International Journal of Recent Engineering Research and Development (IJRERD)
ISSN: 2455-8761
www.ijrerd.com || Volume 02 – Issue 12 || December 2017 || PP. 38-55

Development of Next Generation Positioning System Using Novel False Echo Mitigation Techniques for Coke Oven Machines.

Prabal Patra[1] & Chitresh Kundu[1]
[1]*Instrumentation and Control Group, Automation Division, TATA STEEL LTD, Jamshedpur, India*

Abstract: Advances in technology and new demands in growing industries, requires next generation of positioning techniques using wireless methods. An absolute positioning system provides lot of opportunities in industry in terms of safety and man-less operations. LASER systems are precise but they suffer enormously in dusty environment and erroneous alignment. Conventional RADAR systems are rugged but prone to false echoes from various surrounding metallic structures, usually present at industrial site. This affects the measurement statistics greatly and limits the range to few meters (50 meters). Hence an active RADAR based system has been designed and developed which is suitable for industrial conditions and is used in positioning requirements of rail borne vehicles.

The system operates in ISM band and measures distance using Return Time of Flight (RTOF) method. The echo signal is a coded active return, generated by the slave to measure distance with very high precision and accuracy. Using this method the distance between the stations can be accurately determined over a range of 500 meters.

This paper presents a methodology for false echo mitigation in radar based positioning system which is suitable for industrial conditions, specifically steel plant. It can be used in various positioning requirements of rail borne vehicles like overhead cranes and coke oven machines.

Keywords: RTOF, Radar, Laser, False Echo, Positioning, Coke Ovens, IR Sensor, Radar, RFID, Binary, Infrared, Steel, Image processing

I. INTRODUCTION

A premium grade blast furnace operation requires the highest quality of raw materials, operation and operators. Coke is the most important raw substance fed into the blast furnace in terms of its effect on blast furnace operation and hot metal quality. A good grade coke produces highest thermal energy and it is highly efficient in case of metal reduction. Usage of good grade coke to a blast furnace will ensure lower coke rate, higher productivity and lower hot metal cost. In order to concentrate the carbon in coke the coke making process involves carbonisation of coal to high temperature (1100°C) in an oxygen free atmosphere. There is always a need to efficiently automate the coke oven operations as much as possible. In order to improve the level of control and management of coke oven, the research on intelligent control system is carried out. In modern advanced control system of coke oven, the control scheme of combination of feedback & feed-forward merged with management are widely utilized. The integrated management and control system of coke oven is introduced systematically, including the production plan and scheduling management (Dynamic scheduling) and heating control system (Mathematical modeling) i.e. evaluating battery temperature, intelligent combustion control system and the pressure control of gas collector of coke oven battery.

Fig. 1: Coke Oven

Coke plants are one of the highly challenging areas in steel plants and to automate the identification of the coke ovens, different techniques are used. The major limitation of coke plant automation is the extreme environmental conditions prevalent in the plant location such as high temperature, humidity and so on. Identification of oven position from each machine is very difficult considering the harsh environment in which these machines operate. The solution should be rugged enough to withstand the rough environment like heat, fumes, dust, jerk and vibration. Several solutions have been developed over the time to achieve oven identification. In this paper we will be discussing about the different solutions developed for oven identification.

In Coke plant automation, it is essential to know the position of the moving machines with respect to the oven position. This can be achieved by applying different approaches such as sensor driven, RFID based, imaging, RADAR based approaches etc. This paper introduces various approaches towards oven position identification and a comparative study on such systems and a novel method using RADARS has been discussed.

Different types of rail borne moving machines operate within the premise of a coke plant. The different types of machines being used are Stamp charge/Top Charge coke oven battery, Pusher cars , Coke Guide Car or simply guide car and Quenching Loco. To run the coke making process safely and efficiently few conditions are imposed on the movement of these machines. Identification of the coke oven helps in the auto positioning of the door extraction cars which in turn extract the door of the oven to push the converted coke into the bin. To achieve this condition precise oven identification is essential for each machine. Similarly machine interlocking would be mandatory to operate these machines. These interlock logics are implemented in the machine PLCs for preventing any untoward incident like wrong pushing.

In Coke plant automation, it is essential to know the position of the moving machines with respect to the oven position. Hence, an automatic positioning system (AUTOSPOT) has been developed for enabling rail borne vehicles, such as coke plant machines, to be driven accurately to the defined positions. The Auto spot sensor unit has been shown in the **Fig. 2**.

This system identifies the predefined position such as oven number and its alignment status with respect to the defined position. In this system slotted plates which are binary coded, are placed in front of each oven. The reader units are placed on the machine. The advantages of this system are that it is almost 100% accurate. It is proven to be rugged and cost effective too. As regards its disadvantages the prerequisite for this system to operate efficiently is the track linearity and levelling. The smooth movement of the machines on the track is also essential for this system to perform up to the mark. Perfect alignment is mandatory. A Typical Binary Coded marker plate has been shown in the **Fig.3**.

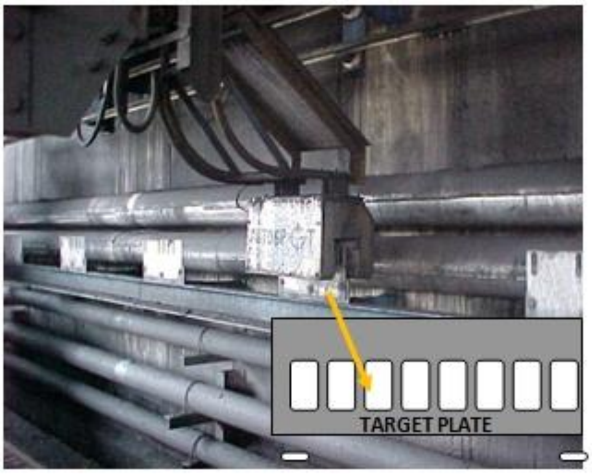

Fig. 2: Autospot Sensor unit

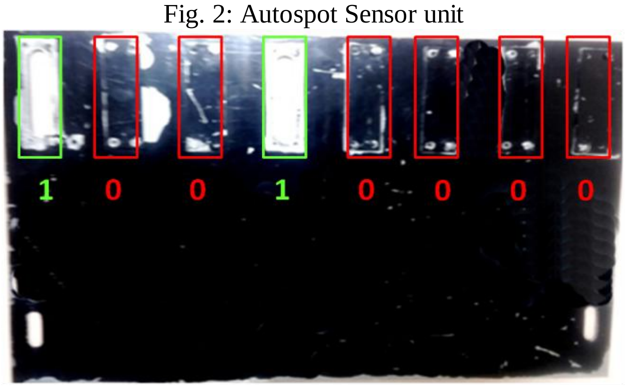

Fig. 3: Binary Coded Marker plate

RFID tags **[1]**(Fig.4) are positioned on a wall alongside the locomotive track at the same distance as between coke oven door centres. Machine is fitted with a sealed RFID antenna/Reader which is directional. This locates each locomotive to within 30cm and the location is presented in the cab on a monitor. This location data is transmitted in real time to the central coke plant control room so that the precise location of each locomotive is shown. In this technique, RF tags are placed in front of each oven. RF reader is placed on the machine. The advantages of this system are that its alignment is not critical. It can be also read from a distance. The disadvantages of this system are the following. Interference from nearby tags can occur if placed very closely. High temperature tags are not easily available. These tags cannot withstand mechanical collision. Deposition of conductive coal dust on them forces the system to malfunction.

