ENGINEERING STATEMENT

For Type Certification of

Radio Shack; a Division of Tandy Corporation

Model No: 21-1860
FCC ID: AAO2101860

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 Division of Tandy Corporation, to make type certification measurements on the 21-1860 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 type certification is requested.

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Rowland S. Johnson

Dated: November 28, 2000

A. INTRODUCTION

The following data are submitted in connection with this request for type certification of the 21-1860 transceiver in

accordance with Part 2, Subpart J of the FCC Rules.

The 21-1860 is a mobile, 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 6 Vdc supply. Output power rating is 0.5 watts ERP.

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

1. Name of applicant: Radio Shack, a Div. of Tandy Corp.

2. Identification of equipment: FCC ID: AAO2101860

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

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 0.5 W ERP.
   d. Maximum power permitted is 0.5 watts, and the 21-1860 fully complied with that power limitation.
   e. The dc voltage and dc currents at final amplifier:

      Collector voltage: 5.9 Vdc
      Collector current: 0.17 mA

   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 included as a separate exhibit.



B. GENERAL INFORMATION REQUIRED FOR TYPE CERTIFICATION (continued)

   j. A description of circuits for stabilizing frequency is included in the Theory of Operation.
   k. A description of circuits and devices employed for suppression of spurious radiation and for limiting modulation is included in the Theory of Operation.
   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 21-1860 has a permanently attached built in antenna without provisions for a coaxial connector.

Therefore RF power output was determined by substitution.

TABLE 1

| Operating Freq., MHz | Power watts into a dipole antenna |
|---|---|
| 462.5625 | 0.47 |

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).



D. MODULATION CHARACTERISTICS (continued)

3. Figure 3 is a graph of the post-limiter low pass filter which provides 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 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 2836 Hz, the frequency of maximum response. Measured modulation under these conditions was 1.7 kHz.

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. Unmodulated carrier reference is 0 dBm.

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

The 21-1860 has a permanently attached antenna. There is no connector for an external antenna. Therefore, no antenna terminal conducted measurements were made.

