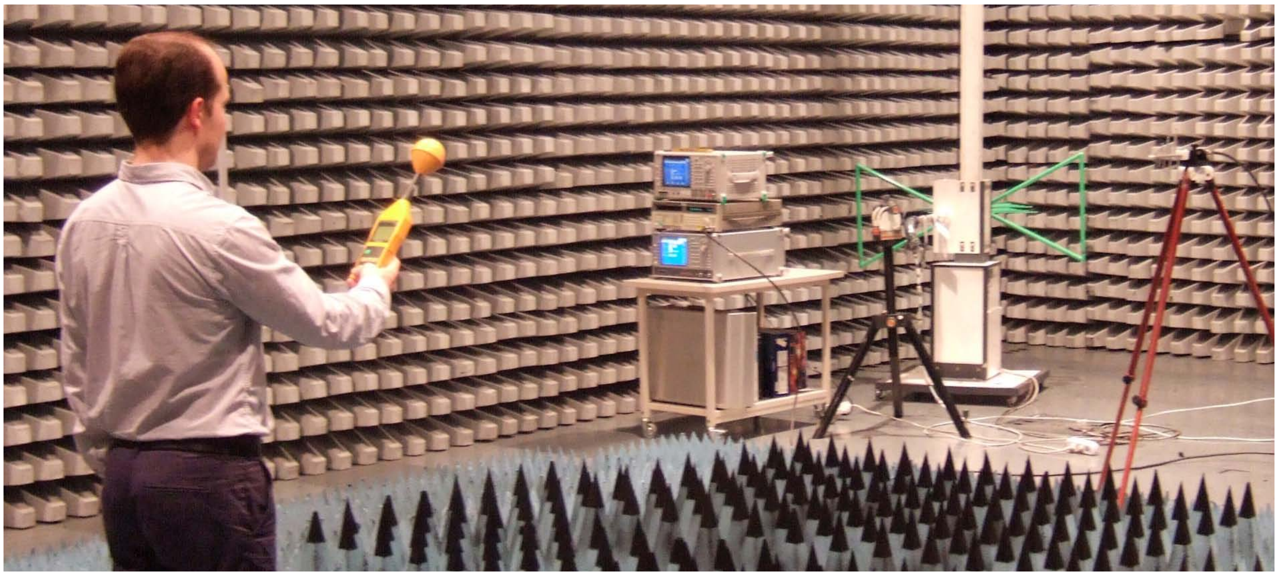
Electrosmog meters put to the test

Sobering testing results for 8 GHz meters under €500



The testing focused on low-cost meters for radio-frequency radiation up to 8 GHz. The German consumer protection organization Wissenschaftsladen Bonn e.V. (WILA Bonn) commissioned IMST GmbH, an accredited EMC testing facility in Germany, to perform the testing. It was found that none of the meters in the test even remotely met the performance specifications or advertising claims made by the manufacturers. Based on the IMST testing results, WILA Bonn took a critical look at how well the meters are suited for an assessment following the *Building Biology Evaluation Guidelines* and for being used in a home environment. Overall, WILA Bonn has come to the disappointing conclusion: „Not recommended“ for the reliable assessment of EMF exposures.

Many homeowners and tenants would like to know what levels of RF radiation they are exposed to in their own home from cell towers, Wi-Fi, microwave ovens, cordless phones and the like. For a long time, consumer-grade broadband RF meters have been available for the frequency range 2.5 GHz / 3 GHz. Over the last few years, low-cost broadband RF meters have come on the market that claim to be able to cover the extremely large frequency range from sometimes below 100 MHz up to 8 GHz. The EMF Testing and Information Center of WILA Bonn had five of these meters with this extremely broad frequency range of up to 8 GHz tested by the IMST GmbH at its EMC testing facility in Kamp-Lintfort (Germany).

A first generation of consumer-grade broadband RF meters up to 2.5 GHz has already been assessed by the Building Biology Association (VB) back in 2004. The RF meters were tested for their measurement capability of the most common RF sources, including cell towers, cordless phones, radar, and Wi-Fi in the frequency range between 900 MHz and 2.5 GHz. From the meters below €500 in this test, which had been approved of by the Building Biology Association, only those meters by Gigahertz Solutions GmbH are still commercially available.

