Multi-Band CPW-Fed Flexible and Transparent Antenna for Active ISM RFID Tag using Genetic Algorithm

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ABSTRACT: In this paper multi-band coplanar waveguide-fed antenna for ISM active RFID application is designed and optimized using adaptive genetic algorithm (AGA). The optimization goals are gain maximization and bandwidth enhancement. Here silver coated conductive polymer AgHT-8(AgF8) thin film used as CPW ground and radiator. Polyethylene terepthalate (PET) is used as substrate, to design the antenna with transparency of above 80%. The antenna is designed at multiple frequencies1.5 GHz, 2.4 GHz, 3.5 GHz and 5.8 GHz. The overall dimension of proposed antenna is 39X36X0.175 mm. The antenna is suitable for WiMax, GPS, Wi-Fi, Bluetooth and ISM applications. The proposed antenna is considerably light weight and less thickness compared with non transparent designs. Antenna model is simulated in Ansoft HFSS and Matlab.

KEYWORDS: Keywords – Multi band, Transparent, Genetic Algorithm, RFID, Active Tag, PET, AgHT-8, CPW, ISM, Flexible.

I. INTRODUCTION

Today, automation technology plays a major role in industries, transportation and domestic sectors [1-5]. In automation process identification and tracking of objects is major task. Some of familiar techniques to identify and tracking objects are Bar code, QR code, and Radio Frequency Identification (RFID). The advances in several applications involving identification, detection, vehicular communication [6] and navigation [7,8] require antennas which are conformal and optically transparent. These special antennas are not only required for detection and navigational communication but are also necessary to enhance performance such as security, light weight and aesthetic. Transparent antennas are designed with transparent materials or meshed conductors.

Sapphire, RT duroid, and polyethylene etc having transparent nature and used as substrate in transparent antennas. Previously, Patch and ground are designed with non transparent conducting materials, due to this visibility of antenna increases and it is not consider as transparent antenna. In recent years transparent conducting materials are developed like conductive silver ink. The meshed antennas are fabricated from printing with conductive ink or from electroformed mesh. High surface resistance due to meshed lines is one of the limitations [9].

RFID applications are designed at High Frequency (HF), Ultra High Frequency (UHF) and microwave Industrial Scientific and Medical (ISM) band range. HF and UHF band RFID tags transfer low data due to low frequency. Microwave band RFID antennas transfer high data rates because of high frequency and at the same time size of antenna is less compared to HF and UHF antennas. High speed data transfer is required between tag and reader for tracking of moving object [6]. RFID tag contains a tag antenna and an IC chip. RFID antennas are classified into 3 types according to powering-up Integrated Circuit (IC) chip as passive tag antenna, semi passive tag antenna and active tag antenna [10]. In passive RFID tag antennas, RFID reader transmits signal first and receives back scatter signal from tag. No need of any additional power source in passive tag antenna. If impedance matching between tag and IC is more, then tag receives more power [11]. In case of active RFID system no need of reader to transmit signal to power up IC because an onboard power supply is available on active RFID tag. Hence design of active antenna is simple compared to passive tag antenna. So active RFID antenna at microwave attracting researcher's interest.

Genetic algorithm is one of the evolutionary algorithms to optimize the antenna parameters. It uses Darwin theory of genetic evaluation; stronger genes become stronger in successive generations [10,12]. Here first initial population is

generate and selects best population to next generations, this population is called parents. By using best parents, offspring are produced using crossover technique. In crossover technique, part of parent value is interchange between two parents to produce best off spring. After crossover one or more values of new population is changed, this is called mutation. Now this new population is applied to problem and observe solution using fitness function. This fitness function contains the goal of the problem solution. If solution reached desired goal, optimization stops otherwise the process continues until it reach stopping criteria.

