PowerLink IP

A revolution in PLC technology for digital transmission grids

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PowerLink IP
A revolution in PLC technology for digital transmission grids

AGENDA

- Evolution of powerline communications and digital substations
- Highlights of PowerLink IP
- System overview and benefits
- Use cases and migration scenarios
Siemens Powerline Carrier Technology
More than 85 years of experience

- Ew Send 6 (1930)
- ESB 500 (1960)
- PowerLink (1980)
- PowerLink 50/100 (1990)
- PowerLink IP (2004)
- Analog PLC (1970-1990)
- Valve technology (1930-1970)
- Pure packet-based architecture (2017)
Siemens Powerline Carrier Technology
Proven PLC technology with global penetration

~6,000* PowerLink systems installed globally

Installed base per country

> 600 200-600 200

* PowerLink since 2004
PowerLink IP
The door to an innovative era of powerline communication

**FROM TRADITIONAL HV SUBSTATION**

- Few applications: teleprotection, control center commands, analog voice, grid control
- Standalone systems: no/limited integration into enterprise IT
- Declining expert know-how: rapidly declining PLC competence

**TO DIGITAL HV SUBSTATION**

- Bouquet of applications: grid control, teleprotection, video surveillance, access control, remote access, monitoring, data analytics
- IT environment: full integration into Ethernet infrastructure
- Focus on IP-based technology: IP knowledge readily available

Low data rate sufficient
⇒ up to max. 320 kbps

Data rate demand increasing
⇒ fiber? what about backup?
PowerLink IP
PLC technology for data transmission in HV networks

PLC accessories

- **Line trap**
  Inductor inserted on the power line to guide the communication signal between sender and receiver and to reduce frequency disturbances.

- **Coupling capacitor**
  HV capacitor used to couple/decouple the communication signal onto the power line and to provide safety insulation between HV and LV side.

- **Coupling or Line matching unit**
  Impedance matching between HV line and communication signal, incl. overvoltage protection.

- **Power line carrier equipment (PLC)**
  Modem to transmit and to receive communication signals between HV substations.
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HIGHLIGHTS

Data rate up to 2 Mbit/s for modern digital substations

Smart frequency management
up to 256 kHz bandwidth, simplified frequency planning

High availability
< 1 sec synchronization time incl. automatic levelling

Optimized for Ethernet-LAN/ IP packet-based communication
PowerLink IP
Bi-directional traffic up to 2 × 2.0 Mbps

High data rate capabilities

- A datarate up to 2.0 Mbps can be achieved under ideal line conditions at a bandwidth of 256 kHz
- Decreasing power from 100 W to 50 W reduces maximum bitrate by ~200 kbps @ 256 kHz
- Moving from low frequency (≥36 kHz) to high frequency band (≥200 kHz) reduces range and increases sensitivity to line conditions

Assumptions:
- Amplifier power 100 W
- Start frequency 36 kHz
- Bandwidth 256 kHz

Spread indicates variation depending on weather (acc. IEEE 62488-1)

Source: Simulation based on typical line data acc. IEEE 62488-1

* Ethernet Layer 1
PowerLink IP
Lower bandwidth leads to correspondingly lower datarate

![Graph showing Bit rate vs. Estimation of max. distance]

- **Assumptions:**
  - Amplifier power: 100 W
  - Start frequency: 36 kHz
  - **Bandwidth:** 16–256 kHz

- Spread indicates variation depending on weather (acc. IEEE 62488-1)

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**High data rate capabilities**

- A datarate up to 2.0 Mbps can be achieved under ideal line conditions at a bandwidth of 256 kHz
- Decreasing power from 100 W to 50 W reduces maximum bitrate by ~200 kbps @ 256 kHz
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* Ethernet Layer 1

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Source: Simulation based on typical line data acc. IEEE 62488-1
PowerLink IP
Flexible bandwidth from 8 kHz up to 256 Hz

**Classic PLC**
- preselected, fixed bandwidth from 2 kHz to 32 kHz for each transmission direction
- Bandwidths: 32 kHz

**PowerLink IP**
- Variable channel bandwidth from 8 kHz to 256 kHz (250 Hz steps) for each transmission direction
- Bandwidths: 256 kHz

36 kHz
500 kHz
**PowerLink IP – Smart Frequency Management**

Smart frequency management and efficient bandwidth utilization

1. **Notched frequencies**
   - Parts of the frequency band can be blocked (notched) within the PowerLink IP system's channel band.
   - Allows higher data rates due to the extension of the PowerLink IP frequency band beyond blocked frequencies that are, for example, used by radio services.

