RC and RL Time Constant, Charging and Cut-off Frequency

Time constant of an RC or RL circuit, the share of the final value and the voltage or current reached after a given time, the cut-off frequency and stored energy.

Method: First-order circuit response (exponential charging)

Input parameters

Unit system: SI

Parameter	Value	Unit
Circuit	RC (resistor and capacitor)	
Resistance	10.000	kΩ
Capacitance (RC)	100.00	µF
Inductance (RL)	500.00	mH
Step (supply) voltage	12.000	V
Time after the step	1.0000	s

Calculated results

Parameter	Value	Unit
Time constant	1.0000	s
Time to about 99.3 % (five time constants)	5.0000	s
Share of the final value reached at t	63.212	%
Capacitor voltage at t (RC, charging)	7.5854	V
Current at t	4.4146e-04	A
Cut-off frequency 1/(2πτ)	0.15915	Hz
Energy stored when fully charged	0.007200	J

Formula and method

$$\tau = RC \quad \text{or} \quad \tau = L/R$$

$$1 - e^{-t/\tau}, \quad v_C = V\left(1 - e^{-t/\tau}\right)$$

$$i(t) = \frac{V}{R} e^{-t/\tau} \ (\text{RC}), \quad i(t) = \frac{V}{R}\left(1 - e^{-t/\tau}\right) \ (\text{RL})$$

$$f_c = \frac{1}{2\pi\tau}, \quad W = \frac{1}{2} C V^2 \ \text{or} \ \frac{1}{2} L I^2$$

Variables

$\mathrm{circuit}$	Circuit	-
R	Resistance	Ω
C	Capacitance (RC)	F
L	Inductance (RL)	H
V	Step (supply) voltage	V
t	Time after the step	s
τ	Time constant	s
5τ	Time to about 99.3 % (five time constants)	s
$1 - e^{-t/\tau}$	Share of the final value reached at t	-

v_C	Capacitor voltage at t (RC, charging)	V
$i(t)$	Current at t	A
f_c	Cut-off frequency 1/(2πτ)	1/s
W	Energy stored when fully charged	J
I	Final current V/R (RL)	A

Method and standards

A first-order circuit driven by a voltage step approaches its final value exponentially with time constant τ. The cut-off frequency of the same circuit used as a filter is 1/(2πτ).

Assumptions and limits

- Ideal components; step input; starts from zero.

References

- First-order circuit response (exponential charging)

Report details

Report reference	FCC-9CH8-ZPJP (the same inputs always give the same reference)
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Results are for engineering estimation. Verify critical designs against the referenced standards and your own data.

This calculator online

https://calc.firecad.com/electrical/circuits/rc-rl-time-constant

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.