

HYAK LABORATORIES, INC.

7011 CALAMO STREET, SUITE 107
SPRINGFIELD, VIRGINIA 22150
(703) 451-1188
FAX (703) 644-7492

ENGINEERING STATEMENT

For Certification of

RADIO SHACK, A DIV. OF TANDY CORPORATION

Model No: 21-1840
FCC ID: AAO21-1840

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 Radio Shack, a Div. of Tandy Corp., to make type acceptance measurements on the 21-1840 transceiver. These tests made by me or under my supervision in our Springfield laboratory.

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



Rowland S. Johnson

Dated: September 30, 1998

A. INTRODUCTION

The following data are submitted in connection with this request for Certification of the 21-1840 transceiver in accordance with Part 2, Subpart J of the FCC Rules.

The 21-1840 is a portable, battery operated, UHF, frequency modulated transceiver intended for 12.5 kHz channel family radio service applications in the 462.5625-467.7125 MHz band. It operates from a nominal 4.5 Vdc battery supply. Output power rating is 0.1 watts ERP.

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

1. Name of applicant: Radio Shack, a Div. of Tandy Corp.
2. Identification of equipment: FCC ID: AAO21-1840
 - a. The equipment identification label is shown in Appendix 1.
 - b. Photographs of the equipment are included in Appendix 2.
3. Quantity production is planned.
4. Technical description:
 - a. 11k0F3E emission
 - b. Frequency range: 462.5625 - 467.7125 MHz.
 - c. Operating power of transmitter is fixed at the factory at less than 0.5 W ERP.
 - d. Maximum power permitted is 0.5 watts, and the 21-1840 fully complied with that power limitation.
 - e. The dc voltage and dc currents at final amplifier:

Collector voltage: 3.0 Vdc
Collector current: 0.19 A
 - f. Function of each active semiconductor device:
See Appendix 3.
 - g. Complete circuit diagram is included in Appendix 4.
 - h. A draft instruction book is submitted as Appendix 5.
 - i. The transmitter tune-up procedure is included in Appendix 6.
 - j. A description of circuits for stabilizing frequency is included in Appendix 7.
 - k. A description of circuits and devices employed for suppression of spurious radiation and for limiting modulation is included in Appendix 8.
 - 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)

The 21-1840 has a permanently attached built-in antenna without provisions for a coaxial connector.

Therefore RF power output was calculated using the measured carrier field intensity, See Table 1. (The transmitter was tuned by the factory according to the procedure of Exhibit 4.)

TABLE 1

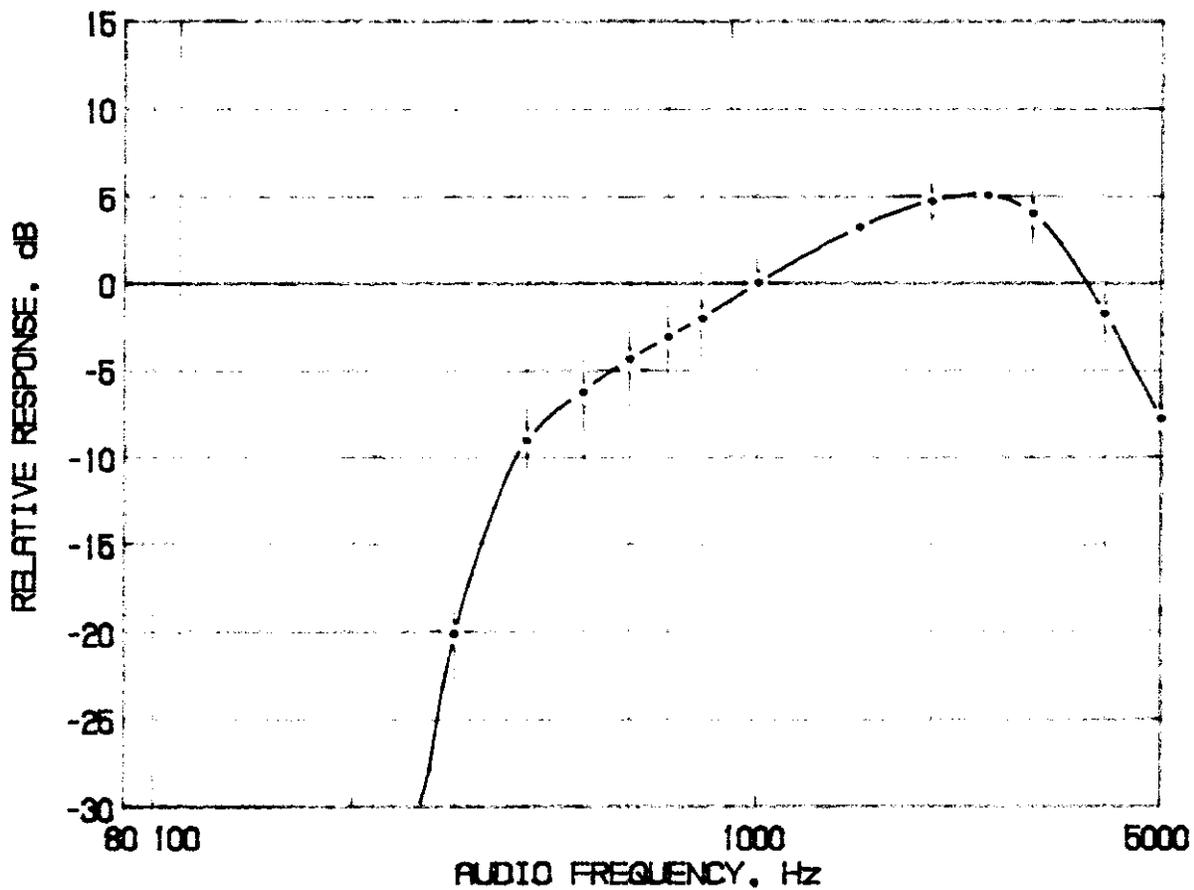
Operating Freq., MHz	Power watts into a dipole antenna
467.7125	0.097

