NATIONAL RADIO ASTRONOMY OBSERVATORY
Green Bank, West Virginia

RFI TESTING OF POWER DRIVE UNIT AND SIX MOTORS

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Introduction

On September 22, 1992 RFI testing of the initial PCD Power Drive Unit (PDU) and associated six motors was performed. The setup is shown in Figure 1. The basic test plan had two ingredients: first, the 100 to 1000 MHz band was monitored from four locations in the building with motors and electronics off and on; second the shielding of the PDU cabinet was evaluated by placing a transmitter in the cabinet and noting the difference between doors open and closed, at various frequencies, from three locations in the room. This report summarizes and analyzes these tests.

Test Summary

A few limitations of the tests should be mentioned. The accuracy of the tests is probably no better than $\pm$ 6 db due to the possibility of multiple reflections in the room. Also, only one quarter of the az/el servo was being measured.

A summary of the measurements of motor, plus motor driver, RFI is given in Table 1, below. Plots of the measurements are referenced in the table and attached to this report. All plots include a reference trace of the ambient noise with the PDU and motors powered down. All plots were generated in Max Hold mode with approx. 30 sec. integration. Reference Figure 1 for "location".

Plot #	Location	Conditions
0	0	Doors open, motors running.
1	1	Just electronics in cabinet on, doors open
2	1	Like #1 plus motors on (no blowers).
3	1	Like #2 plus motor blowers on.
4	1	Like #1 plus blowers on (motors off).
5	2	Motors and blowers on, doors open.
6	2	Like #5, but higher resolution.
7	3	Motors and blowers on, doors open.
8	1	Motors and blowers on, doors open.
9	1	Motors and blowers on, doors closed.

Table 1: Summary of motor and motor driver RFI measurements.

A summary of the measurements of the cabinet shielding effectiveness using a transmitter are given below in Table 2.

Location	Frequency (MHz)	(Doors open/Doors closed) in DB
1	100	-8 ??
1	200	19
1	300	15
1	400	4
2	100	8
2	200	13
2	300	20
2	400	8
3	100	4
3	200	29
3	300	14
3	400	7

Table 2: Summary of cabinet attenuation measurements.

Analysis

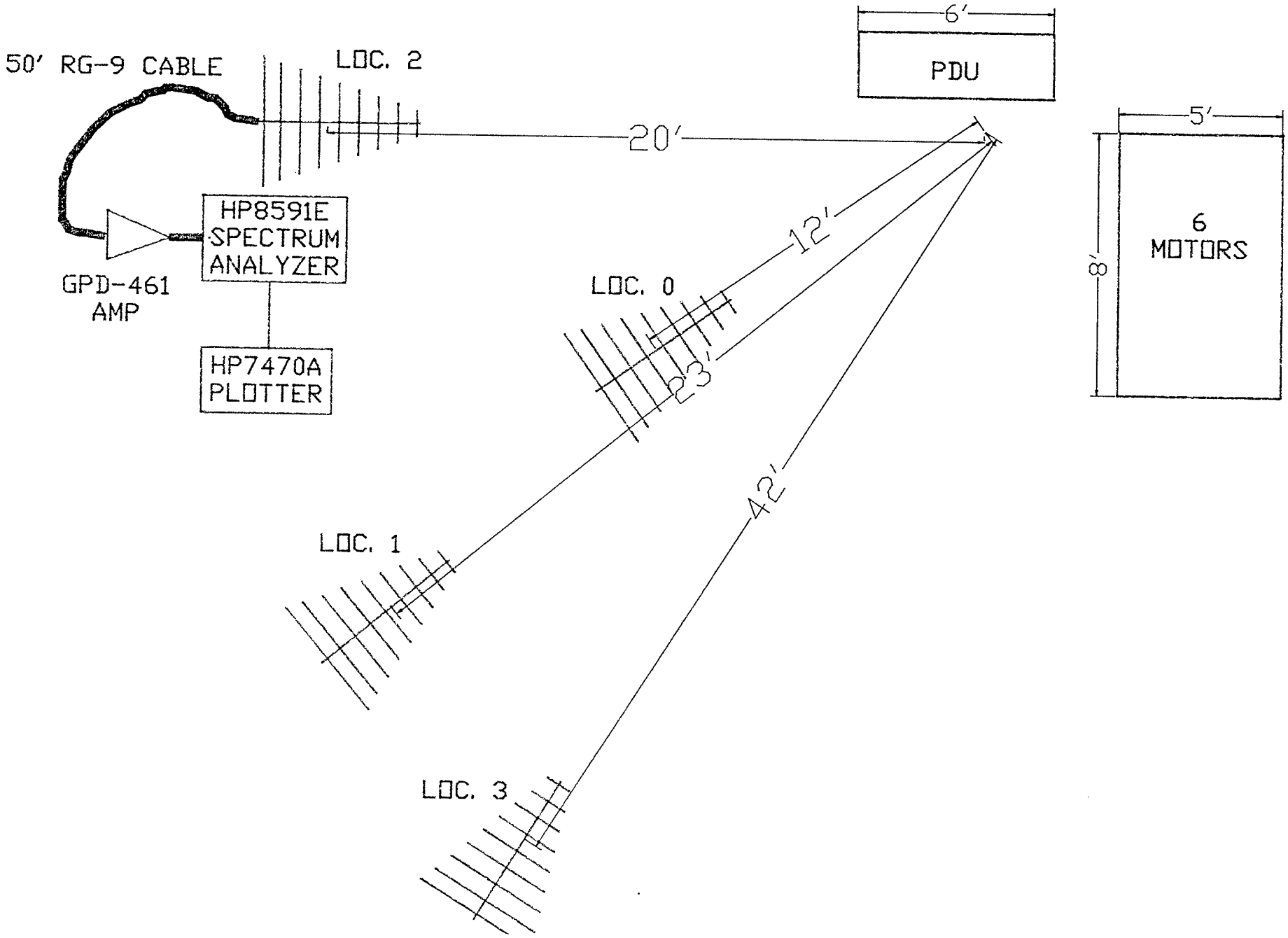
RFI from the PDU and/or motors was detected in several plots up to approximately 500 MHz. After 500 MHz the interference environment was too severe and the noise floor of the equipment too high to allow detection, if any RFI existed. The RFI seemed to be pulsed in nature, as evidence by the manner in which the MAX HOLD sweep seemed to build up in spots. For pulsed interference such as this, the peak detected level is usually about 20 db higher than the average level. As can be seen in Plot 2, peak detected levels are 50 to 60 db higher than the CCIR limit. The average level is, then, 30 to 40 db above the limit. The calculation of the CCIR limits for various frequencies for the existing test set is shown in Table 3.

