TEST REPORT
FROM
RFI GLOBAL SERVICES LTD

Test of: Crane Electronics Ltd
Prowrench Opta Tranceiver

To: FCC Part 15.247: 2004 (Subpart C)

Test Report Serial No:
RFI/RPTE1/RP46959JD01A

This Test Report Is Issued Under The Authority Of Andrew Brown, Operations Manager: **pp**	
Tested By: Fara Razally	**Checked By: Michael Derby**
Report Copy No: **PDF01**	
Issue Date: 20 June 2005	**Test Dates: 05 May 2005 to 13 May 2005**

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Registered in England and Wales. Company number:2117901

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1. Client Information

Company Name:	Crane Electronics Ltd
Address:	Watling Drive Sketchley Meadows Hinckley Leicestershire LE10 3EY
Contact Name:	Mr N. McDonald

2. Equipment Under Test (EUT)

The following information (with the exception of the Date of Receipt) has been supplied by the client:

2.1. Identification of Equipment Under Test (EUT)

Brand Name:	Crane Electronics Ltd.
Model Name or Number:	Prowrench Opta
Unique Type Identification:	PO-976-02CR-75-A
Serial Number:	59309
Hardware Version:	Not stated
Software Version:	Not stated
FCC ID Number:	TA6-PO
Country of Manufacture:	England
Date of Receipt:	05 May 2005

2.2. Accessories

The following accessories were supplied with the EUT:

Description:	RS232 Cable
Brand Name:	Crane Prowrench Opta
Model Name or Number:	F1-CBL-796-01CR-00
Serial Number:	None Sated
Cable Length and Type:	2m, RS232
Connected to Port:	RS232 Port

Description:	Battery charger
Brand Name:	Ansmann
Model Name or Number:	ACS110
Serial Number:	None Sated
Cable Length and Type:	1.8m, 2 core
Connected to Port:	AC Charger Port

Description:	External battery holder (accessory to the EUT, not connected)
Brand Name:	Crane Prowrench Opta
Model Name or Number:	F1-250-981-02
Serial Number:	None Sated
Cable Length and Type:	0.13m, 3 core
Connected to Port:	Not Applicable

2.3. Description of EUT

As stated by the manufacturer:

The ProWrench *Opta* is a family of hand held wrenches that will measure, display, store and transmit torque. The EUT will be put into a special mode so that it is measuring, displaying and transmitting torque.

The family comes in 3 basic torque ranges of 25Nm, 75Nm and 180Nm. The only difference being the shaft where the strain is measured. The rest of the mechanical structure and housing remain the same. Different torque drives can be added to the wrench by a customer. The EUT for these tests will be a 75Nm with a 3/8" drive on a Sturvent Richmond fitting.

The same PCB is used for the whole family. In the case where Bluetooth is not being offered, the Bluetooth Module and antenna will not be fitted. The EUT for these tests will have the Bluetooth module and antenna fitted and operational.

Another variant is that some wrenches will be able to measure angle while torque is being measured due to a Gyro being fitted within the housing. The EUT will have Gyro operating and reporting and reporting its value, which is related to the rotation of the wrench.

Other variations will be via software offering different levels of functionality.

The visual appearance of the wrench can change depending on whom the wrench is supplied to. The EUT for these tests will be in the Crane colours.

There will also be a passive RFID inserted into the wrench, which will not be tested. This devise works at 125 kHz and is read only, obtaining its power from an external, off the shelf reader, which will also not be tested.

The EUT is battery powered, either with 2 alkaline C cells (normally 3 V) or a NiMH rechargeable battery pack (normally 3.6 V). Internally the wrench operates from a variety of voltages which are derived from the battery voltage by switch mode power supplies to generate: +3.3 V, +5 V and –5 V. The current consumption in normal mode is typically between 100 mA to 200 mA in normal operation, falling to 3 mA to 4 mA in low power mode. The EUT for these tests used the 3.6 V, NiMH rechargeable battery pack.

Operation of the EUT can be determined by observing the torque value on the backlit LCD on top or receiving the torque values by Bluetooth.

The wrench in measurement mode is measuring torque constantly every 2 ms.

2.4. Modifications Incorporated in EUT

During the course of testing the EUT was not modified.

2.5. Additional Information Related to Testing

Power Supply Requirement:	Internal battery supply of 3.6 V (NiMH pack)		
Intended Operating Environment:	Residential, Commercial, Heavy Industry and Light Industry		
Equipment Category:	Short Range (Low Power), incorporating Bluetooth technology		
Type of Unit:	Portable (Standalone battery powered device)		
Transmit Frequency Range:	2402 MHz to 2480 MHz		
Transmit Channels Tested:	**Channel ID**	**Channel Number**	**Channel Frequency (MHz)**
	Bottom	1	2402
	Middle	40	2441
	Top	79	2480
Receive Frequency Range:	2402 MHz to 2480 MHz		
Receive Channels Tested:	**Channel ID**	**Channel Number**	**Channel Frequency (MHz)**
	Bottom	1	2402
	Middle	40	2441
	Top	79	2480
Maximum Peak Power Output (EIRP)	-10.9 dBm		

2.6. Port Identification

Port	Description	Type/Length	Applicable
1	Enclosure	-	Y
2	RS232	2m, RS232	Y
3	Charger	Not connected during testing	N

2.7. Support Equipment

No support equipment was used to exercise the EUT during testing. The EUT was unable to operate with the battery charger connected.

2.7.1. Test Results

Reference:	FCC Part 15.247: 2004 Subpart C
Title:	Code of Federal Regulations, Part 15.247 (47CFR22) (Intentional Radiators operating within the bands 902-928 MHz, 2400-2483.5 MHz and 5725-5850 MHz).

2.8. Methods and Procedures

The methods and procedures used were as detailed in:

ANSI C63.2 (1987)
Title: American National Standard for Instrumentation - Electromagnetic noise and field strength.

ANSI C63.4 (2003)
Title: American National Standard Methods of Measurement of Electromagnetic Emissions from Low Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz.

ANSI C63.5 (1988)
Title: American National Standard for the Calibration of antennas used for Radiated Emission measurements in Electromagnetic Interference (EMI) control.

ANSI C63.7 (1988)
Title: American National Standard Guide for Construction of Open Area Test Sites for performing Radiated Emission Measurements.

CISPR 16-1: (1999)
Title: Specification For Radio Disturbance and Immunity Measuring Apparatus and Methods. Part 1: Radio Disturbance and Immunity Measuring Apparatus.

DA00-705 (2000)
Title: Filing and Frequency Measurement Guidelines for Frequency Hopping Spread Spectrum Systems.

2.9. Definition of Measurement Equipment

The measurement equipment used complied with the requirements of the standards referenced in the methods & procedures section above. Appendix 1 contains a list of the test equipment used.

3. Deviations from the Test Specification

None.

4. Operation of the EUT during Testing

4.1. Operating Modes

The EUT was tested in the following operating modes, unless otherwise stated.

For all transmit mode measurements the *Bluetooth* test mode was active and set to transmit on top, middle and bottom channels and hopping on all channels as necessary with the longest data packet size.

Receive mode measurements were performed with the EUT in Bluetooth mode and in its normal search mode.

For reference, the manufacturer referred to the mode of operation as: “quick read / track mode”

4.2. Configuration and Peripherals

The EUT was tested in the following configuration:

Standalone.

5. Summary of Test Results

Range of Measurements	Specification Reference	Port Type	Compliancy Status
Idle Mode Radiated Spurious Emissions	C.F.R. 47 FCC Part 15: 2004 Section 15.109	Antenna	Complied
Transmitter 20 dB Bandwidth	C.F.R. 47 FCC Part 15: 2004 Section 15.247(a)(1)	Antenna	Complied
Transmitter Carrier Frequency Separation	C.F.R. 47 FCC Part 15: 2004 Section 15.247(a)(1)	Antenna	Complied
Transmitter Average Time of Occupancy	C.F.R. 47 FCC Part 15: 2004 Section 15.247(a)(1)(iii)	Antenna	Complied
Transmitter Maximum Peak Output Power	C.F.R. 47 FCC Part 15: 2004 Section 15.247(b)(1)	Antenna	Complied
Transmitter Radiated Emissions	C.F.R. 47 FCC Part 15: 2004 Sections 15.247(d) & 15.209(a)	Antenna	Complied
Transmitter Band Edge Radiated Emissions	C.F.R. 47 FCC Part 15: 2004 Sections 15.247(d) & 15.209(a)	Antenna	Complied

5.1. Location of Tests

All the measurements described in this report were performed at the premises of
RFI Global Services Ltd, Ewhurst Park, Ramsdell, Basingstoke, Hampshire, RG26 5RQ, England.

6. Measurements, Examinations and Derived Results

6.1. General Comments

This section contains test results only.

Measurement uncertainties are evaluated in accordance with current best practice. Our reported expanded uncertainties are based on standard uncertainties, which are multiplied by an appropriate coverage factor to provide a statistical confidence level of approximately 95%. Please refer to section 8 for details of measurement uncertainties.

