

Unlicensed Device Interference to
Wireless Microphones –
Analysis and Measurements



June 30, 2004

NOTE:

This presentation contains sound and video as part of the interference demonstrations.

If you do not hear the audio portion of the videos (beginning on Slide 8), please press the ESCAPE key, adjust the volume upwards and re-start the presentation.

Wireless Microphones are used in a variety of venues and require a significant amount of interference-free spectrum.

Wireless Microphone User Model

User Description

MOBILE = Large numbers of wireless used for a period of time (hours – days) at a temporary location



LARGE FIXED = Large numbers of wireless repeatedly used a permanent location



FIXED = Fewer numbers of wireless repeatedly used at a permanent location



Venue

Sports Production
Film Production
Political Conventions
Shareholder Meetings
Entertainment Tours
Music Festivals

TV and Radio Broadcasting
Houses of Worship (Large)
Theme / Amusements Parks
Hotels (Large)
Government Offices

Schools / Universities
Houses of Worship
Music Clubs
Individuals
Corporate Offices
Hotels (Small)

Wireless Frequencies

30 – 100 Frequencies
 (10-30 mW, typ.)

20 – 50 Frequencies
 (10-30 mW, typ.)

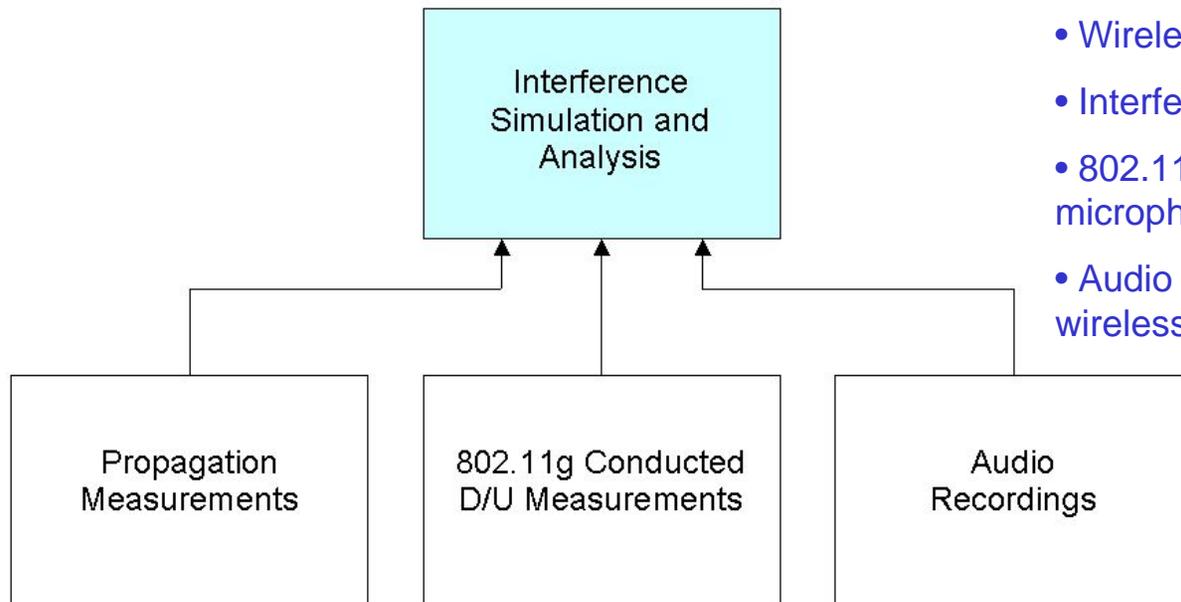
1 – 10 Frequencies
 (10-50 mW, typ.)

Typical Number of Wireless Used at an **LARGE FIXED** Venue (Large House of Worship):

- 20 Wireless Microphones
 - 15 Wireless Personal Monitors
 - 10 Wireless Intercoms
- ➔ **45 Frequencies Required**

Shure conducted an interference analysis of unlicensed devices to wireless microphones. An 802.11g wireless LAN was frequency-translated into the UHF frequency range (conducted) and interference to wireless microphones was measured and recorded.

