New Folder Name Primary Arm Servo

Towards a Primary Arm Servo without Pockels cells

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1. **The measurements concerning the primary arm servo**, relevant to the use of a feed-around path (FA), can be summarized as follows:

   - The cross-over between the mode cleaner piezo path (MCP) and the FA occured at $\sim$ 350 Hz (see Figs. 1, 2)
   - The actual measured open loop gain, with the FA active (Fig. 2), shows a hint of a notch at 200 Hz, in spite of an expected phase margin of 22°
   - The measured FA open loop gain (Fig. 4) is consistent with flat just below 500 Hz (primary cavity pole), $1/f$ behavior between 500 Hz and 10 kHz, and a steeper fall-off at higher frequency, due to an explicit 10 kHz roll-off selected on the Ithaco amplifier, the mode cleaner pole at $\sim$ 30 kHz and additional poles that the Ithaco seems to have
   - The signal to the slow Pockels cells, as well as comparison of primary arm open loop gain measured with the FA on (Fig. 2) and off (Fig. 3), show that, just above 1 kHz, the FA dominates the slow Pockels cell path by 18 dB
   - The unity gain frequency of the primary arm servo is approximately 200 kHz

- The transfer function from the mode cleaner error point to the primary arm error point is consistent with a pole at 500 Hz (primary cavity pole) and a pole at 30 kHz (mode cleaner pole) (Fig. 5). The data above 20 kHz is quite messy, and, unfortunately, one is limited by the maximum frequency span of the spectrum analyzer, 100 kHz

2. **An FA open loop gain** that would hopefully allow to operate the primary cavity without the video Pockels cells, and at the same time provide 10 dB more gain at 1 kHz, is shown in Fig. 6. It is different from the FA gain as used for last weeks experiments in the following details:

   - The low frequency roll-off is moved from 10 Hz to 30 Hz. Since, at low frequencies, the perturbations to the system decrease steeply with frequency, this should reduce the offset which the FA injects into the laser locking to a sufficient degree, such as to make the servo almost as robust as without the FA
   - The gain at the flat portion of the open gain curve in Fig. 6 is 7 dB lower than in Figs. 1, 4. This is meant to increase the phase margin at the cross-over with the MCP, for safer operation
   - above 500 Hz, the gain behaves as $1/f$ all the way down to 0 dB level, which is crossed just below 200 kHz

3. **Implementation aspects:**

   - The resistor network will be replaced by the test input of the main laser locking servo amplifier, as a means to close the FA. This will require 16.5 dB of additional electronic gain
   - The Ithaco and its output network, now providing 36 dB gain, will be replaced by a wideband amplifier(s), which needs to provide a change of sign and will have 50 Ω output impedance
   - The 30 kHz mode cleaner pole needs to be cancelled, e. g. with a 30 kHz - 300 kHz lead filter, which requires 20 dB of additional electronic gain
   - The total electronic gain of the amplifier(s) that will replace the Ithaco is, therefore, 72.5 dB *minimum*

