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May 5, 2020

RE: Installation of a proposed AT&T Mobility personal wireless services facility to be located on a utility pole in Wellesley, MA.

PURPOSE

I have reviewed the information pertinent to the proposed installation. To determine regulatory compliance, theoretical calculations of maximal radio-frequency (RF) fields have been prepared. The physical conditions are that AT&T Mobility proposes to install a Personal Wireless Services (PWS) facility on an existing utility pole in Wellesley. The proposed PWS installation would consist of an omni-directional antenna mounted on an existing utility pole. The mounting centerline height of the antenna is proposed to be 30' above ground level (AGL).

This report considers the contributions of AT&T Mobility's proposed PWS equipment operating at their FCC-licensed capacities. The calculated values of RF fields are presented as a percent of current Maximum Permissible Exposures (%MPE) as adopted by the Federal Communications Commission (FCC),[i,ii] and those established by the Massachusetts Department of Public Health (MDPH).[iii]

SUMMARY

Theoretical RF field calculations data indicate the summation of the proposed AT&T Mobility PWS maximum RF contributions would be within the established RF exposure guidelines (See Figure 2). This includes all publicly accessible areas, and the neighborhood in general. The results support compliance with the pertinent sections of the FCC's guidelines for RF exposure.

Based on the results of the theoretical RF field calculations, it is my expert opinion that the proposed AT&T Mobility facility would comply with all regulatory guidelines for RF exposure.

Note: The analyses, conclusions and professional opinions are based upon the precise parameters and conditions of this particular site; **Utility pole with GQ2412-06613 antenna and (1) 4415 and (1) 4449 RRUs at Wellesley, MA**. Utilization of these analyses, conclusions and professional opinions for any personal wireless services installation, existing or proposed, other than the aforementioned has not been sanctioned by the author, and therefore should not be accepted as evidence of regulatory compliance.

EXPOSURE LIMITS AND GUIDELINES

RF exposure guidelines enforced by the FCC were established by the American National Standards Institute (ANSI) [iv] and the National Council on Radiation Protection and Measurement (NCRP).[v] The RF exposure guidelines are listed for RF workers and members of the public. The applicable FCC RF exposure guidelines for the public are listed in Table 1 and depicted in Figure 1. All listed values are intended to be averaged over any contiguous 30-minute period. NOTE: The values for "workers" is five times the values for members of the public.

Table 1: Maximum Permissible Exposure (MPE) Values in Public Areas

Frequency Bands	Electric Fields	Magnetic Fields	Equivalent Power Density
0.3 – 1.34 MHz	614 (V/m)	1.63 (A/m)	(100) mW/cm^2
1.34 - 30 MHz	824/*f* (V/m)	2.19/*f* (A/m)	(100) mW/cm^2
30 - 300 MHz	27.5 (V/m)	0.073 (A/m)	0.2 mW/cm^2
300 - 1500 MHz	--	--	*f*/1500 mW/cm^2
1500 - 100,000	--	--	1.0 mW/cm^2

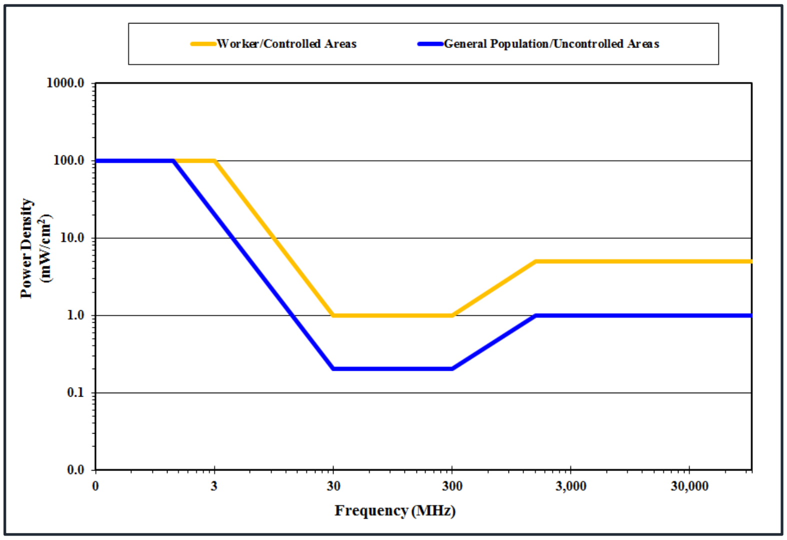

Figure 1: FCC Limits for Maximum Permissible Exposure (MPE)

