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EMI TEST REPORT
for
CERTIFICATION of
FCC PART 15.225 & FCC PART 15.207 TRANSMITTER

FCC ID:	TVN-MARS-24
Manufacturer:	Magellan Technology
Test Sample:	RFID Terminal
Model:	MARS24
Serial No:	Production Prototype
Date:	15th January 2007

NATA Accredited Laboratory Number: 5292

EMI TEST REPORT FOR CERTIFICATION
FOR
CERTIFICATION OF FCC Part 15.225 & FCC PART 15.207 TRANSMITTER

FCC ID: TVN-MARS-24
EMC Technologies Report No. T61218_F
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Test Sample Name:	RFID Terminal
Model Number:	MARS24
Serial Number:	Production Prototype
FCC ID:	TVN-MARS-24
Manufacturer:	Magellan Technology
Tested For:	Magellan Technology
Address:	65 Johnston Street Annandale NSW 2250
Phone:	+61 (02) 9562 9800
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Responsible Party:	Tai Wai Pong
Test Standards:	**FCC Part 15.225 Intentional Radiators** **FCC Part 15.207 Conducted Limits** **ANSI C63.4:2003** **OET Bulletin No. 65**
Test Dates:	13/12/06, 14/12/06 and 10/01/07

Testing Officers:

Kumar Thambiaiah **Christian Kai**

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 Signature:

Les Dickenson
Branch Manager
EMC Technologies Pty Ltd

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EMI TEST REPORT FOR CERTIFICATION
of
FCC PART 15.225 & FCC PART 15.207 TRANSMITTER
on the RFID Terminal

1. SUMMARY of RESULTS

This report details the results of EMI tests and measurements performed on the RFID Terminal, Model: MARS24, in accordance with the Federal Communications Commission (FCC) regulations as detailed in Title 47 CFR, Part 15 Rules for intentional radiators. All results are detailed in this report.

Part 15.31e	
Amplitude stability with supply variation:	Complied
Part 15.207	
Conducted Emissions:	Complied
Part 15.225 a, b &c	
Carrier Signal Field Strength 13.110 – 14.010MHz:	Complied
Part 15.225 d (15.209)	
Field Strength Outside 13.110 – 14.010MHz:	Complied
Part 15.225 e	
Frequency Tolerance:	Complied

2. GENERAL INFORMATION

2.1 General Description of Test Sample

Manufacturer	:	Magellan Technology
Test Sample	:	RFID Terminal
Model	:	MARS24
Serial Number	:	Production Prototype
FCC ID	:	TVN-MARS-24
Equipment Type	:	Intentional Radiator

2.2 Test Sample Description

The Multiple Antenna Reader System (MARS-24) is an RFID read/write device designed to meet the requirements to monitor, manage and control a large number of valuable items.
The MARS-24 is capable of operating up to 24 antennas which can be arranged as required to operate 24 separate read/write stations. Only a single antenna can be activated at any one time.
The unit consists of external power supply, USB, general purpose I/O Interface and Ethernet ports.
Power is provided from an external 12VDC power supply.
Each antenna port is electrically identical.

2.3 Technical Specifications and System Overview

Clock Circuit Speed	:	50MHz, 27.120MHz and 18.432MHz
Real Time Clock	:	32.768 kHz
Microprocessor	:	AT91RM9200
Antenna type	:	External inductive loop antenna
Power Supply	:	Output: 12VDC, 4.17A Input: 100 – 240V, 1.6A, 50-60 Hz Model Number: GT-21097-5012

For more details, refer to Test Sample Test Plan in Appendix H.

2.4 EUT Configurations

During testing, a single port of the MARS-24 will be connected and operating and the unit will be transmitting.
The unit will be polling the antenna during the test cycle.

2.5 Test Sample Support Equipment

- Laptop "Toshiba Tecra 8100"
- USB AtoB cables, shielded type cable, unknown brand, shorter than 3m
- 2 test tags, type "TAGSTAR SYSTEMS ST-104-2.5" and "TAGSTAR SYSTEMS IT-104"

2.6 Test Sample Block Diagram

Refer to Block Diagram in Appendix E.

