

# A REVIEW ON POSITIVE AND NEGATIVE IMPACTS OF BLUETOOTH ENABLED DEVICES

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**Abstract-** In this review, we analysed the benefits and drawbacks of a variety of Bluetooth-enabled devices. Bluetooth is a wireless technology that uses radio frequency to send data over a short distance. Bluetooth devices reportedly feature a 2.4GHz operating frequency, a practical range of 32 feet (10 metres), a variety of power classes, a transfer rate of 1 Mbps, and a throughput of 721 Kbps. One can utilise a Bluetooth device on their smart phone to transmit data or connect to other Bluetooth-enabled devices. Low quantities of non-ionizing radiation are produced by Bluetooth devices. According to the Food and Drug Administration (FDA), persons are normally considered to be safe from regular nonionizing radiation exposure. Bluetooth uses a radio method called frequency-hopping spread spectrum. Frequency-hopping spread spectrum (FHSS) is a technique for delivering radio signals that involves swiftly switching the carrier frequency amongst a large number of different frequencies that inhabit the same spectral range. Changes are managed by a code that is understood by both the transmitter and receiver. Our bodies absorb energy per unit mass at a specific absorption rate (SAR) after being exposed to energy. Most mobile equipment, such as Bluetooth speakers and headphones, are constructed to a SAR level of 1.6 W/kg and 2 W/kg, respectively, for the EU (US limit). The Federal Office for Radiation Protection has SAR values for specific smart phones that can be checked. Various countries may have different maximum SAR limits. Bluetooth Special Interest Group designed and approved all Bluetooth products. More than 35,000 firms in the fields of telephony, computer, networking, and consumer electronics are members of the Bluetooth Special Interest Group (SIG). From -20dBm (0.01Mw) to +20dBm are supported for transmit powers using Bluetooth technology (100Mw). Security is crucial since Bluetooth devices might be compromised. In-car Bluetooth headsets, stereo Bluetooth headsets, Bluetooth-enabled webcams, Bluetooth keyboards, and Bluetooth GPS devices are just a few examples of devices that use Bluetooth technology. Heart rate monitors, sensors, remote controls, thermometers, smart watches, and fitness trackers are examples of common Bluetooth smart gadgets. Smart phones, tablets, portable media players, and laptops are the most common Bluetooth smart-capable devices since they can connect to both Bluetooth and Bluetooth smart devices.

**Keywords:** Bluetooth special interest group, 1.6 W/kg, 2W/kg, Frequency-hopping spread spectrum, specific absorption rate, transmit power.

## I. INTRODUCTION:

A wireless technology known as Bluetooth makes use of pulsed radio frequency transmissions. The Bluetooth logo looks like two triangles that are half-turned to the right. The emblem is a bind rune merging the Younger Futhark runes (Hagall) (ᚷ) and (Bjarkan) (ᚰ), Harald's, which stand for Harald Bluetooth, a Danish Viking King who helped unite Denmark and Norway (c.958 - c.970)[4]. Because Bluetooth was intended to be a universal wireless technology, it was given the name Harald Bluetooth. The shipment of Bluetooth devices has been rising annually, according to figures 2022. By 2027, the size of the global Bluetooth 5.0 market is expected to increase from USD 4.1 billion to USD 7.0 billion, expanding at a Compound Annual Growth Rate (CAGR) of 11.0%. The market is expanding as a result of wireless communication enabled by Bluetooth 5.0 in consumer gadgets. Bluetooth is a fairly recent technology that enables wireless data transfer and communication between electronic devices at 2.4 GHz frequency in the open Industrial, Scientific, and Medical (ISM) band. Technically speaking, there are basically 3 categories of Bluetooth devices. They are Classic Bluetooth, Bluetooth Dual-Mode, and Bluetooth Single-Mode. {For a product to be marketed as a Bluetooth device, the producer must adhere to Bluetooth SIG standards. A collection of patents covering the technology are licensed to specific eligible devices. Approximately 920 million Bluetooth integrated circuit chips are shipped per year as of 2009. Annual Bluetooth device shipments peaked at 3.6 billion in 2017 and were projected to keep growing at a rate of roughly 12% per year through 2018. Total Shipments was 4.7 billion units in 2021, with a 9% growth rate anticipated}[10]. The risk of DNA or cell damage from non-ionizing radiation is very low because of its very modest electromagnetic radiation production. A few examples of this are Bluetooth wireless technology, mobile phones, Wi-Fi networks, energy-efficient meters, microwave radiation, electricity lines, MRI medical equipment, computers, and laptops. Cancer and other neurological problems may become more likely with an increase in radiation above SAR thresholds. Long-term earphone use may compress earwax, making it less fluid and more difficult for the body to naturally eliminate.



