DESIGN AND SIMULATION OF PASSIVE UHF RFID TEMPERATURE SENSOR TAG USING 3D EM SIMULATION TOOL

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Abstract

Temperature monitoring and analysis plays a vital role in many fields, predominantly in supply chain applications. Most commercial wireless tag antenna consists of transceivers, memory and batteries to maintain a temperature and time details which is costly, this in turn limits sensor tag employment. In this project, we propose a low cost temperature sensor on the passive UHF RFID tag to sense temperature variation in specified applications. The variations of field strength are measured through simulation in CST MW Studio. The reader distance range of the tag, in free space is limited over few meters. The probability of the proposed hypothesis is examined via theoretical and simulation means. It will be exposed that this sensing paradigm has great potential for frequently temperature sensing nodes and that helps to improve supply chain performance. To this multi-id tag antenna is implemented and compared to single tag antenna.

Keywords: *RFID tag design, UHF, temperature sensing, long range and CST.*

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1. INTRODUCTION

Radio frequency identification (RFID) is a wireless device that use radio frequency electromagnetic fields to transfer data between reader and tags, for the purpose of automatically identifying and tracking tags attached to objects which contain electronically stored information(up to 4b). In recent years, RFID is very much popular in many commercial applications such as animal tracking, access control and for security. The RFID system consists of two main components tags and reader. The reader always interrogates the tags which is equipped with antenna, transceiver and processor (along with software). The tags (transponder) are powered by and read at short distance ranges via magnetic field such as electromagnetic induction. The tags may use an on-board power source such as a battery, which is called active tag. Another type tag where energy is collected from the interrogating EM field, act as a passive transmitter and receiver to emit UHF (3MHZ to 3GHZ) radio wave is called a passive tag. There are many types of RFID systems uses in different applications and settings which have different power source, operating frequency and functionalities. These properties and dictatorial restrictions of a particular RFID system will determine its physical specifications, manufacturing expenses and performance.

In this paper, the design and optimization of passive RFID tag antenna under microwave simulator at UHF band is done. A meander line pattern is anticipated in antenna structure in order to achieve tag compact size at particular bandwidth. Accordingly in this, simulation analysis is made to ensure its energy efficiency and performance.

2. RELATED WORKS

The RFID tag is used in several applications in which temperature monitoring [1] in human body uses UHF for data transmitted between the reader and tag. The tag antenna should be simple in structure, reduced size and without noise during the transfer of data. If noise increases consequently, speed of the data transfer reduces. In order to overcome this drawback, an enhanced sensor tag [2] is implemented for finding temperature related function and variations in achieving controlled size and long range distance for better performance. Considering about temperature, which resist both thermal and humidity conditions that dramatically applied to this passive printed humidity sensor type [3] with WORM (write once read memory) memory. This provides a single event logging in sensing according to the specific resistive value for different environmental conditions. To the above approach, prototype layout multi-ID tag antenna [4] structure of low cast is implemented to carry out efficient transmission for longer distances. In this multi-ID tag, various data are stored for proficient performance. Meanwhile the structure of any tag antenna type can be reduced in size using meander line pattern with genetic algorithm [6] for construction of new [7] [8] sensor tag antenna. The proposed design is compared with previous version of standard alien squiggle, Higgs according to ECP global class-1 specification. A cost effective [9] [10] generic sensor tags with authentication base is implemented for secured data transmissions. Overall RF RFID [11] passive tag is designed with related paradigm for cost effective RFID tag antenna implementation.

3. DESIGN OF RS-TAG ANTENNA

The design of proposed RFID tag antenna with effective compact size to its improved version is critical. The design measured along with input impedance Zin=Rchip+Xchip=31-j156 ohms at its operating frequency. The loop structure commonly tunes real part with meander line, which facilitates the antenna compact size and finally capacitance is loaded at last part of the antenna to complete the proposed layout tag antenna structure. The necessary parameters of an antenna is obtained using CST microwave studio and following steps are involved in constructing the antenna. In this, size of RFID sensor (RS) tag antenna is $5.8 * 2.5 * 1.0\ cm^3$.

3.1 Step 1: Construction of Rs-Tag Antenna

The figure 1 describes the structure of meander line sensor tag antenna. In this, ground is formed by prototype paper substrate and over that, a component copper conductor material is designed in CST (Computer Simulation Technology) Microwave studio.

3.1.1 Ground Substrate

The figure 2 describes ground substrate (layer1) using paper material of normal type with thermal conduction of 0.05[w/k/m] and along with epsilon 2.31, mue 1 and rho 800[kg/m^3] is approximated. These are the specification of substrate in which thermal ability of heat transfer, elasticity and resistivity are measured.

