Engineering Exhibit in Support of Type Acceptance FCC Form 731

for the

DL-3412 Telemetry Transceiver With the HNET Modem

Model T-96SR

September 3, 1998

AFFIDAVIT

The technical data included in this report has been accumulated through tests that were performed by me or by engineers under my direction. To the best of my knowledge, all of the data is true and correct.

Mark Christensen
Director of Engineering, Johnson Data Telemetry

Johnson Data Telemetry Corporation
Waseca, Minnesota

ENGINEERING STATEMENT OF MARK CHRISTENSEN

The application consisting of the attached engineering exhibit and associated FCC form 731, has been prepared in support of a request for Type Acceptance for the Johnson Data Telemetry (JDT) DL-3412, 403-512 MHz Transceiver with the Data Radio T96H Modem. JDT refers to the T96H modem as the HNET, throughout this report HNET is referencing the T96H modem board. The Transceiver mated with the HNET Modem will be identified by the Johnson Data Telemetry part number 242-4046-XYZ and marketed under the Model name T-96SR. The model name T-96SR refers to the HNET modem mated with a transceiver of any frequency range (132-174 MHz, 403-512 MHz, or 928-960 MHz). The HNET mated with a transceiver in the frequency range 403-512 MHz will be referred to as the DL-4046 throughout this report. The Transceiver/Modem will be identified by the FCC number NP42424046-001. The transceiver operates pursuant to Part(s) 90 of the Rules and Regulations.

EXISTING CONDITIONS

The units utilized for these type acceptance measurements were obtained from the pilot-production. The transceiver is designed to operate on frequencies ranging from 403.000 MHz to 512.000 MHz. The frequency tolerance of the transceiver is .00015% or 1.5 parts per million. The frequency stability of the transceiver is controlled by a temperature compensated crystal oscillator (TCXO) operating at 17.5 MHz.

PROPOSED CONDITIONS

It is proposed to Type Accept the DL-4046, 403-512 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 Type Acceptance measurements were conducted in accordance with Section 2.983 of 47 CFR 1997 of the Rules and Regulations. Equipment performance measurements were made in the engineering laboratory and on the FCC certified Open Area Test Site at the E.F. Johnson Corporation Operations Center in Waseca, Minnesota. All measurements were made and recorded by myself or under my direction. The performance measurements were made between July 2, 1998 and July 25, 1998.

CONCLUSION

Given the results of the measurements contained herein, the applicant requests that Type Acceptance be granted for the 242-4046-XYZ, 403-512 MHz Transceiver/Modem as tested for data communications.

_______________________________________ 9/3/98

Mark Christensen
Director of Engineering, Johnson Data Telemetry

QUALIFICATIONS OF ENGINEERING PERSONNEL

NAME:	Allen Frederick
TITLE:	Certified Technologist
TECHNICAL EDUCATION:	Bachelor of Science Degree in Electronic Engineering Technology (1998) from Mankato State University.
TECHNICAL EXPERIENCE:	2 years experience in analog and radio frequency communications.

NAME:	Constantin Pintilei
TITLE:	R&D Test Engineer

GENERAL INFORMATION

The following report has been generated for FCC Type Acceptance of the Johnson Data Telemetry (JDT) part number 242-4046-XYZ, 403-512 MHz Transceiver/Modem. Unless otherwise noted, all of the measurements were conducted following the procedures set forth in the TIA/EIA-603 standards.

MODEL NUMBER:	T-96SR
PART NUMBER:	242-4046-XYZ
MANUFACTURER:	Johnson Data Telemetry, Waseca, MN 56093
FCC ID NUMBER:	FCC ID: NP42424046-001
FCC RULES AND REGS:	FCC Part (s) 90
FREQUENCY RANGE:	Frequency 403.000 MHz - 512.000 MHz
SERIAL NUMBER (S):	403.000 MHz - 13424 450.000 MHz - 13446 512.000 MHz - 10023

TRANSMITTER

TYPE OF EMISSION:	12.5KHz BW (9600bps) 9K3F1D, 11K0F1D 25KHz BW (19.2Kbps) 15K3F1D, 16K0F1D
MAXIMUM POWER RATING:	5.00 Watts (1-5 W variable)
NUMBER OF CHANNELS:	8 Channel Modem
INPUT IMPEDANCE:	50 ohms, Nominal
VOLTAGE REQUIREMENTS:	13.3 VDC, Nominal

EQUIPMENT IDENTIFICATION:

TRADE NAME	**DESCRIPTION**	**JDT PART NUMBER**
DL-3412	403-512 MHz Transceiver	242-3412-XYZ
HNET	Modem	050-03280-00F

NAME OF TEST: Transmitter Rated Power Output

RULE PART NUMBER: 2.983 (d)(5), 2.985 (a)

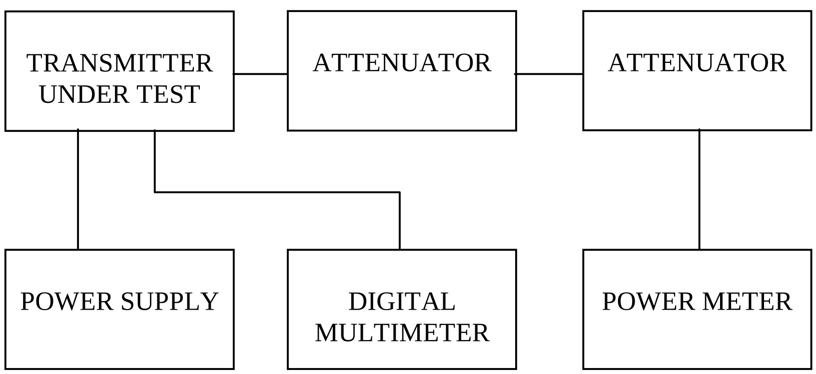
TEST RESULTS: See results below

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, HP 436A

PERFORMED BY: ____________________ DATE: 7/14/98
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)**
450.000	13.3	1.75	23.28	5.0

NAME OF TEST: Transmitter Occupied Bandwidth

RULE PART NUMBER: 2.201, 2.202, 2.989 (h), 90.209 (b)(5), 90.210 (d)

Necessary Bandwidth Measurement: (Sample)

This radiomodem 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:

Peak deviation = ±4 kHz
Modulator signal bit rate 19200 bps,

Bn=15260 Hz
The corresponding emission designator prefix for necessary bandwidth = 15K3

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Table 1 - Measurements results for the HNET unit , 9600 bps BT.3 and 19200 bps BT.3 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	
9600 BT.3	3.0	9.24	9K30
19200 BT.3	4.0	15.26	15K3

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You can rebuild your own measurement set-ups following the descriptions.

For 900 MHz bandwidth:
Same results for necessary bandwidth measurements are for both FCC parts 90 and 101 for 900 MHz.

Also, for VHF and UHF units you will have :
Spectrum efficiency (90.203 (j)(3)) requirement: 4800 bits per second per 6.25 kHz of channel bandwidth.
19200bps=4*4800bps so it is efficient for 25 kHz channel
9600bps=2*4800bps so it is efficient for 12.5 kHz channel

ANNEX….

Occupied Bandwidth Measurement

1. 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), so the mathematics for it are:

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

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

$$OBW=f2-f1$$

where TP (total mean power) is

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

and PSD (power spectral distribution) is

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

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 the RF signal’s trace provided by a digital spectrum analyzer and processed further by computational methods.

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:

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

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.500, k=0.8 (20/25) for 25kHz channel transmitters or k=0.9 (11.25/12.5) for 12.5kHz channel transmitters, so a.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.

The second part has computational requirements related to the trace's values processing.

The following operations must be performed over the trace's (x,y) points:

1. convert y value in dBm (or the analyzer's display y units) units power sample
2. convert y value in W units power sample,
3. add to total power every power sample and get total power value (W units for total power)
4. set low level (0.5%*total power)
5. detect x1-sample which pass low level (convert f1 integrals to sample summing)
6. convert (x1-1)-sample value in frequency units (the x-sample is already in occupied bandwidth),
7. store first frequency correspondent to (x1-1)-sample
8. set up level (99.5%*total power)
9. detect x2-sample which pass up level (convert f2 integrals to sample summing)
10. convert (x2)-sample value in frequency units (the x-sample is now out of occupied bandwidth),
11. store second frequency correspondent to (x2)-sample
12. read the frequency difference , this is ***Occupied Bandwidth***, and display the result.

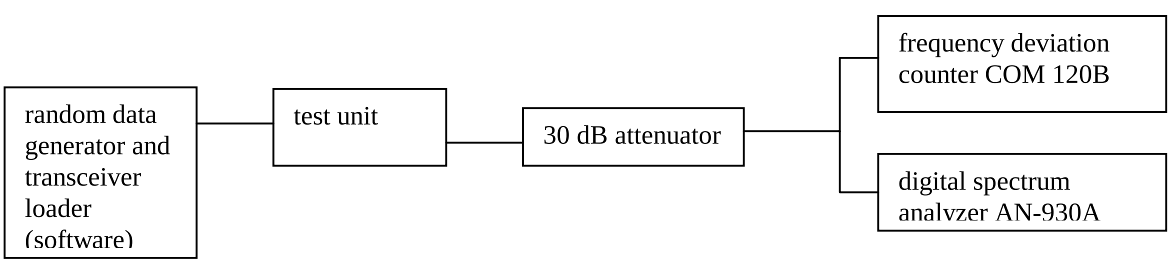
Standard calculation precision is all that is required. The main error factor being the y display resolution is covering calculation precision.

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.

2. Dataradio's Measurement Set-Up

For the above requirements, the occupied bandwidth of a transmitter was measured using an IFR AN930 A spectrum analyzer having adequate macrofunction to perform computational part. The number of power spectrum samples (N) is 500. Because in test results frequency deviation was also a parameter, measurement instruments were completed with an IFR COM-120 B for frequency deviation determination.

The measurement set-up is:



The AN-930 A spectrum analyzer's parameters are adjusted as follow:
-total span is adjusted at 2.8*channel space this means 70 kHz for 25 kHz channel and 35 kHz for 12.5 kHz channel. This setting will result in frequency sample step (f) of 140 Hz for 25 kHz channel and 70 Hz for 12.5 kHz channel.
-RBW is set to 300 Hz, this is better than 1% of total span bandwidth.

-video filter is set to 1Khz;
-all other parameter of the instrument are automatically adjusted to obtain calibrated measurements (sweep time 4s).
-central frequency and reference level are adjusted to the unmodulated carrier frequency and level.

The AN 930 A spectrum analyzer's Occupied Bandwidth macrofunction input parameters are:
-central frequency, same as above, the unmodulated carrier frequency.
-channel spacing, 25 kHz or 12.5 kHz according to the signal,
-percentage of Occupied Bandwidth 99%.

The macro operations are:
-the trace is read;
-follow all the computational steps required.

Each sample is converted from dBm to mW and add to total power (tpow) variable. Then are computed the limits of 0.5% and 99.5% by using variable remaining percent (RemPer), and in same time are stored sample number where these two percentage meet. Then are assigned to the markers the correspondent frequencies of numbers.

- Occupied Bandwidth is then displayed as Delta mode marker (difference between markers).
-return to operational mode.

NOTE 1: The computational part could be performed on every device featured with data acquisition.
NOTE 2: An approximation of the occupied bandwidth calculation can be performed by measuring at the points at which the spectrum, measured with a spectrum analyzer of 300 Hz resolution bandwidth, is 25dB down relative to the unmodulated carrier reference level.

Constantin Pintilei
R&D Test Engineer

NAME OF TEST: Transmitter Occupied Bandwidth
HNET Modem at 9600 bps
In Support of Emission Designator **9K3F1D**

RULE PART NUMBER: 2.201, 2.202, 2.989 (h), 90.209 (b)(5), 90.210 (d)

MINIMUM STANDARD: Mask D
Sidebands and Spurious [Rule 90.210 (d), P = 5 Watts]
Authorized Bandwidth = 11.25 kHz [Rule 90.209(b) (5)]
From Fo to 5.625 kHz, down 0 dB. Greater than 5.625 kHz to 12.5 kHz, down 7.27(f_d-2.88kHz) dB. Greater than 12.5 kHz, at least 50+10$\log_{10}$(P) or 70 dB, whichever is the lesser of the attenuation.

