



LS Research Inc.

500 mW Surveillance Transmitter

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Part 90 Type Acceptance, Conducted Measurements

prepared for

Audio Intelligence Devices



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Surveillance Transmitter

I. Project Information

Project: Surveillance Transmitter

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Proposal Date: 3/9/99
Revision: 1.2
Proposal #: 859
Proposal File: AID Transmitter 1_2
Job Number: 871

Signatures:

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: 500 mW. The Emission Designator becomes **16K4 F3E**

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:**

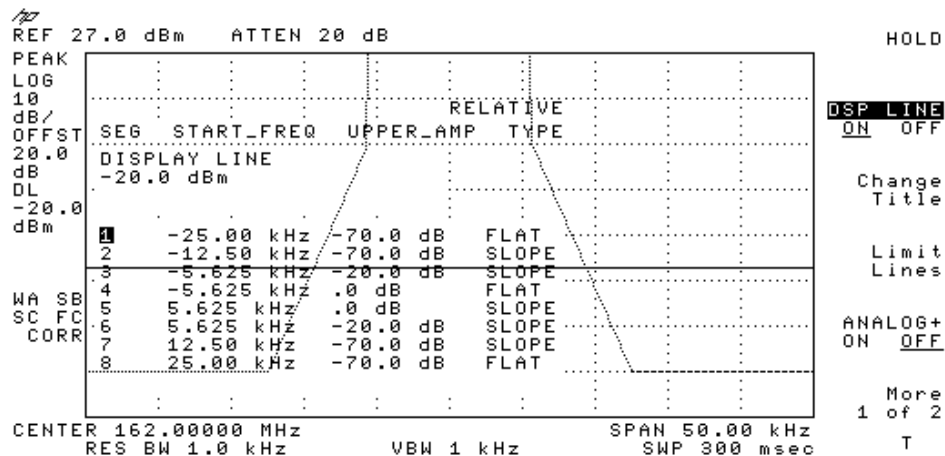
(1) On any frequency from the center of the authorized bandwidth f_o to 5.625 kHz removed from f_o : Zero dB.

(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 $7.27(f_d - 2.88 \text{ kHz})$ dB.

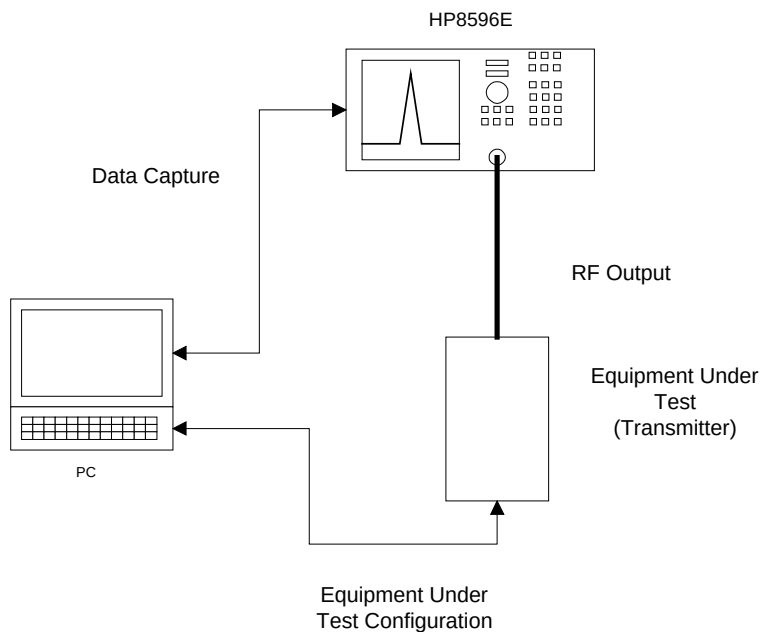
(3) On any frequency removed from the center of the authorized band by a displacement frequency (f_d in kHz) of more than 12.5 kHz : At least $50 + 10 \log(P)$ dB or 70 dB, whichever is the lesser attenuation.

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



c) Test Conditions: Stimulus

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

Set level to 50% rated deviation. (100 % is +/- 2.0 kHz., 50% is 1.0 kHz)

This level occurs at 0.75 mV.



Set modulating frequency to 2500 Hz

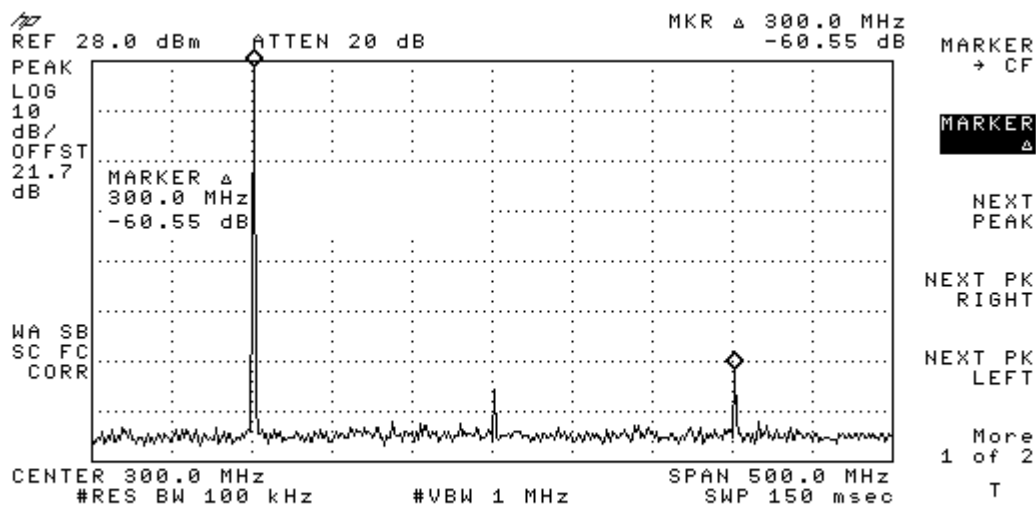
Increase Level by 16 dB: 16 dB - 4.8 dB (pre-emphasis) = 11.2 dB
2.72 mV.

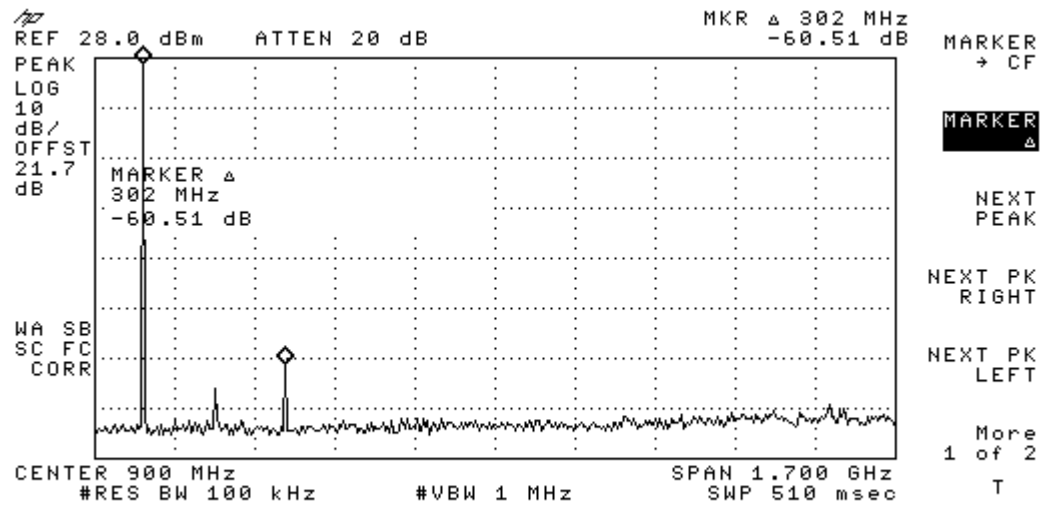
Measure Spectrum Mask (D).

