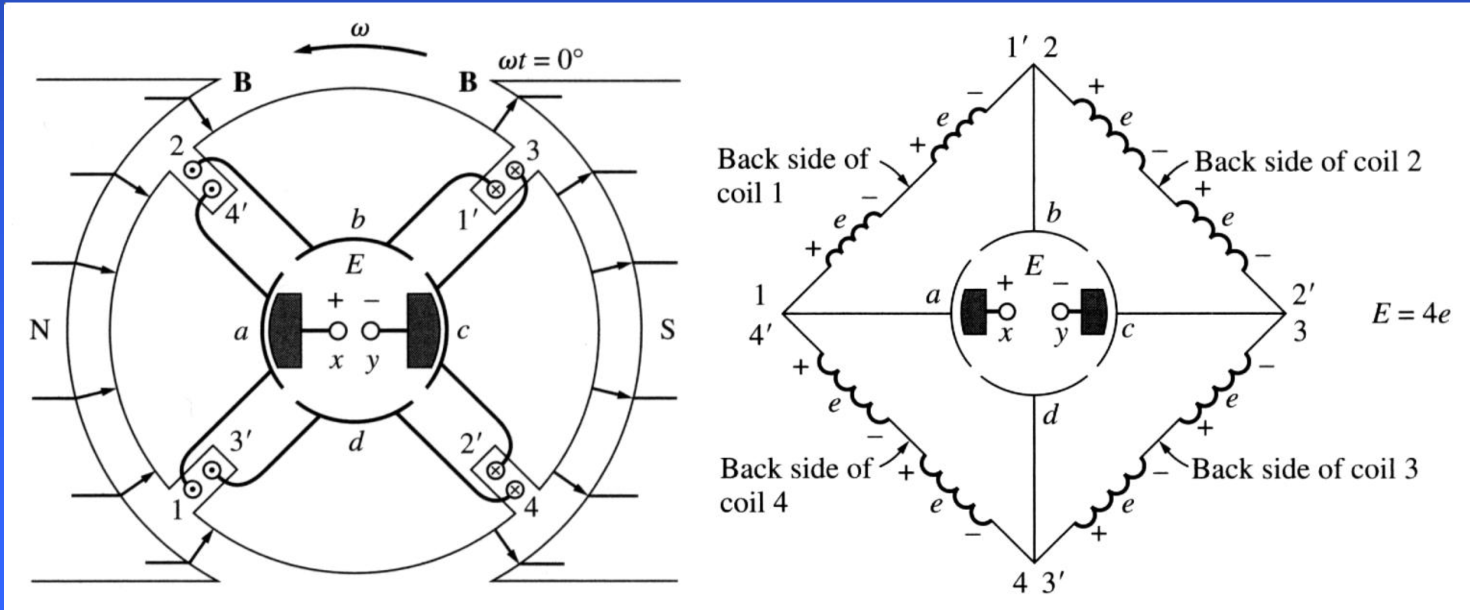
Commutation in a simple 4-loop DC machine

Commutation is the process of converting the AC voltages and currents in the rotor of a DC machine to DC voltages and currents at its terminals.

A simple 4-loop DC machine has four complete loops buried in slots curved in the laminated steel of its rotor. The pole faces are curved to make a uniform air-gap. The four loops are laid into the slots in a special manner: the innermost wire in each slot (end of each loop opposite to the "unprimed") is indicated by a prime.



Loop 1 stretches between commutator segments *a* and *b*, loop 2 stretches between segments *b* and *c*…

