# Wireless Test Report

## FCC ID: 2AAUJ-C002

## FCC Rule Part: 15.209
## ISED Canada Radio Standards Specification: RSS-210

## TÜV SÜD Report Number: 16-3026.W06.1A

**Manufacturer**: Viableware, Inc.

**Model:** TS-CS5

Test Begin Date: **March 21, 2017**
Test End Date: **March 31, 2017**

Report Issue Date: May 5, 2017

FOR THE SCOPE OF ACCREDITATION UNDER LAB Code AT-1921

This report must not be used by the client to claim product certification, approval, or endorsement by ANAB, ANSI, or any agency of the Federal Government.

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# 1 GENERAL

## 1.1 Purpose

The purpose of this report is to demonstrate compliance with Part 15 Subpart C of the FCC's Code of Federal Regulations and ISED Canada's Radio Standards Specification RSS-210.

## 1.2 Product description

The TS-CS is comprised of 5 wireless charging ports. It is based on the Qi standard, version 1.0.2 for wireless power transfer, a loosely coupled inductive charging system. The dock contains transmitter design A1 of the Qi specification which is basically a series loaded LC resonant half bridge converter which operates within 110kHz to 205kHz to provide 5W of power to the receiver circuit. Due to the nature of the LC resonance, a quasi-sinusoidal current waveform is induced in the receiver coil, which is full-wave rectified. This power is then used to feed the battery charger. The whole system can be seen as a 'smart transformer' with loosely coupled primary and secondary windings.

The transmitter and receiver communicate by modulating the power signal with a specific protocol to monitor energy transmission to achieve a target system efficiency and thus control the power transmitter using PWM signals. Both transmitter and receiver are capable of measuring power and thus perform various system control strategies, e.g. efficiency, foreign object detection and fault detection

**Technical Information:**
Frequency of Operation: 110 - 205 kHz
Number of Channels: 1
Modulation: Load modulation on the receiver side for load management only.
Data Rate: N/A
Antenna Type: Near-Field Magnetic Coil Antenna
Antenna Gain: N/A – Power transferred by near-field magnetic induction between coupled coils.
Input Voltage: 120VAC/60Hz

**Manufacturer Information:**
Viableware, Inc.
12220 - 113th Ave, NE Suite 210
Kirkland, WA 98034
USA

**EUT Serial Numbers**: Sample # 22

**Test Sample Condition**: The test samples were provided in good working order with no visible defects.

## 1.3 Test Methodology and Considerations

For radiated emissions as well as AC powerline conducted emissions, The EUT was evaluated as all trays were loaded with the dummy test rails being charged at 100%, 50%, and 0% charge rates respectively. All the results for each charging rate are reported in the present document.

# 2 TEST FACILITIES

## 2.1 Location

The radiated and conducted emissions test sites are located at the following address:

TÜV SÜD America Inc.
2320 Presidential Drive, Suite 101
Durham, NC 27703
Phone: (919) 381-4235

## 2.2 Laboratory Accreditations/Recognitions/Certifications

TÜV SÜD America Inc. is accredited to ISO/IEC 17025 by ANSI-ASQ National Accreditation Board under their ANAB program and has been issued certificate number AT-1921 in recognition of this accreditation. Unless otherwise specified, all test methods described within this report are covered under the ISO/IEC 17025 scope of accreditation.

The Semi-Anechoic Chamber Test Site and Conducted Emissions Site have been fully described, submitted to, and accepted by the FCC and Innovation, Science and Economic Development (ISED) Canada.

FCC Registered Test Site Number: 637011
ISED Canada Test Site Registration Number: 20446

## 2.3 Radiated Emissions Test Site Description

### 2.3.1 Semi-Anechoic Chamber Test Site

The Semi-Anechoic Chamber Test Site consists of a 18' x 28' x 18' shielded enclosure. The chamber is lined with Samwha Electronics Co. LTD Ferrite Absorber, model number SFA300 (HSN-1). The ferrite tile is 10cm x 10 cm and weighs approximately 1.4lbs. These tiles are mounted on steel panels and installed directly on the inner walls of the chamber. On top of the ferrite tiles is DMAS HT-45 (Dutch Microwave Absorber Solutions) hybrid absorber on all walls except the wall behind the antenna mast which has a shorter DMAS HT-25 absorber.

The turntable is 1.50m in diameter and is located 150cm from the back wall of the chamber. The chamber is grounded via 1 - 8' copper ground rod, installed at the center of the back wall, it is bound to the ground plane using short #6 copper wire. The turntable is all steel, flush mounted table installed in an all steel frame. The table is remotely operated from inside the control room located 25' from the turntable. The turntable is electrically bonded to the surrounding ground plane via steel fingers installed on the edge of the turn table. The steel fingers make constant contact with the ground plane.

Behind the turntable is a 2' x 6' x 1.5' deep shielded pit used for support equipment if necessary. The pit is equipped with 2 - 4" PVC chase from the turntable to the pit that allow for cabling to the EUT if necessary. The underside of the turntable can be accessed from the pit so cables can be supplied to the EUT from the pit.

A diagram of the Semi-Anechoic Chamber Test Site is shown in Figure 2.3-1 below:

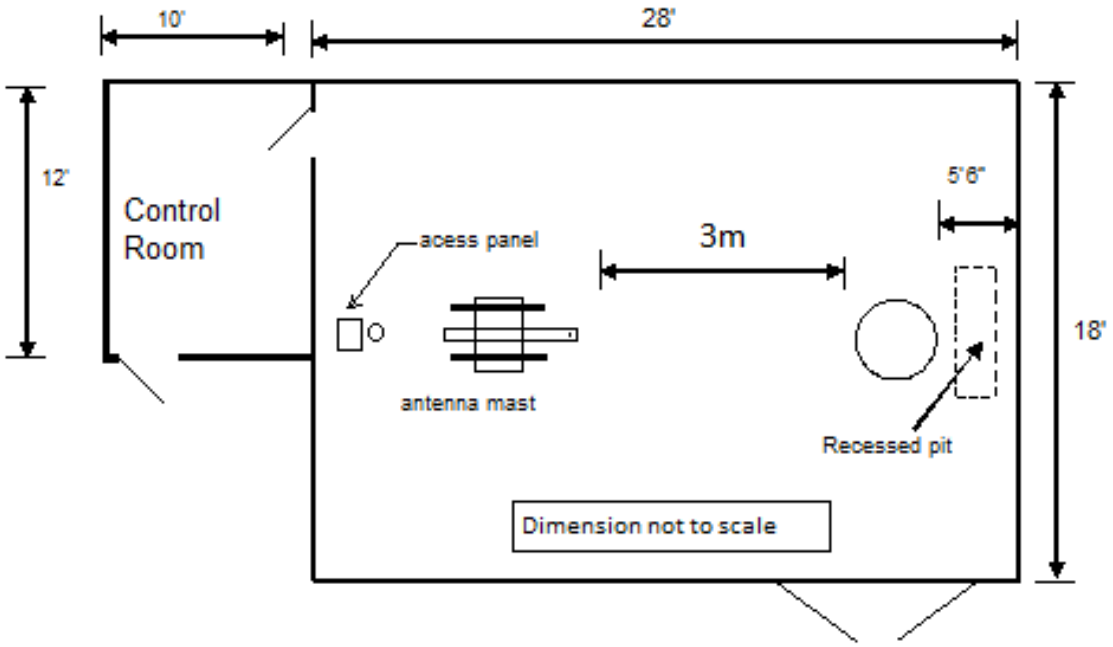


**Figure 2.3-1: Semi-Anechoic Chamber Test Site**

## 2.4 Conducted Emissions Test Site Description

The AC mains conducted EMI site is located in the main EMC lab. It consists of an 8’ x 10’ sheet galvanized steel horizontal ground reference plane (GRP) bonded every 6” to an 8’ X 8’ aluminum vertical ground plane.

A diagram of the room is shown below in figure 2.4-1:

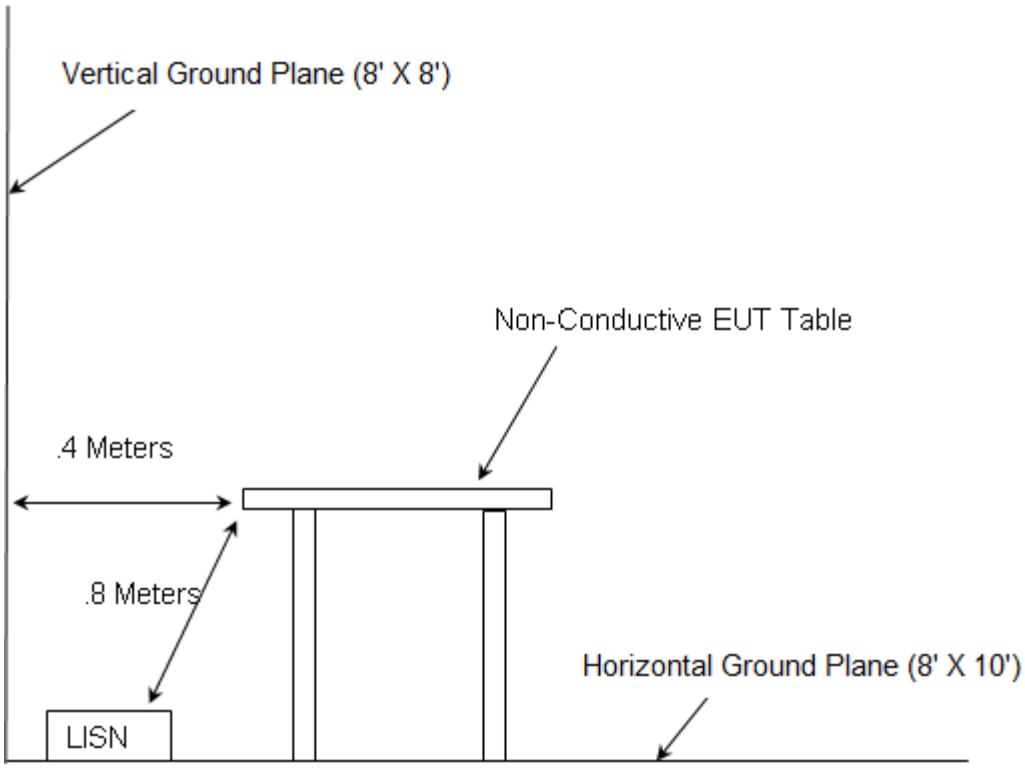


**Figure 2.4-1: AC Mains Conducted EMI Site**

## 3 APPLICABLE STANDARD REFERENCES

The following standards were used:

- ANSI C63.4-2014: American National Standard for Methods of Measurement of Radio-Noise Emissions from low-voltage electrical and electronic equipment in the range of 9kHz to 40 GHz.
- ANSI C63.10-2013: American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices
- US Code of Federal Regulations (CFR): Title 47, Part 15, Subpart C: Radio Frequency Devices, Intentional Radiators, 2016
- Industry Canada Radio Standards Specification: RSS-210 - Low-power License-exempt Radiocommunication Devices (All Frequency Bands): Category I Equipment, Issue 8 December 2010.
- Industry Canada Radio Standards Specification: RSS-216 - Wireless Power Transfer Devices, Issue 2 January 2016.
- ISED Canada Radio Standards Specification: RSS-GEN – General Requirements for Compliance of Radio Apparatus, Issue 4, Nov 2014

## 4 LIST OF TEST EQUIPMENT

The calibration interval of test equipment is annually or the manufacturer's recommendations. Where the calibration interval deviates from the annual cycle based on the instrument manufacturer's recommendations, it shall be stated below.

**Table 4-1: Test Equipment** Table 4.1.2-1 Test Equipment – Radiated Emissions

| Asset ID | Manufacturer | Model # | Equipment Type | Serial # | Last Calibration Date | Calibration Due Date |
|---|---|---|---|---|---|---|
| 277 | EMCO | 93146 | Antennas | 9904-5199 | 9/12/2016 | 9/12/2018 |
| 731 | EMCO | 3104 | Antennas | 2659 | 11/09/2016 | 11/09/2018 |
| 626 | EMCO | 3110B | Antennas | 9411-1945 | 3/21/2017 | 3/21/2019 |
| 628 | EMCO | 6502 | Antennas | 9407-2877 | 02/11/2016 | 02/11/2018 |
| 3002 | Rohde & Schwarz | ESU40 | Receiver | 100346 | 1/12/2017 | 1/12/2018 |
| 3011 | Rohde & Schwarz | ENV216 | LISN | 3011 | 1/12/2017 | 1/12/2018 |
| 3012 | Rohde & Schwarz | EMC32-EB | Software | 100731 | NCR | NCR |
| 3038 | Florida RF Labs | NMSE-290AW-60.0-NMSE | Cable Set | 1448 | 1/3/2017 | 1/3/2018 |
| 3039 | Florida RF Labs | NMSE-290AW-396.0-NMSE | Cable Set | 1447 | 1/3/2017 | 1/3/2018 |
| 3051 | Mountain View Cable | BMS-RG400-264.0-BMS | Cables | 3051 | 1/3/2017 | 1/3/2018 |

NCR = No Calibration Required
Firmware Version: ESU40 is 4.73 SP4
Software Version: EMC32-B is 9.15

