EMC Measurement / Technical Report

FCC Test Specification	**:**	FCC Part 95, Subpart C Radio Control (R/C) Radio Service
Equipment Authorization	**:**	Certification
Manufacturer	**:**	Futaba Corporation of America
Equipment Under Test	**:**	T2ER 72 – 76 MHz Radio Control Transmitter
Test Report No.	**:**	FR1218
Purchase Order No.	**:**	Open

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EMC Measurement / Technical Report
Document No. FR1218
From
Garwood Laboratories, Inc.
World Compliance Division

Test for
Futaba Corporation of America
T2ER
72 – 76 MHz Radio Control Transmitter

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MEASUREMENT / TECHNICAL REPORT SUMMARY

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Type of Authorization	Certification for 72 – 76 MHz R/C Transmitter
Applicable FCC Rules	PART 95 – PERSONAL RADIO SERVICES Prepared in accordance with the requirements of FCC Rules and Regulations as listed in 47 CFR Ch.1 (10-1-98 Edition). The following subparts are applicable to the results in this test report: Part 95, Subpart C - Radio Control (R/C) Radio Service Part 95, Subpart E - Technical Regulations Part 2, Subpart J – Equipment Authorization Procedures The test data presented in this report has been acquired using the guidelines set forth in FCC Part 2, §2.981 through §2.1005 and Part 95. The test results presented in this document are valid only for the equipment identified herein under the test conditions described. Repeatability of these test results will only be achieved with identical measurement conditions. The unit is battery operated; therefore, conducted emission measurements are not applicable.
Equipment Under Test	72 – 76 MHz Radio Control Transmitter
Identification of EUT	Model: T2ER FCC ID: AZPT2ER 72-75
Production Quantity	Multiple Units

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1. General Information

1.1 Product Description

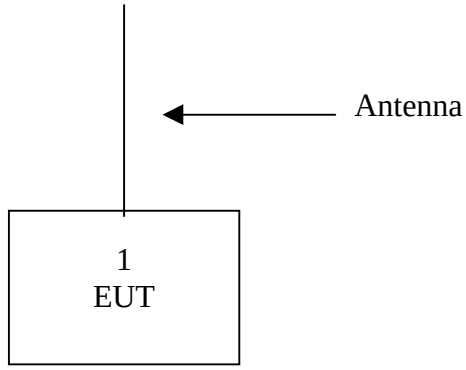
Equipment Under Test	72 – 76 MHz Radio Control (R/C) Transmitter
Model Number	T2ER
Description	The EUT is a 72 – 76MHz radio control transmitter for aircraft and surface craft operation. The transmitter portion of the T2ER operates in the frequency range of 72.010 – 72.990 MHz for aircraft operation or 75.410 – 75.990 MHz for car/boat operation. The transmitting power of the EUT is less than 750mW.
Clock Frequencies	3.41MHz , Transmitting frequencies during test: 72.550MHz and 75.690MHz

1.2 Configuration of Tested System

The following table lists all of the components of the tested system. FCC ID numbers are included if available for a tested system component.

Tested System Details					
Item	*Manufacturer*	*Description*	*Model No.*	*Serial No.*	*FCC ID*
EUT	Futaba Corporation	R/C Transmitter	T2ER	N/A	AZPT2ER 72-76

The Equipment Under Test (EUT) was tested as a stand-alone unit. The EUT contains an integral antenna, which was extended to its maximum length during the test. The EUT derives its operating voltage from eight AA batteries. During the field strength measurements, eight new AA batteries were inserted in the EUT.



1.3 Test Facility

The open area test site (OATS) and measurement facilities used to collect the test data are located at Garwood Laboratories, Inc. World Compliance Division test facility in Placentia, CA. This facility has been fully described in a report submitted to the FCC and accepted in a letter dated 29 January 1999 (31040/SIT 1300F2) registration #90681.