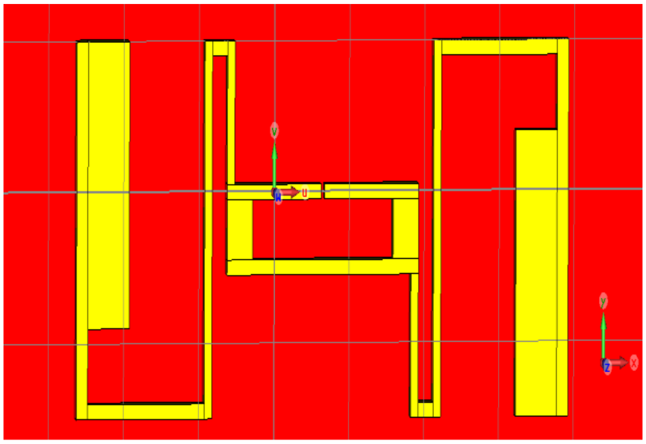

Fig-1: RFID sensor tag antenna

3.1.2 Solid Component Material

The figure 3 explains about layer2 over layer1 substrate. Here, a conductor using copper (annealed) material of lossy metal is used. Substrate specifications: Thermal conductor - 401[W/K/m], Poisson ratio- 0.33 and young's model - 120[KN/mm^2], measures flexibility.

3.2 Step 2: Port Insertion

The figure 4 is a discrete port designed for signal to propagate through S11 a single port and to calculate energy efficiency and its performance with reference impedance is 50 ohms.

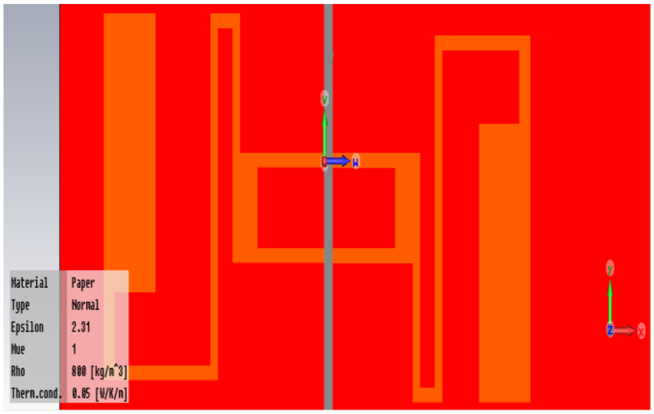

Fig-2: Ground substrate

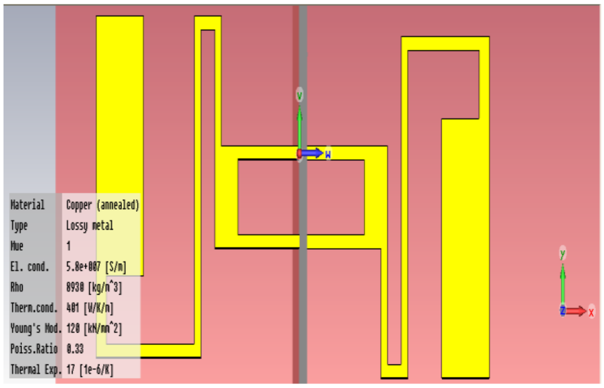

Fig- 3: Conductor layer (copper material)

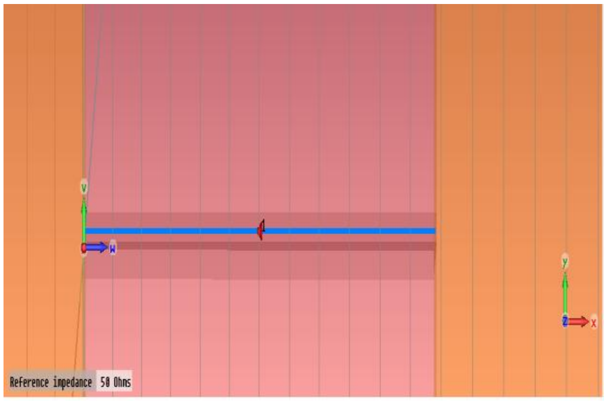

Fig- 4: S11 port in RS-tag

The design is extended to obtain multi –id tag antenna to analysis its overall efficiency and figure 5 explains details of multi-id tag antenna with same structural design procedure of RFID sensor tag. Thus it does not show any appropriate result compared to single tag antenna. The single tag antenna structure is simulated and effective results are obtained.

