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Attn: FCC Office of Engineering and Technology

FCC ID: 2AGZ3S01711
Applicant: Starry Inc.

Ref: 47 CFR Part 30 Far-Field Measurements

Background

The mmWave radio incorporated within the EUT submitted as part of this certification operates between 37-40 GHz and is available with 3 different antenna variants as described below:

- Base radio with integral 8 x 8 patch antenna array. Maximum antenna dimension is 58mm.
- Base radio with integral 8 x 8 patch antenna array plus small reflector plate. Maximum reflector plate dimension is 320mm.
- Base radio with integral 8 x 8 patch antenna array plus large reflector plate. Maximum reflector plate dimension is 515mm.

Per KDB 842590 v1r02, fundamental and out-of-band emissions shall be made in the far field, based on the largest far-field boundary distance of the EUT antenna and the measurement antenna, where the far-field boundary for mmWave antennas is equal to $2D^2/\lambda$. As such, the required far-field boundary distance for each variant is:

- Base radio: 0.90m
- Base radio with 320mm reflector: 27.3m
- Base radio with 515mm reflector: 70.7m

The integral antenna of the base radio has a nominal gain of 23 dBi; the 320 mm reflector adds an additional 10.5 dB to this gain, and the 515 mm reflector adds an additional 15.5 dB of gain.

Testing Strategy

EIRP and Bandedge measurements were first performed on the base radio in the far-field within a fully anechoic chamber. These measurements were then repeated using the worst-case reflector plate (515mm) in the far-field at an outdoor site.

The substitution measurement method per C63.26 Clause 5.5.3 was used for the outdoor measurements. In lieu of the theoretical calculated free space propagation path loss (see C63.26 Equation C.9), substitution measurements were performed to determine the actual free space path loss of the test site at the measurement distance. This value was used as the correction factor for in-band measurements.

Derivation of the Measured Path Loss:

$EIRP = P_T + G_T - L_C$ C63.26 Equation (C.3)

Where,

P_T = transmitter output power
G_T = gain of transmitting antenna
L_C = signal loss in connecting cable between transmitter and antenna

$EIRP = P_R + L_P$ C63.26 Equation (C.7)

Where,

P_R = adjusted received power level
L_P = basic free-space propagation path loss

$P_R – P_{meas} – G_R + L_C + L_{atten} – G_{amp}$ C63.26 Equation (C.8)

Where,

P_{meas} = measured power level
G_R = gain of receive antenna
L_C = signal loss in measurement cable
L_{atten} = value of external attenuation (if used)*
G_{amp} = value of external amplification (if used)*

*-External attenuation or amplification not used for these measurements

Combining Equations. C.3, C.7 and C.8 yields:

Pt + Gtx – Lctx = Pmeas – Grx + Lcrx + Latten – Gamp + Lp

Re-arranging to express path loss as a function of the other parameters:

Lp = Pt + Gtx – Lctx - Pmeas + Grx - Lcrx - Latten + Gamp

<u>Calculation for 37 GHz:</u>

$L_P = 15 + 22.65 – 5.22 – (-48.75) + 23.31 – 5.26 – 0 + 0$

$L_{PMeasured}$ = 99.23 dB

<u>Free Space Path Loss (Theoretical):</u>

$L_P = 20\log F + 20\log d – 27.5$

Where,

L_P = basic free space propagation path loss, in dB
F = center frequency of radiated EUT signal, in MHz
d = measurement distance, in m

Calculation for 37 GHz:

L_P = 20log(37000) + 20log(71) – 27.5

L_P = 91.36 + 37.03 – 27.5

$L_{PTheoretical}$ = 100.89 dB

Summary of substitution measurements

Channel	Freq (GHz)	Meas Distance (m)	P_T (dBm)	L_C (Tx) (dB)	G_T (Tx) (dBi)	G_T (Rx) (dBi)	L_C (Rx) (dB)	Measured Power, P_{meas} (dBm)	Measured Path Loss, L_P (dB)	Theoretical Path Loss, L_P (dB)	Path Loss Delta (dB)
Low BE	37.00	71.00	15.00	5.26	22.65	23.31	5.22	-48.75	99.23	100.89	-1.66
Low Channel	37.10	71.00	15.00	5.26	22.69	23.35	5.26	-49.12	99.64	100.91	-1.27
Mid Channel	38.50	71.00	15.00	5.48	22.57	23.19	5.47	-52.60	102.41	101.23	1.18
High Channel	39.90	71.00	15.00	5.52	22.45	23.36	5.54	-46.91	96.66	101.54	-4.88
High BE	40.00	71.00	15.00	5.69	22.34	23.39	5.59	-46.61	96.05	101.57	-5.51

Validation and Sanity Checks

Knowing the values of the base radio along with the expected added gain of the reflector plate, we can predict the EIRP when testing at the outdoor site.

Channel	Freq (GHz)	Base Radio Measured EIRP At 3m (dBm)	Expected Additional Gain From Reflector (dB)	Predicted EIRP With Reflector	Measured EIRP With Reflector at 71m (dBm)	Measured vs Predicted EIRP Delta (dB)
Low, 160 MHz BW	37.1	51.97	15.5	67.47	65.43	-2.04

Additionally, a spot test of the base unit at 71 meters was made to validate the gain of the reflector.

Channel	Freq (GHz)	Base Radio Measured EIRP At 71m (dBm)	Expected Additional Gain From Reflector (dB)	Predicted EIRP With Reflector	Measured EIRP With Reflector at 71m (dBm)	Measured vs Predicted EIRP Delta (dB)
Low, 160 MHz BW	37.1	49.93	15.5	65.43	65.43	0.0