



EMC / EMI Test Report

As per

**CISPR 32:2015/EN 55032:2015,
CISPR 24:2010/EN 55024:2010,
AS/NZS CISPR 32:2013,
FCC Part 15 Subpart B:2016 &
ICES-003:2016**

Emissions & Immunity for

**Multimedia Class B Equipment
on the**

Pocket Beagle A2

Issued by:

TÜV SÜD Canada Inc.
11 Gordon Collins Dr,
Gormley, ON, L0H 1G0
Canada
Ph: (905) 883-7255

Testing produced for



See Appendix A for full client &
EUT details.

Name,
Project Engineer



Testing Laboratory
Certificate #2955.02



R-4023, G-506
C-4498, T-1246



Registration #
CA6844



Client	BeagleBoard.org Foundation	
Product	PocketBeagle A2	
Standard(s)	FCC Part 15 Subpart B / ICES-003 CISPR 32/EN55032 & CISPR 24/EN55024	

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Client	BeagleBoard.org Foundation	
Product	PocketBeagle A2	
Standard(s)	FCC Part 15 Subpart B / ICES-003 CISPR 32/EN55032 & CISPR 24/EN55024	

Report Scope

This report addresses the EMC verification testing and test results of the **BeagleBone, Pocket Beagle**, Model: **A2**, herein referred to as EUT (Equipment Under Test). The EUT was tested for emissions and immunity compliance against the following standards:

EN 55032:2012/CISPR 32:2012

EN 55024:2010/CISPR 24:2010

AS/NZS CISPR 32:2013

FCC Part 15 Subpart B:2016


ICES-003:2016

Power line conducted emissions, radiated emissions, harmonics emissions, flicker emissions, and immunity testing was evaluated on the EUT. Test procedures, results, justifications, and engineering considerations, if any, follow later in this report.

For a more detailed list of the standards and the revision used, see the "Applicable Standards, Specifications and Methods" section of this report.

This report does not imply product endorsement by any government, accreditation agency, or TÜV SÜD Canada Inc.

Opinions or interpretations expressed in this report, if any, are outside the scope of TÜV SÜD Canada Inc. accreditations. Any opinions expressed do not necessarily reflect the opinions of TÜV SÜD Canada Inc., unless otherwise stated.


Client	BeagleBoard.org Foundation	
Product	PocketBeagle A2	
Standard(s)	FCC Part 15 Subpart B / ICES-003 CISPR 32/EN55032 & CISPR 24/EN55024	

Summary

The results contained in this report relate only to the item(s) tested.

Equipment Under Test (EUT)	Pocket Beagle
EUT passed all tests performed	Yes
Testing conducted by	Marty McLear


For testing dates, see 'Testing Environmental Conditions and Dates'.

Client	BeagleBoard.org Foundation	
Product	PocketBeagle A2	
Standard(s)	FCC Part 15 Subpart B / ICES-003 CISPR 32/EN55032 & CISPR 24/EN55024	

Test Results Summary

Standard/ Method	Description	Criteria	Class / Level	Result
EN 55032/ CISPR 32 FCC 15 - ICES 003	Radiated Emissions	N/A	Class B	Pass
EN 55024/ EN 61000-4-2	Electro-Static Discharge	B	±4kV Contact ±8kV Air	Pass
EN 55024/ EN 61000-4-3	Radiated Field Immunity	A	3 V/m, 80 MHz – 1 GHz	Pass
EN 55024/ EN 61000-4-4	Electrical Fast Transients (Bursts)	B	±0.5kV - I/O	Pass
EN 55024/ EN 61000-4-8	Power Frequency Magnetic Field	A	1 A/m (3 A/m Tested)	Pass
Overall Result				Pass

If the product as tested complies with the specification or requirement, the EUT is deemed to comply and is issued a 'PASS' grade. If not, 'FAIL' grade is issued.

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Notes, Justifications, or Deviations

The following justifications for tests not performed or deviations from the above listed specifications apply:

Client has stated that this equipment is consider a DC device and that the EUT is not intended to be used with a AC/DC power adaptor as part of their system.

The following tests are therefore not applicable for a DC powered device:

- Conducted Emissions
- Power Line Harmonics Emissions
- Flicker Emissions
- Surge Immunity
- Conducted RF Immunity
- Voltage Dips and Interrupts

The client has indicated that the EUT / PCB will be ESD Sensitive and is marked with the ESD Sensitive marking on the silk screen of the PCB.

A later revision of the standard may have been substituted in place of the previous dated referenced revision. The year of the specification used is listed under applicable standards. Using the later revision accomplishes the goal of ensuring compliance to the intent of the previous specification, while allowing the laboratory to incorporate the extensions and clarifications made available by a later revision.

Sample Calculation(s)

Radiated Emission Test

Margin = Limit – (Received Signal + Antenna Factor + Cable Loss – Pre-Amp Gain)

Margin = 50dB μ V/m – (50dB μ V + 10dB + 2.5dB – 20dB)

Margin = 7.5 dB (pass)

Power Line Conducted Emission Test

Margin = Limit – (Received Signal + Attenuation Factor + Cable Loss + LISN Factor)


Margin = 73.0dB μ V – (50dB μ V + 10dB + 2.5dB + 0.5dB)

Margin = 10.0 dB (pass)

Milligauss to A/m Conversion (Magnetic Immunity)


1A/m = 12.57 mG

3A/m = 3*12.57 = 37.7 mG

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Standard(s)	FCC Part 15 Subpart B / ICES-003 CISPR 32/EN55032 & CISPR 24/EN55024	


Applicable Standards, Specifications and Methods

ANSI C63.4:2014	Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz
CFR47 FCC Part 15 Subpart B:2016	Code of Federal Regulations - Radio Frequency Devices
ICES-003, Issue 6 2016	Information Technology Equipment (ITE) - Limits and Methods of Measurement
EN55032:2012/ CISPR32:2012	Electromagnetic Compatibility of Multimedia Equipment – Emission Requirements
EN55024:2010/ CISPR24:2010	Information Technology Equipment - Immunity Characteristics - Limits and Methods of Measurement
AS/NZS CISPR32:2013	Electromagnetic Compatibility of Multimedia Equipment – Emission Requirements
CISPR 16-2-3:2010/A2:2014	Specification for Radio Disturbance and Immunity Measuring Apparatus and Methods - Part 2-3: Methods of Measurement of Disturbances and Immunity - Radiated Disturbance Measurements
IEC/EN 61000-3-2:2014	Limits for Harmonic Current Emissions (equipment input current $\leq 16A$ per phase)
IEC/EN 61000-3-3:2013	Limitation of Voltage Changes, Voltage Fluctuations and Flicker in Public Low-Voltage Supply Systems, for equipment with rated current $\leq 16A$ per phase and not subject to conditional connection.
IEC 61000-4-2:2008 EN 61000-4-2:2009	Testing and Measurement Techniques - Electrostatic Discharge Immunity Test
IEC/EN 61000-4-3:2006/ A2:2010	Testing and Measurement Techniques - Radiated, Radio-Frequency, Electromagnetic Field Immunity Test
IEC/EN 61000-4-4:2004	Testing and Measurement Techniques - Electrical Fast Transient/Burst Immunity Test
IEC 61000-4-5:2005 EN 61000-4-5:2006	Testing and Measurement Techniques - Surge Immunity Test
IEC 61000-4-6:2008 EN 61000-4-6:2009	Testing and Measurement Techniques - Immunity to Conducted Disturbances, Induced by Radio-Frequency Fields
IEC 61000-4-8:2009 EN 61000-4-8:2010	Testing and Measurement Techniques - Power Frequency Magnetic Field Immunity Test
IEC/EN 61000-4-11:2004	Testing and Measurement Techniques - Voltage Dips, Short Interruptions and Voltage Variations Immunity Tests
ISO 17025:2005	General Requirements for the Competence of Testing and Calibration Laboratories

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Standard(s)	FCC Part 15 Subpart B / ICES-003 CISPR 32/EN55032 & CISPR 24/EN55024	

Document Revision Status

Revision 0 September 8th, 2017
Initial Release

Client	BeagleBoard.org Foundation	
Product	PocketBeagle A2	
Standard(s)	FCC Part 15 Subpart B / ICES-003 CISPR 32/EN55032 & CISPR 24/EN55024	

Definitions and Acronyms

The following definitions and acronyms are applicable in this report.
See also ANSI C63.14.

AM – Amplitude Modulation
CDN – Coupling Decoupling Network
EFT – Electrical Fast Transients
ESD – Electro-Static Discharge
HCP – Horizontal Coupling Plane
VCP – Vertical Coupling Plane
LISN – Line Impedance Stabilization Network
NCR – No Calibration Required
NSA – Normalized Site Attenuation
N/A – Not Applicable
RF – Radio Frequency

AE – Associated Equipment. Equipment needed to exercise and/or monitor the operation of the EUT.


Class A Device – A device that is marketed for use in a commercial, industrial or business environment. A 'Class A' device should not be marketed for use by the general public. A 'Class A' device should contain a warning notice in the user manual stating that it could cause radio interference. For example: "**Warning:** Operation of this equipment in a residential environment could cause radio interference."

Class B Device – A device that is marketed for use in a residential environment and may also be used in a commercial, business or industrial environments. NOTE: A residential environment is an environment where the use of broadcast radio and television receivers may be expected within a distance of 10m of the device concerned.

EMC – Electro-Magnetic Compatibility. The ability of an equipment or system to function satisfactorily in its electromagnetic environment without introducing intolerable electromagnetic disturbances to anything in that environment.

EMI – Electro-Magnetic Immunity. The ability to maintain a specified performance when the equipment is subjected to disturbance (unwanted) signals of specified levels.

EUT – Equipment Under Test. A device or system being evaluated for compliance that is representative of a product to be marketed.

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ITE – Information Technology Equipment. Has a primary function of entry, storage, display, retrieval, transmission, processing, switching, or control of data and/or telecommunication messages and which may be equipped with one or more ports typically for information transfer.

Antenna Port – Port, other than a broadcast receiver tuner port, for connection of an antenna used for intentional transmission and/or reception of radiated RF energy.


Broadcast Receiver Tuner Port – Port intended for the reception of a modulated RF signal carrying terrestrial, satellite and/or cable transmissions of audio and/or video broadcast and similar services.

Optical Fiber Port – Port at which an optical fiber is connected to an equipment.

Signal/Control Port – Port intended for the interconnection of components of a EUT, or between a EUT and local AE and used in accordance with relevant functional specifications (for example for the maximum length of cable connected to it). (Examples include: RS-232, USB, HDMI, Fire Wire)

Wired Network Port – Point of connection for voice, data and signaling transfers intended to interconnect widely dispersed systems by direct connection to a single-user or multi-user communication network. (Examples include: CATV, PSTN, ISDN, xDSL, LAN and similar networks)

EMC Test Plan – An EMC test plan established prior to testing. See 'Appendix A – EUT & Client Provided Details'.


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Testing Facility

Testing for EMC on the EUT was carried out at TÜV SÜD Canada testing lab near Toronto, Ontario. The testing lab has a calibrated 3m semi-anechoic chamber which allows measurements on a EUT that has a maximum width or length of up to 2m and a height of up to 3m. The chamber is equipped with a turntable that is capable of testing devices up to 3300lb in weight. This facility is capable of testing products that are rated for 120Vac and 240Vac single phase, or devices that are rated for a 208Vac 3 phase input. DC capability is also available for testing. The chamber is equipped with a mast that controls the polarization and height of the antenna. Control of the mast occurs in the control room adjoining the shielded chamber. Radiated emission measurements are performed using a BiLog antenna and a Horn antenna where applicable. Conducted emissions, unless otherwise stated, are performed using a LISN and using the Vertical Ground plane if applicable.