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

Presented in sub-sections (e) and (f) are the test indications that demonstrate compliance.

e) Test Indications Part 2.991 Conducted Spurious Emissions at Antenna Terminals



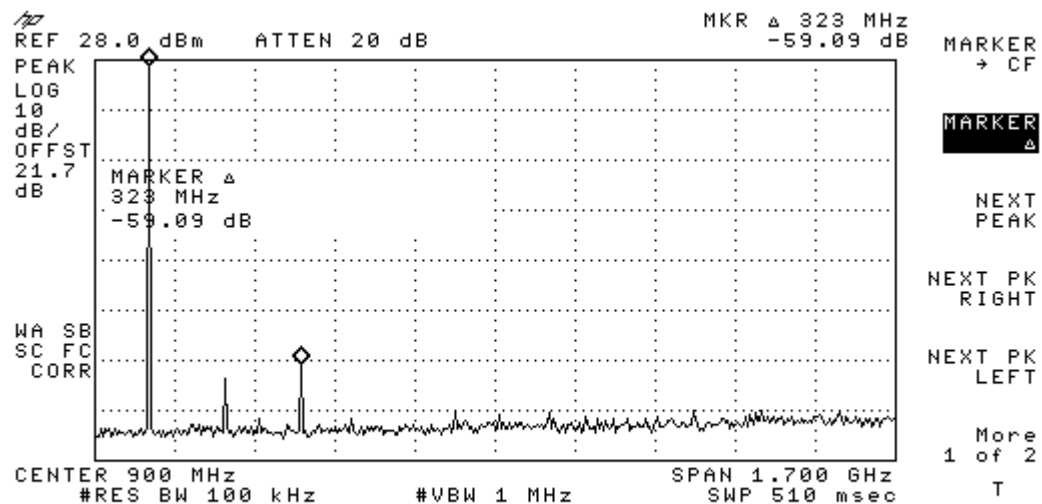
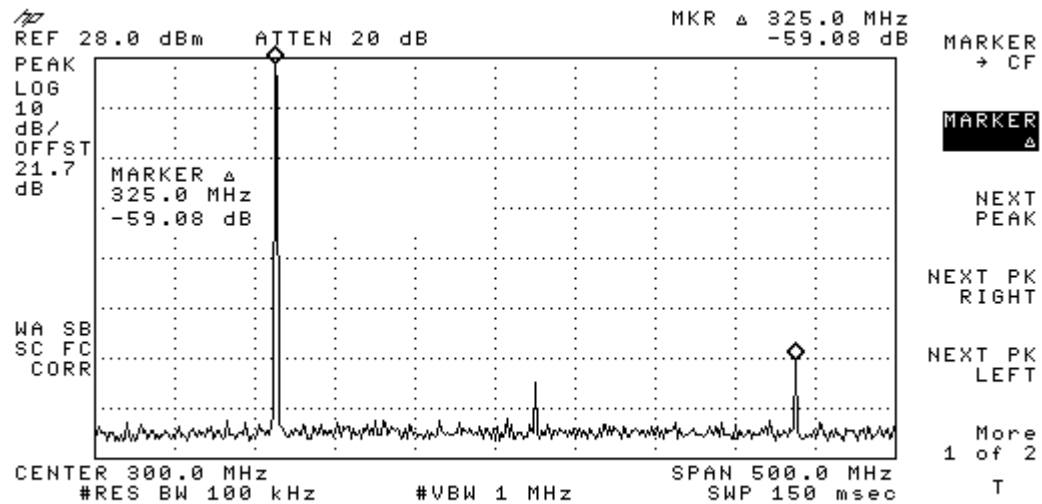


Test Condition: 150 MHz, 500 mW

Test Limit: $10 \log (500 \text{ mW}) + 50 \text{ dB} = 47 \text{ dBc}$

Test Indication: 60.5 dBc

Test Outcome: 60.5 dBc > 47 dBc → PASS



Test Condition: 162 MHz, 500 mW

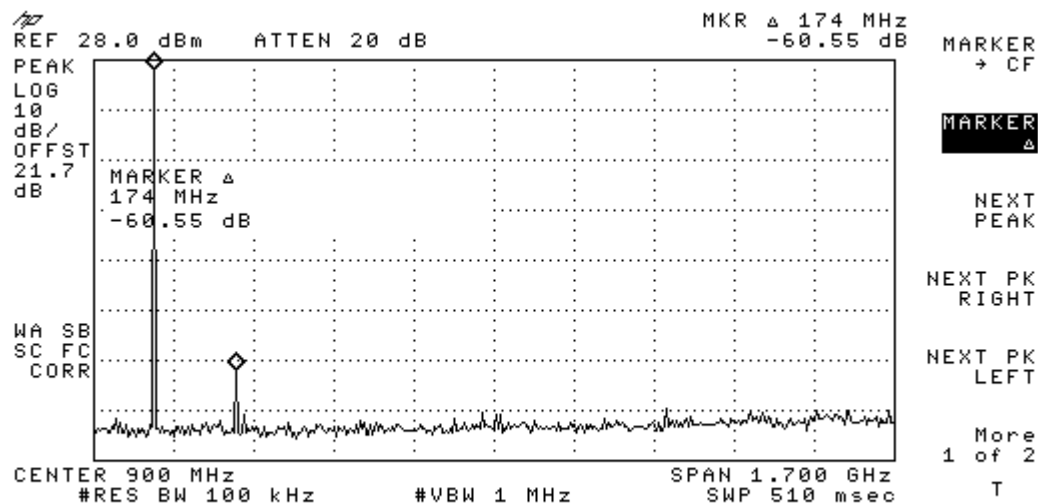
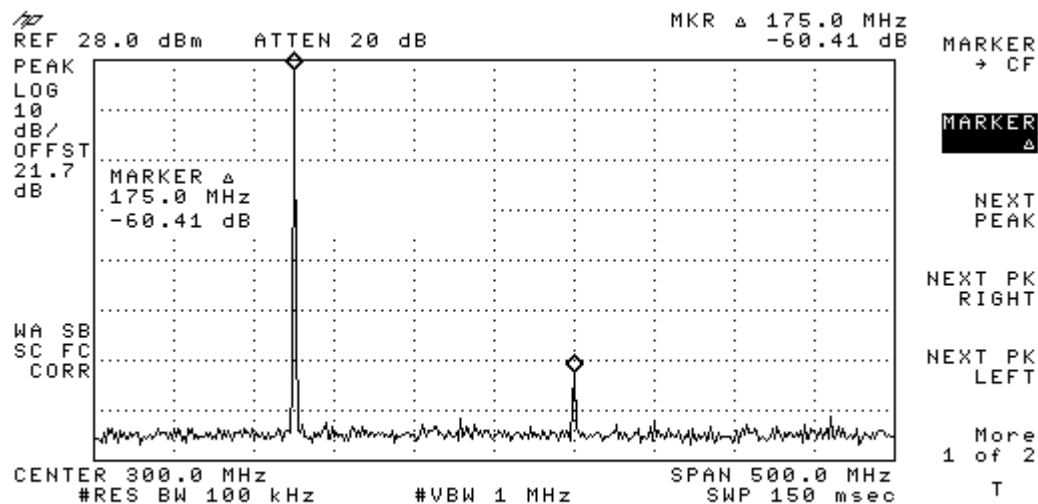
Test Limit: $10 \log (500 \text{ mW}) + 50 \text{ dB} = 47 \text{ dBc}$

Test Indication: 59.1 dBc

Test Outcome: 59.1 dBc > 47 dBc → PASS

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Test Condition: 174 MHz, 500 mW

Test Limit: $10 \log (500 \text{ mW}) + 50 \text{ dB} = 47 \text{ dBc}$

Test Indication: 60.5 dBc

Test Outcome: 60.5 dBc > 47 dBc → PASS

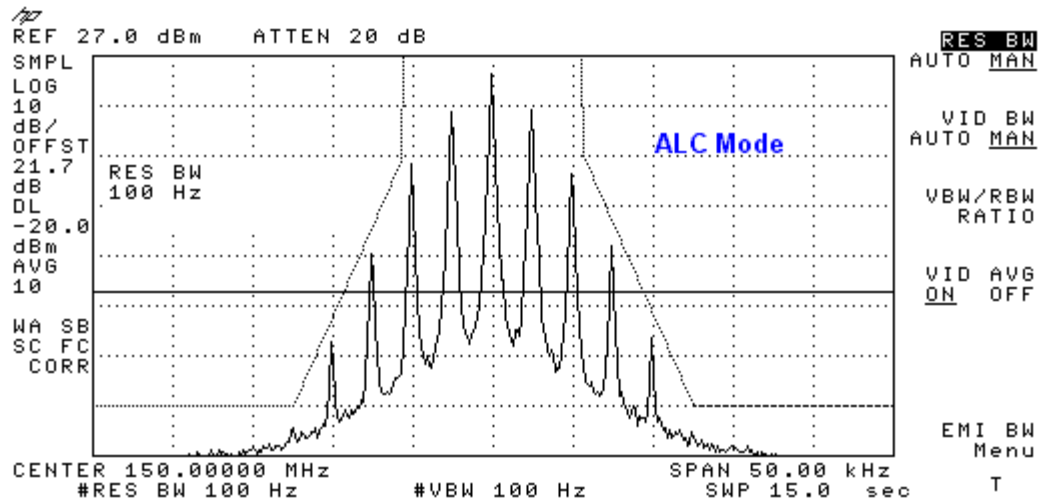
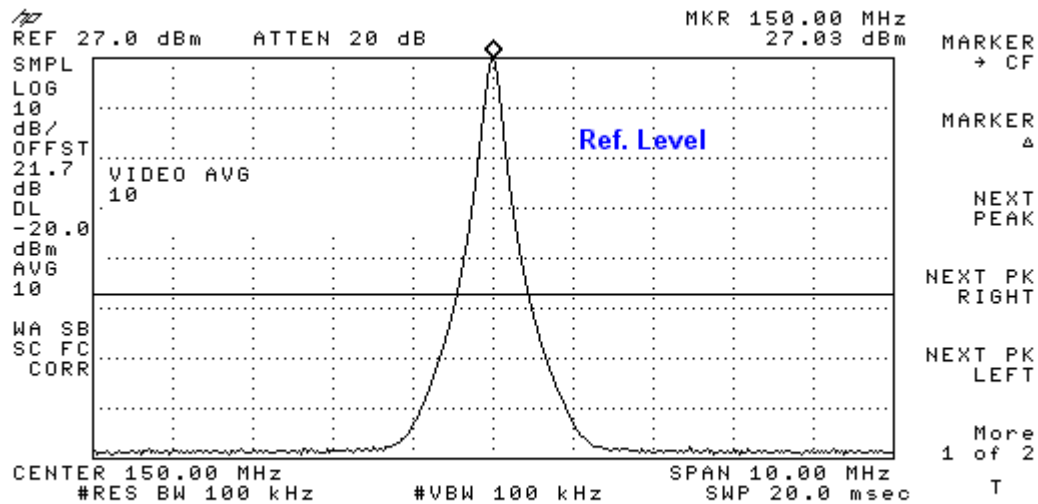
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f) Test Indications Part 2. 989 Occupied Bandwidth

