VLA VHF-refit Test Memo # 1

From: Lincoln Greenhill
Re: Bench performance of prototype receiver systems P1, P2
Contributors: E. Tong, R. Kimberk, S. Leiker, R. Blundell
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Each first generation prototype VHF receiver system comprises three major components: (1) a crossed dipole assembly, (2) four stand-offs that permit the VHF dipole assembly to be clamped to and positioned below the existing VLA P-band dipole assembly, and (3) a receiver module designed for mounting in the barrel cabin.

Crossed Dipole

Tuning peak: 194 MHz

The dipole arms are approximately λ/4 in length and are optimized for 194 MHz. The actual length is somewhat shorter to account for actual performance after assembly. The central hub contains two Collins-type baluns, one for each dipole. When mounted on a VLA antenna, these are connected to the receiver modules via LMR-300 coax that is threaded through the balun and support structure of the P-band dipole assembly into the barrel cabin. The lengths of these cables has been minimized so that as little system noise as possible will be introduced.

Stand-offs

The stand-offs are made of PET. Each consists of two pieces with C-shaped cutouts that cradle the VHF and P-band dipoles. When the two pieces are screwed together, side-by-side, they clamp the dipoles, The separation is ~ 15 cm. Each stand-off requires two screws. When loose, the stand-offs can be slid over the ends of the dipoles. *Lab testing of P-band performance when the VHF dipoles are in place shows that the stand-offs should be places as close to the center as possible.*

Receiver Modules

The receiver modules are manufactured for mounting on the backside of the plates to which the P-band receiver modules are attached. The same model enclosure is used for both receivers so that mounting holes are aligned. Each enclosure is wired to accept 15VDC supply and noise diode control signals, as well as to pass these through to the P-band receiver module so that one supply and one control line may be used for both receivers. A pass through is also included to enable daisy chaining of P-band and VHF RF output.

Each enclosure contains two 2-sided circuit boards. The first is temperature regulated and serves the LNA and Q-hybrid. The second contains unregulated post-amplifiers. In the prototype design, two post-amps, can be accommodated, but the total receiver gain is sufficient if only one post-amp is used. The nominal bandwidth is 178.3-208.3 MHz, defined by the TeleTech HT44-28 Q-Hybrid, though the matching of system components and dipole response are optimized over just ~ 10 MHz around 194 MHz. The output power is –67 dBm over 30 MHz.

Required Dipole Orientation and Definition of Polarization

If receiver input 1 is connected to balun 1 and the horizontal dipole, and input 2 is connected to balun 2 and the vertical dipole, then receiver output channel A will be RHCP (astronomical definition) and channel B will be LHCP (astronomical definition).

At the feed point for each dipole, the center conductor of a balun is connected to one arm of the dipole and the balun shield is connected to the other arm of the dipole. For the sake of argument, we just consider the center conductor side as the "positive" side. We define the positive arm of dipole 2 to be located counter-clockwise from the positive arm of dipole 1, if we look at the crossed dipoles from the far-field (i.e., primary dish) side. The identification of the baluns follows that of the dipoles, which will be marked. In this configuration, if we consider the positive arm of dipole 1 the positive x-axis, then the positive arm of dipole 2 is the positive y-axis.

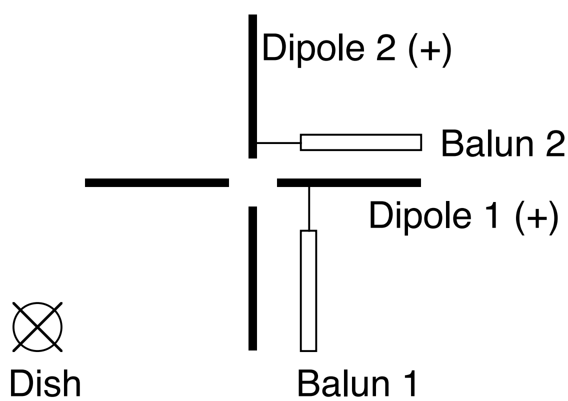


Figure 1—Dipole layout and definitions necessary to define LHCP and RHCP at the receiver output. The horizontal dipole is number 1, and the arm to which the balun central conductor is attached is to the right *when viewed from the sky* and to the left *when viewed from the dish surface*.

