ENEL 476 – Winter 2018

Written Assignment #3

Due Friday April 13, 2018 (drop box on 2nd floor of ICT or via D2L)

A transmission line with Z_o=50 Ω is connected to a load of Z_L=20-j20 Ω. The frequency of operation is 1 GHz, and the velocity of propagation on the line is 0.9 c (where c is the speed of light in free space).

a) Design a series stub tuner to match the load to the line. Select the stub location that is closest to the load. Specify the location of the stub and length of the open-circuited stub required to match the load. Use both wavelengths and physical distance.

b) Design a shunt stub tuner to match the load to the line. Select the stub location that is closest to the load. Specify the location of the stub and length of the open-circuited stub required to match the load. Use wavelengths.

c) Design a quarter-wavelength transformer to match the load to the line. Specify the location of the quarter-wavelength transformer relative to the load (in wavelengths), as well as the impedance of the quarter-wavelength line.

Submit the Smith chart that you used to design the tuners and transformer, as well as a summary of the locations and lengths (stub tuners) or location and impedance (quarter-wavelength transformer).

$Z_L = 20 - j20$

$Z_0 = 50$

$z_L = \frac{20 - j20}{50}$

$\boxed{z_L = 0.4 - j0.4}$

$\lambda = \frac{0.9c}{f}$

$= \frac{0.9c}{1 \times 10^9}$

$= \frac{(0.9)(3 \times 10^8)}{1 \times 10^9}$

$= \frac{2.7}{10}$ $\Rightarrow \boxed{\lambda = 0.27\,m}$

$= 0.27\,m$

a) Series stub tuning

↳ plot z_L

↳ draw constant-s circle

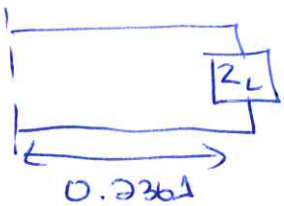
↳ rotate towards generator to intersection with r=1 circle

→ z_L @ 0.43λ

→ z_1' @ 0.166λ

⇒ (0.5 − 0.43)λ = 0.07λ

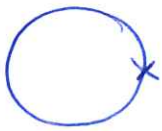
0.07λ + 0.166λ = 0.236λ ⇒ this is stub location



