

NATIONAL RADIO ASTRONOMY OBSERVATORY  
VERY LARGE ARRAY PROJECT  
CHARLOTTESVILLE, VIRGINIA

VLA ELECTRONICS MEMORANDUM #130

Front-End to LO/IF Interface Tests

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This memorandum briefly describes results of testing Front-End Rack A1, IF/LO Rack B2, and Modules T1 and T2 of the Control Room Rack E2 during the period February 22, 1975 until March 20, 1975.

A. 2-4 GHZ LO INTERFACE

The loss between the rack B2 N connector output and the OMQ input of Frequency Converter D was measured to be 1.5 dB at 3 GHz. The power level delivered to the Frequency Converter was +11 dBm to +15 dBm which is well within the +7 to +17 dBm limits for proper operation. No problems were noticed in this interface.

B. LO RFI GENERATION

The Front-End Rack with open waveguide input picked up RFI from the LO Rack at 4800 MHz and at many frequencies in the 1 to 2 GHz ranges. Tests were then conducted with an HP 8555 Spectrum Analyzer connected to a WR650 waveguide-to-coax transition as an antenna. All module covers were installed and the following levels were measured at ~1 meter from the rack:

FREQUENCY	SPECTRUM ANALYZER LEVEL (DBM)	POWER DENSITY* $Wm^{-2}$
1000	-90	$10^{-10}$
1200	-80	$10^{-9}$
1400	-90	$10^{-10}$
1800	-80	$10^{-9}$
4800	<-90 (None Detected)	< $10^{-10}$

\*Assume the transition has 5 dB gain and a collecting area of  $.01 m^2$ .

The effect of these signals can be determined by examining Figure 2A of VLA Electronics Memo #129. When the system is tuned to the frequencies near 1400 MHz or 4800 MHz the RFI must be  $\leq 10^{-16}$  and  $3 \times 10^{-15} \text{ Wm}^{-2}$ , respectively, in the vicinity of the feed horn. Assuming 20 dB attenuation from the vertex room to the feed, 40 dB reduction in level is needed at 1400 MHz and 25 dB or less is required at 4800 MHz.

The 1000, 1200, and 1800 MHz signals are not strong enough to overload the paramp or pass through the band-edge of the 50 MHz bandwidth IF filter. However, it is recommended that the radiated level be reduced by 20 dB to prevent in-band RFI by cross-modulation with other RFI.

The 1200 and 1800 MHz RFI appeared to come from L2 and L3 modules while the 1000 and 1400 appeared to come only from L2.

### C. IF TRANSMISSION S/N

TRG Modems with poor diodes (the only ones available) were used in the tests. The results are best illustrated by Figures 1 and 2 which show the received (at control-room) spectrum with 60 dB and 50 dB of simulated waveguide system attenuation. At 60 dB attenuation the S/N for all 4 IF bands is  $\sim 11$  dB independent of IF drive power (N is determined from noise level at 1500 MHz; Front-End S/N is 31 dB at this point). At 50 dB attenuation the S/N is 14 dB with no IF drive attenuation and 21 dB with 10 dB of IF drive attenuation. The S/N is thus poorer at high drive level due to mixer intermodulation noise; for this particular mixer the best IF drive level is with 10 dB inserted between racks. (The power level delivered to the Rack B input N connector will be -29 dBm per IF; -23 dBm total and any required attenuator will be in T1).

The value of 21 dB S/N at 50 dB attenuation should be compared to the values of 31 dB (best case), 26 dB (typical), and 22 dB (worst case) at 50 dB total loss predicted in VLA Electronics Memo #120 Addendum. The modems must be improved by four dB to provide a minimum S/N of 16 dB at maximum system attenuation of 59 dB.

