



Nemko Test Report: 5891RUS6

Applicant: The Charles Machine Works, Inc.
1959 W. Fir Ave
Perry, OK 73077
USA

Equipment Under Test: 752 Tracker
(E.U.T.)

In Accordance With: **FCC Part 90, Subpart I**
Private Land Mobile Transmitter

Tested By: Nemko USA Inc.
802 N. Kealy
Lewisville, TX
75057-3136

TESTED BY:

David Light, Senior Wireless Engineer

DATE: 06 December 2007

APPROVED
BY:

DATE: 10 December, 2007

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EQUIPMENT: 752 Tracker

PROJECT NO.: 5891RUS6_Rev1

Section 1. Summary of Test Results

Manufacturer: The Charles Machine Works, Inc.

Model No.: 752 Tracker

Serial No.: 8268361

General: **All measurements are traceable to national standards.**

These tests were conducted on a sample of the equipment for the purpose of demonstrating compliance with FCC Part 90, Subpart I.



New Submission



Production Unit



Class II Permissive Change



Pre-Production Unit

THIS TEST REPORT RELATES ONLY TO THE ITEM(S) TESTED.

THE FOLLOWING DEVIATIONS FROM, ADDITIONS TO, OR EXCLUSIONS FROM THE TEST SPECIFICATIONS HAVE BEEN MADE. See "Summary of Test Data".

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EQUIPMENT: **752 Tracker****PROJECT NO.:** **5891RUS6_Rev1**

Summary of Test Data

NAME OF TEST	PARA. NO.	RESULT
RF Power Output	90.205	Complies
Audio Frequency Response	TIA EIA-603.3.2.6	NA
Audio Low-Pass Filter Response	TIA EIA-603.3.2.6	NA
Modulation Limiting	TIA EIA-603.3.2.6	Complies
Occupied Bandwidth	90.210	Complies
Spurious Emissions at Antenna Terminals	90.210	Complies
Field Strength of Spurious Emissions	90.210	Complies
Frequency Stability	90.213	Complies
Transient Frequency Behavior	90.214	Complies

Footnotes:

The DUT has no audio components.

EQUIPMENT: 752 Tracker

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Section 2. General Equipment Specification**Transmitter**

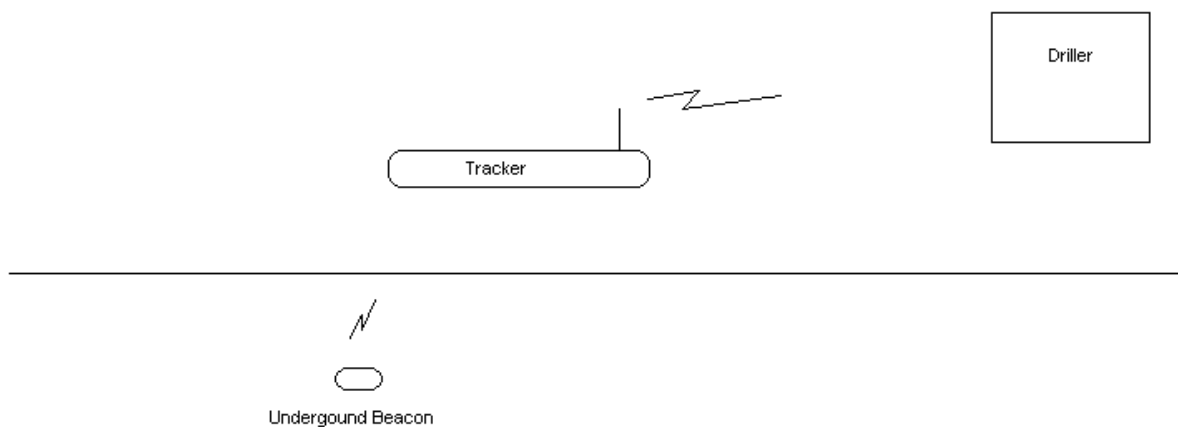
Supply Voltage Input:	9 Vdc										
Frequency Range:	460 to 470 MHz										
Tunable Bands:	461.0375 to 469.550 MHz										
Frequency Deviation(rated):	+/-1.5 kHz max.										
Data rate:	4800 bps										
Necessary Bandwidth:	7.8 kHz (calculated per Carson's Rule) $2(1500\text{Hz}) + 2(4800/2) = 7800 \text{ Hz}$										
Type(s) of Modulation:	<table><thead><tr><th>F3E (Voice)</th><th>F1D</th><th>F2D</th><th>D7W (QAM)</th><th>Other</th></tr></thead><tbody><tr><td><input type="checkbox"/></td><td><input checked="" type="checkbox"/></td><td><input type="checkbox"/></td><td><input type="checkbox"/></td><td><input type="checkbox"/></td></tr></tbody></table>	F3E (Voice)	F1D	F2D	D7W (QAM)	Other	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
F3E (Voice)	F1D	F2D	D7W (QAM)	Other							
<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>							
Emission Designator:	7K8F1D										
Output Impedance:	50 ohms										
RF Power Output (rated):	100 mW										
Channel Spacing(s):	12.5 kHz										
Operator Selection of Operating Frequency:	Dependent on receiver										
Power Output Adjustment Capability:	None										

EQUIPMENT: **752 Tracker**PROJECT NO.: **5891RUS6_Rev1**

System Description

The 752 Tracker is a hand held, 9 channel, dual-conversion, narrow-band FM tracking device used in horizontal directional drilling applications. The tracker provides comprehensive guidance data including pitch, roll angle, depth, location, beacon temperature, battery status, etc. The data is collected and transmitted to a receiver located on the operator's station of a directional drill. The unit operates in the 450MHz-470MHz band and is powered by 6 C-cell alkaline batteries.

System Diagram



EQUIPMENT: 752 Tracker

PROJECT NO.: 5891RUS6_Rev1

Section 3. RF Power Output

NAME OF TEST: RF Power Output	PARA. NO.: 2.985
TESTED BY: David Light	DATE: 05 December 07

Measurement Results: Complies.**Measurement Data:**

Frequency (MHz)	Measured Power (dBm)	Measured Power (Watts)	Rated Power (Watts)
461.0375	20.11	0.103	.100
466.0375	20.05	0.101	.100
469.5500	19.99	0.100	.100

Spectrum Analyzer Settings:

RBW: 1 MHz

VBW: 1 MHz

Detector: Max Peak

Measurement Conditions:

Temperature: 22 °C

Humidity: 31 %

Test Equipment Used: 1036-1082-1469-1470**Measurement Uncertainty:** +/- 1.7 dB

EQUIPMENT: 752 Tracker

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Section 4. Modulation Characteristics

NAME OF TEST: Modulation Characteristics	PARA. NO.: 2.987
TESTED BY: David Light	DATE: 07 December 2007

Measurement Results: Complies.

Measurement Data: See following pages

Measurement Conditions: Temperature: 22 °C
Humidity: 45 %

Measurement Uncertainty: +/- 1.7 dB

Description of modulation: FM

Modulation Limiting

Maximum deviation for non-voice modulation 2.987 kHz.

