ENGINEERING STATEMENT

For Type Certification of

MIDLAND USA

Model No: 70-0511C
FCC ID: NCP700511C

I am an Electronics Engineer, a principal in the firm of Hyak Laboratories, Inc., Springfield, Virginia. My education and experience are a matter of record with the Federal Communications Commission.

Hyak Laboratories, Inc. has been authorized by Midland USA to make type certification measurements on the 70-0511C transceiver. These tests made by me or under my supervision in our Springfield laboratory.

Test data and documentation required by the FCC for Type Certification are included in this report. The data verifies that the above mentioned transceiver meets FCC requirements and Type Certification is requested.

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Rowland S. Johnson

Dated: October 20, 1999

## A. INTRODUCTION

The following data are submitted in connection with this request for Type Certification of the 70-0511C transceiver in accordance with Part 2, Subpart J of the FCC Rules.

The 70-0511C is a VHF, frequency modulated transceiver intended for 25 kHz channel land mobile applications in the 42 - 50 MHz band. It operates from a 13.8 vehicle supply. Output power rating is 60 watts.

B. GENERAL INFORMATION REQUIRED FOR TYPE CERTIFICATION (Paragraph 2.983 of the Rules)

1. Name of applicant: Midland USA

2. Identification of equipment: NCP700511C

   a. The equipment identification label is submitted as a separate exhibit.
   b. Photographs of the equipment are submitted as a separate exhibit.

3. Quantity production is planned.

4. Technical description:

   a. 16k0F3E emission
   b. Frequency range: 42 - 50 MHz.
   c. Operating power of transmitter is fixed at the factory at 60 watts.
   d. Maximum power permitted under Part 90 of the FCC is 350 watts, and the 70-0511C fully complied with those power limitations.
   e. The dc voltage and dc currents at final amplifier:

      Collector voltage: 13.6 Vdc
      Collector current: 9.4 A

   f. Function of each active semiconductor device: See Appendix 1.
   g. Complete circuit diagram is submitted as a separate exhibit.
   h. A draft instruction book is submitted as a separate exhibit.
   i. The transmitter tune-up procedure is submitted as a separate exhibit.

B. GENERAL INFORMATION (continued)

   j. A description of circuits for stabilizing frequency is included in Appendix 2.

   k. A description of circuits and devices employed for suppression of spurious radiation and for limiting modulation is included in Appendix 3.
   l. Not applicable.

5. Data for 2.985 through 2.997 follow this section.

C. RF POWER OUTPUT (Paragraph 2.985(a) of the Rules)

RF power output was measured with a Bird 4421 RF power meter and a Bird 8325-power attenuator as a 50 ohm dummy load. Maximum power measured was 64 watts.

D. MODULATION CHARACTERISTICS

1. A curve showing frequency response of the transmitter is shown in Figure 1. Reference level was audio signal output from a Boonton 8220 modulation meter with one kHz deviation. Audio output was measured with a Audio Precision System One TRMS voltmeter and tracking generator.

2. Modulation limiting curves are shown in Figure 2 using a Boonton 8220 modulation meter. Signal level was established with a Audio Precision System One TRMS voltmeter. The curves show compliance with paragraphs 2.987(b), and 90.211(c).

3. Figure 3 is a graph of the post-limiter low pass filter which meets the requirements of paragraph 90.211(d)(1) in providing a roll-off of 60Logf/3 dB where f is audio frequency in kHz. Measurements were made following EIA RS-152B with an Audio Precision System One selective voltmeter on the Boonton 8220 modulation meter audio output.

