Starting guide
FRENIC Lift

Specific guide to set up asynchronous motor in open loop control mode

3 ph 400 V 4.0 kW – 22 kW

SG_Lift_OpenLoop_EN_0.1.0

Version	Changes applied	Date	Written	Checked	Approved
0.0.1	Draft	02.02.2009	J.Alonso	J. Català	D. Bedford
0.0.2	Draft 2. Chapter 4 is added. Chapter 5 is added. Figures 3.2, 3.3 and 6.1 are modified. Figure 3.4 is added. Some small text corrections Inverters software version is added in chapter 0	12.03.2009	J.Alonso	J. Català	
0.1.0	Text corrections. Units of P09 and P10 corrected. Keypad reference corrected.	03.04.2009	J.Alonso	J. Català	D.Bedford

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0. About this manual

Thank you very much for choosing FRENIC-Lift inverter.

FRENIC-Lift series inverters are specially designed for operation of induction (asynchronous) and permanent magnet synchronous motors used in lift applications. Also induction motors without encoder (open loop) can be controlled obtaining good performance and high positioning accuracy at stop.

This manual tries to explain clearly how to adjust a lift driven by an open loop induction motor. Most important parameters and functions are described.

For additional information, or general information of FRENIC-Lift, please refer to the following documents:

- FRENIC-Lift Starting guide
- FRENIC-Lift Reference Manual
- FRENIC-Lift Instruction Manual

Note This starting guide is based on 1230 and 1231 software version. For other software versions, please contact with Fuji Electric technical department.

1. Motor parameters

In this chapter most important motor data are described. This motor data must be set on the inverter properly in order to perform a correct torque vector control and auto tuning. With the correct torque vector control and auto tuning we will be able to get the best performance from the motor in terms of comfort and landing accuracy (stop position not dependant on the load).

The minimum information that we need from motor plate is the following:

PARAMETER	NAME	REMARKS
P01	Number of motor poles	
P02	Motor capacity	In kW
P03	Motor rated current	In A
F03	Maximum speed	Rated speed of the motor (in rpm)
F04	Rated speed	Base speed/frequency of the motor (units depends on C21)
F05	Rated voltage	Rated voltage of the motor (in V)

⚠CAUTION
Parameters must be set in this order. Otherwise some values could change automatically.

In some motors this information is not given directly, here you have some helpful information:

- **F03 (Maximum speed of the motor)**

  The unit of this parameter is always rpm. This information is always given in the motor name plate.

- **F04 (Base speed of the motor)**

  The units of this parameter depends on the value of parameter C21 (0: rpm, 1: m/min, 2: Hz). You can get base speed of the motor from the followings formulas depending on the case.

  When C21=0

$$F04 = \frac{120 \cdot F_{base}}{P}$$

When C21=1

$$F04 = \frac{L31}{F03} \cdot \frac{120 \cdot F_{base}}{P}$$

When C21=2

$$F04 = F_{base}$$

Where:

F_{base}= Base frequency of the motor (from nameplate) in Hz
P= Number of motor poles
L31= Lift rated speed in m/min

- **P02 (Motor capacity)**

  This parameter must be set in kW. If motor plate does not have this information in kW you can use the following formulas in order to obtain the correct value for the inverter:

  kW = 0,745 · HP
  kW = 0,735 · CV

2. Auto tuning procedure

It is recommended to perform auto tuning procedure before turning the motor. With this procedure we can get important information from the motor. There are two different methods of auto tuning and, depending on which one we choose, we can get different motor information:

PARAMETER	NAME	AUTO TUNING mode 1 P04=1	AUTO TUNING mode 2 P04=2
P06	Motor no-load current (A)		X
P07	Motor %R1	X	X
P08	Motor %X	X	X
P12	Motor slip compensation (Hz)		X

The goal of both auto tuning methods is that both are static. This means that the motor will not turn during auto tuning; therefore there is no need to remove the load from the motor (the motor brake remains closed). It is highly recommended to perform auto tuning mode 2 (P04=2), because with this method we can get more information about the motor.

In order to perform an auto tuning please follow the following procedure:

- Set motor parameters (refer to chapter 1).
- Enable inverter (activate EN control input).
- Set P04=2.
- Push button FUNC/DATA on the inverter keypad (TP-G1-ELS).
- Give run command to the inverter.
  If the inverter is in LOCAL mode by means of buttons FWD REV. If the inverter is in REMOTE mode by means of controller signals (In case of REMOTE mode, controller must keep the signals FWD or REV until the auto tuning has finished).