The test facility is also recognized and accredited from following accreditation organizations:

Acemark Europe, Ltd.	Laboratory Number: 0007 *ISO Guide 25, EN45001, and relevant parts of ISO 9002*	Dated: 03/17/97
Industry Canada	Reference: IC 3298	Dated: 03/11/99
I^2T (*Interference Tech International*)	Certificate Number: 99-051 CE Mark for European Country	Dated: 05/05/99
NVLAP (*NIST)*	NVLAP Lab Code: 200119-0 CISPR, FCC, AUSTEL	Effective Through 12/31/99
VCCI	Registration #'s C574, C575, C576, R561	Effective Through 02/04/00

(Voluntary Control Council for Interference by Information Technology Equipment)

2. Technical Information

Type of Emission	8K00A1D
Frequency Range	72-76MHz
Range of Operating Power	Fixed Output Power
Maximum Output Power	117mW – 75MHz 161mW – 72MHz
FCC Rating Maximum Transmitting Power	750mW
Final Stage Amplifier DC Voltage, Current	Voltage: 12VDC Current: 110mA

2.1 Circuit Diagram

Please refer to the Circuit Schematics in the Attachment section of this report.

2.2 Function of Each Active Device

1. Q1 (2SC4272) – Final Stage RF Amplifier
2. Q2 (2SC3772) – Buffer and Driver
3. IC1 (FP6324) – Encoder, Voltage stabilizer, Waveform shaper, Oscillator and Multiplier

2.3 Tune-up Alignment Procedure

1. Adjust L7, L8, L3, and L9 for maximum power output
2. Turn the core of L6 clockwise until oscillation stops. Then turn L6 counter clockwise to the point where the oscillation just starts and then turn it counter clockwise.
3. Again adjust L7, L8, L3, and L9 for maximum power output
4. Turn the core of L9 clockwise to 1/8

2.4 Frequency Stabilization Circuitry

1. IC1 (FP2108T) – Internal voltage regulator (supply voltage of oscillator)
2. Crystal – Stabilizes oscillating frequency.
3. C1 (CH 3pF) – Temperature compensated capacitor.
4. C24 (RH 33pF) – Temperature compensated capacitor.

2.5Additional Circuit Information

1. The type of oscillator utilized by the transmitter is a Crystal controlled modified Colpitts oscillator.
2. The following components are used for suppression of spurious radiation from the antenna:
   Low Pass π Filter
   - L3, L9 (7GD0005)
   - C8 (RH 68pF)
   - C9 (RH 22pF)
   - C10 (RH 82pF)
   - C38 (CH 39pF)
3. Audio Low Pass Filter
   - IC1 (FP2108T)
   - C13 (15nF)
4. No Digital Modulation technique was employed. No Phase Locked Loop circuitry was used.

3. Product Labeling

3.1 FCC ID Label

FCC ID: AZPT2ER 72-76 **FUTABA** **MADE IN TAIWAN**

3.2 Location of Label on the EUT

3.3 Information to the User

The users manual or instruction manual for an intentional or unintentional radiator shall caution the user that changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

4. Block Diagram(s) of EUT

Please refer to the Attachments section of this report for a Block Diagram of the EUT.

5. Test Results

5.1 Transmitter Power

The transmitter's output power was found by measuring the field strength of the transmitter in the open area test site and converting the field strength in volts/meter to power (EIRP) in watts. The field strength was measured at a distance of 3 meters. The following formula was used to convert the field strength (FS) in volts/meter to transmitter output power (TP) in watts:

$$TP = (FS \times D)^2 / (30 \times G),$$

where D is the distance in meters between the two antennas and G is the antenna numerical gain referenced to isotropic gain. The integral antenna of the EUT is assumed to have a gain of one, G=1. The output power should not exceed 750mW, for an R/C transmitter operating in the frequency band of 72 – 76MHz.

Results:
The measured field strength at 72.550 MHz was 117.3 dBµV/m at a distance of 3 meters. The transmitter output power (EIRP) in watts was calculated to be 161mW.

The measured field strength at 75.690 MHz was 115.9 dBµV/m at a distance of 3 meters. The transmitter output power (EIRP) in watts was calculated to be 117mW.

5.2 Emission Bandwidth

An R/C transmitter is allowed to transmit any appropriate non-voice emission, which meets the emission limitations for an R/C transmitter. The authorized bandwidth for any emission type transmitted by an R/C transmitter is 8kHz.

Test Results:
The occupied bandwidth of the EUT complied with the emission bandwidth requirement. During testing, all control switches and buttons were investigated for the worst case modulated signal. The occupied bandwidth plot submitted was the worst case condition. Test result plots are enclosed in Appendix B.

