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5 U.S.C. 552 (b)(2) and (b)(3),
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HARDNESS VERIFICATION OF ANTENNA LINE PENETRATIONS

STANDARDS AND TECHNOLOGY INTEGRATION MEETING, *Sanitized Version*

21 SEPTEMBER 1994

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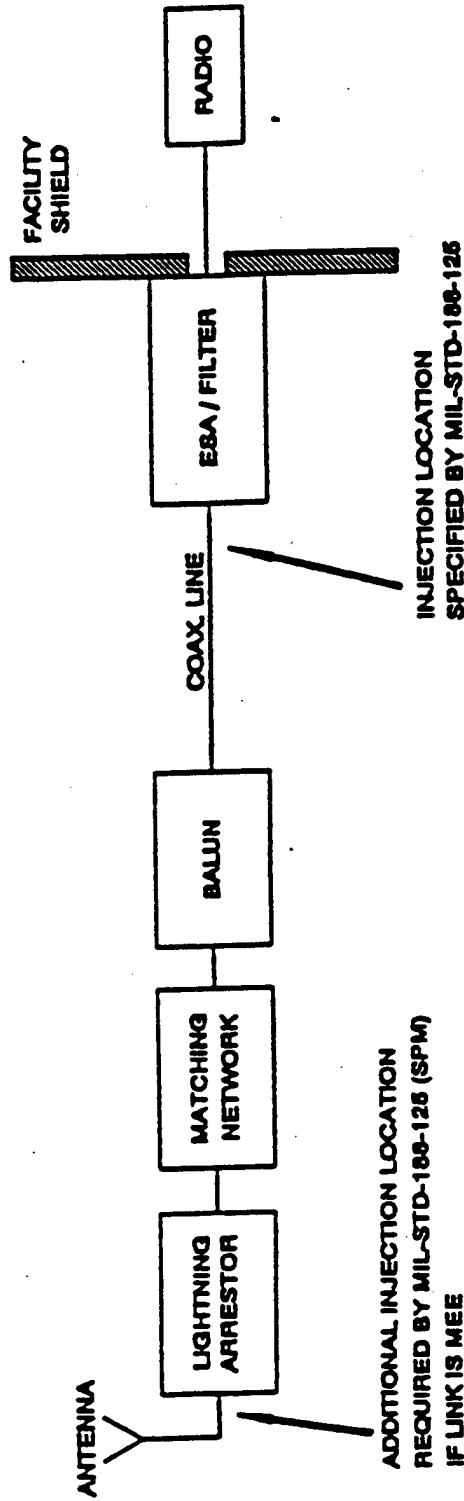
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"Test Techniques for Antenna Line Penetrations," 23 May 1994, MRC/COS-R-1394
[REDACTED], 8/22-9/1/94 - Quick Look Data

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DNA CASE NO. 47-033

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TYPICAL HEMP COUPLING PATH FOR ANTENNA LINES



PROCEDURES REQUIRED BY MIL-STD-188-125

1. The test waveform is a damped sinusoid ($Q = 10 \pm 3$) with peak amplitude and fundamental frequency determined from the maximum linear dimension (L) of the antenna radiating structure by the algorithm:

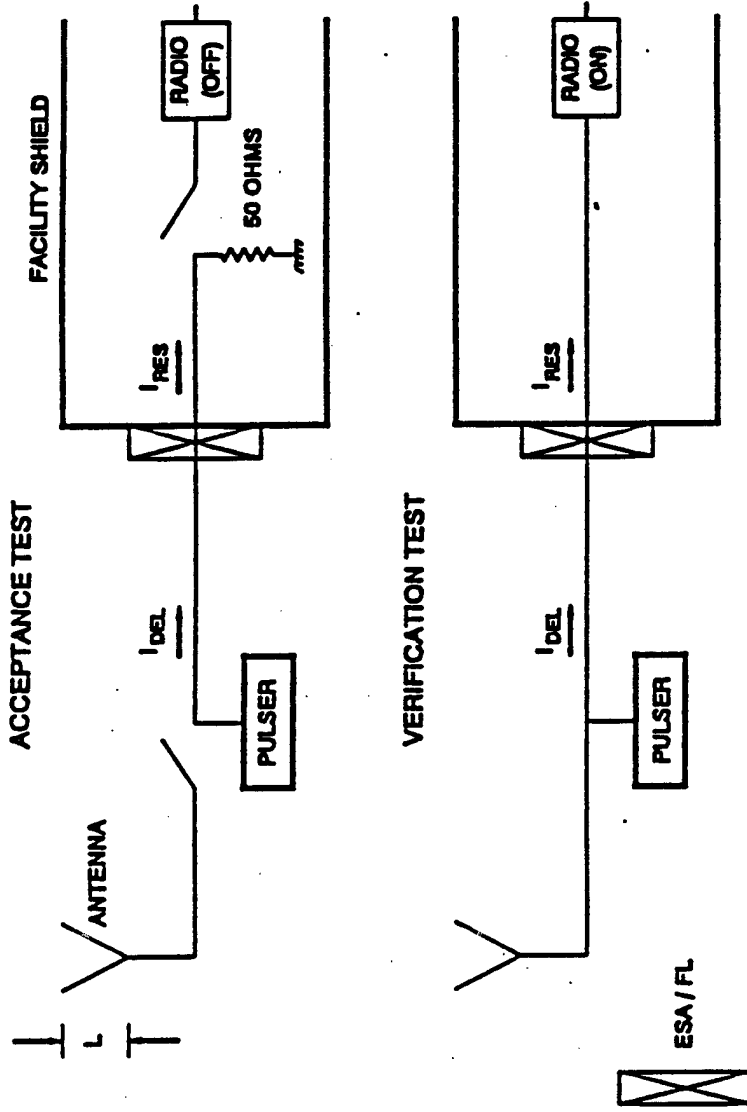
If $300 \text{ m} >$
if $20 \text{ m} >$
if

$L > 20 \text{ m},$
 $L > 3 \text{ m},$
 $L < 3 \text{ m},$

then $f_c = 2 \text{ MHz},$
then $f_c = 30 \text{ MHz},$
then $f_c = 200 \text{ MHz},$

$I_{pk} = 2500 \text{ A};$
 $I_{pk} = 900 \text{ A};$
 $I_{pk} = 250 \text{ A}.$

2. The injections must be performed in the acceptance test and verification test configurations.



- Difficulties with implementation of MIL-STD-188-125 requirements
 - No such pulsers available
 - Test waveforms often do not represent HEMP stresses (test waveform may be inadequate in some cases)
 - Acceptance test pass/fail criteria usually cannot be met
 - Most antenna line penetrations will be SPMs
- 5-step procedure proposed to test antenna lines as SPMs
- Lab and field tests to demonstrate proposed procedure

PROPOSED TEST PROCEDURE

- STEP 1: VERIFY PROT. EQUIPMENT IS WORKING PER SPECIFICATIONS (CWDD of FL, voltage step fn test of ESA)**
- STEP 2: DECIDE PCI LOCATION**
- STEP 3: ESTIMATE LINEAR HEMP STRESS (Wide-area CWIL, local CWIL, other)**
- STEP 4: SELECT PULSER(S), INJECT, AND ESTIMATE TEST COVERAGE**
- $\max I_{RES}^{HEMP}$ vs. $\max I_{RES}^{PCI}$
- $\max I_{DEL}^{HEMP}$ vs. $\max I_{DEL}^{PCI}$
- STEP 5: REPEAT STEP 1**
- HEMP vs. pulse induced outage time (if link is MEE)

EVALUATION OF TEST COVERAGE (ACCEPTANCE TEST CONFIGURATION)

BELOW ESA BREAKDOWN				ABOVE ESA BREAKDOWN			
MAX I _{DEL}	MAX I _{RES} (c)	IS TEST COVERAGE ADEQUATE		MAX I _{DEL} (a)	OUTAGE	MAX I _{RES}	IS TEST COVERAGE ADEQUATE
Peak (A)	Peak (A)	RAINT (A-s.5)	RAINT (A-s.5)	Peak (A)	Time (ns)	Peak (A)	Peak (A)
6.40E1	2.50E-2	5.60E1	2.48E-2	2.37E3	500	(c)	n.a.
5.00E1	3.18E-2	1.65E1	4.30E-3	2.50E3	1000	1.75E1	Yes
4.00E1	2.52E-2	2.80E0	8.42E-4	2.50E3	> 1000	(c)	Yes

HEMP on [REDACTED]

