

Electromagnetic Leakage Through Seams
and Gasketed Joints - A Demonstration

by

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Theory of Demonstration

"Electromagnetic Leakage via Seams" in Shielded Enclosures occurs primarily as a result of currents which cross the seam. Such crossing cause a voltage to appear on the far side of the seam; electromagnetic leakage via the seam is directly proportional to this (transfer) voltage. In Shielding Theory the Seam is characterized in terms of its Transfer Impedance as follows:

$$Z_T = \frac{V}{J_S}$$

Z_T = Transfer Impedance of Seam. (Ohm - meters)

V = Transfer Voltage (Voltage Across Seam)

J_S = Density of Current which crosses the seam (A/m).

SUMMARY

An enclosure measuring 24 inches wide, 24 inches deep and 34 inches high with a hole in the front measuring 18 inches wide by 24 inches high is used to demonstrate the theory. Two plates are electrically bonded to the enclosure where the plates are so positioned as to leave a horizontal gap of .1 inch wide and 18 inches long. Currents which flow across the gap or seam are generated as follows:

1. Using an Electric Dipole Antenna.
2. Using a Magnetic Dipole Antenna.
3. Applying a current directly across the gap at the center of the seam.

The measured fields are:

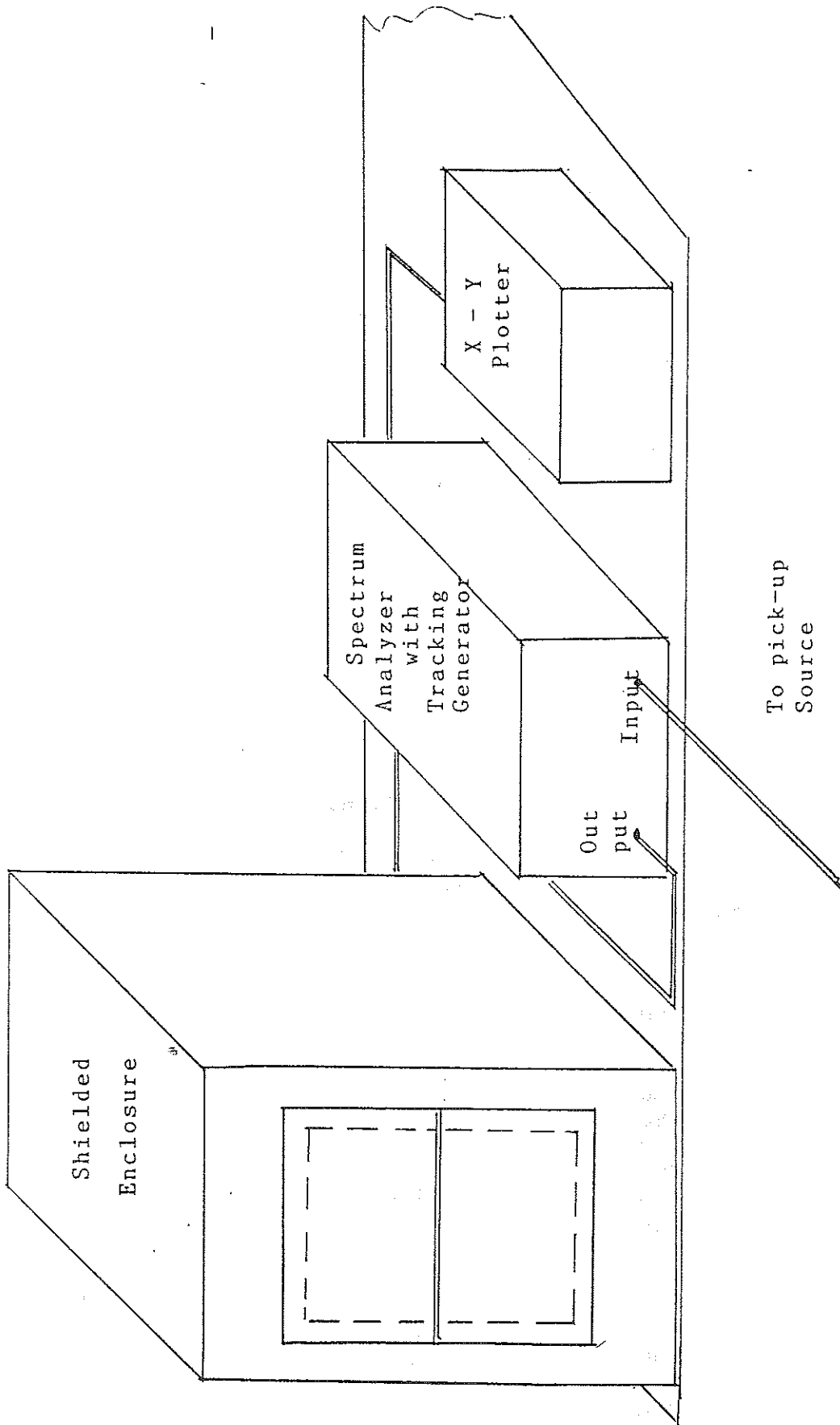
1. E Field 1 meter from the seam.
2. H Field 1 meter from the seam.
3. Transfer Voltage, across the seam.