2.7 EUT Operation Conditions

Refer to Test Sample Test Plan in Appendix H.

2.8 Modifications

No modifications were performed.

2.9 Test Procedure

Radiated Emissions measurements were performed in accordance with the procedures of ANSI C63.4:2003. The measurement distance for radiated emissions was 3 metres from the EUT for range 9kHz-1000MHz.

2.10 Test Facility

2.10.1 General

Conducted Emission measurements of fundamental frequency 13.56 MHz were performed at EMC Technologies Laboratory in Seven Hills, New South Wales, Australia. Radiated Emission measurements in the ranges 9kHz-1000MHz were performed at EMC Technologies' open area test site (OATS) situated at Upper Colo, NSW, Australia.

The above sites have been fully described in a report submitted to the FCC office, and accepted in a letter dated October 18th 2005, **FCC Registration number is 90561**.

2.10.2 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 18GHz 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 Institute (NMI) 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 (A^2LA).

2.11 Units of Measurements

2.11.1 Conducted Emissions

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

2.11.2 Radiated Emissions

Measurements are reported in units of dB relative to one microvolt per metre (dBμV/m). The measurement distance was 3 metres from the EUT for ranges 9kHz-1000MHz.

2.12 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 Institute (NMI). All equipment calibration is traceable to Australia national standards at the National Measurement Institute. The reference antenna calibration was performed by NMI 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 of this report.

2.13 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.

3. CONDUCTED EMISSION MEASUREMENTS

3.1 Test Procedure

The arrangement specified in ANSI C63.4:2003 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 duration peaks were captured.

3.2 Peak Maximizing Procedure

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 was then invoked to measure the actual Quasi-Peak level of the most significant peaks which were detected.

The highest recorded EMI signals are shown on the Peaks List on the bottom right side of the graph. Peaks that were greater than 20dB below the limit were not measured. For each numbered peak the frequency, peak field strength, Quasi-peak field strength, Average field strength and the margin relative to the limit in dB is listed. A negative margin is the level below the limit.

3.3 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:

$V_{EMI} = V_{Rx} + L_{BPF}$

Where:

V_{EMI} = The Measured EMI voltage in dBμV to be compared to the limit.

V_{Rx} = The Voltage in dBμV read directly at the EMI receiver.

L_{BPF} = The insertion loss in dB of the cables and the Limiter and Pass Filter.

3.4 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 was subsequently plotted. A list of the highest relevant peaks and the respective Quasi-Peak and Average values were also plotted on the graphs.

3.5 Conducted EMI Results

3.5.1 Transmitter Terminals Connected to Antenna

Frequency MHz	Line	Measured QP Value dBμV	QP Limit dBμV	Δ QP ±dB	Measured Av. Value dBμV	AV Limit dBμV	ΔAV ±dB
13.56*	Neutral	102.0	60.0	42.0	101.9	50.0	51.9
13.56*	Active	101.3	60.0	41.3	101.4	50.0	51.4
14.61	Active	58.7	60.0	-1.3	44.6	50.0	-5.4
14.61	Neutral	58.4	60.0	-1.6	44.1	50.0	-5.9
14.20	Active	57.6	60.0	-2.4	45.2	50.0	-4.8
14.20	Neutral	57.6	60.0	-2.4	44.8	50.0	-5.2
27.12	Neutral	45.3	60.0	-14.7	47.2	50.0	-2.8
15.05	Active	52.7	60.0	-7.3	39.4	50.0	-10.6
15.05	Neutral	52.4	60.0	-7.6	39.2	50.0	-10.8
12.91	Neutral	51.9	60.0	-8.1	38.0	50.0	-12.0
12.91	Active	51.6	60.0	-8.4	38.2	50.0	-11.8
27.12	Active	45.0	60.0	-15.0	46.1	50.0	-3.9

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* Fundamental Frequency of Transmitter

Note: The transmit carrier was excluded from the test with the antenna connected. The highest emission was 14.61MHz on the Active line, which were measured 1.3dB below the Quasi-peak and 5.4dB below the Average limits.

The measurement uncertainty for conducted emissions is ± 1.8 dB.