Fig. 4: RF Tags

Imaging based Oven Identification is another method for automatic identification of coke ovens for auto positioning systems in coke plants of steel industries. Image Processing techniques are more advantageous to that of using mechanical identification systems of coke ovens. The major limitation of using the mechanical arrangement is that, this system is placed at the bottom of the coke oven machines which is prone to damage due to heat, dust and even collision and other mechanical damages. For this system marked slotted plates are installed in front of each oven and the camera is placed on the machine. The advantages of this system are that it is cost effective and nearly maintenance free. The disadvantages of the system are the following. Presence of PC makes it vulnerable, considering the PC needs to be kept in the moving machine. The glass in front of the camera should be kept very clean providing clear path of sight. Tags **(Fig.4)**should be regularly cleaned, painted. Requirement of cleanliness of tags and continuous power supply to protect the PC against fluctuations should be guaranteed.

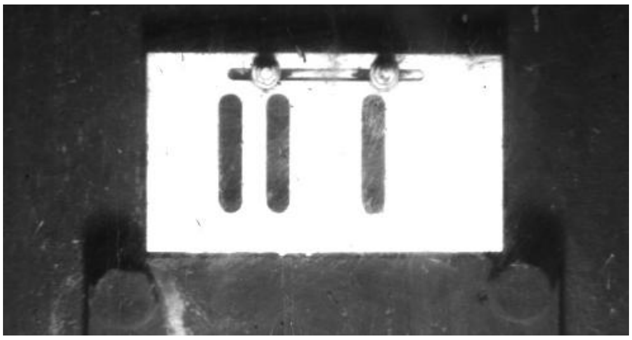

Fig. 5: Binary encoded SS plate

Advances in technology and new demands in growing industries require next generation of positioning techniques using wireless methods **[1]**. An absolute positioning system provides lot of opportunities in industry in terms of safety and man-less operations. LASER systems are precise but they suffer enormous inaccuracies in dusty environment and erroneous alignment. Conventional RADAR systems are rugged but prone to false echoes from various surrounding metallic structures usually present at industrial site **[2] [3] [4].** This affects the measurement statistics greatly and limits the range to a few meters (50 meters) **[5] [6].** Hence, an active RADAR based system has been designed and developed for its suitability in industrial conditions and is used in positioning requirements of rail borne vehicles **[7] [8] [9] [10**] **[11] [12**] **[13]**. Here in this system two RADAR transceivers are mounted on two different machines face to face. Distance between the machines is measured on a continuous basis.

The advantage of this system is continuous measurement of distances .The system is also maintenance free one. As regards disadvantages the system is costly. It is not very accurate in determining exact position. It has heavy dependence on the geometry of the Coke Oven.

II. DEVELOPMENT OF PRECISION RADAR BASED DISTANCE MEASUREMENT SYSTEM

Accuracy and precision are crucial assets of good measurement techniques. The same applies to measurement of distance where contact measurement practices have always carried negligible error. However, with advances in technology and new demands in growing industries, efforts and implementation of next generation of distance measurement and positioning techniques are needed using non-contact methods. Distance measurement and positioning in the industrial arena provides a new dimension for the advancement of the relevant technologies. Global Positioning System (GPS) is one such example in this realm, which uses a constellation of satellites to determine an object's position on the earth **[14].**

Over the last few decades, wireless technology is the biggest contribution given to the mankind. This technology has conquered the heights and limits beyond our sight. Each region of this technology plays an important part in our lives, and in the business. While measuring distances without any mesh of wires or cables can be extremely useful in many applications, but it doeshave its own challenges**[7].** Gaining the equivalent accuracy and precision as that of the contact methods of distance measurement is the utmost task in this wireless domain **[5]**. Once achieved, this precision and accuracy will continue even when the object is moving.

The wireless measurement can be carried through the transmission of waves. Waves are of two types longitudinal and transverse **[15].** The former is the example of sound/mechanical waves. Although these waves are highly energetic and can be transmitted over distances, their measurement suffers from temperature and pressure deviations**[6]**. The latter includes the electromagnetic waves, further classified as visible and the non-visible range. Electromagnetic radiations are transverse waves and travel at the speed of light. The visible spectrum includes the LASER devices. Measurements done by LASER are very precise but they suffer enormously in dusty environment**[16].** Also LASER measurements are error prone when the alignment is not proper.

On the other hand, the non-visible spectrum of electromagnetic waves consists of the microwaves, whose frequency ranges from several megahertz to few Gigahertz. These waves are used in the RADAR systems to detect and measure distance of various objects. Primarily, the distance is measured by using Time of Flight (TOF) principle**[13].** This method tends to have some drawbacks/challenges like clock synchronization. Even a nanosecond offset in the clocks can generate error of several meters in the measured distance. To overcome this proposed invention uses Return Time of Flight (RTOF) method where measurement is carried out using single clock. RTOF measurement using passive reflectors in presence of other scattering objects, suffers additional delay due to multipath propagation. This affects the measurement statistics greatly and needs to be rejected. Hence, a novel measuring instrument with active return with frequency shift has been developed which measures distance with very high precision and accuracy using RTOF.

LASER systems are widely used in positioning systems which is precise but they suffer enormous inaccuracy in dusty environment and erroneous alignment.

On the other hand, passive RADAR based positioning system works well in dusty environments and performance not get altered much in erroneous alignment conditions. Conventional RADAR systems are rugged but prone to false echoes from various surrounding metallic structures, usually present at industrial site. This affects the measurement statistics greatly and limits the range to few 100 meters.Passive RADAR system suffers from multipath propagation from various surrounding metallic structures which is usually present at industrial site. This affects the measurement quality greatly and needs to be improved. Hence, this present technique uses active return with frequency shift to measure distance with very high precision and accuracy. The system uses two active trans-receiving stations at either ends and the distance between them can be accurately determined within few millimetres over a range of 500 meters.