Unlicensed Device Interference Study



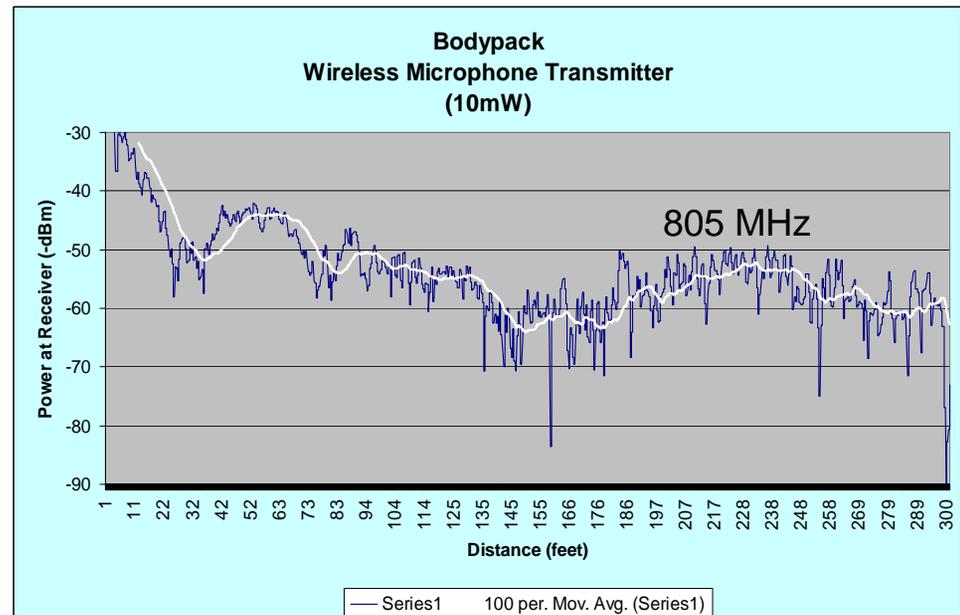
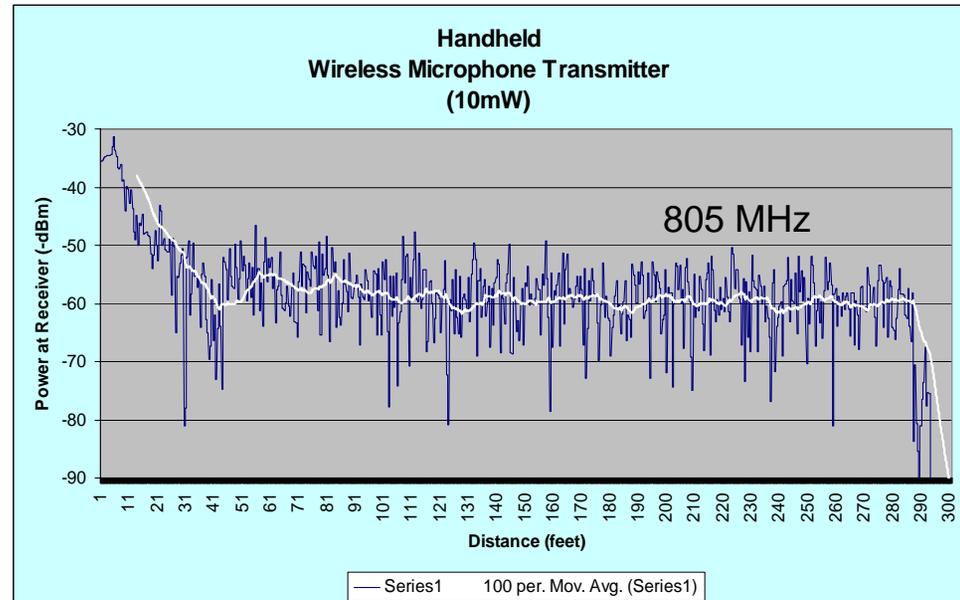
The interference analysis has four components:

- Wireless microphone propagation
- Interference simulation scenarios
- 802.11g interference to wireless microphone measurements
- Audio recordings of interference to wireless microphones

Wireless Microphone propagation (UHF – 805 MHz) was recorded inside a large arena using handheld and bodypack transmitters. (Transmitter is walked away from receiver at a constant rate.)

