APPENDIX 6

TRANSMITTER ALIGNMENT

FIVE (5) PAGE ALIGNMENT PROCEDURE FOLLOWS THIS SHEET

70-1691 Alignment Procedure

SETUP

1 Remove the six securing screws from the bottom cover , and the cover itself.

2 Connect a resistive 50 Ω RF load and wattmeter to Antenna Connector J501.

3 Connect 13.4V DC power to transceiver J505.

4 Connect a 3.2 Ω, 20W resistor to pins 4 and 6 of the Accessory Plug. The jumper between pins 5 and 6 must be temporarily removed to make this connection. The resistor serves as a constant load to replace the speaker's inconsistencies.

CAUTION: Both speaker terminals are LIVE. Never ground either one. Connect grounded receive-audio measuring-equipment to only one side of the speaker, and chassis ground. Normally, voltage measurement will be half of true values.

5 Turn the radio on (Push on and Push off switch), set the VOLUME control to a mid-position.

Connect the Programmer to Programming Port Mic Jack J302.
Upload the radio programming Data-Packet into the Programmer and initiate its Remote Control Mode. Refer to the appropriate manual for details.

SYNTHESIZER ALIGNMENT

•VCO Resonance

1 Select the Remote Control Mode of the Programmer and enter the following test frequencies:

	A-Band	B-Band
RX Frequency	403.00	450.00
TX Frequency	403.00	450.00

2 Adjust Channel RX Tank L713 for 1.5V DC at VC (VCO Steering) .

3 Active transmit mode (using the programmer) and adjust TX Tank L702 for 1.5V DC at VC (VCO Steering) .

•Reference Oscillator

4 Initiate transmit on any channel. Measure transmitted RF carrier frequency without modulation and, if necessary, adjust REFERENCE OSCILLATOR X701 for carrier frequency to within ±300Hz of channel frequency.

100-W PA MODULE ALIGNMENT

The 70-1691 should be adjusted to have a 27 MHz channel spread (20 MHz B-Band) at 100W. To do so :

1 Remove the four screws on the PA cover.

2 Change the TX test frequency to 430 MHz for A-Band, or 470MHz for B-Band.

3 Activate transmit mode, then adjust CV501 and CV502 to obtain maximum RF power at j502. NOTE: if transistor Q511 and Q512 have been replaced, test the transmit at 50W output. This will allow CV502 to be coarse adjusted. CV502 sets the balance between Q511 and Q512.

4 Set RF output power to 100W at J502 using the programmer. Re-peak CV502 as necessary for maximum output.

MODULATOR ALIGNMENT

•Modulation Limiting

1 Disconnect the hand microphone from its front panel Mic Jack J302. Apply 3Vrms of 1000Hz signal to pin 1 of Mic Jack J302, then initiate transmit.

2 Measure total carrier deviation and, if needed adjust modulation limiting to obtain ±5KHz (wide) or ±2.5KHz (narrow) using the programmer.

•Microphone Gain

3 No alignment for Microphone gain is required.

•CTCSS/DCS

4 Remove the 1KHz audio signal from Mic Jack J302.

5 Add 250.3Hz CTCSS tone to the transmit test by testing frequency using the programmer.

6 Adjust CTCSS deviation to ±750 Hz ± 10 Hz (wide) or ± 375 Hz ± 10 Hz (narrow) deviation using the programmer.

7 Change 67.0 Hz CTCSS tone to the transmit test by testing frequency using in the programmer.

8 Adjust RV401 for ±750 Hz ± 10 Hz (wide) or ± 375 Hz ± 10 Hz (narrow) deviation.

9 Change the transmit DCS code +023 to the transmit test by testing frequency using the programmer.

10 Adjust RV401 so that modulation waveform from modulation analyzer matches the correct waveform shown in Figure 2-1.

11 Change 250.3 Hz CTCSS tone to the transmit test by testing frequency using the programmer. Carefully adjust RV401 for ± 750 Hz ± 10 Hz (wide) or ± 375 Hz ± 10 Hz (narrow) deviation.

• DTMF

12 Clear the CTCSS tone, then initiate transmit test by testing frequency using the programmer.

13 Adjust DTMF deviation to ± 2.0KHz ± 10 Hz (wide) or ± 1KHz ± 10 Hz (narrow) deviation using the programmer.

RECEIVER ALIGNMENT

1 Change the RX test frequency to 416.5 MHz for A-Band radios, 460.0MHz for B-Band.

•First Injection

2 No adjustment for first injection is required.

•Preselector Alignment

3 No adjustment for the preselector (L201, L202 and LV201) is required.

•Quadrature Detector

4 No adjustment for the quadrature is required.

•First IF

5 Apply enough modulated (by 1KHz tone at ± 3KHz (wide) or ± 1.5KHz (narrow) deviation) on-channel carrier to maintain 12 to 15 dB SINAD. Adjust L215, L216, and L217.

• Tight Squelch

6 Squelch level set maximum (80). by using the front UP / DN switch.

7 Apply 0.95 uV of modulated standard deviation on-channel RF signal to the 50 Ω antenna connector.

Adjust Squelch range RV402 counter-clockwise just until squelch opens (audio on).

COMPLETE REALIGNMENT

Complete realignment is only needed when a component that affects alignment has been replaced.
RADIO REPROGRAMMING WITH TEST FREQUENCIES IS REQUIRED.

TEST EQUIPMENT REQUIRED

TEST INSTRUMENT	INSTRUMENT CAPABILITIES	USE
Regulated DC Power supply	13.4 V DC, 40 A	Radio power source
RF Wattmeter for 70-1691	150 W, 403 - 470MHz, 50 ohm circuit	Transmitter power measurements
RF Load Resistor	50 ohm, 200 W	Antenna dummy load
Frequency Modulation Meter	403 - 470 MHz, peak-responding, +/- 5KHz range	Modulation level measurements
Frequency Meter or Frequency Counter	403 - 470 MHz, 1.0 ppm accuracy	Carrier frequency measurements
Audio Generator	1,000KHz sine-wave 0-4 Vrms output	Modulation level measurements
RF Signal Generator	403 - 470 MHz range, 0.1 - 1 KuV output, 3KHz FM mod. With 1 KHz tone	All receiver measurements
Distortion Analyzer	1 KHz notch, 1% measuring range	Receiver performance test and IF alignment
Load Resistor (audio)	3.2 ohms, 20 W	Speaker load for all receiver measurements
AC Voltmeter	10mV to 10 Vrms	Audio level adjustments
Oscilloscope	DC to 500KHz bandwidth	
Digital Multimeter	0.1 to 20 V DC	Test point measurements and power supply setup
Programmer	PC Programming Software	Manual radio control

APPENDIX 7

CIRCUITS AND DEVICES TO STABILIZE FREQUENCY

A 12.8 MHz TCXO referenced PLL circuit establishes and stabilizes output frequency.

APPENDIX 8

CIRCUITS TO SUPPRESS SPURIOUS RADIATION, LIMIT MODULATION AND CONTROL POWER

POWER AMPLIFIER

RF impedance at the collector of final-stage Q511 and Q512 is transformed by PC stripline and fine-tuned by CV502 to match circuit impedance at the RF relay K501. L518-L521 and C564-C568 comprise the harmonic filter. R515 and R516 serve to drain static and other DC potentials from the antenna.

AUTOMATIC POWER CONTROL

A PC stripline ahead of the harmonic filter, and a thin PC runner adjacent to it, serves as a directional coupler. D502 rectifies a small RF sample that is developed across the thin runner, producing a DC voltage that increases with RF power traveling forward into the antenna. This power level sensing voltage is inverting input of the comparator IC501 pin 6.