2. **Asymmetrical data streams**
   - PowerLink IP’s data upstream and downstream channels can be adjusted to different bandwidths.
   - Enables the data throughput to be adapted to the special requirements of modern grid applications.

3. **Channel spreading**
   - If part of the PowerLink IP frequency band is disturbed, additional frequency bandwidth can be requested from adjacent PowerLink IP systems. Systems operating in adjacent channels automatically exchange information about the individual bit rate to be transmitted and optimize the band utilization for all systems operating in neighboring frequency bands.
   - Ensures maximum data throughput for all PowerLink IP systems in the event of external disturbances.
PowerLink IP – Smart Frequency Management
Safeguarding other systems, maximizing bandwidth utilization

1. Examine available spectrum
2. Reserve frequency bands for other services
3. Define maximum bandwidth for PowerLink IP
4. Let PowerLink IP dynamically manage available bands

Source: Field test on 110 kV powerline (30 km)
PowerLink IP – Smart Frequency Management
Dynamic frequency allocation between neighboring* PowerLink IP

Source: conceptual layout based on field test

* devices on neighboring links
PowerLink IP
Easy to operate – the PowerLink IP management system

Benefits

• Remote administration or by local craft terminal
• Use of commercial Web browsers
• Secure access using user specific log-in and password
• State-of-the-art Web user interface in Siemens' digital grid design
• Ready for touch-screen operation
• Supports integration into higher-level management systems using SNMP
PowerLink IP
Intuitive user interface and device management
Use Cases

• Primary solution
  – for IP/Ethernet transmission on HV links with no fiber-optic or radio connection

• Backup solution
  – for optical transmission with higher data throughput (bit rate)

Migration capabilities

• Support of legacy devices
  – seamless integration of legacy devices into PowerLink IP

• Coexistence of traditional PLC and PowerLink IP
  – parallel use of both systems on the same powerline
PowerLink IP
Exclusive solution for HV substations without fiber or radio

Characteristics / benefits:
• Power line as only communication path between HV substations
• Single communication system for a variety of communication requirements
• Developed to meet the communication challenges of future-proof digital HV substations (IP/Ethernet)
• Integrated SWT 3000 for distance protection devices
• Most economical solution for robust communication

* IEC 60870-5-104
PowerLink IP
Backup communication parallel to a fiber-optic link

Characteristics/ benefits

- Primary communication path provided by Ethernet over SDH system or multi-protocol label switching
- PowerLink IP is a reliable backup path for critical grid applications (including protection, RTUs, voice)
- The combination of fiber-optic communication technology with broadband PowerLink IP offers the highest possible reliability for HV grids
PowerLink IP – Migration scenario 1
Integration of legacy devices via gateway/router

Characteristics/ benefits

- New substation devices that only have IP/Ethernet interfaces can be directly connected to PowerLink IP
- Traditional functions like analog phone and IEC 60870-5-101 RTU can be connected via small gateway, router or converter
- Stepwise exchange of legacy devices can be realized in line with customer strategy

Field devices

- Distance protection
- Corporate applications
- IEC 104* RTU
- IP/analogue phone
- IEC 101** RTU
- PABX

* IEC 60870-5-104
**IEC 60870-5-101

HV substation

PowerLink IP with integrated SWT 3000

Coupling capacitor and line trap
Coupling unit

Power line with PLC communication

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PowerLink IP – Migration scenario 2
Coexistence of traditional PLC and PowerLink IP

- Legacy devices are connected to the classic-narrow band PLC
- New IP/Ethernet-based devices will be connected to PowerLink IP
- Step-by-step replacement of legacy devices according to customer strategy
- Potential reuse of coupling capacitor, line trap, and coupling unit possible

**Characteristics/ benefits**

**Field devices**

**HV substation**

- Coupling capacitor and line trap
- Coupling unit
- PowerLink IP with integrated SWT 3000
- Ethernet switches
- Communication LAN
- HV substation
- S/I controller
- IEC 104* RTU
- PMU
- Fault recorder
- PQ recorder
- Protection devices
- CCTV
- IP phone
- Corporate applications
- Physical access control
- Teleprotection device w/ binary I/O

* IEC 60870-5-104
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