After that, the inverter will close the main contactors (in case that the inverter has the control) and we will hear some noise coming from the motor. If auto tuning 1 is performed the tuning procedure will take around 15 seconds (we can hear 3 times a noise coming from the motor); if auto tuning 2 is performed the tuning procedure will take around 25 seconds (we can hear 5 times a noise coming from the motor). After that, auto tuning is finished.

In case that inverter trips with error *Er7* please check motor parameters and auto tuning procedure, if error persists, change from auto tuning 2 to 1.

3. Setting up of slip compensation gains

The rated slip function (P12, in Hz) defines the value of the slip frequency of the motor. It is the key function for good slip compensation by the inverter. This means that this function is very important in open loop control of induction motors especially for a good landing accuracy; it will ensure that the rotating frequency of the motor is the same regardless of the load condition of the motor.

The value of slip measured by the inverter during auto tuning 2 is correct.

In some installations, due the behavior of the motor or the mechanical installation, is possible that we have to adjust the value of slip in braking mode (motor braking the load) or in driving mode (motor driving the load). It is easy to see because the cabin (the lift) stopping position (in the same floor) is different depending on the load conditions of the lift. For this purpose the inverter has the following parameters:

- P09: Slip compensation driving gain (%)
- P10: Slip compensation braking gain (%)

The best way to know when the inverter is working in driving or braking mode is to check torque generated by the inverter. This is possible to check in the menu 3.OPERATION MONITOR in the 2^{nd} screen, as is shown in figure 3.1.
When TRQ (percentage) applied is positive, the inverter is driving the motor load, when TRQ applied is negative the inverter is braking the motor load.

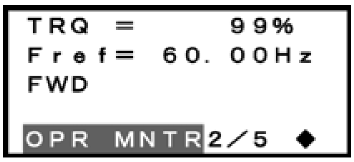

Figure 3.1 Reference torque in inverters keypad (TP-G1-ELS)

Theoretically the torque generated by the motor should be as is shown in the diagram of figure 3.2. The torque is generated depending on the motor load and the direction of the cabin.

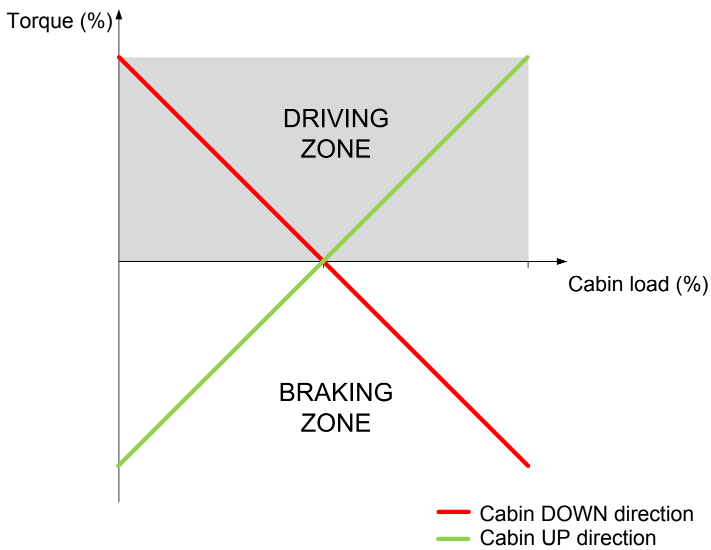

Figure 3.2 Theoretical torque generated by the motor.

Because a lot of times the lift is not perfectly balanced, and the mechanical system or the motor (due to gearbox and shaft efficiency) has some losses the real diagram is the one shown in figure 3.3.

