Flexible Microstrip Patch Antenna for ISM Band Application

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ABSTRACT - The flexible antenna is designed to operating a single frequency band with microstrip patch and slot that is significant for ISM band applications. The design involves a slot, a rectangular shaped microstrip patch. The single band frequency is 2.4GHZ ISM band. By using the CRO algorithm for receiving length and breadth .The substrate layer used is Polyimide as it is flexible and it's dielectric constant is 3.6.The feeding type used is microstrip feed and HFSS software is used for designing antenna.The design process encompasses the selection of a flexible substrate material, determination of patch geometry, substrate dimension and feed mechanism .Special attention is given to impedance matching, bandwidth consideration and achieving the desired radiation pattern .The flexibility requirement is addressed through careful material selection and design modification .

KEY WORDS: Rectangular Microstrip Patched – Flexible and Wearable Antenna – Coral Reefs optimization - Substrate layer polyimide.

INTRODUCTION:

It focuses on the development of a flexible microstrip patch antenna for the ISM frequency band frequency (2.45 GHZ). It aims to address the need for antennas suitable for applications in Industries, Scientific research and Medical field. The project involves the optimization of the antenna's dimensions, substrate material, and feeding techniques to achieve desired radiation characteristics while maintaining the flexibility required for the intended applications [1]. Design of a textile antenna operating at multi frequency band with microstrip patched is proposed in this paper significant for applications operating at 5G and LTE band. The design involves a U-Shaped slot, a rectangular shaped microstrip patched and two annular concentric slots [2]. The wearable antenna for wireless body area network is trending in recent time. The demand for lightweight wearable antennas for body area networks is growing every day, as an antenna is one of the most vital parts of a wireless body area network. By putting numerous devices on the human body, WBAN has developed communication between them. Different types of miniaturized microstrip patch antennas play a different important role. This paper presents a small sized, low-profile, and flexible antenna using FR-4material as the substrate [3]. This study presents a compact, low-profile, and flexible fabric antenna specifically designed for on-body Wireless Body Area Networks operating within the Industrial, Scientific, and Medical (ISM) frequency band at a central frequency of 2.45 GHz. The proposed antenna employs a jeans substrate [4]. The Flexible antenna is experiencing major growth recently because of the demand for wearable devices, military applications, health monitoring systems, communication devices, and global positioning systems (GPS). The choice of the flexible antenna relies on many factors such as materials used, substrate, antenna performance, processing technique, and the surrounding environment [5]. In the current decade, researchers can view huge popularity of different wireless portable smart devices such as laptops, tablets and smart phones. The increase of usage of these smart devices have increased the bandwidth requirements of wireless devices for covering the recent allocation of the LTE frequency band and 5G frequency band [6].

OBJECTIVE:

To create a flexible microstrip patch antenna .To implement CRO algorithm for optimization process .To operate antenna well within the ISM frequency 2.45GHZ .To choose the flexible substrate material for ISM band applications .To optimize key antenna parameters, such as return loss S11, gain, radiation pattern, bandwidth, and efficiency to achieve high performance.

PROPOSED WORK:

In this proposed system, we used CRO(Coral Reef Optimization) optimization algorithm to find out the value of length and width. By using the optimized value of rectangular patch antenna with slot is designed in HFSS simulation. Different shapes of slots to enhance the bandwidth of the antenna.

ALGORITHIM:

Step 1: Constants and Parameters
Step 2: Define substrate permittivity

Step 3: Main Optimization Loop
Step 4: Update Best Coral and Positions
Step 5: Reflection Coefficient Plotting
Step 6: Generate and Plot Optimized Antenna
Step 7: Print Optimization Results
Step 8: Antenna Fitness Function
Step 9: Coral Reef Update Function
Step 10: Create Rectangular Patch Antenna Function

EXPLANATION:

Step 1: Constants and Parameters

Explanation: This section initializes constants and parameters for the optimization process. It sets the frequency, wavelength, population size, maximum iterations, and bounds for the design variables (coral parameters such as length, width, and thickness). The coral population is randomly initialized within the specified bounds.

Step 2: Define substrate permittivity

Explanation: The relative permittivity of the substrate is defined as a constant for use in the antenna fitness function.

Step 3: Main Optimization Loop

Explanation: This loop runs the main optimization process for a specified number of iterations. It evaluates the fitness of each coral colony using the antenna fitness function. The fitness is based on the efficiency of the antenna design, and the reflection coefficients are calculated for each coral.

Step 4: Update Best Coral and Positions

Explanation: After evaluating fitness, it checks if any coral colony has better fitness than the current best. If found, the best coral parameters and associated fitness values are updated. The coral positions are then updated using the Coral Reef Optimization (CRO) operators implemented in the coral_reef_update function.

