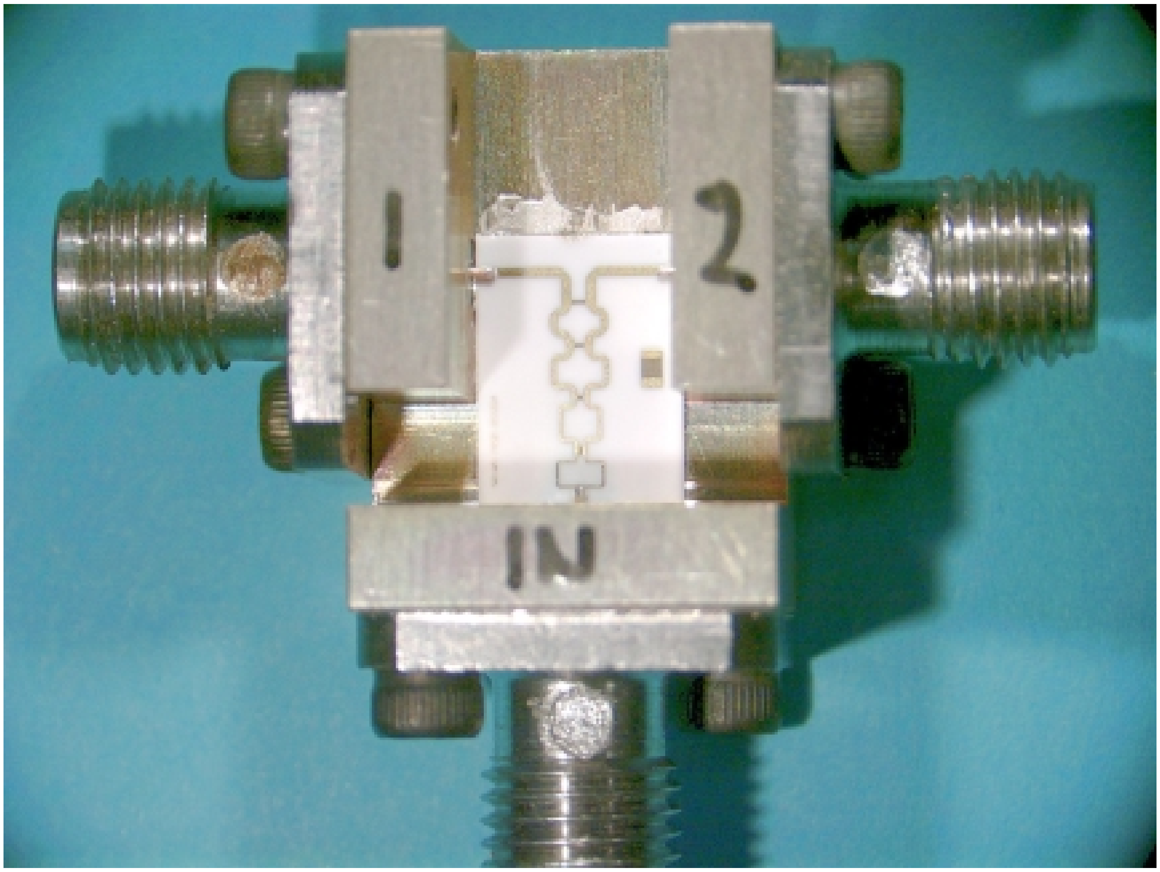
Maas 2-way Wilkinson Divider Measurements

