Bima Memo # 27

THE IF/LO SUBSYSTEM   WJW   1/12/92

I. Introduction and general description.

This subsystem consists of the single cable between the laboratory and the antenna and the filters that enable the encoding onto the cable and separation from the cable of the various signals. Some of the signals are transmitted from the lab to the antenna, some return, and some go both ways. The signals fall into various frequency bands. The telemetry signal passes to and from the antenna in the 0-3 MHz band. The 10 MHz reference goes from the lab to the antenna in the 3-20 MHz band. The 20-70 MHz band brings the TV signal back to the lab. The IF from the antenna returns in the 70-900 MHz band, and the high frequency reference goes out to the antenna in the 1100-1260 MHz band. The latter is also slightly offset in frequency and returned whenever the round-trip cable delay is being measured. In addition, the Telemetry band is further subdivided so that the band from 0-100 kHz may be used for modem connection of a portable computer at an antenna with the control computer.

The basic filters are in two separate sub-units. The BandPass/BandStop unit divides the frequency range 0-1260 MHz into 0-900 MHz and 1100-1260 MHz. The HighPass/LoPass unit, or Channel Dropping Filter, separates the 0-900 MHz range into all the other ranges. The former unit is a bandpass/bandstop diplexer; the later is a sequence of high pass-low pass diplexers. In order to have a good match at all frequencies, we use Butterworth filters in all the diplexers.

There are, in addition, other sub-units. In the lab, the IF channel is passed into the IF Filter/Equalizer unit where the cable loss is offset by amplifiers, the IF is passed through high and low pass filters to eliminate cross talk from the 10 MHz and the high frequency reference signals, and the frequency dependent cable loss is equalized. At the antenna, the reference signal is passed into the line length transmitter unit where it is amplified for the harmonic generator and where it may be offset by 78 Hz and returned through the side port of the 20 db coupler to the lab for the line length measurement. At the lab, the offset signal is separated out by the 3db coupler and detected in the line length receiver.

The run of cable consists of 1000 feet of semi-rigid coaxial cable underground between each small pit by the side of the runway and a junction plate under the laboratory computer floor, a 15 foot length of flexible coaxial cable between the junction plate and the IF/LO chasis, and two 50 foot lengths of Gore-Tex cable between the small pit and the receiver front end. The latter is temperature regulated. In addition, the IF/LO chasis is temperature regulated, in both cases to reduce phase and delay drifts in the system.

The overall block diagram is shown in Figure 1 below. For the system tests in Berkeley, a 1000 foot roll of the rigid cable is used to simulate the underground cable at Hat Creek. The other cables are also part of the test set-up.

