

### 4.6 Synchronous motor

At the beginning of the 21th century, the synchronous motor seems to have a good future as traction motor. With the permanent magnets which produce a high magnetic density, synchronous motors can be built lighter and more compact as induction motors of same power. The construction of such motors succeeds with the development of rare-earth-magnets reinforced by fibers. Their price is now higher as induction motors. The three-phase converters are very similar as converters for induction motors (Transpôle : VAL 208, BCT : H40LF). This drive was first used for city transit but is also chosen for high speed trains (Japan and France NTV: *Italo*).

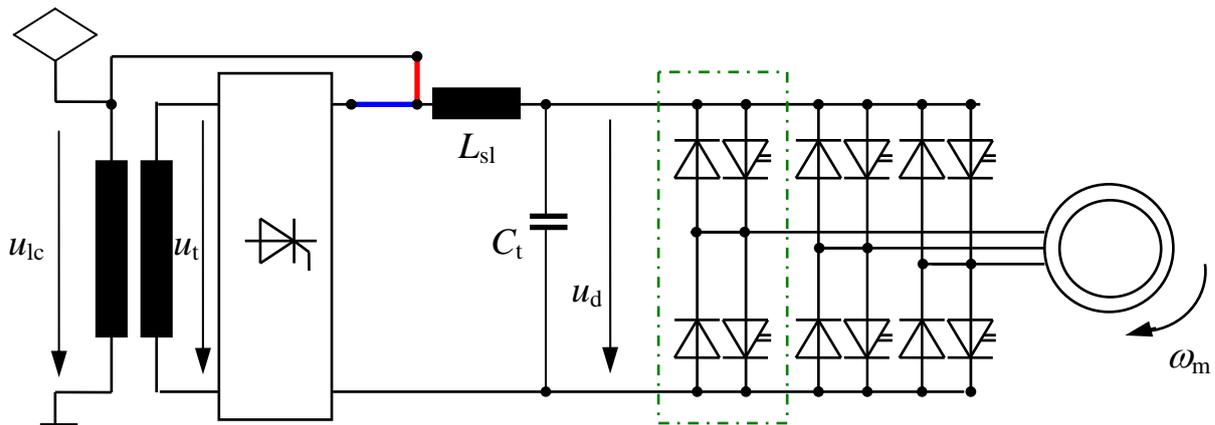


Fig. 4.178A Permanent magnet synchronous motor and a three-phase converter for DC- or AC-line. Schema of principle.

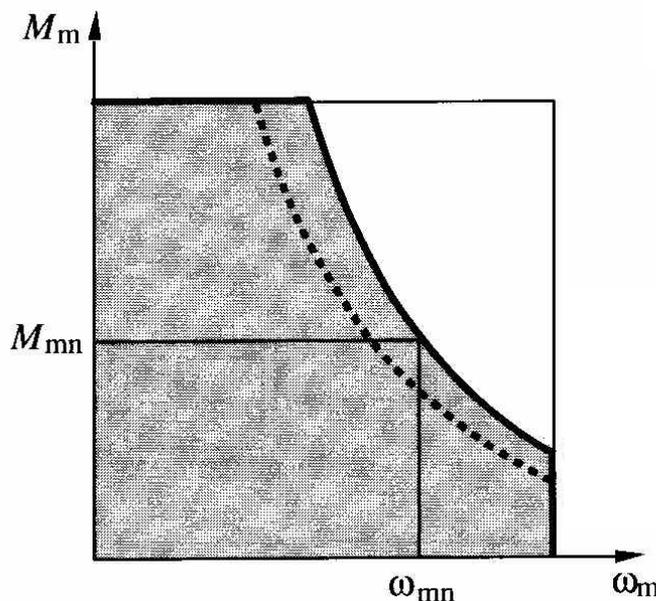
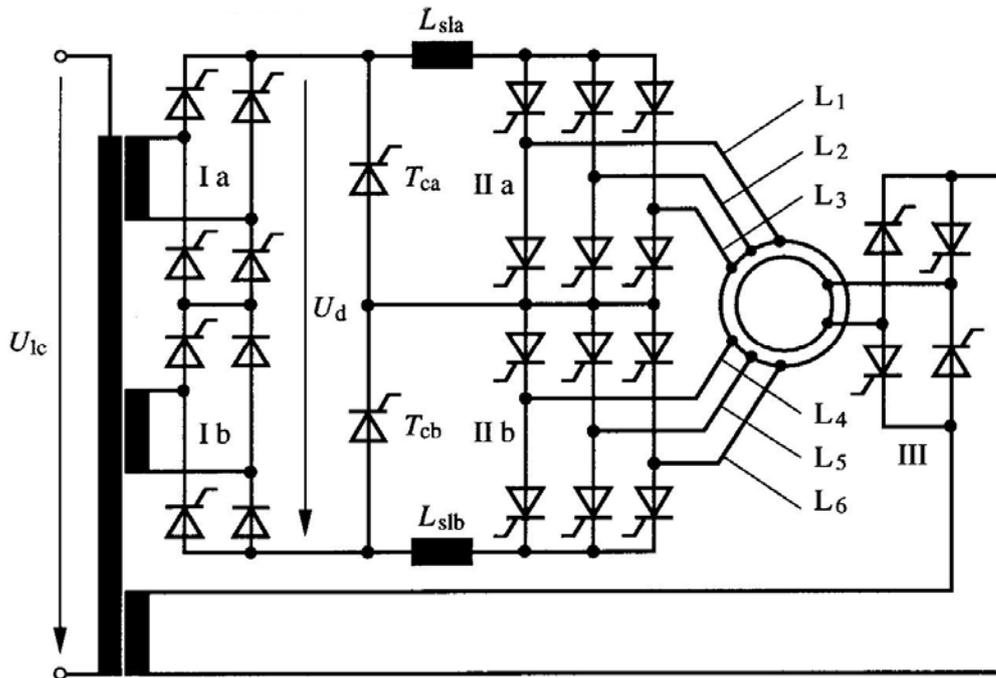


