T E C H N O S O F T
MOTION TECHNOLOGY

Start Modes Description

Application Note

Easy Motion Studio II

Table of contents

1. Application description

This application note describes the available start modes required at power-on or reset to enable the vector control (field-oriented control) operation of the drive. These procedures are essential for aligning the magnetic fields in the motor. Without them, the system cannot determine the actual position of the rotor field relative to the stator field.

2. Start modes description

The preferred start mode can be selected during the setup phase through the “Application Settings” setup page in EasyMotion Studio II.

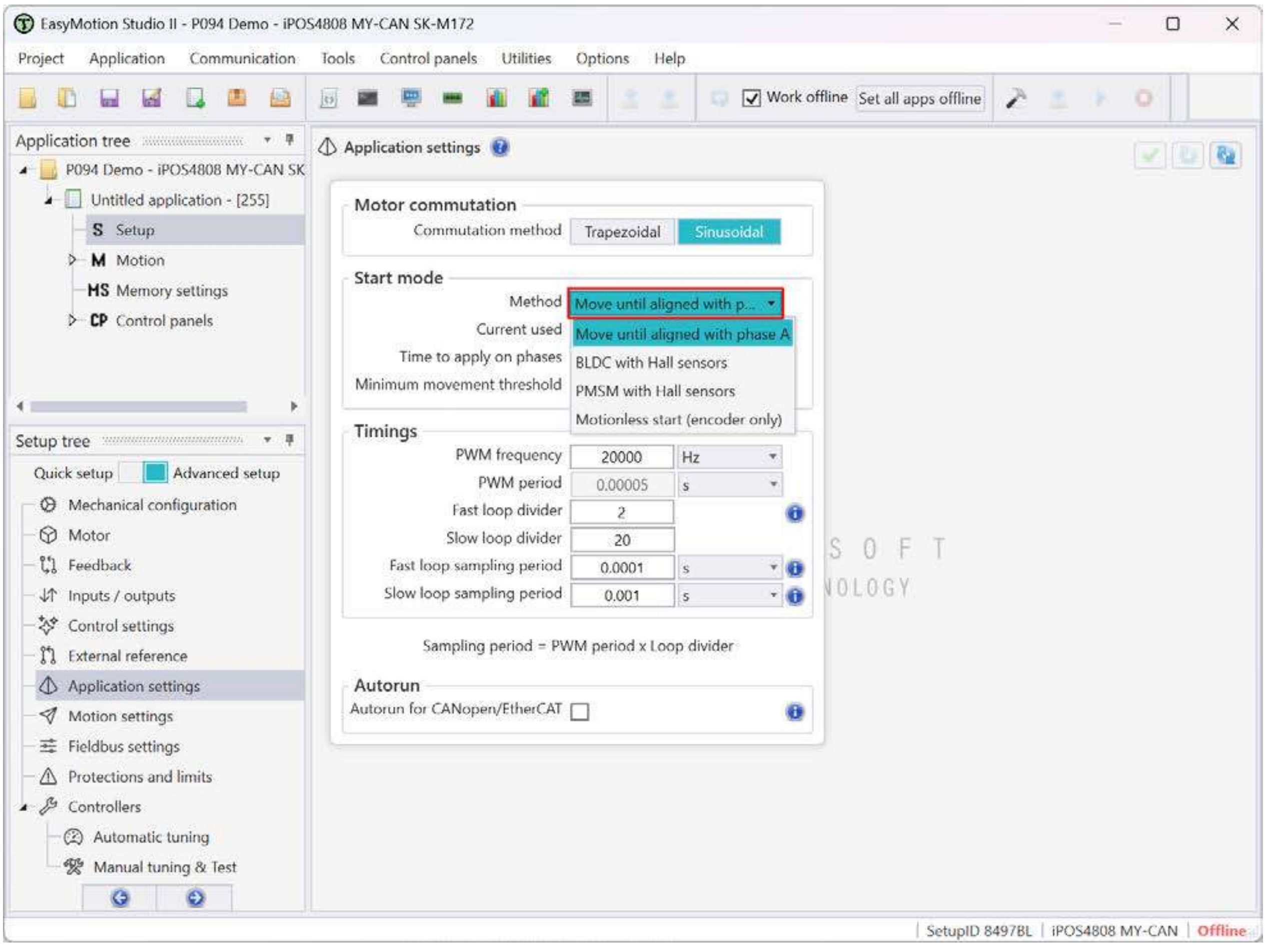

Figure 1 - Start mode selection

Depending on the system configuration (drive model, motor type and feedback sensors), the available start modes vary from one project to another. Below is a complete list of the available start modes.

1) Move until aligned with phase A;
2) BLDC (Brushless Direct Current) with Hall sensors;
3) PMSM (Permanent Magnet Synchronous Motor) with Hall sensors; {also referred to as BLAC}
4) Direct start, using the absolute position sensor;
5) Motionless start (encoder only).

The start mode selection will depend on the application requirements and system configuration. For example, in the case of a gravitational system (vertical axis) not equipped with an absolute position sensor, the recommended start modes are “BLDC / PMSM with Hall sensors” (if the motor is equipped with digital Hall sensors) or “Motionless start (encoder only).” The “Move until aligned with phase A” start method is not recommended because the load might be at a mechanical limit, preventing the motor from performing the necessary alignment movements.

2.1 Move until aligned with phase A start mode

This start method involves a small motor movement to align the magnetic field of the rotor with phase A of the motor. The motor is energized to align first with phase B, then with phase A, to avoid the situation where the initial electrical angle between the rotor's magnetic field and phase A of the motor is 180 degrees.

