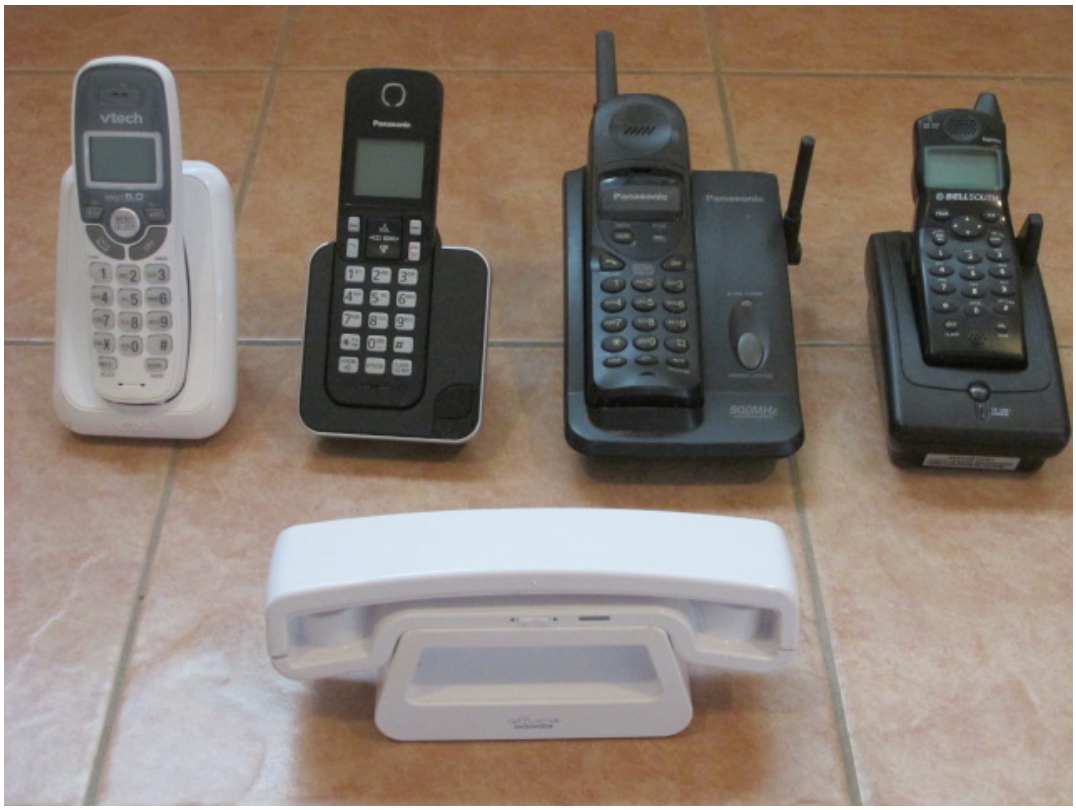
Radiation test of cordless phones



We tested the radio frequency radiation from five cordless phones of three different types. We also measured two basic mobile phones for comparison. We found enormous differences in how the phones expose people to RF radiation.

Keywords: *cordless phone, radiation, radio frequency radiation, RF radiation, DECT, ECO DECT, ECO Mode, ECO Plus, ECO Mode Plus, 900 MHz, 900MHz, measurement*

The purpose of these tests

Using a corded landline telephone exposes the user, and people nearby, to the least amount of EMF radiation. However, sometimes landlines are not available or not practical, or there are sometimes other reasons they cannot be used.

In our tests we looked for wireless telephones that exposed the user and bystanders to the least amount of radiation. This includes when the phone is not actively used, which is most of the time.

This document provides our actual data and a brief summary of the results. For a more reader-friendly article, based on our data, see www.eiwellspring.org/telephone.html.

Summary of results

We found that the level and pattern of radiation from cordless phones can vary dramatically. The typical DECT cordless phones and bases actively transmit to each other all the time, whether there is an active call or not, and regardless of whether the handset is in its cradle or not.

The radiation from the DECT base stations is higher than from the handset and can be substantial even 20 feet (6.2 meters) away.

The older 900 MHz cordless phones do not transmit when there is no active call. Here there is just low levels of radiation from the internal circuits, such as power supply, receiver's oscillator, etc.

