August 2022
"Vol. 5, No. 1"

ELEKTRON

A Publication of Department of Electrical Engineering.
University of Engineering and Technology, Lahore.

MESSAGE FROM THE VICE CHANCELLOR

"

University of Engineering and Technology is an institution which has always nurtured its students to set and achieve lofty goals by provideing them the freedom to polish their skill set thriugh curricular and co-curricular activities. A commendable product of such efforts and skills is Elektron, a magazine by the Department of Electrical Engineering, produced by the student chapter of IEEE, UET Lahore. Elektron reflects the creative minds of the students of Electrical Engineering and their abilities to breathe life into their innovative ideas.

To make this magazine a constant source of guidance and inspiration for the masses, the work done by the team Elektron is needed worthy of appreciation. The efforts put forth by the team Elektron should serve as a motivation for other students of UET Lahore to embark upon similar initiatives.
I wish them best in their future endeavors.

"

Prof. Dr. Syed Mansoor Anwar

Vice Chancellor,

University of Engineering & Technology, Lahore

MESSAGE FROM THE CHAIRMAN

"

The aphorism "publish or perish" asserts the importance of publishing the scholarly work by the faculty and students. The Department of Electrical Engineering, historically, has been highly reputed for its outstanding undergraduate program. It has never been more important to involve undergraduate students in research. To publish the work carried out by undergraduates has always been a challenge, due to the lack of availability of proper forum of this purpose, This is no more a limitation due to the introduction of Elektron magazine. The IEEE UET Lahore team has put an extensive effort to make the idea a realization. Elektron provides an excellent opportunity to both undergraduate as well as graduate students to publish their work. I believe this initiative will go a long way and will be pivotal in defining the careers of many.

"

Prof. Dr. Muhammad Tahir
Chairman, Department of Electrical Engineering
University of Engineering & Technology, Lahore

MESSAGE FROM THE EDITOR IN CHIEF

“

In Pakistan, the students at the pre university level are often curious about opting their areas of professional education. However, it is observed that the students at those levels do not have access to the relevant knowledge to help make their minds taking suitable decision.

Electron magazine is an effort of the department of electrical engineering of UET Lahore, to remove this knowledge deficit of the pre university students. Specially, this magazine is an attempt to provide some knowledge to both the foundations and advances of the domain of science and engineering, in general and electrical engineering and its applications, in particular. Link among religion, philosophy and science is another relevant area of study, published under the scope of this magazine.

Other than helping pre university students, Elektron is also publishing articles to enhance the knowledge of early semester students of electrical engineering, professional scientists, engineers, specially, electrical engineers, and of the other readers interested in learning and knowing about foundations and advances of science and engineering.

This issue of electron invited the articles with very broad scope, but the preferred areas of interest for this issue were, but not limited to

- Religion and Science
- Contribution of Muslims in the Field of Science
- Science and Philosophy (a union)
- Technical Innovations in Electrical and Electronics Engineering
- Engineering Mathematics
- Engineering Protocols and Ethics
- Engineering Book Reviews
- Works of a Renowned Researcher
- Engineering Case Studies

In this issue, we have introuduced two new sections to appreciate our alumni and also our current students.

1. Learn from Our Alumnus
2. Skills of Our Student

Through these two sections, our aim is to introduce our readers to the immense potential of our Alumni and also our currently registered students. I hope, this issue of Elektron will also gain your attention and appreciation.

”

Dr. Muhammad Salman Fakhar
Editor In Chief (faculty)
Lecturer, Department of Electrical Engineering
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EDITOR IN CHIEF (STUDENT)

Muhammad Anas Baig

MAGAZINE DESIGNER

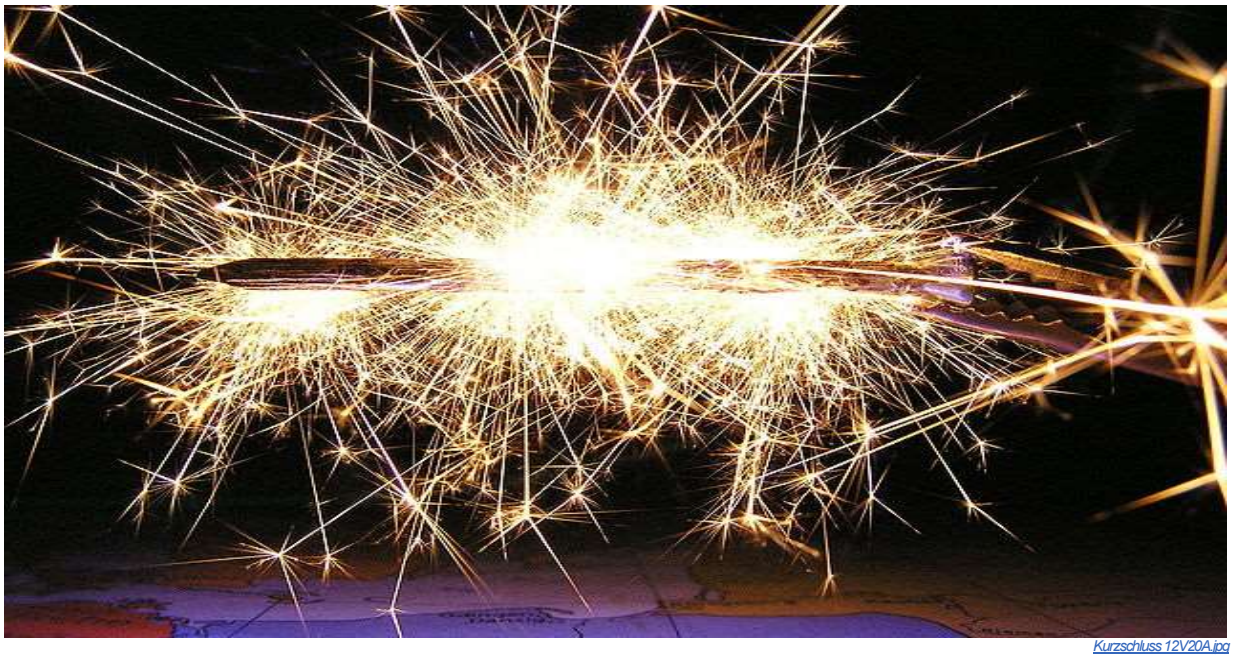
Aqsa Zahid

CONTENT

لَا الشَّمْسُ يَنۢبَغِى لَهَآ أَن تُدْرِكَ ٱلْقَمَرَ وَلَا ٱلَّيْلُ سَابِقُ ٱلنَّهَارِ ۚ
وَكُلٌّ فِى فَلَكٍ يَسْبَحُونَ ﴿٤٠﴾

It is not for the sun to catch up with the moon, nor does the night outrun the day. Each just swims along in its own orbit

القرأن [36:40]



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Electricity Theft & Asset Management

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ABSTRACT

This article has been written after research from several credible sources and it is intended to introduce students to distribution problems in Pakistan. The production of resources is important but without proper distribution, the resources are prone to be wasted. The same goes for electricity which is an energy source. In Pakistan, distribution problems are more prevalent than production problems. Two such notable issues are asset management and electricity theft [1]. Electricity theft causes the prevention of legal distribution where asset mismanagement includes the non-maintenance of assets of distribution networks such as distribution transformers. This study describes how these problems can be countered [2].

KEYWORDS

APMS-Asset Performance Management System, SEP Project-Sustainable Energy for Pakistan Project, HT-High Tension, LT-Low Tension, DT-Distribution Transformer, PT-Potential Transformer, CT-Current Transformer, MCCB-Moulded case circuit breaker, DISCOS-Distribution Companies

INTRODUCTION

Pakistan depends on IMF (International Monetary Fund) for financial needs. In return, IMF presents certain conditions which are to be fulfilled. One such condition was the proper management of assets and the insurance of proper electricity distribution. For this purpose, the SEP project was carried out in collaboration with the US-AID. The project has been implemented 1-2% and is dominantly done in LESCO. The proposed project includes APMS [1]. This project can be implemented within 5 years throughout Pakistan.

PROBLEM

In most countries the thermal losses i.e., losses due to technical problems or faults are often 6-8 %. In Pakistan, the percentage of such losses is alarmingly more than 35% and even 50% in DTs [2]. The prevalent cause is electricity theft, and it is a crime as the source should be distributed fairly. PESCO (Peshawar Electric Supply Company) and HESCO (Hyderabad Electric Supply Company) have become the bases for electricity theft. These companies are mentioned because in these areas not only some of the public is involved but the companies are heavily involved too. This is an obstacle in proper distribution [2].

Sometimes DTs or other components are badly damaged due to overcurrent, over-voltage, or other faults [3]. And practically such components are difficult to be repaired instantly in remote locations. This sometimes causes electricity to be cut off from areas. This is another distribution problem.

It would be much better if assets can be monitored and maintained remotely before they are damaged. This willreduce cost and ensure proper distribution. The SEP project consisting of APMS aims to solve these problems [1].

