ELTECdata #131

Vibration Sensitivity of Pyroelectric Detectors: TESTING DATA

All materials which are pyroelectric are piezoelectric (although the converse is not true; some materials, like quartz, do not exhibit primary pyroelectricity because it does not possess a single unique polar axis). Thus all pyroelectric materials can generate charge in response to properly applied force. In a typical pyroelectric optical radiation detector, the pyroelectric wafer is supported from one side within a sealed environment (case or can) with a window directly over the wafer. It is thus protected from pressure changes or external mechanical contact. However, vibration of the detector housing accelerates the sensitive wafer which has mass (although small) resulting in a force on the wafer, producing an output.

The magnitude of the vibration sensitivity is trivial in the majority of pyroelectric applications. (When making an accelerometer the sensing crystals are usually stacked in series to give a bigger signal and, more importantly, a seismic mass is placed atop the stack.) For a pyroelectric detector the vibration sensitivity may become a consideration in railroad hot box detection where a train literally passes within inches of the detector. But even in this case, vibration isolation mounting of the detector reduces the sensitivity to acceptable levels.

Eltec manufactures several thermally compensated detectors in which 2 crystals are connected in electrical opposition with one crystal blinded from incident radiation. This is done to cancel spurious output from transient heating of the detector housing -- and is quite effective at that task! It would seem that such a design would also compensate for vibration sensitivity. However, no tests to date have shown such cancellation. This is especially puzzling for detectors with photoprocessed crystals which have the 2 opposing sensing areas on the same physical crystal.

Recommendation: In applications which involve high levels of shock or vibration, Eltec recommends detectors employing Eltec's patented loop mounting of the sensing crystal. Vibration isolation of the assembly which houses the detector can be very helpful -- but must be done in accordance with good design practices so as not to actually amplify the effects of input vibration via resonances in supporting structures. In high shock applications, as in military tank flame detection systems, there may be great physical shock (explosive hitting tank) which may or may not generate measurand sought by detector (fire ball). Eltec recommends the use of 2 detectors: One with window with desired optical bandpass and one with solid can (no entry for optical radiation). By comparing instantaneous outputs one can subtract the signal from the blinded detector from the signal from the measuring detector to see if the difference signal is of sufficient magnitude to represent the optical phenomenon sought and thence triggering fire suppression or other appropriate action.

Data: Test Series I (detectors with integral source followers)

A metal block with cavity to hold the detector can via wax putty was mounted on a shaker and the vibration level was monitored with a piezoelectric accelerometer.

Model 406 is single element detector (2 mm dia.) on 3 gold loops.

Model 4067 (now Model 407) is thermally compensated with 2 crystals in over/under arrangement. Crystals are cantilever mounted (like diving board) and are 1 x 2.5 mm connected in parallel opposition. (Note only the lower 4067 curve -- has better crystal attachment that is now standard for the Model 407).

Model 4192 is exactly like the 4067 except crystals are cantilever and side-by-side for external optical cancellation in people sensing applications.

Model 4143 is 2 side-by-side sensing areas on the same crystal (photoprocessed), loop mounted, with the 1 x 2 mm sensing areas connected in series opposed.

Responsivities: 406 about 2,600 V/W; 4067 (407) about 1100 V/W; 4192 about 2,500 V/W; and the 4143 about 7,000 V/W; all at 1 Hz.

Test Series II (detectors without integral electronics)

In 1987 the United Technologies Research Center ran tests on detectors WITHOUT INTERNAL ELECTRONICS. See circuit used to produce useable output signal. Note that vibration responsivity was tested with both sine and random physical input and with the detectors in both vertical and horizontal orientation.

The Model 420 is a laser detector with hard-mounted crystal (to better dissipate heat) with a 2.5 x 2.5 mm crystal a little thicker than crystals in non-laser detectors.

The Model 400M5 has 2 sensing areas on the same crystal (photoprocessed) with dimensions of 0.8 x 1.6 mm with separation of 0.3, with one area "blinded" and the areas in series opposition. (Crystal is loop mounted).

The Model 400M6 has 2 crystals in over/under configuration (like Model 407) each 1 x 2.5 mm, cantilever mounted, connected in parallel opposition.

