DETECTION OF CRACKS ON RAILWAY TRACK USING FREQUENCY ANALYSIS

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***Abstract*—Huge number of train accidents are to due to derailment which is a proven fact from the survey named "INDIAN RAILWAY ACCIDENTS STATISTICS - PERCENTAGE OF ACCIDENTS BY TYPE". In period of 6 years between 2009 and 2014 there were 803 accidents in Indian Railways which killed 620 people and injured 1855 people. The Standing Committee on Railways, while examining safety and security in the railways they had noticed that more than half of the accidents are only due to lapses on the part of railway staff. Such lapses include carelessness in working, poor maintenance work, adoption of short-cuts and non-observance of laid down safety rules and procedures. The committee had recommended that a regular refresher course for each category of railway staff should be conducted. This can be minimized by reducing the manual based crack checking and replacing it with equipment-based crack detection.**

The proposed model is a simple system based on the voice tracking. Healthy track frequency is obtained and saved as reference signal.MSP-SA430SUB1GHZ is the spectrum analyser used to analyze the obtained frequency spectrum from the voice recorder. Voice recorder is placed in the trolley and provides voice recording which is further converted to frequency through spectrum analyzer. The deviation of the obtained frequency from the reference frequency beyond allowable range will be regarded as presence of crack. GPS location tracker will track the location at which crack is observed GSM module is used to transmit the location through SMS.

***Index Terms*—Frequency Analysis,Gprs tracking, Rail track ,crack detection ,voice recording.**

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I. TECHNOLOGY USED IN EXISTING MODELS

TRACK RECORDING/GEOMETRY CARS:

A track geometry car ,also known as a track recording car is an automated track inspection vehicle on rail transport system used to test several geometric parameters of the track without obstructing normal railroad operations.

Some of the parameters generally measured include position, curvature, alignment of the track, smoothness, and the cross level of the two rails. The cars use a variety of sensors, measuring systems, and data management systems to create a profile of the track being inspected.

3.1.1.1 Advantage:

Track inspection was originally done by track inspectors walking the railroad and visually inspecting every section of track. This was hazardous as it had to be done while trains were running. It was also manpower intensive, and inspectors were limited in the amount of track they could inspect on a given day. Manual instruments had to be used to measure various parameters of the track.

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The primary benefits of track geometry cars are the time and labour saved when compared to doing manual inspections of track. Track geometry cars may travel up to 217 miles per hour (335 kilometres per hour), inspecting track the whole time. More commonly, on freight railroads, geometry cars travel at track speed (up to seventy miles per hour) in order to minimize service disruptions. Current track geometry cars may cover large portions of the system in a single day. Many times, maintenance gangs will follow the geometry car and fix defects as the geometry car moves along the track.

Because track geometry cars are full-sized rail cars (with the exception of some lighter hi-rail geometry cars), track geometry cars also provide a better picture of the geometry of the track under loading (when compared to the manual methods which did not take this into account). Finally, track geometry data is generally stored and can be used to track trends in the degradation of track. This data can be used to pinpoint and predict troubleshoots in the track and plan maintenance programs accordingly.

1.1 Parameters measured:

The tolerances of each parameter varies by the track level of the track being measured. In the United States, geometry cars generally classify each defect as either "Class II" or "Class I" (though the exact name may vary by the railroad). A class II defect is known as a maintenance level defect, meaning that the track doesn't meet a particular railroad's own standards. Each railroad has their own standard for a maintenance level defect. A class I defect is a defect in violation of the Federal Railroad Administration's (FRA) track safety standards. Railroads must fix these defects within a certain period of time after their discovery or else they risk being fined.

1. Alignment: "Alignment is the projection of the track geometry of each rail or the track centreline onto the horizontal plane," (FRA Definition). Also known as the "straightness" of the tracks.

2. Cross level: The variation in cant of the track over the length of a predetermined "chord" length (generally sixty-two feet). On straight or tangent track, ideally there should be no variation, while on curves, a cant is generally desired.