Remark: If the electrical angle between the rotor's magnetic field and phase A of the motor is 180 degrees, the rotor will not move when phase A is energized. This is because the force exerted on the rotor by stator phase A is split into two perfectly equal smaller forces, canceling each other out. To avoid this, phase B is energized first, followed by phase A. There are two scenarios:

When the “Move until aligned with phase A” start mode is selected, the related parameters will be displayed in the “Start mode” group box.

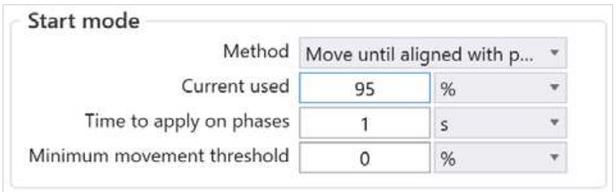

Figure 2 - Move until aligned with phase A stat mode parameters

This section allows setting the current used during the alignment procedure (as a percentage of the motor's nominal current, defined in the “Motor” setup branch) and the “time to apply on phase.”

The current value depends on the mechanical system's inertia. To avoid start method failure, the current value can be set to 90% or 100% of the motor's nominal current.

Remark: If the mechanical system has very high inertia, the alignment current can be set to 110% or 120% of the motor's nominal current.

The default time for phase alignment is set 1 s but it can be adjusted function on the load inertia. It’s important to wait until the load stops and stands still, without any oscillations.

Based on the encoder indication, the drive can automatically detect if the “Move until aligned with phase A” start mode was performed successfully or if it failed. The protection can be activated through the “Minimum movement threshold” field, by setting the threshold value to a value different than 0%.

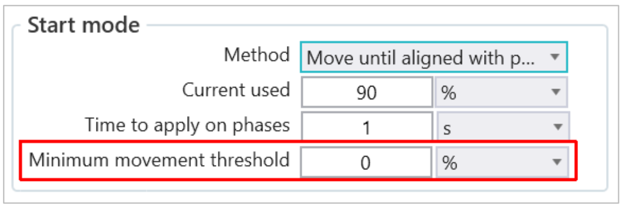

Figure 3 - Move until aligned with phase " start mode protection setting

The “Minimum movement threshold” value activates/deactivates the protection and sets its level.

Example: A threshold of 70% means the protection is active and set to 70% of the expected movement (70% of 120 electrical degrees).

