IMPULSE HIT

Content

Vision

IMPULSE HIT is a yearly newsletter to share upcoming technologies in various fields of Electronics & Communication Engineering. This issue of newsletter introduced the advanced research topics in the field of antenna, RF & Microwave Engineering, Image Processing as well as Nano Electronics. These brief technical articles will influence many students and faculty members to extend research works in these fields in near future.

Team Members

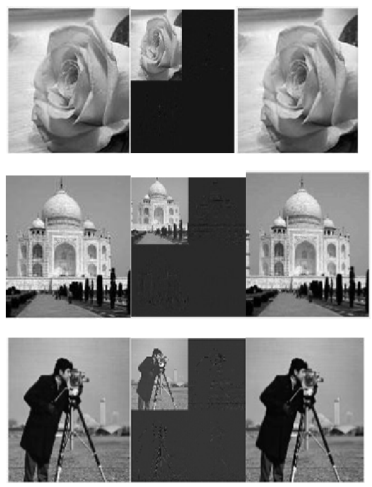
Image Compression

Shruti Priya, 4th Year, ECE

Image compression has become one of the most important disciplines in electronics because of the ever growing popularity and usage of the internet and multimedia systems combined with the high requirements of the bandwidth and storage space. The increasing volume of data generated by some medical imaging modalities which justifies the use of different compression techniques to decrease the storage space and enhance efficiency of transfer the images over the network for access to electronic patient records. An effective algorithm to compress and to reconstruct gray scale image and communications in medical image has been presented. Various image compression algorithms exist in today's commercial market. An introduction of lifting scheme based on Haar wavelet transform has been presented. The Haar wavelet is famous for its simplicity and speed of computation. Computation of the scaling coefficients requires adding two samples values and dividing by two. Calculation of the wavelet coefficients requires subtracting two samples values and dividing by two.

Lifting scheme was developed for the construction of bi-orthogonal wavelets. The main feature of the lifting scheme is that all constructions are derived in the spatial domain. It does not require complex mathematical calculations that are required in traditional methods. Lifting scheme is simplest and efficient algorithm to calculate wavelet transforms. It does not depend on Fourier transforms. Lifting scheme is used to generate second-generation wavelets, which are not necessarily translation and dilation of one particular function. It was started as a method to improve a given discrete wavelet transforms to obtain specific properties. Later it became an efficient algorithm to calculate any wavelet transform as a sequence of simple lifting steps. Digital signals are usually a sequence of integer numbers, while wavelet transforms result in floating point numbers. For an efficient reversible implementation, it is of great importance to have a transform algorithm

That converts integers to integers. Fortunately, a lifting step can be modified to operate on integers, while preserving the reversibility. Thus, the lifting scheme became a method to implement reversible integer wavelet transforms. Constructing wavelets using lifting scheme consists of three steps: The first step is split phase that split data into odd and even sets. The second step is predicting step, in which odd set is predicted from even set. Predict phase ensures polynomial cancellation in high pass. The third step is update phase that will update even set using wavelet coefficient to calculate scaling function. Update stage ensures preservation of moments in low pass.



Original image, transformed image and reconstructed image.

Superior performance of lossless image compression model using the Lifting Scheme has been presented in the above figure.

Substrate Integrated Waveguide & Substrate Integrated Folded Waveguide Technology

Wriddhi Bhowmik, Assistant Professor, ECE

The substrate integrated waveguide (SIW) technology makes it possible to fabricate the rectangular waveguides in a planar form. The classical rectangular waveguides can easily be integrated with the planar structures using this technology. The SIW structures preserve the advantages of rectangular waveguides such as high Q factor and high power handling capability. SIW technology reduces the losses associated with the microstrip lines. SIW structures can be fabricated in the planar form by using periodic metallic via holes, air holes or holes filled with a different dielectric. The SIW made with air holes or holes filled with a different dielectric produces more leakage in comparison to the SIW with metallic via holes. The metallic pins shield the electromagnetic waves and these pins also connect the surface currents in order to preserve the guided wave propagation.

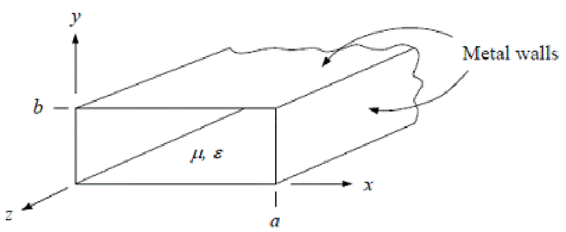


Fig. 1. Non planar classical rectangular waveguide.

