



ABB Ltd / Power Systems / Utility Communications – Jan 2013

ETL600 R1 – R4

Universal Digital Power Line Carrier

ETL600 - Universal Digital Power Line Carrier

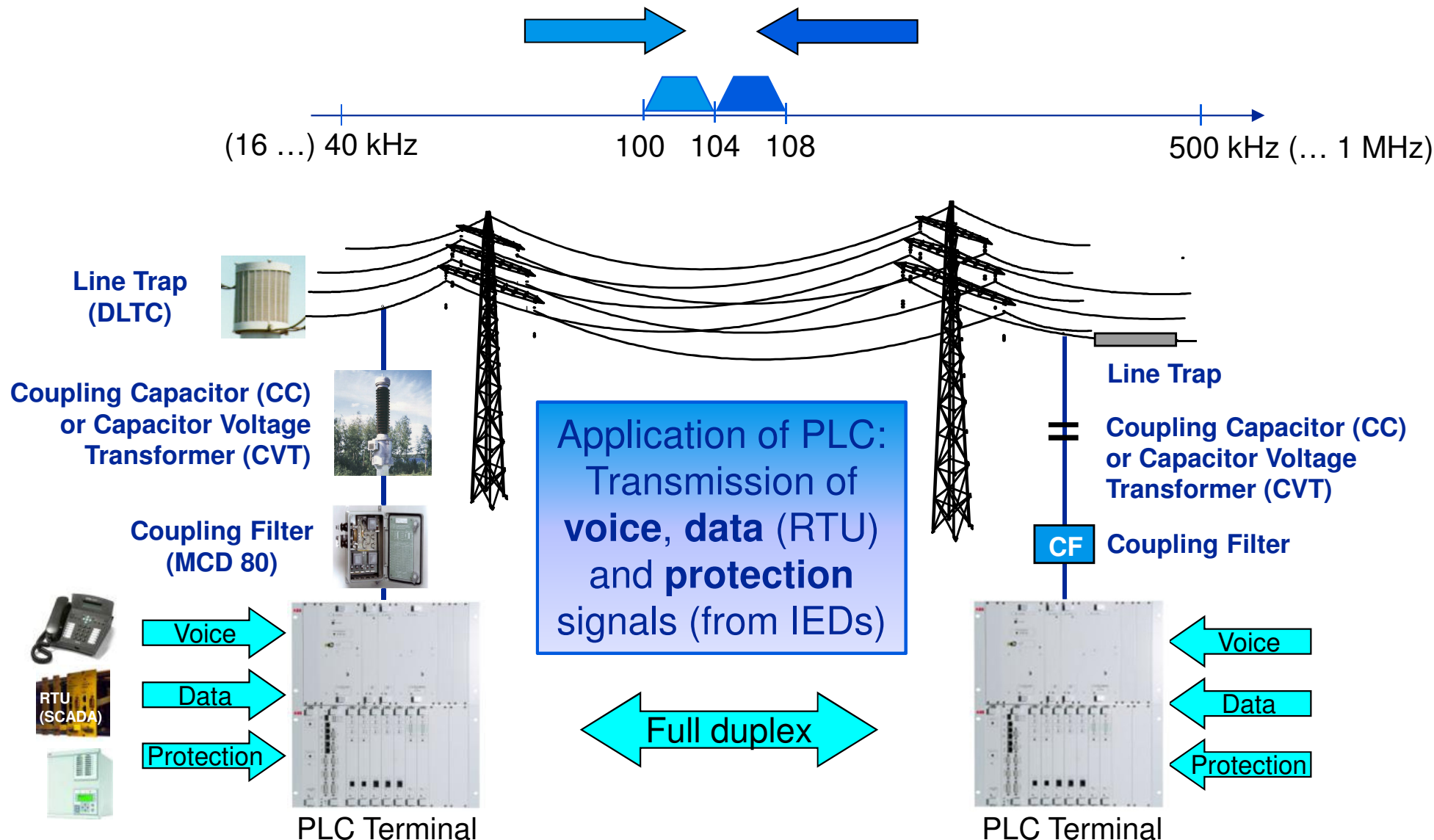
Table of contents

ETL600 R1 – R4

- Analog and/or Digital PLC
- ETL600 System Overview
- Services Multiplexing Principle
- Channel and Bandwidth Allocation
- Analog versus Digital Speech
- Integrated Teleprotection NSD600
- MOD600 / MUX600 / NSK600
- LAN600 Services
- HMI600 User Interface
- Network Management

References and Project Examples

Power Line Carrier (PLC) System



IED = Intelligent Electronic Device
(i.e. digital protective relay)

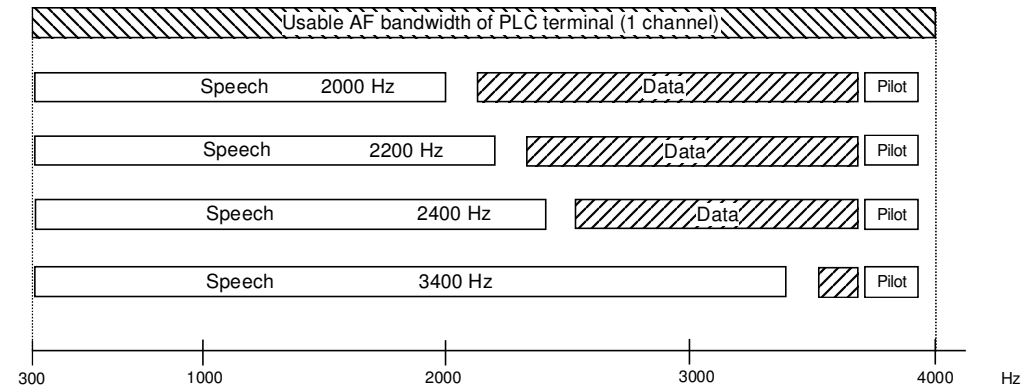
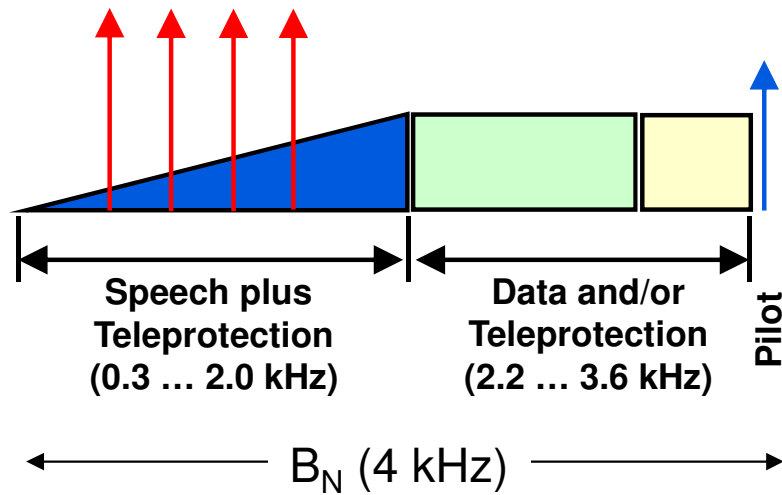
Why (still) PLC ?



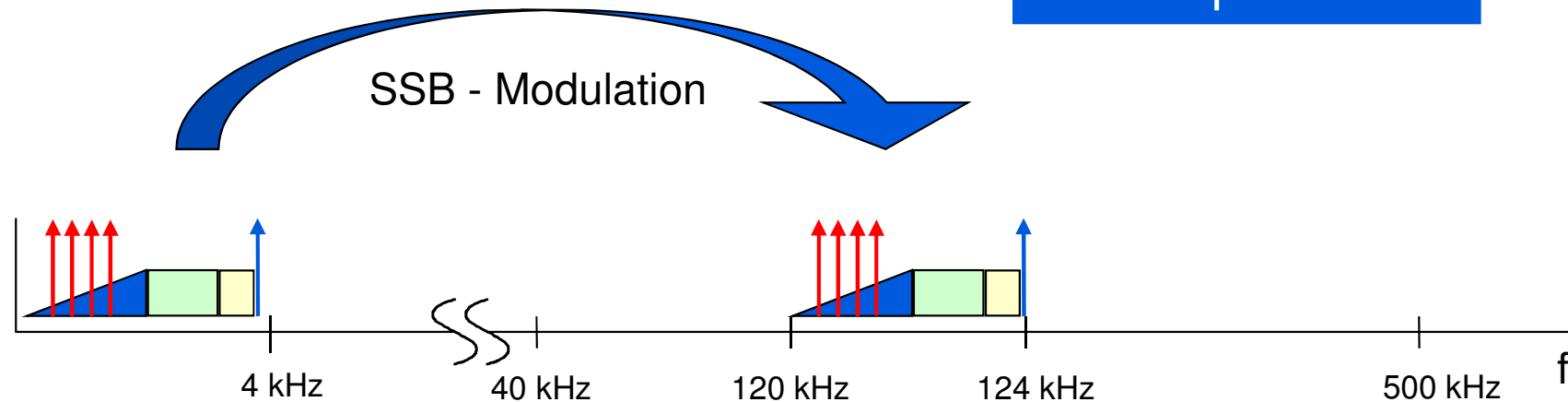
- Economic justification
- Uses existing power lines
- Transmission medium as reliable as the power line itself
- Shortest link for teleprotection
- Back-up of critical services
- Very long distances without repeaters
- Fully under control of the Electric Utility
- For the **control and protection** of the electric power grid

"Insurance"

The traditional Single Sideband PLC (SSB)



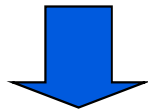
- Limited capacity
- 1 or 2 channels
- Low speed data



Modern PLC is different



- Need for higher data speeds
 - Need for more channels
 - Solve frequency congestion problem
 - Integration into Digital Networks
 - LAN/IP connectivity
 - Network management
-
- Compatibility with legacy systems, services and application practice



Analog Services

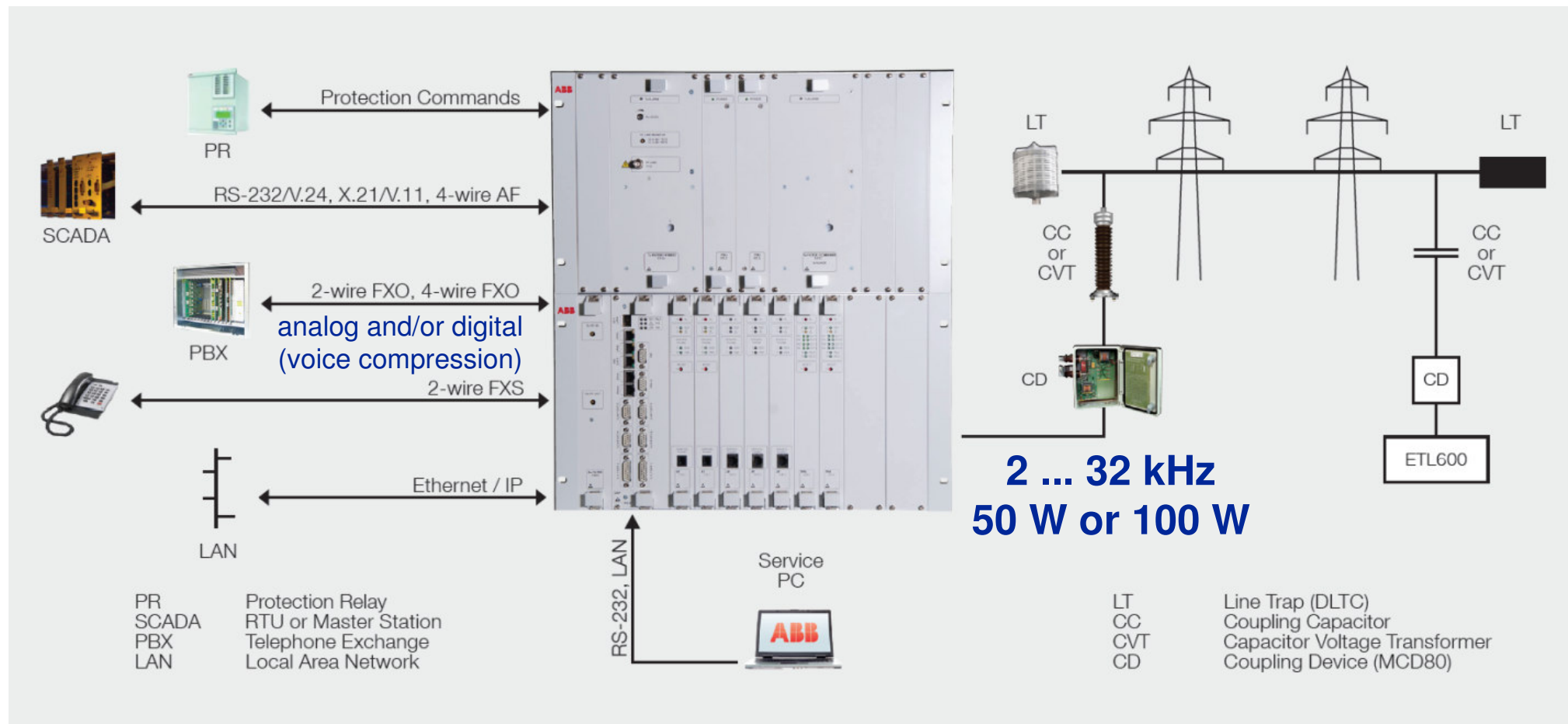


Digital Services

ETL600 – Universal Digital PLC

Power Line Carrier (PLC) System

ETL600 R4 System Overview



Multi-service equipment
 ETL600 integrates all the applications
 that are critical for electrical utilities