III. THEORY OF OPERATION

There are mainly three types of measurement principles being used these days: angle of arrival (AOA), Received signal strength (RSS) and systems based upon the time of propagation of signal which can be further sub-divided into the following parts: Time of arrival (TOA) , Round trip time of flight (RTOF) and Time difference of arrival (TDOA). By using the concept of Round Trip time of Flight (RTOF), where the propagation time of the signal from the transmitter along with the time taken for the echoed signal to reach to the transmitter station is measured for getting the information regarding the local positioning in the industrial environment**[17][12].**

Passive Radar technology as shown in **Fig.6**, uses signal reflection from a remote object (suspected target) based on RTOF method.[10]The emitted radar signal can be sent out from a 360°antenna in all directions or, highly focussed, in one direction. For accurate distance measurement, it is mandatory to have a focussed beam pointing at the target. The beam opening angle is typically in the range of 2° to 5°. A smaller opening angle can only be achieved with very large antennas, not suitable to for the given size of distance measurement units in industrial use of Radar Technology. The following image depicts the phenomenon of Passive Radars:

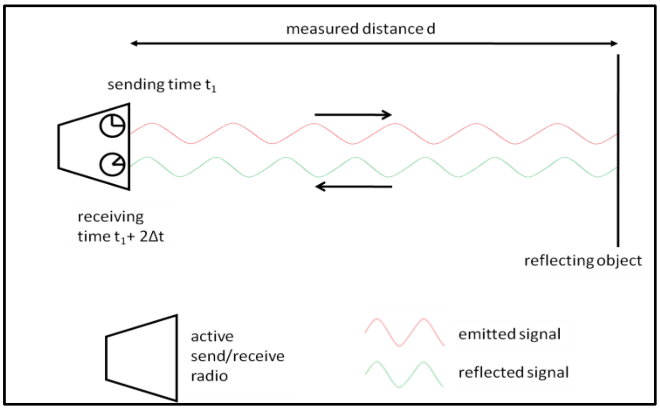

Fig. 6: Radar Transceiver with return signal reflected by object (Passive Radar).

The Passive mode of radar operation is well suited for aerial or marine navigation systems since they use massive antennas with much higher signal power along with dedicated frequency bands, making the system robust for detecting large distant objects like airplanes or ships.

However, this method does not work well in industrial where there are multiple metallic scattering objects nearby. These possess challenges in measurement like

- Target Identification
- Multiple Echoes

As depicted in the **Fig. 7** below a narrow beam antenna is used to measure distance from the target.

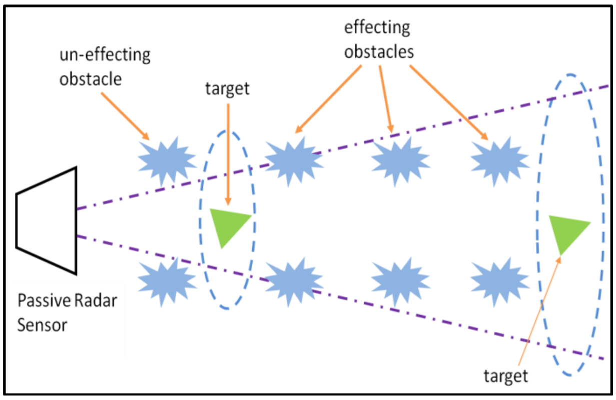

Fig. 7: Effect of signal opening angle with passive radar

As the distance between the antenna and the target is increased, the beam footprint will also get bigger. This will result in everything within this beam diameter to reflect the signal as target and is likely to strongly affect the accuracy of the distance measured.A near target is likely to be detected properly, despite other obstacles around. However, a far target will only be "seen" among a number of other radar reflecting objects and cannot be identified as single target with a precise distance.To mitigate with this problem of Passive Radar technique, the Active Radar technique is usedwhich can be readily used in industrial domain.

The Active Radar technique shown in **Fig. 8** uses two separate frequency bands for the master and the slave, and implements Band Stop Filter (BSF) along with relative components to eliminate the need of encoding the signal, thus eliminating its overhead. The master transmits at frequency *f1*, which is received by the slave, and on receiving this signal the slave transmits at frequency *f2*, which is further received by the master as a feedback.

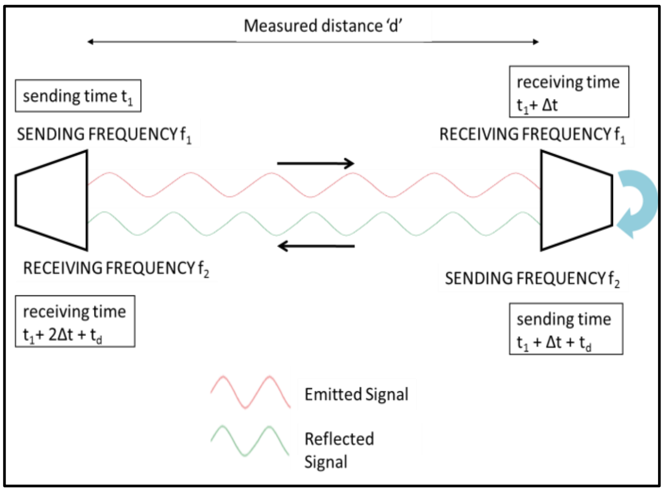

Fig. 8: Two Radar (Master / Slave) signal emitter cum receiver, dual frequency operation (Enhanced Active Radar)

This technique is suitable for environments requiring extremely high precision calculation, where the encoding process of conventional Radar technique may induce some degree of effective error.

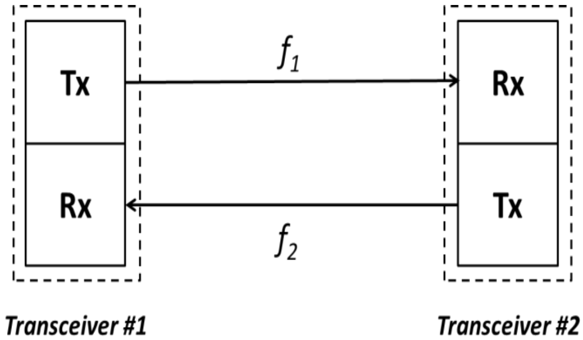

Fig.9 : The frequency link between Transceiver#1 and #2

The method uses two **[7] [9]**active trans-receiving stations of different frequencies of uplink and downlink **Fig.9** to measure distance between two points using RTOF (Return Time of Flight). These two trans-receiving stations can be termed as Master and Slave. They are separated by distance (d) which has to be measured. The signal sent by Master at time (t_1) is received by the Slave at time ($t_1 + \Delta t$), where Δt is the time of flight between the stations. The value of Δt increases with increase in the distance between the Master and Slave, i.e. Δt is directly proportional to the distance 'd'. The Slave provides a delay of time (t_d), to the signal in addition to the propagation delay. Hence, the Master receives the signal at ($t_1 + 2\Delta t + t_d$) time. The RTOF (Return Time of Flight) is calculated by the difference of the reception time ($t_1 + 2\Delta t + t_d$) and the transmission time(t_1) at the master. While calculating the RTOF the fixed processing delay from the slave (t_d) has been subtracted. Thus the distance between the stations (d) is calculated as half the product of the Speed of light(c) and RTOF.
The accurate distance between both the transceivers can be calculated by the formula:

$$RTOF = \frac{2d}{c} = 2\Delta t + t_d \quad \text{---- } \textbf{Eq. 1}$$

Where,
Δt is propagation delay of electromagnetic waves
t_d is processing delay of slave station

