

Emitted Radiated Interference of Video Monitoring Systems

Subjects: Transportation

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Video monitoring systems (VMSs) operated throughout an extensive railway area are responsible for the safety of people and property transport processes. Emissions of radiated electromagnetic interference generated in an unintended manner by traction vehicles within a railway line lead to interference in the VMS operating process. Based on the knowledge of actual VMS operating process data, spectral characteristics and values of individual components of disturbing signals occurring in the emissions of radiated electromagnetic interference, it is possible to determine the parameters of damage intensities for the devices and elements of this system. Using that data enables determining the VMS reliability parameters within its operating system, for an extensive railway area.

Keywords: video monitoring system (VMS) ; radiated electromagnetic interference ; damage intensity ; system model ; reliability

1. Introduction

Video monitoring systems (VMSs) are one of the most important electronic security systems (ESS). They operate in buildings, open areas, parking lots, logistics bases, airports, etc., and extensive public and railway areas ^{[1][2][3]}. Depending on the operational mode within extensive areas in warehouse and railway facilities, VMSs can be divided into two groups:

- Stationary, i.e., operated in facilities permanently set on the ground (foundations), e.g., railway stations, platforms, tunnels, level crossings, turnpikes, underground passages, warehouses and logistics bases storing spare parts, repair workshops, parking spaces—parking lots, warehouse buildings, driveways, etc. ^{[4][5][6]};
- Non-stationary (facilities not permanently fixed to the ground)—e.g., locomotives, electric multiple units, electric locomotives, passenger and freight carriages, trucks, mass transit vehicles and vehicles intended for transporting various materials, etc. ^{[7][8][9]}.

Both VMS and all ESSs (especially the fire alarm system—FAS) must send information on their ongoing technical status via two independent telecommunication channels to an Alarm Receiving Centre (ARC) or the State Fire Service (PSP) ^[10]. The most important ESS operational technical states include the states of alerting, monitoring and damage, whereas the latter is sent only to ARC in the case of FAS ^[11]. The use of two independent telecommunications channels to exchange information within security systems is associated with ensuring a certain level of reliability, especially in the case of alerting states ^[12]. In the case of stationary and non-stationary VMSs within a railway area, the facilities of which are classified as the so-called state critical infrastructure (SCI), it is essential to ensure proper organization of the entire system notifying of threats within a railway area and not only the VMSs ^{[12][13]}. This is why the following telecommunications lines are set up for stationary and non-stationary VMSs:

- Stationary VMS—Permanent telecommunications link in the form of a leased telephone line using a railway optical fibre network (protected against wide-frequency band electromagnetic interference within the railway area), as well as a wireless (encrypted) link with a modular signal, which is IT-protected against an intentional third-party and internal attack ^{[14][15]};
- Non-stationary VMS—Two independent wireless telecommunications links utilizing various transmitter carrier frequencies, modulated with a digital signal in alarm control units (ACU), which are resistant to electromagnetic interference generated within an extensive railway area, encrypted with appropriate transceiving antenna characteristics ^{[16][17]}.

In addition, in the case of stationary and non-stationary VMSs, all technical facilities that utilize this system shall be equipped with a local device for recording video-recorder signals of specified external memory size, the technical parameters of which are set out in domestic regulations (e.g., stadiums) [18][19][20].

A supplementary and very important issue associated with the VMS and ESS operation process is ensuring specific power supply reliability for these systems operated in a stationary and non-stationary manner [21][22]. ESS shall have ensured basic power supply—from an industrial power grid (stationary facilities) or via transducers from a railway overhead contact line (3 kV DC) (non-stationary facilities) [23][24]. Backup power supply, most often in the form of a battery bank of specific capacity determined by the power balance, is organized in order to guarantee proper ESS functioning in the event of basic power supply failure. This guarantees the functioning of these systems in the monitoring and alerting modes for a time specified by regulations and standards [25][26]. Information on the technical condition of a backup power supply (e.g., battery bank or UPS voltage level, etc.) shall be monitored continuously by the security system alarm control unit, and the information regarding this parameter should be sent to ARC, just like other security signals. In addition, battery banks are located in a metal housing with ACU. The metal housing is locked with a coded lock. In addition, it is monitored with an anti-tampering contact, which generates an alert signal in the event of an unauthorized opening [12][25].

