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Federal Communications Commission
Office of Engineering and Technology
7435 Oakland Mills Road
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RE: FCC ID: 2BBSF-SC11-AAB RF Exposure Assessment.

To Whom it May Concern,

The Dense Air STC-v11-Node-n77, Model: AAB contains a single sector 5G radio consisting of a 2x2 MIMO 5G radio with integrated switched beam system with external antenna arrays and integrated 60GHz beam steered mmWave radio for backhaul.

The equipment is considered to be fixed equipment and intended for operation with separation distances greater than 20cm between any person and the equipment. Therefore the RF Exposure performance can be assessed by a Maximum Permissible Exposure (MPE) calculation using the limits defined in Part 1.1310(e)(1) Tables (i) and (ii).

The equipment incorporates two independent radio transmitters that can operate simultaneously, each transmitter has been assessed individually to confirm compliance with applicable MPE limits. Additionally, the combined RF exposure under simultaneous transmission conditions has been assessed.

This was assessed by applying section 7.2 for Transmitters used in mobile devices exposure conditions for simultaneous transmission operations in FCC KDB 447498 D01 v06 to ensure the sum of the MPE ratios is ≤ 1.0 .

The equipment architecture allows the radiating structures to be divided into two distinct groups with each group consisting of both 5G and 60GHz antennas where the worst-case exposures can occur. Each antenna grouping is described as a physical sector only due to their mechanical alignment, the two physical sectors are considered to be identical to each other. This analysis will consider the RF exposures from a single physical sector consisting of a pair of 5G antennas and a single 60GHz mmWave radio. The operation of the 5G radio and 60GHz radio are not synchronised, they are considered to operate under simultaneous transmission conditions.

The 5G radio operates in the 3.7-3.98GHz 3.7GHz Service band under FCC Part 27 using Time Division Duplex with maximum transmitter duty cycle of 75%.

The 60GHz mmWave radio operates in the 57-71GHz band under FCC Part 15.255 with a maximum duty cycle of >99%. The 60GHz radio is beam steered $\pm 45^\circ$ in the azimuth plane, the worst-case



simultaneous transmission exposure condition occurring when the beam is aligned with the 5G radio antenna 3dB beamwidth peak.

The 5G radio supports a Switched Beam Antenna system, for the RF exposure calculations, the modes with the highest EIRP will be assessed for MPE compliance.

Part 27 5G Radio System Analysis

The 5G radio in the equipment is a 2x2 MIMO radio, internally the RF outputs are split in the Switched Beam Antenna system. Each RF output from the internal 5G radio provides a single RF carrier, the RF carriers in the 2x2 MIMO radio are not correlated with each other. The SBA circuit switches and splits each carrier into multiple signals, these signals are correlated and will create array gain when both antenna arrays in the physical sector are enabled.

The 5G antenna system comprises of 4 individual panel arrays with 2 arrays mounted in each physical sector on the enclosure, each antenna array is a ± 45 degree dual cross-polarised array with gain of 14dBi. The total power radiated from each array is the combination of the power from each polarisation.

The maximum conducted RF power available at any of the 8 RF connectors is up to +27dBm per carrier, this analysis focuses on a single physical sector of the equipment as both physical sectors are the same. The conducted RF power on each port will change based on the selected SBA mode due to the varying RF paths selected. This analysis is based upon the worst-case operating modes of the switched beam antenna (SBA) system.

The MPE calculations will assess the combined MPE from both polarisations from a physical sector for the following worst-case scenarios.

- a) where the SBA system enables one antenna array in the physical sector the SBA insertion loss is 6dB.
- b) where the SBA system enables both antenna arrays in the physical sector the SBA insertion loss is 10dB.



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5G Transmitter Conducted Power Calculation (per Polarisation)

Device Information	Single Array	Dual Array	
Internal 5G Tx Power per Carrier Output Setting	33	33	dBm
Upper Power Tolerance	2.5	2.5	dB
Duty Cycle	0.75	0.75	
RF Line Losses (worst-case)	0	0	dB
SBA RF Switch Carrier Combiner Loss	0	0	dB
SBA Minimum Insertion Loss (excl. Combiner)	-6	-10	dB
Tx Conducted Power per Carrier	28.251	24.251	dBm
No. of Carriers Combined per Antenna Port	1	1	
Total Conducted Tx Power per Antenna Port	28.251	24.251	dBm
Total Conducted Tx Power per Antenna Port	0.668	0.266	W

Table 1: 5G Radio Tx Conducted RF Power Calculation

5G EIRP Calculation

Antenna Type	Dipole Array	Dipole Array	
Antenna Gain (per polarisation)	14.0	14.0	dBi
No. of Antenna Polarisations	2	2	
No. of Active Antenna Arrays	1	2	

Table 2: 5G Antenna Parameters

The maximum EIRP for both the single and dual polarisation cases is calculated below. Where 2 antenna arrays are active in the physical sector, array gain is created, this is included in the Max EIRP calculation.

Max EIRP per Antenna Array (per Polarisation)	42.251	38.251	dBm
Max EIRP per Antenna Array (both Polarisations)	45.261	41.261	dBm
Array Gain in Physical Sector	0.000	3.010	dB
Max EIRP per Physical Sector	45.261	44.271	dBm
Max EIRP per Physical Sector	33.581	26.738	W

Table 3: 5G Radio EIRP Calculations

5G Radio MPE Calculation

The Maximum Permissible Exposure (Power Density, S) at the minimum 0.2m distance is calculated using OET Bulletin 65 equation (3).

