

**NATIONAL RADIO ASTRONOMY OBSERVATORY
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**BEAM SHAPE AND SYSTEM TEMPERATURE OF
85-3 TELESCOPE AT 610 MHZ**

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Beam Shape and System Temperature of 85-3 telescope at 610 MHz

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This report discusses beam shape and system temperature measurements of the 85-3 telescope at 610 MHz. A spectrum analyzer (Anritsu MS2602A) is used as a total power meter for all the measurements. It is configured in the zero span mode. The center frequency is selected as 609.25 MHz and the resolution bandwidth as 3 MHz. This frequency range was relatively free of interference. The calibration noise is switched at ~ 1 sec rate using an *HP (Hewlett – Packard)* 3310A Function generator. The video bandwidth of the spectrum analyzer is set to 10 Hz. An Epson printer is used to print the spectrum analyzer display.

1 Beam Shape

Radio source Virgo (RA(1950): 12:28:17.6, DEC(1950): 12:40:02; $S_{610MHz} = 390$ Jy) was used for the beam shape measurement. The scans taken in hour angle (slew rate = $30^\circ/\text{min}$) and declination (slew rate = $20^\circ/\text{min}$) for the two orthogonal polarizations (channel A and B) are shown in Figs. 1a, b, c & d.

2 System Temperature

For system temperature measurement, the telescope was pointed to a few positions in the sky and the calibration noise was switched at ~ 1 Hz. The system temperature is calculated using $T_{sys} = v_1/(v_2 - v_1) \times T_{cal}$ where v_1 and v_2 are the voltages measured by the spectrum analyzer when the calibration noise is turned off and on respectively. These voltages are proportional to the total powers. T_{cal} is the measured calibration noise temperature. Table. 1 gives the measured values and the system temperature in terms of the calibration noise temperature. Similar measurements were made towards Virgo which are also included in Table. 1. Figs. 2a to k show the spectrum analyzer outputs corresponding to all these measurements.

The calibration noise temperatures for the 85-3 receiver system were measured earlier by Coe (1989). At 610 MHz these temperatures were 4.6 K and 5.3 K for channel A and B respectively. The mean off-source system temperature obtained using the noise temperature values are 188.6 K for channel A and 295.2 K for channel B. The antenna temperature due to Virgo can be calculated by taking the difference between the off-source system temperature and the system temperature measured towards Virgo. The antenna temperature thus obtained are 112.2 K for channel A and 126.7 K for channel B. These values for antenna temperature cannot be obtained even if the aperture efficiency of the telescope is 100 %. Therefore we conclude that the present values of the calibration noise temperature are not the quoted values in Coe (1989).

The system temperature can indirectly be calculated using the measurements towards

Table 1: Results of the measurements made on 85-3 telescope

RA	DEC	HA	v_1^*		v_2^*		$\frac{v_1}{v_2 - v_1}$		Fig. ref
hh:mm:ss	° : ' : "	(hrs)	Ch A	Ch B	Ch A	Ch B	Ch A	Ch B	
12:08:17.6	12:40:02	~ -3.5	0.849	0.835	0.869	0.85	42.5	55.7	2a,b
12:28:17.6	17:40:02	~ -3.5	0.951		0.975		39.6		2c
12:28:17.6	17:40:02	~ -3.5	0.914		0.936		41.5		2d
~ 10:00:00	~ 50:00:00	~ -1	0.93		0.953		40.4		2e
12:28:17.6	12:40:02	~ -3.5	0.969	0.955	0.984	0.967	64.6	79.6	2f,g (Virgo)
12:28:17.6	12:40:02	~ -3	0.95		0.965		63.3		2h (Virgo)
12:28:17.6	12:40:02	~ -3	0.956		0.97		68.3		2j (Virgo)
~ 13:00:00	~ -40:00:00	-4.6	0.962		0.968		160.3		2k [§]

* All voltages are relative values.

§ Note that the antenna is pointed to ground at this position

Table 2: Estimated System temperature for 85-3 telescope

Off-source		$\frac{T_{syson}}{T_{sysoff}}$				T_{sysoff}	
RA(1950)	DEC(1950)			$\eta = 0.4$		$\eta = 0.5$	
hh:mm:ss	° : ' : "	Ch A	Ch B	Ch A (K)	Ch B (K)	Ch A (K)	Ch B (K)
12:08:17.6	12:40:02	1.54	1.43	55.2	69.3	69.1	86.7
12:28:17.6	17:40:02	1.65		45.9		57.4	
12:28:17.6	17:40:02	1.58		51.4		64.3	
~ 10:00:00	~ 50:00:00	1.62		48.1		60.2	

Virgo. The ratio of the system temperature towards Virgo to that at an off-source position is independent of the calibration noise temperature. Using this ratio the system temperature can be estimated if we assume an aperture efficiency (η). Table 2 gives the estimated system temperature for different aperture efficiencies. For these calculations, an average of all the measurements towards Virgo is used.

3 Reference

Coe, J. R. 1989, NRAO memorandum.

Virgo Channel A

RFI TEST SETUP 0-1 GHz

MKR: 12.84s

56.939 μ V

AT 5dB

RB 3MHz#

SEL SUP

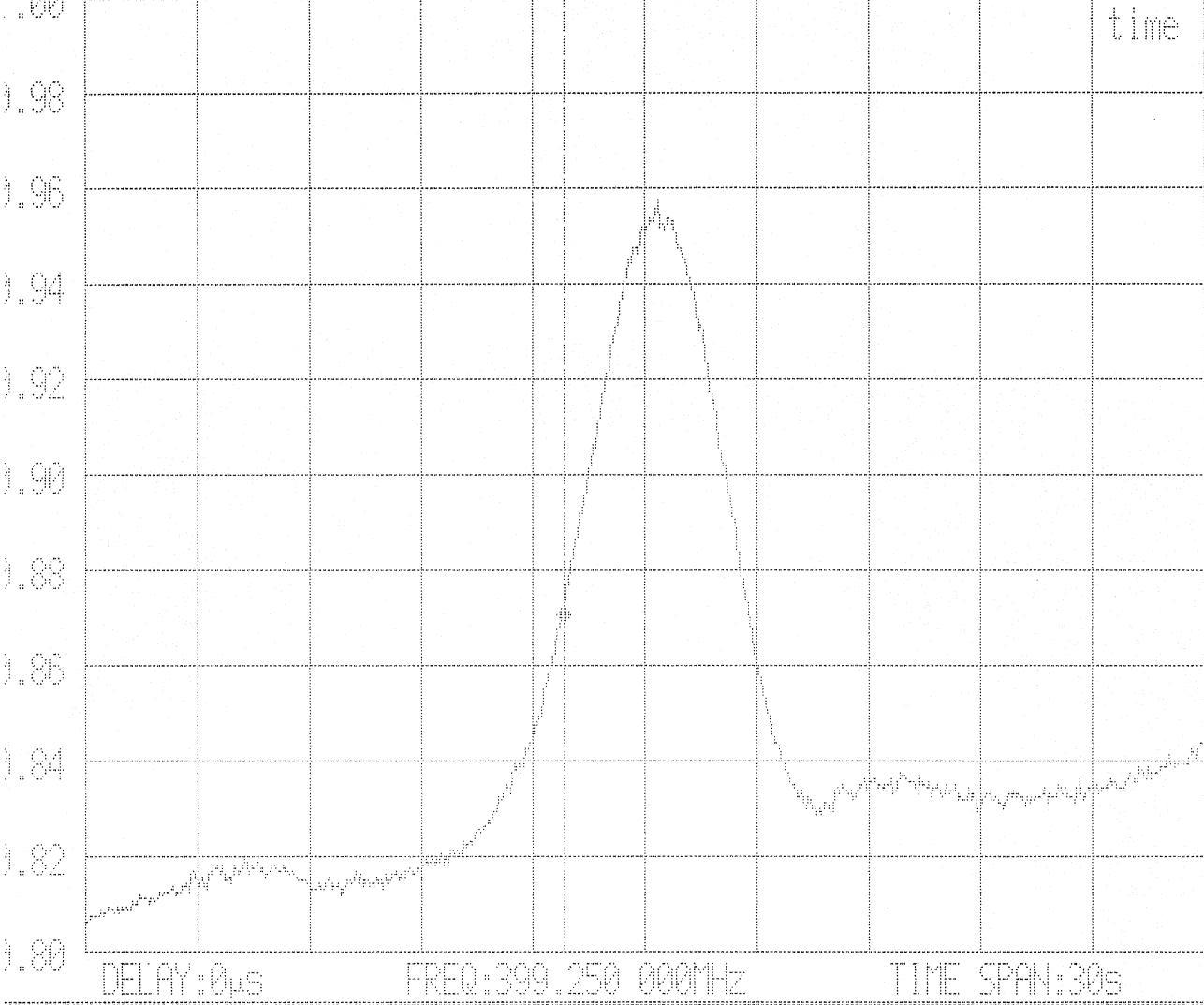
AMPTD(1/2)

PLV: 65.2 μ V

TS 30s

VB 10Hz#

T: SMP



REF LEVEL

REF LEVEL
STEP SIZE

LOG SCALE

LIN SCALE

LOG SCALE
UNIT

etc.