In order to connect antenna with RFID system different fed mechanisms are using in active RFID system like Co-Planar Wave guide (CPW) fed and probe fed mechanism. In probe fed technique, slight variation in probe position leads to significant change in antenna performance and also at lower thinness of antennas; probe fed fabrication is difficult [13]. To overcome these drawbacks, CPW fed technique is utilizing, owing to ease of implementation and fabrication [14]. Multiband CPW fed transparent antenna at ISM band with operating frequencies of 2.4GHz, 3.5GHz and 5.8GHz for different applications are RFID, WiMax, Wi-Fi, Bluetooth and GPS. ISM band of 2.4GHz, 3.3GHz, 5.65GHz [15], GPS bands of L band (1.5GHz) and S band 2.4GHz[16] and WiMax bands of 2.5GHz and 3.5GHz [17]. The proposed antenna covers resonating bandwidth of 2.2 GHz from 1.5 GHz to 3.7 GHz and bandwidth of 0.7 GHz from 5.3 GHz to 6.0 GHz

The rest of the paper is organized as follows. Related Work is explained in section II. Proposed antenna deign is explained in section III. Simulation results are presented in section IV. Concluding remarks are given in section V.

II. RELATED WORK

In [2], optically transparent antenna is investigated. The conventional microstrip line fed patch antenna designed using RT-Duroid 5880 substrate is not optically transparent. Conformal and optically transparent antennas are need for applications involving vehicular communications and navigation. These special antennas not only required for communication and navigation but also necessary to enhance the vehicular performance, such as, aesthetic and security. In [4], label type UHF antenna is investigated. To achieve flexibility to antenna in this paper PET substrate is used and antenna designed to operate at UHF band. In [5], need of GPS and RFID system is investigated for localization and tracking. In [6], RFID road marker navigation system is investigated. In this paper RFID system is using as alternate, where GPS not works. In [9], property of optically transparent patch antenna for meshed conductor and transparent films is investigated. In [18], the optimization of a meander line antenna FEM model by means of an adaptive genetic algorithm is investigated. To search for optimal antenna configurations, the present method employs a GA with an adaptive method that adjusts the characteristics of its selection, crossover and mutation operators in order to maintain a diverse set of high quality candidate solution during its execution. In [4], a single UHF band probe-fed transparent antenna for RFID applications is investigated using the printed conductive polymer on the polyethylene terepthalate (PET) substrate. In the design, a modified polymer is used to increase the conductivity of the material; however, it increased the visibility to the human eye. In addition, a slight deviation from the exact position of the feed line will significantly decrease the performance of the antenna. To avoid this drawback, the CPW-fed technique could be utilized, owing to ease of fabrication and implementation [13]. In [24], a dual band CPW-Fed active antenna for ISM active RFID is investigated using AgHT-8 thin film. In the design, antenna is designed to operate only at 2.45 GHz and 5.8 GHz; however this antenna is not useful for GPS function for localisation and tracking [5] along RFID system. In addition the gain of antenna is acceptable, but less.

III. ANTENNA DESIGN

Multi band antenna is designed using Ansoft HFSS, Microsoft Visual Base Script and Matlab software. Here antenna parameters are generated and tuned using Genetic algorithm. Antenna model is simulated in High Frequency System Simulator (HFSS) software to generate antenna parameters like return-loss, gain, radiation pattern, and other parameters. A Wrap program is developed in Matlab using Microsoft Visual script software to make interface between Genetic algorithm and HFSS antenna model. Conventional genetic algorithm only depends on fitness function and it is not depend on previous data [18-21]. In this paper, along fitness function, algorithm depends on previous data for adaptive nature [18, 22]. Genetic algorithm is implemented in Matlab and a script file is generated by Matlab according to parameters generated in GA. This script file is run in Microsoft Command window by Matlab to start simulation in HFSS and simulation results sends back to Matlab. In Matlab, results are analysis and takes decision on Selection and

