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Assurance of the electromagnetic compatibility in the chosen transport telematic systems

M. SIERGIEJCZYK[a], J. PAS[b], A. ROSINSKI[a]
[a] WARSAW UNIVERSITY OF TECHNOLOGY, Faculty of Transport, Koszykowa 75, 00-662 Warsaw, Poland
[b] WARSAW MILITARY UNIVERSITY OF TECHNOLOGY, Faculty of Electronic, gen. S. Kaliskiego 2, 00-908 Warsaw, Poland
EMAIL: msi@wt.pw.edu.pl

ABSTRACT
This paper presents the issues related to electromagnetic compatibility in the chosen transport telematic systems. Intentional or unintentional (stationary or mobile) electromagnetic disturbance occurring over a large rail area may cause disruption of their operations. Therefore, it becomes important to analyse disturbances affecting these systems and to develop methods for reducing their impact.

KEYWORDS: electromagnetic compatibility, transport, electronic devices

1. Introduction

Fundamentals of how electromagnetic interference impacts transport telematic systems operating under different electromagnetic environment conditions were presented in paper [6]. Such interference may originate from both intentional and unintentional (stationary and mobile) electromagnetic interference spanning across vast areas of railway activity [7]. Failure or malfunction of key system functionalities may cause life and health hazards [8,10].

2. Fundamentals of electromagnetic compatibility in the railway environment

Elements of a transport telematic system operate in a specific electromagnetic environment. The natural electromagnetic environment created by natural phenomena and elements is seriously disrupted over railway areas. Numerous sources of electromagnetic fields radiating both intentionally and unintentionally are the reason. Every electric and electronic device powered with electricity generates its own electromagnetic field as it operates. Both rail track and railside equipment/electronic systems should function properly regardless of any interference (definition of electromagnetic compatibility) [1].

Those systems include the rail traffic control system (signalling system), frequently used transport (supervisory) security systems, e.g. fire signalling system, CCTV, burglar alarm system etc. Electromagnetic compatibility was defined as systems' ability to coincide and simultaneously function properly over a railway area in the given electromagnetic environment without having to introduce inadmissible disrupting factors.

A wide-band electromagnetic interference generated across a railway area affects the transport telematics system – Fig. 1. The spectrum of disruptive signal is determined by the operating frequency of system (devices), harmonic oscillations and intermodulation frequencies caused by the non-linearity of e.g. electronic components [2].

Modern electronic equipment used in transport telematic systems are expected to e.g. be miniature in size, energy efficient and highly reliable [3,4,9,12]. All those parameters mean the useful signals may equal the interference generated by e.g. static and mobile sources of interference (radio and TV stations, power transmission lines, transformer stations, electric equipment).

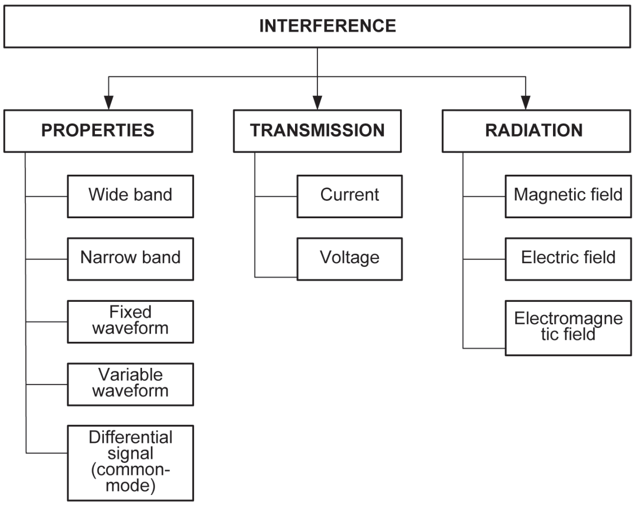

Fig. 1. Electromagnetic interference influencing transport telematic systems

When discussing the impact of electromagnetic interference on transport telematic systems, the following criteria need to be factored in:

- system resilience to interference - defined as the ability to function properly under conditions of electromagnetic interference.
- sensitivity to interference - reaction of the system in operation to internal and external interference;
- system resistance to interference - defined as the ability to retain original system properties after removing interference.

