QUESTION:
When and how should I use Sensorless Vector Control (SLVC) on the MM440?

ANSWER:

**Applying Sensorless Vector Control (SLVC)**

Sensorless Vector Control requires careful commissioning and setting up. This should only be carried out by commissioning engineers who have experience of operating MM440 drives in SLVC.

Reliable SLVC operation relies on continuous recalculation of the rotor position, and if, for any reason, the rotor position information is lost ("Loss of Orientation") the response of the drive is unpredictable. Loss of Orientation can be caused by an incorrectly commissioned motor, loss of motor temperature information following power failure, or similar disturbances.

Although expert commissioning can largely overcome these problems, it is recommended that SLVC is not used where continuous, uninterrupted performance is important, or where loss of orientation may cause problems such as in lifting or hoisting applications.

Furthermore,
- SLVC should not be used where the motor inverter power ratio is less than 1:4
- SLVC cannot be used where the maximum frequency is 200 Hz or greater
- SLVC should not be used on multi-motor applications
- If a contactor is placed between the inverter and the motor, the contactor must never be opened whilst the inverter is running.

**Important Note**

No fault is generated automatically in the event that the vector control loses orientation. While this is an unlikely occurrence, the following parameters must be set to ensure that a fault is internally generated in this case if SLVC is being used:

- P0003 = 3; P2106 = 53.5; P2155 = 200.00 Hz. This will generate the fault F0085 in the case where the vector control loses orientation.

**Recommended means of commissioning**

For correct operation under SLVC control it is extremely important that the motor data is correctly entered and that the motor identification is carried out. The order this is carried out is also important as the quick commissioning procedure provides the initial motor model, and the motor identification measurements refine this. The procedure for doing this is as follows:

1. **Quick Commissioning and setting initial motor model**

   - P0003 = 2 (allows user access level 2)
   - P0010 = 1 (Quick Commissioning):
     - P0300s: Motor data according to motor nameplate
     - P0700, P1000, P1080/2, P1120/1…control selection, setpoint selection, Fmin/max, ramp times etc.
   - P1300 = 20 Sensorless Vector Control
   - P1910 = 1
(A0541 will appear at this point)
P3900 = 1
"- - - -" or “busy” will appear on the BOP for approximately 1 minute, or longer on very large inverters, while the motor parameters are being calculated. After this A0541 will now be flashing on the BOP.

This completes the quick commissioning and the initial motor model is now complete.

2. Motor Identification using P1910

Two automated series of measurements must now be carried out.

**Note:** This must be carried out on a **cold** motor. It is also necessary to ensure that the motor ambient temperature is correctly entered in P0625 if this is significantly different from the default value of 20°C. This must be done after the quick commissioning has been completed (P3900) but before the motor identification measurements are carried out.

P1910 =1. Give a RUN command: This initiates the motor identification measurements.

A0541 will continue to flash; a number of measurements are made by pumping current into the motor for short bursts making an audible hum. This is followed by "- - - -" or “busy” on the BOP while the internal motor parameters are calculated.

If you get a fault message F0041, this means that the measured value does not match the expected value from the initial motor model. Check the wiring (particularly star / delta connection) and also the parameter values entered. If all of these are ok, then you should try to run the drive, unloaded, in V/f control (set P1300 = 0), with a setpoint of ca. 80% of motor rated frequency. Look at the value for output current (r0027) and enter this as the motor magnetisation current in P0320 (as % of motor rated current, P0305) and recalculate the motor parameters (set P0340 = 1).

P1910 = 3 (identification of saturation curve) can improve the performance: You don't need to go into Quick Commissioning for this. Once P1910 is set to 3, A0541 will appear. Now give a RUN command. The behaviour will be similar to the description above.

At this point, the inverter can be run under SLVC. However an optimisation procedure is recommended to get best regulation.