- Data
- Telephony
- Teleoperation
- Teleprotection

ETL600 – Key Features

ETL600-050-1

(50 W, single rack system)



- *Scalable*
- *Flexible*
- *Future-proof*

ETL600 integrates Digital PLC and Analog PLC in the same platform

Analog

- Digital emulation of Analog PLC
- Up to 3 "speech plus" channels
- Programmable Single-Side-Band modulation (SSB)
- Integrated FDM multiplexing
- Integrated Teleprotection

Digital

- Flexible bandwidth selection
- Integrated digital modulation (MCM, OFDM)
- Dynamic speed adaptation (DSA)
- Integrated TDM multiplexing
- Integrated Ethernet switch / IP router
- Up to 16 compressed telephony channels
- Integrated Teleprotection

ETL600-100-2

(100 W, dual rack system)

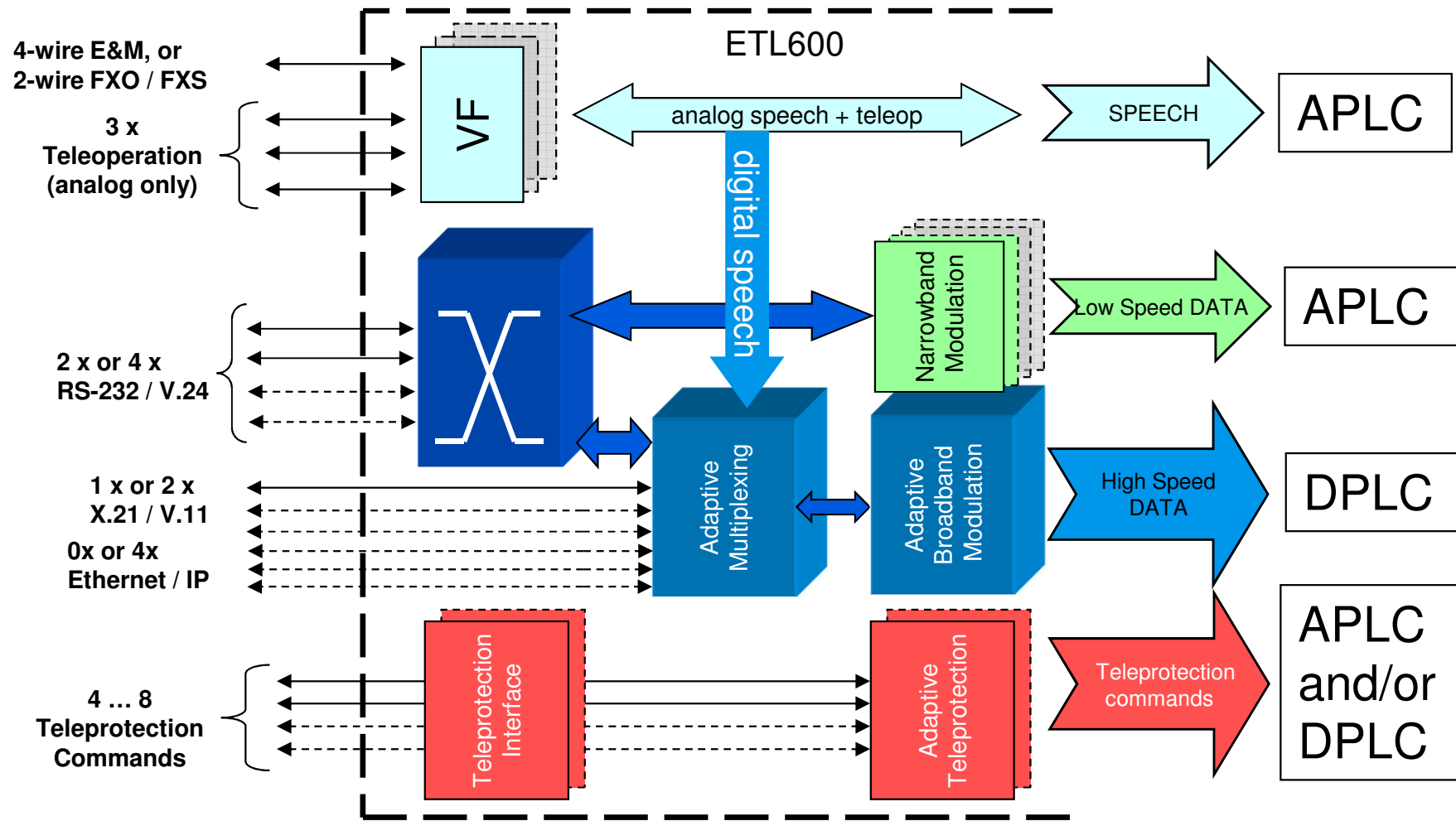


ETL600-050-2

(50 W, dual rack system)

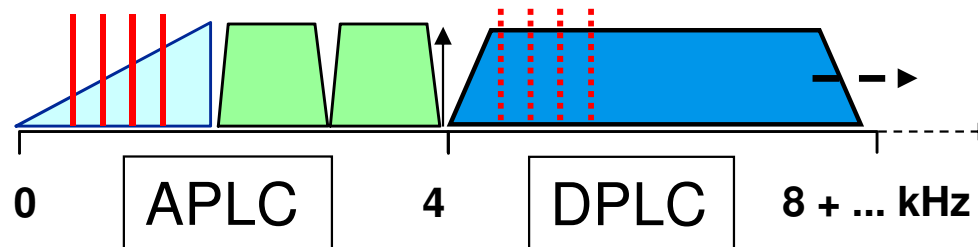
→ also available

ETL600 R4 – Services and Functions



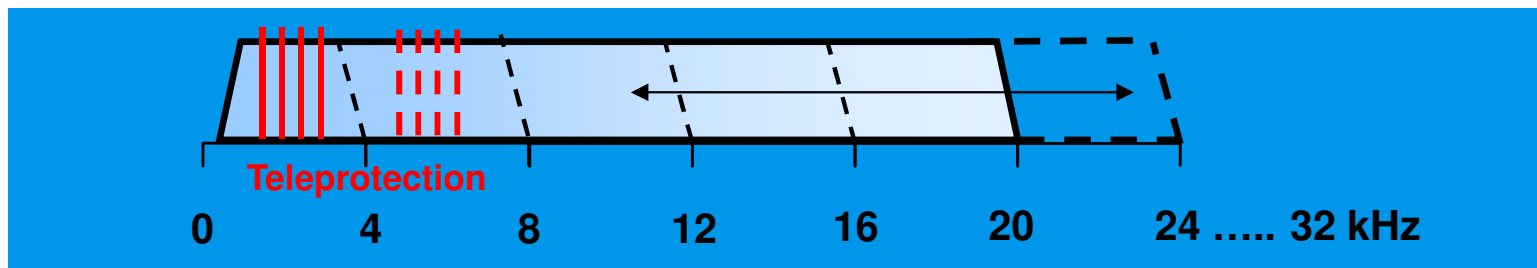
Software programmable

Up to 3 traditional analog PLC channels with 4 kHz ...



... and/or one digital PLC channel with 32 kHz max. (up to 256+ kbps data)

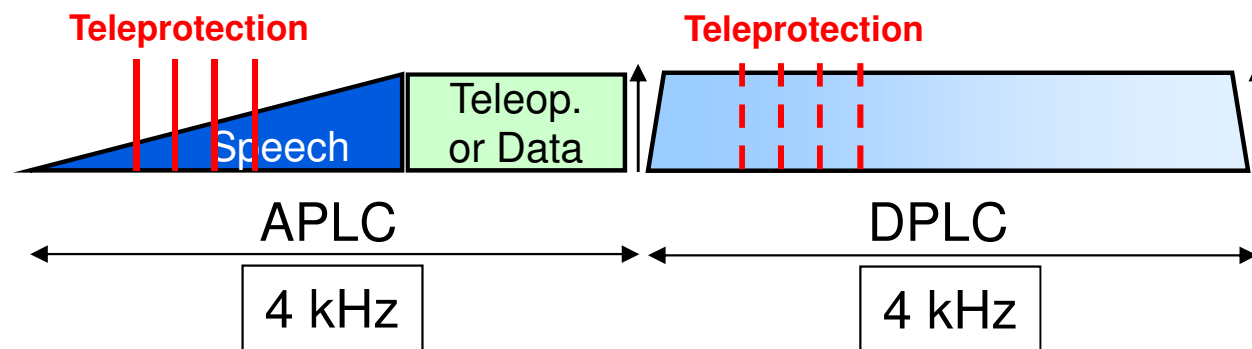
ETL600 - Flexible Bandwidth Selection



Up to 3 traditional analog PLC channels with 4 kHz ...

... and/or one digital PLC channel with 32 kHz max. (up to 256+ kbps data)

Example:

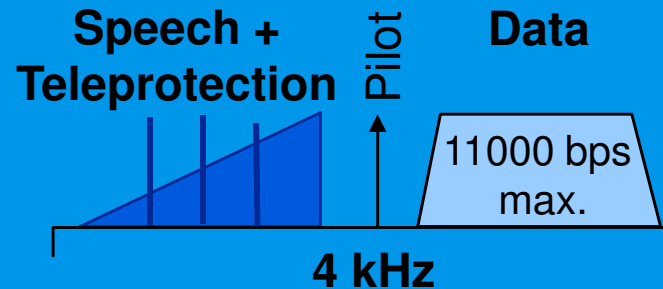


- *Use the bandwidth as you prefer*
- *Increase functionality as you need*

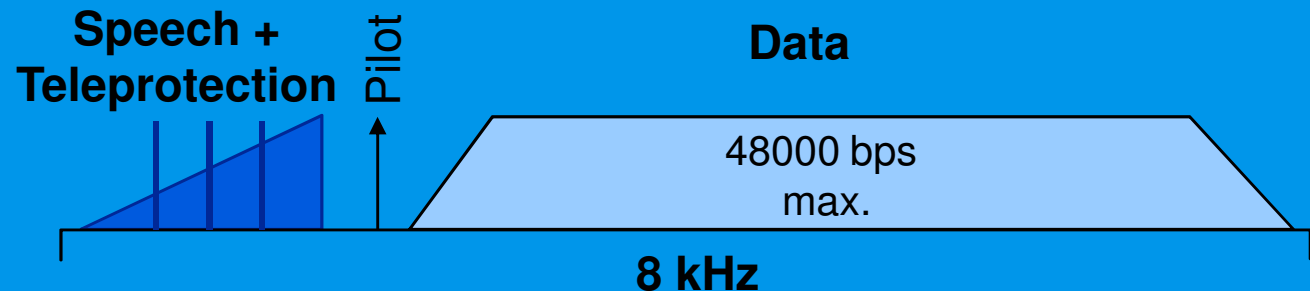
MOD600: Optimized Bandwidth Utilization

Configurable DPLC bandwidth: **2**, 4, **6**, 8, 12, 16, 20, 24, 28, 32 kHz

0, 1 or 2 x
APLC 4 kHz
+
1 x APLC 2 kHz
1 x DPLC 2 kHz

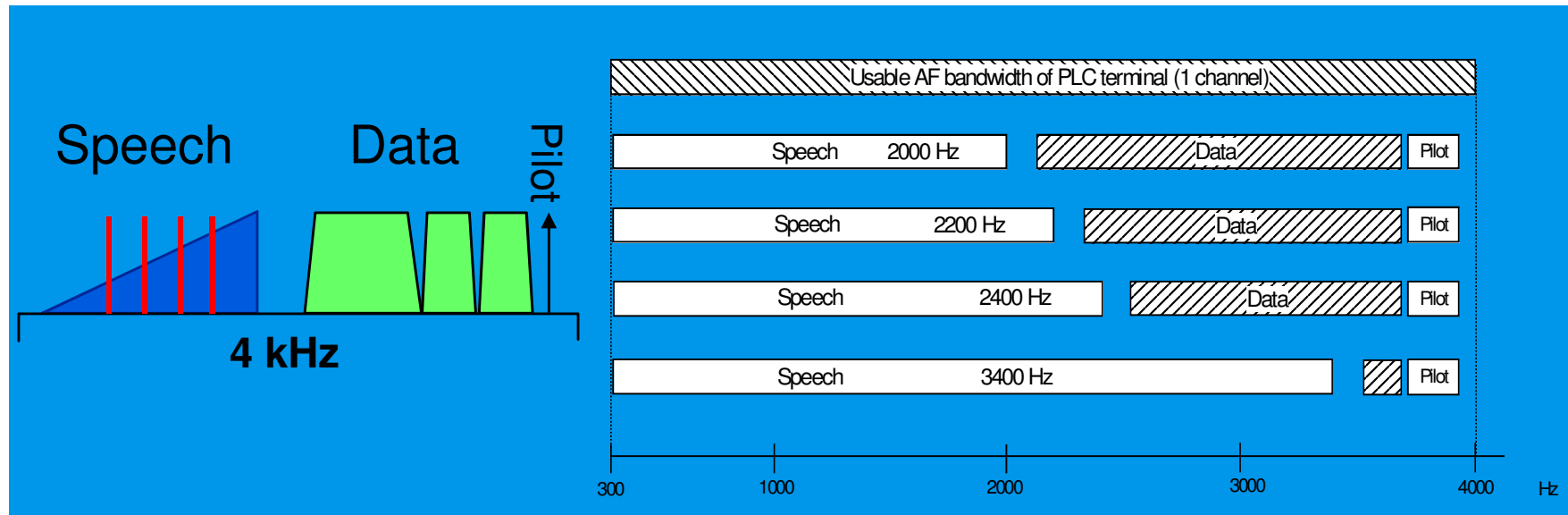


0, 1 or 2 x
APLC 4 kHz
+
1 x APLC 2 kHz
1 x DPLC 6 kHz



- *Optimum use of the scarce bandwidth resource*
- *Best fitting into existing frequency plans*
- *Low delay for analog speech in transit operation*

