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A Design of PCB Antenna for Application BasedWireless Sensor Node

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ABSTRACT: In this paper, an antenna has been designed and implemented for wireless sensor node. The antenna element of the proposed node is based on Omni directional PCB (printed circuit board) patch antenna. It uses meandering connecting strip which is optimized to have frequency band operation, between 2.40 to 2.49 GHz for |S11| ≤ -10 dB. This work is a part of development of the wireless sensor node for a specific application. We have designed a dipole antenna suitable for the specific application using FR-4 epoxy glass laminate material, and have presented the simulated result obtained from NEC 4.0V simulation tool. This design has a better power handling capacity. Further, we have implemented this for the wireless sensor node as well.

KEYWORDS: WSN Antenna, Patch Antenna, Antenna Design, PCBantenna

I. INTRODUCTION

The antenna is a key constituent in a wirelesscommunication system. The main objective of an antenna is totransform electrical signals into RF electromagnetic waves.The electromagnetic waves are then propagated into free space(transmit mode) and are transformed into electrical signals(receive mode). A characteristic antenna is basically an air coreinductor of definite wavelength. The AC current through aninductor or conductor lags the voltage by approximately 90degrees so the maximum power is delivered at ¼ wavelengths.If wavelength is λ then the λ/2 dipole produces most power atthe ends of the antenna with little power in the centre of theantenna. The other similar work with different geometry andapplication of antenna are cited in articles [1,4].

II. DESIGN THEORY

There are diverse types of antenna for the better outputpower, sensitivity and antenna gain. Reducing its frequency bya factor of 2 doubles its range (line of sight). Lowering theoperating frequency also signifies that the antenna increases insize. When choosing the operating frequency for a radiodesign, the available board space must also accommodate theantenna. So the choice of antenna, and the size available shouldbe considered at an early stage in the design.

$$\lambda \; in \; meters = \frac{2.99792458E8 \; m \; / sec}{f(GHz)}$$

Moritz Von Jacobi's maximum power theory states thatmaximum power transfer happens when the source resistanceequals the load resistance. For complex impedances, themaximum power delivered from a transmission line withimpedance Z_0 to an antenna with impedance is Z_a, It isimportant that Z_0 is properly matched to Z_a. If a signal withamplitude V_{IN} is sent in to the transmission line, then only apart of the incident wave will be transmitted to the antenna if.Z_0 is not properly matched to Z_a then it is.

$$Z0 = Z_a{}'$$

The complex reflection coefficient (Γ) is defined as theratio of the reflected waves' amplitude to the amplitude of theincident wave. Γ can be calculated from the impedance of thetransmission line and the impedance of the antenna, as shownin the equation:

$$\Gamma = \frac{Z_a - Z_0}{Z_a + Z_0}$$

The reflection coefficient is zero if the transmission lineimpedance is the complex conjugate of the antenna impedance.Thus if Z0 = Za´ then the antenna is perfectly matched to thetransmission line and all the applied power is delivered to theantenna. Antenna matching typically uses both; the ReturnLoss and the Voltage Standing Wave Ratio (VSWR)terminology. VSWR is the ratio of the maximum output (Input+ Γ) to the minimum waveform (Input – Γ) shown in followingequation. This means that a specific geometry can be madeabout half the size of a required patch (area of interest). Theinput impedance levels have much the same dependence as thatfor the required patch. By selecting the required position toobtain as good a match as possible to with a connector and theVSWR bandwidth was computed. It can be seen that thebandwidth varies if there is change in patch size [2].

$$VSWR = \frac{V_{max}}{V_{min}} = \frac{V_{input} + V_{reflected}}{V_{input} - V_{reflected}} = \frac{1 + |\Gamma|}{1 + |\Gamma|}$$

The power ratio of the reflected wave to the incident waveis called Return Loss. This indicates as to by how manydecibels is the reflected wave power below the incident wavereturn loss for the same port. It can be seen that a very goodimpedance match ($|S_{11}|$ less than -20 db) is achieved for eachdesired level of miniaturization [3].

$$S_{11} = 20\log(\Gamma) = 20\log\left[\frac{VSWR - 1}{VSWR + 1}\right]$$

Antenna design, VSWR and Return Loss are measures withwhich we can find out how well the antenna functions. Themismatching of the antenna is one of the largest factors thatreduce the total RF link budget. To avoid unnecessarymismatch losses, it is recommended to add a pi-matchingnetwork so that the antenna can always be matched. If theantenna design is adequately matched then it just takes onezero ohm resistor or DC block cap to be inserted into the π_matchingnetwork. There are a numerous issues to considerwhen selecting the antenna:

- Antenna placement
- Ground planes for ¼ wavelength antennas
- Undesired magnetic fields on PCB
- Antenna mismatch (VSWR)
- Objects that alter or disrupt Line of Sight (LOS)
- Antenna gain characteristics
- Antenna bandwidth
- Antenna Radiation Efficiency

III. Proposed Design Dimension

There are several antenna types to choose from whiledeciding what kind of antenna to be used in an RF product.Size, cost and performance are the most vital factors to be keptin mind at the time of choosing an antenna. The three mostcommonly used antenna types for short range devices are; PCBantennas, chip antennas and Segment antennas, all of whichhave their own pros and cons. Here, we have focused on PCBantenna since they are very cost effective, easy to implementand have better performance at more than 868 MHz. Also, asmall size PCB antenna at high frequencies can be design asper the application requirement.

The antennas discussed in this paper are for the license freeworld wide band 2.4000 GHz - 2.4900 GHz band and the allthe standard frequency bands at sub 1 GHz. For the sub 1 GHzbands; there is usually a "low" sub 1 GHz band and a "high"sub 1 GHz band. Our ambition is to provide excellent antennadesigns for our application with Omani directional radiation.

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Total area covered by the antenna is shown in fig 1 andphysical dimension on each strip of antenna are described in fig2, Total length of track c/c = (270+55x6+150x6+145) = 1645mils. The width of track is 20 mils and its spread area is260x280, The length of Ltips = 165 mils (Segment D strip infig 2), PCB thickness is 31 mils, Cap track (segment E) is 273mils, The capacitance track below segment is 273 mils forthickness of PCB 0.08mm. This assembly can maintain thecapacitance of around 0,22pF. The material used for the PCB isFR-4 epoxy glass which is laminated with HTE Copper ofthickness of 0.0032 inches ± 10%.Aim of the proposed algorithm is to maximize the network life by minimizing the total transmission energy using energy efficient routes to transmit the packet. The proposed algorithm is consists of three main steps.

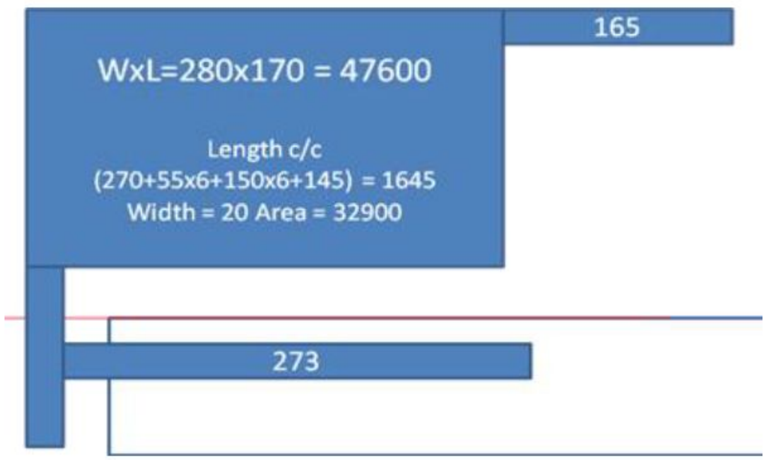

Figure 1Required patch area and layout

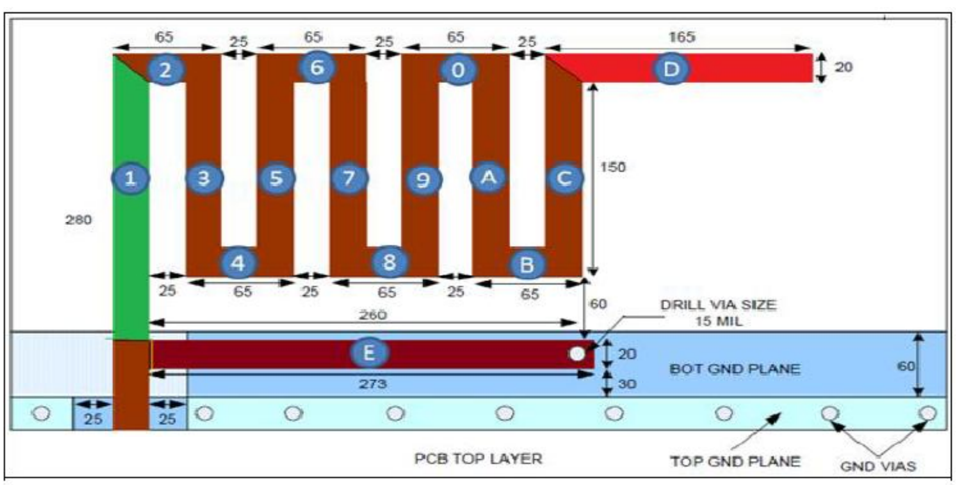

Figure 2Design dimensions for proposed geometry

After carrying out the design calculations of the proposedantenna we reach Fig 2, which consists of 16 segments. Thedimension details for creating this image in simulation softwareare given in the following table in geometrical absolutecoordinate system.

