



ROGERS

Labs, Inc.

4405 West 259TH Terrace • Louisburg, KS 66053 • PHONE & FAX: (913) 837-3214

FCC CERTIFICATION REPORT

ELECTROMAGNETIC INTERFERENCE TEST RESULTS For CFR 47

FOR PART 15C - INTENTIONAL RADIATORS

For

GRH ELECTRONICS, INC.
4520 South 36th Street
Omaha, NE 68107-1329

Kenneth Hoberman,
President

MODEL: VISICOM RADIO-LINK MODULE
2101-XXXX
Frequency 916.5 MHz
FCC ID: F6V-2101-0011-A

Test Date: May 24, 1999

Certification Date: May 24, 1999

Certifying Engineer: Scot D. Rogers

Scot D. Rogers
ROGERS LABS, INC.
4405 West 259th Terrace
Louisburg, KS 66053
Phone: (913) 837-3214
FAX: (913) 837-3214

- (2) Identification: Model: VISICOM RADIO-LINK MODULE
FCC I.D.: F6V-2101-0011-A
- (3) Instruction Book:
Refer to Exhibit for Instruction Manual.
- (4) Description of Circuit Functions:
Refer to Exhibit for Circuit Description.
- (5) Block Diagram with Frequencies:
Refer to Exhibit for Block Diagram.
- (6) Report of Measurements:
Follows in this Report.
- (7) Photos: Construction, Component Placement, etc.:
Refer to Appendix of this report for Photographs of equipment.
- (8) No Peripheral Equipment Was Necessary.
- (9) Transition Provisions of 15.37 are not being requested.
- (10) Direct Sequence Spread Spectrum:
Not Applicable.
- (11) Not Applicable. The EUT is not a Scanning Receiver.

2) Equipment Tested

<u>EUT</u>	<u>FCC I.D.#</u>
VISICOM RADIO-LINK MODULE	F6V-2101-0011-A

3) Equipment Function and Testing Procedures

The EUT is a 916.5 MHz radio transceiver used in conjunction with a current carrier Visual Paging System. The radio-link module is operated from the VisiCom transceiver. The

VisiCom transceiver is targeted for professional offices where paging of various personnel at different times is required. The radio-link receives power and paging information from the Visicom transceiver and then broadcasts the information in a one to two second time interval. The radio-link is designed for use in excessively "noisy" (high ambient noise levels on the powerline) application areas. For testing purposes only, the transceiver was set to a maximum transmit cycle with the radio-link continuously enabled. This mode of operation ensured the maximum radio frequency power was transmitted from the EUT. NOTE: This test mode of operation is used for production testing purposes only and is not allowed by the end user.

4) Equipment and Cable Configurations

Conducted Emission Test Procedure

The test setup, including the EUT, was arranged in a typical equipment configuration and placed on a 1 x 1.5-meter wooden bench, 0.8 meters high located in a screen room. The power lines of the system were isolated from the power source using a standard LISN with a 50- μ Hy choke. EMI was coupled to the spectrum analyzer through a 0.1 μ F capacitor internal to the LISN. The LISN was positioned on the floor beneath the wooden bench supporting the EUT. The power lines and cables were draped over the back edge of the table.

Radiated Emission Test Procedure

The EUT was placed on a rotatable 1 x 1.5-meter wooden platform, 0.8 meters above the ground plane at a distance of 3 meters from the FSM antenna. EMI energy was maximized by equipment placement, raising and lowering the FSM antenna, changing the antenna polarization, and by rotating the turntable. Each emission was maximized before data was taken using a spectrum analyzer. Refer to photos in Appendix for EUT placement.

5) List of Test Equipment

A Hewlett Packard 8591EM Spectrum Analyzer was used as the measuring device for the emissions testing of frequencies below 1 GHz. A Hewlett Packard 8562A Spectrum Analyzer was used as the measuring device for testing the emissions at frequencies above 1 GHz. The analyzer settings used are described in the following table. Refer to Appendix for a complete list of Test Equipment.

HP 8591 EM ANALYZER SETTINGS		
CONDUCTED EMISSIONS:		
RBW	AVG. BW	DETECTOR FUNCTION
9 kHz	30 kHz	Peak / Quasi Peak
RADIATED EMISSIONS:		
RBW	AVG. BW	DETECTOR FUNCTION
120 kHz	300 kHz	Peak / Quasi Peak
HP 8562A ANALYZER SETTINGS		
RBW	VIDEO BW	DETECTOR FUNCTION
100 kHz	100 kHz	PEAK
1 MHz	1 MHz	Peak / Average

<u>EQUIPMENT</u>	<u>MFG.</u>	<u>MODEL</u>	<u>CAL. DATES</u>	<u>DUE.</u>
LISN	Comp. Design	1762	9/98	9/99
Antenna	ARA	BCD-235-B	9/98	9/99
Antenna	EMCO	3147	9/98	9/99
Antenna	EMCO	3143	4/99	4/00
Analyzer	HP	8591EM	6/98	6/99

6) Units of Measurements

Conducted EMI: Data is in dBµV; dB referenced to one microvolt.

Radiated EMI: Data is in dBµV/m; dB/m referenced to one microvolt per meter.

7) Test Site Locations

Conducted EMI: The AC powerline conducted emissions tests were performed in a shielded screen room located at Rogers Labs, Inc., 4405 W. 259th Terrace, Louisburg, KS.

ROGERS LABS, INC.
4405 W. 259th Terrace
Louisburg, KS 66053
Phone/Fax: (913) 837-3214

GRH ELECTRONICS, INC.
MODEL: VISICOM RADIO-LINK MODULE
Test #: 990602 FCCID#: F6V-2101-0011-A
Test to: FCC Parts 2 and 15c

Radiated EMI: The radiated emissions tests were performed at Rogers Labs, Inc. 3 meters Open Area Test Site (OATS).

Site Approval: Refer to Appendix for FCC Site Approval Letter, Reference 31040/SIT 1300F2, Dated February 6, 1998.

8) SUBPART B – UNINTENTIONAL RADIATORS

Conducted EMI:

The EUT was arranged in a typical equipment configuration and placed on a 1 x 1.5-meter wooden bench 80 cm above the conducting ground plane, floor of a screen room. The bench was positioned 40 cm away from the wall of the screen room. The LISN was positioned on the floor of the screen room 80-cm from the rear of the EUT. The power cord of the EUT was connected to the LISN. A second LISN was also positioned on the floor of the screen room and used to power the auxiliary equipment. EMI was coupled to the spectrum analyzer through a 0.1 μ F capacitor, internal to the LISN. Power line conducted emissions testing was carried out individually for each current carrying conductor of the EUT. The excess length of lead between the system and the LISN receptacle was folded back and forth to form a bundle not exceeding 40 cm in length. The screen room, conducting ground plane, analyzer and LISN were bonded together to the protective earth ground. Preliminary testing was performed to identify the frequencies

of the emissions, which had the highest amplitudes. The cables were repositioned to obtain maximum amplitude of measured EMI level. Once the worst case configuration was identified, plots were made of the EMI from 0.15 MHz to 30 MHz then the data was recorded with maximum conducted emissions levels.

Radiated EMI:

The EUT was arranged in a typical equipment configuration and operated through all of its various modes. Preliminary testing was performed in a screen room with the EUT positioned 1 meter from the FSM. Radiated emissions measurements were performed to identify the frequencies, which produced the highest emissions. Plots were made of the frequency spectrum from 30 MHz to 1000 MHz for the preliminary testing. The EUT and cable locations were noted and reconfigured at the open area test site. The highest radiated emission was then re-maximized at this location before final radiated emissions measurements were performed. Final data was taken with the EUT located at the OATS at a distance of 10 meters between the EUT and the receiving antenna. The frequency spectrum from 30 MHz to 1000 MHz was searched for radiated emissions. Measured emission levels were maximized by EUT placement on the table, changing cable location, rotating the turntable through 360 degrees, varying

the antenna height between 1 and 4 meters above the ground plane and changing antenna position between horizontal and vertical polarization. Antennas used were Broadband Biconical from 30 to 200 MHz, Log Periodic from 200 MHz to 5 GHz, and or a Biconilog from 30 to 1000 MHz.

Sample Calculations:

RFS = Radiated Field Strength

dB μ V/m @ 3m = dB μ V + A.F. - Amplifier Gain

dB μ V/m @ 3m = 54.9 + 9.8 - 35
= 29.7

Data: Conducted (6 Highest Emissions):

Frequency In MHz	Level L1 In dB μ V	Level L2 In dB μ V	FCC Limit in dB μ V
7.1	23.8	23.6	48.0
11.1	29.4	30.7	48.0
14.3	22.4	25.5	48.0
17.9	26.1	24.9	48.0
22.1	23.9	26.7	48.0
28.7	23.4	27.4	48.0

Other emissions present had amplitudes at least 10 dB below the limit.

Data: Radiated (6 Highest Emissions) :

Freq. In MHz	FSM Hor. (dBuV)	FSM Vert. (dBuV)	Ant. Fact. (dB)	Amp. Gain (dB)	Comp. Hor. (dBuV/m) @ 10m	Comp. Vert. (dBuV/m) @ 10m	CISPR 22 Limit
44.1	54.9	57.3	9.8	35	29.7	32.1	40.0
66.5	60.8	61.4	6.1	35	31.9	32.5	40.0
121.5	49.0	63.2	3.7	35	20.7	34.9	43.5
133.6	49.8	61.5	8.1	35	22.9	34.6	43.5
165.9	57.1	62.6	9.3	35	31.4	36.9	43.5
176.9	56.7	62.5	9.1	35	30.8	36.6	43.5

Other emissions present had amplitudes at least 10 dB below the limit.