3. Curvature: The amount by which the rail deviates from being straight or tangent. The geometry car checks the actual curvature of a curve versus its design curvature.

4. Over headlines (or catenary): Measures the height and stagger of contact wire, the position of catenary masts or poles, and the positions of the wire bridges if applicable.

5. Railguage: The distance between the rails. Over time, rail may become too wide or too narrow. In North America and most of the world, standardgauge is 4 feet, 8.5 inches.

6. Rail profile: Looks for rail wear and deviations from standard profile.

7. Warp: The maximum change in cross level over a predetermined chord length.

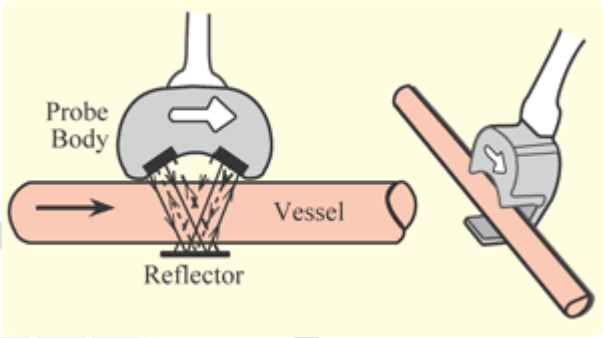
1.2 Inertial-Based Track geometry:

Compact and lightweight no-contact measuring system allows an accurate evaluation of railroad track geometry in a variety of operational conditions. The system integrates a robust inertial measuring unit - incorporating high accuracy accelerometers and solid-state rategyroscopes - with optical-gauge boxes and provides measurements of all critical track geometrical parameters from 0 km/h up to 400 km/h (250 mph). Modular and scalable architecture allows implementation of "all-in-one" full rail profile measurement as well as a completely unattended configuration.

a**ULTRASONIC FLOW DETECTOR:**

An ultrasonic flow meter is a type of flow meter that measures the velocity of a fluid with ultrasound to calculate volume flow. Using ultrasonic transducers, the flow meter can measure the average velocity along the path of an emitted beam of ultrasound, by averaging the difference in measured transit time between the pulses of ultrasound propagating into and against the direction of the flow or by measuring the frequency shift from the Doppler effect. Ultrasonic flow meters are affected by the acoustic properties of the fluid and can be impacted by temperature, density, viscosity and suspended particulates depending on the exact flow meter. They vary greatly in purchaseprice but are often inexpensive to use and maintain because they do not use moving parts, unlike mechanical flowmeter.

Transit time ultrasonic flowmeters send and receive ultrasonic waves between transducers in both the upstream and downstream directions in the pipe. At no flow conditions, it takes the same time to travel upstream and downstream between the transducers. Under flowing conditions, the upstream wave will travel slower and take more time than the (faster) downstream wave. When the fluid moves faster, the difference between the upstream and downstream times increases. The transmitter processes upstream and downstream times to determine the flow rate. They represent about 12% of all flowmeters sold



II. PROPOSED MODDEL

1.INTRODUCTION

In a country like India, majority of people prefer travelling through rails. That is, about 2.2 crores of Indians generally travel by trains per day as per the statistics. In a 6 year period, between 2009-2015, there were a total of 803 accidents killing 620 people and injuring 1855 people. 47% of these accidents were only due to derailment of trains. Such lapses include carelessness in working, poor maintenance work, adoption of short-cuts and non-observance of laid down safety rules and procedures. Hence crack detection system in India should be addressed with at most attention. Normally, the trained employees will manually inspect the track by walking along with the track to search for any visual abnormalities. Hence existing system for crack detection should be made effective and automation of it is crucial.

Rail is manufactured in different weights; there are different rail conditions (wear, corrosion etc) present; there are a significant number of potential defects possible; and the task has to be performed with some speed to reliably inspect the thousands of miles of track stretching across the land. Sperry Rail Service, one of the country's leading inspector of railroad tracks, has been using specialized test equipment mounted on self-propelled rail cars for over seventy years to protect the safety of passengers and freight. This information provides a brief look at rail inspection.

