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FCC PARTS 2, 20, 22, 24, 27 TEST REPORT

| Applicant | Dali Wireless, Inc. |
|----------------------|---|
| Address | 535 Middlefield Road, Suite 280, Menlo Park, CA 94025, USA |
| FCC ID | HCOHD304NACEHIO1A |
| Model Number | HD30-4-NA-CEHI-O1H |
| Product Description | 700, 850, 1900, AWS Indoor Remote Unit, Quad-Band |
| Date Sample Received | October 18th, 2016 |
| Date Sample Tested | October 18 th to October 21 st , 2016 |
| Tested by | Sophie Piao |
| Approved by | Andrew Leung |
| Report No. | HD30-4-NA-CEHI-O1H |
| Test Results | Compliant |

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Revision History

| Revision | Date | Reason For Change | Reviewed By | Author(s) |
|----------|------------------------------------|---|--------------------|-----------|
| 0.1 | October 21 st , 2016 | Initial release | | S. Piao |
| 0.2 | Nov 23 rd , 2016 | Edit | | S. Piao |
| 2.0 | Dec 06 th , 2016 | Modification in response to TIMCO-TCB's comments | | S. Piao |
| 3.0 | Dec 20th, 2016 | Approver's signature added | A. Leung | S. Piao |



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ACRONYMS AND ABBREVIATIONS

| BTS | Base Transceiver Station |
|-------|---|
| CW | Continuous Wave |
| dB | deciBel (logarithmic ratio) |
| dBm | deciBels related to 1 Mw |
| DL | Downlink |
| EIRP | Effective Isotropic Radiated Power |
| GSM | Groupe Spéciale Mobile, Global System for Mobile communications |
| IF | Intermediate Frequency |
| IM | Inter-Modulation |
| kHz | kilo Hertz |
| LTE | Long Term Evolution |
| MHz | Mega Hertz |
| NF | Noise Figure |
| PCS | Personal Communications Service |
| RF | Radio Frequency |
| RX | Receiver |
| ТХ | Transmit |
| UL | Uplink |
| WCDMA | Wideband Code Division Multiple Access |
| | |



1 <u>Overview</u>

1.1 Scope

The purpose of this document is to present test results in the context of a full qualification test report for FCC Part 2, 22, 24, 27 as applicable to the equipment under test. The scope of this document is limited to the tests listed below in the downlink mode.

1.2 Attestation Statement

The device under test does fulfill the general approval requirements as identified in this test report.

This equipment has been tested in accordance with the standards identified in this test report. To the best of our knowledge and belief, these tests were performed using the measurement procedures described in this report. All instrumentation and accessories used to test products for compliance to the indicated standards are calibrated regularly in accordance with ISO 17025:2005 requirements.

We attest that the necessary measurements were made, under my supervision, at DALI WIRELESS, INC. located at 8618 Commerce Court, Burnaby, British Columbia, V5A 4N6, Canada.

Authorized Signatories:

Think Pin

Written by Sophie Piao Test Engineer Date: October 23rd, 2016

Approved by Andrew Leung VP Operations Date: December 20th, 2016

1.3 Report Summary

| Disclaimer | The test results relate only to the items tested. |
|----------------|--|
| Report Purpose | To demonstrate the DUT compliance with FCC Parts 2, 22, 24 and 27 requirements for a quad-band digital repeater. |



| Applicable Rule Parts | FCC CFR 47 Parts 2 Lower and Upper 700 MHz Band: 27.5(c), 27.50(c), 27.53(c, g) Cellular Band: 22.905, 22.913, 22.917 AWS-1 Band: 27.5(h), 27.50(d), 27.53(h) Broadband PCS Band: 24.229, 24.232, 24.238 |
|-----------------------|--|
| Test Procedures | ANSI/TIA-603-C: 2004; FCC KDB 935210 D05 v01r01, Feb 12, 2016; FCC KDB 971168 D01 v02r02, Oct 17, 2014; FCC KDB 971168 D03 v01, Jan 06, 2016 |

1.4 Test Environment

| Test Facilities | Tests were performed by Dali Wireless Inc. located at 8618 Commerce Court, Burnaby, BC, V5A 4N6, Canada. |
|-----------------|--|
| Test Conditions | Temperature: 25° C Relative Humidity: 60% Atmospheric Pressure: 98.1 kPa |

1.5 Test Setup

| Deviation to the rules | There was no deviation from the test standards. |
|-------------------------|--|
| Modification to the DUT | No modification was made to the DUT. |
| Test Exercise | The DUT was placed in continuous transmit mode of operation. |

1.6 Device Under Test Information

| Manufactured by | Dali Wireless Inc. |
|-----------------|---|
| DUT Description | 700, 850, PCS, AWS Remote Unit, Quad-Band Bi- directional Distributed System |



| FCC ID | HCOHD304NACEHIO1A |
|---|--|
| Model Name | HD30-4-NA-CEHI-O1H |
| Operating Frequency | Downlink 728 – 757 MHz, Downlink 869 – 894 MHz, Downlink 1930 – 1995 MHz, Downlink 2110 – 2155 MHz. |
| Emission Designators | 3K00GXW, 5M00D7W, 5M00G7D, 5M00G7W, 5M00W7D |
| Test Signals | Broadband: representative AWGN test signal with 4.1 MHz 99% occupied bandwidth; Narrowband: representative MSK modulation signal with a Gaussian Filter of 0.3 and a data rate of 270 kbps |
| User Power Range and Control | There are NO user power controls |
| Test Item | Production |
| DC Voltage and Current into final amplifier | 48V DC |
| Type of Equipment | Fixed |

1.7 Measurement Uncertainty

| Radio Frequency | ±1 ppm |
|----------------------------------|----------|
| Total RF Power: Conducted | ±1 dB |
| RF Power Density: Conducted | ±2.75 dB |
| Spurious Emissions: Conducted | ±3 dB |



| Temperature | ±1°C |
|----------------------------------|------|
| Humidity | ±5 % |
| DC and Low Frequency Voltages | ±3 % |

1.8 Equipment List

| Description | Manufacturer | Model | Serial Number | Cal Interval | Cal Due Date |
|----------------------|--------------|------------|------------------|--------------|--------------|
| Spectrum Analyzer | Agilent | EXA-N9010A | MY49061160 | 3 years | Mar-09-2018 |
| Signal Generator | Agilent | MXG-N5182B | MY53051862 | 2 years | Jun-27-2018 |

1.9 Test Procedure

General

The hd30 remote – EUT hereafter, is connected to the hdHost in a manner consistent with a typical installation. A digital modulation signal generator is connected to the TX_IN port of the appropriate band of the hdHost and spectrum analyzer is connected to the EUT downlink antenna port through an attenuator, nominally 40 dB for the band under consideration.