The “Move until aligned with phase A” start mode can be used in any application with horizontal load, where the motor can move freely. It is not recommended for vertical loads or systems with hard mechanical limits, as the motor may not have enough space to move.

2.2 BLDC and PMSM with Hall sensors start modes

These start modes are available only for motors equipped with digital Hall sensors.

Compared to the “Move until aligned with phase A” start mode, the start methods based on digital Hall sensors have the advantage of not requiring initial motor movement. The command is adjusted based on the first read Hall combination.

When using the **BLDC with Hall sensors** start mode, the drive uses the trapezoidal commutation method and commutes to sinusoidal after the first Hall sensors transition is detected.

The **PMSM with Hall sensors** option starts the motor directly in the sinusoidal mode and adjusts the electrical angle after the first Hall sensors transition.

For this start modes to work correctly, it is mandatory to detect the Hall configuration during the setup phase through the “Feedback - Test” setup page.

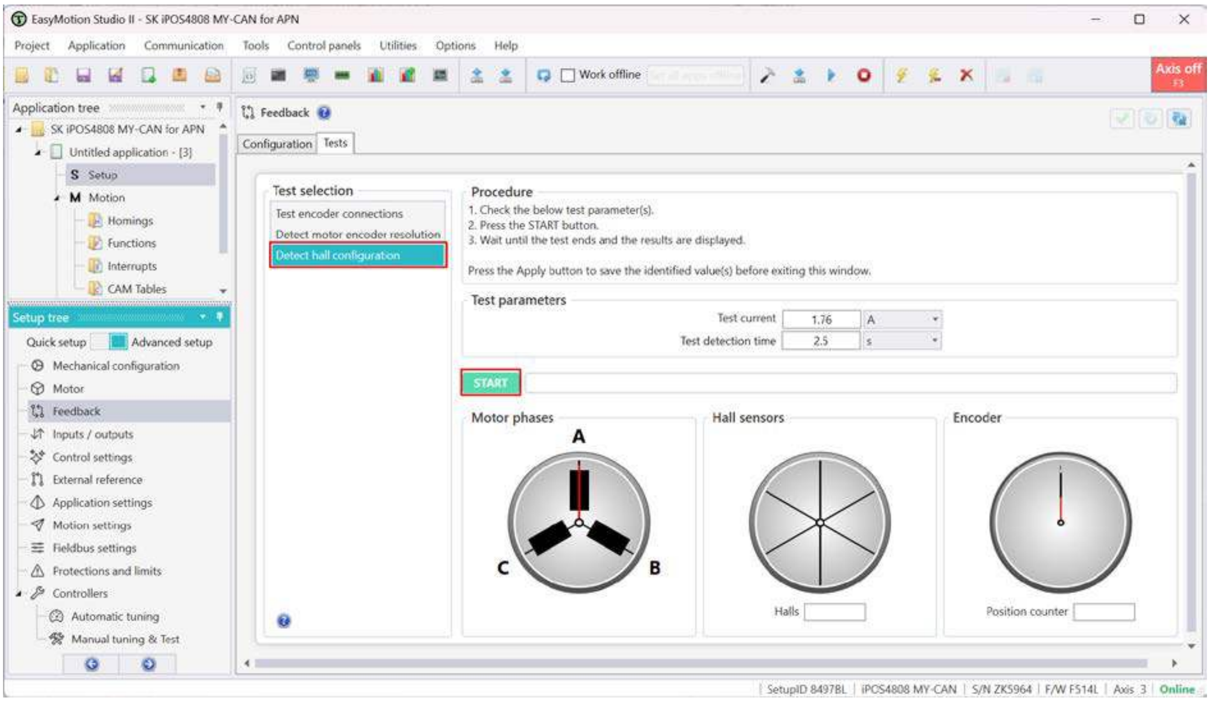

Figure 4 – Hall configuration detection test

During the test, the motor should be able to move freely as the Hall case is detected by reading the active Hall sensors while the motor is aligned with the “B” phase and then with “A” phase.

Since this is a hot test (power is delivered to the motor), the EasyMotion Studio II test wizard allows setting a test current and a detection time.