The reference voltage applied to the comparator IC501 pin 5 is fed from IC901 pin 71, of which command is controlled by the programmer in alignment mode. Differential amplifier output drives Q507 which is a current source that feeds primary DC to the collector circuit of predriver Q501.

The feedback loop, from the directional coupler to Q507, holds RF output power at a constant level that is determined by IC901.

MICROPHONE AUDIO CIRCUIT

Voice signals from the hand microphone are applied to audio filter of IC401, where frequency response is pre-emphasized and splatter filtered. Gain is such that stronger signals bring IC401 into clipping, which limits modulation. Harmonics above the 3 kHz (wide) or 1.5 kHz (narrow) modulation pass-band are removed by the 2.5 kHz pi-network in IC401. Modulation signals are then adjusted so that modulation at limiting will produce transmitted carrier deviation of 5 kHz (wide or 2.5 kHz (narrow). Output of processed voice signals at IC405 Pin 8 is fed to gain control IC401.

APPENDIX 9

TRANSIENT FREQUENCY BEHAVIOR (90.214) TEST PROCEDURE

FOLLOWS THIS SHEET

<u>REQUIREMENTS:</u> In the 450 - 470 MHz frequency band, transient frequencies must be within the maximum frequency difference limits during the time interval indicated below for 25, 12.5 and 6.25 kHz channels:

Time Interval	Maximum Frequency 12.5 kHz CH	Maximum Frequency 25 kHz CH	Mobile Radios 450 - 470 MHz
t_1	±12.5 kHz	±25.0 kHz	10 ms
t_2	±6.25 kHz	±12.5 kHz	25 ms
t_3	±12.5 kHz	±25.0 kHz	10 ms

Note: Transmitter of 6W or less, the frequency difference (t_3) may exceed the maximum for this time period.

<u>TEST PROCEDURE</u>: TIA/EIA TS603, PARA. 2.219, the levels were set as follows:

1. Using the variable attenuator, the transmitter level was set to 40 dB below the test receivers maximum input level, then the transmitter was turned off.

2. With the transmitter off, the signal generator was set 20 dB below the level of the transmitter in the above step (this level was maintained with the signal generator throughout the test).

3. Attenuation between the transmitter and the RF detector was reduced by 30 dB.

4. The transient frequency behavior was observed and recorded.

Para. 2.995(a)(b)(d) Frequency stability

90.214 (continued) Transient Frequency Behavior

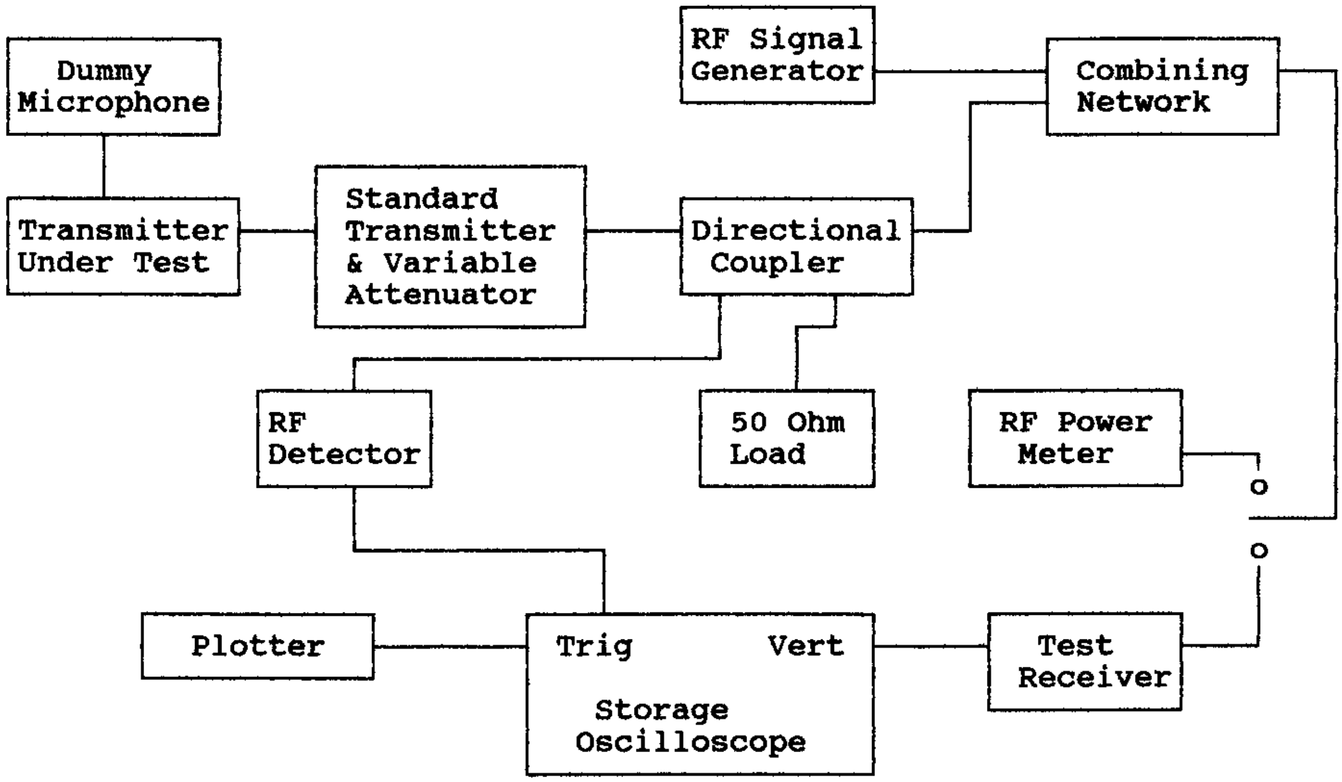
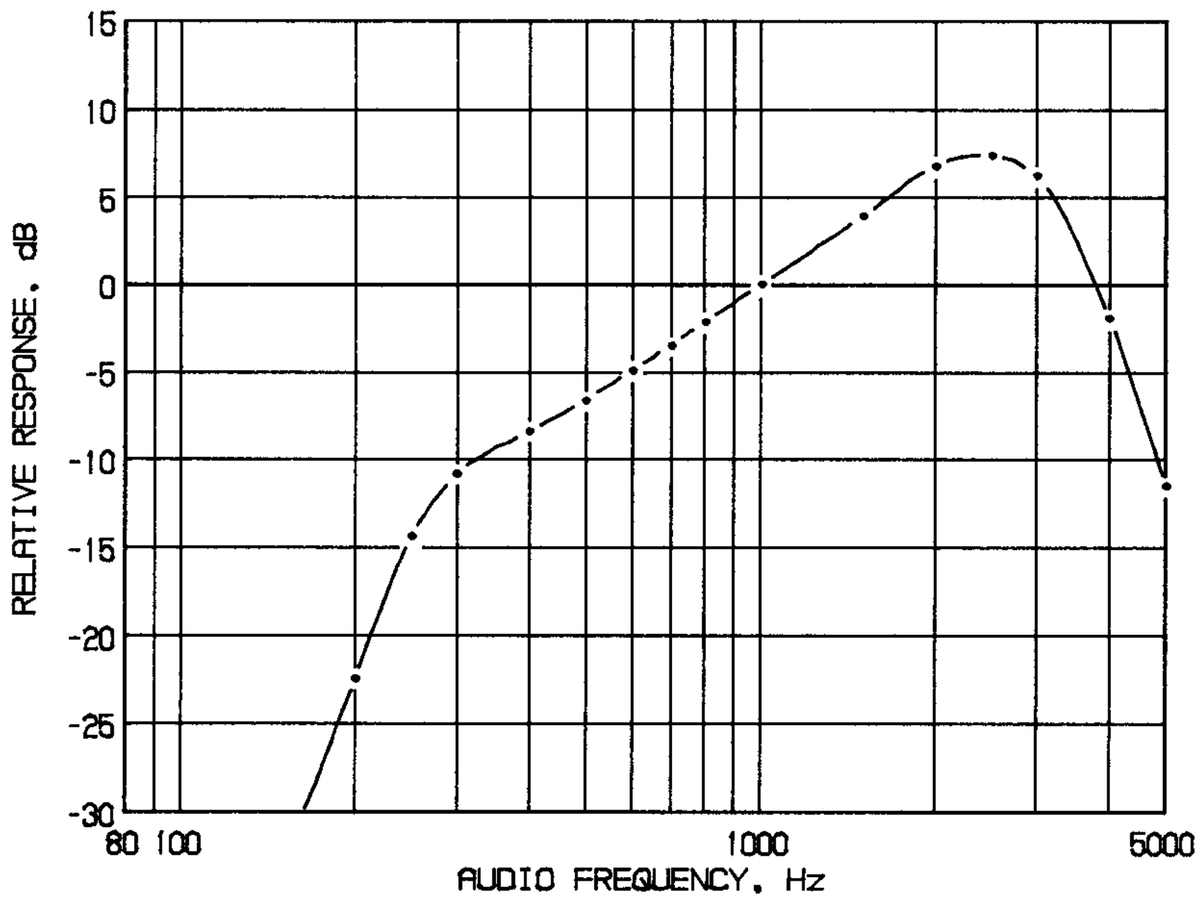


