Engineering Report

in Support of Certification FCC Form 731
for Integra-TR DL3422 radiomodem

Subject:	Compliance of Radio Modem with Respect to FCC Rules & Regulations Parts 2 and 90 Certification FCC Form 731
Equipment:	VHF Radio Modem
FCC Id:	NP4MCUA5Q
Applicant:	Dataradio COR Ltd. 299 Johnson Ave. PO Box 1733 Waseca, MN 56093-0833

June 4, 2001
Dataradio Inc

Dataradio COR Ltd.
Waseca, Minnesota

ENGINEERING STATEMENT OF CHRIS LUDEWIG

The application consisting of the attached engineering exhibit and associated FCC form 731, has been prepared in support of certification for the Dataradio COR Ltd. (DRL) DL-3422, 132-174 MHz Transceiver with the Dataradio 3315 (Integra) Modem. The Transceiver mated with the Integra Modem will be identified by the part number 242-4018-XY0 where X represents range and Y represents IF bandwidth (see below for part#). The model name is INTEGRA-TR DL3422. The Transceiver/Modem will be identified by the FCC number NP4MCUA5Q. The transceiver operates pursuant to Part(s) 90 and 15 of the Rules and Regulations.

EXISTING CONDITIONS

The units utilized for these certification measurements were obtained from the pilot-production. The transceiver is designed to operate on frequencies ranging from 131.640 MHz to 174.000 MHz. The frequency tolerance of the transceiver is .0001% or 1 part per million. The frequency stability of the transceiver is controlled by a temperature compensated crystal oscillator (TCXO) operating at 14.85 MHz for Range 4 and 17.5 MHz for range 6 and 7. Range 4 operates in the frequency range 132-150 MHz. Range 6 operates in the frequency range 150-174 MHz. Range 7 operates in the frequency range 138-163 MHz.

PROPOSED CONDITIONS

It is proposed to Type Accept the INTEGRA-TR DL3422, 132-174 MHz Transceiver/Modem, for operation in the band of frequencies previously outlined. The applicant anticipates marketing the device for use in wireless transmission of data.

PERFORMANCE MEASUREMENTS

All certification measurements were conducted in accordance with the Rules and Regulations Section 2.1041of Pike & Fischer Inc., CD ROM revision 9/28/98. Equipment performance measurements were made in the engineering laboratory and on the FCC certified Open Area Test Site at the Transcrypt International / E.F. Johnson Radio Products located at 299 Johnson Avenue in Waseca, Minnesota. All measurements were made and recorded by myself or under my direction. The performance measurements were made between Apr 27, 2001 and May 30,2001.

CONCLUSION

Given the results of the measurements contained herein, the applicant requests that certification be granted for the INTEGRA-TR DL3422, 132-174 MHz Transceiver/Modem as tested for data communications. We further request that the Certification be issued for both mobile MO operation and for fixed FX operation since the equipment meets the requirements for both.

______________________6/4/01

Christopher J. Ludewig
Director of Engineering, Dataradio Ltd.

Part Number

X	Freq Range
4	132-150 MHz
6	150-174 MHz
7	138-163 MHz

Y	IF Bandwidth
0	6.25 kHz

QUALIFICATIONS OF ENGINEERING PERSONNEL (2.911)

NAME:	Larry M. Dickinson
TITLE:	Senior Engineer
TECHNICAL EDUCATION:	Associate of Science Degree in Electrical Engineering Technology (1989) from Community College of the Air Force. Bachelor of Science Degree in Electrical Engineering (1994) from University of Illinois.
TECHNICAL EXPERIENCE:	15 years experience in analog and radio frequency communications

NAME:	Allen Frederick
TITLE:	Electrical Engineer II
TECHNICAL EDUCATION:	Bachelor of Science Degree in Electronic Engineering Technology (1998) from Mankato State University
TECHNICAL EXPERIENCE:	3 years experience in analog and radio frequency communications

NAME:	Matthew Schellin
TITLE:	Electrical Engineer I
TECHNICAL EDUCATION:	Bachelor of Science Degree in Electrical Engineering (2000) from Mankato State University
TECHNICAL EXPERIENCE:	1 year experience in analog and radio frequency communications

Contents

Engineering Summary

This report contains the results of the engineering evaluation performed on a Dataradio Inc. radio modem, having a frequency range of 132-174 MHz, model Integra-TR DL3422. Dataradio COR Ltd. (DRL) carried out the tests in accordance with FCC Rules and Regulation Part 2 and Part 90.

The radio modem was evaluated for output power levels of 1 and 5 watts.

Based on test results, it is certified that the product meets the requirements as set forth in the above specifications for Certification.

The Integra-TR DL3422 VHF radio modem is comprised of a Dataradio 3315 loader/modem board and a DL 3422 Telemetry transceiver. Test data and graphs for this configuration are presented in this report.

General Information

FCC submission information

FCC Id:	EOTMCUA5Q
Equipment:	VHF radio modem
Model:	INTEGRA-TR DL3422
Applicant:	Dataradio COR, Ltd. (DRL) 299 Johnson Ave. PO Box 1733 Waseca, MN 56093-0833
Manufacturer:	Dataradio Incorporated 5500 Royal Mount Ave., Suite 200 Town of Mount Royal, H4P 1H7 Quebec, Canada
Test laboratory:	Dataradio COR, Ltd. (DRL) 299 Johnson Ave. PO Box 1733 Waseca, MN 56093-0833

Manufacturer's data

Equipment:	VHF radio modem
Model:	Integra-TR DL3422
Serial Number:	00001 (prototype serial)
Reference:	FCC Rules and Regulations Part 2 and Part 90
Manufacturer:	Dataradio Incorporated

Product's general specifications

1	Frequency range:	132-174 MHz	
2	Ratted transmitted output power:	1 - 5W	
3	Data modulation:	DRCMSK	
4	Channel spacing:	6.25 kHz	6.25 kHz
5	Emission type:	3K42 F1D	3K75 F1D
6	Frequency deviation:	± 1.05 kHz	± 1.64 kHz
7	Data rate:	4800 bps	2400 bps
8	Antenna impedance:	50 Ω	
9	Power source:	13.3 V	

Information for Certification

Ref: FCC Part 2 paragraph 2.1033 (c)

1. Name of Applicant:

Ref: FCC Part 2 paragraph 2.1033 (c)(1)

Applicant:	Dataradio COR Ltd. 299 Johnson Ave. PO Box 1733 Waseca, MN 56093-0833
Manufacturer	Dataradio Incorporated 5500 Royal Mount Ave., Suite 200 Town of Mount Royal, H4P 1H7 Quebec, Canada

2. FCC Identifier

Ref: FCC Part 2 paragraph 2.1033 (c)(2)

Model No.:	Integra-TR DL3422 (DRL 242-4018-xx0), comprised of two boards: MCU 3315 (Dataradio 210-03315-0xx)- modem board DL 3422 (DRL 242-3422-xx0)- transceiver board
Serial No.:	00001 (prototype serial) xxx-3315-0xx-modem board 3422- xxxxxx-xx0-transceiver board
FCC Id:	EOTMCUA5Q

3. Instruction book

Ref: FCC Part 2 paragraph 2.1033 (c) (3)

See technical manual in Integra-TR Technical Manual, Attachment E,

.4 Types of emission

Ref: FCC Part 2 paragraph 2.1033(c)(4)

Channel spacing	6.25 kHz	6.25 kHz
Emission type	3K42 F1D	3K75 F1D
Frequency deviation	± 1.05 KHz	± 1.64 kHz

5. Frequency range

Ref: FCC Part 2 paragraph 2.1033(c)(5)

132-174 MHz

6. Range of operating power levels

Ref: FCC Part 2 paragraph 2.1033(c)(6)

The power is adjusted at the manufacturer at a level of 5W.

7. Maximum Power rating

Ref: FCC Part 2 paragraph 2.1033(c)(7)

5 Watts

8. DC voltages and currents into final amplifier

Ref: FCC Part 2 paragraph 2.1033(c)(8)

Refer also to RF output and DC input power measurement in section “Test Results”.

9. Tune-up procedure

Ref: FCC Part 2 paragraph 2. 1033(c)(9)

1. Connect the transceiver to be aligned to a DC power source. A DC current meter capable of measuring at least 2.5 Amps should be connect in line with the DC source. Connect the output of the transceiver through a watt meter and into a 50 ohm dummy load.

2. Load the synthesizer with the center channel frequency.

3. Key the transmitter and make certain that the supply voltage at the RF board is 13.3 VDC. (Do not transmit for extended periods of time.)

4. Adjust R535 clockwise for 5.0 Watts of output power.

5. Check the power levels on the low and the high frequencies for 5.0 Watts +/- 1 Watt.

10. Complete circuit diagram, circuitry and devices for determining and stabilizing frequency, circuits for suppression of spurious radiation, limiting of modulation and limiting of power

Ref: FCC Part 2 paragraph 2. 1033(c)(10)

For the main control circuits and the modem circuits see the section Dataradio MCU modem, in Description of Circuitry, Attachment A part 1.

For the transceiver circuits see the section DRL DL-3422 Telemetry Transceiver, in Description of Circuitry, Attachment A part 2.

Circuitry’s mainly involved in determining and stabilizing frequency are VCO block and Synthesizer block described in Transceiver’s part.

i) spurious radiation- The main suppression of spurious radiation is performed by the filter described in “Low Pass Filter” paragraph from DRL DL-3422 Telemetry Transceiver, Description of Circuitry part 2, Attachment A

ii) limiting of modulation- Limiting of modulation is given by amplitude limited audio signal provided by modem part as it was explained in “Modem” paragraph from Dataradio MCU modem, Description of Circuitry part 1, Attachment A. Supplementary limiting of modulation is described in “ Frequency Modulation” paragraph from Synthesizer section DRL DL-3422 Telemetry Transceiver, Description of Circuitry part 2, Attachment A.

iii) limiting of power- A very tight control of transmission power is maintained by circuitry described in “Power Control” paragraph from DRL DL-3422 Telemetry Transceiver, Description of Circuitry part 2, Attachment A

See schematics in Schematics, Attachment B

11. Equipment identification plate/label

Ref: FCC Part 2 paragraph 2.1033(c)(11)

A scanned image of the Equipment identification label is provided in Photographs, Attachment C

12.Photographs of the equipment

Ref: FCC Part 2 paragraph 2.1033 (c)(12)

All scanned photographs of the Equipment are provided in Photographs, Attachment C

13. Digital modulation techniques

Ref: FCC Part 2 paragraph 2.1033 (c) (13)

The digital modulation used by the MCU modem is DRCMSK (Differential Raised Cosine Minimum Shift Keying). A modem using such type of modulation is divided in three main units. They are:

1. Scrambler,
2. Differential encoder,
3. Waveshape generator.

We will explain each of those units, starting with the scrambler.

1. Scrambler:

The scrambler converts data stream to a new data stream having better characteristics for a FM radio system. Here are the main advantages:

-It removes the DC component from a DRCFSK signal,

-It randomizes the data in such a way we can avoid predictable patterns, by example:

00000000, 111111111, 01010101, 00110011, etc.

-It keeps the power spectrum more compact by avoiding sequences like 01010101…

All these functions are performed with a serial shift register and 2 exclusive OR gates that implement the polynomial form X^7+X^5-1. The receiver side of our radio modems has a similar circuit called descrambler to decode the received scrambled data.

2. Differential encoder:

After data is scrambled, we encode the data with a differential encoder. Here is the process that differential encoder does:

Previous input bit	current input bit	output bit
0	0	0
0	1	1
1	0	1
1	1	0

Example:

From a sequence of 0100101111010001010100010, differentially encoded data stream is:

1101110001110011111110011.

The differential encoder is used to make the modem insensitive to audio polarity inversion of the FM radio system.

3. Waveshape generator:

The waveshape generator converts the processed data bits (scrambled and differentially encoded for DRCMSK) to the audio signal that will modulate a FM transmitter. This gives the DRCMSK waveshape having a compact spectrum to fit inside FCC Part 90 masks according to the channel bandwidth intended.

Furthermore, the modem itself generates a RF signal heading the transmission in normal usage and a test pattern for test purposes.

1. Transmission preamble:

Each data transmission begins by sending a 15ms preamble of sinewave (101010…). This is to synchronize the digital phase looked loop of the receiver modem**.**

2. Test pattern generator:

A test pattern sequence is generated by test software at “test data” click button event. According to the baud rate, the highest resulting modulating frequency is (baud rate)/2 Hz. The sequence is sent with baud rate speed, and its data has the pattern:

###ABCDEFGHIJKLMNOPQRSTUVWXYZabcdefghijklmnopqrstuvwxyz0123456789\r\n,

repeated.

14. Test data

Ref: FCC Part 2 paragraph 2.1033 (c)(14)

All applicable test data according to:
-Part 2: 2.1046, 2.1047, 2.1049, 2.1051, 2.1053, and 2.1057
-Part 90, Subpart I: 90.209, 90.210, 90.211, 90.213 and 90.214
are provided in section Test Results of this Engineering Report

15. Other data

For data according to 2.1033(c)(15,16), this unit is not designed for the mentioned purposes.