5.3 Unwanted Radiation

Measurements were made to detect unwanted emissions. The EUT was placed 80 centimeters above the ground plane on a non-conductive tabletop 1.0-meter width by 1.5-meter length. The configuration of the EUT and its cables were varied to maximize the amplitude level of the emissions. Rotating the turntable 360 degrees and varying the antenna height from 1 to 4 meters maximized the emissions. Measurements were made with a Bi-Log antenna up to the 10^{th} harmonic of the fundamental in both vertical and horizontal polarization. The distance between the EUT and the measuring antenna was 3 meters. The unwanted emissions should be less than the transmitter field strength by at least 56 + 10 log (TP) dB on any frequency removed from the center of the authorized bandwidth by more than 250%. The following table contains the results:

Tuned Frequency: 72.550 MHz
Measurement Distance: 3m
FCC Limit: 117.3 – (56 + 10log 0.161)
= 69.2 dBµV

Frequency of Emission (MHz)	***Emission Level (dBµV)***	***Correction Factor* (dB)***	***Corrected Reading (dBµV/m)***	***FCC Limit @ 3 meters (dBµV/m)***	***Delta to FCC limit (dB)***
72.550	132.8	-15.5	117.3	-	-
145.100	75.2	-9.0	66.2	69.2	-3.0
217.650	64.8	-11.0	53.8	69.2	-15.4
290.200	60.1	-7.1	53.0	69.2	-16.2
362.750	48.6	-3.9	44.7	69.2	-24.5
435.300	54.5	-2.2	52.3	69.2	-16.9
507.850	54.7	-0.6	54.1	69.2	-15.1
580.400	54.0	0.6	54.6	69.2	-14.6
652.950	54.6	2.2	56.8	69.2	-12.4
725.500	50.6	4.4	55.0	69.2	-14.2

- The Correction Factor consist of Antenna Factor + Cable Loss – Preamplifier Gain.
- Measurements were performed with both vertical and horizontal antenna polarization. Vertical antenna polarization measurements were worst case.
- All readings are peak with specified CISPR bandwidth unless stated otherwise.

Tuned Frequency: 75.690 MHz
Measurement Distance: 3m
FCC Limit: 115.9 – (56 + 10log 0.117)
= 69.2dBµV

Frequency of Emission (MHz)	***Emission Level (dBµV)***	***Correction Factor* (dB)***	***Corrected Reading (dBµV/m)***	***FCC Limit @ 3 meters (dBµV)***	***Delta to FCC limit (dB)***
75.690	130.5	-14.6	115.9	-	-
151.380	72.6	-8.9	63.7	69.2	-5.5
227.070	67.0	-10.7	56.3	69.2	-12.9
302.760	64.6	-6.5	58.1	69.2	-11.1
378.450	52.4	-3.8	48.6	69.2	-20.6
454.140	53.8	-1.9	51.9	69.2	-17.3
529.830	46.8	-0.0	46.8	69.2	-22.4
605.520	52.8	1.7	54.5	69.2	-14.7
681.210	55.1	3.4	58.5	69.2	-10.7
756.900	53.6	5.6	59.2	69.2	-10.0

- The Correction Factor consist of Antenna Factor + Cable Loss – Preamplifier Gain.
- Measurements were performed with both vertical and horizontal antenna polarization. Vertical antenna polarization measurements were worst case.
- All readings are peak with specified CISPR bandwidth unless stated otherwise.

5.4 Frequency Stability

Frequency stability is the ability of the transmitter to maintain an assigned carrier frequency over variations of extreme ambient temperature and supply voltage.

The EUT was placed in a temperature chamber. The temperature was set to the lowest requirement, -30°C, and there was a waiting period of at least 2 hours, until a stable temperature was reached inside the EUT. A frequency measurement was made once a period of time elapsed, sufficient enough to stabilize all of the components of the oscillator circuit. The temperature was then increased by 10°C increments. Again, sufficient time was allowed to elapse in order to stabilize the components of the oscillator circuit, and then a frequency was measurement was made. This was done until the maximum temperature requirement, +50°C, was reached. The following table contains the results:

Frequency Stability vs. Temperature

Frequency tuned: 75.690 MHz
Frequency Accuracy Required: 0.002%

Operating Temperature (℃)	*Frequency Measured (MHz)*	*Frequency Deviation (Hz)*	*Frequency Deviation (%)*
-30	75.689499	-501	-0.000662
-20	75.689682	-318	-0.000420
-10	75.689805	-195	-0.000258
0	75.689998	-2	-0.000003
+10	75.690083	83	0.000110
+20	75.690086	86	0.000114
+30	75.690055	55	0.000073
+40	75.690039	39	0.000052
+50	75.690087	87	0.000115

