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MEASUREMENTS OF EMISSIONS FROM TORNADO MODEL PRODUCTS LTD LOOP TRANSMITTER TYPE 2-1

ERA TEST REPORT NO 5043/2F3/1   FEBRUARY 1980

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ERA Test Report No :	5043/1F3/1
Test For :	Radio Frequency Emissions
Test On :	Tornado Model Products Loop Transmitter Type 2-1
Purpose of Test :	Approval
Test Requested By :	Tornado Model Products Ltd 520 Coventry Road, Small Heath, Birmingham B10 OUN ENGLAND
Company Order No :	
Test Specification :	Subpart D Para 15.111 FCC Rules
Equipment Serial No :	
Equipment Manufacturer :	Tornado Model Products Ltd

Test Started :	13.2.80
Test Completed :	13.2.80
Final Test Result :	PASS

Report Written By : Test Engineer :	Mr A.J. Maddocks	A J Maddocks
Supervisor :		
Manufactuer's Repres :	Mr T. Cooper	

MEASUREMENTS OF EMISSIONS FROM TORNADO MODEL PRODUCTS LTD LOOP TRANSMITTER TYPE 2-1

1. INTRODUCTION

The Tornado Model Products loop transmitter operating on 137 kHz has been examined to determine compliance with Subpart D para 15.111 of the FCC Rules relating to Low Power Communication Devices operating at frequencies below 1600 kHz. This follows the original series of tests carried out in September 1979 which was reported on in ERA Test Report No 5043/1X7/1. Further tests were regarded as necessary and this present investigation was devised to satisfy all inquiries relating to the original measurements.

According to the manufacturer's information, the loop sizes vary from small loops of 10 x 8 feet to the largest loop of about 50 feet diameter. The smallest loop is the only one which is likely to be elevated above ground.

Several loop sizes and configurations have been examined and field strength measurements have been made at various distances from the loop centre and at selected points around the loop.

In addition, measurements have been made of the distribution of transmitter harmonics and also of the dependance of the fundamental radiation on supply voltage and tuning.

2. TEST METHOD

Measurements of r.f. radiation were made at the ERA open field test site at Leatherhead England. The measurements were made using a Schwarzbeck FSME 1515 H.F. interference measuring receiver in conjunction with a Stoddart 92200-3 screened loop aerial; details of the measuring equipment are given in Appendix A.

2.1 Variation of field strength with distance.

Owing to the presence of background noise due to remote broadcast transmitters it was not possible to measure the fundamental radiation at 137 kHz at distances greater than 50 metres from the centre of the loop, and therefore a calculation of the field at 300 metres was necessary.

The rate of reduction of field intensity with increasing distance was therefore necessary in order to make an accurate extrapalation to greater distances. To this end, measurements of field intensity were made at several distances from two different loop configurations, a 10 x 8 foot loop and a 46 x 46 foot loop. The magnetic field intensity was measured at 5 distances away from the former loop, and 7 distances away from the latter, sufficient to establish a uniform rate of decay.

2.2 Loop Orientation

Measurements were made for the 10 x 8 foot loop both when it was laid on the ground, and when elevated to a horizontal plane 4 feet above the ground on a rotatable turntable. The field strength was monitored whilst the loop was rotated through 360° about a vertical axis.

For the 46 x 46 foot loop measurements were made at points 30 metres from the centre of the loop, which were separated by angles of 90° and corresponded to East, North and West directions from the loop.

2.3 Loop Configurations

In addition to the square 46 x 46 foot loop, having approximately the same area as a 50 foot diameter circle which is the largest likely to be encountered with this system, two other configurations of loop were tested. One comprised two loops of 23 x 46 feet, and the other three loops of 15 x 46 feet. For each configuration the transmitter was tuned to obtain maximum current through the loop wire.

2.4 Harmonic Emissions

Measurements were made at 5 metres from the 10 x 8 foot loop of all the emissions from the loop which included harmonic frequency emissions up to the 28th harmonic at 3.83 MHz.

2.5 Additional Tests

Measurements were also made of the field intensity due to the 46 x 46 foot loop at the fundamental frequency for the conditions when the transmitter tuning was adjusted to reduce the output current in the loop to about half of the resonant current.

Measurements were also made of the field intensity when the supply voltage was varied over the range 85% to 104% of nominal.

