Engineering Exhibit in Support of Type Acceptance FCC Form 731

for the

DL-3422 Telemetry Transceiver With the HNET Modem

Model T-96SR

September 3, 1998

Johnson Data Telemetry Corporation
Waseca, Minnesota

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-3422, 132-174 MHz Telemetry Transceiver with the Data Radio T96H Modem. JDT refers to the T96H modem as the HNET, throughout this report HNET is referencing the Data Radio T96H modem board. The Transceiver/Modem will be identified by the Johnson Data Telemetry part number 242-4016-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 132-174 MHz will be referred to as the DL-4016 throughout this report. The Transceiver/Modem will be identified by the FCC number NP42424016-001. 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 132.000 MHz to 174.000 MHz. The frequency tolerance of the transceiver is .00025% or 2.5 parts 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 5, 17.5 MHz for range 6. Range 4 operates in the frequency range 132-150 MHz. Range 5 and 6 operate in the frequency range 150-174 MHz.

PROPOSED CONDITIONS

It is proposed to Type Accept the DL-4016, 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 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 3, 1998 and July 25, 1998.

CONCLUSION

Given the results of the measurements contained herein, the applicant requests that Type Acceptance be granted for the 242-4016-001, 132-174 MHz Transceiver/Modem as tested for data communications.

_______________________________________ 9/3/98
Mark Christensen
Director of Engineering, Johnson Data Telemetry

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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 Transceiver/Modem part number 242-4016-XYZ. 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:	242-4016-XYZ
MANUFACTURER:	Johnson Data Telemetry Corporation, Waseca, MN 56093
FCC ID NUMBER:	FCC ID: NP42424016-001
FCC RULES AND REGS:	FCC Part (s) 90
FREQUENCY RANGE:	Frequency 132.000 MHz - 174.000 MHz
SERIAL NUMBER (S):	132.000 MHz - 41004 150.000 MHz - 53003 153.000 MHz - 53003 174.000 MHz - 53003

TRANSMITTER

TYPE OF EMISSION:	12.5KHz BW (9600bps) 9K3F1D, 11K0F1D 25KHz BW (19.2Kbps) 15K3F1D, 16K0F1D
MAXIMUM POWER RATING:	5.00 Watts
NUMBER OF CHANNELS:	8 Channel Modem
INPUT IMPEDANCE:	50 ohms, Nominal
VOLTAGE REQUIREMENTS:	13.8 VDC, Nominal

MODEL NUMBER	**DESCRIPTION**	**JDT PART NUMBER**
HNET	Modem	050-03280-00F
DL-3422	132-174 MHz Transceiver	242-3422-XYZ

DESCRIPTION OF CIRCUITRY

RULE PART NUMBER: 2.983 (d)(10)

THEORY OF OPERATION

1.0 PURPOSE

This report has been prepared to support the application for FCC Type Acceptance PER CODE OF FEDERAL REGULATIONS, TITLE 47, PARTS 2 AND 90 AND for the transmitter subsystem of the JDT Model 242-3422-XYZ Transceiver. The report presents necessary information concerning electrical circuit description, measured performance and physical construction and configuration.

2.0 DL-3422 TRANSCEIVER

The main subassemblies of this transceiver are the RF board, VCO board, TCXO and modem assembly. A block diagram of the transceiver is located in Figure 2.

The VCO board is enclosed by a metal shield and soldered directly to the RF board. The VCO is not serviceable.

The DL-3422 has a reference oscillator stability of ±2.5 PPM. The 14.85 MHz TCXO (Temperature Compensated Crystal Oscillator) is soldered directly to the RF board. The TCXO is not serviceable.

2.1 SYNTHESIZER

The synthesizer output signal is produced by a VCO (voltage controlled oscillator). The VCO frequency is controlled by a DC voltage produced by the phase detector in U811. The phase detector senses the phase and frequency of the two input signals and causes the VCO control voltage to increase or decrease if they are not the same. The VCO is then "locked" on frequency.

Programming of the synthesizer provides the data necessary for the internal prescaler and counters. One input signal is the reference frequency. This frequency is produced by the 14.85 MHz reference oscillator (TCXO). The other input signal is the VCO frequency.

VOLTAGE-CONTROLLED OSCILLATOR

Oscillator (Q872)

The VCO is formed by Q872, several capacitors and varactor diodes, and air wound inductor L872. It oscillates at the transmit frequency in transmit mode and first injection frequency in the receive mode (132-174 MHz in transmit and 153.45 - 195.45 MHz in receive).

Biasing of Q872 is provided by R873, R874 and R876. An AC voltage divider formed by C872, C874 and C875 initiates and maintains oscillation and also matches Q872 to the tank circuit. air wound inductor L872 is grounded at one end to provide shunt inductance to the tank circuit.

Frequency Control and Modulation

The VCO frequency is controlled by a DC voltage across varactor diodes CR852, CR853, and CR854. As voltage across a reverse-biased varactor diode increases, its capacitance decreases. Therefore, VCO frequency increases as the control voltage increases. CR852/CR853 and CR854 are paralleled varactors to divide the capacitance and improve linearity. The varactors CR852/CR853 are biased at -2.0V so the control line voltage can operate closer to ground. CR854 is pin shifted in when transmitting to increase the VCO gain in transmit. The control line is isolated from tank circuit RF by choke L852/L853. The amount of frequency change produced by CR852/CR853/CR854/ is controlled by series capacitor C854.

The -2.0V applied to the VCO is derived from the 14.85 MHz TCXO frequency that is amplified by Q902, rectified by CR902 and filtered by C912, C917, C918 and C920 on the RF board.

The VCO frequency is modulated using a similar method. The transmit audio/data signal from J201, pin 6 is applied across varactor diode CR861 which varies the VCO frequency at an audio rate. Series capacitors C855/C856 set the amount of deviation produced along with CR862 and C865. R863 provides a DC ground on the anodes of CR861/CR862, and isolation is provided by R862, and C863.

The DC voltage across CR862 provides compensation to keep modulation relatively flat over the entire bandwidth of the VCO. This compensation is required because modulation tends to increase as the VCO frequency gets higher (capacitance of CR852/CR853/CR855 gets lower). CR862 also balances the modulation signals applied to the VCO and TCXO. The D/A Converter U911 can be programmed to apply a compensating voltage to CR862 to adjust the modulation sensitivity between the TCXO and VCO.

The DC voltage applied across CR862 comes from the modulation adjust control R827 on the RF board. R826 applies a DC biasing voltage to CR86. C821 provides DC blocking. RF isolation is provided by C865, and R862.

VCO AND REFERENCE OSCILLATOR MODULATION

Both the VCO and reference oscillator (TCXO) are modulated in order to achieve the required frequency response. If only the VCO was modulated, the phase detector in U811 would sense the frequency change and increase or decrease the VCO control voltage to counteract the change (especially at the lower audio frequencies). If only the reference oscillator frequency is modulated, the VCO frequency would not change fast enough (especially at the higher audio frequencies). Modulating both VCO and reference oscillators produces a flat audio response. Potentiometer R827 sets the VCO modulation sensitivity so that it is equal to the reference oscillator modulation sensitivity.

CASCADE AMPLIFIERS/VCO (Q871/Q872)

The output signal on the collector of Q871 is coupled to buffer amplifier Q872 which forms a cascade amplifier. This is a shared-bias amplifier which provides oscillation, amplification and isolation from the stages which follow. The signal is coupled and matched from the collector of Q872 through inductors and capacitors and a T-pad to amplifier Q882.

AMPLIFIER (Q882)

Q882 provides final amplification of the VCO signal. Biasing of Q882 is provided by Q881 and several resistors. Matching to the transmitter and receive first injection is provided by L891 and C892. A 6dB T-pad is used to isolate the transmitter and receive first injection.

VOLTAGE FILTER (Q901)

Q901 on the RF board is a capacitance multiplier to provide filtering of the 8.6V supply to the VCO. R901 provides transistor bias and C901 provides the capacitance that is multiplied. If a noise pulse or other voltage change appears on the collector, the base voltage does not change significantly because of C901. Therefore, base current does not change and transistor current remains constant. CR901 decreases the charge time of C901 when power is turned on. This shortens the startup time of the VCO. C902, and C903 are RF decoupling capacitors.

VCO FREQUENCY SHIFT (Q841)

The VCO must be capable of producing frequencies from 132 - 195.45 MHz to produce the required receive injection and transmit frequencies.
If this large of a shift was achieved by varying the VCO control voltage, the VCO gain would be undesirably high. Therefore, capacitance is switched in and out of the tank circuit to provide a coarse shift in frequency.

This switching is controlled by the T/R pin shift (RX_EN) on J201, pin 4, Q841/Q842 and pin diode CR851. When a pin diode is forward biased, it presents a vary low impedance to RF; and when it is reverse biased, it presents a very high impedance. The capacitive leg is switched in when in transmit and out when in receive.

When J201, pin 4 is high in receive (+5V), Q173 is turned on and the collector voltage goes low. A low on the base of Q172 turns the transistor on and the regulated +9.6V on the emitter is on the collector for the receive circuitry. Q171 applies a low on the base of Q841 the transistor is off and the collector is high. With a high on the base of Q842 and a low on the emitter, this reverse biases CR850 for a high impedance.

The capacitive leg on the VCO is formed by C852, CR851, and C853. When J201, pin 4 is low in transmit, Q842 is turned on and a high is on the emitter, Q171 is turned off and the collector voltage goes high. A low on the base of Q173 turns the transistor off and the regulated +9.6V is removed from the receive circuitry. With a high on the base of Q841 the transistor is on and the collector is low. With a low on the base of Q842 and a high on the emitter, this forward biases CR851 and provides an RF ground through C852 and C853 is effectively connected to the tank circuit. This decreases the resonant frequency of the tank circuit.

2.2 SYNTHESIZER INTEGRATED CIRCUIT (U811)

Introduction

This device contains the following circuits: R (reference), Fractional-N, NM1 and NM2; phase and lock detectors, prescaler and counter programming circuitry. Refer to Figure 1 for Synthesizer IC block diagram.

Channel Programming

Frequencies are selected by programming the R, Fractional-N, NM1 and NM2 in U811 to divide by a certain number. These counters are programmed by Loader board or a user supplied programming circuit.

As previously stated, the counter divide numbers are chosen so that when the VCO is oscillating on the correct frequency, the VCO-derived input to the phase detector is the same frequency as the reference oscillator-derived frequency.

The VCO frequency is divided by the internal prescaler and the main divider to produce the input to the phase detector.

LOCK DETECT

When the synthesizer is locked on frequency, the SYNTH LOCK output of U811, pin 18 (J201, pin 7) is a high voltage. Then when the synthesizer is unlocked, the output is a low voltage. Lock is defined as a phase difference of less than 1 cycle of the TCXO.

2.3 RECEIVER CIRCUIT DESCRIPTION

PRESELECTOR FILTER, RF AMPLIFIER (Q202)

Capacitor C201 couples the receive signal from the antenna switch to the LC preselector filter composed of L201, L202, L203, CR281, CR282, C202, C203, C204, C205, C206, and C207. (The antenna switch is described in later.) The preselector filter is a two pole discrete LC varactor tuned bandpass filter adjusted to pass only a narrow band of frequencies to the receiver. This attenuates the image and other unwanted spurious frequencies. The preselector filter is tuned in frequency by varying the reverse bias voltage of the varactors CR 281 and CR 282. The filter control voltage is generated by Digital to Analog Converter (DAC) U911 and amplified by U831 to generate a higher voltage swing to the varactors and minimize filter loss. R206 and capacitors C281 through C285 filter the varactor voltage and provide RF isolation.

Impedance matching between the preselector filter and RF amplifier Q202 is provided by C207 and L204. CR201 protects the base-emitter junction of Q202 from excessive negative voltages that may occur during high signal conditions. Q201 is a switched constant current source which provides a base bias for Q202. Q201 base bias is provided by R202/R203. Current flows through R201 so that the voltage across it equals the voltage across R202 (minus the base/emitter drop of Q201). In the transmit mode the receive +9.6V is removed and Q201 is off. This removes the bias from Q202 and disables the RF amplifier in transmit mode. This prevents noise and RF from being amplified by Q202 and fed back on the first injection line.

Additional filtering of the receive signal is provided by a three pole discrete LC varactor tuned bandpass filter composed of filter L212, L213, L214, L221, L222, L223, L224, CR283, CR284, CR285, C214, C215, C216, C217, C221, C222, and C223. L211 and C213 provide impedance matching between Q202 and this filter. Resistor R205 is used to lower the Q of L211 to make it less frequency selective. The same control voltage that adjusts to two pole filter on frequency adjusts this filter as well. The inductors are factory tuned to align the filter tracking and should not be adjusted.

MIXER (Q232)

First mixer Q232 mixes the receive frequency with the first injection frequency to produce the 21.45 MHz first IF. Since high-side injection is used, the injection frequency is 21.45 MHz above the receive frequency. Q231 biases Q 232 in similar fashion to Q201 described above. The RF signal is coupled to the mixer through C233. R226 attenuates high voltage excursions on the base of Q232. The LO injection is proved across L232 and R236 on the emitter of Q232. Emitter injection is used to provide isolation between the LO port and the RF port. L233 and C238 provide a low impedance on the emitter at the IF frequency improving noise performance and conversion gain.

FIRST L.O. AMPLIFIER/BUFFER (Q301, Q302)

The first L.O. amplifier provides amplification and buffering of the receive first injection. R305, R306, and R307 form a 3dB 50 ohm pad C303 couples the signal to C304 and L301 which match Q302 to 50 ohms L302 and C307 match Q302 to the mixer Q232. Q301, R301, R302, R303, and R304 provide biasing for Q302 R308 enhances the stability of Q302. C302 and C306 provide RF decoupling.

CRYSTAL FILTER (Z231/Z232)

The output of Q232 is matched to the crystal filter, Z231 and Z232 by L231, C234, and C237. This filter presents a low impedance to 21.45 MHz and attenuates the receive, injection, and other frequencies outside the 21.45 MHz passband.

Z221 and Z222 form a 2-section, 4-pole crystal filter with a center frequency of 21.45 MHz and a -3 dB passband of 8 kHz (12.5 kHz BW) or 15 kHz (25 kHz BW). This filter establishes the receiver selectivity by attenuating the adjacent channel and other signals close to the receive frequency. C241 and C242 adjust the coupling of the filter. L242, C244, C245 and R243 provide impedance matching between the filter and 241.

SECOND LO OSCILLATOR (U241), BUFFER (Q251)

The second LO oscillator is built into U241 which provides the base and emitter connections for an internal oscillator transistor. The oscillator tank circuit consists of L251, C253, and CR251. Oscillator feedback is provided by C254, C256 and C257. The oscillator frequency is adjusted by applying a control voltage across R253 to CR251. The control voltage is provided by the charge pump of the auxiliary synthesizer in U811. The emitter of the oscillator transistor is connected to the common collector buffer amplifier Q251 by C251. R257, R258, R259 and R254 provided bias for Q251. R254 additionally provides an RF load to decrease the buffer level. C258, C259, and L252 filter the unwanted harmonics from the oscillator output. The output of Q251 is coupled to the auxiliary synthesizer phase detector by C814. The oscillator is phase locked at 21.9 MHz with L251 adjusted to center the control voltage.

SECOND MIXER/DETECTOR (U241)

Oscillator and Mixer

U241 contains the second oscillator, second mixer, limiter, detector, and squelch circuitry. The 21.45 MHz IF signal is mixed with a 21.9 MHz signal produced by second LO amplifier Q401 from TCXO Y801.

Second IF Filter

The output of the internal double-balanced mixer is the difference between 21.45 MHz and 21.9 MHz which is 450 kHz. This 450 kHz signal is fed out on pin 3 and applied to second IF filters Z241 and Z242. These filters have passbands of 9 kHz (12.5 kHz BW), or 20 kHz (25 kHz BW) at the -6 dB points and are used to attenuate wideband noise.

Limiter-Amplifier

The output of Z241/Z242 is applied to a limiter-amplifier circuit in U241. This circuit amplifies the 450 kHz signal and any noise present; then limits this signal to a specific value. When the 450 kHz signal level is high, noise pulses tend to get clipped off by the limiter; however, when the 450 kHz signal level is low, the noise passes through the limiter. C275/C276 decouple the 450 kHz signal.

Quadrature Detector

From the limiter stage the signal is fed to the quadrature detector. An external phase-shift network connected to pin 8 shifts the phase of one of the detector inputs 90× at 450 kHz (all other inputs are unshifted in phase). When modulation occurs, the frequency of the IF signal changes at an audio rate as does the phase of the shifted input. The detector, which has no output with a 90× phase shift, converts this phase shift into an audio signal. L253 is tuned to provide maximum undistorted output from the detector. R255 is used to lower the Q of L253. From the detector the audio and data signal is fed out on pin 9. The audio/data output of U241, pin 9 is applied to J201, pin 13.

Receive Signal Strength Indicator (RSSI)

U241, pin 5 is an output for the RSSI circuit which provides a current proportional to the strength of the 450 kHz IF signal. The voltage developed across R275 is applied to J201, pin 12.

2.4 TRANSMITTER CIRCUIT DESCRIPTION

BUFFER (Q501)

The VCO RF output signal is applied to R892, R893 and R894 that form a resistive splitter for the receive first local oscillator and the transmitter. The VCO signal is then applied to a 50 ohm pad formed by R501, R502, and R503. This pad provides attenuation and isolation. Q501 provides amplification and additional isolation between the VCO and transmitter. Biasing for this stage is provided by R504 and R505, and decoupling of RF signals is provided by C503 . Impedance matching to the predriver is provided by L511 and C512.

PRE-DRIVER (Q511)

Pre-driver Q511 is biased class A by R511 and R512 and R515. L513, Q517 and C518 match Q511 to U531. R514 provides a resistive feedback path to stabilize Q511 and C515 provides DC blocking. C516 bypasses RF from the DC line, and R513 provides supply voltage isolation and ties the +9V transmit supply to the circuit.

FINAL (U531), COMPARATOR (U111C)

RF module U531 has an RF output of 1 to 5W and operates on an input voltage from 10-16V.

Power control is provided by U581, U111, Q531 and a stripline directional coupler. The power is adjust by Power Set Control R535 that provides a reference voltage to U111C. U111C drives Q531 and PA module U531.

One end of the balun directional coupler is connected to a forward RF peak detector formed by R591, CR591, C591 and U581A. The other end of the stripline directional coupler is connected to a reverse RF peak detector formed by R593, CR592, C593 and U581B.