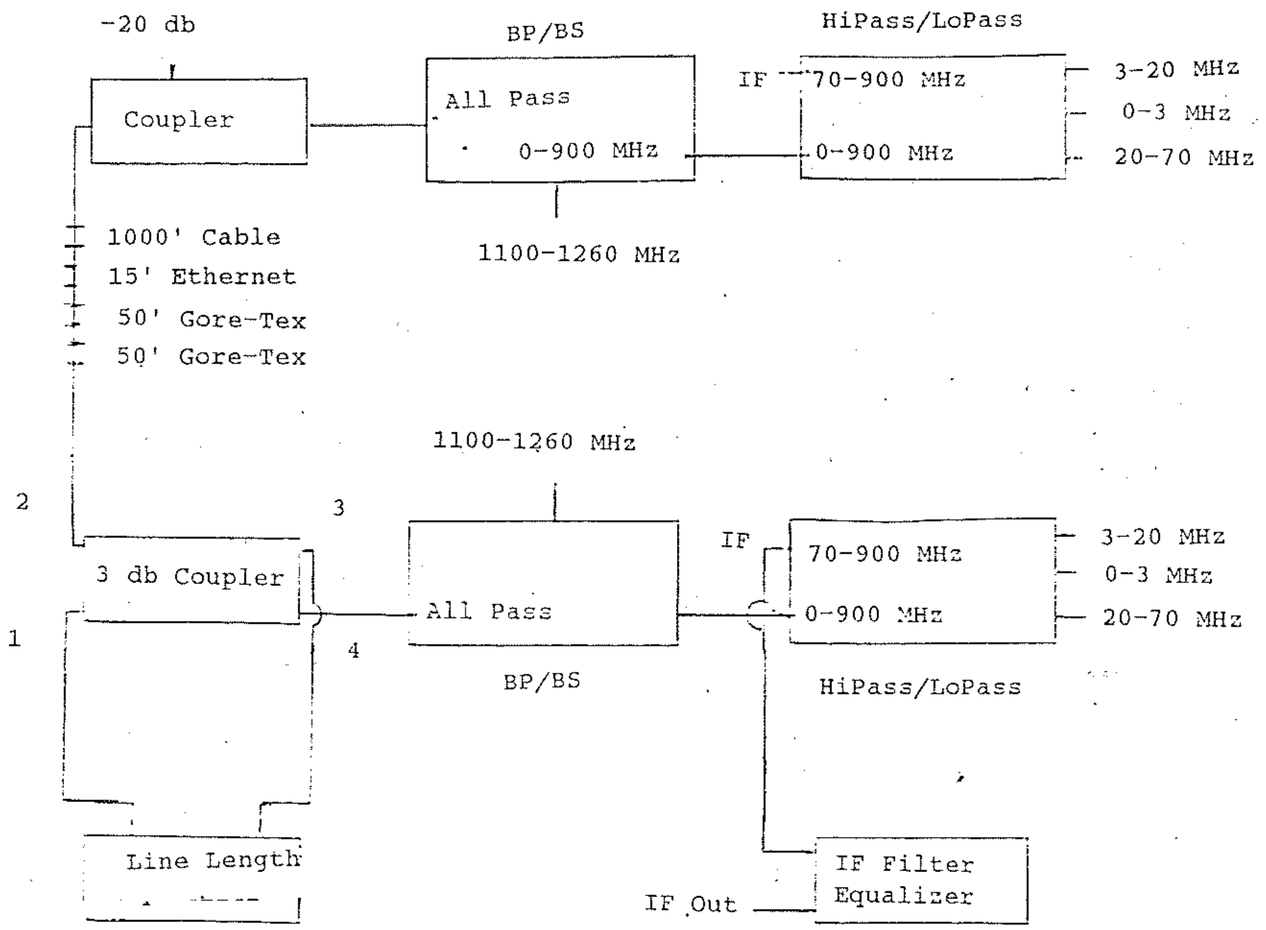

Figure 1

II. <u>Overall transmission between the antenna and the lab.</u>

a) Telemetry (0-3MHz).

300 kHz: -2.0 db
1.0 MHz: -2.9 db
3.0 MHz: -6.8 db

b) Figure 2 shows the amplitude transmission of the 3-20 MHz channel for the 10 MHz. The loss at 10 MHz is 5.7db.

c) Amplitude transmission through the 20-70 MHz channel.

