Microstrip Patch Antenna- A Historical Perspective of the Development

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Abstract

This paper presents a historical perspective of the development of microstrip antennas. A survey on microstip antenna papers is conducted to evaluate the evolution of the research activity on the topic since the last 40 years. The early years of the microstrip technology and microstrip antennas are analyzed. The fast evolution of the research and development activities that happened in the last 40 years is described in the context of the associated technologies and areas of application with present situation.

1. Introduction:

Microstrip antenna was first introduced in the 1950s. However, this concept had to wait for about 20 years to be realized after the development of the printed circuit board (PCB) technology in the 1970s. Since then, microstrip antennas are the most common types of antennas with wide range of applications due to their apparent advantages of light weight, low profile, low cost, planar configuration, easy of conformal, superior portability, suitable for array with the ease of fabrication and integration with microwave monolithic integrate circuits (MMICs).They have been widely engaged for the civilian and military applications such as radio-frequency identification (RFID), broadcast radio, mobile systems, global positioning system (GPS), television, multiple-input multiple-output (MIMO) systems, vehicle collision avoidance system, satellite communications, surveillance systems, direction founding, radar systems, remote sensing, missile guidance, and so on.

2. Microstrip Antenna:

Antenna is a transducer which transmits or receives electromagnetic waves. Microstrip antennas have several advantages over conventional microwave antenna and therefore are used in a variety of practical applications. Microstrip antenna in its simplest design is shown in Figure 1. It consists of a radiating patch on one side of dielectric substrate ($\epsilon_r \leq 10$), with a ground plane on other side.

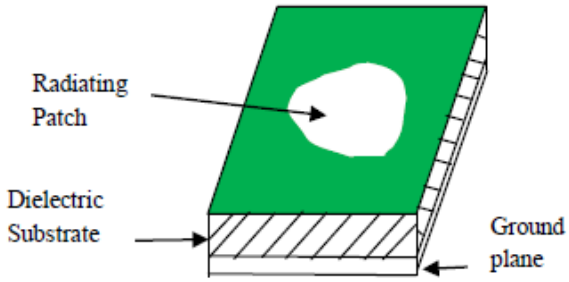

Figure 1: Microstrip antenna configuration

3. Microstrip patch antenna:

A microstrip patch antenna (MPA) consists of a conducting patch of any non-planar or planar geometry on one side of a dielectric substrate and a ground plane on other side. It is a printed resonant antenna for narrow-band microwave wireless links requiring semi-hemispherical coverage. Due to its planar configuration and ease of integration with microstrip technology, the microstrip patch antenna has been deeply. The rectangular and circular patches are the basic and most commonly used microstrip antennas.

4. Feeding Techniques:

Different methods are available to feed microstrip patch antennas. These methods can be contacting and non-contacting methods. In the contacting method, the RF power is fed directly to the radiating patch using a connecting element such as a microstrip line. In the non-contacting method, power is transferred between the microstrip line and the radiating patch through electromagnetic coupling. There are many feed techniques but the four most popular feeding techniques used are microstrip line, coaxial probe (both contacting schemes), aperture coupling and proximity coupling (both non-contacting schemes).

4.1 *Microstrip Line Feed:*

In this, a conducting strip is connected directly to the edge of the microstrip patch. The conducting strip is smaller in width as compared to the patch. This kind of feed arrangement has the advantage that the feed can be etched on the same substrate to provide a planar structure.

4.2 *Coaxial Feed:*

In this, the inner conductor of the coaxial connector extends throughout the dielectric and is soldered to the radiating patch, while the outer conductor is coupled to the ground plane. The major advantage of this is that the feed can be placed at any of the desired 26 locations inside the patch in order to match with its input impedance. The disadvantage is that it provides narrow bandwidth and is complex to model.

4.3 *Aperture Coupled Feed:*

In this technique, the radiating patch and the microstrip feed line are separated by the ground plane. The patch and the feed line is coupled through a slot in the ground plane. The coupling slot is centered below the patch, leading to low cross polarization due to symmetry of the configuration. Since the ground plane separates the patch and the feed line, spurious radiation is minimized. The main disadvantage of this feed technique is that it is difficult to fabricate due to multiple layers, which also increases the antenna thickness.

4.4 *Proximity Coupled Feed:*

This type of feed technique is also called as the electromagnetic coupling scheme. Two dielectric substrates are used and the feed line is between the two substrates. The radiating patch is on top of the upper substrate. The main advantage of this feed technique is that it eliminates spurious feed radiation and provides very high bandwidth (as high as 13%). The major disadvantage of this feed scheme is that it is difficult to fabricate because of the two dielectric layers which need proper alignment.

5. SURVEY ON MICROSTRIP ANTENNA PAPERS:

The number of microstrip antenna papers published yearly since 1973 in the IEEE Transactions on Antennas and Propogation is shown in Table 1 and figure 7.