## 5 SUPPORT EQUIPMENT

**Table 5-1: Support Equipment**

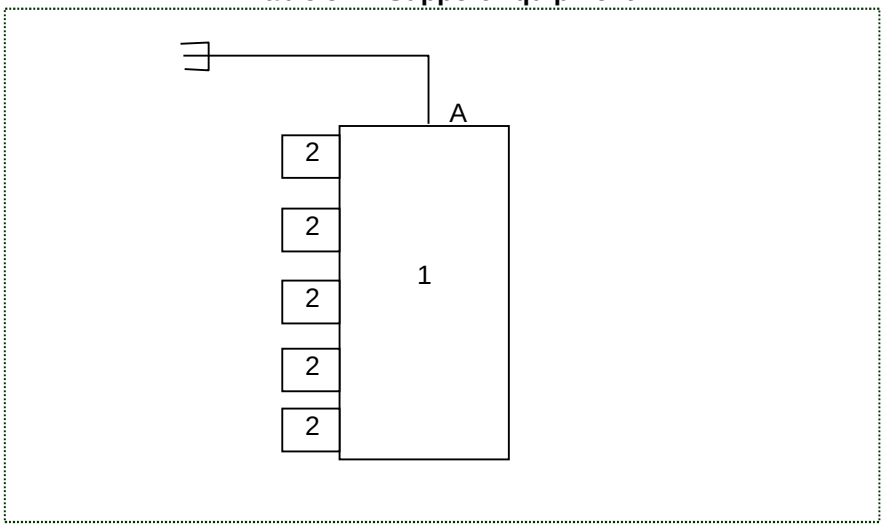


Table 3.3-1: EUT and Support Equipment Description

| Item # | Type Device | Manufacturer | Model/Part # | Serial # |
|---|---|---|---|---|
| 1 | EUT | TableSafe, Inc. | TS-CS5 | Sample #22 |
| 2 | Test rails (5) | TableSafe, Inc | N/A | Samples #9-13 |

Table 3.3-2: Cable Description

| Cable # | Cable Type | Length | Shield | Termination |
|---|---|---|---|---|
| A | Power | 1.5 m | No | EUT to AC Mains |

# 6 SUMMARY OF TESTS

Along with the tabular data shown below, plots were taken of all signals deemed important enough to document.

## 6.1 Power Line Conducted Emissions – FCC: 15.207; ISED Canada: RSS-Gen 8.8

### 6.1.1 Measurement Procedure

ANSI C63.10-2013 section 6 was the guiding document for this evaluation. Conducted emissions were performed from 150kHz to 30MHz with the spectrum analyzer's resolution bandwidth set to 9kHz and the video bandwidth set to 30kHz. The calculation for the conducted emissions is as follows:

**Corrected Reading = Analyzer Reading + LISN Loss + Cable Loss**
**Margin = Applicable Limit - Corrected Reading**

### 6.1.2 Measurement Results

**Table 7.2.2-1: Conducted EMI Results – Line 1, 100% Charge Rate**

| Frequency (MHz) | QuasiPeak (dBµV) | Average (dBµV) | Limit (dBµV) | Margin (dB) | Meas. Time (ms) | Bandwidth (kHz) | Line | Filter | Corr. (dB) |
|---|---|---|---|---|---|---|---|---|---|
| 0.496000 | --- | 24.38 | 46.06 | 21.68 | 2000.0 | 9.000 | L1 | OFF | 9.6 |
| 0.496000 | 41.22 | --- | 56.06 | 14.84 | 2000.0 | 9.000 | L1 | OFF | 9.6 |
| 0.752000 | 43.14 | --- | 56.00 | 12.86 | 2000.0 | 9.000 | L1 | OFF | 9.6 |
| 0.752000 | --- | 26.46 | 46.00 | 19.54 | 2000.0 | 9.000 | L1 | OFF | 9.6 |
| 0.796000 | 44.27 | --- | 56.00 | 11.73 | 2000.0 | 9.000 | L1 | OFF | 9.6 |
| 0.796000 | --- | 30.97 | 46.00 | 15.03 | 2000.0 | 9.000 | L1 | OFF | 9.6 |
| 1.124000 | --- | 26.76 | 46.00 | 19.24 | 2000.0 | 9.000 | L1 | OFF | 9.6 |
| 1.124000 | 43.68 | --- | 56.00 | 12.32 | 2000.0 | 9.000 | L1 | OFF | 9.6 |
| 1.488000 | --- | 29.08 | 46.00 | 16.92 | 2000.0 | 9.000 | L1 | OFF | 9.7 |
| 1.488000 | 41.34 | --- | 56.00 | 14.66 | 2000.0 | 9.000 | L1 | OFF | 9.7 |
| 2.208000 | --- | 30.65 | 46.00 | 15.35 | 2000.0 | 9.000 | L1 | OFF | 9.7 |
| 2.208000 | 40.46 | --- | 56.00 | 15.54 | 2000.0 | 9.000 | L1 | OFF | 9.7 |
| 3.540000 | --- | 32.34 | 46.00 | 13.66 | 2000.0 | 9.000 | L1 | OFF | 9.8 |
| 3.540000 | 42.85 | --- | 56.00 | 13.15 | 2000.0 | 9.000 | L1 | OFF | 9.8 |
| 3.776000 | --- | 32.18 | 46.00 | 13.82 | 2000.0 | 9.000 | L1 | OFF | 9.8 |
| 3.776000 | 42.49 | --- | 56.00 | 13.51 | 2000.0 | 9.000 | L1 | OFF | 9.8 |
| 16.878000 | --- | 33.82 | 50.00 | 16.18 | 2000.0 | 9.000 | L1 | OFF | 10.0 |
| 16.878000 | 40.84 | --- | 60.00 | 19.16 | 2000.0 | 9.000 | L1 | OFF | 10.0 |
| 17.882000 | --- | 32.98 | 50.00 | 17.02 | 2000.0 | 9.000 | L1 | OFF | 10.1 |
| 17.882000 | 40.65 | --- | 60.00 | 19.35 | 2000.0 | 9.000 | L1 | OFF | 10.1 |