E1 Pulser

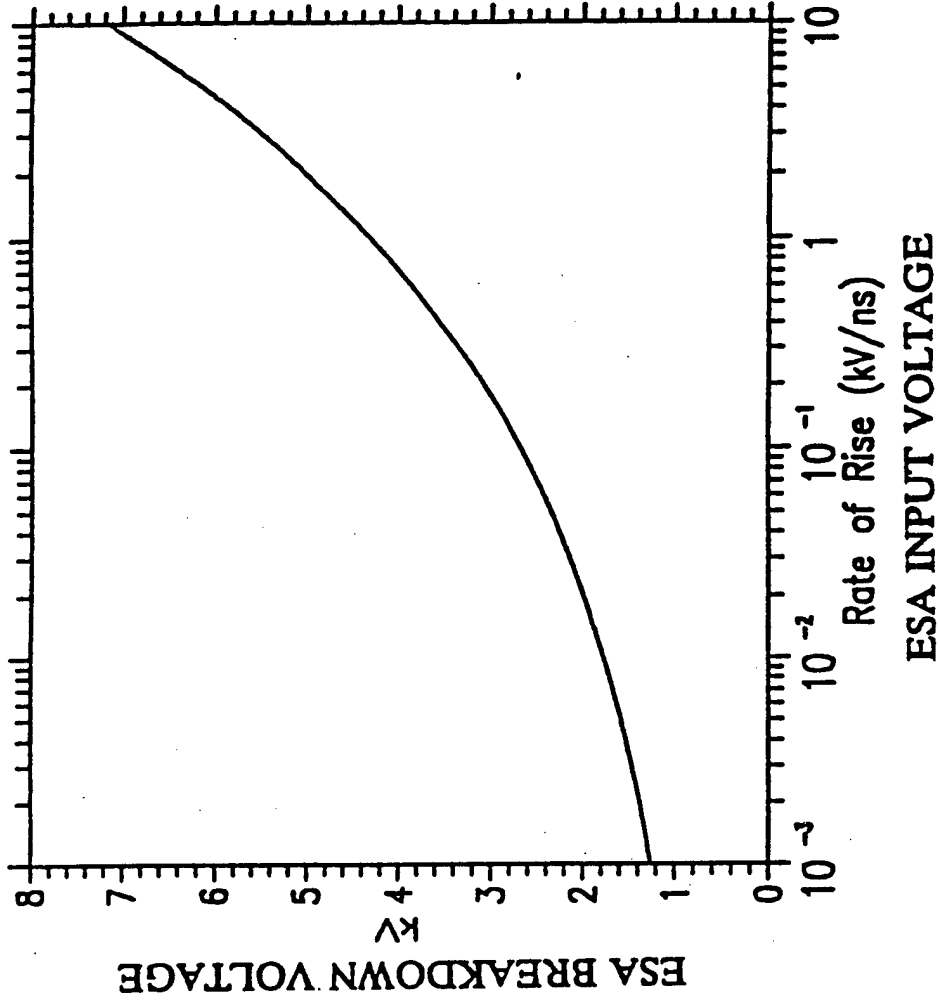
2MHz DS per MIL-STD-188-125

TEST OBJECTIVES

1. Implement/demonstrate the proposed test procedures
2. Evaluate the test coverage achieved with charged line pulser
3. Determine feasibility of local CW illumination to estimate HEMP stresses

*Page 9 removed
in its entirety.*

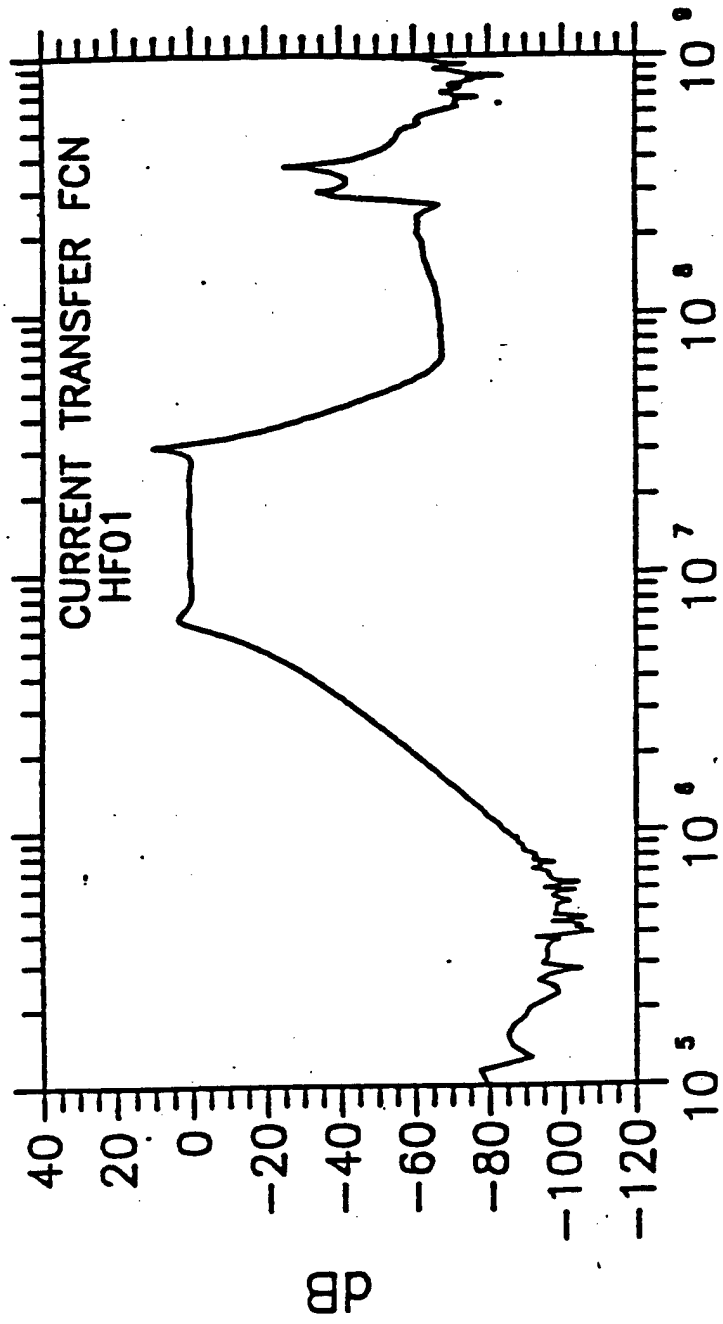
Table 2-2. Specifications of the ESA tested.



Model:	Polyphaser IS-B50LN-CO
Type:	Gas Tube
Turn-on Characteristics:	600 VDC +/- 20% 2.5 ns for 2 kV/ns input

Table 2-1. Specifications of the ~~_____~~ filters tested.

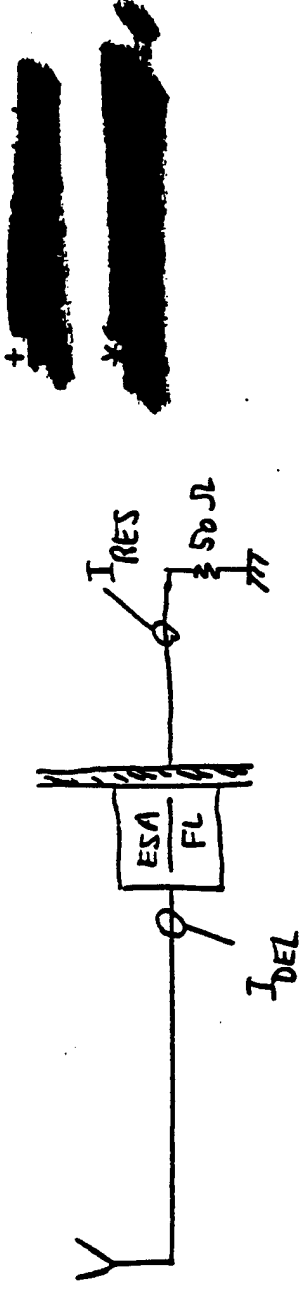
_____	_____	_____	_____
_____	_____	_____	_____



**HEMP STRESS ESTIMATES
USING WIDE AREA CWIL VS. LOCAL CWIL WITH SE ANTENNAS**

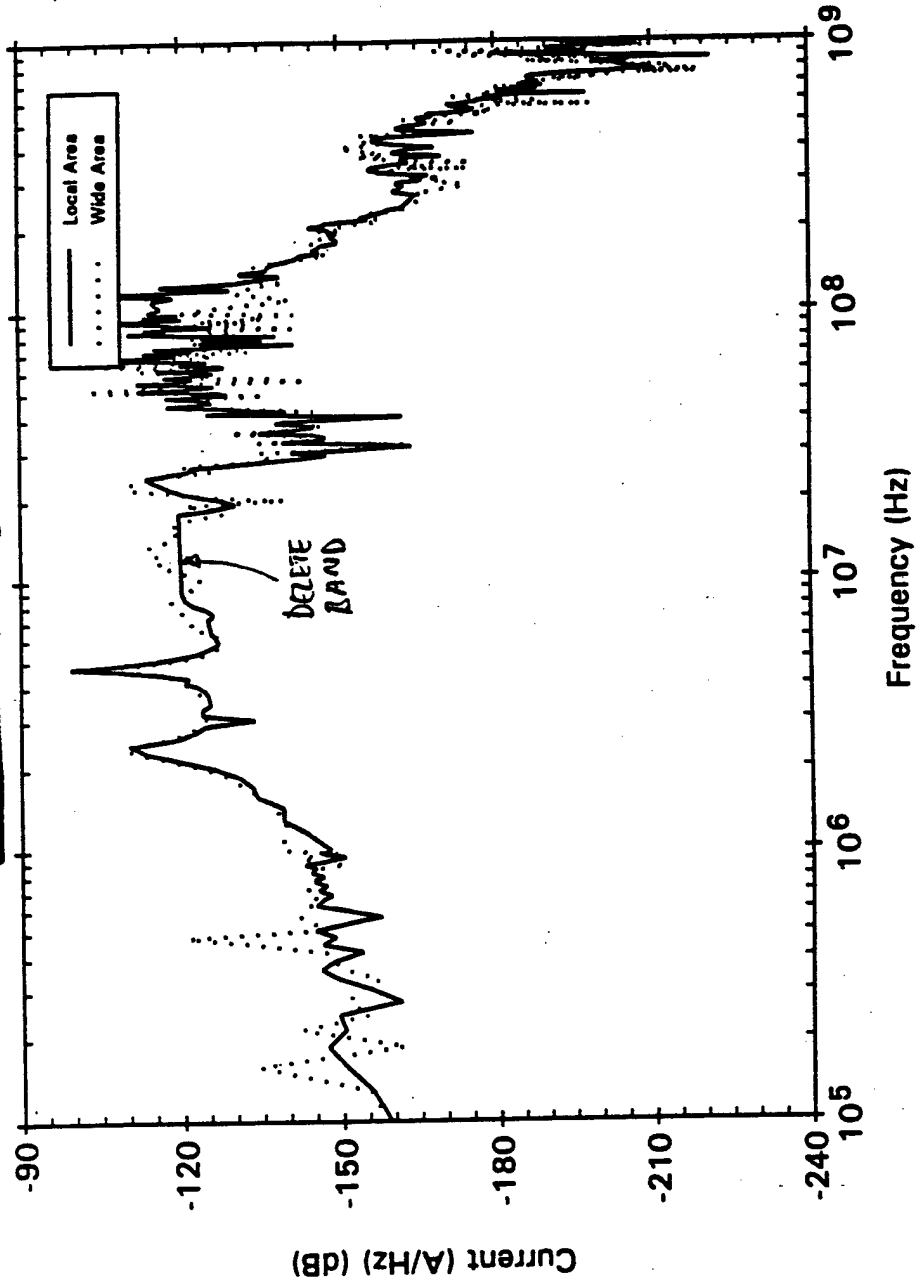
Antenna	Port	ESA + K&L FL:	Peak Curr. I_{DEL} (A)		Peak Curr. I_{RES} (A)	
			Wide Area CWIL	Local CWIL	Wide Area CWIL	Local CWIL
			59.2*	76.2	13.4*	14.8
			54.7	97.1	2.7	1.8
			35.8	76.3	1.5	3.0
			30.2	45.8	4.5	6.3
			43.3	53.2	2.9	4.5