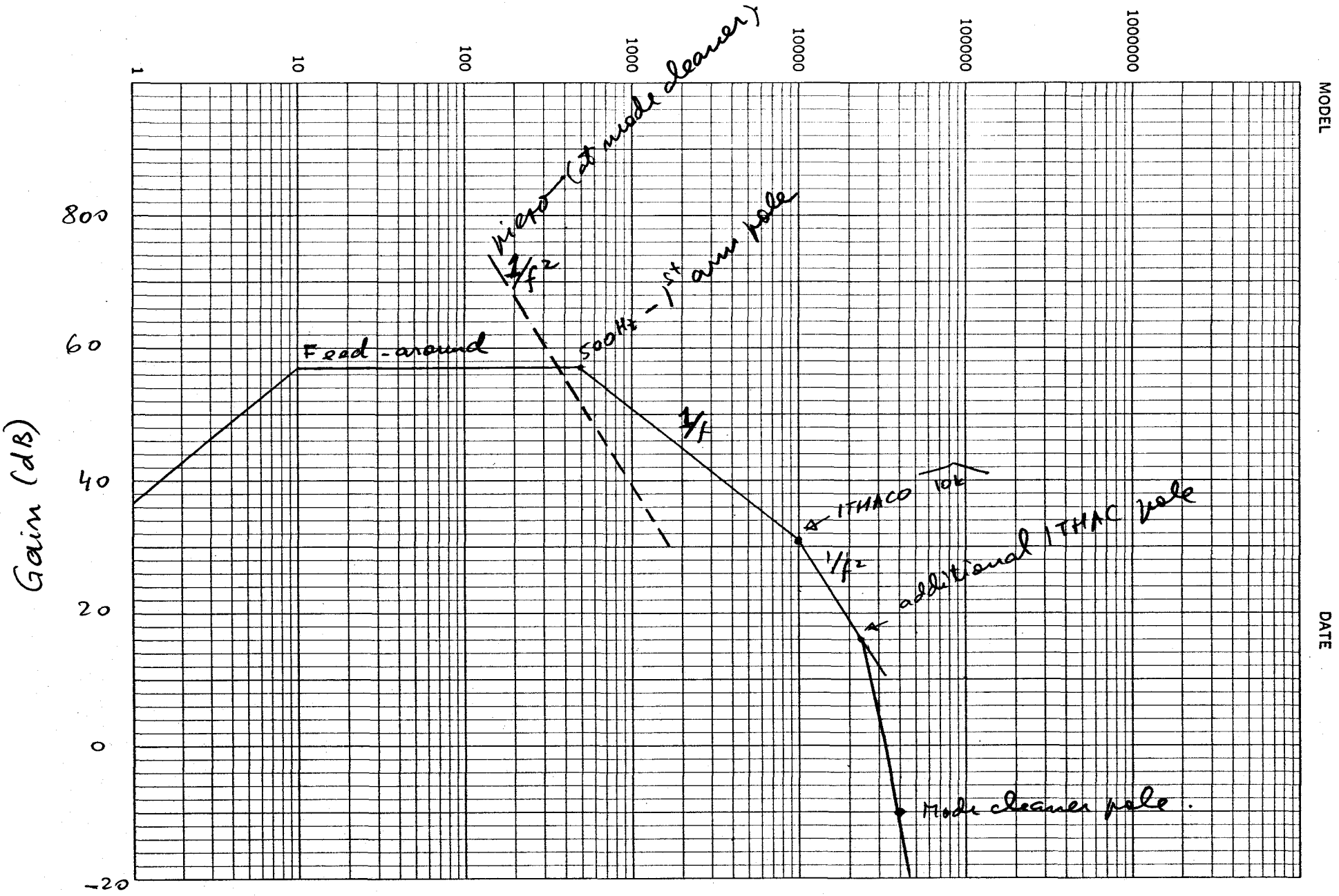


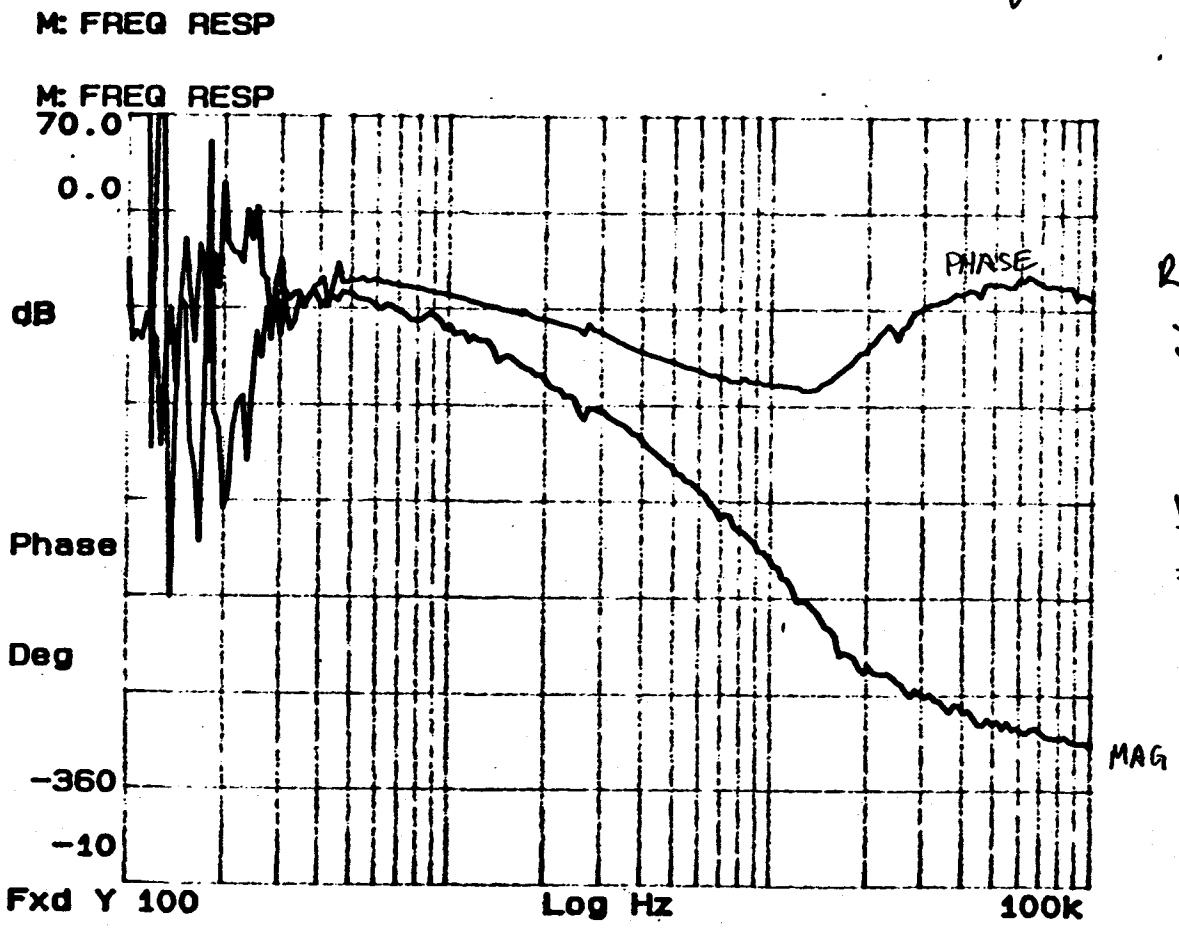
Fig. 1

26-Sep-90 14:55

1st arm loop gain - with feed-around

same conditions as 14:40

Feed-around loop settings: as 25-Sep-90 16:10 (p. 63W)



RF levels:
Interf: -7dB
modecleaner -15dB.

