



EMC Electromagnetic Compatibility

Applicable Specifications

EMC for RoboteQ products refers to the unintended emission of RF frequency.

EMC is regulated by the FCC for USA and IEC for Europe.

As far as USA, the applicable specification is FCC Part 15 .

As far as Europe the generic EMC specification is the Directive 2014/30/EU and the IEC/EN 61000-6-4 2011.

This last one states at the introduction:

This generic EMC emission standard is applicable if no relevant dedicated product or product-family EMC emission standard exists.

Since a dedicated specification exists for electronic power drives, that one will take over from IEC 61000-4.

RoboteQ controllers applications fall under the spec IEC61800-3 2017-02 Edition 3.0 which covers:

Adjustable speed electrical power drive systems Part 3: EMC requirements and specific test methods.

Therefore the applicable specification for Europe is IEC 61800-3.

USA specification

FCC part 15 distinguishes between Class A and Class B.

RoboteQ products are Class A, meaning they are not for residential use, but for industrial applications.

Where RoboteQ products would be integrated in systems for use in an industrial plant, they would be exempted under the provision of article 15.103 (c), but although this is the greatest majority of the cases, RoboteQ will follow the recommendation that the RF radiation be estimated as support information for the system integrator.

RoboteQ applies the limits for Class A.

European Specification

Directive 2014/30/EU governs the electromagnetic compatibility.

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It refers to "apparatus" which is defined as any finished appliance or combination thereof made available on the market as a single functional unit, intended for the end-user and liable to generate electromagnetic disturbance ...



RoboteQ products do not fall in the category of “apparatus” being them components that are not sold to end user but are sold for incorporation in an installation, as per Article 3 (2). A stand alone RoboteQ controller does not perform any useful function and can only be utilized if connected as a minimum to a power source and a motor (installation).

However RoboteQ evaluates its products in the spirit of article Introduction (32), which states that it should not be permitted to compromise the conformity of the fixed installation into which it is incorporated.

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FCC specification limits

Class A limits are the following:

Frequency	Specified	equivalent
	10 meters	3 meters
<input type="checkbox"/> 30 – 88 MHz	40.0 dB	50.0 dB
<input type="checkbox"/> 88-261 Mhz	43.5 dB	53.5 dB
<input type="checkbox"/> 216 – 960 MHz	47.0 dB	57.0 dB

IEC61800-3 Specification limits

Specification 61800-3 describes four categories of products:

- Consumer
- Commercial
- Industrial
- Industrial above 1,000 Volt

Systems implemented with RoboteQ controllers fall in category 3. They are intended to be used for the second environment.

The second environment definition is the following:

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3.2.3

Second environment:

Environment that includes all establishments other than those directly connected to a low voltage power supply network which supplies buildings used for residential purposes.

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The limits applicable to EMI are the ones applicable to the enclosure port at 6.4.2.4, Table 20 (see below):

TABLE 20 for category 3

Distance in meters	10	3
30 to 230 MHz	50 dBuV/M	60 dBuV/M
230 to 1,000 MHz	60 dBuV/m	70 dBuV/M



Test Site

A RoboteQ electronic speed controller is a component or BDM (Basic Controller Module) that will be integrated in installations, or CDM (Complete Drive Module) further integrated in a PDS (Power Drive System). For this reason we carry a verification of RF emission in conditions as close as possible to a standard fully validated test site, but not on a fully compliant and validated test site.

The system integrator has the responsibility of verification to conformance for the whole system. RoboteQ can only verify in conditions as close as possible to the ones of a standard validated test site, as guidance for the system integrator.

There are many different installations since they are customer dependent.

In the case of radiated emission tests, CISPR 11 allows open-area test site (OATS)

Equipment of category C3 should preferably be tested on a test site compliant with requirements of CISPR 16-1-4. However, when this proves to be impossible for practical reasons of weight, size or power, tests may be done in a location not fully compliant with the test site requirements. The use of this location shall be justified in the test report.

In our case it is impossible to predict the weight, size or power of the many installations to which RoboteQ controllers are destined.

As far as the test distance between antenna and EUT, both 10 meters and 3 meters are acceptable depending on the volume of the application. For reasons of expediency RoboteQ has chosen to perform measurements at 3 meters. Since we have no way of predicting the volume of the installation, we use a fixed table supporting the EUT.

We have chosen an Open Area Test Site OATS, following the details of CISPR 14-1

We have chosen:

- Flat terrain in open country, far from most radio broadcasting activity.
- 3 meters distance.
- Ambient noise (EUT OFF) having a maximum peak at least six dB below the lowest limit of limit of 50 dB(μ V/m).
- Metallic Ground Plane omitted being impossible to predict the actual system configuration of the customer. Ground is asphalt, and being the test site situated in an un-inhabited desert open country in Arizona, it is free from buried metallic structures. The ground is paved, homogeneous, solid and flat; weather conditions are sunny and dry and consistent day after day .



Similarly CISPR 14 – 1 states:

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5.5 Ground plane

The ground plane may be composed of a wide range of material from earth to highly conductive, metallic material. The plane can be at earth level or elevated on a suitably sized platform or roof site. A metal ground plane is preferred, but for certain equipment and applications, it may not be recommended by certain product publications. Adequacy of the metal ground plane will be dependent on whether the test site meets the site validation requirements in 5.6. If no metallic material is used, caution is required to select a site that does not change its reflective characteristics with time, weather condition, or, due to buried metallic material such as pipes, conduits, and non-homogeneous soil. Such sites generally give different site attenuation characteristics compared to those with metallic surfaces

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Electrical Load Emulation

The most common load is a motor; we emulate the load with a resistor and a series inductor.

A motor can be in general represented by its series resistance, series inductance and BEMF voltage.