NOTE: FCC 5% Rule – At multiple transmitter sites, actions necessary to bring the area into compliance with the RF exposure guidelines are the shared responsibility of all licensees whose transmitters produce RF field levels in excess of 5% of the applicable FCC MPEs.

INTRODUCTORY INFORMATION: MAKING SENSE OF THE "G"S

There are many references to the so-called "generation" of wireless technologies in use. Each new "generation" of wireless technologies, designated by a numbered "G",[1] seemingly garners more public attention. The latest "G" to come out, the fifth generation of wireless technologies or so called "5G", has attracted extensive research interest, both inside and outside the scientific community. According to the 3rd generation partnership project,[2] 5G networks should support three major families of applications: (1) Enhanced mobile broadband; (2) Machine type communications, and (3) Ultra-reliable and low-latency communications. There are also enhanced "vehicle-to-everything" communications which are expected to be supported by 5G networks. These situations require much more "connectivity" than the latest fourth generation (aka "4G" or "Long Term Evolution (LTE)") networks can handle. Thus, new networks must be able to handle this high system throughput, in addition to supporting existing older technologies still in use. This is being accomplished through additional spectrum assignments both higher and lower than currently assigned frequencies used by PWS facilities. In fact, currently deployed 5G networks are operating at frequencies once used by television stations.

Nonetheless, frequencies assigned by the FCC for 5G use are all within the bands currently under regulatory oversight, including setting safe limits of exposure to RF energy for both workers, and members of the public. Just recently (4/2020) the FCC has reaffirmed the efficacy of their regulatory exposure limits to RF energy; including those for 5G.

From an RF safety standpoint, there is nothing peculiar about the fifth generation of wireless technologies that would set it apart from any of the other advancements of technologies; including the first two generations (first analog then digital communications), the third generation (the first to be referred to a numbered-series as "3G"), and the currently deployed fourth generations (LTE). Recently published studies in peer-reviewed journals[vi] have show typical exposures to RF energy from operating 5G systems to be well-within the exposure limits.

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[1] PWS "Generations"

1G: Analog voice.
2G: Digital voice.
3G: Mobile data.
4G: LTE and mobile Internet.
5G: Mobile networks interconnect people, control machines, objects, and devices with multi-Gbps peak rates, ultra-low latency, and massive capacity.

[2] SOURCE: (https://www.3gpp.org/about-3gpp) The 3rd Generation Partnership Project (3GPP) unites [Seven] telecommunications standard development organizations (ARIB, ATIS, CCSA, ETSI, TSDSI, TTA, TTC), known as "Organizational Partners" and provides their members with a stable environment to produce the Reports and Specifications that define 3GPP technologies.

OBSERVATIONS IN CONSIDERATION WITH FCC RULES §1.1307(B) & §1.1310

Will it be physically possible to stand next to or touch any omnidirectional antenna?
NO; access to the utility pole will be restricted, and the site will adhere to RF safety guidelines regarding the PWS antennas, including appropriate signage.

THEORETICAL RF FIELD CALCULATIONS - GROUND LEVELS METHODOLOGY

These calculations are based on what are called "worst-case" estimates. That is, the estimates assume 100% use of all transmitters simultaneously. Additionally, the calculations make the assumption that the surrounding area is a flat plane. The resultant values are thus conservative in that they over predict actual resultant power densities.