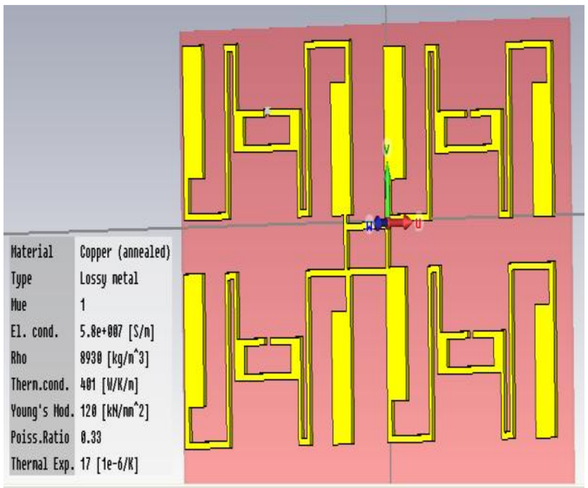

Fig- 5: Multi-Id Tag Antenna

4 .SIMULATION AND RESULTS

In order to verify the structure, the design is simulated and the results are analyzed to ensure performance for better data transmission. The fig- 6 shows time signal at S11-port where the input signal is i1 and output signal is o11 which travels at 10 ns that cause variation over amplitude at 1.

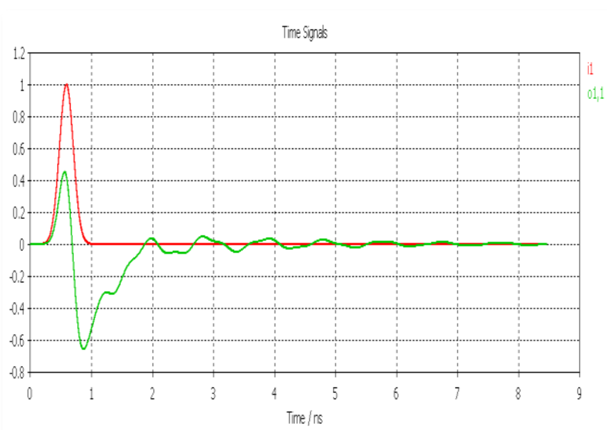

Fig 6 Input and output signal at S11 port

The fig- 7 illustrate S-parameter magnitude of S11 port on y-axis which various according to frequency in x-axis. The magnitude of port1 is represented as s_{11} .In this, both reflected and incident signal over the frequency are matched. The minimization of s11 to desire operating frequency is describes the fitness of the structure designed. Thus the figure explains superior arrangement structure of tag antenna to its frequency.

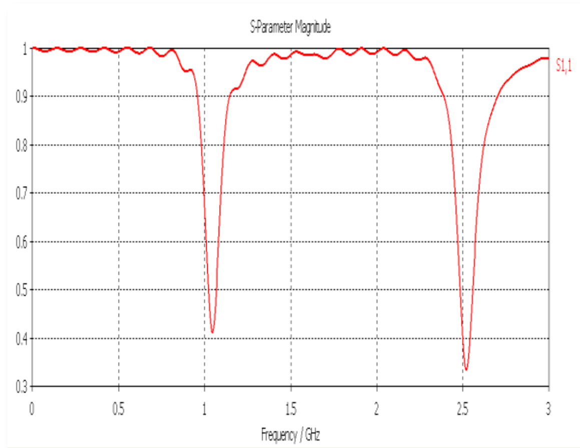

Fig- 7: s11 parameter

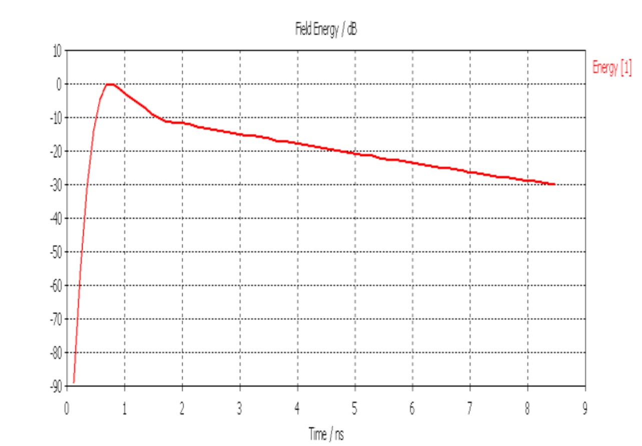

Fig-8: Field Energy

Fig- 8 explain the field energy and field strength of ES-tag antenna. In this field energy/dB various over time in 10ns accordingly the curve gets dropped at 8ns at -20 dB which brings that at particular time the energy drop is less comparatively.