↳ at z_1', the impedance $z_1' = 1 + j1.1$

↳ need stub with $z_{stub} = -j1.1$ to cancel imaginary component

↳ start at open & rotate around outside of chart to $-j1.1$



→ open @ 0.25λ

→ $-j1.1$ @ 0.368λ

⇒ (0.368 − 0.25)λ = 0.118λ ⇒ this is stub length

⇒ Stub location: 0.236λ or (0.236)(0.27) = 6.372cm

Stub length: 0.118λ or (0.11)(0.27) = 3.186 cm

Normalized Impedance Smith Chart

version 1.0
2014-01-30

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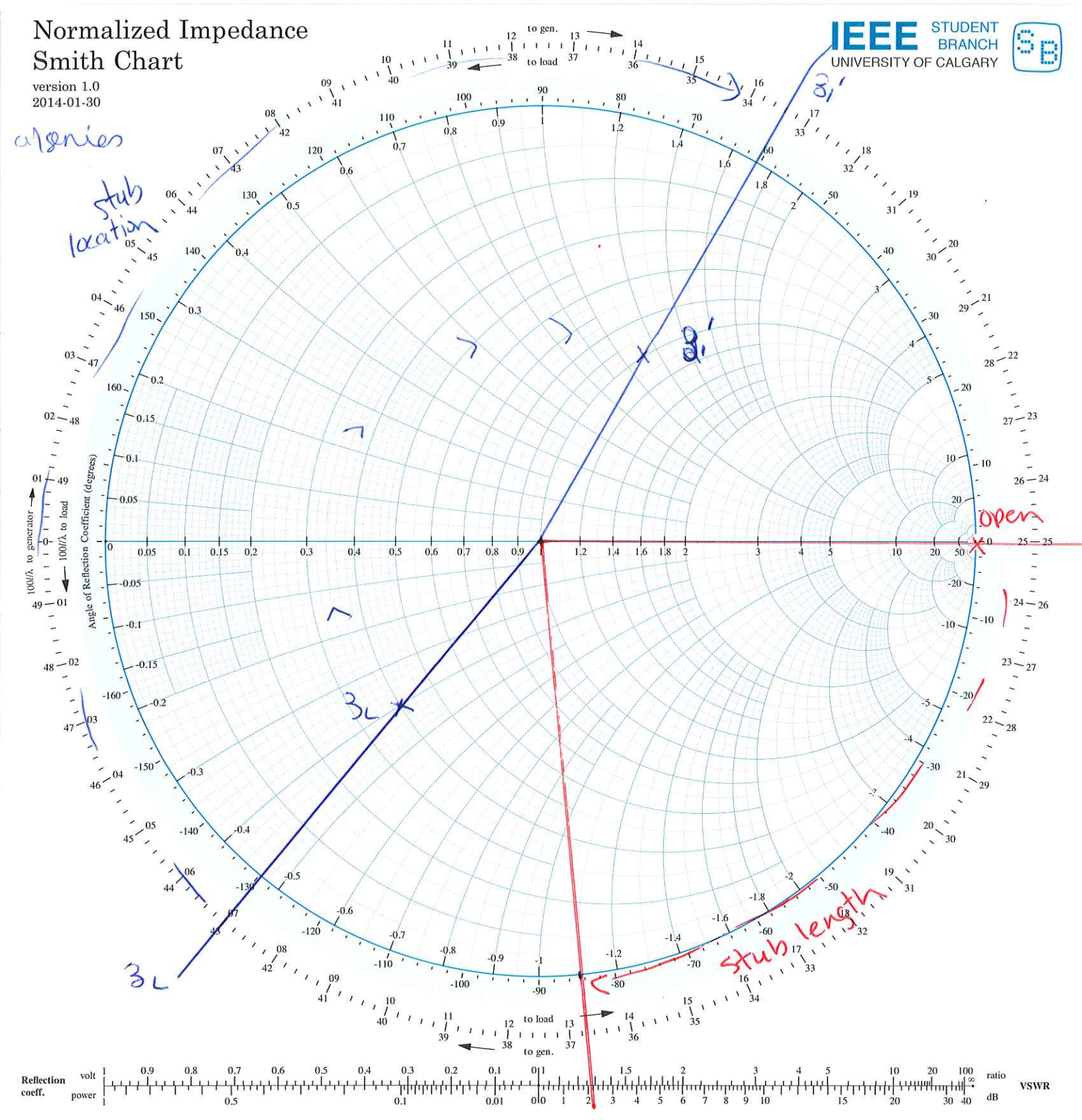

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b) shunt stub tuning

↳ plot z_L

↳ rotate 180° on chart to obtain y_L

(working in parallel ⇒ want to use admittance)

↳ draw constant s-circle

↳ rotate towards generator to intersection with $g=1$ circle

→ y_L @ 0.182λ

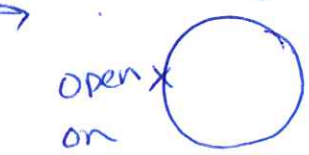
→ y_1' @ 0.334λ

→ $(0.334 - 0.182)\lambda = 0.152\lambda$ ⇒ stub location

↳ @ y_1', $y_1' = 1 - j1.1$.

↳ need stub with $y_{stub} = j1.1$ to cancel imaginary part

→



→ start @ open & rotate around outside of chart to $j1.1$.