Worst case conditions are when the current in load is small, as it maximizes the dv/dt of the voltage. In fact the specification states:

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The rate of change of voltage or current is expected to be the main source of high-frequency emission. For this type of disturbance, the highest values of the dv/dt are mostly relevant, which usually occurs with output currents lower than the rated current of the PDS. Therefore, these tests are light load tests. The tests shall be applied to the relevant ports where they exist and shall be performed in a well-defined and reproducible manner on a port-by-port basis.

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Test frequency range and Antenna Factor

Tests are done between 30 and 1,000 MHz, quasi-peak detector, EMC filter in.

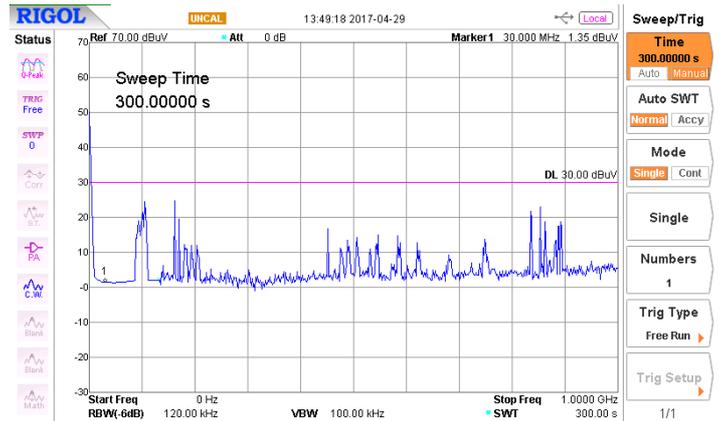
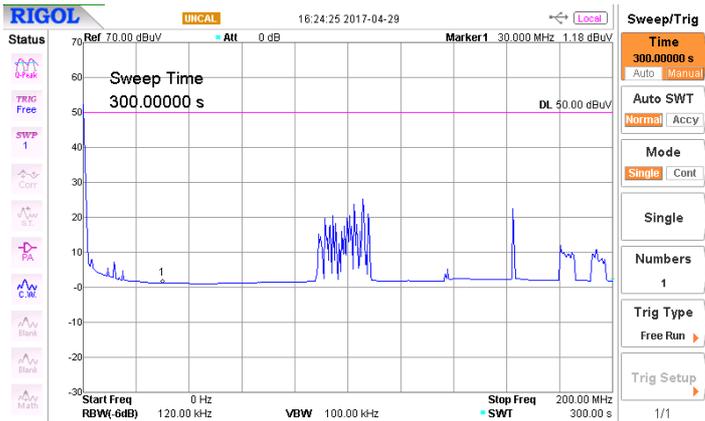
The antenna factor is as follows:

Frequency in MHz	30	65	100	160	230	500	750	1000
AF Antenna Factor dB	30.6	23.2	19.4	17	18.1	25.5	32.5	34.3

All readings in the pictures below must be corrected by adding the AF applicable at that frequency.

Ambient Noise

The Left picture below shows the ambient noise spanning 30 to 200 MHz
 There is activity only in the FM band and at 160 MHz.
 The FM peak plus the antenna factor is 44 dB(μ V/m), 6 dB(μ V/m) below the 50 dB(μ V/m) limit.
 The 160 MHz peak is at 40 dB(μ V/m), 10 dB below the 50 dB(μ V/m) limit



The picture on the right above shows the ambient noise at 30 to 1,000 MHz..

The picture on the left shows the 0 to 200 MHz range.

The highest peak is at 110 MHz, at 25 dB(μ V/m) plus the antenna factor of 19 dB (44 dBuVolt/m); 9 dB below the lowest limit of 53 dBuVolt/m.

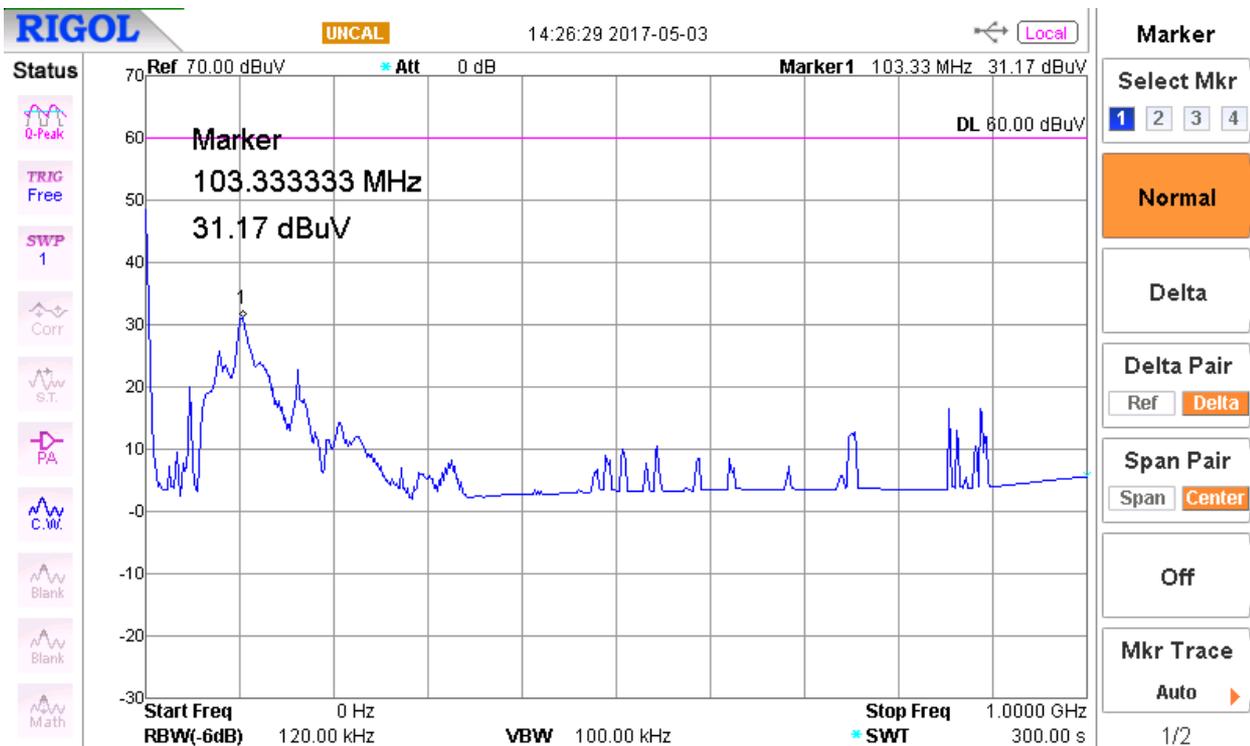
At 88 MHz, the reading is 20 dBuV/m, plus the antenna factor of 20 dB, (40 dBuV/m); this is 10 dB below the limit of 50 dBuV/m.

