TELEMECANIQUE MOTOR CONTROLLER

Use and Instructions

Bachelor's thesis

Degree Program in Automation Engineering

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Yaw Adjei

ABSTRACT

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ABSTRACT

Electric motors are versatile electrical machines used in the industry and in many domestic appliances. They convert electrical energy into mechanical (rotational) energy. Following the advent of Induction motors, which are simple, rugged, reliable, low cost and highly efficient, they need no extra starting motor or brushes, much of the modern day motor controllers are geared induction motors.

Telemecanique Motors Controllers Te Sys LUCM1XBL and Te Sys LUCBX6BL are Direct On-Line (DOL) motor starters which could be used to:

- give protection and control to 3-phase motors;
    - breaking function,
    - overload and short-circuit protection,
    - thermal overload protection and power switching.

LUCM1XBL can also be used for single-phase motors and offers the following added advantage:

- control the application;
    - protection function alarms,
    - application monitoring (running time, number of faults, motor current values, ...),
    - logs (last 5 faults saved, together with motor parameter values).

This project seeks to provide electrical connection diagrams for the motor controller and instruction manual so that people with only the basic knowledge in electrical could safely connect, program/set and use the controllers thus, offering the possibility for the controllers to be used for student laboratory works. With this information, users could decide with which abnormal condition(s) the controller should give a warning signal and when to turn/switch the motor off.

Keywords Motor control, protection and monitoring.

Pages 28 p. + appendices 7 p.

CONTENTS

1 INTRODUCTION

This project was made at HAMK AutoMaint Lab, that is owned and run by Hämeen Ammattikorkeakoulu (HAMK University of Applied Sciences). In this project, the uses of Telemecanique motor controllers Te Sys LUCM1XBL and Te Sys LUCBX6BL were explained and the instructions for its use provided.

The monitoring and controlling of three (3) phase induction motors has become the priority of most motor control designers and manufacturers with induction motors becoming the most used motors in the industry due to their comparable advantages. Hence, the controlling and monitoring of three (3) phase induction motors has become an indispensable objective in most industries.

This project seeks to provide connection diagrams, user's manuals for the Telemecanique Controllers Te Sys LUCM1XBL and Te Sys LUCBX6BL.

I wish to thank HAMK AutoMaint Unit for giving me this opportunity to undertake this thesis project as well as the whole HAMK institution. My profound gratitude also goes to Osmo Leiniäinen, my project supervisor and Hannu Pohjasto for their immense contribution and support.

2 MOTORS

Electrical Motors are generally referred to as electrical machines in that, well designed electric motors at times operate as generators. Rotating electrical machines could be used as a motor or a generator.

There are basically, AC and DC electric motors, based on the type of operating power supply. In AC motors, there are single phase (1-φ) and three phase (3- φ) motors. AC motors are usually either synchronous or asynchronous (induction) motors. The induction machine has gained popularity in the market due to its simple construction, durability, robustness, high efficiency and ease of starting.

Motors vibrate mechanically when in use. Motors are also used to drive different systems such as conveyors, pumps, fans and so on, hence motors need to be securely fixed to a place, usually referred to as mounting, to ensure good mechanical performance during use. Motor mounting may be implemented as foot or flange mount or as both.

Structurally, motors are usually semi-enclosed or at times totally enclosed. Semi-enclosed motors usually have fans fitted at the non-drive end (N-end) to cool the motor during operation. For totally enclosed motors, air-water cooling with an interchangeable cassette cooler method is employed. Exploded view of an induction machine is shown in figure 1

Motors need to be kept at the correct degree of protection to ensure long lifetime when operated under heavy duty conditions in severe environments. Two letters IP (International Protection) state the degree of protection. The first IP letter indicates the degree of protection against contact and penetration of solid objects whilst the second digit states the motor's degree of protection against water.

The ends of a motor, as illustrated in figure 1, are as defined in the International Electrotechnical Committee (IEC) Standard as follows:

- The D-end, which is the drive end of the motor.
- The N-end, which is the non-drive end of the motor.

Figure 1 Exploded view of an induction machine

2.1 Squirrel cage motor

The Squirrel cage motor is the focus here because of its de-facto market dominance. The squirrel cage motor consists of a stationary stator and rotating rotor. The stator is firmly fixed into the motor casing known as the yoke or core. The stator is made of laminated iron plates to reduce eddy current effects from ac operation. The stator has axial grooves known as slots to accommodate the stator windings needed in the creation of a magnetic field for operation. Power supplied to the motor is connected to the stator.

The rotor of a squirrel cage motor is comprised of a cylindrical laminated core with parallel slots for carrying the rotor conductors (which are heavy bars of copper, aluminium, or alloys). The rotor bars are electrically connected by brazing, welding or bolting to two (2) heavy short- circuiting end-rings, which create permanently short-circuited rotor bars, hence the name 'squirrel cage'.

Three-phase induction motors are self starting due to the presence of rotating magnetic field created by the three-phase supply which are out of phase. In single phase motors some form of starting is required. Common mechanisms of starting are through the use of starting winding or a capacitor. In using winding for starting, the main stator winding and the starting windings are made to be electrically out-of-phase leading to the creation of torque on the rotor. Capacitor start methods create an out-of-phase field with the stator winding's field leading to the creation of torque. In most situations, the starting mechanism is removed when the motor gains speed. Figures 2 and 3 shows the current-speed and torque-characteristics of an induction motor. (Thereja & Theraja 2007, 1244–1246.)

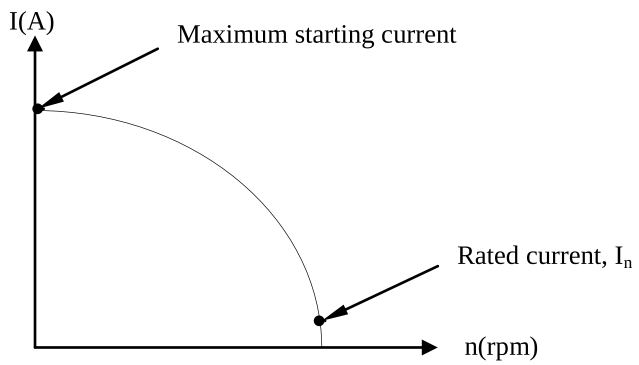


Figure 2 Current-speed characteristics of an induction motor

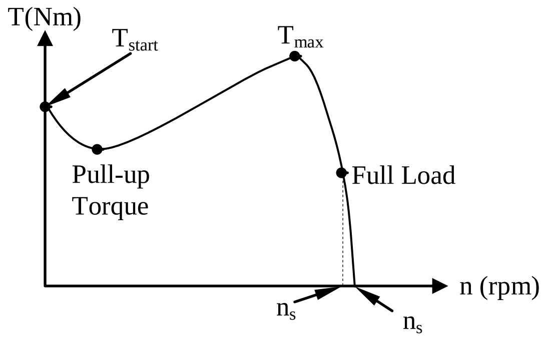


Figure 3 Torque-speed characteristics of an induction motor

2.1.1 Voltage

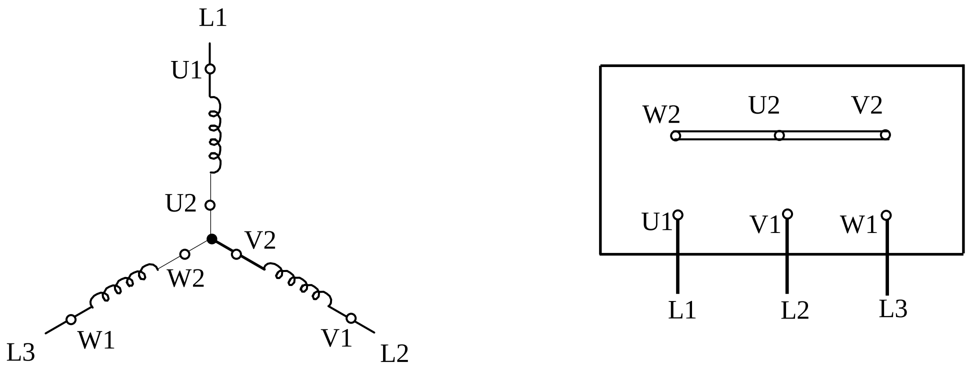
Single phase induction motors can normally be connected to one (stated) voltage level, which depends on the market manufactured for. In most European countries, the normal single phase voltage supply is 230V.

Three phase motors (with a fixed number of poles) can normally be operated from two (2) different levels, depending on the connection of the stator windings. The stator windings are either connected in star (Y) or delta (D).

In star connection, all the ends of the three (3) stator windings are connected at a common (star) point, with the coil starts (the other end) connected to the supply lines. In such a situation, the voltage across each coil (between a line and the star point) is $^{1}/\sqrt{3}$ of the supply line voltage. So if the line voltage is 415V, the phase voltage is 230V.