The fields are also measured with 1/2 inch long gasket segments across the gap at 6 inch intervals and 3 inch intervals.

The frequencies used in the demonstration are between 10 kHz to 50 MHz. This is accomplished by setting the center frequency of the spectrum analyzer to 25 MHz and the frequency span per division to 5 MHz.

Outline of Demonstration

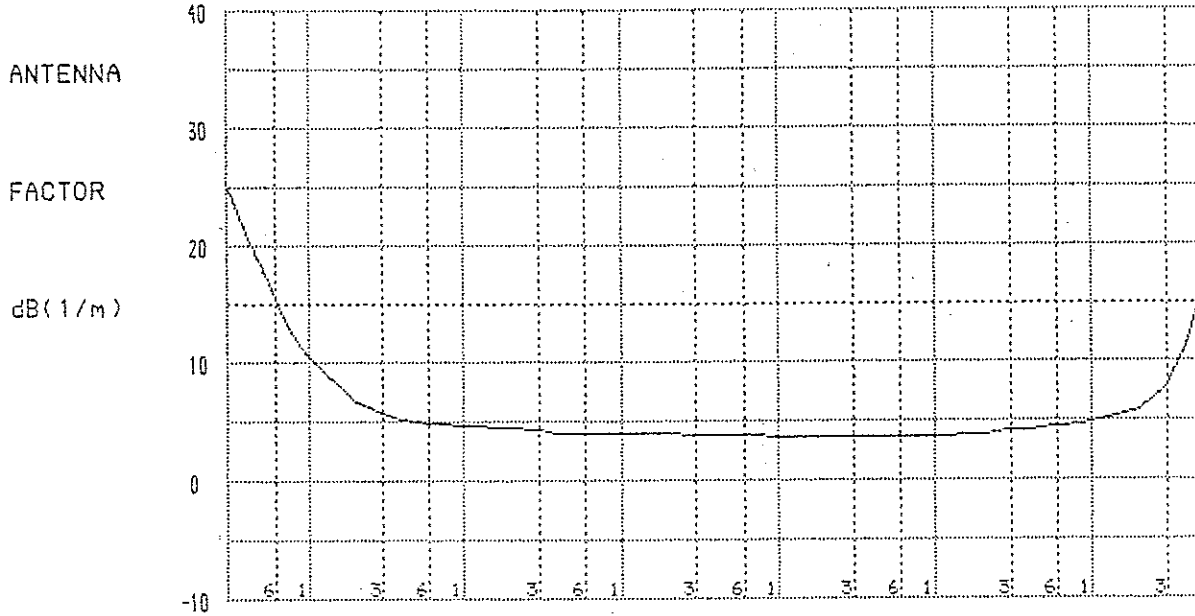
1. Set up shielded box, spectrum analyzer and plotter as illustrated in figure 1.
2. Place electric dipole antenna in box, apply power to antenna and measure and record the transfer voltage across the plates and E field emanating from the slot 1 meter from the box with 41 inch rod antenna.
3. Place small gasket segments at 3 inch intervals in gap and repeat step 2.
4. Place small gasket segments at 6 inch intervals in gap and repeat step 2.
5. Using a new sheet of paper in the plotter measure and record the transfer voltage across the plates and H field emanating from the slot with a loop antenna located 1 meter from the box.
6. Repeat step 5 with a small segment of gasket at 6 inch intervals in the gap.
7. Repeat step 5 with a small segment of gasket at 3 inch intervals in the gap.
8. Replace the electric dipole antenna in the box with a magnetic dipole antenna and repeat steps 2 through 7.
9. Remove the magnetic dipole antenna from the box and apply the power directly to the set of plates across and at the center of the gap and repeat steps 2 through 7.



General Test Set-up

Figure 1

THE ELECTRO-MECHANICS CO.
 ANTENNA FACTORS
 FOR
 ACTIVE MONOPOLE ANTENNA
 MANUFACTURED BY
 THE ELECTRO-MECHANICS CO.
 MODEL NUMBER 3301B
 S/N 3370



FREQUENCY RANGE (30HZ-50MHZ).

FREQUENCY [Hz]	ANTENNA FACTORS dB(1/m)
30	25.4
40	21.1
50	18.0
60	15.6
70	13.6
80	12.5
90	11.4
100	10.5
200	6.7
300	5.7
400	5.2
500	5.0
600	4.9
700	4.8
800	4.7
900	4.7
1,000	4.7
2,000	4.5
3,000	4.3
4,000	4.0
5,000	4.0

SPECIFICATION COMPLIANCE TESTING FACTOR TO BE ADDED TO
 RECEIVER METER READING IN dBuV TO CONVERT TO FIELD INTENSITY
 IN dBuV/METER. CALIBRATED 21/04/93, CALIBRATION PER
 IEEE STD 291