*The site did not permit illumination testing in the HF band, except for these two measurements.

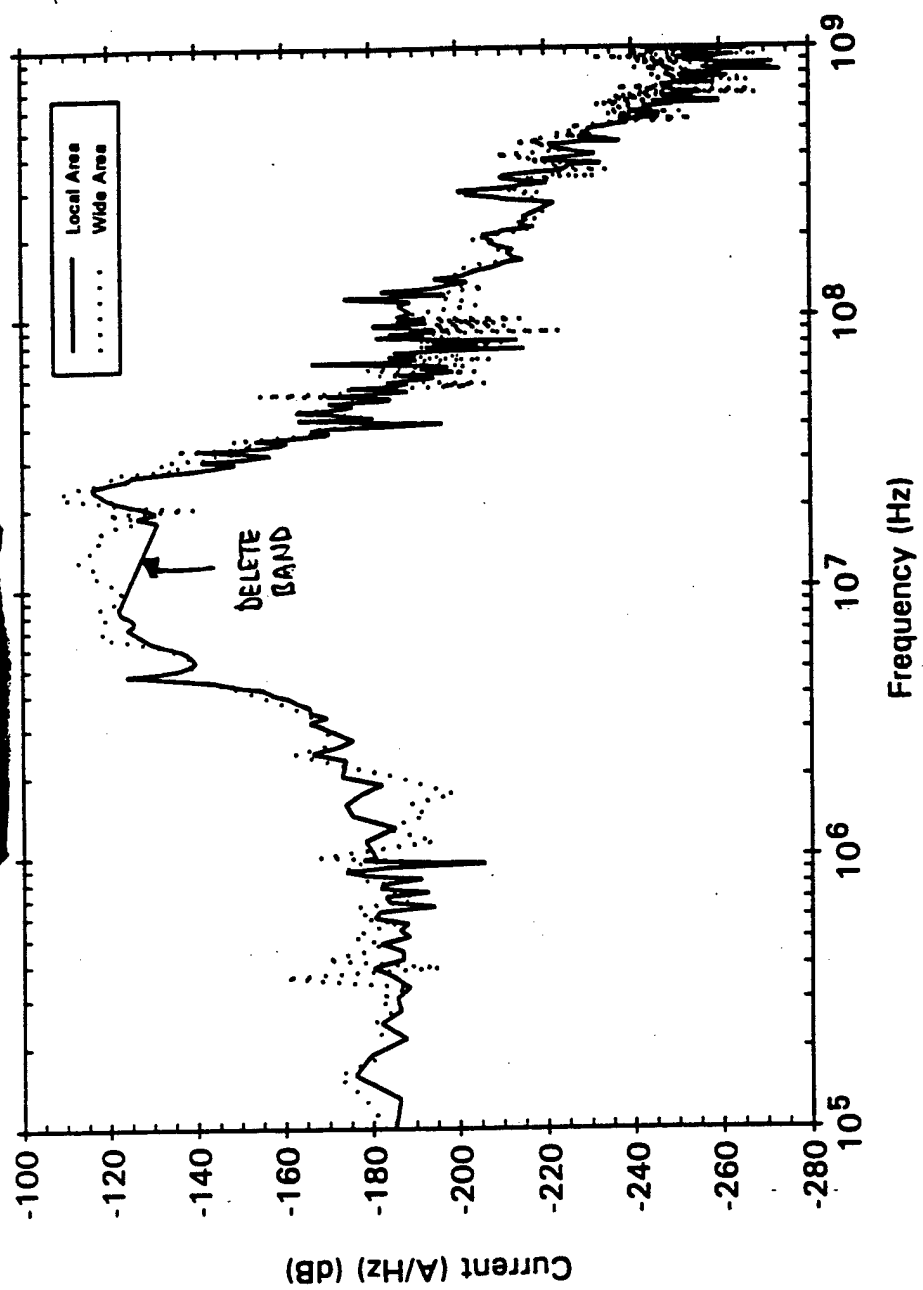


HEMP STRESS EST. METHOD #3: CALC. I_{SC}^{ANT} , $MSD.Z^{ANT}$ - IN PROGRESS

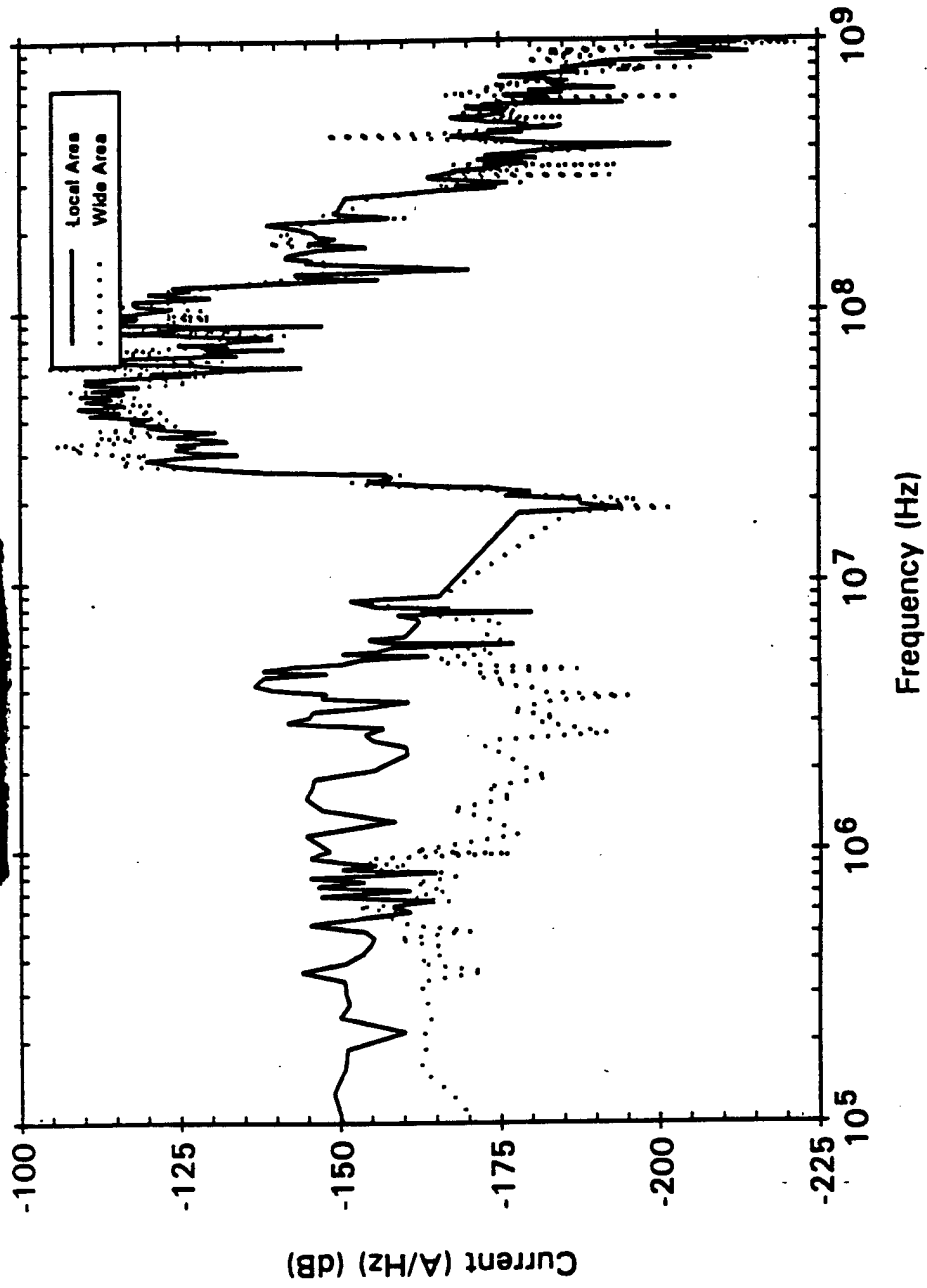
Delivered Current [REDACTED] HF Filter



