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A Survey of Different Reconfigurable Antennas for Various Wireless Applications

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ABSTRACT: Different reconfigurable wireless communication antennas are studied and discussed detail in this paper. Properties of antenna such as gain, bandwidth, directivity, radiation pattern, return loss, radiation efficiency etc are varied based on their shapes, dimensions, thickness, dielectric constant, and conducting material and feeding techniques. Reconfigurable antennas are used to operate the antenna for various applications just by change their pattern, polarization and frequency. Reconfiguration techniques and types of antennas are varied based on their applications.

KEYWORDS: Reconfigurable antenna, wireless communication, pattern reconfiguration, polarization reconfiguration, frequency reconfiguration.

I. INTRODUCTION

Wireless communication is a transfer of information from one point to another point via air medium. Antennas play major role in wireless communication. Antenna is a conductor which converts electrical power into the signal in the form of radio waves or vice versa. It acts as transducer. Different types of antennas and different techniques are used in wireless communication for efficient and secure communication. Adaptive array or MIMO antennas are smart antennas. It is used to measure DOA (Direction of Arrival) of signal and to calculate beam forming. Metal or patch is mounted on the large rectangular sheet is called microstrip patch or Printed antenna. Reconfigurable antennas change their function dynamically. Single antenna can be used for multipurpose application by changing their parameter such as frequency, pattern or polarization. This paper describes about various roles of reconfigurable antennas in wireless communication.

A. *Reconfiguration techniques*

- Frequency reconfiguration
- Pattern reconfiguration
- Polarization reconfiguration

B. *Properties of an antenna*

(1) Gain

It is defined as maximum power at desired direction and reduced power in undesired direction. It is a measurement of directivity at antenna's radial pattern. Gain of the antenna referred as,

$$G=\frac{power\ radiated\ by\ an\ antenna}{power\ radiated\ by\ reference\ antenna} \quad \text{eq. (1)}$$

(2) Aperture

Active participation of antenna part for transmission and reception of radio waves is called aperture. It is formulated as below,

$$A=\frac{P_r}{P_d}m^2 \quad \text{eq. (2)}$$

(3) Directivity

Maximum power at particular direction is known as directivity.

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(4) Polarization
- Vertical antenna – Polarized at vertical direction
- Horizontal antenna –polarized at horizontal direction
- Combination of vertical and horizontal antenna – circularly polarized

(5) Effective length
Effective length of an antenna is described as below,

$$\text{Effective length}=\frac{Area\ under\ non\ uniform\ current\ distribution}{Area\ under\ uniform\ current\ distribution} \quad \text{eq. (3)}$$

(6) Polar diagram
A property of an antenna is defined as radiation pattern or polar diagram.

C. *Applications*
- Cognitive radio
- Military application
- Medical or telemedicine application
- Space and satellite application
- Mobile radio application
- RADAR and remote sensing application

D. *Antenna design*

(1) Ground plane

(2) Substrate
- FR4 (ε_r=4.4)
- Roger_RT Duroid(ε_r=2.32)
- Quartz (ε_r =3.8)
- Alumina (ε_r =10)

(3) Patch
- Microstrip patch
- Microstrip slot patch
- Printed dipole patch

(4) Feed
- Microstrip line feed
- Coax feed
- Aperture feed
- Proximity feed

II. RELATED WORK

A. *Polarization reconfigurable meander antenna for wireless communication*

Microstrip patch antenna is mostly used in wireless communication because it has some properties such as, small sized antenna, less expensive with less difficulty in fabrication. Polarization reconfiguration technique is used, so that single antenna can be used for various applications with different polarization. Rectangular, square, circular and meander shaped antennas are compared. Operating frequency for meander antenna is at 2.4GHz. For antenna design FR4 substrate (Dielectric substrate = 4.4, Thickness = 1.6mm) and coax feed techniques are used. Results which are obtained for these techniques are [9] listed out in table. 1.