Cordless phones have a shorter reach than mobile phones and thus a lower maximum radiation level. However, if there is a nearby mobile phone base station, a basic mobile phone (i.e. not a "smart phone") may not irradiate the user any more than a cordless phone. We found that basic mobile phones transmit rarely when not in use, as opposed to DECT phones that transmit continuously 24/7.

A problem with the cordless phones is that they are not designed to be turned off. To turn them off, the cover has to be opened and the battery physically disconnected. In contrast, mobile phones are all designed to be turned off easily. Many of them also have airplane modes, where they do not actively transmit.

We tested a fancy ECO DECT phone that should radiate less, but it was a disappointment. It cost about four times as much as a regular DECT phone and provided just marginal improvement in radiation exposures. We were particularly dismayed by its "booby trap" where the handset went into extreme radiation mode whenever there was a power outage.

There is thus no "best" wireless phone available. All choices are compromises. In some cases, the basic mobile phones or a fixed wireless system will be superior to

the cordless phones. In other cases, older 900 MHz cordless phones are the better choice.

We can't see any scenario where the standard DECT cordless phone is best. In Europe the ECO DECT Plus phones seems like a good option. These are presently not available in North America.

The phones we tested

We tested five cordless phones of three different types. For comparison, we also tested two basic mobile phones (not smart phones) and one fixed wireless system.

The types of phones tested were:

- Typical cordless phones (DECT)
- Older cordless phones (900 MHz)
- Low-radiation cordless phone (ECO DECT)
- Basic mobile phones
- Fixed wireless system

The specific models we tested are shown in the table below:

Type	Manufacturer	Model
DECT	Vtech	CS6114
DECT	Panasonic	KX-TGCA35
ECO DECT	Swissvoic	ePure
900 MHz	Panasonic	KX-TC1461B
900 MHz	Bell South	MH9111
Mobile	Huawei	H110C
Mobile	Samsung	SCH-U360
Fixed Wireless	Huawei	FT2260VW

Table 1: The tested wireless phones

The five cordless phones were purchased in the United States in the years 2017 and 2018. The two mobile phones and the fixed wireless device were a few years older. We consider this lineup representative of the basic phones available in the United States as of 2018.

The DECT cordless phones were introduced in Europe in 1995 and came much later to the United States, which used the 900 MHz phones instead for about a decade. DECT is now the globally dominant type of cordless phone.

The two 900 MHz phones we tested were introduced in 2001 and 2002, and have since been discontinued, but we were able to buy them from online vendors.

The two mobile phones we tested were very basic. They had no other features than voice calling and the ability to send and receive text (SMS) messages.

We did not test any smart phones, since they are not suitable for low-radiation needs. Depending on what apps they have running and whether Wi-Fi/Bluetooth is active, they can expose people to a much higher cumulative dose than the technologies we tested.

We also looked at a fixed wireless system. That is essentially a basic mobile phone that is stationary and hooked up to a traditional landline phone. Since the telephone can be placed far away from the wireless part, this is an interesting way to use wireless with minimal exposures.

The ECO low radiation phones

We tested one "low radiation" phone, a so-called "ECO DECT" phone. These phones radiate less when close to their base than regular the DECT cordless phones.

In Europe they have "ECO DECT Plus" phones, which should not transmit at all when there is no active call — unlike all other DECT phones which radiate nonstop whether there is an active call or not. Unfortunately, these phones are not available in North America (or they have the "Plus" feature removed). It is illegal to import one from Europe, since they use a different frequency band and thus can interfere with other wireless users in America. We were not able to test any ECO DECT Plus phones.

The range test

Cordless phones are designed for use over shorter distances than mobile phones. To get an idea how far our sample phones reach, and thus how powerfully they radiate relative to each other, we tested how far they reached over open land.

We placed each base on a wooden stool out in the open in a rural area. A volunteer then walked away from the base while listening to the dialtone. He made sure there were no obstacles between the phone and the base (including his

own head, vegetation, etc.). When the dialtone became "staticky" the distance was measured.

	Vtech DECT	**Panasonic DECT**	**Swissvoice ECO DECT**	**Panasonic 900 MHz**	**Bellsouth 900 MHz**
distance ft	720	380	300	300	120
distance meters	230	120	95	95	38

Table 2: Reach of cordless phones over open land with line-of-sight. Numbers in feet and meters.

