Detection of Spurious Train Occupancy at Platforms for Indian Railways

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Abstract— In this project we are going to divide the railway track into a block of specific length and will be sending a square wave as an incident wave and using the principle of Time Domain Reflectometry (TDR), we will be measuring the time at which the wave has been reflected back. Reference length of the wire will be set and reflected time will be measured and will be converted into length by using CTMU of pic microcontroller. If there is shunting in between this block, its exact distance will be known as the time will be proportional to the distance at which the short has occurred.

Key words: CTMU, Time Domain Reflectometry (TDR), Shunting

I. Introduction

Most railroads use track circuits to determine which sections of track are occupied by trains. In order for the system to work, tracks are divided into blocks of varying length. Each block is divided from the adjacent blocks by an insulated joint between rails. Each block has a track circuit which determines whether a train is present. Track circuits work by running a circuit using the rails to connect a power source at one end of the block with a relay at the far end. The relay and power source are connected to each rail by cables. As long as the circuit is complete, low voltage power flows down one rail, through a relay, and returns to the power source via the other rail. If the circuit is complete, the relay will be energized, which keeps signals in the "clear" position. A broken rail or a failed power source causes the relay to become de-energized and report the section of track as occupied.

An unoccupied track circuit is shown in diagram "A". The power source is located at the number "1", with the relay shown at number "2". The completed circuit is shown in green on the diagram.

A train is detected because it shorts the circuit. In railroading, this is called "shunting" the circuit. When a train enters a block, the metal wheels and axle conduct the circuit as a short cut which bypasses the relay. This de-energizes the relay, which causes signals to report the block as occupied. This is reflected in diagram "B": "1" shows the power source, "3" is the wheel/axle of a train, and "4" is the de-energized relay.

Due some inadvertent reasons, like pre-stressed slippers. The shunting occurs, giving false signaling at the control panel in control room about occupancy of train at the platform/section. Traditionally, all the slippers are sequentially scanned, to locate a faulty one, a huge amount of man-hours, therefore, is wasted in detecting the faulty slipper. Hence there is need of a system to confirm the exact location of faulty sleeper (short circuit). We have used time domain reflectometry to determine this location of shunting.

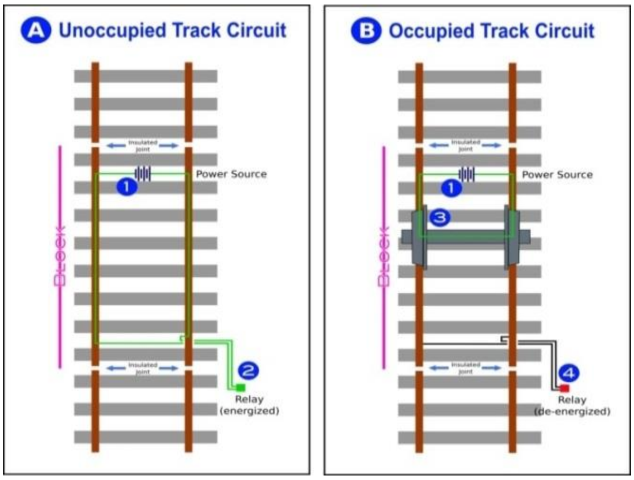

Fig. 1: Unoccupied and occupied track circuit.

II. Preliminaries

In this section, we will introduce Time Domain Reflectometry (TDR) briefly.

III. Time-domain reflectometer (TDR)

It is an electronic instrument that uses time-domain reflectometry to characterize and locate faults in metallic cables (for example, twisted pair wire or coaxial cable). In time domain reflectometry (TDR) attenuation and dispersion of the reflected signal limit the reachable accuracy for wire faults location. Because time of flight is evaluated,the wire faults with small impedance changing are difficult to locate.[1]

The delay time between the incident and reflected signals implies where the discontinuity point from source is, and the amplitude and polarity of the reflected signal indicates the magnitude and type of fault. TDR has been suggested to enhance accuracy in detection and localization of the faults in a coaxial cable. It can also be used to locate discontinuities in a connector, printed circuit board, or any other electrical path.[2]

A TDR is similar in principle to radar. The reflections will have the same shape as the incident signal, but their sign and magnitude depend on the change in impedance level. If there is a step increase in the impedance, then the reflection will have the same sign as the incident signal; if there is a step decrease in impedance, the reflection will have the opposite sign. The magnitude of the reflection depends not only on the amount of the impedance change, but also upon the loss in the conductor. The reflections are measured at the output/input to the TDR and displayed or plotted as a function of time. Alternatively, the display can be read as a function of cable length because the speed of signal propagation is almost constant for a given transmission medium. Because of its sensitivity to impedance variations, a TDR may be used to verify cable impedance characteristics, splice and connector locations and associated losses, and estimate cable lengths.[3]

The impedance for a coaxial probe type transmission line can be approximated using the formula Where εb is the dielectric constant of a material surrounding the transmission line, a and b the diameter of inner and outer conductors, respectively.

$$Z_0 = \frac{60}{\sqrt{\varepsilon_b}} \ln(b/a) \quad (1.1)\ [4]$$

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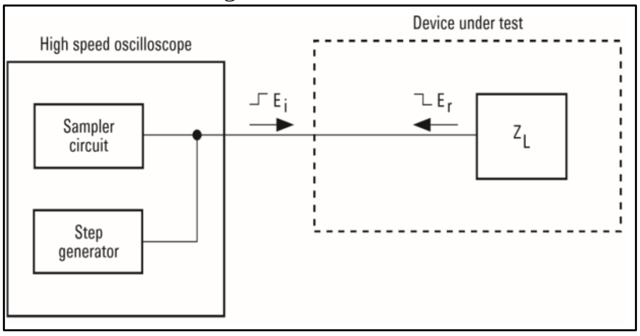