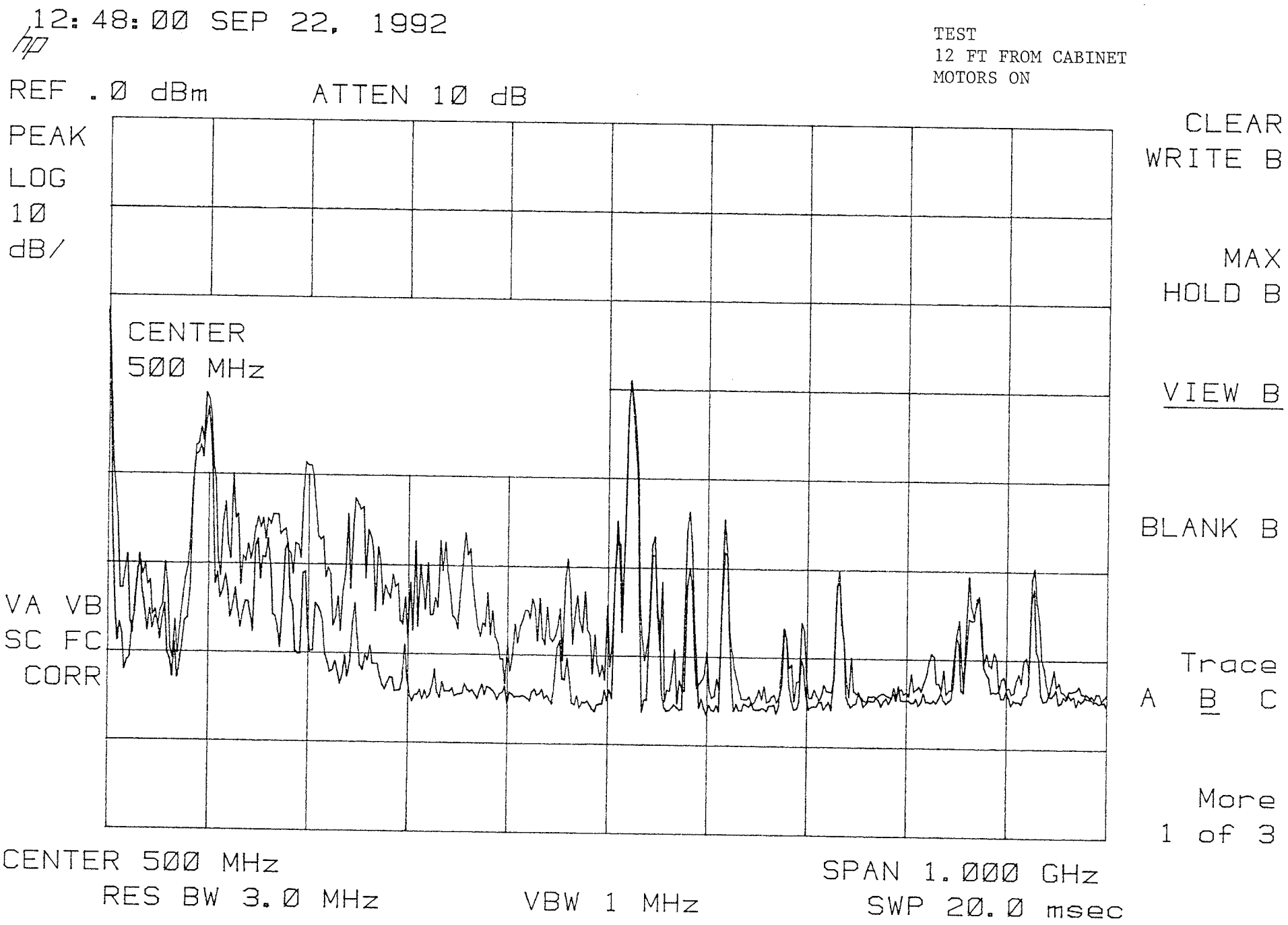
The cabinet shielding, as measured by the transmitter enclosed in the cabinet (Table 2) and by plot 9, was of order 5 to 20 db. If the source of the RFI is the PDU, then significant improvements can be made by proven shielding and filtering techniques.