Determining when the phone became staticky was subjective, but done by the same person on the same day for the five phones. He walked back and forth to determine each point he considered it became staticky.

When used inside a building, the reach will be less due to damping of the signals by walls, furniture, etc.

The further a phone reaches, the more powerfully it irradiates the user. However, as we'll see, the ECO DECT phone's radiation level depends on how far the base and handset are from each other.

The Specific Absorption Rate (SAR) is a measure of how much a cordless or mobile phone irradiates a user under specific conditions. We were able to find manufacturer's data for two of our cordless phones:

Panasonic DECT	**Swissvoice ECO DECT**
0.017	0.01

Table 3: SAR values for cordless phones. Numbers in W/kg.

Mobile phones, which can reach much further, typically have SAR values in the 0.7 to 1.2 range. The lowest SAR value we've found for a mobile phone was 0.12 (Motorola MPX200).

The SAR value is measured with the phone transmitting at full power. When mobile phones are near a tower, they will transmit less powerfully and may not radiate any more than a cordless phone.

Radiation measurements

We placed each device to be measured on a wooden stool, 24 inches (60 centimeters) off the ground on flat rocky land in a remote area with no nearby homes or transmission towers.

We did each measurement by recording the MAX (peak) value over 60 seconds, since these are digital signals that are not continuous.

For more technical details about how the study was done, see the end of this article.

We tested how much the bases radiated by themselves with their handsets turned off. The bases consider this "out of range."

	Vtech DECT	**Panasonic DECT**	**Swissvoice ECO DECT**	**Panasonic 900 MHz**	**Bellsouth 900 MHz**
3 ft/1 m	4005	483	114	0	0.7
10 ft/3 m	1045	2	55	0	0.6
20 ft/6.2 m	273	2	0	0	0.3

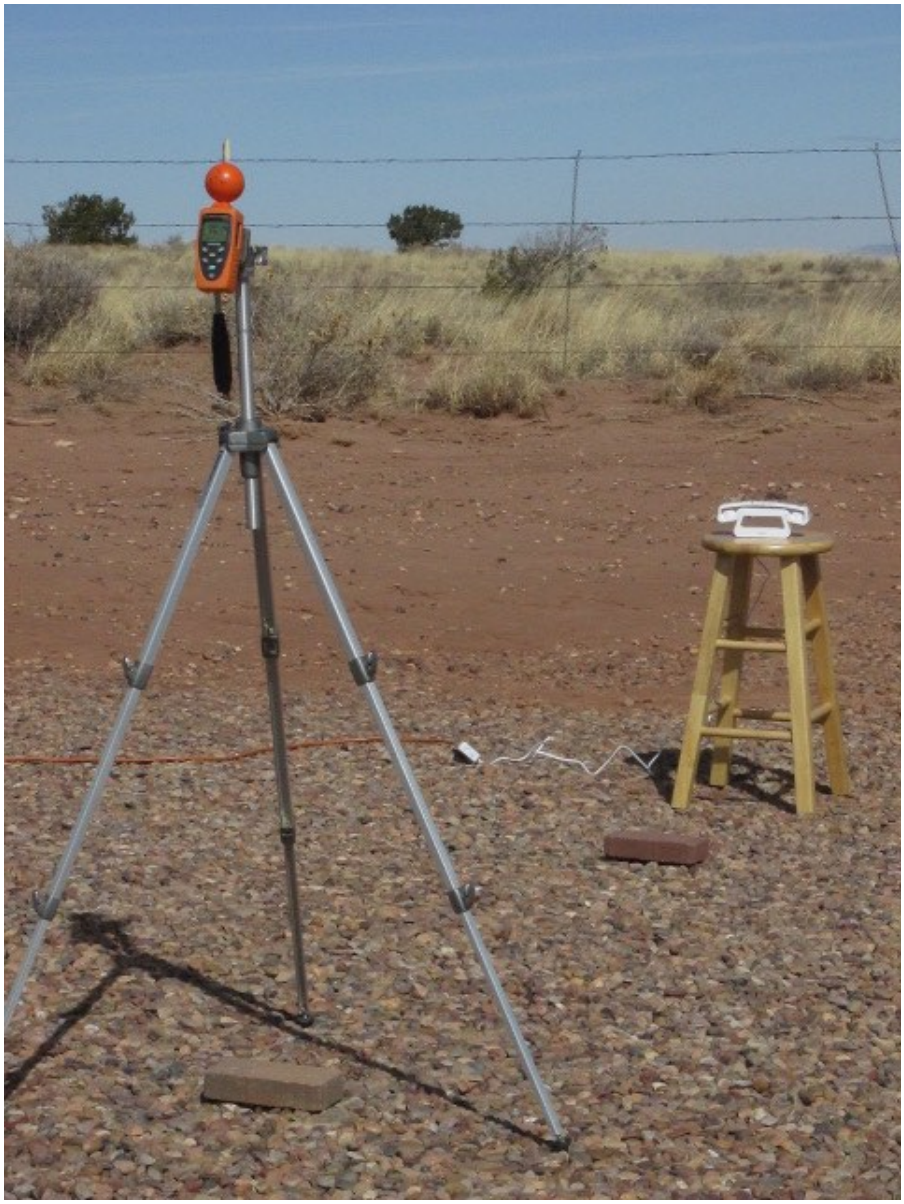
Table 4: Radiation from cordless phone bases with handset "out of range." Numbers in uW/m^2.

