

Before the
Federal Communications Commission
Washington DC 20554

In the Matter of)
)
Expanding the Economic and Innovation) Docket No. 12-268
Opportunities of Spectrum Through)
Incentive Auctions)

**PETITION FOR RECONSIDERATION OF
SENNHEISER ELECTRONIC CORPORATION**

Mitchell Lazarus
FLETCHER, HEALD & HILDRETH, P.L.C.
1300 North 17th Street, 11th floor
Arlington VA 22209
(703) 812-0440
Counsel for Sennheiser Electronic Corporation

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Pursuant to Section 1.429(a) of the Commission’s rules, Sennheiser Electronic Corporation seeks reconsideration in two respects of the Report and Order in the above-captioned proceeding.¹

A. SUMMARY

Wireless microphones transmit in vacant TV channels. The Commission’s prior reallocation of TV channels 52-69 (698-806 MHz) to other uses, followed by an auction, made it unlawful to operate wireless microphones on those channels. As of June 2010, users had to take all 700 MHz microphones out of service and replace them, regardless of remaining useful life.

Now, if the 600 MHz spectrum auction and TV band repacking proceed as planned, microphone users will lose most of their remaining spectrum. The proposal to allow operation in the 600 MHz guard bands will not nearly make up for the loss. The guard bands are likely to receive out-of-band emissions from neighboring operations and to have power limits inconsistent with some uses of wireless microphones. Moreover, a performer’s ear monitors require frequencies separated from those for the microphone, resulting in a need for two distinct bands in UHF.

¹ *Expanding the Economic and Innovation Opportunities of Spectrum through Incentive Auctions*, Report and Order, 29 FCC Rcd 6567 (2014) (R&O).

The industry is working hard to move non-critical applications out of UHF, and to pack more microphones into every available slot of UHF spectrum, but that will not be enough. We ask the Commission to revisit its policies so as to make adequate UHF spectrum available. Options include reserving the “naturally occurring” vacant channel and channel 37 for wireless microphones, or setting aside additional spectrum from that to be auctioned.

Some of the equipment that wireless microphone users purchased just a few years ago, to replace scrapped 700 MHz equipment, operates in the 600 MHz band. Now users will have to discard that equipment as well and, for the second time in just a few years, shoulder the replacement costs to make room for auction winners.

The Commission has recognized elsewhere the inequity of leaving incumbents to bear their own costs of relocating to a different band for the sole benefit of auction winners. Accordingly it has often required auction winners to cover the relocation expenses. It should do the same here, using the same statutory provisions it has relied on in the past, with no need to invoke the Spectrum Act. The rationale for reimbursement would apply in full even if wireless microphones operated on a secondary basis (which they do not), and applies equally to unlicensed microphones.

B. ABOUT SENNHEISER

Sennheiser Electronic Corporation is a wholly-owned subsidiary of Sennheiser electronic GmbH & Co. KG, headquartered in Germany. The parent company is a global leader in microphone technology, RF-wireless and infrared sound transmission, headphone transducer technology, and active noise cancellation. The U.S. subsidiary, based in Old Lyme, Connecticut, represents Sennheiser products in the United States and distributes a variety of other professional audio lines.

Sennheiser is a leading manufacturer of the wireless microphones used in the United States. Most of its U.S. product line is manufactured in Albuquerque, New Mexico.

C. WIRELESS MICROPHONES ARE VITAL TO THE ECONOMY AND THE NATION'S PUBLIC LIFE

TV band wireless microphones are more than a convenience. They are vital to a large component of the U.S. economy and support a major sector of U.S. exports.

Wireless microphones are ubiquitous in all aspects of the entertainment business, in news reporting, in sports, and in U.S. commercial, civic, and religious life. They are essential to the production of virtually all non-studio broadcast events, and to nearly all studio-produced programs as well. These include college and professional team sports, political conventions, election coverage, awards shows, events such as the Olympics, NASCAR races, and the Kentucky Derby, and on-the-scene news reporting of all kinds. These broadcasts routinely attract millions of viewers.