Summary of Results for Conducted Emissions:

The conducted emissions for the EUT meet the requirements for FCC Part 15B CLASS B Digital Devices. The EUT had a 17.3 dB minimum margin below the limit. Other emissions were present with amplitudes at least 10.0 dB below the limit.

Summary of Results for Radiated Emissions:

The radiated emissions for the EUT meet the requirements for FCC Part 15B CLASS B Digital Devices. The EUT had a 6.6 dB minimum margin below the limit. Other emissions were present with amplitudes at least 10 dB below the limit.

Statement of Modifications:

No modifications to the EUT were required for the unit to meet the FCC Part 15B CLASS B emissions standards. There were no deviations to the specifications.

9) Subpart C - Intentional Radiators

As per CFR Part 15, Subpart C. The following information is submitted:

15.203 Antenna Requirements

The unit is produced with a permanently attached antenna. The antenna is not replaceable or user serviceable. The requirements of 15.203 are met; there are no deviations or exceptions to the specification.

Restricted Bands of Operation Per 15.205

Spurious emissions falling in the restricted frequency bands of operation were measured at the OATS. The EUT utilizes frequency, determining circuitry, which generates harmonics falling in the restricted bands. Emissions were checked at the OATS, using appropriate antennas or pyramidal horns, amplification stages, and a spectrum analyzer. No other significant emission was observed which fell into the restricted bands of operation.

Data 15.205:**Radiated Emissions In Restricted Bands:**

Emission Frequency (MHz)	FSM Horiz. (dBµV)	FSM Vert. (dBµV)	Ant. Factor (dB)	Amp. Gain (dB)	RFS Horiz. @ 3m (dBµV/m)	RFS Vert. @ 3m (dBµV/m)	Limit @ 3m (dBµV/m)
2749.5	35.5	31.3	33.4	25	43.9	39.7	54
3666.0	31.6	32.3	38.3	25	44.9	45.6	54
4582.5	31.0	31.5	42.5	25	48.5	49.0	54

No other emissions found in the restricted bands.

Sample Calculations:

$$\begin{aligned}
 \text{Computed Peak (dBµV/m @ 3m)} &= \text{FSM(dBµV)} + \text{A.F. (dB)} - \text{Gain(dB)} \\
 &= 35.5 + 33.4 - 25 \\
 &= 43.9
 \end{aligned}$$

15.209 Radiated Emissions Limits; General Requirements**Radiated EMI:**

The EUT was arranged in a typical equipment configuration and operated through all of its various modes. Preliminary testing was performed in a screen room with the EUT positioned 1 meter from the FSM. Radiated emissions measurements were performed to identify the frequencies, which produced the highest emissions. Plots were made of the frequency spectrum from 30 MHz to 1000 MHz for the preliminary testing. The highest radiated emission was then re-maximized at this location before final radiated emissions measurements were performed. Final data was taken with the EUT located at the open field test site at a distance of 3 meters between the EUT and the receiving antenna. The

frequency spectrum from 30 MHz to 1000 MHz was searched for radiated emissions. Measured emission levels were maximized by EUT placement on the table, changing cable location, rotating the turntable through 360 degrees, varying the antenna height between 1 and 4 meters above the ground plane and changing antenna polarization between horizontal and vertical. Antennas used were Broadband Biconical from 30 MHz to 200 MHz, Log Periodic from 200 MHz to 5 GHz and/or Biconilog from 30 MHz to 1000 MHz.

Data 15.209:

Radiated (6 Highest Emissions) 15.209

Emission Freq. (MHz)	FEM Horiz. (dBuV)	FEM Vert. (dBuV)	Ant. Factor (dB)	Amp. Gain (dB)	RFS Horiz. @ 3m (dBuV/m)	RFS Vert. @ 3m (dBuV/m)	Limit @ 3m (dBuV/m)
44.1	54.9	57.3	9.8	35	29.7	32.1	40.0
66.5	60.8	61.4	6.1	35	31.9	32.5	40.0
121.5	49.0	63.2	3.7	35	20.7	34.9	43.5
133.6	49.8	61.5	8.1	35	22.9	34.6	43.5
165.9	57.1	62.6	9.3	35	31.4	36.9	43.5
176.9	56.7	62.5	9.1	35	30.8	36.6	43.5

Other emissions were present with amplitudes at least 10 dB below limits.

Sample Calculations:

RFS = Radiated Field Strength

dBuV/m @ 3m = dBuV + A.F. - Amplifier Gain

dBuV/m @ 3m = 54.9 + 9.8 - 35

= 29.7

Summary of Results for Radiated Emissions:

The radiated emissions for the EUT meet the requirements for FCC Part 15C Intentional Radiators. The EUT had a 6.6 dB minimum margin below the limits. Other emissions were present with amplitudes at least 10 dB below the FCC Limits.

15.249 Operation in the Band 902-928 MHz

The power output was measured on an open field test site @ 3 meters. Data was taken per Paragraph 2.1046(a) and 15.249.

(a) The EUT was placed on a wooden turntable 0.8 meters above the ground plane and at a distance of 3 meters from the FSM antenna. The amplitude of the carrier frequency was measured using a spectrum analyzer. The amplitude of the emission was then recorded from the analyzer display.

(b) Emissions radiated outside of the specified bands, except for harmonics, shall be attenuated by at least 50 dB below the level of the fundamental or to the general radiated emission limits in 15.209, whichever is the lesser attenuation. The amplitudes of each spurious emission were measured at a distance of 3 meters from the FSM antenna at the OATS. The amplitude of each spurious emission was maximized by varying the FSM antenna height, polarization, and by rotating the turntable. A Biconilog Antenna was used for measuring emissions from 30 to 1000 MHz, a Log Periodic Antenna for 200 to 5000 MHz; and/or Pyramidal Horn Antenna

from 4 to 40 GHz. Emissions were measured in dB μ V/m @ 3 meters.

FREQ.	FSM IN HOR. dB μ V	FSM IN VERT. dB μ V	ANTENNA FACT.	AMP. GAIN	LEVEL IN dB μ V/m @ 3m HOR.	LEVEL IN dB μ V/m @ 3m VERT.	LEVEL IN dB μ V/m @ 3m
916.5	74.0	89.6	22.3	25	71.3	86.9	94.0

Note: Level was measured @ 3 meter site.

$$\begin{aligned}
 \text{dB}\mu\text{V/m@ 3m} &= \text{FSM} + \text{A.F.} - \text{AMP. GAIN} \\
 &= 74.0 + 22.3 - 25 \\
 &= 71.3
 \end{aligned}$$

$$\begin{aligned}
 \mu\text{V/M} &= 10^{((\text{dB}\mu\text{V/M})/20)} \\
 &= 3,672.8
 \end{aligned}$$

Refer to Figures showing plots taken in the screen room from the spectrum analyzer at a distance of 1 meter. The band edges are protected due to the frequency band of operation.