6.2. Test Results

6.2.1. Idle Mode Radiated Spurious Emissions: Section 15.109 - Electric Field Strength Measurements (Frequency Range: 30 to 1000 MHz)

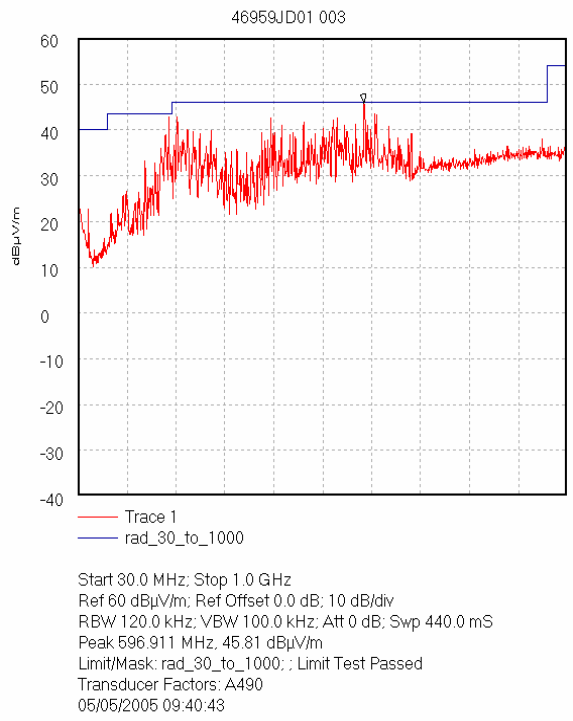
The EUT was configured as for radiated emission testing as described in section 8.8 of this report.

Tests were performed to identify the maximum receiver or standby radiated emission levels.

Results:

Frequency (MHz)	Antenna Polarity	Q-P Level (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Result
210.123	Horiz.	30.3	43.5	13.2	Complied
210.263	Horiz.	28.8	43.5	14.7	Complied
597.196	Horiz.	31.8	46.0	14.2	Complied

Idle Mode Radiated Spurious Emissions: Section 15.109 - Electric Field Strength Measurements (Frequency Range: 30 to 1000 MHz) (Continued)



Note: This plot is a pre-scan and for indication purposes only. For final measurements, see accompanying tables.

6.2.2. Idle Mode Radiated Spurious Emissions: Section 15.109 - Electric Field Strength Measurements (Frequency Range: 1 to 12.5 GHz)

Results:

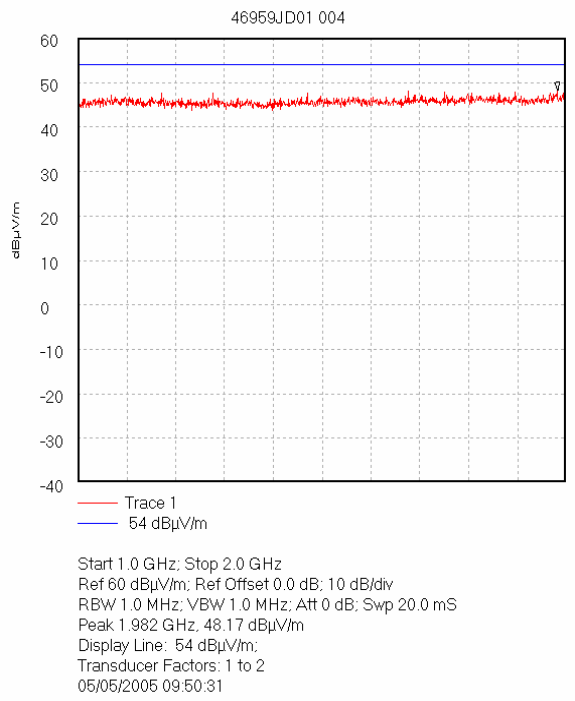
Highest Peak Level:

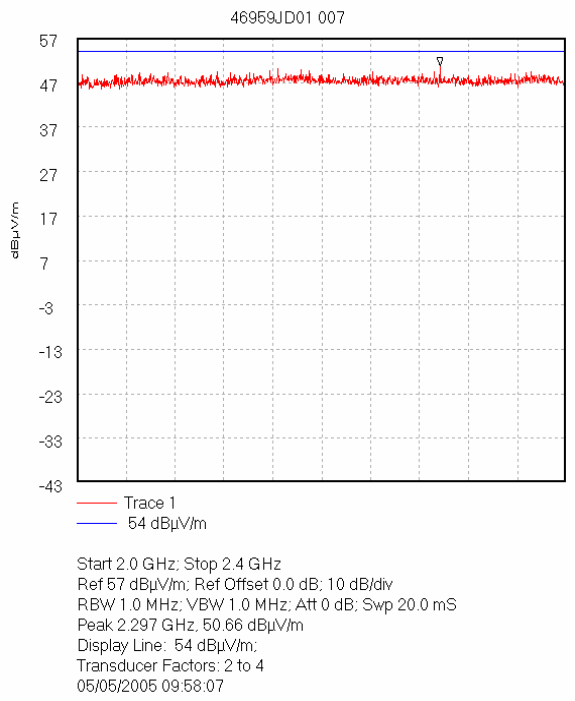
Frequency (GHz)	Antenna Polarity	Detector Level (dBμV)	Antenna Factor (dB)	Cable Loss (dB)	Actual Level (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Result
2.2974	Vert.	9.7	21.5	9.6	40.8	54.0	13.2	Complied

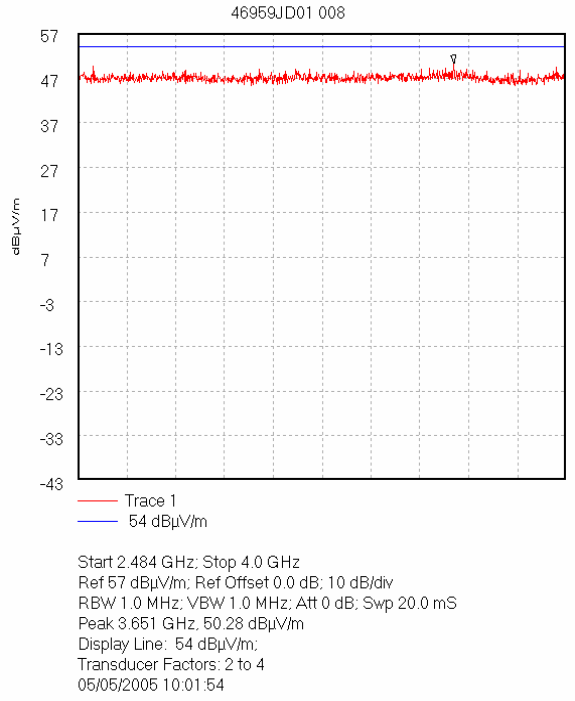
Note(s):

1. *No spurious emissions were detected above the noise floor of the measuring receiver; therefore the highest peak noise floor reading of the measuring receiver was recorded as shown in the table above.*

Idle Mode Radiated Spurious Emissions: Section 15.109 - Electric Field Strength Measurements (Frequency Range: 1 to 12.5 GHz) (Continued)







Note 1: These plots are pre-scans and for indication purposes only. Final measurements are in tables.
Note 2: Plot 008 shows a start frequency of 2.484 GHz but in fact the start frequency was 2.4835 GHz, due to the fact that the data capture software was set to record only 3 decimal places and therefore rounded up.

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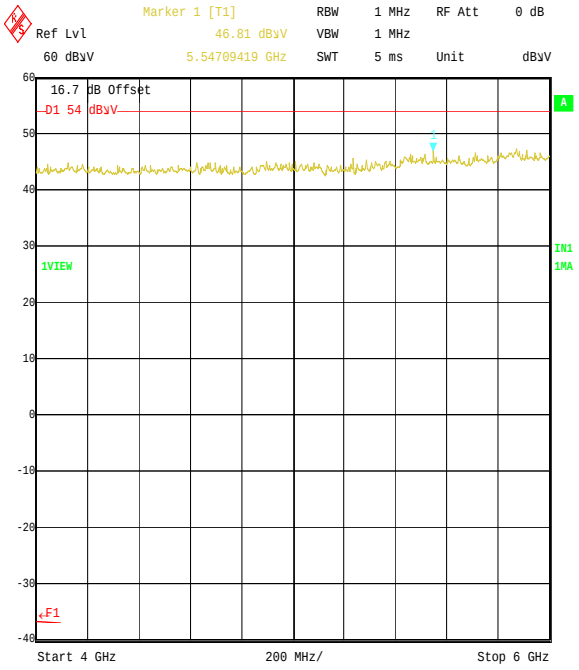
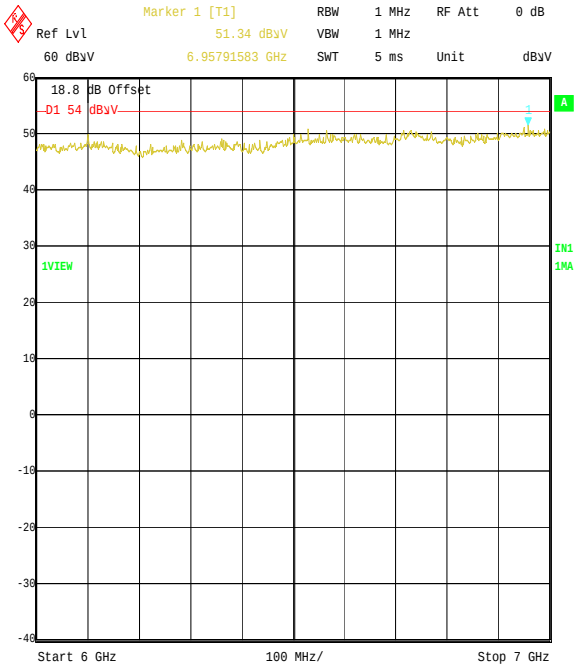
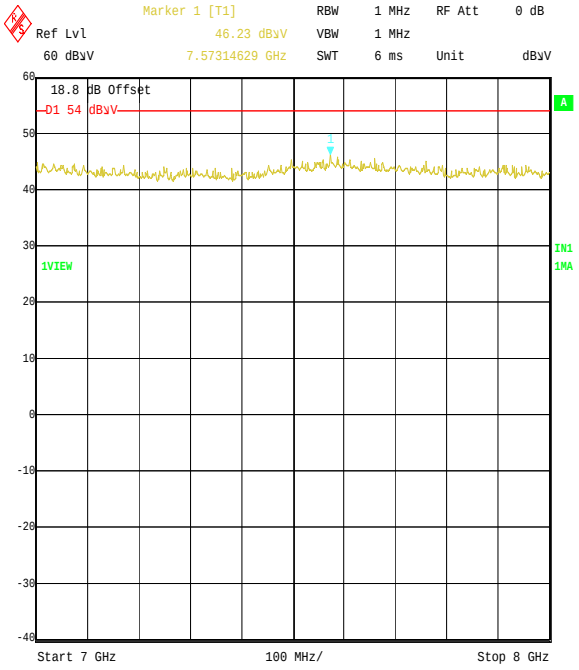
Idle Mode Radiated Spurious Emissions: Section 15.109 - Electric Field Strength Measurements (Frequency Range: 1 to 12.5 GHz) (Continued)