Attenuation = 0 dB at Fo to 5.625 kHz
Attenuation = 20 dB at 5.625 kHz and 70 dB at 12.5 kHz
Attenuation = 57 dB at > 12.5 kHz

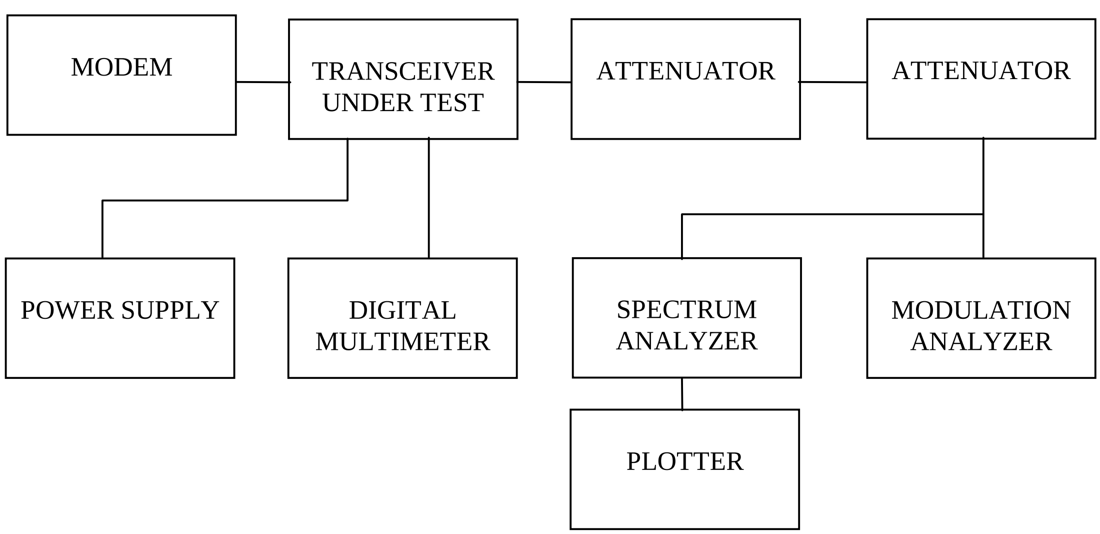
TEST RESULTS: Meets minimum standard (see data on the following pages)

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
Modulation Analyzer, Model HP8901A
Spectrum Analyzer, Model HP8563E
Plotter, HP7470A

PERFORMED BY: Allen Frederick DATE: 7/21/98

TEST SET-UP:



NAME OF TEST: Transmitter Occupied Bandwidth (Continued)
HNET Modem at 9600 bps
In Support of Emission Designator **9K3F1D**

MODULATION SOURCE DESCRIPTION:

The digital modulation type used in the HNET 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 then 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 30 s 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.

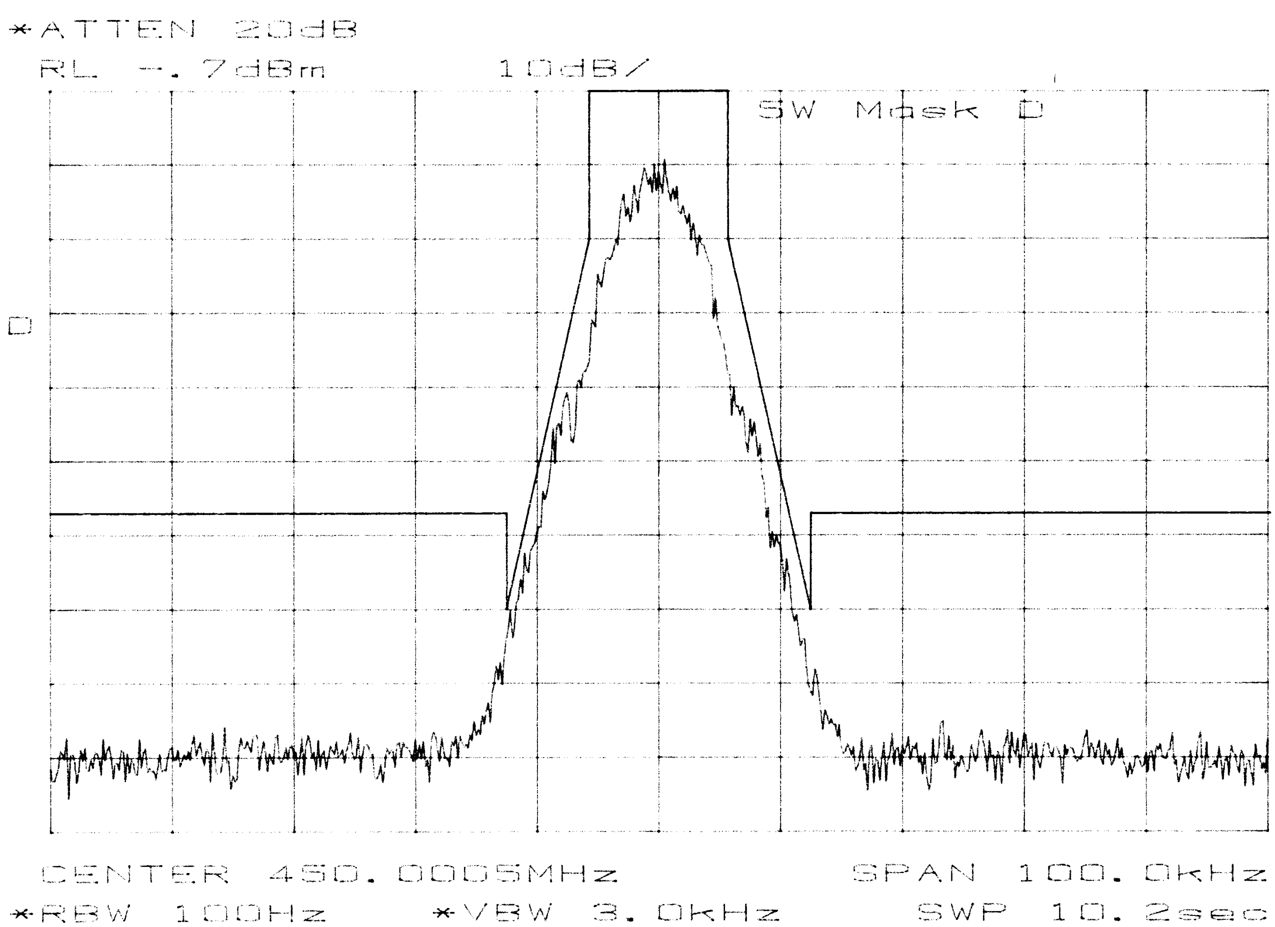
NECESSARY BANDWIDTH (Bn) CALCULATION

See Page 25 for emission designator determination.

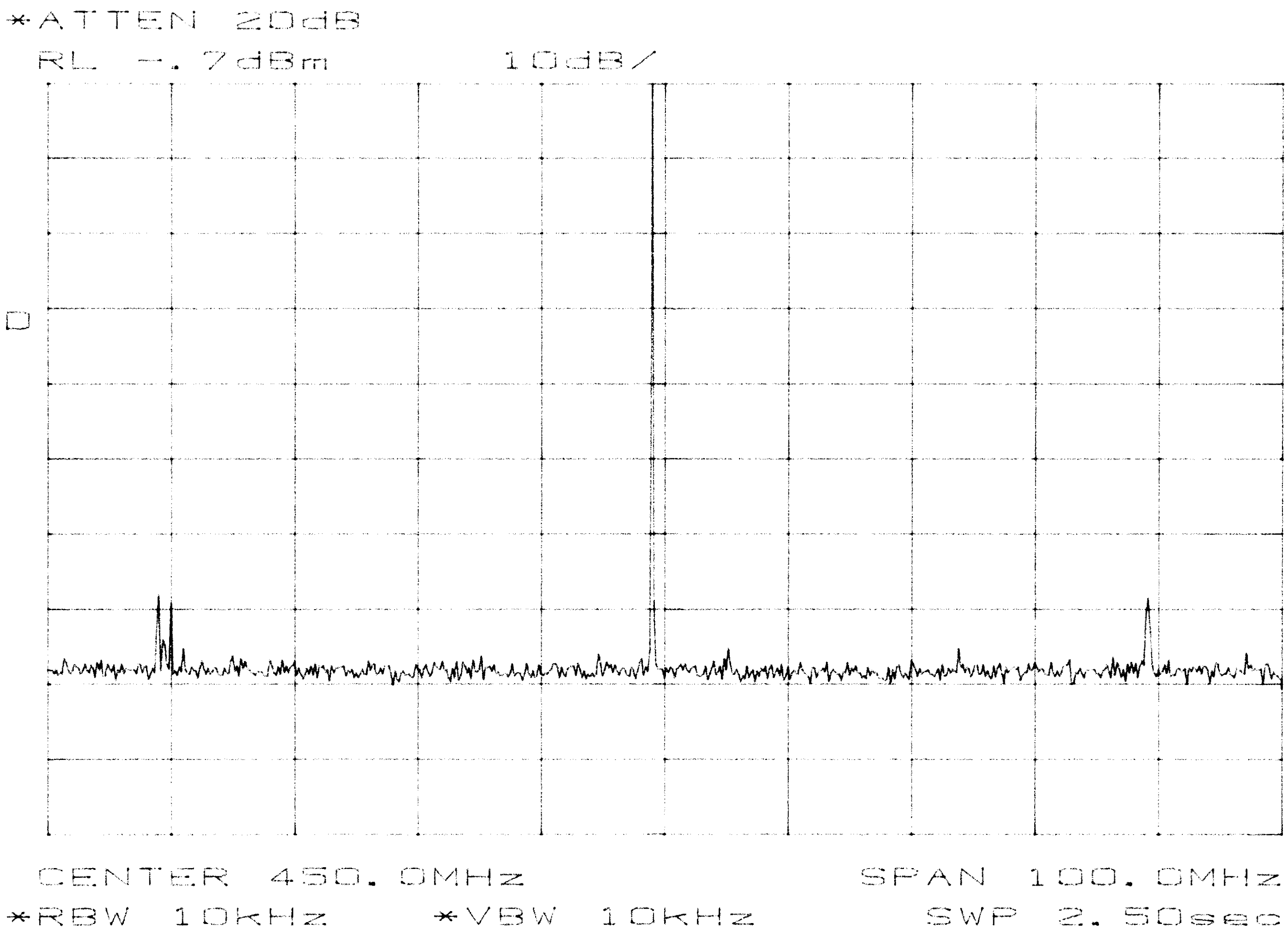
The corresponding emission designator prefix for necessary bandwidth = **9K3.**

TEST DATA: Refer to the following graphs:

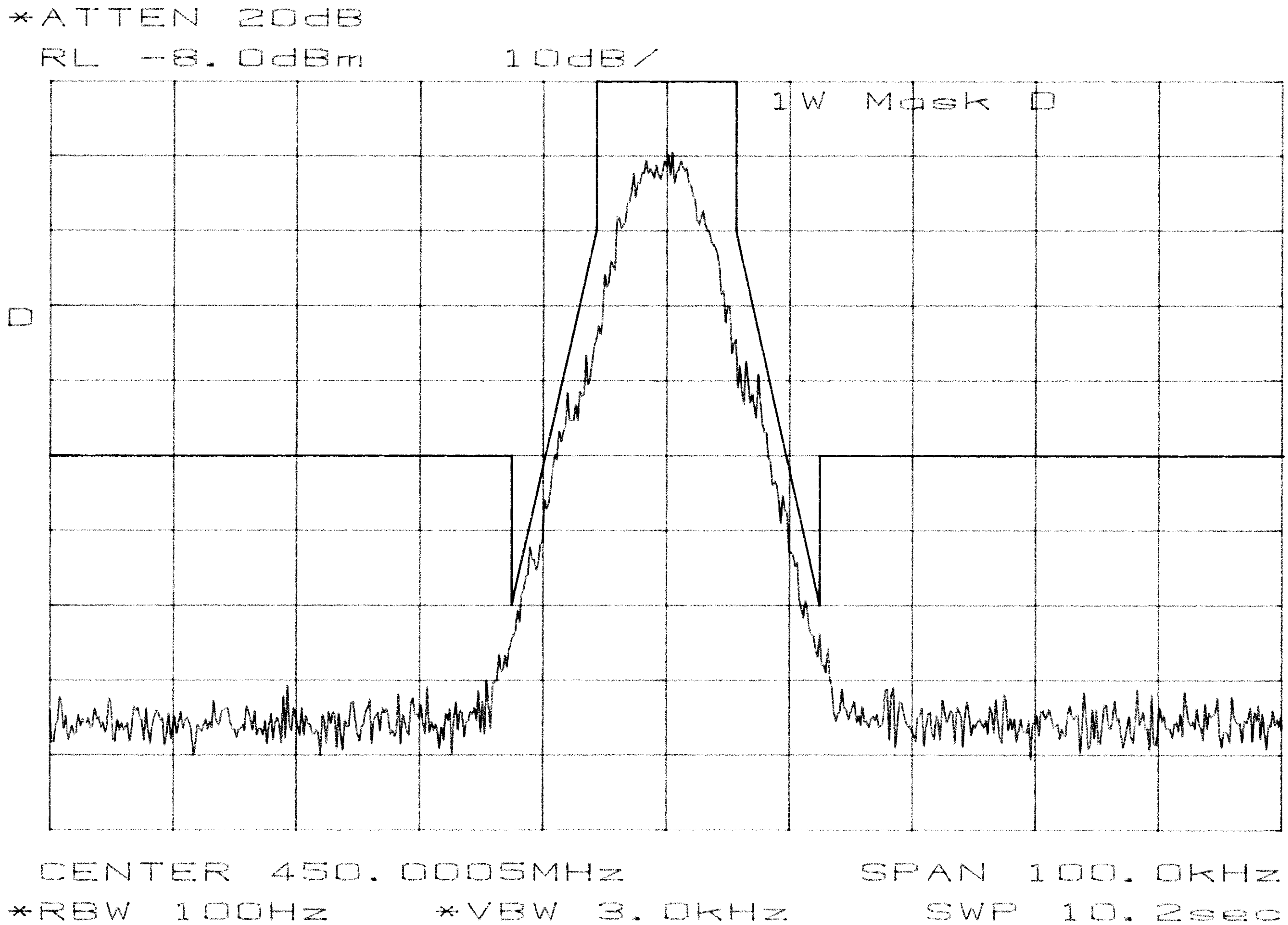
MASK: **D**
SPECTRUM FOR EMISSION **9K3F1D**
OUTPUT POWER: 5 Watts
9600 bps
PEAK DEVIATION = 3000 Hz
SPAN = 100 kHz



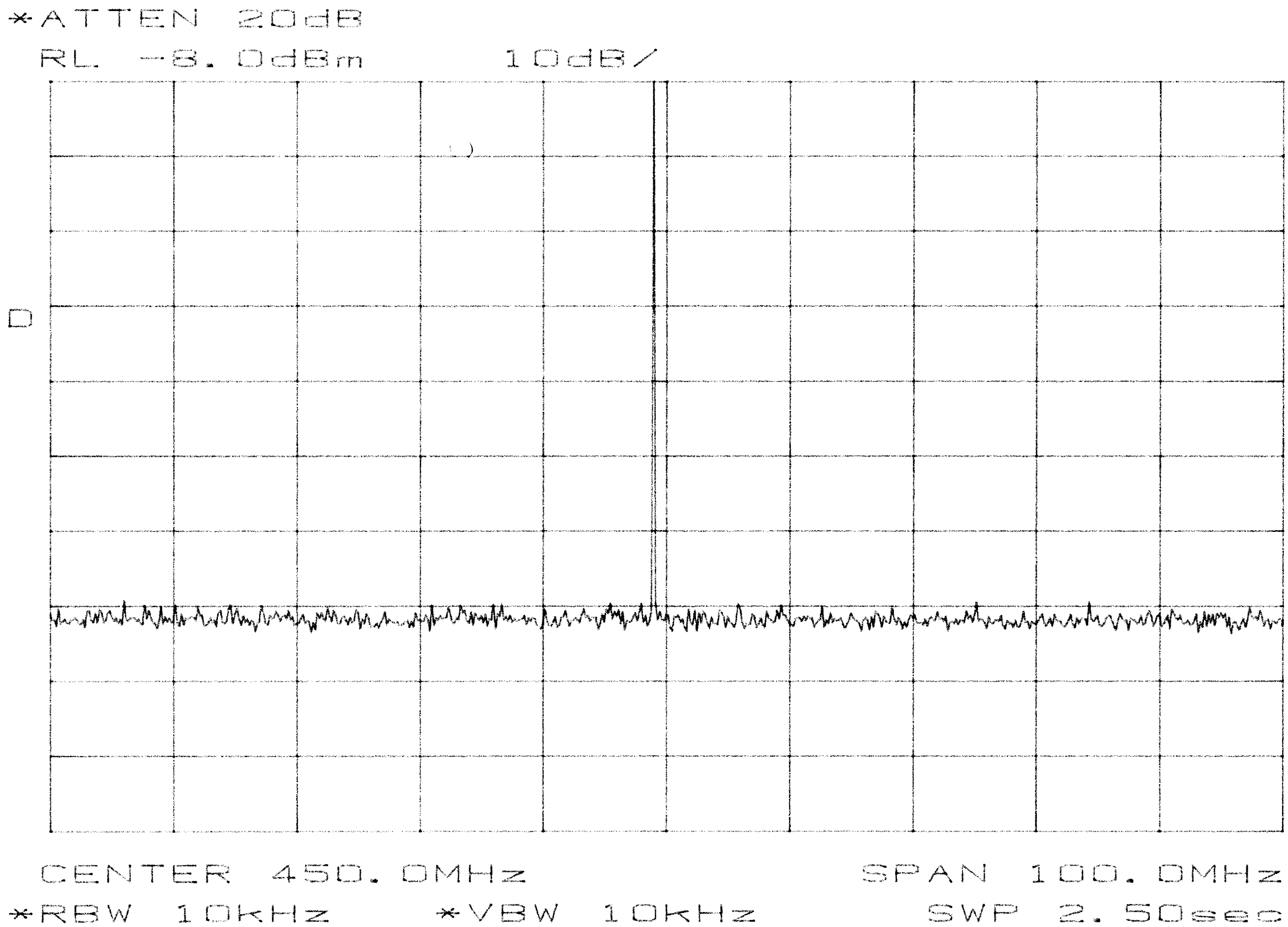
MASK: **D**
SPECTRUM FOR EMISSION **9K3F1D**
OUTPUT POWER: 5 Watts
9600 bps
PEAK DEVIATION = 3000 Hz
SPAN = 100 MHz



MASK: **D**
SPECTRUM FOR EMISSION **9K3F1D**
OUTPUT POWER: 1 Watts
9600 bps
PEAK DEVIATION = 3000 Hz
SPAN = 100 kHz



MASK: **D**
SPECTRUM FOR EMISSION **9K3F1D**
OUTPUT POWER: 1 Watts
9600 bps
PEAK DEVIATION = 3000 Hz
SPAN = 100 MHz



NAME OF TEST: Transmitter Occupied Bandwidth
HNET Modem at 19200 bps
In Support of Emission Designator **15K3F1D**

RULE PART NUMBER: 2.201, 2.202, 2.989 (h), 90.209 (b)(5), 90.210 (d)

MINIMUM STANDARD: Mask B
Sidebands and Spurious [Rule 90.210 (b), P = 5 Watts]
Authorized Bandwidth = 20 kHz [Rule 90.209(b) (5)]
From Fo to 50% of Authorized BW Removed from Fo, down 0 dB.
From 50% to 100% removed, at least 25 dB.
From 100% to 250% removed, at least 35 dB.
Greater than 250% remove, at least 43 + $10\log_{10}(P)$ dB.

Fo to 10 kHz Attenuation = 0 dB
10 kHz to 20 kHz, Attenuation = 25 dB minimum
20 kHz to 50 kHz, Attenuation = 35 dB minimum
> 50 kHz, Attenuation = 50 dB minimum (5 watts)
> 50 kHz, Attenuation = 43 dB minimum (1 watt)

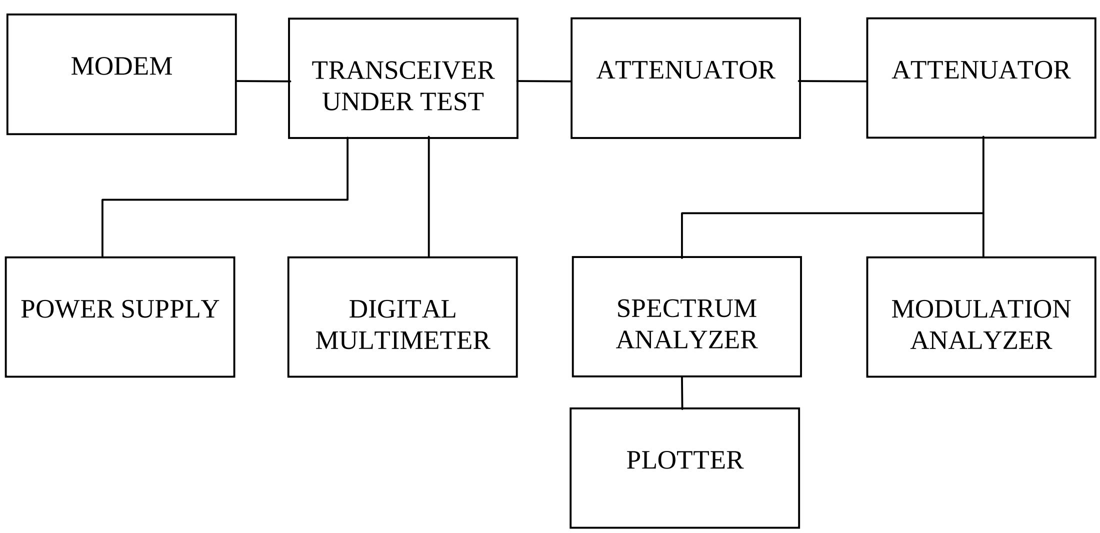
TEST RESULTS: Meets minimum standard (see data on the following pages)

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
Modulation Analyzer, Model HP8901A
Spectrum Analyzer, Model HP8563E
Plotter, HP7470A

PERFORMED BY: Allen Frederick DATE: 7/21/98
Allen Frederick

TEST SET-UP:



NAME OF TEST: Transmitter Occupied Bandwidth (Continued)
HNET Modem at 19200 bps
In Support of Emission Designator **15K3F1D**

MODULATION SOURCE DESCRIPTION:
The digital modulation type used in the HNET 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 30 s 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.

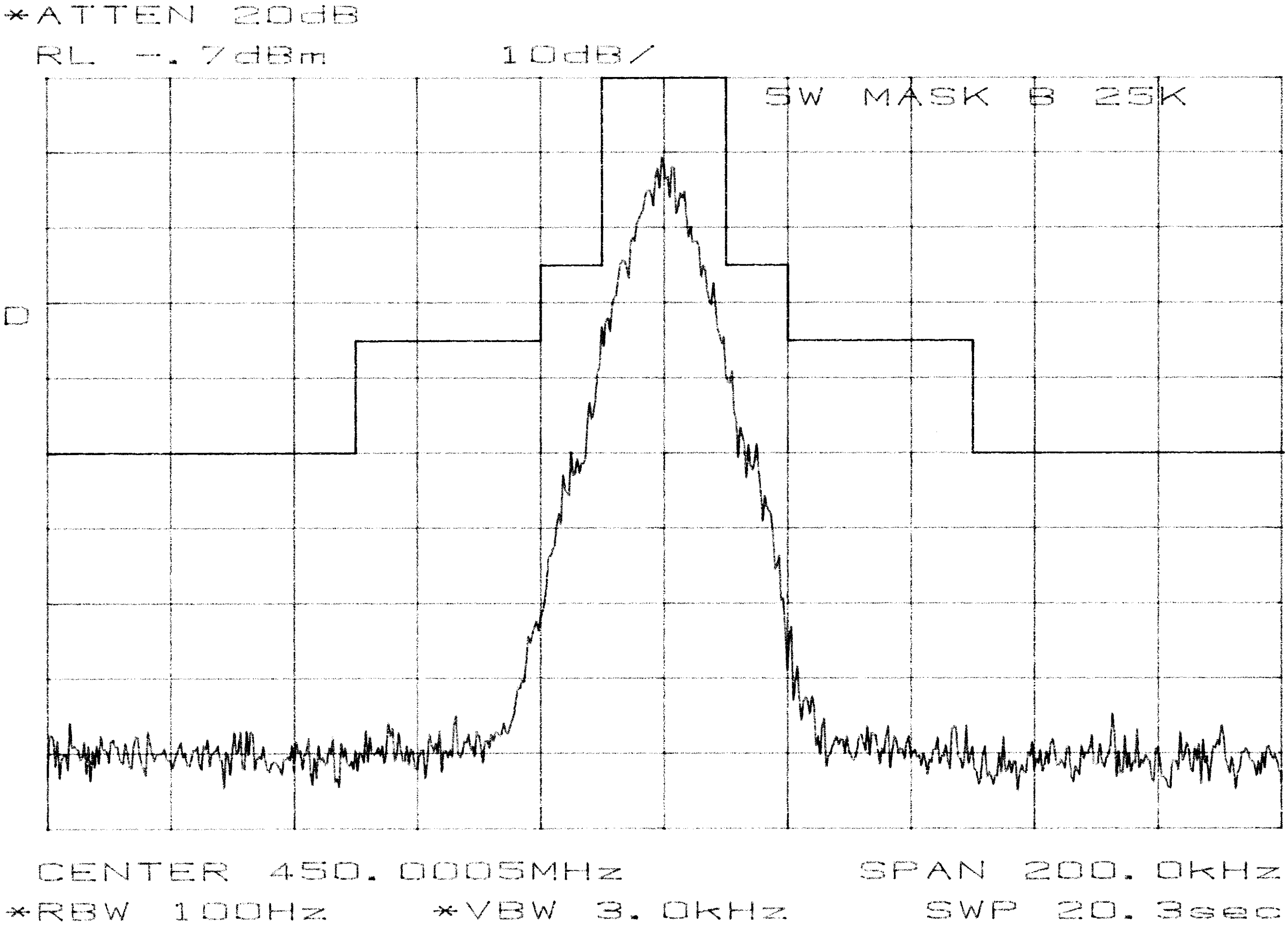
NECESSARY BANDWIDTH (Bn) CALCULATION

See Page 25 for emission designator determination.