~~200~~
~~200~~
~~200~~
 $\sim \delta + 5^\circ$
↑
Virgo DEC

Fig 1 a
Slew rate - $20^\circ/\text{min}$
Channel A

↓
 $\sim \delta - 5^\circ$

Virgo channel B

FI TEST SETUP 0-1 GHz

MKR: 12.84s

23.765 μ V

AT 0dB

RB 3MHz#

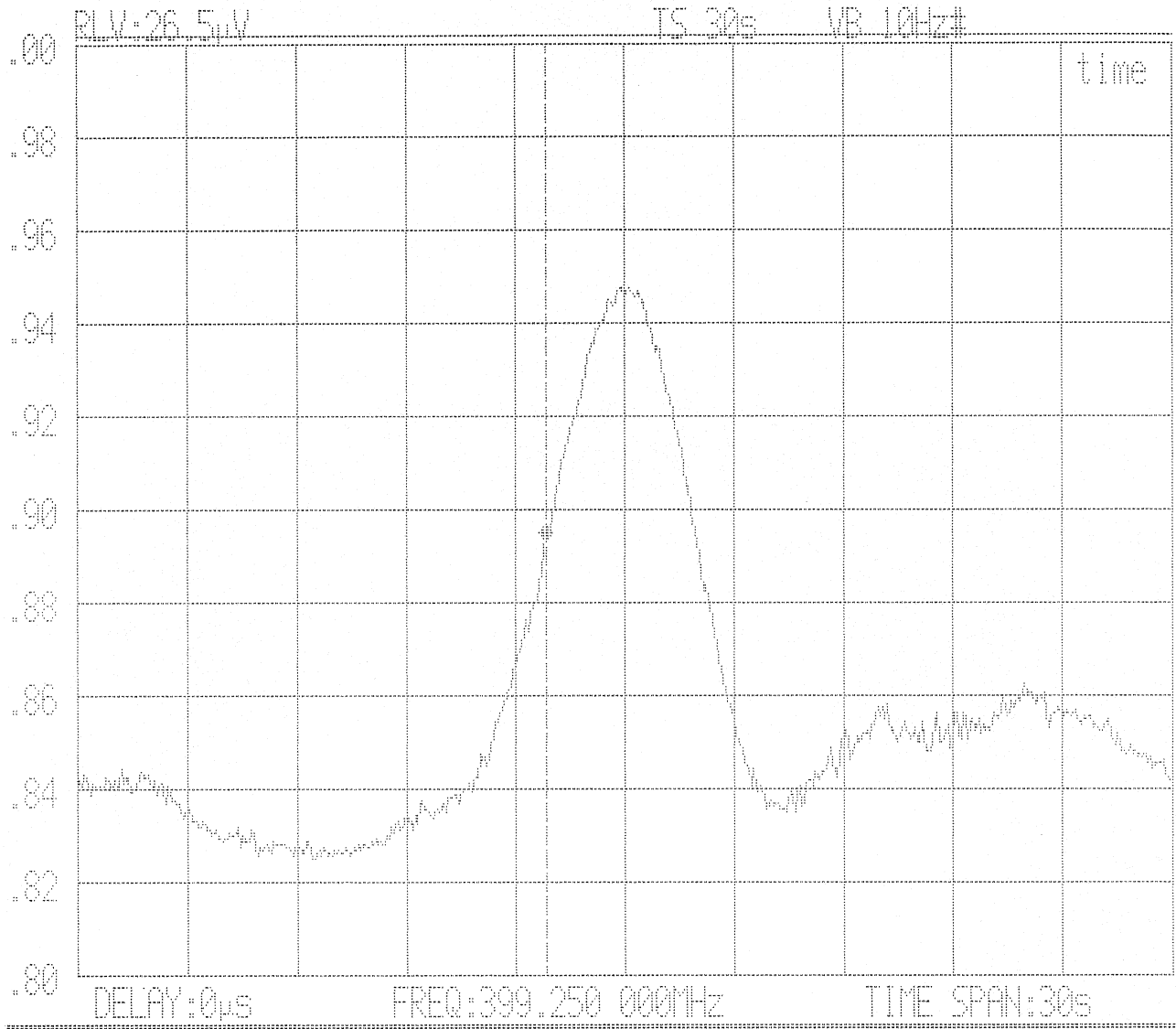
SGL SWP

AMPTD(1/2)

TS 30s

VB 1GHz#

T: SMP



REF LEVEL
* REF LEVEL STEP SIZE
* LOG SCALE
* LIN SCALE
* LOG SCALE UNIT
etc.

