W66 N220 Commerce Court ● Cedarburg, WI 53012
Phone: 262.375.4400 ● Fax: 262.375.4248
www.lsr.com

RF Evaluation Exclusion Exhibit For:

VRS (TWIG)

Prepared by:

Khairul Aidi Zainal, Engineering Manager-EMC Test Services

10-6-2016

W66 N220 Commerce Court ● Cedarburg, WI 53012
Phone: 262.375.4400 ● Fax: 262.375.4248
www.lsr.com

Contents

W66 N220 Commerce Court ● Cedarburg, WI 53012
Phone: 262.375.4400 ● Fax: 262.375.4248
www.lsr.com

Product Description:

The VRS (TWIG) module is a high performance 900MHz IEEE 802.15.4 radio (AT86RF212 & RF amplifier and low noise amplifier circuit) and microcontroller (ATXMEGA256A3).

Microcontroller

The Atmel XMEGA A3 is a family of low power, high performance and peripheral rich CMOS 8/16-bit microcontrollers based on the AVR® enhanced RISC architecture. By executing powerful instructions in a single clock cycle, the XMEGA A3 achieves throughputs approaching 1 Million Instructions Per Second (MIPS), thus allowing the system designer to optimize power consumption versus processing speed.

Radio

The Atmel AT86RF212 is a low-power, low-voltage 800/900 MHz transceiver specially designed for low-cost IEEE 802.15.4, ZigBee™, and high data rate ISM applications. Furthermore hardware accelerators improve overall system power efficiency and timing.

RF Front End Module

The module contains a high performance RF Front End Module for 900MHz wireless applications.

It also has a built in low noise amplifier for the receiver to increase sensitivity and all antenna switching.

Associated Antenna(s):

The antennas associated with the EUT are:

+6 dBi Dipole Antenna

The HyperGain® HGV-906 is a high performance omni-directional antenna designed for the 900 MHz band. It is ideally suited for multipoint, Non Line of Sight (NLOS) and mobile applications where high gain and wide coverage is desired. Per the manufacturer, the antenna operates in 824-960 MHz range. The maximum gain is +6 dBi.

Articulating Dipole Antenna

W66 N220 Commerce Court ● Cedarburg, WI 53012
Phone: 262.375.4400 ● Fax: 262.375.4248
www.lsr.com

A dipole with a gain of +2.0 dBi was connected to both ports of the radio board. The antenna can articulate 90 degrees.

Bowtie Antenna

A custom bowtie-PCB antenna with a gain of +3.7 dBi.

Custom Antenna

A custom PCB antenna with a gain of -9.9 dBi.

Statement of compliance:

The VRS (TWIG) was evaluated against the requirements and limits of OET Bulletin 65 as well as RSS-102 Issue 5 and was found to be compliant.

Limits:

OET Bulletin 65 limits for General population/Uncontrolled Exposure

Frequency Range (MHz)	Electric Field Strength (E) (V/m)	Magnetic Field Strength (H) (A/m)	Power Density (S) (mW/cm^2)	Averaging Time $\|E\|^2$, $\|H\|^2$ or S (minutes)
0.3-1.34	614	1.63	(100)*	30
1.34-30	824/f	2.19/f	($180/f^2$)*	30
30-300	27.5	0.073	0.2	30
300-1500	--	--	f/1500	30
1500-100,000	--	--	1.0	30

f = frequency in MHz *Plane-wave equivalent power density

LSR
a Laird Business
ACCREDITED
TESTING CERT #1255.01
W66 N220 Commerce Court ● Cedarburg, WI 53012
Phone: 262.375.4400 ● Fax: 262.375.4248
www.lsr.com

RSS 102 limits for General population/Uncontrolled Exposure

Frequency Range (MHz)	Electric Field (V/m rms)	Magnetic Field (A/m rms)	Power Density (W/m^2)	Reference Period (minutes)
0.003-10^{21}	83	90	-	Instantaneous*
0.1-10	-	$0.73/f$	-	6**
1.1-10	$87/f^{0.5}$	-	-	6**
10-20	27.46	0.0728	2	6
20-48	$58.07/f^{0.25}$	$0.1540/f^{0.25}$	$8.944/f^{0.5}$	6
48-300	22.06	0.05852	1.291	6
300-6000	$3.142\,f^{0.3417}$	$0.008335\,f^{0.3417}$	$0.02619f^{0.6834}$	6
6000-15000	61.4	0.163	10	6
15000-150000	61.4	0.163	10	$616000/f^{1.2}$
150000-300000	$0.158\,f^{0.5}$	$4.21 \times 10^{-4}\,f^{0.5}$	$6.67 \times 10^{-5}\,f$	$616000/f^{1.2}$

Note: f is frequency in MHz.
*Based on nerve stimulation (NS).
** Based on specific absorption rate (SAR).