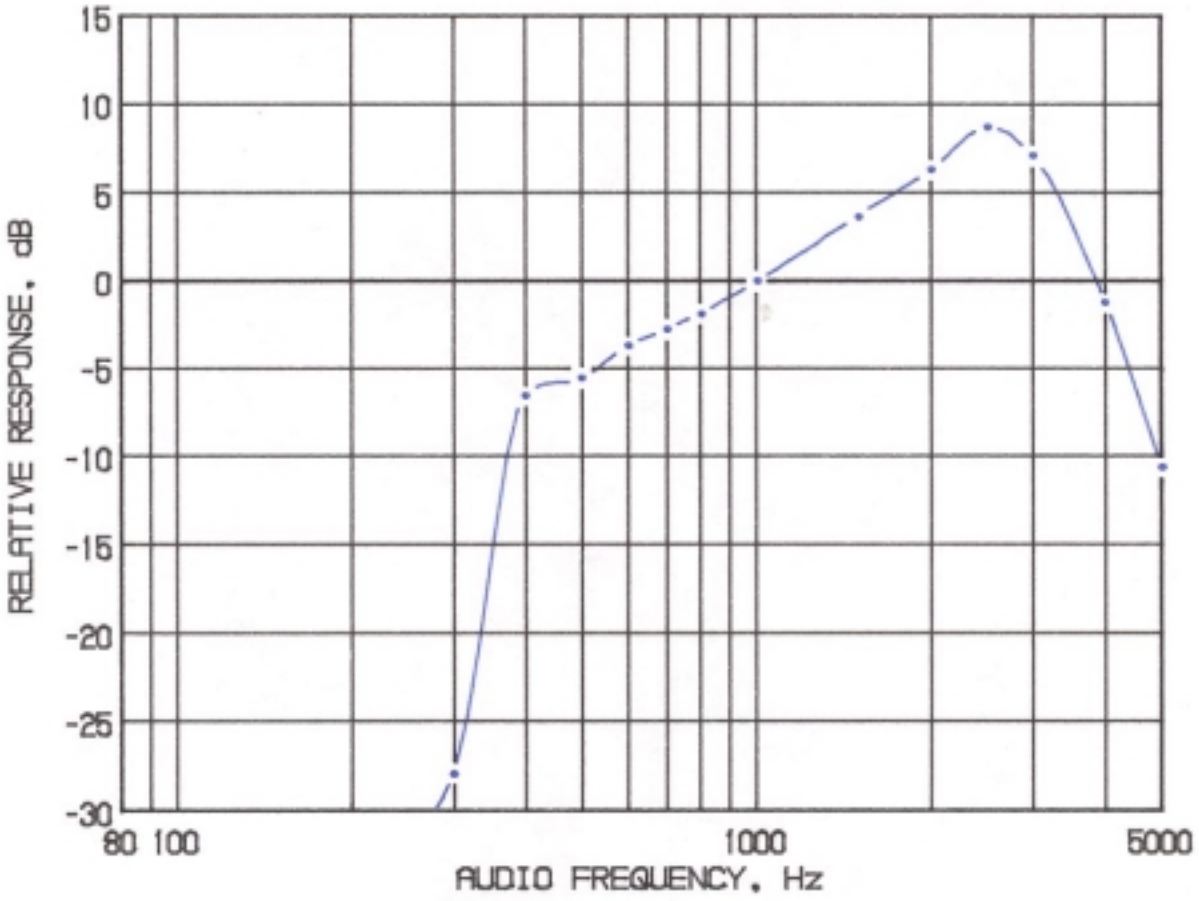
## F. DESCRIPTION OF RADIATED SPURIOUS MEASUREMENT FACILITIES

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.