Controller model measured and results

Model: SBL1360 Controller
Highest peak frequency: 103 MHz
Highest Peak Value: 31 dB(μ V/m)
Antenna Factor at Peak Frequency 19.4
Adjusted emission (value+AF) : 50.4 dB(μ V/m)
CISPR 11 Emission 3 meter Limits: 60 dB(μ V/m)
FCC Part 15.109 3 meter Class A Limits: 53.5 dB(μ V/m)



Results: **PASS**



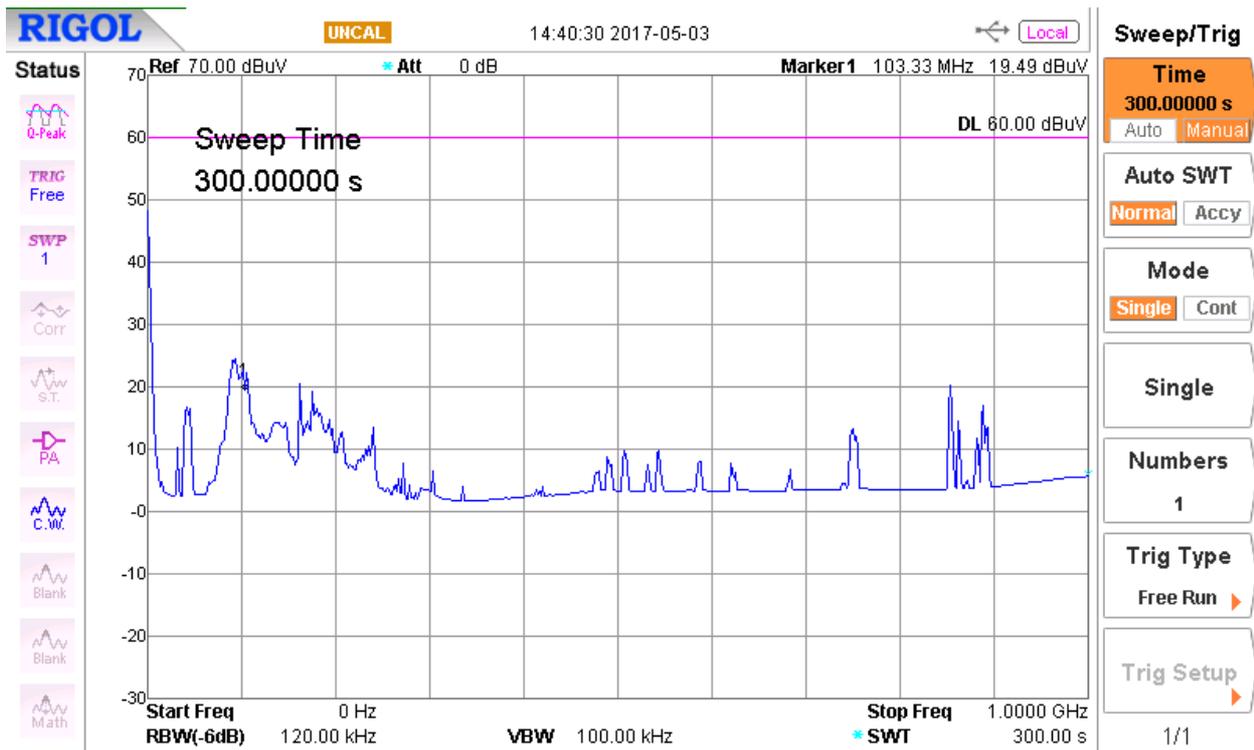


Controller model measured and results

Model: MBL1660 Controller
Highest peak frequency: 100 MHz
Highest Peak Value: 25 dB(μ V/m)
Antenna Factor at Peak Frequency 19.4
Corrected emission (value+AF) : 44.4 dB(μ V/m)
CISPR 11 Emission 3 meter Limits: 60 dB(μ V/m)
FCC Part 15.109 3 meter Class A Limits: 53.5 dB(μ V/m)



