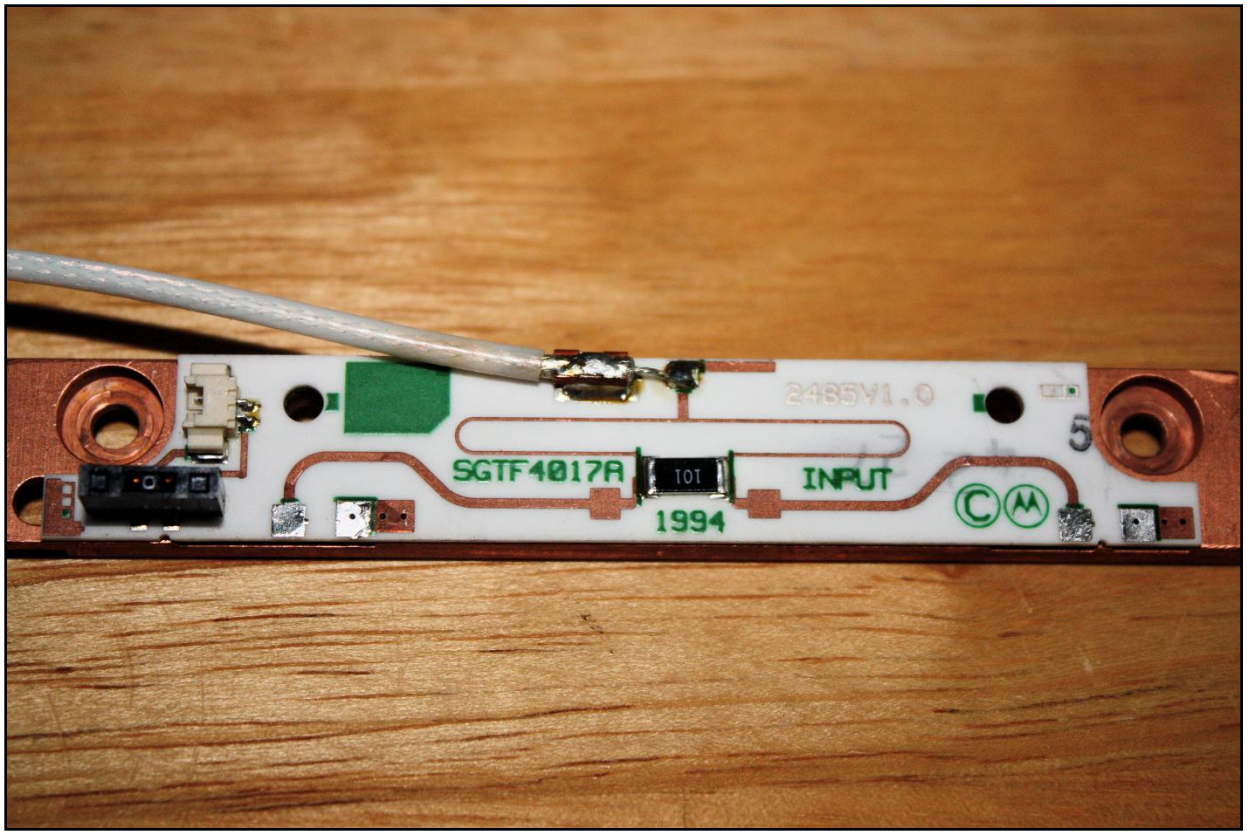
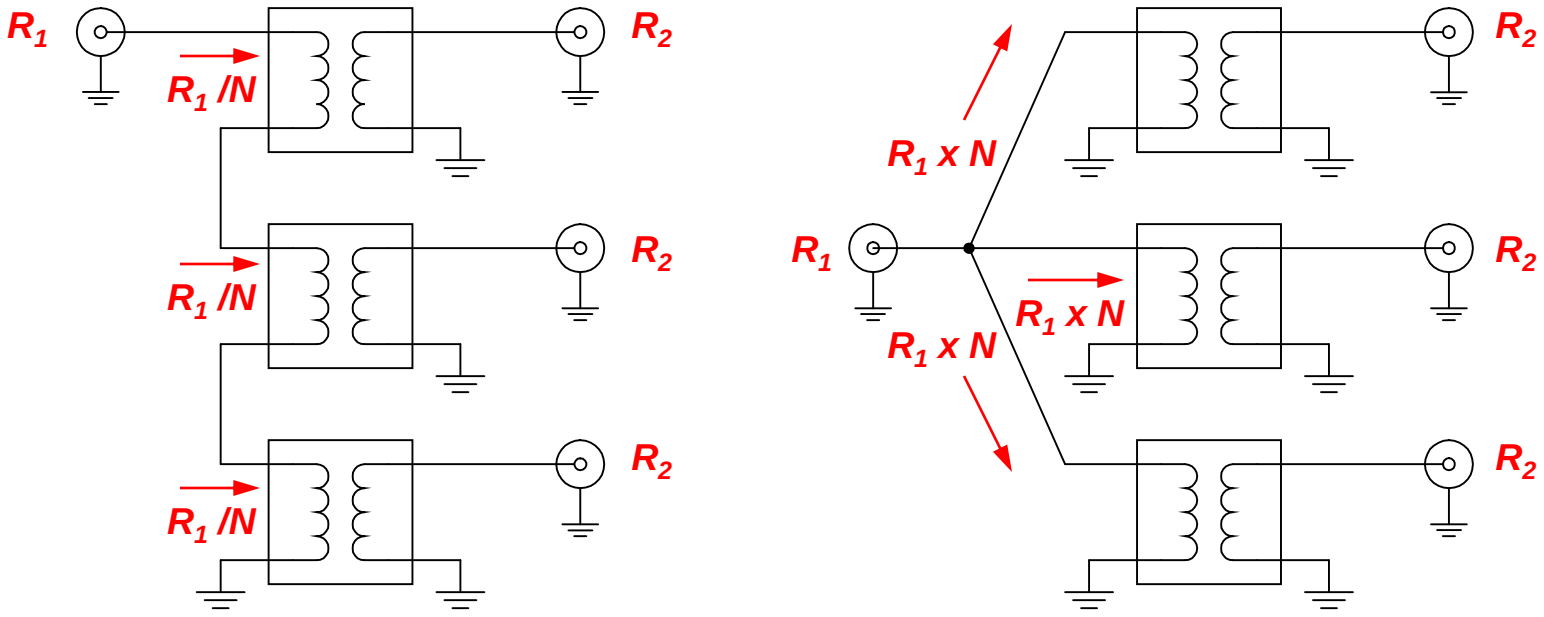
TRANSFORMERS, SPLITTER-COMBINERS & HYBRIDS