Utilization of 4 kHz APLC Channel(s)



- **Speech**
 - 4-w E&M, 2-w FXO, 2-w FXS with ringing
- **Teleprotection**
 - 4 independent and simultaneous commands in speech band
- **Data**
 - 4 integrated programmable Narrowband Modems (100 bps to 9600 bps)
 - Very low delay, very short resynchronization time
 - 4 x 2400 bps or 2 x 4800 bps or 1 x 9600 bps in 4 kHz band
 - 2 x 2400 bps or 1 x 4800 bps above speech 2000 Hz

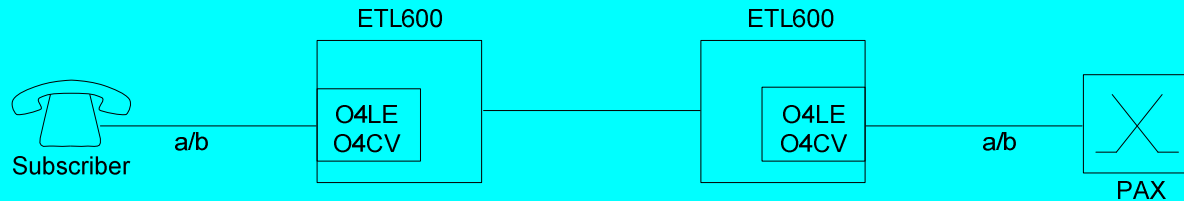
Single, double or triple channel operation

Telephony Operation Modes

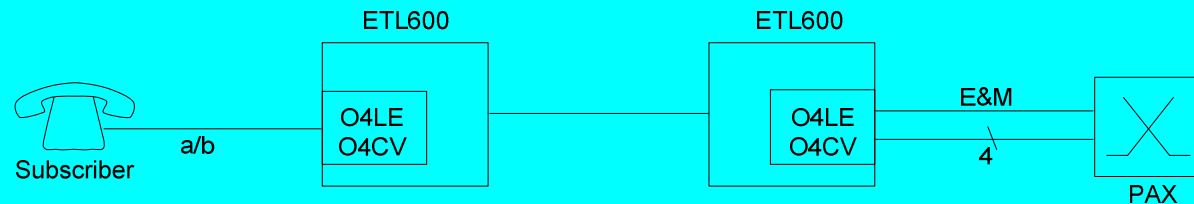
2-wire Service Phone
2-wire point-point hot
line (direct phone)



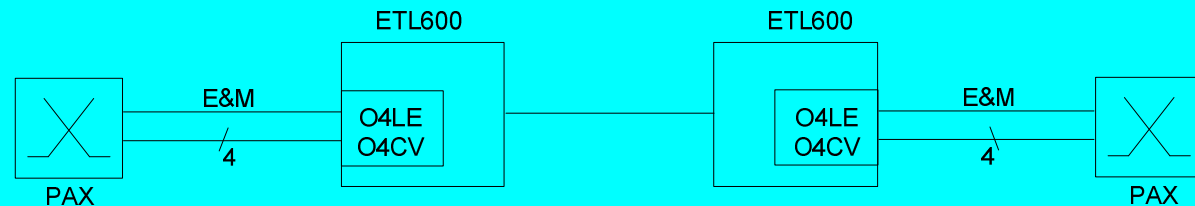
2-wire
Remote Subscriber



4-wire
Remote Subscriber

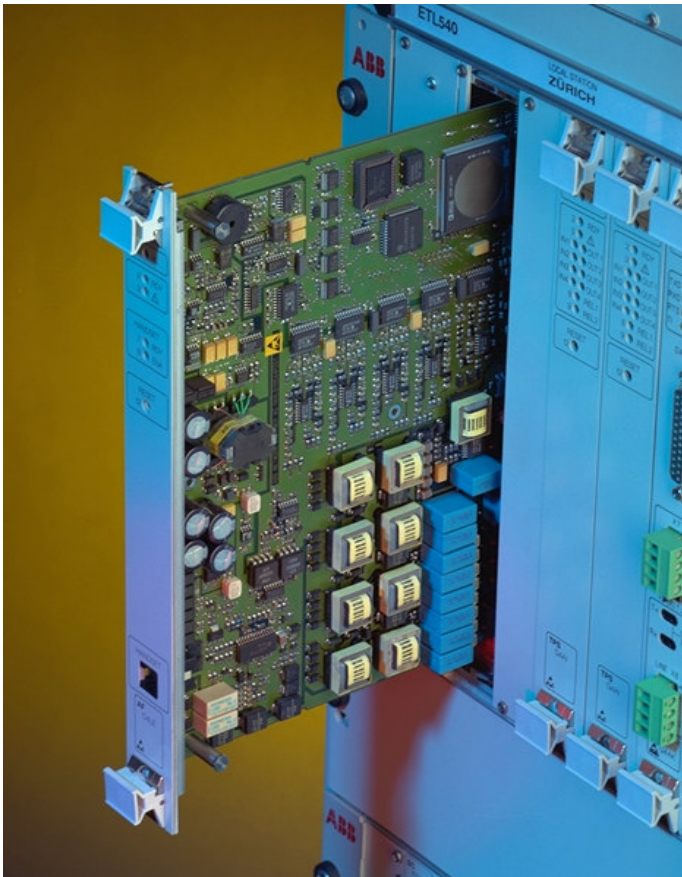


4-wire PABX
with E&M signaling



PAX - Private Automatic eXchange
PABX - Private Automatic Branch eXchange

Analog Speech plus Teleoperation



VF (O4LE)

- Universal Voice Frequency interface module for "transparent" transmission of
 - Speech signals
 - One telephony channel, I/Os programmable for
 - 4-wire E&M ("Ear & Mouth" signaling)
 - 2-wire Foreign eXchange Subscriber (FXS), or Foreign eXchange Office (FXO)
 - Hotline or Service Phone
 - Teleoperation signals
 - 4 VF teleoperation I/Os, 300 to 3720 Hz (with telephony -> 3 teleoperation I/Os)
 - 4 **programmable digital transit filters** (with telephony -> 2 digital transit filters)
 - configurable to I/P or O/P ports
- Up to 5 interface modules pluggable

Integrated Vocoder

Digital Compressed Speech

- More speech channels
 - “Clear voice” - no disturbing corona noise
-
- 4 channels per module, up to 4 modules pluggable
 - Speech compression acc. ITU-T G.723.1
5.3 kbps (ACELP) or 6.3 kbps (MPC-MLQ)
 - up to 4 speech channels in 4 kHz
 - up to 8 speech channels in 8 kHz
 - up to 16 speech channels in 16 kHz
-

More speech channels - noise-free



Integrated Digital Voice Compression

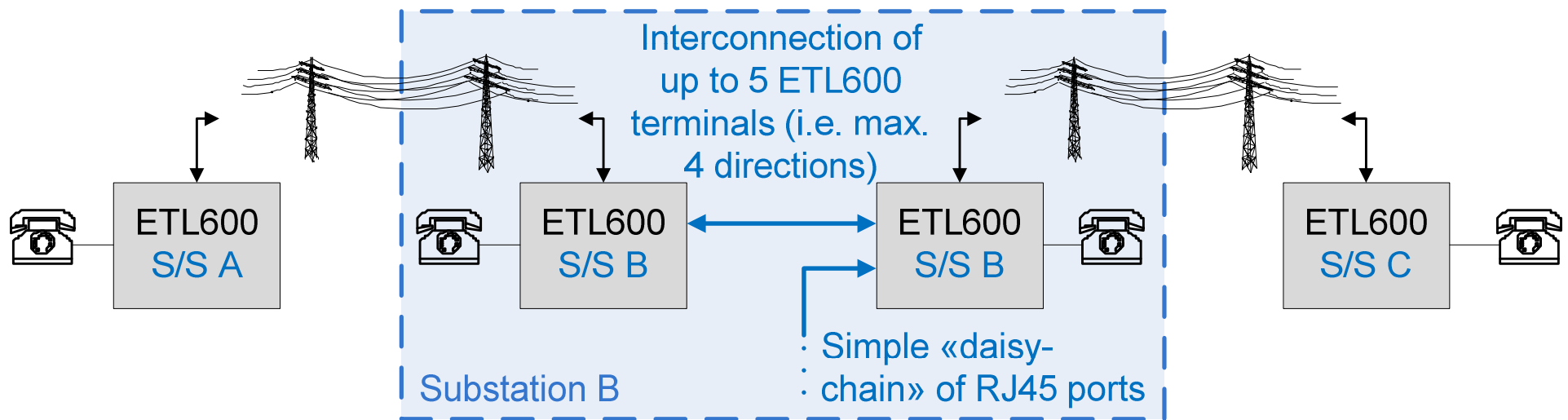


Digital Speech (O4CV)

- Configurable interfaces per channel
 - Foreign eXchange Subscriber (FXS)
 - Foreign eXchange Office (FXO)
 - 4-wire with E&M signaling
- Voice coder, optimized for human voice
 - according to ITU-T G.723.1
 - with 5.3 or 6.3 kbps data rate
- Services
 - Voice
 - FAX
 - Signalization
 - DTMF
 - E&M with pulse-code dialing
 - Call Progress Tones CP (dial-, busy- & idle-tones)

ETL600 R4

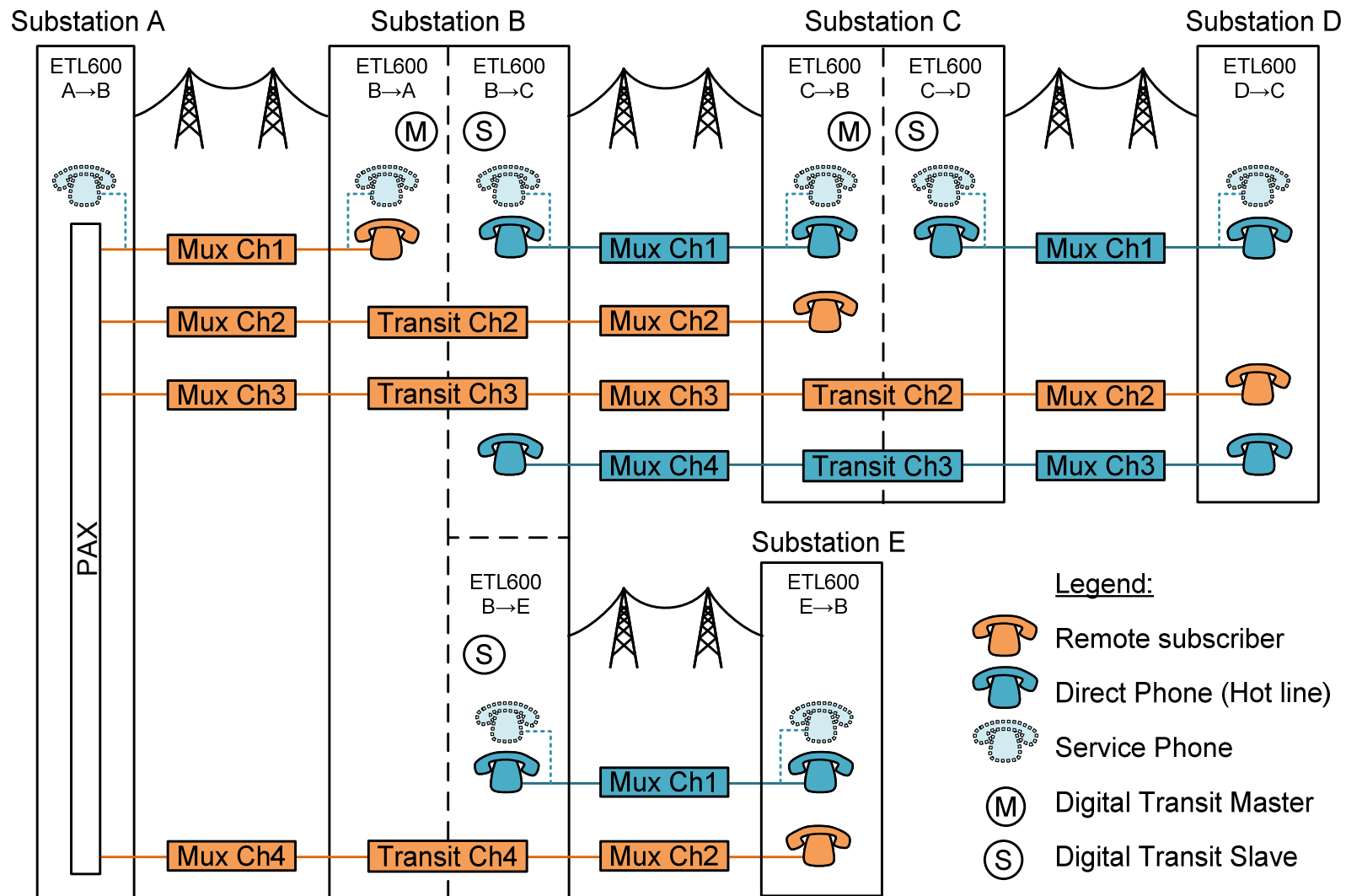
Digital transit of compressed voice channels