Mutation process in genetic algorithm. This process continues until optimization meets desired goal or stopping criteria.
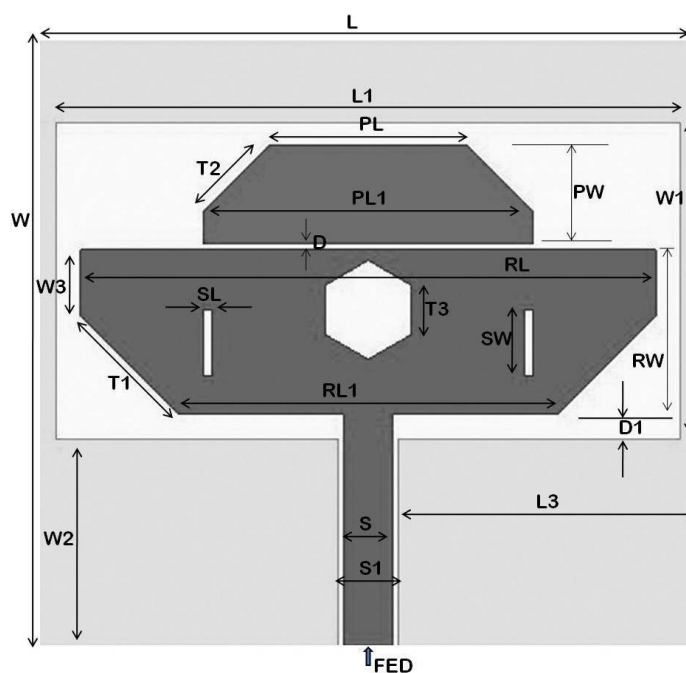

Figure 1.   Antenna Design Model

Proposed antenna shown in Figure 1 is designed using AgHT-8 thin film. AgHT-8 is above 80% transparent to human eye [23]. AgHT-8 is composition of two layers, poly teraphatalet as substrate and silver conductive polyester as radiating layer [23]. Antenna is designed as coplanar waveguide because of low thickness. Radiating patch is polygon shape (similar to semi octagonal shape).
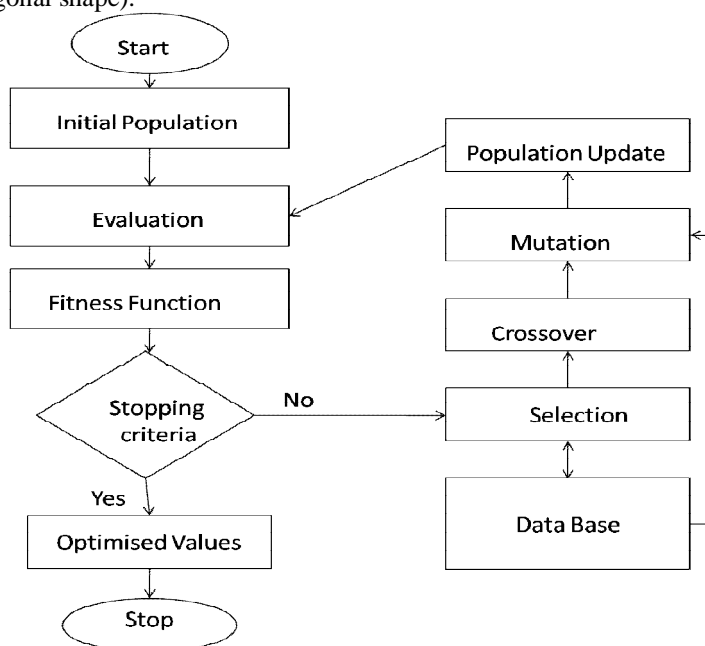

Figure 2.   Algorithm Flow Chart

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Here monopole antenna resonates at 1.7 GHz, 2.4 GHz, 3.5 GHz and 5.8 GHz and size of antenna is 39mmx37mmx0.175mm at this dimension 5.8 GHz frequency resonates. In order to achieve low frequencies at this dimension some of the techniques are used. Triangular cuts are used to limit dimensions of antenna at low frequencies 1.5 GHz and 2.4 GHz and also these cuts reduces the mutual coupling between radiating patch and ground plate. If mutual coupling between ground and radiating patch is more, current flow to upper levels of ground plates decreases and this decreases gain [24]. To increase flow of current to upper level of ground plates triangular cuts are made to radiating patch, which reduces mutual coupling. The wide slot ground with long stubs mounted on top of antenna helps to return distributed currents and covers the waste area around radiating patch to avoid large antenna size mainly at lower frequencies. Width of patch is directly proportional to upper resonant frequency i.e., 5.8 GHz [24] and it is not shown any effect on resonance at lower frequencies, at the same time height of patch is inversely proportional to magnitude of return loss at lower frequencies [24]. For 3.5 GHz parasitic polygon is used. Due to this parasitic radiator bandwidth at lower frequencies is increased and gain is improved from - 1.5dBi to 0.5dBi, besides that overall gain also improved. Here 50O CPW fed is using for matching purpose. Two rectangular slots and hexagonal slots are used to resonate, antenna at 5.8 GHz [26].

