Nemko Test Report:	14911RUS1
Applicant:	The Charles Machine Works, Inc. 1959 W. Fir Ave Perry, OK 73077 USA
Equipment Under Test: (E.U.T.)	8500TK Tracker
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: _____ DATE: 21 August 2008

David Light, Senior Wireless Engineer

APPROVED BY: _____ DATE: 28 August, 2008

Total Number of Pages: 30

Table of Contents

Section 1. Summary of Test Results

Manufacturer: The Charles Machine Works, Inc.

Model No.: 8500TK Tracker

Serial No.: 73

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".

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.

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Section 2. General Equipment Specification

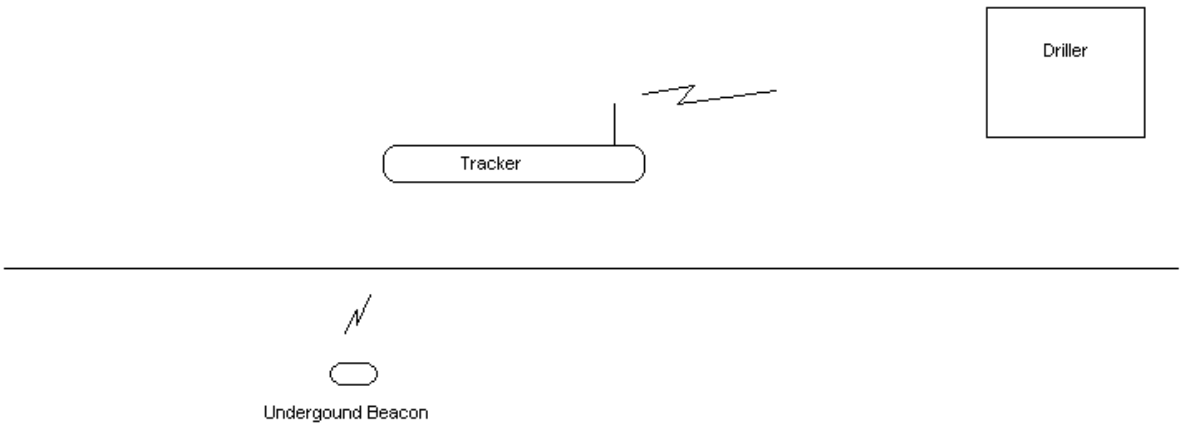
Transmitter

Supply Voltage Input:	9 Vdc
Frequency Range:	466.0375 to 466.3625 MHz
Necessary Bandwidth:	7.8 kHz (calculated per Carson's Rule) 2(1500Hz) + 2(4800/2) = 7800 Hz
Type(s) of Modulation:	**F3E (Voice)** ☐ **F1D (FSK)** ☒ **F2D** ☐ **D7W (QAM)** ☐ **Other** ☐
Data Rate:	9600 bps (4800 bps per 6.25 kHz BW)
Emission Designator:	7K80F1D
Output Impedance:	50 ohms
RF Power Output (rated):	0.100 W
Channel Spacing(s):	12.5 kHz
Operator Selection of Operating Frequency:	Only factory programmed channels are selectable.
Power Output Adjustment Capability:	None

System Description

The 8500TK Tracker is a hand held, 14 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 466.0375 to 466.3625 MHz band and is powered by 6 C-cell alkaline batteries.

System Diagram



Section 3. RF Power Output

NAME OF TEST: RF Power Output	PARA. NO.: 2.985
TESTED BY: David Light	DATE: 18 August 2008

Measurement Results: Complies.

Measurement Data:

Frequency (MHz)	Measured Power (dBm)	Measured Power (W)	Rated Power (W)
466.0375	19.71	0.0935	0.100
466.1625	19.70	0.0933	0.100
466.3625	19.71	0.0935	0.100

Spectrum Analyzer Settings:

RBW: 1 MHz
VBW: 1 MHz
Detector: Max Peak

Measurement Conditions:

Temperature: 22 °C
Humidity: 31 %

Test Equipment Used: 1659-1082-1469

Measurement Uncertainty: +/- 1.7 dB

Section 4. Modulation Characteristics

NAME OF TEST: Modulation Characteristics	PARA. NO.: 2.987
TESTED BY: David Light	DATE: 19 August 2008

Measurement Results: Complies.

Measurement Data: Maximum measured deviation for non-voice Modulation is 2.774 kHz.

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

Measurement Uncertainty: +/- 1.7 dB

Description of modulation: FSK

Test Equipment Used: 1659-1082-1469

Measurement Uncertainty: +/- 1.7 dB

Section 5. Necessary Bandwidth

NAME OF TEST: Occupied Bandwidth	PARA. NO.: 2.989
TESTED BY: David Light	DATE: 19 August 2008

Measurement Results: Complies.

