



Nemko Test Report: 10033RUS4


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

Equipment Under Test: 750 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: 07 April, 2008

APPROVED
BY:


Mike Cantwell, Frontline Manager

DATE: 8 May, 2008

Total Number of Pages: 30

Table of Contents

SECTION 1.	SUMMARY OF TEST RESULTS	3
SECTION 2.	GENERAL EQUIPMENT SPECIFICATION	5
SECTION 3.	RF POWER OUTPUT	7
SECTION 4.	MODULATION CHARACTERISTICS	8
SECTION 5.	OCCUPIED BANDWIDTH	9
SECTION 6.	SPURIOUS EMISSIONS AT ANTENNA TERMINALS	11
SECTION 7.	FIELD STRENGTH OF SPURIOUS EMISSIONS	14
SECTION 8.	FREQUENCY STABILITY	15
SECTION 9.	TRANSIENT FREQUENCY BEHAVIOR	17
SECTION 10.	TEST EQUIPMENT LIST	20
ANNEX A - TEST METHODOLOGIES		21
ANNEX B - TEST DIAGRAMS		26

EQUIPMENT: 750 Tracker

PROJECT NO.: 10033RUS4

Section 1. Summary of Test Results

Manufacturer: The Charles Machine Works, Inc.

Model No.: 750 Tracker

Serial No.: 8270423

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: **750 Tracker****PROJECT NO.:** **10033RUS4**

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: 750 Tracker

PROJECT NO.: 10033RUS4

Section 2. General Equipment Specification**Transmitter**

Supply Voltage Input:	9 Vdc										
Frequency Range:	460 to 470 MHz										
Tunable Bands:	469.50 to 469.55 MHz										
Necessary Bandwidth:	12.5 kHz										
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										

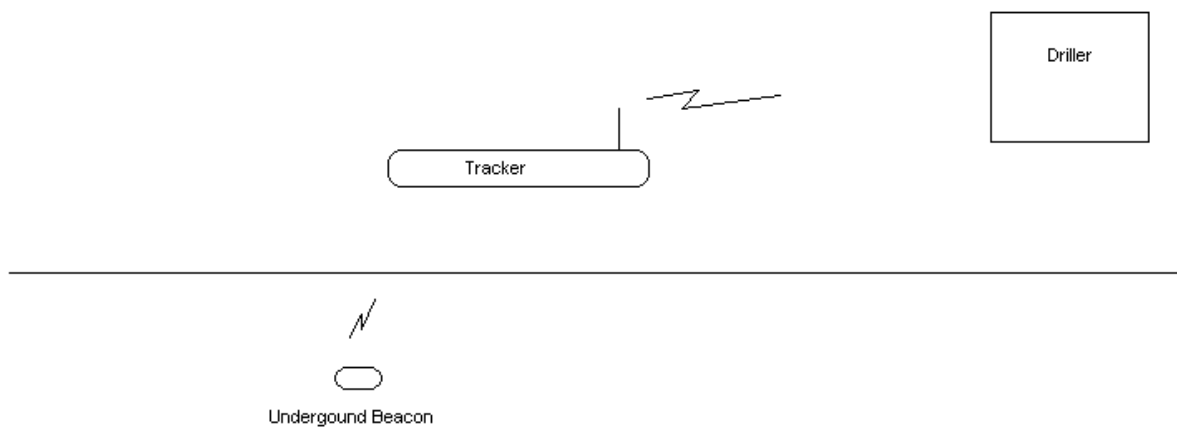
EQUIPMENT: 750 Tracker

PROJECT NO.: 10033RUS4

System Description

The 750 Tracker is a hand held, 2 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: 750 Tracker

PROJECT NO.: 10033RUS4

Section 3. RF Power Output

NAME OF TEST: RF Power Output	PARA. NO.: 2.985
TESTED BY: David Light	DATE: 04 April 2008

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

Frequency (MHz)	Measured Power (dBm)	Measured Power (Watts)	Rated Power (Watts)
469.50	20.29	0.107	0.100
469.55	20.58	0.114	0.100

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: **750 Tracker**PROJECT NO.: **10033RUS4**

Section 4. Modulation Characteristics

NAME OF TEST: Modulation Characteristics	PARA. NO.: 2.987
TESTED BY: David Light	DATE: 04 April 2008

Measurement Results: Complies.**Measurement Data:** Maximum deviation for non-voice
modulation 2.774 kHz.

Limit: 12 kHz

Measurement Conditions: Temperature: **22** °C
 Humidity: **45** %**Measurement Uncertainty:** +/- 1.7 dB**Description of modulation:** **FM****Test Equipment Used:** 1036-1082-1469-1470**Measurement Uncertainty:** +/- 1.7 dB

EQUIPMENT: 750 Tracker

PROJECT NO.: 10033RUS4

Section 5. Occupied Bandwidth

NAME OF TEST: Occupied Bandwidth	PARA. NO.: 2.989
TESTED BY: David Light	DATE: 04 April 2008

Measurement Results: Complies.