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, 500 mW

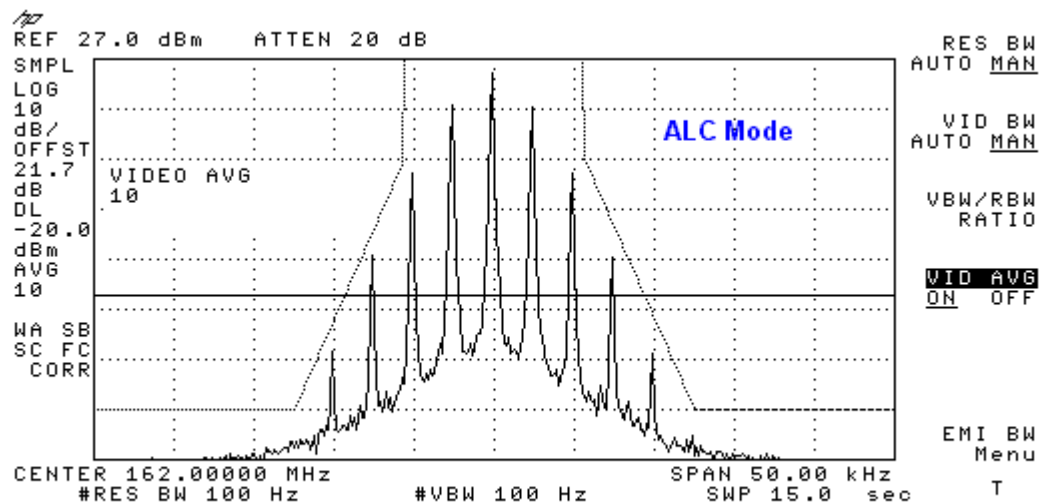
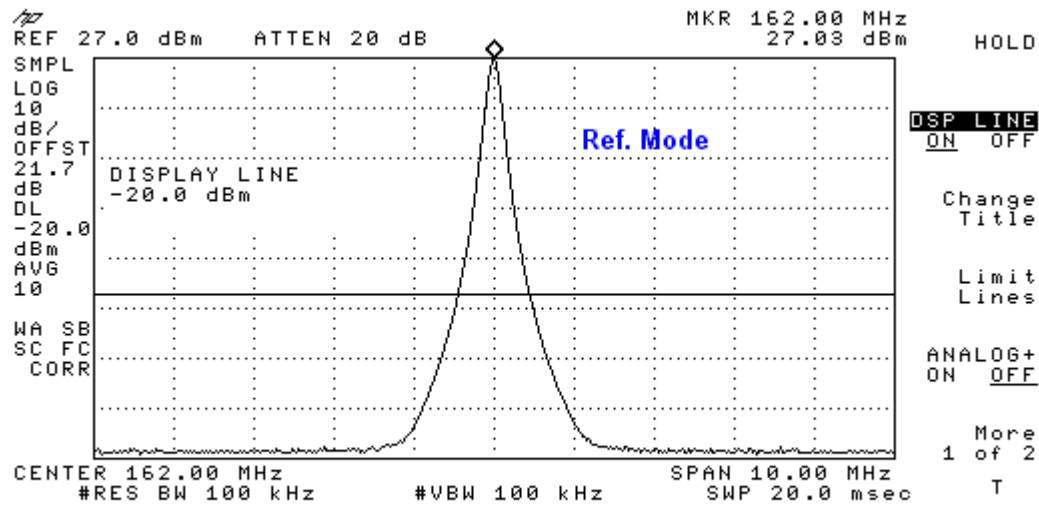
Test Limit: Indicated Mask - see sub-section (a).

Test Indication: Indicated Spectrum falls below Indicated Mask

Test Outcome: Spectrum falls below Indicated Mask → PASS

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Test Condition: 162 MHz, 500 mW

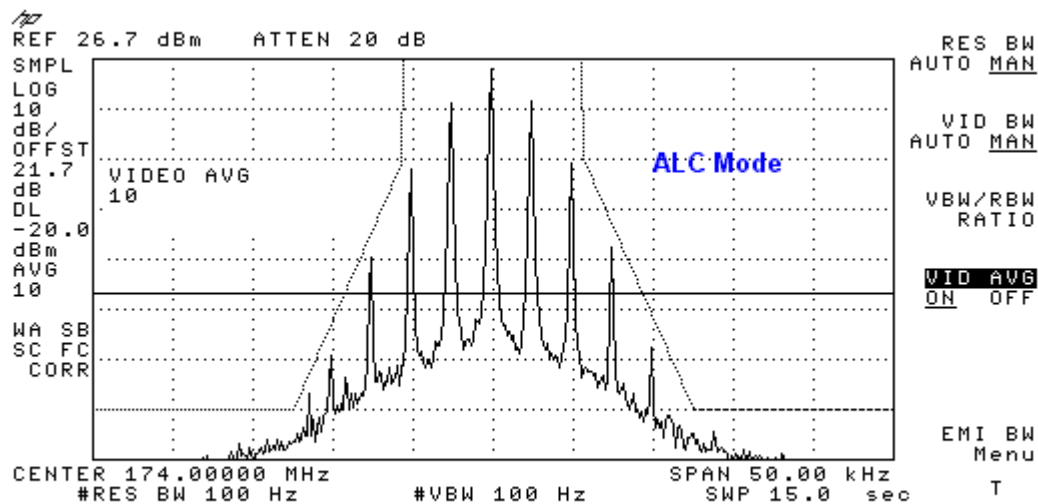
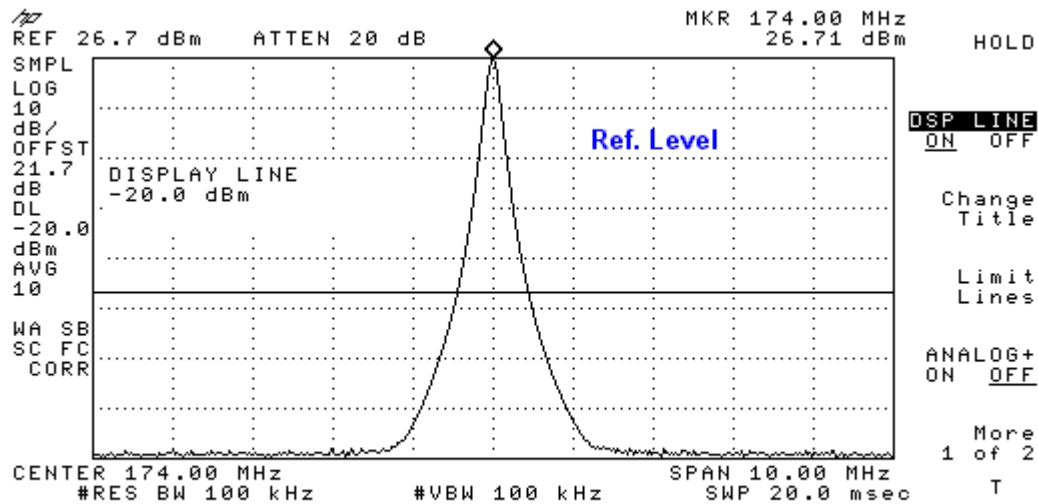
Test Limit: Indicated Mask - see sub-section (a).