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Antenna	Return loss	VSWR
Circular	-10.85dB	1.8
Rectangular	-13.31dB	1.5
Square	-14.80dB	1.4
Meander antenna	-26.60dB	1.09

Table- I. Result of Return Loss and VSWR for Various Antennas

B. *PIFA antenna for medical application*

Bio implantable antennas are used to diagnosis the diseases. Main disadvantage of this antenna produces more side effects for human body. To overcome this drawback, PIFA antenna is used. It is also called as Linear Inverted F Antenna. It can be used for both short and long distance communication. Omni directional radiation pattern is produced by this antenna. PIFA antenna has some features such as,

- Small in size,
- Minimum radiation effects,
- Increased gain, efficiency and date rate.
- Low radiation effects
- Reduced backward radiation and power absorption

These are all the characteristics suitable to use this antenna in medical application. Load capacitance is used for impedance matching. Width of the antenna affects the resonant frequency [8]. Antenna parameters for PIFA antenna are mentioned in table. 2.

Return loss	-36.45dB
Bandwidth	64 MHz
Peak gain	1.5dB
VSWR	2

Table- II. Results of PIFA Antenna in Medical Application

C. *Reconfigurable antennas for space and wireless application*

Based on the environment electrical and geometry property of an antenna is modified to produce the reconfigurable antenna. These types of antenna can be used for various applications such as cognitive radio, satellite communication, MIMO and space applications. By modifying the properties such as frequency, pattern, polarization and radiating elements antenna reconfigurability is achieved. There are four types of reconfigurable antennas are used. Electrical changes done with help of MEMS switches, PIN diode switches, varactor diode which will change electrical properties of an antenna. Optical reconfiguration is provided by photoconductive material. Radiation properties are then changed by type of material which is used for an antenna and physical structure of reconfigurable antenna. Four reconfiguration techniques are there such as polarization, pattern, frequency and frequency reconfigurable antenna with polarization diversity. In future intelligent antenna can be developed to learn and adopt depends upon the environment changes in the networks. It will be useful for cognitive radio and various wireless communications especially for emergency applications [2].

D. *MEMS reconfigurable antenna for public safety radios*

Volumetric PIFA antenna is used in cognitive public safety radios. MEMS switches are used to achieve frequency reconfiguration. It is operated in two modes. Mode 1 is at active state when two switches are ON state. When two switches in OFF state then mode 2 will be active. This antenna is operated at a frequency of 700MHz and (800-900) MHz. biasing circuits are used to switch over the frequency. Coax feed and quartz dielectric materials are used for an antenna design. Dielectric constant of quartz substrate is 3.9. Increase in usage of MEMS switches will increase the fabrication complexity. It is mainly used by police, fire fighters and also for emergency operation. PIFA achieves 22% of bandwidth at 700 MHz and 17% of bandwidth at 850 MHz for mode 1 and mode 2 respectively [1].

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E. *A survey of reconfigurable microstrip patch antenna*

Different reconfigurable antennas are analysed in this survey. Antenna properties such as frequency, gain, directivity, bandwidth, radiation pattern etc are modified based on shapes, material, slots, and dimensions of the antenna.

Pattern reconfigurable antennas are used for satellite, radar and security communications. Pattern reconfigurability can also achieve with MEMS switches.

MIMO concept is used in reconfigurable patch antenna. Multiple of input and multiple of output provide increased link capacity and high gain.

Staked coupling of two circular shaped reconfigurable antennas is used to improve gain and efficiency of an antenna. It will produce circular polarization [5].

F. *Reconfigurable rotatable antenna for cognitive radio*

UWB and narrow band antennas are used for the purpose of sensing and reconfiguration respectively. Frequency reconfiguration is done by rotating the patch antenna. Rotation motion is controlled by stepper motor. Stepper motor is controlled by LABVIEW which is on the computer. Parallel port of computer is connected to NPN Darlington array which drives the stepper motor. Roger substrate and coax feed design is used. Dielectric constant of roger substrate is 2.2 and thickness is of 1.6mm. At different rotating position resonant frequency of antenna varies which helps to operate the antenna at different frequency. Sensing antenna covers the frequency from 2GHz to 10GHz [10].

G. *Square spiral antenna with pattern reconfiguration*

Two MEMS switches are used for radiation pattern reconfiguration. Square spiral patch antenna is used for this technique. Minor modifications made to the switch to reduce an impedance mismatch. Coax feed technique is used for the antenna design. Roger substrate with dielectric constant of 2.2 is used. To operate MEMS switches to reconfigure the pattern of an antenna 90V supply is given to gate and source of the MEMS. Switch is considered as closed circuit when high impedance is connected to switch. When it is connected to highly reflective load, switch is considered as open circuit. When switch 1 is in ON state antenna will produce End-Fire radiation pattern. If switch 2 is in ON state broadside radiation pattern will be produced. In future switches and antennas together fabricated in same substrate which will reduce the impedance mismatch [3].