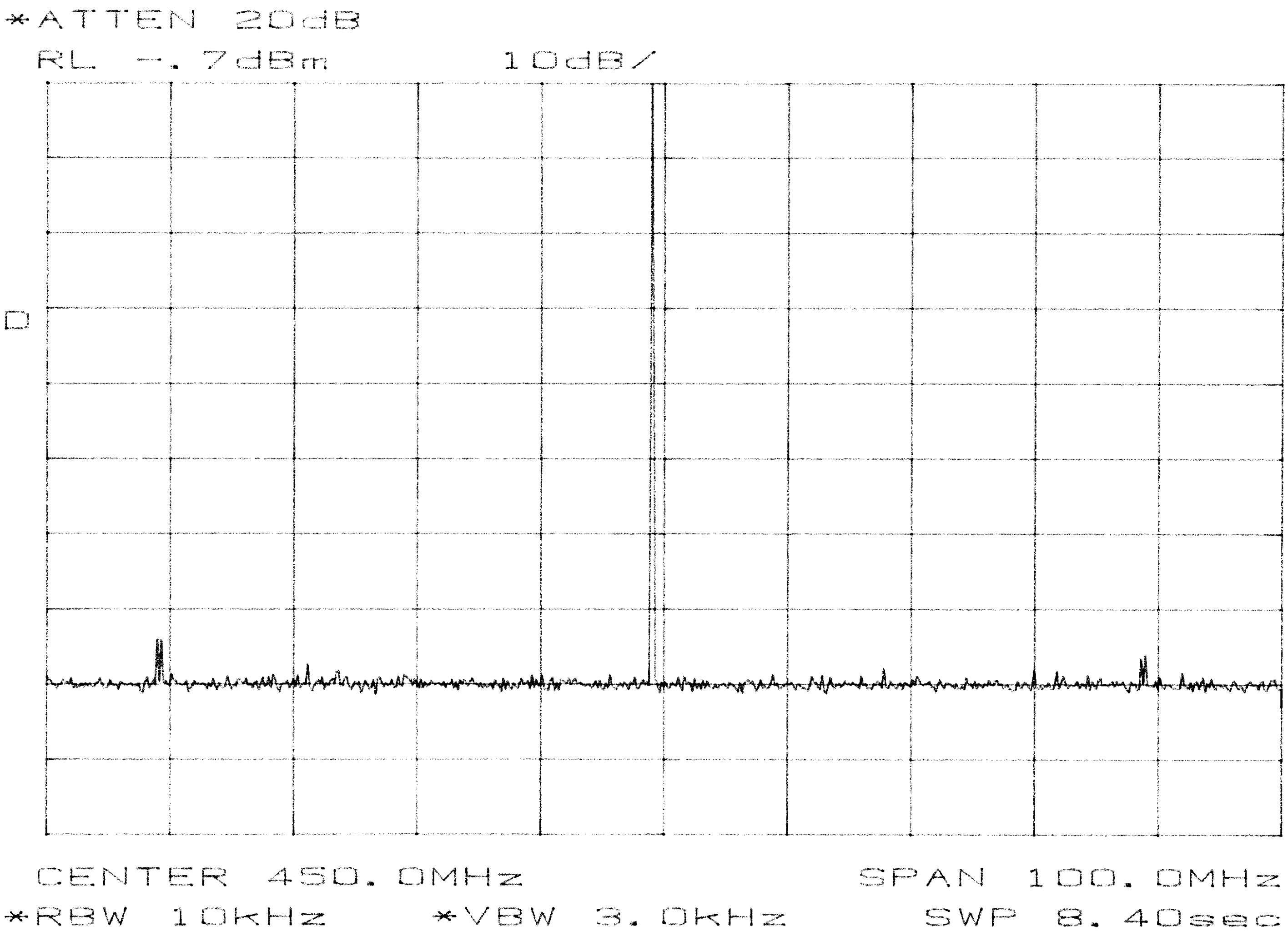
The corresponding emission designator prefix for necessary bandwidth = **15K3**

TEST DATA: Refer to the following graphs:

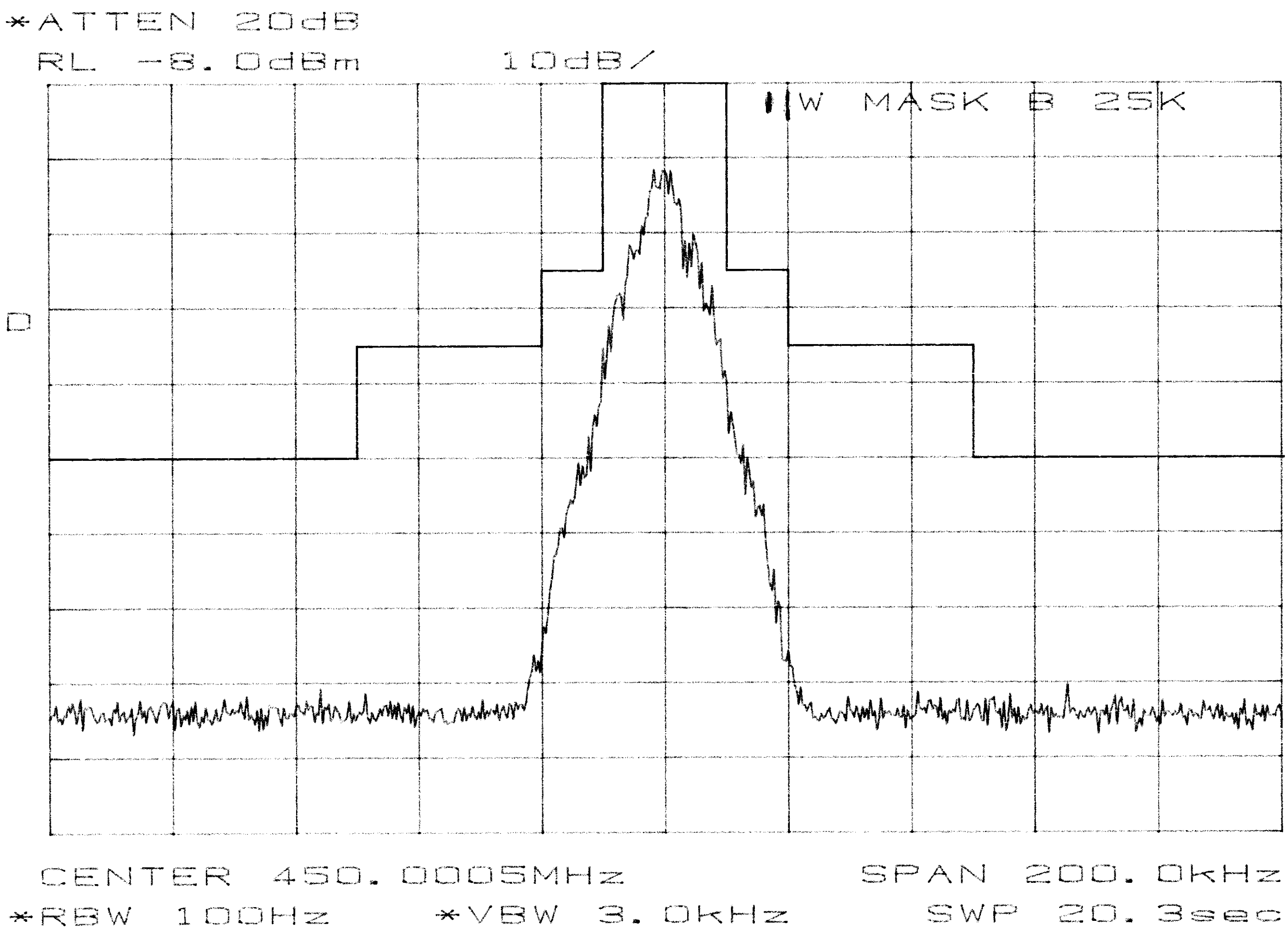
MASK: **B**
SPECTRUM FOR EMISSION **15K3F1D**
OUTPUT POWER: 5 Watts
19200 bps
PEAK DEVIATION = 4000 Hz
SPAN = 200 kHz



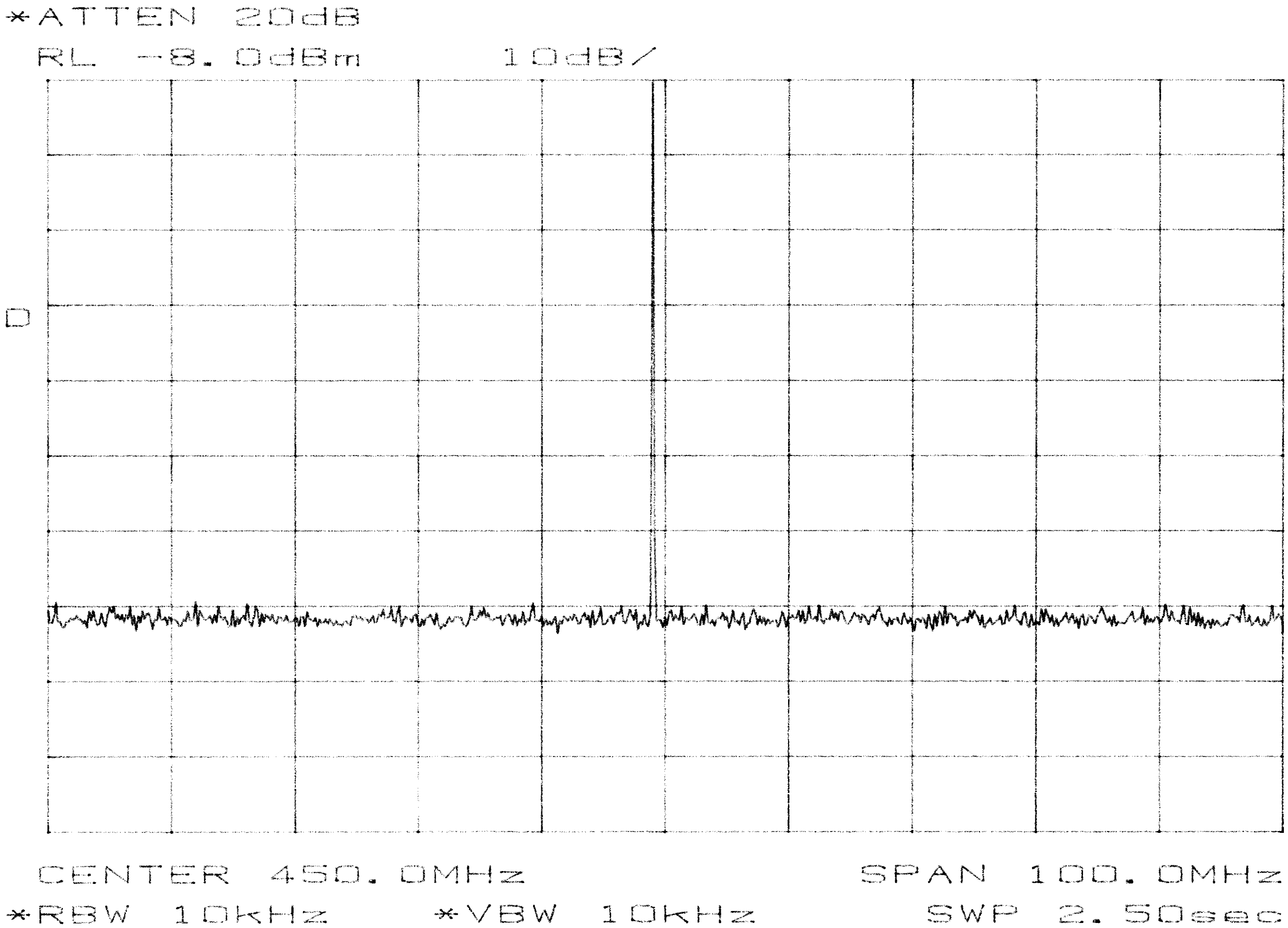
MASK: **B**
SPECTRUM FOR EMISSION **15K3F1D**
OUTPUT POWER: 5 Watts
19200 bps
PEAK DEVIATION = 4000 Hz
SPAN = 100 MHz



