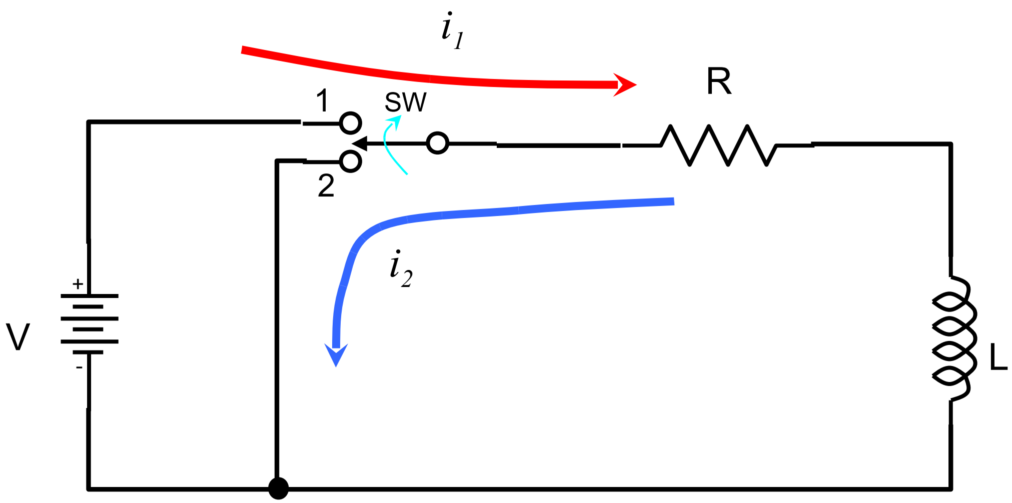
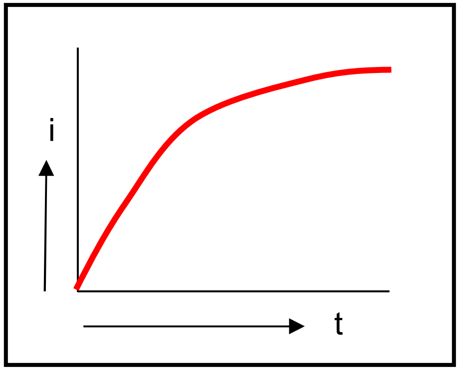
Transient Analysis: RL Circuit

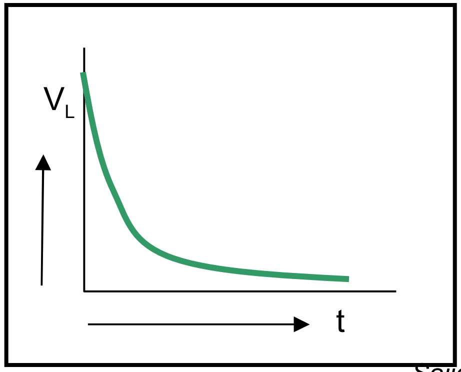


When switch (SW) in Position 1:

$$i_1 = \frac{V}{R}\left(1 - e^{-\frac{tR}{L}}\right)$$

$$V_L = V e^{-\frac{tR}{L}}$$





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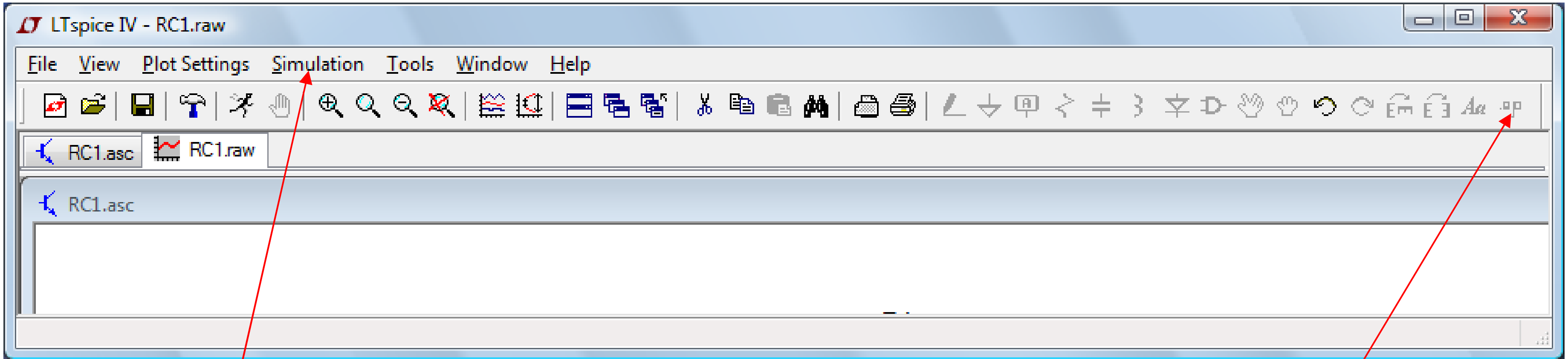
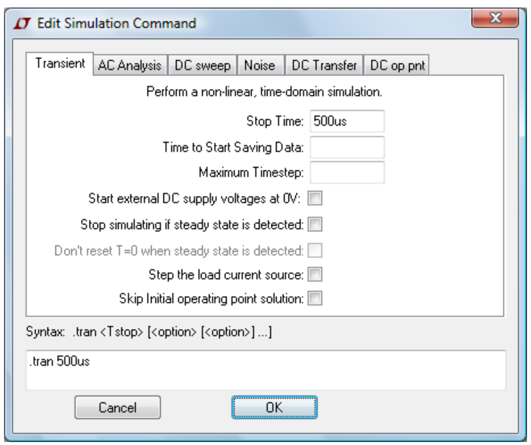
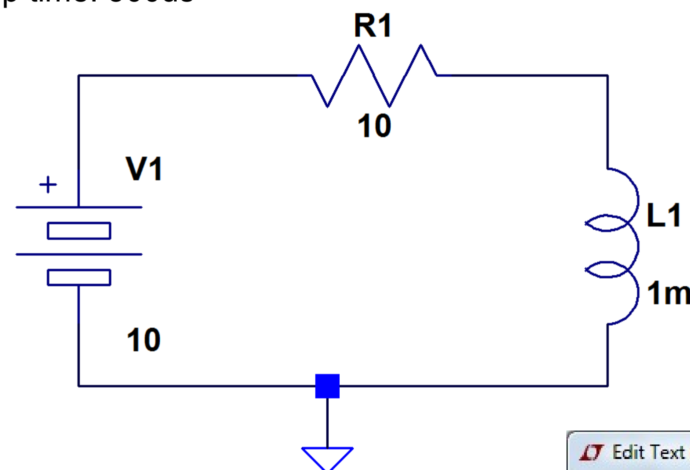
LT SPICE Simulation: Adding components and directive



Simulation > Edit simulation > Stop time: 500us

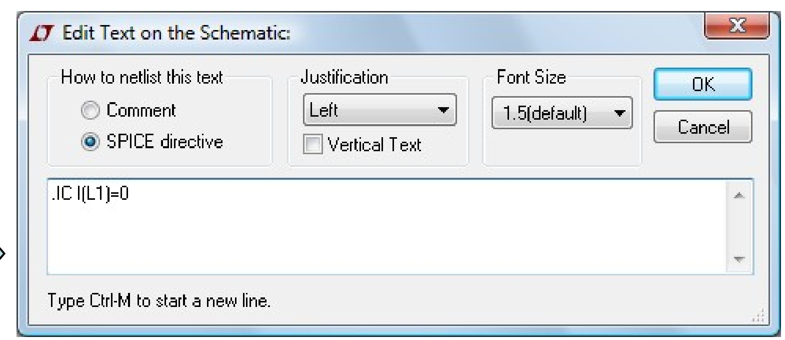




.IC I(L1)=0
.tran 500us

Add Spice Directive

Adding Spice directive: .IC I(L1)=0
Means setting initial condition:
At time t =0, I(L1) =0