Limit: 12 kHz

Test Equipment Used: 1036-1082-1469-1470

Measurement Uncertainty: +/- 1.7 dB

EQUIPMENT: 752 Tracker

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Section 5. Occupied Bandwidth

NAME OF TEST: Occupied Bandwidth	PARA. NO.: 2.989
TESTED BY: David Light	DATE: 05 December 07

Measurement Results: Complies.**Measurement Data:** See attached data**Frequency Deviation(rated):** +/-1.5 kHz max.**Data rate:** 4800 bps**Necessary Bandwidth:** 7.8 kHz (calculated per Carson's Rule)

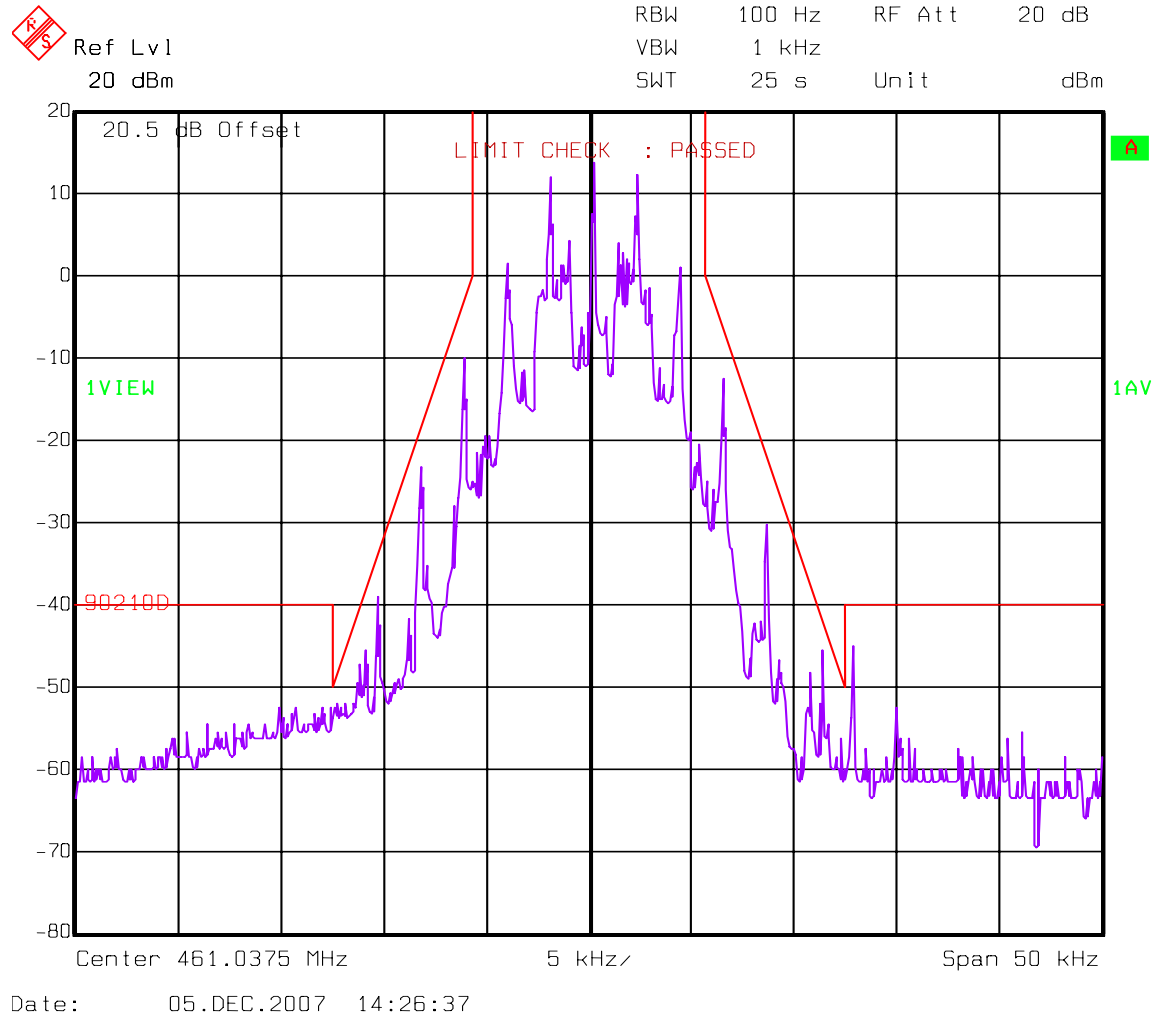
$$2(1500\text{Hz}) + 2(4800/2) = 7800 \text{ Hz}$$

Measurement Conditions: Temperature: 22 °C
Humidity: 31 %**Measurement Uncertainty:** +/- 1×10^{-7} ppm**Test Equipment Used:** 1036-1082-1469-1470

EQUIPMENT: 752 Tracker

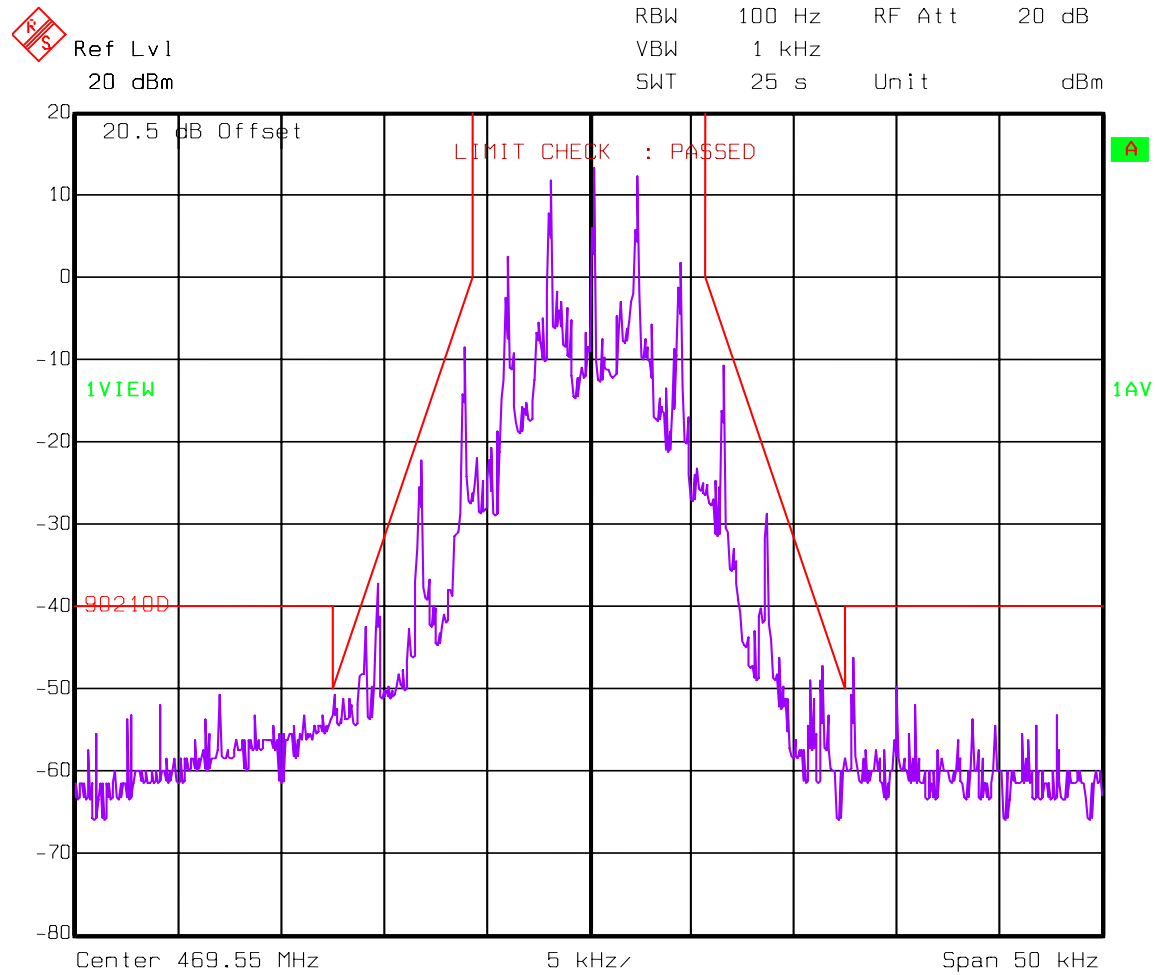
PROJECT NO.: 5891RUS6_Rev1

Test Data – Occupied Bandwidth



EQUIPMENT: **752 Tracker**

PROJECT NO.: **5891RUS6_Rev1**



Date: 05.DEC.2007 14:02:56

EQUIPMENT: 752 Tracker

PROJECT NO.: 5891RUS6_Rev1

Section 6. Spurious Emissions at Antenna Terminals

NAME OF TEST: Spurious Emissions @ Antenna Terminals	PARA. NO.: 2.991
TESTED BY: David Light	DATE: 05 Dec 07

Measurement Results: Complies.

