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LS Research Inc.

250 mW Surveillance Transmitter

Part 90 Type Acceptance, Conducted Measurements

prepared for

Audio Intelligence Devices

Revision 1.0

Table of Contents

Surveillance Transmitter

I. Project Information

Project: Surveillance Transmitter

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Revision: 1.2
Proposal #: 859
Proposal File: AID Transmitter 1_2
Job Number: 871

Signatures: **Brian Petted**

Technical Approval

II. FCC Conducted Tests

A. Part 90 Subpart I

1. 90.207 (a) (1) Types of Emissions (Device Classification)

   Classified as an ***F3E*** emitter (Frequency Modulation, Analog Modulation, Voice). Power level: 250 mW. The Emission Designator becomes ***F3E 15K0***

2. 90.209 (a) (5) Bandwidth Limitations (Device Classification, Test Condition).

   12.5 kHz Nominal Channel Bandwidth

3. Part 2.985 Output Power, Part 2.991 Spurious Emissions at Antenna terminals and Part 2.989 Occupied bandwidth using 90.210 (d) Emission Mask for F3E Transmitter.

a) Test Requirement:

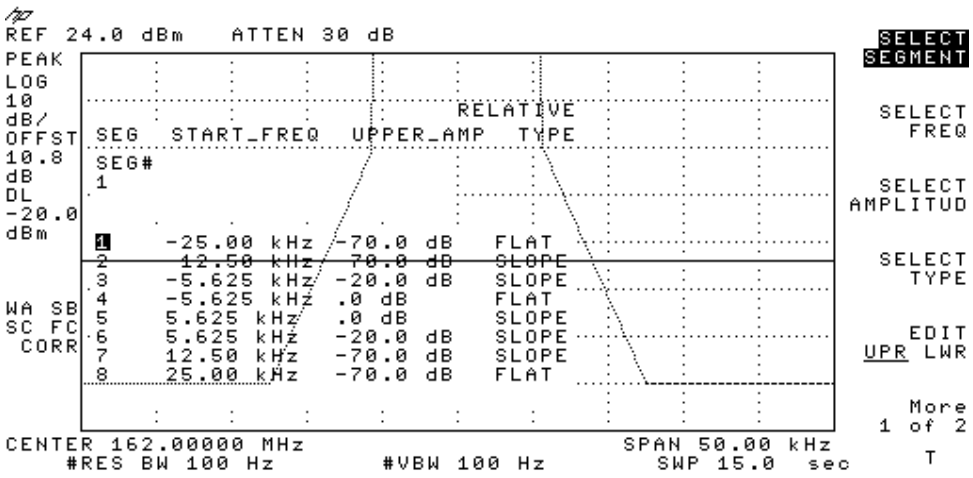
(1) On any frequency from the center of the authorized bandwidth f_o to 5.625 kHz removed from f_o: Zero dB.

(2) On any frequency removed from the center of the authorized bandwidth by a displacement frequency (f_d in kHz) of more than 5.625 kHz but no more than 12.5 kHz: At least 7.27(f_d -2.88 kHz) dB.

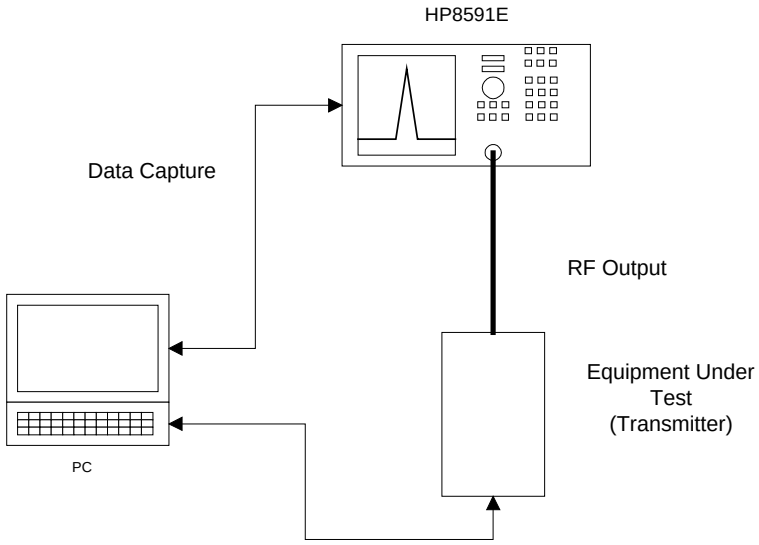
(3) On any frequency removed from the center of the authorized band by a displacement frequency (f_d in kHz) of more than 12.5 kHz : At least 50 + 10 log (P) dB or 70 dB, whichever is the lesser attenuation.

The test condition is presented in Tabular form below. The definition of the spectrum mask as indicated on the spectrum analyzer is also presented, where the display line set to –20 dBm applies to $|f_m| > 12.5$ kHz.

90.210 (d)	Absolute Frequency Offset Range: $\|f_m\|$	Attenuation relative to Carrier power P.
(1)	0 to 5.625 kHz	0 dB
(2)	5.625 kHz to 12.5 kHz	7.27($\|f_m\|$ -2.88) dB
(3)	> 12.5 kHz	Min (50 + 10 log $_{10}$(P) dB ,70 dB) = -20 dBm



b) Test Configuration



Equipment Under Test Configuration

c) Test Conditions: Stimulus

Input nominal audio signal at 3 kHz: (3.5 mV).

Set level to 50% rated deviation. (100 % is +/- 2.2 kHz., 50% is 1.1 kHz)

This level occurs at 0.78 mV.

Set modulating frequency to 2500 Hz

Increase Level by 16 dB: 16 dB - 4.8 dB (pre-emphasis) = 11.2 dB
2.83 mV.

Measure Spectrum Mask (D).

d) Equipment Under Test Conditions, Instrument Conditions and Indicated Numerical Data for Part 2.985 Output Power.

Presented below is a table that summarizes the equipment under test conditions, instrument conditions and numerical data. Numerical Data for the Transmitter Power under each of the test conditions is indicated in the Table. The source of the numerical data is presented in sub-sections(e),and (f), Test Indications. Demonstration of compliance is presented in sub-sections (e) and (f).

	Audio Mode	Set f (MHz)	Po (dBm)	Set Po (mW)	Trim (count)	2nd (dBc)	fcenter (MHz)	span (MHz)	RBW (kHz)	VBW (kHz)	filename (*.pcx)
Conducted Emission - Harmonic Output	Compression	150	24.02	250	-34	48.02	300	500	100	1000	150a
						47.54	900	1700	1000	3000	150b
		162	24.22	250	-28	52.96	300	500	100	1000	162a
						52.31	900	1700	1000	3000	162b
		174	24.05	250	26	60.66	300	500	100	1000	174a
						58.80	900	1700	1000	3000	174b
Conducted Emission - Occupied Bandwidth	Compression	150	24.02	250	-34		150	0.05	0.1	0.03	C150
		162	24.22	250	-28		162	0.05	0.1	0.03	C162
		174	24.05	250	26		174	0.05	0.1	0.03	C174
	ALC	150	24.02	250	-34		150	0.05	0.1	0.03	A150
		162	24.22	250	-28		162	0.05	0.1	0.03	A162
		174	24.05	250	26		174	0.05	0.1	0.03	A174

Set f : E.U.T Carrier frequency Setting .

Po and Set Po: Nominal E.U.T Power Settings.

Trim: Programming Parameter Setting for output power.

2nd : Second Harmonic Level in dB relative to absolute Power

fcenter: Spectrum Analyzer Center Frequency Setting

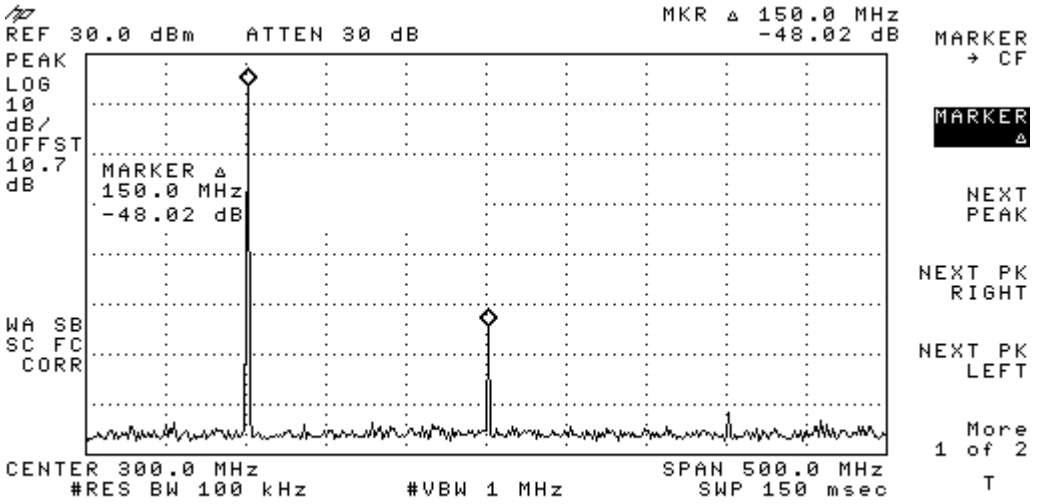
span: Spectrum Analyzer Frequency Span Setting.

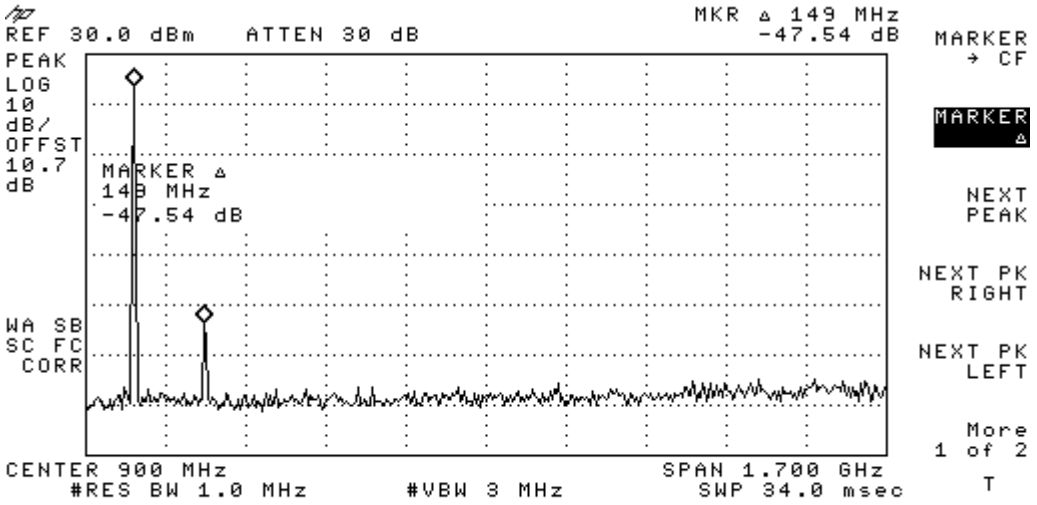
RBW: Spectrum Analyzer Resolution Bandwidth.