If the power output of U531 decreases due to temperature variations, etc., the forward peak detector voltage drops. This detector voltage drop is buffered by U581A and applied to inverting amplifier U111C which increases the forward bias on Q531. The increase on Q531 increases the power output level of U531. If the power output of U531 increases, the forward peak detector voltage increases and U111C decreases the forward bias on Q531. The decrease on Q531 decreases the output power of U531.

The output of CR591 and CR592 are fed to U581A/B respectively. If the output of either buffer increases, the increase is applied to the inverting input of U111C. The output of U111C then decreases and Q531 decreases the input voltage to U531 to lower the power. The control voltage is isolated from RF by ferrite bead EP532 and C531 decouples RF.

The forward/reverse power voltages from U581A/B are also applied to U913/U912 for diagnostics outputs on J201.

The low-pass filter consists of L551, C552, L552, C553, L553, C555, L554 and C856. The filter attenuates spurious frequencies occurring above the transmit frequency band. The transmit signal is then fed through the antenna switch to antenna jack J501.

ANTENNA SWITCH (CR561, CR562)

The antenna switching circuit switches the antenna to the receiver in the receive mode and the transmitter in the transmit mode.
In the transmit mode, +9V is applied to L555 and current flows through diode CR561, L561, diode CR562, and R561. When a diode is forward biased, it presents a low impedance to the RF signal; conversely, when it is reverse biased (or not conducting), it presents a high impedance (small capacitance). Therefore, when CR561 is forward biased, the transmit signal has a low-impedance path to the antenna through coupling capacitor C562.

L561, and C564 form a discrete quarter- wave line. When CR561 is forward biased, this quarter-wave line is effectively AC grounded on one end by C564. When a quarter-wave line is grounded on one end, the other end presents a high impedance to the quarter-wave frequency. This blocks the transmit signal from the receiver. C561 and C563 matches the antenna to 50 ohms in transmit and receive.

TRANSMITTER KEY-UP CONTROL

Q121, Q122, and Q123 act as switches which turn on with the RX_EN line. When the line goes low the Q121 is turned of which turns Q122 on turning Q123 on. This applies 13.6V to U111 before the TX_EN line goes high. U111A/B provides the key-up and key-down conditioning circuit. C116 and R117 provide a ramp up and ramp down of the 9.0TX during key-up and key-down which reduces load pull of the VCO during key-up. The conditioning provides a stable 5.5V output by balancing the 5.5V reference with the 5.5V regulated supply. The output on U111B, pin 7 is applied to comparator U111D, pin 12, the non-inverting input. The output of U111D, pin 14 is applied to the base of current source Q124. The output of Q124 is on the emitter and is applied back to the inverting input of comparator U111D, pin 13. A decrease or increase at U111D, pin 13 causes a correction by U111D to stabilize the 9V transmit output. R125/R126 establish the reference voltage on U111D, pin 13. C123 provides RF bypass, C124 provides RF decoupling and C125 stabilizes the output. The 9V transmit voltage is then distributed to the circuits.

2.5 VOLTAGE REGULATORS

+9.6V REGULATED

The 5V applied on J201, pin 5 is applied to the base of Q131 turning the transistor on. This causes the collector to go low and applies a low to the control line of U141, pin 1 and R131 is a pull up resistor. The 13.6V from J201, pin 2 is on U141, pin 6 to produce a +9.6V reference output on U141, pin 4. C145 stabilizes the voltage and C146 provides RF decoupling. C144 provides RF bypass and C118 provides RF decoupling. C137 provides is a bypass capacitor for U131.

+5.5 REGULATED

When 5.0V is applied to J201, pin 5 it is applied to the base of Q131 turning the transistor on. This causes the collector to go low and applies a low to the control line of U131, pin 1. C136 decouples RF and R131 is a pull up resistor. The 13.6V from J201, pin 2 is on U131, pin 6 to produce a +5.5V regulated output on U131, pin 4. C135 stabilizes the voltage and C136 provides RF decoupling. C137 provides is a bypass capacitor for U131.

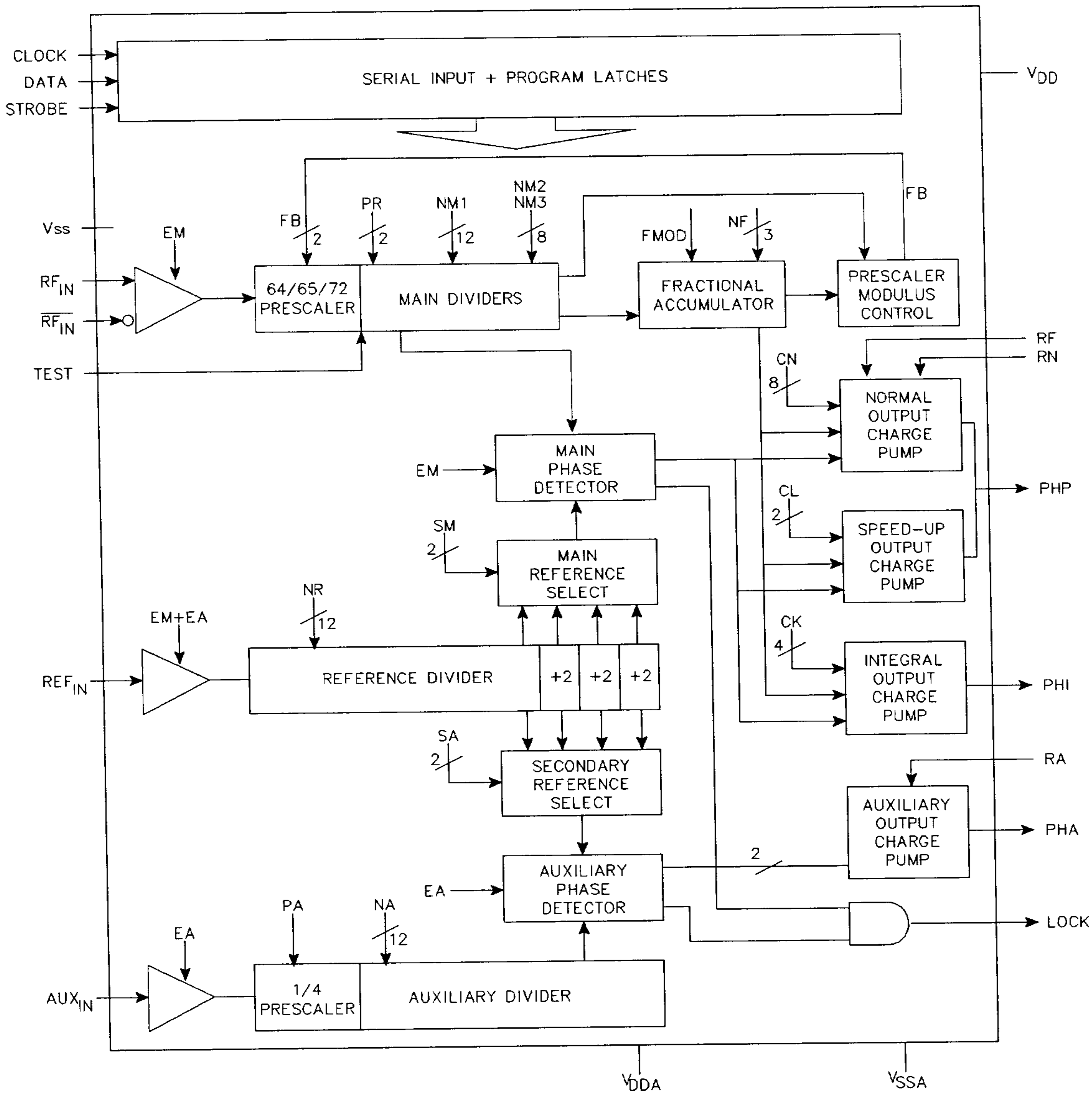


Figure 1: DL-3422 SYNTHESIZER INTEGRATED CIRCUIT (U811)

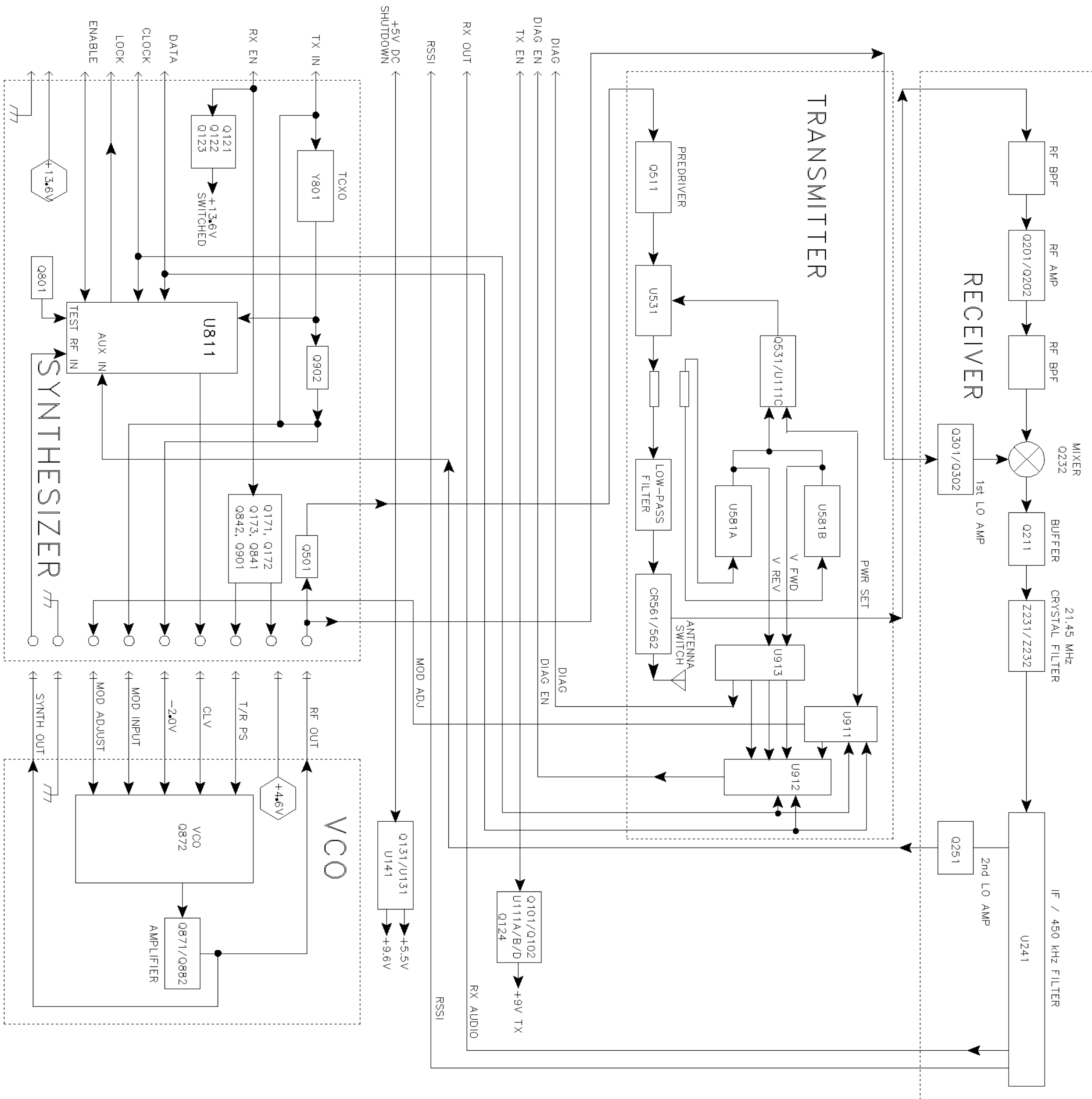


Figure 2: **DL-3422 TRANSCEIVER BLOCK DIAGRAM**

3.0 HNET MODEM Board Circuit Description

3.1 GENERAL

The Loader/Modem board, Part No. xxx-03280-001, is a plug-in circuit board. The four main functions of the Loader/Modem board include, loading the radio synthesizer, providing the baseband modulating signal for the transmitter and demodulating receive audio signals. The Loader/Modem board is programmed by a personal computer and software. The Loader/Modem board connects to the radio through 14-pin connector P1/J201. User data, programming channels and other operating parameters are provided through a DE-15 connector. A block diagram of the modem is shown at the end of this section.

3.2 TRANSMIT DATA

Transmit Data from the RS-232 port is level-shifted to TTL by U1, then gated through U6 and converted from asynchronous to synchronous format by U2. The CPLD modem, U6 takes the digital data stream and synthesizes to the constant-amplitude analog baseband signal, which is filtered by U12, buffered by U10B then applied to radio module TXA at P1-6.

The modem IC is a CPLD based on a Philips extended Programmable Logic Array (XPLA, PZ5128) which, with a programmable Raise–Cosine filter (U12), operates in DRCMSK[1] mode at 4800, 9600 and 19200 bits/sec. It incorporates a 7-bit hardware scrambler and uses Differential (NRZI) encoding in DRCMSK mode to minimize data pattern-sensitivity. Electronic potentiometer U9B (E-Pot), controlled by CPU U5, is used to set the transmitter deviation by amplitude adjustment of the baseband signal.

3.3 RECEIVE DATA

Received signals are applied to the RXA pin on P1-13 and amplified by U7A, whose gain is set by the electronic potentiometer U9A, then filtered by U12. The same filter circuit is used for transmission and reception: two analog multiplexer/demultiplexer gates (U11 A and B) controlled by TX_EN line are used for sharing. The filter U12 cut-off frequency is programmable by the CPU, based on the data rate. The analog signal is then fed to Peak Detectors U7C and U7D, to the slicer circuit U8C via U7B and U8B. The resulting synchronous bit stream is converted to asynchronous at U2 and shifted to RS-232 levels by U1.

3.4 SYNTHESIZER PROGRAMMING

The CPU programs the RF module synthesizer serially on each Tx/Rx transition. Logic of U1 and U11A/B switch the receive and transmit data path from the modem to the radio and/or the external serial port, under CPU control. The CPU also controls the sync/async converter U2, the filter cut-off frequency, the serial port handshake lines, and the LED indicators via Q1-3.

Three channel select inputs, ESD protected by D1, 2,3, in parallel with the on-board DIP switches, are read by the CPU to select the active channel. The fourth DIP switch puts the unit in TEST mode, which sends a test, tone (data rate/4).

[1] DRCMSK = Differential Raise Cosine Minimum Shift Keying

3.5 POWER SUPPLIES

The main DC power (13.3V nom.) coming from J1.5, 10 is filtered out for transient and then sent directly to power-up the radio module at P1.2. Voltage Regulator U14 (AVCC) provides 5 V for the receiver RX_5V and analog modem circuitry, while U13 (DVCC) provides 5V for the CPU and other digital logic.

3.6 MISCELLANEOUS FUNCTIONS

U4 generates a power-on reset for the CPU and U3 is a temperature sensor used by the firmware to compensate for variations in RSSI.

The RF module's RSSI output, P1-12, is read by an analog input on the CPU, which implements a squelch threshold in software. Other analog inputs are used to read ambient temperature (used to correct RSSI variations) and various internal voltages (B+_LVL, AVCC, etc.).

The DTR_PGM input, J2-10, puts the CPU in programming mode in which the CPU accepts commands and setup data from the Radio Service Software.

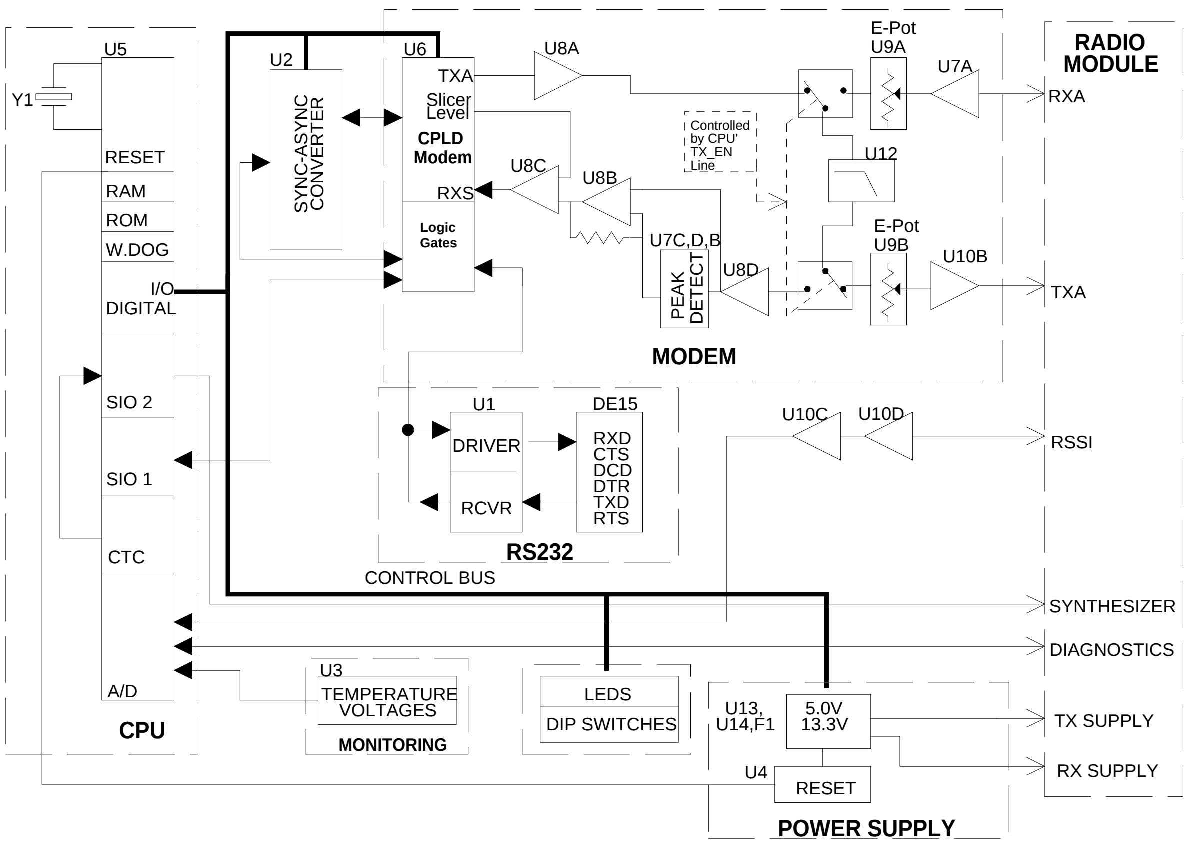


Figure 3: HNET MODEM BLOCK DIAGRAM

TRANSISTOR, DIODE, AND IC FUNCTIONS

RULE PART NUMBER: 2.983 (d)6)