The 700 MHz (728 – 757 MHz), 850 MHz (869 – 894 MHz), PCS (1930-1995 MHz) and AWS (2110-2155 MHz) band was investigated. Measurements were performed with two types of test signals recommended by FCC KDB 935210 D05 v01r01. A quote is shown below:

3.0 Test Methods for CMRS Non-Consumer Repeater/Amplifier and Industrial Booster Devices 3.1 General

Commercial Mobile Radio Services (CMRS) non-consumer RF repeaters, amplifiers, and industrial boosters shall be tested for compliance with the applicable regulatory technical requirements. Input and output power and emissions measurements must be performed using test signals that are intended to bound the typical signal space encountered within the CMRS bands. Broadband amplifiers/boosters shall be tested using a representative band-limited AWGN signal. The AWGN test signal must have a 4.1 MHz 99 % occupied bandwidth (OBW) (representative of a 5 MHz LTE channel). Narrowband test signals shall use a representative MSK modulated signal, with a Gaussian Filter of 0.3 and a data rate of 270 kbps (representative of a GSM-TDMA signal).

In the tests reported here the LTE and GSM signals were used as the two test signal representatives:

- LTE (5MHz channel bandwidth representing wide band signal) and
- GSM (GMSK modulation with a Gaussian Filter of 0.3 and a data rate o 270kbs representing narrow band signal of about 200kHz bandwidth)

for the mid, lowest and highest frequency for declared bandwidths. The modulation types are described in detail in Table 1- Table 5.



Figure 1-1 Conducted Emission Test Setup Diagram



AGC Threshold Level

The measurement procedure used was KDB 935210 D05. AGC threshold level is measured by connecting a Spectrum Analyzer to the RF antenna port via an attenuator and a Signal Generator to the supporting device -hdHost RF source port.

A GSM signal was generated on the center frequency of the operating band under test. Channel power was measured using 1% of the emission bandwidth. AGC threshold level was determined when increasing the input signal amplitude 0.5dB will no longer cause 0.5dB increase in the output signal amplitude.

Out of Band Rejection

The measurement procedure used was KDB 935210 D05. The Signal Generator sent CW signal sweep in the range of $\pm 250\%$ of the passband. So is the Spectrum Analyzer span was set to. The RBW was set to 5% of the passband. An input signal level 5dB below the AGC threshold was injected. Two traces were obtained, via Max-Hold and Clear-Write. The peak frequency in the Max-Hold trace was recorded and would be allocated for the system gain and output power measurement.

Occupied Bandwidth – Input versus Output Signal Comparison

The measurement procedure used was KDB 935210 D05. Occupied Bandwidth is measured by connecting a Spectrum Analyzer to the RF output connector.

The required measurement resolution bandwidth (RBW) is 1% of the emission bandwidth. 99% energy rule was applied to measure the occupied channel bandwidth. The emission bandwidth is measured as the width of the signal between two frequency points on the channel edge, outside of which the transmission power is attenuated at least 26dB below the transmitter output power. The carrier allocated on the center frequency of the passband was investigated with input amplitude 0.5dB below the AGC threshold, for both input and output signal occupied band width. The output was then measured again with input amplitude 3dB above the AGC threshold.

RF Power Output

The measurement procedure used was KDB 971168 D01 Section 5.2.1. The EUT was configured to transmit continuously. RF power is measured by connecting a spectrum analyzer to the RF output connector. With an input power 0.5dB below and 3dB above the AGC threshold, respectively, the RF output is measured via Spectrum Analyzer's channel power function. The carrier was located at the peak frequency obtained in the out of band rejection measurement.

Out of Block Emissions



The measurement procedure used was KDB 935210 D05. The out of block emission was measured under two stimulus conditions. 1). Two adjacent test signal sequentially tuned to the lower and upper band edges; 2). A single test signal, sequentially tuned to the lowest and highest channels within the operating band. The intermodulation emission out of block was produced by the two carrier test signal as well. The peak emission was measured in 100kHz or 1MHz integrated bandwidth within 300kHz or 3MHz span immediate out of band, for carriers below or above 1GHz, respectively. The input power was set with two amplitude levels, i.e. 0.5dB below and 3dB above the AGC threshold level.

Spurious Emissions

The procedure used was ANSI/TIA-603-C: 2004. The spectrum was scanned from 9 kHz to at least the tenth harmonic of the fundamental using a spectrum analyzer. For digital modulation, the carrier is modulated to its maximum extent. The measurements were made in accordance with standard ANSI/TIA-603-C: 2004. The input power was set 0.5dB below the AGC threshold level. Simultaneous three carriers were allocated on the lowest, center and highest channels. The spurious emissions were then measured in the above range exclude the operating band \pm 300kHz or \pm 3MHz, in a reference bandwidth of 100kHz or 1MHz, for carriers below or above 1GHz, respectively.

Intermodulation Product Spurious Emissions

The procedure used was ANSI/TIA-603-C: 2004 and KDB 971168 D03. Three tones (modulated) method was used. Two tones are close to each other on the one edge and the third one is alone on the other edge of the passband. The input power to the amplifier was set to 0.5dB below the AGC threshold level by combining the three tones. The intermodulation product emissions were measured in band and spurious emissions were measured out of band.

1.10 Operational Description

Dali MatrixTM is a modular, end-to-end digital RF distribution system. Matrix is implemented in two tiers:

Modular Universal Base Station Interface Tray (UBiT) functioning as a headend

Modular digital remote units are for indoor and outdoor deployments. A single optical fiber interface, based on the CPRI protocol, is used to connect the *UBiT digital Host module* with a number of *hd30/37/43 remote* units, in a star, daisy-chain, or hybrid star/daisy-chain configuration. The *digital* remote units can be installed up to 20km away from the *UBiT headend*. Both *headend and remote units* contain a digital processing section and an RF processing section.

The UBit integrated headend typically interface RF signals with Base Stations via coaxial RF cables or digital baseband signal via optical fibers.

The remote unit hd30, which is the EUT in this test report is a quad band unit with 1 W average output power per band. Bands supported and scope of the requested license is as follows:

• Lower and Upper 700 MHz Band: 27.5(c), 27.50(c), 27.53(c,g)



- Cellular Band: 22.905, 22.913, 22.917 •
- AWS-1 Band: 27.5(h), 27.50(d), 27.53(h)
- Broadband PCS Band: 24.229, 24.232, 24.238

The band set that particular remote unit support is determined by the type of module that is installed in the unit, each containing frequency of operation limiting RF band-pass filters and band set specific multiplexer (please refer to Spectral management section).

It is marketed for commercial cellular applications. All band support broadband 2G, 3G, and 4G waveforms.

