

The Application Note is pertinent to the Unidrive SP Family

A Guide to Tuning the Unidrive SP

Introduction:

The Unidrive SP provides a number of features that greatly assist the user in tuning the drive and motor for optimum performance. This application note will describe how these may be used in closed loop vector and servo modes. This procedure assumes that the feedback and motor map parameters have been correctly set up.

Drive Parameters:

The table below lists parameters relevant to the tuning of the drive, in numeric order. The drive main menu address is used with the equivalent menu 0 parameter where this exists.

Parameter	Brief Description
#3.10	Speed loop proportional gain.
#3.11	Speed loop integral gain.
#3.12	Speed loop derivative gain.
#3.17	Defines method used for the drive to calculate speed loop gains.
#3.18	Motor and load inertia in kg / m ²
#3.19	Compliance angle in motor shaft degrees.
#3.20	Velocity loop bandwidth in Hz
#3.21	Damping factor
#3.25	Encoder Phase angle. Electrical degrees.
#3.42	Drive encoder filter in ms
#4.12	Current Demand Filter 1
#4.13	Current loop proportional gain
#4.14	Current loop integral gain
#4.22	Inertia compensation enable
#5.12	Auto tune selector.
#5.17	Motor stator resistance in ohms
#5.24	Motor transient inductance
#5.25	Stator inductance (not used in servo mode)
#5.29	Motor saturation break point 1
#5.20	Motor saturation break point 2
#5.32	Motor torque constant in NM / A

Closed Loop Vector Tuning Procedures

Static Autotune (#5.12 =1)

1. First ensure that the following motor map parameters are correctly set in accordance with the Unidrive SP advanced user guide

Parameter	Description
#5.06	Motor rated frequency
#5.07	Motor rated current
#5.08	Rated load rpm
#5.09	Motor rated voltage
#5.11	Number of motor poles

2. The autotune procedures are made simpler if the drive is set up temporarily in keypad mode. This is achieved by setting parameter 1.14 to “Pad” or 4 from CT soft.

3. Select the static autotune by setting parameter #5.12 = 1.

4. Enable the drive by jumpering or closing a contact between terminals 22 and 31. The drive keypad display will show “ready”. A temporary switch or contact will be more convenient to use during the autotune procedures as the drive has to be disabled after each autotune procedure.

5. Press the green start key on the drive keypad. The drive display will show a flashing tune message until the static autotune is complete at which point it will drop back to “ready”. The static autotune will calculate and set the motor stator resistance (#5.17), the transient inductance (#5.24) and current loop proportional (#4.13) and integral (#4.14) gains. **It should be noted that this test will only work correctly when the motor stator resistance is less than 30 ohms.**

6. The calculated values are automatically saved into the drive EEPROM.

Rotating Autotune

1. Set parameter #5.12 to 2.

2. Enable the drive as described in paragraph 4 of the previous section.

3. Press the green start key to perform the rotating autotune. The motor will accelerate at the rate defined in parameter #2.11 until it reaches 2/3 of rated speed. This speed will be held for up to 36 seconds. This test calculates and sets new values for stator inductance (#5.25) and motor saturation breakpoints (#5.29 and #5.30).

4. These parameters are automatically saved to the drive EEPROM.

Inertia Measurement Test

Please note that this test should be performed with the motor coupled to the load. It can only be used with constant inertia loads that are free to rotate with no electrical or mechanical travel limits.

1. Set parameter #5.12 to 3.
2. Enable the drive.
3. Press the green start key to perform the autotune. The drive will attempt to accelerate the motor and load up to $\frac{3}{4}$ rated speed and back to zero. Multiple attempts may be made starting with current limit set to produce 1/16 of rated torque for the first attempt and stepping up to a maximum of rated torque if required. A maximum of 5 attempts is allowed with the first 4 using a 5 second accel time and the last using a 60 second accel time. If the test is unsuccessful a **tune1** trip will occur. Unless the application is intended to use very long acceleration times a tune1 trip suggests that the motor may be too small for the application. On successful completion of the test the motor and load inertia is calculated and automatically stored in parameter #3.18.
4. This test assumes a motor efficiency of 0.9 and the inertia value will not be accurate if the actual efficiency differs much from this. The test also compensates for any effect other than the acceleration and deceleration torque required (such as windage losses and friction)

Automatic Setting Of The Drive Speed Loop Gains

The drive can be set to use the results of the preceding autotunes to optimize the speed loop P (#3.10) and I (#3.11) gains. There are two alternative methods provided to accomplish this by setting either the desired bandwidth (#3.20) or the compliance angle (#3.19). This document only describes the use of compliance angle to set the speed loop gains.