DELAY: 0 μ s FREQ: 399.250 000MHz TIME SPAN: 30s

REFERENCE LEVEL = 23.765 μ V

$\pm 5^\circ$
 in
 dec
 ↓
 $\sim 5 + 5^\circ$
 ↑
 Virgo DSC

$20^\circ/\text{min}$

Fig 1 b

Slew rate - $20^\circ/\text{min}$

Channel B

↓
 $\sim 5 - 5^\circ$

Virgo

Channel A

F1 TEST SETUP 0-1 GHz

MKR: 12.84s

60.460 μ V

AT 5dB

RB 3MHz#

SGL SWP

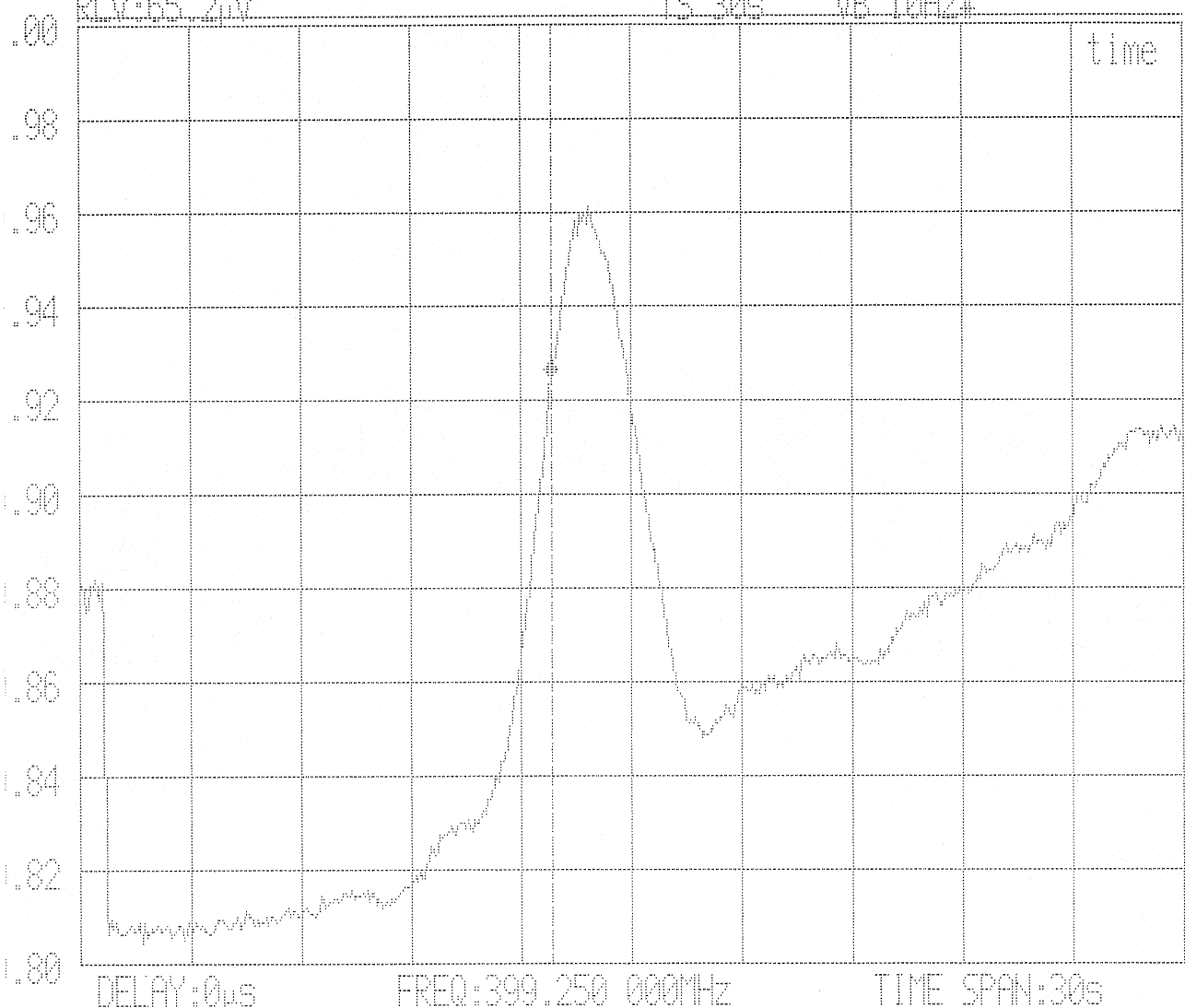
AMPTD(1/2)

RLV: 65.2 μ V

TS 30s

VB 10Hz#

T: SMP



- REF LEVEL
- * REF LEVEL STEP SIZE
- * LOG SCALE
- * LIN SCALE
- * LOG SCALE UNIT
- etc.

DELAY: 0 μ s FREQ: 399.250 000MHz TIME SPAN: 30s

REFERENCE LEVEL = 65.2 μ V

20 mV
 AF W to E
 ↓
 ~ RA + 20m
 ↑
 (Virgo RA)

Fig 1c
 Slew rate 30°/min
 Channel A

↓
 ~ RA + 20m

Virgo

channel B

FI TEST SETUP 0-1 GHz

MKR:12.84s

24.619μV

AT 0dB

RB 3MHz#

SGL SWP

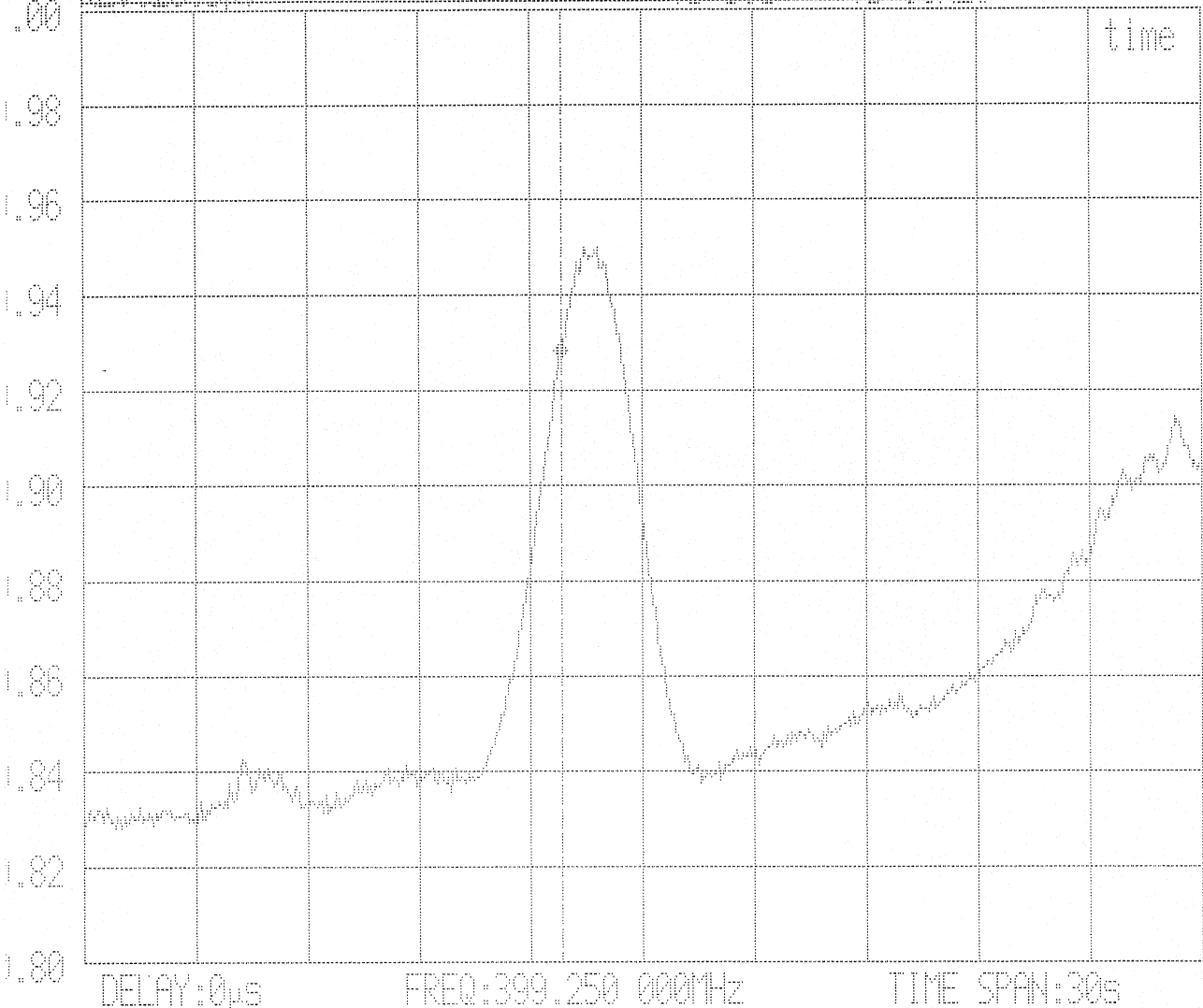
AMPTD(1/2)

RLV:26.5μV

TS 30s

VB 10Hz#

T:5MP



- REF LEVEL
- * REF LEVEL STEP SIZE
- * LOG SCALE
- * LIN SCALE
- * LOG SCALE UNIT
- etc.

