with GoCBName, GoID, DatSet.
- GOOSE frame count for the active flow and all flows.
- Latency analysis: current, average, minimum, maximum, range and standard deviation computed over the active flow.

# Sample: **SV & GOOSE**

CB advises other IED of the action by issuing a **GOOSE message-2**. The exchange of time-critical messages described above is based on the publisher/subscriber messaging model in which one or more IED subscribe to the publisher stating that they want to be notified of a particular event (in this case, to act as sinks for SV or GOOSE packets).







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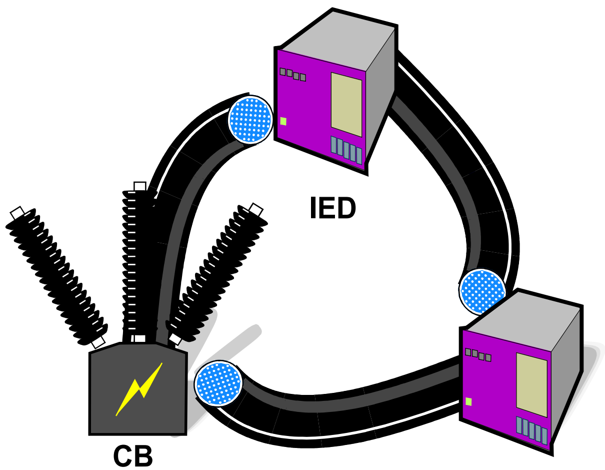
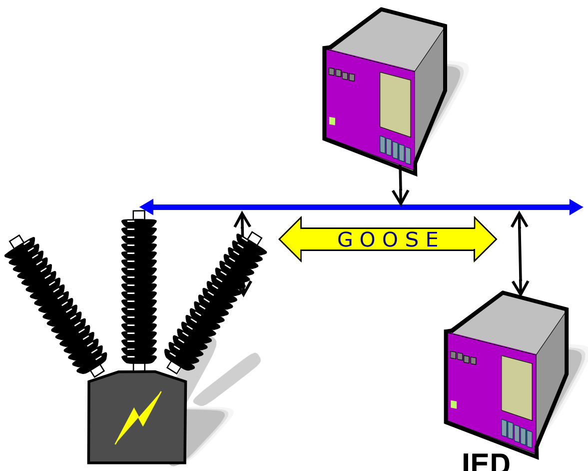
# Goose **Benefits**

Hardwired Signals




Communicating via GOOSE



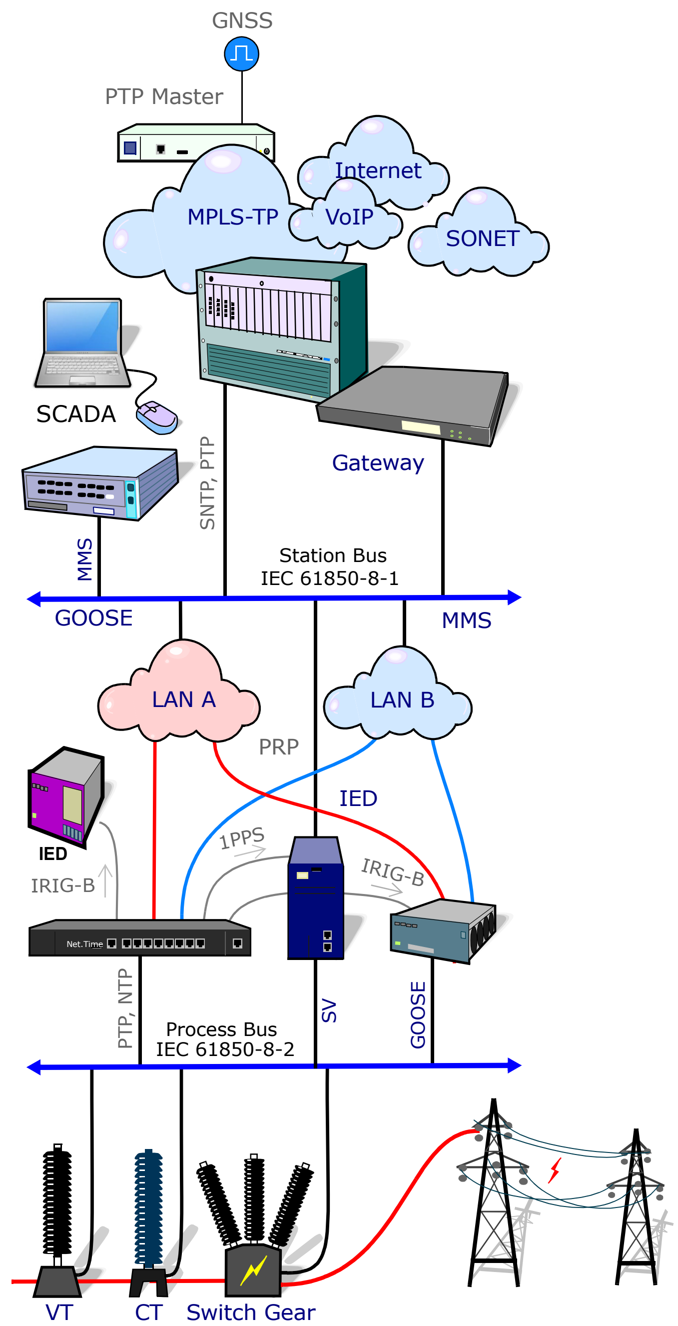

1. **Installation Costs**: due to the replacement of thousands individual control copper cables with a limited number of fiber optic cables from the terminal blocks to the relay terminals with a single pair of fiber.
2. **Testing cost:** It makes easier the testing of all hardwired interfaces vs. Ethernet GOOSE messages.
3. **Flexibility**: using GOOSE messages and virtual signals of the SCL configuration language can be achieved without the need for physical presence in the substation.
4. **Multipoint:** a single message can reach multiple subscribers then simplifies the interconnection particularly when several IED are involved for instance in a protection operation.
5. **Interoperability** the use of standard improves the reliability on the subscription of both IEDs on each side of several manufacturers.
6. **Reduced Maintenance** hard wired connections cannot be monitored then verification of all interfaces between individual components of the protection and control system is expensive.
7. **Remote Testing** protection systems in a digital substation allows the testing to be performed remotely by means of GOOSE and SV messages.

# Substation Automation & **Timing**

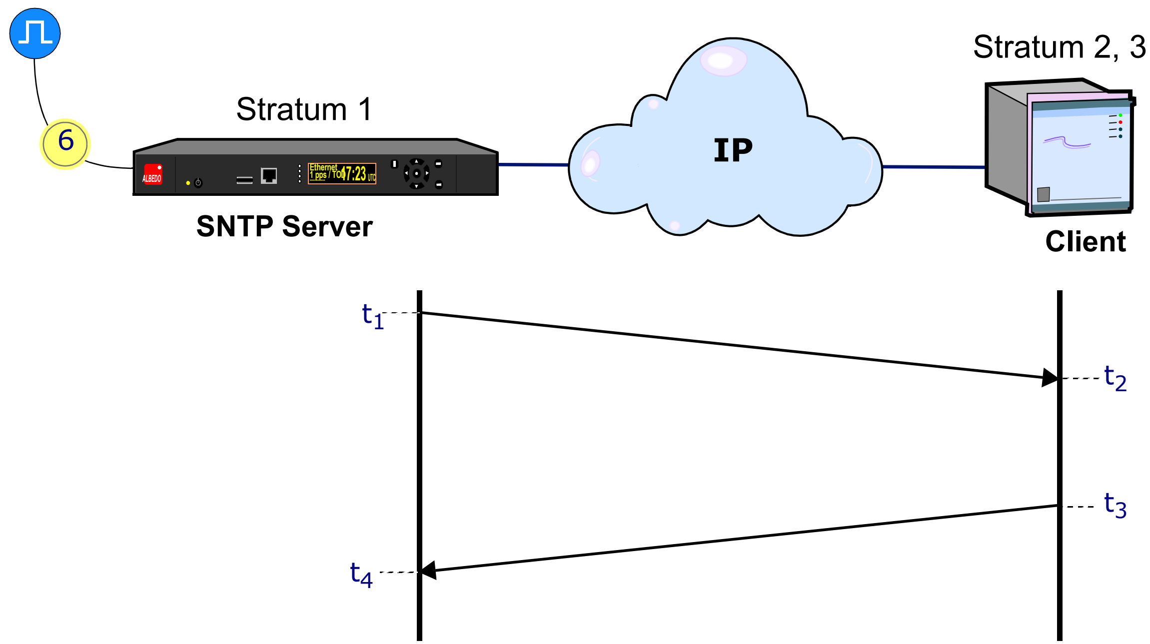
Time **synchronization** is used to precisely adjust internal clocks in IEDs, merge units (MUs), protection/control units, Ethernet switches and processes. It helps to achieve accurate control and precise global analysis of network response and when, where and why any faults have occurred and to generate the correct response. The following applications require time synchronization:

- IEC 61850 protocols like SV, GOOSE and MMS
- Real-time data acquisition from IEDs, RTUs and MUs
- Management applications such as SCADA
- Protection process and devices Relays, Switchgears
- Events recording for fault and performance analysis

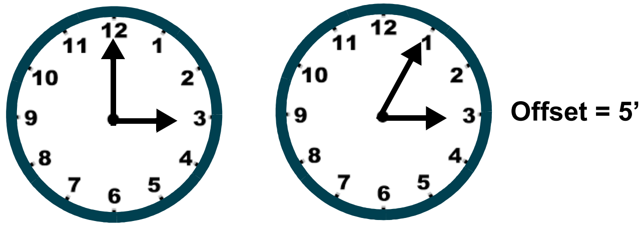
Alternatives for timing include SNTP and PTP (both part of the IED 61850 standard) but also is common the use of Synchronous Ethernet, T1/E1, 1PPS and IRIG-B



