Designing of an Equipment for Monitoring Electromagnetic Radiation

Ashok Kumar Kajla, Vaishali, Vivek Kumar

Abstract— **Every object on Earth emits radiation of one kind or other. Even human body emits radiations off electromagnetic in nature. But these radiations become a concern when human health comes at risk. Here's the question do electromagnetic radiation; more specifically radio frequency radiation really affect our health? This paper includes about a designing of a circuit which is helpful to measure such radiations which are coming from general household gadgets like laptop charger, internet modem, electric clock, cell phones etc. These radiations are categorized into non ionized radiation. International Commission on Non Ionized Radiation Protection (ICNIRP) sets guidelines for limiting exposure of magnetic field, electric field and electromagnetic field.**

Index Terms— **Specific Absorption Rate (SAR), Dosimety, Maximum Permissible Exposure (MPE), Radio Frequency (RF) wave, ICNIRP, Electromagnetic Field (EMF).**

I. Introduction

From mid of 1990 there is an explosive growth in the production of electronic gadgets like cell phones, laptop, refrigerator, television etc. At the current period the annual turnover of electronic gadgets in India is $40 billion only for Samsung Electronics. If it includes other companies then it crosses the mark of $400 billion easily. This turnover increases by the rate of 15% annually. Now there is a need to check the amounts of radiation coming from such a large number electronic gadgets are in appropriate level or not. To check this radiation level there is a need of a device which is easy to operate by human, less in cost and easy to available.

So there is a need to check whether the radiations come from these equipment affect human beings or not. This papers focus on non-ionized radiation which is a type of electromagnetic radiation that does not carry enough energy per quantum to ionized atoms or molecules. The energy level of such radiation is below 10eV. Non-ionized radiation consist ultraviolet (UV) radiation, visible rays, Infra-red radiation, Microwave, Radio frequency (RF) and static field. Mobile towers work on radio frequency so there is a need to calculate generated power in a specific region. This power is generated by electric and magnetic field which are radiated by these towers.

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Ashok Kumar Kajla, currently working as an Associate Professor and Head of the Department in Electronics and Communication Engineering, Arya Institute of Engineering and Technology, Jaipur, Rajasthan.

Vaishali, pursuing her Master of Technology in Digital Communication branch from Arya Institute of Engineering and Technology, Rajasthan Technical University, Jaipur.

Vivek Kumar, pursuing his Bachelor of Engineering in Electronics and Communication branch from Birla Institute of Technology, Mesra, Ranchi.

There are lots of guidelines issued by ICNIRP and IEEE for RF exposure in a particular frequency range. Specific Absorption Rate (SAR) is an important parameter that we have to calculate from this radiation. It represents the power absorbed for unit of mass and is given in watt for kilogram [W/kg]. In others words, represents the spatial average over all the exposed mass to radiations in frequencies great than 10MHz. SAR will depend upon thermal and non- thermal nature of system. For thermal nature, SAR is considered as being the variation in the time of the increase absorbed energy, dW in a volume element dV of mass dm, and density ρ [1].

It is observed that the SAR is directly proportional to the local increase of temperature, responsible for the thermal effect. For entire body exposition the average SAR can be considered, because in different part of the body as hands, fists, ankles and feet this value of SAR is different. The SAR will be the relation enters the total power absorbed by the body and its mass.

Second technique that is used to measure SAR is *RF densitometry* or *RF dosimetry* that belongs to enable compliance assessment. The IEEE C95.1-1999 Standard establishes the so called *maximum permissible exposure* (MPE) limits for free-space field quantities such as the *rms* electric and magnetic fields, and the corresponding equivalent power density. The rationale is that meeting MPE limits ensures SAR compliance as well, thus enabling the choice of simpler densitometry techniques rather than far more complex SAR measurements for compliance assessments [2].

According to telecommunication the whole EMF zone is categorized into three parts:

- Potential exposure to EMF is below the applicable limits for both controlled/occupational exposure and uncontrolled/general public exposure, it is known as Compliance zone.
- Potential exposure to EMF is below the applicable limits for controlled/occupational exposure but exceeds the applicable limits for uncontrolled/general public exposure, it is known as Occupational zone
- Potential exposure to EMF exceeds the applicable limits for both controlled/occupational exposure and uncontrolled/general public exposure, it is known as Exceedance zone

This technique mainly includes the non-thermal parameter that deals with Effective Isotropic Radiated Power (EIRP) [3].

