International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Smart Wearable Devices- IoT Comparisons

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ABSTRACT:

Wearable devices are electronic components or computers that are designed to be worn on a person's body. By utilizing some type of connectivity capacity, wearable devices will allow users to access information in real time. It also has a drawback in terms of how it affects the user's body .The information offered in this paper Levels of SAR in currently available in wearable devices Standards and measurement techniques that are up to date .The conclusions in this paper are clear: in order to better address consumer concerns and promote this new technology, we recommend that The general public be kept up to speed on the latest information on commercial wearable devices Associated safety regulations be kept up to date and Manufacturers be trained on the most recent research and legislation.

Keywords: Wearables, Connectivity, SAR, Standards, Measurement, Safety, Regulations, Manufacturers

Introduction:

We are currently surrounded by vast technological advancements, and we cannot imagine a
World without machines and computers. Technology has progressed to the point that it has shrunk the computer down to our palm size and made it much more powerful to compete with the computer's speed and processing capability. For obvious reasons, humans are far more reliant on this technology for their daily needs. Daily tasks include not only communication but also documentation, entertainment, the availability of numerous programs, and online browsing. We cannot fathom a day without it, and this is where the problem begins: the user is unable to let go of the device for an extended amount of time, resulting in the risk factor. Because this technology not only provides benefits, it also has drawbacks [2]. The most prevalent drawbacks are that it distracts the user from their surroundings, causes eyestrain when used for long periods, and has some serious side effects. Radiation is a type of radiation. There are a variety of technologies and devices on the market that can assist humans in a variety of ways. It includes desktops, laptops, electronic calculators, and other personal digital assistants (PDAs). The existence of portable electronics, calculators, electronic wristwatches, headphones, and other such items gives rise to the concept of wearable computing. Wearable computing focuses on the fact that these devices may be carried everywhere and participate actively in human activities. There are varieties of business fields in the globe that require computer-related labour, but they like to keep their hands free. As a result, wearable computing is attempting to address the issues in all of these sectors.

1 Application Areas

1.1 Sensory Integration

Wearable devices use built-in sensors to monitor the environment and human health, such as heart rate tracking smartwatches. Various sensors and core algorithms like step counting and activity identification are discussed.

1.2 Medical Applications

Wearable devices provide real-time health monitoring and prognosis, activity detection, and supported living, playing a significant role in medicine.

1.3 Communication Management

Wearable devices use Weighted Average Coupon (WAC) and speech recognition to manage personal communications, acting as a virtual secretary for mobile communications.

1.4 Visual Filter

Wearable devices can digitally magnify images or text, aiding visually impaired individuals with reading through digital visual filters.

1.5 Face Recognition

Face recognition systems, combined with proper software, can be used in wearable computing for various applications, including for the police, lawmakers, and visually impaired individuals.

1.6 Finger Tracking

Camera-based wearable computing can graphically monitor the user's finger, allowing fingertip manipulation of the computer like a mouse.

1.7 Augmented Memory

Remembrance Agents (RAs) are wearable devices that provide context-based reminders, constantly active and engaged.

1.8 Other Technological Challenges

Wearable devices have limited auditory and visual output channels. A study on notification channels for wearable rings found vibration to be the most reliable and fastest method for transmitting sensor notifications

2 Methodology:

2.1 SAR Analysis Framework

This section details the mathematical formulas for describing and deriving SAR averaged over mass and time.

2.2 SAR as a Key Metric: A Justification

Electromagnetic waves can penetrate human tissue, causing dielectric heating and potential damage. PD and SAR are common metrics for measuring EMF exposure severity, but SAR is preferred for close-proximity devices due to its ability to account for temperature elevation at the point of contact.

2.3 SAR Average

SAR is defined as the average over a certain mass. ANSI C95.1-1982 and IEEE guidelines specify time-averaged SAR limits: 0.40 W/kg over 6 minutes for local exposure and whole-body averaging periods of 30 minutes. Local exposure ERLs are four times the whole-body ERL.

2.4 Assumption of Worst-Case Exposure

This study considers the potential maximum exposure a consumer might face, without implementing mitigation strategies, to guide towards conservative safety recommendations.

2.5 Proposed Methodology for Measuring EMF Exposure

Alternative methods to evaluate human EMF exposure are discussed.

2.6 Temperature Measurement

A temperature-based dosimetry system using optical fibre thermal sensors within a phantom aligns well with electric field probe measurements but has spatial resolution limitations. MRI temperature mapping has been used for EMF energy deposition measurement.

