CIRCUIT REVIEW

OHM'S LAW

\[ I = \frac{V}{R} \]

\[ V = I \cdot R \]

* IMPORTANT TO GET V "+" CORRECT WITH RESPECT TO I "->"

POWER DISSIPATED P = VI

KCL (KIRCHHOFF CURRENT LAW)

\[ I_1 + I_2 + I_3 = 0 \]

\[ \sum_{k=1}^{n} I_k = 0 \]

SUM OF CURRENTS FLOWING INTO A NODE EQUALS 0
KVL (KIRCHHOFF VOLTAGE LAW)

\[ V_1 + V_2 + V_3 = 0 \]

\[ \sum_{k=1}^{n} V_k = 0 \quad \text{Sum of Voltages Around a Loop Equals 0} \]

Getting Signs Correct

Can define \( I \) (or \( V \)) anyway you want but must have \( I \) \( V \) for one device to be consistent.

Example 1

\[ V_B - V_R = 0 \]

\[ V_R = V_B \]

If \( V_B = +1V \)

\[ R = 1 \Omega \Rightarrow I_R = 1A \]

\[ V_R = 1V \]
**Ex 2**

![Circuit diagram]

\[ V_B + V_R = 0 \]
\[ V_R = -V_B \]
\[ I_R = \frac{V_R}{R} \]

If \( V_B = 1\text{V} \)
\( R = 1\Omega \) then \( I_R = \frac{-1\text{V}}{1\Omega} = -1\text{A} \) \( \checkmark \)
\( V_R = -1\text{V} \)

**Ex 3**

**WRONG**

\[ V_R = V_B \]
\[ I_R = \frac{V_R}{R} \] \( \times \)

If \( V_B = 1\text{V} \)
\( R = 1\Omega \) then \( I_R = \frac{1\text{V}}{1\Omega} = 1\text{A} \) \( \times \)

Actually \( I_R = -1\text{A} \)

Could use \( I_R = -\frac{V_R}{R} \) but why not just get device: \( V_I \) consistent.
INDEPENDENT SOURCES

VOLTAGE

DEVELOPMENT SOURCES

VCVS
VOLTAGE CONTROLLED VOLTAGE SOURCE

VCCS
VOLTAGE CONTROLLED CURRENT SOURCE

CCVS

CCC

RM [Ω]
A circuit of voltage sources, current sources and resistors (independent + dependent sources) can be converted to

\[ \begin{align*}
V_s & \quad + \\
M & \quad A \\
R_\text{s} & \\
\quad - & \quad B
\end{align*} \]

where \( V_s \) is open circuit voltage, \( V_{oc} \) seen at \( A-B \) & \( R_s \) is resistance seen at \( A-B \) when independent sources are zeroed.

Voltage source zeroed \( \Rightarrow \) short circuit current \( \Rightarrow \) open current
CURRENT SOURCE EQUIVALENT
(NORTON EQUIVALENT)

A VOLTAGE SOURCE EQUIVALENT CAN BE CONVERTED TO

\[ I_S = \frac{V_S}{R_S} \]

\( I_S \) IS SHORT CIRCUIT CURRENT, \( I_{sc} \) AT A-B

\( R_S \) IS RESISTANCE SEEN AT A-B WHEN INDEPENDENT SOURCES ARE ZEREOED

Note \( R_S = \frac{V_S}{I_S} \) OR \( R_S = \frac{V_{oc}}{I_{sc}} \)

\( V_{oc} \Rightarrow V_{AB} \) WHEN OPEN CIRCUIT

\( I_{sc} \Rightarrow I_{AB} \) WHEN SHORT CIRCUIT
Calculate $V_{oc}$

$V_{oc} = 7.5V$

$\Rightarrow U_S = 7.5V$

Calculate $R_S$

$R_S = 2k$
$I_S = \frac{V_S}{R_S} = 3.75\, mA$
WHEN TO USE VOLTAGE SOURCE OR CURRENT SOURCE?
EITHER CAN BE USED BUT BETTER INSIGHT IF 

RS SMALL ⇒ VOLTAGE SOURCE
RS LARGE ⇒ CURRENT SOURCE

\[
\begin{align*}
    &\text{RS} \quad \text{Vout} \\
    &\text{Vs} \\
\end{align*}
\]

AS RS → 0 BECOMES MORE IDEAL

\[
\begin{align*}
    &\text{I}_S \quad \text{RS} \\
    &\text{Vout} \\
\end{align*}
\]

AS RS → ∞ BECOMES MORE IDEAL

LARGE OR SMALL COMPARED TO NEXT STAGE INPUT RESISTANCE

THIS KEEPS VALUE OF "Vs" OR "I_S" A REASONABLE VALUE (NOT UNREASONABLY LARGE)
CAPACITORS + INDUCTORS

CAPACITOR

\[ q = CV_c \]

\[ \frac{dq}{dt} = C \frac{dV_c}{dt} \]

\[ I_C = C \frac{\Delta V_c}{\Delta t} \text{ if constant current } I_c \]

CHARGE, \( q \) \text{ units of coulombs}

CURRENT, \( I \) \text{ units of amps } \Rightarrow \text{ coulombs/second}

CAPACITOR IMPEDANCE

\[ Z = \frac{1}{SC} \]

\( S \Rightarrow \text{ LAPLACE TRANSFORM VARIABLE} \)

LET \( S = j\omega \) for sinusoidal frequencies
CAPACITOR ENERGY (POTENTIAL ENERGY)
\[ E_C = \frac{1}{2} CV_C^2 \] (STORED IN ELECTRIC FIELD)

INDUCTOR INDUCTANCE \( L \)
\[ V_L = \frac{1}{3} L \frac{di_L}{dt} \]

INDUCTOR IMPEDANCE
\[ Z = \frac{L}{\sigma} \]

INDUCTOR ENERGY (POTENTIAL ENERGY)
\[ E_L = \frac{1}{2} L i_L^2 \] (STORED IN MAGNETIC FIELD)