

# **Study of Different Reconfiguration Techniques in patch antenna for Cognitive Radio Application**

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**ABSTRACT:** This survey is based on the analysis of different techniques used in reconfigurable antennas for cognitive radio application. Main problem in cognitive radio networks is to utilize the spectrum of unused band effectively. These unused spectrums can be utilized in proper manner by reconfigurable antennas. There are three types reconfiguration techniques are used such as frequency, pattern and polarization. Out of three reconfiguration techniques here frequency reconfiguration is involved. Frequency reconfiguration is achieved with help of ideal switches, pin diode switches, MEMS switches or rotatable antennas. Biasing circuits or algorithms are used in frequency reconfigurable antennas to switch over the frequency from one to another. Different frequency reconfigurable antennas and techniques are discussed in detail.

**KEYWORDS:** Reconfigurable antenna, Cognitive Radio Networks, Switches, Rotatable antennas, Spectrum efficiency

## **I. INTRODUCTION**

Currently reconfigurable antennas are used for wireless applications especially for cognitive radio networks. Reconfigurable antennas are subdivided into three types for instance First type is frequency reconfiguration. The radiation patterns of these antennas remain unaffected when the frequencies are tuned from one band to another. PIN diode, MEMS switches and rotatable antennas are used to achieve this reconfiguration. MEMS switches are needs biasing circuits, resistor is for short circuit and capacitor is for open circuit. Reconfigurable antenna is used to attain efficient spectrum utilization. Rotatable antennas don't require biasing circuits, rotating motion of antenna will operate that antenna in different band of frequency. Rotating motion can be controlled with stepper motor or FPGA. These different kinds of reconfiguration techniques are explained in detail. The second type is radiation pattern reconfiguration. Frequency band is unchanged whereas the radiation pattern change depends on the system needs. The third one is polarization reconfiguration. Signal reception is enhanced in multipath fading environment. Piezoelectric transducer (PET) is used to switch over the polarization.

## **II. RELATED WORK**

Enhancing the performance of radio communication systems by the effective utilization of radio spectrum, reconfigurable wideband patch antenna is used. Double c- slot patch antenna is used as reconfigurable antenna for cognitive radio communication. It is operated at 5, 6, 7 GHz. Frequency tuning is done by switching ON and OFF two patches. Two pin diode switches and two chip capacitor is used. Double C slot shape is employed to induce multiple

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resonances at different frequencies. Two switches were attached to the feed of each patch. Two dc block chip capacitor is used with 10pF [9].

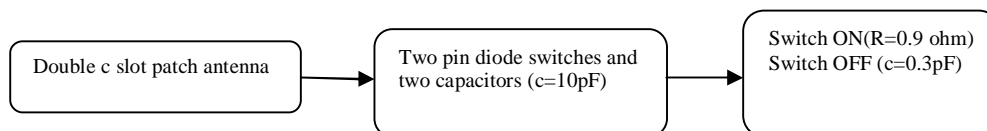


Fig. 2.1 Operations of PIN diode reconfigurable antenna

Biasing circuits are used to control the toggling process resistor is used for ON state and capacitor is for OFF state. Switching operation varies the patch dimension which in turn changes the modes of resonant frequency. FR4 substrate with microstrip line feed is used for antenna design. Fig 2.1 shows the operation of PIN diode reconfigurable antenna.

TABLE. I RESULTS FOR VARIOUS SWITCHING STATES OF ANTENNA

Switch 1	Switch 2	Frequency	Impedance bandwidth
ON	OFF	(5-5.7) GHz	4.2 and 2.4 %
OFF	ON	5.6 and 6.2 GHz	5.2 and 4.85 %
ON	ON	(4.9-7) GHz	33.52 %

Table 1. shows the results of reconfigurable antenna while it is switched from ON to OFF or vice versa.