An extensive railway area experiences a distorted electromagnetic environment generated by stationary (radio transmitters and TV transmitters, GSM-R, power supply and overhead contact network, etc.) or non-stationary (electric multiple units, rail carriages, portable security system transmitters, etc.) radiation sources [27][28]. Electromagnetic radiation within a railway area is generated intentionally—e.g., wireless signals of security systems, cellular telephony such as GSM—these signals will be used by authorized railway services. Other sources generate unintentional electromagnetic radiation—e.g., power supply, railway overhead traction lines, high current and voltage consumers—e.g., traction converters, locomotive motors present within these areas [29][30]. Electromagnetic interference generated within a railway area is characterized by a very broad spectrum, from low (single Hz) to very high (single GHz) frequencies. This is due to this railway system accumulating various sources of radiation used by railway workers, as well as power supply and overhead contact line systems used by the pantographs of electric locomotives to draw high-value current (in the order of several dozen kA) upon startup for a short period. It is a serious problem related to the distortion of the electromagnetic environment within such a railway area. Therefore, conducted and radiated interference shall be considered [31][32][33]. The selected aforementioned issues of ESS and VMS operation throughout an extensive railway area are presented in **Figure 1**.

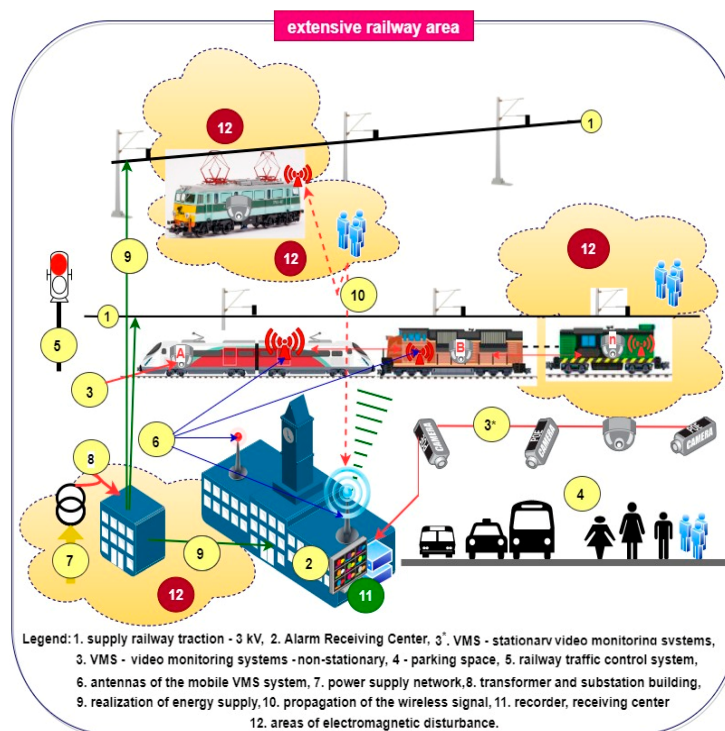


Figure 1. Operational issues, i.e., environment, electromagnetic interference, legal restrictions, telecommunications, etc., resulting from VMS within a railway area.

Figure 1 shows only the selected operational aspects of ESS use within an extensive railway area. The geometric figure in No. 12 shows examples of regions with low and high-frequency band electromagnetic interference originating only from overhead contact lines and systems supplying the entire railway area. High-frequency band electromagnetic interference,

so-called radiated interference, occurs throughout the railway area, and its value depends on, among others, distance from the source of a signal generated intentionally or unintentionally.

