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Integration of Iot with Self Powered Nodes for Railway Condition Monitoring

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***Abstract:** It is obvious that technological advancements are increasing at a faster pace. Development in the field of energy harvesting and monitoring railway stations is also evolved. In these days monitoring track is quite difficult due to lack of proper equipment and need more manpower. So we propose a system where we can continuously monitor the multiple parameters of the track and update them to monitoring stations. In this system, we also harvest energy from the vibration of the track to power up the nodes. Here we use the cloud as a medium for storing the data, and we can monitor the parameters of railway condition from anywhere in the world.*

***Keywords** - energy harvesting, Internet of Things (IoT), magnetic levitation oscillator, railway condition monitoring, self-powered nodes.*

I. INTRODUCTION

Rail transport, is a means of mass transport medium for both passengers and cargo. It plays a significant role in the economy and transport of any country. The railway foundation has witnessed a tremendous development in the past two decades, specifically in growing young nations like India. Nevertheless, in suburban areas, due to lack of wired power electrification it is quite complex to ensure the provision of electric power for railway track-side surveillance instrument. Using wireless electric power units such as battery poses a tedious issue for the supervision and replacement of battery units in such places. Hence the self-powered nodes are used and the nodes get powered from the track vibration. The MAGLEV energy collector consists of one Peltier and two piezoelectric crystals to produce energy which is stored in a battery. The MQTT (Message Queuing Telemetry Transport) algorithm is used to send the data to the control station.

This method helps to resolve the power provisioning issues of railway track-side surveillance devices and monitors various parameters using different sensors in the track and improves the evolution of Internet of Things (IoT) in the field of smart transport. The railway track side sensors are combined to the rail track end equipment and are energized by the MAGLEV energy collector. The information is sent to the control station with the help of MQTT broker and can be accessed through a webpage over the internet with cloud storage services.

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II. REVIEW OF LITERATURE

Concerning energy collectors applied to the transportation region, demands of piezoelectric platform for railway track observation had been conceived. Moreover, investigation about track-borne production of energy in terms of piezo-electric and electromagnetic gathering was done [1]. Likewise track borne energy collector with magnetic levitation was involved. The instrument with a pack of 15 cm ×12.5 cm ×9.5 cm could produce 100 milliWatt energy output on a graduated roller arrangement, which pretended the payload train speed of 80 km/h. In the earlier works, the electrical parameters, instrument setup, and shake characteristics of track-borne electromagnetic and piezo-electric power convertors were studied [2].

In the area of auto-energized rail condition tracking, the significant study aimed predominantly on the energy gathering solutions; but there was few methods for observing the parameters of railway track [3]. The devices can be placed at a certain distance to give proper communication to nodes and the monitoring stations. This will gives the real-time condition of the track for every instance [4].If any parameters have changed it will give alert to the monitoring station. It is easy to locate the defect on track using coordinates of IoT modules.

III. WORKING PRINCIPLE

A. *Magnetic Suspension Oscillator*

The magnetic Suspension oscillator has the property of broad-band response and it is suitable for this operation. The dynamic technique with bilinear reclaim force as in the suspension type can be represented in the form of forced oscillations equation is as follows:

$$\ddot{a} + 2\omega_0\beta a + \omega_0^2 a + \alpha x^3 = H\cos(\omega t + \varphi) \qquad (1)$$

where a is denoted as displacement, t is denoted as time, β is represented as damping ratio, ω_0 is denoted as natural radian frequency, α is denoted as nonlinear stiffness characteristic, H is denoted as excitation amplitude, and φ is denoted as phase. After the implementation of the analysis between magnitude and frequency, it has been found that, the magnitude of the primary input component will vary the oscillator response.

It also contains unstable periodic decisions and the expected outcomes will be reviewed in the forth coming sections.