The calculations are based on the following information (See Table 2 data):

1. Effective Radiated Power (ERP).
2. Antenna height (LOWEST centerline, above ground level (AGL)).
3. Antenna vertical energy patterns; the source of the negative gain (G) values. "Directional" antennas are designed to focus the RF signal, resulting in "patterns" of signal loss and gain. Antenna energy patterns display the loss of signal strength relative to the direction of propagation due to elevation angle changes. The gain is expressed as "G^{E}".

   Note: "G" is a unitless factor usually expressed in decibels (dB); where $G = 10^{(dB/10)}$
   For example: for an antenna *gain* of 3 dB, the net factor $(G) = 10^{(3/10)} = 2$
   For an antenna *loss* of -3 dB, the net factor $(G) = 10^{(-3/10)} = 0.5$

To determine the magnitude of the RF field, the power density (S) from an isotropic RF source is calculated, making use of the power density formula as outlined in FCC's OET Bulletin 65, Edition 97-01: [vii]

$$S = \frac{P \cdot G}{4 \cdot \pi \cdot R^2}$$

Where:
P → Power to antenna (watts)
G → Gain of antenna
R → Distance (range) from antenna source to point of intersection with the ground (feet)
$R^2 = (\text{Height})^2 + (\text{Horizontal distance})^2$

Since: P · G = EIRP (Effective Isotropic Radiated Power) for broadcast antennas, the equation can be presented in the following form:

$$S = \frac{EIRP}{4 \cdot \pi \cdot R^2}$$

In the situation of off-axis power density calculations, apply the negative elevation gain (G^E) value from the vertical energy patterns with the following formula:

$$\mathbf{S = \frac{EIRP \cdot G^E}{4 \cdot \pi \cdot R^2}}$$

Ground reflections may add in-phase with the direct wave, and essentially double the electric field intensity. Because power density is proportional to the *square* of the electric field, the power density may quadruple, that is, increase by a factor of four (4). Since ERP is routinely used, it is necessary to convert ERP into EIRP by multiplying by the factor of 1.64 (the gain of a half-wave dipole relative to an isotropic radiator). Therefore, downrange power density estimates can be calculated by using the formula:

$$\mathbf{S = \frac{4 \cdot (ERP \cdot 1.64) \cdot G^E}{4 \cdot \pi \cdot R^2} = \frac{ERP \cdot 1.64 \cdot G^E}{\pi \cdot R^2} = \frac{0.522 \cdot ERP \cdot G^E}{R^2}}$$

To calculate the % MPE, use the formula:

$$\mathbf{\%\ MPE = \frac{S}{MPE} \cdot 100}$$

The results of the calculations for the potential RF emissions resulting from the summation of the proposed AT&T Mobility PWS antenna are depicted in Figure 2 as plotted against linear distance from the base of the utility pole. Note that the values have been calculated for a height of 6’ AGL in accordance with regulatory rationale. Also depicted on the graphs are values for a height of 16’ AGL (height of a typical 2^{nd} story).

A logarithmic scale was used to plot the calculated theoretical %MPE values in order to compare with the MPE of 100%, which is so much larger that it would be off the page in a linear plot. The curves are variable due to the application of the vertical energy patterns. See Appendix A for typical PWS vertical energy patterns.

ANTENNA INVENTORY

Table 2: Transmitter and Antenna Data and Supporting Parameters for Proposed AT&T Mobility PWS Site on an Existing Utility Pole in Wellesley, MA						
Remote Radio Head Unit (RRH or RRU) (See Appendix B)			**Antenna See Appendix A for Energy Patterns**			
Model	Frequency (MHz)†/ Technology	# Tx X Output Power (watts)‡	Manufacturer/ Model	Gain (dBi)	**ERP** (watts)⁂	Centerline Height ('AGL)
RRUS-4415	1930 / PCS-1900	4 X 40	Galtronics / GQ2412-00613	8.9	757	30'
RRUS-4449	720 / LTE-700	1 X 40		7.8	147	
RRUS-4449	850 / UMTS-850	1 X 60		7.8	220	

Table Notes

† Transmitter (Tx) Frequency: Central transmit frequency used to account for multiple channels.