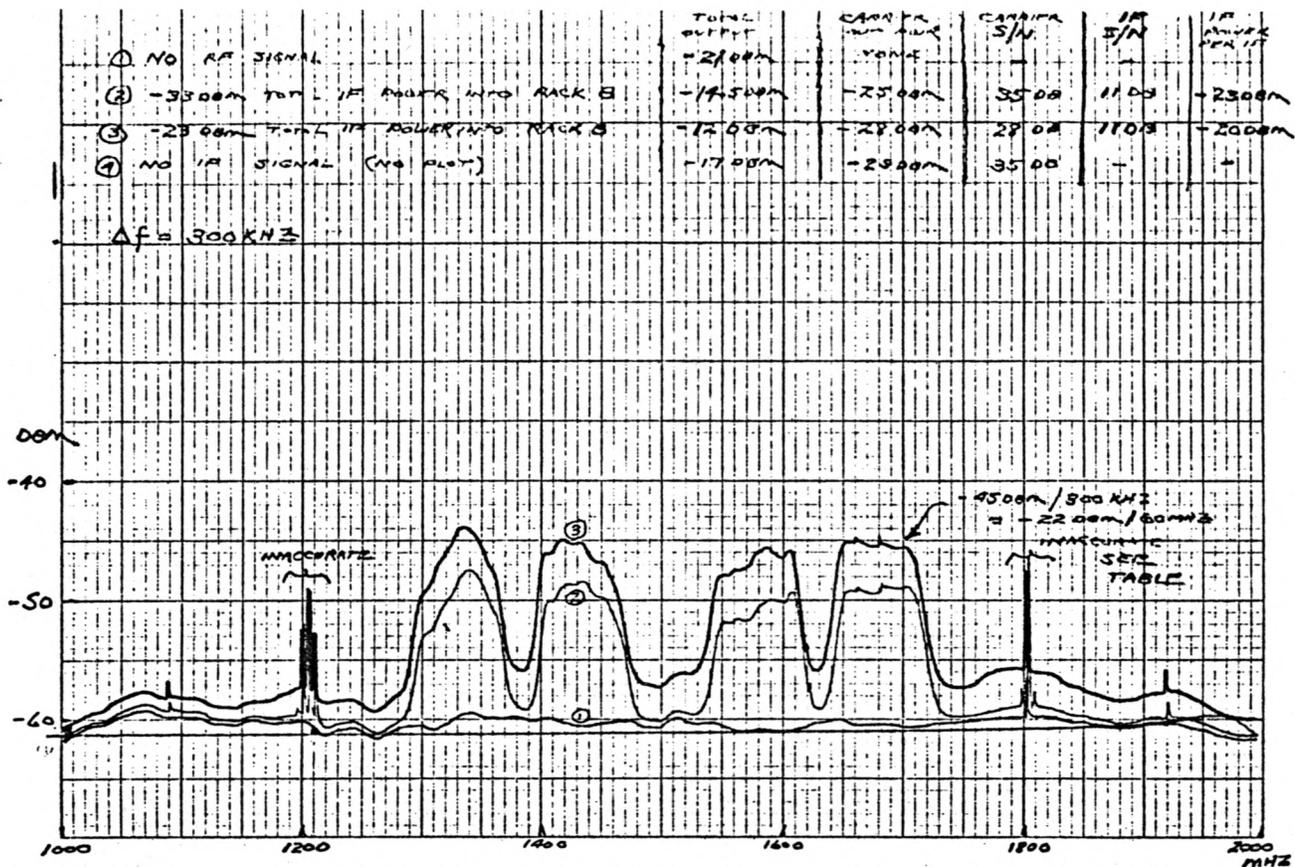


FIGURE 1. Output power spectrum for 60 dB simulated waveguide attenuation. The bands centered at 1325, 1425, 1575, and 1675 MHz are IF bands A, B, C and D respectively.