Step 5: Reflection Coefficient Plotting

Explanation: This part stores the reflection coefficients for each coral colony during the current iteration and plots the evolution of reflection coefficients over the optimization iterations. It uses a subplot to display the graph.

Step 6: Generate and Plot Optimized Antenna

Explanation: In the second subplot, it generates and plots the optimized antenna structure using the parameters of the best coral found so far. The antenna structure is displayed using the show function. A title is added to the plot indicating the frequency and iteration number. A pause is optional and allows time to visualize the plot for each iteration.

Step 7: Print Optimization Results

Explanation: After the optimization loop, it prints the final results, including the optimized length, patch width, patch thickness, and reflection coefficient of the best coral.

Step 8: Antenna Fitness Function

Explanation: This is the function that calculates the efficiency and reflection coefficient of the antenna based on the coral parameters.

Step 9: Coral Reef Update Function

Explanation: This function updates the coral positions using Coral Reef Optimization (CRO) operators, considering the fitness values and iteration parameters.

Step 10: Create Rectangular Patch Antenna Function

Explanation: This function creates a rectangular patch antenna structure based on specified parameters.

FLOWCHART:

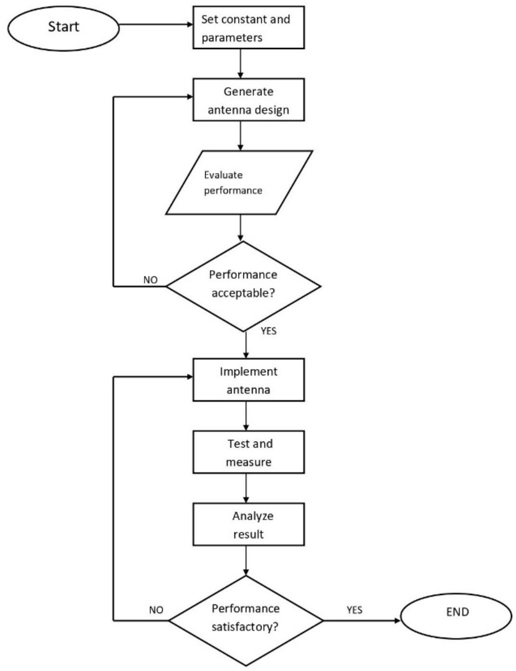
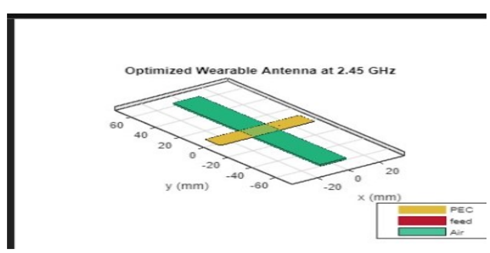


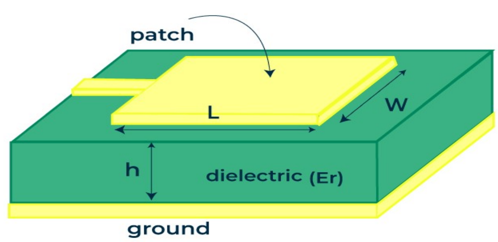
TABLE FOR THE OPTIMIZED VALUE OF ANTENNA:

Length of patch	29.28	mm
Width of patch	38.03	mm
Return loss	-17.18	db
Dielelctric constant	3.6	
frequency	2.45	Ghz

OPTIMIZED ANTENNA DESIGN:



MICRO STRIPPATCH ANTENNA:



EQUATION:

RESONANT FREQUENCY: $f = \frac{c}{2.\sqrt{\varepsilon_{eff}}.\sqrt{\frac{L}{(L+W).\varepsilon_r}}}$

EFFECTIVE DIELECTRIC CONSTANT: $\varepsilon\, eff = \frac{\varepsilon r+1}{2} + \frac{\varepsilon r-1}{2} \cdot (1 + \frac{10h}{W})^{-1/2}$