MARKER
177.5 MHz
37.96 dB μ V

ACTV DET: PEAK
MEAS DET: PEAK QP
MKR 177.5 MHz
37.96 dB μ V

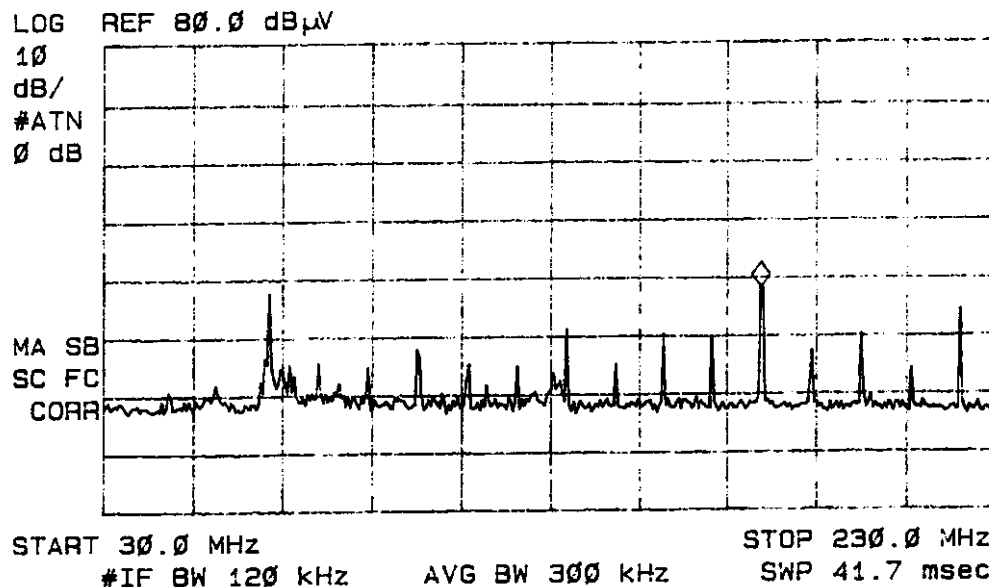


Figure 1 Emissions @ 1 Meter in Screen Room

MARKER
918 MHz
65.39 dB μ V

ACTV DET: PEAK
MEAS DET: PEAK QP
MKR 918 MHz
65.39 dB μ V

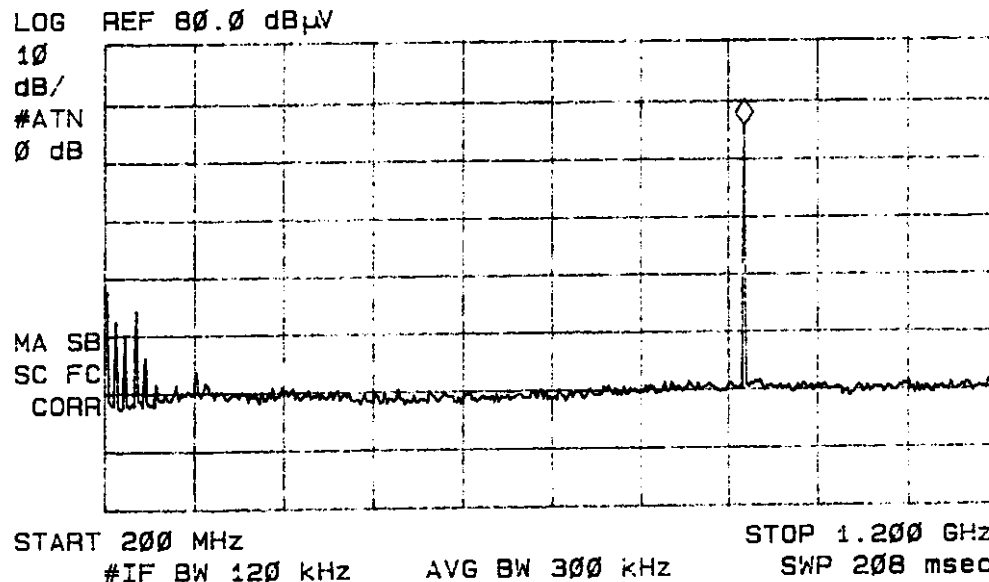


Figure 2 Emissions @ 1 Meter in Screen Room

STOP
928.00 MHz

ACTV DET: PEAK
MEAS DET: PEAK QP
MKR 916.63 MHz
69.49 dB μ V

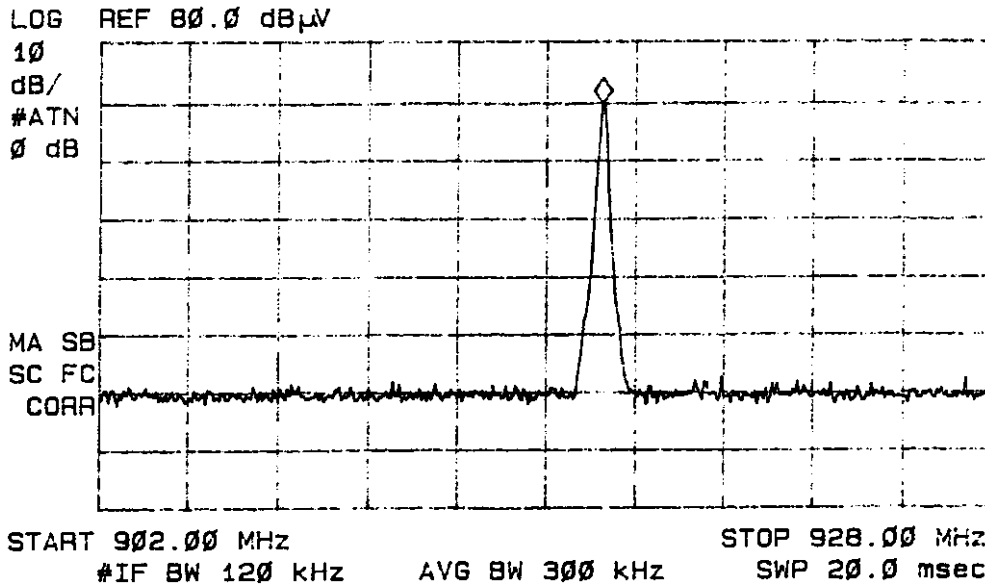


Figure 3 Emissions @ 1 Meter in Screen Room

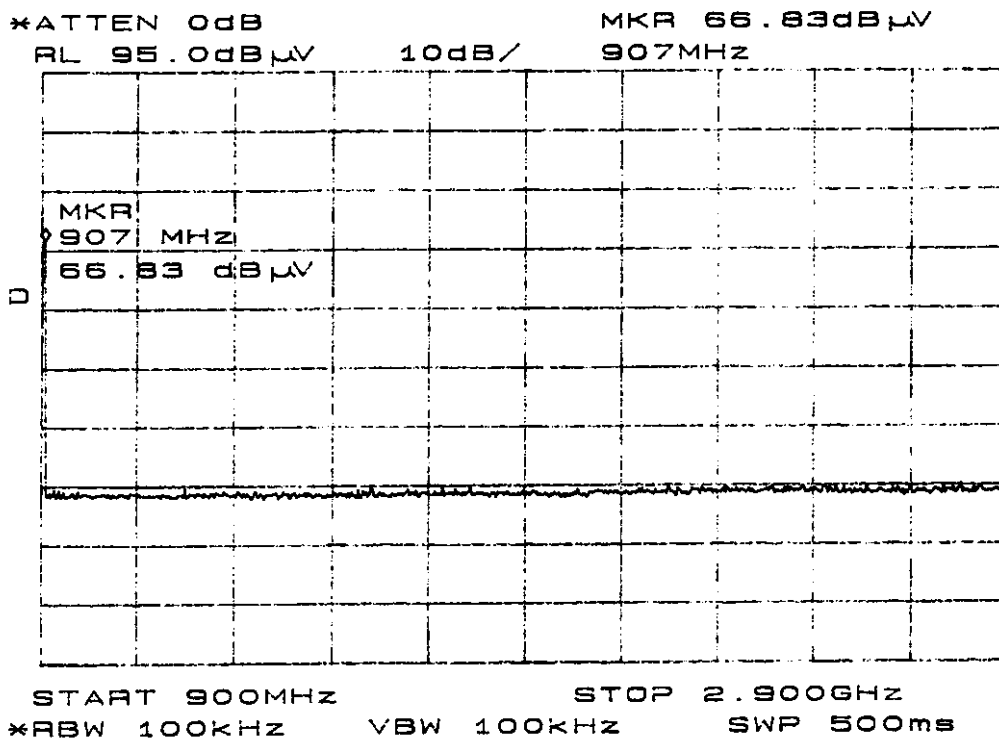


Figure 4 Emissions @ 1 Meter in Screen Room

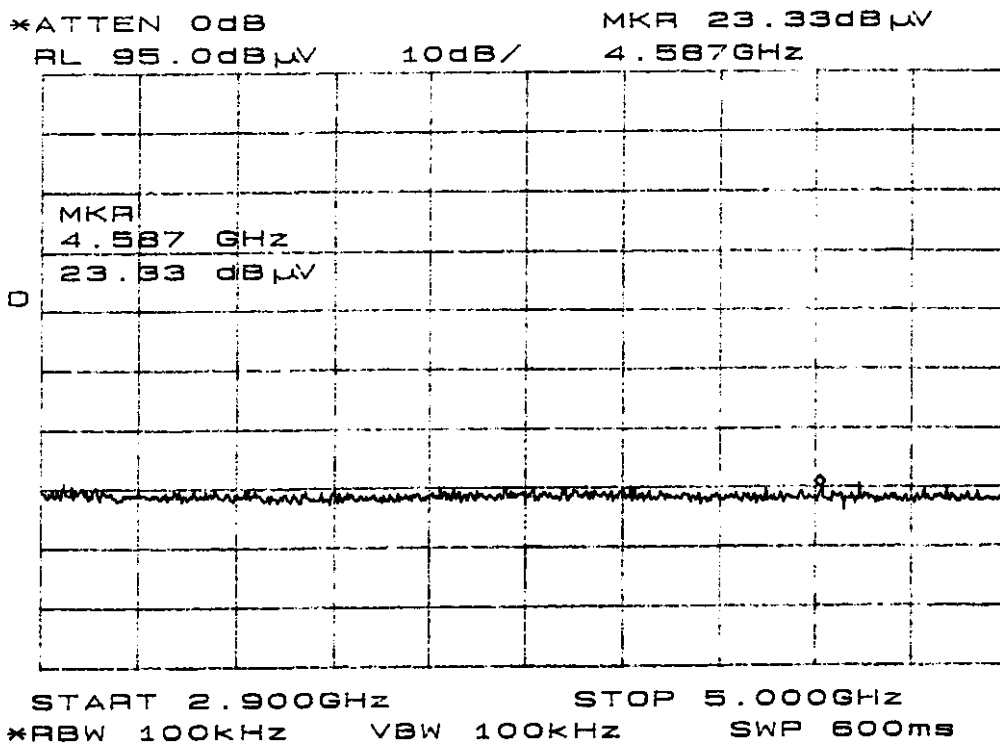


Figure 5 Emissions @ 1 Meter in Screen Room

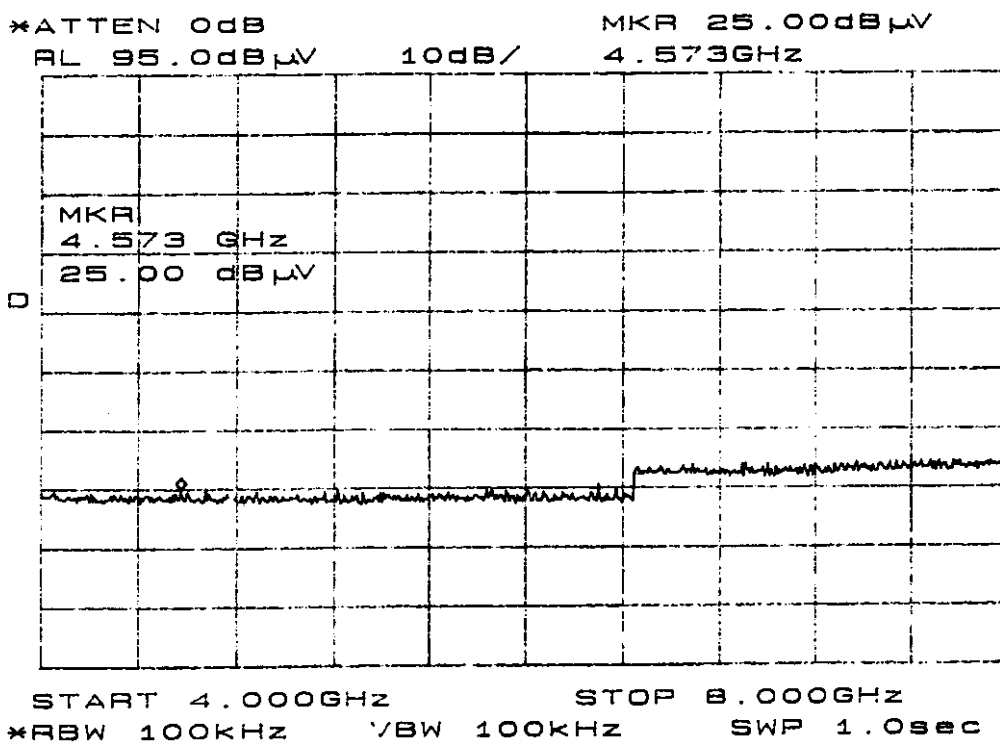


Figure 6 Emissions @ 1 Meter in Screen Room

ROGERS LABS, INC.

4405 W. 259th Terrace

Louisburg, KS 66053

Phone/Fax: (913) 837-3214

GRH ELECTRONICS, INC.

MODEL: VISICOM RADIO-LINK MODULE

Test #: 990602 FCCID#: F6V-2101-0011-A

Test to: FCC Parts 2 and 15c

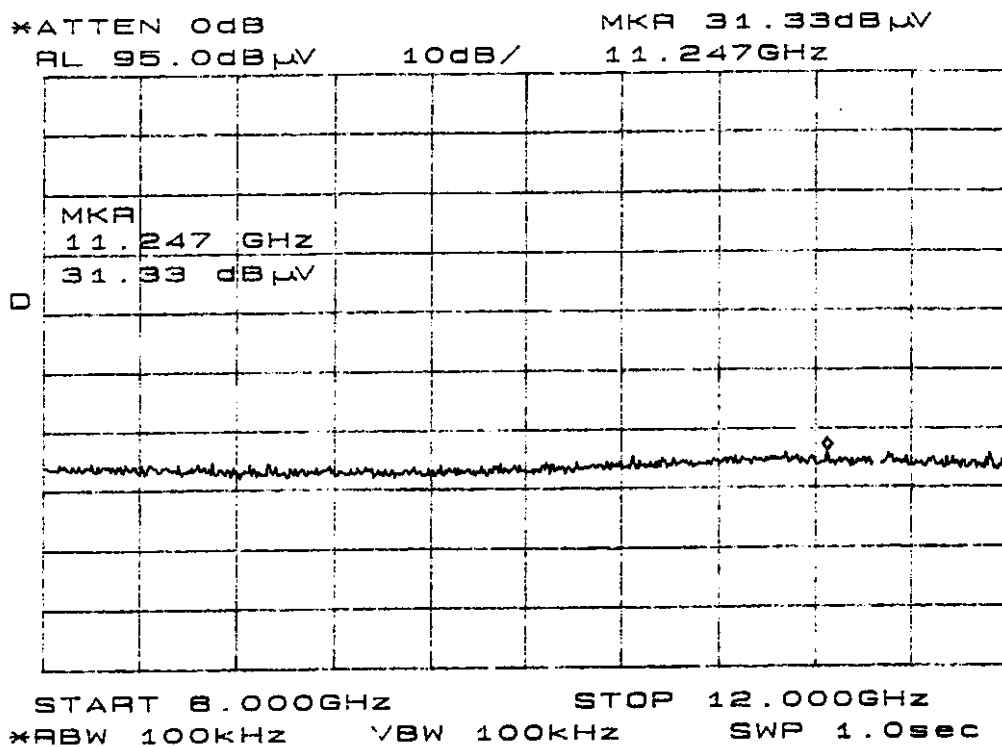


Figure 7 Emissions @ 1 Meter in Screen Room

Radiated Emissions of Intentional Radiator:

The EUT had a 7.1 dB margin below the limits. The radiated emissions for the EUT meet the requirements for FCC Part 15C Intentional Radiators. There are no measurable emissions in the restricted bands other than those recorded in this report. Other emissions were present with amplitudes at least 10 dB below the FCC Limits. The specification of 15.249 are met, there are no deviations or exceptions to the requirements.

Statement of Modifications:

No modifications to the EUT were required for the unit to meet the FCC Part 15B CLASS B emissions standards. There were no deviations to the specifications.

TEST EQUIPMENT LIST FOR ROGERS LABS, INC.

The equipment is used daily and kept in good calibration and operating condition. Calibration of critical items are checked for accuracy each time used.

List of Test Equipment:Calibration Date:

Scope: Tektronix 2230	2/99
Wattmeter: Bird 43 with Load Bird 8085	2/99
Power Supplies: Sorensen SRL 20-25, DCR 150, DCR 140	2/99
H/V Power Supply: Fluke Model: 408B (SN: 573)	2/99
R.F. Generator: Boonton 102F	2/99
R.F. Generator: HP 606A	2/99
R.F. Generator: HP 8614A	2/99
