

## Electric Circuits Fundamentals

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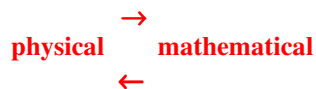
### DEVELOPING PHYSICAL INSIGHT AND INTUITION

#### (Some Thoughts on What Sets this Book Apart from the Competition)

The electric circuits discipline is based on the following steps: starting from the physical reality of a circuit, (a) it develops *conceptual models* for a rigorous and systematic description of the circuit, (b) it effects appropriate *mathematical manipulations* upon these models to analyze and predict circuit behavior, and (c) it interprets conceptual results in terms of *known physical behavior*.

The last step is important for two reasons: (a) Since engineering is an applied discipline, the correctness of any conceptualization must ultimately be *tested against physical substance*, not mere abstraction as in the case of purely abstract disciplines; (b) Relating theory to practice helps the student develop a *feel for the physical operation of the circuit*, how its individual components interact and collaborate in of making the circuit work. An early development of *physical insight and intuition* benefits the student not only in subsequent courses such as micro-electronics courses, but also after graduation because this is how engineers function in the practice of their profession. This claim is made by someone who, before becoming an educator, has had significant experience in industry.

The motivation for writing this book stems precisely from the author's frustration with the insufficient attention devoted by current books to relating the theoretical back to the practical. Once the first step from the physical to the mathematical has been accomplished, the common trend seems to be that of confining the reader within the abstract realm. Though circuit theory is unquestionably a subject of intrinsic beauty, its advantages can be realized effectively only if we go the full cycle by closing the loop



Though this spirit is interspersed throughout the book and can be fully appreciated only through daily sage, the accompanying list provides a quick reference for the verification of the stated claims. If only

- p. 66 top:** *Voltage divider approximations* (elementary)
- p. 362 center:** *Creating diverging responses* (intermediate)
- p. 619-620:** *Physical meaning of poles and zeros* (advanced)

For a more detailed list of instances emphasizing physical insight, please refer to the following:

- p. 8 top:** Physical operation of the potentiometer
- p. 11 center:** Illustrating the active/passive sign conventions using power-transfer concepts
- p. 29 center:** Hydraulic analogy for KCL
- p. 32 top:** Hiking analogy for KVL
- p. 42 center:** Hydraulic analogy illustrating the difference between voltage and current sources
- p. 57-58:** Limiting cases for resistances in series
- p. 59-60:** Limiting cases for resistances in parallel
- p. 66 top:** Voltage divider approximations
- p. 68 bottom:** Current divider approximations
- p. 106-107:** Checking techniques in nodal analysis

<b>p. 115 top:</b>	Checking techniques in loop analysis
<b>p. 201-203:</b>	Resistance transformation by dependent sources
<b>p. 203 center:</b>	Physical discussion of negative resistance
<b>p. 229-231:</b>	A physical view of interstage loading
<b>p. 254-255:</b>	Physical operation of the voltage buffer
<b>p. 258-259:</b>	Virtual short - a physical view
<b>p. 272-273:</b>	Negative-resistance application
<b>p. 298 center:</b>	Water-tank analogy for the capacitor
<b>p. 298-299:</b>	Physical capacitors in series/parallel
<b>p. 311-313:</b>	The memory function in the $s$ plane
<b>p. 314-320:</b>	Physical significance of the natural, forced, transient, and steady-state components
<b>p. 328-338:</b>	Physical behavior of $RC$ and $RL$ circuits
<b>p. 352-356:</b>	Pulse response of $RC$ and $RL$ circuits
<b>p. 357 top:</b>	Physical behavior of the differentiator
<b>p. 358 bottom:</b>	Physical behavior of the integrator
<b>p. 362 center:</b>	Energy considerations in the creation of diverging responses
<b>p. 386 center:</b>	$RLC$ circuit oscillations in terms of energy
<b>p. 389 center:</b>	The automobile as a critically damped system
<b>p. 402 center:</b>	Physical comparison of rise times of 1st- and 2nd-order systems
<b>p. 407-411:</b>	Energetic comparison of $KRC$ and $RLC$ circuits
<b>p. 432 center:</b>	Limiting $L$ and $C$ behavior
<b>p. 438-439:</b>	A physical discussion of high-pass behavior
<b>p. 442-443:</b>	A physical discussion of low-pass behavior
<b>p. 447-448:</b>	A physical discussion of band-pass behavior
<b>p. 450 top:</b>	Using physical insight to predict band-pass behavior
<b>p. 475 center:</b>	Limiting cases for impedance
<b>p. 483:</b>	Impedances of element pairs, and limiting cases
<b>p. 486 top:</b>	A physical view of the $R$ - $C$ AC divider
<b>p. 487 center:</b>	A physical view of the $C$ - $R$ AC divider
<b>p. 527 bottom:</b>	A physical view of AC matching
<b>p. 532 bottom:</b>	Power-factor correction using physical insight
<b>p. 577 center:</b>	Series resonance from a physical viewpoint
<b>p. 582 bottom:</b>	Mechanical analogy for resonance
<b>p. 586 top:</b>	Parallel resonance from a physical viewpoint
<b>p. 594-595:</b>	Physical significance of positive feedback and negative $Q$ s
<b>p. 619-620:</b>	Physical significance of poles and zeros
<b>p. 621-624:</b>	Asymptotic reasoning and approximations
<b>p. 627-631:</b>	Effect of roots on source-free responses
<b>p. 640-641:</b>	Physical visualization of DC passing and AC blocking
<b>p. 641-642:</b>	Physical visualization of DC blocking and AC passing
<b>p. 647-648:</b>	Effect of roots on frequency responses
<b>p. 742-744:</b>	Physical significance of $u(t)$ and $\delta(t)$
<b>p. 772-773:</b>	Physical effect of the initial conditions on the response of a circuit
<b>p. 786 top:</b>	Physical distinction between forced and natural responses
<b>p. 838-839:</b>	Effect of filtering in the time and frequency domains