**Table 7.2.2-2: Conducted EMI Results – Line 2, 100% Charge Rate**

| Frequency (MHz) | QuasiPeak (dBµV) | Average (dBµV) | Limit (dBµV) | Margin (dB) | Meas. Time (ms) | Bandwidth (kHz) | Line | Filter | Corr. (dB) |
|---|---|---|---|---|---|---|---|---|---|
| 0.150000 | --- | 40.90 | 56.00 | 15.10 | 2000.0 | 9.000 | N | OFF | 9.6 |
| 0.150000 | 54.32 | --- | 66.00 | 11.68 | 2000.0 | 9.000 | N | OFF | 9.6 |
| 0.720000 | --- | 21.79 | 46.00 | 24.21 | 2000.0 | 9.000 | N | OFF | 9.6 |
| 0.720000 | 38.67 | --- | 56.00 | 17.33 | 2000.0 | 9.000 | N | OFF | 9.6 |
| 0.820000 | --- | 21.81 | 46.00 | 24.19 | 2000.0 | 9.000 | N | OFF | 9.6 |
| 0.820000 | 39.36 | --- | 56.00 | 16.64 | 2000.0 | 9.000 | N | OFF | 9.6 |
| 1.416000 | --- | 25.34 | 46.00 | 20.66 | 2000.0 | 9.000 | N | OFF | 9.6 |
| 1.416000 | 39.72 | --- | 56.00 | 16.28 | 2000.0 | 9.000 | N | OFF | 9.6 |
| 3.324000 | --- | 29.89 | 46.00 | 16.11 | 2000.0 | 9.000 | N | OFF | 9.7 |
| 3.324000 | 40.28 | --- | 56.00 | 15.72 | 2000.0 | 9.000 | N | OFF | 9.7 |
| 4.272000 | --- | 32.22 | 46.00 | 13.78 | 2000.0 | 9.000 | N | OFF | 9.8 |
| 4.272000 | 40.71 | --- | 56.00 | 15.29 | 2000.0 | 9.000 | N | OFF | 9.8 |
| 4.988000 | --- | 30.01 | 46.00 | 15.99 | 2000.0 | 9.000 | N | OFF | 9.8 |
| 4.988000 | 39.66 | --- | 56.00 | 16.34 | 2000.0 | 9.000 | N | OFF | 9.8 |
| 15.382000 | --- | 34.02 | 50.00 | 15.98 | 2000.0 | 9.000 | N | OFF | 10.0 |
| 15.382000 | 42.88 | --- | 60.00 | 17.12 | 2000.0 | 9.000 | N | OFF | 10.0 |
| 16.770000 | --- | 35.18 | 50.00 | 14.82 | 2000.0 | 9.000 | N | OFF | 10.0 |
| 16.770000 | 42.48 | --- | 60.00 | 17.52 | 2000.0 | 9.000 | N | OFF | 10.0 |
| 17.778000 | --- | 36.01 | 50.00 | 13.99 | 2000.0 | 9.000 | N | OFF | 10.1 |
| 17.778000 | 43.69 | --- | 60.00 | 16.31 | 2000.0 | 9.000 | N | OFF | 10.1 |

**Table 7.2.2-1: Conducted EMI Results – Line 1, 50% Charge Rate**

| Frequency (MHz) | QuasiPeak (dBµV) | Average (dBµV) | Limit (dBµV) | Margin (dB) | Meas. Time (ms) | Bandwidth (kHz) | Line | Filter | Corr. (dB) |
|---|---|---|---|---|---|---|---|---|---|
| 0.400000 | --- | 26.66 | 47.71 | 21.05 | 2000.0 | 9.000 | L1 | OFF | 9.6 |
| 0.400000 | 36.53 | --- | 57.73 | 21.20 | 2000.0 | 9.000 | L1 | OFF | 9.6 |
| 0.664000 | --- | 30.45 | 46.00 | 15.55 | 2000.0 | 9.000 | L1 | OFF | 9.6 |
| 0.664000 | 39.96 | --- | 56.00 | 16.04 | 2000.0 | 9.000 | L1 | OFF | 9.6 |
| 0.872000 | --- | 28.52 | 46.00 | 17.48 | 2000.0 | 9.000 | L1 | OFF | 9.6 |
| 0.872000 | 41.52 | --- | 56.00 | 14.48 | 2000.0 | 9.000 | L1 | OFF | 9.6 |
| 1.848000 | --- | 23.85 | 46.00 | 22.15 | 2000.0 | 9.000 | L1 | OFF | 9.7 |
| 1.848000 | 36.86 | --- | 56.00 | 19.14 | 2000.0 | 9.000 | L1 | OFF | 9.7 |
| 3.552000 | --- | 31.38 | 46.00 | 14.62 | 2000.0 | 9.000 | L1 | OFF | 9.8 |
| 3.552000 | 39.73 | --- | 56.00 | 16.27 | 2000.0 | 9.000 | L1 | OFF | 9.8 |
| 3.568000 | --- | 28.56 | 46.00 | 17.44 | 2000.0 | 9.000 | L1 | OFF | 9.8 |
| 3.568000 | 38.68 | --- | 56.00 | 17.32 | 2000.0 | 9.000 | L1 | OFF | 9.8 |
| 10.206000 | --- | 30.10 | 50.00 | 19.90 | 2000.0 | 9.000 | L1 | OFF | 9.9 |
| 10.206000 | 38.34 | --- | 60.00 | 21.66 | 2000.0 | 9.000 | L1 | OFF | 9.9 |
| 11.286000 | --- | 33.35 | 50.00 | 16.65 | 2000.0 | 9.000 | L1 | OFF | 9.9 |
| 11.286000 | 41.64 | --- | 60.00 | 18.36 | 2000.0 | 9.000 | L1 | OFF | 9.9 |
| 12.206000 | --- | 32.81 | 50.00 | 17.19 | 2000.0 | 9.000 | L1 | OFF | 10.0 |
| 12.206000 | 40.43 | --- | 60.00 | 19.57 | 2000.0 | 9.000 | L1 | OFF | 10.0 |
| 14.970000 | --- | 26.10 | 50.00 | 23.90 | 2000.0 | 9.000 | L1 | OFF | 10.0 |
| 14.970000 | 36.69 | --- | 60.00 | 23.31 | 2000.0 | 9.000 | L1 | OFF | 10.0 |