4. Occupied Bandwidth
(Paragraphs 2.989(c), 90.209(b)(4) and 90.210(d) of the Rules)

Figure 4 is a plot of the sideband envelope of the transmitter taken with a Advantest R3361A spectrum analyzer. Modulation corresponded to conditions

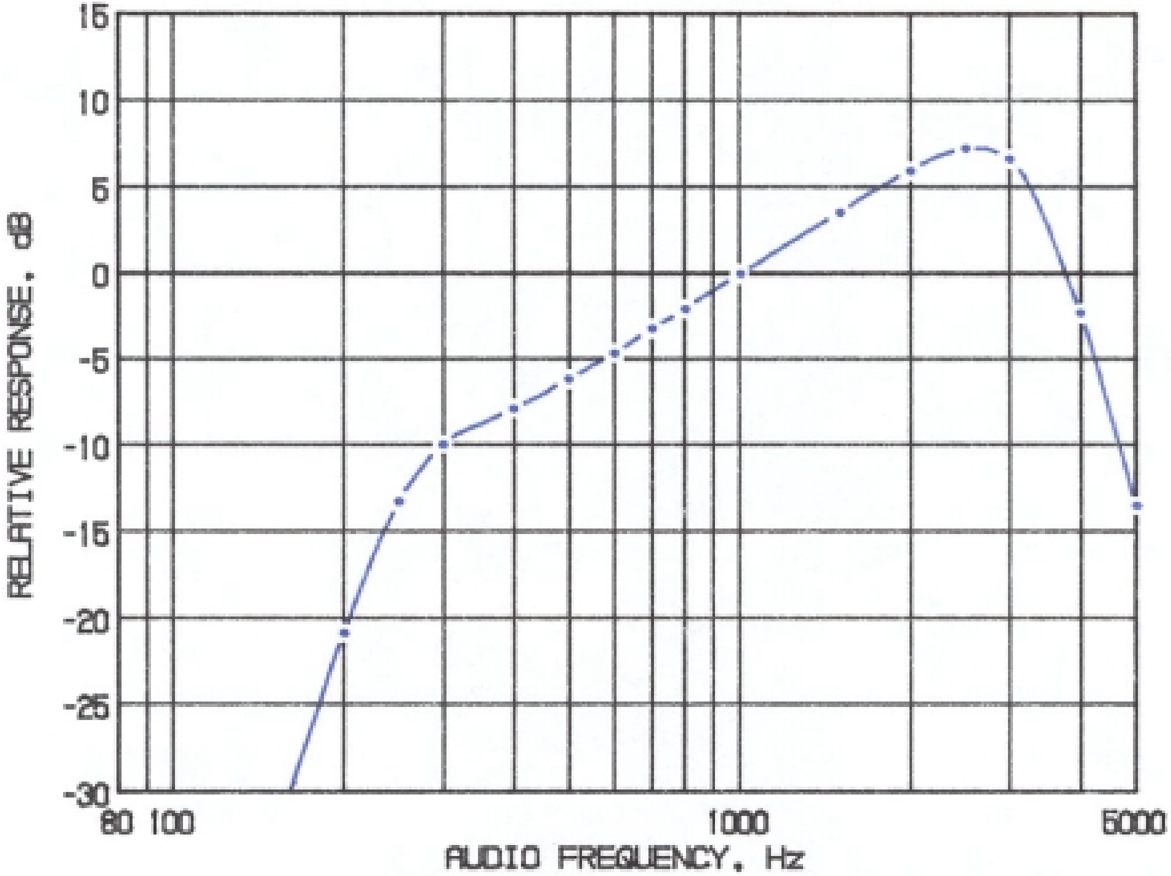
D. MODULATION CHARACTERISTICS (continued)

of 2.989(c)(1) and consisted of 2500 Hz tone at an input level 16 dB greater than that necessary to produce 50% modulation at 2638 Hz, the frequency of maximum response. Measured modulation under these conditions was 3.9.