mode cleaner light levels: out of lock: 200mV
in lock: 80mV

Stored on disk as: AIFA2609

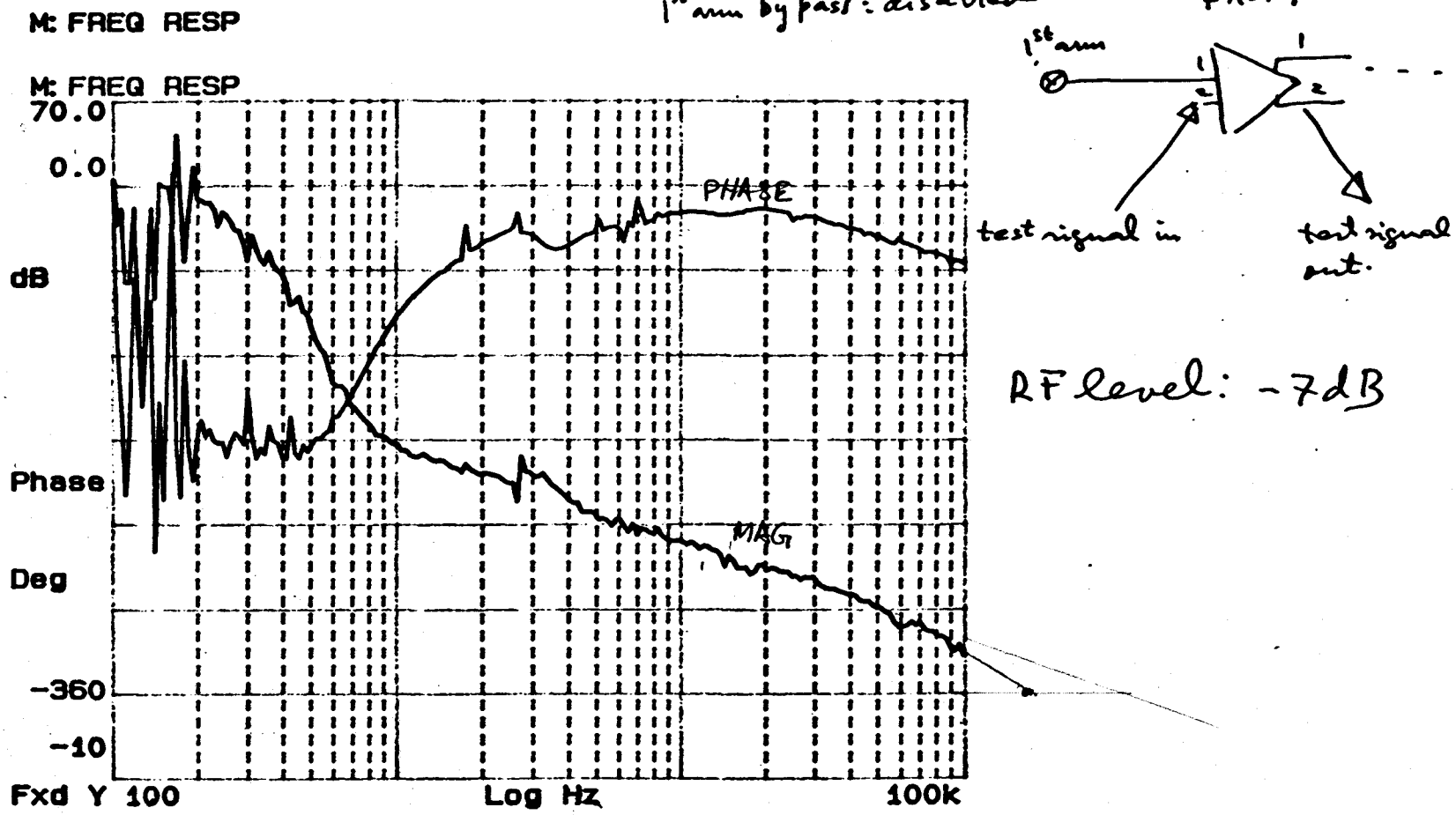
Fig. 2

26-Sep-90 14:40

1st arm loop gain - without feed-around

Light levels : out of lock : 1.8 V
in lock. 0.7 V

FAST 4' set at 5
1st arm by pass : disabled



RF level: -7dB

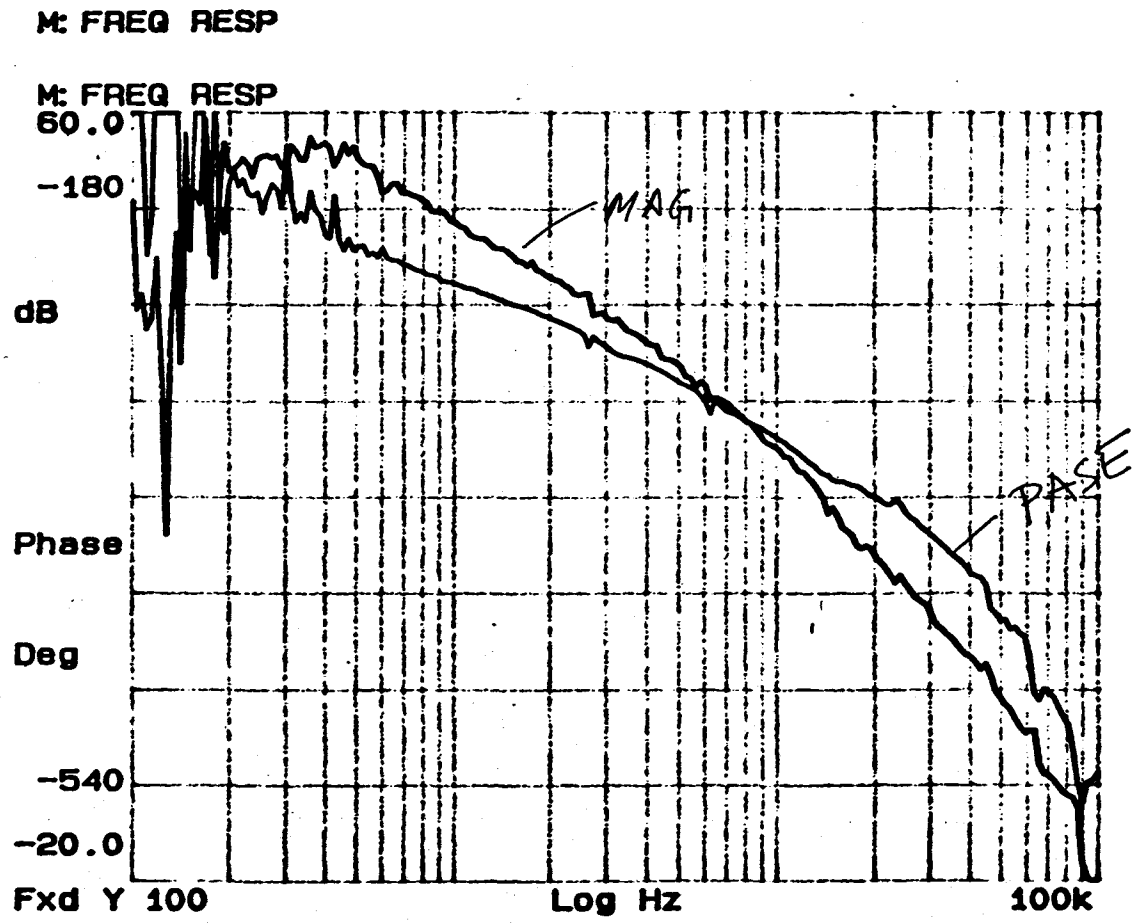
Stored on disk as: A1LG2609

Fig. 3

26-Sep-90 16:40

Feed around path gain