The test by WILA Bonn builds on the previous test and examines the new generation of RF meters, some of which are priced very low. The results are sobering: The meters in the test did not even remotely meet the specifications claimed by the manufacturers. What is important to consumers? An RF meter must be sufficiently sensitive to be able to measure RF exposure levels at or below a power density level of 10 µW/m² since the precautionary Building Biology Evaluation Guidelines SBM-2015 recommend to take remedial action above this threshold level. According to the manufacturers' specifications, all meters should have reliably measured power density levels up to a frequency of 8 GHz. The test, however, revealed that in one meter this exposure level was below the meter's own noise floor and thus could not be detected. Two of the meters could not detect this exposure level in the higher frequency range. At the lower frequencies, it was at least possible to obtain measurement results for general orientation purposes with these two meters, although with major limitations, as will be discussed for each meter in more detail below. Some of the the stronger test signals (1000 µW/m²) were at least mostly detected by all meters, but each meter only did so at 3 out of 14 individual measurements within the specified tolerance range. (That in four meters three measurements fell actually within the tolerance range was purely incidental because each measurement had different combinations of frequencies. Sole one exception: due to its design characteristics, the esi 24 was unable to obtain any precise measurement results.)

The meters in the test

The following meters were put to the test:

- esi 24 (from France/Germany/Poland, statements regarding the country of origin are inconsistent)
- TM-196 (from Taiwan)
- TES-593 (from Taiwan)
- Cornet ED78S (from the USA)
- Acoustimeter (from Great Britain).

The above meters were purchased online, with prices ranging from €172 to €408. When purchasing meters from suppliers outside the EU (which was the case for the TM-196, TES-593 and Cornet ED78S), they must be picked up from your local customs office. In addition to the purchase price, the local value-added tax and a purchase price-based customs fees must be paid, all of which (for Germany) are included in the prices presented here. Current sales prices, which are listed for each meter below, tend to be somewhat higher by now.

Testing by IMST Test Center

The accredited EMC testing facility in Kamp-Lintfort of the IMST GmbH was commissioned to perform the testing. This EMC testing facility is equipped with state-of-the-art testing equipment and an EMC anechoic chamber, which is essential to the accurate measurement of RF radiation. In such a chamber testing conditions can be controlled because the shielding keeps ambient interfering signals out.

In this test, the typical operating frequencies of the mobile networks GSM, UMTS and LTE were generated by a simulator and the signals of a DECT (cordless phone), 2.4 GHz and 5 GHz Wi-Fi networks were generated by original devices. To test the meters for their specified frequency range, CW signals—which are much more easily detectable—down to 100 MHz as well as a mixed signal, consisting of GSM900 and UMTS signals, were also applied. For the test, the threshold levels 10 µW/m² and 1000 µW/m² were chosen because they are the threshold levels between the slight and severe anomaly range and the severe and extreme anomaly range of the precautionary Building Biology Evaluation Guidelines for Sleeping Areas (SBM-2015). The lower threshold level is especially important because it provides information about whether the exposure level is still acceptable or remediation recommendations should be made. Furthermore, the noise threshold of each meter was determined at 900 MHz as an example. During the testing, each meter was exposed to a total of 34 different signals.

Testing results

Due to the complexity of the testing, it is next to impossible to summarize the testing results in a single table or graph because the data would quickly turn confusing. On the one hand, this has to do with the sheer amount of data, but on the other hand, it also has to do with the fact that, without detailed expert knowledge, naked numbers can easily be misinterpreted. Therefore, we pulled out the core data from the extensive testing series and prepared them in such a way as to explain critical product characteristics and prepare the readers of this report to ask their own critical questions.