VBW: Spectrum Analyzer Video Bandwidth.

Filename: Data Capture Filename

e) Test Indications Part 2. 991 Conducted Spurious Emissions at Antenna Terminals



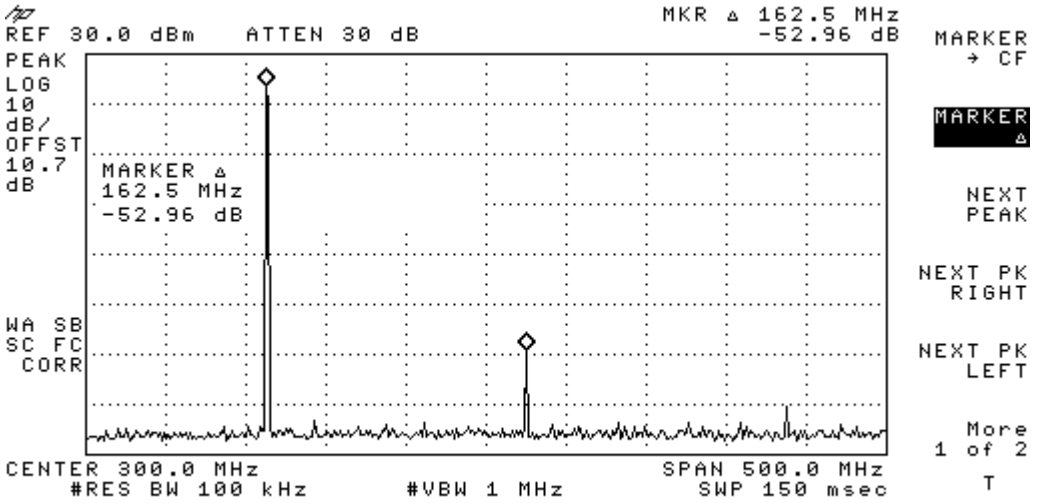


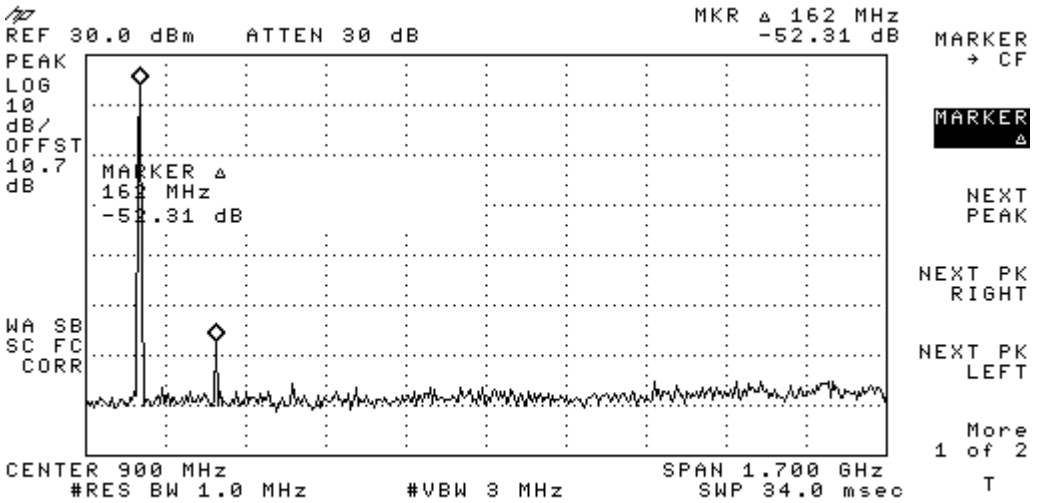
Test Condition: 150 MHz, 250 mW

Test Limit: 10 log (0.250 W) + 50 dB = 44 dBc

Test Indication: 47.5 dBc

Test Outcome: 47.5 dBc > 44 dBc → PASS



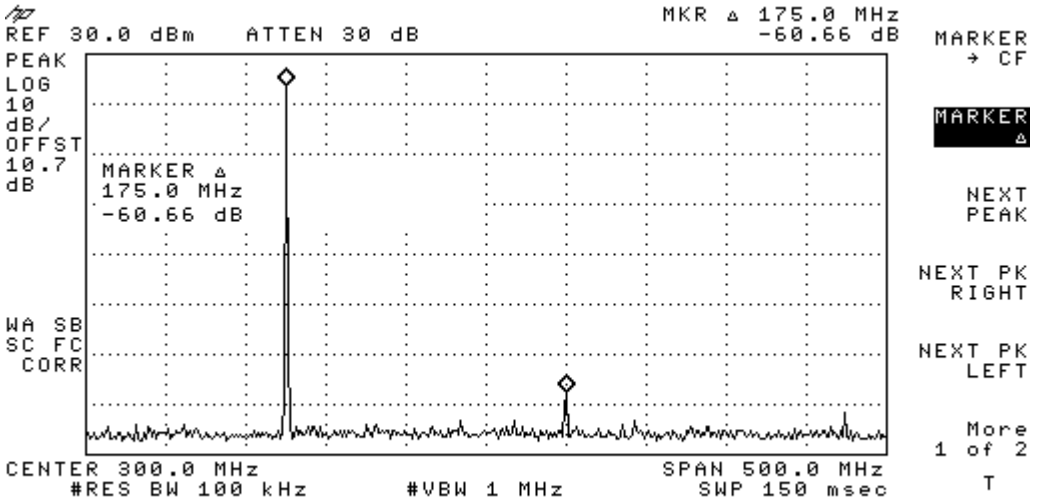


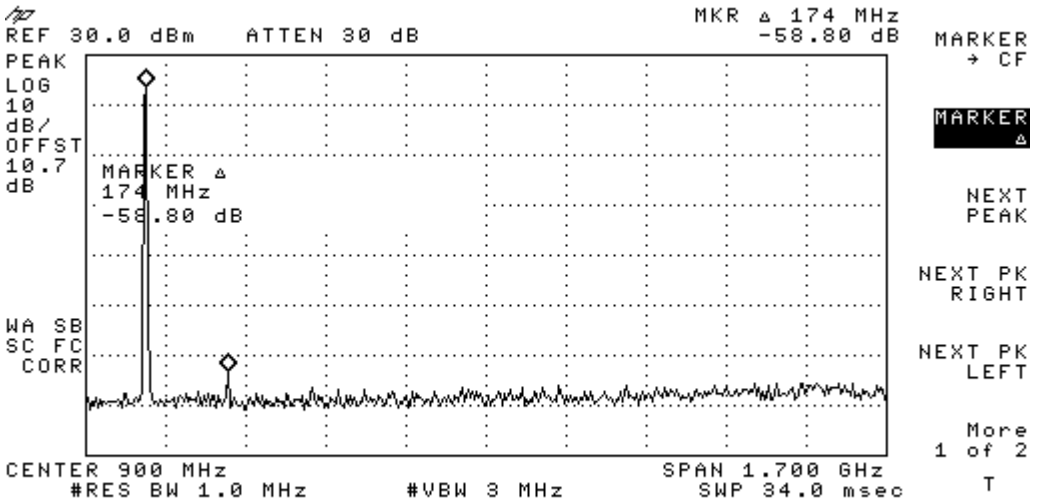
Test Condition: 162 MHz, 250 mW

Test Limit: 10 log (0.250 W) + 50 dB = 44 dBc

Test Indication: 52.3 dBc

Test Outcome: 52.3 dBc > 44 dBc → PASS





Test Condition: 174 MHz, 250 mW

Test Limit: 10 log (0.250 W) + 50 dB = 44 dBc

Test Indication: 58.8 dBc

Test Outcome: 58.8 dBc > 44 dBc → PASS

f) Test Indications Part 2. 989 Occupied Bandwidth

1. Deviation Set as indicated in Stimulus Test Conditions.

2. ALC Mode presented as worst case.

3. Reference Level setting under these conditions:

   (a) Span = 10 MHz.

   (b) Resolution Bandwidth = 100 kHz.

   (c) Video Bandwidth = 100 kHz.

   (d) Video Averaging for 10 sweeps. Display and Set Reference Level to Peak.

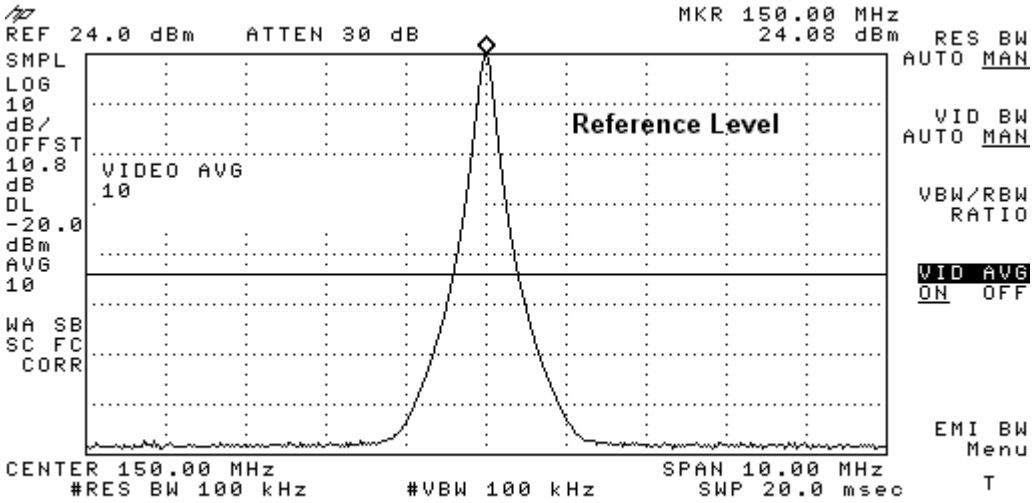
4. Measurement Indication under these conditions:

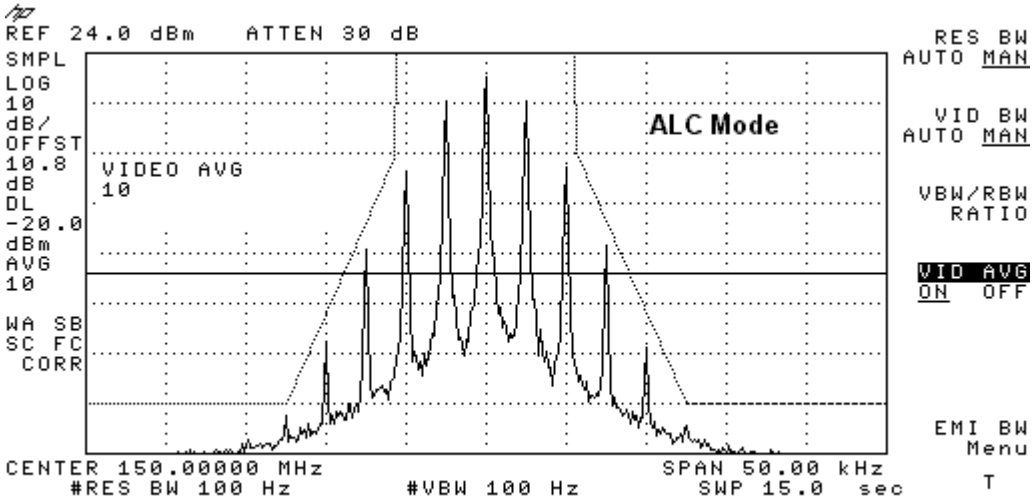
   (a) Span =50 kHz

   (b) Resolution Bandwidth = 100 Hz.

