

CERTIFICATION TEST REPORT

Report Number.: 12901678-E3V2

Applicant: APPLE, INC.

1 APPLE PARK WAY

CUPERTINO, CA 95014, U.S.A.

Model : A2161, A2219, AND A2220

FCC ID : BCG-E3306A

IC: 579C-E3306A

EUT Description: SMARTPHONE

Test Standard(s): FCC 47 CFR PART 15 SUBPART C

ISED RSS-247 ISSUE 2 ISED RSS-GEN ISSUE 5

Date Of Issue:

August 23, 2019

Prepared by:

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REPORT REVISION HISTORY

| Rev. | Issue Date | Revisions | Revised By |
|------|---------------|-----------------------------------|-------------|
| V1 | 8/19/2019 | Initial Issue | Chin Pang |
| V2 | 8/23/2019 | Addressed TCB's initial questions | Chris Xiong |

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SETUP PHOTOS285

11.

1. ATTESTATION OF TEST RESULTS

COMPANY NAME: APPLE, INC.

1 APPLE PARK WAY

CUPERTINO, CA 95014, U.S.A.

EUT DESCRIPTION: SMARTPHONE

MODEL: A2161, A2219, AND A2220

SERIAL NUMBER: Radiated & Conducted

G6TYW00YN393, G6TYW010N393, G6TYW05BN393,

G6TYW005N395

DATE TESTED: JUNE 1, 2019 – AUGUST 23, 2019

APPLICABLE STANDARDS

STANDARD TEST RESULTS

CFR 47 Part 15 Subpart C Complies
ISED RSS-247 Issue 2 Complies
ISED RSS-GEN Issue 5 Complies

UL Verification Services Inc. tested the above equipment in accordance with the requirements set forth in the above standards. The test results show that the equipment tested is capable of demonstrating compliance with the requirements as documented in this report.

The results documented in this report apply only to the tested sample, under the conditions and modes of operation as described herein. It is the manufacturer's responsibility to assure that additional production units of this model are manufactured with identical electrical and mechanical components. All samples tested were in good operating condition throughout the entire test program. Measurement Uncertainties are published for informational purposes only and were not taken into account unless noted otherwise.

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Consumer Technology Division UL Verification Services Inc.

Chris Xiong Test Engineer

Consumer Technology Division UL Verification Services Inc.

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2. TEST METHODOLOGY

The tests documented in this report were performed in accordance with FCC CFR 47 Part 2, FCC CFR 47 Part 15, ANSI C63.10-2013, RSS-GEN Issue 5, KDB 558074 D01v05r02 and RSS-247 Issue 2.

3. FACILITIES AND ACCREDITATION

The test sites and measurement facilities used to collect data are located at 47173 and 47266 Benicia Street, and 47658 Kato Road, Fremont, California, USA. Line conducted emissions are measured only at the 47173 address. The following table identifies which facilities were utilized for radiated emission measurements documented in this report. Specific facilities are also identified in the test results sections.

| 47173 Benicia Street | 47266 Benicia Street | 47658 Kato Rd |
|--------------------------|--------------------------|--------------------------|
| Chamber A (ISED:2324B-1) | Chamber D (ISED:22541-1) | Chamber I (ISED:2324A-5) |
| Chamber B (ISED:2324B-2) | Chamber E (ISED:22541-2) | Chamber J (ISED:2324A-6) |
| Chamber C (ISED:2324B-3) | Chamber F (ISED:22541-3) | Chamber K (ISED:2324A-1) |
| | Chamber G (ISED:22541-4) | Chamber L (ISED:2324A-3) |
| | Chamber H (ISED:22541-5) | |

The above test sites and facilities are covered under FCC Test Firm Registration # 208313. Chambers above are covered under Industry Canada company address and respective code

UL Verification Services Inc. is accredited by NVLAP, Laboratory Code 200065-0

4. CALIBRATION AND UNCERTAINTY

4.1. MEASURING INSTRUMENT CALIBRATION

The measuring equipment utilized to perform the tests documented in this report has been calibrated in accordance with the manufacturer's recommendations, and is traceable to recognized national standards.

4.2. SAMPLE CALCULATION

RADIATED EMISSIONS

Where relevant, the following sample calculation is provided:

Field Strength (dBuV/m) = Measured Voltage (dBuV) + Antenna Factor (dB/m) + Cable Loss (dB) – Preamp Gain (dB)

36.5 dBuV + 18.7 dB/m + 0.6 dB - 26.9 dB = 28.9 dBuV/m

MAINS CONDUCTED EMISSIONS

Where relevant, the following sample calculation is provided:

Final Voltage (dBuV) = Measured Voltage (dBuV) + Cable Loss (dB) + Limiter Factor (dB) + LISN Insertion Loss.

