4-8 GHz Petter 180 Hybrid for the Pbar Debuncher Pickup

Ed Cullerton
Beams Division / RF & Instrumentation

Abstract: This paper describes the circuit card, assembly, and measured results of the 4-8 GHz Petter hybrid used in the debuncher pick up tanks. The hybrid operates at liquid helium temperature inside the pickup tanks. The circuit enclosure was designed by trial and error to obtain the best measured results. Measurements were made at room temperature and at liquid nitrogen temperature. This hybrid was chosen due to its excellent amplitude and phase balance, good bandwidth characteristics, and excellent common mode rejection in difference mode.

Circuit Board

The top and bottom sides of the circuit board are shown in figs 1 and 2. The dimensions given are in inches to give an idea of the size of the circuit board. Photographs of the actual circuit board are shown in figs 3 and 4. The board is 31 mil Arlon CUCLAD 2.33 dielectric. The input lines are 88 mils wide, designed for 50 Ohms. A T-section combiner is used to sum the two input signals. After the T-section combiner, there is a two section stepped impedance transformer to bring the impedance back to 50 Ohms. The 20 dB coupled ports are a quarter wavelength at 6 GHz, and the spacing is 36 mils.

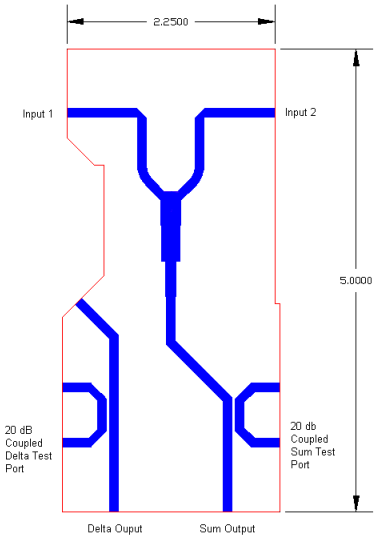


Fig. 1. Top side of the circuit board

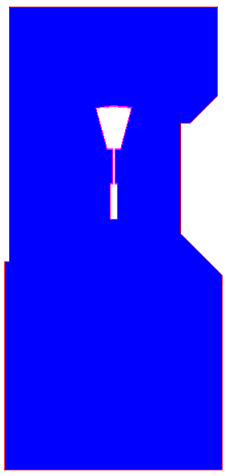


Fig. 2. Bottom side of the circuit board

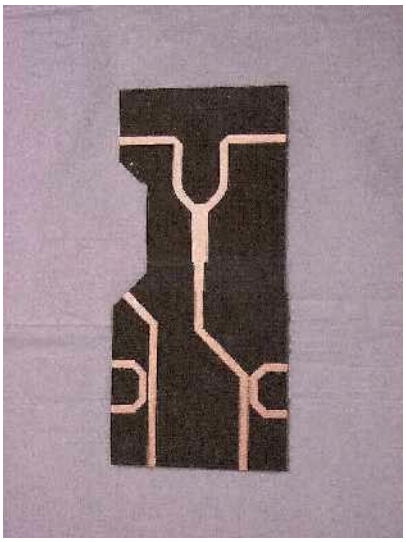


Fig. 3. Top side of the circuit board

Fig. 4. Bottom side of the circuit board

Circuit assembly

The first step of the assembly is to wrap the edges of the circuit card with copper tape. The copper tape provides a ground connection between the top and bottom of the circuit enclosure where it is needed. A photograph of the circuit card wrapped with copper tape is shown in fig 5.

Fig. 5. Circuit board with copper tape wrapping

The next step is to attach the coaxial line for the delta output. The delta signal is achieved by separating the ground planes of the input lines with an open slot on the backside of the circuit as shown. This slot creates a potential difference between the ground planes of the two input lines. The shape of the slot was created experimentally for best results. The center pin of the coaxial line is soldered to one side of the slot, and the outer conductor of the coaxial line is soldered to the opposite side of the slot. The potential difference of the ground planes travel through the coaxial line and back onto the board to the delta output. The connection is shown in the photograph in fig. 6. The coax line is .085 copper hard line. A SMA right angle male connector is connected to a flange mounted female connector to bring the delta signal back on to the circuit board. A detail of the coax connection is shown in fig. 7. The solder used contains 96.5% Sn and 3.5% Ag. This solder is best suited for liquid helium temperature.

