Fermilab

TM-1390
2563.800

A NEW PREAMPLIFIER FOR DRIFT CHAMBERS

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March 1986

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Abstract

A new preamplifier has been developed by T. Kondo and a monolithic version built by Fujitsu of Japan. The monolithic device, MB43468, is in a 14 pin small outline IC package and contains four amplifiers. The package is similar to the MB43458, which was built by Fujitsu for the Fermilab VTPC and covered in TM-1284. However, unlike the MB43458, the device is an inverting negative feedback amplifier, intended for positive outputs. This report documents the results of the tests performed on this device.

I. CIRCUIT DESCRIPTION

The MB43468 is a four channel preamplifier in a 14 pin SOIC package. The chip pin out and the schematic of one channel are shown in Figures 1 and 2. Only the input and output of each amplifier are available. The supply voltage is specified as +8V. The circuit is an inverting common emitter amplifier in the cascode configuration, with a bootstrapped load for high impedance. This is followed by two emitter followers, providing a low impedance output. A 20K negative feedback resistor is inside the chip and determines the DC gain. A reverse biased transistor is used as a feedback capacitance, determining impulse gain. One input diode provides some protection against negative transients. It is probably desirable to back terminate the output with an external resistance equal to cable impedance.

II. GAIN AND LINEARITY

The gain test circuit is shown in Figure 3, along with a picture of the impulse response for a 1,000,000 electron input. Note that the output is back terminated for all tests, so that all measurements are half the value that would be measured directly at the amplifier output. Table 1 and Figure 4 show the gain in mv/pc for different amounts of input charge. The output amplitude is not limited by the standing current in the output transistor since the transistor is being turned on for positive output pulses. For larger amplitude output pulses, a negative overshoot begins to appear.

Table 1 - MB43468 Impulse Gain

Qin (pc)	Vout+ (mv)	Gain (mv/pc)
.0208	7.0	337
.0416	14	337
.052	18	346
.104	38	365
.156	58	372
.208	80	385
.26	104	400
.52	225	433
.78	350	449
1.04	470	452
1.3	600	462
1.56	710	455
2.08	920	442

The gain of the amplifier changes with temperature. An amplifier output was seen to change from 209 mv at ambient to 200 mv at stabilized operating temperature.

The MB43468 will produce negative output pulses from positive inputs, however, the pulses saturate at 50 mv because of the 2 ma standing current in the output. At levels well below saturation, the gain is comparable to the positive output gain, although slightly lower. An external output pull down resistor will increase the negative output range if desired.

III. RISE AND FALL TIMES

The MB43468 set at +100 mv output amplitude exhibits a clean pulse and is quite similar in shape to the MB43458 output. The rise and fall times of the Fujitsu chips and the well known Radeka amplifier are compared in Table 2.

Table 2 - Rise and Fall Times (10%-90%, 100 mv output)

Amplifier	Rise Time	Fall Time
MB43468	5.5 ns	26 ns
MB43458	6 ns	30 ns
Radeka	4 ns	80 ns

IV. CROSSTALK

Since crosstalk is very layout sensitive, the MB43468 was mounted on a small board above a ground plane, with short input runs, and a .1 ufd bypass as close as possible to the power leads. The worst case crosstalk was about +/- 1%. Crosstalk waveforms for all four channels are shown in Figure 5. The top waveform is the output of the channel receiving the input signal, and the bottom waveform is the output of another channel, showing the crosstalk to that channel. All waveforms are labelled by channel number, channel 1 being the amplifier whose input is pin 1 on the chip. Crosstalk for this chip is a little larger than for the MB43458. This may be due to the harder to implement layout geometry of the MB43468 chip (all inputs on one side, all outputs on the other).

V. NOISE

The noise of the MB43468 was measured by observing the distribution of output pulse areas at 100 ns gate time. The setup used is shown in Figure 6. Results are shown and compared with the MB43458 in Table 3. The noise of the MB43468 seems considerably lower than the

MB43458 at high input capacitance.

Table 3 - Equivalent Input Noise vs. Input Capacitance for 100 ns gate (e RMS)

Device	Cin=10 pf	25 pf	43 pf	78 pf
MB43468	2740	3120	3600	4770
MB43458	3250	4050	5190	8030

VI. FREQUENCY RESPONSE

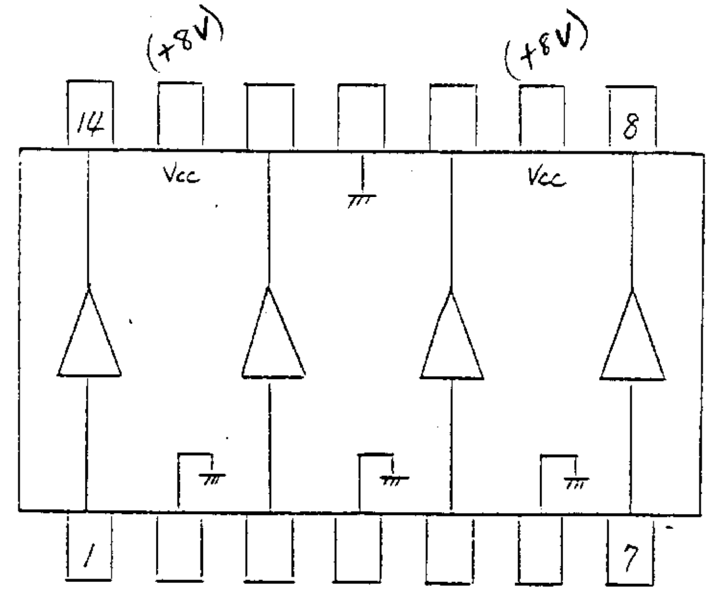
The magnitude and phase response of the MB43468 as measured on a network analyzer is shown in Figure 7. Nominal low frequency voltage gain is 30 db. The 3 db frequency is approximately 21 MHZ. By comparison, the MB43458 3 db frequency is 10 MHZ.