20 MHz: -18.3 db
25 MHz: -8.5 db
60 MHz: -12.8 db
70 MHz: -18.6 db

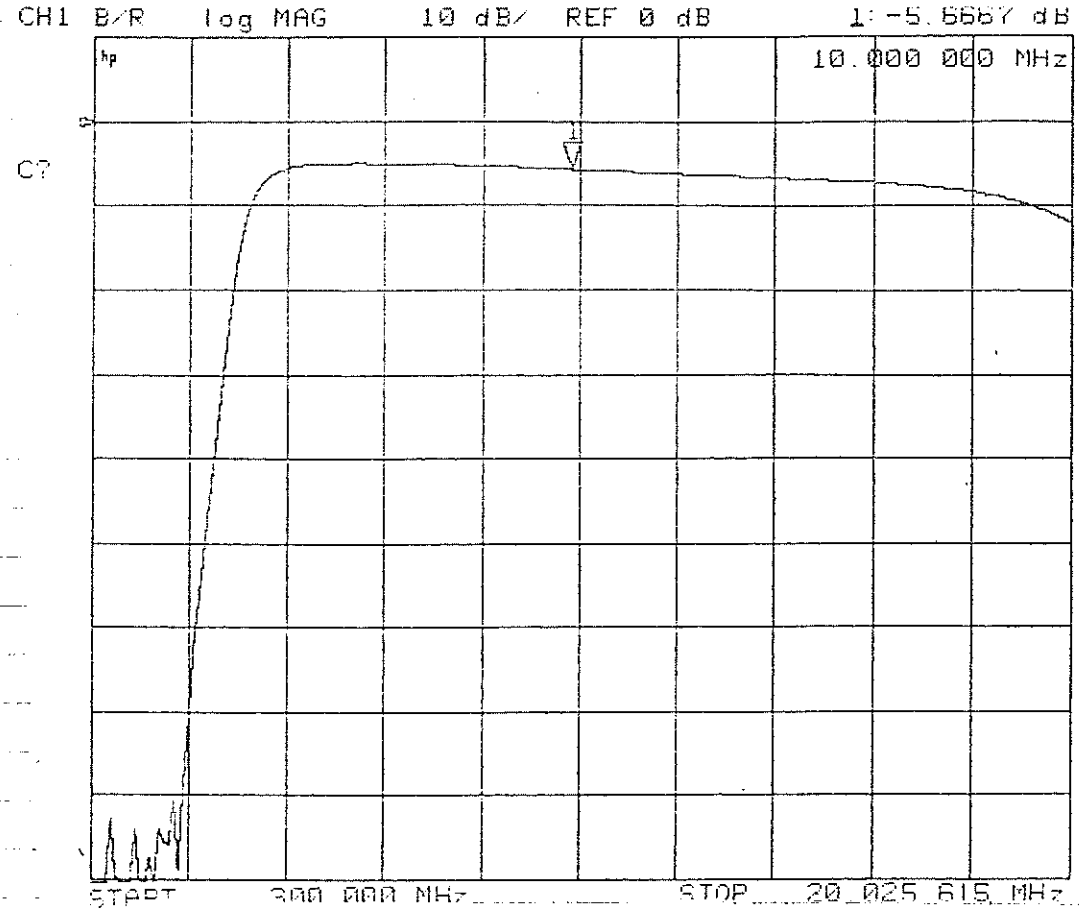

Figure 2

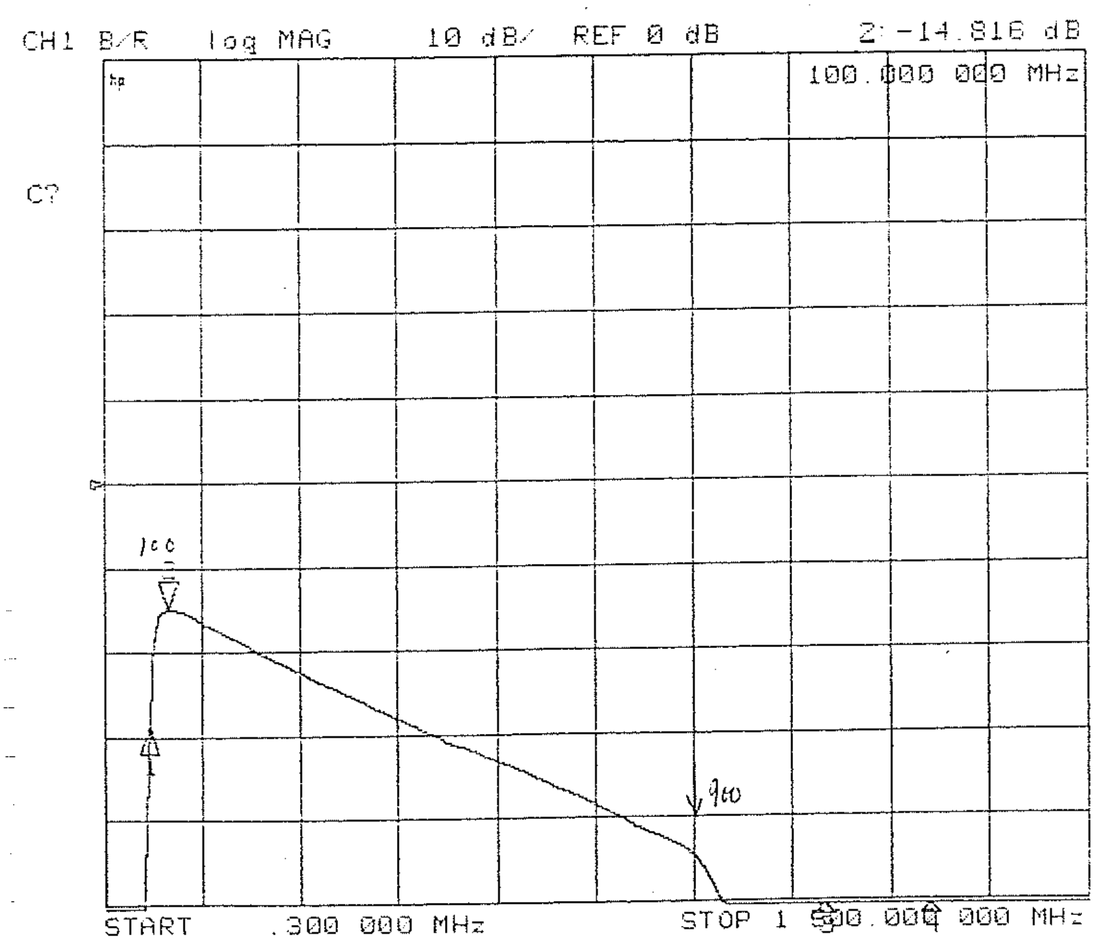

Figure 3

d) Amplitude transmission through the 70-900 MHz IF channel.

Figure 3 shows the transmission between the "IF" ports. The curve is smooth, showing no effect of standing waves.

Figure 4 shows the transmission between the IF port on the front end and the output of the IF Filter and Equalizer. The 3 db points are at 82 MHz and 913 MHz. The average gain is -16db for this prototype. Additional amplifiers will be added, so that the final system will have an overall gain of about +5db. Thus, with an output of about 0 dbm from the IF amplifier on the front end, the output from this system will be about +5 dbm.

e) Transmisison between the 1100-1260 Reference ports.