‡ Maximum rated output power (per channel).

⁂ **ERP**: Effective Radiated Power is the directional (RF) power (in watts) that would have to be radiated by a half-wave dipole antenna to give the same radiation intensity as the actual source at a distant receiver located in the direction of the antenna's strongest beam (main lobe). ERP measures the combination of the power emitted by the transmitter and the ability the antenna to direct that power in a given direction. It is equal to the input power to the antenna multiplied by the gain of the antenna. (Source Wiki).

Personal Wireless Services (PWS) Technologies

LTE: Long Term Evolution (a.k.a. "4G")

PCS: Personal Communication System

UMTS: Universal Mobile Telecommunications Services

RESULTS OF THEORETICAL RF FIELD CALCULATIONS

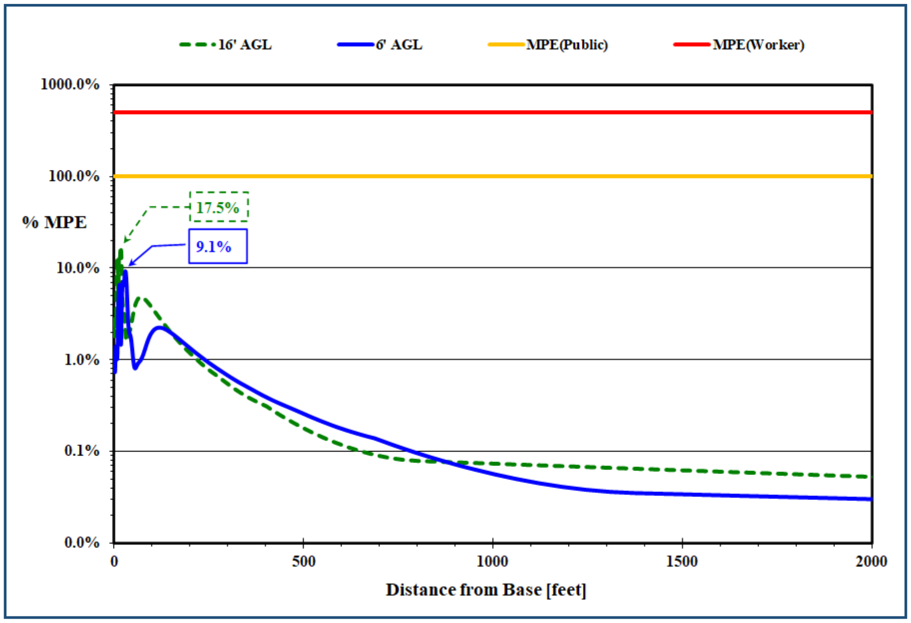


Figure 2: Theoretical Cumulative Maximum Percent MPE - vs. – Distance (Summation of the Proposed AT&T Mobility maximum RF Contributions)

CONCLUSION

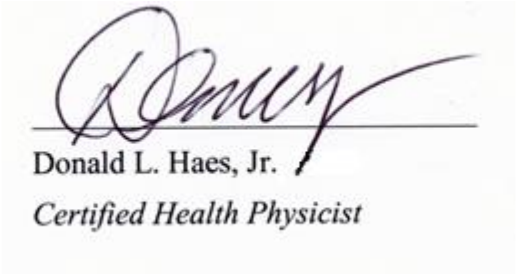
Theoretical RF field calculations data indicate the summation of the proposed AT&T Mobility PWS maximum RF contributions would be within the established RF exposure guidelines (See Figure 2). This includes all publicly accessible areas, and the neighborhood in general. The results support compliance with the pertinent sections of the FCC's guidelines for RF exposure.

The number and duration of calls passing through PWS facilities cannot be accurately predicted. Thus, in order to estimate the highest RF fields possible from operation of these installations, the maximal amount of usage was considered. Even in this so-called "worst-case", the resultant increase in RF field levels are far below established levels considered safe.