**Fig.1:** Bluetooth logo

### 1.1 .Bluetooth Levels: [6]

- **Level 1:** devices at level one can pair with any other Bluetooth device, regardless of version or level, without Bluetooth the owner's approval. The biggest security risk to your personal data comes from these gadgets.
- **Level 2:** Without the verification of the pin, level two devices cannot link. There is still potential for crooks to access your data, even though the risk is not as high as it is with level one device.
- **Level 3:** Level three devices pair using switch security codes, closing all security gaps. However, coding mistakes could happen and expose your device to risk.
- **Level 4:** Compared to all other levels, level four devices have more robust and intricate authentication mechanisms. There are substantially less Bluetooth security issues with them.

### 1.2 The following are a few elements that influence Bluetooth devices: [7]

**Radio spectrum:** Bluetooth is a suitable option for wireless communication because of its frequency band.

**Physical layer (PHY):** This specifies certain crucial elements of how the radio is used to send and receive data, including the data rate, error detection and correction procedures, interference protection, and other methods that affect signal clarity at various ranges.

**Receiver sensitivity:** The minimum signal strength at which a receiver can still receive and accurately decode data is known as the receiver sensitivity.

**Transmission power:** As you can anticipate, the longer the achievable range is, the stronger the sent signal is. However, raising the transmission power will hasten the battery's depletion.

**Antenna gain:** In essence, this is the process by which electrical signals from the transmitter are converted into radio waves, and then the reverse is done at the receiving end.

**Path loss:** The signal may get weaker due to a number of factors, such as distance, humidity, and the medium it travels through (such as wood, concrete or metal).

### 1.3 Various versions of Bluetooth technology:

**Table 1:** Versions of Bluetooth [15]

Bluetooth versions	Specifications	Year
Bluetooth v1.0 to v1.08	Mandatory Bluetooth hardware device and address	1999
Bluetooth v1.1	IEEE standard 802.15.1-2002	2001
Bluetooth v1.2	Faster connection	2003
Bluetooth v2.0+EDR	Enhanced data rate	2005
Bluetooth v2.1	Secure simple pairing	2007
Bluetooth v3.0	High speed data transfer	2009
Bluetooth v4.0	Low energy consumption recently used in apple Iphone-4s	2010
Bluetooth v4.1	Low energy and supports multiple devices	2013
Bluetooth v4.2	Allows chips to use Bluetooth over internet protocol version 6 (IPv6) for direct internet access. Transmits data at 1Mbps and can hold connection to another device for maximum of 60 meters (200 feet).	2016
Bluetooth v5.0	Bluetooth 5.0 transmits data at 2 Mbps and can hold connection to another device for a maximum of 240 meters (800 feet).	2016
Bluetooth v5.1	It has more accurate tracking, GATT caching enhancements and advertising sync transfer	Jan 2019
Bluetooth v5.2	Bluetooth LE allows high-quality audio to be transmitted without sacrificing battery power.	Dec 2019
Bluetooth v5.3	Faster switching between low duty and high duty cycles, and is therefore more energy efficient than 5.2	2021