FIGURE 1

MODULATION FREQUENCY RESPONSE

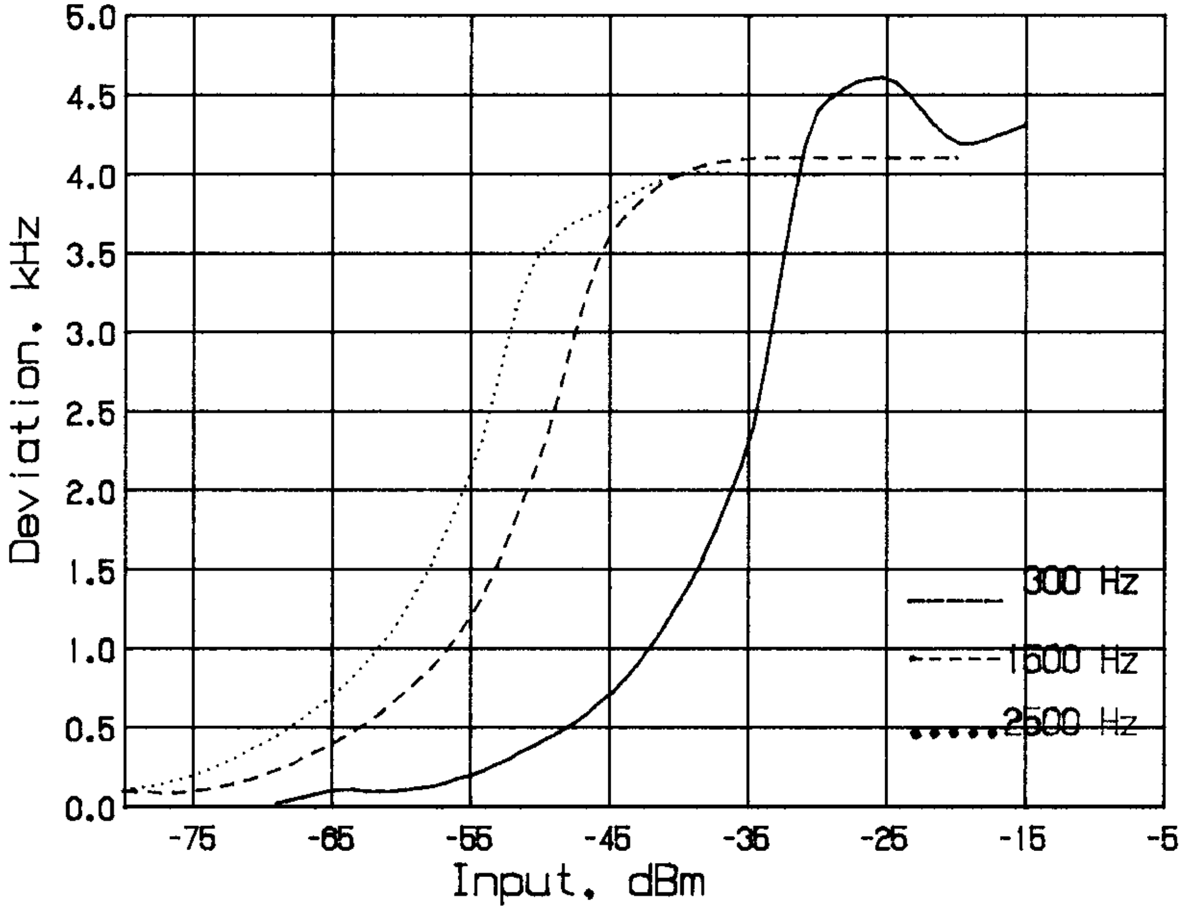


MODULATION FREQUENCY RESPONSE
FCC ID: NCP701691B

FIGURE 1

FIGURE 2a

AUDIO LIMITER CHARACTERISTICS

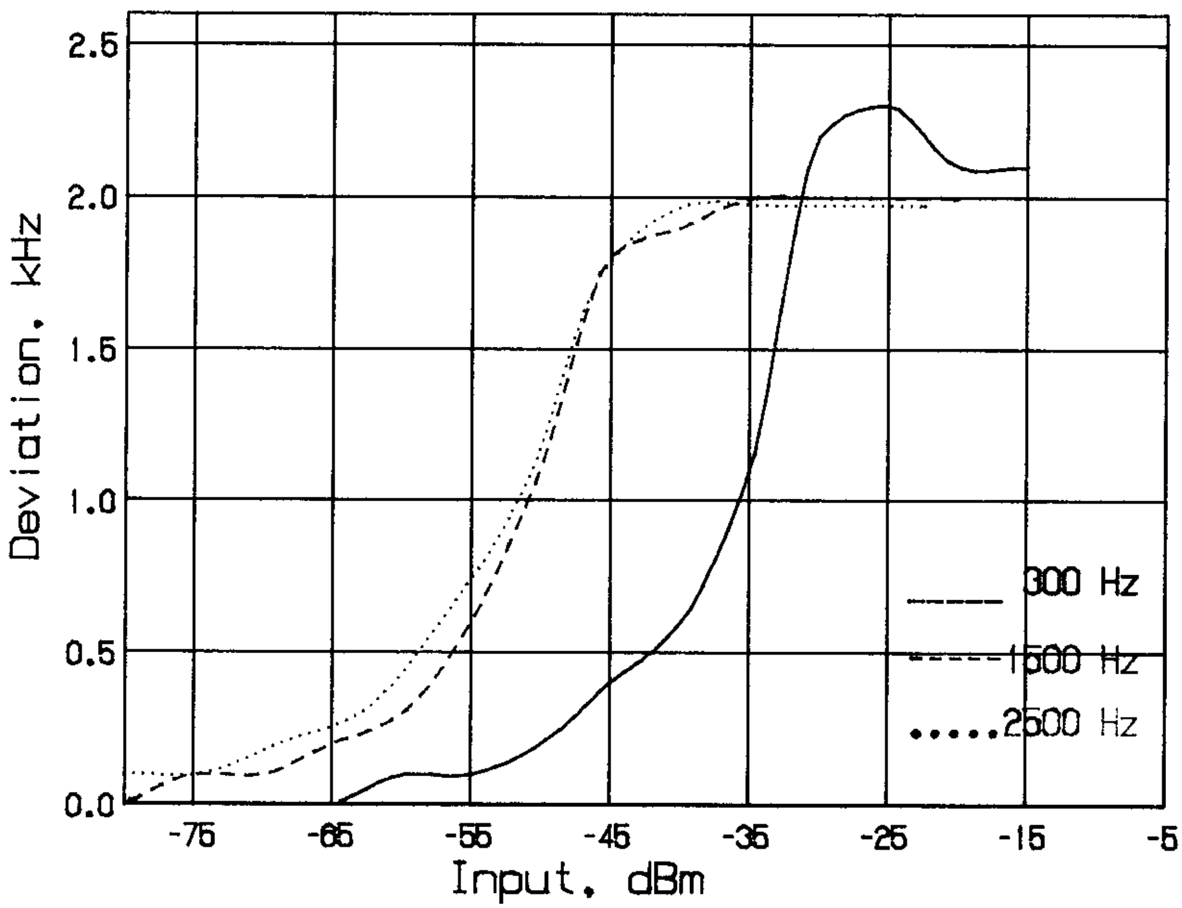


