FCC Test Report

on

the MT300

300 WATT, FM Transmitter,

as per

the FCC Certification

Approval Process

Introduction

This manual provides Richardson's customers, end users and FCC agents with documented proof that the equipment known as the MT300 has been measured under FCC rules and regulations, **Parts 2 and 73**, and found to pass all test. The MT300 is equipped to function in either the monaural or stereo modes. Mode switching is performed by relocating jumper switches in the exciter module that slides through the face plate. The appendix contains an illustration of the programmable options for the selection of carrier frequency, pre-emphasis and stereo/monaural mode.

The manual is divided into three parts. Part I contains test results that were performed in the laboratory at Richardson Electronics. Part II contains the radiation test that was performed at the Elite Electronic Engineering Company. Elite has an anechoic chamber that is FCC certified to simulate an 'open field'. Part III contains support data and illustrations.

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General Notes

The goal of this manual is to interpret the FCC rules and to provide instructions for duplicating all measurements. For "Equipment Authorization", the FCC requires FM transmitters to be approved under the "Verification" process. The FCC requires the manufacturer to complete the tests and keep test records on file for two years after the last equipment is manufactured. The FCC requires the customer to verify periodically that their purchased equipment is compliant. If an FCC agent needs to visit the FM station, they will require an Owners Manual which is supplied with every MT300. The instructions for these test are written so that the customer can understand the procedures and duplicate the tests.

Test Conditions

The test conditions that were common to all test are as follows:

1. The test frequency was always in the center of the band at 98 MHz where the worse case conditions occur.
2. The output power was always at 300 watts.
3. An AC input of 115 vac was applied to the MT300.
4. All audio signal levels were made with a function generator connected to the MT300 in parallel with a 50 ohm load. If an audio generator is used, then a 600 ohm load should be used.
5. All the modulation set ups were made with the transmitter in the 'clip' or 'limit' mode.

The transmitter is normally operated in this mode by the customer. Without the limiting mode, the transmitter will have an occasion to exceed the occupied bandwidth allowed by the FCC.

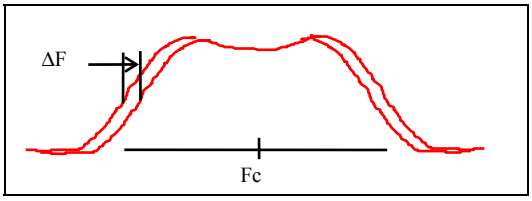
Measurement Techniques

Technique for measuring frequency deviation (ΔF)

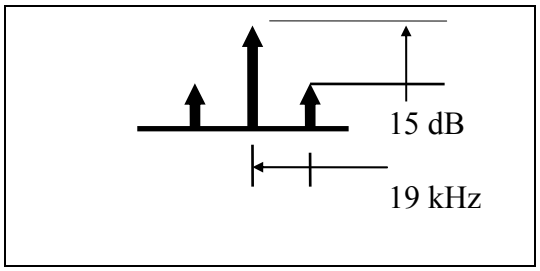
The FCC requires a test pattern with a modulation of 85% for monaural mode and 38% for stereo mode when modulated with an FM signal of 15 kHz (See FCC Part 2.989_d_3&5). In Part 73.1570, the FCC defines 100% modulation equivalent to 75 kHz. Therefore, the frequency deviation (ΔF) for 85% and 38% modulation would be equal to 63.75 kHz and 28.5 kHz, respectively.

The index of modulation (m) is defined by the equation: $m = \Delta F/FM$

Therefore the FCC requires that the index of modulation for monaural and stereo should be set to 4.25 and 1.9 , respectively (or 63.75÷15 and 28.5÷15).



The technique for measuring a wave form with an index of modulation greater than (1) involves a process of observing the wave form on the spectrum analyzer and measuring the time difference at the slope of the wave form ($\Delta F = 1/\Delta t$).



The technique for measuring a wave form with an index of modulation less than (1) involves a different process for observing the wave form. The equation used to calculate the side band modulation is as follows:

Equation:

Pout - Psb= -20 x Log (m/2) with m =M/100 where M is expressed in percent.

For 9% Modulation at a FM of 19 kHz:

The Index of Modulation is equal to :

m = 9% x 75kHz ÷ 19kHz = .355

The side band modulation is equal to :

Pout - Psb = -20 x Log (.355/2) = -(-15.0) dB or -15 dBc

For stereo operation, Part 73.322 requires that the Pilot tone and harmonic at 19 kHz and 38 kHz shall be between the limits of 8% to 10% and less than 1%, respectively. This corresponds to a side band modulation of -16 dBc to -14 dBc for the Pilot tone and a minimum value of -34 dBc for the harmonic of the Pilot tone.