# SNTP (Network Time Protocol)




Offset: difference between clocks




$$\text{Offset} = \frac{(t_2 - t_1) + (t_3 - t_4)}{2}$$

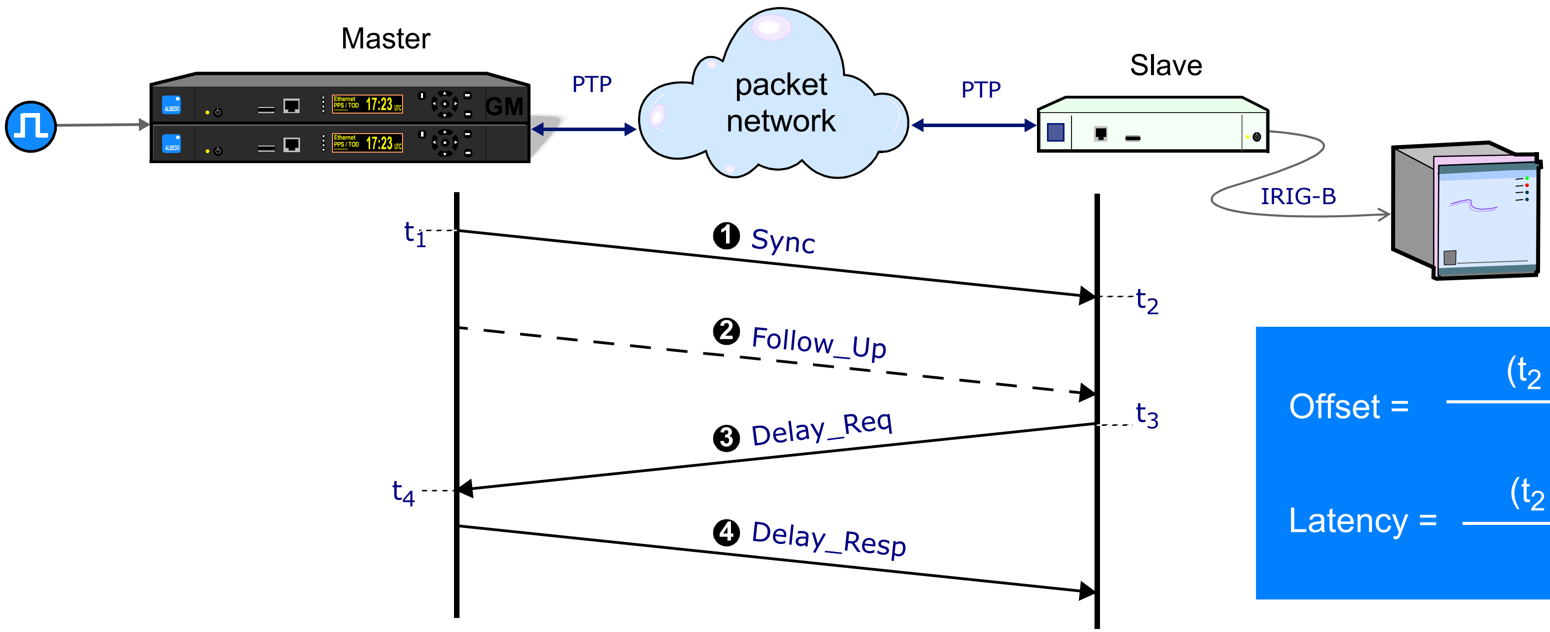
$$\text{Round Trip Delay} = (t_2 - t_1) + (t_4 - t_3)$$

SNTP is part of the IEC 61850 standard (a simplified version of NTP) which can provide a milisecs range of precision, is good enough for the station bus to synchronize SCADA and Ethernet switches but is not for the Process Bus with GOOSE and SV messages and devices that require an accuracy of microsecs.

- Network Time Protocol (NTP) is an Internet protocol for synchronizing the clocks of computer systems over packet network with variable latency.
- The clock frequency is then adjusted to reduce the offset gradually, creating
- Precision 1 - 10 ms. in Internet, (0,5 - 1 ms for LAN ideal conditions)

# PTP - Precision Time Protocol (IEEE 1588)






$$\text{Offset} = \frac{(t_2 - t_1) - (t_4 - t_3)}{2}$$

$$\text{Latency} = \frac{(t_2 - t_1) + (t_4 - t_3)}{2}$$

It is a cost-efficient solution and can be applied on the basis of the existing Ethernet network in a substation. PTP (IEEE 1588) applies master/slave time synchronization mechanisms and supports hardware time stamps. The basic parameters of Latency / Offset are computed from the $t_{1...4}$ stamps.

- Grandmaster sends a series of messages with date and time to client-clocks
- Client-clocks compensate the delays and get synchronized with the Master
- Frequency is then recovered with a precise time-of-d
- PTP prevents error accumulation in cascaded topologies, fault tolerance and enhances the flexibility and PTP can use an existing Ethernet reducing cabling costs and requires just a few resources.

# IRIG-B configuration by Zeus

**IRIG - Xabc**

Rate
- A: 1000 PPS
- **> IRIG-B: 100 PPS <**
- D: 1 PPM
- E: 10 PPS
- G: 10000 PPS
- H: 1 PPS

Coding
- 0: BCD, CF, SBS
- 1: BCD, CF
- 2: BCD
- 3: BCD, SBS
- 4, 5, 6, 7: others

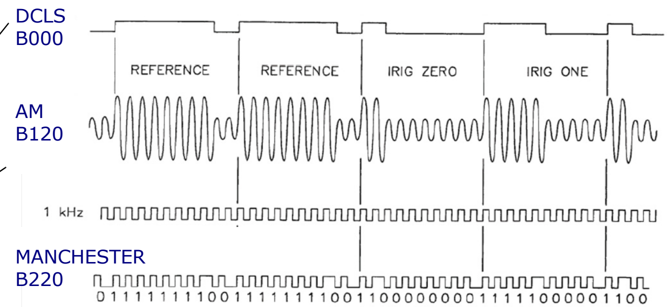
Carrier
- 0: No carrier (DCLS)
- 1: 100 Hz
- 2: 1 kHz
- 3: 10 kHz
- 4: 100 kHz
- 5: 1 MHz

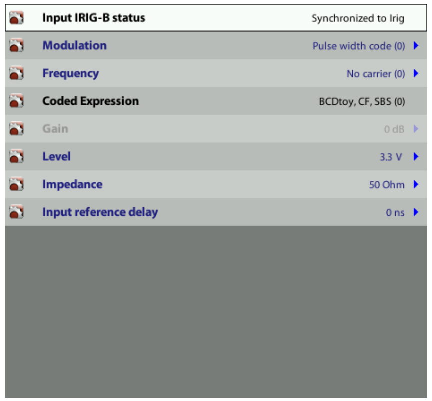
Modulation
- 0: Unmodulated DCLS
- 1: AM (Amplitude Modulated)
- 2: Manchester Modulated

BCD
0000 = 0
0001 = 1
0010 = 2
0011 = 3
0100 = 4
0101 = 5
0110 = 6
0111 = 7
1000 = 8
1001 = 9

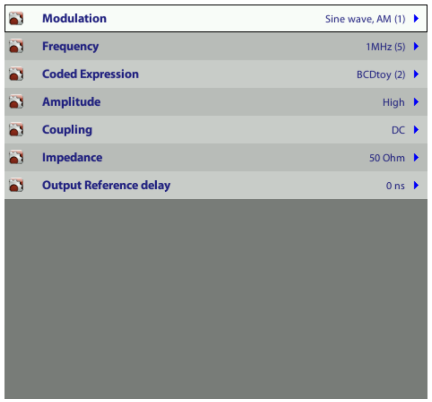
BCD - Binary Coded Decimal, coding of time (HH,MM,SS,DDD)
SBS - Straight Binary Second of day (0....86400)
CF - Control Functions depending on the user application