THE ELECTRO-MECHANICS CO.
 ANTENNA FACTORS
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 ACTIVE MONOPOLE ANTENNA
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 MODEL NUMBER 3301B
 S/N 3370

FREQUENCY [Hz]	ANTENNA FACTORS dB(1/m)
6,000	4.0
7,000	4.0
8,000	4.0
9,000	4.0
10,000	4.0
20,000	3.9
30,000	3.8
40,000	3.8
50,000	3.7
60,000	3.7
70,000	3.7
80,000	3.7
90,000	3.7
100,000	3.7
200,000	3.6
300,000	3.6
400,000	3.6
500,000	3.6
600,000	3.6
700,000	3.6
800,000	3.6
900,000	3.6
1,000,000	3.6
2,000,000	3.8
3,000,000	4.1
4,000,000	4.2
5,000,000	4.3
6,000,000	4.5
7,000,000	4.5
8,000,000	4.6
9,000,000	4.7
10,000,000	4.8
20,000,000	5.8
30,000,000	7.8
40,000,000	10.8
50,000,000	15.2

SPECIFICATION COMPLIANCE TESTING FACTOR TO BE ADDED TO
 RECEIVER METER READINGS IN dBuV TO CONVERT TO FIELD INTENSITY
 IN dBuV/METER. CALIBRATED 21/04/93, CALIBRATION PER

THE ELECTRO-MECHANICS CO.
 ANTENNA FACTORS
 FOR
 ELECTRO-MECHANICS
 MODEL 6507
 ACTIVE LOOP ANTENNA
 S/N 1303

FREQUENCY (MHz)	MAGNETIC ANTENNA FACTOR (dB)	ELECTRIC ANTENNA FACTOR (dB)
.001	1.5	53.0
.002	-6.9	44.6
.003	-11.3	40.2
.005	-16.5	35.0
.007	-19.8	31.7
.009	-21.9	29.6
.010	-22.9	28.6
.020	-28.7	22.9
.050	-33.5	18.0
.075	-34.6	16.9
.100	-35.1	16.4
.150	-35.4	16.1
.250	-35.5	16.0
.500	-35.6	15.9
.750	-35.6	15.9
1.000	-35.0	16.5
2.000	-34.8	16.7
3.000	-34.8	16.7
4.000	-34.9	16.7
5.000	-34.9	16.6
10.000	-34.8	16.7
15.000	-34.6	17.0
20.000	-34.1	17.5
25.000	-33.7	17.8
30.000	-34.3	17.2

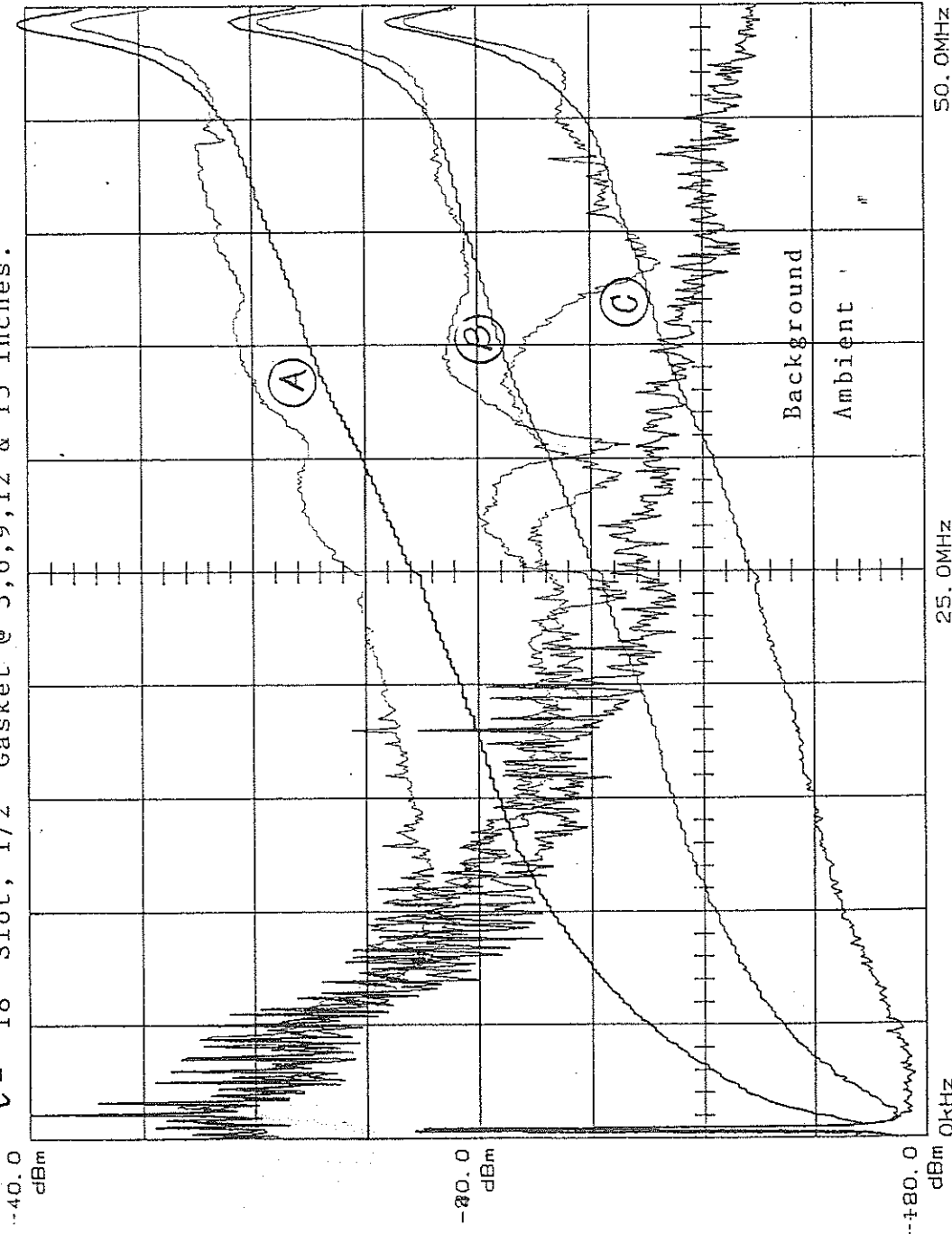
SPECIFICATION COMPLIANCE TESTING FACTOR TO BE ADDED TO RECEIVER
 READING IN dBuV TO CONVERT TO MAGNETIC FIELD INTENSITY IN dBuA/METER
 OR TO EQUIVALENT ELECTRIC FIELD INTENSITY IN dBuV/METER. CALIBRATED ON
 26/05/93 (DD/MM/YY). CALIBRATION PER IEEE STD-291, INDUCTION FIELD METHOD.