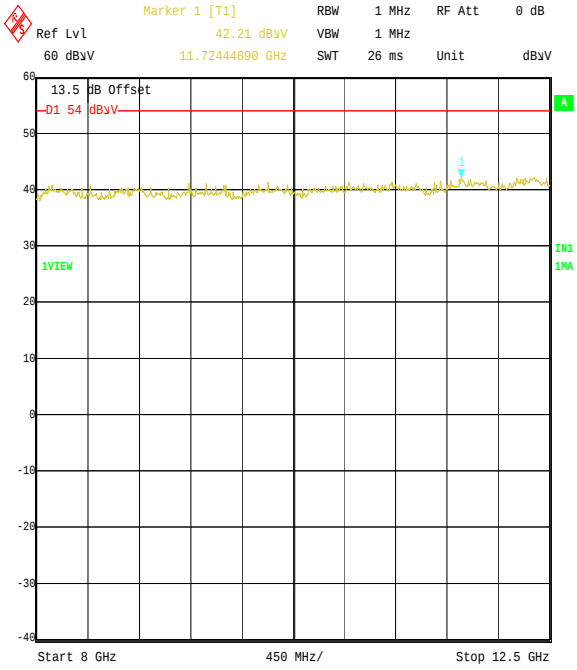
Title: Crane Electronics FCC Part 15.247 Electronic Torque Wrench
Comment A: Radiated Spurious Emissions Receive Mode
Date: 13.MAY.2005 14:46:17



Title: Crane Electronics FCC Part 15.247 Electronic Torque Wrench
Comment A: Radiated Spurious Emissions Receive Mode
Date: 13.MAY.2005 14:49:12



Title: Crane Electronics FCC Part 15.247 Electronic Torque Wrench
Comment A: Radiated Spurious Emissions Receive Mode
Date: 13.MAY.2005 14:50:21



Title: Crane Electronics FCC Part 15.247 Electronic Torque Wrench
Comment A: Radiated Spurious Emissions Receive Mode
Date: 13.MAY.2005 14:59:32

Note: These plots are pre-scans and for indication purposes only. For final measurements, see accompanying tables.

6.2.3. Transmitter 20 dB Bandwidth: Section 15.247(a)(1)

The EUT was configured for 20 dB bandwidth measurements as described in section 9 of this report.

Tests were performed to identify the 20 dB bandwidth.

Results:

Transmitter 20 dB Bandwidth (kHz)	Limit (kHz)
943.887776	None specified

Title: Crane Electronics FCC Part 15.247 Electronic Torque Wrench
Comment A: 20dB Bandwidth hopping on all channels
Date: 13.MAY.2005 10:55:25

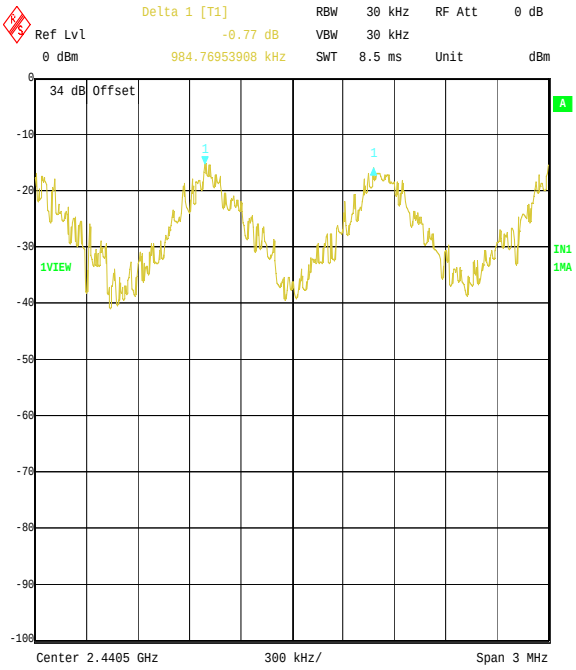
6.2.4. Transmitter Carrier Frequency Separation: Section 15.247(a)(1)

The EUT was configured for carrier frequency separation measurements as described in section 8.4 of this report.

Tests were performed to identify the carrier frequency separation.

Results:

Transmitter Carrier Frequency Separation (kHz)	Limit ≥20 dB BW (kHz)	Margin (kHz)	Result
984.769539	943.887776	40.882	Complied



Title: Crane Electronics FCC Part 15.247 Electronic Torque Wrench
Comment A: Carrier Separation hopping on all channels
Date: 13.MAY.2005 11:00:48

6.2.5. Transmitter Average Time of Occupancy: Section 15.247(a)(1)(iii)

The EUT was configured for average time of occupancy measurements as described in section 9 of this report.

Tests were performed to identify the average time of occupancy in a period of 32 seconds.

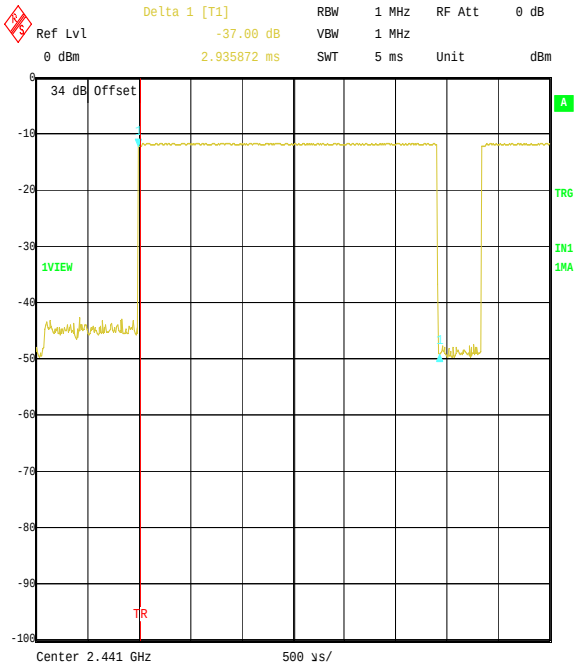
Results:

Emission Width (μs)	Number of Hops in Seconds	Average Time of Occupancy (s)	Limit (s)	Margin (s)	Result
2935.872	128	0.376	0.4	0.024	Complied

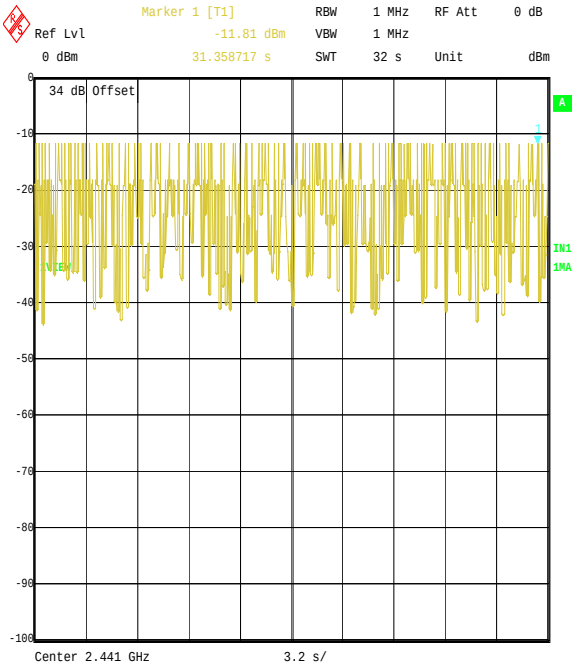
Note(s):

1. Tests were performed to identify the average time of occupancy in number of channels (79) x 0.4 seconds. The calculated period is 31.6 seconds.

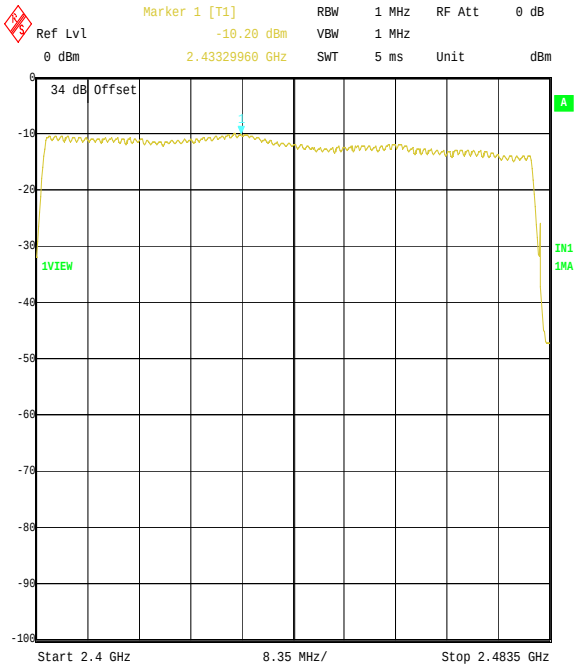
Transmitter Average Time of Occupancy: Section 15.247(a)(1)(iii) (Continued)



Title: Crane Electronics FCC Part 15.247 Electronic Torque Wrench
Comment A: Emission width. Centre of Hopping channel
Date: 13.MAY.2005 11:07:08



Title: Crane Electronics FCC Part 15.247 Electronic Torque Wrench
Comment A: 31.6s hops. Centre of Hopping channel
Date: 13.MAY.2005 11:13:30



Title: Crane Electronics FCC Part 15.247 Electronic Torque Wrench
Comment A: No of hops. Centre of Hopping channel
Date: 13.MAY.2005 11:17:12

6.2.6. Transmitter Maximum Peak Output Power: (EIRP) Section 15.247(b)(1)

The EUT was configured for transmitter peak output power measurements as described in Section 8.6 of this report.