Things to note about these plots:

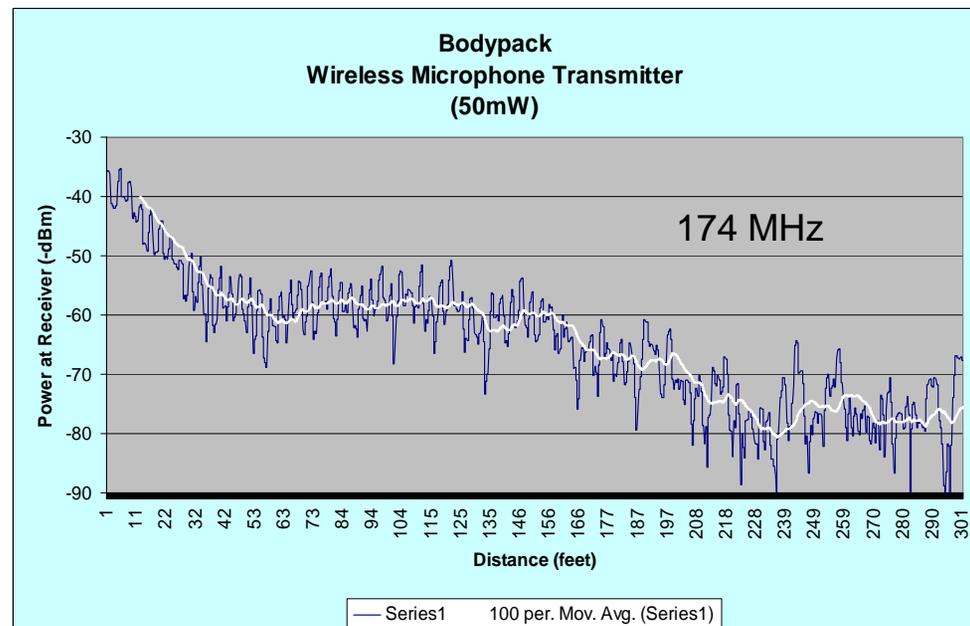
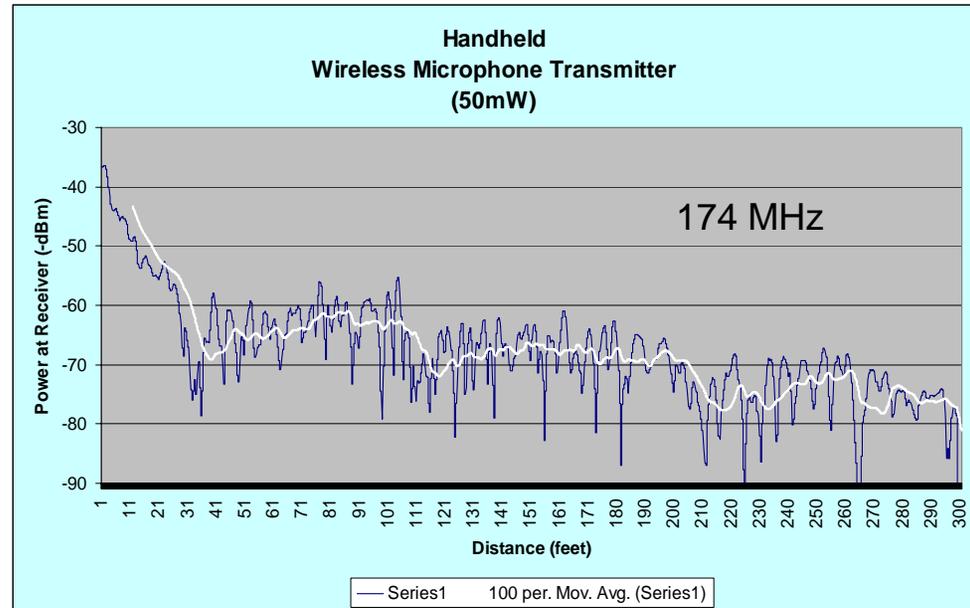
- Multi-path reflections cause deep signal nulls and cancellation
- Handheld and body absorption lowers effective radiated power
- Typical transmitter power of 10 – 30 mW is used at UHF



Wireless Microphone propagation (VHF – 174 MHz) was recorded inside a large arena using handheld and bodypack transmitters. (Transmitter is walked away from receiver at a constant rate.)