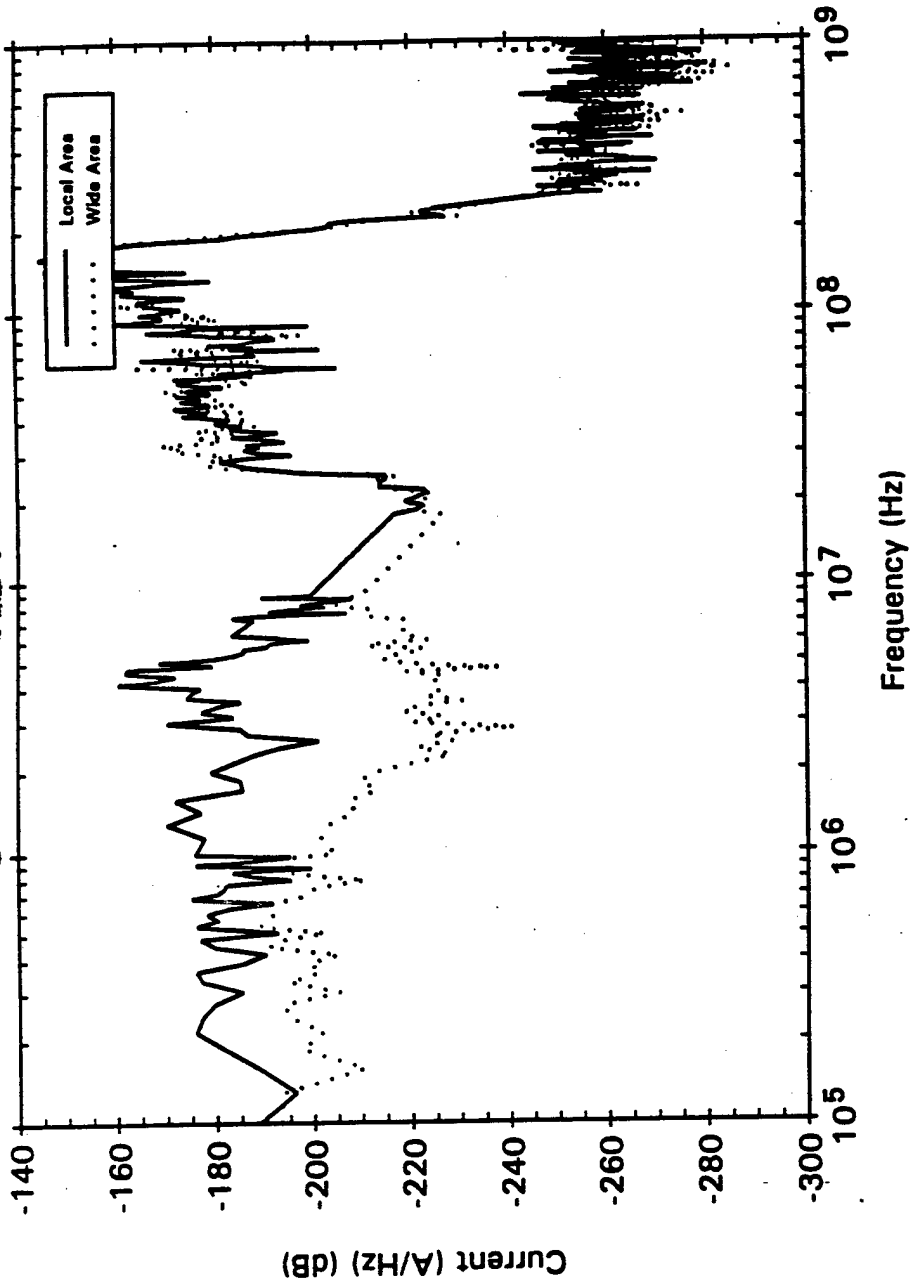
Residual Current
[REDACTED] HF Filter



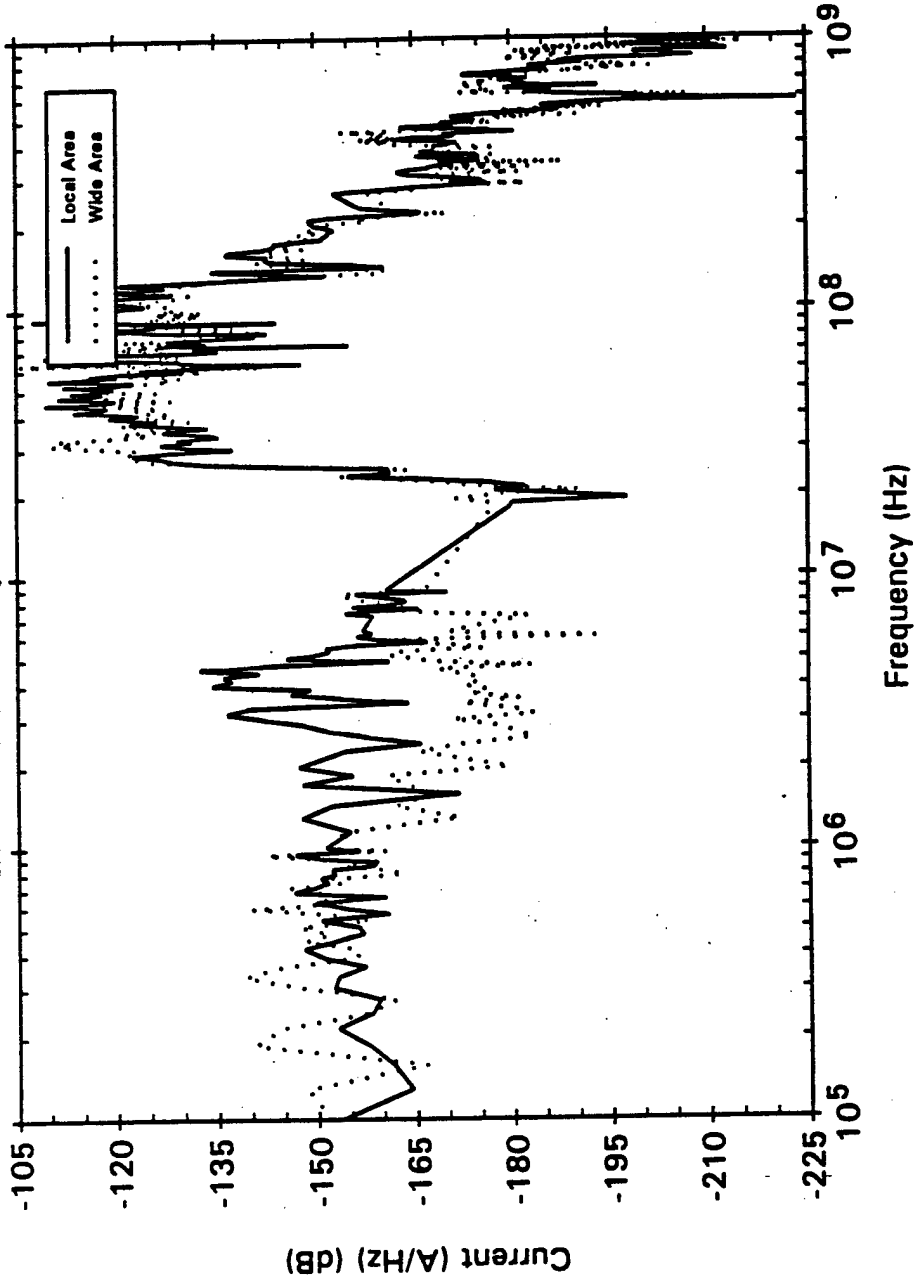
Delivered Current
[REDACTED] VHF Filter



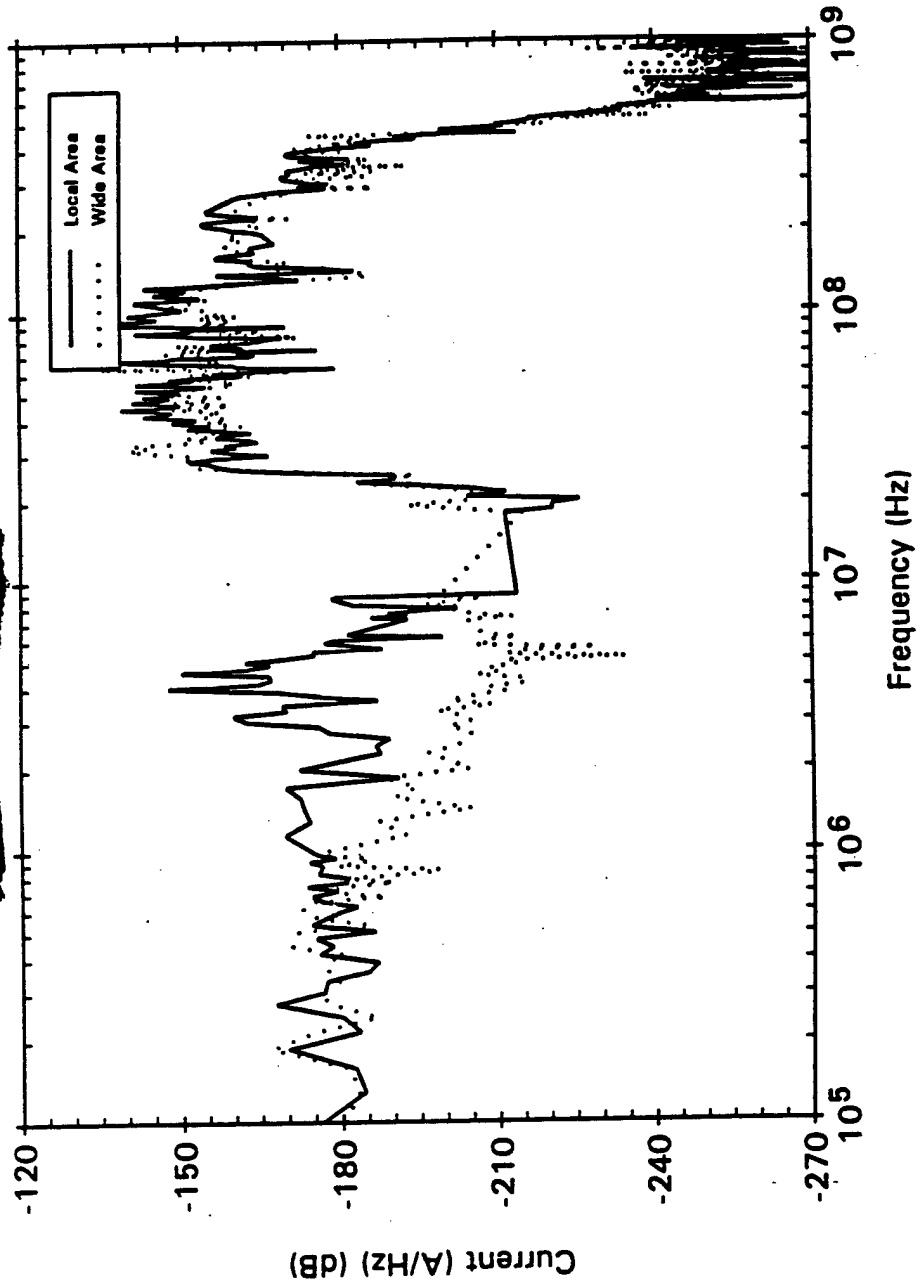
Residual Current
[REDACTED], VHF Filter



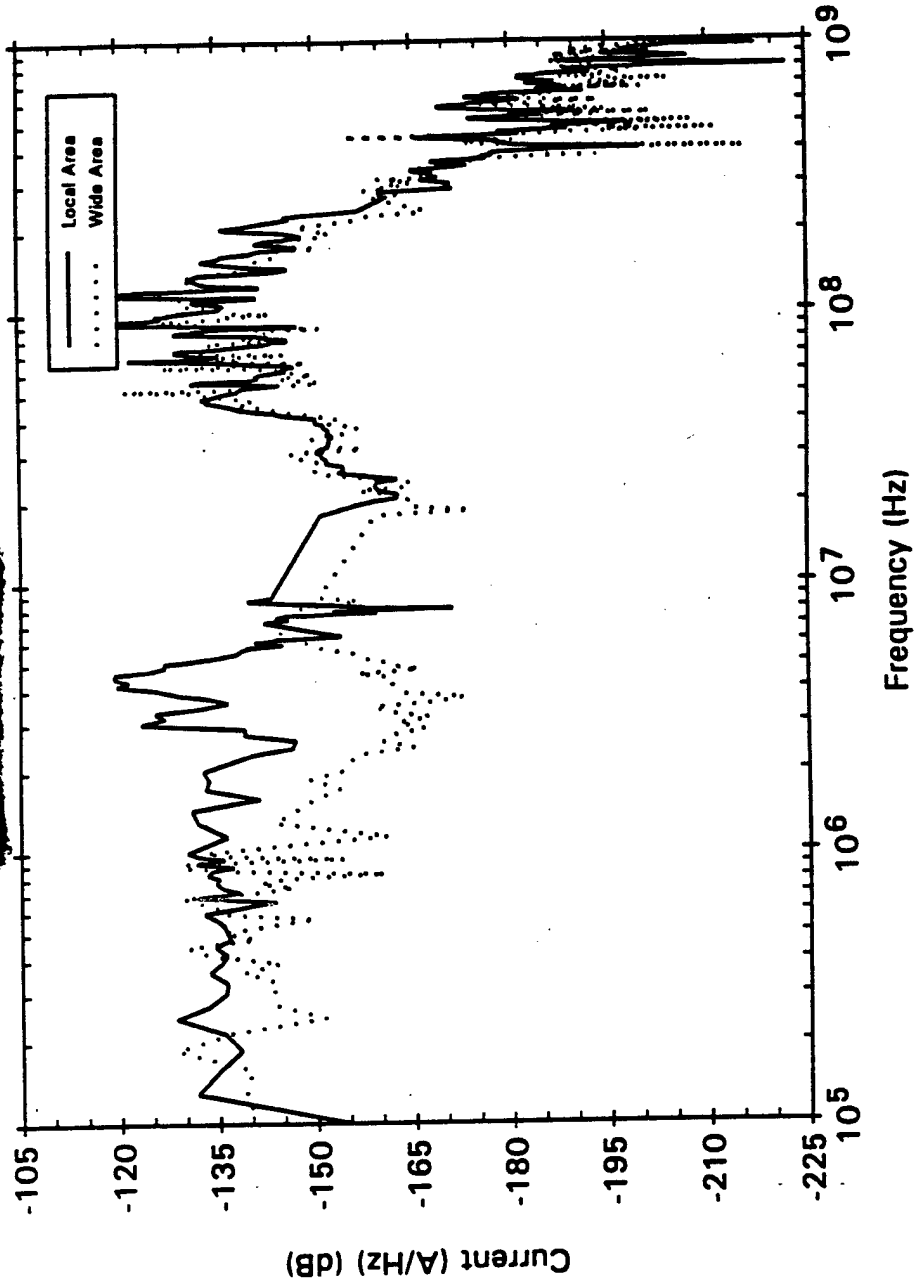
Delivered Current [REDACTED], UHF Filter