2. Emitted Radiated Interference Generated by a Selected Rail Traction Unit on the Operating Process of Trackside Video Monitoring Systems

Variable environmental conditions, a change in low- and high-frequency electromagnetic interference level in particular (conducted, coupled L, C and radiated interference) is one of the significant factors [34][35][36] leading to a direct change in the damage intensity λ . This operating parameter λ directly impacts the reliability of VMS elements, modules and devices, as well as VMS functioning. Therefore, the researchers of [37][38][39] discussed electromagnetic interference from the entire frequency band generated within an extensive railway area, specifying their levels, amplitudes and spectra [40][41]; however, they failed to analyse their impact on the reliability of individual system elements (e.g., camera, recorded, switch, etc.) or the entire VMS.

Variable, pulsed, and non-linear power supply line loads of high inrush currents can present within an overhead railway line and lead to current harmonics appearing in power supply lines [42][43][44]. They can cause VMS and ESS functioning interference and be the reason for additional losses in transformer cores and traction vehicle startup motors. The pulsed loads occurring within the power supply and overhead contact networks also cause changed rated voltages [45][46]. This may lead to unacceptable changes in the guaranteed voltage level ($U = 12\text{ V}$) for individual VMS elements [43][47]. The presence of harmonics in a power supply and overhead contact network [48][49] also means additional losses in the cables themselves, especially the ones supplying individual VMS and ESS elements (e.g., cameras), which are distributed throughout an extensive railway area (e.g., failure to satisfy the condition of permissible supply line voltage dip) [50][51][52]. The presented source literature on the phenomena in power supply lines does not reference a change in damage intensity λ . The studies conducted by the researchers enable assessing the impact of the aforementioned interference on VMS reliability.

A variable, pulsed load in an overhead contact line and power lines supplying an extensive railway area cause electromagnetic interference of large amplitudes from within the entire frequency band [53][54][55]. The occurring electromagnetic interference that causes conducted interference (e.g., common grounding impedance), inductance coupling or parasitic capacitances for VMS elements or devices through signal lines or cables providing the supply voltage [56][57][58]. Conducted interference from a higher frequency band (above 30 MHz) propagates into the surrounding space within a railway area through the generally available environment [59][60]. Individual VMS elements and devices with external conduits or metal housings with openings and wide bandwidth antennas are treated by these interfering signals as parasitic signal receivers [61]. In their researches, the researchers did not analyse the impact of interference on the reliability of electronic components. In the case of non-linear elements that comprise VMS, these signals may interfere with or change the processing characteristics or cause the presence of intermodulation phenomena [62][63]. In the course of studying the characteristics of radiated interference generated within a railway area, a method was proposed that would enable the determination of a change in the intensity index λ for VMS elements or equipment operated within such a railway area.

An important issue related to security systems, including VMS, is also the process of diagnosing their technical condition [64][65][66]. Generally available articles and studies present general assumptions of measurement systems that implement this important operational process under the following static and dynamic conditions, employing various diagnostic techniques and technical solutions [12][17][67]. However, these studies do not take into account the impact of natural or artificial electromagnetic interference present within a railway area. They result from, e.g., long signal loops of cameras, control lines for PTZ cameras and devices transmitting an alert or damage state [17][68][69]. The researchers of the said papers mitigated these errors contributed by interfering signals [12][70]. Testing the electromagnetic interference present in a railway environment, as well as the observation and measurement of output signals in alarm control units where the decision-making process takes place—i.e., conditioning and working out output waveforms—enables determining the impact of the aforementioned factors, e.g., on the output signal informing about the monitoring, alerting or damage state, or other forced operation process [12][17][65][71].

An important issue associated with the VMS operation processes is the transmission of video, alerting, monitoring, or damage signals to ARC [12][72][73]. The researchers of published articles took only the basic problems into account. This included reliability, availability, quality or, e.g., transmission time to ARC [17][74][75]. In contrast, the researchers of the developed article also conducted an analysis of notification and ARC service response to a damage signal [12][17][76]. The calculations conducted as part of this article included this parameter, e.g., in VMS recovery intensity μ [12][17][77]. It is an

issue that is particularly important for restoring a VMS to an original (initial) state—i.e., the state of fitness of an entire system [78][79][80][81].

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