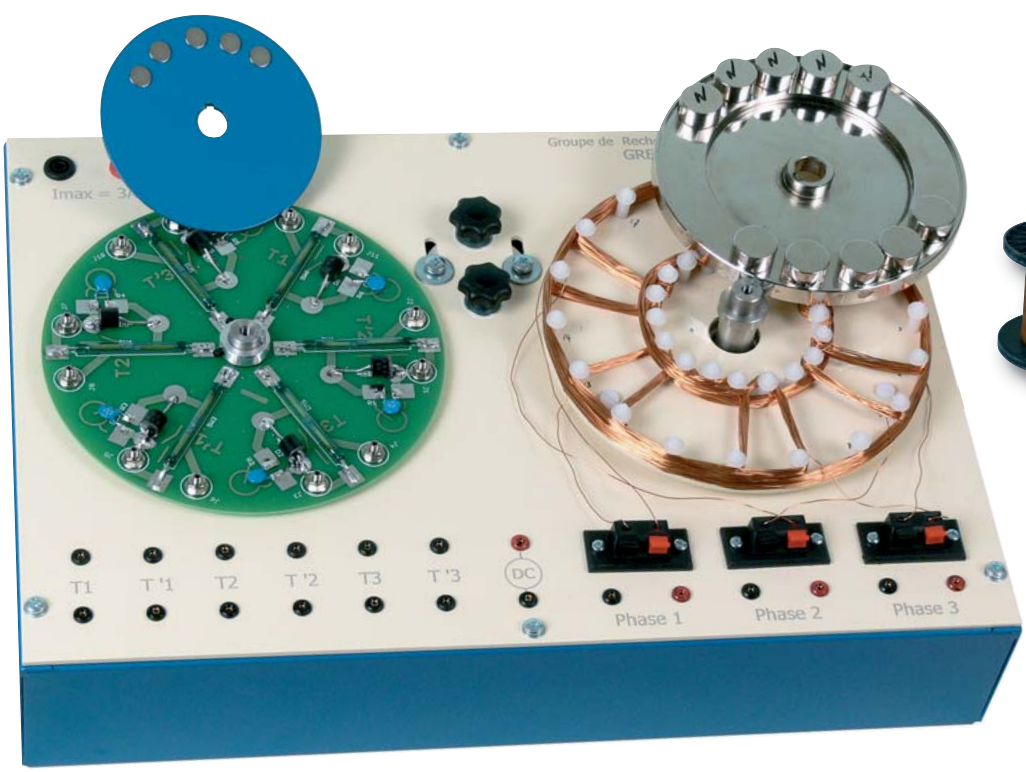
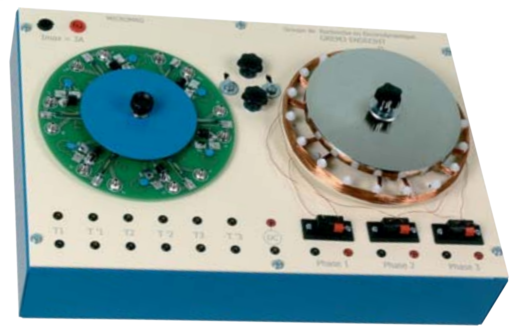
Automatically controlled synchronous machine



SCOPE OF SUPPLY

Supplied complete and in working order, together with:

- 1 wound stator
- 2 additional bare combs for winding
- enamelled wire dia. 0.5 mm
- 14 leads dia. 2 mm
- 1 full set of instructions with amended tutorials.



ref. MICROMAG

In contrast to the black box form of an industrial machine, MICROMAG is completely open and can be dismantled. Students can learn to identify all of its components, create one or more windings themselves and adjust the switch. This switch uses only dry contacts (with no complex electronic circuit) so that its operation is accessible to everyone. Using this model, students discover little by little the various components of an automatically controlled synchronous machine and, more generally, of a motor, via a theoretical and practical approach. The theoretical approach can be accessed at three study levels: secondary school leaving qualification targeting immediate employment, Institute of Technology or vocational diploma or engineering school. At the secondary school level, the torque, the EMF and the number of turns in the winding are calculated simply by applying formulae. Engineering students will have the necessary mathematical knowledge to establish these relationships by using the laws of electromagnetism (Laplace's law, Ampere's theory and Faraday's law) and applying them to the MICROMAG machine.
MICROMAG comes with a manual containing all of the basic laws which are necessary for understanding the tutorials. Wherever necessary, colour drawings are used to illustrate comments. Angular diagrams, timing diagrams and schematic diagrams are used to illustrate, step-by-step, the operation and/or stages of implementation. In addition to tutorials which are accessible to all, there are also questions + tutorials for higher education students, along with their answers. In addition, the following is required for all tutorials:

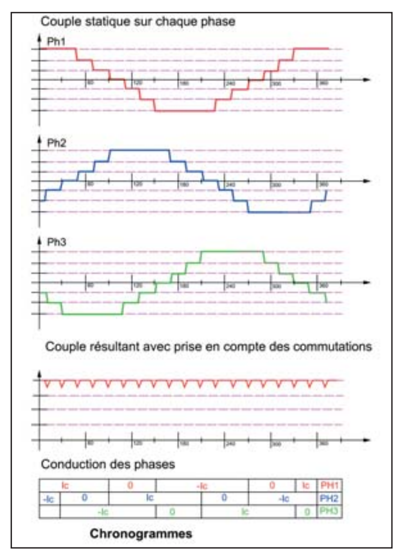
- a 30V DC 2A power supply
- an oscilloscope with a memory function
- a dynamometer
- a gaussmeter – not essential – used for checking the current of the field
- enamelled wire for winding on the rotor(s) (supplied)

TUTORIALS WHICH CAN BE ACCESSED AT ALL LEVELS OF TRAINING

Because the motor is open, students can see the air gap, the orientation of the magnetic field, the direction of the current, the direction of rotation, the "active" winding part and the yoke. MICROMAG can be used as a motor or a generator. By manually rotating the rotor, the machine will operate as a generator. Students read out from the oscilloscope the EMF on the two-phase terminals. This voltage indicates indirectly the torque ripple when the machine is operating as a motor.

EXAMPLE 1

For each of the three phases, students produce a static torque diagram (or EMF diagrams for each phase) based on the rotor's angular position. Students check the values experimentally by measuring torques using a dynamometer and the EMFs shown on the oscilloscope.
They plot torques in a graph and check them experimentally (EMFs respectively) when the two phases are connected in anti-series, or three phases in anti-series and parallel. They produce a phase power diagram based on the rotor's angular position.

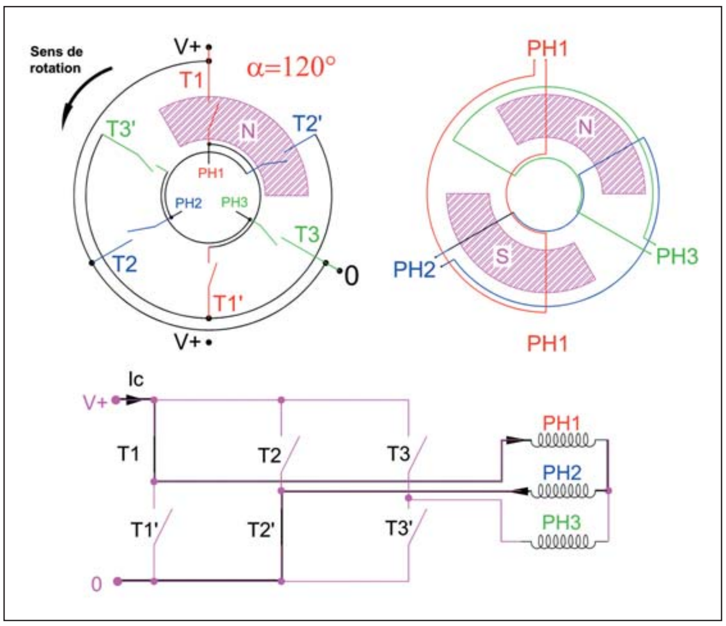


EXAMPLE 3

The MICROMAG winding can include one, two or three notches per pole and per phase. Students perform a theoretical calculation to determine the number of notches and turns of the winding required for a torque specified by the teacher. They then perform this winding on a comb using enamelled wire. Next, they check the obtained static torque in practice using a dynamometer.

