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White Paper

Challenges in Testing Specific Absorption Rate (SAR) in Modern Mobile Phones

Abstract

As mobile phones and other devices become increasingly integrated into our daily lives, the RF energy emitted from these devices can remain a concern for some people. Specific Absorption Rate (SAR) measures the rate at which the human body absorbs radio frequency (RF) energy emitted by devices used next to the body. This white paper explores the challenges associated with testing SAR in modern devices considering evolving technology, compliance regulations, and the need for consistent regulation.

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Jon Kenny has over 20 years' experience in SAR testing. Initially, he worked as a test engineer for the cellular test team at an independent test lab, and later moved to a full-time specialisation in the SAR testing area.

He began his RF-exposure career working to get the UK's first UKAS-accredited SAR testing facility off the ground. After several years, he made the move from independent test house to mobile device manufacturer, Ericsson, and then Sony Ericsson (SEMC), working on bringing their diverse range of cellular products to market.

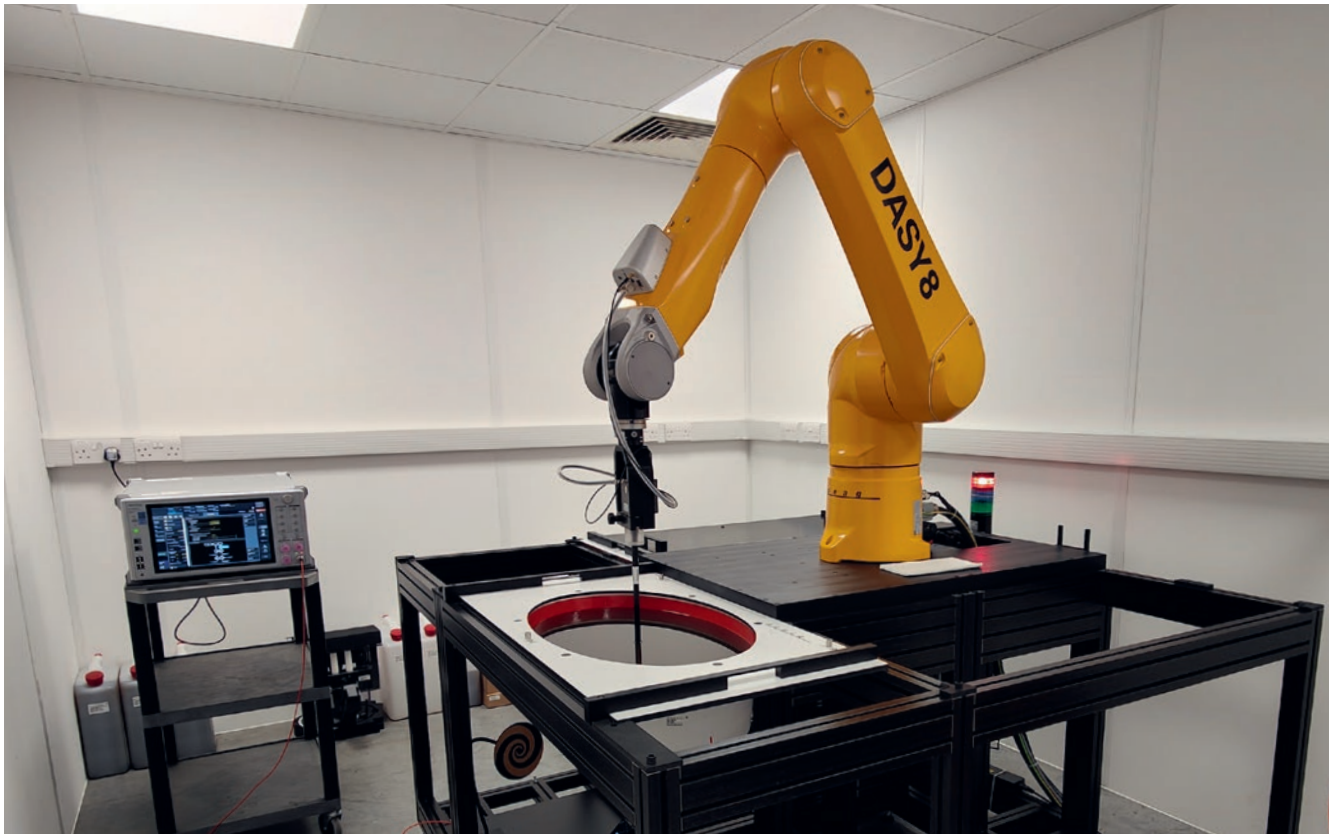
At SEMC, he became the SAR technical lead engineer responsible for the company's SAR testing supporting Sweden, UK, the US, China, and Japan. He also represented the company within the RF-exposure testing community dealing with international groups. Additionally, he provided input to SAR standards groups such as the IEEE and IEC groups.