**The plot has unmodulated carrier as 0 dBm reference.**

FIGURE 1

MODULATION FREQUENCY RESPONSE

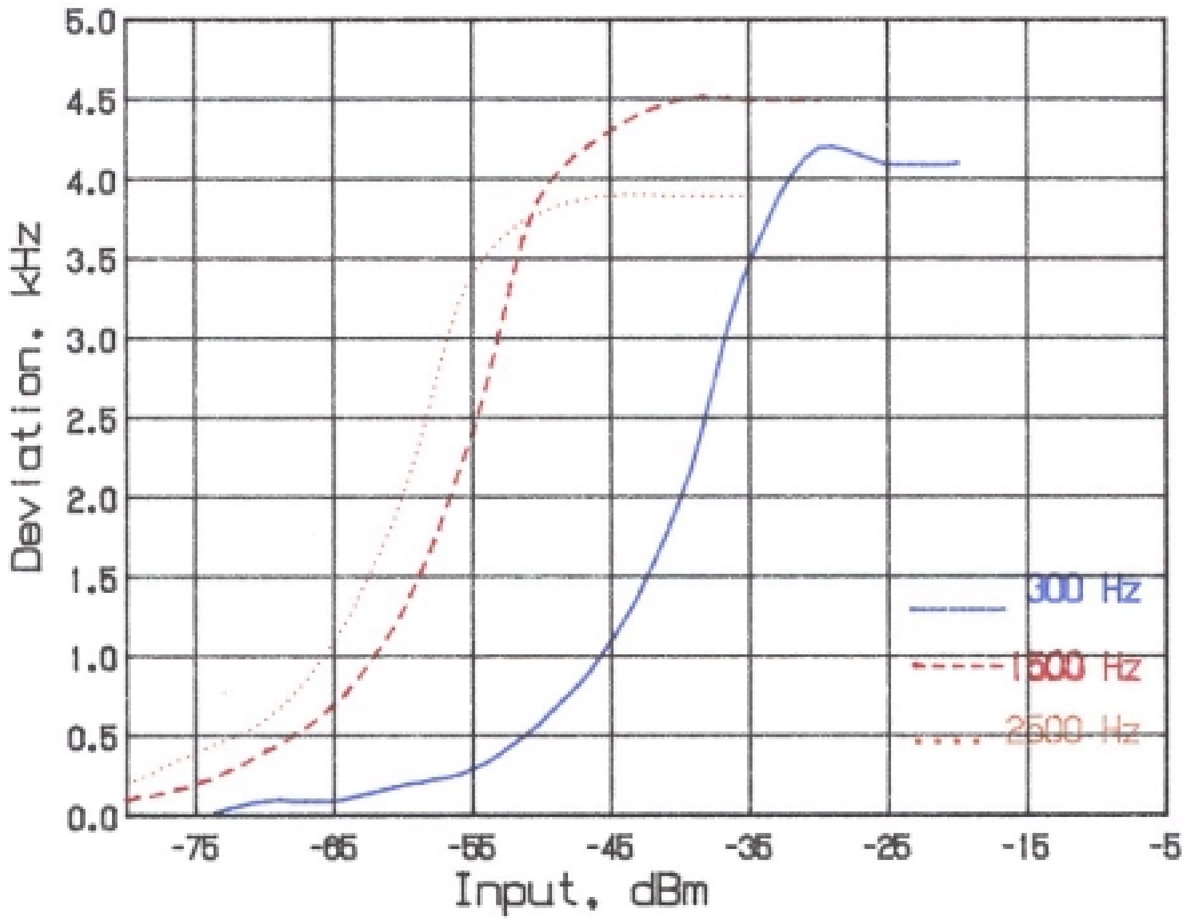



MODULATION FREQUENCY
RESPONSE
FCC ID: NCP700511C

FIGURE 1

FIGURE 2

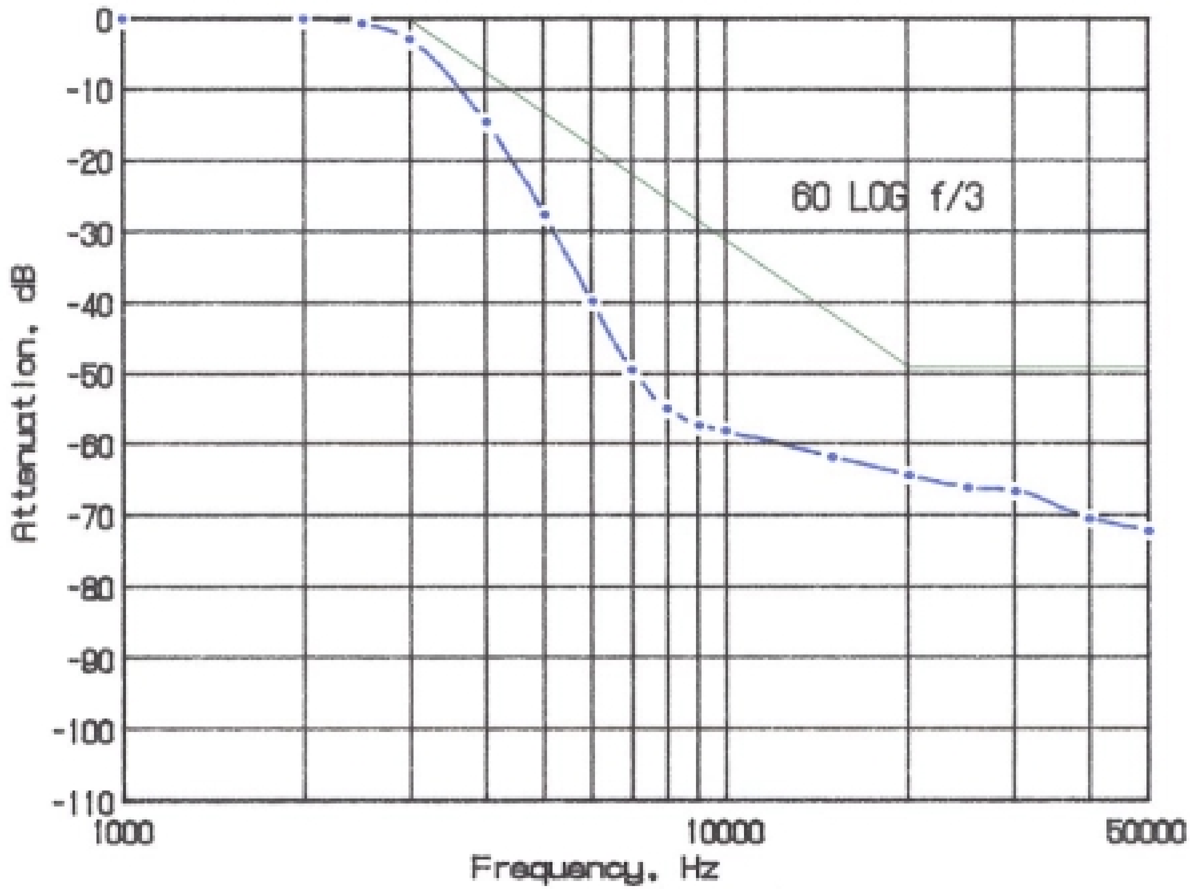
AUDIO LIMITER CHARACTERISTICS




AUDIO LIMITER CHARACTERISTICS
FCC ID: NCP700511C

FIGURE 2
FIGURE 3

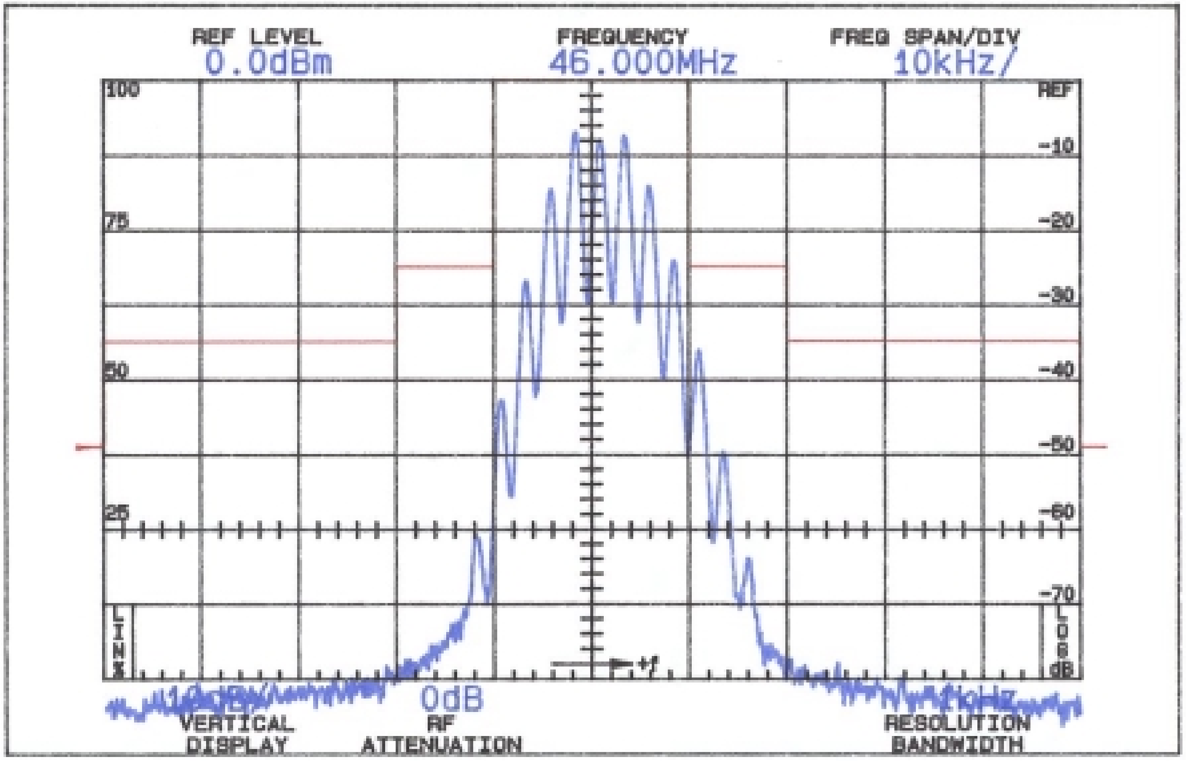
AUDIO LOW PASS FILTER RESPONSE




AUDIO LOW PASS FILTER RESPONSE
FCC ID:  NCP700511C

FIGURE 3
FIGURE 4

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 = 61 (P = 64 W) |

OCCUPIED BANDWIDTH
FCC ID: NCP700511C

FIGURE 4

D. MODULATION CHARACTERISTICS (Continued)

The plot is 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 70-0511C 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% deviation