Section 5 - 2983(e) Application for type acceptance - Measurement Data and Methods

5.1 - General measurement conditions and parameters

Standard test conditions
Unless otherwise stated, the following conditions were applicable during the tests:

Ambient temperature:		21 to 26 °C
Ambient humidity	:	40 to 60 %
DC supply	:	7.2 V ± 5 %

The equipment is intended to operate from a nominal 7.2V DC NiMH or NiCd battery

Frequency range to be investigated
The highest transmitter frequency is 162.0000 MHz. Investigation was made from 1 MHz up to 10 times the carrier frequency (1700 MHz).

Two tone test signal
Paragraph 2.985(b) of the FCC Rules, defines that the equipment should be tested when modulated simultaneously with two tones of 500 Hz and 2400 Hz. The single sideband spectrum of this equipment is, however, modified to implement the transparent tone in band technique (TTIB). This splits the audio input signal at 1.65 kHz, and shifts the upper half up by 300 Hz and the lower half down by 300 Hz. Thus, to simulate the effect of two tone modulation on a conventional SSB system, two tones can be used that produce the same RF spectrum. These tones are obtained as follows:

first tone	=	500 + 300	= 800 Hz
second tone	=	2400 - 300	= 2100 Hz

For convenience, this test signal can be generated internally within the equipment by a digital signal processor under the control of an external personal computer. Unless otherwise stated, the level of the test signal was increased until rated output power was achieved at the output of the transmitter.

Measured Parameters

2.985	RF Output Power
2.987	Modulation Characteristics
2.989	Occupied Bandwidth
2.991	Spurious emissions at antenna terminals
2.993	Field strength of spurious radiation (in both transmit and receive mode)
2.995	Frequency stability
90.210(e)	Radiated and conducted out of channel emissions

Measurements for FCC Rules Paragraphs 2.985, 2.987, 2.989, 2.991, 2.995 and 90.210(e) were carried out at the Linear Modulation Technology Inc., Intek Global House, Westfield Industrial Estate, Midsomer Norton, Bath, Avon, BA3 4BS, The United Kingdom.

Measurements for FCC Rules Paragraphs 2.993, Part 15 Subpart B and 90.210(e) were carried out by an independent test house, TÜV Product Service (formally Assessment Services Ltd), Segensworth Road, Titchfield, Fareham, Hampshire, PO15 5RH, The United Kingdom.

5.2 - 2.985(a) RF Output power

Method
Fully modulate the transmitter with 800 Hz and 2100 Hz tones to 5 W PEP nominal.

Measure Peak Envelope Power (PEP) in a 10 kHz bandwidth. The spectrum analyser is set to maximum hold (span 200 kHz, RBW 10 kHz, VBW 10 kHz, positive peak detector). Measurements are made on the lowest, centre and highest channel frequencies.

Power is calculated according to the equation:

$$P = 10^{(\frac{A+L}{10})-3}$$

Where : A is the attenuation in dB between the transmitter and the spectrum analyser.
L is the maximum level measured on the spectrum analyser in dBm.
P is the peak envelope power in watts.

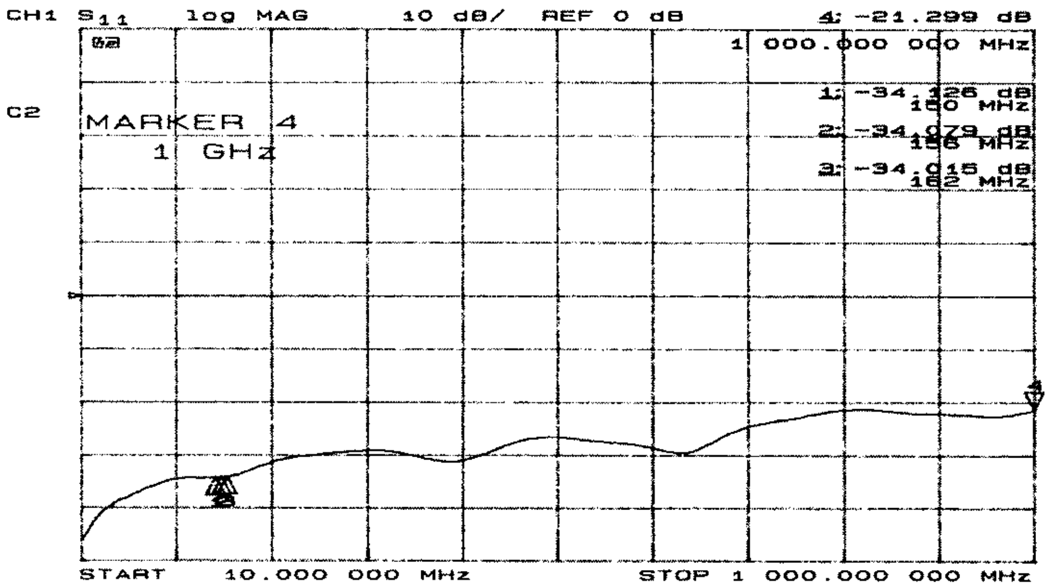
Results
Transmitter fully modulated with 800 Hz and 2100 Hz tones.

Frequency	Measured Level (L)	Attenuation (A)	Power (P)
MHz	dBm	dB	Watts
150.0000	6.32	30.6	4.92
156.0000	6.32	30.6	4.92
162.0000	7.0	30.7	4.80

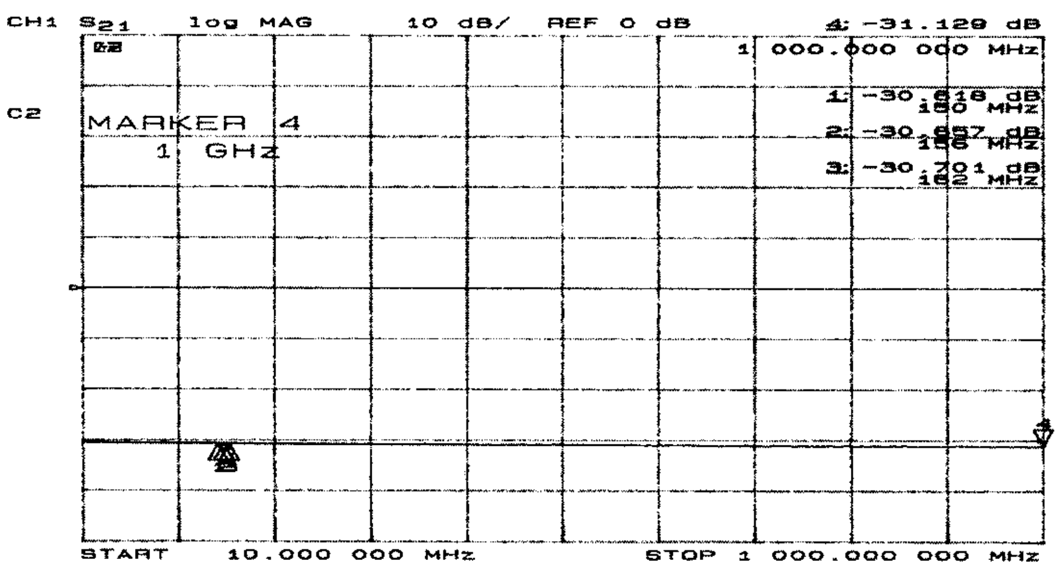
The RF characteristics of the load are shown over leaf.