K5TRA

N-WAY SPLITTERS & COMBINERS (3-WAY EXAMPLE)

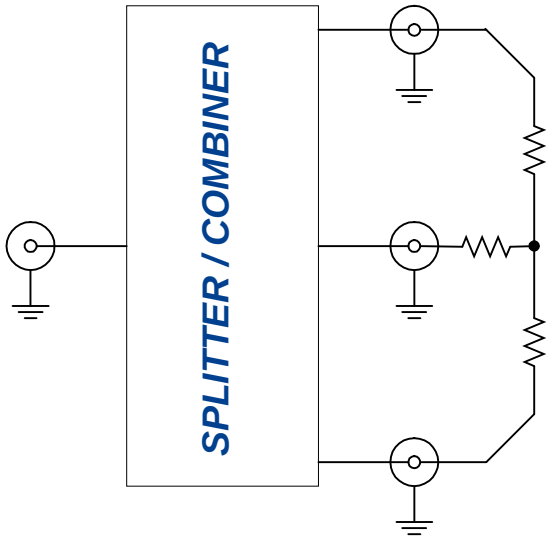
IMPEDANCE TRANSFORMATION IS REQUIRED FOR SPLITTERS & COMBINERS



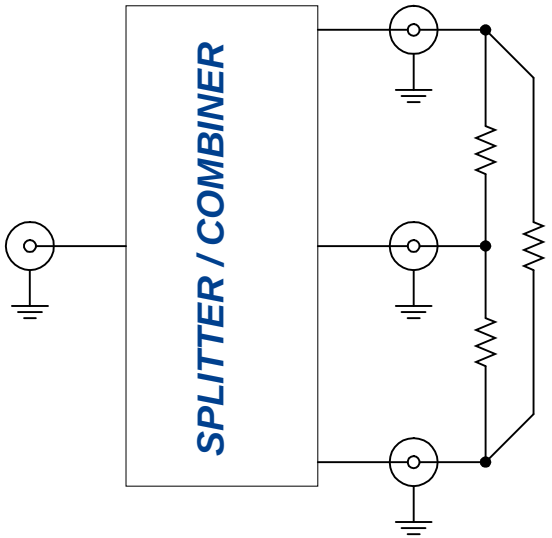
3-WAY EXAMPLE: N = 3

N-WAY ISOLATION TERMINATION (3-WAY EXAMPLE)

TERMINATION OF UNBALANCED (NOT IN-PHASE) MODES



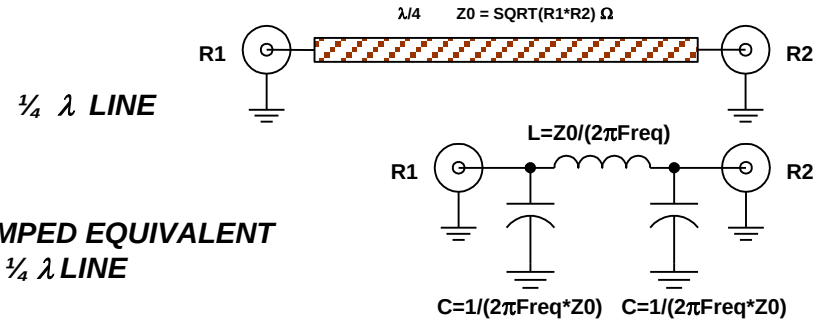
STAR TERMINATION (3-WAY IS Y)

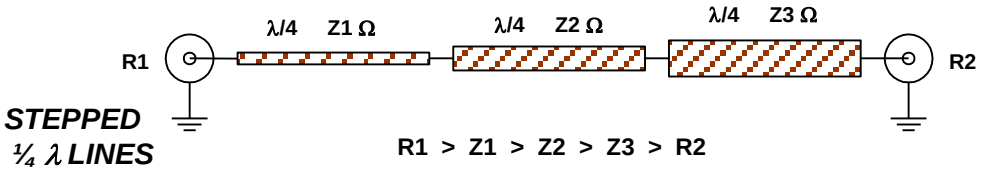


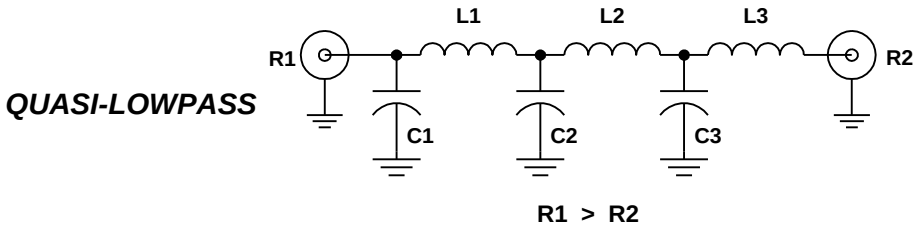
RING TERMINATION (3-WAY IS DELTA)

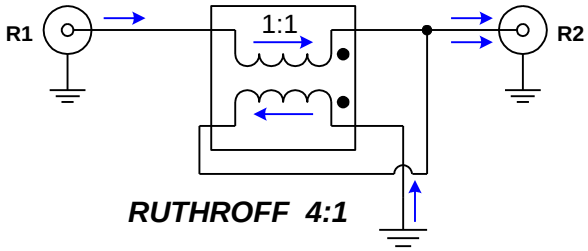
MANY TYPES OF TRANSFORMERS CAN BE USED

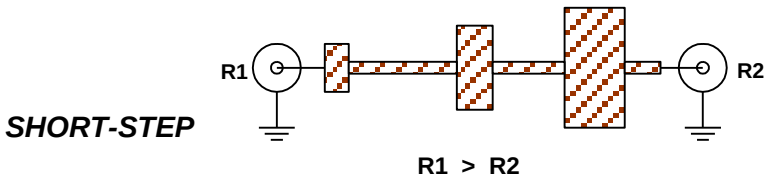
- Distributed or lumped
- Symmetric Z inverter or Asymmetric network
- Bandwidth requires more elements
- Ruthroff type transformers
- Conventional transformers
- Even wave-guide realizations!





