Webology, Volume 18, Number 4, 2021
ISSN: 1735-188X
DOI: 10.29121/WEB/V18I4/129

An Anlysis of light and electromagnetic spectrum in spectral range system

Durgaprasad Gangodkar[1], Devesh Pratap Singh[2], Sandeep Sunori[3]

[1]Department of Computer Science & Engineering,Graphic Era Deemed to be University, Dehradun, Uttarakhand India
[2]Department of Computer Science & Engineering,Graphic Era Deemed to be University, Dehradun, Uttarakhand India
[3]Department of Electronics & Communication Engineering, Graphic Era Deemed to be University, Dehradun, Uttarakhand India

ABSTRACT
The electromagnetic spectrum is defined as the energy flowing at the speed of light in all places. through a physical medium or empty space. It is a type of magnetic and electric field. Radio waves, visible light and gamma rays are some examples of electromagnetic wavelength. The experimental study was then performed, accounting for numerous atmospheric variables, in both a lab and in real-world settings. It also depicts the range of spectral energy form ground level to excited level. The field of energy level differs according to the wavelength of the spectrum. This study investigates, conceptually and practically, how atmospheric variables affect the intensity of absorbed radiation. This paper mainly focus on the frequencies and wavelength of the free space or material medium objects, and the applicability of the electromagnetic spectrum. The optical light with a wavelength of around 10 m has better transmission properties than near-infrared wavelengths under conditions of limited visibility (such as light rain and fogs). Analytical research yielded the same conclusion.

Keywords: Electromagnetic spectrum, light stimulus, electromagnetic radiations, free spacequantum, IR photodetector; wireless communication, cascade laser.

INTRODUCTION
In history there is an adorable change in technological movements. Wireless technology paly a vital role in the rise of technology. In comparison to 30 years ago, the proliferation of digital networks and devices has been significantly faster. They will likely continue to play a significant role in modern society for some time to come.

Since there is a shortage of radio frequency spectrum, it is necessary to consider other wireless technology possibilities at higher frequencies of electromagnetic radiation. OWC is the employment of optical particles in the visible, infrared, and ultraviolet (UV) bands of unsupervised propagation media. Fog, ship flags, lighthouse flames, and telegraph signals were all employed in the past [1]. Since the beginning of time, people have communicated over great distances using sunlight. The ancient Romans are credited with using sunlight for transmission for the first time when they used their polished shields to reflect the light during battles [2].

Webology, Volume 18, Number 4, 2021
ISSN: 1735-188X
DOI: 10.29121/WEB/V18I4/129

Although the heliograph was intended for geodetic survey, military applications predominated in the late 19th and early 20th centuries. The photophone, which is generally referred to be the first mobile phone system, was created by Alexander Graham Bell in 1880. It was based on the transmitter's mirror experiencing vibrations brought on by speech. The vibrations were reflected and radiated by the sun, and at the receiver they were transformed back into sound. "The biggest advance had ever been devised, greater than the phone," said Bell of the photophone" even though it was never commercialized [3].

OWC uses lasers or LEDs as transmitters in the contemporary sense. In 1962, MIT Lincoln Labs developed an experimental OWC link that could send TV signals 30 miles away using a light-emitting GaAs diode. OWC was intended to be an important laser deployment location after the invention of the laser, and numerous experiments 2 were carried out. Just a few months after the initial public disclosure of a functioning laser in July 1960, Bell Labs scientists utilised a ruby laser to broadcast signals 25 kilometres away [5].

A comprehensive list of OWC tests using various lasers and modulation techniques that were conducted between 1960 and 1970 can be found in [6]. Results were frequently subpar because of significant laser beam divergence and inability to handle air disturbances. Low-loss fibre optics, which first appeared in the 1970s, quickly replaced OWC systems as the go-to technology for long-distance optical signals. Over the years, OWC has primarily been used for covert military purposes [7], [8], and aeronautical engineering projects like inter-satellite and deep-space links1. With the exception of IrDA, which has emerged as a very effective and high-quality short-range transmission option, OWC's mainstream market penetration has been modest.