Tests Results for Integra-TR DL3422 radio modem

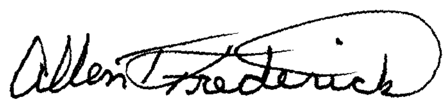
NAME OF TEST: Transmitter Rated Power Output

RULE PART NUMBER: 2.1033 (c)(6)(7) and 2.1046 (a)

TEST RESULTS: See results below

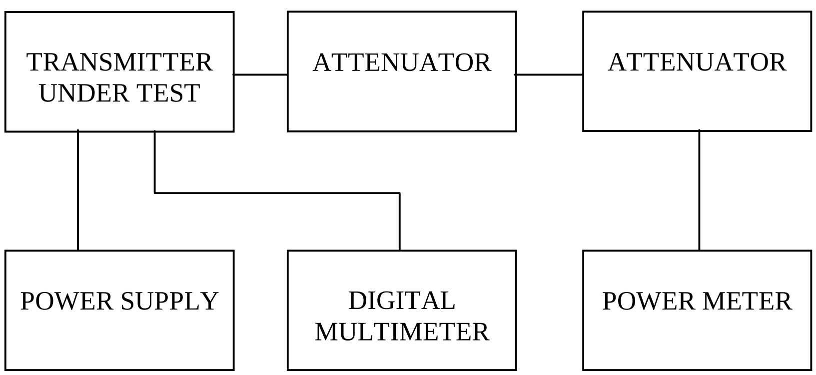
TEST CONDITIONS: Standard Test Conditions, 25 °C

TEST EQUIPMENT: Attenuator, BIRD Model / 9715 / 50-A-MFN-06 / 6 dB / 50 Watt
Attenuator, BIRD Model / 9716 / 25-A-MFN-20 / 20 dB / 25 Watt
Digital Voltmeter, Fluke Model 8012A
DC Power Source, Model HP6284A
Power Meter, Hewlett Packard 436A



PERFORMED BY: ______________________ DATE: 4/27/01
Allen Frederick

TEST SET-UP:



TEST RESULTS:

Frequency (MHz)	**DC Voltage at Final (VDC)**	**DC Current into Final (ADC)**	**DC Power into Final (W)**	**RF Power Output (W)**
150.000	13.3	1.55	20.61	5.0
150.000	13.3	0.86	11.44	1.0

NAME OF TEST: Transmitter Occupied Bandwidth

RULE PART NUMBER: 2.201, 2.202, 2.1033 (c)(14), 2.1049 (h), 2.1041;90.203(j)(3)

Necessary Bandwidth Measurement

This radio modem uses digital modulation signals, passing through a linear 8th order low-pass filter (Raise-Cosine alpha 1 approximation), to an FM transceiver. The necessary bandwidth calculation for this type of modulation (DRCMSK) is not covered by paragraphs (1), (2) or (3) from 2.202(c). Therefore, the approach outlined in (2.202(c)(4)) is applicable in this case.

The measurement explanations are provided in “Annex” (following pages)

Necessary Bandwidth Measurement:

Channel spacing	6.25 kHz	6.25 kHz
Emission type	3K42 F1D	3K75 F1D
Frequency deviation	± 1.05 KHz	± 1.64 kHz

Modulator signal bit rate 4800 bps,
Peak deviation = ± 1.05 kHz
Bn= 3.42 kHz
The corresponding emission designator prefix for necessary bandwidth = 3K42 F1D

Modulator signal bit rate 2400 bps,
Peak deviation = ± 1.64 kHz
Bn= 3.75 kHz
The corresponding emission designator prefix for necessary bandwidth = 3K75 F1D

****
Table 1 - Measurements results for the INTEGRA-TR unit , 4800 bps BT.4 and 2400 bps BT.5 and frequency deviations set to obtain specified values .

unit’s software settings	measured data (kHz)		Emission designator
bit rate (data settings)	freq. dev	99% occupied BW	
4800 BT.4	± 1.05	3.42 kHz	3K42 F1D
2400 BT.5	± 1.64	3.75 kHz	3K75 F1D

****

ANNEX

a)Theory of Measurement

The way to define the ***Occupied Bandwidth*** is "the frequency bandwidth such that, below its lower and above its upper frequency limits, the mean powers radiated are each equal to 0.5 percent of the total mean power radiated by a given emission" (FCC 2.202), the mathematics are as follows:

$$0.005*TP=P_{(f1)}=\int_0^{f1} PSD_{(f)}df$$

$$0.995*TP=P_{(f2)}=\int_0^{f2} PSD_{(f)}df$$

$$OBW=f2-f1$$

where TP (total mean power) is

$$TP=\int_0^{+\infty} PSD_{(f)}df =(1/t)\int_{-\infty}^{+\infty} |z_{(t)}|^2dt$$

and PSD (power spectral distribution) is

$$PSD_{(f)}=|Z_{(f)}|^2+|Z_{(-f)}|^2 \qquad 0\leq f<\infty$$

and expresses the positive frequency representation of the transmitter output power for z(t) signal.

By applying these mathematics to the measurements, it is possible to measure the Occupied Bandwidth using a digital spectrum analyzer.

The Occupied Bandwidth measurement is in two parts relatively independent of each other. The first gives the RF spectrum profile, and the second calculates the frequency limits and they result in the Occupied bandwidth. While the first involves RF measurement instrumentation, the second is strictly a computational part related to measured trace.

Getting an equally-sampled RF power spectrum profile requires a Digital Spectrum Analyzer. In addition to the instrument's usual requirements, a special attention must be paid to the analyzer's span (bandwidth to be investigated).

This bandwidth must be large enough to contain all the power spectral components created by the transmitter. The frequency step, where the samples are picked, is directly dependent on the span's value.

Δf= span/number of points displayed

The frequency resolution will determine the measurement accuracy. So for greater accuracy, less bandwidth will give better values because of the constant number of points that can be displayed. Taking into account the purpose of transmitter, an acceptable balance can be set. For channel-limited transmitters all the power spectral components can be found in main channel and a number of adjacent channels, upper and lower, from the main channel. The relation between these two requirements, number of channels and accuracy, is depicted by:

$$a(\%) \cong (2*k*n/N)*100,$$

where a is desired accuracy, in percentage units, n is the number of channels in span, including main channel, N is displayed number of points and k= (authorized bandwidth) /channel bandwidth.

For usual spectrum analyzers $N\cong500$, k=0.8 (6) for 6.25kHz channel transmitters, so $a \cong n/2.5$ (%) can estimate the expected precision for measurement.

All other requirements for spectrum analyzer are the same as they are for mask compliance determination.

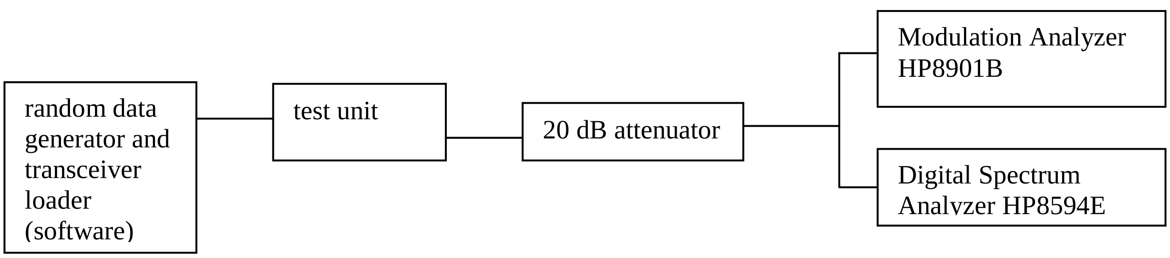
Standard calculation precision is all that is required. The main error factor being the y display resolution is covering calculation precision.

The absolute error for this measurement is (-0/+2*)f. It is not possible to decrease span bandwidth under 2 channels bandwidth because this will affect the significance of result by cutting off the power's spectral distribution edges.

b) Dataradio's Measurement Set-Up

For the above requirements, the occupied bandwidth of a transmitter was measured using an HP8594E using the following settings:
Channel Spacing: 6.25 kHz
Channel Bandwidth: 6.00 kHz
OCC BW % Power: 99%
Trace: Max Hold A
The following settings are set by the instrument to measure per the requirements above:
RBW: 100 Hz
VBW: 1 kHz
SPAN: 18.75 kHz

The measurement set-up is:



INTEGRA Modem at 2400 bps

In Support of Emission Designator **3K75F1D**

RULE PART NUMBER: 2.201, 2.202, 2.1033 (c)(14), 2.1049(h), 2.1041, 90.209(b)(5), 90.210 (d)

MINIMUM STANDARD: Mask E
Sidebands and Spurious [Rule 90.210 (d), P =5 Watts]
Authorized Bandwidth = 6 kHz [Rule 90.209(b) (5)]
From Fo to 3.0 kHz, down 0 dB. Greater than 3.0 kHz to 4.6 kHz, down 30 + 16.67(f_d-3kHz) dB. Greater than 4.6 kHz, at least 55+10$\log_{10}$(P) or 65 dB, whichever is the lesser of the attenuation.

Attenuation = 0 dB at Fo to 3.0 kHz
Attenuation = 30 dB at 3.0 kHz and 57 dB at 4.6 kHz
Attenuation = 62 dB (55 dB @ 1 Watt) at > 4.6 kHz

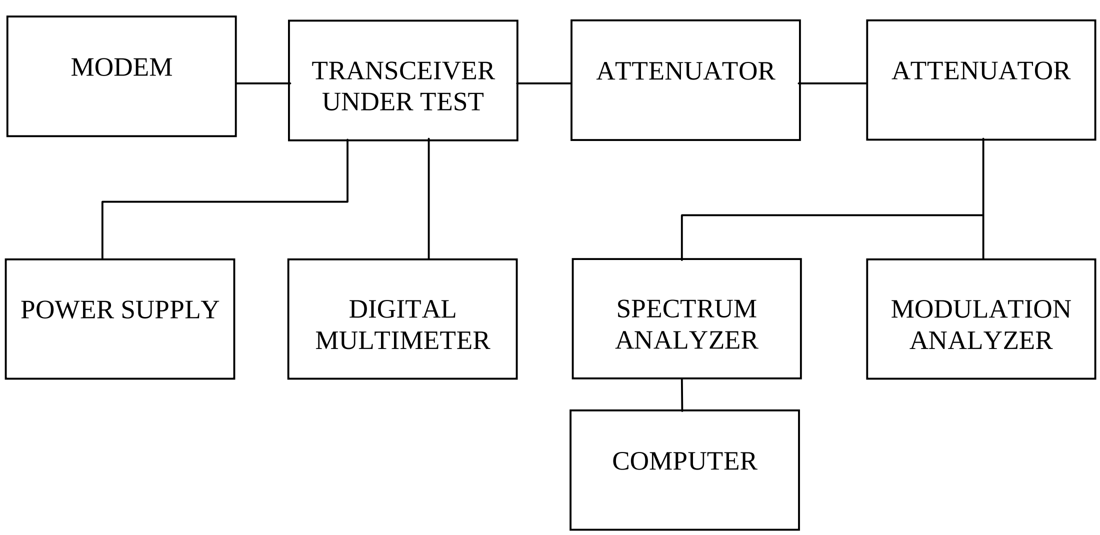
TEST RESULTS: Meets minimum standard (see data on the following pages)

TEST CONDITIONS: Standard Test Conditions, 25 °C

TEST EQUIPMENT: Attenuator, BIRD Model / 9716 / 25-A-MFN-20 / 20 dB / 25 Watt
Digital Voltmeter, Fluke Model 8012A
DC Power Source, Model HP6284A
Modulation Analyzer, Model HP8901A
Spectrum Analyzer, Advantest Model R3365A
Computer, Compaq Deskpro

PERFORMED BY: ______________________ DATE: 5/22/2001
Larry M. Dickinson

TEST SET-UP:



NAME OF TEST: Transmitter Occupied Bandwidth (Continued)
INTEGRA Modem at 2400 bps
In Support of Emission Designator **3K75F1D**

MODULATION SOURCE DESCRIPTION:
The digital modulation type used in the INTEGRA is DRCMSK (Differential Raised Cosine Minimum Shift Keying). A modem using such type of modulation is divided into three main functional units in a CPLD chip:
Scrambler:
The scrambler converts the data stream to a new data stream more suitable for FM transmission.
-It randomizes the data to avoid predictable patterns: 00000000, 111111111, 01010101, 00110011, etc.
-It keeps the power spectrum more compact by avoiding sequences like 01010101…
The scrambler is made with a serial shift register and 2 exclusive OR gates which implement the polynomial form X^7+X^5-1. For the receiver side, a similar circuit performs the descrambling function to decode the received scrambled data.

Differential encoder:
After data is scrambled, we encode the data with a differential encoder. The differential encoder XOR's the current input bit with the previous bit. The differential encoder is used to make the modem insensitive to audio polarity inversion of the FM radio system.

Waveshape generator:
The waveshape generator converts the processed data bits (scrambled and differentially encoded for DRCMSK) to the DRCMSK audio signal. This audio signal is passed through a low-pass filter before modulating the RF transmitter.

TRANSMISSION PREAMBLE:
Each data transmission begins by sending a 15 millisecond preamble of sinewave (101010...). This is to synchronize the digital phase locked loop of the receiver modem.

TEST PATTERN GENERATOR:
A test pattern sequence is generated by the test software when the "test data" button is clicked. The highest resulting modulating frequency is (baud rate)/2 Hz. The following pseudo random test pattern was used to modulate the transmitter:

###ABCDEFGHIJKLMNOPQRSTUVWXYZabcdefghijklmnopqrstuvwxyz0123456789\r\n,

In this pattern ### is replaced by the number of replays, \r is a carriage return and \n is a linefeed. The data is fed to the RS232 interface IC and processed as described above. The async-to-sync conversion, scrambler and differential encoder make the ABCDE... pattern appear random over the air.