Test Indication: Indicated Spectrum falls below Indicated Mask

Test Outcome: Spectrum falls below Indicated Mask → PASS

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Test Condition: 174 MHz, 500 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

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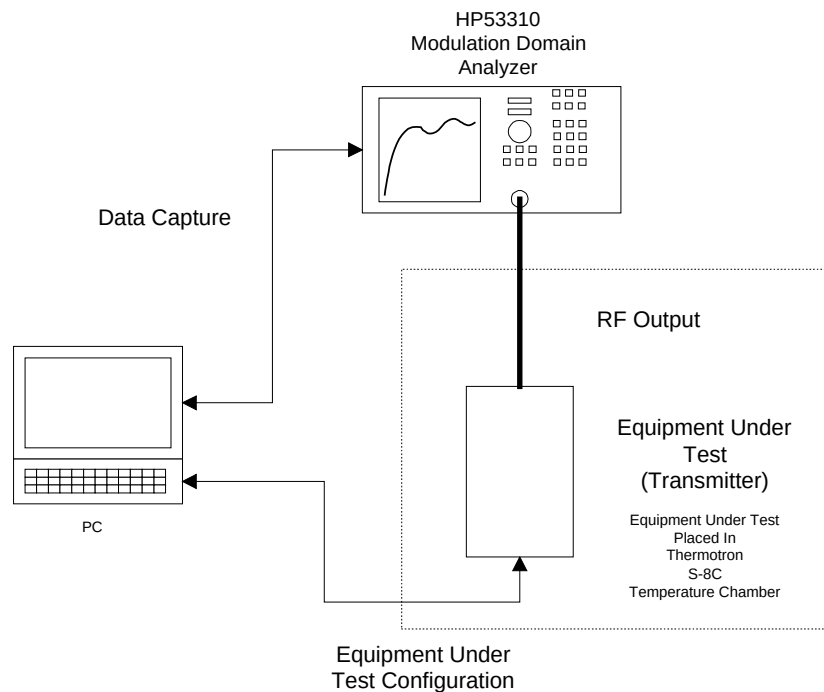
4. Part 2.995 and 90.213 (a) Frequency Stability

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





c) Test Conditions, Numerical Test Indications

T (deg. C)	f (MHz)	ppm w.r.t. 25 deg. C	ppm absolute
-30	162.000036863	0.55	0.23
-20	162.000021390	0.45	0.13
-10	161.999947398	-0.01	-0.32
0	161.999993136	0.28	-0.04
10	162.000154885	1.28	0.96
20	162.000011242	0.39	0.07
25	161.999948209	0.00	-0.32
30	161.999925023	-0.14	-0.46
40	161.999911939	-0.22	-0.54
50	161.999943037	-0.03	-0.35

Test Condition: 162 MHz, 500 mW (-30 deg. C to 50 deg C, 10 degree steps)

Test Limit: 5 ppm Maximum Frequency Offset

Test Indication:

Maximum Frequency Offset is 1.28 ppm Relative to 25 deg C and 0.96 ppm absolute.

Test Outcome: 1.28 ppm and 0.96 ppm < 5 ppm → PASS



5. 90.214: Transient Frequency Behavior.

a) Test Requirement

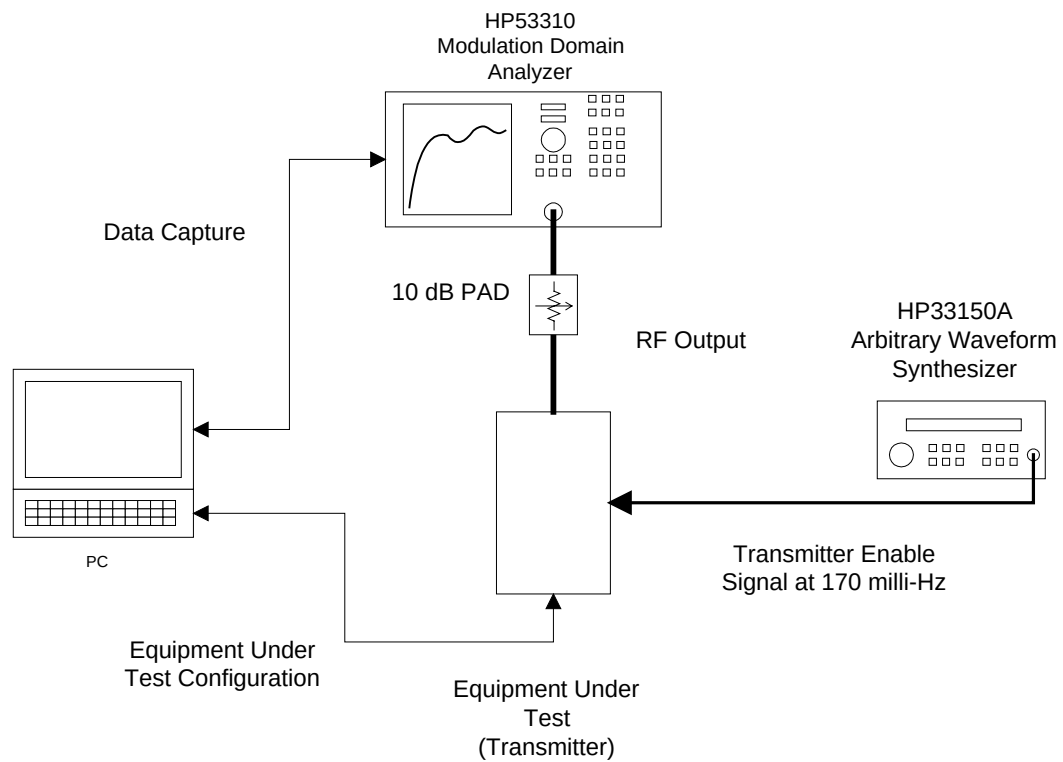
Transmitters designed to operate within the 150 to 174 MHz bands must maintain transient frequencies within the maximum frequency difference during the time intervals indicated in the table below. This device is designed to operate on 12.5 kHz channel bandwidth. The output power of the device is less 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