Per RSS 102 issue 5 section 2.5.2, RF exposure evaluation is required is separation distance between the user and/or bystander and the device's radiating element is greater than 20cm, except when the device operates as follows:

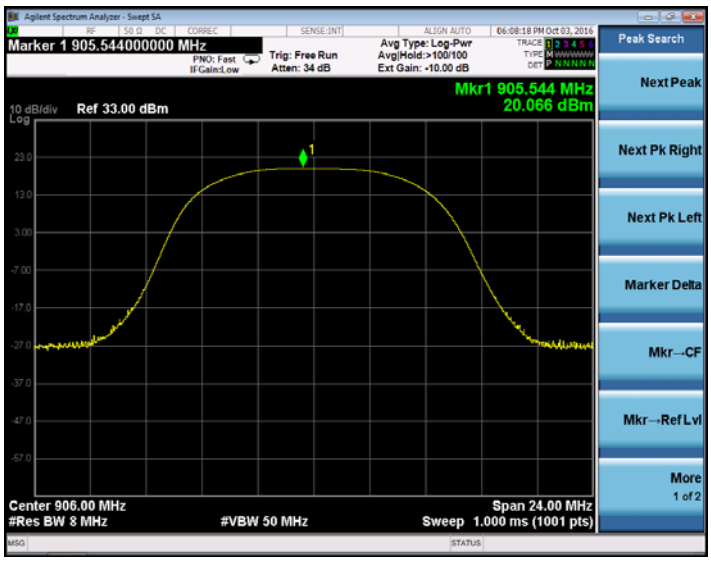
- below 20 MHz and the source-based, time-averaged maximum e.i.r.p. of the device is equal to or less than 1 W (adjusted for tune-up tolerance);
- at or above 20 MHz and below 48 MHz and the source-based, time-averaged maximum e.i.r.p. of the device is equal to or less than $22.48/f^{0.5}$W (adjusted for tune-up tolerance), where f is in MHz;
- at or above 48 MHz and below 300 MHz and the source-based, time-averaged maximum e.i.r.p. of the device is equal to or less than 0.6 W (adjusted for tune-up tolerance);
- at or above 300 MHz and below 6 GHz and the source-based, time-averaged maximum e.i.r.p. of the device is equal to or less than $1.31 \times 10^{-2}\,f^{0.6834}$ W (adjusted for tune-up tolerance), where f is in MHz;
- at or above 6 GHz and the source-based, time-averaged maximum e.i.r.p. of the device is equal to or less than 5 W (adjusted for tune-up tolerance).

W66 N220 Commerce Court ● Cedarburg, WI 53012
Phone: 262.375.4400 ● Fax: 262.375.4248
www.lsr.com

Data and calculations:

Channel Frequency (MHz)	Max Peak Conducted Power (dBm)	Power Limit (dBm)	Power margin (dB)	Peak PSD in 3kHz Minimum BW (dBm)	PSD in 3kHz limit(dBm)	PSD margin (dBm)
906	20.1	30.0	9.9	7.2	8.0	0.8
914	19.9	30.0	10.1	7.6	8.0	0.4
924	19.6	30.0	10.4	7.7	8.0	0.3

Screen Capture of maximum output power



Frequency 906MHz

W66 N220 Commerce Court ● Cedarburg, WI 53012
Phone: 262.375.4400 ● Fax: 262.375.4248
www.lsr.com

MPE Calculation

The following MPE calculations are based on a measured conducted RF power of +20.1 dBm with tune-up tolerance of 2dB as presented to the antenna. The peak gain of this antenna, based on the data sheet is 6.0 dBi.

Prediction of MPE limit at a given distance

Equation from page 18 of OET Bulletin 65, Edition 97-01

$$S = \frac{PG}{4\pi R^2}$$

where: S = power density
P = power input to the antenna
G = power gain of the antenna in the direction of interest relative to an isotropic radiator
R = distance to the center of radiation of the antenna

Maximum peak output power at antenna input terminal:	22.10	(dBm)
Maximum peak output power at antenna input terminal:	162.181	(mW)
Antenna gain(typical):	6	(dBi)
Maximum antenna gain:	3.981	(numeric)
Prediction distance:	20	(cm)
Prediction frequency:	906	(MHz)
MPE limit for uncontrolled exposure at prediction frequency:	0.6	(mW/cm^2)

Power density at prediction frequency: 0.128449 (mW/cm^2)

Maximum allowable antenna gain: 12.7 (dBi)

Margin of Compliance at 20 cm = 6.7 dB

W66 N220 Commerce Court ● Cedarburg, WI 53012
Phone: 262.375.4400 ● Fax: 262.375.4248
www.lsr.com

RF Exposure Evaluation:

Evaluated against exposure limits: General Public Use ☒ Controlled Use ☐
Duty cycle used in evaluation: 100 %
Standard(s)/Procedure(s) used for evaluation (e.g. IEEE C95.3):OET Bulettin 65 and RSS 102
Measurement distance: 20 cm
RF field strength value: **0.128** V/m ☐ A/m ☐ mW/cm² ☒
Measured ☐ Computed ☐ Calculated ☒

Summary MPE:

The calculated power density of the EUT was found to be below the OET Bulletin 65 MPE limit.

RSS 102 Evaluation.

Pout = 20.1dBm

Antenna gain = 6.0dBi

Tune-up tolerance = 2.0dB

EIRP = 20.1 + 6.0+ 2.0 = 28.1dBm = 0.646 W

Summary RSS 102:

Per RSS 102 issue 5 section 2.5.2, since the EUT operates at less than

$1.31 \times 10^{-2} * (906)^{0.6834}$ W = 1.37W

The EUT is compliant with RSS 102 issue 5.