There are four states of transport telematic system operating under conditions of electromagnetic interference:

- control system has no reaction to external and internal interference - interference too low, within the limit of interference, the system does not change its operational state in which it stays;
- equipment part of the control system removes the interference automatically by active and passive filters, screening, appropriate location and network solutions;
- occurrence of interference causes the system transition from the state of full ability to the state of reached operational ability - the restoring of full ability state requires staff intervention or service;
- occurrence of interference in control system causes a damage to the system (complete or partial) – a system failure.

3. Limiting interference in transport telematic systems

When deciding about limiting the influence of interference on transport telematic system, issues of electromagnetic compatibility EMC have to be addressed in a comprehensive manner, i.e. the rule of synergy employed. EMC synergy means utilising all available technical, organizational and legal resources, which allow to limit the impact of electromagnetic interference on transport telematic systems [5]. Combination of filters (devices), utilisation of screening equipment, appropriate location of interfering devices and devices sensitive to interference on printed circuit board, employing standards and legal acts concerning limitation of electromagnetic interference gives a greater net EMC effect than a total of all the aforementioned operating independently – Fig. 2.

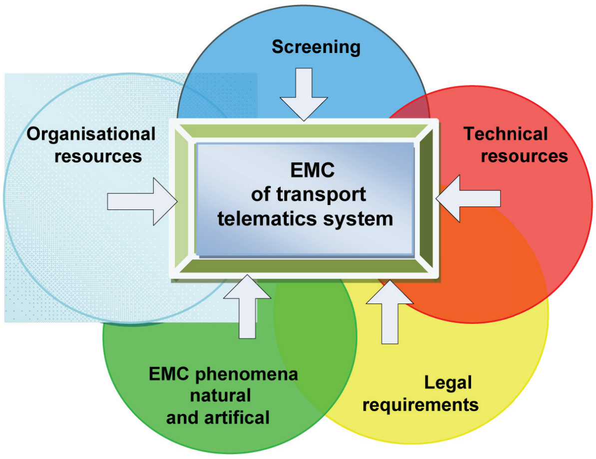

Fig. 2. EMC synergism in a transport telematic system

Three elements are necessary for the problem of electromagnetic interference on a transport telematic system to arise, i.e. a source of interference, a circuit of the transport telematic system sensitive to interference and a transmission channel via which the interference would travel from the source to the receiver – Fig. 3.

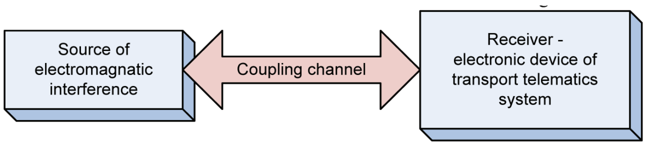

Fig. 3. Typical EMC interference in a transport telematic system

In order to minimise the electromagnetic interference in transport telematic systems a distinction has to be made between the source of interference and the receiver and how they interact [11]. Hence, there are three ways to limit the propagation of interference:

- damping of interference at the source (e.g. shielding screening);
- employing a transport telematic receiver insensitive to interference from the electromagnetic environment (electronic elements utilising latest technology);
- minimising the interference transmission (e.g. decoupling filters, grounding, photocouplers, screening etc.).

4. Interference affecting transport telematic systems

Parameters of electromagnetic interference generated by operating devices of a transport telematic system should be defined in relation to the following circuits:

- high-voltage power lines (e.g. traction substations feeding the power grid lines, overhead lines, traction return system,

traction units with energy transducers and driving motors, etc.).
- low-voltage power lines (rail traffic control systems (signalling systems), telecommunication on-board equipment, e.g. GPS, vehicle diagnostics systems and road safety systems status over radio, e.g. fire systems, burglar alarm etc., public-address speakers installed in rail cars, electronic CO and water sensors).

The interference generated by traction substations and traction units (power cars, electrical trains) is a synchronous interference.

The supply network provides alternating current, 50 Hz frequency. The driving motor and energy transducer are also powered by an alternating current. The interference (spectrum) generated by traction lines and traction units is synchronised with the base frequency (power-line frequency f=50 Hz) for a given traction power system.

