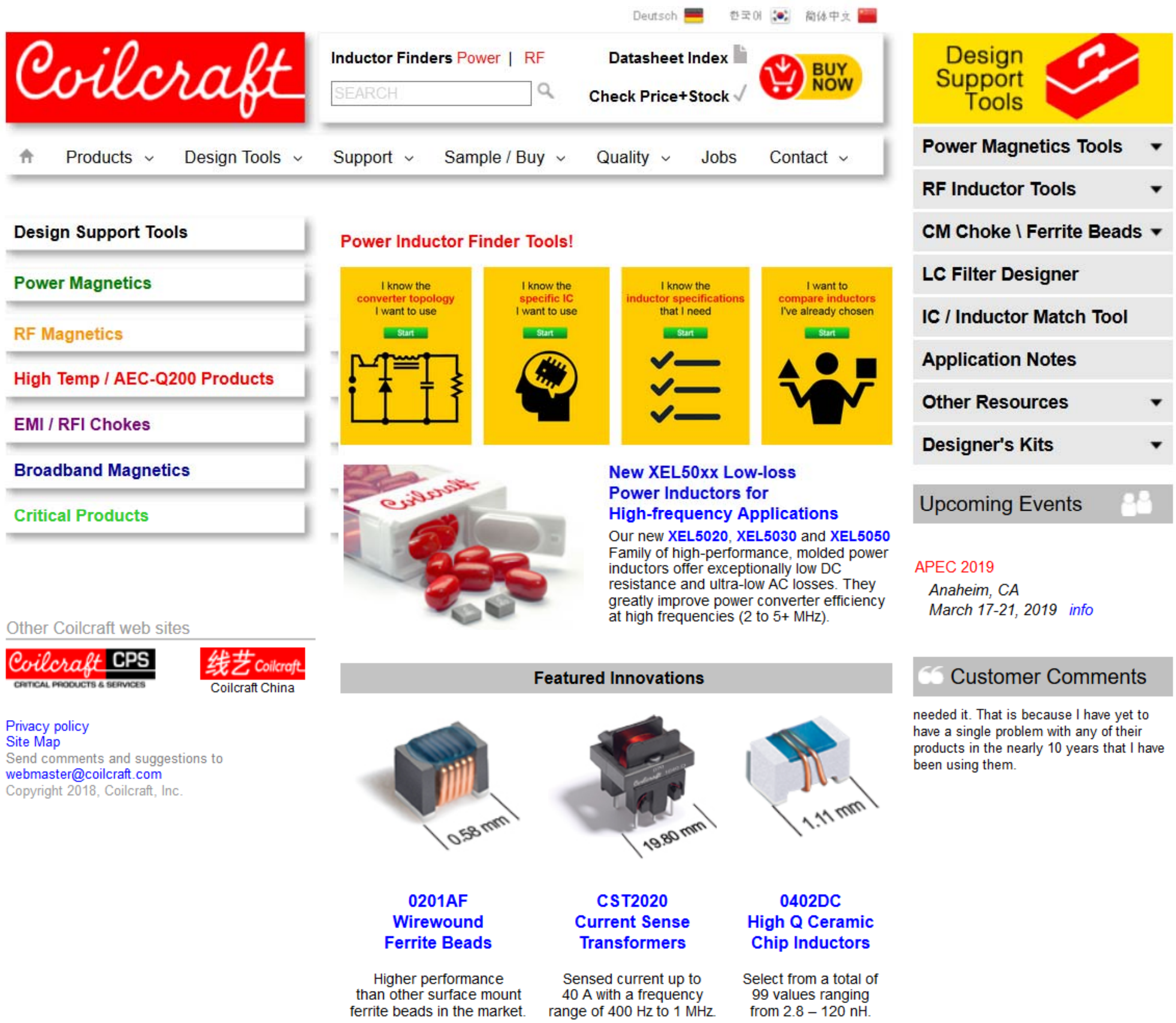
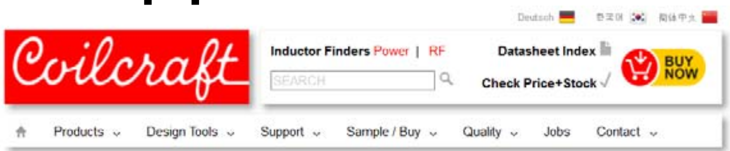
*E*lectrical
*E*ngineering
*T*echnology

Inductor Transient Analysis

Application Areas and Design Support



Application Areas and Design Support



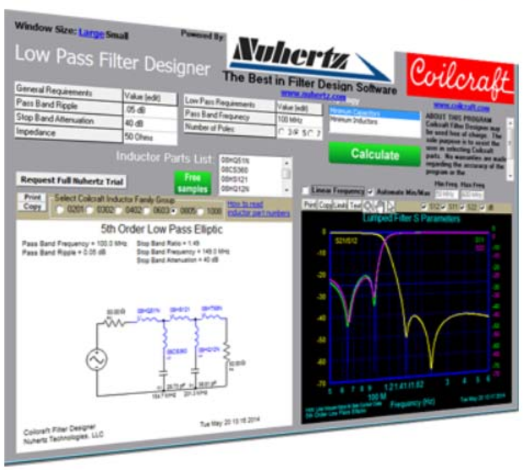
RF Inductor Finder

- Use this tool to find the Coilcraft inductors best suited to your requirements.
- Please use a period for decimals: 1.25 not 1,25