METHODOLOGY

The easiest explanation is that both problems are tackled via metering. APMS consists of a smart metering device, minimum 3G communication module, CTs, PTS, MCCB, relay and bus bars. The APMS is installed at HT (11 KV) after the power transformer. After APMS, feeders are present in the distribution networks after which DTs are present. At LT (415 V) another specialized meter is installed for each DT. The DTs distribute electricity to consumers (e.g., residential houses) where each consumer has a separate metering device. APMS has two functions:

1. It detects faults such as ground fault, overvoltage, under voltage, short circuit fault and overcurrent

through other problems such as financing are also present. Though, this project gives us hope for a better and more efficient distribution network. consumers whereas the APMS has total unit reading, which is the sum of the units of all the DTs [1].

2. The specialized meter of each DT has the sum of units that were distributed to individual

3. This follows that [1]:

   I. Units of DT(n)=$\sum_{i=1}^{n} Consumer(i)$
   II. Units of APMS$(calculated) = \sum_{n=1}^{k} DT(n)$
   III. But Units of APMS (detected) = Units of generation
   IV. When Units of APMS (detected) = Units of APMS (calculated), electricity theft is present. In such a case individual units will be observed on each DT and consumers to investigate where the theft took place [1].
   V. This metering will also ensure the verification of meter tampering and similar issues [1].

throughout the distribution network. The CTs and PTS and metering of APMS work in coordination with the entire distribution network. When such faults are detected, the relay installed in APMS trips the circuit breaker before damage occurs. Moreover, the CTs, PTs, metering and circuit breakers of APMS maintain the assets by assessing them remotely so that corrective action may be taken even before a problem occurs. In this way, proper distribution is ensured [1].

The methodology is part of the SEP Project by US-AID.

CONCLUSION

If SEP Project will be implemented completely, it will be an excellent way to solve distribution problems. But there are issues such as resistance from DISCOS among which dominant are HESCO and PESCO. The cause of this resistance is primarily the patronage system and corruption

REFERENCES

[1] Tetra Tech ES. Inc, “Asset Performance Management System (APMS) Specifications-Sustainable Energy for Pakistan (SEP) Project”, North Courthouse Road, Suite 600-Arlington, VA 2201, 2021

[2] Zahoor Hussain, Shahzad Memon, Razahussain Shah, Zulfiqar Ali Bhutto, Mahmoud Aljawarneh,”Methods and Techniques of Electricity Thieving in Pakistan”, Journal of Power and Energy Engineering, Vol.4 No.9,September 2016 Accessed from: https://www.scirp.org/journal/paperinformation.aspx?paperid=70365

[3] Distribution Transformer Failure| What Goes Wrong”, Available: https://www.engineeringworldchannel.com/transformer-failure/

Learn from Our Alumnus

Dr. Umar Tabraiz Shami

Dr. Umar Tabraiz Shami has been serving as an Associate Professor in the department of electrical engineering, UET Lahore. He has been one of the most famous and admired faculty members, very renowned among his students as a quality teacher, especially in the domain of power electronics. He has also been instructing an in-depth course in power electronic converters and advance power electronics. During the pandemic, he launched his YouTube channel in which he uploaded his high-quality lectures for the following courses.

- Semiconductor devices
- Electric Machinery Fundamentals
- Power Converters

We proudly present this online contribution of our great alumnus and faculty member.

A Glance at Dr. Shami's YouTube Channel

SemiConductor Device Class lecture 20	SemiConductor Device Class lecture 19	SemiConductor Device Class lecture 18	SemiConductor Device Class lecture 17
90 views • 1 year ago	70 views • 1 year ago	94 views • 1 year ago	98 views • 1 year ago

Channel Link: https://tinyurl.com/3dvccc3s

AC Filters Pak Matiari Lahore ±600kV HVDC Transmission Line

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ABSTRACT

In HVDC system to eliminate harmonics and to compensate reactive power AC filters are widely used. In this article basic knowledge and function of AC filters, Harmonics, Reactive power compensation strategies and filter types are discussed. In the later part, protection system of AC filters and its configuration is discussed which is implemented in 1st HVDC project in Pakistan (Matiari to Lahore ±600kV HVDC Transmission Line Project).

KEYWORDS

AC Filters in HVDC, Harmonics, Reactive power control strategies, protection system

INTRODUCTION

In HVDC system AC filter has very important role, which can prevent the AC-side harmonics effectively and compensate reactive power consumed by the converter station. Converter valves in HVDC system requires reactive power from its AC source, that may result drop of voltage in AC system, that's why AC filters used in AC yard provide reactive power to converter valves. Thyristors in converters also generate harmonics in AC system. Harmonics of low order are eliminated by converters itself and for high order harmonics, double-tuned filter and triple-tuned filter are widely used in HVDC system.

AC HARMONIC

Harmonics are AC voltages and currents with frequencies integer multiples of the fundamental frequency [1]. Harmonics are the result of non-linear loads that convert AC line voltage to DC. Because of nonlinear electronic switching devices harmonics flow into the electrical system, such as computer power supplies, variable frequency drives (VFDs) and energy-efficient lighting [2].

OPERATION CONDITIONS

In Pak Matiari HVDC project The Operation conditions are considered generally from three main aspects：

1. Present and future AC network
2. Different operation conditions for AC and DC systems
3. Assumptions for Harmonic Currents

CHARACTERISTIC HARMONICS

Characteristic harmonics generated by a 12-pulse converter are 12n±1, where n=1,2, 3.... The highest harmonic frequency is up to 49 times in the actual calculation. The harmonic components are obtained by Fourier decompositions of the current waveforms generated by the 12-pulse converter. Main factors that affect the harmonics characteristics are mentioned below

Uac	AC system voltage
Ud	DC voltage
dx	Converter transformer relative inductive voltage drop
α/γ	Firing angles
Id	DC current level

NON-CHARACTERISTIC HARMONICS

There are many factors that can influence the magnitude and the phases of harmonics. Some non-ideal inverter parameters and some parameters used in the calculation of characteristic harmonic currents are used in the calculation of non-characteristic harmonic currents. For non-characteristic harmonic calculations non-ideal situations needed to be considered which includes the following:

1. difference, dx in the phases
2. difference, dx between D- and Y-bridges
3. difference, Udio between D- and Y-bridges
4. difference, α/γ between the valves
5. negative sequence voltage fundamental voltage at an arbitrary phase angle.

For each DC current level, Monte Carlo simulations are carried out. Each simulation randomly selected different commutation reactance's, dx, firing angles and negative sequence voltage phase angles. Then the harmonic contents are obtained by Fourier decomposition of currents generated by 12-pulse converter. Finally, the maximum harmonic amplitude was selected as a calculation result from the simulations of the currents in the three phases. In these calculations maximum order of non-characteristic harmonic is the order of 50.

To obtain the worst case of AC harmonic impedance for each harmonic order, different operation modes and contingencies of AC network and different operation modes of DC transmission are considered. The worst case is obtained from all combinations of the above factors.

REACTIVE POWER COMPENSATION AND CONTROL STRATEGY

The reactive power generation is performed by the harmonic AC filter and shunt capacitor banks. The total reactive power compensation capacity provided by the filter in the design should be greater than the maximum reactive power consumption, generally considering the capacity of one sub-bank of filters as backup as shown in Tabel 1.

Table 1: Detail of Filter Banks at Lahore converter station

Type	Rated Power
ACF	150Mvar*8
SHC	160Mvar*8
Total	2480Mvar

REACTIVE POWER ABSORBING EQUIPMENT

The minimum reactive power absorption is calculated at the minimum power (400MW at Matiari/rectifier AC bus) for normal power direction, full DC voltage bipolar operation and with reduced firing angle(α)., we use the shunt reactors for this purpose at the converter stations.

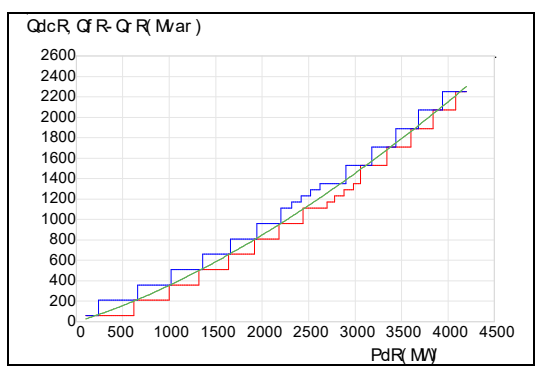
REACTIVE POWER CONTROL (RPC)

The Reactive Power Control (RPC) is an integral function provided in control system. The RPC switches in or switches out the AC filter / shunt capacitor banks to control the reactive power exchange with the AC system (Q Control) or to control the AC bus voltage (U Control). Switching order is initiated if the controlled quantity exceeds the limits of a pre-defined dead band. The harmonic filtering requirement is supervised by the functions "Min Filter" and "Abs Min Filter" provided in the RPC. To avoid over-voltage, two more functions, "Q Maximum" and "U Maximum", are implemented in the RPC which allow it to disconnect filters / shunt capacitors to minimize protection action on over-voltages. The different functions in RPC are assigned a set priority as follows:

1. AbsMinFilter
2. U_Maximum
3. Q_Maximum
4. MinFilter
5. Q_Control / U_Control

CONVERTER REACTIVE POWER CONTROL (QPC)

The Converter Reactive Power Control (QPC) uses increased firing angles to increase the reactive power absorption of the converter and thereby maintain the reactive power balance within the limits.