   (c) Video Bandwidth = 100 Hz.

   (d) Video Averaging for 10 Sweeps



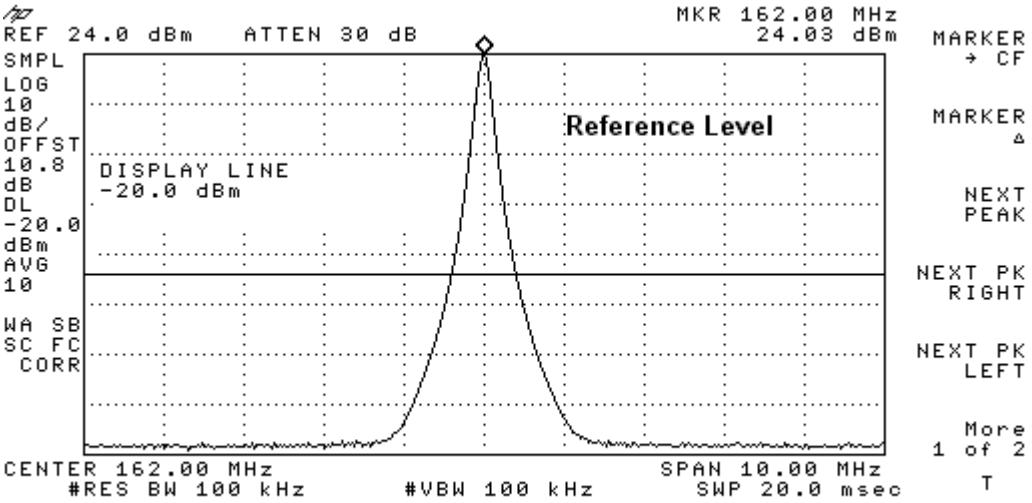


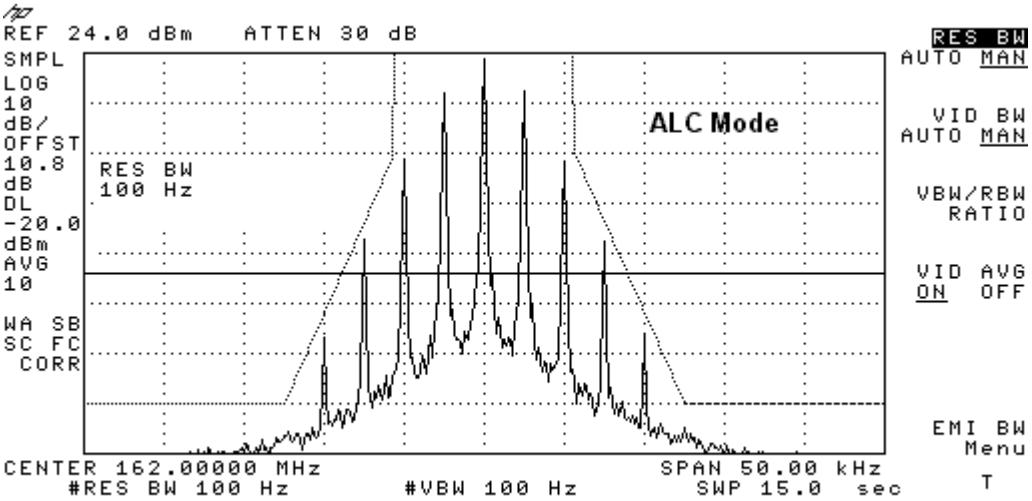
Test Condition: 150 MHz, 250 mW

Test Limit: Indicated Mask (see sub-section (a)

Test Indication: Indicated Spectrum falls below Indicated Mask

Test Outcome: Spectrum falls below Indicated Mask → PASS



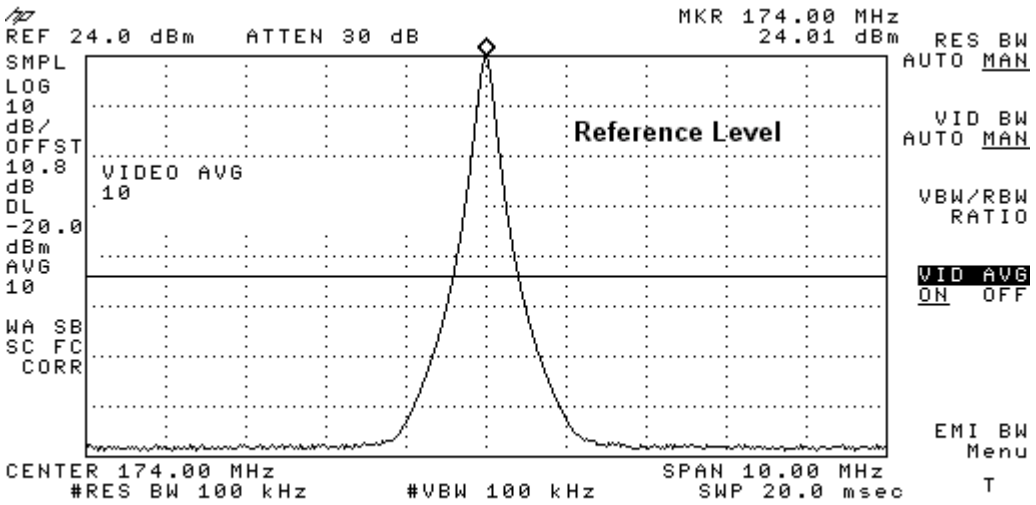


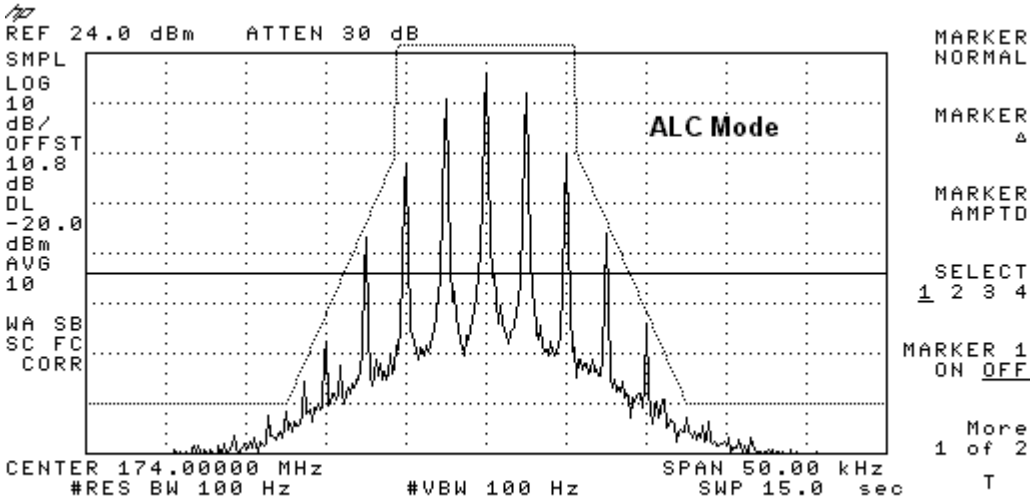
Test Condition: 162 MHz, 250 mW

Test Limit: Indicated Mask (see sub-section (a)

Test Indication: Indicated Spectrum falls below Indicated Mask

Test Outcome: Spectrum falls below Indicated Mask → PASS





Test Condition: 174 MHz, 250 mW

Test Limit: Indicated Mask (see sub-section (a)

Test Indication: Indicated Spectrum falls below Indicated Mask

Test Outcome: Spectrum falls below Indicated Mask → PASS

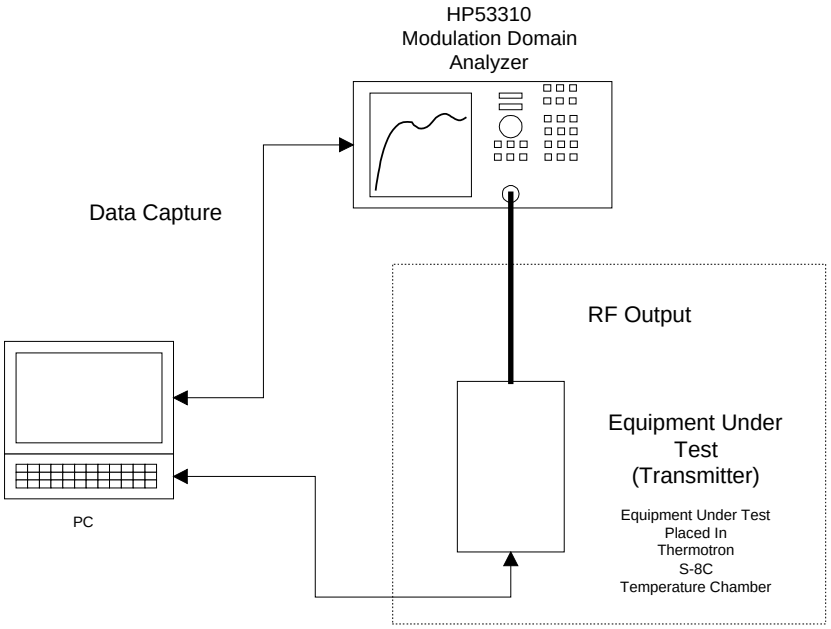
4. Part 2.995 and 90.213 (a) Frequency Stability

a) Test Requirement

Mobile stations below 2W output power must have an absolute frequency stability of ***5 ppm*** when operating with a 12.5 kHz bandwidth.

