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AE-MAESTRO INTEGRATED LIFT CONTROLLER

TECHNICAL TRAINING COURSE -3

SPEED AND MOTOR CONTROL

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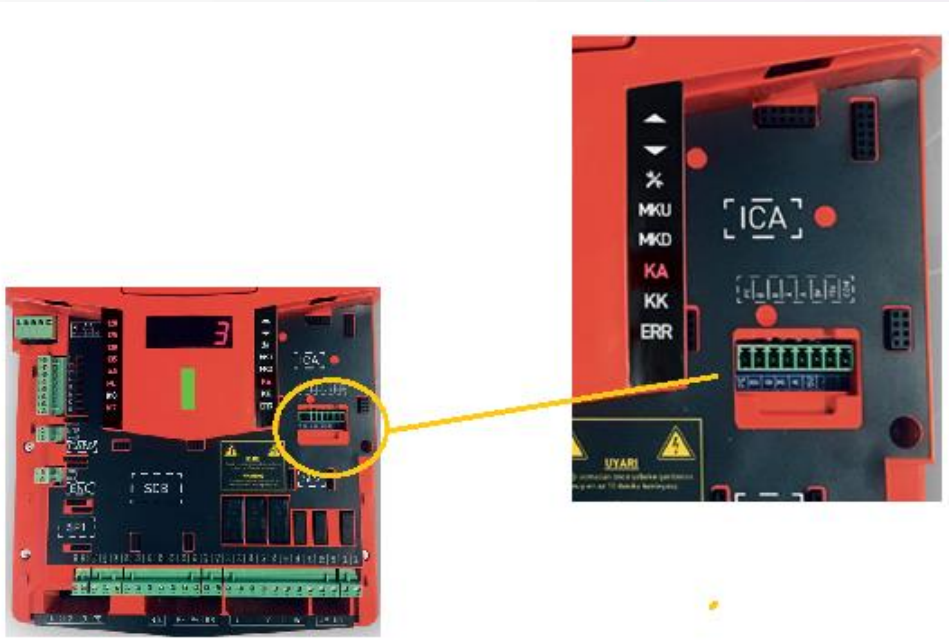
ASYNCRONOUS MACHINE – CLOSED LOOP

[A03] MOTOR TYPE

0	Asynchronous Open Loop Asynchronous motor in open loop (without encoder)
1	Asynchronous Closed Loop Asynchronous motor in closed loop (with encoder)
2	Synchronous Gearless Machine with synchronous motor (closed loop with absolute encoder)

- When asyncronous machine is requested to be driven as **closed loop**, Incremental encoder is connected to the input denoted by yellow circle at the right side.
- **Encoder pulse (PPR)** must be set in parameter **M01**.
- **M16 Encoder Type** parameter must be 0 [**M16=0**].
- For **closed loop** applications set A03 Motor Type to 1 **[A03=1].**



[M16] – ENCODER TYPE

0	**INCREMENTAL**
~~1~~	~~ENDAT~~
~~2~~	~~SINCOS~~
~~3~~	~~BISS (Gray)~~
~~4~~	~~SSI (Gray)~~
~~5~~	~~ENDAT-SPI~~
~~6~~	~~BISS-BINARY~~
~~7~~	~~SSI-BINARY~~

ASYNCRONOUS MACHINE – OPEN LOOP

- When asyncronous machine is requested to be driven as **open loop** no interface **is required.**

- For **open loop** applications set A03 Motor Type to 0 **[A03=0].**

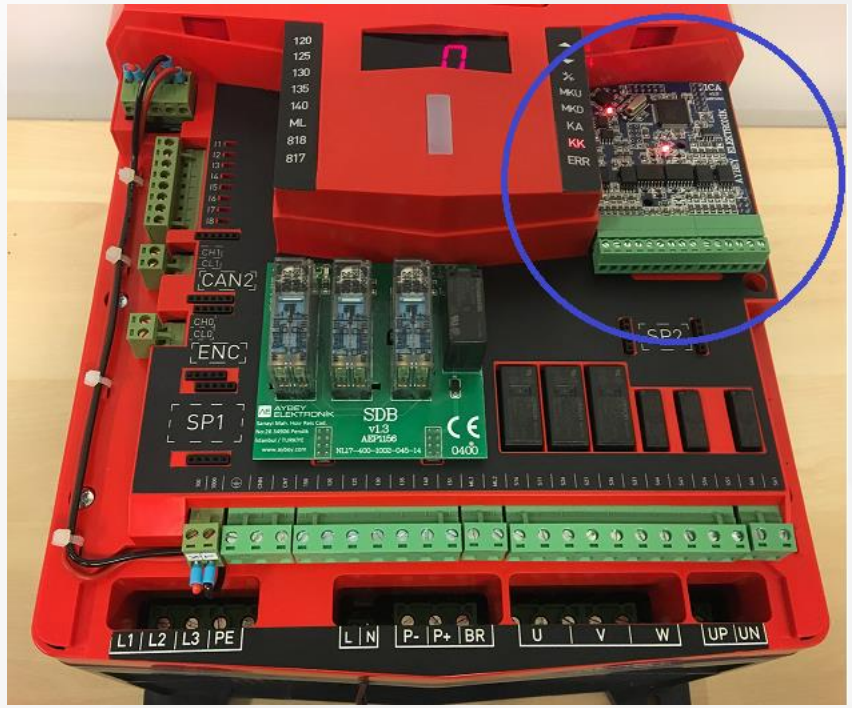
[A03] MOTOR TYPE

0	Asynchronous Open Loop Asynchronous motor in open loop (without encoder)
1	Asynchronous Closed Loop Asynchronous motor in closed loop (with encoder)
2	Synchronous Gearless Machine with synchronous motor (closed loop with absolute encoder)

ENCODER – SYNCHRONOUS MACHINE

[A03] MOTOR TYPE

0	Asynchronous Open Loop Asynchronous motor in open loop (without encoder)
1	Asynchronous Closed Loop Asynchronous motor in closed loop (with encoder)
2	Synchronous Gearless Machine with synchronous motor (closed loop with absolute encoder)



- When synchronous motor is used, **ICA encoder interface board** should be plugged onto the connector indicated with blue circle.
- **Absolute encoder** is necessary for synchronous motors.
- Absolute encoder is connected to the terminal on **ICA board.**
- **Encoder pulse number (PPR)** must be defined in **parameter M01.**
- **Parameter M16** must be set to between **1...7** depending on encoder type.
- **A03** must be set to 2 **[A03=2].**

[M16] – ENCODER TYPE

~~0~~	~~INCREMENTAL~~
1	**ENDAT**
2	**SINCOS**
3	**BISS (Gray)**
4	**SSI (Gray)**
5	**ENDAT-SPI**
6	**BISS (Binary)**
7	**SSI (Binary)**

MOTOR VALUES AND TUNING

- Before running motor, the values in motor label should be written into the device in **P05 – MOTOR PARAMETER.**
- Then tuning process must be done to introduce motor to AE-MAESTRO.
- In this process, **electrical values** and **encoder offset (for sync. motors)** are measured and registered in motor parameters.
- If motor parameters and encoder information are given correctly for **asynchronous motors (geared),** motor usually runs without needing any tuning process.
- But **synchronous motors need always encoder offset angle**. Therefore, giving motor label to the device will not be sufficient to run the motor properly. Therefore, tuning for getting encoder offset must be performed when syncronous motors are used.

Parameters required from motor and encoder labels.

[M01] – ENCODER PULSE
[M02] – MOTOR SPEED
[M03] – MOTOR RPM
[M04] – MOTOR FREQUENCY
[M05] – MOTOR CURRENT
[M06] – MOTOR VOLTAGE
[M07] – MOTOR COS Phi
[M08] – MOTOR POLE NUMBER
[M09] – MOTOR NOLOAD CURRENT
[M16] – ENCODER TYPE

Parameters stored and measured in tunning process

[M10] – MOTOR Rs (ohm)
[M11] – MOTOR Ls (mH)
[M12] – MOTOR Rr (ohm)
[M13] – MOTOR Lm (mH)
[M14] – MOTOR Tr (ms)
[M15] – ENCODER OFFSET

TUNING PROCESS

[M18] – TUNING MODE

0	**Stationary Tuning** Tuning process is carried out while motor is held stationary. Motor brakes must be held closed to prevent any rotation.
1	**Rotating Tuning** Tuning process is carried on with motor rotation. Brakes must be opened to allow rotation.

[M17] – ENCODER DIRECTION

1	**CLOCKWISE**
2	**COUNTER CLOCKWISE**

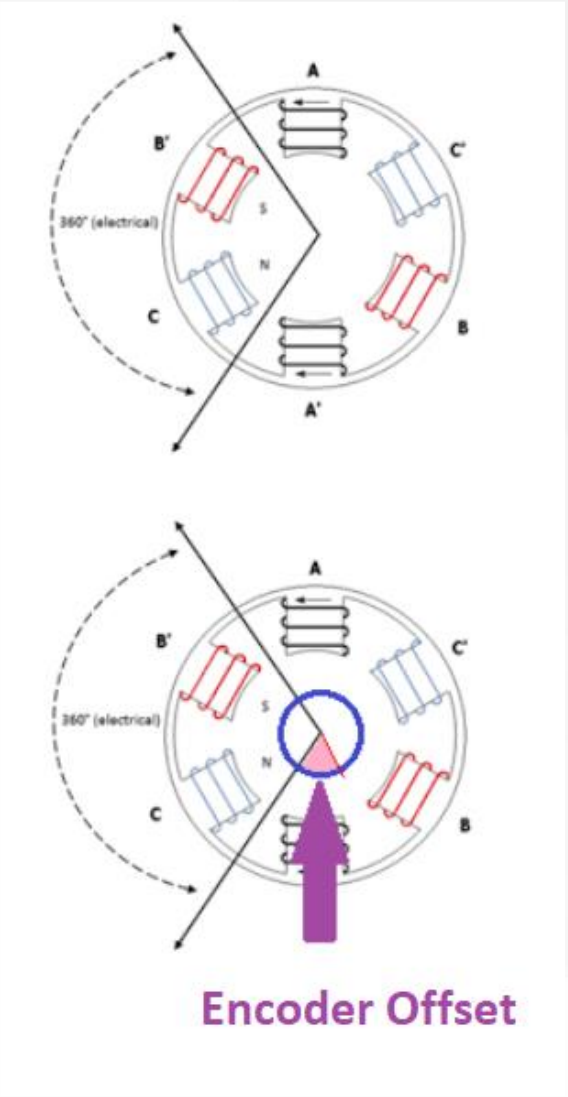
[M19] – MOTOR DIRECTION

0	**DIRECTION 1**
1	**DIRECTION 2**

- Tuning process can be carried out stationary or rotating.
- Related procedures are explained in installation guides.
- After completing tuning process, motor reaction must be observed in inspection mode by giving run commands.
- If the motor does not rotate or any abnormal motion is observed then parameter **M17-Encoder Direction** must be reversed. No need to exchange motor wires.
- If the motor runs properly but in the opposite direction to command, then parameter **M19-Motor Direction** must changed.