Measurement Data: 7.8 kHz (calculated per Carson's Rule)

2(1500Hz) + 2(4800/2) = 7800 Hz

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

Measurement Uncertainty: +/- $1X10^{-7}$ ppm

Section 6. Spurious Emissions at Antenna Terminals

NAME OF TEST: Spurious Emissions @ Antenna Terminals	PARA. NO.: 2.991
TESTED BY: David Light	DATE: 18 August 2008

Measurement Results: Complies.

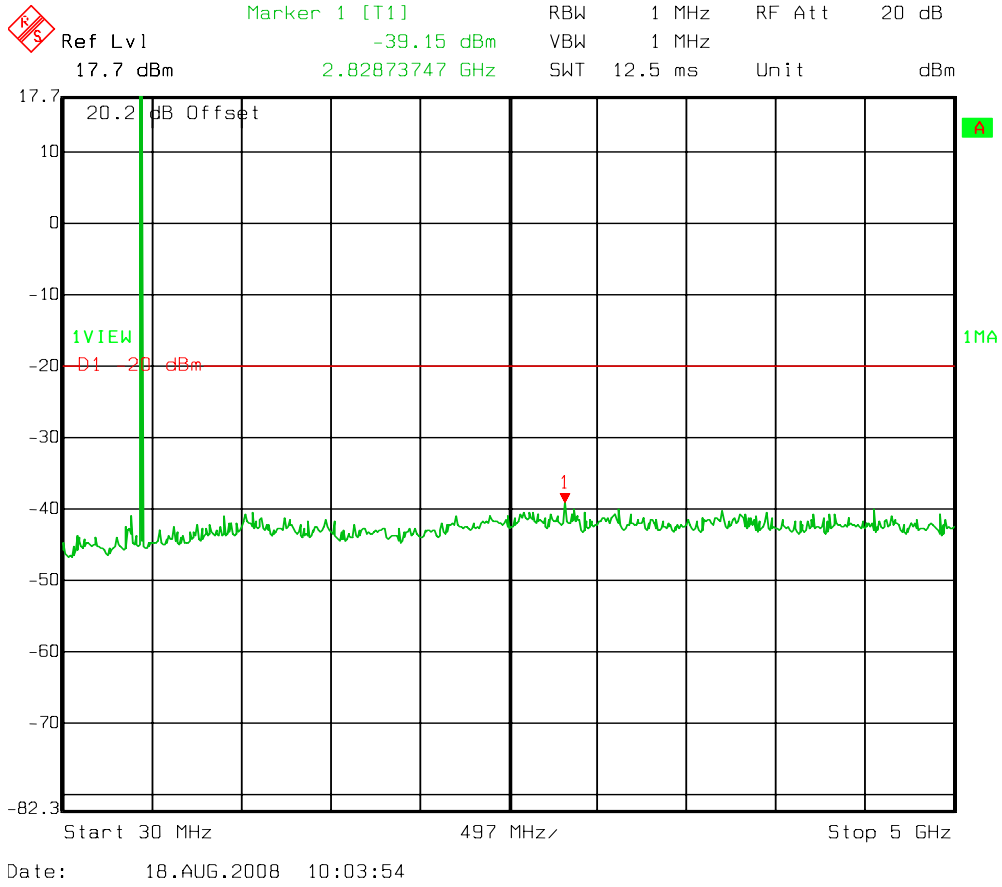
Measurement Data: See attached data

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

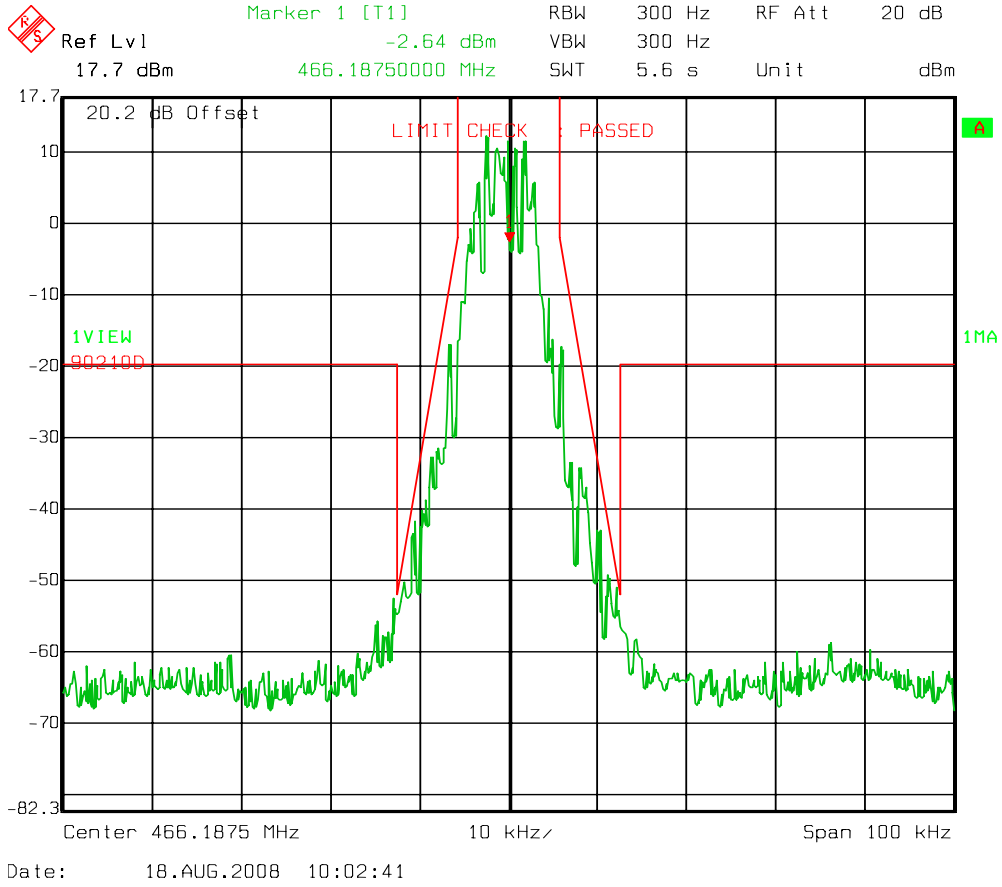
Measurement Uncertainty: +/- 1.7 dB

Test Equipment Used: 1659-1082-1469

Test Data – Spurious Emissions at Antenna Terminals



Test Data – Spurious Emissions at Antenna Terminals



Section 7. Field Strength of Spurious Emissions

NAME OF TEST: Field Strength of Spurious Emissions	PARA. NO.: 2.993
TESTED BY: David Light	DATE: 19 August 2008

Measurement Results: Complies.

Measurement Data: See attached.

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

Test Data – Radiated Spurious Emissions

Frequency (MHz)	Meter Reading (dBm)	Substitution Level (dBm)		Pre-Amp Gain (dB)	Substitution Antenna Gain (dBd)	ERP (dBm)	Limit (dBm)	Margin (dB)	Polarity	Comments
