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## Starting Synchronous Motors

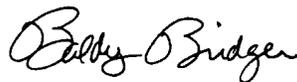
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Starting synchronous motors is a two-step process. The first step is to accelerate the motor to near synchronous speed. Most synchronous motors are equipped with a squirrel cage winding on the rotor for starting purposes. This differs from an induction motor squirrel cage in that it is not rated to carry load, but only to assist in starting. The synchronous motor is started as a squirrel cage induction motor, and can use any starting method that is used on a squirrel cage induction motor: full voltage, autotransformer, reactor, capacitor, etc. Protection required for the motor's stator and this first stage of its starting sequence is the same as required for an induction motor of similar size and starting method.

Once the motor reaches near synchronous speed, usually defined as about 95% speed, d.c. is applied to the rotor's field winding, pulling the rotor into step at 100% of synchronous speed. This is the second step of the starting process. During the acceleration stage, the field winding is shorted through a field discharge resistor, which is removed from the circuit before the d.c. is applied.

There are two basic types of fields used on synchronous motors, brush type and brushless. For either type, much detailed information about the motor's characteristics is required for proper application of starting equipment. On brush type motors, which are an older design, the two ends of the field winding are brought to slip rings, which are contacted by brushes, giving this type its name. D.c. from an external supply is applied to the field using external switching devices, usually a field contactor. The external supply may be a rotating exciter, either shaft-driven or a separate m-g set; an excitation bus; or the output of a solid-state excitation package. Speed is sensed by measuring the frequency of the induced a.c. current which flows in the field winding and the field discharge resistor. This frequency decreases as the motor speed increases. When an appropriate speed is reached, the control closes the field contactor, opening the discharge resistor circuit and closing the main field circuit. The control may be electro-mechanical or solid-state, and includes protection against loss of field and incomplete starting sequence.

Brushless motors have the armature of an a.c. generator, a rectifier package, the field discharge resistor, and a solid-state sensing and switching package mounted on the rotor of the synchronous motor. The a.c. generator serves as the exciter, and its field winding is stationary, and requires no slip rings or brushes. A small d.c. supply is required for this field winding, and is usually supplied by a solid-state package. Controls are also usually solid-state. Protective relays are unable to measure the d.c. field of the synchronous motor directly, so loss of field protection is provided by relays looking at the power factor of the motor, which changes suddenly when field is lost.



Baldwin Bridger, P.E.  
Technical Director