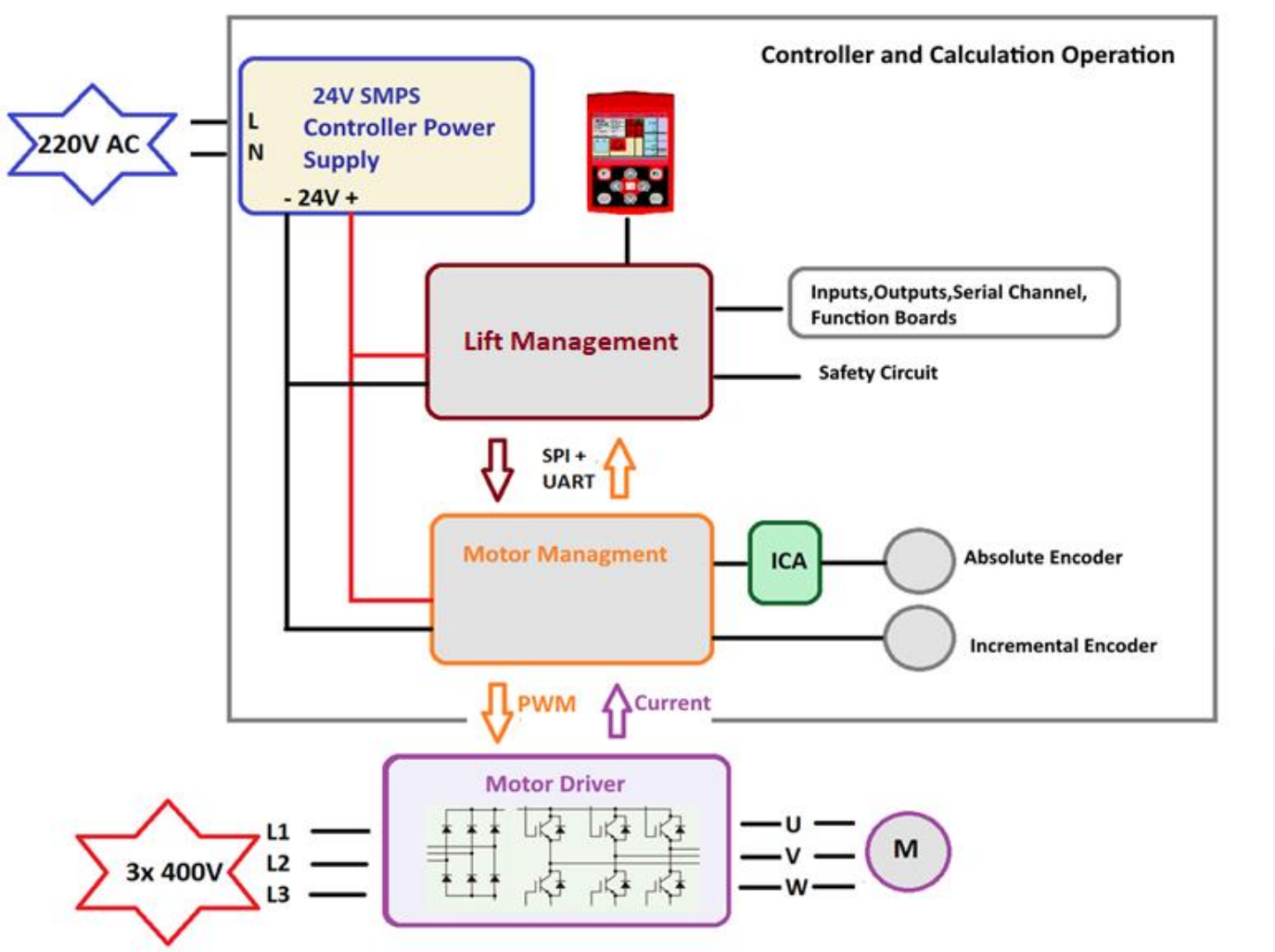
ENCODER OFFSET

- Encoder offset indicates mechanical difference between encoder zero degree angle and motor zero degree angle.
- Current signal for sychronous motor must be calculated with reference to rotor angle. Otherwise the motor does not rotate or behaves abnormally.
- Encoder offset is the difference between encoder and motor angles.
- Encoder offset is stored in parameter **M15**.
- It is also possible to edit M15 by manually.
- In case of replacing an integrated controller with a new one, there is no need to perform tunning again. When **M15 and other parameters** are transfered to the new controller it will run properly.
- But If **encoder is changed** or **motor wires** are not connected in the same sequence after disconnecting, then encoder angle and directions will change. In this case tuning must be carried out once more.



Encoder Offset

SYSTEM INTERNAL BLOCKS

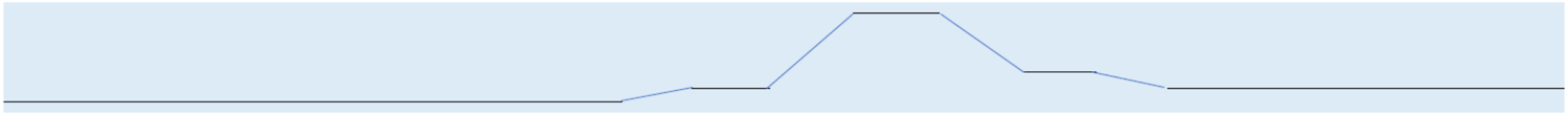


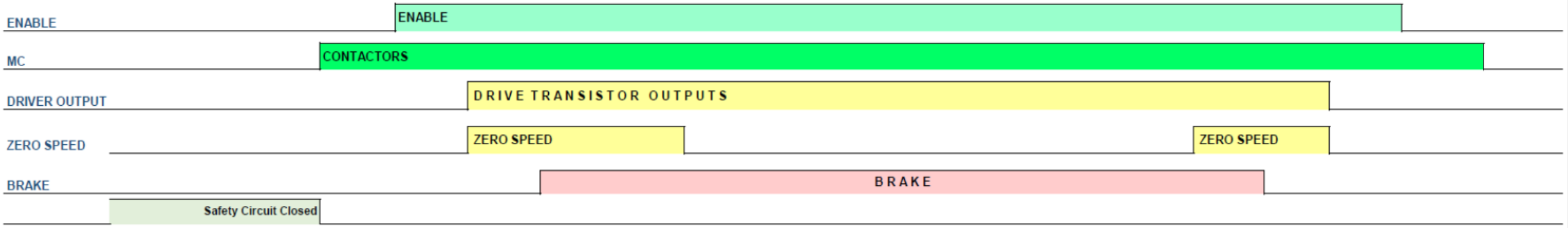
- The system consists of 3 main parts:
- Lift Manager
- Motor Manager
- Motor Driver

TIMING CHART

TIMING CHART

stage	REST	REST	READY	CONT_ON	ENB_ON	TRAVEL										AT_STOP			ENB_OFF	REST
stage	0	0	10	20	35	40										38			33	0
mphase	0	0	0	0	0	41	42	42	43	44	45	46	47	48	49	59	60	61	0	0
	CONTROLLER					MOTOR CONTROL													CONTROLLER	
	idle	Normal Mode: Calls are received Other Modes: Motion request	Close Door Check Inputs Check Safety Activate SG Coil	wait for Start Timer Contactors ON	Drive Outputs Are Enabled (no time delay- only EN checking)	Zero Speed At Start			< Motor rotates – Lift moves >							Zero Speed At Stop		INVERTER OFF	Drive Outputs Are Disabled	Job Completed
									Starting Speed		< Normal Travel >			Seeking Floor Level	Down to Zero					
						DriveON	BrakeON	BrakeON	Ramp Period to Start Speed	Starting Speed	Accelerating	Constant Speed	Decelerating	Creeping Speed	Stopping	Stopping Speed Detected	Brake Off	job Completed		