Inductance		Frequency	Q min	Current	DCR max	Body size	Length max	Height max	AEC-Q200	Optimize for
to option ○ µH ◉ nH	○ L at frequency ◉ L nominal	1 MHz (1 - 3000 MHz)		rms ○ A ◉ mA	○ Ω ◉ mΩ	0201 (0603) 0302 (0805) 0402 (1005)	◉ mm ○ in	◉ mm ○ in	☐ Grade 1 (125°) ☐ Grade 3 (85°)	Move the most important factors to the top of the list: Footprint, Q factor, SRF, Impedance, Price

FIND

Coilcraft LC Filter Designer Software



New in Version 3.4

Includes new **0402DF** high inductance, low DCR inductors

Links from Parts List to web pages

64- and 32-bit versions

- Design Low Pass Elliptic filters
- Select 3, 5, or 7 poles
- 50 Ohm terminations
- S-Parameter analysis in log and linear frequency scale
- Minimum capa… inductor topol…
- Uses actual C…
- Request free i…

Download 64-b…

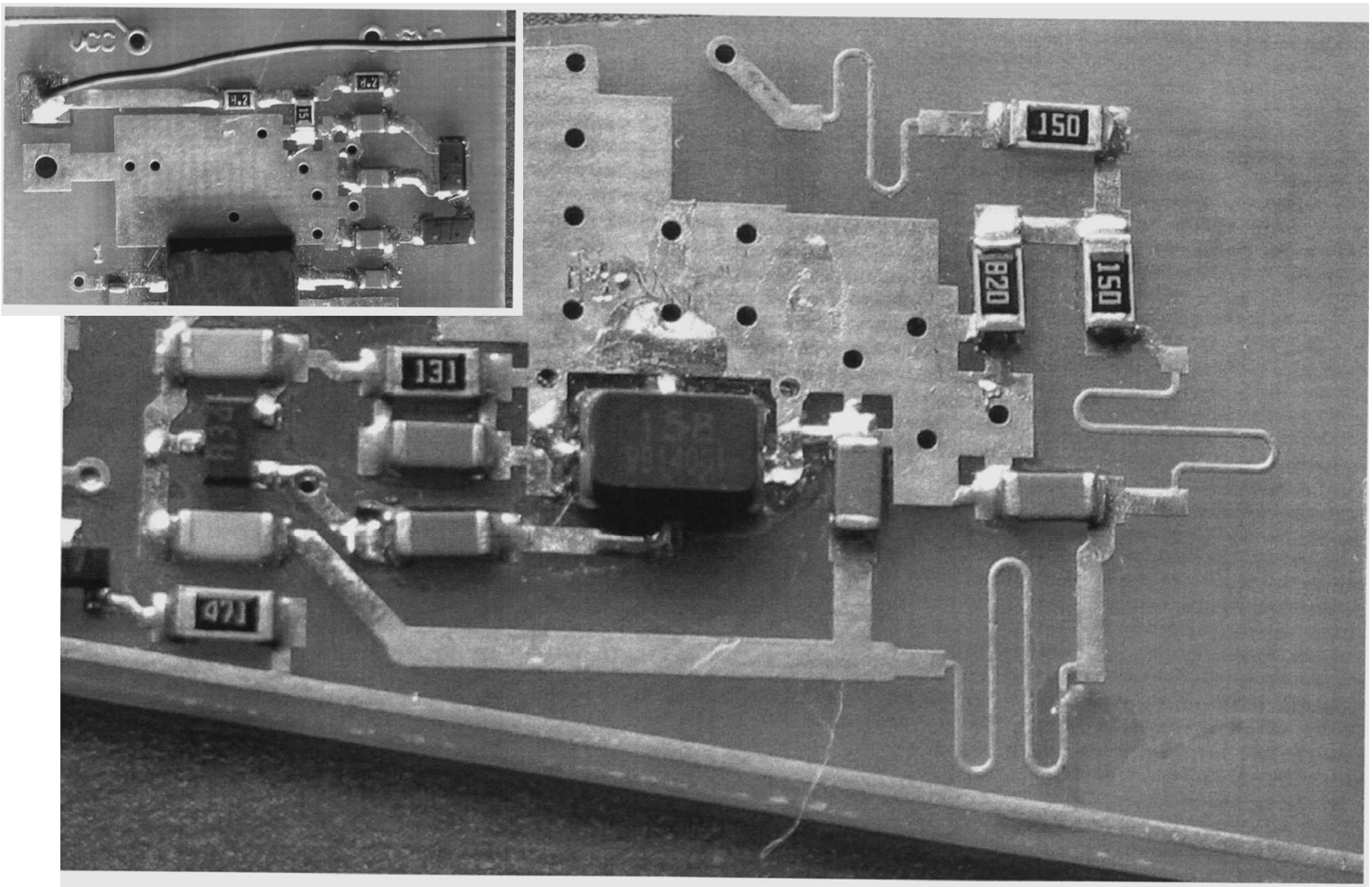
Power Inductor Finder

- Find all the power inductors that meet your exact requirements
- Search for the nominal inductance or the actual inductance at your operating current