Technique for measuring pre-emphasis.

Preemphasis is the asymptotic response of the audio signal caused by an RC time constant. Radio receivers are equipped with deemphasis circuits. The system noise figure is improved with preemphasis and deemphasis. There are two valid methods for measuring preemphasis as follows:

1. Change the input signal level and keep the deviation constant.
2. Or keep the input signal level constant and measure the change in deviation.

This report will focus on the second method because it can be performed on a spectrum analyzer which is more readily available. In the USA, preemphasis for the transmitter is programmed to match the deemphasis of FM radios; namely, 75 microseconds or 75 usec. Outside the USA, a preemphasis of 50 usec is more commonly used. A preemphasis of 75 usec corresponds to a corner frequency of 2.1 kHz or f = 1÷ (2p x 75 usec) = 2.1 kHz.

The corner frequency is the location where the audio response is attenuated 3 dB. At this frequency, the FCC establishes an upper and lower limit between +3 dB and 0 dB. The technique for measuring preemphasis is to show that the audio signal is attenuated midway

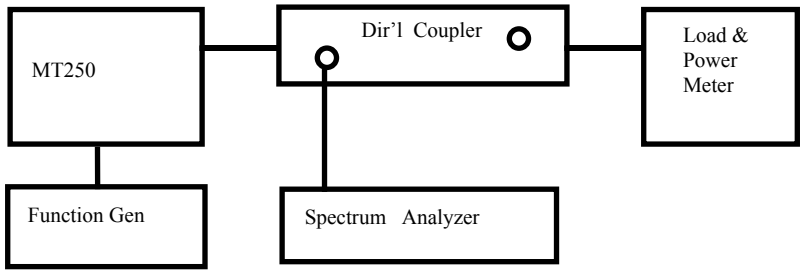
between the two FCC limits at 2.1 kHz and follows an asymptotic response out to 15 kHz with a slope of 6 dB per octave (or 20 dB per decade).

The asymptotic response is calculated by the equation:
Delta Gain
= 20 x log (Vout÷Vref) = 20 x log (Fnew÷Fref) = 20 x log (m x FM÷FMref)

The FM data is the changing modulation frequency of the function generator. The referenced FM data is the FM frequency at 2.1 kHz. The index of modulation (or m) is calculated from the measured data of the side band modulation (Pdbc) by the equation:
m = 2 ÷ 10^(Pdbc÷20), which is derived from a more familiar equation:

Pdbc = Pout - Psb = -20 x log (m÷2)

Test Set Up:



Procedure:

The first data point starts at 2.1 kHz by adjusting the audio input for a Psb of 6 dBc (or 100%). Calculations are made to show that the attenuation falls midway between the FCC limits. The Psb of the next data point at 4 kHz is measured with the same (or constant) audio input level. The procedure is repeated with the first data point at 2.1 kHz and adjusting the audio input for a Psb of 12 dBc (or 50 %). At 25 % modulation, the Psb is adjusted for 22 dBc or as close as possible.

Name of Test:

FM Transmission System Requirements (or Conducted Test)

FCC reference:

Part 73.317 subparts a,b,c and d.

Test Description as quoted from the "Code of Federal Regulations" book:

"FM broadcast stations .....must maintain the bandwidth occupied by their emissions (or occupied bandwidth conditions) in accordance with the following specifications.

1) Any emission appearing on a frequency removed from the carrier by 120 kHz and 240 kHz inclusive must be attenuated at least 25 dB below the level of the un-modulated carrier.

2) Any emission appearing on a frequency removed from the carrier by 240 kHz and 600 kHz must be attenuated at least 35 dB below the level of the un-modulated carrier.

3) Any emission appearing on a frequency removed from the carrier by more than 600 kHz must be attenuated at least 43 + 10 x log (Power in watts) dB below the level of the un-modulated carrier, or 80 dB, whichever is the lesser attenuation."

SPECS: As stated above.

Test Conditions:

In Part 2.989 , occupied bandwidth for an FM transmitter is the modulation of the carrier in the monaural and stereo modes as follows:

Item 1 (subpart 3):

"FM broadcast transmitters not used for multiplex operation (i.e. monaural mode) ....shall be modulated 85 percent by a 15 kHz input signal."

Item 2 (subpart 5):

"FM broadcast transmitters for stereophonic operation shall be modulated with a 15 kHz signal at the pilot subcarrier simultaneous. The input signal shall produce a 38 percent modulation and the pilot subcarrier shall produce 9 percent modulation."

