Investigating Wi-Fi Radiation Levels at Residences

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***Abstract*—Due to the increase in the number of radiation sources, the high frequency radiation has become a major health and environmental concern in the world. Many studies have linked high frequency radiation to various types of illnesses, while low frequency fields from power lines have been linked to leukemia. Therefore, we have initiated a set of studies to measure and document the levels at various outdoor areas in Kuwait, to confirm their safety and to document the current levels for further studies by scientists. One growing source of radiation is the wireless LAN at houses, private and public locations. The technology has become very common in the majority of residences resulting in an accumulation of several networks in each house. This increases the amount of radiation and supports the possibly of increased hazard. In this study we aim at documenting the state of radiation due to WLAN sources at 2.4GHz at various residences in Kuwait.**

***Index Terms*—WiFi, WLAN, access point, rf radiation, survey.**

I. Introduction

The technological advance in electronic communication devices and systems has resulted in an increase in high frequency radiation sources. This is accompanied by a worldwide concern regarding its health effects. Therefore, many organizations [1]-[5] and individual scientists [6]-[10] have conducted studies and surveys of radiation levels and the associated health hazards. Although limits have been set by expert organizations [11], [12] an increasing number of scientists are relating it to health problems and are questioning the adequacy of the existing limits. The main focus of concern has been on mobile phone related technology, especially handsets and base stations.

Previously [13] we have conducted a survey of electromagnetic radiation in outdoor areas in Kuwait due to several sources at the band of 75MHz to 3000MHz. It has provided us with a table of electromagnetic radiation levels, due to the mobile phone network. This study is concerned with the WLAN band utilizing the Wi-Fi technology. We aim to determine if radiation levels at different residences pose a health threat by exceeding the ICNIRP standard limit. Another aim is to collect information regarding radiation levels due to routers at various residences in Kuwait. In the next Section we present a short overview of research outcome on R.F. related health hazards, followed by a summary on WiFi technology. In Section IV we present an experimental methodology while results are presented in Section V. The paper is brought to conclusion in Section VI.

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II. RF Related Health Hazard

Besides the heating effect many studies [14]-[21] have found a link between high frequency radiation and some diseases. However, other studies have attempted to prove otherwise. An addition to the view that radiation could have adverse health effects is the IEGMP report [15]. The IEGMP was setup by the UK government. In May 2000 it reported that there is now scientific evidence which suggests that there may be biological effects occurring at exposures below standard limits. It goes on suggesting a precautionary approach is justified since at RF levels below the national guidelines it is not without adverse health effects. The Bioinitiative report [22] raises more concern as it presents evidence on possible health effects and questions the current standard limits. It states that The effects of long-term exposure to wireless technologies is not known with certainty, the body of evidence at hand suggests that bioeffects can be found at thousands of times below public safety limits, and RF exposures can be considered genotoxic at exposure levels that are lower than existing safety limits. Additionally they found that "Very low-level ELF and RF exposures can cause cells to produce stress proteins, meaning that the cell recognizes ELF and RF exposures as harmful and it happens at levels far below the existing public safety standards." This study is concerned with the WLAN band utilizing the Wi-Fi technology.

III. WiFi Technology

The Access point is the device connected to the internet via a DSL connection and provides a gateway to the internet for many devices wirelessly. An access point may also be called a router, a gateway, a base station or a hot spot. In this paper we will use the term access point or AP. The Wi-Fi technology uses part of the 2.4 to 2.5 GHz band that is dedicated to the industrial-scientific-medical (ISM) band. The new Wi-Fi version that utilizes the bands above 5GHz is out of the scope of our study.

The channels used are 22MHz wide. Manufacturers claim the devices operate at low powers below 100mW, however, some devices may operate at 1W. Another source of WiFi band radiation is the computer card communication with the AP. Although it may be a source of most of the radiation a user is exposed to, our study does not measure the radiation transmitted from computers. The software we use focuses on APs and provides approximate levels in color coded maps. The meter used to measure the signal spectrum and exact levels at each frequency measures all sources transmitting at the Wi-Fi band including computers if available and turned on. We turn off computers at the local residence, but not neighboring, at all times. Therefore, we may assume that the measurements are when the local APs at the surveyed

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residence are idle.