Based on the results of the theoretical RF field calculations, it is my expert opinion that the proposed AT&T Mobility facility would comply with all regulatory guidelines for RF exposure.

Feel free to contact me if you have any questions.

Sincerely,



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STATEMENT OF CERTIFICATION

1. I certify to the best of my knowledge and belief, the statements of fact contained in this report are true and correct.

2. The reported analyses, opinions, and conclusions are limited only by the reported assumptions and limiting conditions, and are personal, unbiased professional analyses, opinions and conclusions.

3. I have no present or prospective interest in the property that is the subject of this report and I have no personal interest or bias with respect to the parties involved.

4. My compensation is not contingent upon the reporting of a predetermined energy level or direction in energy level that favors the cause of the client, the amount of energy level estimate, the attainment of a stipulated result, or the occurrence of a subsequent event.

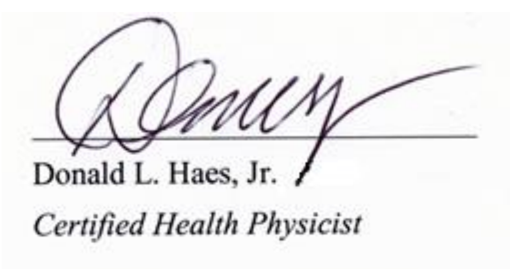
5. This assignment was not based on a requested minimum environmental energy level or specific power density.

6. My compensation is not contingent on an action or event resulting from the analyses, opinions, or conclusions in, or the use of, this report.

7. The consultant has accepted this assessment assignment having the knowledge and experience necessary to complete the assignment competently.

8. My analyses, opinions, and conclusions were developed and this report has been prepared, in conformity with the *American Board of Health Physics* (ABHP) statements of standards of professional responsibility for Certified Health Physicists.

Date: May 5, 2020



SUMMARY OF QUALIFICATIONS

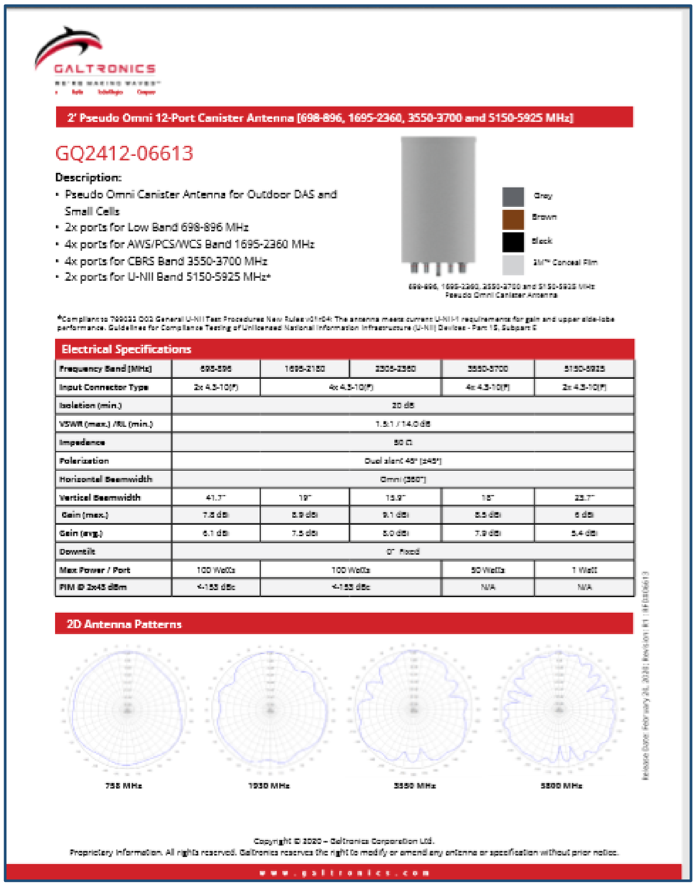
- **Academic Training -**
  - Graduated from Chelmsford High School, Chelmsford, MA; June 1973.
  - Completed Naval Nuclear Naval Nuclear Power School, 6-12/1976.
  - Completed Naval Nuclear Reactor Plant Mechanical Operator and Engineering Laboratory Technician (ELT) schools and qualifications, Prototype Training Unit, Knolls Atomic Power Laboratory, Windsor, Connecticut, 1-9/1977.
  - Graduated Magna Cum Laude from University of Lowell with a Bachelor of Science Degree in *Radiological Health Physics*; 5/1987.
  - Graduated from University of Lowell with a Master of Science Degree in *Radiological Sciences and Protection*; 5/1988.

