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Optical Reconfigurable Microstrip Patch Antennae for Wideband Applications: A Review

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ABSTRACT

This paper provides a complete understanding of reconfigurable microstrip patch antennae by using optical switches from literature. Reconfigurable antennae cought users attention because it provides multiple functions to users for connecting to different types of services at a times by allowing spectrum reallocation and dynamic spectrum management. Eventually it offers numerous advantages like easy fabrication, less size and low cost . Number of designs has made so for to improve size, gain, switching speed and reconfigurability. This paper also provides comparison with other switches and give us reasons for shifting to optical switches. Reduction of power and area consumption has become important in in the world of modern wireless technology by developing different new design methodologies.

Keywords: Less interference, low power , OCMS switches, patch antenna, reconfigurability.

I. INTRODUCTION

Since the wireless communication comes in to the picture in the modern world there has been enormous growth in wireless communication. In this era whole of the world is completely dependent on wireless technology. Right from very starting it was not possible to carry out the long communication through wired technology then this problem overpowered by wireless technology. In today's era of telecommunication system, compact size and wide bandwidth antennas are opted. Because of this requirement Microstrip patch antenna comes in to the picture. Microstrip patch antenna construction is not only famous for its simplicity and small size but also popular for its ease of construction with printed circuit technology. Microstrip patch antennas are mostly used for microwave and radar application for communication purposes.

Microstrip patch antenna is exposed to being designed as sole element or part of array. Instead of lots of benefits they are failed to provide good efficiency and wide bandwidth. But in recent year's research, researchers made possible to use single antenna in numerous applications. Configuration request made for Switching from one application to another which is possible by changing the radiating properties of antenna and such antenna known as the reconfigurable antenna. Most important types of antennas which have changed the levels of antennas to great extent are micro strip antennas because they are very compatible and ease to design. They were very prevalant in the 1970s mostly because of its space tolerated applications. These days they are used for government and profitable applications. There have been three layers in micro strip patch Antennas, top most metallic patch, middle layer substrate and the bottom one is ground. The top most layer i.e. metallic patch can take many different configurations. Ease of examination and fabrication and alluring radiation characteristics made the rectangular and circular patches antennae the most popular. They are so compatible

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with MMIC technology when attached on inflexible surfaces and very multipurpose in terms of resonant frequency, polarization, pattern, and impedance. These kinds of micro strip antennas made designing comfortable, simple, low profile to fabricate using modern printed-circuit technology.

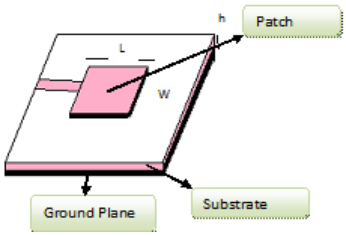

Fig 1. Microstrip antennas [1]

II. RECONFIGURABLE ANTENNAE

Reconfigurability means multiple functions at the single time and having the computing capability of system, so that its behaviour can be changed by reconfiguration. These kinds of antennas are not only capable of switching between different kinds of narrowband modes but they also provide operating characteristics through mechanical, electrical and other means. These reconfigurable antennas have been utilising for the best solution to use in the system where there is a need to switch from one application to another. Reconfiguration is achieved while working on Microstrip Patch antennas. So it is important to understand the basic structure of Microstrip patch antenna, its feeding technique and method of analysis before studying reconfigurable antennas. S. Shoukat et al. [2] proposed a Frequency Reconfigurable Patch Antenna for dual Band Global System for Mobile communication and Wi-Fi Applications in which the centre metallic patch enclosed by two metallic rings is used with ideal optical switches. Design uses Rogers RT duroid. This paper demonstrates that by changing the state of switches antenna could able to radiate at different frequency. Proposed antenna provides optimum directivity of 7.8 dBi and efficiency of 48% to 93 % in two frequency bands which are used in Wi-Fi and Global System and Mobile applications.

III. OPTICAL RECONFIGURABLE MICROSTRIP PATCH ANTENNAE

New term “optical” is added to reconfigurable antenna, which actually the further research work of the researchers to use alternate switches instead of PIN and MEMS switches? Due to some disadvantages they are overpowered by the Optical Control Microwave Switches. As we have discussed latter that PIN and Micro Electromechanical switches requires biasing metallic biasing line which are having the maximum probability of interference with radiation patterns. On the other side if we talk about OCMS by using fiber optic cables for activation of optical switches. These are having advantages like they are electromagnetically apparent and so do not interfere with the radiation properties of the antenna. With all these good sides antenna and control circuitry get thermal and electric isolation. Reconfigurable antenna uses MEMS, PIN and OCMS switches. MEMS and PIN switches have drawbacks of high power consumption as compared to OCMS Switches. When we use Optical switches then they exclude the need of metallic wires that may interfere with the antenna’s radiation properties. Electric isolation and thermal isolation achieved by these antennas between control circuitry.

