

Application Note: SyMAX Permanent Magnet Motor Simple Startup Procedure

Variable Frequency Drives Optimize Performance and Further Improve Efficiency by using Permanent Magnet Motor Control.

Title: SyMAX PM Motor Simple Startup Procedure

Product(s): A1000, U1000, V1000

Doc. No. AN.SYMAX.01

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The following application note provides the user with basic instructions on how to quickly configure a Marathon Symax Permanent Magnet motor using a Yaskawa drive.

Introduction

Controlling the speed of ac motors is accomplished using a variable frequency drive (VFD) in most cases. While many scenarios involve using VFDs with induction motors with stator windings to generate a rotating magnetic field, they also can achieve precise speed control using speed or position feedback sensors as a reference to the VFD. In some situations, it is possible to obtain comparably precise speed control without the need for feedback sensors. This is made possible using permanent magnet motors. A PM motor is an ac motor that uses magnets imbedded into or attached to the surface of the motor's rotor. The magnets are used to generate a constant motor flux instead of requiring the stator field to generate one by linking to the rotor, as is the case with an induction motor. Aside from precise speed control capabilities, efficiency improvements can be obtained using PM motor over induction machines.

Marathon Electric Motors offers an off the shelf interior permanent magnet motor line call the SyMAX motors. The SyMAX PM motor line can be effortlessly configured to be operated by a number of Yaskawa AC drives. The following document will provide an example of a quick start procedure for configuring a Yaskawa AC drive to operate a SyMax PM motor.

Applicable Products

The Yaskawa Drive must have PM motor control capabilities. Options Include:

- OLV-PM Control (A1-02 = 5)
- AOLV-PM Control (A1-02 = 6)
- CLV-PM Control (A1-02 = 7)

Yaskawa AC Drives Series	Models
A1000	200V: CIMR-AU2A0004xxx to CIMR-AU2A0415xxx 400V: CIMR-AU4A0002xxx to CIMR-AU4A1200xxx
U1000	200V: CIMR-UU2A0028xxx to CIMR-UU2A0248xxx 400V: CIMR-UU4A0011xxx to CIMR-UU4A0930xxx
V1000	200V: CIMR-VU2A0001xxx to CIMR-VU2A0069xxx 400V: CIMR-VU4A0001xxx to CIMR-VU4A0038xxx

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Symax Application Checklist

To ensure optimal performance from your SyMAX® motor, it is important to follow the following checklist. These guidelines are intended to augment sound engineering practice, and therefore should be considered only one tool in applying Permanent Magnet AC motors in various applications.

Basic Considerations:

1. Operating speed range and base RPM.
2. Torque requirements throughout speed range.
3. Description of power supply.
4. Drive Model.
5. Description of surrounding environment; specify required protection.
6. Frame size limitations and preferences, if any.
7. Mounting requirements (base, flange, horizontal, vertical, etc.).
8. Belting data, if applicable
9. Duty cycle, eg. "continuous", "60 minute", etc.
10. Special considerations, eg. load sharing, short accel/decel requirements, etc.
11. Special performance requirements.
12. Required accessories, modifications and options.

VFD Considerations

While SyMAX® motors are designed to operate with multiple brands and models of PM drives, special consideration must be made to ensure optimal drive and motor performance. To ensure a successful application, the following must be addressed. Like the motor application checklist above, this checklist should be considered a tool in addition to consultation with the VFD manufacturer's documentation and advice.

1. Required software or firmware update, or confirmation of suitability for PM motors.
2. Minimum and maximum carrier frequency settings; impact on performance.
3. Recommended feedback device and module, if required.
4. Special motor parametric data for tuning, if required.
5. Maximum allowable Back EMF voltage, to avoid damage to drive components.
6. Special ambient conditions, if applicable.
7. Special enclosure requirements, if applicable.
8. Special performance requirements, if applicable.
9. Limitations, such as load sharing, speed search, etc.

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SyMAX Comprehensive Motor Nameplate

Marathon SyMAX motor nameplates provide motor characteristic information that directly correlates to Yaskawa drive parameters for PM motor control. Entering these values in to the correct setting is typically all that is involved in achieving an operational state with a SyMAX PM motor. Only motor horsepower needs to be converted to kW before being entered into the appropriate setting (1 HP = 0.746 kW).

