A Study Report on Effects of EMF Exposure from Wearables and Preventive Measures

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Abstract

The concern about human health is often overseen, while wearable technologies attract exploding interests. Reports have shown that increased exposure to the electromagnetic field from these devices can cause cell damage and protein induction. High-frequency Electromagnetic Field (EMF) is shown to have a direct impact on our sweat glands, peripheral nerves, and eyes. As various interactive devices are being incorporated into our daily life, privacy issues rise since these devices rely on constant capturing of multimedia- photos, videos, or sound, in order to provide services that assist users' activities. Therefore, it is necessary to build tools that safeguard users against possible compromise or misuse of microphones in the age of smart devices. The report provides an extensive review of the effects on continued exposure to EMF and Specific Absorption Rate (SAR) from various commercial wearable devices that are currently available in the market. The report also highlights the privacy breach issues with an increase in the number of smart devices around us. A possible jamming solution has also been proposed along with a detailed description of the recently introduced Wearable Microphone Jammer. A research study on the adverse effects of Jammers on blood factors has also been included.

Keywords: Wearable devices, EMF Expos, Preventive Measures.

1. Introduction

In today's world, life without technology seems impossible. As technology keeps advancing, our lives tend to get more dependent on it. Technology has made our lives easier, more comfortable, convenient, and safer. Almost everything we do today involves the use of technology. This technology boom has resulted in an increase in the number of electronic devices around us. As these devices get smarter, we lose our control over them. They operate continuously and thus, are constantly recording and analyzing their environment to provide user assistance. With the Internet of Things, all these devices are connected to each other through the internet. This implies that these devices continuously communicate with each other, and their radiation is all around us. As these devices communicate with each other, they constantly send and receive information in the form of voice recordings, images, files, etc. This communication releases electromagnetic radiation around us.

2. Human Electromagnetic Field Exposure in Wearables

The growth of smart technology in healthcare has resulted in the use of daily wearables such as watches, as fitness and healthcare gadgets. These mobile wearable communications devices have been possible, thanks to advancements in micro and nano-scale electronics fabrication, wireless communications, batteries, and data analytics. These wearable devices are used to provide a broader range of value-added services such as indoor positioning and navigation,

financial payments, physical and mental health monitoring, sports, and medical analytics.

The biggest concern regarding wearable devices is the EMF generated by them. Mainly due to the extreme proximity or direct physical contact to the human skin, wearable communications devices are known to cause higher levels of specific absorption rate (SAR) at the skin surface. Absorption of these radiations causes thermal or non-thermal heat in the affected tissues, and its prolonged exposure can also lead to neurodegenerative diseases and even cancer. Research has shown that the softer brains of children make them much more susceptible to radiation, which means they absorb more radiation than adults. For this reason, exposure to EMF generated by wearable devices can be particularly dangerous for children. Studies have concluded that exposure to EMF for occupation can result in changes in the diurnal rhythms of the heart, lowering of heart rate amplitudes and a shift of the acrophase.

Current safety guidelines

International agencies such as the U.S. Federal Communications Commission (FCC) and the ICNIRP set the maximum amount of EMF radiation that the human body can be exposed to without resulting in potential health hazards. Similar to other wireless devices, the design of a body-worn device is required to undergo compliance tests based on the safety guidelines. The World Health Organization (WHO), which established the International Electromagnetic Field Project (IEFP), also provides information on health hazards.

Specific Absorption Rate (SAR) is considered an essential and adequate metric to quantify the amount of radiation released from these devices. There are two types of SAR guidelines for the general public (head and trunk), which suggest that the subsequent human health impact depends on the exact area where the device is placed. The SAR limit is 1.6 W/kg averaged over 1 gram (g) of tissue for use on the head, and 4.0 W/kg averaged over 10 g of tissue for use on the wrist, based on dosimetric considerations. This limit is recognized in the USA, Canada, and Korea. On the other hand, the SAR limit is 2.0 W/kg averaged over 10 g of tissue for use on the head and 4.0 W/kg averaged over 10 g of tissue for use on the wrist, is applied in the EU, Japan, and China.

