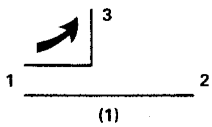
APPENDIX A

SOURCE MATCH OF LEVELED OR RATIO SYSTEMS AND COUPLER VS. 2- and 3-RESISTOR SPLITTERS

COUPLERS:

The effective source reflection coefficient of a coupler-leveled or ratio system has been shown[7] to be $\Gamma_s = \Gamma_c + TD$



Where Γ_c = output reflection coefficient of couplers main or through arm = S_{22}

T = transmission coefficient of through arm = $\sqrt{\text{power transmitted}} = S_{21}$

e.g., 10-dB coupler ≅ 0.95
20-dB coupler ≅ 0.995

$$D = \text{Directivity} = \frac{S_{32}\ \text{(isolation)}}{S_{31}\ \text{(coupling)}}$$

The above is a vector equation. Since the techniques described do not derive phase information, the maximum source match can be calculated by adding terms of the equation assuming worst-case vector addition.

EXAMPLES:

HP 11692D Broadband 2 to 18-GHz coupler at 18 GHz is specified:

1. 1.4 main line SWR = 0.167 reflection coefficient
2. 20-dB coupling = 0.995 transmission coefficient
3. 26-dB directivity = 0.05

Maximum Source Match = 0.167 + 0.995 x 0.05 = 0.217 (ρ)
= 1.55 SWR

@ 8 GHz specs are:

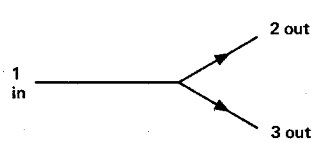
1. 1.3 SWR
2. 20-dB coupling
3. 30-dB directivity

Maximum Source Match = 0.131 + 0.995 x 0.03 = 0.164
@ 8 GHz = 1.39 SWR

The above solutions do represent absolute worst cases but are usually modified somewhat. The through line mismatch of a coaxial coupler is largely due to the effects of both input and output connectors. Since the input connector is within the loop and its effects thus removed, some recommend including only 50 to 70% of the specified through line match.

POWER SPLITTERS:

Using similar flow-graph techniques the effective source match of a power splitter on either arm EQUALS



$$\Gamma_s = S_{22} - S_{21} \times \frac{S_{32}}{S_{31}} \quad \text{or}$$

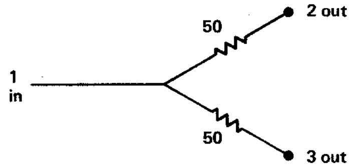
$$= S_{33} - S_{31} \times \frac{S_{23}}{S_{21}}$$

or = output reflection coef − tracking x directivity (equivalent to the equation for couplers).

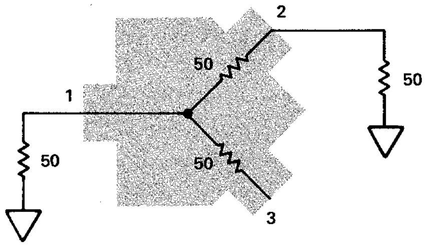
[7] Paul C. Ely, Jr., "Swept Frequency Techniques," Proc. of the IEEE vol. 55 #6 June, 1967.

TWO-RESISTOR SPLITTER:

For the HP 11667A, a 2 resistor —50 Ω configuration is employed



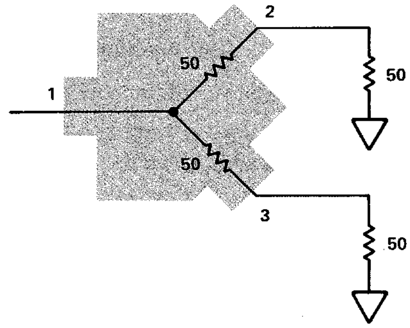
First, let's calculate S_{33}: the equivalent resistance in a 50 Ω reference s-parameter measurement is



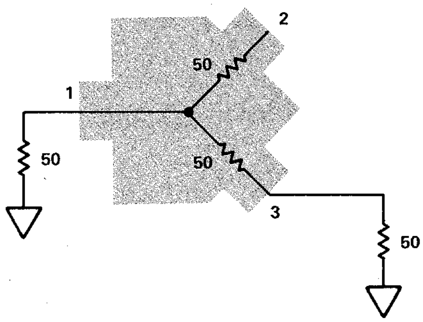
$$R = 50 + \frac{50 \times 100}{50 + 100} = 83.33\Omega$$

$$S_{33} = \frac{R - Zo}{R + Zo} = \frac{33.33}{133.33} = .25$$

$$S_{22} = S_{33}$$



$$S_{21} = S_{31} = .5$$



$$S_{23} = S_{32} = .25$$

APPLYING EQ (2) $\Gamma_s = .25 - .5 \times \frac{.25}{.5} = 0$

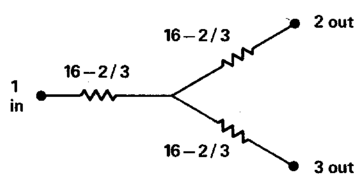
Since all elements are resistive, phase angles are zero and perfect cancellation occurs in the ideal case. Actual equivalent source match is specified as:

<1.20 SWR at 8 GHz
<1.33 SWR at 18 GHz

due mainly to connector imperfections.

THREE-RESISTOR SPLITTER:

The conventional three-resistor splitter is configured:



At any port equivalent input $R = 16\frac{2}{3} + \frac{16\frac{2}{3} + 50}{2} = 50\ \Omega$

$$S_{22} = S_{33} = S_{11} = 0$$

$$S_{12} = S_{21} = S_{13} = S_{31} = S_{32} = S_{23} = 0.5$$

Again applying Equation (2) : $\Gamma_s = 0 - 0.5 \times \frac{0.5}{0.5} = 0.5$

A Γ_s of 0.5 is an equivalent source SWR of 3:1. A 3:1 source SWR will cause a 1 dB ripple when measuring a device with a 1.25 input SWR. Thus, the three-resistor power splitter should never be used in leveling or ratio applications.