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EMI TEST REPORT
for
CERTIFICATION to
FCC PART 15 Subpart C (Section 15.247)
& RSS-210

FCC ID: EJE-WL0006
Industry Canada ID: 337J-WL0006
Test Sample: Mini-PCI WLAN (Atheros 11a+b/g)
WLAN Model: WLL4030

Report Number M040222_Cert_Mace_Atheros_2.4

Tested for: Fujitsu Australia Ltd.

Issue Date: 4th March 2004

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NATA Accredited Laboratory
Number: 5292

EMI TEST REPORT FOR CERTIFICATION
to
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EMC Technologies Report No. M040222_Cert_Mace_Atheros_2.4
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**EMI TEST REPORT FOR CERTIFICATION to
FCC PART 15 Subpart C (Section 15.247) & RSS-210**

Report Number: M040222_Cert_Mace_Atheros_2.4
Test Sample: Mini-PCI WLAN (Atheros 11a+ b/g) Module

WLAN Model Number: WLL4030
WLAN Manufacturer: Askey Computer Corp.
Interface Type: Mini-PCI Wireless LAN Module

FCC ID: EJE-WL0006
Industry Canada ID: 337J-WL0006
Equipment Type: Intentional Radiator (Transceiver)

LifeBook PC: LifeBook T Series
Model Number: T3010D
Codename: Mace
Manufacturer (LifeBook): Fujitsu Limited
Address: 1405, Ohmaru, Inagi-shi, Tokyo 206-8503, Japan
Contact: Mr. Kanbe Katsuhito

Tested for: Fujitsu Australia Ltd
Address: 5 Lakeside Drive,
Burwood East, VIC 3151 Australia
Phone: +613 9845 4300
Fax: +613 9845 4600
Contact: Mr Praveen Rao – Senior Compliance Engineer

Test Standards: FCC Part 15, Subpart C – Intentional Radiators
FCC Part 15.247, 2400 – 2483.5 MHz Operation Band
ANSI C63.4 – 1992
OET Bulletin No. 63

RSS-210 Issue 5 Low Power Licence-Exempt RadioCommunication
Devices: 6.2.2 (o) 2400 – 2483.5 MHz Spread Spectrum

RSS-102 Issue 1 (Provisional), Evaluation Procedure for Mobile and
Portable Radio Transmitters with respect to Health Canada's Safety
Code 6 for Exposure of Humans to Radio Frequency Fields

Test Dates: 29th January to 1st March 2004

Test Officer: 
Chieu Huynh B.Eng (Hons) Electronics

Attestation: *I hereby certify that the device(s) described herein were tested as described in this report and that the data included is that which was obtained during such testing.*

Authorised Signatory: 
Chris Zombolas
Technical Director
EMC Technologies Pty Ltd



EMI TEST REPORT FOR CERTIFICATION to FCC PART 15 Subpart C (Section 15.247) & RSS-210

1.0 INTRODUCTION

EMI testing was performed on test sample Mini-PCI Wireless LAN Module (Atheros 11a+b/g), Model WLL4030.

The Atheros module supports IEEE 802.11a, IEEE 802.11b and IEEE 802.11g configurations. Tests were performed in all three configurations and results for configurations IEEE 802.11b, IEEE 802.11g are reported in this test report.

The results for IEEE 802.11a configuration are reported separately (refer to EMC Technologies' test report: M040222_Cert_Mace_Atheros_5.2).

Test results and procedures were performed in accordance with the following Federal Communications Commission (FCC) standards/regulations:

- 47 CFR, Part 15, Subpart C: Rules for intentional radiators (particularly section 15.247)
- Section 15.203: Antenna requirements
- Section 15.205: Restricted bands of operation
- Section 15.207: Conducted Emission Limits
- Section 15.209: Radiated Emission Limits (General requirements)
- Section 15.247: Operation in the bands 902-928 MHz, 2400-2483.5 MHz, 5725-5850 MHz

The test sample **complied** with the requirements of 47 CFR, Part 15 Subpart C - Section 15.247.

The test sample also complied with the Industry Canada RSS-210 issue 5 (Low Power Licence-Exempt Radiocommunication Devices (All Frequency Bands)) clause 6.2.2(o) and the RF exposure requirements of RSS-102.

1.1 Summary of Results

1.1.1 WLAN, Atheros 802.11b/g - FCC PART 15 Subpart C (Section 15.247)

FCC Part 15, Subpart C Clauses	Industry Canada RSS-210 Clauses	Test Performed	Result
15.203	5.5	Antenna Requirement	Not Applicable
15.205	6.3	Operation in Restricted Band	Complies
15.207	6.6	Conducted Emissions	Complies
15.209	6.3	Radiated Emissions	Complies
15.247 (a)(2)	6.2.2(o)(iv)	Channel Bandwidth	Complies
15.247 (b)(3)	6.2.2(o)(b)	Peak Output Power	Complies
15.247 (b)(5)		Radio Frequency Hazard	*Complies with SAR requirements
15.247 (c)	6.2.2(o)(e1)	Out of Band Emissions	Complies
15.247 (d)	6.2.2(o)(iv)	Peak Power Spectral Density	Complies

*Refer to EMC Technologies' report M040121_Atheros_SAR_2.4



1.1.2 WLAN, Atheros 802.11a - FCC PART 15 Subpart E (Section 15.407)

FCC Part 15, Subpart E Clauses	Industry Canada RSS-210 Clauses	Test Performed	Result
15.203	5.5	Antenna Requirement	Not Applicable
15.205	6.3	Operation in Restricted Band	Complies
15.207	6.6	Conducted Emissions	Complies
15.209	6.3	Radiated Emissions	Complies
15.407 (a)(4)	6.2.2(q1)	Peak Transmit Power	Complies
15.407 (a)(5)	6.2.2(q1)	Peak Power Spectral Density	Complies
15.407 (a)(6)		Peak Excursion	Complies
15.407 (b)	6.2.2(q1)	Undesirable Emission	Complies
15.407 (f)		Radio Frequency Hazard	Complies
15.407 (g)	6.4	Frequency Stability	Complies

Refer to EMC Technologies Report No: M040222_Cert_Mace_Atheros_5.2

The measurement procedure used was in accordance with ANSI C63.4-1992 and OET Bulletin No. 96-43. The instrumentation conformed to the requirements of ANSI C63.2-1987.