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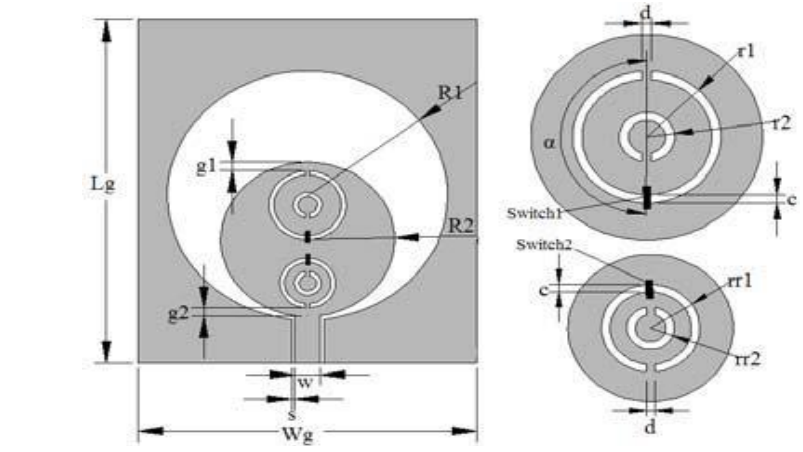
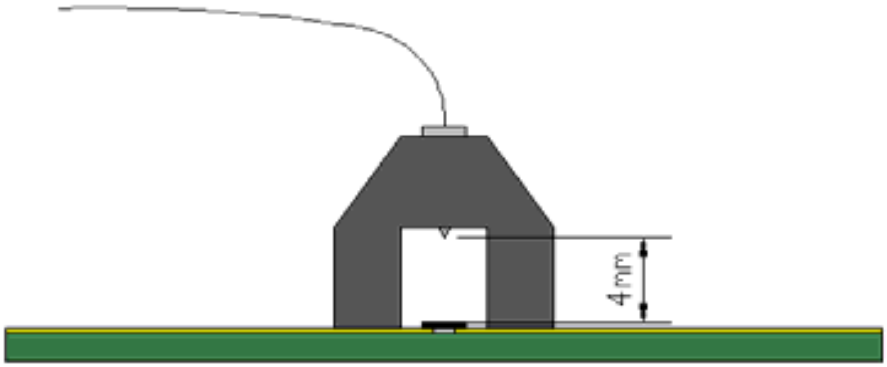
D. Zhao et al. [3] proposed the optically controlled reconfigurable antenna which is using microwave switches for configuration which require less than 100 mW optical powers to activate each Optical Control Microwave Switches. Two autonomous narrow-band CSRR (complementary split ring resonators) are used in design. Antenna fabrication was done on FR4 substrate with dielectric constant of 4.6. Designed antenna provides four reconfigurable UWB band-notched states and offers many attractive advantages like low optical power requirement and interference free optical control.



(a)



(b)

Fig 2 (a) proposed antenna; (b) fiber installation for the optical control of the proposed antenna [3]

S. Zheng et al. [4] proposed compact reconfigurable antenna had optical control circuitry. Design used four photoconductive optical switches. Proposed design was having two parts one is U shaped monopole Ultra-Wide Band antenna for spectrum detecting and other was an open-annulus for communication. Fire Retardant (FR4) substrate having dielectric constant of 4.4 was used for fabrication. Reconfiguration bands are achieved and provide good simulation results offering advantages like less electromagnetic effect on antenna radiation and high frequency transition speed improved. D. Zhao et al. [5] Presented a design for Microstrip patch antenna of reconfigurable beams which is optically controlled and had low power handling capabilities. Design comprises of one T-shape driven patch and one slot-etched parasitic patch. Photoconductive silicon switches has been used. Design was printed on FR-4 substrate. Design provides good simulation results and having the good performance in reconfigurable beams forming, feed impedance matching and low optical power requirement which is less than 30 mW.

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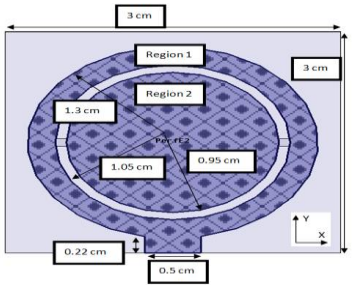
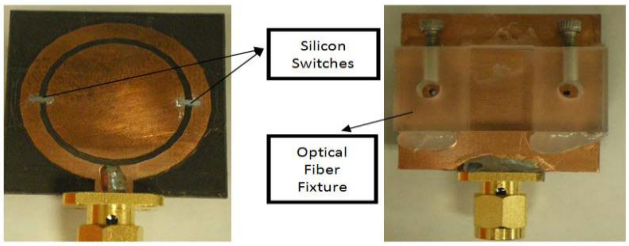
Y.Tawk et al. [6] presented a design of reconfigurable antenna using optical switches. Design is having the new approach for coupling the light energy from LASER in to an optically reconfgurable antenna with the use of semiconductor switches. Design chooses substrate of Rogers Duroid with dielectric constant of 2.2. Two transition was used one was CPW and other was stripline for feeding. Design used less optical power and provides frequency bands corresponding to conventional wireless standard such as Global System for Mobile Communication, Code Division Multiple Access and Wi-MAX etc.