Measurement Data: See attached data

Measurement Conditions: Temperature: 22 °C
Humidity: 31 %

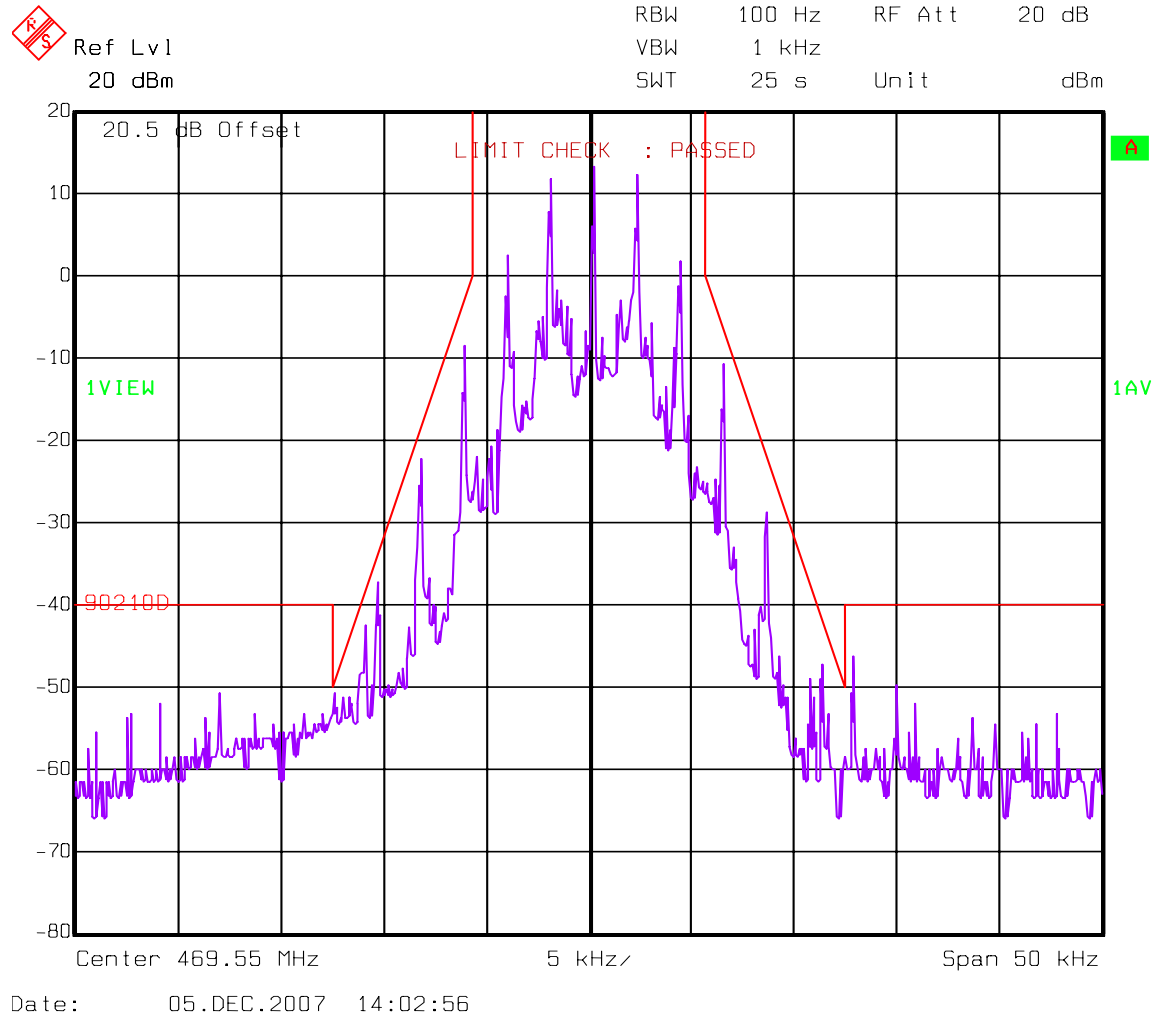
Measurement Uncertainty: +/- 1.7 dB

Test Equipment Used: 1036-1082-1469-1470

EQUIPMENT: 752 Tracker

PROJECT NO.: 5891RUS6_Rev1

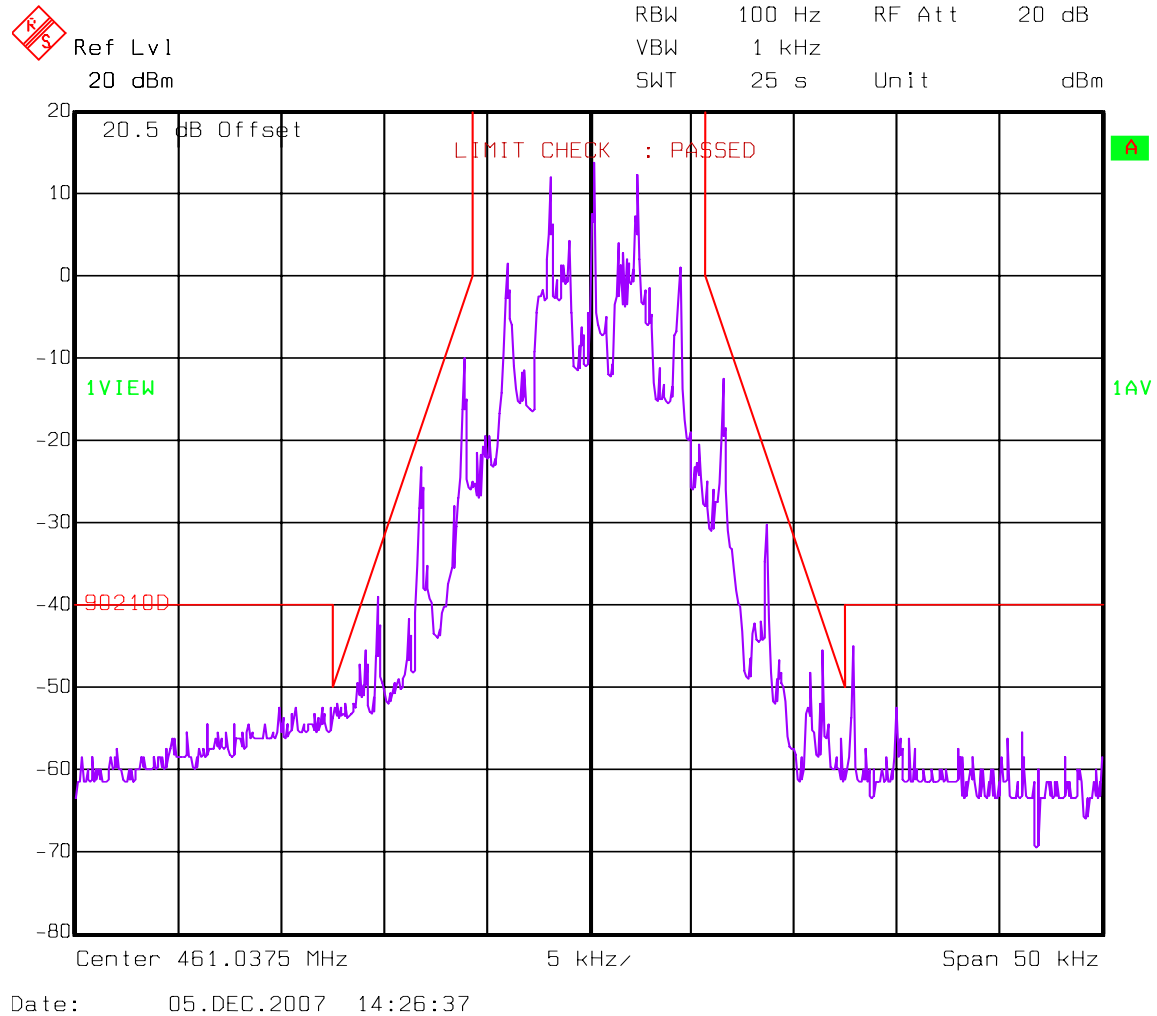
Test Data – Spurious Emissions at Antenna Terminals