**IRIG SAMPLES: B000, B120, B220**



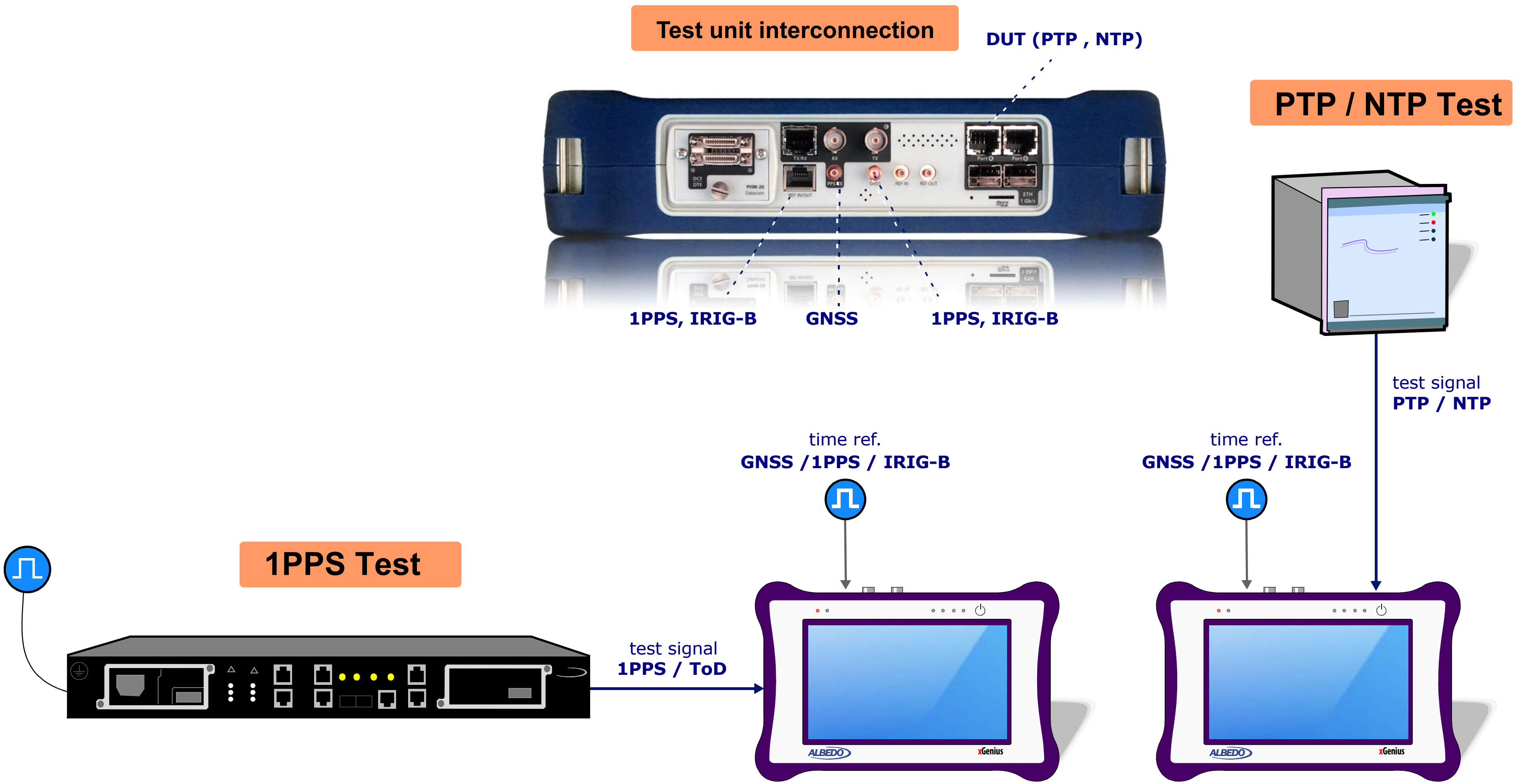




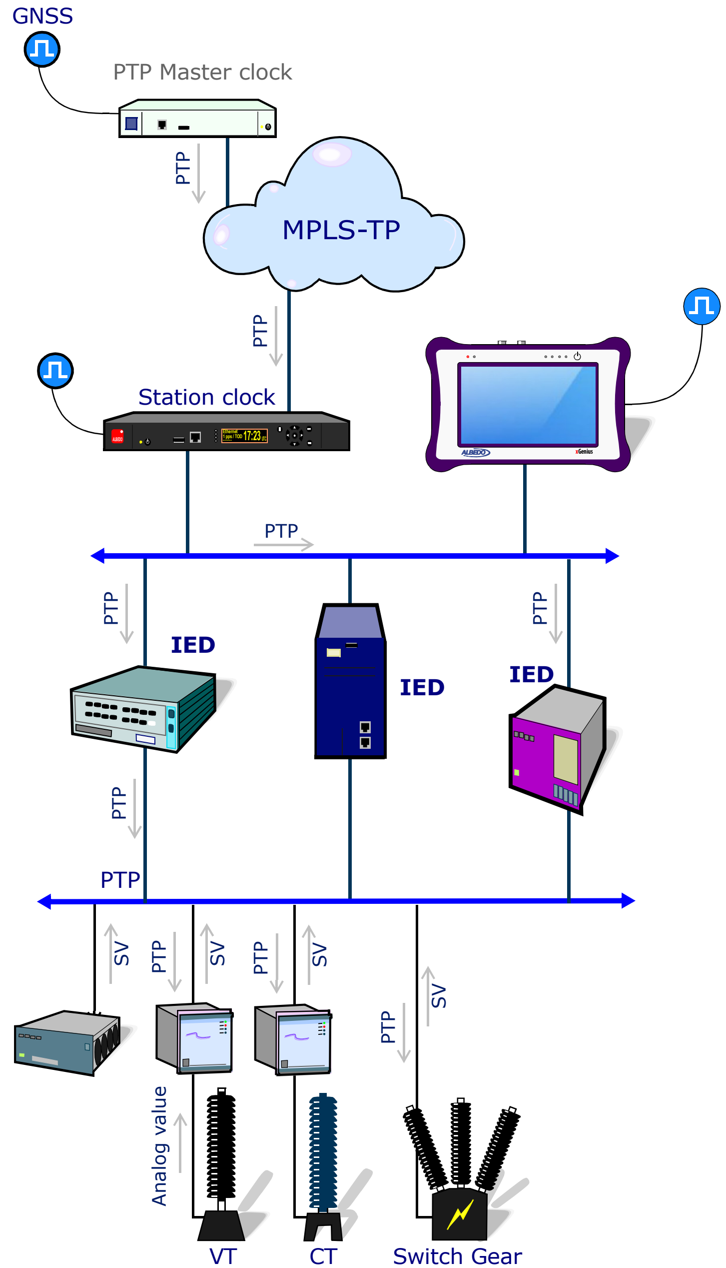

IRIG-B sends a timing signal every second at 100 pulse/sec rate therefore the 100 is the number of bits of each frame. IRIG-B info includes Year, Day, Hour, Min, Sec.

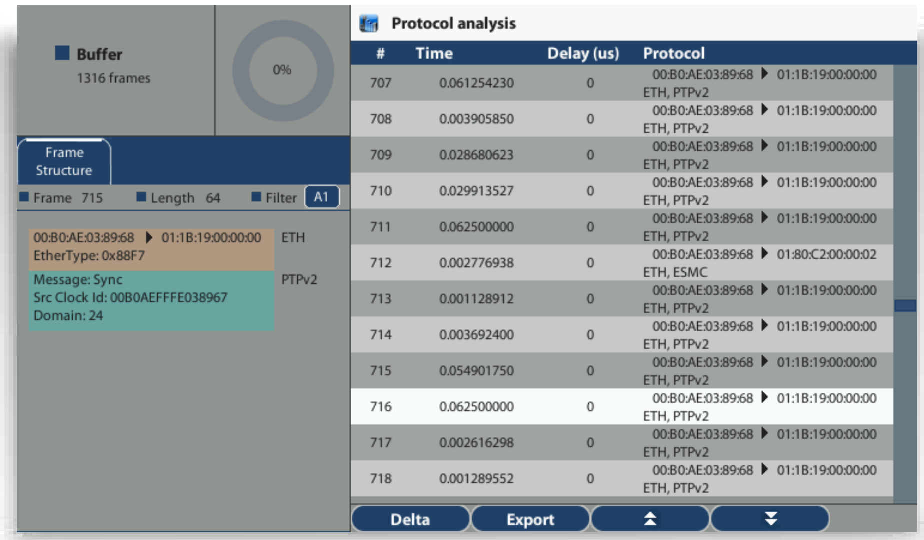
- AM modulated clock reference input and output
- Unmodulated (DCLS) i/o over RS-422 / RS-485 or TTL
- Manchester encoded IRIG-B input and output

# Testing with time referecence



# PTP testing



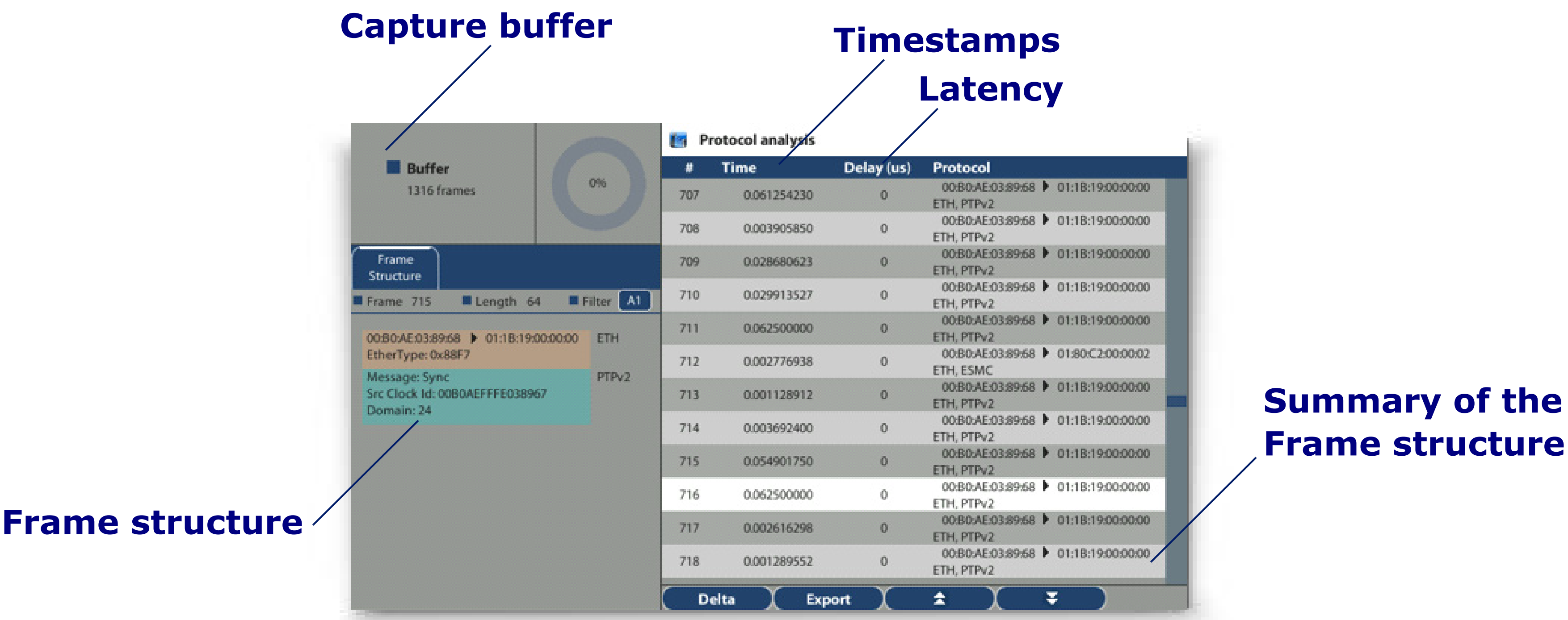




Precision Time Protocol (IEEE 1588) with **Power Profile** defined in IEEE C37.238 address the requirements of the power industry in terms of accuracy, continuous operation (24/7) and deterministic failure behavior.

Testing PTP with Zeus:

- Master / Slave operations
- Generation / Decoding
- PDV metrics

# PTP Test: Traffic Capture




- Captures in pass-through and endpoint modes.
- High resolution hardware time-stamping.
- Synchronized captures (GNSS, IRIG-B, 1PPS / ToD).
- Packet-by-packet delay analysis.
- Frame analysis of many protocols: DNS, DHCP, GOOSE, SV, NTP, PTP, etc.
- Export to PCAP and PCAPng

# PTP wander and TE **Results**

**Built in TE chronograph**


## Wander metrics

- TIE
- MTIE
- TDEV
- Tables and Graphs

## Time Error (TE) test

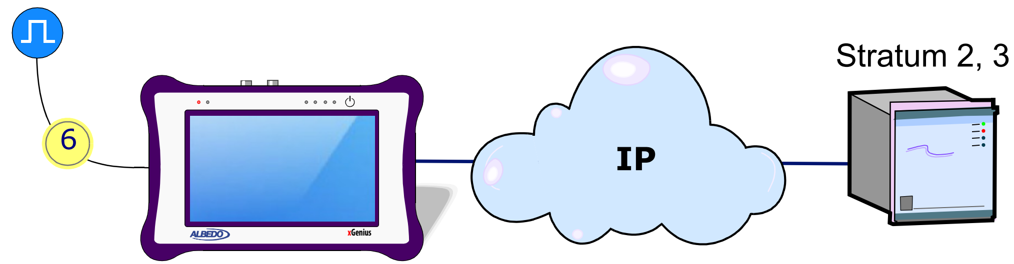
- Two-way TE and max |TE|
- Low frequency TE as the cTE + dLTE
- High frequency TE
- Path Delay Asymmetry
- Between PTP master to client clocks