AUDIO LIMITER CHARACTERISTICS
FCC ID: NCP701691B

FIGURE 2a Wideband (5 kHz)

FIGURE 2b

AUDIO LIMITER CHARACTERISTICS

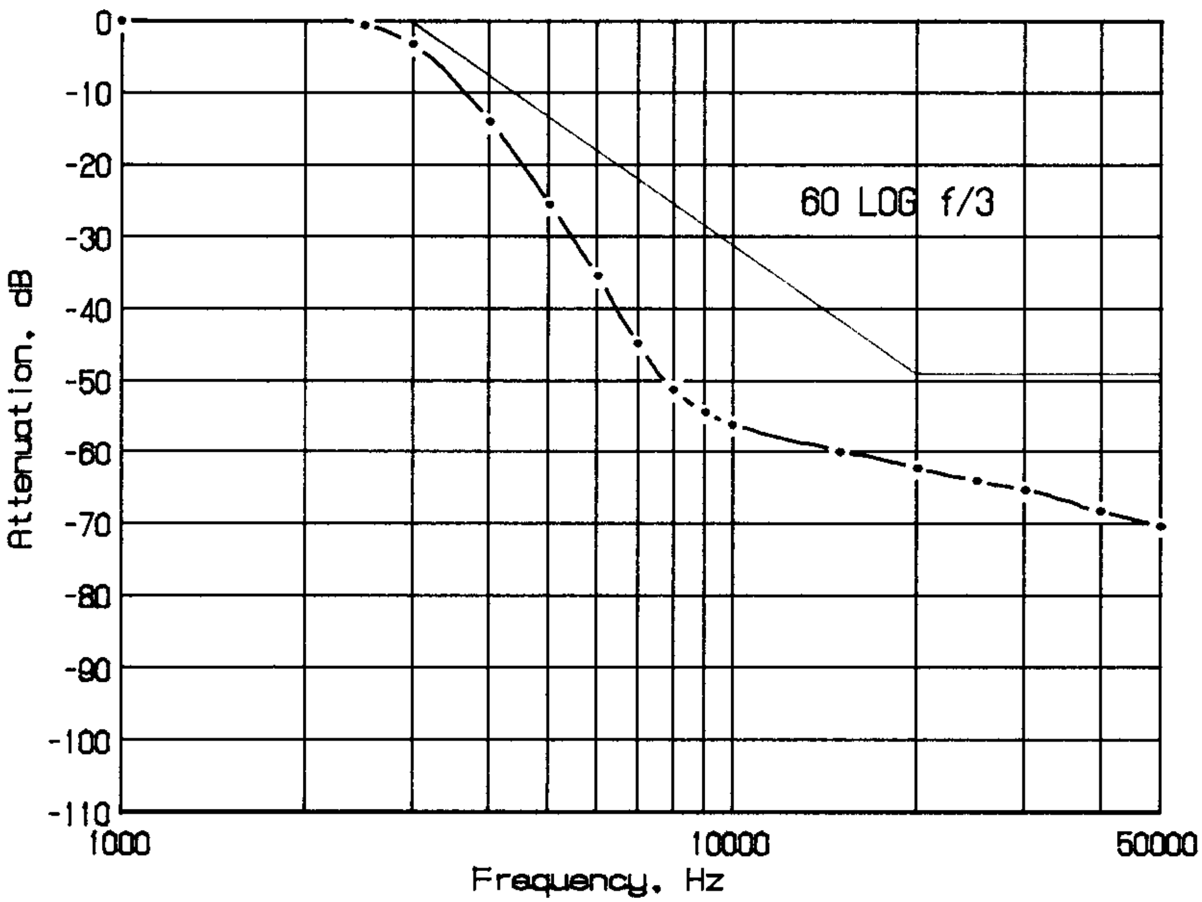


AUDIO LIMITER CHARACTERISTICS
FCC ID: NCP701691B

FIGURE 2b Narrow band (2.5 kHz)