II. IEEE SAFETY STANDARDS

On 3rd October 2005, according to IEEE Std. C95.1 "Standards for Safety Levels with Respect to Human

Exposure to Radio Frequency Electromagnetic Fields, 3kHz to 300 GHz". In 2001, the name International Committee on Electromagnetic Safety (ICES) was approved by the IEEE Standards Association Standards Board in place of SCC-28. Some observers and interested groups, including the Mobile Manufacturing Forum (MMF), have taken positions with respect to the International Commission on Nonionizing Radiation Protection (ICNIRP) guidelines and their relationship to the new IEEE standard.

According to recent *View Point* article, "New IEEE C95.1 Revision a Significant Step towards Global Standards Harmonisation," the two ranges asserted by MMF that encompass the frequencies used in mobile telecommunications and wireless devices and systems, the new IEEE Std C95.1 and the ICNIRP exposure guidelines are harmonized. The two frequency ranges mentioned are 100 kHz to 3 GHz with respect to SAR limits and 30 MHz to 100 GHz regarding external field intensity and power density limits for the general public. According to the new IEEE standard, in the frequency ranges from 100 kHz to 3 GHz of 0.08 W/kg averaged over the whole body is based on restricting heating of the body during whole body exposure which is to be applied when an RF safety program is not available. For the most of the part of body the new basic restriction for localised exposure is 2W/kg.

For frequencies between 3–100 GHz, the basic restrictions are the same as the derived limits of maximum permissible exposures (MPEs). The value of MPE is obtained by averaging over some specified time periods that vary 2.5–30 min for different frequencies. The frequency dependent MPE is a convenient metric for exposure assessment and can be used in determining whether an exposure complies with the basic SAR restrictions. They are referred to as action levels in the new IEEE standard and for incident power densities; they range from 1,000 W/m^2 at 100 kHz, to 10 W/m^2 at 100 GHz, with the lowest value of 2 W/m^2 between 30–400 MHz. Again, these values were established to protect against tissue heating.

III. IEEE RECOMMENDED PRACTICE FOR MEASUREMENTS AND COMPUTATIONS OF RADIO FREQUENCY ELECTROMAGNETIC FIELDS WITH RESPECT TO HUMAN EXPOSURE TO SUCH FIELDS (100 KHZ–300 GHZ)

There are some techniques and instruments which are specified to measure and compute the potentially hazardous electromagnetic fields (EM) both in the near field and the far field of electromagnetic sources. The specifications previously set forth in IEEE Std. C95.3™-1991 are extended and combined. These techniques and instruments include leakage and near-field measurements, a description of the concepts, techniques, and instruments that can be applied to the measurement of specific absorption rate (SAR) or the electric field strength in organisms (including humans) and phantoms exposed to electromagnetic fields.

In 1960, the American Standards Association approved the initiation of the Radiation Hazards Standards project under the co-sponsorship of the Department of the Navy and the Institute of Electrical and Electronics Engineers. Prior to 1988, C95 standards were developed by accredited standards committee C95, and submitted to ANSI for approval and issuance as ANSI C95 standards. Between 1988 and 1990, the committee was converted to Standards Coordinating Committee 28 under the sponsorship of the IEEE Standards Board, and in 2001, this committee is also known as the International Committee on Electromagnetic Safety (ICES). In accordance with policies of the IEEE, C95 standards will be issued and developed as IEEE standards, as well as being submitted to ANSI for recognition.

IV. SCOPE

The present scope of ICES:

"Development of standards for the safe use of electromagnetic energy in the range of 0 Hz–300 GHz relative to the potential hazards of exposure of man, volatile materials, and explosive devices to such energy. The committee does not address infrared, visible, ultraviolet, or ionizing radiation. The committee will coordinate with other committees whose scopes are contiguous with ICES."

IEEE International Committee on Electromagnetic Safety is responsible for this recommended practice.

There are five subcommittees concerned with the following:

— I Techniques, Procedures, Instrumentation, and Computation

— II Terminology, Units of Measurements and Hazard Communication

— III Safety Levels with Respect to Human Exposure, 0–3 kHz

— IV Safety Levels with Respect to Human Exposure, 3 kHz–300 GHz

— V Safety Levels with Respect to Electro-Explosive Devices

Current versions are as follows:

IEEE Std C95.1™,1999 edition, IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz–300 GHz.

