# 鉄道系研究グループ／Railway Group
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## Train Control Method for Suppressing Delay Propagation through Radio Communication Based Continuous Position Information

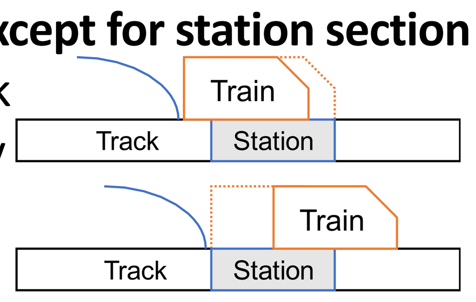
Keisuke Sakai

### I. Delay Propagation

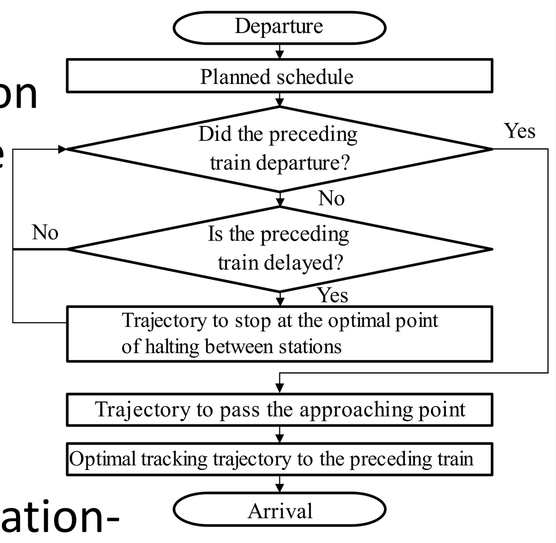
Delay propagation is a situation where the following train is forced to decelerate or stop and it gets delayed due to the preceding train's delay. In a highly frequent urban train service, suppression of delay propagation due to excessive dwell time is significant. We propose a train control method to minimize the interval between departure and arrival at a station.

### II. Features

1. **Moving block signaling except for station section**
   We assume moving block signaling system but only one train can enter a station section.

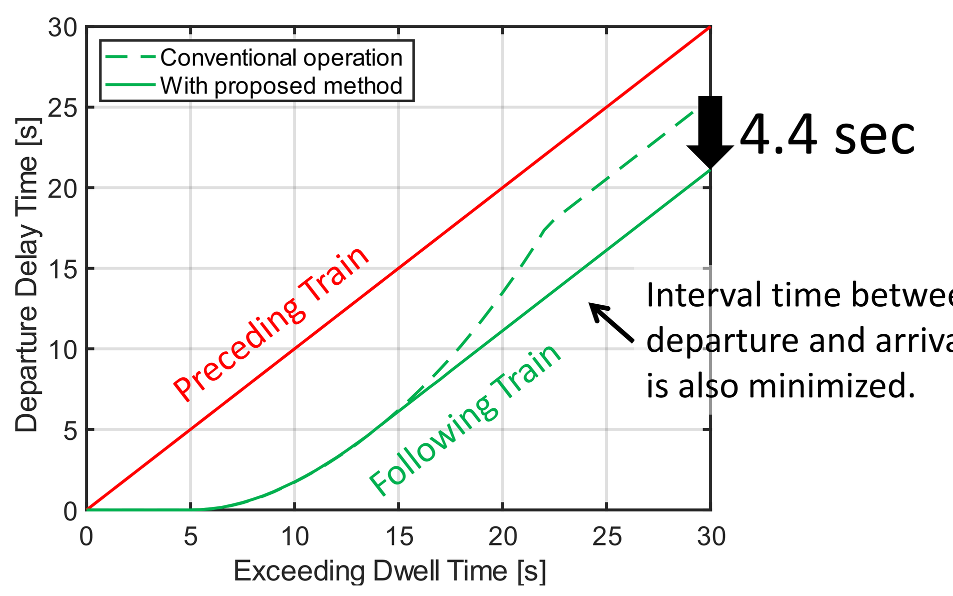



2. **Uncertainty of delay time of the preceding train**
   The proposed method does not need prediction of the delay time of the preceding train. It switches trajectory based on the real-time continuous position of the preceding train obtained by Communication-Based Train Control system(CBTC).