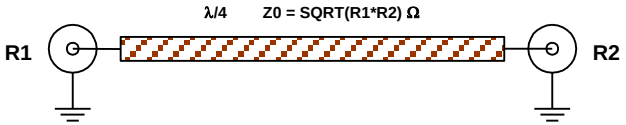




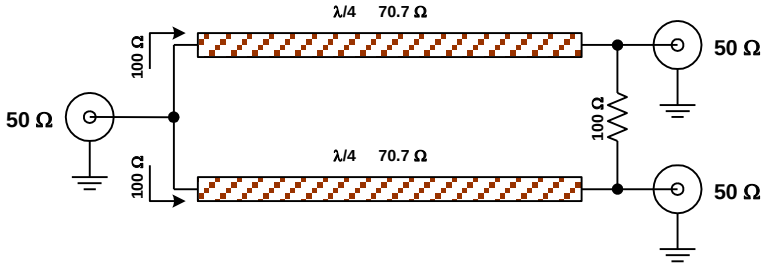


BASIC WILKINSON

- Two-way splitter / combiner
- Quarter –wave line transformer
- Odd mode termination resistor
- Half octave bandwidth performance



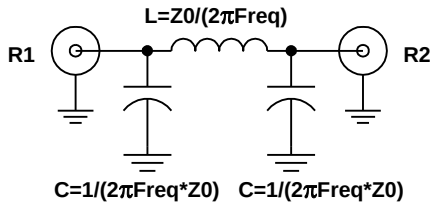
¼λ Z INVERTER



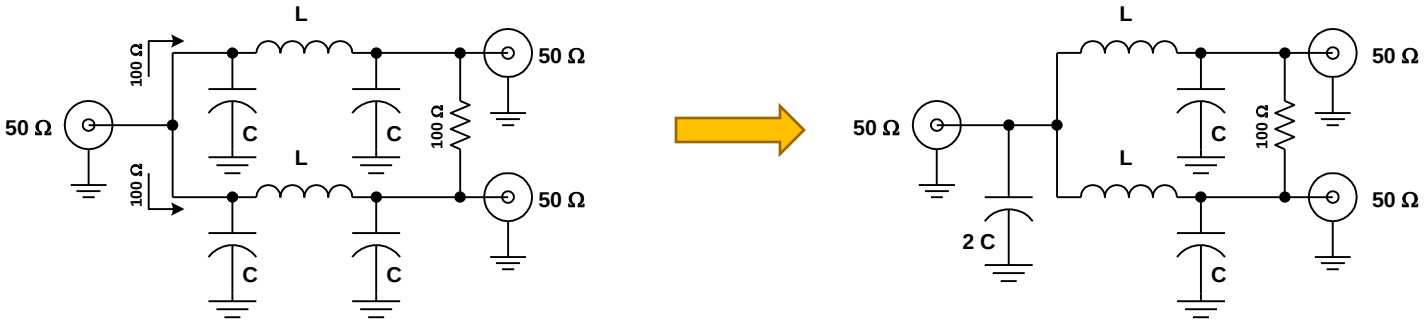
WILKINSON SPLITTER/COMBINER

LUMPED ELEMENT WILKINSON

- Two-way splitter / combiner
- Lumped LC quarter-wave equivalent
- LC impedance inverter transformer
- Odd mode termination resistor
- Half octave bandwidth performance



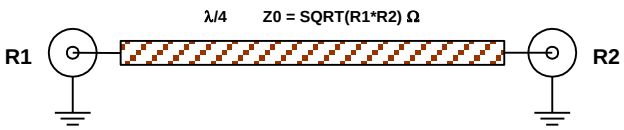
LC Z INVERTER



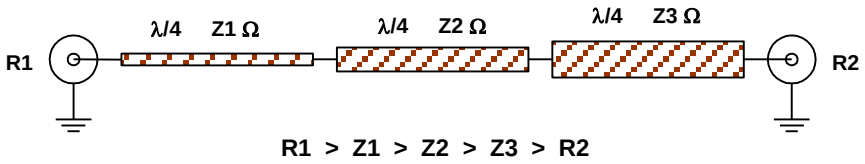
LUMPED LC WILKINSON SPLITTER/COMBINER

STEPPED ¼λ "MULTISECTION WILKINSON"

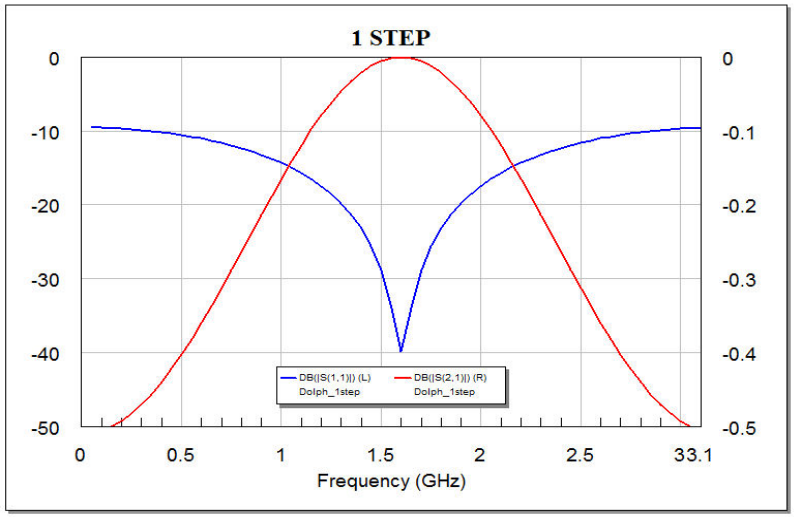
- Half octave performance from single quarter-wave line transformer
- Nearly 2-octave performance from 3 stepped quarter-wave lines
- Comparison for 50Ω to 100Ω transformation (BW also depends on this)