Fig. 1 shows a non planar structure of classical rectangular waveguide, which is able to transmit electromagnetic wave with very low attenuation up to a very high frequency, but it is impossible to integrate with planar structures as well as it is bulky and expensive.

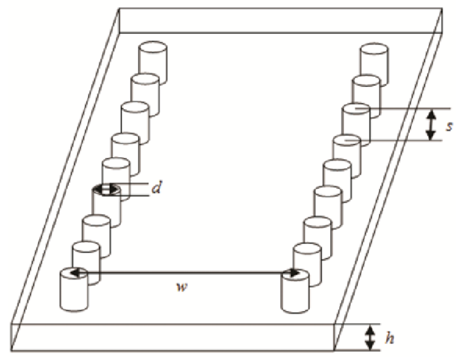


Fig. 2. Substrate Integrated Waveguide

The width (*w*) of SIW can be calculated as follows

$$w_{eff} = w - 1.08\frac{d^2}{s} + 0.1\frac{d^2}{w}$$

Where *d* is the diameter of metallic vias, *s* is the center to center distance between the vias and w_{eff} is the effective width of equivalent rectangular waveguide. If the conditions like $s/d < 2.5$ and $d/w < 1/5$ are followed to build up the SIW structure, the leakage loss will be very small. For TE_{10} mode the w_{eff} can be calculated as follows

$$w_{eff} = \frac{c}{2(f_c)_{10}\sqrt{\mu_r \varepsilon_r}}$$

Where *c* is the speed of light in free space, μ_r and ε_r is the relative permeability and permittivity of dielectric material and $(f_c)_{10}$ is the cut off frequency of the waveguide for TE_{10} mode.

Fig. 2 presents the structure of SIW. It preserves all the advantages of rectangular waveguide as well as it is compact and less expensive. It can also be integrated with other planar devices.

The planar implementation of rectangular waveguide using SIW technology reduces the width of waveguide by a factor of $1/\sqrt{\varepsilon_r}$, where ε_r is the relative permittivity of the substrate material. To reduce the width of SIW the substrate integrated folded waveguide (SIFW) technology has been chosen. It finally reduces the width of standard waveguide by a factor $1/(2\sqrt{\varepsilon_r})$ without affecting the cut-off frequency.

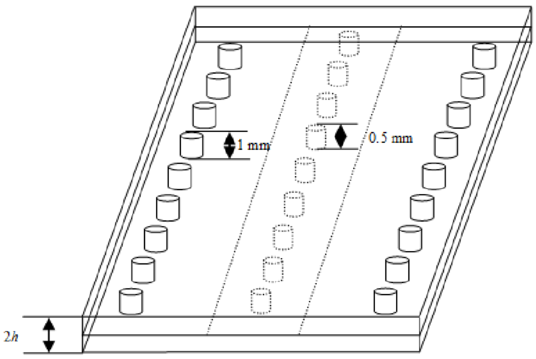


Fig. 3. Structure of Substrate Integrated Folded Waveguide.

Fig. 3 represents the structure of SIFW. The width of SIFW is exactly half compared with SIW; it means the structure is more compact.

Adaptive Array System

Avisankar Roy, Assistant Professor, ECE

The adaptive array systems are able to dynamically react to the changing RF environment, hence can be referred as total smart system. This system combines the multiple radiation patterns to form a single directive beam. The signal processing then steers the beam towards a desired mobile user, follows the user as it moves, and at the same time minimizes interference arising from other users by introducing nulls in their directions.

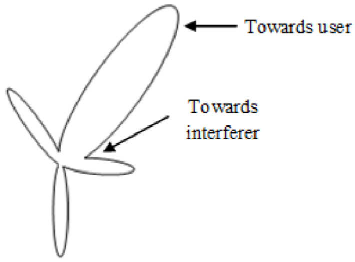


Fig. 1. Beam formation for adaptive array antenna system.

The radiation performance of the adaptive array system is shown in Fig. 1. The estimation of direction of arrival of all the incoming signals including the interfering signals and the multipath signals are done by the direction of arrival algorithms (DOA). After that the desired user signal is identified and separated from the rest of the unwanted incoming signals. Finally the directive beam is steered to the direction of the desired signal and it is tracked as the user moves, while placing the broad nulls at interfering signal directions by constantly updating the complex weights. The signal processing makes the system smart. The processing is mainly governed by complex computationally intensive algorithms.