at 2638 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 64 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
46.000, 13.8 Vdc Input, 64 W

| Spurious Frequency MHz | dB Below Carrier Reference |
|---|---|
| 92.000 | 95 |
| 138.000 | 90 |

| | |
|---|---|
| 184.000 | 91 |
| 230.000 | 77 |
| 276.000 | 78 |
| 322.000 | 80 |
| 368.000 | 90 |
| 414.000 | >106 |
| 460.010 | >102 |
| Required: 43+10Log(P) | 61 |

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 70-0511C 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 64 Watts at 46.000 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 64 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 $$E = \frac{(49.2x64.0)^{1/2}}{3} = 18.7 \text{ V/m}$$

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

18.7 volts/meter = $18.7x10^6$ uV/m

dBu/m = $20 \text{ Log}_{10}(18.7x10^6)$

= 145 dBu/m

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

145 - 107 = 38 dBm

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*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

46.000 MHz, 13.8 Vdc, 64 Watts

| Spurious Frequency MHz | dB Below Carrier Reference[1] |
|---|---|
| 92.000 | 74H |
| 138.000 | 74H |

| | |
|---|---|
| 184.000 | 67H |
| 230.000 | 73V |
| 276.000 | 70H |
| 322.000 | 82* |
| 368.000 | 76V |
| 414.000 | 82* |
| 460.000 | 86* |
| Required: | 61 |

[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 the tenth harmonic 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 64 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 46.000 MHz. No transient keying effects were observed.