Transmitter section consists of an oscillator tuned at frequency f_1, which is then amplified and fed to RF switch. Transmitter section consists of an oscillator tuned at frequency f_2, which is then amplified and fed to RF switch. Transmitter is a pulsed RF source**[11]** as shown **Fig.6**. Power required at antenna input is 10 dBm.
The ASK modulated pulse shown above requires an on time of 2 µsec, with a frequency of 10KHZ. ASK signal produced should have a power level of 10 dBm when ON, and during OFF, the power level should be <-90 dBm.

The maximum range at witch a target can be located that the leading edge of the received backscatter from that target is received before transmission begins for the next pulse. This range is called maximum unambiguous range or the first range ambiguity. The pulse-repetition frequency (PRF) determines this maximum unambiguous range of a given radar before ambiguities start to occur. This range can be determined by using the following equations:

$$R_{max} = c \cdot (PRF - \tau)/ 2 \qquad \textit{Eq. 2}$$

Where,
R_{max} is the maximum range
PRF is Pulse Repetition Frequency
τ is transmitting time
c is speed of light

Receiver section starts with the signal received from RF switch. The received signal is at a frequency f_2.
During simulation the received power corresponding to minimum and maximum range have been calculated using Friis transmission as shown in **Eq. 3**

$$\frac{P_r}{P_t} = G_t G_r \left(\frac{\lambda}{4\pi R}\right)^2 \qquad \textit{Eq. 3}$$

Where,
P_r is received power
P_t is transmitted power
G_t is Gain of transmitting antenna
G_r is Gain of receiving antenna
λ is wavelength at that frequency
R is distance between transmitter and receiver

Band Stop Filter (BSF 1) has been used to avoid the leakage signal from the RF switch from entering the Amplifier. BSF is having a very high insertion loss of -50dB in the stop band. Low Noise Amplifier (LNA) has been selected with a very low noise figure and to provide sufficient amplification. A second stage of BSF has beenimplemented after the amplifier (BSF 2). Following this, a Digital Step Attenuator (DSA) is used to provide attenuation for implementing automatic gain control. After DSA, a second stage of amplification is required, followed by a BPF at f_2 frequency. Signal should then pass on to a Limiter before feeding it into the envelope detector. The overall receiving section block diagram is shown in

A Band Stop Filter is a combination of a Low Pass Filter and a High Pass Filter in a parallel connection. It blocks the signals falling within a small frequency band and passes all frequencies below or above that frequency band. Because of this characteristic it is also termed as Band Elimination Filter, Band Reject Filter or a Notch Filter. It has two cut-off frequencies, any frequencies falling between these two cut-off frequencies are attenuated, and rest frequencies are passed. An implementation of a lumped band stop filter has been shown in the **Fig. 10.**

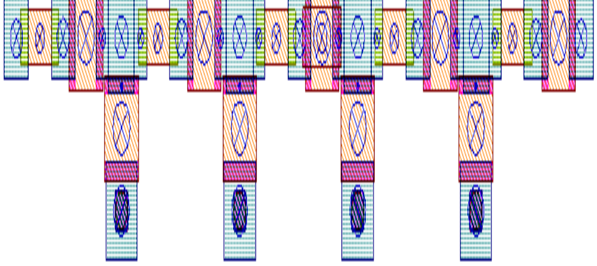

Fig 10.Band Stop implementation using lumped elements

The simulated S-parameters are shown in **Fig.11**. The stop-band of this lumped element filter is ta 400 MHz.

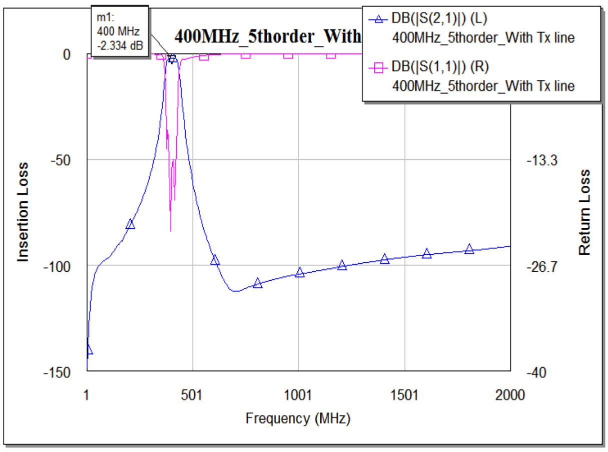

Fig 11.Simulated frequency response for the band stop filter

However, the lumped element filter works well upto MHz frequencies. For higher frequencies distributed element approach has been used, consisting of micro-strip elements as shown in **Fig. 12.**

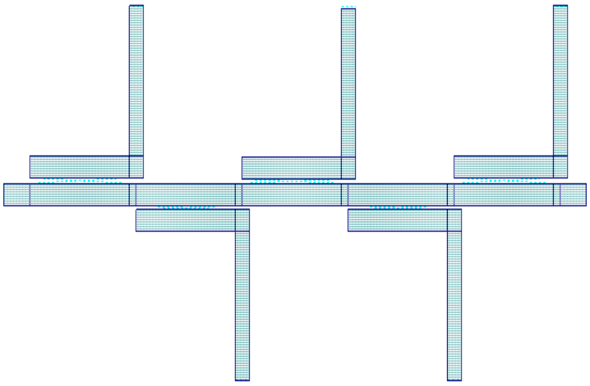

Fig 12.Full wave simulation model for the micro-strip band stop filter.