Motion-picture production relies heavily on wireless microphones for clear, accurate audio. Live events, from Broadway productions to stadium-sized outdoor concerts, need wireless microphones to reach the back row. Presenters in auditoriums, lecture halls, and houses of worship find them indispensable.

U.S. news and entertainment content is globally acknowledged as the best in the world. The widespread popularity of these products has made entertainment content not only a major domestic industry, but also one of the nation's leading exports. The United States leads the world in both share of GDP and share of employment attributable to the copyright industries.² Wireless microphones are one of the key production tools that fuel these successes. Professional users

² For details and citations, *see* Comments of Sennheiser Electronic Corporation in Docket No. 12-268 at 3-4 (filed Nov. 4, 2013).

insist on TV band equipment because it provides the best sound reproduction and absolutely reliable, drop-out-free performance.

Wireless microphones undergo continual innovation. News and entertainment—music, TV, live performance, and films—are very different now than they were a few decades ago. Wireless microphones have evolved to keep pace with production demands and spectrum constraints. Today’s equipment is much more sophisticated than its predecessors, delivering better sound quality with greater reliability and spectrum efficiency. Still, at least for some hypercritical applications, past and foreseeable innovation does not eliminate the need for the particular propagation characteristics available only in UHF.

D. WIRELESS MICROPHONES NEED TWO BLOCKS OF CLEAN, RESERVED UHF SPECTRUM.

The wireless microphone industry acknowledges that its future will offer far less prime spectrum than was available than in the past.

Since long before loss of the 700 MHz band, the industry has been working to make the best use of limited spectrum. This effort has taken two main directions: removing from UHF those functions, such as intercom, cueing, and interruptible fold-back, that do not require highest-quality audio; and increasing the density of microphones per 6 MHz video channel. Squeezing more microphones into a channel raises the cost, but Sennheiser is trying to bring the cost differential down.³

³ As Sennheiser explained earlier in the proceeding: multiple transmitters, such as wireless microphones, are subject to a form of interference called “intermodulation” in which two or more desired signals combine in a receiver to produce undesired signals outside the spectra of the desired signals. This is a particular challenge with microphones, because they are constantly moving. The legacy solution has been to space units across a TV band in such a way that the intermodulation products caused by any combination of microphones and other TV band signals—these can number in the thousands—do not fall into the spectrum of another microphone signal. To achieve denser spacing, manufacturers must defeat intermodulation by

A third measure is not available: the principles of information theory say there is no way for each wireless microphone signal to occupy significantly less radio-frequency bandwidth without unacceptably impairing audio quality and or throughput latency (delay). Professional-grade microphones use analog modulation within the required 200 kHz bandwidth.⁴ An uncompressed digitally modulated microphone that delivers the same quality likewise requires about 200 kHz.⁵ Although a digital signal is more amenable to compression than an analog signal, compression necessarily adds latency, degrades audio quality, or both. This rules out compression for high definition professional applications such as recording and live performance. High audio quality is obviously essential; and a performer cannot tolerate more than a few milliseconds of delay over the entire loop from the microphone back to the monitor.⁶ The microphone must deliver the best possible signal, as all of the subsequent processing will tend to both degrade quality and add latency.

making the microphones highly “linear,” which requires more battery power, which in turn adds bulk to body-worn units. Higher linearity also requires aggressive filtering to keep the signals isolated. Each of the techniques used to combat intermodulation adds significant cost.

⁴ 47 C.F.R. § 74.861(e)(5).

⁵ Also from an earlier pleading: the usual sampling rate in a digital wireless microphone system is 44,100 times per second, the same as in audio CDs. An adequate dynamic range (softest to loudest) requires that each sample occupy 20 bits of information. For a single audio channel, this gives a data rate of $44,100 \times 20 = 882,000$ bits/second. Necessary overhead for framing and coding adds about 35%, for a total bit rate of around 1,200,000 bits/second. A reasonably efficient modulation achieves about 6 bits/second/Hertz. The required bandwidth thus remains at about $1,200,000 / 6 = 200$ kHz.