Calibrations and Accreditations


The 3m semi-anechoic chamber is registered with Federal Communications Commission (FCC, CA6844), Industry Canada (IC, 6844A-3) and Voluntary Control Council for Interference (VCCI, R-4023, G-506, C-4498, and T-1246). This chamber was calibrated for Normalized Site Attenuation (NSA) using test procedures outlined in ANSI C63.4 "Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz". The chamber is lined with ferrite tiles and absorption cones to minimize any undesired reflections. The NSA data is kept on file at TÜV SÜD Canada. For radiated susceptibility testing, a 16 point field calibration has been performed on the chamber. The field uniformity data is kept on file at TÜV SÜD Canada. TÜV SÜD Canada Inc. is accredited to ISO 17025 by A2LA with Testing Certificate #2955.02. The laboratory's current scope of accreditation listing can be found as listed on the A2LA website. All measuring equipment is calibrated on an annual or bi-annual basis as listed for each respective test.

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Testing Environmental Conditions and Dates

Following environmental conditions were recorded in the facility during time of testing:

Date	Test	Initials	Temperature (°C)	Humidity (%)	Pressure (kPa)
September 6th, 2017	Radiated Emissions	MM	23.5	49.3	100.5
September 6th, 2017	Electro-Static Discharge	MM	23.5	49.3	100.5
September 6th, 2017	Radiated Field Immunity	MM	23.5	49.3	100.5
September 5th, 2017	Electrical Fast Transients	MM	22.1	56.1	99.9
September 6th, 2017	Power Frequency Magnetic Field	MM	23.5	49.3	100.5

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Detailed Test Result Section

Client	BeagleBoard.org Foundation	
Product	PocketBeagle A2	
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Radiated Emissions

Purpose

The purpose of this test is to ensure that the RF energy unintentionally emitted from the EUT does not exceed the limits listed below as defined in the applicable test standard and measured from a receiving antenna. This helps protect broadcast radio services such as television, FM radio, pagers, cellular telephones, emergency services, and so on, from unwanted interference.

Limits & Method

The limits and method are as defined in ANSI C63.4 and CISPR 32, EN55032, 47 CFR FCC Part 15 Section 15.109(g), and ICES-003 Issue 6 Section 6.2:

CLASS A

Frequency Range ^a	Quasi-Peak Limits - 10m ^b	Quasi-Peak Limits - 3m ^b
30 MHz – 230 MHz	40 dB μ V/m	50 dB μ V/m
230 MHz – 1 GHz	47 dB μ V/m	57 dB μ V/m

CISPR 32 / EN 55032,

Frequency Range ^a	Average Limit - 3m ^c	Peak Limit - 3m ^d
1 GHz – 3 GHz	56 dB μ V/m	76 dB μ V/m
3 GHz – 6 GHz	60 dB μ V/m	80 dB μ V/m

FCC Part 15 Subpart B,

Frequency Range ^a	Average Limit - 3m ^c	Peak Limit - 3m ^d
1 GHz and Up	60 dB μ V/m	80 dB μ V/m


^aThe frequency range scanned is in accordance to CISPR 32 Table 1 and FCC Part 15 Section 15.33(b).

^bLimit is with a resolution bandwidth of 120 kHz, a video bandwidth at least three times greater than the resolution bandwidth, and using a Quasi-Peak detector.

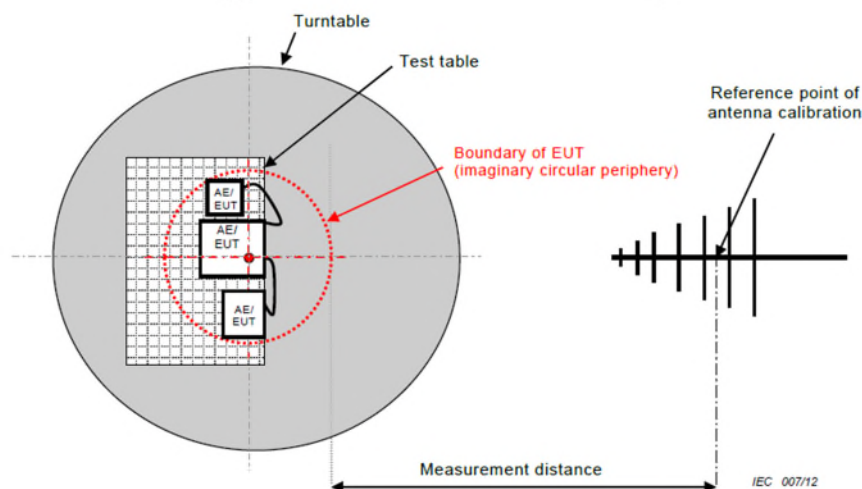
^cLimit is with a resolution bandwidth of 1 MHz and using an Average detector.

^dLimit is with a resolution bandwidth of 1 MHz, a video bandwidth at least three times greater than the resolution bandwidth, and using a Peak detector.

Based on ANSI C63.4 Section 4.2 and CISPR 32 Annex C.3, if the Peak detector measurements do not exceed the Quasi-Peak limits, where defined, then the EUT is deemed to have passed the requirements.

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Typical Radiated Emissions Setup



Note: In accordance with CISPR 32 Annex C, testing was performed at a 3 meter test distance.


Measurement Uncertainty

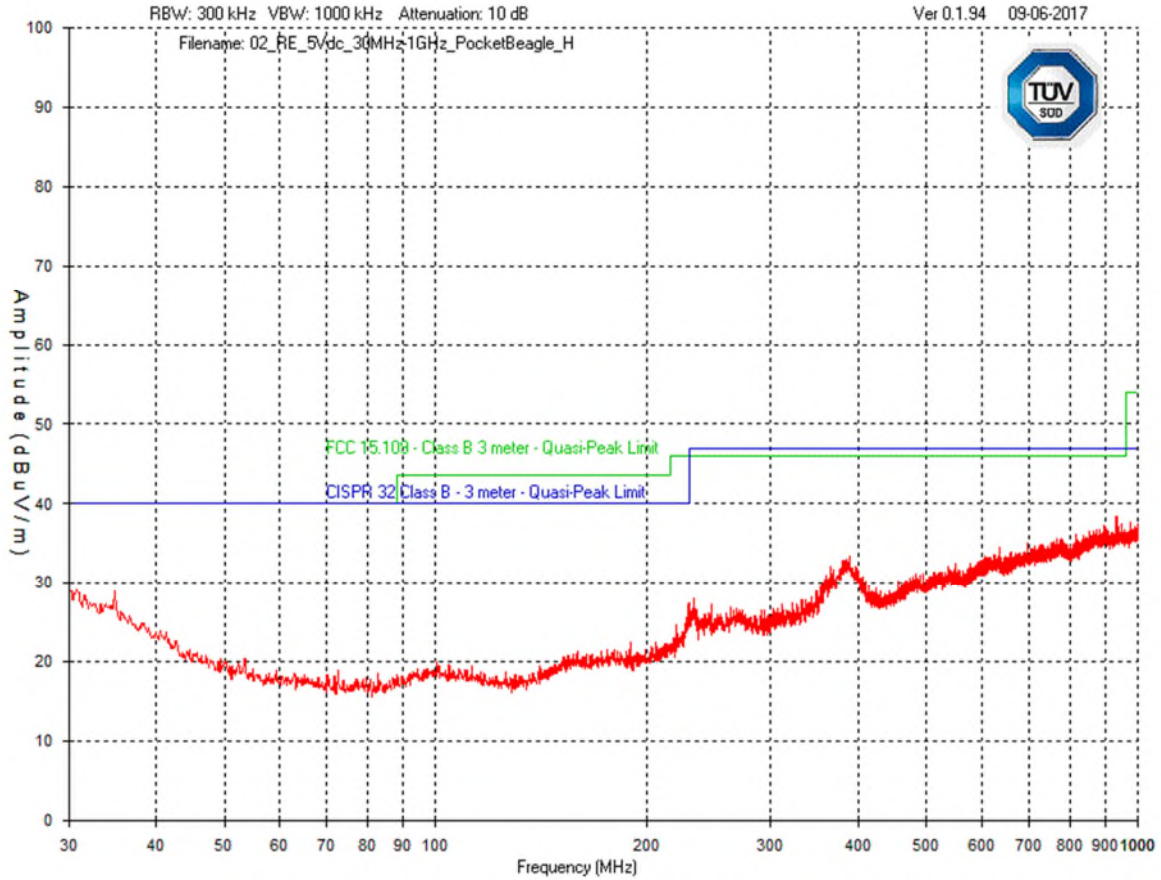
The expanded measurement uncertainty is calculated in accordance with CISPR 16-4-2 and is $\pm 4.25\text{dB}$ for 30MHz – 1GHz and $\pm 4.93\text{dB}$ for 1GHz – 18GHz with a 'k=2' coverage factor and a 95% confidence level.

Preliminary Graphs


The graphs shown below are maximized peak measurement graphs measured with a resolution bandwidth greater than or equal to the final required detector over a full 0-360°. This peaking process is done as a worst case measurement and enables the detection of frequencies of concern for final measurement. For final measurements with the appropriate detector, where applicable, please refer to the tables under Final Measurements.

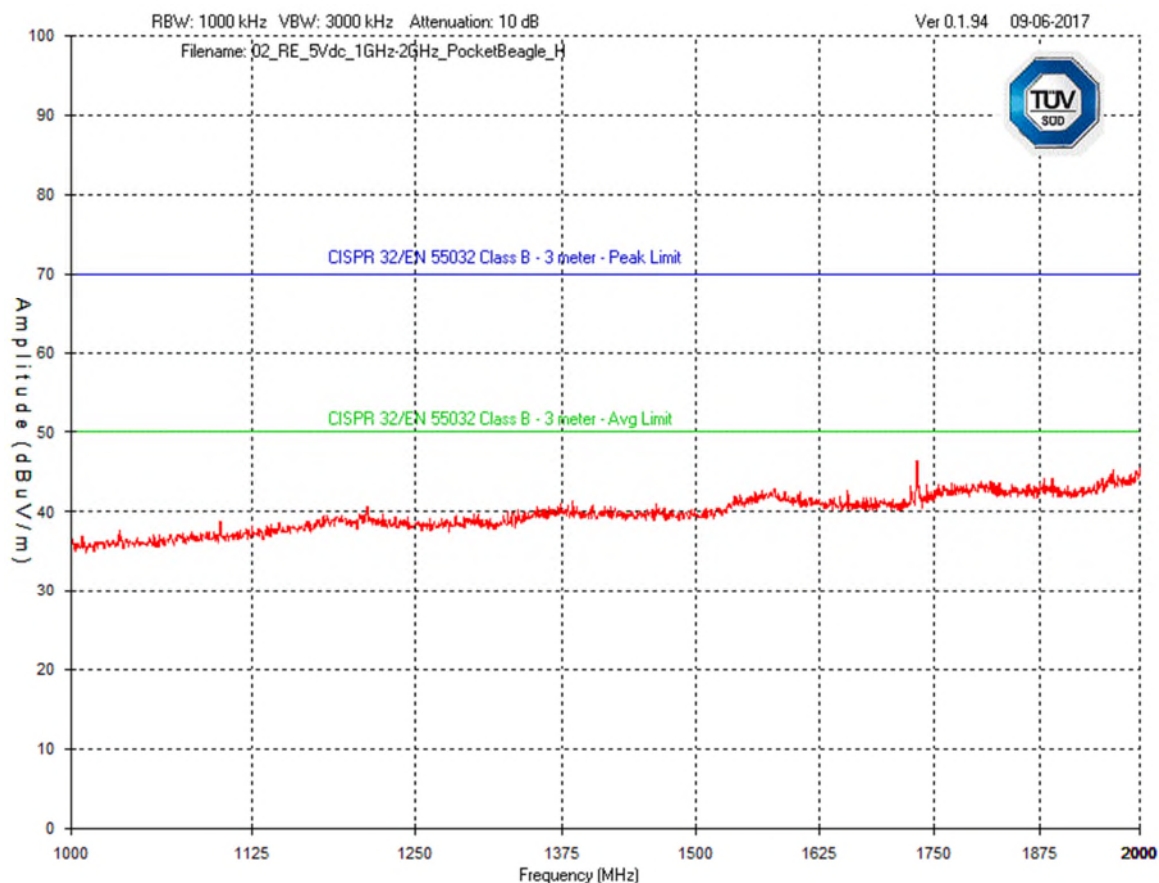
In accordance with FCC Part 15, Subpart A, Section 15.33 and CISPR 32 Table 1, the EUT was scanned to a minimum of a 1 GHz. For devices containing clocks higher than 108 MHz, they were scanned above 1 GHz to meet the requirements of FCC Part 15 Section 15.33 and CISPR 32.