IEEE Std C95.2™-1999 IEEE Standard for Radio Frequency Energy and Current Flow Symbols (Supersedes ANSI C95.2-1982) IEEE Std C95.3-2002, IEEE Recommended Practice for Measurements and Computations of Radio Frequency Electromagnetic Fields with Respect to Human Exposure to such Fields, 100 kHz–300 GHz. (Supersedes IEEE Std. C95.3-1991.) IEEE Std. C95.4-2002, IEEE Recommended Practice for Determining Safe Distances from Radio Frequency Transmitting Antennas When Using Electric Blasting Caps During Explosive Operations. IEEE Std. 1460™-1996, IEEE Guides for the Measurement of Quasi-Static Magnetic and Electric Fields [2].

Subcommittee 1 was originally organized on 7 April 1960, to establish specifications for techniques and instrumentation used in evaluating potentially hazardous radio frequency (RF) radiation. In June 1985 the scope was clarified and the purpose was extended to establish specifications for techniques and instrumentation to be used in evaluating potential RF hazards to mankind from exposure to manmade sources of EM radiation or from the exposure of volatile materials and explosive devices to such radiation. The subcommittee does not address infrared, visible, ultraviolet, or ionizing radiation.

V. FREQUENCY RANGE

Approximately used frequency lie between from 100 KHz to 100 GHz. In general for measurement of both electric field and magnetic field, techniques and instrumentation developed for the frequency range used below 900 MHz. To evaluate potentially hazardous near-field situations at frequencies below a few hundred M, both electric and the magnetic field strengths are required respectively. A series of commercially available instruments has been developed for this purpose. Specific Absorption Rate can be measured using RF-transparent temperature sensors from the frequency range of 100 kHz to about 6 GHz and can be measured in phantoms using E-field probes over the frequency range of 300 MHz to about 3 GHz. Above about 6 GHz, absorption is confined to the surface of a biological system and thermo graphic cameras can be used to measure the surface SAR up to about 300 GHz [6].

VI. PARAMETERS OR QUANTITIES THAT ARE TO BE MEASURED

For measurements performed at distances from the source greater than a a^2 / λ (a is the largest dimension of the effective aperture of the source, and λ is the wavelength), power density is usually a meaningful quantity that has been widely adopted as a hazard indicator. Practically this rule is applied for the frequencies above than 300 MHz. Except in cases of stationary, single-component, plane-wave fields of known polarization, the power density is difficult to determine. Till today, no existing instrument actually measures power density directly; all measure one or more components of the electric field strength (E), or the magnetic field strength (H), or both, and then infer an equivalent power density from the far-field, plane-wave relationship $S = |E|^2 /(120\pi)$ or $120\pi\ |H|^2$, where E is the rms electric field strength in volts per meter, S is the power density in watts per meter squared and H is the rms magnetic field strength in amperes per meter. The field configuration can be extremely complex and one must measure both E and H separately which is mainly applied in the case of near field region and where scattering, reflection and multiple sources are present. Measurements will be required in the reactive or radiating near-field regions where reactive fields or standing waves exist. In case of general conditions, the time-averaged power density is not a reliable hazard indicator, even if practical probes could be developed for its measurement, and in case complex conditions, induced current (for frequencies below about 100 MHz) and SAR (for frequencies between about 100 kHz and about 6 GHz) are the more meaningful quantities.

VII. CURRENT LIMITS OF RADIATION LEVEL

These are the following limits which are considered by ICNIRP and also accepted by Telecommunication Engineering Center (TEC), India [3].

Table-1: Standard limits of Radiation level given by ICNIRP

Type of Exposure	Frequency range	Electric field strength (V/m)	Magnetic field Strength (A/m)	Equivalent Plane Wave Power Density Seq (W/m^2)
General Public	400-2000 MHz	**$0.434f^{½}$**	**$0.0011f^{½}$**	**f/2000**
	2-300 GHz	**19.29**	**0.05**	**1**

VIII. ABOUT THE DEVICE

This radiation meter is compact in nature and is used to monitor low frequency electromagnetic radiation. All functions and parameters are set already in the basic unit of the device. The PC software including with the device are "Proteus version 7.6" and "Keil µVision4" software to burn the microcontroller. It also includes the antenna which is used to measure non directional radiations. Readings are generally applicable for near field regions only.