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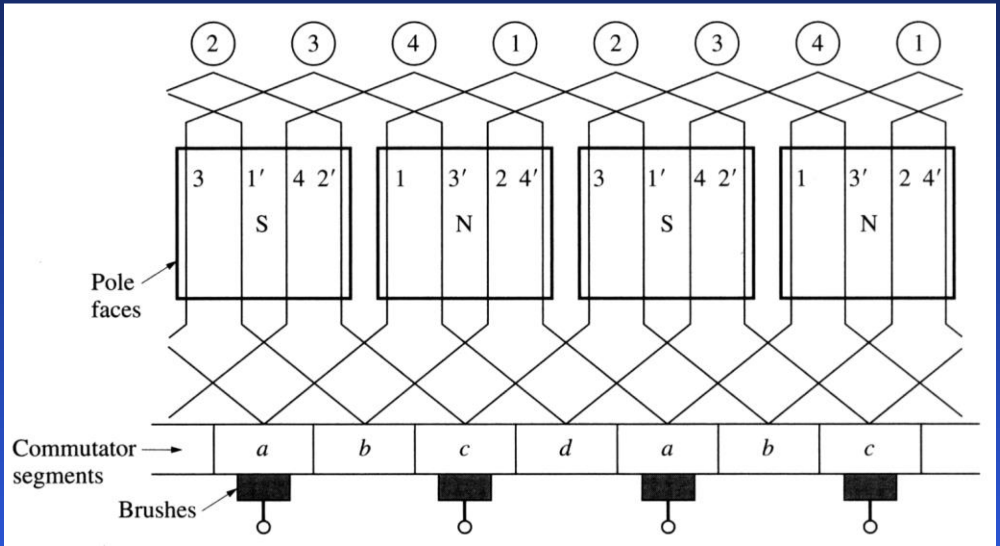
At a certain time instance, when $\omega t = 0^0$, the 1, 2, 3', and 4' ends of the loops are under the north pole face and the 1', 2', 3, and 4 ends of the loops are under the south pole face. The voltage in each of 1, 2, 3', and 4' ends is given by



$$e_{ind} = (\mathbf{v} \times \mathbf{B}) \times \mathbf{l} = vBl \quad \text{– positive, out of the page} \qquad (5.16.1)$$

The voltage in each of 1', 2', 3, and 4 ends is

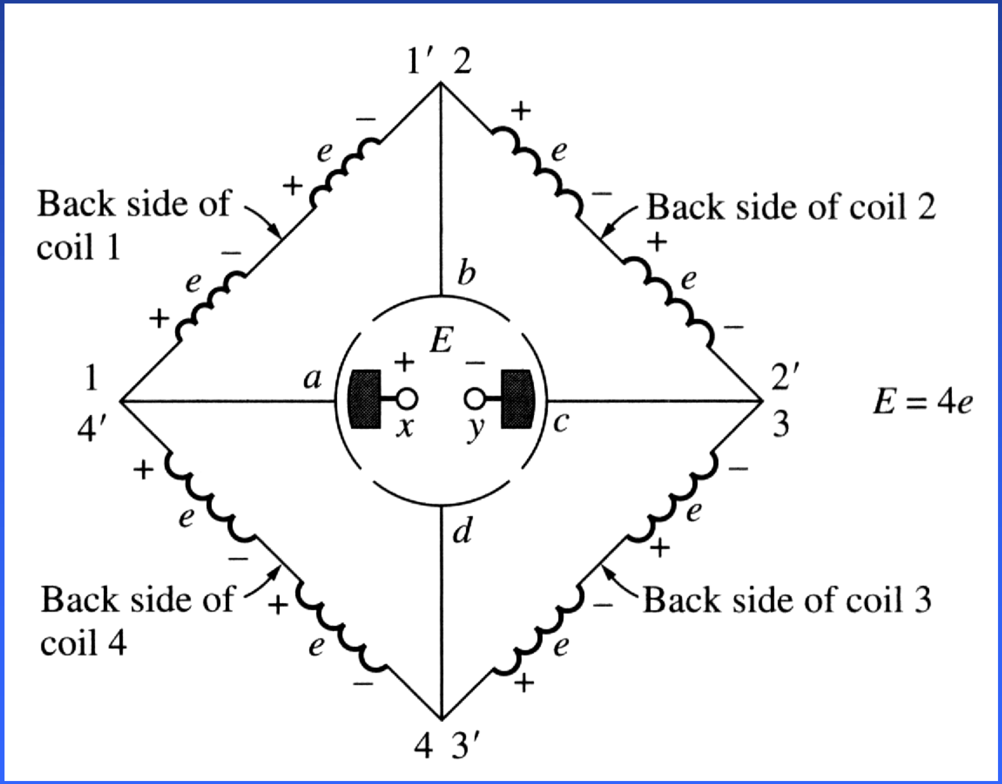
$$e_{ind} = (\mathbf{v} \times \mathbf{B}) \times \mathbf{l} = vBl \quad \text{– positive, into the page} \qquad (5.16.2)$$

If the induced voltage on any side of a loop is (5.16.1), the total voltage at the brushes of the DC machine is

$$E = 4e \qquad at\ \omega t = 0° \qquad (5.16.3)$$

Commutation in a simple 4-loop DC machine

We notice that there are two parallel paths for current through the machine! The existence of two or more parallel paths for rotor current is a common feature of all commutation schemes.