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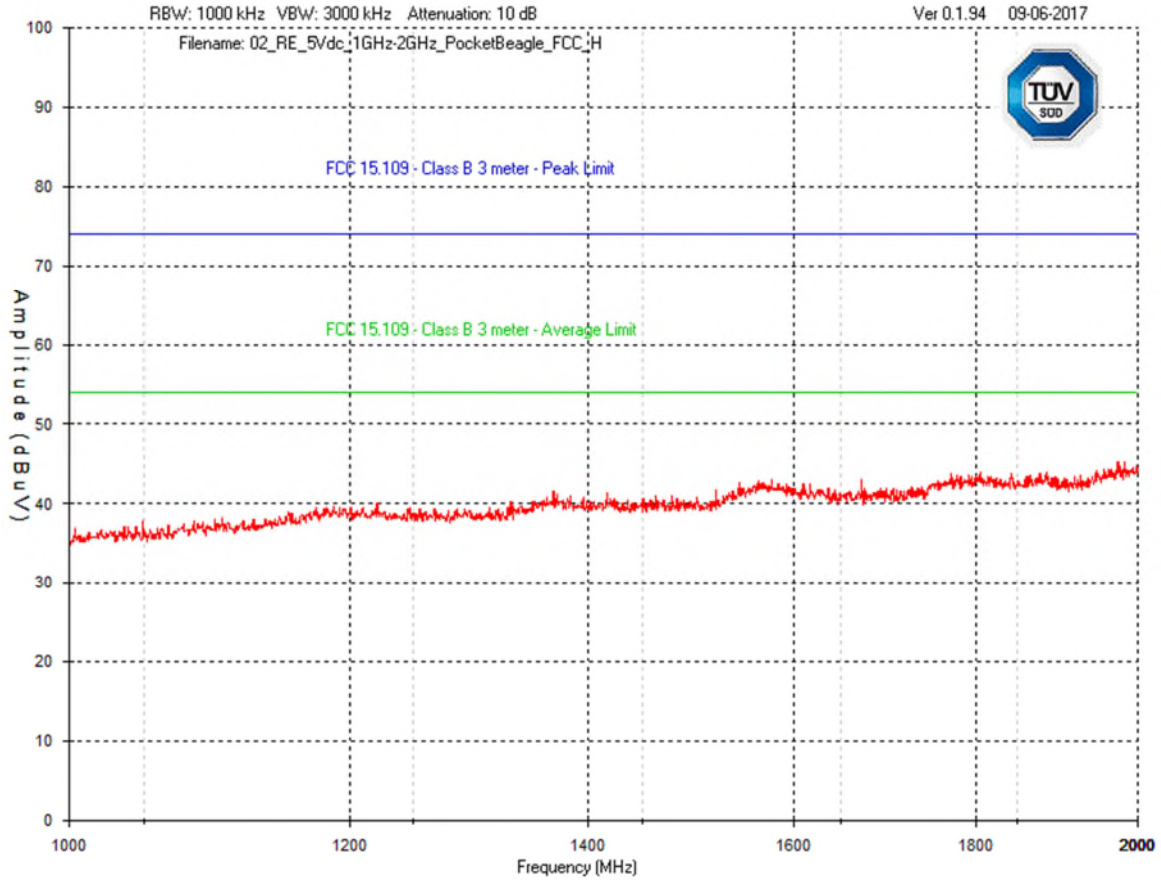
Horizontal – Peak Emissions Graph
5Vdc – 30MHz – 1GHz

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Standard(s)	FCC Part 15 Subpart B / ICES-003 CISPR 32/EN55032 & CISPR 24/EN55024	




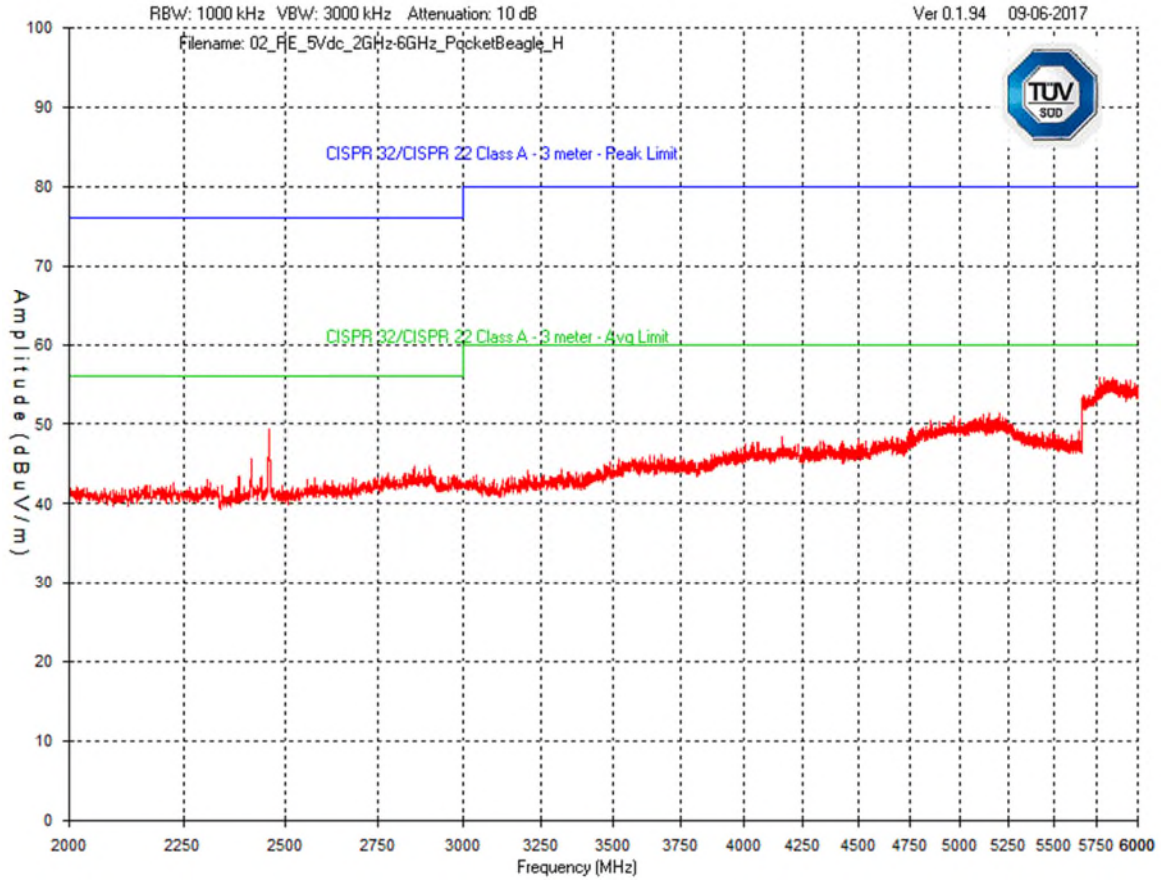
Horizontal – Peak Emissions Graph
5Vdc – 1GHz - 2GHz (CISPR 32/EN 55032)

Client	BeagleBoard.org Foundation	
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Standard(s)	FCC Part 15 Subpart B / ICES-003 CISPR 32/EN55032 & CISPR 24/EN55024	




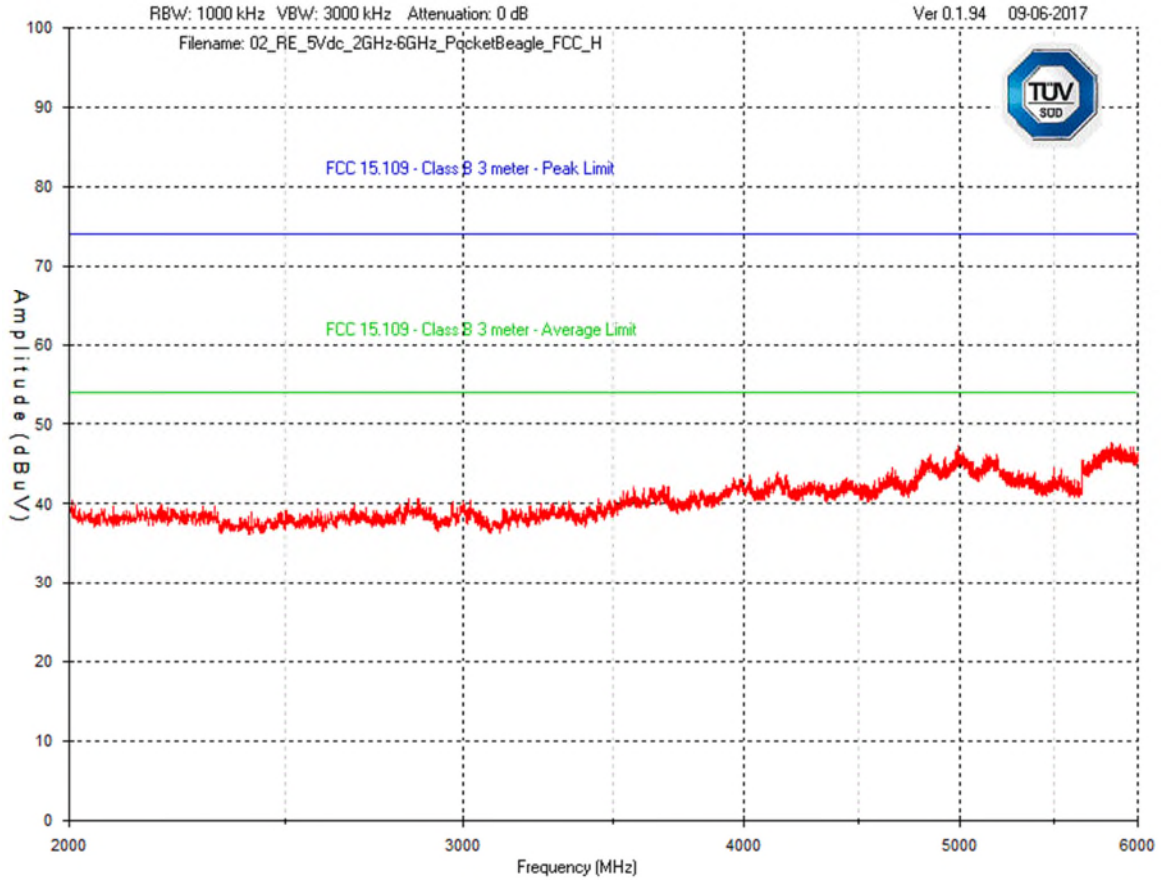
Horizontal – Peak Emissions Graph
5Vdc – 1GHz - 2GHz (FCC 15.109)

Client	BeagleBoard.org Foundation	
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Standard(s)	FCC Part 15 Subpart B / ICES-003 CISPR 32/EN55032 & CISPR 24/EN55024	