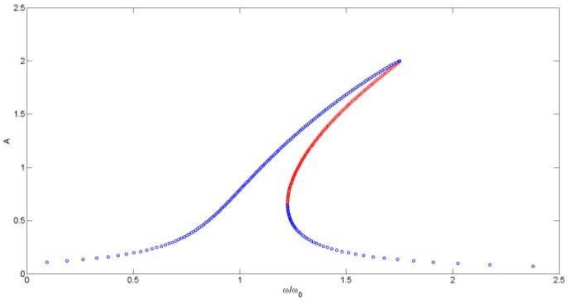

Fig.1 Analysis of Magnitude -Frequency response of the magnetic oscillation device (blue dot: stable periodic response; red dot: unstable periodic response)

B. *Rail track-Borne Energy gathering*

The energy savers can be combined to the rail either connected serially or parallel. It has been classified as the parallel joined rail track-borne electromagnetic power collector instead of the voice coil, resonant coil, and magnetic oscillator (as illustrated in Figure 2). In this type, as indicated in Figure 2, the gathering arrangements are fixed to the rail pad and related to the shocks produces by the wheel set/rail system. In the series arrangement, the energy gathering is usually placed between the track and sleeper bar, or placed between the ballast and sleepers; hence, the presence of the serially-joined equipment will alter the hardness of the rail. Whereas in the parallel setup, the energy collector is firmly fixed to the network of rails or bottom of rail; it is not joined to the wheelset and also the rail sleeper bar, so it can be considered as the parallel arrangement as an additional weight to the rail, and compute the vector modifications of the rail weight and the moment of inertia required by the track.

As per Lenz' law statement, the path of the induced emf always be opposition with the change that produced it. This describes the opposing force in the electromagnetic energy collector. Considering a harmonic excitation, the final damping force can be computed.

$$p \quad v^2 N AB^2 F_{damping} \quad = \quad \frac{}{y(t)} \; \frac{}{(R\, i\omega L)\, x\, (t)\, R} \; \dot{} = + \; \dot{} = + x^{\cdot}\,(t) \quad (2)$$

where p is the power, v is the induced emf; R and L are the resistance and inductance of the coil respectively. A,B, and N denotes cross-section area of the wire, and the gradient of magnetic flux density, the number of coil turns respectively. The power produced at a given time interval (also power produced by damping) can be computed by

$$\text{B. } V=2\int_{-X0}^{X0} c a^{\cdot}(t)\, da = -2c\omega X0 e^{i\omega t} 2X0 = -4c\omega X2 0 e^{i\omega t} \quad (3)$$

Because the energy collectors were firmly fixed to the rail and compelled to the shaking movement produced by the wheel shaft/rail assembly, this sudden change can be utilized to make the rail-track energy level convertor for power gathering; moreover, the availability of the rail-track energy level convertor could apply the force in the inverse manner for the vibration response, specifically when more number of energy convertors were placed onto the rails. In this situation, the total participations originated from the energy changer could be sufficient to make the impact on the rail path deflection. Complete evaluation and equipment design structure of the rail path electromagnetic power saver could be available in the review of literature.

C. *Sensing action*

This prototype model contains various sensing elements such as accelerometer, sensing element which reads temperature, device which measures humidity and infrared demodulator fixed to a ZigBee transceiver at track-side.

The devices such as ADXL series MEMS devices (ADXL345 and ADXL1001) are involved. For example, the device like ADXL345 model is a small (0.3 cm × 0.5 cm × 0.1 cm LGA package) and very low-power (less than 350 μW). And the 3-axis MEMs sensor device have the range of measurement up to ±16 g. Digitized output information is accessed over SPI (3 or 4 wires) or I2C hardware mechanism. This can compute the stationary momentum of gravity in tilt sensing applications and the dynamic momentum which results from movement or vibration. The ADXL345 is better option for mobile equipment application with a resolution of (3.9 mg/LSB) with the measurable range of inclination changes less than 1.0°

Fig.2: Accelerometer

The DHT11 is a tiny pack of (3.2 cm×1.4 cm) digital temperature/humidity sensing device. This device contains a more resistive sensing element with a NTC type thermometer. Moreover this device also has a range of measurement between 20% – 90% relative humidity and 0 – 50 °C. The exactness of the measurement lies between 5% RH and ±2 °C with a 1 percent intention.

The HC-SR501 is a more responsiveness and very low-power (325 μW) human infrared sensing module. It contains an LHI778 probe with two triggering modes. The HC-SR501 has the specific arrangement of self-induction with a observing distance of lower than obtuse angle at a detectable distance less than 7 m.