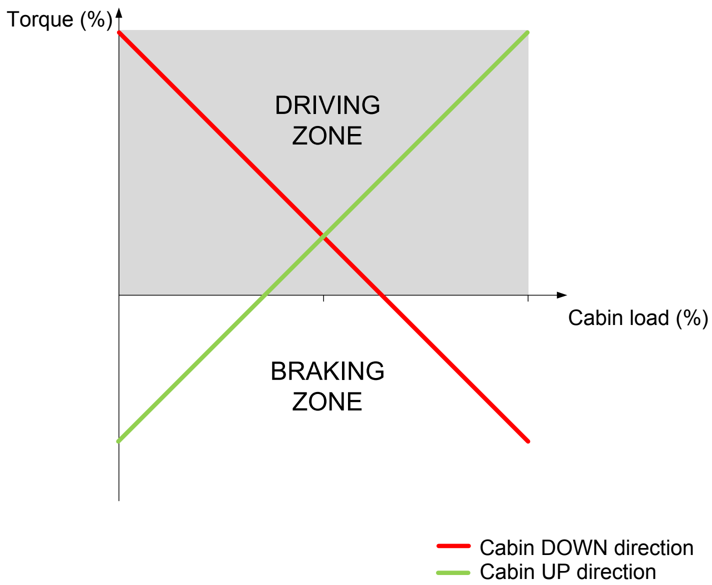

Figure 3.3 Torque generated by the motor in a real lift

In the case that the torque never achieves big negative values (not less than 10%) there is no need to set up the braking gain (P10), because there is no real braking condition. In this case it is only important to set driving gain (P09).

Frequency applied by the inverter is dependant of the slip and the torque. Where $F_{out}1$ is Reference speed (final). The formula that relates these values is following:

$$F_{out}2=F_{out}1+P12\cdot TRQ$$

We propose 2 methods in order to set up slip compensation gains. In both cases, please check before balance condition (refer to Chapter 4) and the mechanical efficiency of the lift.

3.1 Method 1

For this method a half load of the cabin is needed. When we have half load inside the cabin we should have a balanced condition, in this case the slip influences should be almost zero.

Choose one floor and wait out of the cabin. Call the lift to come (with cabin empty) to the floor where you are waiting in down direction (from an upper floor) and check stopping position. Measure the distance that the lift has stopped from the floor.

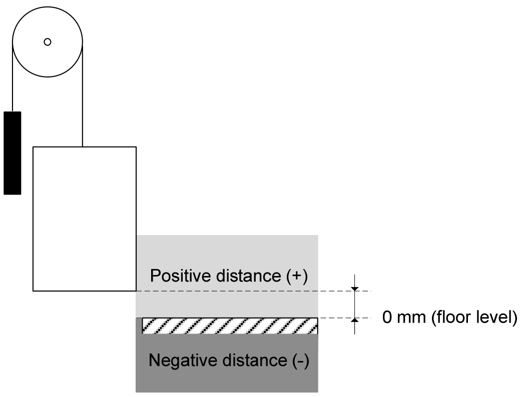

Figure 3.4 Cabin positioning at floor level

If the cabin is above the level, the distance is positive (ex. +4mm); if the cabin is below the level, the distance is negative (ex. -13mm); check the same stopping level but with half load inside the cabin. Doing so, we are checking the slip in driving condition.

- If the cabin landing position is higher without load than with half load it means that the slip is not enough. We need to give more slip when the cabin is empty (with more slip the lift will go faster without load in driving condition); in this case increase P09 (slip compensation driving gain) by 10%.

- If the cabin landing position is higher with half load than without load it means that the slip is too much. We need to give less slip when the cabin is empty (with less slip the lift will go slower without load in driving condition); in this case decrease P09 (slip compensation driving gain) by 10%.

- If the cabin landing position is the same with half load and without load, there is no need to set up slip compensation driving gains. Slip frequency is correctly adjusted in driving condition.

Repeat the test calling the lift to come to the floor where you are waiting in up direction (from a lower floor) and check stopping condition in both cases, cabin empty and half load. With this test we will check the slip in braking condition.

- If the cabin landing position is higher without load than with half load it means that the slip is not enough. We need to give more slip when the cabin is empty (with more slip the lift will go slower without load in braking condition); in this case increase P10 (slip compensation braking gain) by 10%.

- If the cabin landing position is higher with half load than without load it means that the slip is too much. We need to give less slip when the cabin is empty (with less slip the lift will go faster without load in braking condition); in this case decrease P10 (slip compensation braking gain) by 10%.

- If the stop distance is the same with half load and without load, there is no need to set up slip compensation braking gains. Slip frequency is correctly adjusted in braking condition.

The aim of this test is to achieve the same stopping position in both cases, cabin with half load (no slip influences) and empty (maximum slip influences). If we can achieve repeatability of stopping, no dependant of the cabin load, we only have to reduce (or increase) inverter ramps or move lift magnets (or flags, etc.) in order to stop at floor level.

3.2 Method 2

For this method a tachometer is needed. At slow speed the slip compensation is more critical in torque vector control. For that reason we recommend to measure the speed of the motor at very slow speed, because we can observe better the effect of the slip compensation. For this test we can move the lift in inspection mode at very slow speed (lower than the speed used normally in inspection mode).