TIMING CHART

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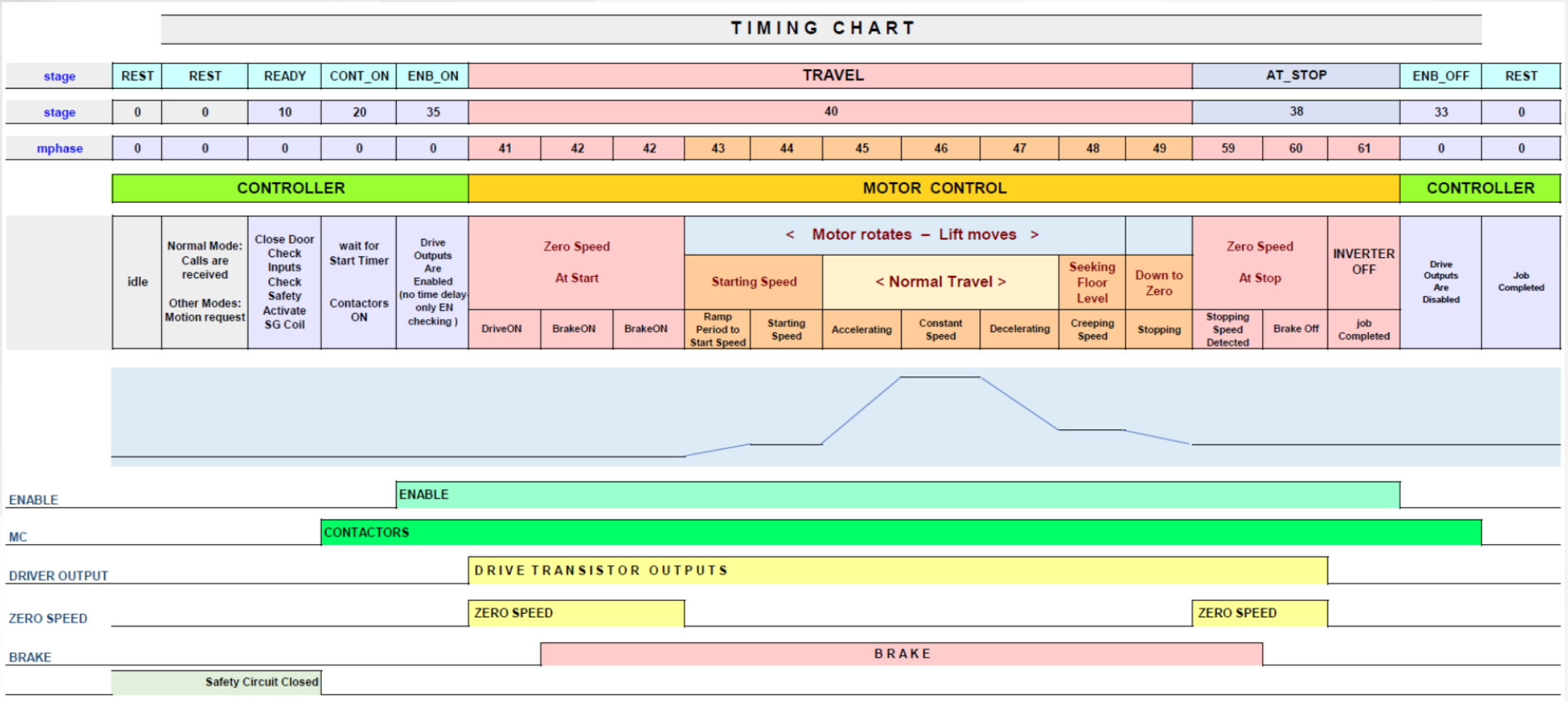
									Starting Speed		< Normal Travel >			Seeking Floor Level	Down to Zero					
						DriveON	BrakeON	BrakeON	Ramp Period to Start Speed	Starting Speed	Accelerating	Constant Speed	Decelerating	Creeping Speed	Stopping	Stopping Speed Detected	Brake Off	job Completed		

- In the system, controller process phases are shown as **stage**, and motor control process phases as **mphase**.
- Controller phases are managed by lift manager and motor process phases by motor manager.
- Both phases are zero when there is no motion.
- When there is a motion request, lift manager energizes contactors after checking safety line.
- Then lift manager allows motor manager to run the motor activating enable command.
- Motor manager activates brake coils and makes the motor run.
- All speed, motor and comfort tasks are controlled by motor manager.
- When the lift arrives at the target floor, motor manager stops motion and deactivates brakes.

TIMING CHART



Timers T07 to T13 control timing of the phases starting from activating contactor to deactivating brake coils at the end of motion.

STAGE & MPHASE INFO

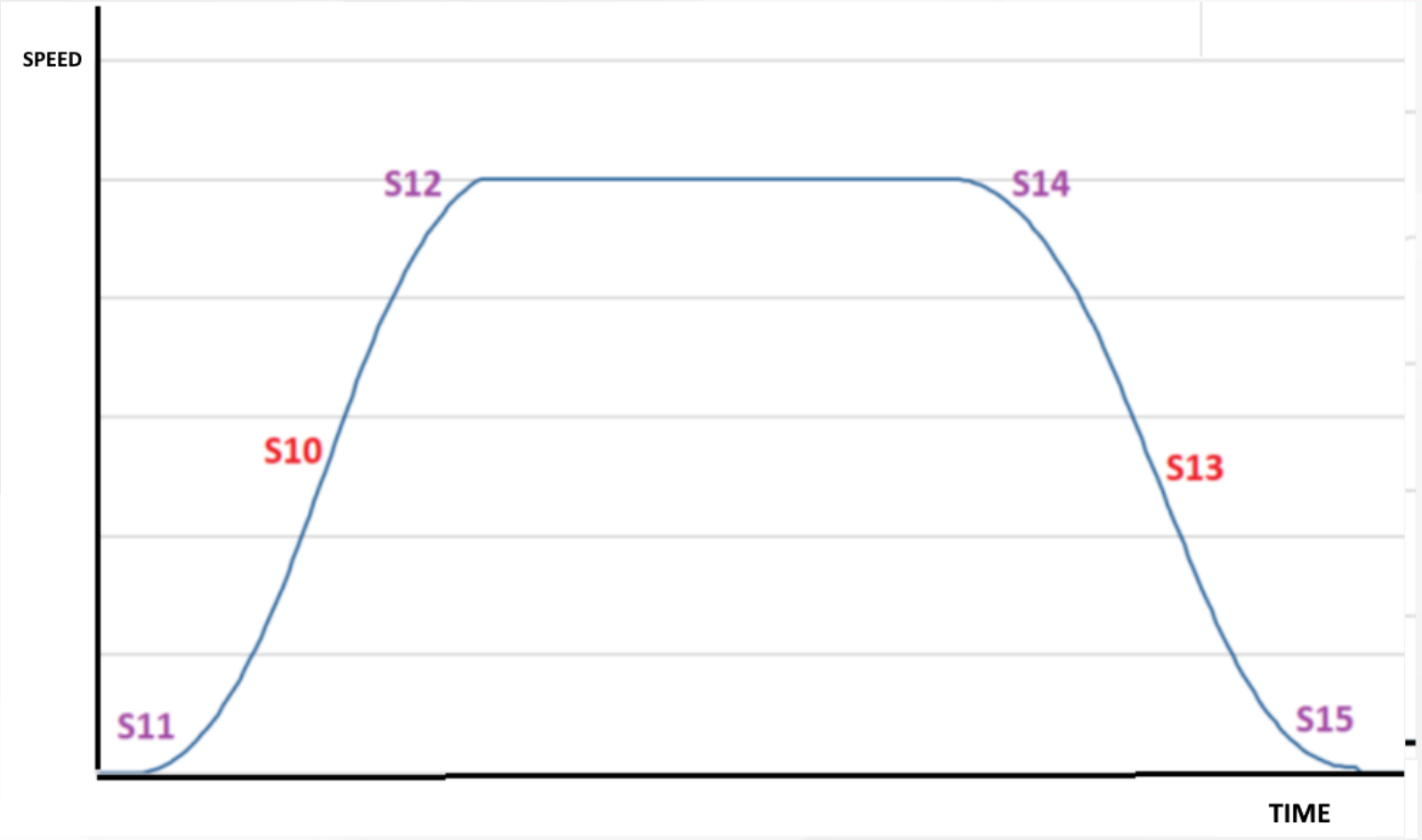
Lift phase (stage) and motor phase (mphase) are shown on the top right of hand terminal.

SPEEDS

0,01 … 5,0	**[S01] NOMINAL SPEED**	Maximum allowed travel speed in normal operation
0,01… 2,0	**[S02] RECALL SPEED**	The travel speed used in recall operation.
0,005 … 0,1	**[S03] RELEVELLING SPEED**	The speed used in relevelling
0,01 … 0.63	**[S04] INSPECTION NORMAL SPEED**	The travel speed in inspection motion below 817 downwards [817=0] and above 818 upwards [818=0].
0,01 … 0,3	**[S05] INSPECTION SLOW SPEED**	The travel speed in inspection motion below 817 downwards [817=0] and above 818 upwards [818=0].
0,01 … 0,5	**[S06] RESCUE SPEED**	The travel speed in rescue operation.
0,05 … 2,0	**[S07] RESETTING TRAVEL SPEED**	The travel speed in resetting.
0,02 … 0,20	**[S08] CREEPING SPEED**	The travel speed used when approaching target floor.

