

**ACCeI500 AC DRIVES
OPEN/CLOSED LOOP MOTOR TUNING**

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ACCe1500 AC DRIVES
OPEN/CLOSED LOOP MOTOR TUNING

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ACCe1500 AC DRIVES OPEN/CLOSED LOOP MOTOR TUNING

SECTION I

OPEN LOOP VECTOR CONTROL OPERATIONS

These instructions are intended to improve the performance of open loop motor control. The aim of tuning is to find the proper settings to get the motor model as good as possible. As a result, the torque control accuracy and the motor operation will be improved.

1-1 FREQUENCY CONTROLLED APPLICATION

For frequency-controlled applications (typically pump and fans), there is usually no need for high torque on low speed. It's usually enough when U/f – curve is set and voltage drop at the stator resistance is measured.

1-2 SPEED CONTROLLED APPLICATION

For speed-controlled applications, high torque on low speed is usually needed. It's often necessary to complete all the tuning steps: U/f-curve, stator resistance, torque boost and speed control.

SECTION II

U/f CURVE TUNING

When tuning the U/f-curve manually (not using identification run) the motor shaft must not be connected to a load and the motor control mode must be frequency control (P2.6.1).

2-1 PARAMETERS

The open loop U/f curve tuning parameters are:

- U/f ratio selection P2.6.3
- Field weakening point P2.6.4
- Voltage at field weakening point P2.6.5
- U/f curve midpoint frequency P2.6.6
- U/f curve midpoint voltage P2.6.7
- Output voltage at zero frequency P2.6.8

