Spice S-parameter Measurement with MicroSim AppNote Method

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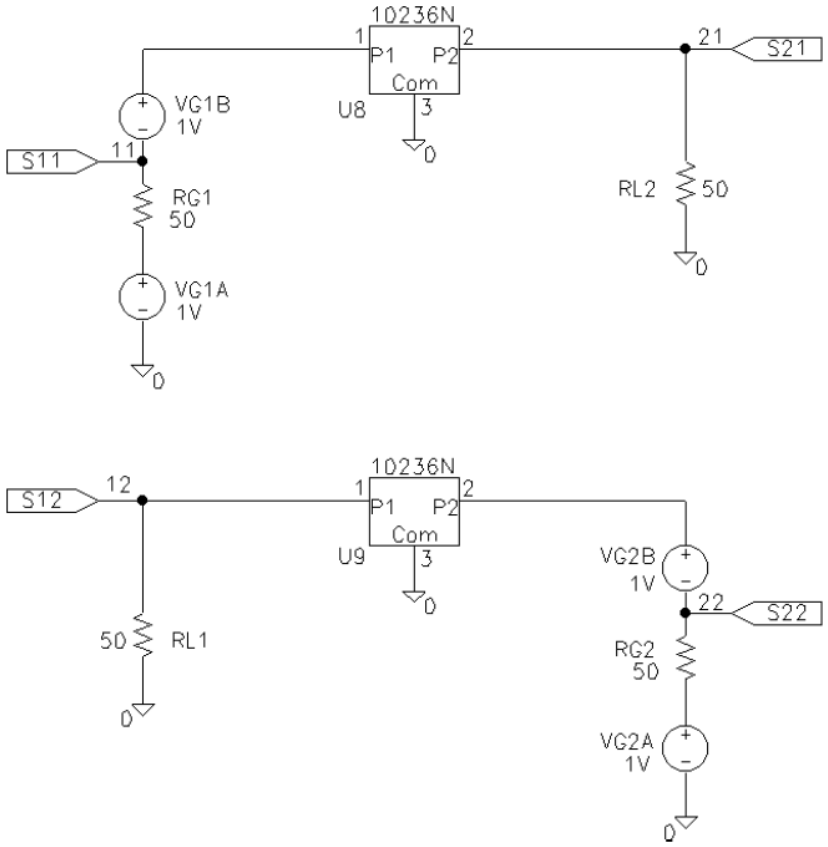
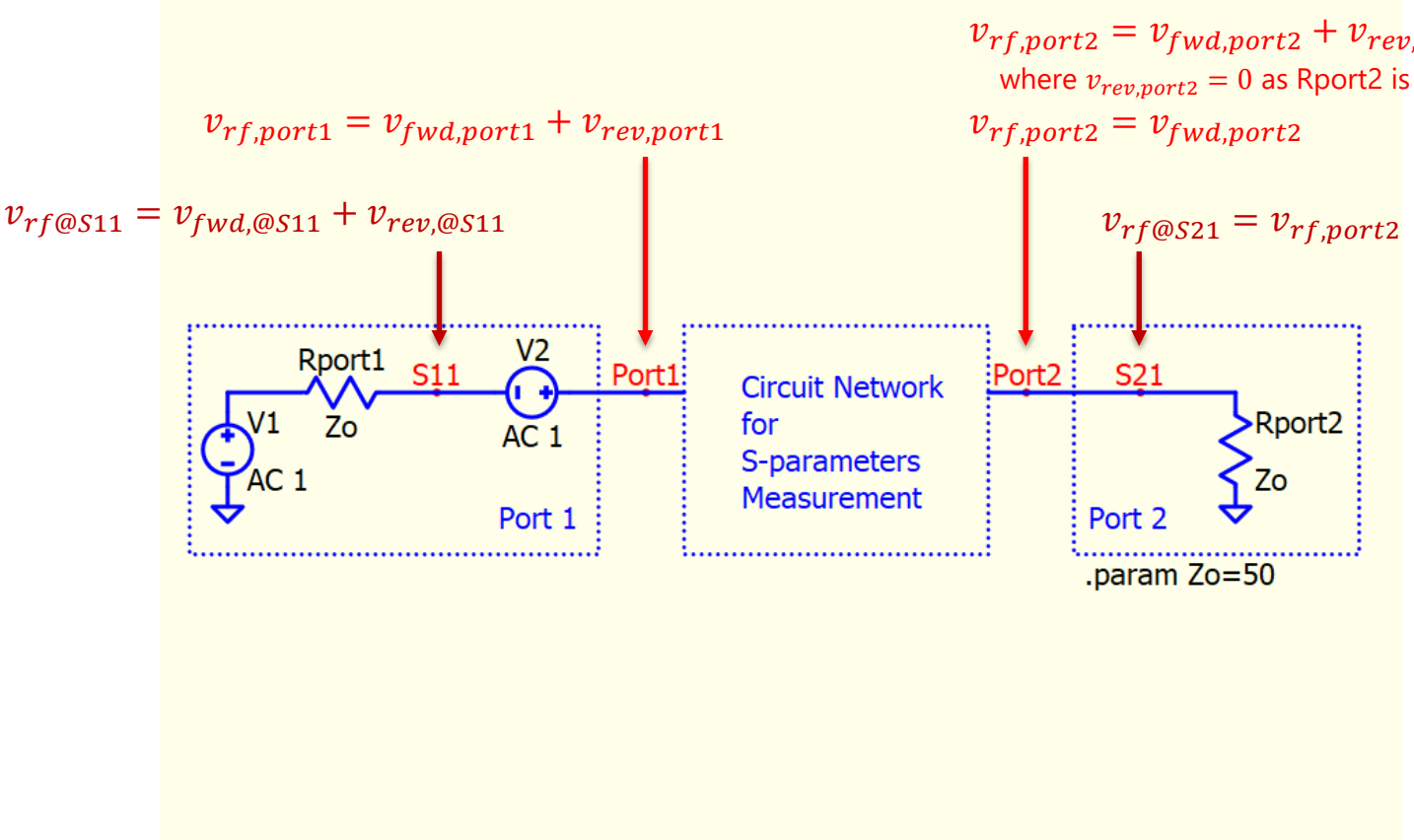
S-Parameters Measurement Circuit

