SMART ANTENNAS TECHNOLOGY FOR

FUTURE WIRELESS COMMUNICATION SYSTEMS

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ABSTRACT

At millimetre wave frequencies, it is possible to expect increased system performance through the use of smart antenna configurations associated with some signal processing capabilities. The analysis and design of intelligent antenna arrays for millimetre wave systems applications can be undertaken using different technologies and techniques but a new and powerful approach using CPW (coplanar waveguide) fed microstrip antennas offer some supplementary alternatives. A theoretical approach supported by both numerical and experimental results obtained for different configurations and frequencies will be presented and the fit of these results with desirable design values will be further discussed.

INTRODUCTION

Future broadband wireless communication systems require the development of smart antennas that are performant, small, and affordable to a large number of users. These smart antennas must also go broadband to provide newer generation technology the possibility of offering more capacity to the busiest cell sites or create specific beams for each mobile user while continuously adapting to the changing environment. In the 3-G system, the possibility offered by smart antennas will permit to have less interference from other users and will effectively boost the current generation networks.

In other applications, such as the future indoor systems, millimetre waves is able to offer a large bandwidth with the additional benefit of mobility and cellular strategies enabling substantial amounts of information to be distributed simultaneously to many users of a significant area. These systems will provide to business and residential subscribers with a vast array of voice, data, image and multimedia services.

Working at these frequencies presents new challenges, both at the propagation [1] and at the circuitry and antennas [2] levels. For the latter, the development of appropriate smart array and associated technology will be important to the success of broadband wireless systems deployment at millimetre wave frequencies. Therefore, monolithic Microwave Integrated Circuit (MMIC) technology is considered vital for the success of such systems [3]. The analysis and design of intelligent antenna arrays undertaken using CPW (coplanar waveguide) fed microstrip antennas offer some supplementary alternatives. It is now possible to design multi-beam patch antennas with a dual feed system on the same substrate that permits handling of dual frequencies mode systems.

II. ANTENNA TECHNOLOGIES

It is now possible to design multi-beam patch antennas, with a dual feed system on the same substrate, which permit handling of dual frequencies mode systems. The impedance matching circuitry, either with stubs or transformers, can also be successfully implemented on the same substrate if provisions are made for good accuracy etching processes. Reasonable channel separation can be achieved if proper choices are made for the geometry of the feeding and adaptation circuits that will optimize the use of the useful substrate surface.

Using specific considerations, it can be shown that technology now also allows considering having antenna arrays with dual polarizations and frequencies on the same CPW substrate. In this case, architectures, geometries as well as components layout and separation problems must be handled simultaneously. The design of the aperture coupled patch elements involves the following steps:

a) first, the dimensions of the antenna patch are determined using a cavity model [3] in order to resonate at the operational frequency, 38 GHz in this example, using an ε = 9.9 substrate.

b) the side length of the square patch, the width of the aperture (chosen large enough to enable good electromagnetic coupling through the slot) the length of the slot (adjusted to get a low level of back radiation), and the tuning stubs are optimized using an electromagnetic simulator (in our case Momentum tools for HP).

For maximum coupling, the patch is to be centred over the slot on one side and, on the other side, the feed is positioned perpendicular to the slot at its centre. The tuning stub, with a CPW open circuited stub patterned in the centre conductors is used to tune the excess reactance of the slot-coupled patch. The results are shown in Fig. 1.

