L16 Inductance

Lecture outline:

• Inductance.
• Solenoids.
• Transformers.

L16.1 Inductance

The magnetic flux $\Phi_B$ produced by a current coil is usually proportional to the current:

$$\Phi_B = \frac{Li}{N}$$

where $L$ is the inductance, (number of turns in coil)

$$\therefore e = -N \frac{d\Phi_B}{dt} = -L \frac{di}{dt}$$

Such a coil is called an inductor. The energy in the inductor is $U = \frac{1}{2}Li^2$
L16.2 Inductance

Example: a long solenoid
The magnetic field is \( B = \frac{\mu_0 Ni}{l} \)
and the magnetic flux is \( \Phi_B = \frac{\mu_0 Ni}{l} A \).

Therefore \( \frac{d\Phi_B}{dt} = \frac{\mu_0 NAi}{l} \frac{di}{dt} \)
and \( L = \frac{N\Phi_B}{i} = \frac{\mu_0 N^2 A}{l} = \mu_0 n^2 l A, \)
where \( n = N/l \).

The energy in the solenoid is therefore \( U = B^2 A l / 2\mu_0 \)
so the energy per unit volume is \( u = B^2 / 2\mu_0 \).
This energy can be regarded as residing in the magnetic field produced by the coil.

L16.3 Inductance

Transformers

Consider 2 wires wrapped around an iron core.
AC current (\( i_p \)) in primary winding gives alternating magnetic flux in core, which gives an induced EMF: \( V_p = -N_p \frac{d\Phi_B}{dt} \).

In the secondary winding there is the same flux, so \( V_s = -N_s \frac{d\Phi_B}{dt} \).

Therefore \( \frac{V_s}{V_p} = \frac{N_s}{N_p} \) so we can boost up the voltage by changing the number of turns.
L16.4 Inductance

With a load, there is an AC current \(i_s\) in the secondary winding. The power in each winding is

\[ V_p i_p = V_s i_s, \]

so

\[ \frac{i_s}{i_p} = \frac{N_p}{N_s}, \]

If \(R\) is the resistance in the secondary, \(i_s = \frac{V_s}{R}\) which is the effective load seen in the primary winding.

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\begin{array}{c}
\text{L16.5 Inductance} \\
\text{Contact breaker closed, current in primary magnetizes core. Contact breaker open, collapse of B gives high induced voltage in secondary.}
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