Test in accordance to conditions called out in Part 2.995 (a) (1): Frequency stability must be measured from ***–30 to 50 degrees centigrade for (b) steps of 10 degrees*** . Allowing for thermal equilibrium, the measurement was performed after the desired temperature was maintained for 15 minutes.

b) Test Configuration



Equipment Under
Test Configuration

c) Test Conditions, Numerical Test Indications

T (deg. C)	f (MHz)	ppm w.r.t. 25 deg. C	ppm absolute
-30	162.000203163	1.08	1.25
-20	162.000189700	0.99	1.17
-10	162.000139032	0.68	0.86
0	162.000110020	0.50	0.68
10	162.000091968	0.39	0.57
20	162.000068559	0.25	0.42
25	162.000028595	0.00	0.18
30	162.000057622	0.18	0.36
40	162.000053550	0.15	0.33
50	162.000061438	0.20	0.38

Test Condition: 162 MHz, 250 mW (-30 deg. C to 50 deg C, 10 degree steps)

Test Limit: 5 ppm Maximum Frequency Offset

Test Indication:

Maximum Frequency Offset is 1.25 ppm and 1.08 ppm Relative to 25 deg C.

Test Outcome: 1.25 ppm and 1.08 ppm < 5 ppm → PASS

5. 90.214: Transient Frequency Behavior.

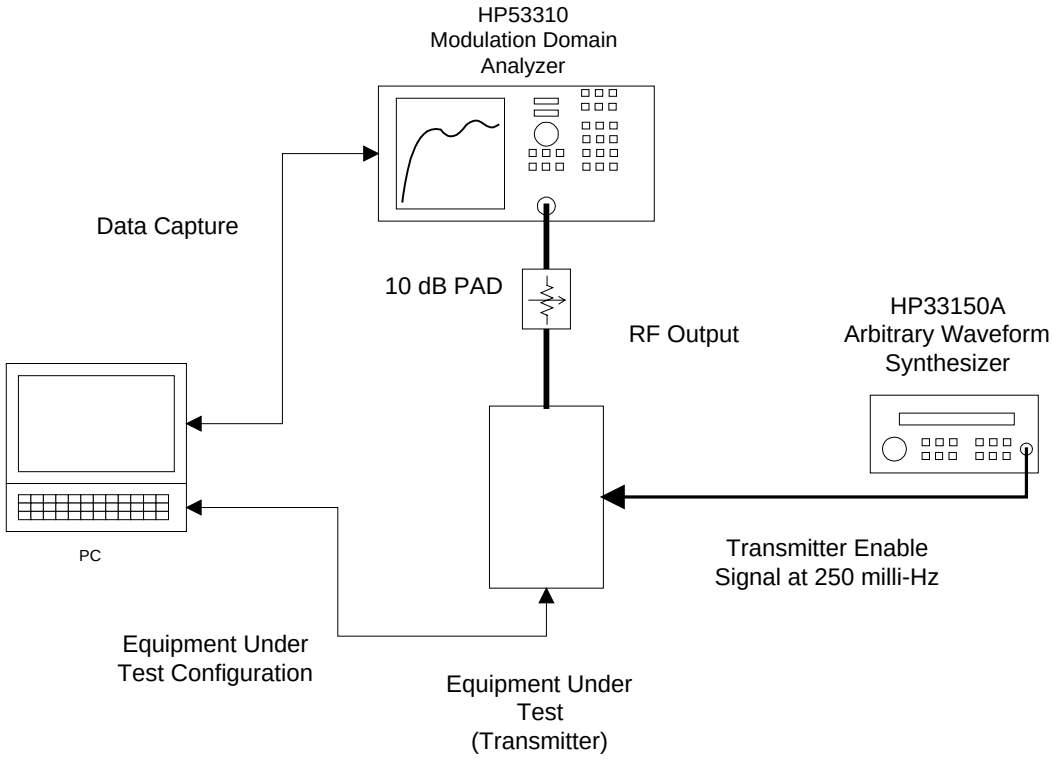
a) Test Requirement

Transmitters designed to operate within the 150 to 174 MHz bands must maintain transient frequencies within the maximum frequency difference during the time intervals indicated in the table below. This device is designed to operate on 12.5 kHz channel bandwidth. The output power of the device is less than 6 Watts, therefore the transient frequency can exceed the limit for the time intervals t_{on} to t_1 and t_{off} to t_3.

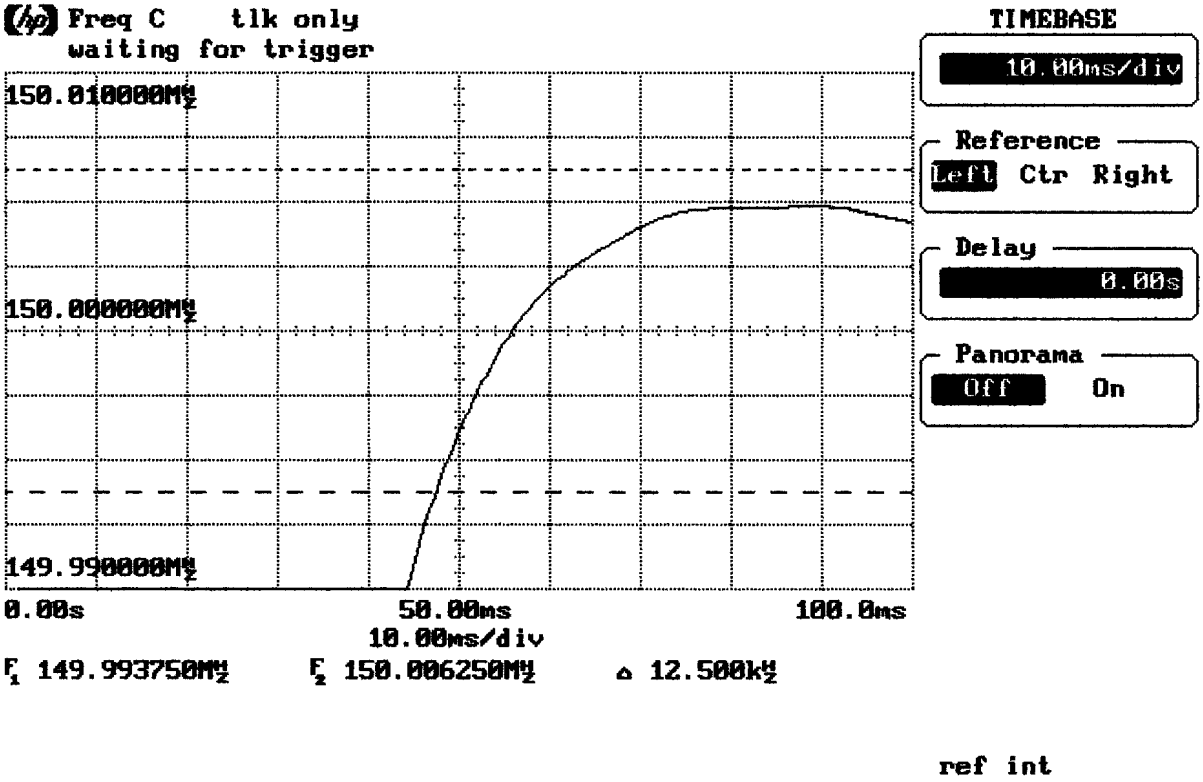
The time,t_{on} ,is defined when the transmitter power exceeds –13 dBm at the transmitter output. The modulation domain analyzer is triggered on the envelope of the RF power and the zero time indication is reference to this trigger level. The time, t_{off} , is defined when the transmitter is turned off and the power level falls below –13 dBm.

Time Interval	Transient Frequency Limit	Settling Time
t_1	±12.5 kHz	5.0 ms
t_2	±6.25 kHz	25.0 ms
t_3	±12.5 kHz	5.0 ms

b) Test Configuration



c) Test Conditions and Test Indications

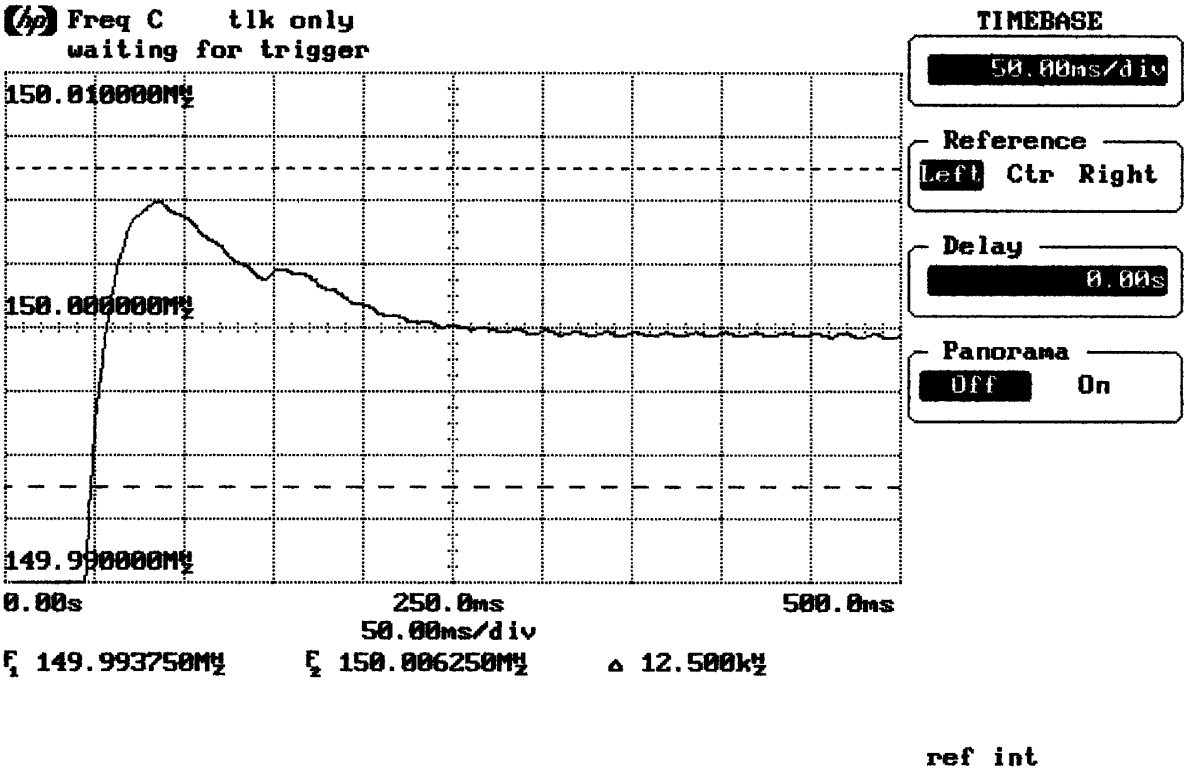


Test Condition: 150 MHz, 250 mW. Frequency Up to 100 ms

Test Limit: ±12.5 kHz within 5 ms, ±6.25 kHz within 25 ms

Test Indication: Transient Frequency < ±6.25 kHz for all times beyond t_{on}.

