



# IMPACT OF ANTENNA MATCHING ON APPLICATION PERFORMANCE

Alexey Starikovich

# INDEX

- Wi-Fi bandwidth and power limits
- Measuring Power
- Importance of FCC and EU accreditation
- Demo I
- Demo II
- Demo III

## WI-FI

### Bandwidth, Frequencies and Power Limit 2.4GHz

Channel	Center Frequency (MHz)	USA (FCC)	Europe (ETSI)	China	Japan
1	2412	✓	✓	✓	✓
6	2437	✓	✓	✓	✓
11	2462	✓	✓	✓	✓
12	2467	(Limited power)	✓	✓	✓
13	2472	(Limited power)	✓	✓	✓
14	2484	✗	✗	✗	✓ (802.11b only)
Allowed Bandwidths		20, 40 MHz	20, 40 MHz	20, 40 MHz	20, 40 MHz
Common Non-Overlapping		1, 6, 11 (3 channels)	1, 5, 9, 13 or 1, 6, 11	1, 6, 11	1, 6, 11
Power Limit		36 dBm / 4 W	20 dBm / 0.1 W	20 dBm / 0.1 W	24.12 dBm / 0.26 W

# WI-FI

## Bandwidth and Frequencies 5GHz

Center Frequency (MHz) for 20 MHz Channel	U-NII Band Name / Channels	USA (FCC)	Europe (ETSI)	China	Japan
5180, 5200, 5220, 5240	UNII-1 (Ch 36 - 48)	✓	✓ (Indoor Only)	✓ (5150-5350 MHz range)	✓ (Indoor Only)
5260, 5280, 5300, 5320	UNII-2A (Ch 52 - 64)	✓ (DFS/TPC)	✓ (DFS/TPC, Indoor Only)	✓ (5150-5350 MHz range, DFS/TPC)	✓ (DFS/TPC, Indoor Only)
5500 - 5700 (Ch 100 - 140)	UNII-2C	✓ (DFS/TPC)	✓ (DFS/TPC)	✗	✓ (DFS/TPC)
5745, 5765, 5785, 5805, 5825	UNII-3 / ISM (Ch 149 - 165)	✓	✗ (Typically not allowed)	✓ (5725-5850 MHz range)	✗
Common Allowed Bandwidths		20, 40, 80 MHz	20, 40, 80 MHz	20, 40, 80 MHz	20, 40, 80 MHz

- **DFS** (Dynamic Frequency Selection): A mechanism that requires the device to monitor a channel for a period of time to ensure it is not interfering with military or weather radar systems before using it. This is mandatory for certain channels.
- **TPC** (Transmit Power Control): A requirement to automatically adjust transmission power to the lowest level necessary to maintain communication, further reducing interference.
- **UNII-3/ISM (5.8 GHz)**: This band (channels 149-165) is generally for **outdoor** and **high-power use in the USA and China**, but is **not permitted** for standard Wi-Fi use in **Europe** and Japan (or is highly restricted)

## WI-FI

### Power Limits 5GHz

5 GHz Sub-Band / Channels	USA (FCC) EIRP	Europe (ETSI) EIRP	China (SRRC) EIRP	Japan (MIC) EIRP
U-NII-1 (Ch 36-48) 5150-5250 MHz	36 dBm (4 W) Outdoor APs. 30 dBm (1 W) Indoor APs/Clients.	23 dBm (200 mW) <b>Indoor Use Only.</b>	23 dBm (200 mW) <b>Indoor Use Only.</b>	20 dBm (100 mW) <b>Indoor Use Only.</b>
U-NII-2A/2C (Ch 52-144) 5250-5725 MHz	30 dBm (1 W) <b>DFS Mandatory.</b>	30 dBm (1 W) <b>DFS/TPC Mandatory.</b> Indoor/Outdoor.	30 dBm (1 W) <b>DFS/TPC Mandatory</b> (for allowed channels).	30 dBm (1 W) <b>DFS Mandatory.</b> Indoor/Outdoor.
U-NII-3 (Ch 149-165) 5725-5850 MHz	36 dBm (4 W) <b>No DFS.</b>	14 dBm (25 mW) Typically restricted/ <b>not for general Wi-Fi.</b>	36 dBm (4 W) Used for general Wi-Fi/FWA.	Not allowed for general Wi-Fi.