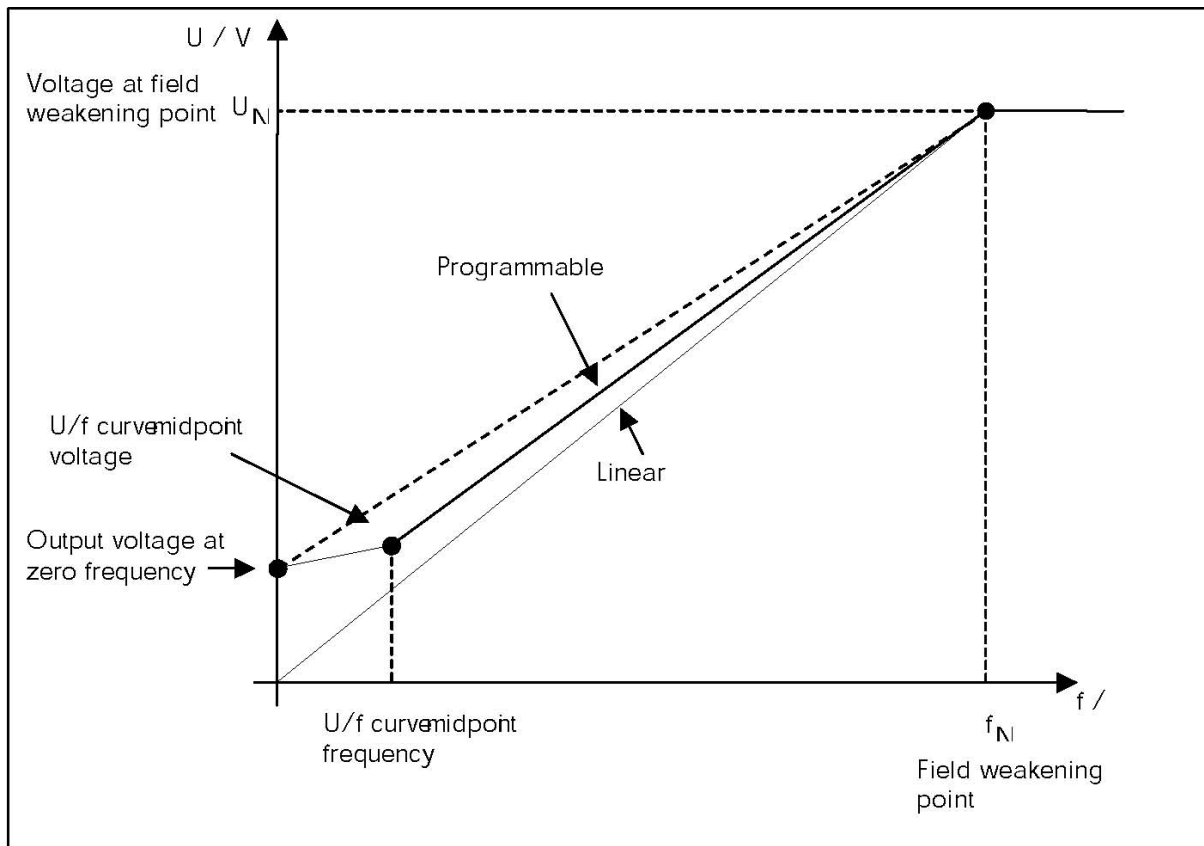


Figure 2-1. Open Loop U/f-Curve Tuning Parameters

When using the linear U/f curve with increased zero frequency voltage, be sure that motor current does not increase too much between 3 to 7 Hz.

2-2 TUNING STEPS

1. Set the motor nameplate values.
 - Nominal voltage of motor P2.1.6
 - Nominal frequency of motor P2.1.7
 - Nominal speed of motor P2.1.8
 - Nominal current of motor P2.1.9
 - Motor cos phi P2.1.9
2. Run the motor using frequency reference $2/3 * f_N$. Read the motor current from the monitoring menu (V1.4) or use NCDriver for monitoring. This current is the motor magnetizing current.
3. Change the U/f- curve ratio selection to programmable-mode = 2 (P2.6.3).
4. Run motor with zero frequency reference and increase motor zero point voltage (P2.6.8) until motor current is approximately same than motor magnetizing current. (If motor is only short periods on low frequency area, it is possible to use up to 80% of I_n).
5. Set then the midpoint voltage (P2.6.7) to $1.4142 * P2.6.8$ ($\sqrt{2} * \text{Zero Point Voltage}$) and midpoint frequency (P2.6.6) to value $P2.6.8/100\% * P2.1.7$.
 ((ZeroPoint Voltage/100%) * Nominal frequency of motor)

$$P2.6.7 = \sqrt{2} * P2.6.8$$

$$P2.6.6 = \frac{P2.6.8}{100} * P2.1.7$$

Hint for the ADDapt ACC User:

When the zero point voltage is set correctly, run the motor with slow ramp (~20 s) to $1/2$ of f_n . Select output frequency and motor current to the ADDapt_ACC monitoring window. If the midpoints parameters are set correctly, motor current should be stable during acceleration. (Refer to Figure 2-2: red line).

If there is a peak in the monitored motor current (such as yellow line in Figure 2-2), check the output frequency on the max/min current point, and assign this value to midpoint frequency (P2.6.6). Then adjust midpoint voltage so that the current behavior is near ideal.