Test Outcome: Transient Frequency within limits → Pass.

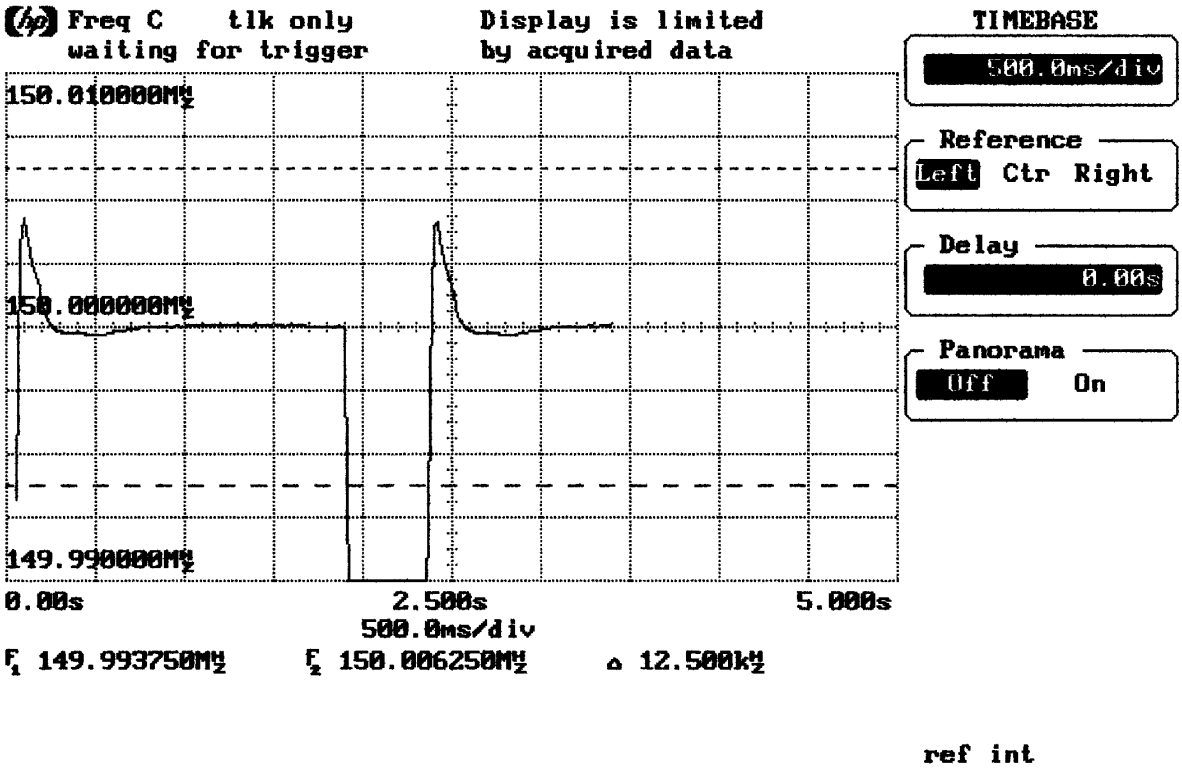


Test Condition: 150 MHz, 250 mW. Frequency Up to 500 ms

Test Limit: ±12.5 kHz within 5 ms, ±6.25 kHz within 25 ms

Test Indication: Transient Frequency < ±6.25 kHz for all times beyond t_{on}.

Test Outcome: Transient Frequency within limits → Pass.

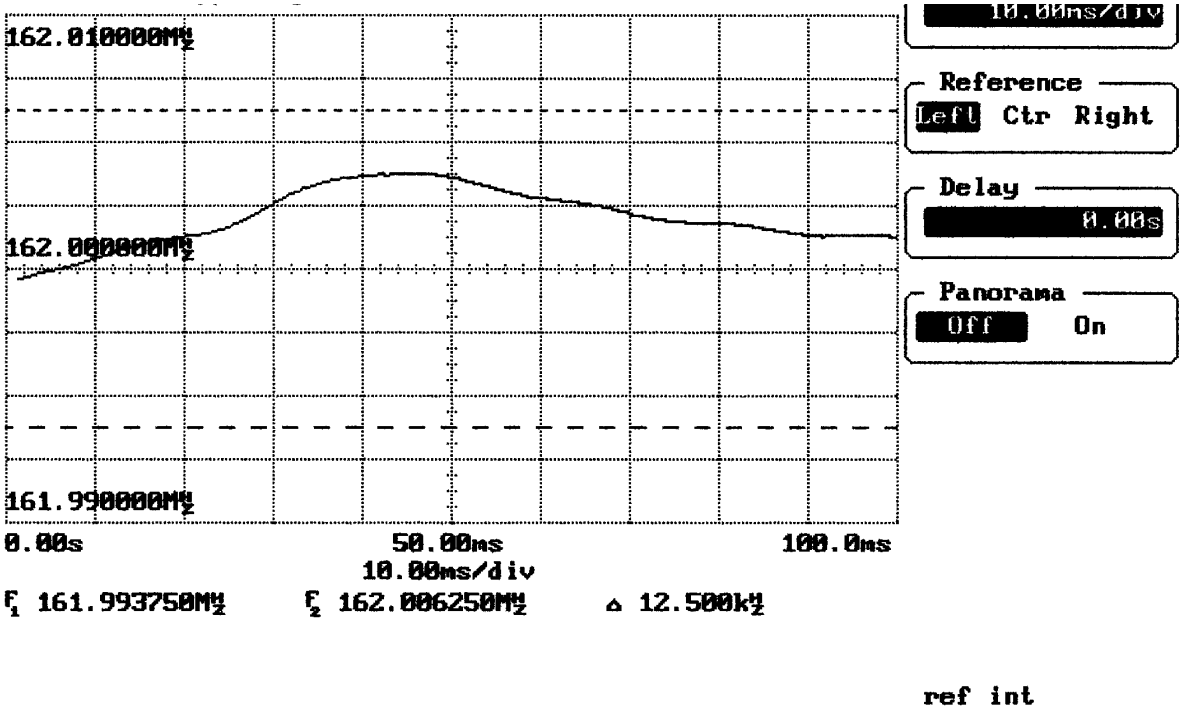


Test Condition: 150 MHz, 250 mW. Transmitter Release Transient Frequency.

Test Limit: ±12.5 kHz within 5 ms of t_{off}

Test Indication: Transmitter exhibits no post-release transient behavior, power level drops below –13 dBm. .

Test Outcome: Transient Frequency within limits → Pass.

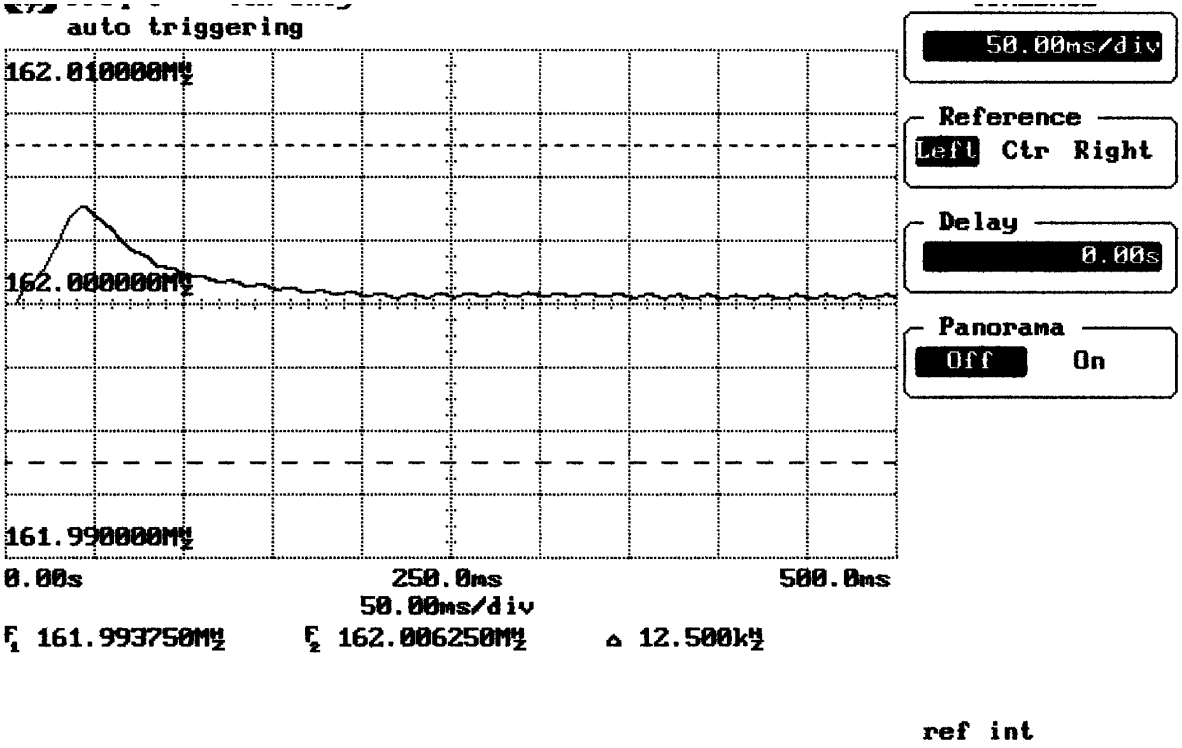


Test Condition: 162 MHz, 250 mW. Frequency Up to 100 ms

Test Limit: ±12.5 kHz within 5 ms, ±6.25 kHz within 25 ms

Test Indication: Transient Frequency < ±6.25 kHz for all times beyond t_{on}.

Test Outcome: Transient Frequency within limits → Pass.