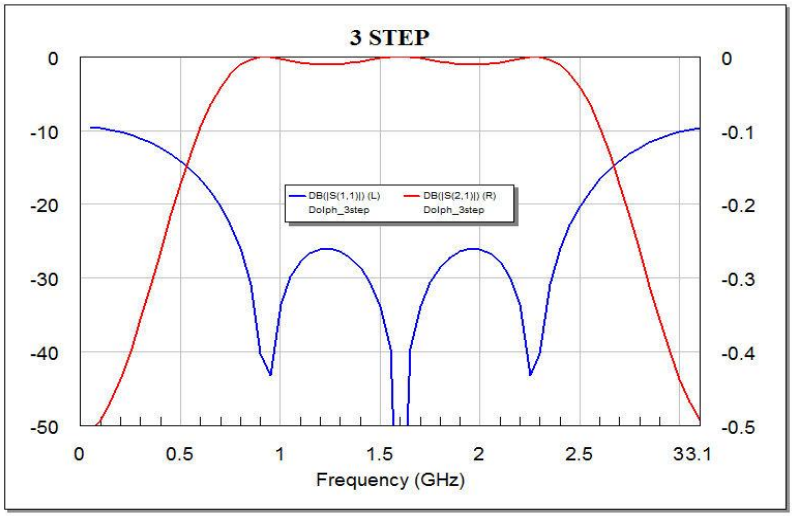


¼λ Z INVERTER

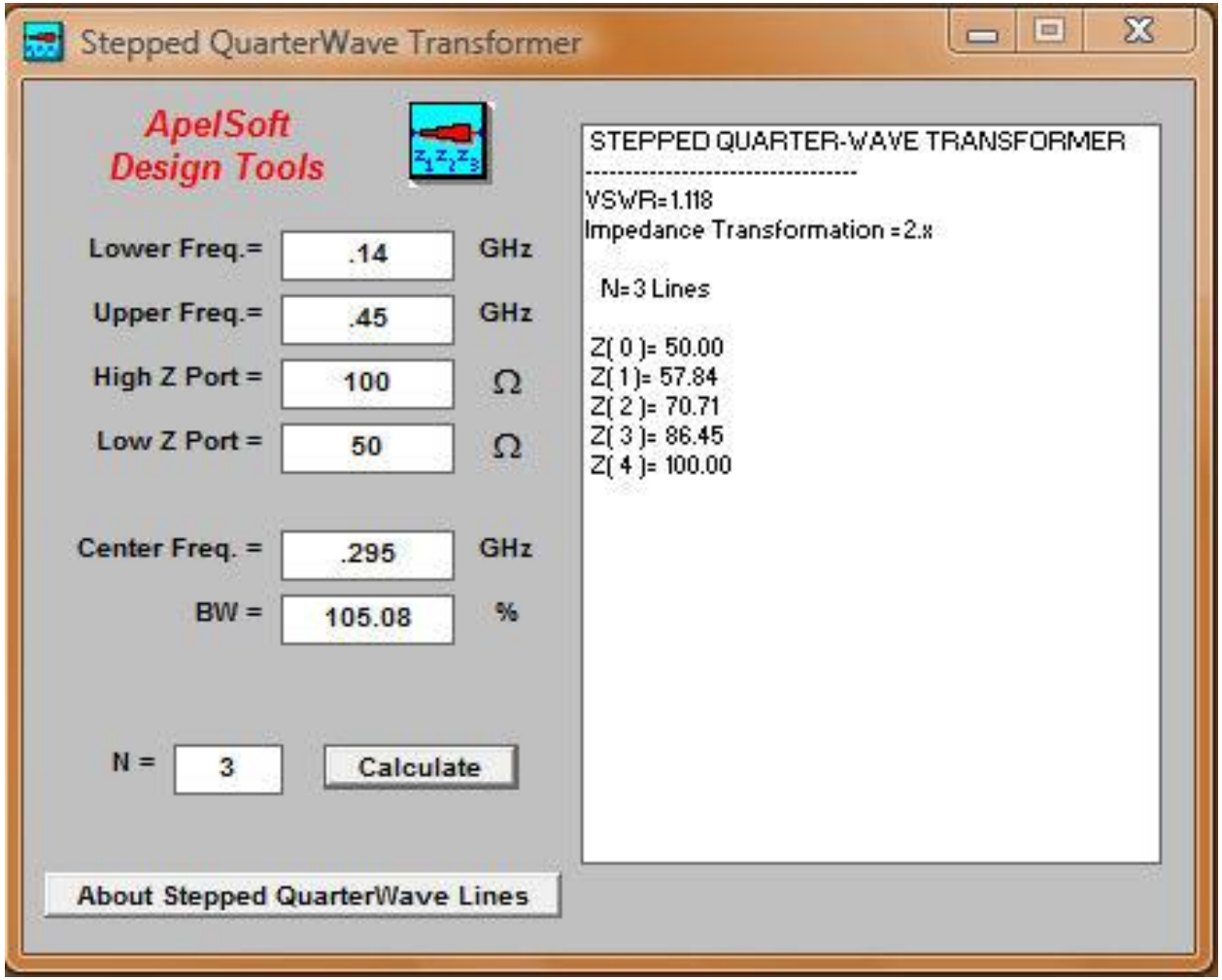


STEPPED Z TRANSFORMER





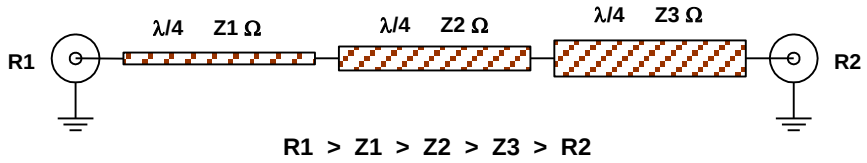
STEPPED ¼λ TRANSFORMER CALCULATION



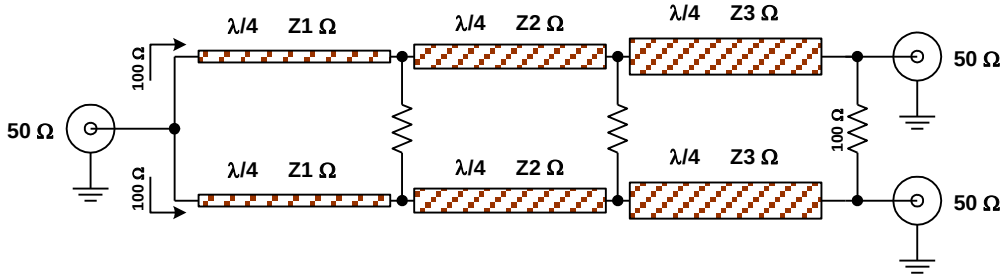
DOWNLOAD FROM: **http://k5tra.net/**

STEPPED ¼λ "MULTISECTION WILKINSON"

- Two-way splitter / combiner
- Stepped quarter-wave transformer
- Odd mode termination resistors
- Two octave bandwidth performance