DL-3422

Designator	Part Number	Function	JEDEC or Vendor Type
CR561	523-1504-001	Antenna switch	MMBV3401
CR562	523-1504-001	Antenna switch	MMBV3401
CR591	523-1504-016	Directional coupler	MMBD701LT
CR592	523-1504-016	Directional coupler	MMBD701LT
CR851	523-1504-001	Pin shift diode	MMBV3401
CR852	523-5005-023	Rectifier	MMBV609
CR853	523-5005-023	Rectifier	MMBV609
CR861	523-5005-022	Varactor	BB535E7908
CR862	523-5005-022	Varactor	BB535E7908
CR901	523-5005-022	Varactor	BB535E7908
CR902	523-1504-023	Rectifier	BAV99LT1
Q101	576-0013-046	Tx enable	MUN5213T1
Q102	576-0013-032	Tx enable	MUN2114T1
Q121	576-0013-046	Rx enable	MUN5213T1
Q122	576-0013-046	Rx enable	MUN5213T1
Q123	576-0013-032	Rx enable	MUN2114T1
Q124	576-0006-027	Soft key up control	PZT2222AT1
Q131	576-0013-046	5 volt shutdown	MUN5213T1
Q171	576-0013-046	Pin shift	MUN5213T1
Q172	576-0013-032	Pin shift	MUN2114T1
Q501	576-0003-640	RF buffer	MSA-2111
Q511	576-0003-636	RF driver	NE85633
Q531	576-0006-027	Power control	PZT2222AT1
Q801	576-0013-701	Constant voltage source	MSD1819A-RT1
Q841	576-0013-046	Pin shift	MUN5213T1
Q842	576-0013-032	Pin shift	MUN2114T1
Q871	576-0003-651	VCO buffer	NE85619-T1
Q872	576-0003-651	Oscillator	NE85619-T1
Q881	576-0013-700	Bias regulator	MSB1218A-AT1
Q882	576-0003-636	Amplifier	NE85633
Q901	576-0013-701	Capacitance multiplier	MSD1819A-RT1
Q902	576-0003-634	Amplifier	MMBT918LT1
U111A	544-2020-020	Soft key up control	LMC660AMI
U111B	544-2020-020	Soft key up control	LMC660AMI
U111C	544-2020-020	Power control	LMC660AMI
U111D	544-2020-020	Soft key up control	LMC660AMI
U131	544-2603-093	Voltage regulator	TK11900MTL
U141	544-2603-093	Voltage regulator	TK11900MTL
U531	544-4001-062	RF power module	M57732
U581A	544-2019-017	V-fwd amp	MC33172DT
U581B	544-2019-017	V-rev amp	MC33172DT
U811	544-3954-027	Synthesizer	SA7025DK-T

TRANSISTOR, DIODE, AND IC FUNCTIONS (continued)

RULE PART NUMBER: 2.983 (d)6)

HNET MODEM

Reference designator	Function	Type
CZ1	Transient Voltage Suppressor 5.6v, 0805	VC080505A150
CZ2	Transient Voltage Suppressor 5.6v, 0805	VC080505A150
CZ3	Transient Voltage Suppressor 14v, 0805	VC080514A300
CZ6	Transient Voltage Suppressor 14v, 0805	VC080514A300
CZ7	Transient Voltage Suppressor 14v, 0805	VC080514A300
CZ8	Transient Voltage Suppressor 14v, 0805	VC080514A300
CZ9	Transient Voltage Suppressor 14v, 0805	VC080514A300
CZ10	Transient Voltage Suppressor 14v, 0805	VC080514A300
CZ11	Transient Voltage Suppressor 14v, 0805	VC080514A300
CZ12	Transient Voltage Suppressor 14v, 0805	VC080514A300
CZ4	Transient Voltage Suppressor 5.6v, 0805	VC080505A150
CZ5	Transient Voltage Suppressor 5.6v, 0805	VC080505A150
D1	reverse power supply protection	1N4001
D2	reference setting	BAV99LT1
D3	TTL input protection	BAV99LT1
D4	TTL input protection	BAV99LT1
D5	TTL input protection	BAV99LT1
D6	negative peak detector	MBD301LT1
D7	positive peak detector	MBD301LT1
D8	DIODE,ZENER 4.7v	BZX84C4V7LT1
DS1	Led, Narrow Beam, Yellow	HLMP-6400-010
DS2	Led, Narrow Beam, Red	HLMP-6000-010
DS3	LED, Narrow Beam, Green	HLMP-6500-010
Q1	LED Switch	MMBT3904LT1
Q2	LED Switch	MMBT3904LT1
Q3	LED Switch	MMBT3904LT1
Q4	phase peak shape formatter	MMBT3904LT1
Q5	phase peak shape formatter	MMBT3904LT1
U1	RS-232 Driver/Receiver 5v	MC145407DW
U2	Data Set (sync/async) Interface	MC145428DW
U4	Undervoltage Sensing Circuit	MC33064D
U5	Microprocessor ,QFP-80	68HC711K4FU
U6	CPLD 64 Macrocell, Digital Modem	PZ5064-I12A44
U7	Dual , Op Amp	LMC6484AIM
U8	Quad, Op Amp	TLC2274I
U9	Digital Potentiometer	AD8402AR50
U10	Quad, Op Amp	TLC2274I
U11	Analog Multiplexers/Demultiplexers	MC74HC4053D
U12	Filter, Linear Phase Low Pass	LTC1069-7
U13	Regulator, Micropower Voltage	LP2951CD
U14	Regulator, Micropower Voltage	LP2951CD

TRANSMITTER TUNE UP PROCEDURE

RULE PART NUMBER: 2.983 (d)(9)

TRANSMITTER TUNE UP PROCEDURE

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 C525 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.

INSTRUCTION BOOK

RULE PART NUMBER: 2.983 (d)(8)

The attached Service Manual for the DL-3422 is an updated and released version.

NAME OF TEST: Transmitter Rated Power Output

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

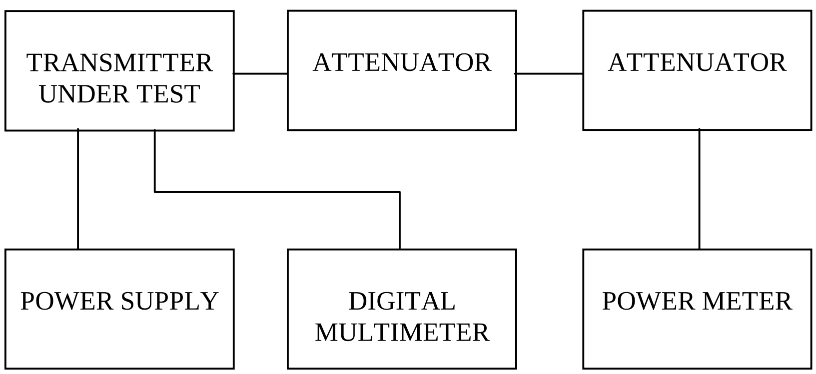
TEST RESULTS: See results below

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, Hewlett Packard 436A

PERFORMED BY: ______________________________ DATE: 7/9/98
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)**
132.000	13.3	1.21	16.09	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 8^{th} 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

****

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

****

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

$$TP=\int_{0}^{+\infty} PSD_{(f)}df =(1/t)* \int_{-\infty}^{+\infty} |z_{(t)}|^2dt$$

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.

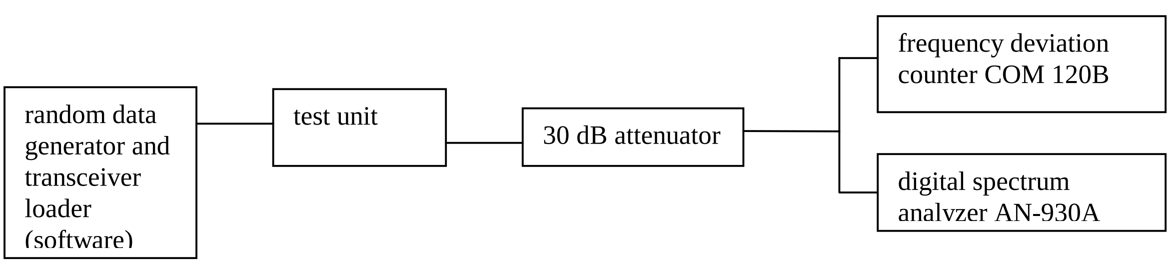
Standard calculation precision is all that is required. The main error factor being the y display resolution is covering calculation precision.

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

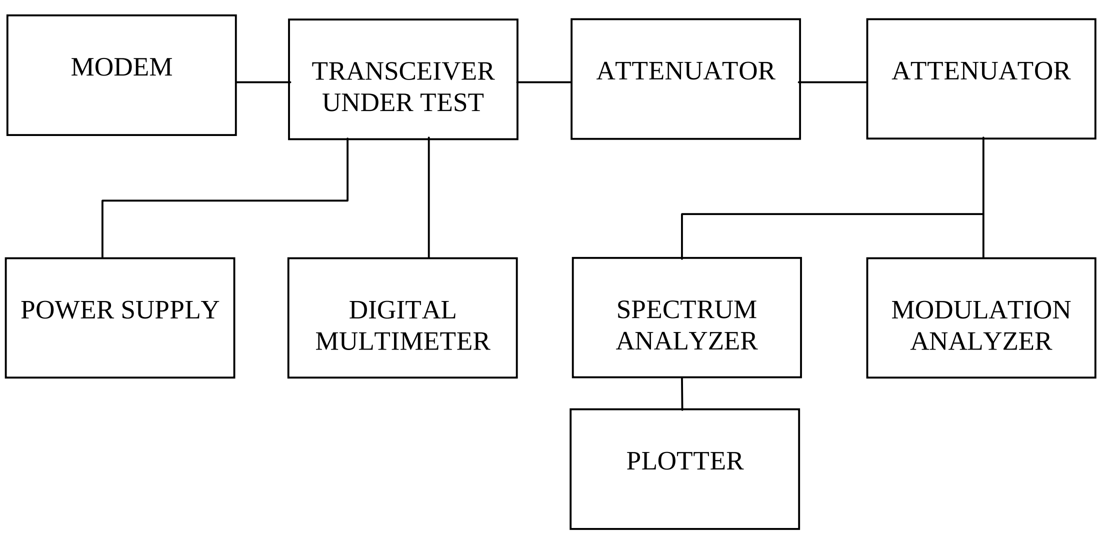
TEST RESULTS: Meets minimum standard (see data on the following pages)

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: 7/3/98

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 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.

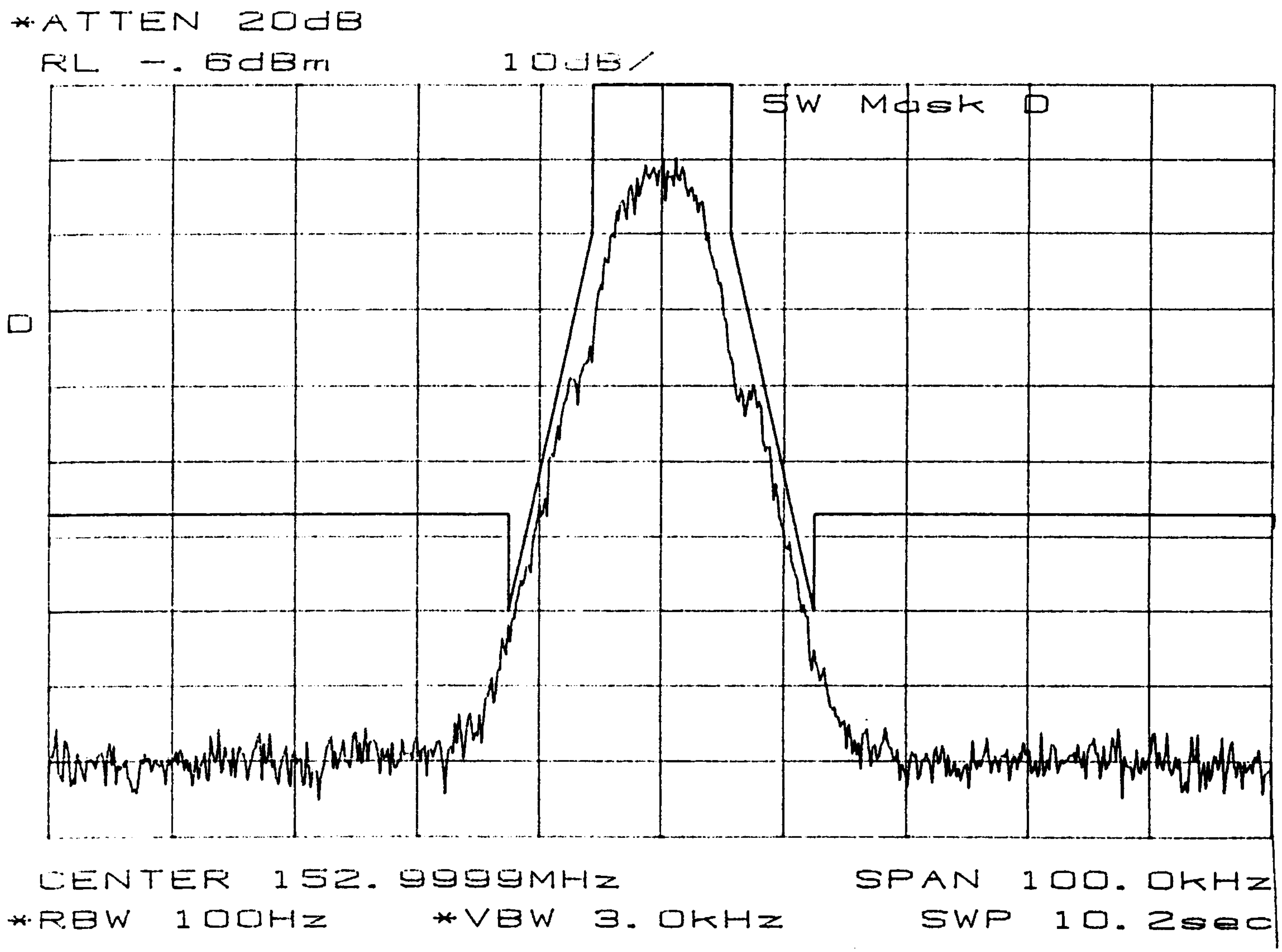
NECESSARY BANDWIDTH (Bn) CALCULATION

See page 24 for Emission Designator determination.

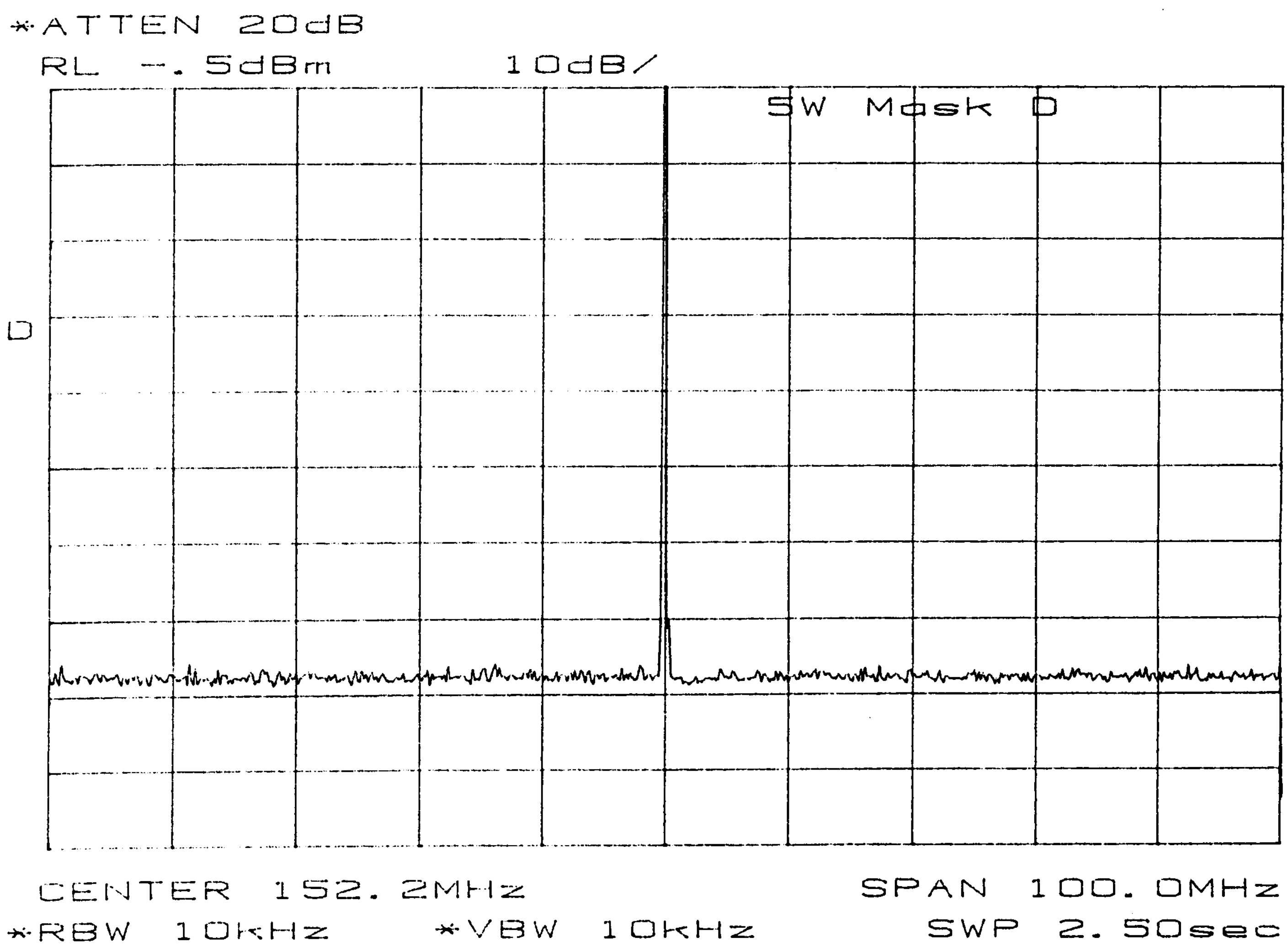
The corresponding emission designator prefix for necessary bandwidth = **9K3**