Results: **PASS**

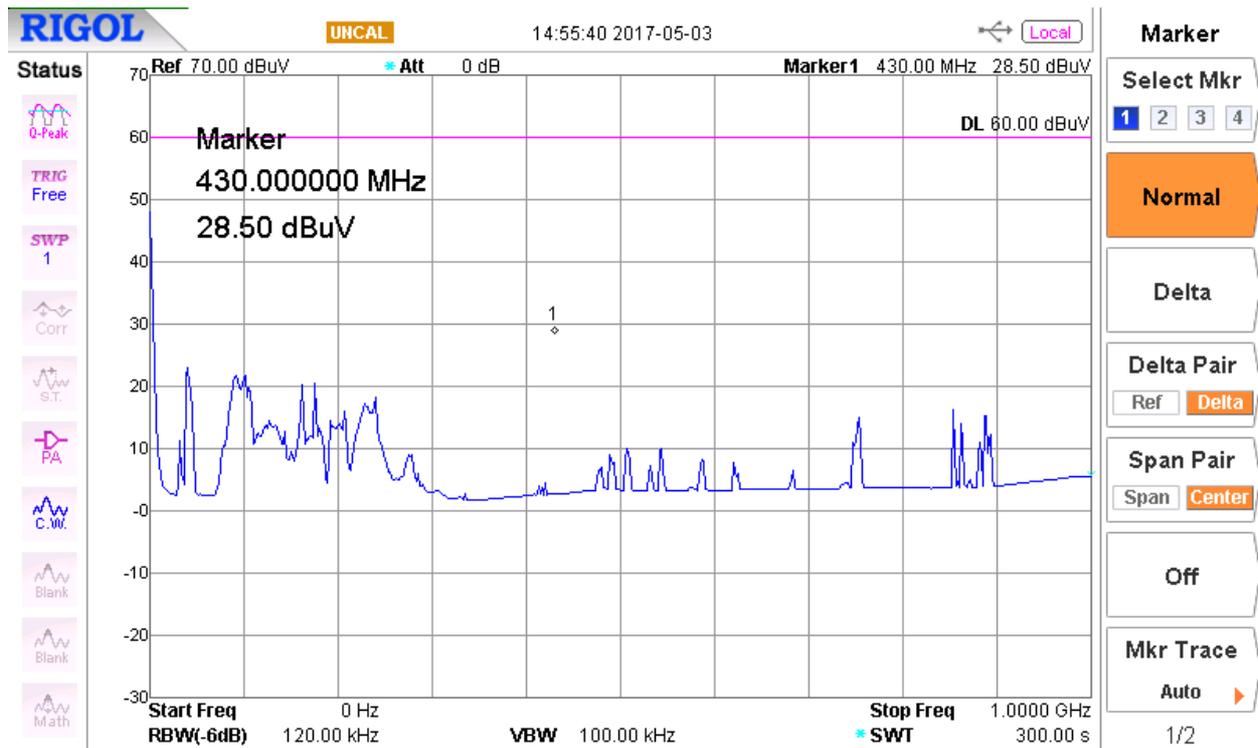


Controller model measured and results

Model: HBL1660 Controller
Highest peak frequency: 45 MHz
Highest Peak Value: 22 dB(µV/m)
Antenna Factor at Peak Frequency 24
Corrected emission (value+AF) : 46 dB(µV/m)
CISPR 11 Emission 3 meter Limits: 60 dB(µV/m)
FCC Part 15.109 3 meter Class A Limits: 50 dB(uV/m)



Results: **PASS**



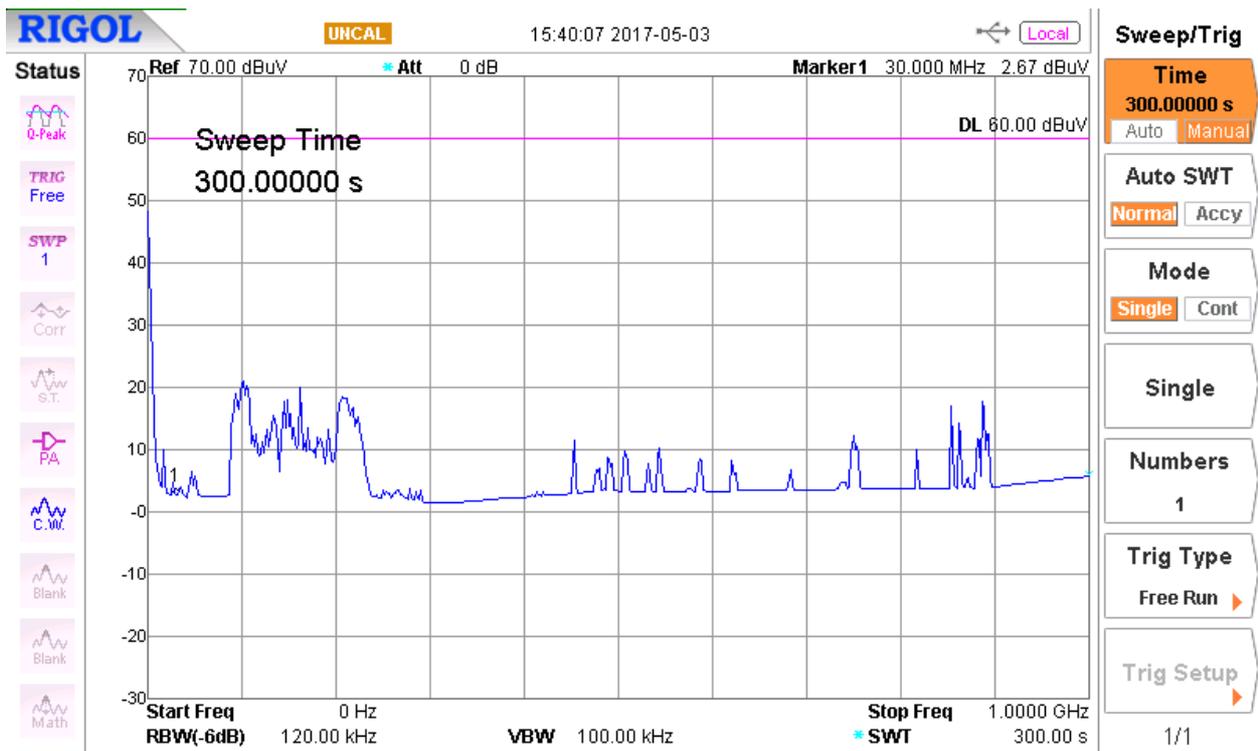


Controller model measured and results

Model: MDC1460 Controller
Highest peak frequency: 100 MHz
Highest Peak Value: 20 dB(μ V/m)
Antenna Factor at Peak Frequency 19.4
Corrected emission (value+AF) : 39.4 dB(μ V/m)
CISPR 11 Emission 3 meter Limits: 60 dB(μ V/m)
FCC Part 15.109 3 meter Class A Limits: 53.5 dB(μ V/m)