MASK: **B**
SPECTRUM FOR EMISSION **15K3F1D**
OUTPUT POWER: 1 Watts
19200 bps
PEAK DEVIATION = 4000 Hz
SPAN = 200 kHz



MASK: **B**
SPECTRUM FOR EMISSION **15K3F1D**
OUTPUT POWER: 1 Watts
19200 bps
PEAK DEVIATION = 4000 Hz
SPAN = 100 MHz



NAME OF TEST: Transmitter Spurious and Harmonic Outputs

RULE PART NUMBER: 2.991, 90.210 (d)(3)

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

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

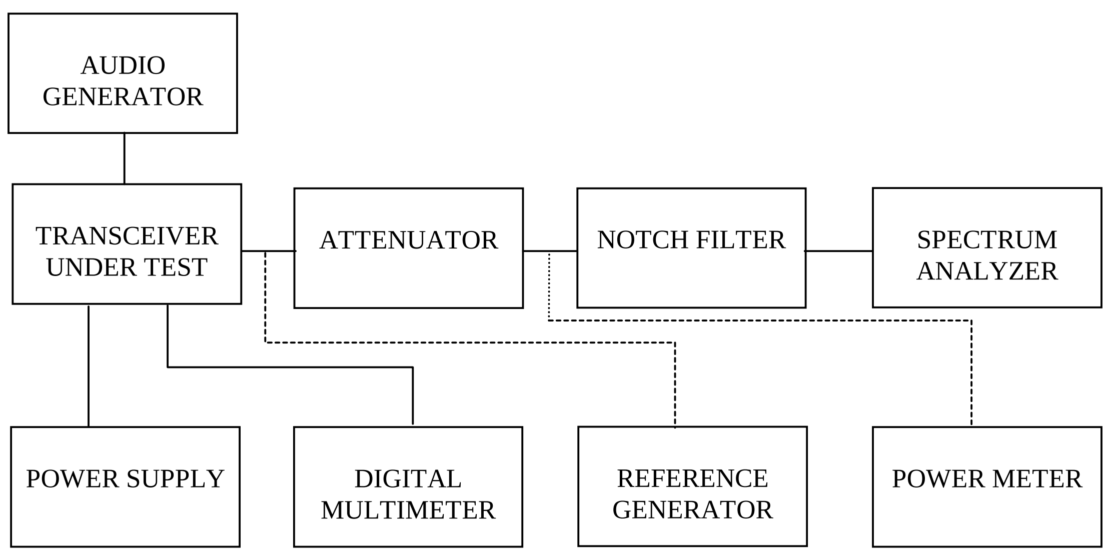
TEST CONDITIONS: Standard Test Conditions, 25 C
RF voltage measured at antenna terminals

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
Spectrum Analyzer, Model HP8563E
Plotter, HP7470A
Reference Generator, Model HP83732B
Power Meter, Model HP436A
Audio Generator, Model HP8903B

PERFORMED BY: Allen Frederick (signature) Date:7/27/98
Allen Frederick

TEST SET-UP:



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

MEASUREMENT PROCEDURE:

1. The transmitter carrier output frequency is 403.000, 457.000 and 512.000 MHz. The reference oscillator frequency is 17.5000 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:

F_o = 403.000 MHz
5 Watts = 37dBm

Transmitter Spurious and Harmonics

Frequency (MHz)	Relation	Level (dBm)	Level Relative To Carrier (dBc)
806	2 Fo	-47	-84
1209	3 Fo	-35	-72
1612	4 Fo	-39	-76
2015	5 Fo	-54	-91
2418	6 Fo	-54	-91
2821	7 Fo	-44	-81
3224	8 Fo	-58	-95
3627	9 Fo	-57	-94
4030	10 Fo	-56	-93

F_o = 457.000 MHz
5 Watts = 37dBm

Transmitter Spurious and Harmonics

Frequency (MHz)	Relation	Level (dBm)	Level Relative To Carrier (dBc)
914	2 Fo	-35	-72
1371	3 Fo	-34	-71
1828	4 Fo	-50	-87
2285	5 Fo	-45	-82
2742	6 Fo	-56	-93
3199	7 Fo	-46	-83
3656	8 Fo	-54	-91
4113	9 Fo	-59	-96
4570	10 Fo	< -82	< -119

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

F_o = 512.000 MHz
5 Watts = 37dBm

Transmitter Spurious and Harmonics

Frequency (MHz)	Relation	Level (dBm)	Level Relative To Carrier (dBc)
1024	2 Fo	-36	-73
1536	3 Fo	-52	-89
2048	4 Fo	-53	-90
2560	5 Fo	-42	-79
3072	6 Fo	-37	-74
3584	7 Fo	-53	-90
4096	8 Fo	-56	-93
4608	9 Fo	-61	-98
5120	10 Fo	-64	-101

F_o = 403.000 MHz
1 Watts = 30 dBm

Transmitter Spurious and Harmonics

Frequency (MHz)	Relation	Level (dBm)	Level Relative To Carrier (dBc)
806	2 Fo	-41	-71
1209	3 Fo	-41	-71
1612	4 Fo	-49	-79
2015	5 Fo	-61	-91
2418	6 Fo	-60	-90
2821	7 Fo	-65	-95
3224	8 Fo	-65	-95
3627	9 Fo	-54	-84
4030	10 Fo	<-84	< -114

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

F_o = 457.000 MHz
1 Watts = 30 dBm

Transmitter Spurious and Harmonics

Frequency (MHz)	Relation	Level (dBm)	Level Relative To Carrier (dBc)
914	2 Fo	-49	-79
1371	3 Fo	-46	-76
1828	4 Fo	-66	-96
2285	5 Fo	-54	-84
2742	6 Fo	-70	-100
3199	7 Fo	-44	-74
3656	8 Fo	-59	-89
4113	9 Fo	-59	-89
4570	10 Fo	-76	-106

F_o = 512.000 MHz
1 Watts = 30 dBm

Transmitter Spurious and Harmonics

Frequency (MHz)	Relation	Level (dBm)	Level Relative To Carrier (dBc)
1024	2 Fo	-51	-81
1536	3 Fo	-61	-91
2048	4 Fo	-60	-90
2560	5 Fo	-53	-83
3072	6 Fo	-55	-85
3584	7 Fo	-51	-81
4096	8 Fo	-63	-93
4608	9 Fo	-76	-106
5120	10 Fo	<-84	< -114

NAME OF TEST: Field Strength of Spurious Radiation

RULE PART NUMBER: 2.993, 90.210 (d)(3)

MINIMUM STANDARD: For 5 Watts; $50+10\text{Log}_{10}(5) = -57$ dBc

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

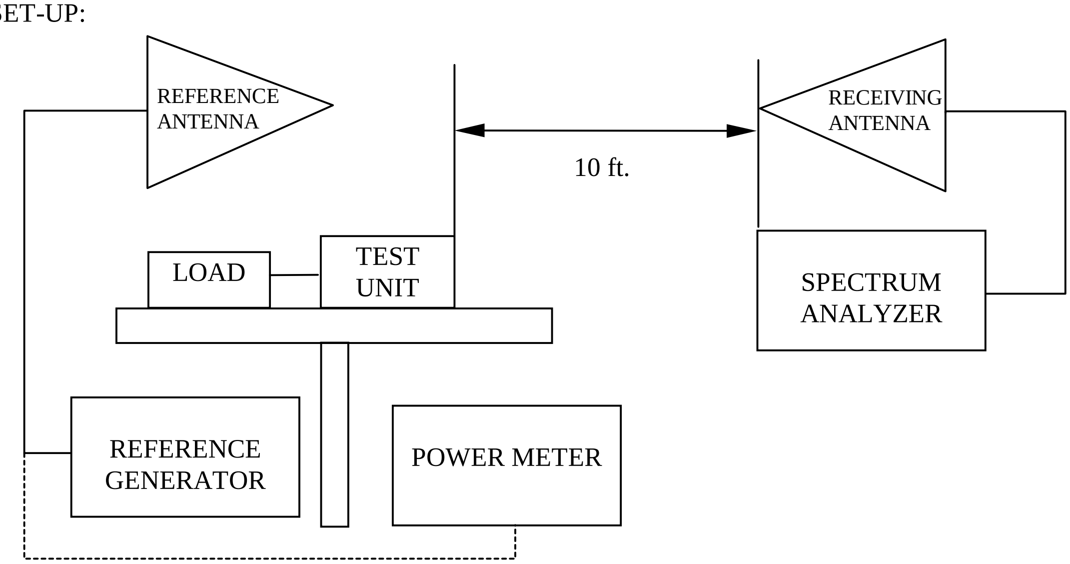
TEST CONDITIONS: Standard Test Conditions, 25 C

TEST PROCEDURE: TIA/EIA - 603, 2.2.12

TEST EQUIPMENT: Dipole Antenna Kit, Electro-Mechanics Model 3121C
Log Periodic Antenna, Model LPA-112
Reference Generator, Model HP83732A
Load, Tenuline Model 8340-200 (20 dB)
Spectrum Analyzer, Model HP8563E
Power Meter, Model HP436A
Power Supply, Model HP-6284A

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: 7/2/98

NAME OF TEST: Spurious Radiation Attenuation (Continued)

Frequency: 403 MHz
Power: 5 Watts
37.0 dBm

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
806	H	-67.50	-32.00	5.67	-2.05	0.00	-76.71
	V	-71.50	-31.00	5.67	-2.05	0.00	-75.71
1209	H	-97.17	-53.50	6.17	1.20	3.00	-98.46
	V	-97.00	-52.00	6.17	1.20	3.00	-96.96
1612	H	-66.67	-20.00	6.83	1.20	3.00	-65.62
	V	-75.00	-30.00	6.83	1.20	3.00	-75.62
2015	H	-74.83	-24.50	8.17	1.20	3.00	-71.46
	V	-76.33	-21.00	8.17	1.20	3.00	-67.96
2418	H	-87.50	-42.50	8.83	1.20	3.00	-90.12
	V	-81.67	-34.00	8.83	1.20	3.00	-81.62
2821	H	-82.67	-30.50	9.50	1.20	3.00	-78.79
	V	-79.17	-24.50	9.50	1.20	3.00	-72.79
3224	H	-90.67	-41.50	11.00	1.20	3.00	-91.29
	V	-83.33	-33.00	11.00	1.20	3.00	-82.79
3627	H	-91.17	-42.00	12.33	1.20	3.00	-93.12
	V	-88.00	-36.00	12.33	1.20	3.00	-87.12
4030	H	-82.00	-28.00	12.00	1.20	3.00	-78.79
	V	-86.67	-29.00	12.00	1.20	3.00	-79.79