The simulated results show that the stop band occurs at 5.7 GHz. The response is shown in **Fig.13.**

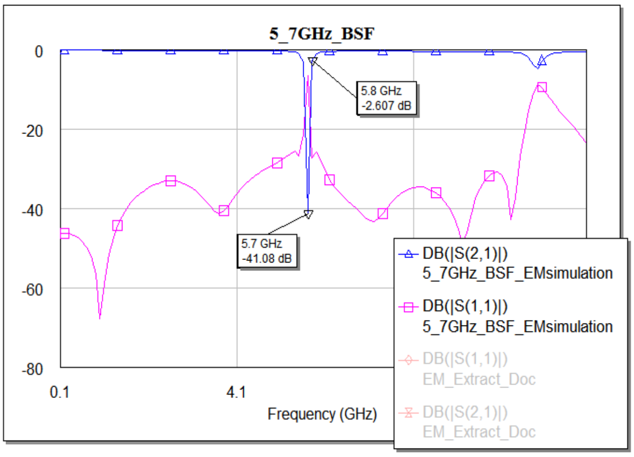

Fig 13 Simulated frequency response for the band stop filter.

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ISSN: 2455-8761
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Similarly, a 5450 MHz interdigital filter band pass filter **Fig. 14** has also been simulated and implemented for improving the receiver selectivity.

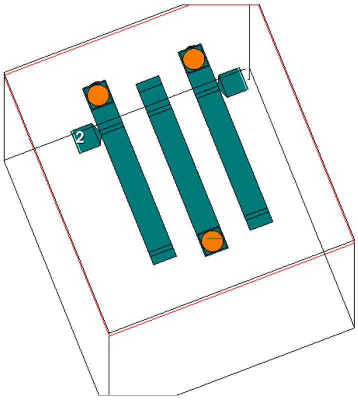

Fig 14.Full wave model for the band pass filter.

The simulated results **Fig. 15** shows low insertion loss of -1.368 dB at pass band, centred at 5450 MHz

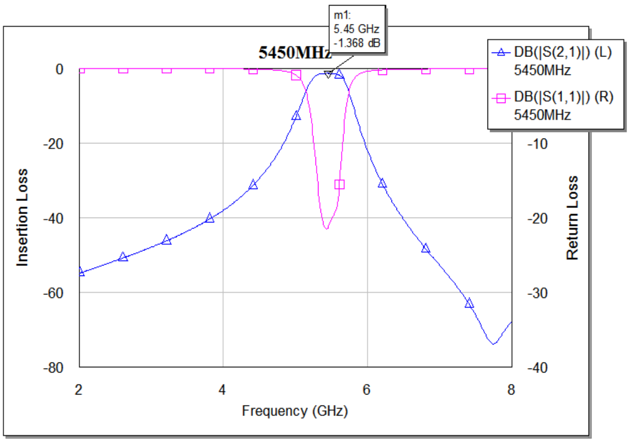

Fig 15.Simulated frequency response for the band pass filter.

IV. RESULTS & DISCUSSION

Transmitter Path Test Results:

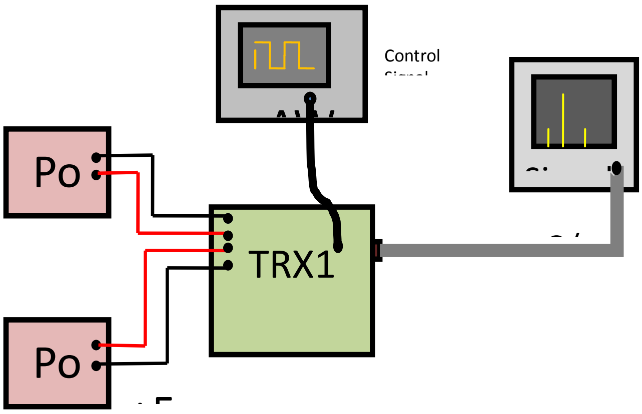

Fig 16: Transmitter Setup.

PULSE signal with duty cycle of 10us 'ON' time and 90us 'OFF' time is generated using arbitrary waveform generator to Activate Transmitter path. The transmitted pulse signal Output is observed using Signal

Analyser. In CW Mode, Output power of the Transmitted signal is 4.5dBm at 5.75GHz.Transmitted signal's frequency, power; Harmonics and Spurious levels are noted in our Test record format.
In Pulse Mode, Pulse modulated signal with 10Khz frequency is measured and shown below.

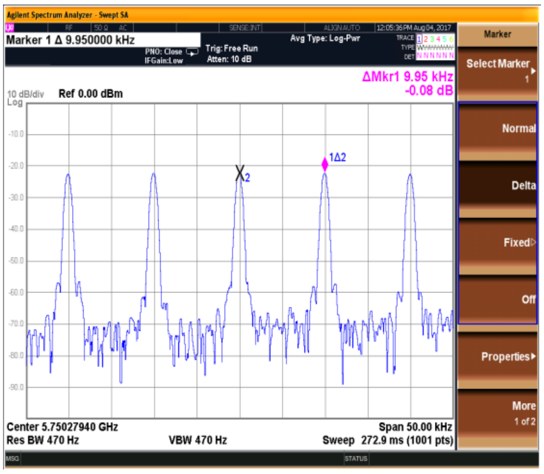

Fig 17: Receiver Path Test Results

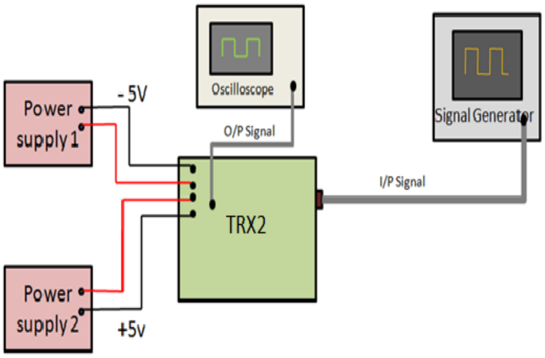

Figure 18: Receiver Setup.

Power supplies of +5V and -5V are connected to the supply pins of TRX2.Input signal of -60 to -15dBm power at 5.85GHz is generated using Signal generator. Output of TRX2 is connected to the oscilloscope, output signal observed through Oscilloscope are shown below.

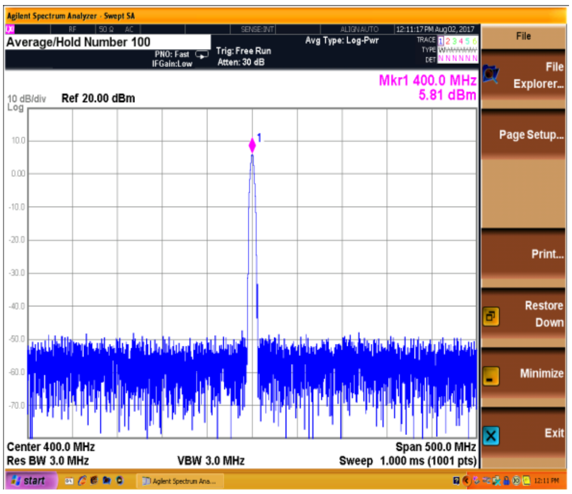

Fig 19 : Receiver output before detector in CW mode:

Output power before DETECTOR is 5.81dBm at 400MHz frequency.