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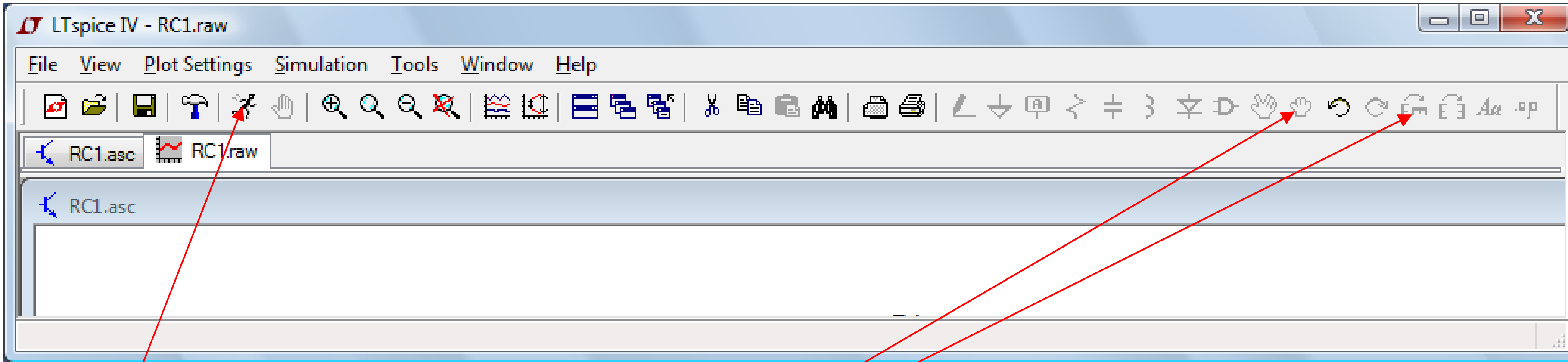
Run: Simulation