⁶ For a demonstration of latency due to compression, call a cell phone from a landline in the same room, put one phone to each ear, and talk. The high degree of compression in the cell phone signal helps to conserve carrier spectrum, but typically adds hundreds of milliseconds of delay, and delivers audio quality inferior to the landline.

The 600 MHz guard bands will be useful for some less critical operations, but will not provide the quality and reliability needed for professional recording and broadcast of spontaneous news and high-end live events. Some of these are viewed by millions. Some, such as hurricane and tornado alerts, have public safety consequences that make reliability paramount. Unplanned broadcasts often occur in challenging environments and circumstances that require the propagation characteristics of UHF, and do not allow for a second “take.”

The guard bands, including the duplex gap, are intended primarily as buffers to limit interference between primary services, in part by capturing their out of band emissions. Studies in Europe of the duplex gap have demonstrated interference to wireless microphones.⁷ We can expect the same in the United States.

Further, we are concerned by this passage in the *R&O*:

[B]roadcasters and cable programming networks operating wireless microphones on a licensed basis will be permitted to obtain interference protection from unlicensed devices in a portion of the duplex gap at specified times and locations, on an as-needed basis.⁸

This implies that wireless microphones operating in even the very limited 4 MHz of duplex gap spectrum they have available may have to seek interference protection in the TV White Space (TVWS) database. The fast pace of a breaking story rarely leaves time for registration, even if the Commission were to accelerate the process. Advance registration becomes vastly more difficult in the case of a breaking story that spans across a metropolitan area, such as the 2013

⁷ “The findings of previous studies that LTE UE operating at 837 MHz can generate harmful interference to PMSE [Program Making and Special Events] systems operating in the 821-832 MHz LTE duplex gap were confirmed.” *PMSE System Operation in the 800 MHz LTE Duplex Gap: Findings from the coexistence measurements in Ispra, 13-15 November 2013*, European Commission Joint Research Centre at 38 (February 2014).

⁸ *R&O* at ¶ 684.

Boston Marathon bombing. Moreover, registration makes protection dependent on the proper functioning and speed of a complex, multiply administered database system, the infrastructure that supports it, the reliability of local Internet facilities, and the complete integrity of all TVWS devices governed by the system.⁹

While we welcome the recent revisions on co-channel operation with TV broadcast stations,¹⁰ the relatively high in-channel noise will limit both reliability and dense packing of microphones. Even though closer co-channel location will help to satisfy spectrum needs as to some wireless microphone applications, it is not a complete substitute for clean, reserved channels.

Wireless microphones have another requirement as well, in addition to adequate spectrum: professional applications need two separated bands within UHF. The critical performance links that must remain in UHF include the microphone itself—the performer’s “stick” or body pack—and the invisible ear monitors lodged in the performer’s ear canal that receive the live, processed microphone signal. These two devices require separated channels to send and receive, just as two-way radio service or wireless broadband does.¹¹ The “naturally occurring” vacant channel might serve as one these,¹² if it were reserved for wireless

⁹ Elsewhere, in another context, the Commission mentions the possibility of placing television stations in the duplex gap to accommodate market variation. *R&O* at ¶ 105. This would further complicate wireless microphone operation in the duplex gap.

¹⁰ *R&O* at ¶¶ 304-07.

¹¹ If the signals are too close in frequency, the relatively strong transmission from the close-by microphone will overpower the ear monitor receiver and drown out the intended signal from backstage equipment.

¹² *R&O* at ¶ 309.

microphones. The guard bands, apart from being shared, are likely to be too noisy to work as the other member of the pair.