20 m/s
 RA
 $\sim RA - 20 \text{ m}$
 \uparrow
 (Virgo RA)

$20^\circ/\text{min}$

Fig 1d

Slew rate - $30^\circ/\text{min}$

Channel B

\downarrow
 $\sim RA + 20 \text{ m}$

FI TEST SETUP 0-1 GHz

MKR: 8.56s

54.671 μ V

AT 5dB

RB 3MHz#

SGL SUP

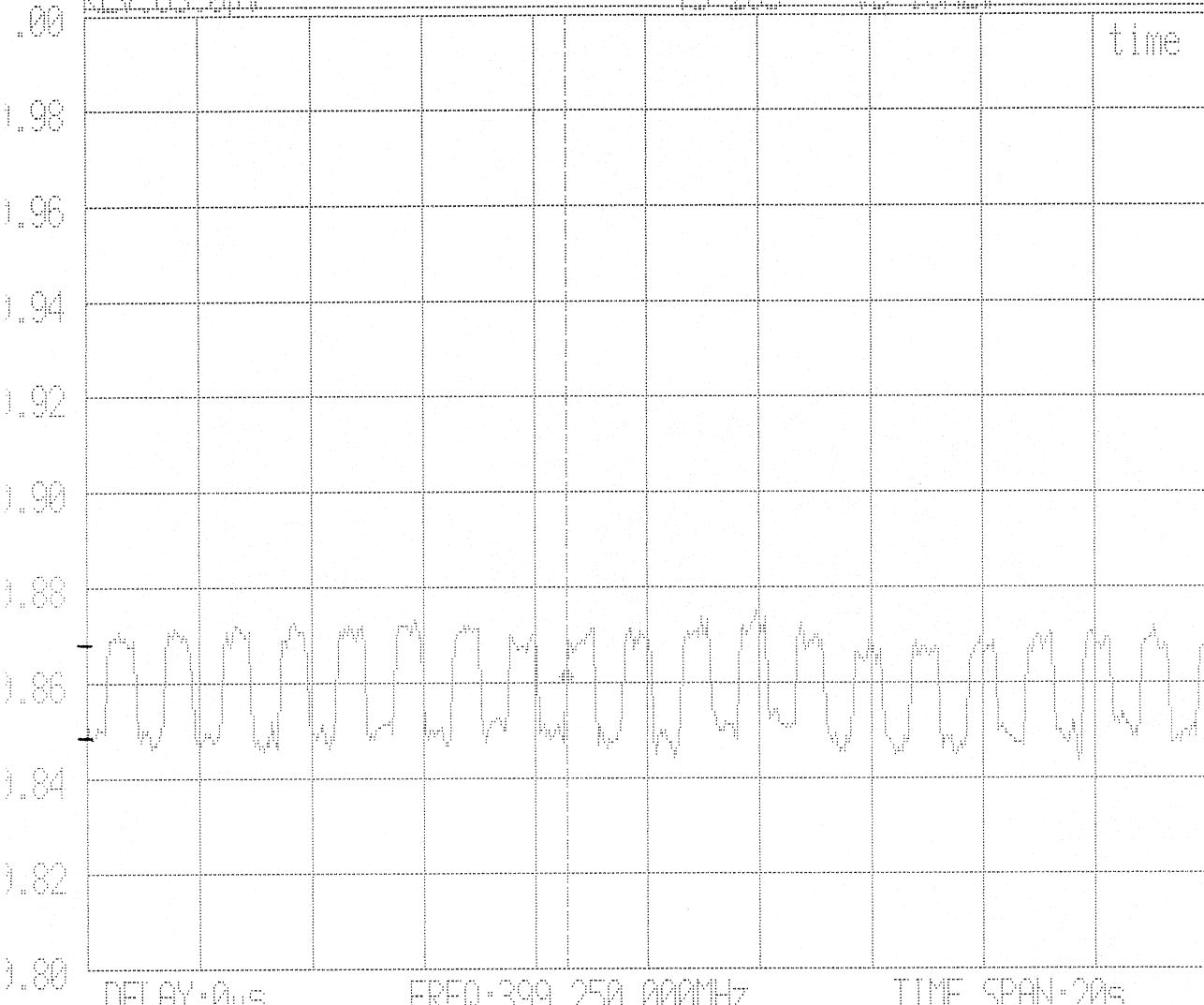
AMPTD(1/2)

T:SMP

PLV: 63.0 μ V

TS: 20s

VB: 10Hz#



REF LEVEL

REF LEVEL *
STEP SIZE

LOG SCALE *

LIN SCALE *

LOG SCALE *
UNIT

etc.

DELAY: 0 μ s

FREQ: 399.250 000MHz

TIME SPAN: 20s

REFERENCE LEVEL: -86.0dBm

Source Channel A
Virgo RA-20m

0.8489/0.8689

Fig 2a

FI TEST SETUP 0-1 GHz

MKR: 8.56s

22.117µV

AT 0dB

RB 3MHz#

SGL SWP

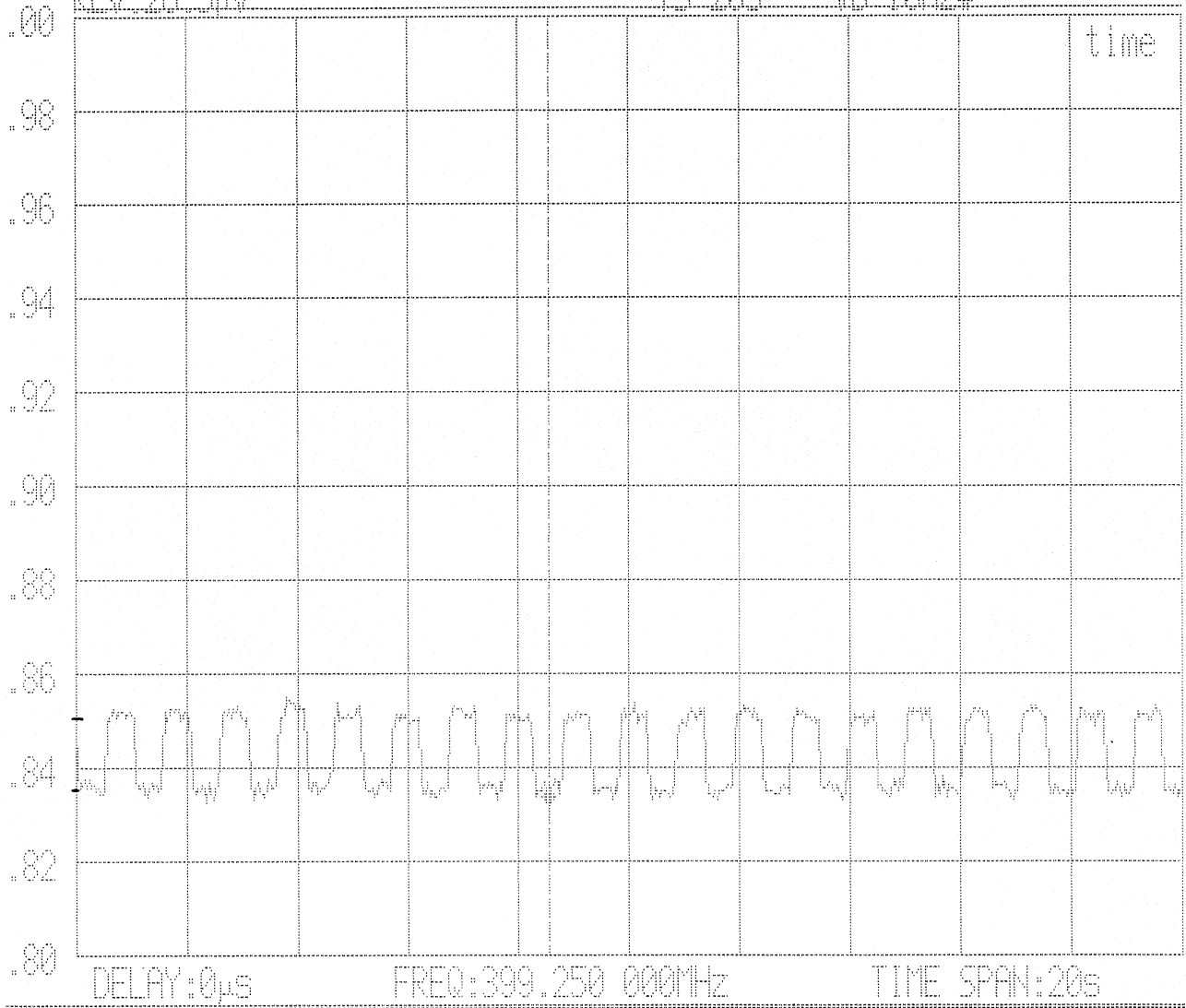
TIME

T: SMP

RLV: 26.5µV

TS 20s

VB 10Hz#



DELAY TIME
TIME SPAN
EXPAND MODE *
STORAGE/DET MODE *
FM/TRIG MONITOR *
DISPLAY LINE *

off source Channel B

Virgo RA - 20m*

off level = 0.835 / 0.85

GN level = 0.955 / 0.967 (source)