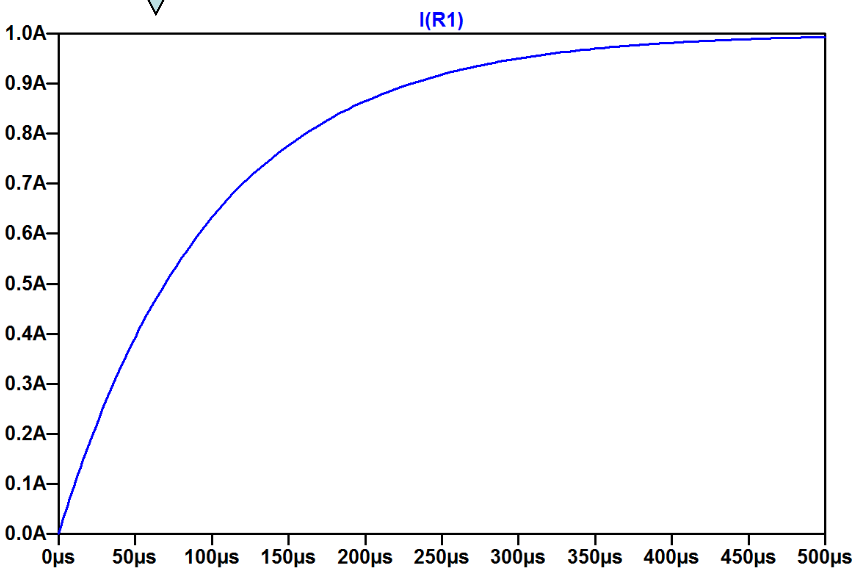


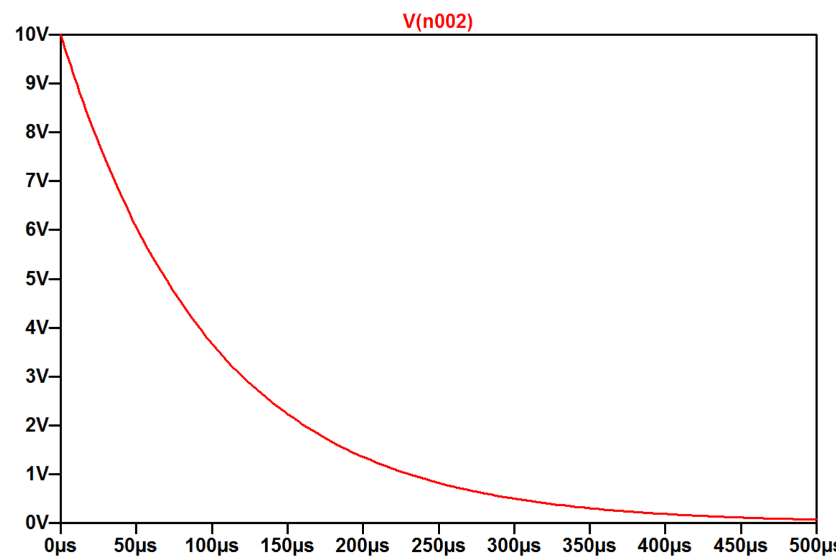
Run

Place current probe on R1 and Click

If you see current-direction is negative:
DRAG and **ROTATE** R1 twice

Place voltage probe at L1 and click





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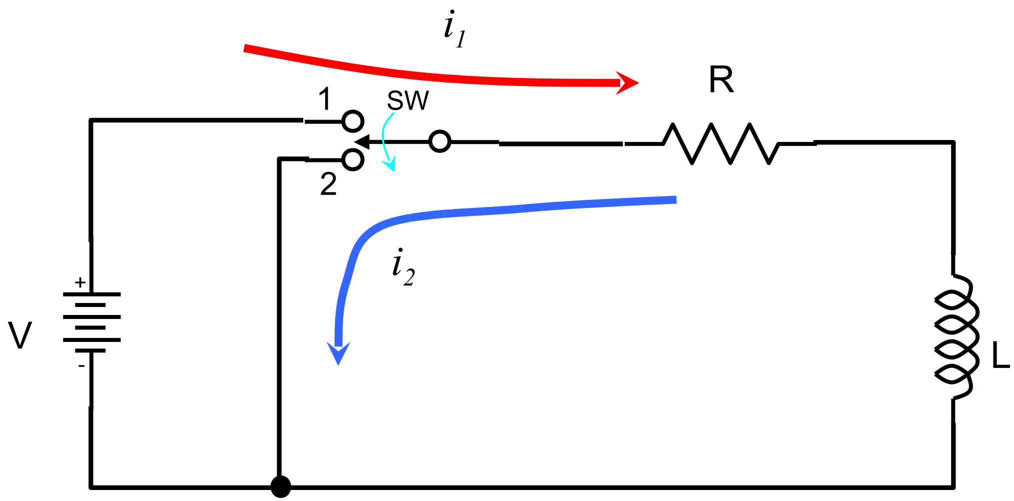
Switch ⇨ Position 2: Stored energy in the inductor is released



Keeping the switch (sw) in Position 1 for some time, The steady state current :