Sources of interference affecting transport telematic systems located over a vast area comprise:

- traction substations with frequency converters,
- high-power, phase controlled traction units,
- electrical and electronic equipment installed in railway facilities (e.g. computer systems, internal low-voltage electrical network, lighting systems, internal and external PA speaker system, standard equipment available at the facilities etc.);
- external electromagnetic interference (generated e.g. by radio, television and cellular network stations as well as internal communication systems, tram traction lines near railway station buildings, high-voltage power transmission lines, high and medium-voltage transformer stations etc.).

Traction units are mobile sources of radio interference over railway areas. The voltage supplied on electric motor terminals is adjusted by phase control. It may employ a pulse width modulation (given constant pulse frequency) or a frequency change at a constant pulse width.

The impact of interference on transport telematic systems (a term related to internal and external electromagnetic compatibility) should be considered for two cases – the criterion being the electromagnetic interference divided into two sub-ranges. The distinction is made based on the frequency range and the following properties of electromagnetic field:

- the way interference propagates;
- dampening of interference propagation;
- interference screening in a transport telematic system;
- impact of interference on a transport telematic system;
- interference shielding in a transport telematic system;
- power of source of interference occurring in the railway area, where the transport telematic system operates.

Another source of interference, which could occur where a transport telematic system operates, consists of e.g. power transmission wires and atmospheric discharges. Overhead power lines generate radio interference, however, they create an asymmetrical line (a type of waveguide), which transmits interference generated by substations and traction units.

Transmission network (waveguide) parameters and determined by:

- electric properties of soil;
- structural design of the traction line system;
- weather conditions over the area, where the power supply system is located (e.g. humidity, temperature, pressure, air pollution around waveguide).

The radio and pulse interference is generated in power supply networks. Each interference being a high-power electromagnetic interference causes the radio interference of specific frequency spectrum. The spectrum width is determined by the propagation time of disturbing pulses.

The level of radio interference is the function of:

- power of the interference source;
- distance from the interference source;
- damping properties of transmission lines;
- distance from transmission lines (for induced interference);
- natural obstacles in the way of propagating interference, e.g. natural undulation, trees, hedges, railway buildings from different materials etc.).

In low-voltage networks powering transport telematic systems, the main reason for the pulse interference is:

- presence/absence of induced loads (railway motors, high-voltage transformers, field coils in traction lines etc.);
- presence/absence, switching of high power receiving electric circuits (motors, electric heating);
- temporary states caused by damage to network equipment;
- non-linear loads (e.g. transformers, electrical valves, motors, thyristors etc.);
- direct and indirect atmospheric discharge;
- low quality of electricity (e.g. exceeded limit of current harmonics h in the grid, voltage fluctuations and dips etc.) or incorrect contact points (e.g. incorrectly executed connection with the mass - high resistance R in the fire alarm system).

5. Conclusion

Because electric and electronic devices are widespread in telecommunications, automatics, IT and power engineering as well as in other areas they often have to operate within close proximity to each other. The utilisation of integrated circuits in transport telematic systems means miniaturisation of electronic equipment and its greater compaction in less volume. Hence a higher probability of interferences generation. Transport telematic system should be designed to factor in the real operating conditions, i.e. being surrounded by numerous devices. Therefore, external sources of interference and the system itself should not generate interference (external and internal electromagnetic compatibility). Transport telematic systems because of electromagnetic compatibility are divided into components (e.g. sensors, modulators, chassis units, transmission buses, combinational circuits, thyristor matrix, manipulators, matching units etc.) according to the following criteria:

- which frequencies are used by system components?
- are circuits inside system elements are operating simultaneously?
- which system component has a high pulse power consumption?
- which system components use sensitive sensors?
- which components are analogue and which digital?
- which connections (signals, power etc.) are established inside the system?

Then the element of a transport telematic system needs to be assessed in terms of its compatibility with the environment, factoring in the following criteria:

- do system components use high frequencies?
- do system components have high pulse power consumption?
- do system components use sensitive sensors and digital gates?
- what cables were used to connect system components with the environment/other circuits - shielded, unshielded, twisted-pair cable etc., and how are the cables introduced into the system (isolated, shielded, common ground etc.)?
- in what electromagnetic environment do system components operate?

External EMC requirements are usually known, whilst internal conditions usually become known in the design process.

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