# WI-FI

## Power Explanation

Wi-Fi Component	Hearing Analogy
Conducted Power dBm	How loud is screaming
Antenna Gain dBi	How good is hearing
EIRP dBm	How far away it can be heard

$$\text{EIRP (dBm)} = \text{Tx Power (dBm)} + \text{Antenna Gain (dBi)}$$

Real Case Example:

$$17 \text{ dBm} = -10 \text{ dBm} + 27 \text{ dBi}$$

The outcome of 17 dBm resides comfortably beneath the maximum thresholds established by nearly all global Wi-Fi standards, such as 20 dBm in Europe and 30 dBm in the US for numerous applications.

Country: Germany

Antenna Gain: 27 (max 30, min 0, default 27)

Channel: Low Power SRD

Band: 5GHz AX

Channel Width: 20MHz

Skip DFS Channels: all

Status: running

Current Channel: 5825/ax

Registered Peers: 1

Authorized Peers: 1

Tx Power: -10

# WHY IS IT SO IMPORTANT?

## Real Case of FCC Rules Violation

### Ubiquiti Settles for \$250K for Equipment Marketing Violations

**Full Title:** Ubiquiti Inc

**Document Type:** Order/Consent Decree

**Bureau(s):** Enforcement

**Description:**

The FCC's Enforcement Bureau reaches a settlement with Ubiquiti Inc. for \$250,000, an admission of liability, and a compliance plan, resolving its investigation into unauthorized marketing of radio frequency devices

**DA/FCC #:** DA-20-1224

**FCC Record Citation:** 35 FCC Rcd 11673 (15)

**FCC Record:** [DA-20-1224A1\\_Rcd.pdf](#)

#### Files

#### Document Dates

**Released On:** Oct 21, 2020

**Adopted Date:** Oct 21, 2020

**Issued On:** Oct 21, 2020

#### Tags:

[Enforcement](#) - [Devices](#) - [Radio frequency \(RF\) device](#) - [Devices, Engineering & Technology](#) - [Equipment](#) - [Released Documents](#) - [Consent Decree](#) - [Equipment Marketing](#)



FEDERAL COMMUNICATIONS COMMISSION  
ENFORCEMENT BUREAU  
Region 2

**Miami Office**  
P.O. Box 266468  
Weston, FL 33326

July 13, 2016

Wide Cloud Communications  
Hialeah, Florida

#### NOTIFICATION OF HARMFUL INTERFERENCE

Case Number: EB-FIELDSCR-16-00021831  
Document Number: W201632600019

The Miami Office, in response to a complaint from the Federal Aviation Administration (FAA) that its Terminal Doppler Weather Radar (TDWR) serving the Fort Lauderdale-Hollywood International Airport (FLL) was experiencing harmful interference from radio emissions on or adjacent to the TDWR frequency of 5645 MHz, conducted an investigation in the area. On July 6, 2016, an agent from this office confirmed by direction finding techniques that radio emissions on the frequency band 5655 - 5675 MHz were emanating from one of your wireless transmitters located on the roof of 1840 W. 49<sup>th</sup> St, Hialeah, FL 33012. Wide Cloud Communications personnel confirmed that it was operating a Ubiquiti Rocket M5 Unlicensed National Information Infrastructure (U-NII) device on the frequency band 5655 – 5675 MHz, and agreed to change the operating frequency when notified of the interference. The interference to the TDWR then ceased.