Required Inputs					Optional Inputs				
Inductance		Frequency	Current	Ripple pk-pk	DCR max	Length max	Height max	Construction	AEC-Q200
to option ◉ µH ○ nH	○ L at current ○ L nominal	100 ◉ kHz ○ MHz	A ◉ Ipeak ○ Ipc	40 % A	○ Ω ◉ mΩ	◉ mm ○ in	◉ mm ○ in	☑ SMT ☑ Leaded	☐ Grade 1 (125°) ☐ Grade 3 (85°)

FIND

RF Inductors – Examples SMT and PCB



Induced Voltage

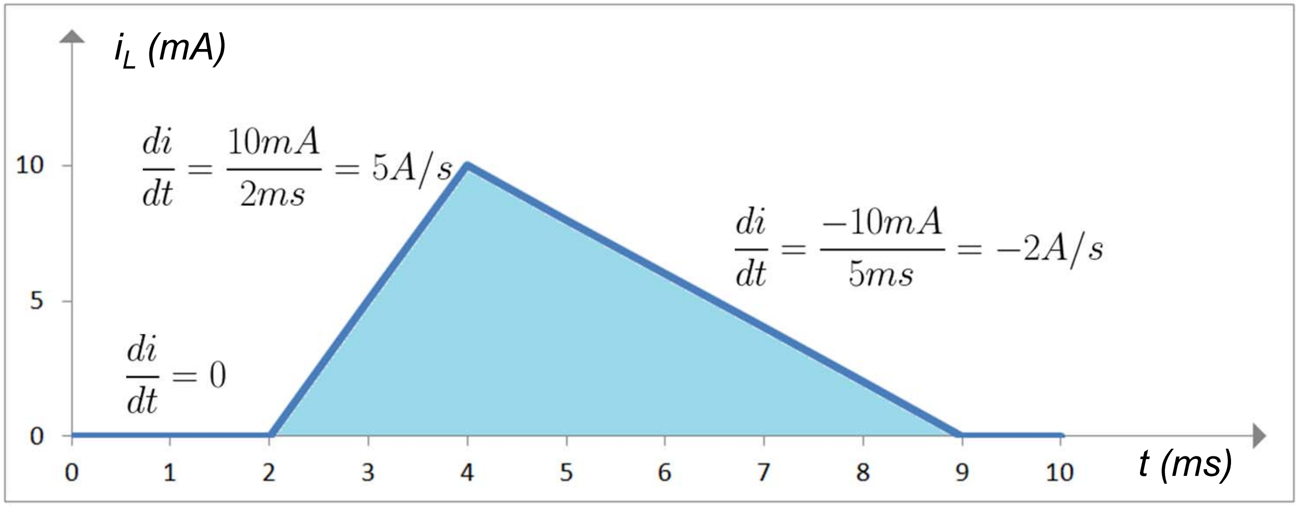
- Recall:
  - A current carrying conductor produces a magnetic field
  - This field (strength) is linearly related to the current (amplitude) that created it
- A changing magnetic field can induce a voltage in a neighboring circuit. This voltage is proportional to the time rate of change of the current producing the field.