 $36.5 \, dBuV + 0 \, dB + 10.1 \, dB + 0 \, dB = 46.6 \, dBuV$

4.3. MEASUREMENT UNCERTAINTY

Where relevant, the following measurement uncertainty levels have been estimated for tests performed on the apparatus:

| PARAMETER | UNCERTAINTY |
|---|-------------|
| Worst Case Conducted Disturbance, 9KHz to 0.15 MHz | 3.84 dB |
| Worst Case Conducted Disturbance, 0.15 to 30 MHz | 3.65 dB |
| Worst Case Radiated Disturbance, 9KHz to 30 MHz | 2.52 dB |
| Worst Case Radiated Disturbance, 30 to 1000 MHz | 4.88 dB |
| Worst Case Radiated Disturbance, 1000 to 18000 MHz | 4.24 dB |
| Worst Case Radiated Disturbance, 18000 to 26000 MHz | 4.37 dB |
| Worst Case Radiated Disturbance, 26000 to 40000 MHz | 5.17 dB |

Uncertainty figures are valid to a confidence level of 95%.

5. EQUIPMENT UNDER TEST

5.1. EUT DESCRIPTION

The EUT is a smartphone with multimedia functions (music, application support, and video), cellular GSM, GPRS, EGPRS, UMTS, LTE, TD-SCDMA, CDMA, IEEE 802.11a/b/g/n/ac/ax, Bluetooth, Ultra-Wide band, GPS and NFC. All models support at least one UICC based SIM. The second SIM, if present, is either UICC based pSIM (physical SIM) or e-SIM (electronic SIM). The device has a built-in inductive charging receiver. The rechargeable battery is also not user accessible.

5.2. DIFFERENCE IN MODEL NUMBER

Model A2161, A2219, and A2220 is electrically identical to Model A2161. Three model numbers are allocated for marketing and logistic purposes only. A2161 was used to perform all final tests.

5.3. MAXIMUM OUTPUT POWER

The transmitter has a maximum peak conducted output power as follows:

| Antenna | Config | Frequency Range | Mode | Output | Output |
|-------------|------------|-----------------|--------------------|--------|--------|
| | | (MHz) | | Power | Power |
| | | | | (dBm) | (mW) |
| | | 2402 - 2480 | Basic GFSK | 17.22 | 52.72 |
| | High Power | 2402 - 2480 | QPSK | 17.98 | 62.81 |
| Antenna 4 | | 2402 - 2480 | Enhanced 8PSK | 18.20 | 66.07 |
| Antenna 4 | | 2402 - 2480 | Basic GFSK | 12.69 | 18.58 |
| | Low Power | 2402 - 2480 | QPSK | 10.99 | 12.56 |
| | | 2402 - 2480 | Enhanced 8PSK | 11.28 | 13.43 |
| | | 2402 - 2480 | Basic GFSK | 19.62 | 91.62 |
| | High Power | 2402 - 2480 | QPSK | 17.95 | 62.37 |
| Antonno 2 | | 2402 - 2480 | Enhanced 8PSK | 18.15 | 65.31 |
| Antenna 3 | | 2402 - 2480 | Basic GFSK | 12.72 | 18.71 |
| | Low Power | 2402 - 2480 | QPSK | 11.01 | 12.62 |
| | | 2402 - 2480 | Enhanced 8PSK | 11.30 | 13.49 |
| | | 2402 - 2480 | Basic GFSK TxBF | 20.27 | 106.41 |
| | High Power | 2402 - 2480 | QPSK TxBF | 19.99 | 99.77 |
| Antenna 4 + | | 2402 - 2480 | Enhanced 8PSK TxBF | 20.26 | 106.17 |
| Antenna 3 | | 2402 - 2480 | Basic GFSK TxBF | 15.75 | 37.58 |
| | Low Power | 2402 - 2480 | QPSK TxBF | 14.04 | 25.35 |
| | | 2402 - 2480 | Enhanced 8PSK TxBF | 14.31 | 26.98 |

5.4. DESCRIPTION OF AVAILABLE ANTENNAS

| Frequency Range | Ant. 4 | Ant. 3 |
|-----------------|--------|--------|
| (GHz) | (dBi) | (dBi) |
| 2.4 | -0.9 | -2.3 |

5.5. SOFTWARE AND FIRMWARE

The EUT firmware installed during testing was BT FW Version: 17.1.140.1283.