Description of FCC Test Performed on FM Transmitters Under the "Certification" Process

Name of Test:

FM Transmission System Requirements (or Preemphasis Test)

FCC reference:

Part 73.317 subpart e

Test Description as quoted from the "Code of Federal Regulations" book:

"Pre-emphasis shall not be greater than the impedance-frequency characteristics of a series inductive resistance network having a time constant of 75 usec."

SPECS:

The audio signal has a 3 dB corner frequency at 2.1 kHz (or $1 \div (2p \times 75usec)$).

The audio response is 'flat' from DC to 2.1 kHz where it starts to 'roll off' by 3 dB.

At 15 kHz the audio signal shall be attenuated 17 dB or $20 \times \log (15000 \div 2100)$.

The test can be performed with an audio analyzer or a spectrum analyzer.

Description of FCC Test Performed on FM Transmitters Under the "Certification" Process

Name of Test:

FM Stereophonic Sound Transmission Standards (or Pilot Modulation Test)

FCC reference:

Part 73.322 subparts a2 and a5.

Test Description as quoted from the "Code of Federal Regulations" book:

"The pilot sub-carrier at 19 kHz ±2 Hz must frequency modulate the main carrier between the limits of 8 and 10 percent."

SPECS: To convert to dBc, the following equation is used:

Let 9% be the desired limit & then,

dBc = $20 \times \log(m \div 2)$ where m is the index of modulation or

m = $(9\% \times 75 \text{ kHz}) \div 19 \text{ kHz} = .355$ then

dBc = $20 \times \log(.355 \div 2)$ = - 15 db or 15 dBc

Consequently, the limits for 8 and 10 % convert into 16 dBc and 14 dBc.

"The stereophonic sub-carrier at 38 kHz must be suppressed to a level less than 1% modulation of the main carrier:

SPECS: Using the equation above, the limit converts into -34 dB or 34 dBc minimum.

Description of FCC Test Performed on FM Transmitters Under the "Certification" Process

Name of Test:

Frequency Stability (TXCO with power line variations)

FCC reference:

Parts 2.995 subpart 4 and 73.1545 subpart b

Test Description as quoted from the "Code of Federal Regulations" book:

"The frequency stability shall be measured with variation of primary supply voltage as follows:

Vary the primary supply voltage from 85 to 115 percent of the nominal value."

SPECS: From Part 73.1545 subpart b, for FM stations, " The departure of the carrier or center frequency of an FM station with an authorized transmitter output more than 250 watts may not exceed ±2000 Hz from the assigned frequency."

Test Evaluation:

The FCC wants to insure that the frequency doesn't vary by more than ±2 kHz when the line voltage is varied from the nominal AC voltages that USA electric companies like to maintain. Nominal voltage is the name that is given to the ideal operating voltage of the equipment; for example, 110 vac, 115 vac or 117 vac. Because of line voltage drops, electric companies try to maintain a line voltage of 120 vac with a low line limit of 108 vac (120-10%) and a high line limit of 132 vac (120+10%). Based upon what electric companies supply as typical voltages, the FCC limits are as follows:

For 120 vac equipment:

$$\text{Low limit} = 120 \times .85 = 102 \text{ vac}$$

$$\text{High Limit} = 120 \times 1.15 = 138 \text{ vac}$$

For 230 vac equipment:

$$\text{Low limit} = 230 \times .85 = 195.5 \text{ vac}$$

$$\text{High Limit} = 230 \times 1.15 = 264.5 \text{ vac}$$

Frequency Stability versus Power Line Voltage Variations

For The MT300

Voltage Variation (vac)	Frequency (MHz)	Change (MHz)	Output Power MT250 (Watts)	Line Curent(Amps)
138.0	97.999991	0.000000	310	4.60
132.3	97.999991	0.000000	312	4.82
120.0	97.999991	0.000000	312	5.37
115.0	97.999992	0.000001	312	5.57
102.0	97.999991	0.000000	310	6.43
97.8	97.999991	0.000000	308	6.71
85.0	97.999991	0.000000	307	7.83

FCC Limit: ± 0.002000 Mhz

Note:

1. At a line voltage of 85 vac, the MT300 continued to operate without any loss in power.

2. The MT300 will accept any AC line voltage from 94 vac to 240 vac without the need to mechanically alter the input.

Description of FCC Test Performed on FM Transmitters Under the "Certification" Process

Name of Test:

Carrier Frequency Departure Tolerance at Warm Up.