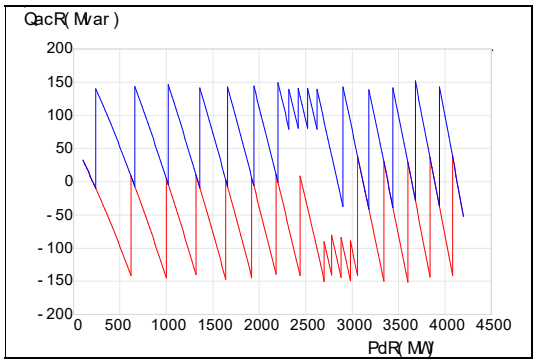


Figure 1: Reactive power exchange curve

AC FILTERS DESIGN

AC Filter Configuration in Lahore Converter Station

For Lahore converter station, the configuration is as follows:

Eight (8) HP12/24 filter sub-banks of 150 Mvar each

Eight (8) Shunt capacitor sub-banks for 160 Mvar each.

These sub-banks are in 4 banks. Characteristically, there are two types of filters, namely, double tuned high pass (DTHP) and high pass C-type (HP-C).[3] The circuit diagrams, including protective arresters, of these two principal types are shown in Figure 2 and Figure 3. A damping reactor is connected to the shunt capacitors as shown in Figure 4.

PROTECTION

Here describe overall design, basic principle, hardware and software configuration, function and implementation of AC filter and parallel capacitor protection of Matiari Converter Station and Lahore Converter Station of the ± 660 kV HVDC Project from Matiari to Lahore in Pakistan. The protection range of AC filter is AC filter bus, AC filter, parallel capacitor, and related areas.

REDUNDANCY FUNCTION

AC filter protection adopts dual redundant configuration. Each protection system is available for complete and required protective functions and spans the given areas, to protect the required equipment and areas entirely and accurately. Physically and electrically dual protection system is totally independent from the other two protection systems. The redundant configuration of protection ensures that each device or area protected under any operating condition can be protected properly. Any protection system that is disabled due to fault, maintenance or other reasons will not affect other protection systems and normal operation of the whole DC system.

BASIC DESIGN PRINCIPLE

The goal of the protection system is to quickly remove short -circuit fault or abnormal operating equipment in the system to prevent its damage to or interference with the normal operation of other parts of the system. The protection design has a full coverage without any omission. The configured protection has its own accurate protection algorithm, tripping and alarm criteria, and enough flexibility in software and hardware design. The selection of protection settings can satisfy the correct coordination between all AC filter protections in all operating states. AC filter system protection (including

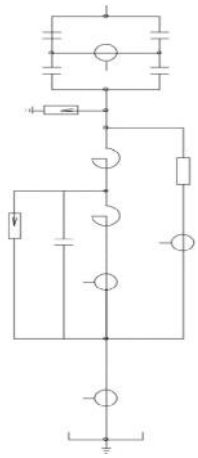


Figure 2: Circuit diagram for DTHP filter

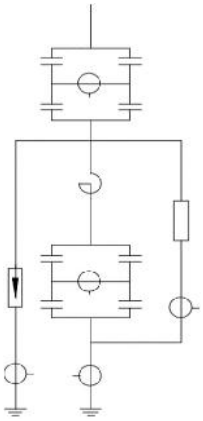


Figure 3: Circuit diagram for HP3 filter

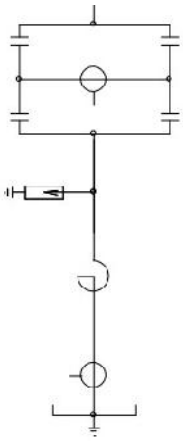


Figure 4: Shunt capacitor with damping reactor

hardware and software) uses advanced, standard microprocessor and digital signal processor. The filter sub-bank overhaul shall not affect normal operation of other devices of the filter bank in design, to facilitate maintenance and overhaul.

DESIGN PRINCIPLE

The protection system of AC filter is of the output logic of "start + protection". The hardware of start-up and protection is completely independent from the sampling and protection logic to output. Only when the start-up channel is open and the protection channel reaches the action setting, will output occur. The tripping outlets of AC filter protection are equipped with hard straps, so that the operators and maintenance personnel can clearly know the protection enabling/disabling condition, convenient for maintenance and test. Maintenance straps are provided for filter sub-bank and bank, and soft straps are set for the enabling/disabling of each protection function. Figure 4 shows protection scheme of AC filter banks and Figure 5 shows protection

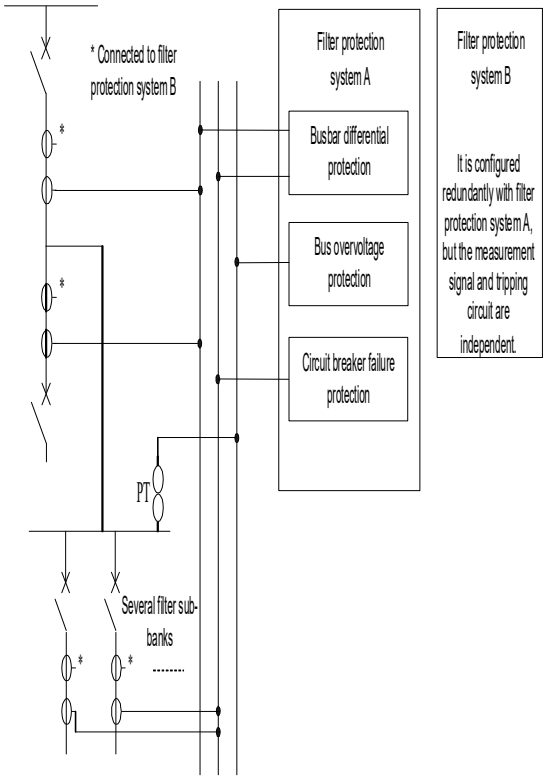


Figure 5: Protection Function Configuration of AC Filter Bank

CONCLUSION

In this article it is concluded how AC filter plays a very important role in the stabilization of power transmission in HVDC system. Functions and types of AC filters are discussed, and an overview is given of how different strategies are used in the HVDC system to control the reactive power and AC voltages.

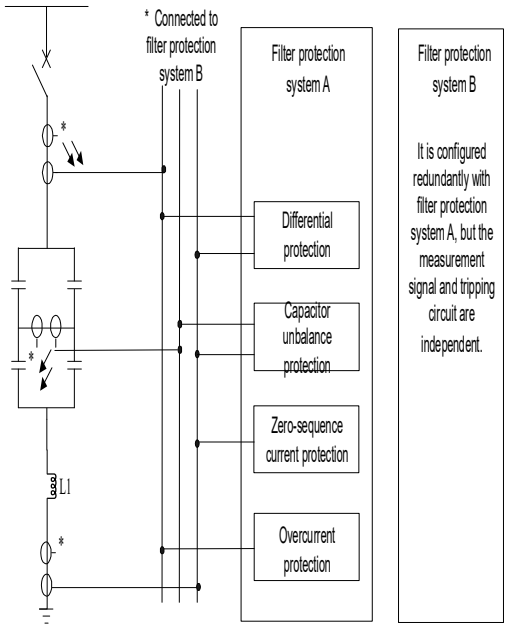


Figure 6: Protection Function Configuration of Parallel Capacitor

REFERENCES

[1] J. Arrillaga, D. Bradley and P. Bodger, Power System Harmonics, Chicester:John Wiley & Sons, 1985.

[2] Zhongming Du, "Study on reactive power compensation for the secondary HYDC project from Guizhou to Guangdong", *Power System Technology*, vol. 10, pp. 69-74, 2006.

[3] Yao Xiao, "Algorithm for parameters of triple tuned filter", *China Southern Power Grid Technology Research*, vol. 3, pp. 43-56, 2005.

[4] Guopei Wu, Zhen Ren and Zhuoyao Tang, "Characteristic analysis of double-tuned filter in HVDC systems", *Power System Technology*, vol. 8, pp. 32-34, 1999.

[5] Yao Xiao, "Algorithm for parameters of double tuned filter and third order filter", *Hu Bei Power*, vol. 2, pp. 5-6, 2000.