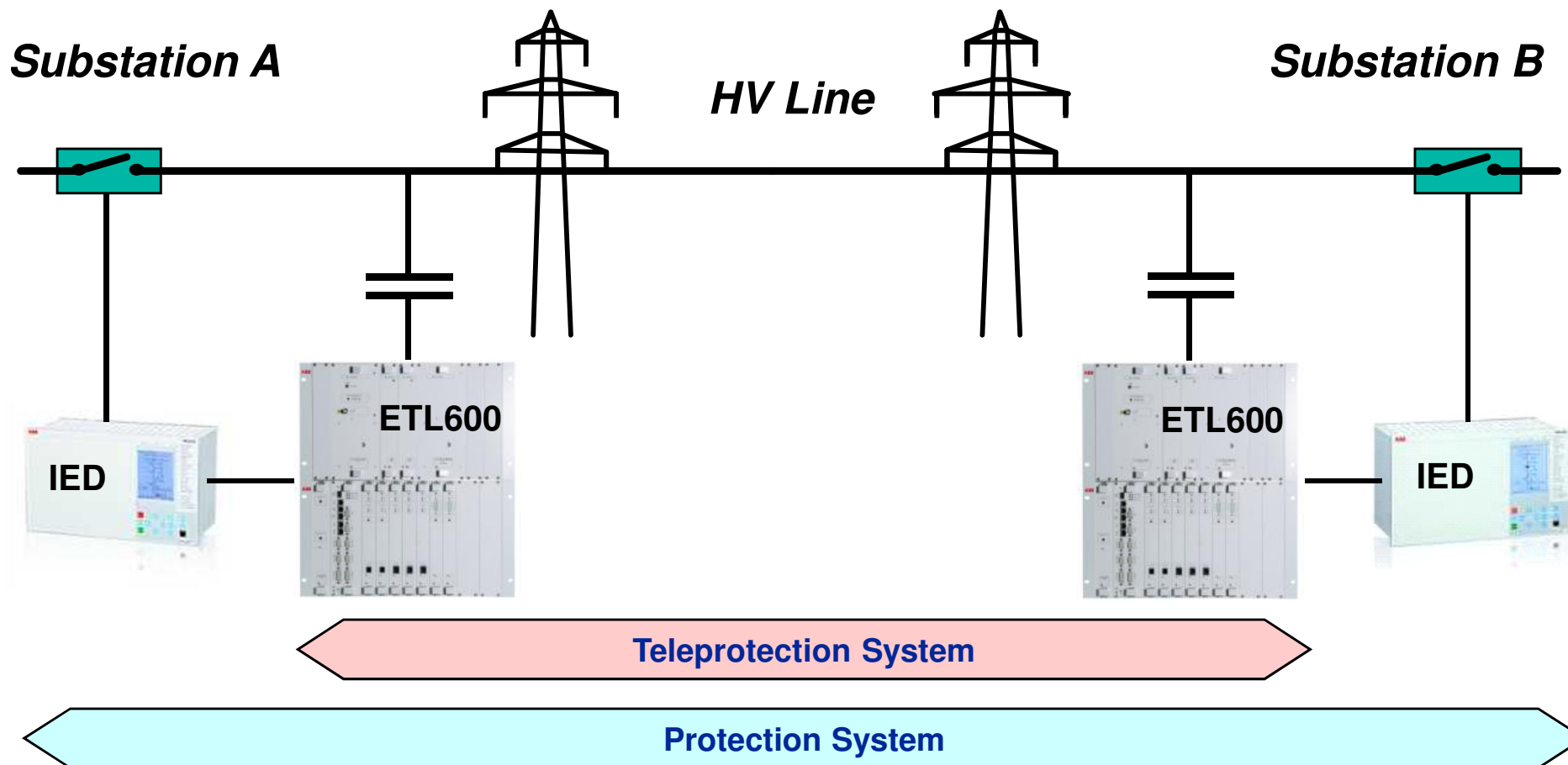
- **Reduced delay** and **unchanged speech quality** for digital transit
→ no compression / decompression procedures required
 - Increased number of compressed telephony links connected in tandem:
Analog Transit **max. 3**, Digital Transit **max. 6** (i.e. 5 intermediate stations)
- Local use or through connection of selected channels
 - Max. 16 compressed voice channels per ETL600 terminal
 - Transferred from a single source ETL600 to a single destination ETL600

ETL600 R4

Digital transit of compressed voice channels - example



Integrated Teleprotection



*Integrated Teleprotection eliminates the need for external devices
➔ Performance and reliability optimized solution*

Integrated Teleprotection Equipment NSD600

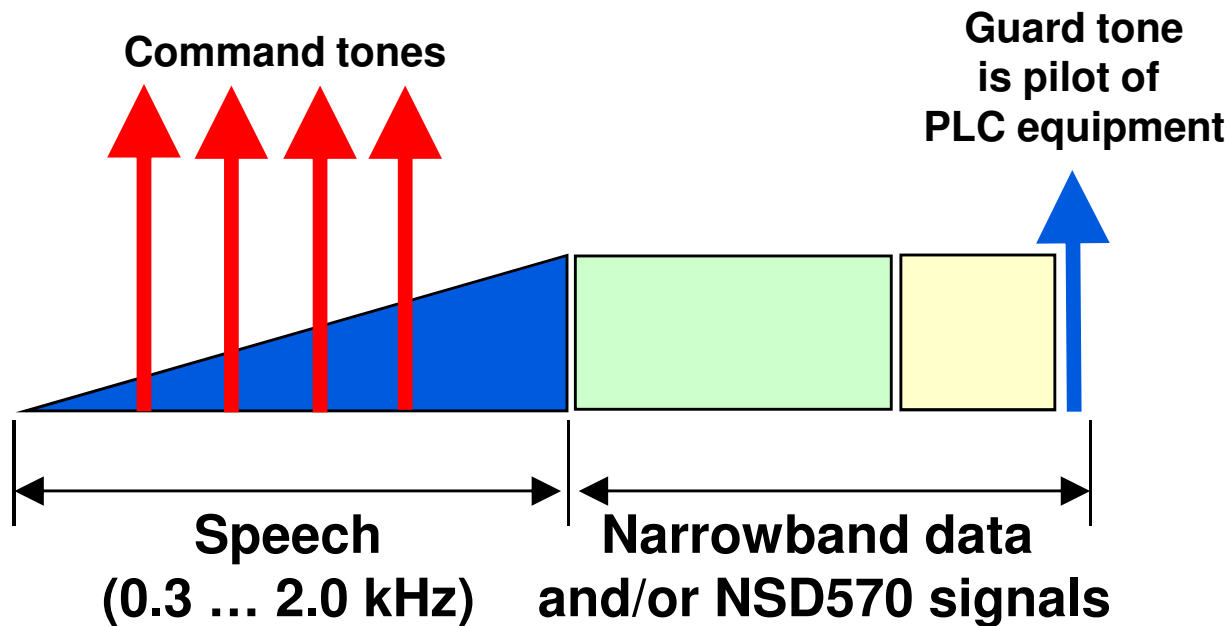


- For the transmission of **blocking, permissive- and direct tripping** protection commands
- 4 commands in 4 kHz bandwidth
- 8 commands in 8 kHz bandwidth
- Commands are **independently configurable** and **simultaneously transferrable** in any combination (patent protected)
- **Adaptive signal evaluation for shortest transmission times**, without compromising security (patent protected)
- **No extra bandwidth** required:
 - Alternate operation with speech
 - Alternate operation with data

Fast, dependable and secure

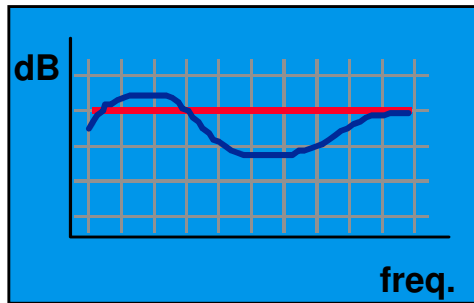


NSD600 Functionality



- Requires virtually no bandwidth
- Command signals transmitted in PLC speech band
- **Signal boosting** for best use of available Tx power
- Guard signal = PLC pilot
- Programming of own NSD600 guard signal is possible

Adaptive Equalizer for DAPSK Modems NSK600

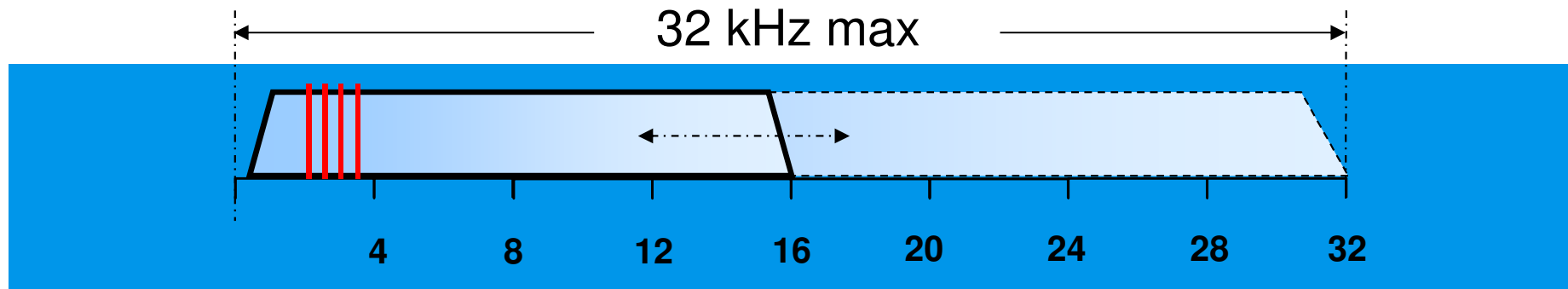


Fact:

Higher bandwidth efficiency DAPSK modems are more vulnerable to changing line conditions over time (e.g. due to varying load energy)

- **ABB solution** (patent protected):
 - **Adaptive equalizer** for modems with data transfer rates of 2'400, 4'800 and 9'600 bps working with DAPSK modulation (**D**ifferential **A**mplitude and **P**hase **S**hifted **K**eying)
 - Up to 4, i.e. 1 individual equalizer for each DAPSK modem
- Allows **maintenance free operation** of the DAPSK modems
- **Improves data link reliability / long term performance**

High-speed data transmission



Bandwidth (kHz)	Max. data speed (kbps) *)
4	32
8	64
12	96
16	128
20	160
24	192
28	224
32	256

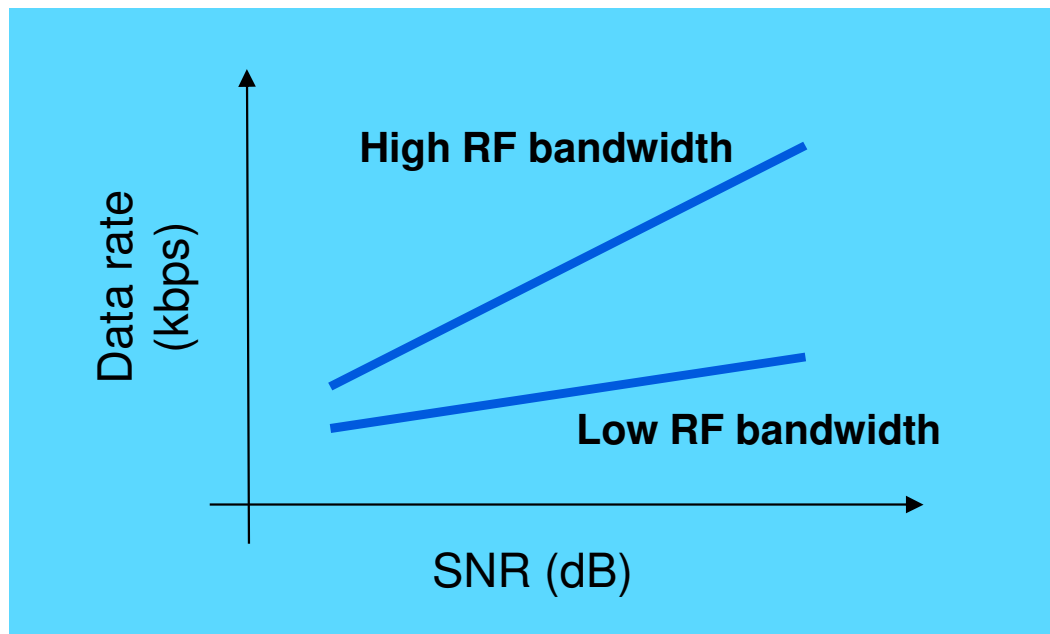
- **Programmable bandwidth**
- **Dynamic speed adaptation (DSA)**
- **Automatic jammer suppression**
- **Internal TDM Multiplexer for 10 data channels and 16 compressed voice channels**