2.7 Chronic Exposure

The National Toxicology Program describes chronic exposure through cancer bioassays. Table 1 lists SAR and key parameters for Air Pod, Fitbit, and Snap wearable video cameras.

Apple Air Pod A2031, Left ear (next to mouth)	Frequency	N/A	2441
	Spacing (mm)	N/A	10
	Conducted Power [dBm]	N/A	12.5
	Duty Cycle (percentage)	N/A	100
	Reported SAR (averaged over 1 g) [W/Kg]	N/A	0.071
Apple Air Pod A2031, Left ear (body-mounted)	Frequency	N/A	2441
	Spacing (mm)	N/A	0
	Conducted Power [dBm]	N/A	12.5
	Duty Cycle (percentage)	N/A	100
	Reported SAR (averaged over 10 g) [W/Kg]	N/A	0.501
Apple Air Pod A2032, Right ear (next to mouth)	Frequency	N/A	2441
	Spacing (mm)	N/A	10
	Conducted Power [dBm]	N/A	12.5
	Duty Cycle (percentage)	N/A	100
	Reported SAR (averaged over 1 g) [W/Kg]	N/A	0.095
Apple Air Pod A2032, Right ear (body-mounted)	Frequency	N/A	2441
	Spacing (mm)	N/A	0
	Conducted Power [dBm]	N/A	12.5
	Duty Cycle (percentage)	N/A	100
	Reported SAR (averaged over 10 g) [W/Kg]	N/A	0.581
Fitbit xRAFB202	Frequency	N/A	2441
	Spacing (mm)	N/A	0
	Conducted Power [dBm]	18.3	N/A
	Duty Cycle (percentage)	100	N/A
	Reported SAR (averaged over 10 g) [W/Kg]	1.124	N/A
Fitbit xRAFB503	Frequency	2437	N/A
	Spacing (mm)	0	N/A
	Conducted Power [dBm]	18.4	N/A
	Duty Cycle (percentage)	100	N/A
	Reported SAR (averaged over 10 g) [W/Kg]	0.45	N/A
Snap wearable video camera, 2AIRN-002 Veronica	Frequency	2412	N/A
	Spacing (mm)	0	N/A
	Conducted Power [dBm]	12.65	N/A
	Duty Cycle (percentage)	92-96	N/A
	Reported SAR (averaged over 10 g) [W/Kg]	0.94	N/A
Snap wearable video camera, 2AIRN-002 Nico	Frequency	2412	N/A
	Spacing (mm)	0	N/A
	Conducted Power [dBm]	12.65	N/A
	Duty Cycle (percentage)	92-96	N/A
	Reported SAR (averaged over 10 g) [W/Kg]	1	N/A

Objective:

1. To examine the levels of SAR in wearable devices.
2. To evaluate and summarize the existing standards and measurement techniques related to SAR in wearable devices.
3. To ensure the general public is kept informed about the latest safety information and developments regarding wearable devices.

Tools & Technologies

3.1 SAR Measurement Model

- SAR modelling is complex due to tissue variation across body parts, often requiring computer models to simulate the relationship between an antenna and a load.
- Despite simulations, physical probes are used for most EMF-emitting systems to ensure accuracy.
- Conventional SAR measurement devices use physical probes.

3.1.2 Time-Average SAR Measurement

- Traditional SAR measurements use a liquid-filled model to mimic body tissues with a physical electric field probe.
- This setup is cumbersome and inefficient due to the invasiveness, time requirements, and probe calibration specifications.

3.2 Current Measurement Methodologies

3.2.1 DASY Setup

- The DASY system is the most common method for SAR measurement, consisting of a high precision robot, probe alignment sensor, phantom, robot controller, measurement server, data acquisition electronics, and a dosimetry probe.
- The dosimetry probe is calibrated in liquid for accuracy.

3.2.2 Calculation of Time-Averaged SAR

- Time-averaged SAR is calculated by defining unit measurements, scanning areas, and performing zoom scans.
- Standard procedures include SAR reference measurement, area scans to find peak SAR positions, and zoom scans for cube-averaged SAR.

3.2.3 Controversy

- Challenges include accurately simulating the human body due to variables like age, gender, and health.
- Current methods, based on an outdated model, do not fully represent the average person's use.

3.3 Common Tools for Measuring Electromagnetic Frequency

- EMF meters measure AC electromagnetic fields, and gauss meters measure DC fields.
- EMF is measured in volts per meter (V/m), and reputable brands test appliances to ensure compliance with ICNIRP guidelines.