FIGURE 1

MODULATION FREQUENCY RESPONSE



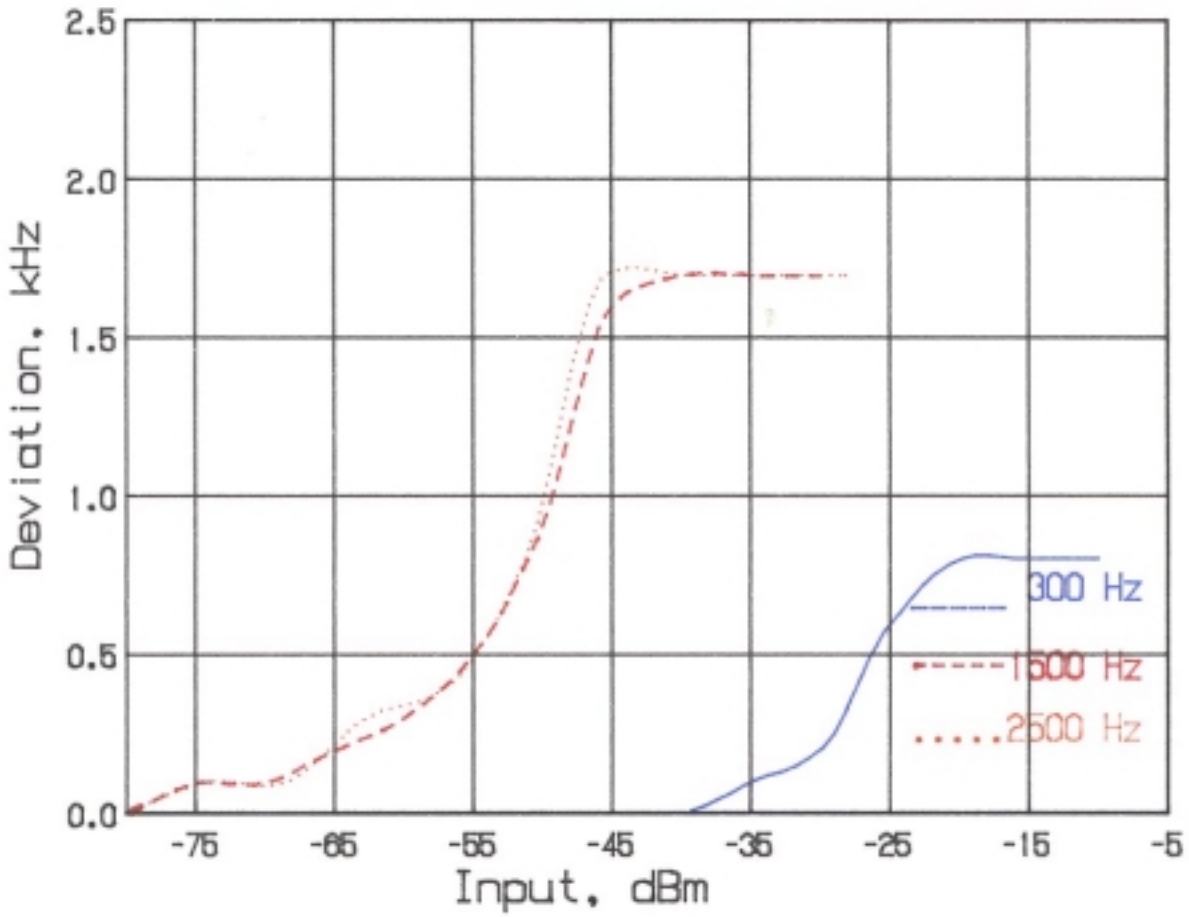

MODULATION FREQUENCY RESPONSE
FCC ID: AAO2101860

FIGURE 1



FIGURE 2

AUDIO LIMITER CHARACTERISTICS



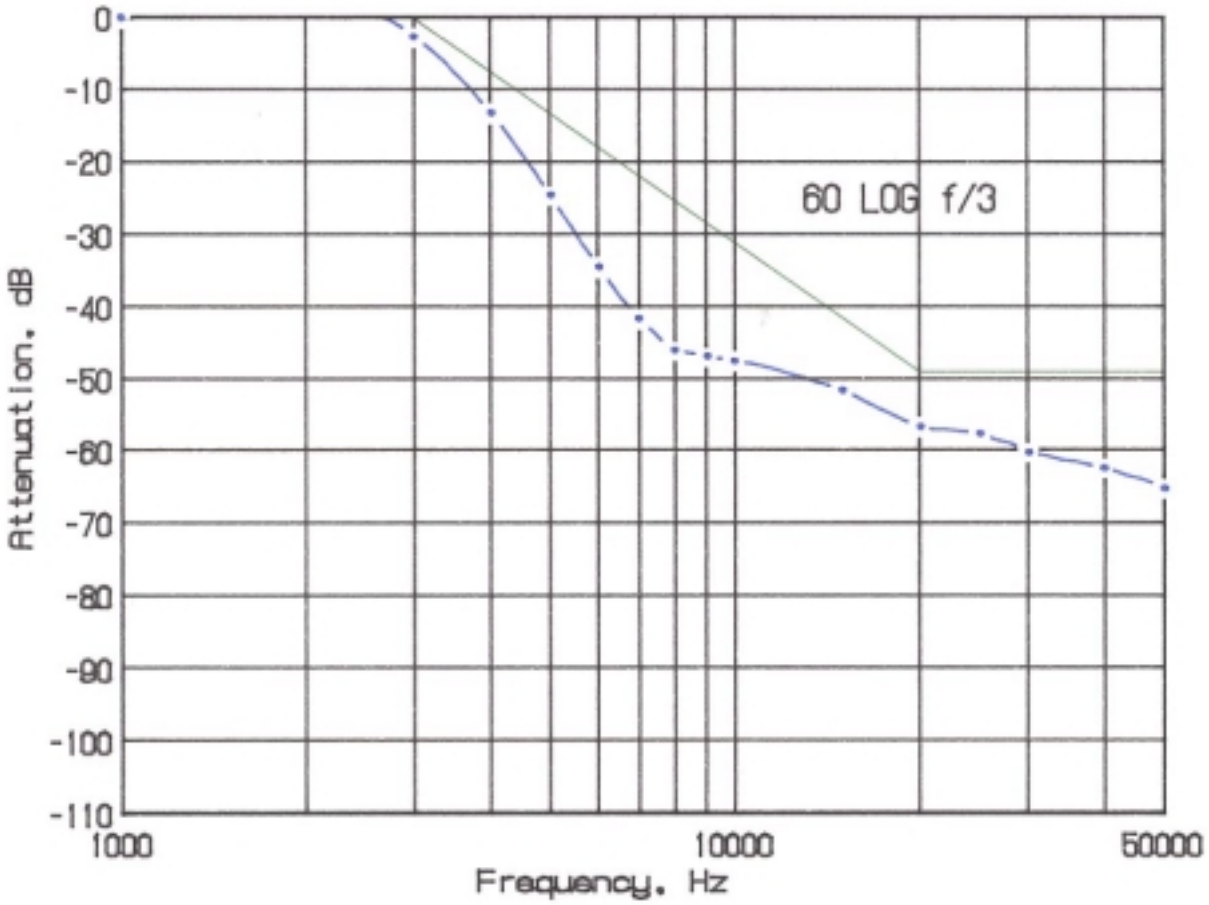

AUDIO LIMITER CHARACTERISTICS
FCC ID: AAO2101860

FIGURE 2



FIGURE 3

AUDIO LOW PASS FILTER RESPONSE



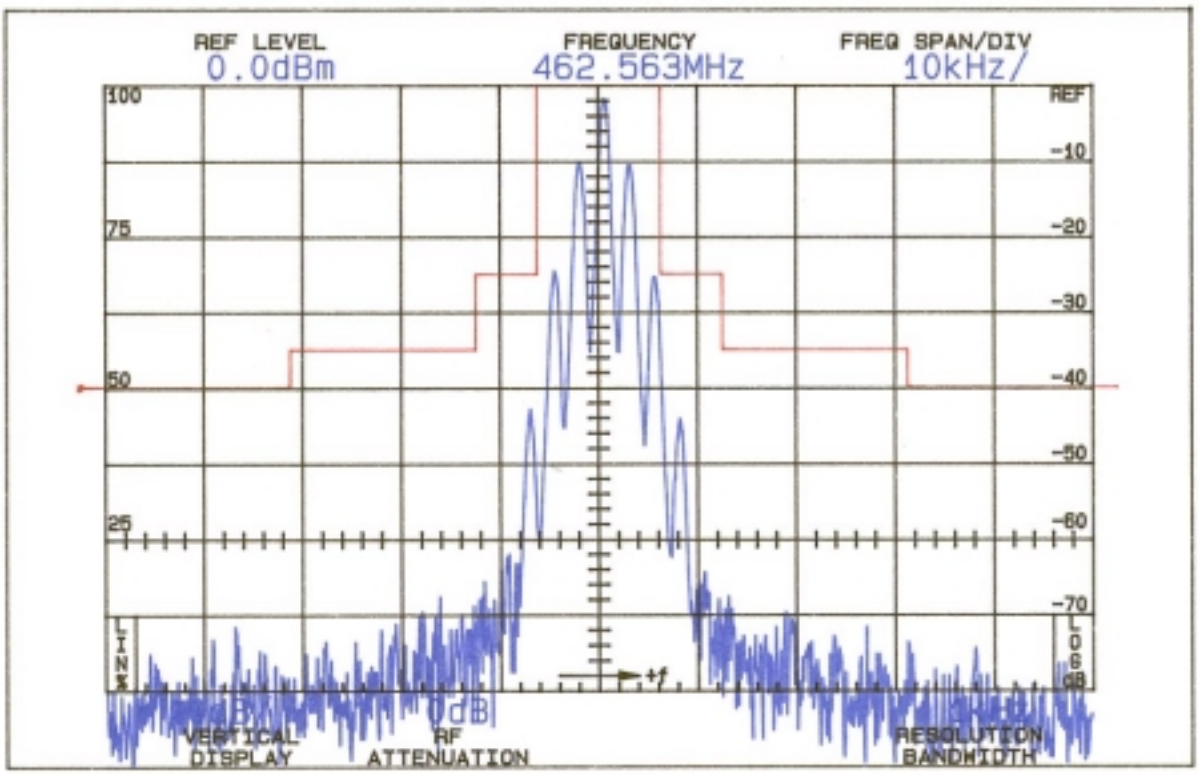

AUDIO LOW PASS FILTER
RESPONSE
FCC ID: AAO2101860

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+10LogP = 40 (P = 0.47W) |

OCCUPIED BANDWIDTH
FCC ID: AAO2101860

FIGURE 4



## G. FIELD STRENGTH MEASUREMENTS OF SPURIOUS RADIATION

Field intensity measurements of radiated spurious emissions from the Radio Shack 21-1860 were made with a Tektronix 494P spectrum analyzer using Singer DM-105 dipoles 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 6 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 by substitution from the lowest frequency generated within the unit (21.7 MHz), to 10 times operating frequency. Data are shown in Table 3.