IV. Experimental Methodologies

Initially we run TamoGraph Site Survey; a software program capable of producing an image of signal levels at the monitored residence. It requires moving the laptop computer, with the program running, around the surveyed location. The program compiles an image that shows signal levels in color coded regions. Using the produced image we can determine locations of peak radiation levels. The color codes range from blue to red where blue and green regions are considered as high level regions, while yellow and orange are considered as medium and red or no color regions as low or weak regions. Next the Selective Radiation Meter, (SRM-3000) is used to produce a spectrum of the signal level at the colored region. This is repeated at each of the several residences under investigation during the phase of the project.

We have categorized the residences into 5 types as follows:

1) Apartment in an apartment complex building that has more than three levels or floors.
2) An apartment in a house instead of a building complex.
3) A small house on a land that is less than 600 square meters that does not include apartments at top floors.
4) A small house on a less than 600 square meters, with more than one family residing. Such a house includes apartments at the top floor.
5) A large house on a land that is more than 600 square meters. This may include more than one family with some living in separate apartments, while the main family resides in the bottom one or two floors.

We aim to survey two to four different locations of each of the five types to reduce bias in drawn conclusions. Additionally, to improve statistical reliability of obtained results, we repeat the survey at each location.

A. The Selective Radiation Meter, SRM-3000

The Selective Radiation Meter (SRM) used in our project is a handheld selective measuring device made by Narda Inc., for safety analysis of radio frequency and microwave electromagnetic fields. The SRM displays the total field exposure and the contributions of the individual services. The SRM consists of a basic unit and a measurement probe. The basic unit contains a spectrum analyzer for the frequency range 100 kHz to 3 GHz. The tri-axial probe allows isotropic (non-directional) measurements in the range from 75 MHz to 3 GHz, covering FM radio up to the W-CDMA and UMTS services. The results can be displayed as a percentage of an exposure limit, or as absolute values in dBA/m, dBV/m, V/m, A/m or W/m^2 and mW/cm^2. It measures the entire frequency range for all selected services and automatically sets its resolution bandwidth (RBW) to fit the smallest frequency span to be measured.

The general approach for obtaining the required measurements was based on the ICNIRP recommendations. For each instrument reading we record location, and meter readings. As suggested by international standard measurements procedure to find the field strength level or percentage of permissible exposure level each measurement value is an average reading over six minutes at one meter above ground level. In this paper we compare radiation levels to the ICNIRP standard limit. Radiation level measurements in percentage of ICNIRP limits can be summed to obtain a total level of exposure at a certain location. Using this total we can find the total radiation due to APs a subject is exposed to. Additionally, this total is used to calculate the percentage of contribution of the WiFi band.

B. The Tamograph Site Survey Software

TamoGraph is a wireless site survey software tool for collecting, visualizing, and analyzing 802.11 a/b/g/n/ac Wi-Fi data. It provides a comprehensive WLAN analysis with a color coded visualization of signal level (as in Fig. 1 to Fig. 3), interference, access point coverage areas & location, data rates, network issues. It also provides detailed information about every access point: location, channel, maximum data rate, vendor, encryption type and other AP related information.

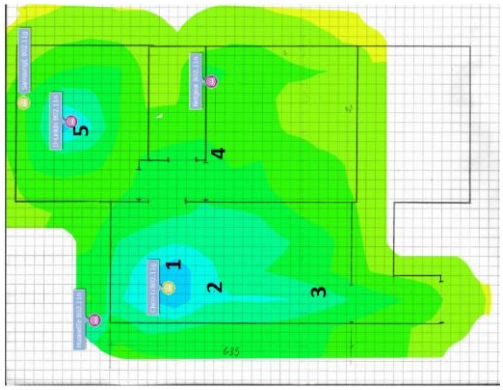

Fig. 1. Signal level due to all APs at the surveyed residence.

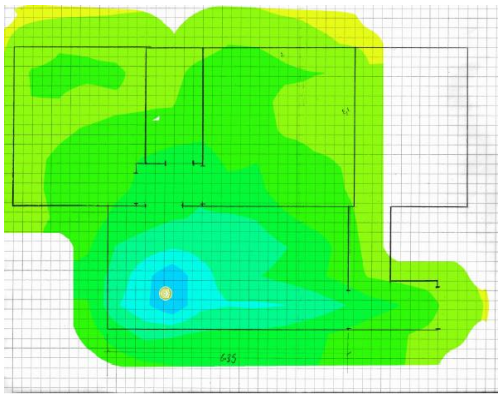

Fig. 2. Signal levels due to local AP with SSID yosry at the surveyed residence.