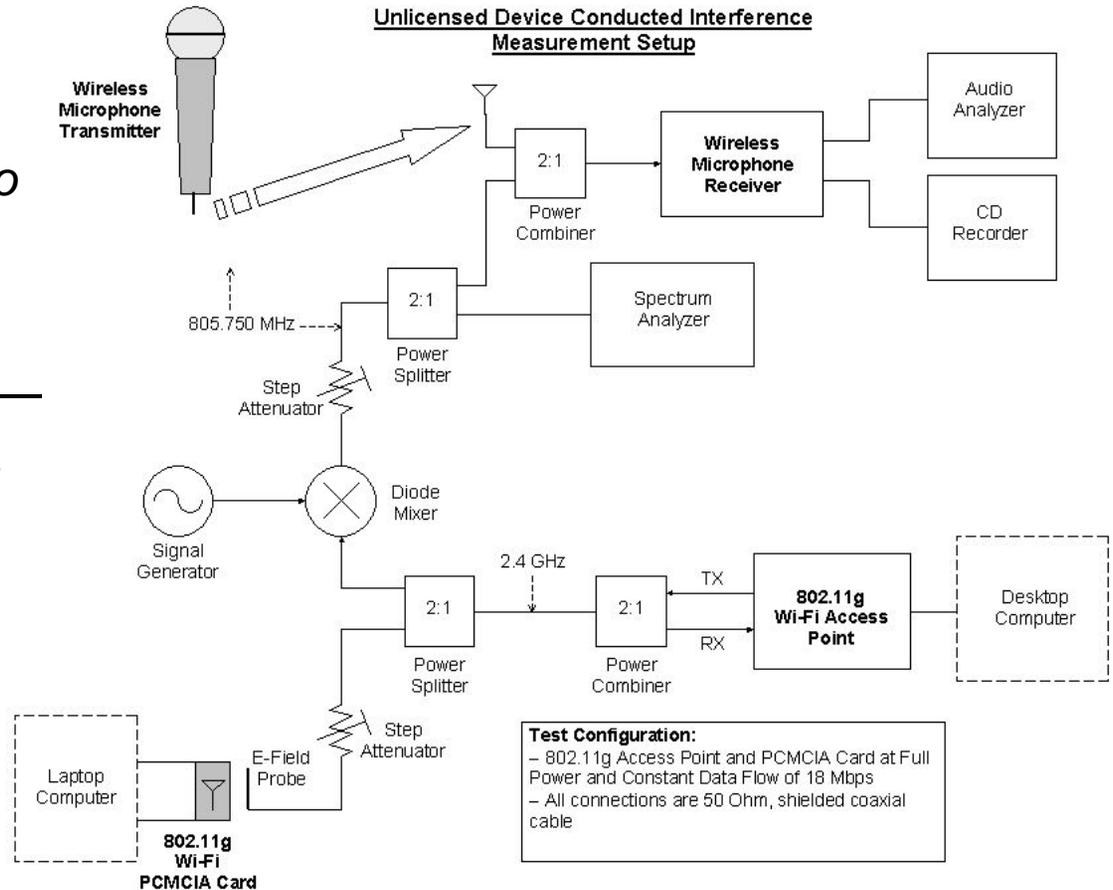
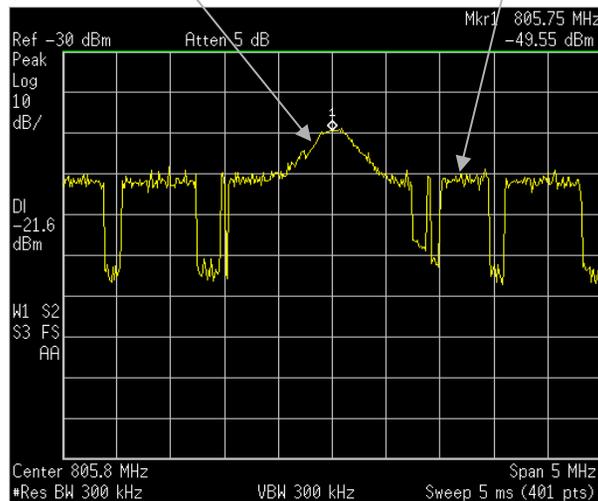
Things to note about these plots:

- Low antenna efficiency at VHF, handheld and body absorption reduces effective radiated power
- Received power at 300 feet is ~ 20 dB lower than at UHF
- Multi-path reflections cause deep signal nulls and cancellation

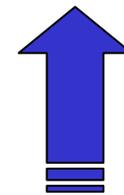
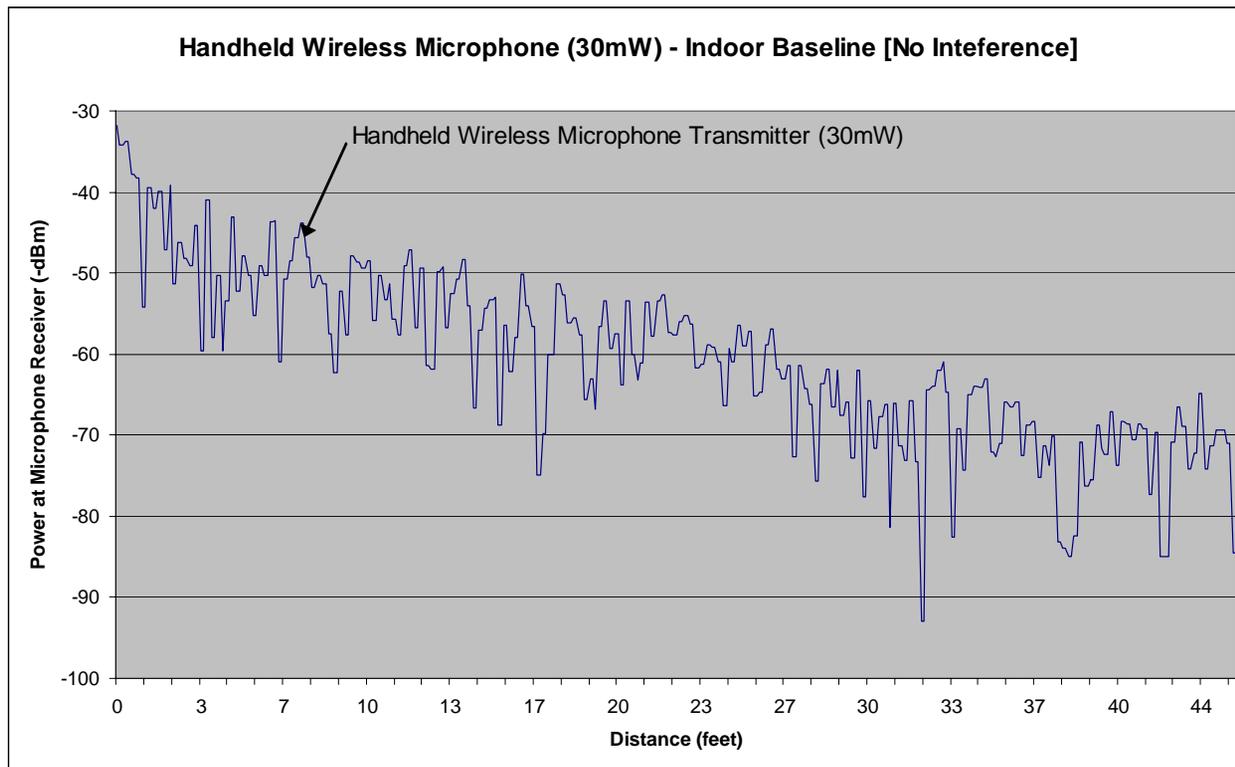


An 802.11g wireless LAN is translated to 805 MHz and combined with a radiated wireless microphone signal. The 802.11g power level is varied and the interference to the wireless microphone is measured and recorded.

Wireless Microphone Signal 802.11g Signal



*A baseline recording is made of the wireless microphone without interference.
(Transmitter is walked away from receiver at a constant rate while speaking.)*



Click on image to play recording.