Trapezoidal shaped monopole antenna is designed at a frequency of (2.4, 3.5, and 5) GHz. Rectangular slot with inspired split ring resonator is used to achieve dual resonance. It has negative permeability. Antenna is tuned between WLAN & WiMAX with single PIN diode. For antenna design FR4 substrate with 1.6mm thickness and dielectric constant of 4.4 is used. One more c slot SRR is introduced with common loop for both slits. Ring will introduce solenoidal current with time varying magnetic field. Gaps in the ring enhance the performance of the SRR. If inner is closed magnetic response will decay. If outer is closed then SRR will lose its magnetic property and it will not exhibit negative permeability. Gap is closed by PIN diode switches and it is placed at the outer ring [8]. Fig 2.2 shows the overall set up for metamaterial reconfigurable antenna.

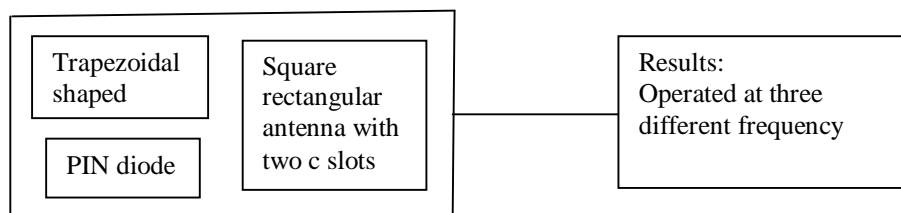


Fig.2.2 Metamaterial reconfigurable antenna

PSO and FDTD algorithms are combined together and implemented in rectangular patch antenna and E-shaped patch antenna to verify the results from these two antennas. These techniques are mainly used to reduce the computational time. EO (Evolutionary optimization) methodology is used in patch antenna to reduce the computational time in wireless applications. (GA)Generic Algorithm can also be used. PSO/FDTD algorithm is similar to bees searching for food. This algorithm is used to find the finest space for users in wireless communication. For this

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algorithm PSO kernel is used. Particle swarm, iterations, particle position are allocated at random. Personal best is the location where the particle attains its best fitness value. Global best is the best fitness value conquered by any particle. Fitness values are recorded by RPC scheme generator. Non repetitive position is reorganized each time. Repeated position is assigned directly from the previous iteration value. This technique is implemented in rectangular and E-shaped patch antenna to verify the performances of the antenna with these algorithms.

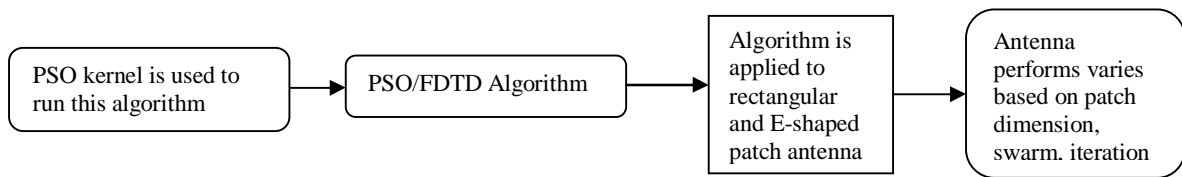


Fig. 2.3 Operation of multiband antenna with PSO/FDTD algorithm

PSO/ FDTD algorithm is implemented in rectangular patch antenna, E-shaped patch antenna and tested its performance as shown in fig2.3. Selection of particle number and maximum iteration depends on the dimension of the solution space and fitness function. When Slot dimension varies then patch width and bandwidth of the antenna is also varied which operates the antenna at multi resonant frequency. Broad bandwidth and reduced computational time is achieved further by employing this algorithm with pipelining operation in various applications [4]. Table 2 Shows the performances of two different antennas.