FCC reference:

Part 73.1545 subparts b

Test Description as quoted from the "Code of Federal Regulations" book:

"The departure of the carrier or center frequency of an FM station with an authorized transmission output power of more the 10 watts may not exceed ±2000 Hz from the assigned frequency."

SPECS: At room temperature the carrier frequency shall not exceed ±2 kHz.

Part 2.995 requires the same stability between the limits of 0° and 50° C.

Carrier Frequency Departure Tolerance

During Warm Up For

The MT300

Time	Frequency (MHz)	Change (MHz)
12:40	97.999850	0.000000
12:50	97.999883	0.000033
1:00	97.999920	0.000070
1:10	97.999946	0.000096
1:20	97.999959	0.000109
1:30	97.999966	0.000116
1:40	97.999968	0.000118

FCC Limit: ± 0.002000 Mhz

Description of FCC Test Performed on FM Transmitters Under the "Certification" Process

Name of Test:

Conducted Harmonics

FCC reference:

Part 2.989 & 2.991 & 2.997 & 73.317

Test Description as quoted from the "Code of Federal Regulations" book:

"In all of the measurements set forth, the spectrum shall be investigated from the lowest radio frequency signal generated...up to the tenth harmonic of the highest fundamental."

SPECS: From Part 73.317, " ....any emission appearing on a frequency removed from the carrier by more than 600 kHz, must be attenuated at least 43 + 10 $\times$ log (Power in watts) dB below the level of the unmodulated carrier, or 80 dB, which ever is the lesser attenuation."

Test Conditions:

As per Part 2.989, the transmitter is setup for occupied bandwidth. In the monaural mode, the modulation of the carrier is set for 85% modulation with a 15 kHz input signal. In the stereo mode, the modulation of the carrier is set for 38% modulation with a 15 kHz input signal. The conducted harmonics and spurs are routed through a notch filter into the spectrum analyzer. The purpose of the notch filter is to improve the measuring quality of the analyzer.

Statement of Conformity

This equipment has been tested in accordance with the requirements contained in the appropriate Commission regulations. To the best of my knowledge, these tests were performed using measurement procedures consistent with industry or Commission standards and demonstrates that the equipment complies with industry standards as specified herein. I further certify that the listed measurements were made by the following company and at the following test location.

Company: Richardson Electronics__

Location: La Fox, Illinois_

Type of Equipment: FM Transmitter_

Model Number: MT300_

Test Engineer: Charles Anzalone_

Test Performed	FCC Reference	Status
Conducted Test	Parts 2.989, 2.991, 73.317	Passed
Pre-emphasis Test	Part 73.317 subpart e	Passed
Pilot Modulation Test	Part 73.322 subparts a2 & a5	Passed
TXCO with Line Variation	Parts 2.995 & 73.1545	Passed
Carrier Departure at Warm Up	Parts 2.995 & 73.1545	Passed
Conducted Harmonics	Parts 2.989,2.991,2.997,73.317d	Passed

Note: Test were performed from February thru April 2001.

Witness: David White_

Company: Richardson Electronics_

Location: La Fox, Illinois_

Description of FCC Test Performed on FM Transmitters

Under the "Certification" Process

Name of Test:

Spurious Radiation at an Open Field with a Dummy Load (or Radiation Test)

FCC reference:
Parts 2.991 and 2.993 with modulation specifications in Parts 2.989 subparts 3 & 5

Test Description as quoted from the "Code of Federal Regulations" book:

"For this test, single sideband, independent sideband and controlled carrier transmitters shall be modulated under the conditions specified in Part 2.989. For equipment operating below 890 MHz, an open field test is normally required. Information submitted shall include the relative radiated power of each spurious emission with reference to the rated power output, assuming all emissions are radiated from a half wave dipole."

SPECS: From Part 73.317, " ....any emission appearing on a frequency removed from the carrier by more than 600 kHz, must be attenuated at least 43 + 10 $\times$ log (Power in watts) dB below the level of the unmodulated carrier, or 80 dB, which ever is the lesser attenuation."

Test Conditions:

In Part 2.989 , occupied bandwidth for an FM transmitter is the modulation of the carrier in the monaural and stereo modes as follows:

Item 1 (subpart 3):

"FM broadcast transmitters not used for multiplex operation (i.e. monaural mode) shall be modulated 85 percent by a 15 kHz input signal."

Item 2 (subpart 5):

"FM broadcast transmitters for stereophonic operation shall be modulated with a 15 kHz signal an the pilot subcarrier simultaneous. The input signal shall produce a 38 percent modulation and the pilot subcarrier shall produce 9 percent modulation."