R.F. Generator: HP 8640B	2/99
Spectrum Analyzer: HP 8562A,	2/99
Mixers: 11517A, 11980A & 11980K	
HP Adapters: 11518, 11519, 11520	
Spectrum Analyzer: HP 8591 EM	6/98
Frequency Counter: Weston 1255	2/99
Frequency Counter: Leader LDC 825	2/99
Antenna: EMCO Log Periodic	9/98
Antenna: BCD 235/BNC Antenna Research	9/98
Antenna: EMCO Dipole Set 3121C	2/99
Antenna: C.D. B-100	2/99
Antenna: Solar 9229-1 & 9230-1	2/99
Antenna: EMCO 6509	2/99
Microline Freq. Meter: Model 27B	2/99
Dana Modulation Meter: Model 9008	2/99
Audio Oscillator: H.P. 200CD	2/99
R.F. Power Amp 65W Model: 470-A-1000	9/97
R.F. Power Amp 50W M185- 10-500	9/97
R.F. PreAmp CPPA-102	9/97
Shielded Room 5 M x 3 M x 3.0 M (100 dB Integrity)	
LISN 50 μ Hy/50 ohm/0.1 μ f	9/98
LISN Compliance Eng. 240/20	2/99
SCS Power Amp Model: 2350A	2/99
Power Amp A.R. Model: 10W 1000M7	2/99
Power Amp EIN Model: A300	1/99
Linear Amp Mini Circuits: ZHL-1A (2 Units)	2/99
Combiner Unit Mini Circuits: ZSC-2-1 (2 Units)	2/99
ELGAR Model: 1751	2/99
ELGAR Model: TG 704A-3D	2/99
ELGAR Model: 400SD (PB)	2/99
ESD Test Set 2000i	10/95
Fast Transient Burst Generator Model: EFT/B-100	10/95
Current Probe: Singer CP-105	8/97
Current Probe: Solar 9108-1N	8/97
Field Intensity Meter: EFM-018	10/95

03/01/99

ROGERS LABS, INC.

4405 W. 259th Terrace

Louisburg, KS 66053

Phone/Fax: (913) 837-3214

GRH ELECTRONICS, INC.

MODEL: VISICOM RADIO-LINK MODULE

Test #: 990602 FCCID#: F6V-2101-0011-A

Test to: FCC Parts 2 and 15c

QUALIFICATIONS

Of

SCOT D. ROGERS, ENGINEER**ROGERS LABS, INC.**

Mr. Rogers has approximately 12 years experience in the field of electronics. Six years working in the automated controls industry and 6 years working with the design, development and testing of radio communications and electronic equipment.

POSITIONS HELD:

Systems Engineer:	A/C Controls Mfg. Co., Inc. 6 Years
Electrical Engineer:	Rogers Consulting Labs, Inc. 5 Years
Electrical Engineer:	Rogers Labs, Inc. Current

EDUCATIONAL BACKGROUND:

- 1) Bachelor of Science Degree in Electrical Engineering from Kansas State University.
- 2) Bachelor of Science Degree in Business Administration Kansas State University.
- 3) Several Specialized Training courses and seminars pertaining to Microprocessors and Software programming.