Frequency Stability vs. Temperature

Frequency tuned: 72.550 MHz
Frequency Accuracy Required: 0.002%

Operating Temperature (°C)	*Frequency Measured (MHz)*	*Frequency Deviation (Hz)*	*Frequency Deviation (%)*
-30	72.549227	-773	-0.001065
-20	72.549662	-338	-0.000466
-10	72.549883	-117	-0.000161
0	72.549962	-38	-0.000052
+10	72.549937	-63	-0.000087
+20	72.549840	-160	-0.000221
+30	72.549694	-306	-0.000422
+40	72.549552	-448	-0.000618
+50	72.549459	-541	-0.000746

Frequency Stability vs. Supply Voltage

Frequency stability was measured with variation of primary supply voltage. For battery powered equipment, the primary supply voltage was reduced to the battery operating end point. The following table contains the results:

Frequency Tuned: 75.690 MHz Frequency Accuracy Required: 0.002%
Normal Input Voltage: 12VDC Temperature: 20°C

Input Voltage (V)	*Frequency Measured (MHz)*	*Frequency Deviation (Hz)*	*Frequency Deviation (%)*
10.20	75.690075	75	0.000099
11.00	75.690074	74	0.000098
11.50	75.690073	73	0.000096
12.00	75.690071	71	0.000094
12.50	75.690069	69	0.000091
13.00	75.690065	65	0.000086
13.80	75.690062	62	0.000082

Frequency Stability vs. Supply Voltage

Frequency Tuned:	72.550 MHz	Frequency Accuracy Required:	0.002%
Normal Input Voltage:	12VDC	Temperature:	20°C

Input Voltage (V)	*Frequency Measured (MHz)*	*Frequency Deviation (Hz)*	*Frequency Deviation (%)*
10.20	72.549867	-133	-0.000183
11.00	72.549857	-143	-0.000197
11.50	72.549852	-148	-0.000204
12.00	72.549848	-152	-0.000210
12.50	72.549843	-157	-0.000216
13.00	72.549839	-161	-0.000222
13.80	72.549833	-167	-0.000230

5.5 Modulation Characteristics

Please refer to Appendix B for detailed plots of the modulation characteristics.

5.6 Crystal Access Restrictions

The EUT has no control, switch, or other type of adjustment either on the operating front panel or on the exterior of the transmitter enclosure which when manipulated can result in violation of the rules. The plug in crystal of the transmitter is glued and therefore not accessible to the user.

6. Photographs of Test Arrangement and EUT Construction

6.3 EUT Construction Front View (72 & 75 MHz Units)

6.4 EUT Construction Front View

6.5 EUT Construction Back View

6.6 EUT Construction Top View

6.7 EUT with Enclosure Removed

6.8 EUT PCB Components Side (1)

6.9 EUT Solder Side (2)

APPENDIX A - TEST EQUIPMENT USED

The absolute performance calibration of equipment requiring calibration is performed on an as needed basis in accordance with MIL-STD 45662A. However, calibration periods do not exceed one (1) year. The test equipment is capable of making measurements within tolerances of at least +/- 2dB amplitude and +/- 2% frequency deviation. Equipment certifications showing traceability to NIST (National Institute of Standards and Technology) are maintained on file at Garwood Laboratories, Inc. Placentia, CA. All equipment is checked and verified for proper operation before and after each series of tests.