**TE analysis** (PASS/FAIL)

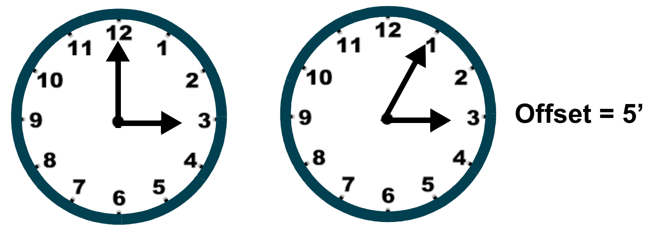
**Two way TE statistics** PASS

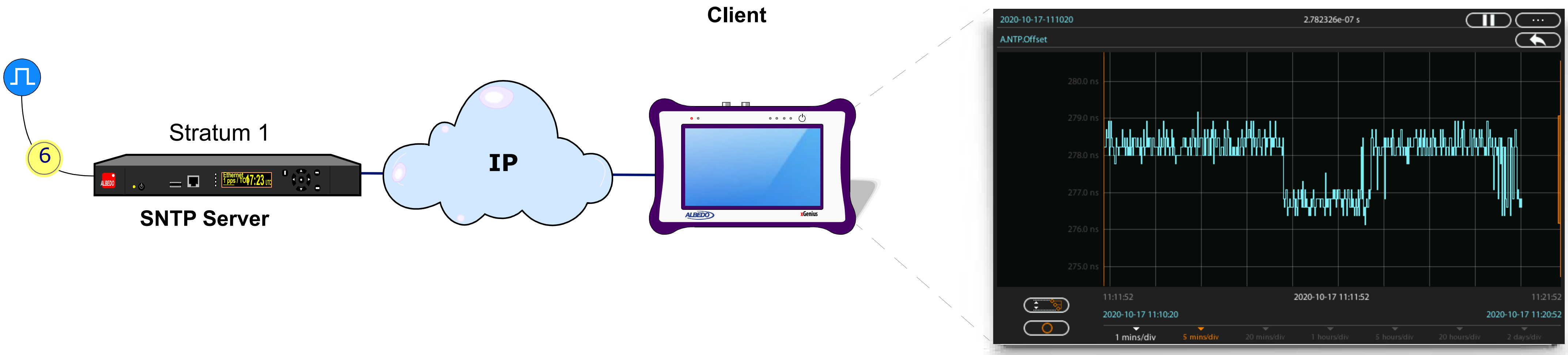
| | Current | Minimum | Maximum |
|---|---|---|---|
| **Total** | 41 ns | 7 ns | 61 ns |
| **Low frequency** | 40 ns | 32 ns | 58 ns |
| **High frequency** | 0 ns | -32 ns | 5 ns |

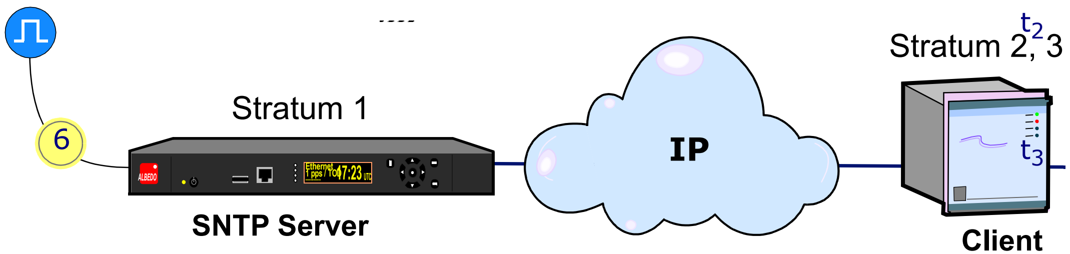
# NTP test and results




Offset: difference between clocks




Zeus and xGenius can manage:

- NTPv3/v4 server and client emulation
- Traffic filtering, classification, analysis
- NTP delay, asymmetry
- Time Error (TE) statistics



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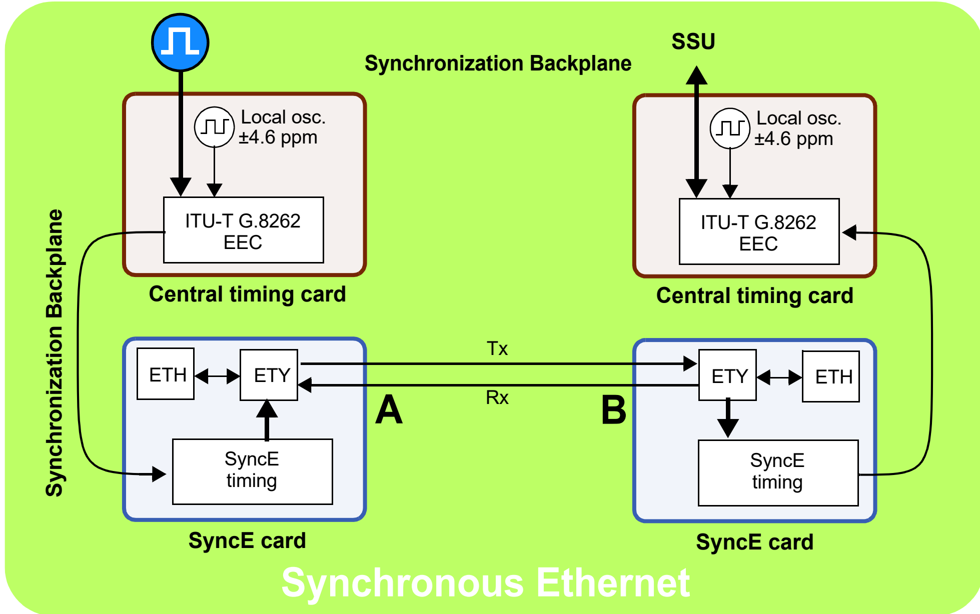
# Testing Synchronous Ethernet (SyncE)




SyncE is not part of the IEC 61850 but is being used in the Power industry

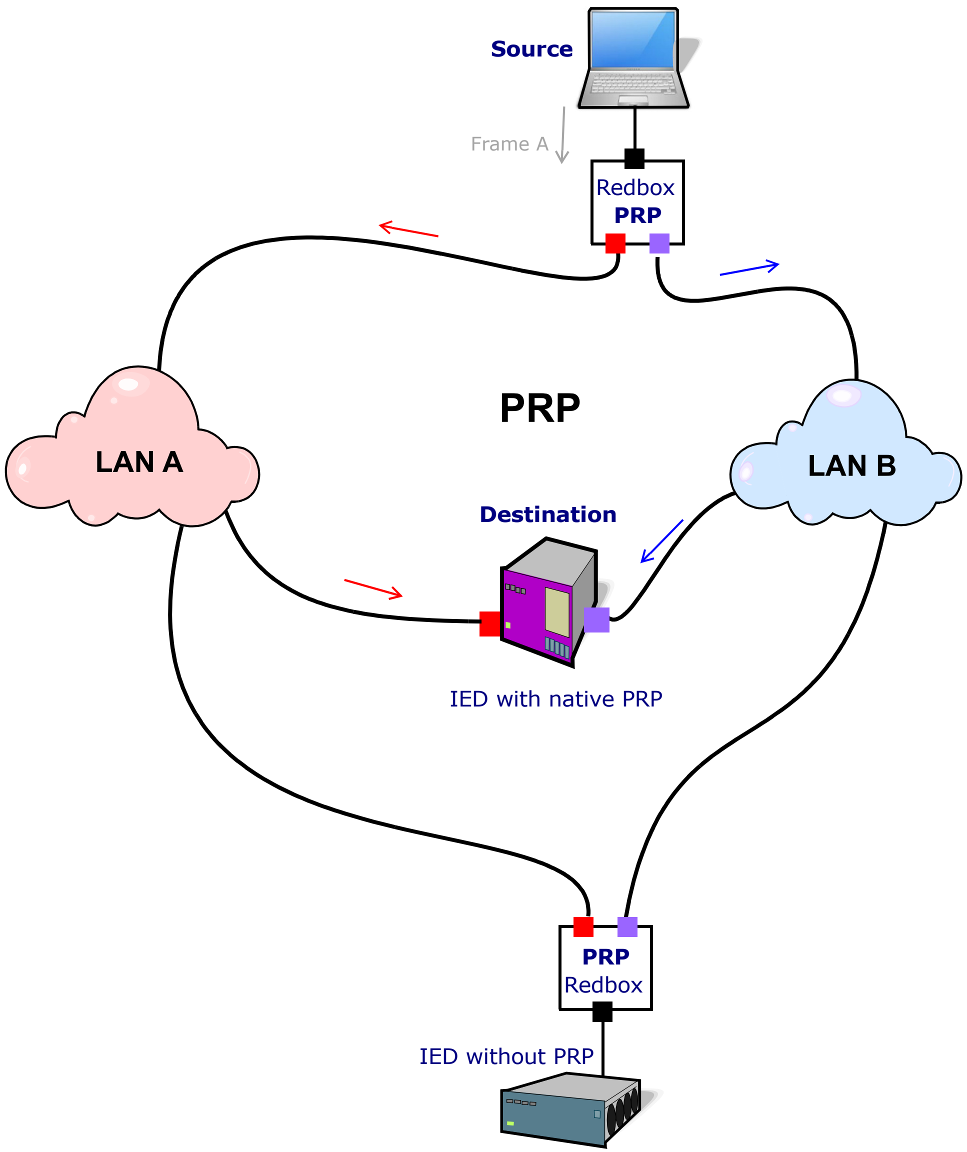
- Rx gets synchronized using the recovered clock
- Tx uses a traceable reference clock

Zeus features

- Frequency (MHz), offset (ppm), drift (ppm/s)
- TIE / MTIE / TDEV on Ethernet (ITU-T O.172)
- Decoding of the QL transported in SSM
- Resolution of TIE, MTIE and TDEV results: 100 ps

# **PRP** - Parallel Redundancy Protocol






Network redundancy is crucial for maintaining **high network availability**, and many redundancy technologies can provide millisecond-level recovery. However, some mission-critical and time-sensitive applications **cannot tolerate** even **a millisecond** of network interruption without severely affecting operations or jeopardizing the safety of on-site personnel.

Parallel Redundancy Protocol (**PRP**) provide **seamless fail-over** from a single point of failure. PRP realizes active network redundancy by packet duplication over two independent networks that operate in parallel.

Based on these two seamless redundancy protocols, a redundancy box (**Redbox**) can quickly activate non-HSR or non-PRP devices connected to HSR or PRP networks with zero switch-over time.