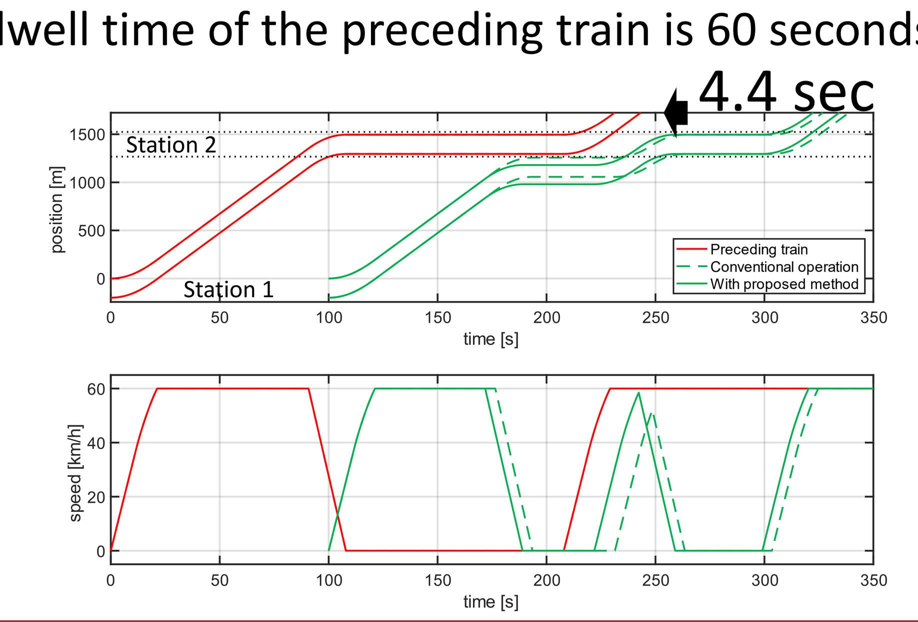



### III. Case Study Result

A result of a case study shows that the proposed method can reduce the delay time of the following train by 4.4 seconds at most compared to a conventional driving method to get as close to the preceding train as possible.




➢ Trajectories of two trains when the exceeding dwell time of the preceding train is 60 seconds




### IV. Conclusion

The proposed method can suppress delay propagation even though it does not use prediction the delay time of the preceding train. However, another result revealed that it has a problem of increasing energy consumption to drive between stations.