- S-Parameters Measurement Circuit
  - Reference : MicroSim Application Notes Version 8 June-1997
    - Section : Create S-Parameter Subcircuits for Microwave and RF Applications

- Definition of S11 and S21
  - $S_{11} = \frac{v_{rev,port1}}{v_{fwd,port1}} = \sqrt{\frac{P_{rev,port1}}{P_{fwd,port1}}}$
    - Given $v_{rev,port2} = 0V$ ($p_{rev,port2} = 0W$)
  - $S_{21} = \frac{v_{fwd,port2}}{v_{fwd,port1}} = \sqrt{\frac{P_{fwd,port2}}{P_{fwd,port1}}}$
    - Given $v_{rev,port2} = 0V$ ($p_{rev,port2} = 0W$)
  - Measurable voltage (v_{rf}) is summation of forward and reverse voltage
    - $v_{rf} = v_{fwd} + v_{rev}$



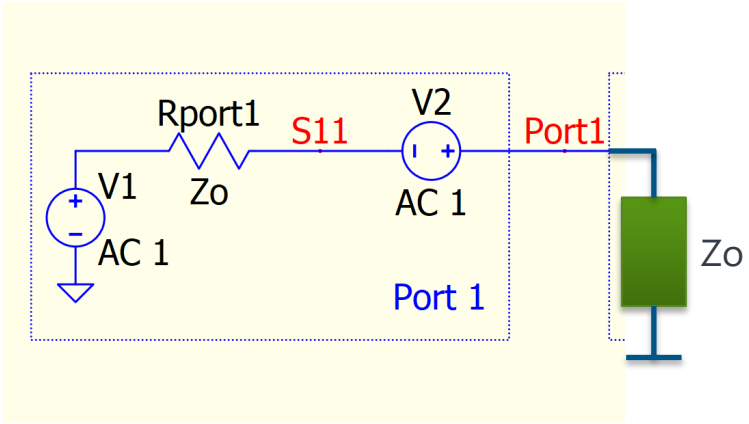
S-Parameters Measurement Circuit



Explanation of S21

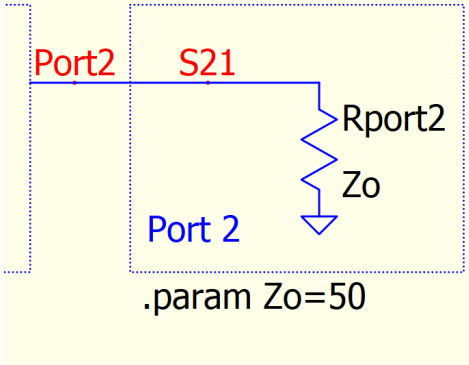
- Forward voltage @ Port1
  - To measure forward voltage @ Port1, break connection and connect a terminal impedance equal characteristic impedance (Zo)
  - $v_{rev,port1} = 0$
  - Kirchhoff's voltage law

$$v_{fwd,port1} = \frac{Z_o}{Z_o + Z_o}(1+1) = 1$$



- Forward voltage @ Port2
  - As Port2 is terminated with Zo, $v_{rev,port2} = 0$
  - $v_{rf,port2} = v_{fwd,port2} + v_{rev,port2} = v_{fwd,port2}$
  - $v_{fwd,port2} = v_{rf,port2} = v_{rf,@S21}$

- By $S_{21} = \frac{v_{fwd,port2}}{v_{fwd,port1}} = \frac{v_{rf,@S21}}{1} = v_{rf,@S21}$
  - Therefore, S21 = V(S21)



Explanation of S11

- Forward voltage @ Port1
  - To measure forward voltage @ Port1, break connection and connect a terminal impedance equal characteristic impedance (Zo)
  - $v_{rev,port1} = 0$
  - $v_{fwd,port1} = \frac{Z_o}{Z_o+Z_o}(1+1) = 1$
  - Kirchhoff's voltage law

    $$v_{fwd,@S11} = -1 + v_{fwd,port1} = 0$$

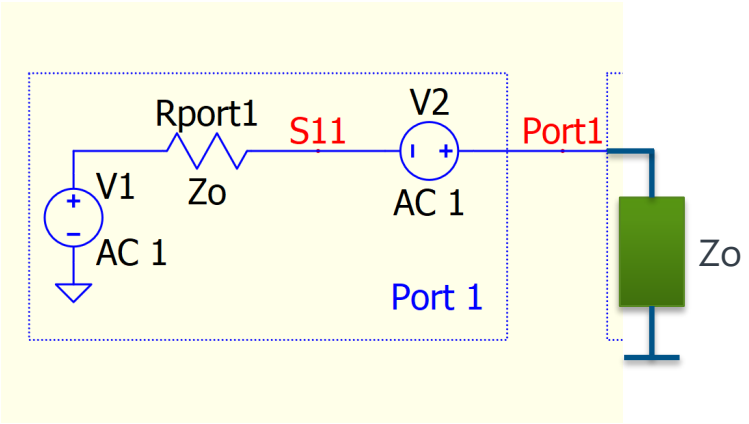
- Reverse voltage @ Port1
  - $v_{rf,port1} = v_{fwd,port1} + v_{rev,port1}$

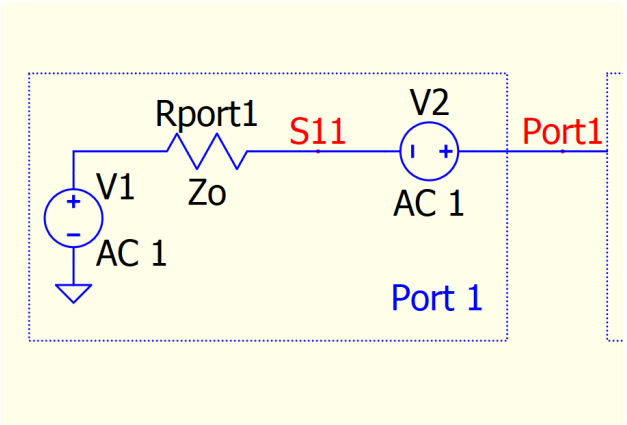
    $$v_{rf,port1} = 1 + v_{rev,port1}$$
  - Kirchhoff's voltage law