FIGURE 3

AUDIO LOW PASS FILTER RESPONSE

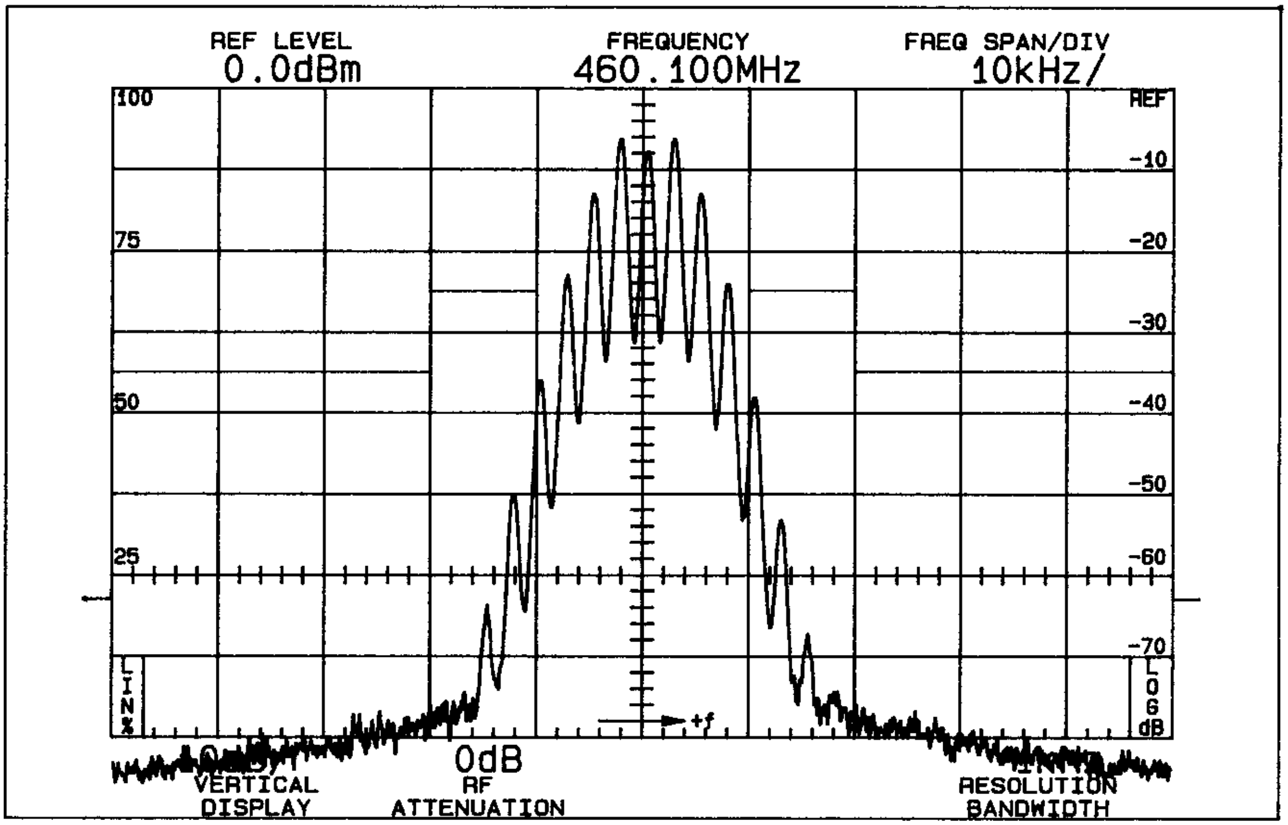


AUDIO LOW PASS FILTER RESPONSE
FCC ID: NCP701691B

FIGURE 3

FIGURE 4a

OCCUPIED BANDWIDTH



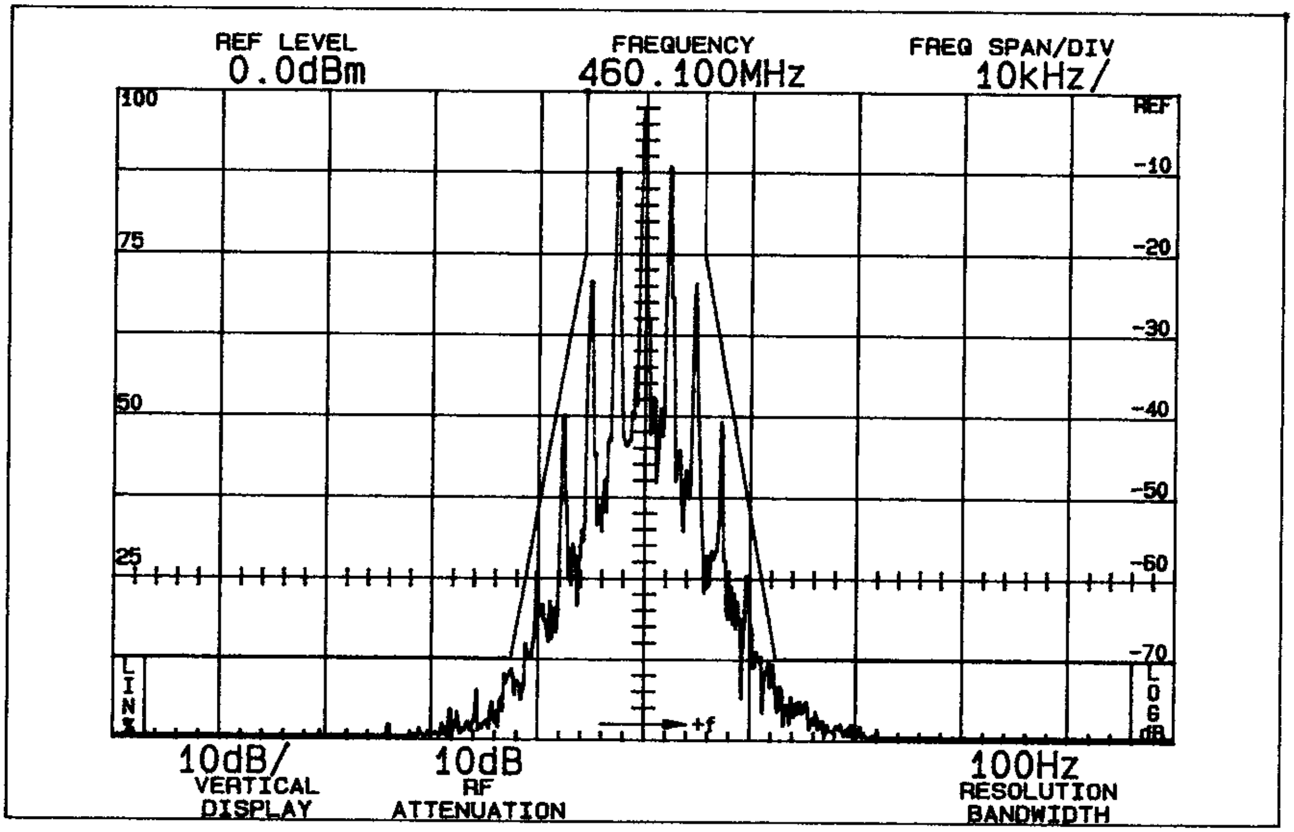
	ATTENUATION IN dB BELOW MEAN OUTPUT POWER Required
On any frequency more than 50% up to and including 100% of the authorized bandwidth, 20 kHz (10-20 kHz)	25
On any frequency more than 100%, up to and including 250% of the authorized bandwidth (20-50 kHz)	35
On any frequency removed from the assigned frequency by more than 250% of the authorized bandwidth (over 50 kHz)	43+10LogP = 64 (P = 117 W)

OCCUPIED BANDWIDTH (117 W)
FCC ID: NCP701691B

FIGURE 4a (5 kHz)

FIGURE 4b

OCCUPIED BANDWIDTH



	ATTENUATION IN dB BELOW MEAN OUTPUT POWER Required
(1) On any frequency from the center of the authorized bandwidth f_o to 5.625 kHz removed from f_o: Zero dB.	0
(2) On any frequency removed from the center of the authorized bandwidth by a displacement frequency (f_d in kHz) of more than 5.625 kHz but no more than 12.5 kHz: At least 7.27(f_d - 2.88 kHz) dB.	20 to 70
(3) On any frequency removed from the center of the authorized bandwidth by a displacement frequency (f_d in kHz) of more than 12.5 kHz: At least 50 + 10 log (P) dB or 70 dB, whichever is the lesser attenuation.	50+10LogP = 71 (P = 117 W)

OCCUPIED BANDWIDTH (117 W)
FCC ID: NCP701691B

FIGURE 4b (2.5 kHz)

D. MODULATION CHARACTERISTICS (Continued)

The plots are within the limits imposed by Paragraph 90.211(c) for frequency modulation. The horizontal scale (frequency) is 10 kHz per division and the vertical scale (amplitude) is a logarithmic presentation equal to 10 dB per division.

E. SPURIOUS EMISSIONS AT THE ANTENNA TERMINALS (Paragraph 2.991 of the Rules)

The 70-1691B transmitter was tested for spurious emissions at the antenna terminals while the equipment was modulated with a 2500 Hz signal, 16 dB above minimum input signal for 50% (2.5 kHz deviation) modulation at 2719 Hz, the frequency of highest sensitivity.

Measurements were made with Tektronix 494P spectrum analyzer coupled to the transmitter output terminal through a Bird 8325 power attenuator. A notch filter was used to attenuate the carrier.

During the tests, the transmitter was terminated in the 50 ohm attenuator. Power was monitored on a Bird 43 Thru-Line wattmeter; dc supply was 13.8 volts throughout the tests.