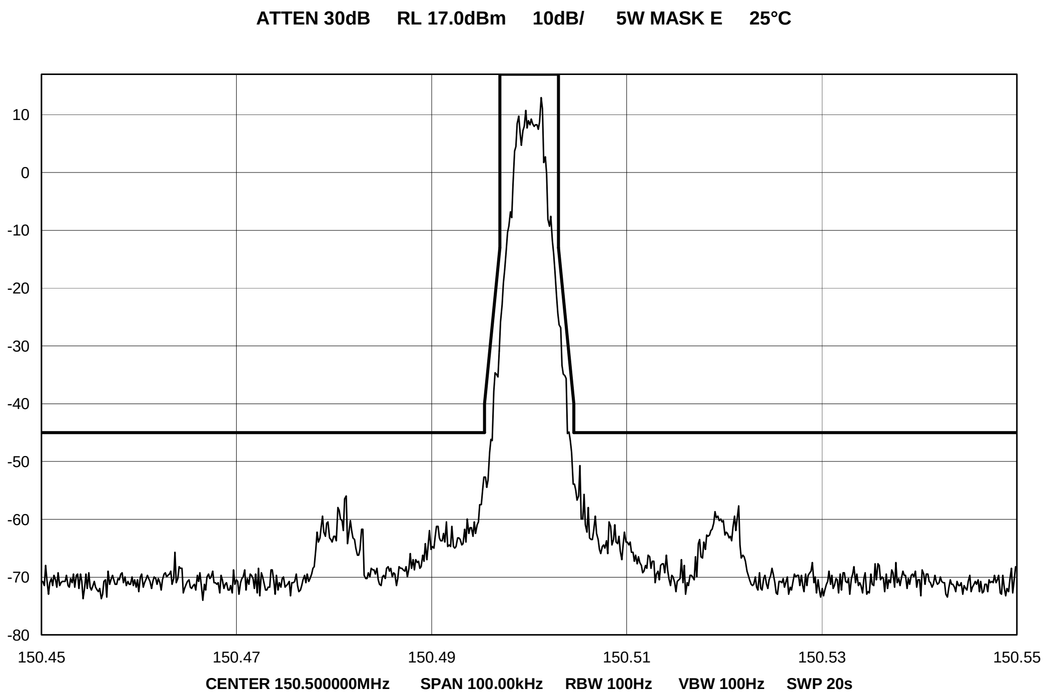
NECESSARY BANDWIDTH (Bn) CALCULATION

See page 12 for Emission Designator determination.

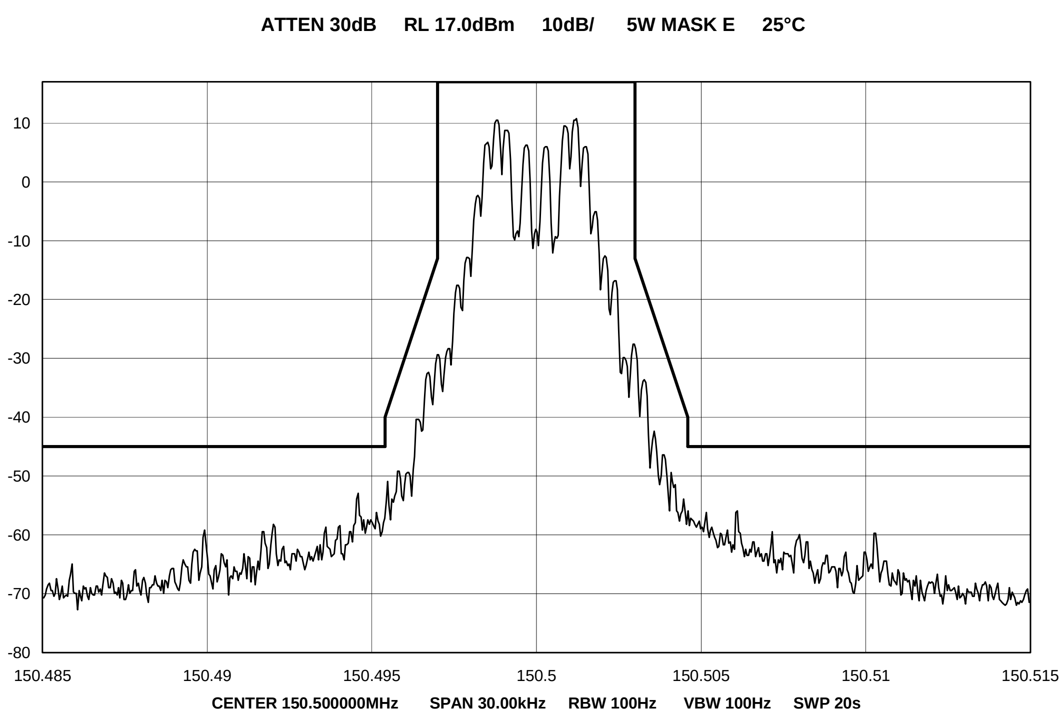
The corresponding emission designator prefix for necessary bandwidth = 3K75

TEST DATA: Refer to the following graphs:

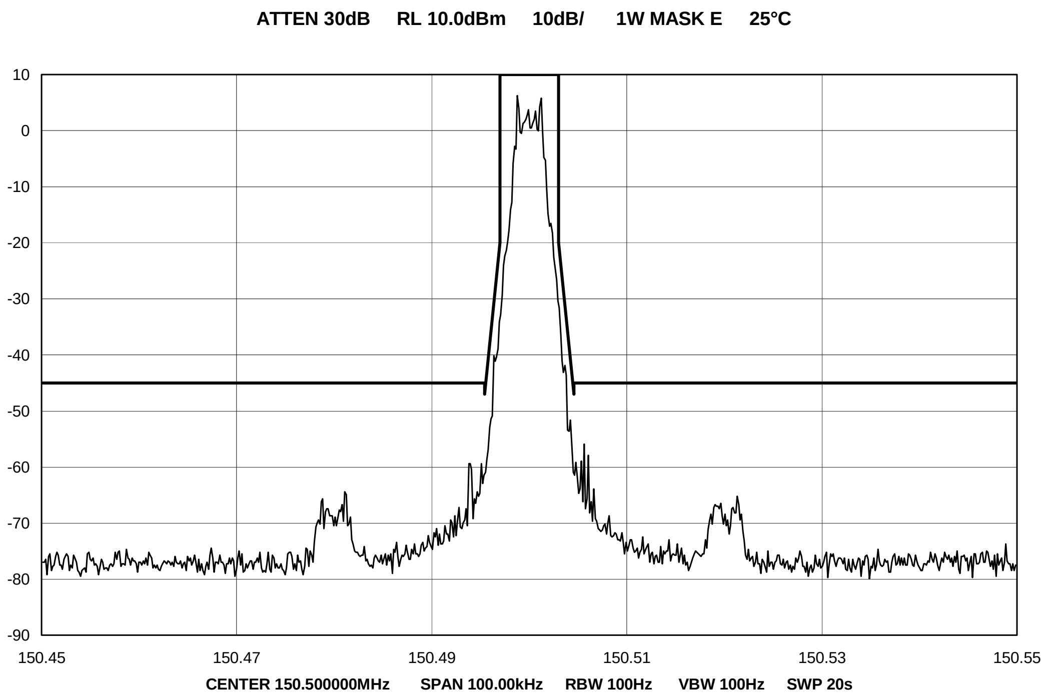
MASK: E, 5W
SPECTRUM FOR EMISSION **3K75F1D**
OUTPUT POWER: 5 Watts
2400 bps
PEAK DEVIATION = 1640 Hz
SPAN = 100 kHz



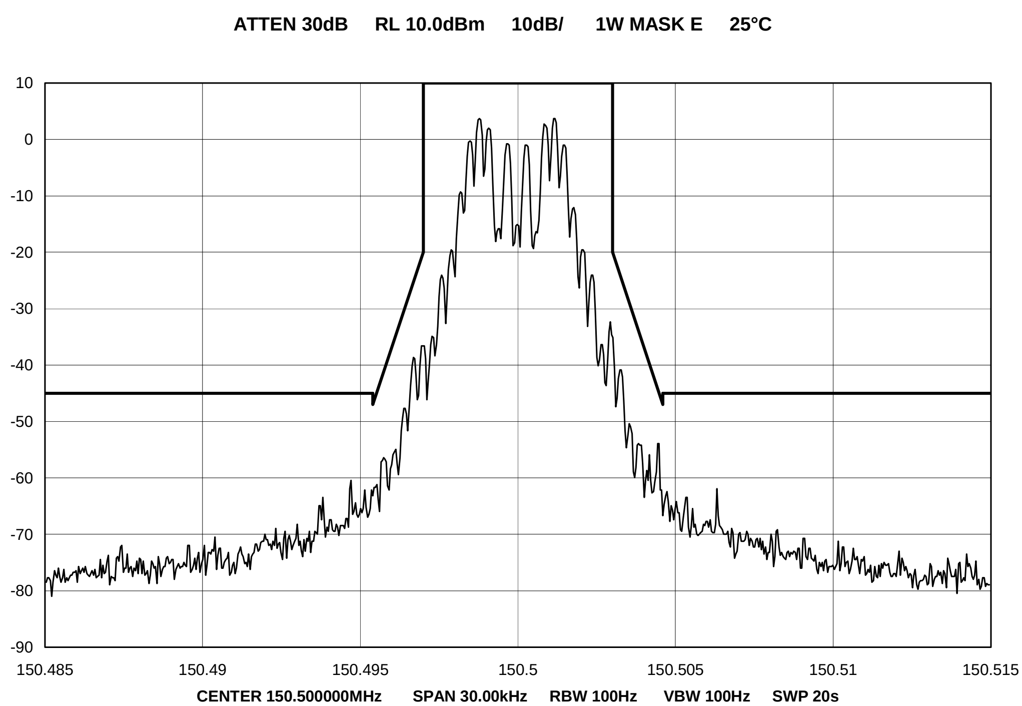
SPAN = 30 kHz



MASK: E, 1W
SPECTRUM FOR EMISSION **3K75F1D**
OUTPUT POWER: 1 Watts
2400 bps
PEAK DEVIATION = 1640 Hz
SPAN = 100 kHz

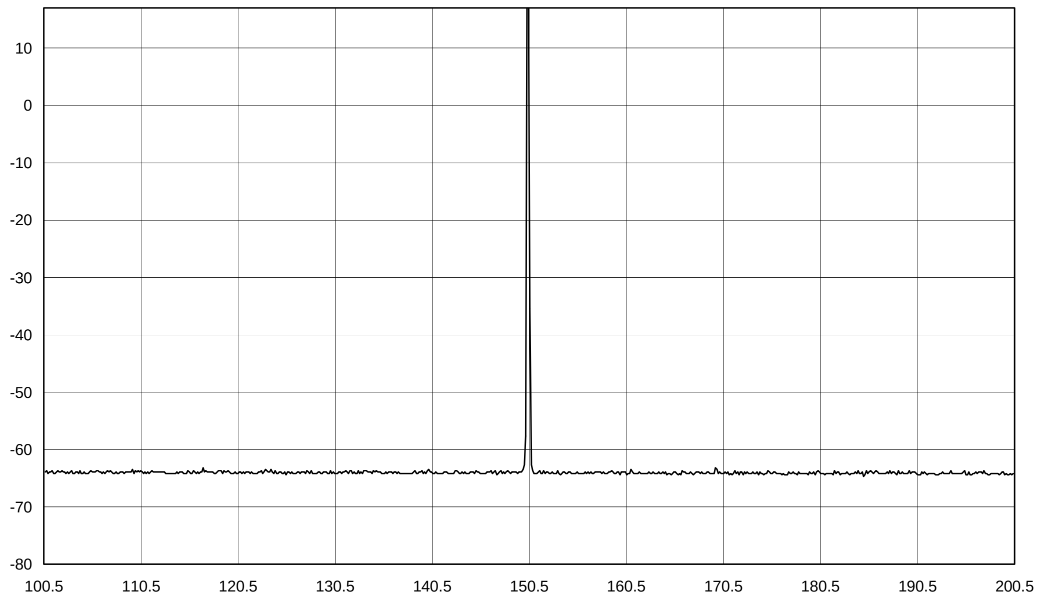


SPAN = 30 kHz



WIDE SPAN = 100 MHz
OUTPUT POWER: 5 Watts

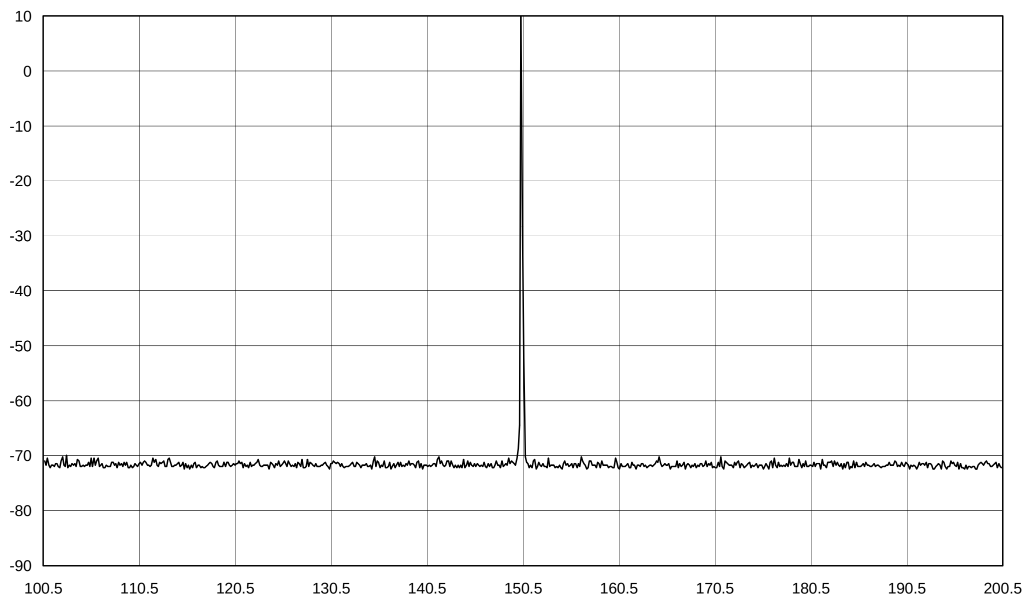
ATTEN 30dB RL 17.0dBm 10dB/ 25°C



CENTER 150.500000MHz SPAN 100.00MHz RBW 10.0kHz VBW 10.0kHz SWP 20s

WIDE SPAN = 100 MHz
OUTPUT POWER: 1 Watts

ATTEN 30dB RL 10.0dBm 10dB/ 25°C



CENTER 150.500000MHz SPAN 100.00MHz RBW 10.0kHz VBW 10.0kHz SWP 20s

INTEGRA Modem at 4800 bps

In Support of Emission Designator **3K42F1D**

RULE PART NUMBER: 2.201, 2.202, 2.1033 (c)(14), 2.1049(h), 2.1041, 90.209(b)(5), 90.210 (b)

MINIMUM STANDARD: Mask E
Sidebands and Spurious [Rule 90.210 (d), P =5 Watts]
Authorized Bandwidth = 6 kHz [Rule 90.209(b) (5)]
From Fo to 3.0 kHz, down 0 dB. Greater than 3.0 kHz to 4.6 kHz, down 30 + 16.67(f_d-3kHz) dB. Greater than 4.6 kHz, at least 55+10$\log_{10}$(P) or 65 dB, whichever is the lesser of the attenuation.