Receiver Bench Performance

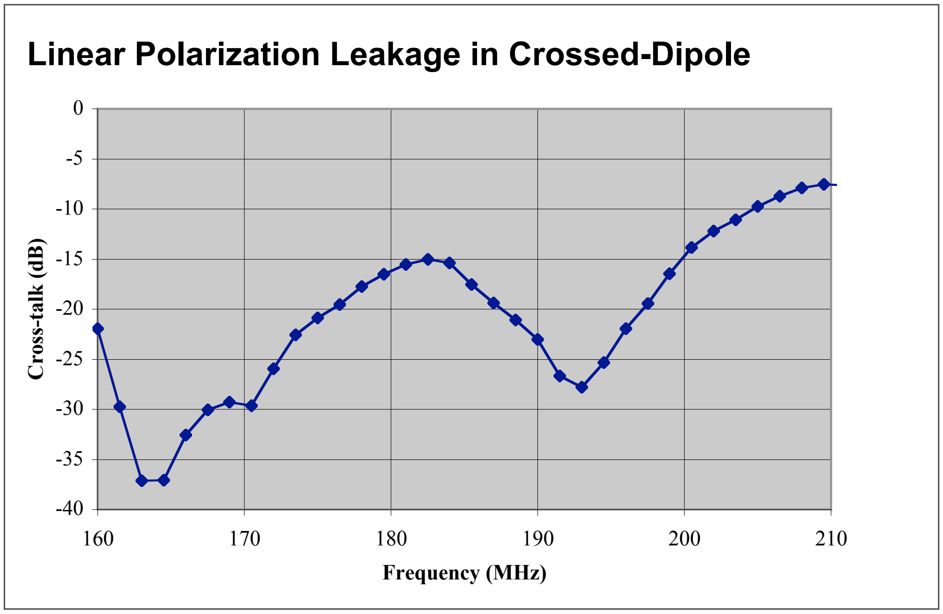


Figure 2— Polarization leakage measured at the balun output for an incident 100% linearly polarized signal.

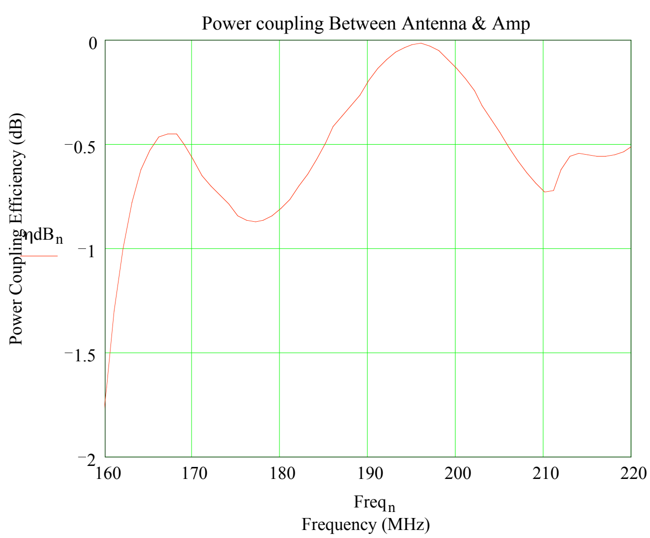


Figure 3— Coupling loss between VHF antenna and LNA. The useful bandwidth of the prototype system is 178-208 MHz, but key science requires 186-202 MHz, over which the loss is < 0.3 dB.

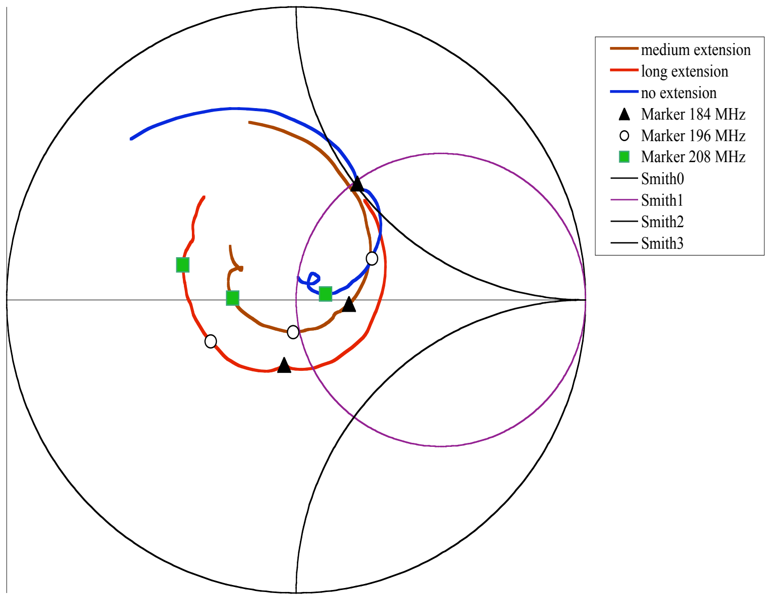


Figure 4—Smith chart showing the input impedance of the VHF dipole assembly. The brown trace (also second from left) corresponds to the dipole length used for prototyping.