Measurement Data: 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 %

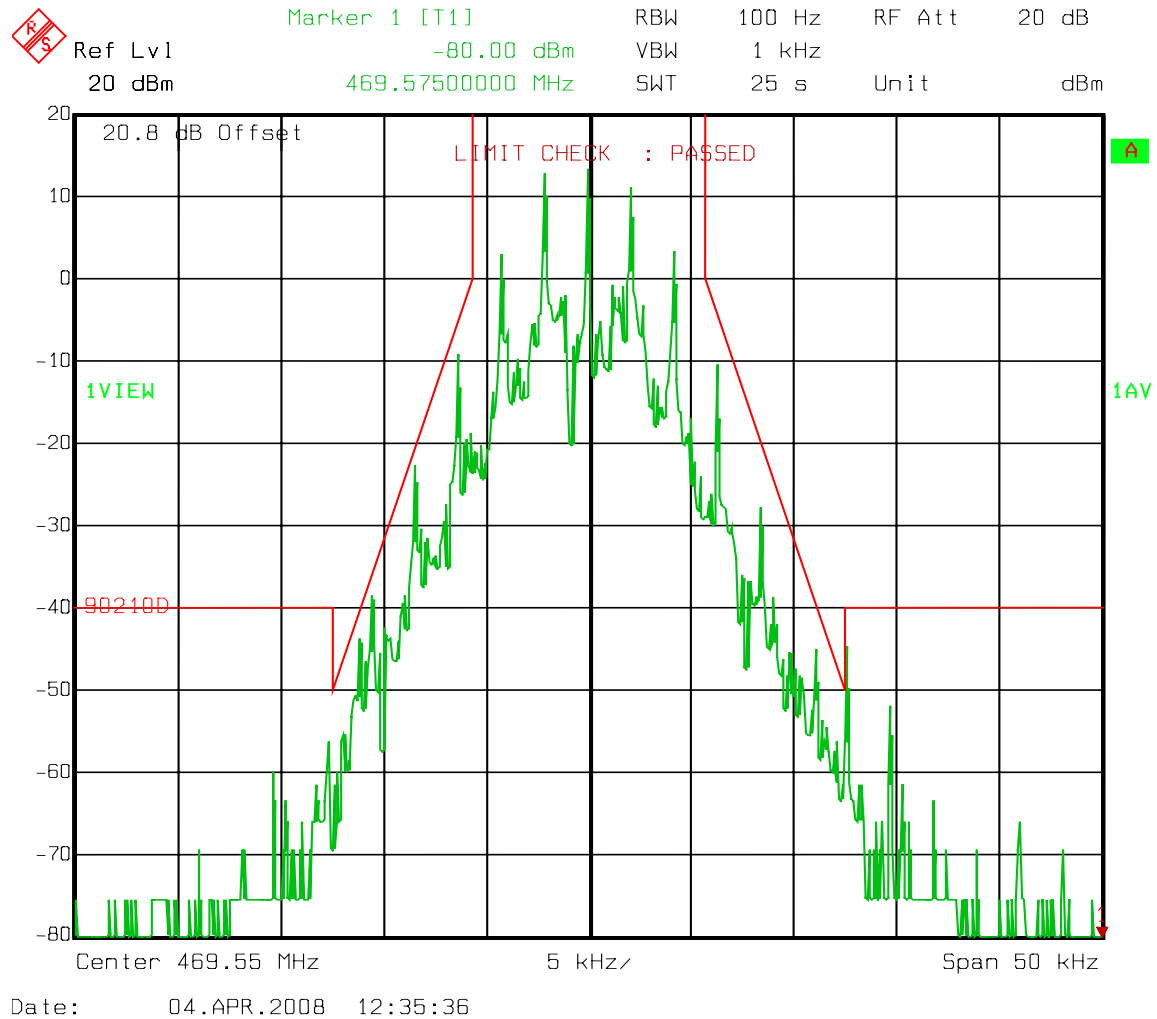
Measurement Uncertainty: +/- 1×10^{-7} ppm

Test Equipment Used: 1036-1082-1469-1470

EQUIPMENT: 750 Tracker

PROJECT NO.: 10033RUS4

Test Data – Occupied Bandwidth



EQUIPMENT: 750 Tracker

PROJECT NO.: 10033RUS4

Section 6. Spurious Emissions at Antenna Terminals

NAME OF TEST: Spurious Emissions @ Antenna Terminals	PARA. NO.: 2.991
TESTED BY: David Light	DATE: 04 April 2008

Measurement Results: Complies.