The default value for the “test current” is half of the motor's nominal current, which was previously declared in the “Motor” setup section. Depending on the load inertia, the test current can be increased to the motor's nominal current or even by 20% more if the load is heavy.

The default value for the “test time” is 2.5 seconds, but it can be adjusted based on the load inertia. As in the case of the “Move until aligned with phase A” start mode, it’s important to avoid load oscillations while the active Hall sensors configuration is read.

These start modes are recommended for applications where an uncontrolled movement of the motor is not allowed or where mechanical limits might be involved.

2.3 Direct start using the absolute position sensor method

When an absolute position sensor is present on the motor, the rotor position is always known, allowing the motor to be started directly. However, for this start mode to work correctly, it is crucial to first perform the encoder offset detection test.

This test is part of the “Feedback - Tests” setup page and must be performed only once, during the drive commissioning procedure. The procedure needs to be repeated only if the motor or the encoder is changed, or if the encoder is temporarily dismounted / realigned.

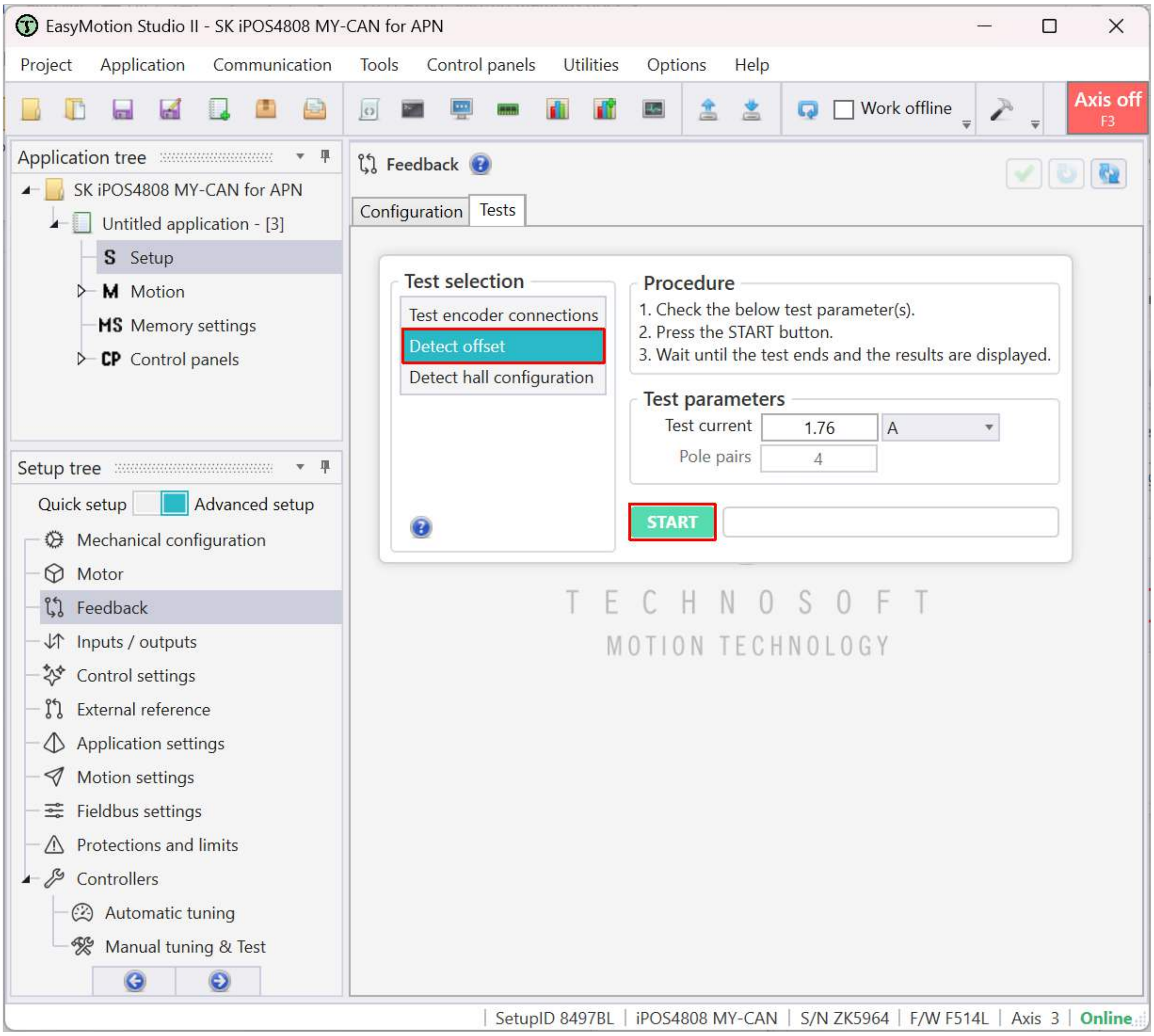

Figure 4 - Absolute position sensor offset detection test

During the encoder offset detection test, the drive performs a pole lock (align the rotor with the “A” phase) and reads the absolute sensor indication. This value will be used at startup to identify the offset between the rotor and the “A” phase and compute the initial electrical angle.