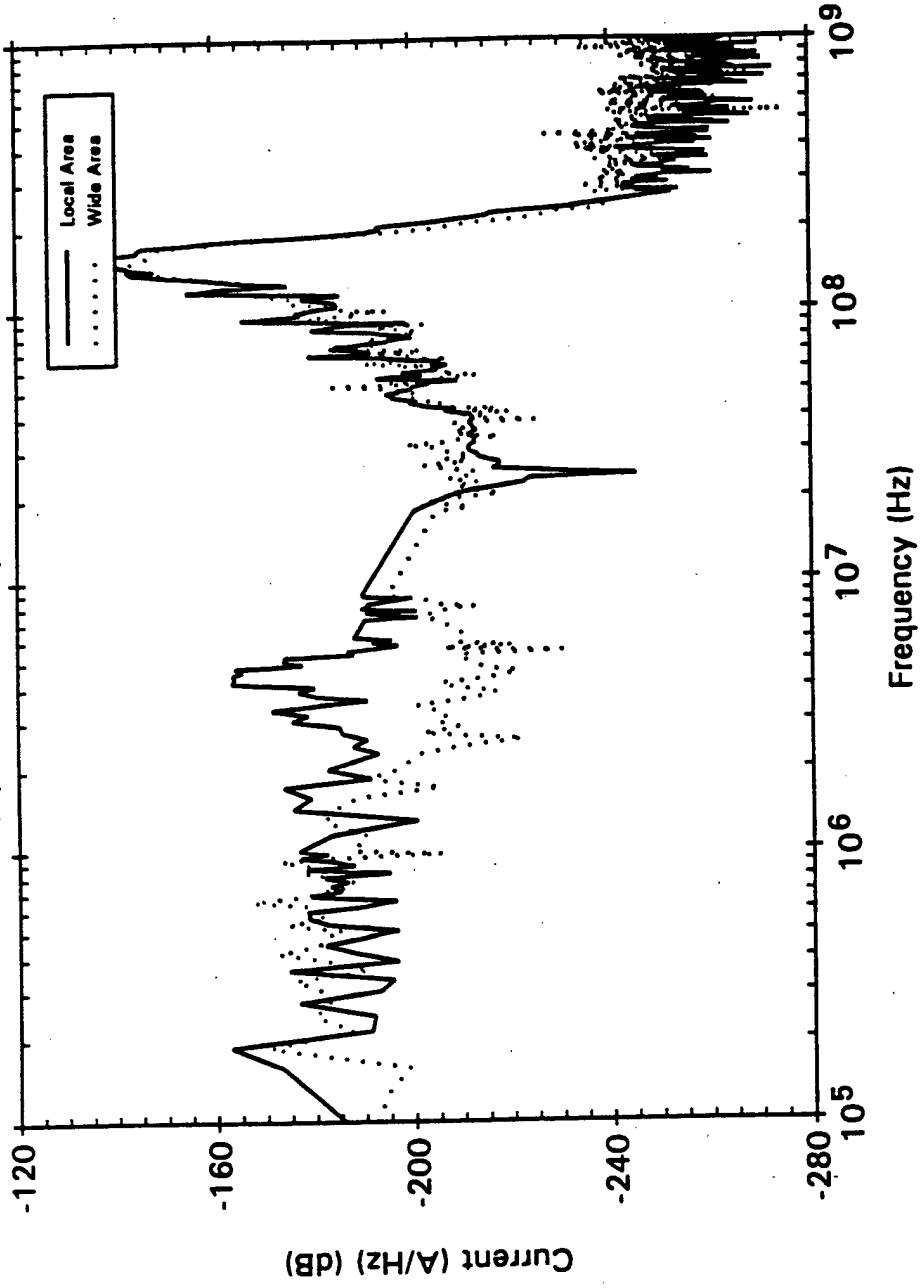
Residual Current UHF Filter



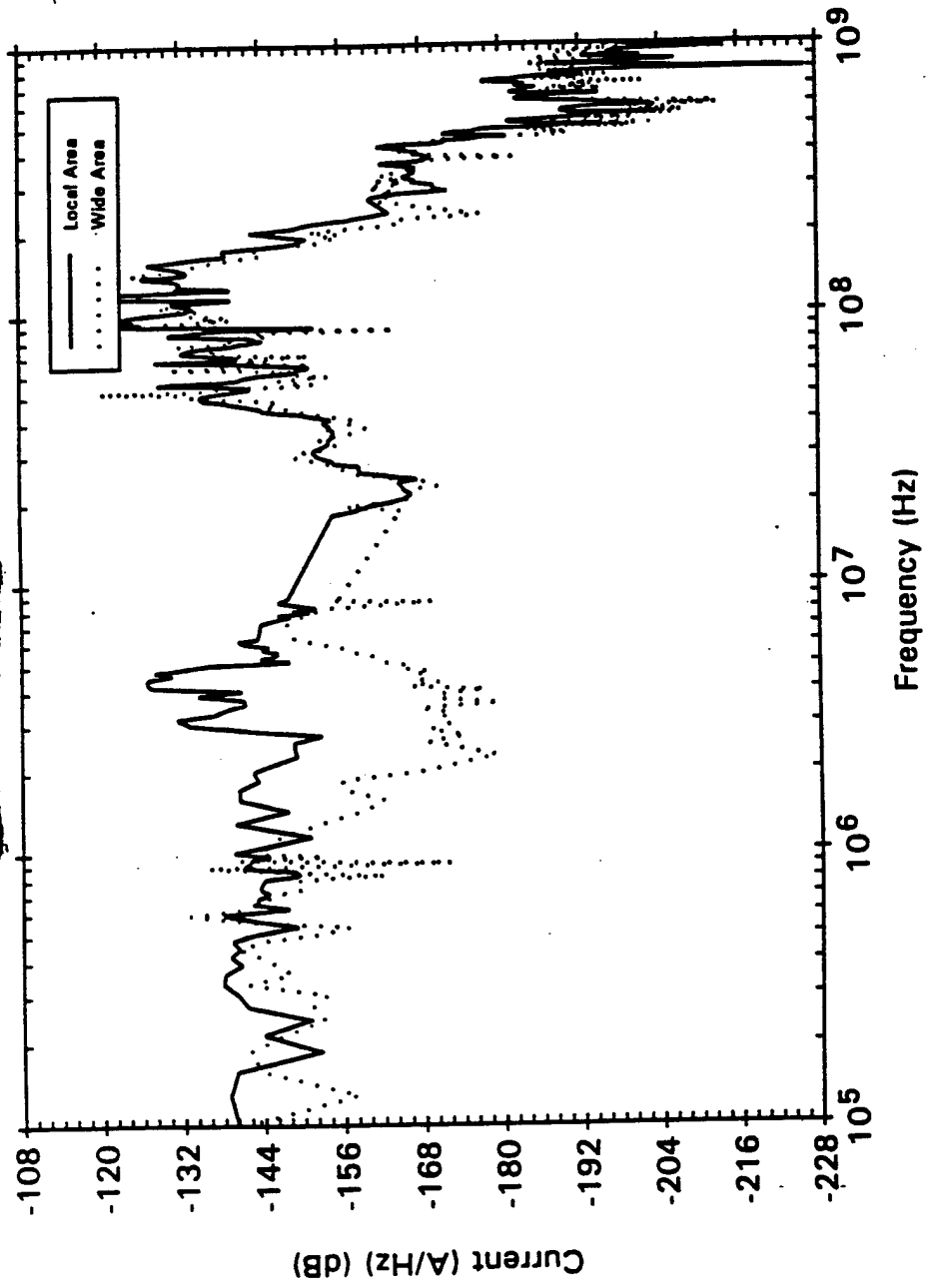
Delivered Current
[REDACTED] VHF Filter



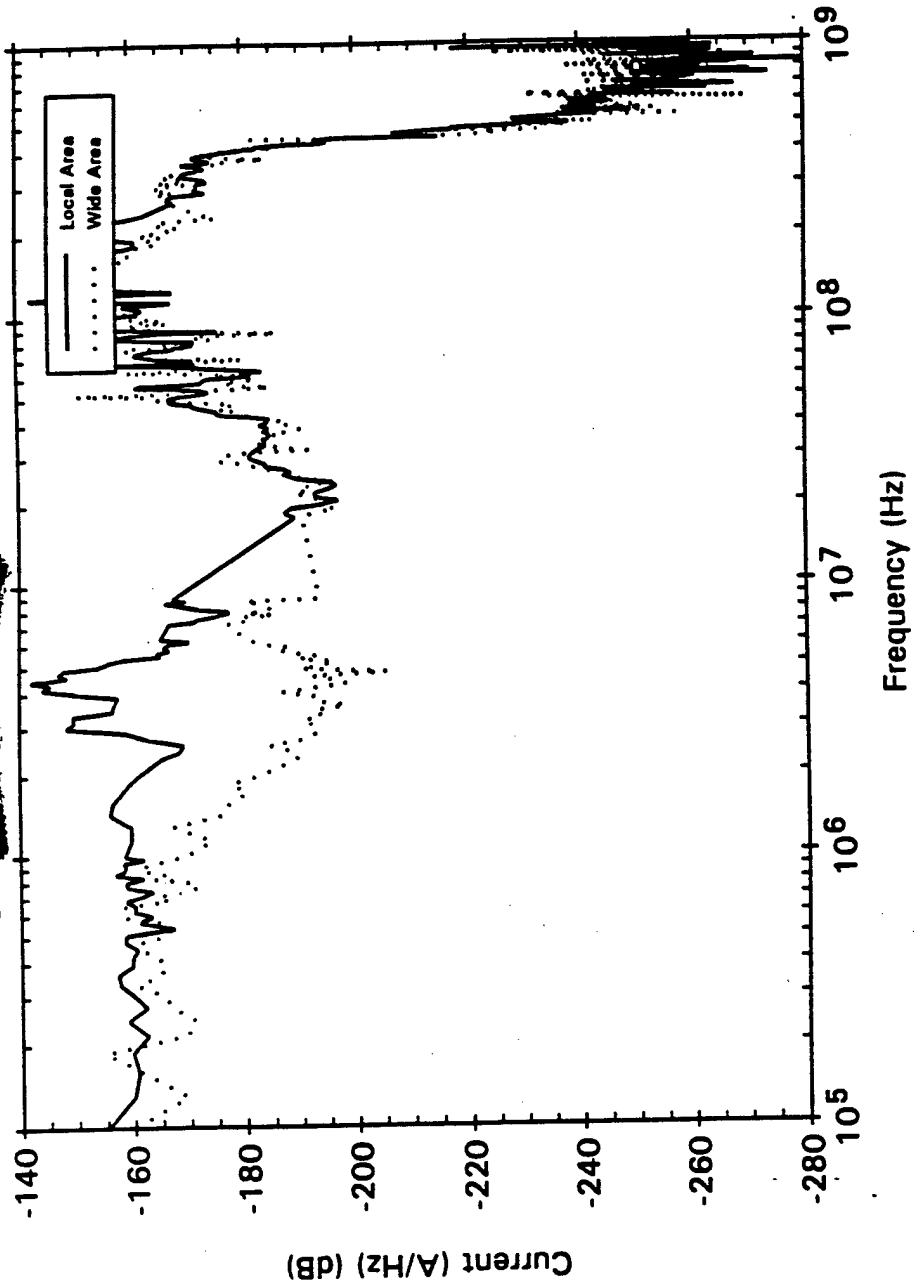
Residual Current
[REDACTED] VHF Filter



Delivered Current [REDACTED] UHF Filter



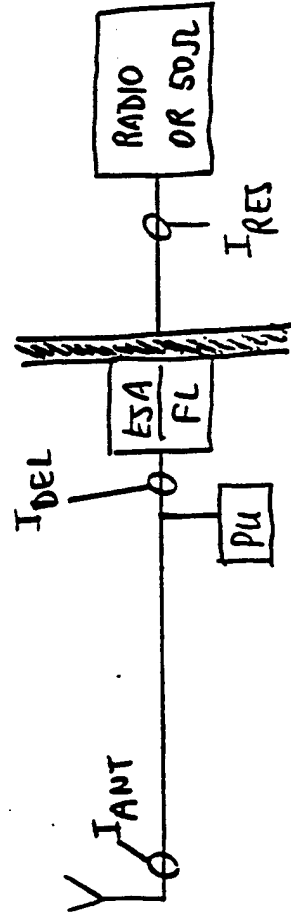
Residual Current
[REDACTED]