VII. RESPONSE VS. SUPPLY VOLTAGE

With Vcc = +8V, the chip draws 14.2 ma, dissipating 114 mW. It was noticed that as the supply voltage was decreased, the low frequency gain increased, and for Vcc = +5.8V, the response curve was identical to that for Vcc = +8V. However, this was for a small input amplitude on the network analyzer. Using the gain test circuit of Figure 3, output pulses on a scope were observed while changing Vcc and it was found that +8V is not necessarily the optimum Vcc for highest impulse gain. The gain was a little higher for a Vcc of about +7V, and then dropped off for Vcc lower than 7V. A 100 mv pulse only lost about 10% of its amplitude when Vcc was changed from +8V to +5.8V. This is shown in Figure 9. However, this behavior was observed with the test circuit, not with a chamber. It is suspected, but not known, that the same characteristics would be observed if the amplifier was driven by an actual chamber.

Perhaps it is possible and advantageous to run the MB43468 at a lower supply voltage, depending on gain and amplitude desired. The current draw at +5.8V is 12.3 ma, resulting in a dissipation of only 71 mW. Also, the output noise in a 10 MHZ bandwidth is about 30% less at Vcc = +5.8V. The output noise voltage peaks at about Vcc = +6.5V and drops off for Vcc higher or lower than this value.

ブロック図，端子名称



TOP VIEW

Pin No.	記号	機能
1	INA	ACH 入力
2	GND	GND
3	INB	BCH 入力
4	GND	GND
5	INC	CCH 入力
6	GND	GND
7	IND	DCH 入力
8	OUTD	DCH 出力
9	Vcc	Vcc 電源
10	OUTC	CCH 出力
11	GND	GND
12	OUTB	BCH 出力
13	Vcc	Vcc 電源
14	OUTA	ACH 出力

FIGURE 1 - PIN OUT

ドリフトチェンバ用プリアンプ 等価回路図

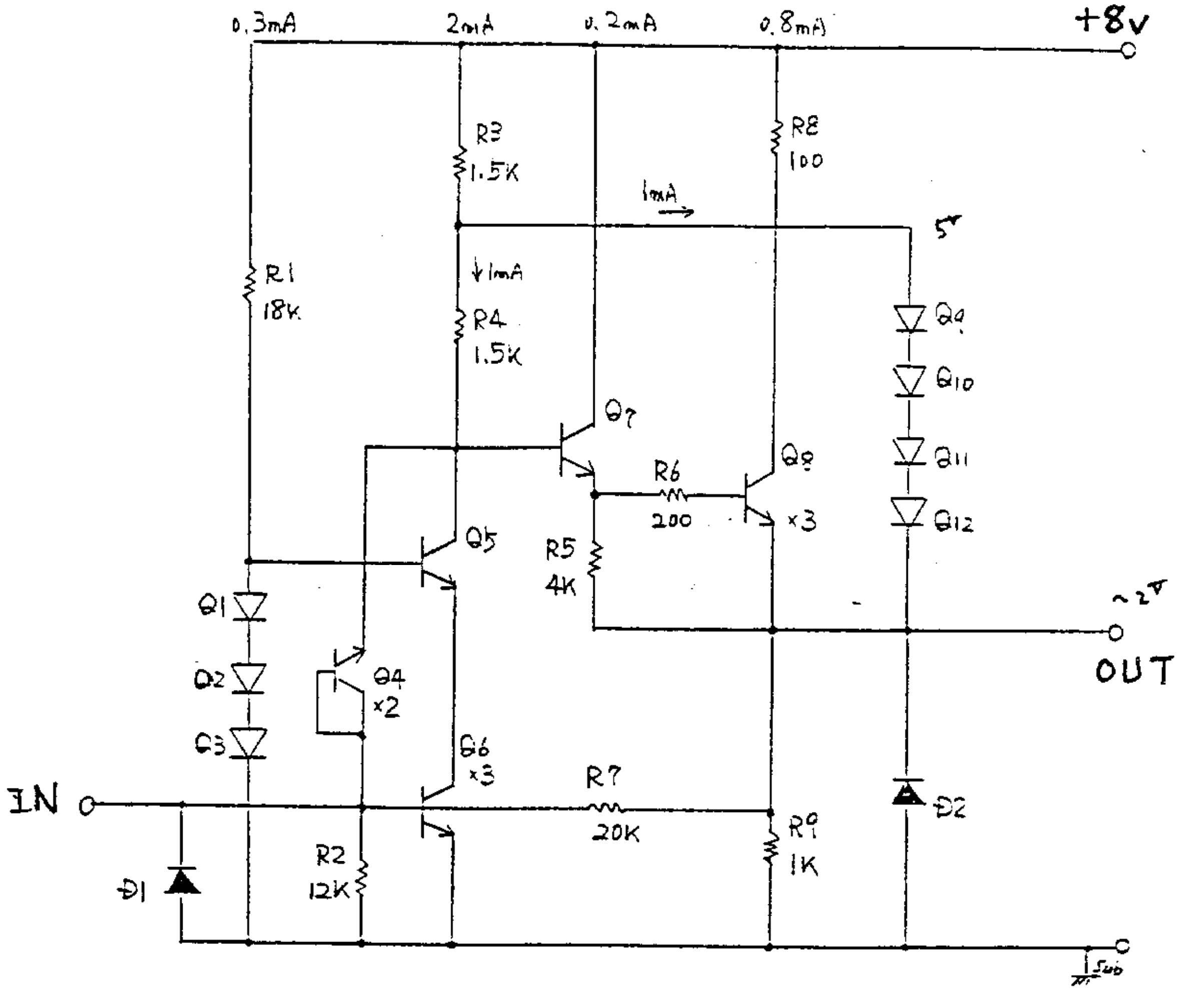
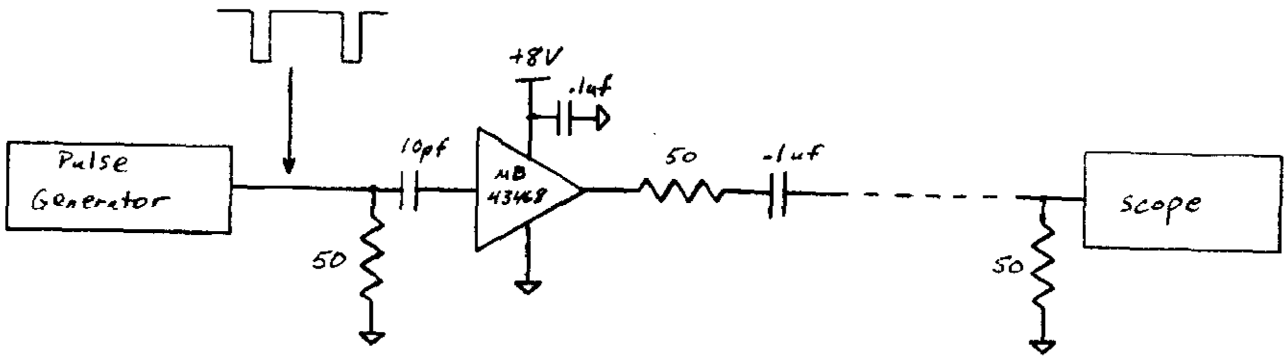
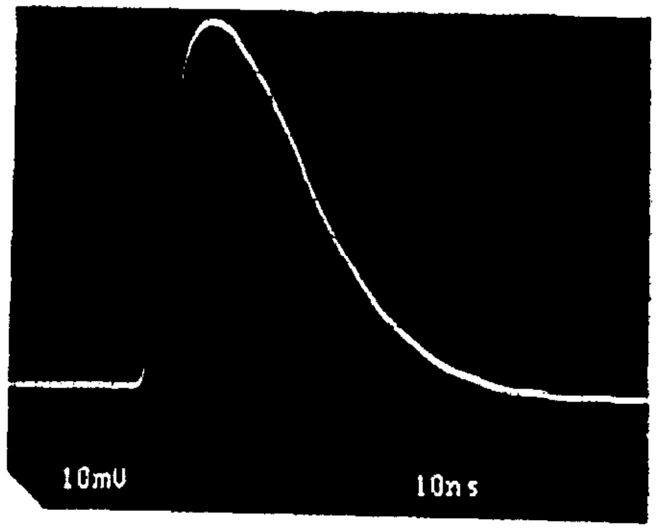