# **Protection** schemes

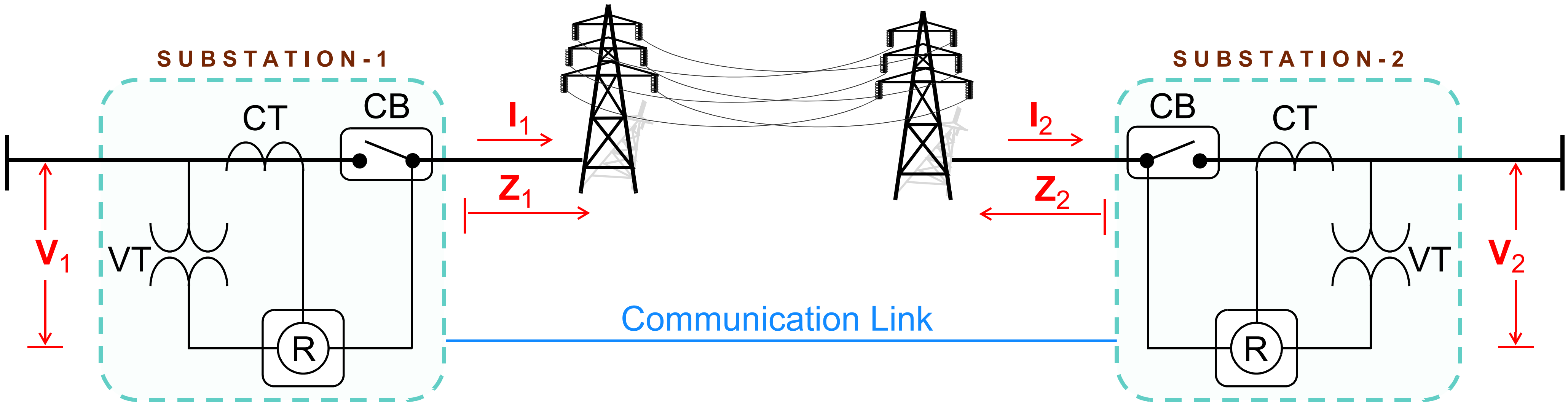


A secure and uninterrupted supply of electricity is only possible with the help of comprehensive protection and control functions which ensure the reliable operation of the power system. Protection schemes have the objective of keeping the Power System **stable and isolated** from natural events (storms, earth-quakes, animals, winds), equipment failure, mis-operation... that may damage power grid elements:

- Power Generators
- Transformers in Plants and Substations
- Capacitors
- Power Lines (transmission & distribution)

Each component has its **particular way of protection** (fuse, differential, relay, disconnection...)

# **Line** Protection

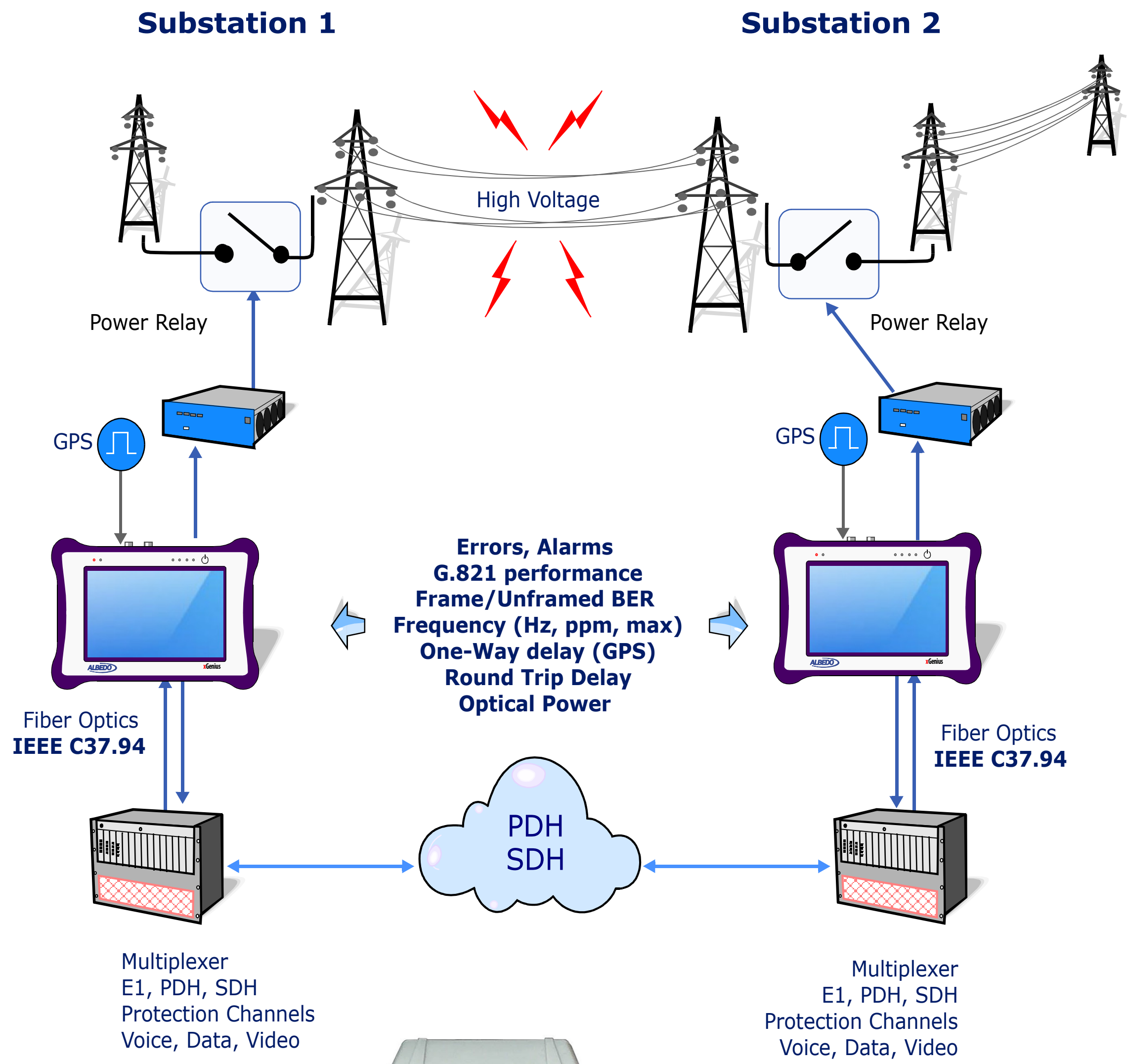



There are several line Protection schemes based on the measurement of electric values:

1. Stand-alone schemes:
   - **Overcurrent**: Relay responds to overcurrent condition read on CTs indicates tripping to CB
   - **Directional Overcurrent**: Relay responds to overcurrent condition in the forward direction only
   - **Impedance**: Relay responds to $Z_i$ changes measured at CT and VT
2. With communication link between Switchgears:
   - **DCB** (Directional Comparison Blocking): CB tripping is allowed unless a block signal is received
   - **POTT** (Permissive Overreaching Transfer Trip): CB tripping is allowed only if a signal is received
   - **Line Current Differential**: current at $I_1$ is compared with the going $I_2$

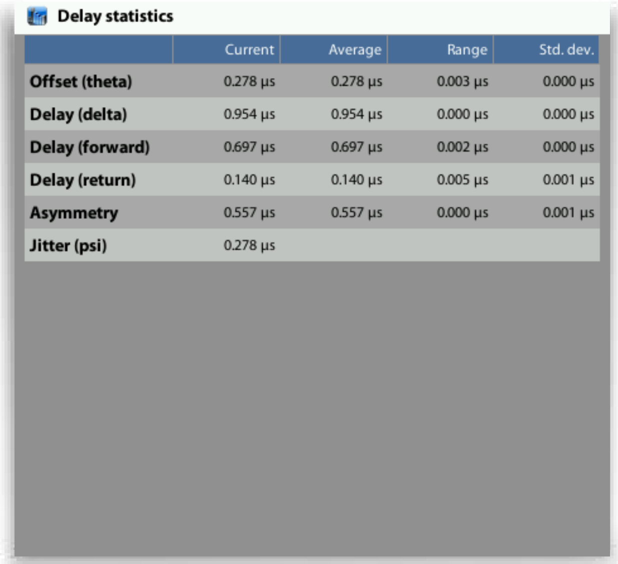
# C37.94 : Teleprotection Interface Test







Dual C37.94 module



Delay statistics

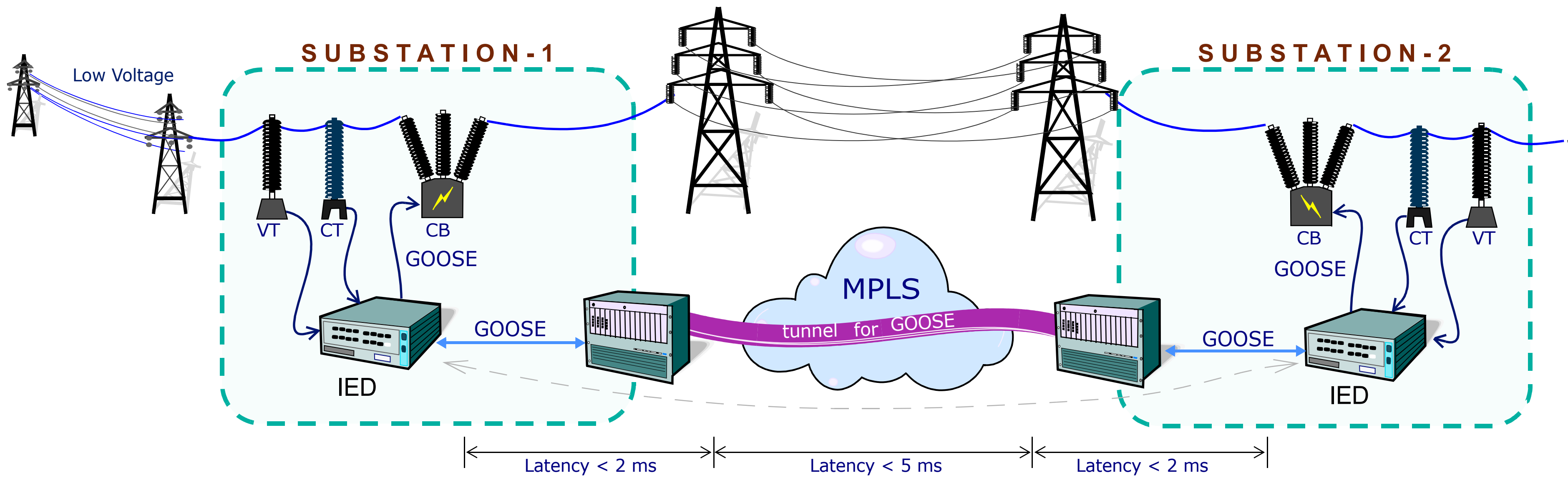
| | Current | Average | Range | Std. dev. |
|---|---|---|---|---|
| Offset (theta) | 0.278 µs | 0.278 µs | 0.003 µs | 0.000 µs |
| Delay (delta) | 0.954 µs | 0.954 µs | 0.000 µs | 0.000 µs |
| Delay (forward) | 0.697 µs | 0.697 µs | 0.002 µs | 0.000 µs |
| Delay (return) | 0.140 µs | 0.140 µs | 0.005 µs | 0.001 µs |
| Asymmetry | 0.557 µs | 0.557 µs | 0.000 µs | 0.001 µs |
| Jitter (psi) | 0.278 µs | | | |