Investigated were two optical lines with lengths of 1.5 and 10 m. the actual bit error rate considered when evaluating transmission quality. A wavelength of about 10 m was found to have superior transmission properties in the case of restricted sight as contrasted to near-infrared waves. Similar situations involving the determination of acceptable qualities of the sources of signals being supplied across noisy distribution channels in order to maximise signal quality also occur in conventional transmission channels.

Electromagnetic spectrum and light

Figure 1 shows the detecting module of the electromagnetic spectrum
It's a revised form of VIGO System S.A.'s VPAC line of modules..

Figure 1: Electromagnetic spectrum and light

Webology, Volume 18, Number 4, 2021
ISSN: 1735-188X
DOI: 10.29121/WEB/V18I4/129

The electromagnetic spectrum can be described in terms of frequencies, wavelengths, and energy, as shown in Fig. 1. For modern radio transmission, the electromagnetic spectrum wavelengths extend to short-wavelength gamma radiations. An infrared photons sensor, a four-stage TEC with a temperature controller, a wideband preamplifier, EMIs, and a small fan that disperses heat from the cooler are all included in the module's standard housing. In addition, a TEC regulator and a DC power source are included in this set. A schematic representation of this module is shown in Figure 2.

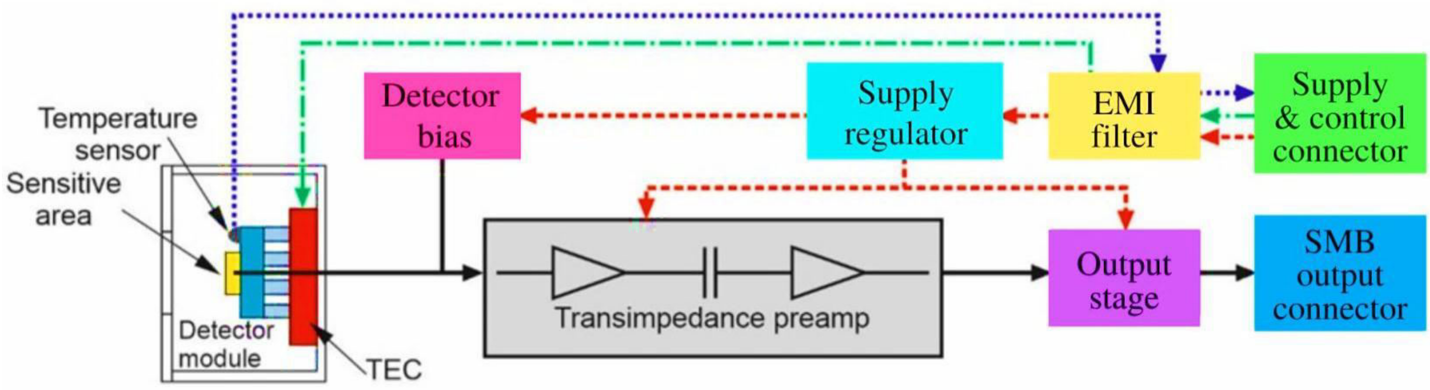

Figure 2: The detection module's block diagram.

The abbreviations TEC, EMI, and SBC stand for thermoelectric cooler, electromagnetic noise filter, and subminiature version B connector, respectively (SMB).

A wideband trans-impedance amplifier that operates at a frequency of roughly 1 GHz reads the current signal from the HgCdTe photodiode. Additionally, the detector receives a 200 mV continuous reverse power source from this amplifier. In a broad frequency band, this lays the groundwork for reaching the best practicable signal-to-noise ratio. The most significant characteristics of this module, which is designed for a wavelength of 10 m, are listed in Table 1. Additional explanations and research investigations on the detecting modules shown in Figure 2 are available.

Table 1. The detection module's basic characteristics were designed for a wavelength range of 10 m [9].

