MAGNETIC & ELECTROMAGNETIC INDUCTION - LR Circuits

H21

X60. LR Circuit Driven by Square Wave - 8W

Purpose: Illustrate wave forms in an LR circuit driven by a square-wave emf with a projected 2-sweep CRT display.

Equipment: LR circuit (see sketch); Inductance is the red solenoid (R_{lp} = 10 \ \Omega; \ L = 73 \text{ mH});
External variable resistance set at 90 ohms (i.e. R_{total} = 100 \ \Omega); CRT (2-sweep) displayed with TV.

Procedure:
- Drive circuit with square wave (and also single step function?)
- Project V_R and V_L vs time on same CRT; V_R is measure of current
- Measure time constant: t on scope; compare to predicted value
- t = L/R = 0.07/100 = 0.7 ms
- Change resister R; watch time constants change on CRT
- Change L by putting iron wire bundle in solenoid gradually: L \rightarrow 1.0 \text{ H}
- Again note time constant changes.

Note: The quantity V_L measured by the scope is the emf generated in the inductor by the changing flux. Beware of referring to V_L as an ordinary potential difference; if one carries a charge around the circuit, the net work \frac{d\Phi}{dI} integrated around the circuit is non-zero.
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A large solenoid and a decade resistor are connected in series to a square wave generator. The voltage across the inductor and the voltage across the resistor are shown on an oscilloscope. The display shows the RL time constant.

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[Diagram of LR Time Constant (Oscilloscope)]

- Scope
- Function Generator
- Resistor Box (≈ 90Ω)
- Transformer (XFMR)
- Coil W/ Core

(Note: Too fast more like 60Hz)
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Long inductor without core. Measured with an L-meter, the large inductor has an inductance of 112 mH. When the demo is set up as noted in the write up, the total resistance in the circuit is about 100Ω (96Ω in resistor box + 7.4Ω in coil)

Using these values, the time constant should be:

\[
\tau = \frac{L}{R} = \frac{112 \times 10^{-3} \text{ H}}{100 \Omega} = 1.12 \text{ msec}
\]

When measuring \( \tau \) on the scope, we seek the time it takes the current \( (\alpha V_r) \) to reach a value of 63% of its peak value. With the scope set according to the directions in the write-up, this turns out to be: \( \tau = (1.1 \text{ division}) (1 \text{ ms/div}) = 1.1 \text{ msec} \).
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Equipment needed:
- Tektronix 465 scope
- H/P 3310A Function Generator FG2
- Decade Box Resistor (R3 has approx. 0.2 mH inductance) it's best to use new decade resistors
- Isolation transformer
- Large Coil with core
- Banana cables: 3 long, 3 medium
- BNC cables: 2 small
- Banana to BNC Conn: 2
- BNC to Banana Connector: 1

Settings:
- FG2: Range: 10
  Knob: approx. 12
  Function: SQ
  DC offset: 0
  Output: high (to x-former)
  Sync output: to scope
- Scope:
  CH1: 1 V/DIV
  CH2: 2 V/DIV invert
  Vert. Mode: Chop
  Trig Mode: Auto
  Coupling: DC
  Source: CH1 or CH2
  Time/Div: 1ms

Decade Box Resister: 90 Ω (or approx. 96 Ω when using new coils that have 7.1 Ω internal resistance)
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Using these values, the time constant should be:

$$\tau = \frac{L}{R} = \frac{112 \times 10^{-3} \text{H}}{100\Omega} = 1.12 \text{ msec}$$

When measuring $\tau$ on the scope, we seek the time it takes the current ($\alpha V_s$) to reach a value of 63% of its peak value. With the scope set according to the directions in the write-up, this turns out to be: $\tau = (1.1 \text{ division}) (1 \text{ ms/div}) = 1.1 \text{ msec.}$