TEST DATA: Refer to the following graphs:

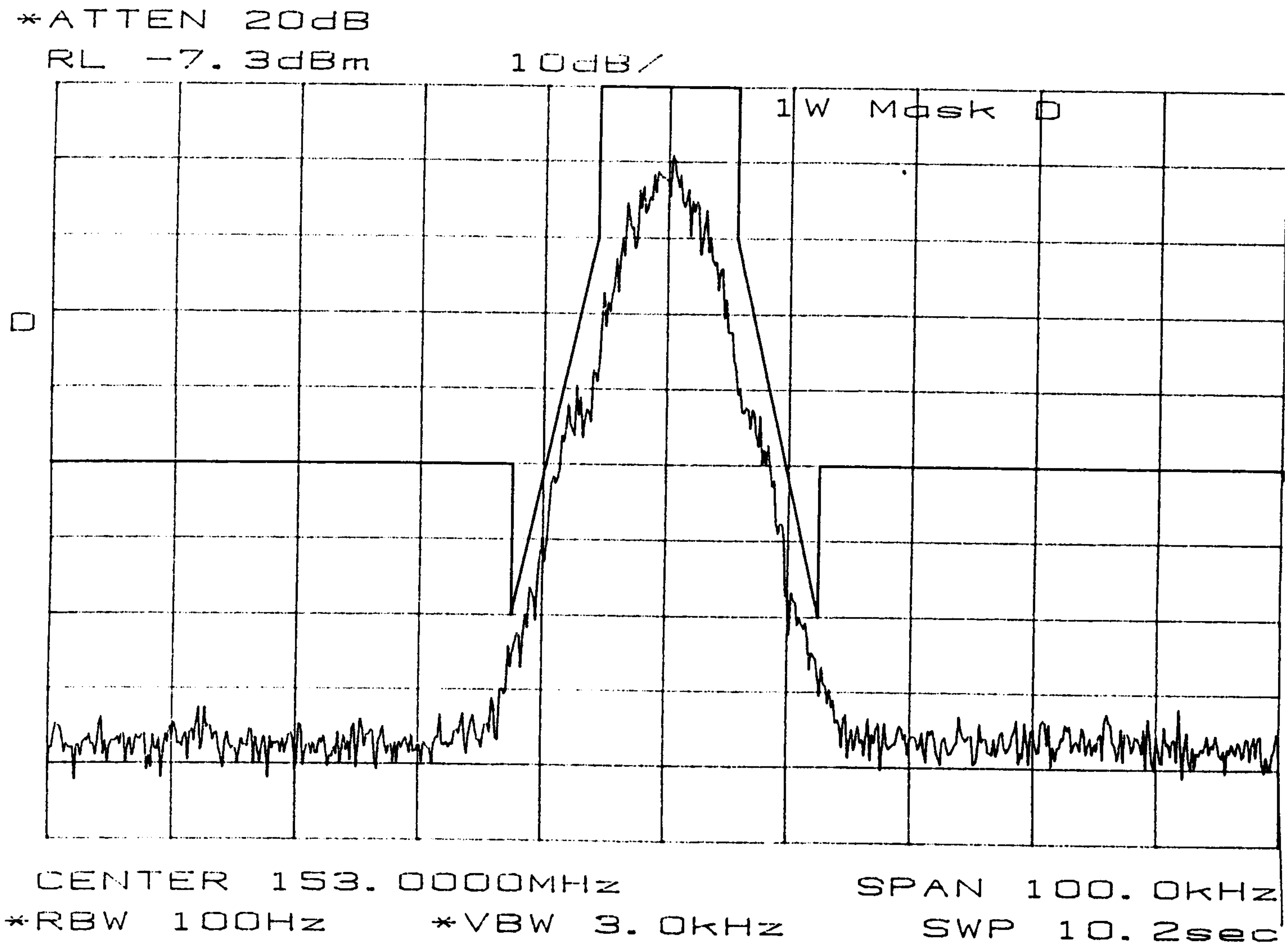
MASK: **D**
SPECTRUM FOR EMISSION **9K3F1D**
OUTPUT POWER: 5 Watts
9600 bps
PEAK DEVIATION = 3000 Hz
SPAN = 100 kHz



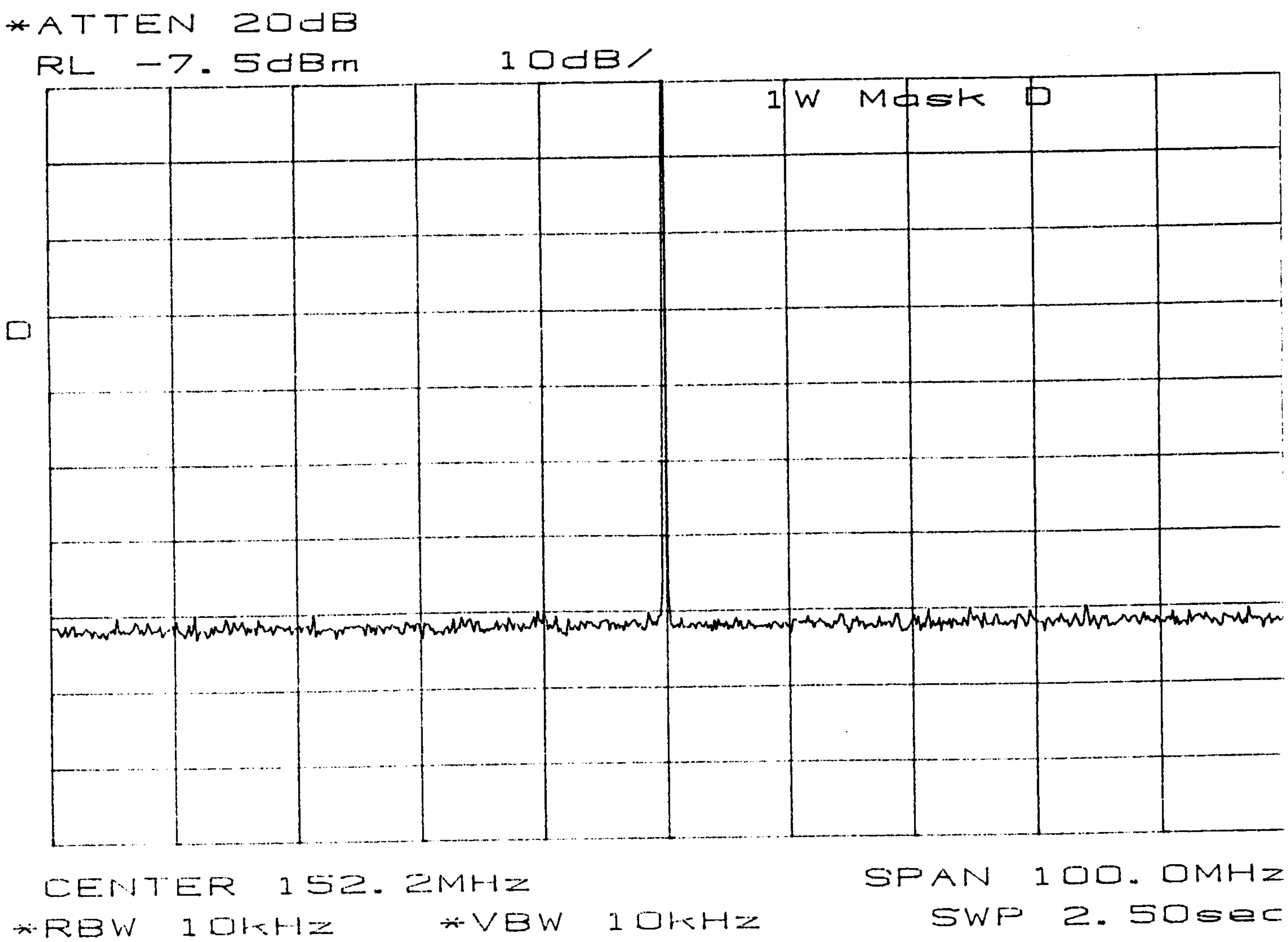
MASK: **D**
SPECTRUM FOR EMISSION **9K3F1D**
OUTPUT POWER: 5 Watts
9600 bps
PEAK DEVIATION = 3000 Hz
SPAN = 100 MHz



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 19.2 Kbps
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)

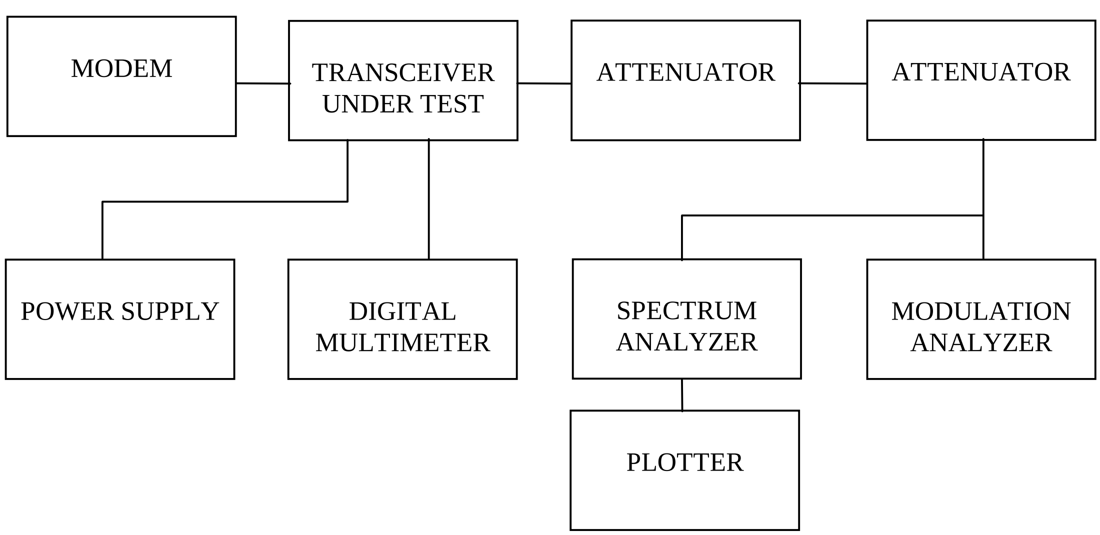
TEST RESULTS: Meets minimum standard (see data on the following pages)

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: ______________________ DATE: 7/3/98
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.

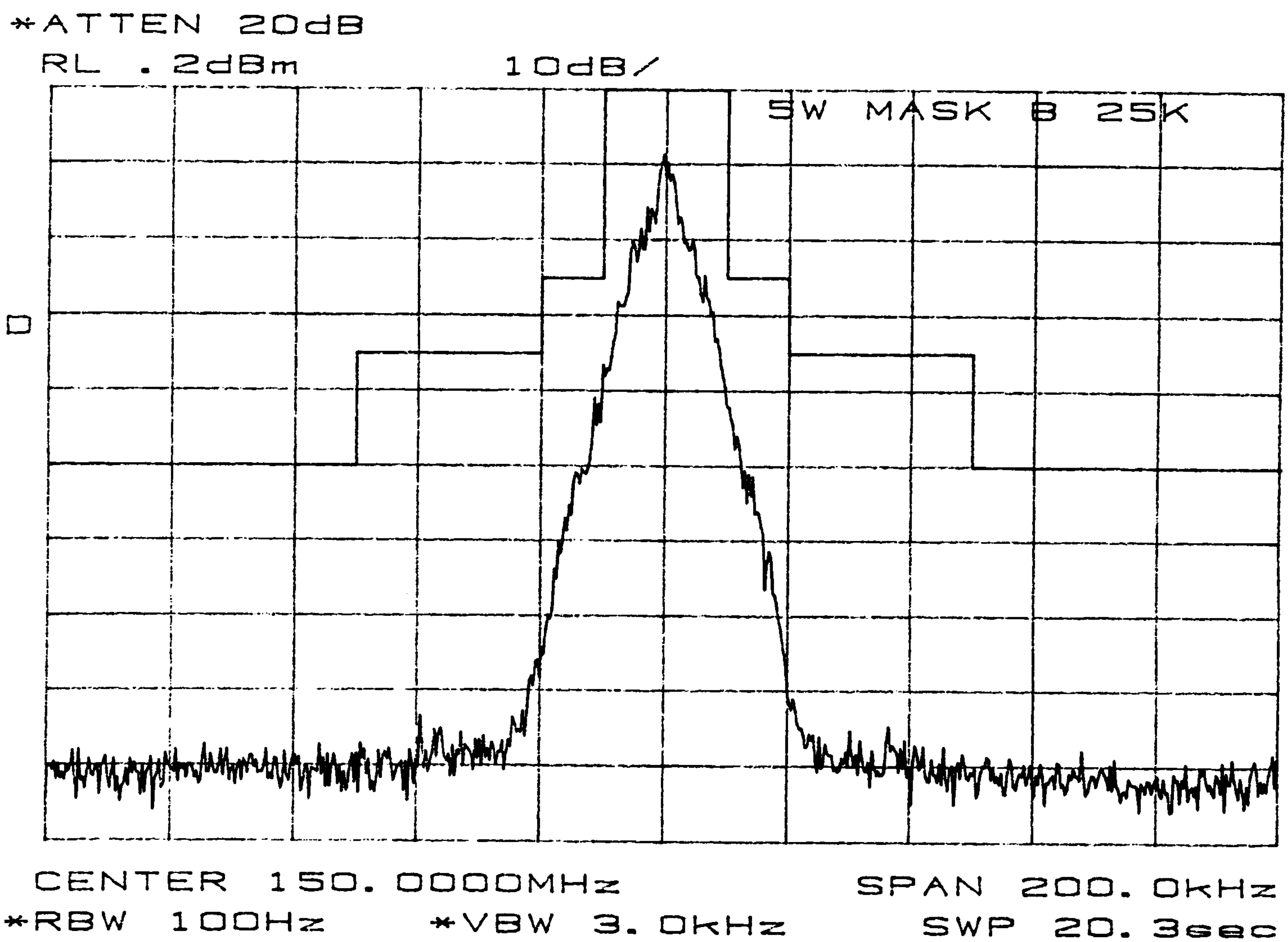
NECESSARY BANDWIDTH (Bn) CALCULATION

See page 24 for Emission Designator determination.

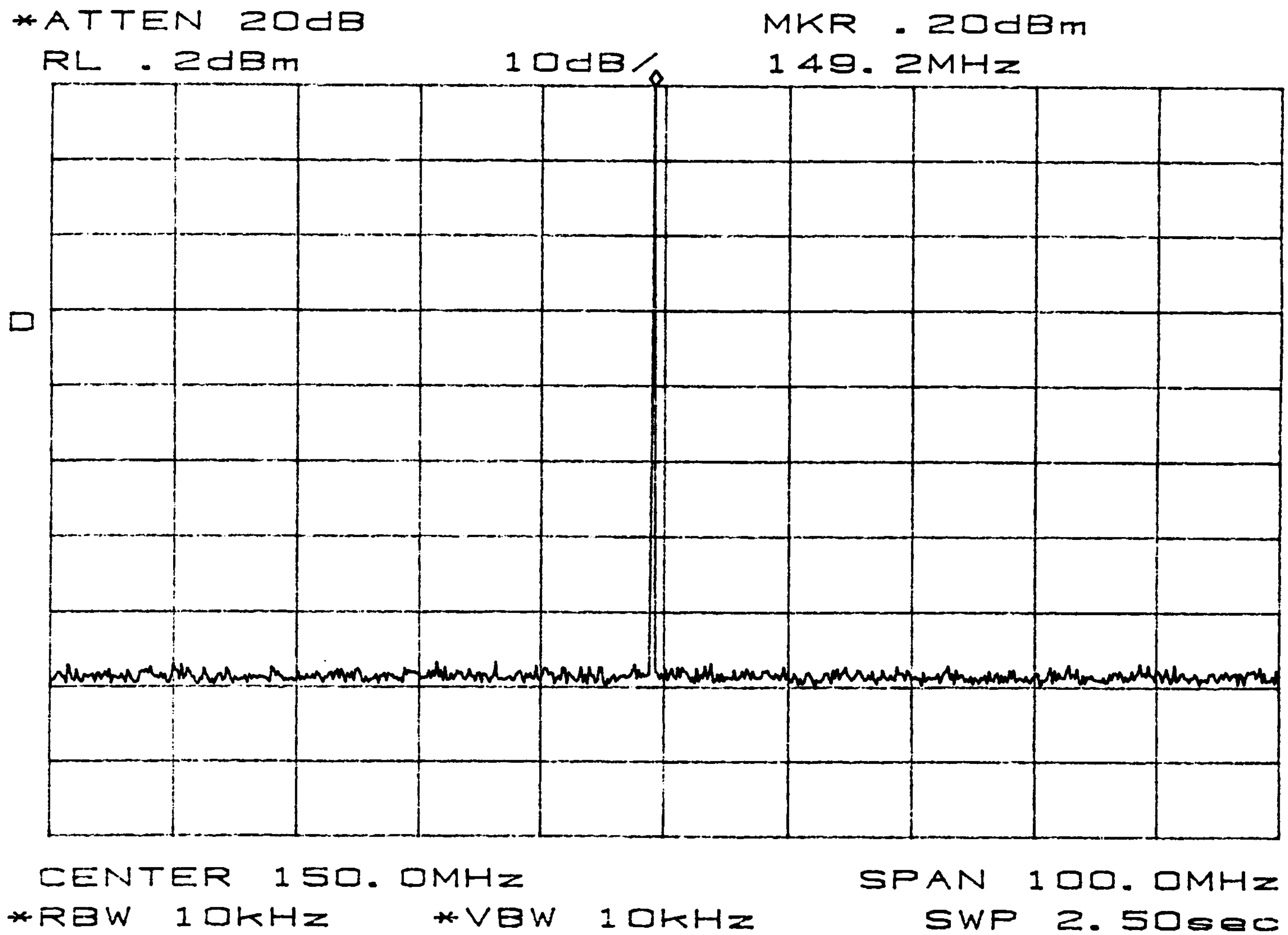
The corresponding emission designator prefix for necessary bandwidth = **15K3**

TEST DATA: Refer to the following graphs:

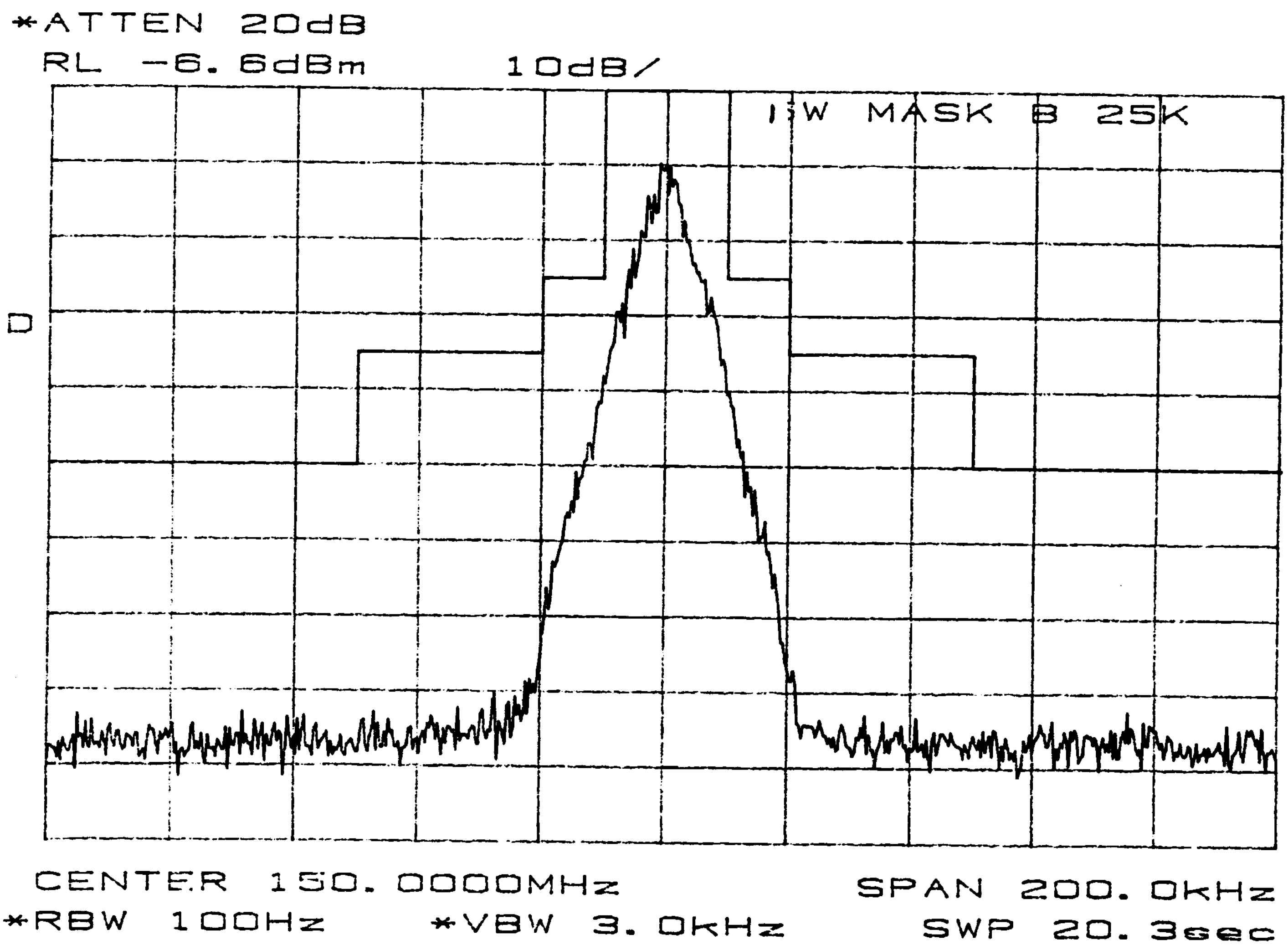
MASK: **B**
SPECTRUM FOR EMISSION **15K3F1D**
OUTPUT POWER: 5 Watts
19200 bps
PEAK DEVIATION = 4000 Hz
SPAN = 200 kHz



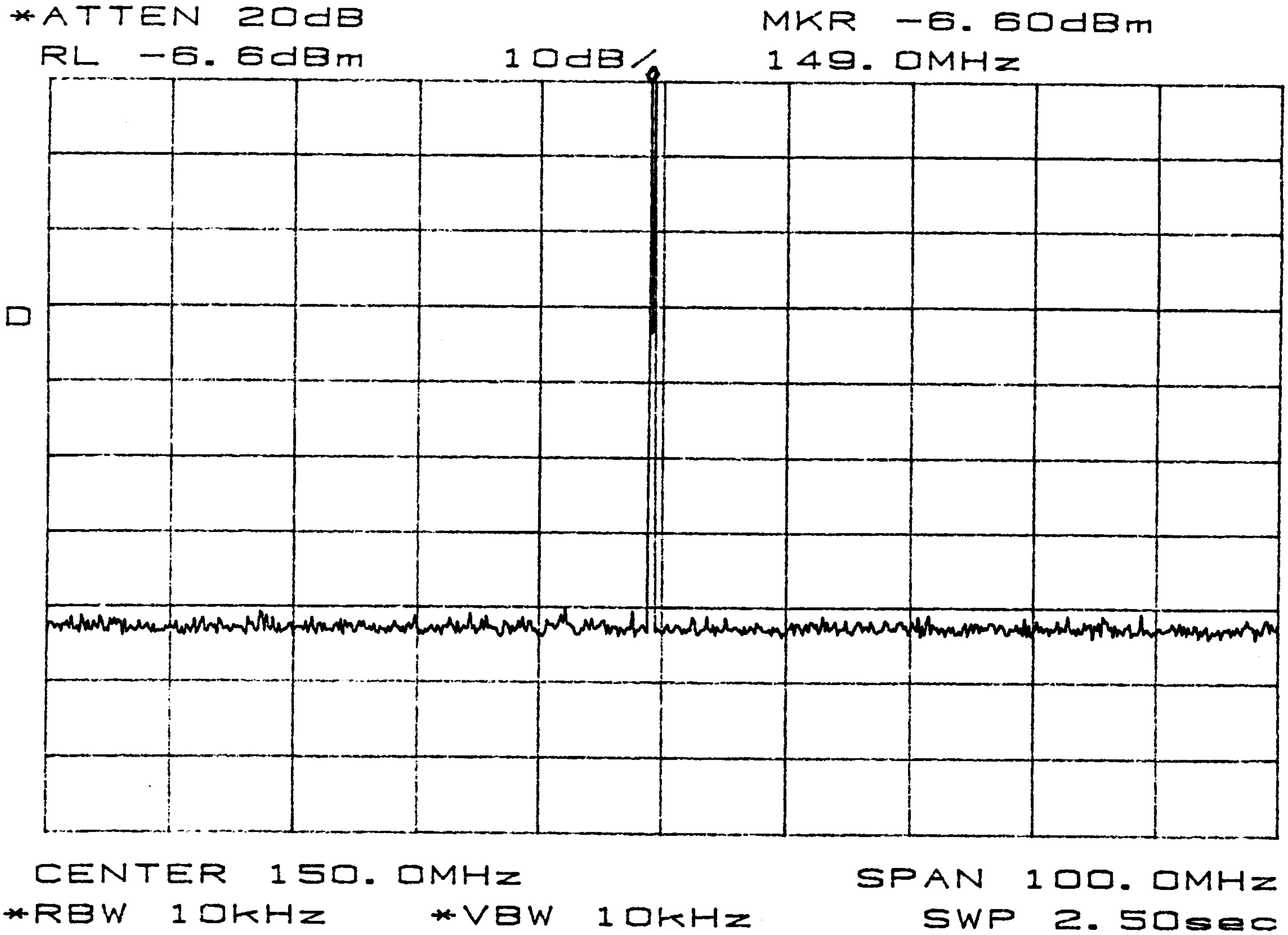
MASK: **B**
SPECTRUM FOR EMISSION **15K3F1D**
OUTPUT POWER: 5 Watts
19200 bps
PEAK DEVIATION = 4000 Hz
SPAN = 100 MHz



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

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

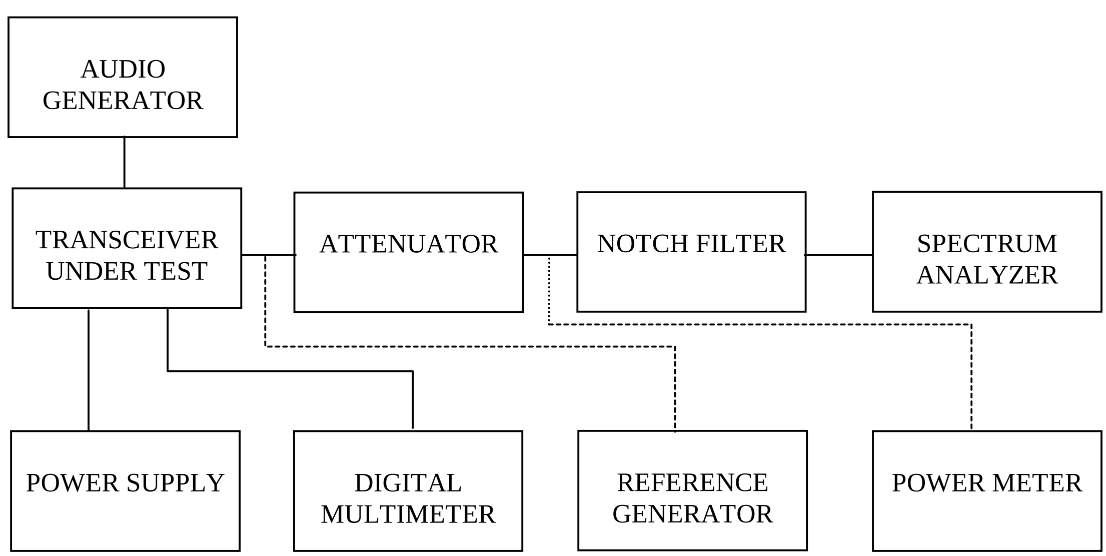
TEST CONDITIONS: Standard Test Conditions, 25 C
RF voltage measured at antenna terminals

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: ______________________________ Date:7/23/98
Allen Frederick

TEST SET-UP:



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

MEASUREMENT PROCEDURE:

1. The transmitter carrier output frequency is 132.000, 153.000 and 174.000 MHz. The reference oscillator frequency is 14.85 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 = 132.000 MHz
5 Watts = 37dBm Transmitter Spurious and Harmonics

Frequency (MHz)	Relation	Level (dBm)	Level Relative To Carrier (dBc)
264	2 Fo	-39	-76
396	3 Fo	-46	-83
528	4 Fo	-60	-97
660	5 Fo	-54	-91
792	6 Fo	-53	-90
924	7 Fo	-71	-108
1056	8 Fo	-70	-107
1188	9 Fo	-71	-108
1320	10 Fo	-69	-106

F_o = 153.000 MHz
5 Watts = 37dBm Transmitter Spurious and Harmonics

Frequency (MHz)	Relation	Level (dBm)	Level Relative To Carrier (dBc)
306	2 Fo	-46	-83
459	3 Fo	-69	-106
612	4 Fo	-54	-91
765	5 Fo	-66	-103
918	6 Fo	-59	-96
1071	7 Fo	-71	-108
1224	8 Fo	-71	-108
1377	9 Fo	-62	-99
1530	10 Fo	-78	-115

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

F_o = 174.000 MHz
5 Watts = 37dBm

Transmitter Spurious and Harmonics

Frequency (MHz)	Relation	Level (dBm)	Level Relative To Carrier (dBc)
348	2 Fo	-52	-89
522	3 Fo	-68	-105
696	4 Fo	-62	-99
870	5 Fo	-51	-88
1044	6 Fo	-83	-120
1218	7 Fo	-72	-109
1392	8 Fo	-52	-89
1566	9 Fo	-73	-110
1740	10 Fo	-70	-107

F_o = 132.000 MHz
1 Watts = 30 dBm

Transmitter Spurious and Harmonics

Frequency (MHz)	Relation	Level (dBm)	Level Relative To Carrier (dBc)
264	2 Fo	-55	-92
396	3 Fo	-68	-105
528	4 Fo	-67	-104
660	5 Fo	-60	-97
792	6 Fo	-61	-98
924	7 Fo	-71	-108
1056	8 Fo	-79	-116
1188	9 Fo	-74	-111
1320	10 Fo	-60	-97

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

F_o = 153.000 MHz
1 Watts = 30 dBm

Transmitter Spurious and Harmonics

Frequency (MHz)	Relation	Level (dBm)	Level Relative To Carrier (dBc)
306	2 Fo	-48	-85
459	3 Fo	-70	-107
612	4 Fo	-59	-96
765	5 Fo	-71	-108
918	6 Fo	-63	-100
1071	7 Fo	-82	-119
1224	8 Fo	-68	-105
1377	9 Fo	-62	-99
1530	10 Fo	-72	-109

F_o = 174.000 MHz
1 Watts = 30 dBm

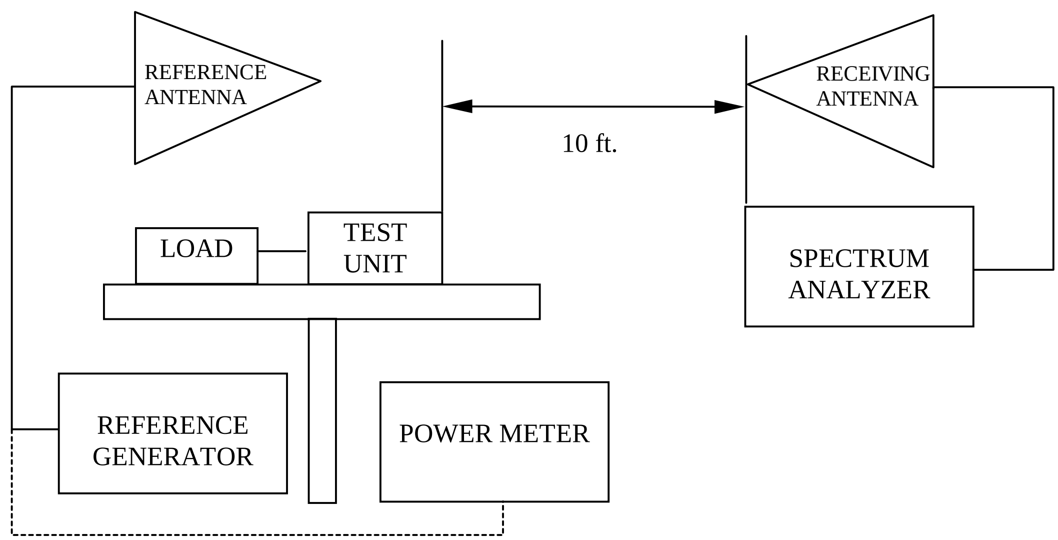
Transmitter Spurious and Harmonics

Frequency (MHz)	Relation	Level (dBm)	Level Relative To Carrier (dBc)
348	2 Fo	-62	-99
522	3 Fo	-73	-110
696	4 Fo	-80	-117
870	5 Fo	-62	-99
1044	6 Fo	-80	-117
1218	7 Fo	-75	-112
1392	8 Fo	-52	-89
1566	9 Fo	-76	-113
1740	10 Fo	-82	-119

NAME OF TEST:	Field Strength of Spurious Radiation
RULE PART NUMBER:	2.993, 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: 7/24/98

NAME OF TEST: Spurious Radiation Attenuation (Continued)

Frequency: 132 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
264	H	-68.30	-45.50	2.17	-0.85	0.00	-85.51
	V	-76.30	-44.00	2.17	-0.85	0.00	-84.01
396	H	-96.17	-67.00	2.50	-0.35	0.00	-106.84
	V	-93.80	-66.50	2.50	-0.35	0.00	-106.34
528	H	-71.17	-36.00	3.00	-1.15	0.00	-77.14
	V	-76.00	-44.50	3.00	-1.15	0.00	-85.64
660	H	-60.30	-29.00	3.50	-1.15	0.00	-70.64
	V	-72.50	-31.50	3.50	-1.15	0.00	-73.14
792	H	-66.30	-27.50	4.00	-2.05	0.00	-70.54
	V	-72.17	-34.00	4.00	-2.05	0.00	-77.04
924	H	-82.33	-38.00	4.33	-1.65	0.00	-80.97
	V	-85.00	-46.00	4.33	-1.65	0.00	-88.97
1056	H	-76.00	-24.00	5.33	1.20	3.00	-68.12
	V	-83.50	-37.00	5.33	1.20	3.00	-81.12
1188	H	-89.83	-46.00	5.67	1.20	3.00	-90.46
	V	-90.67	-48.00	5.67	1.20	3.00	-92.46
1320	H	-88.67	-42.00	5.83	1.20	3.00	-86.62
	V	-84.33	-42.50	5.83	1.20	3.00	-87.12

Frequency: 132 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
264	H	-82.50	-60.00	2.17	-0.85	0.00	-93.02
	V	-75.33	-43.00	2.17	-0.85	0.00	-76.02
396	H	-96.50	-67.00	2.50	-0.35	0.00	-99.85
	V	-95.83	-67.50	2.50	-0.35	0.00	-100.35
528	H	-74.17	-39.00	3.00	-1.15	0.00	-73.15
	V	-74.33	-42.50	3.00	-1.15	0.00	-76.65
660	H	-60.83	-29.50	3.50	-1.15	0.00	-64.15
	V	-72.00	-31.00	3.50	-1.15	0.00	-65.65
792	H	-66.83	-28.00	4.00	-2.05	0.00	-64.05
	V	-70.81	-32.50	4.00	-2.05	0.00	-68.55
924	H	-80.17	-36.00	4.33	-1.65	0.00	-71.98
	V	-86.67	-47.50	4.33	-1.65	0.00	-83.48
1056	H	-73.17	-21.50	5.33	1.20	3.00	-58.63
	V	-94.50	-48.00	5.33	1.20	3.00	-85.13
1188	H	-88.83	-45.00	5.67	1.20	3.00	-82.47
	V	-87.17	-44.50	5.67	1.20	3.00	-81.97
1320	H	-88.83	-42.00	5.83	1.20	3.00	-79.63
	V	-83.67	-41.50	5.83	1.20	3.00	-79.13

NAME OF TEST: Spurious Radiation Attenuation (Continued)