Figure 5 shows the amplitude transmission between these ports. The transmission to the three db coupler from the antenna has less loss by about 1.5 db, because the loss of the BP/BS filter is avoided.

Figure 6 shows the residual phase shift across this band after a delay of 1388.5 nanoseconds has been removed. The small remaining fine structure is just noise. An integration time corresponding to 64 scans was required for this level of residual noise in the network analyzer.

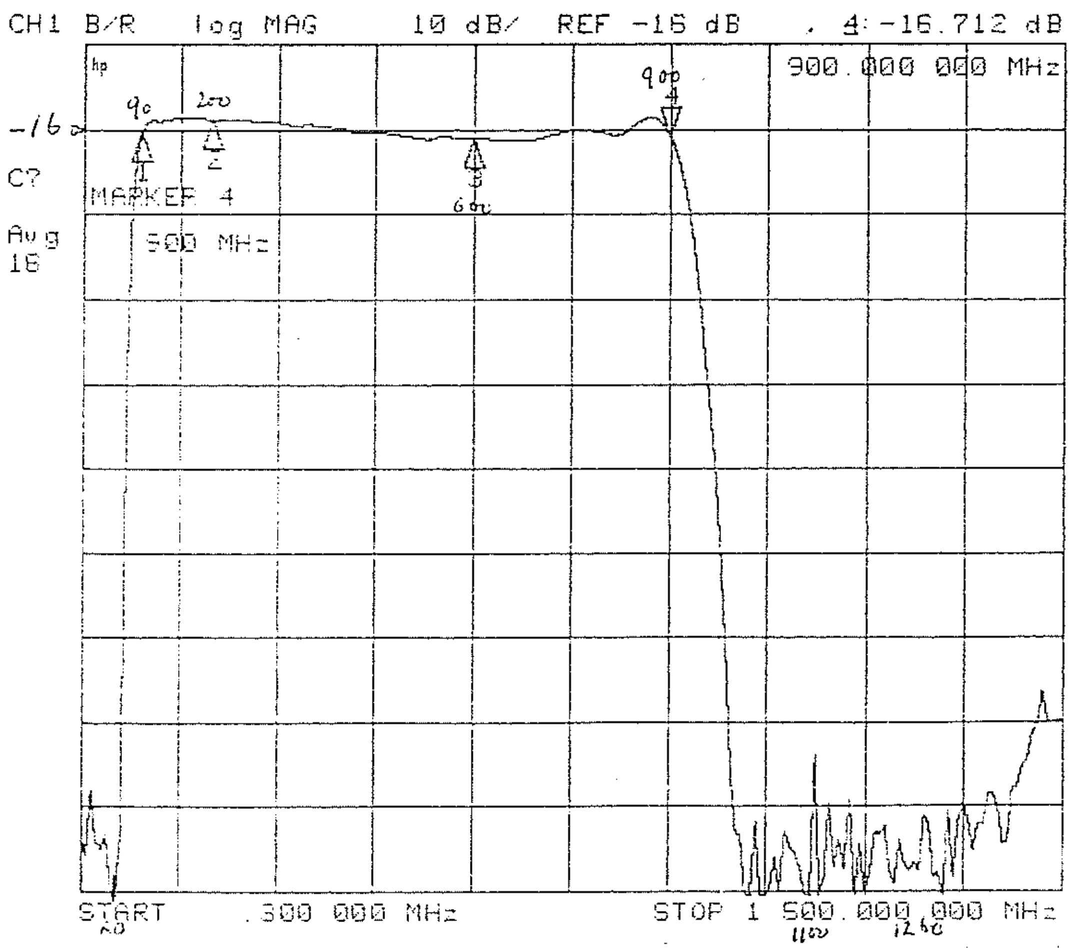

Figure 4

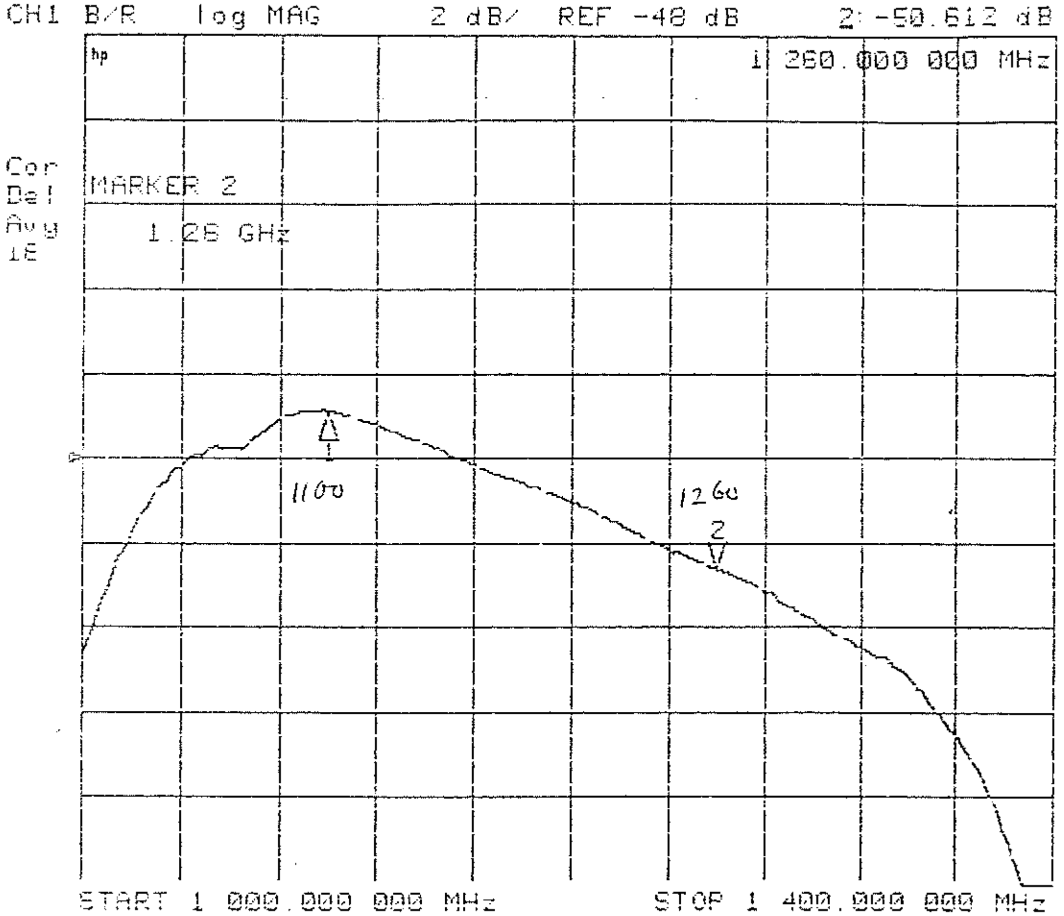

Figure 5

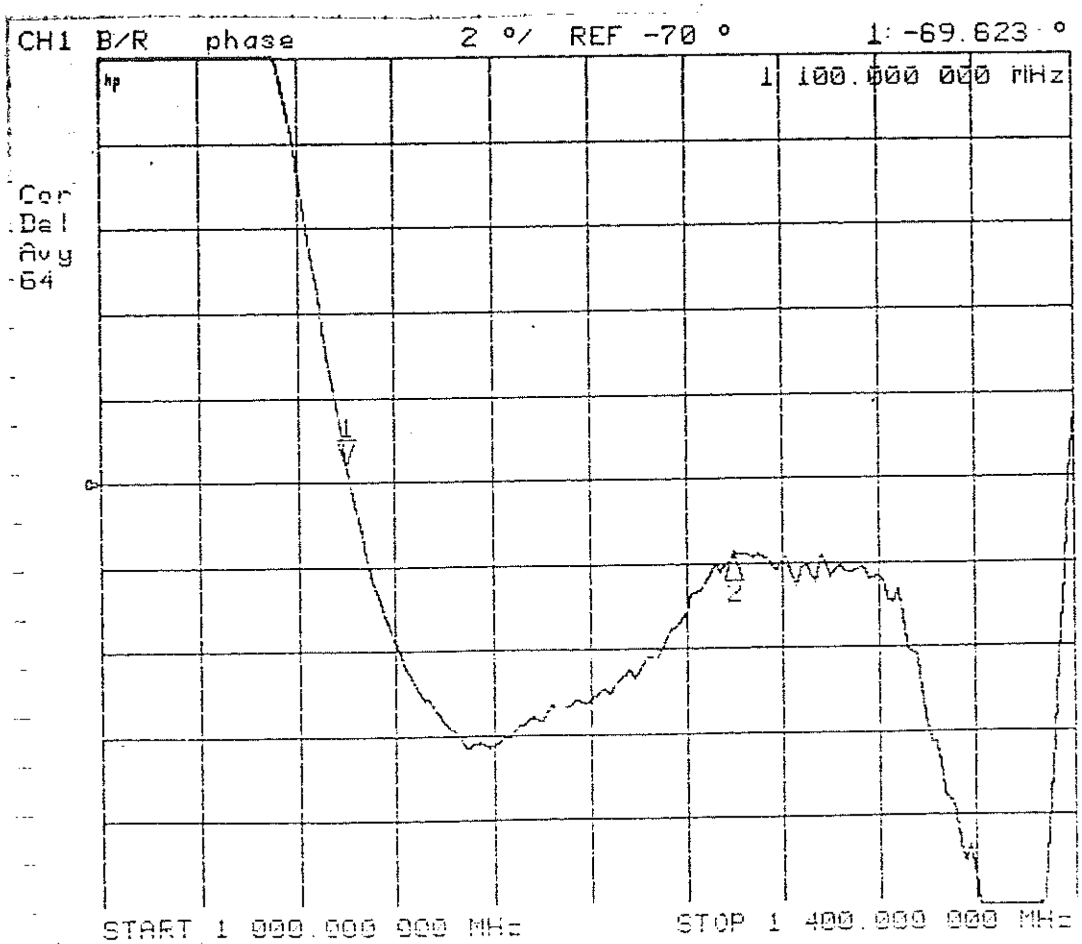

Figure 6

III. A few characteristics of the HiPass/LoPass filters, including thermal stability and isolation between channels.