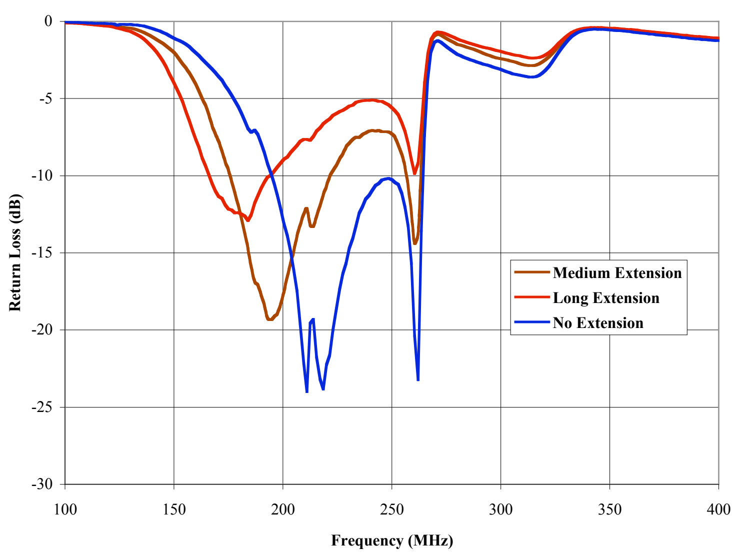


Figure 5— Input match and return loss looking into the output of the balun. Each trace shows a different trim on the dipole length. Over the bandwidth required for key science, 186-202 MHz, the return loss is < -15 dB (brown or middle trace).

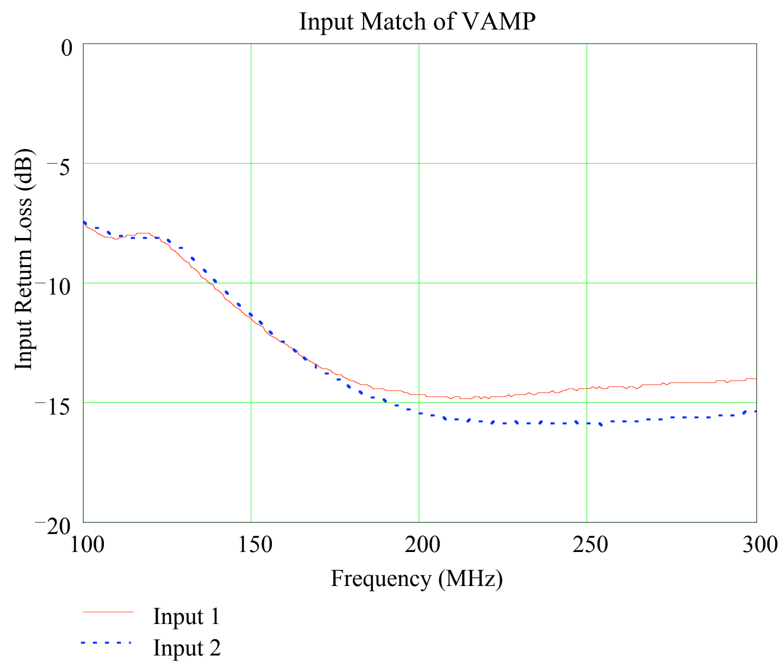


Figure 5—Return loss at input of receiver prototype 1.

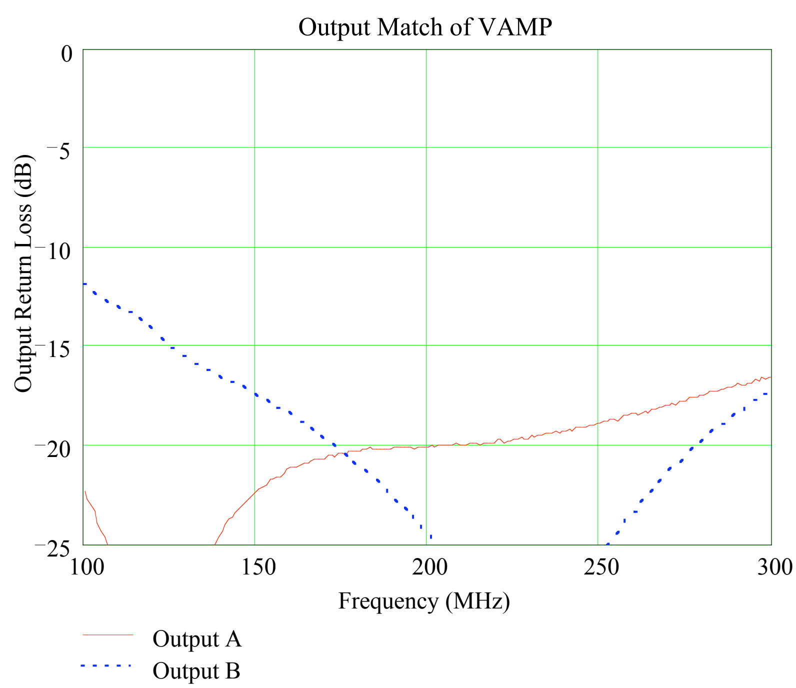


Figure 7—Return loss at output of receiver prototype 1.