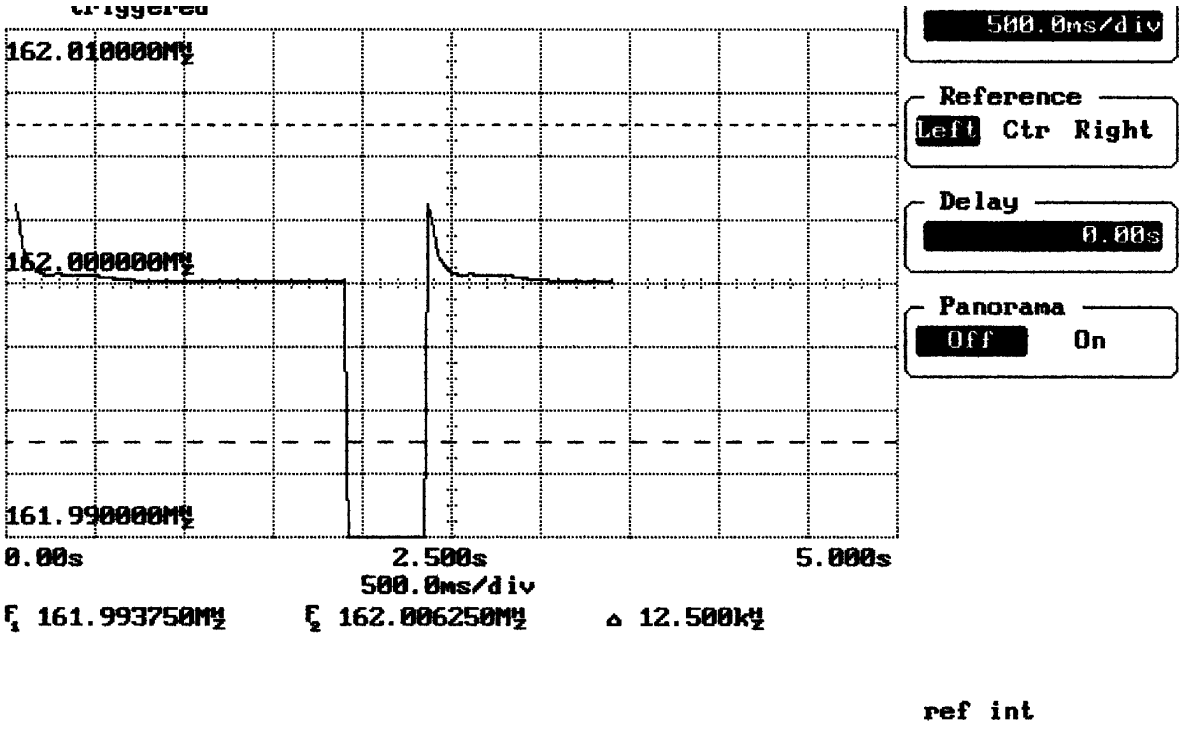


Test Condition: 162 MHz, 250 mW. Frequency Up to 500 ms

Test Limit: ±12.5 kHz within 5 ms, ±6.25 kHz within 25 ms

Test Indication: Transient Frequency < ±6.25 kHz for all times beyond t_{on}.

Test Outcome: Transient Frequency within limits → Pass.

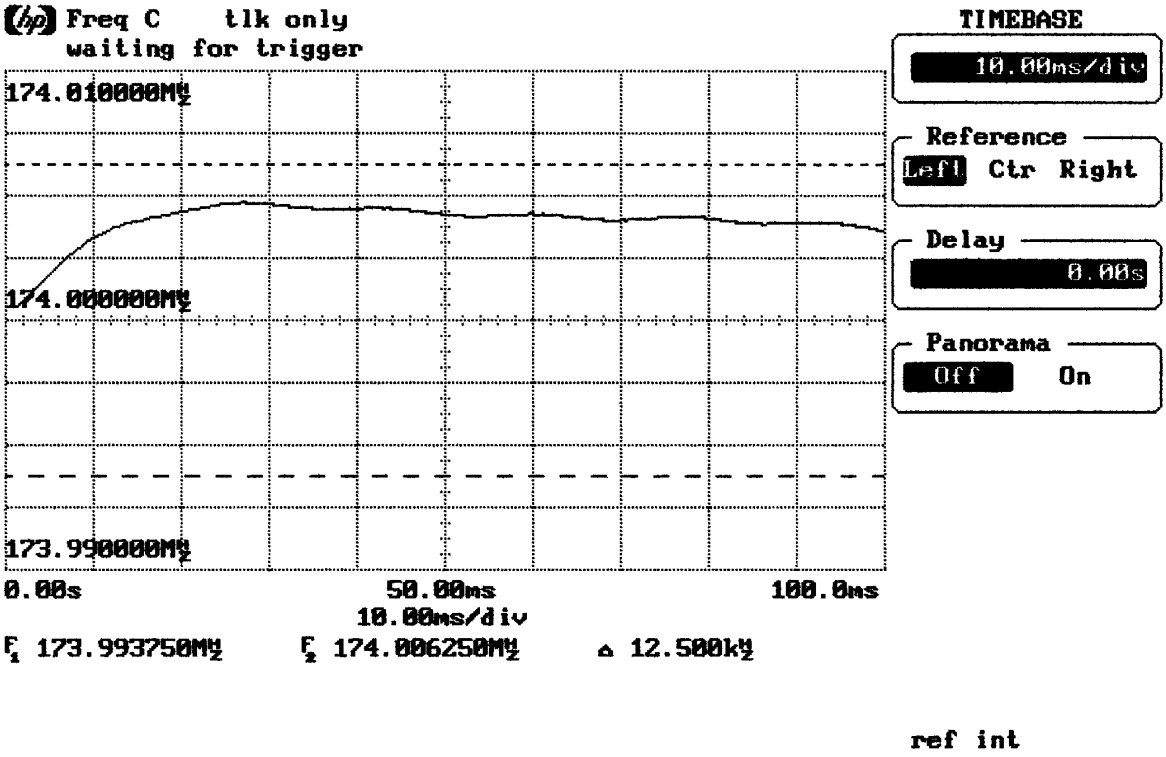


Test Condition: 162 MHz, 250 mW. Transmitter Release Transient Frequency.

Test Limit: ±12.5 kHz within 5 ms of t_{off}

Test Indication: Transmitter exhibits no post-release transient behavior, power level drops below –13 dBm. .

Test Outcome: Transient Frequency within limits → Pass.

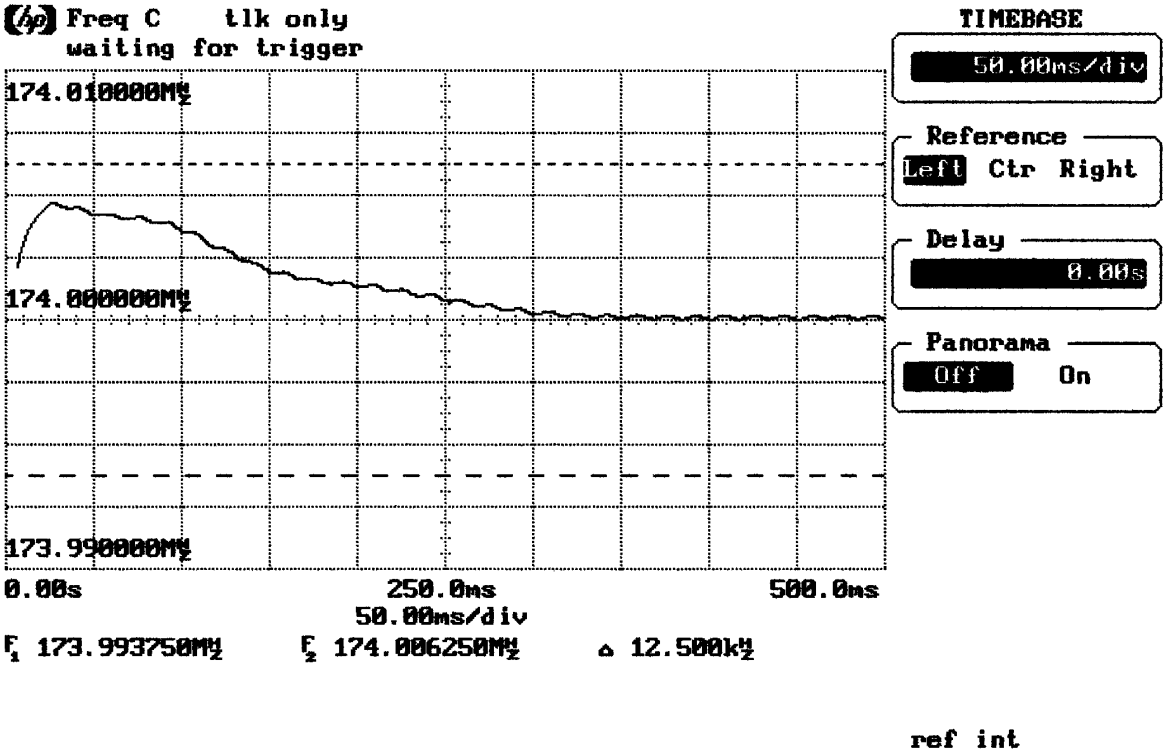


Test Condition: 174 MHz, 250 mW. Frequency Up to 100 ms

Test Limit: ±12.5 kHz within 5 ms, ±6.25 kHz within 25 ms

Test Indication: Transient Frequency < ±6.25 kHz for all times beyond t_{on}.

Test Outcome: Transient Frequency within limits → Pass.