i_1 ⇨ V/R

⇩

Now the switch is in Position 2

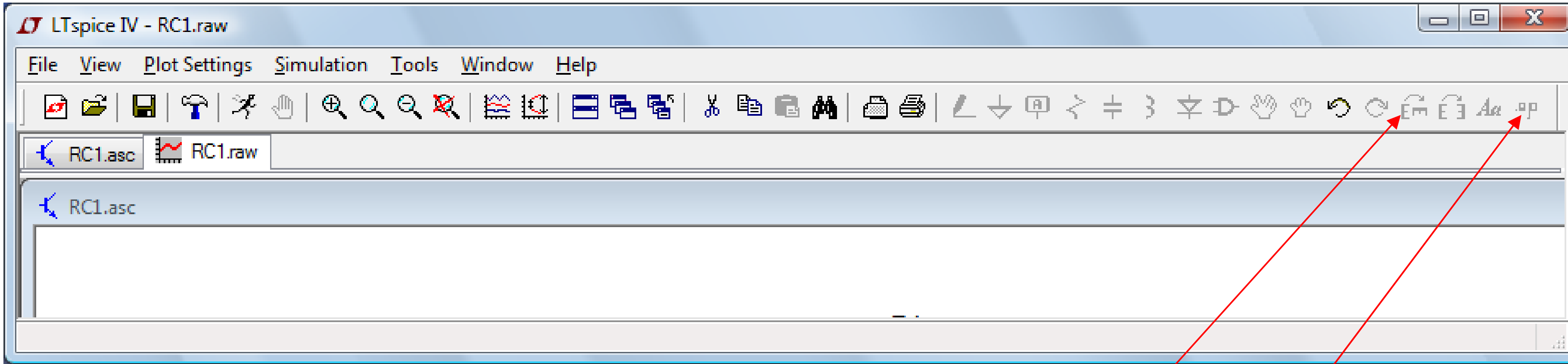
$i_{2(t=0)} = V/R$

$$i_2 = i_{2(t=0)}\, e^{-\frac{tR}{L}}$$

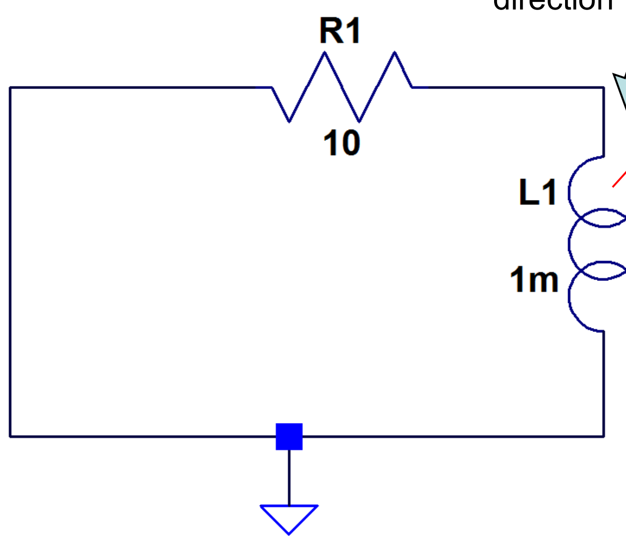
$$V_L = L\frac{di_2}{dt}$$

In practice whenever a switch like this breaking the contact from position 1, V_L= L di/dt becomes very high energy stored in the inductor is dissipated as electrical arc at the contact. However by electronic devices (replacing the mechanical switch) it is possible to make a smooth transition (I'll discuss it later)

LT SPICE Simulation: Stored inductor-energy dissipating



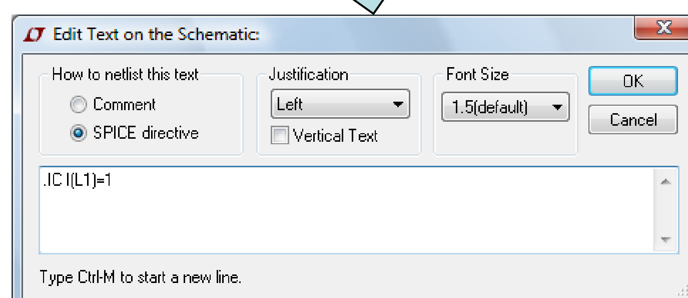
L1 Rotated twice to get
The current in positive
direction



