Application Note


Reliable data transmission in railway networks with LineRunner SCADA NG

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Specifications

Transmission of information in railway networks has a long history. At the dawn of transmission technology, telegraph signals and subsequently voice signals had to be transmitted. As time passed by, control functions also required transmission.

Nowadays, it is inconceivable that railway networks could be run without extensive data networks for information transmission.
At access level, data-transmission paths connect axle counters and railway crossings, in other words parts of outdoor systems of electronic signal boxes. Integrated systems, such as voice and live video services, are also being increasingly connected via IP networks. A typical application is found in systems for train-number reporting and train tracking.

The operational environment and the existing infrastructure have a strong influence on the requirements placed on suitable transmission technology:

- Suitability of the transmission technology for linear networks (railway networks are linear by their very nature)
- Usage of different media (copper wire, fibre optics and existing backbone networks)
- Long product-life cycles
- Maximum reliability over a long period of time
- Strong vibrations and fluctuating temperatures
- Maximum immunity from typical railway malfunctions and influences (longitudinal and lateral effect of traction currents and atmospheric discharge)
- Dependable transmission of the (digital) signals, but at the same time constantly increasing demands for transmission speed

Over the years, standards have been created that describe the conditions of the railway environment in technical terms. KEYMILE has developed products to comply with these standards.

In terms of electrical parameters, interference emission, interference coupling and electrical and laser safety, these include:

- ETSI EN 300 386 – electromagnetic compatibility and radio spectrum matters for setting up the telecommunications network
- ETSI ES 201 468 – requirements of telecommunications equipment for extended availability of services in specific applications (test level 2)
- EN 61000-6-2 – Interference immunity for industrial applications
- EN 61000-6-3 – Interference emitted for residential, commercial and light-industrial environments
- ITU-T Rec. K.20, K.21, K.45
- EN 50121-4 – Electromagnetic compatibility for railway applications
- EN 60950-1 – Safety for information technology equipment

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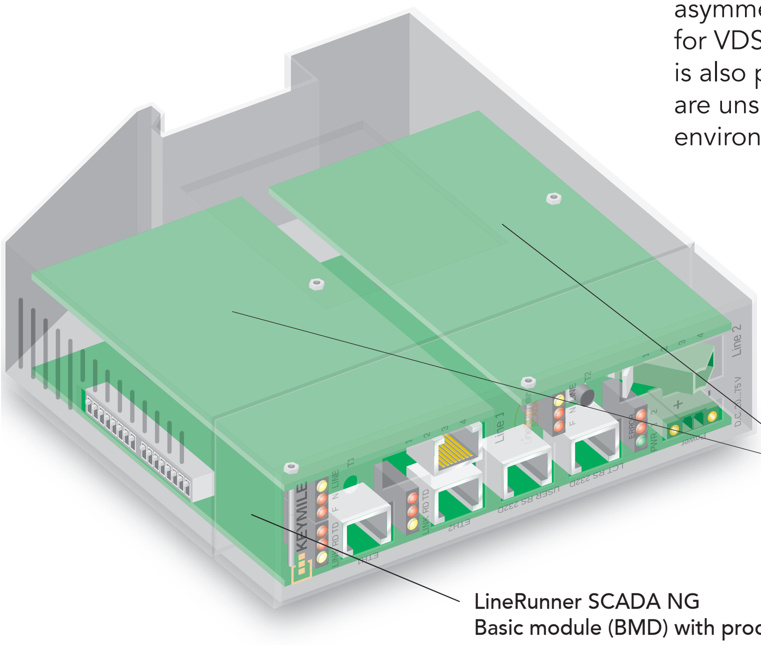
In railway environments the mechanical demands are of course very high too.
Here is a brief list:

- Air conditioning for operating telecommunications equipment in line with ETSI EN 300 019-2-3 V2.2.2 (2003-04)
  - Environmental equipment
  - Environmental conditions and tests for telecommunications equipment
  - Part 2-3: Specification of environmental tests
  - Stationary usage in weather-protected locations
- In connection with DIN EN 60068-2-6:1996 Fc tests: vibration (sinusoidal)
  - DIN EN 60068-2-29:1995 – Eb tests: Bumps
  - DIN EN 60068-2-64:1995 – Fh tests: Vibration, broadband random
  - DIN EN 60068-2-47:2000 – affixing components, equipment and other technical products during vibration, impact and other dynamic tests

In other words, equipment suitable for the railway environment is subjected to many testing and qualification phases. For some years, the LineRunner SCADA NG has established itself as a reliable data-transmission facility in many railway companies (and in utility networks too).