Skills of Our Student

Uroosa Baig

Ms. Uroosa Baig is currently a student of BSc (session 2020), in the Department of Electrical Engineering, UET Lahore. She started doing paintings using poster paints and acrylics, during her secondary school education and got appreciation from the former prime minister of AJK Chaudhry Abdul Majid. She has also ornamented the power systems simulation research lab of the Electrical Engineering Department by gifting her two precious paintings. We are very proud to present this wonderful artist of our department.

Samples of Uroosa's Artwork

Photo by Andreas Gücklhorn on Unsplash

Solar Panels & Future Prospects in Pakistan

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ABSTRACT:

Enhancing the use of solar energy is a crucial strategy for lowering greenhouse gas emissions and addressing global climate issues. A photovoltaic solar power system uses solar energy to create electricity, making it a renewable energy source. Notably, solar energy has the capacity to sufficiently meet the world's energy needs both now and in the future. This can be accomplished by efficient and ongoing research as well as technical innovation, which will provide greater solar energy collecting and utilization wherever there is enough sunlight.

POTENTIAL PROSPECTS:

The primary drivers of the solar panel market's growth are consumers' growing environmental consciousness, the availability of essential solar cells and module components like polysilicon and silver. Cost-effective renewable energy sources are increasingly preferred over traditional energy sources. Additionally, because solar panels don't burn fuel, they are two to three times more efficient than combustion technologies and produce no noise or pollution. The fast growth of sustainable energy practices is anticipated in Pakistan throughout the forecast period because of increased public awareness of energy efficiency. During the forecast period, it is anticipated that government programs like feed-in tariffs and subsidies for PV systems will increase regional capacity and boost demand for solar panels [1]. As the demand for energy resources has increased, it has brought more challenges in a developing nation, fighting many other problems, like Pakistan. Many national and multinational companies have taken advantage of these problems and have begun work on renewable and sustainable energy practices like windmills and primarily solar panels. The system's electricity can be utilized to boost an existing business or launch a new one, diversifying sources of income. As credit agreements are frequently used to fund solar panel systems, the revenue earned can aid in further recouping the initial expenditure. However, there is currently insufficient research demonstrating how much domestic solar panel systems are used for commercial reasons. Indeed, data on this is difficult to obtain. According to reference [2], although a survey can be made from the owners of the solar panels to understand the patterns of usage of solar panels, but unfortunately, the surveying is very limited and is also irrelevant of specifying their usage over time. Moreover, the survey data taken by utilizing the backward-looking approach does not serve the true purpose of surveying because such data collection has reporting and recollection biases.

UTILIZATION FOR BUSINESS PURPOSES:

Solar panels and their utilization for business purposes can be analysed by surveying the data obtained from customers at the time of purchase. This goes on in steps including the customer's likelihood of usage based on their hourly patterns of electricity demand in the first few months following the purchase and installation of the solar panel, they estimate that they will be daily using the system for business purposes [3]. To accomplish this, a machine learning algorithm is employed usually referred to as a classifier or supervised learning technique, that works by

linking the binary result of business/non-business use to a healthy number of statistical data that describe the patterns and variability of daily energy usage [4].

Thus, we can forecast each person's likelihood of using en ergy in a manner consistent with their line of work, which alters as time goes on and power consumption patterns c hange. After this, we analyse if the customers using solar panels for businesses can pay their loans and debts off or not to study the profitability of the business. The surging demand for electricity globally is primarily due to tendencies toward the usage of solar-driven appliances. PV installations, storage grids, and solar panels in the residential rooftop applications are expected to fuel the solar panel market growth thus, making the business quite profitable potentially. Fortunately, Pakistan has immense potential of harnessing solar energy, owing to geography. As an economically less developed country, Pakistan has limited electricity resources already, solar panel systems not only provide electricity for private consumption but creates opportunities for the generation of further income [5]. Businesses can generate their own efficient energy supply instead of using more expensive electricity from the grid by installing solar photovoltaic (PV) panels on existing assets like their roof, parking lot, or ground area. Thus, the bright future of solar panels is quite evident however, there are chances that the industry will not flourish to a great extent considering the initial cost that is to be borne by the consumers.

NEW SOLAR TECHNOLOGIES TO LOOK AROUND FOR:

I. Photovoltaic solar power systems designed to flo at on dams, reservoirs, and other bodies of water are referred to as "photovoltaics.
II. Building-integrated photovoltaics are integrated into the design of buildings as roofs, canopies, curtain walls, facades, and skylight systems. BIPV solar panels, in contrast to conventional solar PV panels, can enhance rather than detract from the aesthetics of a structure.
III. Solar skins are a cutting-edge PV technology that allows solar panel systems to incorporate unique designs. The bus window ad wraps and the solar skin technology are comparable.
IV. To overcome the issue of highway traffic noise in US, 48 states have built, Photovoltaic solar noise barriers (PVNB) for about 3,000 miles. [6]

These are few of the latest and most interesting innovations using solar power however, only time will tell how far and sustainable these practices prove to be.

REFERNCES

[1] P. D. Maycock and G. F. Wakefield, “Business analysis of solar photovoltaic energy conversion,” *IEEE,* 1998.

[2] S. Haider, “Solar energy potential in Pakistan,” *Journal of Renewable and Sustainable Energy,* 2012.

[3] Jones, Geoffre and L. Bouamane.

[4] H. Overholm, “Spreading the rooftop revolution: What policies enable solar-as-a-service,” *Energy Policy,* 2015.

[5] W. Christoph, L. Friederike, L. Yao, K.-K. Krisztina and K. Thomas, “Using solar panels for business purposes: Evidence based on high-frequency power usage data,” *Development Engineering,* 2021.

[6] J. Sandhu, “Which new solar panel technologies will revolutionize energy production?,” *SolarReviews,* 2022.

ALUMNI ACHIEVEMENT

TABRAIZ AHMED ALVI (MS-EE, PMP®)

Engr. Tabraiz Ahmed Alvi , 2007-2011-UET alumni of Electrical Engineering started his career in 2011 by teaching in University of Management and Technology Lahore, in School of Engineering ,Electrical Engineering department. He taught there for 3.5 years, designed many theory & lab courses as per HEC, PEC and international standards. Evaluated & supervised many final year projects related, his projects get ICT funding as well. After completing master's in electrical engineering in 2015 with A grade from UET Lahore, he moved to KSA in Power/Energy/EPC Sector.

Currently he is working as Project Manager in a Multi-national company which is a leading number in KSA energy market for delivery successful EPC/LMTK projects related to 380kV/132kV Grid Stations, OHTL, UGC, STATCOM, SOLAR , Distribution, Metering and list goes with many portfolios and clients like National Grid of Saudi Electricity Company & Saudi Aramco etc.

During his career in energy market from 2015, he worked from grass root level from position of QA/QC engineer, Site engineer, Project Engineer, Site Manager and finally as Project Manager. During progress of projects, he collaborated with many multinational companies like ABB, SIEMENS, HYUNDAI, HYSONG, ALFANAR, CEPCO, GE, ALSTOM, BEST, SEL for works related to GIS, MV SWGRs, POWER TRANSFORMERS, CAPACITOR BANKS, C&P Panels, Substation Automation System, SCADA, TELECOM works of Substation. In addition to electrical works of projects he managed civil & electro-mechanical works of projects like HVAC system, Fire Fighting & Security Systems. He delivered projects with thousands of safe man hours keeping strong focus on HSE at 5-star level.

He energized & closed many projects in Saudi Arabia including two Projects in Makkah & Madina as well. Below is the list his projects which he successfully energized, closed and handed over in KSA.

- 110/13.8kV KHALDIYA S/S (MADINA) , WOA-KSA
- 110/13.8kV MADINA HOUSING S/S (MADINA) , WOA-KSA
- 132/13.8kV TABUK HOUSING S/S (TABUK) , WOA-KSA
- 110/13.8kV OSAILA S/S (MAKKAH) , WOA-KSA
- 132/33/13.8kV SHARURAH Town PP1 Extension S/S, SOA-KSA
- 132/33/13.8kV SHARURAH Town PP1 S/S, SOA-KSA
- 132/33kV Reinforcement of SHARURAH PP2 S/S, SOA-KSA
- 132/33/13.8 kV KHAMIS WEST Sub-Station, SOA-KSA
- 132/33 kV MUDAYLIF Sub-Station SOA-KSA.
- 132/33 kV QILWAH Sub-Station SOA-KSA
- 132/33 kV Construction of BAREQ Sub-Station SOA-KSA
- 132/33 kV ALQUZ Sub-Station SOA-KSA
- 132/33/13.8 kV ISKAN AL-HISMA Sub-Station SOA-KSA
- 132/33 kV AL-SHAYBYN Sub-Station SOA-KSA
- 132/33 kV AL-EHSAR (SIFFA) Sub-Station SOA-KSA
- 132/13.8 kV ALQUNFUDAH Sub-Station, SOA-KSA,
- 132/13.8 kV BISHA Town Sub-Station, SOA-KSA.