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 integrated test system.
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 integrated test system. The curves show compliance with paragraphs 2.987(b).
3. Figure 3 is a graph of the post-limiter low pass filter which provides a roll-off of $60\text{Log}f/3$ dB where f is audio frequency in kHz. Measurements were made following EIA RS-152B with an Audio Precision System One integrated test system on the Boonton 8220 modulation meter audio output.
4. Occupied Bandwidth
(Paragraphs 2.989(c) of the Rules)

Figure 4 is a plot of the sideband envelope of the transmitter output taken with a Tektronix 494P spectrum analyzer. Modulation corresponded to conditions 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 2506 Hz, the frequency of maximum response. Measured modulation under these conditions was 2.1 kHz.

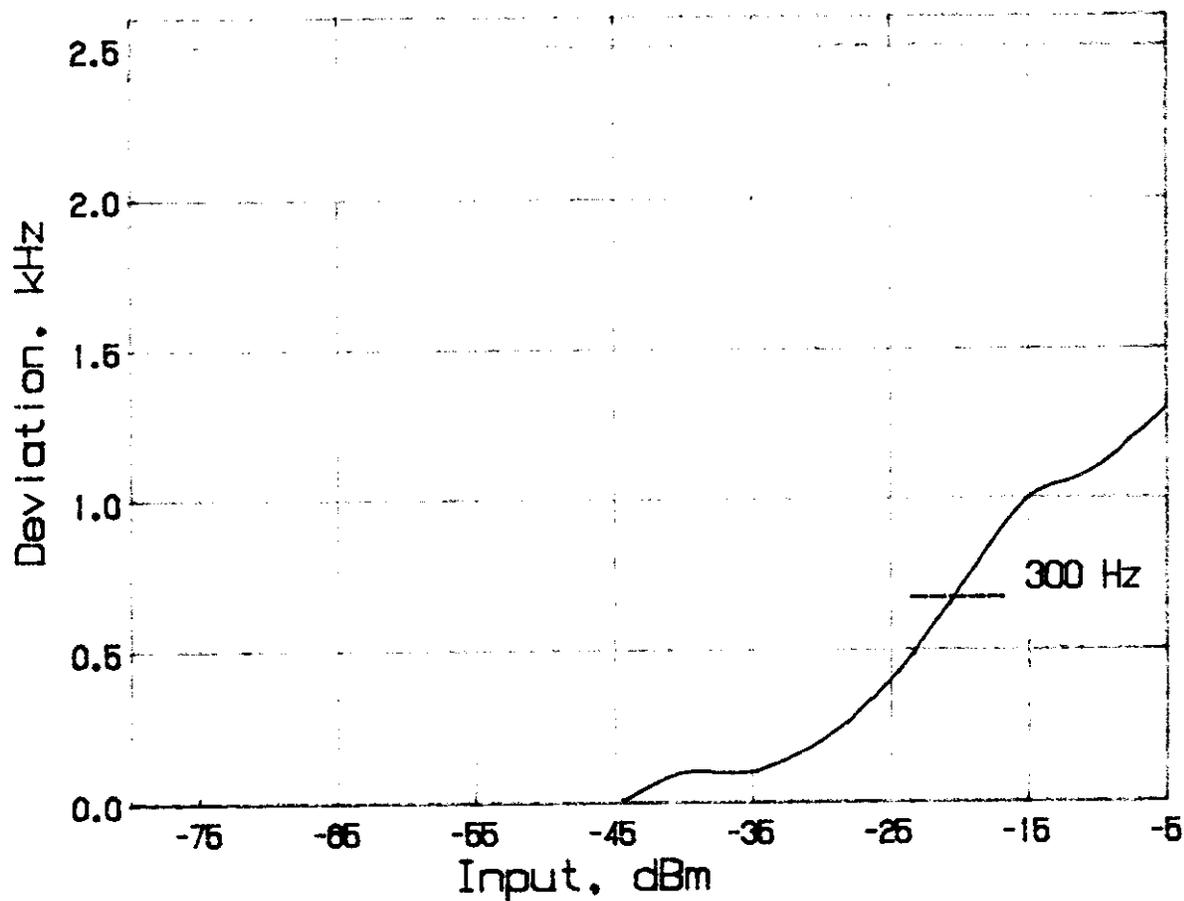
FIGURE 1
MODULATION FREQUENCY RESPONSE



MODULATION FREQUENCY RESPONSE
FCC ID: AAO21-1840

FIGURE 1

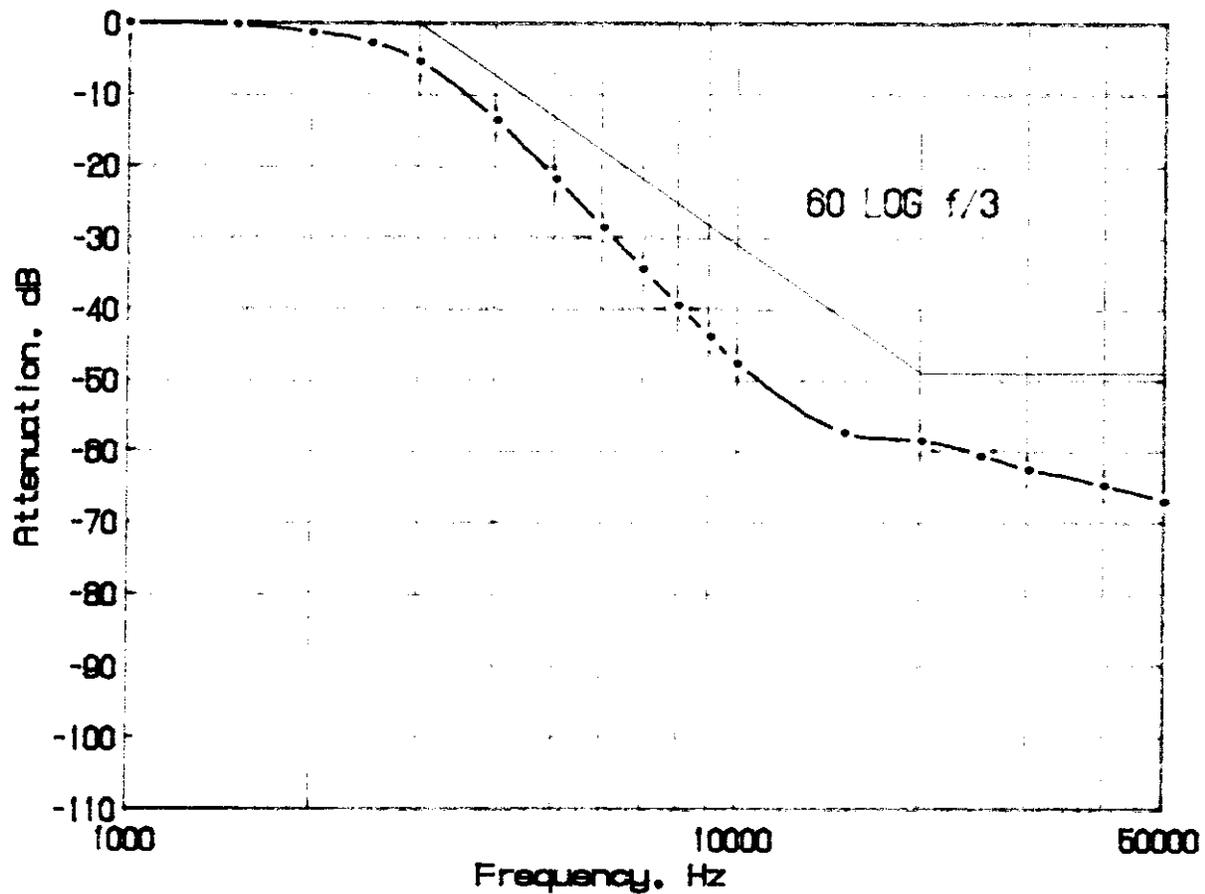
FIGURE 2
AUDIO LIMITER CHARACTERISTICS



AUDIO LIMITER CHARACTERISTICS
FCC ID: AAO21-1840

FIGURE 2

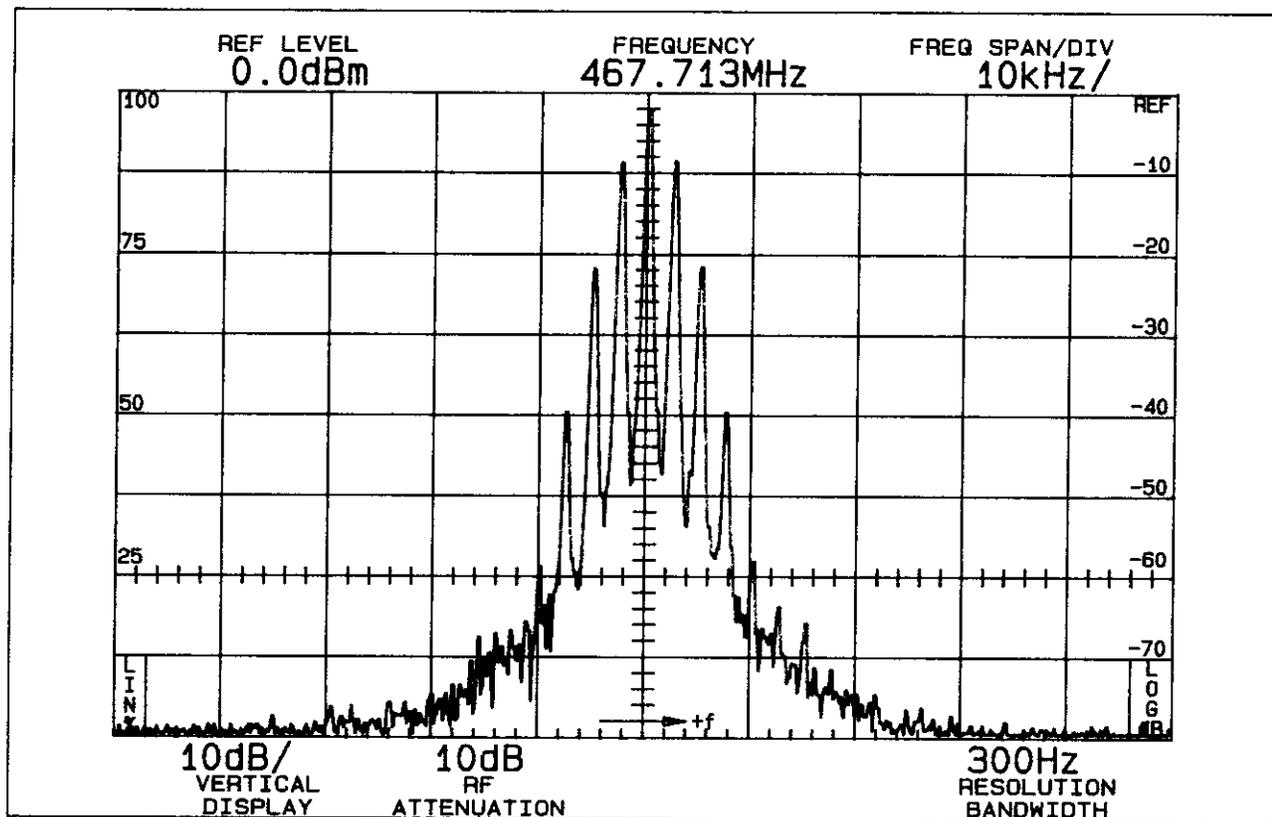
FIGURE 3
AUDIO LOW PASS FILTER RESPONSE



AUDIO LOW PASS FILTER
RESPONSE
FCC ID: AAO21-1840

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, 12.5 kHz
(6.25-12.5 kHz)

25

On any frequency more than 100%,
up to and including 250% of the
authorized bandwidth (12.5-31.25
kHz)

35

On any frequency removed from
the assigned frequency by more
than 250% of the authorized
bandwidth (over 31.25 kHz)

$$43 + 10 \log P = 33$$

$$(P = 0.097W)$$

OCCUPIED BANDWIDTH
FCC ID: AAO21-1840

FIGURE 4

D. MODULATION CHARACTERISTICS (Continued)

The plots are within FCC limits. 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 21-1840 has a permanently attached antenna. There is no connector for an external antenna. Therefore, no antenna terminal conducted measurements were made.