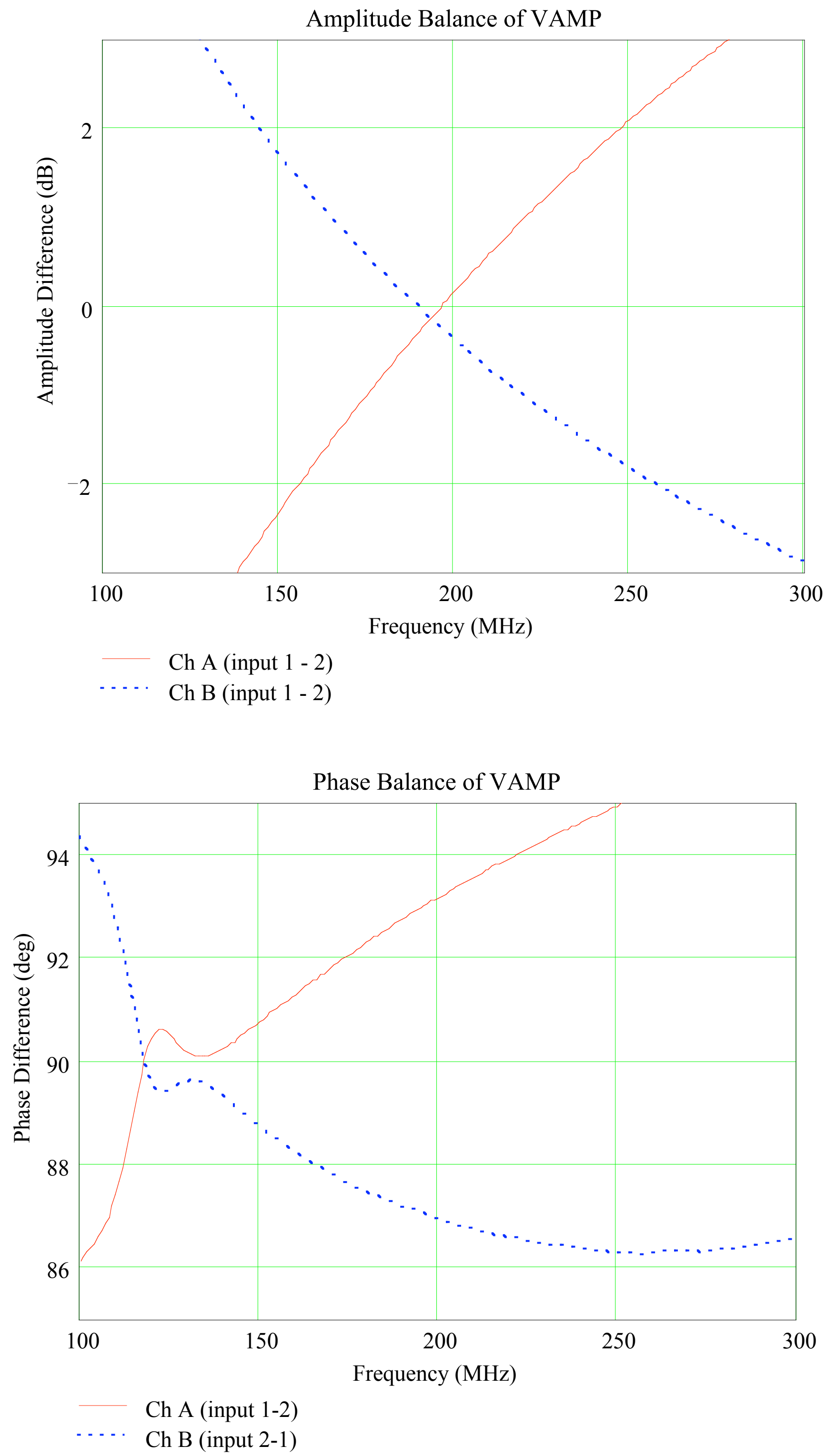
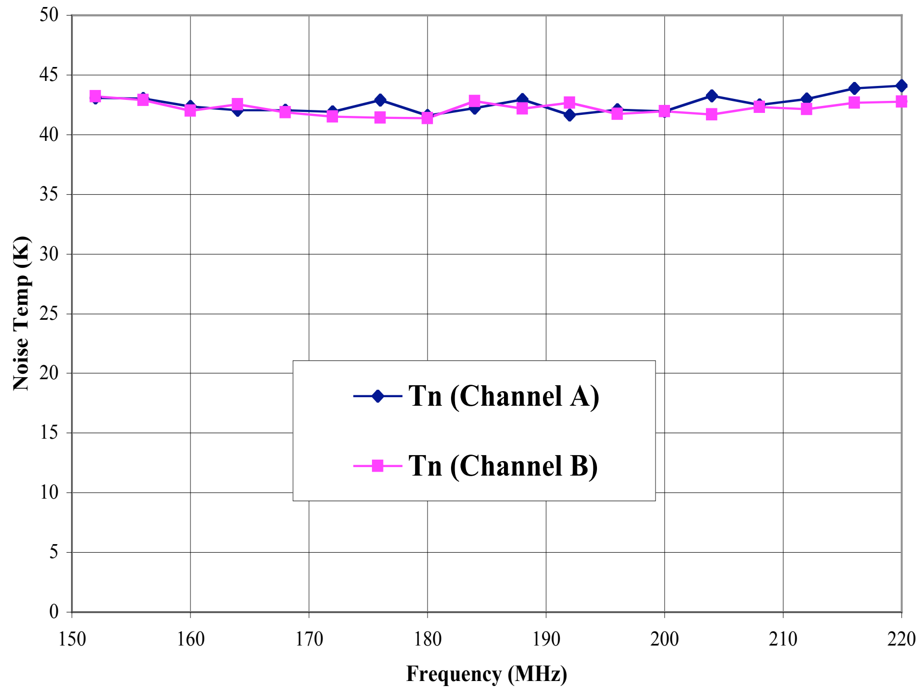