TABLE 3

TRANSMITTER CABINET RADIATED SPURIOUS

462.5625 MHz, 6 Vdc, 0.47 watts

| Emission Frequency MHz | dB Below Carrier Reference[1] |
|---|---|
| 462.563 | 0 |
| 925.125 | 61V |
| 2312.819 | 60H |

Required: 43+10 Log(P) = 40

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

All other spurious from 21.7 MHz to the tenth harmonic were 20 dB or more below FCC limit.



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 -20°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 6 Vdc. Frequency was measured with a HP 5385A frequency counter connected to the transmitter through a power attenuator. Measurements were made at 462.5625 MHz.

TABLE 4

FREQUENCY STABILITY AS A FUNCTION OF TEMPERATURE

462.5625 MHz, 6 Vdc, 0.47W

| Temperature, °C | Output Frequency, MHz | p.p.m. |
|---|---|---|
| -20.4 | 462.561910 | -1.3 |
| - 9.6 | 462.562538 | 0.1 |
| 0.3 | 462.562732 | 0.5 |
| 10.1 | 462.562685 | 0.4 |
| 20.3 | 462.562646 | 0.3 |
| 29.9 | 462.562859 | 0.8 |
| 40.2 | 462.562837 | 0.7 |
| 49.8 | 462.563026 | 1.1 |

Maximum frequency error: 462.561910
462.562500

- .000590 MHz

FCC Rule 95.627(b) specifies .00025% (2.5 p.p.m.) or a maximum of ± 0.001156 MHz, which corresponds to:

| | |
|---|---|
| High Limit | 462.563656 MHz |
| Low Limit | 462.561344 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 voltage was varied from ±15% above the nominal 6 Vdc 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 5

FREQUENCY STABILITY AS A FUNCTION OF SUPPLY VOLTAGE

462.5625 MHz, 6 Vdc Nominal; 0.47W

| Supply_Voltage | | Output_Frequency,_MHz | p.p.m. |
|---|---|---|---|
| 6.9 | 115% | 462.562580 | 0.2 |
| 6.6 | 110% | 462.562621 | 0.3 |
| 6.3 | 105% | 462.562639 | 0.3 |
| 6.0 | 100% | 462.562646 | 0.3 |
| 5.7 | 95% | 462.562658 | 0.3 |
| 5.4 | 90% | 462.562672 | 0.4 |
| 5.1 | 85% | 462.562685 | 0.4 |
| 4.8* | 80% | 462.562697 | 0.4 |

Maximum frequency error: 462.562697
462.562500

+ .000197 MHz

FCC Rule 95.627(b) specifies .00025% (2.5 p.p.m.) or a maximum of ±0.001156 MHz, corresponding to:

| | |
|---|---|
| High Limit | 462.563656 MHz |
| Low Limit | 462.561344 MHz |

*MFR rated battery end-point.



APPENDIX 1

FUNCTION OF DEVICES
21-1860

| **Reference** | **Type** | **Function** |
|---|---|---|
| Q106 | NE5500179 | Final Amplifier |
| Q108 | 2SC3356 | Buffer |
| Q109 | 2SC4226 | Driver |

| | | |
|---|---|---|
| Q112 | 2SC4226 | Buffer |
| Q110 | 2SC4226 | VCO |
| | | |
| IC101 | MC3361 | 2nd-IF AMP/Detector |
| IC102 | M64082 | PLL |
| IC103 | NJM3403 | Mike Amp/Limiter/L.P Filter |
| IC104 | MC14001 | Ring OSC |
| IC105 | LM324 | 300Hz High Pass Filter |
| IC106 | NJM2070 | Audio Amplifier |
| IC2 | LM324 | 300Hz HP Filter |
| IC3 | LM324 | 300Hz LP Filter |
| IC4 | AT93C46SI | Memory |
| IC6 | TK1135BM | Supply Power |
| IC7 | UPD78F9405 | MCU |

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APPENDIX 1