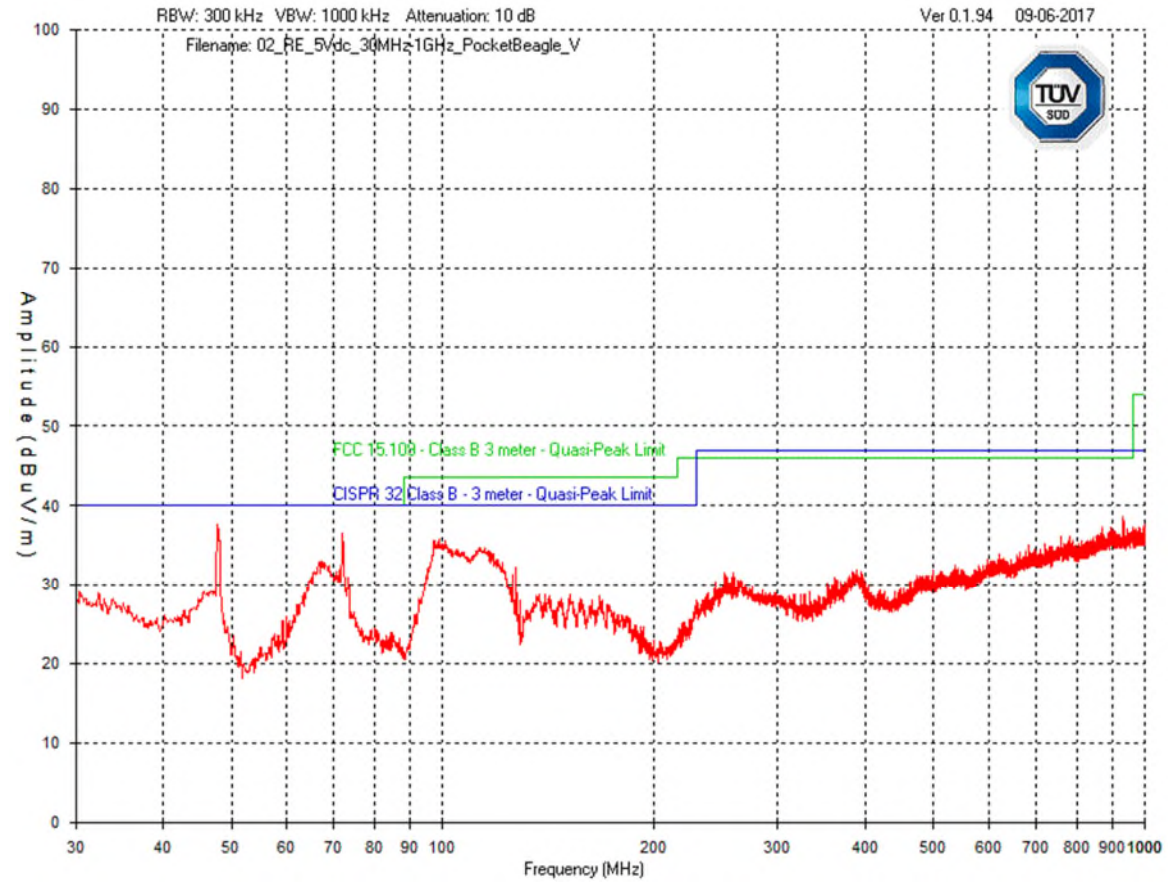
Horizontal – Peak Emissions Graph
5Vdc – 2GHz - 6GHz (CISPR 32/EN 55032)

Client	BeagleBoard.org Foundation	
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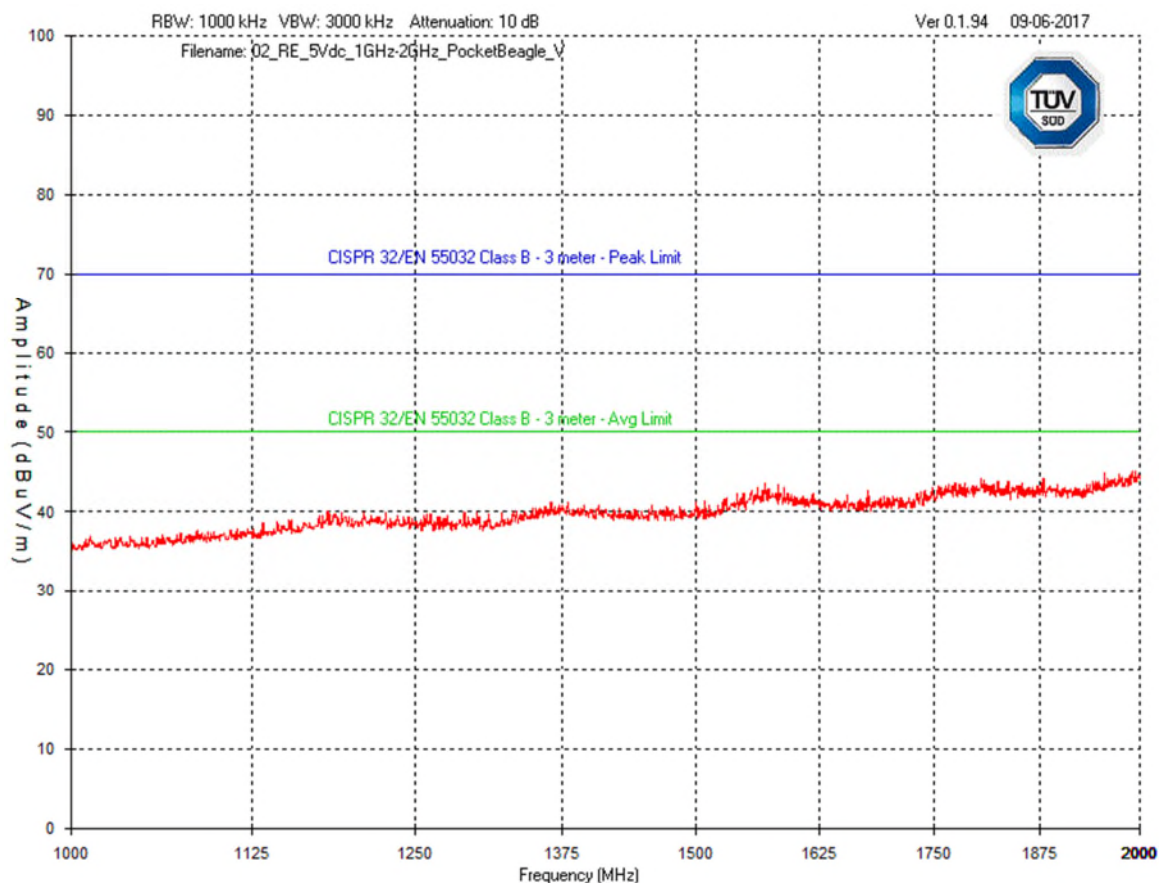
Horizontal – Peak Emissions Graph
5Vdc – 2GHz - 6GHz (FCC 15.109)

Client	BeagleBoard.org Foundation	
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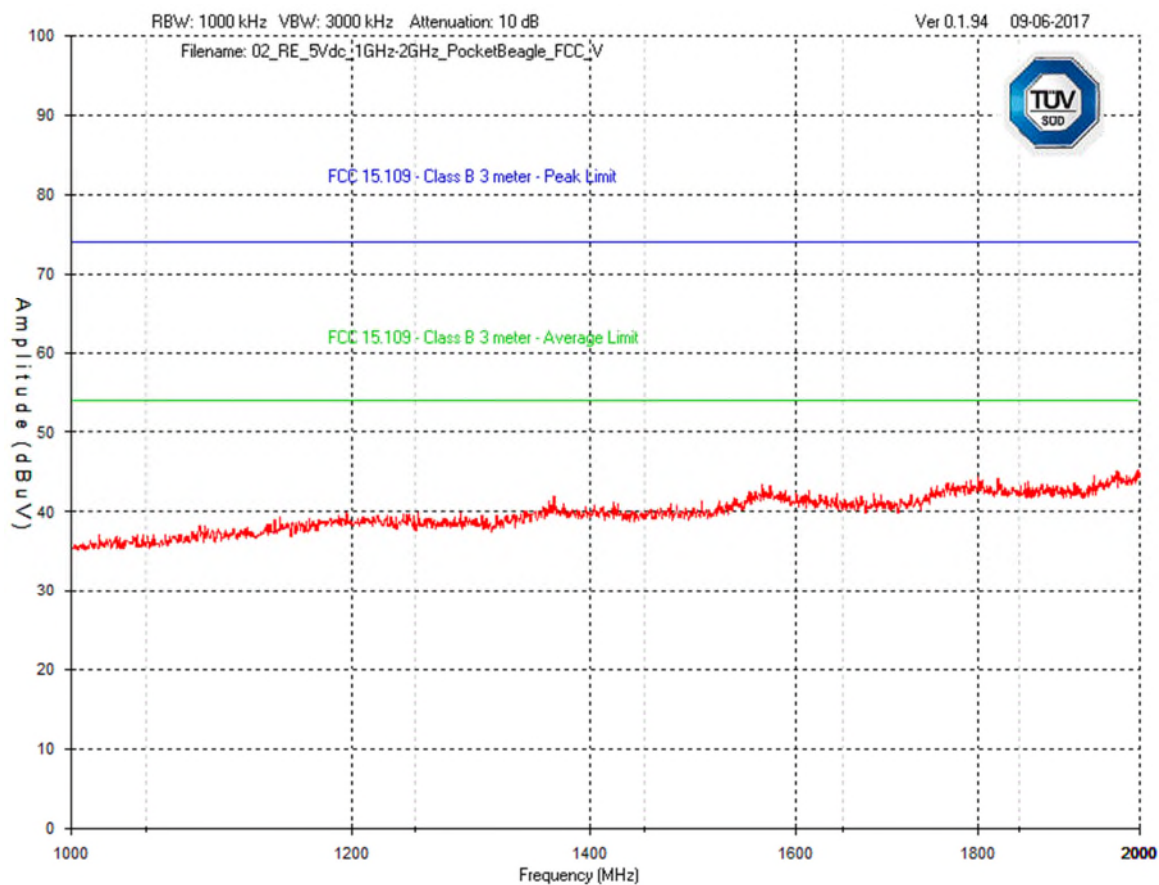
Vertical – Peak Emissions Graph
5Vdc – 30MHz – 1GHz

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Standard(s)	FCC Part 15 Subpart B / ICES-003 CISPR 32/EN55032 & CISPR 24/EN55024	




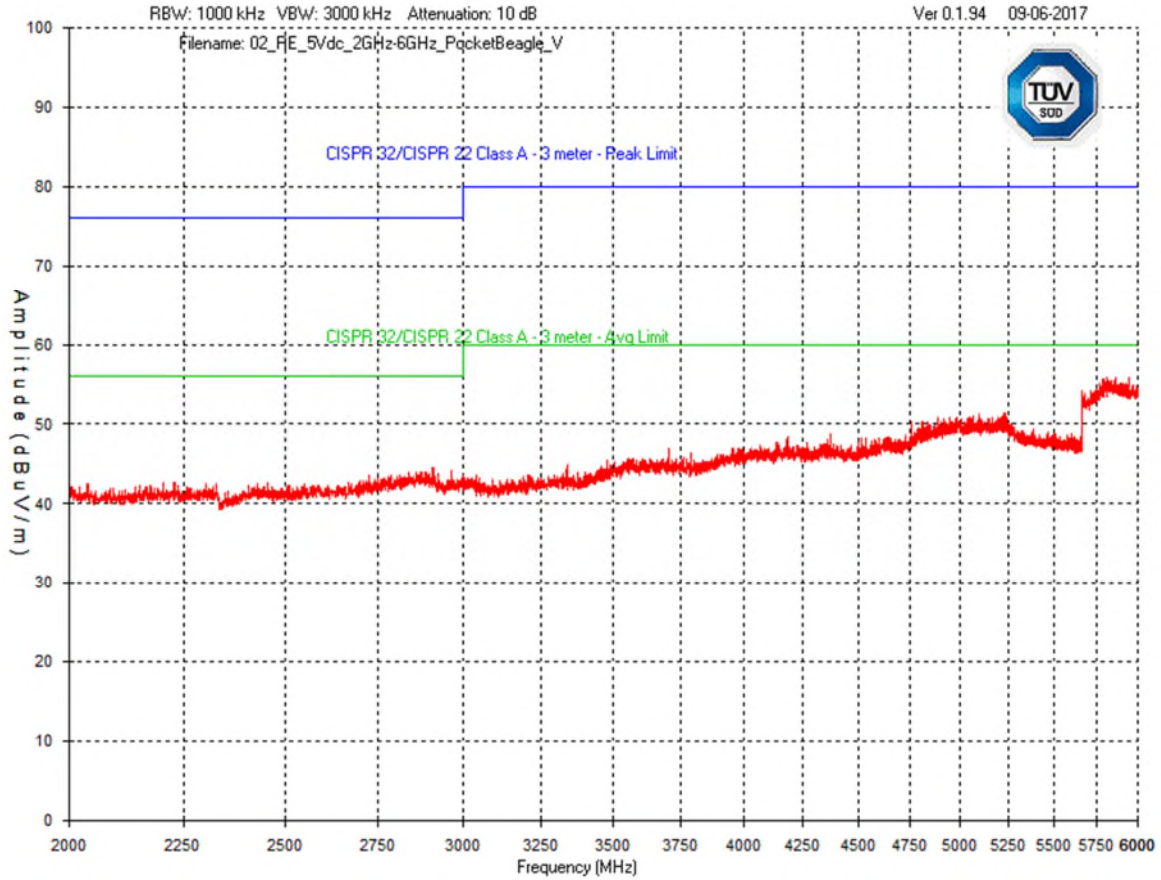
Vertical – Peak Emissions Graph
5Vdc – 1GHz - 2GHz (CISPR 32/EN 55032)