TABLE. II RESULTS ANALYSIS OF E-SHAPED PATCH ANTENNA

Design	Frequency	Return loss	Bandwidth
Antenna 1	1.8 GHz	-18.5dB	110MHz
Antenna 2	2.4 GHz	-19.4dB	270MHz

A MEMS switch is used to change the slot dimension to operate the antenna in dual resonant frequency. Biasing circuits are used to control the switches to ON and OFF state. DC voltage is applied to the biasing circuits to operate MEMS switch, -90V and 0V is applied to gate of the MEMS switch to ON and OFF the switch. Switching operation is done with help of Particle swarm optimization and nature inspired optimization techniques. Here E-shaped patch antenna is used. Coax feed and roger substrate is used for antenna design. Operating frequency range of this antenna is from (2-3.2) GHz [3].

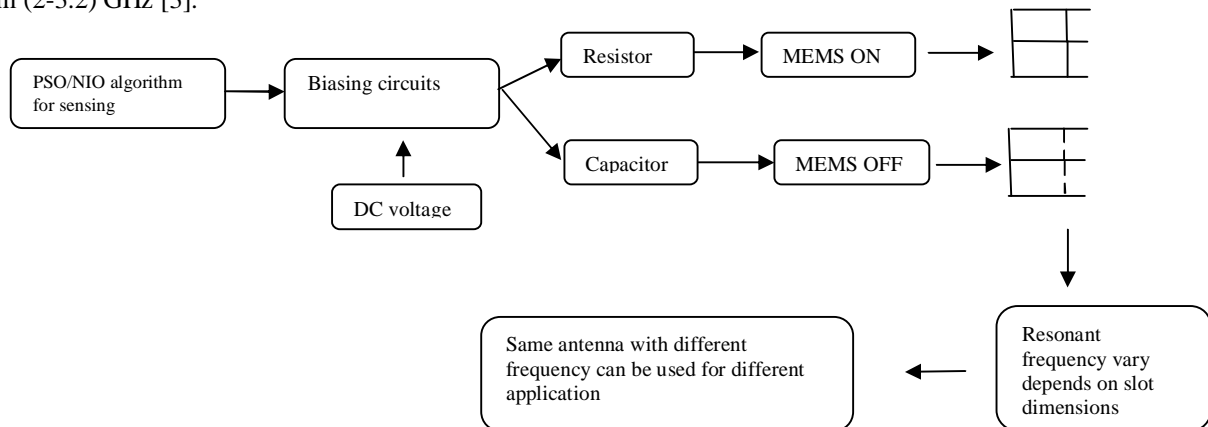


Fig. 2.4 Pictorial representation of MEMS reconfigurable antenna operation

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When switch is in ON state resistor is connected in parallel and it covers the frequency of (2-2.6) GHz. at this stage biasing circuits considered as short circuit and it provide -25dB return loss. When switch is in OFF state, biasing circuit will be in open circuit. Capacitor is connected in parallel and it covers frequency of (2.6-3.2) GHz

A single patch is connected to CPW ground plane with help of strips. Shunt inductance or series capacitance are used to control the mode of operation. It is operated in two modes. Operating frequency is about 1.7GHz and 5.3GHz. It is suitable for modern wireless applications due to its reduced size with good radiation pattern. When strip thickness increases resonant frequency will reduce which in turn induce the inductance. It will maintain the CRLH approach. FR4 substrate and coax feed is used as antenna design [1]. Table. 3 show the performances of antenna at two different modes.

TABLE. III ANTENNA PARAMETERS AT VARIOUS MODES

Parameters	Mode 1	Mode 2
Frequency	1.7 GHz	5.3 GHz
Bandwidth	5.3%	17%
Radiation pattern	Dipole	Monopole
Cross polarization	-60dB	-40dB

Reconfigurable patch antenna is designed for cognitive radio communication to utilize the spectrum in effective manner. Reconfiguration is attained by rotating motion of antenna. The reconfigurability is also achieved by using dynamic switches. Two types of antennae are used here. UWB for channel sensing and Triangular shaped antenna for reconfiguration. Sensing antenna and narrow band antenna are integrated into the same substrate. Reconfigurable antenna consists of two layers. Slots included in top layer of polygon-shaped patch. Partial ground is given to bottom layer. Reconfiguration is achieved via rotating the antenna by 180 degree. The rotation will generate different resonances, which is used to communicate at certain frequency by sensing antenna. Roger substrate with microstrip line feed is used in antenna design. UWB antenna covers the frequency from 3GHz to 11 GHz. Narrow band antenna covers (5.15-5.35) GHz. It achieves Omni directional radiation pattern. [10].