IX. CIRCUIT DIAGRAM

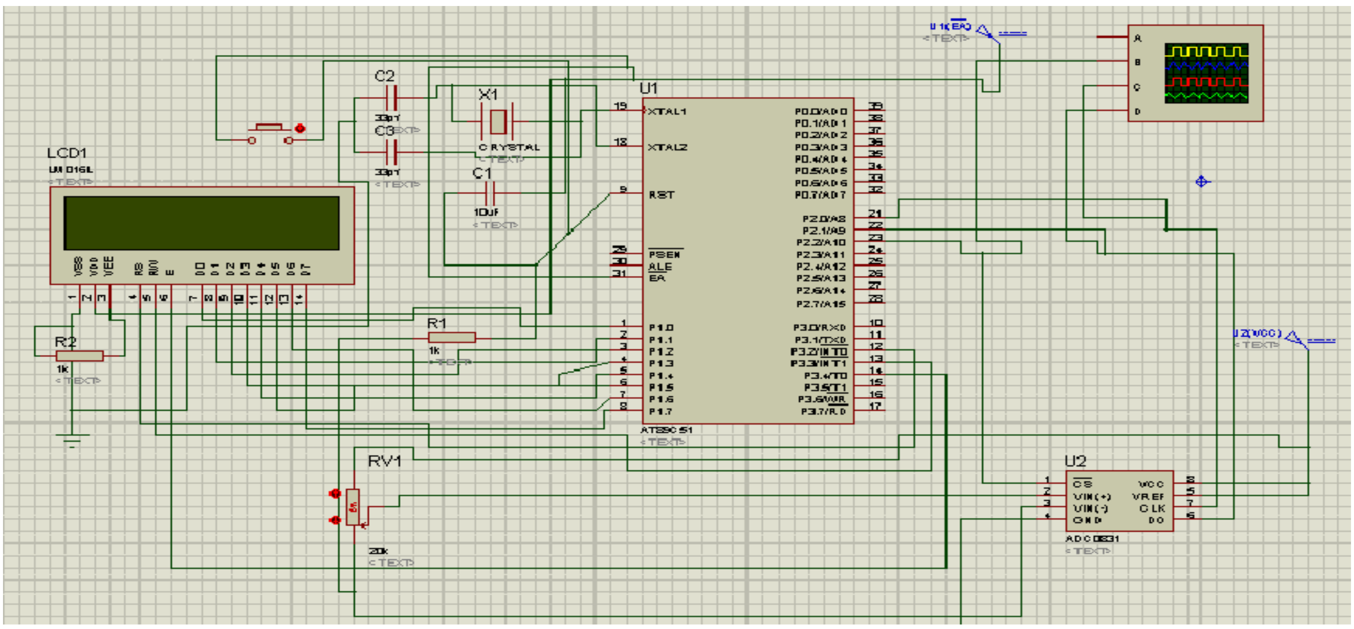


Fig. 1. Circuit Diagram of the equipment by using Software Proteus version 7.6

home, offices, field etc. from graph we can easily check the radiation level of such devices.

NOTE- These values are highly dependable upon frequency also. Generally the readings are taken under low frequency or such devices can be operated on low frequency region. If frequency increases, the value of filter network which is used in the circuit is also increases which also affect the cost of the system.

Graphical analysis of above readings is shown as follows:

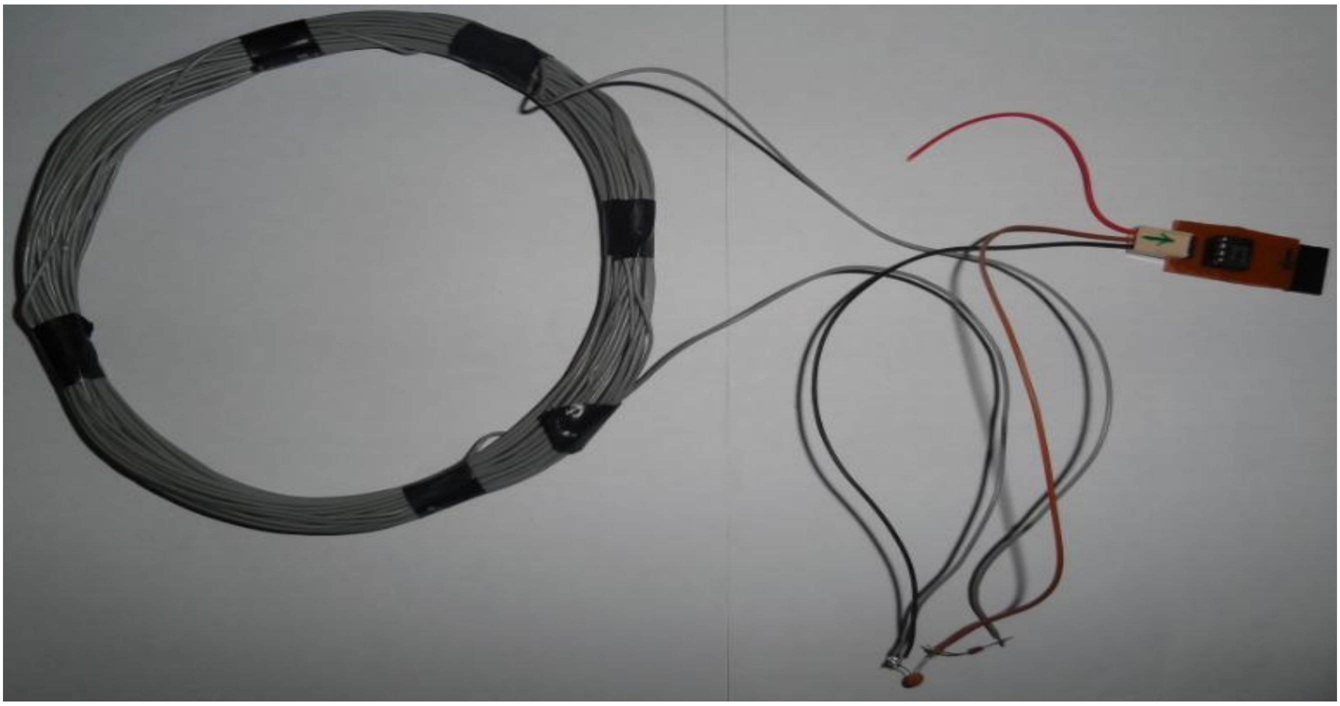


Fig. 2. Antenna receptor for electromagnetic radiation

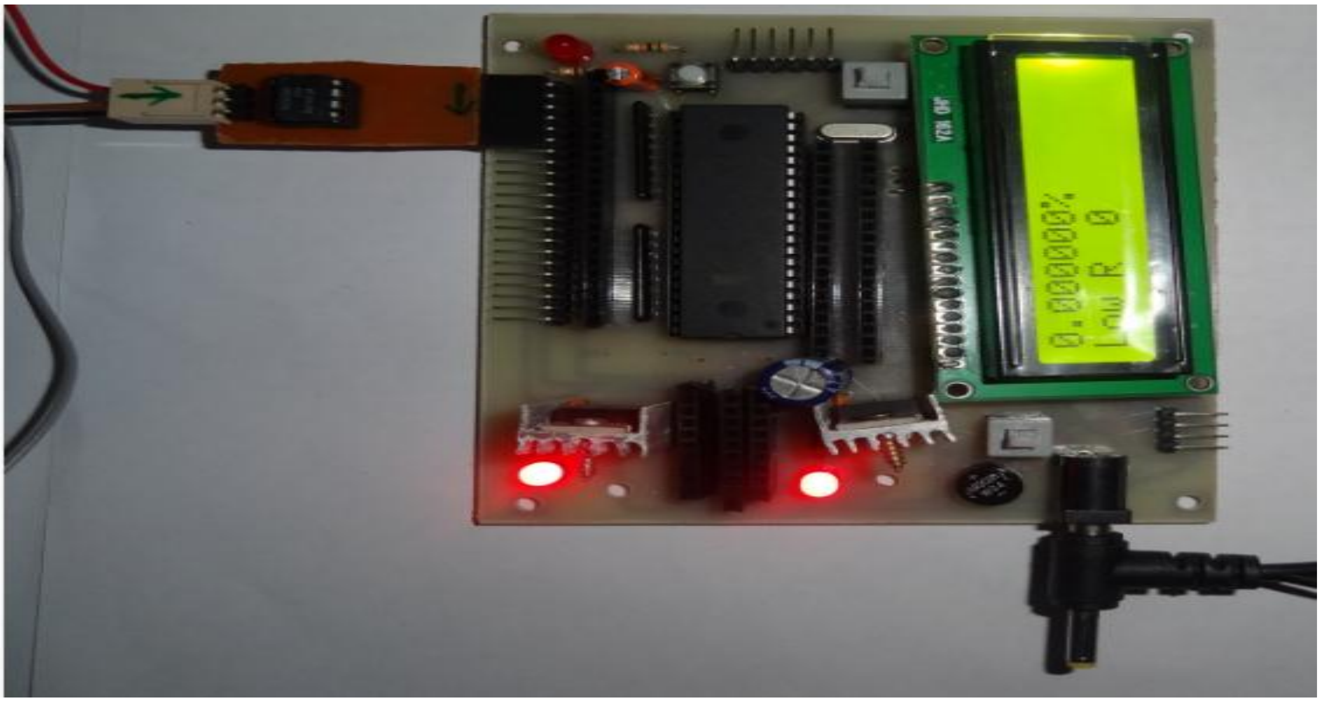


Fig. 3. Circuit diagram of device to monitor radiation level

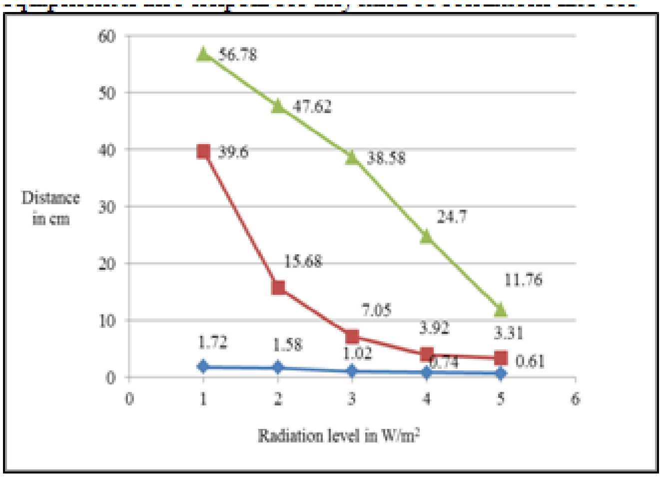
X. RESULT

Readings of some of the household devices are taken as follows:

Table-2: Radiation level of some household devices which shows the Variation with respect to distance

S. No.	Name of Device		Distance in cm				
			5	10	15	20	25
1	Cell phone	**Radiation level in W/m²**	1.72	1.58	1.02	0.74	0.61
2	AC to DC adaptor (12V, 2A)		39.6	15.7	7.05	3.92	3.31
3	CFL (15W, 240 V)		56.8	47.6	38.6	24.7	11.7

In above table the general house hold devices are taken which are very frequently used. Now these readings may be helpful for the humans for taking appropriate precautions and maintain a limited distance when operating such devices. This equipment is also helpful for any kind of conditions like for



Where, shows readings taken from cell phone,
Shows reading taken from AC to DC adaptor
Shows readings taken from CFL

Fig. 4. Graphical representation between distance in centimetre and radiation level in W/m²

XI CONCLUSION

According to telecom regularities and other committees which are working on non- ionized radiation, the value of Specific Absorption rate is less than 2 W/m^2. Now, we have to check time to time weather companies follow these rules or design their equipment as per policy. From above readings, it is clearly shown that for a particular brand it is less than as per given level. But as for precaution humans must use headphone when they are using cell phone for long term talking that does not affect the health. As per graphical representation when distance increases the value of radiation level decreases. This device is helpful for humans to monitor the value of electromagnetic radiation from not only for cell phones but for other electronic gadgets also.