UHF Filter



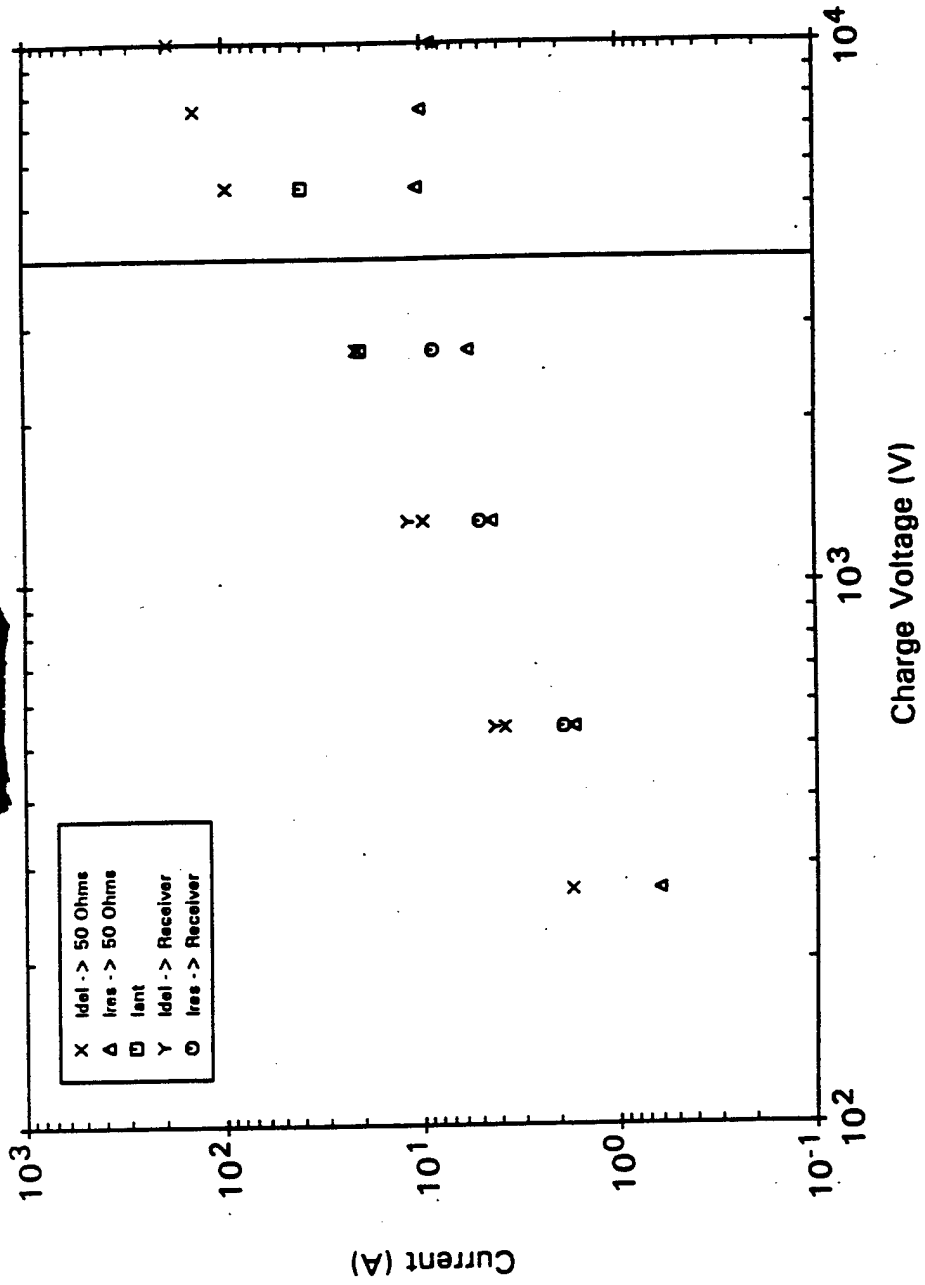
Verification Test of the [REDACTED] Antenna Penetration

Estimated HEMP Stress: Delivered to the protection device $I_{DEL} : 59.2 \text{ A}$
 Residual on the protected side $I_{RES} : 39.8 \text{ A}$

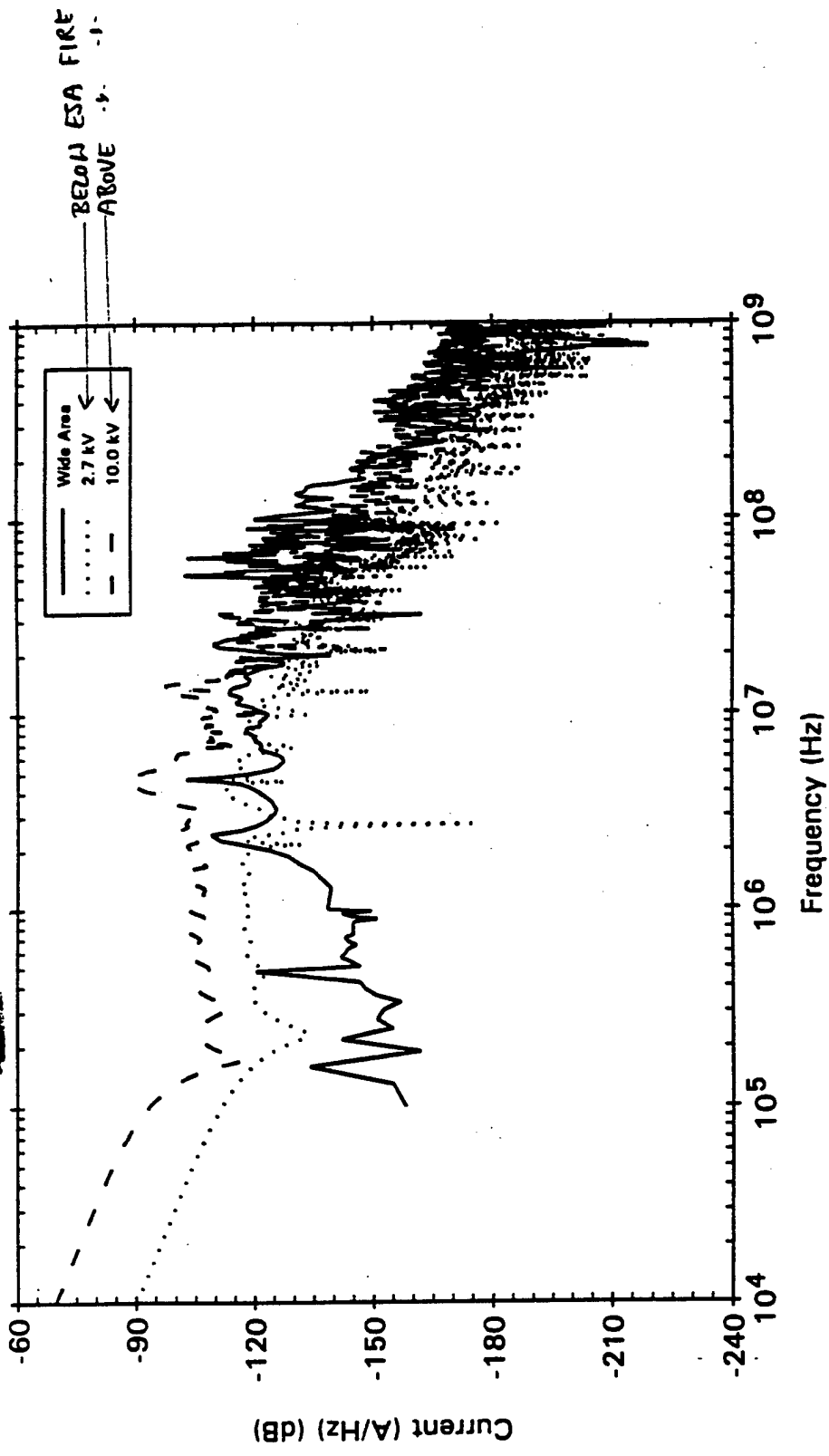
Pulser Charge Voltage (V):	Ant. line terminated in 50 ohms		Ant. line terminated in the radio	