Attenuation = 0 dB at Fo to 3.0 kHz
Attenuation = 30 dB at 3.0 kHz and 57 dB at 4.6 kHz
Attenuation = 62 dB (55 dB @ 1 Watt) at > 4.6 kHz

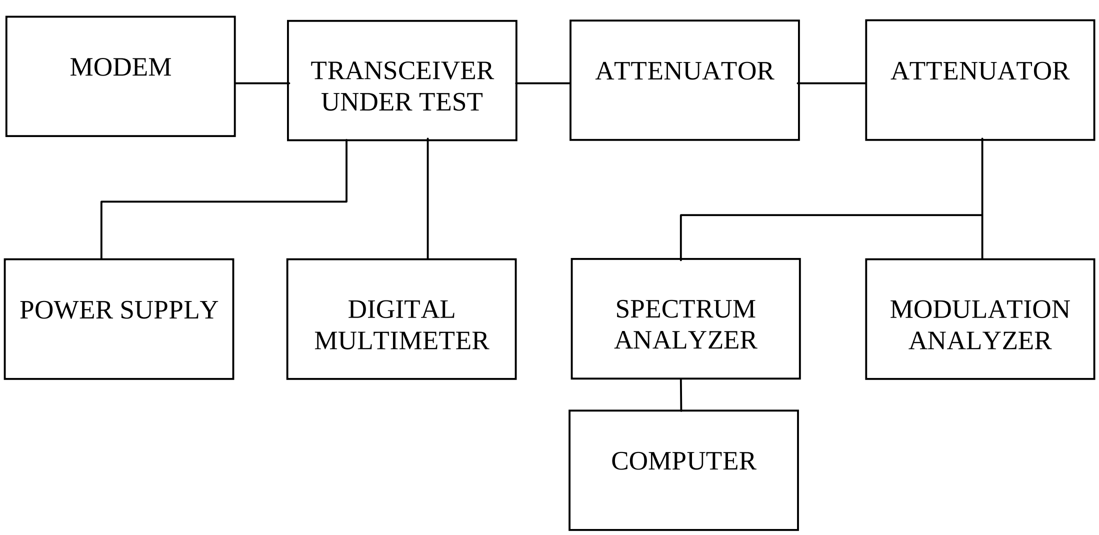
TEST RESULTS: Meets minimum standard (see data on the following pages)

TEST CONDITIONS: Standard Test Conditions, 25 °C

TEST EQUIPMENT: Attenuator, BIRD Model / 9716 / 25-A-MFN-20 / 20 dB / 25 Watt
Digital Voltmeter, Fluke Model 8012A
DC Power Source, Model HP6284A
Modulation Analyzer, Model HP8901A
Spectrum Analyzer, Advantest Model R3365A
Computer, Compaq Deskpro

PERFORMED BY: ______________________________ DATE: 5/22/2001
Larry M. Dickinson

TEST SET-UP:



NAME OF TEST: Transmitter Occupied Bandwidth (Continued)
INTEGRA Modem at 4800 bps
In Support of Emission Designator **3K42F1D**

MODULATION SOURCE DESCRIPTION:
The digital modulation type used in the INTEGRA is DRCMSK (Differential Raised Cosine Minimum Shift Keying). A modem using such type of modulation is divided into three main functional units in a CPLD chip:
Scrambler:
The scrambler converts the data stream to a new data stream more suitable for FM transmission.
-It randomizes the data to avoid predictable patterns: 00000000, 111111111, 01010101, 00110011, etc.
-It keeps the power spectrum more compact by avoiding sequences like 01010101…
The scrambler is made with a serial shift register and 2 exclusive OR gates which implement the polynomial form X^7+X^5-1. For the receiver side, a similar circuit performs the descrambling function to decode the received scrambled data.

Differential encoder:
After data is scrambled, we encode the data with a differential encoder. The differential encoder XOR's the current input bit with the previous bit. The differential encoder is used to make the modem insensitive to audio polarity inversion of the FM radio system.

Waveshape generator:
The waveshape generator converts the processed data bits (scrambled and differentially encoded for DRCMSK) to the DRCMSK audio signal. This audio signal is passed through a low-pass filter before modulating the RF transmitter.

TRANSMISSION PREAMBLE:
Each data transmission begins by sending a 15 millisecond preamble of sinewave (101010...). This is to synchronize the digital phase locked loop of the receiver modem.

TEST PATTERN GENERATOR:
A test pattern sequence is generated by the test software when the "test data" button is clicked. The highest resulting modulating frequency is (baud rate)/2 Hz. The following pseudo random test pattern was used to modulate the transmitter:

###ABCDEFGHIJKLMNOPQRSTUVWXYZabcdefghijklmnopqrstuvwxyz0123456789\r\n,

In this pattern ### is replaced by the number of replays, \r is a carriage return and \n is a linefeed. The data is fed to the RS232 interface IC and processed as described above. The async-to-sync conversion, scrambler and differential encoder make the ABCDE... pattern appear random over the air.

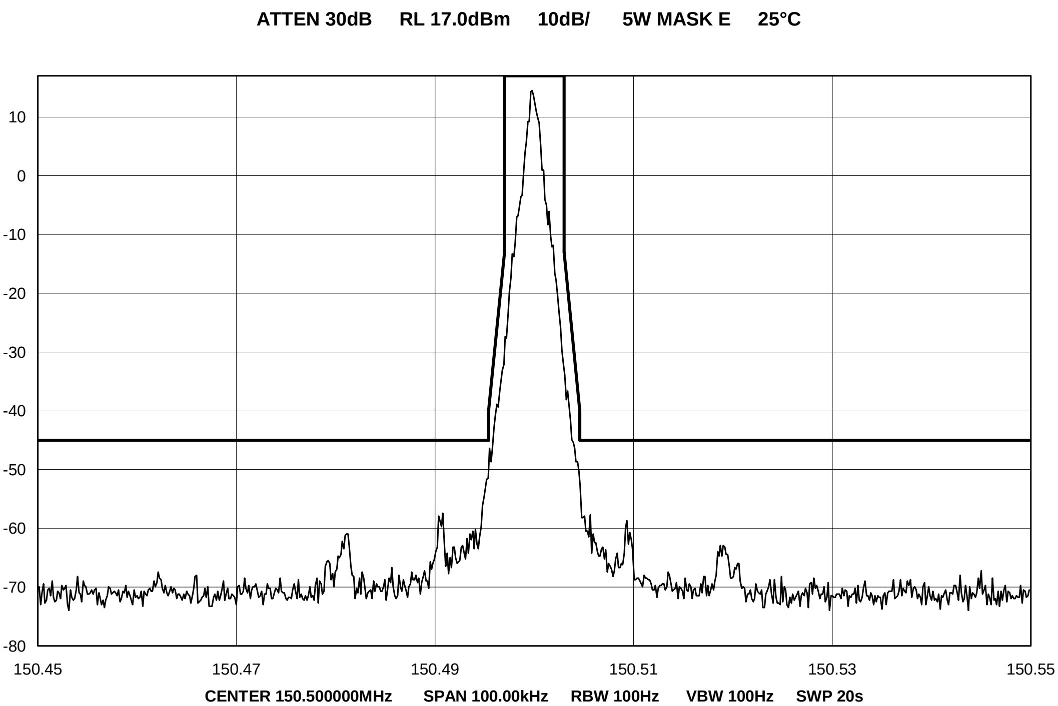
NECESSARY BANDWIDTH (Bn) CALCULATION

See page 12 for Emission Designator determination.

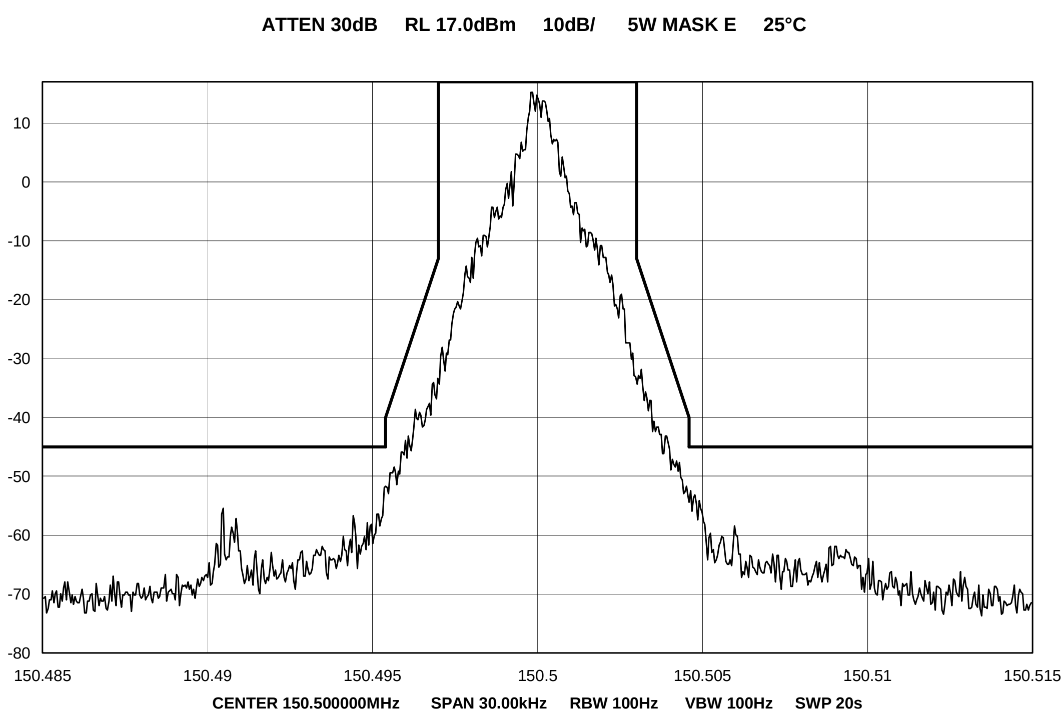
The corresponding emission designator prefix for necessary bandwidth = 3K42

TEST DATA: Refer to the following graphs:

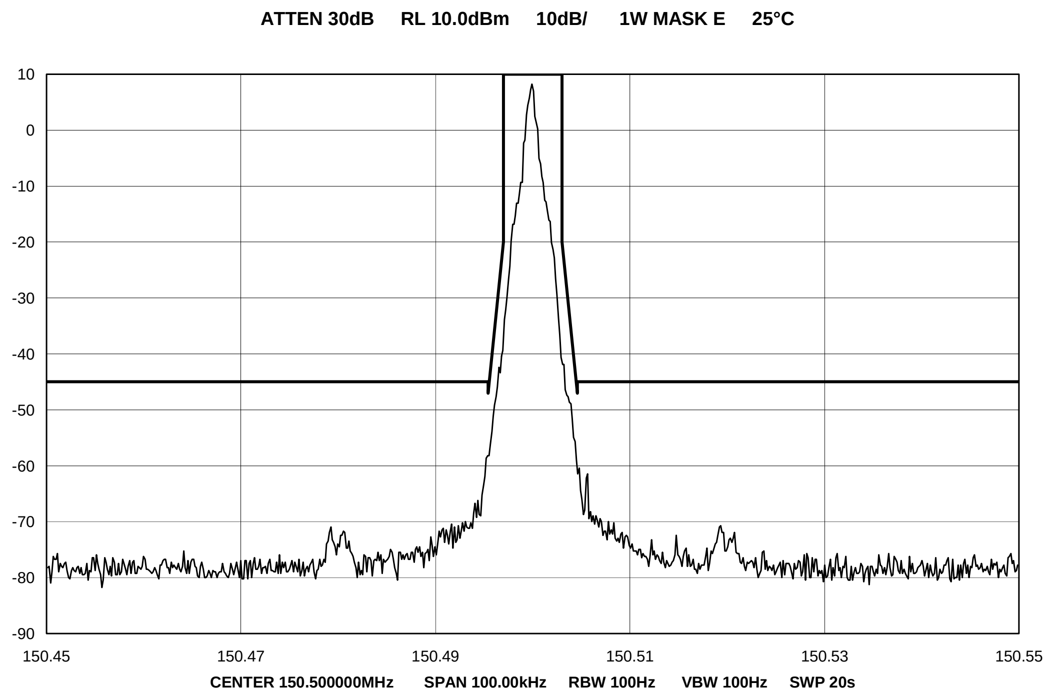
MASK: E, 5W
SPECTRUM FOR EMISSION **3K42F1D**
OUTPUT POWER: 5 Watts
4800 bps
PEAK DEVIATION = 1050 Hz
SPAN = 100 kHz