Since the motor is energized during this test, a “test current” is required. As with similar tests mentioned in the previous chapters, the default “test current” value is half of the declared motor nominal current, but it can be adjusted based on the load size.

The direct start mode, based on the absolute encode position indication, can be used in all situations, as it is independent of movement limitations or other mechanical constraints.

2.4 Motionless start (encoder only) method

In the absence of an absolute position sensor or digital Hall sensors, the motor must be aligned with a known reference position. This alignment is essential for optimal vector control, where the internal motor angle is maintained at 90 degrees to maximize torque generation while minimizing current consumption.

Typically, this alignment is performed using the "Move till aligned with phase A" startup mode. However, as previously explained, there are situations where this method cannot be used. To address this limitation, the "Motionless Start" method was developed.

For the initial alignment, the "Motionless start" method employs an angle controller that reverses the roles of the stator and rotor. Rather than physically moving the rotor to align it with the stator, the drive adjusts the electromagnetic field generated by the stator to "find" the rotor’s actual position. This requires only a small movement, in contrast to the larger movement of up to 240 electrical degrees required by the "Move till aligned with phase A" mode. In this case, the movement is limited to just a few electrical degrees.

To prevent unwanted rotor movement, the system uses feedback from the encoder. The angle controller reacts automatically to changes in rotor position. This angle controller is of the PI type and can be configured through the “Test” tab in the “Application settings” configuration dialog.