Results: **PASS**

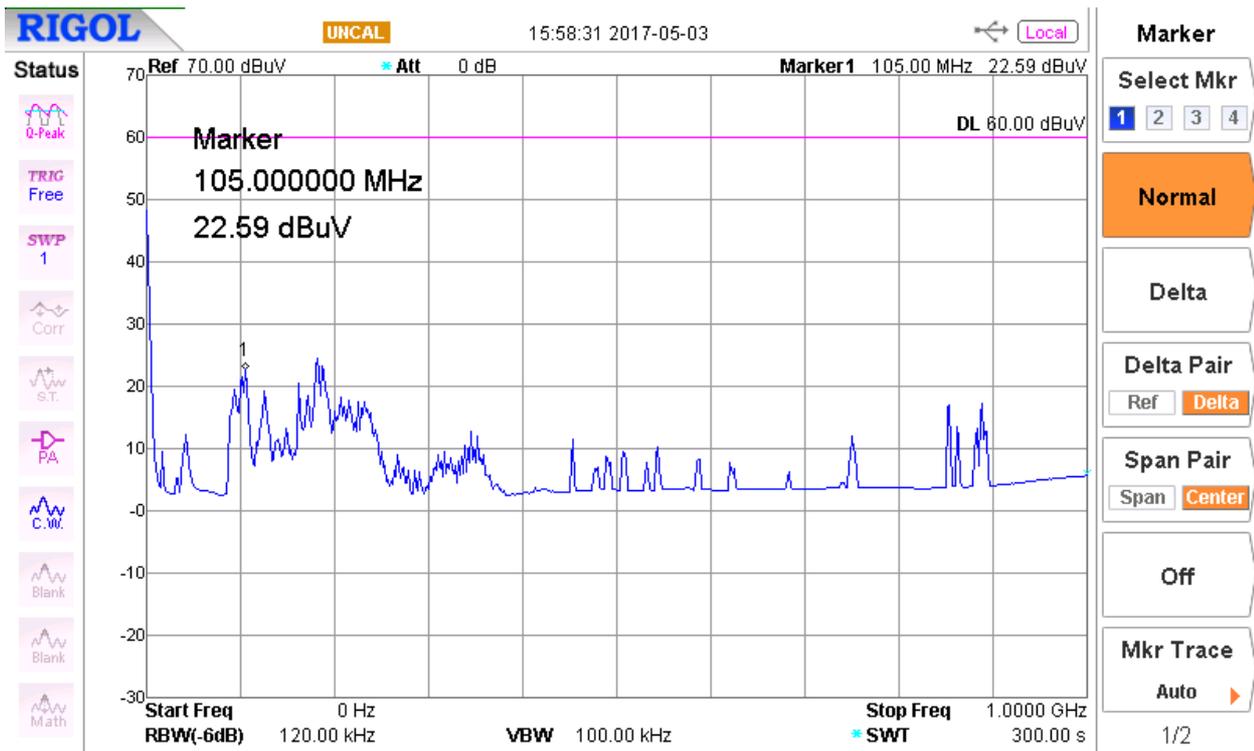




Controller model measured and results

Model: XDC2460 Controller
Highest peak frequency: 105 MHz
Highest Peak Value: 22.59 dB(μ V/m)
Antenna Factor at Peak Frequency 19.4
Corrected emission (value+AF) : 42 dB(μ V/m)
CISPR 11 Emission 3 meter Limits: 60 dB(μ V/m)
FCC Part 15.109 3 meter Class A Limits: 53.5 dB(μ V/m)