Transmission technology and interfaces

Technology for data-transmission equipment is primarily determined by four points:

Transmission media

- Copper-wire pairs in station and network cables
- Fibre optics, preferentially single-mode fibres
- Existing networks (e.g. backbone networks) can be used with suitable interfaces and are really only secondary media because they transmit via fibre optics or copper.
- Wireless (is not examined here)

Transmission procedures

- Low-frequency technology (LF voiceband modem) on copper wire pairs
- Baseband technology (with suitable coding) on copper wire pairs
- Bit-rate symmetrical DSL technology such as SHDSL (previously HDSL too) on copper-wire pairs
- Optical transmission with suitable coding on single-mode fibres
- ADSL, ADSLplus and VDSL have been enhanced for usage in access networks. These procedures are designed for asymmetrical transmission of high bitrates – for VDSL however symmetrical transmission is also possible. However, ADSL and VDSL are unsuitable for network cable in railway environments.

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Interfaces (for data transmission)

- ITU-T V.24/V.28 (RS-232) serial interface
- RS-485 or RS-422 serial transmission
- ITU-T V.11 (also known as X.21) serial transmission
- ITU-T I.430 (ISDN-S_0 serial interface) serial interface
- ITU-T V.35 serial interface (relatively rare in Europe)
- ITU-T V.36 serial interface (not very widespread)
- ITU-T G.703 interface (the E1 interface will be looked at here)
- IEEE 802.3 (LAN) Ethernet interface

Nowadays, the Ethernet interface and (still) the RS-232 interface are the most important.

The interface does however impose certain restrictions. For example, a V.24/V.28 interface is only defined up to 20 kbps. Therefore, it would be conceivable to operate an SHDSL line at 2 Mbps and then find restrictions to 20 kbps on the V.24 interfaces.

LineRunner SCADA NG

The SCADA NG modem was based on long-standing experience with professional data transmission. Developed for the LineRunner product line, similarly to other LineRunner products, it offers excellent transmission properties. SCADA stands for Supervisory Control And Data Acquisition.

Particular attention was paid to transmission via copper-wire pairs (SHDSL technology). In railway companies' copper cables for telecommunications, larger wire diameters (0.8 - 1.4 mm) are used than in

LineRunner SCADA NG Basic module (BMD)

optical line interface

SHDSL line interface

G.703 (E1) line interface

Transmission speed (on the transmission line)

The maximum transmission speed mainly depends on the medium used and the transmission procedure. Generally, we can say that an increase in speed means the range is shortened (on a given medium).

- Voiceband (low frequency): 150 to 38,400 bps
- Baseband: usually up to 512 kbps
- SHDSL: 256 to 5,696 kbps (per copper-wire pair)
- Optical transmission: up to 10 Gbps
- E1 (G.703): 2,048 or 32 x 64 kbps

telecommunications network operators' traditional access networks (0.35 - 0.6 mm).

Many standard SHDSL modems often fail on lines with large wire diameters, with significant reductions in the range possible.

The LineRunner SCADA NG is tailor-made to transmit SCADA data streams. As explained at the outset, special demands apply in industrial and railway environments:

- Long distances mean long lines
- Different and in some cases old cable paths
- Variety of interfaces (serial, Ethernet)
- Maximum reliability
- Wide temperature range

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- Industrial, mechanical construction (19″ mounting rail)

The basic module lies at the heart of a LineRunner SCADA NG. This basic module is extended with exchangeable line interfaces (LIs) and then makes up the SCADA NG as a whole.