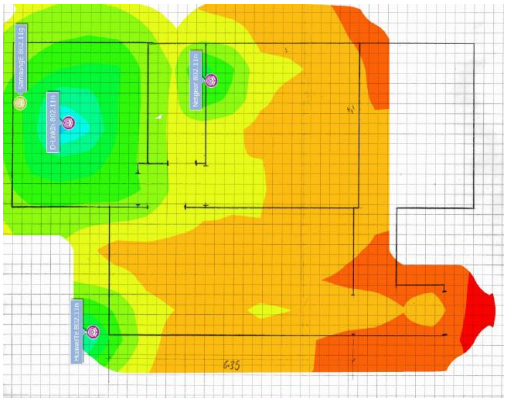

Fig. 3. Signal levels due to neighboring APs at the surveyed residence.

V. Experimental Results

For each residence we present color coded maps indicating radiation levels as in Fig. 4, due to all of the APs, neighboring APs only and local APs only. For the five types of residencies we surveyed 14 locations. Certain locations at a residence are tagged with a number and surveyed further using the SRM-3000 meter. We present the meter signal spectrum at each location in three units of dBA/m, mW/m^2 (10 mW/m^2 = 1μW/cm^2) and percentage of ICNIRP-1998 limit. At most sites the location number 1 is closest to the AP, which normally has the highest radiation level.

Here, we present results for one residence of type 1, i.e. an apartment. At the surveyed location the highest signal is found close to the local router at location 1 of Fig. 1, reaching -62.72dBA/m at 2462MHz. Fig. 5 to Fig. 7 show that the total signal due to all APs at the bandwidth 2400 to 2486 MHz reaches -57.23dBA/m, or 71.50 nW/cm^2 which is 0.0096% of the ICNIRP limit. As shown in Fig. 2 we note that the local AP is covering most of the residence with a green region type signal. Signal levels due to only neighboring APs lead to several green regions due to four neighboring APs, where three are affecting the bedrooms with green signal levels, as shown in Fig. 3. In total 84 APs exist including one local AP, as presented in Table I. This residence suffers from high levels, therefore, locations 2 to 5 all yield levels almost similar to levels of location 1, which is closest to the local AP. Total levels at the wifi bandwidth are -59.43, -61.12, -67.23 and -73.95dBA/m for locations 2 to 5, respectively. Table II shows the top 19 channels transmitting at location 1 of the surveyed residence.

Fig. 4. Color code used to indicate signal levels in dBm.