Frequency: 153 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
306	H	-63.50	-40.00	2.17	-0.85	0.00	-80.01
	V	-69.17	-40.50	2.17	-0.85	0.00	-80.51
459	H	-85.00	-49.50	2.70	0.15	0.00	-89.04
	V	-82.33	-54.50	2.70	0.15	0.00	-94.04
612	H	-66.17	-34.50	3.50	-1.15	0.00	-76.14
	V	-68.50	-30.00	3.50	-1.15	0.00	-71.64
765	H	-59.50	-22.00	4.00	-1.45	0.00	-64.44
	V	-62.83	-24.00	4.00	-1.45	0.00	-66.44
918	H	-74.00	-29.50	4.70	-1.65	0.00	-72.84
	V	-76.17	-38.00	4.70	-1.65	0.00	-81.34
1071	H	-85.33	-33.50	5.30	1.20	3.00	-77.59
	V	-75.50	-31.50	5.30	1.20	3.00	-75.59
1224	H	-98.50	-53.50	5.70	1.20	3.00	-97.99
	V	-101.00	-57.50	5.70	1.20	3.00	-101.99
1377	H	-95.67	-45.50	6.00	1.20	3.00	-90.29
	V	-92.83	-39.50	6.00	1.20	3.00	-84.29
1530	H	-100.00	-60.00	6.00	1.20	3.00	-104.79
	V	-96.50	-53.00	6.00	1.20	3.00	-97.79

Frequency: 153 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
306	H	-69.17	-45.50	2.17	-0.85	0.00	-78.52
	V	-65.17	-36.50	2.17	-0.85	0.00	-69.52
459	H	-80.33	-45.00	2.70	0.15	0.00	-77.55
	V	-81.67	-54.00	2.70	0.15	0.00	-86.55
612	H	-66.00	-34.50	3.50	-1.15	0.00	-69.15
	V	-71.83	-33.50	3.50	-1.15	0.00	-68.15
765	H	-61.50	-24.50	4.00	-1.45	0.00	-59.95
	V	-66.50	-27.50	4.00	-1.45	0.00	-62.95
918	H	-75.83	-31.50	4.70	-1.65	0.00	-67.85
	V	-73.67	-35.50	4.70	-1.65	0.00	-71.85
1071	H	-93.67	-42.00	5.30	1.20	3.00	-79.10
	V	-76.17	-32.50	5.30	1.20	3.00	-69.60
1224	H	-97.83	-52.50	5.70	1.20	3.00	-90.00
	V	-104.50	-60.50	5.70	1.20	3.00	-98.00
1377	H	-94.67	-44.50	6.00	1.20	3.00	-82.30
	V	-97.33	-44.00	6.00	1.20	3.00	-81.80
1530	H	-99.17	-59.00	6.00	1.20	3.00	-96.80
	V	-95.50	-52.50	6.00	1.20	3.00	-90.30

NAME OF TEST: Spurious Radiation Attenuation (Continued)

Frequency: 174 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
348	H	-73.00	-47.50	2.17	-0.25	0.00	-86.92
	V	-75.33	-46.00	2.17	-0.25	0.00	-85.41
522	H	-81.33	-46.50	2.70	-1.15	0.00	-87.34
	V	-80.00	-48.50	2.70	-1.15	0.00	-89.34
696	H	-57.17	-25.00	3.50	-1.85	0.00	-67.34
	V	-55.83	-21.50	3.50	-1.85	0.00	-63.84
870	H	-68.50	-33.00	4.00	-0.85	0.00	-74.84
	V	-68.17	-30.00	4.00	-0.85	0.00	-71.84
1044	H	-76.17	-27.00	4.70	1.20	3.00	-70.49
	V	-82.50	-42.00	4.70	1.20	3.00	-85.49
1218	H	-94.67	-48.50	5.30	1.20	3.00	-92.59
	V	-95.17	-50.50	5.30	1.20	3.00	-94.59
1392	H	-90.00	-39.00	5.70	1.20	3.00	-83.49
	V	-88.83	-41.00	5.70	1.20	3.00	-85.49
1566	H	-102.00	-59.00	6.00	1.20	3.00	-103.79
	V	-100.80	-55.00	6.00	1.20	3.00	-99.79
1740	H	-97.17	-53.17	6.00	1.20	3.00	-97.96
	V	-91.50	-48.50	6.00	1.20	3.00	-93.29

Frequency: 174 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
348	H	-92.67	-47.00	2.17	-0.25	0.00	-79.42
	V	-76.67	-47.50	2.17	-0.25	0.00	-79.92
522	H	-78.67	-43.00	2.70	-1.15	0.00	-76.85
	V	-82.00	-50.00	2.70	-1.15	0.00	-83.85
696	H	-69.33	-37.00	3.50	-1.85	0.00	-72.35
	V	-69.17	-39.50	3.50	-1.85	0.00	-74.85
870	H	-75.33	-40.00	4.00	-0.85	0.00	-74.85
	V	-65.67	-32.00	4.00	-0.85	0.00	-66.85
1044	H	-74.00	-25.00	4.70	1.20	3.00	-61.50
	V	-87.50	-47.00	4.70	1.20	3.00	-83.50
1218	H	-94.67	-48.50	5.30	1.20	3.00	-85.60
	V	-96.33	-51.50	5.30	1.20	3.00	-88.60
1392	H	-89.33	-38.50	5.70	1.20	3.00	-76.00
	V	-88.33	-40.50	5.70	1.20	3.00	-78.00
1566	H	-99.17	-56.00	6.00	1.20	3.00	-93.80
	V	-101.20	-55.50	6.00	1.20	3.00	-93.30
1740	H	-95.00	-57.50	6.00	1.20	3.00	-95.30
	V	-93.00	-50.00	6.00	1.20	3.00	-87.80

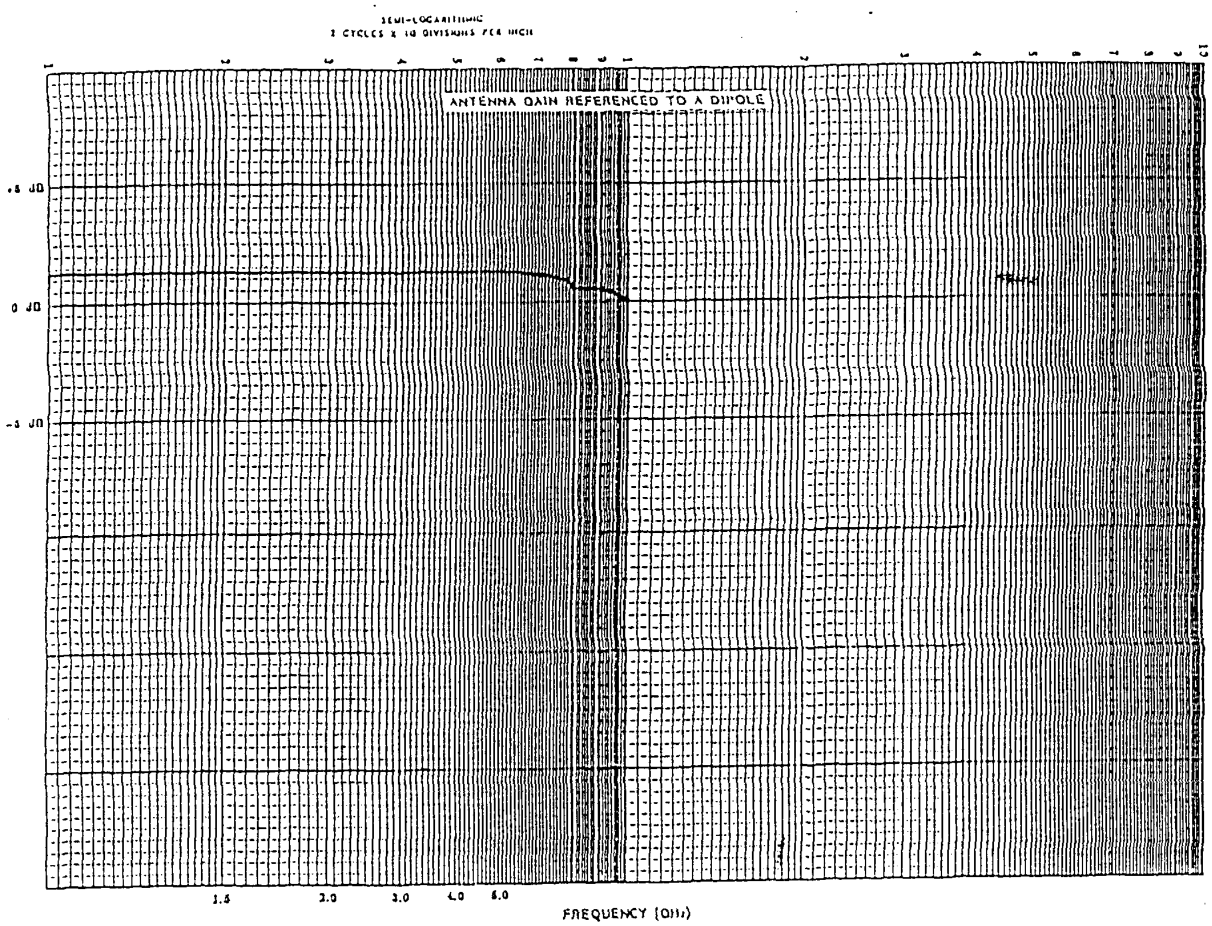
CALCULATIONS FOR FIELD STRENGTH OF SPURIOUS RADIATION TESTS:

The transmitter carrier frequencies were 132.000 MHz, 153.000 MHz, and 174.000 MHz. The reference oscillator frequency of all the transceivers used is 14.85 MHz. The output of the transceivers were searched from 14.85 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 348 MHz (174 MHz tuned), 5 Watts and horizontal polarization.

r = Substitution Gen - Cable Loss	-47.5 - 2.17	= -49.67
R - Reference Generator (dBm)	-49.67	
A - Antenna Gain (dB)	+-.25	
P - Polarization Correction Factor (dB)	0.0	
R' (Corrected Reference (dBm)) = R + A - P	= -49.67 + -.25 - 0.0	= **-49.92 dBm**
Po - Radiated Carrier Power (dBm)	5 Watts = 37 dBm	
Radiated Spurious Emission (dBc) = Po - R'	= -49.92 - (+37)	= **-86.92 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 ± 0.000250% from test frequency, or 2.50 ppm

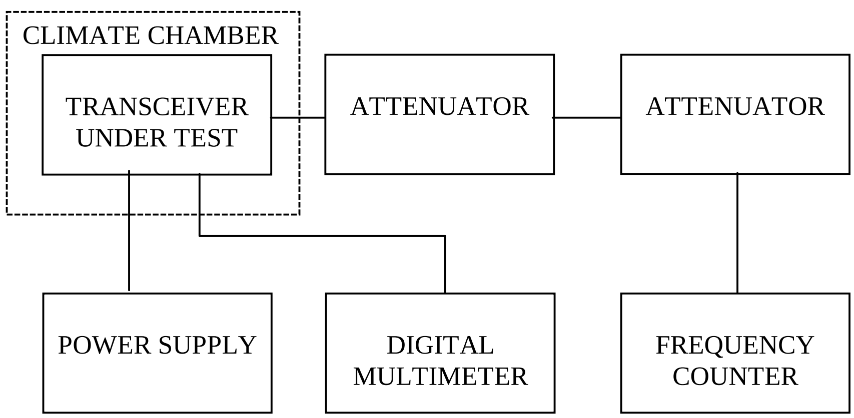
TEST RESULTS: Meets minimum standard, see data on following page

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: 150000000 Hz
Tolerance Requirement: 2.5 ppm
Highest Variation (ppm): 1.953 ppm

TEMP ° C	FREQUENCY MHz	FREQ DELTA Hz	ppm from assigned frequency
-30	150000066	66	0.440
-20	150000129	129	0.860
-10	150000293	293	1.953
0	150000104	104	0.693
10	150000120	120	0.800
20	149999925	-75	0.500
30	149999843	-157	1.047
40	149999798	-202	1.347
50	149999930	-70	0.467
60	149999899	-101	0.673

NAME OF TEST: Frequency Stability with Variation in Supply Voltage

RULE PART NUMBER: 2.995 (d)

MINIMUM STANDARD: Shall not exceed ± 0.000250% from test frequency, 2.50 ppm for ±15% change in supply voltage

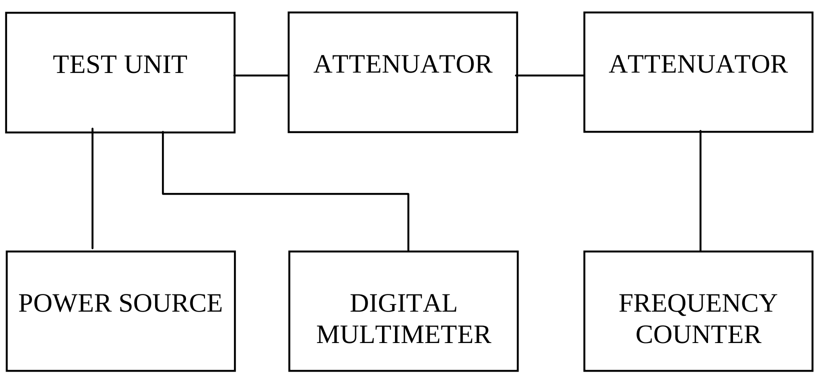
TEST RESULTS: Meets minimum standard, see data on following page

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: ______________________ DATE: 7/23/98
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:

2.5 ppm Reference Oscillator

Frequency Reference Set at 25° C: 149.99999 MHz
Tolerance Requirement: 0.00025 %
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	149.99999	0.00000000	0.00025	0.000
13	**149.99999**	0.00000000	0.00025	0.000
16	149.99999	0.00000000	0.00025	0.000

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 HNET modem modulating the transmitter at 19.2 Kbps, 4 kHz deviation. Also supplied is a transient test which was conducted with the HNET modem modulating the transmitter at 9600 bps, 4 kHz deviation.

MINIMUM STANDARD:

12.5 kHz channel (used worst case numbers from 132 to 174 MHz)
25 kHz channel (used worst case numbers from 132 to 174 MHz)

TIME INTERVAL	**MAXIMUM FREQUENCY DIFFERENCE (kHz)**		**TIME (mS)**
	12.5KHz CH	25KHz CH	
T1	+/- 12.5	+/- 25	5
T2	+/- 6.25	+/- 12.5	20
T3	+/- 12.5	+/- 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

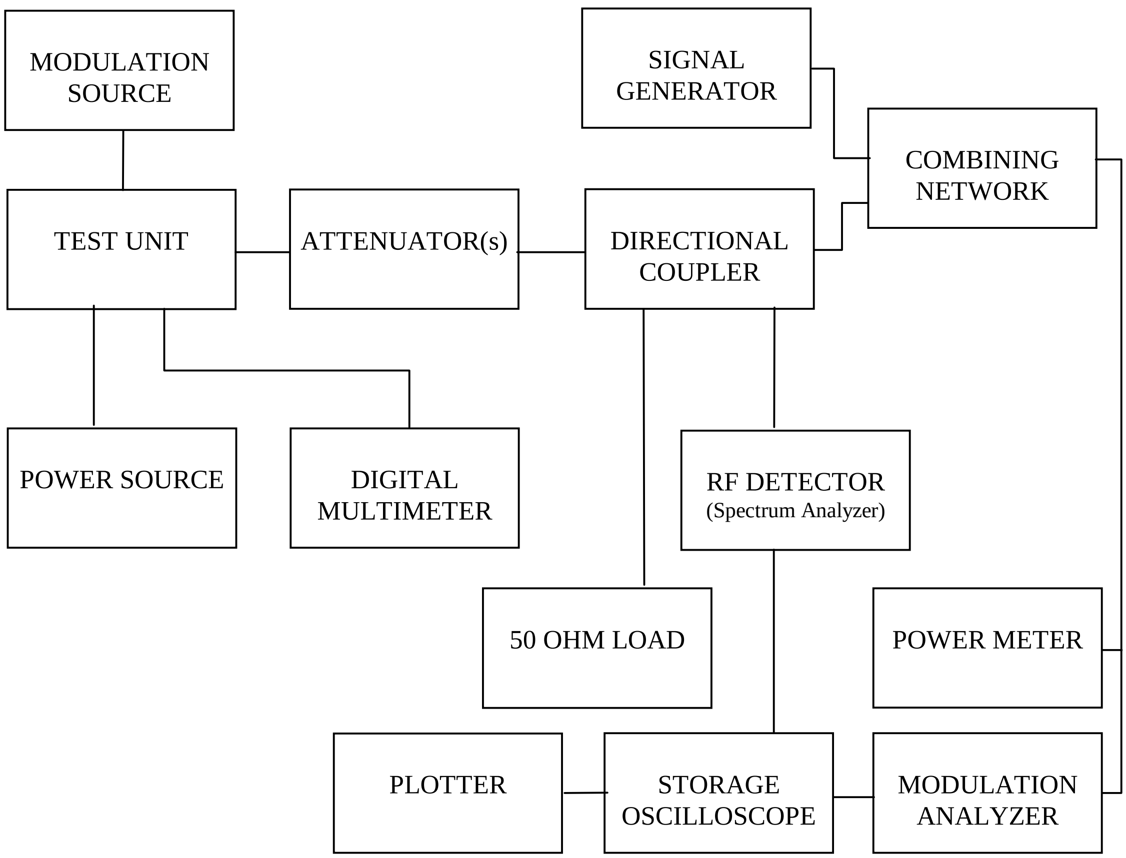
TEST EQUIPMENT:

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
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: ______________________ Date:7/25/98
Allen Frederick