Characteristics of RF load presented to transmitter

RETURN LOSS



INSERTION LOSS



5.3 - 2.987(a) Modulation characteristics - Voice modulated response

Method

Fully modulate transmitter with 800 Hz and 2100 Hz tones to 5 W PEP nominal. Measurements are made at the centre channel frequency (156.0000 MHz).

Set the spectrum analyser to 20 kHz span, RBW 100 Hz, VBW 100 Hz and positive peak detector. Measurements are made at the centre channel frequency (156.0000 MHz).

Note the level of the largest tone in the RF spectrum.

Apply a 1 kHz signal tone to the transmitter input such that the level of the resulting RF signal is the same as that produced by the tone noted above. This is taken as the 0 dB reference point.

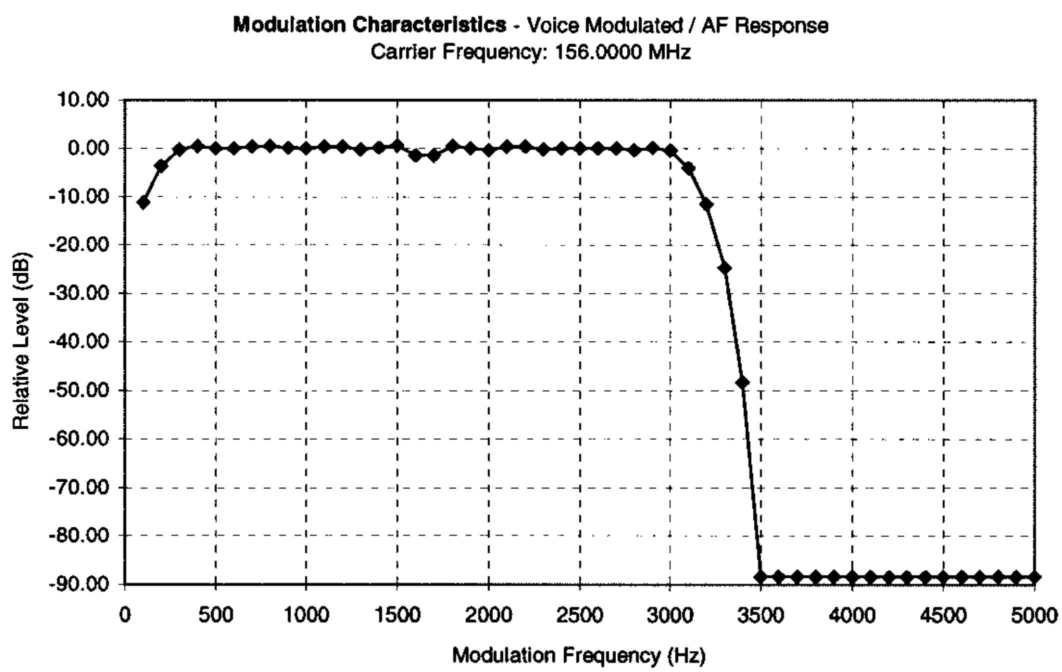
Vary the audio frequency from 100 Hz to 5000 Hz in 100 Hz steps. Note the level of the resulting tone in the RF spectrum at each point.

Results

Transmitter modulated with a single tone. Transmit frequency 156.0000 MHz.

The reference frequency for the measurement is 1 kHz.

The audio frequency of the test signal was varied from 100 Hz to 5 kHz. The audio level was maintained constant.



5.4 - 2.987(b) Modulation characteristics - Modulation limiting

Method

Fully modulate the transmitter with 800 Hz and 2100 Hz tones to 5 W PEP nominal. Note the level of each tone in the resulting RF spectrum. Increase the level from zero to 10 dB above the level required to produce rated transmit power.

Measure Peak Envelope Power (PEP) in a 10 kHz Bandwidth at each level. The spectrum analyser is set to maximum hold (span 200 kHz, RBW 10 kHz, VBW 10 kHz and positive peak detector). Measurements are made at the centre frequency (156.0000 MHz).

Calculate the actual PEP using the equation:

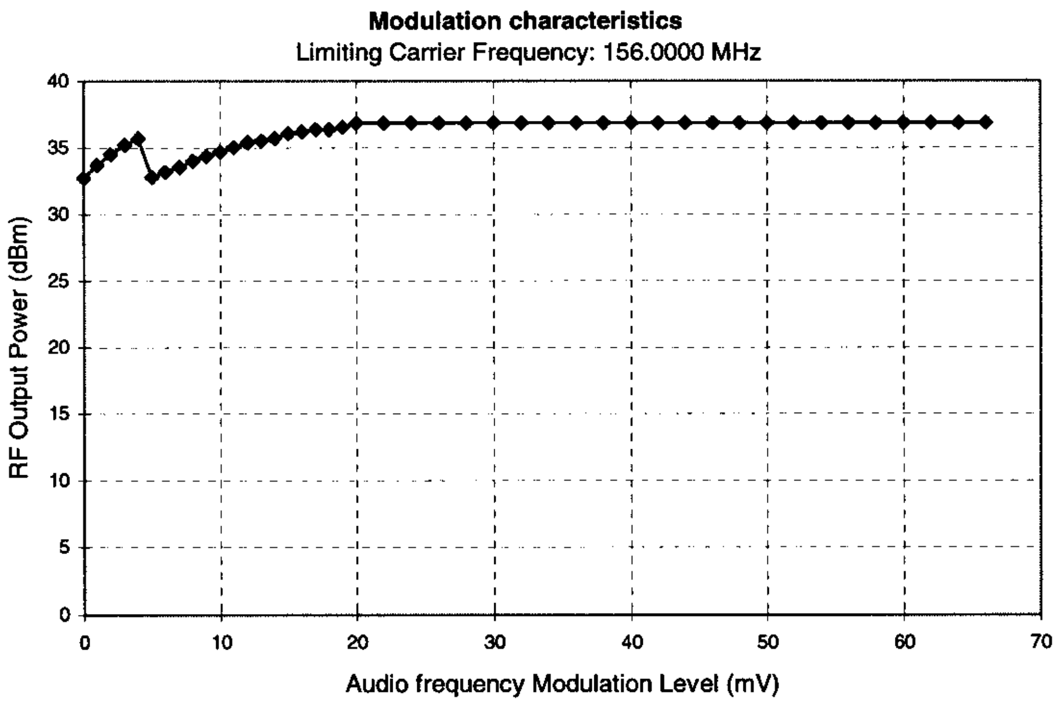
$$P = 10^{\left(\frac{A+L}{10}\right)-3}$$

Where: A is the attenuation in dB between the transmitter and the spectrum analyser
L is the maximum level measured on the spectrum analyser in dBm
P is the Peak Envelope Power (PEP)

Results

Drive level is increased from zero to 10 dB above that required to produce the rated output power.

Transmit frequency 156.0000MHz



5.5 - 2.989 Occupied bandwidth

Method

Fully modulate the transmitter with 800 Hz and 2100 Hz tones to 5 W PEP nominal.

Measurements are made at the centre channel frequency (156.0000 MHz).

Set the spectrum analyser to 10 kHz span, 100 Hz RBW, 100 Hz VBW, reference level 10 dB above the level of the largest signal. Use the spectrum analyser "99% occupied bandwidth" function to measure the occupied bandwidth.

Repeat test method for transmitter fully modulated with 1200 BPS data.

Measurements are made at the centre channel frequency (156.0000 MHz).