Frequency: 403 MHz
Power: 1 Watts
30.0 dBm

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
806	H	-77.17	-41.50	5.67	-2.05	0.00	-79.22
	V	-81.17	-40.50	5.67	-2.05	0.00	-78.22
1209	H	-89.33	-46.00	6.17	1.20	3.00	-83.97
	V	-89.67	-45.00	6.17	1.20	3.00	-82.97
1612	H	-70.83	-24.50	6.83	1.20	3.00	-63.13
	V	-75.67	-30.50	6.83	1.20	3.00	-69.13
2015	H	-84.00	-34.00	8.17	1.20	3.00	-73.97
	V	-84.17	-27.50	8.17	1.20	3.00	-67.47
2418	H	-90.33	-45.50	8.83	1.20	3.00	-86.13
	V	-84.83	-36.50	8.83	1.20	3.00	-77.13
2821	H	-89.17	-37.00	9.50	1.20	3.00	-78.30
	V	-86.33	-31.50	9.50	1.20	3.00	-72.80
3224	H	-96.17	-47.00	11.00	1.20	3.00	-89.80
	V	-87.17	-37.00	11.00	1.20	3.00	-79.80
3627	H	-92.00	-43.00	12.33	1.20	3.00	-87.13
	V	-92.00	-40.00	12.33	1.20	3.00	-84.13
4030	H	-87.83	-34.00	12.00	1.20	3.00	-77.80
	V	-95.17	-37.00	12.00	1.20	3.00	-80.80

NAME OF TEST: Spurious Radiation Attenuation (Continued)

Frequency: 450 MHz
Power: 5 Watts
37.0 dBm

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
900	H	-68.00	-31.50	5.67	-1.15	0.00	-75.31
	V	-74.50	-31.00	5.67	-1.15	0.00	-74.81
1350	H	-66.83	-15.50	6.17	1.20	3.00	-60.46
	V	-72.33	-25.50	6.17	1.20	3.00	-70.46
1800	H	-75.33	-28.00	6.83	1.20	3.00	-73.62
	V	-73.67	-29.50	6.83	1.20	3.00	-75.12
2250	H	-74.00	-28.00	8.17	1.20	3.00	-74.96
	V	-72.17	-27.50	8.17	1.20	3.00	-74.46
2700	H	-88.17	-40.50	8.83	1.20	3.00	-88.12
	V	-78.50	-31.00	8.83	1.20	3.00	-78.62
3150	H	-71.33	-23.00	9.50	1.20	3.00	-71.29
	V	-63.00	-13.00	9.50	1.20	3.00	-61.29
3600	H	-84.50	-35.00	11.00	1.20	3.00	-84.79
	V	-83.17	-33.50	11.00	1.20	3.00	-83.29
4050	H	-91.83	-37.00	12.33	1.20	3.00	-88.12
	V	-91.17	-36.00	12.33	1.20	3.00	-87.12
4500	H	-78.50	-26.50	12.00	1.20	3.00	-77.29
	V	-77.83	-25.00	12.00	1.20	3.00	-75.79

Frequency: 450 MHz
Power: 1 Watts
30.0 dBm

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
900	H	-65.17	-29.00	5.67	-1.15	0.00	-65.82
	V	-71.50	-27.50	5.67	-1.15	0.00	-64.32
1350	H	-76.50	-25.50	6.17	1.20	3.00	-63.47
	V	-81.33	-35.00	6.17	1.20	3.00	-72.97
1800	H	-70.33	-23.50	6.83	1.20	3.00	-62.13
	V	-72.67	-28.50	6.83	1.20	3.00	-67.13
2250	H	-86.67	-40.50	8.17	1.20	3.00	-80.47
	V	-84.33	-39.50	8.17	1.20	3.00	-79.47
2700	H	-86.00	-38.50	8.83	1.20	3.00	-79.13
	V	-85.17	-37.50	8.83	1.20	3.00	-78.13
3150	H	-81.50	-33.00	9.50	1.20	3.00	-74.30
	V	-76.17	-26.00	9.50	1.20	3.00	-67.30
3600	H	-90.00	-41.00	11.00	1.20	3.00	-83.80
	V	-87.17	-37.50	11.00	1.20	3.00	-80.30
4050	H	-87.33	-32.50	12.33	1.20	3.00	-76.63
	V	-90.33	-35.00	12.33	1.20	3.00	-79.13
4500	H	-80.83	-28.00	12.00	1.20	3.00	-71.80
	V	-82.67	-30.00	12.00	1.20	3.00	-73.80

NAME OF TEST: Spurious Radiation Attenuation (Continued)

Frequency: 512 MHz
Power: 5 Watts
37.0 dBm

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
1024	H	-60.00	-16.50	5.67	1.20	3.00	-60.97
	V	-62.17	-20.00	5.67	1.20	3.00	-64.46
1536	H	-78.33	-35.00	6.17	1.20	3.00	-79.96
	V	-81.83	-36.50	6.17	1.20	3.00	-81.46
2048	H	-73.50	-19.00	6.83	1.20	3.00	-64.62
	V	-75.17	-19.00	6.83	1.20	3.00	-64.62
2560	H	-78.00	-32.00	8.17	1.20	3.00	-78.96
	V	-78.67	-33.00	8.17	1.20	3.00	-79.96
3072	H	-83.67	-33.50	8.83	1.20	3.00	-81.12
	V	-83.83	-35.00	8.83	1.20	3.00	-82.62
3584	H	-87.00	-38.00	9.50	1.20	3.00	-86.29
	V	-83.83	-34.00	9.50	1.20	3.00	-82.29
4096	H	-83.17	-28.00	11.00	1.20	3.00	-77.79
	V	-87.83	-31.00	11.00	1.20	3.00	-80.79
4608	H	-85.50	-31.50	12.33	1.20	3.00	-82.62
	V	-87.83	-33.50	12.33	1.20	3.00	-84.62
5120	H	-92.17	-34.00	12.00	1.20	3.00	-84.79
	V	-96.00	-37.50	12.00	1.20	3.00	-88.29

Frequency: 512 MHz
Power: 1 Watts
30.0 dBm

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
1024	H	-66.67	-22.50	5.67	1.20	3.00	-59.97
	V	-70.83	-28.50	5.67	1.20	3.00	-65.97
1536	H	-88.67	-45.00	6.17	1.20	3.00	-82.97
	V	-93.83	-48.50	6.17	1.20	3.00	-86.47
2048	H	-84.50	-30.00	6.83	1.20	3.00	-68.63
	V	-93.33	-37.50	6.83	1.20	3.00	-76.13
2560	H	-72.50	-26.50	8.17	1.20	3.00	-66.47
	V	-85.83	-40.00	8.17	1.20	3.00	-79.97
3072	H	-85.50	-37.50	8.83	1.20	3.00	-78.13
	V	-68.87	-20.00	8.83	1.20	3.00	-60.63
3584	H	-93.17	-44.00	9.50	1.20	3.00	-85.30
	V	-87.67	-38.50	9.50	1.20	3.00	-79.80
4096	H	-93.17	-38.00	11.00	1.20	3.00	-80.80
	V	-90.83	-34.00	11.00	1.20	3.00	-76.80
4608	H	-83.50	-29.50	12.33	1.20	3.00	-73.63
	V	-88.00	-33.50	12.33	1.20	3.00	-77.63
5120	H	-85.00	-26.50	12.00	1.20	3.00	-70.30
	V	-87.83	-29.00	12.00	1.20	3.00	-72.80

CALCULATIONS FOR FIELD STRENGTH OF SPURIOUS RADIATION TESTS:

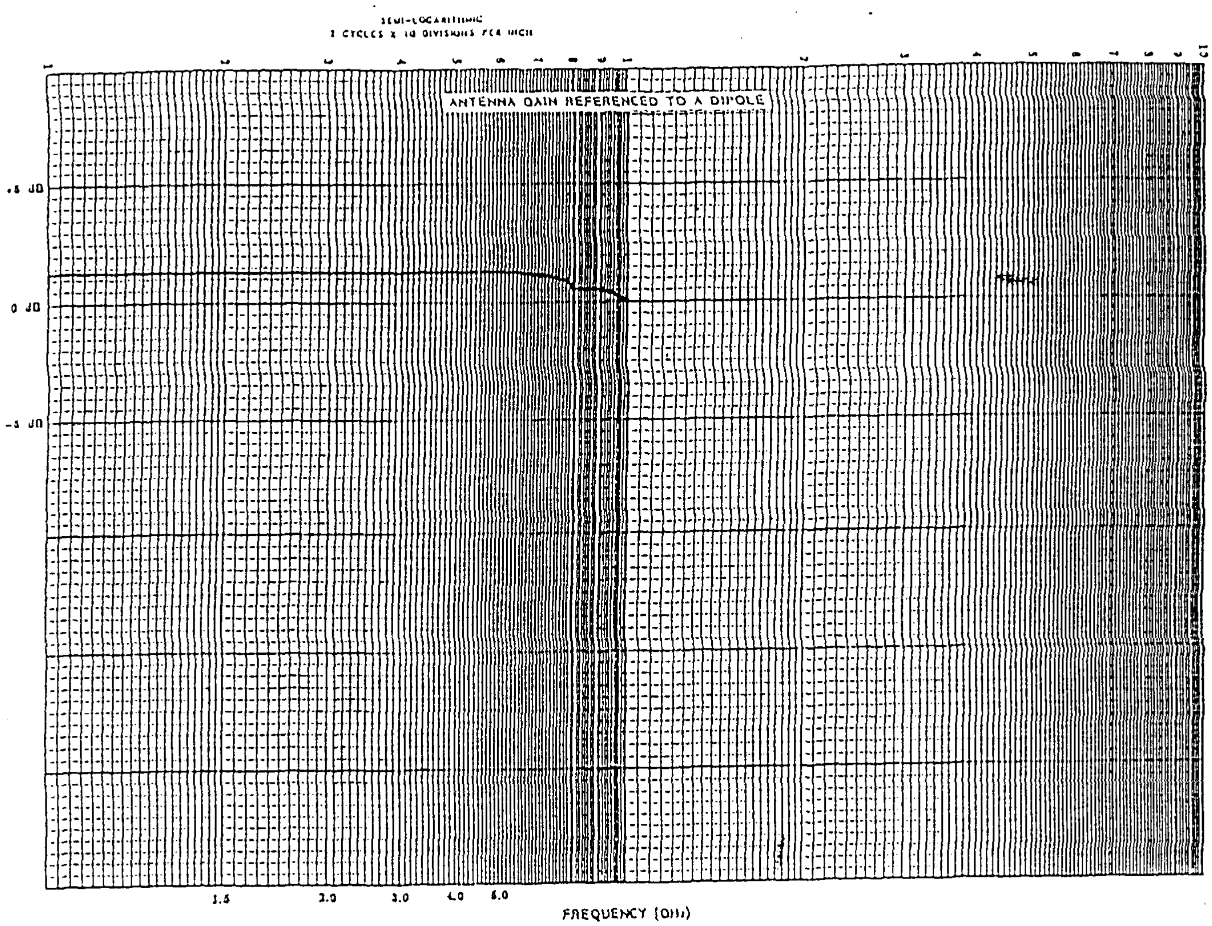
The transmitter carrier frequencies were 403.000 MHz, 450.000 MHz, and 512.000 MHz. The reference oscillator frequency of all of the transceivers is 17.50 MHz. The output of the transceivers was searched from 17.50 MHz to the tenth harmonic of each of the carrier frequencies. The tests were conducted 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 1024 MHz (512 MHz tuned), 5 Watts and horizontal polarization.

r = Substitution Gen - Cable Loss	-16.5 - 5.67	= -22.17
R - Reference Generator (dBm)	-22.17	
A - Antenna Gain (dB)	+1.2	
P - Polarization Correction Factor (dB)	3.0	
R’ (Corrected Reference (dBm)) = R + A - P	= -22.17 + 1.2 - 3.0	= **-23.97 dBm**
Po - Radiated Carrier Power (dBm)	5 Watts = 37 dBm	
Radiated Spurious Emission (dBc) = Po - R’	= -23.97 - (+37)	= **-60.97 dBc**



ANTENNA GAIN GRAPH OF SUBSTITUTION ANTENNA
REFERENCED TO A DIPOLE

NAME OF TEST: Frequency Stability with Variation in Ambient Temperature

RULE PART NUMBER: 2.995 (a)(1), 90.213 (a) (7)

MINIMUM STANDARD: Shall not exceed ± 0.000150% from test frequency, or 1.50 ppm

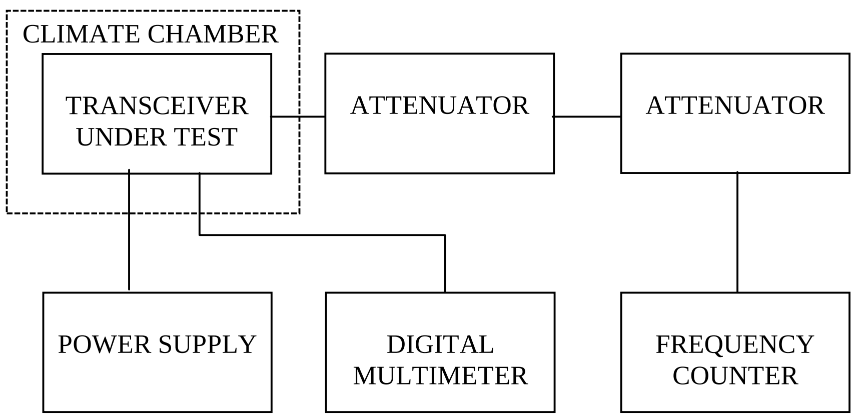
TEST RESULTS: Meets minimum standard, see data on following page

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
Frequency Counter, Fluke Model 1920A
Digital Voltmeter, Fluke Model 8012A
DC Power Source, Model HP6284A
Climate Chamber, TempGard III, Tenney Jr.