As can be seen from Table 4, the DECT phones continued to try to reach their handsets, while the 900 MHz phones did not. The Vtech phone was the most powerful transmitter, which matches our finding that it had the longest range.

Then we tested the typical situation, with the handset placed in its cradle on the base. This is where all of them have to be placed regularly to have their batteries charged. It is also where the distance between the base and the handset is the shortest possible.

	Vtech DECT	Panasonic DECT	Swissvoice ECO DECT	Panasonic 900 MHz	Bellsouth 900 MHz
3 ft/1 m	5197	612	17	0.2	0.7
10 ft/3 m	134	3	1	0.1	0.5
20 ft/6.2 m	2	1	0	0	0.2

Table 5: Radiation from cordless phones with handset in cradle on the base. Numbers in uW/m^2.



Measuring the Swissvoice ePure ECO DECT handset and base.

The DECT phones continued to transmit, even with the handset in the cradle.

The ECO DECT phone did what was expected. It determined that little power was needed to transmit between its two adjacent parts, and throttled it down by about 90%.

It is not clear whether the two 900 MHz phones do any communicating or not. The readings are close to the ambient levels and could simply be from the internal electronics (especially the oscillator in the receiver).

We then separated each base and handset by 20 feet (6.2 meters) to simulate the common scenario where the phone is moved away, but has no active call. We then measured the radiation from the base and from the handset.

	Vtech DECT	**Panasonic DECT**	**Swissvoice ECO DECT**	**Panasonic 900 MHz**	**Bellsouth 900 MHz**
3 ft/1 m	7959	588	384	0.3	0.4
10 ft/3 m	1453	9	7	0	0.4
20 ft/6.2 m	199	2	0	0	0.2

Table 6: Radiation from base, when 20 ft (6.2 m) from handset. No active call. Numbers in uW/m^2.

Again, the longer range of the Vtech phone shows up in the much higher radiation level. Even 20 ft away, it radiates above the ambient level of many homes in North America.

The base of the Swissvoice phone clearly radiated more (about twenty fold) when the handset was moved away. But it is still much less than the Vtech phone.

The radiation from the separated handsets was:

	Vtech DECT	**Panasonic DECT**	**Swissvoice ECO DECT**	**Panasonic 900 MHz**	**Bellsouth 900 MHz**
3 ft/1 m	4	1	0.8	0.2	0.3

Table 7: Radiation from handset, when 20 ft (6.2 m) from base (Vtech handset 40 ft / 13 meters from base). No active call. Numbers in uW/m^2.

Even when the Vtech base was 23 ft (7.4 meters) from the RF meter, it was so powerful it drowned out the radiation from the handset. (We measured 127 uW/m^2.) We moved the Vtech handset 40 ft (13 meters) away from its base to get the 4 uW/m^2 reading. It appears this handset radiates at the same level regardless of the distance to the base.

We then wanted to see how the handsets reacted if they could no longer reach their bases. This will happen if there is a power outage or the handset is carried too far away.

This scenario is important if the handset is kept away from its base, for instance to serve a room with no telephone outlet.

