Electronic Design

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# Mitigate EMI to Keep Railway Safety on Track

**Today's railway systems demand higher power motors and associated equipment, which are main perpetrators of EMI. That interference can in turn take a toll on railway signaling systems.**

Learning from past railway accidents contributes to the improvement of safety and prevention of undesirable events. The "7.23" Yong-Wen line high-speed train accident in 2011 led to a full-blown effort in the research of electromagnetic interference (EMI) protection and better safety for railway signaling. Ensuring railway safety and efficiency necessitates a study of analysis methods to evaluate the influence of EMI over reliability and safety, especially in railway signaling.

The design of electrical railway vehicles, including high-speed trains and subway trains, need to include attention to EMI/EMC problems that contribute to serious concerns regarding safety.

### Railway Safety

Safety Integrity Level (SIL) is defined in CENELEC Standards EN 50126, EN 50128 and EN 50129. SIL functions for railway applications are of major importance to modern electrical railway systems.

Safety integrity combines two basic concepts: integrity against systematic and random failures. Systematic failures represent those specification failures, traceability, design, manufacturing, and maintenance that are caused by a failure or an incorrect human process. Random failures due to mechanical-electronic equipment failures, aging processes, or wear, is the concept most relevant to this article.

### High-Speed Railways

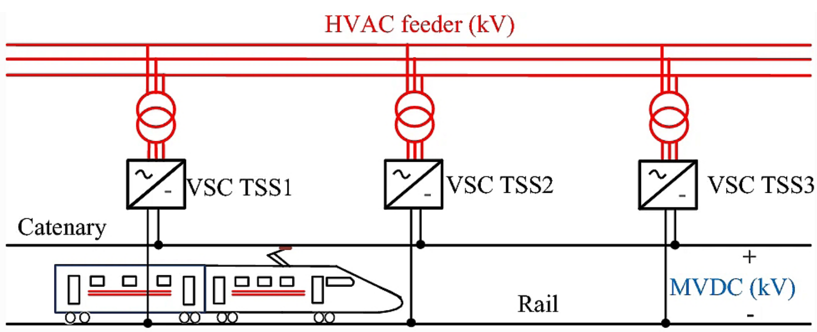
Let's first take a look at high-speed railways with respect to EMI. Mentioned earlier was the "7.23" Yong-Wen line high-speed train accident. Now we also can take a look at low-frequency conductive and radiated EMI in high-speed railways in general.

Some of the most susceptible railway systems/equipment to EMI noise are signal and communication systems, RFID systems, and control systems.

An electromagnetic field in a high-speed railway system can be simulated by the Maxwell and High Frequency Structure Simulator (HFSS) based on finite element method (FEM) theory.

### Electrified Railways

In the design of electric railway vehicles, including high-speed trains and subway trains, EMI/EMC problems have become very serious issues. First, more powerful motors and equipment come with an increase in EMI. Second, high-power electrical systems may cause interference to monitoring signals in electric railway vehicles as well as those existing by the track side.




**Shown is the layout of a MVDC railway electrification system (Image from Reference 3)**

Traditional railway vehicle EMI/EMC design relied mainly on experience and test, but this isn't efficient enough for fault location and solution seeking. Thus, it becomes a troublesome bottleneck in vehicle system performance.

Distributed high-power traction devices, along with automatic monitoring devices and their computerized control systems, are the heart and brain of the electric vehicle. These systems help to ensure the safe and stable operation of electric train vehicles.

High-frequency electromagnetic (EM) harmonics will occur due to nonlinear electrical systems such as the traction system and auxiliary power-supply system, when the output power reaches about the megawatt level. This will cause interference to small signal sensors, such as a network control systems, passenger information systems, and communication systems, which can travel along a metal vehicle body or cables. It not only poses a serious EMI threat to overall system security and reliability, but can also affect the passengers' electronic equipment, like mobile phones, computers, artificial heart devices, etc.

### Medium-Voltage Direct-Current (MVDC) Transportation Electrification Systems

Conventional direct-current railway electrification systems (DC-RES) are employed in local and short distance runs for trains. Medium-voltage direct-current railway electrification systems (MVDC-RES) are very promising for long-distance/high-speed corridors *(see figure)*.

MVDC-RES systems use traction substations (TSS), which are located much farther apart than conventional DC-RES. Train loads in MVDC-RES also will carry much heavier loads than the conventional DC-RES. MVDC-RES creates a major change in catenary voltage, TSS spacing, and train loading; this will affect rail potential as well as stray currents.

### EMI Effects on Railway Signaling

As mentioned, a very important and fundamental approach in railway accident prevention is to learn from past incidents. Prevention techniques can be implemented in future railway systems by observation of those past accidents via accident models.

High-speed and heavy-load railways are experiencing a very rapid growth. Because of this, EMI in traction current has increased. Signal equipment may degrade or malfunction due to harsh working environments, and even the safety of train operation may be threatened once the fail-danger side fault occurs. Although railway signaling must follow the basic principle of "Fail-Safe," safety is unfortunately a probability parameter—EMI might make signal equipment breakdown, and even cause "Fail-Safe" signal equipment to fail.

Some experts claim that the SIL of signal equipment should be at Level 3 and an EMI risk assessment is necessary. The Beta Factor Method is an approximation method used for the quantitative evaluation of common cause failures (CCFs). CCFs are single faults that result in the failure of multiple components.

### Summary

EMI risks are increasing in railway vehicles. Track circuit characterization is of utmost importance for EMC and safety in railway systems. And electrified railways, such as MVDC and DC-RES systems, need to address EMI effects especially on railway signaling devices.

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