EQUIPMENT: 752 Tracker

PROJECT NO.: 5891RUS6_Rev1

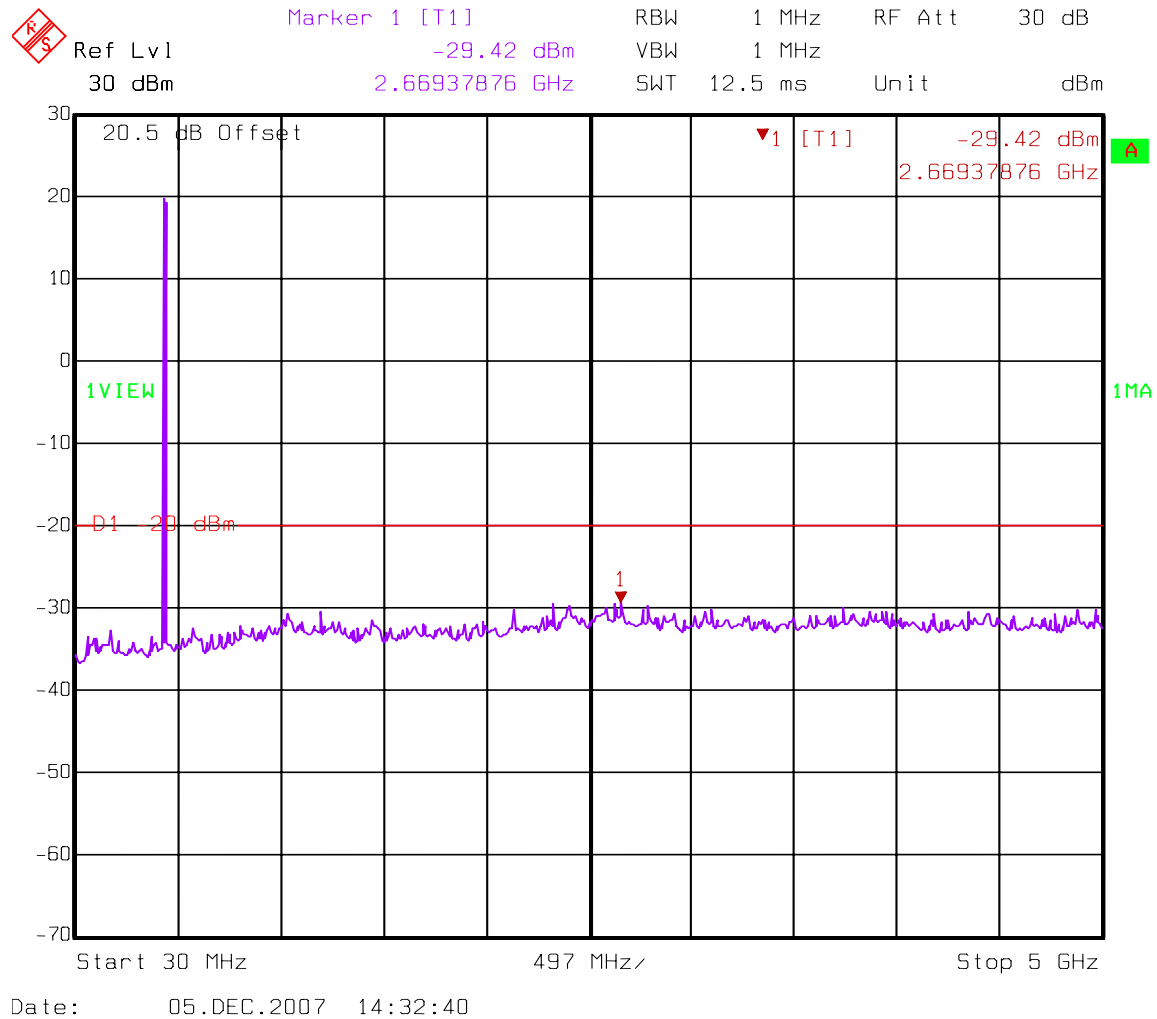
Test Data – Spurious Emissions at Antenna Terminals



EQUIPMENT: 752 Tracker

PROJECT NO.: 5891RUS6_Rev1

Test Data – Spurious Emissions at Antenna Terminals



EQUIPMENT: 752 Tracker

PROJECT NO.: 5891RUS6_Rev1

Section 7. Field Strength of Spurious Emissions

NAME OF TEST: Field Strength of Spurious Emissions	PARA. NO.: 2.993
TESTED BY: David Light	DATE: 05 Dec 07

Measurement Results: Complies.**Measurement Data:** There were no emissions observed within 20 dB of the specification limit of -20 dBm.

The spectrum was searched from 30 to 5000 MHz.

Below 1000 MHz	RBW=VBW=100 kHz	Peak detector
Above 1000 MHz	RBW=VBW=1 MHz	Peak detector

Measurement Conditions:
Temperature: 22 °C
Humidity: 31 %**Measurement Uncertainty:** +/- 1.7 dB**Test Equipment Used:** 1464-1484-1485-1016-791-759-760-993

EQUIPMENT: 752 Tracker

PROJECT NO.: 5891RUS6_Rev1

Section 8. Frequency Stability

NAME OF TEST: Frequency Stability	PARA. NO.: 2.995
TESTED BY: David Light	DATE: 06 Dec 07

Measurement Results: Complies.

