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New Regulations for Unlicensed Operation in the 6 GHz Band Explained

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New Regulations for Unlicensed Operation in the 6 GHz Band Explained

Introduction

On April 23rd, 2020 the Federal Communications Commission (FCC) voted unanimously to adopt sweeping new rules for wireless operation in the 6 GHz band [1], opening up 1200 megahertz of spectrum to unlicensed devices. Specifically, the FCC approved the rules it informally released to the public about three weeks prior to this momentous vote [2].

This development has been widely hailed as a big win for Wi−Fi® – and rightly so – but what exactly did the FCC decide and what do the new regulations mean for Wi−Fi and the 6 GHz band?

In this note, we provide an overview of the 6 GHz band, the process that lead to the new regulations and the details of the rules that the FCC has approved for operation of unlicensed devices in 6 GHz.

The Road to 6 GHz

The 6 GHz Band Incumbents

The spectrum that is commonly referred to as “the 6 GHz band” actually consists of the frequencies between 5.925 MHz and 7.125 MHz, totaling 1200 MHz of spectrum.

Prior to the April 23rd announcement from the FCC, the 6 GHz band was designated as exclusive non−federal spectrum and licensed to a number of different radio services.

Figure 1 illustrates the use of the 6 GHz band by the incumbent services.

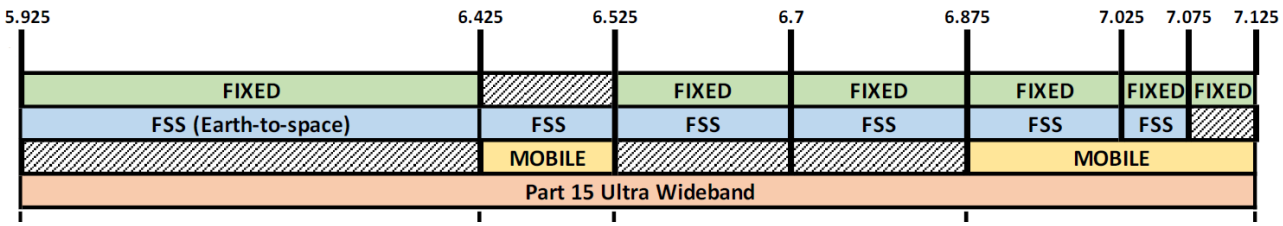

Figure 1. Incumbent Services in 6 GHz (from [4])

Fixed Service (FS) and Fixed−Satellite Service (FSS) operations are spread throughout most of the 6 GHz band. Fixed Service is used for reliable point−to−point microwave links. These links support a variety of services such as public safety, management of electric grids, long−distance telephone service and backhaul. FSS is allowed for Earth−to−space communication in all but the upper 150 MHz of the 6 GHz band. FSS uses these frequencies for content distribution, live news and sports events, cable television and backhaul of telephone and data traffic.

Mobile operations are permitted in the 6.425−6.525 GHz band and in the 6.875−7.125 GHz band. These services include Broadcast Auxiliary Service (BAS), Cable Television Relay Service (CARS) and Local Television Transmission Services (LTTS).

Figure 2 shows the number of licensed user assignments in the 6 GHz band, normalized per MHz.

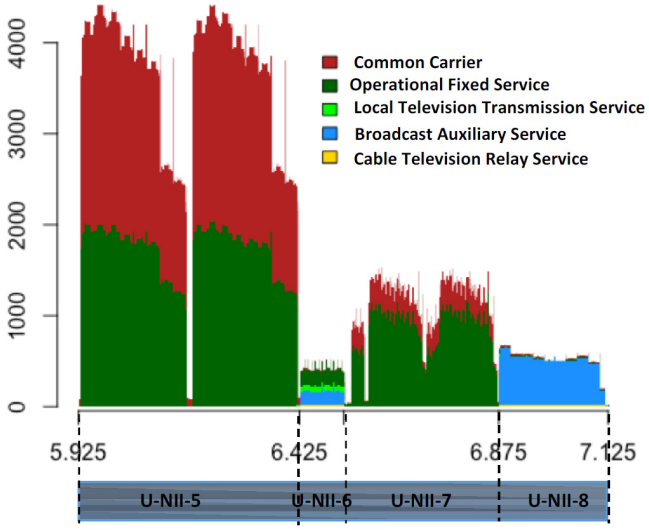

Figure 2. Density of Incumbent Services in the 6 GHz Band (from [4])

A major challenge in allowing additional non−licensed operation in the 6 GHz band was the protection of these existing incumbent users. As we will see later, some of the new regulatory rules explicitly address this issue.