Figure 8—Amplitude and phase balance of receiver prototype 1. The nominal balance should be 0 dB and 90°.



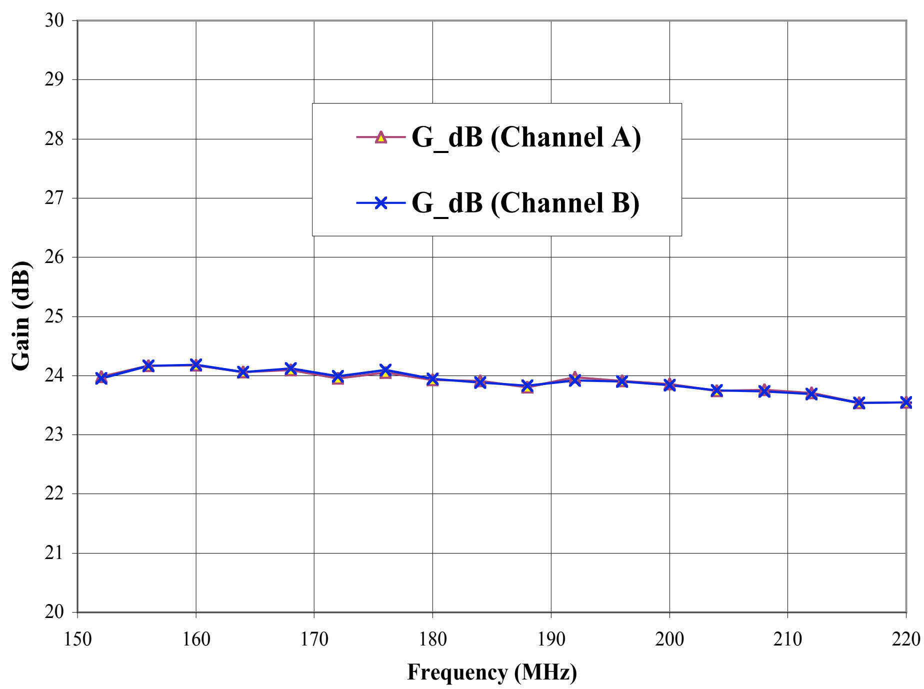


Figure 9 – Noise temperature *(top)* and gain *(bottom)* of prototype 1.

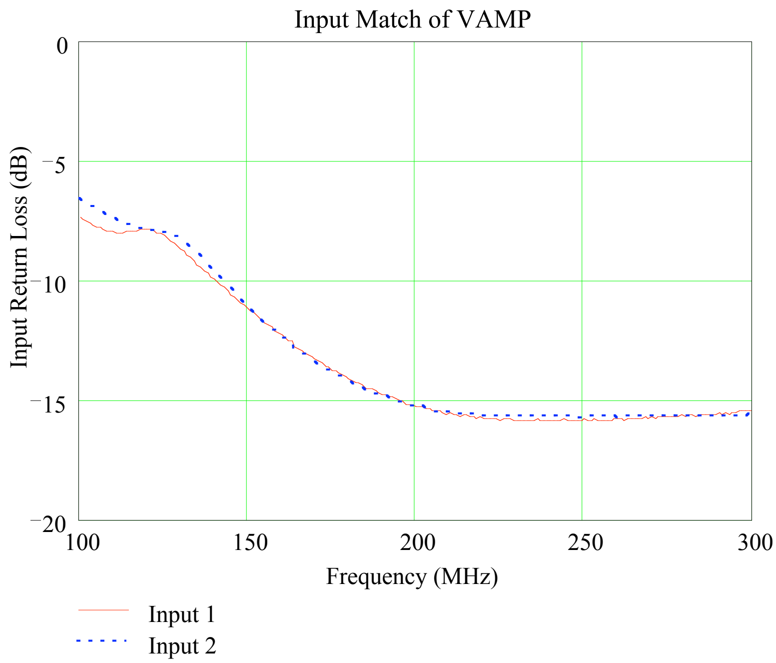


Figure 10—Return loss at input of receiver prototype 2.