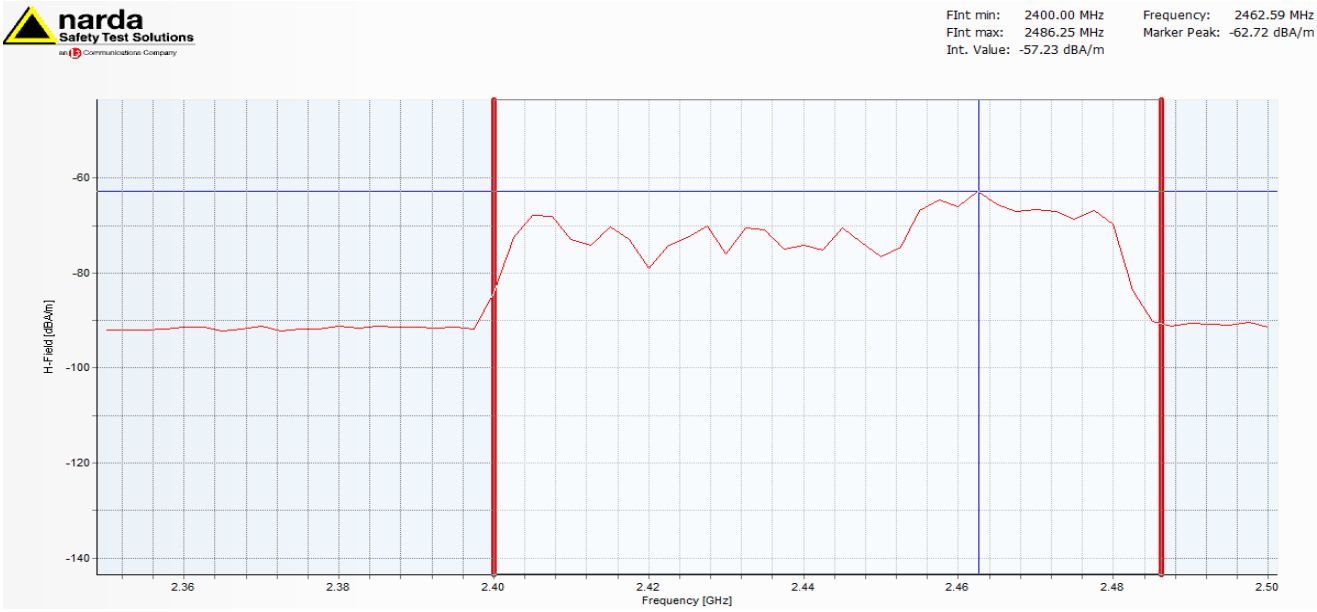

Fig. 5. SRM-3000 signal levels in dBA/m unit at location 1 of the surveyed residence.

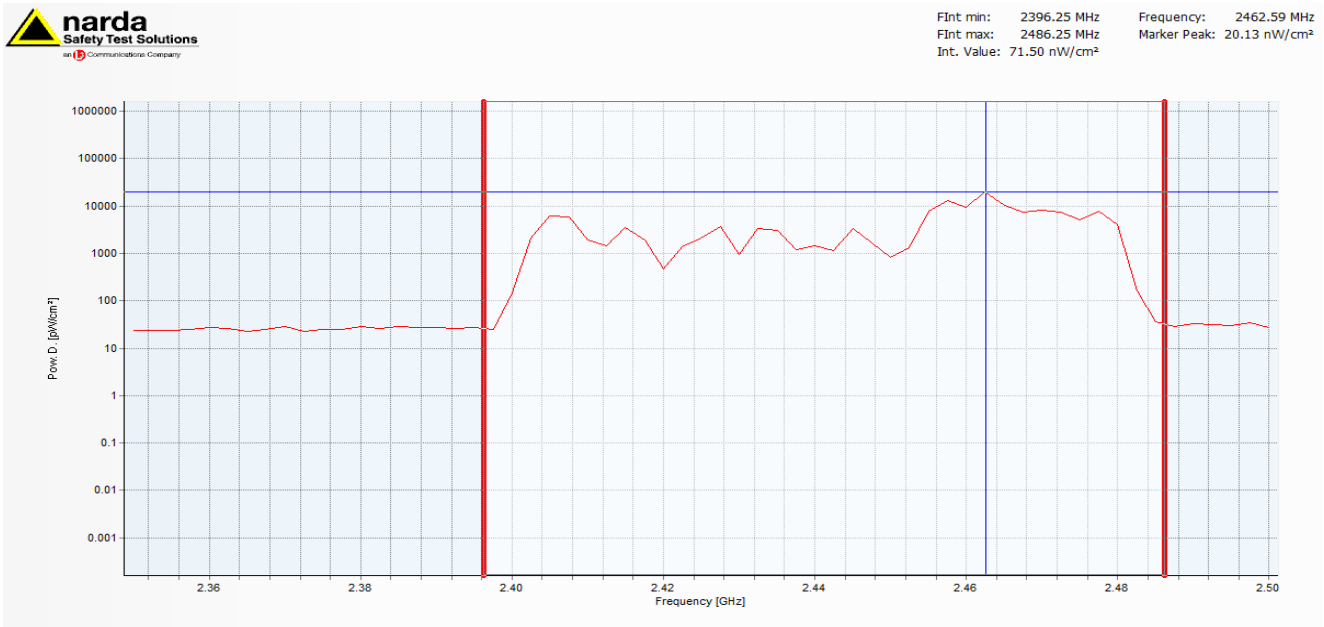

Fig. 6. SRM-3000 signal levels in W/cm^2 unit at location 1 of the surveyed residence.