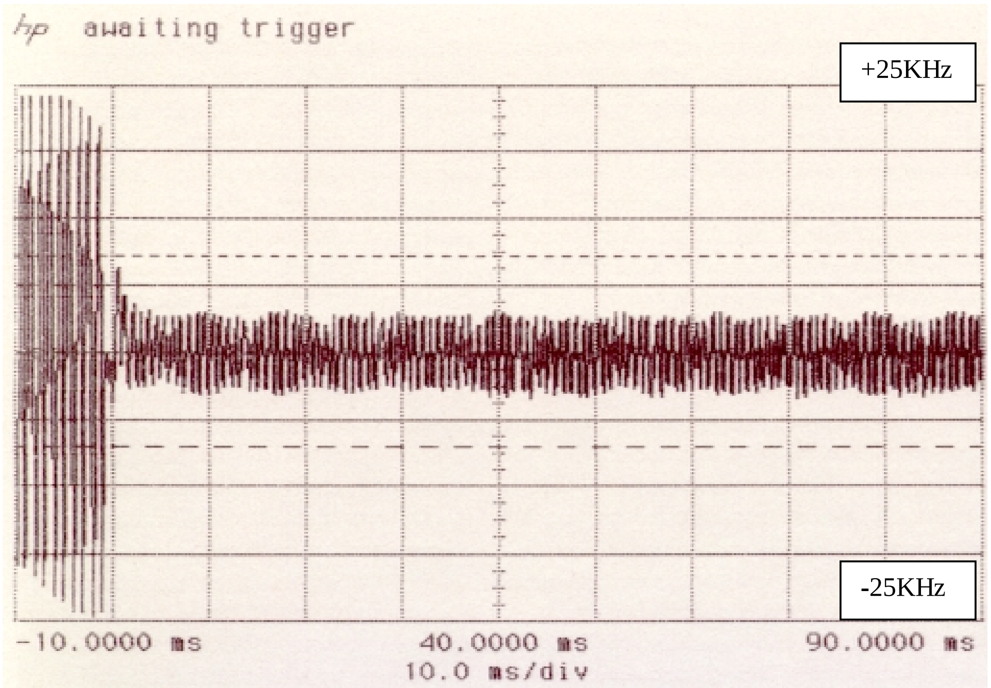
NAME OF TEST: Transient Frequency Behavior (Continued)

TEST SET-UP:

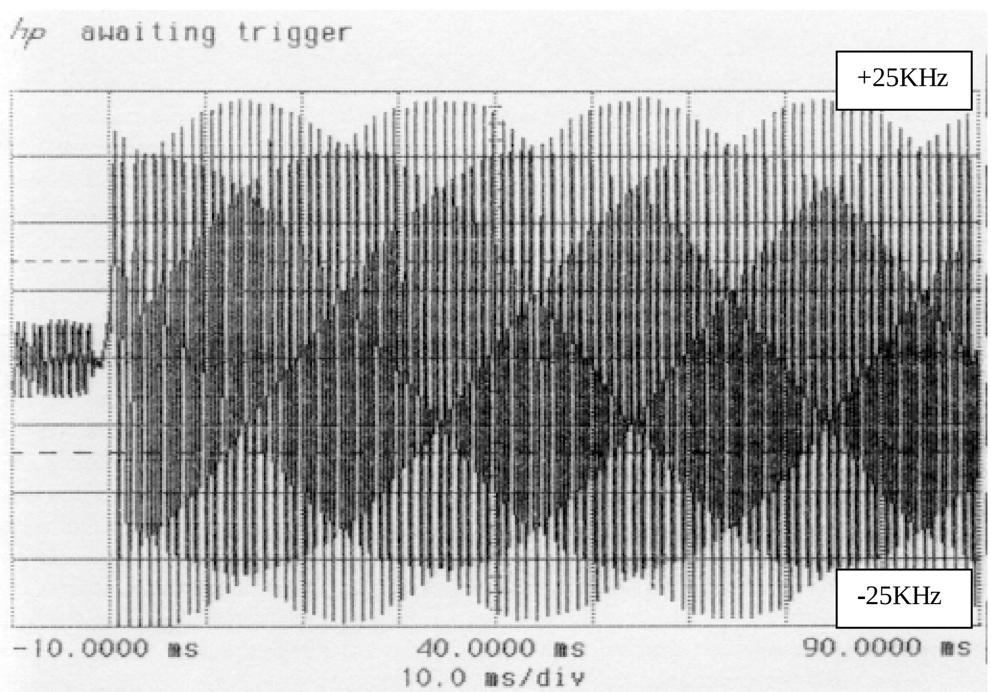


TRANSIENT FREQUENCY RESPONSE
TRANSCEIVER MODULATED BY HNET MODEM 4 kHz DEVIATION

This corresponds to the HNET modem set to 19.2 Kbps.

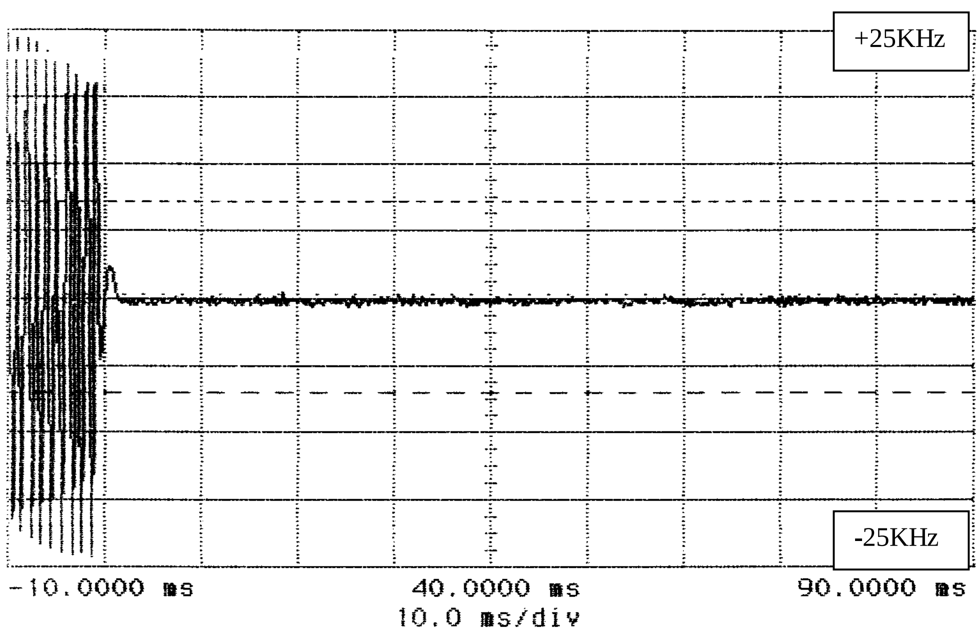


KEY UP



KEY DOWN

TRANSIENT FREQUENCY RESPONSE
TRANSCEIVER WITHUNMODULATED CARRIER



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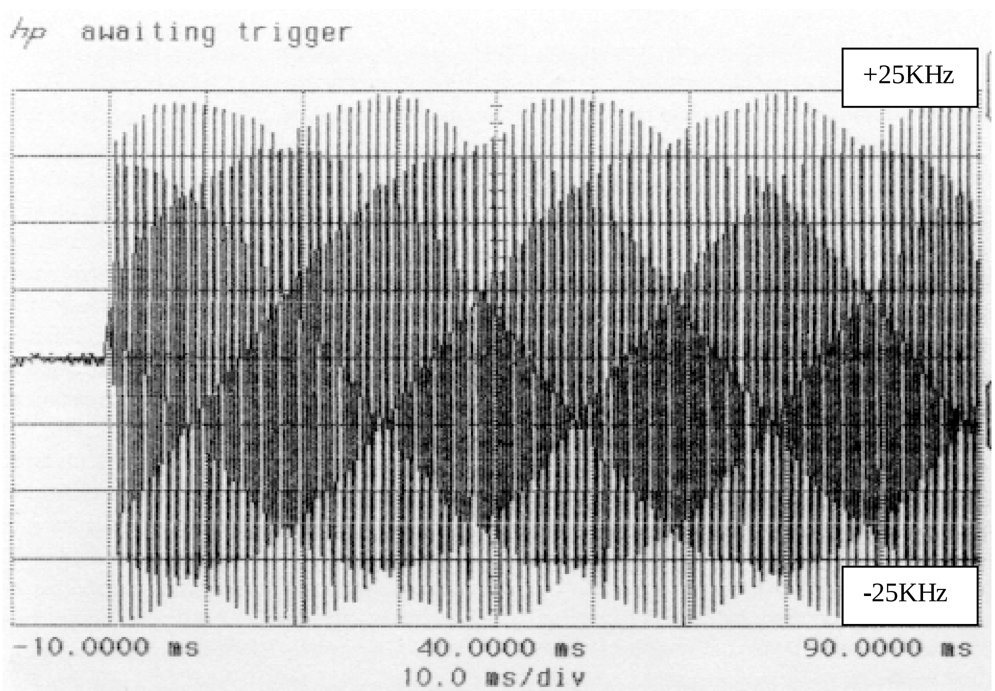
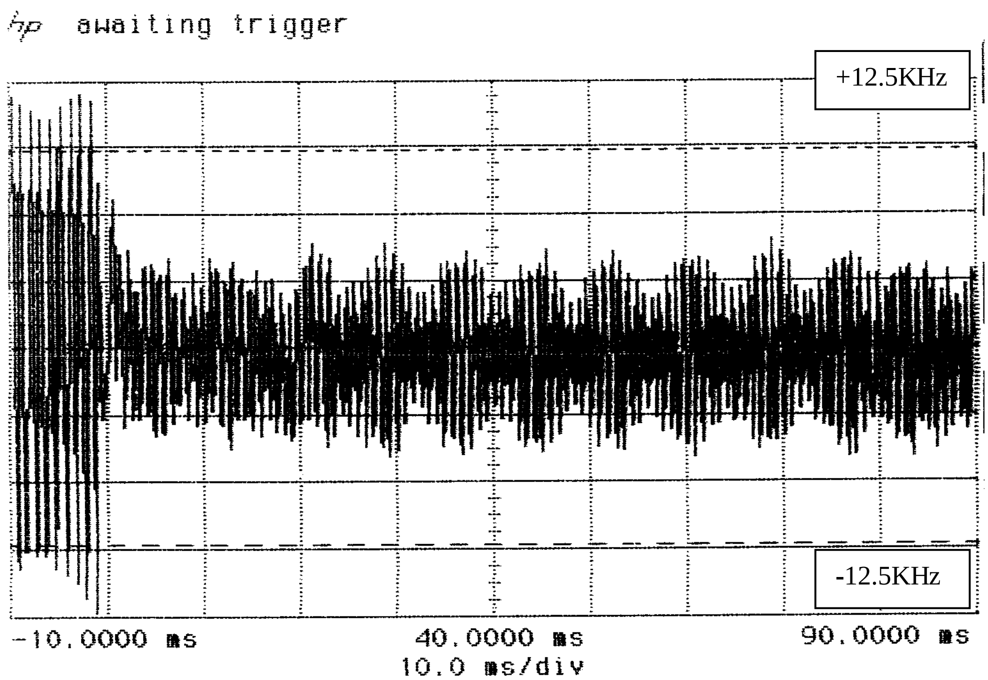


KEY DOWN

TRANSIENT FREQUENCY RESPONSE
TRANSCEIVER MODULATED BY HNET MODEM

This corresponds to the HNET modem set to 9600 bps.



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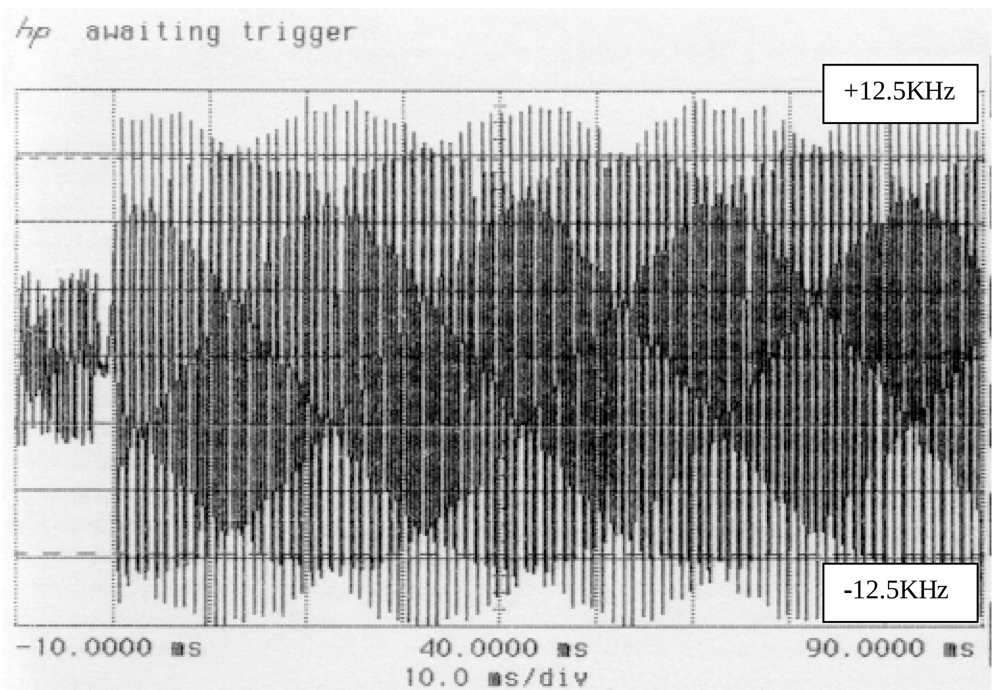
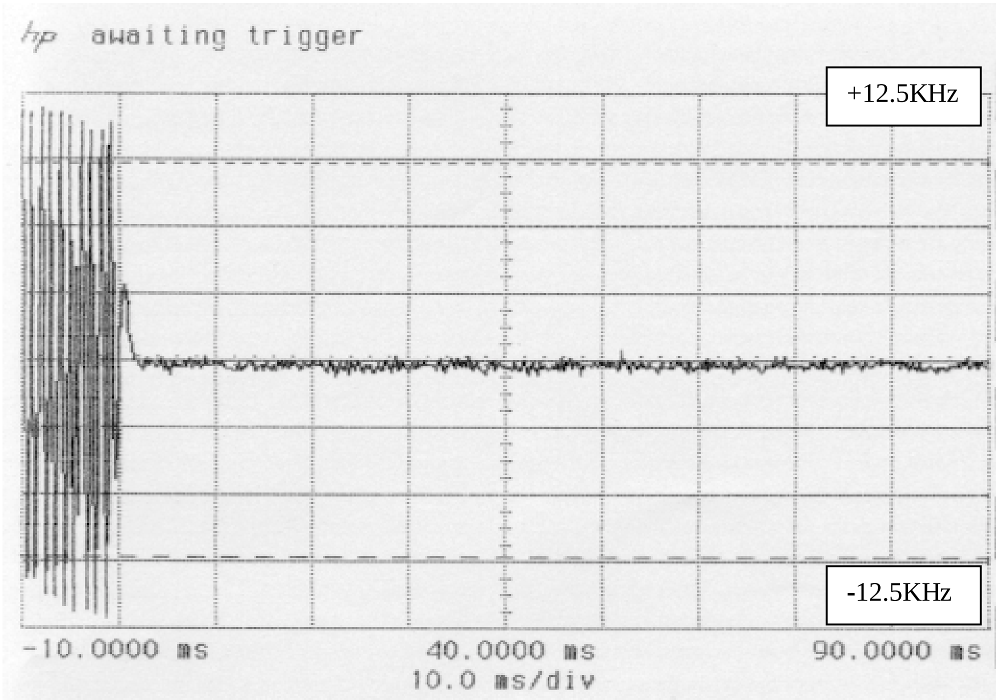


KEY DOWN

TRANSIENT FREQUENCY RESPONSE
TRANSCEIVER WITH UNMODULATED CARRIER



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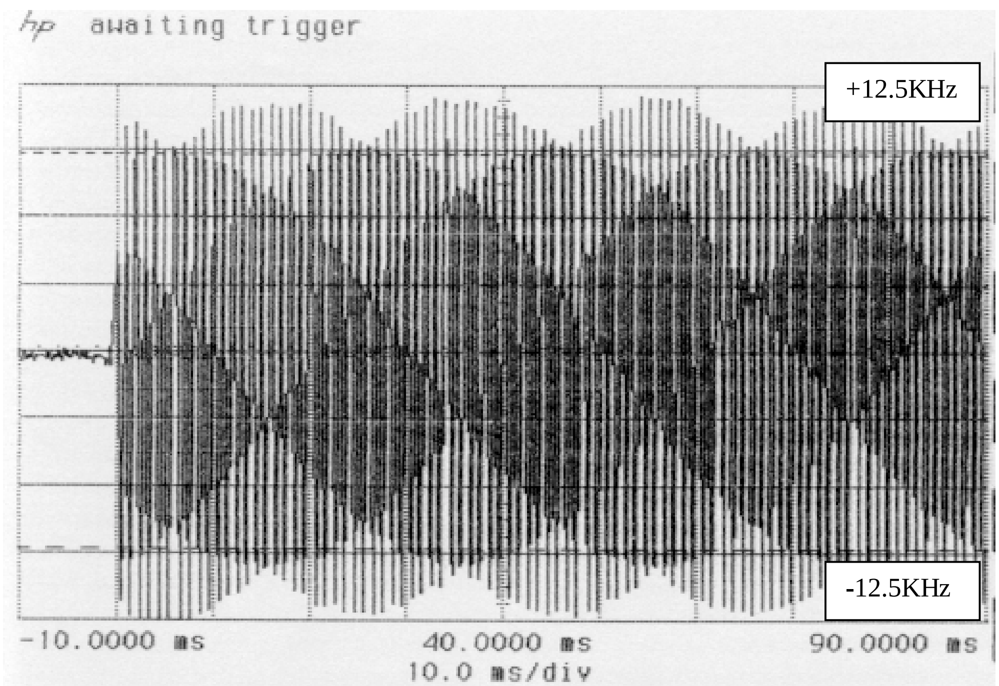


KEY DOWN

FCC LABEL:

RULE PART NUMBER: 2.983 (f)