VIBRATION SENSITIVITY TEST SERIES I

VIBRATION SENSITIVITY OF MODELS 406, 4067, 4143, 4192

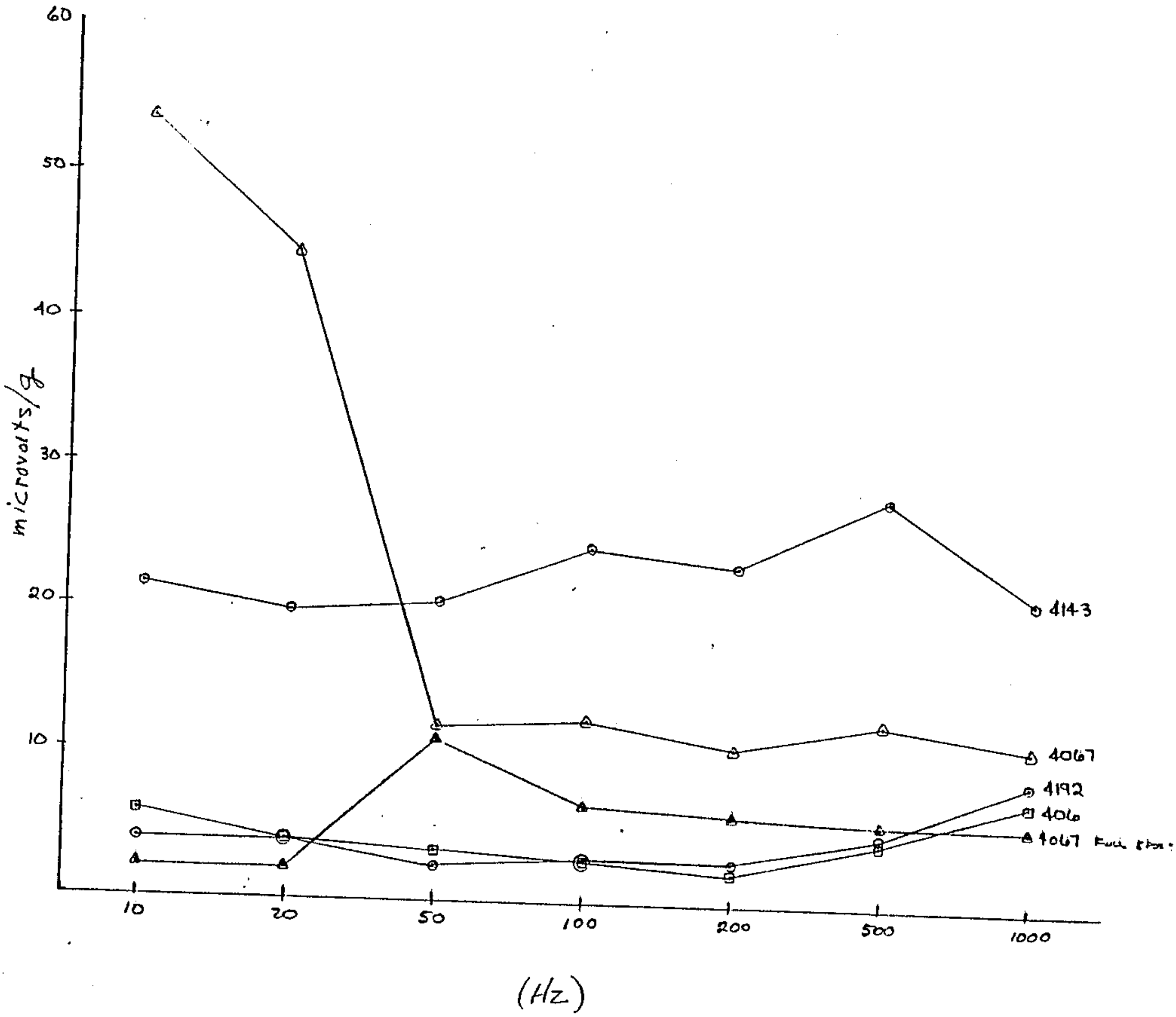

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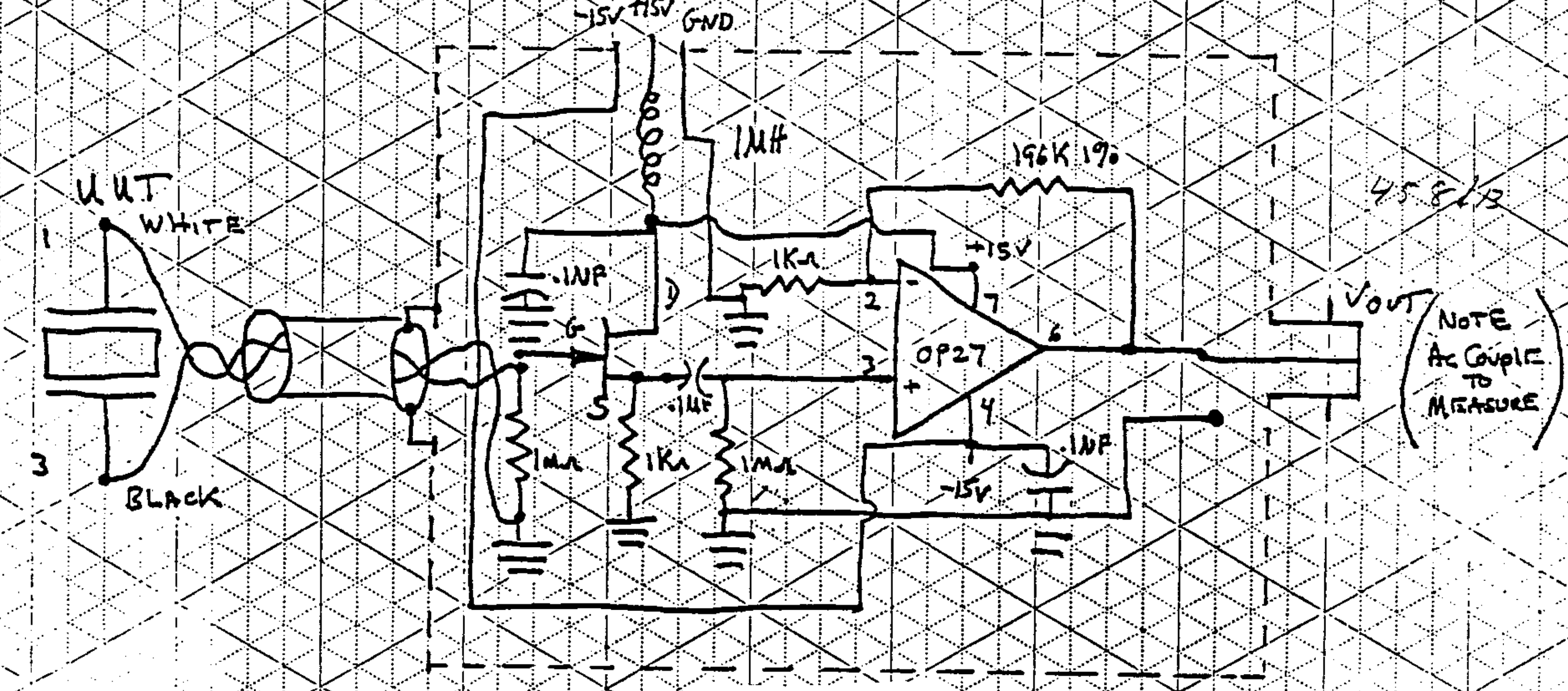
FIG II

VIBRATION NOISE TEST BOX
FOR
PYROELECTRIC DETECTORS



* MEASURE GAIN= 196

* MEASURED WITH LOW IMPEDANCE SOURCE

312.5 MV/INCH ? vertical scale or slot?

GRAPH NO. 3 DATE 27 Apr 87 LING A-246 (7500 FORCE POUNDS)

ENVIRONMENTAL TEST LABORATORY REPORT NO. 13810

ELTEC 420-3-3085

UNIT TESTED PYROELECTRIC DETECTORS SINGLE

SINUSOIDAL INPUT LEVEL 1G 5-11 Hz ; 5G's 11-2000 Hz. (4.0 min SWEEP)

INPUT LOCATION FIG I ACCELEROMETER NO. AG95

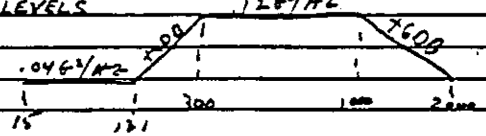
OUTPUT LOCATION — ACCELEROMETER NO. —

PLANE: VERTICAL PERFORMED BY: R. PAGE JR.