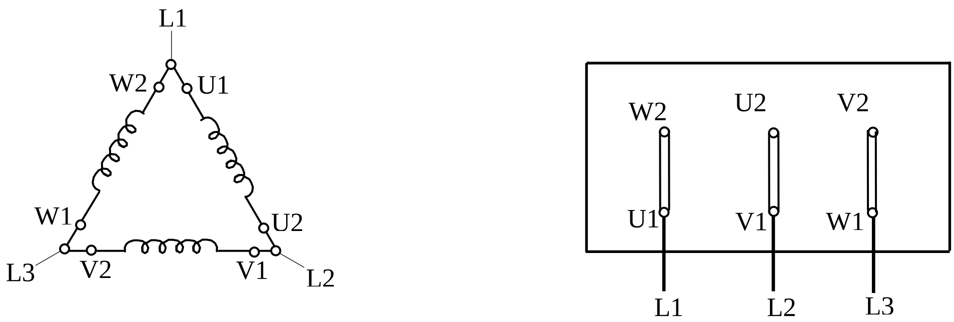
In delta connection, the end (or the finish) of the first coil is connected to the start of the second coil, the second coil's end is connected to the start of the third coil and the end of the third coil is connected to the start of the first coil. Thus, a loop is formed.

In delta connected motor, the electrical power input (and mechanical output power) is three (3) times that of a star connected motor.
Circuit symbols and terminal block connections on a motor for star and delta connections are shown in figures 4 and 5. (ABB. Softstarter Handbook, 2010,7.)



a. Circuit diagram b. Motor terminal block

Figure 4 Star (Y) connection circuit diagram and on motor terminal block



a. Circuit diagram b. Motor Terminal block

Figure 5 Delta (Δ) connection circuit diagram and on motor terminal block

2.1.2 Power Factor (p.f.)

AC devices make use of three (3) forms of power – active (P), reactive (Q) and apparent power (S). The active power is the one consumed by the motor and which it converts to mechanical power (action). The reactive power is needed for the magnetization of the motor (field). The phasor representation of various powers is as shown below in Figure 6.

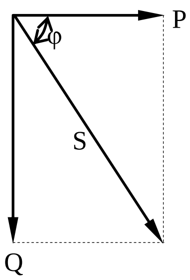


Figure 6 Power triangle

The various powers are given by;

$$S = VI = (IZ)I = I^2Z \text{ volts} - \text{amperes (VA)} \quad (1)$$

$$P = I^2R = VIcos\varphi \text{ watts(W)} \quad (2)$$

$$Q = I^2 \text{XL} = I^2 Z \sin\varphi = I(IZ)\sin\varphi$$
$$= VI \sin\varphi \ \text{ volt} - \text{amperes reactive (VAR)} \qquad (3)$$

where,
I is the circuit current
X_L is the circuit's inductive reactance
R is the circuit's resistance
Z is the circuit's total impedance.

The ratio of the active power (W) to the reactive (VA) is known as the power factor (p.f.). The power factor is also the cosine of the angle (φ) the current lags or leads the voltage. The power factor is usually between 0.7 and 0.9 for running motors. Usually large motors have large power factors and small motors have lower p.f. values. (ABB. Softstarter Handbook, 2010, 8; Thereja & Theraja 2007, 510–511.)

2.1.3 Speed

The synchronous speed of AC motor is determined by the number of poles of the stator windings and the frequency of the supply. The synchronous speed, n_s is given by;

$$n_s = \frac{120f}{p} \qquad (4)$$

where,
f is the supply frequency
p is the number of poles.
Example
For a 4-pole motor running on a 50Hz supply, the synchronous speed is

$$n_s = \frac{120 \times 50}{4} = 1500 \text{ rpm}$$

In practice, the rotor speed of an induction motor will never reach the synchronous speed. The motor's speed is very close to the synchronous speed when not loaded but drops when the motor is loaded. Figure 7 shows the variations in speed of a motor with different loads.

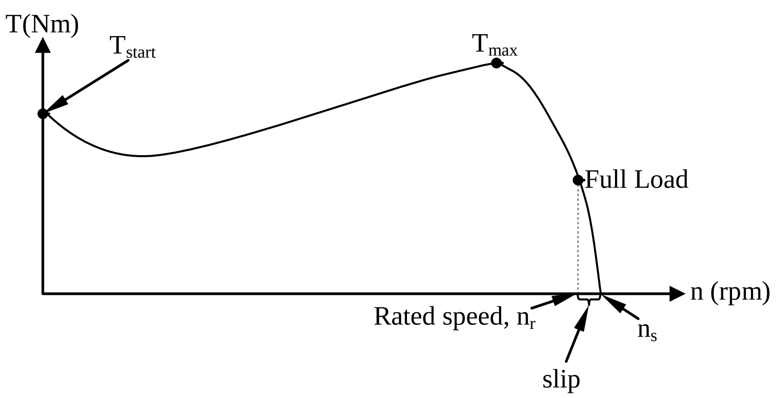


Figure 7 Induction motor torque-speed characteristics (slip shown)

The difference between the synchronous speed (n_s) and the rotor speed (n_r), expressed a percentage of the synchronous speed is known as the slip (s). The slip is usually between 1 and 3%.

$$\text{Slip, } s = \frac{n_s - n_r}{n_s} \quad (5)$$

(ABB. Softstarter Handbook, 2010, 6; Thereja & Theraja 2007, 1254—1256.)

2.1.4 Torque

The torque developed by a three phase (3-φ) induction motor depends on the speed (refer to figure 7). The starting torque of an induction motor is usually about 1.5 times the rated torque. The maximum torque that could be developed an induction motor is about 2.5 times the rated torque. Motors with powers less than 30kW could have high maximum torque, up to about 3 times the rated torque. The maximum torque usually occurs at a rotor speed of about 80% of the synchronous speed.

The rated torque M_r of a motor could be calculated using the following formula;

$$M_r = \frac{9.55 \text{ x } P_{out}}{n_r} \quad (6)$$

M_r is the rated torque (Nm)
P_{out} is the rated motor output (W)
n_r is the rated speed of the motor (rpm)
(ABB. Softstarter Handbook, 2010, 9; Thereja & Theraja 2007, 1280—1281.)

2.2 Starting Methods

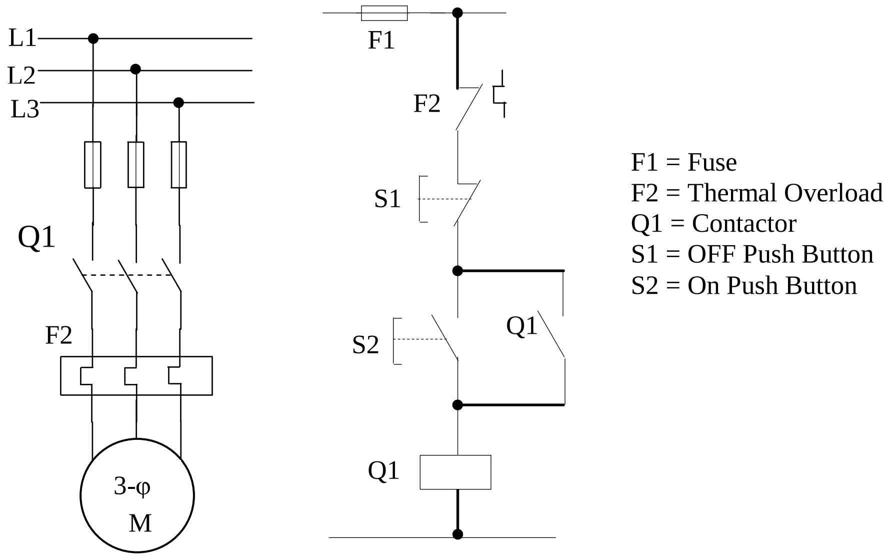
The most common starting methods are;

i. Direct-on-line
ii. Star-delta
iii. Frequency converter
iv. Soft starter

2.2.1 Direct-on-line (D.O.L.)

This happens to be the most common and simple starting method. This starting method employs the use of a main contactor and a thermal or electronic overload relay. In this method, the motor is connected in star or delta throughout its use. The starting current of this method is the short circuit current and is higher, about seven (7) times the rated motor current. With the motor not being energised at the first instant of starting, there exists also a current peak that can rise to about fourteen (14) times the motor's rated current. Generally, smaller motors tend to have higher values of starting currents when used on D.O.L. starting. This is a major setback with this starting method.