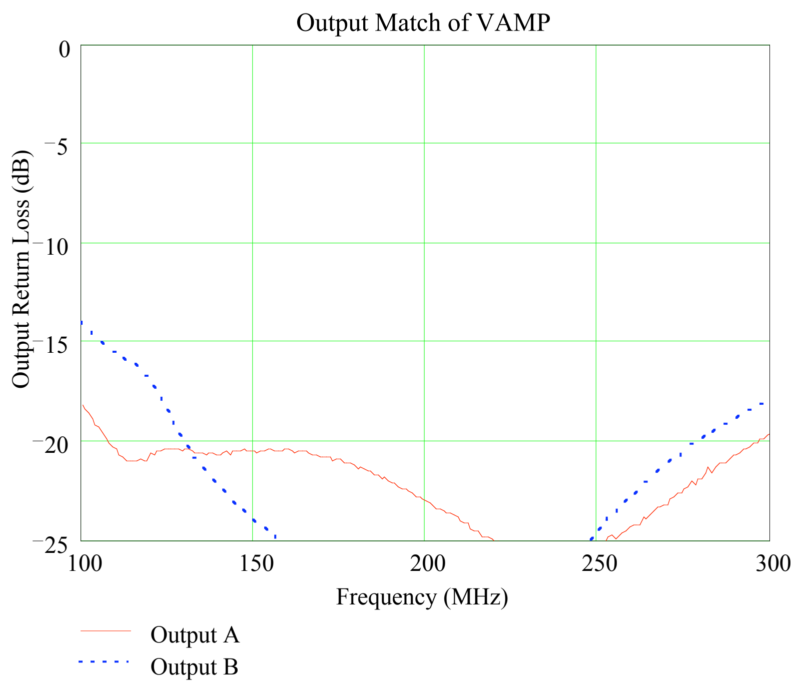
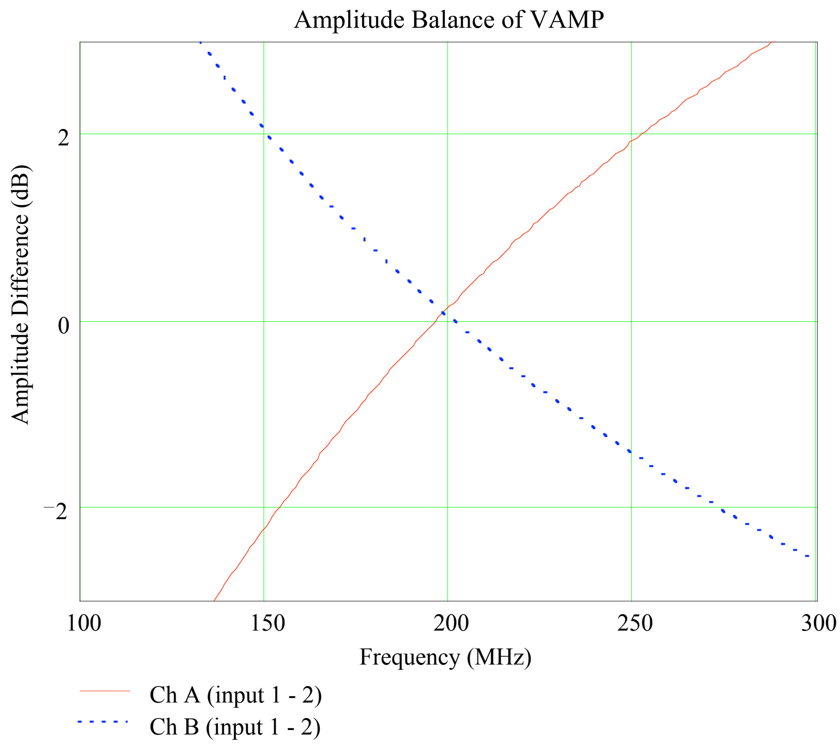


Figure 11—Return loss at output of receiver prototype 2.