Parameter	**Transimpedance @RLOAD = 50 Ω**	**Output resistance**	**Gain bandwidth**	**Noise voltage**	**Voltage sensitivity**	**Detectivity**
Unit	V/A	Ω	MHz	nV/Hz1/2	V/W	cmHz1/2/W
Value	14.5 × 103	60	0.001÷770	80	2.4 × 105	4 × 1010

Webology, Volume 18, Number 4, 2021
ISSN: 1735-188X
DOI: 10.29121/WEB/V18I4/129

The LDD 400 module was in charge of operating the laser. It has an output that makes it possible to monitor the amount of current flowing through the laser structure. A low-impedance tape was used to link the LDD 400 system to the LLH laser head. The LDD needed to be powered by an outside generator. The temperature range of the QC laser was controlled using a TCU 200 controller. A PT100 temperature sensor incorporated into the head was used to measure the temperature. The temperature control range is 40 to +80 degrees Celsius.

Figure 3 depicts the wavelength of an electromagnetic spectrum. According toy he energy flow it varied from the electric field to magnetic field.

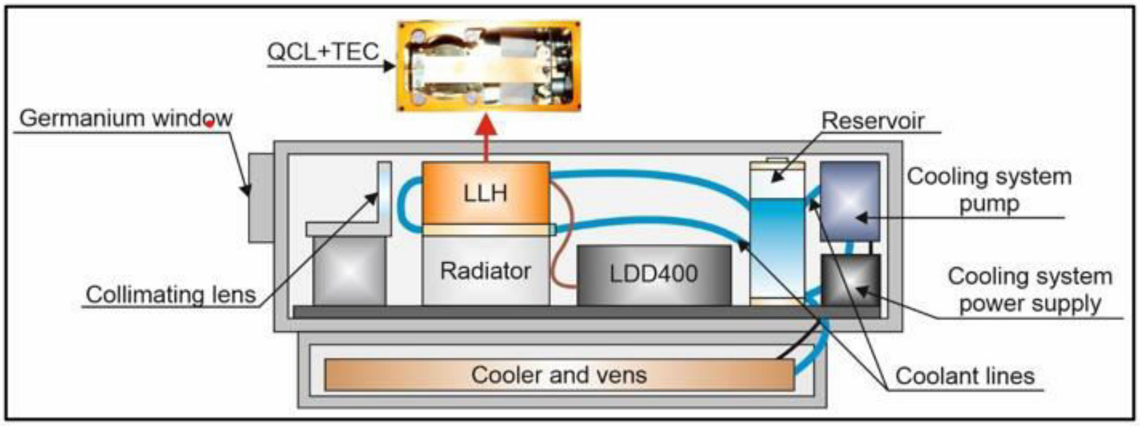

Figure 3.Simplified picture of an electromagnetic wave

3.Application of electromagnetic radiation:

The application of electromagnetic radiation covers allrounder in any aspects. For human vision the visible light is more significant in day to day life. It is applicable oly with the solar wavelength region from 250mm in the UV to 2,500 mm. Electromagnetic spectrum requires a certain amount of energy difference between both energy levels. Fig.4 depicts the energy level, which increase from the ground level to excited level.

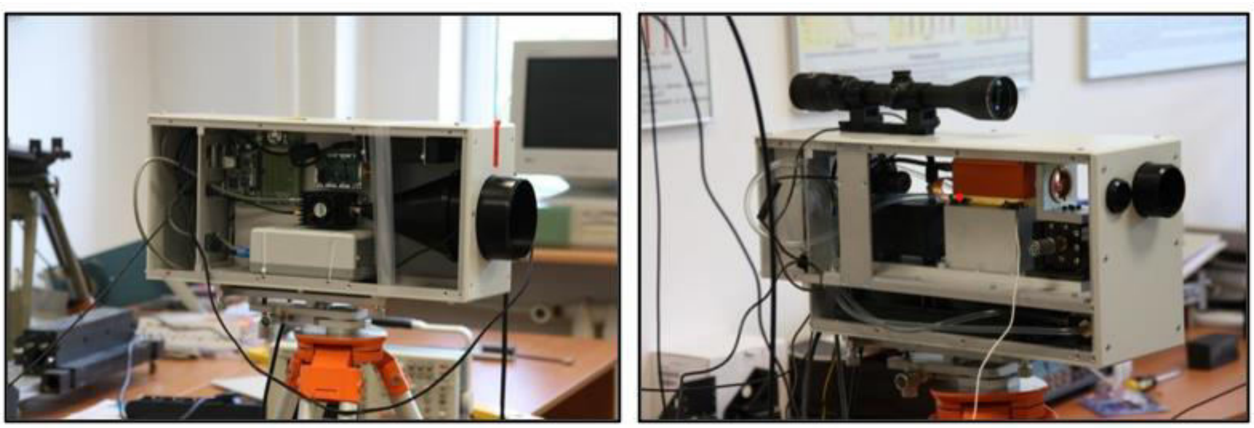

Figure 4. Energy level diagram

Webology, Volume 18, Number 4, 2021
ISSN: 1735-188X
DOI: 10.29121/WEB/V18I4/129

4.Outcome:

The constructed transmission and reception modules then were employed in the research facility setup shown in Figure 4 as the following stage. They have been on the contrary direction of the lab, close to each other and confronting the mirror. The optical route was approximately 70 metres long. Figure 5 depicts the layout of the lab test stand.

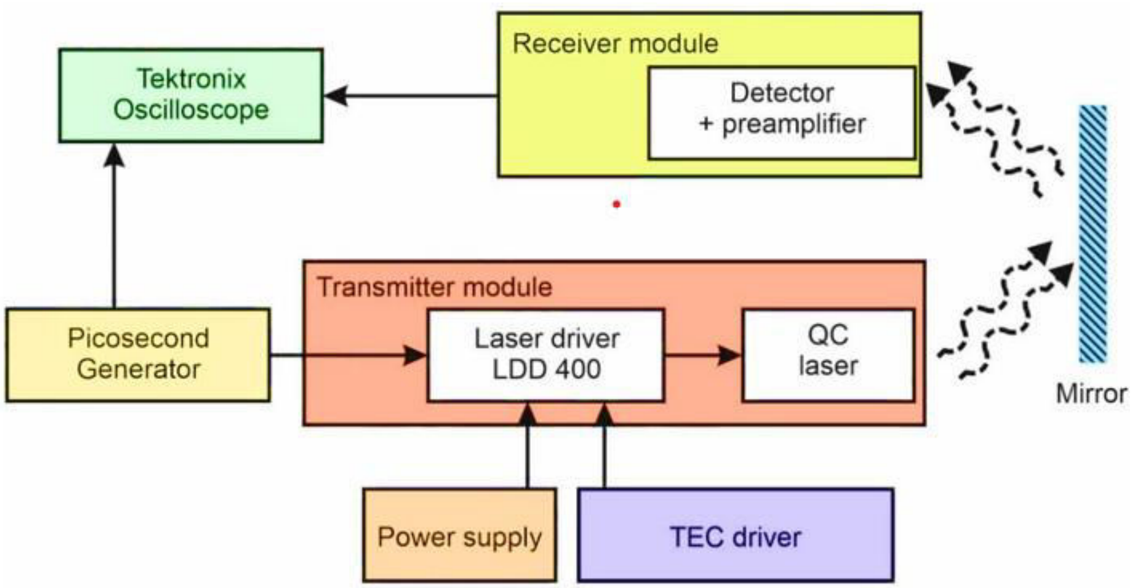

Figure 5. The research stance for evaluating the connection under laboratory circumstances is depicted in this diagram. QC stands for quantum cascade and LDD stands for laser diode driver.

To test the viability of the suggested measurement technique, 15000 RZ code pseudo-random signals with values of 2.5 V, 1 MHz, and 100 ns each were produced using the Picosecond 12000 generator. By preserving the collected waveforms in the system storage and simultaneously scanning the oscilloscope, the generator's pulse series could be seen. Then, the Q factor, transmission ratio, and RMS noise level at logical levels "0" and "1" were assessed together with the signal average score at these two levels. The observations were made by limiting the measurement region and using cursors to determine the pulse width. An instance of the oscillogram acquired during the measurements is shown in Figure 6. The approach for determining individual signal characteristics was also checked.

The coefficients of the Q and S/N indices were obtained from the oscillogram. They are, correspondingly, 4.918 and 91.05. The data analysis revealed that when the gating was turned on, the value of the Q factor was compatible with the value calculated using the formula.

Webology, Volume 18, Number 4, 2021
ISSN: 1735-188X
DOI: 10.29121/WEB/V18I4/129

Figure 6. Bit error rate (BER) measurements resulted in this sample oscillogram.

