The measured bandwidth with the 3 dB axial ratio is 5.69 GHz to 5.87 GHz.

A reconfigurable multiband compact microstrip antenna has been presented[32]. The multiple frequency bands with 56% effective bandwidth have been achieved using the concentric metallic semicircles around a central semi-circular microstrip patch of the antenna and can increased the operating frequencies up to 75%. A Vivaldi antenna, which is having the capability of dynamically rejecting interference, has been reported in 2011[33]. The main objective of design was to allocate the dynamic frequencies which are useful for multi standard communication. This Vivaldi antenna was being operated from 2.5 to 8 GHz and suitable for vehicle to vehicle communication with a stop band from 1.8 to 5.8 GHz. The antenna shows better impedance matching at 2.5 GHz - 8 GHz with band rejection between 1.8 GHz - 5.8 GHz. So, antenna covers the important wireless standards such as WiFi, WLAN (802.11a), Bluetooth (802.15.1), WiMAX (802.16) etc. Finally, the absolute gains measured at 2.5 GHz, 5.5 GHz and 8 GHz are 5 dBi, 7.9 dBi and 11 dBi respectively.

In 2012, a new pixel slot antenna structure with frequency reconfiguration has been proposed for wireless communication[36]. In the antenna the various radiating structures are connected together with the help of canonical switched slot element. In order to generate various resonant frequencies to attain the higher degrees of freedom, the conventional slot or slot with a loop is used to resonate the pixel slot antenna. The 4-switch single-pixel slot have been used in antenna structure. The cover frequency range is 1.56 GHz to 3.30 GHz. A novel reconfigurable slot antenna with three switchable frequencies has been proposed[39]. The uniqueness of this design is that it allowed passing the various frequency bands by selecting states (ON/OFF) of and used 3-switches. The measured resonance bands of the antenna are 2.47, 3.60 and 5.70 GHz with the measured gain values 2.34, 3.16 and 2.91 dBi respectively.

All electrical switching techniques presented in this section have both advantages and disadvantages. In comparison of all the design, there is a shift in use from RF-MEMS to PIN-Diodes to achieve switching. While PIN or Schottky diodes require less biasing lines, the difficulties encountered with biasing RF-MEMS are not alleviated by the use of PIN or Schottky diodes. RF-MEMS switches are used because of their significance in frequency re-configurability.

1.3 Optical Switching based Reconfigurable Antenna

An optically controlled reconfigurable antenna has been proposed[37], which is used for integration of wideband and narrowband for Cognitive Radio (CR) applications. The four conductive silicon switches have been used to get the frequency reconfiguration. The ON and OFF position of switches is depend on light illumination. The switch behaves as short circuit when light beam fall on the switch and will be off when there is no beam of light. The structure of the inner antenna varied by combining different slender ring parts which are controlled by optical switch. The four reconfigurable frequency bands are obtained i.e. Band1: 5.8 GHz – 6.8 GHz, Band2: 6.7GHz – 7.3 GHz, Band3: 7.0 GHz – 8.4 GHz and Band4: 7.9 GHz – 9.2 GHz, those focus on the upper frequency sub-band to obtain the UWB application. The gain variation for UWB is 2.6 to 4.1 dBi and for narrowband is varies from -0.1 to 4.5 dBi at all achieved bands.

1.4 Physical Angular Alteration based Reconfigurable Antenna

The angular alteration or mechanical movement in the geometry of antenna can provide a vast frequency shifts as compared to electrical switching changes, but there is big challenge to design this kind of antenna that have actuation mechanism and also maintain the other characteristics with significant structural changes.

A novel antenna designed for CR Applications has been presented[35]. The antenna structure works on wideband (UWB) range with frequency reconfigurable characteristics. In this proposed system the UWB antenna is used to scans the frequency bands as a channel while the tuning section of reconfigurable system for communication to cover these bands. To acquire frequency agility, the patch antenna is rotated to cover the entire band i.e. 2 GHz - 10 GHz. It is also observed that the measured gain of the antenna is 6.2, 6.67, 7.4, 7.77 and 8.4 dB depending on different the shapes of antenna system.

An antenna system is having a rectangular patch with microstrip fed-line presented in 2017[35]. The ground plane structure of the antenna is separated in three sections, one is moving plane and others two are fixed. The two actuators are controlling the moving ground plane, that allow vertical movement and tilting position. The actuators controlling is based on pulse width modulation, which is governed by Arduino board.

Antenna system for cognitive radio has been proposed that has two antennas, one antenna is used for channel detecting and the second one is utilised for transfer of information[38]. A printed monopole antenna has been designed for sensing, which is having the position out of the plane of a reconfigurable antenna at some height below the surface of patch. In this system, a slit cut in the hardened wall supports the whole antenna system and the sensing antenna is positioned inside the slit. The sensing antenna's position provides a better isolation with the communicating antenna.

1.5 Reconfigurable Antenna Based on Material Change

The change in the material characteristics of the antenna design can make it possible for the antenna system to tune at the different frequency is possible for the antenna system. As we know, the relative permittivity and permeability of the ferroelectric material is changed by applying the static electric field and static magnetic field respectively. The variation in relative permittivity and permeability can change the effective electrical length of an antenna, which produces the operating frequency shift. If the relative permittivity and permeability are high as compared to commonly used substrate materials, then it is very useful to reduce the antenna size. The main drawbacks of using standard ferroelectric and ferrite bulk materials apart from any complexities resulting from the bias structure are their high conductivity about other substrates that can severely degrade the efficiency of the antenna.

In 2011, a reconfigurable structure based on smart materials has been presented[34]. It has seen that the proposed structure has the potential to realize the adaptive antennas for emerging communication devices. In this work, a reconfigurable axial mode helical antenna has been designed. The height of the antenna has been adjusted by an alloy spring actuator. The measured and simulated results have been compared for some helix height of the proposed antenna (60, 70, 80 mm). It is observed that good impedance matching has been shown from 4 GHz to 4.5 GHz for all sweep points of the conical helix. The conical helix with 6 turns has 18 mm maximum radius at the radius ratio of 0.55 and the variation in height is from 50 - 90 mm which ratifies the pertinent matching for a wideband of 3 GHz approximately. Accordingly, at 3 GHz the patterns of the conical helix for the cylindrical helix were shown by changing the height of the helix from 40 to 95 mm. Also, with the total fixed length of the helix wire, the gain has been obtained with from 10 -11.5 dB range and the HPBW is 65^0 to 50^0.

1- Conclusion

After performing in-depth literature survey mainly from 2005 to 2018, it has been observed that immense research has done on the reconfigurable antenna design and the various feeding methods. Various antenna designs have been offered and every design has its own advantage and disadvantage in terms of performance. It is found that antenna size and its bandwidths are average in almost every case. Literature survey shows that reconfigurable antenna with reduced size has been very rarely presented. In view of the above, study has been made by incorporating new designs of reconfigurable antenna geometry for lower frequencies which are suitable for wireless applications. In addition, the presentation highlights a design requirement to achieve the ability of an antenna with simultaneous and independently flexible reconfigurations of frequency, radiation patterns and polarization characteristics.

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