(To continue after movie is completed, press ANY KEY or click the mouse once.)

A simulation is created by locating an unlicensed device **1000 feet** from a wireless microphone receiver resulting in an unlicensed device signal level of **-64 dBm**.

Unlicensed Device Interference Analysis - Scenario #1

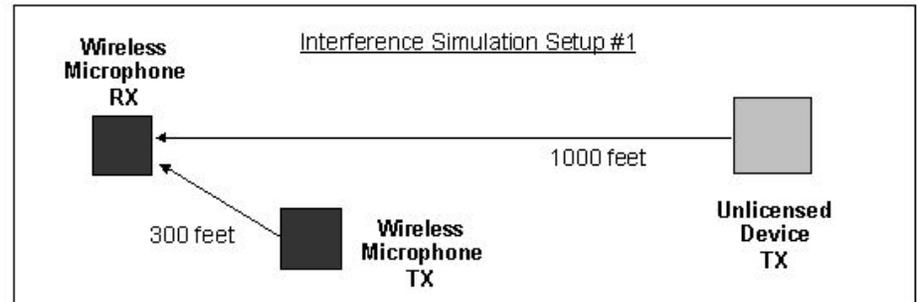
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Simulation Assumptions:

- Unlicensed device interference is co-channel to the wireless microphone
- Unlicensed device transmit power is equally spread across a 6 MHz wide BW

Wireless Microphone		Unlicensed Device
10 mW	Transmit Power	100 mW
1	Transmit Antenna Gain	4
300 feet	Distance to Microphone Receiver	1000 feet
600 MHz	Frequency	600 MHz
N/A	Bandwidth Spreading Correction Factor (400kHz/6MHz)	-12 dB
-58 dBm (Desired)	Power at Wireless Microphone Receiver	-64 dBm (Undesired)
Desired / Undesired Ratio = 6dB		

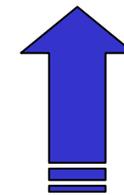
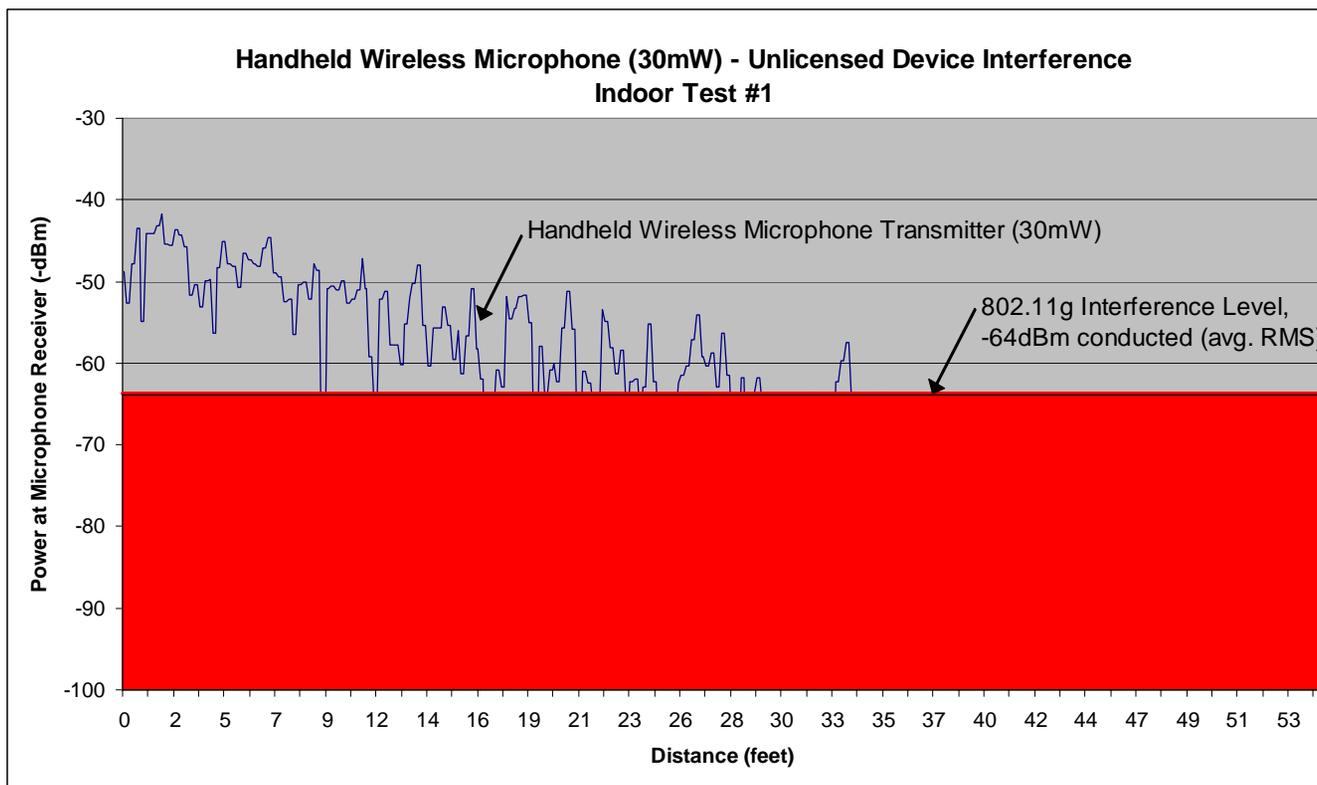
RESULT:
An Unlicensed Device transmitting 1000 feet from a wireless microphone receiver will cause interference at a Desired/Undesired signal ratio of **6 dB**.