**) actual speeds depend on prevailing line condition (signal attenuation, noise level)*

High speed data transmission

The available data speed depends on:

- The spectral bandwidth (kHz)
- The Signal-to-Noise ratio (SNR) at the receiver input (dB)

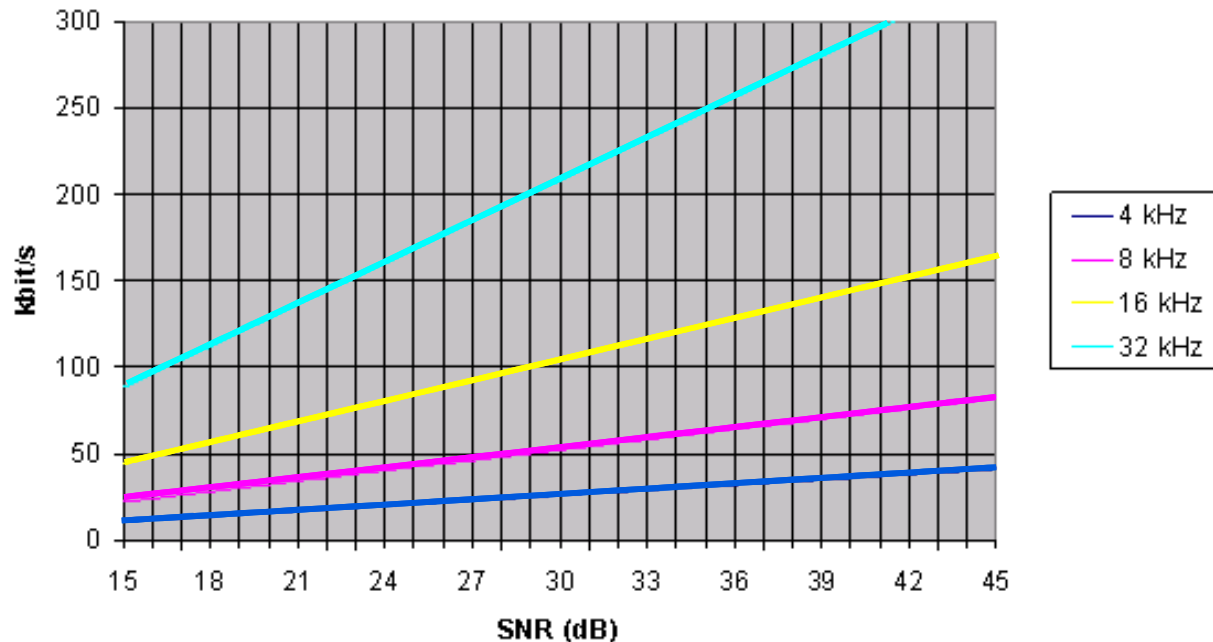


Signal quality (SNR) is weather dependent

ETL600 uses automatic / **dynamic speed adaptation** for **optimum performance** and **highest data throughput**

ETL600 – High speed data transmission

Historically, data speed over PLC channels had been limited to few kbps. Now up to 300 kbps are possible!



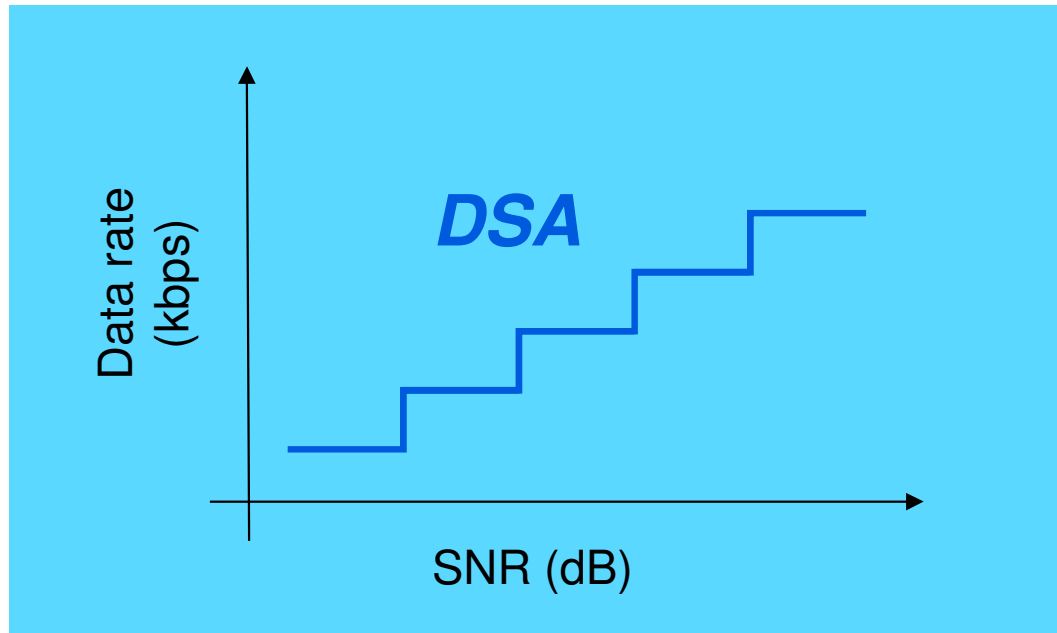
foul ... fair weather

- Higher speed = higher vulnerability by line noise
- Go / No-Go threshold characteristic of digital systems may cause communication to fail

➔ **Automatic/dynamic speed adaptation is a must!**

- *Data transmission speed up to 300 kbps*
- *Dynamic Speed Adaptation + Automatic Jammer Suppression for maximum data throughput and availability*

DSA - The key to high link availability



foul ... fair weather
high low noise

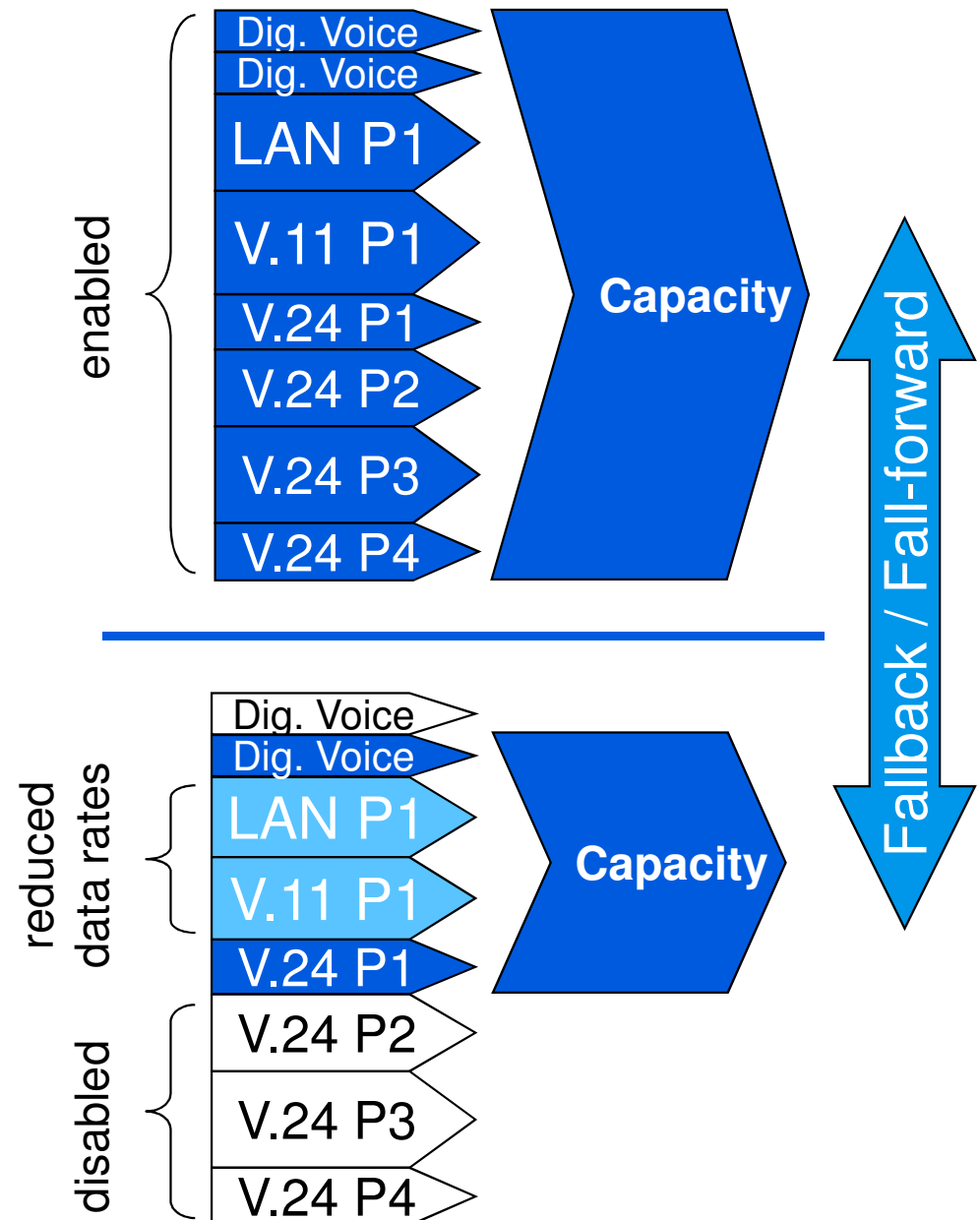
- DSA keeps your system running over a wide range of SNR
- Highest average data throughput
- Sustained operation under difficult channel conditions

- *Dynamic Speed Adaptation (DSA)*
automatically adapts the data rate to the prevailing line conditions
- *Programmable service priorities*
- *Teleprotection always has 1st priority*

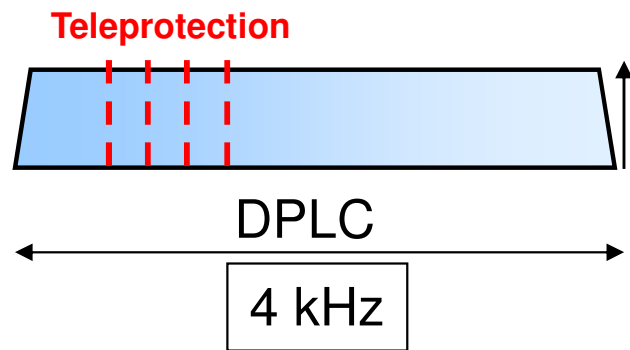
Fallback/Fall-forward and adaptive multiplexing

- The sum of the data speeds assigned to the data ports cannot exceed the speed of the MOD600 modem capacity
- The speed of the broadband modem follows the prevailing line condition (SNR) in 5 user-defined steps
-> Dynamic Speed Adaptation DSA
- In case of fallback/fall-forward:
 - The V.11 / LAN ports adapt their speed according to user-defined data rates
 - The V.24 / compressed voice ports are disabled/enabled according to a user-defined priority scheme
 - Data flow is controlled via hardware handshake (CTS, DCD)

DSA for maximum data throughput and availability



Digital “speech plus”: up to 16 channels



Example

Services:

Speech channels (5300 bps)
Data 9600 bps (V.11)
Data 4800 bps (V.24)
Teleprotection

Weather:

fair	foul
3	1
1	0
2	2
1	1

Fallback / Fall-forward

- Advantages:
 - More services in the same bandwidth compared to traditional analog services
 - No disturbing noise effects (corona) -> clear voice (essential for transit operation of speech channels)
 - Full digital system -> longer reach, higher reliability

LAN600: Provides Three Services

1. Switching/Routing

- Transmission of Ethernet/IP traffic over PLC link (via MUX/MOD600)
- No external switch/router needed (4 port switch, 16 IP routes)
- Efficient use of LAN600 capacity due to IP packet header compression (TCP/IP → RFC 1144, VoIP → RFC 3095)

2. HMI over LAN

- Direct access over LAN, in addition to RS-232 interface
- Remote broadband access over DPLC, instead of EOC (100 Bd)