$$V_L(t) = L\frac{di}{dt}$$

Constant of proportionality

Example

- Find $V_L(t)$ for L = 4mH and the current waveform shown below



$$V_L(t) = L\frac{di}{dt}$$

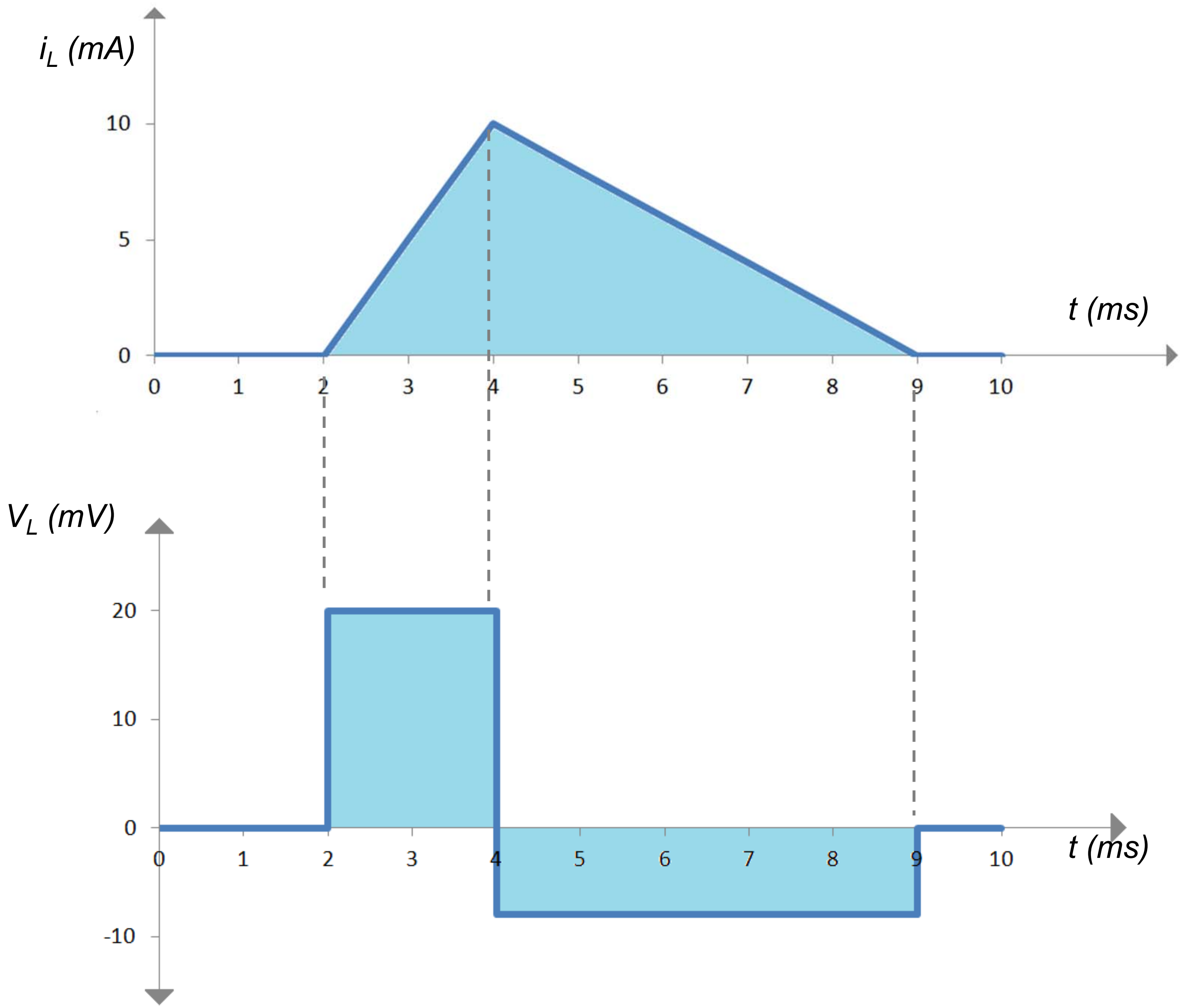
$$V_L = (4mH)\frac{5A}{s}$$

$$V_L = 20mV$$

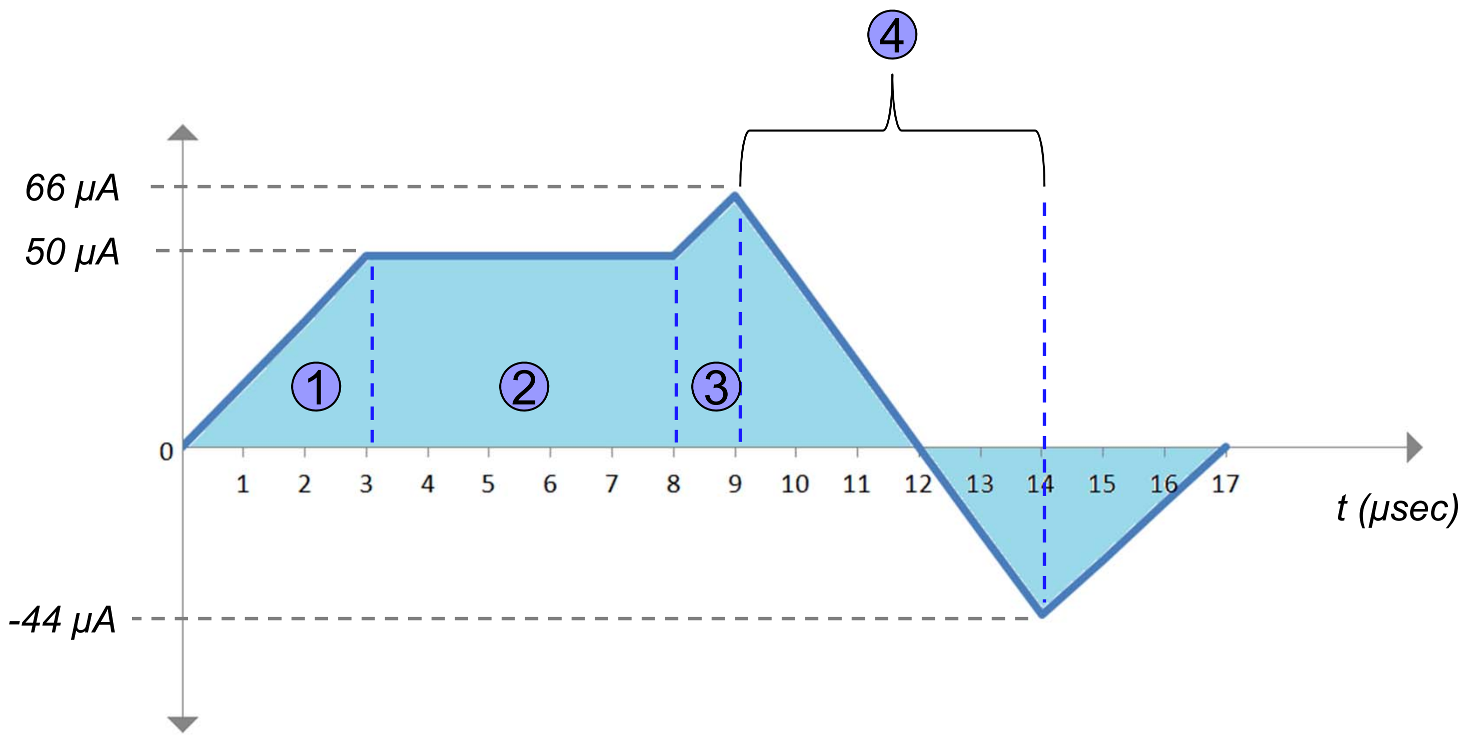
$$V_L = (4mH)\frac{-2A}{s}$$

$$V_L = -8mV$$

Example – Resulting Vl(t)