FIGURE 2 - SCHEMATIC OF ONE CHANNEL





Impulse response for 10^6 electron input

FIGURE 3 - GAIN TEST CIRCUIT

PEAK OUTPUT VOLTAGE VS. INPUT CHARGE MB43468

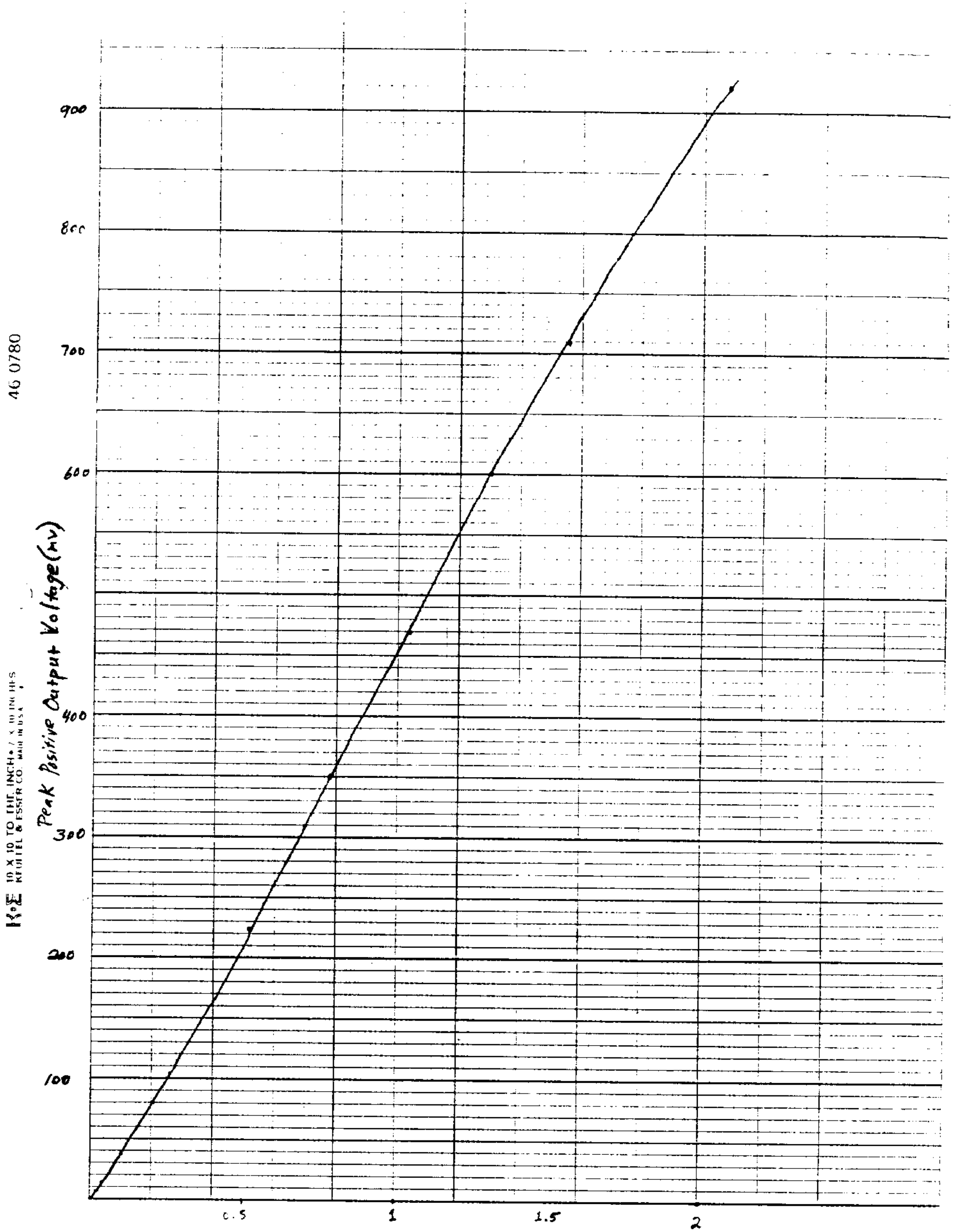
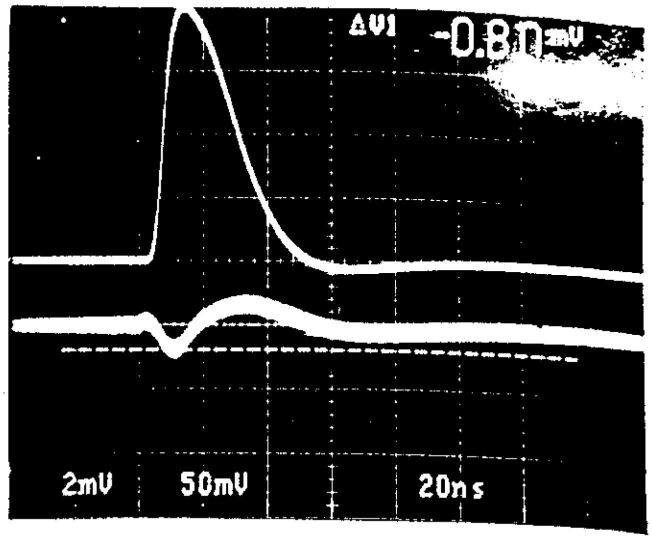
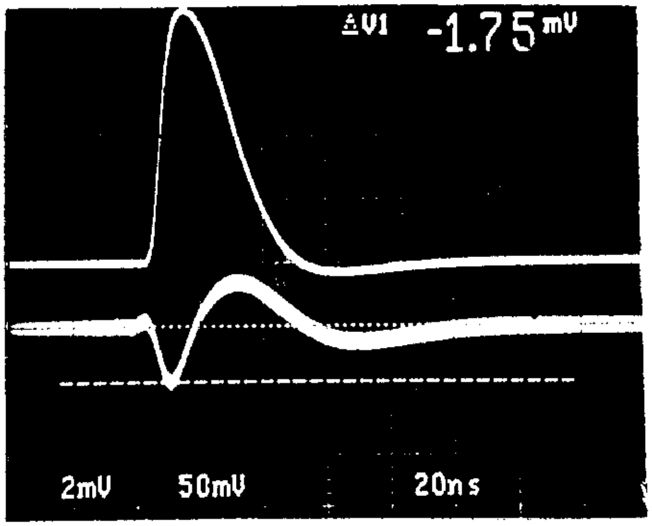
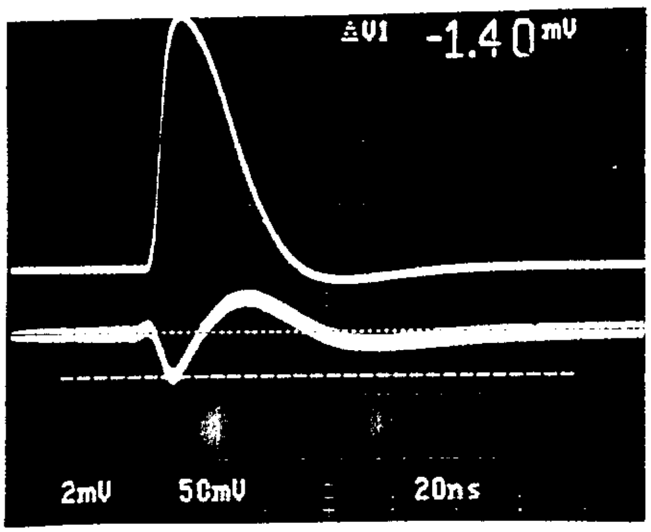