Results

Transmitter frequency 156.0000 MHz. Transmitter fully modulated in all cases

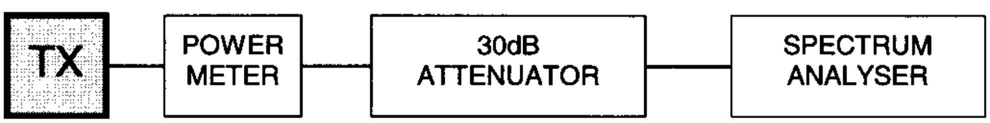
Test Signal	Occupied bandwidth (kHz)
800 Hz and 2100 Hz tones	2.08
1200 BPS data	2.00

5.6 - 2.991 / 90.210(e) Spurious emission at antenna terminals

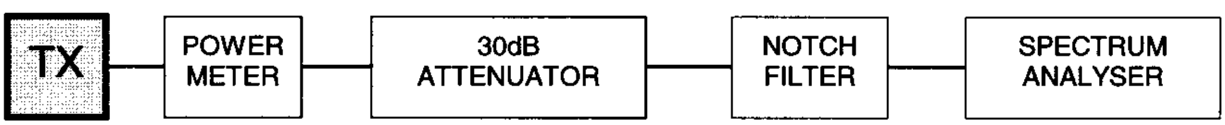
Method

For all measurements of signals at the antenna port, the equipment was configured as shown below:

EMISSIONS LESS THAN 250kHz FROM CARRIER



EMISSIONS GREATER THAN 250 kHz FROM CARRIER



1. Measure the attenuation vs. frequency of the first set-up over the frequency range 1 MHz to 1700 MHz.

2. Set the transmitter to 156.0000 MHz.

3. Fully modulate the transmitter with 800 Hz and 2100 Hz tones to 5 W PEP nominal. Measure Peak Envelope Power (PEP) in a 10 kHz bandwidth. The spectrum analyser is set to maximum hold, with a span 200 kHz, RBW 10 kHz, VBW 10 kHz and positive peak detection.

4. Calculate the actual PEP using the equation:

$$P = 10^{(\frac{A+L}{10})-3}$$

Where: A is the attenuation in dB measured in step 1.
L is the maximum level measured on the spectrum analyser in dBm in step 3.
P is the Peak Envelope Power.

5. Calculate the maximum required attenuation using the equation:

$$ATTEN=55+10log(P)$$

6. A search is now made for all products within 20 dB of the calculated limit:
Set the spectrum analyser to 25 MHz span, 10 kHz RBW, 10 kHz VBW positive peak detect and reference level equal to L measured above.

   Over a frequency range from 1 MHz to 1700 MHz, observe the spectrum in 20 MHz steps, identify all spurious signals and note the frequency.

7. At all frequencies where products **250 kHz or more from the carrier** are identified, detailed measurements are now made.

   To avoid errors due to harmonics generation in the spectrum analyser, measurements at frequencies at or above the second harmonic frequency should be made with either a notch or high pass filter in place. This is shown in the set-up diagram.

   Set the spectrum analyser to 200 kHz span, 10 kHz VBW, positive peak detect and reference level equal to L measured above.

   Locate each previously identified spurious signal, set the analyser to maximum hold and measure the maximum level of each signal. Note the frequency and the level. Repeat for all spurious signals.

   At all frequencies where spurious products were measured, measure the attenuation of the path from the transmitter output to the spectrum analyser input.

8. A search is now made for all spurious signals **250 kHz or less from the carrier**:

   Set the spectrum analyser to 20 kHz span, 100 Hz RBW, 100 Hz VBW, positive peak detect, centre frequency equal to the carrier frequency.

   Measure the level of the largest signal. Calculate the power of the largest signal using the equation:

$$P = 10^{(\frac{A+L}{10})-3}$$

Where: A is the attenuation in dB measured in step 1
L is the maximum level measured on the spectrum analyser in dBm in step 8
P is the Peak Envelope Power

Calculate the minimum required attenuation using the equation:

$$ATTEN=55+10\log(P)$$

Set the spectrum analyser to 600 kHz span, 100 Hz RBW, 100 Hz VBW, positive peak detector, reference level equal to 10 dB above L measure above.

Locate each previously identified spurious signal, set the analyser to maximum hold and measure the maximum level of the signal. Note the frequency and the level. Repeat for all spurious signals.

Results

For signals more than 250 kHz from the carrier, measurements are made with 10 kHz RBW and VBW for signals less than 250 kHz from the carrier, measurements are made with 100 Hz RBW and VBW.
Transmitter fully modulated with 800 Hz and 2100 Hz tones at 156.0000 MHz.

a) Signals more than 250 kHz from carrier

True level calculated using the equation.

$$P = 10^{(\frac{A+L}{10})-3}$$

Measured level of the transmit signal in 10 kHz bandwidth (L) = 6.32 dBm
Attenuation at 156.0000 MHz (A) = 30.6 dB
Power of transmit signal (P) = 4.92 W (36.92 dBm)
Minimum required attenuation of spurious emissions is calculated using the equation:

$$ATTEN=55+10\log(P)$$

Minimum required attenuation is therefore = 61.92 dB

Maximum allowed level of spurious signal is 36.92 – 61.92 dBm = -25.00 dBm

True level (dBm) = Measured level (dBm) + Attenuation (dB) = L + A

Level below the limit (dB) = -25.0 dBm - True level (dB)

Maximum allowed level of Spurious signals is -25.0 dBm

b) Signals less than 250 kHz from the carrier

True level calculated using the equation.

$$P = 10^{(\frac{A+L}{10})-3}$$

Measured level of the transmit signal in 100 Hz bandwidth (L) = -1.97 dBm
Attenuation at 156.0000 MHz (A) = 30.6 dB
Power of transmit signal (P) = 0.73 W (28.63 dBm)

Minimum required attenuation of spurious emissions is calculated using the equation:

$$ATTEN=55+10log(P)$$

Minimum required attenuation is therefore = 53.63 dB

Maximum allowed level of spurious signal is 29.08- 54.08dBm = -25.00 dBm

True level (dBm) = Measured level (dBm) + Attenuation (dB) = L + A

Level below the limit (dB) = -25.0 dBm - True level (dB)

Maximum allowed level of Spurious signals is -25.0 dBm
Results

Transmitter fully modulated with 800 Hz and 2100 Hz tones.

Maximum allowable level of spurious signal is -25.0 dBm

All signals within 20 dB of the limit are reported (-45.0 dBm)

Frequency	Measured Level (L)	Attenuation (A)	True Level	Margin
MHz	dBm	dB	dBm	dB
132.0033	-66.5	31.03	-35.47	10.47
155.9636	-74.43	30.6	-43.83	18.83
155.9829	--73.93	30.6	-43.33	18.33
180.0000	-72.77	30.95	-41.82	16.82
312.0000	-71.77	31.86	-39.91	14.91