3. SNMP (Simple Network Management Protocol)

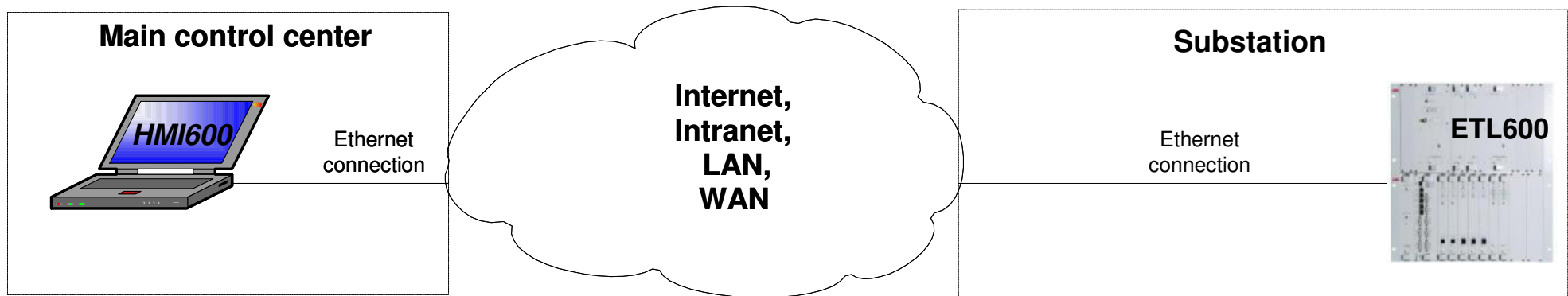
- ETL alarm polling with SNMP interface (SNMP v1 and v2 supported)
- Supervision of mixed ETL500/ETL600 networks possible
- Integration in communication network management system

- *3 electrical ports (10/100Base-TX with auto MDI/MDIX)*
- *1 optical port (SFP transceiver)*

LAN600 Service “HMI over LAN”

- **Application**

- HMI600 direct connectivity to ETL600 via notebook Ethernet port
- HMI600 remote connectivity to ETL600 e.g. over S/S LAN



- **Security**

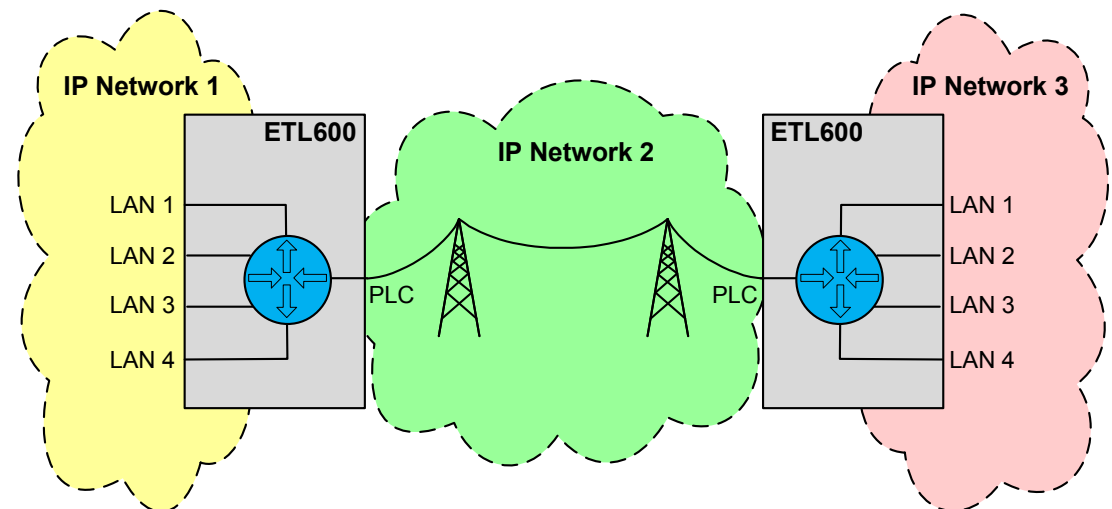
- Secure remote connection of HMI600 to ETL600 using SSL (Secure Sockets Layer), with authentication (internal private key, exchange of public key and certificates)
- User administration in ETL600 (individual accounts with three-level access rights view/modify/admin; password check → must meet complexity requirements)
- ETL600-internal logging of security relevant data and manipulations (to support NERC CIP or other cyber/IT security standards)
- Password protection for local connection via RS-232 (to get write access)

LAN600 Service “Switching/Routing”

- 4 priority queues
- Flow Control
- IP header compression (RFC 1144, 3095)
- Link Fault Pass Through

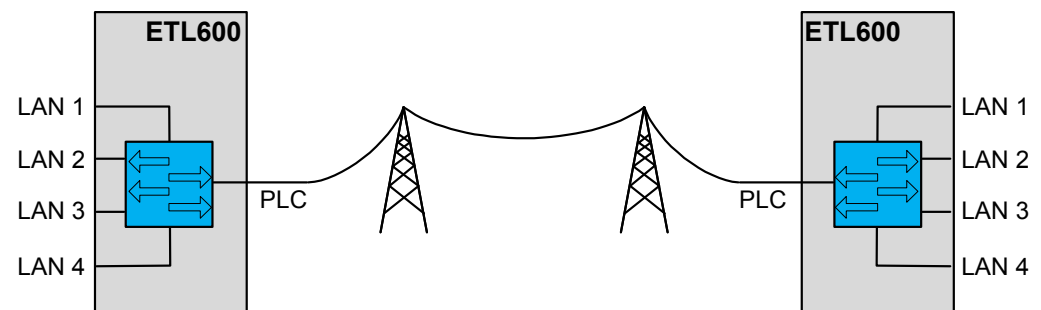
- **Router Mode**

- 16 routes configurables
- Port based priority



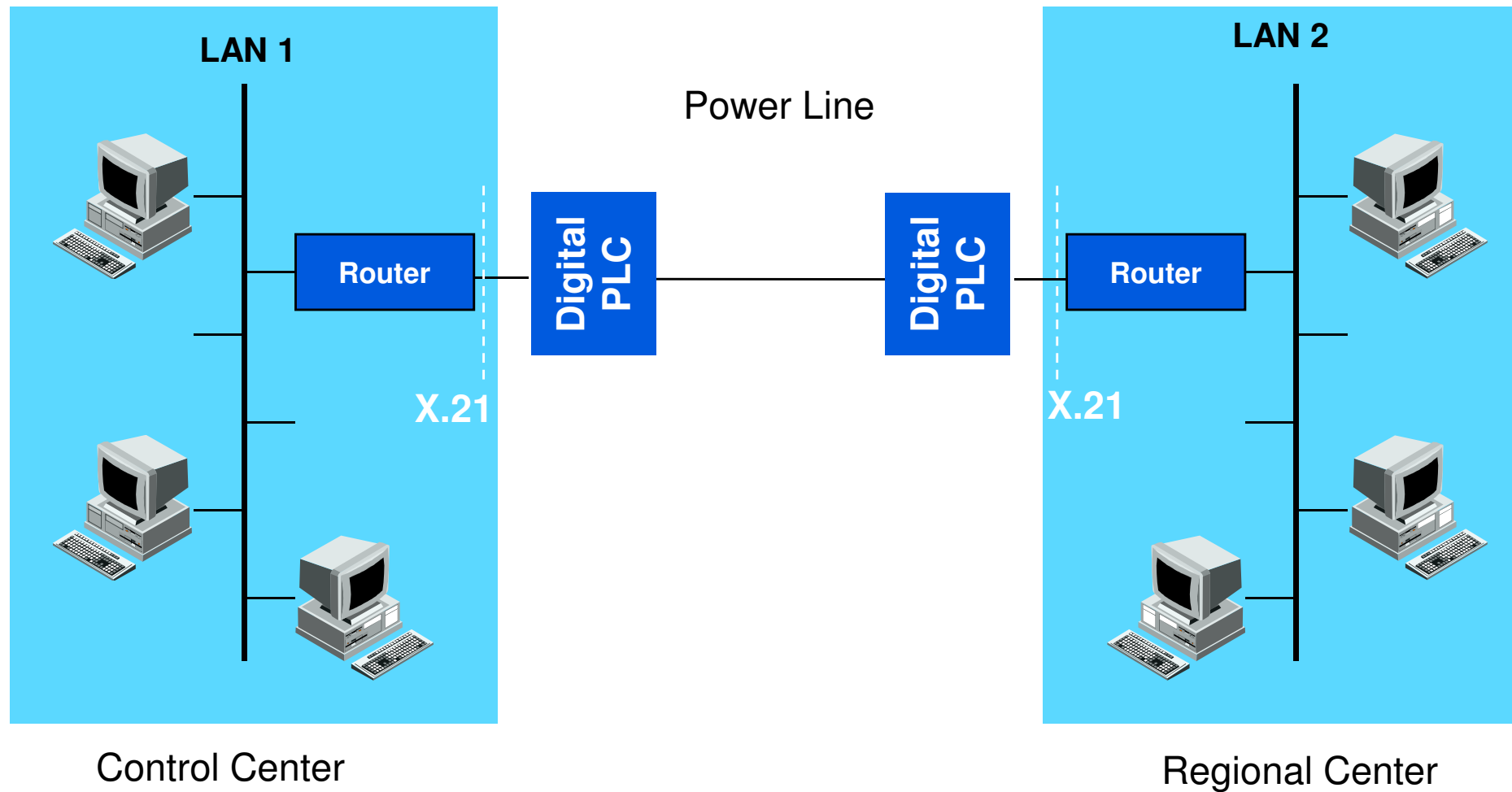
- **Switch Mode**

- VLAN support (IEEE 802.1q)
- MAC self-learning with ageing function



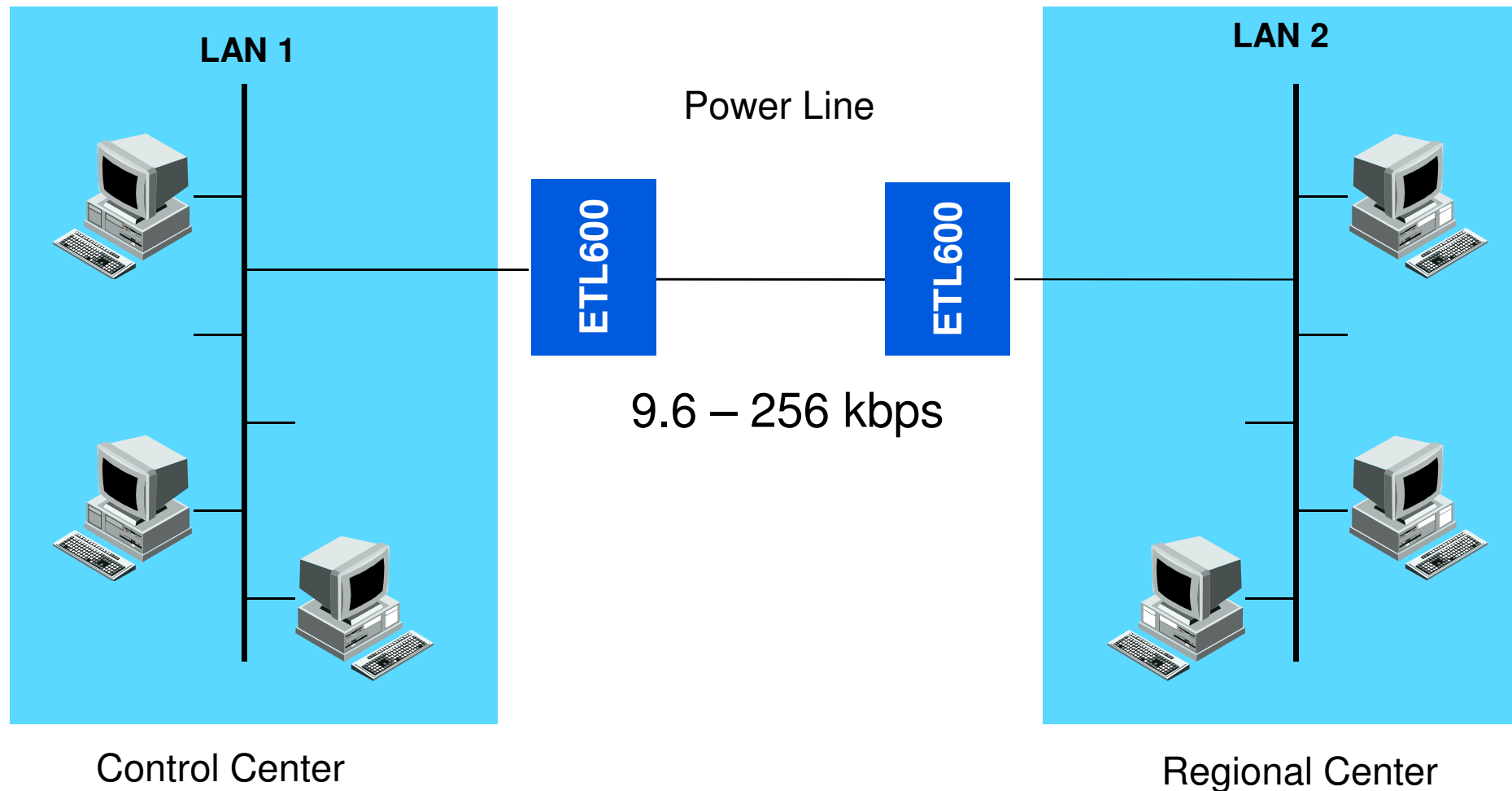
LAN Coupling: Without ETL600/LAN600

LAN – Coupling requires external router



LAN600 Service “Switching/Routing”

