
# Measurement of Noise by Sensor Technology for Automatic Level Crossings

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***Abstract*– Recently the level crossing in India witnessed an accident rate which is increasing year by year. Indian railway network is the biggest in South Asia and most complicated of all. There are nearly 38,000 level crossings in India, out of which nearly 16500 are unmanned level crossings. This is a big challenge for Government to supervise and manning the level crossings. Presently government is also involved in deploying some warning devices at unmanned level crossings to prevent accidents. Hence there is a need to introduce some type of train actuated devices which can detect the presence of train at various speeds. This paper is presenting the train detection system "RND- Rolling Noise Detection" involved in train detection before the arrival of train. Rolling noise is main contributor of noise produced due to the running of train over the tracks. It is produced by the wheel rail interaction at the 0 m height. As it is a sound wave, it can travel in air as well as in solids. In air it is audible to us but in solids it travels as seismic waves. It is detectable in air and solids also, but the speed varies in both mediums. Sound waves travel faster in solids than air. Authors experimentally detected the rolling noise inside the rail tracks well before the arrival of train at measurement point and have tried to provide a solution for railways to make unmanned level crossings more safe and reliable by detecting train well before in time so that warning and barrier actuation can be done on time. This can be done by detecting rolling noise caused by train in advance to the arrival of train at some reference measurement point.**

***Index Terms*– Unmanned Level Crossing, Rolling Noises, Rolling Noise Detection (RND) and Piezo Sensor**

## I. INTRODUCTION

IT'S our pride that we are having 2nd largest network in Asia. But the accident rate in our railway system is a big challenge for our country. Being a larger network, we are still lacking in manned level crossings. There are 38000 level crossings in Indian network and still nearly 16500 are unmanned which is still a large number [8]. Accident rate due to unmanned level crossings is increasing year by year. Level crossing accidents are mainly due to the impatient driving of the commuters crossing the tracks. They hurriedly cross the level crossings without realizing the super-sonic speed of trains. That's why it is necessary to look forward and design some more safe, reliable and technologically advanced systems that can make unmanned level crossings accident free at a low cost of implementation.

## II. LEVEL CROSSINGS

The interaction of railway tracks and highways/roads at same level is called level crossings and are of following types:

Manned Level crossings: manpower is required for controlling of crossing.

Unmanned Level Crossings: these are the crossings without any manpower.

## III. ROLLING NOISES

Running train produces many type of noises. Fig. 1 shows the noises associated with trains. Among all rolling noise is the main contributor of noises at 0 meter and 0.5 meter heights. Environmental noise from railways can be subdivided broadly into dominant contributions from traction (engines, fans, gears etc) up to around 50 km/h, rolling (wheel/rail interaction) from around 50 km/h to around 270 km/h, and aerodynamic effects from around 270 km/h [3], [6], [10]. The contributor over the widest speed range is rolling noise. This is a function of the excitation of the wheel and track system by the combined roughness at the wheel/rail interface as the wheel rolls on the rails, the vibration response of the various coupled components and the resultant radiation of sound from these components. It is this source that is of greatest interest in railway noise mapping, although traction noise and aerodynamic noise can still be important contributors [3], [6].

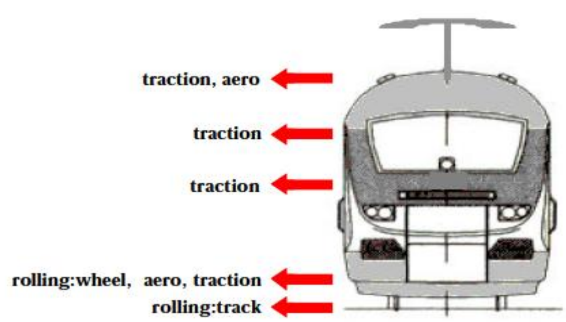



Fig. 1: Production of noises

## IV. RND – ROLLING NOISE DETECTION

Rolling noise detection is based on the measurement of wave propagation in solids and this is done with the help of sensor attached with the solid. The sensor of high sensitivity will be used to measure the vibration noise. The output signal of the sensor is then fed to the interfacing and amplifying circuit.

Firstly a model is constructed to demonstrate the railway tracks and a sensor is used to measure the sound intensity of rolling noise in the direction of propagation of rolling noise that is the direction of train.