RESULTS OF TEST

E Field Source
41 inch Rod Receiving Antenna.

Tek
2710

- A - 18" Slot No Gasket
- B - 18" Slot 1/2" Gasket at 6" x 12"
- C - 18" Slot, 1/2" Gasket @ 3,6,9,12 & 15 inches.



25.0MHz
040dBmBARERE
5.0MHz/
3KHz RBW

ATTN 50dB
VF 30Hz
10 dB/

TIME: 2 s/DIV
Voltage Reading
at 0 dBm

PEAK MODE

Tracking Generator:
0.0dBm**
TRKG 1.980kHz

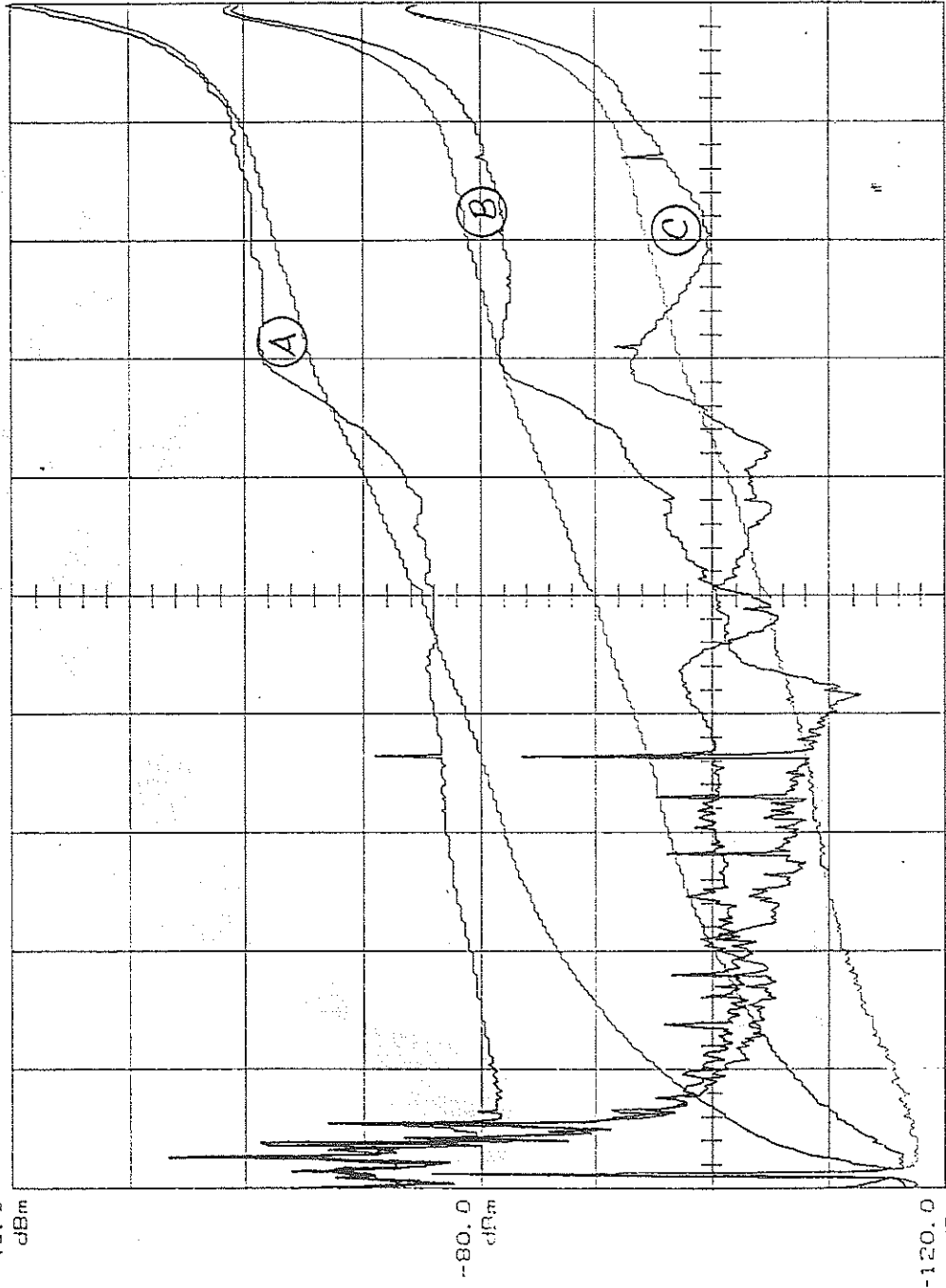
Note: Readouts
correspond to
waveform 'B'