Scot D Rogers
Scot D. Rogers

July 6, 1999
Date

1/11/99

ROGERS LABS, INC.
4405 W. 259th Terrace
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MODEL: VISICOM RADIO-LINK MODULE
Test #: 990602 FCCID#: F6V-2101-0011-A
Test to: FCC Parts 2 and 15c

FEDERAL COMMUNICATIONS COMMISSION

7435 Oakland Mills Road
Columbia, MD 21046
Telephone: 301-725-1585 (ext-218)
Facsimile: 301-344-2050

February 6, 1998

IN REPLY REFER TO
31040/SIT
1300F2

Rogers Labs, Inc.
4405 West 259th Terrace
Louisburg, KS 66053

Attention: Scot D. Rogers

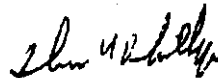
Re: Measurement facility located at above address
(3 and 10 meter site)

Gentlemen:

Your submission of the description of the subject measurement facility has been reviewed and found to be in compliance with the requirements of Section 2.948 of the FCC Rules. The description has, therefore, been placed on file and the name of your organization added to the Commission's list of facilities whose measurement data will be accepted in conjunction with applications for certification or notification under Parts 15 or 18 of the Commission's Rules. Our list will also indicate that the facility complies with the radiated and AC line conducted test site criteria in ANSI C63.4-1992. Please note that this filing must be updated for any changes made to the facility, and at least every three years the data on file must be certified as current.

Per your request, the above mentioned facility has been also added to our list of those who perform these measurement services for the public on a fee basis. This list is updated monthly and is available on the Laboratory's Public Access Link (PAL) at 301-725-1072, and also on the Internet at the FCC Website www.fcc.gov/oet/info/database/testsite/.

Sincerely,



Thomas W. Phillips
Electronics Engineer
Customer Service Branch

ROGERS LABS, INC.
4405 W. 259th Terrace
Louisburg, KS 66053
Phone/Fax: (913) 837-3214

GRH ELECTRONICS, INC.
MODEL: VISICOM RADIO-LINK MODULE
Test #: 990602 FCCID#: F6V-2101-0011-A
Test to: FCC Parts 2 and 15c

EXHIBIT – 1

**ATTACHMENT TO FCC CERTIFICATION
REPORT**

STATEMENT OF INTENDED USE

AND

DESCRIPTION

**MODEL: VISICOM RADIO-LINK MODULE
2101-0011**

Frequency – 916.5 MHz

FCC ID: F6V-2101-0011-A

VisiCom Radio Link

Intended Use and Description

The VisiCom Radio Link is an accessory used to establish a radio-based communication link between VisiCom units in situations that prohibit the use of power line carrier signaling or physical network wiring. In such cases, the RS-485 network interface (VisiCom rear-side RJ-11 jack) is connected to a VisiCom Radio Link Module, allowing the necessary interconnection for communications between VisiCom units via radio waves. The RJ-11 jack is used to transfer data to and from the Radio Link, and to provide the 5 volt power supply required by the radio circuitry.

Radio frequency modulation of the VisiCom signal is provided by an RF Monolithics (RFM) DR1007-LRIP Data Radio Board, which incorporates one (RFM) HX2000 transmitter and one (RFM) RX2020 receiver. This data radio produces a 916.500MHz carrier signal during the transmission of a high level digital signal (mark). The data radio produces a "no carrier transmit" interval during transmission of a low-level digital signal (space).

Radiation is accomplished via a permanently fixed antenna system, which is neither user serviceable nor user changeable.

EXHIBIT – 2

ATTACHMENT TO FCC CERTIFICATION REPORT

TRANSMITTER MODULE DATA

**MODEL: VISICOM RADIO-LINK MODULE
2101-0011**

Frequency – 916.5 MHz

FCC ID: F6V-2101-0011-A

HX2000

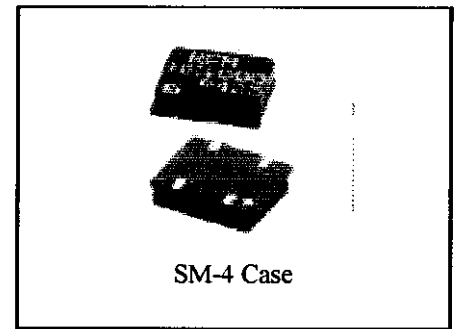
916.5 MHz

Hybrid Transmitter

RFM.

- Ideal for 916.5 MHz Unlicensed Transmitters in the USA and Canada
- Self-Contained RF Functions Shorten Development Time
- Compact, Surface-Mount Case with < 90 mm² Footprint

The HX2000 is a miniature transmitter module that generates on-off keyed (OOK) modulation from an external digital encoder (not included). The carrier frequency is quartz, surface-acoustic-wave (SAW) stabilized, and output harmonics are suppressed by a SAW filter. The result is excellent performance in a simple-to-use, surface-mount device with a low external component count. The HX2000 is designed specifically for unlicensed remote-control, wireless security, and data-link transmitters operating in the USA under FCC Part 15.249 and in Canada under TRS RSS-210.



Electrical Characteristics

Characteristic		Sym	Notes	Minimum	Typical	Maximum	Units
Operating Frequency	Absolute Frequency	f_o	1, 2, 3, 4, 10	916.300		916.700	MHz
	Tolerance from 916.500 MHz	Δf_o				± 200	kHz
RF Output Power into 50 Ω at 25°C		P_O	2, 4, 5, 10	-3	0		dBm
	Within Specified Temperature Range		2, 3, 4, 5	-5	0		
Harmonic Spurious Emissions			2, 3, 4, 5		-40		dBc
Modulation Input	Input HIGH Voltage	V_{IH}	3, 4, 5	2.5		V_{CC}	V
	Input LOW Voltage	V_{IL}		0.0		0.3	
	Input HIGH Current	I_{IH}				100	μA
	Input LOW Current	I_{IL}		0.0			
Data Timing Parameters	Modulation Rise Time	t_R	3, 4, 5, 6		10	20	μs
	Modulation Fall Time	t_F			10	20	
Power Supply	Voltage	V_{CC}	5, 7	2.7	3	3.3	VDC
	Peak Current	I_{CC}	3, 4, 5, 8		9	11	mA
	Standby Current		5, 9			1.0	μA
Operating Case Temperature Range		T_C	5	-40		+85	°C
Lid Symbolization (in addition to Lot and/or Date Codes)		RFM HX2000					



CAUTION: Electrostatic Sensitive Device.
Observe precautions for handling.

NOTES:

- One or more of the following United States patents apply: 4,454,488; 4,616,197; 4,670,681; and 4,760,352.
- Typically, equipment utilizing this device requires emissions testing and government approval, which is the responsibility of the equipment manufacturer.
- Applies over the specified range of operating temperature.
- Applies over the specified range of operating power supply voltage.
- The design, manufacturing process, and specifications of this device are subject to change without notice.
- The maximum modulation bandwidth (and data rate) is dependent on the characteristics of the external encoding circuitry (not included).
- Unless noted otherwise, case temperature $T_C = +25^\circ C \pm 2^\circ C$, test load impedance = 50 Ω , and modulation input is at logic HIGH.

- The maximum operating current occurs at the maximum specified power supply voltage and maximum specified operating temperature.
- Standby current¹ is defined as the supply current consumed with the modulation input at logic LOW.
- Improper antenna loading affects performance of HX device.

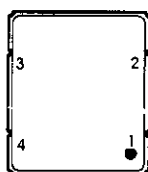
Absolute Maximum Ratings

Rating	Value	Units
Power Supply and/or Modulation Input Voltage	10	V
Nonoperating Case Temperature	-40 to +85	°C
Ten-Second Soldering Temperature	230	°C

The HX Series SMT Hybrid Transmitters

Electrical Connections

Terminal Number	Connections
1	Data Input
2	+DC Supply
3	Ground
4	RF Output to 50 Ω

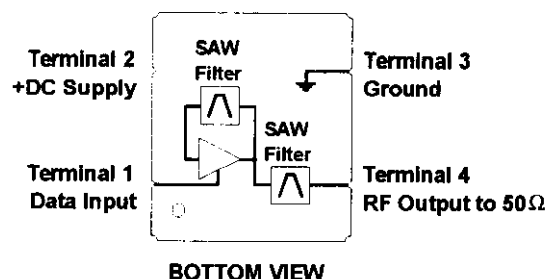


TOP VIEW

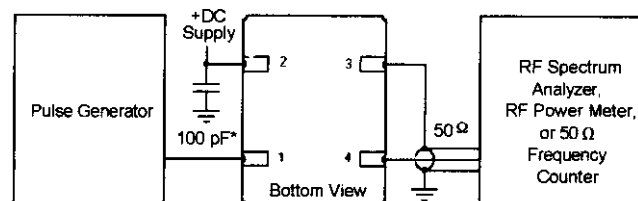
Footprint



Block Diagram

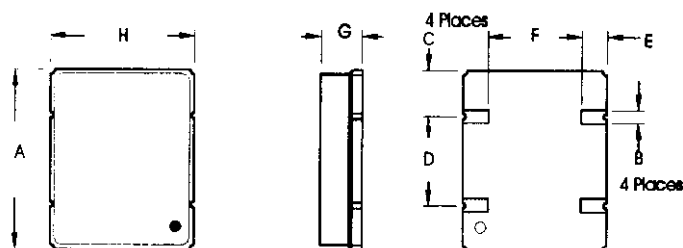


Typical Test Circuit



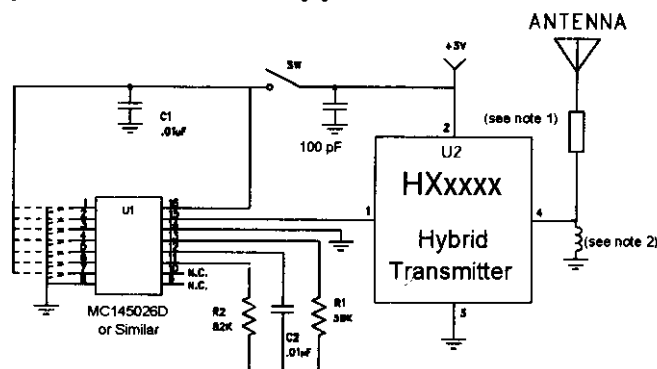
*Note: Bypass required only for "HX2..." series transmitters in the 902 to 928 MHz band.