We have to move the lift in maintenance mode with empty cabin in UP direction and in DOWN direction. For a 4 Hz of maintenance speed, speed measured in the motor shaft by means of a tachometer, has to be 120 rpm. If the measured speed is not the expected we should proceed as is explained below:

- If speed measured in DOWN direction is smaller than 120rpm, slip is not enough; in that case increase P09 (slip compensation driving gain) by 10%.
- If speed measured in DOWN direction is higher than 120rpm, slip is too much; in that case decrease P09 (slip compensation driving gain) by 10%.
- If speed measured in UP direction is smaller than 120rpm, slip is too much; in that case decrease P10 (slip compensation braking gain) by 10%.
- If speed measured in UP direction is higher than 120rpm, slip is not enough; in that case increase P10 (slip compensation braking gain) by 10%.

The aim of this test is to reduce the differences between theoretical speed (120 rpm) and measured speed. After that we can check the stopping position with different loads. If we achieve repeatability of stopping, no dependant of the cabin load, we only have to reduce (or increase) inverter ramps or move lift magnets (or flags, etc.) in order to stop at floor level.

3.3 Additional settings

The motor no-load current (parameter P06) defines the value of the current of the motor when no load is applied to the motor (magnetizing current). No-load current range normally is from 30 % of motor rated current (P03) up to 70 % of P03. In the majority of the cases the value measured by the auto tuning will be correct (when using P04=2). In few cases, no-load current value measured by auto tuning is not enough. If the no-load current is not enough, a repeatable stop (not dependant on the load condition) will not be achieved. In this later case the value of P06 must be set manually. To calculate no-load current you can use the formula

$$\mathrm{P06} = \sqrt{(\mathrm{P03})^2 - \left(\frac{\mathrm{P02} \cdot 1000}{1.47 \cdot \mathrm{F05}}\right)^2}$$

Too low values of P06 will make that the motor does not have enough torque. Too high values will make that the motor vibrates (the vibration in the motor may be transmitted to the cabin).

4. How to check if the lift is well balanced

To achieve a good performance a well balanced lift is needed. The formula that gives us the load of the counterweight is the following (for a lift balanced with half load):

$$Counterweight(kg) = Cabin_{weight}(kg) + \frac{Cabin_{load}(kg)}{2}$$

Normally we don’t have a mechanical data, so an empiric way to check if the lift is balanced is:

- To put half load inside the cabin
- To move the lift around the half of the shaft
- To check I_{out} in inverters keypad (Menu 3. DRIVE MONITORING in the 1st screen) going up and down, for example moving the lift in maintenance speed.

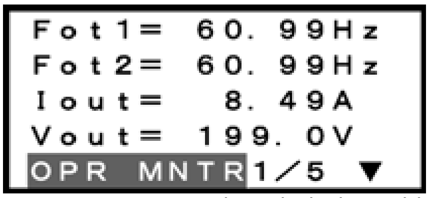

Figure 4.1 Inverter output current shown in the keypad (TP-G1-ELS)

If the lift is correctly balanced (correct counterweigh for lift weight) current must be approximately same moving cabin in up and down direction. The motor needs same current to move the load in up and down directions. If the current is not the same we can have two situations:

- I_{out} UP DIRECTION < I_{out} DOWN DIRECTION

Motor needs more current to move the counterweight than the cabin. It means that the counterweight is too heavy. Remove some weight from the counterweight and test again.

- I_{out} UP DIRECTION > I_{out} DOWN DIRECTION

Motor needs more current to move the cabin than the counterweight. It means that the cabin is too heavy. Add some weight to the counterweight and test again.

5. Recommended inverters setting

It is not easy to recommend a complete inverter setting because a lot of parameters depend on the installation, motor and lift controller. In the following table we try to summarize minimum parameters which have to be set on the inverter in order to obtain quickly a good behavior.

PARAMETER	NAME	VALUE
C21	Speed command units	2: Hz
P01	Number of motor poles	Motor name plate (poles)
P02	Motor capacity	Motor name plate (kW)
P03	Motor rated current	Motor name plate (A)
P06	Motor no-load current	Measured by Auto tuning mode 2
P07	Motor %R1	Measured by Auto tuning modes 1 and 2
P08	Motor %X	Measured by Auto tuning modes 1 and 2
P12	Rated slip	Measured by Auto tuning mode 2
F03	Maximum speed	Motor name plate (rpm)
F04	Rated speed	Motor name plate (Hz)
F05	Rated voltage	Motor name plate (V)
F20	DC braking starting speed	0.20 Hz
F21	DC braking level	50 %
F22	DC braking time	1.00 s
F23	Starting speed	0.50 Hz
F24	Starting speed holding time	0.50 s
F25	Stop speed	0.20 Hz
F42	Control mode	2: Torque vector control for induction motors
L83	Brake control OFF delay time	0.00 s (in case that inverter control the brake)

For speed, ramps and S-curves parameters, please refer to FRENIC-Lift starting guide; the parameters values depend on the controller signals and the lift installation. Normally the inverter default setting for ramps and S-curve are correct values. To achieve a stopping non dependant on the load a short ramp from creep speed to stop is advisable.