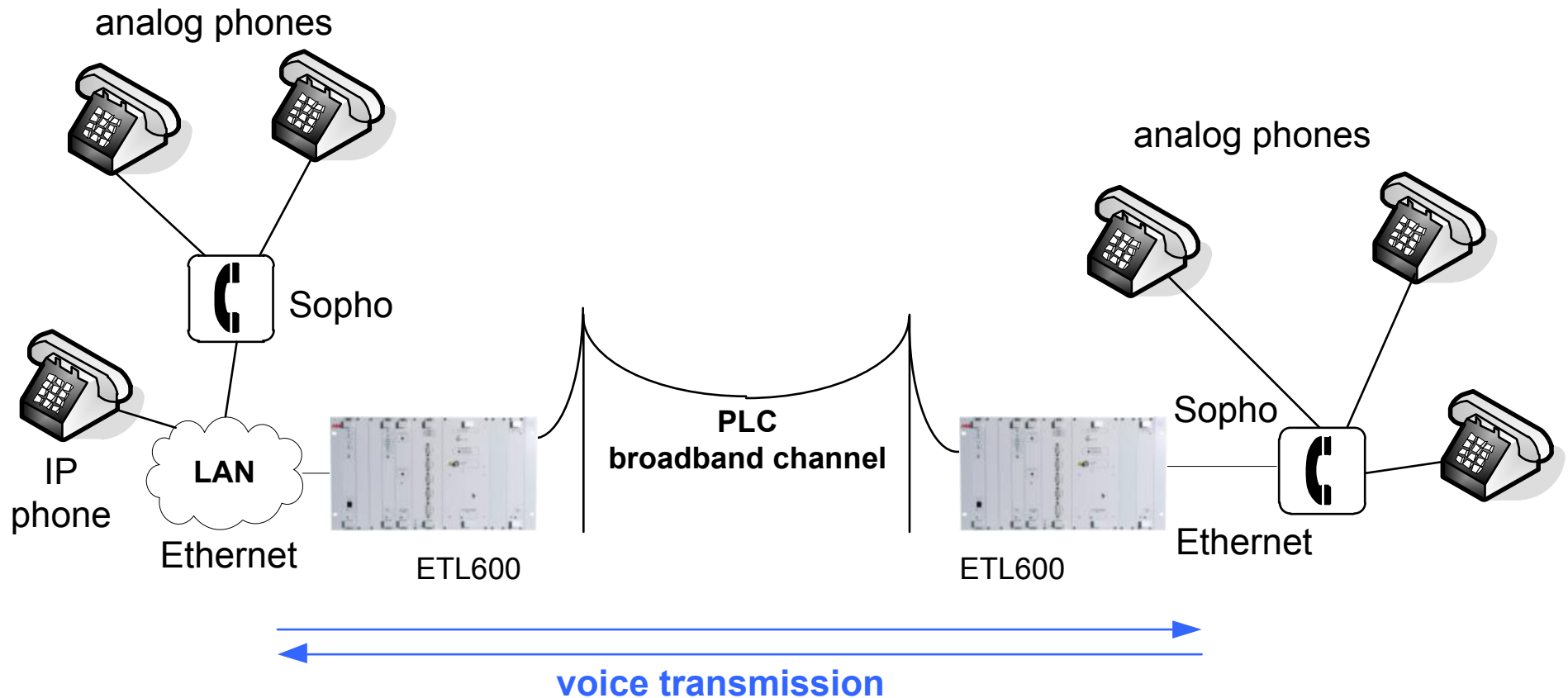
LAN – Coupling without external router is possible



***Fall-back / fall-forward supported
→ Speed adapts to link condition***

Typical VoIP Application

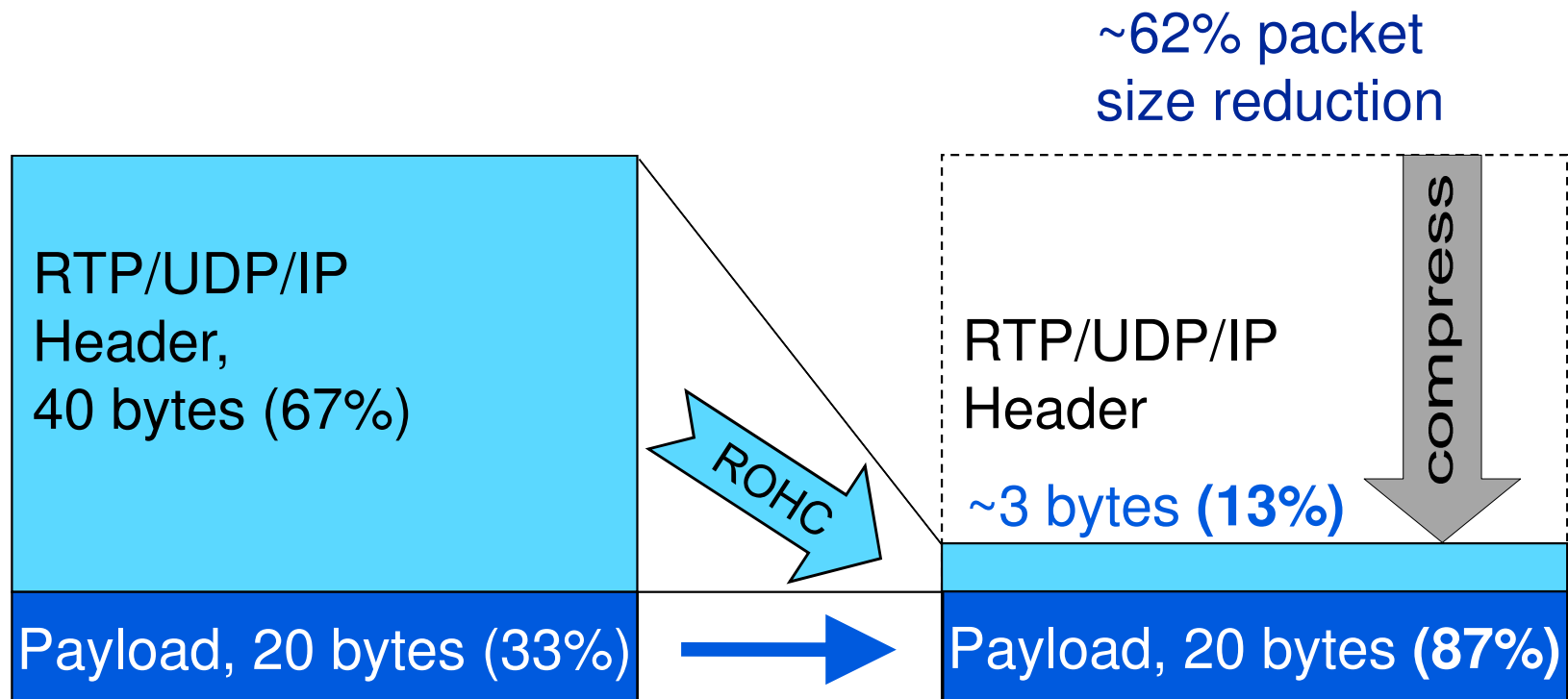
Customers want to transmit IP-based voice traffic over the ETL600 PLC link



IP = Internet Protocol
LAN = Local Area Network
PLC = Power Line Carrier

Robust Header Compression (ROHC)

- ROHC according to RFC 3095
 - Example for G.729 codec (8 kbit/s), 20 ms packet interval
 - From 40 header bytes down to approx. 3 bytes (under optimal conditions)

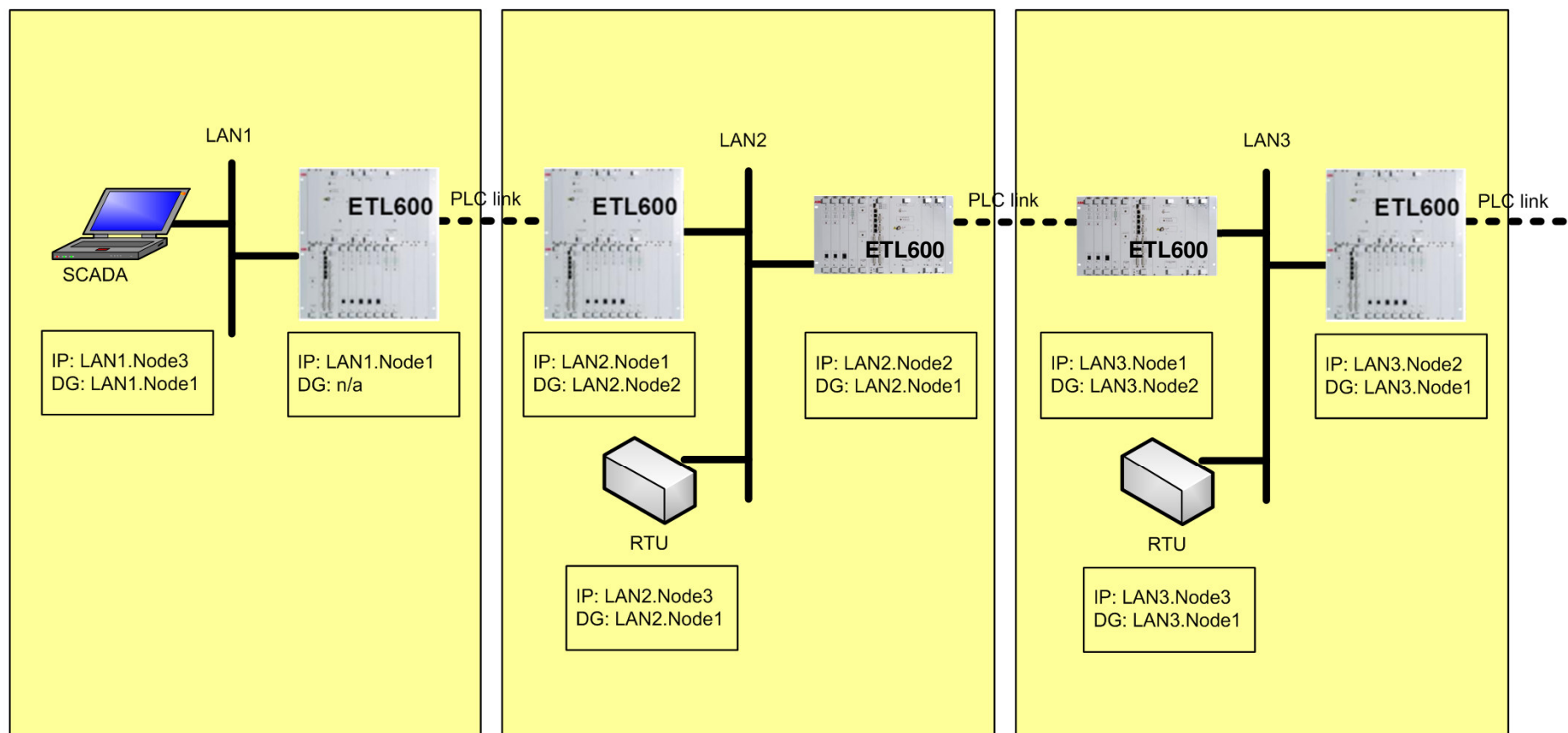


LAN600 Application

Integrated Ethernet/IP functions

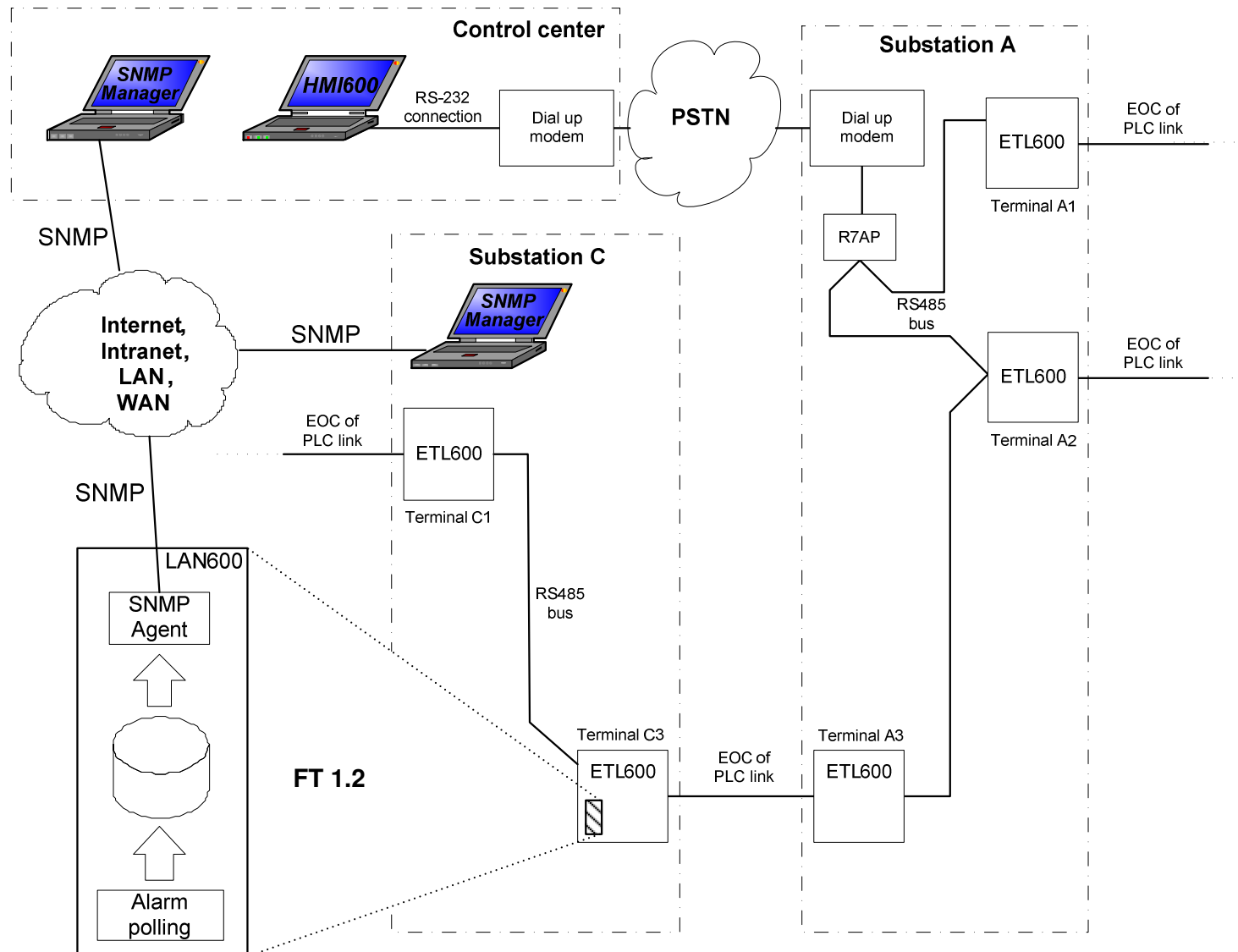
Example: TCP/IP based SCADA according IEC60870-5-104