Method:

1. Set a starting value for the compliance angle in parameter #3.19
The compliance angle is defined as the angular distance in degrees, the motor shaft could be moved when an external torque equal to motor rated torque is applied with the drive enabled. The actual angle required for optimum tune will depend on the motor and load characteristics as well as the resolution of the feedback device and will be determined by trial and error. A good starting point for a typical vector motor fitted with a 1024 PPR encoder is **30 degrees**.
2. Set parameter #3.17 to 2 and the drive will calculate and set parameters #3.10 and #3.11.
3. Enable the drive and ensure that the motor is stable (if not reduce the value of #3.19).
4. Reset #3.17 to 0 after the autotune completes. Leaving #3.17=2 may create instability, as the drive will continuously adjust #3.10 and #3.11 while the motor is running. If there is an audible noise when the run command is closed, changing #4.12 (Digital filtering the current loop) to a value between 2.0ms and 5.0ms should eliminate this audible sound without degrading the tuning of the drive to motor.
5. Run the motor through its speed range and check stability. Parameter #3.19 may need to be adjusted to achieve stable running. Best tune will be with the compliance angle as high as possible commensurate with stable running.

Servo Mode Tuning Procedures

In order to run a permanent magnet servo motor the drive needs to know the absolute position of the motor shaft within one revolution. This requires one of the following feedback devices:

1. An incremental encoder with additional absolute commutation tracks (phases U, V and W).
2. An SSI or Sin Cos absolute encoder.
3. A resolver (requires an SM resolver option module fitted to the drive).

For the drive to be able to commutate correctly it needs to know the angular relationship between the feedback device and the motor shaft. The Unidrive SP is able to measure and store this relationship as an offset in electrical degrees so that on power up it is immediately able to commutate the motor correctly. There are a number (= number of motor pole pairs) of valid positions for this offset for any given motor.

Parameter #5.12 is used to perform the measurement of this “phase offset” and to carry out autotuning routines similar to those used in vector mode.

Phase offset measurement method:

Note this test can only be performed with the motor mechanically uncoupled from any load.

1. Put the drive in keypad mode by setting parameter #1.14 to “pad” or 4 from CTSofT.
2. Set parameter #5.12 to 1.
3. Enable the drive by jumpering or closing a contact between terminals 22 and 31. A temporary switch or contact will be more convenient than a jumper as the drive has to be disabled after each autotune procedure.
4. Press the green start key.
5. The motor will rotate 720 electrical degrees in the forward direction (normally clockwise viewed from the shaft end).
6. If successful a new value will be set in parameter #3.25.
7. With drive software version 1.05 and later the new value must be manually saved by setting any menu parameter 0 to a value of 1000 and then pressing the red reset key on the drive. Earlier software versions will automatically save the parameter.

Failure of the test will result in trip codes for the reasons tabulated below.

Trip Code	Reason	Remedy
TunE2	Feedback direction incorrect	Swap A and B phases of encoder or any two motor power phases if forward direction is to be reversed.
TunE3	Commutation phases incorrect	Swap U and V encoder phase connections. All 4 wires need to be swapped.
TunE4	U commutation signal fail	Check wiring or replace encoder.
TunE5	V commutation signal fail	Check wiring or replace encoder
TunE6	W commutation signal fail	Check wiring or replace encoder
TunE7	Motor pole setting incorrect.	Check and correct #5.11 *
TunE	Test ended prematurely	Do not disable or stop drive until complete

* If the number of motor poles is not known the following test can be used to ascertain the correct value.

1. Connect a DC voltmeter between any two motor phase wires (with the motor disconnected from the drive).
2. Rotate the motor shaft by hand through one revolution while counting the number of polarity swings displayed by the meter.
3. The number of swings is equal to the number of pole pairs. (3 for a six pole motor)

Phase Offset And Current Loop Gain Setting

The procedure is exactly the same as that in the previous section except that parameter #5.12 should be set to 2.

This test will measure and set the transient inductance (#5.24) as well as the phase offset (#5.25). Finally it will calculate and set the current loop P (#4.13) and I (#4.14) gains.

The parameters will have to be manually saved as described above if the software is 1.05 or later.

Possible trips and remedies are the same as described in the previous section.

This test can usually be performed with the motor coupled to the load, but take care that sufficient space exists before any mechanical or electrical limit is hit.

Inertia Measurement Of Motor And Load

This is basically the same as that described in the vector mode description above except that the motor torque constant in NM / A must be manually entered into parameter #5.32. It should also be noted that if this test is not possible due to motion being restricted by mechanical stops or electrical limits the inertia should have been calculated during application sizing. It can then be manually entered in parameter #3.18. Please ensure that the value entered is in kg cm².

Automatic Setting Of Speed Loop Gains

The procedure is exactly as described for vector mode except that the starting values for compliance angle will be smaller. Typical examples are:

- 10 degrees for servo with 4096 PPR encoder (Unimotor).
- 15 to 20 degrees for servo with 2048 encoder (EZ, Magna and NT motors)
- 4 degrees for a motor with high resolution sin cos encoder.

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