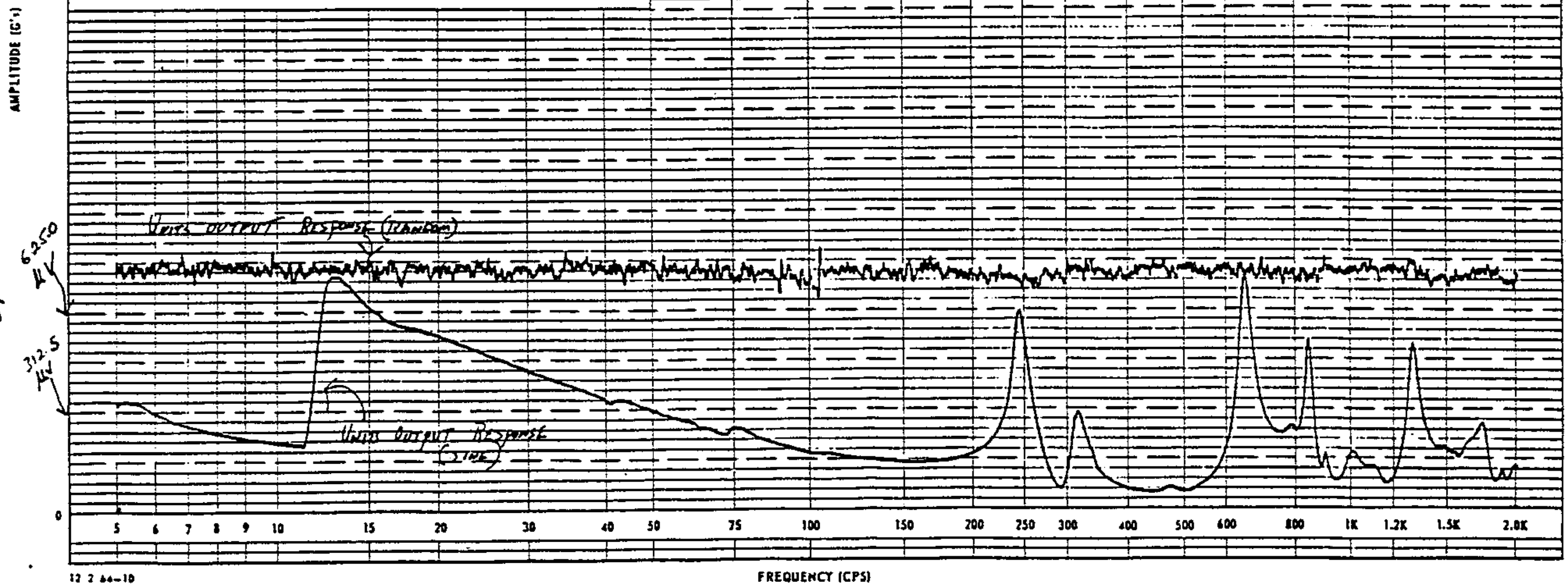
REMARKS:

RANDOM VIB. 12.7 G RMS

INPUT LEVELS



312.5 μV/INCH



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420-3

GRAPH NO. 6 DATE 27 Apr 87 LING A-246 (7500 FORCE POUNDS)

ENVIRONMENTAL TEST LABORATORY REPORT NO. 13810

UNIT TESTED Pyroelectric Detectors, ELTEC 420-3-3685 SINGLE

SINUSOIDAL INPUT LEVEL 1G 5-11 Hz, 5G 11-2000 Hz (40 min. Sweep)

INPUT LOCATION FG-I ACCELEROMETER NO. AG95

OUTPUT LOCATION — ACCELEROMETER NO. —

PLANE: Horizontal PERFORMED BY: R. Pare' Jr.

REMARKS:

Random Vib. 12.2 Grms

Input Levels:

