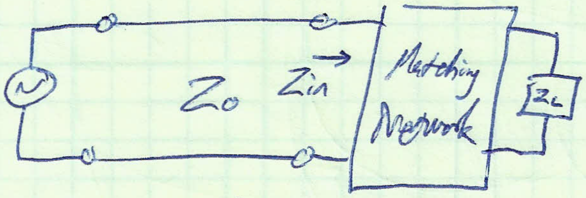
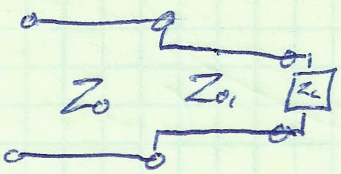
Impedance Matching

- Length of transmission line, or lumped element that is added to a circuit to eliminate reflections from propagating back toward generator
- There can be internal reflections in matching circuit, but the net reflected power toward generator is canceled



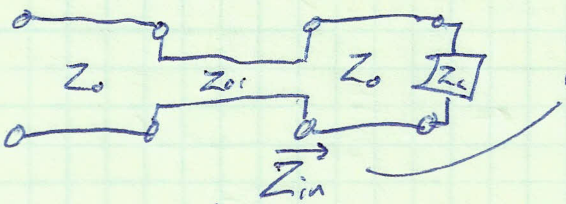
Choose matching network so that $Z_{in} = Z_0$

- If Z_L is real, we can use quarter wave transformer



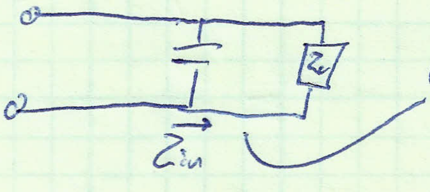
$$Z_{01} = \sqrt{Z_0 Z_L}$$

- If Z_L is complex, we can still use quarter wave transformer, but offset



Choose length to make Z_{in} real, then choose $Z_{01} = \sqrt{Z_0 Z_{in}}$

- Can also use lumped elements in shunt with transmission line



Choose length to make Z_{in} real (and Y_{in})

With shunt elements, it is easiest to work in admittance

$Y_{in} = Y_d + Y_s$ ← admittances add in shunt

Admittance $Y = G + jB$ ← Susceptance

↑ Conductance

$Y_{in} = (G_d + jB_d) + jB_s$

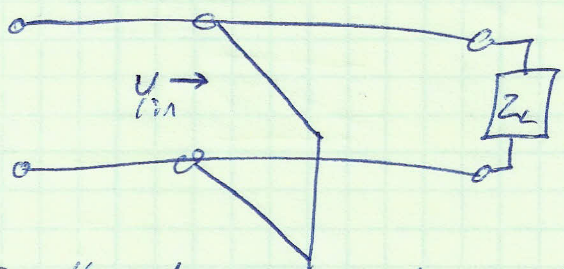
$(G_d + jB_d)$ ← load + line

jB_s ← shunt element or stub

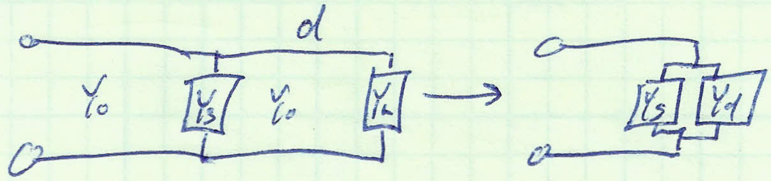
normalized quantities $y_{in} = g_d + j(b_d + b_s)$

matching condition: $g_d = 1$, $b_d = -b_s$

- Can also realize shunt susceptance using length of open or short transmission line



- In all of these cases, take equivalent admittance of line and load and treat in parallel with lumped element or stub



Design procedures for matching circuits using smith chart

- Quarter wave transformer at distance d from load
  - locate point z_L normalized load impedance on chart
  - draw circle of constant $|\Gamma|$ around origin
  - rotate from z_L to a point on the real axis (clockwise!)
  - read distance in wavelengths from chart
  - get Z_d from real axis on chart
  - design $\lambda/4$ transmission line with $Z_1 = \sqrt{Z_0 Z_d}$
- Shunt stub (or lumped element)
  - locate point z_L normalized load impedance on chart
  - draw circle of constant $|\Gamma|$ around origin
  - locate point y_L on opposite point on constant $|\Gamma|$ circle
  - rotate from y_L to the $g=1$ circle (clockwise!)
  - read distance in wavelength from the chart
  - read value of b_d from the chart
  - for lumped element matching:

$$B_d = b_d Y_0$$
$$B_s = -B_d = \omega C \text{ for capacitor}$$
$$-B_d = \frac{1}{\omega L} \text{ for inductor}$$

  - for stub matching:
    - Choose open or short (remember Y is at opposite side from Z) that is closest to $-b_d$ (remember you will be rotating clockwise)
    - read length in wavelengths from the chart