Zeus can turn up C37.94 teleprotection:

- Endpoint emulation. Replaces a multiplexer or a protection relay
- Intrusive bidirectional pass-through mode. Monitor and loopback modes
- Performance testing: BERT, G.821
- Analysis/generation of events
- Optical power and frequency metering
- One-way / round-trip delay, asymmetry
- Jitter and wander generation and analysis

# GOOSE is state-of-the-art teleprotection

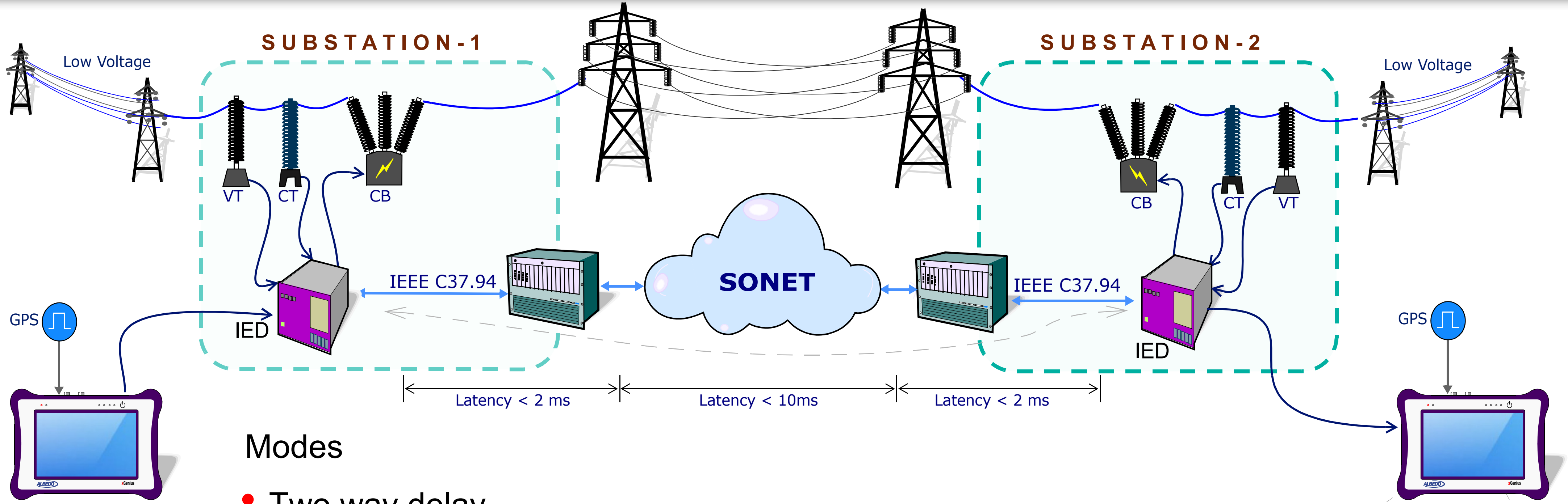





GOOSE is a Layer 2 protocol (not routable) used by IEDs send messages inside the substation LANs, nevertheless using MLPS it can be extended to remote substations and Tele-protection. MPLS facilitates GOOSE traffic through the WAN extending the LAN thus IEDs can exchange information with remote devices at remote substations:

- MPLS means good performance particularly on latencies that are critical for GOOSE
- GOOSE/MPLS architecture it is very scalable and inter-connectable with devices from different vendors.

# Latency analysis in ALL the intefaces




Modes

- Two way delay
- One way assisted with GNSS or ToD and far-end identification

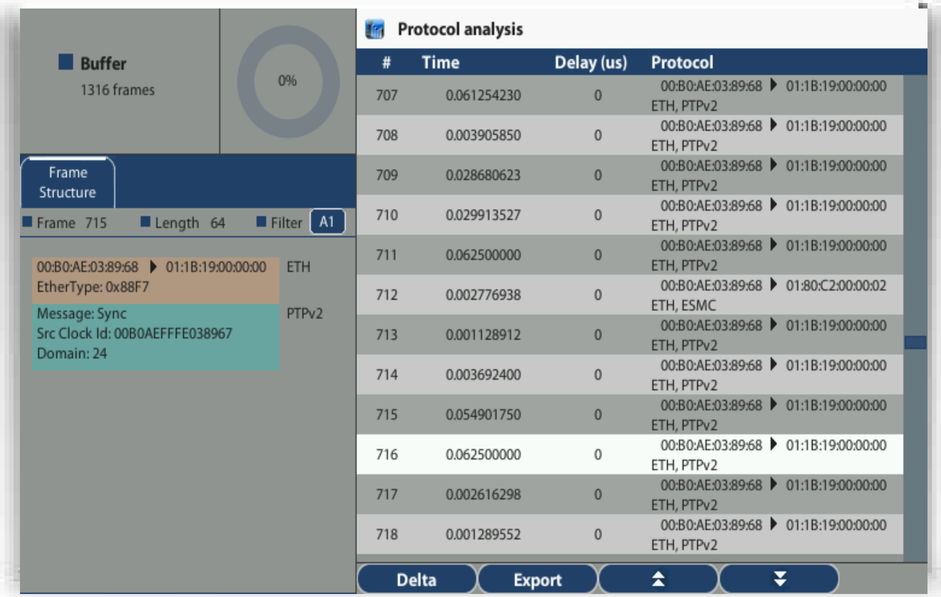
Results

- Round Trip Delay (RTD)
- One way Forward / Reverse Path delay
- Asymmetry with min. / max. records
- Patch cord delay compensation
- Pass / Fail indication

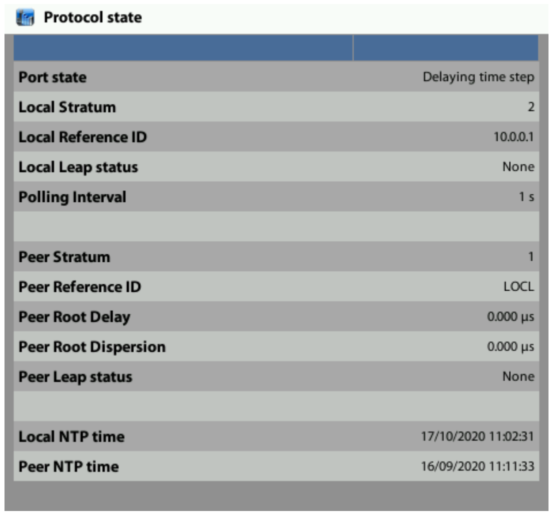
Delay (Port A)

| | Current | Minimum | Maximum |
|---|---|---|---|
| Round-trip delay | 552 us. | 552 us. | 552 us. |
| Forward path delay | 511 us. | 511 us. | 511 us. |
| Return path delay | 41 us. | 41 us. | 41 us. |
| Asymmetry | 470 us. | 470 us. | 470 us. |
| Remote host | xxx0408P | | |