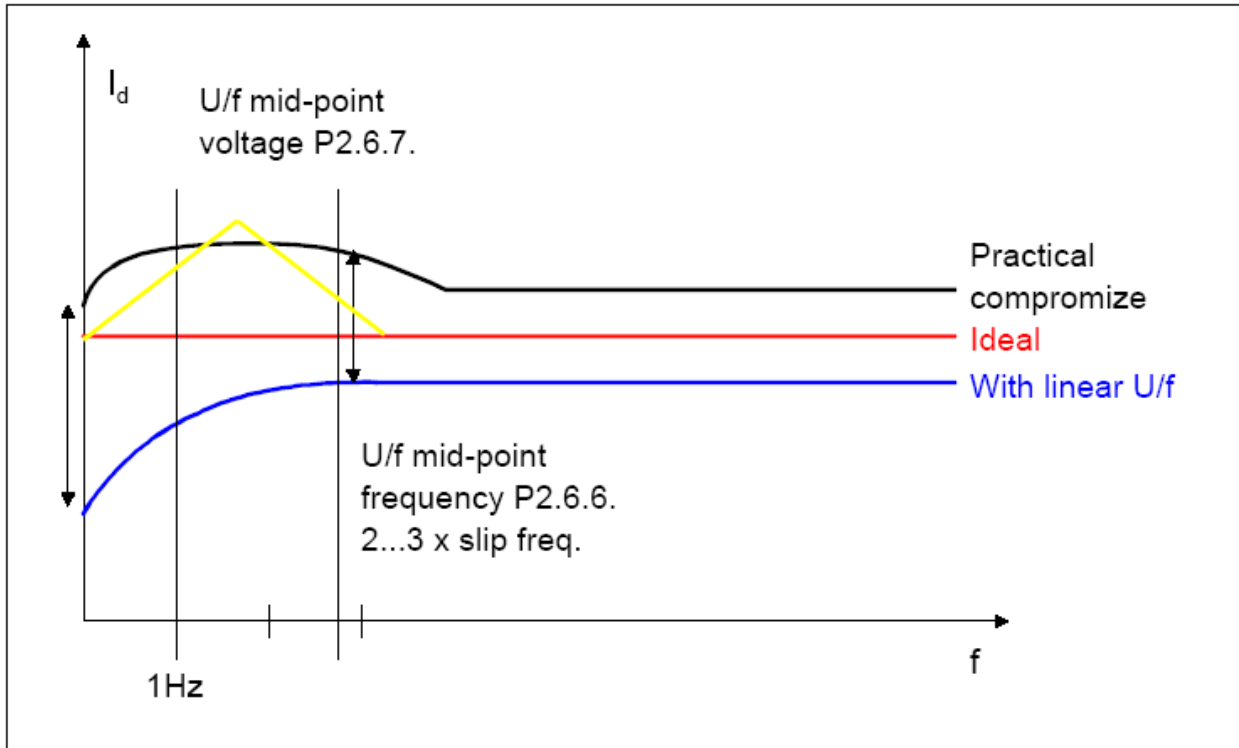


Figure 2-2. Motor Current after U/f-Curve Tuning

6. Make the stator impedance initialization using DC-brake at start:
 - Define the DC brake current (= motor nominal current) (P2.4.8).
 - Set the DC brake time at start to 2 seconds (P2.4.11).
 - Give the start command

Now the drive will make the corrections to the stator impedance, and the motor torque calculation will be better this also improves slip compensation accuracy. (Stator resistance voltage loss compensation, see Figure 2-3.)

- Change the dc brake time at start at zero. Notice that the calculated stator impedance value goes back to the default if the frequency converter's power is switched off. (Stator impedance can also be a parameter → special application.)