The radiation direction of the main beam of an array depends upon the phase difference between the elements of the array. Hence the continuous steering of the beam in any direction is possible by adjusting the progressive phase difference β between the elements. The same principle is used achieve maximum radiation in the desired direction by adaptive array system.

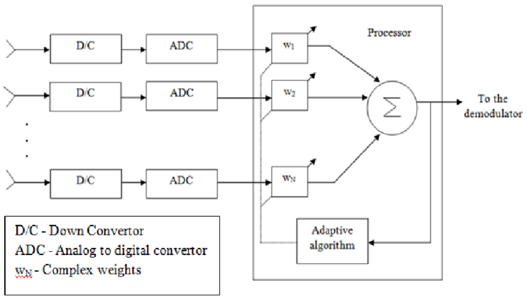


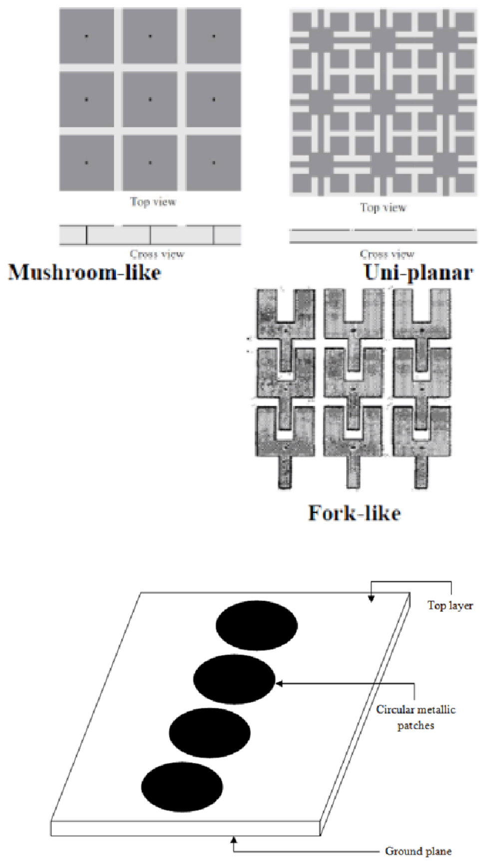
Fig. 2. Basic block diagram of adaptive array system.

In a typical adaptive array system the single desired beam is formed by intelligently combining the signals incident at the individual radiating elements. The signal from each radiating element sends to the digital signal processor. Before that the received signal is down converted to the baseband or intermediate frequencies (IF's). The digital signal processor works on the digital signal, hence the down converted signal is transformed to the digital format. The analog to digital convertor (ADC) performs the specific operation. Adaptive antenna array systems use digital signal processors (DSP's) to weight the incoming signal as shown in Fig.2. The digital signal processor makes the system smart. The complex weights mainly the amplification and phase information is determined by the digital signal processor. The multiplication of the weights to the each element output to optimize the array pattern also performs by the processor. The optimization is based on a particular criterion, which minimizes the contribution from noise and interference while producing maximum beam gain at the desired direction. All these functions take place in the processor and driven by the software.

Mutual Coupling Reduction in Antenna Array using Electromagnetic Band Gap Structures

Aarti Kumari, 3rd Year, ECE

EBG is an efficient technology to suppress surface wave excitation. The implementation of EBG structure is low cost and can be easily integrated with microstrip structures.



Circular metallic patches as EBG unit

Fig. 1. Different types of EBG units.

Different forms of EBG cells can be implemented with microstrip patch antennas. Periodic structure of air holes through substrate, periodic metal patches with grounding vias, uniplanar compact EBG (UC-EBG) structure, spiral EBG structure (it consists of ground plane, a dielectric substrate, connecting vias and square metal patches with inserted spiral branches), periodic planar rectangular metal patches or circular slots etched in ground plane are different forms of EBG structure. Fig. 1 presents different EBG structures.

At the high microwave frequency microstrip antennas suffer from surface wave excitation which leads to increase the level of mutual coupling between the antenna array elements and it degrades the radiation performance of the whole system. To reduce the mutual coupling and improve the overall radiation performances of antenna array, electromagnetic band gap (EBG) structures may be introduced between the antenna elements.

A proposal for reduction of surface wave excitation as well as the level of mutual coupling in an antenna array by inserting EBG units between the array elements has been represented in the Fig. 2.