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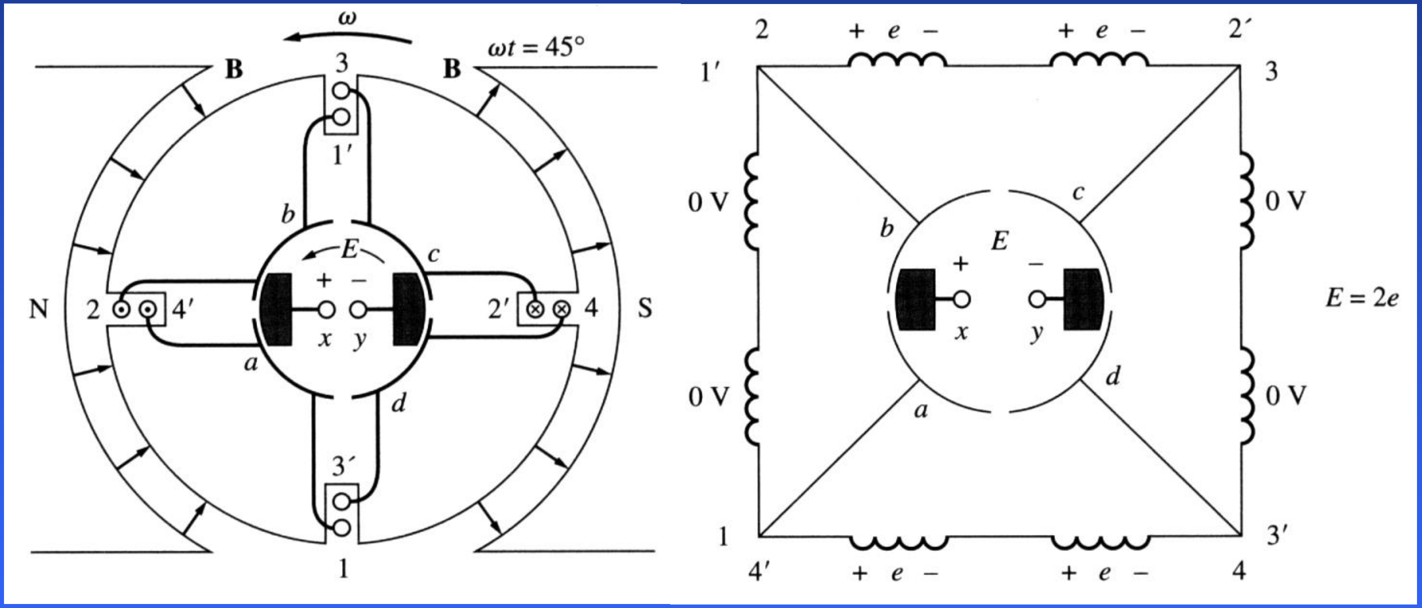
If the machine keeps rotating, at ωt = 45^0, loops 1 and 3 have rotated into the gap between poles, so the voltage across each of them is zero. At the same time, the brushes short out the commutator segments *ab* and *cd*.

This is ok since the voltage across loops 1 and 3 is zero and only loops 2 and 4 are under the pole faces. Therefore, the total terminal voltage is