a) The phase shift in the transmission from the 0-900 MHz port to the 70-900(IF) port (after a delay has been removed) is shown in Figure 7. There is an obvious large residual phase dispersion due to the Butterworth filters employed in the diplexer circuit. On the other hand, the dispersion should be very nearly the same for every antenna, and it should not be present in the visibility phase, which is the difference in phase for each pair of antennas.

b) The temperature dependence in the phase of a 10 MHz signal passing from the input to the 3-20 MHz port.

Measurements were made over the range 10C to 23C. The temperature coefficient was found to be .025deg/degC. Because the unit will be in an environment where the temperature is controlled to 0.1C (p-p), the maximum phase excursion should be less than .0025deg. The second LO at 1270 MHz is generated on the antenna from the 10 MHz, and it therefore will experience an excursion 127 times greater. Including a factor of sqrt2 for the two units, we find an expected excursion of 0.5 deg (p-p) in the second LO phase due to temperature effects.

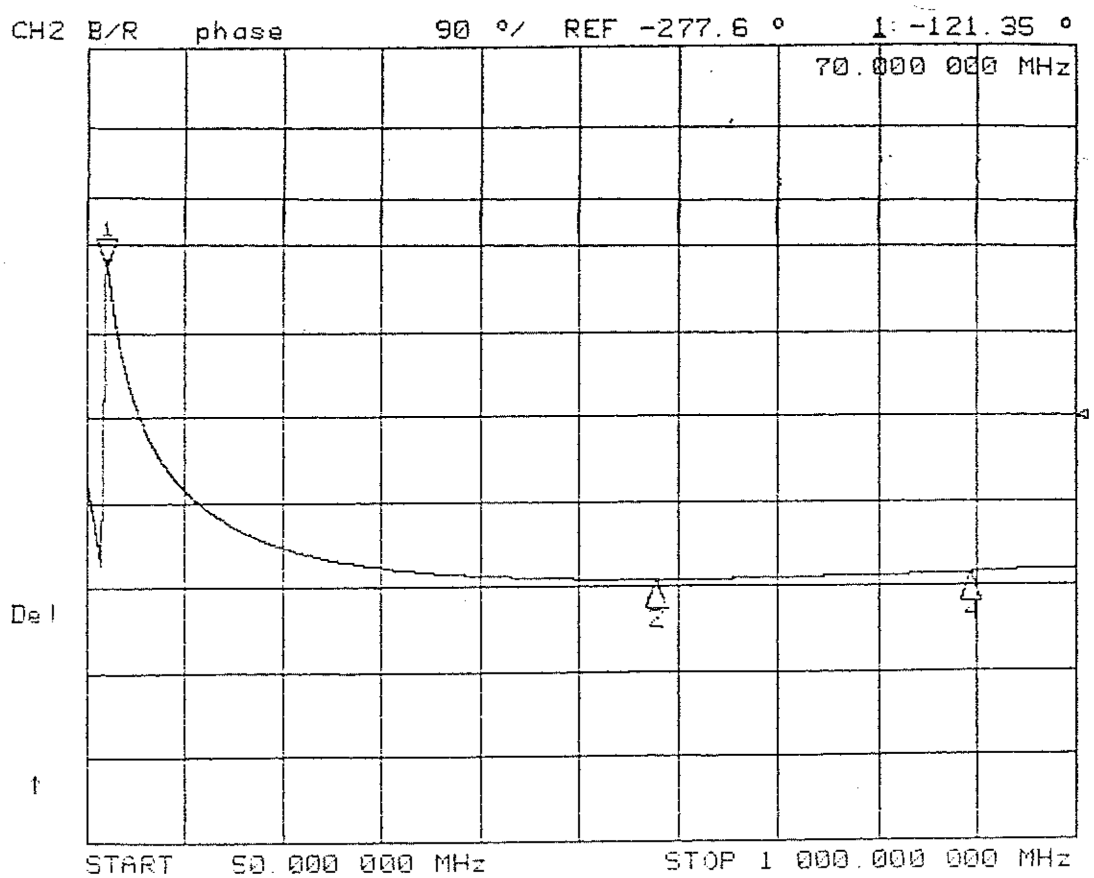

Figure 7

c) The temperature dependence of delay through the IF port was found to be less than one picosecond over a temperature change of 10C.

d) Cross talk between the telemetry (0-3MHz) port and the 10 MHz (3-20 MHz) port.

