

## The Hows and Whys of SAR Testing

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RF exposure and safety concerns about wireless products have been getting increased news coverage in the past few years. The massive increase in wireless device usage and the emergence of mobile productivity devices have increased awareness among the news media and the general public of the existence of RF exposure as a potential concern, even though the RF design community has always known about this and regulations have been in place for years. One of the key components of RF exposure evaluation is the SAR measurement.

Specific Absorption Rate, or SAR, is a measure of the heating value of radiated RF energy on human tissue. SAR evaluates the relative safety of low-power transmitters in close proximity to the human body or high-power transmitters at greater distances.

Because SAR test methods are quite involved, requiring specialized equipment that is not widely available at certification labs, testing adds expense and delay to the certification process.

Does your product require SAR testing? It's a somewhat complicated issue. Knowing the answer at the outset of a project can prevent some unpleasant surprises at the back end when it comes time for certification. Unfavorable test results may also require a change in design direction. While this paper is by no means a complete or final guide to determining SAR requirements for a specific product, it provides an overview of basic requirements and SAR-related considerations during the design process.

Three factors affect SAR requirements: classification, separation, and field intensity.

The FCC classifies products as fixed, mobile, or portable based on how they are installed and used. Fixed products are permanently located with an antenna that's affixed to a structure so that it can't be easily relocated. These types of products typically require some type of license other than a general Part 15 certification. This paper will not address this class.

Mobile and portable products, as the names imply, can be moved from one location to another and possibly used in close proximity to the body. The distinction is separation distance. Mobile devices are used 20 cm or more from the body, and portable devices are used within 20 cm of the body. One exception involves body extremities: devices held in the hand can still be classified as mobile.

Portable devices will require SAR evaluation unless their FCC rule part specifically excludes it. Among devices required to have SAR testing:

- Cellular Radiotelephone Service, part 22, subpart H
- Personal Communications Service (PCS), part 24
- Satellite Communications Services, part 25
- General Wireless Communications Service, part 26
- Wireless Communications Service, part 27
- Maritime Services, part 80



- Specialized Mobile Radio Service, part 90
- 4.9 GHz Band Service
- Wireless Medical Telemetry Service (WMTS)
- Medical Implant Communications Service (MICS)

Unlicensed devices (part 15) are *not* required to have SAR testing unless:

- the specific rule part covering them requires it
- the source-based time-averaged output power is  $> 60/f(\text{GHz})$  mW
- multiple transmitters are used in the same location

One rule section that specifically calls for RF exposure evaluation is part 15.247. This part covers many commonly used radios in modern products, including 802.11 wireless networking, Bluetooth devices, and Zigbee or other 802.15.4 devices. If any of these products are to be used in an application within 20 cm of the human body, they will need to be evaluated.

Output power limits for some of the common unlicensed frequencies are summarized in the following table.

f (MHz)	(mW)
315	190.48
434	138.25
915	65.57
2450	24.49

If an inherent property of the modulation or transmission protocol limits the maximum duty cycle of the transmitter, the output power used for SAR determination may be reduced. If, for example, the transmitter has an output power of 100 mW (+20 dBm) at 915 MHz but it is time division duplexed such that it is active for only 50 mS out of every 100 mS, then the power may be calculated as 50 mW (+17 dBm). Without the source-based average, the product would be above the SAR threshold; but once the duty cycle is taken into account, the product drops below the limit.

Antenna gain must also be factored into the calculation. If the product has an output power of 50 mW (+17 dBm) but an antenna with a gain of 3 dBi is attached, the radiated output used for comparison is now 100 mW (+20 dBm).

The conditions in the previous paragraphs apply only to single transmitters intended for stand-alone operation. Products containing more than one transmitter are becoming increasingly common, though. In these products, total output power must be considered. While each individual transmitter may be within SAR compliance, it is also necessary to evaluate a worst-case condition with all transmitters operating simultaneously. Documentation showing the duty cycles and coincidence of operation must be provided with the compliance test materials.



This extremely brief overview has been intended to give a quick look at the requirement for RF exposure evaluation. The fundamental points to remember are:

- RF exposure testing exists. It must be planned for during the initial concept and design phases of a product.
- Regulations can be confusing and are continually being updated. Working with a compliance lab during product design is recommended.
- SAR evaluation is an added step in compliance certification. Plan ahead for increased cost and test time. A good compliance facility can help with this.
- Carefully document the transmit duty cycle(s) of your product. The result may exclude your product from SAR testing. If it does require testing, this information will be needed for the test report.
- Special software may be needed for SAR testing to cause the worst-case output to run continuously for measurement purposes.

Much more has been written about SAR and the need for testing. Each product is unique and must be evaluated as such. Output power, antenna gain, duty cycle, and separation from the body all weigh into the testing requirements. Knowing these factors during the product's design phase can avoid problems when it comes time for certification.

### References/Quick Links

*U.S. Government Printing Office*

<http://ecfr.gpoaccess.gov/cqj/t/text/text-idx?c=ecfr&sid=496692fbd7007e3e220b3219a5569f1e&rqn=div5&view=text&node=47:1.0.1.1.3&idno=47>

*FCC Part 15*

<http://ecfr.gpoaccess.gov/cqj/t/text/text-idx?c=ecfr&sid=496692fbd7007e3e220b3219a5569f1e&rqn=div5&view=text&node=47:1.0.1.1.14&idno=47>

*Title 47 CFR*

[http://ecfr.gpoaccess.gov/cqj/t/text/text-idx?sid=496692fbd7007e3e220b3219a5569f1e&c=ecfr&tpl=/ecfrbrowse/Title47/47tab\\_02.tpl](http://ecfr.gpoaccess.gov/cqj/t/text/text-idx?sid=496692fbd7007e3e220b3219a5569f1e&c=ecfr&tpl=/ecfrbrowse/Title47/47tab_02.tpl)

### Additional References

1. *OET Bulletin 65, Edition 97-01, August 1997*

[http://www.fcc.gov/Bureaus/Engineering\\_Technology/Documents/bulletins/oet65/oet65.pdf](http://www.fcc.gov/Bureaus/Engineering_Technology/Documents/bulletins/oet65/oet65.pdf)

2. *FCC Knowledge Database KDB 447498 D01 v03r03*

<https://fjallfoss.fcc.gov/oetcf/kdb/forms/FTSsearchResultPage.cfm?switch=P&id=20676>

3. *Title 47 CFR, part 2.1091*

4. *Title 47 CFR, part 2.1093*