IMST GmbH determined the noise threshold of each meter at 900 MHz. This value describes the measurement sensitivity of a given meter and the power density level from which the meter will respond to ambient RF radiation. This test revealed that only one manufacturer stated the measurement sensitivity of his meter correctly. The others had made their meters appear more sensitive than they actually were. Below its noise threshold, a meter basically cannot be used to take any measurements.

esi 24 by eSmog Tec

Price: €238.00 (price at manufacturer in summer 2015)
Display: traffic light system with LEDs

	ACCORDING TO THE MANUFACTURER	IMST TESTING RESULTS
FREQUENCY RANGE AT 10 µW/m²	50 MHz – 8 GHz	Up to 900 MHz rough indicator, otherwise at or below noise threshold of meter
FREQUENCY RANGE AT 1000 µW/m²	50 MHz – 8 GHz	No meaningful measurements obtainable, with a tendency to underestimate exposure levels. Factor 10-500 (except for GSM 900)
SENSITIVITY	0.06 µW/m²	6.5 µW/m² (ca. 100 times less sensitive)*

* Noise threshold at 900 MHz

The esi 24 is the only meter that comes with a German user guide. It is rather annoying that extensive tables try to suggest a level of measurement accuracy that cannot be achieved when taking measurements in everyday measurement situations.

The measured noise threshold of the esi 24 turned out to be about 100 times less sensitive than stated by the manufacturer. Due to the coarse scale of the LED indicator lights, measurements in the actual sense of the term are not possible. Depending on the number of illuminated LEDs, the corresponding exposure level (power density level) can be read off an accompanying table. Since a certain number of illuminated diodes corresponds with very different levels of power density, depending on the frequency, no meaningful results can be obtained without knowing the actual frequency. The frequency, however, cannot be determined with this meter. Thus it is virtually impossible to make an accurate measurement with the esi 24 for a mixture of frequencies, which occur in most everyday situations.

Here is an example to illustrate this point: When a field strength of 10 µW/m² was applied, the meter erroneously indicated levels of „no anomaly“ for most RF sources, except for the important mobile network GSM 900. In the latter case, four LEDs lit up, which, according to the user guide, indicate a level between 1.0 µW/m² („slight anomaly“ according to the SBM) and 79.9 µW/m² („severe anomaly“ according to the SBM) depending on the frequency. According to the IMST testing results, four LEDs can also mean that at 8 GHz there are 1000 µW/m²—an extreme anomaly according to the SBM.

In another table of the user guide, it is stated that exposure levels below 80 µW/m² would be in the no anomaly range at 5 GHz, but that the same exposure level would represent an extreme anomaly at 900 MHz. The recommended guideline values of the Standard of Building Biology Testing Methods (SBM) apply equally to the broad range of frequencies of the entire range of radio-frequency radiation, though certain types of modulations - again: regardless of the frequency - are assessed even more critically.

The esi 24 also offers testing for ELF electric and magnetic fields. The IMST GmbH did not perform any tests for ELF electric or magnetic fields so that the team at WILA Bonn performed a quick check. With this meter, ELF electric fields can neither be measured with nor without reference to ground, which is essential to a reproducible measurement. Since a measurement *with* ground reference would require a ground connection with a ground wire and for a measurement *without* ground reference, the meter must not be touched and would have to be mounted on a special tripod, these types of measurements cannot really be performed with the esi 24 for practical reasons. To In order to measure ELF magnetic fields at typical everyday exposure levels in any meaningful way, the meter lacks a linear frequency response. The stated frequency response is extremely distorted: traction current levels at 16.7 Hz are extremely underestimated, mains current‘s field strength levels at 60 Hz are significantly overestimated and harmonics in the 1 kHz range are severely overestimated (by a factor of > 10).

Conclusion: Due to a greatly distorted frequency response and a very coarse scale of LED indicator lights, it is not possible to take reliable readings with the esi 24 that could be used for comparing them to the building biology guideline values. This applies even more so to typical living environments where usually several unknown field sources are present. With this meter, it is of particular concern that the advertising and the user guide with its extensive conversion tables seem to suggest a very easy and at the same time reliable measurement of everyday EMF exposure levels.

TM-196 by Tenmars

Price: €238.00 (price at a German online shop in summer 2015)
Display: digital

	ACCORDING TO THE MANUFACTURER	IMST TESTING RESULTS
FREQUENCY RANGE AT 10 µW/m²	10 MHz – 8 GHz	Not detected because below noise threshold of meter
FREQUENCY RANGE AT 1000 µW/m²	10 MHz – 8 GHz	Only individual test signals are detected within the specified measurement tolerance, namely GSM 900, GSM 1800 and 8 GHz
SENSITIVITY	3.8 µW/m²	41.1 µW/m² (ca. 10 times less sensitive)*

* Noise threshold at 900 MHz

This meter only comes with an English user guide. It contains comprehensive technical specifications and setting options but lacks instructions on how to perform a proper measurement.

