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Optimal underground timetable design based on power flow for maximizing the use of regenerative-braking energy

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Abstract-

This paper deals with the design of underground rail system timetables that synchronize the movement of trains to allow the energy consumption from substations to be reduced by maximizing the use of regenerative-braking energy. Nowadays, most trains are equipped with regenerative-braking systems and any of this recovered energy not used by on-board auxiliary services can be consumed by other trains in the same rail section. A mathematical programming optimization model has been designed to synchronize the braking of trains arriving at station with the acceleration of trains exiting from the same or another station. In addition, a power flow model of the electrical network has been developed to calculate the power-saving factor for each synchronization event in order to encourage better synchronizations, particularly those which have fewer energy losses. These models were applied in the design of a schedule for line 3 of the Madrid underground system. This schedule was then trialled for a week. Energy savings were measured and a significant correlation with the synchronization of train movements was observed. It was concluded that a modification in the published timetables would result in energy savings, with no effect on the quality of service for passengers and low associated investment costs.

Index Terms- Energy efficiency, regenerative-braking system, train timetabling problem, underground scheduling

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