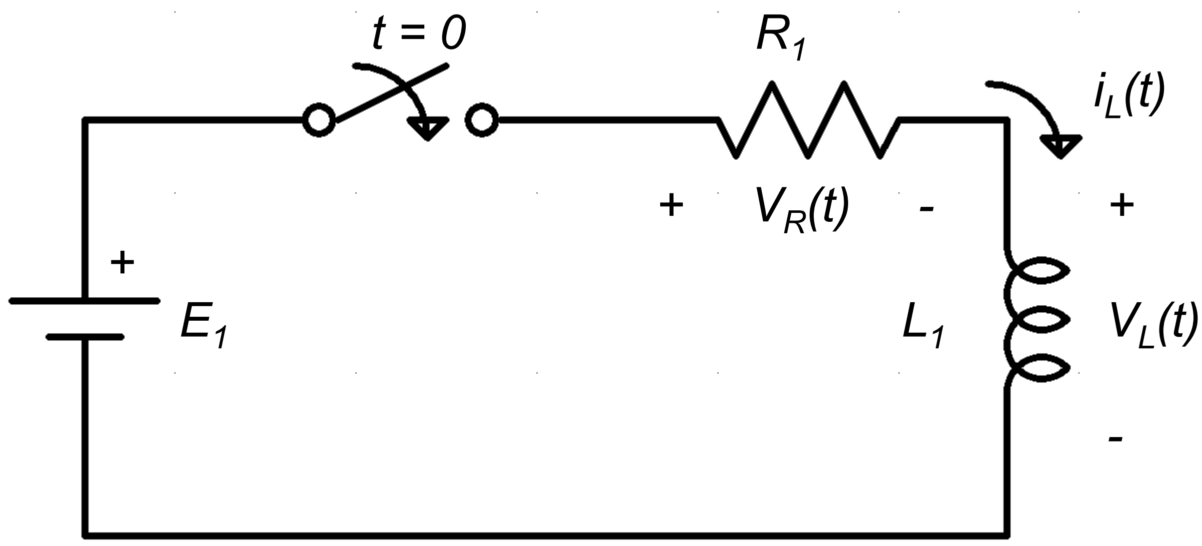


ICP



Given L = 200mH, find $V_L(t)$ for each region (1, 2, 3 and 4)

R-L Transients – What do we know?



$$V_L(t) = L\frac{di}{dt}$$

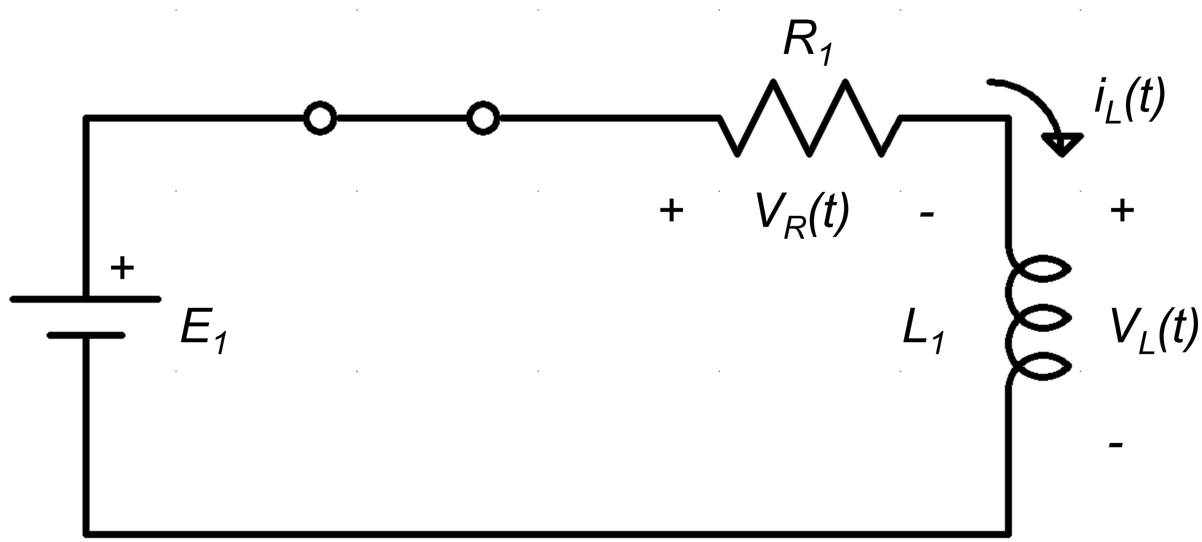
We can't change the current through an inductor instantaneously