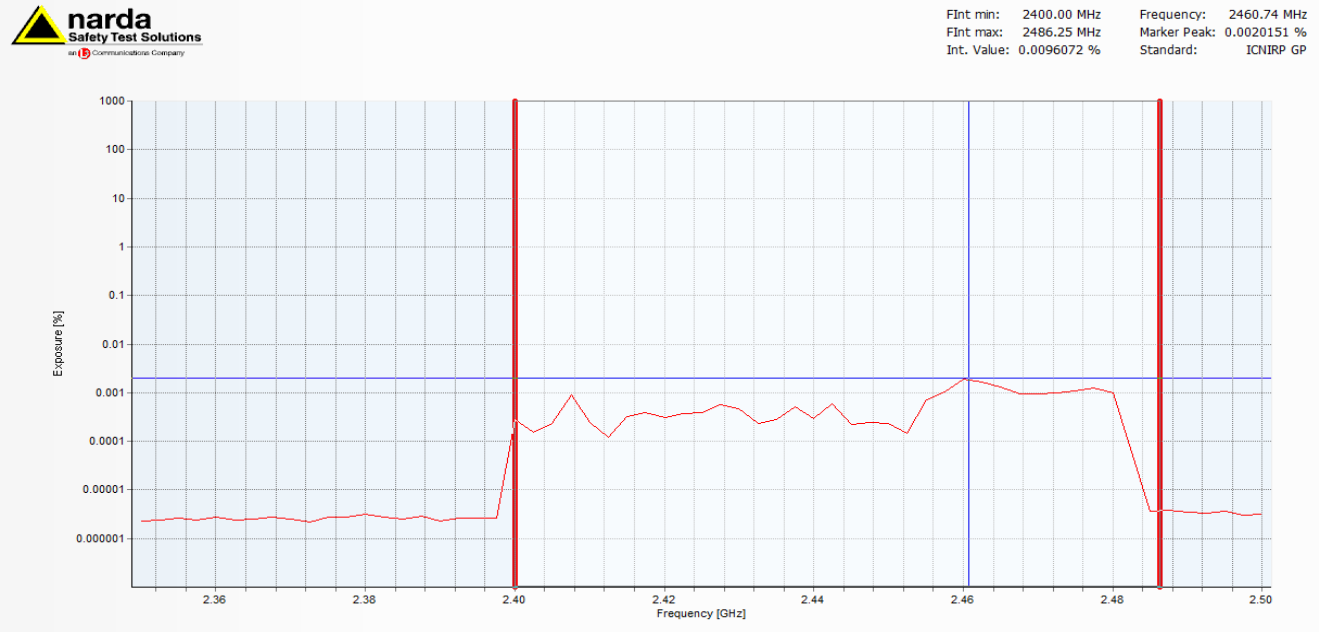

Fig. 7. SRM-3000 signal levels in percentage of ICNIRP limit at location 1 of the surveyed residence.