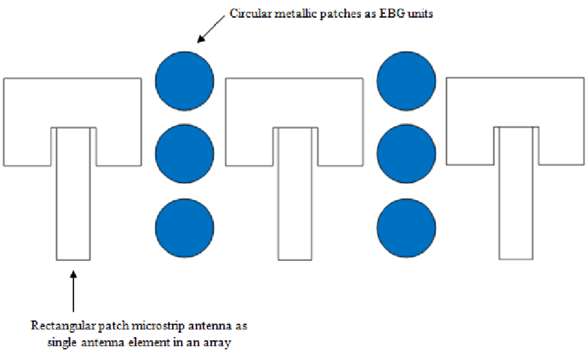
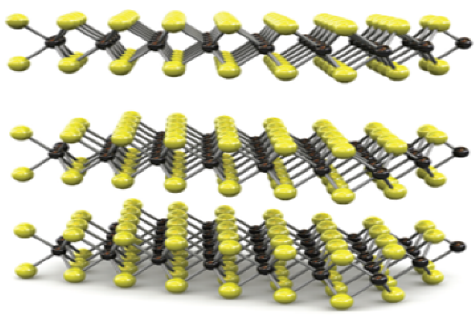


Fig. 2. Methodology to suppress the effect of mutual coupling in an antenna array by using EBG units.

New 2-D Quantum Materials for Nano Electronics

Kushal Roy, Assistant Professor, ECE

In this 21st century we are enjoying well developed electronics. The field of electronics has got tremendous impact on the contemporary society and in plenty of real time applications. The revolution in electronics is through the discovery of the transistors. They have been considered as the backbone of the development of electronics and electronic era because the real electronics what it is called today was actually started after the visualization of transistor effect. Transistor opened the road for the electronics and there after electronics got its independent identity in electronics engineering. More importantly it laid the path for the progress of computing world. Surprisingly, our scientists gave birth to the idea of assembling many electronic components on a single mother board called INTEGRATED CIRCUIT. In 1965 Gordon Moore came out with an awesome paper called “Cramming more Components onto Integrated Circuits”. In that paper he described that the number of transistors used on a single chip of silicon will grow exponentially. Modern technology is characterized by its emphasis on miniaturization and at the same time with improved efficiency and less power consumption. This paper will show case such devices with a family of new two dimensional (2-D) materials exhibiting exotic quantum properties that may enable a variety of nanoscale electronics. These 2-D materials are predicted to show a phenomenon called the quantum spin Hall (QSH) effect, and belong to a class of materials known as transition metal dichalcogenides (TDMC), with layers a few atoms thick .Using these materials a design for a new kind of transistor called a topological field-effect transistor, or TFET, is being made by scientists at MIT. The design of this device is based on a single layer of the 2-D material sandwiched by two layers of 2-D boron nitride. Such devices could be produced at very high density on a chip and have very low losses, allowing high-efficiency operation.



Schematic model of transition metal dichalcogenide atomic layers.

Nanotechnology is the understanding and control of matter at dimensions between approximately 1 and 100 nanometers (nm), where unique phenomena enable novel applications not feasible when working with bulk materials or even with single atoms or molecules. It has wide range of applications such as boat hulls, sporting equipment and automotive parts, sunscreens and cosmetics. A thought provoking application of nanotechnology has made on a family of two-dimensional materials exhibiting exotic quantum properties that may enable a new type of nanoscale electronics. These materials are predicted to show a phenomenon called the Quantum Spin Hall (QSH) effect and belong to a class of materials known as transition metal dichalcogenides, with layers a few atoms thick. QSH materials have the unusual property of being electrical insulators in the bulk of the material, yet highly conductive on their edges. This could potentially make them a suitable material for new kinds of quantum electronic devices. This could further lead to new kinds of low-power quantum electronics, as well as spintronics devices — a kind of electronics in which the spin of electrons, rather than their electrical charge, is used to carry information. These compounds naturally form thin sheets, just atoms thick, that can spontaneously develop a dimerization pattern in their crystal structure resulting a design for new kind of transistor based on the calculated effects called a topological field-effect transistor, or TFET, the design is based on a single layer of the 2-D material sandwiched by two layers of 2-D boron nitride. These devices could be produced at very high density on a chip and have very low losses, allowing high-efficiency operation. In addition, this is one of the most promising known materials for possible use in quantum computers. This exciting result will bridge two very active subfields of condensed matter physics, topological insulators and dichalcogenides.