#### 1.4 History:

The wireless technology known as Bluetooth employs pulsed radio frequency impulses. What Dr. Andrew Goldsworthy has to say is as follow "Pulses carried by microwaves are particularly dangerous"[2]. When Ericsson started exploring the idea of using wireless communications rather than cords to connect accessories to mobile phones and computers in 1994, the concept of Bluetooth was born. Joining the SIG promoter group is the first Bluetooth technical specification, version 1.0A, produced in 1999 by 3Com, Lucent, Microsoft and Motorola [1]. In the end, Haartsen was able to develop a technique that employed UHF radio waves at 2.4 GHz by testing with many various variables and resources. He managed to make this protocol use a relatively small amount of energy while still functioning adequately at a closer range. The problem was that Wi-Fi also used this frequency; therefore Haartsen devised a method to use frequency hopping techniques to make Bluetooth connections dependable and forgiving [13]. The Bluetooth Special Group (SIG), which was established in 1998 and now publishes and advertises the standard and its updates, was founded. This organisation is still in operation today and is in charge of further Bluetooth updates and new features. At originally, the Bluetooth SIG only had Ericsson, IBM, Intel, Nokia, and Toshiba as members; but, by the end of its first year, there were 4,000. Devices started arriving on the market not long after the Interest Bluetooth SIG was established. Over 30,000 companies at various levels of influence are currently part of the association.[9]SIG prohibited others from developing a similar protocol by obtaining trademark licences and filing patents that made Bluetooth a standard for wireless communication. Because of this, Bluetooth doesn't really have any other comparable competitors on the market [13].In 1999; the first Bluetooth gadget was introduced. The "Best of show Technology Award" at COMDEX went to a hands-free mobile headset. The Ericsson T36 was the first Bluetooth mobile phone, but the T39 model, which had been updated, was the one that actually hit store shelves in 2001. Parallel to this, IBM unveiled the IBM ThinkPad A30 in October 2001, the first laptop with built-in Bluetooth. [10]

#### 1.5 The timeline events of Bluetooth technology:

**1999:** In1999, Bluetooth 1.0, the original Bluetooth specification, was released.

**2001:** The first mobile phone using Bluetooth was the Sony Ericsson T36.

**2004:** Marked the introduction of Bluetooth 2.0 and Enhanced Data Rate (EDR), which increased both bandwidth and range.

**2009:** High Speed transfers were a feature of Bluetooth 3.0 that allowed devices to communicate through Bluetooth while transferring files over Wi-Fi. This significantly increased transfer speeds from the previous iterations to 23 Mbit/s.

**2013:** For battery-powered portable devices like wearables, the Bluetooth SIG endorsed Bluetooth 4.0 and offered an optional Low Energy (LE) mode. A Classic variation was created from the default, longer range implementation.

**2017:** Launch of Bluetooth 5 continues the trend of enhancing transmission and range for both Classic and Low Energy flavours.

#### 1.6 LIMITATIONS:

In Bluetooth, "class" refers to the three levels of power for Bluetooth devices: Class 1, 2, and 3.

The following table 2 compares power and range of these three classes:

**Table 2:** Different classes of Bluetooth

Class	Maximum Power	Operating range
<b>Class 1</b>	10 to 100mW (+10 to+20dBm)	100 meters
<b>Class 1.5</b>	2.5 to 10mW (+4 to +10dBm)	Up to 30 meters
<b>Class 2</b>	1 to 2.5mW (0 to +4dBm)	10 meters
<b>Class 3</b>	0.01 to 1mW (-20 to 0dBm)	1 meter

Both endpoints of the communication must have a class 1 BT device in order to operate beyond the 100 meters range. A class 1 or class 2 device is needed at both ends in order to communicate over the 10 meters range.

**Note:** Due to their extremely constrained range, Class 3 devices are rare.

#### 2. List of maximum SAR limits of various countries:

**Table 3:** SAR limits of various countries

Country	Maximum SAR limit (w/kg)
USA	1.6
European Union	2.0
India	1.6
Japan	2.0
China	1.6
Korea	1.6
South America	2.0
Australia	2.0
New Zealand	2.0

All cell phone manufacturers are expected to carry out their SAR testing under the most extreme worst-case (and highest power) operational settings for all of the frequency bands. For instance, the Federal Communication Commission (FCC) of the United States mandates that mobile phones adhere to a SAR limit of 1.6 watts per kilogram, averaged from 1 g of tissue volume. The SAR limit for the human body has been established by the Council of the European Union at 2.0 watts per kilogram averaged over 10 grams of tissue. Similarly, the government of India has set the SAR limit at 1.6 watts per kilogram, averaged from 1 gram of tissue volume.

From the electric field within the tissue, SAR for electromagnetic energy can be estimated as follows:

$$SAR = \frac{1}{V} \int_{sample} \frac{\sigma(r)E(r)^2}{\rho(r)} dr$$

$\sigma$  is the sample electrical conductivity.

$\rho$  is the sample density.

E is the RMS electric field.

V is the volume of the sample.