ALUMNI ACHIEVEMENT

ESO/C. Malin - http://www.eso.org/public/images/ann12092a/

Dual Polarized Electromagnetic Band Gap Antenna

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ABSTRACT

This article focuses on designing a dual-polarized electromagnetic bandgap (EBG) antenna and an analysis of the main parameters. The antenna is excited by two ports to achieve dual linear polarization. A periodic array of patch cells is formed and fed by the microstrip line onto the ground plane through a slot cut and excitation for the second mode through the Microstrip-T feed line on the upper substrate's top layer**.** Using these two feeding ports achieves the dual linear polarization. The simulated antenna has a bandwidth of 33% with $|S_{11}|$< -10 dB and provides 55 dB to 69 dB interport isolation.

KEYWORDS

Electromagnetic bandgap, Aperture coupling, Microstrip-T feed, Interport isolation

INTRODUCTION

Because of its numerous benefits, the microstrip patch antenna is widely employed in communication systems. Because of its low profile, low cost, and high compatibility, patch antenna gained a lot of attention, despite being narrowband. Many methods for overcoming this challenge have been documented in [1] proximity coupled stacked microstrip patch antenna is used to achieve high bandwidth, Circular polarized aperture coupled antenna is designed in [2], metamaterial-based low-profile broadband mushroom antenna and an L-probe proximity feed antenna is presented in [3, 4], Over the last decades, the composite right/left handed (CRLH) transmission line have paved the ways to design antennas due to their unique characteristics [5, 6], Metamaterials based grid slotted patch antenna with aperture coupling is used for high bandwidth [7], To provide continuously beam steering and high bandwidth, a variety of leaky wave antennas are presented in [8-10].

Electromagnetic bandgap (EBG) Materials have grabbed the interest of microwave researchers in recent years. They are used in the microwave, millimetre wave devices, and antennas. EBG materials are made up of periodic arrays identified by the stop and passband [11]. These materials are widely used in microwave filters implementation. Due to the small size of microstrip patch antennas gained more popularity. However, there are some disadvantages of a microstrip patch antenna, which are narrowband and have low gain and directivity because of surface waves. The vital role that suppresses the surface waves increases antenna performance [12]. The interport isolation is an essential parameter in dual port antennas. When radiating elements and the feeding network are positioned on the same layer, the interport isolation is relatively high, so to achieve high interport isolation requires multilayers substrate. Because of its unique characteristics, the electromagnetic bandgap (EBG) has made considerable

improvements in radio frequency (RF) and microwave applications. To increase antenna performance, recent improvements in wireless communication systems need the use of increasingly modern electromagnetic materials. The idea of "metamaterials" got significant attention from researchers [13].

Designing a low-profile wideband, dual-polarization antenna is difficult since significant bandwidth needs a thick substrate with a low dielectric constant. A wideband, dual polarization, dual port grid slotted patch antenna with high interport isolation has been presented. Two types of feeding are employed in dual polarization. One method is to couple aperture into a ground plane parallel to the slot, precisely under the patch's centre. The antenna is also excited by the Microstrip-T feed line. The TM_{10} mode, as well as antiphase TM_{20} modes, are excited simultaneously.

ELECTROMAGNETIC BAND GAP ANTENNA

Figure 1. depicts the proposed EBG antenna's triple-layer construction, with the bottom and top substrates being Roggers RO4003C having dielectric constant 3.38, loss tangent of 0.0027, and corresponding thicknesses of h and h_o. The periodic array of patch cells ($P_L \times P_W$) is printed on the top surface of the upper substrate. There are six radiating slots because of two ports of width g_x. Table 1 lists the optimum dimensions of the proposed antenna. Dual modes have resonance frequencies of 5 GHz and 5.7 GHz, respectively. The dual band frequencies are calculated using the equations below. [7].

$$\frac{\beta_u p_x}{\pi} = \frac{1-2\beta_e \Delta L/\pi}{m_x}, \qquad \text{TM}_{10} \text{ mode} \tag{1}$$

$$\frac{\beta_u p_x}{\pi} = \frac{1-2\beta_e \Delta L/\pi}{m_x/2}, \qquad \text{TM}_{20} \text{ mode} \tag{2}$$

$$\beta_e = \frac{2\pi f\sqrt{\varepsilon_{re}}}{c} \tag{3}$$

$$\varepsilon_{re} = \frac{\varepsilon_r+1}{2} - \frac{\varepsilon_r-1}{2}\left(1+\frac{12h}{W_p}\right) \tag{4}$$

$$\frac{\Delta L}{h} = 0.412\,\frac{(\varepsilon_{re}+0.3)(W_p/h+0.262)}{(\varepsilon_{re}-0.258)(W_p/h+0.813)} \tag{5}$$

Where, c is the speed of light in vacuum, f is the operating frequency, β_e is the propagation constant in an extended region of the patch, and β_u is the propagation constant of the patch unit cell with length ΔL because of fringing.

SIMULATED RESULTS

The proposed EBG antenna is simulated, and S-Parameters are shown in Fig 2. The S_{11} curve is caused by aperture coupling feeding, and the antenna has resonance frequencies of 5.1 and 6.1 GHz. Due to aperture coupling, the antenna is vertical polarized while S_{22} is due to Microstrip-T feed line and antenna is horizontally polarized. S_{21} shows the mutual coupling between the ports and isolation between ports is reciprocal, so the interport isolation can easily be determined from the S_{21} parameter.

Figure 3 depicts the simulated antenna's radiation pattern. There are back lobes when the antenna is excited through port 1, and the gain is 7.1 dBi. The gain through port 2 is 5.5 dBi.

CONCLUSION

The electromagnetic bandgap antenna is presented in this article. The main focus is to design a dual linear polarized antenna which is achieved by using another microstrip-T feed line. The measured results in the future will verify the simulated results.

REFERENCES

[1] S. D. Targonski and D. M. Pozar, "Design of wideband circularly polarized aperture-coupled microstrip antennas," IEEE Transactions on Antennas and Propagation, vol. 41, no. 2, pp. 214–220, Feb. 1993. doi: 10.1109/8.214613.

[2] W. Liu, Z. N. Chen, and X. Qing, "Metamaterial-based low-profile broadband mushroom antenna," IEEE Transactions on Antennas and Propagation, vol. 62, no. 3, pp. 1165–1172, March. 2014. doi: 10.1109/TAP.2013.2293788.

[3] Yong-Xin Guo, Chi-Lun Mak, Kwai-Man Luk, and Kai-Fong Lee, "Analysis and design of L-probe proximity fed-patch antennas," IEEE Transactions on Antennas and Propagation, vol. 49, no. 2, pp. 145–149, Feb. 2001. doi: 10.1109/8.914252.

[4] G. V. Eleftheriades and K. G. Balmain, Negative-refraction metamaterials: Fundamental properties and applications, Hoboken, NJ, USA: J. Wiley, 2005, pp. 62–82.

[5] C. Caloz and T. Itoh, Electromagnetic metamaterials: Transmission Line theory and Microwave applications. Hoboken, NJ, USA: John Wiley & amp; Sons, 2006.

[6] W. Liu, Z. N. Chen, and X. Qing, "Metamaterial-based low-profile broadband aperture-coupled grid-slotted patch antenna," IEEE Transactions on Antennas and Propagation, vol. 63, no. 7, pp. 3325–3329, Jul. 2015. doi: 10.1109/TAP.2015.2429741.

[7] S. Lim, C. Caloz, and T. Itoh, "Metamaterial-based electronically controlled transmission-line structure

as a novel leaky-wave antenna with tunable radiation angle and beamwidth," IEEE Transactions on Microwave Theory and Techniques, vol. 53, no. 1, pp. 161–173, Jan. 2005. doi: 10.1109/TMTT.2004.839927.

[8] F. P. Casares-Miranda, C. Camacho-Penalosa, and C. Caloz, "High-gain active composite right/left-handed leaky-wave antenna," IEEE Transactions on Antennas and Propagation, vol. 54, no. 8, pp. 2292–2300, Aug. 2006. doi: 10.1109/TAP.2006.879210.

[9] Y. Dong and T. Itoh, "Composite right/left-handed substrate integrated waveguide and half mode substrate integrated waveguide leaky-wave structures," IEEE Transactions on Antennas and Propagation, vol. 59, no. 3, pp. 767–775, Mar. 2011. doi: 10.1109/TAP.2010.2103025.

[10] Nasimuddin, Zhi Ning Chen, and Xianming Qing, "Multilayered composite right/left-handed leaky-wave antenna with consistent gain," IEEE Transactions on Antennas and Propagation, vol. 60, no. 11, pp. 5056–5062, Nov. 2012. doi: 10.1109/TAP.2012.2207680.