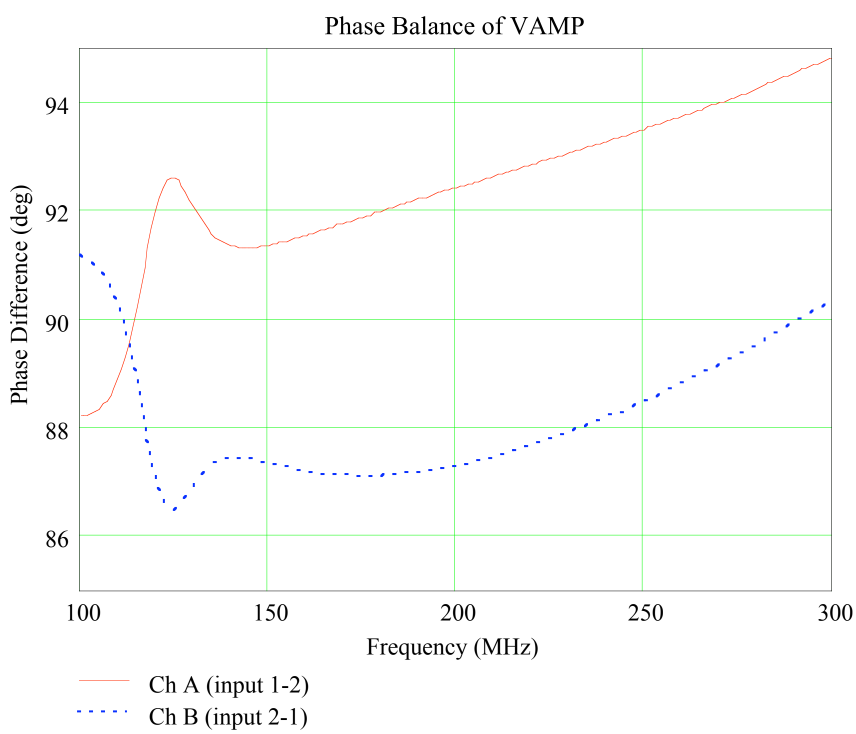
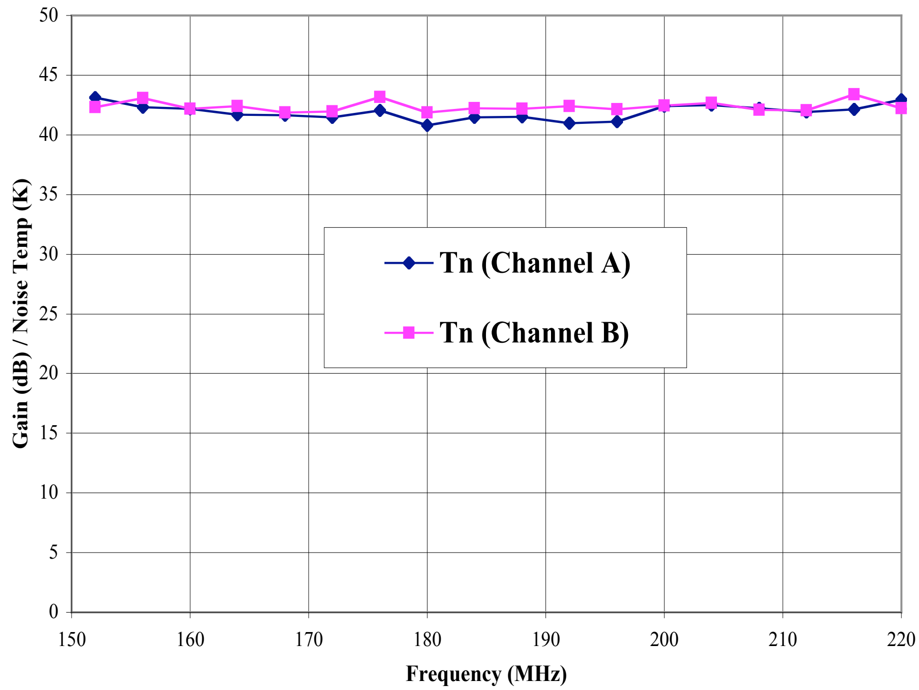


Figure 12—Amplitude and phase balance of receiver prototype 2. The nominal balance should 0 dB and 90°.