Fig 2b

03/14/2000
20:30 →

FI TEST SETUP 0-1 GHz

MKR: 4.28s

15.229mV

AT 5dB

RB 3MHz#

SGL SWP

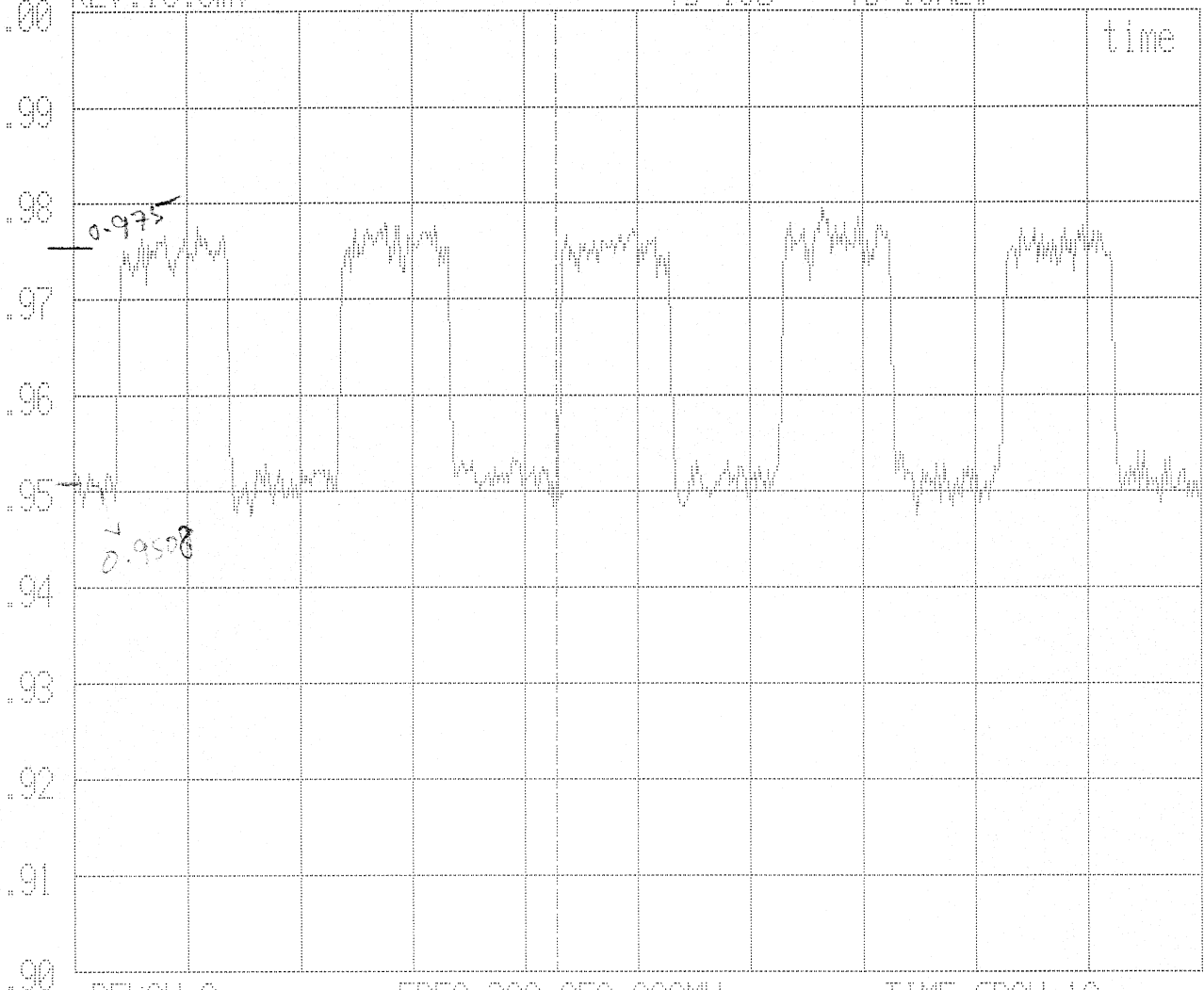
AMPTD(1/2)

T: SMP

RLV: 16.0mV

TS 10s

VB 10Hz#



REF LEVEL

REF LEVEL
STEP SIZE

LOG SCALE

LIN SCALE

LOG SCALE
UNIT

etc.

DELAY: 0μs

FREQ: 399.250 000MHz

TIME SPAN: 10s

REFERENCE LEVEL = 15.229mV

$V_{sig} = 6 + 5^0$ (adjustment)

Channel A

$T_{sys} = 39.8 \times T_{ant}$

Fig 2c

03/14/2000

FI TEST SETUP 0-1 GHz

MKR:4.28s

15.664mV

AT 5dB

RB 3MHz#

SGL SUP

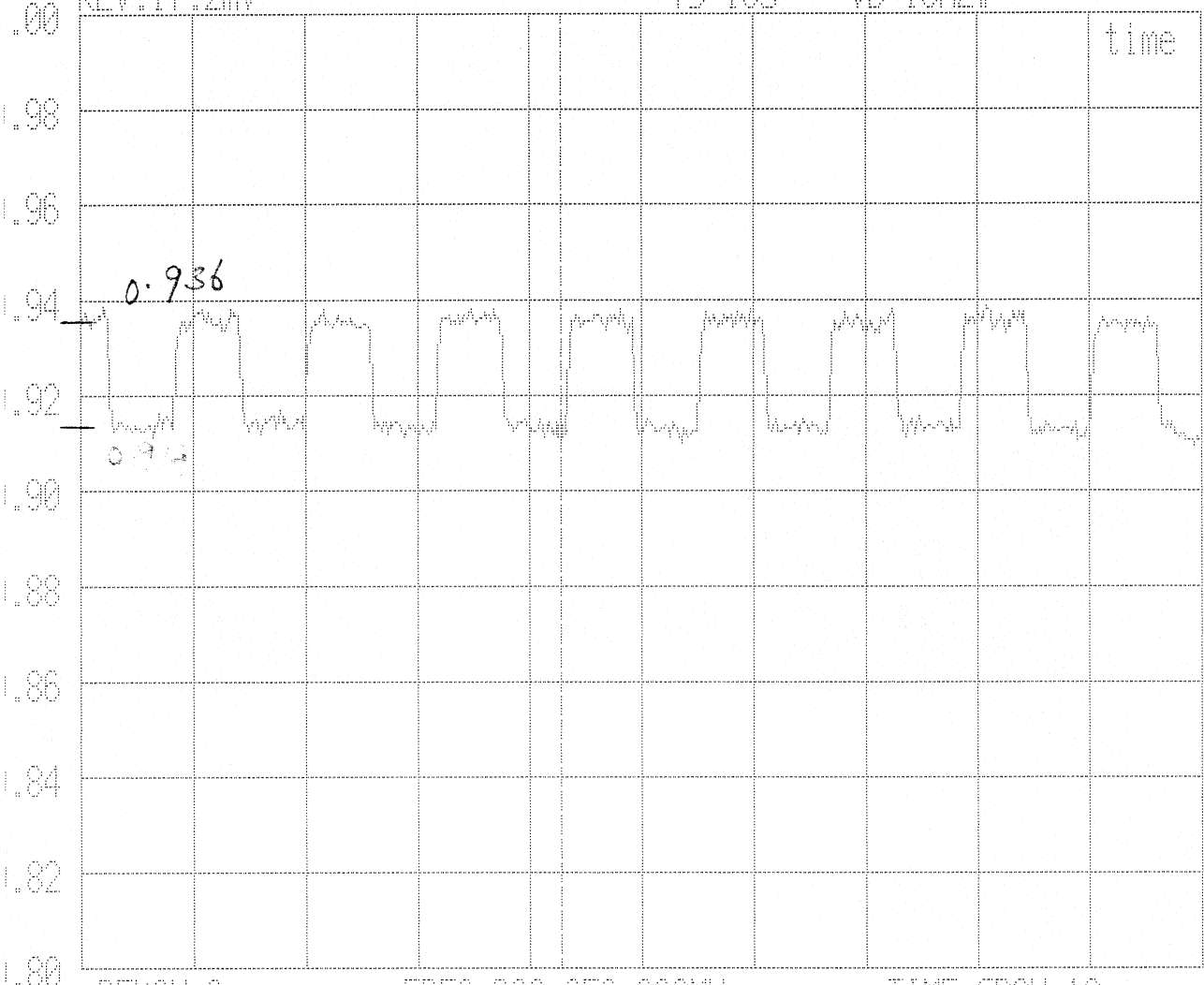
AMPTD(1/2)

RLV:17.2mV

TS 10s

VB 10Hz#

T:SMP



- REF LEVEL
- * REF LEVEL
- STEP SIZE
- * LOG SCALE
- * LIN SCALE
- * LOG SCALE
- UNIT
- etc.