To maintain declared output power, and to prevent Power Amplifier (PA) to go into saturation condition, Automated Level Control (ALC) circuitry is implemented inside power amplifier section. The ALC circuitry monitors PA output power via built in average power detector, and if detected output power level is above threshold (set during manufacturing process), introduces attenuation in a PA lineup (PA gain reduction) that is equivalent to power difference between detected power and threshold power, hence maintains output power at level equal to ALC threshold level. The ALC attenuation range is from 0 dB to 30 dB. The ALC threshold level is set 1 dB above the declared maximum average output power, thus to +31 dBm in a case of the *hd30* remote unit.

| | | Table 1 | Test Signal Applied | |
|------------|------------|-------------------|------------------------|----------------------------------|
| Modulation | # Carriers | BW/Carrier | Notation Apply to Test | |
| GSM | 1 | 200kHz | GSM-1C | OBW, Pout, Out of Block Emission |
| GSM | 2 | 200kHz | GSM-2C | Out of Block Emission |
| GSM | 3 | 200kHz | GSM-3C | Spurious Emission |
| GSM | 3 | 200kHz | GSM-3TIM | Intermodulation |
| LTE | 1 | 5MHz | LTE-1C | OBW, Pout, Out of Block Emission |
| LTE | 2 | 5MHz | LTE-2C | Out of Block Emission |
| LTE | 3 | 5MHz | LTE-3C | Spurious Emission |
| LTE | 3 | 5MHz | LTE-3TIM | Intermodulation |

1.11 Measurement Configuration

Table 2 700 MHz DL Measurement Matrix

| Notation | Frequency (MHz) |
|----------|--|
| GSM-1C | 728.2, 742.5, 756.8 |
| GSM-2C | 728.2 and 728.4, or 756.6 and 756.8 ^a |
| GSM-3C | 728.2, 742.5, 756.8 |
| GSM-3TIM | 728.2, 728.8, 756.8 ^b |
| LTE-1C | 730.5, 742.5, 754.5 |
| LTE-2C | 730.5 and 735.5, or 749.5 and 754.5 ^a |
| LTE-3C | 730.5, 742.5, 754.5 |



| LTE-3TIM | 730.5, 735.5, 754.5 ^b | |
|----------|---|--|
| | a. 2 carriers on band edges | |
| | b. 2 carriers on the one edge 600kHz apart, the third on the other edge | |

Table 3 85

850 MHz DL Measurement Matrix

| Notation | Frequency (MHz) | | |
|----------|---|--|--|
| GSM-1C | 869.2, 881.5, 893.8 | | |
| GSM-2C | 869.2 and 869.4, or 893.6 and 893.8 ^a | | |
| GSM-3C | 869.2, 881.5, 893.8 | | |
| GSM-3TIM | 869.2, 869.8, 893.8 ^b | | |
| LTE-1C | 871.5, 881.5, 891.5 | | |
| LTE-2C | 871.5 and 876.5, or 886.5 and 891.5 ^a | | |
| LTE-3C | 871.5, 881.5, 891.5 | | |
| LTE-3TIM | 871.5, 876.5, 891.5 ^b | | |
| | a. 2 carriers on band edges | | |
| | b. 2 carriers on the one edge 600kHz apart, the third on the other edge | | |

Table 4 PCS DL Measurement Matrix

| Notation | Frequency (MHz) | |
|----------|---|--|
| GSM-1C | 1930.2, 1962.5, 1994.8 | |
| GSM-2C | 1930.2 and 1930.4, or 1994.6 and 1994.8 ^a | |
| GSM-3C | 1930.2, 1962.5, 1994.8 | |
| GSM-3TIM | 1930.2, 1931.4, 1991.6 ^b | |
| LTE-1C | 1932.5, 1962.5, 1992.5 | |
| LTE-2C | 1932.5 and 1937.5, or 1987.5 1992.5 ^a | |
| LTE-3C | 1932.5, 1962.5, 1992.5 | |
| LTE-3TIM | 1932.5, 1937.5, 1992.5 ^b | |
| | a. 2 carriers on band edges | |
| | b. 2 carriers on the one edge 1.2MHz apart, the third on the other edge | |

 Table 5
 AWS DL Measurement Matrix

| Notation | Frequency (MHz) |
|----------|--|
| GSM-1C | 2110.2, 2132.5, 2154.8 |
| GSM-2C | 2110.2 and 2110.4, or 2154.6 and 2154.8 ^a |
| GSM-3C | 2110.2, 2132.5, 2154.8 |
| GSM-3TIM | 2110.2, 2111.4, 2154.8 ^b |
| LTE-1C | 2112.5, 2132.5, 2152.5 |
| LTE-2C | 2112.5 and 2117.5, or 2147.5 and 2152.5 a |
| LTE-3C | 2112.5, 2132.5, 2152.5 |



| LTE-3TIM | 2112.5, 2117.5, 2152.5 ^b |
|-----------------------------|---|
| a. 2 carriers on band edges | |
| | b. 2 carriers on the one edge 1.2MHz apart, the third on the other edge |



2 AGC Threshold Level

2.1 Methodology

Measurements were performed at narrow band single carrier for the center frequency within the 700 MHz (728 – 757 MHz), 850 MHz (869 – 894 MHz), PCS (1930-1995 MHz) and AWS (2110-2155 MHz) band.

Tabular data is shown in section 2.3 for the all bands. The AGC threshold level is to provide the instruction of input signal amplitude for the emission in conducted measurement address in this report.

The AGC threshold was determined following test method defined in FCC KDB 935210 D05 (Feb 2016) Section 3.2.

2.2 Interpretation

The equipment under test (EUT) is featured automatic level control (ALC), which electronically adjusts the output power not exceed a certain maximum level. In order to align with the measurement guidance, the AGC threshold is used throughout the report, representing the ALC trip point (input power).

At amplitude above the AGC threshold, an increase of 1dB in the input power will no longer cause a 1dB increase in the output signal power.

AGC Threshold Levels

Table 6

| Band | Frequency (MHz) | Modulation | AGC Threshold (dBm) | Max Output Power (dBm) |
|------|--------------------|------------|------------------------|---------------------------|
| 700 | 742.5 | GSM | -8.5 | 30.2 |
| 850 | 881.5 | GSM | -6.0 | 30.4 |
| PCS | 1962.5 | GSM | -7 | 29.9 |
| AWS | 2132.5 | GSM | -7 | 30.4 |

2.3 Results

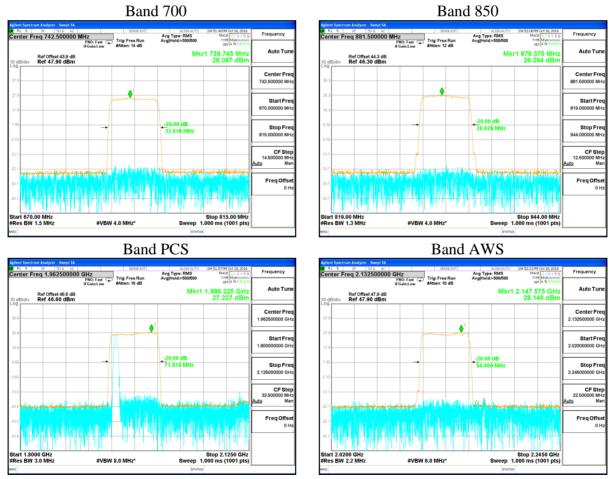


3 Out-of-band Rejection

3.1 Methodology

Measurements were performed at CW signal sweep in a frequency range of 5 times the operating bandwidth centered at the operating band. The operating bands are 700 MHz (728 – 757 sMHz), 850 MHz (869 – 894 MHz), PCS (1930-1995 MHz) and AWS (2110-2155 MHz) on the downlink – transmitting direction - where the air interface exists.

The measurement procedure follows the KDB 935210 D05 Section 3.3. The input power level was set 5dB lower than the AGC threshold level, so that no output suppression occurred in any of the EUT bands. 20dB down bandwidth was measured compared to the peak power in-band. The peak power frequency was recorded and would be used to check the EUT output power.