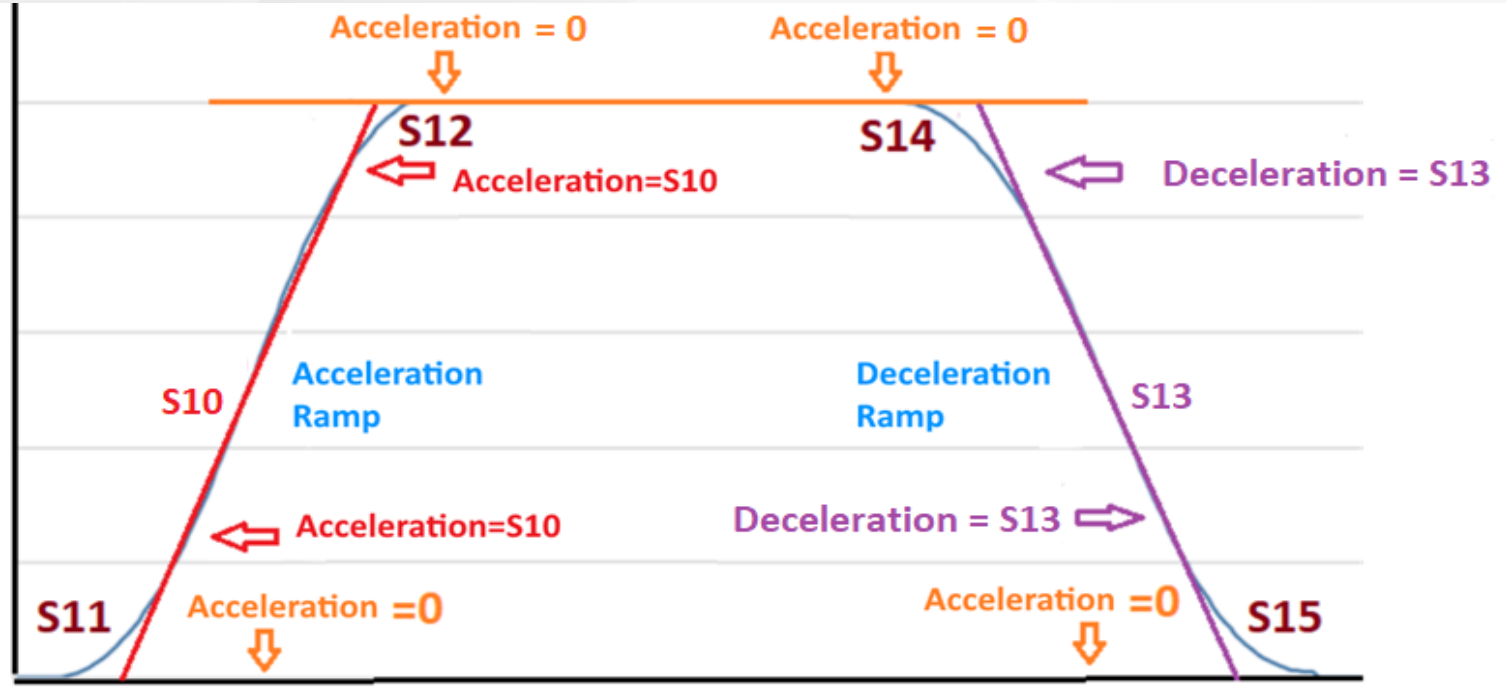
- The parameters related to speed types are shown in the table above.
- All speed parameters are in m/sec.
- The system runs at defined fixed speeds in special travels such as rescue, resetting or inspection travel.
- The system takes the values in parameters **M02 – MOTOR SPEED** and **M04 – MOTOR FREQUENCY** as reference in all speed and distance calculations.
- Thus, travel distance, target, deceleration starting point will be miscalculated if these parameters are not set correctly.
- In order to achieve a good comfort it is also very important to register motor speed correctly

TRAVEL CURVE



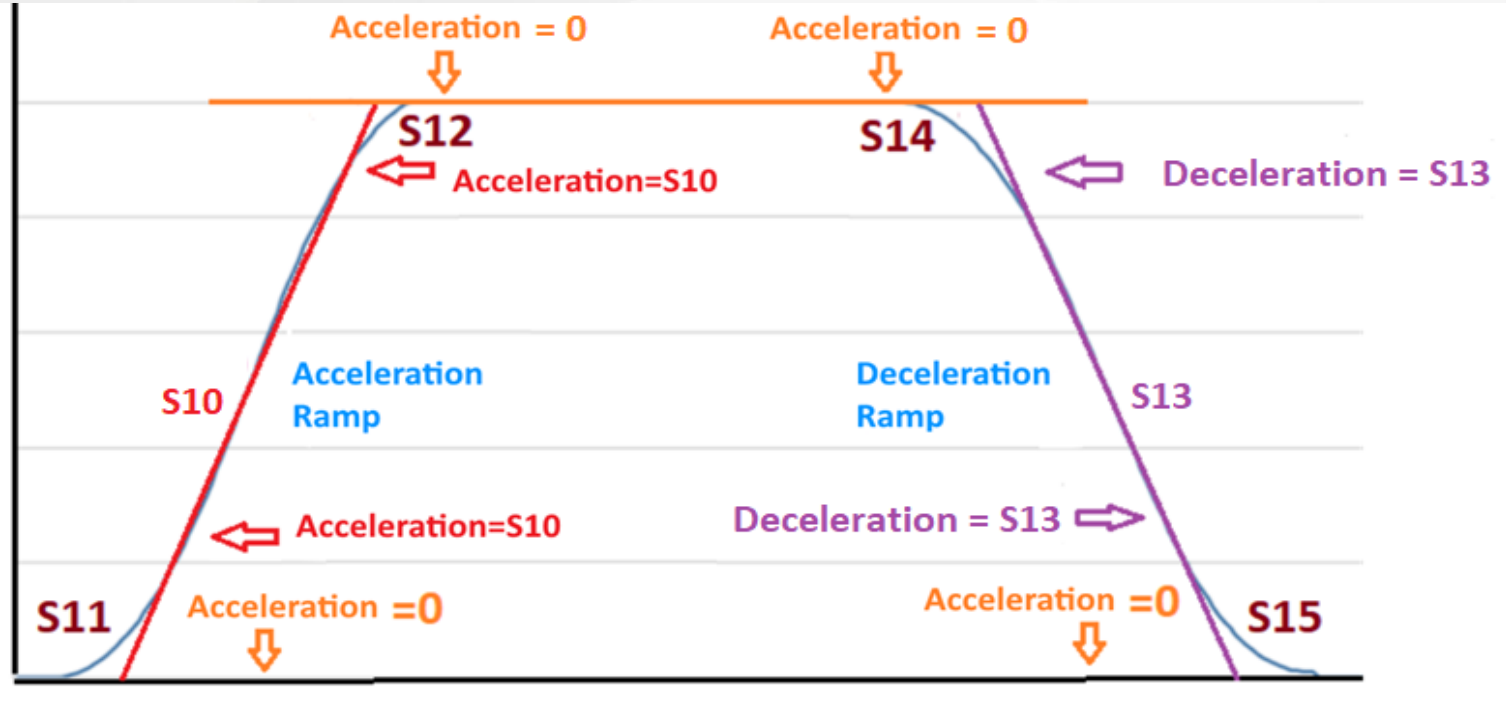
- Acceleration and Deceleration control is done mainly by 6 parameters.
- Parameter **S10** determines **acceleration**, and parameter **S13 deceleration**.
- The other parameters shown in the graph are responsible for S-Curves.

S- CURVES - ACCELERATION



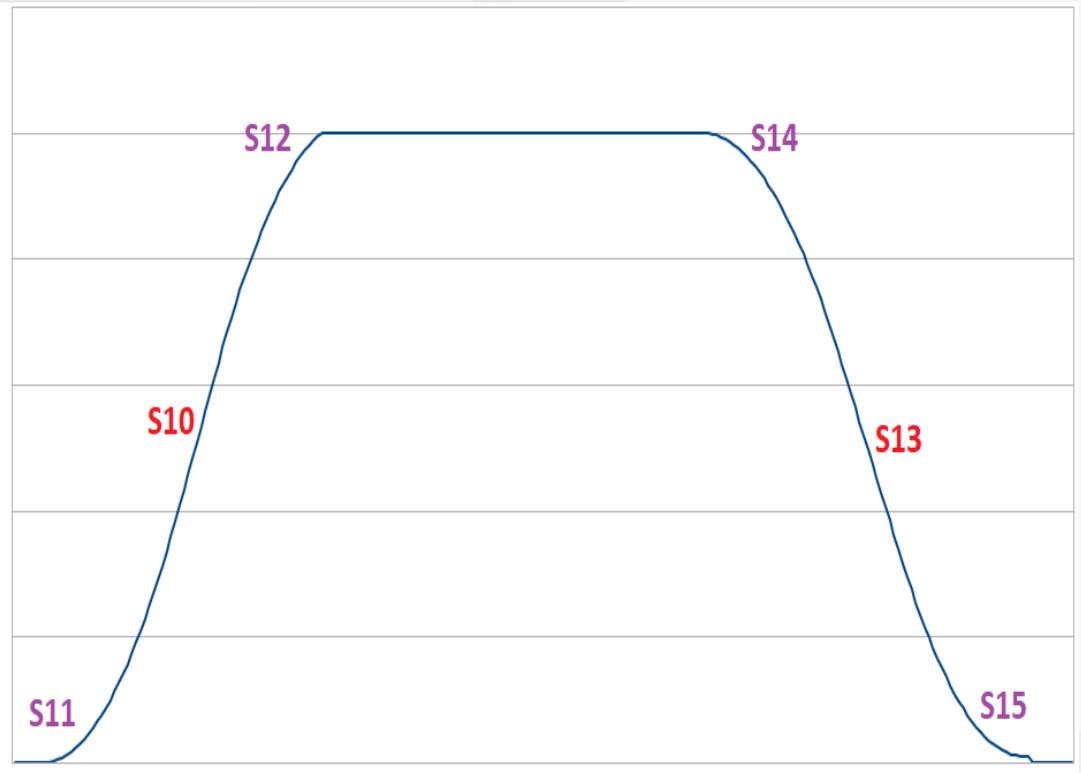
- Acceleration of a stationary lift is **zero.**
- Acceleration parameter is **S10.**
- The system increases acceleration gradually with the value in **S11** until reaching to the value in **S10.**
- In acceleration ramp **Acceleration stays constant at the value in S10**.
- While approaching to the target speed, Acceleration is reduced gradually from **S10** to **zero** by taking the value in **S12.**
- When the lift travels at target speed, acceleration is **zero**.

S- CURVES - DECELERATION



- Acceleration is **zero** at fixed speed.
- When lift starts slowing down for the target floor, Deceleration is increased to the value **S13** step by step by using **S14**.
- In slow down ramp, **Deceleration S13** stays fixed.
- While approaching to the target floor level Deceleration **S13** is reduced to zero in gradually with the value in **S15**.
- Finally the lift stops and deceleration is zero.

TRAVEL CURVE



Values of S12 and S11 must be less than S10.