Direct-on-line starting generally has higher torque, which is usually more than the necessary torque for most applications. This high torque leads to the creation of high stress on the couplings and the driven applications. Interestingly, there are situations in which this starting method works perfectly which make it the ideal starting method comparatively.
Figures 8 and 9 shows the circuit diagrams and picture of direct-on-line starter.



a. Power diagram b. Control diagram

Figure 8 Direct-on-line starting; a. Power diagram and b. Control diagram

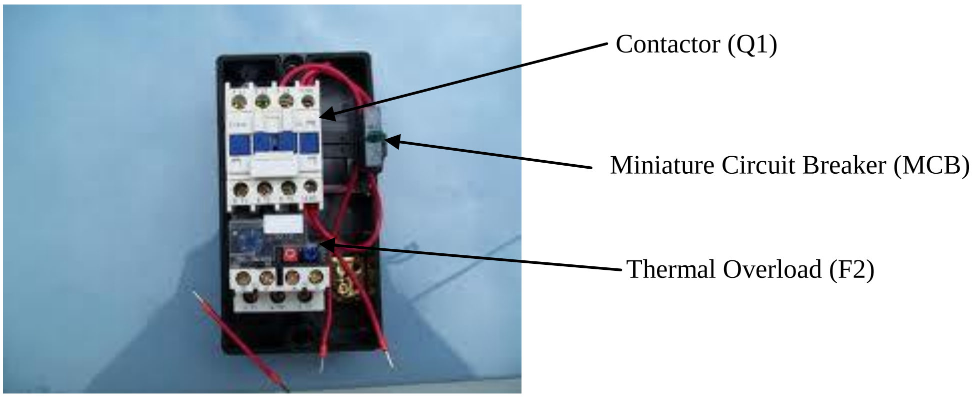


Figure 9 Picture of Direct-on-line starter

2.2.2 Star-Delta (Y-Δ) Starting

Star-delta starting has the starting torque and starting current reduced. Starting equipment is normally made of three (3) contactors, an overload relay and a timer. The timer is used to set the time the motor remains in the star position after start. Motors used for star-delta must be connected in delta during normal run, in order to use this starting arrangement.

With the motor connected in star during starting, the starting current is about 33% of the starting current if it was connected with D.O.L. starting and the starting torque too is about 25% of the available torque at D.O.L. starting.

Star-delta only works if the application has a light starting load. If the motor is too heavily loaded, the torque developed will not be enough to accelerate the motor up to speed before changing over to the delta position. This method is suited for loads like pumps and fans where the starting torque is low. To reach the rated speed, a switch over to delta is a must. Switching to delta results in high torques and peak currents. Such current peaks could be even higher than for D.O.L. starting.

At delta, the motor accelerates till the rated speed is reached, which is usually about 80-85% of the synchronous speed. The motor will finally settle at the speed where the load torque equals the motor torque and acceleration ceases. Applications with load torques higher than 50% of the motor rated torque will not be able to start using star-delta starting. Figures 10, 11 and 12 show the circuit diagrams and picture of star-delta connected starter.

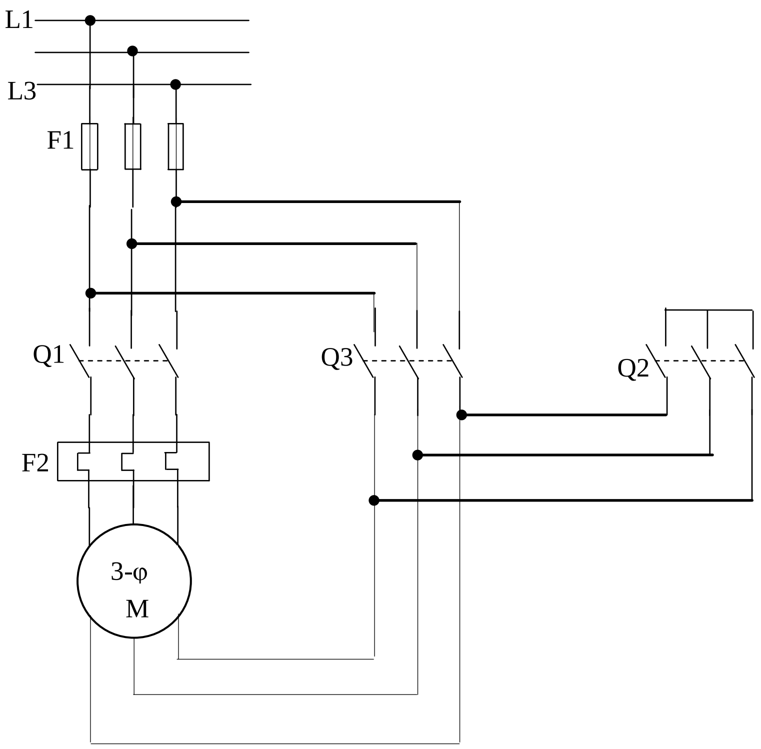


Figure 10   Star-delta power diagram

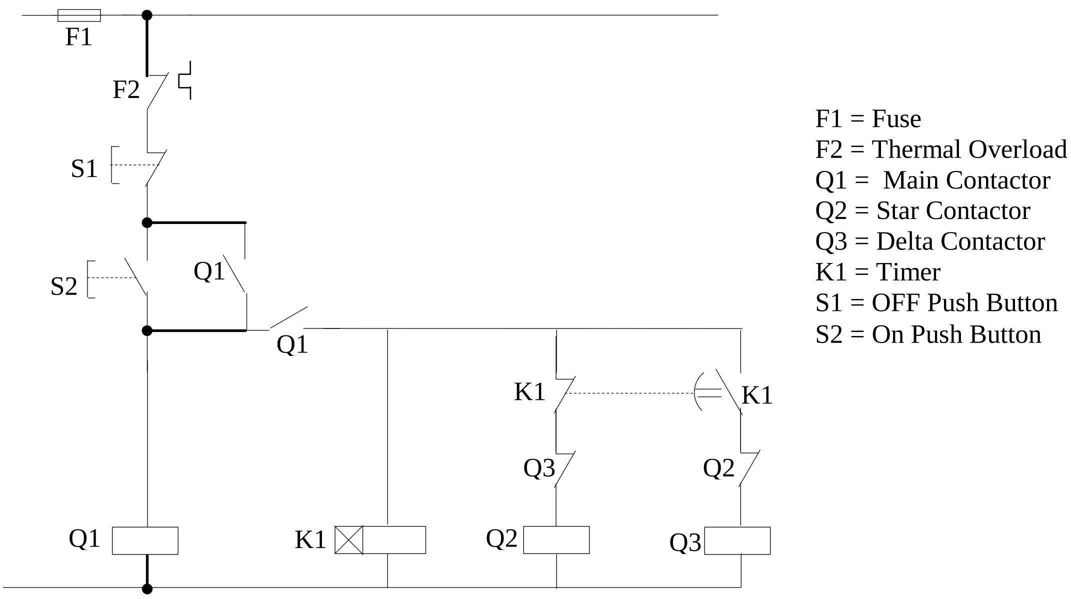


Figure 11 Star-delta control diagram

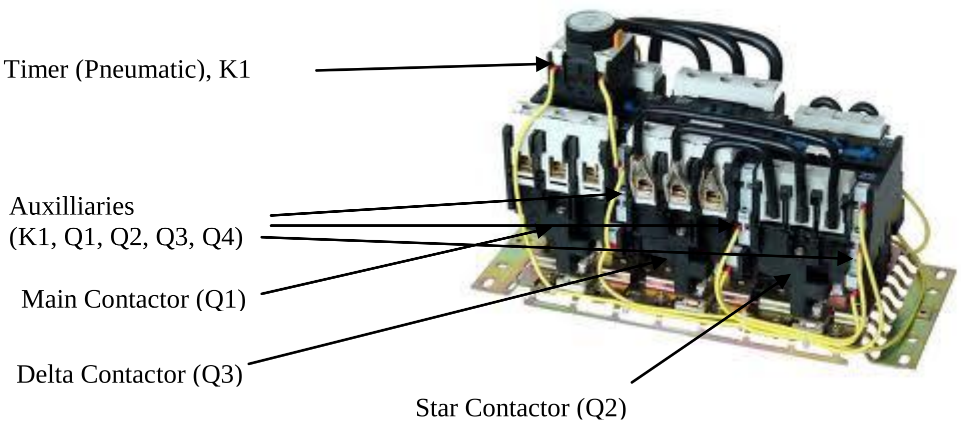


Figure 12 Picture of star-delta starter

(ABB. Softstarter Handbook, 2010, 9—15; Thereja & Theraja 2007, 1329–1338.)

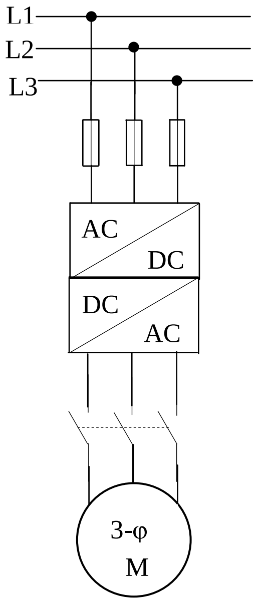
2.2.3 Frequency Converter

The frequency converter, also known as variable frequency drive (VFD), variable speed drive (VSD) or drive converts the usual supply AC voltage of constant frequency to AC voltage whose frequency could be varied.

The drive consists of mainly two parts – a rectifier and an inverter. The rectifier converts the AC (50 or 60Hz) to DC and the inverter converts the DC back to AC of variable frequency (usually 0-250Hz). The drive helps to control the speed of an induction motor easily as the speed of an induction motor depends on the supply frequency (refer to equation 4).