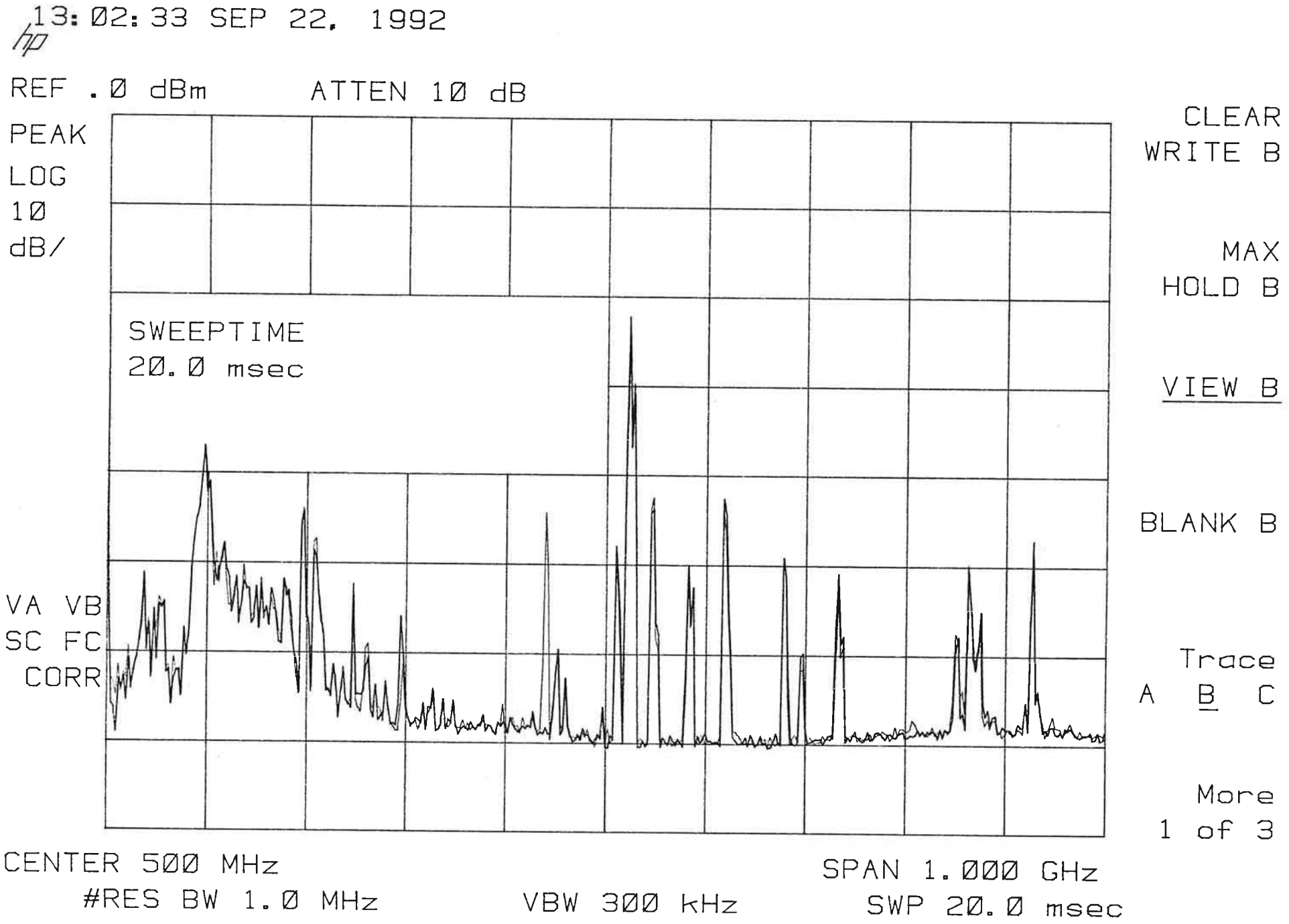
File: S_RFI992.wp

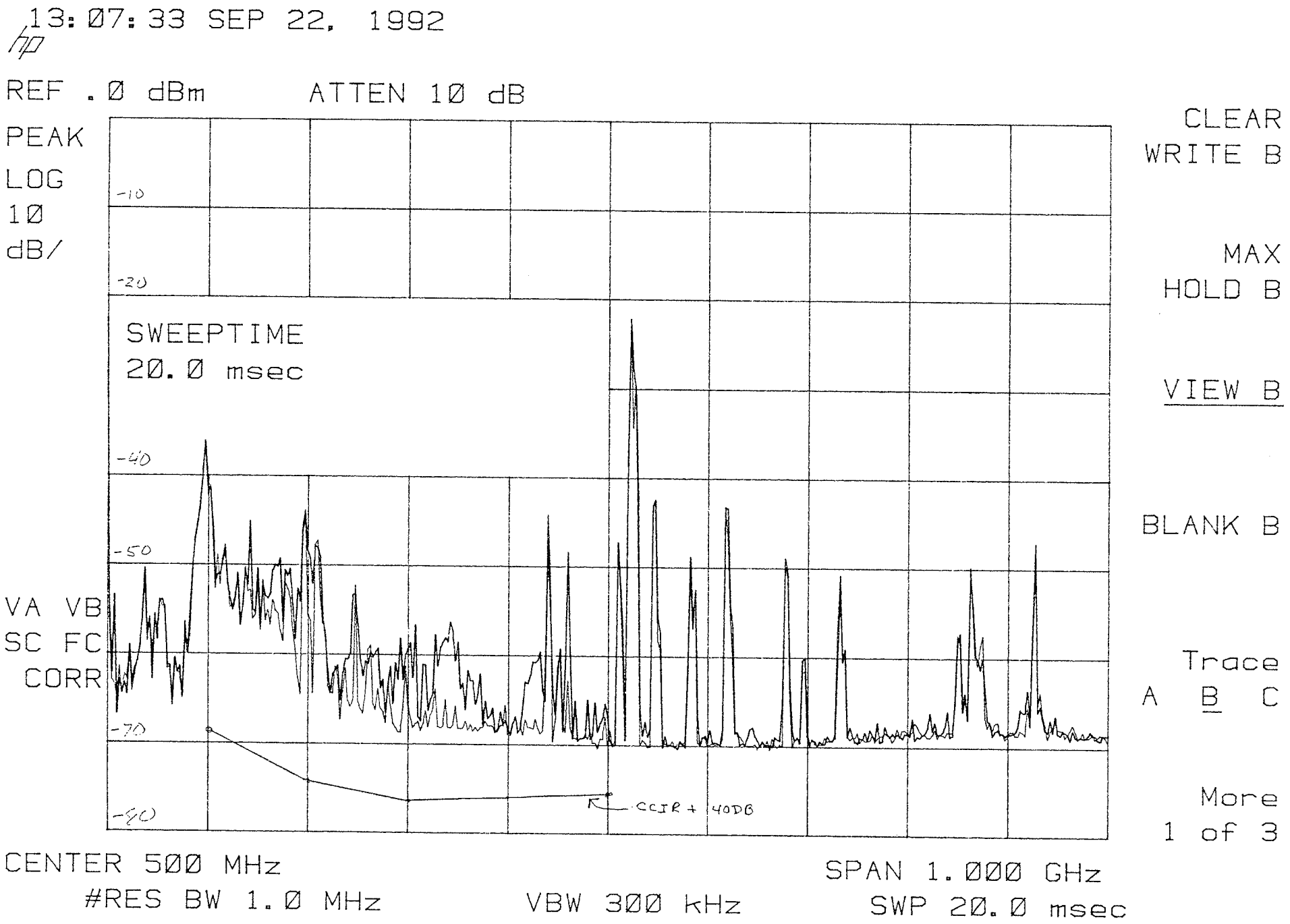
ROW #	ITEM	FREQUENCY (MHz)					
		100	200	300	400	500	UNIT
A	Antenna Area $\sim \frac{\lambda^2 (Gain)}{4\pi}$	2.8	0.716	0.318	0.179	0.114	m^2
B	Amp Gain (linear) $10^{1.5}$	32	32	32	32	32	--
C	Cable loss (linear)	1.26	1.44	1.61	1.77	1.93	--
D	Radiated power to produce -90 dbm with existing setup $\frac{10^{-12} Watts}{A} \cdot \frac{C}{B}$	1.4×10^{-14}	5.5 1O^{-14}	1.23×10^{-13}	2.2×10^{-13}	3.5×10^{-13}	W/m^2
E	Power at 1Km rel. to D; attenuated by $\left[\frac{25\,ft \cdot (.3m/ft)}{1000m}\right]^2$	8.1×10^{-19}	3.2×10^{-18}	7.1×10^{18}	1.3×10^{-17}	2.0×10^{-17}	W/m^2
F	CCIR Limit	1.26×10^{-26}	1.26×10^{-26}	1.58×10^{-26}	3.16×10^{-26}	3.98×10^{-26}	$W/(m^2 \bullet Hz)$
G	CCIR limit for 1 MHz BW 1.26×10^{-20}	1.26×10^{-20}	1.26×10^{-20}	1.58×10^{-20}	3.16×10^{-20}	3.98×10^{-20}	$W/(m^2 \bullet MHz)$
H	Ratio CCIR limit to -90 dbm $10 \log \left[\frac{G}{E}\right]$	-18	-24	-27	-26	-27	db
I	Locus of CCIR plus 40 db on plots	-68	-74	-77	-76	-77	dbm