5.6. WORST-CASE CONFIGURATION AND MODE

The EUT was investigated in three orthogonal orientations X, Y and Z on Antenna 4 (Core 0) and Antenna 3 (Core 1). It was determined that X (Flatbed) orientation was the worst-case orientation for Ant 4, Ant 3, and 2TX Beamforming.

Radiated band edge, harmonic, and spurious emissions from 1GHz to 18GHz were performed with the EUT set to transmit at highest power on Low/Middle/High channels.

Radiated emissions below 30MHz, below 1GHz, 18-26GHz and power line conducted emissions were performed with the EUT transmitting at the channel with the highest output power as worst-case scenario.

For below 1GHz tests, EUT was connected to AC power adapter as the worst case; and for above 1GHz tests, the worst-case configuration reported was with EUT only. There was no emission found below 30MHz within 20dB of the limit. For AC line conducted emission, test was investigated with AC power adapter and with laptop.

For simultaneous transmission of multiple channels in the 2.4GHz BT and 5GHz bands, no noticeable new emission was found.

GFSK, DQPSK, 8PSK average power are all investigated. The GFSK & 8PSK power are the worst case. For average power data, please refer to section 8.7.

Worst-case data rates as provided by the client were:

GFSK mode: DH5 8PSK mode: 3-DH5

BFTX, DH5 BFTX, 3-DH5

There are two vendors of the WiFi/Bluetooth radio modules: variant 1 and variant 2. The WiFi/Bluetooth radio modules have the same mechanical outline (e.g., the same package dimension and pin-out layout), use the same on-board antenna matching circuit, have an identical antenna structure, and are built and tested to conform to the same specifications and to operate within the same tolerances.

Baseline testing was performed on the two variants to determine the worst case on all conducted power and radiated emissions.

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5.7. DESCRIPTION OF TEST SETUP

SUPPORT EQUIPMENT

| Support Equipment List | | | | | | | |
|---|-------------------|-------------|-------------------|--------------|--|--|--|
| Description Manufacturer Model Serial Number FCC ID | | | | | | | |
| Laptop | Apple | A1502 | HRP003436 | QDS-BRCM1080 | | | |
| Laptop AC/DC adapter | Liteon Technology | PA-1450-BA1 | B123 | NA | | | |
| EUT AC Adapter | Apple | A1385 | D29325SM03XDHLHC9 | NA | | | |

I/O CABLES

| | I/O Cable List | | | | | | | | |
|--|----------------|-------|------|-------------|------------|----------------------|--|--|--|
| Cable Port # of identical Connector Cable Type Cable Remarks | | | | | | | | | |
| No | | ports | Type | | Length (m) | | | | |
| 1 | Antenna | 1 | SMA | Un-Shielded | 0.2 | To spectrum Analyzer | | | |
| 2 | USB | 1 | USB | Shielded | 1 | N/A | | | |
| 3 | AC | 1 | AC | Un-shielded | 2 | N/A | | | |

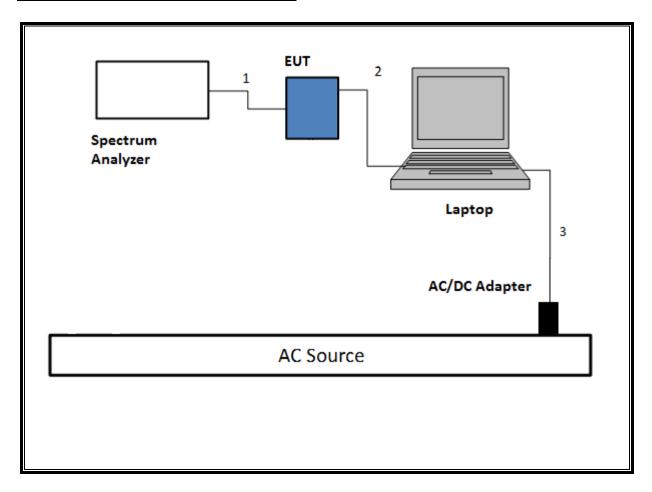
I/O CABLES (BELOW 1GHz AND AC POWER LINE TEST WITH ADAPTER AND LAPTOP)

| | I/O Cable List | | | | | | | |
|---|----------------|---|-----|-------------|---|-----|--|--|
| Cable Port # of Connector Cable Type Cable Remarks No identical Type Length (m) | | | | | | | | |
| 1 | AC | 1 | AC | Un-shielded | 2 | N/A | | |
| 2 | USB | 1 | USB | Un-shielded | 1 | N/A | | |