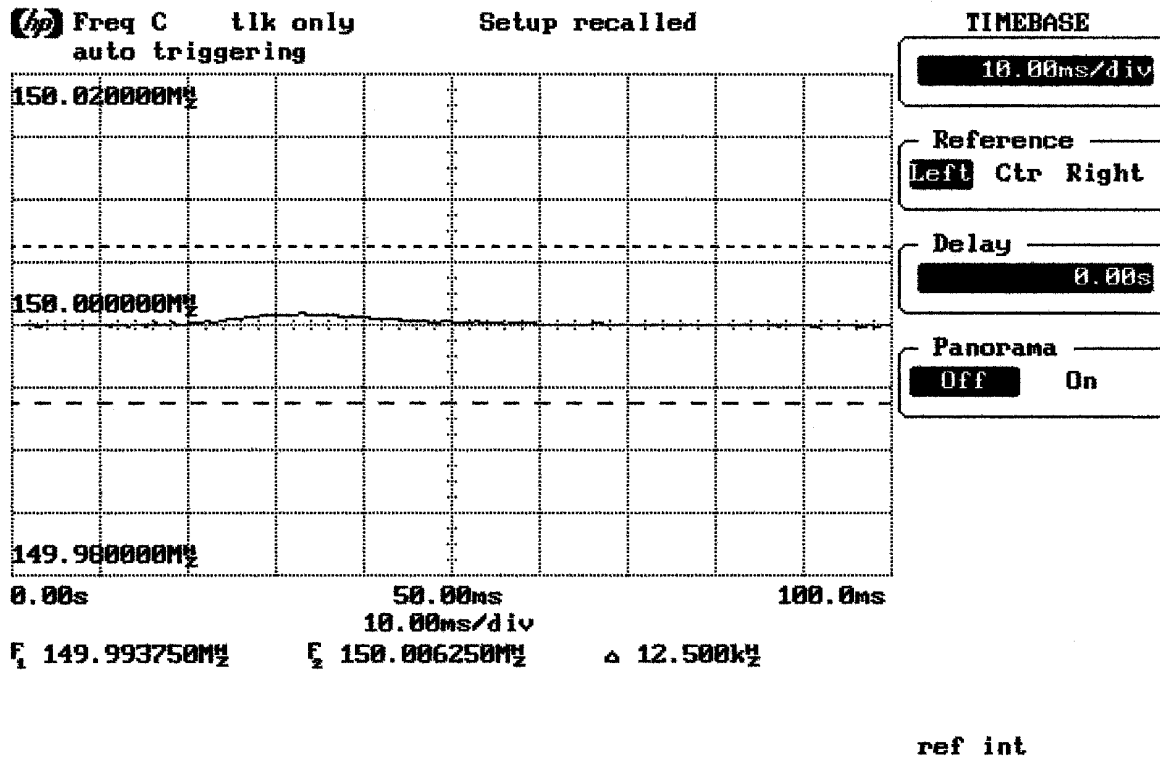


b) Test Configuration





c) Test Conditions and Test Indications

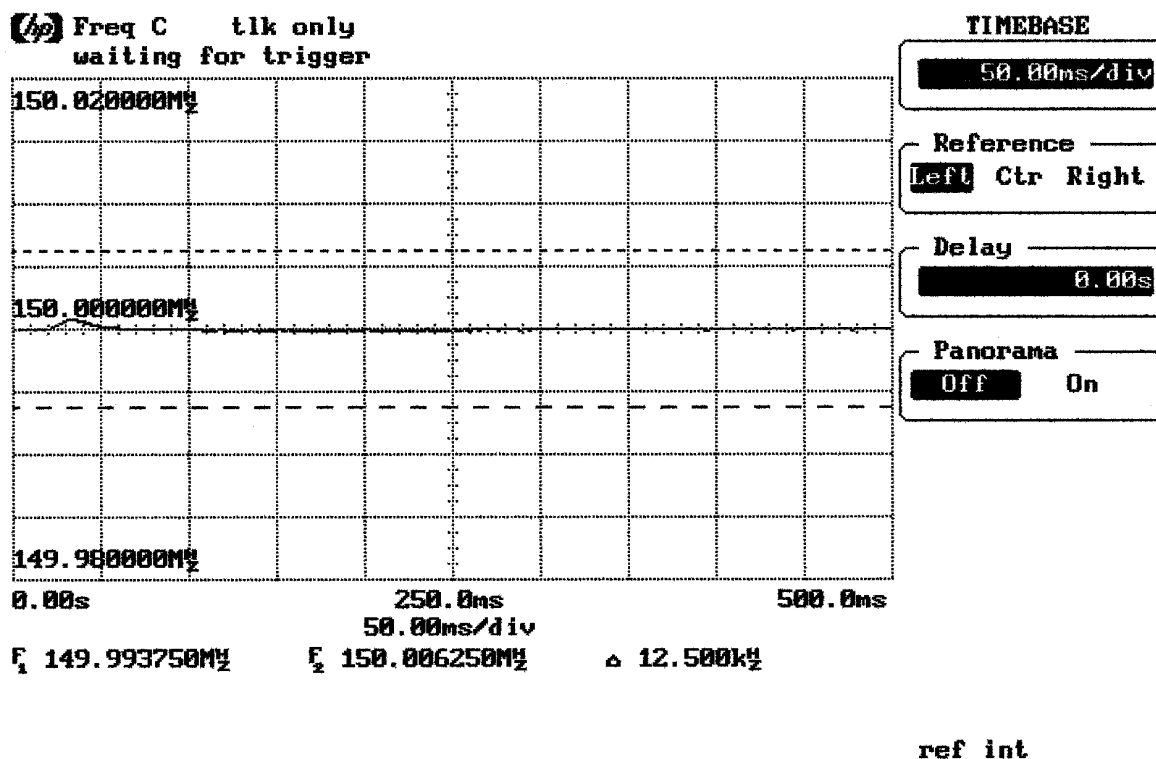


Test Condition: 150 MHz, 500 mW. Frequency Up to 100 ms

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

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

Test Outcome: Transient Frequency within limits $\rightarrow$ PASS.

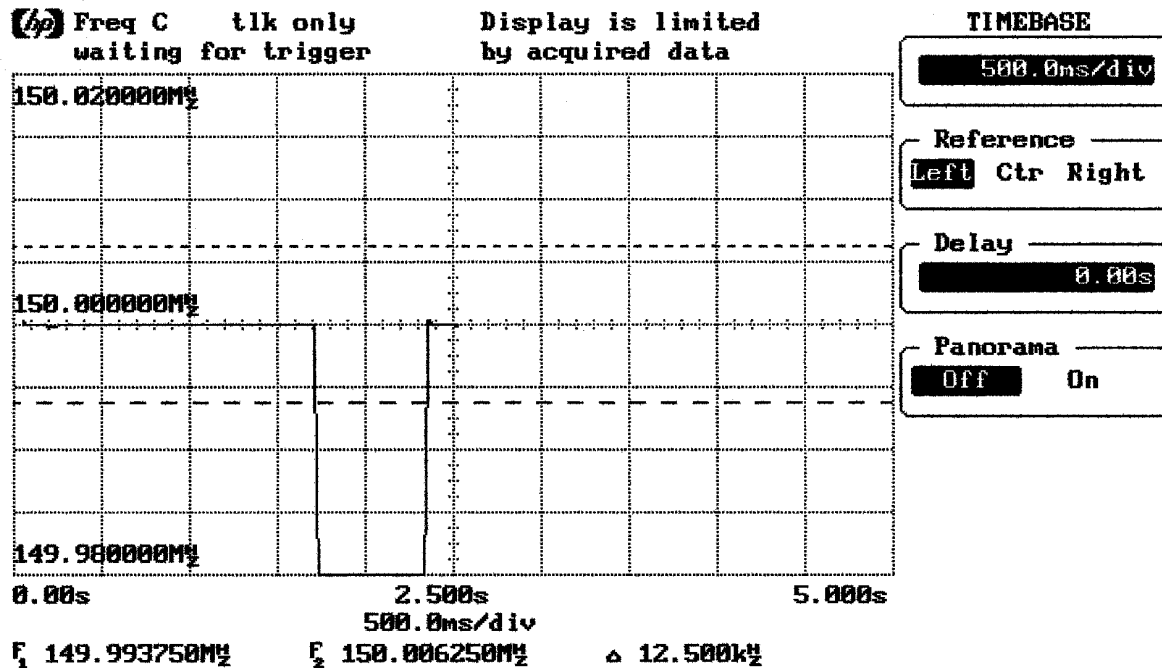


Test Condition: 150 MHz, 500 mW. Frequency Up to 500 ms

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

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

Test Outcome: Transient Frequency within limits → PASS.



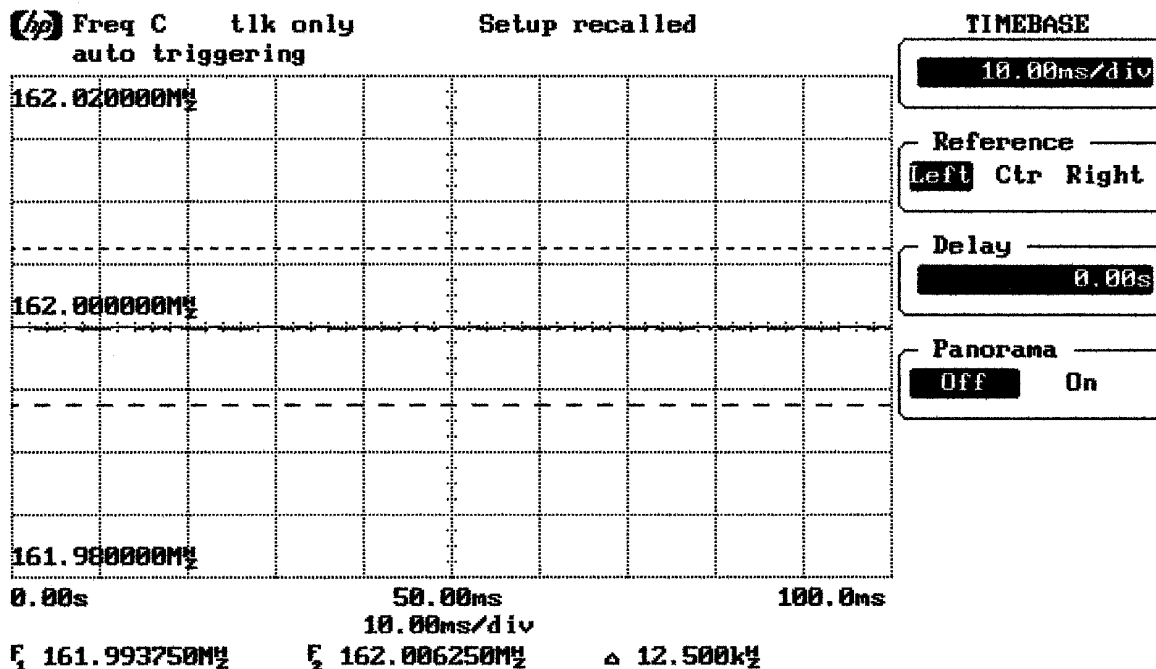
ref int

Test Condition: 150 MHz, 500 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 $\rightarrow$ PASS.

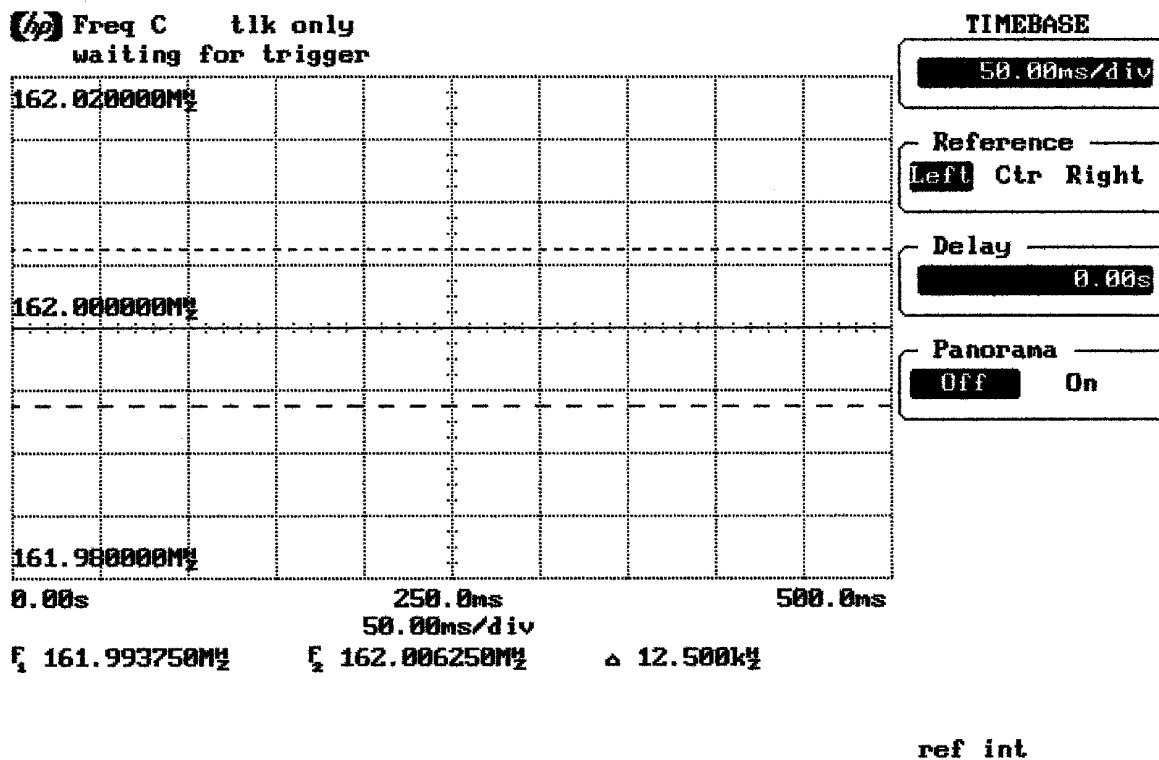


Test Condition: 162 MHz, 500 mW. Frequency Up to 100 ms

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

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

Test Outcome: Transient Frequency within limits $\rightarrow$ PASS.

