



2023

IMPULSE



NEWSLETTER

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*Electronics & Communication Engineering
Haldia Institute of Technology*

2023

The Institute's Vision and Mission

Vision

To achieve Centre of Excellence in the field of Science, Technology and Management Education for creating dynamic human resources of global standards with capabilities of accepting new challenges.

Mission

- ✓ To impart quality and value based education to raise satisfaction level of all stakeholders.
- ✓ To create competent, creative professionals, and great entrepreneurs who can work as individual or in group in multi-cultural global environments.
- ✓ To prepare citizens who would grow to be competent enough to contribute significantly with personal integrity and civic responsibility for the betterment of mankind throughout their careers and profession.

Department Vision and Mission

Vision:

To produce dynamic human resources of global standards by imparting quality teaching, carrying out research and technology development in the emerging areas of Electronics & Communication Engineering.

Mission:

- ✓ To produce electronics and communication engineers having strong theoretical foundation, good design experience and exposure to research and technology development in frontier areas of electronics and communication engineering.
- ✓ To create competent professionals who can work as an individual or in a group with effective communication and leadership skills meeting the requirements of multi-cultural global environments.
- ✓ To help the student be a successful and responsible engineer for the betterment of mankind by inculcating social and ethical values in professional engineering programme.

Program Educational Objectives (PEOs)

PEO-1: To equip graduates with strong foundation in Electronics and Communication Engineering with an objective of being real time problem solvers.

PEO-2: To provide exposure to emerging technologies in order to become competent both as an individual and team with ever changing industrial requirements.

PEO-3: To prepare successful and responsible engineering graduates with socio-ethical values and leadership qualities in professional engineering practices.

Program Specific Outcomes (PSOs)

After completion of the program, the students will have ability to:

PSO-1: Apply basic knowledge in diversified fields of Electronics and Communication Engineering to solve engineering and socio-ethical problems.

PSO-2: Design, Verify and Validate electronic functional elements for a variety of experiments and projects with skills to analyze, interpret and communicate results either independently or in teams.

PSO-3: Recognize contemporary issues to adapt lifelong learning and develop consciousness for technical, professional, managerial and legal responsibilities.



IMPULSE

Vision

IMPULSE 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, Microwave and Mobile communication. These brief technical articles will influence many students and faculty members to extend research works in these fields in near future.

Content

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- ✓ Anchor-Based Street and Traffic Aware Routing (A-STAR) in VANET

Adaptive Array System

Dr. Avisankar Roy, Associate 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.

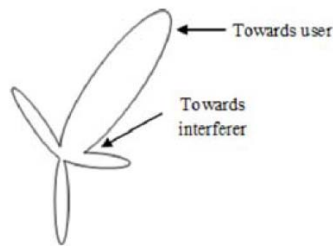


Fig. 1. Beam formation for adaptive array antenna System

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 to achieve maximum radiation in the desired direction by adaptive array system.

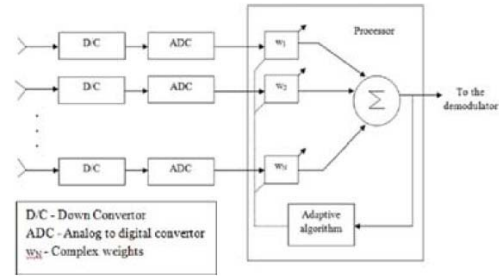


Fig. 2. Basic block diagram of adaptive array system.

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 converter (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

Ashish Mishra, 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.

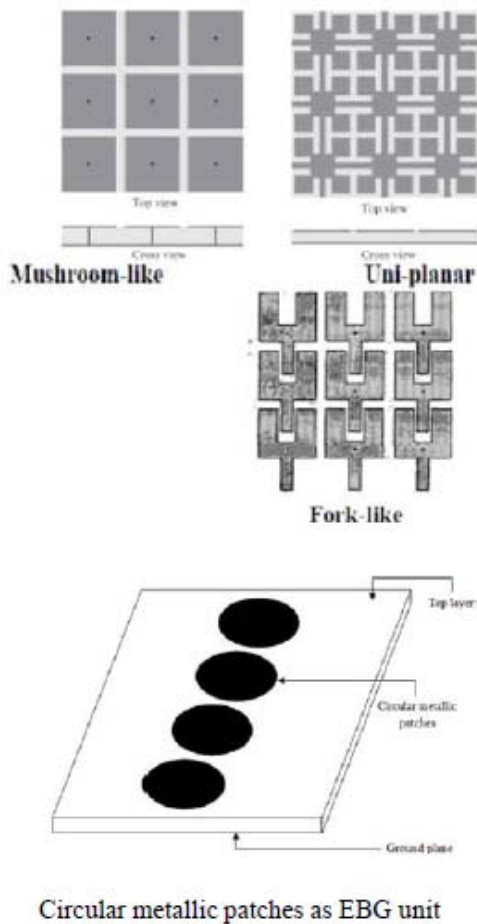


Fig. 1. Different types of EBG units.