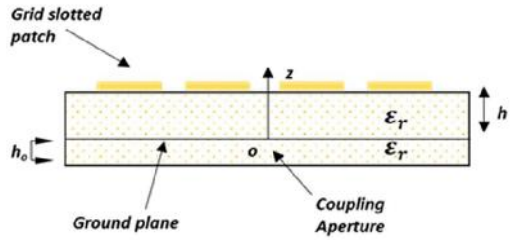
[11] Young Ju Lee, Junho Yeo, R. Mittra, and Wee Sang Park, "Application of electromagnetic bandgap (EBG) superstrates with controllable defects for a class of patch antennas as spatial angular filters," IEEE Transactions on Antennas and Propagation, vol. 53, no. 1, pp. 224–235, Jan. 2005. doi: 10.1109/TAP.2004.840521.

[12] Fan Yang and Y. Rahmat-Samii, "Applications of electromagnetic band-gap (EBG) structures in microwave antenna designs," 2002 3rd International Conference on Microwave and Millimeter Wave

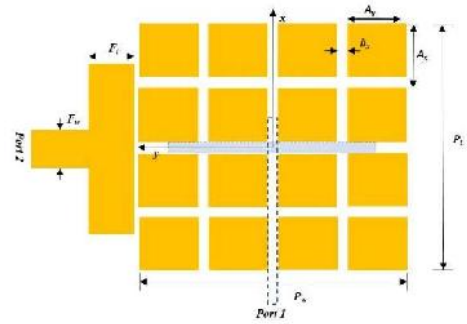
[13] Technology, 2002. Proceedings. ICMMT 2002., pp. 528–531, 2002. doi: 10.1109/ICMMT.2002.1187753.

[14] M. S. Alam, N. Misran, B. Yatim, and M. T. Islam, "Development of electromagnetic band gap structures in the perspective of microstrip antenna design," International Journal of Antennas and Propagation, vol. 2013, pp. 1–22, 2013. doi: 10.1155/2013/507158.

[15] A. A. Ibrahim and W. A. E. Ali, "High gain, wideband and low mutual coupling AMC-based millimeter wave MIMO antenna for 5G NR Networks," AEU - International Journal of Electronics and Communications, vol. 142, p. 153990, 2021. doi: 10.1016/j.aeue.2021.153990.



(a)



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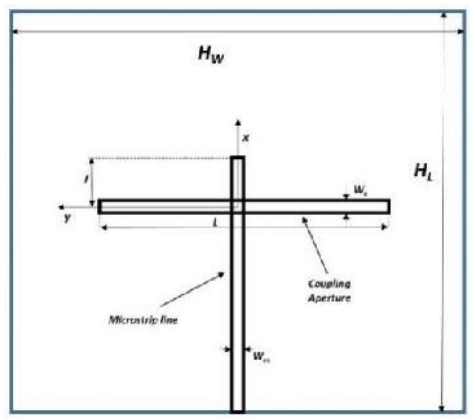


(c)

Figure 1. Structure of Antenna (a) Side view (b) Top View of EBG Antenna (c) Top View of Coupling Aperture

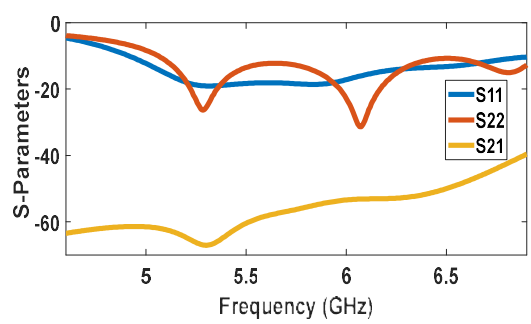


Figure 2: S-Parameters of Proposed

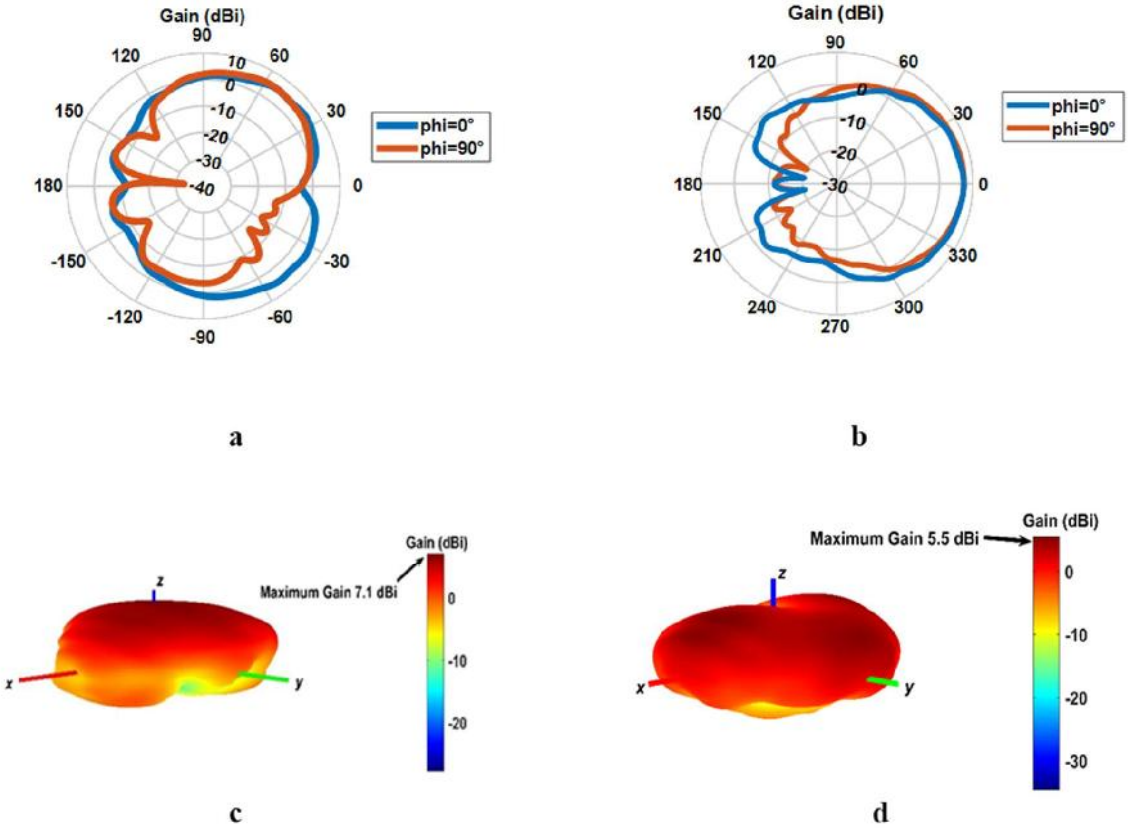


Figure 3: (a) The polar plot when the antenna is excited through port 1 (b) The polar plot when the antenna is excited through port 2 (c) The radiation pattern when the antenna is excited through port 1 (d) The radiation pattern when the antenna is excited through port 2

Table 1: Proposed antenna dimensions (unit mm)

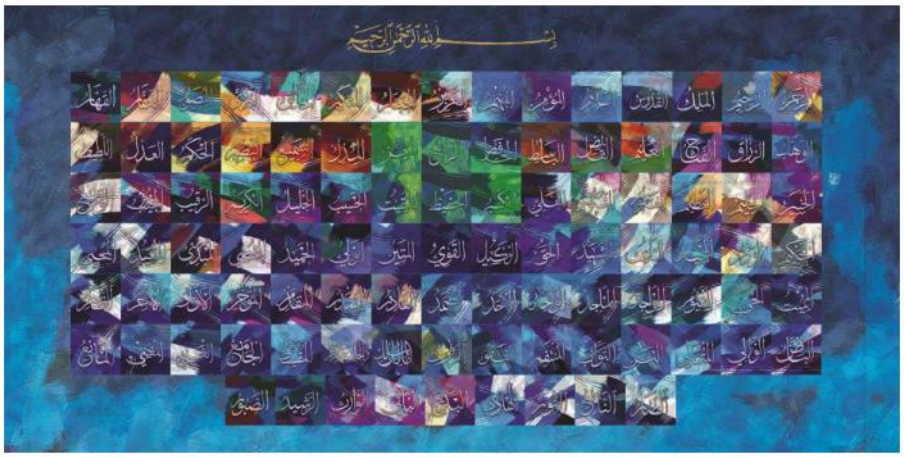
H_W	H_L	W_s	W_m	J	L	A_y	A_x
60	60	2	1.85	9	26	9	1
by	F_t	F_w	h	h_o	P_L	P_w	
1	7.5	7.5	3.25	0.81	39	39	