312.5 μV/Inch

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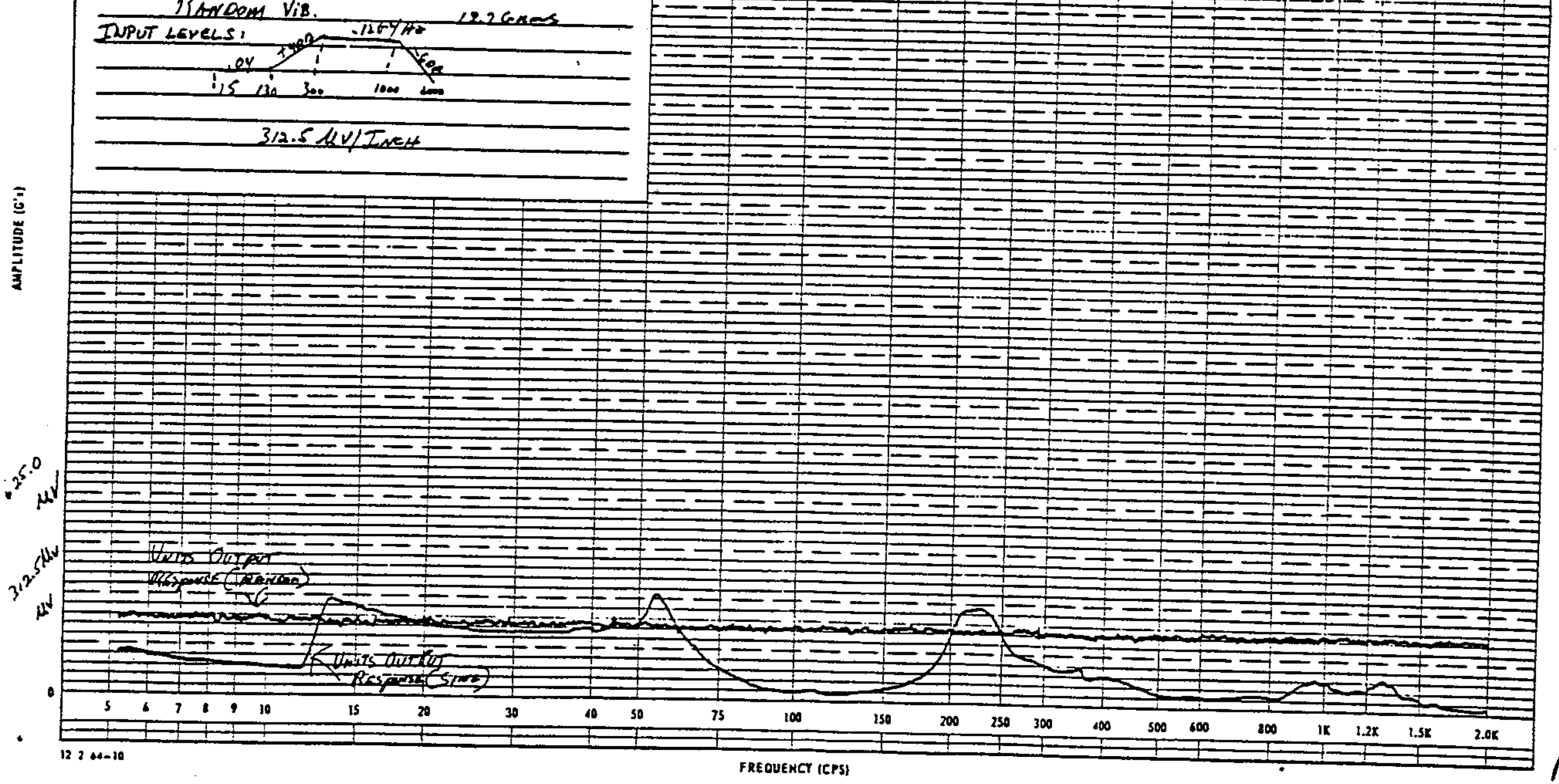

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400M5

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GRAPH NO. 1 DATE 24 APR 87 LING A-246 (7500 FORCE POUNDS)

ENVIRONMENTAL TEST LABORATORY REPORT NO. 13810

ELTEC 400m 5.3.0457

UNIT TESTED PYROELECTRIC DETECTOR

INPUT LEVEL SINE/RANDOM (SEE BELOW)

INPUT LOCATION FIG. I ACCELEROMETER NO. A695

OUTPUT LOCATION — ACCELEROMETER NO. —

PLANE: VERTICAL INTO WINDOW PERFORMED BY: R. PARE'JR.