3.3.1 Inability of Smartphones to Detect EMF

- Smartphones can only detect EMF from communication technologies (Wi-Fi, 2G, 3G, 4G, 5G, Bluetooth) but not true EMF.
- Apps like Ultimate EMF Detector and Electromagnetic Detector EMF measure magnetic fields, not true EMF. True EMF measurement requires capacitors.

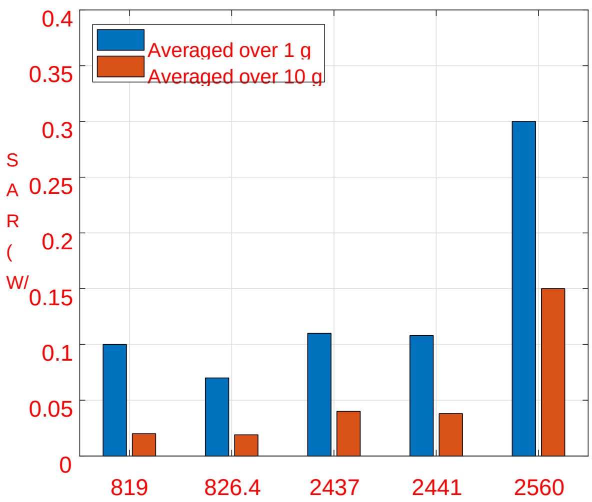
Data Analysis

Air Pod's Bluetooth

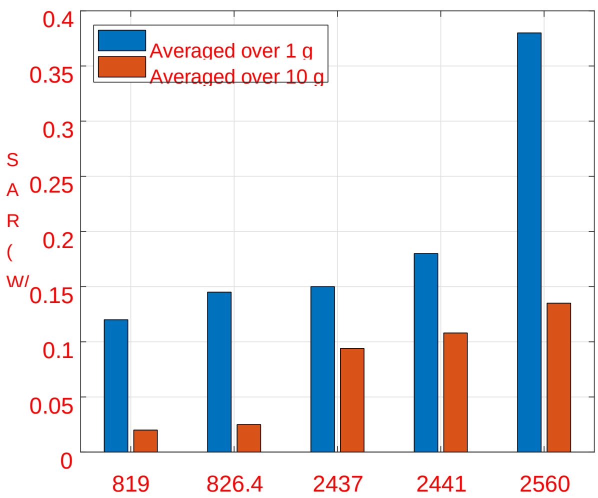
The SARs for Air Pod's Bluetooth operation is higher. The SAR for Air Pods is 0.581 W/kg for the left earbud and 0.501 W/kg for the right earbud, according to Table I. When both ears are worn, the total power output is 1.082 W/kg. In contrast, an iPhone XS has a SAR of 1.19 W/kg, which is just 10% higher than the Air Pods.

Apple Air Pod A2031, Left ear (next to mouth)	Frequency	N/A	2441
	Spacing (mm)	N/A	10
	Conducted Power [dBm]	N/A	12.5
	Duty Cycle (percentage)	N/A	100
	Reported SAR (averaged over 1 g) [W/Kg]	N/A	0.071
Apple Air Pod A2031, Left ear (body-mounted)	Frequency	N/A	2441
	Spacing (mm)	N/A	0
	Conducted Power [dBm]	N/A	12.5
	Duty Cycle (percentage)	N/A	100
	Reported SAR (averaged over 10 g) [W/Kg]	N/A	0.501
Apple Air Pod A2032, Right ear (next to mouth)	Frequency	N/A	2441
	Spacing (mm)	N/A	10
	Conducted Power [dBm]	N/A	12.5
	Duty Cycle (percentage)	N/A	100
	Reported SAR (averaged over 1 g) [W/Kg]	N/A	0.095
Apple Air Pod A2032, Right ear (body-mounted)	Frequency	N/A	2441
	Spacing (mm)	N/A	0
	Conducted Power [dBm]	N/A	12.5
	Duty Cycle (percentage)	N/A	100
	Reported SAR (averaged over 10 g) [W/Kg]	N/A	0.581
Fitbit xRAFB202	Frequency	N/A	2441
	Spacing (mm)	N/A	0
	Conducted Power [dBm]	18.3	N/A
	Duty Cycle (percentage)	100	N/A
	Reported SAR (averaged over 10 g) [W/Kg]	1.124	N/A
Fitbit xRAFB503	Frequency	2437	N/A
	Spacing (mm)	0	N/A
	Conducted Power [dBm]	18.4	N/A
	Duty Cycle (percentage)	100	N/A
	Reported SAR (averaged over 10 g) [W/Kg]	0.45	N/A
Snap wearable video camera, 2AIRN-002 Veronica	Frequency	2412	N/A
	Spacing (mm)	0	N/A
	Conducted Power [dBm]	12.65	N/A
	Duty Cycle (percentage)	92-96	N/A
	Reported SAR (averaged over 10 g) [W/Kg]	0.94	N/A
Snap wearable video camera, 2AIRN-002 Nico	Frequency	2412	N/A
	Spacing (mm)	0	N/A
	Conducted Power [dBm]	12.65	N/A
	Duty Cycle (percentage)	92-96	N/A
	Reported SAR (averaged over 10 g) [W/Kg]	1	N/A