List of test equipment used for measurement and testing

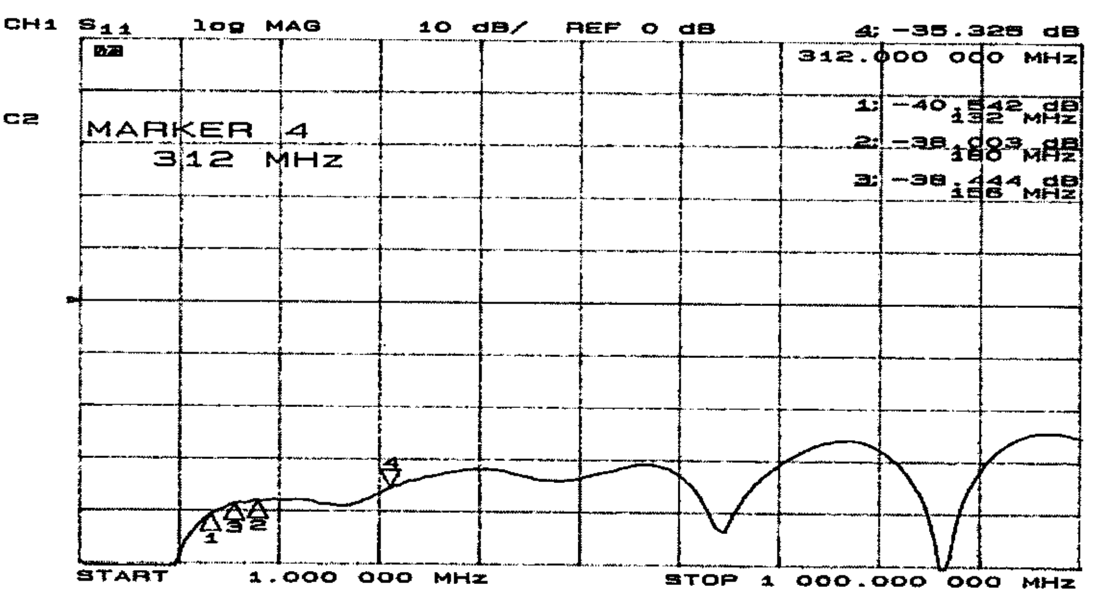
Equipment	Model Number	Manufacture	Serial Number	Comments
Spectrum Analyser	HP8560E	Hewlett Packard	3240A00299	
Power Meter	4391	Bird Electronic Corp.	2363	100-250 MHz, 5W

Audio Signal Generator	HP8904A	Hewlett Packard	2948A03259	DC-600 kHz
Attenuator	BIRD 8308-300-N	Bird Electronic Corp.	ATT005	30dB, 25W
Notch Filter	NR-160-1CN	Aerial Facilities Ltd	3081B	162.5 MHz, 50W
RF Signal Generator	HP8657A	Hewlett Packard	3034A02539	
Network Analyser	HP8753B	Hewlett Packard	2716U00828	
Digital Volt meter	77	Fluke	68232030	

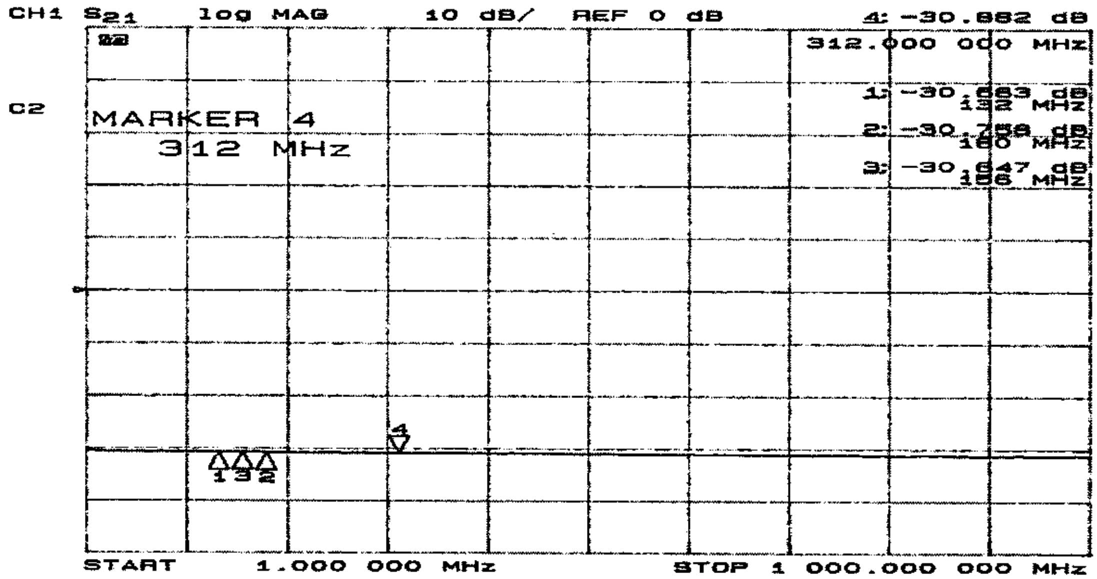
Characteristics of RF load presented to the transmitter.