TEST SETUP

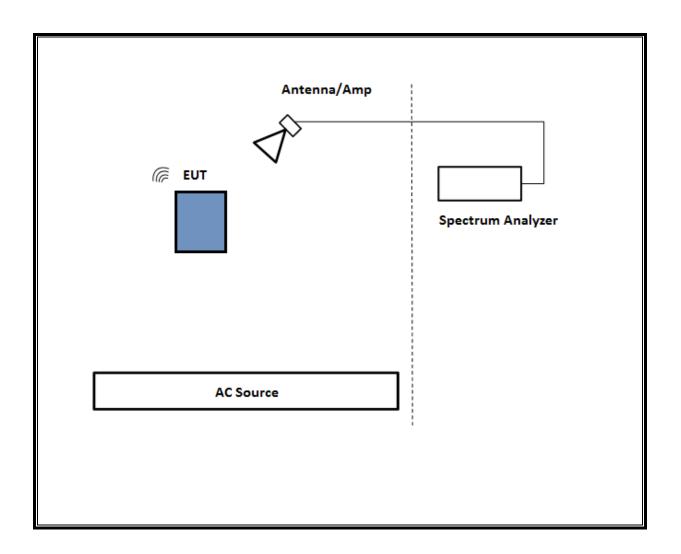
The EUT is connected to a test laptop during the tests. Test software exercised the radio card.

SETUP DIAGRAM FOR CONDUCTED TESTS

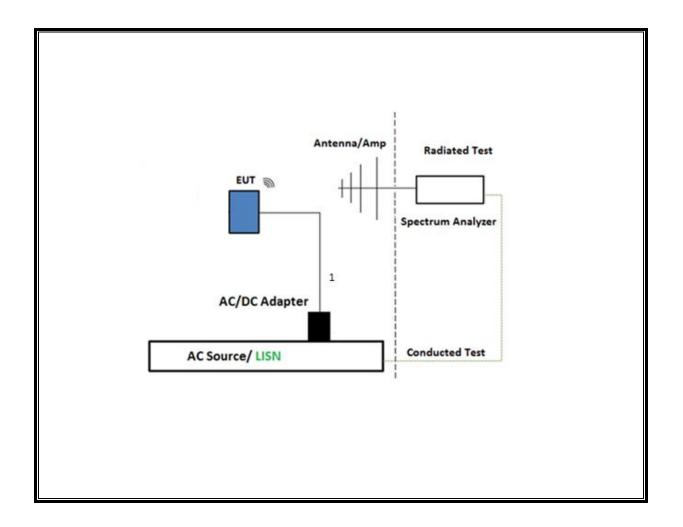


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SETUP DIAGRAM FOR RADIATED TESTS Above 1GHz

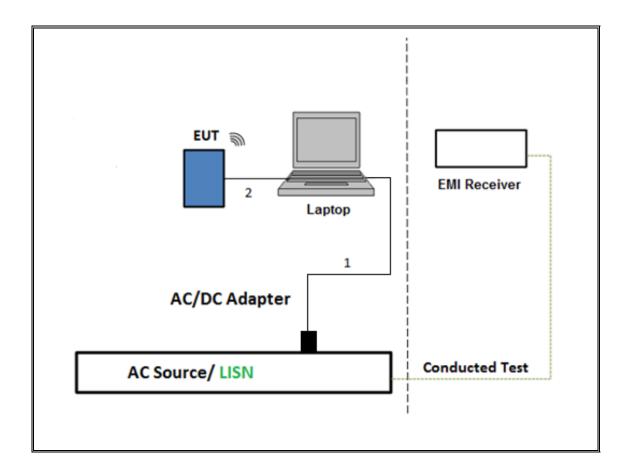


SETUP DIAGRAM FOR BELOW 1GHz and AC LINE CONDUCTED TEST



DATE: 8/23/2019 IC: 579C-E3306A

TEST SETUP- AC LINE CONDUCTED: LAPTOP CONFIGURATION



DATE: 8/23/2019 IC: 579C-E3306A

6. TEST AND MEASUREMENT EQUIPMENT

The following test and measurement equipment was utilized for the tests documented in this report:

| report: | TEST | EQUIPMENT LIST | | | |
|--|---------------------------------|----------------------------|-----------------------|---------------------|------------|
| Description | Manufacturer | Model | ID Num | Cal Due | Last Cal |
| Spectrum Analyzer, PXA, 3Hz to 44GHz | Agilent (Keysight) Technologies | N9030A | T908 | 01/23/2020 | 01/23/2019 |
| Horn Antenna 1-18GHz | ETS-Lindgren | 3117 | T136 | 06/14/2020 | 06/14/2019 |
| Horn Antenna 1-18GHz | ETS-Lindgren | 3117 | T345 | 04/20/2020 | 04/25/2019 |
| Amplifier, 10KHz to 1GHz, 32dB | Sonoma Instrument Co. | 310N | T15 | 10/20/2019 | 10/20/2018 |
| Antenna, Horn 1-18GHz | ETS Lindgren | 3117 | T712 | 02/26/2020 | 02/26/2019 |
| Amplifier, 1 to 18GHz | Miteq | AFS42-00101800- 25-S-42 | 138301 | 09/15/2019 | 09/15/2018 |
| Antenna, Horn 1-18GHz | ETS Lindgren | 3117 | T120 | 05/10/2020 | 05/10/2019 |
| Spectrum Analyzer, PXA 3Hz to 44GHz | Keysight | N9030A | T1454 | 01/23/2020 | 01/23/2019 |
| Amplifier, 1 to 18GHz | Miteq | AFS42-00101800- 25-S-42 | T491 | 05/30/2020 | 05/30/2019 |
| Antenna, Horn 1-18GHz | ETS-Lindgren | 3117 | T863 | 05/30/2020 | 05/30/2019 |
| Amplifier, 1 to 8GHz, 35dB | Miteq | AMF-4D- 01000800-30-29P | T1156 | 08/30/2019 | 08/30/2018 |
| Antenna, Active Loop 9KHz to 30MHz | ETS-Lindgren | 6502 | T1616 | 10/18/2019 | 10/18/2018 |
| *Hybrid Antenna, 30-3Ghz | SunAR rf Motion | JB3 | PRE0181574 | 08/01/2019 | 08/01/2018 |
| *Antenna, Horn 18 to 26.5GHz | ARA | MWH-1826/B | T447 | 06/16/2019 | 06/16/2018 |
| Antenna, Horn 1-18GHz | ETS Lindgren | 3117 | T119 | 03/22/2020 | 03/22/2019 |
| Amplifier, 1 to 18GHz | Miteq | AFS42-00101800- 25-S-42 | T740 | 10/062019 | 10/062018 |
| Amplifier, 1 - 18GHz | Miteq | AFS42-00101800- 25-S-42 | T1165 | 02/02/2020 | 02/02/2019 |
| Spectrum Analyzer, PXA, 3Hz to 44GHz | Agilent (Keysight) Technologies | N9030A | T340 | 01/22/2020 | 01/22/2019 |
| Amplifier, 1 - 18GHz | Miteq | AFS42-00101800- 25-S-42 | T1567 | 01/26/2020 | 01/26/2019 |
| *Pre-Amp 18-26GHz | Agilent Technology | 8449B | T404 | 03/23/2020 | 03/23/2019 |
| Antenna, Horn 1-18GHz | ETS Lindgren | 3117 | T344 | 05/07/2020 | 05/07/2019 |
| Amplifier, 1 to 18GHz | Miteq | AFS42-00101800- 25-S-42 | T931 | 05/11/2020 | 05/11/2019 |
| Power Meter, P-series single channel | Agilent (Keysight) Technologies | N1911A | T227 | 10/29/2019 | 10/29/2018 |
| Filter, HPF 3GHz | Micro-Tronics | HPM17543 | T1014 | 01/26/2020 | 01/26/2019 |
| Power Sensor | Power Sensor | Keysight | T1226 | 02/06/2020 | 02/06/2019 |
| | AC | Line Conducted | | | |
| EMI Test Receiver 9Khz- 7GHz | Rohde & Schwarz | ESCI7 | T1436 | 02/14/2020 | 02/14/2019 |
| Power Cable, Line Conducted Emissions | UL | PG1 | T861 | 08/31/2019 | 08/31/2018 |
| LISN for Conducted Emissions CISPR-16 | Fischer | 50/250-25-2-01 | T1310 | 01/24/2020 | 01/24/2019 |
| | UL AUTO | MATION SOFTWAR | RE | | |
| Radiated Software | UL | UL EMC | Ve | r 9.5, April 26, 20 | 016 |
| Conducted Software | UL | UL EMC | | 5.4, October 13, | |
| AC Line Conducted Software | UL | UL EMC | Ver 9.5, May 26, 2015 | | |

^{*}Testing is completed before equipment expiration date.