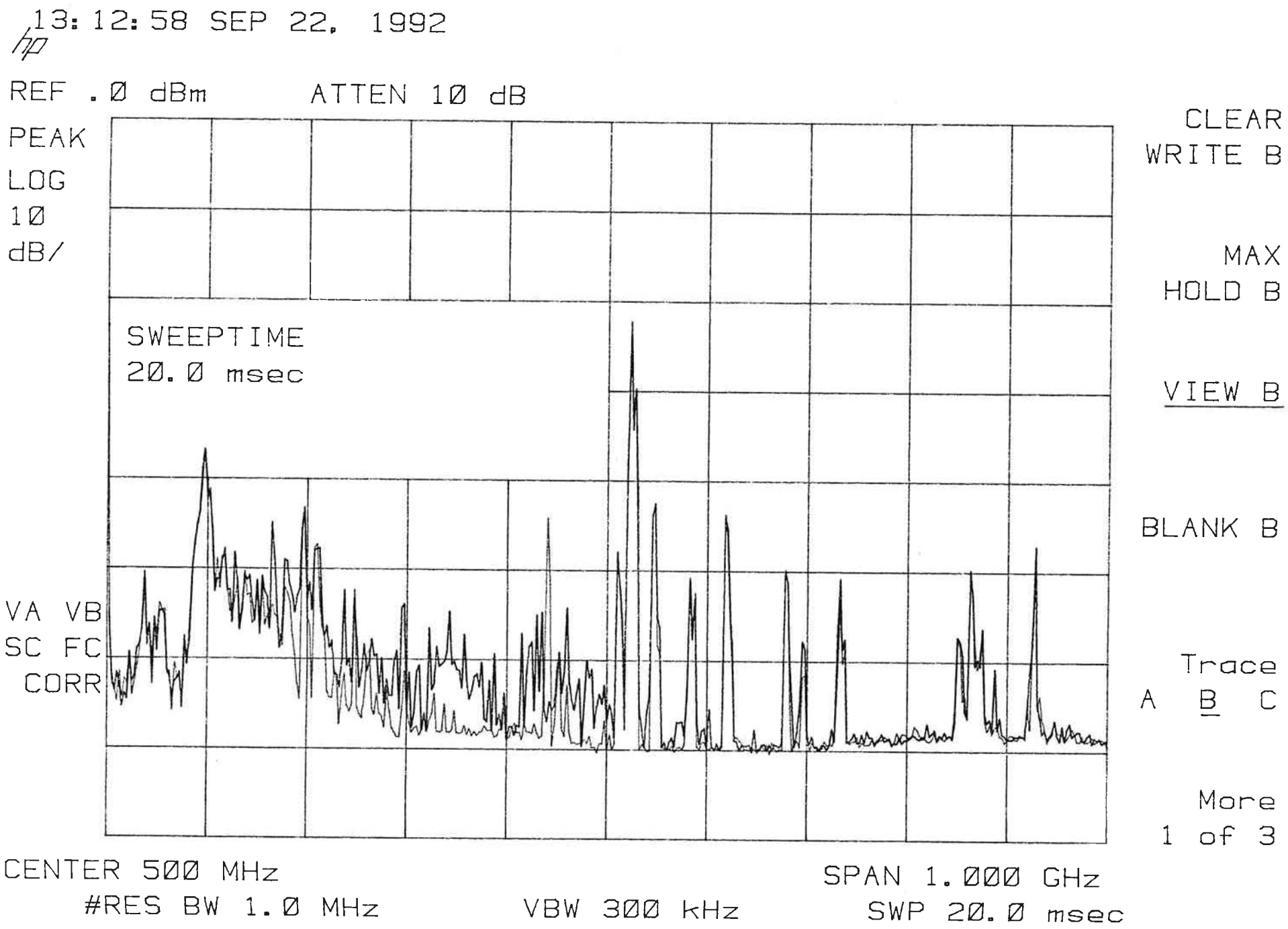
Table 3: CCIR limits for the measurements configuration shown in figure 1, for 25 ft distance and 1 MHz resolution bandwidth.