Case Design



Dimensions	Millimeters		Inches	
	Min	Max	Min	Max
A		11.13		0.438
B	1.27 Nominal		0.050 Nominal	
C	2.67 Nominal		0.105 Nominal	
D	5.08 Nominal		0.200 Nominal	
E	1.70 Nominal		0.067 Nominal	
F	5.36 Nominal		0.211 Nominal	
G		2.03		0.110
H		9.86		0.388

Typical Transmitter Application



Notes:

1. This matching component is required only for antennas that are not 50 ohms. It is typically a chip inductor to match to stub antennas shorter than $\frac{1}{4}$ wavelength. For very low radiated field-strength applications, a resistor can also be used.
2. For ESD protection.

EXHIBIT – 3

ATTACHMENT TO FCC CERTIFICATION REPORT

RECEIVER MODULE DATA

**MODEL: VISICOM RADIO-LINK MODULE
2101-0011**

Frequency – 916.5 MHz

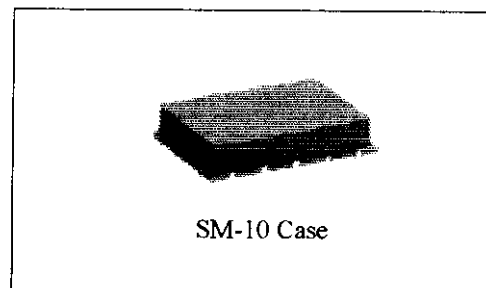
FCC ID: F6V-2101-0011-A

RX2020

916.5 MHz ASH Receiver

RFM

- Ideal for 916.5 MHz, 3 V Data Receivers in Europe
- High-Sensitivity Passive Design with No RF Oscillation
- Use with HX2000 for 19.2 kbps Data Rate
- Simple to Apply with External Parts Count
- Rugged, Surface-Mount Package with 130 mm² Footprint



This amplifier-sequenced hybrid (ASH) receiver is based on several leading-edge technologies that allow outstanding performance in a small and simple-to-apply module. Two surface-acoustic-wave (SAW) devices are employed. Front-end filtering by a low-loss coupled-resonator SAW filter provides excellent selectivity. Typical sensitivity better than -80 dBm is achieved with no RF oscillating or regenerative circuits. This results in virtually no RF spurious emissions. A low-loss SAW delay line provides the time delay necessary to sequence the two RF amplifiers. Time sequencing of the RF gain eliminates the need for frequency conversion prior to AM detection. This receiver is designed to operate from a 3 V lithium battery with typically 2.5 mA current. For system design flexibility, the baseband output is accessible, and the comparator threshold can be changed externally between two settings. Typical applications include unlicensed wireless remote-controls, and digital data links operating in the USA under FCC Part 15.249 and in Canada under DOC RSS-210.

Electrical Characteristics

Characteristic		Sym	Notes	Minimum	Typical	Maximum	Units
Operating Radio Frequency		f _C	2, 3	916.50 Nominal			MHz
Received Carrier Modulation Type			4, 5	Pulse Modulation (OOK)			
RF Band	Sensitivity		6		-72		dBm
	Operating Signal Strength				-10		
	Channel Width			f _C ±200			kHz
	Input Impedance	Z _{IN}		50 Nominal			W
Interference Rejection	Half-Frequency Spurious		7		80		dB
	f _C ± 1 MHz				15		
Sequencing (Sampling)	Sample Duration		8		700		ns
	Sample Repetition Rate				625		kHz
Baseband	Data Rate		9		20		kb/s
	3 dB Bandwidth				24		kHz
Comparator Threshold	Default (Terminal 5 NC)		10		25		mV
	Override (Terminal 5 LOW)				0		
Digital Output	CMOS Load Capacitance		11			10	pF
	Output HIGH Voltage	V _{OH}		V _{CC} -0.2		V _{CC}	V
	Output LOW Voltage	V _{OL}		0.0		0.2	
	Rise Time	t _R			3		μs
	Fall Time	t _F			3		
Power Supply	Operating Voltage	V _{CC}	1	2.7	3.0	3.5	VDC
	Current at 25C and 3.0 V	I _{CC}			2.5	3.0	mA
Operating Ambient Temperature		T _A	1	-40		+85	°C
Lid Symbolization (in addition to Lot and/or Date Codes)		RFM RX2020					

The RX Series SMT Hybrid ASH Receivers



CAUTION: Electrostatic Sensitive Device. Observe precautions for handling.

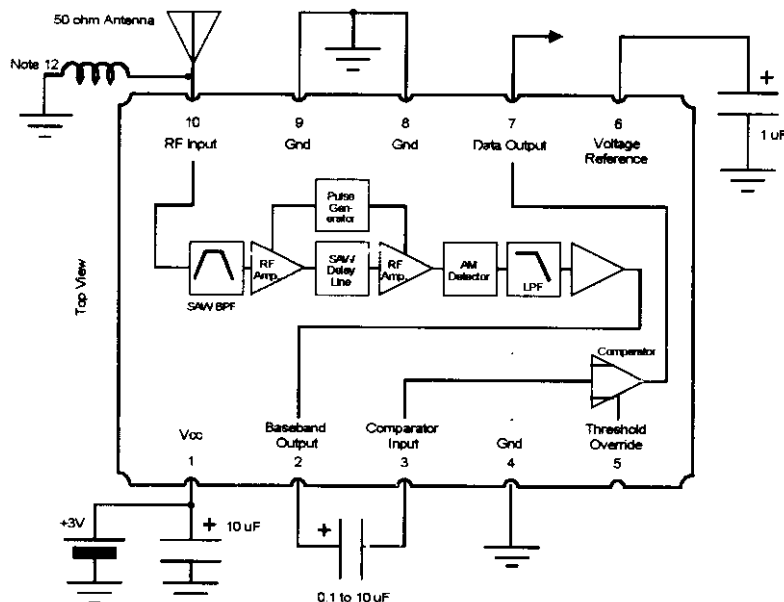
Notes:

1. Unless noted otherwise, specifications apply over the entire specified operating temperature and voltage ranges.
2. One or more of the following United States patents apply: 4,454,488; 4,616,197; 4,749,964; 4,902,925. Other patents are pending.
3. Typically, equipment utilizing this device requires emissions testing and government approval, which is the responsibility of the equipment manufacturer.
4. The design, manufacturing process, and specifications of this device are subject to change without notice.
5. A variety of on-off-keyed (OOK) pulse modulation schemes are possible since digital decoding is an external function (not included in the ASH receiver).
6. These parameters apply over the absolute minimum operating passband which is referenced to f_c .
7. With interfering signal matched to the receiver modulation and code. See "Typical Modulated Interference Rejection" for a more detailed view.
8. Sample repetition rates greater than 1 MHz are available in custom versions. Contact RFM for details.
9. Baseband bandwidths and data rates are available to 140 kHz and 56 kHz, respectively, in custom versions. Contact RFM for details.
10. The default comparator threshold (with terminal 5 not connected) is optimized for low duty-cycle, or "bursty" data and eliminates noise output when there is no RF signal. The override threshold (with terminal 5 connected to ground) is optimized for continuous data.
11. The ASH receiver is designed to drive a single CMOS load
12. For ESD protection..