3.2 Results – Frequency Responses

Figure 3-1 Frequency Response of EUT

Table 7

AGC Threshold Levels



| Band | Operating Bandwidth (MHz) | Modulation | 20dB Passband (MHz) | Peak Frequency (MHz) |
|------|---------------------------------|------------|---------------------------|-------------------------|
| 700 | 29 | CW | 32.916 | 739.745 |
| 850 | 25 | CW | 28.625 | 879.375 |
| PCS | 65 | CW | 71.919 | 1986.225 |
| AWS | 45 | CW | 50.48 | 2147.575 |

4 Input-versus-output Signal Comparison

4.1 Methodology

Measurements were performed at narrow band and wide band signal for the mid frequency within the 700 MHz (730 – 755 MHz), 850 MHz (871 – 892 MHz), PCS (1930-1995 MHz) and AWS (2100-2155 MHz) band. Measurement method was following KDB 935210 D05 Section 3.4.

Occupied bandwidth (OBW) of input and output signal is shown in Figure 4-1 and Figure 4-2 side by side for the four operating bands. The output OBW was tested under two input conditions:

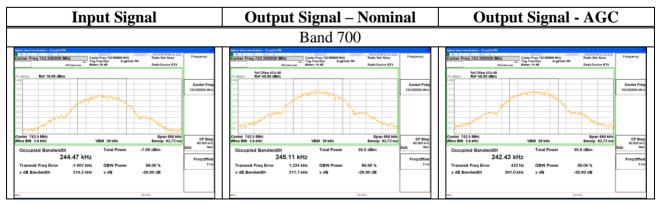
- Nominal: with input 0.5dB below AGC threshold
- AGC: with input 3dB above AGC threshold

A brief summary of applicable FCC specifications is listed in the table below.

2.1049 Measurements required: Occupied bandwidth. The occupied bandwidth, that is the frequency bandwidth such that, below its lower and above its upper frequency limits, the mean powers radiated are each equal to 0.5 percent of the total mean power radiated by a given emission shall be measured

4.2 Results – Occupied Bandwidth

Figure 4-1 Screen Captures of OBW Measurement – Input and Output Narrow Band Signal





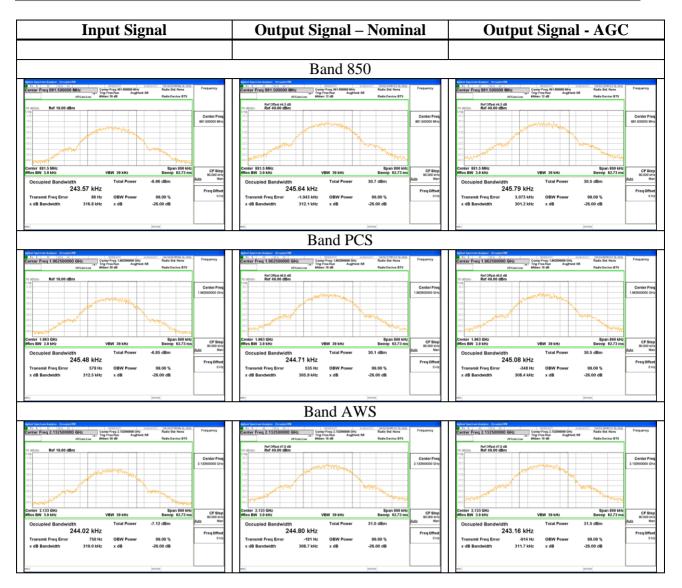


Figure 4-2 Screen Captures of OBW Measurement – Input and Output Wide Band Signal

| Input Signal | Output Signal – Nominal | Output Signal - AGC | |
|--------------|-------------------------|---------------------|--|
| Band 700 | | | |





Conclusion:

There is no change of the OBW comparing input and output signal. There is also no change of the OBW in the output signal when the EUT is working under AGC active or inactive status. The maximum deterioration observed is less than 1% of the input signal.



5 Output Power

5.1 Methodology

Measurements were performed at narrow band and wide band signal for the peak output power within the 700 MHz (728 – 757 MHz), 850 MHz (869 – 894 MHz), PCS (1930-1995 MHz) and AWS (2110-2155 MHz) band. Measurement method was following KDB 935210 D05 Section 3.4 and KDB 971168 D01 Section 5.2.1.

Average output power is shown in the Figure 5-1 and Figure 5-2 for the four operating bands. The output power was tested under two input conditions:

- Nominal: with input 0.5dB below AGC threshold
 - AGC: with input 3dB above AGC threshold

A brief summary of applicable FCC specifications is listed in the table below.

```
2.1046 Measurements required: RF power output.
```

(a) For transmitters other than single sideband, independent sideband and controlled carrier radiotelephone, power output shall be measured at the

RF output terminals when the transmitter is adjusted in accordance with the tune-up procedure to give the values of current and voltage on the circuit elements specified in § 2.1033(c)(8). The electrical characteristics of the radio frequency load attached to the output terminals when this test is made shall be stated.

5.2 Interpretation

The peak output power was allocated in the previous out-of-band rejection test. In the case that a full channel cannot accommodate in-band by setting the carrier frequency to the exact peak frequency, the test carrier location was moved inward to the first applicable channel.

5.3 Results

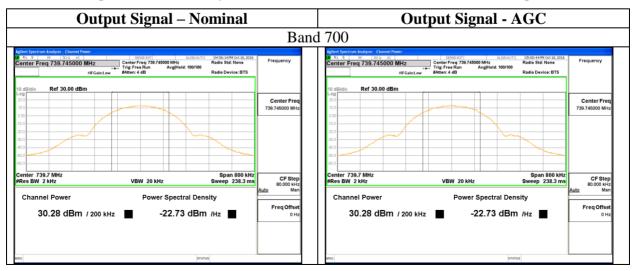
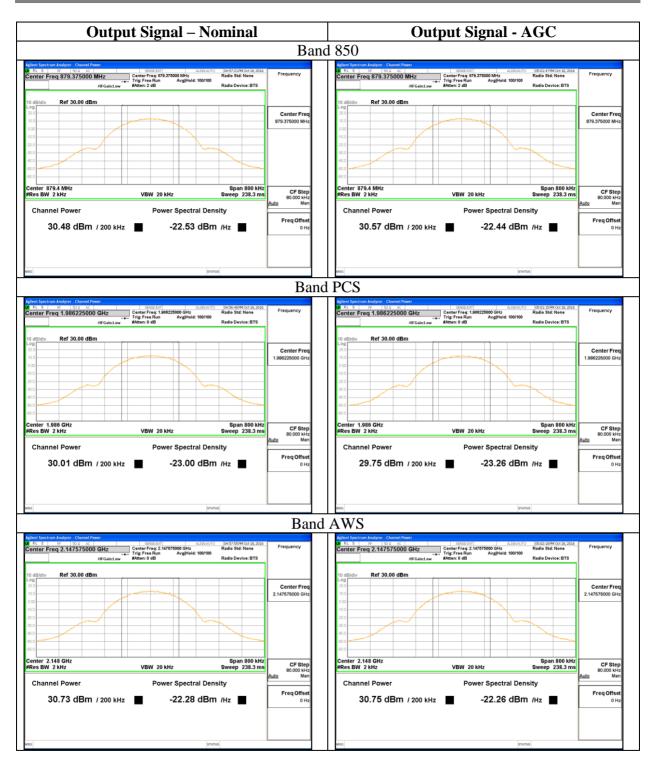