In addition to the licensed fixed and mobile services, ultra−wideband systems (UWB) are permitted to operate in the 6 GHz band on a non−interference basis. It's important to note however that UWB is not considered a licensed user of the band.

Changing Regulations in the 6 GHz

Noting the "explosive demand" for unlicensed spectrum, primarily driven by Wi−Fi, the FCC embarked on a process to investigate the possible use of the 6 GHz band for unlicensed services.

The FCC is an independent federal agency that regulates interstate and international communications by radio, television, wire and satellite across the US. It is also responsible for implementing and enforcing communications law and regulations. When considering changes to regulations, the FCC employs a process known as ”notice and comment” rulemaking. Under this process, the FCC first provides notice to the public about its intention to modify existing rules. Each of these notices is followed by a period of public comments where interested parties can submit feedback on the tentative proposals. This feedback is considered by the FCC before issuing its final rules on the subject.

As part of the process the FCC can publish a number of different documents:

- *Notice of Inquiry (NOI):* this is an initial invitation to the public to allow the FCC to gather information on a broad subject. An NOI about the use of the 6 GHz by unlicensed users was issued by the FCC in July 2017 [3].
- *Notice of Proposed Rulemaking (NPRM):* the NPRM contains more details on the proposed changes to the Commission’s rules. It may follow an NOI. Each NPRM is followed by a period of at least 30 days where comments can be submitted to the FCC. The FCC issued its NPRM on unlicensed use of the 6 GHz Band in October 2018 [4].
- *Further Notice of Proposed Rulemaking (FNPRM):* An FNPRM may be issued after review of comments on an NPRM and provides an opportunity to comment further on a related or specific proposal.
- *Report and Order (R&O):* this is issued after considering comments to an NPRM or an FNPRM and specifies new rules, amends existing rules or makes a decision not to do so. After the approval of the R&O, the new or amended rules become effective 30 days after publication in the Federal Register.

The 6 GHz NPRM [4] generated significant interest from both proponents of unlicensed operations and representatives of incumbent services. 115 companies or organizations commented on the NPRM. During the subsequent discussion period, over one hundred technical studies were submitted to the FCC to address specific issues, simulate performance impacts, investigate technical claims, …

The FCC duly considered the provided input and issued its R&O in April 2020. At the same time, it also published an FNPRM to solicit input on additional topics that were not part of the original NPRM.

New Rules for Unlicensed Operation in the 6 GHz

Under the FCC nomenclature for unlicensed use, the 6 GHz spectrum is now further subdivided into four U−NII (Unlicensed National Information Infrastructure) radio bands: U−NII−5 to U−NII−8. Some of the rules adopted by the FCC depend on the U−NII band the unlicensed device is operating in. The edges of the U−NII bands coincide with the frequency

ranges that currently divide the operating frequencies of the licensed 6 GHz services (see Figure 1).

Figure 3 shows the frequencies and edges of the various parts of the 6 GHz band.

