ENGINEERING STATEMENT

For Type Certification of

FMA Direct

Model: T-80RF
FCC ID: KH8-RFD1

I am an Electronics Engineer, a principal 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 FMA Direct to make type certification measurements on the T-80RF transmitter. These tests were made by me or under my supervision in our Springfield laboratory.

Test data and other documentation required by the FCC for type certification are included in this report. It is submitted that the above mentioned transmitter meets FCC requirements and type certification is requested.

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Rowland S. Johnson

Dated: June 5, 2001

A. INTRODUCTION

The following data are submitted in connection with this request for type certification of the T-80RF transmitter in accordance with Part 2, Subpart J of the FCC Rules.

The T-80RF is a low power, non-voice, transmitter intended for remote control of model vehicle and model aircraft in the 72 - 76 MHz band.

The equipment employs a vertical polarized antenna directly mounted on the unit and meets Paragraphs 95.645, 95.647, 95.649, and the technical requirements established in the Report & Order in PR Docket 90-222.

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

1. Name of applicant: FMA Direct

2. Identification of equipment: FCC ID: KH8-RFD1

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

3. Quantity production is planned.

4. Technical description:

    a. 6k00F1D emission
    b. Frequency range: 72.01 – 75.99 MHz.
    c. Operating power of transmitter is fixed at the factory at 0.050 Watt – ERP(d).
    d. Maximum power permitted under Paragraph 95.635(b) of the FCC Rules is 750 milliwatts, and the T-80RF fully complied with those power limitations.
    e. The dc voltage and dc currents at final amplifier:
       Collector voltage: 10.2 Vdc
       Collector current: 90 mA
    f. Function of each active semiconductor device: See Appendix 1.
    g. Complete schematic diagram is submitted as a separate exhibit.
    h. Draft instruction book is submitted as a separate exhibit.

B. GENERAL INFORMATION (continued)

i. The transmitter tune-up procedure is submitted as a separate exhibit.
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.

6. RF_Power_Output (Paragraph 2.985(a) of the Rules)

Since the T-80RF has an immediately attached, integral antenna, no antenna port exists. Power was determined by substitution comparison.

Assuming an ideal dipole (not the actual monopole)

ERP(d) = 0.050 watts.

C. MODULATION CHARACTERISTICS

Occupied_Bandwidth
(Paragraphs 2.989(i), and 95.635(b) of the Rules)

Figure 1 is a plot of the sideband envelope of the transmitter taken with an Tektronix 494P spectrum analyzer. Modulation corresponded to conditions of 2.989(i) and consisted of the multiple pulses and synchronizing space normally used in radio control applications. (Modulation is achieved by a varicad shunting the crystal oscillator resulting in FM.) Operator controls were adjusted for worst-case emission.

The plot is within the limits imposed by paragraph 95.635(c).