Measurement Data: See attached data

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

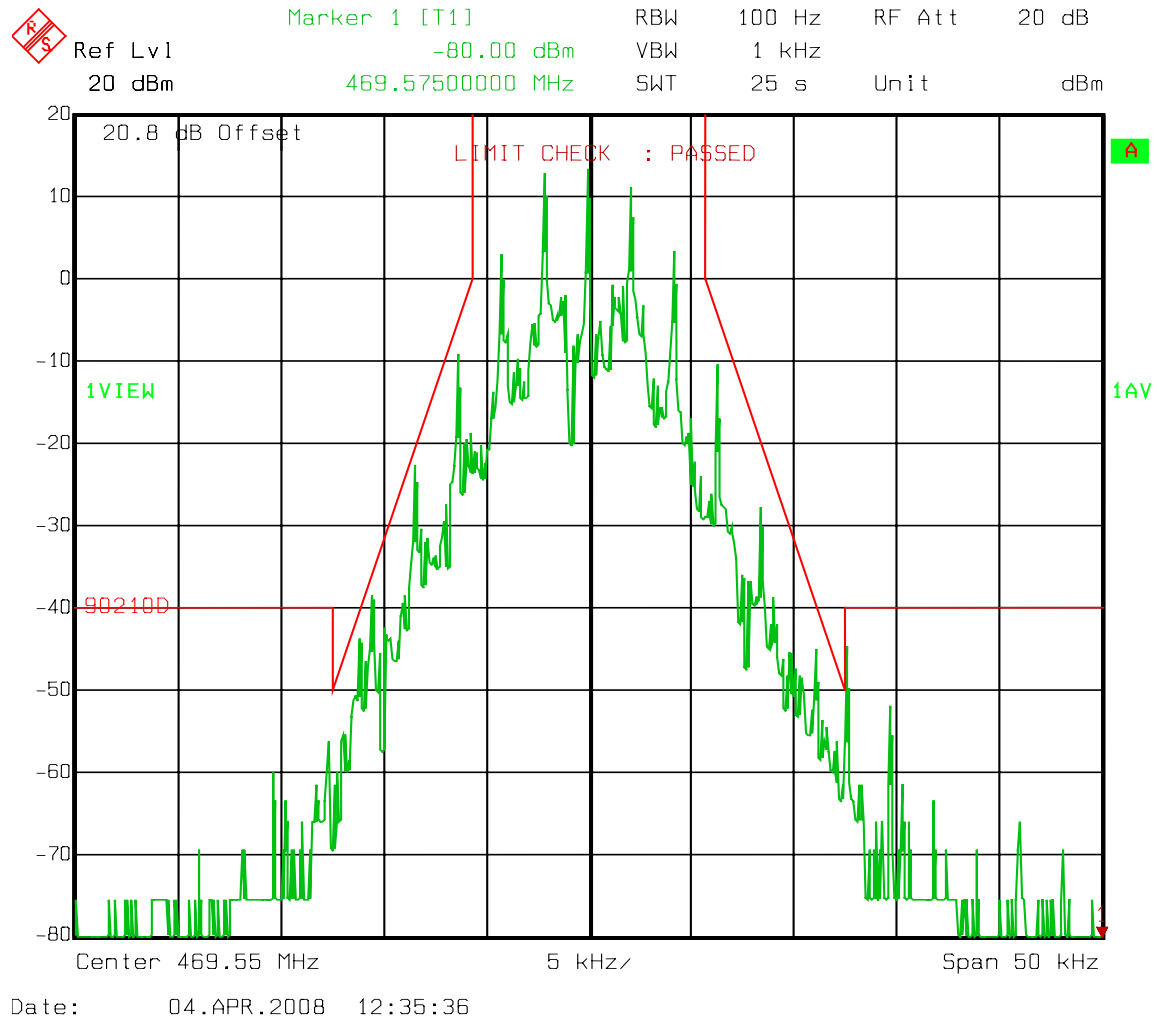
Measurement Uncertainty: +/- 1.7 dB

Test Equipment Used: 1036-1082-1469-1470

EQUIPMENT: 750 Tracker

PROJECT NO.: 10033RUS4

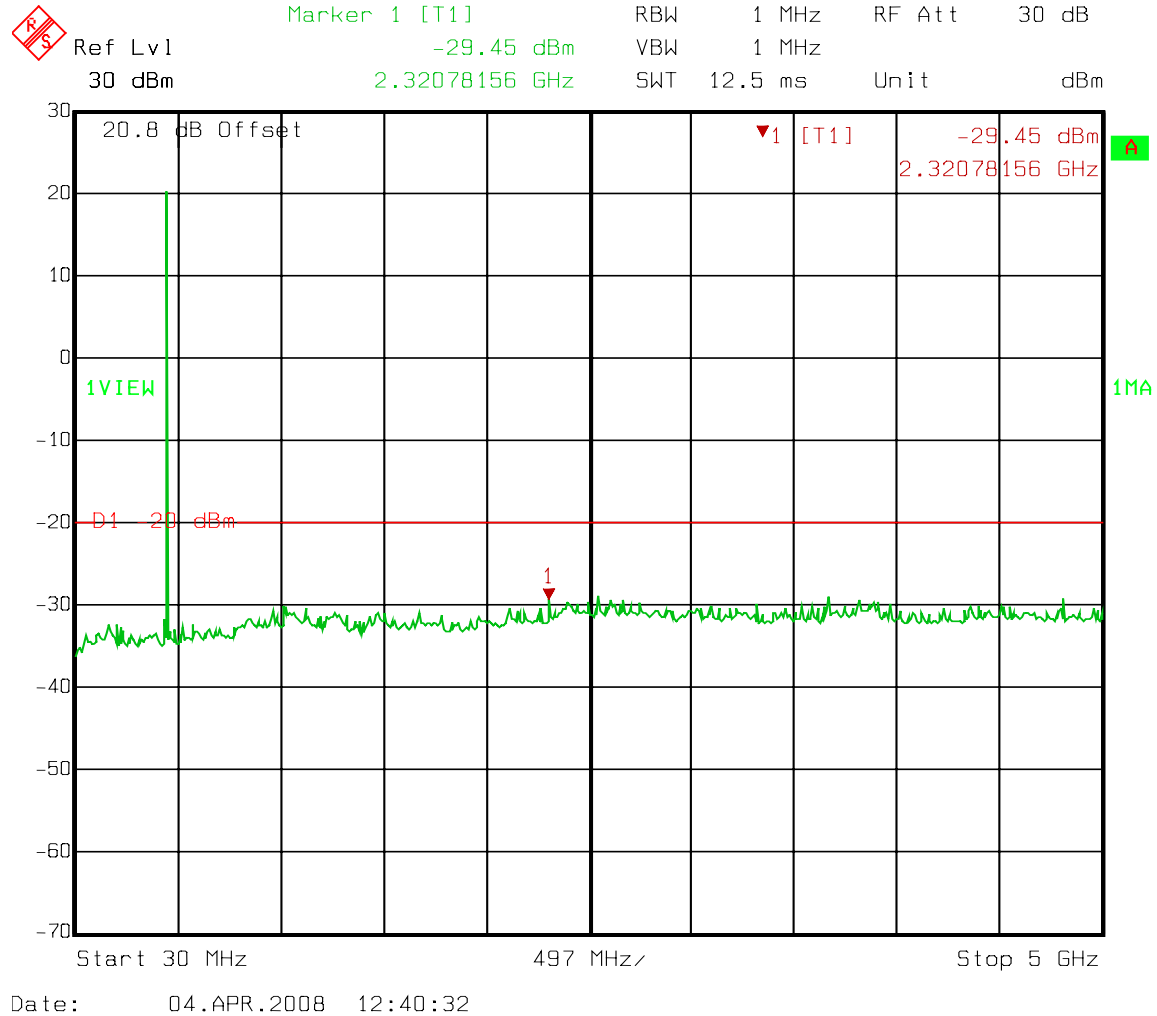
Test Data – Spurious Emissions at Antenna Terminals



EQUIPMENT: 750 Tracker

PROJECT NO.: 10033RUS4

Test Data – Spurious Emissions at Antenna Terminals



EQUIPMENT: **750 Tracker**PROJECT NO.: **10033RUS4**

Section 7. Field Strength of Spurious Emissions

NAME OF TEST: Field Strength of Spurious Emissions	PARA. NO.: 2.993
TESTED BY: David Light	DATE: 04 April 2008

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:** 1464-1484-1485-1016-993-1763-1762-1025

EQUIPMENT: 750 Tracker

PROJECT NO.: 10033RUS4

Section 8. Frequency Stability

NAME OF TEST: Frequency Stability	PARA. NO.: 2.995
TESTED BY: David Light	DATE: 07 April 2008

Measurement Results: Complies.

Measurement Data: See attached data

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