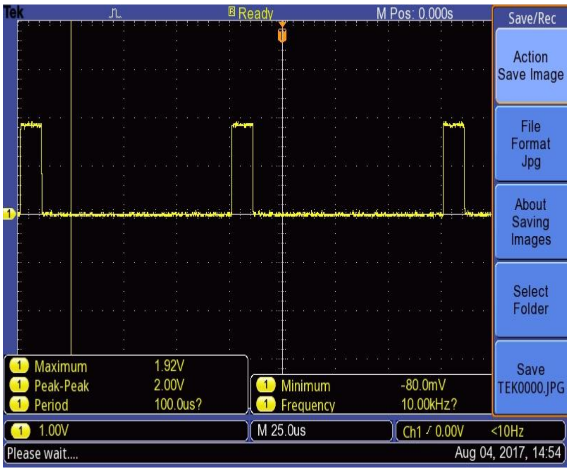

Fig 20: Signal At Receiver Output:

Final output of the RECEIVER is   Vp-p = 2V, Frequency = 10KHz,

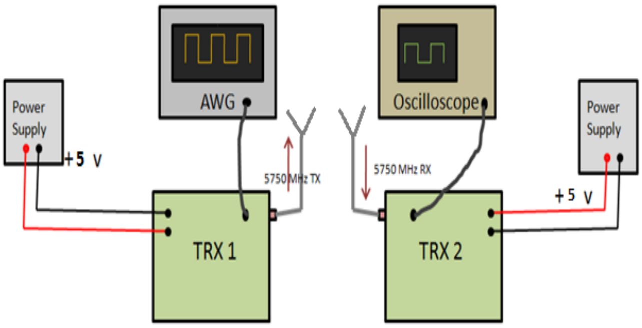

Figure 21: Transceiver Final Setup Using Antenna.

PULSE signal with duty cycle of 10us 'ON' time and 90us 'OFF' time is generated using arbitrary waveform generator to Activate Transmitter path. Output transmitter signal of 4dBm power at 5.75GHz TRX1 is transmitted using Antenna. In our LAB, we maintained 5 Meters distance between the two Antennas. Output of TRX2 is connected to the Oscilloscope, output signal observed through Oscilloscope are shown below.

Fig 22: Lab setup

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ISSN: 2455-8761
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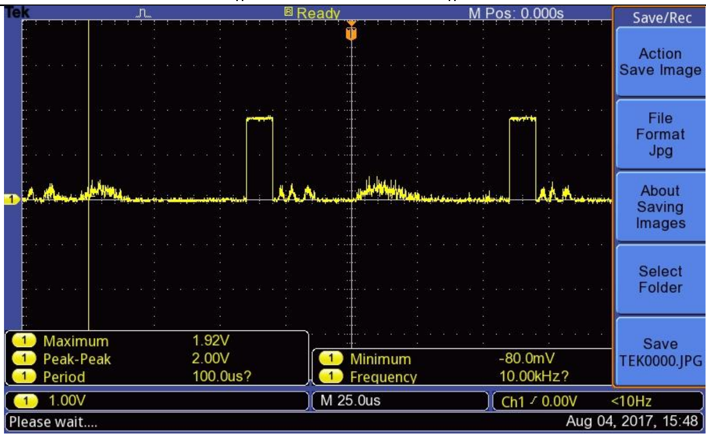

Fig 23: Complete Final Output:

V. Hardware Implementation

After successful simulation for the individual components, the design implementation has been done. The positioning system for the plant environment has been made mechanically stable and robust. A single layer, double sided PCB was designed and simulated with additional features like AGC, temperature compensation circuitry and RS485 communication link built into it. The **Fig. 24 and Fig. 25**shows the actual photograph of the in-house developed prototype system. The radar module consists of 3 major blocks: RF module, Signal processing unit and power supply. The whole assembly has been encased in a machined aluminium block.

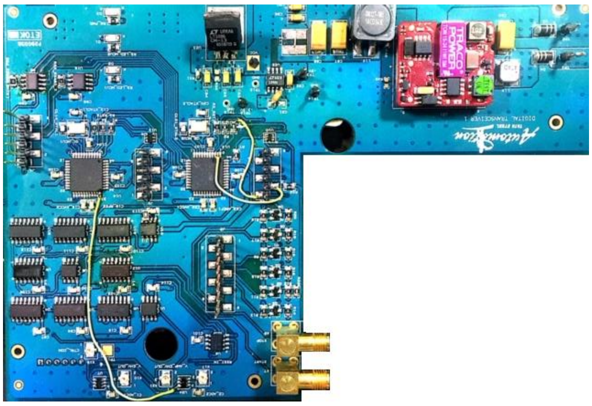

Fig 24: Final product layout of the digital board with appropriate power conditioning circuitry.

Fig 25: Final substrate layout design along with the RF components with proper shielding.

Enclosure Design

An all-aluminium enclosure has been designed with two separate chambers, one for RF component and other for power supply and digital signal processing as shown in figure. 26

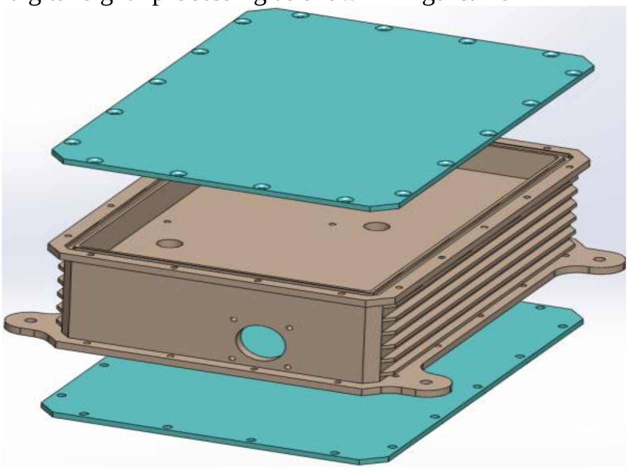

Figure 26: Aluminium enclosure for assembly

Mode of Heat transfer:

Heat generated in IC's will be transferred through convection to enclosure wall. Heat will be dissipated to ambient temperature from enclosure wall through fins. The heat also dissipate from IC to board and board enclosure by conduction heat transfer

Material: Aluminium 6061

Thermal Properties of aluminium
CTE, linear 68°F:23.6 µm/m-°C
CTE, linear 250°C: 25.2 µm/m-°C
Specific Heat Capacity: 0.896 J/g-°C
Thermal Conductivity: 167 W/m-K
Melting Point: 582 - 652 °C
Solidus: 582 °C
Liquids: 652 °C
The aluminium 6061 is used for heat sinks to dissipate heat.