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 was accepted for radiation measurements from 25 to 1000 MHz on October 1, 1976 and is currently listed as an accepted site.

G. FIELD STRENGTH MEASUREMENTS OF SPURIOUS RADIATION

Field intensity measurements of radiated spurious emissions from the Radio Shack 21-1840 were made with a Tektronix 494P spectrum analyzer using Singer DM-105 for the measurements to 1 GHz, and EMCO 3115 horn to 4.8 GHz.

The transmitter was located in an open field 3 meters from the test antenna. Supply voltage was a power supply with a terminal voltage under load of 4.5 Vdc.

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 100 dB or more 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 3.

TABLE 3

TRANSMITTER CABINET RADIATED SPURIOUS

467.7125 MHz, 4.5 Vdc, 0.097 watts

<u>Spurious Frequency MHz</u>	<u>Radiated Field uV/m @ 3M</u>	<u>dB Below Carrier Reference</u> ¹
467.713	728618.2	0.0
935.426	595.7	61.8V
1403.138	331.1	66.9V
1870.851	154.9	73.5V*
2338.564	177.8	72.3H*
2806.277	167.9	72.8V*
3273.990	309.0	67.5H*
3741.702	329.1	70.1H*
4209.415	248.3	69.4V*
4677.128	266.1	68.8H*

Required: $43+10 \text{ Log (P) = 33}$ ¹Worst-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.

Power Computation:

$$P = (F.I.x3)^2/49.2$$

$$= 0.097 \text{ W}$$

H. FREQUENCY STABILITY
 (Paragraph 2.995(a)(2))

Measurement of frequency stability versus temperature was made at temperatures from -20°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 4, 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 4.5 volts. Frequency was measured with a HP 5385A frequency counter connected to the transmitter through a power attenuator. Measurements were made at 467.7125 MHz. No transient keying effects were observed.

TABLE 4

FREQUENCY STABILITY AS A FUNCTION OF TEMPERATURE

467.7125 MHz, 4.5 Vdc, 0.097 W

<u>Temperature, °C</u>	<u>Output Frequency, MHz</u>	<u>ppm</u>
-19.3	467.712506	0.0
- 9.3	467.712194	-0.7
- 0.2	467.711457	-2.2
10.2	467.711863	-1.4
19.8	467.712193	-0.7
30.4	467.712503	0.0
39.8	467.712761	0.6
50.4	467.713106	1.3

Maximum frequency error: 467.711457
467.712500

- .001043 MHz

FCC Rule 95.627(b) specifies .00025% (2.5 ppm) or a maximum of + 0.001169 MHz, which corresponds to:

High Limit	467.713669 MHz
Low Limit	467.711331 MHz

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 $\pm 15\%$ above the nominal 4.5 volt rating to below the battery end point. A Fluke 197 digital voltmeter was used to measure supply voltage at transmitter primary input terminals. Measurements were made at 20°C ambient.

TABLE 5

FREQUENCY STABILITY AS A FUNCTION OF SUPPLY VOLTAGE

467.7125 MHz, 4.5 Vdc Nominal; 0.097 W

<u>Supply Voltage</u>		<u>Output Frequency, MHz</u>	<u>ppm</u>
5.2	115%	467.712139	-0.8
5.0	110%	467.712149	-0.8
4.7	105%	467.712167	-0.7
4.5	100%	467.712193	-0.7
4.3	95%	467.712237	-0.6
4.1	90%	467.712262	-0.5
3.8	85%	467.712281	-0.5
3.6*	80%	467.712299	-0.4
Maximum frequency error:		467.712139	
		<u>467.712500</u>	
		- .000361 MHz	

FCC Rule 95.627(b) specifies .00025% (2.5 ppm) or a maximum of ± 0.001169 MHz, corresponding to:

High Limit	467.713669 MHz
Low Limit	467.711331 MHz

*Battery end point.