→ open @ 0

→ $j1.1$ @ 0.132λ ⇒ stub length: 0.132λ

⇒ stub location: 0.152λ or $(0.152)(0.27) = 4.104\text{cm}$

stub length: 0.132λ or $(0.132)(0.27) = 3.564\text{cm}$

Normalized Impedance Smith Chart

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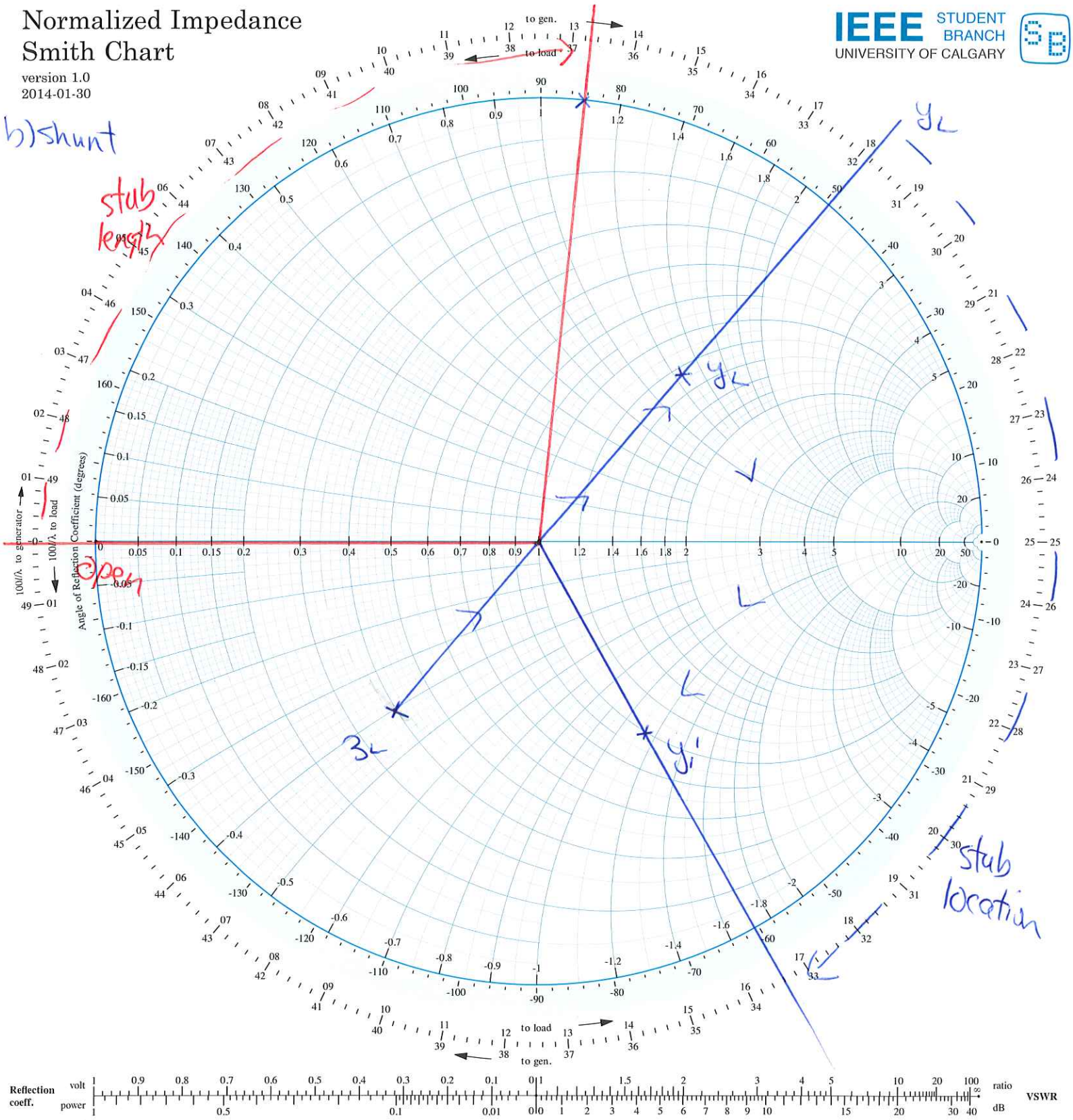

Reflection coeff. volt power

VSWR ratio dB

c) $\lambda/4$ transformer

→ plot z_L

→ draw constant s-circle

→ rotate from z_L to axis (i.e. want imaginary part of impedance to be zero)