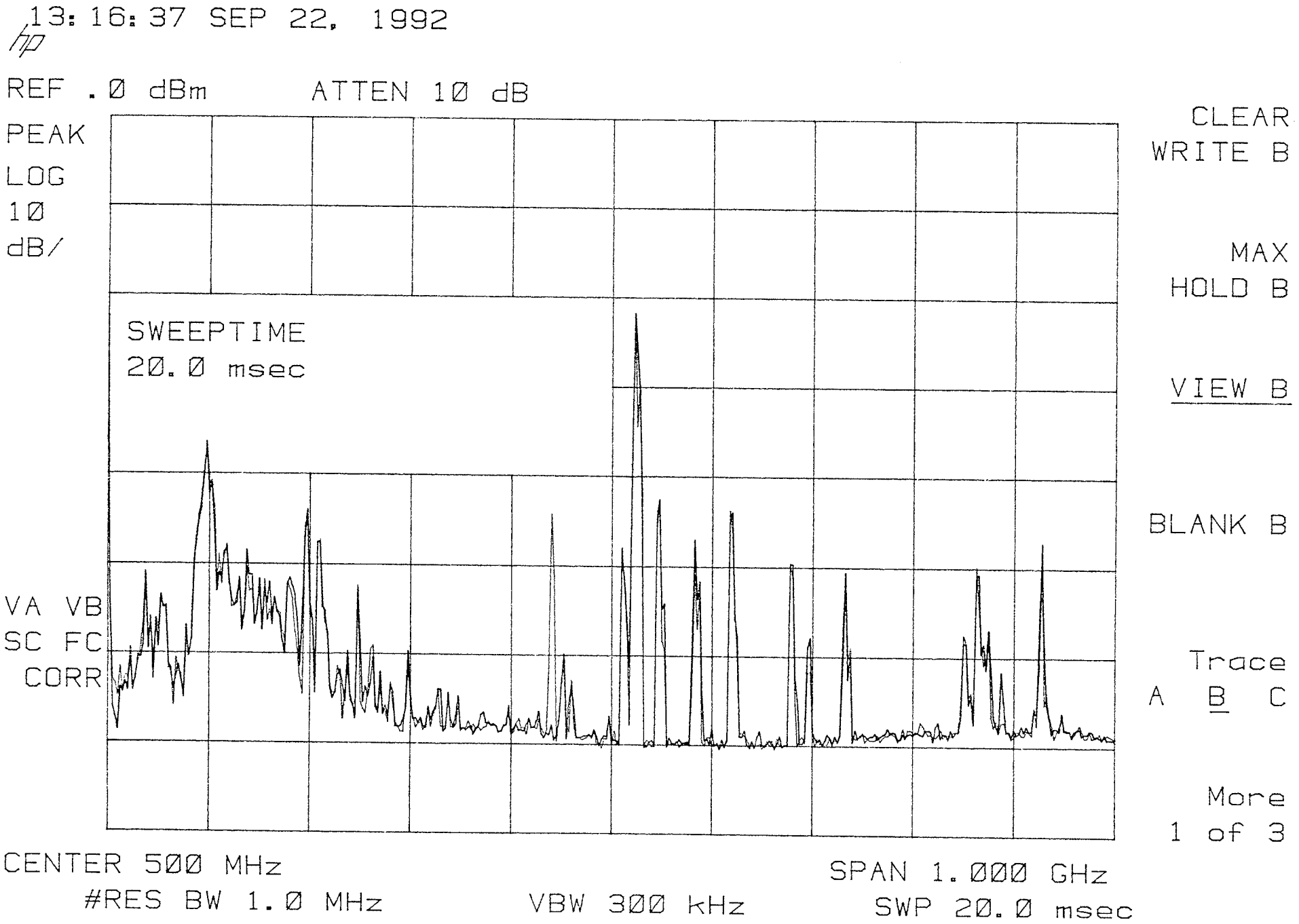

50' RG-9 CABLE
LOC. 2
20'
6'
PDU
5'
6
MOTORS
8'
HP8591E
SPECTRUM
ANALYZER
GPD-461
AMP
HP7470A
PLOTTER
12'
LOC. 0
23'
42'
LOC. 1
LOC. 3

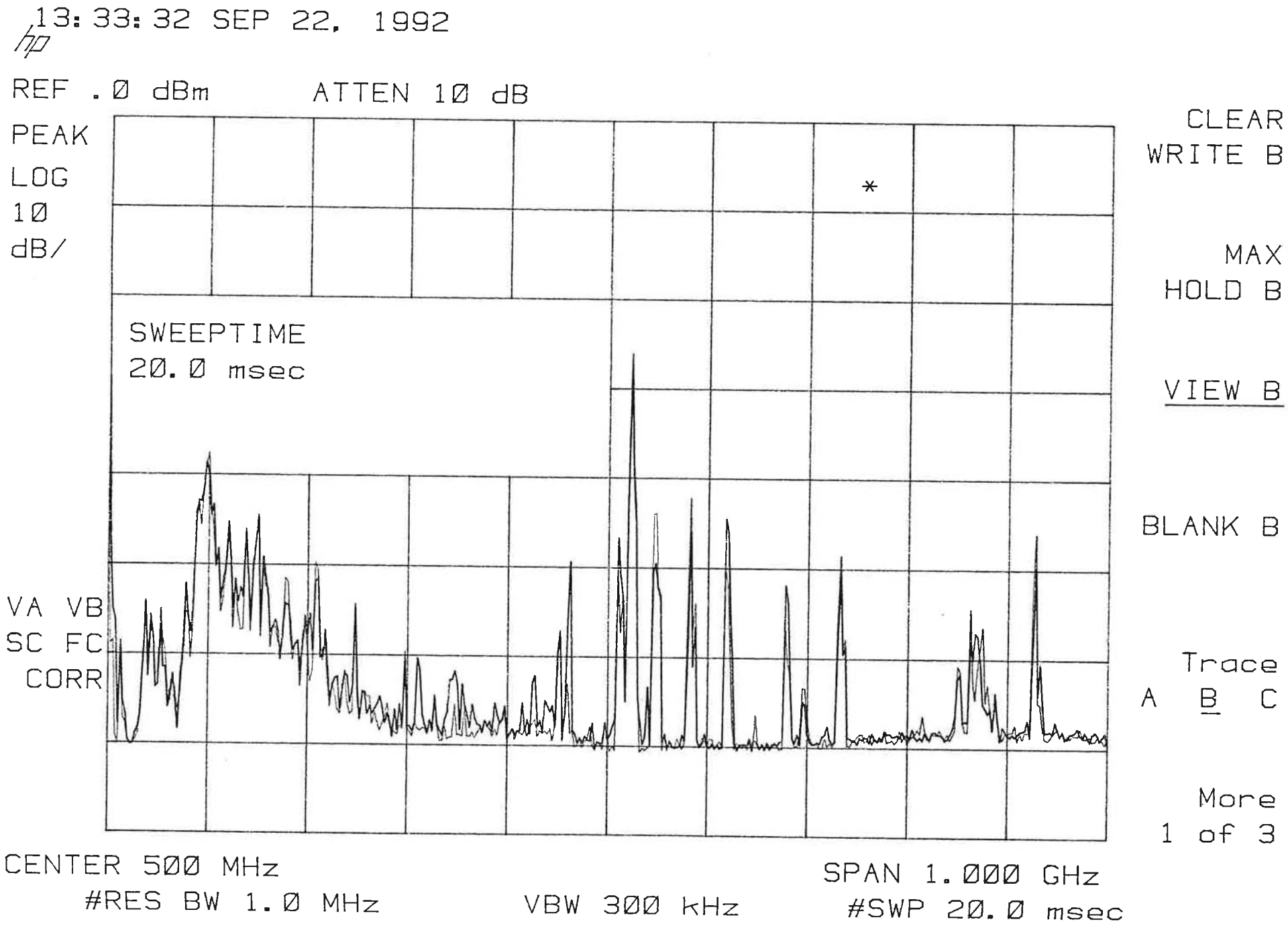

12: 48: 00 SEP 22, 1992
TEST
12 FT FROM CABINET
MOTORS ON
REF .0 dBm
ATTEN 10 dB
PEAK
LOG
10
dB/
CENTER
500 MHz
CLEAR
WRITE B
MAX
HOLD B
VIEW B
BLANK B
VA VB
SC FC
CORR
Trace
A B C
More
1 of 3
CENTER 500 MHz
RES BW 3.0 MHz
VBW 1 MHz
SPAN 1.000 GHz
SWP 20.0 msec