Jon moved back to his roots at an independent test house and has been with TÜV SÜD for over four years where he's looking after and growing the RF-exposure testing services.

Introduction

SAR testing is used to measure the amount of electromagnetic radiation absorbed by the human body when using wireless devices

The ubiquitous use of mobile devices in contemporary society necessitates stringent and consistent certification standards. Among these test standards, SAR measurement is crucial in assessing the potential health risks associated with RF exposure. This white paper explores the challenges faced in testing the SAR of modern devices and the implications for the consumer.



Background

SAR testing has been in use for over 20 years and is the primary method for quantifying the RF exposure absorbed into a body from a mobile device. The test methodology has remained largely unchanged throughout this duration with the testing being carried out on one primary test system. This means that the test methods and definitions are well documented and understood which should lead to a high level of confidence that reported SAR values should be consistent the world over.

This is significant to the mobile industry because in the initial years of technology adoption there were legitimate concerns from users of mobile devices that having an RF source so close to the body could cause adverse health effects.

SAR testing allowed the industry to demonstrate that mobile devices emit levels of non-ionizing radiation (RF-energy) far below levels that would cause adverse health effects.

It is also important to note that the limits set in international regulations for consumer technologies fall far below the limits for non-ionizing radiation levels that would be deemed unsafe. This means that although a device might be non-compliant to a regulatory test requirement, it is highly unlikely that that same device would be unsafe. This is particularly true when we factor in how much overall RF output power a small device can transmit, which is very low in terms of actual RF safety. It's important to consider this when looking at news stories and social media posts which suggest that such devices might pose safety concerns where none exist.

Evolution of mobile technology

The landscape for mobile technology has changed greatly since the introduction of SAR tests. Initially, 20 years ago we had typically three frequency bands available consisting of two bands for the UK and one band for roaming (in the US for example). Each of those bands could be tested in half a day and then a test report could be produced containing simple content.

Fast forward to today and a typical cellular device could have as many as 65 identifiable frequency bands of operation, with each one having to be considered for SAR testing. The result is that testing programmes can now consist of many 100s of individual test cases. A typical SAR test case run time would be approximately 20 minutes so a manufacturer of consumer devices used close to the body must provide a high level of investment and diligence to get a product successfully to market.

SAR testing procedures

SAR testing procedures can be broadly split into two main areas. Testing against the head and testing against the body. Testing against the head is performed against a standardised head at the left and then the right ear. Testing at the ear is then further divided into two test positions to accommodate a difference in the way that users hold their devices.

For devices used against the body, testing is carried out against a flat surface and then a separation distance is defined, if required. The separation distance should reflect the primary user case for the device under test and consider reasonably foreseeable use.

SAR testing procedures for body testing incurred a significant change with the introduction of mobile hotspot (tethering) technology introduced in Android version 2 (2010) and iOS shortly after. The US regulator (FCC) defined this technology as an “unattended” service meaning that a user may not be aware of what their device is doing with regards to the radio transmit status.

This meant that almost overnight manufacturers had to test their devices at an instructed distance of 0mm (in contact with the body) when in the hotspot (tethered) mode. To meet these requirements most devices had to employ the use of different output powers based on the operating condition. This is a practice that is adopted globally and in widespread use today.

Compliance regulations

SAR tests have a unit of measurement that is the Watt per kilogram (W/kg). The measurements then need to be averaged over an amount of tissue. Most measurement requirements fall into two camps which are either for Europe or North America. In Europe SAR is averaged over a 10g mass with a limit of 2.0 W/kg and in North America SAR is averaged over a 1g mass with a limit of 1.6 W/kg. The North American conditions form a more stringent compliance requirement. Most other world regions generally adopt one of these test requirements.

The limits referenced above are for testing against the body and head. In addition to those limits, there are relaxed limits for the limbs and extremities due to the absence of major organs and the increased presence of bone and cartilage. The limits referenced above are for the general public (uncontrolled exposure).

Challenges in modern phone testing

Modern devices have something in the region of 65 identifiable frequency bands in them. In addition to this they also have multiple antenna solutions associated with those bands and in most, if not all, cases there is user and body detection systems to control the maximum power that can be transmitted from the device. These features multiply up to form a very complicated set of measurement conditions where the following points need to be considered.

A fundamental issue of this inherent complexity is that in most cases it would be almost impossible to get stable and reliable SAR data from a complex device without input from the manufacturer. This might affect the integrity of a blind test or perhaps a market surveillance activity. Consumer devices now employ power reduction strategies that involve off-body or on-body detection. For the consumer, perceived quality and performance of a device depends on the maximum power than can be transmitted from that device. With SAR values decreasing with an increase in distance from a body, output power could be increased if we knew that it was, for example, on a table away from the user.