UNCAL

E Field Source
Loop Receiving Antenna

Tek
2710

- A - 18 inch slot
- B - 18 inch slot with 1/2 inch gasket at 6 and 12 inches.
- C - 18 inch slot with 1/2 inch gasket at 3, 6, 9, 12 and 15 inches



25.0MHz
-40.0dBm PRE
5.0MHz/
3KHz RBW

ATTN 10dB
VF 30Hz
10 dB/

TIME: 2 s/DIV
Voltage Reading
at 0 dBm

PEAK MODE

Tracking Generator:
0.0dBm*
TRKG 1.320kHz

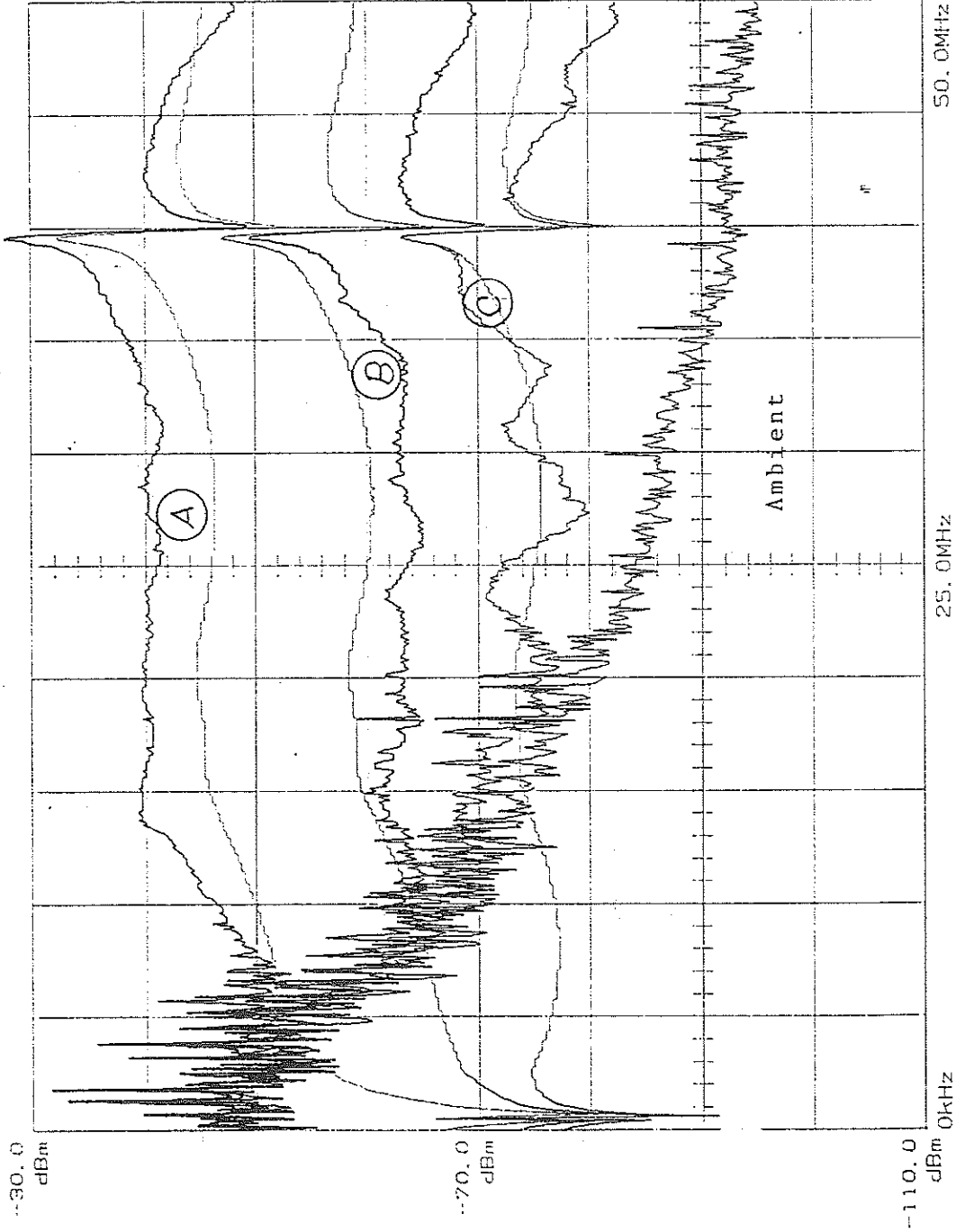
Note: Readouts
correspond to
waveform 'B'