The shortage of spectrum for wireless microphones results not only from the past and present repackings, but also from the Commission's long-standing policies toward TVWS. Those look increasingly unwise as time goes by. When TVWS proponents first came forward, the environment offered plenty of vacant UHF spectrum and also an apparent need for the services the proponents promised to deliver. Now, though, twelve years after the initial Notice of Inquiry,¹³ and two years after a supposed large-scale roll-out,¹⁴ there are still no mobile devices certified, and so far as we can tell, little actual fixed TVWS usage. This in itself is not a surprise; promising technologies often fail to develop as expected. The pages of the FCC Record are strewn with ideas that offered great hopes, but after receiving Commission approval either never reached the market or else fizzled soon afterward.

TVWS has been particularly slow to develop. In part the delays have resulted from the complex technical rules needed to protect other spectrum users. Also, the world has changed since the initial TVWS proposals in 2002. Not only has vacant TV spectrum become scarce, but Wi-Fi has proliferated into every corner of the country. To succeed, TVWS not only must implement elaborate rules in vanishing spectrum, but also must compete with the vast installed base of inexpensive Wi-Fi equipment—access points everywhere, plus the advanced Wi-Fi capabilities that come built into every smartphone, tablet, and laptop. TVWS will also have to

¹³ *Additional Spectrum for Unlicensed Devices Below 900 MHz and in the 3 GHz Band*, Notice of Inquiry, 17 FCC Rcd 25632 (2002).

¹⁴ *Office of Engineering and Technology Authorizes TV White Space Database Administrators to Provide Service to Unlicensed Devices Operating on Unused TV Spectrum in the East Coast Region*, ET Docket No. 04-186, Public Notice, DA 12-1956 (released Dec. 6, 2012).

contend with other emerging technologies that promise many of the same advantages, including Citizens Broadband Radio Service¹⁵—whose proposed Spectrum Access System is a direct descendant of the TVWS database.

As the Commission divides the small amount of remaining UHF spectrum between wireless microphones and TVWS, it chooses between an irreplaceable service that has delivered high value for decades, *versus* one that has yet to realize the ambitious promises it made twelve years ago. The *R&O* offers 20-34 MHz of spectrum “newly available for unlicensed use,” including use by unlicensed broadband devices, *in addition to* TV white space channels that remain after the repacking¹⁶—while wireless microphones lose their two reserved channels and most of the other spectrum they previously had available. We ask the Commission to reassess these priorities.

More specifically, given the slow roll-out of TVWS, channel 37 (assigned exclusively to TVWS) and the “naturally occurring” vacant channel (shared with TVWS) may never see much TVWS use. We ask that both channels be made available exclusively for wireless microphones.¹⁷ Alternatively, noting that TVWS has particularly promised service to rural areas,¹⁸ the Commission could reserve the naturally occurring channel for wireless microphones in urban and

¹⁵ *Commercial Operations in the 3550-3650 MHz Band*, Further Notice of Proposed Rulemaking, 29 FCC Rcd 4273 (2014).

¹⁶ *R&O* at ¶ 264.

¹⁷ The Wireless Medical Telemetry Service and the Radio Astronomy Service both operate at fixed locations in channel 37. Wireless microphones will be able to protect these, just as they have successfully protected TV operations for decades.

¹⁸ *E.g., Unlicensed Operation in the TV Broadcast Bands*, Third Memorandum Opinion and Order 27 FCC Rcd 3692 at ¶ 6 (2012).

suburban areas, and maintain TVWS with database registration in rural areas, where registration is likely to be infrequent.

If none of these options is feasible, then we ask the Commission either to reserve two separated 6 MHz channels on the TV side of the boundary for wireless microphone use, or (less preferably) to keep for wireless microphones an unauctioned 5 MHz pair on the wireless broadband side, adjacent to the guard bands.

E. THE COMMISSION HAS ALL NEEDED AUTHORITY TO REQUIRE COMPENSATION FOR WIRELESS MICROPHONE USERS DISPLACED FROM THE 600 MHz BAND.

The upcoming 600 MHz spectrum auction will require one group, the wireless microphone users, to expend funds for the sole benefit of another group: the carriers that will sell services in the 600 MHz band.