1.2 Modifications by EMC Technologies

No modifications were required.

2.0 GENERAL INFORMATION

(Information supplied by the Client)

2.1 Product Details

Test Sample: Mini-PCI WLAN (Atheros 11a+b/g)
WLAN Model Number: WLL4030
WLAN Manufacturer: Askey Computer Corp.
Interface Type: Mini-PCI Wireless LAN Module

FCC ID: EJE-WL0006
Industry Canada ID: 337J-WL0006
Equipment Type: Intentional Radiator (Transceiver)

Host PC: LifeBook T Series
Model Number: T3010D
Code Name: Mace
Serial Number: Pre-production Sample
Manufacturer: Fujitsu Limited

CPU Type and Speed: Pentium-M 1.4 GHz
SDRAM: 256MB
LCD Screen: 12.1"XGA

Wired LAN: Realtech 10/100Base-T (On Board)
Modem: MBH7MD33 / MBH7MD35
Wireless LAN (WLAN) Module: Atheros 11a+b/g (WLL4030)
Port Replicator Model: Calexico2 11b/g (WM3B2200BG) FPCPR39 or FPCPR39AP



AC Adapter:	Tests were performed with CA0-1007-0850
AC Adapter Model Number:	CA01007-0850
Alternate Models:	UJ88
Voltage:	16 V
Current Specs:	3.75 A
Watts:	60 W

2.2 Technical Specifications

2.2.1 WLAN Transmitter Specifications

WLAN Transmitter:	Mini-PCI Wireless LAN Module
Wireless Module:	Atheros
Model Number:	WLL4030 (11a+b/g module)
Manufacturer:	Askey Computer Corp.
Modulation Type:	Direct Sequence Spread Spectrum (DSSS for 802.11b) Orthogonal Frequency Division Multiplexing (OFDM for 802.11g) Orthogonal Frequency Division Multiplexing (OFDM for 802.11a)
802.11a	BPSK – 6Mbps, 9Mbps QPSK – 12Mbps, 18Mbps 16QAM – 24Mbps, 36Mbps 64QAM – 48Mbps, 54Mbps
802.11g	BPSK – 6Mbps, 9Mbps QPSK – 12Mbps, 18Mbps 16QAM – 24Mbps, 36Mbps 64QAM – 48Mbps, 54Mbps
802.11b	DBPSK – 1Mbps DQPSK – 2Mbps CCK – 5.5Mbps, 11Mbps
Maximum Data Rate:	802.11b = 11Mbps, 802.11g and 802.11a = 54Mbps
Frequency Range:	2.4 –2483.5 GHz for 11b/g 5.15 - 5.35 GHz and 5.725 - 5.825 GHz for 11a
Number of Channels:	11 maximum (for 11b/11g) 12 maximum (for 11a) *Passive Scan only
Antenna Type:	Monopole Dielectric Antenna
Antenna Part Number:	DA120D-2545M-FJ01
Max. Output Power:	802.11b = 15 dBm 802.11g = 14.5 dBm 802.11a Band 1 (5.15 to 5.25 GHz) = 13.5 dBm 802.11a Band 2 (5.25 to 5.35 GHz) = 14 dBm 802.11a Band 3 (5.725 to 5.825 GHz) = 14.5 dBm
Power Supply:	3.3 VDC from PCI bus
Chipset Used:	Atheros AR5212, AR5112
Turbo Mode:	For 802.11g & 802.11a only
Data rate (Turbo):	12 MBps to 108 Mbps



Frequency allocation for 802.11b/g:

Channel Number	Frequency (MHz)	Turbo mode Frequency (MHz) FOR 802.11g ONLY
1	2412	--
2	2417	--
3	2422	--
4	2427	--
5	2432	--
6	2437	2437
7	2442	--
8	2447	--
9	2452	--
10	2457	--
11	2462	--

Frequency allocation for 802.11a:

Channel Number	Frequency (MHz)	Turbo mode Frequency (MHz)
36	5180	5210
40	5200	--
44	5220	--
48	5240	5250
52	5260	--
56	5280	5290
60	5300	
64	5320	
149	5745	
153	5765	5760
157	5785	--
161	5805	5800

2.3 Operational Description

The EUT is a Mini-PCI Wireless LAN (WLAN) Module (Atheros 11a+b/g, Model WLL4030) (installed in Host PC – LifeBook T Series, Model T3010D (Mace).

The WLAN module is an OEM product from Askey Computer Corp., which is already certified by FCC ID: H8NWLL4030 and IC: 1353A-WLL4030 and re-certified by Fujitsu Ltd under FCC ID: EJE-WL0004, IC:337J-WL0004 & EJE-WB0002, IC: 337J-WB0002.

The intention of this application is to certify the WLAN module in LifeBook T Series, Model T3010D (Mace). The Mace is a notebook/Pentablet.

The highest CPU speed, Pentium-M 1.4 GHz model was chosen for the tests and all other Mace models which are identical to the tested model except with lower CPU speed shall be declared compliant based on this test report.



2.4 Test Configuration

The Askey software was used to set-up the WLAN module to continuously transmit during the tests. The LCD screen was observed for the transmitter status shown for the respective software.

Antenna

The Atheros (11a+b/g) WLAN, Model WLL4030 is configured with a Monopole Dielectric antenna, Part No DA120D-2545M-FJ01. The installation of the OEM WLAN module and the Antenna in Fujitsu LifeBook T Series, Model T3010D (Mace) is in a controlled environment. The installation is performed during the production/assembly process at the Fujitsu factory.

Refer to Appendix N – Antenna Information.

AC Adapter

The AC adapter CA01007-0850 was used for all the tests. This adapter is also identified as CA01007-0870, SEB80N2-16.0 & UJ88. The manufacturer has stated that all these adapters are identical electrically and mechanically.