H. *Multi frequency reconfigurable patch antenna for wireless communication*

Rectangular microstrip patch antenna is analysed by employing different feeding techniques. It is operated with multi band of frequency 1.9 GHz & 2 GHz. For antenna design, low dielectric materials produce high radiation efficiency but large size and maximized bandwidth. To use the small sized antenna high dielectric materials should be used. Circular polarization is obtained from this antenna design. Polarization is depends on three parameters,

- Axial ratio
- Tilt angle
- Rotation

Axial ratio is zero for linear polarization and it is unity for circular polarization. Circular polarization is provided here by two techniques such as, dual feed patch and single feed patch. Multi frequency reconfigurable microstrip patch antenna can operate in 2G and 3G simultaneously [6].

I. *Frequency reconfigurable patch antenna for cognitive radio*

E-shaped patch antenna is employed with MEMS switches to operate it in different frequency. Particle swarm optimization and nature inspired optimization techniques are involved in this design. It is used to sense the spectrum. Biasing circuits are employed with this antenna to operate switches. Here capacitor is used for open circuit and resistor is for closed circuit. Operating frequency of this antenna is from (2-3.2) GHz. it covers (2-2.6) GHz for OFF state and (2.6-3.2) GHz for ON state. It produces the return loss up to -40dB for OFF state of an antenna and -35dB when switches in ON state. For antenna design coax feed and substrate is used. Ideal switch and MEMS switch results are compared together in this paper. MEMS switches provide better frequency reconfiguration results than ideal switches. Ideal switches provide -25dB return loss for ON state and -30dB for OFF state. Dimension of the slot varies with help of switches which will operate the antenna in different resonant frequency. It provides better suitability for cognitive radio communication [4].

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J. *SATCOM antenna for military aircraft application*

Navy aircraft should have high profile and high data rate. PARCA SDR technology is applied to SATCOM antennas which are to provide quick reconfigurability and to track the satellites from ground vehicles. PARCA antennas have some important features which are suitable to use this antenna for navy and military applications [7]. Benefits of SATCOM antennas with PARCA SDR technology is described in table. 3.

Features	Benefits to navy
Frequency reconfiguration	Enhanced effective mission
Aperture	Simplified design with reduced parts
Electric steerable	Increased performance
conformal	Less aerodynamic drag

Table- III. Features and Their Benefits of PARCA SDR Technology

III. COMPARATIVE ANALYSIS VARIOUS RECONFIGURABLE ANTENNA

In table.4 Literature review papers, technology used for different reconfigurable antennas, applications and explanations are listed out.

Paper Name	Technology used	Antennas	Application	Remarks
A Meander Antenna with Reconfigurable Polarization for Wireless Communication [9]	Polarization reconfiguration	Meander antenna	Wireless communication	A antenna can be used at different polarization and for various applications.
Design of PIFA Antenna for Medical Applications [8]	Bio-implantation technique with PIFA antenna	PIFA antenna	Medical application	Reduced radiation effects with small size antenna which is suitable in medical and Nanotechnology applications.
MEMS Integrated Reconfigurable Antenna For Cognitive Public Safety Radios [1]	Frequency reconfiguration using MEMS switches	PIFA antenna	Emergency applications	Single antenna can be operated with different frequency at the same time. It needs biasing circuits to reconfigure the frequency.
MEMS Reconfigurable Optimized E-Shaped Patch Antenna Design for Cognitive Radio [4]		E-shaped antenna	Cognitive radio communication	
Low Cost Conformal Transmit/Receive SATCOM Antenna for Military Patrol Aircraft [7]	Frequency reconfiguration	SATCOM antenna with PARCA technology	Satellite, space, navy and military application	
Reconfigurable Antennas for Wireless and Space	(1) Frequency reconfiguration	Rotatable antenna	Cognitive radio	