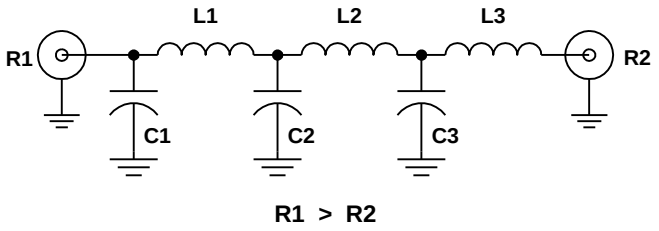
STEPPED Z TRANSFORMER



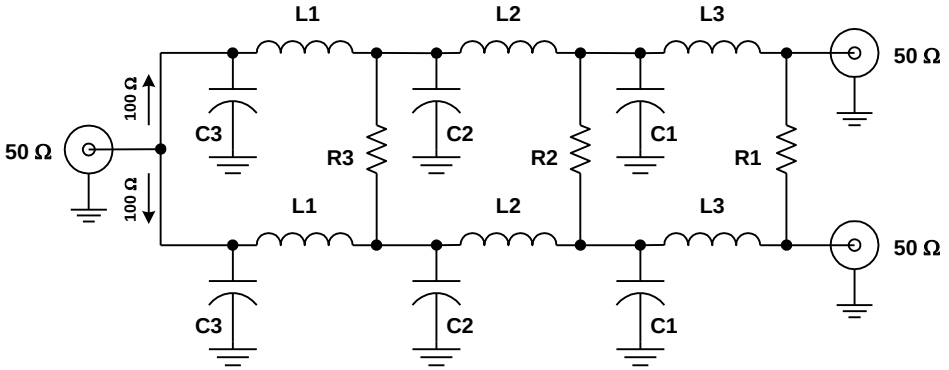
STEPPED Z SPLITTER/COMBINER

QUASI-LOWPASS TRANSFORMER and SPLITTER

- Two-way splitter / combiner
- Quasi-lowpass LC transformer
- Odd mode termination resistors
- 1.7 octave bandwidth performance