UNCAL

H Field Source
41 inch Rod Receiving Antenna

Tek
2710

- A - 18 inch slot
- B - 18 inch slot with 1/2 inch gasket at 6 and 12 inches
- C - 18 inch slot with 1/2 inch gasket at 3, 6, 9, 12 and 15 inches.



25.0MHz
-30.0dBm PRE
5.0MHz/
3KHz RBW

ATTN 20dB
VF 30Hz
10 dB/

TIME: 2 s/DIV
Voltage Reading
at 0 dBm.

PEAK MODE

Tracking Generator:
-10.0dBm*
TRKG 840Hz

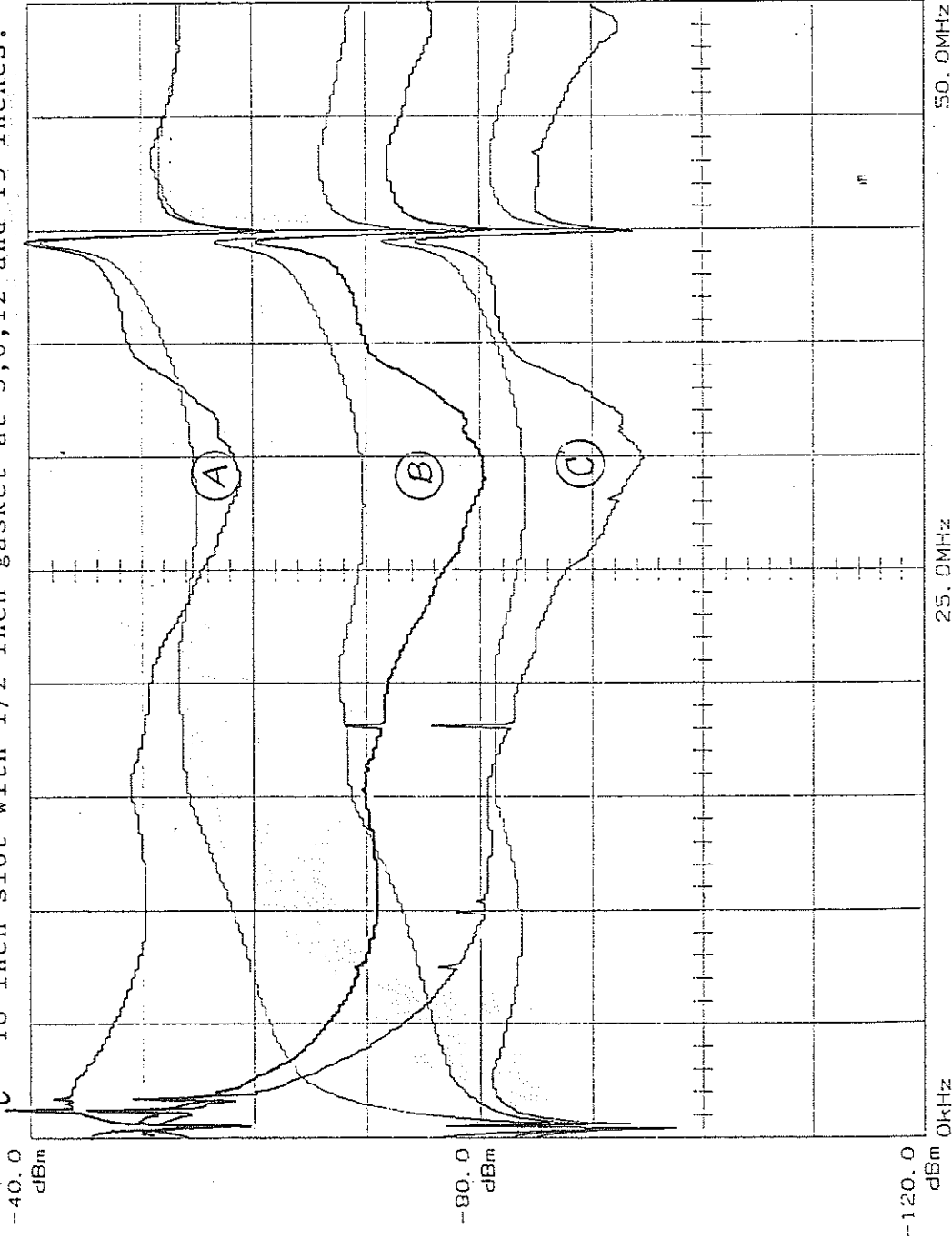
Note: Readouts
correspond to
waveform 'B'

UNCAL

H Field Source
Loop Receiving Antenna

Tek
2710

- A - 18 inch slot
- B - 18 inch slot with 1/2 inch gasket at 6 and 12 inches
- C - 18 inch slot with 1/2 inch gasket at 3,6,12 and 15 inches.