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7. MEASUREMENT METHODS

On Time and Duty Cycle: ANSI C63.10-2013 Section 11.6

Occupied BW (20dB): ANSI C63.10-2013 Section 6.9.2

Occupied BW (99%): ANSI C63.10-2013 Section 6.9.3

Carrier Frequency Separation: ANSI C63.10-2013 Section 7.8.2

Number of Hopping Frequencies: ANSI C63.10-2013 Section 7.8.3

Time of Occupancy (Dwell Time): ANSI C63.10-2013 Section 7.8.4

Peak Output Power: ANSI C63.10-2013 Section 7.8.5

Conducted Spurious Emissions: ANSI C63.10-2013 Section 7.8.8

Conducted Band-Edge: ANSI C63.10-2013 Section 6.10.4

Radiated Spurious Emissions Below 30MHz: ANSI C63.10-2013 Section 6.4

Radiated Spurious Emissions 30-1000MHz: ANSI C63.10-2013 Section 6.3 and 6.5

Radiated Spurious Emissions above 1GHz: ANSI C63.10-2013 Section 6.3 and 6.6

Radiated Band-edge: ANSI C63.10-2013 Section 6.10.5

AC Power-line conducted emissions: ANSI C63.10-2013, Section 6.2.

8. ANTENNA PORT TEST RESULTS

8.1. ON TIME AND DUTY CYCLE

LIMITS

None; for reporting purposes only.

PROCEDURE

ANSI C63.10, Section 11.6: Zero-Span Spectrum Analyzer Method.

ON TIME AND DUTY CYCLE RESULTS

| Mode | ON Time | Period | Duty Cycle | Duty | Duty Cycle | 1/T |
|---------------------|---------|--------|-------------------|--------|--------------------------|-------------|
| | В | | x | Cycle | Correction Factor | Minimum VBW |
| | (msec) | (msec) | (linear) | (%) | (dB) | (kHz) |
| Bluetooth GFSK | 2.57 | 2.57 | 1.000 | 100.0% | 0.00 | 0.010 |
| Bluetooth 8PSK | 2.57 | 2.57 | 1.000 | 100.0% | 0.00 | 0.010 |
| Bluetooth GFSK TxBF | 2.57 | 2.57 | 1.000 | 100.0% | 0.00 | 0.010 |
| Bluetooth 8PSK TxBF | 2.57 | 2.57 | 1.000 | 100.0% | 0.00 | 0.010 |

Note: Low power duty cycle is same as high power

DUTY CYCLE PLOTS



8.2. 20 dB AND 99% BANDWIDTH

LIMITS

None; for reporting purposes only.

TEST PROCEDURE

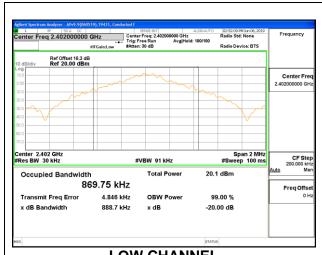
The transmitter output is connected to a spectrum analyzer. The RBW is set to \geq 1% of the 20 dB bandwidth. The VBW is set to \geq RBW. The sweep time is coupled.

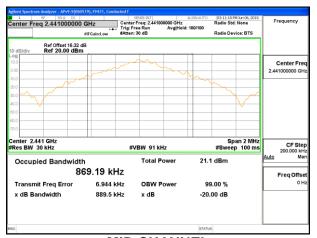
RESULTS

HIGH POWER BASIC DATA RATE GFSK MODULATION 8.2.1.