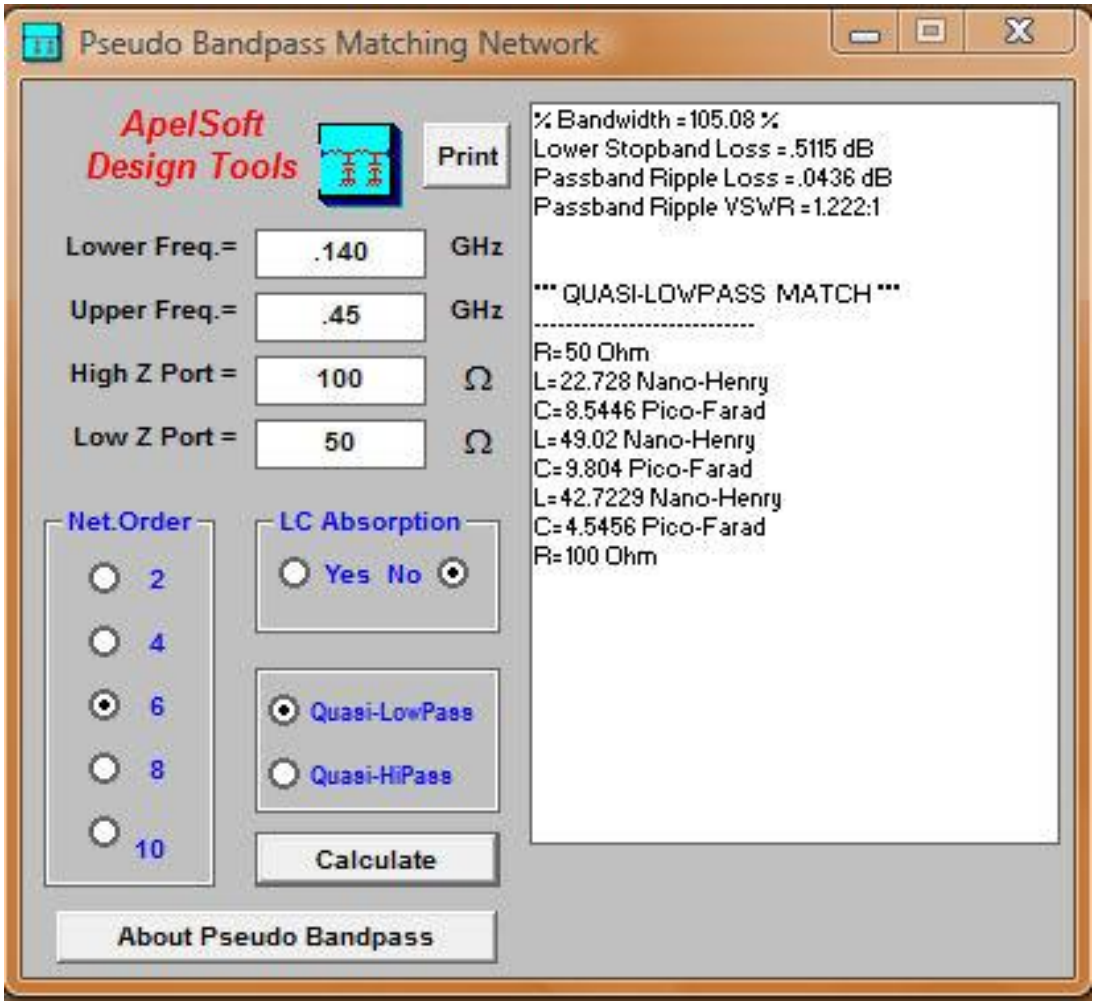


LC IMPEDANCE TRANSFORMER



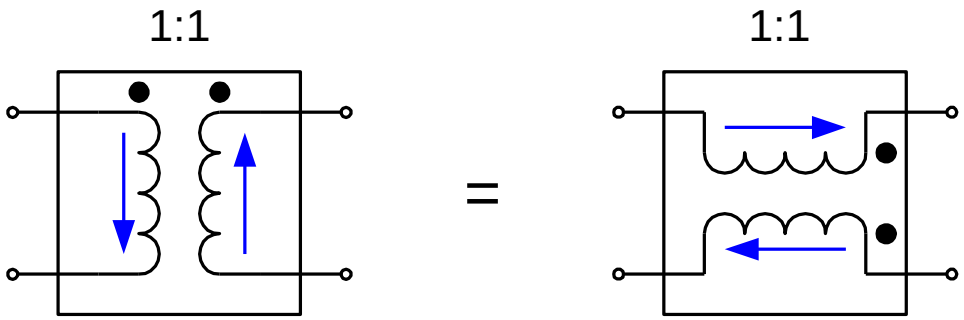
STEPPED Z SPLITTER/COMBINER

QUASI-LOWPASS TRANSFORMER CALCULATION



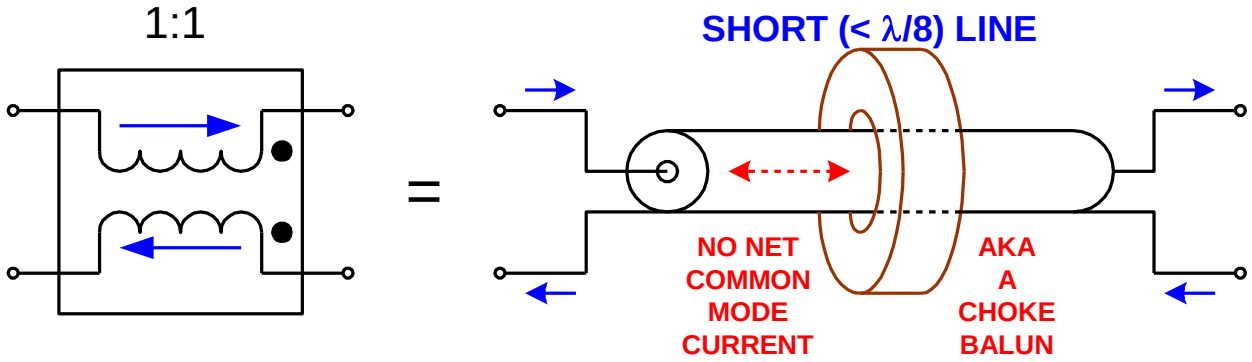
DOWNLOAD FROM: **http://k5tra.net/**

TRANSMISSION LINE TRANSFORMER – ELEMENTS



CONVENTIONAL TRANSFORMER

TRANSMISSION-LINE TRANSFORMER

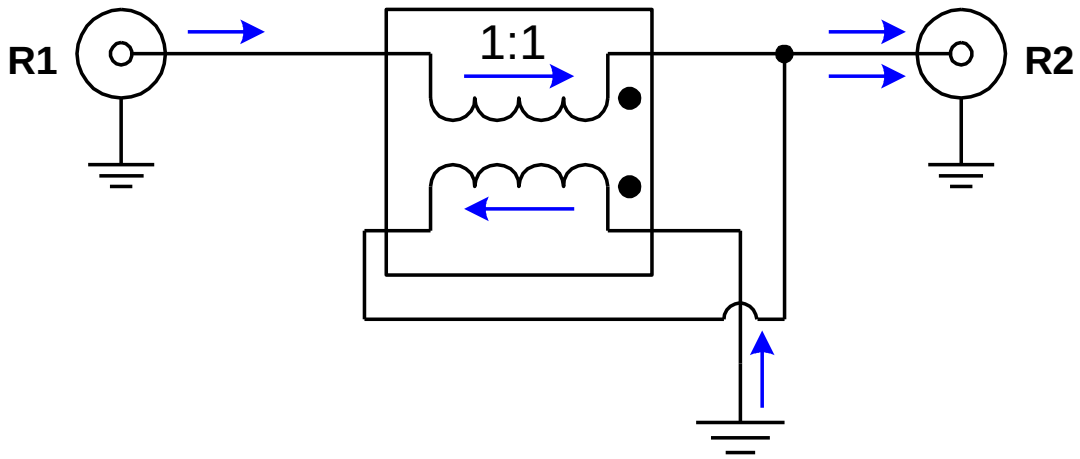


SYMBOLIC

PHYSICAL

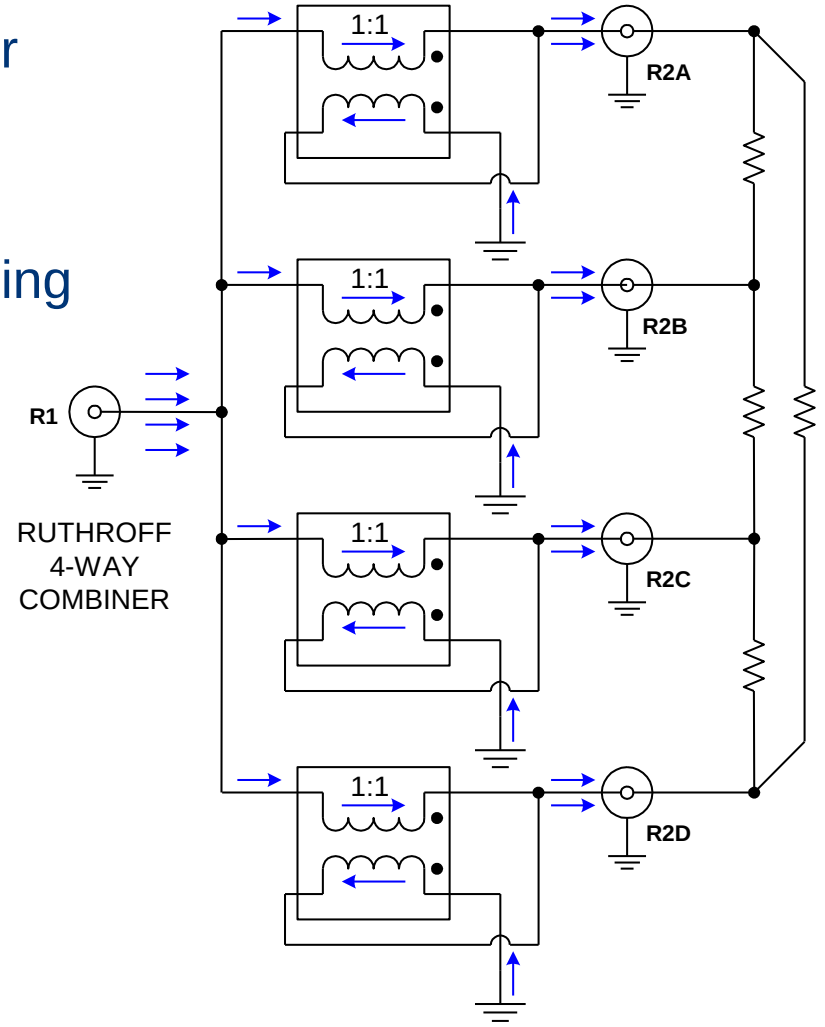
RUTHROFF TRANSFORMER

- Transmission line ‘unit’ element
- Physically short lines (length < λ / 8)
- Analysis based on currents
- $R_1 / R_2 = (I_2 / I_1)^2 = 4$
- Ferrite loading extends bandwidth (low end)