Secondly Sensor is placed at 0 m level from rolling noise (rail height); it is the point on rail track as shown in figure 2. Sensor is placed for the measurement of rolling noise inside the rails. Output of sensor is fed to designed circuit and then finally recorded with the help of analyzing software as shown in Fig. 6.

Fig. 2 shows the arrangement for the placement of sensor. This arrangement is used to measure the parameters related to wave propagation at a measurement point which is far advance to the train. Impact point is the location of interaction of wheel and rail and is the origin of wave propagation in both directions inside the rails as well as in air in all directions. Measurement point (MP) is the location of placement of sensor unit well in advance for the measurement of wave propagation inside the rails. Wheels of running rails are producing rolling noise at impact point and this rolling noise is observed and recorded with the help of design circuit and analyzing software. Speed of train is measured by marking the rails at certain distances and recording the time to cover that distance.

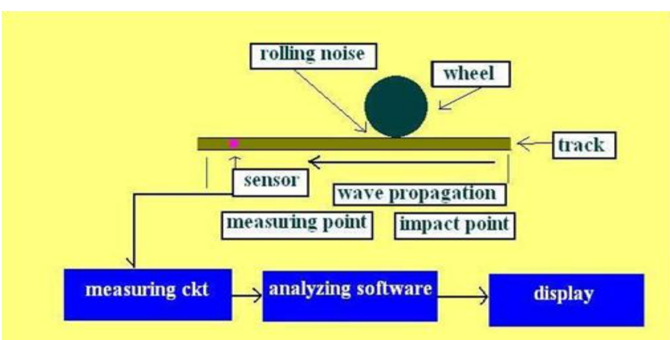



Fig. 2: Measurement of rolling noise

## V. VIBRATION MEASURING SENSOR

The rolling noise generated in the tracks needs to be measured for analysis. For this choice sensitive seismic sensor is must. The sensor should be efficient enough to measure the vibrations properly. For this the piezo sensor is the best choice in terms of efficiency, availability. The capacitor acts like a piezo sensor. When hit with some vibrations its output give potential which is then fed to a computer via an amplifying and interfacing circuit. The piezo sensor has a piezo element. When some pressure is applied on the surface of the piezo element then a potential is generated. The changes in the dimension of the piezo structure yield positive charge on one side of the surface and negative charge on the other side of the piezo surface. The higher is the pressure, the higher is the potential generated which upon amplification is inputted to the computer for the recording and analysing purpose.

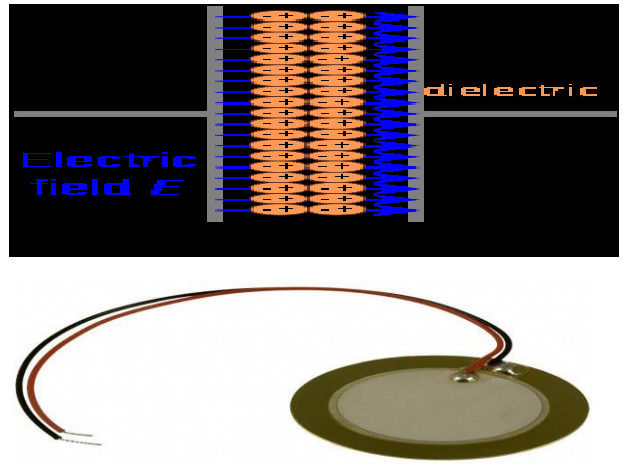



Fig. 3: Capacitor as piezo sensor

## VI. VIBRATION MEASURING SENSOR CIRCUIT

Fig. 4 is the circuit used for measuring the vibrations produced inside the rails. It is sensitive seismic measurement circuit and can detect very light movements produced due to any vibrations. This circuit is assembled on PCB and is used to actually measure the waves on the main track. A standard piezo - sensor is used to detect vibrations/sounds due to pressure changes. The piezo element acts as a small capacitor having a capacitance of a few nanofarads. When the piezo element is disturbed, it discharges the stored charge. This alters the voltage level at the inputs of IC1 and the output momentarily swings high as indicated by green LED1. The IC TLO71 is MESFET op amp which acts like a amplifier and has output voltage frequency which can be directly fed to the mic jack of the computer. The circuit itself is an interfacing circuit.