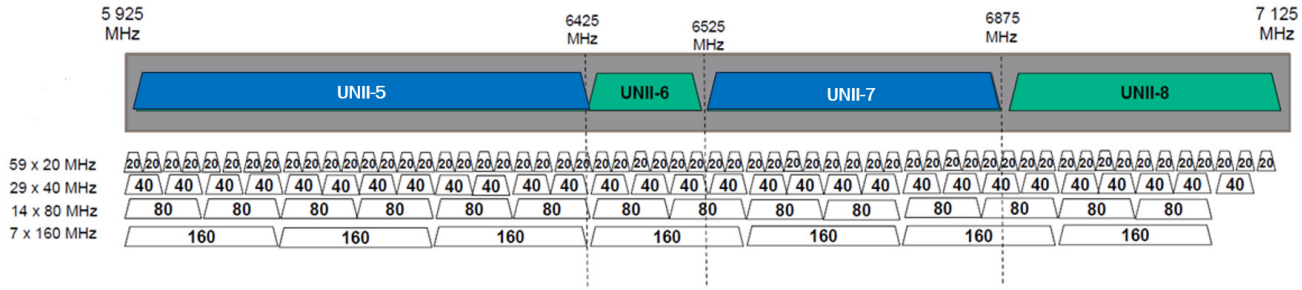

Figure 3. Illustration of the 6 GHz Band and Possible Wi−Fi Channelization

In its updated regulations for 6 GHz, the FCC now allows two types of unlicensed devices to operate in the 6 GHz:

- Low−power Access Points (APs) and their associated client devices
- Standard−power Access Points (APs) and their associated client devices

Each class of devices comes with its own set of regulatory rules.

Low Power Operation

Low−power APs are allowed in the 6 GHz band, provided they comply with the following transmit power requirements:

- Total transmitted power below 30 dBm EIRP[1]
- Power Spectral Density (PSD) limited to 5 dBm/MHz EIRP or less
- Meet the emission mask and an emission limit of −27 dBm/MHz limit at frequencies below the bottom of the U−NII−5 band and above the upper edge of the U−NII−8 band

This corresponds to for instance 18 dBm in 20 MHz, 21 dBm in 40 MHz, 24 dBm in 80 MHz, 27 dBm in 160 MHz and 30 dBm in 320 MHz. Bandwidths higher than 320 MHz are not allowed.

Low−power APs are confined to indoor use only and are allowed to use the complete 6 GHz spectrum, i.e. U−NII−5, U−NII−6, U−NII−7 and U−NII−8. This amounts to 1200 MHz of new spectrum.

The FCC felt that the combination of lower power and mandatory indoor use were sufficient to afford the required protection to incumbent services in the 6 GHz band. Since indoor use (and its resulting signal attenuation towards outside areas) is a crucial assumption in the interference

[1] EIRP (Equivalent Isotropically Radiated Power) is the amount of power allowed for a radiator that emits energy uniformly (“isotropically”) in all directions. Directional antennas have to adjust their effective transmit power such that the energy radiated in the direction of the strongest beam does not exceed that of an isotropic antenna along the same direction.

that will be generated by these devices, the FCC further imposes restrictions that are intended to prevent the use of low−power APs outdoors.

Specifically:

- Low−power APs can not be weather resistant, preventing them from being installed outside permanently
- Low−power APs can only have integrated antennas and it is prohibited to provide the capability of connecting other antennas to the devices
- Low−power APs can not be battery operated
- Low−power APs have to be clearly labeled with a notice that states that “FCC regulations restrict operation of this device to indoor use only”

While none of this is full proof, the intention is clearly to only use these devices indoor.

Low−power APs are not allowed to operate while in motion, with exception of large passenger aircraft operating over 10,000 feet.

Client devices that are associated with the low−power AP have to operate at the following power levels:

- Total transmitted power below 24 dBm EIRP
- Power Spectral Density limited to −1 dBm/MHz EIRP or less

There are exceptions such as client devices operating in a mesh networks or as Wi−Fi extenders. In those cases, the power limits of the low−power AP apply, provided that the client devices also follow the relevant AP rules and are all located within a single structure.

Standard Power Operation

Standard−power APs are allowed to operate at the following transmit powers:

- Total transmitted power below 36 dBm EIRP
- Power Spectral Density limited to 23 dBm/MHz EIRP or less
- Meet the emission mask and an emission limit of −27 dBm/MHz limit at frequencies below the bottom of the U−NII−5 band and above the upper edge of the U−NII−8 band

In this case, the PSD requirement allows the device to always operate at 36 dBm EIRP for all bandwidths. As for low−power APs, bandwidths higher than 320 MHz are not allowed.

