SEA Inc. of Delaware

APPLICATION FOR CERTIFICATION MODIFICATION

MODEL ESP1100 100W TRANSMITTER

PROPOSED FCC ID: BZ6ESP1100

CONTAINS:

LIST OF EXHIBITS AND
EXHIBITS 1 THROUGH 13

Wednesday, May 9, 2001

TABLE OF CONTENTS

EXHIBIT 1

GENERAL INFORMATION REQUIRED FOR CERTIFICATION, Per §2.1033 (c)

1) Name and Address of the manufacturer of the device and the applicant for certification:
SEA Inc. of Delaware - Manufacturer and value added vendor
7030 220th St. S.W.
Mountlake Terrace, WA 98043

2) FCC ID: BZ6ESP1100

3) Instruction and Operating Manuals: Please see attached exhibits.

4) Types of Emissions: 4K00J3E and 4K00J2D. See EXHIBIT 4.

5) Frequency Range: 220 to 221 MHz

6) Power Output: 100 W PEP fixed

7) Maximum power rating for base stations in this service: 500 W ERP

8) DC Voltages and Currents:

Device	Vdc	Idc
TX Final Amplifier	+28V	3.9A

9) Tune up Procedure: Please see attached exhibit (Instruction Manual).

10) Schematic Diagrams and Circuit Descriptions: Please see attached exhibit (Instruction Manual).

11) Equipment Identification Label: Please see EXHIBIT 3.

12) Photographs: Please see EXHIBIT 3.

13) Digital Modulation Description: Please see EXHIBIT 4.

14) Test Data: All tests were performed in accordance with 47CFR Part 2, sections 2.947, 2.1033(c), 2.1041, 2.1046, 2.1047, 2.1049, 2.1051, 2.1055, 2.1057 and Part 90. Please see attached EXHIBITS 6 through 11.

EXHIBIT 2

DESCRIPTION OF MODIFICATION, §2.1043(c)

The ESP1100 transmitter (FCC ID: BZ6ESP1100), the transmitter portion of the ESP1100 repeater, was granted type acceptance on August 1, 1995 for emission types 4K00J3E and 4K00J2D and Part 90 service. The product currently offers, and its type acceptance grant permits, voice operation and 1200 bps data operation using the novel modulation technique described in the original ESP1100 type acceptance report.

This modification application is presented because SEA wishes to offer expanded data capability in the ESP1100. The modifications allow the ESP1100 to pass higher data rates (up to 9600 bps). Specifically, the applicable product modifications include the addition of new DSP firmware programs to permit this operation. Also, a minor hardware modification (removal of transmit audio input transformer: T2 on ASY-1000-06 C/I Board) is made. The new DSP firmware creates a uniform, flat bandwidth from 300 to 3600 Hz, permitting audio subcarrier modem input to the repeater. (The original modulation firmware split the audio spectrum into two segments, shifting one in frequency and adding a low speed trunking data carrier at 1650 Hz and a pilot carrier at 3900 Hz.) The new DSP firmware retains the use of the 3900 Hz pilot but disables the trunking data carrier.

Upon grant of this modification, both firmware sets (original voice + 1200 bps data and new high speed data) will be available in new ESP1100s. The selection of firmware mode is made by programming the repeater via its front panel controls. The system operator can still select the original conventional or trunked voice operation. The new firmware adds a third mode called *base station*. Base station mode is to be used only in dedicated data systems.

New version firmware sets will be included in all newly-shipped repeaters. Products in the field may be easily retrofitted if desired, but that is the option of the system operator.

SEA requests that the original FCC Identifier assigned to the ESP1100, BZ6ESP1100, be retained as a result of this requested modification grant.

EXHIBIT 3

IDENTIFICATION LABEL AND EQUIPMENT PHOTOGRAPHS, §2.1033(c)(11,12)

See under separate cover.

EXHIBIT 4

TECHNICAL DESCRIPTIONS, §2.1033(c)

INTRODUCTION

SEA INC. OF DELAWARE (SEA) is pleased to submit this application for type acceptance (certification) modification for its Model ESP1100 100W repeater transmitter. The ESP1100 is suitable for use on 5 kilohertz channels in the 220-222 MHz band authorized by Part 90 Subpart T.