	$I_{DEL} \text{ (A)}$	$I_{RES} \text{ (A)}$	$I_{DEL} \text{ (A)}$	$I_{RES} \text{ (A)}$
270	1.7	0.6	4.3	1.9
540	3.8	1.7	11.8	5.1
1300	9.9	4.4	21.3	8.7
2700	20.6	5.8		
5400	95.5	10.5		
7500	139.0	10.0		
10000	188.0	8.9		



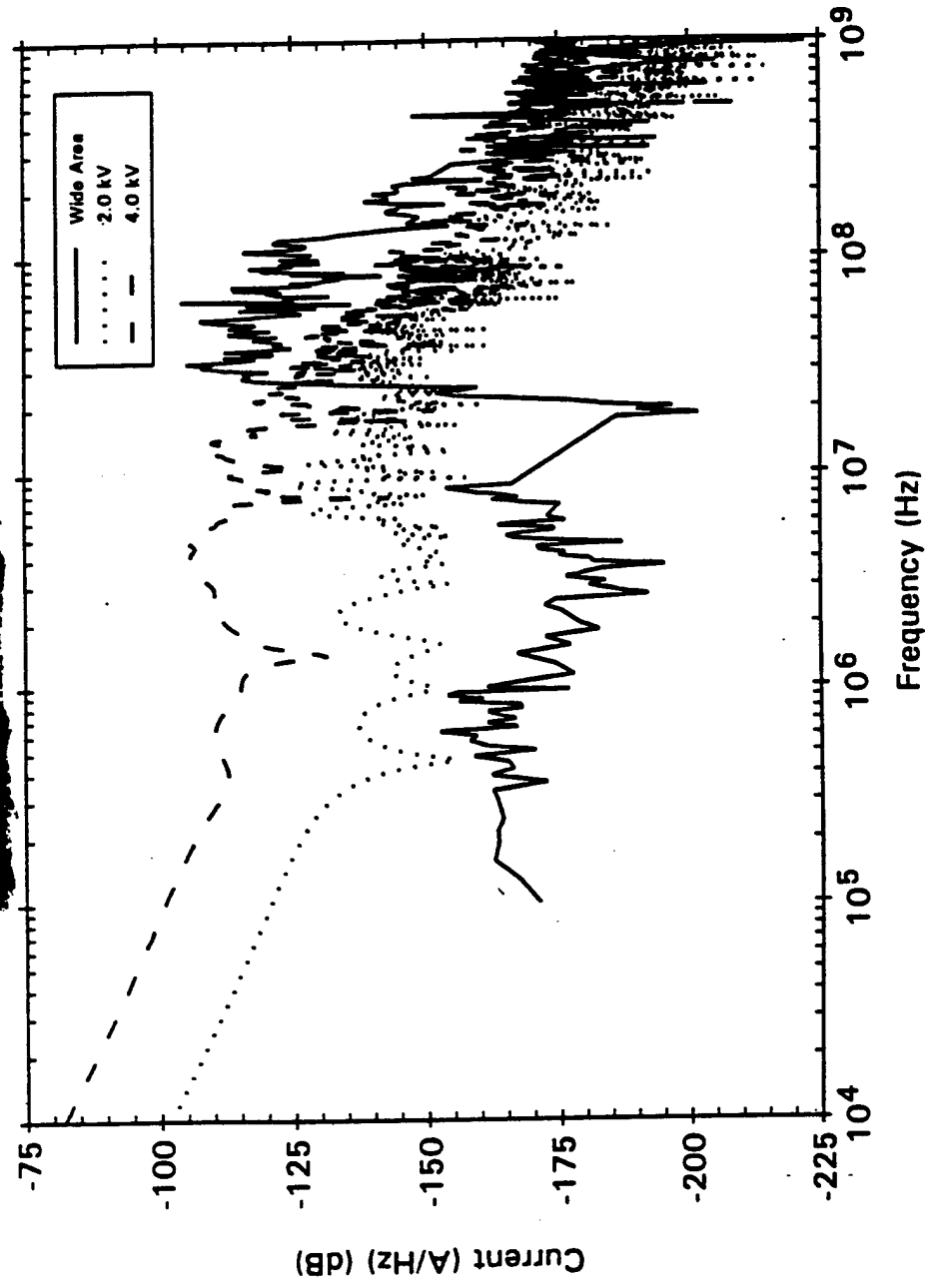
Measured Currents vs. Charge Voltage HF Filter