Tests were performed to identify the transmitter maximum peak output power (EIRP) of the EUT.

Results:

Battery Powered Devices

Channel	EIRP (dBm)	Limit (dBm)	Margin (dB)	Result
Bottom	-10.9	30.0	40.9	Complied
Middle	-11.1	30.0	41.1	Complied
Top	-13.5	30.0	43.5	Complied

Note(s):

1. *These tests were performed radiated; therefore the EUT antenna gain is encompassed in the final result and not separately measurable.*

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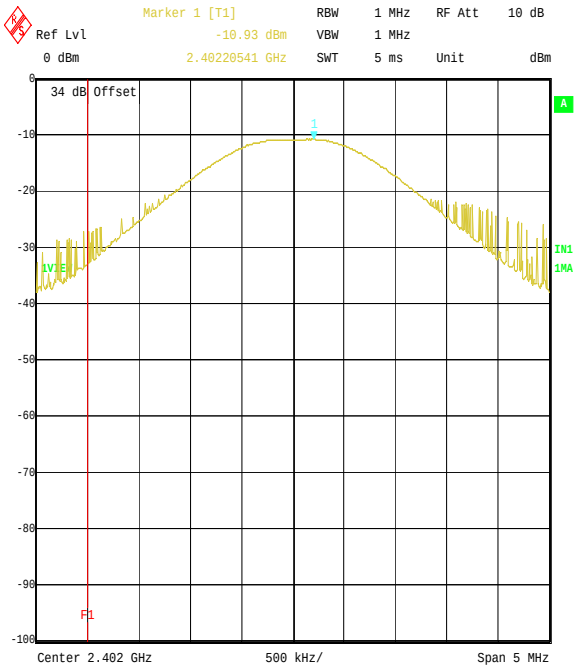
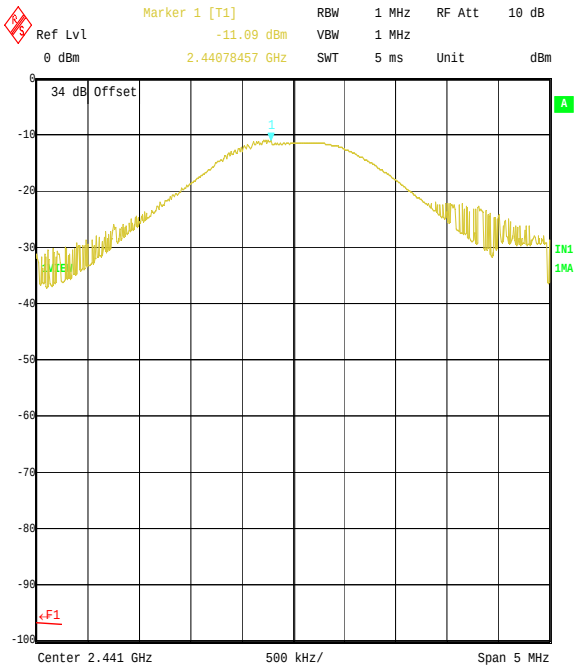
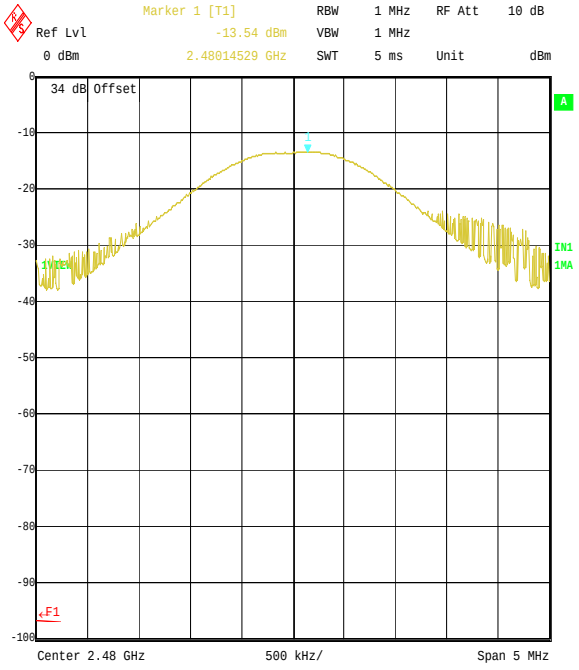
Transmitter Maximum Peak Output Power: (EIRP) Section 15.247(b)(3) (Continued)



Title: Crane Electronics FCC Part 15.247 Electronic Torque Wrench
Comment A: Peak Output Power Bottom Channel
Date: 13.MAY.2005 12:08:48



Title: Crane Electronics FCC Part 15.247 Electronic Torque Wrench
Comment A: Peak Output Power Middle Channel
Date: 13.MAY.2005 12:08:03



Title: Crane Electronics FCC Part 15.247 Electronic Torque Wrench
Comment A: Peak Output Power Top Channel
Date: 13.MAY.2005 12:06:38

6.2.7. Transmitter Radiated Emissions: Section 15.247(d) and 15.209(a) - Electric Field Strength Measurements: 30 to 1000 MHz (emissions outside the restricted bands)

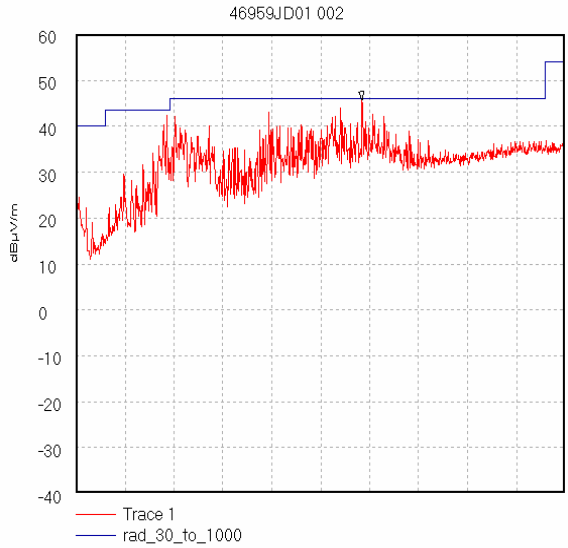
The EUT was configured for radiated emission testing as described in section 9 of this report.

Tests were performed to identify the maximum transmitter radiated emission levels.

Results:

Top Channel

Frequency (MHz)	Antenna Polarity	Peak Level (dBµV/m)	-20 dBc Limit (dBµV/m)	Margin (dB)	Result
210.123	Horiz.	30.3	64.3	34.0	Complied
412.263	Horiz.	28.8	64.3	35.5	Complied
597.196	Horiz.	31.8	64.3	32.5	Complied



Note(s):

1. *The preliminary scans showed similar emission levels below 1 GHz, irrespective of RF channel selection, therefore final radiated emissions measurements were performed with the EUT set to the top channel only.*
2. *These plots are pre-scans and for indication purposes only. For final measurements, see accompanying tables.*

6.2.8. Transmitter Radiated Emissions: Section 15.247(d) and 15.209(a) - Electric Field Strength Measurements (Frequency Range: 1 to 25.0 GHz) (emissions occurring in the restricted bands)

The EUT was configured for radiated emission testing as described in section 9 of this report.

Tests were performed to identify the maximum transmitter radiated emission levels.

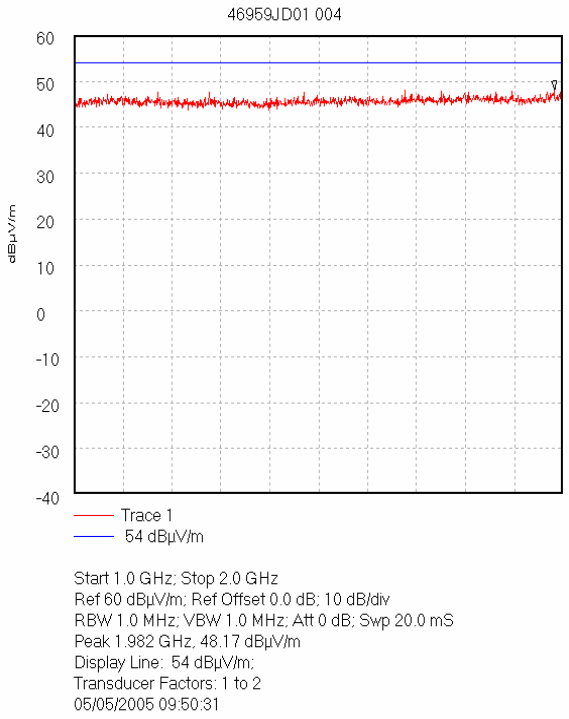
Results:

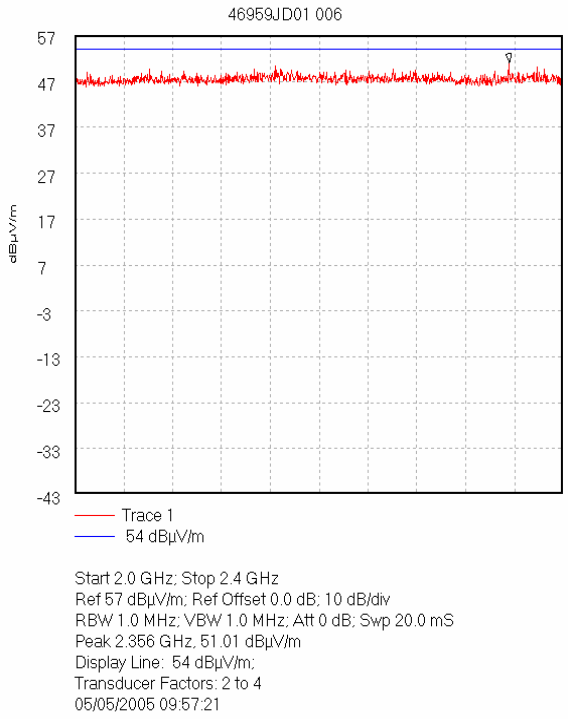
Highest Peak Level:

Frequency (GHz)	Antenna Polarity	Detector Level (dBµV)	Antenna Factor (dB)	Cable Loss (dB)	Actual Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Result
2.3555	Vert.	10.2	21.5	9.6	41.3	54.0	12.7	Complied

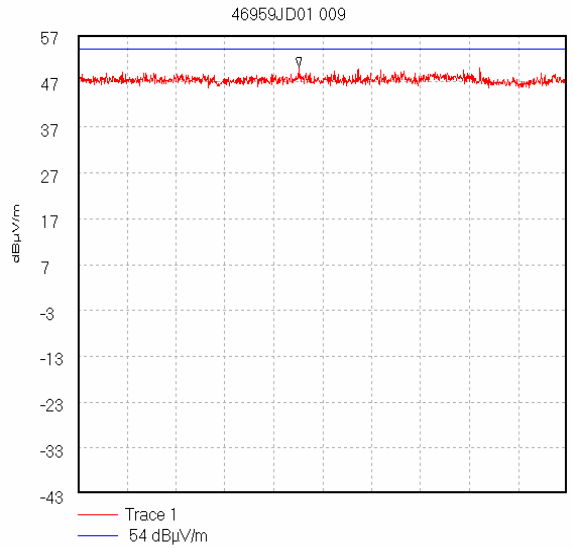
Note(s):

1. *No spurious emissions were detected above the noise floor of the measuring receiver; therefore the highest peak noise floor reading of the measuring receiver was recorded as shown in the table above.*

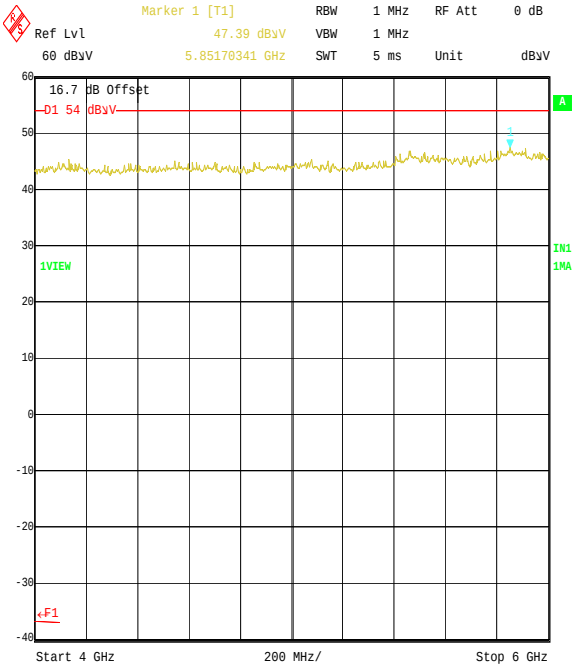




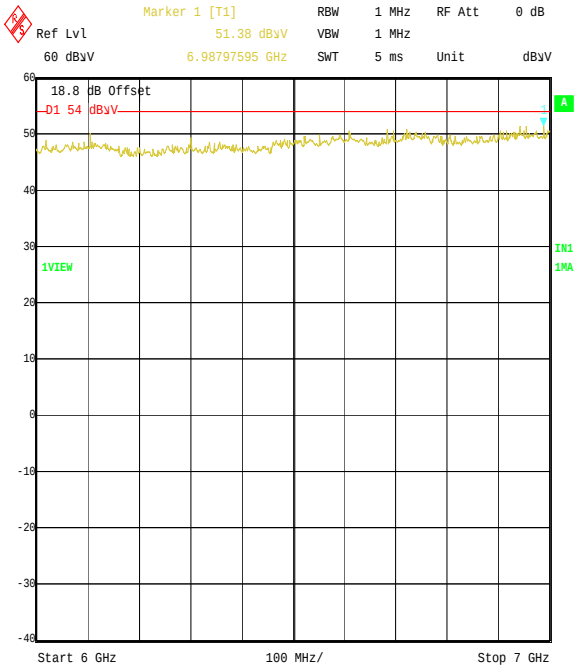
Transmitter Radiated Emissions: Section 15.247(d) and 15.209(a) - Electric Field Strength Measurements (Frequency Range: 1 to 25.0 GHz) (emissions occurring in the restricted bands) (Continued)



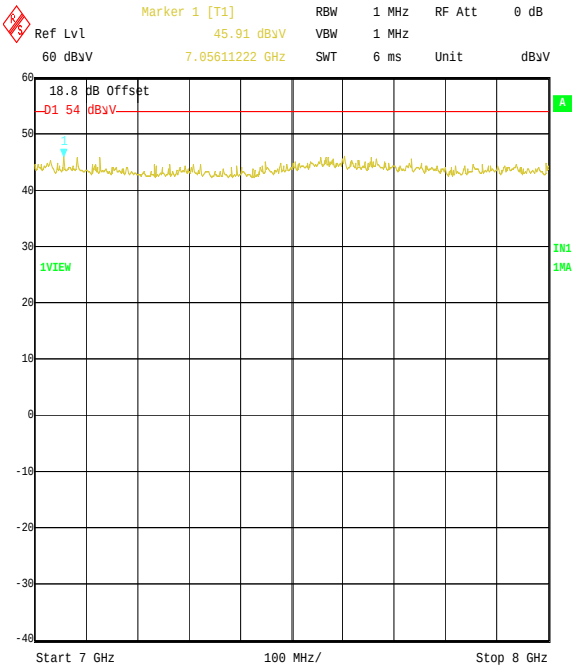
Start 2.484 GHz; Stop 4.0 GHz
Ref 57 dBµV/m; Ref Offset 0.0 dB; 10 dB/div
RBW 1.0 MHz; VBW 1.0 MHz; Att 0 dB; Swp 20.0 mS
Peak 3.168 GHz, 50.12 dBµV/m
Display Line: 54 dBµV/m;
Transducer Factors: 2 to 4
05/05/2005 10:03:28



Title: Crane Electronics FCC Part 15.247 Electronic Torque Wrench
Comment A: Radiated Spurious Emissions Transmitting on Top Channel
Date: 13.MAY.2005 14:44:27



Title: Crane Electronics FCC Part 15.247 Electronic Torque Wrench
Comment A: Radiated Spurious Emissions Transmitting on Top Channel
Date: 13.MAY.2005 14:51:58

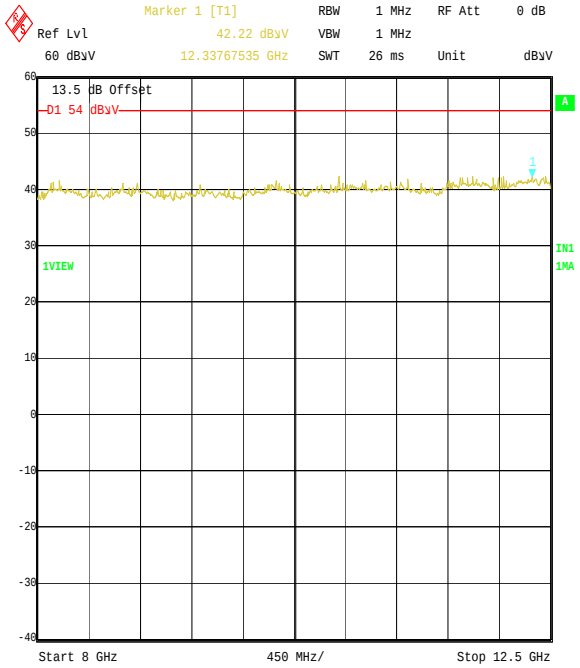


Title: Crane Electronics FCC Part 15.247 Electronic Torque Wrench
Comment A: Radiated Spurious Emissions Transmitting on Top Channel
Date: 13.MAY.2005 14:52:58

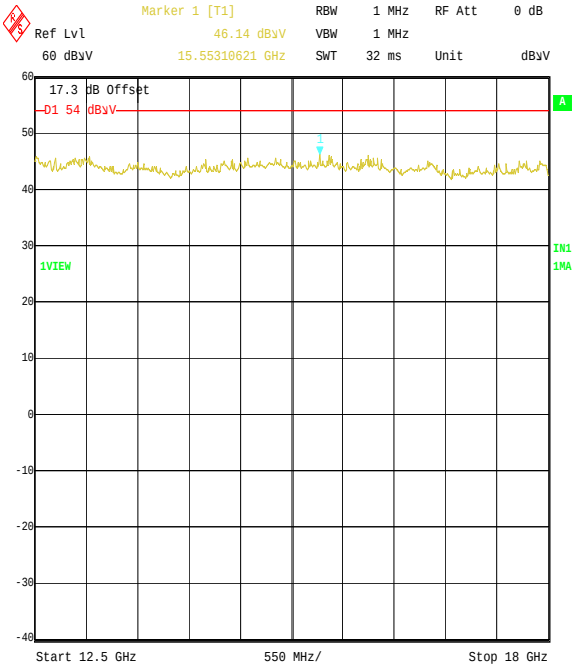
Note: Plot 009 shows a start frequency of 2.484 GHz but in fact the start frequency was 2.4835 GHz, due to the fact that the data capture software was set to record only 3 decimal places and therefore rounded up.