DELAY:0.5s

FREQ:399.250 000MHz

TIME SPAN:10s

REFERENCE LEVEL: 7.2mV

Channel A

Visgo $0/(\delta + 5^\circ)$

Channel A
Referred to
Cross check

$$T_{sys} = A1.6 + T_{cal}$$

Fig 2d

03/14/2000

FI TEST SETUP 0-1 GHz

MKR: 4.28s

15.129mV

AT 5dB

RB 3MHz#

SGL SWP

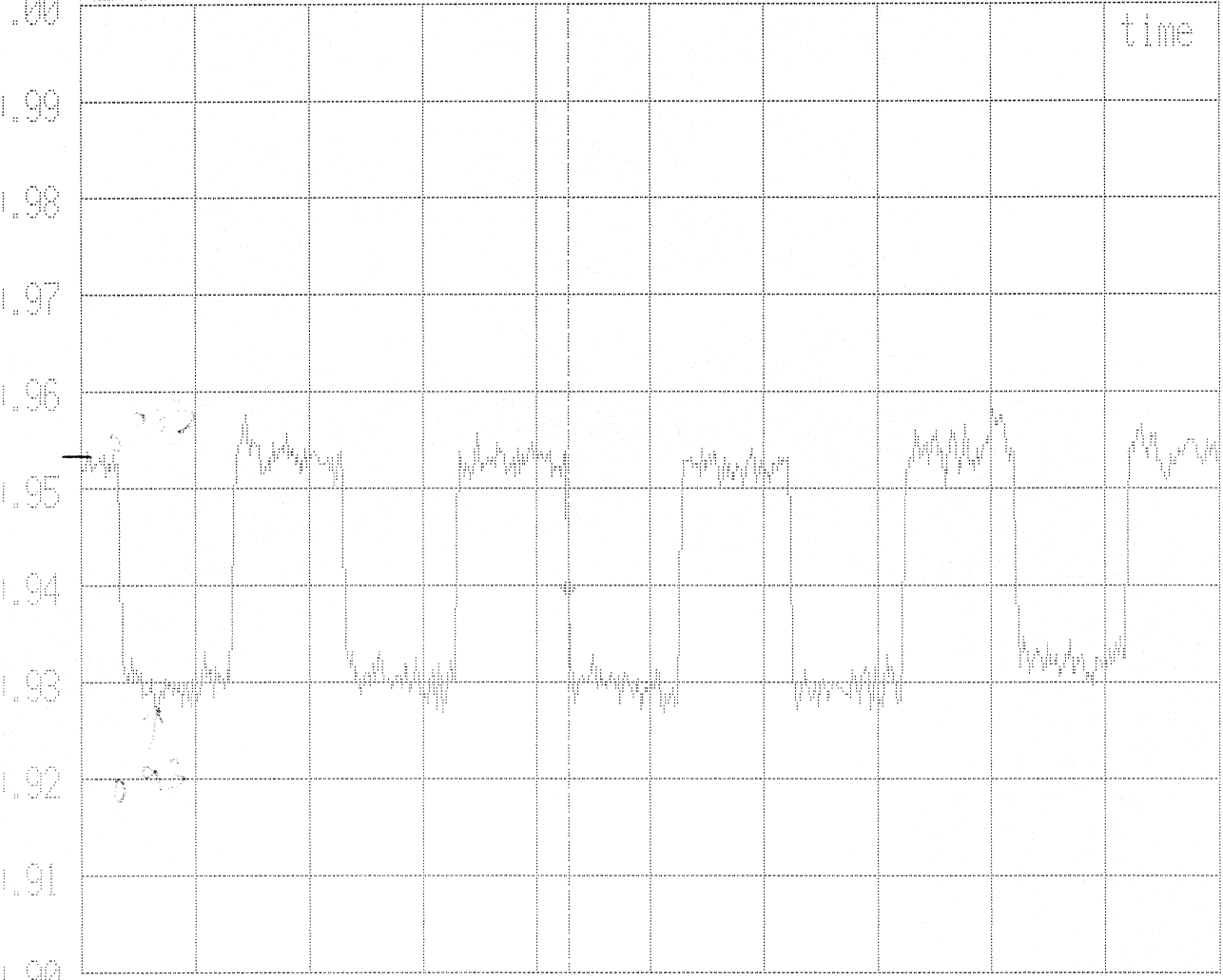
AMPTD(1/2)

RLV: 16.0mV

TS 10s

VB 10Hz#

T: SMP



- REF LEVEL
- * REF LEVEL STEP SIZE
- * LOG SCALE
- * LIN SCALE
- * LOG SCALE UNIT
- etc.

DELAY: 0.0s

FREQ: 399.250000MHz

TIME SPAN: 10s

REFERENCE LEVEL: 13.8mV

RR \approx 10:00:00
 $\delta \sim +50^\circ$

"High elevation"
 2/10/00

Channel A
 To check the
 elevation dip
 $\frac{2}{3}$ on Tsys

Fig 2c

RFI TEST SETUP 0-1 GHz

SGL SUP AMPTD(1/2)