										Tx at 466.1875 MHz
932.375	-70.0	-68.3		28.8	3.6	-64.7	-20.0	-44.6700	V	
1398.563	-68.8	-68.2		31.2	3.7	-64.5	-20.0	-44.5400	V	
1864.750	-69.8	-70.2		31.5	6.2	-64.0	-20.0	-43.9700	V	
2330.938	-63.0	-59.9		31.8	5.6	-54.3	-20.0	-34.2600	V	
2797.125	-61.0	-54.9		30.8	7.1	-47.8	-20.0	-27.7600	V	
3263.313	-54.0	-45.7		31.3	7.4	-38.3	-20.0	-18.3300	V	
3729.500	-45.6	-34.8		31.7	8.0	-26.9	-20.0	-6.8500	V	
4195.688	-57.2	-42.9		31.5	7.9	-35.0	-20.0	-15.0200	V	
4661.875	-69.3	-58.6		30.7	9.1	-49.5	-20.0	-29.5400	V	
932.375	-70.7	-69.5		28.8	3.6	-65.9	-20.0	-45.8700	H	
1398.563	-71.5	-71.0		31.2	3.7	-67.3	-20.0	-47.3400	H	
1864.750	-70.6	-68.6		31.5	6.2	-62.4	-20.0	-42.3700	H	
2330.938	-62.1	-57.1		31.8	5.6	-51.5	-20.0	-31.4600	H	
2797.125	-63.3	-60.5		30.8	7.1	-53.4	-20.0	-33.3600	H	
3263.313	-53.8	-50.7		31.3	7.4	-43.3	-20.0	-23.3300	H	
3729.500	-48.0	-45.8		31.7	8.0	-37.9	-20.0	-17.8500	H	
4195.688	-61.5	-58.1		31.5	7.9	-50.2	-20.0	-30.2200	H	
4661.875	-67.6	-63.3		30.7	9.1	-54.2	-20.0	-34.2400	H	

Notes:

Section 8. Frequency Stability

NAME OF TEST: Frequency Stability	PARA. NO.: 2.995
TESTED BY: David Light	DATE: 21 August 2008

Measurement Results: Complies.