Quarter Wave transformer Design (with offset d)

The Complete Smith Chart

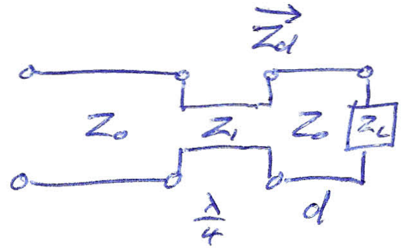
Black Magic Design

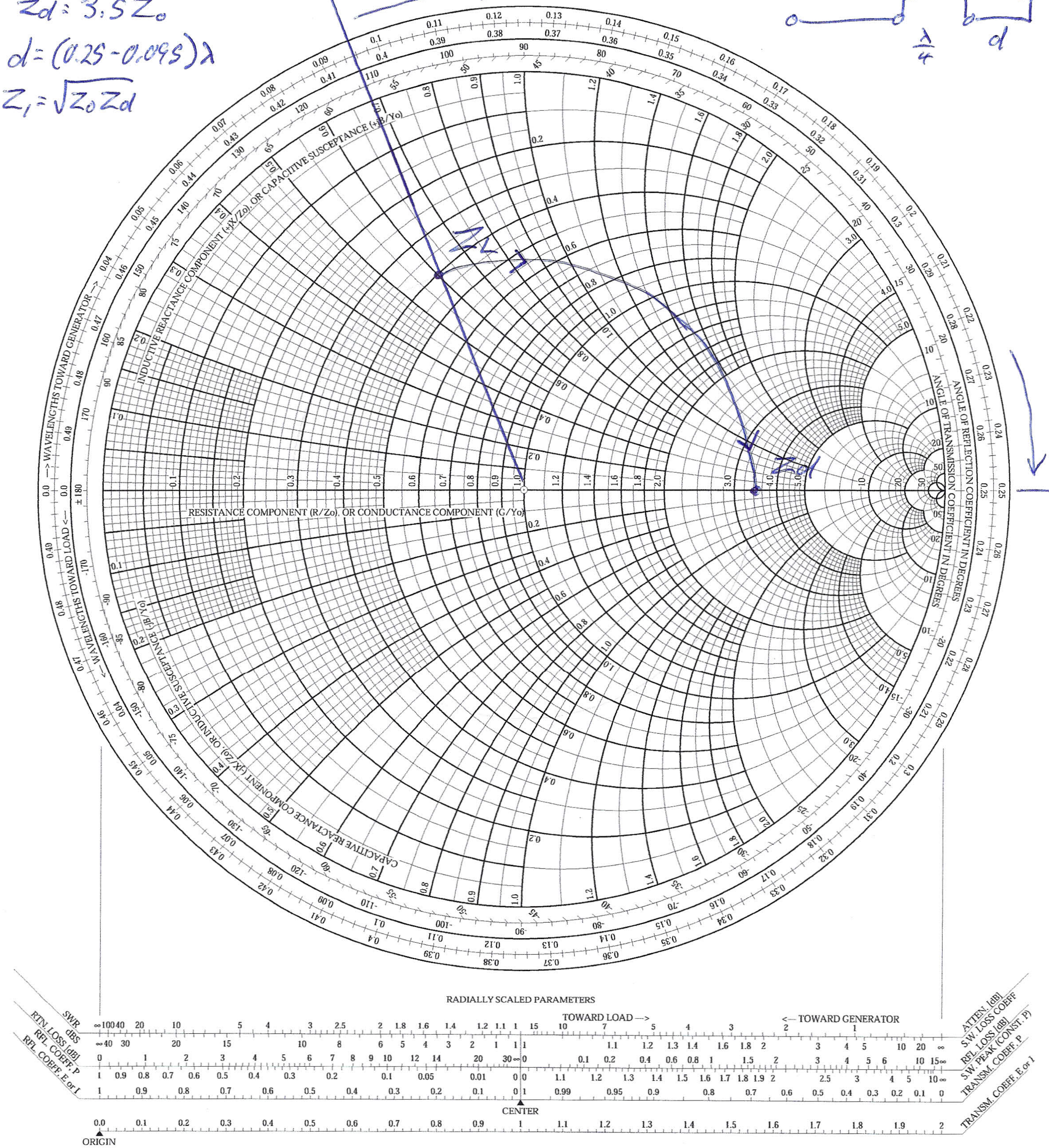
$z_L = (0.4 + 0.6j) Z_0$

$z_d : 3.5 Z_0$

$d = (0.25 - 0.095)\lambda$

$Z_1 = \sqrt{Z_0 Z_d}$





Single stub (or lumped element) Design

$Z_L = 0.4 + 0.6j$

$Y_L = 0.8 + 1.0j$

$d = [(0.5 - 0.342) + 0.17]\lambda$

$Y_d = 1.3$

$l\,(\text{stub}) = (0.352 - 0.25)\lambda$

The Complete Smith Chart

Black Magic Design