2.5 Block Diagram

Refer to Appendix D - Block Diagram

2.6 Support Equipment

External Monitor/s:

Conducted EMI	Videocom, Model DCM-1588VAE, FCC ID: H79DCM-1588
Radiated EMI	Hewlett Packard 15" Color monitor, Model D2827A, FCC ID: C5F7NFCMC1515X

USB Floppy Drives:

Fujitsu Model: FPCFDD11, P/N CP032173-01
Fujitsu Model: FPCFDD12, P/N CP078720-01

Headphones:

Verbatim Multimedia Stereo headset

USB Mouse:

Microsoft Intellimouse, S/N 00723014, FCC ID: C3KKS9

USB Keyboard

Logitech, Model: YBA9, S/N MCT94602411

LAN Hub:

Kingston SOHO Hub Model: KNE8TP/H (FCC ID: JICKNE8TP-HO)

PCMCIA Slot:

8 MB flash card, Kingmax ATA008M

2.7 Test Procedure

Emissions measurements were performed in accordance with the procedures of ANSI C63.4-1992. Radiated emissions tests were performed at a distance of 3 and 10 metres from the EUT. OET Bulletin 63 dated October 1993 was used for reference.

2.8 Test Facility

2.8.1 General

Radiated Emission measurements were performed at EMC Technologies open area test site (OATS) situated at Lerderderg Gorge, near the township of Bacchus Marsh in Victoria, Australia. Conducted emission measurements were performed at EMC Technologies' laboratory in Tullamarine, Victoria Australia.

The above sites have been fully described in a report submitted to the FCC office, and accepted in a letter dated June 14, 2002, **FCC Registration Number 90560**.

EMC Technologies open area test site (OATS) has also been accepted by Industry Canada for the performance of radiated measurements in accordance with RSS 212, Issue 1 (Provisional).

Industry Canada File Number, IC 4161, (Registration Date - November 5th 2001).



2.8.2 NATA Accreditation

EMC Technologies is accredited in Australia to test to the following standards by the National Association of Testing Authorities (NATA).

“FCC Part 15 unintentional and intentional emitters in the frequency range 9kHz to 18 GHz excluding TV receivers (15.117 and 15.119), TV interface devices (15.115), cable ready consumer electronic equipment (15.118), cable locating equipment (15.213) and unlicensed national information infrastructure devices (Sub part E).”

The current full scope of accreditation can be found on the NATA website: www.nata.asn.au
It also includes a large number of emission, immunity, SAR, EMR and Safety standards.

NATA is the Australian national laboratory accreditation body and has accredited EMC Technologies to operate to the IEC/ISO17025 requirements. A major requirement for accreditation is the assessment of the company and its personnel as being technically competent in testing to the standards. This requires fully documented test procedures, continued calibration of all equipment to the National Standard at the National Measurements Laboratory (NML) and an internal quality system to ISO 9002. NATA has mutual recognition agreements with the National Voluntary Laboratory Accreditation Program (NVLAP) and the American Association for Laboratory Accreditation (A²LA).

2.9 Units of Measurements

2.9.1 Conducted Emissions

Measurements are reported in units of dB relative to one microvolt. (dB μ V).

2.9.2 Radiated Emissions

Measurements are reported in units of dB relative to one microvolt per metre (dB μ V/m).

2.10 Test Equipment Calibration

All measurement instrumentation and transducers were calibrated in accordance with the applicable standards by an independent NATA registered laboratory such as Agilent Technologies (Australia) Pty Ltd or the National Measurement Laboratory (NML). All equipment calibration is traceable to Australia national standards at the National Measurements Laboratory. The reference antenna calibration was performed by NML and the working antennas (biconical and log-periodic) calibrated by the NATA approved procedures. The complete list of test equipment used for the measurements, including calibration dates and traceability is contained in Appendix A.

2.11 Ambients at OATS

The Open Area Test Site (OATS) is an area of low background ambient signals. No significant broadband ambients are present however commercial radio and TV signals exceed the limit in the FM radio, VHF and UHF television bands. Radiated prescan measurements were performed in the shielded enclosure to check for possible radiated emissions at the frequencies where the OATS ambient signals exceeded the test limit.



RESULTS

WLAN Module - Atheros 802.11b/g (WLL4030)

1.0 CONDUCTED EMISSION MEASUREMENTS

Testing was performed in accordance with the requirements of FCC Part 15.207

1.1 Test Procedure

The arrangement specified in ANSI C63.4-1992 was adhered to for the conducted EMI measurements. The EUT was placed in the RF screened enclosure and a CISPR EMI Receiver as defined in ANSI C63.2-1987 was used to perform the measurements.

The EMI Receiver was operated under program control using the Max-Hold function and automatic frequency scanning, measurement and data logging techniques. The specified 0.15 MHz to 30 MHz frequency range was sub-divided into sub-ranges to ensure that all short duration peaks were captured.

1.2 Peak Maximising Procedure

The various operating modes of the system were investigated. For each of the sub-ranges, the EMI receiver was set to continuous scan with the Peak detector set to Max-Hold mode. The Quasi-Peak detector and the Average detector were then invoked to measure the actual Quasi-Peak and Average level of the most significant peaks, which were detected.

1.3 Calculation of Voltage Levels

The voltage levels were automatically measured in software and compared to the test limit. The method of calculation was as follows:

$$VEMI = VRx + LBPF$$

Where:

- VEMI** = the Measured EMI voltage in dB μ V to be compared to the limit.
- VRx** = the Voltage in dB μ V read directly at the EMI receiver.
- LBPF** = the insertion loss in dB of the cables and the Limiter and Pass Filter.

1.4 Plotting of Conducted Emission Measurement Data

The measurement data pertaining to each frequency sub-range were then concatenated to form a single graph of (peak) amplitude versus frequency. This was performed for both Active and Neutral lines and the composite graph were subsequently plotted. A list of the highest relevant peaks and the respective Quasi-Peak and Average values were also plotted on the graph.