R-L Transients - Qualitatively

<u>$t = 0^-$</u>

$i_L(0^-) = 0A$, *no initial current*

<u>$t = 0^+$</u>



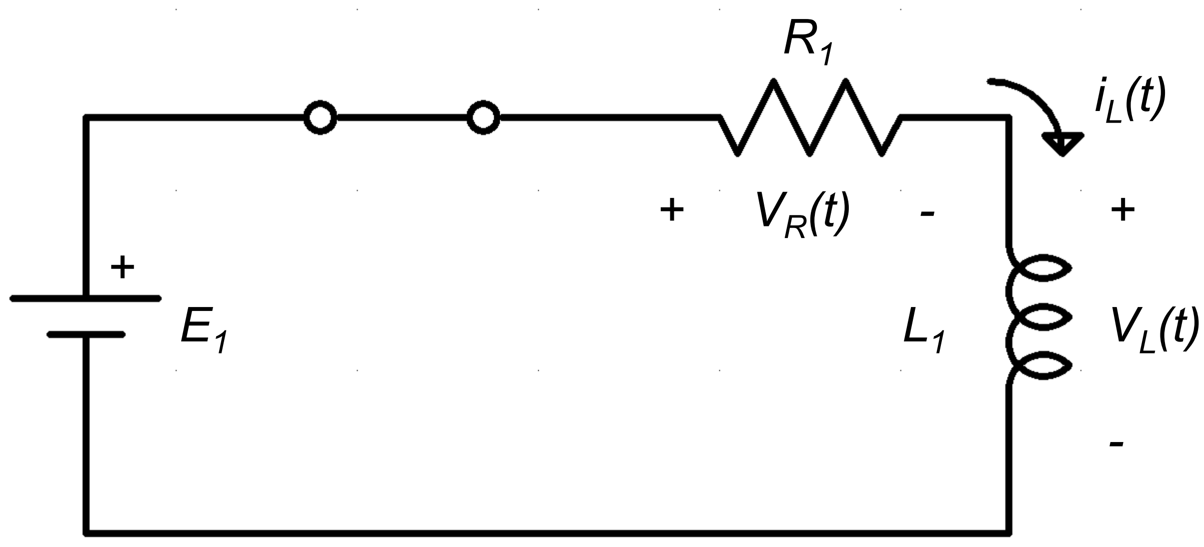
$i_L(0^+) = 0A$

Therefore, L_1 *acts like an open circuit at* $t = 0^+$

and $V_L(0^+) = E_1$

R-L Transients - Qualitatively

t = ∞

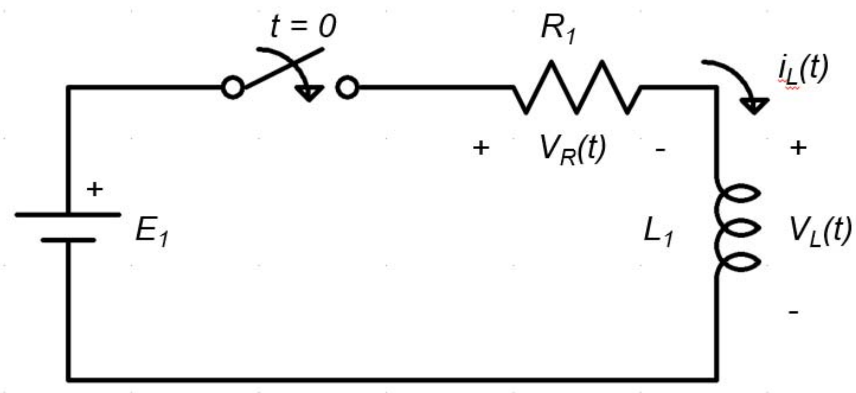


$$i_L(\infty) = \frac{E_1}{R_1}$$

$$V_L(\infty) = 0V$$

L_1 acts like a short circuit at t = ∞

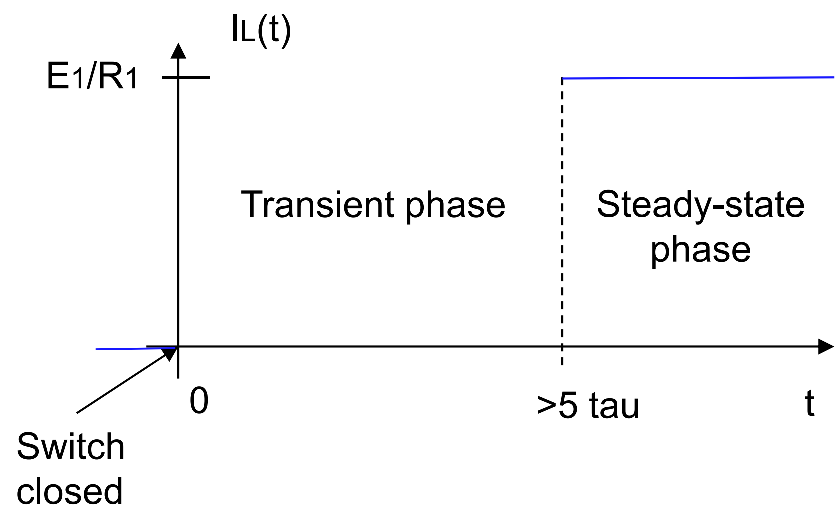