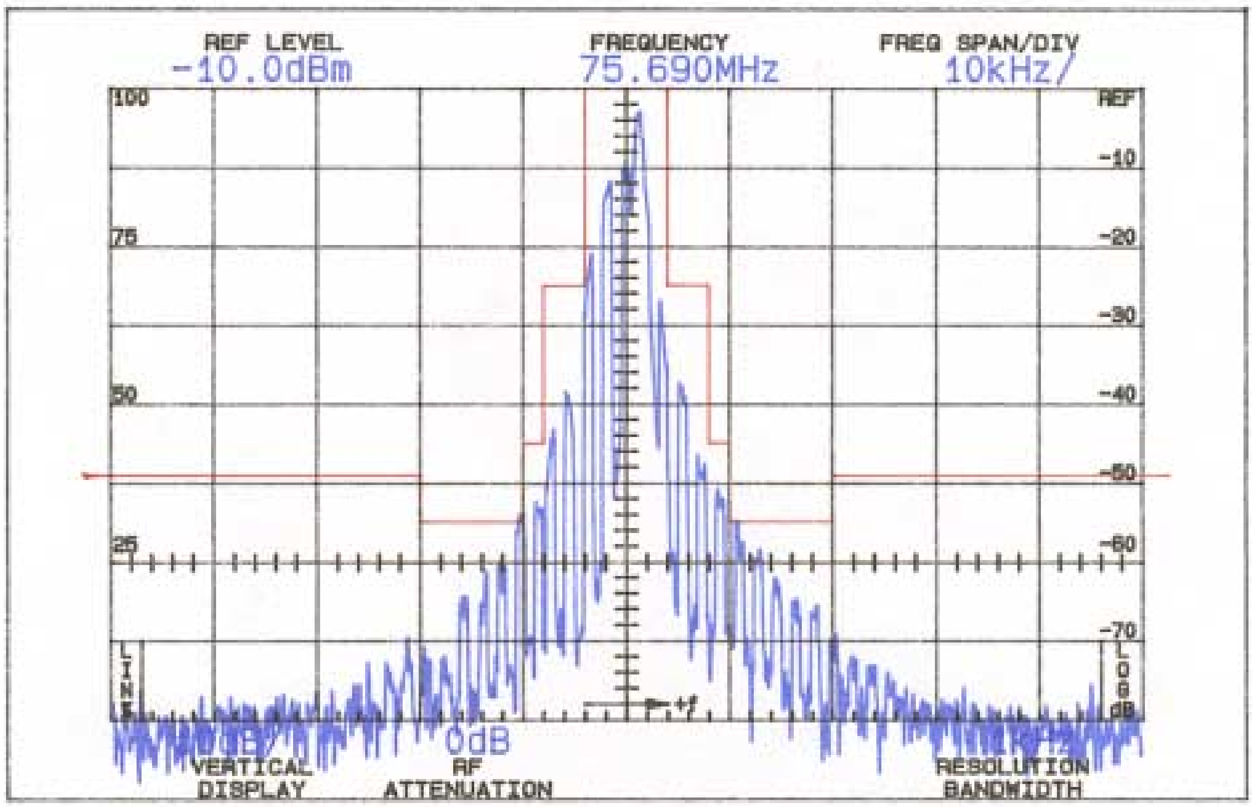
The horizontal scale (frequency) is **10** kHz per division and the vertical scale (Amplitude) is a logarithmic presentation equal to 10 dB per division.

Resolution bandwidth was 1 kHz; video bandwidth was 100 kHz.

Figure 2 is a plot from a Tektronix 494P spectrum analyzer with 2 mS/division sweep in the time domain of the modulated carrier. Modulation consisted of five bursts with a nominal 0.8 mS duration at a nominal 125 Hz repetition rate.

FIGURE 1

OCCUPIED BANDWIDTH



95.635:

(3) At least 25 dB on any frequency removed from the center of the authorized bandwidth by more than 50% up to and including 100% of the authorized bandwidth (4 to 8 kHz).

(10) At least 45 dB on any frequency removed from the center of the authorized bandwidth by more than 100% up to and including 125% of the authorized bandwidth. (8 to 10 kHz)

(11) At least 55 dB on any frequency removed from the center of the authorized bandwidth by more than 125% up to and including 250% of the authorized bandwidth. (10 to 20 kHz)