Table 1: Antenna Parameters

Parameter	D	D1	L	L1	L3	PL	RL	RL1	RW	S
Size(mm)	0.35	1.5	39	37	17.2	12	20	23	10	3
Parameter	S1	SL	SW	T1	T2	T3	W	W1	W2	W3
Size(mm)	3.6	0.5	4	8.48	5.65	3	36	19.2	12.5	4

To search optimized antenna parameters, Adaptive genetic algorithm is using and flow chart is shown in Figure 2. Genetic algorithm is a process in which candidate solution is optimized iteratively varying the values of each candidate. Here a candidate is nothing but a length or width or position of antenna elements. These candidate values are changes iteratively by 3 steps, called selection, crossover and mutation [12]. In this algorithm all candidates are not participate in these 3 steps, only candidates which are need to optimize are participate in 3 steps, this can be done by comparing previous data available in data base and current results. In selection process, candidates are selected using tournament model. Candidate which are best in candidate solution set are taken. In mutation, a value is either increase or decrease. AGA takes a decision by using previous and current data to increase or decrease value.
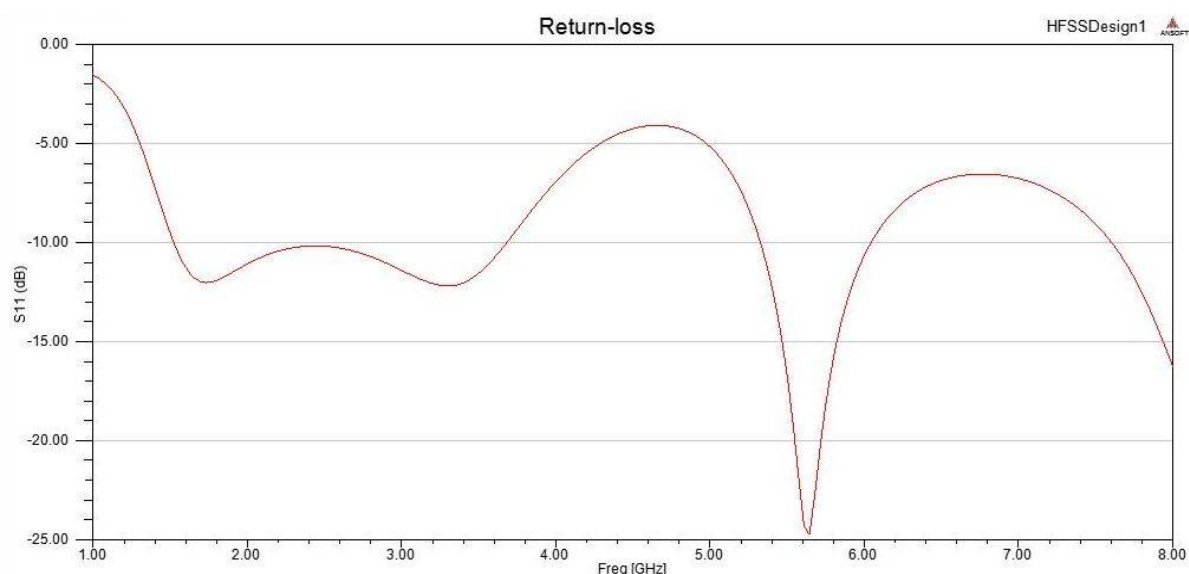
IV. RESULTS