Measurement Data: See attached data

Measurement Conditions: Temperature: 22 °C
Humidity: 31 %

Test Equipment Used: 1036-1082-1469-1470-619-283

Measurement Uncertainty: +/- 1×10^{-7} ppm

EQUIPMENT: **752 Tracker**PROJECT NO.: **5891RUS6_Rev1****Test Data – Frequency Stability**

Frequency Stability							
Page <u>1</u> of <u>1</u>							
Job No.: 5891		Date: 12/6/2007					
Specification: 90.210		Temperature(°C): <u>20</u>					
Tested By: <u>David Light</u>		Relative Humidity(%) <u>32</u>					
E.U.T.: <u>752 Tracker</u>							
Configuration: <u>Tx Center Channel</u>							
Sample Number <u>1</u>							
Test Equipment Used							
Antenna: _____		Directional Coupler: _____					
Pre-Amp: _____		Cable #1: <u>1082</u>					
Filter: _____		Cable #2: _____					
Receiver: <u>1036</u>							
Attenuator #1 <u>1064</u>							
Attenuator #2: <u>1065</u>							
Measurement Uncertainty: <u>1x10⁻⁷ppm</u>		Standard Test Frequency <u>466.037500</u> MHz					
Temp (°C)	Measured Frequency (MHz)	Rho	Test Voltage	Frequency Error (Hz)	Limit (+/-Hz)	Error (ppm)	Comment
20	466.037646			146	1165.1	0.3	Vcc= 5.2 Vdc (Battery endpoint)
20	466.037592			92	1165.1	0.2	Vcc= 9 Vdc
20	466.037601			101	1165.1	0.2	Vcc= 10.4 Vdc
50	466.037743			243	1165.1	0.5	
40	466.037699			199	1165.1	0.4	
30	466.037755			255	1165.1	0.5	
10	466.037329			-171	1165.1	-0.4	
0	466.037289			-211	1165.1	-0.5	
-10	466.037320			-180	1165.1	-0.4	
-20	466.037248			-252	1165.1	-0.5	
-30	466.037135			-365	1165.1	-0.8	
Notes: _____							

Limit +/- 2.5 ppm

EQUIPMENT: 752 Tracker

PROJECT NO.: 5891RUS6_Rev1

Section 9. Transient Frequency Behavior

NAME OF TEST: Transient Frequency Behavior	PARA. NO.: 90.214
TESTED BY: David Light	DATE: 07 December 2007

Measurement Results: Complies.**Measurement Data:** See attached data

Frequency deviation: +/- 2987 Hz

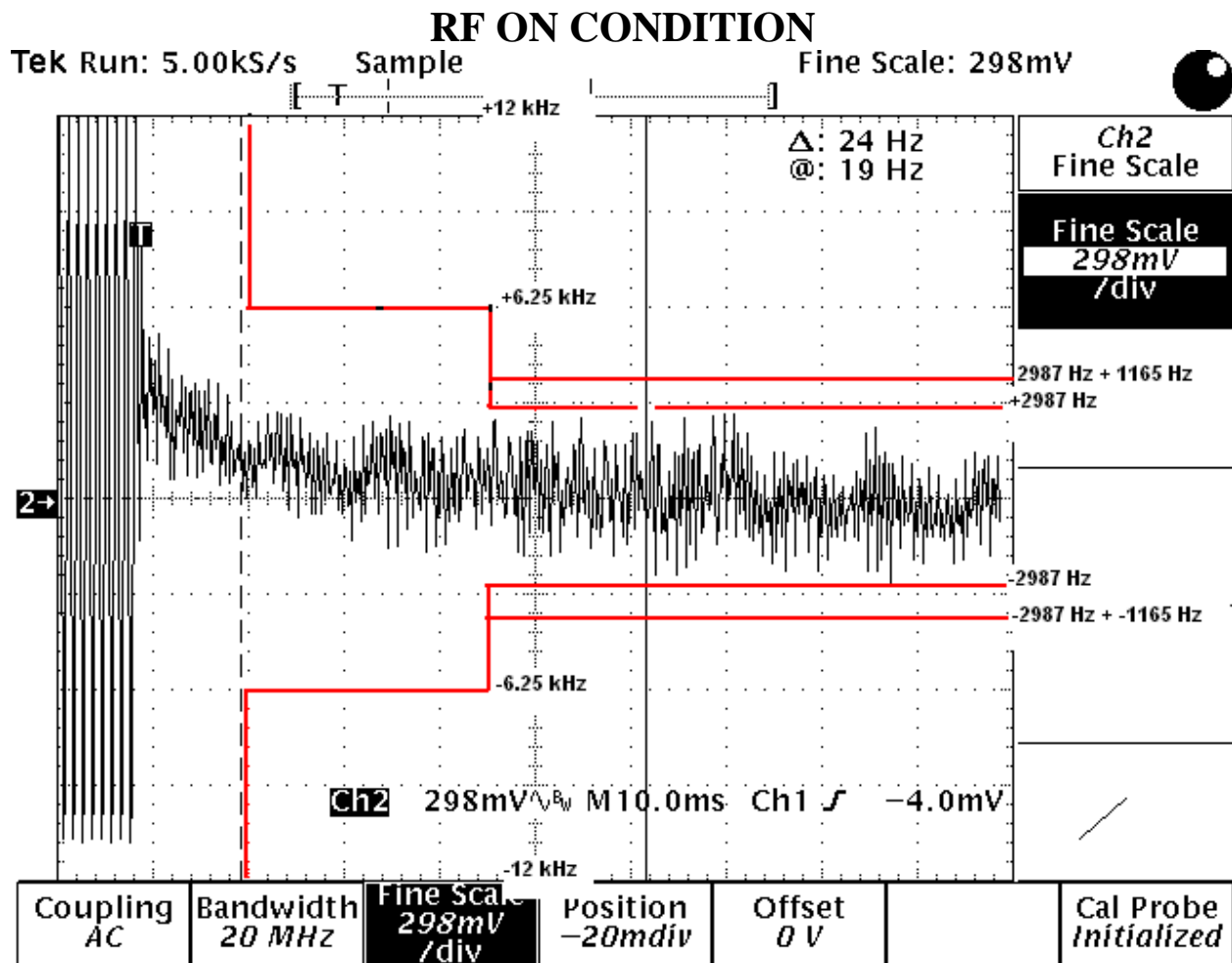
Maximum frequency drift: +/- 1165 Hz

Measurement Conditions: Temperature: 22 °C
Humidity: 31 %**Test Equipment Used:** 1463-1082-1054-1093-1051**Measurement Uncertainty:** +/- 1×10^{-7} ppm