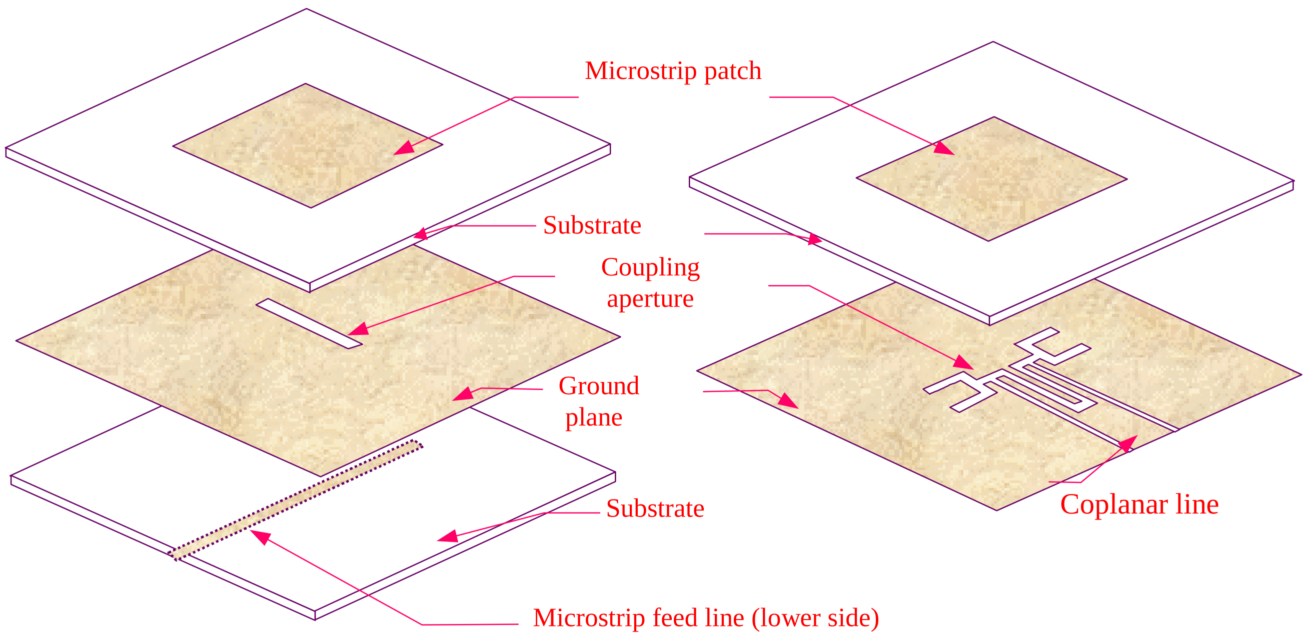

Figure 1. CPW fed patch antenna in comparison with a microstrip fed patch.

To achieve dual frequency operations, a cross-slot coupling patch antenna, as illustrated in Fig. 2 is used, where a rectangular microstrip patch is placed on one side of the substrate while a cross slot fed by a coplanar line is arranged opposite to the patch in the ground plane on the other side of the substrate.

This antenna possesses a dual-matching capability by single feed point and this has been demonstrated by experimental results. It means that it has the capability of matching the input impedance at two frequencies with a single feed point, a most promising aspect.

As shown in Fig. 3, the antenna configuration is based on a cross-slot coupling of a patch antenna, where the microstrip patch is placed on one side of the substrate while a cross-slot fed by a coplanar line is arranged opposite to the patch in the ground plane on the other side of the substrate.

Advantages of this configuration over classical ones are its single geometry and the reduction of substrate levels over aperture-coupled microstrip antenna.Also, a major advantage is that the reverse side of the antenna can be used for the active and feed components, a fundamental requirement to make the resulting antenna really smart.