The influence of the light beam repetition rate, the pulse cycle frequency, and the laser working temp on the BER value was tested using a Picosecond 12,000 generator. Table 2 shows the characteristics of the produced pulses. The study generator allowed for the creation of a pseudo-random series of bits in the device's system storage. As per the previously made pseudo-random series, pulse waveform with a specific frequency, length, and intensity were produced at the induction generator.

Table 2. The parameters of the pulses produced by the Picosecond 12,000 generator were used in the BER studies

Parameter	**Type of work**	**The length of the generated code**	**Character length**	**Code type**	**Pulse frequency**	**Pulse duty cycle**	**Operating temperature of the laser**	**Low-level voltage**	**High-level voltage**
Value	Pseudo-random sequence	14,000 bits	15	RZ (return to zero)	from 450 kHz to 8.0 MHz	from 0.6% to 50%	from −15 ◦C to 25 ◦C	5.5 V	0 V

Webology, Volume 18, Number 4, 2021
ISSN: 1735-188X
DOI: 10.29121/WEB/V18I4/129

The equvation of energy wavelength and frequency of an EM photon given below,

$$E = hn = \frac{hc}{0}$$

The seven parts of the EMS are listed in table3. With this one can get the energies of the visible region that is limited. According to frequency of the higher energies gamma ray photon with l=1fm, the n =3Hz. For radio the range of wave span is 300Hz to 30 MHz.

Table 3 The spectrum of electromagnetic radiation

The computed BER relationships for various pulse power levels, bandwidth values, and laser working temperatures are shown in Figures 7–9.

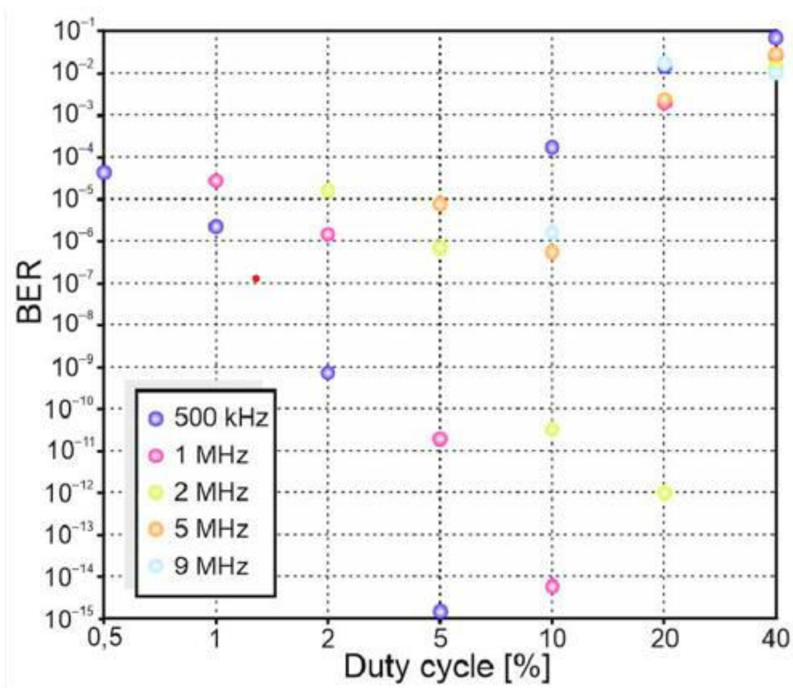

Figure 7. At a laser working temperature of 10°C, BER values for various pulse duty factors and frequency were calculated.