Absolute Maximum Ratings

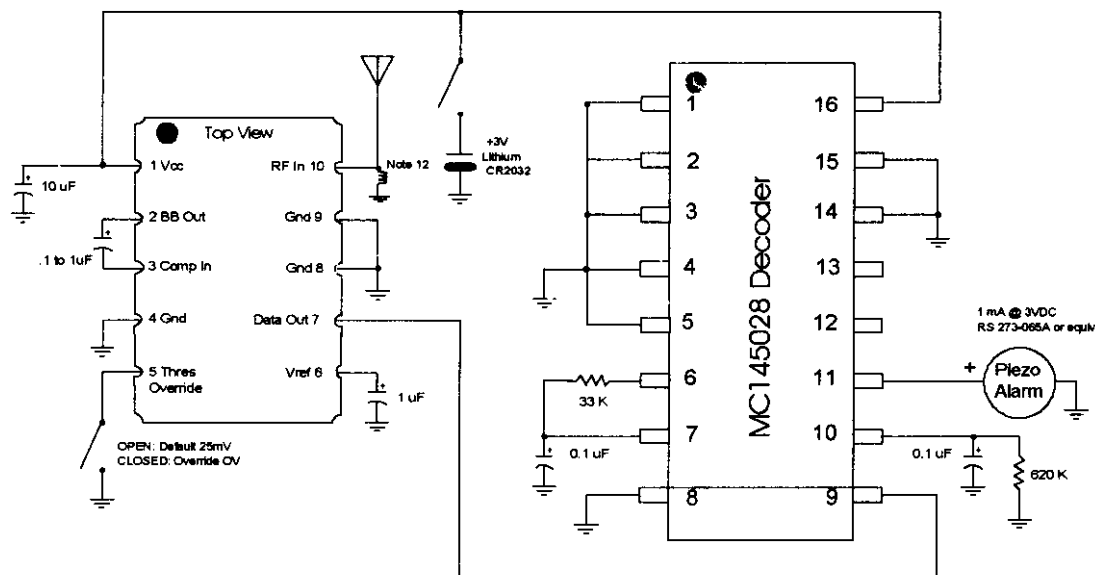
Rating	Value	Units
Incident RF Power	+10	dBm
Power Supply Voltage (V_{CC} to Ground)(Observe ESD Precautions)	-0.3 to +4.0	VDC
ESD (100 pF, 1.5 kW)	Terminals 2, 3, or 7 to Ground	± 2000
	All Other Terminals to Ground	± 300
Case Temperature ¹	-40 to +100	°C

Block Diagram and Electrical Connections



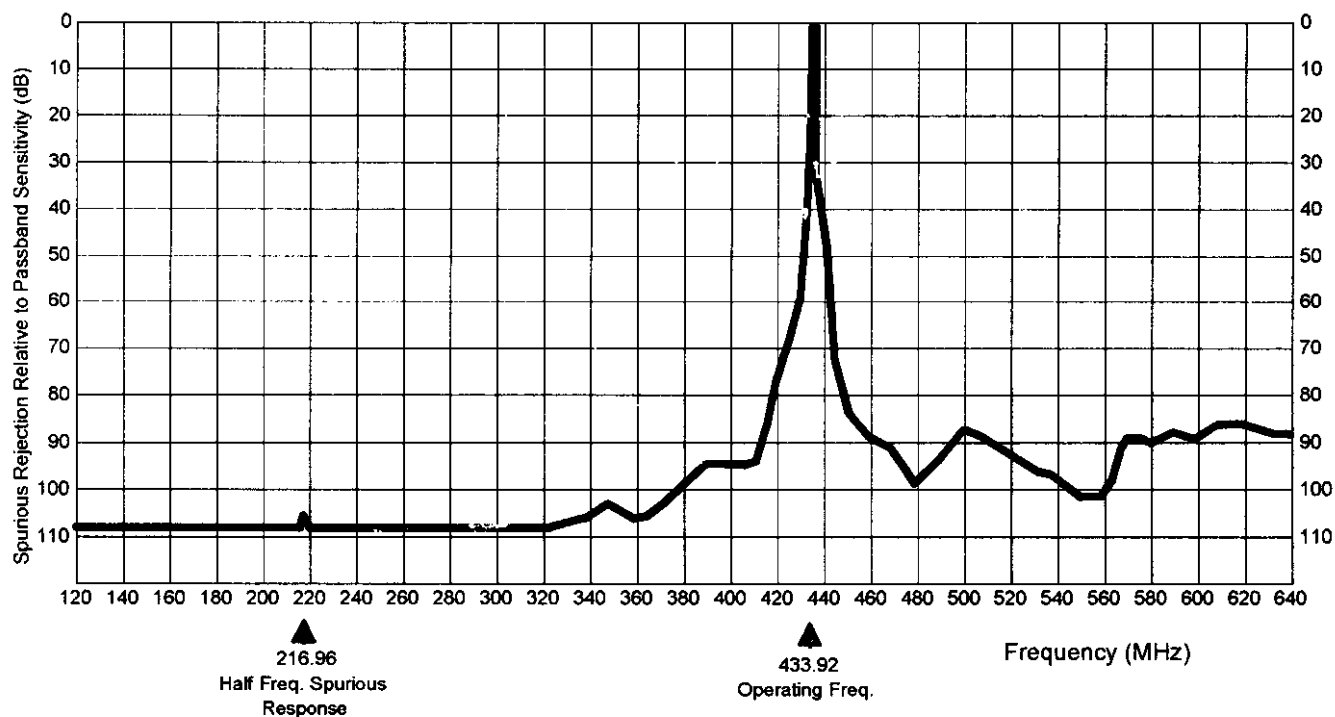
The RX Series SMT Hybrid ASH Receivers

Demonstration Circuit



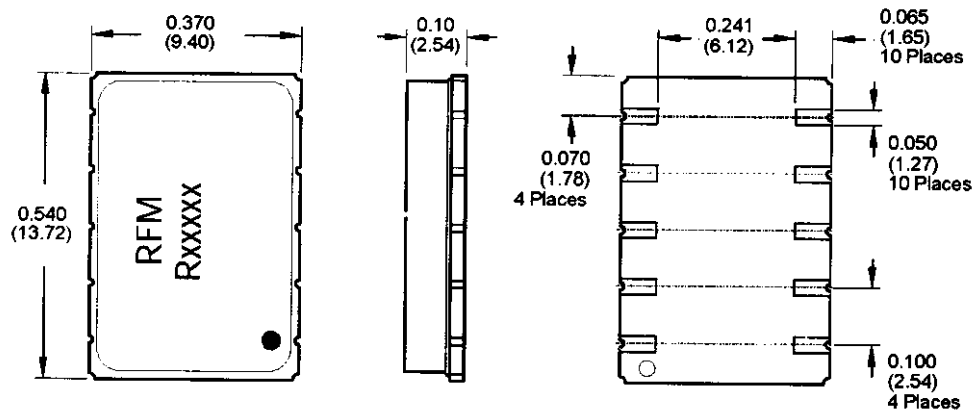
Typical Modulated Interference Rejection (433.92 MHz RX1000 Shown)

This plot is for an interfacing signal modulated with the receiver's modulation and code. Continuous wave (CW) or signals with other modulation or codes typically result in significantly better rejection performance.

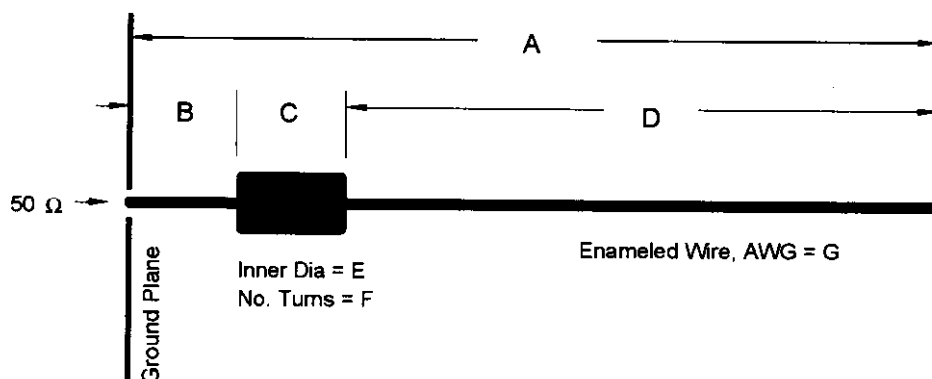


The RX Series SMT Hybrid ASH Receivers

Case Design



Typical Antennas



Dimensions	Units	Frequency			
		303.825	418.0	433.92	916.5
A	Inches	5.35	3.9	3.55	1.58
	Millimeters	135.89	99.06	90.17	40.13
B	Inches	1.0	0.6	0.6	0.4
	Millimeters	25.4	15.24	15.24	10.16
C	Inches	0.25	0.6	0.55	0.18
	Millimeters	6.35	15.24	13.97	4.57
D	Inches	3.7	2.7	2.4	1.0
	Millimeters	93.98	68.58	60.96	25.4
E	Inches	0.375	0.1	0.1	0.1
	Millimeters	9.53	2.54	2.54	2.54
F	Number of Turns	4T	16T	15T	7T
G	AWG	#20	#22	#22	#24

EXHIBIT – 4

ATTACHMENT TO FCC CERTIFICATION REPORT

DATA RADIO - THEORY OF OPERATION, SCHEMATIC, BILL OF MATERIALS AND ARTWORK

**MODEL: VISICOM RADIO-LINK MODULE
2101-0011**

Frequency – 916.5 MHz

FCC ID: F6V-2101-0011-A

5 Theory of Operation

5.1 Data Radio Boards

I/O Interface- Referring to the Data Radio Board schematic diagram, connector P1 is the interface connector to the protocol board. Pin 1 is the transmitter data input and can be

driven directly by a CMOS gate. The transmitter is on-off key (OOK) modulated by a signal on this line changing from 0 to 3 volts. A high level turns the transmitter oscillator on and a low level turns it off. The input impedance to this line is approximately 18K ohms. Pin 2 is the Vcc line for the transmitter. Vcc can be applied to this line on a continuous basis without a current penalty, since the transmitter does not draw current until the data input line is pulled high.