## Disturbance Observer Based Anti-Slip Re-Adhesion Control for Electric Train

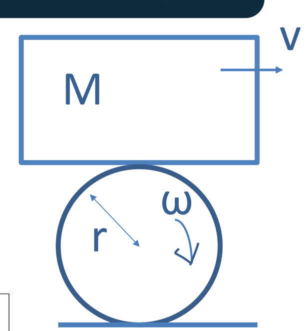
Shikha Saini

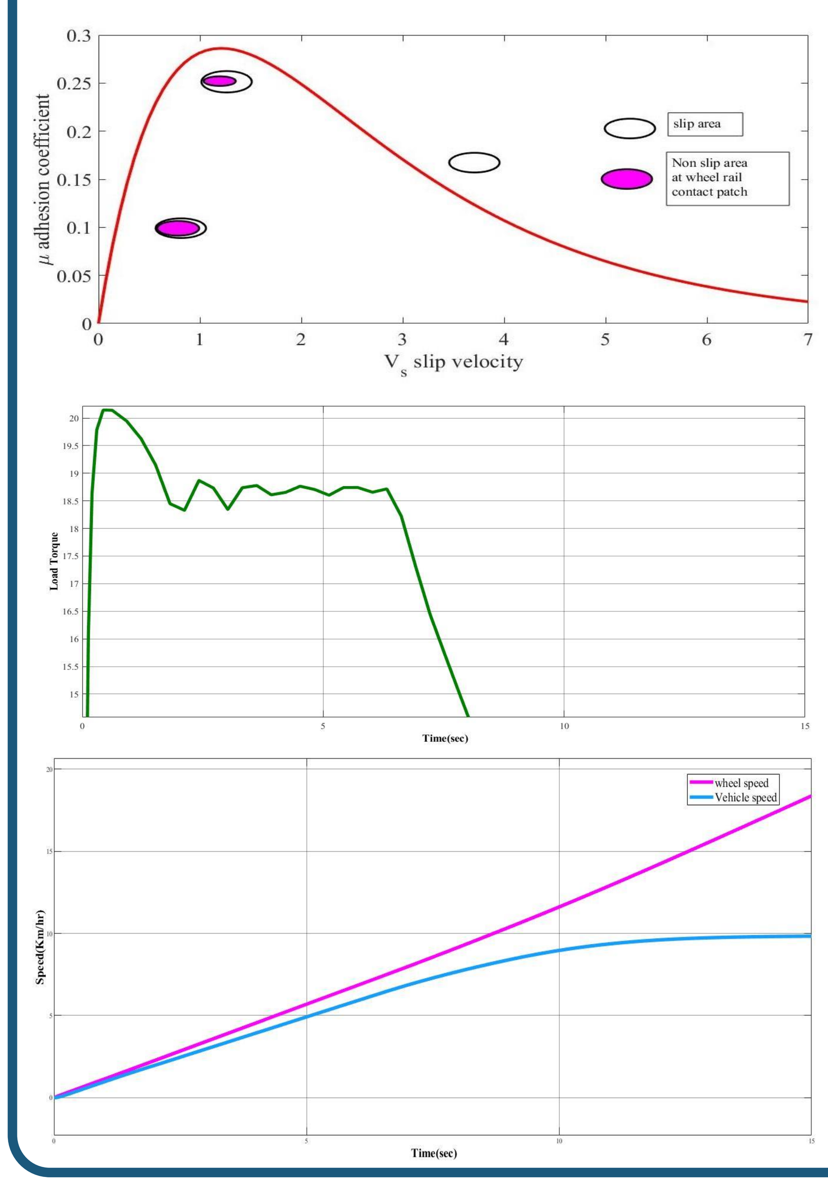
### I. Abstract

In this study, induction motor torque control using a disturbance observer and PID controller is proposed for wheel slip control and re-adhesion. Based on typical characteristic of adhesion coefficient and slip velocity, a two mass rail and wheel load model driven by DC motor controlled by proposed method is analyzed using Simulink for better appreciation and to extend the understanding further for analyses of real train model. In proposed control method change in rail and wheel adhesion is observed as change in load torque by disturbance observer to adjust input torque obtained by motor accordingly. Also literature review is done for the re adhesion methodologies governed by the concept of *rate of change in slip velocity* and *conservation of angular momentum*. Future work is envisaged to do Simulink based performance analyses of proposed control and re-adhesion method for real train model.

### II. Rail Wheel Interaction and Modelling

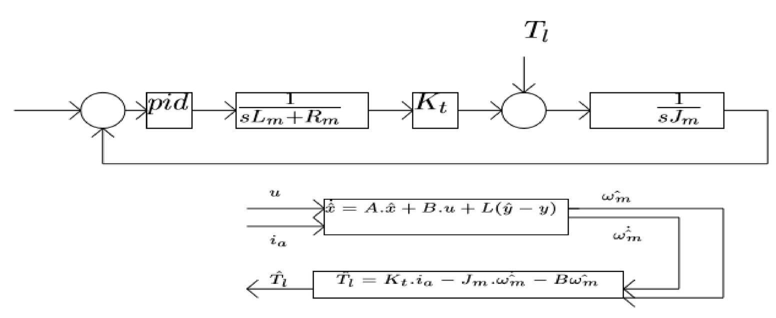
- ❑ Two mass rail wheel model
- ❑ Adhesion and slip characteristics
- ❑ Simulation results



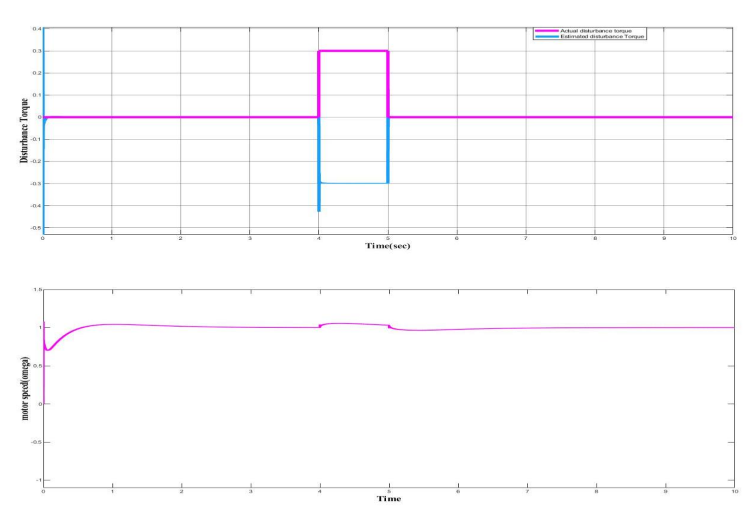




### III. DC Motor Control

**DC motor and observer block diagram used for analysis**




**Disturbance compensation and motor speed response**



Motor speed maintained almost to unity(reference)