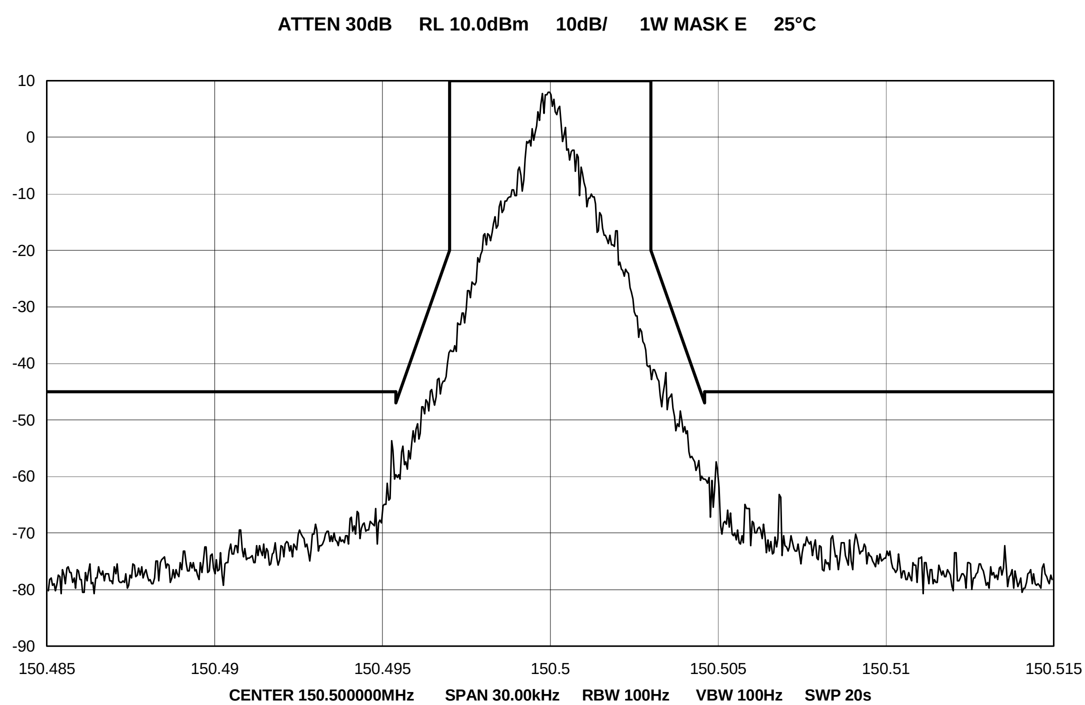
SPAN = 30 kHz



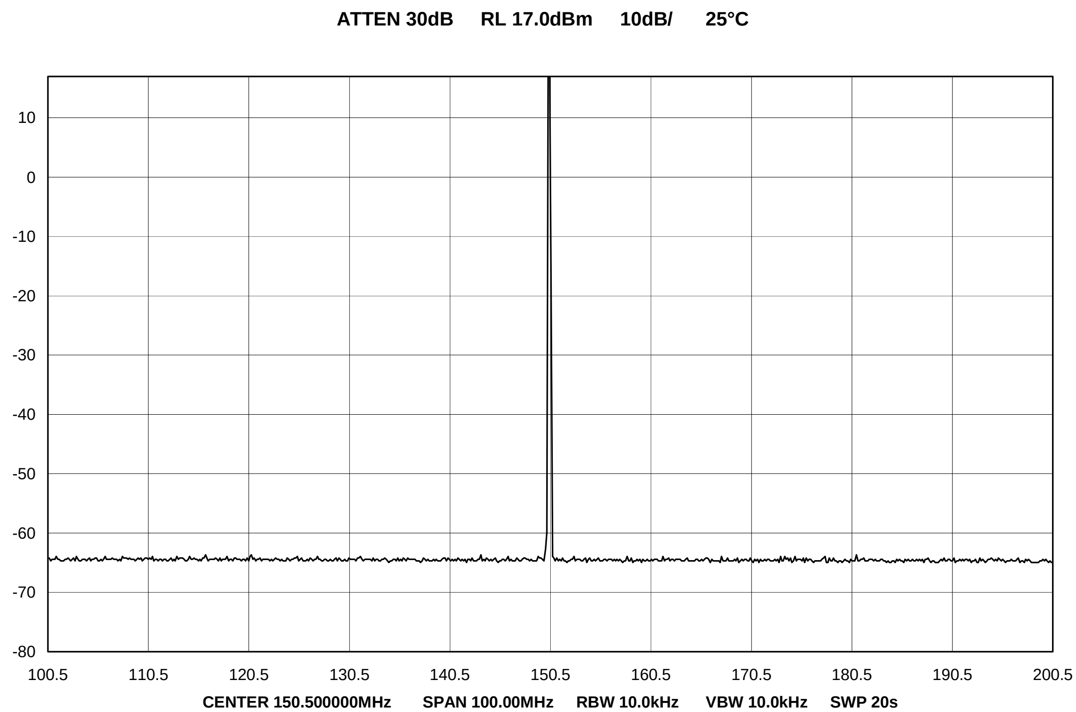
MASK: E, 1W
SPECTRUM FOR EMISSION **3K42F1D**
OUTPUT POWER: 1 Watts
4800 bps
PEAK DEVIATION = 1050 Hz
SPAN = 100 kHz



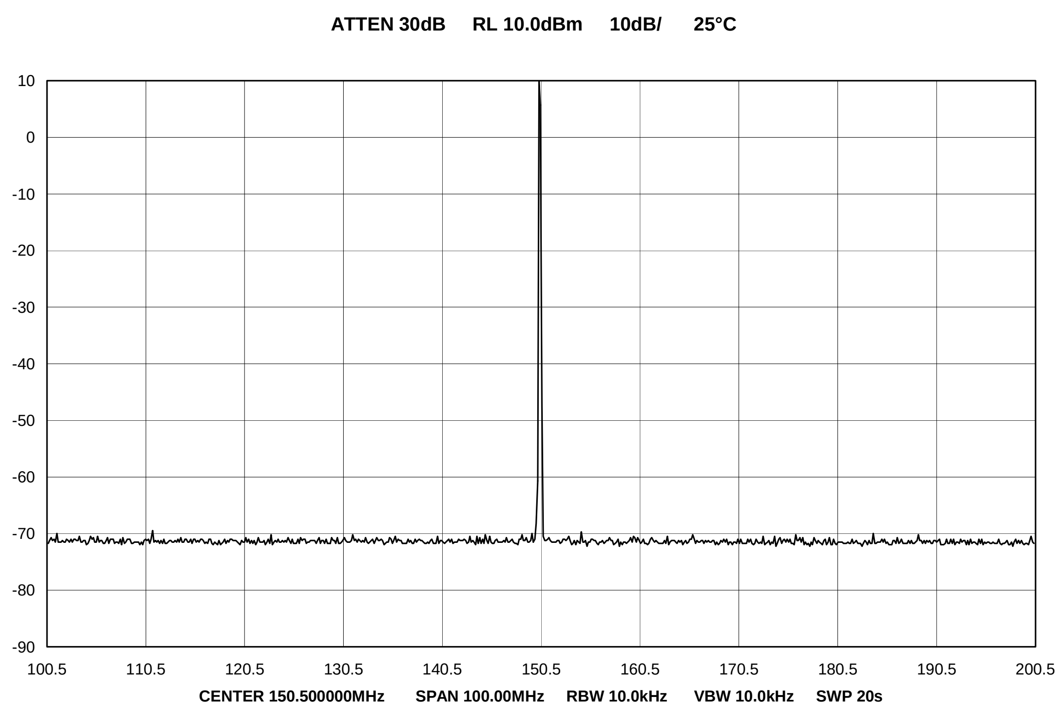
SPAN = 30 kHz



WIDE SPAN = 100 MHz
OUTPUT POWER: 5 Watts



WIDE SPAN = 100 MHz
OUTPUT POWER: 1 Watts



NAME OF TEST: Transmitter Spurious and Harmonic Outputs

RULE PART NUMBER: 2.1033 c(14), 2.1041, 2.1051, 90.210 (d)(3)

MINIMUM STANDARD: For 5 Watt; $50+10\text{Log}_{10}(5\text{ Watts}) = -57$ dBc
or -70 dBc whichever is the lesser attenuation.

TEST RESULTS: Meets minimum standard (see data on the following page)

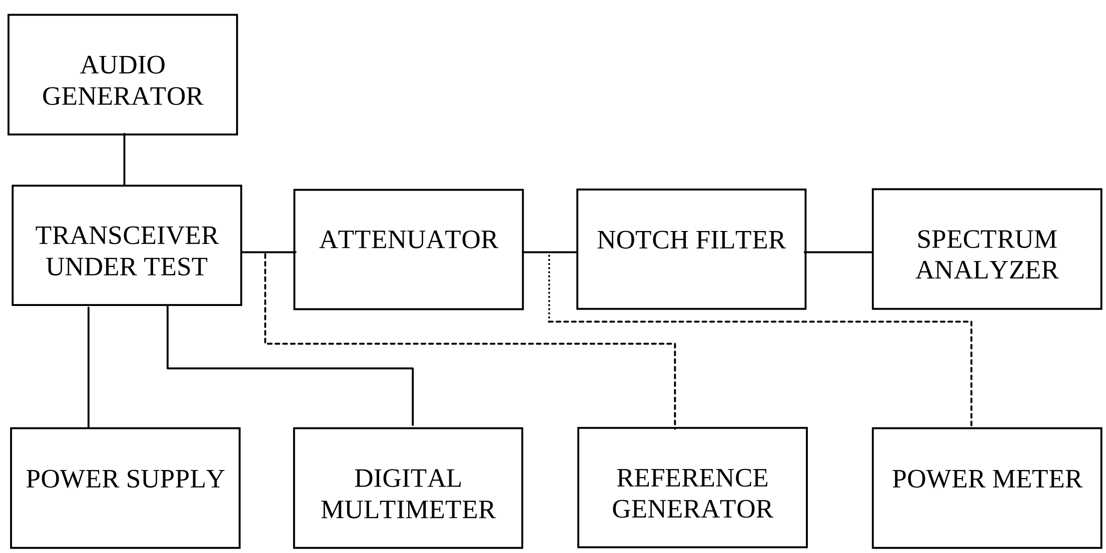
TEST CONDITIONS: Standard Test Conditions, 25 °C
RF voltage measured at antenna terminals

TEST PROCEDURE: TIA/EIA - 603, 2.2.13

TEST EQUIPMENT:
Attenuator, BIRD Model / 9715 / 50-A-MFN-06 / 6 dB / 50 Watt
Attenuator, BIRD Model / 9716 / 25-A-MFN-20 / 20 dB / 25 Watt
Digital Voltmeter, Fluke Model 8012A
DC Power Source, Model HP6284A
Modulation Analyzer, Model HP8901A
Spectrum Analyzer, Model HP8563E
Plotter, HP7470A
Reference Generator, Model HP83732B
Power Meter, Model HP436A
Audio Generator, Model HP8903B

PERFORMED BY: Allen Frederick (signature) Date:4/28/01
Allen Frederick

TEST SET-UP:



NAME OF TEST: Transmitter Spurious and Harmonic Outputs (Continued)

MEASUREMENT PROCEDURE:

1. The transmitter carrier output frequency is 132 MHz, 150 MHz and 174 MHz. The reference oscillator frequency is 14.85 MHz or 17.5 MHz.

2. After carrier reference was established on spectrum analyzer, the notch filter was adjusted to null the carrier Fc to extend the range of the spectrum analyzer for harmonic measurements.

3. At each spurious frequency, Generator substitution was used to establish the true spurious level.

4. The spectrum was scanned to the 10th harmonic.

TEST DATA:

Tuned Frequency		132 MHz	Tuned Frequency		132 MHz
Power		5 Watts	Power		1 Watts
		37.0 dBm			30.0 dBm
Minimum Specification		57.0 dBm	Minimum Specification		50.0 dBm
Worse Case		65.0 dBc	Worse Case		74.0 dBc
Spurious Frequency (MHz)	Relation to Carrier	Relative to Carrier (dBc)	Spurious Frequency (MHz)	Relation to Carrier	Relative to Carrier (dBc)
300	2 fo	65.0	300	2 fo	74.0
450	3 fo	79.0	450	3 fo	96.5
600	4 fo	91.5	600	4 fo	105.5
750	5 fo	104.5	750	5 fo	95.5
900	6 fo	104.5	900	6 fo	108.0
1050	7 fo	116.5	1050	7 fo	116.5
1200	8 fo	120.0	1200	8 fo	117.0
1350	9 fo	113.0	1350	9 fo	111.0
1500	10 fo	106.5	1500	10 fo	89.5

NAME OF TEST: Transmitter Spurious and Harmonic Outputs (Continued)

Tuned Frequency	150 MHz		Tuned Frequency	150 MHz	
Power	5 Watts		Power	1 Watts	
	37.0 dBm			30.0 dBm	
Minimum Specification	57.0 dBm		Minimum Specification	50.0 dBm	
Worse Case	72.5 dBc		Worse Case	95.0 dBc	
Spurious Frequency (MHz)	Relation to Carrier	Relative to Carrier (dBc)	Spurious Frequency (MHz)	Relation to Carrier	Relative to Carrier (dBc)
300	2 fo	72.5	300.0	2 fo	95.0
450	3 fo	98.5	450	3 fo	117.0
600	4 fo	123.0	600	4 fo	127.0
750	5 fo	107.0	750	5 fo	113.0
900	6 fo	110.5	900	6 fo	122.0
1050	7 fo	114.0	1050	7 fo	130.0
1200	8 fo	108.5	1200.0	8 fo	117.0
1350	9 fo	87.5	1350.0	9 fo	138.0
1500	10 fo	132.0	1500.0	10 fo	125.0