Emissions measurements for spurious less than 250kHz from the carrier

RETURN LOSS



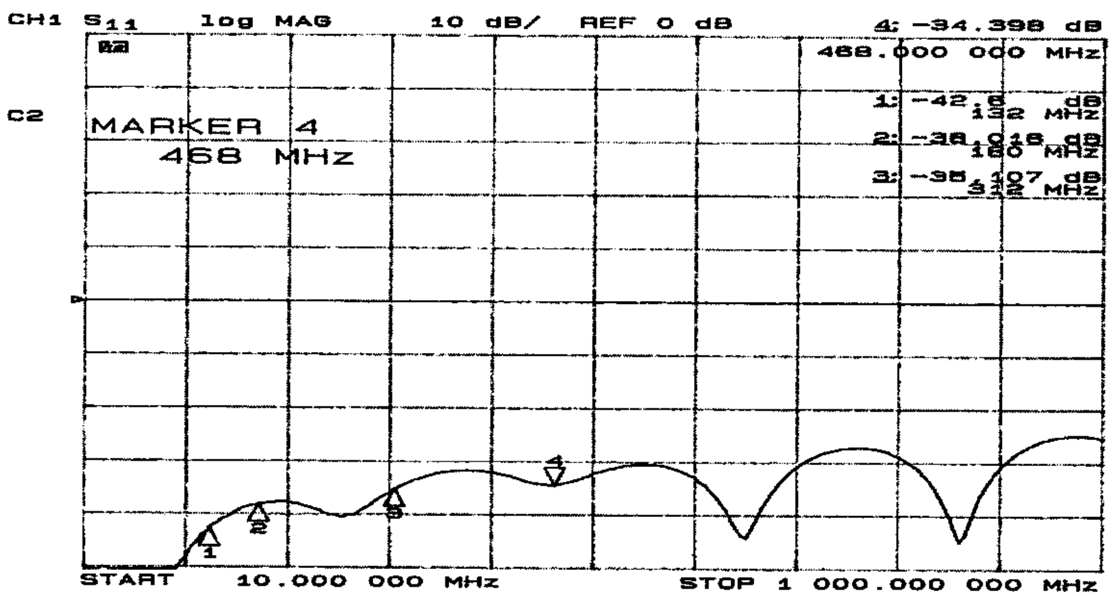
INSERTION LOSS



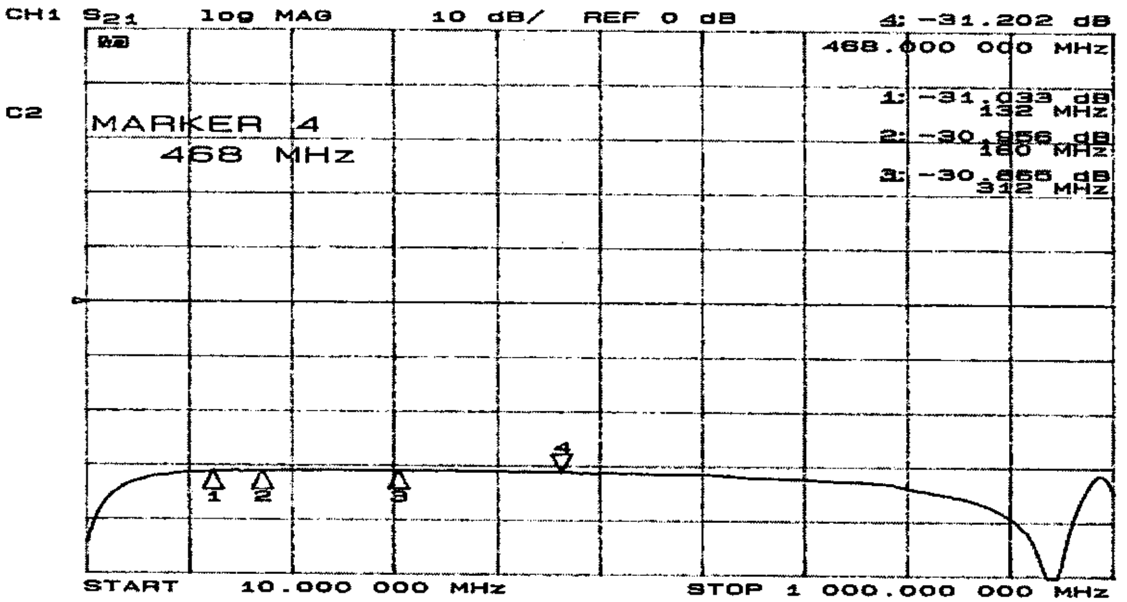
Characteristics of RF load presented to transmitter.

Emissions measurements for spurious greater than 250kHz from carrier

RETURN LOSS



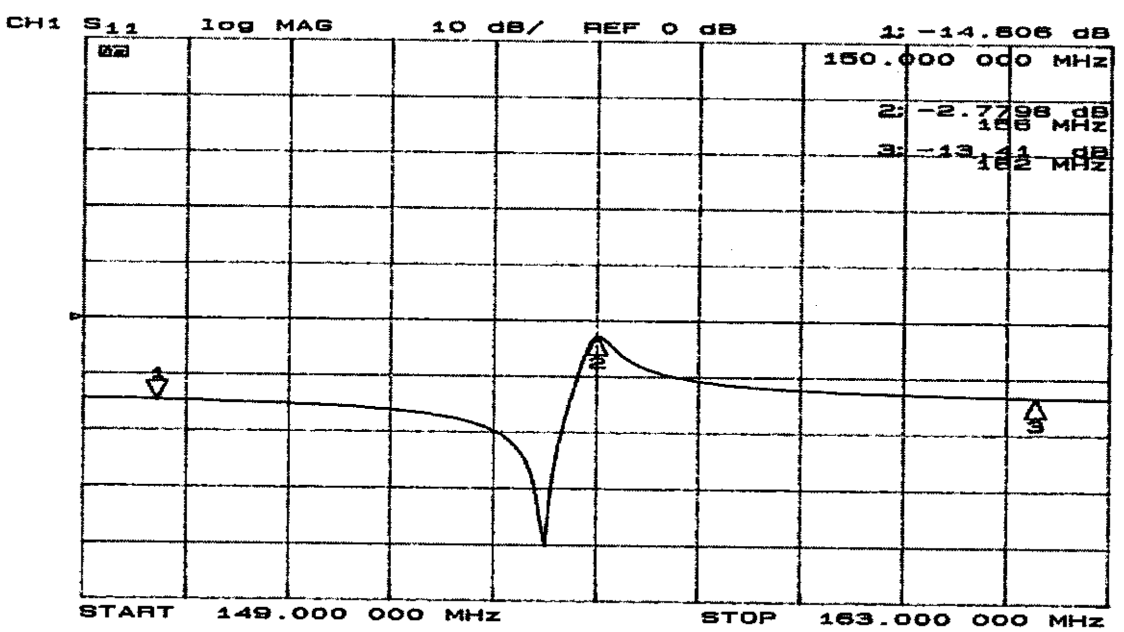
INSERTION LOSS



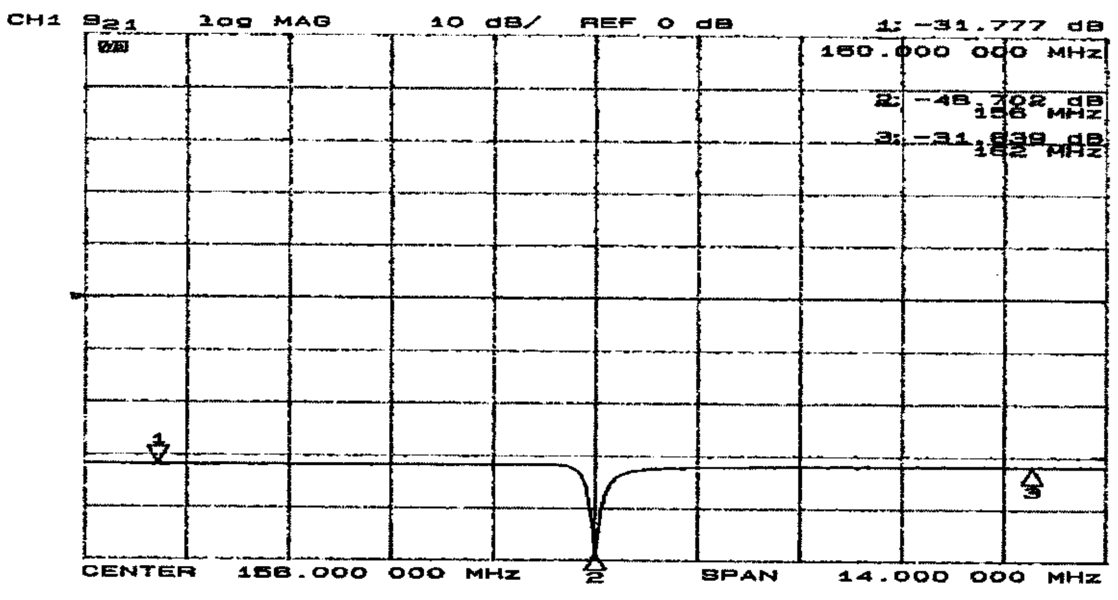
Characteristics of RF load presented to transmitter.

Emissions measurements for spurious greater than 250kHz from carrier (close to notch)

RETURN LOSS



INSERTION LOSS



90.210(e) Spurious emissions within 10 kHz of carrier / transmit mask

Method
The measurement method is in accordance with TIA/EIA TSB57.

All measurements are made with 20 kHz span, 100 Hz RBW and 100 Hz VBW, reference level is 10 dB above the level of the highest emission.

1. The transmitter is fully modulated with 800 Hz and 2100 Hz tones at the centre channel frequency.

2. The signal is applied to a spectrum analyser through a suitable attenuator.

   The spectrum analyser is set to the centre channel frequency, 20 kHz span, 100 Hz RBW, 100 Hz VBW, positive peak detector.The trace is set for Maximum Hold.

   The reference level is set so that the highest level of the emission is 10 dB below the spectrum analyser reference level.

3. The power level of the highest emission in the authorised bandwidth (P), is calculated using the formula:

$$P = 10^{(\frac{A+L}{10})-3}$$

Where: A is the attenuation between the transmitter and the spectrum analyser.
L is the level of the highest emission in the (6 kHz) bandwidth as viewed on the spectrum analyser in dBm

4. The spectrum analyser display is plotted and the mask is superimposed on the plot.

The mask limits are as follows:

4.1 The attenuation required between 3 and 4.6 kHz is the lesser of :

a) $30 + 16.67(f_d - 3)$ dB
b) $55 + 10 \log(p)$ dB
c) 65 dB

Where f_d is the displacement from the carrier frequency.