Figure 8 shows the transmission between these ports to be -68.4 db at 10 MHz.

The principal interference will occur at the antenna where the telemetry is stronger and the 10 MHz is weaker.

Signal: The 10 MHz leaves the laboratory at +8dbm and arrives at the antenna at +2.4 dbm.

Noise: The telemetry signal is sent from the antenna at +13 dbm and is measured to have -30 db sidelobes at 10 MHz, that is, -17dbm at 10 MHz in the 0.25 MHz BW of the second LO lock loop. Including the -68.4 db crosstalk of the filter, we find a noise level of -85 dbm /0.25 MHz of telemetry added to the 10 MHz.

Sig/Noise: This is 2.4 -(-85) = 88 db

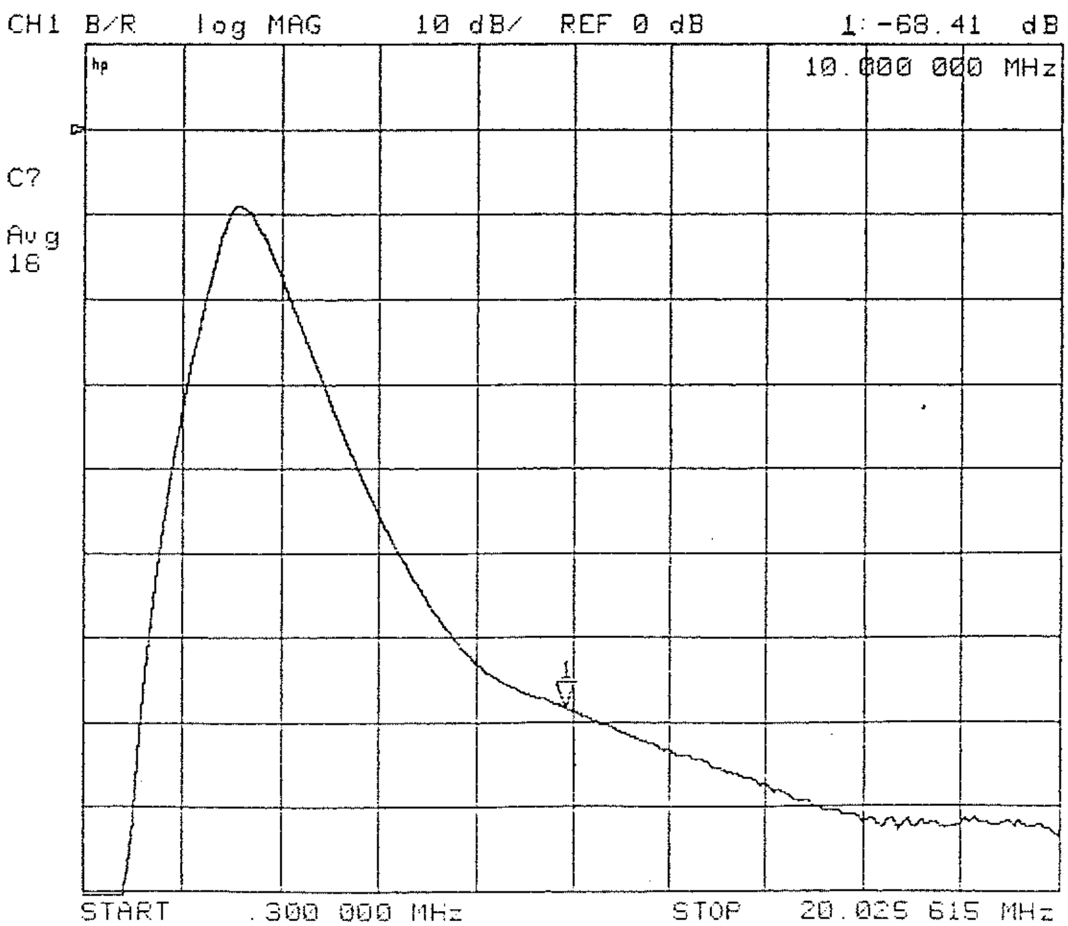

Figure 8

The 10 MHz is used, in part, as the reference for the 1270 MHz second LO. The multiplication of 127 degrades the S/N of the reference by $(127)^2$ or 42 db.