A. Harris 28.8.01

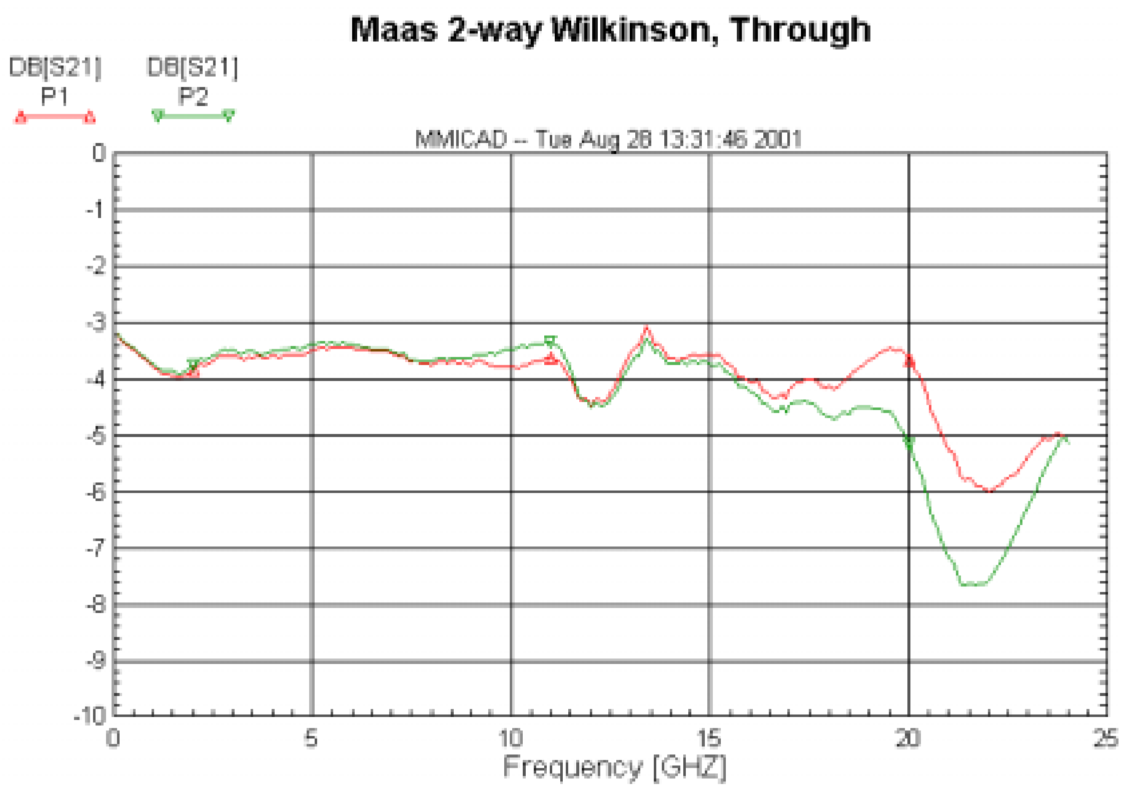
Assembly

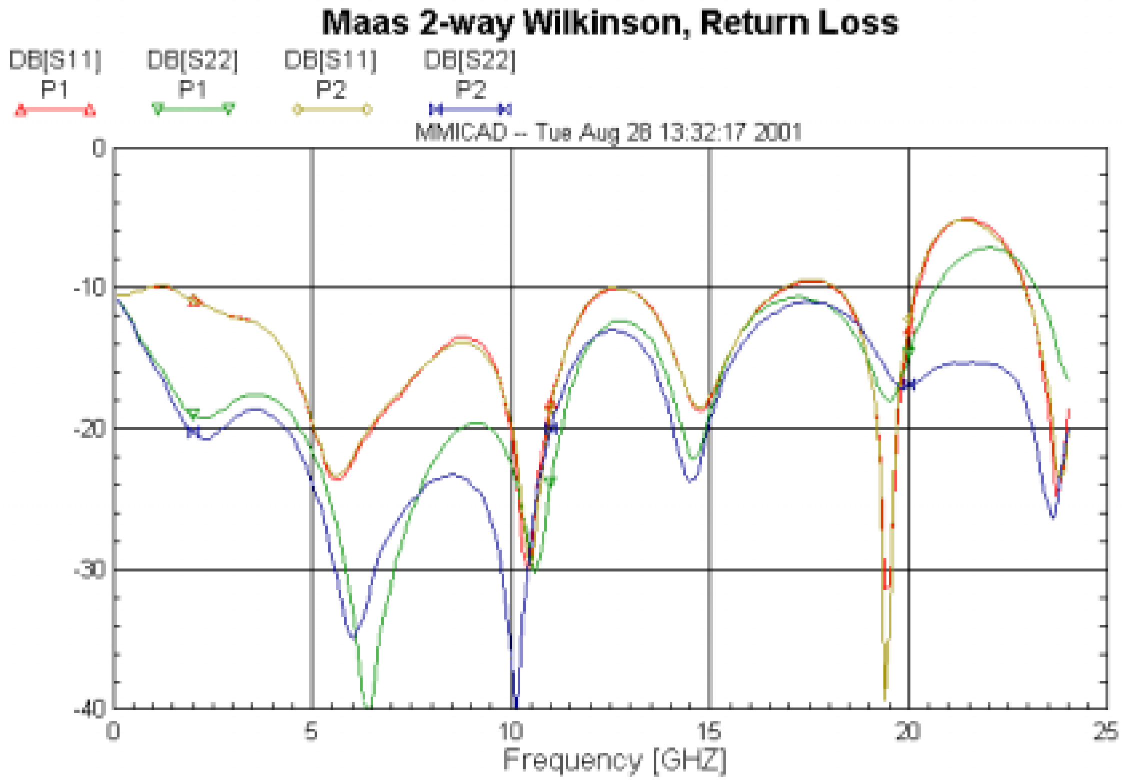
So far I’ve only assembled the 2-way divider (the 16-way divider holder was mis-machined). The holder is Iridite-coated aluminum, substrate attached with conductive epoxy across its ground plane, and SMA connector center pins attached with a drop of epoxy. The SMA connectors are Amphenol 901-9004-1 parts with a 0.086” diameter Teflon extension, 0.125” long, and a 0.010” diameter pin. I cut the pin length to about 1 mm past the Teflon end. The substrate fits in the aluminum holder with a few mils clearance on either side, just about right to account for the radius between the wall bottom and floor. A photo of the block is below with the input and two output ports marked.