Use Case: RTU Polling, IP Routing



LAN600 Service “SNMP”

→ Up to 5 SNMP management stations can be served



FT = Transmission Frame Format according IEC 60870-5-1

ETL600 - Human-Machine Interface HMI600



***Simplified Commissioning,
Operation and Maintenance***

- Windows®- based HMI
 - Equipment settings
 - System monitoring
- Commissioning support
 - Link equalization
 - Filter tuning
 - Spectral analysis
- In-service monitoring
 - Local and remote terminal
 - Equipment status
 - Link performance
 - Alarm polling (network)

ETL600 GUI HMI600 with integrated test tools

Configure system

Equipment settings | Channel settings | Alarm settings | Alarm relays on R1BC

RF

Tx nominal frequency f_n [kHz]: 132.0

Rx nominal frequency f_n [kHz]: 100.0

Swap Tx and Rx frequ.

S-value: 6.0

S-value non-disconnectable: 0.0

Max. power (PEP) [dBm]: 50

ETL600 overall channel mode

☒ Erect (APLC low, DPLC high)
☐ Inverted (DPLC low, APPLC high)

APLC channel mode

3 channels of 4 kHz; CH1, CH2, CH3 inverted

RF position

APLC/DPLC splitting of nominal bandwidth

Nominal bandwidth B_n : 32 kHz
 APPLC bandwidth: 12 kHz
 DPLC bandwidth: 20 kHz

Bandwidths of APPLC channels

Bandwidth CH1: 4 kHz
 Bandwidth CH2: 4 kHz
 Bandwidth CH3: 4 kHz

AF

Pilot frequency [Hz]: 3840

Allpass filter for group delay equalization (transmitter-sided): ☒ enabled

APPLC CH1

Pilot frequency [Hz]: 3840

☒ enabled

APPLC CH2

Pilot frequency [Hz]: 3840

☒ enabled

APPLC CH3

Pilot frequency [Hz]: 3840

☒ enabled

Network management

☒ EOC enabled

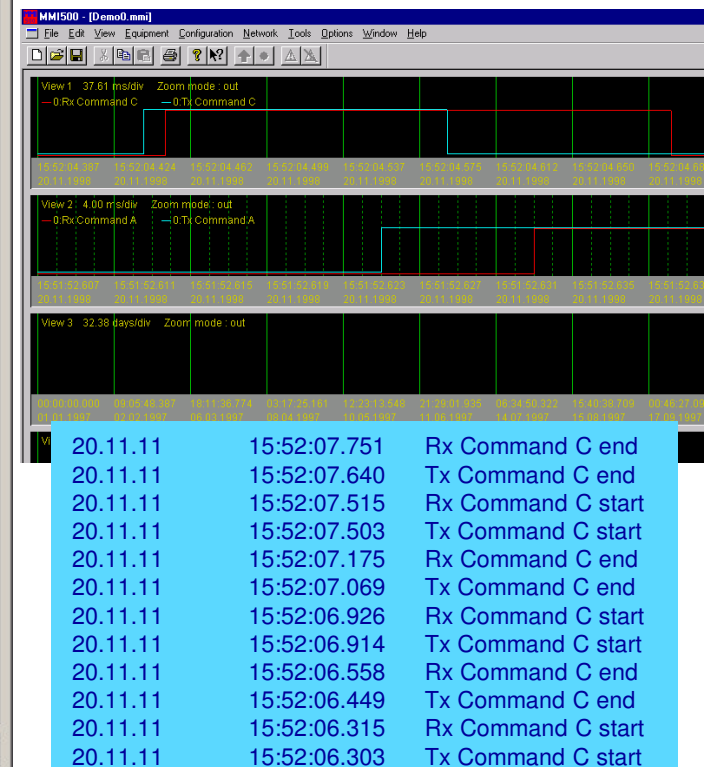
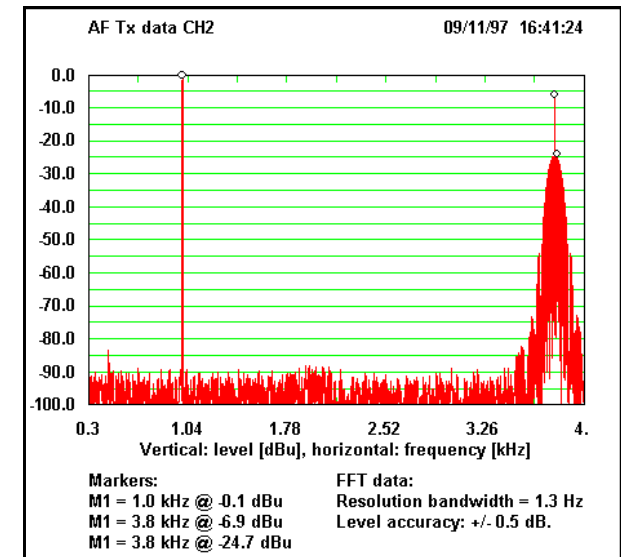
Event recorder

☐ Ext. real time clock sync. available:

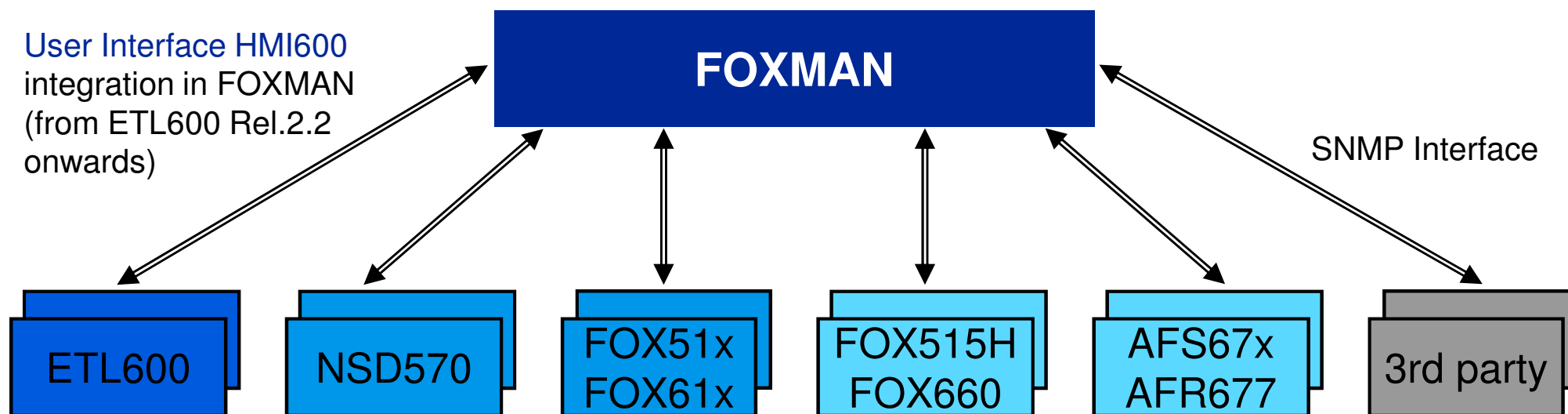
Automatic frequency control

☒ AFC enabled

OK Cancel

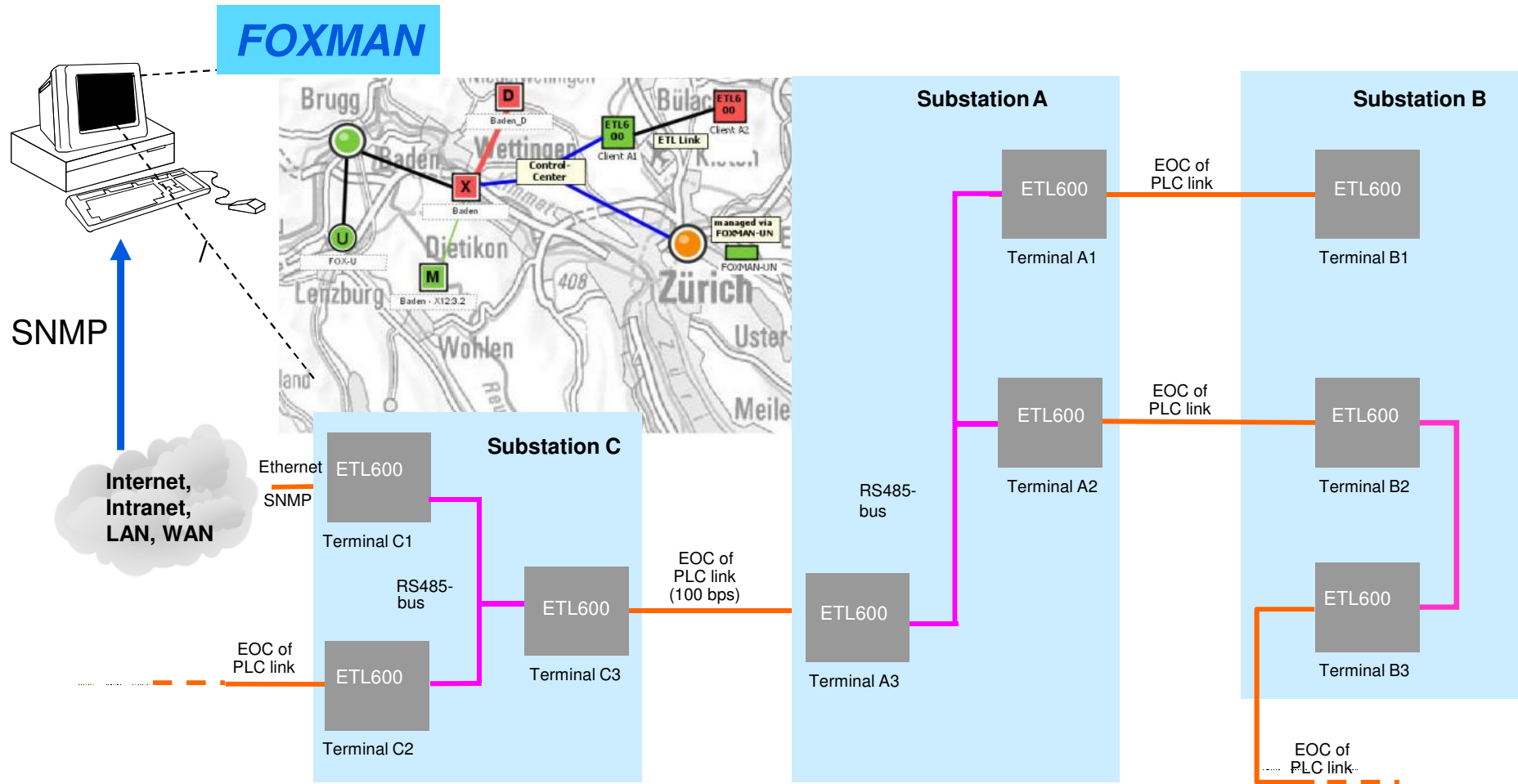


Communication Network Management - FOXMAN ONE Management System



- ETL600: Power Line Carrier for High Voltage Lines
- NSD570: Standalone Teleprotection Equipment
- FOX51x: PDH / SDH multiplexers for optical communication incl. Teleprotection modules TEBIT, OPTIF
- FOX61x: Universal access transport multiplexer for optical communication incl. Teleprotection modules TEPI1, OPIC1
- FOX515H/Hs: Higher order multiplex equipment providing aggregate interfaces up to STM-64
- FOX660: Higher order multiplex equipment providing enhanced Ethernet features and SDH aggregate interfaces up to STM-16
- AFS/AFR67x: Ethernet Switch and Router products for utility environment

ETL600 - Network Management with FOXMAN



→ User Interface HMI600 is started after clicking on ETL600 icons

Power and productivity
for a better world™