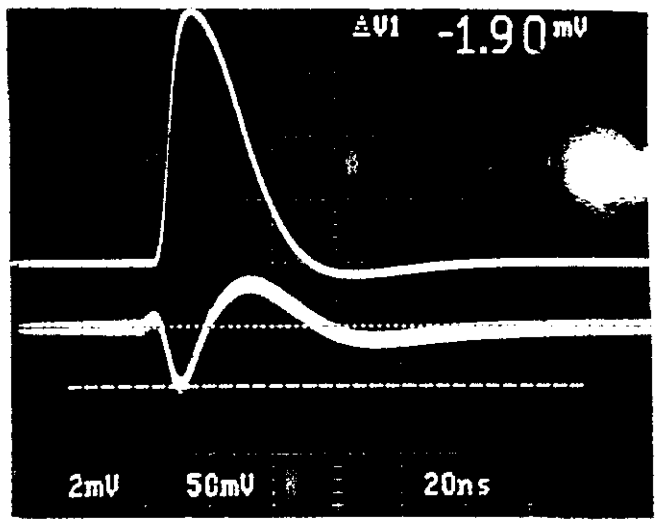
FIGURE 4

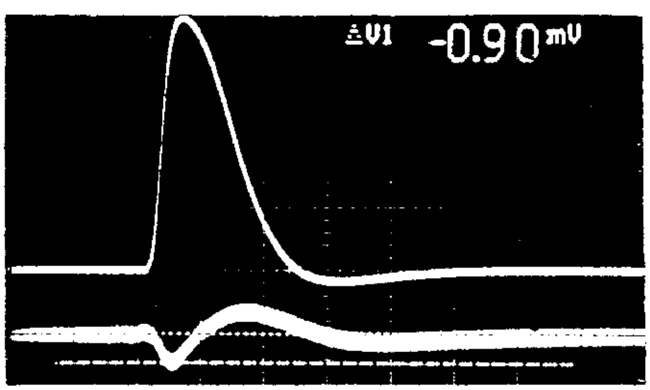
FIGURE 5 - CROSSTALK WAVEFORMS

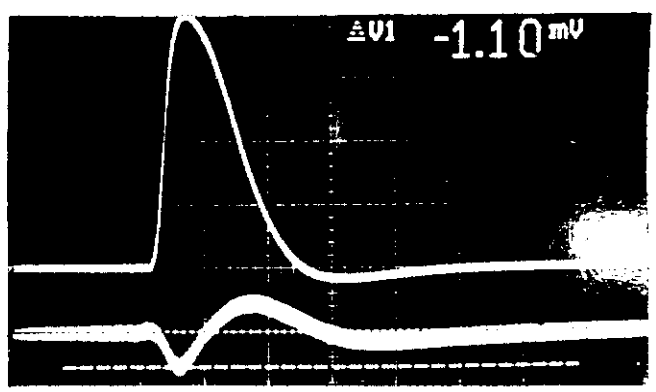


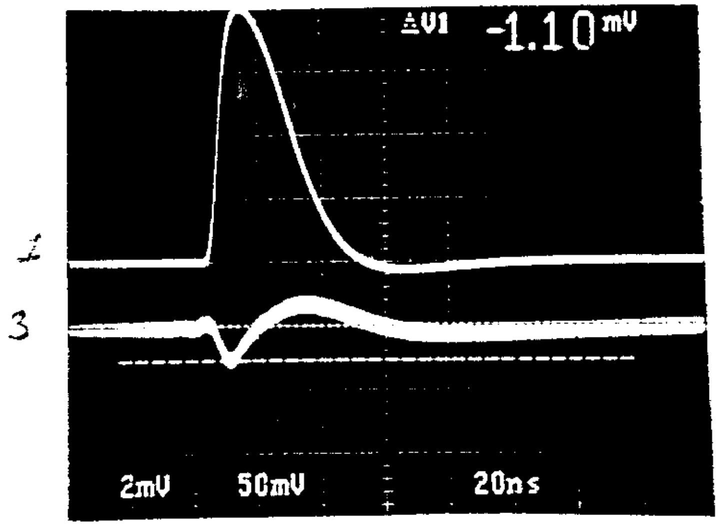