    $v_{rf,@S11} = -1 + v_{rf,port1}$

    $v_{rf,@S11} = -1 + 1 + v_{rev,port1} = v_{rev,port1}$

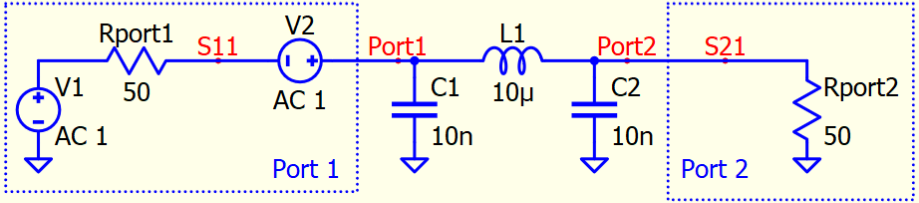
- By $S_{11} = \frac{v_{rev,port1}}{v_{fwd,port1}} = \frac{v_{rev,port1}}{1} = v_{rf,@S11}$
  - Therefore, S11=V(S11)
  - ** The beauty of this method is that, V(S11) measure 0V forward voltage and only measure reverse voltage.





QSpice Simulation for S_{11} and S_{21} : QSpice_Sparam_Simulation_MicroSim.qsch

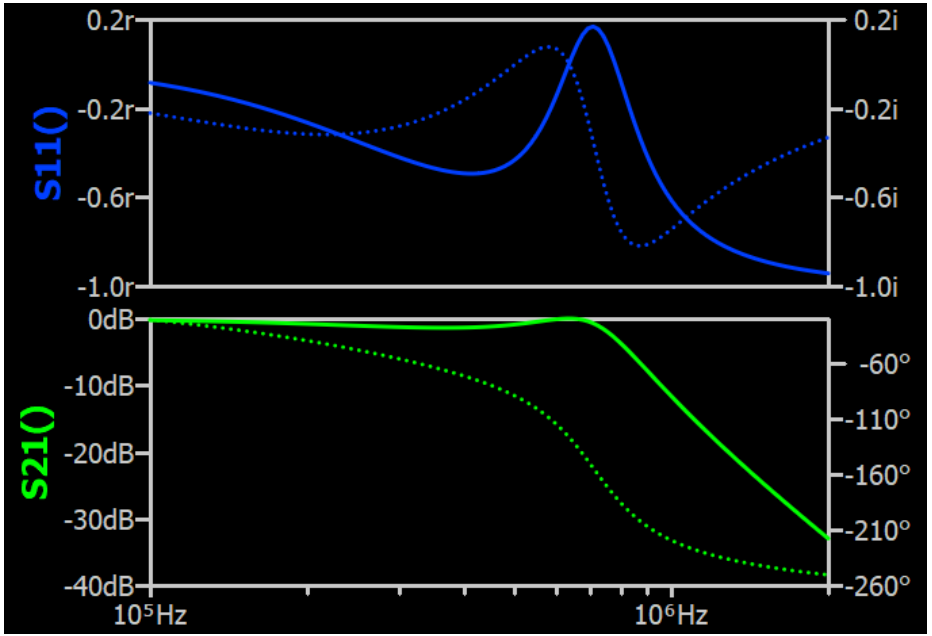
Schematic




```
.param Zo=50
From MicroSim App Notes
.func S11() V(S11)
.func S21() V(S21)
```

```
.ac dec 100 100K 2Meg
.plot S21()
.plot S11()
```

Simulation Results



Plot S11 into SmithChart Range

- Plot S11 into SmithChart Range
  - Method
    - Plot S11 with y-axis as imag(S11) and x-axis as real(S11), and plot have to be Cartesian representation
  - Y-Axis (Left)
    - Change Y expression to : im(S11())
    - Change Representation from Polar to Catesian
    - Change Range from -1 (bottom) to +1 (top)
  - Y-Axis (Right)
    - Select “No Imaginary”
  - X-Axis
    - Change Quantity Plotted to : re(S11())
    - Change Range from -1 to 1
    - Disable “Logarithmic”