PERFORMED BY: Allen Frederick DATE: 7/23/98

TEST SET-UP:



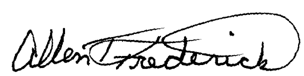
(Test data on next page)

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

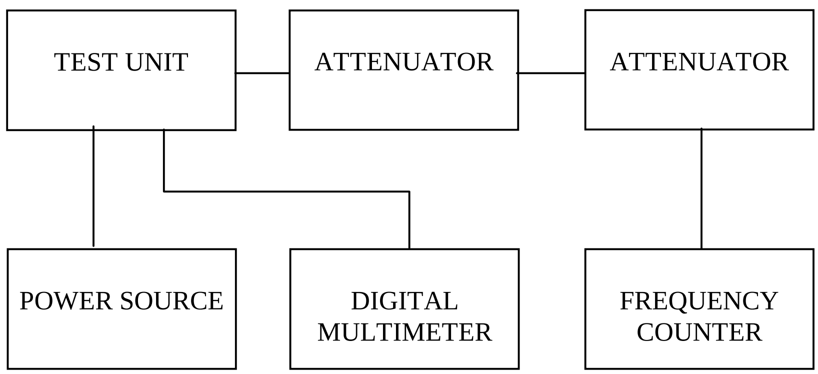
Frequency Reference: 450000000 Hz
Tolerance Requirement: 1.5 ppm
Highest Variation (ppm): 0.462 ppm

TEMP ° C	FREQUENCY MHz	FREQ DELTA Hz	ppm from assigned frequency
-30	450000208	208	0.462
-20	449999974	-26	0.058
-10	449999859	-141	0.313
0	449999856	-144	0.320
10	449999897	-103	0.229
20	450000034	34	0.076
30	450000171	171	0.380
40	450000036	36	0.080
50	449999912	-88	0.196
60	449999956	-44	0.098

NAME OF TEST:	Frequency Stability with Variation in Supply Voltage
RULE PART NUMBER:	2.995 (d)
MINIMUM STANDARD:	Shall not exceed ± 0.000150% from test frequency, 1.50 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 / 9715 / 50-A-MFN-06 / 6 dB / 50 Watt 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:  Allen Frederick DATE: 7/23/98

TEST SET-UP:



(Test data on next page)

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

MEASUREMENTS TAKEN:

1.5 ppm Reference Oscillator

Frequency Reference Set at 25° C: 450.00001 MHz
Tolerance Requirement: 0.00015 %
Highest Variation (%): 0.00000000 %
Highest Variation (ppm): 0.000 ppm

SUPPLY VDC	FREQUENCY MHz	DELT FREQ % of assigned f	SPEC LIMIT % of assigned f	ppm from assigned frequency
10	450.00001	0.00000000	0.00015	0.000
13	**450.00001**	0.00000000	0.00015	0.000
16	450.00001	0.00000000	0.00015	0.000

NAME OF TEST: Transient Frequency Behavior

RULE PART NUMBER: 90.214

TEST CONDITIONS: The transient test was performed with the transmitter transmitting just a carrier tone. Also supplied is a transient test which was conducted with the HNET modem modulating the transmitter at 19200 bps, 3.5 kHz deviation. Also supplied is a transient test which was conducted with the HNET modem modulating the transmitter at 9600 bps, 3.5 kHz deviation.

MINIMUM STANDARD: **12.5 kHz channel** (used worst case numbers from 403 to 512 MHz)
25 kHz channel (used worst case numbers from 403 to 512 MHz)

TIME INTERVAL	MAX FREQ DIFFERENCE (kHz)	MAX FREQ DIFFERENCE (kHz)	TIME (ms)
	12.5KHz CH	25 kHz CH	
T1	+/- 12.5	+/- 25	10
T2	+/- 6.25	+/- 12.5	25
T3	+/- 12.5	+/- 25	10

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

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

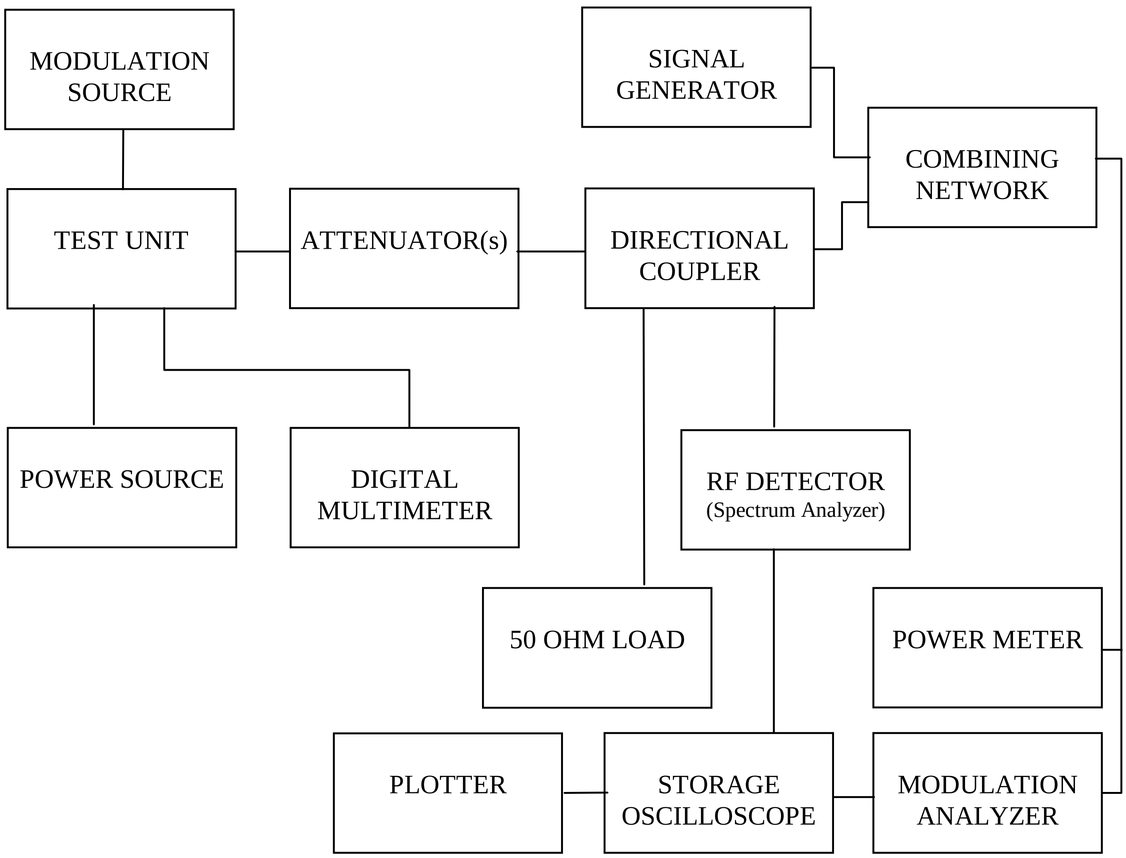
TEST PROCEDURE: TIA/EIA - 603, 2.2.19

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
Plotter, Model HP2671G
Reference Generator, Fluke Model 6071A
Power Meter, Model HP436A
Power Combiner, Model MCL ZFSC-4-1
Oscilloscope, Model HP54503A
Directional Coupler, Model HP778D

PERFORMED BY: Allen Frederick (signature) Date: 7/25/98
Allen Frederick

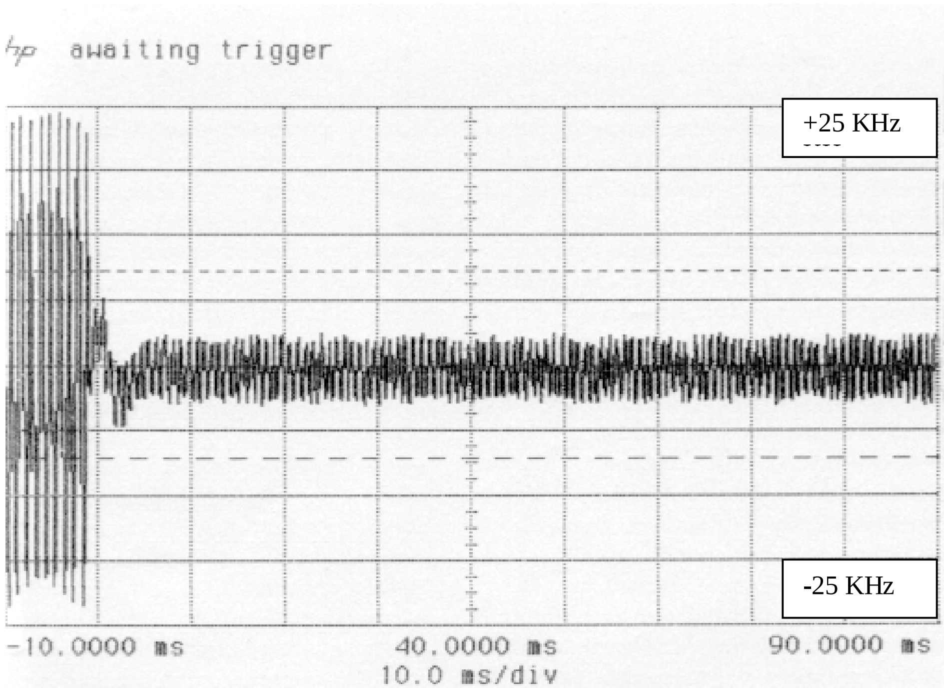
NAME OF TEST: Transient Frequency Behavior (Continued)

TEST SET-UP:

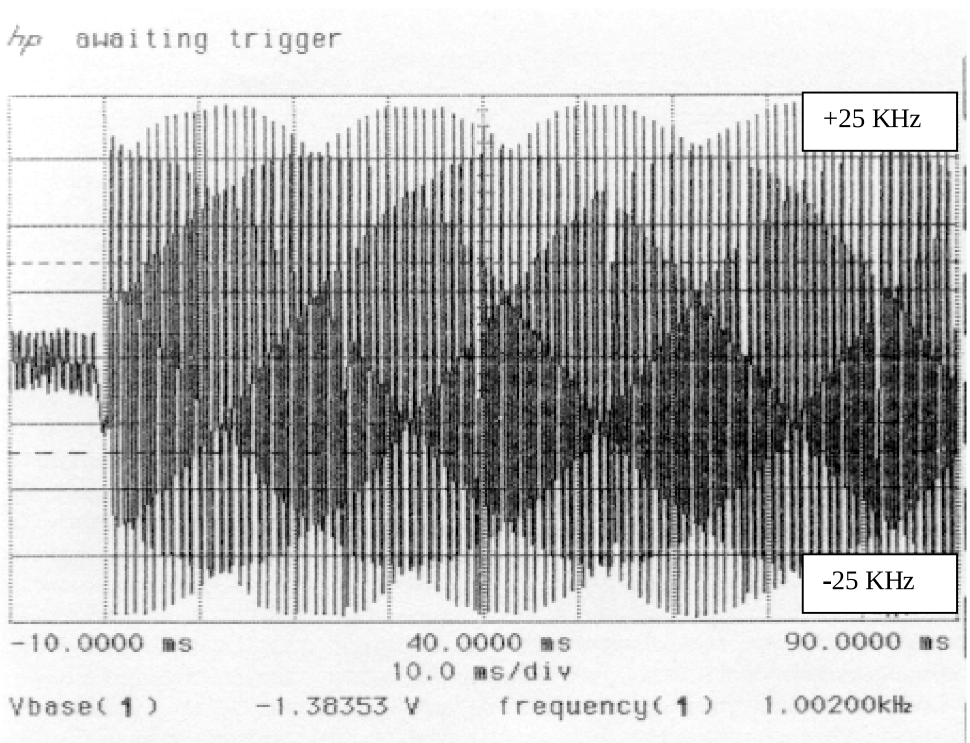


TRANSIENT FREQUENCY RESPONSE
TRANSCEIVER MODULATED BY HNET MODEM

The HNET modem was set to 19.2 Kbps.