3. Optimisation

(a) Motor Model

SLVC requires a good motor model. A good measure of this is r1787 (Output of Xm adaptation). This should be below +/- 15 %. If this not the case you may need to improve the model

The motor model can be improved by measuring the magnetisation current. Refer to the document in FAQ ID { HYPERLINK "http://support.automation.siemens.com/-snm-0135109872-1110474974-000002348-0000010057-1113282889-emm-WW/view/en/20279537" "Tips and Tricks: Measuring the Magnetising Current" for the correct procedure, or use the procedure described previously. If the procedure cannot be followed (e.g. because the motor cannot be decoupled from load) then you should try values of magnetisation current (set P0320 followed by P0340 = 1 to recalculate the motor model) until you find that r1787 is in an acceptable range.

Note: once you have established the correct magnetisation current for a motor, this will be more or less valid for all motors of that type, so it should not be necessary to carry out these measurements for each motor, but
rather set P0320 appropriately

(b) Performance

The motor identification will set initial values for the sensorless vector control which will allow the motor to be run up to 50 Hz. In order to get good vector performance, it is necessary to optimise the vector control loop according to the mechanics of the motor / load system.

The following parameters can be adjusted by the user to improve performance. For best results you should use an oscilloscope to measure the effect of any adjustments:

P0003 = 3
P0342: motor / load inertia ratio in combination with P1496 (scaling acceleration pre-control)
P1470: SVC P gain
P1472: SVC I term
P1511: additional torque setpoint
P1520 / P1521: Torque limits
P1610: SVC open loop boost
P1750: enable observer model

Refer to function diagrams 7000, 7200, 7500, 7800 and 7900 in the Parameter List

P0342 - should be appropriately set where this is known or can be estimated as described. This is used in conjunction with P1496 to generate an extra torque to overcome load inertia. For best results set P1496 = 100% and try values of P0342 = 1, 3, 6 etc. You should see that the performance becomes better with increasing values until the value is set too high and causes instability. This is normally only useful for systems where a pulse of torque is required to start an inertial load moving, but not subsequently required.

P: P1470 and I: P1472 - these are initially set to allow a large range of applications. The optimal settings are dependent on the mechanical system. Good results can be achieved by increasing the P term and decreasing the I term while observing the system behaviour. Ideally this should be done by looking at the unfiltered output frequency (r0066) on a scope via the analogue output (P0771[0] = 66). It is also useful to monitor the output current, either with a clamp as shown or using a second analogue output (P0772[1] = 27).

Here are examples of how changing the values of P1470 and P1472 affect a resonance while ramping up. In each case trace (a) is the motor current using a clamp and trace (b) is the unfiltered output frequency (r0066)

P1470 = 12; P1470 = 80 ms

P1470 = 6; P1472 = 25 ms

P1511 - additional torque setpoint. This is particularly useful for applications where instantaneous torque is required (e.g. lifting drive). This can be connected to a value as follows: P1511 = 2890 and set P2890 = xx% (e.g. 40%)
P1520/P1521 - Reducing these can reduce instability, while increasing can give better dynamic performance.

P1610 - SVC boost for open loop operation. The default is 50% and this can be increased to increase low speed torque.

P1750 - Setting P1750.0 = 0 allows the observer model to be used from standstill provided that the frequency setpoint is greater than 5 Hz*. Setting P1750.1 = 0 allows the observer model to be used when passing through 0 Hz. In general using the observer model provides best performance and avoids the transition between open loop and Sensorless Vector Control at 5 Hz*.

P1755 - Switchover frequency for vector control. This can be reduced below its default on large motors to allow full vector control below the 5Hz* default. However this should not be reduced below 2 x motor rated slip frequency.

Note that optimised performance will depend on what you are trying to achieve (e.g. this might be different depending on whether you require very good speed holding or high torque at low speeds). You should always test and measure against this.

Before leaving site, you should always test your settings across a range of loads and also in worst case conditions.

Try shock loading, coupling and decoupling load, or if this is not possible run the motor up to a given speed, set the ramp times P1120/1 to 0, and give a frequency setpoint step change of a few Hz (add fixed frequency using DIN).

Check performance following a power cycle to ensure behaviour is still as required.

The optimised values you have achieved should be useable on any machine of identical mechanical and electrical construction. However we always recommend carrying out the motor identification measurements (P1910 = 1 & 3). After this the values for P1470 etc. can be entered without the need for a full optimisation.