# A NEW SYSTEM FOR AUTOMATIC DETECTION OF TRAINS

VINOD CHANDRA

Thesis submitted in partial fulfilment
of the requirements for the degree of

DOCTOR OF PHILOSOPHY
in Electrical Engineering
to
Indian Institute of Technology, Delhi

1977

ACKNOWLEDGEMENT

The author is extremely grateful to Prof P.V.Indiresan without whose constant encouragement and guidance this work would not have been possible.

The work was supported financially by the Research Design and Standards Organisation, Lucknow, Indian Railways. The RDSO also extended help in testing and field trials of the equipment. The author is obliged to various officers and staff of RDSO for the help and assistance rendered by them. Shri C.M. Joseph, Director ( S & T), RDSO ( now CSTE, Southern Railway) extended all possible help from his organisation and this is gratefully acknowledged. The author his highly grateful to Shri S. Vedantham, Joint Director ( S & T ), RDSO, who not only coordinated the project on behalf of the Railways but also made valuable suggestions in the design of the equipment. The help of Shri S.C. Gupta, Asst. Director (S & T) and Shri Ravi Kumar, Deputy Director ( S & T) is gratefully acknowledged for conduct of field trials and development of track devices. Shri S.P. Arora and Shri C.J. Jindani also made useful contributions in testing of the equipment.

Shri L.C.Vaswani, Addl. CSTE, Northern Railway and Shri R. Krishnaswamy, SSTE Northern Railway provided help in the study of the SEL equipment.

The author is thankful to his colleaques, Shri Anshul Kumar, Shri Shashi Kumar , Shri Rajendar Tahl and Shri A.L.Vyas, Senior Scientific Officers for useful suggestions from time to time. Thanks are due to Prof. A. I. Bhattacharyya for permission to use laboratory facilities of the Centre for Applied Research in Electronics. Shri R.K. Goyal and Shri R.L. Khanna provided help in fabrication and procurement of components.

The author is grateful to Shri Harish Thatia for expert typing of the manuscript and to Shri S.K. Chopra for excellent drawing work.

Thanks are due to my wife Shanta for patient help in organising the manuscript.

Vinod Chandra

September 20, 1977. ( VINOD CHANDRA)

## SYNOPSIS

This thesis describes the design and hardware implementation of a system for detecting the presence of any train or part of a train over a specified railway track section. Conventionally, a simple arrangement known as a 'track circuit' is used for train detection. This consists of a battery at one end of the track section, normally energising a relay at the other end of the section, and two rails of the section being used to complete the circuit; the presence of the train is indicated by the relay de-energising due to the short circuit across the two rails by the train axles. Several improved versions of the track circuit have been developed, however, they suffer from the common disadvantages that their operation is considerably influenced by the length of the section monitored and the change in ballast resistance due to climatic conditions. Moreover, track circuits need scarce wooden sleepers and insulated rail joints, increasing track maintenance cost and reducing travelling comfort.

A different kind of system for train detection, described in this thesis, uses axle counting at two detection points, one at each end of the track section, imposing no special requirements on the railway track. These detec-

tion points are actuated by the wheels of the train, as many times as the number of axles in the train, and convey this information to a common electronic processing unit. The detection of the wheel is based on the principle that the coupling between two transducers attached suitably to the railway track depends on the presence or absence of the train wheel. By means of this track device the number of axles that enter a section at a detection point is electronically counted and the number that leaves the section at the other detection point is subtracted from this count. The difference of the two counts provides a continuous indication of the clear or occupied state of the track section. Whenever the difference is zero it is decided that the track is clear and when the count difference is non-zero the track is declared occupied. The system has the ability to work independently of the direction in which the train is moving and in fact it can handle even the case where the train is being shunted forward or backward or even comes to a standstill on the train detection device.

This kind of a system has been developed by Standard Elektrik Lorenz ( SEL) and used extensively in the German Railways. The SEL system has certain

disadvantages especially in the context of the requirements of the Indian Railways. A completely new and improved design, based on the basic axle counting principle, has been developed. The major features of the new design are as follows:

1. The SEL system uses an electromagnetic transducer as the wheel detection device. This transducer has been found satisfactory for both electrified and non-electrified tracks, however, preliminary trials with thyristor controlled locos which the Indian Railways plan to introduce, have not been satisfactory. The interference level induced in the track detection device from the thyristor controlled loco is found to be sufficient to affect the axle count in the electronic counter.

An ultrasonic transducer has been developed to overcome this problem of interference from thyristor controlled locos.

2. The designs for the SEL electronic processing unit utilize mostly discrete components for hardware implementation. The new design makes extensive use of latest integrated circuits to obtain fail safe

features as laid down by ORE report on technical requirements for the design of electronic signalling systems. This gives the system an exceptional reliability and compactness.

3. Certain failure modes of components in the SEL circuits leading to unsafe output state of the train detection system have been identified. These faults have been eliminated in the new design of the electronic processing unit. All components have been protected against failure modes as specified by ORE catalogue on failure of electronic components.

4. The equipment has been tested for satisfactory operation under operational and environmental conditions as laid down in signalling standards of the Indian Railways. The system has undergone a very extensive series of field trials with the Indian Railways and currently a number of prototype have been manufactured by the railway workshops and are under actual trial use in two railway systems.

This thesis gives full details of the design both from the theoretical and from the practical point of view and is organised in the following manner.

The first chapter gives a review of the various methods of train detection and the principle of the train detection system using axle counting.

The second chapter contains a description of the SEL system. The results of trials conducted with thyristor controlled locos on the SEL transducer and the extent of interference caused are given in this chapter. The disadvantages of the SEL system and its potential unsafe features are pointed out.

The third chapter gives details of the new designs developed both for the wheel detection device and for the electronic processing unit. The performance details of the ultrasonic transducer are given in this chapter.

A comparison of the new circuits developed for the electronic processing unit and the SEL circuits is given in the fourth chapter. The designs are compared for safety of the system under various modes of individual component failures. Certain new circuit designs for implementing fail safe circuits using integrated circuits are indicated in this chapter.

A reliability analysis of the system is carried out in the fifth chapter. Results of simulation of the

system with assumed component faults to verify the fail safe feature of the system are also given in this chapter.

The sixth chapter gives the results of field trials, conclusion and scope of future work.

C O N T E N T S