In this test we turned off the base and measured the handset.

	Vtech DECT	**Panasonic DECT**	**Swissvoice ECO DECT**	**Panasonic 900 MHz**	**Bellsouth 900 MHz**
3 ft/1 m	0.1	0.2	420	0	0.4
10 ft/3 m	0.1	0.2	52	0	0.3
20 ft/6.2 m	0	0	0	0	0.1

Table 8: Radiation from handset when they cannot locate their bases, such as during a power outage. Numbers in uW/m^2.

As Table 8 shows, most handsets go dormant to save their batteries. To our surprise, the Swissvoice phone mounted a supreme effort to try to locate its base. It radiated powerfully for 60 seconds, then was dormant for 60 seconds, before again radiating powerfully for 60 seconds and so on. Presumably it would continue to do so until the battery was exhausted.

Other handset radiation

We tested for lower frequency radiation from the handsets. These would not show up on an RF meter.

We used an extended-range gaussmeter, an ME 3951A from Gigahertz Solutions in Germany, set to a certified range of 50 Hz to 400 kHz.

We also used a basic AM radio, set to the lowest frequency in its range (about 530 kHz). This is a crude tool that has only a limited ability to quantify radiation levels through its speaker.

The measurements were done with the base station powered up and 20 ft (6.2 meters) away. We moved the gaussmeter and AM radio around the handset and directly in contact with it. The highest reading was recorded. The ambient ELF level was 0.2 nT (0.002 milligauss).

	Vtech DECT	**Panasonic DECT**	**Swissvoice ECO DECT**	**Panasonic 900 MHz**	**Bellsouth 900 MHz**
Magnetic 50 – 400K	2.2	5.9	1.3	0.6	1.2
AM radio	high static	static	static	none	static

Table 9: Lower frequency emissions from handsets. Numbers in nanotesla (1 nanotesla = 0.01 milligauss).

Two phones sharing a landline

We were curious about how the cordless phones would react when sharing a landline with a corded phone. A sensitive person may normally use a corded phone on the landline and then occasionally use the cordless phone when away from the telephone outlet, such as in homes with just one outlet.

The question was whether talking on the corded phone would activate the cordless phone on the same line.

Since the DECT phones radiate regardless whether there is an active call or not, we just tested the two 900 MHz phones.

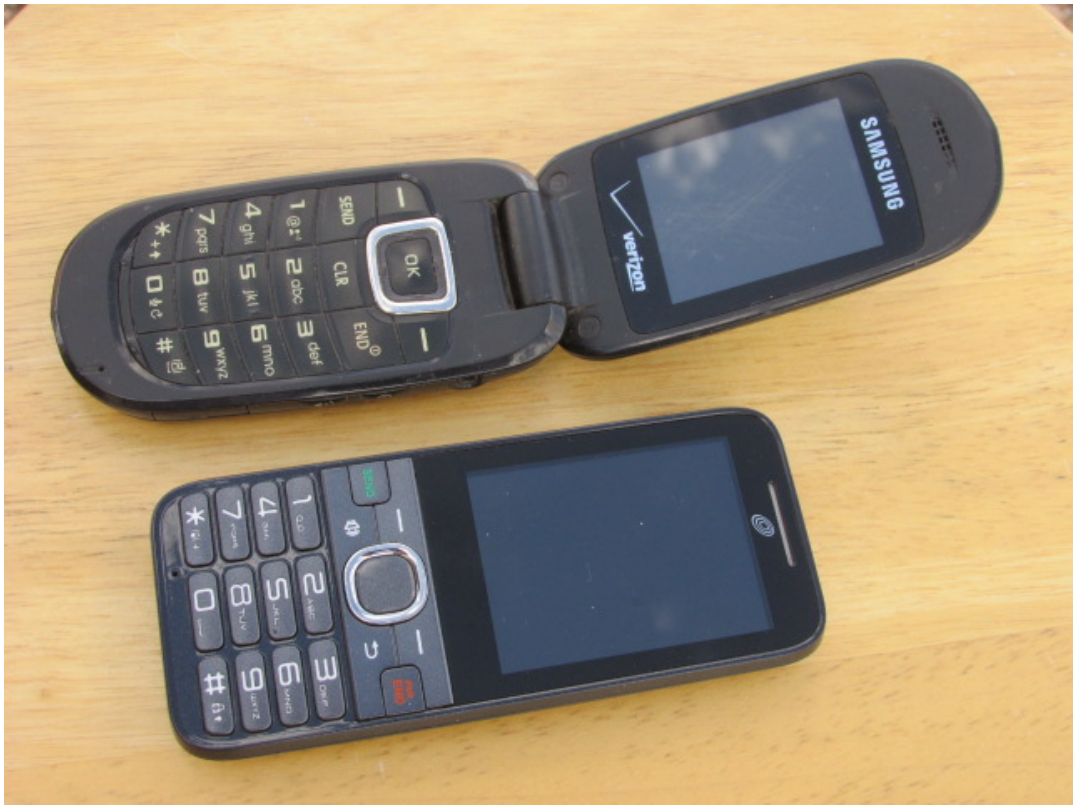
	Panasonic 900 MHz	**Bellsouth 900 MHz**
Handset in cradle	No	No
Handset out of cradle	No	No