Year	No. of papers	No. of Microstrip Antenna Papers	% of Microstrip Antenna Papers
1973	218	0	0.0
1974	178	1	0.6
1975	191	1	0.5
1976	173	1	0.6
1977	179	3	1.7
1978	164	4	2.4
1979	177	8	4.5
1980	155	1	0.6
1981	161	32	19.9
1982	215	16	7.4
1983	186	16	8.6
1984	249	17	6.8
1985	216	20	9.3
1986	219	23	10.5
1987	237	18	7.6
1988	243	16	6.6
1989	231	25	10.8
1990	289	41	14.2
1991	286	24	8.4
1992	228	17	7.5
1993	249	19	7.6
1994	253	29	11.5
1995	234	32	13.7
1996	217	24	11.1
1997	261	39	14.9
1998	274	35	12.8
1999	248	37	14.9
2000	243	33	13.6
2001	239	39	16.3
2002	241	47	19.5
2003	420	92	21.9
2004	431	81	18.8
2005	524	102	19.5
2006	477	79	16.6
2007	471	70	14.9
2008	494	79	16.0
2009	508	80	15.7
2010	528	82	15.5
2011	609	35	5.4
2012	212	42	19.8

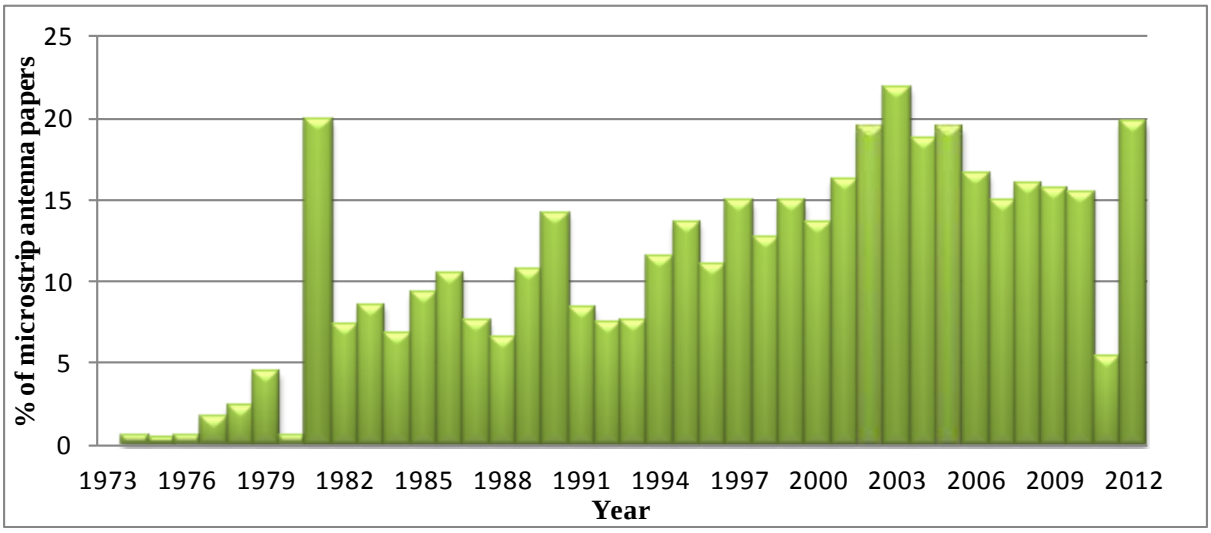

Figure 2: Percentage of Microstrip antenna papers published in the IEEE Transactions on Antenna and Propogations

6. Applications

The microstrip patch antennas are famous for their performance and robust design. Microstrip patch antennas have applications in various fields such as in the medical field, satellites and even in the military systems just like in the rockets, aircrafts missiles and many more. Now they are booming in the commercial aspects due to their low cost of the substrate material and the fabrication. Microstrip patch antenna has a number of applications. Some of these applications are discussed as below:

6.1 *Mobile and satellite communication application:*

Mobile communication requires small, low profile, low cost antennas. Microstrip patch antenna meets all the necessities and a number of microstrip antennas have been designed for use in mobile communication systems. In case of satellite communication, circularly polarized radiation patterns are required and can be realized using either square or circular patch with one or two feed point.

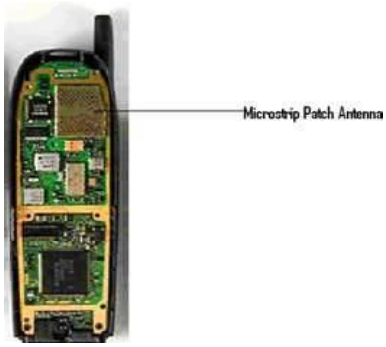

Figure 3: Microstrip Antenna used in Mobile communication

6.2 *Global positioning system applications:*

Microstrip patch antennas having high permittivity sintered substrate material for global positioning system (GPS). These antennas are circularly polarized, very compact

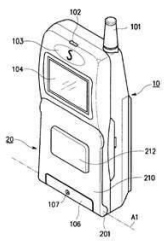

Figure 4: Microstrip Antenna used in GPS system

6.3 *Radio frequency identification (RFID):*

RFID is used in different areas like mobile communication, logistics, manufacturing, transportation and health care. RFID system generally uses frequencies between 30 Hz and 5.8 GHz depending on its applications. Basically RFID system is a tag or transponder and a transceiver or reader.