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.

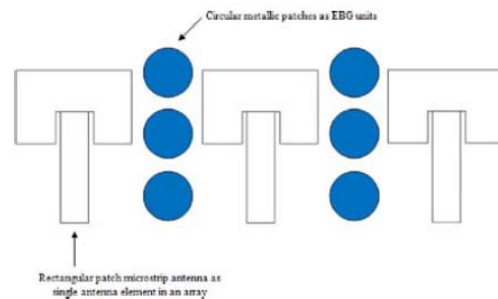


Fig. 2. Methodology to suppress the effect of mutual coupling in an antenna array by using EBG units.

Switched Beam Smart Antenna System

Prachi, 3rd Year, ECE

The switched beam system employs an antenna array which generates fixed overlapping beams that cover the certain angular area. The switched beam system is employed in the base station, when an incoming signal is detected by the base station, the system selects the right beam which is best aligned to the signal-of-interest direction and then switches to that beam to communicate with the user. The selection of right beam is usually based on the maximum received power for that user. A typical cellular area is divided into three sectors with 120° angular width. Each sector served by the six overlapping fixed directional narrow beams as shown in Fig. 1. The spatially separated directional beams can significantly reduce the co-channel interferences which lead to increase the frequency reuse as well as the capacity of the cellular system. The uplink and downlink communication can be served by the same beam.



Fig. 1. Coverage pattern of switched beam antenna system.

The radiation performance of the switched beam antenna system is shown in Fig. 1. A typical switched beam system for a base station would consist of multiple arrays with each array covering a certain sector in the cell. It consists of a phase shifting network, associated with the antenna array as shown in Fig. 2, forms

multiple directive beams in different directions. The selection of the right beam which is best aligned to the signal of interest direction is made by the control logic. The control logic is driven by an algorithm, scans all the beams and selects the suitable beam which receives the strongest signal. The detector makes the measurement, which beam receives the strongest signal. Based upon this data of the detector the control logic selects the right beam. Finally switch to the right beam is made by the RF switch.

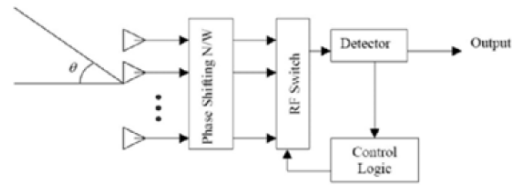


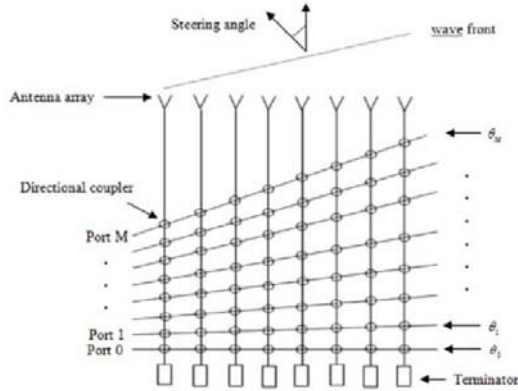
Fig. 2. Basic block diagram of a typical switched beam system.

The working mechanism of switched beam system is simpler than the adaptive array but the system is not suitable for high interference areas. Let us consider a user is served by a directional beam. When another user is at the direction of the broad null then there would be no interference from the second user. But if the second user enters into the same area of the beam as the first user, then that user could cause interference to the first user. Therefore switched beam systems are best suited for a small or zero-interference environment. Although this is a disadvantage of the switched beam system but it provides a significant enhancement in capacity of the wireless system, considerable interference rejection when the desired user is at the centre of the beam. Also, it is less expensive and can be easily implemented in older systems.