Table 10: When landline is used by other phone, will the cordless handset or base start transmitting?

As shown in Table 10, our RF meter did not detect increased emissions from the cordless handsets or bases when their shared landline was in use.

Testing basic mobile phones

Mobile phones are designed differently than cordless phones. They are typically away from chargers for hours every day, so conserving the battery is important. They also use a set of base stations that are shared among many users, so it needs to limit congestion and be able to switch over to other base stations if they provide a stronger signal.



The two basic mobile phones we tested. Without any "smart" features, they were silent for at least 10 minutes at a time.

Mobile phones can reach much further than cordless phones. In remote and rural areas we have seen mobile phones communicate with base stations ten miles (16 kilometers) or even further away. This means a mobile phone must be able to transmit much more powerfully than a cordless phone.

However, to conserve the battery a mobile phone will transmit with less power if the tower is close by. Some sources state they may go as low as 100 to 200

milliwatts, which is similar to the DECT cordless phones. At their highest power mobile phones can transmit with a radiated effect of about 2 watts, i.e. about twenty times as strong.

This information is stated by various credible sources, so we did not attempt to verify it. What we were interested in was how often does a mobile phone transmit when it does not handle an active call, i.e. most of the time.

A friendly engineer working for one of the biggest companies in the mobile industry told us some years ago that mobile phones typically contact a tower base station about once every 15 minutes. This does not include smart phones or Wi-Fi enabled phones, which typically have a lot more going on. Also, it assumes the phone is not in a moving car, where it may need to keep switching which tower base station it is talking to.

We wanted to verify this information. We tested two basic mobile phones (not smart phones) and one fixed wireless device, which basically acts like a mobile phone.

In our tests, we could see the mobile devices transmit to the tower base station at the very end of their startup process. It shows up quite clearly on an RF meter as a short burst.

In our test we gave the mobile devices a minute to fully start up. Then we set an RF meter to record the peak (MAX) radiation over ten minutes. If the phone transmitted, the meter would record a reading several orders of magnitude above ambient.

	Huawei H110C	**Samsung SCH-U360**	**Verizon/Huawei FT2260W**
Technology	Mobile phone	Mobile phone	Fixed wireless "Home Phone Connect"
Number of transmissions	zero	zero	zero

Table 11: Number of transmissions during 10 minute period for mobile phone technologies.

As the table above shows, none of the mobile devices transmitted at all during the ten minutes after initial power-up. This was as expected, according to our insider information.

We then tested to see whether creating marginal or changing reception would get the phones to communicate more frequently with the nearby tower. This simulates a person walking around with the phone inside a home, including homes with metallic walls or appliances.

We placed the phone inside an all-metal room. We also had a volunteer walk around outdoors with the phone while turning both himself and the phone. Finally, we tried to wrap and unwrap the phone in shielding aluminum foil.

	Huawei H110C	**Samsung SCH-U360**
Shielded room test	zero	zero
Walking around test	zero	zero
foil test	zero	zero

Table 12: Number of transmissions during 10 minutes for three marginal reception scenarios within range of same rural base station.