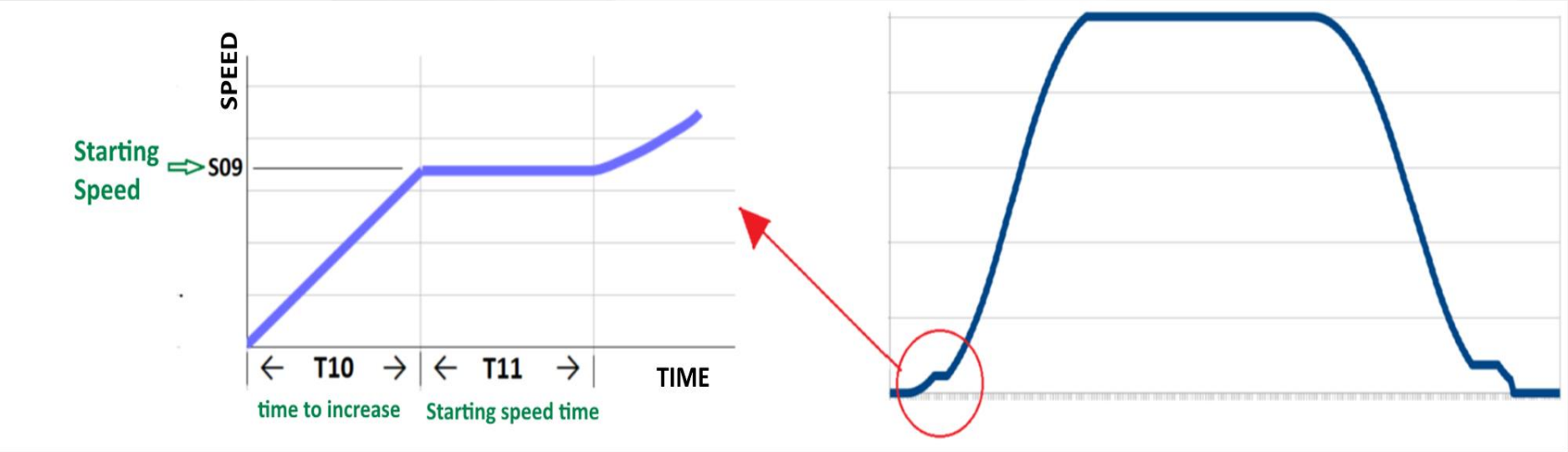
Values of S14 and S15 must be less than S13.

The values in S-curve parameters influences travel comfort very much.

As the values in S-Curve parameters are getting smaller, the travel times are getting longer.

It means that making comfort better makes the travel times longer.

MOTION START – STARTING SPEED

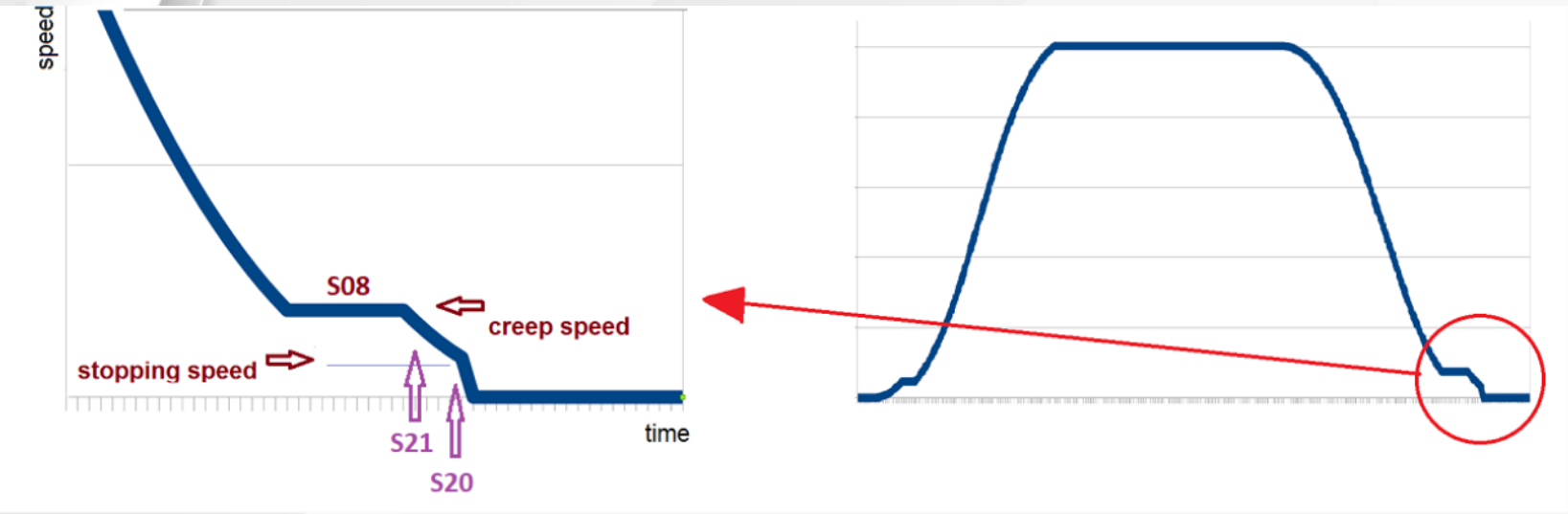


[S09] STARTING SPEED (m/s)

0,0 … 0,1	If this parameter is zero then the device starts its motion from zero. If this parameter is non-zero then the device accelerates in [T10] time period to starting speed [S09] at start.

- S09 determines starting speed. If it is zero, then lift starts motion from speed zero.
- If this parameter is greater than zero, then the speed increases to **[S09]** within period **[T10]** and then continues at the speed **S09** for a period **[T11].**
- Starting speed is usually used in **open loop applications** if required.

DECELERATION STOP - CREEPING PATH



- At the end of deceleration curve, car travels at fixed speed **S08** to target during path (mm) specified in parameter **S22.**
- At the end of creeping path, the system slows down by **S21 stop deceleration start s-curve** and **S20 stopping deceleration** and its motion stops at **stop speed reference S18**.
- At the end of motion, it is recommended to move the car **at least 30 mm** at **creeping speed S08**.
- At the moment of stop, value of **parameter S22** must be increased if the car goes beyond floor level.
- At the end of deceleration, **M02 – Motor speed** may be set incorrectly if the car travels at creeping speed more than path specified in S22.

[S22] CREEPING PATH

0 ... 500	This parameter defines the travel path in creeping speed. Unit is mm.

[S18] STOP SPEED REFERENCE

0	Real Speed
1	Drive Speed

[S17] STOP SPEED (m/s)

0 ... 0,1	When the speed is below the value defined in this parameter during a travel while the car is approaching the floor in slow down phase then the device accepts this as stop command.

[S08] CREEPING SPEED (m/s)

0,02 ... 0,20	The travel speed used while approaching the floor.

[S21] STOPPING DEC. START S-CURVE (m/s³)

0,01 ... 5,0	This parameter defines S-curve rate to reach the deceleration in [S20], when the car gets stop command while travelling at creeping speed.

[S20] STOPPING DECELERATION (m/s²)

0,1 ... 5,0	This parameter defines the deceleration rate when the car gets stop command while travelling at creeping speed.

ANTI-ROLLBACK AT START

Rollback at start is mainly seen in gearless machine with synchronous motor when brakes are opened.

There are 2 ways to prevent this.

The methods are **pre-torque** and **anti-rollback.**

Pre-Torque is applied to motor before opening motor brakes as a result of some calculations.

In anti-rollback control, the system opens the brakes and observes rollback direction and speed firstly. Then it calculates and sends a signal to the motor to hold the motor fixed.

ANTI-ROLLBACK CONTROL

[S19]	Start Mode
0	Passive
1	Anti Rollback - Smart In case of detecting rollback, the controller immediately starts motion by switching from zero speed phase to acceleration phase.
2	Anti Rollback - Fast Pre-torque is applied by giving reaction to rollback and reducing read period of encoder.
3	Anti Rollback – Smart + Fast Options 1 and 2 are applied together.

- Car rollback is observed and torque is applied in the opposite direction.
- No weight transducer or feedback loop is used.

PRE-TORQUE CONTROL

PARAMETERS REQUIRED FOR PRE-TORQUE			Active for
U8	PRE TORQUE KP	This indicates at gain of the pre-torque system. Pre-torque power increases when Kp is set to higher.	S19 = 5 S19 = 4
U9	PRE TORQUE PULSE	It specifies pre-torque starts after how many pulses of encoder occurs.	S19 = 5 S19 = 4
U10	PRE TORQUE STARTING SPEED	It specifies pre-torque is applied at which speed car reaches.	S19 = 5 S19 = 4
U11	PRE TORQUE PERIOD	Interval Ti of the process is mentioned. Less value set, more pre-torque is applied.	S19 = 5 S19 = 4

- The parameters U8, U9, U10 and U11 determine the behaviour of the system in Pre-Torque process.
- Using **weight transducer feedback** is results in smooth starting in gearless machines.

PRE-TORQUE DIGITAL

[S19]	Start Mode
4	Pre-Torque Digital At the moment of zero speed, pre-torque is applied. That could be done either without feedback or by information from digital weight transducer of car.

x% : Car weight at motion start / Car load capacity CL: Car weight at motion start	LS1 %25	LS2 %50	LS3 %75
CL < 25%	0	0	0
25% <= CL < 50%	1	0	0
50% <= CL < 75%	1	1	0
CL > 75%	1	1	1

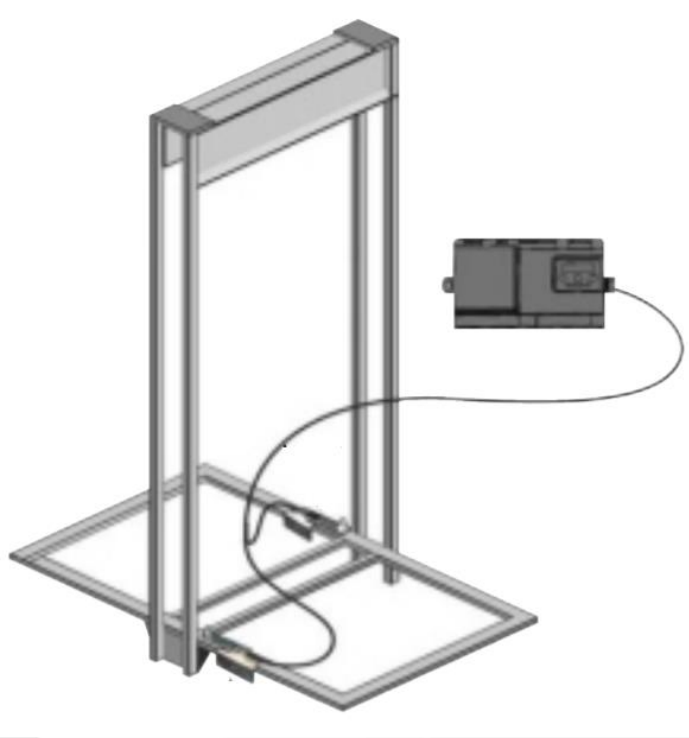
- There are 3 inputs called **LS1**, **LS2** and **LS3** respectively, in order to receive digital information from car weight transducer.
- These inputs should be connected to the digital outputs of weight transducer.
- The outputs of the device should be adjusted as shown in the table.
- If two outputs are used, **LS1, LS2** must be adjusted as **30%** and **70%** respectively.
- If only one output is used, **LS1** must be adjusted as **50%.**