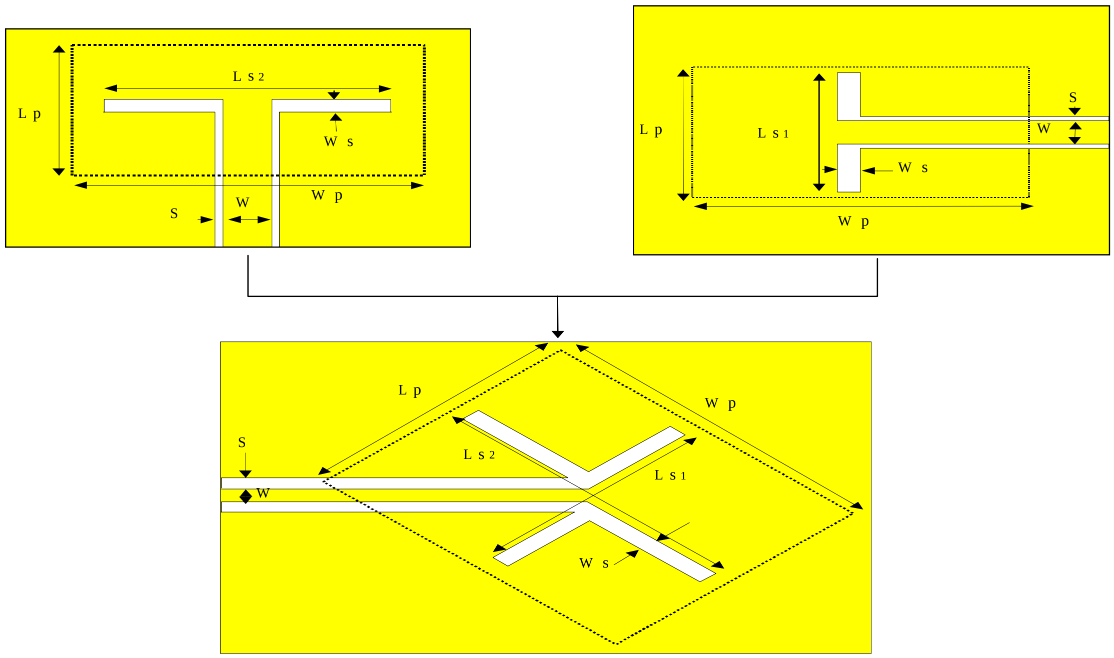

Figure 2. Dual frequency CPW fed patch antenna .

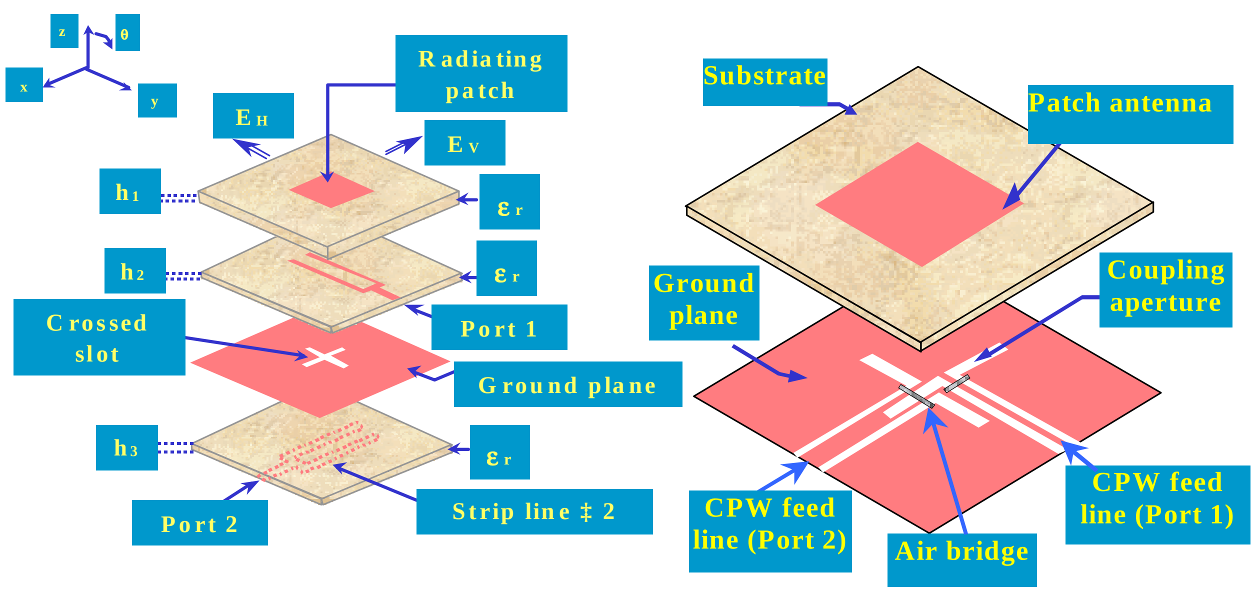

Figure 3. Polarization diversity antenna using CPW-coupled fed patch antenna with a crossed slot.