Battery is removed and
Initial current : $I_{2(t=0)}$= 1 A

.IC I (L1)=1

.tran 500us



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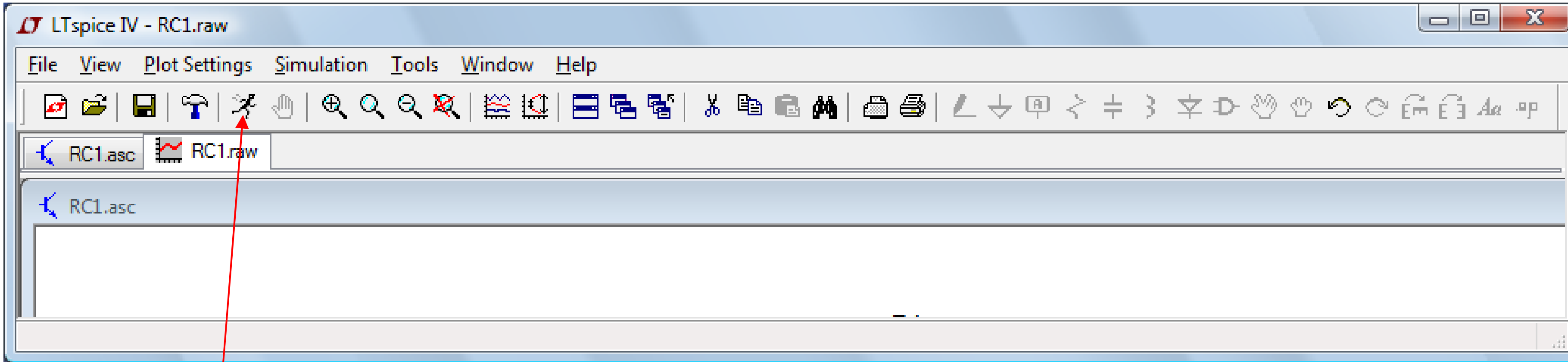
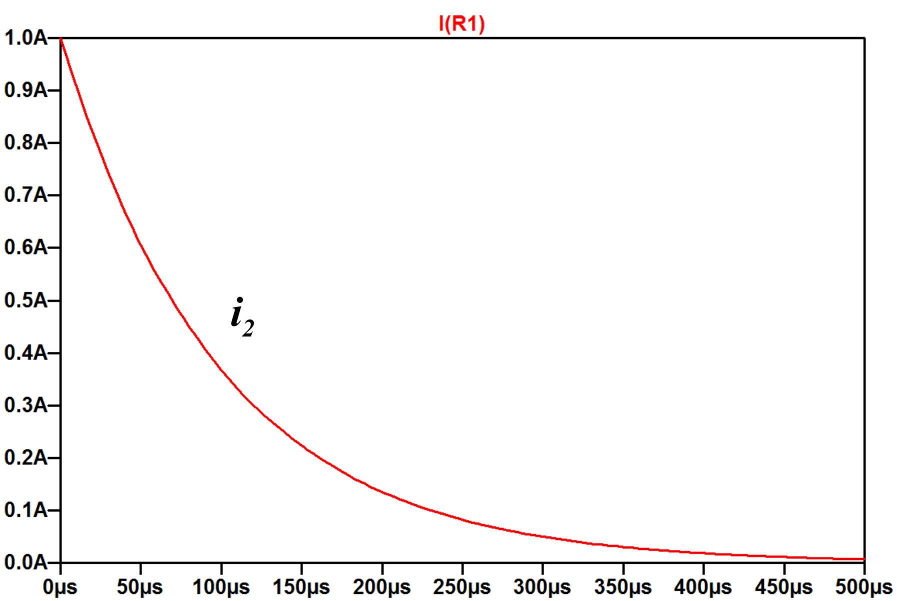
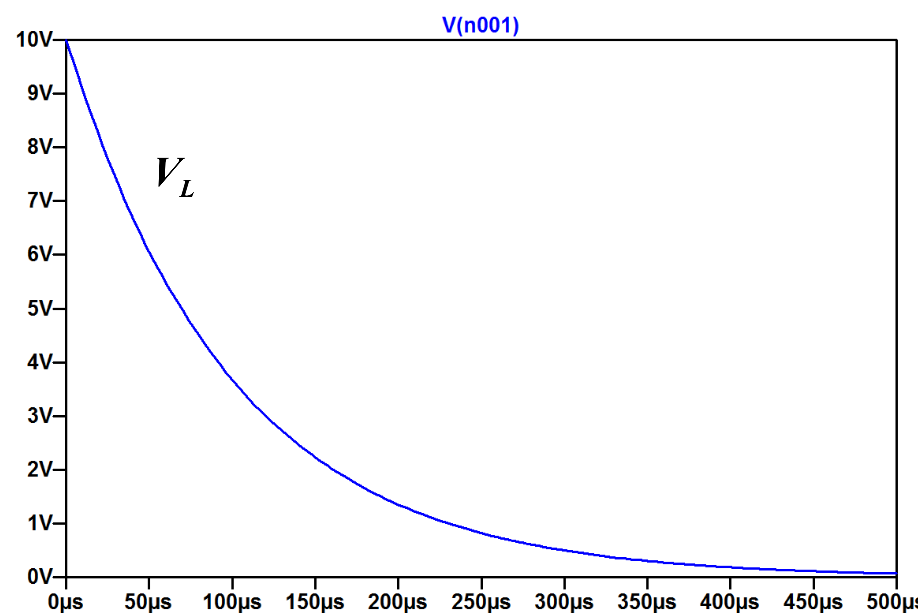
RUN: Simulation