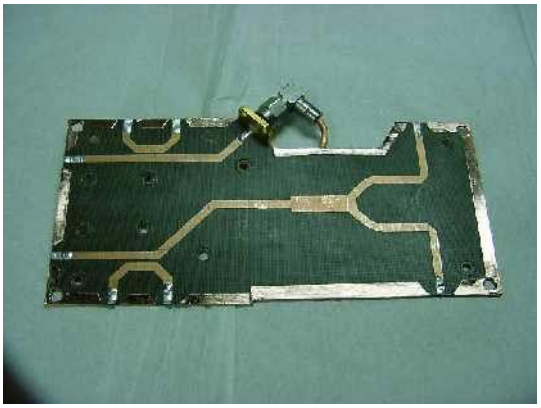


Fig 6. Coax connection of the delta output

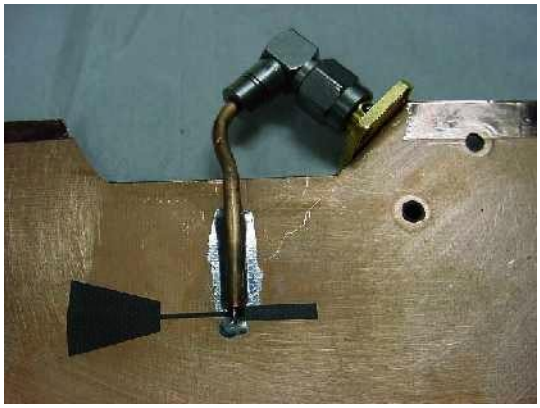


Fig 7. Close up of the coax connection

After the delta coax has been assembled, the board is mounted to the bottom mounting plate. Screws are used to mount the board to the plate. The screws also improve the ground connection of the board to the plate. Connectors are soldered to the board using the appropriate solder for liquid helium temperatures. A photograph of the circuit board mounted to the plate is shown in fig 8.

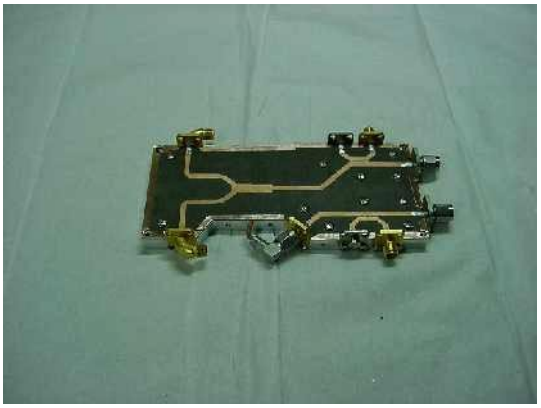


Fig. 8. Circuit board mounted to bottom plate

Fig. 9. Top cover assembled

The top enclosure is assembled, along with the two aluminum plates that are screwed into the sides of the assembly. The two aluminum plates provide a solid ground connection between the top and bottom of the circuit enclosure. The assembly is shown in fig 9. The next step is to assemble the cover plate with an absorber material attached to it. The cover with the absorber material attached with screws and a washer as shown in fig 10. There is a right angle lip on the cover provides a solid ground connection between the top and the bottom. Three locking washers are used at the corners to compensate for the space between the cover and the assembly created by the absorber material. The absorber material can be used at liquid helium temperatures. The absorber is from ARC technologies, inc. model number DD-10214. The underside of the circuit enclosure is shown in fig. 11.