III. SIGNAL PROCESSING ASPECTS

Spatial filtering with smart antennas, whether of the switched beam, direction finding or optimum combining type requires that appropriate, signal processing techniques be implementable using a reasonable amount of digital electronics. When dealing with beam-forming type, it could be fixed beams or adaptive beams with SNR or Maximum likelihood or Minimum Mean squared error while for adaptive optimal combining it involves maximum SNR, maximum MSE (mean square error), minimum variance distorsionless response and many others. Therefore, physical implementation of the intelligence with the antenna is a real challenge, particularly at millimetre ware frequencies. It is a fundamental reason why so few real physical smart antennas exist.

However, it has been shown that filtering in the space domain can separate spectrally and temporally overlapping signals, making it useful for CDMA, TDMA or FDMA systems. Moreover, when wideband systems are envisaged, the design considerations and guidelines for EHF smart antennas are of the utmost importance. Algorithms implementation must be optimized for real time execution on commercially available processors with broadband-coupled patch antennas on the RF front end. Intelligent antenna act as “spatial filter” which can enhance or reject signals based on their direction of arrival. Intelligent antenna system combines the outputs of multiple antenna elements with signal processing capabilities to transmit and/or receive RF signals in an adaptive, spatially sensitive manner.

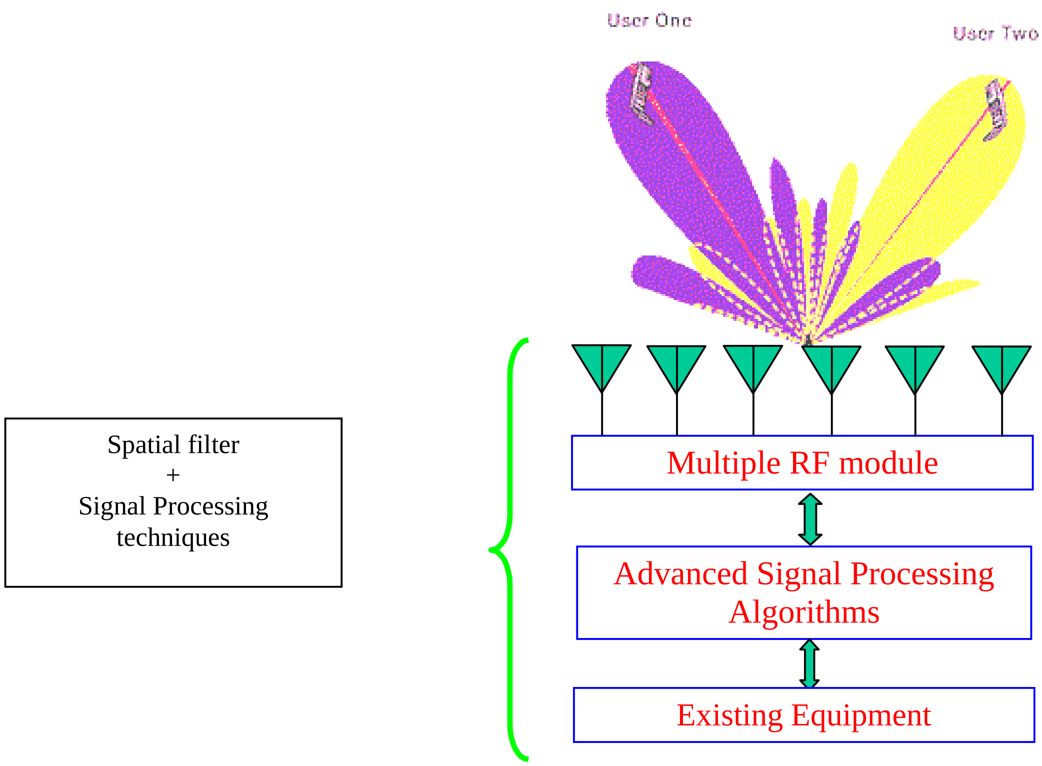

Figure 4. Intelligent antennas as a spatial filter.

Frequency translation from RF to baseband for signal processing and algorithm operation is still necessary to achieve reasonable overall structure losses. More details will be presented at the conference.

IV REFERENCES

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