Figure 5-1 Screen Captures of Power Measurement – Narrow Band Signal







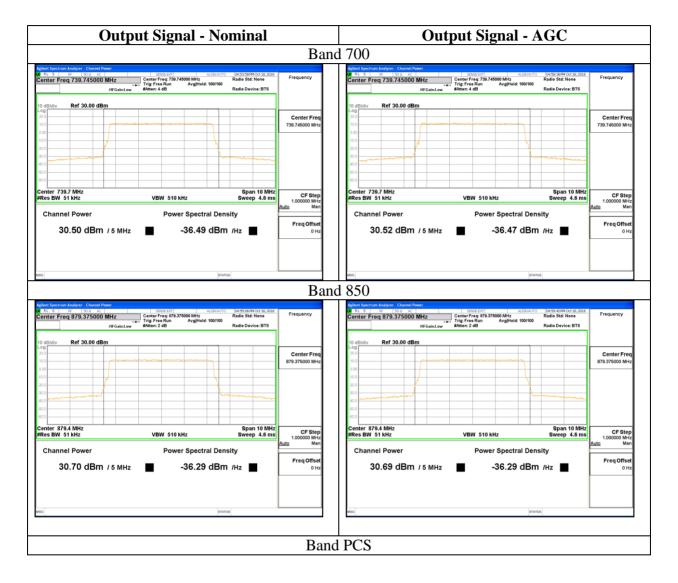


Figure 5-2 Screen Captures of Power Measurement – Wide Band Signal



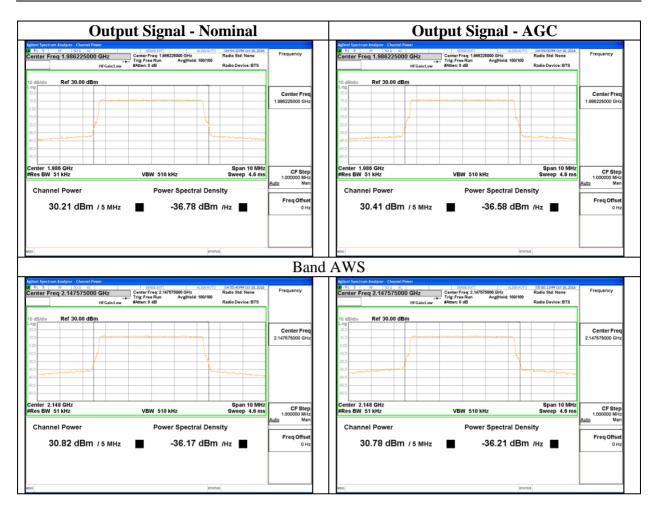


Table 8 EUT Maximum Output Power

| | Narrow Band Signal Pout (dBm) | | Wide Band Signal Pout (dBm) | |
|----------|-------------------------------|-------|-----------------------------|-------|
| | Nominal | AGC | Nominal | AGC |
| Band 700 | 30.28 | 30.28 | 30.5 | 30.52 |
| Band 850 | 30.48 | 30.57 | 30.7 | 30.69 |
| Band PCS | 30.01 | 29.75 | 30.21 | 30.41 |
| Band AWS | 30.73 | 30.75 | 30.82 | 30.78 |

Conclusion:

The maximum output power occurred on band AWS. The maximum output level was 30.8 dBm.

Due to the AGC feature, the output power with input 0.5 dB below and 3 dB above AGC threshold produced output power differencing less than 0.5dB, with narrow band or wide band signal.



6 Emission at Antenna Terminal

6.1 Methodology

All test conditions and measurement procedures were performed in accordance with FCC CFR47 part 2 subpart J Clause 2.1051. Detailed measurement method was following KDB 935210 D05 Section 3.6.

A brief summary of the applicable FCC specifications are listed in the table below.

2.1051 Measurements required: Spurious emissions at antenna terminals.

The radio frequency voltage or powers generated within the equipment and appearing on a spurious frequency shall be checked at the equipment output terminals when properly loaded with a suitable artificial antenna. Curves or equivalent data shall show the magnitude of each harmonic and other spurious emission that can be detected when the equipment is operated under the conditions specified in § 2.1049 as appropriate. The magnitude of spurious emissions which are attenuated more than 20 dB below the permissible value need not be specified.

2.1057 Frequency spectrum to be investigated.

(a) In all of the measurements set forth in §§ 2.1051 and 2.1053, the spectrum shall be investigated from the lowest radio frequency signal generated in the equipment, without going below 9 kHz, up to at least the frequency shown below:

(1) If the equipment operates below 10 GHz: to the tenth harmonic of the highest fundamental frequency or to 40 GHz, whichever is lower.

27.53 Emission limits.

(c) (1) For operations in the 746-758 MHz band and the 776-788 MHz band, the power of any emission outside the licensee's frequency band(s) of operation shall be attenuated below the transmitter power (P) within the licensed band(s) of operation, measured in watts, in accordance with the following:

On any frequency outside the 746-758 MHz band, the power of any emission shall be attenuated outside the band below the transmitter power (P) by at least $43 + 10 \log (P) dB$

(g)For operations in the 600 MHz band and the 698-746 MHz band, the power of any emission outside a licensee's frequency band(s) of operation shall be attenuated below the transmitter power (P) within the licensed band(s) of operation, measured in watts, by at least $43 + 10 \log (P) dB$. Compliance with this provision is based on the use of measurement instrumentation employing a resolution bandwidth of 100 kilohertz or greater. However, in the 100 kilohertz bands immediately outside and adjacent to a licensee's frequency block, a resolution bandwidth of at least 30 kHz may be employed.

(h) For operations in the 1710-1755 MHz and 2110-2155 MHz bands, the power of any emission outside a licensee's frequency block shall be attenuated below the transmitter power (P) by at least $43 + 10 \log_{10}$ (P) dB.

(1) Compliance with this provision is based on the use of measurement instrumentation employing a resolution bandwidth of 1 megahertz or greater. However, in the 1 megahertz bands immediately outside and adjacent to the licensee's frequency block, a resolution bandwidth of at least one percent of the emission bandwidth of the fundamental emission of the transmitter may be employed. The emission bandwidth is defined as the width of the signal between two points, one below the carrier center frequency and one above the carrier center frequency, outside of which all emissions are attenuated at least 26 dB below the transmitter power.

22.917 Emission limits.

(a) Out of band emissions. The power of any emission outside of the authorized operating frequency ranges must be attenuated below the transmitting power (P) by a factor of at least $43 + 10 \log(P) dB$.

24.238 Emission limitations for Broadband PCS equipment.

(a) Out of band emissions. The power of any emission outside of the authorized operating frequency ranges must be attenuated below the transmitting power (P) by a factor of at least $43 + 10 \log(P) dB$.

The limit is = -13 dBm.