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Standard(s)	FCC Part 15 Subpart B / ICES-003 CISPR 32/EN55032 & CISPR 24/EN55024	




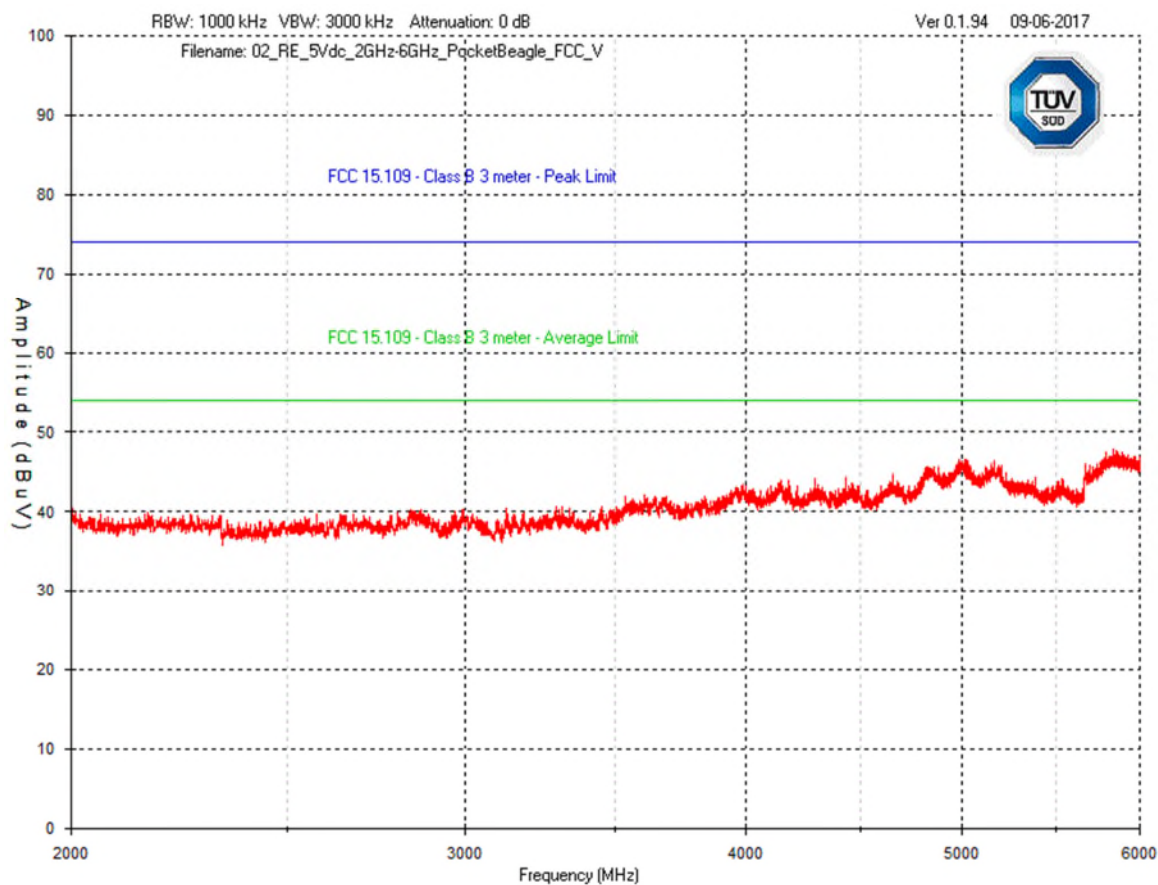
Vertical – Peak Emissions Graph
5Vdc – 1GHz - 2GHz (FCC 15.109)

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Vertical – Peak Emissions Graph
5Vdc – 2GHz - 6GHz (CISPR 32/EN 55032)

Client	BeagleBoard.org Foundation	
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Vertical – Peak Emissions Graph
5Vdc – 2GHz - 6GHz (FCC 15.109)


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Final Measurements

The worst case measurement as listed in the table below appeared at a vertical antenna height of 100 cm and a table azimuth of 360 degrees, as pictured in Appendix B.

Product Category			Class B - CISPR 32/ EN 55032							
Supply			5Vdc							
Frequency (MHz)	Detector Peak/QP	Received Signal (dBµV)	Antenna Factor (dB/m)	Atten Factor (dB)	Cable Factor (dB)	Pre-Amp (dB)	Level (dBµV/m)	QP Limit (dBµV/m)	QP Margin (dB)	Pass/Fail
Horizontal Antenna Polarization										
45.43	QP	28.5	9.0	6	0.4	-31.7	12.2	40.0	27.8	Pass
712.00	QP	39.8	6.4	6	0.5	-32.5	20.2	40.0	19.8	Pass
47.85	PEAK	54.0	9.0	6	0.4	-31.7	37.7	40.0	2.3	Pass
71.90	PEAK	56.2	6.4	6	0.5	-32.5	36.6	40.0	3.4	Pass
98.87	PEAK	54.3	8.0	6	0.6	-33.0	35.9	40.0	4.1	Pass
992.82	PEAK	36.7	23.8	6	2.5	-33.2	35.8	47.0	11.2	Pass
Vertical Antenna Polarization										
931.62	PEAK	39.9	23.4	6	2.3	-33.2	38.4	47.0	8.6	Pass
30.78	PEAK	36.4	17.3	6	0.3	-30.9	29.1	40.0	10.9	Pass
763.42	PEAK	37.2	22.3	6	2.1	-33.4	34.2	47.0	12.8	Pass
388.22	PEAK	43.2	16.5	6	1.4	-33.6	33.5	47.0	13.5	Pass
233.41	PEAK	42.9	11.7	6	1.0	-33.6	28.0	47.0	19.0	Pass
246.99	PEAK	41.7	12.2	6	1.0	-33.6	27.3	47.0	19.7	Pass

Quasi-Peak Emissions Table - CISPR 32/ EN 55032

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Standard(s)	FCC Part 15 Subpart B / ICES-003 CISPR 32/EN55032 & CISPR 24/EN55024	

Product Category			Class B - FCC Subpart B 15.109							
Supply			5Vdc							
Frequency (MHz)	Detector Peak/QP	Received Signal (dBμV)	Antenna Factor (dB/m)	Atten Factor (dB)	Cable Factor (dB)	Pre-Amp (dB)	Level (dBμV/m)	QP Limit (dBμV/m)	QP Margin (dB)	Pass/Fail
Horizontal Antenna Polarization										
45.43	QP	28.5	9.0	6	0.4	-31.7	12.2	40.0	27.8	Pass
712.00	QP	39.8	6.4	6	0.5	-32.5	20.2	40.0	19.8	Pass
47.85	PEAK	54.0	9.0	6	0.4	-31.7	37.7	40.0	2.3	Pass
71.90	PEAK	56.2	6.4	6	0.5	-32.5	36.6	40.0	3.4	Pass
98.87	PEAK	54.3	8.0	6	0.6	-33.0	35.9	43.5	7.6	Pass
992.82	PEAK	36.7	23.8	6	2.5	-33.2	35.8	54.0	18.2	Pass
Vertical Antenna Polarization										
931.62	PEAK	39.9	23.4	6	2.3	-33.2	38.4	46.0	7.6	Pass
30.78	PEAK	36.4	17.3	6	0.3	-30.9	29.1	40.0	10.9	Pass
763.42	PEAK	37.2	22.3	6	2.1	-33.4	34.2	46.0	11.8	Pass
388.22	PEAK	43.2	16.5	6	1.4	-33.6	33.5	46.0	12.5	Pass
233.41	PEAK	42.9	11.7	6	1.0	-33.6	28.0	46.0	18.0	Pass
246.99	PEAK	41.7	12.2	6	1.0	-33.6	27.3	46.0	18.7	Pass


Quasi-Peak Emissions Table – FCC Subpart B 15.109

Note:

Peak = Peak measurement

QP = Quasi-Peak measurement


See 'Appendix B – EUT, Peripherals, and Test Setup Photos' for photos showing the test set-up for the highest radiated emission.

Client	BeagleBoard.org Foundation	
Product	PocketBeagle A2	
Standard(s)	FCC Part 15 Subpart B / ICES-003 CISPR 32/EN55032 & CISPR 24/EN55024	

Test Equipment List

Equipment	Model No.	Manufacturer	Last Calibration Date	Next Calibration Date	Asset #
Spectrum Analyzer	8566B	HP	Nov 27, 2015	Nov 27, 2017	GEMC 190
Quasi-Peak Adapter	85650A	HP	Nov 27, 2015	Nov 27, 2017	GEMC 191
BiLog Antenna	3142-C	ETS	Feb. 22, 2017	Feb. 22, 2019	GEMC 137
Attenuator 6 dB	612-6-1	Meca Electronics, Inc	NCR	NCR	GEMC 287
Pre-Amp 100 kHz-10 GHz preamp	LPA-10-20	RF Bay Inc.	Feb. 2, 2017	Feb. 2, 2019	GEMC 244
Pre-Amp 1 – 26.5 GHz	HP 8449B	HP	Nov. 27, 2015	Nov. 27, 2017	GEMC 189
RF Cable 3m	LMR-400-3M- 50Ω-MN-MN	LexTec	NCR	NCR	GEMC 273
RF Cable 10m	LMR-400-10M- 50Ω-MN-MN	LexTec	NCR	NCR	GEMC 27
Emissions Software	0.1.94	TUV SUD Canada, Inc	NCR	NCR	GEMC 58

CISPR32-FCC_RE-A_Rev1

Client	BeagleBoard.org Foundation	
Product	PocketBeagle A2	
Standard(s)	FCC Part 15 Subpart B / ICES-003 CISPR 32/EN55032 & CISPR 24/EN55024	

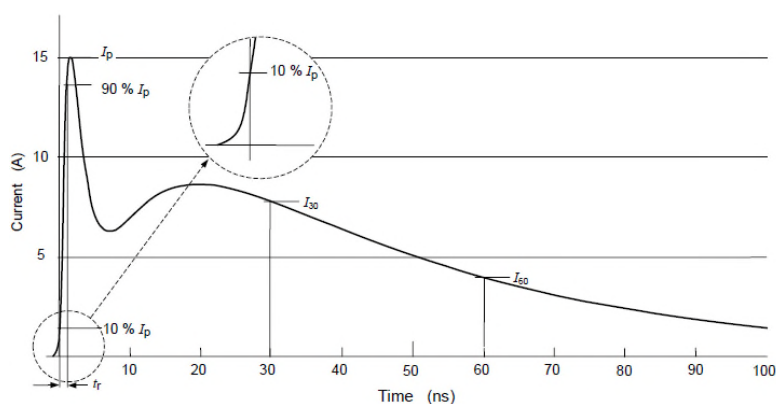
Electro-Static Discharge

Purpose


The purpose of this immunity test is to apply a static electricity discharge from the operator to the EUT or create a nearby discharge field. An example of this discharge can be seen in low humidity conditions when a person touches an object and creates a small spark. This spark could potentially be harmful to the operation of the EUT. The contact method, with related reduced voltages, has been shown to be roughly equivalent to air discharges in severity and due to its reproducibility, contact is the preferred test method. Air discharge is used where contact discharge cannot be applied since the discharge point is significantly insulated and the insulation cannot be easily broken through. This test ensures a minimum level of immunity which is likely to occur in a normal usage environment. This test does not guarantee that the EUT will not be exposed to higher discharge levels which could cause it to fail.