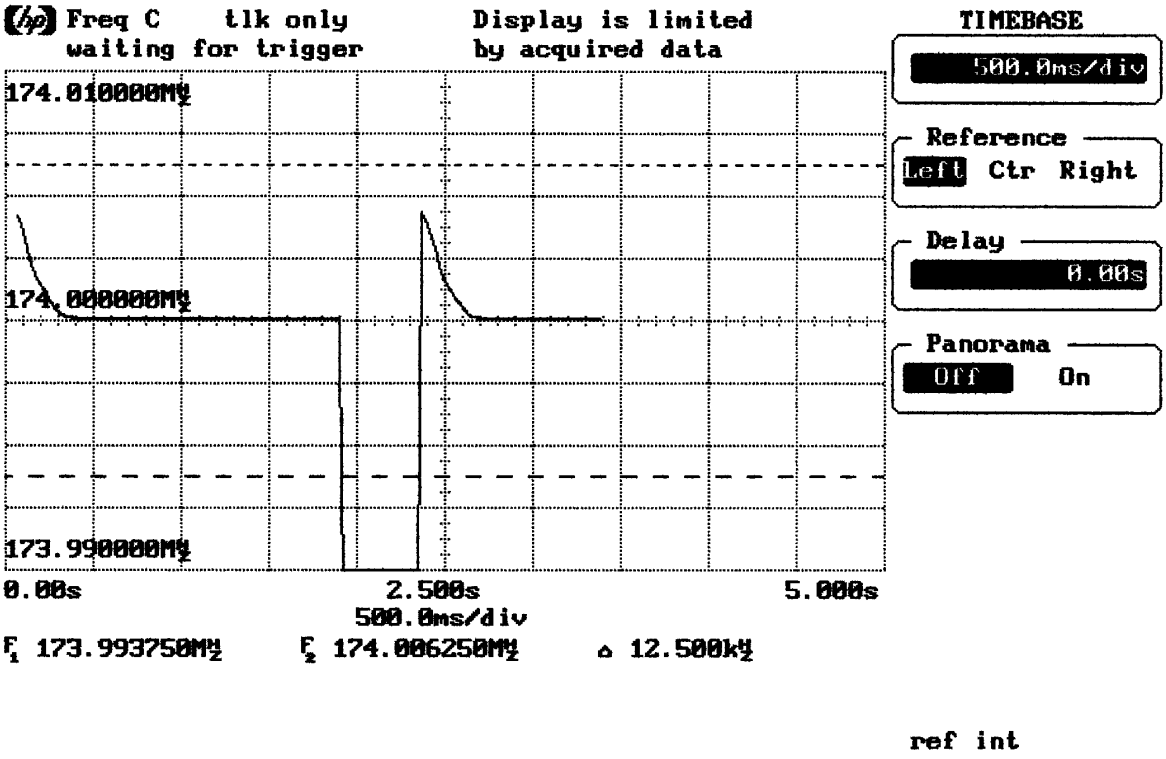


Test Condition: 174 MHz, 250 mW. Frequency Up to 500 ms

Test Limit: ±12.5 kHz within 5 ms, ±6.25 kHz within 25 ms

Test Indication: Transient Frequency < ±6.25 kHz for all times beyond t_{on}.

Test Outcome: Transient Frequency within limits → Pass.



Test Condition: 174 MHz, 250 mW. Transmitter Release Transient Frequency.

Test Limit: ±12.5 kHz within 5 ms of t_{off}

Test Indication: Transmitter exhibits no post-release transient behavior, power level drops below –13 dBm. .

Test Outcome: Transient Frequency within limits → Pass.

6. 2.987 (a), (b) Modulation Characteristics

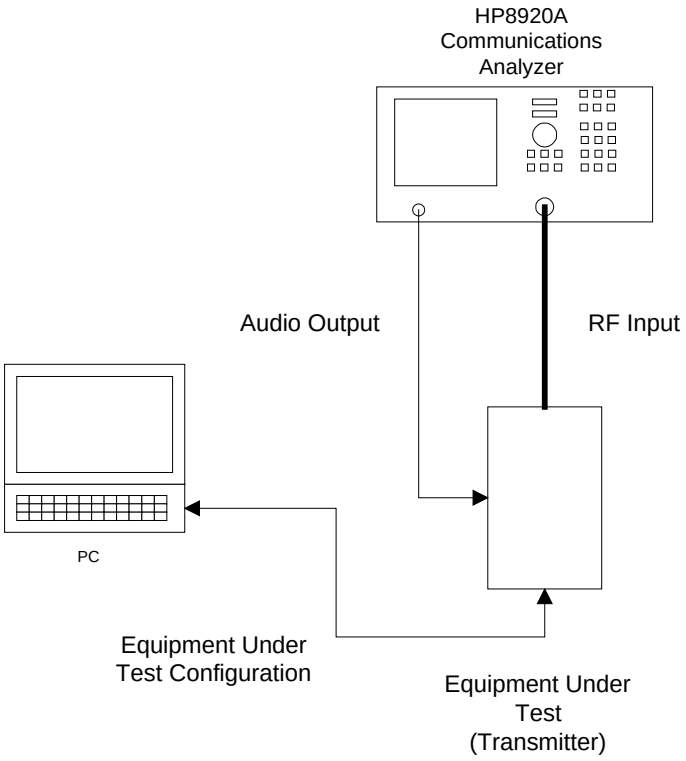
a) Test Requirement

(a) For voice modulated transmitter a frequency response curve of the audio processor between the microphone and modulator must be submitted.

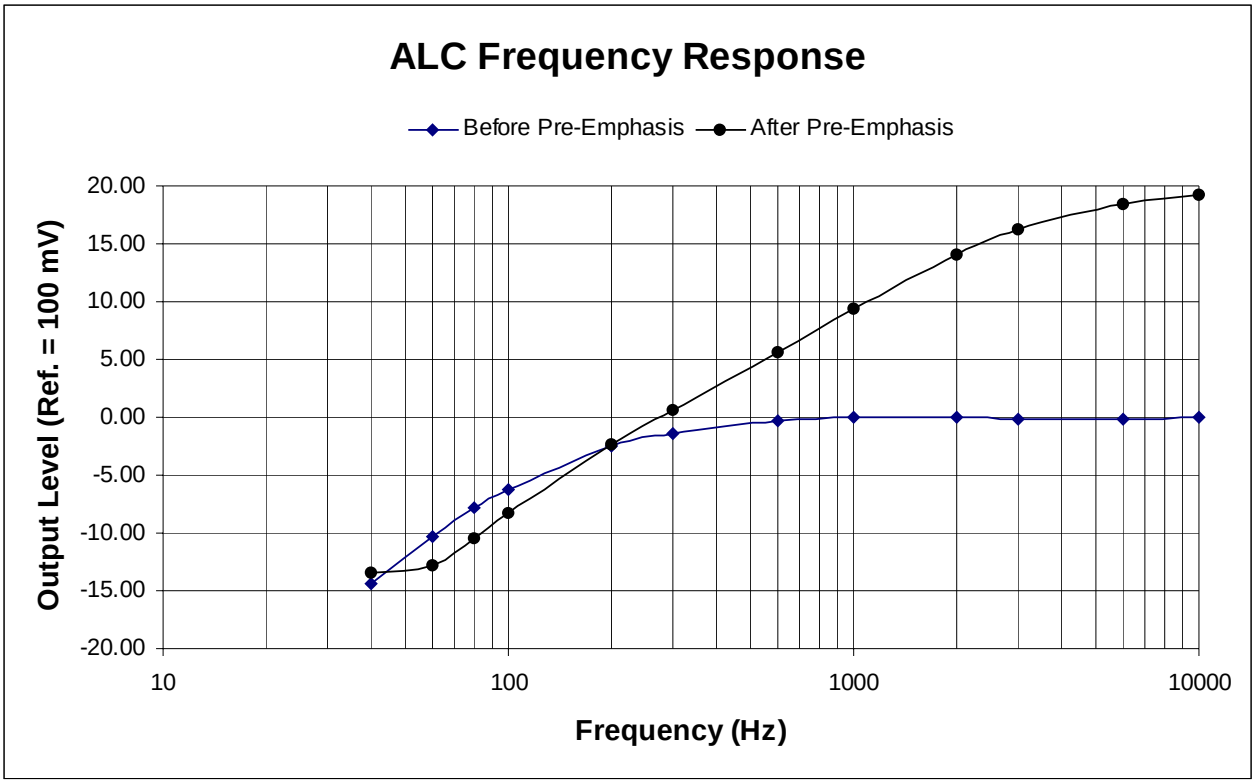
(b) A curve of frequency deviation versus level must be made across the range of input audio frequencies.

The test is configured such that the audio generator presents a source impedance of 4.3 k-Ohms to the audio circuitry, simulating the presence of the microphone.

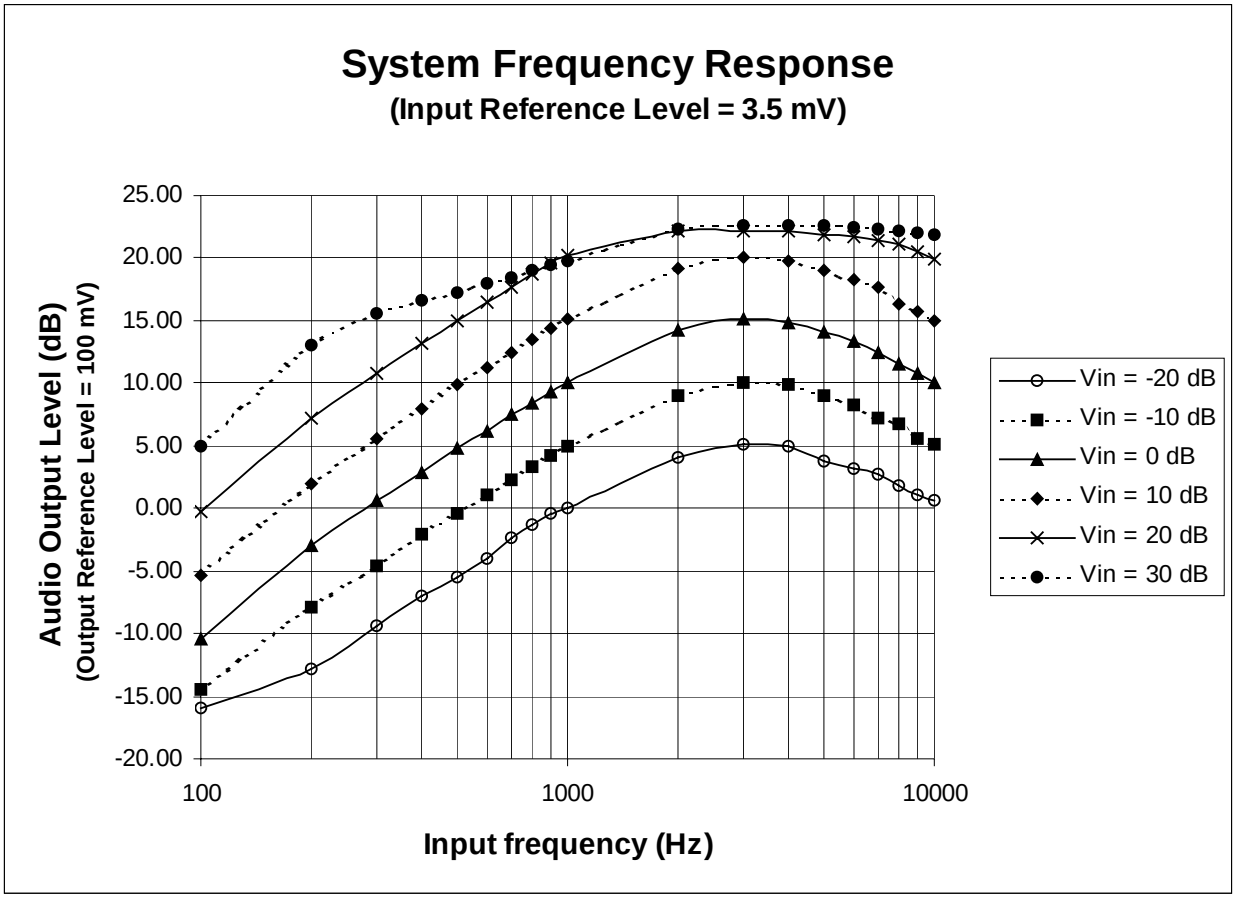
b) Test Configuration (Deviation versus Level)



c) Test Conditions and Indications: Audio Responses



ALC Mode Frequency Response



2:1 Dynamic Range Compressor Frequency Response

W66 N220 Commerce Court, Cedarburg, Wisconsin 53012 • 414-375-4400 • FAX 414-375-4248
Email: eng@lsr.com www.lsr.com