Run, place current probe on R1 and click

place voltage probe on L1 and click





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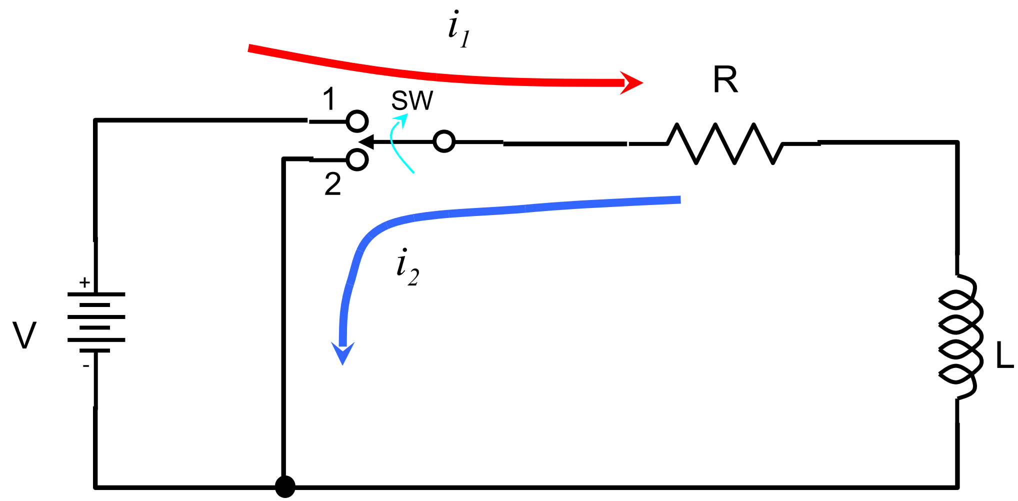
Calculating Power and Energy



When the switch is in position 1 for a long time, current i_1 takes the steady state value: $i_1 = V/R$

The switch is then on to position 2: Power dissipated by the resistor R is:

$$P = i_2^2 R = \frac{V^2}{R} e^{-\frac{2tR}{L}}$$

Total energy consumed by the resistor R is

$$E = \int P.dt = \frac{V^2}{R} \int_0^\infty e^{-\frac{2tR}{L}}$$

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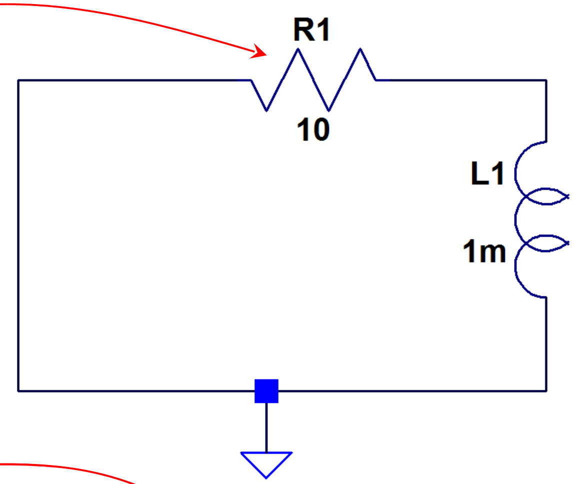
LTSpice to find Power and energy

