A New Analysis Method For Subway Grounding Systems

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Abstract. This work deals with the calculation of touch voltages and leakage current density distribution in direct-current subway grounding systems.

A new approach for direct-current subway grounding systems calculations was developed. In this approach, all system components are modelled as multi-input, multi-output blocks, which are interconnected using appropriate electrical equation.

Results obtained using the proposed approach show good agreement with results reported in previous works.

Keywords - Grounding Systems, Subway, EMC

1 Introduction

On subways, the feed system operates, on general, in direct current, using one of the two rails as a negative terminal.

The positive terminal can be a catenary or a lateral rail, called third rail (3T). In this work we will always call the positive terminal third rail, but the method can also be applied on subways that possess a catenary.

Three different metallic parts compose the subway grounding system as Fig. 1 shows:

TV - the railway grounding
TT - the tunnel grounding
TE - the external grounding

It is interconnected system, and Fig. 1 shows that a dangerous voltage between the platform and the train could be applied to a passenger. In order to decrease the voltage between the train and the platform, TV and TT could be interconnected. However, this solution implies a leakage density current increase and, as consequence, the system will suffer from corrosion. Another solution to this problem is isolate TV but this implies a touch voltage increase.

The solution for these two antagonistic solutions is the installation of the rail on a material with high electric resistance, which grounds TV to the structural hardware of the tunnel. TT is electrically connected, through concrete (high electric resistivity 600 $\Omega.m$) to the metallic rings that make the locking of the tunnel, called external grounding TE.
2 Methodology

Figure 2 shows an elementary length of the railway system (length $\Delta x$).

Kirchhoff’s Laws could be applied to this circuit in order to obtain:

$$\frac{d}{dx} \begin{bmatrix} v_1 \\ v_2 \\ v_3 \\ i_1 \\ i_2 \\ i_3 \end{bmatrix} = \begin{bmatrix} 0 & 0 & 0 & -r_S & 0 & 0 \\ 0 & 0 & 0 & 0 & -r_T & 0 \\ 0 & 0 & 0 & r_S & 0 & r_{TT} \\ -gst & gst & 0 & 0 & 0 & 0 \\ gst & -(gst + gtt) & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix} \begin{bmatrix} v_1 \\ v_2 \\ v_3 \\ i_1 \\ i_2 \\ i_3 \end{bmatrix} = A.$$

This set of equations could be solved using an equivalent circuit as proposed by (Pereira, [1997]). This approach is based upon on the model of transmission lines proposed by (Stevenson, [1982]).