Application Level Requirement

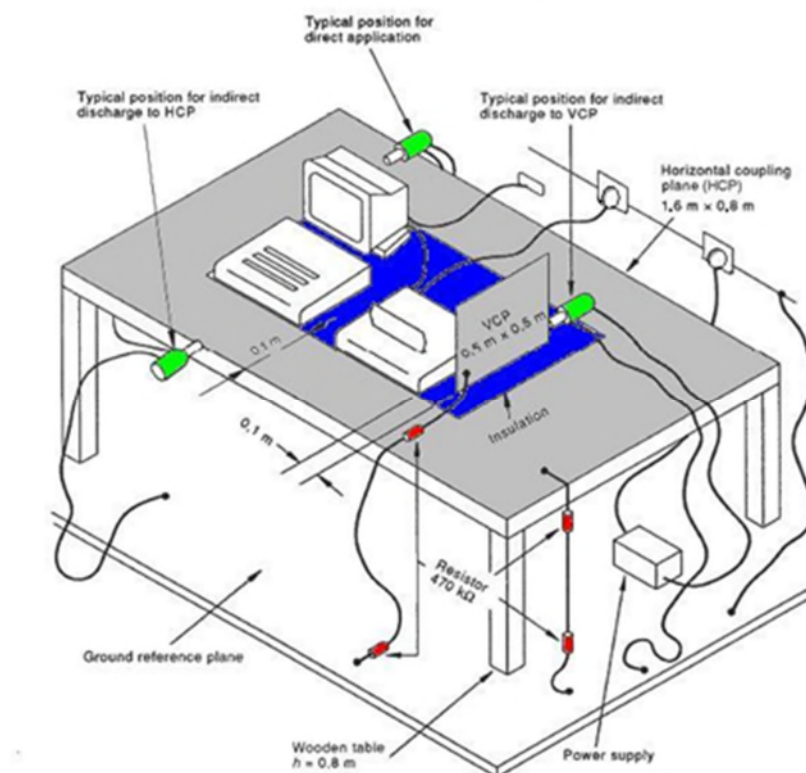
This test is performed in accordance with the methodology defined in IEC 61000-4-2. Ten hits in the positive and negative polarity are applied at each defined discharge point on the EUT. These are called direct discharges, regardless of contact or air being applied. Horizontal Coupling Plane (HCP) and Vertical Coupling Plane (VCP) discharges are also applied and these are called indirect discharges. A typical test setup representation is shown on the following page. A photograph of the actual test setup is shown in Appendix B. See the results table under Test Results for the actual EUT discharge points.



A level of $\pm 4\text{kV}$ contact or $\pm 8\text{kV}$ air, where applicable, is applied to each defined discharge point. For air discharge testing, the test is applied at the lower test levels first. Performance Criteria level B as defined in "Appendix A – EUT & Client Provided Details" is applied to this test. However, all anomalies, if any, are noted.


Client	BeagleBoard.org Foundation	 Canada
Product	PocketBeagle A2	
Standard(s)	FCC Part 15 Subpart B / ICES-003 CISPR 32/EN55032 & CISPR 24/EN55024	

Typical ESD Setup



Application Level Accuracy


Contact discharge: $\pm 15\%$ for the first peak current, $\pm 5\%$ for the output voltage and $\pm 25\%$ for the rise time as measured at the discharge electrode tip of ESD generator.

Client	BeagleBoard.org Foundation	
Product	PocketBeagle A2	
Standard(s)	FCC Part 15 Subpart B / ICES-003 CISPR 32/EN55032 & CISPR 24/EN55024	

Test Results

The EUT passed the requirements. The EUT met Criteria B as defined in "Appendix A – EUT & Client Provided Details". No anomalies were observed.


Location	Test Voltage	Discharge Type	Pass / Fail
1. HCP	±4kV	Contact	Pass
2. VCP	±4kV	Contact	Pass
3. Micro USB connector	±4kV	Contact	Pass
4. Micro SD holder	±4kV	Contact	Pass
5. Micro USB connector	±8kV	Air	Pass

Client	BeagleBoard.org Foundation	
Product	PocketBeagle A2	
Standard(s)	FCC Part 15 Subpart B / ICES-003 CISPR 32/EN55032 & CISPR 24/EN55024	

Test Equipment List

Equipment	Model No.	Manufacturer	Last Calibration Date	Next Calibration Date	Asset #
ESD Generator	NSG 437	Teseq	Jun. 28, 2017	Jun. 28, 2019	GEMC 130
ESD HCP	80CM x 160CM	TUV SUD Canada, Inc	NCR	NCR	GEMC 50
ESD VCP	50CM x 50CM	TUV SUD Canada, Inc	NCR	NCR	GEMC 51
ESD 470K A	2x470kΩ 100CM	TUV SUD Canada, Inc	NCR	NCR	GEMC 52
ESD 470K B	2x470kΩ 100CM	TUV SUD Canada, Inc	NCR	NCR	GEMC 53

IEC61000-4-2_ESD_Rev4

Client	BeagleBoard.org Foundation	
Product	PocketBeagle A2	
Standard(s)	FCC Part 15 Subpart B / ICES-003 CISPR 32/EN55032 & CISPR 24/EN55024	

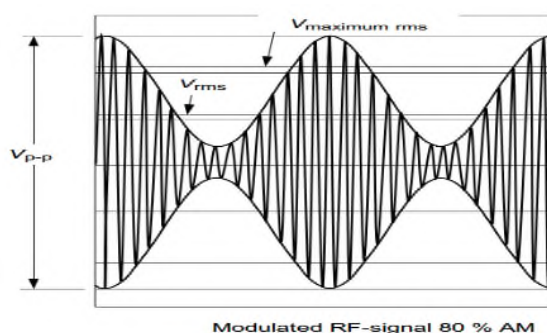
Radiated Field Immunity

Purpose


The EUT will likely be exposed to intentional sources of electromagnetic radiation during its regular application. Sources of such radiation can be cellular phones, FM radio, television, remote car alarms, garage door openers, and other broadcast transmissions. These sources of radiation are licensed or certified for broadcast and therefore, the EUT should be immune to their RF energy. This test assesses the immunity of the EUT to the applicable field strength test level. This test, however, does not guarantee that the EUT will not be exposed to higher level fields during its operation, which may cause it to fail.

Application Level Requirement

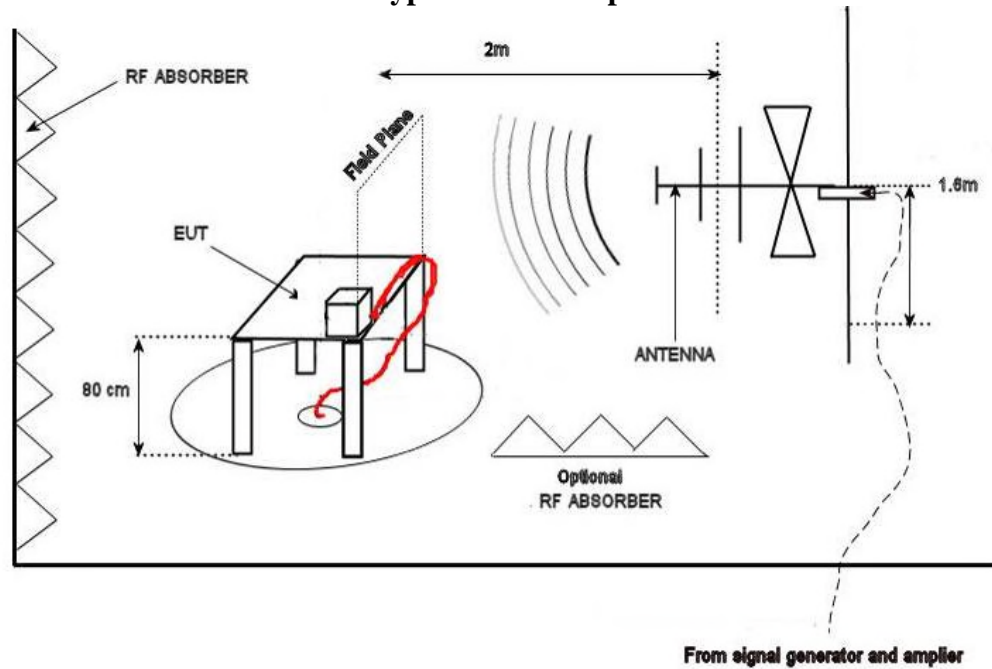
This test is performed in accordance with the methodology defined in IEC 61000-4-3. The immunity test is performed over the frequency range of 80MHz to 1.0GHz. As the frequency range is swept incrementally, the step size used is calculated at 1% of the preceding frequency value, rounded down to the nearest kHz. Known clock frequencies, local oscillators, etc. are analyzed separately, where applicable, and these are defined in "Appendix A – EUT & Client Provided Details". The field uniformity is calibrated at 3V/m and a modulation of 80% AM 1kHz sine wave is applied during the application of the RF energy at each frequency.



The RF field is applied in both horizontal and vertical antenna polarization and four sides of the EUT are subjected to this RF field. The dwell time used for each frequency is 3 seconds. Forward power is monitored and records are kept on file at TÜV SÜD Canada Inc. An isotropic field probe is also placed in near proximity of the EUT to verify the application of the RF field. Performance Criteria level A as defined in "Appendix A – EUT & Client Provided Details" is applied to this test.


Client	BeagleBoard.org Foundation	
Product	PocketBeagle A2	
Standard(s)	FCC Part 15 Subpart B / ICES-003 CISPR 32/EN55032 & CISPR 24/EN55024	

Typical Test Setup



Application Level Accuracy

As per IEC 61000-4-3, the RF field is specified as 0dB to +6dB for at least 12 of the 16 calibration points. For a 10 V/m field, this allows for the EUT to be subjected to a field of 10 V/m to 20 V/m with at least 75% coverage at this level.

Client	BeagleBoard.org Foundation	
Product	PocketBeagle A2	
Standard(s)	FCC Part 15 Subpart B / ICES-003 CISPR 32/EN55032 & CISPR 24/EN55024	

Test Results


The EUT passed the requirements. The EUT met Criteria A as defined in "Appendix A – EUT & Client Provided Details". No anomalies were observed.

Input Voltage and Frequency	5V DC	
Frequency Range and Field Strength	80MHz – 1GHz 3V/m (80% AM)	
Sweep Step	1% of Fundamental	
Dwell Time	3 sec.	
Clock Frequencies Analyzed Separately		
Clock	Frequency Inspected	Dwell Time
CPU clock	1GHz	60 sec
DDR clock	400MHz	60 sec
Result	PASS	

Test Equipment List

Equipment	Model No.	Manufacturer	Last Calibration Date	Next Calibration Date	Asset #
Signal Generator	SMU 200A	Rohde & Schwarz	Jan. 7, 2016	Jan. 7, 2018	GEMC 236
BiLog Antenna	3142-C	ETS	Feb. 22, 2017	Feb. 22, 2019	GEMC 137
Power Amplifier	50S1G6	AR	NCR	NCR	GEMC 263
Field Probe	FL 7018	AR	Sept. 21, 2016	Sept. 21, 2018	GEMC 164
Field Monitor	FM 7004	AR	NCR	NCR	GEMC 13
Power Head	PH 2000	AR	Feb. 1, 2017	Feb. 1, 2019	GEMC 15
Power Meter	PM 2002	AR	Feb. 1, 2017	Feb. 1, 2019	GEMC 16
Immunity Software	V221	TUV SUD Canada, Inc	NCR	NCR	GEMC 57

IEC61000-4-3_RadiatedImmunity_Rev4

Client	BeagleBoard.org Foundation	
Product	PocketBeagle A2	
Standard(s)	FCC Part 15 Subpart B / ICES-003 CISPR 32/EN55032 & CISPR 24/EN55024	

Electrical Fast Transients / Bursts

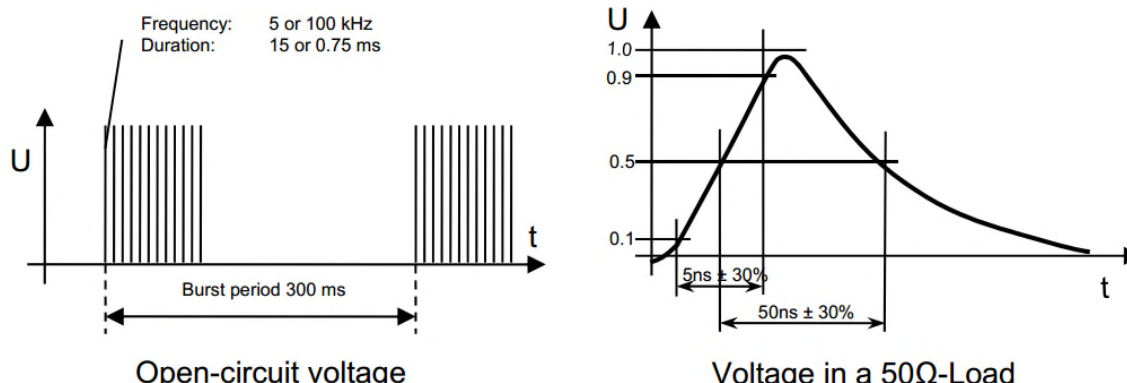
Purpose

Electrical Fast Transients is a series of bursts consisting of a number of fast transients, which in a typical application environment, can be coupled into the supply and onto the I/O lines of the EUT. These transient signals usually arise from nearby switching circuitry such as a light switch, relay bounces, electric motor noise, interruption of inductive loads, etc. This test is to verify that the EUT is immune to such transient disturbances based on the applicable test levels. This test, however, does not guarantee that the EUT will not experience higher level burst impulses during its operation, which may cause the EUT to fail.