Through the control of the frequency, the rated motor torque is available at low speed and the starting current too, is low, between 0.5 and 1.0 times the motor rated current. The highest current would be 1.5 times the rated current (I_n).

Another useful feature of the drive is its softstop function. A drive system could be brought to a stop gradually and avoid jerking. The softstop function is very useful, for instance when transporting fragile items, the conveyor carrying the items could be brought to a stop gradually to reduce the incidence of breakage when stopping. Circuit diagram and a picture of a frequency drive is shown in Figure 13.



a. Circuit diagram

b. Picture of drive

Figure 13 Frequency converter a. Circuit diagram and b. Picture

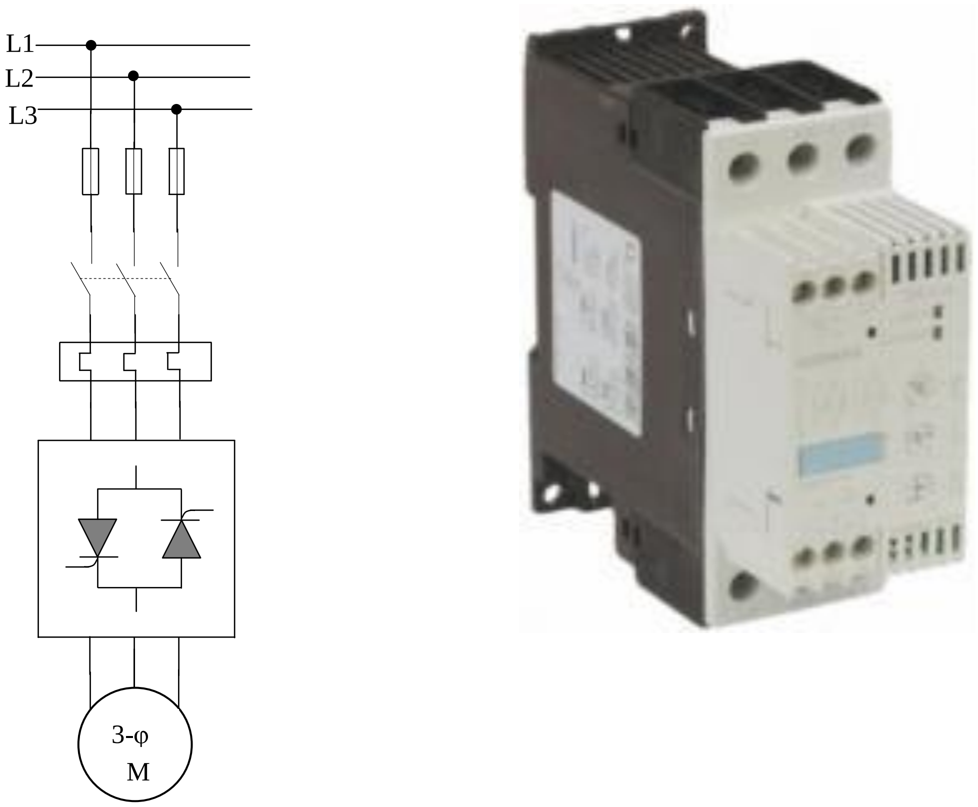
(ABB. Softstarter Handbook, 2010, 16—17; Thereja & Theraja 2007, 1824–1828.)

2.2.4 Softstarter

The softstarter regulates a motor's voltage with printed circuit board made mainly of thyristors. Softstarters produce low starting voltage thus, motor's starting current and starting torque are also low. Low voltage starting prevents jerks, produced starting torque just play between gear wheels or stretching of driving belts (or chains). Voltage is then increased gradually so, the motor starts to accelerate.

One advantage of the softstarter is the ability to adjust the torque to the exact need of the motor, either loaded or unloaded. Even though the full torque is achieved during running but, the low starting torque reduces strain on the drive system which leads to low maintenance on the drive.

Softstarters also have softstop function which is very useful when momentary stops are not required in a drive system, for instance, to prevent water hammering in a pipe system and protecting of fragile materials on a conveyor. Figure 14(a and b) shows the circuit diagram and picture of a softstarter.



a. Circuit diagram b. Picture

Figure 14 Softstarter a. Circuit diagram and b. Picture

(ABB. Softstarter Handbook, 2010, 18—19; Thereja & Theraja 2007, 1825.)

3 TELEMECANIQUE MOTOR CONTROLLERS

Telemecanique Motors Controllers Te Sys LUCM1XBL and Te Sys LUCBX6BL are Direct On-Line (DOL) motor starters which could be used to:

- give protection and control of a 3-phase motors;
    - breaking function,
    - overload and short-circuit protection,
    - thermal overload protection and power switching.

LUCM1XBL can also be used for single-phase motors and offers the following added advantage;

- control the application;
    - protection function alarms,
    - application monitoring (running time, number of faults, motor current values, ...),
    - logs (last 5 faults saved, together with motor parameter values).

3.1 Te Sys LUCBX6BL

Telemecanique Motor Controller Te Sys LUCBX6BL is used in conjunction with Motor Starter Power Base LUB12 for light loads (12A up to 600VAC) or LUB32 for heavy loads (32A, 600VAC), both from Telemecanique. In this Thesis, the LUB12 Motor Starter Power Base was used.

3.1.1 LUB12

LUB 12 is a Non-reversing motor starter base from Telemecanique.
Table 1 gives the technical details of the LUB 12.

Table 1 LUB12 Starter technical specifications

Horse Power/Wattage Rating	(3-Phase) 3HP/2238W @200/240VAC; 7.5HP/5595W@460VAC; 10HP/7460W@575/600VAC: (1-Phase) 0.5HP/373W@120VAC; 2HP/1492W@240VAC
Control Connection	Screw Clamp Terminals
Self Protected	Yes
Ampere Rating	12A
Auxiliary Contacts	1NO/1NC
Action	Non-Reversing
Terminal Type	Screw Clamp
Weight	1.98Pounds/0.9kg

Figure 15 shows the parts of the LUB12 motor starter together with its blanking covers.

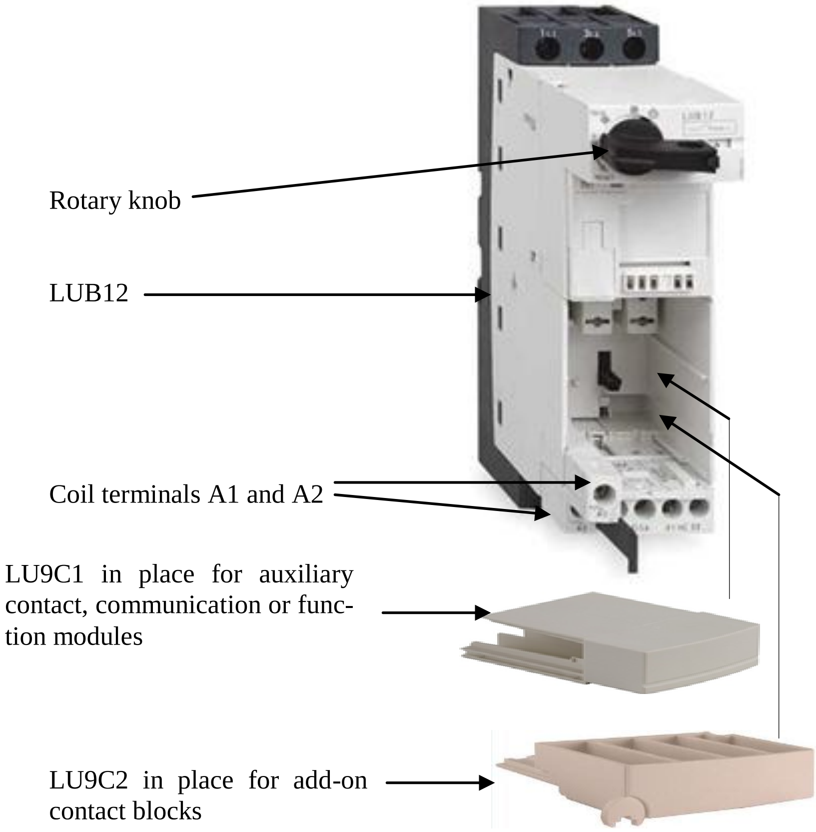


Figure 15 LUB12 and blanking covers

Note: In order to use the starter LUB12, voltage (24V DC) must be supplied to the coil terminals A1 and A2.

The blanking covers could be replaced with the following modules, in table 2, for additional features.