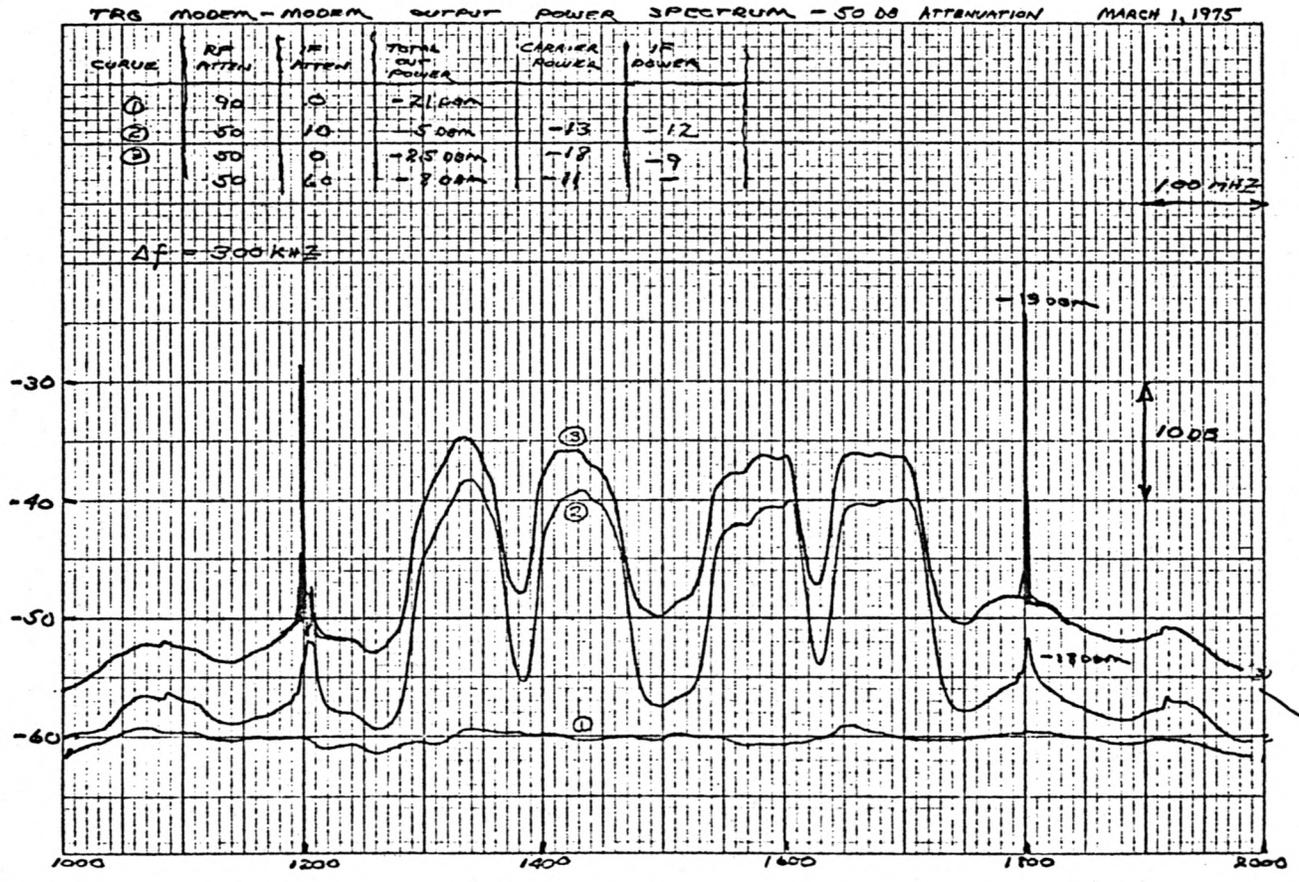


FIGURE 2. Output power spectrum for 50 dB simulated waveguide attenuation.

D. LO TRANSMISSION S/N

The S/N for the 1800 MHz LO carrier is shown in the spectral plot of Figure 3 for different values of IF drive power. At the IF drive power which optimizes IF S/N the LO S/N is 47 dB for 100 kHz noise bandwidth. For 600 MHz phase transmitted to the antenna the effective bandwidth is 500 Hz ( $\sim 1$  ms integration time) and the resulting S/N of 70 dB will contribute less than  $.02^\circ$  rms phase jitter. For 5 MHz sidebands down 10 dB from the 1200 MHz carrier the S/N is 7 dB worse to give  $.05^\circ$  rms phase jitter at 5 MHz. The tolerable jitter is  $0.2^\circ$  rms so the LO S/N is 12 dB greater than required. For LO signals transmitted from antenna to control room the integration time is 50 times greater and the S/N margin is 29 dB. These S/N are at 50 dB loss