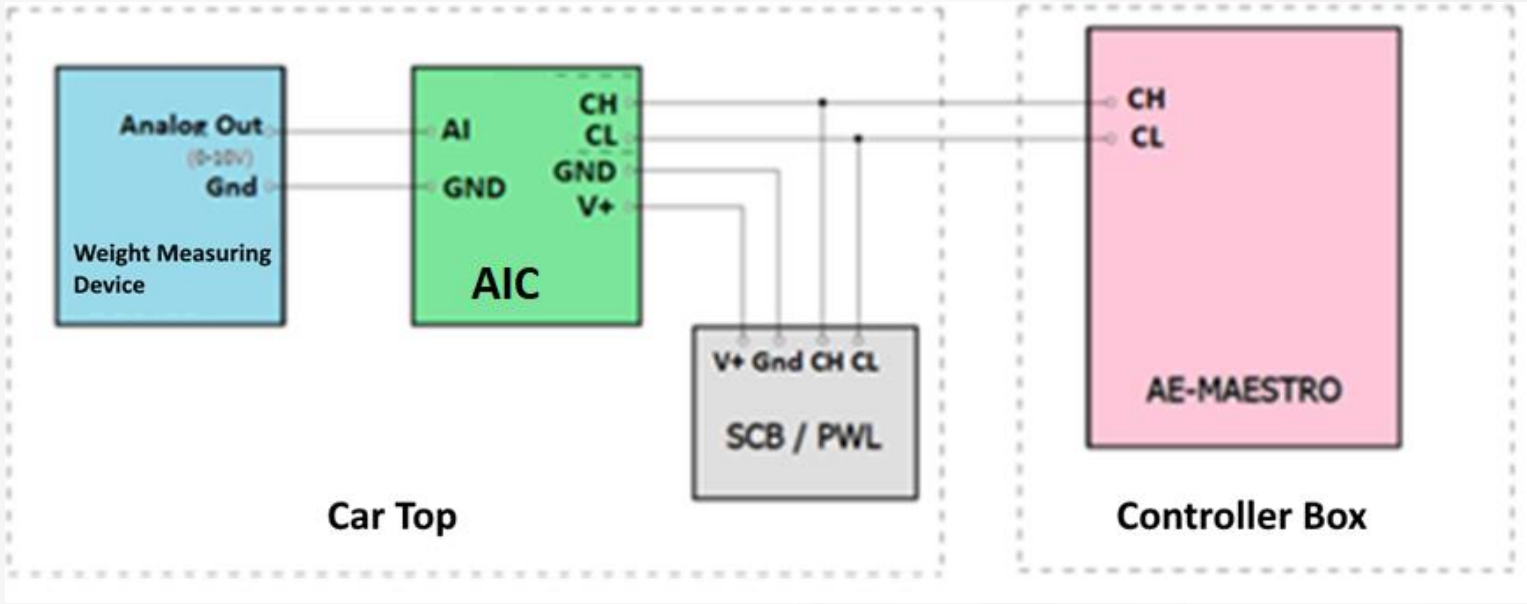
PRE-TORQUE ANALOG

[S19]	Start Mode
5	Pre-Torque Analog At the phase of zero speed, information coming from car weight transducer is processed in pre-torque.

- This is the **best anti rollback method**.
- There must be an analog weight transducer which gives an output proportional to the weight in the cabin.
- Controller applies a pre-torque to fix car position calculated by using analog weight information.
- Any succesfull value of pre-torque is used in future events to prevent rollback.
- So, the controller learns pre-torque levels for various loads in cabin.
- Thus system performance gets better after a series of travels with various loads and no rollback or shift will be observed.

PRE-TORQUE ANALOG FROM CAR

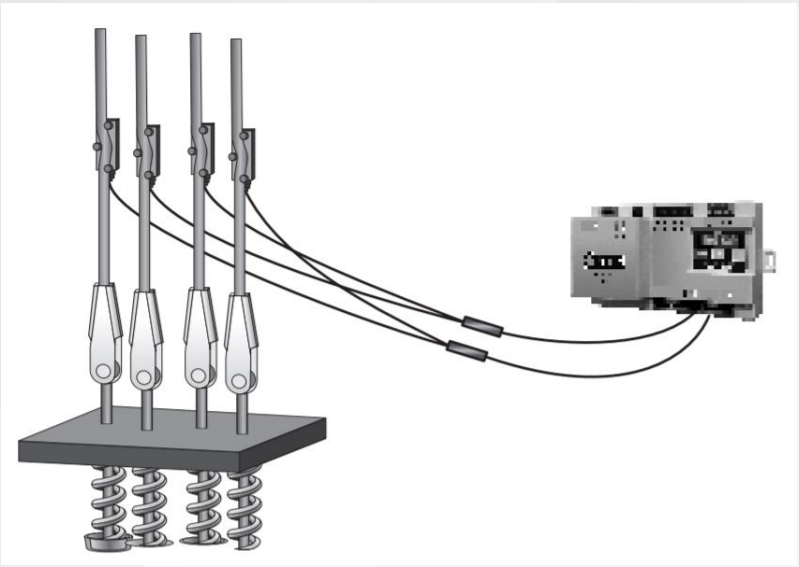


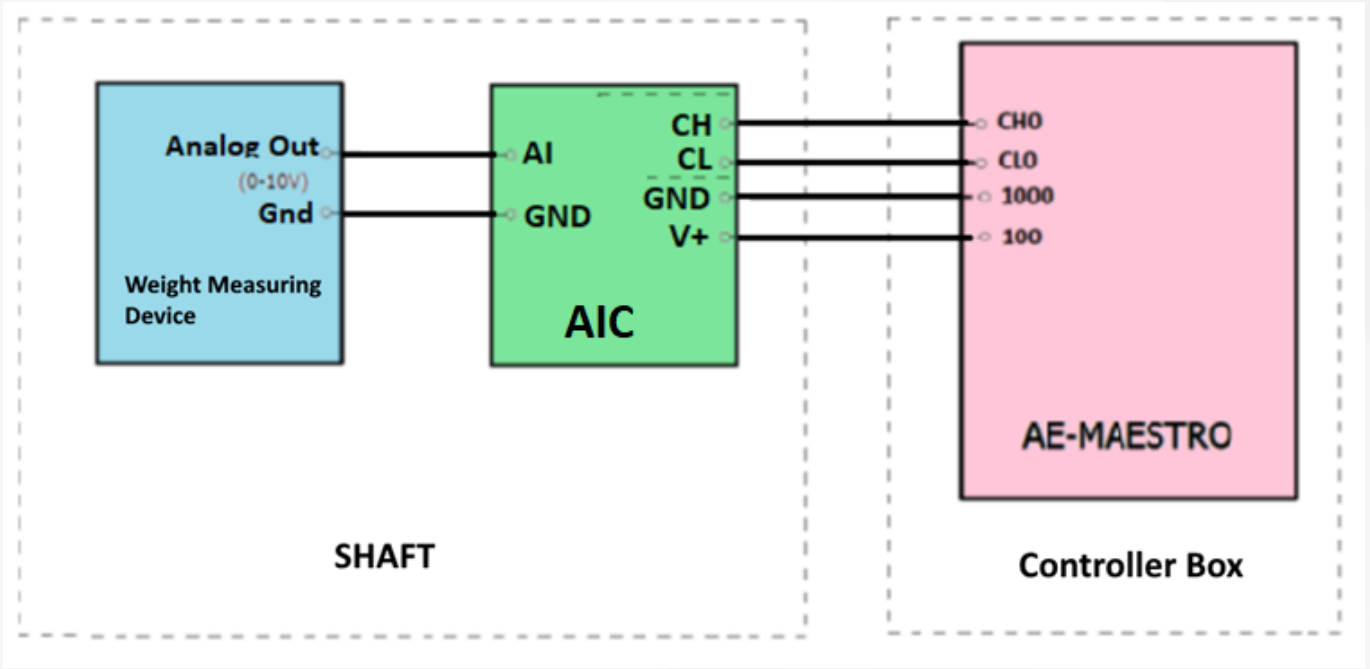


If the weight measurement is done on car frame in analog pre-torque application, **AIC board** must be installed as close as possible to the weight measurement device on the top of car.

AIC is connected to **CAN0**.

PRE-TORQUE ANALOG FROM ROPE

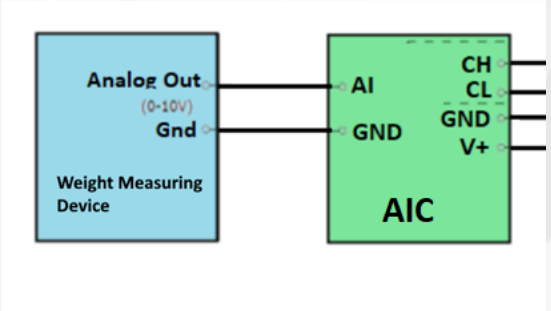


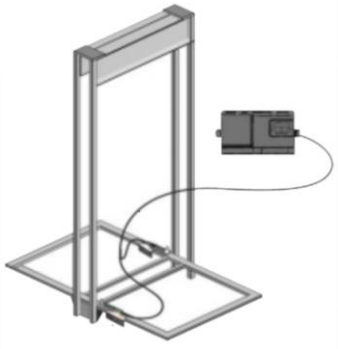


In case of weight measurement from rope in pre-torque application, **AIC board** must be installed near load measurement device on the top of shaft.