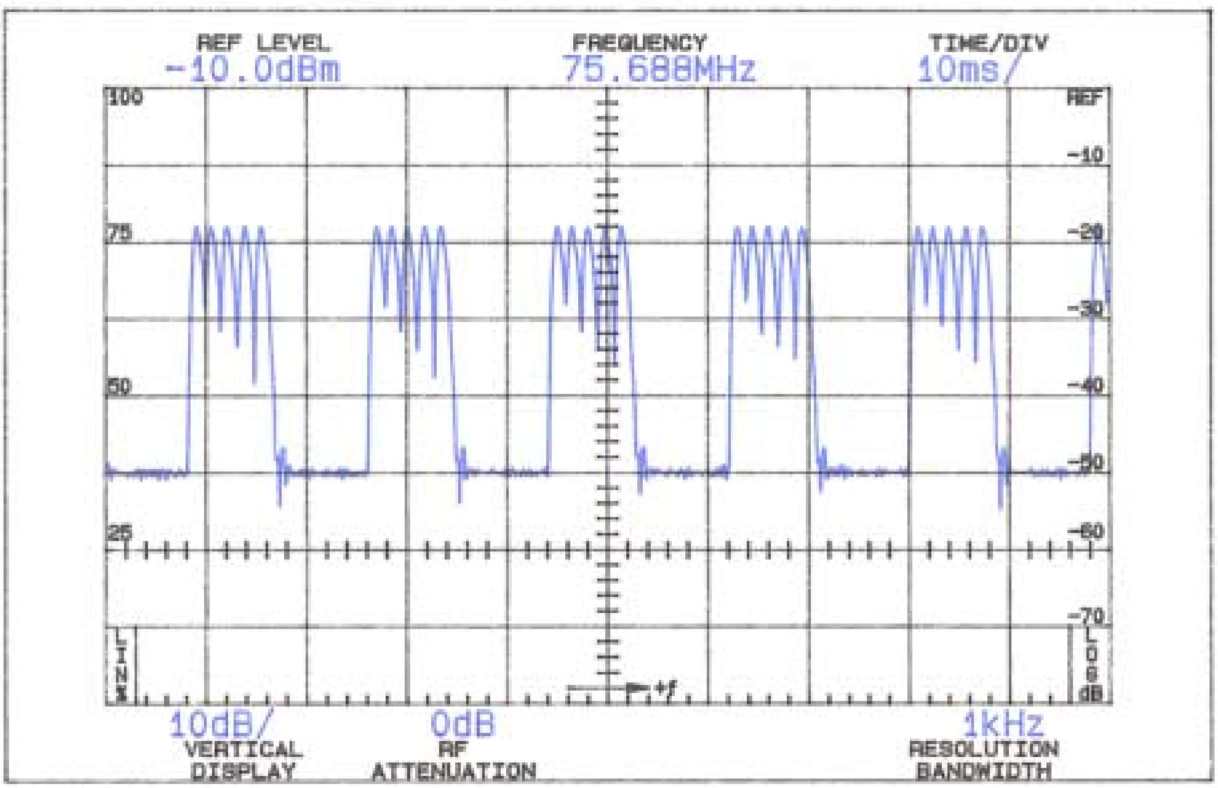
(12) At least 56+10 $\log_{10}$ (TP) dB on any frequency removed from the center of the authorized bandwidth by more than 250%.

OCCUPIED BANDWIDTH
FCC ID: KH8-RFD1

FIGURE 1

FIGURE 2

MODULATING WAVEFORM
TIME DOMAIN



10 millisecond/division sweep, time domain

OCCUPIED BANDWIDTH
(Modulating Waveform)
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FIGURE 2

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

Since the T-80RF transmitter meets FCC Rules 95.645, there are no provisions for antenna terminal output measurements.

Substitution of a suitable matching network and retuning to permit observations at 50 ohms would not be representative of normal operation.

Accordingly data on radiated spurious emissions are included in lieu of antenna terminal conducted spurious emissions.

E. MEASUREMENTS OF SPURIOUS RADIATION
(Paragraph 2.993(a) (b) (2) of the Rules)

Measurements of radiated spurious emissions from the T-80RF were made with a Tektronix 494P spectrum analyzer using EMCO 3121C calibrated test antennas using substitution comparison.

The transmitter and its integral vertical antenna were located in an open field 3 meters from the test antenna. Supply voltage was from a fresh set of batteries with a terminal voltage under load of 10.7 Vdc. The transmitter and test antennas were arranged to maximize pickup. Both vertical and horizontal test antenna polarization were employed.

Reference was power at the carrier frequency.

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, (F_c/5), to 10 times operating frequency.