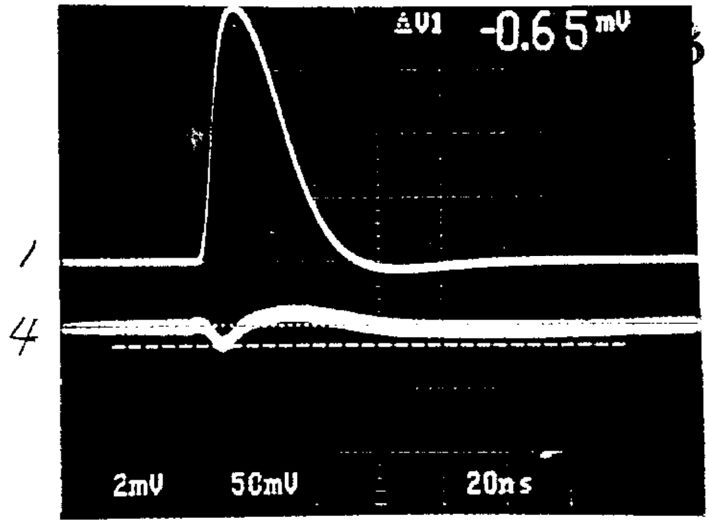


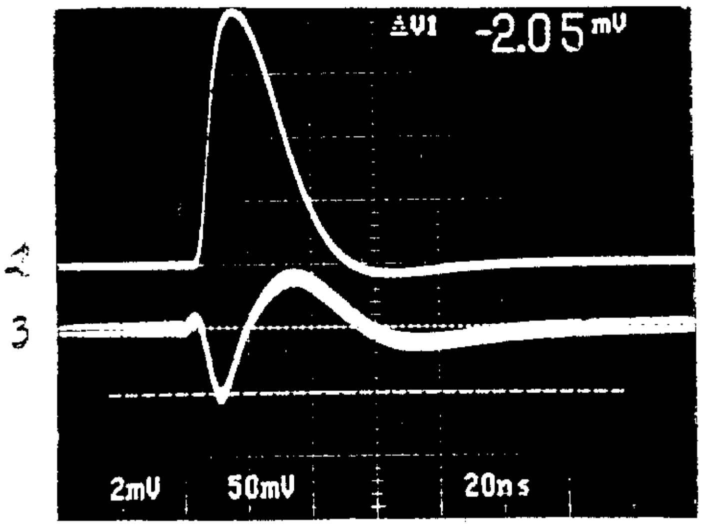


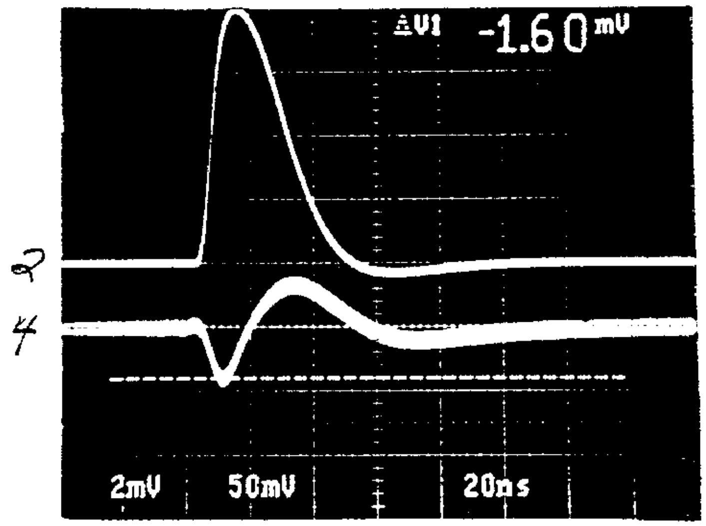


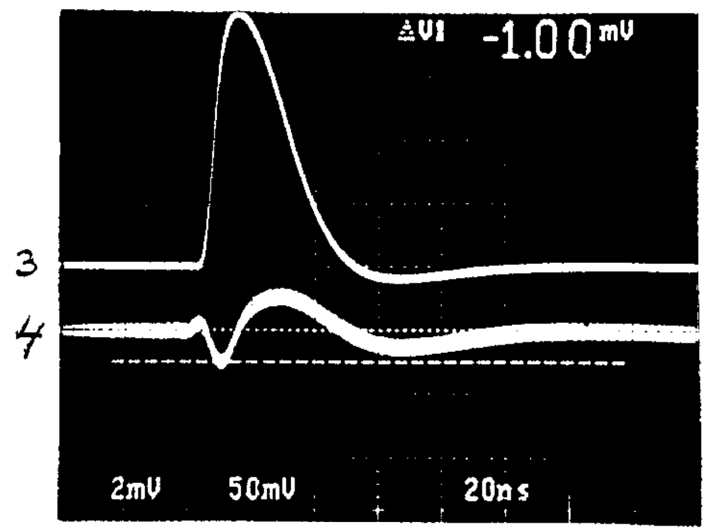












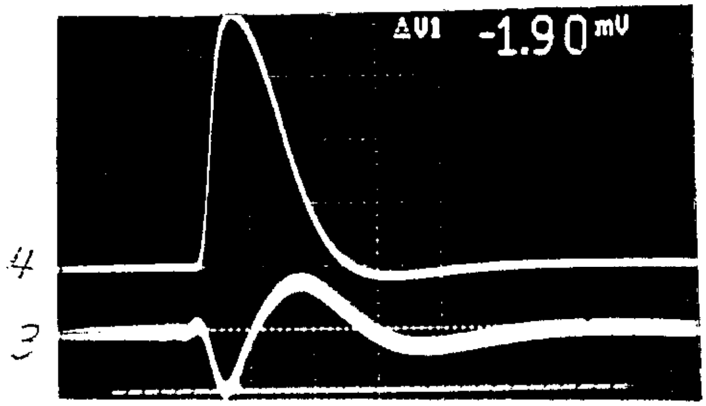


FIGURE 5 (CONT.)