Webology, Volume 18, Number 4, 2021
ISSN: 1735-188X
DOI: 10.29121/WEB/V18I4/129

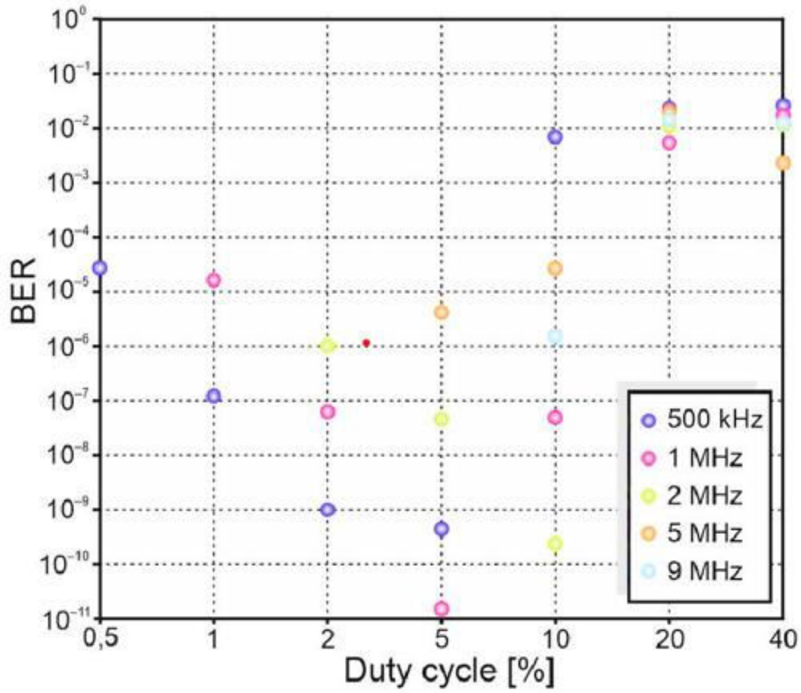

Figure 8. BER values for various pulse duty factors and frequency were calculated at a laser operating temperature of 0°C.

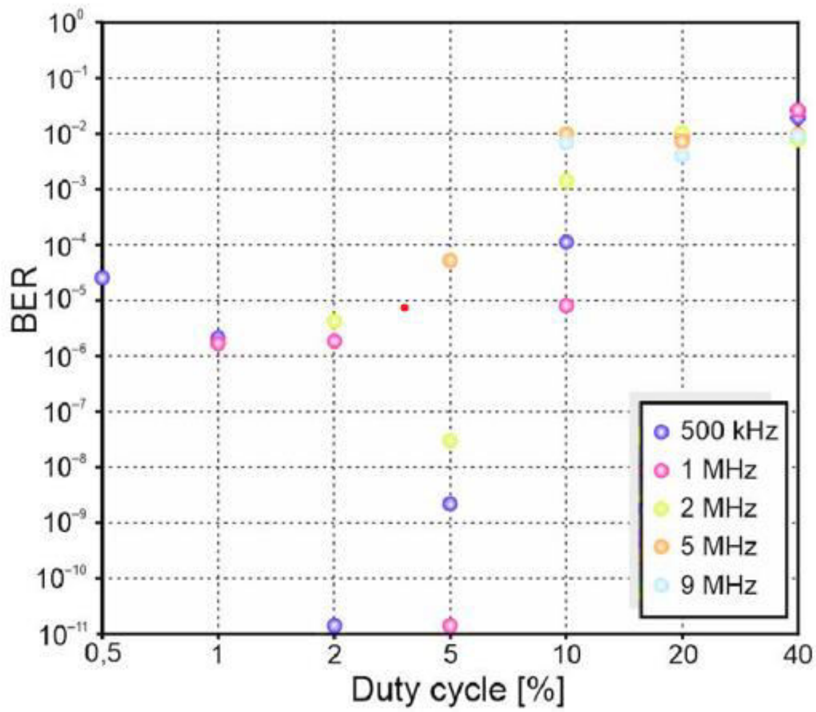

Figure 9. BER values for various pulse duty factors and frequency were calculated at a laser working temperature of 20°C.

Webology, Volume 18, Number 4, 2021
ISSN: 1735-188X
DOI: 10.29121/WEB/V18I4/129

The minimal BER value was attained with shorter pulse lengths as the laser working temperature rises. The influence behavioral and noise rise at the logical "1" level are caused by the warming of the laser component during long-duration production.

An increase in the variation of the frequency of the pulses was seen as the working heat of the laser increased. It's owing to the QC structural heating during flow of current, and also the shift in operational conditions caused by the cooling system's low effectiveness. Raising the laser working temperature causes a further fall in loudness and a rise in the distortion value, in addition to increasing the pulse width. The link working point is determined by a trade-off between the needed amplitude, frequency, and noise level.