Refer to Appendix I, Graphs 1 and 2.

3.5.2 Transmitter Terminals Connected to a Resistive Load

Frequency MHz	Line	Measured QP Value dBμV	QP Limit dBμV	Δ QP ±dB	Measured Av. Value dBμV	AV Limit dBμV	ΔAV ±dB
13.56	Active	47.1	60.0	-12.9	46.5	50.0	-3.5
13.56	Neutral	46.6	60.0	-13.4	46.4	50.0	-3.6
0.522	Neutral	45.8	56.0	-10.2	37.8	46.0	-8.2
0.518	Active	54.0	56.0	-11.0	36.9	46.0	-9.1

The transmit antenna was replaced by a resistive load and the conducted emissions measurements were repeated.

The highest emission was 13.56MHz on the Active line, which were measured 12.9dB below the Quasi-peak and 3.5dB below the Average limits.

The measurement uncertainty for conducted emissions is ± 1.8 dB.

Refer to Appendix I, Graphs 3 and 4.

3.6 Results of Conducted Emission Measurement

The EUT complied with the limits of FCC Rule Part 15 Subpart C – Intentional Radiators. Emissions at the fundamental frequency of 13.56 MHz are excluded from the results with the antenna loop connected.

4. RADIATED EMISSION MEASUREMENTS – 9 kHz to 1 GHz

4.1 Frequency Range of Radiated Measurements

The highest frequency of the EUT is 50MHz (refer to section 2.3 of this report).

Highest frequency generated or used in the device or on which the device operates or tunes [MHz]	Upper frequency of measurement range [MHz]
1.705 - 108	1000
108 – 500	2000
500 – 1000	5000
Above 1000	10^{th} harmonic of the highest frequency or 40 GHz, whichever is lower

Frequencies above 1 GHz: Average trace taken (RBW 1MHz, VBW 100 kHz)

According to the table in FCC Part 15, Section 15.33 and the highest radio frequency signal generated or used in the EUT is 50MHz , the radiated emissions measurement were performed from 9kHz to 1GHz.

4.2 Test Procedure

Radiated emissions measurements were performed in accordance with the procedures of ANSI C63.4:2003 Radiated emission tests from 9 kHz to 1GHz were performed at the Open Area Test Site (OATS) an EUT distance of 3 metres. OET Bulletin 65 was used for reference.

The EUT was placed on a timber table 0.8m above an inground and operated in accordance with section 2 of this report. The EMI Receiver was operated under software control via the PC Controller.

4.2.1 0.009 – 30 MHz Range

The 0.009 MHz to 30 MHz 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. The EUT was slowly rotated with the Peak Detector set to Max-Hold. The receive loop antenna was set to 1m above the ground plane with the Quasi-Peak detector ON. The measurement data for each frequency range was automatically corrected by the software for cable losses, antenna factors and preamplifier gain and all data was then stored on disk in sequential data files. The orientation of the receive loop antenna was varied to ensure that the emissions were maximised. The EUT was further rotated through three orthogonal directions to ensure worst case emissions are measured. The carrier test was performed at the worst-case operation voltage.

4.2.2 30 – 1000 MHz Range

The 30 MHz to 1000 MHz 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. The EUT was slowly rotated with the Peak Detector set to Max-Hold. The EUT was further rotated through three orthogonal directions to ensure worst case emissions are measured. This was performed for two receiver antenna heights. Each significant peak was then investigated and maximised by rotating the turntable and scanning the height of the receiver antenna between 1 to 4 metres with the Quasi-Peak detector ON. The measurement data for each frequency range was automatically corrected by the software for cable losses, 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 receive antenna polarisation.

4.3 Plotting of Measurement Data for Radiated Emissions

4.3.1 0.009 – 30 MHz Range

The stored measurement data was combined to form a single graph which comprised of all the frequency sub-ranges over the range 0.009 – 30 MHz. The fundamental frequency was measured at the OATS. The worst case radiated EMI peak measurements as recorded using the Max-Hold data are presented as the **RED** trace while the respective ambient signals are presented as the lower or **GREEN** trace. Occasionally, an intermittent ambient arose during the EUT ON measurement (RED trace) and could not be captured when the Ambient trace was being stored. The ambient peaks of significant amplitude with respect to the limit are tagged with the "#" symbol while EMI peaks are identified with a numeral. Ambient peaks that were present during the EUT ON measurement (RED trace) and not captured during the AMBIENT measurement were also tagged with "#" symbol.