**Table 7.2.2-2: Conducted EMI Results – Line 2, 50% Charge Rate**

| Frequency (MHz) | QuasiPeak (dBµV) | Average (dBµV) | Limit (dBµV) | Margin (dB) | Meas. Time (ms) | Bandwidth (kHz) | Line | Filter | Corr. (dB) |
|---|---|---|---|---|---|---|---|---|---|
| 0.154000 | --- | 29.37 | 55.76 | 26.39 | 2000.0 | 9.000 | N | OFF | 9.6 |
| 0.154000 | 46.82 | --- | 65.76 | 18.94 | 2000.0 | 9.000 | N | OFF | 9.6 |
| 0.728000 | --- | 15.87 | 46.00 | 30.13 | 2000.0 | 9.000 | N | OFF | 9.6 |
| 0.728000 | 33.70 | --- | 56.00 | 22.30 | 2000.0 | 9.000 | N | OFF | 9.6 |
| 2.000000 | --- | 29.68 | 46.00 | 16.32 | 2000.0 | 9.000 | N | OFF | 9.7 |
| 2.000000 | 37.53 | --- | 56.00 | 18.47 | 2000.0 | 9.000 | N | OFF | 9.7 |
| 3.600000 | 38.66 | --- | 56.00 | 17.34 | 2000.0 | 9.000 | N | OFF | 9.7 |
| 3.600000 | --- | 29.59 | 46.00 | 16.41 | 2000.0 | 9.000 | N | OFF | 9.7 |
| 3.652000 | 38.92 | --- | 56.00 | 17.08 | 2000.0 | 9.000 | N | OFF | 9.7 |
| 3.652000 | --- | 27.88 | 46.00 | 18.12 | 2000.0 | 9.000 | N | OFF | 9.7 |
| 3.780000 | --- | 29.61 | 46.00 | 16.39 | 2000.0 | 9.000 | N | OFF | 9.8 |
| 3.780000 | 38.59 | --- | 56.00 | 17.41 | 2000.0 | 9.000 | N | OFF | 9.8 |
| 9.738000 | --- | 30.40 | 50.00 | 19.60 | 2000.0 | 9.000 | N | OFF | 9.9 |
| 9.738000 | 38.66 | --- | 60.00 | 21.34 | 2000.0 | 9.000 | N | OFF | 9.9 |
| 11.614000 | --- | 35.25 | 50.00 | 14.75 | 2000.0 | 9.000 | N | OFF | 10.0 |
| 11.614000 | 42.30 | --- | 60.00 | 17.70 | 2000.0 | 9.000 | N | OFF | 10.0 |
| 11.774000 | --- | 34.08 | 50.00 | 15.92 | 2000.0 | 9.000 | N | OFF | 10.0 |
| 11.774000 | 42.88 | --- | 60.00 | 17.12 | 2000.0 | 9.000 | N | OFF | 10.0 |
| 14.826000 | --- | 27.66 | 50.00 | 22.34 | 2000.0 | 9.000 | N | OFF | 10.0 |
| 14.826000 | 40.39 | --- | 60.00 | 19.61 | 2000.0 | 9.000 | N | OFF | 10.0 |

**Table 7.2.2-1: Conducted EMI Results – Line 1, 0% Charge Rate**

| Frequency (MHz) | QuasiPeak (dBµV) | Average (dBµV) | Limit (dBµV) | Margin (dB) | Meas. Time (ms) | Bandwidth (kHz) | Line | Filter | Corr. (dB) |
|---|---|---|---|---|---|---|---|---|---|
| 0.744000 | --- | 25.46 | 46.00 | 20.54 | 2000.0 | 9.000 | L1 | OFF | 9.6 |
| 0.744000 | 39.65 | --- | 56.00 | 16.35 | 2000.0 | 9.000 | L1 | OFF | 9.6 |
| 1.432000 | --- | 24.97 | 46.00 | 21.03 | 2000.0 | 9.000 | L1 | OFF | 9.7 |
| 1.432000 | 35.33 | --- | 56.00 | 20.67 | 2000.0 | 9.000 | L1 | OFF | 9.7 |
| 3.040000 | --- | 27.95 | 46.00 | 18.05 | 2000.0 | 9.000 | L1 | OFF | 9.7 |
| 3.040000 | 37.87 | --- | 56.00 | 18.13 | 2000.0 | 9.000 | L1 | OFF | 9.7 |
| 3.660000 | --- | 27.82 | 46.00 | 18.18 | 2000.0 | 9.000 | L1 | OFF | 9.8 |
| 3.660000 | 36.34 | --- | 56.00 | 19.66 | 2000.0 | 9.000 | L1 | OFF | 9.8 |
| 9.946000 | --- | 31.73 | 50.00 | 18.27 | 2000.0 | 9.000 | L1 | OFF | 9.9 |
| 9.946000 | 39.96 | --- | 60.00 | 20.04 | 2000.0 | 9.000 | L1 | OFF | 9.9 |
| 13.654000 | --- | 28.70 | 50.00 | 21.30 | 2000.0 | 9.000 | L1 | OFF | 10.0 |
| 13.654000 | 37.76 | --- | 60.00 | 22.24 | 2000.0 | 9.000 | L1 | OFF | 10.0 |
| 14.730000 | --- | 34.88 | 50.00 | 15.12 | 2000.0 | 9.000 | L1 | OFF | 10.0 |
| 14.730000 | 43.58 | --- | 60.00 | 16.42 | 2000.0 | 9.000 | L1 | OFF | 10.0 |
| 14.822000 | --- | 30.33 | 50.00 | 19.67 | 2000.0 | 9.000 | L1 | OFF | 10.0 |
| 14.822000 | 40.07 | --- | 60.00 | 19.93 | 2000.0 | 9.000 | L1 | OFF | 10.0 |
| 15.258000 | --- | 32.32 | 50.00 | 17.68 | 2000.0 | 9.000 | L1 | OFF | 10.0 |
| 15.258000 | 40.46 | --- | 60.00 | 19.54 | 2000.0 | 9.000 | L1 | OFF | 10.0 |
| 19.594000 | --- | 26.12 | 50.00 | 23.88 | 2000.0 | 9.000 | L1 | OFF | 10.1 |
| 19.594000 | 33.39 | --- | 60.00 | 26.61 | 2000.0 | 9.000 | L1 | OFF | 10.1 |