1.5 Results of Conducted Emission Measurements (AC Mains Ports)

Conducted Emission Measurements were performed on the LifeBook T Series, Model T3010D with WLAN module (Atheros – 11a+b/g, WLL4030).

Initial investigations were performed with the WLAN in both configurations (802.11b and 802.11g) and all modulation types: (BPSK, QPSK, 16QAM, 64QAM, DBPSK, DQPSK and CCK). No significant differences in emissions were observed. Final testing was performed while the WLAN transmitter continuously operated with configuration 802.11g on the high (Channel 11, 2462 MHz) frequency channel with the modulation rate of 6 Mbps (BPSK).

The reported frequencies in the tables below are mainly concerned with the Host PC emissions and not directly related to the WLAN module emissions.



Frequency MHz	Line	Measured QP Level dB μ V	QP Limit dB μ V	Δ QP \pm dB	Measured AV Level dB μ V	AV Limit dB μ V	Δ AV \pm dB
24.97	Neutral	50.1	60.0	-9.9	47.1	50.0	-2.9
23.55	Neutral	53.1	60.0	-6.9	46.4	50.0	-3.6
23.94	Active	53.4	60.0	-6.6	46.2	50.0	-3.8
24.41	Active	52.4	60.0	-7.6	46.1	50.0	-3.9
0.488	Active	45.6	56.2	-10.6	41.4	46.2	-4.8
25.98	Neutral	50.8	60.0	-9.2	44.5	50.0	-5.5
0.625	Active	44.9	56.0	-11.1	40.5	46.0	-5.5
25.61	Active	51.1	60.0	-9.0	44.4	50.0	-5.6
24.65	Neutral	54.0	60.0	-6.0	43.6	50.0	-6.4
22.11	Active	49.6	60.0	-10.4	42.8	50.0	-7.2
0.349	Active	46.4	59.0	-12.6	41.6	49.0	-7.4
0.276	Active	48.6	60.9	-12.4	43.4	50.9	-7.5

The worst case conducted EMI occurred at 24.97 MHz and complied with the quasi peak and average limits by margins of 9.9 dB and 2.9 dB respectively. The measurement uncertainty was \pm 2.0 dB. Refer to Appendix I for plots of the conducted EMI measurements.

Result: Complies



2.0 RADIATED EMISSION MEASUREMENTS

2.1 Test Procedure

Testing was performed in accordance with the requirements of FCC Part 15.247(c).

Radiated emission measurements were performed to the limits as per section 15.209. The measurements were made at the open area test site.

The EUT was set up on the table top (placed on turntable) of total height 80 cm above the ground plane, and operated as described in section 2 of this report. The EMI Receiver was operated under software control via the PC Controller through the IEEE.488 Interface Bus Card Adaptor. The test frequency range was sub-divided into smaller bands with sufficient frequency resolution to permit reliable display and identification of possible EMI peaks while also permitting fast frequency scan times. A calibrated Biconical antenna was used for measurements between 30 MHz to 232 MHz and a calibrated Logperiodic antenna used for measurements between 230 MHz to 1000 MHz. Calibrated EMCO 3115 and EMCO 3116 Horn antennas were used for measurements between 1 to 25 GHz.

The measurement of emissions between 30 - 1000 MHz was measured with the resolution bandwidth of 120 kHz and the video bandwidth of 300 kHz.

The measurement of emissions above 1000 MHz, appearing in the restricted bands, was made using an average detector with a bandwidth of 1.0 MHz.

The EUT was slowly rotated with the Peak Detector set to Max-Hold. This was performed for two antenna heights. When an emission was located, it was positively identified and its maximum level found by rotating the automated turntable, and by varying the antenna height. Each significant peak was investigated with the Quasi-Peak/Average Detectors. The software for cable losses automatically corrected the measurement data for each frequency range, antenna factors and preamplifier gain and all data was then stored on disk in sequential data files. This process was performed for both horizontal and vertical antenna polarisations.

2.2 Calculation of field strength

The field strength was calculated automatically by the software using all the pre-stored calibration data. The method of calculation is shown below:

E = V + AF - G + L Where:

- E** = Radiated Field Strength in dB μ V/m.
- V** = EMI Receiver Voltage in dB μ V. (measured value)
- AF** = Antenna Factor in dB(m⁻¹). (stored as a data array)
- G** = Preamplifier Gain in dB. (stored as a data array)
- L** = Cable insertion loss in dB. (stored as a data array of Insertion Loss versus frequency)

- **Example Field Strength Calculation**

Assuming a receiver reading of 34.0 dB μ V is obtained at 90 MHz, the Antenna Factor at that frequency is 9.2 dB. The cable loss is 1.9 dB while the preamplifier gain is 20 dB. The resulting Field Strength is therefore as follows:

$$34.0 + 9.2 + 1.9 - 20 = 25.1 \text{ dB}\mu\text{V/m}$$

Measurement uncertainty with a confidence interval of 95% is:

- Free radiation tests (1000 MHz – 18,000 MHz) \pm 4.1 dB
- (30 MHz – 1,000 MHz) \pm 3.7 dB



2.3 Results - Out of Band Emissions (Spurious and Harmonics)

2.3.1 Frequency Band: 1 – 25 GHz

All measurements above 1 GHz were initially made over a distance of 3 metres. This was decreased to 1.0 metre as the emission levels from the device were very low.

The 54 dB μ V/m limit at 3 metres has been converted to 64 dB μ V/m at 1 metre using a factor of 20 dB per decade where emissions were located in the restricted bands.

Testing was performed while the WLAN transmitter continuously operated. Harmonics related to the WLAN transmitter are reported below.

The field strength at 2483.5 MHz when the EUT was operating at its highest channel (2462 MHz), was 40.6 dB μ V/m peak (noise floor) and was > 20 dB below the maximum field strength of the in-band carrier.

The field strength at 2400 MHz when the EUT was operating at its lowest channel (2412 MHz), was 39.2 dB μ V/m peak (noise floor) and was > 20 dB below the maximum field strength of the in-band carrier.