Figure 3.   Return-loss Plot

Return loss of proposed antenna is shown in Figure 3. It is clear that proposed antenna resonates at 1.7GHz, 3.1GHz and 5.7GHz and magnitude of return-loss is -11.96 dB, -12 dB and -24.7 dB respectively. It also covers ISM band, WIMAX, GPS band as shown in Figure 3. Antenna purposed in paper [24], covers only 2.4GHz and 5.8GHz ISM bands only.
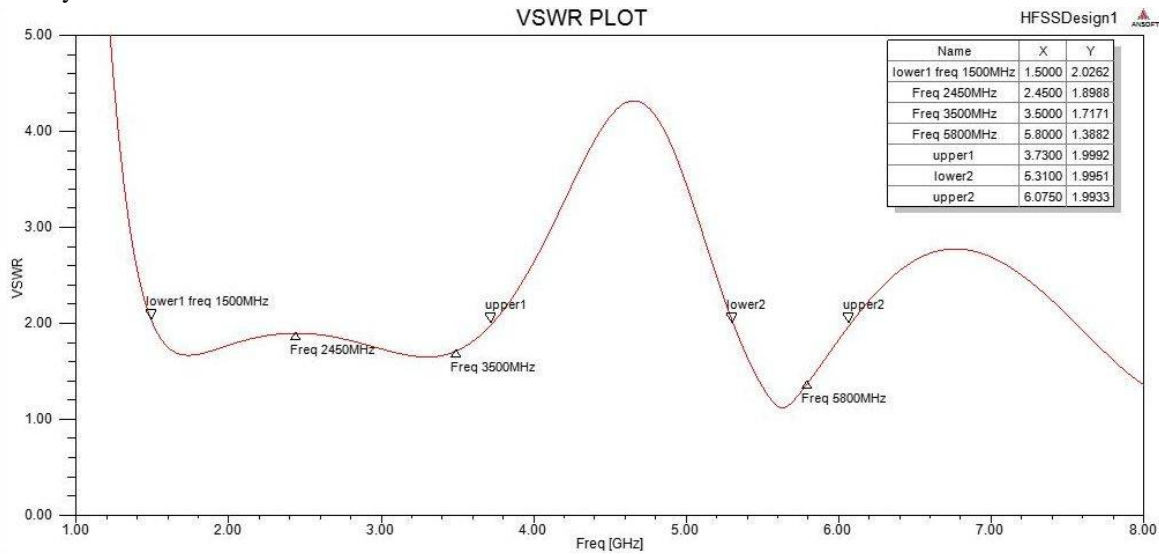

Figure 4.   VSWR Plot

Proposed antenna has VSWR < 2 over frequency ranges from 1.5GHz to 3.7GHz and from 5.3GHz to 6.1GHz shown in Figure 4. Gain of proposed antenna in paper [24] is a -2.5dBi, -4.5dBi at 2.4GHz and 5.8 GHz respectively.
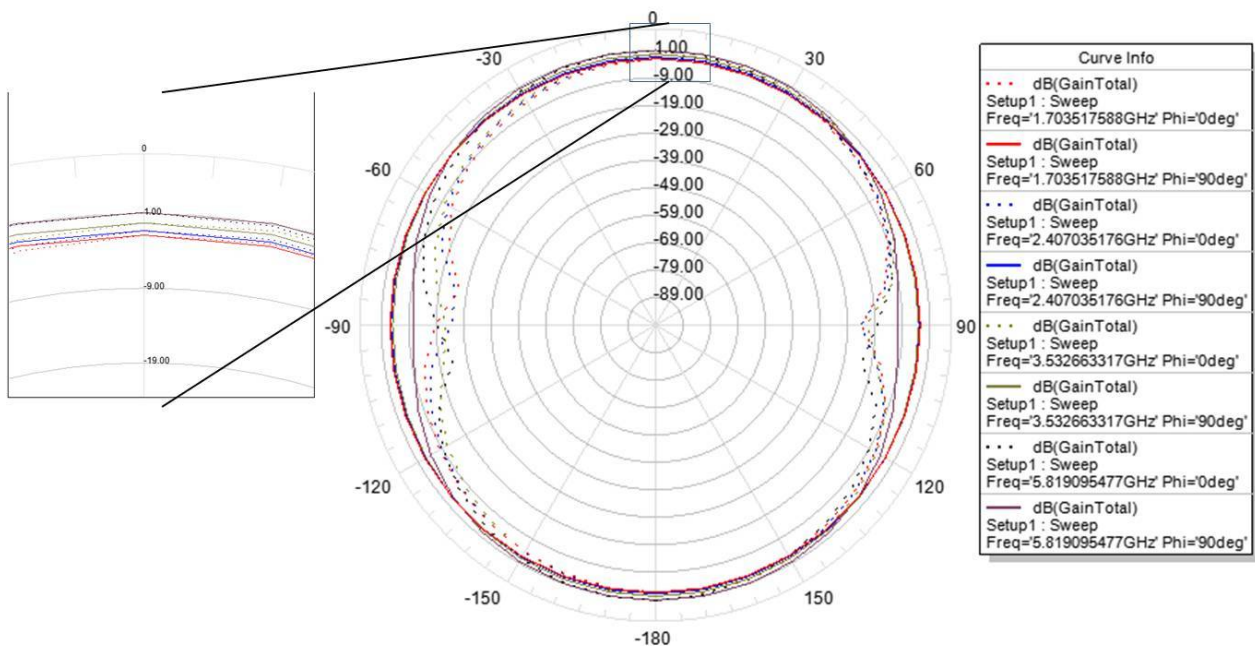