Air pod's Bluetooth SAR Table-1



a) Chart of Apple A1889



b) Chart of Apple A1891

Apple Watch

Table II SAR and other statistics for the Apple Watch series, which operate in a broader range of spectrum bands, including UMTS at 850 and 1750 MHz, LTE in Bands 7 and 26, IEEE 802.11b, and Bluetooth. Apple Watch radios were set to their greatest transmission levels during testing and positioned in settings that simulated usual use, including 10 mm separation for use against the head and no separation for use on the wrist [10]. In cellular transmission, Wi-Fi, and Bluetooth, the greatest SARs are 0.37 W/kg, 0.17 W/kg, and 0.13 W/kg, respectively, throughout the Apple Watch Series 4 models. Simultaneous transmission (i.e., cellular and Wi-Fi) is also supported by the model, resulting in a SAR of 0.50 W/kg. It is worth noting that each of these four numbers complies with current safety standards. (Recall the values of 1.6 W/Kg and 2.0 W/Kg. It's worth noting that each of these four numbers complies with current safety standards. (Recall the FCC's 1.6 W/Kg and ICNIRP's 2.0 W/Kg, respectively.)

Chart a and b show the SAR of Apple A1889 and A1891 versus the carrier frequency, respectively. A broad pattern can be seen in the two pictures, indicating that the SAR increases as the frequency increases. The rationale can be found in the definition of a SAR, It has the denominator 'penetration depth': a greater carrier frequency results in a lesser penetration depth. In other words, even though a higher frequency EMF goes to a shallower place in human skin, it absorbs a bigger amount of EMF energy. Then, using current SAR measuring procedures for standard compliance checks, this paper demonstrated how the time-averaged SAR is actually measured. Some prominent commercial goods' SAR levels were studied using these mathematical equations and measuring approaches. Wearable communications at 60 GHz were discovered to induce SAR beyond the criteria, despite the fact that the existing guidelines do not control SAR at that frequency, inferring the guidelines specified at lower frequencies. According to ICNIRP and FCC, the separation distances were 12 and 15 mm, respectively.