Wireless microphone users had to junk and replace all of their 700 MHz units just a few years ago, as a consequence of the digital TV conversion and repacking. The incentive auction process will now require the same with 600 MHz equipment—much of it purchased in order to vacate 700 MHz. Repeatedly singling out wireless microphone users to bear the cost and disruption of band reallocations is simply unfair. Worse: where the last repacking entailed mostly one-for-one replacements, this one will be more difficult and expensive. When wireless microphones left 700 MHz, they could migrate to 600 MHz; but now they have more limited alternatives. While they can operate more densely in the limited spectrum that remains, this will increase costs.

Sennheiser earlier asked the Commission to require 600 MHz auction winners to compensate displaced wireless microphone users for the expense of replacing their equipment. The Commission responded:

We reject requests that we develop a mechanism for reimbursement of wireless microphone users' relocation costs [citations omitted], as wireless microphone users are not eligible for any such reimbursement. See Spectrum Act § 6403(b)(4)(A); § V.C.5.a (statutory reimbursement mandate applies only to full power and Class A television licensees that are involuntarily reassigned to new channels in the repacking process pursuant to § 6403(b)(1)(B)(i)). Wireless microphone users operate on a secondary or unlicensed basis.¹⁹

Neither of these grounds for refusing Sennheiser's request—lack of statutory authority and “secondary or unlicensed operation”—justifies the outcome.

1. *The Commission has statutory authority outside the Spectrum Act to require reimbursement.*

Sennheiser's request did not rely on the Spectrum Act, as the Commission suggests. Rather, we cited earlier auction proceedings that required reimbursement under statutory authority that predates the Spectrum Act.²⁰ The proceeding that required the Personal Communications Service to reimburse fixed microwave incumbents, for example, invoked Sections 4(i), 7(a), 303(c), (g), and (r).²¹ Other proceedings since have taken a similar approach.²² All of these found adequate powers to require reimbursement in Titles I and III as

¹⁹ *R&O* at ¶ 316 n.957.

²⁰ See Comments of Sennheiser Electronic Corporation in Docket No. 12-268 at 7-8 (filed Nov. 4, 2013).

²¹ *Redevelopment of Spectrum to Encourage Innovation in the Use of New Telecommunications Technologies*, First Report and Order and Third Notice of Proposed Rule Making, 7 FCC Rcd 6886 at ¶¶ 24, 42 (1992).

²² See, e.g., *Advanced Wireless Services in the 2155-2175 MHz Band*, 22 FCC Rcd 17035 at ¶ 9 (2007) (requiring compensation of incumbents); *Fixed and Mobile Broadband Access, Educational and Other Advanced Services in the 2150-2162 and 2500-2690 MHz Bands*, 21 FCC Rcd 5606 at ¶ 23 (2006) (same); *Spectrum Below 3 GHz for Mobile and Fixed Services to Support the Introduction of New Advanced Wireless Services*, 20 FCC Rcd 15866 at ¶ 12 (2005) (same); *Fixed and Mobile Broadband Access, Educational and Other Advanced Services in the 2150-2162 and 2500-2690 MHz Bands* 19 FCC Rcd 14165 at ¶ 290 (2004) (same); *Spectrum at 2 GHz for Use by the Mobile-Satellite Service*, 13 FCC Rcd 23949 at ¶ 15 (1998) (same).

they stood before passage of the Spectrum Act. Although the Spectrum Act added new authority for the compensation of broadcasters in the unprecedented context of an incentive auction, it took nothing away from the preexisting authority the Commission has relied on for more than two decades.

2. *Wireless microphones are not “secondary,” and even if they were, that would not block reimbursement.*

The Commission asserts that TV-band wireless microphones are authorized on a secondary basis, and for that reason are not entitled to reimbursement.²³

The Table of Frequency Allocations shows no secondary allocation in the TV bands.²⁴ Wireless microphones therefore cannot be secondary.²⁵

True, a 2010 wireless microphone order describes wireless microphones and certain other devices as “secondary.”²⁶ That order in turn cites footnote NG115 in the Table of Allocations, which states:

In the bands 54-72 MHz, 76-88 MHz, 174-216 MHz, 470-608 MHz, and 614-698 MHz [the TV bands], wireless microphones and wireless assist video devices may be authorized *on a non-interference basis*, subject to the terms and conditions set forth in 47 CFR part 74, subpart H.²⁷

²³ R&O at ¶ 316 n.957.