Antenna 4

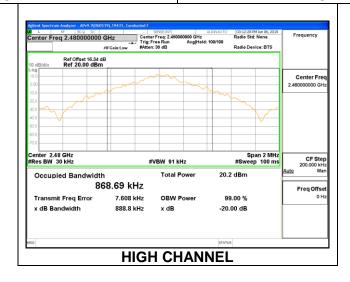
| Channel | Frequency | 20dB Bandwidth | 99% Bandwidth |
|---------|-----------|----------------|---------------|
| | (MHz) | (MHz) | (MHz) |
| Low | 2402 | 0.889 | 0.8698 |
| Mid | 2441 | 0.890 | 0.8692 |
| High | 2480 | 0.889 | 0.8687 |





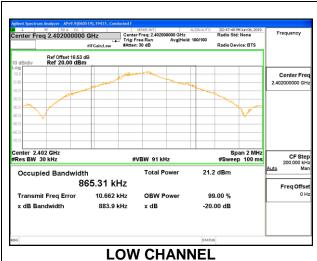
LOW CHANNEL

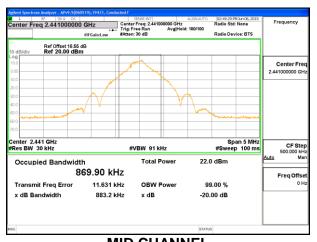




Antenna 3

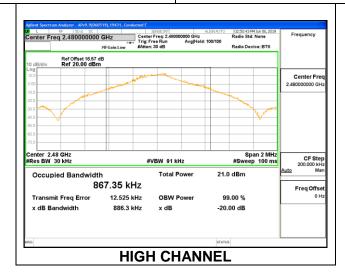
| Channel | Frequency | 20dB Bandwidth | 99% Bandwidth |
|---------|-----------|----------------|---------------|
| | (MHz) | (MHz) | (MHz) |
| Low | 2402 | 0.884 | 0.8653 |
| Mid | 2441 | 0.883 | 0.8699 |
| High | 2480 | 0.886 | 0.8674 |





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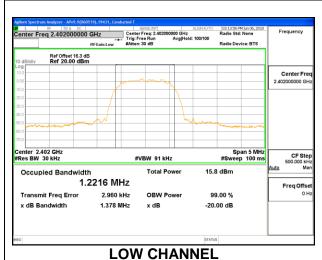
IC: 579C-E3306A

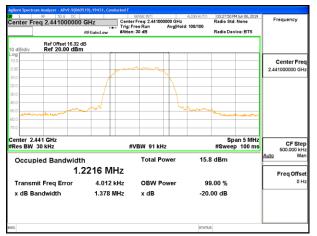


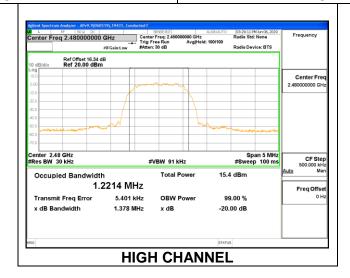
HIGH POWER ENHANCED DATA RATE 8PSK 8.2.2. **MODULATION**

Antenna 4

| Channel | Frequency | 20dB Bandwidth | 99% Bandwidth |
|---------|-----------|----------------|---------------|
| | (MHz) | (MHz) | (MHz) |
| Low | 2402 | 1.378 | 1.2216 |
| Mid | 2441 | 1.378 | 1.2216 |
| High | 2480 | 1.378 | 1.2214 |

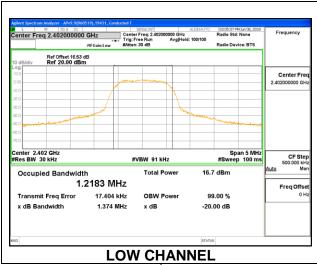


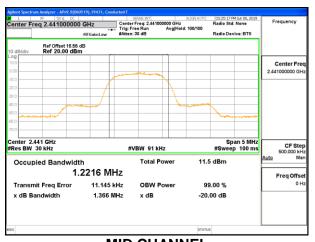




Antenna 3

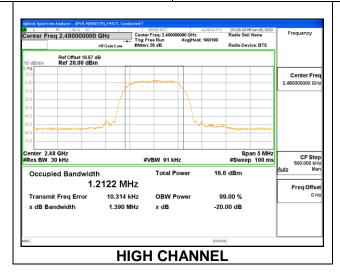
| Channel | Frequency | 20dB Bandwidth | 99% Bandwidth |
|---------|-----------|----------------|---------------|
| | (MHz) | (MHz) | (MHz) |
| Low | 2402 | 1.374 | 1.2183 |
| Mid | 2441 | 1.366 | 1.2216 |
| High | 2480 | 1.390 | 1.2122 |





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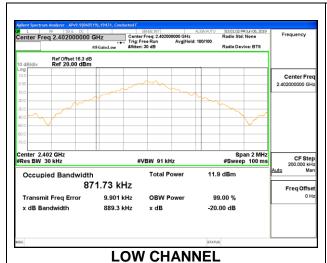
IC: 579C-E3306A