In the test laboratory these tests would be conducted twice and would utilise the power output values that would be contained in a power table of output values. The on-body and the off-body tests would be performed at separation distances appropriate for those user conditions. The on-body would be performed at typically 0mm separation at the lower power setting and the off-body would be performed at typically 5mm at the slightly higher power level.

A device in the real world would then utilise sensors to detect the on- or off-body condition. This would typically be done by monitoring the accelerometer output or another kind of proximity sensor. In the total absence of a sensor signal or some ambiguity of location, the device would typically default to the lower power condition.

The difficulties here can arise when a laboratory is unaware how a manufacturer has defined their detection strategy. So, a condition could exist whereby a device is hard clamped into a test system without a separation

distance to test the on-body condition, but no provision has been made to trigger the detection. This would result in an artificially high SAR reading and a seemingly non-compliant device.

Additionally, devices are using more complex antenna implementations that allow for a higher data throughput to be supported using multiple simultaneous antenna configurations. Those multiple antennas can also be used to actively move the transmit signal on a device to, for example, avoid a hand that might be gripping the device and causing the device output signal to be attenuated.

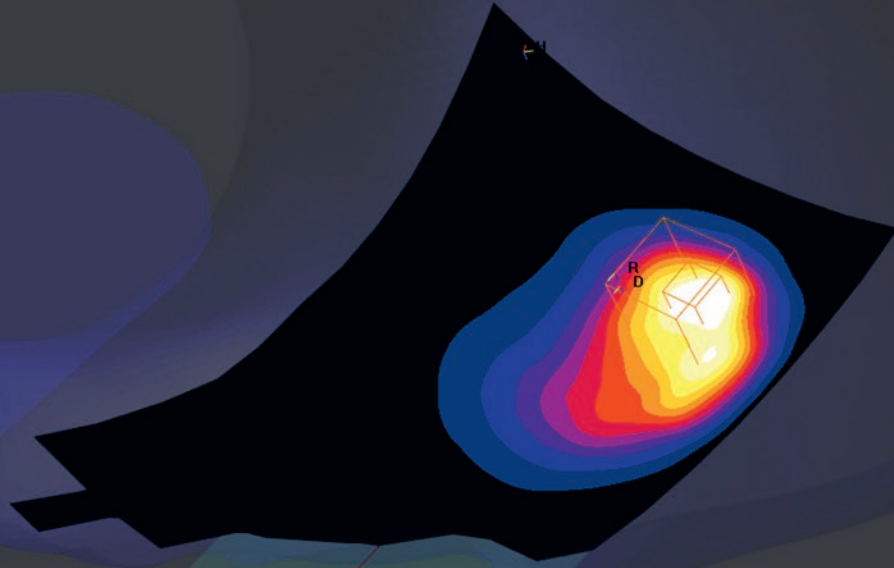
This scenario can cause particular issues when testing a device's time averaged SAR algorithm (TAS).

TAS is an additional strategy that a manufacturer can employ to reduce a user's exposure to RF-energy. A device utilising TAS can vary the output power of a device over a period of time to ensure that the SAR levels experienced by a user are kept low overall.

The measurement of TAS is performed by measuring the RF output power at a defined point within an artificial head or body. This point is found by measuring the area over a device and plotting a RF map over the device. From this map the highest RF single point can be found. Once positioned at this point, the test system simply continuously records the RF level against time.

One of the challenges here is that if a device is not fully understood then it is possible for a TAS algorithm to not be triggered. Additionally, if the device is not preconditioned correctly, it is possible that a device may move the active transmit antenna after the RF map has been defined. This could result in an unexpectedly high SAR value if the device thinks it is on a table because on-body detection has not been triggered, or unexpectedly low if the device has moved the output antenna.

Many of the device operation issues can be avoided by ensuring that the manufacturer has outlined how the power management strategies have been implemented and operated.



Conclusion

Comprehensive device knowledge ensures accurate SAR tests and adherence to rigorous manufacturer standards and market regulations.

Modern devices are very complicated and must be fully understood in their capabilities and their operation before the commencement of any testing activities.

The likelihood of a third party being able to take a phone from a shop shelf and achieve SAR levels that are all in line with published data in all areas of test could be quite unlikely.

Manufacturers' test data is in some cases in the public domain and often falls under great scrutiny from competitors and sometimes the general public.

Reputable manufacturers commit large amounts of resources and money to get these measurements right. Their test reports go through expert technical review before a device can be placed on the market so we can be confident that the SAR tests have been carefully considered. It is therefore important to understand device operation and to engage with the manufacturers for external activities such as market surveillance, for example.

Find out more about TÜV SÜD's SAR testing

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