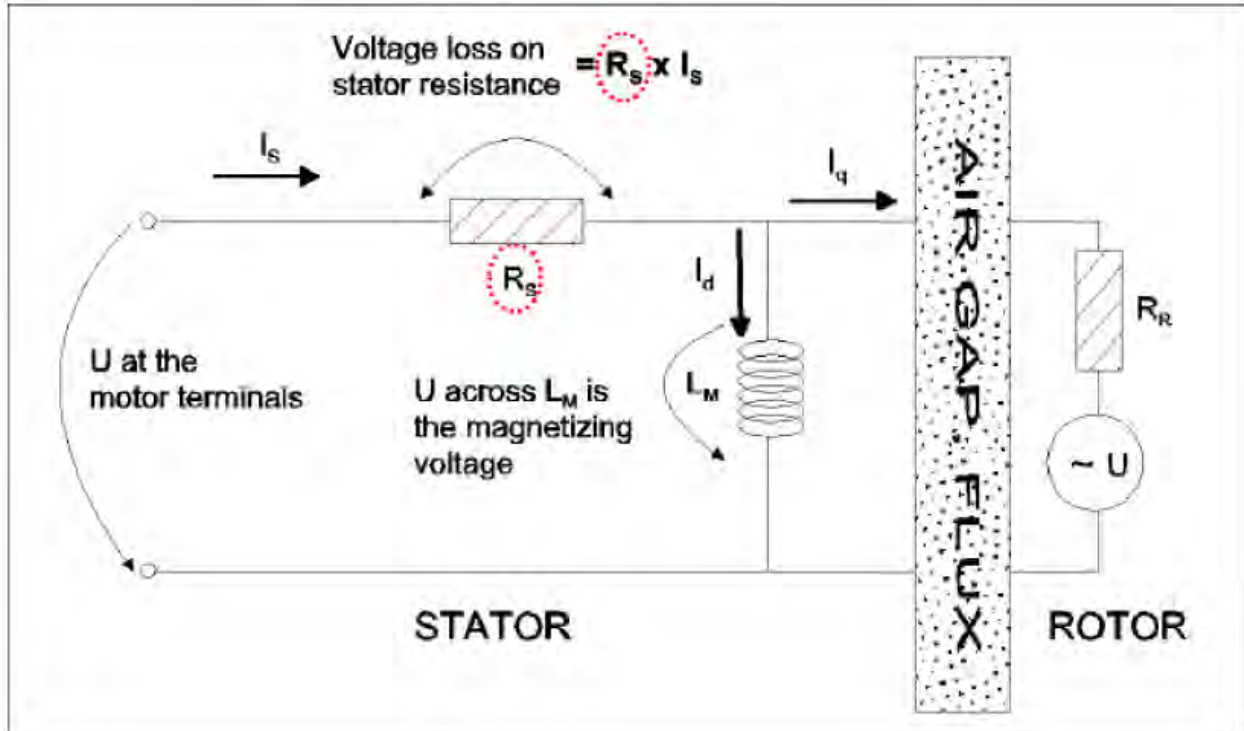


Figure 2-3. Motor Equivalent Circuit

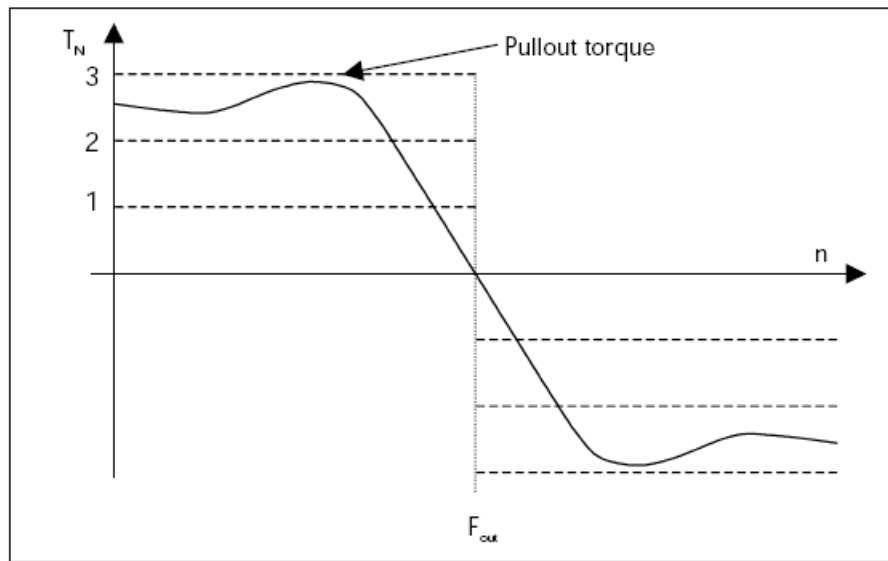
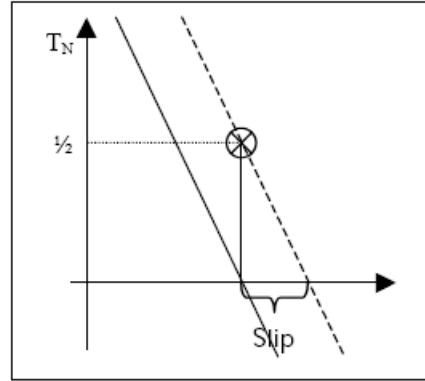
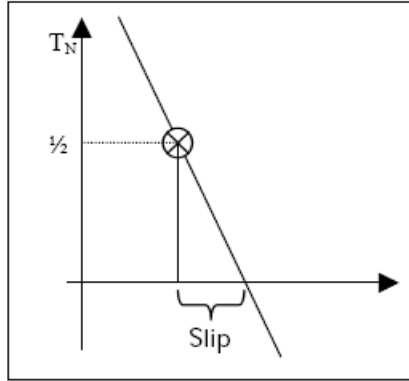
7. Change the motor control mode to the speed control (P2.6.1 = 1)
8. Change the U/f-optimization to ON if more torque is needed on low frequencies (P2.6.2). Note that this will increase motor voltage on load; check motor current behavior.

