Main Classes of Electromechanic Transducers – Electrodynamnic vs. Electromagnetic

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Extended abstract

Among the 12 measuring methods of mechanic quantities by electric means [1] we make an attempt to compare electrodynamnic with electromagnetic ones, starting from a particular example, such as Magnetic or Electrodynamnic Force, that US Patent subclass 335/195 places together under the same title.

Certain authors use interchangeably the two words having the same “root”, but their fundamental difference is given by the way of inducing voltages: by moving or, respectively, by transformation [2].

<table>
<thead>
<tr>
<th>ELECTRODYNAMIC</th>
<th>ELECTROMAGNETIC</th>
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<tbody>
<tr>
<td>Moving coil</td>
<td>Transformation (or moving magnet)</td>
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![Diagram showing electrodynamnic vs electromagnetic force]

INDUCTION LAW

\[ u = B \cdot l \cdot v \]

where \( v = ds/dt \)

\[ u = \text{electromotive force} \]

\( B \) – magnetic induction

\( l \) – conductor length

\( v \) – speed of moving coil

\( s \) – space of movement

\( t \) – time

Example: Precision balances

FARADAY’S LAW (1831)

\[ u = -N \cdot d\Phi/dt \]

where \( \Phi = B \cdot A \)

\( u \) – electromotive force

\( B \) – magnetic induction

\( \Phi \) – magnetic flux

\( N \) – number of turns

\( A \) – turns cross section area

\( t \) – time

Example: Guitar chords

A current flow in a magnetic field generates a force \( F \), which is proportional to the magnetic induction \( B \), the current \( I \) and the path length \( l \) \((F = B \cdot I \cdot l)\). In electromagnetic weighing systems an applied mass generates a force under the influence of gravity. The conversion from a force to a current is not achievable. This leads to a compensation principle where the force due to the mass is compensated by a counter force so that the difference between the two forces is zero. The current used to achieve the equilibrium is proportional to the force. This is a dynamic system and the principle is often called electrodynamnic force compensation [3].

This principle is illustrated for small forces [4–7] and large forces [8, 9] as well.
Moving coils are also used for measuring plantar pressure [10], in micromechanical testers [11] and for multifunctional tactile sensors [12].

Another category of applications is given by Electromagnetic / Electrodynamic Actuators [13–15]. Any electromagnetic system includes at least a coil, an air gap and a magnet made of ferromagnetic materials. The main function of every electromagnet is the conversion of supplied electrical energy into mechanical work, actuating specific tools. This process is reversible and a lot of force transducers are based on electromagnetic methods or principles. Schematic of electro-magneto-mechanical energy conversion for actuators and, reversely, for transducers is as follows:

The “combined” acronym EMAT (Electro-Magnetic Acoustic Transducer) [16] extends the sphere of applications and suggests a variety of electromechanical analogies [17].

A complex equipment which links electrical and mechanical power is the Watt Balance, designed in order to redefine the SI unit kilogram [18]. It is based on a special superconducting coil which carries out simultaneously both experimental parts: static weighing and measuring the emf (i.e. electrodynamic force) induced by the coil motion.

A lot of recent works suggest complex connections between electric, magnetic and mechanic domains, visible even by simply examining the titles in the reference list [19-26].

Selected references


16. NN. *EMAT Technology from the R&D Lab to the Field*. ©2009 Innerspec Technologies, Inc., Lynchburg, VA, USA.