With the RF probe sticking out from the meter, isotropic measurements are promised, which basically sounds okay. One look inside the probe, however, gives rise to serious doubts as to its isotropy. The design of the probe rules out a clear directionality so that it is hardly possible to locate a source with this meter. At a test signal of 10 µW/m², the meter showed no response at any frequency, which does not come as a surprise since its noise threshold is so high. It took more than 40 µW/m² (which is a „severe anomaly" according to the SBM) to make the display change at last. The measurement range does not start at 3.8 µW/m², as claimed by the manufacturer, but only above 41 µW/m². This is extremely insensitive.

At a test signal of 1000 µW/m², the TM-196 actually displayed measurement values for some test frequencies, but the values were either far too high or far too low. Only three out of fourteen applied frequencies were displayed within the specified measurement tolerance (± 3 dB). At the other frequencies, the TM-196 showed either nothing or a maximum that was 34 times higher than the actual exposure level. Since the readings of this meter are all over the place, it is not even possible to obtain a rough estimate in the presence of higher exposure levels.

Conclusion: Among all the meters tested, the TM-196 was the greatest disappointment. In contrast to the yellow, almost professionally looking measurement probe, which is offset from the meter itself, the measurement characteristics are completely unacceptable across the entire frequency range tested. In particular, its very high noise threshold makes this meter completely useless for building biology assessments.

TES-593 by TES Electrical Electronic

Price: €420–470 (sales price in summer 2015, including 19% VAT and 4% customs fee payable at the customs office)

Display: digital

	ACCORDING TO THE MANUFACTURER	IMST TESTING RESULTS
FREQUENCY RANGE AT 10 µW/m²	10 MHz – 8 GHz	Not meaningfully detected because depending on the frequency - 20 times over - or 100 to 500 times underestimated
FREQUENCY RANGE AT 1000 µW/m²	10 MHz – 8 GHz	Only individual test signals are detected within the specified measurement tolerance, namely mixed signal, DECT and 3.5 GHz
SENSITIVITY	1.0 µW/m²	4.8 µW/m² (ca. 5 times less sensitive)*

* Noise threshold at 900 MHz

This meter also comes with only an English user guide, which—similar to the TM-196—describes comprehensive technical specifications and setting options. Instructions on how to perform proper measurements are missing. Again, users are promised that they can take isotropic measurements with the RF probe offset from the meter itself. One look inside the probe, however, gives rise to serious doubts as to its isotropy. Due to the design of the probe, a clear directionality is not to be expected so that it will be rather difficult to locate an RF source with this meter.

At 10 µW/m², the display readings are completely useless: At 100 MHz and 400 MHz, the readings were more than 20 times higher, at 900 MHz 30 times lower and at higher frequencies even 100 to 500 times lower than what would be correct. The test signal of 10 µW/m² at 3.5 GHz, for example, was displayed as only 0.03 µW/m² and the wireless LAN signal at 5 GHz at 0.02 µW/m². The TES-593 did not respond at all to the UMTS signal at 2140 MHz; the meter only showed its own noise threshold level.

When the higher test signal of 1000 µW/m² was applied, the measurements displayed at 100 MHz and 400 MHz were also far too high (10 to 20 times higher). From 800 to 1900 MHz, the displayed measurements were close to the tolerance range, but the UMTS signal at 2140 MHz was displayed below the specified tolerance; some of the measurement values up to 8 GHz were even as far as six times lower than that. Exception: the 3.5 GHz signal was displayed correctly.

Conclusion: At the higher exposure levels of about 1000 µW/m², the TES-593 was able to provide useful estimates. At the threshold level of 10 µW/m² between the slight and severe anomaly range of the SBM, however, the meter only showed a less than 1% of the actual exposure levels (except for the range between 100 and 900 MHz) so that the meter is not really suitable for building biology assessments.