TABLE 3
FREQUENCY STABILITY vs. TEMPERATURE
46.000 MHz; 13.8 Vdc; 64 W

| Temperature, °C | Output Frequency, Hz | p.p.m. |
|---|---|---|
| -29.6 | 45.999970 | -0.7 |

| | | |
|---|---|---|
| -19.7 | 45.999987 | -0.3 |
| -10.0 | 45.999993 | -0.2 |
| 0.3 | 46.000007 | 0.2 |
| 10.1 | 46.000017 | 0.4 |
| 20.0 | 46.000025 | 0.5 |
| 30.3 | 46.000027 | 0.6 |
| 39.9 | 46.000024 | 0.5 |
| 49.7 | 46.000018 | 0.4 |

Maximum frequency error: 45.999970
46.000000
__________
- .000030 MHz

The device met a stability of .002% (20 PPM) or a maximum of ± .000920 MHz

High Limit 46.000920 MHz
Low Limit 45.999080 MHz

FCC Rule 90.213(a) specifies .002%.

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
46.000 MHz, 13.8 Volts Nominal, 64 W

| % | Supply Voltage | Output Frequency, MHz | p.p.m. |
|---|---|---|---|
| 115 | 15.87 | 46.000021 | 0.5 |
| 110 | 15.18 | 46.000021 | 0.5 |
| 105 | 14.49 | 46.000022 | 0.5 |
| 100 | 13.80 | 46.000025 | 0.5 |
| 95 | 13.11 | 46.000029 | 0.6 |
| 90 | 12.42 | 46.000030 | 0.7 |
| 85 | 11.73 | 46.000030 | 0.7 |

Maximum frequency error: 46.000030
46.000000

________

+ .000030 MHz

The device met a stability of .002% (20 PPM) or a maximum of ± .000920 MHz.

| | |
|---|---|
| High Limit | 46.000920 MHz |
| Low Limit | 45.999080 MHz |

FCC Rule 90.213(a) specifies .002%

APPENDIX 1

FUNCTION OF DEVICES

## 70-0511 ACTIVE SEMICONDUCTORS (1/3)

| SYMBOL | TYPE | FUNCTION |
|---|---|---|
| Q201 | 2SC3357 | RF Amp |
| Q203 | 2SK508K52 | IF Amp |
| Q204 | 2SK360E | IF Amp |
| Q205 | RT1N241C | Switch |
| Q206 | RT1N241C | Switch |
| Q207 | IMD3 | Switch |
| | | |
| | | |
| IC201 | TA31136FN | FM.I.F. |
| IC202 | TDA1519A | Audio Amplifier |
| IC203 | HA178L05UA | 5V Regulator |
| | | |
| Q301 | RT1N241C | Switch |
| Q302 | 2SC2462C | Switch |
| Q303 | 2SD1421ED | Switch |
| Q304 | RT1N241C | Switch |
| | | |
| IC301 | HA178L05UA | 5V Regulator |
| IC302 | M38203 | Micro Computer |
| IC303 | XC61AC4102 | Reset Switch |
| IC305 | HD14538 | Switch |
| IC306 | BU4066BCFV | Analog Switch |

| | | |
|---|---|---|
| Q401 | 2SC2462C | Buffer Amplifier |
| Q402 | 2SC2462C | Switch |
| Q403 | 2SC2462C | Switch |
| Q404 | RT1N241C | Switch |
| Q405 | RT1N241C | Switch |
| Q406 | UMH1N | Switch |
| Q407 | UMH1N | Switch |
| Q408 | RT1N241C | Switch |
| | | |
| IC401 | AK2368 | Audio Processor |
| IC402 | BA3308F | MIC Amplifier |
| IC403 | MF6CWMX | Operational Amplifier |
| IC404 | BA14741F | Operational Amplifier |