The spectrum of the 1800 MHz LO carrier modulated with a 300 kHz square-wave is shown in Figures 4, 5 and 6 with progressively higher resolution. This square-wave simulates applied digital data modulation. The main result, shown in Figure 6, is that the applied modulation has no effect on the spectrum close to the 1800 MHz carrier; this is a necessary condition for non-interaction between LO and digital data transmission. Also note in Figure 6 that the LO S/N is 61 dB per 500 Hz noise bandwidth within 10 kHz from the carrier. This S/N was present at the modem input and is a property of the 5 MHz oscillator and multiplier chain; it is not deteriorated by the 70 dB S/N in the modem link.

In Figure 4 the 5 MHz modulation transferred from the 1200 MHz carrier is noted to be 30 dB below the carrier. It should also be noted that the first 300 kHz sideband-to-noise ratio is  $\sim 30$  dB for 1 MHz noise bandwidth; this is more than adequate for digital data transmission.

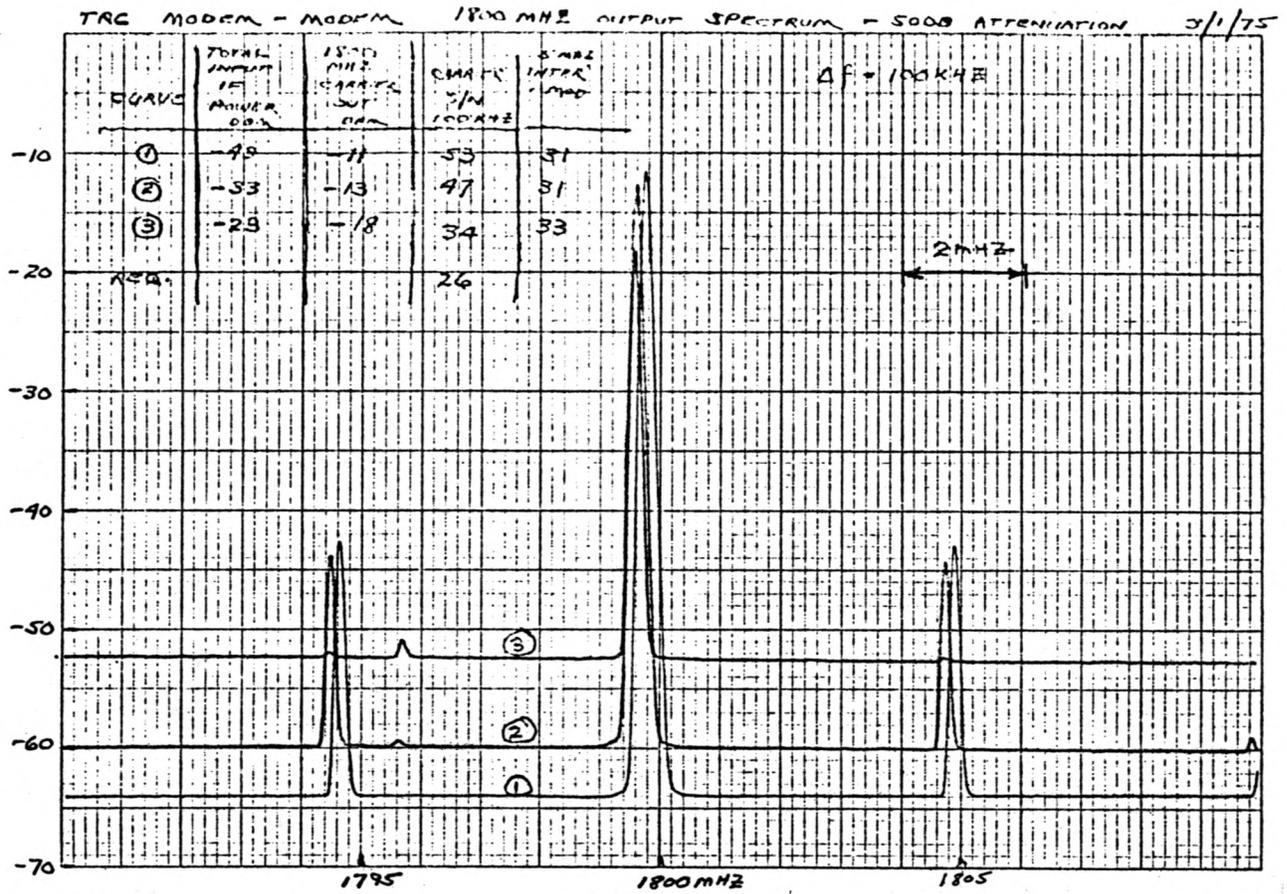


FIGURE 3.

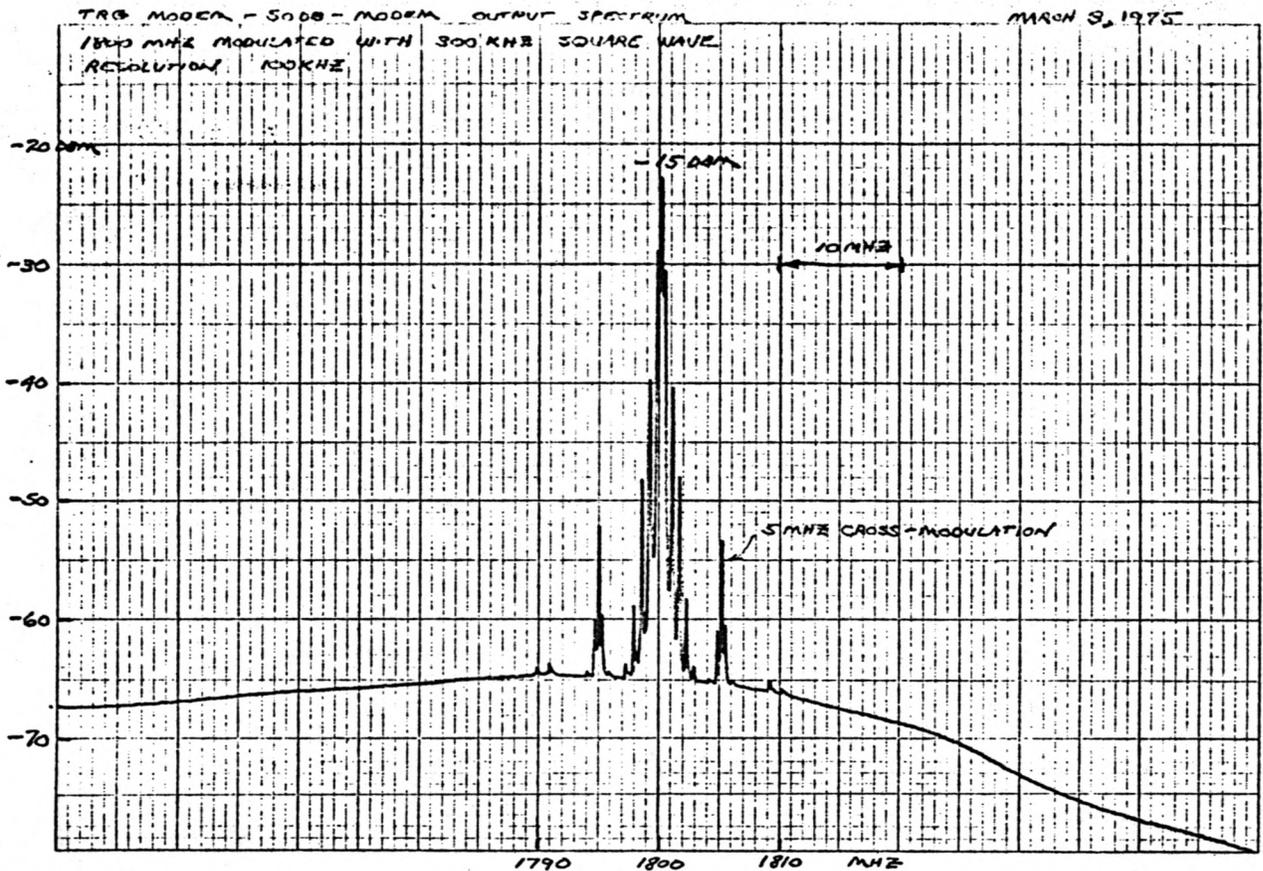


FIGURE 4.