Example Marathon Motor Nameplate:



CAT. NO:	MODEL NO: NS6PNRA10100	DATE:	RPM:	HZ:	TQ(IN LBS):	HP:
SERIAL NO:	CUST. PN:	CC:	MIN:	90	4.5	17.5
DUTY: CONT	INS: F3	TYPE: TS	BASE:			
AMB: 40°C	PH: 3	ENCL: TENV	RATED:	1800	90	17.5
FR: S56C	CODE:	DES: B	MAX:	2160	108	14.6
IP: 54	POLES: 6		@ RATED HP			
BEMF: 76/152 V/kRPM L-L			VOLTS: 230/460 AMPS: 1.9/0.8 EFF: 83%			
PF (cosφ): 80 (0.8)			PER PHASE			
ROTOR INERTIA: 3.17 LB-IN ²			R: $\frac{3.3}{13.2} \Omega$	Ld: $\frac{17.3}{69} H$	Lq: $\frac{40.6}{162} mH$	

WARNING SHAFT ROTATION GENERATES VOLTAGE AT TERMINALS, EVEN WHEN POWER IS DISCONNECTED

MADE IN USA - FOR PERMANENT MAGNET PWM VFD USE ONLY
 WARNING: FAILURE TO FOLLOW ALL SAFETY INFORMATION CAN RESULT IN SERIOUS PERSONAL INJURY OR DEATH. DISCONNECT DRIVE INPUT POWER AND VERIFY DRIVE OUTPUT DC VOLTAGE IS ZERO BEFORE SERVICING. INSTALL GROUND PER LOCAL AND NATIONAL CODES. CONSULT QUALIFIED PERSONNEL WITH ANY QUESTIONS

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The nameplate provides the following essential motor data:

- Power: 0.5 HP (0.373 kW)
- Rated speed: 90 Hz @ 1800 RPM
- Number of Poles: 6 Poles
- Rated Voltage: 230/460 Vac
- Rated Current: 1.9 / 0.8 A
- Resistance: 3.3 / 13.2 ohms (per phase)
- d-Axis Inductance: 17.3 / 69 mH
- q-Axis Inductance: 40.6 / 162 mH
- BEMF (K_E): 76 / 152 V-I,RMS/kRPM

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Marathon SyMAX Motor Simple Startup Procedure

*The following assumes a 230 Vac Yaskawa Drive SyMAX motor configuration using Yaskawa's PM control method 5. Control Method 5 (OLV/PM) is suitable for variable torque pump and fan loads.

Step 1: Set Control Method

- A1-02 = 5 (OLV/PM)

Step 2: Set motor data based on SyMAX nameplate data

- E5-01 (Motor Code): FFFF Custom
- E5-02 (Motor Power): 0.37 kW
- E5-03 (Motor FLA): 1.9 A
- E5-04 (Motor Poles): 6
- E5-05 (Terminal Resistance): 3.3 ohms
- E5-06 (d-axis inductance): 17.3 mH
- E5-07 (q-axis inductance): 40.6 mH
- E5-09 (Ke constant 1) = 0.0 V
- E5-24 (Ke Constant 2) = 76 VAC

Step 3: Set Voltage and Speed Parameters

- E1-04 (Max. Frequency) = 90 Hz
 - This SyMAX motor design allows this setting to be as high as 108 Hz.
- E1-05 (Max. Voltage) = 230 VAC
- E1-06 (Base Frequency) = 90 Hz
- N8-62 = 230 VAC

Step 4: Motor Performance Tuning Adjustments

- Set n8-55 (Load Inertia) for PM motor according to the machine inertia (motor shaft conversion) to be applied.
- In the same way, set C1-01 (acceleration time), C1-02 (deceleration time), C2-01 (S-Curve Characteristic at Accel Start) and n8-51 (Acceleration Time Pull-In Current) according to the load inertia and load torque.
- Perform actual-load operation. If vibration, overrun or a failure to start occurs, try to adjust the following parameters.