Two observation tracks are used in the experimental testing of the suggested FSO system in real-world situations. The first with the planned link, and the second with a laser that generates 1.5 m wavelength light. The third path, which used a laser to generate 550 nm wavelength photons, has been used to determine accessibility. A digital thermometer was used to determine the temp, and a hygrometer was used to determine the relative moisture. Figure 10 shows a diagram of the study stand used to investigate the impact of meteorological pressure on link operation.

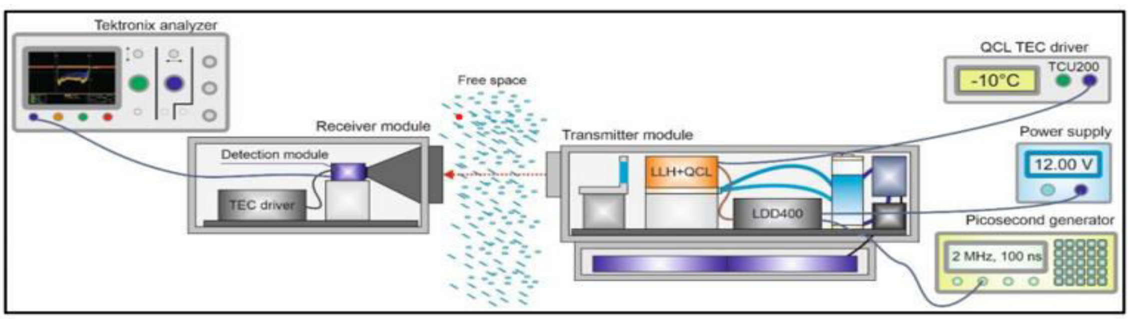

Figure 10. The measurement scheme for the electromagnetic link in real-world situations.

Figure 11 depicts the circumstances under which the test was conducted. The link was roughly 80 metres long and ran from side to side across the Military University of Technology. It depicts the results of experiments conducted in light hazy conditions: the air temperature was 10 degrees Celsius, and the humidity levels was 100 percent.

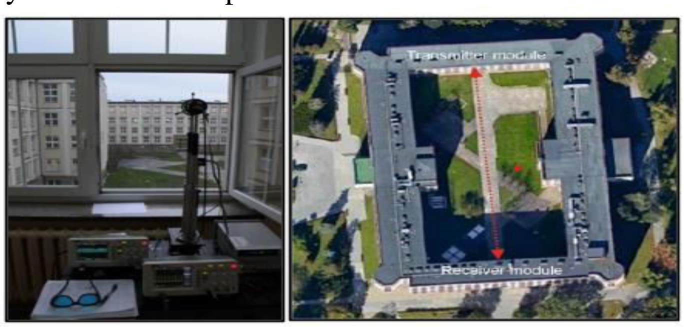

Figure 11. Outside the Military University of Technology building, the laboratory is used to test the electromagnetic ink.

Webology, Volume 18, Number 4, 2021
ISSN: 1735-188X
DOI: 10.29121/WEB/V18I4/129

Every 20 minutes, the intensity of the signals at the photoreceivers' source was measured. The obtained results were matched to the analytical calculations performed in the earlier article using the MathCAD software. The formula incorporating the transmission factor, propagation duration, and extinction coefficient as well as the relation between humidity and liquid sedimentation signal are used in these computations. The connection operating with a frequency of 10 m was characterized by a range of 1 km, which equates to light fog. As a result, in the case of limited sight, light with a frequency of 10 m has higher transmission qualities than near-infrared wavelengths. The observed attenuation, considering the diffraction pattern, is similar for the three examined wavelengths for visibility under 600 mm. This means that in bad weather, with drastically reduced vision, all systems will have trouble maintaining adequate communication reliability, and there may well be issues establishing a connection. In addition, compared to the short light, radioactivity with a frequency of 10 m is less susceptible to disturbance in the atmosphere. The absorption of both wavelengths rose as visibility decreased.