The ESP1100 100 W repeater is rated for one hundred (100) watts peak envelope power (PEP) and is capable of voice or audio subcarrier data modem transmission using upper sideband suppressed carrier modulation.

TYPES OF EMISSION and DIGITAL MODULATION DESCRIPTION,
§ 2.1033(c)(4): 4K00J3E and 4K00J2D

Note: §90.209(b)(5) specifies an authorized bandwidth of 4 kHz.

The main RF carrier is amplitude modulated, upper sideband, suppressed carrier. A pilot tone is included at 3900 Hz above the suppressed carrier frequency. Either an external analog voice signal or an audio subcarrier data signal is input to the repeat audio input. There are two modulation modes as described below:

1. The audio input signal band of 300 to 3000 Hz is internally filtered into two band segments of 300 to 1600 Hz and 1600 to 3000 Hz. The two band segments are then split apart by 700 Hz. This provides a 700 Hz gap between the two spectral segments into which a 300 bit per second binary frequency shift keyed data subcarrier (at 1950 Hz above the suppressed carrier frequency) is inserted. The ESP1100 transmitter was originally type accepted using this modulation mode. Please refer to Exhibit 6, RF Power Output Test in the original type acceptance filing for further discussion of these signals.

2. The audio input band of 300 to 3600 Hz is bandlimited and combined with the 3900 Hz pilot tone. Changes to the product to permit this operation are the modification for which this filing is made.

FREQUENCY DETERMINING AND STABILIZATION CIRCUITS, § 2.1033(c)(10)

The frequency determining and stabilization circuits do not change as a result of this modification. The description of same on file in the original type acceptance report still applies to the product after modification

DESCRIPTION OF MODULATION LIMITING, POWER LIMITING AND SPURIOUS RADIATION SUPPRESSION CIRCUITRY, § 2.1033(c)(10)

The modulation limiting, power limiting, and spurious radiation suppression circuitry does not change as a result of this modification. The description of same on file in the original type acceptance report still applies to the product after modification.

EXHIBIT 5

INTRODUCTION TO TRANSMITTER MEASUREMENTS

Exhibits 6 through 11 on the following pages present the required measured transmitter performance data for parts §2.1046 through §2.1055. Part 90 references are also included in each exhibit as appropriate.

The transmitter was fitted with operating system software and programmed to transmit on 220.0025 MHz. Tests were performed on this frequency and 220.9975 MHz as specified in the attached exhibits.

Transmit frequency selection was made from the front panel of the ESP1100 repeater. The repeater was programmed to operate in base station mode, that is, where the trunking data carrier is disabled, the passband is a uniform, flat bandwidth from 300 to 3600 Hz, and transmit audio is input at the accessory connector at the rear of the repeater.

There are three possible audio modulation inputs to the transmitter provided by the Computer/Interface (C/I) board: mic, repeat audio, and accessory. Only the accessory input is used for high speed data operation and was the only input used in the following tests. It is considered improper operation to apply audio modem data to the microphone input terminals because the mic compressor action of integrated circuit U23B is not desired.

CERTIFICATION OF TEST DATA, §2.911(d)

Please see page 5-2 for the test supervisor's statement.

MEASUREMENT PROCEDURES, §2.947

Specific measurement procedures and test setup diagrams are presented along with the resultant data in Exhibits 6 through 11 for the tests prescribed by §2.1046 et. seq.

TEST EQUIPMENT LIST, §2.947(d)

The equipment used for the tests is listed on page 5-3.

STATEMENT OF TEST SUPERVISOR

See under separate cover.