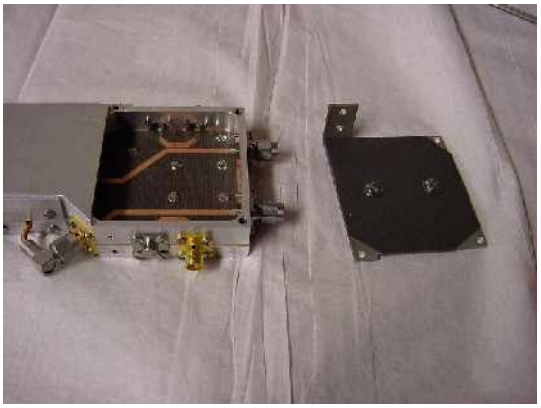


Fig. 10. Cover plate with absorber material

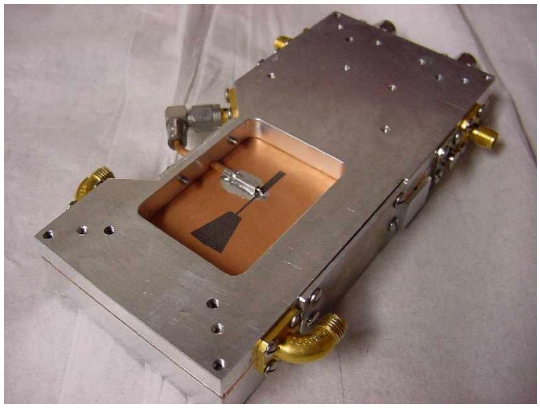


Fig. 11. Under side of the circuit

The final step is to attach the circuit to the mounting plate the goes on the pickup tank. The mounting plate includes mounting pads for the low noise amplifies at the output of the circuit. The mounting plate is shown in fig 12. The plate also includes a post to suppress a resonance in band. Figs 13, 14, and 15 show views of the completed assembly.

Fig. 12. Mounting plate to the pick up tank

Fig. 13. Complete assembly

Fig. 14. Circuit assembly

Fig. 15. Circuit assembly

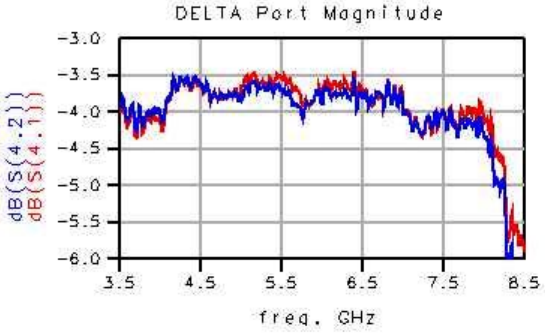
The FermiLab drawing names and numbers are listed in the table below.

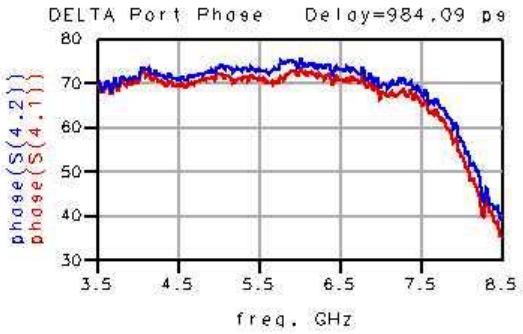
Drawing Number	Drawing Name
8035.000-MC-375880	Pbar Source 4-8 GHz Pickup Production Petter Hybrid Top Plate
8035.000-MC-375881	Pbar Source 4-8 GHz Pickup Production Petter Hybrid Bottom Plate
8035.000-MC-375882	Pbar Source 4-8 GHz Pickup Production Petter Hybrid Cover Plate
8035.000-MC-375883	Pbar Source 4-8 GHz Pickup Production Petter Hybrid Slotted Side Plate
8035.000-MC-375884	Pbar Source 4-8 GHz Pickup Production Petter Hybrid Side Plate
8035.000-MC-375885	Pbar Source 4-8 GHz Pickup Production Petter Hybrid Assembly
8035.000-MC-375886	Pbar Source 4-8 GHz Pickup Production Petter Hybrid B1 Mount Plate
8035.000-MC-375887	Pbar Source 4-8 GHz Pickup Production Petter Hybrid B2 Mount Plate
8035.000-MC-375888	Pbar Source 4-8 GHz Pickup Production Petter Hybrid B3 Mount Plate
8035.000-MC-375889	Pbar Source 4-8 GHz Pickup Production Petter Hybrid B4 Mount Plate