4.2 The minimum ultimate attenuation required for displacement frequencies equal to or greater than 4.6 kHz is calculated using the formula:

$$ATTEN=55+10\log(P)$$

5. The measurement process is repeated for a transmitter fully modulated with 1200 BPS data.

Results
Transmitter frequency 156.0000MHz. The transmitter was fully modulated in all cases.

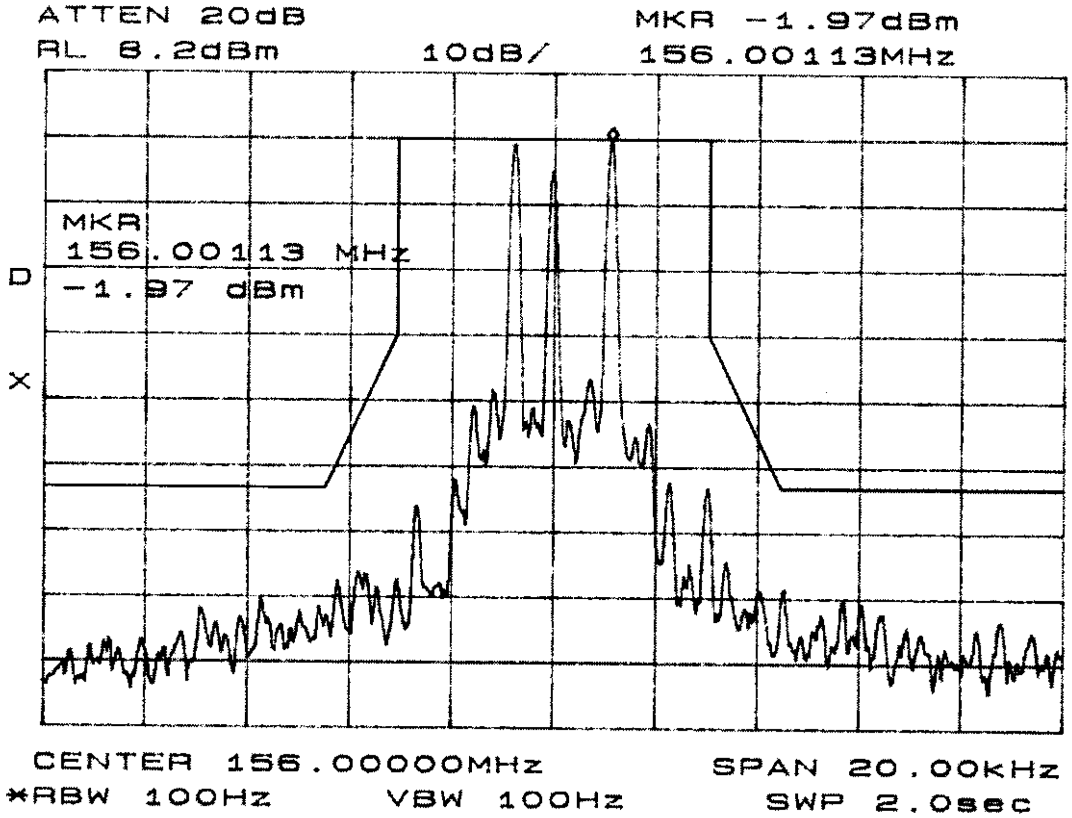
Test Signal	Level of Highest Emission (L)	Attenuation (A)	Power of Highest Emission (P)	Required Attenuation $f_d = 3$ kHz	Required Attenuation $f_d = 4$ kHz	Required Attenuation $f_d = 4.42$ kHz	Ultimate Attenuation $f_d > 4.6$ kHz
	dBm	dB	W	dB	dB	dB	dB
800 Hz and 2100 Hz	-1.97	30.6	0.73	30	46.67	53.63	53.63
1200 BPS FFSK	-2.13	30.6	0.70	30	46.67	53.45	53.45

Refer to the attached 2 plots with superimposed transmitter masks:

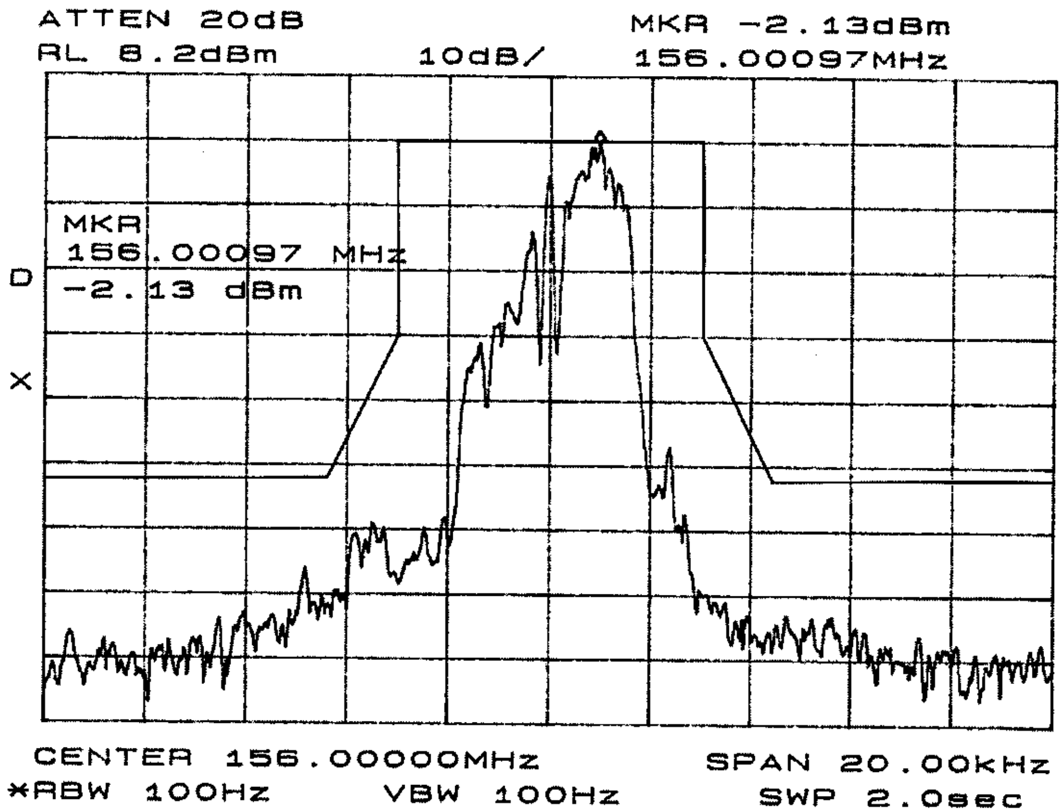
Plot 1 - 800 Hz and 2100 kHz tones

Plot 2 - 1200 BPS (FFSK) data

Plot 1 - 800 Hz and 2100 kHz tones



Plot 2 - 1200 BPS (FFSK) data



5.7 - 2.993 Field strength of radiated spurious emissions

Method
In transmit mode the unit meets the requirements of FCC Rules Part 90, Paragraph 90.210(e) for radiated spurious emissions. The results for this test are recorded below. The minimum required attenuation relative to the wanted transmit signal is given by:

$$ATTEN = 55 + 10\log(P)$$

(Where P is the measured power, in Watts, of the highest emission signal in the authorised bandwidth).