In high torque, low speed applications, it is likely that the motor will overheat. If the motor has to run a prolonged time under these conditions, special attention must be paid to cooling the motor.

2-3 SLIP COMPENSATION IN OPEN LOOP

The drive uses motor torque and motor nominal rpm to compensate slip. If motor nominal rpm 1410, nominal slip is 90 rpm. And when motor torque is 50%, slip is 45 rpm. To keep reference speed drive must increase output frequency by:

$$\frac{50\% * 90 \text{ rpm}}{1500 \text{ rpm}} * 50.00 \text{ Hz} = 1.5 \text{ Hz}$$



Motor torque behavior when frequency is constant.

SECTION III

CLOSED LOOP VECTOR CONTROL OPERATIONS

Select the Closed loop control mode by setting value 3 or 4 for parameter 2.6.1. Closed loop control mode is used when enhanced performance near zero speed and better static speed accuracy with higher speeds are needed. Closed loop control mode is based on "rotor flux oriented current vector control". With this controlling principle, the phase currents are divided into a torque producing current portion and a magnetizing current portion. Thus, the squirrel cage induction machine can be controlled in a fashion of a separately excited DC motor.

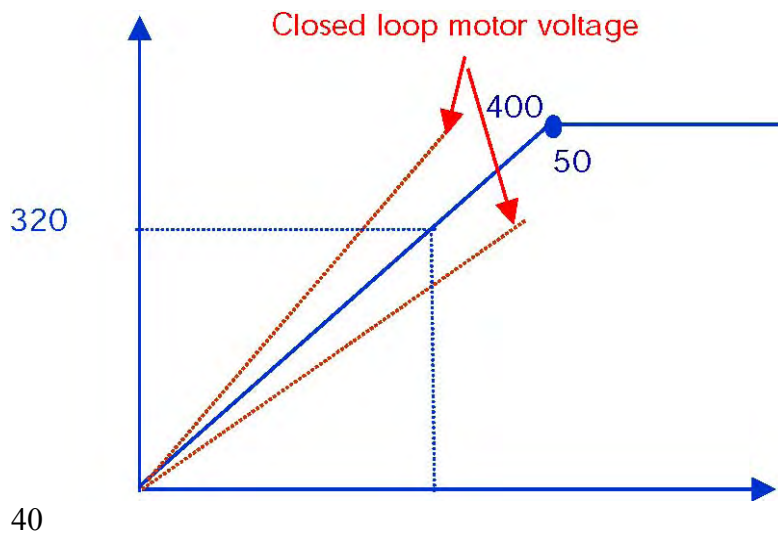
3-1 TUNING STEPS

1. Set the motor nameplate values.
 - Nominal voltage of motor P2.1.6
 - Nominal frequency of motor P2.1.7
 - Nominal speed of motor P2.1.8
 - Nominal current of motor P2.1.9
 - Motor cos phi P2.1.9
2. Check encoder Pulse/Revolution rate and set this value to expander menu P7.3.1.1. Parameter is visible only if OPTA4 or OPTA5 is installed to slot C.
3. Set motor control mode to open loop frequency control (P2.6.1=0)
4. Run the motor without load using frequency reference $2/3 * f_N$. Read the motor current from the monitoring menu (V1.4) or use ADDapt_ACC for monitoring. This current is the motor magnetizing current.
5. Check from the expander board menu (monitoring page V7.3.2.1) that the encoder frequency is approximate same than the output frequency. Check also that the direction is correct.
 - If the encoder frequency is opposite direction than the output frequency, change encoder connection or motor phase order.
6. Set motor control mode to closed loop (P2.6.1=3 or 4).
7. Set the motor magnetizing current P2.6.15.1. (measured in step 4)

If further adjustment is necessary, read section 3.2 "FINE TUNING."