*Interference Test #1: **-64 dBm** Interference to Wireless Microphone Audio (co-channel)*

-- The microphone level and interference were recorded along with the microphone audio as the transmitter is walked away from the receiver at a constant rate.

-- The microphone and interference signal levels are shown below as well as on the recording.



Click on image to play recording.

(To continue after movie is completed, press ANY KEY or click the mouse once.)

A simulation is created by locating an unlicensed device **300 feet** from a wireless microphone receiver resulting in an unlicensed device signal level of **-54 dBm**.

Unlicensed Device Interference Analysis - Scenario #2

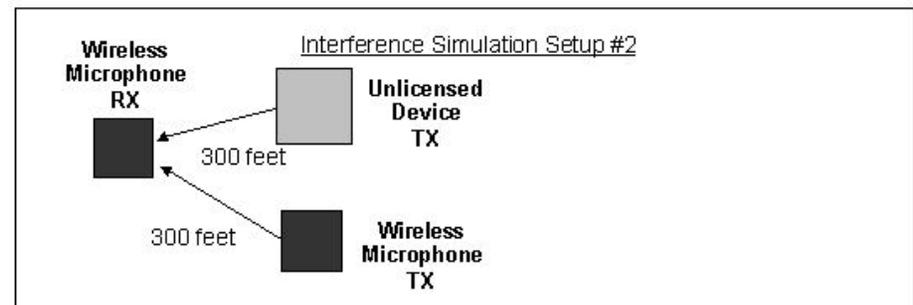
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Simulation Assumptions:

- Unlicensed device interference is co-channel to the wireless microphone
- Unlicensed device transmit power is equally spread across a 6 MHz wide BW

Wireless Microphone		Unlicensed Device	
10 mW	Transmit Power	100 mW	
1	Transmit Antenna Gain	4	
300 feet	Distance to Microphone Receiver	300 feet	
600 MHz	Frequency	600 MHz	
N/A	Bandwidth Spreading Correction Factor (400kHz/6MHz)	-12 dB	
-58 dBm (Desired)	Power at Wireless Microphone Receiver	-54 dBm (Undesired)	
Desired / Undesired Ratio = -4dB			