Fig. 2: Working of TDR

IV. Methodology

TDR works on the principle that when an electrical signal traveling along a transmission line encounters a deviation from the characteristic impedance, some (or all) of the signal will be reflected according to the degree of impedance mismatch. This principal is employed in instruments that are used to locate faults in transmission lines such as underground telephone cables. If a cable is damaged, there is nearly always an associated local change in the transmission line impedance. To locate the damage, a TDR instrument is connected to one end of the cable, electrical pulses are sent into the cable, and any signals reflected back to the instrument are detected and displayed. These echo signals have a time delay that is proportional to the distance to the fault, and the shape of the echo identifies the type of reflector. Specifically, an open-circuit will reflect the original pulse shape while a short-circuit will reflect an inverted pulse shape. The detection range of a TDR instrument is mostly determined by the shape and energy of the initial transmitted pulse, the rate of signal attenuation along the cable (to the reflector and back), and the sensitivity of the receiver. To summarize, a TDR instrument connected to one end of a transmission line can determine the type and location of any significant impedance variation along the cable, including open or short circuits, by transmitting an electrical pulse and then measuring the time delay and the shape of any returning echo.

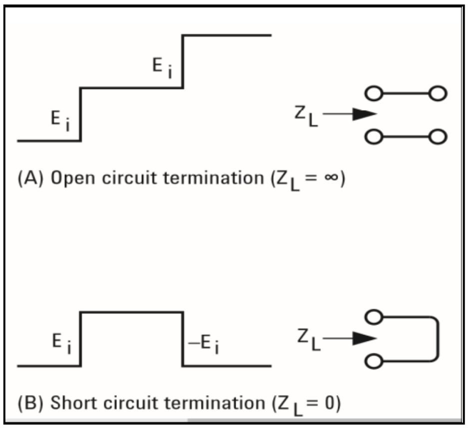

Fig. 3: Open and short circuit termination.

The key innovation of this research is to apply the same test method to the task of train occupancy at various platforms/ sections by treating the two rails track bed as an open two-wire transmission line. Here, a track occupation would also be detectable as a short circuit reflector, by the inverted shape of the echo.

This principle could also be extended for the task of broken rail detection. The latter problem is more pronounced in the areas where anti-social elements break the rail track thereby taking many innocent lives. The concept is that the lead locomotive of every train would be equipped with a TDR-based system to search the track ahead for open circuits caused by broken rails.

Thus, with little dependence on external equipment, the proposed system would identify train occupancy at various platforms/ sections. This principle could be extended to detect any broken rail within the TDR detection range, calculate the distance ahead, and generate appropriate displays and warning alarms for the train crew.

V. Experimental Results and Analysis

Two optical cables were taken and wave was launched at one end. The optical cables were used as a transmission line. Both the cables were shorted intentionally at full length and half-length as shown in fig. 4(a) and 4(b). PIC18F46K80 with Charge Time Measurement Unit i.e.CTMU, (block diagram shown in figure 5) in it was taken to calculate the distance at which the shunting has occurred. A pulse is given to the CTMU and at the positive edge of the pulse, the capacitor of the CTMU starts charging. At the negative edge of the pulse, the capacitor stops charging i.e. if a capacitor is charged with a constant current 'I' for a time 't', then capacitance varies inversely with voltage. This voltage is proportional to time and this time is used to calculate the distance at which the wave is reflected back. [6]

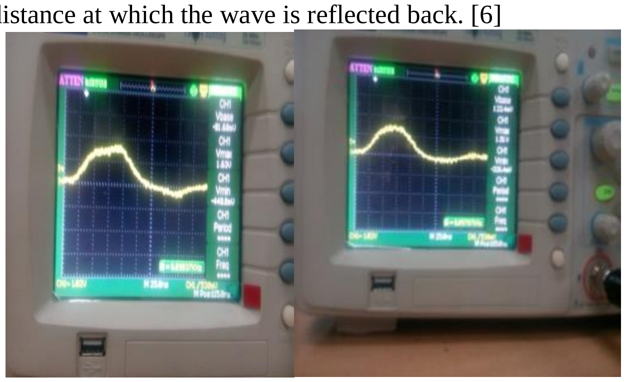

Fig. 4(a) and 4(b): Shunting at full length and half length.

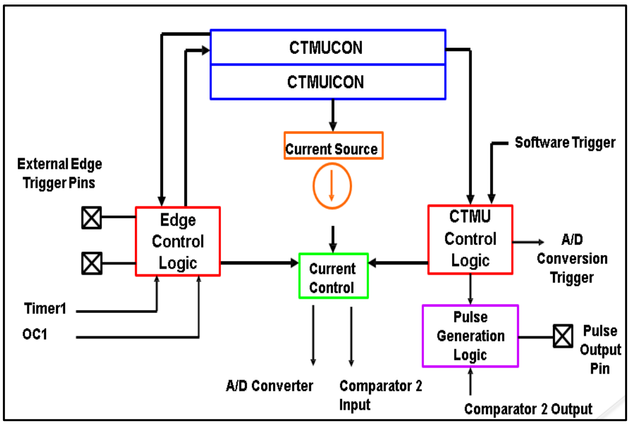

Fig. 5: CTMU block diagram.

VI. CONCLUSION

A technique for detecting the occupancy of railway track and a suitable model for detecting the exact location of shunting was proposed in the paper. Our work uses Time Domain Reflectometry as the main concept to detect the reflected wave and a function of charge time measurement unit was used to give the exact distance at which the shunting has occurred.

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