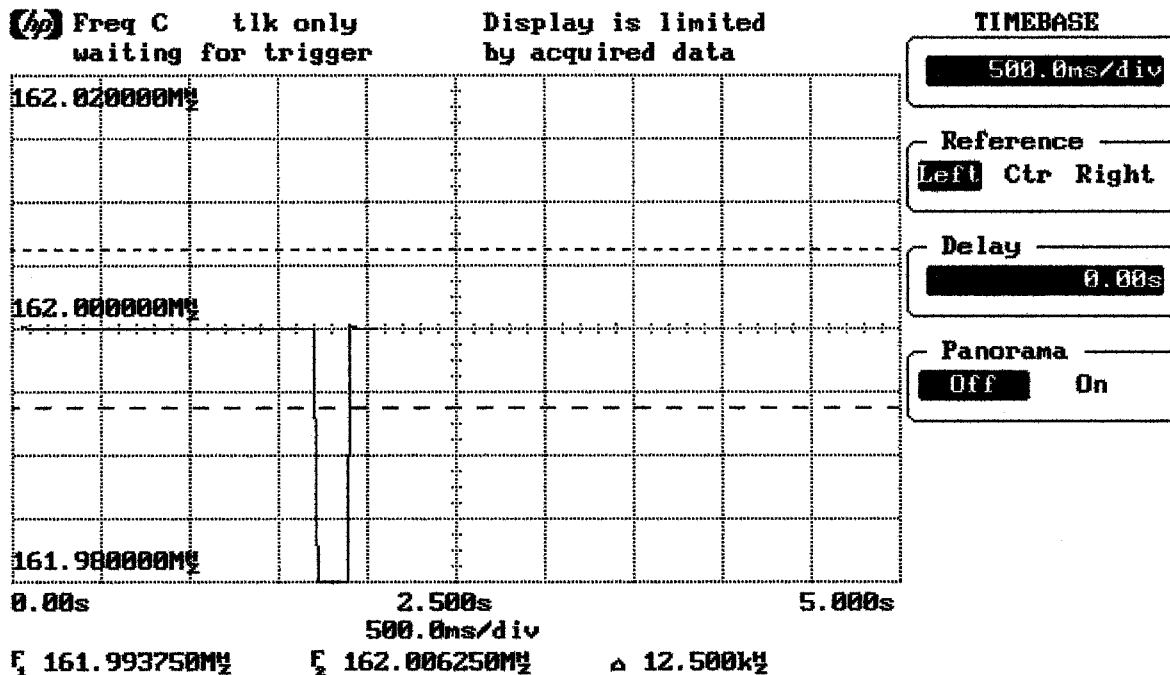


Test Condition: 162 MHz, 500 mW. Frequency Up to 500 ms

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

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

Test Outcome: Transient Frequency within limits → PASS.



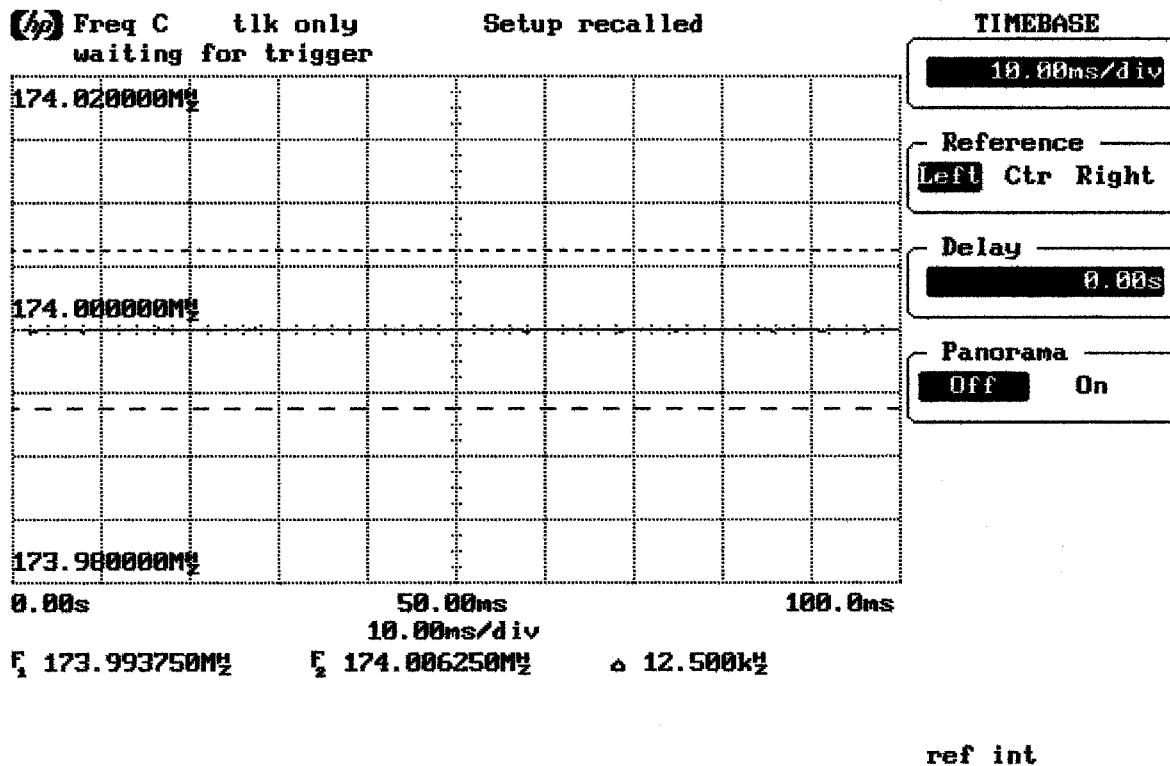
ref int

Test Condition: 162 MHz, 500 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 $\rightarrow$ PASS.

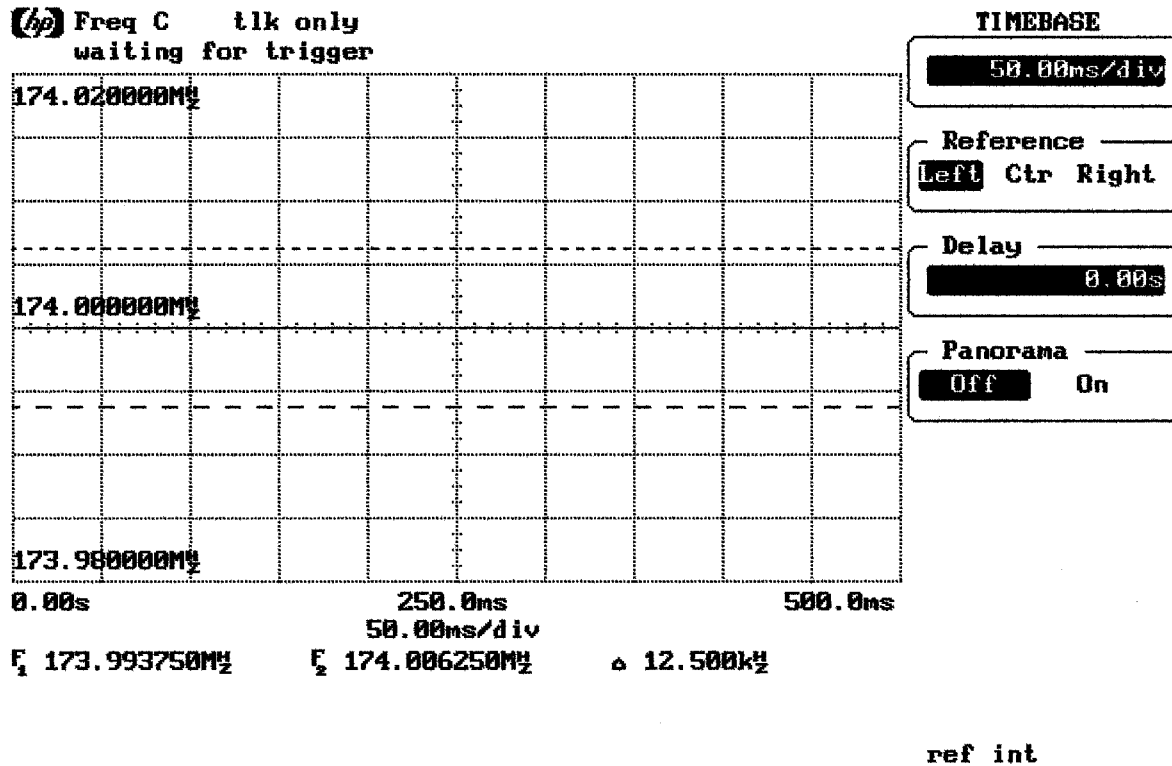


Test Condition: 174 MHz, 500 mW. Frequency Up to 100 ms

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

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

Test Outcome: Transient Frequency within limits $\rightarrow$ PASS.