The significantly higher power permitted for standard−power APs comes at a price, however. These devices are only allowed in U−NII−5 and U−NII−7, accounting for about 850 MHz of spectrum. Importantly, even in these bands, standard−power APs can only operate under the direction of a so−called Automated Frequency Coordination (AFC) system. An AFC system is aware of the location of incumbent services and will inform the AP of which parts of the spectrum

it is allowed to operate in, based on the AP's location, antenna height and transmit power. The R&O provides extensive details on the operation of the AFC system, which we'll discuss below.

What it means for the AP is that the AP needs to be able to determine its geographical location to provide it to the AFC. This geo−location capability can be either internal (like a built−in GPS) or external (provided by a connected device). The AP also needs to provide its antenna height above ground to the AFC system. This information can be configured manually or be determined automatically.

The AP is expected to contact the AFC system at least once a day to check for changes to the allowed frequencies. If a connection can not be established, the AP is required to stop operations after a 24 hour grace period.

The AFC is intended mainly to protect Fixed Services, but standard−power APs are also expected to limit their upward radiated power (above 30 degrees) to 21 dBm to protect Fixed Satellite Services.

Like low−power APs, Standard−power APs are not allowed to operate while in motion, with exception of large passenger aircraft operating over 10,000 feet.

Client devices that are associated with the standard−power AP have to operate at the following power levels:

- Total transmitted power below 30 dBm EIRP
- Power Spectral Density limited to 17 dBm/MHz EIRP or less

Note however, that the final power the AP is allowed to operate at may be reduced by the AFC for specific frequencies. If the final allowed power for the AP is below 36 dBm, the allowed power for its associated client devices needs to be reduced by the same amount. Specifically, the allowed maximum power for client devices associated with standard−power APs is always 6 dB below the allowed maximum power for the AP − whatever that level may be.

Figure 4 summarizes the power requirements for both types of AP and their associated clients.

Device Class	Operating Bands	Maximum EIRP	Maximum EIRP Power Spectral Density
Standard-Power Access Point (AFC Controlled)	U-NII-5 (5.925-6.425 GHz) U-NII-7 (6.525-6.875 GHz)	36 dBm	23 dBm/MHz
Client Connected to Standard-Power Access Point		30 dBm	17 dBm/MHz
Low-Power Access Point (indoor only)	U-NII-5 (5.925-6.425 GHz) U-NII-6 (6.425-6.525 GHz) U-NII-7 (6.525-6.875 GHz) U-NII-8 (6.875-7.125 GHz)	30 dBm	5 dBm/MHz
Client Connected to Low-Power Access Point		24 dBm	-1 dBm/MHz

Figure 4. Summary of Power Requirements in 6 GHz

Automated Frequency Coordination (AFC)

A major new requirement for Wi−Fi systems (or for that matter any unlicensed system wanting to operate in the 6 GHz band using standard Tx power) is the requirement to operate under the direction of an AFC system. The published R&O lays out a number of requirements for the AFC system as well.

The main focus of the AFC is to protect fixed service microwave links. However, it is also used to protect frequencies used by certain radio astronomy observatories. The AFC's knowledge of microwave links is based on the Universal Licensing System (ULS) database, which is an existing official database for licensed microwave links in the U−NII−5 and U−NII−7 bands. The AFC system is supposed to synchronize with the ULS database on a daily basis.

After being contacted by an AP device, the AFC system will determine suitable channels for this AP based on a model of the interference that this AP would generate. The calculation will establish an "exclusion zone" where the AP would generate interference towards incumbents in excess of what is allowed. This calculation needs information about the AP's location and antenna height. To model the interference, the AFC system assumes a channel model to simulate the interference generated by the AP. The R&O explicitly specifies the channel model and interference criterion that should be used for this calculation.

The final feedback from the AFC system to the AP is a list of channels that the AP is allowed to use at a range of different powers.