Nonlicensed operation of a U-NII device is subject to the condition that it must not cause harmful interference and, if harmful interference occurs, operation of the device must cease. *See* 47 C.F.R. §§ 15.5(c), 15.405. Harmful interference is defined as “[a]ny emission, radiation or induction that endangers the functioning of a radio navigation service or of other safety services or seriously degrades, obstructs or repeatedly interrupts a radio communications service.” 47 C.F.R. § 15.3(m).

Your operation of a U-NII device on 5655 – 5675 MHz caused harmful interference to the TDWR serving Fort Lauderdale-Hollywood International Airport and your operation of this device on these frequencies must not resume. You are also warned that operation of otherwise authorized equipment that continues to cause harmful interference after your receipt of this warning, constitutes a violation of Federal law and could subject the operator to severe penalties, including, but not limited to, substantial monetary fines, *in rem* arrest action against the offending radio equipment, and criminal sanctions including imprisonment. (*see* 47 U.S.C. §§ 301, 401, 501, 503 and 510).

# DEMO SETUP I

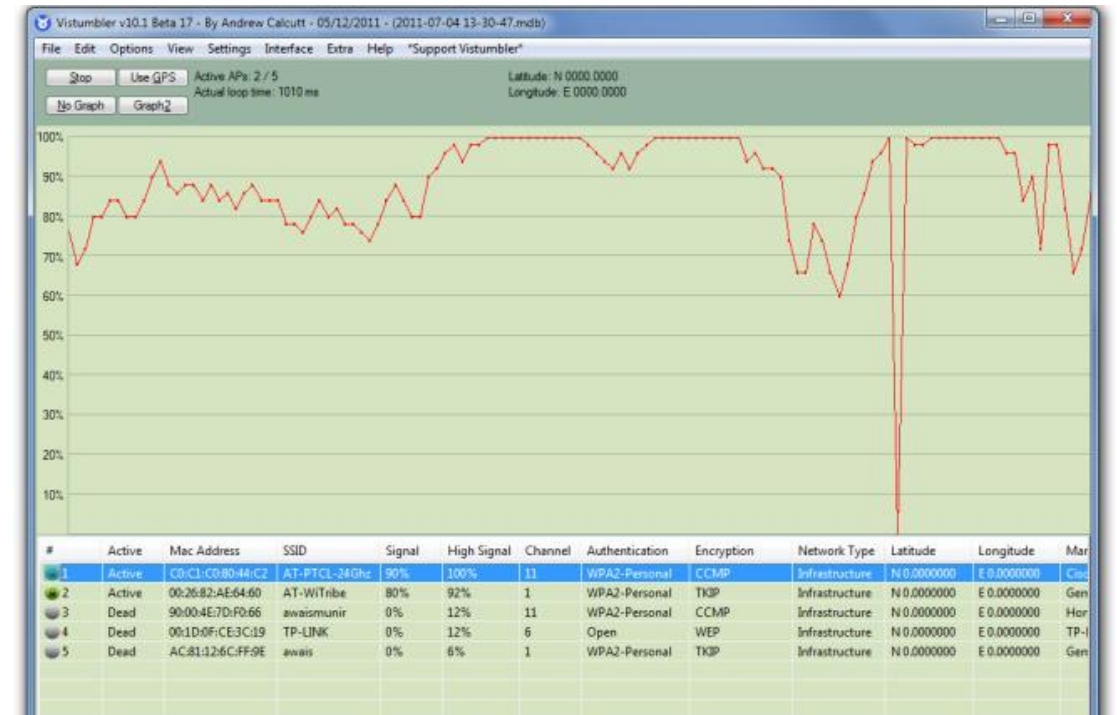
## Signal Strength Measuring



Client with  