Tuned Frequency	174 MHz		Tuned Frequency	174 MHz	
Power	5 Watts		Power	1 Watts	
	37.0 dBm			30.0 dBm	
Minimum Specification	57.0 dBm		Minimum Specification	50.0 dBm	
Worse Case	71.5 dBc		Worse Case	77.0 dBc	
Spurious Frequency (MHz)	Relation to Carrier	Relative to Carrier (dBc)	Spurious Frequency (MHz)	Relation to Carrier	Relative to Carrier (dBc)
348	2 fo	71.5	348	2 fo	77.0
522	3 fo	102.0	522	3 fo	116.0
696	4 fo	113.0	696	4 fo	113.5
870	5 fo	110.0	870	5 fo	106.5
1044	6 fo	109.5	1044	6 fo	109.0
1218	7 fo	92.5	1218	7 fo	86.5
1392	8 fo	91.5	1392	8 fo	84.5
1566	9 fo	116.0	1566	9 fo	109.0
1740	10 fo	119.0	1740	10 fo	106.0

NAME OF TEST: Field Strength of Spurious Radiation

RULE PART NUMBER: 2.1033 c(14), 2.1041, 2.1053, 90.210 (d)(3)

MINIMUM STANDARD: For 5 Watts; $50+10Log_{10}(5) = -57$ dBc

TEST RESULTS: Meets minimum standard (see data on the following page)

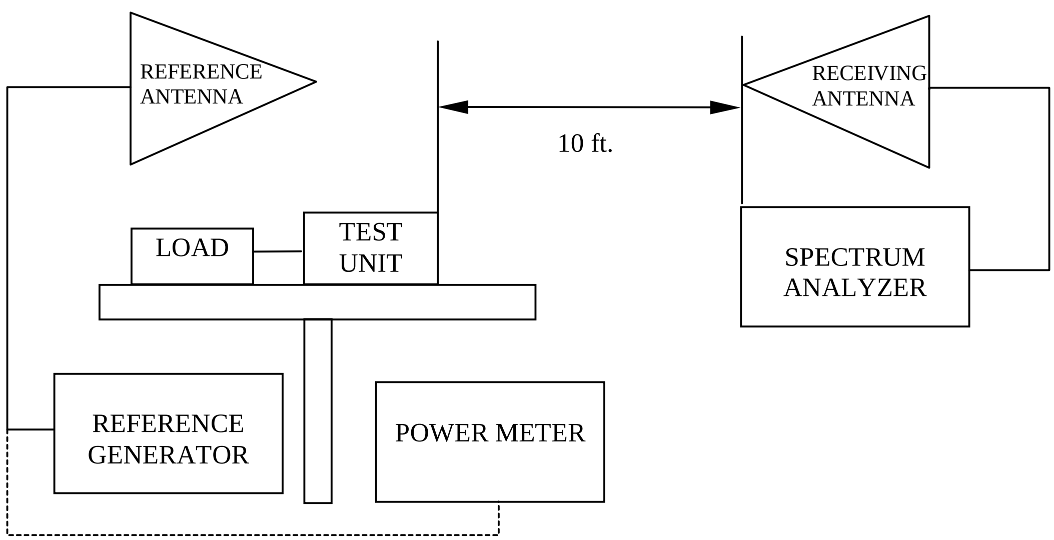
TEST CONDITIONS: Standard Test Conditions, 25 C

TEST PROCEDURE: TIA/EIA - 603, 2.2.12

Test Equipment:
Dipole Antenna Kit, Electro-Mechanics Model 3121C
Load, Tenuline Model 8340-200 (20 dB)
Spectrum Analyzer, HP 8563E
Reference Generator, HP83732A
Power Meter, HP437A

MEASUREMENT PROCEDURE: Radiated spurious attenuation was measured according to TIA/EIA Standard 603 Section 2.2.12

TEST SET-UP:



PERFORMED BY: Allen Frederick DATE: 4/28/01

Freqency:	150 MHz		Min Spec			-57.0	dB
Power:	5 Watts=37.0dBm		Worst Case			**-69.5**	dBc

Spurious Frequency (MHz)	Polarization (Horz/Vert)	Spurious Level (dBm)	Substitution Generator (dBm)	Cable Loss (dB)	Antenna Gain (dBd)	Circular Polarization Correction (dB)	Spurious Attenuation dBc
300	H	-60.0	-35.0	2.83	-0.25	0.00	-75.1
	V	-59.7	-33.0	2.83	-0.25	0.00	-73.1
450	H	-67.7	-40.0	3.50	-1.15	0.00	-81.6
	V	-70.8	-42.0	3.50	-1.15	0.00	-83.6
600	H	-67.8	-37.0	4.00	-1.85	0.00	-79.8
	V	-78.5	-44.0	4.00	-1.85	0.00	-86.8
750	H	-81.7	-47.0	4.33	-0.85	0.00	-89.2
	V	-89.5	-49.0	4.33	-0.85	0.00	-91.2
900	H	-83.8	-50.0	5.00	1.20	3.00	-93.8
	V	-86.8	-49.0	5.00	1.20	3.00	-92.8
1050	H	-81.2	-39.0	5.33	1.20	3.00	-83.1
	V	-83.2	-43.0	5.33	1.20	3.00	-87.1
1200	H	-83.0	-42.0	5.67	1.20	3.00	-86.5
	V	-84.7	-42.0	5.67	1.20	3.00	-86.5
1350	H	-68.3	-25.0	5.67	1.20	3.00	-69.5
	V	-71.0	-29.0	5.67	1.20	3.00	-73.5
1500	H	-87.7	-45.0	5.67	1.20	3.00	-89.5
	V	-92.0	-50.0	5.67	1.20	3.00	-94.5

Freqency:	150 MHz		Min Spec			-50.0	dB
Power:	1 Watt=30.0dBm		Worst Case			**-57.1**	dBc

Spurious Frequency (MHz)	Polarization (Horz/Vert)	Spurious Level (dBm)	Substitution Generator (dBm)	Cable Loss (dB)	Antenna Gain (dBd)	Circular Polarization Correction (dB)	Spurious Attenuation dBc
300	H	-49.5	-24.0	2.83	-0.25	0.00	-57.1
	V	-56.5	-30.0	2.83	-0.25	0.00	-63.1
450	H	-78.2	-51.0	3.50	-1.15	0.00	-85.7
	V	-85.7	-57.0	3.50	-1.15	0.00	-91.7
600	H	-73.5	-43.0	4.00	-1.85	0.00	-78.9
	V	-84.7	-49.0	4.00	-1.85	0.00	-84.9
750	H	-91.7	-56.0	4.33	-0.85	0.00	-91.2
	V	-92.2	-57.0	4.33	-0.85	0.00	-92.2
900	H	-89.0	-54.0	5.00	1.20	3.00	-90.8
	V	-90.3	-52.0	5.00	1.20	3.00	-88.8
1050	H	-92.7	-52.0	5.33	1.20	3.00	-89.1
	V	-94.3	-55.0	5.33	1.20	3.00	-92.1
1200	H	-84.8	-44.0	5.67	1.20	3.00	-81.5
	V	-87.5	-45.0	5.67	1.20	3.00	-82.5
1350	H	-72.5	-29.0	5.67	1.20	3.00	-66.5
	V	-74.8	-32.0	5.67	1.20	3.00	-69.5
1500	H	-94.5	-52.0	5.67	1.20	3.00	-89.5
	V	-96.5	-54.0	5.67	1.20	3.00	-91.5

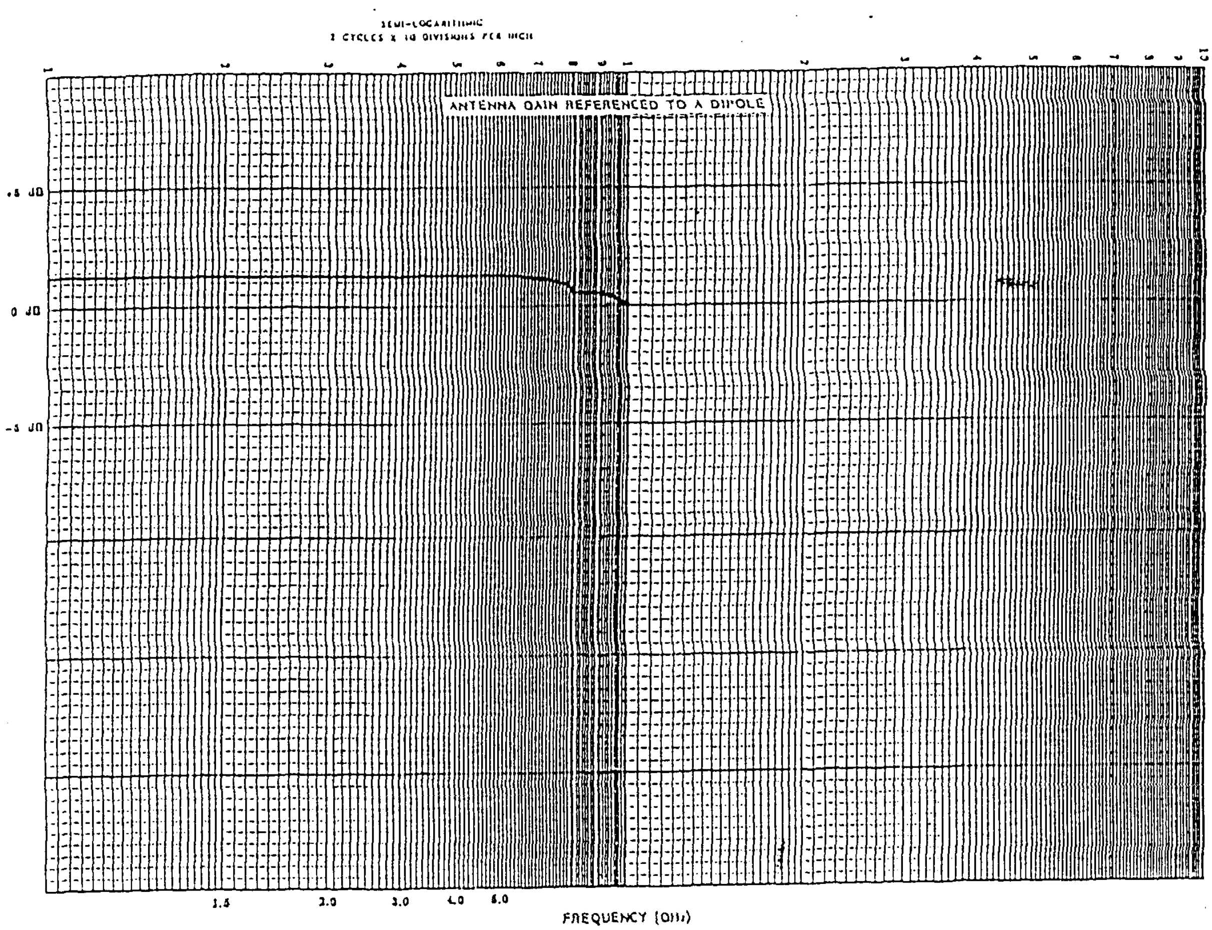
CALCULATIONS FOR FIELD STRENGTH OF SPURIOUS RADIATION TESTS:

The transmitter carrier frequency was 150.000 MHz. The reference oscillator frequency of the transceiver used is 17.5 MHz. The output of the transceiver was searched from 17.5 MHz to the tenth harmonic of each of the carrier frequencies. The tests were conducted with the transceiver and modem inside of the enclosure.

Because the antennas used for the measurements recorded above 1 GHz were not flat in gain and differed from a dipole, the generator output was corrected for gain at each spurious frequency. The cable loss in the measurements is the loss in the cable between the signal generator and the substitution antenna. An additional 3 dB correction was also made to the spurious responses measured above 1 GHz to correct for the 3 dB polarization loss in the reference path.

EXAMPLE:
At 300 MHz (150 MHz tuned), 5 Watts and horizontal polarization.

r = Substitution Gen - Cable Loss	-35.0 - 2.83	= -37.83
R - Reference Generator (dBm)	-37.83	
A - Antenna Gain (dB)	+-.25	
P - Polarization Correction Factor (dB)	0.0	
R' (Corrected Reference (dBm)) = R + A - P	= -37.83 + -.25 - 0.0	= **-38.08 dBm**
Po - Radiated Carrier Power (dBm)	5 Watts = 37 dBm	
Radiated Spurious Emission (dBc) = Po - R'	= -38.08 - (+37)	= **-75.08 dBc**



ANTENNA GAIN GRAPH OF SUBSTITUTION ANTENNA
REFERENCED TO A DIPOLE

NAME OF TEST: Frequency Stability

-with Variation in Ambient Temperature

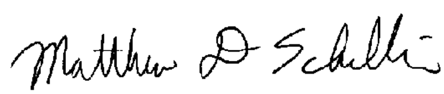
RULE PART NUMBER: 2.1033 c(14), 2.1041, 2.1055(a)(1), 90.213(a)

MINIMUM STANDARD: Shall not exceed ± 0.000100% from test frequency, or 1.00 ppm

TEST RESULTS: Meets minimum standard, see data on following page

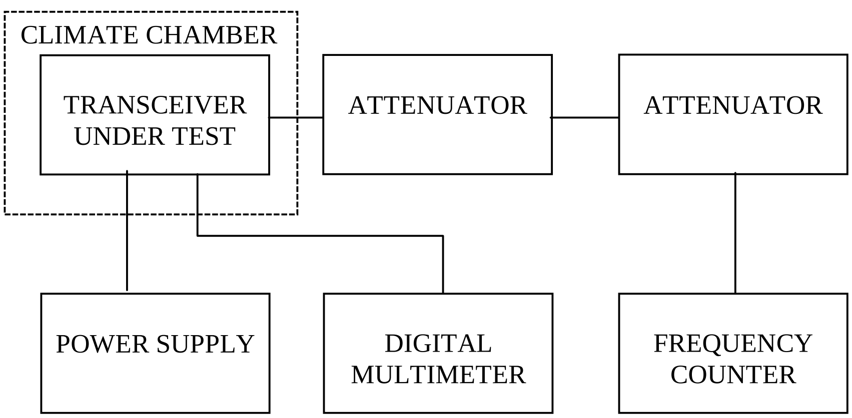
TEST CONDITIONS: Standard Test Conditions, 25 °C

TEST EQUIPMENT:
Attenuator, BIRD Model / 9716 / 25-A-MFN-20 / 20 dB / 25 Watt
Frequency Counter, Fluke Model 1920A
Digital Voltmeter, Fluke Model 8012A
DC Power Source, Model HP6284A
Climate Chamber, TempGard III, Tenney Jr.