Results: **PASS**



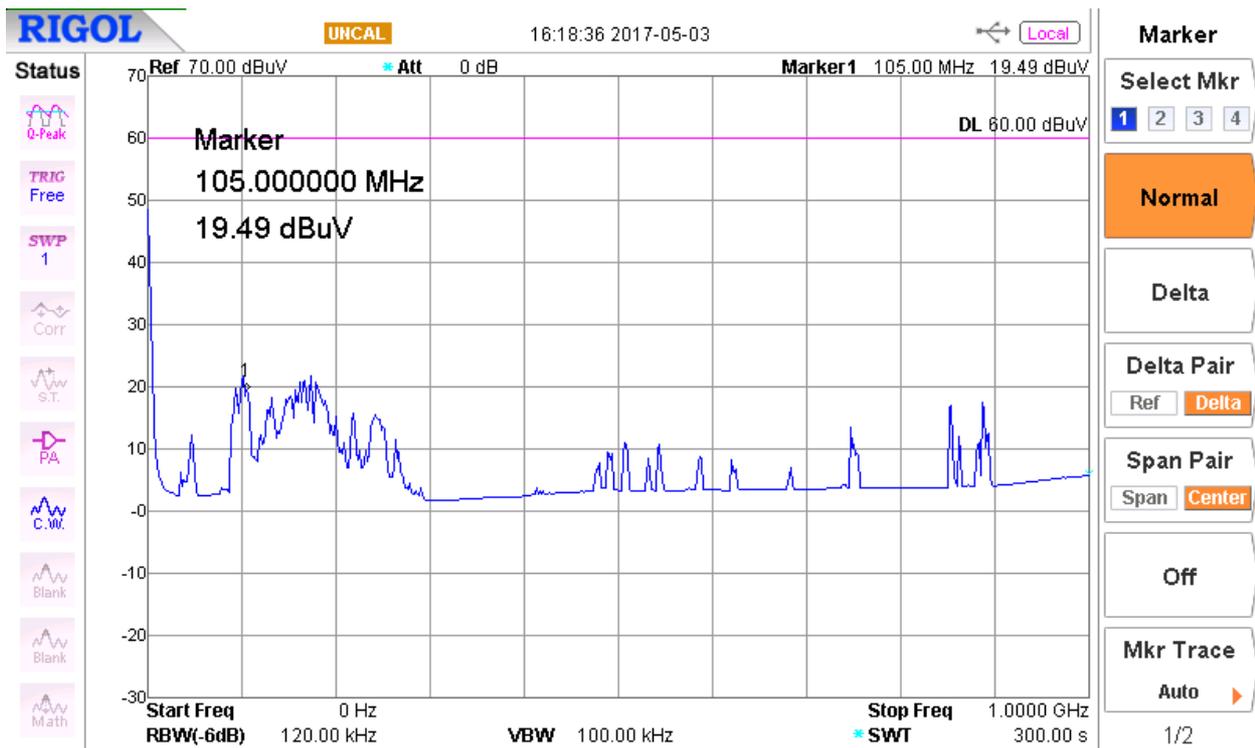


Controller model measured and results

Model: HDC2460 Controller
Highest peak frequency: 105 MHz
Highest Peak Value: 19.49 dB(μ V/m)
Antenna Factor at Peak Frequency 19.4
Corrected emission (value+AF) : 38.89 dB(μ V/m)
CISPR 11 Emission 3 meter Limits: 60 dB(μ V/m)
FCC Part 15.109 3 meter Class A Limits: 53.5 dB(μ V/m)



Results: **PASS**

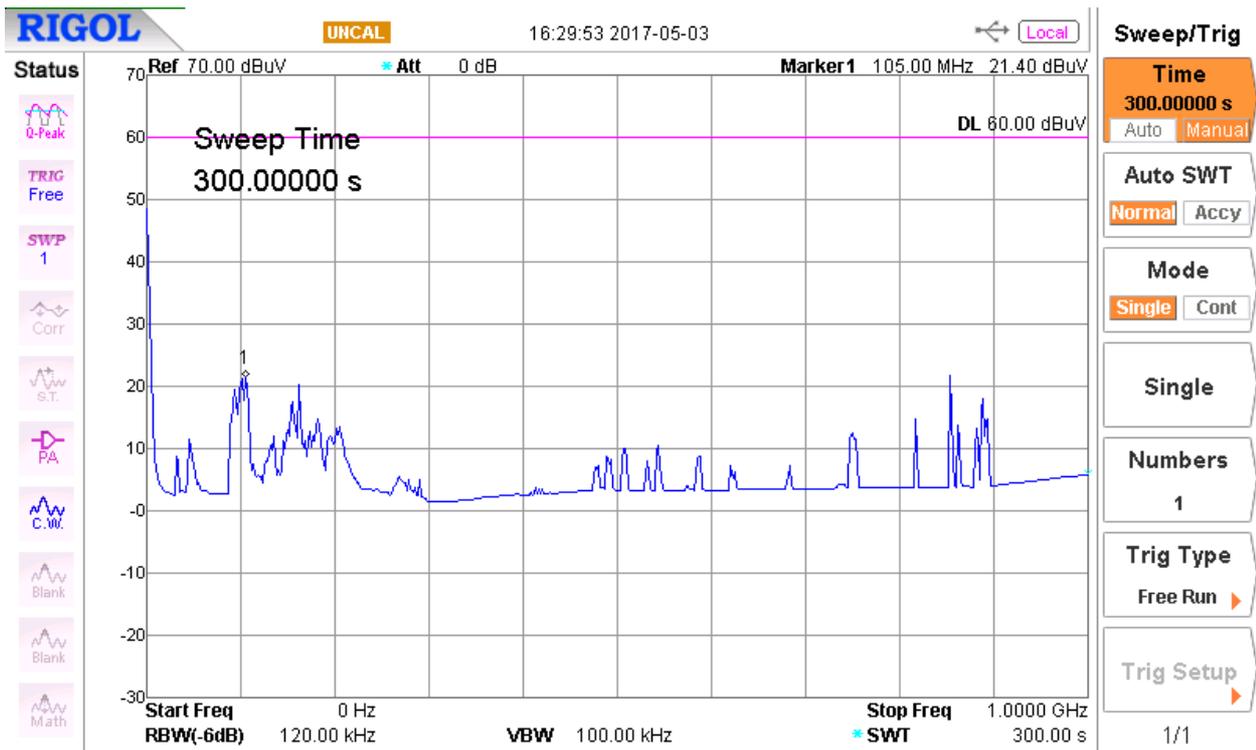




Controller model measured and results

Model: MDC2460 Controller
Highest peak frequency: 105 MHz
Highest Peak Value: 21.4 dB(μ V/m)
Antenna Factor at Peak Frequency 19.4
Corrected emission (value+AF) : 40.8 dB(μ V/m)
CISPR 11 Emission 3 meter Limits: 60 dB(μ V/m)
FCC Part 15.109 3 meter Class A Limits: 53.5 dB(μ V/m)