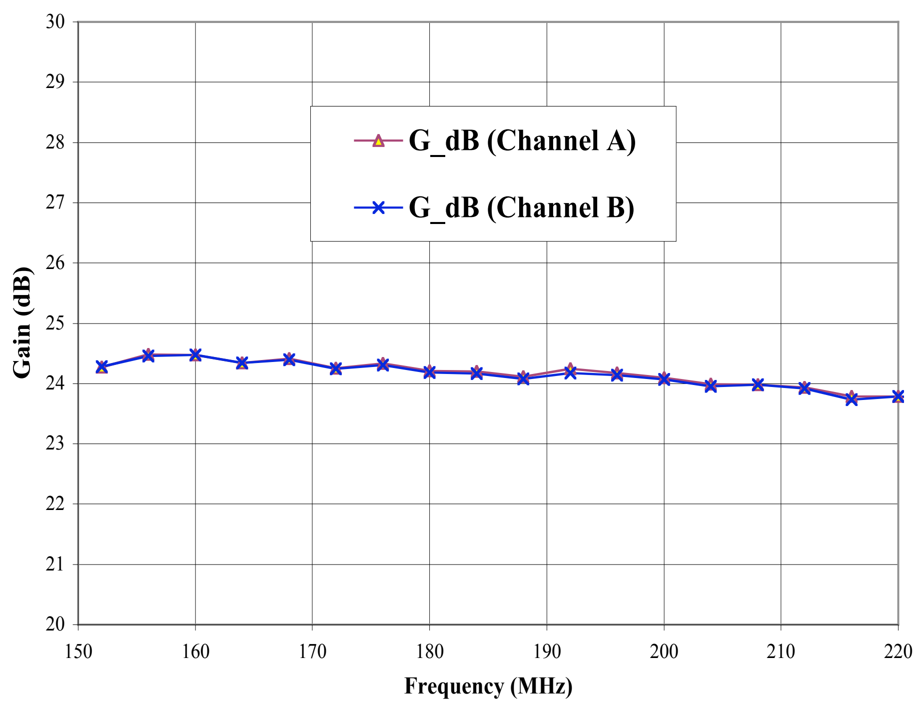


Figure 13 – Noise temperature *(top)* and gain *(bottom)* of prototype 2.

Impact of the VHF dipole assembly on P-band system performance

Early lab testing showed degradation of P-band forward gain (on axis) of 0.3-0.7 dB across a 300-340 MHz band when a VHF dipole was placed infront of a P-band dipole assembly. When a full VHF dipole assembly was clamped-on, the degradation was worse. This holds whether the VHF dipoles are loaded or left open at the balun output. However, when the VHF dipole is shorted at the balun input, the forward gain of the P-band assembly is improved, as shown in Figure 1. The VHF assembly appears to act as a director, which could improve illumination of the primary and improve overall P-band system performance. Field testing is required to test this hypothesis and to assess the impact on system noise.

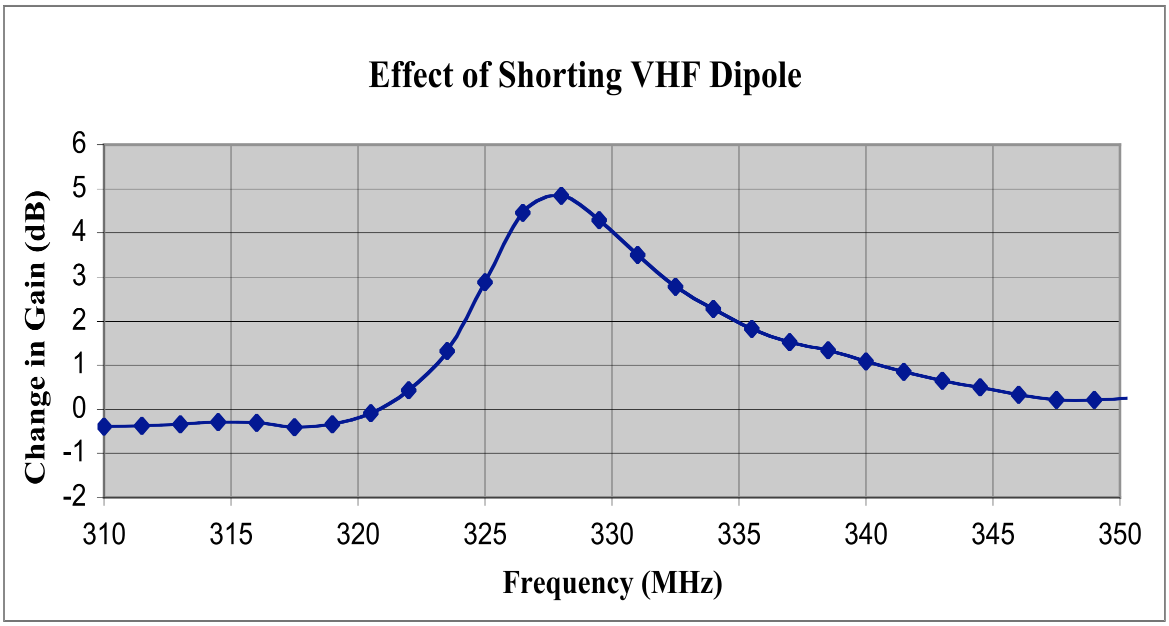


Figure 14 --Change in forward gain for a VLA P-band dipole assembly when a VHF dipole assembly is attached, with stand-offs placed as close as possible to on-axis.