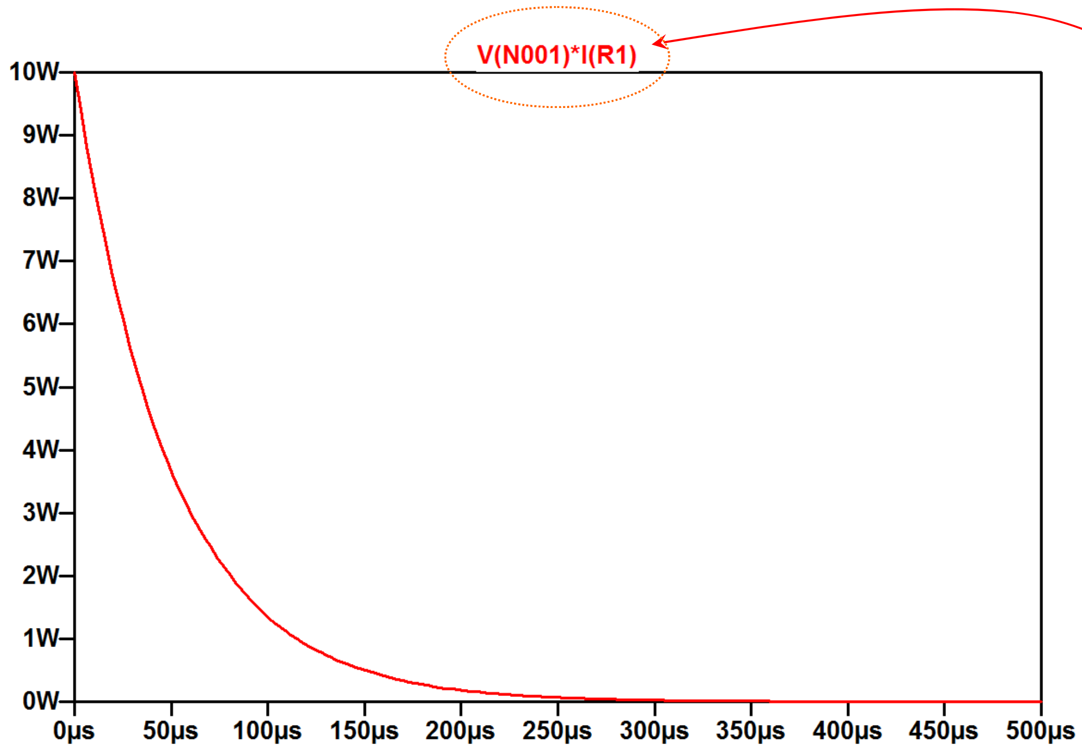


.IC I (L1)=1

.tran 500us

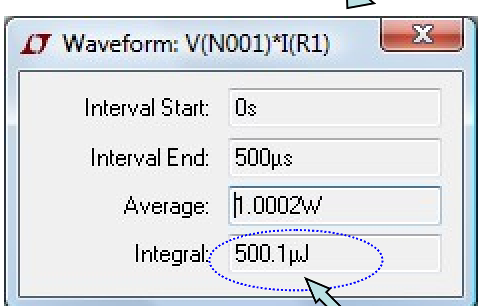
Press down **ALT** key and place the cursor on R1 (You will see an icon of thermometer) and click

You will get the power data as shown



Press down **CTRL** and place the cursor on V(N001)*R1 as shown and click

You will get the window like this



Energy

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