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Ashok Kumar Kajla , received the B.E. degree from M.B.M. college, Jodhpur in Electronics and Communication and M.E. in digital communication from Arya College of Engineering and Information Technology, Jaipur and Ph.D.(Pursuing) from JNIT University, Jaipur, Rajasthan.
He is currently working as an Associate Professor and Head of the Department in Electronics and Communication Engineering, Arya Institute of Engineering and Technology, Jaipur, Rajasthan respectively. He has authored in five International journals and in eight National journals and also

attended one International conference respectively. He is reviewer of various IEEE conferences. His interest and research studies are focused to the wireless communication and optical fibre from field measurement, numerical analysis and software tools for educational purposes.

Vaishali, received Bachelor of Technology degree in Electronics and Communication branch with honours from Arya Institute of Engineering and Technology, Rajasthan Technical University, Jaipur. She is currently pursuing her Master of Technology in Digital Communication branch from Arya Institute of Engineering and Technology, Rajasthan Technical University, Jaipur.

Her areas of interests are wireless communication, mobile communication and telecommunication. Her research studies deal with analytical, mathematical and numerical approaches, field measurement and their solutions related with the field of current cellular system.

Vivek Kumar is currently an undergraduate student who is pursuing his Bachelor of Engineering in Electronics and Communication branch from Birla Institute of Technology, Mesra, Ranchi.

His areas of interests are Wireless communication, Telecommunication, Microprocessor and Microcontroller. His research studies are focused in forming various kinds of circuit devices which are operating on microcontroller coding and are helpful for humans.