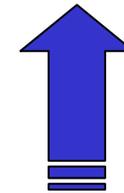
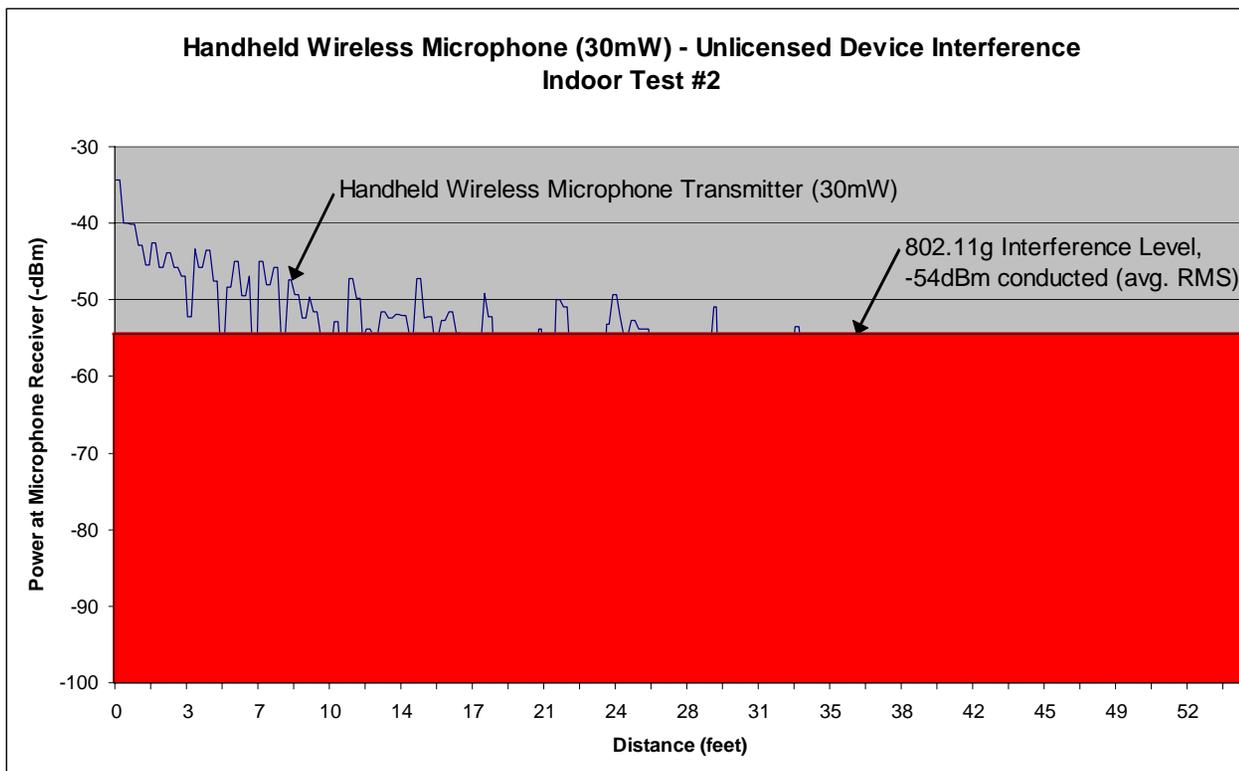
RESULT:
An Unlicensed Device transmitting **300 feet** from a wireless microphone receiver will cause interference at a Desired/Undesired signal ratio of **-4 dB**.



*Interference Test #2: **-54 dBm** Interference to Wireless Microphone Audio (co-channel)*

-- The microphone level and interference were recorded along with the microphone audio as the transmitter is walked away from the receiver at a constant rate.

-- The microphone and interference signal levels are shown below as well as on the recording.



Click on image to play recording.

(To continue after movie is completed, press ANY KEY or click the mouse once.)

CONCLUSIONS:

- *Wireless microphones are used in a **variety of venues** and require a significant amount of **interference-free spectrum***
 - *Large venues require more than **100 frequencies** for wireless microphones*
- *Wireless microphones are **portable** and suffer from **body absorption** which reduces the effective radiated power*
- *Wireless microphone propagation is subject to **multi-path reflections** which cause **cancellation**, resulting in a very **small signal margin** at the receiver*
- ***Unlicensed devices** operating at the NPRM parameters (100 mW) will cause **co-channel interference** to wireless microphones at distances of **more than 1000 feet***
- ***Wireless microphones** will become **unusable** in the presence of **interference** from unlicensed devices – users will return them thinking they are **defective***
- ***Rules must be established** to prevent **interference from unlicensed devices** to wireless microphones*
- ***Shure** is ready to contribute **solution ideas** to solve these **interference problems** to wireless microphones*