ED78S by Cornet Microsystems

Price: € 170–200 (sales price in summer 2015, including 19% VAT and 4% customs fee payab le at the customs office)

Display: digital and LED traffic light display

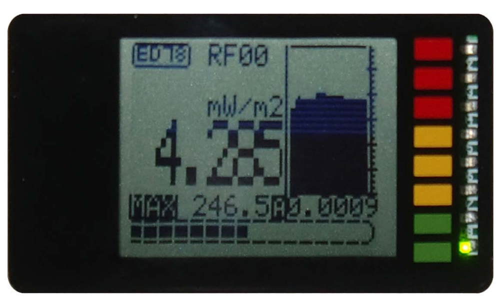
	ACCORDING TO THE MANUFACTURER	IMST TESTING RESULTS
FREQUENCY RANGE AT 10 µW/m²	100 MHz – 8 GHz	Only GSM 900 and UMTS signals were detected within the specified tolerance range
FREQUENCY RANGE AT 1000 µW/m²	100 MHz – 8 GHz	Only individual test signals are detected within the specified tolerance range, namely GSM 900, DECT and 3.5 GHz
SENSITIVITY	0.5 µW/m²	0.7 µW/m²*

* Noise threshold at 900 MHz

The ED78S also comes with only an English user guide and also without important instructions on how to perform a measurement. At least, this manufacturer points out that the device provides measurements for „reference use only." It bears mentioning that this was the only meter where the IMST testing results regarding the lowest detection level of the meter were almost identical with the specifications of the manufacturer. The situation with the applied test signals was quite different: Even if the measurements are meant as a rough guide only, users should be able to rely on the manufacturer's specifications regarding frequency response and field strengths within the stated tolerance ranges. However, this is not the case. At the weaker test signal not even half of the advertised frequency range up to 8 GHz is actually reached (3.5 GHz) and not even near the stated accuracy:

Above 2.5 GHz, the meter responded to lower levels (10 µW/m²) only if the signal was not modulated at 3.5 GHz (just below the specified tolerance range) and at 6.5 GHz (10 times less sensitive). At all other frequencies, the meter only displayed the value that was always shown as default—even if a test signal was applied.

The meter is very small so that the user must be rather careful not to cover the internal antenna accidentally with his or her fingers, in which case the measurement values would be distorted even further. At the tiny display screen, the actual measurement value gets almost lost among all the other additional information. For a quick overview, there is an additional „traffic light" LED display. Actually a great idea, but it would even be better if it worked. In a practical testing situation, which the team of WILA Bonn carried out, the adjoining picture emerged:

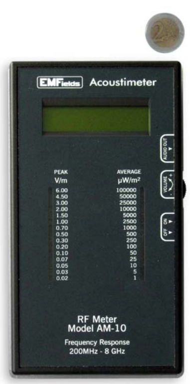


At a measurement value of above 4 mW/m² (= 4000 µW/m²), which from a building biology perspective is extremely high, the green LED at the bottom of the scale lit up to sound the „all-clear." Now and then, for just a fraction of a second, yellow LEDs would also dimly light up, which, according to the user guide, would still be considered „safe." Very confusing to the user! The solution to this puzzle: a DECT cordless phone in the immediate vicinity whose type of modulation the meter was unable to properly process.

The ED78S has an additional option for measuring ELF magnetic fields. The testing of ELF magnetic fields was not part of the IMST test and therefore our in-house team checked its magnetic field performance. At the mains frequency, the displayed measurement values for ELF magnetic fields were quite a bit off target, but they provided at least a rough estimate. Due to the lack of instructions on how to properly use the single-axis probe, it can easily happen that only a fraction of the actual field strength of the magnetic field is measured. Furthermore, the meter misses the frequency of the railroad system almost completely, but harmonics are more or less overestimated (by up to a factor of 10).

Conclusion: Like the other meters, the ED78S also greatly exaggerates its frequency range up to 8 GHz and measurement accuracy. The dependence of the measurement values on how the meter is held, a sometimes extreme underestimation of exposure levels at higher signal strengths and the occasional discrepancy between the LED lights and the digital display, taken together, do not allow us to recommend this meter either, even though it provides rough estimates at lower exposure levels and frequencies.