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Table 1: Feeding dimensions for simulation

	X1	Y1	Z1	X2	Y2	Z2	Thick
Segment 1	0	0	0	0	0	T	0.005
Segment 2	0	0	T	0	w	T	0.005
Segment 3	0	w	T	0	w	T-h	0.005
Segment 4	0	w	T-h	0	2*w	T-h	0.005
Segment 5	0	2*w	T-h	0	2*w	T	0.005
Segment 6	0	2*w	T	0	3*w	T	0.005
Segment 7	0	3*w	T	0	3*w	T-h	0.005
Segment 8	0	3*w	T-h	0	4*w	T-h	0.005
Segment 9	0	4*w	T-h	0	4*w	T	0.005
Segment A	0	4*w	T	0	5*w	T	0.005
Segment B	0	5*w	T	0	5*w	T-h	0.005
Segment C	0	5*w	T-h	0	6*w	T-h	0.005
Segment D	0	6*w	T-h	0	6*w	T	0.005
Segment E	0	6*w	T	0	6*w+h	T	0.005
w= 0.00143 m; T=0.007112 m; h=0.00381 m							

IV. SIMULATION RESULTS

As an outcome of our data, we get the simulated antenna image similar to Fig 3. This antenna design falls in a dipole antenna category with loading effect. In this antenna feed is offset, but it is not a monopole structure unlike most of the antenna. It is wire base meander based antenna. In order to reduce the vertical height, we have applied the meander shape as loading. The power handling capacity will be up to +60dBm as shown in Fig 5.

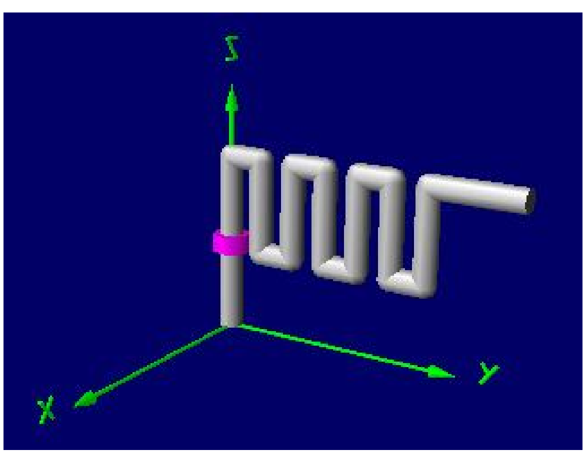

Figure 3Result: 3D view of antenna.

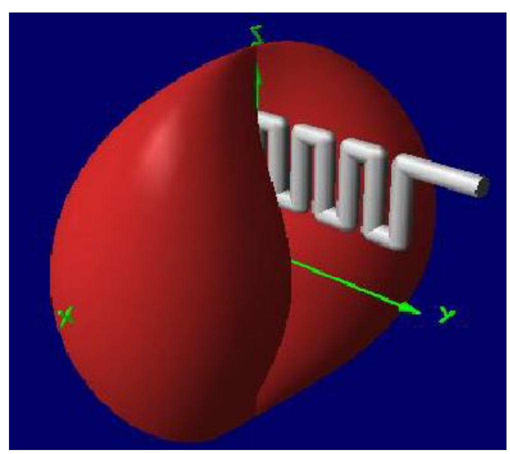

Figure 4Result

This fig 4 shows the 3D pattern of the field strength & inclination. This fig also shows horizontal plane having directivity, “eight shapes” pattern is obtained due to dipole structure. This shows f/b ratio optimization but is not our

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focus. It shows impedance is 35 ohm. The co-polarize pattern is around -12db down. The entire antenna factor is better the other tried samples and pattern