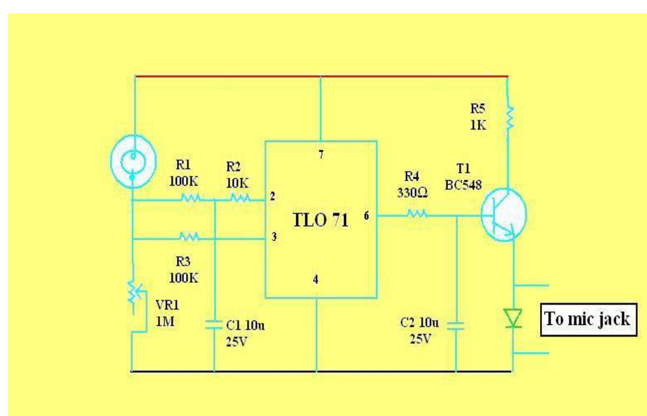



Fig. 4: Rolling noise measurement circuit

Fig. 5 shows the actual placement of rolling noise measurement circuit. Wheels of running trains are producing rolling noise at impact point and this rolling noise is observed and recorded with the help of design circuit and analyzing software. Speed of the train is measured by marking the rails at certain distances and recording the time to cover that distance.

Fig. 5: Actual placement of rolling noise measurement circuit

## VII. DATA PRESENTATION

The wave propagation is sensed by sensor and recorded with the help of analyzing software and recorded data is presented in figure 6. Figure 6 shows the status of the train before the measurement point (MP).

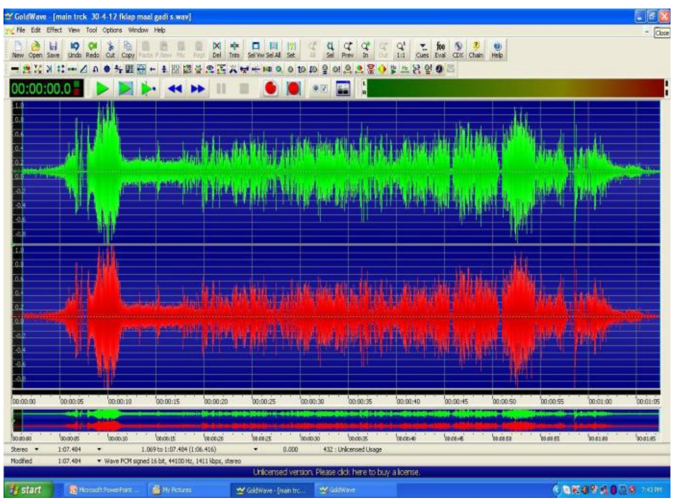


Fig. 6: Measurement of train before measurement point

It is clear from the recorded data that wave propagation is possible inside the rails and magnitude and frequency of that wave is increasing with the arrival of train at measurement point and after crossing of train sudden reduction in both is observed.

## VIII. SPECTRUM ANALYSIS

The spectrum analysis of the recorded data is done to get an insight about the behaviour of the signals. The spectrum analysis yields some interesting facts about the signals frequency.

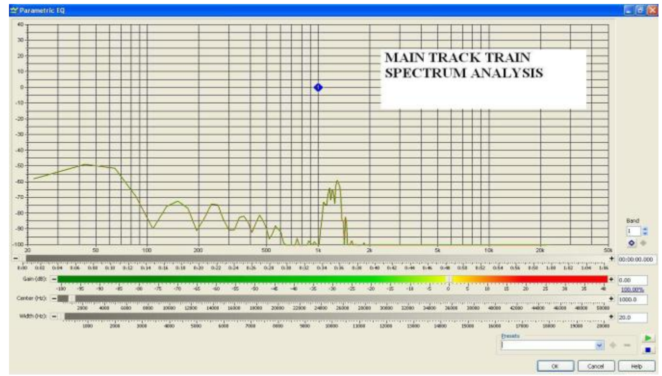



Fig. 7: Spectrum analysis

The graph shown in Fig. 7 is the spectrum graph of main track signal measured in decibel. The graph yields some interesting facts about the rolling noise signal. As the signal is a noise type signal so it consists of various frequency components. It is clearly shown that the maximum frequency component is at 1.8 kHz and the maximum amplitude of the signals is from 20 to 100 Hz and then from 1 kHz to 1.5 kHz.