Acoustimeter by EMFields



Price: € 431.18 (price at manufacturer in summer 2015, £305.69)
Display: digital + LED + acoustic

	ACCORDING TO THE MANUFACTURER	IMST TESTING RESULTS
FREQUENCY RANGE AT 10 µW/m²	200 MHz – 8 GHz	400 MHz to 2.7 GHz with major limitations (Note by WILA: measurement value greatly depends on how the meter is held, not suitable for mixtures of frequencies; for explanations, see text below)
FREQUENCY RANGE AT 1000 µW/m²	200 MHz – 8 GHz	
SENSITIVITY	1.0 µW/m²	5.2 µW/m²*

* Noise threshold at 900 MHz

The display concept of different measurement units for peak and average values is problematic. For example, when a 100 times higher power density (in µW/m, the common display unit used in building biology) is shown in V/m, this value, in terms of numbers, is only by a factor of 10 higher—which makes it appear less harmful to laypersons. Therefore, the two rows of LEDs of both signals hardly provide any additional benefit. In the user guide, the explanations regarding this matter are rather confusing and, moreover, technically questionable.

Like the other meters, the specification for 8 GHz is also clearly exaggerated: not a single test signal of 10 µW/m² (threshold level between the slight and severe anomaly range of the SBM) above 2.7 GHz was detected by the meter. It only displayed its own noise. In this higher frequency range, the Acoustimeter responded to stronger test signals, but the displayed measurement values were 25 to more than 30 times lower. The test signal of 783 µW/m² at 8 GHz, for example, was displayed as only 21.5 µW/m².

In the frequency range below 2.7 GHz, the limitations of the internal antenna compromise the otherwise good design efforts. Therefore, the measurement values, which have been obtained by the experts from IMST under ideal testing conditions, can not necessarily be reproduced under real-life conditions and by technical laypersons. The measurement value can be dependent on where the user touches the meter and at which angle it is held in space. The user guide (which is available in English only) remains far too vague regarding the instructions on how to perform the measurements, and the recommendation to comfortably hold the meter at an angle may lead to measurement results that can be only a fraction of the actual exposure level, especially at the lower frequencies.

And there is another major limitation that tarnishes the image: The meter is based on a logarithmic RF detection module that is designed to measure a single RF source. In a typical living environment, we usually encounter a broad mix of different RF sources (e.g. mobile networks, DECT, Wi-Fi, etc.), which is why this meter only displays the strongest RF source and the others fall by the wayside. This also greatly reduces the practical benefit of the audio analysis to recognize active RF sources by their typical sounds because any other RF source but the strongest are cut out.

Conclusion: For the Acoustimeter, a frequency range specification of up to 2.7 GHz instead of 8 GHz would have been appropriate. Good design efforts at the lower frequency range, at least at the lower field strengths of the test signals, are compromised by the exaggerated specification, systemic weaknesses of the internal RF probe and the processing of the measurement value. Thus the recommendation of the user guide to hold the meter at an angle may cause the measurement values to drop to only a fraction of the correct values in typical testing situations, and also in the frequency range below 2.7 GHz. Furthermore, only the strongest signal is considered for the displayed measurement value and the—useful—acoustic interpretation of the modulation. Since all other signals of RF sources fall by the wayside, they either do not register at all on the display or are greatly underrepresented so that the mix of frequencies, which is nearly ubiquitous in modern living environments, will be easily overlooked and certainly underestimated.

Our recommendation

It is good to maintain a healthy skepticism toward offers that promise an amazing performance at extremely favorable prices. And it is always good to remember that professional testing equipment never combines RF and ELF measurement probes in one single meter or fits an RF antenna into the meter casing. Prices also increase significantly the larger the frequency range or the more sensitive the RF probe is.

In general, it is not possible to display accurate measurements through LED indicator lights. Antennas/probes that are integrated into the meter casing are also a great source of errors. Prefer meters with a digital display and an external measurement antenna. A highly directional logarithmic-periodic antenna (which looks like a Christmas tree or fish skeleton) is very useful in determining the direction from where the RF radiation originates.

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