Spurious emissions were measured at 117 watts output throughout the RF spectrum from 12 (lowest frequency generated in the transmitter is 12.8 MHz) to the tenth harmonic of the carrier.

Any emissions that were between the required attenuation and the noise floor of the spectrum analyzer were recorded. Data are shown in Table 1.

F. DESCRIPTION OF RADIATED SPURIOUS MEASUREMENT FACILITIES

A description of the Hyak Laboratories' radiation test facility is a matter of record with the FCC. The facility meets ANSI 63.4-1992 and was accepted for radiation measurements from 25 to 1000 MHz on October 1, 1976 and is currently listed as an accepted site.

TABLE 1

TRANSMITTER CONDUCTED SPURIOUS
460.100, 13.8 Vdc Input, 117 W

Spurious Frequency MHz	dB Below Carrier Reference
920.200	77
1380.300	92*
1840.400	91
2300.500	92*
2760.600	97*
3220.700	>101*
3680.800	>100*
4140.900	94*
4601.000	>100*
Required: 43+10Log(P)	64 (71) 90.210(d)

All other emissions from 12 MHz to the tenth harmonic were 20 dB or more below FCC limit.

*Reference data only, more than 20 dB below FCC limit.

NOTE: Carrier notch filter used to increase dynamic range.

G. FIELD STRENGTH MEASUREMENTS OF SPURIOUS RADIATION

Field intensity measurements of radiated spurious emissions from the Midland 70-1691B were made with a Tektronix 494P spectrum analyzer using Singer DM-105A calibrated dipole antennas below a GHz, and Polarad CA-L or CA-S from 1-4.6 GHz.

The transmitter and dummy load were located in an open field 3 meters from the test antenna. Supply voltage was a power supply with a terminal voltage under load of 13.8 Vdc.

Output power was 117 watts at 460.100 MHz operating frequency. The transmitter and test antennas were arranged to maximize pickup. Both vertical and horizontal test antennae polarization were employed.

Reference level for the spurious radiations was taken as an ideal dipole excited by 117 watts, the output power of the transmitter according to the following relationship:*

$$E = \frac{(49.2P_t)^{1/2}}{R}$$

where E = electric-field intensity in volts/meter

P_t = transmitter power in watts

R = distance in meters

for this case $$E = \frac{(49.2x117.0)^{1/2}}{3} = 25.3 \text{ V/m}$$

Since the spectrum analyzer is calibrated in decibels above one milliwatt (dBm), a conversion, for convenience, was made from dBu to dBm.

$$25.3 \text{ volts/meter} = 25.3x10^6 \text{ uV/m}$$

$$\text{dBu/m} = 20 \text{ Log}_{10}(25.3x10^6)$$

$$= 148 \text{ dBu/m}$$

Since 1 uV/m = -107 dBm, the reference becomes

148 - 107 = 41 dBm

---

*Reference Data for Radio Engineers, Fourth Edition, International Telephone and Telegraph Corp., p. 676.

G. FIELD STRENGTH MEASUREMENTS (Continued)

The transmitter and test antennae were arranged to maximize pickup. Both vertical and horizontal test antenna polarization were employed.

The measurement system was capable of detecting signals 95 dB below the reference level. Measurements were made from the lowest frequency generated within the unit (12 MHz), to 10 times operating frequency. Data after application of antenna factors and line loss corrections are shown in Table 2.

TABLE 2

TRANSMITTER CABINET RADIATED SPURIOUS

460.100 MHz, 13.8 Vdc, 117 watts

Spurious Frequency MHz	dB Below Carrier Reference[1]	
920.200	78V	
1380.300	84V	
1840.400	86H	
2300.500	90V	
2760.600	86H	
3220.700	89H	
3680.800	91V	
4140.900	97H	
4601.000	98H*	
Required:	64	(71) 90.210(d)

[1]Worst-case polarization, H-Horizontal, V-Vertical.

* Reference data only, more than 20 dB below FCC limit.

All other spurious from 12 MHz to 4.6 GHz were 20 dB or more below FCC limit.

H. FREQUENCY STABILITY
(Paragraph 2.995(a)(2) and 90.213 of the Rules)

Measurement of frequency stability versus temperature was made at temperatures from -30°C to +50°C. At each temperature, the unit was exposed to test chamber ambient a minimum of 60 minutes after indicated chamber temperature ambient had stabilized to within ±2° of the desired test temperature. Following the 1 hour soak at each temperature, the unit was turned on, keyed and frequency measured within 2 minutes. Test temperature was sequenced in the order shown in Table 3, starting with -30°C.

A Thermotron S1.2 temperature chamber was used. Temperature was monitored with a Keithley 871 digital thermometer. The transmitter output stage was terminated in a dummy load. Primary supply was 13.8 volts. Frequency was measured with a HP 5385A frequency counter connected to the transmitter through a power attenuator. Measurements were made at 460.100 MHz. No transient keying effects were observed.

TABLE 3

FREQUENCY STABILITY vs. TEMPERATURE

460.100 MHz; 13.8 Vdc; 117 W

Temperature, °C	Output Frequency, MHz	ppm
-29.4	460.099454	-1.2
-19.4	460.099213	-1.7
- 9.9	460.099158	-1.8
0.3	460.099278	-1.6
10.2	460.099532	-1.0
20.4	460.099865	-0.3
30.4	460.100189	0.4
40.2	460.100373	0.8
50.2	460.100459	1.0

Maximum frequency error: 460.099158
460.100000

\- .000842 MHz

The device met a stability of .00025% (2.5 p.p.m.) or a maximum of ± .001150 MHz

High Limit	460.101150 MHz
Low Limit	460.098850 MHz

FCC Rule 90.213(a) specifies .00025%.

I. FREQUENCY STABILITY AS A FUNCTION OF SUPPLY VOLTAGE (Paragraph 2.995(d)(2) of the Rules)

Oscillator frequency as a function of power supply voltage was measured with a HP 5385A frequency counter as supply voltage provided by an HP 6264B variable dc power supply was varied from ±15% above the nominal 13.8 volt rating. A Fluke 197 digital voltmeter was used to measure supply voltage at transmitter primary input terminals. Measurements were made at 20°C ambient.

TABLE 4

FREQUENCY STABILITY AS A FUNCTION OF SUPPLY VOLTAGE

460.100 MHz, 13.8 Vdc Nominal, 117 W

%	Supply Voltage	Output Frequency, MHz	ppm
115	15.87	460.099865	-0.3
110	15.18	460.099865	-0.3
105	14.49	460.099863	-0.3
100	13.80	460.099865	-0.3
95	13.11	460.099869	-0.3
90	12.42	460.099867	-0.3
85	11.73	460.099869	-0.3

Maximum frequency error:	460.099863
	460.100000
	- .000137 MHz

The device met a stability of .00025% (2.5 p.p.m.) or a maximum of ± .001150 MHz.