Test Results:

Elite's data is measured in a 50 ohm system with cable losses that increase with frequency. Each harmonic is measures through a band pass filter for the maximun value in dBuv. At one meter, 0dBm converts to 10 $\times$ log [(1 mw) ÷(1 uv^2÷50)] = 107dBuv. Elite uses a conversion of 97.5 dB for their 3 meter set up. This value is derived from the free space equation and the gain of their antenna. The FCC limit is -13 dbm or 84.5 dBuV (97.5-13). The plots vary slightly, but the tables are accurate because each harmonic is measured in the 'sample and hold' mode.

Description of FCC Test Performed on FM Transmitters Under the "Certification" Process

Name of Test:

Carrier Frequency Departure Tolerance with Temperature

FCC reference:

Parts 2.995 subpart 3 and 73.1545 subpart b

Test Description as quoted from the "Code of Federal Regulations" book:

"From 0° to 50° centigrade for equipment to be licensed for use in the Radio Broadcast Services under Part 73. Frequency measurements shall be made at the extremes of the specified temperature range at intervals of not more than 10° centigrade through the range."

SPECS: From Part 73.1545 subpart b, for FM stations, " The departure of the carrier or center frequency of an FM station with an authorized transmitter output more than 250 watts may not exceed ±2000 Hz from the assigned frequency."

SPECIAL NOTE: Elite's data indicates that the frequency departure of the carrier was within the FCC spec. However the output power decreased from 10 % of its nominal value. This problem was corrected with a fan that provides more air flow and additional cooling. See memo in Part 3 from David White. Addition information from Ingenium indicates that this problem has been resolved.

Carrier Frequency Departure Tolerance
With Temperature For
The MT300

Data from Elite's 'General Data Sheet' is reproduced herein:

Temperature	Frequency (MHz)	Change (MHz)
25 °C	97.999870	0.000000

0 °C	97.999982	0.000112
10 °C	98.000067	0.000197
20 °C	97.999940	0.000070
30 °C	97.999859	-0.000001
40 °C	97.999850	-0.000020
50 °C	97.999961	0.000091

FCC Limit: ± 0.002000 Mhz

Statement of Conformity

This equipment has been tested in accordance with the requirements contained in the appropriate Commission regulations. To the best of my knowledge, these tests were performed using measurement procedures consistent with industry or Commission standards and demonstrates that the equipment complies with industry standards as specified herein. I further certify that the listed measurements were made by the following company and at the following test location.

Company: Elite Electronics__

Location: Dowers Grove, Illinois_

Type of Equipment: FM Transmitter_

Model Number: MT300_

Test Engineer: Mark Longinotti_

Test Performed	*FCC Reference*	*Status*
Radiation Test	Parts 2.989,2.993,2.997,73.317	Passed
Frequency vs. Temperature	Parts 2.995 & 73.1545	Passed

Witness: Charles Anzalone_

Company: Richardson Electronics_

Location: La Fox, Illinois_

Appendix

This section contains:

1) Current readings at rated output power

2) Configuration of the Jumper Switches

3) Temperature De-rating Modifications

4) Photographs taken with MT300 in Elite's anechoic chamber

5) CONVERSION Table fo VSWR vs Transmitted Power

AC Input Current Measurements

For The MT300 with

115 vac Supply

	Typical Current (amps)	Supply (vac)	Pout (watts)	Efficiency(%)
Current at full output:	5.08	126	310	48.4
Idle Current	0.48	126		

June 13, 2001

To: Charles Anzalone

Subject: MT300 Temperature De-rating

Ingenium has responded to the fax regarding the temperature tests on MT300.

From the tests they made in the Ingenium laboratory, they saw that the transmitter warranted its performances up to 45° ambient temperature, as shown on their specification datasheet. In order to have the same performances even at 2000 meters above sea level with a temperature of 45°, the EBM PAPST 3314-140 model fan was necessary. The fan on the prototype that we have in

La Fox is only a substitute. They indicate that their supplier could not provide the right model fan in time. The correct fans should be mounted on all the transmitters in production. As soon as possible, they will send a fax with the datasheets of both models of fans. The p/n of the substitute fans is EBM PAPST 3124F.

I have communicated with Ingenium that the FCC rules are clear that all transmitters must operate to specification up to 50 Degrees "C". To complete the FCC verification testing we will need the fan assembly to permit us to retro-fit and correct the deficiency on the MT300 that was supplied. I have requested data sheets, the proper fan(s), and necessary components to mount and operate the MT300 for re-testing as required. As soon as these items are available to us we can conclude the test on this product.

Regards,

David A. White
Product Manager, PL181
Broadcast Richardson