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

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

EQUIPMENT: **750 Tracker**PROJECT NO.: **10033RUS4****Test Data – Frequency Stability**

Nominal Test Frequency = 469.55 MHz

Temp (°C)	Measured Frequency (MHz)		Test Voltage	Frequency Error (Hz)	Limit (+/-Hz)	Error (ppm)	Comment
20	469.549980		9 Vdc	-20	1173.9	-0.04	Nominal
20	469.549980		5.2 Vdc	-20	1173.9	-0.04	Battery cutoff
20	469.549980		10.4 Vdc	-20	1173.9	-0.04	
50	469.549960		9 Vdc	-40	1173.9	-0.09	
40	469.549960		9 Vdc	-40	1173.9	-0.09	
30	469.549960		9 Vdc	-40	1173.9	-0.09	
			9 Vdc				
10	469.550020		9 Vdc	20	1173.9	0.04	
0	469.550020		9 Vdc	20	1173.9	0.04	
-10	469.550020		9 Vdc	20	1173.9	0.04	
-20	469.550020		9 Vdc	20	1173.9	0.04	
-30	469.550020		9 Vdc	20	1173.9	0.04	
Notes:							

Limit +/- 2.5 ppm

EQUIPMENT: 750 Tracker

PROJECT NO.: 10033RUS4

Section 9. Transient Frequency Behavior

NAME OF TEST: Transient Frequency Behavior	PARA. NO.: 90.214
TESTED BY: David Light	DATE: 04 April 2008

Measurement Results: Complies.