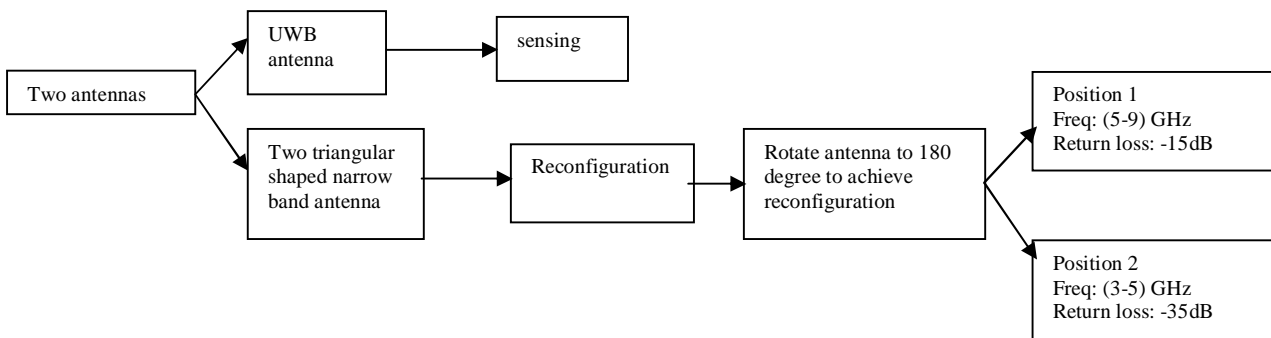


Fig. 2.5 operation of rotatable antenna

Reconfigurable antenna covers (3-5) GHz at position 2 and (5-9) GHz at position 1. It produce return loss of less than -15dB in position 1 and less than -35dB in position 2 as shown in fig2.5. UWB antenna produce return loss of -30dB both in position one and two. For upcoming work, rotating motion of reconfigurable communicating antenna can be controlled via a field programmable gate array (FPGA). Design a sensing antenna to cover up a superior bandwidth from 700 MHz to 11 GHz [10]. It is mainly used for the applications of RADAR, space and remote sensing. With help of SAR high reconfigurable radiation pattern can be achieved both in elevation and azimuth axis. It achieves high directivity but minimum sensitivity if the T/R module failure. SAR has pattern profile behaviour. Array factor of normal array antenna and phased array antenna are compared and the results of gain, directivity, efficiency for these antennas are obtained. While comparing the parameters transmission line, mutual coupling, VSWR, insertion loss etc

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[5]. Fig 2.6 shows that Fourier transform is applied to array of an antenna. Fig 2.7 shows the operation involved in phased array antenna.