To overcome these mishaps due to derailment, we have designed this system. The main aim is to detect the cracks if any, on a railway track with more advanced method rather than manual detection. This is because manual work is less reliable and hence we go for automation. We are using an Educational Booster pack mkii to record the sound and that is going to be fixed in an inspection trolley. Healthy track frequency is obtained and saved as reference signal.

The Educational Booster pack provides voice recording which is further converted to frequency through spectrum analyzer. The sound and vibrations of the track is being

recorded. This recording is the converted into frequency using a spectrum analyzer. MSP-SA430SUB1GHZ is the spectrum analyzer used to analyze the obtained frequency spectrum from the Educational Booster pack which is placed on the trolley. The deviation of the obtained frequency from the reference frequency beyond allowable range will be regarded as presence of crack.

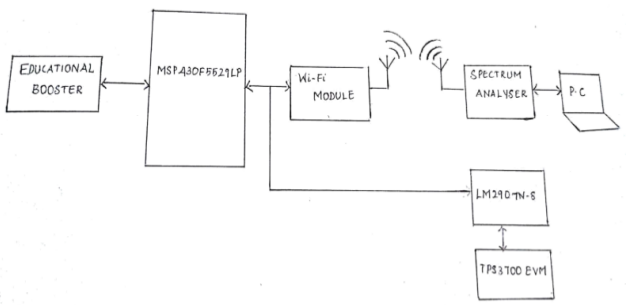
At first, n numbers of samples are taken and the average of all the samples is taken as the threshold level. Then we record the sound of the tracks in use and compare the frequencies of this track with the threshold level set already. The difference in the frequency levels is considered as the percentage of error. On basis of percentage of damage priority is given for the higher percentage crack. GPS location tracker will track the location at which crack is observed GSM module is used to transmit the location through SMS.

All the existing systems rely on the tracks which is prone to the wear and tear with respect to the weather conditions. The sensors installed in the existing systems will soon show inaccurate results. Thus, this makes it important for us to device a method which will not be deployed on the track itself but still could track the cracks and the health condition of each rail track that are under working. This led to the proposal of this railway track crack detection method using frequency analysis. Hence this becomes a much simple and efficient way to detect the cracks on a track.

To overcome the mishaps due to derailment, we have designed this system which is demonstrated in the above block diagram. All the existing systems rely on the tracks which is prone to the wear and tear of weather conditions. The sensors installed will soon show inaccurate results. Thus , this makes it important for us to device a method which will not be deployed at track but still could track the cracks and the health condition of each rail track that are under working .The main aim is to detect the cracks if any, on a railway track with more advanced method rather than manual detection. This is because manual work is less reliable and hence we go for automation.

Using the educational booster pack as the mic interface to the msp430f5529 processor, voice recording of healthy track is obtained this sample is then converted to corresponding voltage. The voltage of this sample is considered as reference voltage. Now an experimental audio sample is obtained, frequency and voltage of this audio signal will be compared with the reference sample of healthy track. . The comparators used will define the threshold of the sample. Deviation beyond the threshold has been identified as crack. The deviation of the experimental track from the healthy sample will provide the amount of crack developed on the railway track.The various stages in the analysis states will ensure the efficiency of the model .Hence this becomes a much simple and efficient way to detect the cracks on a track. Following is the block diagram used to detect and estimate the crack on Railway track.

❖ **BLOCK DIAGRAM:**



A. Functions of major components

1.Educational booster pack.

The BOOSTXL-EDUMKII Booster Pack (see Figure 1)kit is an easy-to-use plug-in module that offers a high level of integration for developers to quickly add to Launchpad development kit designs.