Table 2 Blanking covers replacement modules

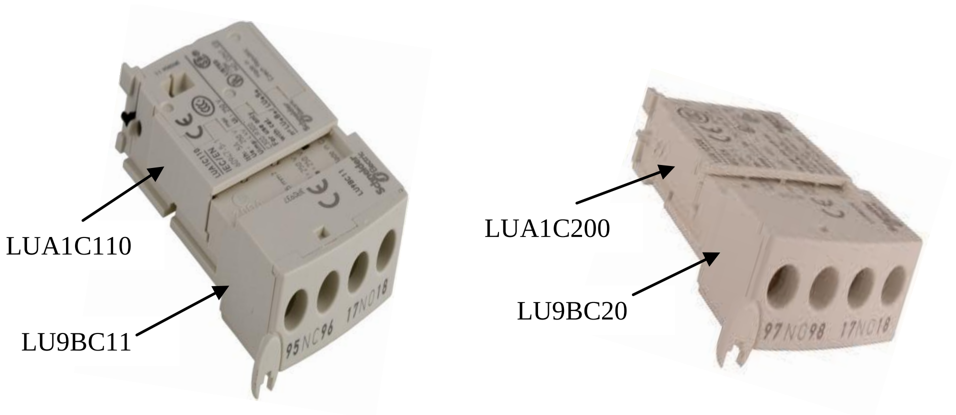
Cover	Replacement Module	Function(s)
LU9C2	LU9BC11 LU9BC20	To give additional 1NC (95-96) – fault signalling and 1NO (17-18) contact – indicating rotary knob in position To give additional 2NO contacts. 1NO (97-98) for fault signalling and 1NO (17-18) for indicating rotary knob in ready position
LU9C1	LUFN02 (Auxiliary contact module) LUFN11 (Auxiliary contact module)	For additional 2NC contacts (31-32 and 41-42) For additional 1NC contact (31-32) and 1 NO contacts (43-44)

	LUFN20 (Auxiliary contact module)	For additional 2NO contacts (33-34 and 43-44)
	LUFDA01/LUFDA10 (Function module)	Thermal fault and automatic or remote reset
	LUFW10 (Function module)	Thermal overload alarm module
	LUFV2 (Function module)	Motor load indication module
	LUFC00 (Communication module – Parallel bus)	Parallel wiring module
	ASILUFC5 (Communication module – Serial bus)	AS-Interface communication module
	LULC07 (Communication module – Serial bus)	Profibus DP communication module
	LULC031 (Communication module – Serial bus)	Modbus communication module

The following modules are used with Telemecanique LUCB/LUCC/LUCD control units only (here Te Sys LUCBX6BL):

- LUFDA01/LUFDA10
- LUFDH11
- LUFW10
- LUFV2

All other modules could be used with both Telemecanique LUCB/LUCC/LUCD and LUCM (here Te Sys LUCM1XBL – discussed later) control units. Figure 16(a and b) below show pictures of LU9BC11 and LU9BC20



a. LU9BC11 b. LU9BC20

Figure 16 Picture of a. LU9BC11 and b. LU9BC20 with their bases

The pictures below in Figure 17 shows the replacement modules for LU9C1

a. LUFN02

b. LUFN11

c. LUFN20

d. LUFDA10

e. LUFW10

f. LUFV2

g. LUFC00

h. ASILUFC5

i. LULC07

j. LULC031

Figure 17 Replacement modules for LU9C1

3.1.2 Te Sys LUCBX6BL Installation

The Te Sys LUCBX6BL is installed in the unit LUB12 in conjunction with LU9C1 and LU9C2 or their replacement modules. Before use, the current settings on the device must be set to conform to the load it is to protect. The Te Sys LUCBX6BL has the following technical specifications given in table 3:

Table 3 Te Sys LUCBX6BL technical specifications

Motor power	92W at 400 ... 440V AC 50/60Hz
Thermal protection adjustment range	0.15 ... 0.6A
Control circuit voltage (Uc)	24V DC (20 ... 27V for DC 24V circuit in operation)
Overload tripping class	Class 10 – frequency limit: 40 ... 60Hz, -25 ... 70^{o}C
Main functions	Earth fault protection Manual Reset Protection against overload and short-circuit Protection against phase failure and phase imbalance
Mounting mode	Plug-in
Current consumption	130mA at 24V DC I maximum while closing with LUB12; 602mA at 24V DC Irms sealed with LUB12
Operating time	35ms opening with LUB12 for control circuit; 70ms closing with LUB12 for control circuit
Load type	3-phase motor – self cooled
Tripping threshold	14.2 x Ir +/- 20%
Tripping class	10 (time out, in seconds, prior to trigger)
Rated insulation voltage (Ui)	690V conforming to IEC 60947-1
Rated impulse withstand voltage (Uimp)	6kV conforming to IEC 60947-6-2
Mass	0.140kg

Figure 18 below shows parts of the LUCBX6BL parts.

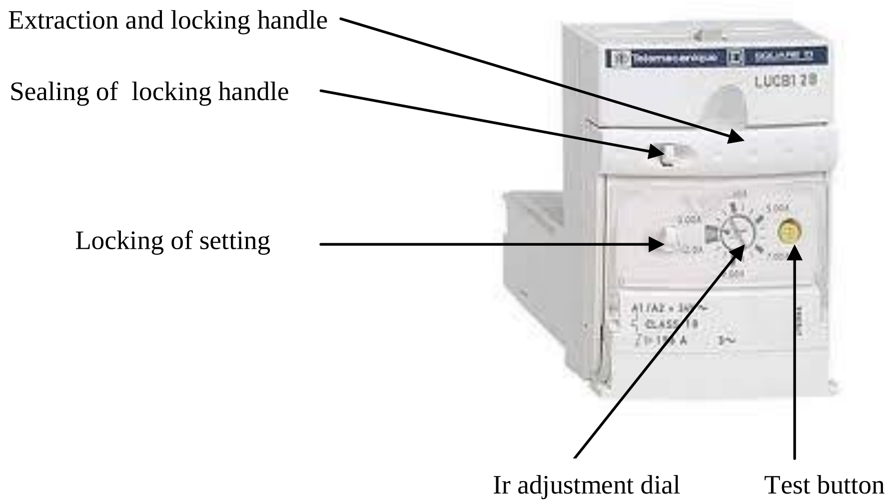


Figure 18 LUCBX6BL control unit parts

I_r, denotes the trip current and is the current above which the controller will trip the motor circuit. Figures 19 and 20 show the mounting procedure of LUCBX6BL and its connection and equivalent scheme respectively.

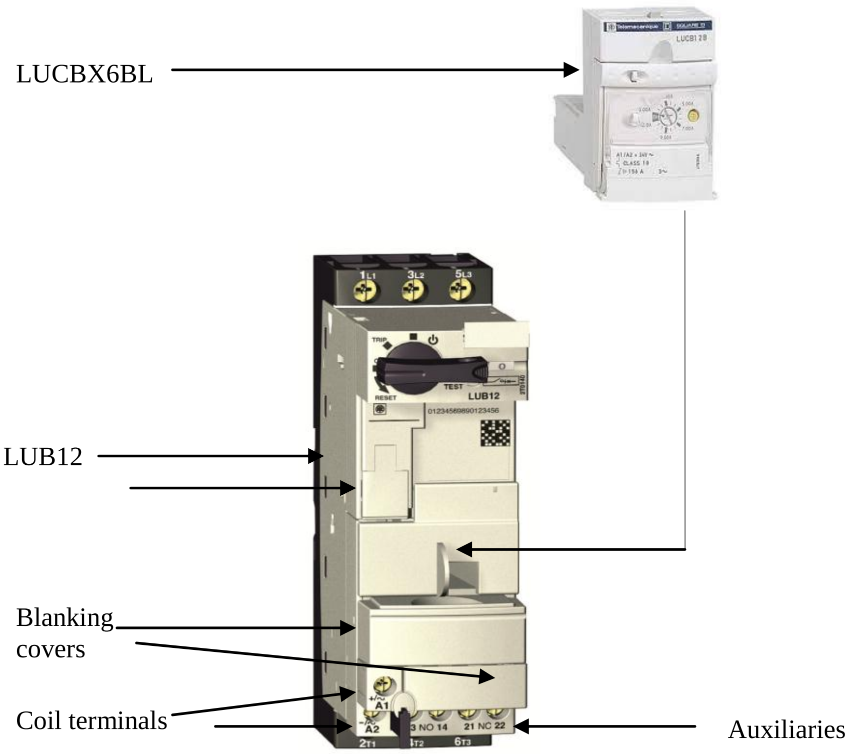


Figure 19 Mounting of LUCBX6BL into LUB12

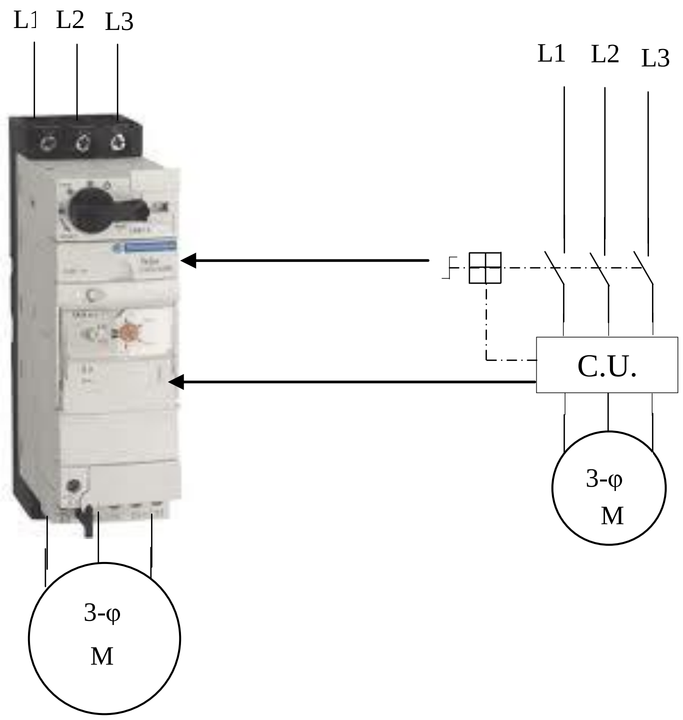


Figure 20 Connection and equivalent scheme of the motor control unit (C.U.)