D. *Tools and Techniques*

Hardware Requirements:

- Energy harvester
- Micro controller(PIC16F877A)
- Accelerometer
- Heat sensor
- Humidity sensor
- Infra Red Detector

Software Requirements:

- Embedded C
- MPLAB

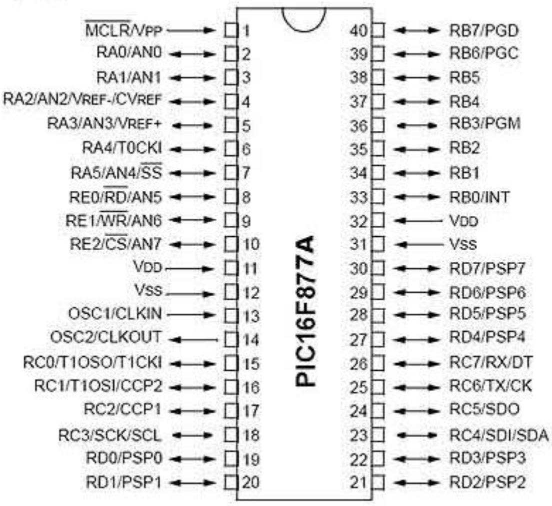

Fig.3. Microcontroller (PIC16F877A)

IV. IMPLEMENTATION METHODOLOGIES

A single chip is required to perform all functions. A microprocessor is a single board computer that is used to perform multiple operations and it requires more number of chips to handle the various processes.

A microcontroller is a dedicated microcomputer which has inbuilt memory and other interfaces to perform various operations.

Specifically, these are designed with CMOS techniques, and a proficient fabrication method that utilizes reduced power and is highly resistant to power transients than other methods. The microcontroller contains a Processing Unit, ROM, RAM, Input and Output ports, and timers like a general computing machine, but they are designed to perform only a unique task to maintain a single architecture. They are very much small and simplified. There are two different types of architectures employed in microcontrollers – RISC and CISC. The most predominant and commonly used architecture is CISC (Complex Instruction Set Computer). CISC can execute addressing modes or multi-step operations within one instruction set. In this architecture, one instruction performs many low-level operations. Later, microprocessors came into the picture, and microcontrollers can able to integrate onto a circuit arrangement. Now, controllers are having capacity of stuffing all of the required components onto a single IC. Since they can able to control a single operation, and few complex devices consist of number of processors. Controllers are employed indifferent domains and can be found in domestic applications, computer machine, and in the field of instrumentation. Their applications involve the areas like automotive industries, and have many workshop uses as well. Presently it has become a main part of industrial automation. Generally they are utilized to control single specific tasks by computing simple instructions. Hence microcontrollers do not require essential processing power.

(i) Humidity sensor

The presence of water vapour in the air is called humidity and it is detected using humidity sensor. The quantity of water vapour in the atmospheric air can disturb the people comfort as well as many production processes in factories. The parameters such as physical and Bio chemical, methods are pronounced by humidity. The measurement of humidity in factories is crucial as it may change the market cost of the product and the welfare, secured life of the personnel. It is important to sense the humidity, particularly in the distributed control systems for industrial processes.

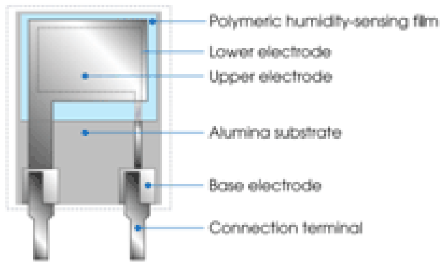

Fig.4.Basic capacitive type humidity sensor

The control of humidity is also essential for the purification of chemical gases, dryers, microwave ovens, desiccation of film, production of paper pulp, garment production and processing of food. In agriculture, the important measurement is measuring the humidity for plant protection (dew prevention), monitoring of soil moisture, etc. Particularly for home applications, humidity control is necessary for a living environment in residential blocks, protection setup for microwave ovens, etc. For these types of applications and many others, humidity sensors are involved to represent the levels of moisture in the environment.

(ii) Heat sensor

A thermistor is a ceramic semiconductor whose resistance is a function of temperature. It shows a large change in resistance with change in its body temperature. The words 'THERMAL' and 'RESISTOR' are combined to get the portmanteau word thermistor. Although there are both positive coefficient (PTC) and negative coefficient (NTC) are available, for our application we employ negative coefficient (NTC) type thermistor.