SAR gauges field exposure at frequencies between 100 kHz and 10 GHz (known as radio waves).

It is frequently used to gauge how much power is consumed by mobile devices and during MRI scans. The value will be greatly influenced by the geometry of the body portion exposed to the RF energy as well as by the precise location and geometry of the RF source. In order to avoid this, tests must be conducted with each unique source, such as a particular model of mobile phone, and in the specified environment. [14]

**2.2 How does Bluetooth work?**

A Bluetooth connection can have one master and up to seven slaves. The master device is the one who starts conversations with other gadgets. Between itself and the slave devices connected to it, the master device manages the communications channel and traffic. The slave devices must respond to the master device and align their broadcast and receive timing with the time set by the master device as shown in figure 2.



**Figure 2:** Working of Bluetooth






Conditions for successful data transmission in Bluetooth technology are as follows:




- Maximum number of Master Node - 1
- Maximum number of Slave Nodes - 7
- Maximum number of Nodes in a Piconet - 8
- Maximum number of devices that can be paired -  $2^8 - 1 = 255$
- Number of devices that can be parked → Infinite ( $\infty$ )

**4. Various Bluetooth ENABLED Devices**

**Table 4:** Types of Bluetooth devices

Type of device & year	Working Procedure	Country of origin	Image

1. Bluetooth headsets & 2004	With the headset, you may use your mobile phones to make or receive calls without the need for cords or your hands. Since the headsets have been fixed with voice rearrangement, you can dial and talk on the phone without needing a mobile headset.	Southern California	
2. Stereo headsets & 2004	Stereo headsets operate in the same way that standard headsets do without the use of wires. This kind of headset utilises wireless connection to connect to music players so that we may hear the music from our smartphone or mobile device. The audio headset and Smartphone have a relatively small distance range. Additionally compatible with Bluetooth-enabled mobile phones is this headset.	Southern California	
In-car Bluetooth headset & 2001	The music player system in the cars is wirelessly connected to the mobile Bluetooth device. We can receive and make calls using the in-car speaker system. Without a handheld device.	United states	
Bluetooth equipped printer & 1999	The printers that support Bluetooth are the ones that can print written documentation and images from any Bluetooth device. The Bluetooth gadgets are similar to computers, PDAs, and printers that can print data wirelessly. The gadgets are in range to connect to the printers and are in sync with one another.	Netherland	
Bluetooth enabled webcam & 1993	The Bluetooth-enabled camera functions in the same way as a regular webcam. They are wirelessly linked. Instead of being docked onto or close to the computer like typical cameras, the wireless features give the device more mobility.	UK	

Bluetooth GPS device & 1942	The GPS with Bluetooth is advancement above the standard GPS. Using voice commands, this device can be communicated with. The GPS may obtain instructions to a location and provide voice guidance if we speak or mention it on the screen.	America	
Bluetooth keyboard & 2011	The Wireless keyboard functions without the aid of any cords connecting the gadget to a laptop or PC. This Bluetooth gadget is compatible with smart phones and other mobile devices.	Netherlands	
Bluetooth smart watches & 2000	Modern smart watches have a local touch screen interface for everyday usage and an attached smart phone app for management and telemetry. A smart watch is a wearable computer in the shape of a watch. Early devices could do simple things like add, subtract, tell the time digitally, translate, and play games, but smart watches produced since 2015 offer additional capability similar to smart phones, including mobile apps and a mobile operating system	Canada	

## 5. PRO'S:

- On mobile phones, transferring things like photos and mp3 audio is really simple.
- For wireless networking between laptops and desktop PCs, a small amount of bandwidth is required.
- The PC is connected to all of the peripheral devices, including a mouse, keyboard, printers, speakers, etc. cordlessly
- A cost-effective option for short distances is Bluetooth technology.
- The Bluetooth is installed using built-in software, therefore there is no setup file required.
- Bluetooth is typically found in cellphones, music players, speakers, and other devices.
- The Bluetooth uses international technical standards.
- Transferring files like photographs and MP3 audio is incredibly easy on mobile devices.
- A minimal amount of bandwidth is needed for wireless networking between laptops and desktop PCs.
- All of the PC's add-ons, such as a mouse, keyboard, printers, speakers, etc., are connected to it. cordlessly
- For short distances, Bluetooth technology is a reasonable choice.
- Since the Bluetooth is installed using built-in software, a setup file is not necessary.
- Mobile phones, music players, speakers, and other products frequently contain Bluetooth technology.
- International technical standards are used by Bluetooth.