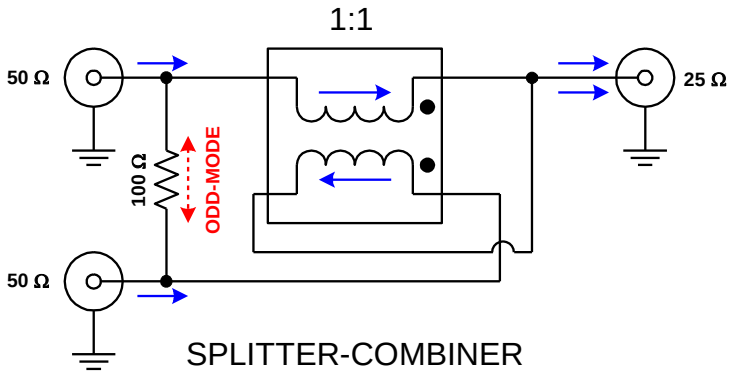
RUTHROFF 4-WAY SPLITTER/COMBINER

- 4-way (6 dB) splitter / combiner
- Four 4:1 transformers
- All ports same impedance
- Isolation shown with resistive ring

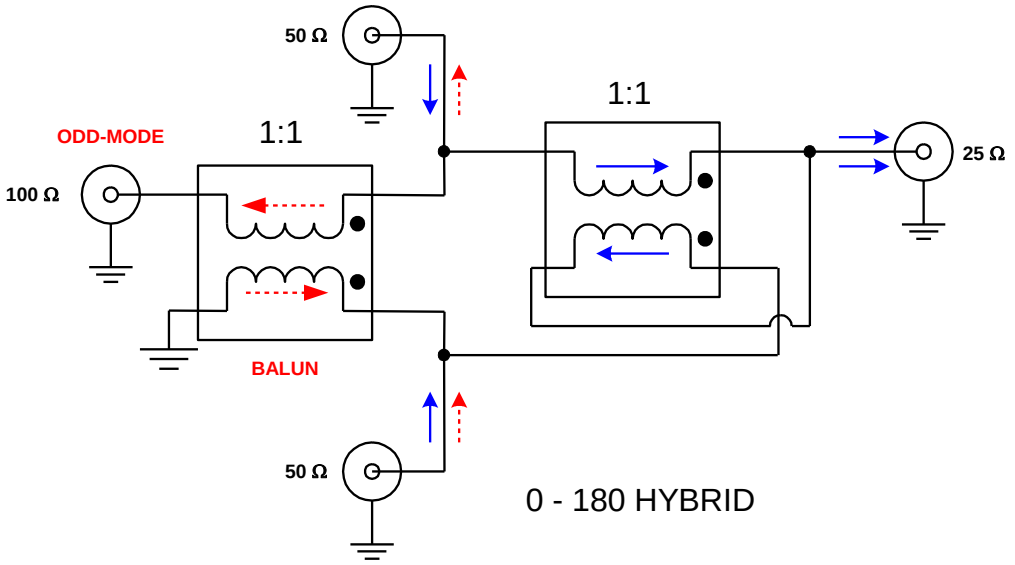


RUTHROFF 2-WAY SPLITTER/COMBINER

- Common port is half impedance
- Differential termination is 2 X
- A 4-port hybrid is formed by adding a balun interface to differential terminals
- Ferrite loading extends bandwidth



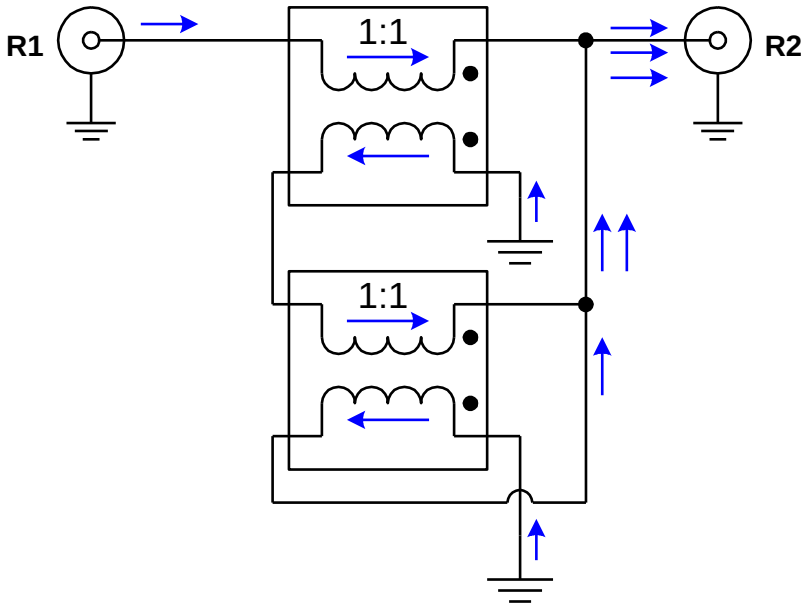
SPLITTER-COMBINER



0 - 180 HYBRID

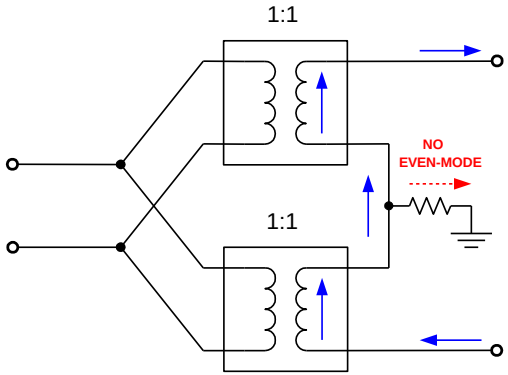
RUTHROFF TYPE 9:1 TRANSFORMER

- Transmission line ‘unit’ elements
- Physically short lines (length < λ / 8)
- Analysis based on currents
- $R_1 / R_2 = (I_2 / I_1)^2 = 9$
- Ferrite loading extends bandwidth (low end)

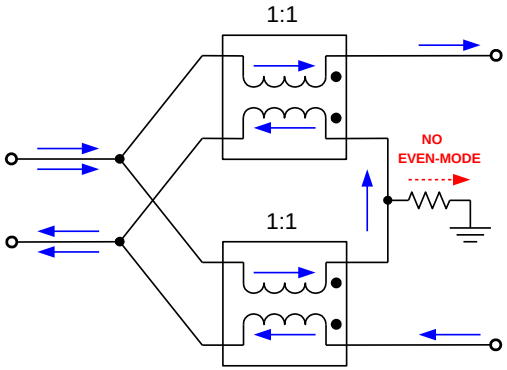


GUANELLA (4:1) BALANCED TRANSFORMER

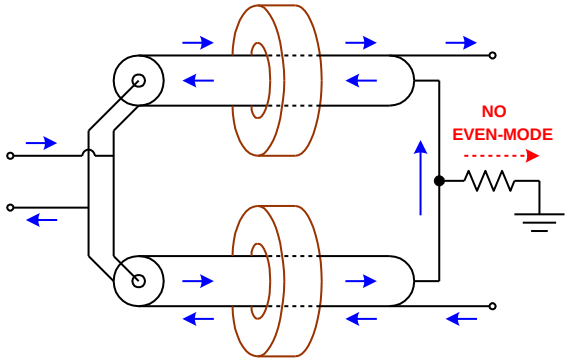
- Two ‘unit’ elements can be used to form a balanced 4:1 transformer
- Analysis based on currents
- $R_1 / R_2 = (I_2 / I_1)^2 = 4$
- Ferrite loading extends bandwidth (low end)