TABLE I: OF APS AT THE SURVEYED RESIDENCE

Name	SSID	MAC	Vendor	Channel	Max Rate	Encryption
Netgear 802.11n	BNJAK	10:0D:7F:2A:9A:B2	Netgear	11 (7)	300.0	WPA-CCMP,WPA-TKIP
Cisco-Li 802.11g	yosry	00:1A:70:9B:09:CE	Cisco-Li	11	54.0	WEP
D-Link 802.11g	Zajil Home	00:26:5A:51:66:16	D-Link	11	54.0	WPA-CCMP,WPA-TKIP
EdimaxTe 802.11g	SIMVASTATINO ACTIVO	00:1F:1F:A0:F8:6B	EdimaxTe	11	54.0	WPA-CCMP,WPA-TKIP
D-Linkln 802.11n	Prasanna	84:C9:B2:C5:1F:DC	D-Linkln	1	72.2	WPA-CCMP,WPA-TKIP
HuaweiTe 802.11g	thaaz	D4:6E:5C:62:B1:C1	HuaweiTe	1	54.0	WPA-TKIP
D-Linkln 802.11n	DLink	CC:B2:55:30:FD:2B	D-Linkln	1 (5)	300.0	WPA-CCMP
Netgear 802.11n	samba	10:0D:7F:2A:68:45	Netgear	6	144.0	WPA-CCMP
D-Linkln 802.11g	Terrace F2	1C:AF:F7:08:B2:08	D-Linkln	6	54.0	WEP
Unknown 802.11g	Ap1	00:4F:62:1C:D5:4B		6	54.0	WPA-TKIP
D-Linkln 802.11n	Sabri	BC:F6:85:DB:67:DF	D-Linkln	11 (7)	300.0	WPA-CCMP,WPA-TKIP
Netgear 802.11g	HAROUT	00:24:B2:FD:64:28	Netgear	11	54.0	WEP
Unknown 802.11g	Jimmy_2	2E:C6:8E:15:9E:F8		11	54.0	WEP
D-Linkln 802.11g	sony	1C:AF:F7:08:B3:2E	D-Linkln	6	54.0	WEP
HuaweiTe 802.11n	VIVA-4G-LTE-F33F	50:9F:27:F5:F3:3F	HuaweiTe	9	144.0	WPA-CCMP,WPA-TKIP
Netgear 802.11n	Qnet	10:0D:7F:2A:A9:2B	Netgear	11 (7)	300.0	WPA-CCMP,WPA-TKIP
EdimaxTe 802.11n	abohamza	00:1F:1F:F2:54:39	EdimaxTe	6	144.0	WEP
Netgear 802.11g	Ayman	E0:46:9A:BB:E7:E0	Netgear	6	54.0	WPA-TKIP
D-Linkln 802.11n	Abdul Rawoof	78:54:2E:7A:82:13	D-Linkln	9	72.2	WPA-CCMP,WPA-TKIP
Netgear 802.11n	ABAYA	E0:46:9A:63:4D:B9	Netgear	11	144.0	WEP
SamsungE 802.11g	AndroidAP	78:52:1A:BF:7C:FB	SamsungE	6	54.0	WPA-CCMP
D-Linkln 802.11g	Terrace F3	B8:A3:86:5E:D5:86	D-Linkln	6	54.0	WEP
Shenzhen 802.11n	Zain-Hotspot-4G-LTE	24:DB:AC:7D:03:7C	Shenzhen	6	144.0	WPA-CCMP,WPA-TKIP
D-Link 802.11g	AHMAD	00:26:5A:51:1E:38	D-Link	11	54.0	WEP
D-Linkln 802.11n	andrew	B8:A3:86:30:79:64	D-Linkln	1	72.2	WEP
HuaweiTe 802.11n	VIVA-4G-LTE-3107	40:CB:A8:97:31:07	HuaweiTe	6	144.0	WPA-CCMP,WPA-TKIP
D-Linkln 802.11n	KEMS	1C:BD:B9:CF:E3:58	D-Linkln	11	144.0	WPA-CCMP,WPA-TKIP
Shenzhen 802.11n	Fida	24:DB:AC:ED:E7:F1	Shenzhen	6	72.2	WPA-CCMP,WPA-TKIP

TABLE II: CHANNELS TRANSMITTING AT LOCATION 1.

Index	Frequency	Level
1	2462.59 MHz	-62.72 dBA/m
2	2457.77 MHz	-64.56 dBA/m
3	2469.96 MHz	-66.63 dBA/m
4	2477.21 MHz	-66.73 dBA/m
5	2406.13 MHz	-67.40 dBA/m
6	2433.60 MHz	-69.90 dBA/m
7	2426.98 MHz	-69.91 dBA/m
8	2415.24 MHz	-70.26 dBA/m
9	2445.27 MHz	-70.39 dBA/m
10	2439.90 MHz	-74.10 dBA/m
11	2497.18 MHz	-90.41 dBA/m
12	2490.76 MHz	-90.56 dBA/m
13	2369.61 MHz	-91.09 dBA/m
14	2385.28 MHz	-91.22 dBA/m
15	2380.31 MHz	-91.26 dBA/m
16	2394.46 MHz	-91.32 dBA/m
17	2360.76 MHz	-91.34 dBA/m
18	2389.67 MHz	-91.42 dBA/m
19	2375.90 MHz	-91.76 dBA/m

VI. CONCLUSION

In this study we aimed at collecting information on radiation levels due to wifi or access point routers at several types of residences in Kuwait. A total of fourteen residences were surveyed using a professional meter and a special software dedicated for surveying access points. Results show several neighbouring router actively radiating at the residence in addition to the local router. The highest level recorded was -57dBA/m, which is equivalent to 0.0096% of the ICNIRP limit. However, this low level in comparison to the ICNIRP limit is not always considered safe by all expert reports. Some reports cited here consider no low safe limit exists. Therefore, efforts must be made to reduce exposure time by turning off the local APs at each residence, when not in use, for example overnight.

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