Brief info about the LineRunner SCADA NG

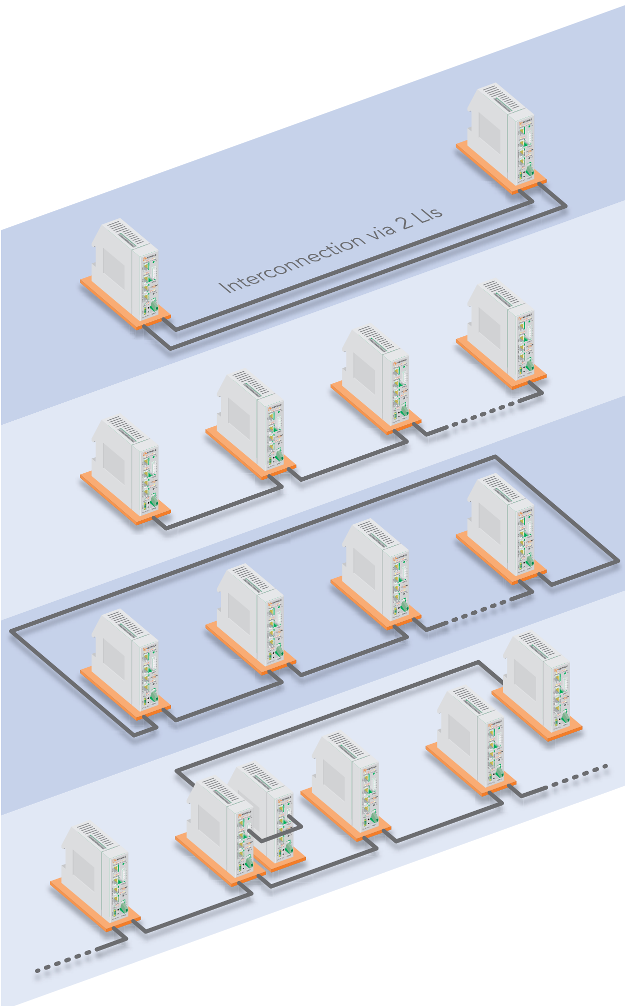
- Fitting on a 35 mm DIN mounting rail
- Electricity supply 20-75 V DC
- Two line interfaces can be fitted (also mixed)
- Two Ethernet interfaces (for separate networks)
- A serial user interface RS-232 (asynchronous)
- A serial interface for local configuration (LCT)
- Control LEDs for all key functions

Ethernet interfaces

- ETH1 and ETH2 can be activated separately
- ETH1 and ETH2 are allocated to separate networks (no layer-2 switch)
- Maximum data throughput can be adjusted with management system
- ETH1: 10BaseTX autoMDX
- ETH2: 10/100BaseTX autoMDX

Line interfaces (LIs)

- SHDSL on a copper-wire pair, 256 to 5,696 kbps
- Point-to-point connection at 11.4 Mbps (bundling)
- Optical interface 2 Mbps short-haul 20 km, one fibre
- Optical interface 2 Mbps long-haul 40 km, one fibre



Point-to-point connection
In order to connect individual applications at 5.7 Mbps with an exchange via a wire pair (e.g. high resolution video transmission). Coupling two LIs is possible to maximise the bandwidth.

Chain structure
To connect up to 64 applications at 5.7 Mbps (e.g. serial sensor data along a railway line).

Ring structure
To connect up to 63 applications via a transmission path protected from failure. (E.g. transmission media via the SHDSL path, back-up line SDH/PDH).

Ring or chain structure with bridged tap
In order to integrate single remote applications into another transmission path (e.g. in networks for local utility facilities). Branching into a bridged tap via the user interface (Ethernet).

- Optical interface 6 Mbps, long-haul 35 km, one fibre
- Electrical E1 interface, 120 ohms, 6 dB, symmetrical

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IP20 is the basic module's protection type (International Protection Class, also Ingress Protection Class). SCADA NG is used in control cabinets, telecommunications rooms or protective housings. When fitting on masts or walls outdoors, a special housing with IP64 is available (e.g. SCADA NG as regenerator). An underfloor housing with IP68 can be supplied if necessary.

The LineRunner SCADA NG is extended with a remote supply unit (RFS/RPS) for feed via copper-wire pairs. This solution is often used for regenerator operation.