3-2 FINE TUNING

1. Tuning parameter P2.6.15.6 (Slip Adjust) to get the voltage slightly above (when motor is loaded) the linear U/f-curve with the motor frequency at about 2/3 of the motor nominal frequency (If motor is generating, then slightly below):
 - Run the motor in frequency control mode (P2.6.1=0) and see motor voltage (V1.7) using linear U/f-curve (P2.6.3=0).
 - At 35Hz, voltage should be $35/50 * 400V = 280V$
 - Run motor now in closed loop control mode with the same reference as in open loop. Check the motor voltage.
 - Adjust P2.6.15.6 (Slip Adjust) so that motor voltage is slightly above the linear U/f-curve.
 - If motor voltage is low, decrease the value of Slip Adjust (P2.6.15.6).



3.2.1 FINE TUNING PARAMETERS

2.6.15.2 Speed control P gain

Sets the gain for the speed controller in % per Hz. 100 means nominal torque with 1 Hz frequency error.

2.6.15.3 Speed control I time

Sets the integral time constant for the speed controller. A too short integration time makes the control unstable. Integral part gain is obtained from the ratio Speed Control Kp / Speed Control Ti.

2.6.15.4 Load drooping

The load drooping may be enabled by setting a proper value to the LoadDrooping. This function enables the speed to decrease as the load torque increases. At rapid load changes this gives a smoother torque response when a part of the required power is taken from the system inertia. This operation causes a constant, torque-dependent steady-state error in speed response.

2.6.15.5 Acceleration compensation

Sets the inertia compensation to improve speed response during acceleration and deceleration. The time is defined as acceleration time to nominal speed with nominal torque. This parameter is active also in advanced open loop mode.

2.6.15.7 Magnetizing current at start

2.6.15.8 Magnetizing time at start

These parameters are certain type of DC Brake in start. With these parameter, it is possible to shorten the time when motor is fully magnetized. This parameter is needed especially when motor is large.

2.6.15.9 Zero speed time at start

After giving the start command the drive will remain at zero speed for the time defined by this parameter. The ramp will be released to follow the set frequency/speed reference after this time has elapsed from the instant, where the command is given.

2.6.15.10 Zero speed time at stop

The drive will remain at zero speed with controllers active for the time defined by this parameter after reaching the zero speed when a stop command is given. This parameter has no effect, if the selected stop function (P 2.4.7) is coasting.

2.6.15.11 Startup torque

Choose here the start-up torque. Torque Memory is used in crane applications. Start-up Torque FWD/REV can be used in other applications to help the speed controller.

- 0 = Not Used
- 1 = TorqMemory
- 2 = Torque Ref
- 3 = Torq.Fwd/Rev

2.6.15.12 Start-up torque, forward

Sets the start-up torque for forward direction, if selected with par. 2.6.15.11.

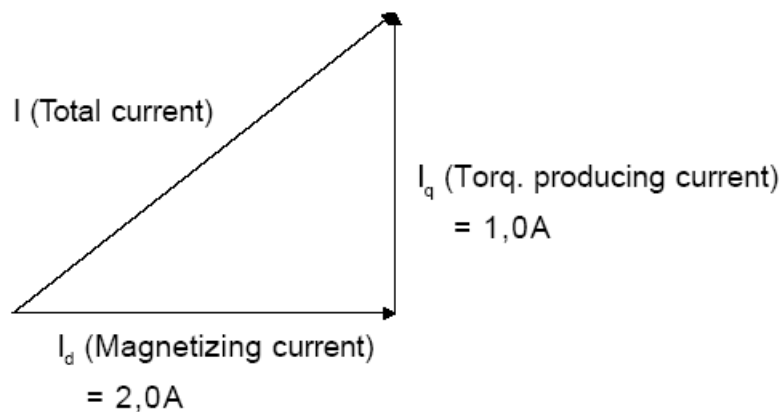
2.6.15.13 Start-up torque, reverse

Sets the start-up torque for reverse direction, if selected with par. 2.6.15.11.

2.1.5 CURRENT LIMIT

This parameter determines the maximum motor current from the frequency converter. The parameter value range differs from size to size. On closed loop control mode this limits torque (=torque producing current).

For example, if motor magnetizing current is 2.0 A and current limit is 1.0 A, total motor current can be:



$$I^2 = I_d^2 + I_q^2$$

$$I = \sqrt{I_d^2 + I_q^2} \quad \longrightarrow \quad I = 2,24A$$