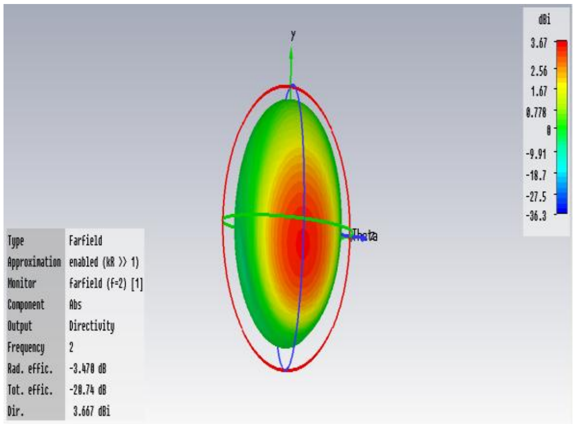

Fig- 9: Radiation Pattern

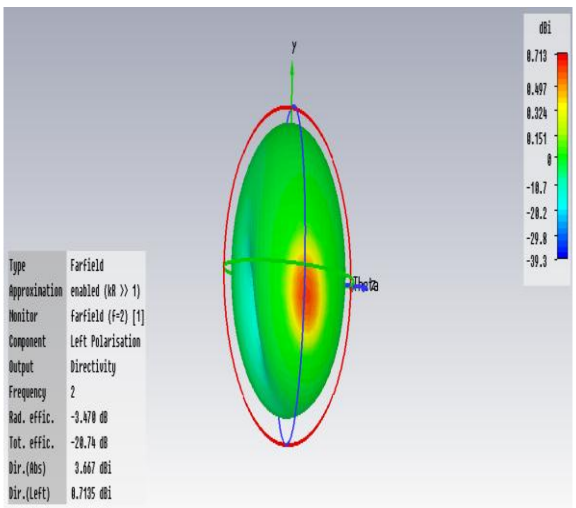

Fig-10: Left Polarization

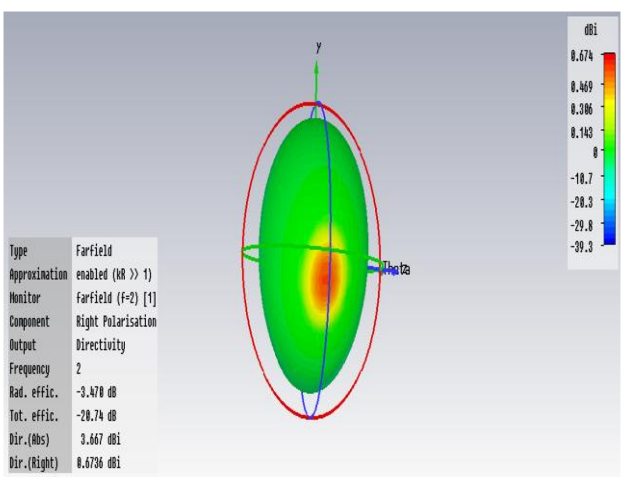

Fig 11 Right Polarization

Figure 9 describes the 3D far field radiation pattern to obtain the directivity of ES-tag antenna at 2 GHz frequency. The directivity in terms of dBi various over blue to red color (i.e. -36dBi to 3dBi respectively) .In this maximum intensity direction is said to be directivity of antenna which incline 3.67 dBi along with this radiation efficiency is -3.478dB is calculated. To that the Polarization direction of rotation in right hand polarization and left hand polarization found. In which the figure (10) illustrate left hand polarization in a far field radiation pattern in this directivity is measured in terms of dBi and output of directivity (left) is 0.7135 dBi. While the figure (11) illustrate right hand polarization in a far field radiation pattern in this directivity is measured in terms of dBi and output of directivity (right) is 0.7135 dBi.

5. CONCLUSIONS

In this paper, we have designed the enhanced RFID sensor Tag (RS-Tags) antenna in UHF (Ultra High Frequency) bandwidth of about 2GHz. The tag antenna designed using various substrate materials with necessary thermal conduction and young’s model approximation. In this lumped elements and port are implemented for the efficient calculation of the antenna structure. Thus the RS-Tag is designed and simulated with the help of CST (computer simulation technology) microwave studio software and the performance of this design will be computed which will be cost-effective RFID Tag for sensor data transmission.

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