Pin 3 is the PTT line that enables the transmit mode. This line puts the transmit/receive RF switch in the transmit mode when it is high (2.5 volts minimum at 2.0 mA maximum). Pin 4 provides power to the receiver AGC circuitry, 2.7 to 3.3 volts. Pin 5 is ground. Pin 6 is a reference voltage output (VRef) from the hybrid receiver that is used in the "low battery" detection process on the protocol board. Pin 7 provides power to the receiver hybrid, 2.7 to 3.3 volts. Pin 8 is the data output from the comparator in the receiver hybrid. This data output is CMOS compatible and is capable of driving a single CMOS gate or a bipolar transistor with a 51 K base resistor. The last connection to the data radio board is the 50 ohm antenna input (see Appendix A for antenna pad location). The antenna can either be connected directly to the board or connected remotely by using a 50 ohm coaxial cable.

Transmitter- Referring to the Data Radio Board schematic diagram, the RF transmitter is an HX surface mount hybrid. Pin 1 of the HX device is the transmitter data input previously discussed as connected directly to Pin 1 of connector P1. Pin 2 is the transmitter Vcc (power) connection. HX hybrids draw a maximum peak current of 10 mA with a Vcc of 3 volts. Since the transmitter is only turned on when the data line is high, the average transmitter current depends on the duty cycle of the incoming data. Pin 3 of the HX device is ground and Pin 4 is the RF output. The RF output power of the HX is nominally 0 dBm with a 50 ohm load. The transmitter power is applied to the antenna port through the transmit/receive switch, Q1. When the PTT line is pulled high, Q1 is turned on to connect the transmitter to the antenna.

Receiver- The receiver is an RX2020 amplifier-sequenced hybrid (ASH) receiver. The architecture, theory and operational characteristics of this receiver are included in the application note, "New UHF Receiver Architecture Achieves High Sensitivity and Very Low Power Consumption". Vcc is applied to Pin 1 of the receiver from Pin 7 of connector P1. A 10 uF bypass capacitor, C8, and a 27 pF RF bypass capacitor, C14, are also connected to this pin. C8 is necessary to keep the RX internal comparator switching noise out of the base-band amplifier circuitry in the RX.

Pin 2 is the base-band output. The signal at Pin 2 is the detected, filtered signal before it is applied to the comparator input. The Pin 2 output is dc-coupled to the internal detector output. The output from Pin 2 is connected to the comparator input, Pin 3, by the coupling capacitor, C7, and is also RF bypassed by C3. The value of the coupling capacitor, C7, is determined by the longest pulse width to be encountered in the data stream. The capacitor must be large enough to prevent long data pulses from "sagging" at the comparator input. Capacitive coupling is used for two reasons. The first reason is to prevent the dc offset voltage on the base-band amplifier output from false triggering the comparator. The second reason is to prevent the output from the detector, produced by an in-band CW or FM interfering signal, from triggering the comparator, while allowing changes in dc level, due to a desired signal, to pass through to the comparator input. Note that a resistor, R8, is connected between the comparator input and ground on the 916.5 MHz boards. This will be explained in conjunction with the discussion on Pin 5.

Pin 4 is a dc ground. Pin 5 is the comparator threshold override pin. If this pin is left open, the threshold voltage for the comparator is 25 mV. If it is grounded, the threshold voltage is zero volts. The internal 25 mV threshold level is very desirable for use in the 300 - 450 MHz range due to the higher RX sensitivity and higher average RF noise in this band. However, a lower voltage threshold is required for RX receivers at 916.5 MHz to obtain best performance. Thus, Pin 5 is grounded for 916.5 MHz receivers and left open for the lower frequency receivers. Spurious noise on the comparator output of an RX receiver at 916.5 MHz is minimized by using a resistor, R8, from Pin 3 to ground. This resistor

effectively reduces the dc offset on the comparator input which is equivalent to using a very low threshold level. Pin 6 is the reference voltage output of the power supply included in the custom IC used in the RX. This pin must be bypassed by a 1 uF capacitor, C11, to avoid comparator switching noise in the base-band amplifier. Pin 6 is also RF bypassed by C16. Pin 7 is the comparator output or data output. The comparator is capable of driving a single CMOS gate input. Pins 8 and 9 are primarily RF grounds. Pin 10 is the RF input port of the RX device. This port is to be driven from a 50 ohm source.

Preamp/AGC/Antenna Switch- The out-of-band interfering signal rejection of the RX amplifier-sequenced receiver architecture is excellent and allows the receiver to perform in the presence of large interfering signals without range degradation. However, there are some applications that will encounter in-band interference. The majority of in-band interference encountered is CW and primarily comes from unintentional radiators such as clock harmonics from computers or local oscillators from superheterodyne receivers. The AGC circuit discussed here is primarily intended for CW or FM in-band interfering signals. These are of particular concern in an office environment.

The RX receiver, as discussed in the previous section, has capacitive coupling between the base-band amplifier output and the comparator input. Thus, a dc level generated in the detector and base-band amplifier by either an FM or a CW signal is blocked from the comparator input, and only OOK (AM) signals pass. The limiting factor for in-band interference rejection is the dc level at which the detector and its associated base-band amplifier saturate. The RX2020 used on the DR1007 saturates at a level of approximately -50 dBm. The Preamp/AGC circuit used on the DR1007 provides about 15 dB of gain in quiet conditions for improved operating range while providing 30 dB of AGC range to minimize saturation of the receiver by in-band interfering signals.

Referring to the schematic diagram for the data radio board, an RF amplifier, U1, is placed between the antenna and the receiver input. Transistors Q2 and Q3 serve as the gain control for U1, providing a total AGC range of approximately 30 dB and an "on"

insertion gain of 15 dB. This effectively extends the range over which the receiver can operate without saturation by 15 dB.

The reference voltage for the AGC circuit is derived from the VRef Pin 6 of the RX. This reference voltage is very constant from one receiver IC to another. The signal level dependent input to the AGC circuit is derived from the base-band output of the receiver which is dc-coupled to the internal RF detector. The dc offset of the base-band output, with no signal applied to the receiver, can vary 25 or 30 mV from one receiver IC to another. This makes it necessary to include a potentiometer, R14, in the circuit to adjust the engage point for the AGC. The VRef voltage and the base-band signal are both applied to the inverting and non-inverting inputs, respectively, of the operational amplifier, U2A. The data is filtered out of the base-band signal using C13. R15 sets the dc gain of the amplifier and C10, in conjunction with C13, set the time constant or corner frequency of the AGC circuit.

The time constant of the AGC circuit was chosen to be long enough to avoid a response to the individual data bits of the desired signal. U2A drives the inverting input of U2B. The output of U2B is applied to the base of Q2, which in turns drives the base of Q3. Thus, as an interfering signal level increases, transistor Q3 and preamp U1 gradually turn off. The PTT line presents 50 kohms to ground in the receive mode, so it does not affect the AGC voltage applied to Q2 by U2B.

In the transmit mode, the PTT line is pulled high, overriding the AGC circuit by biasing the base of Q2 off through U2B. Q3 and U1 are thus turned off, isolating the RX2020 from the antenna port. The high voltage on the PTT line also turns Q1 on, connecting the HX2000 output to the antenna port.

DR1007 Data Radio Board Specifications

Operating Frequency	916.5 MHz
Modulation	On-Off Keyed (OOK)
Antenna	50 ohm
Maximum Data Rate	11.5 kbps (87 μ sec min. pulse width @ TX input)
TX Frequency Tolerance	less than ± 200 kHz, including set-on, temperature and aging drift (5 year)
TX Output Power	-5 dBm minimum
TX Harmonics	less than -32 dBc
Receiver Performance	BER less than $10E-4$ for a -90 dBm input (11.5 kbps, RFM dc-balanced encoding used)
RX Pulse Distortion	less than $\pm 35\%$ for a 87 μ sec TX pulse
RX Dynamic Range	-90 to -10 dBm
Data DC Balance	receiver performance shall be maintained for data with an average "1" density from 40 to 60%
Data Run Length	receiver performance shall be maintained for "1" or "0" run lengths of at least 8 bits

RX Off-Channel Rejection

greater than 60 dB, 0.25 to 890 MHz and
945 to 2500 MHz

RX On-Channel Rejection

less than 30% BER degradation for a CW interfering
signal at least 15 dB below the desired signal after 16
bits (50% duty cycle) of the desired signal received,
interfering signal -65 dBm or less

RX No-Signal Output

less than one noise "spike" average in any 10 ms
interval under "white thermal noise" reception
conditions

Transceiver Mode Change

1 ms

RX to TX

5 ms

TX to RX

2.7 to 3.5 Vdc, 10 mV max peak-to-peak ripple

DC Power Supply

less than 11.5 mA ave @ 3 Vdc supply

Supply Current, RX Mode

less than 20 mA peak @ 3 Vdc supply

Supply Current, TX Mode

3 V CMOS logic level for serial TX input; serial RX
output capable of driving one 3 V CMOS gate

I/O Data Interface

low for RX, high for TX (source 2 mA @ 2.5 V min.)

TX/RX Control Input

Operating Temperature Range -40 to +85 deg C