# 70-0511 ACTIVE SEMICONDUCTORS (2/3)

| SYMBOL | TYPE | FUNCTION |
|---|---|---|
| IC405 | BA14741F | Operational Amplifier |
| IC406 | HD14053BFP | Analog Switch |
| IC407 | BU4066BCFV | Analog Switch |
| IC408 | BA728F | Buffer Amplifier |
| IC409 | BA728F | Buffer Amplifier |
| IC410 | SC14S66F | Analog Switch |
| IC411 | SC14S66F | Analog Switch |
| IC412 | TC4W53FU | Analog Switch |
| IC413 | TC4W53FU | Analog Switch |
| IC415 | BA728F | Operational Amplifier |
| | | |
| Q501 | 2SC2538 | Power Amp |
| Q502 | 2SC2539 | Power Amp |
| Q503 | 2SC2694S | Power Amp |
| Q504 | 2SB945Q/P | APC |
| Q505 | 2SC2462C | APC |
| | | |
| IC501 | BA728F | Operational Amplifier |
| | | |
| Q701 | 2SA1121C | Charge Pump |
| Q702 | 2SC2462C | Charge Pump |
| Q703 | 2SA1121C | Charge Pump |
| Q704 | 2SC2462C | Charge Pump |
| Q705 | RT1N241C | Switch |
| Q706 | 2SK508K52 | VCO |
| Q707 | 2SC3356 | Pre Amp |
| Q708 | 2SC3357 | Pre Amp |
| Q709 | 2SA1576A | Switch |
| Q710 | UMH1N | Switch |
| Q712 | DTB123YK | Switch |
| Q713 | DTB123YK | Switch |
| Q714 | UMH1N | Switch |
| Q715 | 2SB1197K | Switch |
| Q716 | 2SD596DV3 | Filter |
| Q717 | 2SC3357 | Local Amp |

# 70-0511 ACTIVE SEMICONDUCTORS (3/3)

| SYMBOL | TYPE | FUNCTION |
|---|---|---|
| IC701 | MB1504PF | Synthesizer |
| IC702 | BU4066BCFV | Analog Switch |
| IC703 | μPC1675G | Operational Amplifier |
| IC704 | μPC1675G | Operational Amplifier |
| IC705 | μPC1675G | Operational Amplifier |
| | | |
| Q801 | 2SK508K52 | Switch |
| Q802 | 2SK508K52 | Switch |
| Q803 | 3SK151GR | Buffer Amplifier |
| Q804 | 2SC2462C | Buffer Amplifier |
| Q805 | 2SA1121C | Multi Vibrator |
| Q806 | 2SA1121C | Multi Vibrator |
| Q807 | 2SC2462C | Buffer Amplifier |
| Q808 | 2SA1121C | Buffer Amplifier |
| Q809 | 2SA1121C | Rectifier Amplifier |
| Q810 | 2SA1121C | Rectifier Amplifier |
| Q811 | 2SC2462C | Rectifier Amplifier |
| Q812 | DTC124EKA | Switch |
| | | |
| IC801 | MC1350DR2 | AGC Amplifier |
| | | |
| Q901 | 2SC2462C | Switch |
| Q902 | RT1N241C | Switch |
| Q903 | 2SJ246S | Switch |
| Q904 | RT1N241C | Switch |
| Q905 | RT1N241C | Switch |
| | | |
| IC901 | M38079EFFP | Micro Computer |
| IC902 | AT24C32N | E2PROM |
| IC904 | NJM7808DLA | 8V Regulator |
| IC905 | HA178L05UA | 5V Regulator |
| IC906 | RH5VL45AA | 5V Regulator |
| IC907 | XC61AC4102MR | Reset Switch |
| IC910 | RH5RL50AA | 5V Regulator |

FUNCTION OF DEVICES
FCC ID:  NCP700511C

APPENDIX 1

## APPENDIX 2

## CIRCUITS AND DEVICES TO STABILIZE FREQUENCY

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

# APPENDIX 3
# CIRCUITS TO SUPPRESS SPURIOUS RADIATION, LIMIT MODULATION AND CONTROL POWER

## RF Power Amplifier

A PC-board stripline is used to match Q501-base terminal to the coax. RF impedance at Q501-collector is transformed by PC-board stripline to the base terminal of driver Q502 and the collector of Q502 is transformed to the base of Q503. RF impedance at the collector of final-stage Q503 is again transformed by PC stripline. L511-L513 and C539-C545 comprise the harmonic filter. R511 serve to drain static and other DC potentials from the antenna.

## Modulator

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 in IC401. Modulation signals are then adjusted by IC401 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 the gain control IC401.

## 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 the 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 Q504 which is a current source that feeds primary DC to the collector circuit of predriver Q501. The feedback loop, from the directional coupler to Q504, holds RF output power at a constant level that is determined by IC901.