The highest recorded EMI signals are shown on the Peaks List on the bottom right hand side of the graph. For radiated EMI, each numbered peak is listed as a frequency, peak field strength, Quasi-peak field strength, limit and the margin relative to the limit in dB. A negative margin is the deviation of the recorded value below the limit. At times, the quasi-peak level may appear to be higher than the peak level. This happens because the individual peak is further maximised with the QP detector AFTER the MAX-HOLD trace has been stored. This will be apparent when the peaks list at the foot of the graphs shows the quasi peak level higher than the peak level.

4.3.2 30 – 1000 MHz

The stored measurement data was combined to form a single graph which comprised of all the frequency sub-ranges over the range 30 – 1000 MHz. The accumulated EMI (EUT ON) was plotted as the Red trace while the Ambient signals (AMBIENT) were plotted as Green trace. The worst case radiated EMI peak measurements (as recorded using the Max-Hold data are presented as the upper or **RED** trace while the respective ambient signals are presented as the lower or **GREEN** trace. Occasionally, an intermittent ambient arose during the EUT ON measurement (RED trace) and could not be captured when the Ambient trace was being stored. The ambient peaks of significant amplitude with respect to the limit are tagged with the "#" symbol while EMI peaks are identified with a numeral. Ambient peaks that were present during the EUT ON measurement (RED trace) and not captured during the AMBIENT measurement were also tagged with "#" symbol.

The highest recorded EMI signals are shown on the Peaks List on the bottom right hand side of the graph. For radiated EMI, each numbered peak is listed as a frequency, peak field strength, Quasi-peak field strength, limit and the margin relative to the limit in dB. A negative margin is the deviation of the recorded value below the limit. At times, the quasi-peak level may appear to be higher than the peak level. This happens because the individual peak is further maximised with the QP detector AFTER the MAX-HOLD trace has been stored. This will be apparent when the peaks list at the foot of the graphs shows the quasi peak level higher than the peak level.

4.4 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 dBµV/m.
V	=	EMI Receiver Voltage in dBµV. (measured value)
AF	=	Antenna Factor in dB/m (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)

Example Field Strength Calculation

Assuming a receiver reading of 34.0 dBµV is obtained at 90 MHz, the Antenna Factor at that frequency is 9.2 dB. The cable loss is 1.9dB while the preamplifier gain is 20dB.

34.0 + 9.2 + 1.9 – 20 = 25.1 dBµV/m

4.5 Radiated Field Strength Measurement Results – Section 15.225

4.5.1 13.56 MHz Carrier Field Strength Measurement

Frequency MHz	Peak Level dBμV/m	Limit @ 3m dBμV/m	Result ± dB
13.56	97.3	124.0	-26.7

The mains supply was varied as per Section 15.31e between 100V 60 Hz to 138V 60Hz to determine if the carrier amplitude varies with supply voltage. No variation was recorded. The test was performed at 120V 60Hz.

Complied with a margin of greater than 20dB with Section 15.225 Subpart a, b & c. The measurement uncertainty was ±4.6dB. **Refer to Appendix I, Graph 5**.

4.5.2 9 kHz to 30 MHz Field Strength Spurious Emissions

Complied with a margin of greater than 10dB with Section 15.225 Supart d (15.209). The measurement uncertainty was ±4.6dB. **Refer to Appendix I, Graph 6**.

4.5.3 30 - 1000MHz Field Strength Spurious Emissions –Section 15.225 d (15.209)

Frequency (MHz)	Rx Antenna Polarisation	Quasi Peak Level (dBμV/m)	Limit @ 3m (dBμV/m)	ΔResult (dB)
189.84	Horizontal	39.0	43.5	-4.5
203.39	Horizontal	38.7	43.5	-4.8
40.68	Vertical	32.3	40.0	-7.7

Summary of Results
The highest radiated spurious emission was 4.5dB below the limit at 40.68MHz for Horizontal Polarisation. The highest points on both Vertical and Horizontal are reported on the graphs Appendix I. The measurement uncertainty was ±4.6dB.
Refer to Appendix I, Graphs 7 and 8.