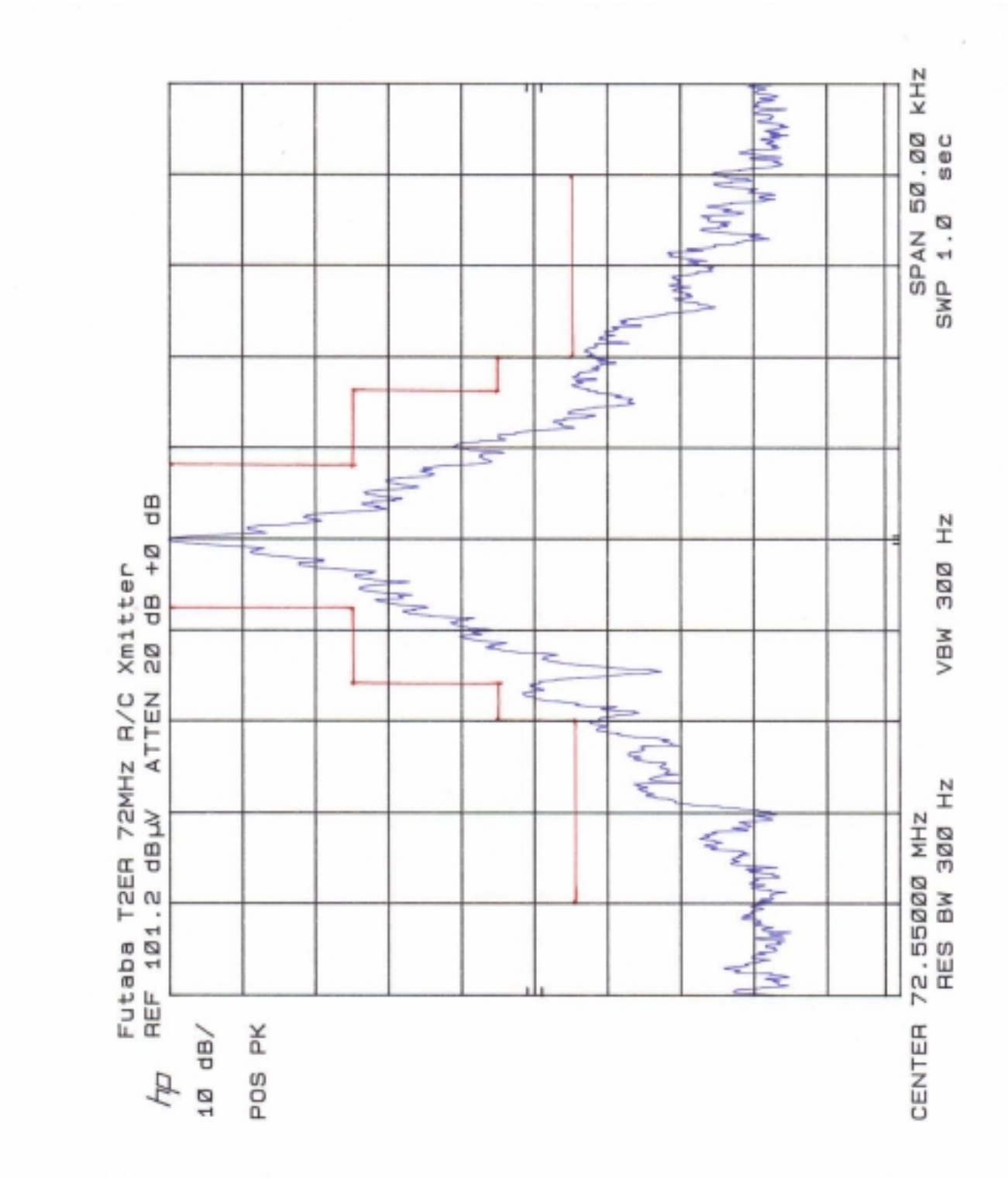
A.1 Specific Equipment Used

Test	*Instrument*	*MFG / Model No.*	*Asset No.*	*CAL. Due Date*
Conducted Emission Test				
	EMI Receiver System	Hewlett Packard	System 1	07/15/00
	RF Coax Cable	Pasternack / RG 223	20170	03/05/00
	Line Impedance Stabilization Network	ISCI/3PH-20A	20071	03/16/00
Radiated Emission Test				
	EMI Receiver System	Hewlett Packard	System 3	10/14/99
	RF Coax Cable	Times Microwave / LMR 600	20180	03/05/00
	BiLog Antenna	Chase / CBL6111A	20062	07/09/00
	Pre-Amplifier	ISCI / RFPA/Z FL-2000	20007	03/05/00
	High Pass Filter	Mini-Circuits / NHP-100	20359	Verify Before Use
	High Pass Filter	Mini-Circuits / NHP-250	20361	Verify Before Use