Results: **PASS**

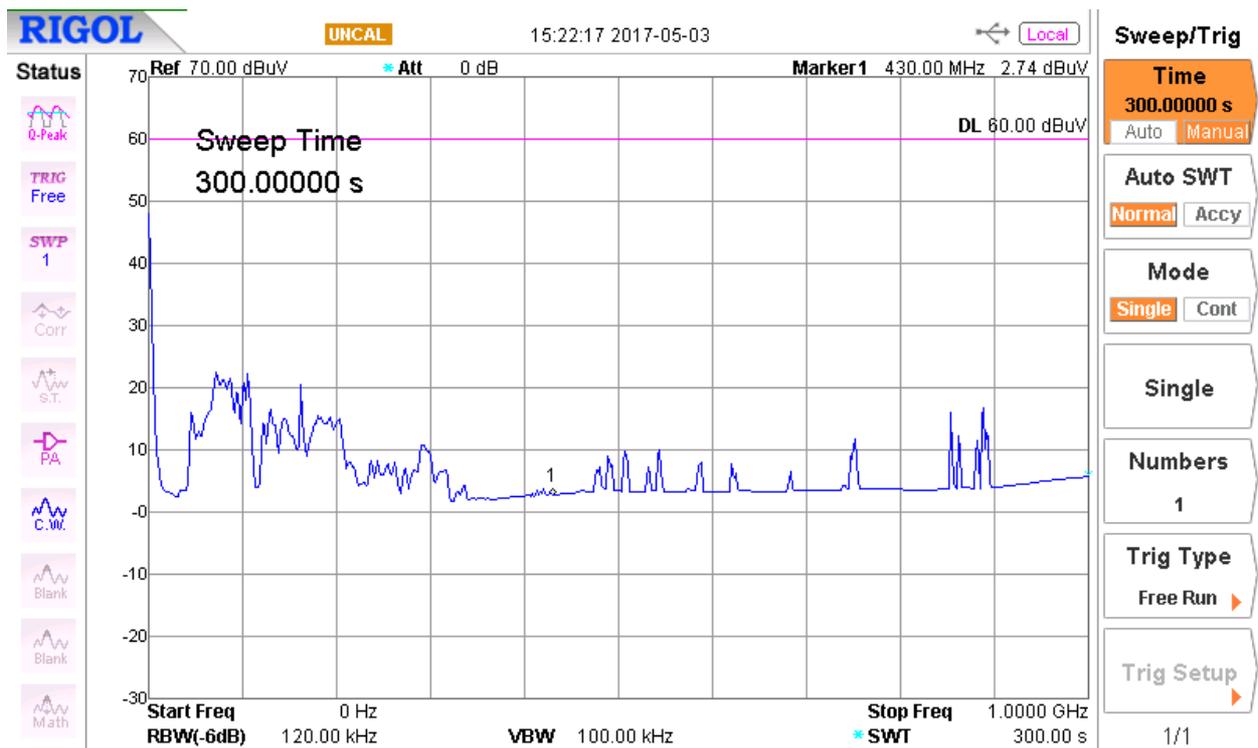


Controller model measured and results

Model: SDC2160 Controller
Highest peak frequency: 105 MHz
Highest Peak Value: 22 dB(μ V/m)
Antenna Factor at Peak Frequency 19.4
Corrected emission (value+AF) : 41.4 dB(μ V/m)
CISPR 11 Emission 3 meter Limits: 60 dB(μ V/m)
FCC Part 15.109 3 meter Class A Limits: 53.5 dB(μ V/m)