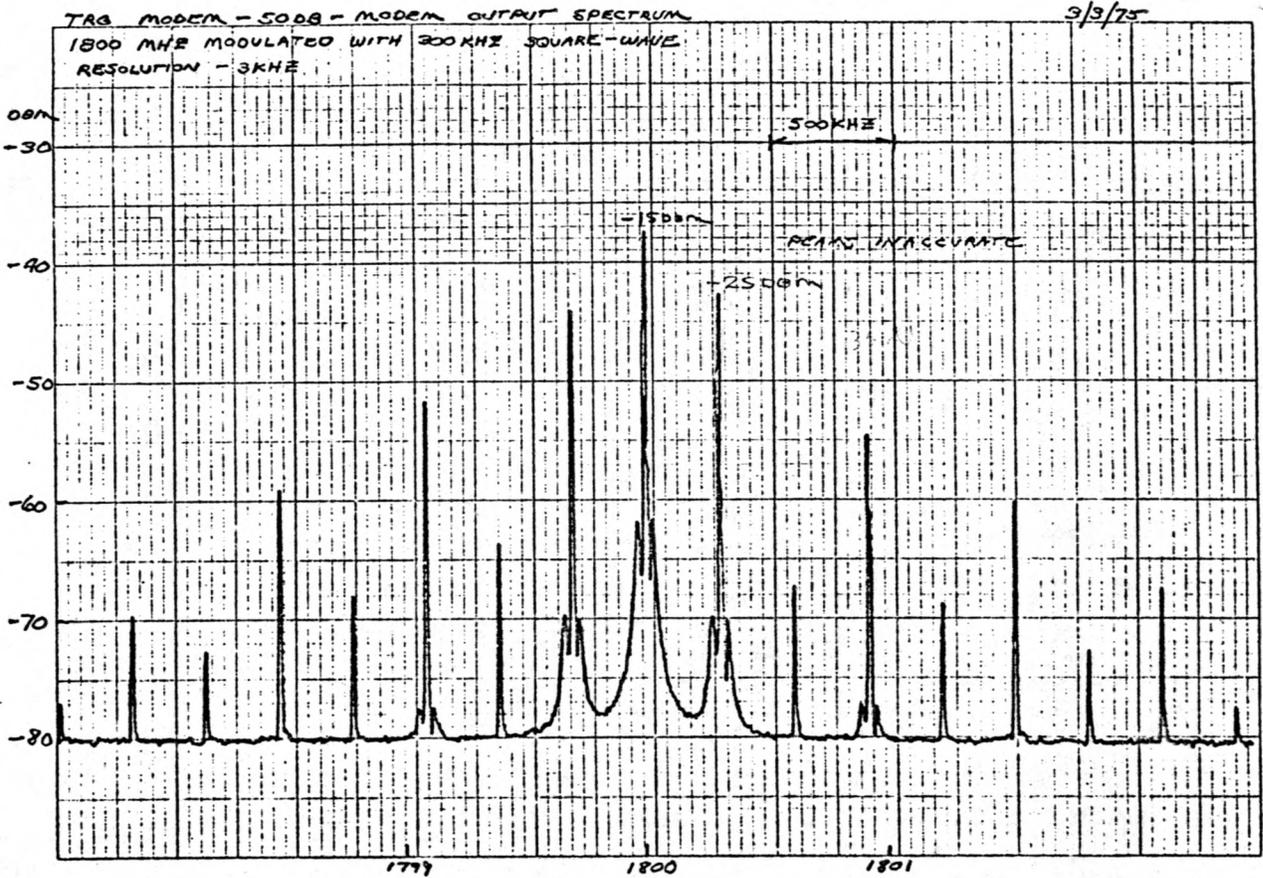


FIGURE 5.