S-parameter measurements

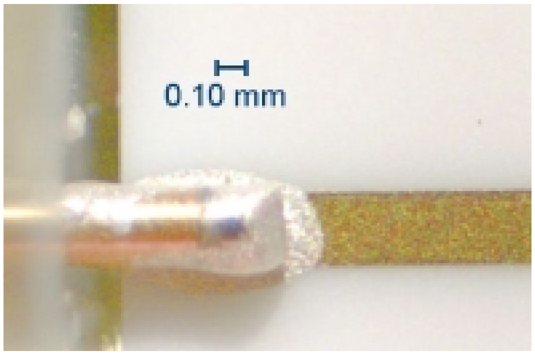
I used an HP8722D (0.05-40 GHz) vector network analyzer for the measurements. It was set up for a 0.05 to 24 GHz sweep with a full 2-port calibration on open, short, and broadband loads from the HP 85052D economy calibration kit. Adaptors on the network analyzer's 2.4 mm ports convert to the 3.5 mm test cables, with SMA adapters as semi-expendable ends of the test cables. The third port of the coupler was terminated with a Narda SMA termination with a measured return loss better than –20 dB across the band. The termination was not critical, and could be loosened during measurement with negligible change in any of the measured S-parameters until just before the center pin disengaged. The measurements are summarized below, with P1 and P2 denoting the two output ports marked in the figure above.



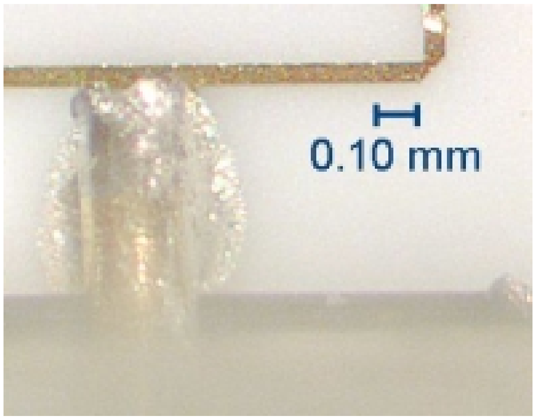


The return loss seems a little higher than I'd remembered from the prediction, so I made a few sanity checks for the setup: the Narda termination has a low return loss, and a TRM DMS265 2-26.5 GHz splitter has return loss within specifications (better than –15 dB) and S21 with slightly less structure.

It is possible I've got too much epoxy on the connector pins, especially at the input, as the two photos below show (I didn't take a photo of Port 2's pin, but it's nearly the same as Port 1's). The scale bars are close to right but perhaps not exact.



Port 1 pin



Input port pin

This was my first try with this kind of assembly, so I'm still finding the right amount of epoxy and a good way to apply it; in addition, I think that the epoxy flowed some during its cure (150° C for 1 hour). The higher reflection may not be the epoxy alone, since there are some few-mil gaps between the substrate edges and walls, and the Teflon bead ends about 5 mils or so behind the wall.

On the other hand, the return loss seems high at lower frequencies as well as higher, and S22 for both ports are quite similar, so it may not be the transitions alone.

Radiation, surface waves
I made a quick check for radiation and surface waves by poking around with a ~1 mm^2 stick of absorber and by covering the cavity with metal. There are no strong effects; about 0.5 dB in S21 at 24 GHz at most. The most sensitive place for the absorber (other than directly on the lines) is just off the edge of the substrate at the output end, close to the output pins. A top cover excites a weak box resonance that affects the band above 22 GHz, but there is no effect from and end cap.

Conclusion
Overall, the coupler looks good. There is a minor wiggle in S21, but it's less than 1 dB; the low-frequency insertion loss is something like 0.5 dB, with about 1 dB of frequency-dependent slope across the band. The return loss is always better than –10 dB, but not lower. The main question at this stage is why the return loss is higher than I expected. Possible answers are:

1. I haven't remembered the correct return losses.
2. There is too much epoxy at the connector-microstrip transition, and this adds an unwanted section of low-impedance line at the inputs.
3. Something else is up with the gaps and other mechanical parts of the transitions, adding some extra inductance at the inputs (maybe the two cancel?).

A test of the full cascaded 16-way divider should answer many of these questions since we'll change the number of divider inputs and outputs while holding the number of transitions constant.

Files
The network analyzer files are in Touchstone format with 201 points and are titled:

sm2_p1.s2p – port 1 data
sm2_p2.s2p – port 2 data
dms265.s2p – TRM DMS265 splitter
nardaterm.s2p – Narda termination (S11 are only meaningful data)