Test of: Crane Electronics Ltd
Prowrench Opta Tranceiver
To: FCC Part 15.247: 2004 (Subpart C)

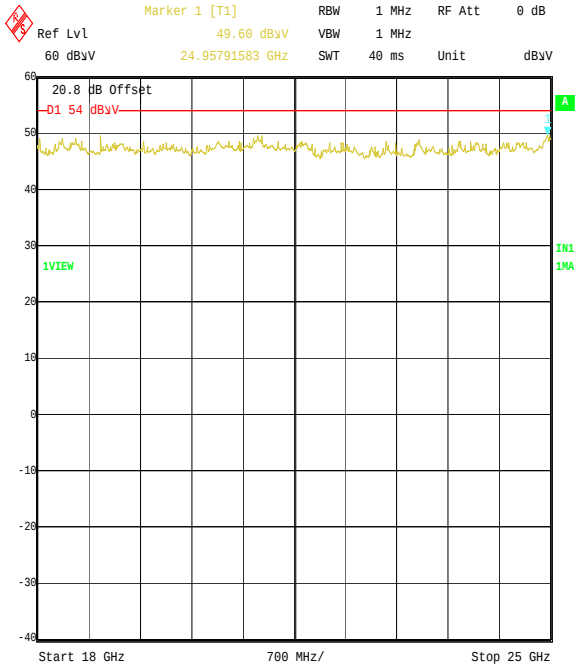
Transmitter Radiated Emissions: Section 15.247(d) and 15.209(a) - Electric Field Strength Measurements (Frequency Range: 1 to 25.0 GHz) (emissions occurring in the restricted bands) (Continued)



Title: Crane Electronics FCC Part 15.247 Electronic Torque Wrench
Comment A: Radiated Spurious Emissions Transmit Mode on Top Channel
Date: 13.MAY.2005 15:03:04



Title: Crane Electronics FCC Part 15.247 Electronic Torque Wrench
Comment A: Radiated Spurious Emissions Transmit Mode on Top Channel
Date: 13.MAY.2005 15:05:56



Title: Crane Electronics FCC Part 15.247 Electronic Torque Wrench
Comment A: Radiated Spurious Emissions Transmit Mode on Top Channel
Date: 13.MAY.2005 15:10:44

Note: These plots are pre-scans and for indication purposes only. For final measurements, see accompanying tables.

6.2.9. Transmitter Band Edge Radiated Emissions: Section 15.247(d) & 15.209(a) - Electric Field Strength Measurements

The EUT was configured for band edge compliance of radiated emission measurements as described in section 9 of this report.

Tests were performed to identify the maximum radiated band edge emissions.

Results:

Peak Power Level, Hopping Mode:

Frequency (GHz)	Antenna Polarity	Detector Level (dBμV)	Antenna Factor (dB)	Cable Loss (dB)	Actual Level (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Result
2.4000	Vert.	27.1	21.5	1.4	50.0	64.3*	14.3	Complied
2.4835	Vert.	33.6	21.1	1.4	56.1	74.0	17.9	Complied

Average Power Level, Hopping Mode:

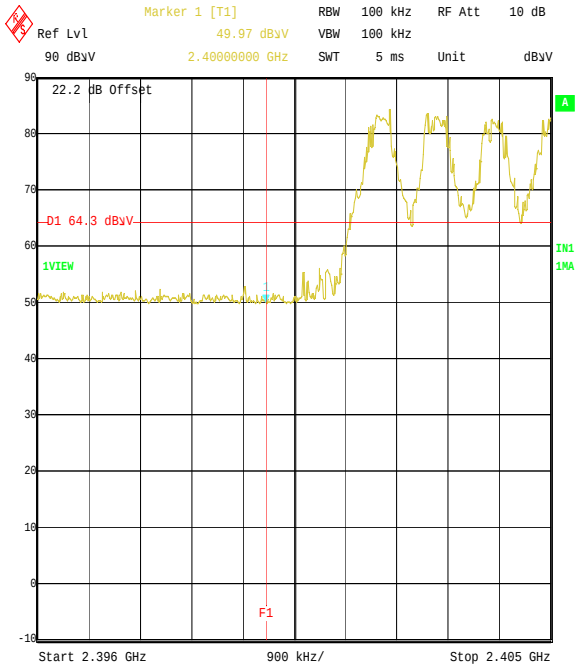
Frequency (GHz)	Antenna Polarity	Detector Level (dBμV)	Antenna Factor (dB)	Cable Loss (dB)	Actual Level (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Result
2.4835	Vert.	22.3	21.1	1.4	44.8	54.0	9.2	Complied

Note(s):

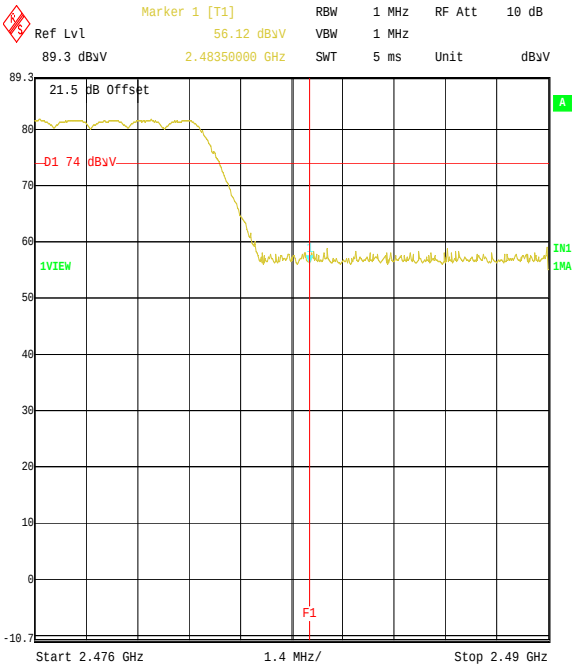
**. -20 dBc limit.*

Test of: Crane Electronics Ltd
Prowrench Opta Tranceiver
To: FCC Part 15.247: 2004 (Subpart C)

Transmitter Band Edge Radiated Emissions: Section 15.247(d) & 15.209(a) - Electric Field Strength Measurements (Continued)



Title: Crane Electronics FCC Part 15.247 Electronic Torque Wrench
Comment A: Radiated Band Edge on Hopping Mode Bottom Channel
Date: 13.MAY.2005 12:22:35



Title: Crane Electronics FCC Part 15.247 Electronic Torque Wrench
Comment A: Radiated Band Edge on Hopping Mode Top Channel
Date: 13.MAY.2005 12:28:36

6.2.10. Transmitter Band Edge Radiated Emissions: Section 15.247(d) & 15.209(a)

The EUT was configured for band edge compliance of radiated emission measurements as described in section 9 of this report.

Tests were performed to identify the average radiated band edge emissions.

Results:

Peak Power Level, Static Mode:

Frequency (GHz)	Antenna Polarity	Detector Level (dBμV)	Antenna Factor (dB)	Cable Loss (dB)	Actual Level (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Result
2.4000	Vert.	27.7	21.5	1.4	50.6	64.3*	13.7	Complied
2.4835	Vert.	38.2	21.1	1.4	60.7	74.0	13.3	Complied

Average Power Level, Static Mode:

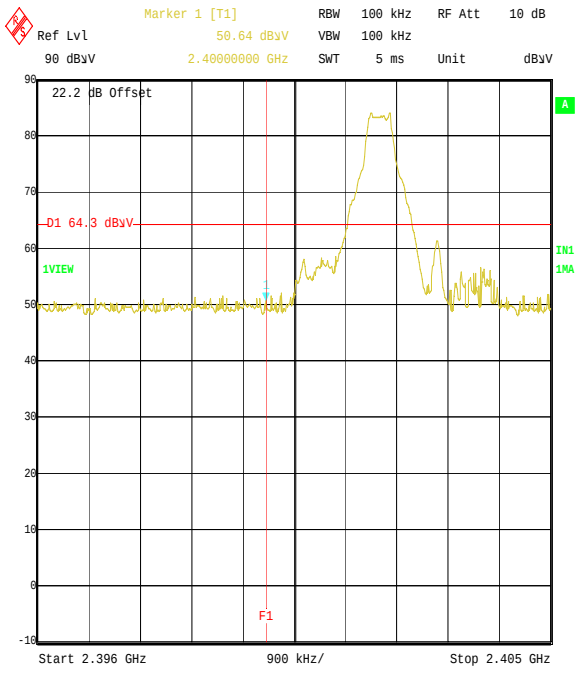
Frequency (GHz)	Antenna Polarity	Detector Level (dBμV)	Antenna Factor (dB)	Cable Loss (dB)	Actual Level (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Result
2.4835	Vert.	22.3	21.1	1.4	44.8	54.0	9.2	Complied

Note(s):