The Telemecanique Te Sys LUCBX6BL has the following built in functions:

- Thermal overload protection
- Over current protection (14.2 x the setting current)
- Short circuit protection (14.2 x the maximum current)
- Protection against phase loss
- Protection against phase imbalance
- Earth fault detection
- Thermal overload test function
- Manual reset
- Thermal overload alarm (with module LUFW10)
- Thermal overload signalling and manual reset (with module LUFDH11)
- Thermal overload signalling and automatic or remote reset (with modules LUFDA01 and LUFDA10)
- Indication of motor load (with module LUFV)

(Schneider Electric. TeSys U Starter-controllers Catalogue, 2008, 1—10, 19.)

3.2 Te Sys LUCM1XBL

Telemecanique Te Sys LUCM1XBL is a multi function motor controller used in conjunction with Telemecanique LUB12 together with the blank covers LU9C1 and LU9C2 or replacement modules for the blank covers. It is a plug-in module for the LUB12 starter. The Te Sys LUCM1XBL is digital motor controller with two (2) line digital display to show the various circuit parameters being controlled and monitored. It also has keypads for the setting of the various configurable parameters. Modules for functional enhancement of the control unit are given in Table 2 above. Figure 21 shows parts of the LUCM1XBL control unit.

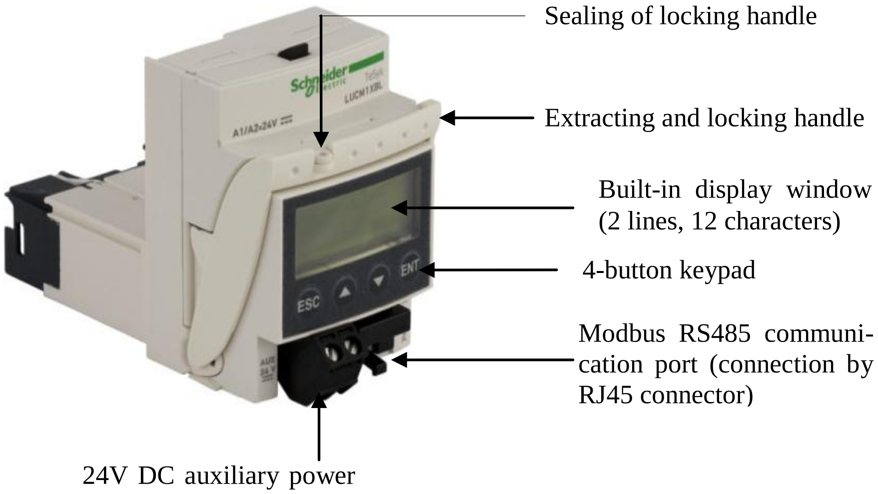


Figure 21 Te Sys LUCM1XBL parts

The Te Sys LUCM1XBL technical specifications are given in table 4.

Table 4 Technical specifications of Te Sys LUCM1XBL

Operating Voltage	415V AC @ 3-phase; 240V AC @ 1-phase
Power	250W (3-phase)
Current setting	0.35 ... 1.4A
Overload Tripping Class	5 ... 30s
Mass	0.175kg

The Te Sys LUCM1XBL has the following built functions

- Thermal overload protection (with choice trip class from 5 ... 30)
- Overcurrent protection 3 to 17 x the setting current
- Short-circuit protection
- Protection against phase loss
- Protection against phase imbalance
- Earth fault protection
- Thermal overload test function
- Overtorque protection/Mechanical jams
- Protection against no-load running/idling
- Protection against long starting time
- Manual or automatic reset
- Fault indication alarm
- Log function (log of the last 5 trips)
- Monitoring function (display of main motor parameters)

3.2.1 Te Sys LUCM1XBL Installation

Figure 22 below describes the installation procedure of LUCM1XBL

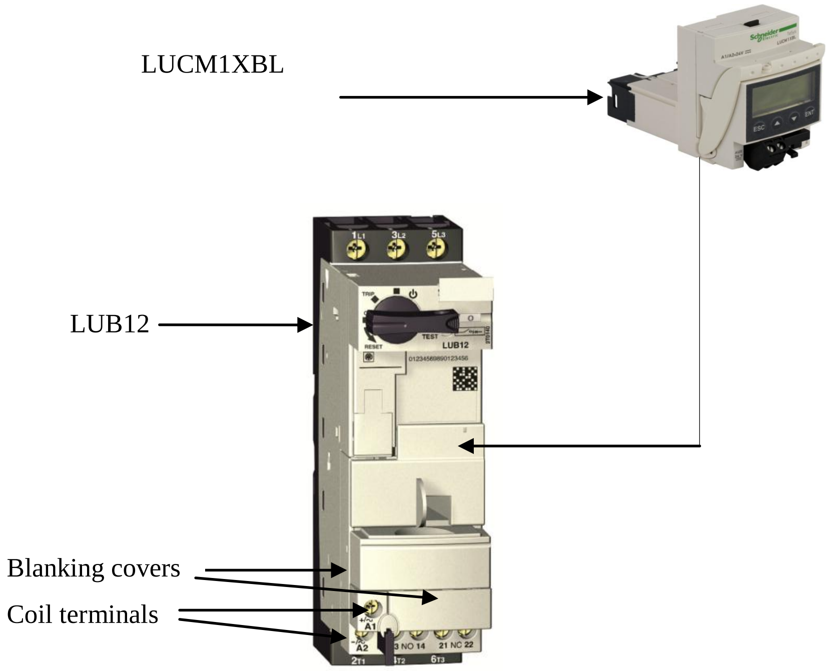


Figure 22 Installation of Te Sys LUCM1XBL

(Schneider Electric. TeSys U Starter-controllers Catalogue, 2008, 11—18, 20.)

3.2.2 Service Temperature

The Te Sys LUCM1XBL control unit has internal temperature monitoring function that cannot be disabled.
The warning message ‘Warm-IntTmp’ is displayed on the display window as soon as the internal temperature exceeds 80^{o}C.
At a temperature of 90^{o}C the control unit triggers the starter and the message ‘Internet Trip’ appears on the display window.

After tripping due to high temperature, the value of the internal temperature is stored in register 472. The value may be monitored via the RS485 communication port:

- locally using the PowerSuite programme
- remotely via the Modbus link.

Some level of clearance is required between adjacent mounted control units, which depend on the ambient temperature of the unit. Figure 23 below highlights the clearance distance required between adjacent control units as given in Table 5.

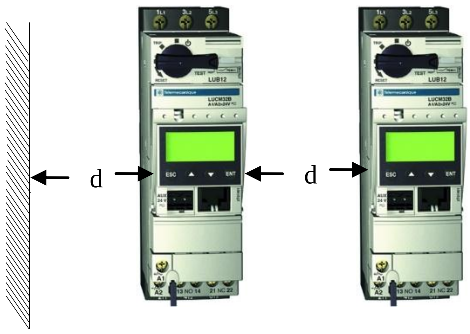


Figure 23 Clearance distance between adjacent control units

Table 5 Recommended distances for various ambient temperatures

Distance to be maintained	Ambient temperature
d = 0mm	45^{o}C
d ≥ 9mm	55^{o}C
d ≥ 20mm	60^{o}C

3.2.3 Te Sys LUCM1XBL Connection

The Te Sys LUCM1XBL has two (2) 24V DC power supply options:

- The supply for the control circuit, accessible only through the A1/A2 terminals on the power base
- The auxiliary power supply, on the unit’s front panel.

The auxiliary power supply is used in the following situations:

- Initial configuration and adjustment before installing the power base or before connecting the power supply of the control circuit to the A1/A2 terminals (here, of LUB12).
- During 'Off' or 'LastTrip' modes and making changes to the settings.
- During 'Off' or 'LastTrip' modes and when displaying fault types or statistics.
- During 'Off' or 'LastTrip' modes and communicating with the multifunction control unit.
- When using a function module (communication or application)

Note: Input A2 of the LUB12 control circuit is internally connected the negative (-) input terminal of the auxiliary power supply. If the polarity of the LUB12 A1/A2 terminal is inverted, the control unit triggers an internal fault.