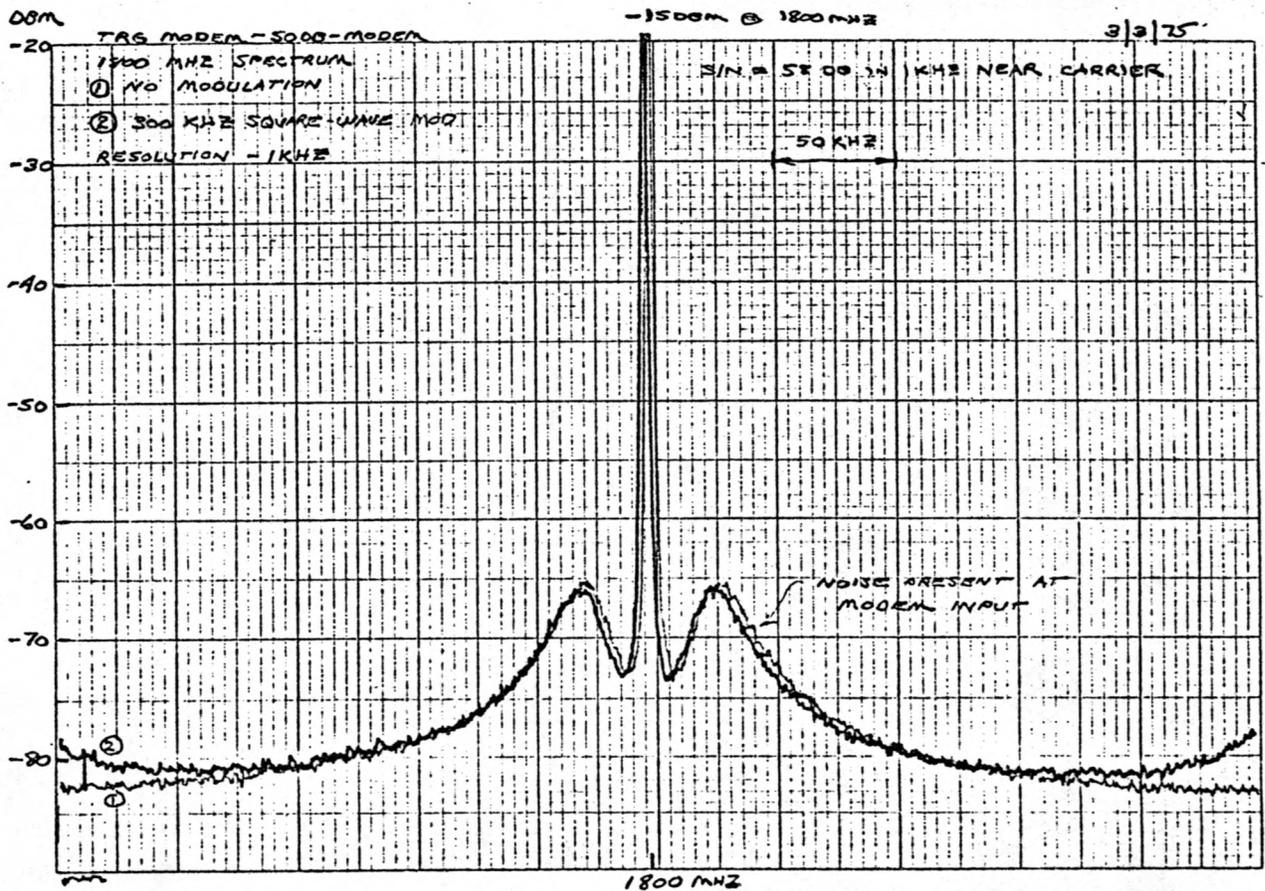


FIGURE 6.

E. PHASE AND AMPLITUDE RESPONSE

The phase and amplitude response of the IF Transmission System with varying amounts of simulated waveguide attenuation is shown in Figure 7. Within a 50 MHz band 3 dB of amplitude variations and 4°rms phase departure from linear can be seen. These variations are excessive; values of 1.5 dB and 2°rms are required. The causes of the ripple and its improvement is being investigated.