Discussion

An electromagnetic system operating in the third-atmosphere propagation window (8–12 m) was presented in this research. According to our research, in the event of severe weather, the proposed link can successfully maintain the connection's continuity. The impact on signal transmission and the location of the disturbance source within the cylinder was discussed. The electromagnetic analysis in tropical climate was explored. The efficiency of electromagnetic spectrum in the marine sector was examined. It was proposed to use a computational formula of signal strength that took into consideration a single-point measurement technique for atmospheric characteristics.

on either hand, looked examined the impact of air turbulence's temporal and spatial features. Temporal traits were found to be slightly greater than spatial ones. It is vital to provide a large bandwidth to ensure optimal signal quality as spatial features increase.

The findings of this study show that the suggested link performs as expected both in the lab and in real-world situations. The experimental data were contrasted to the theoretical predictions, which took into consideration the weather systems. Individual wavelengths had identical attenuation levels, which was surprising.

Conclusion:

The fundamental characteristics of electromagnetic radiation are covered in this paper. In particular, the wavelength, energy level, and frequencies were tracked. While discussed about electromagnetic spectrum we must concern about light, because it is the hasten medium to transmit, the huge information, cost effective, flexibility and mainly optical bandwidth. The application of electromagnetic spectrum in spectral range system is highly described in the paper.

To summarise, the findings of radiation with a wavelength of around 10 m had higher transmission qualities in the presence of limited visibility than near-infrared waves.

Reference:

1. Forestell, Lindsay, David E. Morrissey, and Graham White. "Limits from BBN on light electromagnetic decays." Journal of High Energy Physics 2019.1 (2019): 1-29. http://butane.chem.uiuc.edu/pshapley/GenChem2/A3/3.html
2. Naumova, Maria A., et al. "Exploring the light-induced dynamics in solvated metallogrid complexes with femtosecond pulses across the electromagnetic spectrum." The Journal of chemical physics 152.21 (2020): 214301.
3. Baird, Christopher S. "Electromagnetic radiation." Access Science (2019).
4. lsayed, Ebrahim E., and Bedir B. Yousif. "Performance enhancement of M-ary pulse-position modulation for a wavelength division multiplexing free-space optical systems impaired by interchannel crosstalk, pointing error, and ASE noise." Optics Communications 475 (2020): 126219.
5. Al-Gailani, Samir Ahmed, et al. "A survey of free space optics (FSO) communication systems, links, and networks." IEEE Access 9 (2020): 7353-7373.
6. Singh, Mehtab, et al. "A high-speed radio over free space optics transmission link under dust environment conditions employing hybrid wavelength-and mode-division multiplexing." Wireless Networks 27.7 (2021): 4875-4888.
7. Johnson, Stephen M., Emily Dial, and M. Razeghi. "High-speed free space optical communications based on quantum cascade lasers and type-II superlattice detectors." Quantum Sensing and Nano Electronics and Photonics XVII. Vol. 11288. SPIE, 2020.
8. Tseng, Shin-Pin, et al. "Bipolar optical code division multiple access techniques using a dual electro-optical modulator implemented in free-space optics communications." Sensors 20.12 (2020): 3583.
9. Mukherjee, Rahul, et al. "PAM-4 based long-range free-space-optics communication system with self injection locked QD-LD and RS codec." Optics Communications 476 (2020): 126304.
10. Eid, Mahmoud MA, et al. "Free space and wired optics communication systems performance improvement for short-range applications with the signal power optimization." Journal of Optical Communications (2021).
11. Rebello Sousa Dias, Mariama, and Marina S. Leite. "Alloying: a platform for metallic materials with on-demand optical response." Accounts of chemical research 52, no. 10 (2019): 2881-2891.
12. Yessenov, Murat, et al. "Free-space optical delay line using space-time wave packets." Nature Communications 11.1 (2020): 1-10.
13. Sivakumar, P., et al. "A novel free space communication system using nonlinear InGaAsP microsystem resonators for enabling power-control toward smart cities." Wireless Networks 26.4 (2020): 2317-2328.
14. Fischer, T., Smith, K.L., Kraemer, S., Schmitt, H., Crenshaw, D.M., Koss, M., Mushotzky, R., Larson, K., Vivian, U. and Rigby, J., 2019. A Dissection of Spatially Resolved AGN Feedback across the Electromagnetic Spectrum. The Astrophysical Journal, 887(2), p.200.