3.2.4 Setting/Programming of the Te Sys LUCM1XBL

The Te Sys LUCM1XBL has four buttons for programming/setting the various configurable parameters. It has a 2-line, 12-character digital display to facilitate the programming of the device. Table 6 below gives a snap shot of the use of the various keys in navigating through the LUCM1XBL configurable parameters.

Table 6 Keypad functions

ESC	Move up one level in the menu. The ESC button does not save any settings.	This key may need to be pressed several times to return to the program.
▲ ▼	Browse in: - a programme => sub-programmes - a sub-programme => functions - a function => settings	Some sub-programmes include only functions and their settings. Others include functions with several parameters and the settings
	Browse available settings.	The '=' sign precedes a factory setting. The '?' sign precedes available settings.
	Increase or decrease the value of the displayed setting.	To quickly increase or decrease the value of a setting, hold down the corresponding key.
ENT	1. Move down one level in the programme. 2. Confirm and save the displayed setting.	Once you have saved the setting o The '?' sign is replaced by '=' o The setting is displayed for 2 seconds, then the display returns automatically to the next highest

		level.

3.2.5 Power up and operating modes

The operating mode depends on the system's status. Table 7 below contains the system modes of the LUCM1XBL

Table 7 Te Sys LUCM1XBL System modes

Start-up phase	Initial power up	'Configuration' mode
	Next power-ups	'Pause' mode (with power supply to the to the control circuit A1/A2 of LUB 12) 'Off' mode (with no power supply to the to the control circuit A1/A2 of LUB 12)
After start-up phase		'Run' mode

Initial Power up: The first time the multifunction control unit (Te Sys LUCM1XBL) is powered up, after leaving the factory, the unit is in the 'Configuration' mode. The interface automatically displays the '**Config Menu'** programme.
The LUCM1XBL control unit must be configured before authorising the power poles to be closed.

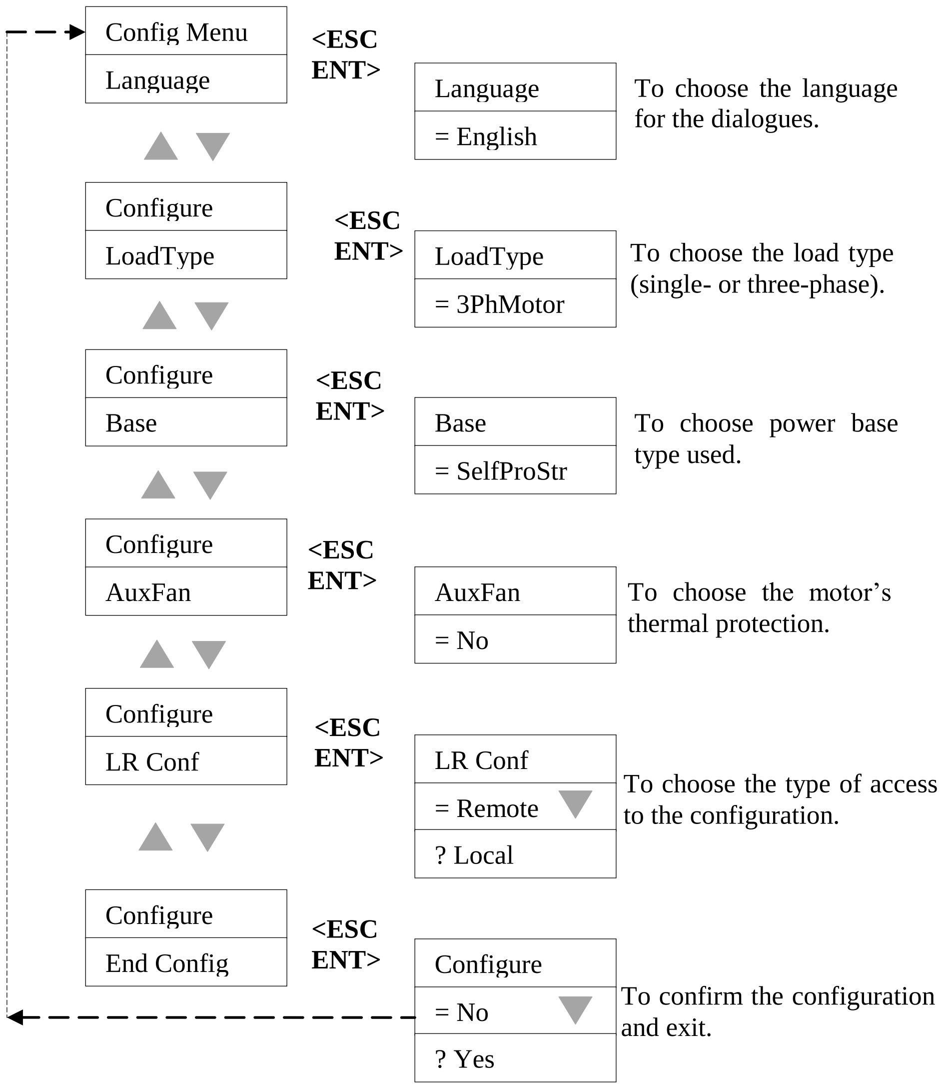
The LUCM1XBL interface consists of two (2) programme: **Config Menu** and **Main Menu.**

The **Config Menu** programme can be accessed:

- either during the commissioning,
- or from the Main programme, by performing a reset using the 84_RstToDfts function.

3.2.6 Configuration (Config) Menu Programme

Configuration settings for the LUCM1XBL consist of the following program:



Note: All subsequent users do not have automatic access to the configuration menu, automatic access is possible only on the first power-up from factory. Default value settings are given in the appendix. Configuration is done with the 4 button/key of the controller.

3.2.7 Main Menu Program

Main menu settings for the LUCM1XBL consist of the following programme:

Main Menu	Keys	Sub-menu	Description
Main Menu / 1_Reference	<ESC ENT>	1_Reference / 11_Catalog	To view the configuration data.
▲ ▼			
Main Menu / 2_Display	<ESC ENT>	2_Display / 21_AvCurrent	To choose the setting to display in 'Run' mode.
▲ ▼			
Main Menu / 3_Setup	<ESC ENT>	3_Setup / 31_FLASet	To adjust the basic parameter.
▲ ▼			
Main Menu / 4_AdvSetup	<ESC ENT>	4_AdvSetup / 41_TripClass	To configure the protection functions and the associated warnings.
▲ ▼			
Main Menu / 5_CommSetup	<ESC ENT>	5_CommSetup / 51_Drop	To configure the Modbus RS 485 communication port.
▲ ▼			
Main Menu / 6_Module	<ESC ENT>	5_CommSetup / 61_ID Clear	To configure the function module.
▲ ▼			
Main Menu / 7_Statistics	<ESC ENT>	7_Statistics / 71_Trip0	To view the statistics on the 'LastTrip' and 'Run' information.
▲ ▼			
Main menu / 8_Password	<ESC ENT>	8_Password / 81_Unlock	To activate the password or reset the parameters and statistics.

The LUCM1XBL has default settings, which it maintains even if the main menu programme has not being set-up. Default values are available at the appendix. Navigating through the main menu programme for set-up is mainly done with the four (4) buttons keypad on the front panel of the control unit: ESC, ▲, ▼, and ENT.

To have access to most of the Sub-programmes, Functions, Parameters and Settings of the LUCM1XBL, it must be programmed when it is in the 'Pause' mode.
It must be noted that, 1_Referenc and 7_Statistics sub-programmes are not alterable in the Main Menu.

Programming in the ‘Run’ mode permits only the 2_Display and 3_Setup functions to be modified.
When in the Main Menu program, if no key is pressed in 30 seconds period, the system returns to the current mode (Run or Pause).
When in the ‘Pause’ or ‘Off’ mode, pressing the ENT key, takes you to the first sub-program (here 1_Reference).
Press ENT again to move to the functions available in the 1_Reference sub-program (11_Catalog), in the function menu, use ▼▲ keys to navigate through available functions or,
in the first sub-program (here 1_Reference) use the ▼▲ keys to move to the next sub-program, pressing the ▼ button takes you to the second sun-program (here 2_Display).
Detailed values for the sub-programs, functions, parameters, factory settings and available optional values are available at the appendix.
(Schneider Electric. LUCM and LUCMT Multifunction Control Unit User Guide, 2008)

CONCLUSION

The objectives set to this project were successfully achieved. The Telemecanique Motor Controllers could be installed, tested and commissioned successfully.

The controllers are to be used in the students' laboratory after the successful commissioning at the AutoMaint Laboratory, which was also realised here, thus the controllers are ready for use by students when the next year starts.

The appendix contains detailed main menu settings options and default values of the various parameters which can help students use the controller (LUCM1XBL) upon a brief orientation.

There are options for the improvement in the use of the controllers. Remote monitoring and configuration can be conducted through the use of the appropriate modules, for which the various communication protocols available are provided in Appendix 2.