Out of all available key sensors mic is used in this model. The CUI CMA-4544PF-W electret microphone uses an OPA344 operational amplifier to boost the output of the microphone. The human ear can hear frequencies between 0 and 20 kHz and the operating range of the microphone is 20 Hz to 20 kHz. The reference designator for the microphone is MIC1.The Educational BoosterPackMKii offers a high level of integration for developers to quickly prototype complete solutions. Various analog and digital inputs/outputs are at your disposal including an analog joystick, environmental and motion sensors, RGB LED, microphone, buzzer, color LCD display, and more.

This BoosterPack was developed with Energia in mind. Energia is an open source, community developed coding environment, which is supported by a robust framework of intuitive APIs and easy-to-use software libraries for rapid firmware development. We recommend Energia v12 or later. Learn more about Energia at www.energia.nu.

Like the CC3100 and MSP430F5529 this also has several unique features that led to its choice and they are as follows:

- Light Sensor:

It is a digital infrared (IR) thermopile contactless temperature sensor that measures the temperature of an object without being in direct contact. Placing your hand over the sensor increases the sensor output. The digital output is reported over an I2C- and SMBus-compatible two-wire serial interface.

- Temperature Sensor:

It is a digital infrared (IR) thermopile contactless temperature sensor that measures the temperature of an object without being in direct contact. Placing your hand over the sensor increases the sensor output. The digital output is reported over an I 2C- and SMBus-compatible two-wire serial interface.

- Servo Motor Connector:

The servo motor connector is a 3-pin header for the user to connect an external servo to be controlled. Users can connect a servo and control it through the application code. The

reference designator for the servo motor connector is J8.

- 3-Axis Accelerometer:

The Kionix KXTC9-2050 is a 3-axis analog accelerometer that measures g-forces. Moving the board along the axes will change the analog signal generated by the accelerometer. The reference designator for the accelerometer is U3.

- User Push Buttons:

The user pushbuttons on the BOOSTXL-EDUMKII are connected to pullup resistors that drive the BoosterPack plug-in module pin high until the button is pressed and the pin is driven low. The reference designators for the user pushbuttons are S1 and S2.

- RGB Multi-color LED:

The Cree CLV1A-FKB RGB multicolor LED light output can make any color by mixing red, green, and blue. Each color channel can be individually modified by pulse width modulation (PWM) to achieve the desired color. The reference designator for the RGB LED is D1.

- Buzzer:

The CUI CEM-1203(42) piezo buzzer can play various frequencies based on the user-provided PWM signal. You can even play different tones back to back to create a song. The reference designator for the piezo buzzer is BUZ1.

- Color TFT LCD Display:

The Crystalfontz CFAF128128B-0145T color 128x128-pixel TFT LCD supports display updates up to 20 frames per second (FPS) while only requiring a few lines to control the TFT LCD module through the SPI interface. This module has a color depth of 262K colors and a contrast ratio of 350. The reference designator for the color LCD is LCD1.

- Microphone:

The CUI CMA-4544PF-W electrets microphone uses an OPA344 operational amplifier to boost the output of the microphone. The human ear can hear frequencies between 0 and 20 kHz and the operating range of the microphone is 20 Hz to 20 kHz. The reference designator for the microphone is MIC1.

- 2-Axis Joystick with Pushbutton:

The ITEAD studio IM130330001 2-axis joystick with pushbutton is simply two potentiometers, one for each axis. The select button is actuated when the joystick is pressed down. The analog read statement reads the voltage present on the joystick axis to provide the position of the joystick to the application (for example, pushing the joystick to the left reads X = 0). The reference designator for the analog joystick is JS1.