Measurements for the WLAN were made on a low (channel 1, 2412 MHz), middle (channel 6, 2437 MHz) and high (Channel 11, 2462 MHz) frequency channel.

2.3.1.1 Configuration 802.11b

Initial investigations were performed with three modulation types: (DBPSK, DQPSK and CCK). No significant differences in emissions were observed. Final testing was performed while the transmitter continuously operated with the modulation rate of 11 Mbps (CCK).

Channel 1 - 2412 MHz

Frequency MHz	Level dB μ V/m		Antenna Polarization	Peak Limit dB μ V/m	Average Limit dB μ V/m	Result
	Peak Detector	Average Detector				
2412	Transmitter	Fundamental				
4824	50.6	38.1	Vert/Hort	74.0	54.0	Pass
7236	55.1	42.2	Vert/Hort	-	-	Pass
9648	48.7	35.9	Vert/Hort	-	-	Pass
12060	51.7	38.6	Vert/Hort	74.0	54.0	Pass
14472	53.6	40.4	Vert/Hort	74.0	54.0	Pass
16884	54.9	42.5	Vert/Hort	-	-	Pass
19296	56.0	44.2	Vert/Hort	84.0* (1m)	64.0* (1m)	Pass
21708	57.8	45.3	Vert/Hort	-	-	Pass
24120	59.9	46.9	Vert/Hort	-	-	Pass

*Measurement was performed at 1 metre distance and the limits were corrected accordingly.



Channel 6 - 2437 MHz

Frequency MHz	Level dBuV/m		Antenna Polarization	Peak Limit dBuV/m	Average Limit dBuV/m	Result
	Peak Detector	Average Detector				
2437	Transmitter	Fundamental				
4874	51.0	38.3	Vert/Hort	74.0	54.0	Pass
7311	55.6	42.3	Vert/Hort	74.0	54.0	Pass
9748	49.2	38.7	Vert/Hort	-	-	Pass
12185	51.6	40.2	Vert/Hort	74.0	54.0	Pass
14622	53.5	41.6	Vert/Hort	-	-	Pass
17059	54.3	42.8	Vert/Hort	-	-	Pass
19496	56.3	44.4	Vert/Hort	84.0* (1m)	64.0* (1m)	Pass
21933	58.8	45.7	Vert/Hort	-	-	Pass
24370	60.1	46.9	Vert/Hort	-	-	Pass

*Measurement was performed at 1 metre distance and the limits were corrected accordingly.

Channel 11 - 2462 MHz

Frequency MHz	Level dBuV/m		Antenna Polarization	Peak Limit dBuV/m	Average Limit dBuV/m	Result
	Peak Detector	Average Detector				
2462	Transmitter	Fundamental				
4924	52.2	39.4	Vert/Hort	74.0	54.0	Pass
7386	56.8	43.1	Vert/Hort	74.0	54.0	Pass
9848	49.0	37.6	Vert/Hort	-	-	Pass
12310	51.7	39.8	Vert/Hort	74.0	54.0	Pass
14772	53.4	41.5	Vert/Hort	-	-	Pass
17234	54.8	43.2	Vert/Hort	-	-	Pass
19696	56.1	44.5	Vert/Hort	84.0* (1m)	64.0* (1m)	Pass
22158	58.6	45.9	Vert/Hort	84.0* (1m)	64.0* (1m)	Pass
24620	60.0	47.3	Vert/Hort	-	-	Pass

*Measurement was performed at 1 metre distance and the limits were corrected accordingly.

Harmonics were recorded within the restricted bands of up to 25 GHz and complied with the FCC Class B average limits by a margin of greater than 10 dB. Harmonics were below the limit in section 15.209. The measurement uncertainty for radiated emissions in this band was ±4.1 dB.

Result: Complies



2.3.1.2 Configuration 802.11g - Normal Operating Mode

Initial investigations were performed with four modulation types: (BPSK, QPSK, 16QAM and 64QAM). No significant differences in emissions were observed. Final testing was performed while the transmitter continuously operated with the modulation rate of 54 Mbps (64QAM).

Channel 1 - 2412 MHz

Frequency MHz	Level dBuV/m		Antenna Polarization	Peak Limit dBuV/m	Average Limit dBuV/m	Result
	Peak Detector	Average Detector				
2412	Transmitter	Fundamental				
4824	47.2	35.1	Vert/Hort	74.0	54.0	Pass
7236	55.5	43.0	Vert/Hort	-	-	Pass
9648	47.8	35.3	Vert/Hort	-	-	Pass
12060	50.1	39.4	Vert/Hort	74.0	54.0	Pass
14472	52.4	41.0	Vert/Hort	74.0	54.0	Pass
16884	54.7	42.6	Vert/Hort	-	-	Pass
19296	56.3	44.3	Vert/Hort	84.0* (1m)	64.0* (1m)	Pass
21708	58.9	45.9	Vert/Hort	-	-	Pass
24120	61.1	47.8	Vert/Hort	-	-	Pass

*Measurement was performed at 1 metre distance and the limits were corrected accordingly.

Channel 6 - 2437 MHz

Frequency MHz	Level dBuV/m		Antenna Polarization	Peak Limit dBuV/m	Average Limit dBuV/m	Result
	Peak Detector	Average Detector				
2437	Transmitter	Fundamental				
4874	48.0	35.7	Vert/Hort	74.0	54.0	Pass
7311	57.1	44.3	Vert/Hort	74.0	54.0	Pass
9748	47.8	35.2	Vert/Hort	-	-	Pass
12185	50.2	39.4	Vert/Hort	74.0	54.0	Pass
14622	52.3	41.0	Vert/Hort	-	-	Pass
17059	54.3	42.6	Vert/Hort	-	-	Pass
19496	56.6	43.9	Vert/Hort	84.0* (1m)	64.0* (1m)	Pass
21933	57.9	45.5	Vert/Hort	-	-	Pass
24370	60.7	47.2	Vert/Hort	-	-	Pass

*Measurement was performed at 1 metre distance and the limits were corrected accordingly.