Measurement Data: See attached data

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

Test Equipment Used: 1659-1082-1469-283

Measurement Uncertainty: +/- $1X10^{-7}$ ppm

Test Data – Frequency Stability

Nominal Test Frequency = 466.1875 MHz

Temp (°C)	Measured Frequency (MHz)		Test Voltage	Freqeuncy Error (Hz)	Limit (+/-Hz)	Error (ppm)	Comment
20	466.187440		9	-60	1165.5	-0.13	
20	466.187443		10.4	-57	1165.5	-0.12	
20	466.187400		7.5	-100	1165.5	-0.21	Battery cutoff
50	466.187220			-280	1165.5	-0.60	
40	466.187120			-380	1165.5	-0.82	
30	466.187120			-380	1165.5	-0.82	
10	466.187620			120	1165.5	0.26	
0	466.187740			240	1165.5	0.51	
Notes:	The device ceased operation after dropping below 0 degrees						

Limit +/- 2.5 ppm

Section 9. Transient Frequency Behavior

NAME OF TEST: Transient Frequency Behavior	PARA. NO.: 90.214
TESTED BY: David Light	DATE: 20 August 2008

Measurement Method:
The test method used was EIA/TIA 603C for voice radios and radios capable of transmitting an unmodulated carrier. For data modulated systems not capable of CW transmission EIA/TIA TSB102.CAAA is used.

Measurement Results: Complies.

Measurement Data: See attached data

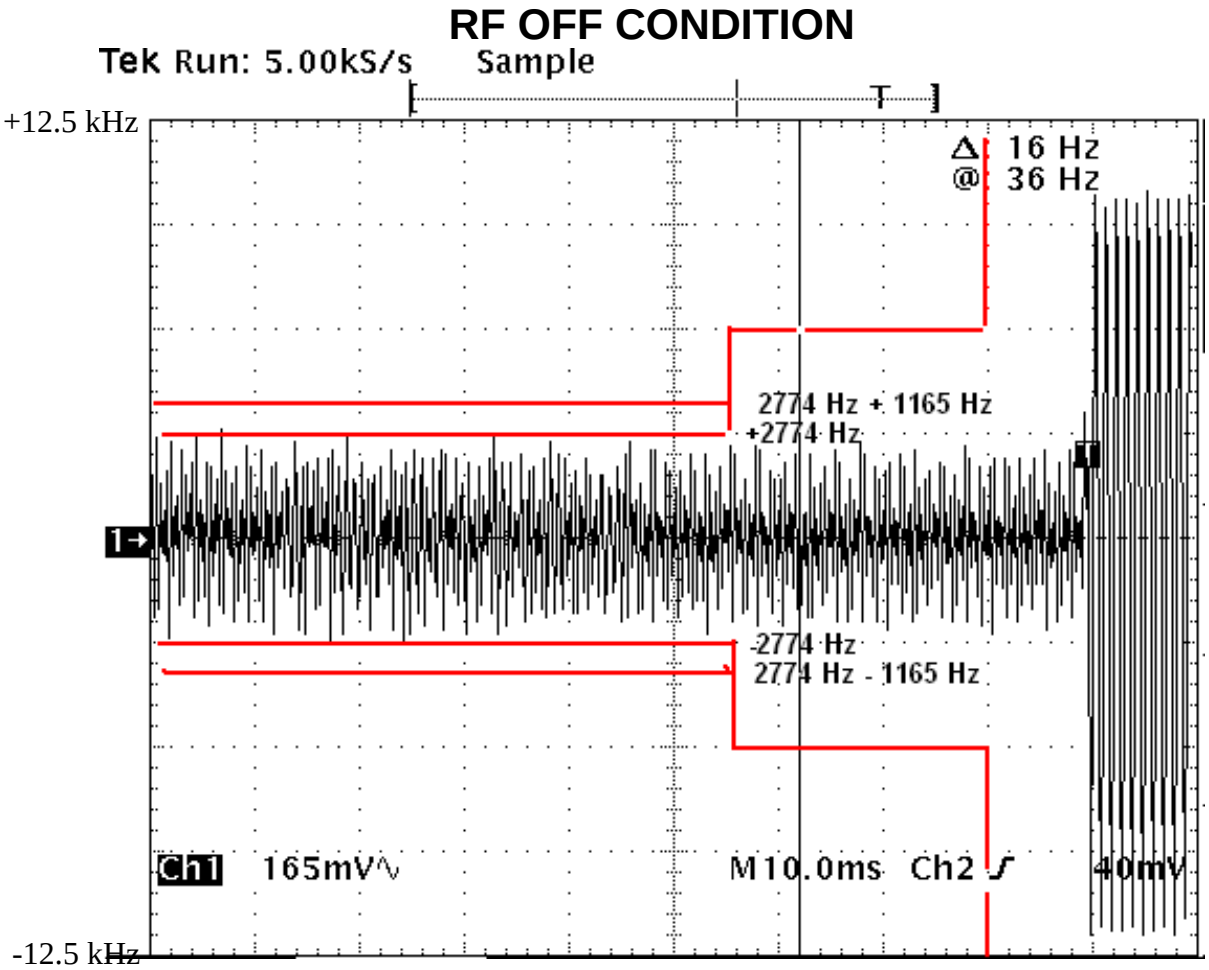
Frequency deviation: +/- 2774 Hz
Maximum frequency drift allowed: +/- 1165 Hz (466.18 MHz x 2.5 ppm)