Application Level Requirement


This test is performed in accordance with the methodology defined in IEC 61000-4-4. The voltage waveform applied has the following characteristics:

- Pulse rise time: $5\text{ns} \pm 30\%$
- Pulse duration (to 50% value): $50\text{ns} \pm 30\%$
- Pulse repetition frequency 5kHz (75 pulses per 15ms burst train)
- Burst duration should be 15ms $\pm 20\%$
- Burst period should be 300ms $\pm 20\%$

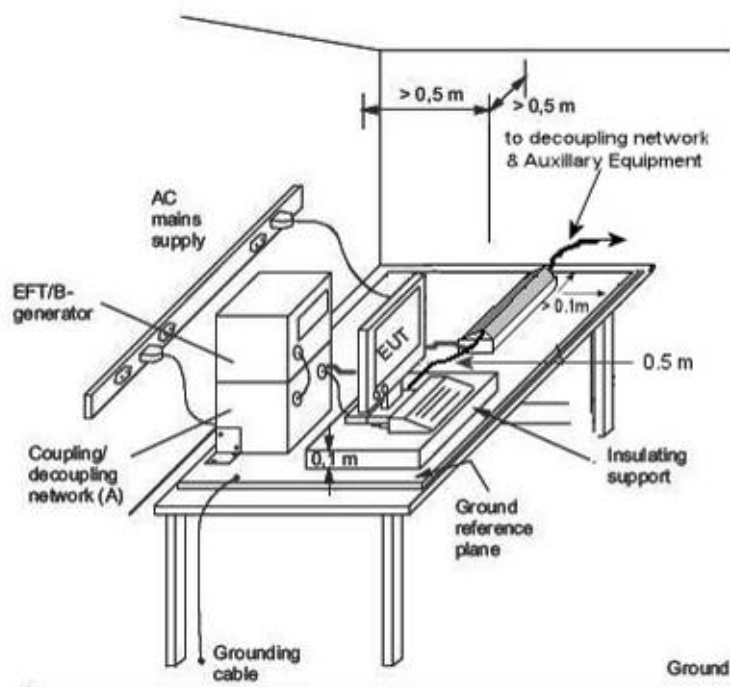


Bursts are applied for 1 minute each at the positive and the negative polarity to the mains power input (common mode) and to each applicable I/O line.

A test level of $\pm 0.5\text{kV}$ is applied to I/O lines via a capacitive coupling clamp via a coupling and decoupling network. Performance Criteria level B as defined in "Appendix A – EUT & Client Provided Details" is applied to this test.


Client	BeagleBoard.org Foundation	 Canada
Product	PocketBeagle A2	
Standard(s)	FCC Part 15 Subpart B / ICES-003 CISPR 32/EN55032 & CISPR 24/EN55024	

Typical Test Setup



Application Level Accuracy

As per IEC 61000-4-4, the test level is specified as being within $\pm 10\%$ into a 50Ω load and $\pm 20\%$ into a 1000Ω load.

Client	BeagleBoard.org Foundation	
Product	PocketBeagle A2	
Standard(s)	FCC Part 15 Subpart B / ICES-003 CISPR 32/EN55032 & CISPR 24/EN55024	

Test Results


The EUT passed the requirements. The EUT met Criteria B as defined in "Appendix A – EUT & Client Provided Details". No anomalies were observed.

Test Voltage	Repetition Rate	Coupling Lines	Result
±0.5kV	5kHz	I/O Line	Pass

Test Equipment List

Equipment	Model No.	Manufacturer	Last Calibration Date	Next Calibration Date	Asset #
Immunity Generator	EMC Pro Plus	Keytek Thermo Corp.	Dec. 19, 2016	Dec. 19, 2018	GEMC 4
CCL Clamp	EMC Pro Plus	Keytek Thermo Corp.	Dec. 19, 2016	Dec. 19, 2018	GEMC 5
Immunity Software	CEWare 32 V4.1	Thermo Fisher Scientific	NCR	NCR	GEMC 182

IEC61000-4-4_EFTB_Rev4

Client	BeagleBoard.org Foundation	
Product	PocketBeagle A2	
Standard(s)	FCC Part 15 Subpart B / ICES-003 CISPR 32/EN55032 & CISPR 24/EN55024	


Power Frequency Magnetic Field

Purpose

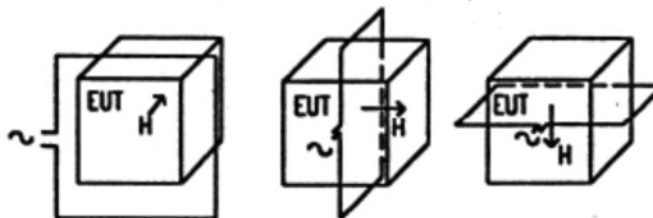
A magnetic field with the frequency of the power line is generated around the EUT. In practice, the EUT will be subjected to power frequency magnetic fields from nearby power lines, transformers, or devices such as televisions or monitors. Since the EUT is usually used in conjunction with other electrical equipment, it is subjected to the steady state magnetic fields. These are magnetic fields that the device is exposed to under normal operating conditions. These fields have lower field strengths compared to typical transient magnetic fields.

Application Level Requirement

This test is performed in accordance with the methodology defined in IEC 61000-4-8. Three orthogonal axis of the EUT are subjected to the field within the magnetic loop. The transient magnetic field, if applicable, is tested for 1 minute while the steady state magnetic field is tested for 15 minutes. The frequencies applied are 50 Hz and 60 Hz. A magnetic field strength of 3 A/m is applied to the EUT in each orthogonal axis. Performance Criteria level A as defined in "Appendix A – EUT & Client Provided Details" is applied to this test.

Client	BeagleBoard.org Foundation	
Product	PocketBeagle A2	
Standard(s)	FCC Part 15 Subpart B / ICES-003 CISPR 32/EN55032 & CISPR 24/EN55024	

Typical Setup Diagram



Application Level Accuracy

As per IEC 61000-4-8, the field over the area that the EUT occupies within the loop must be calibrated to be within $\pm 3\text{dB}$. For a field strength of 3 A/m, this means that the empty calibrated field strength can be between 2.1 A/m and 4.2 A/m over the area that the EUT occupies.

Test Results

The EUT passed the requirements. The EUT met Criteria A as defined in "Appendix A – EUT & Client Provided Details". No anomalies were observed.


When a 50 Hz power frequency magnetic field was applied to the EUT, it was powered at 5Vdc.

Test Equipment List

Equipment	Model No.	Manufacturer	Last Calibration Date	Next Calibration Date	Asset #
Magnetic Loop	F-1000-4-8/9/10-L-1M	FCC	NCR	NCR	GEMC 22
Immunity Generator	EMC Pro Plus	Keytek Thermo Corp.	Dec. 19, 2016	Dec. 19, 2018	GEMC 4
Immunity Software	CEWare 32 V4.1	Thermo Fisher Scientific	NCR	NCR	GEMC 182
Clamp Meter	365	Fluke	Nov. 23, 2016	Nov. 23, 2017	GEMC 260


IEC61000-4-8_MagneticImmunity_Rev3

Appendix A – EUT & Client Provided Details


Client	BeagleBoard.org Foundation	
Product	PocketBeagle A2	
Standard(s)	FCC Part 15 Subpart B / ICES-003 CISPR 32/EN55032 & CISPR 24/EN55024	

General EUT Description

Client Details	
Organization / Address	BeagleBoard.org Foundation, 4467 Ascot Ct, Oakland Twp, MI 48306
Contact	Jason Kridner
Phone	+1-586-764-1992
Email	jkridner@gmail.com
EUT (Equipment Under Test) Details	
EUT Name	PocketBeagle
EUT revision	A2
Software version	pocketbeagle-debug-20170803a.img.xz
Equipment category	Single board computer
EUT is powered using	USB
Input voltage range(s) (V)	5V
Nominal power consumption (W)	0.25
Number of power supplies in EUT	1
Transmits RF energy? (describe)	No
Basic EUT functionality description	Development board
Modes of operation	Running test program
Step by step instructions for setup and operation	* Connect microSD card and microUSB cable to EUT * Connect other microUSB cable end to 5V source
Customer to setup EUT on site?	No
EUT response time (ms)	N/A
EUT setup time (min)	2+ minutes
Frequency of all clocks present in EUT	24MHz oscillator, 1GHz processor clock (internal to OSD3358), 400MHz DDR clock (internal to OSD3358), 48MHz USB clock (internal to OSD3358)

Client	BeagleBoard.org Foundation	
Product	PocketBeagle A2	
Standard(s)	FCC Part 15 Subpart B / ICES-003 CISPR 32/EN55032 & CISPR 24/EN55024	

I/O cable description Specify length and type	3 ft microUSB cable
Available connectors on EUT	microUSB client, microSD card
Peripherals required to exercise EUT Ex. Signal generator	microUSB cable, microSD card
Dimensions of product	L 56 mm W 35 mm H 5 mm
Method of monitoring EUT and description of failure for immunity.	<p>EUT will provide a "heartbeat" pattern on LED USR0. EUT will provide occasional blinks related to microSD card access on LED USR1.</p> <p>1 - Device will recover with no interruptions to LED pattern. Mitigation: none.</p> <p>2 - Device will reset and return to LED pattern with no user interaction. Mitigation: none.</p> <p>3 - Device will reset and fail to boot. Mitigation: requires re-flashing of microSD contents with software image.</p>
Other notes to test lab (URL to product, etc).	https://beagleboard.org/pocket

Client	BeagleBoard.org Foundation	
Product	PocketBeagle A2	
Standard(s)	FCC Part 15 Subpart B / ICES-003 CISPR 32/EN55032 & CISPR 24/EN55024	

EUT Functional Description

The PocketBeagle is a Linux-enabled community-supported, open-source USB-key-fob computer development platform. PocketBeagle is built around Octavo Systems' System-In-Package that integrates a high-performance TI AM3358 processor, 512MB of DDR3, power management, nonvolatile serial memory and over 140 passive components into a single package.

EUT Configuration

Please see Appendix B for a picture of the unit running in normal conditions.

- Cables and earthing were connected as per manufacturer's specification.
- One 5Vdc power source plugged into micro USB port.
- One Digital Multimeter connected to 3V3 line.
- One micro-SD flash memory card was used with specific software loaded to exercise device functionality defined by the manufacturer.

Operational Setup

Peripheral devices were attached to the EUT for its test operation. However, this report does not represent compliance of these peripheral device(s) in any way.

- None.

Modifications for Compliance

The following modifications were made during testing for the sample to achieve compliance with the testing requirements:


- None. The EUT provided met the requirements without need for modification.

Criteria Description


Performance Criterion A: During and after the test, the equipment shall continue to operate as intended as specified by the manufacturer.

Performance Criterion B: After the test, the equipment shall continue to operate as intended as specified by the manufacturer. During testing, temporary degradation, or loss of function or performance which is self-recovering is allowed.

