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Ms. Marlene Dortch
Secretary
Federal Communications Commission
445 12th Street, SW
Washington, DC 20554

Re: *Ex Parte* Letter: Use of Spectrum Bands Above 24 GHz For Mobile Radio Services, GN Docket No. 14-177, IB Docket Nos. 15-256 & 97-95; RM-11664; WT Docket No. 10-112

Dear Ms. Dortch:

Qualcomm respectfully requests the FCC to implement flexible technical rules to encourage innovation and experimentation in the millimeter wave bands. Flexibility is critically important when defining appropriate out-of-band emissions ("OOBE") limits. As Qualcomm and others have explained in this proceeding, it will be challenging to design millimeter wave mobile equipment that meets the OOBE requirements proposed in the *NPRM* at the transmit power levels required to support 5G system performance objectives. The FCC should consider a different approach that reflects the different – and, in some cases, completely novel – operations and deployment scenarios that 5G millimeter wave operations will use. As described below and as reflected in the OOBE limits proposed herein, the average interference from a millimeter wave mobile handset and a base station/small cell with a steerable antenna array is quite different from and varies instant to instant when compared to fixed point-to-point microwave operations.

5G millimeter wave systems will use high-gain beam-steering antenna systems to support the EIRP requirements for 5G system performance. The antenna array and beam forming techniques required to achieve the necessary high-gain performance will increase the OOBE mask (when compared to typical emissions mask used for sub-3-GHz mobile operations) but they also will serve to mitigate interference to other 5G fixed and mobile devices.

Highly directional 5G antenna systems on base stations/small cells mitigate interference to potential victim receivers because their narrow fixed beams continually move from device to device so any on-axis interference a victim experiences is a limited statistical event. The amount of interference to victim receivers is further mitigated as the antenna beamwidth is reduced, which results in substantially lower antenna gain (*i.e.*, much less power) towards off-axis interference victims. Mobile devices with lower transmit power and narrow beamwidths also limit the interference impact and number of potential interference victims.

In addition, whereas traditional fixed microwave and satellite systems typically use one or several antenna elements and it is practical to implement filters prior to the antennas to reduce OOBE, 5G millimeter wave base station and mobile handset antenna arrays can include more than 250 elements, each with an individual amplifier. Thus, it is not feasible to use filters for

each antenna element feed in the millimeter-wave mobile unit or to implement a high order – and physically much larger – filter needed to greatly attenuate OOBE. Millimeter-wave base stations/small cells also are size restricted to integrate array filters on each amplifier and antenna element.

The efficiency of amplifiers in mobile devices is another factor that influences the achievable emissions mask, and this factor is not expected to materially improve over time. Improving preamplifier OOBE emissions performance requires an efficiency sacrifice such that 5G mobile device battery life (and size) would be impacted beyond what is acceptable for today's mobile devices.

Against this background, Qualcomm has analyzed 5G millimeter wave equipment performance and believes the limits in the table below are necessary and appropriate as defined in terms of typical emissions mask breakpoints ending with a limit that is greater than 250% of the emission bandwidth when measured from the center frequency of the operating channel. A measurement bandwidth also is provided to achieve the equivalent -13dBm limit (proposed in the *NPRM*) at a 250% emission bandwidth offset.[1]

Were the Commission to define emissions limits more stringent than those presented in the table, a total radiated power ("TRP") limit definition may be required for equipment that uses directional antenna systems and narrow beamwidth. It is important to recognize that there are many factors to consider in defining a TRP emissions limit including trade-offs between amplifier gain, array elements that impact the system beamwidth, and the present lack of established millimeter wave measurement procedures, all of which make it difficult to define an appropriate TRP limit at this time. For these reasons, Qualcomm requests that the FCC consider the EIRP emissions mask below for 5G millimeter wave equipment. The FCC also can achieve its goals of enabling successful millimeter wave mobile operations by implementing a less detailed mask than that presented here, provided that the resulting limit is not more stringent.

Power (EIRP)	**Emission Limits [dBr]* at certain Frequency Offsets (% emission bandwidth from center frequency) - measured in 1 MHz resolution bandwidth in and out of channel**				**Measurement bandwidth for -13 dBm at >250% offset**
dBm/100 MHz	**50%-60%**	**60%-150%**	**150%-250%**	**>250%**	**[kHz]**
43 (Mobile)	-10	-13	-22	-30	100 kHz
55	-10	-13	-22	-30	100 kHz
62	-10	-13	-22	-30	10 kHz
75	-10	-13	-22	-30	1 kHz

*Note: Where dBr is the relative difference as measured in equal bandwidth for both the transmission signal and the off-channel frequency. The mean transmit power should be used for the dBr reference transmission signal power.

[1] For all but the highest EIRP configuration analyzed, the -13dBm limit that can be achieved at a 250% offset is more stringent than the 4 kHz bandwidth required for satellite terminals in FCC Rule Section 25.202(f). *See* 47 C.F.R. § 25.202(f)(3) ("In any 4 kHz band, the center frequency of which is removed from the assigned frequency by more than 250 percent of the authorized bandwidth: An amount equal to 43 dB plus 10 times the logarithm (to the base 10) of the transmitter power in watts.").

In sum, Qualcomm believes these OOBE limits are necessary for successful 5G operations in the millimeter wave bands. These limits are similar to the millimeter-wave emissions mask used for current 60 GHz 802.11ad Wi-Gig operations. In addition, the Commission recently recognized the need to provide OOBE relief in the 5 GHz band. *See* Revision of Part 15 of the Commission's Rules to Permit Unlicensed National Information Infrastructure (U-NII) Devices (U-NII) Devices in the 5GHz Band, *Memorandum Opinion & Order*, FCC 16-24 (Mar. 2, 2016).

As shown in the table above, Qualcomm believes the FCC should allow for the use of radiated measurements while also permitting the use of conducted measurements for devices that include conducted RF ports. Furthermore, the FCC should allow for the use of the root mean square ("RMS") measurement technique with trace averaging (*i.e.*, not a maximum hold measurement) that is reflected in its other service regulations,[2] and it should permit the use of alternative measurement bandwidths as frequency increases so long as the results are scaled to the original emissions limit bandwidth definition.

Respectfully submitted,

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[2] *See, e.g.*, Amendment of the Commission's Rules with Regard to Commercial Operations in the 3550-3650 MHz Band, *Order on Reconsideration & Second Report and Order*, FCC 16-55 (May 2, 2016).