TEST EQUIPMENT LIST

Item	Description	Model
1.	20 dB RF attenuator	Mini Circuits CAT 20
2.	Audio Step Attenuator	HP350A
3.	RF Wattmeter	Bird 43 w/Bird 25C Element
4.	30 dB RF Attenuator	JFW 50FH-030-100
5.	Oscilloscope	Tektronix TDS320
6.	RF Spectrum Analyzer	HP70000, 0-2.9 GHz
7.	RF Spectrum Analyzer	HP8568B, 0-1.5 GHz
8.	Plotter	HP7470A
9.	D.C. volt/ammeter	Fluke 75
10.	R.F. Signal Generator	Rohde & Schwarz SME 02, 0-1.5 GHz
11.	Frequency Standard	HP105A
12.	Audio Spectrum Analyzer	Stanford Research Model 760
13.	DSP Board	Analog Devices EZ-KIT LITE
14.	7200/9600 bps base modem	Digital Dispatch Systems RBC
15.	Personal Computer	DTK 486DX
16.	Audio Amplifier	SEA designed & built
17.	Calibrated RF Wattmeter, cables & load set	Bird 43 w/Bird 25C Element, Bird 8164 100W 50 ohm RF load
18.	RF Frequency Doubler	Bird FD 2
19.	220 MHz notch filter	SEA designed & built

EXHIBIT 6

RF POWER OUTPUT, §2.1046(b,c), 90.205, 90.209(b)(5) and 90.729(b)

PROCEDURE

Note: This transmitter is rated for 100 Watts peak envelope power (PEP) in the 220-221 MHz band. It operates in the upper sideband (USB) suppressed carrier mode.

Please refer to Figure 6.1 for the test setup.

The transmitter power output was tested on 220.0025 MHz. The radio was tuned-up in accordance with the alignment procedure in the instruction manual. The alignment procedure has not changed as a result of this modification. The transmitter was loaded into a 50 ohm resistive termination.

The following modulation sources were alternately applied to the accessory input terminals:

Data Modulation Type	Abbr.	Data Rate (bits/sec)	Filter Type/Shape	Modulation Source
minimum shift keying	MSK	1200	none	DSP board
frequency shift keying (Bell 202)	FSK	1200	none	DSP board
gaussian minimum shift keying	GMSK	2400	BT= 0.5	DSP board
binary phase shift keying	BPSK	2400	RRC	DSP board
quadrature phase shift keying	QPSK	4800	RRC	DSP board
8-phase shift keying	8PSK	7200	RRC	DDS modem
16-quadrature amplitude mod	16QAM	9600	RRC	DDS modem

Note: RRC = root raised cosine filter. All filters are embodied in the modulation source.

The DSP board modulation source is an Analog Devices ADSP-2181 EZ-Kit Lite DSP development board with SEA-developed firmware to produce the test modulations. The DDS modem is a unit manufactured by Digital Dispatch Systems, Inc. The DDS modem generates modulation with different spectral characteristics depending on whether the link is busy or idle. For all tests that used the DDS modem as a source, both the busy and idle conditions were measured.

Both the DSP board and the DDS modem are external modulation sources not embodied in the ESP1100. An audio amplifier and step attenuator were connected between the DSP board or DDS modem and the ESP1100 to vary the drive level to the transmitter.

The power supply voltages were set to 13.6 Vdc and 28 Vdc, respectively, at the internal DC power supply output terminals with ESP1100 turned on but not transmitting.

Prior to making the actual transmitter power measurements, the test setup was calibrated to determine the spectrum analyzer level that represented 100 W PEP. The transmitter was keyed up in CW test mode at 220.0025 MHz into a calibrated wattmeter, cable, and load set in accordance with the transmitter tune-up procedure. The ESP1100's CW test mode provides a single full power test tone at 2 kHz above the suppressed carrier frequency. In CW test mode the peak envelope power can be read directly from a wattmeter. When transmitting into the calibrated wattmeter, cables, and load set, the transmitter power was adjusted so that the calibrated wattmeter reached the level, which the calibration laboratory certified as 100 W at 220 MHz.

The wattmeter, cables, and attenuators used for actual transmitter RF power measurements were then substituted for the calibrated equipment and connected between the ESP1100 and the HP8568B spectrum analyzer. The transmitter was keyed again in CW mode without changing its power setting. The spectrum analyzer was centered at 220.0025 MHz with 10kHz resolution and video bandwidths and placed in peak hold mode. The display peak was noted as 9.1 dBm. The spectrum analyzer reference level was set to 9.1 dBm, representing 100 W PEP, for the actual transmitter RF power measurements.