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Appendix 1

DEFAULT SETTINGS AND OPTIONAL VALUES FO THE LUCM1XBL

Programme	Sub-programme	Function	Parameter	Factory settings or profile	Optional values
Config Menu	-	Language	-	= English	? Francais ? Espanol ? Deutsch ? Italiano
		Load type	-	= 3PhMotor	? 1 PhMotor
		Base	-	= SelfProStr	? Starter
		AuxFan	-	= No	? Yes
		LR Conf (from version V3.x onwards)	-	= Remote	? Local
		End Config	-	= No	? Yes
Main Menu	1_Reference	11_Catalog	-	LUCM1XBL	
		12_Firmware	-	Rev: 1.11	
		13_FLA Range	-	0.35 ... 1.4A	
		14_LoadType	-	= 3 PhMotor	Read only (configured in Config Menu)
		15_AuxFan	-	= No	
		16_Base	-	= SelfProtStr	
	2_Display	21_AvCurrent	-	= Yes	? No
		22_ThermCap	-	= No	? Yes
		23_L1Current	-	= No	? Yes
		24_L2Current	-	= No	? Yes
		25_L3Current	-	= No	? Yes
		26_GFCurrent	-	= No	? Yes
		27_LastTrip	-	= No	? Yes
		28_PhaseImb	-	= No	? Yes
	3_Setup	31_FLASet	LUCM1XBL	= 0.35	? 0.35 ... 1.4
		32_TestTrip	-	= No	? Yes
		33_Pause	-	= No	? Yes
		34_Language	-	= English	? Francais ? Espanol ? Deutsch ? Italiano
	4_AdvSetup	41_TripClass	-	= 5	? 5 ... 30
		42_ResetMode	-	= Manual	? Remote/Ent ? Auto
		43_RstAdjust	ResetTime	= 120s	? 1...1000
		44_MagTrip	-	= 1420%FLA	? 300...1700
		45_OLWarning	Warning	= On	? Off
			Warm Level	= 85% (Capacity)	? 10...100
		46_GroundFlt	Trip	= On	? Off
			Trip Time	= 1.0s	? 0.1 ...1.2
			TripLevel	= 30%FLA	? 20...500
			Warning	= On	? Off
			Warning Level	= 30%FLA	? 20...500
		47_PhaseImb	Trip	= On	? Off
			TripTimeStrt	= 0.7s	? 0.2...20
			TripTimeRun	= 5s	? 0.2...20
			TripLevel	= 10%IMB	? 10...30
			Warning	= On	? Off
			Warn Level	= 10IMB	? 10...30
		48_Jam	Trip	= On	? Off
			TripTime	= 5s	? 1...30
			TripLevel	= 200%FLA	? 100... 800
			Warning	= On	? Off
			Warn Level	= 200%FLA	? 100...800
		49_UndrLd	Trip	= On	? Off
			TripTime	10s	? 1...200
			TripLevel	= 50%FLA	? 30...100
			Warning	= On	? Off
			Warn Level	= 50%FLA	? 30...100
	5_CommSetup	51_Drop	-	= 1	? 1...247 (Drop address

					127 is reserved for point-to-point with configuration software such as PowerSuite
		52_Baud	-	= 19200bps	?1200...19200
		53_Parity	-	None	? Even
		54_Control	-	= On	? Off
		55_CommLoss	-	= Ignore	? Dropout ? Trip ? Warning
	6_Module	61_ID Clear	-	= Yes	? No
		62_Reference	Module	ID = 0	-
			Catalog	LUCM1XBL	
			Firmware	Rev: 1.11	
		63_ID Set	-	= 0	? 0....149
		64_Param dec	Parameter 1-10	= 00000	?00000...65535
		65_Param hex	Parameter 1-10	= 00000	?00000...FFFF
	7_Statistics	71_Default 0	-	In case of a return to factory settings, the statistical data is erased.	
		72_Trip1	-		
		73_Trip2	-		
		74_Trip3	-		
		75_Trip4	-		
		76_Totals	-		
	8_Password	81_Unlock	-	Passwd?	0000...9999
		82_Lock	-	NewPSD?	0000...9999
		83_Rst Stats	-	= No	? Yes
		84_RstToDFTS	-	= No	? Yes

Appendix 2

REMOTE MONITORING AND CONFIGURATION OF THE TE SYS CONTROL UNITS

1 Te Sys LUCM1XBL

The Telemecanique control unit Te Sys LUCM1XBL has an RJ-45 communication port through which the control unit can be monitored and configured remotely. When used, it is possible to remotely programme and monitor all functions.

The following modules also allows for the stated functions to be remotely monitored/configured on the LUCM1XBL:

- Starter status monitoring (ready, running, fault) – with any communication module (modules ASILUC5, LUFC00, LULC07, LULC031)
- Alarms monitoring – modules LULC031, LULC07
- Remote reset through a bus – modules LULC031, LULC07
- Fault signalling and differentiation – modules LULC031, LULC07
- Log function – modules LULC031, LULC07

2 Te Sys LUCBX6BL

It is also possible to configure/monitor the control unit LUCBX6BL, through the attachment of the appropriate module. The following modules also allows for the stated functions to be remotely monitored/configured on the LUCBX6BL:

- Thermal overload alarm monitoring – module LUFW10
- Thermal overload signalling and manual reset – module LUFDH11
- Thermal overload signalling and automatic or remote reset – module LUFDA10
- Indication of motor load (analogue) – module LUFV2
- Starter status (ready, running, fault) – any communication module (modules ASILUC5, LUFC00, LULC07, LULC031)
- Reset through a bus – modules LULC031, LULC07
- Alarms monitoring – modules LULC031, LULC07
- Indication of motor load – modules LULC031, LULC07
- Fault signalling and differentiation – modules LULC031, LULC07

3 PowerSuite Software

The PowerSuite Software workshop is a user-friendly tool designed for setting up the motor control units.
It contains various functions designed for setup phases such as:

Appendix 2/2

- Preparing configuration
- Start-up
- Maintenance

The PowerSuite software workshop is compatible with Bluetooth wireless link to facilitate start-up and maintenance.
The PowerSuite Software version designed for this controller is the VW3A8104, both for PCs and pocket PCs. Newer versions may be compatible as well.

In order to connect the PC to the control units or modules, the VW3 A8 106 cable is needed.

VW3 A8 106 Cable

3.1 Functions

3.1.1 Preparing and configurations

The PowerSuite software workshop can be used to generate the device configuration, which can be saved, printed and exported to office automation software on its own.

3.1.2 Start-up

When the PC is connected to the device, the PowerSuite software workshop can be used to:

- Transfer the generated configuration
- Adjust
- Monitor. This option has been enhanced with new functions such as:
  - The oscilloscope
  - The high-speed oscilloscope (minimum time base: 2 ms)
  - The FFT *(Fast Fourier Transform)* oscilloscope
  - Display of communication parameters

- Control
- Save the final configuration

3.1.3 Maintenance

To facilitate maintenance operations, the PowerSuite software workshop can be used to:

- Compare the configuration of a device currently being used with a saved configuration
- Manage the user’s installed equipment base, in particular:
    - Organize the installed base into folders (electrical equipment, machinery, workshops, and so.)
    - Store maintenance messages
    - Facilitate Modbus TCP connection by storing the IP address

3.1.4 User interface

The PowerSuite software workshop can be used to:

- Present the device parameters (arranged by function) in the form of illustrated views of diagrams or simple tables
- Customize the parameter names
- Create:
    - A user menu (choice of particular parameters)
    - Monitoring control panels with graphic elements (cursors, gauges, bar charts)
- Perform sort operations on the parameters

Display text in five languages (English, French, German, Italian and Spanish). The language changes immediately and there is no need to restart the programme.

It also features online contextual help:

- On the PowerSuite tool
- On the device functions by direct access to the user manuals.

3.2 Connections

3.2.1 Modbus and serial link

The PowerSuite software workshop can be connected directly to the device terminal port or Modbus network port via the serial port on the PC.

Two types of connection are possible:

- With a single device (point-to-point connection), use a VW3 A8 106 PC serial port connection kit.
- With a number of devices (multidrop connection), use the XGS Z24 interface.

3.2.2 Modbus TCP communication network

The PowerSuite software workshop can be connected to a Modbus TCP network.
In this case, the devices can be accessed:

- Using a TSX ETG 100 Modbus TCP/Modbus gateway

3.2.3 Bluetooth wireless link

The PowerSuite software workshop can communicate via a Bluetooth® radio link if the device is equipped with a Bluetooth® Modbus VW3 A8 11 4. The adapter plugs
into the device connector terminal port or Modbus network port and has a range of
10 m (class 2).
If the PC does not feature Bluetooth® technology, use the VW3 A8 11 5 USB -Bluetooth® adapter.

3.2.4 Remote maintenance

A simple Modbus TCP connection is all that is required for the PowerSuite software workshop to support remote monitoring and diagnostics.
When devices are not connected to the Modbus TCP network, or it is not directly accessible, various remote transmission solutions may be used instead (modem, teleprocessing gateway, and so on).