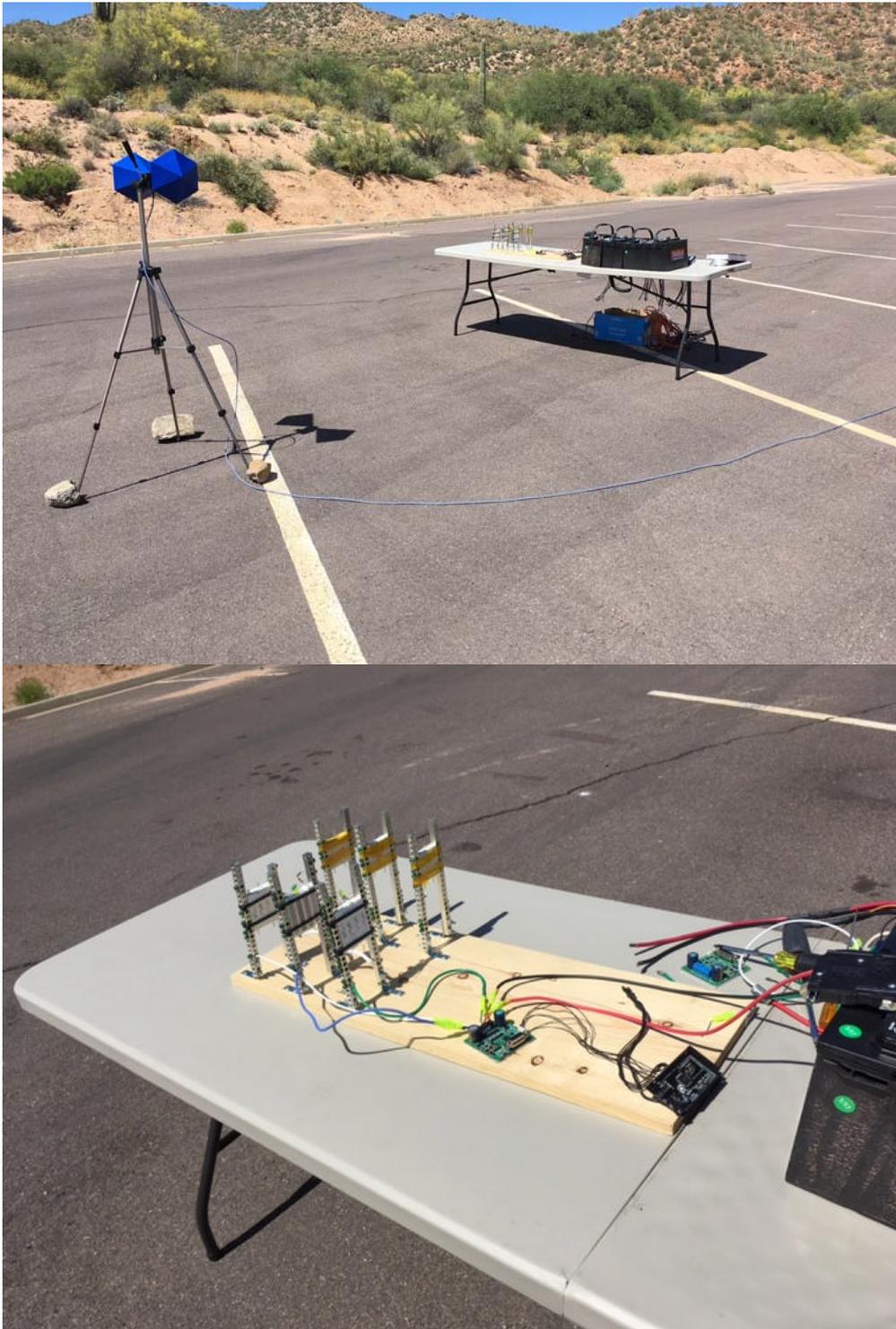


Results: **PASS**



Test Site Details

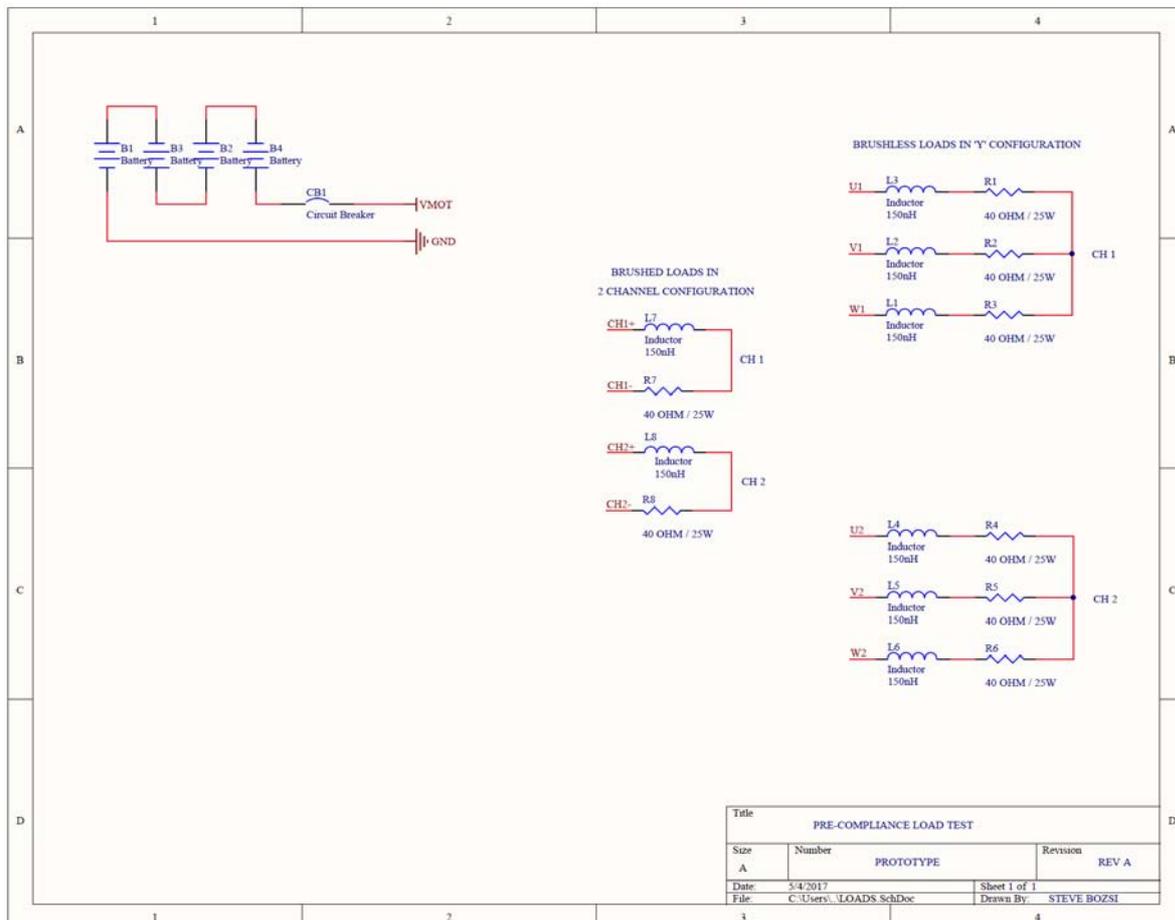
OATS



Battery setup and wiring sequence



Schematic of loads used for testing.





Equipment used:

- Antenna Aaronia model 30100E
- Spectrum analyzer Rigol model DSA815-TG
- Four series-connected deep cycle marine batteries for a total of 50Vdc supply voltage.
- Arduino simulating hall effect sensors drive (brushless controllers only)

Controllers are preset to 50% PWM for maximum switching activity. PWM is at 16 kHz.

Watchdog is set to zero, brushless controllers are driven with an UUT and Antenna are by distance of 3 meters, measured from center of units.

Brushed controllers both single and dual channel are connected to combination resistive / inductive loads per channel, consisting of:

- Qty 4 pcs of Xicon 10 ohm / 25W Cement wire wound axial power resistors for total 40 Ohm DC resistance in series with:
- Epcos BC series RF/VHF chokes. Wire wound ferrite inductors 150nH / 6.5A 17 milliohm axial leaded inductors. DigiKey part number 495-6932-1-ND manufacturer part number B78108E1151M000
- NOTE: the above ferrites simulate the internal inductance of the motor and are NOT for mitigation of radiated RF.**

Spectrum analyzer setup is as follows.

- SPAN from 0 to 1Ghz
- Amplitude in dB(uV/m)
- Reference level 70db/uv
- 10dB scale
- Input attenuator 0db
- Internal RF input preamp ON (automatically compensated by the analyzer).
- BW/Det set to EMI
- Quasi-peak filter ON
- Scan time 300 Seconds, set to single sweep mode

All measurements show the peak to be around 100 MHz, in the same area of the FM broadcasting.

The effective peak is therefore lower than what reported, although the difference is undetermined.

The measurement are therefore worst case.