²⁴ 47 C.F.R. § 2.106.

²⁵ A “secondary” communication is one which “may not cause interference to operations authorized on a primary basis and which are not protected from interference from those primary operations.” 47 C.F.R. § 90.7. Secondary allocations are identified in the Table of Frequency Allocations, 47 C.F.R. § 2.106. The term refers only to interference priority, and has no bearing on the value of the service.

²⁶ *Revision to Rules Authorizing the Operation of Low Power Auxiliary Stations in the 698-806 MHz Band*, Report and Order and Further Notice of Proposed Rulemaking, 25 FCC Rcd 643 at ¶¶ 8-9 (2010) (*Wireless Microphone Order*).

²⁷ 47 C.F.R. § 2.106, footnote NG115 (emphasis added).

The same order also cites other provisions that require wireless microphones to avoid causing harmful interference to authorized stations.²⁸

There being no secondary allocation in these bands, these references to “secondary” can only be a shorthand synonym for “non-interfering.” There is no *a priori* bar to reimbursement for a device that operates on a non-interference basis.

For that matter, there is no *a priori* bar to reimbursement for a secondary device, either. Even if the *R&O* were correct that wireless microphones operate under a secondary allocation, nothing stops the Commission from deciding as a policy matter to reimburse their users.

The Commission does not cite any authority for its proposition that secondary or unlicensed users are ineligible for compensation. The only arguable precedent we know of is a 2003 order concerning various bands near 2 GHz, which indeed says, “[O]nly stations with primary status are entitled to relocation.”²⁹ The stated rationale is that “secondary operations, by definition, cannot cause harmful interference to primary operations.”³⁰ There is a missing step in the logic. Perhaps the Commission meant that secondary users, having a standing obligation to protect primary newcomers in the band, cannot expect compensation for what they must do anyway. In that proceeding, however, the secondary users had accepted new licenses knowing they were specifically secondary to incoming auction winners.³¹ The case here is different: wireless microphone users accepted non-interference (not secondary) status relative to *broadcast*

²⁸ *Wireless Microphone Order* at ¶ 9.

²⁹ *Amendment of Part 2 of the Commission's Rules to Allocate Spectrum Below 3 GHz*, Third Report and Order, Third Notice of Proposed Rulemaking and Second Memorandum Opinion and Order, 18 FCC Rcd 2223 at ¶ 72 (2003).

³⁰ *Id.*

³¹ *Id.* at ¶ 67.

licensees, with no hint of a possible reallocation to new wireless services. The distinction is crucial: wireless microphones can coexist with broadcasters on a non-interference basis, and indeed have done so for decades. Non-interference status relative to wireless services, however, means having to leave the band entirely. The 2003 case cannot support the Commission's assertion that secondary users here are ineligible.

If licensed wireless microphone users are entitled to compensation, as we contend, then unlicensed users should be eligible as well. Ordinarily, licensed and unlicensed users sharing a frequency band employ very different equipment to provide very different services.³² Wireless microphones are the exception: licensed and unlicensed users both operate similar devices for the same purposes. Although unlicensed users are limited to 50 milliwatts, most licensed use likewise does not exceed that power. Many of the same products are used in both licensed and unlicensed settings. Blurring the distinction even further, many users that are eligible for licensing often choose to skip the paperwork and operate on an unlicensed basis instead.³³

These facts give unlicensed users a claim to reimbursement similar to that of licensed users. Both groups sunk investments into equipment without any warning that spectrum might be pulled out from under them. Both groups will be put to great expense solely for the benefit of the incoming wireless providers. They are equally entitled to help in replacing their equipment.