Measurement Data: See attached data

Frequency deviation: +/- 2774 Hz

Maximum frequency drift: +/- 1165 Hz

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

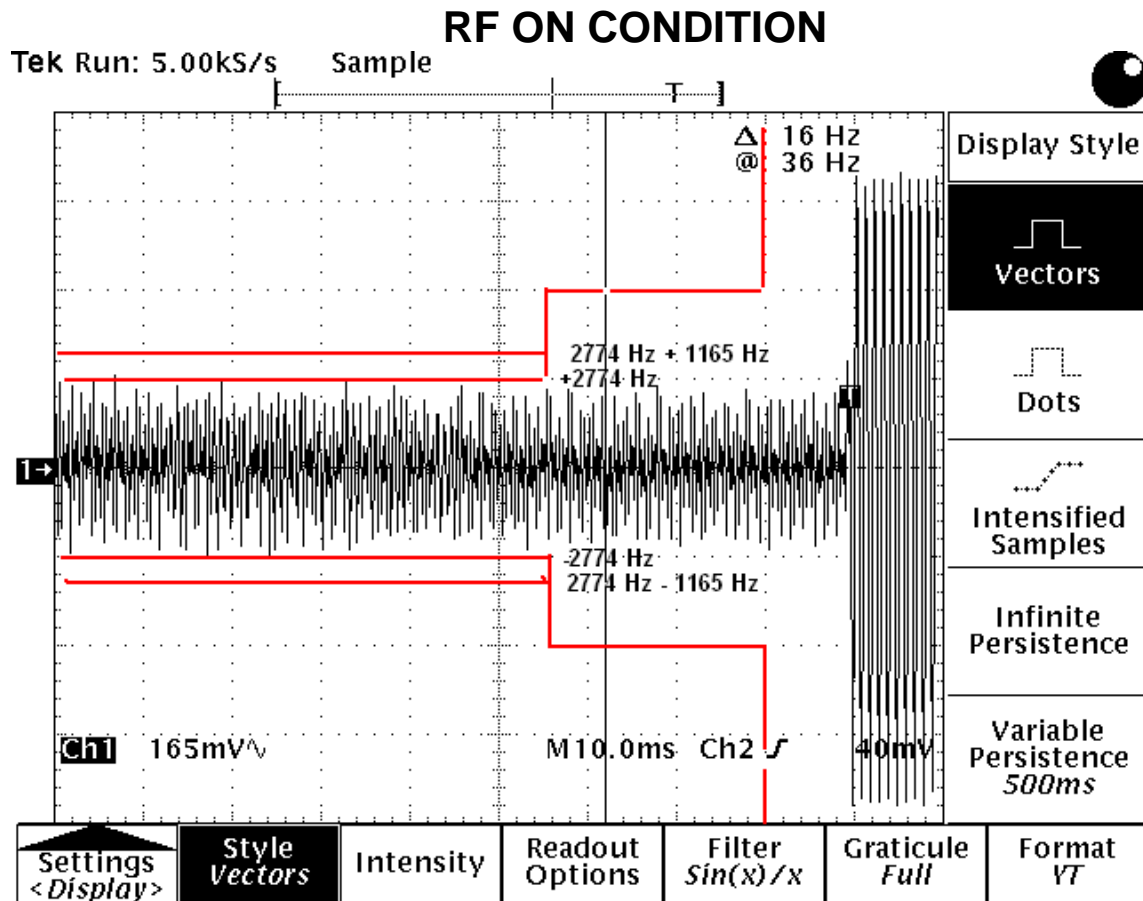
Test Equipment Used: 1463-1082-1054-1093-1051