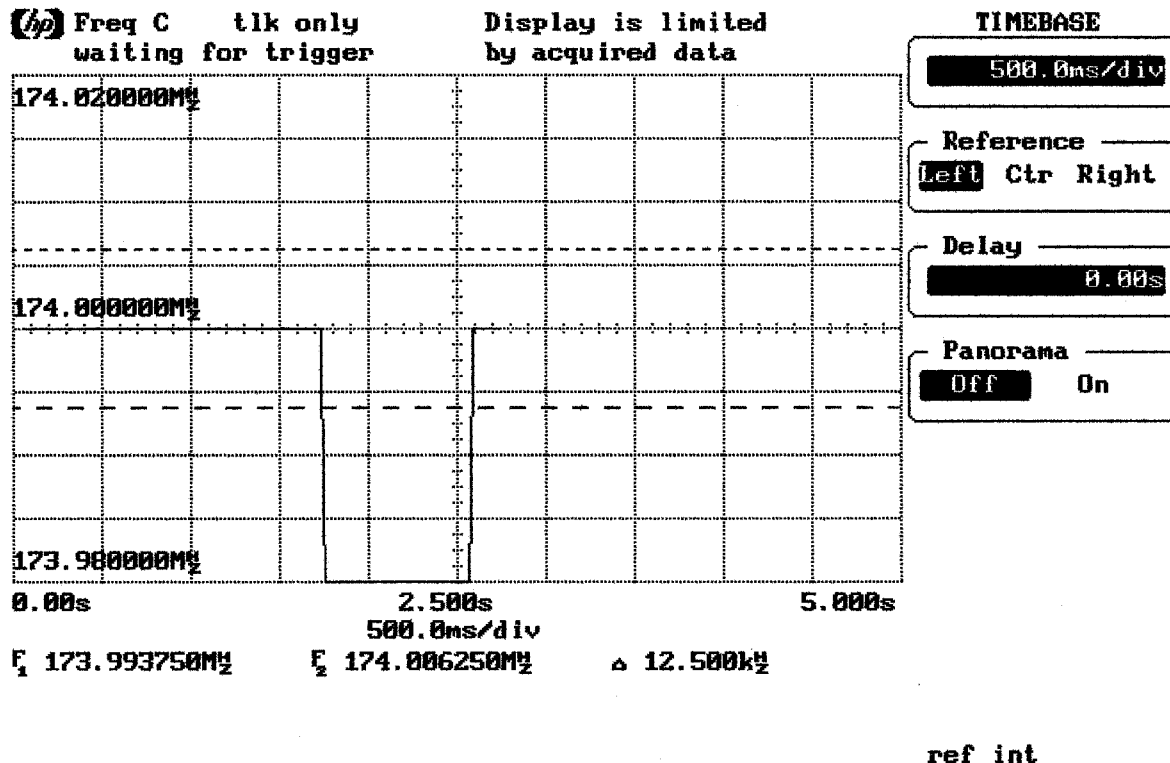


Test Condition: 174 MHz, 500 mW. Frequency Up to 500 ms

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

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

Test Outcome: Transient Frequency within limits $\rightarrow$ PASS.



Test Condition: 174 MHz, 500 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

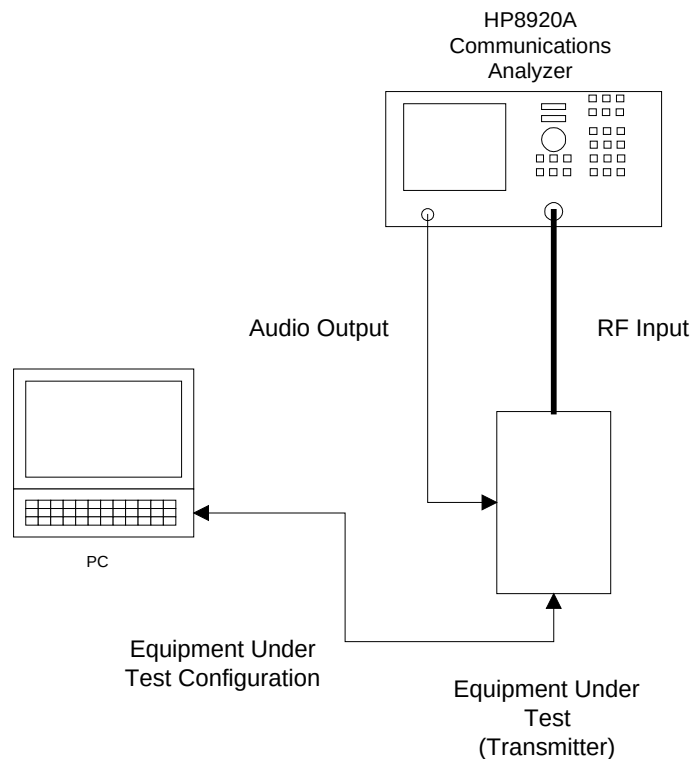
a) Test Requirement

(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)