Figure 5: Microstrip Antenna used in RFID

6.4 *Interoperability for microwave access (WiMax):*

The IEEE 802.16 standard is known as WiMax. It can reach upto 30 mile radius theoretically and data rate 70 Mbps. Microstrip patch antenna generates three resonant modes at 2.7, 3.3 and 5.3 GHz and can, therefore, be used in WiMax compliant communication equipment.

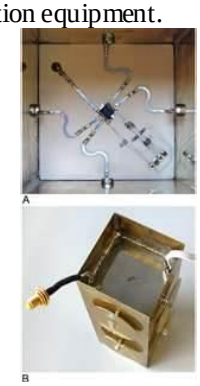

Figure 6: Microstrip Antenna used in Wimax

6.5 *Radar application:*

Radar can be used for detecting moving targets such as people and vehicles. The microstrip antennas are an ideal choice. The fabrication technology based on photolithography enables the bulk production of microstrip antenna with repeatable performance at a lower cost in a lesser time frame as compared to the conventional antennas.

Figure 7: Microstrip antenna used in radar

6.6 *Reduced size microstrip patch antenna for bluetooth applications:*

In this, the microstrip antenna operates in the 2400 to 2484 MHz ISM Band. Although an air substrate is introduced, microstrip antenna occupies a small volume of $33.3\times6.6\times0.8mm^3$.

Figure 8: Reduced size of Microstrip antenna used in Bluetooth

6.7 *Broadband microstrip S-shaped patch antenna for wireless communication:*

This is a single-patch broadband microstrip S-shaped patch antenna. Microstrip S-shaped patch antenna is fed by a coaxial feeding. The antenna is designed by inserting two slots into rotated square patch then it look like English letter 'S'. Because of the slots and thick substrate, bandwidth of antenna is increased.

Figure 9: Microstrip Antenna used as a Broadband

6.8 *Some more areas of development are:*

- Design and Evaluation of E-Shaped Microstrip Patch Antenna (MPA) For Wimax Application
- Rectenna Application
- Telemedicine Application
- Medicinal applications of patch
- A dual-band circularly polarized stub loaded microstrip patch antenna for GPS applications.
- ka band microstrip antenna arrays with high efficiency.
- Optically Transparent Microstrip Patch Antenna
- Flexible liquid metal alloy(EGaIn) Microstrip Patch Antenna
- 2.4 GHz Microstrip Patch Antenna with a single slot for WLAN application
- Compact Tripple Band Slotted Microstrip Patch Antenna.

7. Simulation Softwares

7.1 *IE3D:*

IE3D, from Zeland software Inc., is an electromagnetic simulation and optimization software useful for circuit and antenna design. IE3D has a menu driven graphic interface for model generation with automatic meshing, and uses a field solver based on a full-wave, method-of-moments to solve current distribution on 3D and multilayer structures of general shape.

7.2 *HFSS software:*

HFSS is the industry-standard simulation tool for 3D full-wave electromagnetic field simulation. HFSS provides E- and H-fields, currents, S-parameters and near and far radiated field results. Intrinsic to the success of HFSS as an engineering design tool is its automated solution process where users are only required to specify geometry, material properties and the desired output. From here HFSS will automatically generate an appropriate, efficient and accurate mesh for solving the problem.

7.3 *Advanced design system:*

Advanced Design System is the world's leading electronic design automation software for RF, microwave, and high speed digital applications. In a powerful and easy to use interface, ADS pioneers the most innovative and commercially successful technologies, such as X-parameters and 3D EM simulators, used by leading companies in the wireless communication, networking, aerospace & defense industries. For WiMAX, LTE, multi-gigabit per second data links, radar, & satellite applications, ADS provides full, standards-based design and verification with Wireless Libraries and circuit-system-EM co-simulation in an integrated platform.

7.4 *CST microwave studio:*

CST microwave studio (CST MWS) is a specialist tool for the 3D EM simulation of high frequency components. CST MWS' has made unparalleled performance making it first choice in technology leading R&D departments. CST MWS enables the fast and accurate analysis of high frequency (HF) devices such as antennas, filters, couplers, planar and multi-layer structures and SI and EMC effects..

8. Conclusion

This paper is a survey on the technological advancements in microstrip patch antenna over 40 years. The technological advancement of the microstrip antenna is increasing day by day. A lot of research work is going on microstrip antenna for its better utilization in the future. Many techniques are coming into existence by compensating the gain and bandwidth of the Microstrip Antenna. Survey shows that in the starting years few papers were published about the Microstrip antenna but later on an increase in numbers take place till 2003 and then gradual decrease in number of papers published takes place. Many simulation softwares are developed for microstrip antenna.

9. References

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