AIC is connected to **CAN0**.

HOW TO ADJUST LOAD MEASUREMENT DEVICE



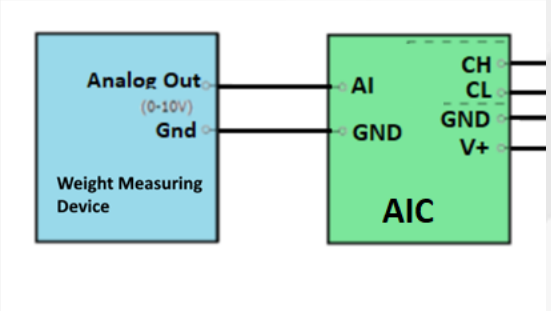


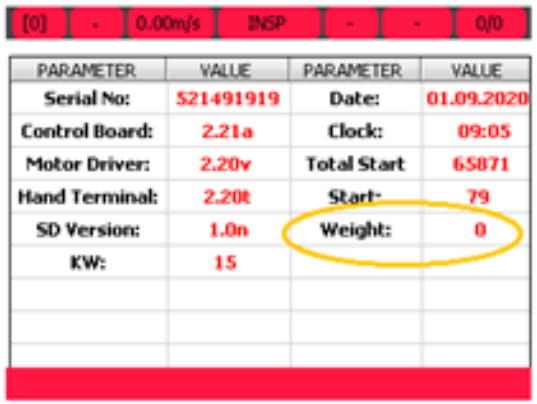
- If **S19=5,** adjustment and installation of the weight measuring device is very important to get a good result.
- **The following steps are important while wiring between load measurement device and CIO interface:**
- CIO Board must be installed near load measurement device.
- Cable between CIO and the device must be as short as possible.
- Connection cable between load measurement device and load cells must not be close to the flex cable.

- **The following adjustment must be performed in sequence :**
- To set to factory default
- To calibrate car weight with 35% load at least or preferablely 50% load.
- When load measurement are done under the cabin then flexible cable must not be connected cabin. It must be connected to the car frame.
- Load calibration must be done at the lowest floor.
- Analog outputs of the device must be activated. (Enter full load value to Analog output menu)

- **After adjustment**:
- The analog output of the device must be 0V at no load, and 10V at full load.

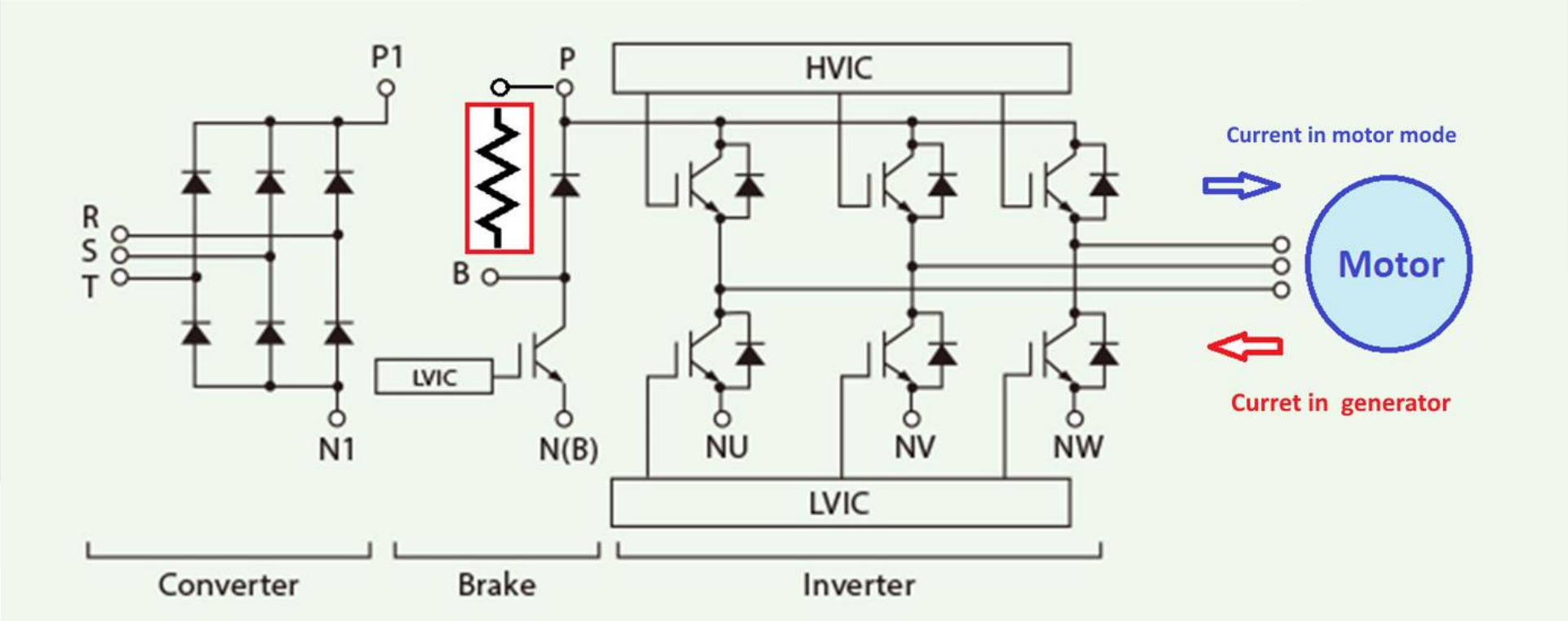
LOAD MEASUREMENT DEVICE ADJUSTMENT





- Pressing ESC button on the hand terminal shows the weight measured by the system (yellow ellipse).
- Weight value on display must be zero when there is no load in cabin.
- It should increase as the load increases and decrease as the load decreases.
- If so, load measurement system can be used for pre-torque.
- After completing installation and adjustment, **Weight chart** must be cleared by using the utility **R19-Clear Load Data** under services menu.
- Parameters **U8, U9 and U10** determines pre-torque process.
- Then weight chart will be filled by different values.
- The system keeps learning pre-torque values for different weights and then pre-torque learned will be applied for next travels.

BRAKING RESISTOR



- In generator mode, motor produces **electric current** and transmits it to **inverter.**
- As a result, dc bus voltage inside the inverter exceeds safe limit of the components.
- The inverter **discharges** this high voltage **into the braking resistor** when DC Bus voltage exceeds a defined limit.
- **An inverter will certainly be damaged if it runs without braking resistor.**
- **An inverter will certainly be damaged if the braking resistor is not connected to the correct terminals.**

BRAKING RESISTOR

- Braking resistor and its power (Watt) varies depending on application and specified in motor driver (Inverter) catalog.
- Braking resistor power should be higher as the motor efficiency is getting higher.
- Thus **braking resistor power for gearless machines should be higher than the ones for geared machine.**
- As the speed of the motor increases, the power of the braking resistors must be increased. Because more energy must be discharged during braking.
- As the number of floors are increasing, the power of the braking resistor must be increased. Because the motor stays longer in generator mode.

BRAKING RESISTOR SELECTION TABLE

3x200V MODELS	4 kW	5,5 kW	7.5 kW	11 kW
Current	18A	25A	32A	45A
Resistor	30 Ω	20 Ω	15 Ω	10 Ω
Minimum Resistor Power Asynchronous Motor (Car speed < 1.6m/s)	1.000 W	1.200 W	1.500 W	2.200 W
Minimum Resistor Power Asynchronous Motor (Car speed ≥ 1.6m/s)	1.500 W	1.800 W	2.250 W	3.300 W
Minimum Resistor Power Synchronous Motor (Car speed < 1.6m/s)	1.500 W	1.800 W	2.250 W	3.300 W
Minimum Resistor Power Synchronous Motor (Car speed ≥ 1.6m/s)	2.000 W	2.400 W	3.000 W	4.400 W
Minimum Resistor Power Synchronous Motor (Car speed ≥ 2.0m/s) (Fan added if Car speed ≥ 2.5m/s)	2.500 W	3.000 W	3.750 W	5.500 W

3x400V MODELS	3 kW	5,5 kW	7.5 kW	11 kW	15 kW	22 kW
Current	7A	13 A	18 A	25A	32A	45A
Resistor	120 Ω	80 Ω	60 Ω	40 Ω	30 Ω	20 Ω
Minimum Resistor Power Asynchronous Motor (Car speed < 1.6m/s)	1.000 W	1.200 W	1.500 W	2.200 W	3.000 W	4.400 W
Minimum Resistor Power Asynchronous Motor (Car speed ≥ 1.6m/s)	1.500 W	1.800 W	2.250 W	3.300 W	4.500 W	6.600 W
Minimum Resistor Power Synchronous Motor (Car speed < 1.6m/s)	1.500 W	1.800 W	2.250 W	3.300 W	4.500 W	6.600 W
Minimum Resistor Power Synchronous Motor (Car speed ≥ 1.6m/s)	2.000 W	2.400 W	3.000 W	4.400 W	6.000 W	8.800 W
Minimum Resistor Power Synchronous Motor (Car speed ≥ 2.0m/s) (Fan added if Car speed ≥ 2.5m/s)	2.500 W	3.000 W	3.750 W	5.500 W	7.500 W	11.000 W

- Braking resistor values for **200V** series and **400V** series are not the same.
- If motor driver current is higher than motor nominal current, then motor current will be the reference for braking resistor calculation.
- Higher valued braking resistor may be applied if a building has more traffic than usual.