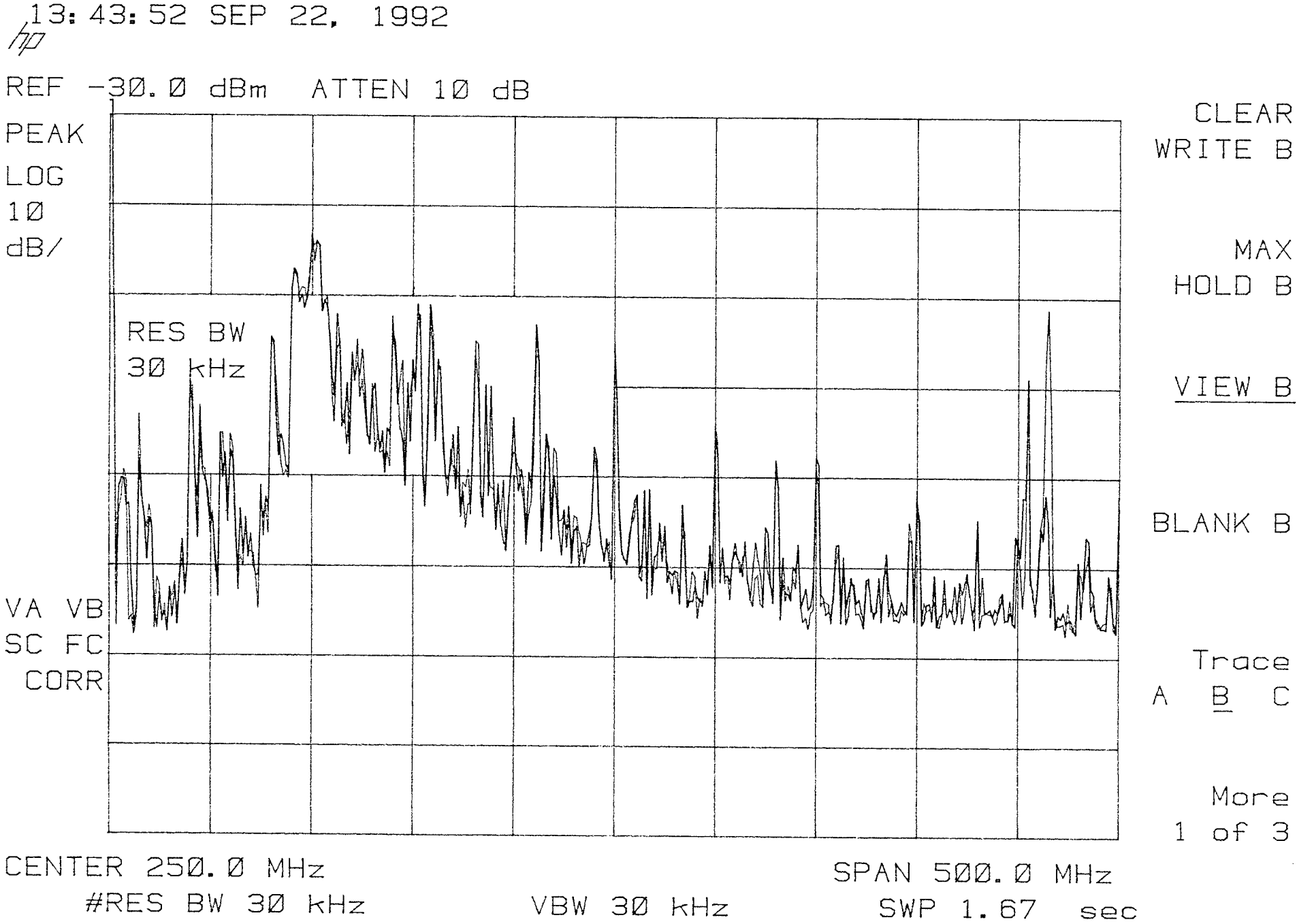

13: 02: 33 SEP 22, 1992
REF .0 dBm
ATTEN 10 dB
PEAK
LOG
10
dB/
SWEEPTIME
20.0 msec
CLEAR
WRITE B
MAX
HOLD B
VIEW B
BLANK B
VA VB
SC FC
CORR
Trace
A B C
More
1 of 3
CENTER 500 MHz
#RES BW 1.0 MHz
VBW 300 kHz
SPAN 1.000 GHz
SWP 20.0 msec