**Table 7.2.2-2: Conducted EMI Results – Line 2, 0% Charge Rate**

| Frequency (MHz) | QuasiPeak (dBµV) | Average (dBµV) | Limit (dBµV) | Margin (dB) | Meas. Time (ms) | Bandwidth (kHz) | Line | Filter | Corr. (dB) |
|---|---|---|---|---|---|---|---|---|---|
| 0.780000 | --- | 20.86 | 46.00 | 25.14 | 2000.0 | 9.000 | N | OFF | 9.6 |
| 0.780000 | 36.85 | --- | 56.00 | 19.15 | 2000.0 | 9.000 | N | OFF | 9.6 |
| 3.012000 | --- | 27.71 | 46.00 | 18.29 | 2000.0 | 9.000 | N | OFF | 9.7 |
| 3.012000 | 36.09 | --- | 56.00 | 19.91 | 2000.0 | 9.000 | N | OFF | 9.7 |
| 3.840000 | --- | 22.05 | 46.00 | 23.95 | 2000.0 | 9.000 | N | OFF | 9.8 |
| 3.840000 | 32.96 | --- | 56.00 | 23.04 | 2000.0 | 9.000 | N | OFF | 9.8 |
| 9.118000 | --- | 28.73 | 50.00 | 21.27 | 2000.0 | 9.000 | N | OFF | 9.9 |
| 9.118000 | 36.06 | --- | 60.00 | 23.94 | 2000.0 | 9.000 | N | OFF | 9.9 |
| 14.210000 | --- | 31.09 | 50.00 | 18.91 | 2000.0 | 9.000 | N | OFF | 10.0 |
| 14.210000 | 40.59 | --- | 60.00 | 19.41 | 2000.0 | 9.000 | N | OFF | 10.0 |
| 14.490000 | --- | 30.18 | 50.00 | 19.82 | 2000.0 | 9.000 | N | OFF | 10.0 |
| 14.490000 | 40.52 | --- | 60.00 | 19.48 | 2000.0 | 9.000 | N | OFF | 10.0 |
| 14.986000 | --- | 29.22 | 50.00 | 20.78 | 2000.0 | 9.000 | N | OFF | 10.0 |
| 14.986000 | 39.50 | --- | 60.00 | 20.50 | 2000.0 | 9.000 | N | OFF | 10.0 |
| 15.522000 | --- | 32.53 | 50.00 | 17.47 | 2000.0 | 9.000 | N | OFF | 10.0 |
| 15.522000 | 41.14 | --- | 60.00 | 18.86 | 2000.0 | 9.000 | N | OFF | 10.0 |
| 15.578000 | --- | 30.73 | 50.00 | 19.27 | 2000.0 | 9.000 | N | OFF | 10.0 |
| 15.578000 | 37.92 | --- | 60.00 | 22.08 | 2000.0 | 9.000 | N | OFF | 10.0 |
| 18.030000 | --- | 27.10 | 50.00 | 22.90 | 2000.0 | 9.000 | N | OFF | 10.1 |
| 18.030000 | 35.59 | --- | 60.00 | 24.41 | 2000.0 | 9.000 | N | OFF | 10.1 |

# 7 SUMMARY OF TESTS

Along with the tabular data shown below, plots were taken of all signals deemed important enough to document.

## 7.1 Antenna Requirement – FCC: Section 15.203

The model TS-CS uses an internal coil antenna that is directly soldered to the PCB. The antenna cannot be removed without damaging the product, thus meeting the requirements of FCC Section 15.203.

## 7.2 20dB / 99% Bandwidth: FCC: Section 15.209 / IC RSS-Gen 4.6.1

### 7.2.1 Measurement Procedure

The EUT was rotated through 360° and the receive antenna height was varied from 1m to 4m so that the maximum radiated emissions level would be detected.

The spectrum analyzer span was set to 2 to 5 times the estimated 20 dB bandwidth of the signal. The RBW was to ≥ 1% to 5% of the estimated emission bandwidth. The trace was set to max hold using a peak detector and the reference level was set to the highest amplitude observed. The bandwidth was measured 20 dB down from the reference level using the delta function of the analyzer.

The 99% occupied bandwidth was measured with the spectrum analyzer span set to fully display the emission, including the emissions skirts. The RBW was greater or equal to 1% of the span. The occupied 99% bandwidth was measured by using a delta marker at the lower and upper frequencies leading to 0.5% of the total power.

### 7.2.2 Measurement Results

Results are shown below in Table 7.2.2-1 and Figures 7.2.2-1 through 7.2.2-2

**Table 7.2.2-1: 20dB / 99% Bandwidth**

| Frequency [MHz] | 20dB Bandwidth [kHz] | 99% Bandwidth [kHz] |
|---|---|---|
| 0.13132 | 13.557 | 12.211 |