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

EQUIPMENT: 750 Tracker

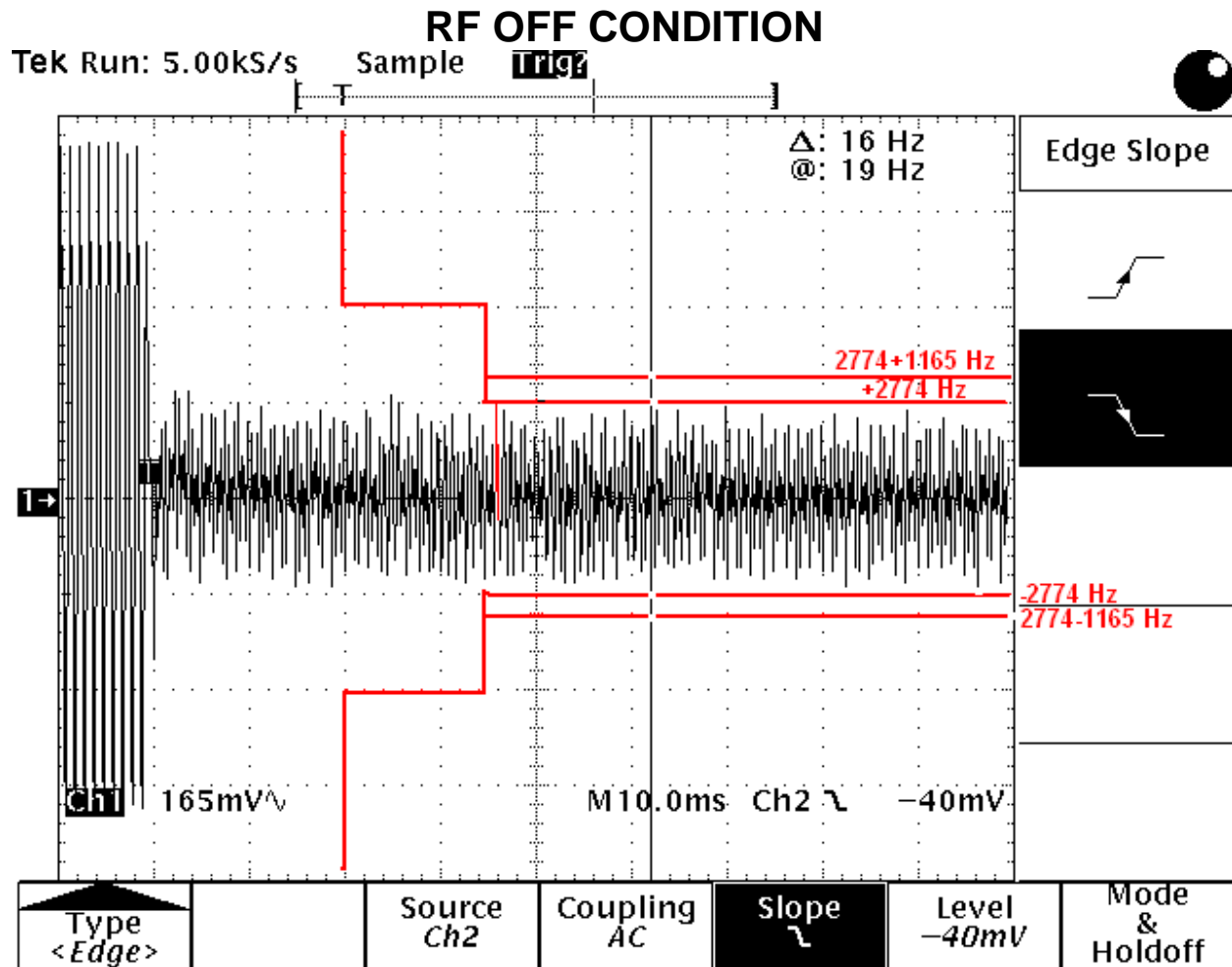
PROJECT NO.: 10033RUS4

Test Data – Transient Frequency Behavior



EQUIPMENT: 750 Tracker

PROJECT NO.: 10033RUS4



EQUIPMENT: **750 Tracker**PROJECT NO.: **10033RUS4****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
1472	20db Attenuator DC 18 Ghz	Omni Spectra 20600-20db	NONE	CBU	N/A
1469	10 db Attenuator DC 18 Ghz	MCL Inc. BW-S10W2 10db-2WDC	NONE	CBU	N/A
283	Environmental Chamber with controller # 1189006	ENVIROTRONICS SH27 & 2030-22844	129010083	06/19/07	06/19/08
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
993	Horn antenna	A.H. Systems SAS-200/571	XXX	08/31/07	08/30/08
1763	Bilog Antenna	Schaffner CBL 6111D	22926	09/21/07	09/20/08
1025	PREAMP, 25dB	Nemko USA, Inc. LNA25	399	12/07/07	12/06/08

ANNEX A - TEST METHODOLOGIES

EQUIPMENT: 750 Tracker

PROJECT NO.: 10033RUS4

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: **750 Tracker**PROJECT NO.: **10033RUS4****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: 750 Tracker

PROJECT NO.: 10033RUS4

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: **750 Tracker**PROJECT NO.: **10033RUS4****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