- **Certification -**
  - Board Certified by the American Board of Health Physics 1994; renewed 1998, 2002, 2006, 2010, 2014, and 2018. Expiration 12/31/2022.
  - Board Certified by the Board of Laser Safety 2008; renewed 2011, 2014, 2017. Expiration 12/31/2020.

- **Employment History -**
  - Consulting Health Physicist; Ionizing/Nonionizing Radiation, 1988 - present.
  - Radiation, RF and Laser Safety Officer; BAE Systems, 2005–2018 (retired).
  - Assistant Radiation Safety Officer; MIT, 1988 – 2005 (retired).
  - Radiopharmaceutical Production Supervisor - DuPont/NEN, 1981 – 1988 (retired).
  - United States Navy; Nuclear Power Qualifications, 1975 – 1981 (Honorably Discharged).

- **Professional Societies -**
  - Health Physics Society [HPS].
  - American Academy of Health Physics [AAHP]
  - Institute of Electrical and Electronics Engineers [IEEE];
  - International Committee on Electromagnetic Safety [ICES] (ANSI C95 series).
  - Laser Institute of America [LIA].
  - Board of Laser Safety [BLS].
  - American National Standards Institute Accredited Standards Committee [ASC Z136].
  - Committee on Man and Radiation [COMAR].

APPENDIX A
PROPOSED ANTENNA SPECIFICATIONS AND ENERGY PATTERNS



2' Pseudo Omni 12-Port Canister Antenna [698-896, 1695-2360, 3550-3700 and 5150-5925 MHz]

GQ2412-06613

Description:

- Pseudo Omni Canister Antenna for Outdoor DAS and Small Cells
- 2x ports for Low Band 698-896 MHz
- 4x ports for AWS/PCS/WCS Band 1695-2360 MHz
- 4x ports for CBRS Band 3550-3700 MHz
- 2x ports for U-NII Band 5150-5925 MHz*

Grey / Brown / Black / 3M™ Conceal Film

698-896, 1695-2360, 3550-3700 and 5150-5925 MHz Pseudo Omni Canister Antenna

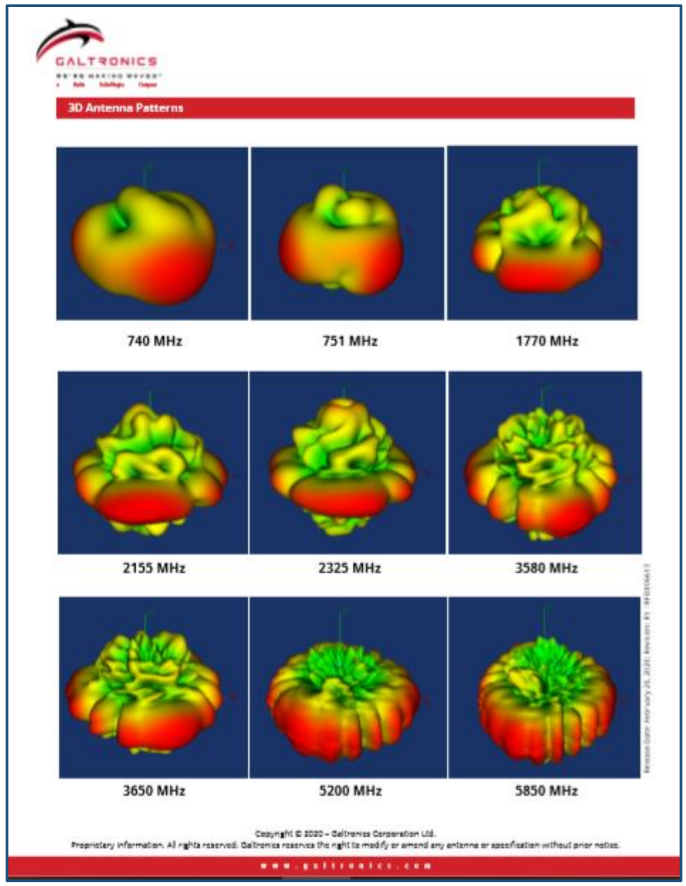
*Compliance to 789033 D02 General U-NII Test Procedures New Rules v01r04: The antenna meets current U-NII-1 requirements for gain and upper side-lobe performance. Guidelines for Compliance Testing of Unlicensed National Information Infrastructure (U-NII) Devices - Part 15, Subpart E