³² As one example: unlicensed users of the 902-928 MHz band (cordless phones, home audio, ZigBee industrial devices, many others) have nothing in common with the licensed amateurs and Location and Monitoring Service providers on the same frequencies, or with the ISM and federal radiolocation users that also share the band.

³³ This does not take away from the importance of a licensing option for those that need it. In this connection Sennheiser particularly welcomes the recent expansion of eligibility to include certain sound companies and venues in *Low Power Auxiliary Stations in the 698-806 MHz Band*, Second Report and Order, 29 FCC Rcd 6103 at ¶¶ 10-20 (2014).

Per our original request, we propose to limit compensation to 600 MHz microphones purchased during the 700 MHz replacement transition, and to prorate compensation based on the duration of the microphones' useful life in the 600 MHz band.³⁴ We estimate that total reimbursement costs should not exceed \$50 million. Although this looks like a large number standing alone, it is a small fraction of the expected auction revenues. Beneficiaries will include not only professional microphone users, but also schools, state and local government facilities, and houses of worship.

In view of long-standing Commission precedent favoring relief for incumbents displaced by an auction, fundamental principles of equity and justice require the Commission to make that relief available here.³⁵

³⁴ See Comments of Sennheiser Electronic Corporation in Docket No. 12-268 at 8-10 (filed Nov. 4, 2013).

³⁵ Sennheiser's comments of November 4, 2013, proposed a procedure for handling compensation, to be administered by the wireless microphone manufacturers at their own expense, with all compensation going to end users. We will work with the Commission and the wireless broadband industry as needed to refine and improve this procedure as needed.

CONCLUSION

The Commission should make adequate UHF spectrum available to wireless microphones, and should exercise its long-standing authority to require compensation for wireless microphone users who recently bought, and will soon have to discard, wireless microphones in the 600 MHz band.

Respectfully submitted,

A handwritten signature in black ink that reads "Mitchell Lazarus". The signature is written in a cursive, slightly slanted style.

Mitchell Lazarus
FLETCHER, HEALD & HILDRETH, P.L.C.
1300 North 17th Street, 11th floor
Arlington VA 22209
(703) 812-0440
Counsel for Sennheiser Electronic Corporation

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COURTESY SERVICE LIST

Tom Wheeler, Chairman
Federal Communications Commission
445 12th Street, SW
Washington, DC 20554

Commissioner Mignon Clyburn
Federal Communications Commission
445 12th Street, SW
Washington, DC 20554

Commissioner Jessica Rosenworcel
Federal Communications Commission
445 12th Street, SW
Washington, DC 20554

Commissioner Ajit V. Pai
Federal Communications Commission
445 12th Street, SW
Washington, DC 20554

Commission Michael O'Rielly
445 12th Street, SW
Washington, DC 205

Gary Epstein, Senior Advisor and Chair,
Incentive Auction Task Force
Federal Communications Commission
445 12th Street, SW
Washington, DC 20554

Julius Knapp, Chief
Office of Engineering and Technology
Federal Communications Commission
445 12th Street, SW
Washington, DC 20554

William Lake, Chief
Media Bureau
Federal Communications Commission
445 12th Street, SW
Washington, DC 20554

Barbara Kreisman, Chief
Video Division
Media Bureau
Federal Communications Commission
445 12th Street, SW
Washington, DC 20554

Roger C. Sherman, Chief
Wireless Telecommunications Bureau
Federal Communications Commission
445 12th Street, SW
Washington, DC 20554

John Leibovitz, Deputy Chief
Wireless Telecommunications Bureau
Federal Communications Commission
445 12th Street, SW
Washington, DC 20554

Margaret Wiener, Chief
Auctions & Spectrum Access Division
Wireless Telecommunications Bureau
Federal Communications Commission
445 12th Street, SW
Washington, DC 20554

Gary Michaels, Deputy Chief
Auctions & Spectrum Access Division
Wireless Telecommunications Bureau
Federal Communications Commission
445 12th Street, SW
Washington, DC 20554