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

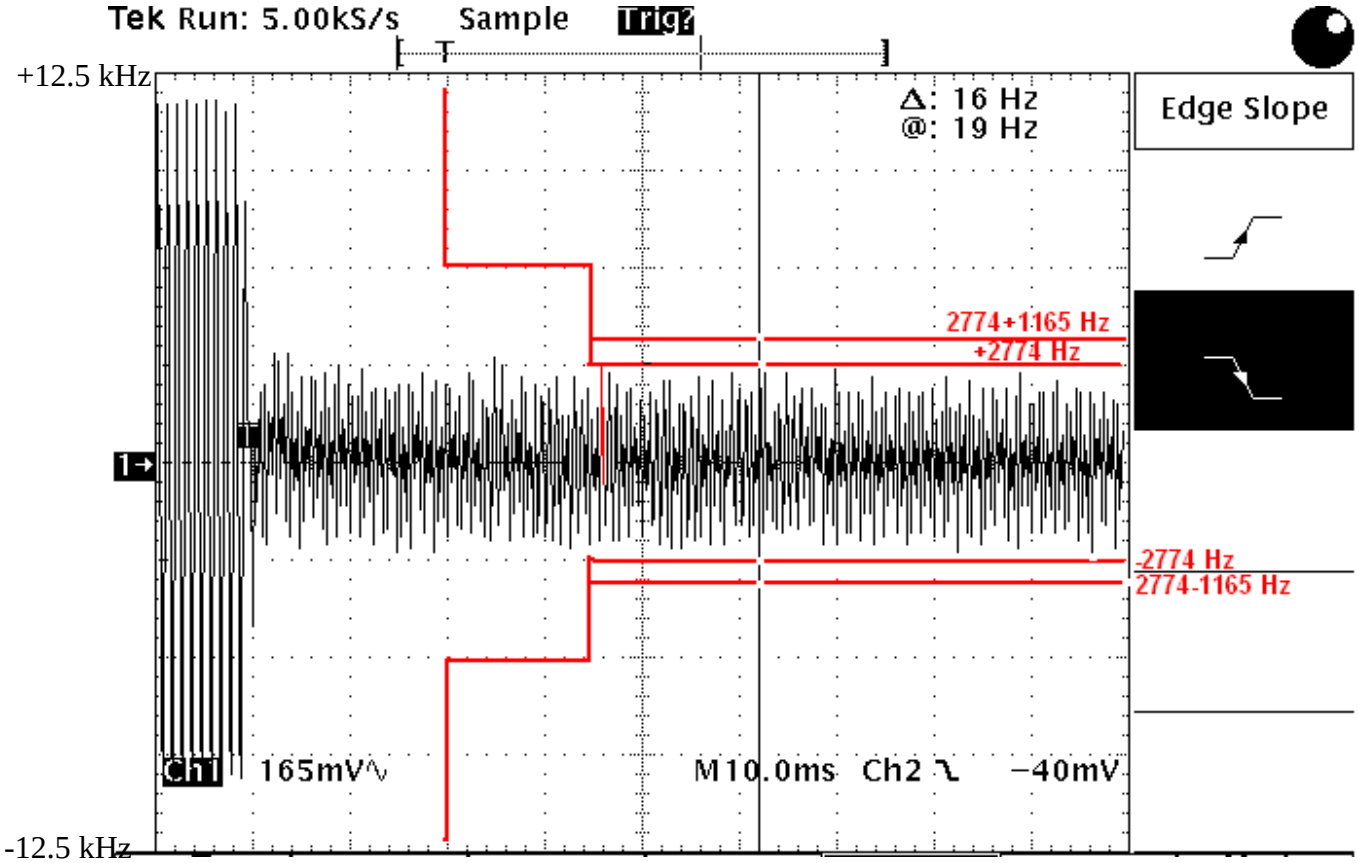
Test Equipment Used: 1463-1082-1054-1093-1051