MKR: 8.56s

61.154μV

AT 5dB

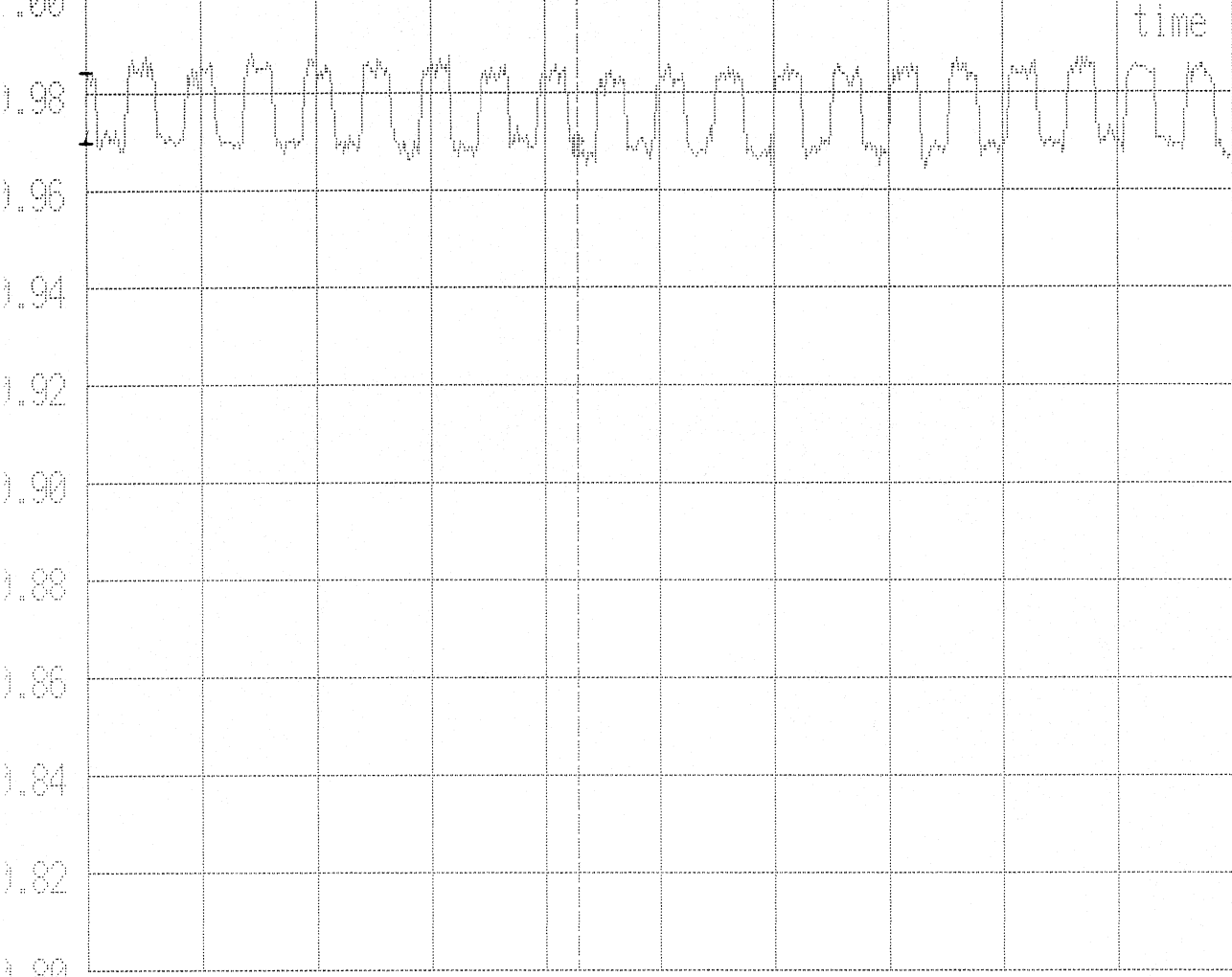
RB 3MHz#

T: SMP

RLV: 63.0μV

TS: 20s

VB: 10Hz#



REF LEVEL

*
REF LEVEL
STEP SIZE

*
LOG SCALE

*
LIN SCALE

*
LOG SCALE
UNIT

etc.

DELAY: 0μs FREQ: 399.250 000MHz TIME SPAN: 20s

REFERENCE LEVEL: 58.0μV

OR source Channel A

0.969/0.984

Virgo

Fig 2f

FI TEST SETUP 0-1 GHz

SGL SUP

TIME

MKR:8.56s

25.355μV

AT 0dB

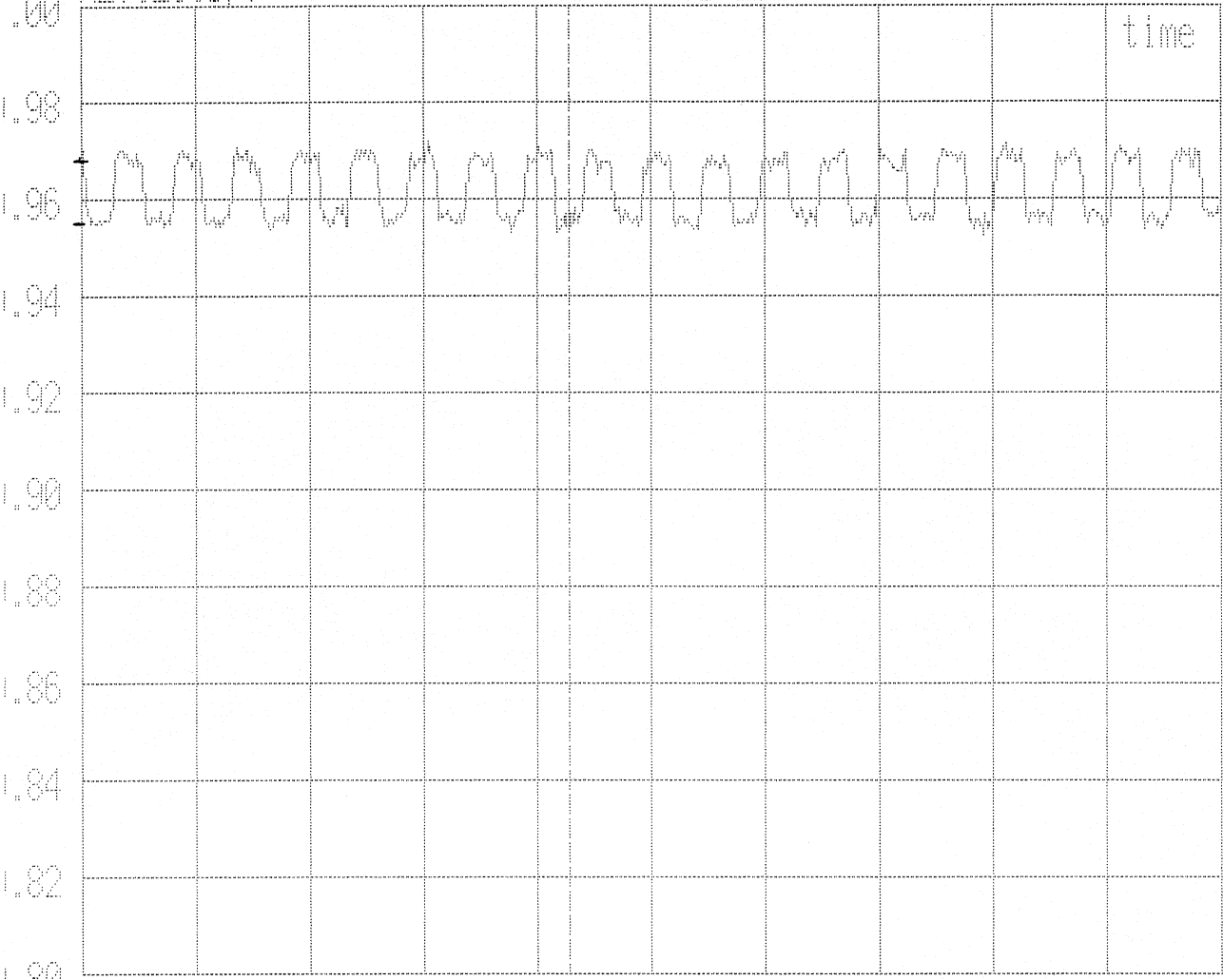
RB 3MHz#

T:SMP

RLV:26.5μV

TS:20s

VR:10Hz#



DELAY TIME

TIME SPAN

EXPAND MODE *

STORAGE/DET MODE *

FM/TRIG MONITOR *

DISPLAY LINE *

DELAY:0μs

FREQ:399.250000MHz

TIME SPAN:20s

ON Source Channel B

(Same scale as off source of channel B)

Virgo

Fig 2g.