Experimental results

The SAR data from the commercially used wearable devices such as Fitbit, Apple AirPod, Apple Watch, and Snap Wearable video camera were analyzed. These devices operated based on two wireless technologies–namely, IEEE 802.11b and Bluetooth (both these technologies use a carrier frequency of 2.4GHz). The results of the experiment are stated below:

- Apple AirPod A2032 shows higher SARs for operating based on Bluetooth. The SAR for AirPods is 0.581 W/kg for the left earbud and 0.501 W/kg for the right ear. That makes for a combined 1.082 W/kg when worn in both ears. In comparison, the SAR for an iPhone XS is 1.19 W/kg, or just 10% more than that of the AirPods.
- Fitbit xRAFB202, which operates on 802.11b, showed a SAR of 1.124 W/kg.
- Snap wearable video camera 2AIRN-002 Veronica showed SAR of 0.94 W/kg while operating on 802.11b.
- Across the Apple Watch Series 4 models, the SARs are found as 0.37 W/kg, 0.17 W/kg, and 0.13 W/kg, in cellular transmission, Wi-Fi, and Bluetooth, respectively.

Furthermore, it was observed that SAR increases with an increase in the carrier frequency used for the operation. This is because the amount of EMF energy absorbed increases with an increase

in frequency. SAR is also inversely proportional to the penetration depth, which suggests a shallower penetration yielding a higher absorption. [1]

3. Privacy issues with Interactive devices

Interactive devices like Amazon Echo, Google Home has embedded sensors and the ability to connect to wireless networks, which allows them to collect data about how we use them and communicate with other devices in our homes. Users today are aware of the fact that these interactive devices are, by default, always listening, recording, and probably saving sensitive personal information. From the outside, these interactive assistants appear to only respond to designated call words like, "Alexa" and "Hey Google", but, their implementation demands them to listen continuously to detect these call words. These devices monitor and record sounds and conversations in real-time, either maliciously, by misconfiguration, or after compromise by hackers. Leaked audio data can be processed to extract confidential information, track user activity, count human speakers, or even extract handwriting content. These negative implications on users' security and privacy are significant and unacceptable.

Possible jamming solutions

It is the need of the hour to come up with a solution to protect the users. Recent research has shown that ultrasonic transducers can actively prevent commodity microphones from recording human speech. These ultrasonic signals are undetected by human ears. They leak into the audible spectrum after being captured by the microphones, producing a jamming signal inside the microphone circuit that jams voice recordings. This leakage is caused by the inherent nonlinearities in the microphone.

Based on my understanding of Jammers and Jamming techniques, any Smart-hybrid jammer with an ability to jam multiple channels and which can be micro sized can serve as an effective jammer for our purpose. [2]

4. Wearable Jammer Bracelet

The currently commercially available ultrasonic transducers are directional, i.e., the user has to point the jammer specifically in the direction of the microphone. This is not possible in cases where the microphones are hidden. Also, these jammers rely on multiple transducers to enlarge the jamming coverage and introduce blind spots, where signals from 2 or more transducers cancel each other. It is noticed that 17% of all locations within 1.2m of a typical multi-transducer jammer are blind spots.

Therefore, a new prototype of a wearable jammer bracelet was engineered. The new device is a bracelet, therefore, it leverages natural hand gestures while speaking, gesturing, or moving around to blur out the blind spots. By arranging transducers in a ring layout, this device jams in multiple directions and protects the privacy of its user's voice, without expecting its user to manually point the jammer to the eavesdropping microphones. [3]

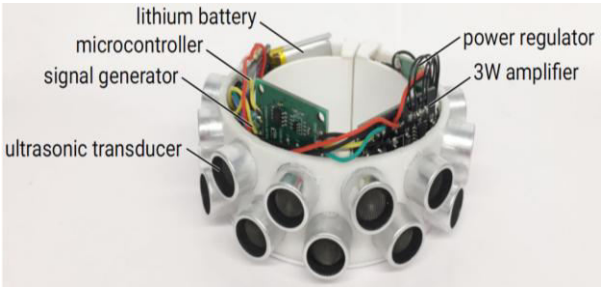

Figure 1: Self contained wearable Jammer

Implementation

The prototype is a self-contained wearable device comprised of the following components: a 3D-printed 9 cm ring (outer diameter) with a slit that acts as a hinge, allowing the wearer to open up the bracelet and fit it around their arm;

23 ultrasound transducers (NU25C16T-1, 25kHz), featuring 12 on the lower ring and 11 on the top ring (one transducer was removed to make space for the aforementioned hinge); a low-power signal generator (AD9833, up to 12.5MHz with 0.004Hz programmable steps); an ATMEGA32U4 microprocessor; an LED status indicator; a tactile switch (not shown); a LiPo battery (3.7V, 500mAh); a 3W audio amplifier (PAM8403), and, a 3.7V to 5V step-up regulator. Our microprocessor controls the signal generator via Serial Peripheral Interface.