Each modulation type listed on Page 6-1 above was input to the ESP1100 in turn and the modulation level was adjusted until the transmitter developed 100 W PEP. The modulation level was adjusted until the peak of the spectrum analyzer display when set to 10 kHz resolution and video bandwidths touched the top of the screen. One plot, Figure 6.2, is included to demonstrate this procedure. When the proper modulation level was obtained, the spectrum analyzer was set to 100 Hz resolution and video bandwidths and placed in peak hold mode. After several sweeps, the display was plotted.

RESULTS:

Please see the following spectrum plots under separate cover.

Figure 6.2	1200 bps MSK modulation, (with both 100 Hz and 10 kHz resolution and video bandwidths)
Figure 6.3	1200 bps Bell 202 modulation
Figure 6.4	2400 bps GMSK modulation
Figure 6.5	2400 bps BPSK modulation
Figure 6.6	4800 bps QPSK modulation
Figure 6.7	7200 bps 8PSK modulation (idle)
Figure 6.8	7200 bps 8PSK modulation (busy)
Figure 6.9	9600 bps 16QAM modulation (idle)
Figure 6.10	9600 bps 16QAM modulation (busy)

Test Setup
RF POWER OUTPUT
§2.1046(b,c), 90.205, 90.209(b)(5) and 90.729(b)