PATCH LENGTH: $L = \frac{c}{2fr\sqrt{\varepsilon_{eff}}}$

REFLECTION COEFFICIENT: $\Gamma = \frac{Z_{in} - Z_0}{Z_{in} + Z_0}$

RETURN LOSS: $RL = -20log_{10}(|\Gamma|)$

PATCH WIDTH: $W = \frac{c}{2fr\sqrt{\varepsilon_{eff}}}$

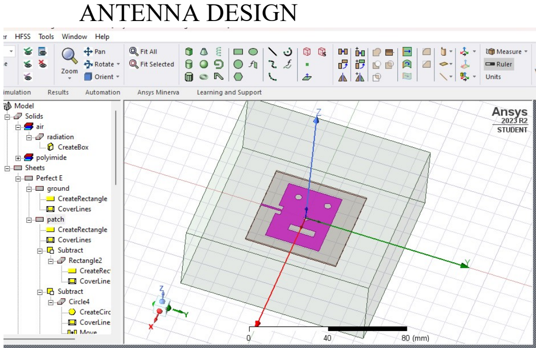
fr is the resonant frequency
c is the speed of light
ε_{eff} is the effective dielectric constant of the substrate.
L is the length of the patch.
W is the width of the patch.
ε_r is the relative permittivity of the substrate.
h is the height of the substrate
Γ is the reflection coefficient.
Z_{in} is the input impedance of the antenna
Z_0 is the characteristic impedance of the transmission line (usually 50 ohms for many RF applications).
RL is the return loss

FUTURE SCOPE:

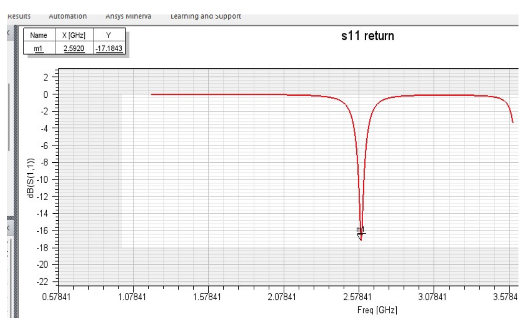
In the future, wearable and flexible microstrip patch antennas for ISM band applications are expected to become smaller, more adaptable to the human body, offer improved communication performance, and incorporate energy harvesting capabilities, catering to diverse technological needs and applications. Advances in manufacturing processes like 3D printing for producing customizable and cost-effective wearable antennas. Research on using microstrip patch antennas in ISM bands for healthcare applications like remote patient monitoring. Exploration of designs that can operate across multiple ISM bands or offer wider bandwidth for diverse communication needs.

ANTENNA DESIGN AND OUTPUT:

ANTENNA DESIGN

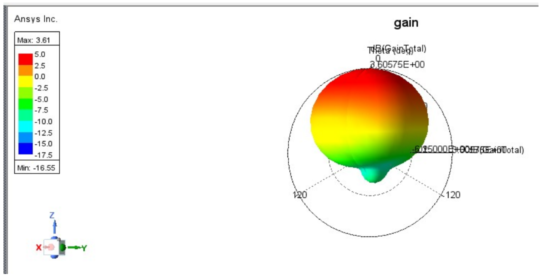


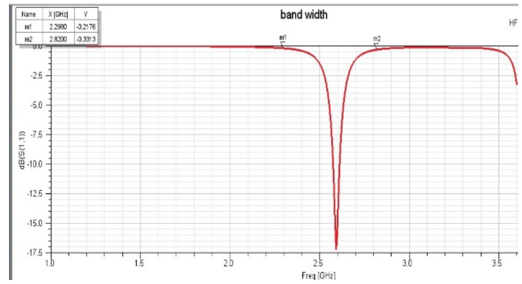
RETURN LOSS



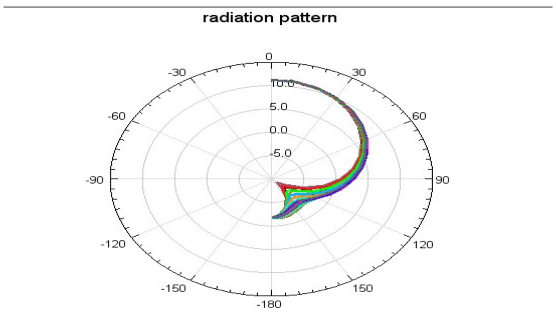
GAIN

BAND WIDTH

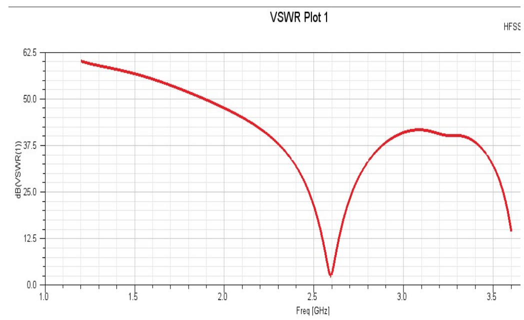




RADIATION PATTERN



VSWR



CONCLUSION:

This study optimizes a flexible microstrip patch antenna for 2.4GHz ISM band applications using the Coral Reef Optimization (CRO) algorithm. It enhances performance parameters like return loss, gain, and bandwidth by adjusting antenna dimensions and substrate material.The selection of polyimide as the substrate material addressed the flexibility requirement,while HFSS software facilatated the design process. The proposed algorithm efficiently guides the optimization process, contributing to the advancement of flexible antenna technology for ISM band applications.

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