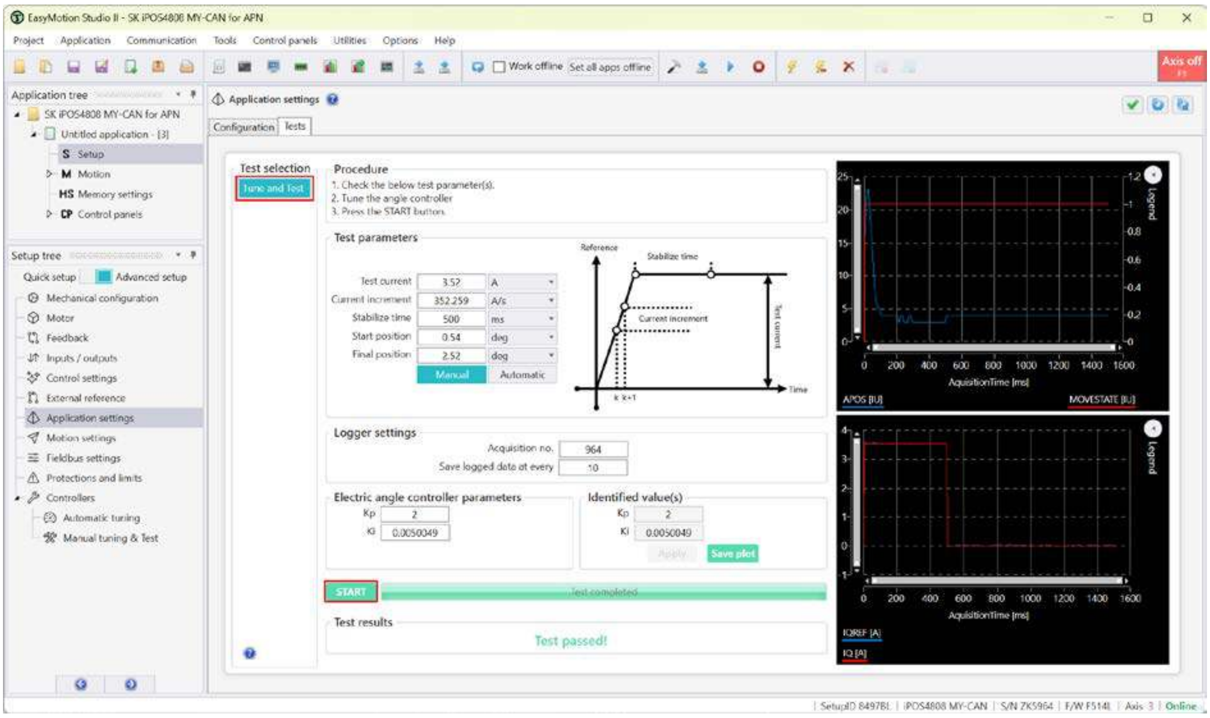

Figure 6 – Tune and test the angle controller

The test sets a current reference and, during runtime, captures and displays the motor current and movement. **Therefore, it is crucial to perform current controller tuning before configuring the "Motionless Start" mode**.

EasyMotion Studio II automatically sets the test parameters based on the motor's nominal parameters. However, the "Test Parameters" group box can be switched to "Manual" at any time to adjust the parameters according to system requirements.

The most important parameter is the “current reference”. When entering the dialogue, the program suggests a default value equal with the declared motor nominal current. If needed the value can be adjusted, keeping in mind that a higher current value reduces the error between the estimated and actual rotor positions, especially for high loads.

The “current increment” parameter sets the slope of the current reference. A higher value of this parameter reduces the time required to estimate the rotor initial position.

The “Stabilize time” parameter sets the time period for which the “test current” is maintained through the motor windings. A higher value set for the parameter will reduce the error between the estimated and the actual rotor position but it will increase the start time.

For the motionless start procedure validation, the algorithm uses the “start position” and the “final position” parameters as follows:

- “Start position” - represents the minimum motor displacement for which the motionless algorithm considers that the motor has moved. It’s also the position around which the motor should return at the end of the motionless start procedure.
- “Final position” – represents the accepted motor position tolerance. If the motionless start ends successfully, the motor position should be the 'Start Position' +/- a tolerance equal to the value set in the “Final position” field.

Once the parameters are set, the test can be started. based on the results, the electrical angle controller tuning parameters can be kept or manually adjusted through the “Kp” and “Ki” parameters as follows:

- Reset “Ki” and slowly increase the “Kp” parameter, until the position (APOS) value gets stabilized close to the “start position”.

- Slowly increase the “Ki” parameter, until the position (APOS) value does stabilize (is not oscillating) and the test passes.

If the test fails, it will return a message to help identify the cause and fix it.

- ***“Test failed! Current protection triggered during test”*** – check the current controller tuning parameters or decrease the “test current” used in the motionless start procedure test.

- ***“Test failed! Test current may not be enough - Please increase the current”***– increase the “test current”. It the test is still failing, check the current controller tuning.

- ***“Test failed!”*** - if the current doesn't decrease to zero, adjust the angle controller parameters.

- ***“Test failed!”*** - if the current decreases to zero, but the motor position (APOS) graph doesn't stabilize to a value close to “stat position” with a tolerance of +/- “final position” a fine angle controller tuning is required.

The motionless start mode can be used in any application, as it doesn’t imply visible motor movement and doesn’t depend on the mechanical limitations.