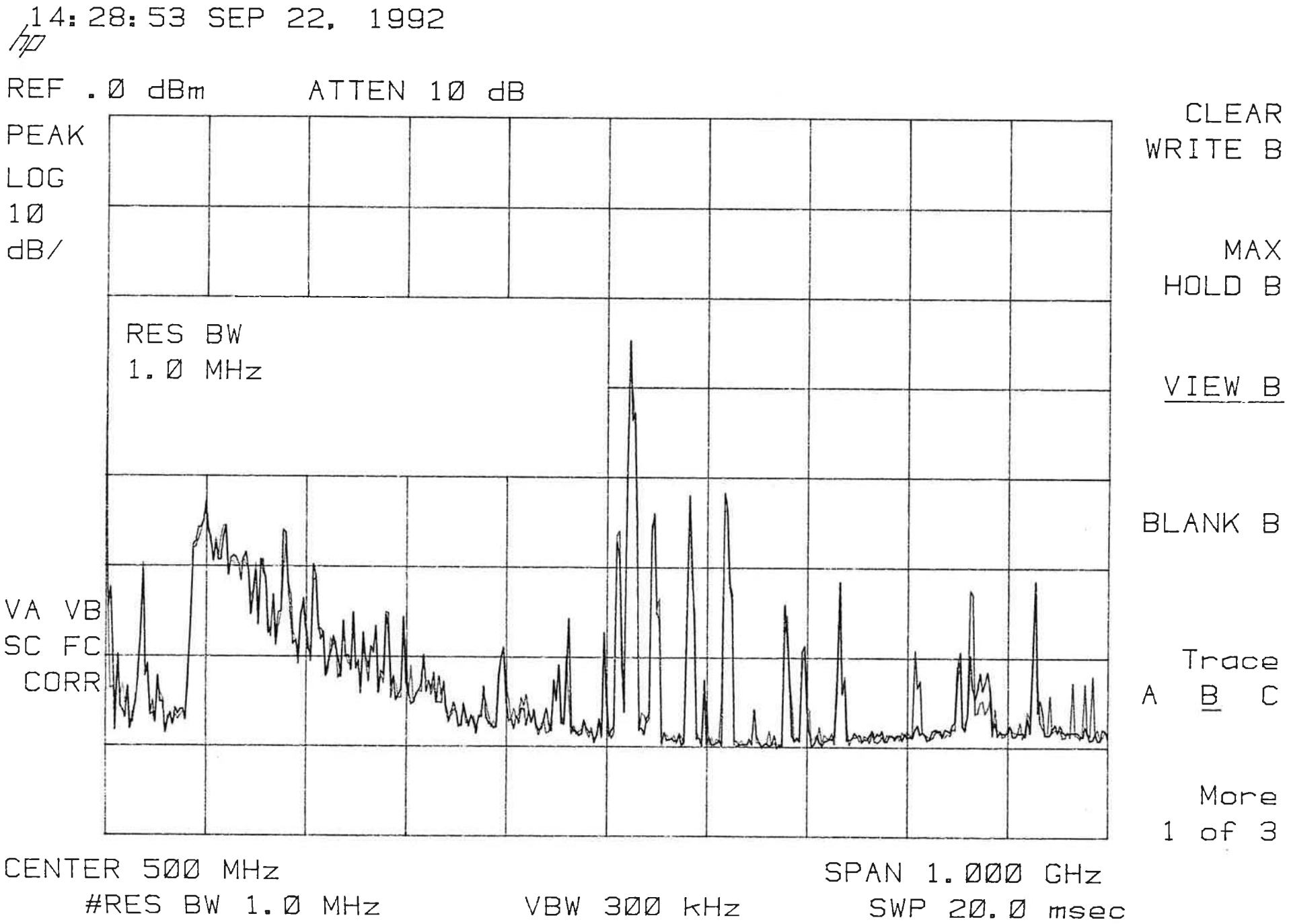

13:07:33 SEP 22, 1992
REF .0 dBm
ATTEN 10 dB
PEAK
LOG
10
dB/
-10
-20
SWEEPTIME
20.0 msec
-40
-50
-70
-80
CCIR + 40DB
VA VB
SC FC
CORR
CLEAR
WRITE B
MAX
HOLD B
VIEW B
BLANK B
Trace
A B C
More
1 of 3
CENTER 500 MHz
#RES BW 1.0 MHz
VBW 300 kHz
SPAN 1.000 GHz
SWP 20.0 msec


13:12:58 SEP 22, 1992
REF .0 dBm
ATTEN 10 dB
PEAK
LOG
10
dB/
SWEEPTIME
20.0 msec
CLEAR
WRITE B
MAX
HOLD B
VIEW B
BLANK B
VA VB
SC FC
CORR
Trace
A B C
More
1 of 3
CENTER 500 MHz
#RES BW 1.0 MHz
VBW 300 kHz
SPAN 1.000 GHz
SWP 20.0 msec


13: 16: 37 SEP 22, 1992
REF .Ø dBm
ATTEN 1Ø dB
PEAK
LOG
1Ø
dB/
SWEEPTIME
20.Ø msec
CLEAR
WRITE B
MAX
HOLD B
VIEW B
BLANK B
VA VB
SC FC
CORR
Trace
A B C
More
1 of 3
CENTER 5ØØ MHz
#RES BW 1.Ø MHz
VBW 3ØØ kHz
SPAN 1.ØØØ GHz
SWP 20.Ø msec


13:33:32 SEP 22, 1992
REF .0 dBm
ATTEN 10 dB
PEAK
LOG
10
dB/
SWEEPTIME
20.0 msec
CLEAR
WRITE B
MAX
HOLD B
VIEW B
BLANK B
VA VB
SC FC
CORR
Trace
A B C
More
1 of 3
CENTER 500 MHz
#RES BW 1.0 MHz
VBW 300 kHz
SPAN 1.000 GHz
#SWP 20.0 msec