EQUIPMENT: 752 Tracker

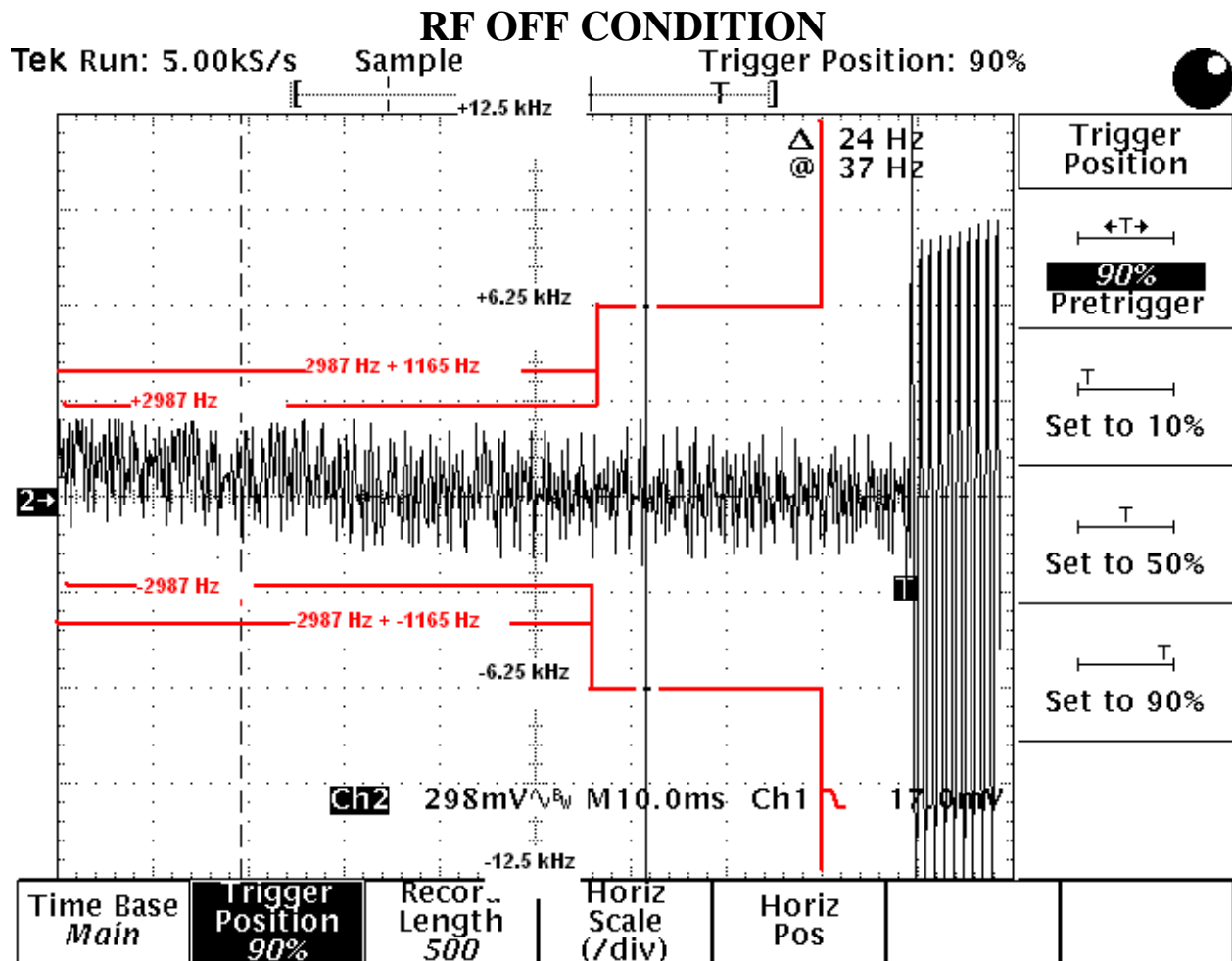
PROJECT NO.: 5891RUS6_Rev1

Test Data – Transient Frequency Behavior



EQUIPMENT: 752 Tracker

PROJECT NO.: 5891RUS6_Rev1



EQUIPMENT: **752 Tracker**PROJECT NO.: **5891RUS6_Rev1****Section 10. Test Equipment List**

Nemko ID	Description	Manufacturer Model Number	Serial Number	Calibration Date	Calibration Due
1036	SPECTRUM ANALYZER	ROHDE & SCHWARZ FSEK30	830844/006	05/26/06	05/26/08
1082	CABLE 2m	Astrolab 32027-2-29094-72TC	N/A	CBU	N/A
1469	10 db Attenuator DC 18 Ghz	MCL Inc. BW-S10W2 10db-2WDC	NONE	CBU	N/A
1470	10 db Attenuator DC 18 Ghz	MCL Inc. BW-S10W2 10db-2WDC	NONE	CBU	N/A
1464	Spectrum analyzer	Hewlett Packard 8563E	3551A04428	01/24/07	01/24/09
1484	Cable	Storm PR90-010-072	N/A	05/02/07	05/01/08
1485	Cable	Storm PR90-010-216	N/A	05/02/07	05/01/08
1016	Pre-Amp	HEWLETT PACKARD 8449A	2749A00159	05/01/07	04/30/08
791	PREAMP, 25dB	Nemko USA, Inc. LNA25	398	05/01/07	04/30/08
759	ANTENNA, LOG PERIODIC	A.H. SYSTEMS SAS-200/510	556	03/30/07	03/29/08
760	Antenna biconical	Electro Metrics MFC-25	477	01/19/07	01/19/08
993	Horn antenna	A.H. Systems SAS-200/571	XXX	08/31/07	08/30/08
619	THERMOMETER	FLUKE 51	4520028	03/01/07	02/29/08
283	Environmental Chamber with controller # 1189006	ENVIROTRONICS SH27 & 2030-22844	129010083	CNR	NA
1463	Color 4 Ch Digitizing Oscilloscope	Tektronix TDS684A	B010460	03/07/07	03/06/08
1054	DUAL DIRECTIONAL COUPLER	NARDA 3020A	34366	CBU	N/A
1093	COMBINER	MINI-CIRCUITS ZFSC-3-4	NONE	CBU	N/A
1051	Radio Communication Analyzer	Rhode & Schwarz CMTA-54	835875/002	CNR	N/A

ANNEX A - TEST METHODOLOGIES

EQUIPMENT: 752 Tracker

PROJECT NO.: 5891RUS6_Rev1

NAME OF TEST: RF Power Output**PARA. NO.: 2.985**

Minimum Standard: Para. No. 90.205(a). The maximum allowable station ERP is dependent upon the stations HAAT and required service area and will be authorized in accordance with Table 1 of 90.205(d).

Method Of Measurement:Detachable Antenna:

The peak power at antenna terminals is measured using a spectrum analyzer with the IF bandwidth filter set to a level greater than the 20 dB bandwidth of the measured rf waveform. Power output is measured with the maximum rated input level.

Integral Antenna:

If the antenna is not detachable from the circuit then the Peak Power Output is derived from the peak radiated field strength of the fundamental emission by using the plane wave relation $GP/4\pi R^2 = E^2/120\pi$ and proceeding as follows:

$$P = \frac{E^2 R^2}{30G} = \frac{E^2 3^2}{30G}$$

where,

P = the equivalent isotropic radiated power in watts

E = the maximum measured field strength in V/m

R = the measurement range (3 meters)

G = the numeric gain of the transmit antenna in relation to an isotropic radiator

EQUIPMENT: 752 Tracker

PROJECT NO.: 5891RUS6_Rev1

NAME OF TEST: Occupied Bandwidth**PARA. NO.: 2.989****Minimum Standard:** Para. No. 90.210, see table 1 below for applicable mask.**Table 1**

Frequency Band (MHz)	Mask for equipment with Low Pass Filter	Mask for equipment without Low Pass Filter
Below 25	A or B	A or C
25 - 50	B	C
72 - 76	B	C
150 - 174	B, D or E	C, D or E
150 Paging only	B	C
220 - 222	F	F
421 - 512	B, D or E	C, D or E
450 paging only	B	H
806 - 821/ 851 - 866	B	G
821 - 824/ 866 - 869	B	H
896 - 901/ 935 - 940	I	J
902 - 928	K	K
929 - 930	B	G
Above 940	B	C
All other bands	B	C

Test Method:

RBW: 1% of emission bandwidth in 0 - 1 GHz range. 1 MHz at frequencies above 1 GHz.

VBW: \Rightarrow RBW

The spectrum is search up to 10 times the fundamental frequency.

EQUIPMENT: 752 Tracker

PROJECT NO.: 5891RUS6_Rev1

NAME OF TEST: Field Strength of Spurious**PARA. NO.: 2.993****Minimum Standard:** Para. No. 90.210, see table 1 for applicable mask.**Calculation of Field Strength Limit**

An example of attenuation requirement of $50 + 10 \log P$ is equivalent to -20 dBm (1×10^{-5} Watts) at the antenna terminal. We determine the field strength limit by using the plane wave relation.

$$GP/4\pi R^2 = E^2/120\pi$$

For emissions ≤ 1 GHz:

G = 1.64 (Dipole Gain)

P = 10^{-5} Watts (Maximum spurious output power)

R = 3m (Measurement Distance)

$$E = \frac{\sqrt{30GP}}{R} = E = \frac{\sqrt{30 \times 1.64 \times 10^{-5}}}{3} = 0.00739 \text{ V / m} = 77.4 \text{ dB}\mu\text{V / m}$$

For emissions > 1 GHz:

G = 1 (Isotropic Gain)

P = 1×10^{-5} Watts (Maximum spurious output power)

R = 3m (Measurement Distance)

$$E = 77.4 - 20 \log \sqrt{1.64} = 75.2 \text{ dB}\mu\text{V / m@3m}$$

MASK	Spurious Limit	FS Limit Below 1 GHz	FS Limit Above 1 GHz
A,B,C,G,H,I	-13dBm	84.4 dB μ V/m@3m	82.2 dB μ V/m@3m
D,J	-20dBm	77.4 dB μ V/m@3m	75.2 dB μ V/m@3m
E,F,K	-25dBm	72.4 dB μ V/m@3m	70.2 dB μ V/m@3m

EQUIPMENT: **752 Tracker**PROJECT NO.: **5891RUS6_Rev1****NAME OF TEST: Frequency Stability****PARA. NO.: 2.995**

Minimum Standard: Para. No. 990.213. The transmitter carrier frequency shall remain

within the assigned frequency below in ppm.