For 5 Watt transmit power, the attenuation must be 62 dB or more below P.

Results
The frequency spectrum from 30 MHz to 1.7 GHz was investigated. However no radiated spurious emissions were discovered within 20 dB of the permissible limit calculated in the equation above. Therefore no measurements were recorded.

5.8 - Compliance statement for radiated emissions to FCC Rules Part 15

In RECEIVE mode, the LMP4213 meets the requirements of FCC rule Part 15 Subpart B (unintentional radiator) for Radiated Electric Field Strength Emissions.

Testing was conducted at TUV Product Service Ltd, Segensworth Road, Fareham, Hampshire, PO15 5RH, UNITED KINGDOM. A test report (Report No. 00605527) demonstrating compliance is held on file at Linear Modulation Technology, and is available for review on request.

5.9 - 2.995/90.213 Frequency stability

2.995(a)(1) - Frequency stability with temperature
As explained in 3.11, the handportable reference oscillator frequency is locked to the Base Station. The radio will not transmit unless it is locked to the Base Station. The AFC circuitry in the handportable has a range of greater than ±5 ppm, compared with a specified drift for the handportable frequency reference over the -30°C to +70°C temperature range of ±2.5 ppm. Therefore the handportable will always be able to lock to the base station.

Therefore the fundamental frequency drift with temperature of the handportable will always be the same as that of the Base Station. The performance of the Base Station Frequency Standard FQS-A is detailed in the submission for the LMC3005 Base Station.

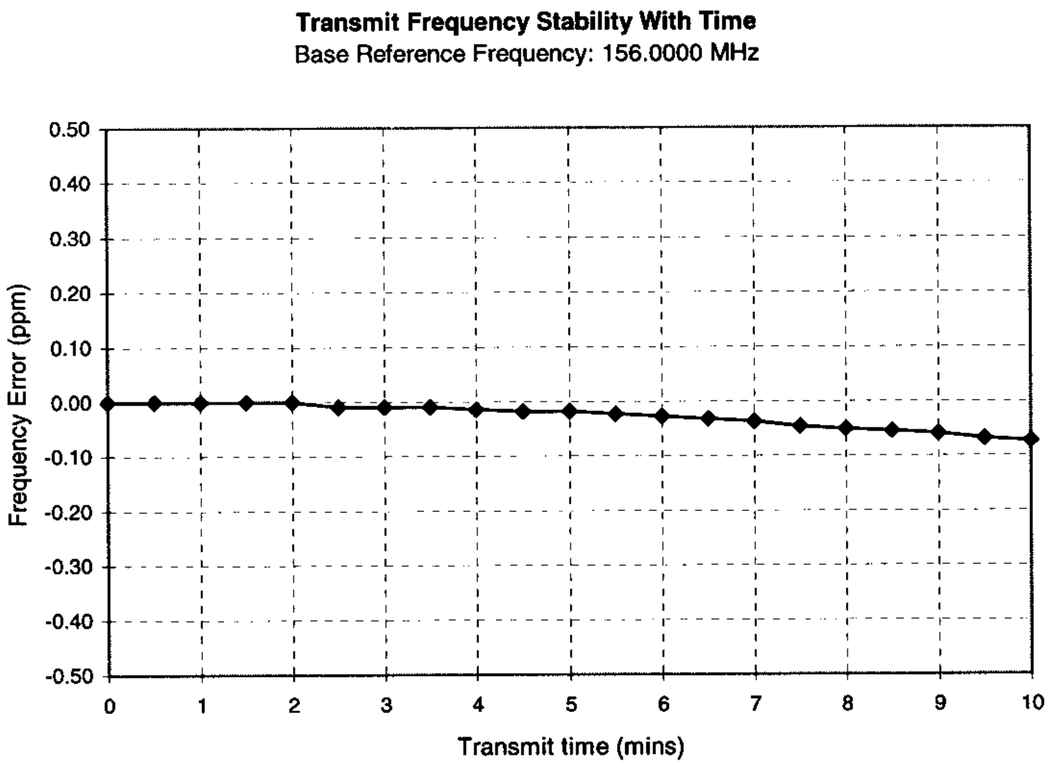
90.213/2.995(e) - Frequency Stability with time

Method
As explained in Section 3.11 , the frequency stability of the handportable transceiver is primarily defined by the base station reference to which it is synchronised. This will be better than ±0.2 ppm.

In addition, the mobile transceiver may drift in frequency with time when transmitting. Note that the maximum transmit time is 4 minutes. This time is controlled by the Signal Processing Unit (SPU).

To measure transmit frequency drift, a radio was first locked to an accurate frequency reference (in receive mode) at a frequency of 155.0000 MHz. The radio was then set to transmit a two tone test signal at maximum PEP. The frequency of the transmitted pilot tone was measured at 30 second intervals for 10 minutes. The test was carried out at room temperature. The frequency stability specified in the FCC Rules (Part 90.213) for a mobile station of 2 watts or greater output power is ±2.0 ppm.

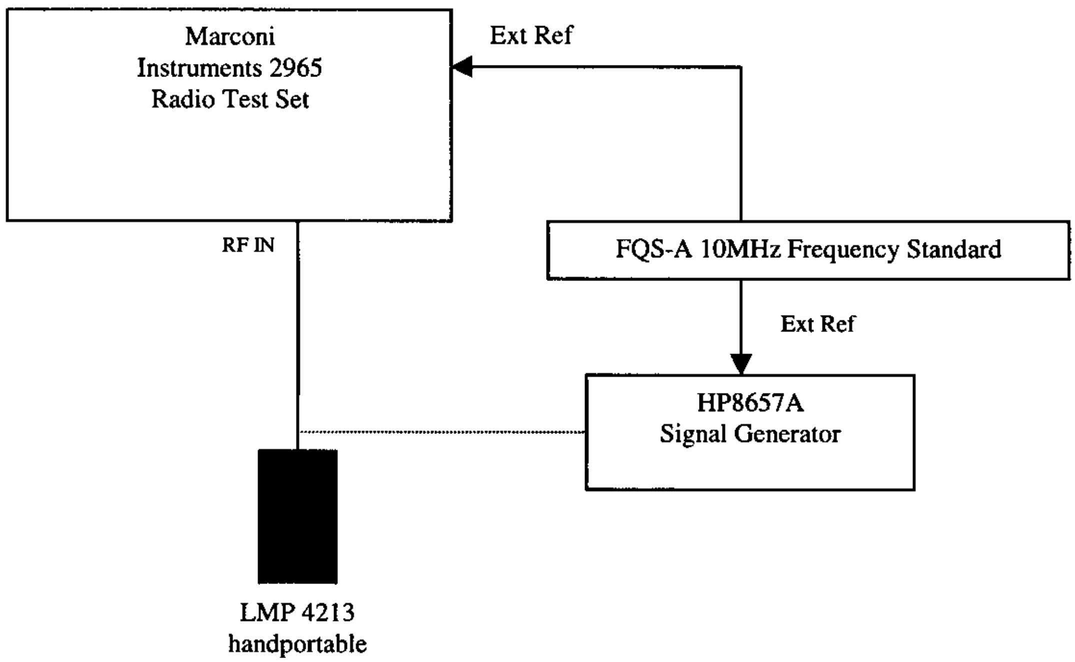
Results


Transmit Frequency Stability With Time
Base Reference Frequency: 156.0000 MHz
0.50
0.40
0.30
0.20
0.10
0.00
-0.10
-0.20
-0.30
-0.40
-0.50
Frequency Error (ppm)
0
1
2
3
4
5
6
7
8
9
10
Transmit time (mins)

5.10 - 90.214 Transient frequency behaviour

In order to measure the frequency stability of the radio with time when the transmitted RF power is switched on a Modulation Domain Analyser was used.