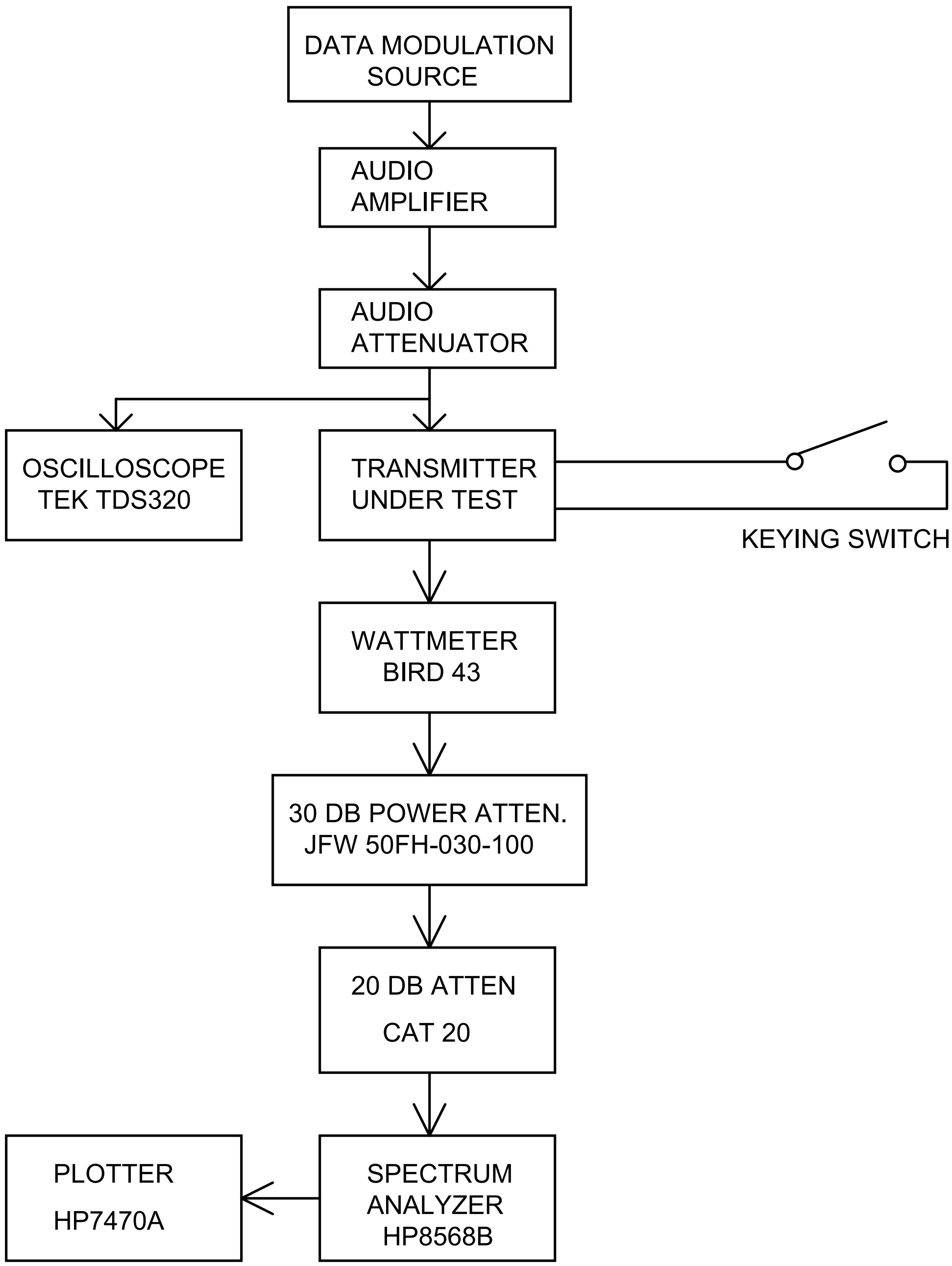

Figure 6.1

EXHIBIT 7

MODULATION FREQUENCY RESPONSE AND MODULATION LIMITING, §2.1047(a),(b)

PROCEDURE

The transmitter and test equipment were set up as shown in Figure 6.1. The test setup was the same as for the Power Output Test (Exhibit 6 herein) but audio tone generator firmware was loaded into the DSP board used as the modulation source. The transmitter was previously tuned up and the test system was calibrated as described in Exhibit 6.

The top of the spectrum analyzer screen represents +50 dBm (100W). The frequency span of the spectrum analyzer was set to display frequencies from 220.0005 MHz to 220.0055 MHz, a 5 kHz span. The peak hold mode was used and one sweep was made at each audio drive frequency.

The transmitter was modulated by stepping the frequency of the DSP board audio generator in 100 Hz steps from 100 Hz to 5 kHz. Three power vs. frequency plots were produced, each the result of a different fixed audio generator level into the accessory connector. These levels encompass the range of levels expected from an external data modulation source. An oscilloscope was used to monitor the peak-to-peak modulation level at the ESP1100 accessory input.

Low drive: The modulation frequency was set to 2.4 kHz and the modulation level was slowly increased until the pilot tone power was reduced approximately 1 dB from its rest level with no modulation, or 11 dB below 100W PEP. 2.4 kHz was chosen because the system gain is maximum at this frequency.

Medium drive: The modulation level was set so that at 2.4 kHz modulation input, the pilot power just reached its minimum level of 16 dB below rated PEP (6 dB total reduction from rest level).

High drive: The modulation level was set 10 dB higher than the medium drive case.

RESULTS

Frequency response plots, Figures 7.1, 7.2, and 7.3 (under separate cover), show the power output in 100 Hz audio frequency increments when the modulation is input to the accessory connector. The pilot tone is the highest frequency tone at the right of each plot.

The pilot power reduction could not be illustrated in peak hold mode because the pilot peaked at its maximum level of 10 dB below PEP whenever the modulation frequency was too low or too high to pass through the audio bandlimiting filters (below 300 Hz or above 3600 Hz) and into the compressor magnitude detector in the DSP. Each plot shows the pilot at its approximate steady-state level of 10 dB below PEP. For frequencies in the 300-3600 Hz range, the pilot level is in fact reduced as described previously.

SSB PEAK ENVELOPE POWER LIMITING, §2.1047(c)

PROCEDURE

The transmitter and test equipment were set up as shown in Figure 6.1. The transmitter was previously tuned up and the test system was calibrated as described in Exhibit 6.

Each type of data modulation drive was applied to the accessory input terminals to conduct the tests. In each case, the maximum modulation drive level capability was set to provide drive levels up to 20 dB in excess of that required to develop rated PEP output.

PEP output levels at each modulation input level setting were measured in the same manner as the Power Output Test, Exhibit 6. That is to say, the spectrum analyzer was set to 10 kHz resolution and video bandwidths in the peak hold mode allowing integration of peak envelope power (indicated in dBm) over several sweeps at each modulation input level setting.

RESULTS

Please see the following figures under separate cover for the respective results.