R-L Transients – Qualitative Summary

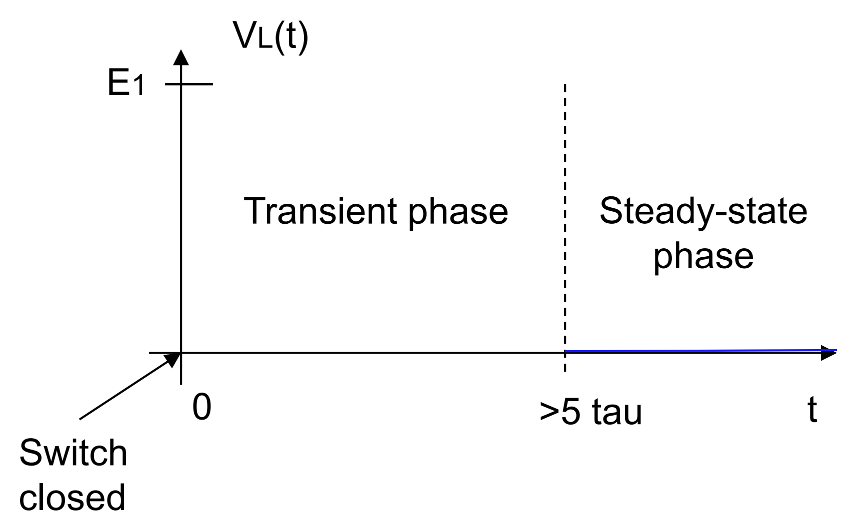


$i_L(0^+) = 0A$ and $V_L(0^+) = E_1$

$$i_L(\infty) = \frac{E_1}{R_1}$$

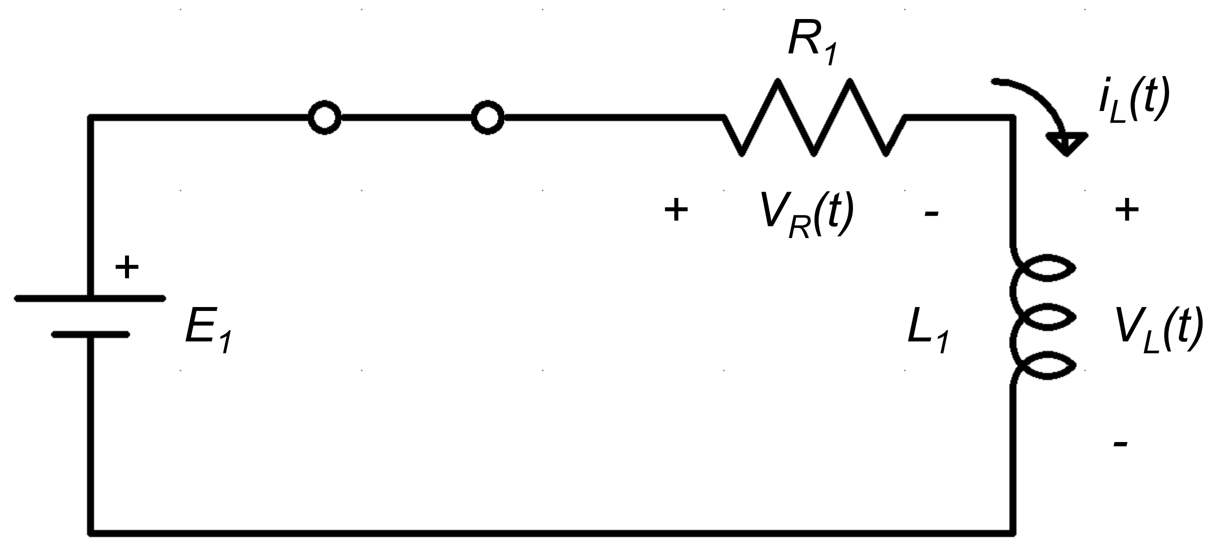
$$V_L(\infty) = 0V$$

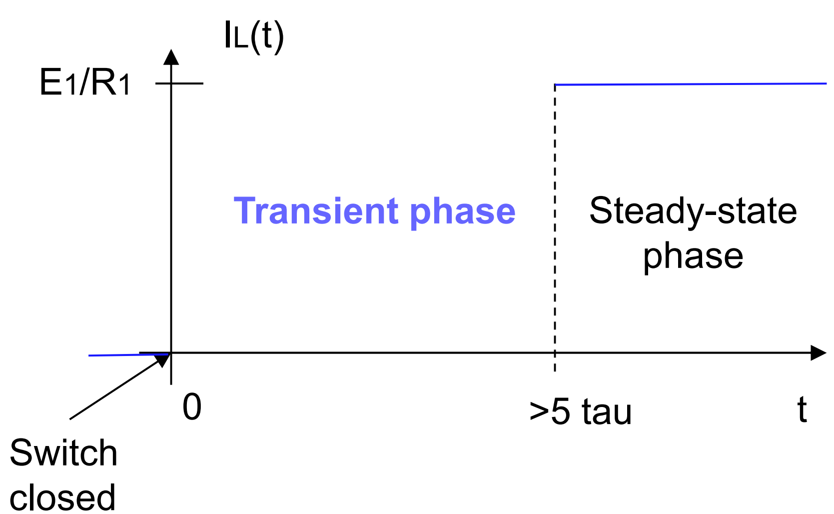




R-L Transients – Transient Phase: $i_L(t)$

$0 < t < 5\tau$

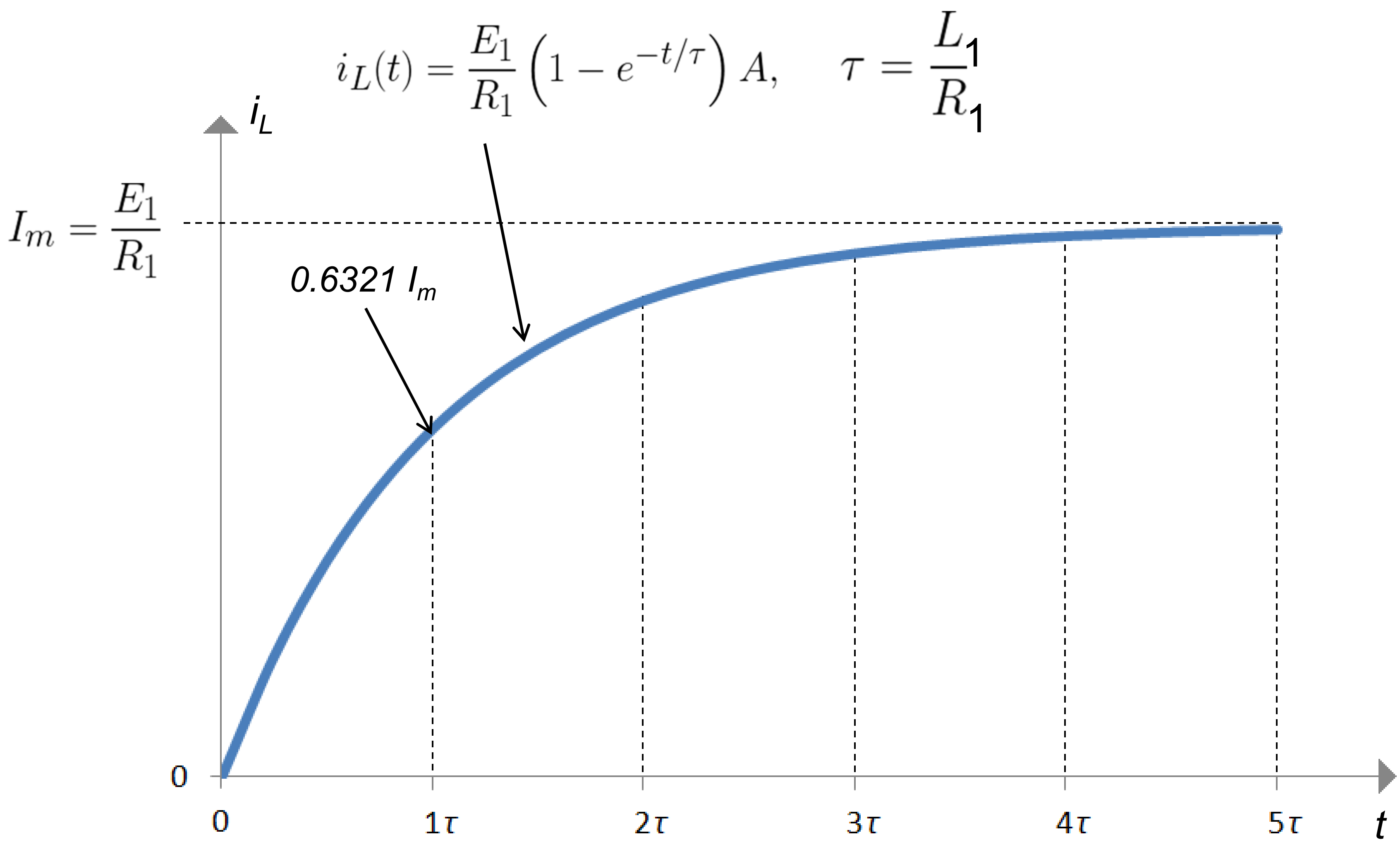




$$i_L(t) = \frac{E_1}{R_1}\left(1 - e^{-t/\tau}\right) A,$$

$$\tau = \frac{L_1}{R_1}$$

R-L Transients – Transient Phase: $i_L(t)$