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Typical Parameter Adjustments:

- C1-01 (Acceleration Time)
 - Increase to prevent motor pull out while starting under load.
- C1-02 (Deceleration Time)
 - Increase to prevent the motor pull out during aggressive deceleration.
- C2-01 (S-Curve at Start of Acceleration)
 - Increase to prevent motor pull out while starting under load.
- B6-02 (Dwell Time at start)
 - 1 to 3 seconds to prevent motor pull out during initial start.
 - Used in conjunction with B6-01 (Dwell Reference at start).
 - Recommendation: 1 to 3 Hz
- N8-48 (Pull-In Current)
 - 20 to 40% Increase if motor pulls out before rotation begins.
- N8-51 (Acceleration Pull-in time)
 - 75 to 85% for better starting torque. Increase if motor pulls out during acceleration.
- N8-55 (Load Inertia)
 - Attempt each setting (0 → 1 → 2 → 3) for better starting/running current. If no improvement is achieved return to last setting which improved performance.

Additional Adjustment Recommendations:

- Overrun at startup, a failure to start at heavy load and high inertia
 - Increase the set value of n8-55 (Load Inertia) to be suitable for the load if it is lower than the actual value.
 - Increase n8-51 (Acceleration Time Pull-In Current) by 10%. (Default: 50%, recommended value: 50 to 150%)
 - Increase C4-01 (Torque Compensation Gain) by 0.10. (Default: 0.00, recommended value: 0.00 to 1.00)
 - Increase C2-01 (S-Curve Characteristic at Accel Start) and C1-01 (Acceleration Time) according to the load.
 - Decrease C6-02 (Carrier Frequency Selection). (Default: Depends on ND/HD and capacity. Recommended value: 2 kHz to default)
 - Accelerate the motor after pulling in the motor once at a low speed by using b6-01 (Dwell Reference at Start) and 02 (Dwell Time at Start). (Recommended value: b6-01 = 3.0 to 6.0 Hz, b6-02 = 0.3 to 1.0 second)

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- Hunting or pull-out with impact loads and heavy loads at constant speed
 - Increase the load inertia setting (n8-55) to match the actual load if set too low.
 - Slowly increase the torque compensation gain set to C4-01 in intervals of 0.10. (Default: 0.00, recommended value: 0.00 to 1.00)

- Overrun at a light load or by oscillation of control and machine systems
 - Increase or decrease n8-45 (Speed Feedback Detection Control Gain) by 0.10 according to the situation. (Default: 0.80, recommended value: 0.20 to 2.00)
 - Decrease n8-55 (Load Inertia) to be suitable for the load if it is higher than the actual value.
 - Increase or decrease C4-02 (Torque Compensation Primary Delay Time) by 20 msec according to the situation. (Default: 100 msec, recommended value: 20 to 200 msec)
 - Decrease C6-02 (Carrier Frequency Selection). (Default: Depends on ND/HD and capacity. Recommended value: 2 kHz to default)
 - In case of oscillation only in the specific operation frequency band, use d3-01 to 04 (Jump Frequencies) to avoid the frequency band where oscillation is apt to occur.
 - If a deflection of analog frequency reference is the cause of overrun, increase H3-13 (Analog Input Filter Time Constant). Recommended value: 0.03 to 1.00 sec.

- Excessive current although there is no problem in startup or operation
 - Decrease n8-55 (Load Inertia) to be suitable for the load if it is higher than the actual value.
 - Decrease n8-51 (Acceleration Time Pull-In Current) by 10%. (Default: 50%, recommended value: 50 to 150%)
 - Decrease n8-48 (Pull-In Current) by 10% if it is too large. (Default: 30%, recommended value: 20 to 40%)
 - Decrease C4-01 (Torque Compensation Gain) by 0.10. (Default: 0.00, recommended value: 0.00 to 1.00)
 - When current fluctuates periodically, refer to the previous item (Overrun at a light load or by oscillation of control and machine systems) to adjust it.

Note: If the above adjustment does not work, confirm again that the values of E5-05, E5-06, E5-07, and E5-09 (or E5-24) match the motor nameplate.

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REVISION	COMMENT / MODIFICATION	DATE
—	ORIGINAL	06/01/2017