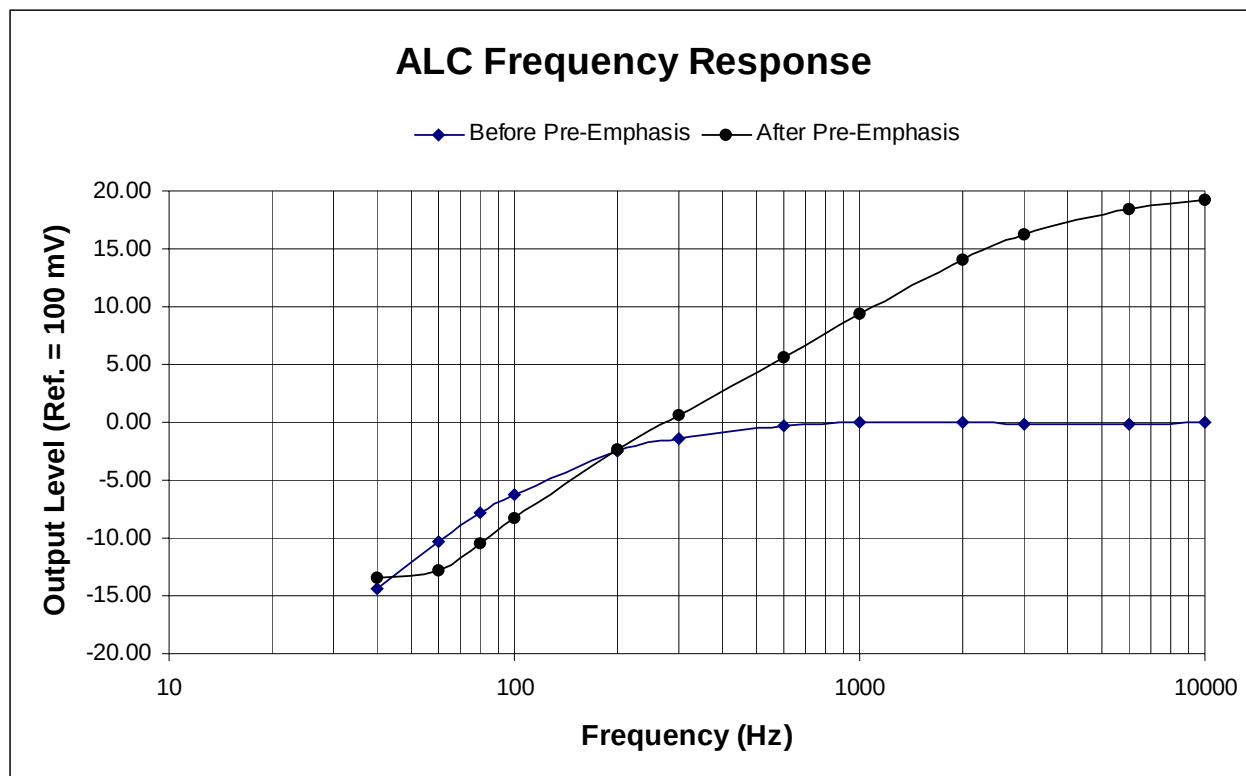


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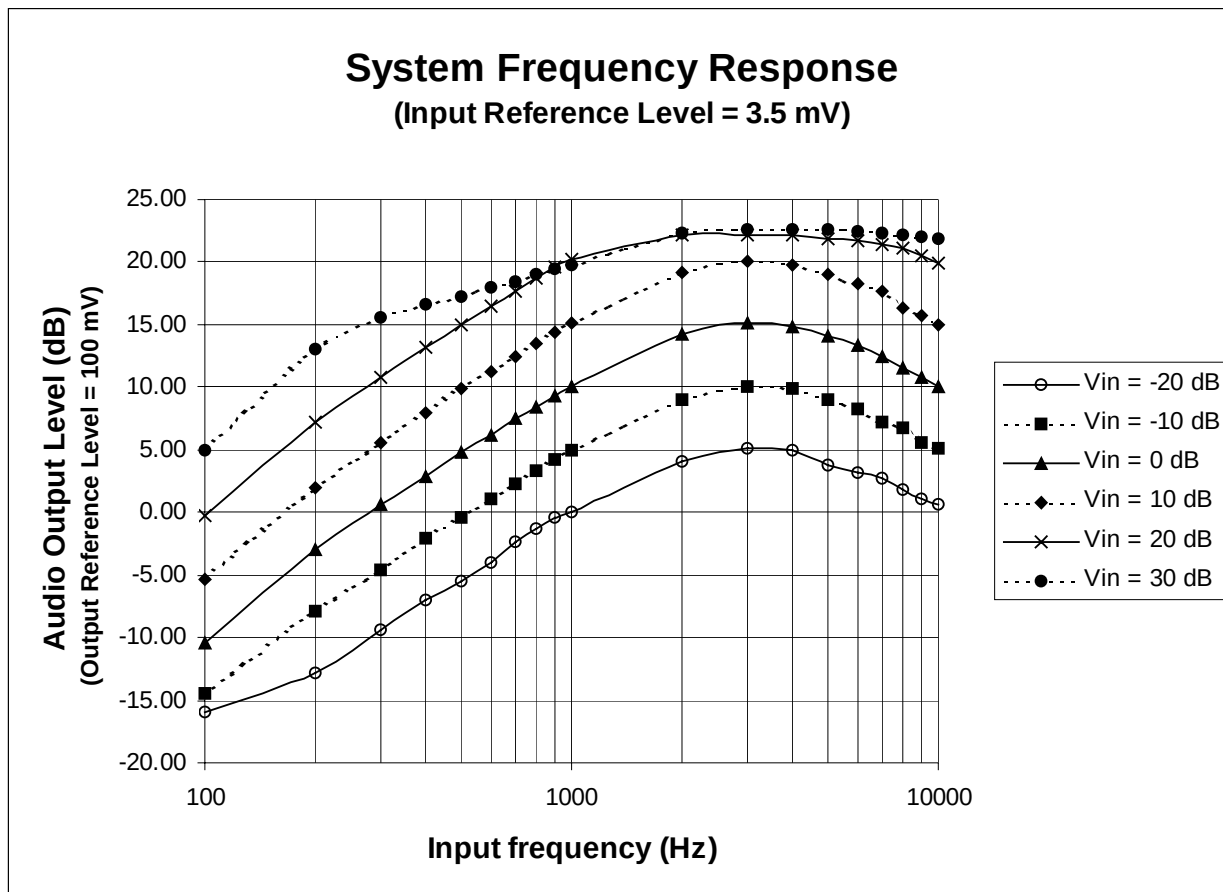
c) Test Conditions and Indications: Audio Responses



ALC Mode Frequency Response

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2:1 Dynamic Range Compressor Frequency Response

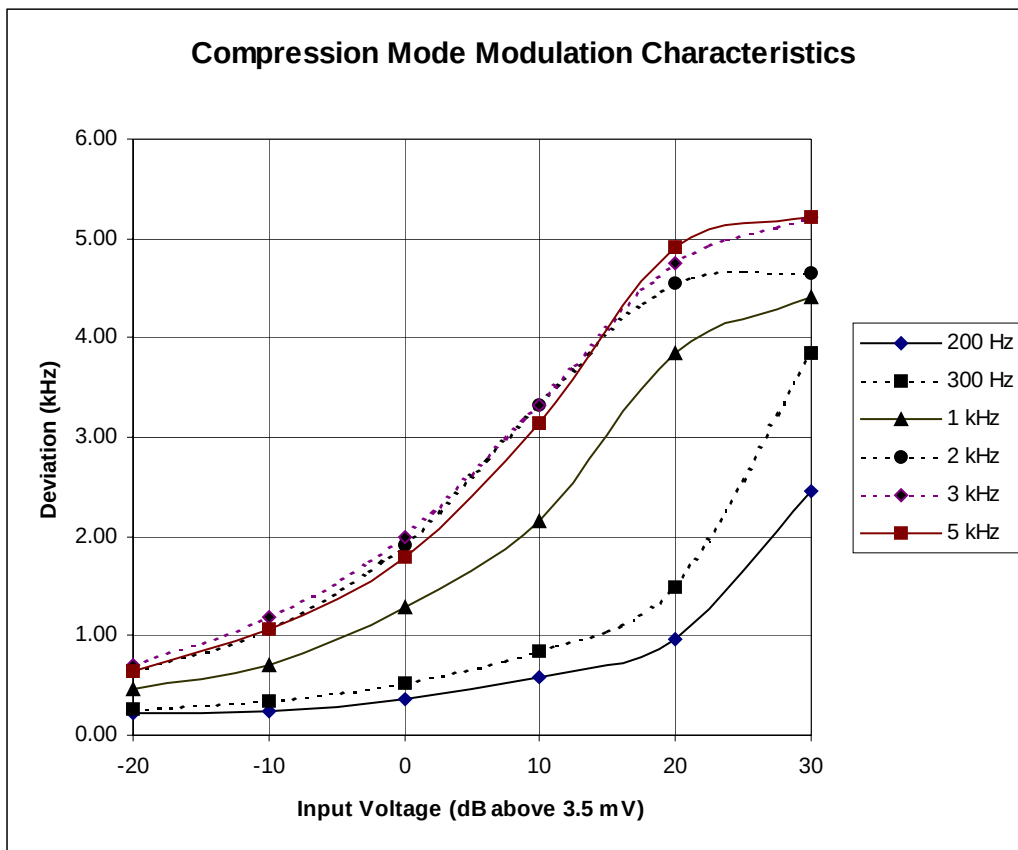


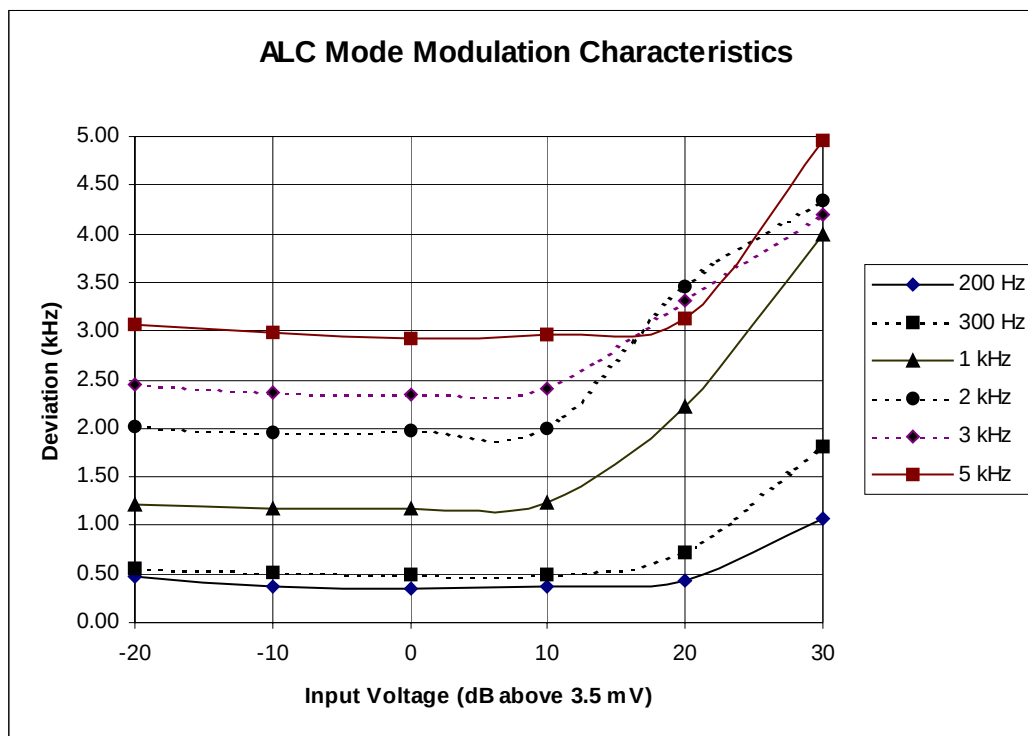
d) Test Conditions and Indications: Peak Frequency Deviation versus Audio Level

Test Conditions: 162 MHz, 500 mW.

ALC: Automatic Leveling Control.

Comp. : 2:1 Dynamic Range Compressor





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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		
Tsmp=100 uS	Gaussian	100 ps rms
Tsmp=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

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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 $\pm a$. The variance of the uniform density is $a^2/3$.

Sum the uncorrelated variances to find the total variance:

$$\text{Total variance} = [(0.3 \text{ dB} + 0.01 \cdot 40 \text{ dB})/3 + (0.4)/3 + (0.15)/3] = 1.25/3 = 0.416$$

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

$$\text{Total Uncertainty} = \pm 1.96 \cdot \sqrt{0.416} = 1.96 \cdot 0.644 = \pm 1.26 \text{ dB}$$