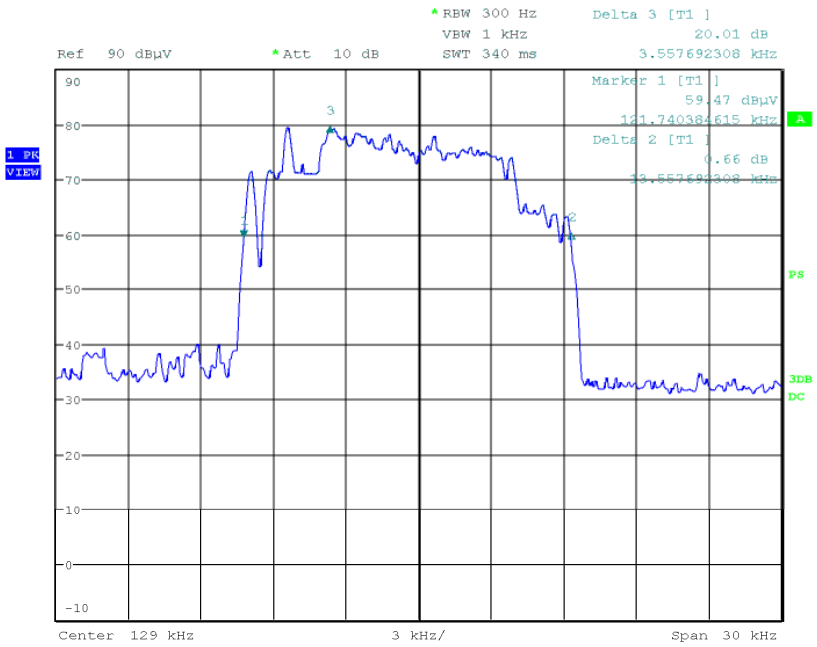


**Figure 7.2.2-1: 20dB Bandwidth**

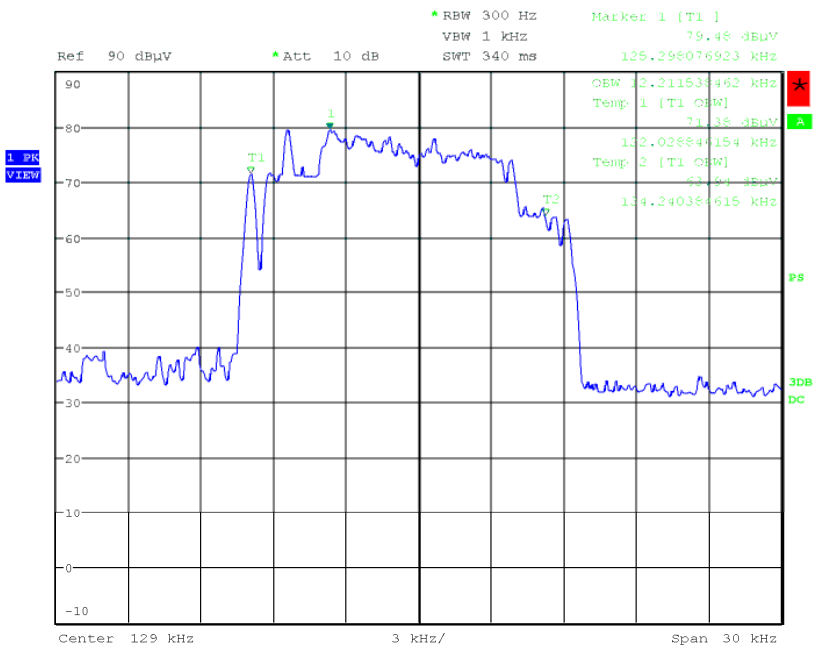


**Figure 7.2.2-2: 99% OBW**

## 7.3 Radiated Spurious Emissions – FCC: Section 15.209 / IC: RSS-210 2.5

### 7.3.1 Measurement Procedure

Radiated emissions tests were made over the frequency range of 10 kHz to 1GHz. Section 15.33(a)(4) specifies, if the intentional radiator contains a digital device, regardless of whether this digital device controls the functions of the intentional radiator or the digital device is used for additional control or function purposes other than to enable the operation of the intentional radiator, the frequency range shall be investigated up to frequency specified in 15.33(b)(1) for unintentional radiators. The upper frequency range for the digital device is 1000MHz which greater than the $10_{th}$ harmonic of the fundamental frequency. The upper frequency range measured was 1000MHz.

Measurements below 30MHz were performed in a semi-anechoic chamber with a 3 meter separation distance between the EUT and measurement antenna. The EUT was rotated 360 and the loop antenna rotated about the vertical axis to maximize each emission. The magnetic loop receiving antenna was positioned with its center 1 meter above the ground.

The spectrum analyzer's resolution and video bandwidth were set to 300 Hz and 1000 Hz respectively for frequencies below 150 kHz and 9 kHz and 30 kHz respectively for frequencies above 150 kHz and below 30 MHz. The fundamental levels were measured using a resolution bandwidth of 20 kHz which is greater than the measured emission bandwidth, and a video bandwidth of 100kHz. For measurements in the frequency bands 9-90 kHz and 110-490 kHz, an average detector was used. When average measurements are specified, the peak emissions were also compared to a limit corresponding to 20 dB above the maximum permitted average limit according to Part 15.35. All other emissions were measured using a Quasi-peak detector. The final measurements were then corrected by antenna correction factors and cable loss for comparison to the limits.

Measurements above 30 MHz were performed in a semi-anechoic chamber with a 3 meter separation distance between the EUT and measurement antenna. The EUT was rotated through 360° and the receive antenna height was varied from 1m to 4m so that the maximum radiated emissions level would be detected. For frequencies below 1000 MHz, quasi-peak measurements were made using a resolution bandwidth (RBW) of 120 kHz and a video bandwidth (VBW) of 300 kHz.

### 7.3.2 Distance Correction for Measurements Below 30 MHz – Part 15.31

Radiated measurements were performed at a distance closer than 300 meters and 30m as required, according to Part 15.209. Therefore, a correction factor was applied to account for propagation loss at the specified distance. The propagation loss was determined by using the square of an inverse linear distance extrapolation factor (40dB/decade) according to 15.31. A sample calculation of the distance correction factor is shown below for limits expressed at a 300m measurement distance and a 30m measurement distance.

Distance correction factor (300m Specified Test Distance) = 40*Log (Test Distance/300)
= 40*Log (3/300)
= - 80 dB

Distance correction factor (30m Specified Test Distance) = 40*Log (Test Distance/30)
= 40*Log (3/30)
= - 40 dB

All the emission found was compared to the radiated emission limits as defined in section 15.209.

The EUT was evaluated during 0%, 50%, and 100% charging rate. The radiated emissions for all 3 cases are reported.

### 7.3.2.1 Measurement Results

**Table 7.2.2.3-1: Radiated Emissions – 100% charge rate**

| Frequency (MHz) | Level (dBuV) | | Antenna Polarity | Correction Factors | Corrected Level (dBuV/m) | | Limit (dBuV/m) | | Margin (dB) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | pk | Qpk/Avg | (H/V) | (dB) | pk | Qpk/Avg | pk | Qpk/Avg | pk | Qpk/Avg |
| **Fundamental Emission** | | | | | | | | | | |
| 0.13132 | 82.62 | 76.77 | H | 10.43 | 93.05 | 87.20 | 125.2 | 105.2 | 32.1 | 18.0 |
| **Spurious Emissions** | | | | | | | | | | |
| 0.39396 | 55.68 | 49.12 | H | 10.40 | 66.08 | 59.52 | 115.7 | 95.7 | 49.6 | 36.2 |
| 0.6566 | | 37.90 | H | 10.60 | --------- | 48.50 | -------- | 71.3 | --------- | 22.8 |
| 0.91924 | | 34.50 | H | 10.90 | --------- | 45.40 | -------- | 68.3 | --------- | 22.9 |
| 1.18188 | | 30.20 | H | 11.25 | --------- | 41.45 | -------- | 66.2 | --------- | 24.7 |
| 1.44452 | | 26.90 | H | 11.17 | --------- | 38.07 | -------- | 64.4 | --------- | 26.3 |
| 1.70716 | | 23.60 | H | 11.09 | --------- | 34.69 | -------- | 69.5 | --------- | 34.8 |
| **Emissions above 30 MHz** | | | | | | | | | | |
| 43.78 | 19.70 | 9.50 | H | 12.72 | --------- | 22.22 | -------- | 40.0 | --------- | 17.8 |
| 118.93 | 29.50 | 26.30 | H | 12.70 | --------- | 39.00 | -------- | 43.5 | --------- | 4.5 |
| 261.29 | 22.30 | 18.10 | H | 13.64 | --------- | 31.74 | -------- | 46.0 | --------- | 14.3 |
| 356.85 | 21.60 | 17.60 | H | 15.57 | --------- | 33.17 | -------- | 46.0 | --------- | 12.8 |
| 34.5 | 22.40 | 18.70 | V | 12.37 | --------- | 31.07 | -------- | 40.0 | --------- | 8.9 |
| 43.8 | 25.40 | 23.00 | V | 12.72 | --------- | 35.72 | -------- | 40.0 | --------- | 4.3 |
| 68.14 | 27.00 | 24.50 | V | 7.98 | --------- | 32.48 | -------- | 40.0 | --------- | 7.5 |
| 119.39 | 27.70 | 24.80 | V | 12.70 | --------- | 37.50 | -------- | 43.5 | --------- | 6.0 |
| 143.13 | 25.50 | 21.90 | V | 12.71 | --------- | 34.61 | -------- | 43.5 | --------- | 8.9 |
| 447.7 | 15.80 | 9.30 | V | 16.90 | --------- | 26.20 | -------- | 46.0 | --------- | 19.8 |