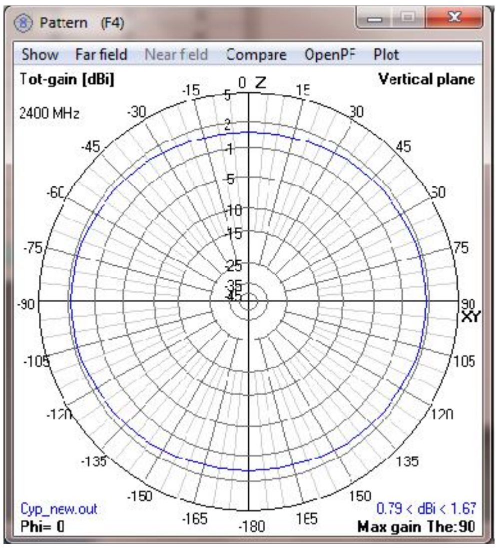

Figure 5 Result

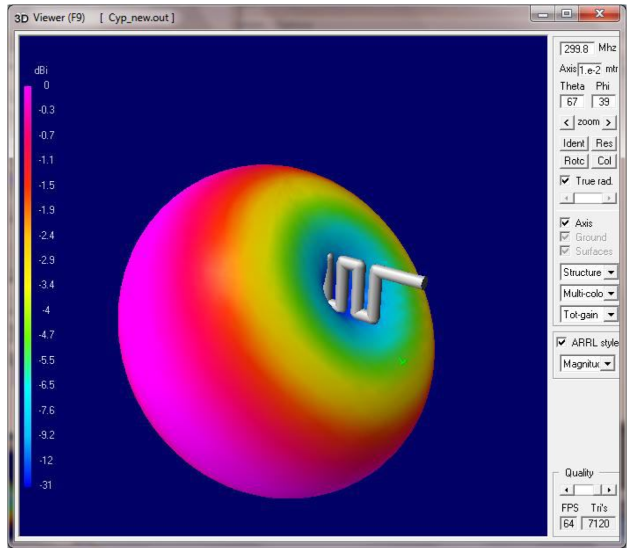

Figure 6 Result

This fig 5 shows the max gain is 1.6 dB in elevation plane the result obtained from the simulation tool which is based on SLOVER IS MOM. The fig 6 shows the Omni directional pattern which obtained in elevation plane. The pattern axis is shifted in H plane, which is due to loading.

V. IMPLEMENTATION RESULTS

After analyzing the result of above work we fabricated the same patch antenna on the PCB of the wireless sensor node* and got the result on lab successfully are going to test on real tile field soon along with the application need and required rules of communication. Due to the loading the impedance is modified from 73 ohm, the reactive part is too high to suppress the antenna efficiency .the antenna factor is low. To match this specification impedance matching circuit is employed. The PCB layout of this antenna is shown in fig 7 and the impedance marching circuit is shown in fig 8. The vales of the capacitanceand inductance can be selected as per the actual impedanceafter fabrication of PCB and require gain.

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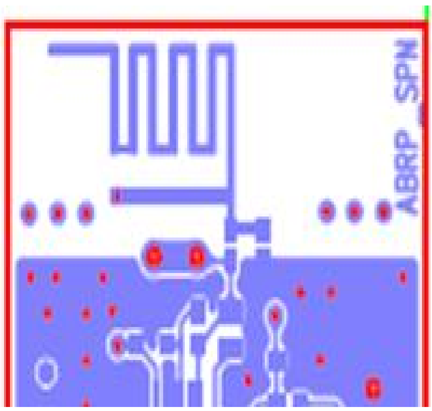

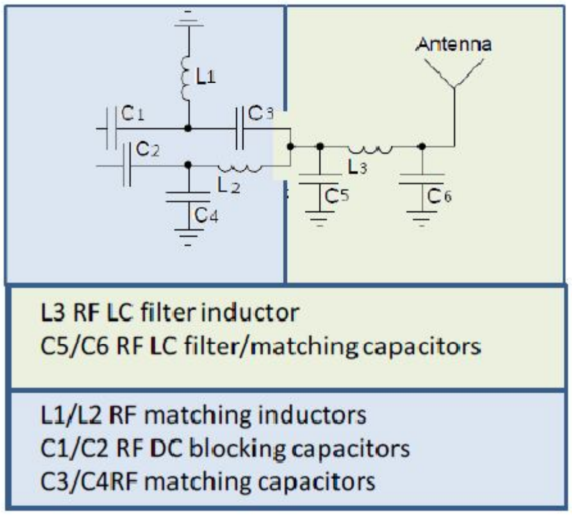

Figure 7 PCB layout of antennaFigure 8 Matching circuits of antenna

VI. CONCLUSION AND FUTURE WORK

From above result discussion we would like to state that thePCB bases antenna is better cost effective solution for wirelesssensor node for a typical application. It shows the betterperformance than inverted F antenna [1]

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