Figure 5.   Gain Pattern

This patch improved overall gain around 3dBi.the radiation patter of proposed antenna is almost Omni directional. At frequency 1.7 GHz, return loss is -11.96dB, gain is -1.8 dBi and radiation pattern is similar to Omni directional, a null point can observe in bore side. At frequency 2.4 GHz, return loss is -10.2dB, gain is -1.2 dBi and radiation pattern is similar to Omni directional, a null point can observe in bore side. At frequency 3.5 GHz return loss is -11.6 dB, gain is -0.24 dBi and radiation pattern is similar to Omni directional, a null point can observe in bore side. At frequency 5.8 GHz return loss is -15.9 GHz, gain is 1.15dBi and radiation pattern is similar to Omni directional, a null point can observe in bore side. Average 99.3% radiation efficiency is achieved.

Radiation pattern at 1.7GHz   Radiation pattern at 2.4 GHz   Radiation pattern at 3.5 GHz   Radiation pattern at 5.8 GHz
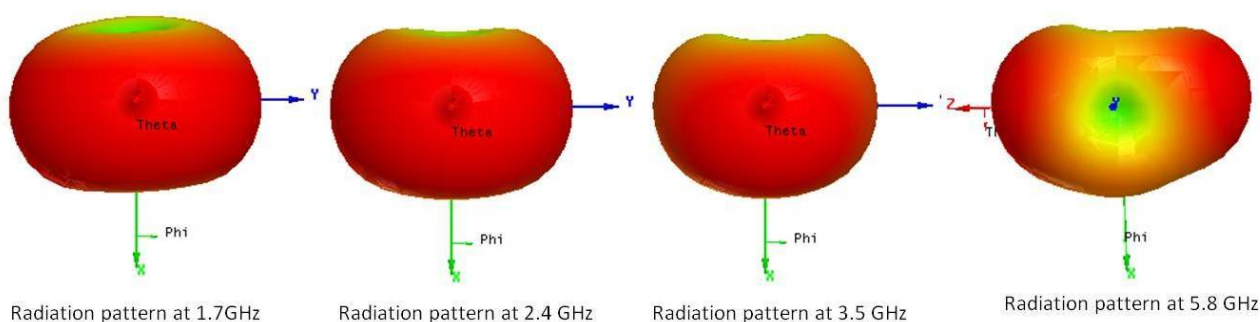
Figure 6.   3-D Radiation Pattern of Proposed Antenna

V. CONCLUSION AND FUTURE WORK

An antenna is designed to operate at different frequency bands like 1.7GHz, 2.4GHz, 3.5GHz and 5.8GHz using adaptive genetic Algorithm optimization method and antenna radiation pattern is observed using Ansoft HFSS simulation software. Proposed antenna covers bandwidth of 2.2GHz from 1.5GHz to 3.7GHz and 0.7GHz from 5.3GHz to 6GHz with return loss < -10dB and VSWR<2. This antenna can use for different applications like RFID, WiMax, Bluetooth, GPS and Wi-Fi.

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