13:43:52 SEP 22, 1992
REF -30.0 dBm ATTEN 10 dB
PEAK
LOG
10
dB/
RES BW
30 kHz
VA VB
SC FC
CORR
CLEAR
WRITE B
MAX
HOLD B
VIEW B
BLANK B
Trace
A B C
More
1 of 3
CENTER 250.0 MHz
SPAN 500.0 MHz
#RES BW 30 kHz
VBW 30 kHz
SWP 1.67 sec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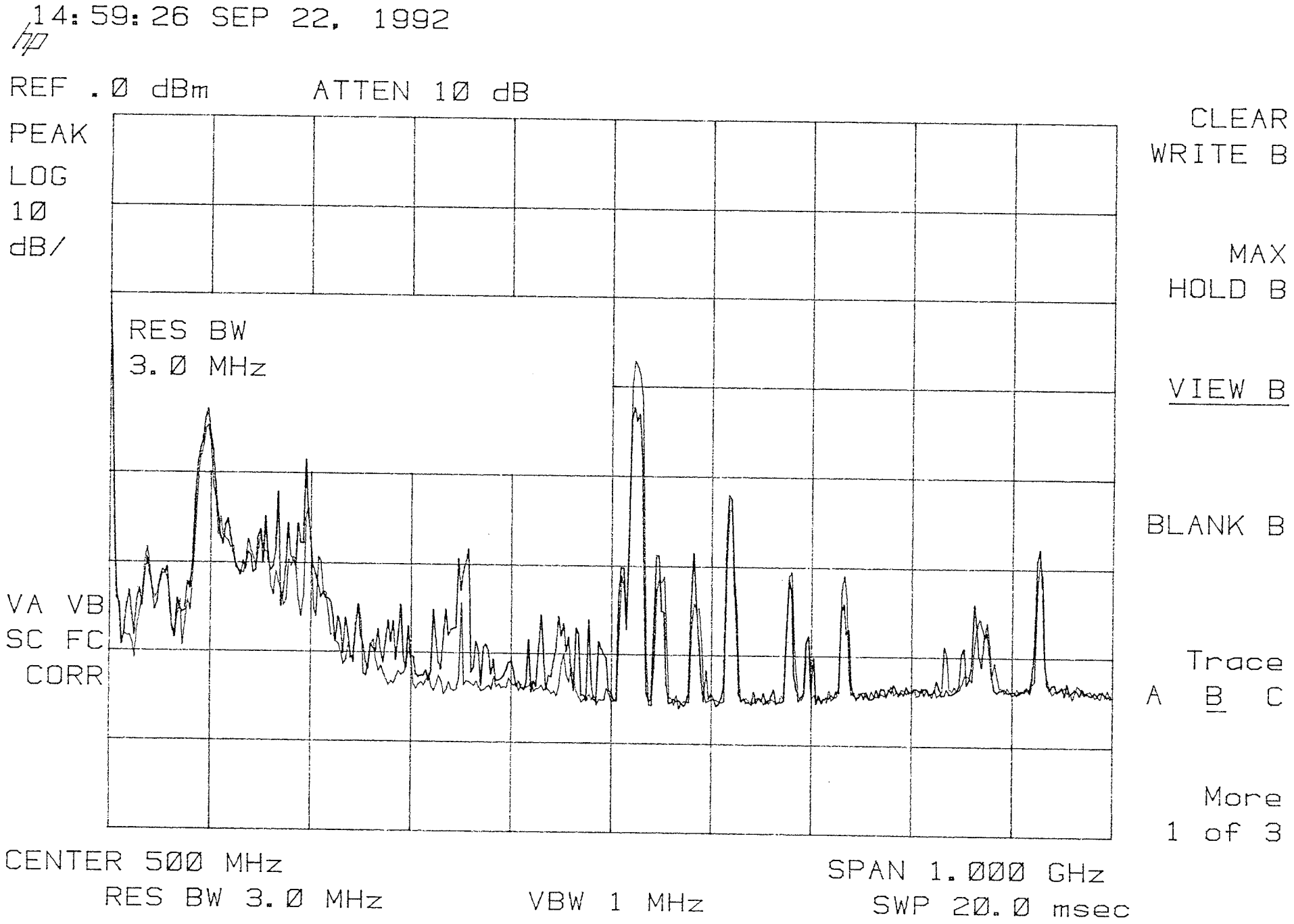
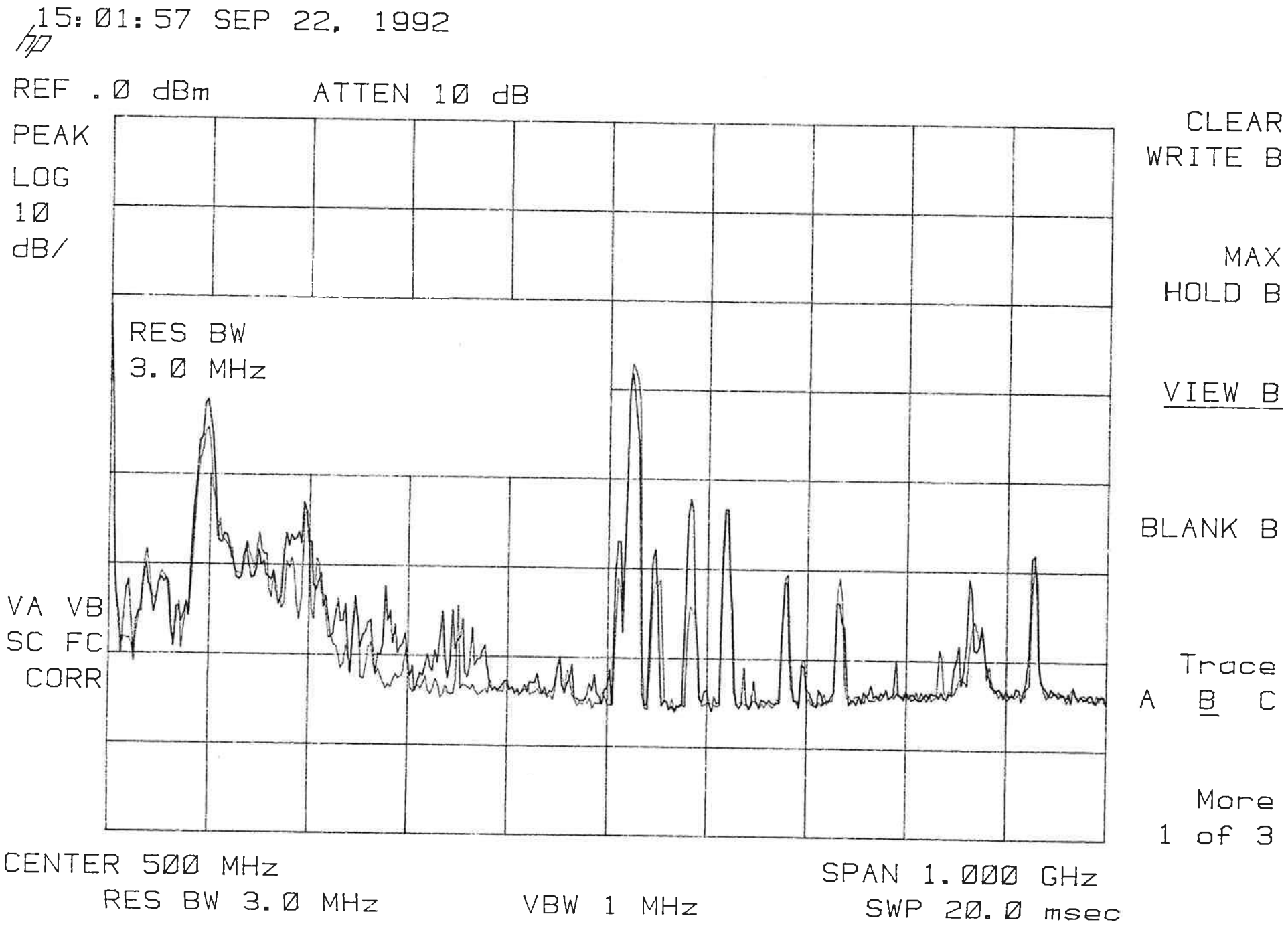
REF .0 dBm
ATTEN 10 dB
PEAK
LOG
10
dB/
RES BW
1.0 MHz
VA VB
SC FC
CORR
CLEAR
WRITE B
MAX
HOLD B
VIEW B
BLANK B
Trace
A B C
More
1 of 3
CENTER 500 MHz
#RES BW 1.0 MHz
VBW 300 kHz
SPAN 1.000 GHz
SWP 20.0 msec


14:59:26 SEP 22, 1992
REF .0 dBm
ATTEN 10 dB
PEAK
LOG
10
dB/
RES BW
3.0 MHz
VA VB
SC FC
CORR
CLEAR
WRITE B
MAX
HOLD B
VIEW B
BLANK B
Trace
A B C
More
1 of 3
CENTER 500 MHz
RES BW 3.0 MHz
VBW 1 MHz
SPAN 1.000 GHz
SWP 20.0 msec


15:01:57 SEP 22, 1992
REF .0 dBm
ATTEN 10 dB
PEAK
LOG
10
dB/
RES BW
3.0 MHz
CLEAR
WRITE B
MAX
HOLD B
VIEW B
BLANK B
VA VB
SC FC
CORR
Trace
A B C
More
1 of 3
CENTER 500 MHz
RES BW 3.0 MHz
VBW 1 MHz
SPAN 1.000 GHz
SWP 20.0 msec