5.0 FREQUENCY TOLERANCE (FCC Part 15 Sections 15.225e)

The frequency stability of the unit was verified under abnormal operating supply voltage and temperature.

FCC Sub Part C Section 15.225 e.

Supply Voltage Variation
The mains supply was lowered from 120V 60Hz to 102V (85% of nominal supply) and maintained until the frequency was stable. The mains supply was then increased from 120V 60Hz to 138V (115% of nominal supply) and maintained until the frequency was stable.

Nominal Voltage	Temperature	Voltage Variation	Frequency Reading [MHz]	Frequency Variation [%]
120 V	20°C	85% (102 V)	13.559964	0.000
120 V	20°C	115% (138 V)	13.559941	0.000

Maximum Frequency Variation to Nominal Frequency:	13.5600	0.000

The frequency tolerance of the carrier signal was maintained within ± 0.01% of the operating frequency during the voltage variation test.

Temperature Variation
The ambient temperature with a supply voltage of 120V 60Hz was varied between -20°C and +50°C. At each 10°C interval the temperature was maintained until the EUT temperature had stabilised. The frequency of the carrier was observed at each 10°C increments and compared to the nominal frequency.

Nominal Voltage	Ambient Temperature	Frequency Reading [MHz]	Frequency Variation [%]
120 V	-20°C	13.559964	0.000
120 V	-10°C	13.559975	0.000
120 V	0°C	13.559952	0.000
120 V	10°C	13.559975	0.000
120 V	20°C	13.560006	0.000
120 V	30°C	13.559919	0.001
120 V	40°C	13.559902	0.001
120 V	50°C	13.559919	0.001
120 V	55°C	13.559948	0.000

Maximum Frequency Variation to Nominal Frequency:	13.5600	0.001

The frequency tolerance of the carrier signal was maintained within ± 0.01% of the operating frequency during the temperature variation test.

6. CONCLUSION

The RFID Terminal, Model: MARS24, FCC ID: TVN-MARS-24, complied with the requirements of FCC Part 15 Rules for linternial radiator when tested in accordance with FCC Part 15.31e, 15.207 and 15.225.

Part 15.31e
Amplitude stability with supply viariation: Complied
Part 15.207
Conducted Emissions: Complied
Part 15.225 a, b &c
Carrier Signal Field Strength 13.110 – 14.010MHz: Complied
Part 15.225 d (15.209)
Field Strength Outside 13.110 – 14.010MHz: Complied
Part 15.225 e
Frequency Tolerance: Complied

APPENDIX A

MEASUREMENT INSTRUMENTATION DETAILS

SUBMITTED AS ATTACHMENT

APPENDIX B

PHOTOGRAPHS TEST SETUP

SUBMITTED AS ATTACHMENT

APPENDIX C

PHOTOGRAPHS TEST SAMPLE (EXTERIOR)

SUBMITTED AS ATTACHMENT

APPENDIX D

PHOTOGRAPHS TEST SAMPLE (INTERIOR)

APPENDIX E

BLOCK DIAGRAM

SUBMITTED AS ATTACHMENT

APPENDIX F

TEST SAMPLE SCHEMATICS

SUBMITTED AS ATTACHMENT

APPENDIX G

TEST SAMPLE PCB LAYOUTS

SUBMITTED AS ATTACHMENT

APPENDIX H

TEST SAMPLE CUSTOMER TEST PLAN

SUBMITTED AS ATTACHMENT

APPENDIX I

FCC ID LABELLING - LOCATION

SUBMITTED AS ATTACHMENT

APPENDIX K

GRAPHS OF EMI MEASUREMENTS

SUBMITTED AS ATTACHMENT

APPENDIX L

USER MANUAL AND READER MANAGER GUIDE

SUBMITTED AS ATTACHMENT