25.0MHz
-40.0dBm PRE
5.0MHz/
3KHz RBW

ATTN 10dB
VF 30Hz
10 dB/

TIME: 2 s/DIV
Voltage Reading
at -10 dBm

PEAK MODE

Tracking Generator:
-10.0dBm*
TRKG 840Hz

Note: Readouts
correspond to
waveform 'B'

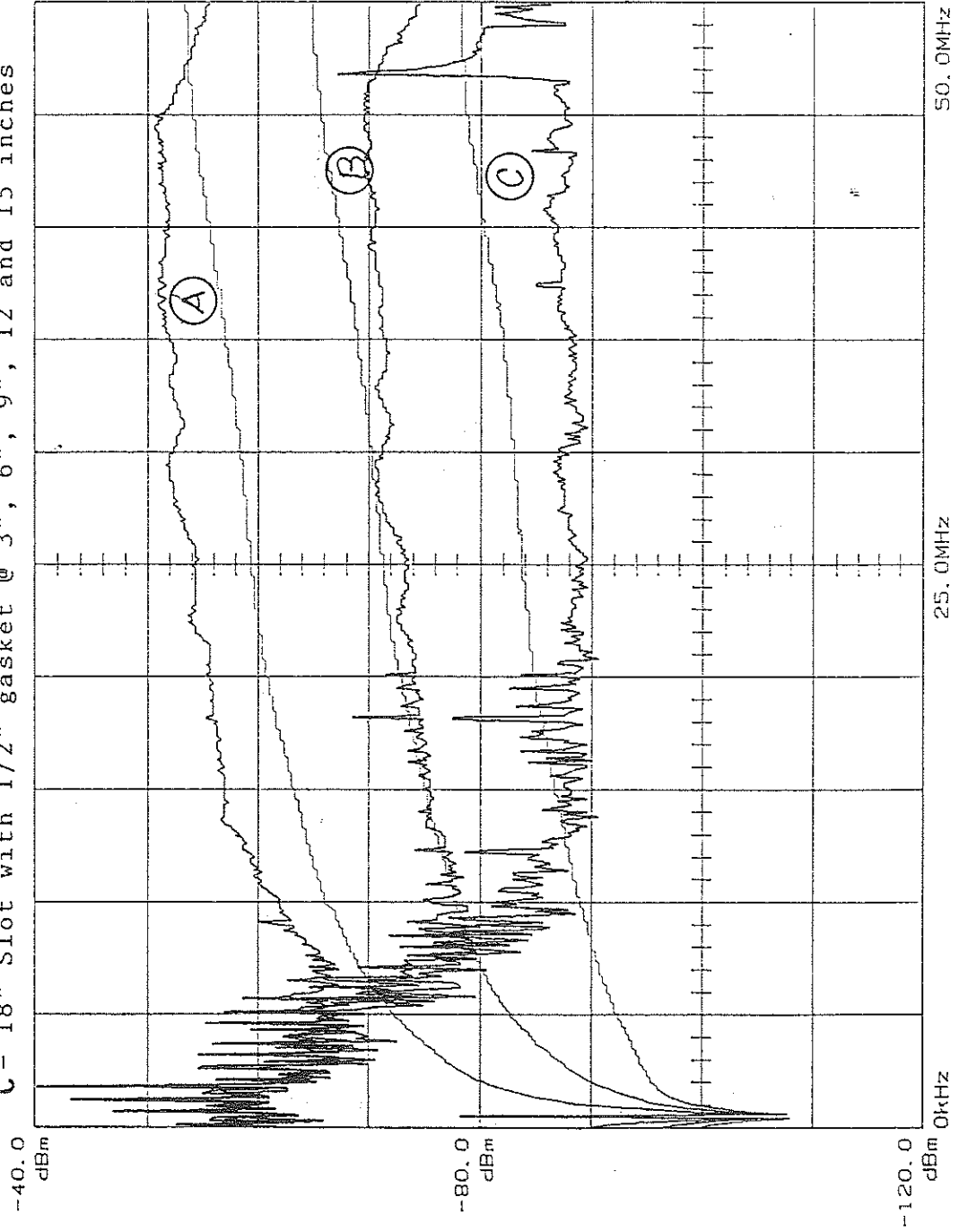
-120.0
dBm 0KHz
UNCAL

Direct Current Source.
41 inch Rod Receiving Antenna.