Channel 11 - 2462 MHz

Frequency MHz	Level dBuV/m		Antenna Polarization	Peak Limit dBuV/m	Average Limit dBuV/m	Result
	Peak Detector	Average Detector				
2462	Transmitter	Fundamental				
4924	48.8	36.1	Vert/Hort	74.0	54.0	Pass
7386	58.3	45.7	Vert/Hort	74.0	54.0	Pass
9848	48.6	35.9	Vert/Hort	-	-	Pass
12310	50.7	38.3	Vert/Hort	74.0	54.0	Pass
14772	52.5	40.6	Vert/Hort	-	-	Pass
17234	54.2	42.7	Vert/Hort	-	-	Pass
19696	55.9	43.7	Vert/Hort	84.0* (1m)	64.0* (1m)	Pass
22158	58.0	45.5	Vert/Hort	84.0* (1m)	64.0* (1m)	Pass
24620	60.3	47.0	Vert/Hort	-	-	Pass

*Measurement was performed at 1 metre distance and the limits were corrected accordingly. Harmonics were recorded within the restricted bands of up to 25 GHz and complied with the FCC Class B average limits by a margin of 8.3 dB. Harmonics were below the limit in section 15.209. The measurement uncertainty for radiated emissions in this band was ±4.1 dB.

Result: Complies

2.3.1.3 Configuration 802.11g - Turbo Mode

Initial investigations were performed with four modulation types: (BPSK, QPSK, 16QAM and 64QAM). No significant differences in emissions were observed. Final testing was performed while the transmitter continuously operated with the modulation rate of 108 Mbps (64QAM).

Channel 6 - 2437 MHz

Frequency MHz	Level dBuV/m		Antenna Polarization	Peak Limit dBuV/m	Average Limit dBuV/m	Result
	Peak Detector	Average Detector				
2437	Transmitter	Fundamental				
4874	46.1	34.8	Vert/Hort	74.0	54.0	Pass
7311	53.3	40.5	Vert/Hort	74.0	54.0	Pass
9748	47.8	36.2	Vert/Hort	-	-	Pass
12185	49.7	38.1	Vert/Hort	74.0	54.0	Pass
14622	51.9	40.3	Vert/Hort	-	-	Pass
17059	53.6	42.3	Vert/Hort	-	-	Pass
19496	55.4	43.5	Vert/Hort	84.0* (1m)	64.0* (1m)	Pass
21933	58.6	45.6	Vert/Hort	-	-	Pass
24370	60.9	47.4	Vert/Hort	-	-	Pass

*Measurement was performed at 1 metre distance and the limits were corrected accordingly.

Harmonics were recorded within the restricted bands of up to 25 GHz and complied with the FCC Class B average limits by a margin of greater than 10 dB. Harmonics were below the limit in section 15.209. The measurement uncertainty for radiated emissions in this band was ±4.1 dB.

Result: Complies



2.3.2 Frequency Band: 30 - 1000 MHz

Testing was performed at a distance of 10 metres.

Initial investigations were performed with the WLAN in both configurations (802.11b and 802.11g) and all modulation types: (BPSK, QPSK, 16QAM, 64QAM, DBPSK, DQPSK and CCK). No significant differences in emissions were observed. Final testing was performed while the WLAN transmitter continuously operated with configuration 802.11g on the high (Channel 11, 2462 MHz) frequency channel with the modulation rate of 54 Mbps (64QAM).

The reported frequencies in the tables below are mainly concerned with the Host PC emissions and not directly related to the WLAN module emissions.

Vertical Polarity

Frequency MHz	Polarisation	QP Measured dB μ V/m	QP Limit dB μ V/m	Δ QP \pm dB
358.85	Vertical	30.7	36.0	-5.4
358.08	Vertical	29.9	36.0	-6.1
92.02	Vertical	23.7	33.5	-9.8
94.14	Vertical	23.0	33.5	-10.6
93.39	Vertical	22.6	33.5	-10.9
110.64	Vertical	21.1	33.5	-12.4
135.18	Vertical	20.5	33.5	-13.0
32.77	Vertical	14.5	30.0	-15.5
97.06	Vertical	18.0	33.5	-15.5
159.19	Vertical	17.9	33.5	-15.6
259.75	Vertical	19.0	36.0	-17.0
47.58	Vertical	11.0	30.0	-19.0

Horizontal Polarity

Frequency MHz	Polarisation	QP Measured dB μ V/m	QP Limit dB μ V/m	Δ QP \pm dB
99.83	Horizontal	29.6	33.5	-3.9
358.58	Horizontal	31.6	36.0	-4.4
99.88	Horizontal	27.4	33.5	-6.1
400.07	Horizontal	29.4	36.0	-6.6
86.03	Horizontal	21.7	30.0	-8.3
93.61	Horizontal	25.0	33.5	-8.5
94.94	Horizontal	24.9	33.5	-8.7
91.68	Horizontal	24.3	33.5	-9.2
81.91	Horizontal	17.9	30.0	-12.1
432.31	Horizontal	23.6	36.0	-12.4
133.86	Horizontal	19.2	33.5	-14.3

The highest radiated emission peak occurred at 99.83 MHz (Horizontal polarity) and complied with FCC quasi peak limit by a margin of 3.9 dB. The measurement uncertainty in this band was \pm 3.7 dB. Refer to tables above for results.

Result: Complies.



2.3.3 Band Edge Measurements

The highest emission level that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the operating band.

Testing was performed while the WLAN transmitter continuously transmitted on a low (2412 MHz) and high frequency (2462 MHz) channel.

The transmitter output was connected to the spectrum analyser in peak hold mode.

The resolution bandwidth of 100 kHz and the video bandwidth of 100 kHz were utilised.

2.3.3.1 Atheros (WLL4030) - Configuration 802.11b

Refer to Appendix K1 for Band Edge plots

NB: D1 line indicates the highest level of the transmitter
 D2 line indicates 20 dB limit below D1.

2.3.3.2 Atheros (WLL4030) - Configuration 802.11g

Refer to Appendix K2 for Band Edge plots

NB: D1 line indicates the highest level of the transmitter
 D2 line indicates 20 dB limit below D1.