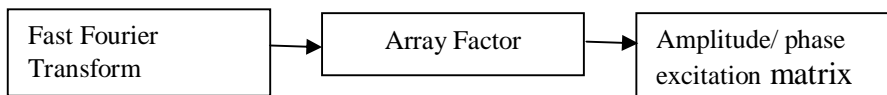


Fig.2.6 operations involved in phased array antenna

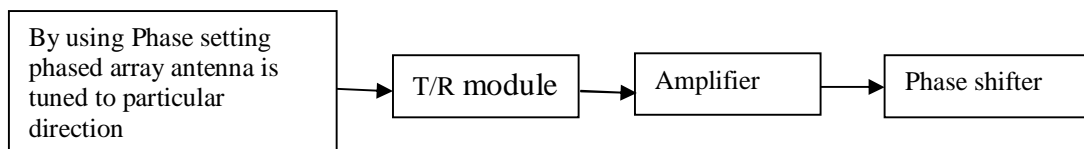


Fig.2.7 working of phased array antenna

To obtain minimal loss and maximum phase swing the reflectarray RF-MEMS reconfigurable antenna is used. Use of reflectarray coupled with MEMS switches; provide low power consumption, high linearity, low loss, and high isolation. By electronically operating the switch configurations, different phase shifts are obtained. The reconfigurable reflectarray with MEMS technology is used for static and dynamic distortion compensation. The length of the slot is changed dynamically by actuating the switches. When the patch length increases the loss and the slope of the phase swing will decrease. Radant MEMS SPST-RMSW100 electrostatic switches were used for reconfiguration. When a DC bias voltage is given between the gate and the source, an electrostatic force then turns on the switch. In future work distortion is reduced by increasing the phase swing with minimum cost [7].

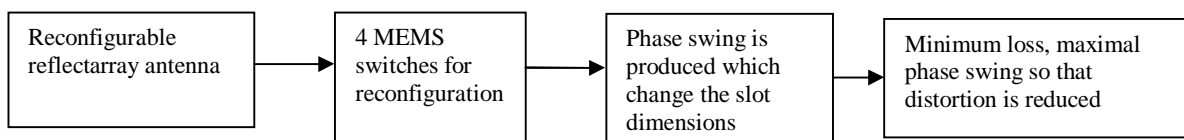


Fig. 2.8 Function of Reconfigurable reflectarray antenna

As shown in fig 2.8 for the phase of 325, 150, 280 return losses is obtained in the sequence of 3.5dB, 1.5dB, 0.4dB-1.5dB respectively [5]. Frequency reconfigurable E-shaped wide band antenna is designed to support the cognitive radio communication by utilizing the unused spectrum by frequency reconfiguration. Here particle swarm optimization algorithm is used. Frequency reconfiguration is achieved using ideal switches [6].

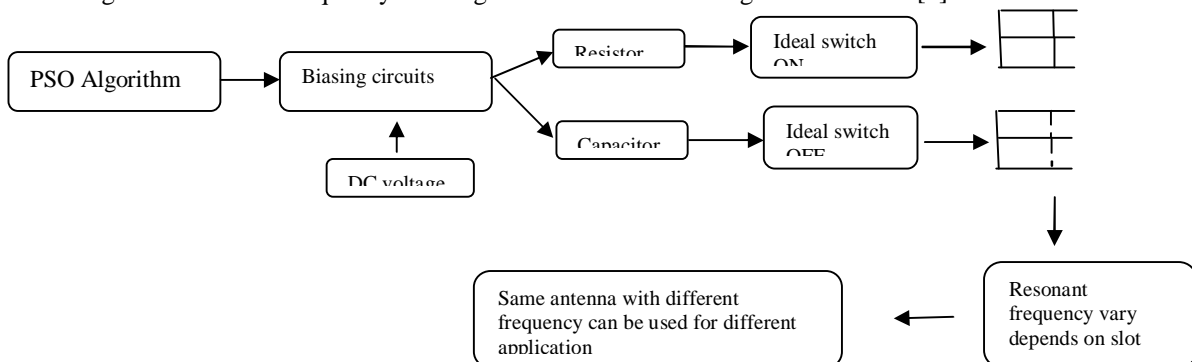


Fig. 2.9 working of reconfigurable antenna using ideal switches

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Fig 2.9 shows the active switches are used to achieve frequency reconfiguration by turning the switches ON and OFF which is used to operate the antenna for various applications

### III. COMPARATIVE ANALYSIS OF DIFFERENT ANTENNAS

Thus various types of antennas with different technologies employed for the antenna are discussed in detail. Table IV shows the consolidated comparative analysis.