The diagram below illustrates the test configuration used.



Test Method

1. Set the transmitter to 150.0000 MHz. (lowest channel). The handportable is then "locked on " to a reference frequency from the signal generator.
2. Connect the RF output from the handportable to the MOD Domain Analyser.
3. Configure the transmitter to transmit a pilot tone when keyed up.
4. Set the Radio Test Set to Rx Test Mode.
6. The transmitter is keyed up by pressing the PTT.

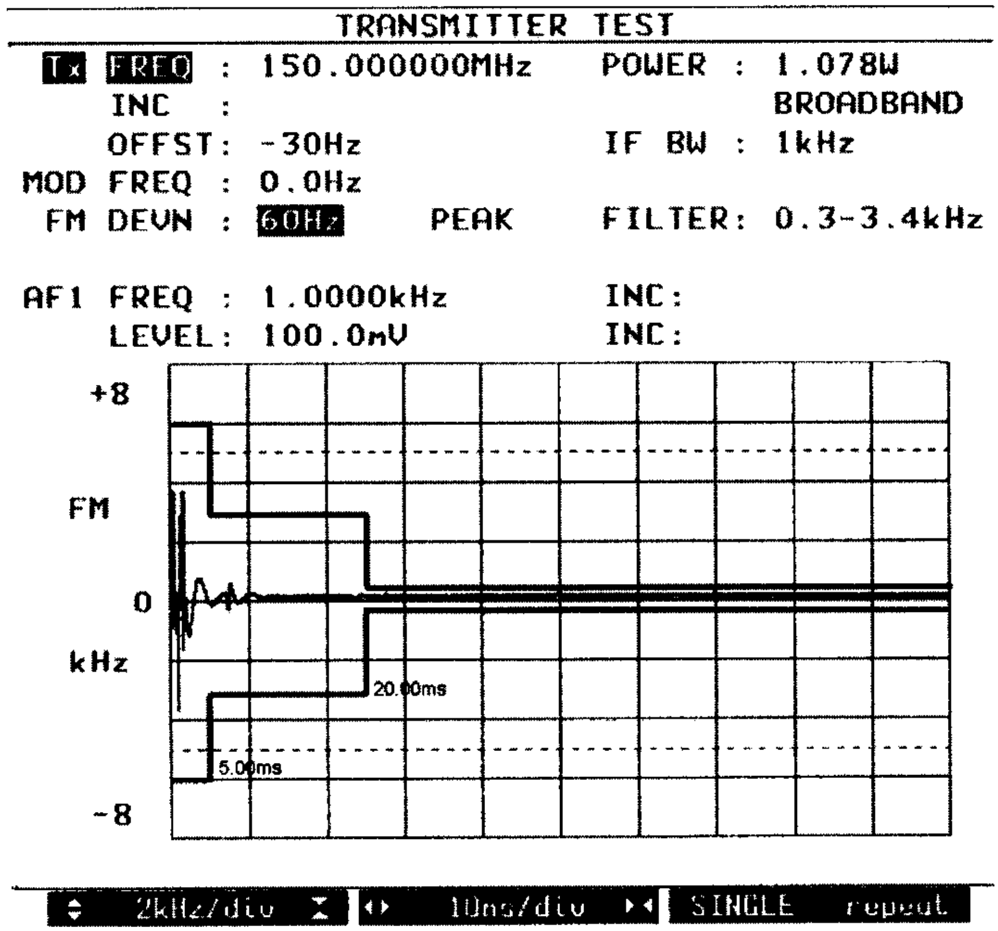
Measurements are made on the lowest, centre and highest channel frequencies.

Results

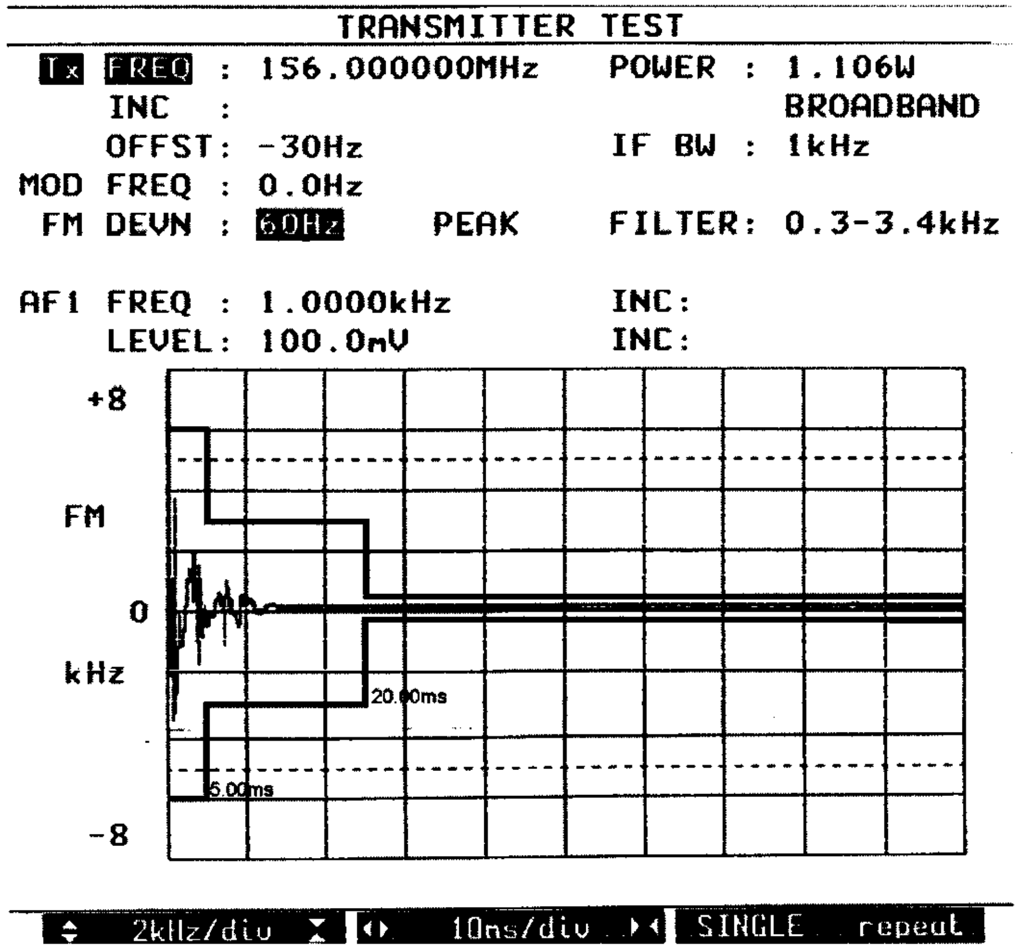
The results of the measurement shown on the following pages demonstrate that the transmitter complies with the requirements of §90.214

The maximum frequency difference limits and there corresponding time intervals are shown on the plots

Transient frequency behaviour plot for low channel (150.0000MHz)



Transient frequency behaviour plot for mid channel (156.0000MHz)



<u>Transient frequency behaviour plot for top channel (162.0000MHz</u>