6.2 Out-of-band Emission

6.2.1 Measurement Configuration

Measurements were performed at narrow band and wide band signal at the lower and upper edge within the 700 MHz (728 – 757 MHz), 850 MHz (869 – 894 MHz), PCS (1930-1995 MHz) and AWS (2110-2155 MHz) band.



Tests were repeated for single carrier and adjacent dual carriers, as defined in 3GPP, on first and last channel in the operating bands.

For each type of signal applied, tests were again repeated under two input conditions:

- Nominal: with input 0.5dB below AGC threshold
- AGC: with input 3dB above AGC threshold

The out-of-band emission was measured within specified frequency range at the edge of the authorized frequency band, 300kHz range for the frequency band below 1GHz and 3MHz range for the one above 1GHz. Normally the reference band width (RBW) in spurious emission measurement was specified to 100kHz for the frequency range below 1GHz and 1MHz for the frequency range above 1GHz. A relaxation of RBW is allowed to be applied to out-of-band emission measurement.

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This is often implemented by permitting the use of a narrower RBW (typically limited to a minimum RBW of 1% of the OBW) for measuring the out-of-band emissions without a requirement to integrate the result over the full reference bandwidth. Beyond the specified frequency range in which this relaxation is permitted, it is also typically acceptable to use a narrower RBW (again limited to a minimum of 1% of OBW) in order to increase accuracy, but the measurement result must subsequently be integrated over the full reference bandwidth.

6.2.2 Results

The immediate out-of-band emission measurement is shown in the Figure 6-1, Figure 6-2, Figure 6-3 and Figure 6-4 for the four operating bands.

Conclusion:

The peak out-of-band emission caused by any of the following combination – narrow band signal vs wide band signal, single carrier vs dual carriers, and nominal input vs input above AGC threshold - is below -13dBm limit.

The narrow band signal is allocated more close to the band edge than the wide band signal, in terms of absolute guard band due to OBW is less than the 3GPP authorized channel bandwidth. Hence the emission caused by narrow band signal is higher than wide band signal.

The band isolation of EUT in the frequency range farther than 1MHz from the band edge plays the main role of suppressing the emission. Hence the intermodulation product of dual-carrier wide band signal shows the lowest emission.

With the input power level above the AGC threshold, higher level emission was observed on narrow band signal compared to no AGC triggered. It worsened the emission by less than 4dB, but still lower than -13dBm limit.

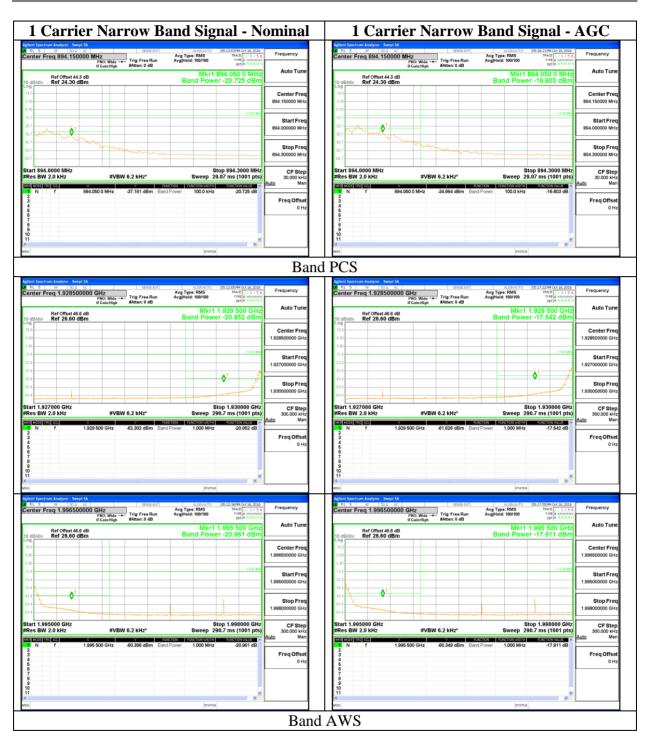
Figure 6-1 Out-of-band Emission in 300kHz or 3GHz Range – 1 Carrier Narrow Band Signal Applied on First or Last Channel in the Appropriate Operating Band

| 1 Carrier Narrow Band Signal - Nominal | 1 Carrier Narrow Band Signal - AGC | |
|--|------------------------------------|--|
| Band 700 | | |