Performance Criterion C: During testing, temporary degradation, or loss of function or performance which is self-recoverable or restorable by the operation of controls.

Client	BeagleBoard.org Foundation	 Canada
Product	PocketBeagle A2	
Standard(s)	FCC Part 15 Subpart B / ICES-003 CISPR 32/EN55032 & CISPR 24/EN55024	

Appendix B – EUT, Peripherals, and Test Setup Photos

Client	BeagleBoard.org Foundation	
Product	PocketBeagle A2	
Standard(s)	FCC Part 15 Subpart B / ICES-003 CISPR 32/EN55032 & CISPR 24/EN55024	

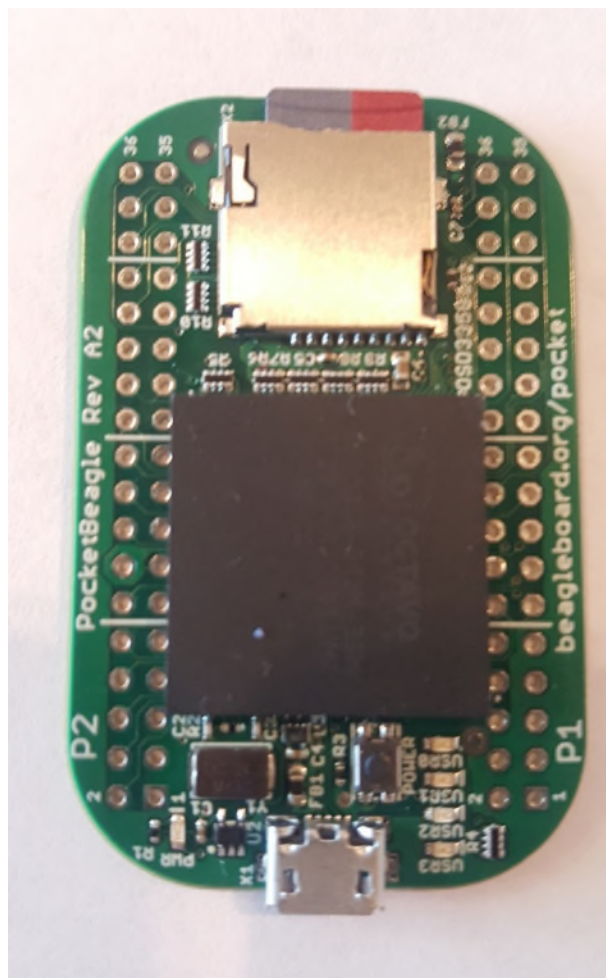



Figure 1 – EUT Close Up – Top

Client	BeagleBoard.org Foundation	 Canada
Product	PocketBeagle A2	
Standard(s)	FCC Part 15 Subpart B / ICES-003 CISPR 32/EN55032 & CISPR 24/EN55024	

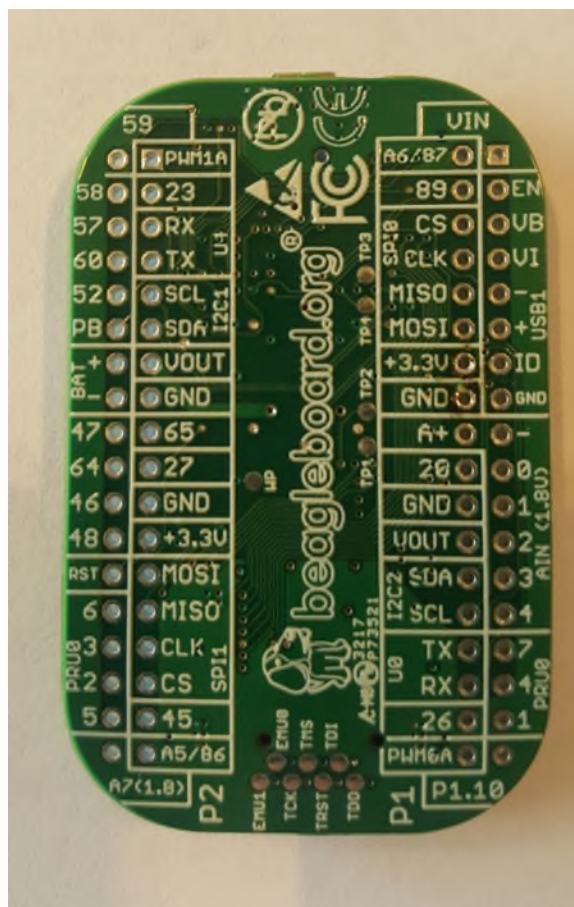


Figure 2 – EUT Close Up – Back


Client	BeagleBoard.org Foundation	
Product	PocketBeagle A2	
Standard(s)	FCC Part 15 Subpart B / ICES-003 CISPR 32/EN55032 & CISPR 24/EN55024	



Figure 3 – Radiated Emissions Setup – Photo 1
30MHz – 1GHz



Figure 4 – Radiated Emissions Setup – Photo 1
1GHz – 2GHz


Client	BeagleBoard.org Foundation	
Product	PocketBeagle A2	
Standard(s)	FCC Part 15 Subpart B / ICES-003 CISPR 32/EN55032 & CISPR 24/EN55024	



Figure 5 – Radiated Emissions Setup – Photo 2
2GHz to 6GHz

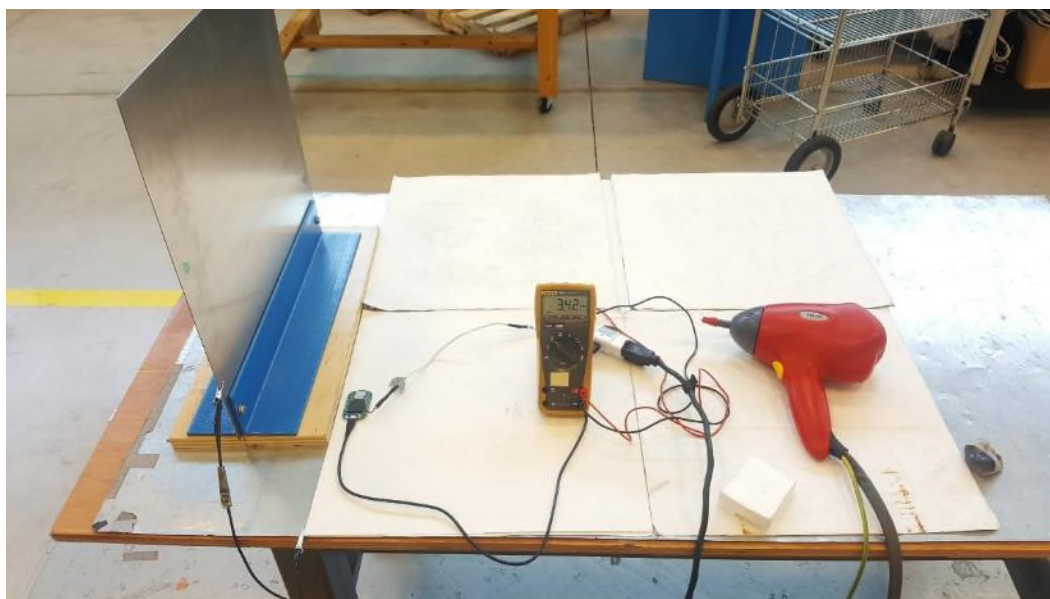


Figure 6 – Electro-Static Discharge Setup


Client	BeagleBoard.org Foundation	
Product	PocketBeagle A2	
Standard(s)	FCC Part 15 Subpart B / ICES-003 CISPR 32/EN55032 & CISPR 24/EN55024	



Figure 7 – Radiated Immunity Setup – Photo 1

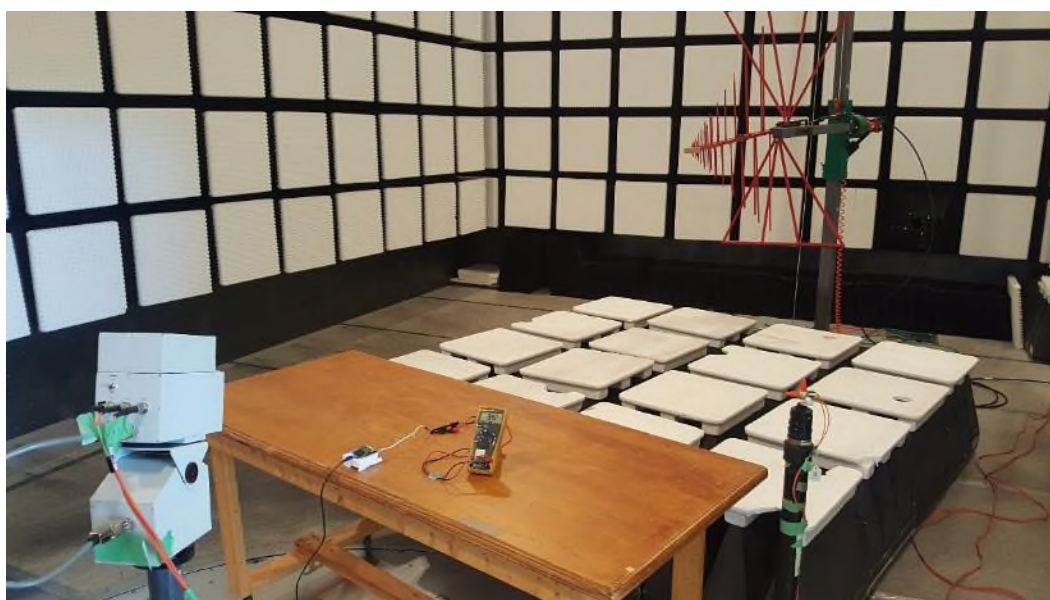


Figure 8 – Radiated Immunity Setup – Photo 2


Client	BeagleBoard.org Foundation	
Product	PocketBeagle A2	
Standard(s)	FCC Part 15 Subpart B / ICES-003 CISPR 32/EN55032 & CISPR 24/EN55024	



Figure 9 – EFT Setup – Signal/Interconnection Lines

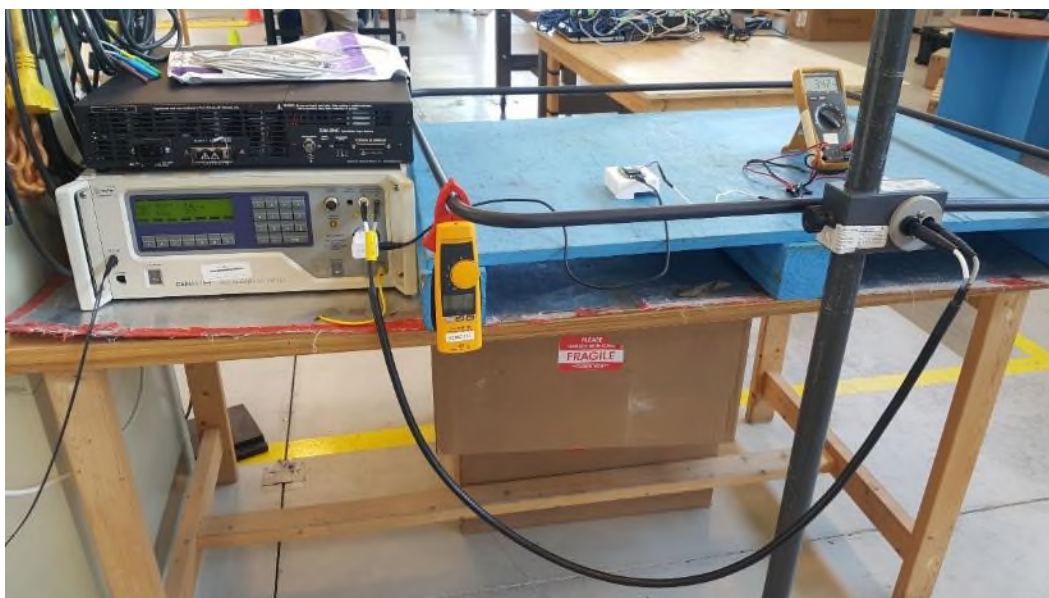


Figure 10 – Power Frequency Magnetic Field Setup