Obtained by multiplying traces from 16:05 and 16:30



Stored as: FA2P2609

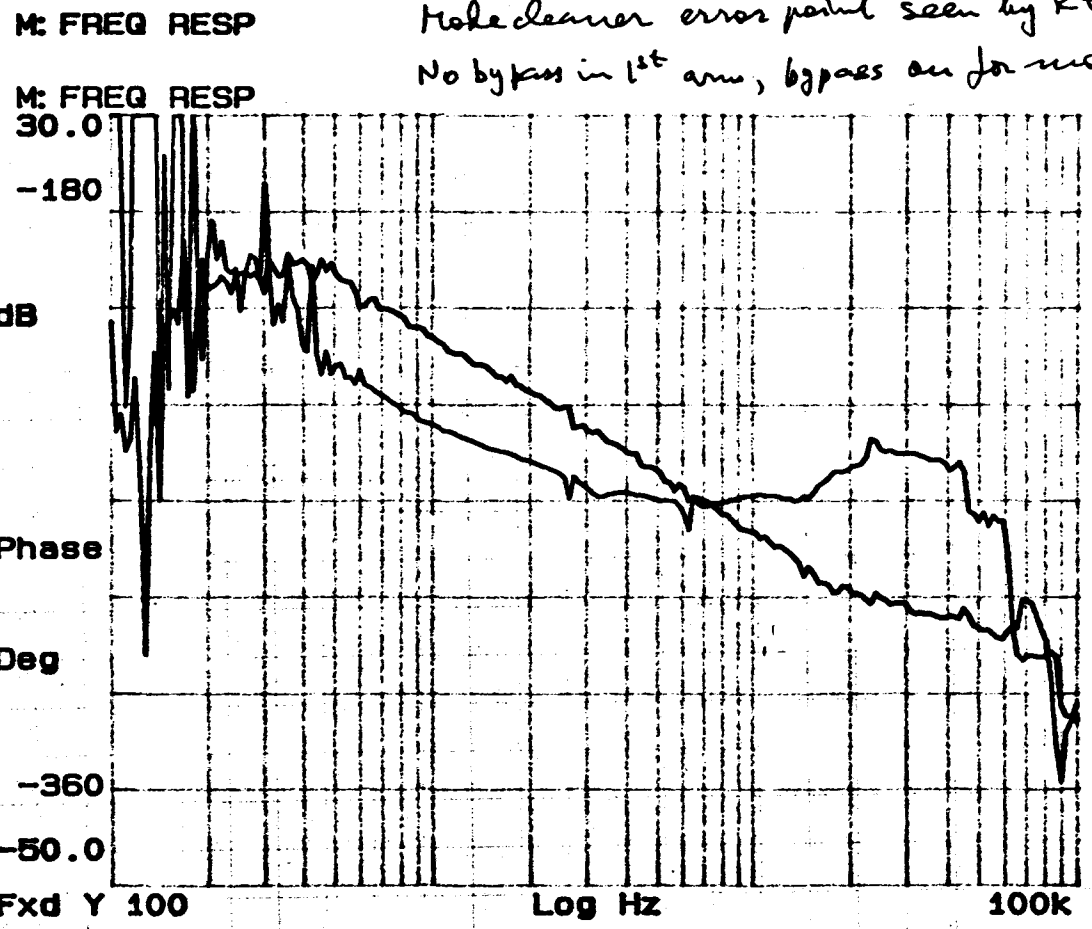
Fig. 4

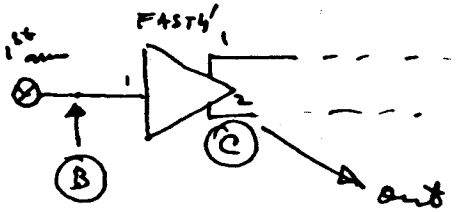
26-Sep-90
16:05

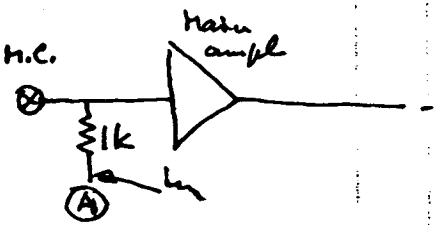
Mode cleaner err.pt. → 1st arm err. pt. transfer function

Light levels: Mode cleaner: 200 mV out of lock, 100 mV in lock
1st arm: 1.5 V — — , 0.145 V in lock

RF levels: Interferometer: -7 dB, mode cleaner: -15 dB.
Mode cleaner error point seen by RF analyzer: |<2MHz|
No bypass in 1st arm, bypass on for mode cleaner.







Displayed traces: $\frac{V_B}{V_A}$

Measured: $\frac{V_C}{V_A}$, then multiplied by G+1 and divided by 21.4 (26.6 dB), which is the gain of FAST4 set at 5.

Fig. 5

Note G is as shown at 14:40. Since at that time light levels were slightly different, there is an certain error in the traces shown here. Hopefully, they are good with ×2.