Electrical Specifications

Frequency Band [MHz]	698-896	1695-2180	2305-2360	3550-3700	5150-5925
Input Connector Type	2x 4.3-10(F)	4x 4.3-10(F)		4x 4.3-10(F)	2x 4.3-10(F)
Isolation (min.)	20 dB				
VSWR (max.) /RL (min.)	1.5:1 / 14.0 dB				
Impedance	50 Ω				
Polarization	Dual slant 45° (±45°)				
Horizontal Beamwidth	Omni (360°)				
Vertical Beamwidth	41.7°	19°	15.9°	18°	23.7°
Gain (max.)	7.8 dBi	8.9 dBi	9.1 dBi	8.5 dBi	6 dBi
Gain (avg.)	6.1 dBi	7.5 dBi	5.0 dBi	7.9 dBi	5.4 dBi
Downtilt	0° Fixed				
Max Power / Port	100 Watts	100 Watts		50 Watts	1 Watt
PIM @ 2x43 dBm	<-153 dBc	<-153 dBc		N/A	N/A

2D Antenna Patterns

www.galtronics.com



3D Antenna Patterns

www.galtronics.com

APPENDIX B
PROPOSED REMOTE RADIO HEAD UNIT (RRHU) SPECIFICATIONS

RISE Research Institutes of Sweden AB

RI.SE

REPORT

Date	Reference	Page
2017-10-23	7P06127-LG	4 (27)

Description of the test object

Equipment:	Radio equipment Radio 4415 B2 B25 Product number KRC 161 636/1 FCC ID: TA8AKRC161636 IC: 287AB-AS161636
HVIN:	AS161636
Hardware revision state:	R1B
Tested configuration:	Multi RAT LTE+GSM
Frequency range:	TX: 1930 – 1990 MHz RX: 1850 – 1910 MHz
IBW:	40 MHz
Output power:	Max 40 W/ antenna port
Antenna ports:	4 TX / 4 RX ports
Antenna:	No dedicated antenna, handled during licensing
RF configurations:	LTE: 1-5 carriers/ port GSM: 1-4 carriers/ port (max 10 carriers/ unit) Max 6 carriers/ port LTE: TX Diversity, 2x2 MIMO, 4x4 MIMO, and NB IoT in-band operation. Carrier Aggregation (CA) inter-band[1] and intra-band. GSM: Single antenna, dual TX. Contiguous Spectrum (CS), Non-Contiguous Spectrum (NCS)
Channel bandwidths:	LTE: 1.4 MHz, 3 MHz, 5 MHz, 10 MHz, 15 MHz and 20 MHz GSM: 200 kHz
Modulations:	LTE: QPSK, 16QAM, 64QAM and 256QAM GSM: GMSK, AQPSK and 8PSK
RF power Tolerance:	+0.6/ -2.5 dB
CPRI Speed	Up to 10.1 Gbit/s
Nominal supply voltage:	-48VDC

[1]Carrier Aggregation (CA) inter-band requires an additional unit operating on the other band.