Measurement Uncertainty: +/- 0.5 msec., $1X10^{-7}$ ppm

Test Data – Transient Frequency Behavior



RF ON CONDITION



Section 10. Test Equipment List

Nemko ID	Description	Manufacturer Model Number	Serial Number	Calibration Date	Calibration Due
1463	Color 4 Ch Digitizing Oscilloscope	Tektronix TDS684A	B010460	05/27/08	05/27/09
1082	CABLE 2m	Astrolab 32027-2-29094-72TC	N/A	CBU	N/A
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	09/20/07	09/20/09
1659	Spectrum Analyzer	Rhode & Schwarz FSP	973353	01/24/07	01/24/09
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
283	Environmental Chamber with controller # 1189006	ENVIROTRONICS SH27 & 2030-22844	129010083	04/24/08	04/24/09
1464	Spectrum analyzer	Hewlett Packard 8563E	3551A04428	01/24/07	01/24/09
1484	Cable	Storm PR90-010-072	N/A	05/07/08	05/07/09
1485	Cable	Storm PR90-010-216	N/A	05/07/08	05/07/09
1016	Pre-Amp	HEWLETT PACKARD 8449A	2749A00159	05/07/08	05/07/09
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
1659	Spectrum Analyzer	Rhode & Schwarz FSP	973353	01/24/07	01/24/09
1469	10 db Attenuator DC 18 Ghz	MCL Inc. BW-S10W2 10db-2WDC	NONE	CBU	N/A

ANNEX A - TEST METHODOLOGIES

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.

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.

NAME OF TEST: Field Strength of Spurious **PARA. NO.: 2.993**

Minimum Standard: Para. No. 90.210, see table 1 for applicable mask.

Test Method:

The test method used was EIA/TIA 603C.

Step A: The device was placed on a test range and the maximum field strength of spurious emissions was measured. The maximum field strength was determined by adjusting the azimuth of the turntable and the height of the receive antenna.

Step B: The device under test was replaced by a reference antenna with calibrated gain.

Step C: The reference antenna was fed with a signal generator tuned to the frequency of the measured spurious emission. The rf level of the signal generator was adjusted until the emission level measured in Step A is achieved.

Step D: The level from Step C is corrected with antenna gain calibration factors for the reference antenna. The resulting corrected value is the effective radiated power or equivalent isotropic radiated power as appropriate.

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

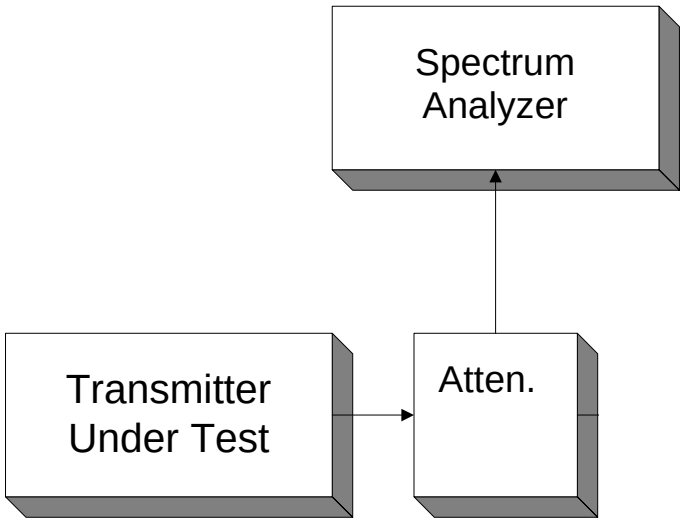
		Frequency ranges (MHz) All equipment					
	Maximum	Base station and portable radios			Mobile Radios		
Time intervals [1,2]	Frequency difference[3] (kHz)	150 - 174 (ms)	450 - 500 (ms)	500 - 512 (ms)	150 - 174 (ms)	450 - 500 (ms)	500 - 512 (ms)
t_1[4]	± 25	5.0	10.0	20.0	5.0	10.0	5.0
t_2	± 12	20.0	25.0	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

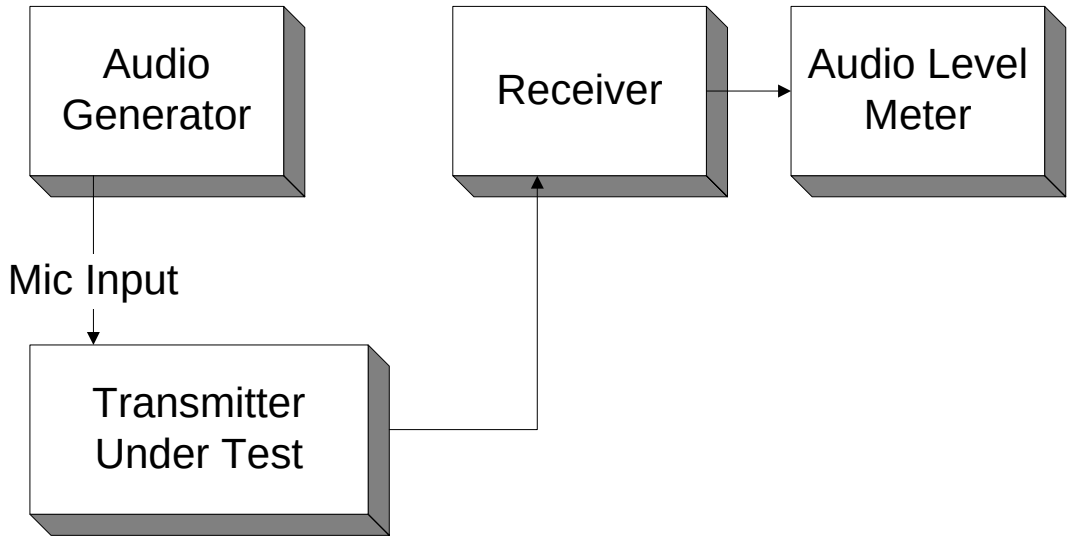
	Maximum	Frequency ranges (MHz) All equipment		
Time intervals [1,2]	Frequency difference[3] (kHz)	150 - 174 (ms)	450 - 500 (ms)	500 - 512 (ms)
t_1[4]	± 12.5 / ± 6.25	5.0	10.0	20.0
t_2	± 6.25 / ± 3.125	20.0	25.0	50.0
t_3[4]	± 12.5 / ± 6.25	5.0	10.0	10.0