Result: Complies.

3.0 PEAK OUTPUT POWER - Section 15.247 (b)(1) & (3)

Testing was performed in accordance with the requirements of FCC Part 15.247(b)(3).

Measurements were performed while the WLAN transmitter continuously transmitted.

The transmitter output was connected to the spectrum analyser in peak hold mode.

The Peak Output Power (P) was calculated as follows:

$$P = R + G + C \quad \text{where} \quad \begin{array}{l} R \text{ is the recorded peak power} \\ G \text{ is the antenna gain in dBi \&} \\ C \text{ is the cable loss} \end{array}$$

Testing was performed while the transmitter continuously transmitted on a low (channel 1, 2412 MHz), middle (channel 6, 2437 MHz) and high (Channel 11, 2462 MHz) frequency channel.

Variation by +/- 15% of the supply voltage, in accordance with Section 15.31(e), to the computer power supply did not vary the output power observed.



3.1 Configuration 802.11b

Initial investigations were performed with three modulation types: (DBPSK, DQPSK and CCK). Power with CCK modulation (rate = 11 Mbps) was observed to be slightly worst (approximately 0.5 dB). Final testing was performed while the transmitter continuously operating with the modulation rate of 11 Mbps (CCK).

The resolution bandwidth of 20 MHz and the video bandwidth of 20 MHz were utilised.

Frequency MHz	R dBm	Coax Loss dB	G dBi	P dBm	Limit dBm	P mW	Limit mW
2412	17.55	2.0	1.0	20.55	30	113.5	1000
2437	17.79	2.0	1.0	20.79	30	119.9	1000
2462	17.91	2.0	1.0	20.91	30	123.3	1000

The specification limit is 1W (30 dBm).

Refer to Appendix M1 for Peak Power plots

Result: Complies.

3.2 Configuration 802.11g - Normal Operating Mode

Initial investigations were performed with four modulation types: (BPSK, QPSK, 16QAM and 64QAM). Power with BPSK modulation (rate = 6 Mbps) was observed to be slightly worst (approximately 0.5 dB). Final testing was performed while the transmitter continuously operated with the modulation rate of 6 Mbps (BPSK).

The resolution bandwidth of 20 MHz and the video bandwidth of 20 MHz were utilised.

Frequency MHz	R dBm	Coax Loss dB	G dBi	P dBm	Limit dBm	P mW	Limit mW
2412	20.33	2.0	1.0	23.33	30	215.3	1000
2437	20.56	2.0	1.0	23.56	30	227.0	1000
2462	20.46	2.0	1.0	23.46	30	221.8	1000

The specification limit is 1W (30 dBm).

Refer to Appendix M2 for Peak Power plots

Result: Complies

3.3 Configuration 802.11g - Turbo Mode

Initial investigations were performed with four modulation types: (BPSK, QPSK, 16QAM and 64QAM). No significant differences in power were observed. Final testing was performed while the transmitter continuously operated with the modulation rate of 108 Mbps (64QAM).

The resolution bandwidth of 50 MHz and the video bandwidth of 50 MHz were utilised.

Frequency MHz	R dBm	Coax Loss dB	G dBi	P dBm	Limit dBm	P mW	Limit mW
2437	20.13	2.0	1.0	23.13	30	205.6	1000

The specification limit is 1W (30 dBm).

Refer to Appendix M2 for Peak Power plots

Result: Complies



4.0 CHANNEL BANDWIDTH

Testing was performed in accordance with the requirements of FCC Part 15.247(a)(2)

In the band 2400 - 2483.5 MHz the minimum 6 dB bandwidth was at least 500 kHz. The 6 dB bandwidth was measured while the transmitter continuously transmitted on a low, middle and high frequency channel.

The transmitter output (antenna port) was connected to the spectrum analyser in peak hold mode.

The resolution bandwidth of 100 kHz and the video bandwidth of 300 kHz were utilised

Measurements were made on a low (channel 1, 2412 MHz), middle (channel 6, 2437 MHz) and high (Channel 11, 2462 MHz) frequency channel.

4.1 Configuration 802.11b

Initial investigations were performed with three modulation types: (DBPSK, DQPSK and CCK). No significant differences in bandwidth were observed. Final testing was performed while the transmitter continuously operating with the modulation rate of 11 Mbps (CCK).

Frequency MHz	Bandwidth MHz	Result	6 dB Bandwidth Plots
2412.0	11.17	Complies	Appendix J1
2437.0	10.52	Complies	Appendix J1
2462.0	10.47	Complies	Appendix J1

The minimum 6 dB bandwidth is at least 500 kHz

Result: Complies

4.2 Configuration 802.11g - Normal Operating Mode

Initial investigations were performed with four modulation types: (BPSK, QPSK, 16QAM and 64QAM). No significant differences in bandwidth were observed. Final testing was performed while the transmitter continuously operated with the modulation rate of 54 Mbps (64QAM).

Frequency MHz	Bandwidth MHz	Result	6 dB Bandwidth Plots
2412.0	16.53	Complies	Appendix J2
2437.0	16.53	Complies	Appendix J2
2462.0	16.53	Complies	Appendix J2

The minimum 6 dB bandwidth is at least 500 kHz

Result: Complies

4.3 Configuration 802.11g - Turbo Mode

Initial investigations were performed with four modulation types: (BPSK, QPSK, 16QAM and 64QAM). No significant differences in bandwidth were observed. Final testing was performed while the transmitter continuously operated with the modulation rate of 108 Mbps (64QAM).

Frequency MHz	Bandwidth MHz	Result	6 dB Bandwidth Plots
2437.0	32.77	Complies	Appendix J2

The minimum 6 dB bandwidth is at least 500 kHz

Result: Complies



5.0 RADIO FREQUENCY EXPOSURE (HAZARD) INFORMATION

Testing was performed in accordance with the requirements of FCC Part 15.247(b)(5)

Spread spectrum transmitters operating in the 2400 - 2483.5 MHz band are required to be operated in a manner that ensures that the public is not exposed to RF energy levels in accordance with CFR 47, Section 1.1307(b)(1).