*** Note: The fundamental emission was measured using a RBW of 20 kHz which is greater than the emission bandwidth.**

**Table 7.2.2.3-1: Radiated Emissions – 50% charge rate**

| Frequency (MHz) | Level (dBuV) | | Antenna Polarity | Correction Factors | Corrected Level (dBuV/m) | | Limit (dBuV/m) | | Margin (dB) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | pk | Qpk/Avg | (H/V) | (dB) | pk | Qpk/Avg | pk | Qpk/Avg | pk | Qpk/Avg |
| **Fundamental Emission** | | | | | | | | | | |
| 0.129 | 82.68 | 78.20 | H | 10.43 | 93.11 | 88.63 | 125.4 | 105.4 | 32.3 | 16.8 |
| **Spurious Emissions** | | | | | | | | | | |
| 0.387 | 54.71 | 49.98 | H | 10.40 | 65.11 | 60.38 | 115.9 | 95.9 | 50.8 | 35.5 |
| 0.645 | | 41.70 | H | 10.60 | --------- | 52.30 | -------- | 71.4 | --------- | 19.1 |
| 0.903 | | 35.40 | H | 10.82 | --------- | 46.22 | -------- | 68.5 | --------- | 22.3 |
| 1.161 | | 32.40 | H | 11.25 | --------- | 43.65 | -------- | 66.3 | --------- | 22.7 |
| 1.419 | | 29.40 | H | 11.17 | --------- | 40.57 | -------- | 64.6 | --------- | 24.0 |
| 1.677 | | 25.80 | H | 11.10 | --------- | 36.90 | -------- | 63.1 | --------- | 26.2 |
| **Emissions above 30 MHz** | | | | | | | | | | |
| 119.45 | 30.30 | 27.40 | H | 11.87 | --------- | 39.27 | -------- | 43.5 | --------- | 4.2 |
| 260 | 23.50 | 19.20 | H | 13.50 | --------- | 32.70 | -------- | 46.0 | --------- | 13.3 |
| 354 | 21.30 | 16.60 | H | 15.54 | --------- | 32.14 | -------- | 46.0 | --------- | 13.9 |
| 38.5 | 23.80 | 21.50 | V | 11.89 | --------- | 33.39 | -------- | 40.0 | --------- | 6.6 |
| 43.8 | 25.70 | 23.40 | V | 10.89 | --------- | 34.29 | -------- | 40.0 | --------- | 5.7 |
| 68.14 | 26.60 | 23.80 | V | 9.80 | --------- | 33.60 | -------- | 40.0 | --------- | 6.4 |
| 121.76 | 31.00 | 28.00 | V | 12.01 | --------- | 40.01 | -------- | 43.5 | --------- | 3.5 |
| 146.27 | 25.70 | 22.20 | V | 12.85 | --------- | 35.05 | -------- | 43.5 | --------- | 8.4 |

*** Note: The fundamental emission was measured using a RBW of 20 kHz which is greater than the emission bandwidth.**

**Table 7.2.2.3-1: Radiated Emissions – 0% charge rate**

| Frequency (MHz) | Level (dBuV) | | Antenna Polarity | Correction Factors | Corrected Level (dBuV/m) | | Limit (dBuV/m) | | Margin (dB) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | pk | Qpk/Avg | (H/V) | (dB) | pk | Qpk/Avg | pk | Qpk/Avg | pk | Qpk/Avg |
| **Fundamental Emission** | | | | | | | | | | |
| 0.13132 | 83.62 | 78.24 | H | 10.43 | 94.05 | 88.67 | 125.2 | 105.2 | 31.1 | 16.6 |
| **Spurious Emissions** | | | | | | | | | | |
| 0.39396 | 54.78 | 49.10 | H | 10.40 | 65.18 | 59.50 | 115.7 | 95.7 | 50.5 | 36.2 |
| 0.6566 | | 42.00 | H | 10.60 | --------- | 52.60 | -------- | 71.3 | --------- | 18.7 |
| 0.91924 | | 34.70 | H | 10.90 | --------- | 45.60 | -------- | 68.3 | --------- | 22.7 |
| 1.18188 | | 32.50 | H | 11.25 | --------- | 43.75 | -------- | 66.2 | --------- | 22.4 |
| 1.44452 | | 28.00 | H | 11.17 | --------- | 39.17 | -------- | 64.4 | --------- | 25.2 |
| 1.70716 | | 26.10 | H | 11.09 | --------- | 37.19 | -------- | 69.5 | --------- | 32.3 |
| **Emissions above 30 MHz** | | | | | | | | | | |
| 120.5 | 30.50 | 26.30 | H | 11.93 | --------- | 38.23 | -------- | 43.5 | --------- | 5.30 |
| 260.97 | 22.8 | 18.5 | H | 13.6067 | --------- | 32.1067 | -------- | 46 | --------- | 13.9 |
| 356.57 | 21.5 | 17.3 | H | 15.5657 | --------- | 32.8657 | -------- | 46 | --------- | 13.1 |
| 40.34 | 27.8 | 23.9 | V | 11.4456 | --------- | 35.3456 | -------- | 40 | --------- | 4.7 |
| 43.85 | 28.3 | 24.7 | V | 10.884 | --------- | 35.584 | -------- | 40 | --------- | 4.4 |
| 58.5 | 28.2 | 24 | V | 9.83 | --------- | 33.83 | -------- | 40 | --------- | 6.2 |
| 121.6 | 32.1 | 28.1 | V | 11.996 | --------- | 40.096 | -------- | 43.5 | --------- | 3.4 |
| 146.76 | 28.5 | 23.7 | V | 12.8704 | --------- | 36.5704 | -------- | 43.5 | --------- | 6.9 |

*** Note: The fundamental emission was measured using a RBW of 20 kHz which is greater than the emission bandwidth.**

#### 7.3.2.2 Sample Calculation:

$R_C = R_U + CF_T$

Where:

| | | |
|---|---|---|
| $CF_T$ | = | Total Correction Factor (AF+CA+AG)-DC (Average Measurements Only) |
| $R_U$ | = | Uncorrected Reading |
| $R_C$ | = | Corrected Level |
| AF | = | Antenna Factor |
| CA | = | Cable Attenuation |
| AG | = | Amplifier Gain |
| DC | = | Duty Cycle Correction Factor |

**Example Calculation: Peak**

Corrected Level: 82.62 + 10.43 = 93.05 dBuV/m
Margin: 125.2dBuV/m – 93.05dBuV/m = 32.15dB

Example Calculation: Average

Corrected Level: 76.77 + 10.43 - 0 = 87.2 dBuV
Margin: 105.2dBuV – 87.2dBuV = 18 dB

## 8 CONCLUSION

In the opinion of TÜV SÜD America Inc. the TS-CS5, manufactured by Viableware, Inc. meets the requirements of FCC Part 15 subpart C and ISED Canada's Radio Standards Specification RSS-210 for the tests documented herein.

# END REPORT