Receipt date	November 15, 2017
Nemko sample ID number	None

3.2 EUT information

Product name	Radio 4449
Model	Radio 4449 B5 B13
Part number	KRC 161 749/1
Revision	R1A
Serial number	B440591478
Antenna ports	4 TX/RX Ports
RF BW / IBW	B5: 25 MHz B13: 10 MHz
FDD	B5: 45 MHz B13: 31 MHz
B5 Frequency range	TX (DL): 869–894 MHz RX (UL): 824–849 MHz
B13 Frequency range	TX (DL): 746–756 MHz RX (UL): 777–787 MHz
Nominal O/P per antenna port	Config 1: B5: Single Carrier, Ports A through D: 1 × 40 W (46 dBm) Config 1: B13: Single Carrier, Ports A through D: 1 × 40 W (46 dBm) Config 2: B5: Single Carrier, Ports A and D: 1 × 60W (47.78 dBm) Config 2: B13: Single Carrier, Ports A and D: 1 × 60W (47.78 dBm)
Accuracy (nominal)	±0.1 ppm
Nominal voltage	2 × −48 V_{DC} @ 20 A
RAT	LTE: SC, MIMO
Modulation	LTE: QPSK, 16 QAM, 64 QAM, 256QAM
Channel bandwidth	LTE: 5 MHz (B5), 10 MHz (B13)
Maximum combined OBW per port	15 MHz
CPRI	10 Gbps
Channel raster	LTE: 100 kHz
Regulatory requirements	Radio: FCC Part 2, 22, 27 EMC: FCC Part 15, ICES-003 Safety: IEC/EN 62368-1, UL/CSA 62368-1 IEC/EN 60950-22, IEC/EN 60529, UL 50E
Emission Designator:	5M00W7D (B5), 10M0W7D (B13)
Supported Configuration	SC, MC, Single Antenna, TX Diversity, MIMO, Carrier Aggregation
Operating temperature	−40 °C to +55 °C
Total Power based on IBW	Config 1: 4 × 40 W (B5) + 4 × 40 W (B13) Config 2: 2 × 60 W (B5) + 2 × 60 W (B13)
Supported carrier / port	LTE BW, B5: 5 (1-3), 10 (1-2); LTE BW, B13: 5 (2), 10 (1)
Optional Fan Tray	N/A

ENDNOTES

[i]. Federal Register, Federal Communications Commission Rules; *Radiofrequency radiation; environmental effects evaluation guidelines* Volume 1, No. 153, 41006-41199, August 7, 1996. (47 CFR Part 1; Federal Communications Commission).

[ii]. Telecommunications Act of 1996, 47 USC; Second Session of the 104th Congress of the United States of America, January 3, 1996.

[iii]. 105 CMR 122.000: Massachusetts Department of Public Health, *Non-Ionizing Radiation Limits for: The General Public from Non-Occupational Exposure to Electromagnetic Fields, Employees from Occupational Exposure to Electromagnetic Fields, and Exposure from Microwave Ovens*.

[iv]. ANSI/IEEE C95.1-1999: American National Standard, *Safety levels with respect to human exposure to radio frequency electromagnetic fields, from 3 KHz to 300 GHz* **(Updated in 2019)**.

[v]. National Council on Radiation Protection and Measurements (NCRP); *Biological Effects and Exposure Criteria for Radiofrequency Electromagnetic Fields*, NCRP Report 86, 1986.

[vi]. Jamshed, Muhammad Ali (Institute of Communication Systems (ICS), Home of 5G Innovation entre (5GIC), University of Surrey, Guildford GU2 7XH, U.K). *Electro-magnetic field exposure reduction/avoidance for the next generations of wireless communication systems*. IEEE Journal of Electromagnetics, RF, And Microwaves in Medicine and Biology, Vol. 4, No. 1, March 2020.

[vii]. OET Bulletin 65: Federal Communications Commission Office of Engineering and Technology, *Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields*; Edition 97-01, August 1999.