### IV. Research Methodology and Future Work

- ❑ Performance analysis of DC motor drive for various load condition (change in adhesion between rail and wheel) for wheel slip control by proposed method.
- ❑ Literature review for various methodologies for wheel slip control and re-adhesion and selection of the suitable parameter to be observed in order to ensure re-adhesion.
- ❑ Improvising the model towards real time situation by replacing DC motor drive by three phase induction motor drive initially with load modelled as two mass system(rail and wheel).
- ❑ Extending the model to 1-inverter controlled 2-induction motor drive configuration in analyzing wheel slip control and re-adhesion.
- ❑ Comparison of the proposed method performance with existing methods for perusing scope for further improvements.

## Study of Unbalance at Point of Common Coupling in 25kV AC Traction System with Different Operational Scenarios

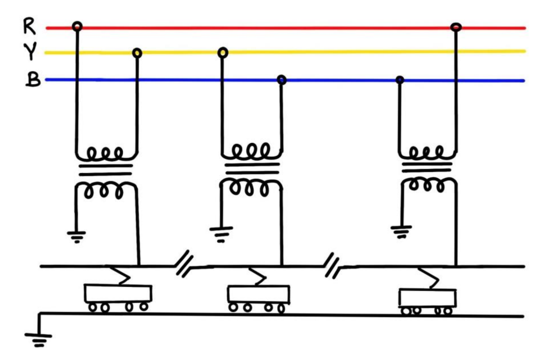
Varsha Singh

### I. Abstract

This research is dedicated to studying the unbalance effect at the point of common coupling (PCC) of the traction distribution network and the utility grid due to each influencing factor: traction transformer configurations like single phase, Scott etc., headway, speed and total weight of the train. Combining these findings with the optimum scheduling of the traction load, unbalance effect is expected to be restricted within specific limits in an already established system where complete replacement of the infrastructure is not economically feasible.

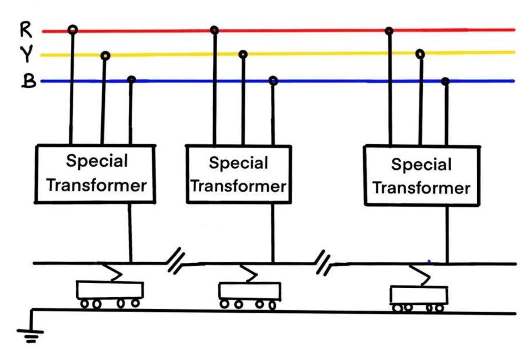
### II. AC Railway Power Supply

**1. Single Phase Traction Transformer**




Two phases are tapped from the grid in cyclic permutation at each substation

**2. Specially connected Transformers**




Specially connected transformers like Scott, LeBlanc, V-v tap all the three phases at each substation.

### III. Voltage Unbalance

- Cause: Asymmetric 1-Φ loading in different sections of traction distribution network. Mathematically represented in terms of sequence components as:

$$\mathrm{VUF}(\%) = \frac{|V_{neg}|}{|V_{pos}|} \times 100\%$$

- Single phase traction transformer system is easier to operate, and the unbalance in grid is minimized when all the three consecutive sections are equally loaded.
- Special transformers like Scott transformer present equal loading in all the three phases when the load in each leg is equal.
- Most of the traction optimization research problems focus on the energy efficient driving of the load.
- This research proposes optimum scheduling of traction load to minimize the unbalance effect at PCC.

### IV. Future Work

1. Development of multi-train movement simulation integrated with traction power supply network.
2. Designing of timetable schedule for reducing the unbalance condition at PCC with certain constraints like transformer infrastructure, mixed-locomotives operation.