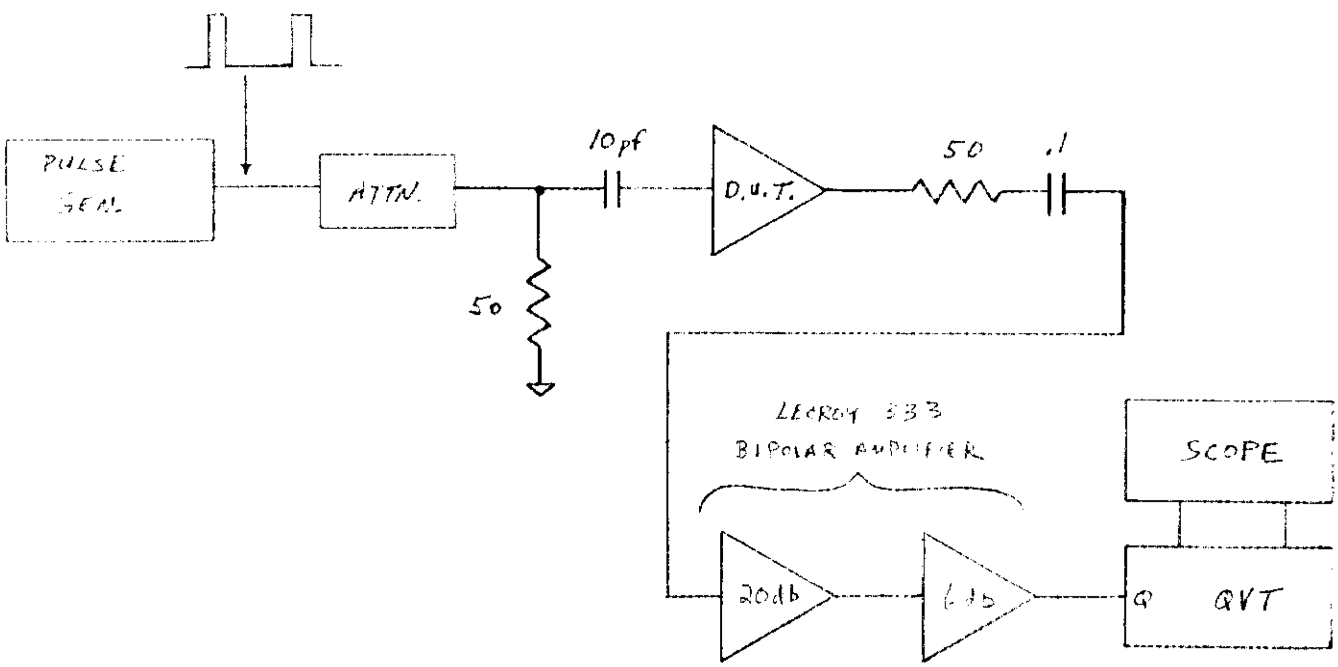


FIGURE 6 - NOISE MEASUREMENT CIRCUIT

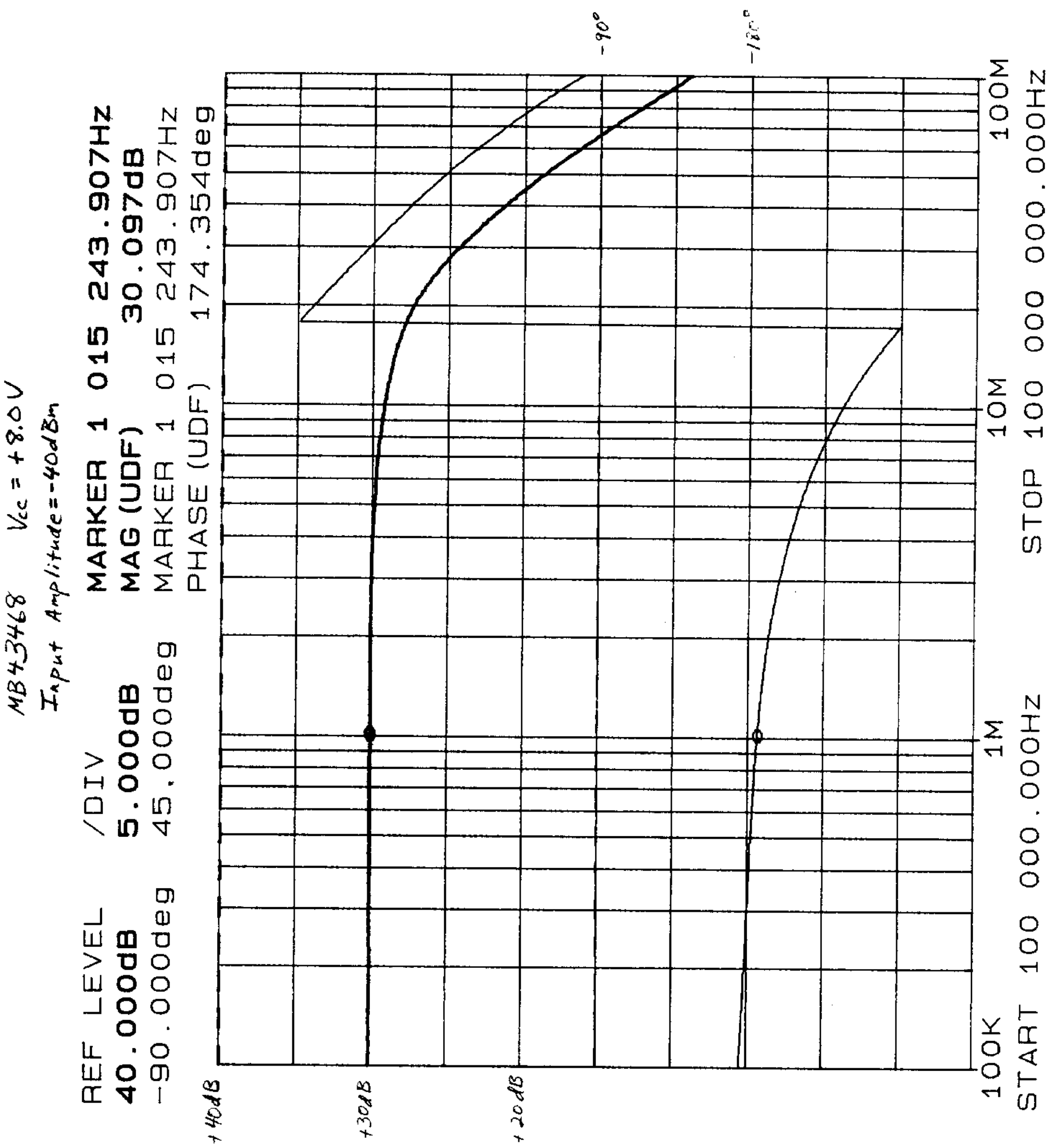


FIGURE 7 - FREQUENCY RESPONSE

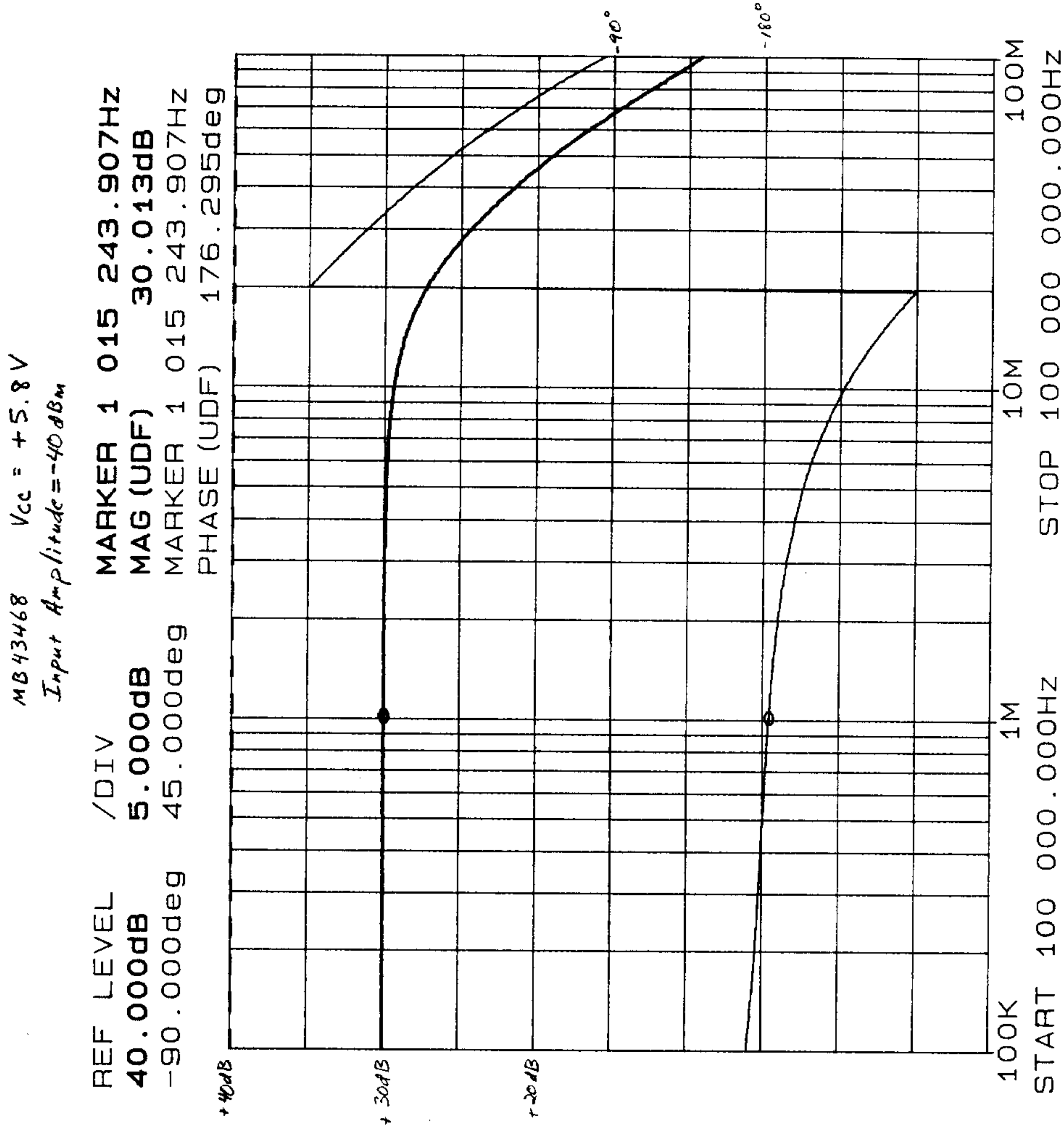
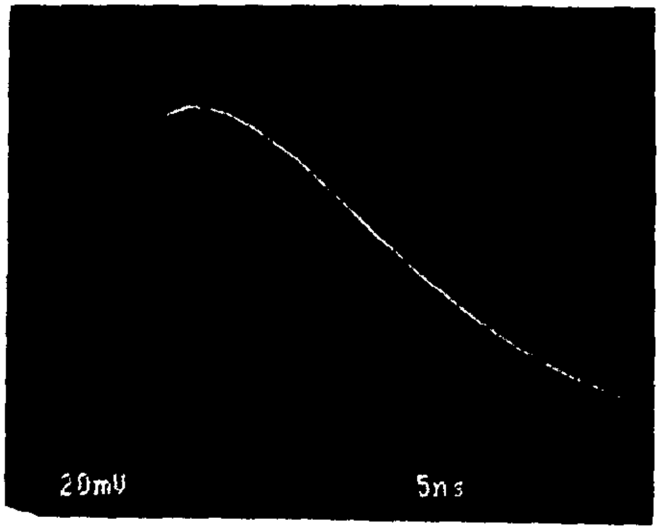


