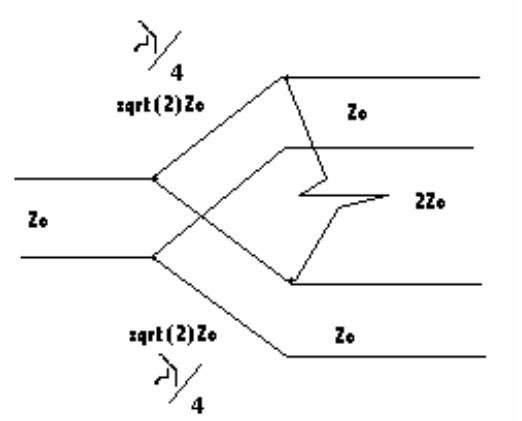
ECE 6130 Wilkinson Power Divider

Text Section 7.3

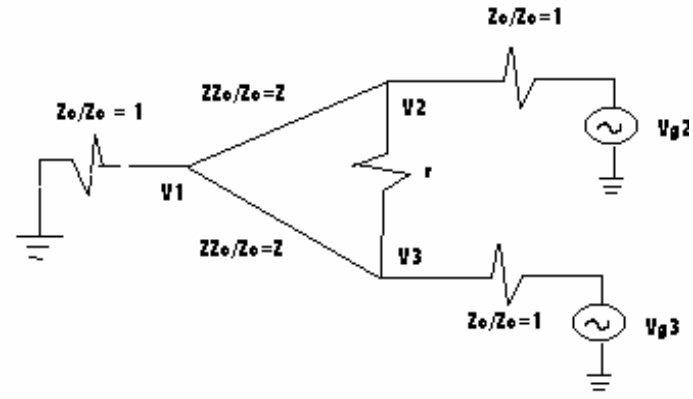
How do you design a Wilkinson Power Divider?
See for example Chapter 7 Problems 9,10

Wilkinson Power Divider:

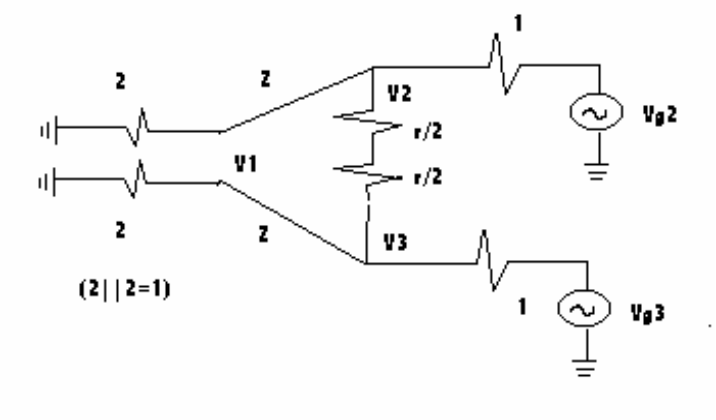
Matched at all ports
Complete isolation between output ports
Lossless when output ports are matched. Lossy when they are not (only reflected power is lost).



Use normalized impedance values (normalized to Zo), and place sources on output ports:



Split down the center, so that the output ports will act on the circuit separately. This will ensure complete isolation later.



S-parameters: S32 = V_3^- / V_2^+ when V_3^+ = 0.

Division of circuit into even and odd modes;

We can't just ground Vg3, because that would eliminate V_3^- , so instead we analyze the circuit for two modes:

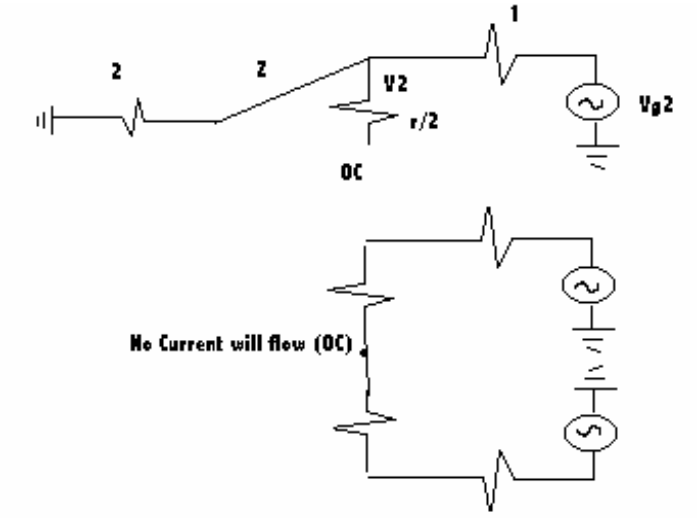
Even Mode Vg3 = Vg2

Odd Mode Vg3 = - Vg2

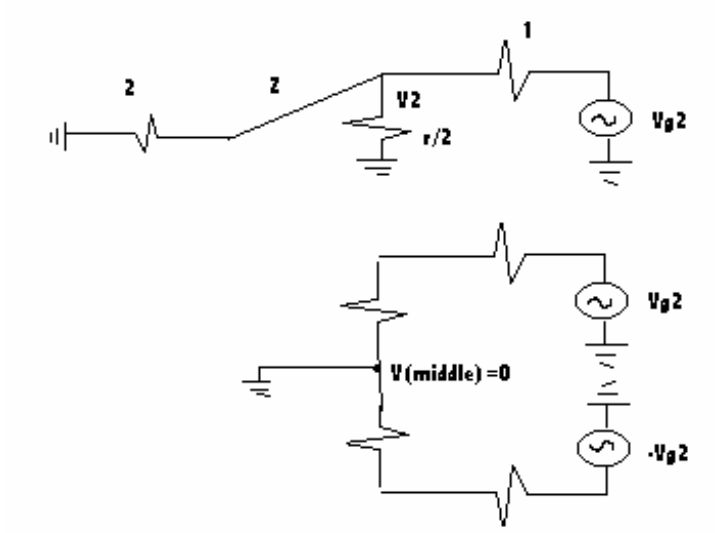
Superposition (adding) the modes:

Even + Odd: V_2^+ = 2 Vg2; V_3^+=0 << just what we wanted.

Bisection of Circuit for Even Mode:



Bisection of Circuit for Odd Mode:



Even Mode:
We want to find V1, so that we can find the S-parameters:
First find impedance looking into port 2 (where r connects to line)
(matching section looks like a quarter-wave section)
$Z = \text{sqrt}((Z_{in}^{e})(2))$; So $Z_{in}^{e} = Z^2 / 2$

Voltage generator defined as 2V.
For matched conditions Z = sqrt (2) and Zin = 1
V_2 = (2V) (1 / (1+1)) =V (voltage divider over Zin and matched line)
The r/2 resistor has no current flowing because of OC, so is superfluous.

Find V1:

a) Define x=0 at port 1 (junction), x = - λ / 4 at port 2
b) Then $V(x) = V^+ (e^{-j\beta x} + \Gamma e^{j\beta x})$
c) $V_2 = V(-\lambda/4) = j V^+ (1-\Gamma) = V$; $V^+ = jV / (\Gamma-1)$
d) $V_1 = V(0) = V^+ (1+\Gamma) = jV^+ (\Gamma+1) / (\Gamma-1)$
e) At port 1, looking into resistor of value 2: $\Gamma = (2 - \sqrt{2}) / (2 + \sqrt{2})$ and $V_1 = -jV\sqrt{2}$

Odd Mode:

To match port 2 (looking into source) r = 2
λ /4 transmission line shorted at end looks like an open circuit. (think of Smith Chart)
Looking into port 2 (toward line), we see OC and r / 2 = 1 in parallel, so port 2 is matched.

$V_2 = 2V (1 / (1+1)) = V$ (voltage divider over 1 and r / 2 = 1) resistors
$V_1 = 0$ (shorted)
All odd-mode power is lost in resistor r /2 .

Find Zin for Wilkonson Divider (looking into port 1 toward the two quarter-wave transformers -- either mode)

The transformers match the input , so the Zin =1 is matched.

Superposition: Find the S-parameters:

$S_{11} = (Zo – Zin) / (Zo + Zin) = 0$
$S_{22} = S_{33} = 0$ (both ports 2 and 3 are matched for both even and odd modes)
$S_{12} = S_{21} = (V_1^e + V_1^o) / (V_2^e + V_2^o) = - j / \sqrt{2}$ (and symmetry due to reciprocity)
$S_{13} = S_{31} = - j / \sqrt{2}$ (symmetry of ports 2 and 3)
$S_{23} = S_{32} = 0$ (due to short or open at bisection)