Device Information	Single Array	Dual Array	
Tx Power (Watts)	33.581	26.738	Watts
Calculation Distance (m)	0.2	0.2	m
Power Density S at distance	66.8069	53.1926	W/m ²

Table 4: 5G Radio Power Density Calculation at 0.2m



OET Bulletin 65 Equation (3) is re-arranged to calculate the minimum distance from the antenna to comply with the MPE Limit.

Device Information	Single Array	Dual Array	
Tx Power (Watts)	33.581	26.738	Watts
Power Density Limit	10	10	W/m ²
Calculated distance to limit	0.5169	0.4613	m

Table 5: 5G Radio Exclusion Distance to General Public/Uncontrolled MPE Limits

The n77 5G radio for a single physical sector as a stand-alone radio complies with the 1mW/cm² (10W/m²) General Public/Uncontrolled MPE Limit defined in 1.1310(e)(1) Table 1 at a distance of 0.52m from the antenna system.

60GHz mmWave Radio System Analysis

The 60GHz radio in the equipment is a dual radio consisting of two 60GHz radio modules oriented at 90° to each other, each physical sector contains one 60GHz radio and aligns with the physical sector analysis presented for the 5G radio. The two 60GHz radio modules are identical and have an integrated Phased Antenna System that allows a beam to be formed and swept in the azimuth direction.

The azimuth sweep is ±45° from a line that is perpendicular to the module PCBA, the scenario where both mmWave radio beams are radiating directly from the front of the enclosure has been considered in Test Report: Dense Air Ltd 14156-3 Issue 01. The measurement showed there is no enhancement of the radiated power due to the proximity of the second radio beam therefore this scenario has not been assessed.

The two 60GHz radio modules operate as independent radios and are not synchronised, additionally they are not synchronised with the 5G radio system.

Device Information	Single Radio	
Antenna Type	Phased Array	
Tx Conducted Power	+17	dBm
Duty Cycle	>0.99	
Line Loss	0	dB
Gain	23	dBi
Tx EIRP (Watts)	10	Watts
General Public/Uncontrolled MPE Limit	10	W/m ²

Table 6: 60GHz Radio EIRP Calculation



60GHz Radio MPE Calculation

The Maximum Permissible Exposure (Power Density, S) at the minimum 0.2m distance is calculated using OET Bulletin 65 equation (3).

Tx EIRP	10	Watts
Calculation Distance (m)	0.2	m
Power Density S at distance	19.8944	W/m ²

Table 7: 60GHz Radio Power Density Calculation at 0.2m

OET Bulletin 65 Equation (3) is re-arranged to calculate the minimum distance from the antenna to comply with the MPE Limit.

Tx EIRP	10	Watts
Power Density Limit	10	W/m ²
Calculated distance to limit	0.2821	m

Table 8: 60GHz Radio Exclusion Distance to General Public/Uncontrolled MPE Limits

The 60GHz radio for a single physical sector as a stand-alone radio complies with the 1mW/cm² (10W/m²) General Public/Uncontrolled MPE Limit defined in 1.1310(e)(1) Table 1 at a distance of 0.3m from the antenna system.

Simultaneous Transmission MPE Analysis

The calculations below are based on the method defined in Section 7.2 of KDB 447498 D01 v06 covering RF Exposure under simultaneous transmission conditions.

	n77 5G Radio Single Array	60GHz Radio	n77 5G Radio Dual Array	60GHz Radio	
EIRP (Duty Cycle Corrected)	33.581	10	26.738	10	Watts
MPE @ 0.2m	66.807	19.894	53.193	19.894	W/m ²
MPE Limit 1.1310(e)(1)	10	10	10	10	W/m ²
Individual MPE Ratio @ 0.2m	6.681	1.989	5.319	1.989	
Contribution Ratio from Each Source	0.771	0.229	0.728	0.272	%
Adjusted MPE limit for Contribution	7.705	2.295	7.278	2.722	W/m ²

Table 9: MPE Contributions from Each Source and Adjusted MPE Limits

After calculating the relative contribution of each RF Source and defining new MPE limits, the separation distance to comply with the MPE limit is re-calculated using the new MPE limits.

	n77 5G Radio Single Array	60GHz Radio	n77 5G Radio Dual Array	60GHz Radio	
Re-Cal Distance for adjusted MPE Limit	0.5889	0.5889	0.5407	0.5407	m
Rounding Up re-calculated distance	0.59	0.59	0.55	0.55	m

Table 10: Re-Calculated Simultaneous Transmission Separation Distance



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To confirm the re-calculated separation distance ensures compliance with the MPE Limits, the Power Density S for each transmitter is re-calculated, converted to a ratio and summed to ensure the ratio is ≤ 1 as per KDB 447498 ratio limit.

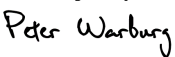
	n77 5G Radio Single Array	60GHz Radio	n77 5G Radio Dual Array	60GHz Radio	
Re-Calculate MPE @ new distance	7.677	2.286	7.034	2.631	W/m ²
New MPE Ratios	0.768	0.229	0.70	0.26	
Sum of MPE Ratios for all RF Sources	0.996		0.97		≤ 1

Table 11: Simultaneous Transmission Ratio Summation

The simultaneous transmission calculations above show the sum of MPE ratios for the STC-v11-Node-n77, Model: AAB complies with the ≤ 1 requirement in KDB 447498 and the equipment complies with the 1mw/cm² (10W/m²) General Public/Uncontrolled MPE limit defined in 1.1310(e)(1) Table 1 at a distance of 0.6m from the antenna system.

A minimum separation distance between any person and the STC-v11-Node-n77, Model: AAB enclosure of 1m has been stated in the DAT075 streetCell v1.1 Installation Guide.

Yours Faithfully

DocuSigned by:

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Peter Warburg
Senior Certification Engineer