3. RESULTS

The measurements of magnetic field are expressed in terms of the equivalent plane wave electric field i.e volts/metre = amps/metre x 377. The readings correspond to the rms value of the sine wave required to obtain the same response on the indicator at the tuned frequency. For continuous wave signals, as we have in this case, the time constants at the detector and the meter play no part, and the response on the Schwarzbeck receiver is identical to that obtained with an "average" or "peak" reading meter.

3.1 Variation of field strength with distance

Figure 1 shows the dependance of field intensity with distances for the two loops, 15 x 8 feet and 46 x 46 feet. The best line through both sets of points gives a dependance on distance of about $d^{-4.2}$, (84dB down per decade of distance), this where both loops are laid out on the ground. For a loop in free space, i.e not near ground, we would expect the rate of decay in the near field to be d^{-3} (60 dB down per decade of distance). For loops which are on the ground, it would be expected for considerable dissipation of radiated energy in the ground to take place with an increased reduction in field strength, for which a rate of about d^{-4} is not unreasonable, and is consistent with our previous experience of systems of this nature.

For loops on the ground we can therefore apply with confidence a factor of -84dB to the field strength at 30 metres to give the field at 300 metres.

This would only apply in the frequency range up to about 160 kHz, where all the distances are less than one sixth wavelength and the near field extends to 300 metres.

For the elevated loop, which approximates more closely to free space conditions, we have applied a - 60 dB factor which is fairly severe approach (without any but theoretical justification), but should provide a worst case figure.

3.3 Loop Configuration

Table 1 shows the complete set of results of measurements on the five loops examined, together with the calculated value of field at 300 metres. For the 10 x 8 foot loop there was a 6dB (2 : 1) increase in field strength when the loop was raised to 4 feet above the ground. For this elevated condition the - 60 dB factor has been applied to the most meaningful measurement to obtain a worst case figure.

For the uniform loops on the ground, the field strength varies approximately according to the area of the loop. The two segmented loops gave field strength which were 10 dB (3 : 1) down on the 46 x 46 foot uniform loop,, which gave the highest figures of 4 dB (μV/metre) i.e. 1.6 (μV/metre).

Figure 2 shows the fields at 300 metres for all the loops when compared with the limits of Para 15.111 of Subpart D. All these values come well down below the limit and the margin in all cases was in excess of 20dB i.e less than $\frac{1}{10}$ of limit value,and complete compliance with the requirements of FCC Rules was obtained under all conditions.

It is also probable that the field strength would be even lower if the loop were to be totally immersed in water. The propogation of the wave through a conducting medium would result in significant attenuation which would only reduce the signal at 300 metres.

3.4 Harmonic Emissions

Table 2 shows the relative magnitudes of the measurable harmonic emissions. The second harmonic was more than 50dB down on the fundamented, the third was more than 70dB down, and all others less than 80dB down.

Using the figures in Table 2 and the ratio of field intensity obtained between the 46 x 46 foot and 10 x 8 foot loops of 35 dB(56:1), an estimate of the field strength at 30 metres of the 9th harmonic at 1.33 MHz, for the 46 x 46 foot loop is 3 dB (μV/metre) i.e 1.4μV/metre, which is 22dB below the FCC limit. All other harmonics above 500 kHz were at least 4dB less than this value, and other loop configurations would be at least 14dB down.

3.5 Additional Tests

Table 3 shows the results of detuning the 46 x 46 foot loop; reductions of 5dB and 4.5 dB were obtained in field strength at 30 metres when the loop current was reduced by adjustment of the transmitter tuning component.

The variation in the supply voltage (Table 4) produced no changes in field strength; the transmitter was operating from a regulated d.c. supply and no variations in output would be expected.

Measurements of field intensity on the receiver used with the transmitting system showed no identifiable signals in the frequency range 100 kHz to 30 MHz with the measuring system at its highest sensitivity.

4. CONCLUSIONS

The assessment of radio frequency emissions from the Tornado Model Products transmitter Type 2 -1 has shown that for the worst case conditions i.e largest loop area and optimum orientation, the maximum field strength of the fundamental radiation was 1.6 μV/metre at 300 metres, which completely complies with the FCC Rules Subpart D Para 15.111 limit of 17.5 μV/metre. Similarly, all harmonic radiation levels complied with the relevant limits by a similar margin of over 20dB.