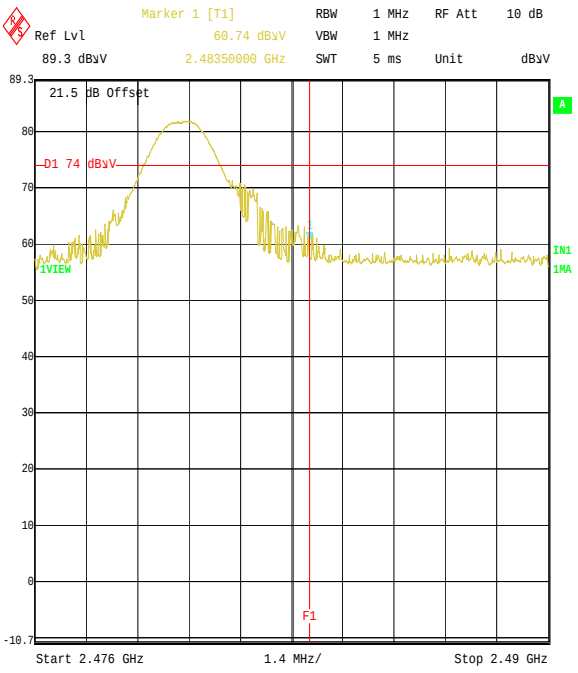
**. -20 dBc limit.*

Test of: Crane Electronics Ltd
Prowrench Opta Tranceiver
To: FCC Part 15.247: 2004 (Subpart C)

Transmitter Band Edge Radiated Emissions: Section 15.247(d) & 15.209(a) (Continued)



Title: Crane Electronics FCC Part 15.247 Electronic Torque Wrench
Comment A: Radiated Band Edge on Static Mode Bottom Channel
Date: 13.MAY.2005 12:23:59



Title: Crane Electronics FCC Part 15.247 Electronic Torque Wrench
Comment A: Radiated Band Edge on Static Mode Top Channel
Date: 13.MAY.2005 12:27:43

7. Measurement Uncertainty

No measurement or test can ever be perfect and the imperfections give rise to error of measurement in the results. Consequently, the result of a measurement is only an approximation to the value of the measurand (the specific quantity subject to measurement) and is only complete when accompanied by a statement of the uncertainty of the approximation.

The expression of uncertainty of a measurement result allows realistic comparison of results with reference values and limits given in specifications and standards.

The uncertainty of the result may need to be taken into account when interpreting the measurement results.

The reported expanded uncertainties below are based on a standard uncertainty multiplied by an appropriate coverage factor, such that a confidence level of approximately 95% is maintained. For the purposes of this document “approximately” is interpreted as meaning “effectively” or “for most practical purposes”.

Measurement Type	Range	Confidence Level (%)	Calculated Uncertainty
Transmitter Maximum Peak Output Power	Not applicable	95%	± 1.78 dB
Transmitter Carrier Frequency Separation	Not applicable	95%	± 0.01 ppm
Transmitter Average Time of Occupancy	Not applicable	95%	± 10 %
20 dB Bandwidth	Not applicable	95%	± 0.12 %
Radiated Spurious Emissions	30 MHz to 1000 MHz	95%	± 5.26 dB
Radiated Spurious Emissions	1 GHz to 40 GHz	95%	± 3.03 dB

The methods used to calculate the above uncertainties are in line with those recommended within the various measurement specifications. Where measurement specifications do not include guidelines for the evaluation of measurement uncertainty, the published guidance of the appropriate accreditation body is followed.

8. Measurement Methods

8.1. Radiated Emissions

Radiated emissions measurements were performed in accordance with the standard, against appropriate limits for each detector function.

Initial measurements covering the entire measurement band in the form of swept scans in a shielded enclosure were performed in order to identify frequencies on which the EUT was generating interference. This determined the frequencies on which the EUT should be re-measured in full on the open area test site. In order to minimise the time taken for the swept measurements, a peak detector was used in conjunction with the appropriate detector IF measuring bandwidth (see table below). Repetitive scans were performed to allow for emissions with low repetition rates.

The initial scans were performed using an antenna height of 1.5 m and a measurement distance of 3 m. Following the initial scans, graphs were produced giving an overview of the emissions from the EUT plotted against the appropriate specification limit. Any emission within 20 dB of the limit were then measured on the open area test site, except in cases where the noise floor was within 20 dB of the limit, in these cases the highest point of the noise floor was measured.

Where an emission fell inside a restricted band, measurements were made at the appropriate test distance using a measuring receiver with a quasi peak detector for measurements below 1000 MHz and an average and peak detector for measurements above 1000 MHz. A peak detector was used for all other measurements.

For the final measurements the EUT was arranged on a non-conducting turn table on a standard test site compliant with ANSI C63.4 – 2003 Clause 5.4.

All measurements on the open area test site were performed using broadband antennas in both vertical and horizontal polarisations.

On the open area test site, at each frequency where a signal was to be measured, the trace was maximised by rotating a turntable through 360°. The angle at which the maximum signal was observed was locked out. For frequencies below 1000 MHz the test antenna was varied in height between 1 m and 4 m in order to further maximise the target emission.

For frequencies above 1000 MHz where a horn antenna was used, height searching was performed to locate the optimal height of the horn with respect to the EUT. At this point the horn was locked off and the turntable was again rotated through 360° to maximise the target signal. It should be noted that the received signal from the EUT would diminish very quickly after it exits the beam width of the horn antenna, for this reason it may not be necessary to fully height search with the horns.

Radiated Emissions (Continued)

At this point, any signals found to be between the limit and a level 6 dB below it were further maximised by changing the configuration of the EUT, e.g. re-routing cables to peripherals and moving peripherals with respect to the EUT.

Scans were performed to the upper frequency limits as stated in section 15.33.

The final field strength was determined as the indicated level in dBμV plus cable loss and antenna factor.

The test equipment settings for radiated emissions measurements were as follows:

Receiver Function	Initial Scan	Final Measurements <1 GHz	Final Measurements ≥1 GHz
Detector Type:	Peak	Quasi-Peak (CISPR)	Peak / Average
Mode:	Max Hold	Not applicable	Max Hold
Bandwidth:	(120 kHz <1 GHz) (1 MHz ≥1 GHz)	120 kHz	1 MHz
Amplitude Range:	100 dB	100 dB	100 dB
Step Size:	Continuous sweep	Not applicable	Not applicable
Sweep Time:	Coupled	Not applicable	Not applicable

8.2. Carrier Frequency Separation / 20 dB Bandwidth

The EUT and spectrum analyser was configured as for radiated measurements and as per FCC Public Notice DA 00-705, Filing and Measurement Guidelines for Frequency Hopping Spread Spectrum Systems.

To determine the bandwidth and separation of each transmission channel the measurement analyser was configured to measure two adjacent channels whilst the EUT was in hopping mode. The spectrum analyser was configured with a resolution bandwidth and video bandwidth greater than 1% of the frequency span.

The analyser was set for a maximum hold scan to capture the profile of the signal. The peak points on the two adjacent channels were noted and the separation between them recorded.

To determine the occupied bandwidth, a resolution bandwidth of 10 kHz was used, which is greater than 1% of the 20 dB bandwidth. A video bandwidth of at least the same value was used.

The analyser was set for a maximum hold scan to capture the profile of the signal. The peak level was then determined and a reference line was drawn 20 dB below the peak level.

The bandwidth was determined at the points where the 20 dB reference line intercepted the power envelope of the emission.

8.3. Average Time of Occupancy

The EUT and spectrum analyser was configured as for radiated measurements and as per FCC Public Notice DA 00-705, Filing and Measurement Guidelines for Frequency Hopping Spread Spectrum Systems.

First the maximum packet length was determined on the centre channel.

The measurement analyser was configured to the time domain mode by setting the span to zero with a sweep time sufficiently wide enough to measure one pulse.

The EUT was configured to operate in normal mode of operation. The pulse width of one transmission was then recorded. The measurement analyser was then configured in zero span, i.e. in the time domain and the sweep time was set to 32 seconds (the closest allowable setting to 31.6 seconds). This 31.6 second period was determined by multiplying the number of channels the device operates over (79) by 0.4 seconds.

The number of transmissions within this period was noted and multiplied by the pulse width recorded earlier. This gives the maximum occupancy over 31.6 seconds.

8.4. Peak Output Power

The EUT and spectrum analyser were configured as for conducted antenna port measurements and as per FCC Public Notice DA 00-705, Filing and Measurement Guidelines for Frequency Hopping Spread Spectrum Systems.

Prior to testing being performed a suitable RF attenuator and cable were calibrated for the required frequencies. For each frequency to be measured, the calibrated level of the attenuator and cable were entered as an offset into a spectrum analyser to compensate for the measurement set up.

To determine the transmitter output power, the EUT was operated at maximum power and a result was obtained from the spectrum analyser using peak detector and trace max hold.

8.5. Effective Isotropic Radiated Power (EIRP)

EIRP measurements were performed in accordance with the standard, against appropriate limits.

The EIRP was measured with the EUT arranged on a non-conducting turn table on a standard test site compliant with ANSI C63.4 – 2003 Clause 5.4. The transmitter was fitted with an integral antenna; therefore all radiated tests were performed with the unit operating into the integral antenna.

The level of the EIRP was measured using a spectrum analyser.

The test antenna was positioned in the horizontal plane. The EUT was oriented in the X plane. The test antenna was then raised and lowered until a maximum peak was observed. The turntable was then rotated through 360 degrees and the maximum peak reading obtained. The height search was then repeated to take into consideration the new angular position of the turntable. The maximum reading observed was then recorded. This procedure was then repeated with the EUT oriented in the Y and Z planes. The highest reading taken in all 3 planes was recorded. The entire procedure was then repeated with the test antenna set in the vertical polarity.

Once the final amplitude (maximised) had been obtained, the EUT was substituted with a horn antenna. The centre of the substitution antenna was set to approximately the same centre location as the EUT. The substitution antenna was set to the horizontal polarity. The substitution antenna was matched into a signal generator using a 6 dB or greater attenuator. The signal generator was tuned to the EUT's frequency under test.