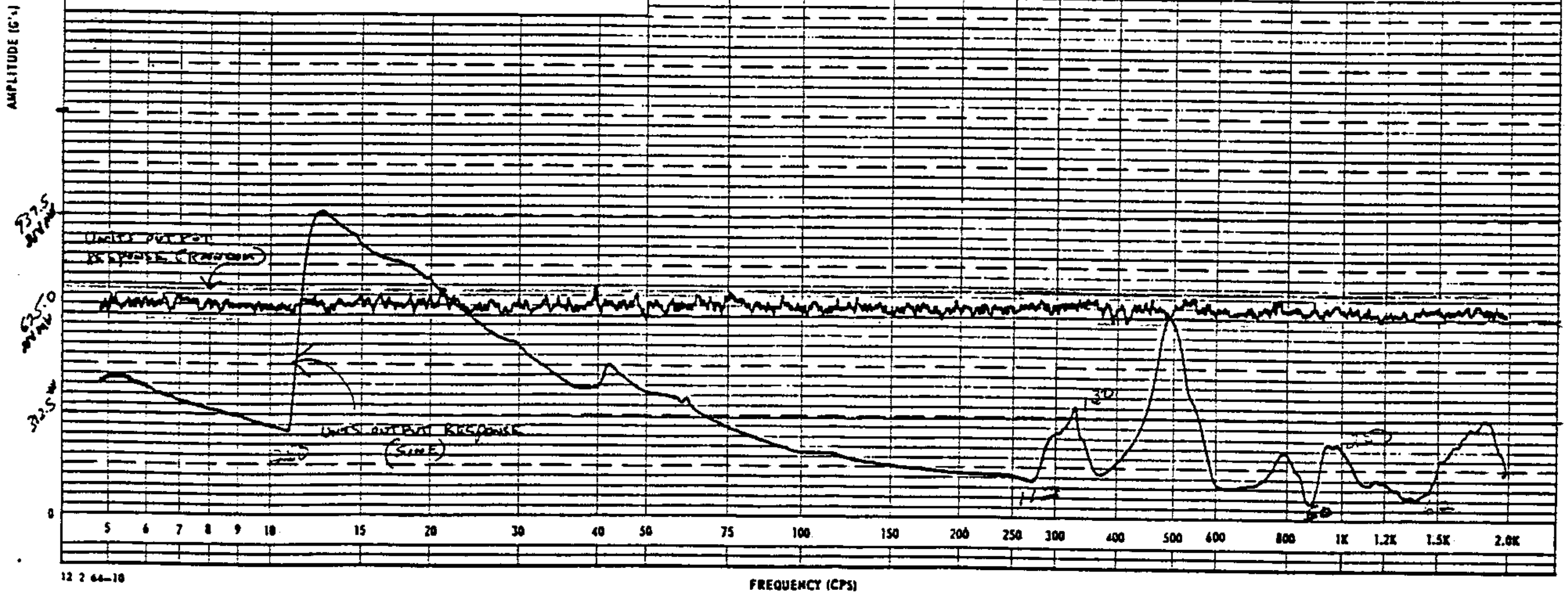
REMARKS:

SINE 1G 5-11 Hz 4.0 MINUTE SWEEP TIME

5G 11-2000 Hz

RANDOM 15 - 150 - 300 - 1000 - 2000

312.5 MV/INCH



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GRAPH NO. 2 DATE 24 Apr 87 LING A-246 (7500 FORCE POUNDS)

ENVIRONMENTAL TEST LABORATORY REPORT NO. 13810

ELTEC 400M5-3-0487

UNIT TESTED Pyroelectric Detectors Series

INPUT LEVEL Sine / Random (See Below)

INPUT LOCATION FIG. I ACCELEROMETER NO. AG-95

OUTPUT LOCATION — ACCELEROMETER NO. —

PLANE: Horizontal PERFORMED BY: R. Pare' Jr.

REMARKS:

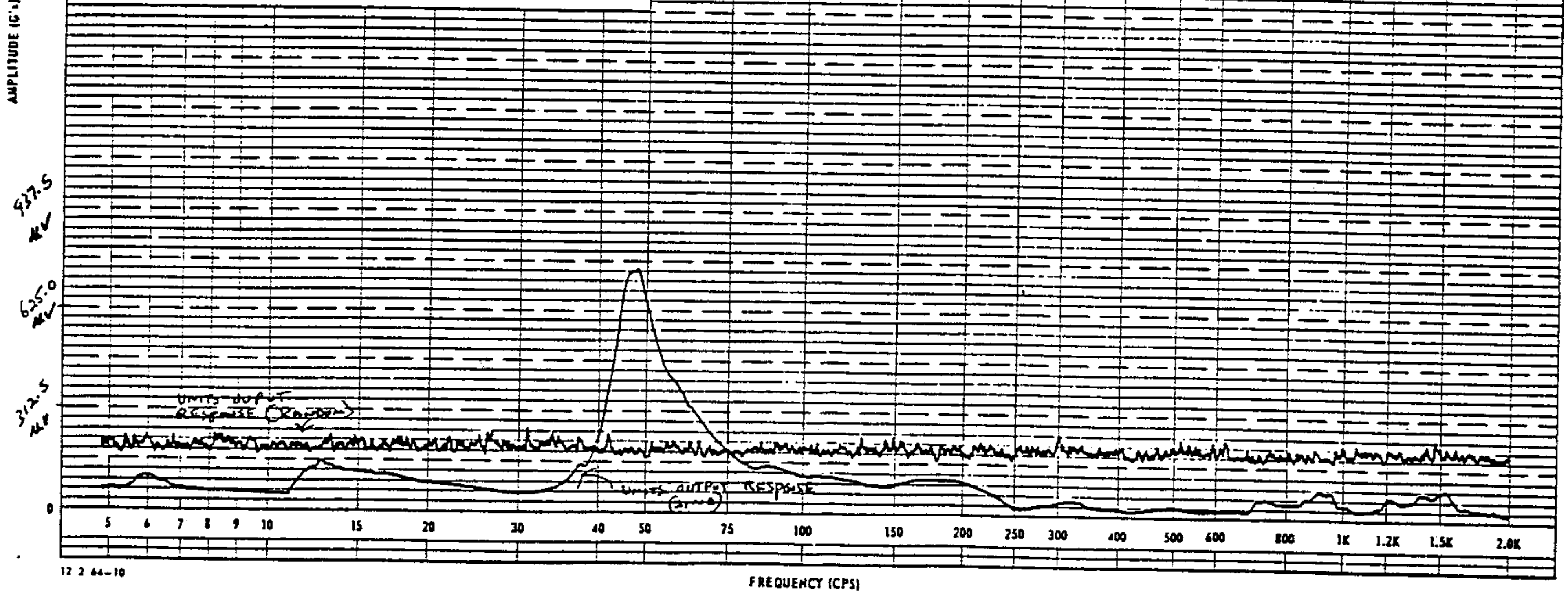
(SINE) 1-G: 5-11Hz 4 minute Sweep Time

5G: 11-2000 Hz

(RANDOM) .04 .12 G²/Hz Total Grms = 12.7

15 300 1000 2000 Hz

312.5 µV/Inch



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400M6

GRAPH NO. 4 DATE 27 Apr 87 LING A-246 (7500 FORCE POUNDS)

ENVIRONMENTAL TEST LABORATORY REPORT NO. 13810

400M 6-3-0487

UNIT TESTED PYROELECTRIC DETECTORS PARALLF

SINUSOIDAL INPUT LEVEL 1G 5-11Hz; 5G's 11-2000Hz (4.0 Min. Sweep)

INPUT LOCATION FIG I ACCELEROMETER NO. AG95

OUTPUT LOCATION — ACCELEROMETER NO. —

PLANE: VERTICAL PERFORMED BY: R. PARE Jr.

REMARKS:

RANDOM 12.7 Grms

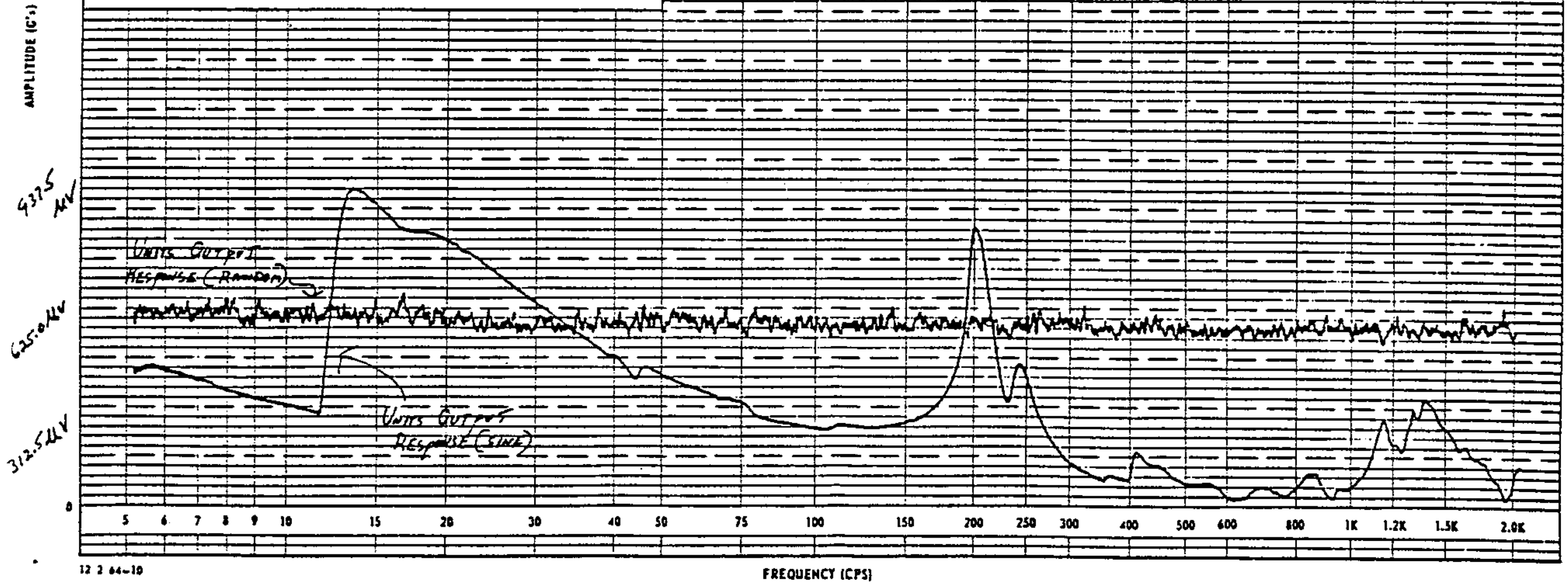
VIB. INPUT LEVELS .126G²/Hz

.04 +4DB -8DB

15 161 300 1000 2000

312.5 MV/INCH

13-6



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400M6

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GRAPH NO. 5 DATE 27 April 87 LING A-246 (7500 FORCE POUNDS)

ENVIRONMENTAL TEST LABORATORY REPORT NO. 13810

UNIT TESTED Pyroelectric Detector 400M6-3-0487 Parallel

SINUSOIDAL INPUT LEVEL 1G, 5-11 Hz 5G -11- 2000 Hz (40 min. Sweep)

INPUT LOCATION FAGI ACCELEROMETER NO. AG95

OUTPUT LOCATION — ACCELEROMETER NO. —

PLANE: Horizontal PERFORMED BY: R. Parr Jr.

REMARKS:

Random Vib. .12G²/Hz

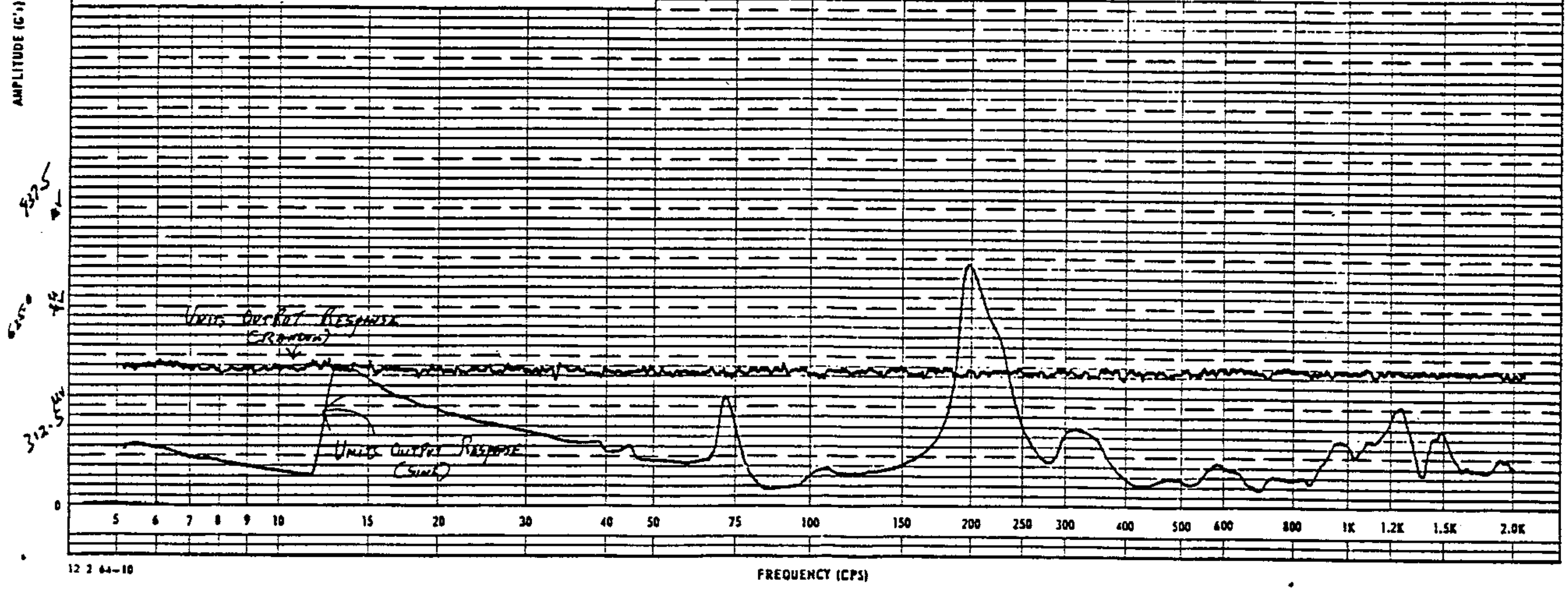
Input Levels: x 3dB 6dB

.04

Total Grms 12.7

15 150 300 1000 2000

312.5 µV/Irms



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