DC BUS VOLTAGE – BRAKING RESISTOR

350…770	**[U03] DYNAMIC BRAKE START**	If DC-Bus voltage exceeds the voltage defined in this parameter, then dynamic braking is started.
345…765	**[U04] DYNAMIC BRAKE END**	Dynamic braking is terminated, if dc-bus voltage gets down under the voltage defined in this parameter.
0…6	**[U05] DYNAMIC BRAKE PERIOD**	Frequency of dynamic braking operation. Factory default is 2 (1ms)

- The dc voltage level after which the braking process is activated is determined in parameter **U03** and the voltage level under which the braking process will be terminated is defined in **U04**.
- Values or U03 and U04 are not the same for 200V series and 400V series.
- The values of U03 and U04 are about 700V for 400V series, and about 400V for 200V series.
- When parameter **U07 – Line Voltage** is changed, it is necessary to check parameters **U03** and **U04**.
- U05 is the checking period of dynamic process termination.

DC BUS VOLTAGE – BRAKING VOLTAGE

350…770	**[U03] DYNAMIC BRAKE START**	If DC-Bus voltage exceeds the voltage defined in this parameter, then dynamic braking is started.
345…765	**[U04] DYNAMIC BRAKE END**	Dynamic braking is terminated, if dc-bus voltage gets down under the voltage defined in this parameter.

When to change parameters U03 – U04?

1) If **ERROR 32- HIGH VOLTAGE** arisses.

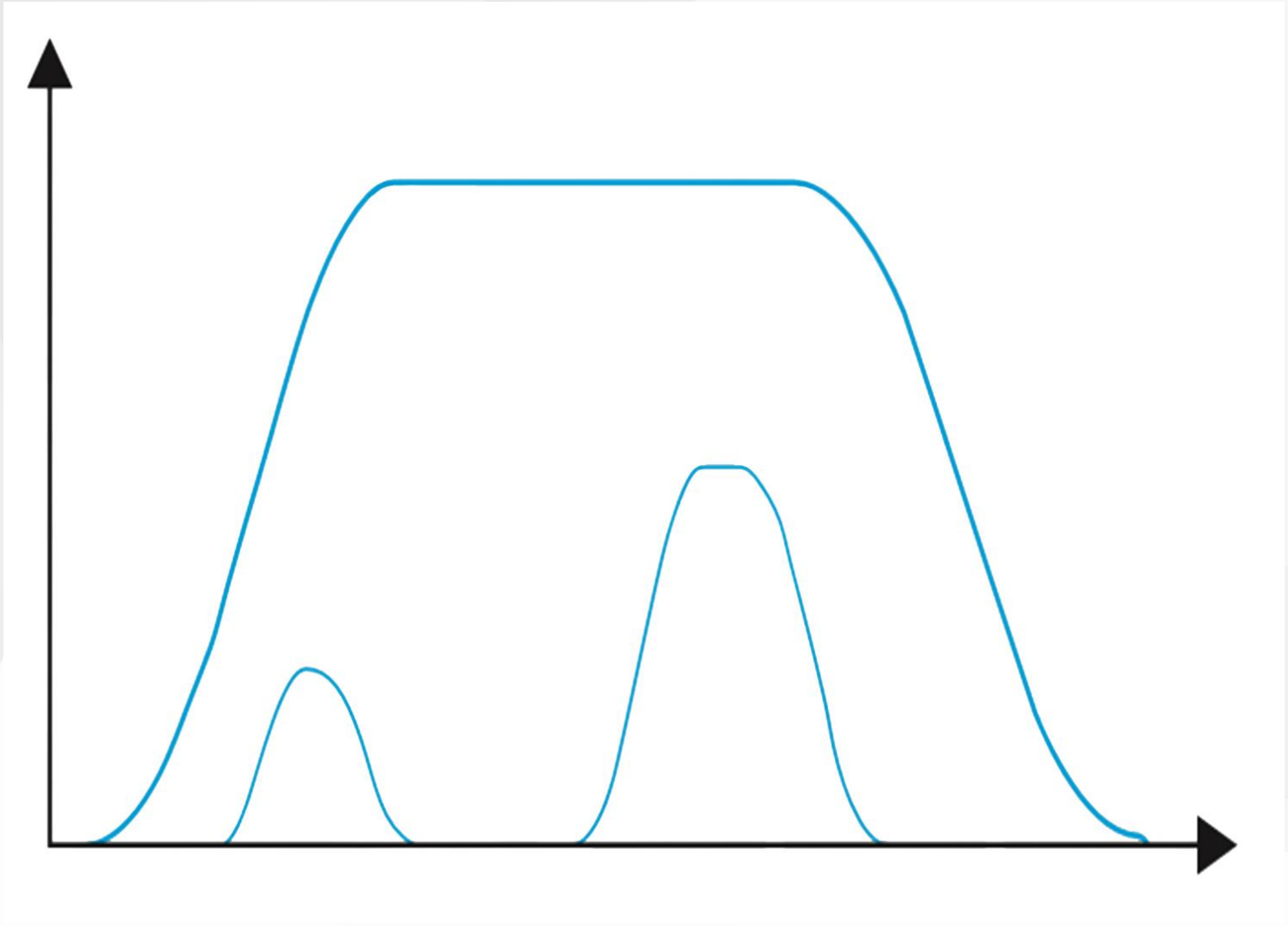
2) **Vibration at motion** is observed while the lift is moving in generator mode. Such as Up motion without load or down motion with full load.

3) Vibration at deceleration phase.

4) If the system is not able to prevent high DC BUS voltage, then braking resistor value and motor current must be checked.

5) If resistor and current are appropriate, then U03 and U04 values should be reduced.

SMART SPEED SYSTEM

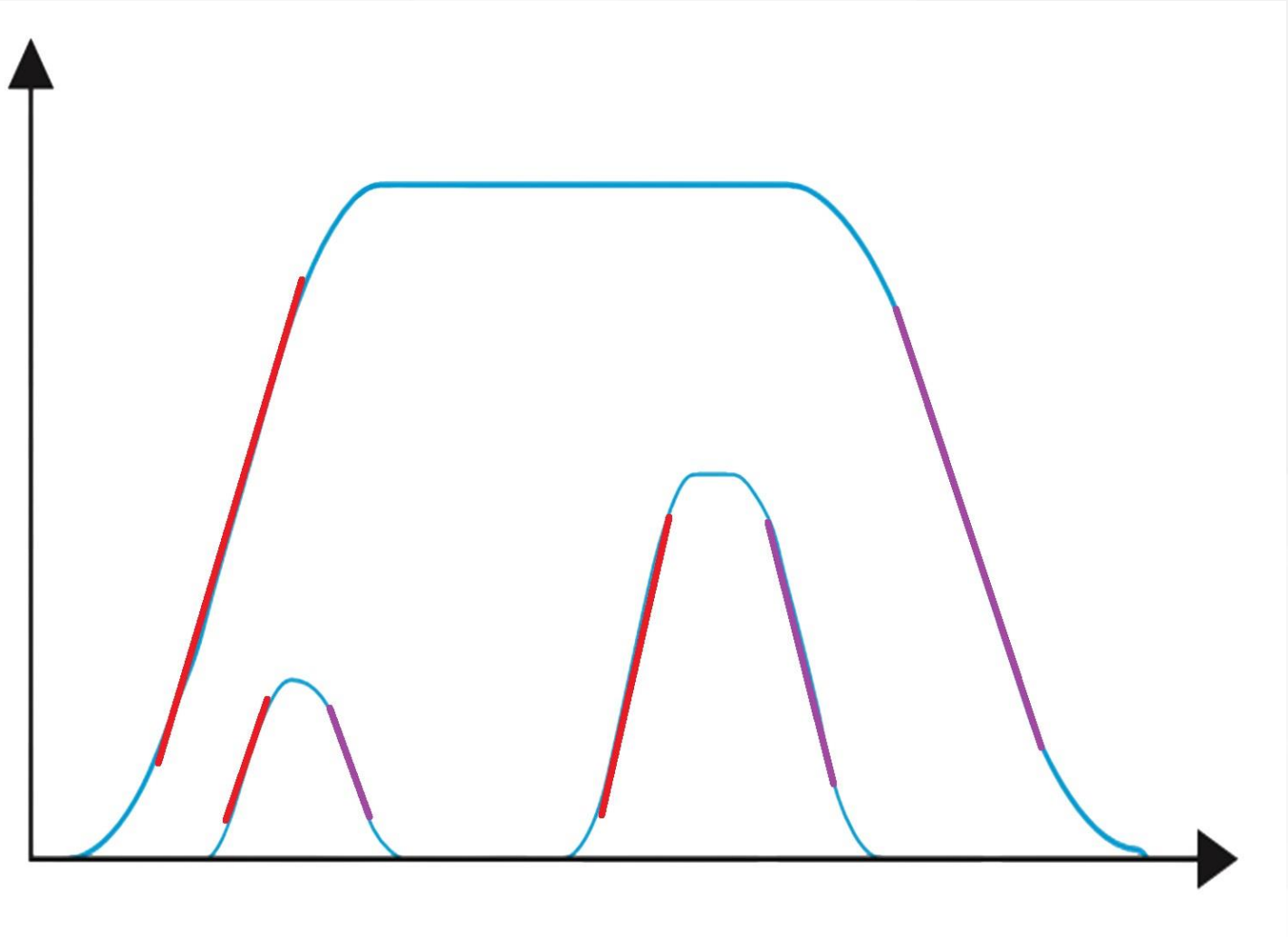


Smart speed system calculates travel speed depending on travel distance.

- **S01 – Nominal Speed** parameter should be given to operate the lift in normal mode.
- The only adjustment necessary is floor levels.
- Smart speed system will be active, when the floor selector is **encoder [A05=2]…[A05=5].**

SMART SPEED SYSTEM

- The lift determines its travel speed depending on the distance to target floor by taking **acceleration and deceleration parameters** into account.
- Interfloor distance and **short floors** does not create a problem.
- Minimum floor to floor distance is just longer than the length of the door open zone.



SWITCH BASED SPEED MANAGEMENT

- Smart speed management will automatically passive, if mono-stable or bi-stable mangetic switches are selected as floor selector.
- Slow down starting point in switch based speed (non-encoder) systems is activated by one magnet in the shaft.
- In monostable system, starting deceleration is triggered by MKU or MKD switches located between floors.
- In bi-stable system, starting deceleration is triggered by M0 switch located between floors.
- Switch based floor selector systems are supported in open loop applications.