Vistumbler



Access  
Point

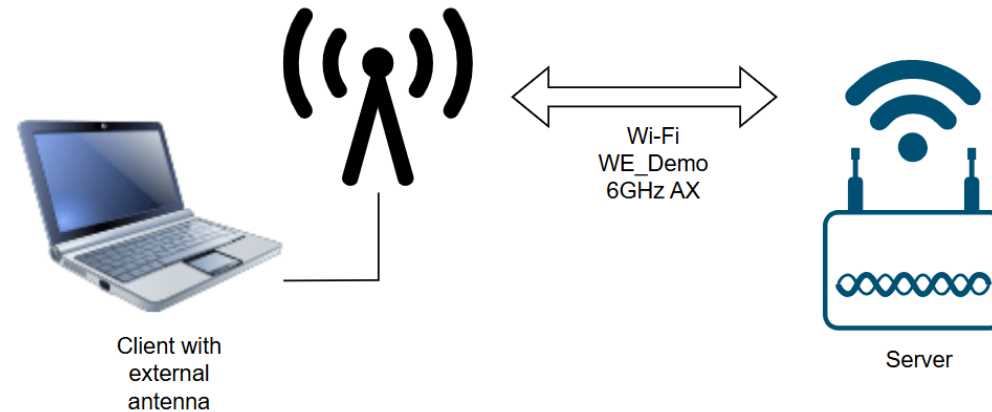


- For this demo we will use a notebook, Access point and open-source wireless network scanner Vistumbler
- How does antenna performance change based on different countries to avoid any FCC/EU limitations violations
- How does matching affect antenna Tx performance



## DEMO SETUP II

How the Antenna Matching Affect Data Transfer Performance



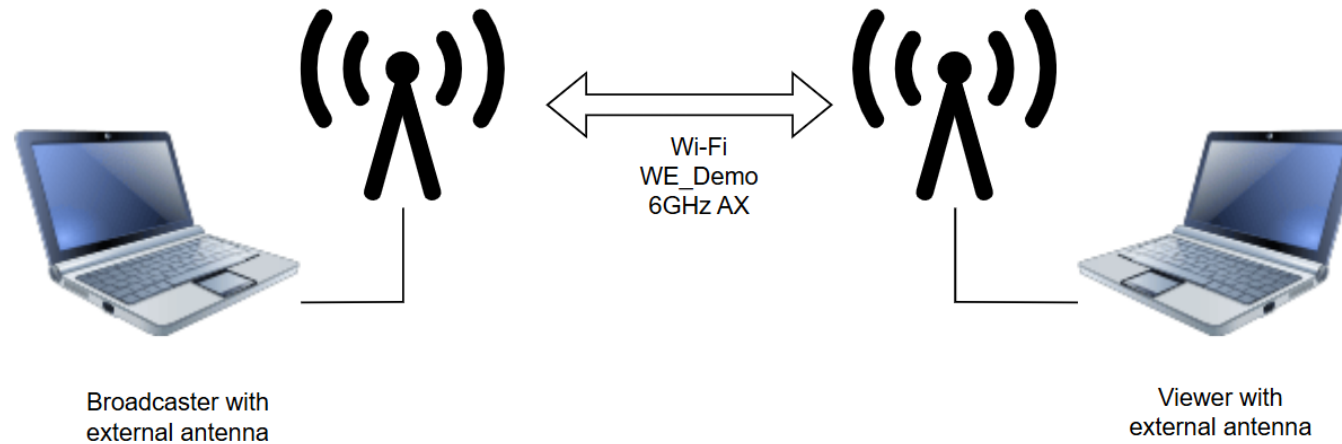
- Rx/Tx and bitrate impact when we download data from Server:
  - When antenna is mismatched on client side
  - When antenna is mismatched on server side

### Important

The requirement of the standard is for a **transmitter** to yield when it decodes another at a level of **3 dB above the noise floor**, or when the **non-decoded noise level is higher than a threshold  $P_{th}$**  which, for Wi-Fi 5 and earlier, is **between -76 and -80 dBm**

## DEMO SETUP III

### Sophisticated Setup for Screen Sharing



- Both computers are connected to different external antennas.
- Broadcaster start broadcasting a real time video from his screen
- Viewer see the screen from Broadcaster
- Broadcast antenna degradation - Immediate, catastrophic video loss.
- Viewer antenna degradation - Degraded quality due to retransmissions.