Blass Matrix

Mr. Surajit Mukherjee, Assistant Professor, ECE

Blass matrix is a phase shifting network. The Blass matrix consists of directional couplers and transmission lines to provide the necessary phase shift between the output ports of the matrix. A Blass Matrix, which fed the 8 elements array to produce directive beams in different directions, has been presented in the figure below. Each node represents the directional coupler which is used to cross-connect the transmission lines. When the signal is fed to the input ports, the specific phase differences between the output ports of the matrix will enable the beams direct to the different steering angle, which are generated by the antenna array. Though the configuration of Blass matrix is simple but the performance of the matrix is not satisfactory due to the losses attributed to the resistive terminations.



Beam forming network implemented by Blass matrix array.

Beam Forming Antenna System using Butler Matrix Array

Mr. Dibyendu Chowdhury, Assistant Professor, ECE

A $N \times N$ Butler matrix consists of N element array can produce N directive beams in different directions ($N = 2^n$). The 3 dB coupler and 45° phase shifter are the basic building block of the Butler matrix array. The system requires

$$2^{n-1} \log_2 2^n \quad \text{and} \quad \left(\frac{2^n}{2}\right) \left[\left(\log_2 2^n\right) - 1\right]$$

number of 3dB coupler and 45° phase shifter respectively. The crossover or 0 dB coupler is used in the path crossing of two transmission lines for the single layer implementation of Butler matrix array. When the input ports of the matrix is excited by a signal, different inter-element phase shifts are obtained between the output ports of the matrix. These phase differences direct the beams in different directions. The antenna elements are connected to the output ports of the matrix, which are used to generate the directive beams. The beams are pointing in direction θ governed by the following equation

$$\theta = \cos^{-1} \left[\frac{\pm (2n - 1) \lambda_0}{8d} \right] \quad (1)$$

Where $n = 1, 2, \dots$ etc, λ_0 is free space wavelength and d is the physical distance between the centers of antenna elements.

Fig. 1(a) and (b) respectively represent the schematic of 4×4 Butler Matrix array and a basic block diagram of a 4×4 Butler Matrix fed antenna array system. The 4×4 Butler Matrix fed antenna array system presented in Fig. 1 (b) can be referred as the multiple beam forming antenna system (MBFAS). As described earlier, the 3dB coupler, 45° phase shifter

and the crossover or 0 dB coupler are considered as the basic building blocks of the Butler Matrix array. A 4×4 Butler Matrix consists of four 3 dB branchline couplers and two 45° phase shifters, for the planar implementation of the system two crossovers are required at the crossing of the transmission lines.

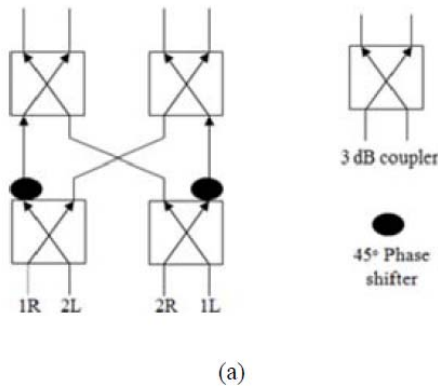


Fig. 1 (a) Schematic of 4×4 Butler matrix array.

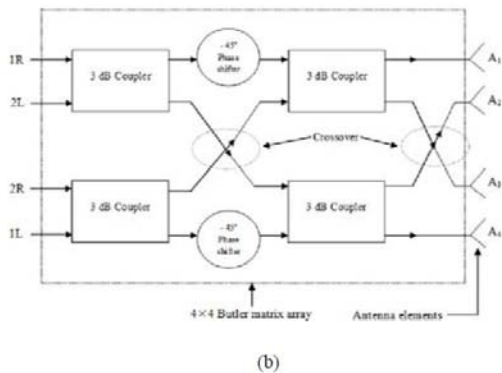


Fig. 1 (b) Basic block diagram of a 4×4 beam forming antenna system.

The output ports of the Butler matrix array feed the antenna elements A_1 , A_2 , A_3 and A_4 as shown in Fig. 1 (b) to create the directive beams in different directions. The input ports of the system are named as 1R, 2L, 2R and 1L based on the specific direction of the major beams (R: Right and L: Left). The 1R port excitation leads the system to generate the major directive beam in the range of 0° to 30° . Similarly remaining major beams

directions should be in the range of -30° to -60° , 30° to 60° and 0° to -30° for 2L, 2R and 1L port excitation respectively as proposed in Fig. 2. The pointing major beam directions for 4×4 beam forming antenna system can be calculated from the Eq. (1).