Network topologies

Data networks in railway environments are often linear. In the real world however, all sorts of topologies occur:

- Point-to-Point
- Point-to-point with redundancy (line protection)
- Star network (several lines going out from an exchange)
- Chain structure (many devices in a row)
- Ring structure (redundancy via an optical connection)
- Ring in linear structure (compressed ring)
- Ring structure (redundancy via a backbone network)
- Ring or chain with bridged taps
- Mesh networking (with routers)

Typical applications

Many railway companies use SCADA NG in their networks. The focus generally lies not on maximum transmission speed, but on flexibility and reliability of transmission. As in many cases copper lines have to be, or can be used as the transmission medium, the data throughput achievable is restricted with the length of the line.

In practical terms, networks are usually planned for 1-3 Mbps. With a 2 Mbps network, migration of serial data transmission to IP-based data streams is easy because the Ethernet interface and the serial interface can be used independently of one another.

This also applies to optical transmission. In many cases, high bit rate optical transmission is not necessary.

Other benefits of fibre optics – for example complete immunity to electrical influences – are often more persuasive when choosing optical line interfaces (LIs). As SCADA NG can be fitted with two different LIs, a converter from copper (SHDSL) to fibre optics can easily be implemented.

The spectral bandwidth of the line signal required in SHDSL line technology is much smaller than for PCM technology previously used. As a result, PCM blocking transformers (longitudinal voltage differences) can remain in lines.

SCADA NG immediately transmits all in-coming data packages to the next device; a regenerator function is also integrated. Therefore, a special regenerator is not required.

An important point is monitoring, sending alarms and remote configuration using the management system (NMS) ASMOS. With the Simple Network Management Protocol (SNMP), integrating the alarm system into higher-level NMSs is easy.

Some examples show how LineRunner SCADA NG is used in various railway companies:

In Germany

The Deutsche Bahn's train-tracking system uses partyline modems (voiceband transmission) on the train-tracking bus. Due to the introduction of electronic signal boxes, there are much bigger distances between the electronic signal boxes. Converting from SHDSL transmission to SCADA NG solved the problem simply:

- Each SCADA NG regenerates the telegram received
- Much bigger distances are easy to bridge
- All SCADA NGs function like multi-drop modems
- The serial interfaces are simple adjusted to suit the parameters required of the (previous) modem
- The whole network can be monitored and managed

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The Ethernet interfaces (two independent networks) are ready for future usage too.

Ticket machines are also connected with SCADA NG via copper lines. Modern PA systems and intercoms (uni-directional/ bi-directional loudspeakers) use VoIP (Voice-over-IP) technology today. SCADA NG is used in this case too. Transmission immunity to traction current (harmonics) is a key criterion.

SCADA NG is used for a variety of signalling and control system tasks. Monitoring railway crossings and – quite generally – data transmission between modern signal boxes are also included.

Reliable transmission with SHDSL technology (and of course via fibre optics) allows multi-purpose usage on paths with all types of traction. A key logical aspect is the restriction to one basic device with flexibly adjustable line interfaces.

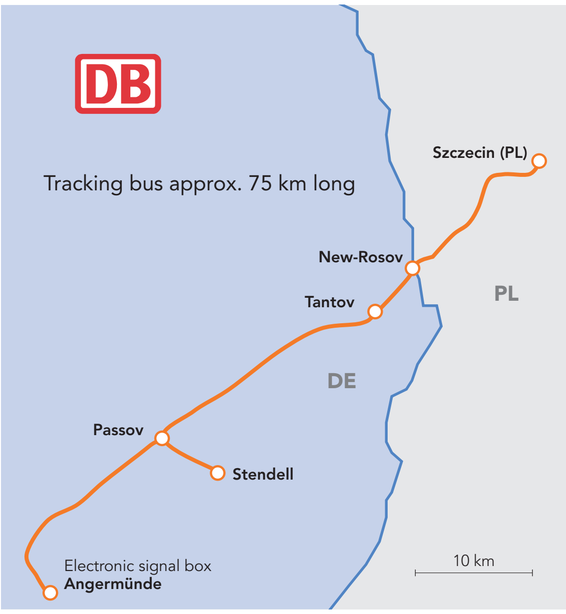

Figure: A typical train-tracking bus with SHDSL transmission

In Luxembourg

Railway company CFL in Luxembourg has primarily created an optical train-number reporting network (comparable with train tracking). However, because some stations are connected via copper wire lines and backbone networks (E1 access to add/drop multiplexers, ADMs) they chose the LineRunner SCADA NG here too. The Ethernet interfaces are ready for future usage – e.g. for Video-over-IP, in other words network cameras.