## IX. ANALYSES OF DATA

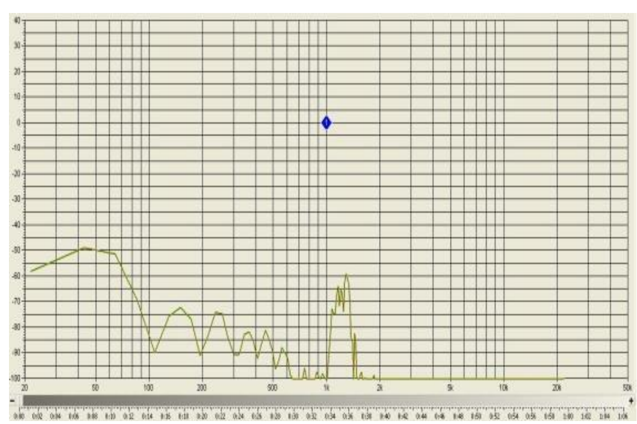
Recorded data is finally analyzed from the GoldWave analyzing software and analyses of data are presented below:

### *A. Analyses Of Measured Data From Railway Tracks* (goods train 80 km/hr)

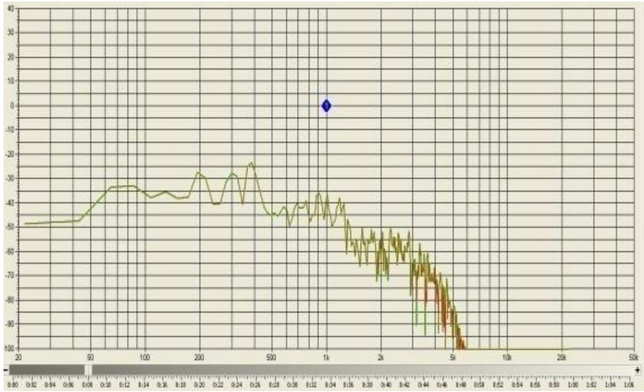
MAIN TRACK:

- AVG AMPLITUDE=0.35 UNITS
- FREQUENCY= 930 CYLCLES /SEC
- B.W=6.5 KHZ
- MAX GAIN (in db) = -48db (At t=0 sec)

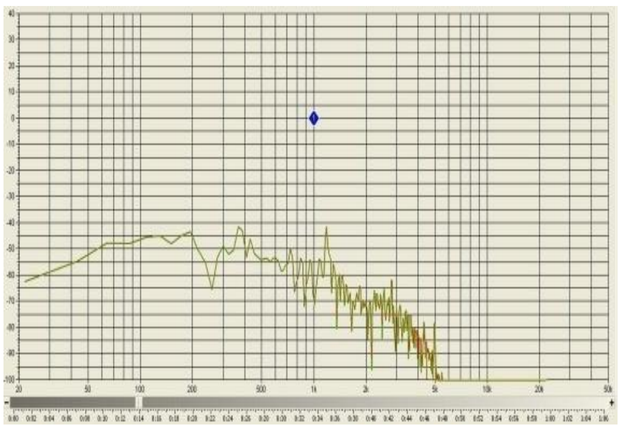
### *B. Spectrum Samples at Various Time of Main Track Signal*