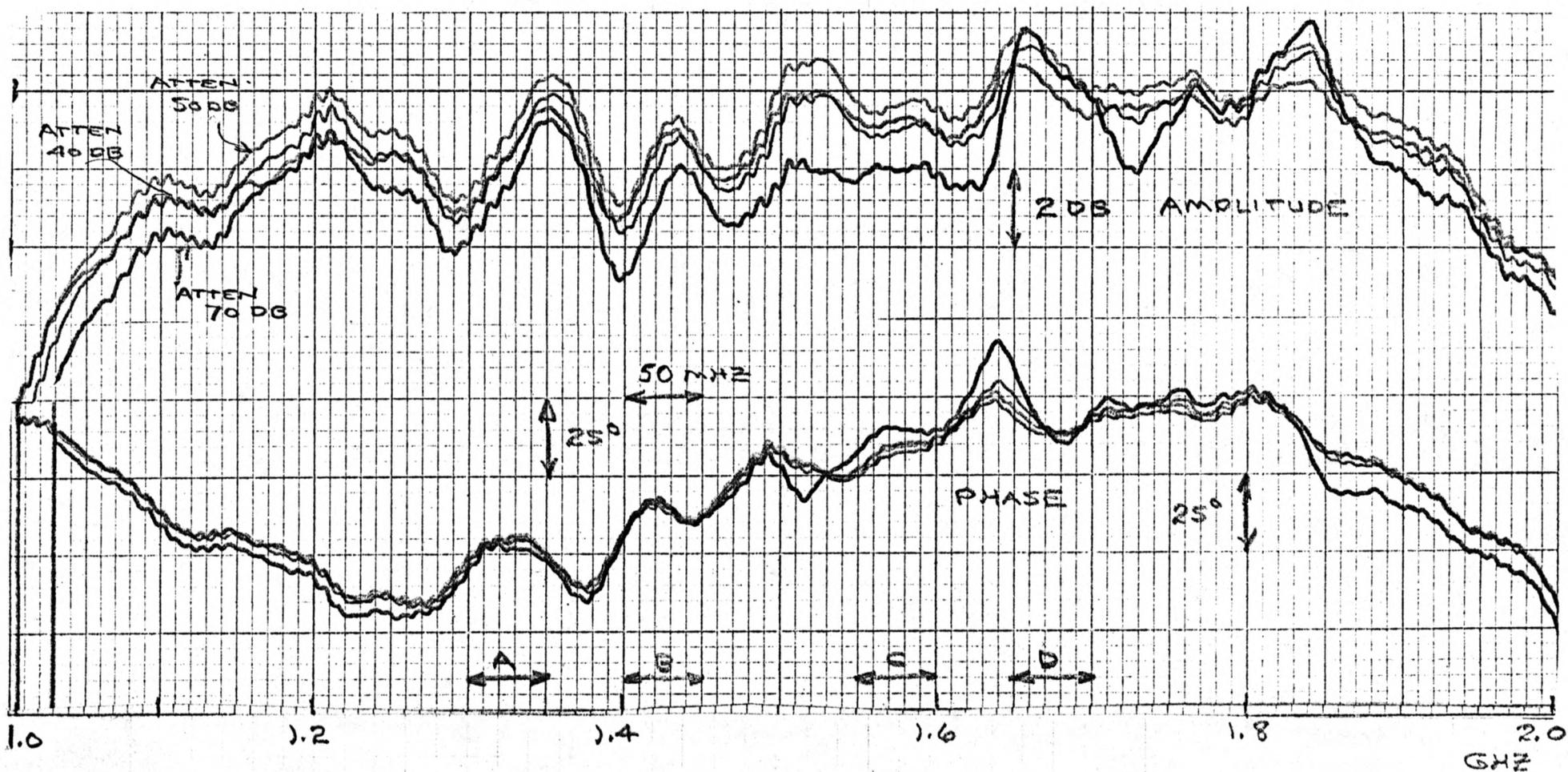


FIGURE 7. Phase and amplitude response of IF transmission system. Modules T2A2, T1A1, AlB2, and T2A1 were connected in cascade.