Tek

2710

A - 18" Slot
B - 18" Slot with 1/2" gasket @ 6" & 12"
C - 18" Slot with 1/2" gasket @ 3", 6", 9", 12 and 15 inches



25.0MHz
-40.0dBm PRE
5.0MHz/
3KHz RBW

ATTN 10dB
VF 30Hz
10 dB/

TIME: 2 s/DIV
Voltage Reading
at 0 dBm

PEAK MODE

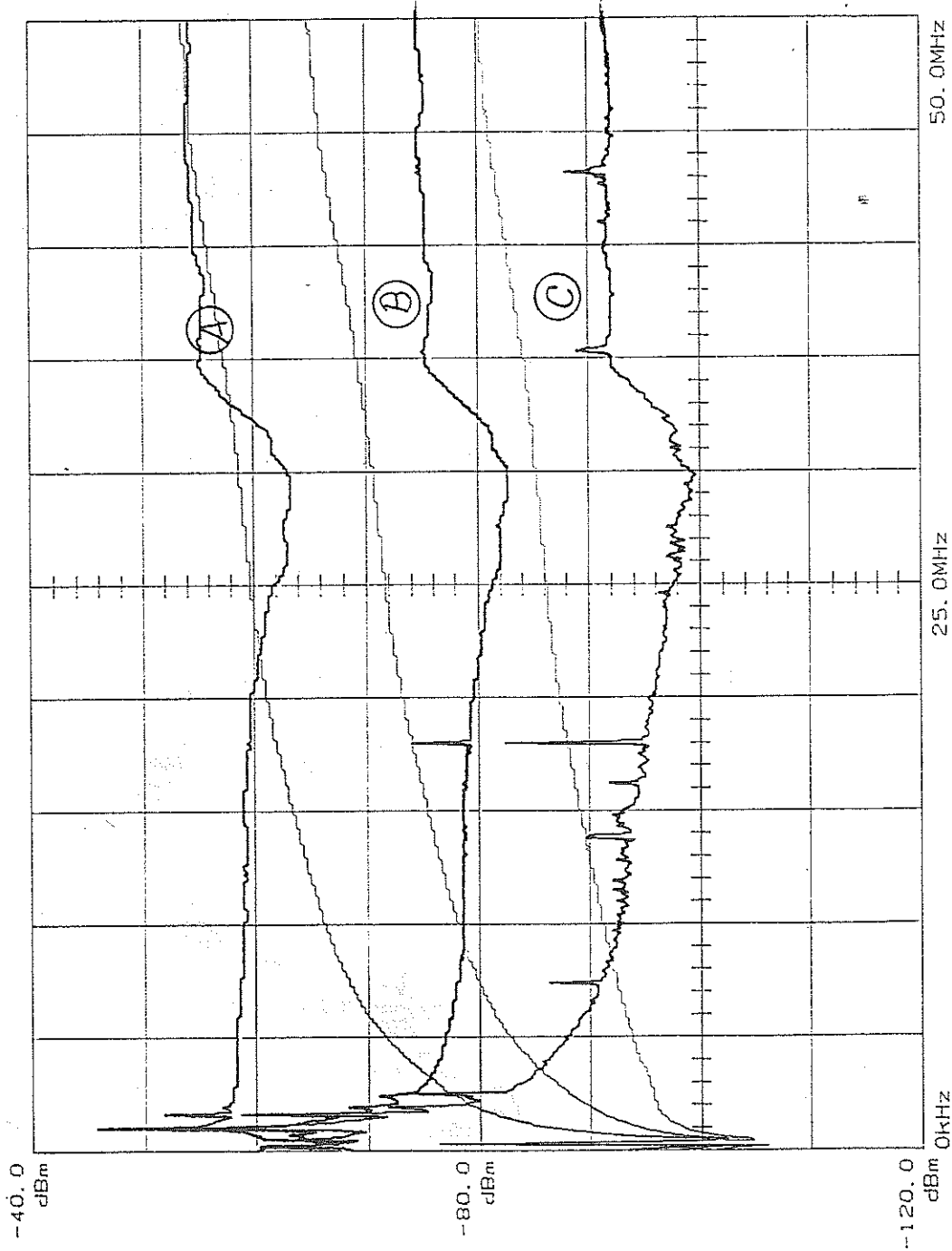
Tracking Generator:
0.0dBm*
TRKG 60Hz

Note: Readouts
correspond to
waveform 'B'

Direct Current Source
Loop Receiving Antenna.

Tek
2710

- A - 18" Slot.
- B - 18" Slot w 1/2" Gasket at 6 & 12 inches
- C - 18" Slot w 1/2" Gasket at 3, 6, 9, 12 & 15 inches.



25.0MHz
-40.0dBm PRE
5.0MHz/
3KHz RBW

ATTN 10dB
VF 30Hz
10 dB/

TIME: 2 s/DIV

Voltage Reading
at 0 dBm

PEAK MODE

Tracking Generator:
0.0dBm*
TRKG 2.220kHz

Note: Readouts
correspond to
waveform 'D'

UNCAL