Technical Report # 19 #19

From: The Crawford Hill VHF Club
Date: April 1982 (revised Oct. 1986)

Subject: A Six-port Quadrature Power Divider/Combiner

This report describes a relatively new and simple branch-line hybrid coupler which is a six-port planar network with four output ports. Each output port has equal amplitude, and phase sequence of 0, 90, 180 and 270 degrees. The network is shown schematically by Figure 1 and may be constructed in coax, stripline, or other type line sections. Particularly note that each line section is an electrical quarterwave in length, and that all line sections have the same characteristic impedance as the terminating and drive port impedances.

Alternatively, all line sections may be constructed with line sections whose characteristic impedance is not exactly the desired port impedances, and then quarter wave linear transformers used at output ports where necessary. This technique can be especially useful when constructing low loss couplers from air-line sections of available materials, such as copper tubing and wire.

An experimental model for 432 mc/s built with sections of RG214 (50 ohms, double shield, silver plated) had a measured insertion loss of 0.5 db and an input port isolation of over 30 db.

This coupler can be used in combining four power amplifiers for higher power generation, and in feeding a quad of dipoles such as the NBS feed antenna to obtain circular polarization. Figure 2 illustrates these applications in schematic form.

The power amplifier application, Figure 2a, permits combining 4 two-tube amplifiers of the type described in Report # 6 to achieve a kilowatt d-c input power amplifier at 1296 mc/s with little stress to the planar triodes. It is suggested that to minimize losses, at least the output combiner be constructed with air-line sections.

The antenna feed application is especially useful since it permits achieving isolated left/right circular polarization which is desirable in all EME communication to eliminate Faraday fading and also to eliminate high-power T/R switching. One form of this application is in feeding a dual linearly polarized NBS feed.

A basic NBS feed is two in-phase dipoles a quarter wavelength above a one wavelength square ground plane.

Figure 2b shows a quad of dipoles arranged for dual linear polarization. By feeding each dipole from a port of the six-port hybrid, the proper equal amplitude and phase relationship is obtained to radiate and receive left and right circular polarization. The planar network may be folded into a cube for convenience and 'dummy' line sections included to complete the cube and add physical strength as shown.

Note that pairs of parallel dipoles are fed at opposite sides of their baluns to preserve the necessary in-phase condition.

References: A. A. M. Saleh, "Planar Multiport Quadrature-Like Power Dividers/Combiners", IEEE Trans. on MTT Vol MTT-29, No. 4, April, 1981, pp 332-337.

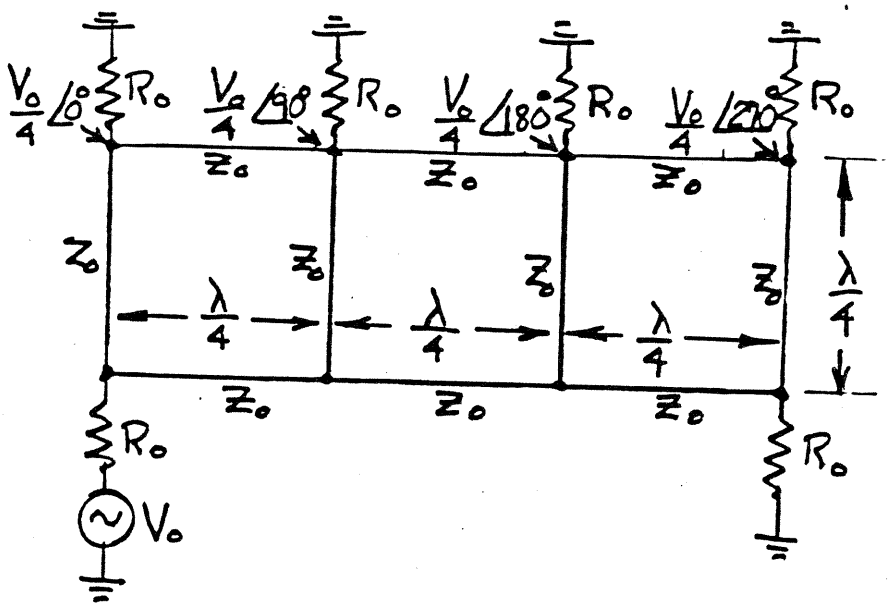
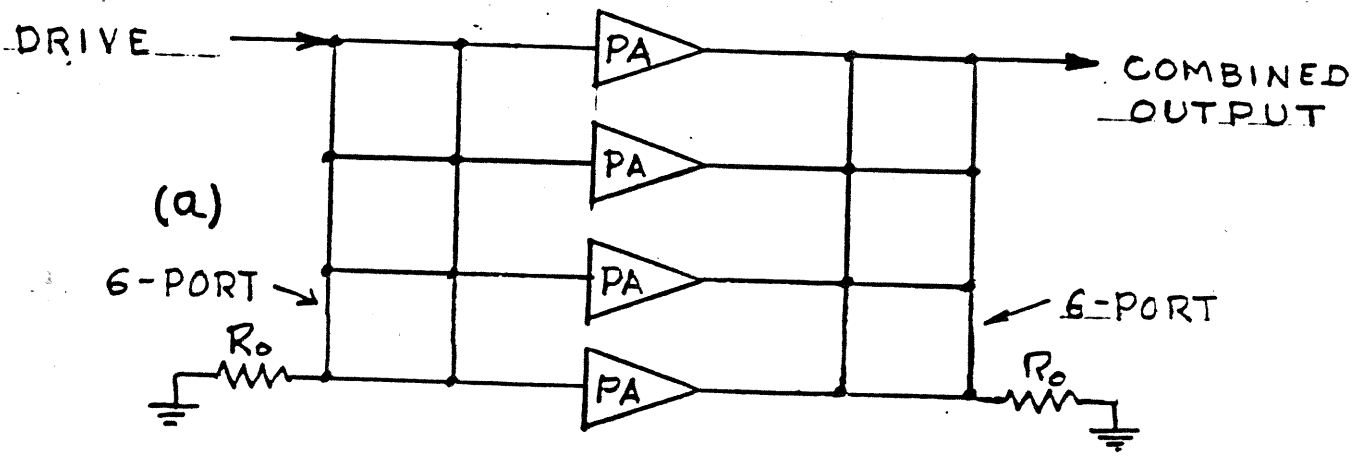