PERFORMED BY: ______________________________ DATE: 5/16/01
Matthew D. Schellin

TEST SET-UP:



(Test data on next page)

NAME OF TEST: Frequency Stability with Variation in Ambient Temperature (Continued)

Frequency Reference: 150500000 Hz
Tolerance Requirement: 1.0 ppm
Highest Variation (ppm): 0.532 ppm

TEMP ° C	FREQUENCY MHz	FREQ DELTA Hz	ppm from assigned frequency
-30	150.50002	20	-0.133
-20	150.50004	40	0.266
-10	150.50008	80	0.532
0	150.50001	10	0.066
10	150.49998	-20	-0.133
20	150.50000	0	0.000
25	150.50002	20	0.133
30	150.50004	40	0.266
40	150.49999	-10	-0.066
50	150.50000	0	0.000
60	150.50002	20	0.133

NAME OF TEST: Frequency Stability

-with Variation in Supply Voltage

RULE PART NUMBER: 2.1033 c(14), 2.1041, 2.1055(d), 90.213(a)

MINIMUM STANDARD: Shall not exceed ± 0.000100% from test frequency, 1.00 ppm for ± 15% change in supply voltage

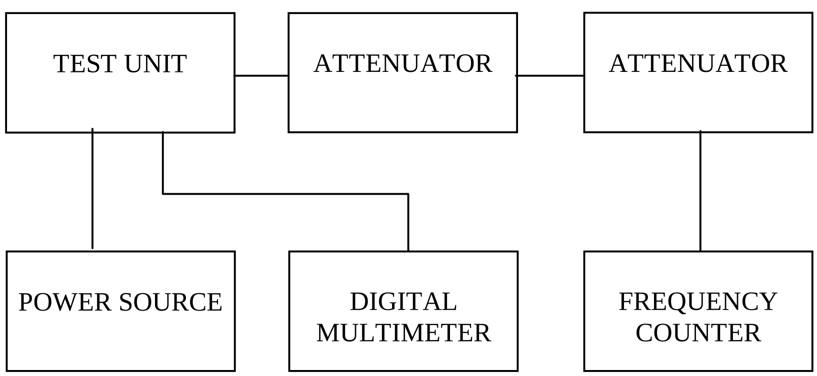
TEST RESULTS: Meets minimum standard, see data on following page

TEST CONDITIONS: Standard Test Conditions, 25 C

TEST EQUIPMENT: Attenuator, BIRD Model / 9716 / 25-A-MFN-20 / 20 dB / 25 Watt
Frequency Counter, Fluke Model 1920A
Digital Voltmeter, Fluke Model 8012A
DC Power Source, Model HP6284A

PERFORMED BY: ______________________________ DATE: 5/1/01
Allen Frederick

TEST SET-UP:



TEST SET-UP

(Test data on next page)

NAME OF TEST: Frequency Stability with Variation in Supply Voltage (Continued)

MEASUREMENTS TAKEN:

1.0 ppm Reference Oscillator

Frequency Reference Set at 25° C: 150.5000 MHz
Tolerance Requirement: 0.000010 %
Highest Variation (%): 0.000000 %
Highest Variation (ppm): 0.000 ppm

SUPPLY VDC	FREQUENCY MHz	DELT FREQ Hz	SPEC LIMIT % of assigned f	ppm from assigned frequency
10	150.5000	0	0.0001	0.0
13	**150.5000**	0	0.0001	0.0
16	150.5000	0	0.0001	0.0

NAME OF TEST: Transient Frequency Behavior

RULE PART NUMBER: 90.214

TEST CONDITIONS: The transient test was performed with the transmitter transmitting an unmodulated carrier tone. Also supplied is a transient test which was conducted with the INTEGRA modem modulating the transmitter at 4800 bps, 1.05 kHz deviation. Also supplied is a transient test which was conducted with the INTEGRA modem modulating the transmitter at 2400 bps, 1.64 kHz deviation.

MINIMUM STANDARD: **6.25 kHz channel** (used worst case numbers from 132 to 174 MHz)

TIME INTERVAL	**MAXIMUM FREQUENCY DIFFERENCE (kHz)**	**TIME (mS)**
	6.25 kHz CH	
T1	+/- 6.25	5
T2	+/- 3.125	20
T3	+/- 6.25	5

TEST RESULTS: Meets minimum standards, see data on following pages

TEST CONDITIONS: RF Power Level = 5 Watts
Standard Test Conditions, 25 °C

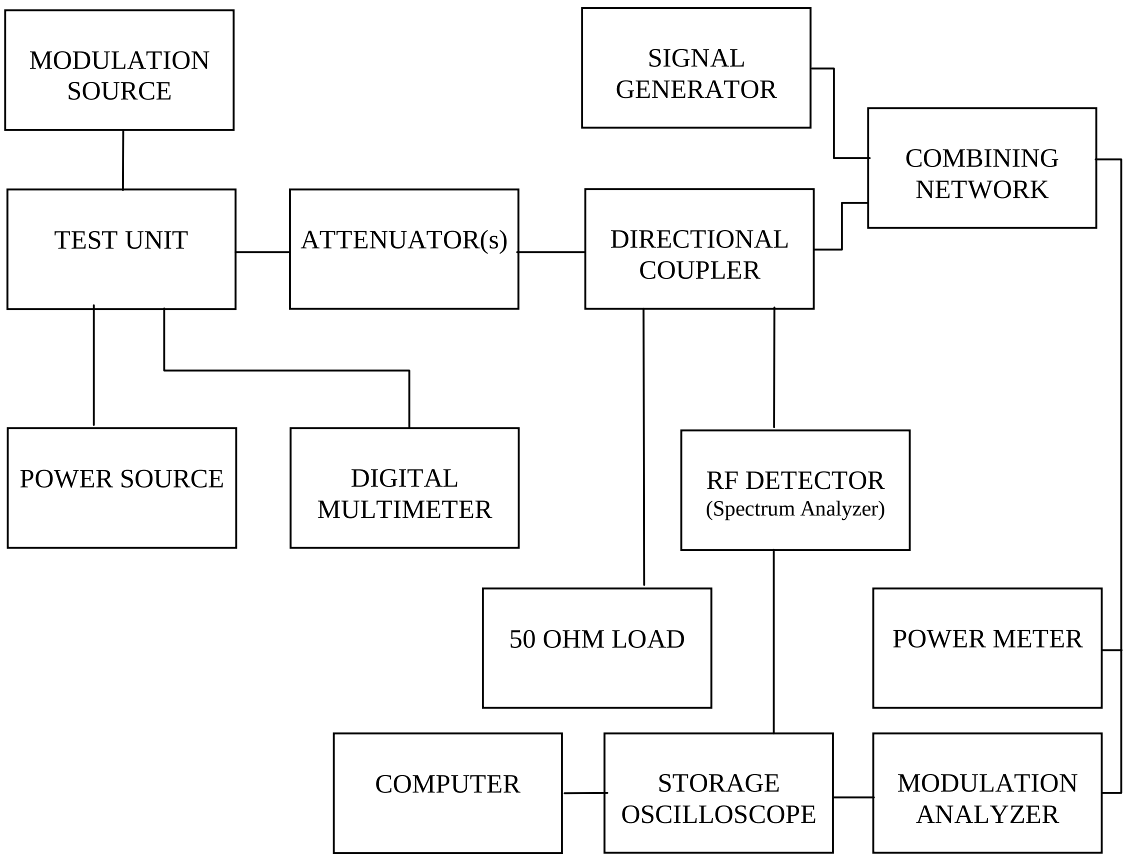
TEST PROCEDURE: TIA/EIA - 603, 2.2.19

TEST EQUIPMENT: Attenuator, BIRD Model / 9716 / 25-A-MFN-20 / 20 dB / 25 Watt
Digital Voltmeter, Fluke Model 8012A
DC Power Source, Model HP6284A
Modulation Analyzer, Model HP8901A
RF Detector (Spectrum Analyzer), Model HP8563E
Reference Generator, Fluke Model 6071A
Power Meter, Model HP436A
Power Combiner, Model MCL ZFSC-4-1
Oscilloscope, Model Tek TDS3012
Directional Coupler, Model HP778D

PERFORMED BY: Matthew D Schellin _______________________________ Date:5/30/01
Matthew D. Schellin

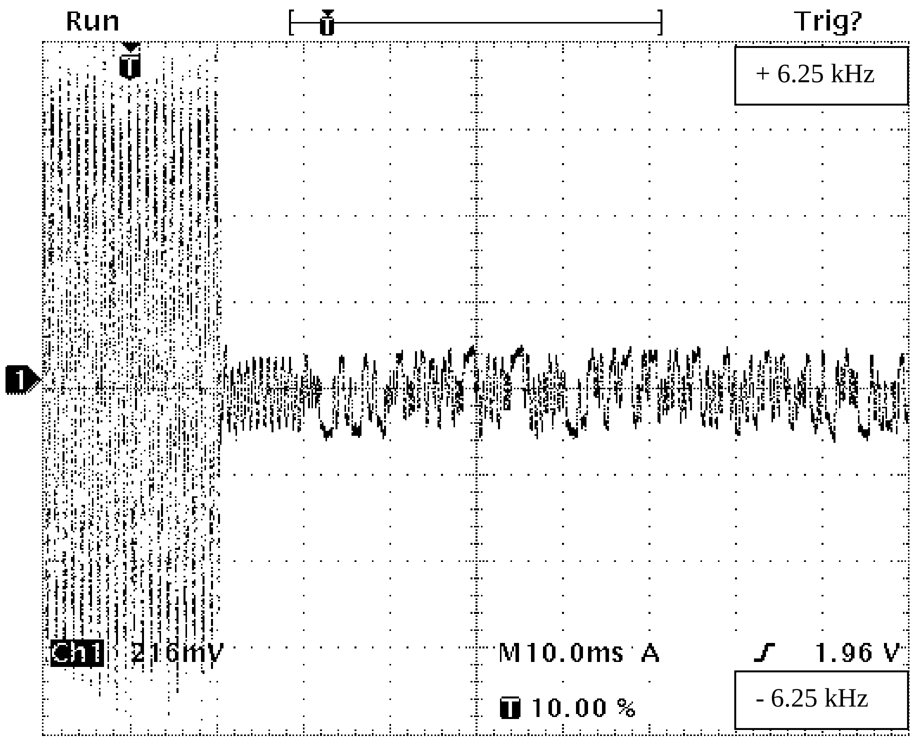
NAME OF TEST: Transient Frequency Behavior (Continued)

TEST SET-UP:

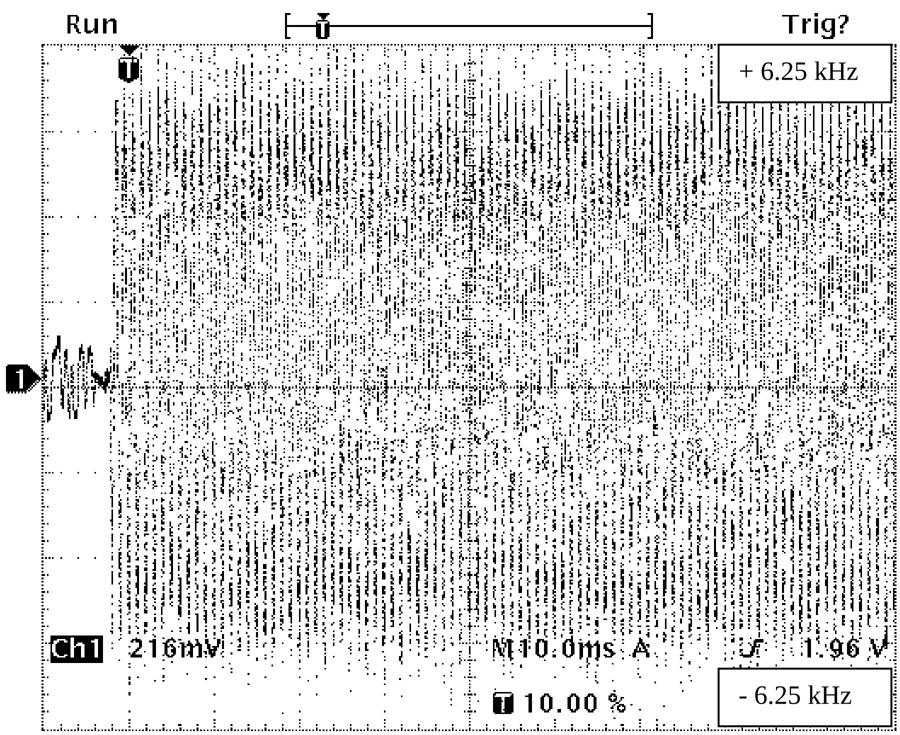


TRANSIENT FREQUENCY RESPONSE
TRANSCEIVER MODULATED BY INTEGRA MODEM 1.05 kHz DEVIATION

This corresponds to the INTEGRA modem set to 4800 bps.