Fig. 4.180A Synchronous motor and three-phase converter: characteristics versus speed.

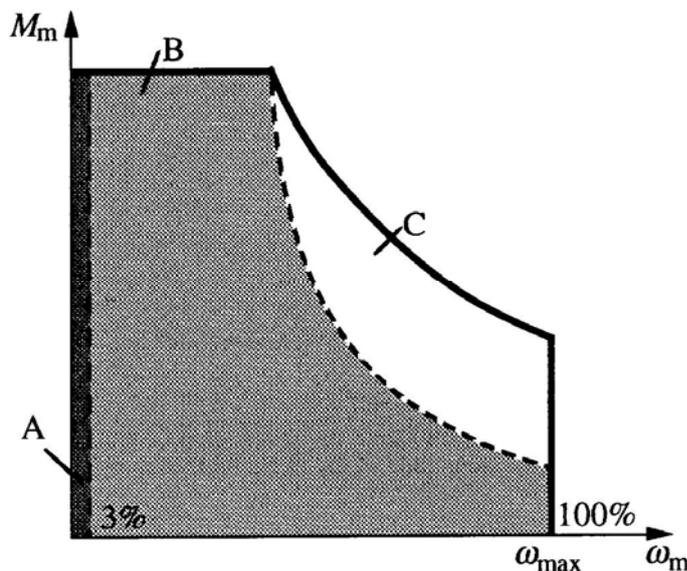
Synchronous motors with wired rotor were used before, with the need of contact rings to supply the rotor windings through a chopper or a rectifier. In these first constructions, three-phase converters were used, with natural commutation. They were controlled by the rotor position measured by two methods. They are called *self-controlled synchronous motors*. The group converter-motor is powered from contact line through a chopper or a converter as a

DC-motor (SNCF : BB 26000 or TGV-A). This drive is also named *DC-motor with static commutator* or *brushless DC-motor*.



**Fig. 4.179** Self-controlled synchronous motor: schema of principle: traction and regenerative braking (SNCF: BB 10004).

The area B is obtained by the triggering angle of bridge I, the C area by field weakening on bridge III. La zone B est obtenue par réglage de l'angle d'allumage du pont I, la zone C est obtenue par affaiblissement du champ sur le pont III. At very low speed, in area A, the switch-off in arms of converter II are obtained by the thyristors  $T_c$ , the induced voltage is not high enough to naturally switch off the arm.



**Fig. 4.180** Self-controlled synchronous motor: characteristics versus speed.