DISK FILE: MCA12609

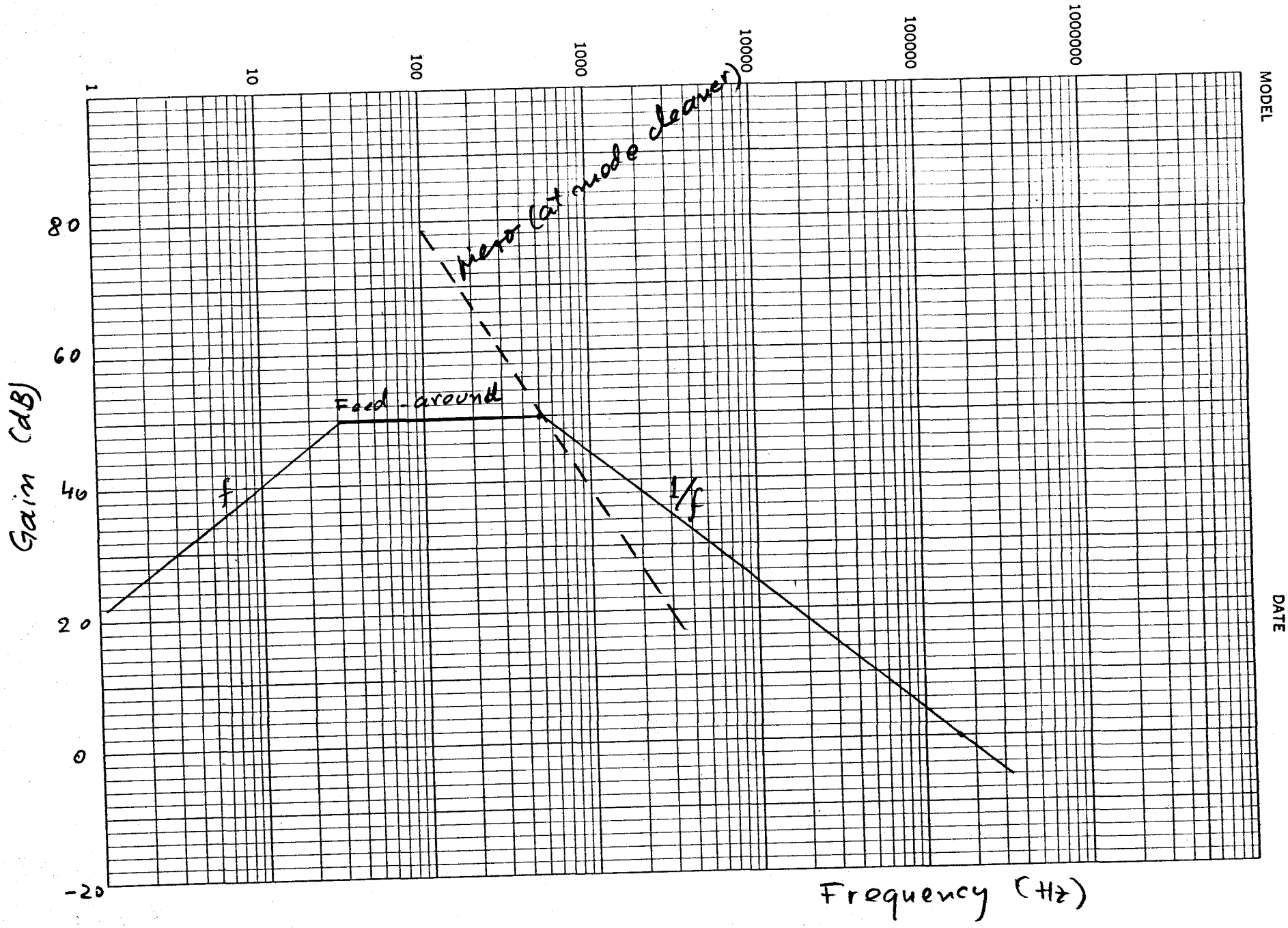


Fig. 6