Figure 7.4	PEP vs input level, 1200 bps MSK modulation
Figure 7.5	PEP vs input level, 1200 bps Bell 202 modulation
Figure 7.6	PEP vs input level, 2400 bps GMSK modulation
Figure 7.7	PEP vs input level, 2400 bps BPSK modulation
Figure 7.8	PEP vs input level, 4800 bps QPSK modulation
Figure 7.9	PEP vs input level, 7200 bps 8PSK modulation (idle)
Figure 7.10	PEP vs input level, 7200 bps 8PSK modulation (busy)
Figure 7.11	PEP vs input level, 9600 bps 16QAM modulation (idle)
Figure 7.12	PEP vs input level, 9600 bps 16QAM modulation (busy)

The 0 dB Relative Drive Level point on the horizontal axis in each figure is the level at which the transmitter develops 100 W PEP output in each case. The 0 dB PEP Change point on the vertical axis represents 100 W PEP output. At low input levels the PEP output is dominated by the pilot signal which is internally generated by the transmitter.

External modems to be used with the ESP1100 normally contain an adjustment for the drive level into the radio transmitter. SEA documentation specifies peak-to-peak drive levels necessary for the ESP1100 transmitter to develop 100 W PEP for a given data modulation type. It is considered improper operation to exceed SEA's recommended drive levels. Nevertheless, it can be seen from each figure that output PEP rises less than 1 dB for 20 dB excess drive.

EXHIBIT 8

OCCUPIED BANDWIDTH, §2.1049(c)(2)

Authorized bandwidth is 4 kHz per §90.209(b)(5). Emission limits are specified in §90.210(f).

PROCEDURE:

Please refer to Figure 6.1 (RF Power Output Test) for the test setup used. The test setup is identical to the test setup used in the RF Power Output Test, Exhibit 6, except for increased modulation input level.

The test was performed at 220.0025 MHz and 220.9975 MHz. Each type of data modulation was applied to the accessory connector in turn. Initially, the data modulation level was adjusted so that the peak RF power emitted was 100 W PEP. The input level was then increased 10 dB for the occupied bandwidth measurement.

The radio was powered as described in Exhibit 6.

The spectrum analyzer was calibrated as described in Exhibit 6. Resolution and video bandwidths were both set to 100 Hz. One extra plot was made (Figure 8.2) with a 30 Hz resolution bandwidth to demonstrate that the pilot tone at the far right of each plot is in fact a single tone.

RESULTS:

Spectrum plots are presented in Figures 8.1 through 8.19. The emission limit mask is also plotted in each case with the top of the mask set at the top of the emission per §90.210(f). The "floor" emission limit is set to 55 + 10log(100 W) dB = 75 dB below the 100 W PEP reference level at the top of the screen.

The DDS external modem used for 7200 and 9600 bps testing produces a short audio subcarrier tone preamble at the beginning of each data transmission when in "busy" mode. In peak hold mode the spectrum analyzer shows the preamble as a peak at the center of the spectrum plots shown in Figures 8.14, 8.15, 8.18, and 8.19. Because the preamble is not present during the actual data transmission, the emission mask was lowered to the second highest peak in these figures.

Please see these results under separate cover.

The following plots are presented:

EXHIBIT 9

SPURIOUS EMISSIONS AT ANTENNA TERMINALS, § 2.1051

PROCEDURE:

Please refer to Figure 9.1 for the test setup diagram.

Spurious emission tests were performed for two transmitter output frequencies, 220.0025 and 220.9975 MHz, one each at the lower and upper frequency range of the transmitter. The transmitter was previously tuned up in accordance with the alignment procedure in the instruction manual. 4800 bps QPSK modulation with input level set 10 dB above that required to develop 100W PEP was input to the accessory connector as a representative modulation source for the spurious emissions test. Other data modulation types were checked and no change in spurious emission levels was noted.

For measurement of spurious emission levels, a notch filter was used to attenuate the fundamental frequency emission. This prevented the spectrum analyzer from internally generating distortion, which could lead to incorrect readings.

At the frequency of each spurious emission to be measured, the loss between the transmitter under test and the spectrum analyzer in use was measured. Then the amplitude of the spurious emission was measured on the spectrum analyzer through the test apparatus. Adding the loss measured to the level measured at each frequency of interest yields the actual spurious product developed at the transmitter output. The HP8568B spectrum analyzer was used for measurements up to 1500 MHz. The HP70000 spectrum analyzer was substituted for frequencies from 1500 MHz up to the 10th harmonic of the transmitter emission at 2.2 GHz.