ANNEX B - TEST DIAGRAMS

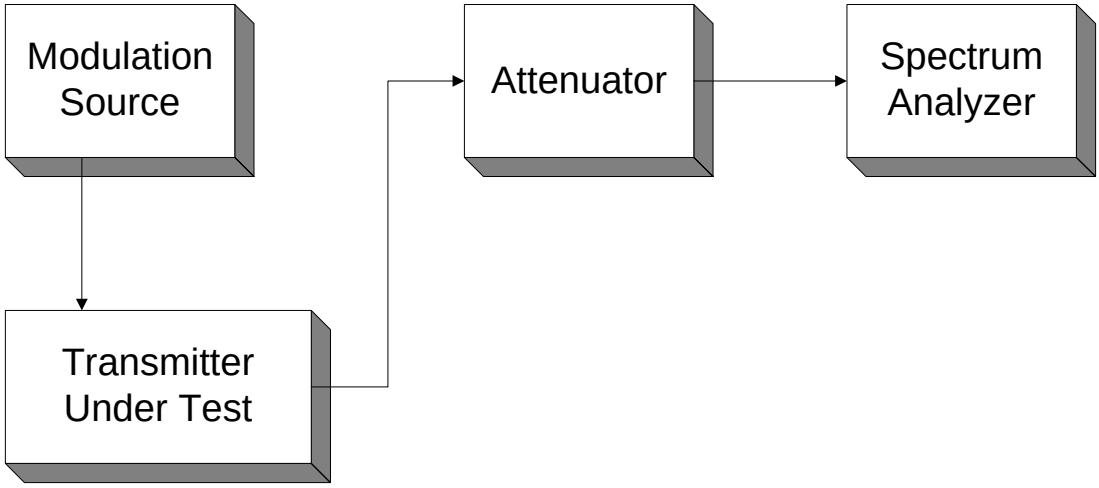
Para. No. 2.985 - R.F. Power Output



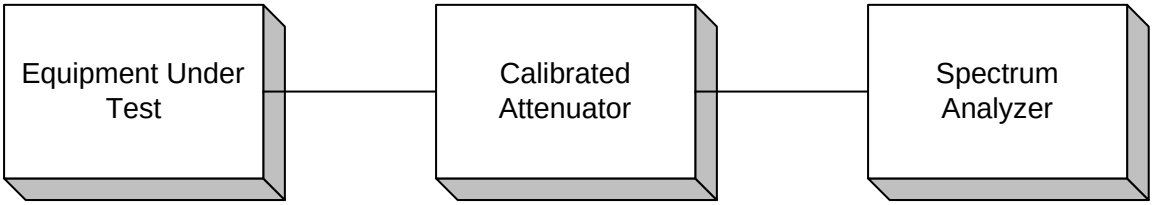
Para. No. 2.987(b) - Modulation Limiting