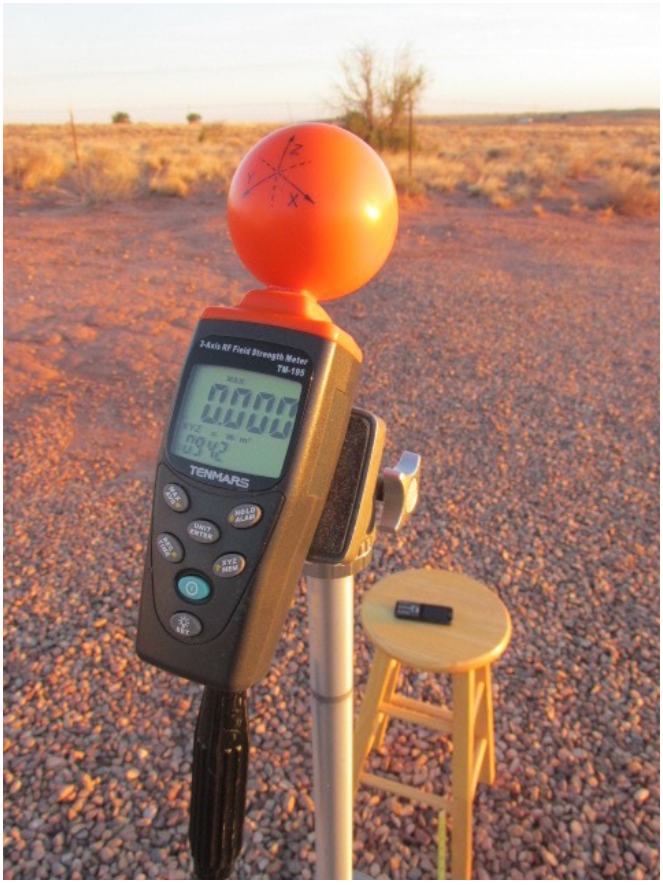
None of these efforts prompted the mobile phones to transmit.

These tests took place in a rural area with no nearby base stations. It is possible that in a city, where there are often two or more nearby base stations, that these exercises would convince the phones that another tower had a better signal and thus start transmitting. Adequately testing this scenario is difficult and we did not attempt it.

About our testing methods

We did all tests in two rural locations with low ambient radiation. The main location was in a remote area with no grid power, no telephone landlines and no line-of-sight transmission tower closer than about 10 miles (16 kilometers). The ambient RF levels were typically well below 1 uW/m^2.

All measurements of RF levels were done here. We intentionally did the measurements of the 900 MHz Panasonic phone one early morning, before sunrise, where the ambient levels were below 0.05 uWm^2, to try to detect the very low levels of radiation from this phone.



Measuring the Panasonic 900 MHz phone one early morning. The instrument is shown not detecting any RF radiation.

Our secondary location had grid power and telephone landline, which was needed for some tests. The closest transmission tower was about 4 miles (6 kilometers) away.

The RF meter was a TENMARS TM-195. It is a consumer-grade instrument that is sensitive to heat. When this was an issue, we did the measurements in ambient temperatures below 80ºF (26ºC), and before sunrise or after sunset to avoid solar infrared heat.

The TM-195 makes three measurements a second, which is not sufficient for pulsed microwaves. To compensate, we measured the MAX (peak) values over 60

seconds. This setup is easily fooled by distant lightning, so we made sure to do the measurements on days with no thunderstorms in the region.

Base stations and mobile phones usually send out powerful signals during their startup. We therefore always gave any equipment 60 seconds to initialize before starting measurements.

The equipment to be measured was placed on a 2 ft (60 cm) wooden stool to avoid reflections from the ground and the stool itself. The stool had no metal screws or parts. The RF meter was placed on a tripod with its sensor about 55 inches (1.4 meters) above the ground.

We did not have the sophisticated equipment needed to measure the standardized SAR values. These are available for most mobile phones, and some cordless phones (see Table 3).

Simply holding an RF meter up against a cordless phone or mobile phone is meaningless. Closer than about 2 ft (60 cm) from such a microwave transmitter, we enter what is called the near field. In the near field special antennas are needed to measure the radiation level. That is the reason all our RF measurements are done at distances of 3 ft (1 meter) or greater.

More information

An article discussing this data and what it means in practice is available at www.eiwellspring.org/telephone.html. That menu also lists other articles about low-radiation telephony issues.

For other technical reports, see www.eiwellspring.org/technical.html.

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