| Carrier Narrow Band Signal - N | ominal | 1 Carrier Narrow Band Signal - AGC |
|--|-----------------------------------|--|
| 15pectrum Analyzer - Swept 54 SDIGE-EXT AUD/AUTO 05:00 / AC 15 19 50 / AC SDIGE-EXT AUD/AUTO 05:00 / AC 15 19 50 / AC SDIGE-EXT AUD/AUTO 05:00 / AC No 16 17 Trig: Free Run Avg[Held: 100/100 Trig: A No No 16 16:01 / 10 4.0 0.0 B Cert AH 114H AVector No No | Frequency | Agent Systems Navign's Sweet 34 States 647 August 100 (06.15.27746 Col.28, 2016) 0 4.1.9 4 5 6 7 5 7 5 7 5 7 5 7 5 7 5 7 5 7 5 7 5 |
| Ref Offiset 433 dB Mkr1 727.950 0 MHz Juliw Ref 23.90 dBm Band Power -21.663 dBm | | Ref Offiset 43.9 dB Mkr1 727.950 0 MHz 10 dB/div Ref 23.90 dBm Band Power -17.224 dBm |
| 1000 1000 1000 1000 1000 1000 1000 100 | Center Freq 727.850000 MHz | 119 Center 300 0 727 80000 0 727 80000 |
| | Start Freq 727.700000 MHz | 3 1 277,70000 |
| | Stop Freq 728.000000 MHz | 661 728.00000 661 728.00000 |
| 1 727.7000 MHz Stop 728.0000 MHz s BW 2.0 kHz #VBW 6.2 kHz* Sweep 29.07 ms (1001 pts) s BW 2.0 kHz x 1001 pts) | CF Step 30.000 kHz Auto Man | Start 727.7000 MHz Stop 728.0000 MHz #Res BW 2.0 kHz #VBW 6.2 kHz* Stop 728.0000 MHz grade BW 6.2 kHz* Stop 728.0000 MHz 30.000 grade BW 6.2 kHz* Stop 728.0000 MHz 30.000 grade BW 6.2 kHz* Stop 728.0000 MHz 30.000 |
| N 1 f 727.9500 MHz 40.347 dBm Band Power 100.0 MHz -21.663 dB | Freq Offset 0 Hz | N 1 7 727,950 0 MHz 38,446 dBm Band Power 100,0 MHz -17,224 dB 5 6 9 9 9 10 10 10 10 10 10 10 10 10 10 |
| ISpectrum Analyzer - Sweyt SA ISPECTURE Analyzer - Sweyt SA 5 6F 200 AC ISPECE EXT ALIZNAUTO DS 10.221MI Oct 10, 2016 | | K Status |
| ter Freq 757.150000 MHz PHO: Wide ++ PHO: Wide ++ PHO: Wide ++ Ref Coffmet 43.9 dB Ref Offmet 43.9 dB Ref Offmet 43.9 dB | Frequency Auto Tune | 00 R.t. 5 #F 300 AC MIDELET ALSPAND DISELEMENTAL Frequency Center Freq 757.150000 MHz PROVING PROVING PROVING Avg Type: RNN More Type: RNN Auto Type: RNN |
| Ref 23.90 dBm Band Power -21.251 dBm | Center Freq 757.150000 MHz | 10 dBiddin Ref 23.90 dBm Band Power -17.318 dBm Center 1 19 19 751 16000 751 16000 751 16000 |
| | Start Freq 757.000000 MHz | 6 10 6 11 3 1 3 1 5 1 5 1 5 1 5 1 5 1 5 1 5 1 5 |
| | Stop Freq 757.300000 MHz | 141 141 15100 1510 1 |
| t 757.0000 MHz Stop 757.3000 MHz BW 2.0 kHz #VBW 6.2 kHz* Sweep 29.07 ms (1001 pts) | CF Step 30.000 kHz Auto Man | Start 757.0000 MHz #Res BW 2.0 kHz #VBW 6.2 kHz* Sweep 29.07 ms (1001 pts) |
| 2006 [DOV BOOL X Y DOWEDD ROWEDDWWOM ROWEDDWWOE A N 1 f 757.050 0 MHz -38.425 dBm Band Power 100.0 kHz -21.261 dB | Freq Offset | DE RUCE HINE POZ 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 |
| | | |
| atanua a | | 11 < |
| | Ba | nd 850 |
| December Analyzer Sweig MA to Bar 200 AC 1 SUBLEDT ALDRAND 051257M-Oct 28,2016 ter Freg 868.8500000 MHZ Fig: Freg 868.8500000 MHZ Fig: Freg 868.8500000 MHZ Fig: Freg 868.8500000 MHZ Fig: Freg 868.8500000 MHZ | Frequency | B R. 10 BF SIM |
| If Calculting Action: 0 dB Output Mkr1 868, 950 0 MHz Bef Offset 44.3 dB Mkr1 868, 950 0 MHz Band Power -20.258 dBm | Auto Tune | rGaileritigs Anten: 0 dB certANINAN Ref Offset 43.03 dB Band Power -10.781 dBm |
| | Center Freq 868.850000 MHz | 123 Center 1 430 689.85000 |
| | Start Freq 868.700000 MHz | 167 267 267 277 |
| | Stop Freq 869.000000 MHz | 4.7 4.7 4.7 |
| 1 868.7000 MHz Stop 869.0000 MHz 8 868.7000 MHz #VBW 6.2 kHz* Sweep 29.07 ms (1001 pts) 호전 [전력 등요 · · · · · · · · · · · · · · · · · · | CF Step 30.000 kHz Auto Man | Start 888.7000 MHz #VEW 6.2 kHz* Stop 869.0000 MHz CF € #Res BW 2.0 kHz #VEW 6.2 kHz* Sweep 29.07 ms (1001 pts) 30.000 CEX (005 Ms (2a) > 201500 ms (1001 pts) Adde |
| N 1 f 868.960 0 MHz -36.617 dBm Band Power 100.0 kHz -20.266 dB | Freq Offset 0 Hz | N F 968.950 0 MHz -35.743 dBm Band Power 100.0 kHz -16.791 dB Freq OI 3 6 5 |
| | | |
| , | | 10 |







| IF Gain: High | Avg Type: RMS Trig: Free Run Avg[Hold: 100/100 | 05:14:43PM Oct 18, 2016 TRACE 11:2 3 4 5 6 Triff A WWWWW DET A NN N N N | | Avg Type: RMS TRACE 2 3 4 5 6 Free Run Avg[Hold: 100/100 Type A WARNAN DET A NUMBER A | Frequency |
|---|---|---|---|--|---------------------------------|
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| 0 | | 2.10850000 GHz | 17.9 7.90 | | Center Fre 2.108500000 GF |
| 1 | | -13 00 d0n Start Freq 2.107000000 GHz | -121 -221 | | Start Fre 2.107000000 GF |
| | | Stop Freq 2.11000000 GHz | 421 | | Stop Fre 2.110000000 GF |
| rt 2.107000 GHz es BW 2.0 kHz #VI | | top 2.110000 GHz 90.7 ms (1001 pts) 2005-001/0244 | Start 2.107000 GHz #Res BW 2.0 kHz #VBW 6.2 kl | FUNCTION FUNCTION WIDTH FUNCTION VALUE | CF Ste 300.000 kł Auto Mi |
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| | | | 8 9 10 | | |
| nt Spectrum Analyzer - Swept SA | STATUS | | MBG Agilent Spectrum Analyzer - Swept SA | STATUS | |
| LS RF 50 Q AC hter Freq 2.156500000 GHz PN0: Wide IE Gain:High | SENSE:EXT ALIGNAUTO Avg Type: RMS Avg Hold: 100/100 #Atten: 0 dB | 05:15:16PM Oct 18,2016 TRACE 12:3:4:5:6 TYPE & WOMMON OET A NN N N N | Center Freq 2.156500000 GHz | SENSE:EXT ALIGNAUTO 12:52:17 PM Oct 20, 2016 Avg Type: RMS TRACE 12:3:45:5 Free Run Avg Hold: 100/100 TVRE A MAMANAN n: 0 dB CEEI A NNINEN | Frequency |
| Ref Offset 47.9 dB IB/div Ref 27.90 dBm | | 2.155 500 GHz er -20.491 dBm | Ref Offset 47.9 dB 10 dB/div Ref 27.90 dBm | Mkr1 2.155 500 GHz Band Power -22.668 dBm | Auto Tur |
| | | Center Freq 2.156500000 GHz | 7.9 7.90 | | Center Fre 2.156500000 GH |
| | | | | -13.00 obe | |
| | | -13.00 (Br) 2.155000000 GHz | -12.1 -22.1 | | Start Fre 2.155000000 GF |
| ¢1 | | Start Freq | -22.1 | | |
| 1 2.155000 GHz s BW 2.00 KHz s W 2.00 KHz | | Start Freq 2:15500000 GHz Stop Freq 2:1580000 GHz 0:7 ms (100 Fpt) 0:7 ms (100 Fpt) | Start 2.155000 CHz RRes BW 2.0 kHz Prove BW 2.0 kHz Prove BW 2.0 kHz | Stop 2.158000 GHz Hz* Sweep 290.7 ms (1001 pts) | 2.155000000 GF |