In accordance with this section and also section 2.1091 this device has been defined as a mobile device whereby a distance of 20 cm normally can be maintained between the user and the device.

In accordance with Section 1.1310, the Maximum Permissible Exposure (MPE) limit for the General Population/Uncontrolled Exposure of 1.0 has been applied, i.e 1mW/cm².

Friis transmission formula: $Pd = (P \cdot G) / (4 \cdot \pi \cdot r^2)$

where: Pd = power density (mW/cm²)
 P = power input to the antenna (mW)
 G = antenna gain (numeric)
 r = distance to the center of radiation of the antenna (cm)

The result was extracted from Results, SECTION 3.0 of this report:

Maximum peak output power at the antenna terminal = 20.56dBm = 113.8mW
 Antenna (Monopole Dielectric) gain (typical) = 1.0 dBi = 1.259 numeric
 Prediction distance = 20 cm
 Prediction frequency = 2437 MHz
 MPE limit for uncontrolled exposure at prediction frequency = 1 mW/cm²

Therefore, the power density at prediction frequency (Pd) = 0.0285 mW/cm²

Calculations show that this device with described antenna does meet the MPE requirements for portable devices falling below the 20 cm clearance required and the SAR value of 0.318 mW/g complies with the FCC human exposure requirements of 47 CFR 2.1093 (d). Refer to EMC Technologies' report - M040121_Atheros_SAR_2.4 for details of SAR compliance.

Results: Complies



6.0 PEAK POWER SPECTRAL DENSITY - Section 15.247(d)

Testing was performed accordance with the requirements of FCC Part 15.247(d)

The transmitter output (antenna port) was connected to the spectrum analyser in peak hold mode.

The resolution bandwidth of 3 kHz and the video bandwidth of 30 kHz were utilised

Testing was performed while the transmitter continuously transmitted on a low (channel 1, 2412 MHz), middle (channel 6, 2437 MHz) and high (Channel 11, 2462 MHz) frequency channel.

6.1 Configuration 802.11b

Initial investigations were performed with three modulation types: (DBPSK, DQPSK and CCK). No significant differences in peak power spectral density were observed. Final testing was performed while the transmitter continuously operating with the modulation rate of 11 Mbps (CCK).

Frequency MHz	Level dBm	Limit dBm	Result	Spectral Density plots
2412.0	- 9.32	8.0	Complies	Appendix L1
2437.0	- 6.81	8.0	Complies	Appendix L1
2462.0	- 6.48	8.0	Complies	Appendix L1

The specification limit is 8 dBm in any 3 kHz band during a continuous transmission.

Result: Complies

6.2 Configuration 802.11g - Normal Operating Mode

Initial investigations were performed with four modulation types: (BPSK, QPSK, 16QAM and 64QAM). No significant differences in peak power spectral density were observed. Final testing was performed while the transmitter continuously operated with the modulation rate of 54 Mbps (64QAM).

Frequency Hz	Level dBm	Limit dBm	Result	Spectral Density plots
2412.0	- 8.73	8.0	Complies	Appendix L2
2437.0	- 6.34	8.0	Complies	Appendix L2
2462.0	- 6.43	8.0	Complies	Appendix L2

The specification limit is 8 dBm in any 3 kHz band during a continuous transmission.

Result: Complies

6.3 Configuration 802.11g - Turbo Mode

Initial investigations were performed with four modulation types: (BPSK, QPSK, 16QAM and 64QAM). No significant differences in peak power spectral density were observed. Final testing was performed while the transmitter continuously operated with the modulation rate of 108 Mbps (64QAM).

Frequency Hz	Level dBm	Limit dBm	Result	Spectral Density plots
2437.0	- 6.95	8.0	Complies	Appendix L2

The specification limit is 8 dBm in any 3 kHz band during a continuous transmission.

Result: Complies



7.0 ANTENNA REQUIREMENT

Testing to the requirements of FCC Part 15.203 was not applicable as this intentional radiator was designed to ensure that no antenna other than that furnished by the responsible party shall be used with the device.

8.0 COMPLIANCE STATEMENT

The Mini-PCI Wireless LAN (WLAN) Module, Model WLL4030 (Atheros 11a+b/g) tested on behalf of Fujitsu Australia Ltd, **complies** with the requirements of 47 CFR, Part 15 Subpart C - Rules for Radio Frequency Devices (intentional radiators), Section 15.247 -Operation in the frequency band 2400 - 2483.5 MHz.

The test sample also complies with the Industry Canada RSS-210 issue 5 (Low Power Licence-Exempt Radiocommunication Devices (All Frequency Bands)) clause 6.2.2(o) 2400 – 2483.5 MHz Spread Spectrum requirements and the RF exposure requirements of RSS-102.

Results were as follows:

WLAN Module, Atheros 802.11b/g

FCC Part 15, Subpart C Clauses	Industry Canada RSS-210 Clauses	Test Performed	Result
15.203	5.5	Antenna Requirement	Not Applicable
15.205	6.3	Operation in Restricted Band	Complies
15.207	6.6	Conducted Emissions	Complies
15.209	6.3	Radiated Emissions	Complies
15.247 (a)(2)	6.2.2(o)(iv)	Channel Bandwidth	Complies
15.247 (b)(3)	6.2.2(o)(b)	Peak Output Power	Complies
15.247 (b)(5)		Radio Frequency Hazard	*Complies with SAR requirements
15.247 (c)	6.2.2(o)(e1)	Out of Band Emissions	Complies
15.247 (d)	6.2.2(o)(iv)	Peak Power Spectral Density	Complies

***Refer to EMC Technologies' report M040121_Atheros_SAR_2.4**

NB: Refer to EMC Technologies' Report M040222_Cert_Mace_Atheros_5.2 for Atheros 802.11a results.



TEST REPORT APPENDICES

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Attachment 1: Atheros_11abg_FCC_Certificate

Attachment 2: Atheros_11abg_RSS_Certificate