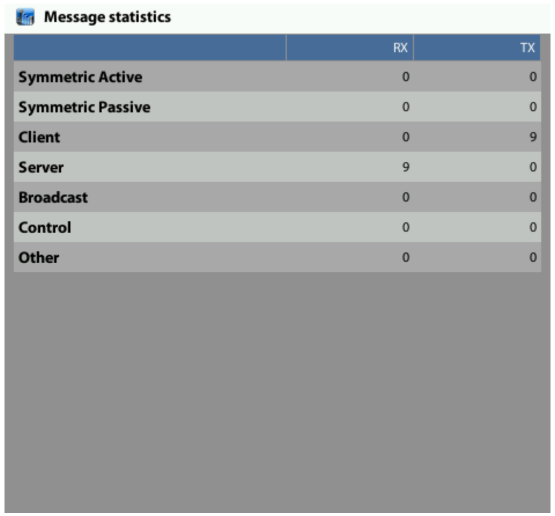
# Sample: **Remote Testing**



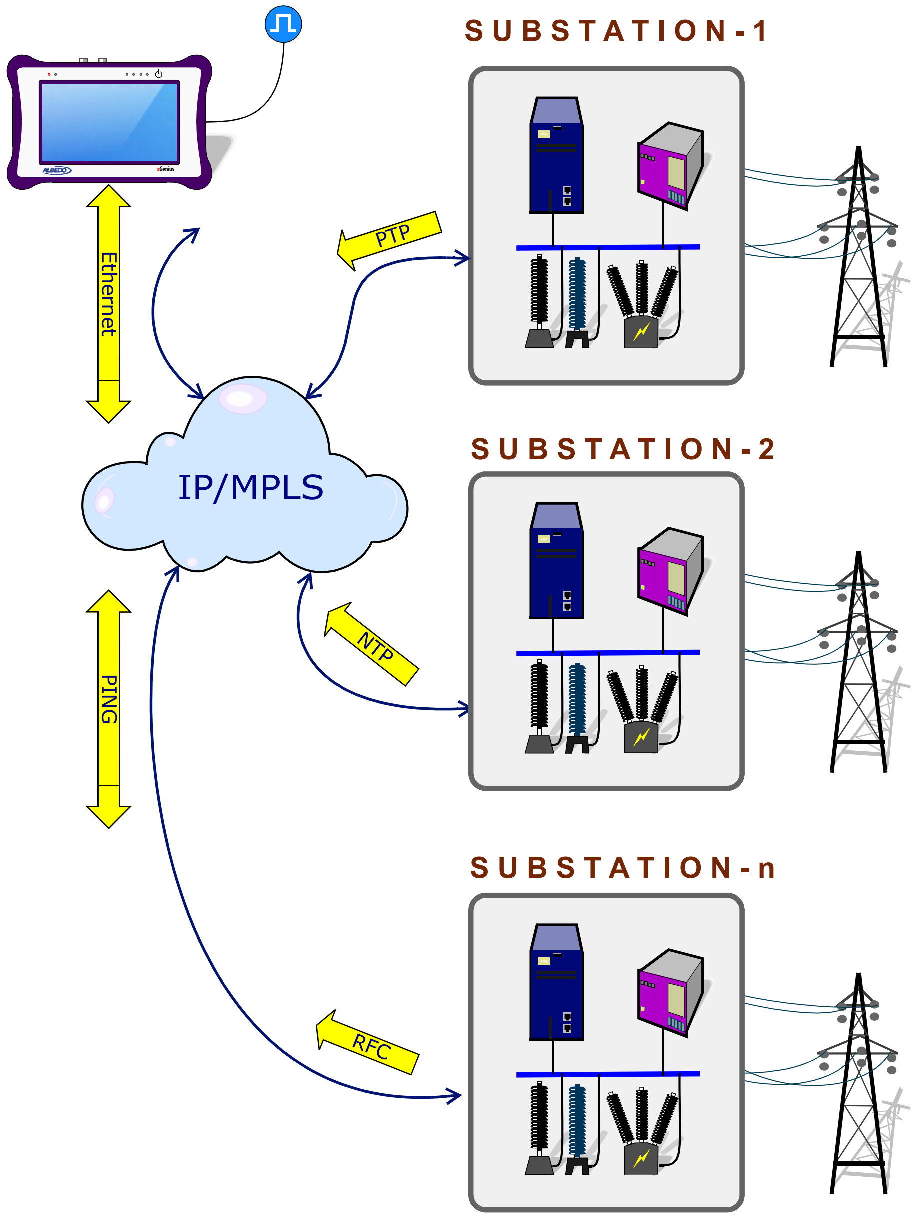

| # | Time | Delay (us) | Protocol |
|---|---|---|---|
| 707 | 0.061254230 | 0 | 00:B0:AE:03:89:68 ▶ 01:1B:19:00:00:00 ETH, PTPv2 |
| 708 | 0.003905850 | 0 | 00:B0:AE:03:89:68 ▶ 01:1B:19:00:00:00 ETH, PTPv2 |
| 709 | 0.028680623 | 0 | 00:B0:AE:03:89:68 ▶ 01:1B:19:00:00:00 ETH, PTPv2 |
| 710 | 0.029913527 | 0 | 00:B0:AE:03:89:68 ▶ 01:1B:19:00:00:00 ETH, PTPv2 |
| 711 | 0.062500000 | 0 | 00:B0:AE:03:89:68 ▶ 01:1B:19:00:00:00 ETH, PTPv2 |
| 712 | 0.002776938 | 0 | 00:B0:AE:03:89:68 ▶ 01:80:C2:00:00:02 ETH, ESMC |
| 713 | 0.001128912 | 0 | 00:B0:AE:03:89:68 ▶ 01:1B:19:00:00:00 ETH, PTPv2 |
| 714 | 0.003692400 | 0 | 00:B0:AE:03:89:68 ▶ 01:1B:19:00:00:00 ETH, PTPv2 |
| 715 | 0.054901750 | 0 | 00:B0:AE:03:89:68 ▶ 01:1B:19:00:00:00 ETH, PTPv2 |
| 716 | 0.062500000 | 0 | 00:B0:AE:03:89:68 ▶ 01:1B:19:00:00:00 ETH, PTPv2 |
| 717 | 0.002616298 | 0 | 00:B0:AE:03:89:68 ▶ 01:1B:19:00:00:00 ETH, PTPv2 |
| 718 | 0.001289552 | 0 | 00:B0:AE:03:89:68 ▶ 01:1B:19:00:00:00 ETH, PTPv2 |



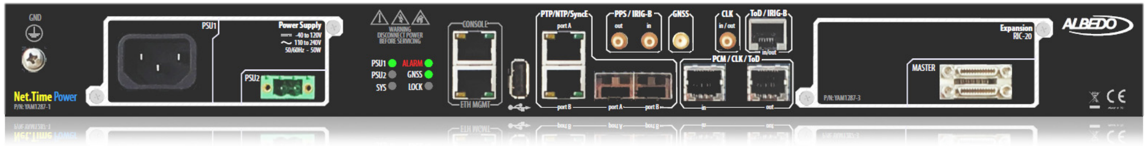

| | |
|---|---|
| Port state | Delaying time step |
| Local Stratum | 2 |
| Local Reference ID | 10.0.0.1 |
| Local Leap status | None |
| Polling Interval | 1 s |
| | |
| Peer Stratum | 1 |
| Peer Reference ID | LOCL |
| Peer Root Delay | 0.000 µs |
| Peer Root Dispersion | 0.000 µs |
| Peer Leap status | None |
| | |
| Local NTP time | 17/10/2020 11:02:31 |
| Peer NTP time | 16/09/2020 11:11:33 |



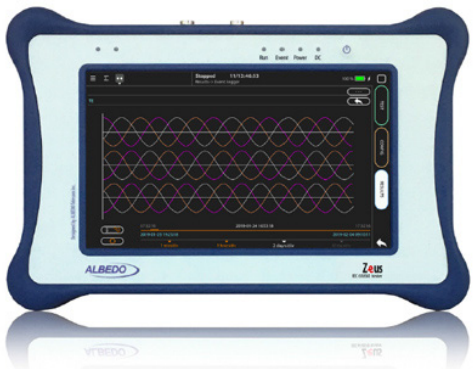

| | RX | TX |
|---|---|---|
| Symmetric Active | 0 | 0 |
| Symmetric Passive | 0 | 0 |
| Client | 0 | 9 |
| Server | 9 | 0 |
| Broadcast | 0 | 0 |
| Control | 0 | 0 |
| Other | 0 | 0 |



# ALBEDO **portfolio** for Utilities & the IEC 61850 **Power Substation** by **Layers**




**Net.Time Power** is a synchronization node, compliant with IEC 61850, that supports PTP over PRP and multiple clock options such as NTP, SyncE, 1PPS, ToD, IRIG-B, etc. to satisfy all timing needs in substations. It also includes Power and Telecom PTP profiles and Rubidium oscillator. Net.Time simplifies the provision of timing facilitating the integration of the installed plant for perfect control, protection and data acquisition.

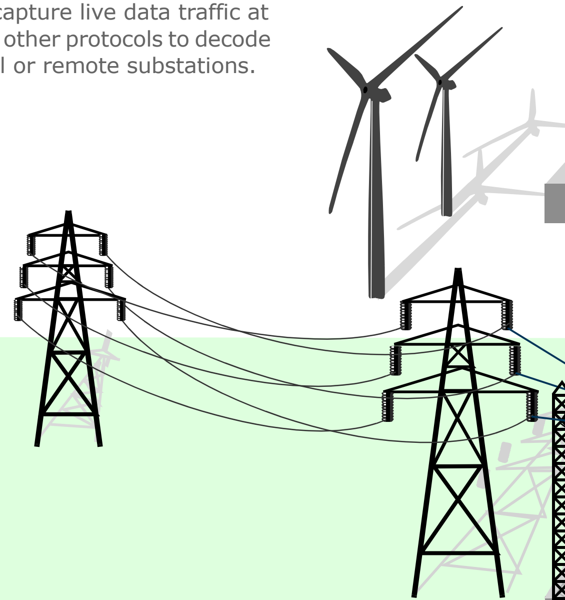


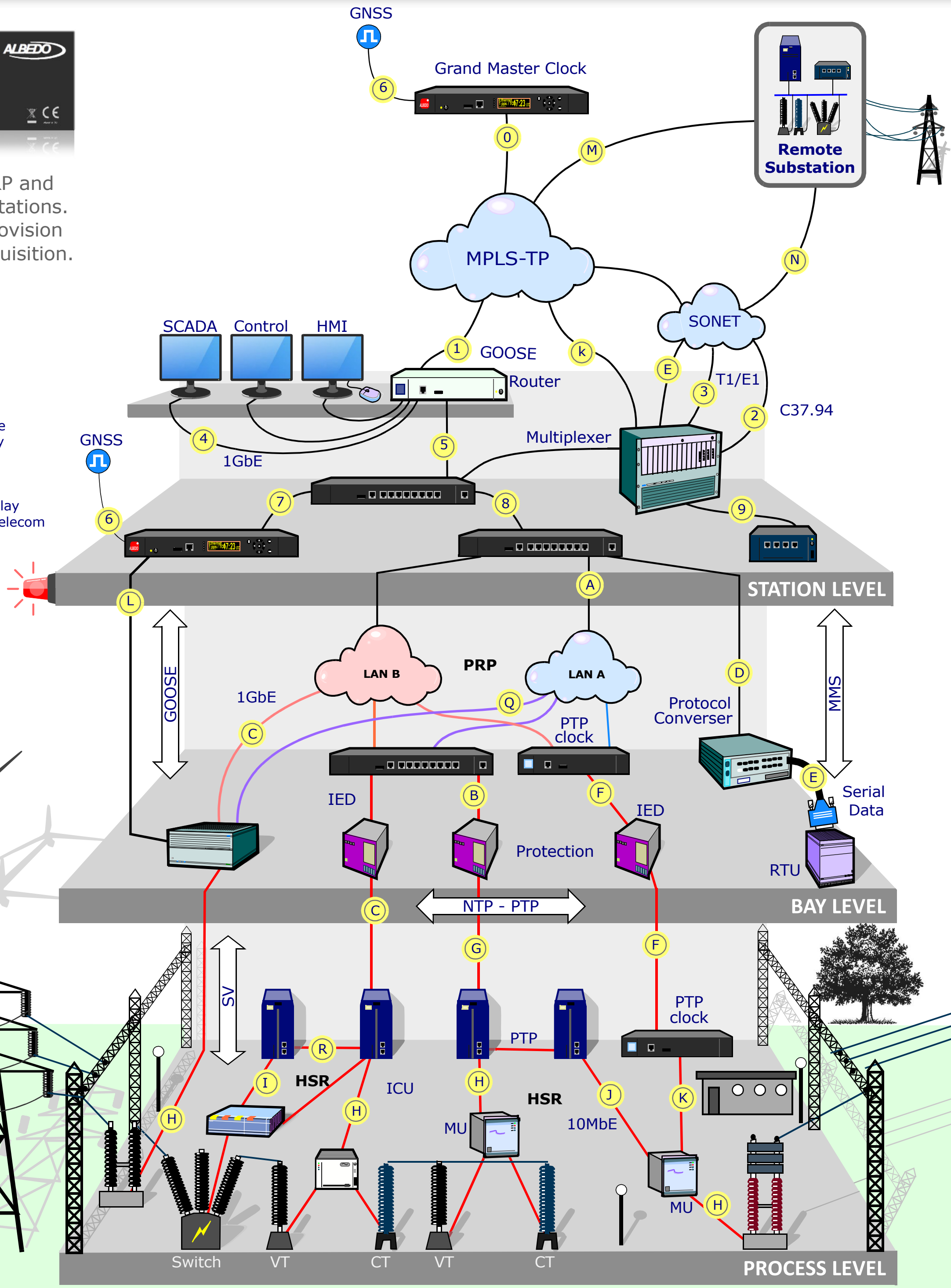

**Test & Monitoring points**

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 - GbE
N - Round Trip Delay
O - PTP Power / Telecom
Q - GOOSE offset
R - PTP wander

**Zeus** provides deep insights to design, install, maintain, troubleshoot and engineer communications infrastructures of the Smart Grid. The unit is able to test Ethernet/IP, PTP, GbE, IRIG-B, T1/E1, G703, C37.94 and GOOSE, SV and MMS protocols. One-way-delay tests, assisted by GPS, is possible at all interfaces. 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 in PCAP format or calculate delays from local or remote substations.