↳ locations of V_{min} & V_{max}

V_{min}

z_L @ 0.43 λ

V_{min} @ 0.5 λ

⇒ move 0.07 λ away from load

⇒ @ V_{min}, $z_{in} = 0.33$

$Z_{in} = (0.33)(50)$

$= 16.5\ \Omega$

$Z_{\lambda/4} = \sqrt{(16.5)(50)}$

$= 28.72\ \Omega$

⇒ move 0.07 λ from load & attach $\lambda/4$ line with impedance 28.72 Ω

Check: $\frac{16.5}{28.72} = 0.575$

↳ plot on chart & rotate $\lambda/4$

↳ $z_{in} \sim 1.75$

$Z_{in} = (1.75)(28.72)$

$= 50.26\ \Omega$ ⇒ close to 50 Ω target

V_{max}

z_L @ 0.43 λ

V_{max} @ 0.25 λ

⇒ move 0.32 λ from load

⇒ @ V_{max}, $z_{in} = 3$

$Z_{in} = 150$

$Z_{\lambda/4} = \sqrt{(150)(50)}$

$= 86.6\ \Omega$

Check: $\frac{150}{86.6} = 1.73$

↳ plot 1.73 & rotate $\lambda/4$

⇒ 0.575

$Z_{in}' = (0.575)(86.6)$

$= 49.795\ \Omega$

↳ close to target

Normalized Impedance Smith Chart

version 1.0
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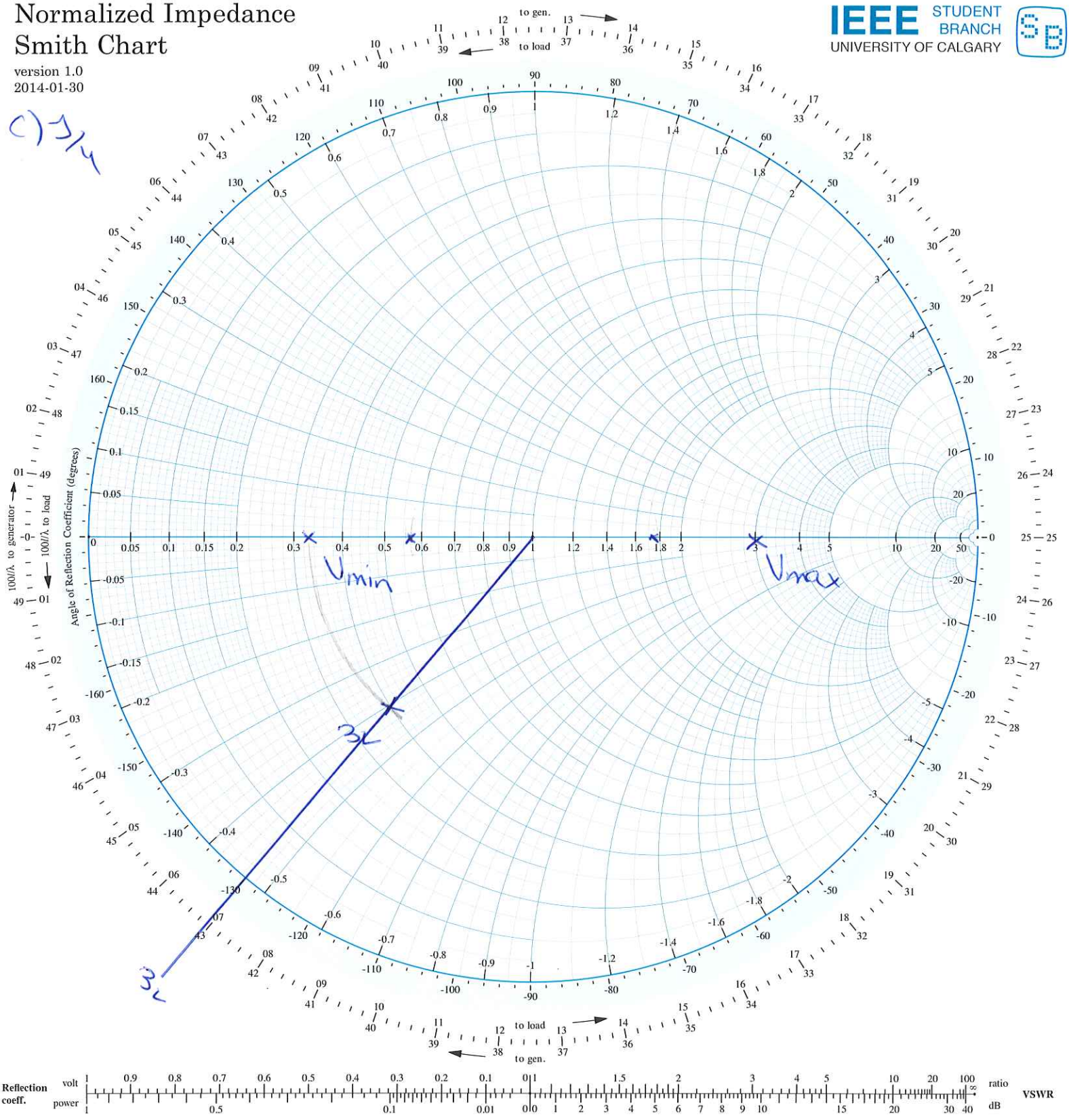
c) 3λ/4



Reflection coeff. volt power

VSWR ratio dB