The spectrum investigation included but was not limited to the following list of frequencies (Fo = authorized emission frequency, Fm = master oscillator frequency):

Frequency	Description
4 MHz = Fpo	Microprocessor clock oscillator.
2Fpo, 3Fpo, etc	Harmonics of the above.
10.275 MHz = Fm	Master carrier crystal oscillator.
2Fm, 3fFm, etc	Harmonics of the above.
Fo - Fm	Master oscillator and fundamental intermod, near 210 MHz
Flo = Fo + Fm	Local oscillator, near 230 MHz
Fim = Flo + Fm	Upper side image, near 240 MHz
2Fo, 3Fo, etc.	Harmonics of the desired channel frequency up to the 10th.
Fo/2, Fo/3, etc.	Subharmonics of the desired channel.

Please note that no frequency multiplier circuits are used in this transmitter.

RESULTS

The absolute spurious emission limit is -25 dBm, which is 75 dB below the 100 W PEP output level of the transmitter under test. Spurious emission levels and margins are tabulated in Figures 9.2 and 9.3 for 220.0025 MHz and 220.9975 MHz fundamental frequencies, respectively. The spurious emission levels are calculated by adding the measured apparatus insertion loss at the spur frequency to the measured spur level. All spurs not explicitly listed had more than 20 dB margin.