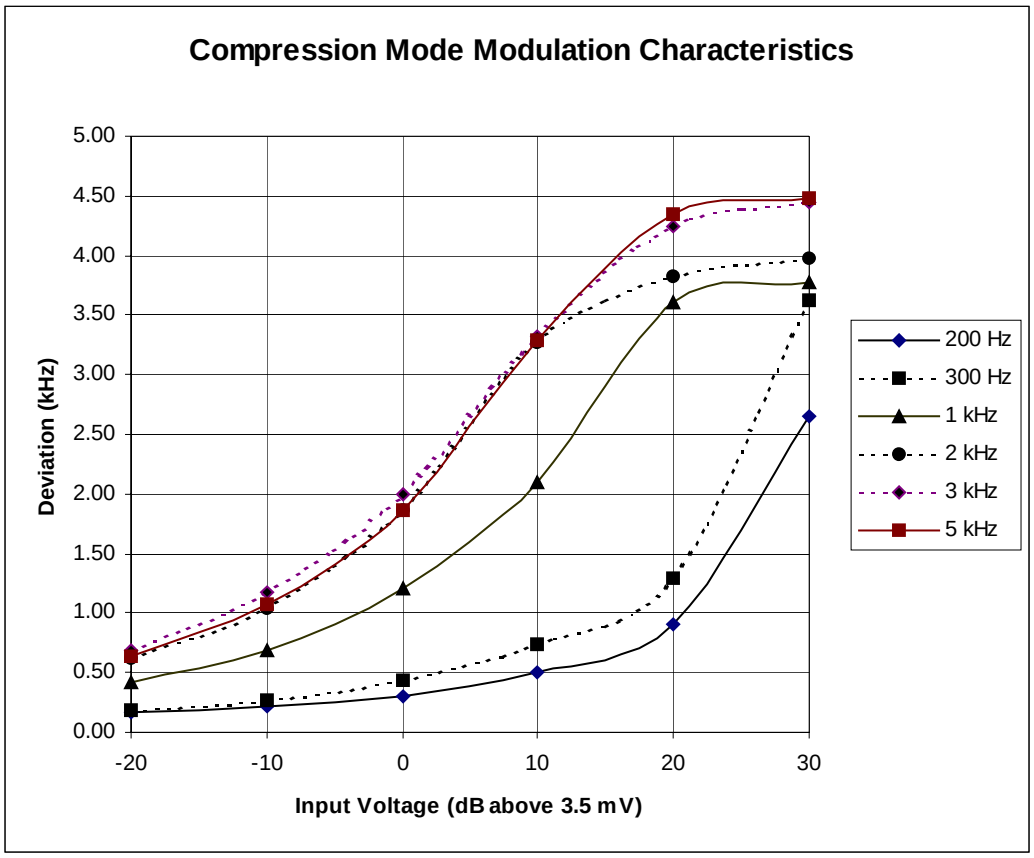
d) Test Conditions and Indications: Peak Frequency Deviation versus Audio Level

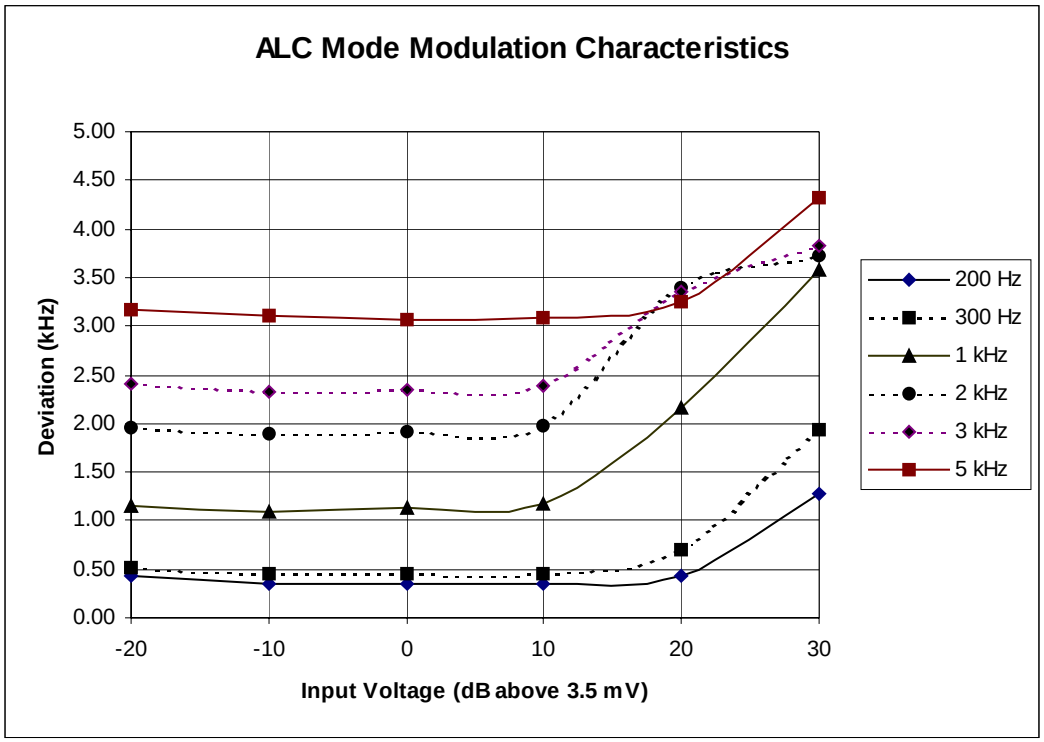
Test Conditions: 162 MHz, 250 mW.

ALC: Automatic Leveling Control.

Comp. : 2:1 Dynamic Range Compressor

	Vin (mV) =	0.35	1.11	3.50	11.07	35.00	110.7
Mode	fm (Hz)	-20	-10	0	10	20	30
Comp.	200	0.16	0.21	0.31	0.51	0.90	2.65
	300	0.19	0.27	0.43	0.73	1.30	3.62
	1k	0.42	0.68	1.20	2.09	3.61	3.77
	2k	0.62	1.04	1.86	3.28	3.83	3.97
	3k	0.69	1.17	1.99	3.33	4.25	4.45
	5k	0.64	1.07	1.86	3.29	4.34	4.48
ALC	200	0.44	0.36	0.34	0.35	0.44	1.27
	300	0.51	0.46	0.45	0.46	0.70	1.93
	1k	1.16	1.10	1.14	1.18	2.17	3.58
	2k	1.95	1.90	1.92	1.98	3.39	3.73
	3k	2.40	2.33	2.34	2.39	3.36	3.82
	5k	3.17	3.10	3.06	3.09	3.26	4.33


Compression Mode Modulation Characteristics
Deviation (kHz)
5.00
4.50
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
-20
-10
0
10
20
30
Input Voltage (dB above 3.5 mV)
200 Hz
300 Hz
1 kHz
2 kHz
3 kHz
5 kHz


ALC Mode Modulation Characteristics
Deviation (kHz)
5.00
4.50
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
-20
-10
0
10
20
30
Input Voltage (dB above 3.5 mV)
200 Hz
300 Hz
1 kHz
2 kHz
3 kHz
5 kHz

III. Equipment List

Equipment	LSR Serial No.	Serial Number	Calibration
HP8596E Spectrum Analyzer	CC000130C	On Record	2/1/93
HP8920A Communication Test Set	-	3820A10282	1/5/99
HP53310 Modulation Domain Analyzer	CC000124C	On Record	12/12/95
Thermotron S-8C Temp Chamber	CC000210C	On Record	6/5/98
HP33120 Arb. Waveform Synthesizer	CC000181C	On Record	9/29/97

IV. Equipment Uncertainties

Specified Characteristic	Specified Probability Density	Specified Uncertainty
HP8596E Spectrum Analyzer		
Reference Level Accuracy	Uniform	+ / -0.3 dB +0.01 X dB from -20 dbm
Calibrator Output	Uniform	+/-0.4 dB
Absolute Amplitude Calibration Uncertainty	Uniform	+/-0.15 dB
Gigatronics 86301A Sensor Calibration Factor	Uniform	1.33%
HP53310 Modulation Domain Analyzer CHAN A ,B		
Absolute Frequency Accuracy (OPT 010)		< 5 X 10-9
Frequency Resolution		
Time: 2 mS/div ,Tsamp=100uS, f=200 MHz	Gaussian	100 Hz rms
Time: 20 mS/div ,Tsamp=1 mS, f=200 MHz	Gaussian	2 Hz rms
Time Interval Error		
Tsamp=100 uS	Gaussian	100 ps rms
Tsamp=1 mS	Gaussian	1nS rms
HP8920A Communication Test Set		
Audio Output Frequency Accuracy	Uniform	0.025%
Audio Output Level Accuracy	Uniform	+/-2% Vset +/- 50 uV
Frequency Deviation Accuracy	Uniform	+/- 4% Reading + 7 Hz rms
Thermotron S-8C Temp. Chamber		
Temperature Accuracy	Uniform	+/- 0.3 deg C

V. Uncertainty Analysis

HP Spectrum Analyzer Total Uncertainty (-60 dBm level):

Perform Root-Sum-Square of three uncertainties to find total uncertainty for a 95% confidence level:

Uniform uncertainties specify the probability density interval ±a. The variance of the uniform density is a/3.

Sum the uncorrelated variances to find the total variance:

Total variance = [(0.3 dB +0.01 • 40 dB)/3 +(0.4)/3+(0.15)/3] = 1.25/3 = 0.416

The uncertainty for a 95% confidence interval is 1.96 times the standard deviation:

Total Uncertainty = ±1.96 • √0.416 = 1.96 • 0.644 = ±1.26 dB