Tuning the SV9000 Sensorless Vector Control

Overview

The SV9000 is shipped standard with seven (7) pre-installed SVReady Applications. The Basic Application provides smooth motor control for a wide range of applications. Only eighteen (18) parameters are required to commission the SV9000 utilizing the frequency motor control mode (V/Hz). Automatic torque boost is available to produce sufficient torque to start and run at low frequencies in applications such as conveyors or compressors. In centrifugal fans and pump applications, where torque demand is proportional to the square of the speed, Squared V/Hz can be optionally selected to reduce the available motor torque and electromechanical noise at lower speeds.

The SV9000 can easily provide enhanced features and functionality by utilizing one of the six (6) remaining SVReady Applications. These include programmable Start/Stop and digital input/output logic, enhanced drive and motor control, protection features, auto restart and special pump and fan control. In any application it is important to set the motor nameplate values as accurately as possible to provide motor protection and performance.

Applications requiring high torque and speed control at low speeds, very accurate speed / torque regulation or controlling speed with a torque reference will require accurate tuning of the SV9000 Sensorless Vector Control. The term "sensorless" refers to control without the use of an external sensor such as an encoder. The term "vector" refers to the control of the motor magnetizing current _and_ the torque producing current. The Multi-purpose Control Application is the most versatile in tuning the sensorless vector capabilities of the SV9000 and was used for this application note. Some parameters described here are not available for adjustment in the Basic or other SVReady Applications.

Select the Application

The first step in providing enhanced SV9000 features and functionality is to select the proper SVReady Application to meet the customers needs. Selecting a SVReady Application resets all parameters to their default values. These default values will insure a known starting point. If the SVReady Application is presently loaded, record the original parameter values or save them to disk with the SVDrive software for later reference if required. Select application as follows:

- Unlock parameters if necessary by setting P1.16 to Changes Enabled (0).

- Open parameter conceal by setting P1.15 to All Visible (0)

- Select application by setting P0.1 to the proper application (0-7)

Set Motor Nameplate and Initial Parameters

Smooth motor control and performance require accurate motor nameplate and supply voltage information. Select the value in P1.14 that matches the nominal voltage of the 3-phase supply. This sets the overvoltage, undervoltage, DB turn on and many other set points. Enter motor nameplate data into the following parameters:

- Enter the nominal voltage of the motor in P1.10. This sets the field weakening point voltage (P6.4) to 100% of this value.

- Enter the nominal frequency of the motor in P1.11. This sets the field weakening point frequency (P6.3). Voltage to the motor is constant (constant HP) over this frequency.

- Enter the nominal speed of the motor in P1.12. This lets the drive know the slip of the motor for correct speed and torque compensation and motor speed display.

- Enter the nominal current of the motor in P1.13. This sets up the internal motor protection function of the drive calibrates the torque calculation.

Enter the maximum motor current the drive will provide short term in P1.7. This value is usually referred to as the current limit level.

Set parameters 1.1 to 1.4 to meet the needs of the application. Acceleration time (P1.3) is the ramp time between Minimum frequency (P1.1) and Maximum frequency (P1.2). Acceleration time may be automatically extended to limit motor current to the value in P1.7. Deceleration time (P1.4) is the ramp time between Maximum frequency (P1.2) and Minimum frequency (P1.1). Deceleration time may also be extended to prevent an overvoltage trip if the Overvoltage controller is operating (P6.8 set to 1).

High torque at low speeds

The torque produced by an induction motor depends on the proper magnetization of the motor stator. In an ideal motor, the impedance of the stator varies directly as the frequency applied so the volts per Hertz ratio is linear between zero and base frequency. When frequency is less than 3 times the nominal slip frequency of a real motor, the resistance of the stator drops a more significant portion of the applied voltage, reducing the magnetic flux producing current and therefore the torque available. IR Compensation is available to boost this current to an appropriate level. The following sections describe IR compensation and speed control for the SV9000 drive.

Fine Tuning the IR Compensation

For optimum low speed performance, the IR compensation can be manually tuned using the following motor identification procedure:

- Measure the motor magnetization (I_m) current by running the motor uncoupled from the load at 48Hz. If the current is notably higher or lower than 0.5 times the motor FLA, re-check the motor nameplate values and check that the motor is uncoupled.

- Set V/Hz (U/f) ratio select (P1.8) to Programmable (2)

- Set the V/Hz (U/f) mid point frequency (P6.5) to 3 times the nominal slip frequency (for a 4 pole motor divide the slip rpm by 30, for a 6 pole motor by 20, and a 2 pole motor by 60) of the motor, around 1 to 3 Hz. Run the motor at this frequency and adjust the V/Hz (U/f) curve mid point voltage (P6.6) until the current reading is the same no load value recorded above. With standard motors the value should be 1 to 2% above the "linear curve" value (10 to 12% if P6.5 was set to 5 Hz).

- Run the motor at 1 Hz and adjust the Zero Freq Voltg (P6.7) until motor current is again the same no load value recorded above. With standard motors the value should be between 1 and 2.5%. Large motors should have a value between 0.5 and 1%.

After the above adjustments, the steady state no load current on the motor should be constant between 0 Hz and the field weakening point and the torque display should read approximately 0%.

Caution: If the voltages are set too high, the motor could saturate drawing excessive current that could damage the motor.

Stator Resistance Measurement

The motor model used in the vector calculation needs the stator resistance value to make accurate calculations. The initial value of stator resistance is based on the motor nominal current value (P1.13). The value of stator resistance varies between different motor designs and as the temperature of the motor changes. The drive measures stator resistance every time DC braking is activated at drive start. For an accurate measurement, the motor shaft must be stopped. To enable Stator Resistance Measurement:

- Set DC braking current (P4.8) 0.8 to 1.0 times the motor FLA

- Make a calibration measurement by setting the DC braking time (P4.11) to 1 second or higher. This will allow the drive to compensate for motor temperature changes during each start operation.

Caution: Do not use Stator Resistance Measurement with an Enclosed SV9000 with either an output contactor or bypass option since the drive is started before the output contactor is closed, preventing proper operation.

Automatic Torque Boost

Increasing torque at low speeds can be accomplished by activating Auto Torque Boost. Automatic torque boost uses an internal vector calculation of a motor model to keep motor magnetization constant for different load levels. To enable Automatic Torque Boost, set V/Hz (U/f) Optimization (P1.9) to Auto Torq Boost (1)

Speed Control Operation

If the application requires controlled torque at low speeds and/or accurate speed regulation (0.5% or better), Speed Control operation is necessary. Using the motor model and an internal vector calculation, speed control compensates for the slip in the motor by boosting the frequency as load increases. The reference is still set in Hz, but the actual speed of the motor will not differ from the set speed by more than ±0.5% of the motor base speed. To enable Speed Control, set Control Mode (P6.1) to Speed Control (1).

Typical Open Loop applications

Machine Tools   .
- Grinders, Spindles, Lathes
- Milling
- Shapers and Planers
- Presses

Process Equipment
- Steel mills
- Paper machines
- Blown plastic film extruders
- Metal forming
- Food processing

Test Equipment
- Engine test stands
- Wheel brake and tire test stands

Others – Elevators, Packaging machines, etc.