03/14/2000

20:30 →

FI TEST SETUP 0-1 GHz

MKR: 4.28s

18.077mV

AT 5dB

RB 3MHz#

SGL SUP

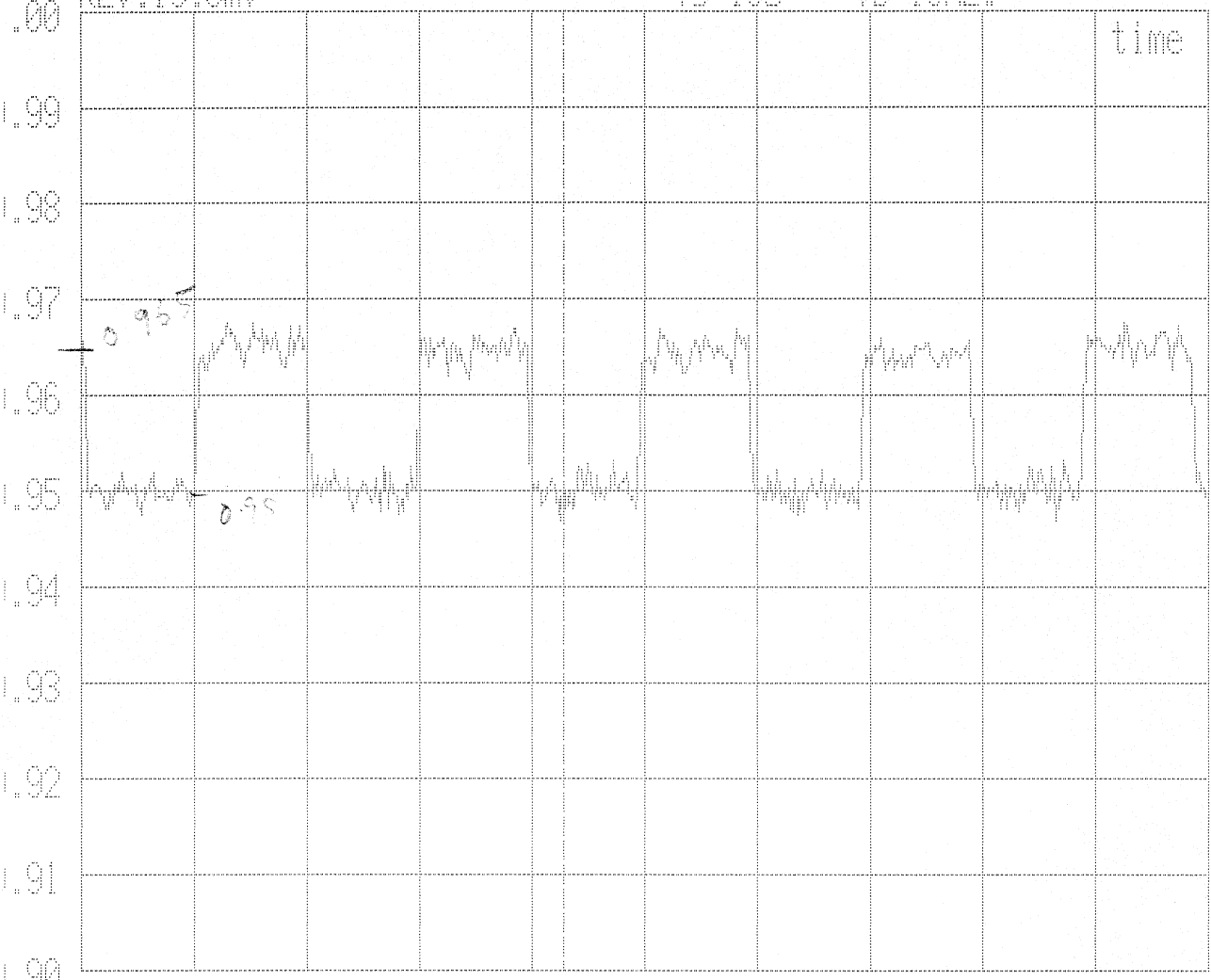
AMPTD(1/2)

T: SMP

RLV: 19.0mV

TS 10s

VB 10Hz#



REF LEVEL

*
REF LEVEL
STEP SIZE

*
LOG SCALE

*
LIN SCALE

*
LOG SCALE
UNIT

etc.

DELAY: 0.0s

FREQ: 399.250 000MHz

TIME SPAN: 10s

REFERENCE LEVEL = 19.0mV

Virgo ON Source

Channel A
Reported on Virgo
to cross check

$T_{sys} = 63.3 \text{ Teal}$

Fig 2h

03/14/2000

20:30 →

FI TEST SETUP 0-1 GHz

MKR: 4.28s

18.474mV

AT 5dB

RB 3MHz#

SGL SWP

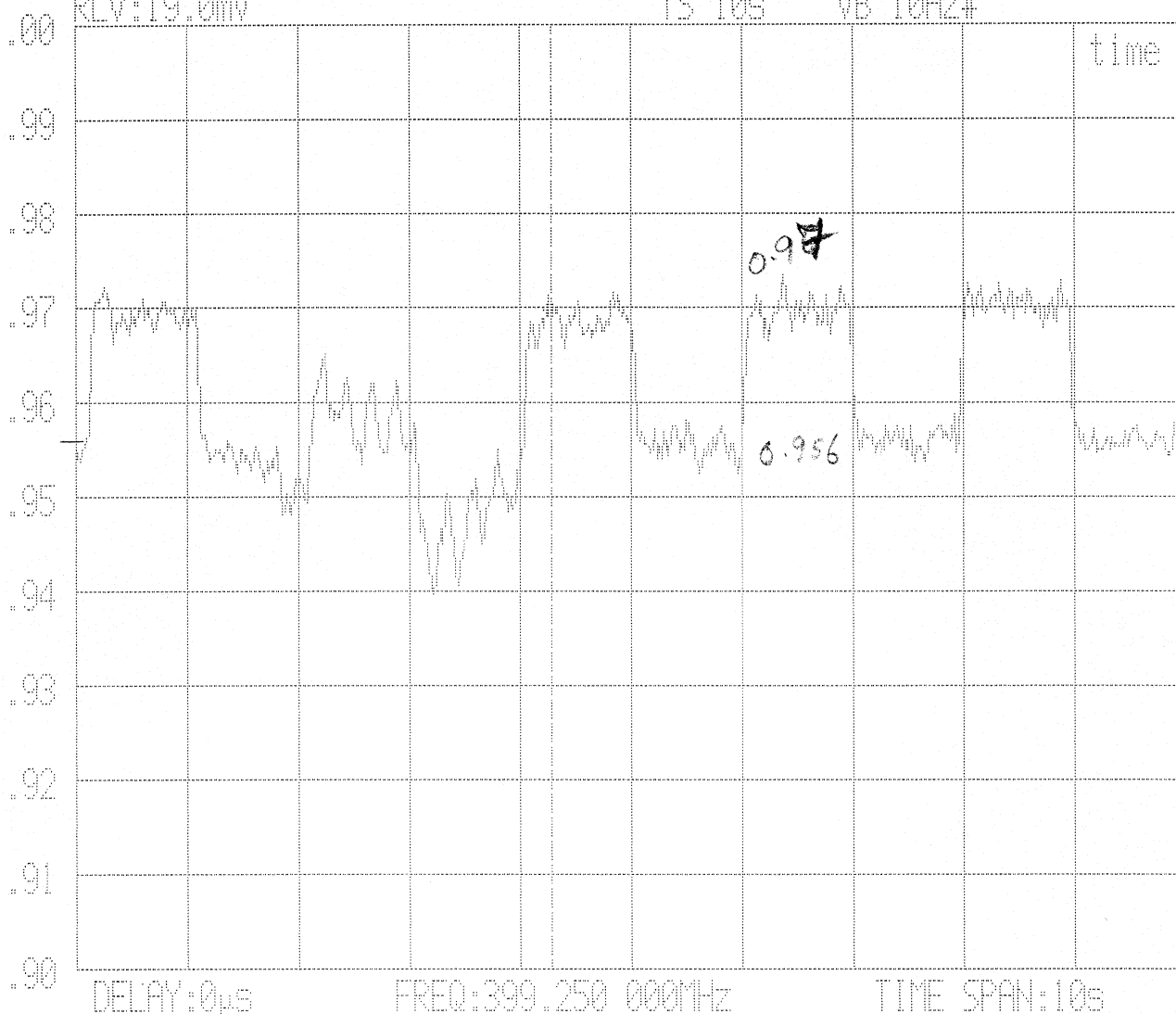
AMPTD(1/2)

T: SMP

RLV: 19.0mV

TS 10s

VB 10Hz#



REF LEVEL

*
REF LEVEL
STEP SIZE

*
LOG SCALE

*
LIN SCALE

RETURN

Virgo on source

Channel A

$$T_{sys} = 68.3 \times T_{eat}$$

Fig 2j

Fig 2j

03/14/2020

FI TEST SETUP 0-1 GHz

MKR:4.28s

24.294mV

AT 5dB

RB 3MHz#

SGL SWP

LIN SCALE

RLV:25.1mV

TS 10s

VB 10Hz#

T:SMP



10%/div

5%/div

2%/div

1%/div

RETURN

DELAY:0μs

FREQ:399.250 000MHz

TIME SPAN:10s

$\Delta_{\text{freq}} = 10 \text{ Hz}$
 $\Delta_{\text{amp}} = 25.1 \text{ mV}$

Channel A
 To measure the
 GND temperature

Fig 2k