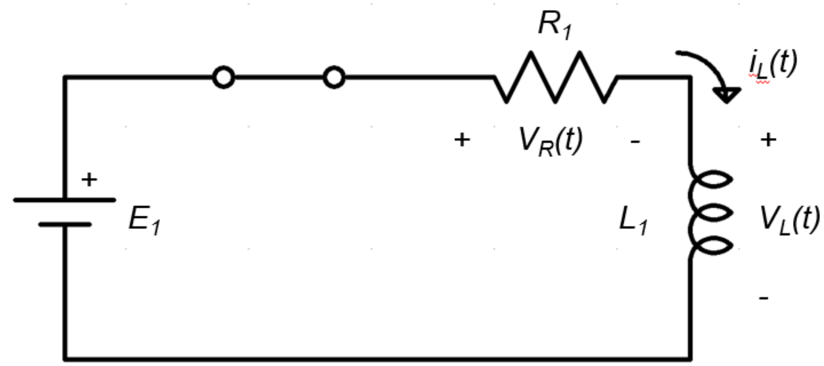


R-L Transients – Transient Phase: VL(t)

$$KVL: E_1 - V_R(t) - V_L(t) = 0$$

$$\begin{aligned} V_L(t) &= E_1 - V_R(t) \\ &= E_1 - R_1 \cdot i_L(t) \\ &= E_1 - R_1 \frac{E_1}{R_1}\left(1 - e^{-t/\tau}\right) \\ &= E_1 - E_1\left(1 - e^{-t/\tau}\right) \\ &= E_1 - E_1 + E_1 \cdot e^{-t/\tau} \end{aligned}$$

$$\boxed{V_L = E_1 e^{-t/\tau} \ \text{V}, \quad \tau = \frac{L_1}{R_1}}$$



R-L Transients – Transient Phase: VL(t)