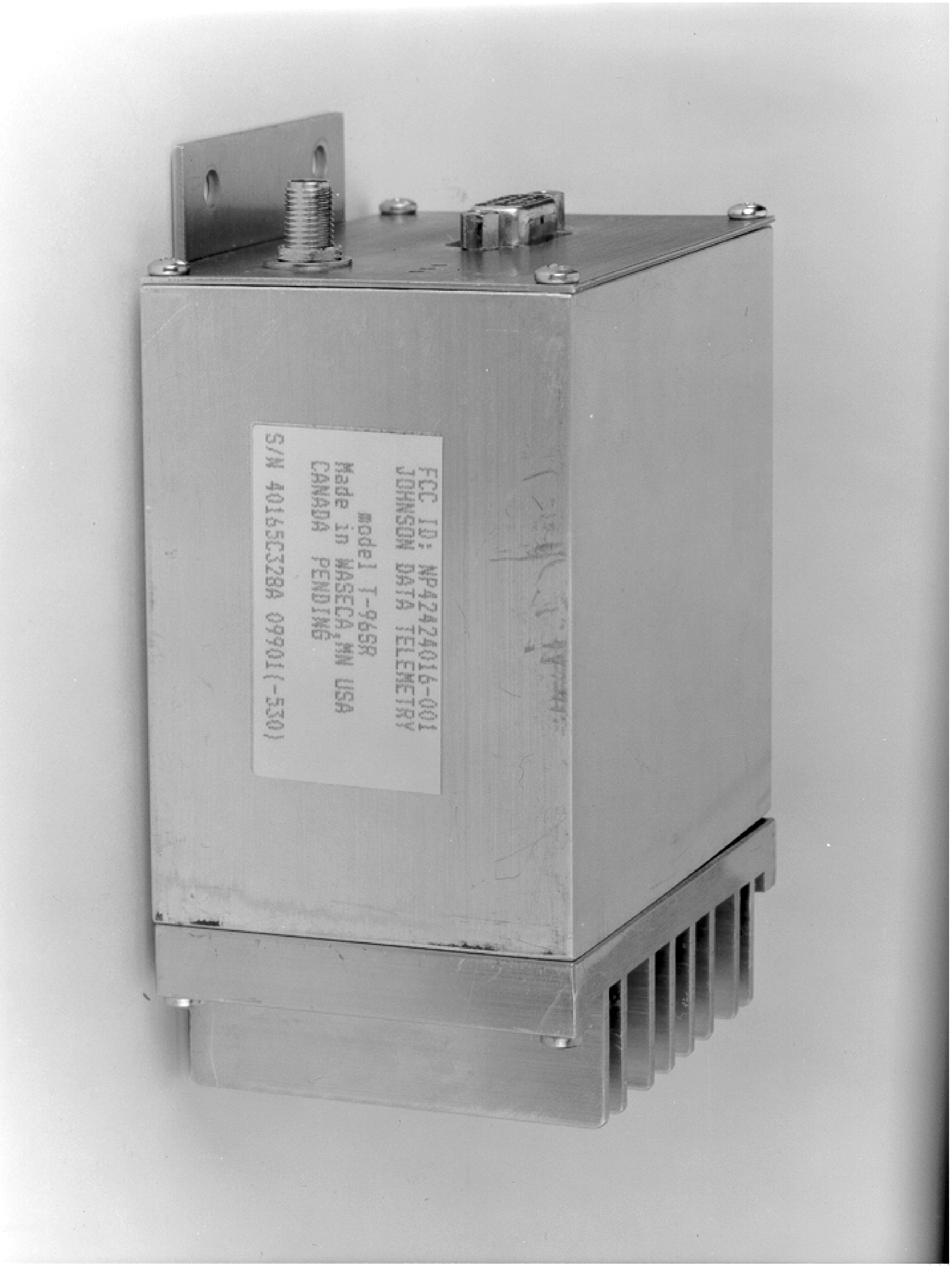
FCC ID: NP42424016-001
JOHNSON DATA TELEMETRY

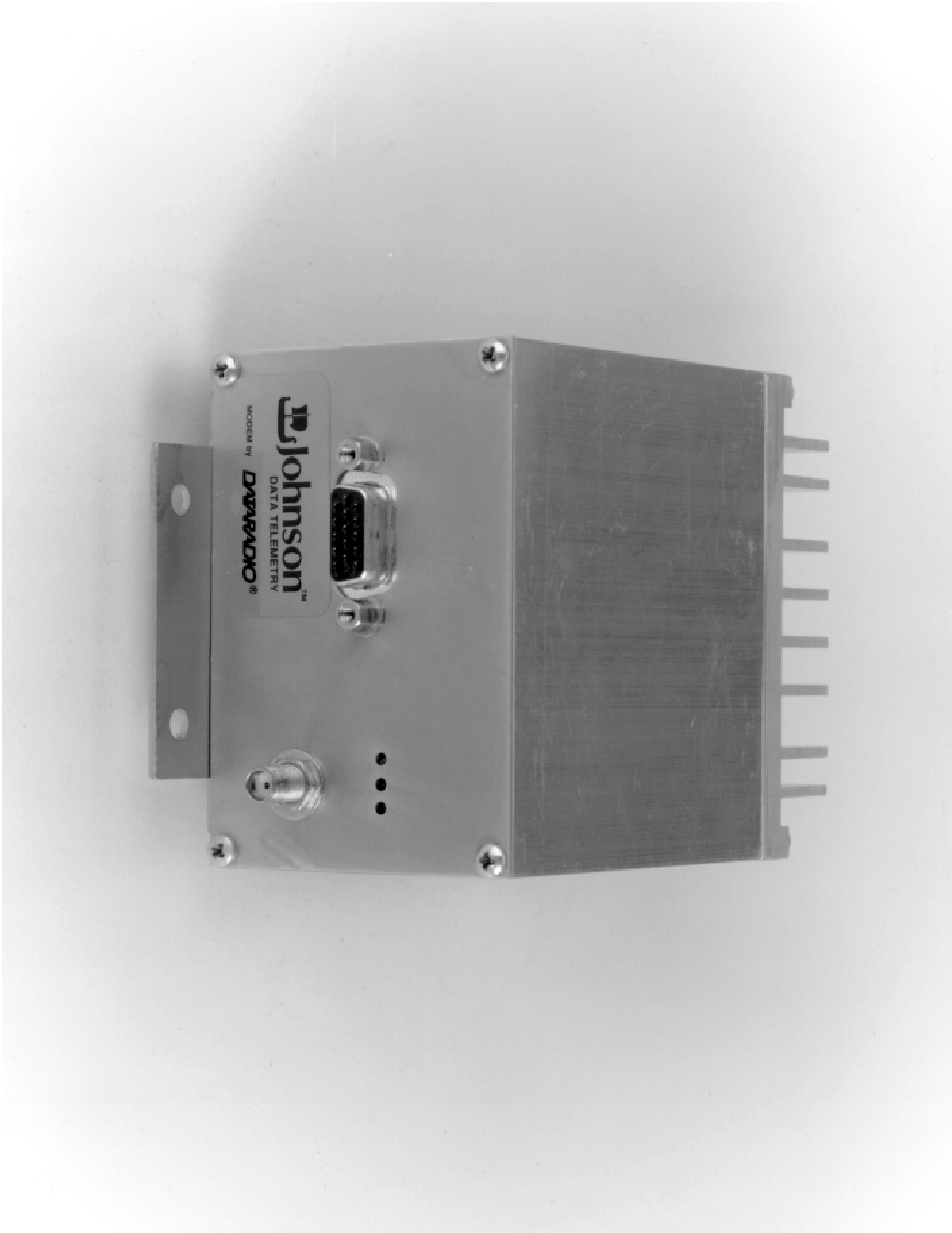
model T-96SR
Made in WASECA,MN USA
CANADA PENDING

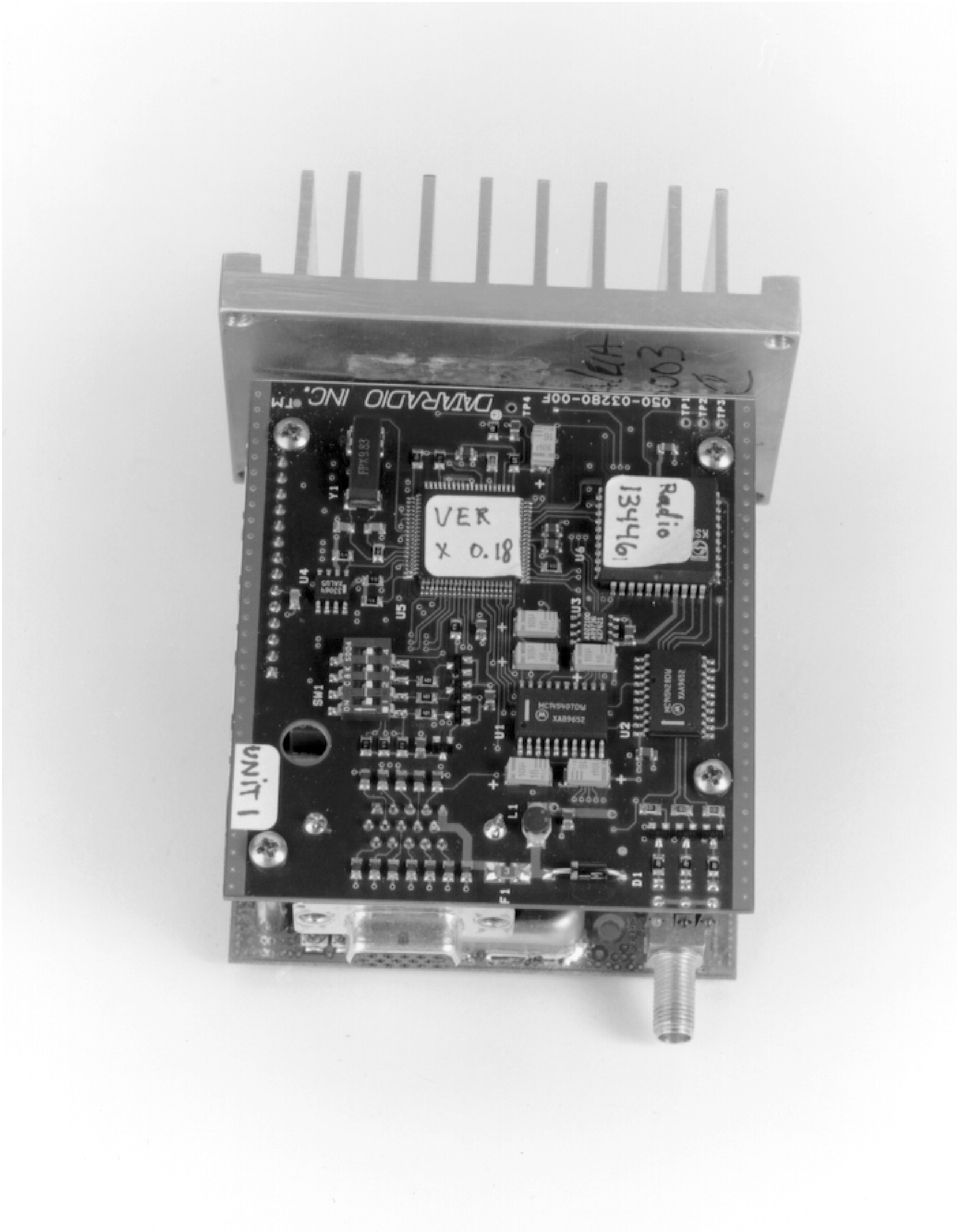
S/N 40165C328A 09902(-530)

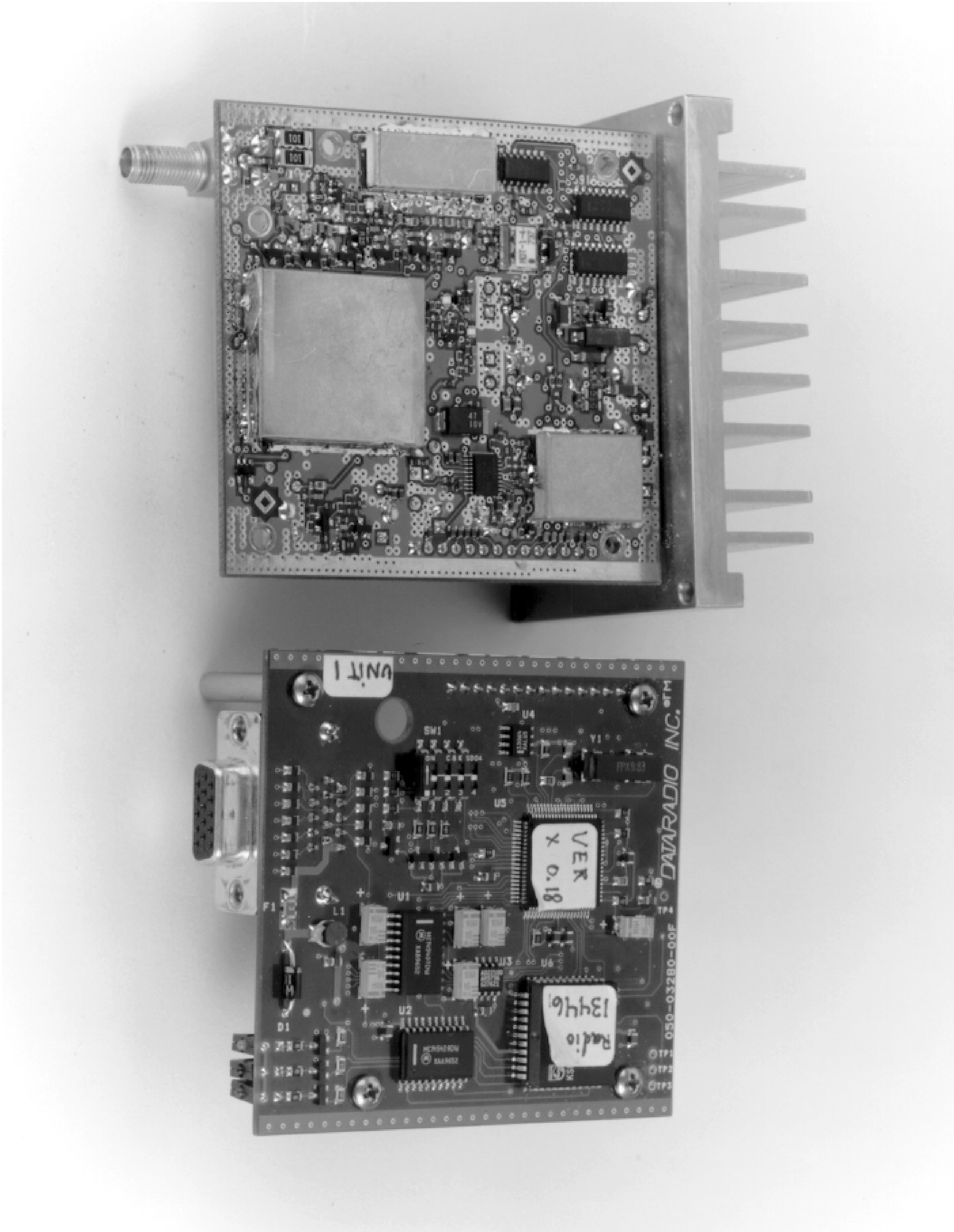
PHOTOGRAPHS:

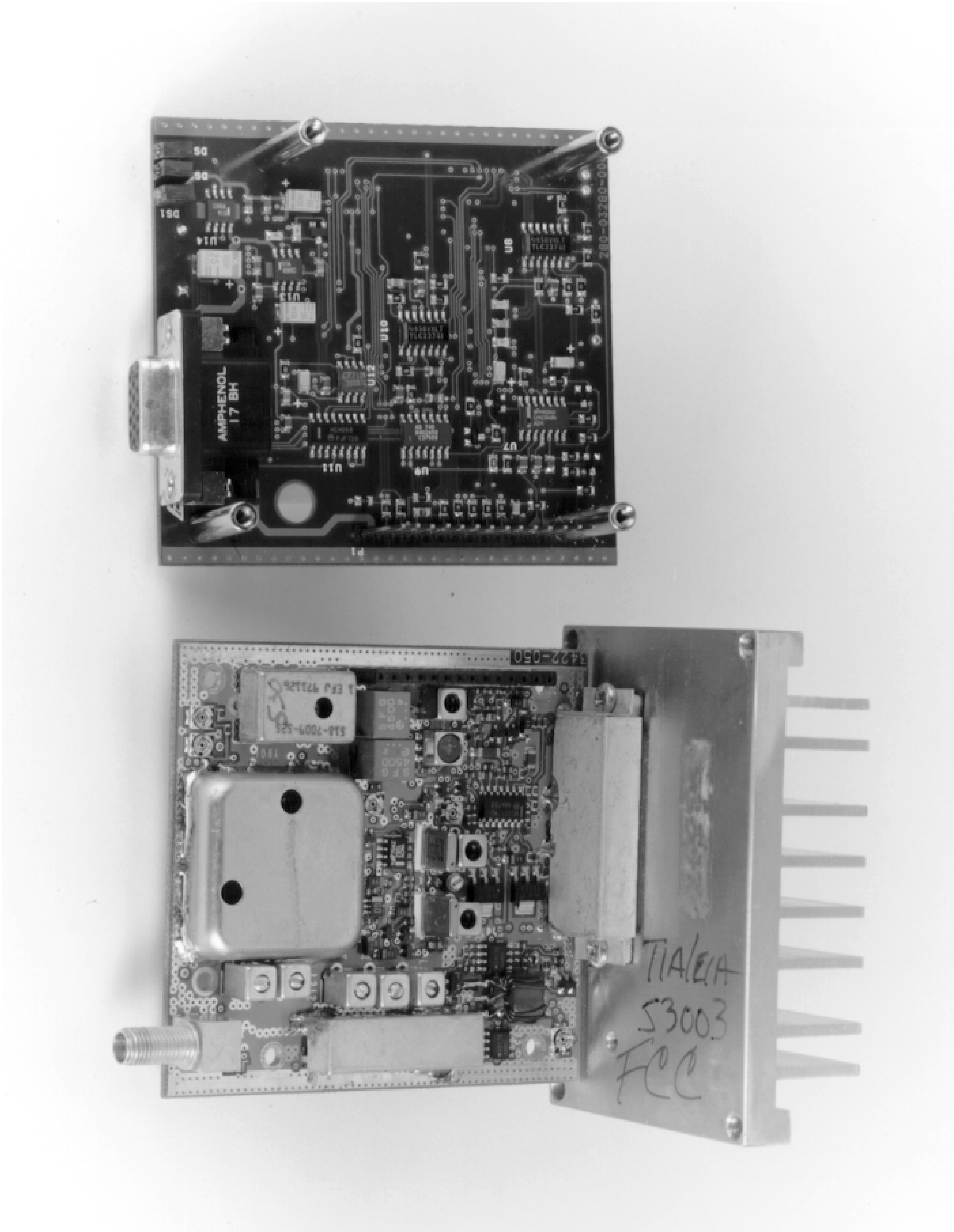
RULE PART NUMBER: 2.983 (g)




Johnson™
DATA TELEMETRY
MODEM by
DATARADIO®


VER
X 0.18
Radio
13446
UNIT 1


UNIT 1
DATARADIO INC.


AMPHENOL
17 BH
TIA/EIA
S3003
FCC

ATTACHMENTS

MANUAL: The DL-3422 manual contains the schematic for DL-3422 Transceiver and VCO.

MANUAL: The HNET manual contains the schematic for the Data Radio HNET modem.