Table 2

Frequency Band (MHz)	Fixed And Base Stations	Mobile Stations	
		> 2 Watts o/p pwr	< 2 Watts o/p pwr
Below 25	100	100	200
25 - 50	20	20	50
72 - 76	5	-	50
150 - 174	5	5	5
220 - 222	0.1	1.5	1.5
421 - 512	2.5	5	5
806 - 821	1.5	2.5	2.5
821 - 824	1.0	1.5	15
851 - 866	1.5	2.5	2.5
866 - 869	1.0	1.5	1.5
869 - 901	0.1	1.5	1.5
902 - 928	2.5	2.5	2.5
929 - 930	1.5	-	-
935 - 940	0.1	1.5	1.5
1427 - 1435	300	300	300
Above 2450	-	-	-

NAME OF TEST: Transient Frequency Behavior**PARA. NO.: 2.214****Minimum Standard:****Transient Frequency Behavior for Equipment Designed to Operate on 25 kHz Channels**

Time intervals ^{1,2}	Maximum Frequency difference ³ (kHz)	Frequency ranges (MHz) All equipment					
		Base station and portable radios			Mobile Radios		
		150 - 174 (ms)	450 - 500 (ms)	500 - 512 (ms)	150 - 174 (ms)	450 - 500 (ms)	500 - 512 (ms)
t ₁ ⁴	± 25	5.0	10.0	20.0	5.0	10.0	5.0
t ₂	± 12	20.0	25.0	50.0	20.0	25.0	20.0
t ₃ ⁴	± 25	5.0	10.0	10.0	5.0	10.0	5.0

Transient Frequency Behavior for Equipment Designed to Operate on 12.5 kHz & 6.25 kHz Channels

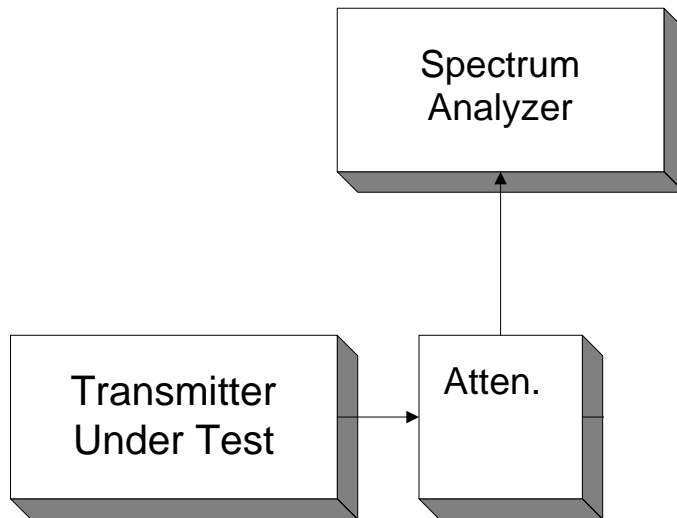
Time intervals ^{1,2}	Maximum Frequency difference ³ (kHz)	Frequency ranges (MHz) All equipment		
		150 - 174 (ms)	450 - 500 (ms)	500 - 512 (ms)
t ₁ ⁴	± 12.5 / ± 6.25	5.0	10.0	20.0
t ₂	± 6.25 / ± 3.125	20.0	25.0	50.0
t ₃ ⁴	± 12.5 / ± 6.25	5.0	10.0	10.0

ANNEX B - TEST DIAGRAMS

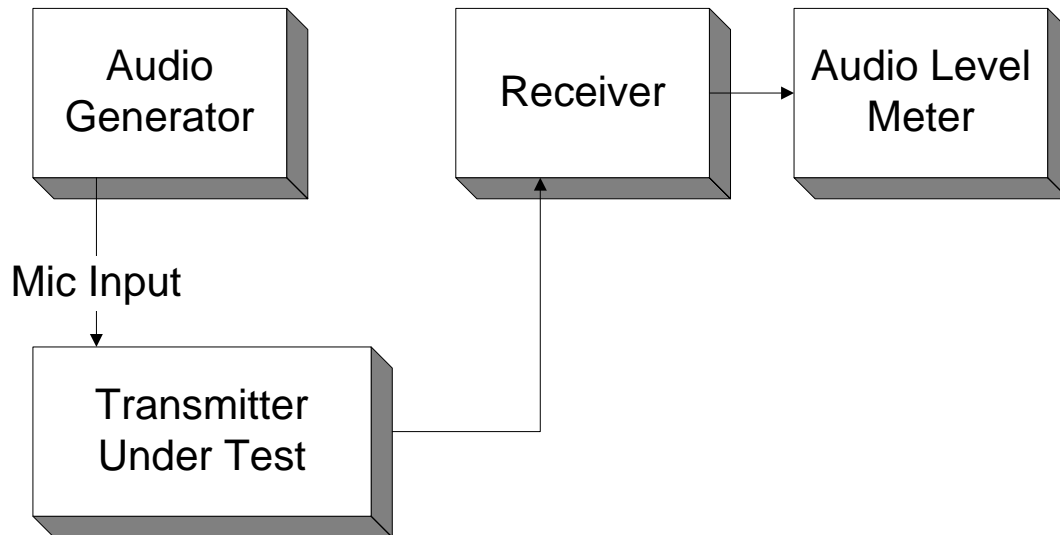
EQUIPMENT: **752 Tracker**

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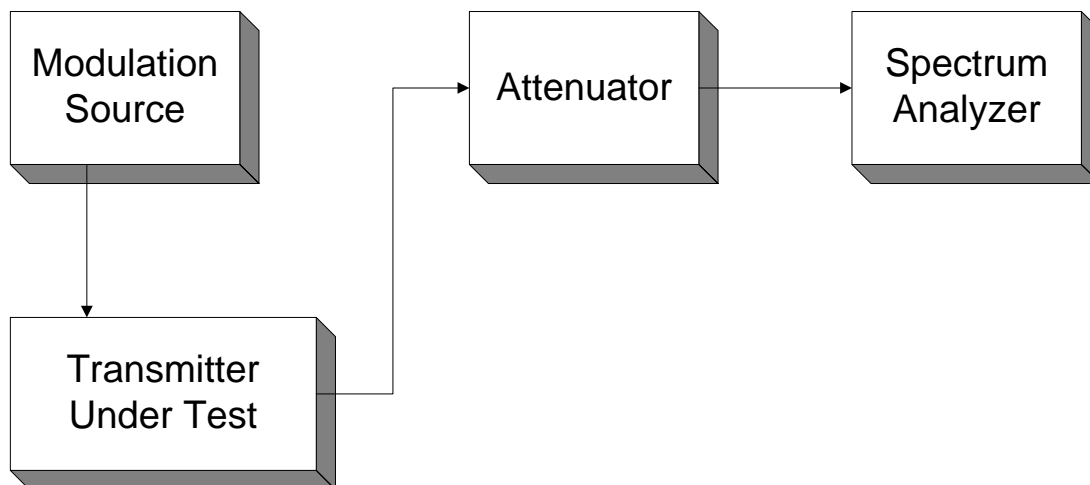
Para. No. 2.985 - R.F. Power Output