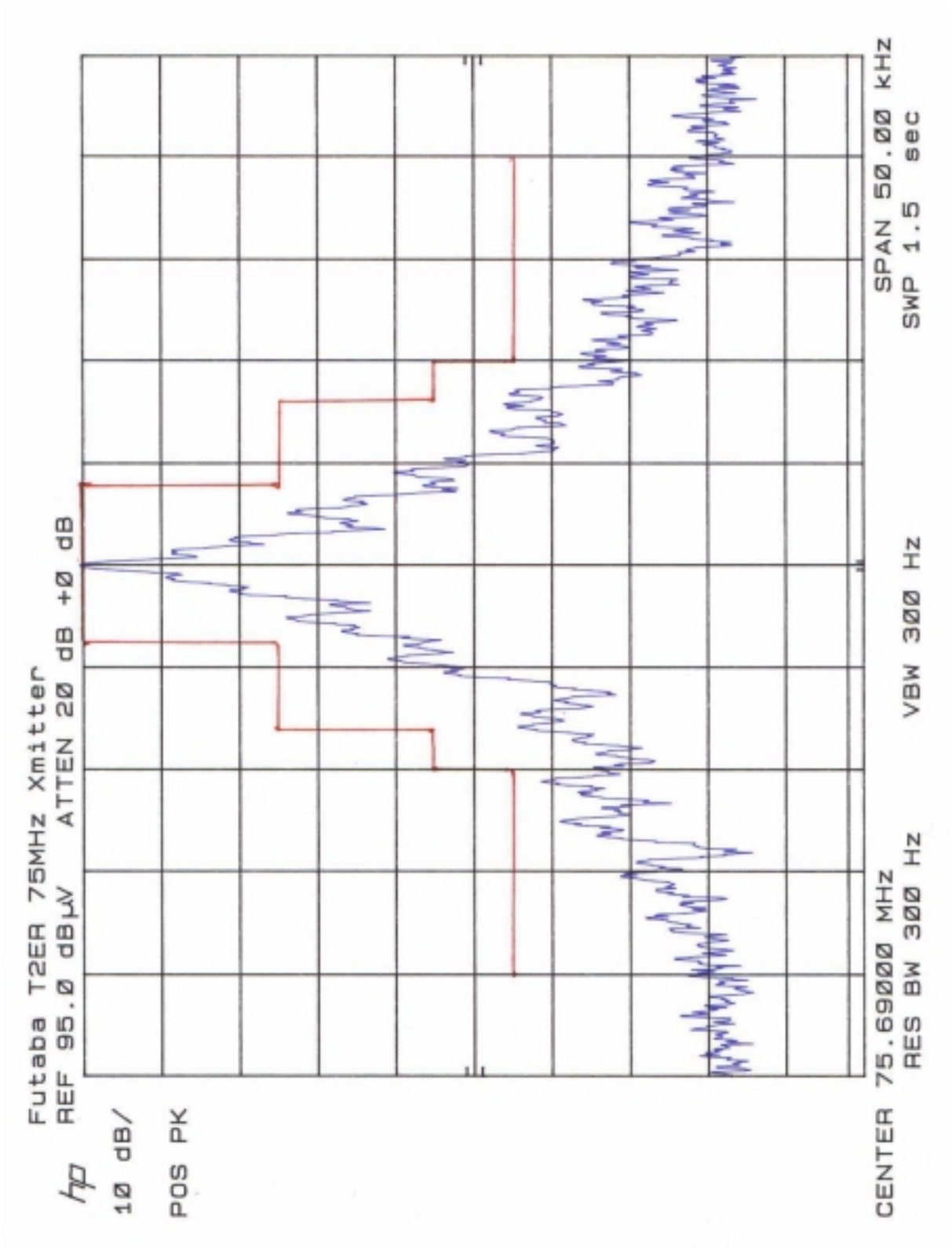
APPENDIX B – SUPPLEMENTAL TEST DATA

Basic Standard	***Test Type***	***Data Format***	***Page No.***
Part 95 Subpart C, E Part 2 Subpart J	Occupied Bandwidth 72.550 MHz	Plotted	B1
	Occupied Bandwidth 75.690 MHz	Plotted	B2
	Modulation Characteristics 72.550 MHz	Plotted	B3
	Modulation Characteristics 75.690 MHz	Plotted	B4