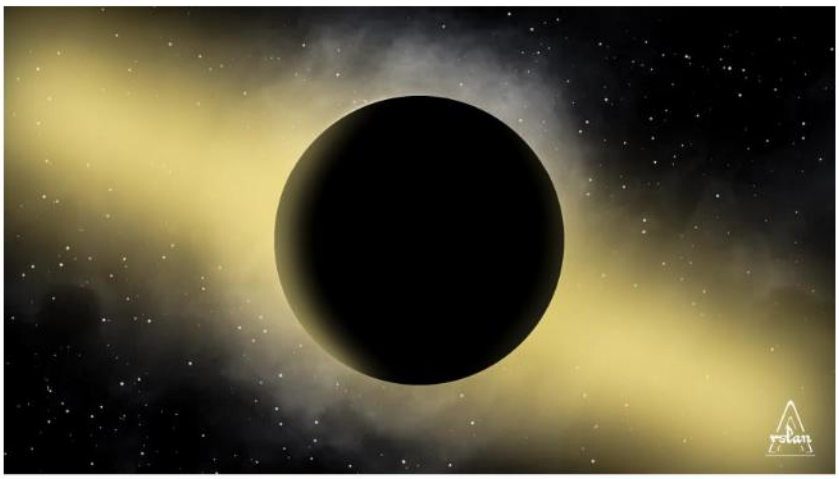
Skills of Our Student

Hafiz Arslan Khan

Mr. Hafiz Arslan Khan is currently a student of Master's (session 2021), in the Department of Electrical Engineering, UET Lahore. He started graphic designing during his early days of BSc. He has been Graphic Designing Head of the IET UET KSK Chapter and has organized several Graphic Designing Workshops for students and members of IET UET KSK. He has also worked as a Graphic Designer for other societies and in Sonic Tech as a Head Graphic Designer. We are very proud to present a great graphics designer of our department.

Samples of Arslan's Artwork





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A 2.4 GHz Switched Beam 2×2 Antenna Array with Single Switch as a Beam Controller

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ABSTRACT

This article presents a 2×2 series fed 2.4GHz patch antenna array capable of generating six switched beams by using six ports to achieve required magnitude and phase excitations. The main features of the proposed design are reduced complexity, size, and low cost. The switching performance is achieved by using six orthogonally placed quarter wave ($\lambda_g/4$) feeds. The proposed antenna is responsible of generating six switched beams when excited from corresponding ports. The antenna array has been simulated on FR4 epoxy substrate having a thickness 1.6mm with a loss tangent(δ) of 0.01 and a relative permittivity of 4.5.

KEYWORDS

Switched Beam, Antenna Array

INTRODUCTION

The beam switched phased array antennas play an important role in modern communication systems. By using them we can get a beam in required directions without moving the receiver, in this way, we get rid of the complexity of using multiple antennas and they can even provide more directivity, gain and bandwidth [1]. In our work, we've proposed a six-beam switching antenna array. Such type of smart antennas can enhance the stability and reliability by improving the signal to noise ratio (SNR) at receiver side even without expanding the transmitted power. Beam switching from an antenna can be achieved in multiple ways like, moving the antenna in circular direction to get the directivity in all directions, or we can use a beam switching controller such that it excites the ports with different phase excitations [2-6]. In our case, we are using a 2×2 elements and six ports feeding them one by one with the same excitation.

ANTENNA DESIGN & WORKING

The proposed 2×2 antenna array is shown in the fig. 1, and the corresponding dimensions have been listed in table 1. Each port can generate one beam according to excited phase, in this way, we get total of 6 beams in 6 different directions.

The proposed antenna array has been simulated on fr4 epoxy substrate with a thickness of 1.6mm, while each element has a 29mm×29mm length and width, respectively. When port 1 and 2 are excited with same phase, we'll get a vertical and horizontal directed beam. On the other hand, when excited from port 2 and 3, beams will be directed at ±30°horizontally, while with port 5 & 6 they'll be directed at ±30°vertically at boresight, or at

60°and 120°with respect to elevation plane, as shown in figure 2. [7,8]

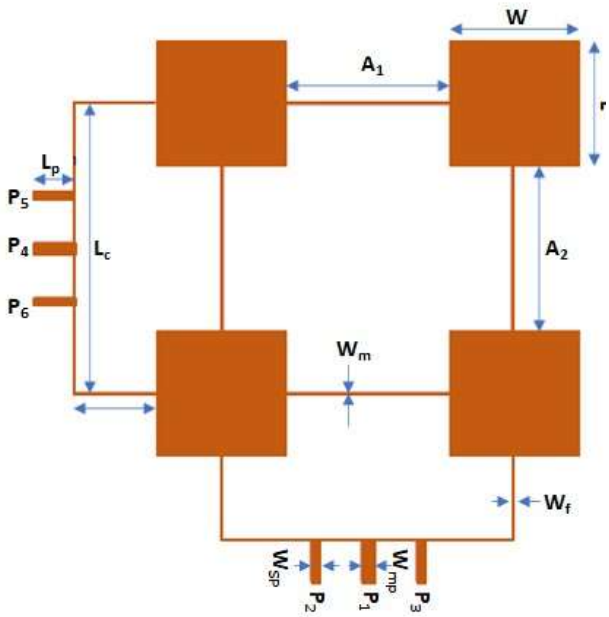


Figure 1: Proposed 2×2 antenna array design

Table 1: Proposed Antenna Dimensions (Unit-mm)			
L_c	66.2	A_1	38
L_p	9	A_2	38
W_m	1	L	29
W_f	0.8	Wmp	3.2
W	29	WSP	2.2

The max. gain and directivity achieved by simulated results are 6.1dB and 11.9dB respectively, so, our simulated antenna is high directive. The radiation pattern when ports 1, 2 and 3 are excited is shown in fig. 6 (a), (b) & (c) respectively. The proposed antenna can be used for circular polarization when excited with ports 1 and 4 with a phase difference of 90°. So, we can get both left hand and right-hand circular polarizations [4].

RESULTS AND DISCUSSION

We've achieved a high return loss of 20dB and coupling of -20dB. This isolation can be enhanced by increasing spacing between ports, but of course, we're bound to reduce the size, and our design meets the conditions as proposed [9].

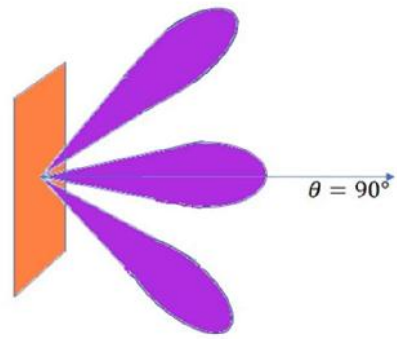


Figure 2: A generalized view of beam switching when fed horizontally from ports 4, 5 and 6 ports

The max. gain and directivity achieved by simulated results are 6.1dB and 11.9dB respectively, which shows that we have designed a high directional directive antenna.[5] The radiation pattern when ports 1, 2 and 3 are excited is shown in fig. 6 (a), (b) & (c) respectively.

The 3D radiation pattern has been shown in fig. 7, when ports 1, 2 and 3 are excited for a elevation angle (-180°≤Θ≤180°) of 0°, 30°and -30°. The proposed antenna array has achieved a 20dB isolation with a approx. 50MHz bandwidth at a resonant frequency of 2.4GHz.

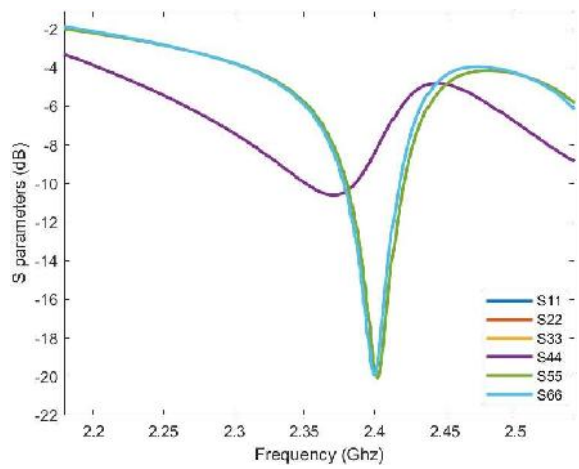


Figure 3: The simulated port matching (S_{11}, S_{22}, S_{33}, S_{44}, S_{55}, S_{66}) results for 2 × 2 series-fed 2.4 GHz patch antenna array

CONCLUSION

A 2.4GHz 2×2 six switched beam antenna was presented which demonstrates a simple planar beam-switching network based on the concept of switched beam capable of operating for indoor mobile wireless systems in the 2.4 GHz band having a bandwidth of 50 MHz. This antenna can be used for communication purpose to avoid multiple

antennas placed in different directions. Six beams have been generated without using conventional techniques like butler matrix. The simulated antenna can generate beams with low side lobe levels (SLL). The return loss is greater than 10dB as depicted in results.

ACKNOWLEDGMENT

The authors thank associate professor Dr. Haq Nawaz, UET, Lahore, for his invaluable communications and guidance during the course and work.