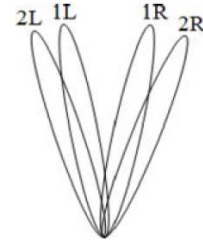


Fig 2. Proposed radiation pattern of 4×4 Butler Matrix fed antenna array system.

Smart Antenna System

Harsh Prabhat, 4th Year, ECE

The Communication between the moving people by radio signal was first demonstrated by Marconi in the year 1897. In the beginning the growth of the wireless communication was slow till the development of the cellular concept by Bell's laboratories in 1960s. By developing highly reliable, miniature, solid-state radio frequency hardwares it was possible to provide wireless communications to an entire population. Pagers, cordless telephones, cellular telephones are the examples of the wireless radio systems. In the recent days the cellular radio communication is in demand. The performance of the wireless communication systems are limited by the mobile radio channels. The mobile radio wave propagation in the line of sight path between transmitter and receiver can vary due to severe obstruction by the buildings, mountains and foliage etc. Multiple reflections from various objects lead to

electromagnetic wave propagation in different paths of the different lengths. The interaction between these waves causes multipath fading at a specific location. Basically in the urban areas the radio waves reflect from the ground and surrounding structures. So the incoming radio waves arrive from different directions with different propagation delays. At any point in the space the signal received by a mobile consists of a large number of plane waves having randomly distributed amplitudes, phases and angles of arrival. The multipath components are combined vectorially at the receiver antenna and make the received signal distorted.

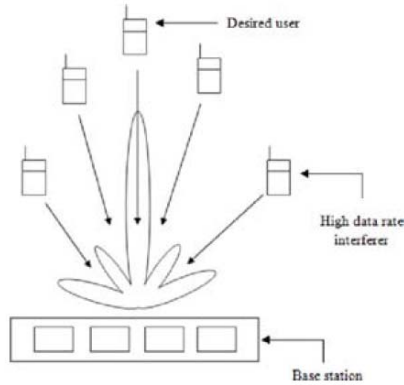
To improve the performance of the high speed wireless communication it is necessary to separate the desired signal or the line of sight signal from the delayed or interfering signal and also to minimize co-channel interference. To achieve these goals the smart antenna system has been developed.

To reduce the multipath fading and co-channel interference effectively, the smart antenna system is the most promising technology. By focusing the radiation pattern in the desired direction the smart antenna system can achieve the goal. Smart antennas employ a set of radiating elements arranged in the form of an array. The switchable or movable beam pattern which follows the desired user is formed by combining the signals from each array element. The arrays incorporated in the smart antenna system are not smart; the digital signal processing makes them smart. The technique of combining the signals from each antenna element and then focusing the radiation pattern in a particular direction is often referred to as digital beam forming. The realization of the smart antenna is often done with the switched beam system or fully adaptive array. A

smart antenna system consists of an antenna array, RF hardware, and a computer controller. The directional pattern which is formed by the antenna array can change its directionality according to the radio frequency environment in order to improve the performance of high speed wireless communication, this function of the system is made by the computer controller. The simplest form of the smart antenna is the switched beam antenna system. The switched beam antenna system generates several overlapping fixed beams. The appropriate pattern is selected for any given set of conditions. The adaptive array can dynamically change its pattern according to the RF environment; this can be achieved by varying the phase of exciting current at each radiating element to optimize the pattern. Smart or adaptive antenna is being considered for use in wireless communication systems. Smart antennas can increase the coverage and capacity of a system. In multipath channels the smart antenna system can increase the maximum data rate and can minimize the fading by rejecting the multipath components. The most important advantage of the smart antenna system is the higher network capacity, makes capable to serve more users per base station, thus increasing revenues of network operators and the probability of blocked or dropped calls is also minimized. Also, the transmission quality can be improved by increasing desired signal power and reducing interference.

The figure shows the typical smart antenna pattern in the RF traffic environment. The smart antenna system is employed in the base station. The cell consists of several users. The smart antenna system directs its pattern to the desired user and broad side nulls to the interfering users as shown in the figure above. The high data rate users are considered as the interferer in

this case. By the above mentioned technique the smart antenna system can reject the interfering signal and improve the quality of communication to the user under consideration.



Smart antenna patterns in a cellular system with high data rate interferers and desired low data rate users.