High Limit	460.001150 MHz
Low Limit	460.998850 MHz

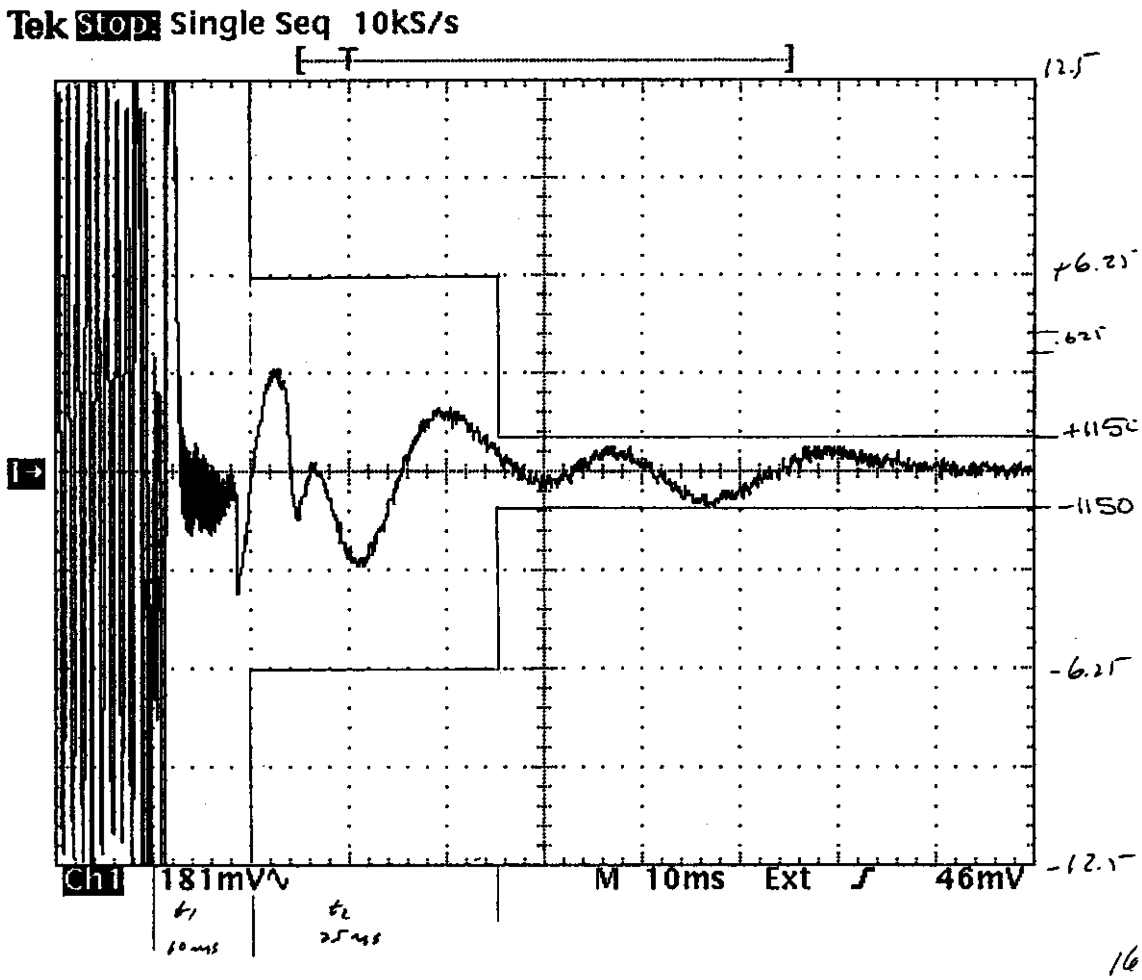
FCC Rule 90.213(a) specifies .00025%

J. TRANSIENT FREQUENCY BEHAVIOR (Paragraph 90.214 of the Rules)

Plots identified as Figures 5a, 5b, 5c and 5d, demonstrate TFB for 12.5 kHz and 25 kHz channel operation respectively. Detailed description of procedures is included in Appendix 9.

FIGURE 5a

TRANSIENT FREQUENCY BEHAVIOR

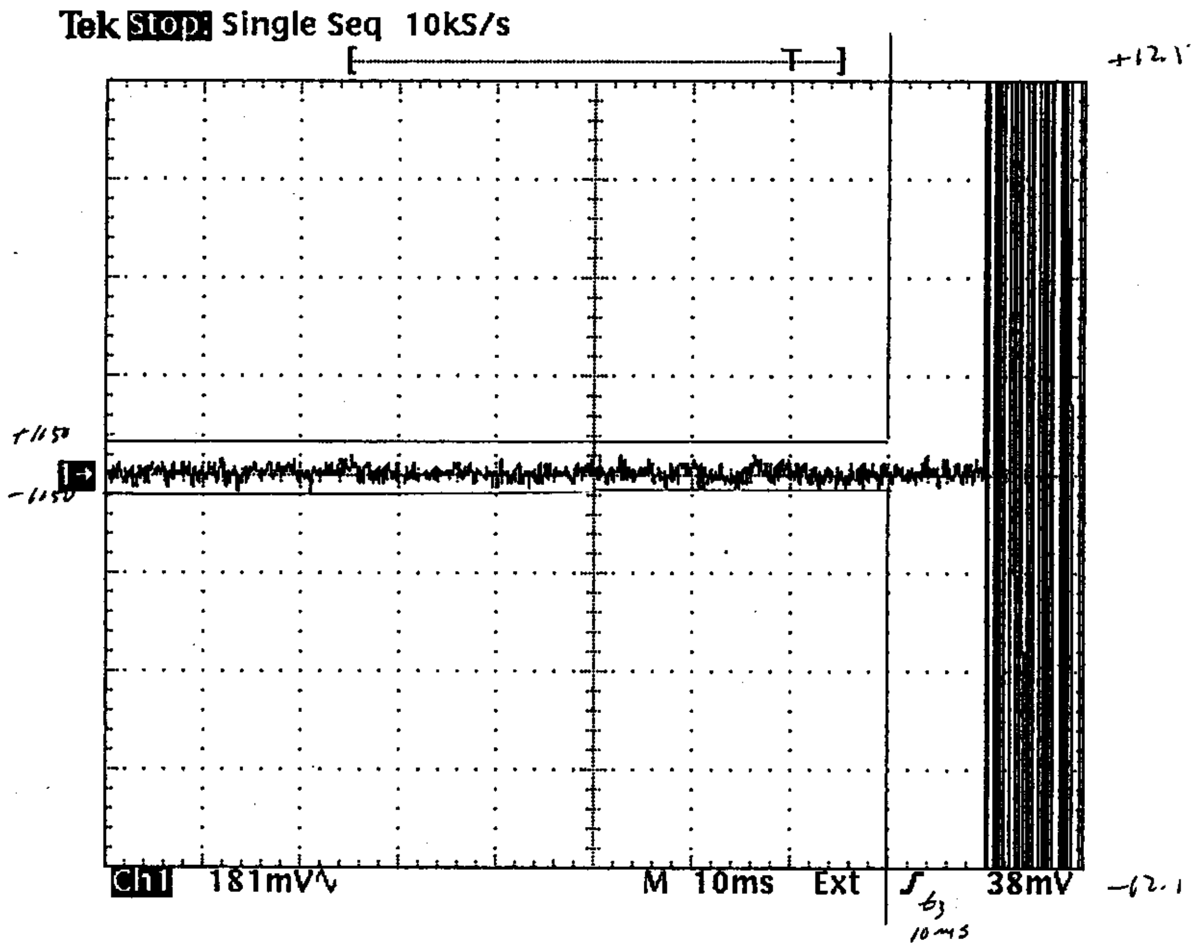


TRANSIENT FREQUENCY BEHAVIOR
FCC ID: NCP701691B

FIGURE 5a Turn-On (12.5 kHz)