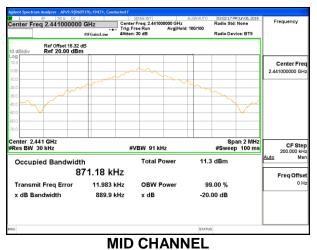


8.2.3. LOW POWER BASIC DATA RATE GFSK MODULATION

Antenna 4

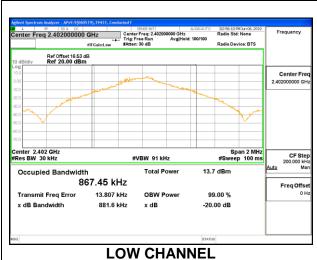
| Channel | Frequency | 20dB Bandwidth | 99% Bandwidth |
|---------|-----------|----------------|---------------|
| | (MHz) | (MHz) | (MHz) |
| Low | 2402 | 0.889 | 0.8717 |
| Mid | 2441 | 0.890 | 0.8712 |
| High | 2480 | 0.889 | 0.8703 |

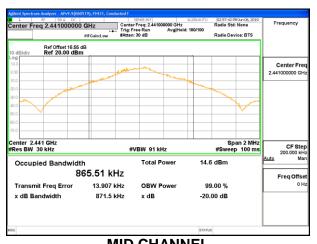




Antenna 3

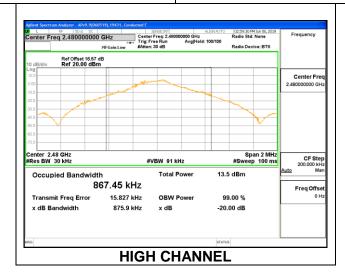
| Channel | Frequency | 20dB Bandwidth | 99% Bandwidth |
|---------|-----------|----------------|---------------|
| | (MHz) | (MHz) | (MHz) |
| Low | 2402 | 0.882 | 0.8675 |
| Mid | 2441 | 0.871 | 0.8655 |
| High | 2480 | 0.876 | 0.8675 |





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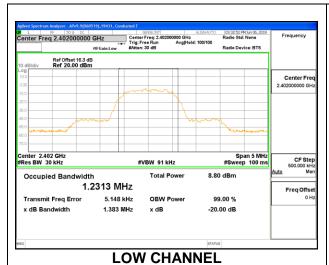
IC: 579C-E3306A

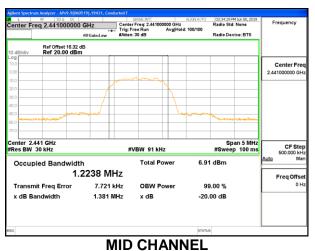


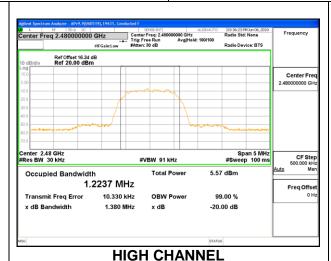
8.2.4 LOW POWER ENHANCED DATA RATE 8PSK MODULATION

Antenna 4

| Channel | Frequency | 20dB Bandwidth | 99% Bandwidth |
|---------|-----------|----------------|---------------|
| | (MHz) | (MHz) | (MHz) |
| Low | 2402 | 1.383 | 1.2313 |
| Mid | 2441 | 1.381 | 1.2238 |
| High | 2480 | 1.380 | 1.2237 |

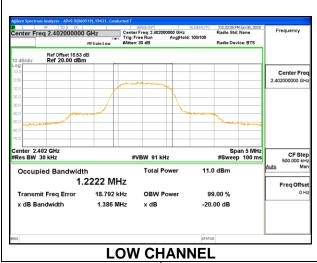


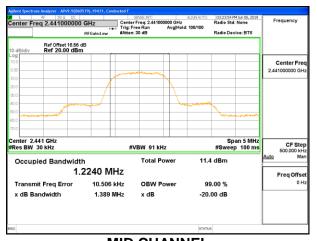




Antenna 3

| (| Channel | Frequency | 20dB Bandwidth | 99% Bandwidth |
|---|---------|-----------|----------------|---------------|
| | | (MHz) | (MHz) | (MHz) |
| | Low | 2402 | 1.386 | 1.2222 |
| | Mid | 2441 | 1.389 | 1.2240 |
| | High | 2480 | 1.398 | 1.2226 |





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