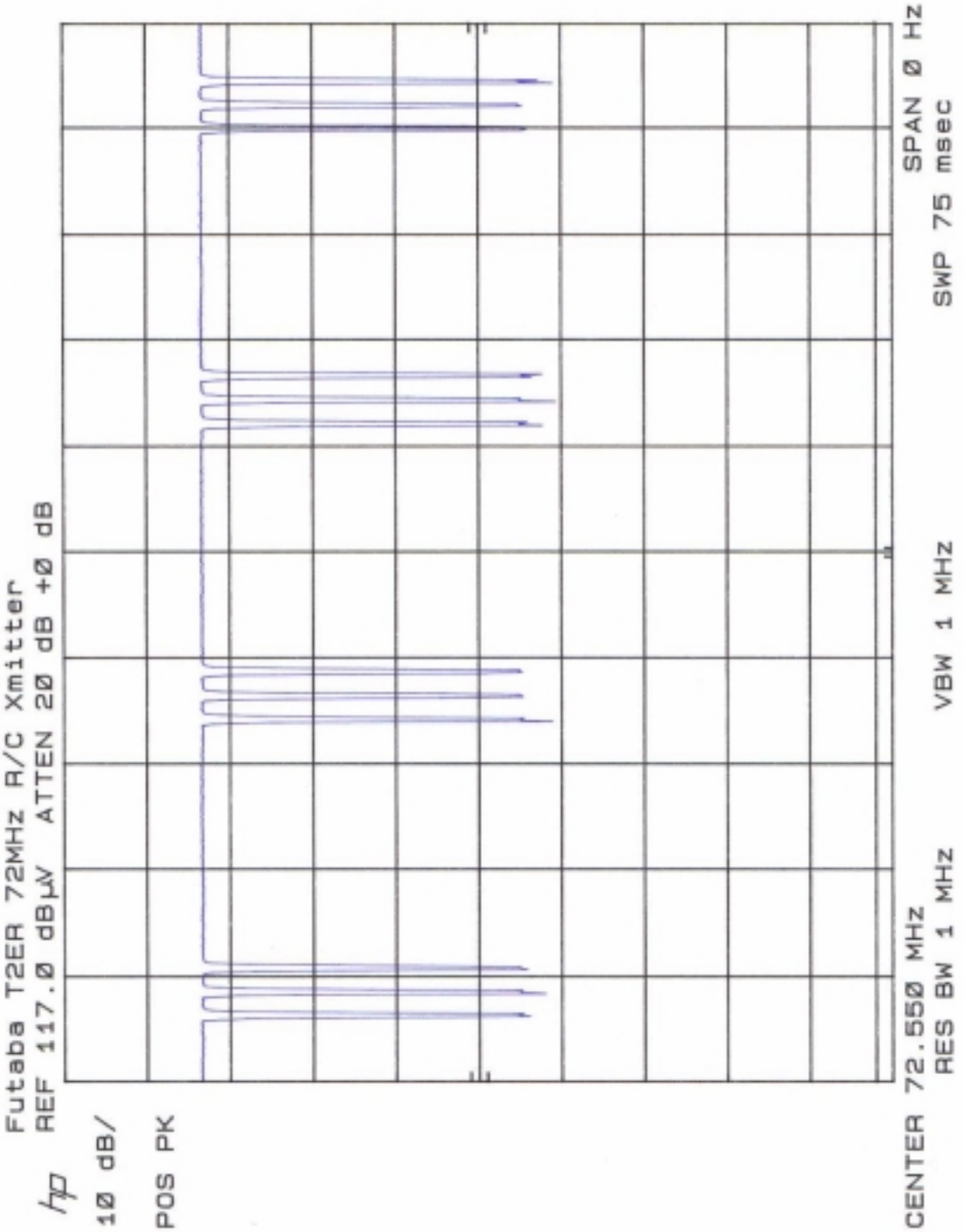
B1


Futaba T2ER 72MHz R/C Xmitter
REF 101.2 dBµV ATTEN 20 dB +0 dB
10 dB/
POS PK
CENTER 72.55000 MHz
RES BW 300 Hz
VBW 300 Hz
SPAN 50.00 kHz
SWP 1.0 sec