FIGURE 5b

TRANSIENT FREQUENCY BEHAVIOR

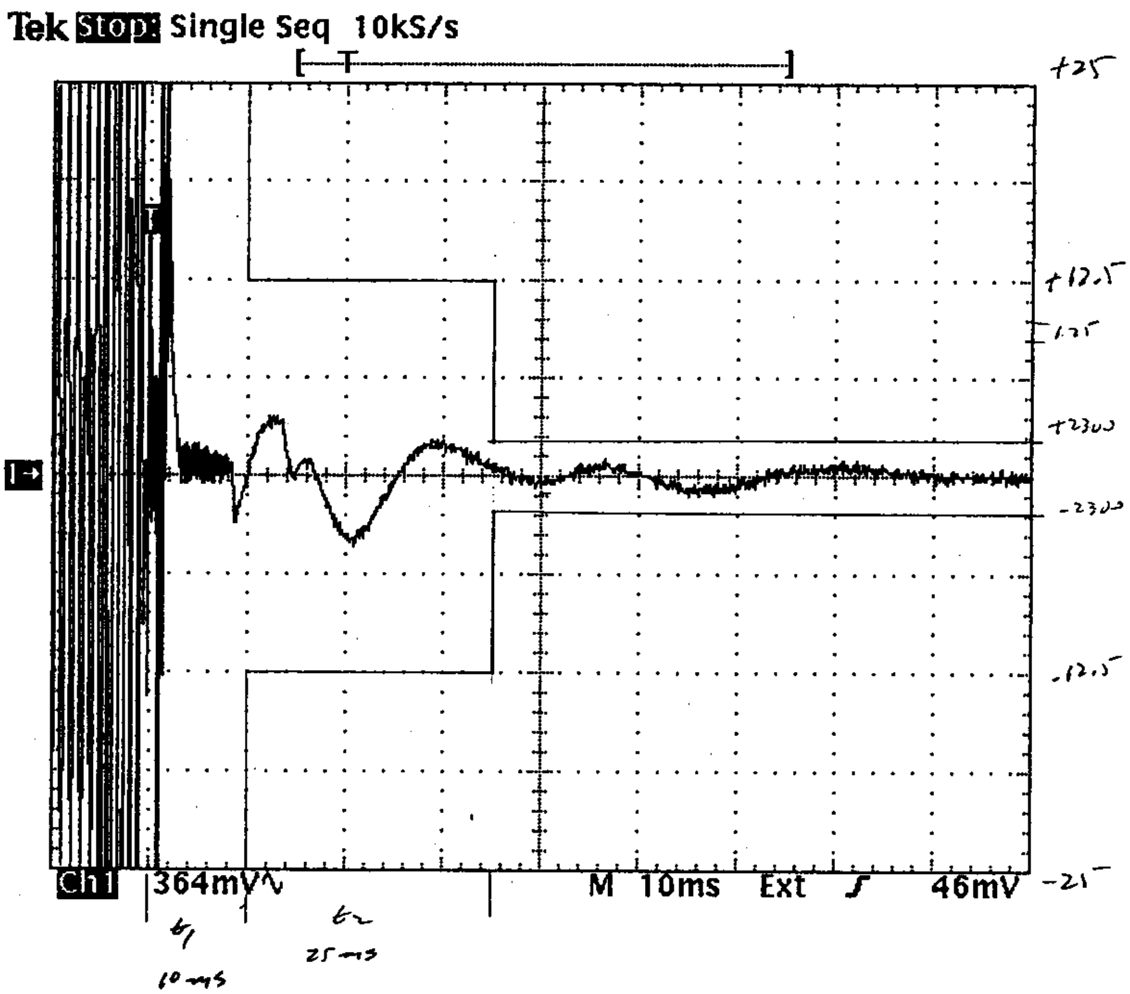


TRANSIENT FREQUENCY BEHAVIOR
FCC ID: NCP701691B

FIGURE 5b Turn-Off (12.5 kHz)

FIGURE 5c

TRANSIENT FREQUENCY BEHAVIOR

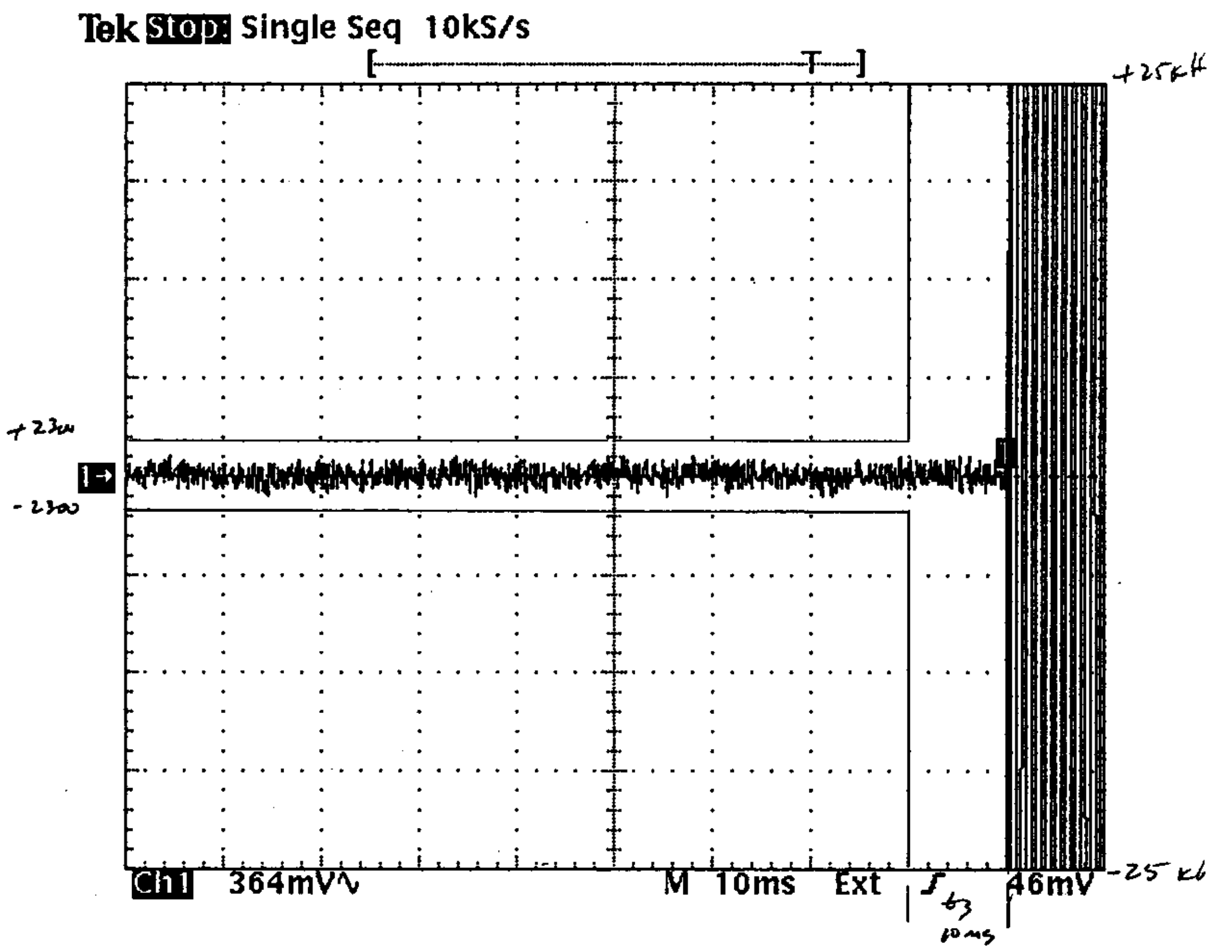


TRANSIENT FREQUENCY BEHAVIOR
FCC ID: NCP701691B

FIGURE 5c Turn-On (25 kHz)

FIGURE 5d

TRANSIENT FREQUENCY BEHAVIOR



TRANSIENT FREQUENCY BEHAVIOR
FCC ID: NCP701691B

FIGURE 5d Turn-Off (25 kHz)