The device consumes approximately 0.47W (3.7V × 127mA) when jamming, which is ten times less energy than that used by the commercially available i4 jammer. Thus, it can continuously jam for around four hours on the 500mA battery. The device and battery weigh only 135 grams.

Experimental results

The above-mentioned Jammer was tested for Angular Power distribution, Jamming speech recognizers, and Jamming microphones covered under daily use materials such as cloth, plastic, paper, etc. The results of these experiments when compared to those of the commercially available i4 and planar jammers showed:

- A wide-spread angular coverage (M = −3.3dBA, SD = 1.6dBA), while the existing jammers are highly directional (planar jammer: M = −19.2dBA, SD = 8.5dBA; i4: M = −17.0dBA, SD = 6.8dBA).
- More effective jamming in multiple directions with an increased Word Error Rate (WER) (M = 96.59% WER, SD = 3.97%) when compared to the other jammers (planar jammer: M = 38.89% WER, SD = 21.72%; i4: M = 57.55% WER, SD = 35.04%)
- WER of above 97% when microphones are hidden under a variety of objects, such as ordinary clothes, foam-based microphone windshields or paper sheets

The device proved effective even against anti-jamming techniques based on Deep Neural Networks and Wiener filter. This was possible because the device uses randomly changing signals, which are hard to predict and cancel out. Apart from this, the motion of the user's gestures and movements is also hard to predict, making it also extremely hard to cancel out these moving signal sources.

5. EMF from Jammers

It is to be noted that the Wearable Microphone Jammer also generates radiations. Therefore, there is a possibility that these radiations can also harm our bodies, and since, the device is placed close to the skin, SAR increases. [4]

Experimental results

A study was conducted to investigate the impact of radiation emitted of mobile phone jammers on hematological factors (blood cell factors and count), including red blood cell indices, mean corpuscular hemoglobin concentration (MCHC), a parameter that measures the concentration of hemoglobin in RBC. Another blood factor is the red blood cell distribution width (RDW-CV), which is an index of deviation in RBC size inside blood sampling. The jammer device used in this study was MB06, which was capable of blocking mobile communications within distance up to 40 meters. The results showed:

- no significant changes in the lymphocyte and WBC counts.
- exposure to jammer on- (experiment) or off- (sham) radiation in adult rats led to a significant increase in RBC (P=0.001) and platelet counts (P=0.001 and 0.02, respectively)

- MCHC, MCV, and RDWCV were statistically comparable in experimental and sham animals
- In immature rats, RBC, WBC, and lymphocyte counts were the same in all groups. The hemoglobin content and hematocrit did not change significantly by exposure to the rate with jammer on- or off-device. Platelets, MCVs and MCHCs showed a significant reduction in jammer-treated rats compared with those in sham

A few key points to be noted are:

- The thermal time constant of an organism plays a vital role in this experiment. With regards to the brain, which is a highly heat-sensitive tissue, the thermal time constant in humans is more than two times that in rats. Therefore, the exposure time to cause thermal damage is correspondingly high. Also, because the behavior of deep tissues in rats and humans of the temperature rise are different, extrapolation from small animals to humans in deep tissues demands to be studied further to understand its effects on humans.
- Also, MB06 operates at 4 different frequency ranges (GSM, 850MHz, 900 MHz, 1800 MHz, 1900 MHz) when compared to the Wearable Microphone Jammer, which operates at much lower frequencies (just above 20KHz). Therefore, the SAR due to the latter is much lower than that of the former.

6. Conclusions

Based on the results included in the report, it can be concluded that EMF released from the wearable devices around us can harm our body. [5] The concern for privacy breaches by these devices also led to the need to use ultrasonic jammers. The Wearable Microphone Jammer proved to have jammed in multiple directions since its transducers are arranged in a ring layout and leveraged natural hand gestures that occur while speaking to blur out blind spots, thus, out-performing other jammers that are available in the market. It also proved to be effective against specific noise-canceling techniques intended to cancel out the jamming signals. We also observed the effects of radiation from Cellphone Jammers on blood factors in rats.

7. References

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