- Train-tracking at CFL at 9,600 bps
- A maximum of 150 km bus length
- Completely redundant set up
- Ethernet can be used freely
- Completely managed with ASMOS

In Poland

The Polish railway company PKP had to modernise its company telephony network. The harmonics in the traction currents significantly interfered with analogue transmission. The entire telephony network was converted to VoIP. As existing copper wire (even overhead lines) was to be used, 1,400 stations were fitted with SCADA NG.

Each sub-network is connected into a powerful router network and with the VoIP exchange.

The key advantage in digital transmission with SHDSL is the avoidance of analogue (and therefore audible interference) in the company's telephony network.

Existing analogue telephones (even telephones along the track) are integrated into the IP networks using analogue telephone adaptors (ATAs).

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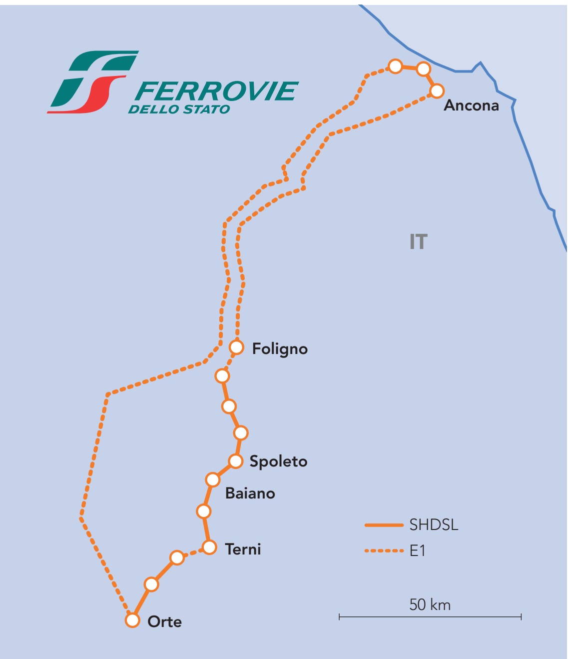
In terms of function, the network is expanded to include voice announcements and bi-directional loud-speaking systems.
An important advantage in using digital transmission (Ethernet) is the ability to adhere to a high frequency threshold of for example 12 kHz without any problems. To make sure announcements are easier to understand, higher frequency thresholds are required in public address systems.

In Italy

The Italian railway company RFI is modernising its telecommunications infrastructure.
The east-west connections will be fully IP based. The familiar standard telephones will also be connected to the station switch via ATAs. All stations are connected with SCADA NG in a ring structure.



- Station announcements with VoIP
- 70 km bus length
- Bus extension to 150 km using SDH
- Completely redundant set-up in a ring
- Serial interface not used
- Fully managed by ASMOS

Further applications

Many railway technology companies use SCADA NG in other countries (Japan, Austria, Portugal, …) for a variety of different purposes. There is a general trend towards many railway companies breathing new life into their existing copper wire lines with SHDSL transmission. Particularly in safety technology, axle counters are installed at short distances and therefore in large quantities. These types of modern, widespread safety systems often use Ethernet as a multi-purpose interface for linking.

Summary and outlook

In railway signalling and control systems, other rules apply than in a network operator's environment (Internet access of residential and business customers). The product life cycles are much longer, with reliability (and not necessarily the price) enjoying top priority. The technical requirements placed on interfaces and the data rate to be transmitted often appear to be somewhat old fashioned. Nevertheless, in this case too (as with the entire industrial SCADA environment) the progression towards an Ethernet/IP-based network structure instead of serial transmission is becoming apparent.

As changing from serial transmission to IP will of course not happen overnight, a transmission device with both interface types is beneficial, particularly because these can be used at the same time. If various media are then used for transmission, the technical and commercial benefits are obvious.

Publisher

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