EQUIPMENT: **750 Tracker**

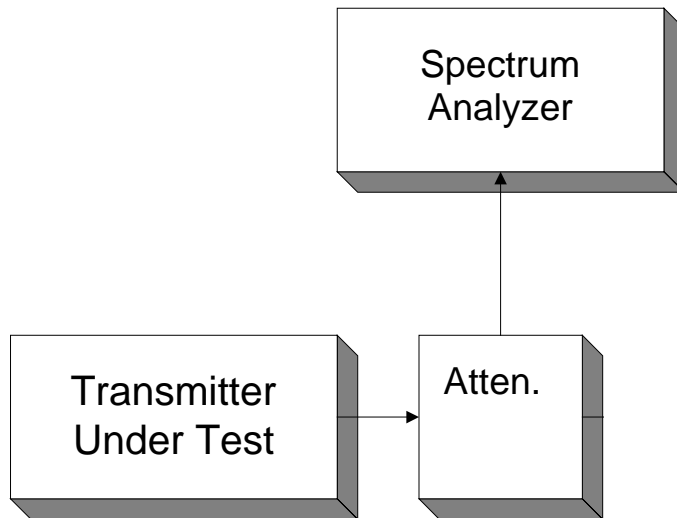
PROJECT NO.: **10033RUS4**

ANNEX B - TEST DIAGRAMS

EQUIPMENT: 750 Tracker

PROJECT NO.: 10033RUS4

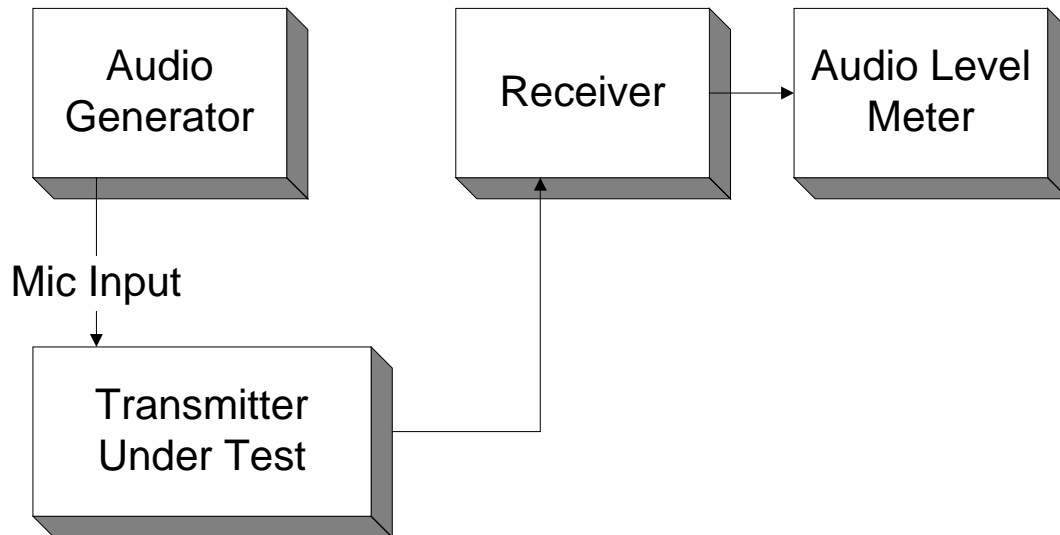
Para. No. 2.985 - R.F. Power Output



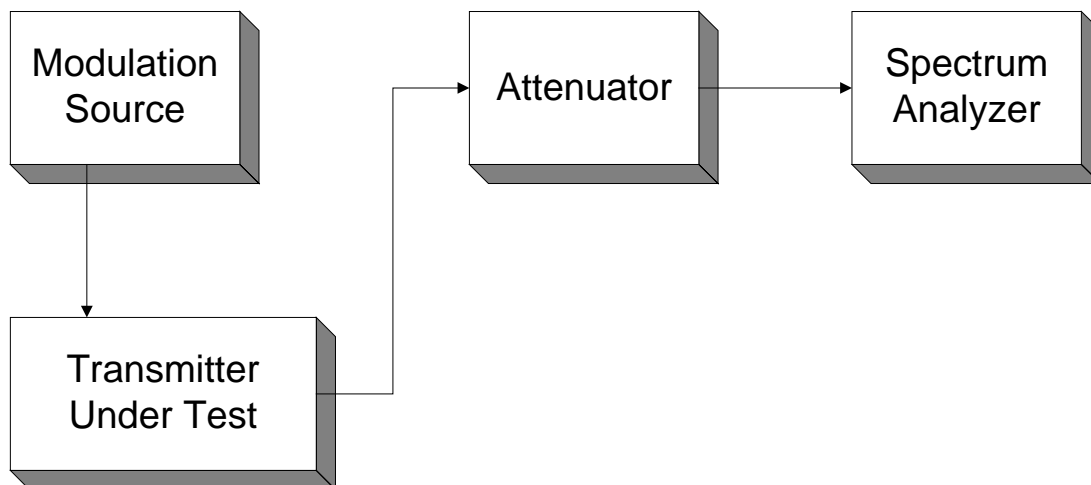
EQUIPMENT: 750 Tracker

PROJECT NO.: 10033RUS4

Para. No. 2.987(b) - Modulation Limiting



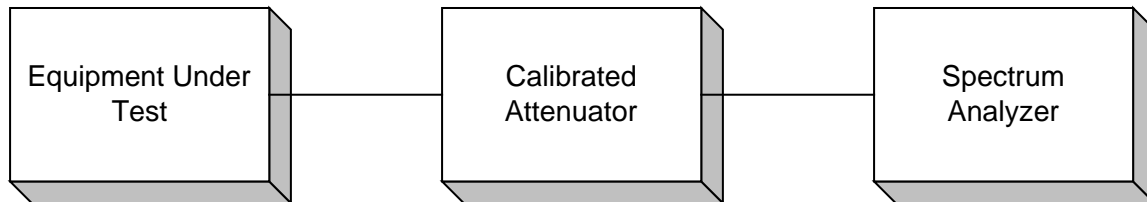