`(a)



(b) (c)

Fig. 3 (a) The stripline fed structure of antenna (b) The top view of antenna prototype (c) The antenna prototype in bottom view [6]

Y. Tawk, S. Hemmady et al. [7] presents reconfigurable antenna based on optical pumping for cognitive radio communication. Design includes two structures one is Ultra-Wide Band structure for channel sensing and other was reconfigurable construction for communication. Reconfigurability was achieved by mixing laser diodes with in the substrate for activating photoconductive switches. Design provides good simulation results and coupling of less than -20 dB is attained for the sensing antenna's whole band.

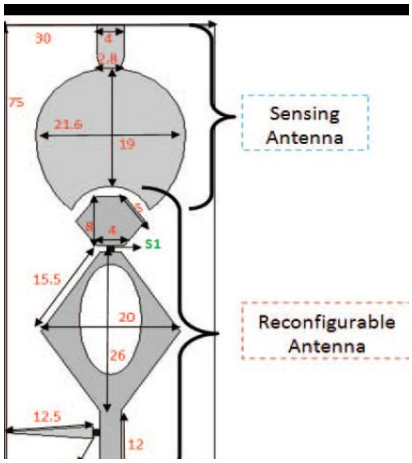


Fig 4. The proposed cognitive radio antenna structure [7]

S. Venkatesh et al. [8] proposed a design of an electromagnetic metamaterial patch antenna for cognitive radio application. Design includes uses of CSRR (complementary split ring resonator) between the patch and ground plane. This was having E-shaped patch geometry for wideband characteristics. Rogers/RT Duroid 5880 had used in design with dielectric constant of 2.2 and thickness of 1.574 mm. Wide bandwidth was attained for proposed patch design and having very low reflection coefficient and 2.0 GHz to 5 GHz frequency bands are achieved.

C. J. Panagamuwa et al. [9] Optically controlled reconfigurable printed dipole antenna has been presented in this paper. For feeding two transitions was used one was wideband coplanar waveguide (CPW) and coplanar strip line (CPS). Design uses two silicon switches and printed on TLY-5 substrate with thickness of 1.17-mm and having dielectric constant of 2.2 and having no ground which allows antenna to radiate on both side. Design was successfully tested which provides high match and gain of 3.1dBi and provides switching from 2.26 GHz to 2.7GHz to 3.15 GHz

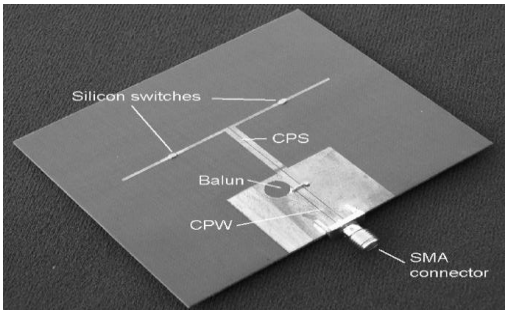


Fig. 5. Photograph of the switched dipole antenna [9]

N. Anvesh Kumar et al. [10] proposed the design of wide and narrow band antennas having three ports radiating structure for cognitive radio application. UWB antenna connected to first port used for spectrum detecting and other two narrow band used for wireless communication. Design printed on Fire Retardant (FR-4) substrate and this antenna covers their own respective spectrum providing good return loss and isolation.

D. Patron et al. [11] different methods have been discussed for reconfigurable antennas with optical control using some commercially available devices. P-i-n photodetector based switching and other was phototransistor controlled switching had investigated in proposed antenna. Design fabricated on Fire Retardant (FR-4) substrate and simulated on Ansoft HFSS software. Overall design was successful at a comparatively low cost and reasonable optical power which was motivation for further generation of cognitive radios. R. K. Saraswat et al. [12] proposed the design of patch antenna having octagonal shape and L-shaped slotted ground for attaining reconfigurability. Antenna switched at five unlike states including Ultra-Wide Band, two narrowband and dual band states with p-i-n diodes as a switching element. Antenna was printed on a Rogers RT duroid 5880 substrate with dielectric constant of 2.2 and thickness 0.40 mm. proposed antenna uses two frequency selective surface designs for improving the gain by about 4 dB-5 dB proposed antenna intended to use in multi-radio and cognitive radio wireless applications.