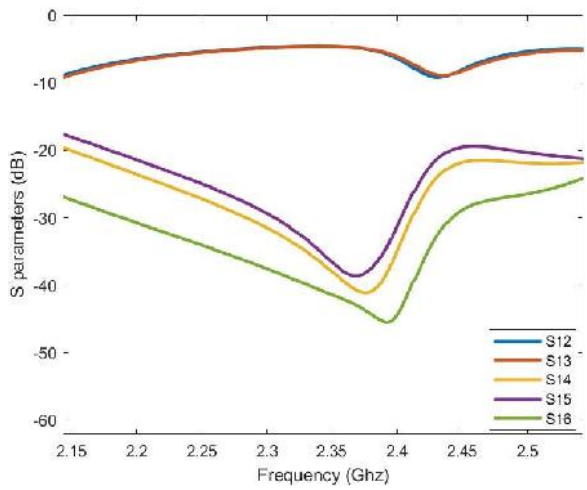


Figure 4: The simulated results of coupling The simulated results of coupling between ports

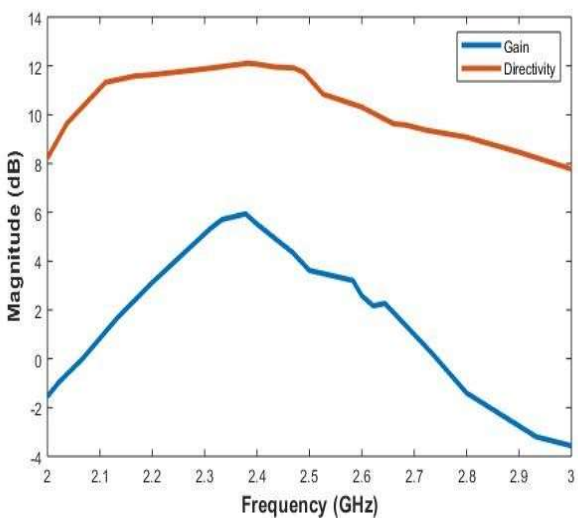
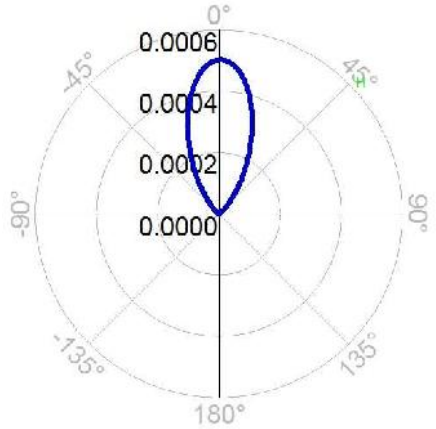
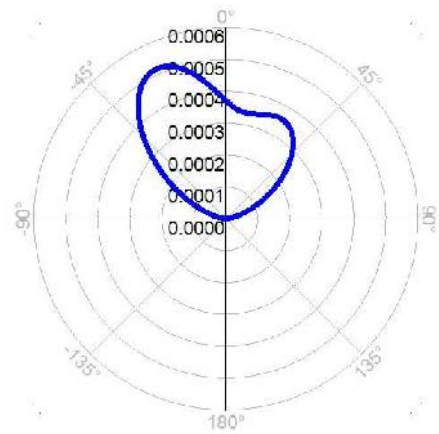


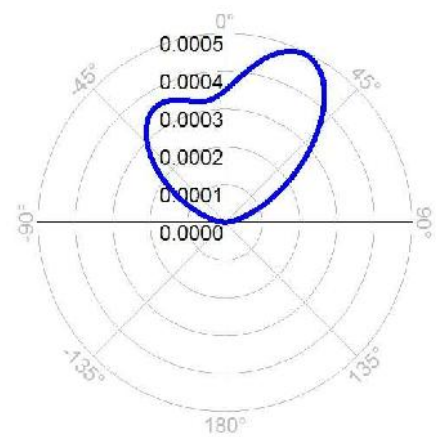
Figure 5: The simulated results for gain & directivity when port 3 is excited



(a)



(b)



(c)

Figure 6: The 2D radiation intensity pattern when (a) port 1, (b) port 2 & (c) port 3 are excited

REFERENCES

[1] Wang H, Zhang Z, Feng Z. A beam-switching antenna array with shaped radiation patterns. IEEE Antennas Wirel Propag Lett. 2012;11:818-821.

[2] Liao W, Chang S, Liu H, Li L, Hsieh C, Yao C. A beam switching array antenna for direction-of-arrival applications. Microw Opt Technol Lett. 2011;53:1601-1606.

[3] Fakoukakis FE, Diamantis SG, Orfanides AP, Kyriacou GA. Development of an adaptive and a switched beam smart antenna system for wireless communications. IEEE Prog Electromagn Res Symp. 2005;8

[4] Ojaroudiparchin N, Shen M, Pedersen GF. A 28 GHz FR-4 compatible phased array antenna for 5G mobile phone applications. 2015 Intern. Symp. on Antennas and Prop. 2015(4):1-4

[5] Imbert M, Romeu J, Jofre L, Papio A, De Flaviis F. Switched´ beam antenna array for 60 GHz WPAN applications. 2014 IEEE Antennas and Propagation Society Inter. Symp. (APSURSI). 2014:1672-1673

[6] Hong T, Song MZ, Liu Y. RF directional modulation technique using a switched antenna array for communication and direction-finding applications. Prog Electromagn Res. 2011;120: 195-213.

[7] Daly MP, Bernhard JT. Directional modulation technique for phased arrays. IEEE Trans Antennas Propag. 2009;57(9):26332640.

[8] Pal A, Mehta A, Mirshekar-Syahkal D, Nakano H. A twelve beam steering low-profile patch antenna with shorting vias for vehicular applications. IEEE Trans Antennas Propag. 2017;65 (8):3905-3912.

[9] Nair S, Ammann MJ. Reconfigurable antenna with elevation and azimuth beam switching. IEEE Antennas Wirel Propag Lett.

[10] 2010;9(4):367-370.

[11] Balanis, C.A. and Ioannides, P.I. (2003) Smart Antenna Systems for Mobile Communications. Ecole polytechnique f´ ed´ erale de´ Lausanne, Lausanne.

[12] Pal A, Mehta A, Mirshekar-Syahkal D, Nakano H. A twelve beam steering low-profile patch antenna with shorting vias for vehicular applications. IEEE Trans Antennas Propag. 2017;65 (8):3905-3912.

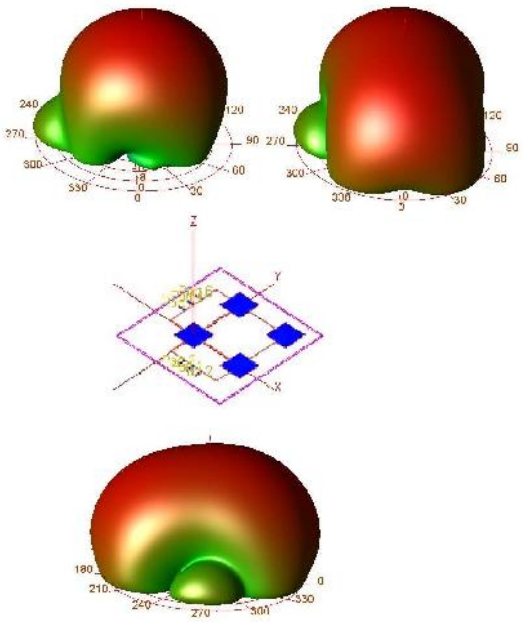


Figure 7: The simulated 3D radiation pattern of 2×2 antenna from each antenna element for different switching states (port 1, 2 and 3).

Learn from Our Alumnus

Fatima Abbas

Fatima Abbas, an alumnus of UET Lahore – (Session 2016), is currently providing her services as Graphics Designer at Discretelogix. She believes in learning and exploring different areas to evolve oneself to a better version. She has never hesitated to opt for courses out of her field, which has proved to be a great benefit for her. She has made an effort to make this journey easier for others by making a YouTube Channel where she is uploading courses, which students can learn and make passive income sources for themselves. Major Categories of her videos are:

1. Graphic Designing
2. Illustrations
3. Animations
4. UI UX Design

She is also planning to make tutorials of developing mobile applications and touch coding areas as these fields have great potential which students can choose as side profession and earn without putting continuous effort.

We proudly present this online contribution of our great alumnus.

A Glance at Fatima's YouTube Channel

Channel Link: https://www.youtube.com/c/XeroToOne/

وَتَرَى الْجِبَالَ تَحْسَبُهَا جَامِدَةً وَّهِيَ تَمُرُّ مَرَّ السَّحَابِ ۚ صُنْعَ اللّٰهِ الَّذِيْٓ اَتْقَنَ كُلَّ شَيْءٍ ۗ
اِنَّهٗ خَبِيْرٌۢ بِمَا تَفْعَلُوْنَ ﴿٨٨﴾

Now you see the mountains, thinking they are firmly fixed, but they are travelling just like clouds. That is the design of Allah, Who has perfected everything. Surely He is All-Aware of what you do.

القرأن [27:88]

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