Phasors and

- Opamps
- Spice

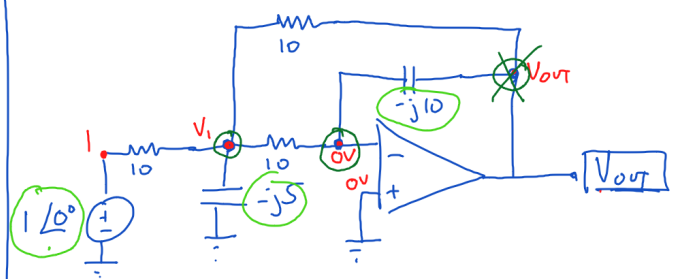
Opamps

- Golden Rules
  - no current into inputs
  - $V^+ = V^-$ if neg feedback
- Squires Rules for Analysis
  - KCL (Nodal) Inputs
  - Never KCL at outputs

$\frac{1}{-j5}$ $\quad 1/(-j5)$

$\frac{j}{5}$ $\quad j/5$

Ex



V_1 : $\frac{V_1 - 1}{10} + \frac{V_1}{-j5} + \frac{V_1}{10} + \frac{V_1 - V_{out}}{10} = 0$

V^- : $\frac{0 - V_1}{10} + \frac{0 - V_{out}}{-j10} = 0$

$V_1\left(\frac{1}{10} + \frac{1}{-j5} + \frac{1}{10} + \frac{1}{10}\right) + V_{out}\left(-\frac{1}{10}\right) = \frac{1}{10}$

$V_1\left(-\frac{1}{10}\right) + V_{out}\left(\frac{1}{j10}\right) = 0$

$\begin{bmatrix} \frac{3}{10} + \frac{j}{5} & -\frac{1}{10} \\ -\frac{1}{10} & -\frac{j}{10} \end{bmatrix} \begin{bmatrix} V_1 \\ V_{out} \end{bmatrix} = \begin{bmatrix} \frac{1}{10} \\ 0 \end{bmatrix} \Rightarrow \begin{bmatrix} V_1 \\ V_{out} \end{bmatrix} = \begin{bmatrix} 0.316\angle -18.4° \\ 0.316\angle 71.6° \end{bmatrix}$

$V_1 - 1 + jV_1 2 + V_1 + V_1 - V_{out} = 0$

$V_1(3 + j2) - V_{out} = 1$

$-jV_{out}(3 + j2) - V_{out} = 1$

$\frac{V_1}{10} = \frac{V_{out}}{+j10} \Rightarrow V_1 = -jV_{out}$

$-j3V_{out} + V_{out}2 - V_{out} = 1$

$V_{out}(1 - j3) = 1$

$V_{out} = \frac{1}{1 - j3} = 0.316\angle 71.6°$

TI-89 keystrokes to solve the matrix equation:

$$\begin{bmatrix} \frac{3}{10}+\frac{j}{5} & -\frac{1}{10} \\ -\frac{1}{10} & -\frac{j}{10} \end{bmatrix} \begin{bmatrix} V_1 \\ V_{out} \end{bmatrix} = \begin{bmatrix} \frac{1}{10} \\ 0 \end{bmatrix}$$

First, put into correct mode:

- Angle → Degrees
- Complex Format→Polar
- Exact/Approx → Approx

```
cSolve((3/10+i/5)x – 1/10y = 1/10 and -0.1x – i/10y = 0, {x, y})
```

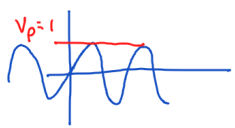
Result: x = 0.316 ∠ -18.4°, y = 0.316 ∠ 71.6°

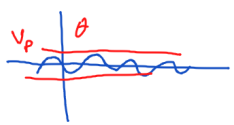
See the handout “How to use your TI-89” in lesson 23 for far greater detail.

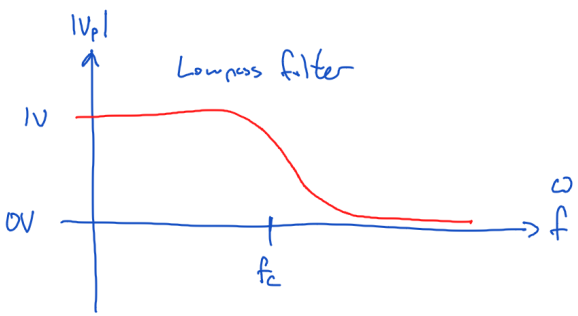
Spice & Phasors

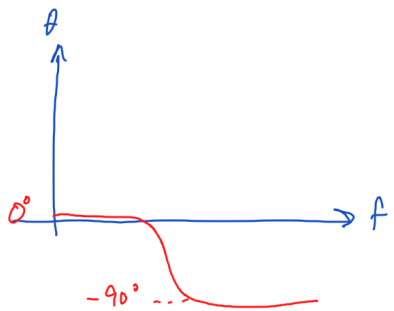
Concept: Given SSS voltage input $1\cos(\omega t)$ sweeping ω
$1\cos(2\pi f t)$ f

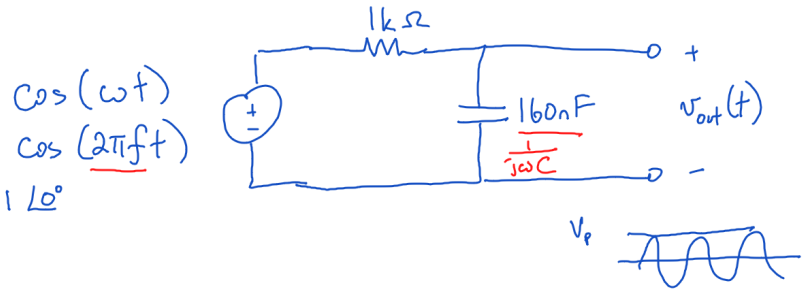
Find magnitude (V_p) of output

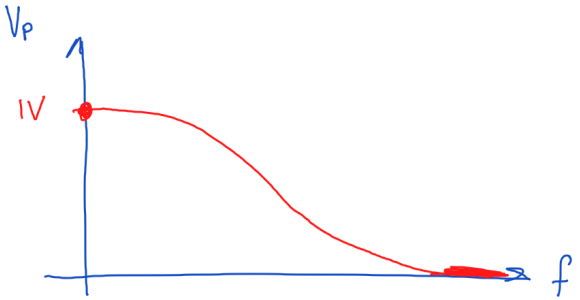









1kΩ
cos(ωt)
cos(2πft)
1∠0°
160nF
1/jωC
+
-
$v_{out}(t)$
V_p


V_p
1V
f