D. Patron et al. [13] proposed the method for controlling the pattern-reconfigurable planar antenna by using optical control with PIN photodetectors and photo transistor based switching. Antenna is fabricated on FR-4 substrate with two top and bottom layers made of four couples of 90* micro strip elements disposed

symmetrical on two layers. Design has shown good simulation results generating four directional patterns or single omnidirectional around the azimuth plane showing better impedance matching.

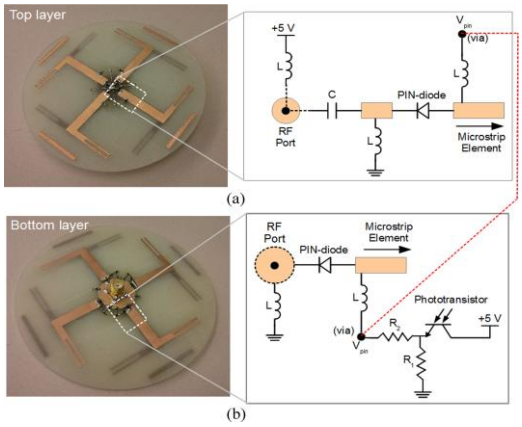


Fig. 6 optical switching circuitry for a pair of symmetric elements. (a) Top biasing circuitry. (b) Bottom optical and biasing circuitry. The voltage and current activated by the phototransistor.

S. Jhon et al. [14] proposed a frequency reconfigurable monopole antenna with switchable symmetric slot structure. Design antenna operating at single and dual band modes. Antenna is constructed on FR-4 substrate with relative permittivity of 4.4. Antenna supports frequency bands above 2 GHz. Slot structure helps to gain reconfigurability when this was placed on ground plane. Antenna design is intended to use for multi-radio applications. A. H. Ramadan et al. [15] proposed the design for wireless applications having low cost multiband reconfigurable U-Kotch Microstrip antenna. Proposed antenna having U- slotted rectangular patch. Proposed antenna was simulated for three different switching cases with Finite Element Method. Antenna is printed on FR-4 substrate and having low cost and easy to fabricate. Simulation results were quite satisfactory. C.Yu et al. [16] proposed a compact nine-band frequency reconfigurable antenna for Long Term Evolution/WAN/Wide Local Area Network handset applications. Inverted L-shaped monopole and two coupled-fed strips shorted to the ground plane which was directly fed to excite the high frequency band. PIN diode was used as switching. Antenna was printed on Fire Retardant (FR-4) substrate. Design shows good simulation results attaining nine operating bands with 6dB return Loss. M. Arora et al. [17] worked for Wideband application of Frequency Reconfigurable Antenna. Antenna Structure is of octagon shaped having eight rectangular slots. Design is fabricated on Rogers RT duroid with dielectric constant of 2.2 and thickness 0.0787. By changing the path of the current and current distribution of the surface using switch give reconfigurability and antenna resonates at 9 GHz with maximum return loss of -39.7774 db also resonating at different frequencies with good return loss.

L.G. Silva et all [18] “Optically Controlled Reconfigurable Filtenna” worked in regarding of optically controlled filtenna, authors proposed integration of broadband printed antenna with a bandpass reconfigurable RF filter which is designed by applying defected microstrip Structure. DMS technique is applied due to the size limitation. It is also applicable to amplifier harmonic suppression, microstrip size reduction and microstrip longitudinal size reduction.

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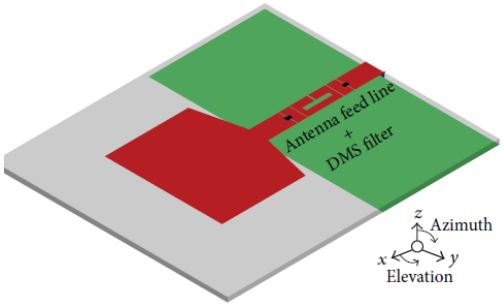

Fig.7 The Reconfigurable filtenna Concept

Discrete SMD capacitors were used for making the antenna bandwidth reconfigurable. Two silicon photo conductive switches was used to for ensuring bandwidth reconfigurability.

IV. CONCLUSION

Optical reconfigurable microstrip patch antennae have their numerous wide band application in diversified area like Wi-fi, Wi-Max, heatlh sector, wireless sensor networks and cognitive radio system. These kind of antennae possess quality to modify radiation characteristics, multiple frequency of operation in real time with low power consumption and fast switching speed. This paper provides a survey of various optical reconfigurable microstrip patch antennae with different optimization technique for switching, area and power consumption. It was attempt to provide quick survey regarding different optical reconfigurable antennae.

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