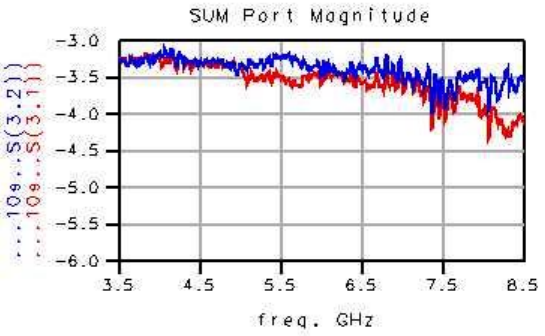
Measurements

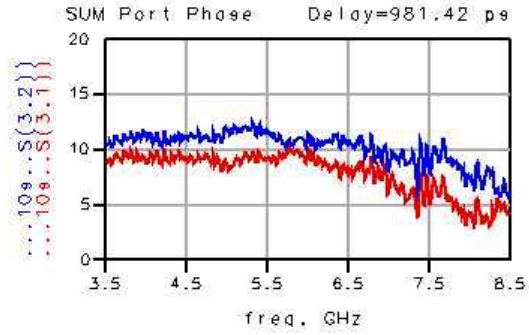
The circuit was tested at room temperature and liquid nitrogen temperature. The measurements were done with the HP8720 Network Analyzer. Measurements of a typical hybrid are shown in the figures below. The delta output shows a typical insertion loss between .5 dB and 1.25 dB in the 4-8 GHz band. The sum output shows a typical insertion loss between .25 dB and 1.0 dB. The phase balance for both the sum and delta outputs are within 5 degrees of each other. Some minor changes can bee seen between the room temperature measurements. The performance is not effected when cooled to liquid nitrogen temperature.

4-8 GHz Petter Hybrid Room Temperature S#10

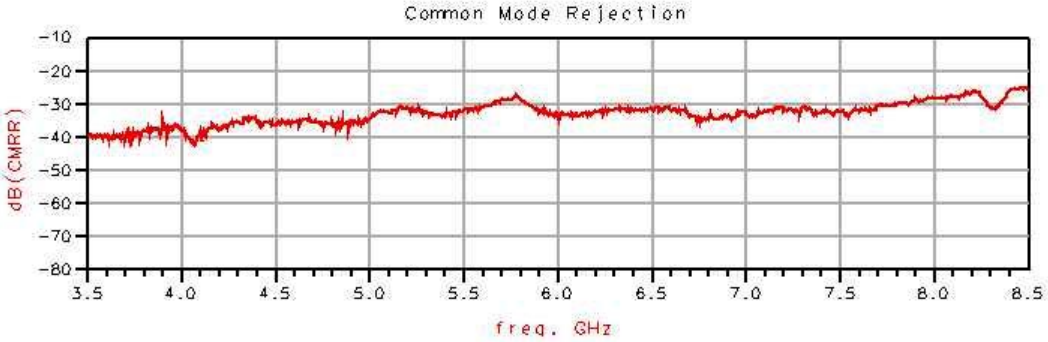




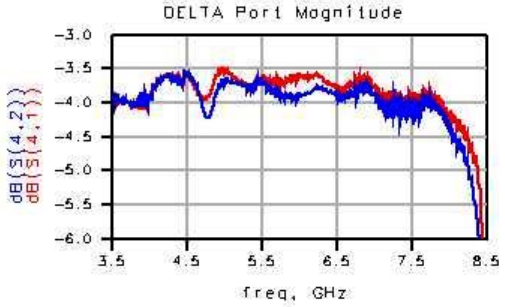


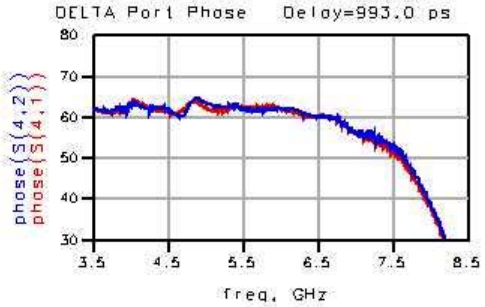


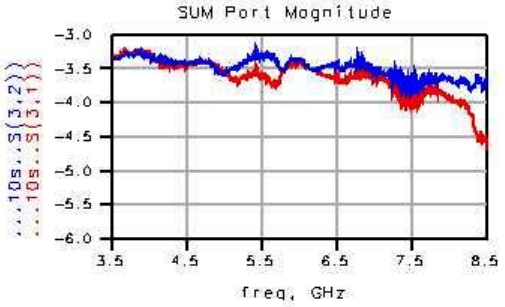
Eqn CMRR=RTS10CMMR..S(4,1)+RTS10CMMR..S(4,2)

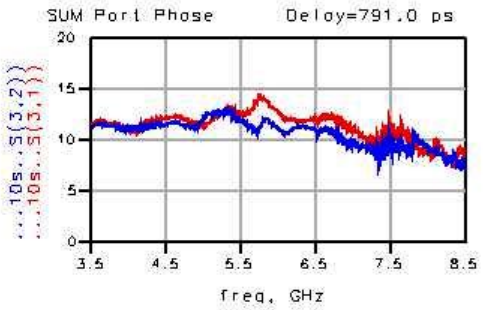


4-8 GHz Petter Hybrid Liquid Nitrogen Temperature #10









Eqn CMRR=LNS10CMMR..S(4,1)+LNS10CMMR..S(4,2)