The final S/N is 88 - 42 = 46 db, which is more than adequate.

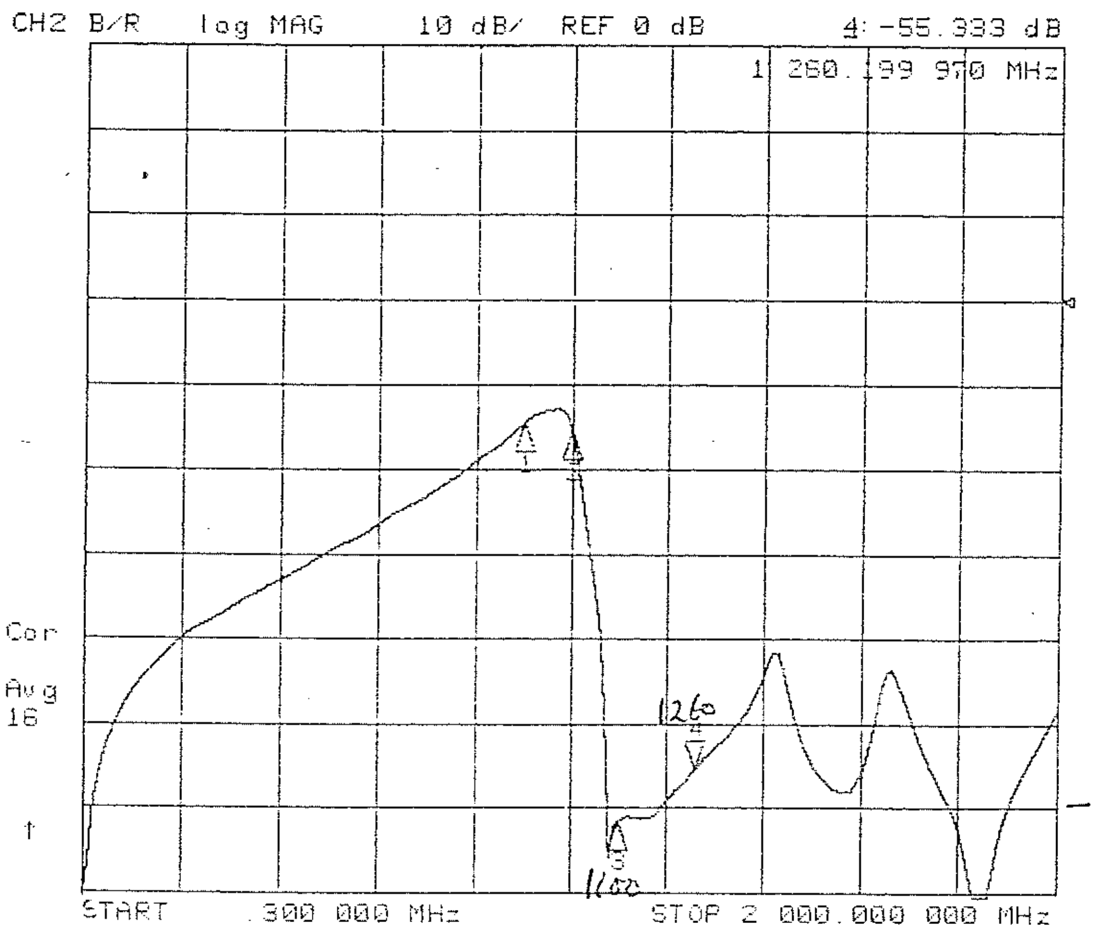

Figure 9

IV. Some properties of the BandPass/BandStop filter, including crosstalk and temperature stability.

a) Temperature dependence of the transmission phase between the input port and the 1100-1260 MHz port.

Measurements were made in the range 18C to 23C at 1180 Mhz. The gradient was found to be 0.16deg/degC. With the temperature variations within 0.1C (p-p), the phase variation is expected to be 0.016deg (p-p). For operation at 240 GHz, the reference is multiplied by about a factor of 200, which gives an expected phase fluctuation of about 3 deg (p-p) for one filter or 5 deg for both filters. With the planned feed forward installed in the two regulators, this number will be reduced to about one deg of phase fluctuation at 240 GHz, which is adequately small.

b) The transmission between the 0-900 MHz port and the 1100-1260 MHz port.

This transmission is shown in Figure 9. It is less than -55 db at any point in the band.

A potential problem is the coupling of the output noise of the main IF amplifier on the front end into the reference port (1100-1260 MHz). The measured output noise of the IF amplifier in the 1100-1260 band is -97 dbm/MHz. This is 17 db greater than the thermal noise of a 300K resistor. The 55db minimum isolation of the filter reduces this noise to -152 dbm/MHz, 38 db below the noise of the 300K resistor and therefore negligible.