Test Setup
SPURIOUS EMISSIONS AT ANTENNA TERMINALS
§2.1051

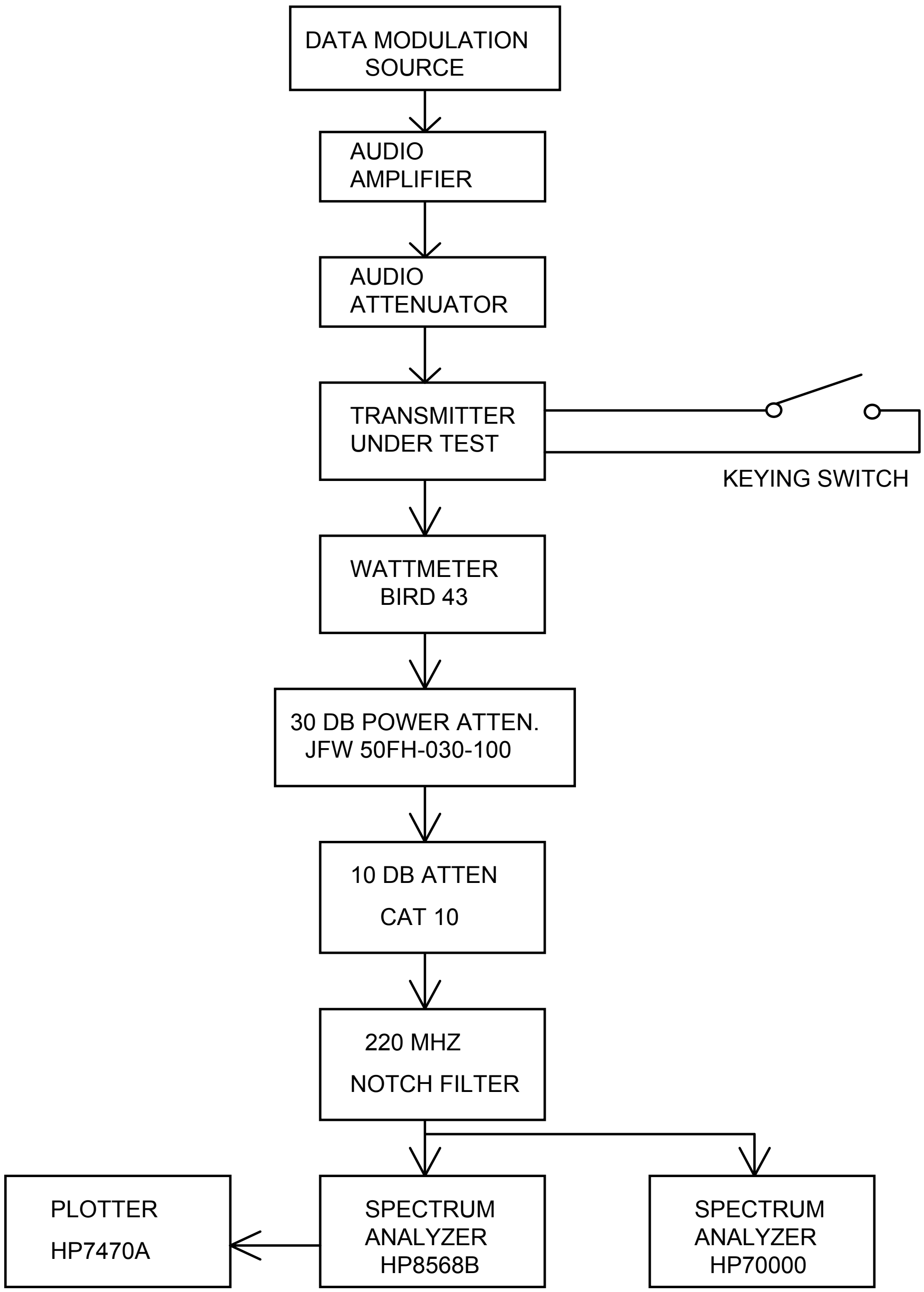

Figure 9.1

Figure 9.2 Table of Reportable Spurs, Fo = 220.0025 MHz

Frequency (MHz)	Mechanism	SA Peak (dBm)	Loss (dB)	Spur Level (dBm)	Margin (dB)	Notes
440.005	2*Fo	-75.7	43.5	-32.2	-7.2	
660.0075	3*Fo	-74.8	44.9	-29.9	-4.9	
880.01	4*Fo	-81.6	44.7	-36.9	-11.9	
1100.0125	5*Fo	-75.5	45.8	-29.7	-4.7	
1320.015	6*Fo	-78.2	47.4	-30.8	-5.8	
1540.0175	7*Fo	-86.5	45.8	-40.7	-15.7	
1760.02	8*Fo	-91.8	52.3	-39.5	-14.5	Noise Floor
1980.0225	9*Fo	-91.9	51.5	-40.4	-15.4	Noise Floor
2200.025	10*Fo	-90.2	53.2	-37	-12	Noise Floor

Figure 9.3 Table of Reportable Spurs, Fo = 220.9975 MHz

Frequency (MHz)	Mechanism	SA Peak (dBm)	Loss (dB)	Spur Level (dBm)	Margin (dB)	Notes
441.995	2*Fo	-76.5	43.5	-33	-8	
662.9925	3*Fo	-75.7	44.8	-30.9	-5.9	
883.99	4*Fo	-80.1	44.3	-35.8	-10.8	
1104.9875	5*Fo	-74.9	45.9	-29	-4	
1325.985	6*Fo	-77.1	46.3	-30.8	-5.8	
1546.9825	7*Fo	-87.1	46.2	-40.9	-15.9	
1767.98	8*Fo	-91.1	53.1	-38	-13	Noise Floor
1988.9775	9*Fo	-91.6	51	-40.6	-15.6	Noise Floor
2209.975	10*Fo	-91.5	54.4	-37.1	-12.1	Noise Floor

EXHIBIT 10

FIELD STRENGTH OF SPURIOUS RADIATION, §2.1053

The proposed modification does not impact or alter the radiated emissions of the product. The spurious radiation data on file in the original type acceptance report still applies to the product after modification.

EXHIBIT 11

FREQUENCY STABILITY MEASUREMENTS, § 2.1055(a)(1) and (d)(1)

The proposed modification does not impact or alter the frequency determining elements or stability of the product. The frequency stability data on file in the original type acceptance report still applies to the product after modification.

EXHIBIT 12

INSTALLATION AND OPERATING INSTRUCTION MANUAL, § 2.1033(c)(3)
PARTS LISTS AND TUNE UP INFORMATION, § 2.1033(c)(9)
SCHEMATIC DIAGRAMS, § 2.1033(c)(10)

See under separate cover.

EXHIBIT 13

RF EXPOSURE INFORMATION § 1.1307(b)

See under separate cover.