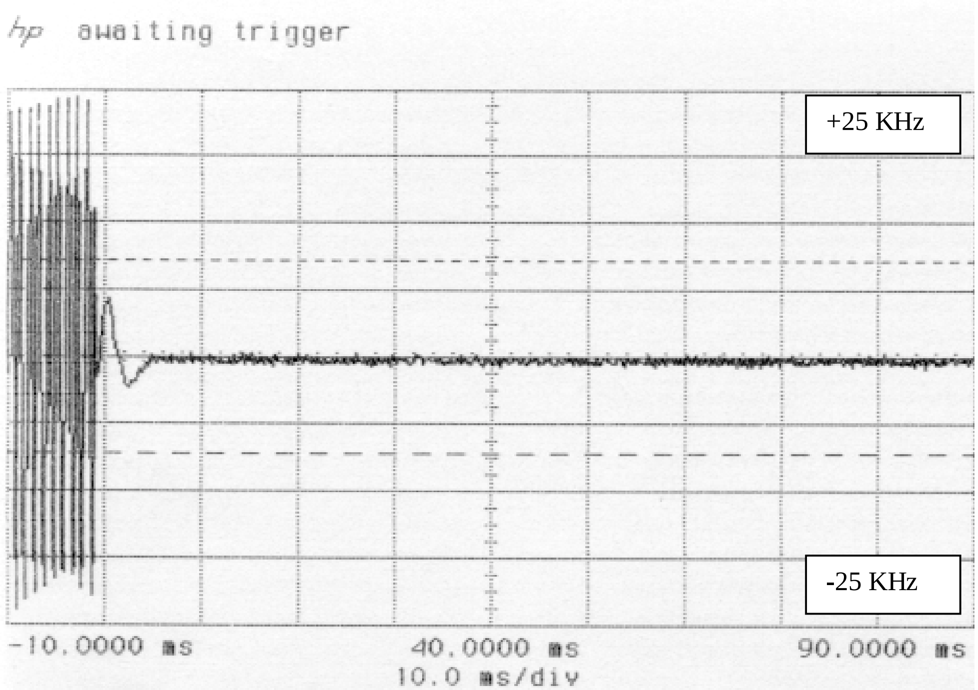


KEY UP



KEY DOWN

TRANSIENT FREQUENCY RESPONSE
TRANSCEIVER UNMODULATED CARRIER



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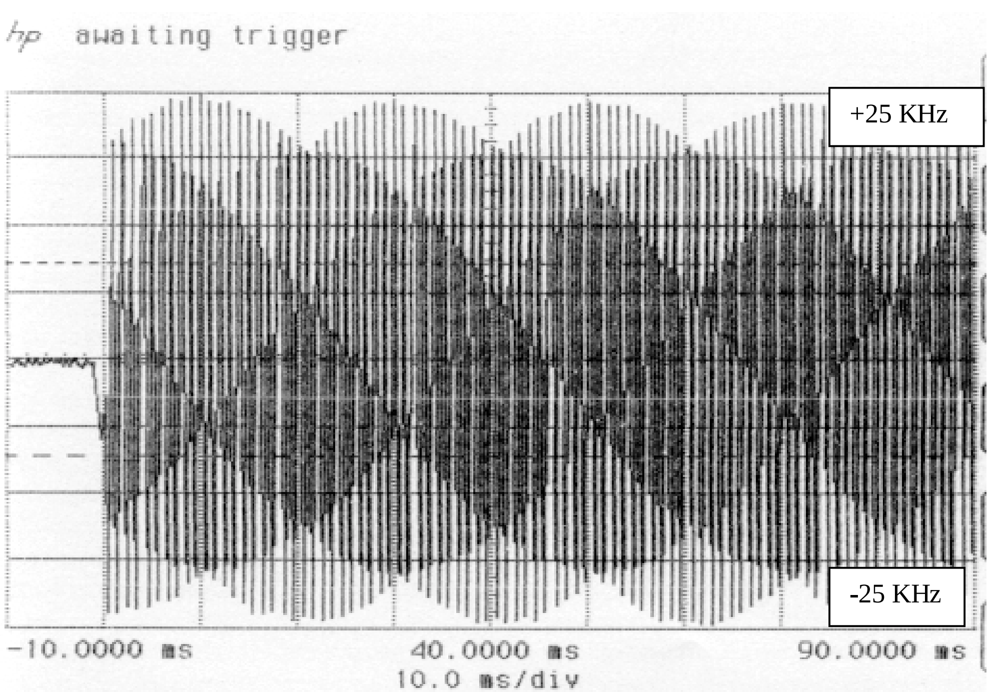
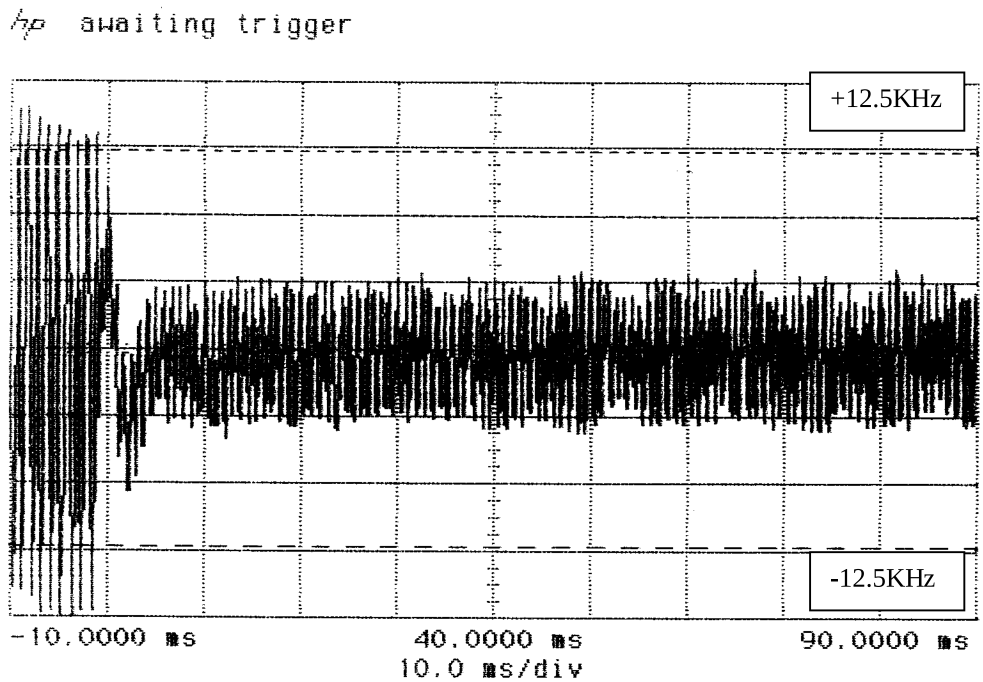


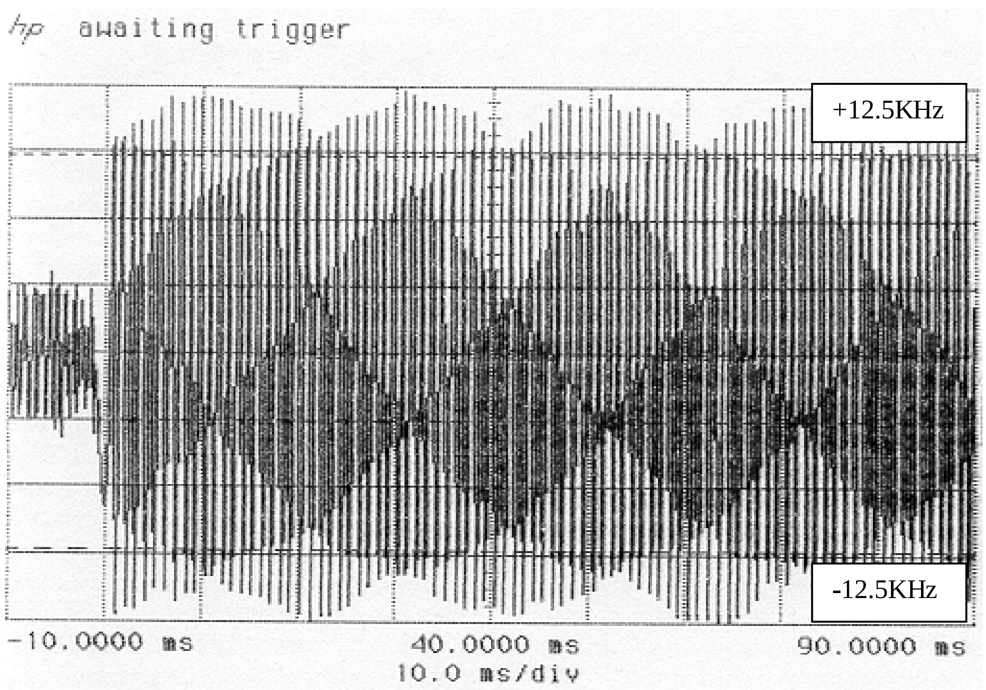
KEY DOWN

TRANSIENT FREQUENCY RESPONSE
TRANSCEIVER MODULATED BY HNET MODEM

The HNET modem was set to 9600 bps

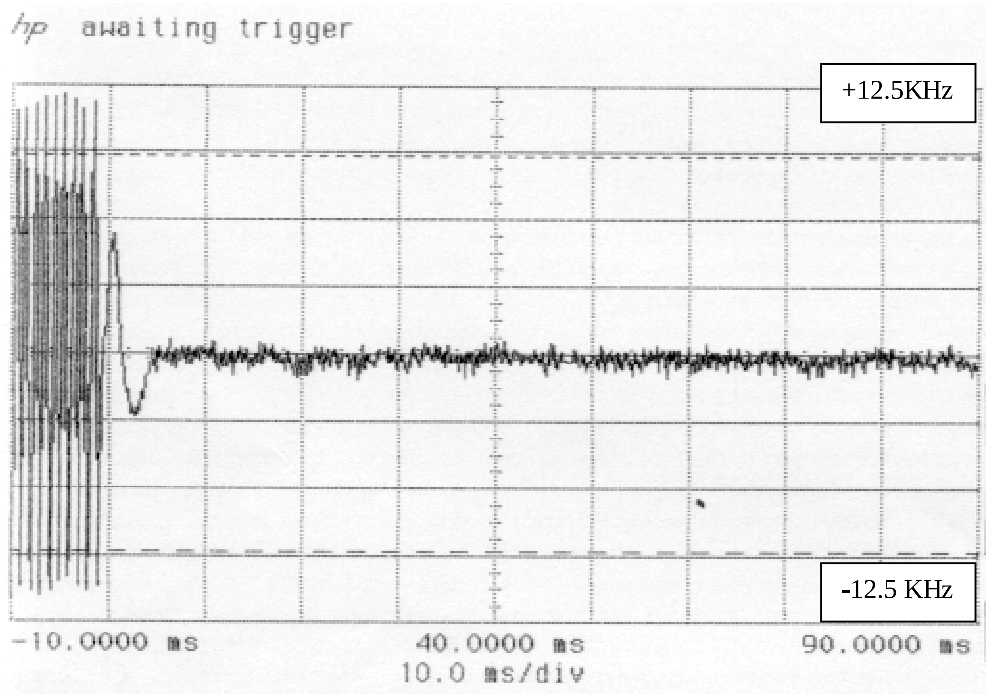


KEY UP



KEY DOWN

TRANSIENT FREQUENCY RESPONSE
TRANSCEIVER WITH UNMODULATED CARRIER



KEY UP