Fig.5: Heat Sensor

(iii) IR module

Infrared sensing elements are the most widely used sensing element by commercial roboteers. By observing the behavior of IR module would enough to represent most of the challenge statements for variety of robotics programs.

It might be a specific black and white path follower, and a wall follower, intruder monitoring, mouse, a more forward flavor of path follower like red path finder, etc, All the challenge statements can be easily informed and granular control can be practiced upon the function of the robot if one has a better functional interpretation of IR sensing elements.

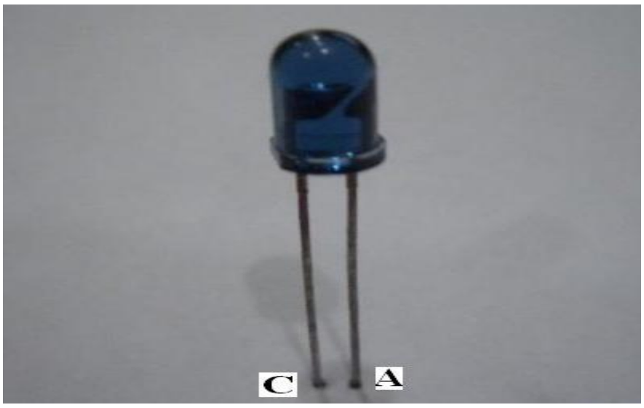

Fig.6: IR detector

Upon careful observation, it can be noticed that there are two legs, one has broad base in the diode, which is normally a cathode terminal (negative) whereas the leg having a very less base would be marked as anode terminal (positive terminal).

V. RESULTS AND DISCUSSION

Table 1: Rail Condition valuation

NODE	ITEM	FREQUENCY	FREQUENCY(WSN)	PSD	PSD (WSN)
N1	SECTION 1 RAIL	8.05	8.05	53.9	50.7
		18.91	18.91	22	21.7
		436.2	433.6	86.7	90.2
		218.1	216.8	11	2
N2	SECTION 2 TRACK	327.3	327.6	11	2
		376.6	374.2	16	5

The Rail track conditions are monitored with different frequencies and the sensor responses were noted and the frequency response curves were drawn.

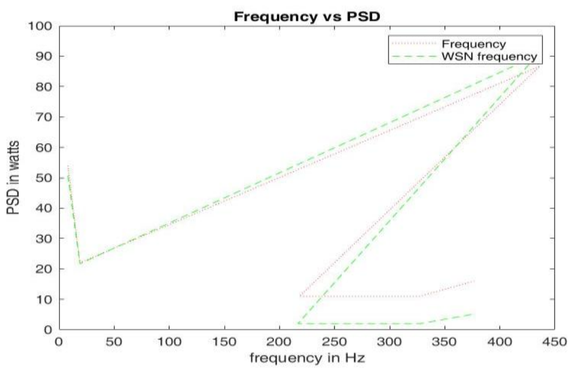

Fig 7: Sensor Node Characteristics

The final prototype of the work is shown below.

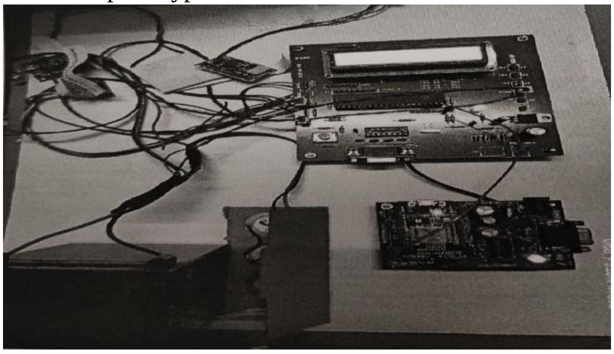

Fig.8: Prototype model

VI. CONCLUSION

This work observed the chance of implementing an auto-energized WSN networks by blending the approach of energy gathering. The objective was focused a trail-path condition observation. Various methods of track-side electromagnetic energy collecting methods were analyzed and we found that energy gathering by magnetic based oscillation is an exact choice for providing the energy for auto-powered nodes. A hardware framework was designed and analyzed to represent the adaptability of the proposed method. Future research work is currently taken to the consideration to compute the long-period functionality of the auto-energized nodes for the rail-path condition observation.

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