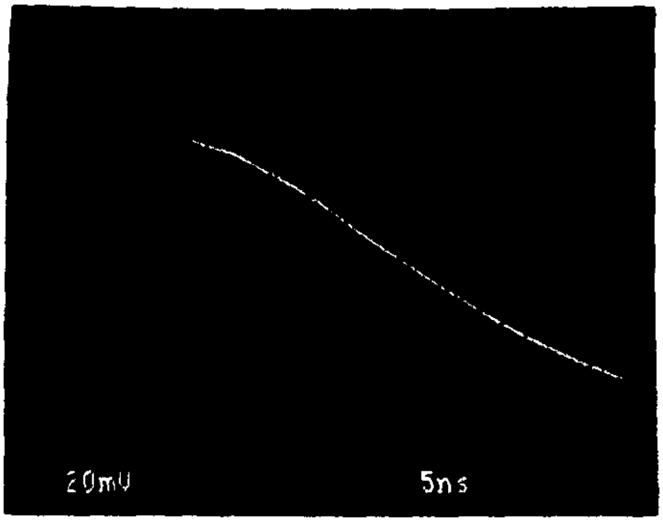
FIGURE 8 - FREQUENCY RESPONSE FOR V_{cc} = +5.8V

$V_{cc} = +8.0\ V$



$t_r = 5.5ns$; $t_f = 26ns$

$V_{cc} = +5.8\ V$



$t_r = 5.2ns$; $t_f = 31ns$

FIGURE 9 – RESPONSE AT DIFFERENT V_{cc}