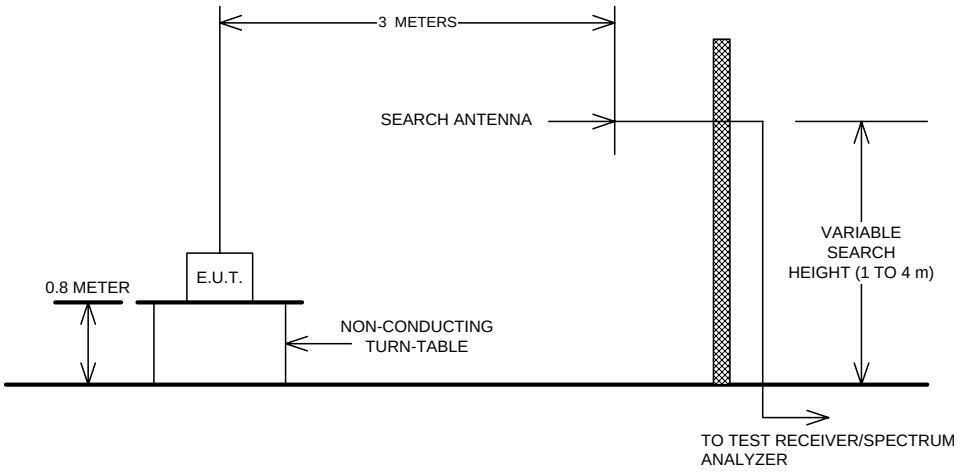
Para. No. 2.989 - Occupied Bandwidth



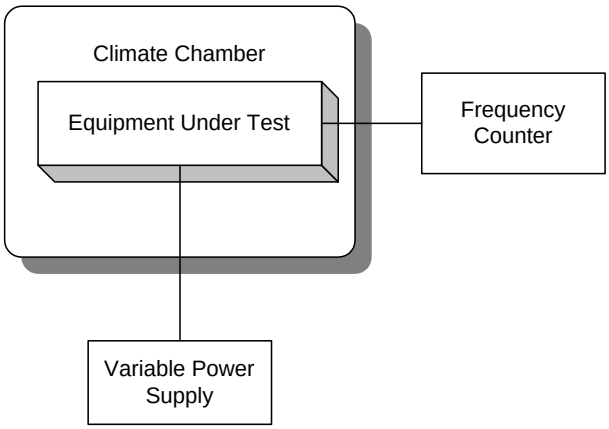
Para. No. 2.991 - Spurious Emissions at Antenna Terminals



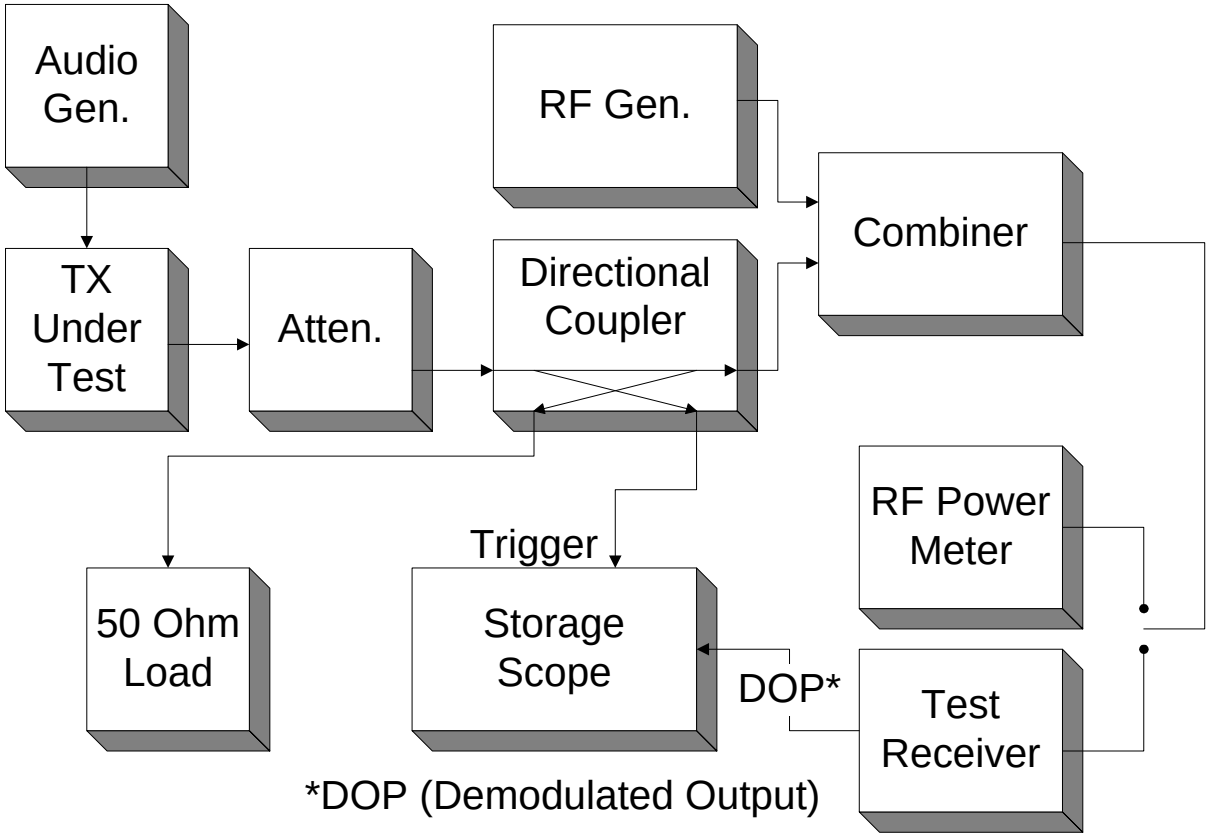
Para. No. 2.993 - Field Strength of Spurious Radiation



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