FIGURE 1. BASIC 6-PORT 90° HYBRID



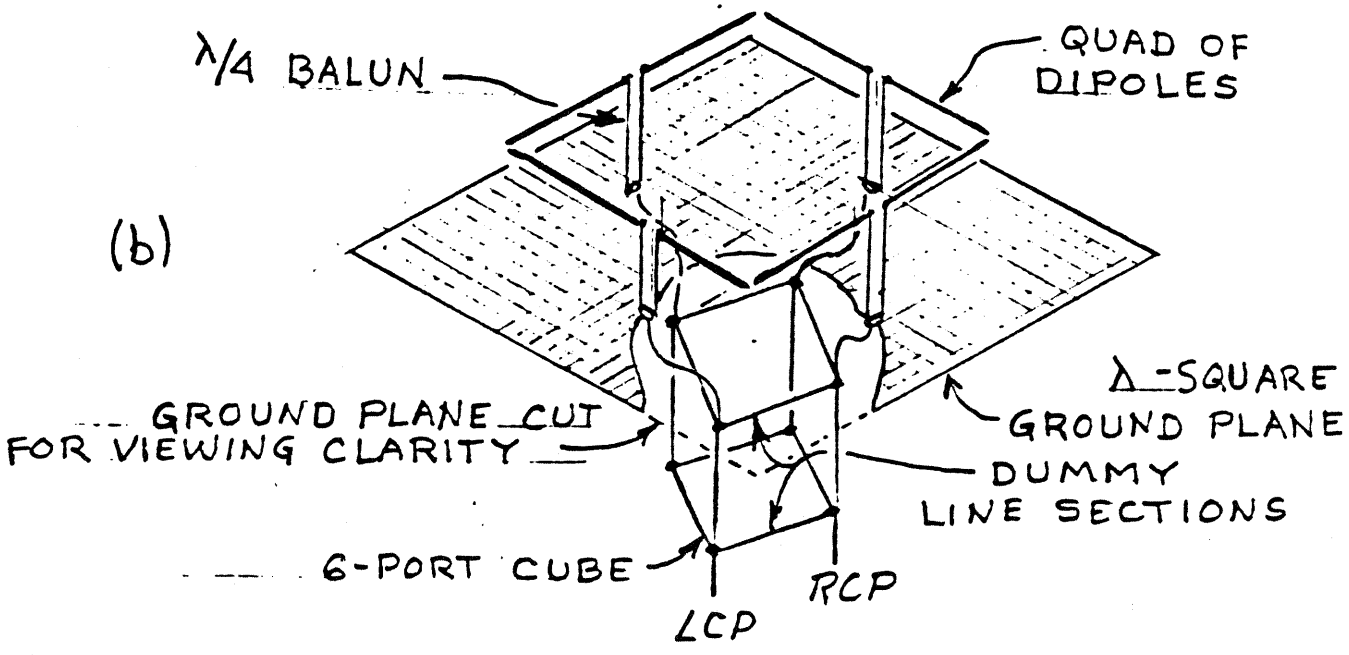


FIGURE 2. (a) POWER AMPLIFIER COMBINER,
(b) CIRCULARLY POLARIZED NBS FEED ANTENNA