Para. No. 2.987(b) - Modulation Limiting



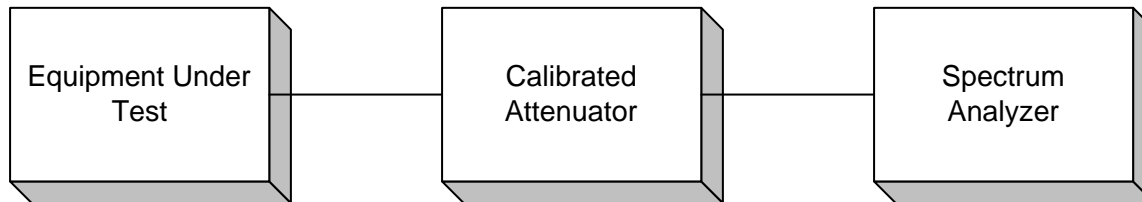
Para. No. 2.989 - Occupied Bandwidth



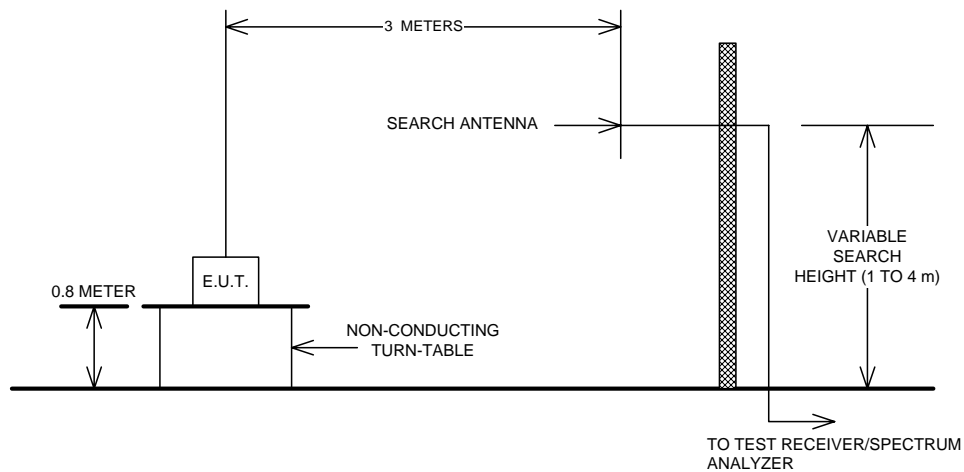
EQUIPMENT: **752 Tracker**

PROJECT NO.: **5891RUS6_Rev1**

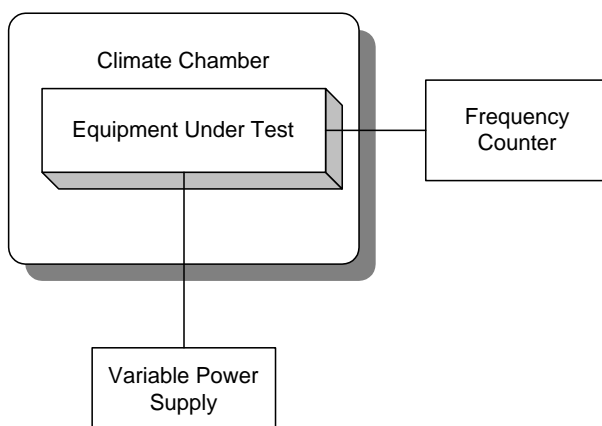
Para. No. 2.991 - Spurious Emissions at Antenna Terminals

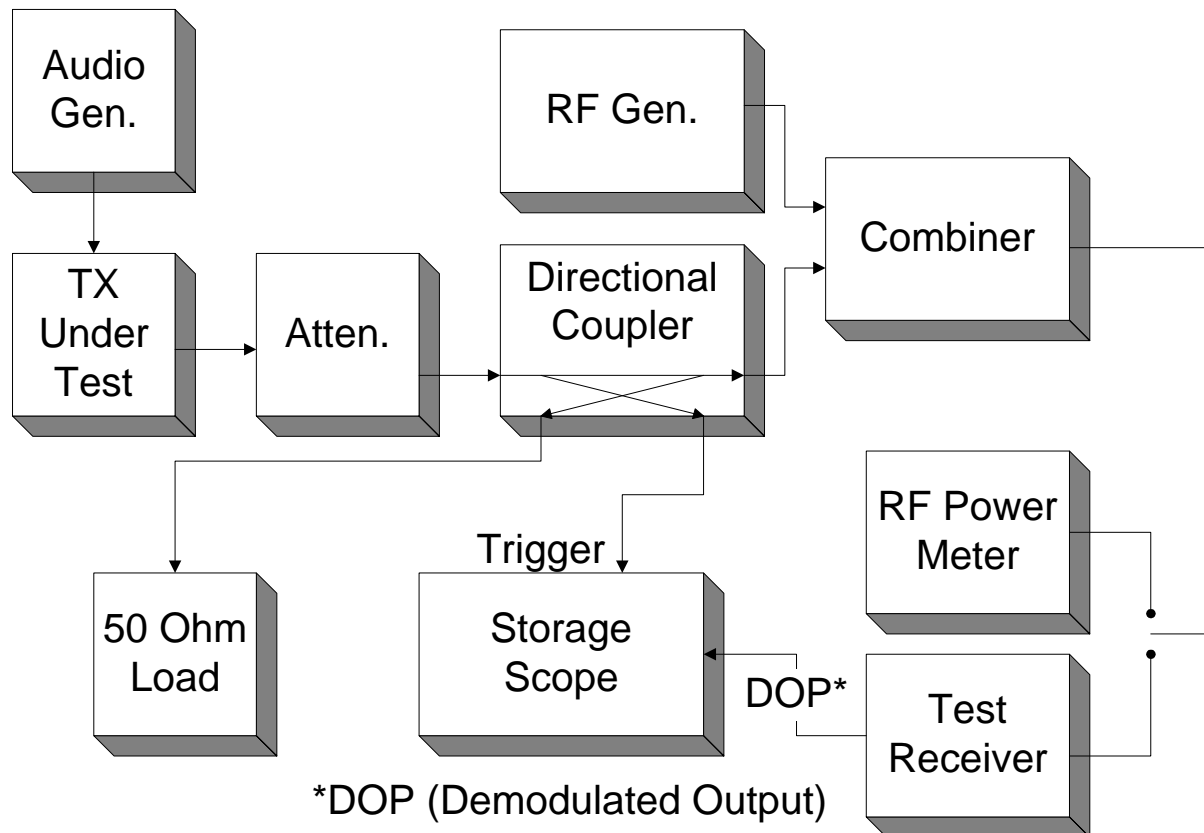


Para. No. 2.993 - Field Strength of Spurious Radiation



Para. No. 2.995 - Frequency Stability



Para. No. 90.214 - Transient Frequency Behavior**Voice**

This measurement was made using measurement procedure TIA/EIA Land Mobile FM or PM Communications Equipment Measurement and Performance Standards TIA/EIA-603 February 1993 Telecommunications Industry Association (American National Standard ANSI/TIA/EIA-603-1992 Approved: October 27, 1992) Para. no. 2.2 Methods of Measurement for Transmitters

Para. no. 2.2.19 Transient Frequency Behavior (page no. 83).

Data

This measurement was made using measurement procedure TIA/EIA Digital C4FM/CQPSK Transceiver Measurement Methods TSB102.CAAA Para. no. 2.2.17 Transient Frequency Behavior