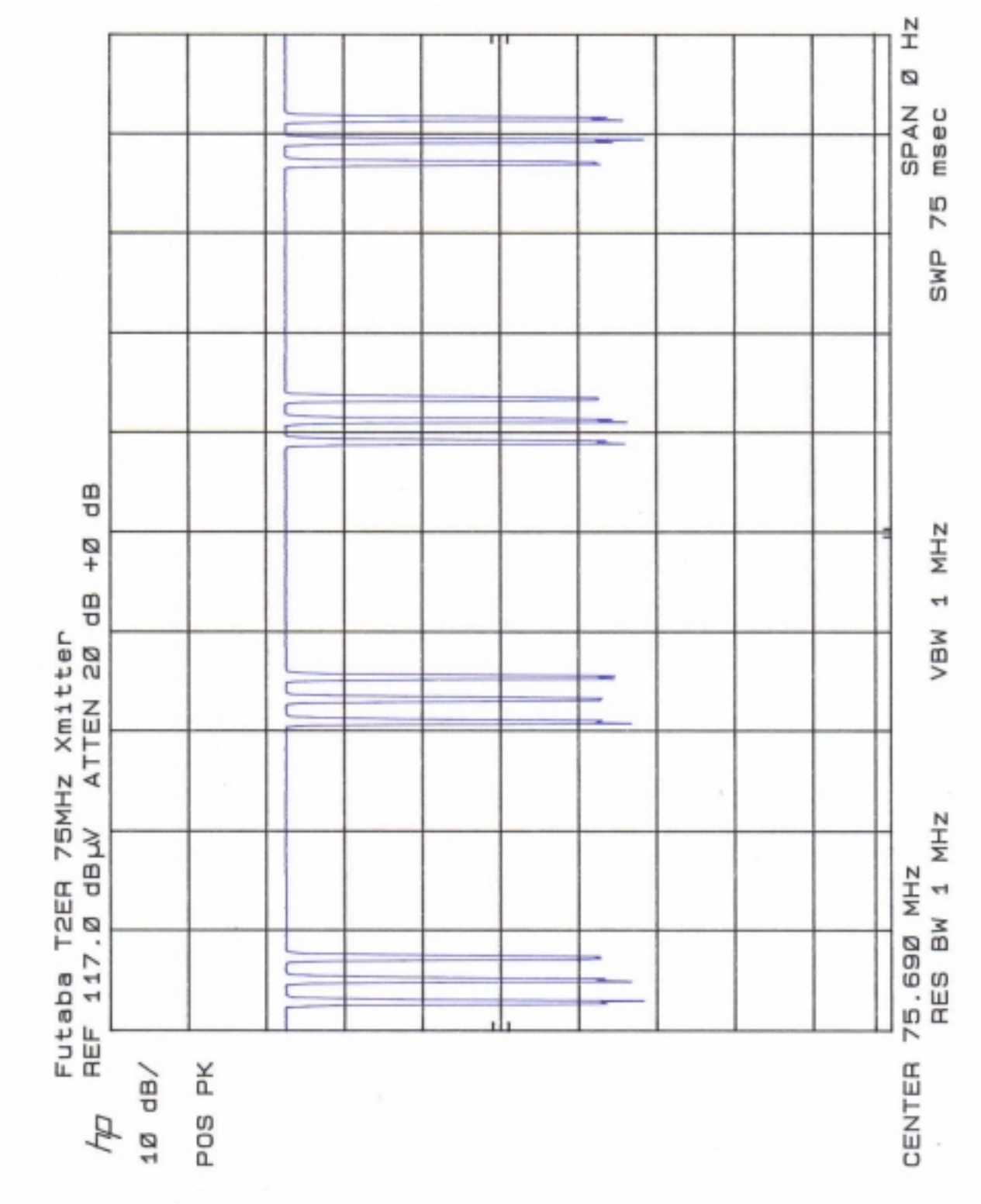
B2


Futaba T2ER 75MHz Xmitter
REF 95.0 dBµV
ATTEN 20 dB +0 dB
10 dB/
POS PK
SPAN 50.00 kHz
SWP 1.5 sec
CENTER 75.69000 MHz
RES BW 300 Hz
VBW 300 Hz

B3


Futaba T2ER 72MHz R/C Xmitter
REF 117.0 dBµV ATTEN 20 dB +0 dB
10 dB/
POS PK
CENTER 72.550 MHz
RES BW 1 MHz
VBW 1 MHz
SWP 75 msec
SPAN 0 Hz

B4


Futaba T2ER 75MHz Xmitter
REF 117.0 dBµV ATTEN 20 dB +0 dB
10 dB/
POS PK
CENTER 75.690 MHz
RES BW 1 MHz
VBW 1 MHz
SWP 75 msec
SPAN 0 Hz

ATTACHMENTS

INDEX OF ATTACHMENTS