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Applications [2]	(2) Pattern reconfiguration	Pattern diversity array antenna	MIMO	
	(3) polarization reconfiguration	Deployable antenna	Satellite application	
Implementation of a Cognitive Radio Front-End Using Rotatable Controlled Reconfigurable Antennas [10]	Frequency reconfiguration technique which is achieved by rotating the patch. Stepper motor is used to rotate the patch. LABVIEW software is used to control the patch rotation.	Rotatable antenna	Cognitive radio	Many users can simultaneously access the single channel at different frequency without using biasing circuits for reconfiguration.
Integration of Packaged RF MEMS Switches With Radiation Pattern Reconfigurable Square Spiral Microstrip Antennas [3]	Radiation pattern reconfiguration using MEMS switches	Square spiral antenna	Used to provide secure communication.	MEMS switches are used here to modify the radiation pattern from End-Fire to broadside or vice versa which is used for secure wireless communication.
Design of a Reconfigurable, Multi-Frequency & Circularly Polarized Microstrip Patch Antenna [6]	Multi-frequency and circular polarization	Rectangular patch antenna	Wireless communication	Since it is a multi-frequency antenna it can be used to access the spectrum simultaneously.

Table- IV. Comparative Studies of Different Reconfigurable Antennas

IV. CONCLUSION AND FUTURE WORK

Different reconfigurable antennas are used in various wireless applications such as cognitive radio, space, satellite communication, mobile radio and medical applications etc. Here different reconfiguration techniques are studied and comparatively explained different antennas for different applications. Reconfigurable antennas are more efficient than all other antenna techniques because single antenna can be operated with different modes. It is suitable for single antenna with multi-use applications or users to use simultaneously. It provides more efficient communication with minimum cost and fewer complexities.

REFERENCES

1. Khoshniat, H. Mopidevi, Y. Damgaci, D. Rodrigo, L. Jofre , B. A. Cetiner, “MEMS Integrated Reconfigurable Antenna For Cognitive Public Safety Radios” was supported by Award No. 2007-IJ-CXK025 and Award No. 2009-SQ-B9-K005 awarded by the National Institute of Justice, Office of Justice Programs, US Department of Justice.
2. By Christos G. Christodoulou, Youssef Tawk, Steven A. Lane, Scott R. Erwin, “Reconfigurable Antennas for Wireless and Space Applications” Manuscript received August 10, 2011; revised December 1, 2011; accepted January 29, 2012. Date of publication April 5, 2012; date of current version, June 14, 2012.

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3. Greg H. Huff, Jennifer T. Bernhard, "Integration of Packaged RF MEMS Switches With Radiation Pattern Reconfigurable Square Spiral Microstrip Antennas," IEEE transactions on antennas and propagation, vol. 54, no. 2, February 2006.
4. Harish Rajagopalan,Joshua M. Kovitz, ,Yahya Rahmat-Samii, "MEMS Reconfigurable Optimized E-Shaped Patch Antenna Design for Cognitive Radio" IEEE Transactions On Antennas And Propagation, Vol. 62, No. 3, March 2014.
5. J.Janetstephy, A.Anusuya, "Survey on Optimization of Reconfigurable MicoStrip Antenna," International Journal of Engineering Trends and Technology (IJETT) – Volume17 Number7–Nov2014.
6. Mrigendra Pratap Singh, Shivraj Singh, "Design of a Reconfigurable, Multi-Frequency & Circularly Polarized Microstrip Patch Antenna," IJRET: International Journal of Research in Engineering and Technology eISSN: 2319-1163 | pISSN: 2321-7308.
7. Mr. Steve Gemeny, "Low Cost Conformal Transmit/Receive SATCOM Antenna for Military Patrol Aircraft", *Syntonics LLC Page 1 of 5*
8. S.Shaheen, S.Dharanya, V.Divya, A.Umamakeswari "Design of PIFA Antenna for Medical Applications", International Journal of Engineering and Technology (IJET) ,ISSN : 0975-4024, Vol 5, No 1, Feb-Mar 2013.
9. Shradha C. Tilekar, Rekha Kadam, "A Meander Antenna with Reconfigurable Polarization for Wireless Communication," international journal of science and research (IJSR) issn (online): 2319-7064 index copernicus value (2013): 6.14 | impact factor (2013): 4.438.
10. Y. Tawk, J. Costantine, K. Avery, and C. G. Christodoulou, "Implementation of a Cognitive Radio Front-End Using Rotatable Controlled Reconfigurable Antennas," IEEE Transactions On Antennas And Propagation, Vol. 59, No. 5, May 2011.

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