Fin Efficiency

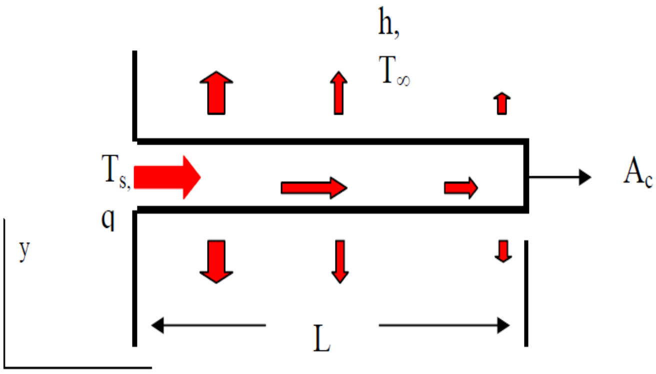

Fig 27: Fin efficiency diagram

$Q = \sqrt{hPkA}$ X θ ***Eq. 4***
Where,
Q = Convection heat transfer
h = Convection coefficient
P = Fin perimeter

A = Cross sectional area of fin
Θ = (T1 – T2)
k = Thermal conductivity
Solution:
h = 25$(W/(m^2K)$, P = 0.36m, A = 343.92mm^2, k = 167 W/m-K, Θ = (67-65) = 2°C
Q = $\sqrt{25X0.36X343.92X10^{\wedge}6X167}$ X 2
Q = 0.712 X 2 = 1.4 W X 12 fins = 16.8W
The Enclosure fins can dissipate heat of 16.8W.

Based on thermal simulation (Fig.28) iteration the enclosure capable of dissipate the heat of 12.7W through fins.

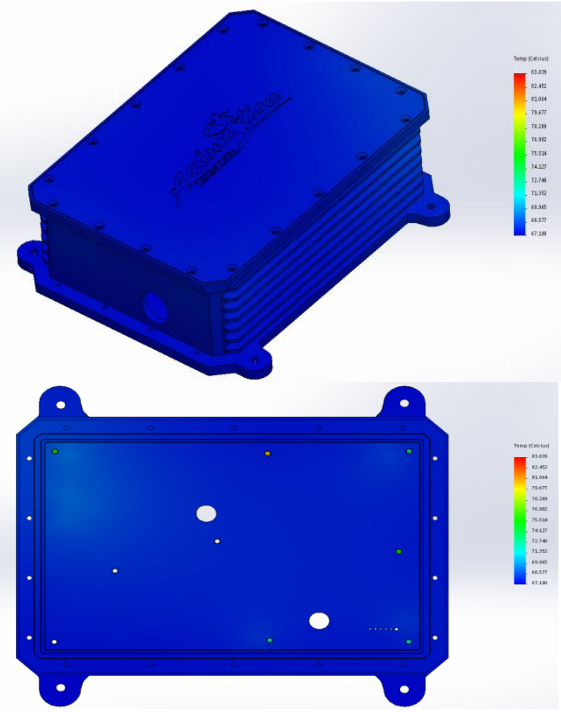

Fig 28: Thermal simulation of Enclosure

VI. SYSTEM PERFORMANCE

After making the system robust and stable, the field trials have been conducted on the shop floor of the steel plant on a moving machine. The trial setup consists of the radar system (test equipment) with two active units, one kept at fixed location and the second one on the rail-borne moving machine. Antennas were mounted on either end, ensuring line of sight between them. A laser distance meter (used as reference unit) has also been installed parallel to this system for initial calibration and subsequent validation of the system. The distance between these two stations has been measured for both these instruments (laser and radar) during LT (Long Travel).

Table 1: Measured Std. deviation for various distance
Max =23.8673 mm , Min = 20.9693 mm

Sl. no.	Distance (meters)	Standard Deviation (pS)	Distance using calibration coefficient in mm
1	10	210	21.6938
2	12	220	23.1428
3	18	211	21.8387
4	25	215	22.4183
5	35	208	21.404
6	50	205	20.9693

7	87	210	21.6938
8	113	211	21.8387
9	113	215	22.4183
10	90	225	23.8673
11	76	209	21.5489
12	65	212	21.9836
13	40	214	22.2734
14	40	211	21.8387
15	55	205	20.9693
16	69	213	22.1285
17	100	222	23.4326
18	140	210	21.6938
19	175	214	22.2734
20	210	208	21.404
21	229	217	22.7081
22	245	205	20.9693
23	272	208	21.404
24	295	217	22.7081
25	300	219	22.9979
26	300	211	21.8387
27	283	210	21.6938
28	255	209	21.5489

Once the calibration coefficients were obtained and fedinto the system, absolute distance readings were obtained from radar. Validation of these values was done by comparing it with the reference distance readings from the laser system. Simultaneous readings of radar and laser were stored into a file. A plot has been generated for multiple measurements carried out during the movement of machine. The distance of the machine from fixed location has been measured by both these instruments and plotted side by side. This plot shows excellent agreement between the measured distance readings from the radar and laser system.

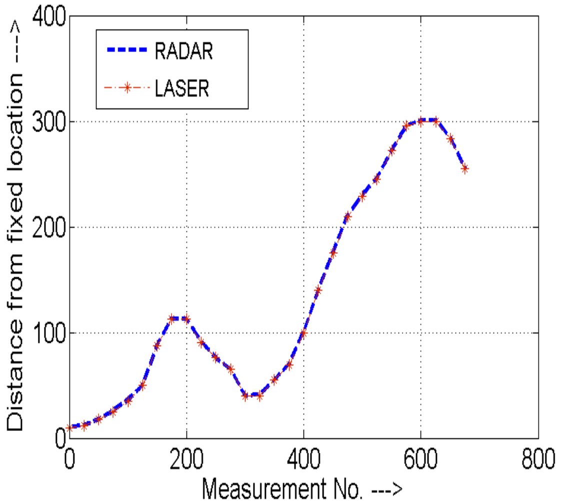

Fig 29: Figure shows distance measured using Radar (Red) and Laser (Blue), during normal movement of moving machine w.r.t. quenching tower. About 675 readings were taken (Measurement #) and distance was measured from both systems.

