2.4 CONTROL CIRCUITS FOR SRM

For motoring operation the pulses of phase current must coincide with a period of accuracy inductance. The timing and dwell (i.e.) period of conductance of the current pulse determine the torque, the efficiency and other parameters. With fixed firing angles, there is a monotonic relationship existing between average torque and rms phase current but generally it is not linear. This may present some complications in feedback-controlled systems. Although it is possible to achieve near servo-quality‘dynamic performance, particularly in respects of speed range torque/inertia and reversing capability. More complex controls are required for higher power drives, particularly where a wide speed range is required at constant power, and microprocessor controls are used. As high-speed operation, the peak current is limited by the self-emf of the phase winding. A smooth current waveform is obtained with a peak/rms ratio similar to that of a half sinewave.At low speed, the self-emf of the winding is small and the current must be limited by chopping or PWM of the applied voltage.

Two types of control circuits used are:

1. Hysteresis type to maintain constant current
2. Voltage pulse width modulation control (or) duty cycle control.

HYSTERISIS TYPE CURRENT REGULATION

As by this control circuit current is maintained more or less constant like ―hysteresis‖

throughout the conduction period in each phase it is known as hysteresis Fig2.4.1 (a) shows the current waveform controlled by the hysteresis type current regulator. The schematic arrangement of the control circuit is shown in fig 2.4.1

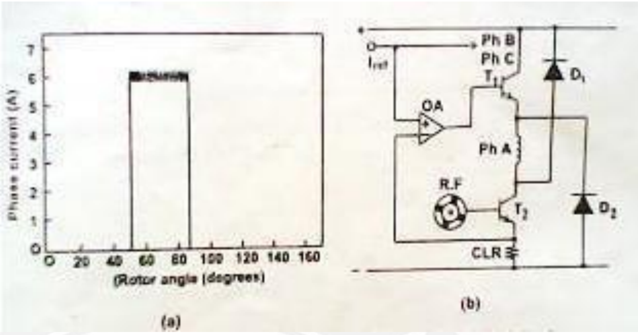

Figure 2.4.1 (a) Chopped current wave form, (b) Hysteresis type current regulation
[Source: "special electric machines" by R.Srinivasan page:3.53]

Principle of operation

As shown in fig. 2.4.1(b) the transducer (a tachogenerator) is connected from the rotor and then the output signal from the transducer is given as a feedback signal at the base of transistor T2. From the emitter of transistor T2, the portion of the feedback signal (current) is fed at the input of the operational amplifier (O.A). There it is compared with the reference current and correspondingly after amplification the feedback signal is given at the base oftransistor T1. This signal in combination with collector current will flow from the emitter oftransistor T1 through A phase winding of the machine. Thus the current through A phase winding can be controlled depending on the requirement. CLR is the resistance for limiting the current as per the design. As the current reference increase the torque increases. At low currents the torque is roughly proportional to current squared but at higher current it becomes more nearly linear. At very high currents, saturation decreases the torque per ampere again. This type of control produces a constant-torque type of characteristics. With loads whose torque increases monotonically with speed, such as fans and blowers, speed adjustment is possible without tachometer feedback but general feedback is needed to provide accurate speed control. In some cases the pulse train from the soft position sensor may be used for speed feedback, but only at relative high speeds.

As low speeds, a larger number of pulses per revolution are necessary and this can be generated by an optical encoder or resolver for alternatively by phase-locking a high frequency oscillator to the pulses of the commutation sensor. System with resolver-feedback or high-resolution optical encoders can work right down to zero speed.

The —hysteresis type‖ current regulator may require current transducers of wide bandwidth, but the SR drive has the advantage that they can be grounded at one end with the other connected to the negative terminal of the lower phase leg switch. The sensors used are shunts or hall-effect sensors or sense fets with in build current sensing.

VOLTAGE PWM TYPE CURRENT REGULATION

The schematic arrangement of PWM type control circuit is shown in fig. 2.4.2

Principle of operation

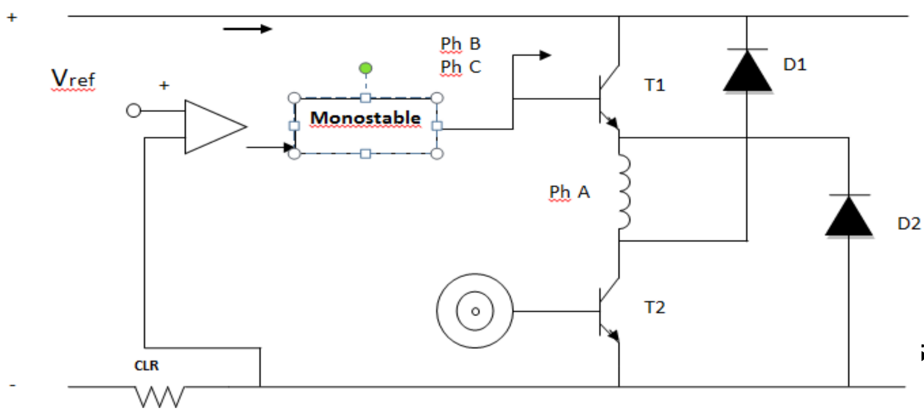

Figure 2.4.2 (a) voltage PWM type current regulator
[Source: "special electric machines" by R.Srinivasan page:3.53]

Through transducer (tachogenerator) the mechanical signal (speed) is converted into electrical signal (current), which is fed from at the base of transistor T2. Thos base current combining with collector current flows the emitter of transistor T2 through CLR to the negative of the supply. Based on the feedback signal, the voltage at phase A changes. This feedback voltage is given as one input to the operational amplifier where it is compared with the reference voltage, correspondingly the difference is amplified and fed to the mono stable circuit. This circuit modulates the pulse width of the incoming signal based on the requirement and the modulated signal is given at the base of T1.This signal combines with collector current of T1 and flows through phase A as modulated current based on the requirement. Thus the current is regulated or controlled using pulse width modulation and rotor feedback.

CLR -Current limiting resistor

R.F-Rotor feed back

OA -Operational Amplifier

T1T2-Switching transistor

D1 D2-Diodes to return stored energy

A desirable future of both control methods is that the current wave form tends to retain the same shape over a wide speed range.When the PWM duty cycle reaches 100%, the motor speed can be increased by increasing the conduction period. These increases eventually reach maximum values after which the torque becomes inversely proportional to speed squared but they can typically double the speed range at constant torque. The speed range over which constant power can be maintained is also quite wide and very high maximum speeds can be achieved, as in the synchronous reluctance motor and induction motor, because there is not the limitation imposed by fixed as in PM motors.