Multiple Beam Forming Antenna System (M-BFAS) Using Empty Substrate Integrated Waveguide (ESIW) Technology for Ultra-High Speed 5G Communication

Dr. Tilak Mukherjee, Assistant Professor, ECE

5G is the key solution to obtain significantly faster mobile broadband speed as well as larger mobile data usage in busy urban areas. In near future 5G will be at the heart of mobile communication. 5G uses three frequency bands as follows, (i). Sub-1GHz; (ii). 1 GHz - 6 GHz and (iii). above 6 GHz . The frequency band 6 GHz and above is needed to meet the ultra-high broadband speeds envisioned for 5G. Ultra-fast 5G services will require such large amounts of spectrum, which can only be

available above 24 GHz. The performance of high speed 5G services will be more precise if the interferences will be minimized at the above mentioned frequency band.

Undesired mobile users signal and multipath components of the transmitted signal are the primary sources of interferences. Significant minimization of such kind of interferences can be achieved if a group of mobile users is served by very narrow and directive beams.

Realization of multiple beam forming antenna system will be a successful attempt to obtain very directive beams in different angular directions, which in turn will assist to achieve highly precise performances in high speed 5G communication. The multiple beam forming antenna system comprises of phase shifting network and antenna array. The Butler matrix array will be considered as the phase shifting network in this proposed project as the network requires very few basic microwave components to realize. The output ports of Butler matrix network will feed the antenna elements to generate directive beams in the different angular directions.

Empty substrate integrated waveguide (ESIW) technology will be used to develop a 4×4 multiple beam forming antenna system (M-BFAS). Planar implementation of the antenna array system is possible by using microstrip technique. Though this technique makes the system profile low and cheaper but at higher frequencies the microstrip feeding network suffers from conductor loss and spurious feed radiation as well as surface wave excitation in the microstrip patch antenna degrade the overall radiation performances of the system. The waveguide technology is well suited to develop the system at higher frequencies as it provides very low loss and high Q factor. Hence this technique can improve the performance as compare to microstrip but make the whole system

bulky, expensive as well as difficult to integrate with other planar circuits. Planar implementation of classical rectangular waveguide (RW) can be possible by substrate integrated waveguide (SIW) technology. It reduces the size of classical RW by a factor of $1/\sqrt{\epsilon_r}$, where ϵ_r is the relative permittivity of dielectric material. This technique preserves all the advantages of RW. But the Q factor of SIW is much less than the Q factor of conventional RW at higher frequencies due to the presence of the dielectric material. To minimize the losses and enhance the Q factor, ESIW technique has been evolved by emptying a rectangular hole in a planar dielectric substrate. It preserves all the advantages of RW in a greater measure than SIW, without losing the low profile and low cost fabrication of a standard planar circuit. At higher frequencies the Q factor of ESIW is much higher than SIW but less than RW. Hence it can be stated that the ESIW is a very promising alternative to the SIW at very higher frequencies.

The expectation to obtain very precise performance of the M-BFAS so as the ultra-high speed 5G communication at the frequency band of above 24 GHz will be possible by using ESIW technology.

Anchor-Based Street and Traffic Aware Routing (A-STAR) in VANET

Aditi, 2nd Year, ECE

Anchor-Based Street and Traffic Aware Routing (A-STAR) is similar to GSR (Geographic Source Routing) in that packets are routed through anchor points of the overlay. However, A-STAR is traffic aware: the traffic on the road determines whether the anchor points of the road will be considered in the shortest path. A-STAR routes based on two kinds of overlaid maps:

a statically rated map and a dynamically rated map. A statistically rated map is a graph that displays bus routes that typically imply stable amount of traffic. **Dijkstra's least-weight path** algorithm is used to compute the anchor of the path. A dynamically rated map is a map that is generated based on the real-time traffic condition on the roads. Road-side deployment units can monitor the city traffic condition and distribute this information to every vehicle. Thus, the difference between a statically rated map and a dynamically rated map is accuracy of road traffic; while a statically rated map is based on bus routes that typically have high traffic volume; a dynamically rated map is based on the traffic monitored dynamically by road-side units. A-STAR also proposes a different recovery algorithm when the packet gets stuck due to disconnectivity of the current path to the destination. The mobility model and propagation model are based on the M- Grid mobility model, a variant of the Manhattan model that considers not only the vehicular movement in a typical metropolis where streets are set out on a grid pattern but also the radio obstacles.