2.MSP430 PROCESSOR

The MSP-EXP430F5529LP is an inexpensive and simple development kit for the MSP430F5529 USB microcontroller. It offers an easy way to start developing on the MSP430 MCU, with onboard emulation for programming and debugging as well as buttons and LEDs for a simple user interface.Processor has USB-enabled MSP430F5529 , it is a 16-bit MCU.The clock timimg is up to 25-MHz System Clock .Operating voltage varies from 1.8-V to 3.6-V operation .In addition it has 128KB of flash with 8KB of RAM .Five timers are present in the processor. It has Up to four serial interfaces ,they are SPI, UART, I2C .There is a 12-bit analog-to-digital converter ,Analog comparator –and Integrated USB, with a complete set of USB tools .Msp430f5529lp is a Texas instruments general purpose processor board which can be used to analyse the audio data obtained through the educational booster pack. The audio file will be saved in the memory of the processor.

3.WIFI MODULE

Processor is connected to the Wi-Fi module called cc3100 which will be used to transmit the audio sample to the spectrum analyser.This will help thew data to be transmitted across the air interface.The device interfaces to an external host using the SPI interface. The CC3100 device can interrupt the host using the HOST_INTR line to initiate the data transfer over the interface. The SPI host interface can work up to a speed of 20 MHz.

WLAN

• 802.11b/g/n integrated radio, modem, and MAC supporting WLAN communication as a BSS station with CCK and OFDM rates in the 2.4-GHz ISM band

• Auto-calibrated radio with a single-ended 50-Ω interface enables easy connection to the antenna without requiring expertise in radio circuit design.

• Advanced connection manager with multiple user-configurable profiles stored in an NVMEM allows automatic fast connection to an access point without user or host intervention.

• Supports all common Wi-Fi security modes for personal and enterprise networks with on-chip security accelerators

• SmartConfig technology: A 1-step, 1-time process to connect a CC3100-enabled device to the home wireless network, removing dependency on the I/O capabilities of the host MCU; thus, it is usable by deeply embedded applications

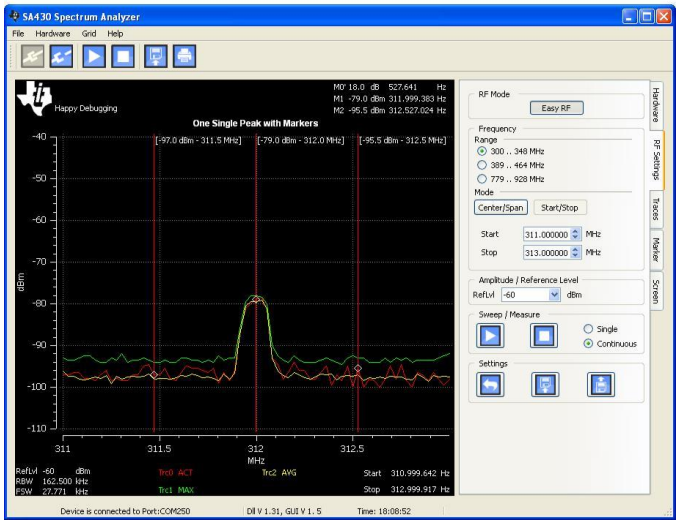
. • 802.11 transceiver mode: Allows transmitting and receiving of proprietary data through a socket without adding MAC or PHY headers. This mode provides the option to select the working channel, rate, and transmitted power. The receiver mode works together with the filtering options.

4.SPECTRUM ANALYSER

The plot of the various frequency components and their respective amplitude are obtained by using spectrum analyser.Variations in the signal amplitudes can be observed by the excel sheet plotted by spectrum analyzer.Pressing the Start button not only starts a measurement, it also applies the RF settings for measurement. To change RF settings during measurement, first enter the new settings and then apply them by pressing the Start button again.

By default, the graph shows all settings and the measurement . Two traces are automatically enabled. Trace 0 shows the actual (ACT) measured values, and trace 1 shows the maximum (MAX) value for each measured frequency point since the start button was last pressed.

Results are displayed immediately in the graph window, which also shows all RF parameters**.**



Conclusion

Therefore this system can be a substitute for the manual checking of cracks decreasing the error probability due to man made errors. Which will lead to drop of accident numbers due to derailment .An efficient system with simple functionality is obtained.

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