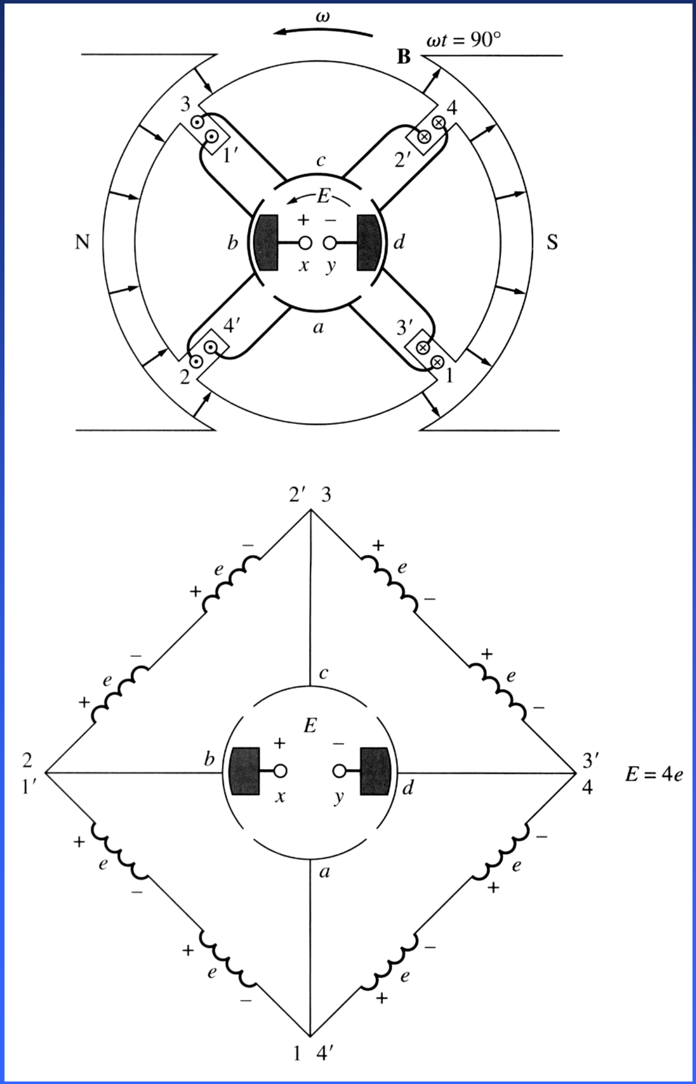
$$E = 2e \qquad at\ \omega t = 45° \qquad (5.18.1)$$

Commutation in a simple 4-loop DC machine

At $\omega t = 90^0$, the loop ends 1', 2, 3, and 4' are under the north pole face, and the loop ends 1, 2', 3', and 4 are under the south pole face. The voltages are built up out of page for the ends under the north pole face and into the page for the ends under the south pole face. Four voltage-carrying ends in each parallel path through the machine lead to the terminal voltage of

$$E = 4e \qquad at\ \omega t = 90^\circ \qquad (5.16.3)$$

We notice that the voltages in loops 1 and 3 have reversed compared to $\omega t = 0^0$. However, the loops' connections have also reversed, making the total voltage being of the same polarity.

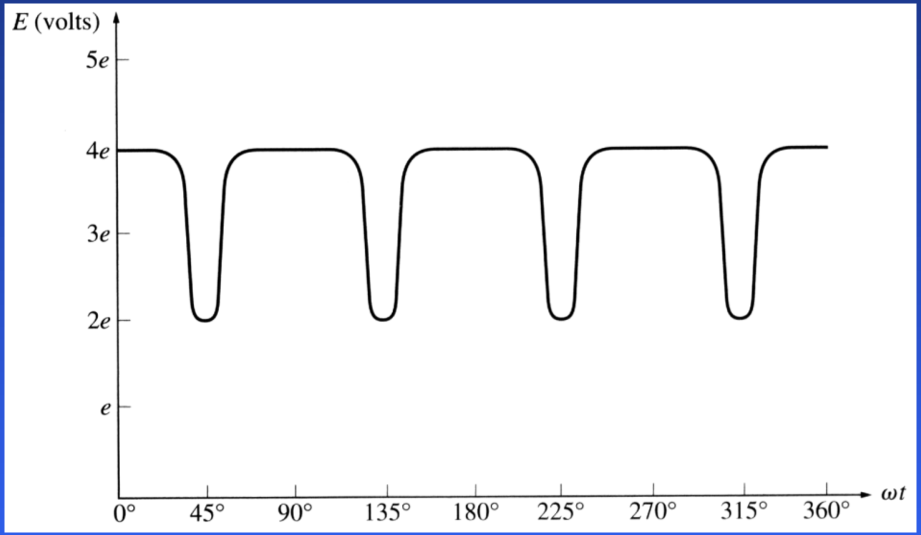


Commutation in a simple 4-loop DC machine

When the voltage reverses in a loop, the connections of the loop are also switched to keep the polarity of the terminal voltage the same.

The terminal voltage of this 4-loop DC machine is still not constant over time, although it is a better approximation to a constant DC level than what is produced by a single rotating loop.

Increasing the number of loops on the rotor, we improve our approximation to perfect DC voltage.



Commutator segments are usually made out of copper bars and the brushes are made of a mixture containing graphite to minimize friction between segments and brushes.

Rael Dc Machine

$$E_A = K\phi\omega$$

$$K = \frac{ZP}{2\pi a}$$

$$E_A = K'\phi n$$

$$K' = \frac{ZP}{60a}$$

Z is the total number of conductors

a is the number of current paths

P is the number of poles

$$\tau_{\text{ind}} = K\phi I_A$$