6. Quick guide to solve problems

This chapter is made in order to give some clues to solve typical problems when setting up an Open Loop induction motor lift with FRENIC-Lift inverter.

The typical problems have been divided in three different zones: starting, travel and stopping.

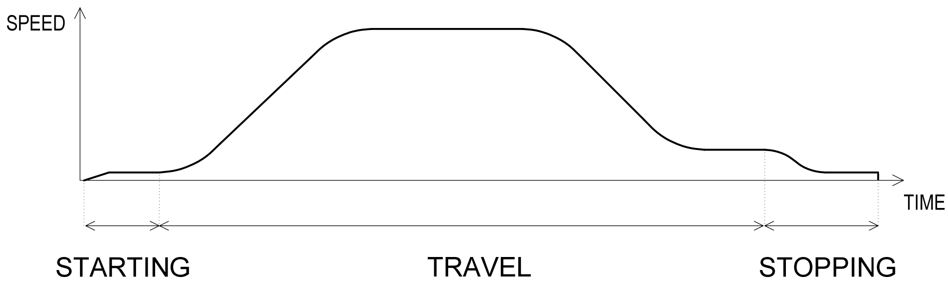

Figure 6.1 Lift typical profile

6.1 Problems at starting

	Cause	Action
Rollback	Due to insufficient starting frequency	Increase **F23** *Max. F23=1.0 Hz*
	Due to early brake opening	Increase **L82** *Max. L82=F24-0.2 s*
	Due to insufficient torque	Increase **P06** *P06=30~70% of P03*
Hit at starting	Due to high value of starting frequency	Reduce **F23** *Min. F23=0.1 Hz*
	Due to late brake opening	Reduce **L82** *Min. F23=0.20 s*
	Due to late brake opening	Increase **F24** *Max. F24=1.5 s*
	Due to high torque	Reduce **P06** *P06=30~70% of P03*
	Not due to inverters parameterization	Check brake operation Check guides Check cabin fixation

6.2 Problems during travel

	Cause	Action
Vibrations	Due to high torque	Decrease **P06** *P06=30~70% of P03*
	Due to motor high speed	Reduce High speed *Use motor rated speed instead of motor synchronous speed*
	Not due to inverters parameterization	Check guides Check cabin fixation Check motor connection (Δ or 人) Check motor gear
Undershoot from high speed to creep speed	Due to slip frequency too high	Reduce **P12** *Min. P12=0.5 Hz*
	Due to fast deceleration	Increase deceleration ramp from High speed to creep speed *Max. **E10-E16, F07-F08**=2.00 s* Increase 2nd S-curve at deceleration *Max. **L19-L28, H57-H60**=50 %* *(NOTE: Control that you always keep creep speed)*
	Due to insufficient torque	Increase **P06** *P06=30~70% of P03*

6.3 Problems at stopping

	Cause	Action
Hit at stopping	Due to early brake closing	Increase **L83** *Max. L83=F22-0.2 s* Check **F25=** 0.2Hz
	Due to heavy DC current injection	Reduce **F21** *Min. F21=50%*
	Due to fast deceleration	Increase deceleration ramp between creep speed and stop *The maximum value depends on the lift magnets*
	Not due to inverters parameterization	Check security chain Check brake operation
Rollback	Due to late brake closing	Reduce **L83** *Min. L83= 0.1s* Check **F25=**0.2 Hz
	Due to soft DC current injection	Increase **F21** *Max. F21= 90%* Check F22≠0.00s
	Due to insufficient torque	Increase **P06** *P06= 30~70% of P03*
	Not due to inverters parameterization	Check security chain Check brake operation
Leveling accuracy (positioning dependent on the load)	Due to insufficient torque	Refer to chapter “3.3 Additional setting”
	Due to incorrect slip compensation gains adjustment	Refer to chapter “3.Slip compensation gains adjustment”

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