TABLE. IV Comparative analysis reconfigurable antennas

Antennas	Remarks
MEMS reconfigurable antenna	To operate the antenna with different application by varying frequency with fast switching operation. [3]
PIN diode reconfigurable antenna	Compact and reliable switching operation. [9]
Reflectarray antenna	Maximum phase swing, reduced loss so that distortion is reduced. [7]
UWB antenna	Used as sensing antenna. [10]
Reconfigurable antenna	Used for adaptation and communication. [3][9]
Rotatable antenna	Biasing circuits are not needed for frequency reconfiguration [10]
Metamaterial antenna	It is used for miniaturize the antenna [8][1]
Phased array SAR	Quick radiation pattern reconfiguration [5]

### IV. CONCLUSION

To utilize the available bandwidth in cognitive radio spectrum different frequency reconfigurable antennas are used. Different frequency reconfiguration techniques are studied in this survey. Patch antenna is used here with different feeding techniques, designed with different substrates and techniques such as ideal switches, pin diode switches, MEMS switches, and rotatable antennas for frequency reconfiguration are studied and analysed. Main process in cognitive radio networks are sensing, analysis, reconfiguration and adaptation these process can be achieved with these antenna designs. Some of the antenna design is based on combination of sensing and reconfigurable antenna with same substrate which will perform cognition operation effectively. Thus these designs of reconfigurable microstrip patch antenna provide flexible and suitable communication for cognitive radio application. Still some analyses are going on to provide better cognitive radio communication with minimum cost and reduced fabrication complexities.

### REFERENCES

- [1] Ashish Gupta, Sameer Kumar Sharma, Raghvendra Kumar Chaudhary, "A Compact CPW-Fed Metamaterial antenna for WLAN/ Wi-Fi Applications," 2015
- [2] Anagnostou.D, Zheng.G, Chryssomallis.M, Lyke.J, Ponchak .G, Papapolymerou.J, and Christodoulou.C, "Design, fabrication and measurements of an RFMEMS based self-similar reconfigurable antenna," *IEEE Trans. Antennas Propag*, vol. 54, no. 2, pp. 422–432, Feb. 2006.
- [3] Harish Rajagopalan, Joshua M. Kovitz, Yahya Rahmat-Samii, "MEMS Reconfigurable Optimized E-Shaped Patch Antenna Design", *IEEE Transactions on Antennas and Propagation*, Vol. 62, No. 3, March 2014.
- [4] Jin.Y and Rahmat-Samii.Y, "Parallel particle swarm optimization and finite-difference time-domain (PSO/FDTD) algorithm for multiband and wide-band patch antenna designs," *IEEE Trans. Antennas Propag.*, vol. 53, no. 11, pp. 3459–3468, Nov. 2005.
- [5] Luigi Cereoli, Andrea Torre, "The Role of Performance Modelling in Active Phased Array SAR," 2007 IEEE.
- [6] Rajagopalan.H, Kovitz.J.M, and Rahmat-Samii.Y, "Frequency reconfigurable wideband E-shaped patch antenna: Design, optimization, and measurements," in *Proc. IEEE Antennas Propag. Soc. Int. Symp.(APSURSI)*, Jul. 8–14, 2012, pp. 1–2.
- [7] Rajagopalan.H, Rahmat-Samii.Y, and Imbriale.M, "RF MEMS Actuated reconfigurable reflectarray patch-slot element," *IEEE Trans. Antennas Propag.*, vol. 56, no. 12, pp. 3689–3699, Dec. 2008.



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- [8] Rajeshkumar V., Raghavan S., "A compact metamaterial inspired triple band antenna for reconfigurable WLAN/WiMAX applications," *Int. J. Electron. Commun. (AEÜ)* 69 (2015) 274–280
- [9] Tarboush.H, Khan, Nilavalan.R, Al-Raweshidy.H, and Budimir.D, "Reconfigurable wideband patch antenna for cognitive radio," in *Proc. Loughborough Antennas Propag. Conf.*, Nov. 2009, pp.141–144.
- [10] Tawk.Y and Christodoulou.C.G, "A new reconfigurable antenna design for cognitive radio," *IEEE Antennas Wireless Propag. Lett.*, vol.8, pp. 1378–1381, 2009.