TABLE 1

TRANSMITTER RADIATED EMISSION

75.69 MHz; 10.7 Vdc; 0.050 watt ERP

Emission Frequency MHz	dB Below Carrier_Reference[1]
75.688	0 (Ref)
151.380	59V
227.070	54V
302.760	51V
378.450	52V
454.140	46V
529.830	41V
605.518	53V
681.206	45H
756.896	56V
Required: **56**+10Log(0.050) =	43

All other spurious from $F_c/5$ - 760 MHz were 20 dB or more below FCC limit.

[1] V/H worst case test antenna polarization.

F. FREQUENCY STABILITY
(Paragraph 2.995(a) and 95.623(c) 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 our 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 2, starting with -30°C.

A Thermotron S1.2 temperature chamber was used. Temperature was monitored with a Keithley 177 DVM and Fluke 150-30 temperature probe. The transmitter output stage was terminated in a dummy load. Primary supply was 10.7 volts. Frequency was measured with a HP 5385A digital frequency counter connected to the transmitter through a power attenuator. Measurements were made at 75.69 MHz. No transient keying effects were observed.

TABLE 2

FREQUENCY STABILITY vs. TEMPERATURE
75.69 MHz; 10.7 Vdc; 0.050 watt (ERP(d))

Temperature, °C	Output Frequency, MHz	ppm
-29.9	75.689812	-2.5
-19.6	75.690067	0.9
-10.1	75.690338	4.5
- 0.5	75.690404	5.3
9.8	75.690316	4.2
20.1	75.690047	0.6
29.1	75.689814	-2.5
39.9	75.689590	-5.4
51.2	75.689382	-8.2

Maximum frequency error: 75.689382
75.690000

- .000618 MHz

Rule 95.623(c) specifies **0.002%** or a maximum of ±0.001514 MHz, which corresponds to:

High Limit	75.691514 MHz
Low Limit	72.688486 MHz

G. 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 an HP 5385A digital frequency counter as supply voltage provided by an HP 6264B variable dc power supply was varied ±15% from the nominal 10.7 volt rating. A Keithley 197 digital voltmeter was used to measure supply voltage at transmitter primary input terminals. Measurements were made at 20^{o}C ambient.

TABLE 3

FREQUENCY STABILITY vs. SUPPLY VOLTAGE
75.69 MHz; 10.7 Vdc; 0.050 watt (ERP(d))

Supply_Voltage	Output_Frequency,_MHz	ppm
12.3	75.690239	3.2
11.8	75.690179	2.4
11.21	75.690112	1.5
10.7	75.690047	0.6
10.29	75.689983	-0.2
9.6	75.689926	-1.0
9.1	75.689864	-1.8
8.6*	75.689806	-2.6

Maximum frequency error: 75.690239
75.690000

\+ .000239 MHz

* Manufacturer's battery end point.

FCC Rule 95.623(c) specifies **0.002%** or a maximum of ±0.001514 MHz, corresponding to:

High Limit	75.691514 MHz
Low Limit	75.688486 MHz

APPENDIX 1

FUNCTIONS OF ACTIVE SEMICONDUCTORS

Reference	Type	Function
Q2	MMBT3904LT1	DC Level Shift
Q3	MMBT3904LT1	Miller Integrator
Q4	MMBR901LT1	Crystal Oscillator
Q5	MMBR901LT1	Driver
Q6	MMBR901LT1	Final RF Amplifier

APPENDIX 2

CIRCUITS AND DEVICES TO STABILIZE FREQUENCY

Transmitter output frequency is determined and stabilized by crystal controlled oscillator operating at $F_c/5$.

APPENDIX 3

CIRCUITS TO SUPPRESS SPURIOUS RADIATION,

1. Spurious emissions are suppressed by the bandpass filter formed by L4,& L5 in the oscillator/modulator. The combination of bandpass filter and modulation shaping keeps the occupied spectrum well within FCC requirements.

2. Sub-harmonics are suppressed by these same circuits and by wave traps on the 1st and 2nd stages.

3. Harmonics are suppressed in part by the above circuits but primarily by the output network formed by L9; L10, C27, C28, C29 and C30.

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APPENDIX 3