- Wireless technology like Bluetooth is independent of wires, cables, and codes. This is regarded as one of Bluetooth's main benefits. It uses less energy and power.
- Any impediment can be connected to it through a wall.
- The device connections are quick and simple.
- Compared to infrared devices and communications, the data range is much better.
- In the market, they are easily accessible.
- Bluetooth updates are simple to do.
- Interoperability problems are not a problem with Bluetooth.
- Using Bluetooth, they may send any type of media, including audio, text, videos, and pictures.
- Frequency-hopping spread spectrum, or FHSS, technology is used in modern Bluetooth to send data securely.
- They are comparatively less expensive than their competitors.
- They are utilised in automobiles, audio equipment, headphones, cell phones, laptops, and desktop computers.
- They perform with a high degree of efficiency.
- They prevent other devices from interfering with their connections.
- Since there is no requirement for software installation, they are plug-and-play devices.
- The Bluetooth technology is highly flexible.
- They are applicable to LANs, or local area networks.
- Both in size and shape, they are small.
- Most supplementary or external Bluetooth devices are connected via USB, or "Universal Serial Bus," making them convenient and safe to use.
- They are welcomed and utilised everywhere.

## 6. CON'S:

- They are more slowly contrasted with other remote innovation like WI-FI and LAN with optic fiber.
- They have a little information scope of up to 50 meters.
- They actually have some security issues while information is moving.
- They have lower data transmission.
- Home RF Innovation additionally works with its recurrence; along these lines can now and again cause misconfigurations and impedence.
- To move an enormous measure of information, utilizing one more wellspring of correspondence and technology is profoundly encouraged.
- It has been seen that Bluetooth can here and there lose its association.
- Restricted gadgets can be associated with Bluetooth.
- Because of some security issues, it tends to be hacked.
- Network issues can happen between two renditions of Bluetooth gadgets.

### Speed: [5]

The major drawback of Bluetooth is its slower speed when compared to wifi and the inability to transfer huge files via Bluetooth. In comparison to the older versions of Bluetooth, the newer versions offer faster speeds and more reliable connections.

### Range:

At first, Bluetooth could only communicate over small distances of up to 10 metres. Bluetooth, however, now supports distances of up to 100 metres. The range depends on the Bluetooth version you are using. The Bluetooth capabilities of the device are another factor that affects speed. Because of its energy efficiency, the range is shorter.

### Security:

While Bluetooth does have certain security protections, they are not strong enough. Most of the time, passwords won't even be needed to login to the devices. Furthermore, security risks might affect Bluetooth because it uses radio frequencies.

### Limited Connections:

In comparison to Wi-Fi, Bluetooth's most recent version, Bluetooth 5, only allows up to seven devices. Up to 4 or 5 devices can be used with the earlier versions. More than 7 devices cannot be connected to a computer or smart phone.

### Upgradability:

It won't be difficult for you to upgrade to newer versions if you use a laptop or a desktop. However, it is not possible to upgrade smaller devices, such as smartphones and headsets. Various versions will employ various technologies. This means that such gadgets cannot be updated.

### Effect on Health:

- Long term exposure to microwave radiation can cause headaches, cancer, Leukemia, brain tumours, Alzheimer, Autism, birth defects, hair loss, suicide, Autoimmune illness. [4]
- Over usage may cause increased cholesterol levels rapidly and significant decrease in haemoglobin and lymphocytes.
- Increased stress due to the increase in leukocyte count.

## 7. CONCLUSION:

Bluetooth technology enables wireless transmission of information between devices. According to the Bluetooth specification, any Bluetooth-enabled device can connect with another Bluetooth-enabled device as long as it is close by and employs a short-range radio frequency. EM radiation is produced by Bluetooth devices. Although real-time voice and data transfers using Bluetooth, a low-power technology, are currently very popular. Bluetooth is developing over time and releasing upgrades that

affect both the speed and connection process. This study illustrated the advantages and disadvantages of Bluetooth devices. Therefore, when used appropriately, Bluetooth gadgets are not dangerous.

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