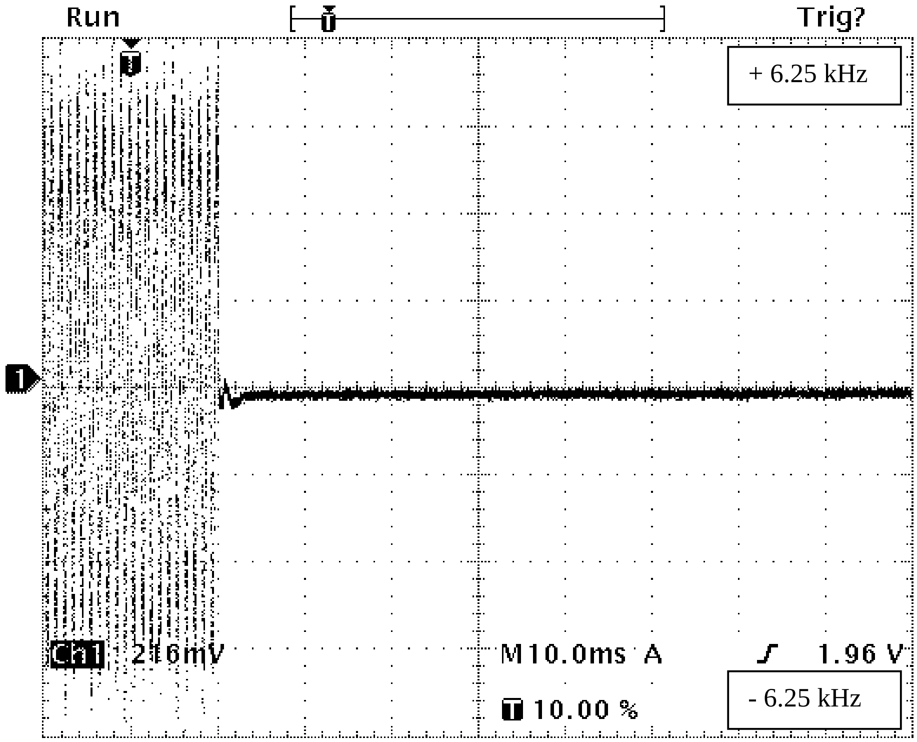


KEY UP

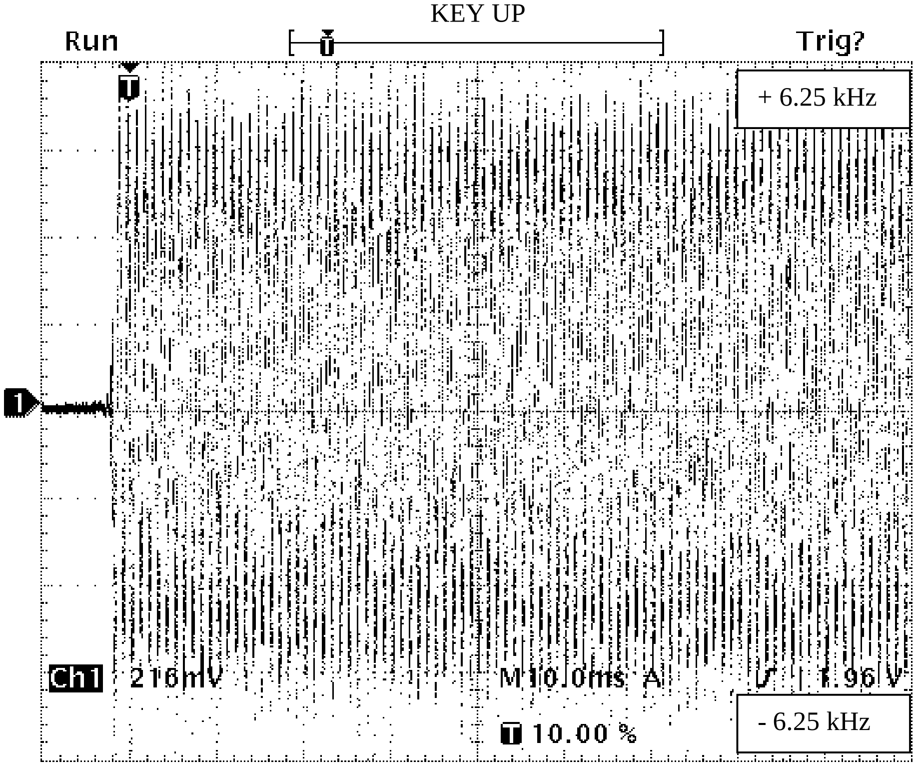


KEY DOWN

TRANSIENT FREQUENCY RESPONSE
TRANSCEIVER WITH UNMODULATED CARRIER



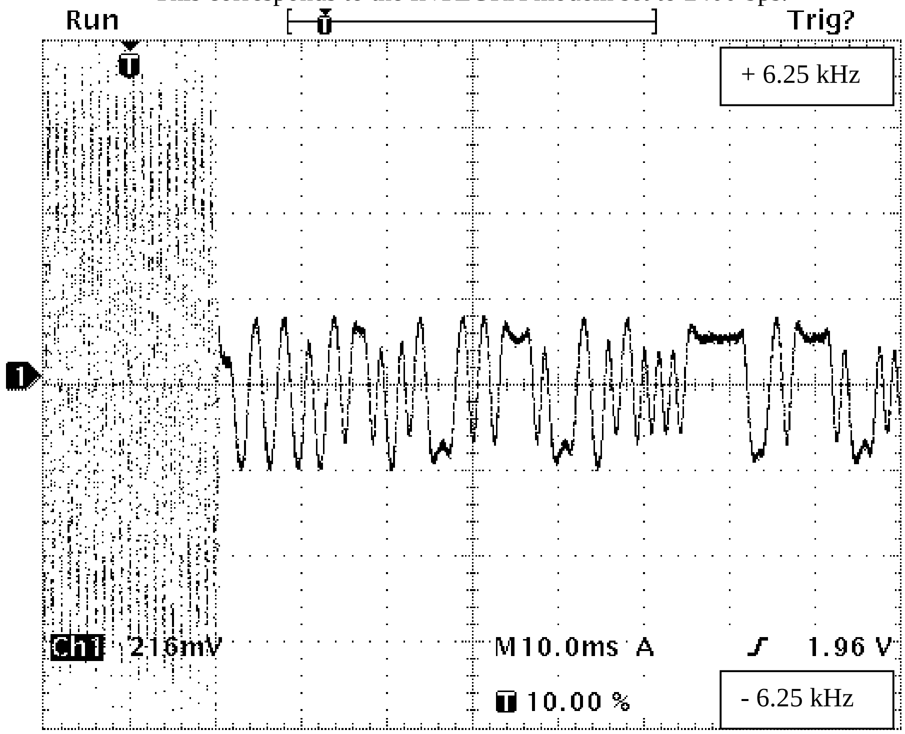
KEY UP



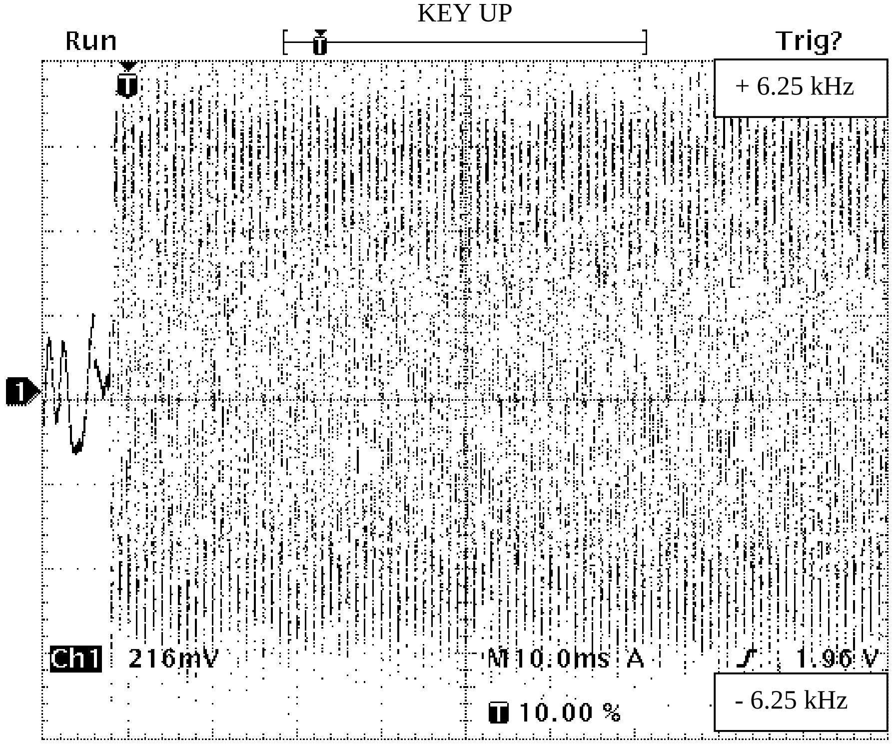
KEY DOWN

TRANSIENT FREQUENCY RESPONSE
TRANSCEIVER MODULATED BY INTEGRA MODEM

This corresponds to the INTEGRA modem set to 2400 bps.

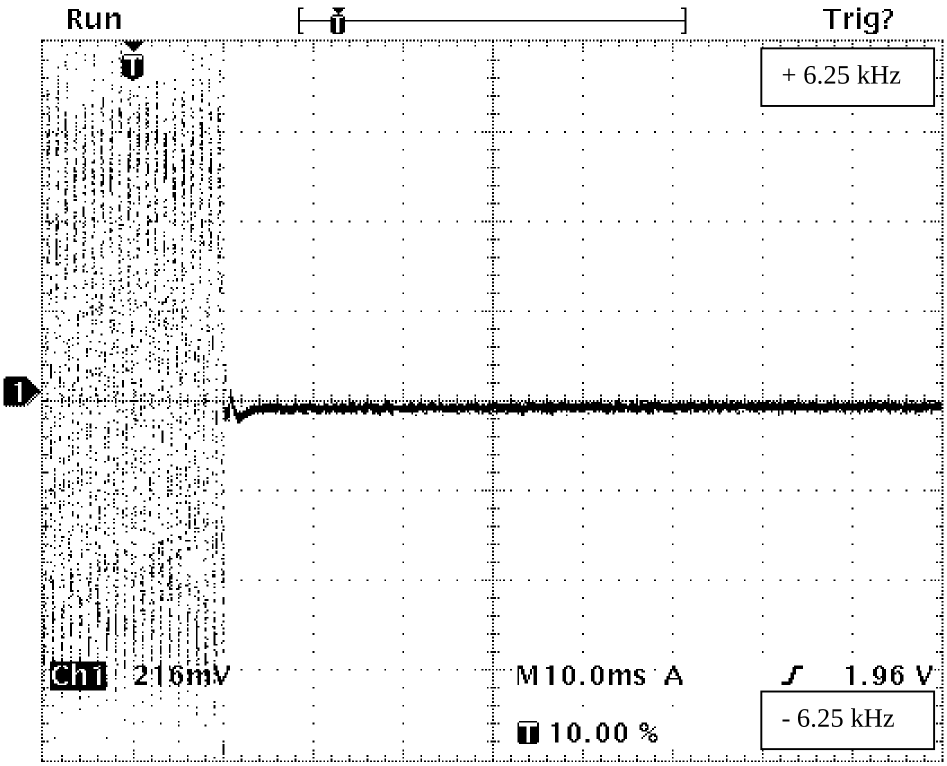


KEY UP

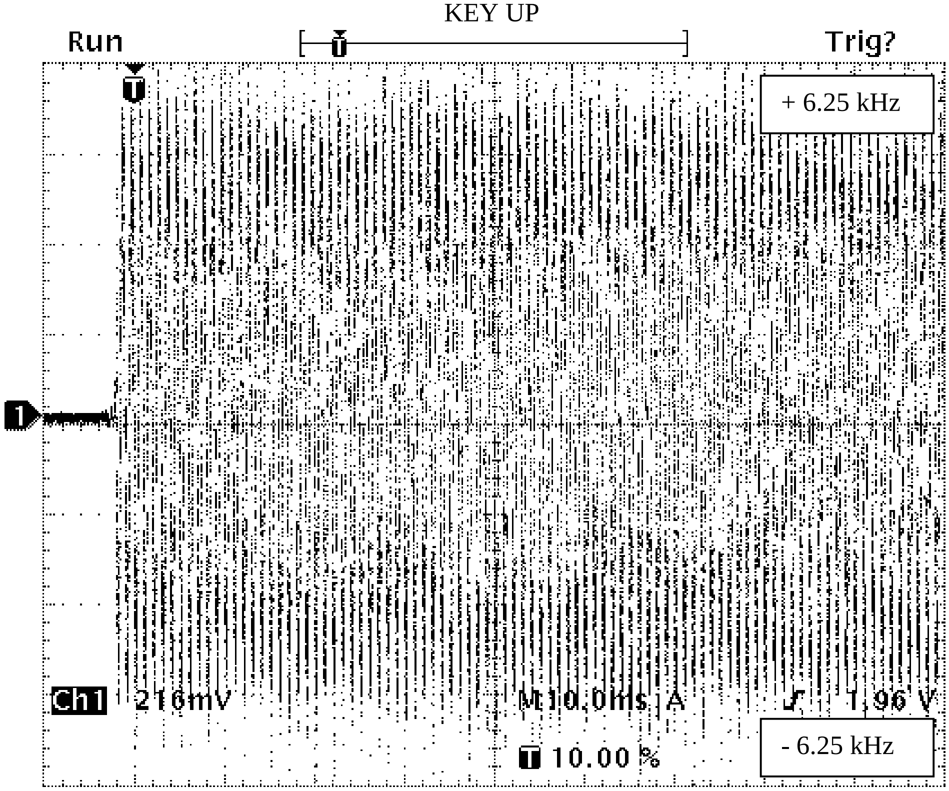


KEY DOWN

TRANSIENT FREQUENCY RESPONSE
TRANSCEIVER WITH UNMODULATED CARRIER



KEY UP



KEY DOWN