The test antenna was then raised and lowered to obtain a maximum reading on the spectrum analyser. The level of the signal generator output was then adjusted until the maximum recorded EUT level was observed. The signal generator level was noted. This procedure was repeated with both test antenna and substitution antenna vertically polarised. The EIRP was calculated as:-

EIRP = Signal Generator Level - Cable Loss + Antenna Gain

Effective Isotropic Radiated Power (EIRP) (Continued)

Circumstances where the signal generator could not produce the desired EUT output power, the substitution was performed with the signal generator set to 0 dBm. The radiated signal was maximised as previously described. The level indicated on the measuring receiver was noted. The delta between this level and the maximum level for the EUT was calculated and also noted. The EIRP of the signal generator was calculated using the above formulae. The recorded delta was added to the calculated EIRP to obtain the substituted EUT EIRP.

Delta (dB) = EUT – SG

where :

EUT = spectrum analyser indicated EUT raw level

SG = spectrum analyser indicated signal generator raw level

The signal generator actual EIRP is calculated as:

EIRP SG= Signal Generator Level - Cable Loss + Antenna Gain

The EUT EIRP is calculated as:

EIRP EUT = EIRP SG + Delta.

The test equipment settings for EIRP measurements were as follows:

Receiver Function	Setting
Detector Type:	Peak
Mode:	Not applicable
Bandwidth:	1 MHz
Amplitude Range:	100 dB
Sweep Time:	Coupled

8.6. Band Edge Compliance of RF Radiated Emissions

The EUT and spectrum analyser were configured as for radiated measurements and as per FCC Public Notice DA 00-705, Filing and Measurement Guidelines for Frequency Hopping Spread Spectrum Systems.

To determine band edge compliance, the analyser resolution bandwidth was set to >= 1% of the analyser span. The video bandwidth was set to be the same or greater than the resolution bandwidth. The sweep was set to auto and the detector to peak. The trace was set to max hold and a trace was produced.

A plot of the lower band edge of the allocated frequency band was produced. A marker was set to the level of the highest in band emission with a limit line set to 20 dB below this. The marker was then placed on the highest out of band emission (the specification states that either the band edge level must be measured or the highest out of band emission, whichever is the greater). The plots show that the highest out of band emission complies with the -20 dBc limit.

The above procedure was then repeated for the upper band edge except that, as the upper band edge fell on a restricted band edge (as defined in section 15.205(a)), the limit for the restricted band was applied instead of the -20 dBc limit, i.e. the general limits defined in section 15.209(a).

Final measurements were performed on the worst-case configuration as described in Part 15.31(i).

Appendix 1. Test Equipment Used

RFI No.	Instrument	Manufacturer	Type No.	Serial No.
A027	Horn Antenna	Eaton	9188-2	301
A031	2 to 4 GHz Eaton Horn Antenna	Eaton	91889-2	557
A1362	Eaton	Stoddart Aircraft Radio Co., Inc.	91889-1	N/A
A256	WG 18 Microwave Horn	Flann Microwave	18240-20	400
A259	Bilog Antenna	Chase	CBL6111	1513
A276	OATS Positioning Controller	Rohde & Schwarz	HCC	
A392	3 dB attenuator (9)	Suhner	6803.17.B	None
A428	WG 12 horn	Flann	12240-20	134
A429	WG 16 horn	Flann	16240-20	561
A430	WG 18 horn	Flann	18240-20	425
A436	WG 20 horn	Flann	20240-20	330
A553	Bi-log Antenna	Chase	CBL6111A	1593
M003	Spectrum Monitor	Rohde & Schwarz	EZM	883 580/008
M023	ESVP Receiver	Rohde & Schwarz	ESVP	872 991/027
M028	FSB Spectrum Analyser	Rohde & Schwarz	FSB	860 001/009 (RF), 860 161/007 (Display)
M088	Receiver / Spectrum Analyser System	Rohde & Schwarz	ESBI	DU:835862/018 RU:835387/006
M1124	Rohde & Schwarz	Rohde & Schwarz	ESIB26	100046K
M1149	Anritsu	Anritsu	MT8852A	6K00001529
M173	Turntable Controller	R.H.Electrical Services	RH351	3510020
S201	Site 1	RFI	1	
S202	Site 2	RFI	2	S202-15011990
S212	Site 12	RFI	12	

NB In accordance with UKAS requirements, all the measurement equipment is on a calibration schedule.

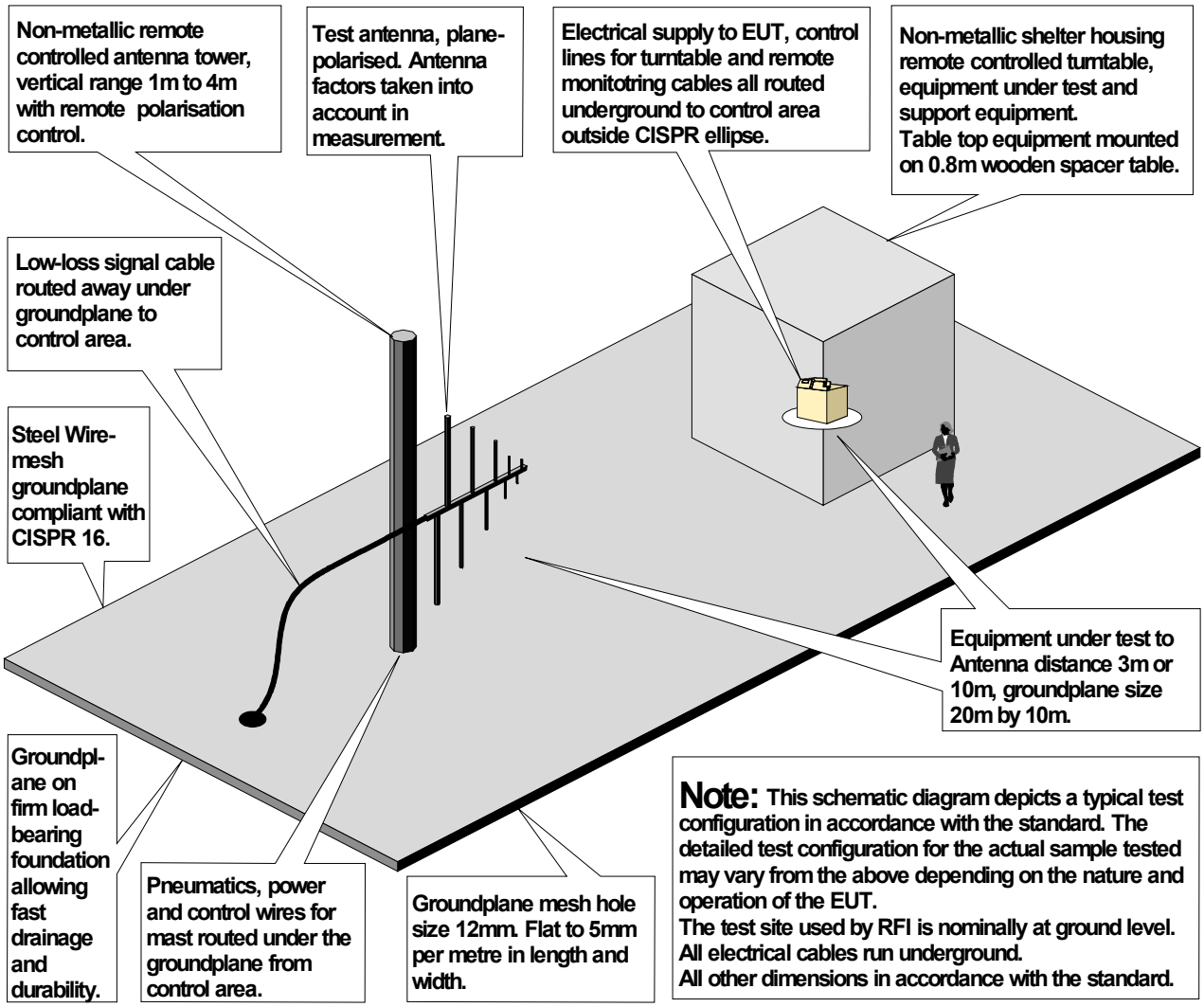
Appendix 2. Test Configuration Drawings

This appendix contains the following drawings:

Drawing Reference Number	Title
DRG\46959JD01A\EMIRAD	Test configuration for measurement of radiated emissions.

Test of: Crane Electronics Ltd
Prowrench Opta Tranceiver
To: FCC Part 15.247: 2004 (Subpart C)

DRG\46959JD01A\EMIRAD



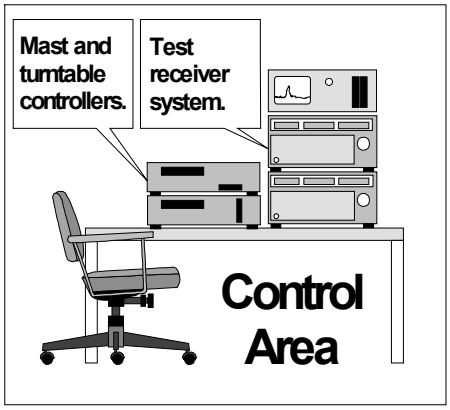
Note: This schematic diagram depicts a typical test configuration in accordance with the standard. The detailed test configuration for the actual sample tested may vary from the above depending on the nature and operation of the EUT.
The test site used by RFI is nominally at ground level.
All electrical cables run underground.
All other dimensions in accordance with the standard.

Test Configuration For Radiated Emissions Measurements

Reflection-free area: >60m by 52m (CISPR ellipse)

Groundplane Earthed

Control room outside CISPR ellipse



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