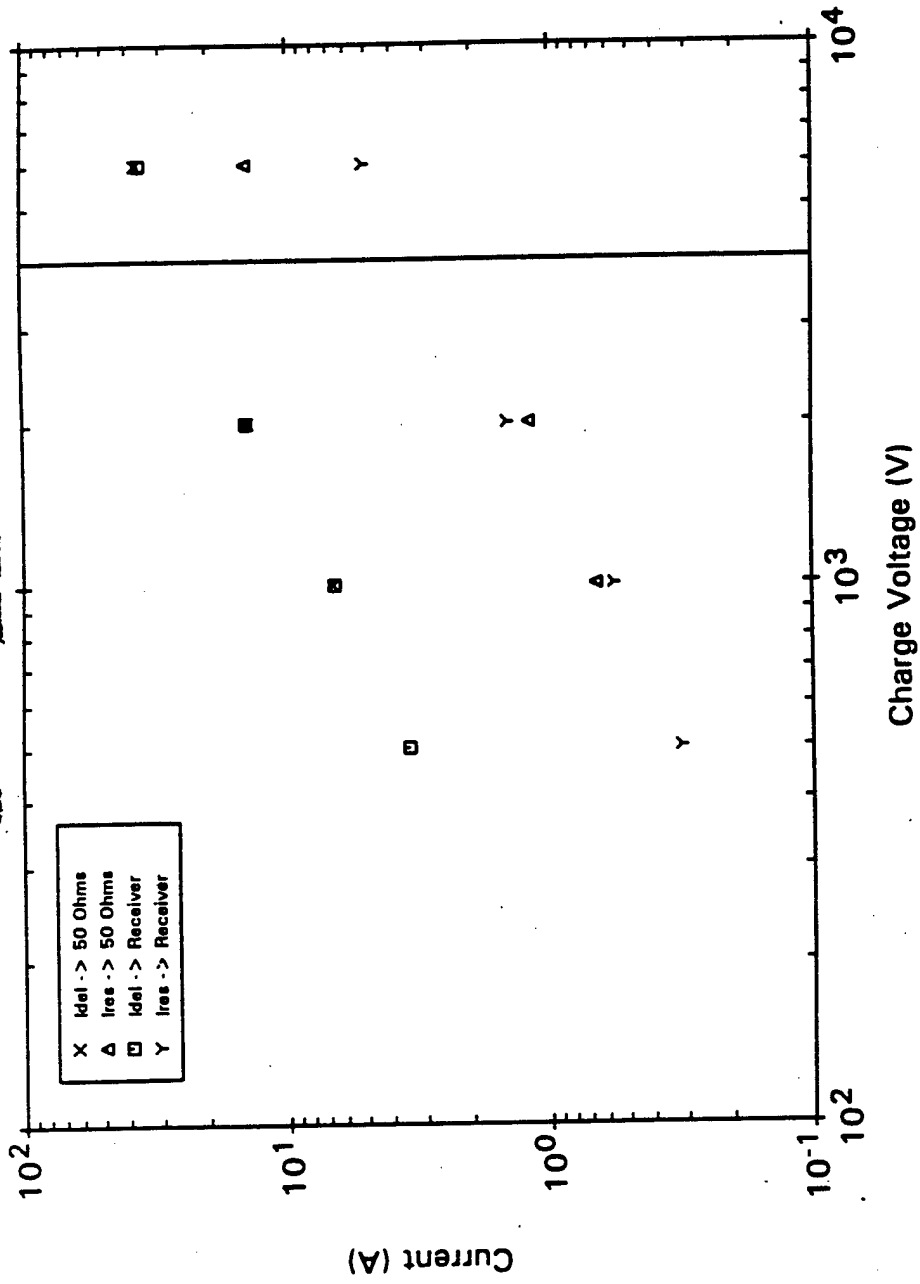
Delivered Current [REDACTED] HF Filter



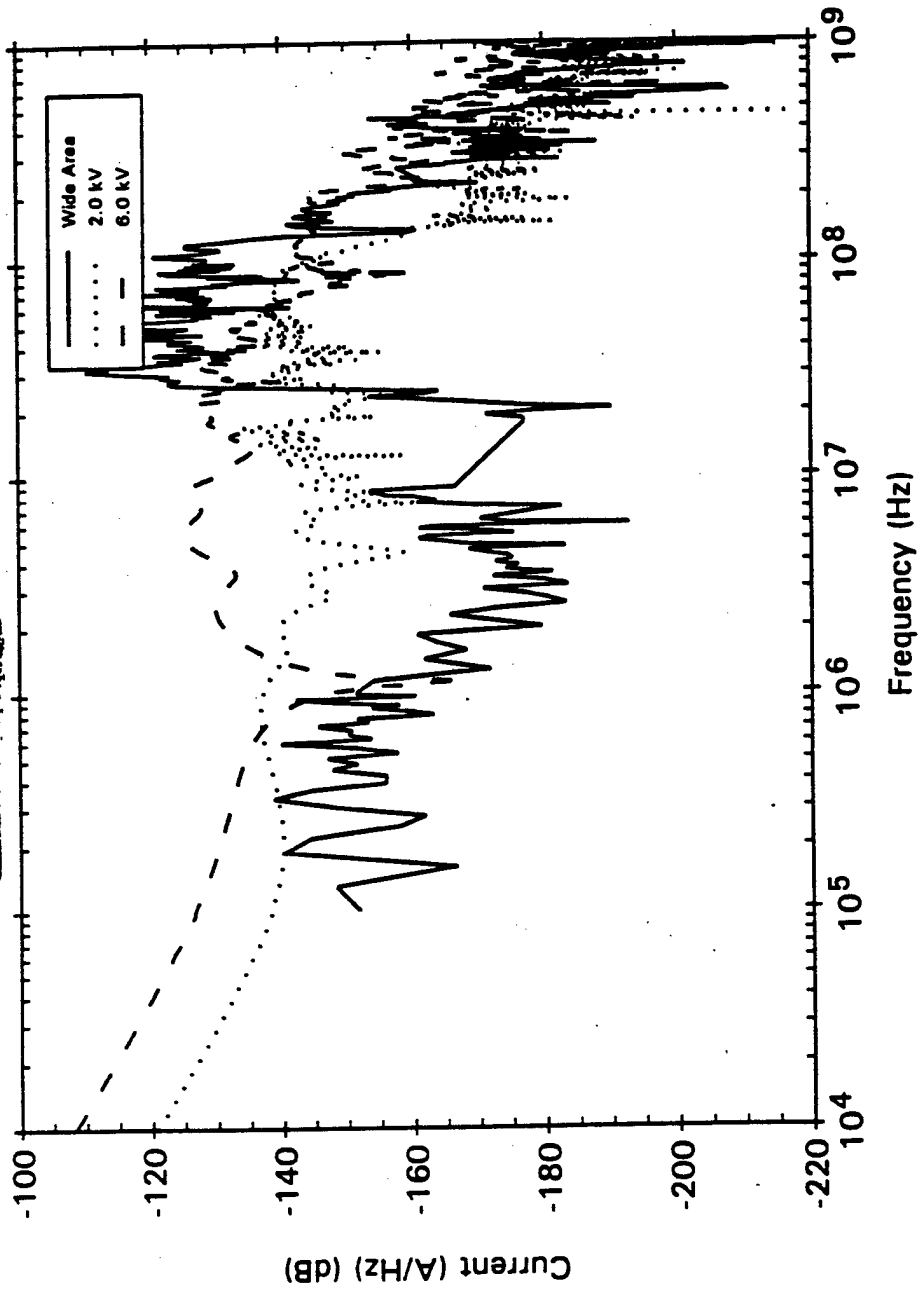
Delivered Current [REDACTED], VHF Filter



Measured Currents vs. Charge Voltage Filter



Delivered Current [REDACTED] Filter



CONCLUSIONS

1. The proposed verification test procedure was implemented and demonstrated at an operational site.
2. The test coverage provided by the charged line pulser was adequate to test the HF, VHF, and UHF antenna lines.
3. HEMP stresses can be adequately estimated with local CW illumination using the SE transmit antennas.
4. The verification test configuration (antenna leg in parallel with the pulser) did not significantly reduce the test coverage.
5. The [REDACTED] operated normally even when the pulser TEE was inserted; i.e., the TEE did not interfere with the link.