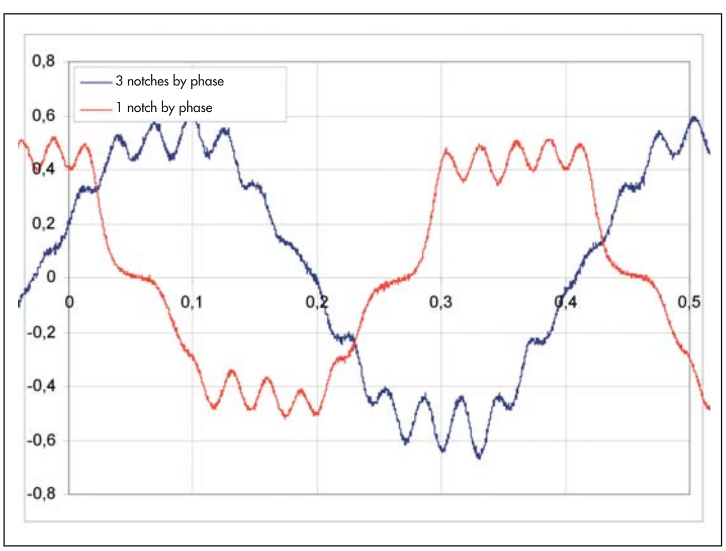
EXAMPLE 2

Using these diagrams, students study the principle of the switch, which powers in sequence the phases of a synchronous machine, based on the rotor's angular position. This switch comprises a "position sensor" and "electrical switching".
This is performed in MICROMAG by means of a rotating disk, which is synchronous with the rotor and carries magnets. The magnets activate reed switches, in series with the windings. Students have to place the magnets onto an angular sector of 120° on the switch's disk in order to power two phases. It is also possible to perform a 180° control by using one anti-series phase and the other two in parallel. By manually activating the disk, students check on the ohmmeter whether the opening/closing sequence of the switches matches the previously established phase power diagram exactly, based on the rotor position.



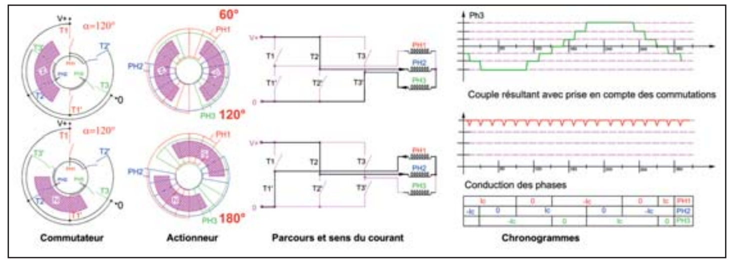
EXAMPLE 4

Students place the windings that they have produced inside the motor. By manually powering one phase after another, they firstly check the connection. Next, they connect the switches of the switching system with the three phases of the stator. By overriding the rotor/switch drive system, students check that its rotation is driving the rotor in synchronism. Finally, by resetting the switch drive by the rotor, students test the machine in automatically controlled operating mode. Students read out from the oscilloscope the currents in two successive phases and their conduction diagram.



EXAMPLE 5

The aim of the tutorials is to draw students' attention to the various power supply strategies, with a view to establishing a rotating field. To this end, they have a document to complete, which shows the successive angular positions of the switch and the rotor, the status of the switches, the current in the windings and the angular diagrams for each phase. They must determine the shape of the torque for each phase, as well as the resulting torque.



TUTORIAL AND MISCELLANEOUS QUESTIONS FOR UNIVERSITY AND ENGINEERING SCHOOL LEVEL

- Principle of axial motor
- Main μa and Ja parameters of a permanent magnet
- Recoil line
- Ampere-turns of a coil equivalent to a magnet.
- Hypotheses about the field and materials
- Magneto-static laws used
- Calculation of field B and comparison with the measurement
- Motor torque calculation Generator EMF calculation
- Relationship between EMF and torque
- Calculation of a number of turns for a given torque
- EMF waveform for a winding with one notch
- Torque wave form for a winding with one notch
- Calculation of the resistance of a phase. Practical check
- For each phase power supply strategy

- establish the opening and closing sequences of the switches
- wire the control circuit.
- based on the waveforms of the torques for each phase, determine the waveform of the resulting torque and currents
- determine the optimal polar arc

DYNAMOMETER FG5000

- Rating: 5000 gf
- Resolution: 1 gf
- Accuracy: 0.2% + 1 dgt
- Automatic shutdown
- Dim.: 240 x 80 x 40 mm
- Weight: 440 g

ref. FG5000