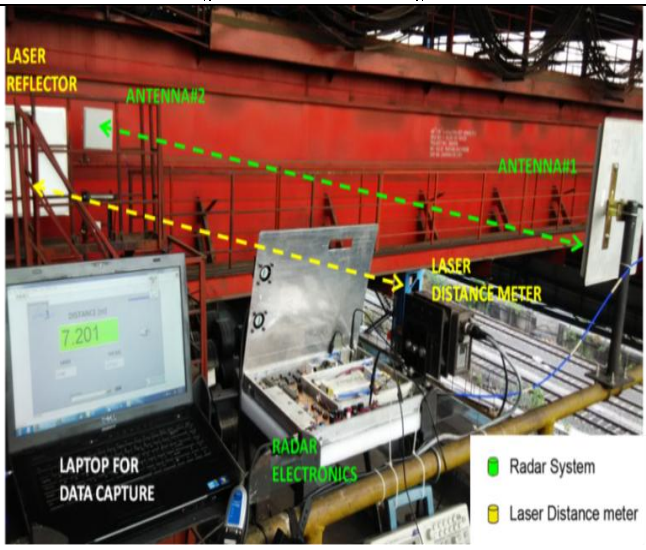

Fig. 30: Experiment Setup

Field trails for the Radar based positioning system**(Fig.30)**at actual site has been conducted. The distance between a fixed position and a moving object (Overhead Crane) has been determined by measuring the return time of flight (RTOF method). The output data obtained was time value which can be easily converted to distance reading. This required a onetime calibration, which was performed with the help of Laser Distance Meter. Also, during each of the readings, it was observed that the measurements followed Gaussian Distribution **Fig.31, Fig.32, Fig.33,Fig.34.** Gaussian distribution of the measured data was applied as a result of multiple random processes in the measurement link.
Observations during testing & system calibration is shown in **Figure .29**

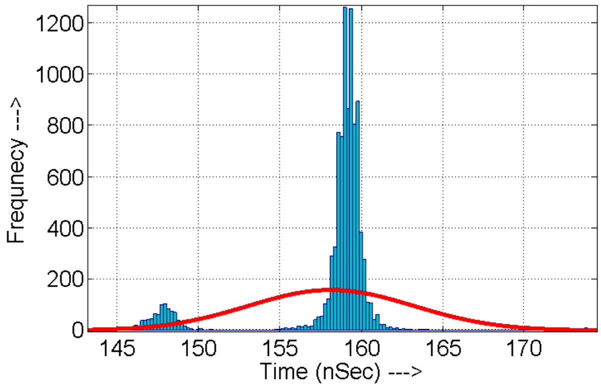

Fig 31. Measured RTOF before implementation of filters Sample 1

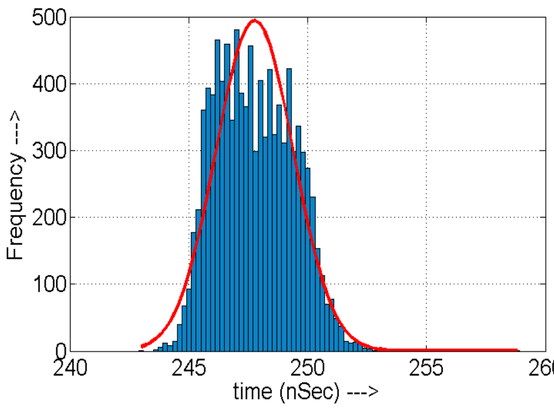

Fig32: Measured RTOF before implementation of filters Sample 2

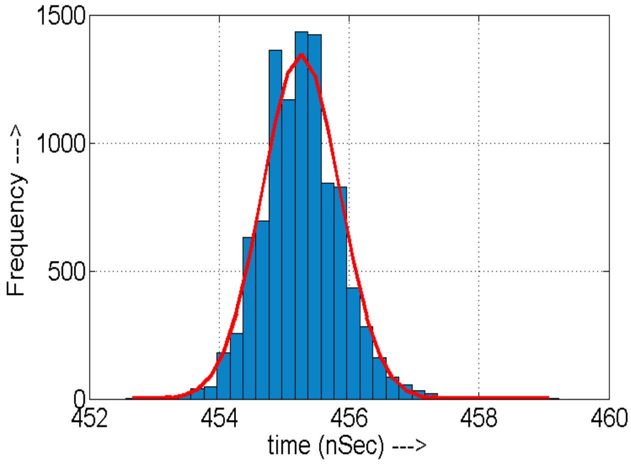

Fig 33: Measured RTOF after implementation of filters Sample 1 .

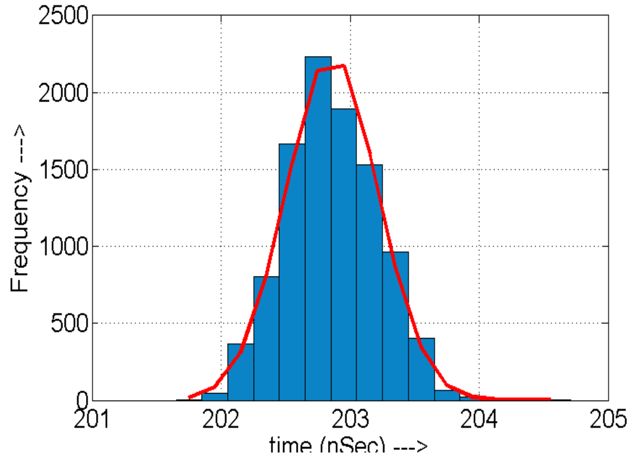

Fig 34: Measured RTOF after implementation of filters Sample 2 .

The results using active radar before and after implementation of filters has been compared. **Fig.31 and Fig.32** shows the measurement result with active radar without using the band stop filters. It can be seen that the standard deviation for the measurement is quite large as compared to the **Fig.33 and Fig.34** where enhanced active radar with frequency shift was used, thus enabling to measure distance much precisely.

VII. CONCLUSION:

There are various distance measuring techniques available for positioning requirements, however only few are suitable for industrial requirements. The system should be robust and shouldn't get affected by the various scattering objects present at industrial site. In this paper a novel method has been discussed which uses active radars with frequency shift over the passive radars in the industrial environment where scattering and false echoes are dominant. It uses an effective radar system for accurate measurement of the distance based upon the return propagation time of flight. The system can be used in various rail-borne vehicles within the steel plant and employed in a practical environment for the local positioning measurement. It was observed that the measurement was accurate and efficient. The data was accumulated employing the active radars which not only made the measurements precise but also reduced multipath distortions emerging due to the dusty environment present in the steel industry.

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IX. AUTHORS :

Prabal Patra received the B. Tech. degree in Instrumentation and Electronics engineering from the Jadavpur University, Kolkata, in 1992. He is currently pursuing the Ph.D. degree with Jadavpur University. He is currently Head of the department of Instrumentation & Control at Automation Division of Tata Steel, which is a R&D department. His research areas include Control systems, Machine Vision, Embedded systems, RF & Microwave Technology.

Chitresh Kundu received his M. Tech. degree from IIT Kharagpur, India, in 2010. He is currently working as Senior Technologist (Instrumentation and Control, Automation Division, TATA Steel. He is responsible for development of various embedded system and radar based application for TATA Steel. His research interests include the fields of antennas, radars, embedded systems, IOT platforms.