t=0 sec

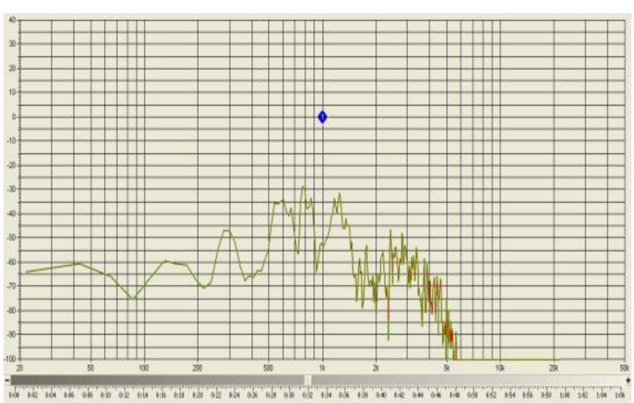


t=0.08 sec

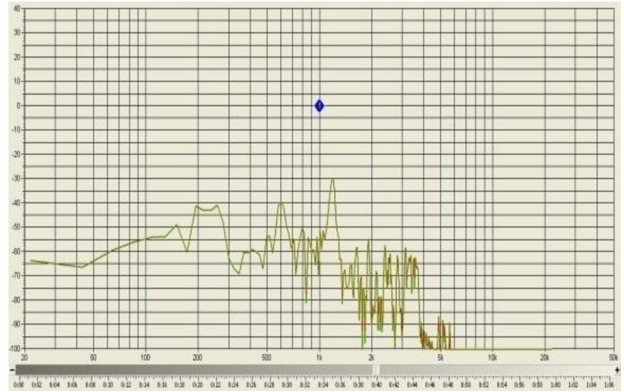


t=0.16sec

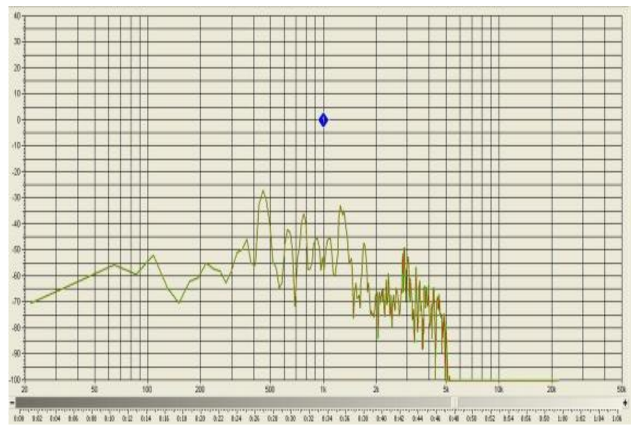
t=0.24sec



t=0.32sec



t=0.40 sec



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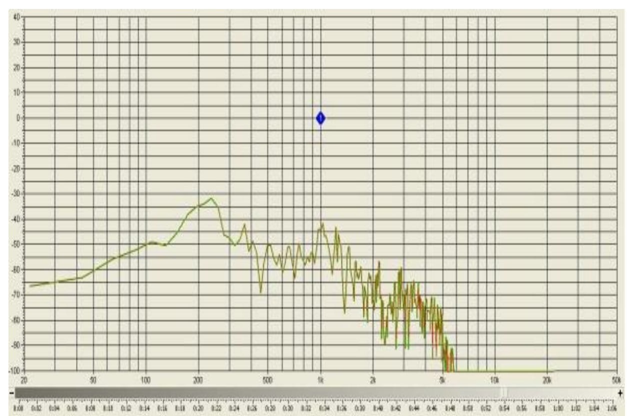

t=0.54 sec

The data table is given as:

Table 1: Representation of data

| S.No | Time (sec.) | B.W(KHz) | Peak Gain(db) |
|---|---|---|---|
| 1 | 0.00 | 1.8 | -48 |
| 2 | 0.08 | 6 | -23 |
| 3 | 0.16 | 5.5 | -42 |
| 4 | 0.24 | 5.2 | -33 |
| 5 | 0.32 | 5.7 | -28 |
| 6 | 0.40 | 5.7 | -31 |
| 7 | 0.48 | 5.2 | -27 |
| 8 | 0.54 | 5.7 | -32 |
| 9 | 0.58 | 2.8 | -29 |
| 10 | 1.06 | 1.5 | -55 |

It can be inferred from the above analysis that the average B.W of the signal in main track is around 6.5 kHz.

## X. CONCLUSION

Followings are the conclusions based on the measurement of the vibration inside the rails produced due to rolling noise:

- The propagation of vibration inside the rails is observed.
- Yes, it is possible to record vibrations before the arrival of train.
- Propagation is more pronounced in forward direction than in reverse direction.
- Amplitude of wave is also increasing and can be used for actuating signals.

At the last it is concluded that the wave propagation inside the railway tracks are possible and this wave propagation can be used for actuating the crossing barriers especially at unmanned level crossings for more safe and reliable crossings.

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