Apple Watch A1860 (next to mouth)	Frequency	836.6	1732.4	N/A	844	2437	2441
	Spacing (mm)	10	10	N/A	10	10	10
	Housing Type	Stainless Steel	Ceramic	N/A	Stainless Steel	Aluminium	Ceramic
	Wrist Band Type	Sport	Sport	N/A	Metal Links	Sport	Sport
	Conducted Power [dBm]	22.89	23.43	N/A	22.8	19.47	12.98
	Duty Cycle (percentage)	100	100	N/A	100	98.2	100
	Reported SAR (averaged over 1 g) [W/Kg]	0.112	0.526	N/A	0.109	0.089	0.094
Apple Watch A1860 (body-mounted)	Frequency	836.6	1732.4	N/A	844	2437	2441
	Spacing (mm)	0	0	N/A	0	0	0
	Housing Type	Ceramic	Ceramic	N/A	Ceramic	Aluminium	Aluminium
	Wrist Band Type	Sport	Metal Links	N/A	Metal Loop	Sport	Sport
	Conducted Power [dBm]	22.89	23.43	N/A	22.8	19.47	12.98
	Duty Cycle (percentage)	100	100	N/A	100	98.2	100
	Reported SAR (averaged over 10 g) [W/Kg]	0.026	0.179	N/A	0.024	0.029	0.034
Apple Watch A1861 (next to mouth)	Frequency	836.6	1732.4	N/A	819	2437	2441
	Spacing (mm)	10	10	N/A	10	10	10
	Housing Type	Stainless Steel	Ceramic	N/A	Stainless Steel	Aluminium	Aluminium
	Wrist Band Type	Sport	Sport	N/A	Metal Links	Sport	Sport
	Conducted Power [dBm]	22.89	23.43	N/A	22.8	19.47	12.98
	Duty Cycle (percentage)	100	100	N/A	100	98.2	100
	Reported SAR (averaged over 1 g) [W/Kg]	0.112	0.526	N/A	0.109	0.166	0.130
Apple Watch A1861 (body-mounted)	Frequency	836.6	1732.4	N/A	819	2437	2441
	Spacing (mm)	0	0	N/A	0	0	0
	Housing Type	Ceramic	Ceramic	N/A	Ceramic	Aluminium	Aluminium
	Wrist Band Type	Sport	Metal Loop	N/A	Metal Loop	Sport	Sport
	Conducted Power [dBm]	23	23.5	N/A	22.88	19.47	12.98
	Duty Cycle (percentage)	100	100	N/A	100	98.2	100
	Reported SAR (averaged over 10 g) [W/Kg]	0.03	0.344	N/A	0.018	0.083	0.070
Apple Watch A1889 (next to mouth)	Frequency	826.4	N/A	2560	819	2437	2441
	Spacing (mm)	10	N/A	10	10	10	10
	Housing Type	Stainless Steel	N/A	Aluminium	Stainless Steel	Aluminium	Stainless Steel
	Wrist Band Type	Metal Loop	N/A	Sport	Metal Links	Sport	Sport
	Conducted Power [dBm]	23.39	N/A	22.9	22.52	19.49	12.81
	Duty Cycle (percentage)	100	N/A	100	100	98.2	100
	Reported SAR (averaged over 1 g) [W/Kg]	0.076	N/A	0.29	0.1	0.109	0.107
Apple	Frequency	826.4	N/A	2560	819	2437	2441

Watch A1889 (body-mounted)	Spacing (mm)	0	N/A	0	0	0	0
	Housing Type	Ceramic	N/A	Aluminium	Ceramic	Aluminium	Aluminium
	Wrist Band Type	Sport	N/A	Sport	Sport	Sport	Sport
	Conducted Power [dBm]	23.39	N/A	22.9	22.52	19.49	12.81
	Duty Cycle (percentage)	100	N/A	100	100	98.2	100
	Reported SAR (averaged over 10 g) [W/Kg]	0.023	N/A	0.146	0.024	0.036	0.033
Apple Watch A1891 (next to mouth)	Frequency	836.6	N/A	2510	819	2437	2441
	Spacing (mm)	10	N/A	10	10	10	10
	Housing Type	Stainless Steel	N/A	Stainless Steel	Ceramic	Aluminium	Aluminium
	Wrist Band Type	Metal Links	N/A	Sport	Metal Links	Sport	Sport
	Conducted Power [dBm]	23.11	N/A	23.04	21.87	19.49	12.81
	Duty Cycle (percentage)	100	N/A	100	100	100	100
	Reported SAR (averaged over 1 g) [W/Kg]	0.134	N/A	0.354	0.11	0.144	0.176
Apple Watch A1891 (body-mounted)	Frequency	836.6	N/A	2535	819	2437	2441
	Spacing (mm)	0	N/A	0	0	0	0
	Housing Type	Ceramic	N/A	Ceramic	Ceramic	Aluminium	Aluminium
	Wrist Band Type	Sport	N/A	Sport	Metal Loop	Sport	Sport
	Conducted Power [dBm]	23.11	N/A	22.9	22.83	19.49	12.81
	Duty Cycle (percentage)	100	N/A	100	100	100	100
	Reported SAR (averaged over 10 g) [W/Kg]	0.028	N/A	0.178	0.021	0.085	0.102

TABLE 2 SAR comparisons of Apple watch

Conclusion

This research paper presents a comprehensive analysis of Specific Absorption Rate (SAR) levels on currently available wearable devices, alongside an evaluation of existing standards and measurement techniques. In conclusion, wearable devices, while providing numerous benefits such as real-time information access and health monitoring, present potential health risks due to electromagnetic radiation exposure. This paper emphasizes the importance of keeping the public informed about the latest safety information and ensuring that manufacturers adhere to up-to-date SAR measurement standards and safety regulations. It highlights the complexity of accurately measuring SAR in wearable devices and the necessity of using physical probes alongside computer models to ensure accurate safety assessments. The study of commercial products like Air Pods and Apple Watches reveals that, although current safety standards are met, there is a need for continuous evaluation and improvement of measurement techniques to better reflect real-world usage and mitigate potential health risks.

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