The AP identifies itself to the AFC system using a unique identifier that consists of the device's FCC identifier (FCC ID), and its serial number. The AFC system can use this to authenticate the device. The identifier can also be used for interference mitigation and enforcement purposes.

The R&O does not provide details on the communication protocol that should be used between the AP and the AFC system, but it does require that any such communication, as well as the data being stored by the AFC system should meet advanced security standards.

AFC systems will be run by "AFC operators". An AFC operator will need an official designation, which will be administered by the Office of Engineering and Technology (OET). The OET will "license" AFC operators for a five−year term that can be renewed by the FCC. To provide the AFC service to standard−power APs, AFC operators will be allowed to charge a fee. To fully address all aspects of AFC operation, the FCC encourages the industry to convene a group of interested stakeholders to address issues such as interference detection and mitigation, security measures, testing and certification procedures, …

FNPRM

In addition to the R&O that spells out the new requirements for unlicensed operation in the 6 GHz band, the FCC also issued a new FNPRM to solicit input on four new questions related to operation in 6 GHz, namely:

- Very Low Power Operation
- Power Spectral Density Increase for Low Power Indoor Operation
- Mobile Standard−Power Access Point Operation
- Higher Power Limits and Antenna Directivity for Standard−Power Access Points

First of all, the FCC seeks input on the operation of so−called “very low−power devices”. The tentative proposal is for these devices to operate at 14 dBm EIRP total power and −8 dBm/MHz PSD EIRP. The intention is to allow these devices in the entire 6 GHz band (U−NII−5 to U−NII−8) for both indoor and outdoor use. Given the lower power, it is suggested that these devices should not be required to use AFC, even for outdoor operation. The FNRPM proposes to allow this very−low power mode but is looking for input on the exact power levels and ways to mitigate interference to incumbent users.

Secondly, the FNPRM invites additional comments on the PSD limit of low−power APs. That level is currently specified at 5 dBm/MHz PSD EIRP. The FCC is asking for input on whether this can be increased to 8 dBm/MHz PSD EIRP, with a maximum permissible EIRP of 33 dBm when a device uses a bandwidth of 320 MHz.

The third item pertains to standard−power access points. These APs are currently allowed in fixed deployments only. The FNPRM seeks input on whether to allow standard−power access points, under AFC control, to be used in mobile applications. Specifically, the impact on AFC needs to be considered.

The fourth item addresses a specific use case for standard−power APs. While the current allowed power level for these devices is set at 36 dBm EIRP, the FNPRM is asking whether this level can be increased for devices that serve point−to−point links with highly directional antennas. As a related question, the FNRPM also seeks input on whether antenna directionality could be incorporated in the AFC system framework.

The comments and discussion generated by the responses to the FNPRM may results in further changes or additions to the rule for unlicensed operation in the 6 GHz band.

Conclusion

With its decision to open the 6 GHz band to unlicensed operation, the FCC has provided up to 1200 MHz of extra spectrum for Wi−Fi operation. This decision will certainly redefine Wi−Fi as we know it, but it's important to understand that the operating rules in 6 GHz are somewhat different from what Wi−Fi is used to in the 2.4 and 5 GHz bands. In this paper, we have attempted to provide some background on the history and details of the new regulation.

References

[1] "FCC Adopts New Rules for the 6 GHz Band, Unleashing 1,200 Megahertz of Spectrum for Unlicensed Use", FCC news release, https://docs.fcc.gov/public/attachments/DOC−363945A1.pdf

[2] 6 GHz Unlicensed R&O/FNPRM, https://docs.fcc.gov/public/attachments/FCC−20−51A1.pdf

[3] Exploring Flexible Use in Mid−Band Spectrum Between 3.7 GHz and 24 GHz, Notice of Inquiry, GN Docket No. 17−183, http://transition.fcc.gov/Daily_Releases/Daily_Business/2017/db0713/DOC−345789A1.pdf

[4] Notice of Proposed Rulemaking, FCC 18−147, https://ecfsapi.fcc.gov/file/1024814219781/FCC−18−147A1.pdf

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