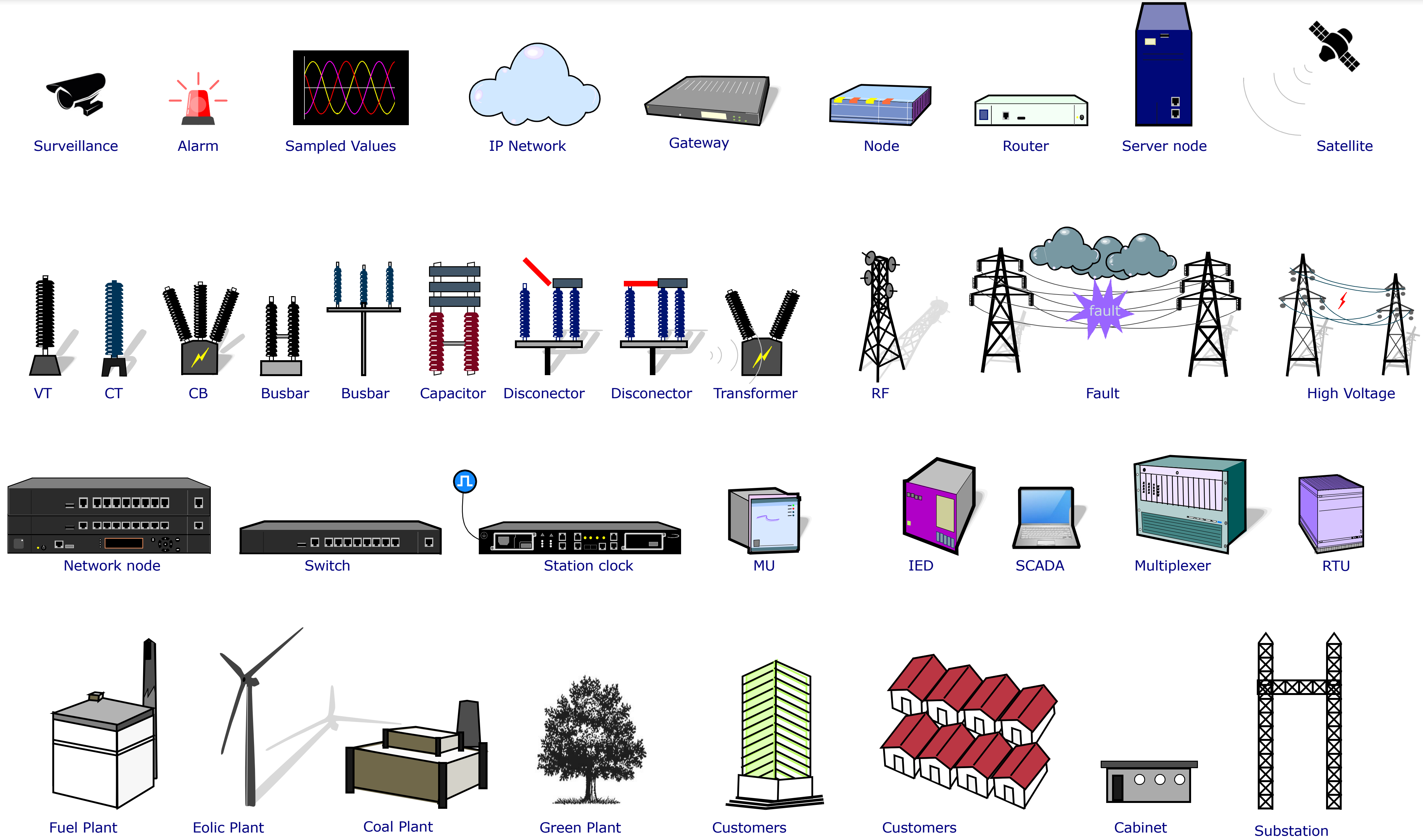

**NetStorm** can simulate the packet network dynamics by means of controlled packet delay, loss, error and duplication. It is fundamental to test the impact of these impairments that have such a strong impact on the Quality of Experience of devices, nodes, protocols and applications such as VoIP, IPTV, VoD, FTP, and critical data.





# Icons




Surveillance
Alarm
Sampled Values
IP Network
Gateway
Node
Router
Server node
Satellite
VT
CT
CB
Busbar
Busbar
Capacitor
Disconector
Disconector
Transformer
RF
fault
Fault
High Voltage
Network node
Switch
Station clock
MU
IED
SCADA
Multiplexer
RTU
Fuel Plant
Eolic Plant
Coal Plant
Green Plant
Customers
Customers
Cabinet
Substation

# Glossary

**AAA**: Authentication, Authorization, and Accounting
**ACL**: Access Control List
**AP**: Access Point
**Busbar**: Metallic strip or bar, typically housed inside switchgear, panel boards, and busway enclosures for local high current power distribution
**C37.94**: TDM interface devoted for teleprotection
**CB**: Circuit Breaker designed to close or open electrical circuit under normal or abnormal conditions. It operates on relays command.
**CBWFQ**: Class-Based Weighted Fair Queuing
**CG**: Connected Grid
**CID**: Individual configuration of each IED
**CIP**: Critical Infrastructure Protection
**CLI**: Command-Line Interface
**CorpSS**: Corporate Substation
**CT**: Current Transformer, used for measurement of current, if too high to apply directly to measuring instruments, a CT produces a proportional current which can be measured and recorded, CT are used in metering and protective relays
**DAN**: Doubly Attached Nodes implementing HSR or PRP
**DAU**: Data Acquisition Unit
**Disconnector**: isolates physically and visually the lines
**DMZ**: Demilitarized Zone
**DCB**: Directional Comparison Blocking
**DCS**: distributed control systems
**DSC**: Differentiated Services Code Point
**ESP**: Electronic Security Perimeter
**Feeder:** Transmits power to the distribution points
**GM**: Grandmaster
**GNSS**: Global Navigation Satellite System
**GOOSE**: Generic Object-Oriented Substation Events is a control model defined as per IEC 61850 which provides a fast and reliable mechanism of transferring event data over entire electrical substation networks. When implemented, this model ensures the same event message is received by multiple physical devices using multicast or broadcast services
**HMI**: Human Machine Interface
**HQoS**: Hierarchical Quality of Service
**HSR**: High-Availability Seamless Redundancy
**IA**: Industrial Automation
**ICS**: Industrial control systems
**ICU**: Intelligent Control Unit
**IEC**: International Electrotechnical Commission
**IEC 61850**: Standard defining communication protocols for intelligent electronic devices at electrical substations
**IED**: Intelligent End Device, microprocessor-based controllers of power system equipment, such as circuit breakers, transformers and capacitor banks to enable advanced power automation.
**IRIG**: Inter-Range Instrumentation Group
**ISE**: Identity Services Engine
**L3VPN**: Layer 3 Virtual Private Network
**LA**: Lightning Arrester protects the power grid from electric storms
**MQC**: Modular QoS Command-Line Interface
**MMS**: Manufacturing Message Specification, messaging system for exchanging real-time data and supervisory control information. Allows client such as SCADA, an OPC server or a gateway to access all IED objects
**MPLS**: Multi-protocol Label Switching
**MU**: Merging Unit connected to the process bus converts analog data(ie. volts, currect...) into digital information
**NERC**: North American Electric Reliability Corporation
**NIST**: National Institute of Standards and Technology
**NMS**: Network Management System
**OAM**: Operations and Maintenance
**PCP**: Priority Code Point
**PIOC**: Instantaneous overcorrent Protection
**PLC**: Programmable Logic Controller
**PMU**: Phasor Measurement Unit
**POTT:** Permissive Overreaching Transfer Trip
**PP**: Primary Power
**Process Bus**: Connects primary units and control equipment to the IEDs
**PRP**: Parallel Redundancy Protocol
**PT**: see VT
**PTP**: Precision Time Protocol
**RedBox**: Redundancy Box
**Relay:** is automatic device which senses an abnormal condition of electrical circuit and closes its contacts and complete the circuit breaker trip.
**REP**: Resilient Ethernet Protocol
**RCT**: Redundancy Control Trailer
**RTU**: Remote Terminal Unit
**SA**: Substation Automation
**SAN**: Singly-Attached Node
**Secondary Lines:** lower voltage side at the substation
**SCADA**: Supervisory Control And Data Acquisition, transmits and receives data from events of controls, measuring, safety and monitoring. Power system elements can be controlled remotely over. Remote switching, telemetering of grids showing voltage, current, power, direction, consumption in kWh, synchronization.
**SCD**: Substation Configuration Description
**SCL**: Substation Configuration Language
**SNTP:** Simple Network Time Protocol
**Station Bus**: Connects the entire substation and helps provide connectivity between central management and individual bays
**STP**: Spanning Tree Protocol
**SV**: Sampled Values, is a method to read instantaneous values such as currents, voltages, impedances, etc. from CTs, VTs or digital I/O and then transmitted to make them are available for those IED subscribed.
**Switchgear**: combination of switches, fuses or CB to control, protect and isolate electrical equipment
**SyncE:** Synchronous Ethernet
**TLV**: Type, Length, Value
**VT:** Voltage Transformer (see CT)Potential Transformer, gives the reference voltage to the Relay for Over-voltage or Under-voltage Protection
**UCA IuG**: Utility Communications Architecture International Users Group
**VDAN**: Virtual Dual Attached Node

# That's all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the Path to Excellence