Figure 6-2 Out-of-band Emission in 300kHz or 3GHz Range – 1 Carrier Wide Band Signal Applied on First or Last Channel in the Appropriate Operating Band

| 1 Carrier Wide Band Signal - Nominal | | 1 Carrier Wide Band Signal - AGC | | |
|--|-------------------------------|--|--|--|
| | Band | 700 | | |
| Mar Spectra Andrez - Swep 54. 8 ≤ 8 w 5 00 x 6 50 x 6 500 x | | Address Systems Railways, Sweys SA BANG Safe BANG Safe BANG Safe Frequency Statistics Safe Safe Safe Safe Avg Type: RMMS BANG Safe Safe Frequency Center Freq 727.850000 MHz Frig. Water ++ Trig: Free Run Avg Type: RMMS BANG Safe Safe Safe Safe Safe Safe Safe Safe | | |
| Price Hale - #Aften: 0 dB cell A UNION cell | Auto Tune | Projektige Factors of B Control Contro | | |
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| | Start Freq 727.700000 MHz | Start Freq 727.70000 MHz | | |
| | Stop Freq 728.00000 MHz | -8.1 Stop Freq 728.00000 MHz | | |
| art 727.7000 MHz Stop 728.0000 MHz tes BW 100 kHz #VBW 300 kHz* Sweep 1.000 ms (1001 pts) 2003 BB 201 X V Rominou Antenoward Antenoward Antenoward Antenoward Antenoward Antenoward Antenoward Antenoward | 30.000 kHz | Start 727.7000 MHz Stop 728.0000 MHz CF Step #Res BW 100 kHz #VBW 300 kHz* Sweep 1.000 ms (1001 pts) 30.000 kHz Use model are less X Romotolit Blockborrowick Auto N 1 7.22.08m Man Auto Man | | |
| N 1 F 727.969 6 MHz -16.736 dBm 3 4 6 7 | Freq Offset 0 Hz | N 1 f 727.9913 MHz -16.272 dBm 3 Freq Offset 4 6 5 7 | | |
| | | 9 9 11 | | |
| STATUS | | MSG STATUS | | |







| 1 Carrier Wide Ba | nd Signal - Nor | minal | 1 Carrier Wide Band Signal - AGC |
|--|---|------------------------------------|---|
| nt Spectrum Analyzer - Swept SA L 5 PP 500 AC STREEDUT tter Freq 1.928500000 GHz PNC: Wide → Fig: Free Run Fischartigh Acten: 0 dB | ALEMANTO (05:08:49PM Oct 18, 2016 Avg Type: RMS (12:3:4:5:6 Avg[Hold: 100/100 (2017) DET (A.H.N.N.N.N. | Frequency | Agineti Spectrum Analyzer, Swept SA Spectrum Analyzer, Swept SA Augustation Option 201 Reset Sa Product Sa Frequency If it is in the second of the se |
| Ref Offset 46.6 dB IB/div Ref 26.60 dBm | Mkr1 1.929 500 GHz Band Power -21.358 dBm | Auto Tune | Ref offset 45.5 dB Mkr1 1.929 500 GHz Auto Tune 10 dB/div Ref 26.60 dBm Band Power -20.875 dBm Auto Tune |
| | | Center Freq 1.928500000 GHz | 16.6 Center Freq 1.92850000 GHz 1.92850000 GHz |
| | -1300 dBm | Start Freq 1.927000000 GHz | |
| | | Stop Freq 1.93000000 GHz | 334 Stop Free 324 193000000 6H |
| rt 1.927000 GHz es BW 100 kHz #VBW 300 kHz* | Stop 1.930000 GHz Sweep 1.000 ms (1001 pts) | CF Step 300.000 kHz | Start 1.927000 GHz #Res BW 100 kHz #VBW 300 kHz" Sweep 1.000 ms (100 tpt) 300.00 Hz 300.000 Hz |
| N 1 f 1.929 500 GHz -33.959 dBm Ban | | Auto Man | Image rates (ring size) X Y Punction worth Function worth |
| | aratua | Freq Offset 0 Hz | 3 FreqOffse 4 0 Hi 5 0 Hi 6 0 Hi 7 0 9 10 11 c c c c c c c c c c c c c c c c c c c |
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| Ter Freq 1.3955000000 GHZ PR0: Wide → Trig: Free Run #Ref Offset 46.5 dB B/div Ref 25.60 dBm | Avg Type: RMS Avg Heid: 100/100 Mkr1 1.995 500 GHz Band Power -20.858 dBm | Auto Tune | Center Freq 1.996500000 CHz PHO: Wida Frequency Trig: Free Run Avg Type: RMS Avg Type: RMS Trig: Frequency Frequency PhO: Wida PHO: Wida Free Run For anizing Trig: Free Run Ref Offset 46.5 dB Avg Type: RMS Trig: Free Run Augleid: 100/100 Trig: Ref Offset Ref Offset 46.5 dB Frequency 10 dBidler Ref Offset 46.5 dB Band Power - 20.887 dBm Auto Tum |
| | | Center Freq 1.996500000 GHz | Caller Free 1.99600000 GH |
| ▲ ▲ ▲ ▲ ▲ ▲ ▲ ▲ ▲ ▲ ▲ ▲ ▲ ▲ ▲ ▲ ▲ ▲ ▲ | -13.00 dbm | Start Freq 1.995000000 GHz | 3.0 |
| | | Stop Freq | 104 Stop Free 19800000 0H |
| t 1.995000 GHz s BW 100 kHz #VBW 300 kHz* | Stop 1.998000 GHz Sweep 1.000 ms (1001 pts) | CF Step 300.000 kHz | Start 1.995000 GHz #W100 kHz \$Stop 1.998000 GHz CF Step 3.000 ms (100 pts) #Res BW 100 kHz #VBW 300 kHz* Sweep 1.000 ms (100 pts) 3.0000 kHz |
| | NCTION FUNCTION WIDTH FUNCTION VALUE | Auto Man Freq Offset | Instruction Instruction Instruction Instruction Auto Max N F 1.996 500 GHz -33.839 dBm Bund Power 1.000 MHz -30.857 dB Freq Offse 3 |
| | | 0 Hz | 4 6 0H 6 0H |
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| | STATUS | Bond | and interval AWS |
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| ter Freq 2.108500000 GHz PNO: Wide Trig: Free Run IFGain:High #Atten: 0 dB | Avg Type: RMS Avg Hold: 100/100 DET A NNNNN | Frequency Auto Tune | Center Freq 2.108500000 GHz PIC: Wilde → Trig: Free Run IFGalkitigh #Atten: 0 dB Avg[Hold: 100/100 Cer[A.IN.N.N.N. |
| Ref Offset 47.9 dB B/div Ref 27.90 dBm | Mkr1 2.109 500 GHz Band Power -16.239 dBm | | 10 dB/div Ref 27.90 dBm Band Power -15.070 dBm |
| | | Center Freq 2.108500000 GHz | 7:9 7:0 2:10 2:10 |
| | | Start Freq 2.10700000 GHz | 221 221 231 231 |
| | | Stop Freq 2.11000000 GHz | 0:1 Stop Free 0:1 2.11000000 GH |
| t 2.107000 GHz s BW 100 kHz #VBW 300 kHz* | Stop 2.110000 GHz Sweep 1.000 ms (1001 pts) | CF Step 300.000 kHz Auto Man | Start 2.107000 GHz #VEW 300 KHz* Stop 2.110000 GHz CF Step Sweep 1.000 ms (1001 pts) Comparing the start 2 201000 Hz 1000 ms (1001 pts) Address |
| 2006 Httle Box X Y H N 1 f 2.109 500 GHz -27.046 dBm Ban | | Freq Offset | International Example 2:109 500 GHz -25:550 dBm Eand Power 1.000 MHz -15:070 dB 2 3 |
| | | | 6 7 |
| | | | 8 9 10 11 |