CONVENTIONAL 4:1 BALANCED TRANSFORMER



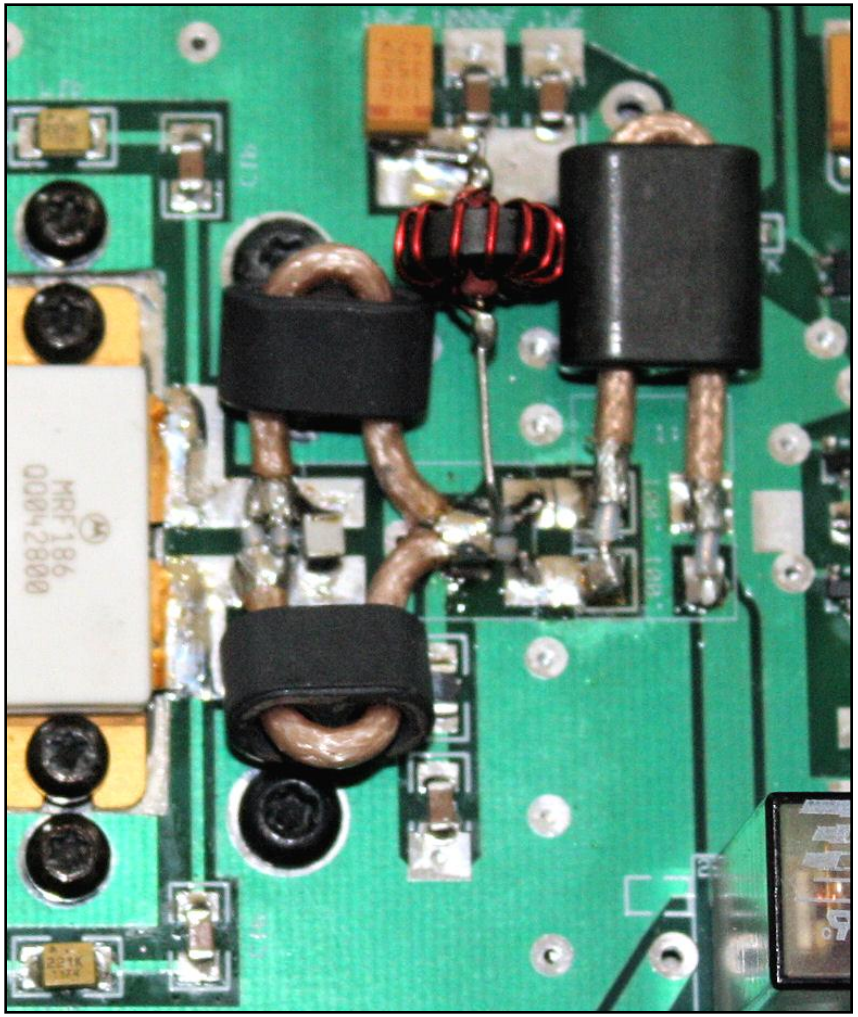
GUANELLA 4:1 SYMBOLIC



GUANELLA 4:1 PHYSICAL

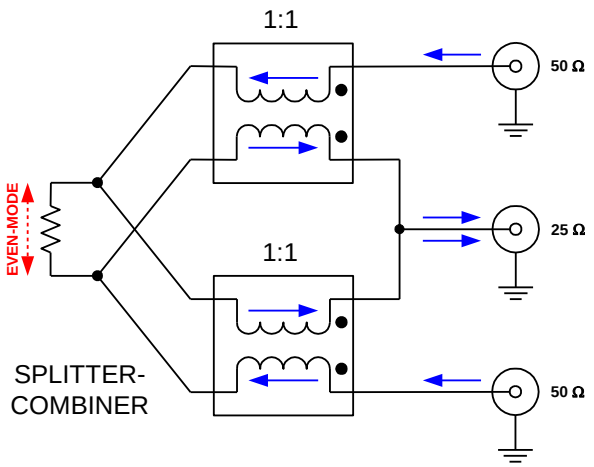
GUANELLA TRANSFORMER and CHOKE BALUN

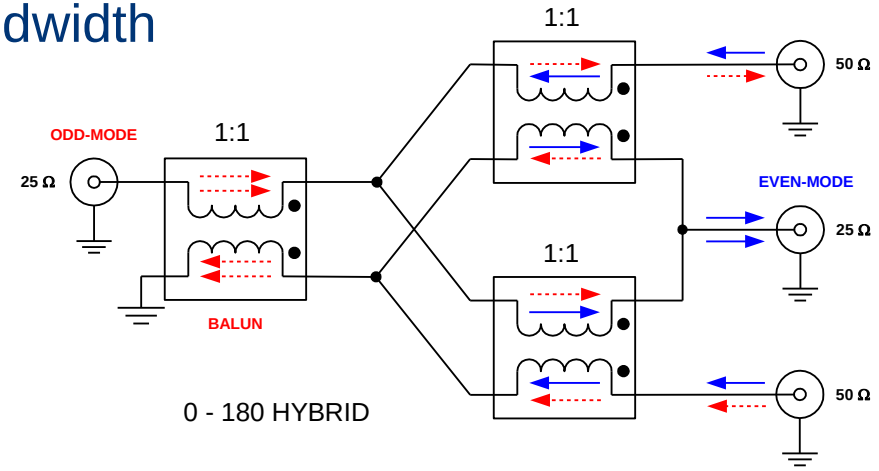
- Pushpull PA match example
- Ferrite loaded ‘unit’ elements
- Guanella transformer from coax
- Choke balun (1:1) from coax



GUANELLA 2-WAY SPLITTER/COMBINER

- In-phase combiner from guanella structure
- Common port is half impedance
- Differential termination is also half
- A 4-port hybrid is formed by adding a balun interface to differential terminals
- Ferrite loading extends bandwidth





SUMMARY

- Combiners are splitters
- Transformers are basis of 0° and 180° combiners
- Bandwidth requires more elements
- Termination of undesired mode provides isolation
- Isolation port connection forms a 0°/180° hybrid (this is also known as a ‘magic T’)