Para. No. 2.989 - Occupied Bandwidth



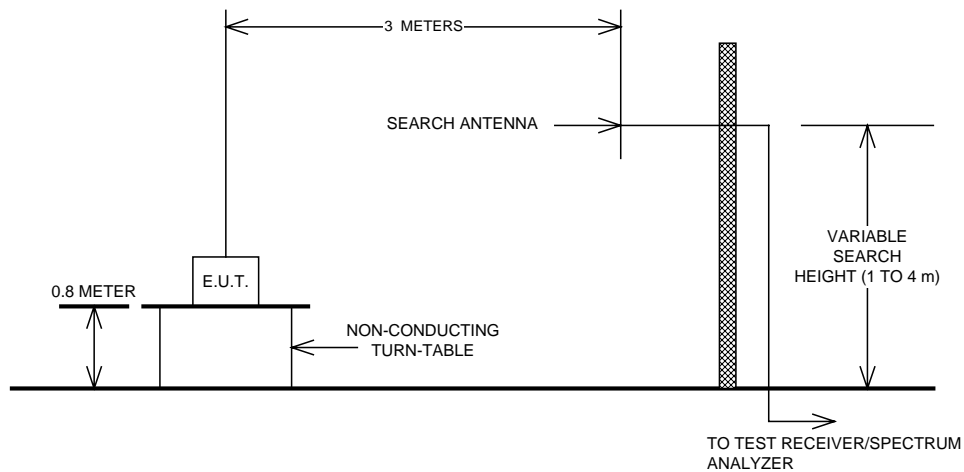
EQUIPMENT: **750 Tracker**

PROJECT NO.: **10033RUS4**

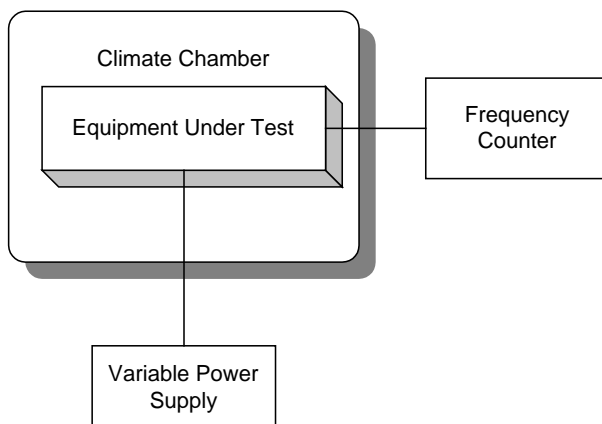
Para. No. 2.991 - Spurious Emissions at Antenna Terminals

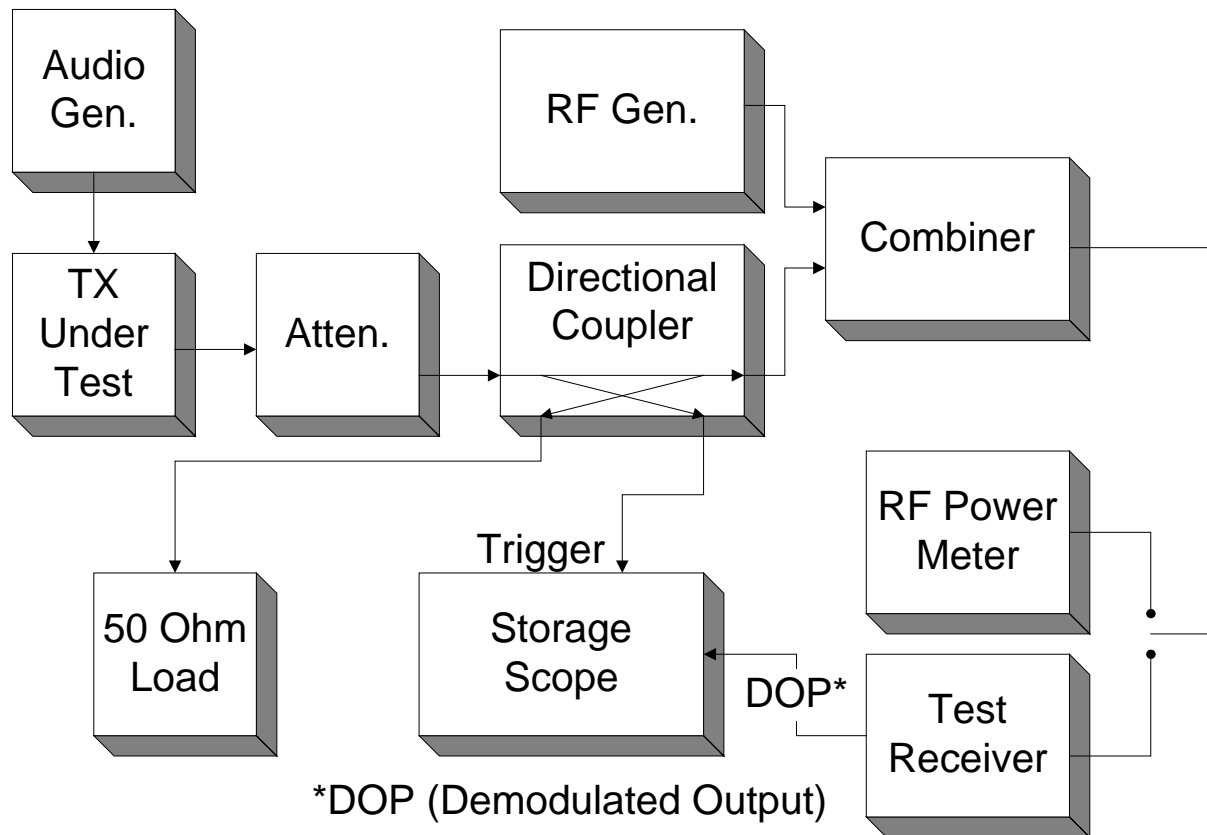


Para. No. 2.993 - Field Strength of Spurious Radiation



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