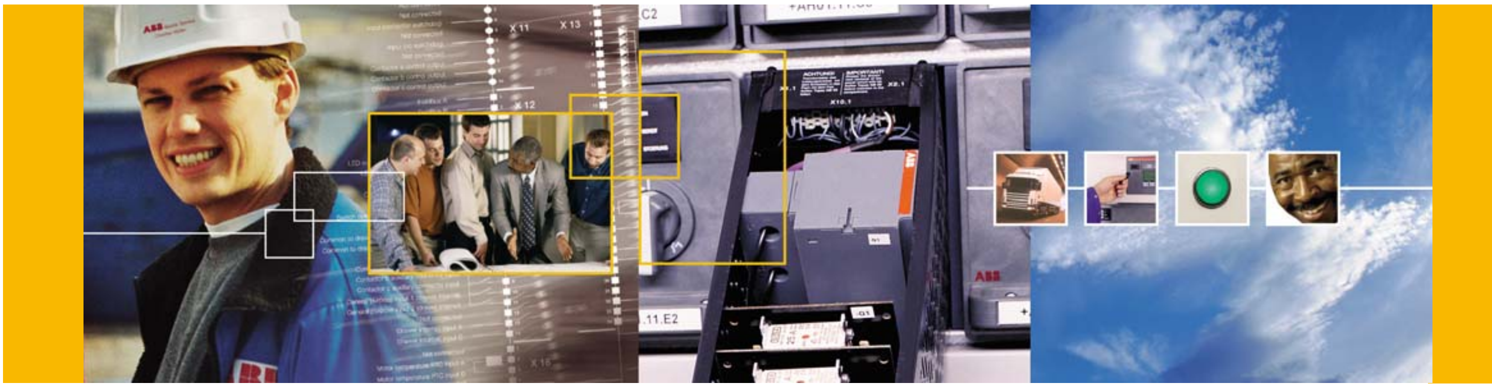
MNS Motor Management INSUM®

MCU Parameter Description
Version 3.0d



INSUM®
MCU Parameter Description

Software Version 3.0d

Reference document 1SCA022641R4170C ABB Control Oy Finland

INSUM® MCU
Parameter Description

Software Version 3.0d

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1 Introduction

1.1 Objective

The objective of this document is to provide a detailed parameter description of the INSUM Motor Control Unit (MCU).

All information refers to INSUM MCU Hardware –4, Software version 3.0d. Before parametering the consistency of software version and documentation should be verified.

Each chapter consists of
- a brief explanation of the function,
- the parameter description along with the range and the default value (factory setting)
- the related parameters
- availability of this parameter for MCU1 and MCU2

Wherever necessary further explanations and examples are given for user's reference.

1.2 Related documentation

1TGC 901007 B0203 INSUM Technical Information
1TGC 901022 M0201 INSUM MCU Users Guide V3.0d
1TGC 901034 M0202 INSUM MMI Operating Instruction V2.3
1TGC 901042 M0202 INSUM Modbus Gateway Manual V2.3
1TGC 901052 M0202 INSUM Profibus Gateway Manual V2.3
1TGC 901060 M0202 INSUM Ethernet Gateway Manual V2.3
1TGC 901080 M0203 INSUM System Clock Manual V2.3
1TGC 901090 M0202 INSUM Control Access Guide V2.3
1TGC 901091 M0202 INSUM Failsafe Guide V2.3
1TGC 901092 M0202 INSUM Dual Redundancy Guide V2.3
1TGC 901093 M0202 INSUM Network Management Guide V2.3

2 Document Overview

2.1 General

The parameterisation of MCU can be performed by using a configuration or paramerization tool (e.g. INSUM MMI or INSUM Operator Station). The motor related parameters and the protection function are to be set based on the motor manufacturer's data sheet. Other parameters of Motor Control Unit are to be carefully selected based on the process and the system requirements.

While changing any parameter, the related parameters that are affected should be noticed by the user and shall be edited if necessary.

2.2 Parameter groups

The parameterisation in the MCU is mainly classified into following functions
Starter Configuration
Analog Output
Motor Data
TOL Protection
Stall Protection
Rotation Monitor
Phase Loss Protection
Unbalance Protection
Underload Protection
Cosphi Underload Protection
Noload Protection
Earthfault Protection
Thermistor Protection
Undervoltage Protection
Start Limitation
Start Interlock
Maintenance
Control Access
System
Device Data
I/O Configuration
General Purpose I/O

These functions are further subdivided into parameters, which need to be set individually. The above functions and its related parameters are covered in each of the subsequent chapters.

3 Starter configuration

Starter configuration function consists of parameters which reflects the configuration of motor feeder. For example the ratings for external current transformers and contactor feedback supervision are included. Parameters involved with the starter configuration function are as below:

Function	Starter configuration
Available parameters	Starter Identifier Starter Type Number Of Phases External CT Installed External CT1 Primary External CT2 Primary External CT Secondary Latched Contactor (NR-DOL, REV-DOL) Actuator Type (Actuator) Feedback Supervision Feedback Delay Feedback Reset Mode Em-Stop Reset Mode MCB Trip Reset Mode External Trip Reset Mode

3.1 Starter Identifier

Function	Starter configuration
MMI text	Starter identifier
Related MCU	1 and 2
Range	SPACE ! " # $ % & ' ( ) * + , - . / 0… 9 : ; < = > ? @ A…Z [\ ] ^ _ ' a…z { | } ~
Default setting	MCC LOCATION
Related parameter	---
Description	see hereunder

The user can give a name for each motor starter (MCU) to simplify addressing and handling. A maximum of 21 characters (ASCII) can be assigned.

3.2 Starter Type (MCU1)

Function	Starter configuration
MMI text	Starter type
Related MCU	1
Range	NR-DOL, REV-DOL, NR-DOL/RCU
Default setting	NR-DOL
Related parameters	Starter configuration / Feedback supervision Motor data / Failsafe status Maintenance / Preset CCx cycles Maintenance / CCx cycles alarm level
Description	see hereunder

MCU supports different kinds of motor connections. This parameter need to be set according to type of control desired for the motor and related starter module equipment.

NR-DOL: Non Reversing Direct On Line.
NR - Non Reversing means that the motor only runs in one direction.

REV-DOL: Reversing Direct On Line.
REV- Reversing means that the motor can run in both directions (clockwise CW, counter clockwise CCW).

NR-DOL-RCU: Non Reversing Direct On Line (remote control of the contactor, bypassing the MCU).
Note! The internal relays CCa and CCb are electrically interlocked.

Following are the starter types explained in detail:

NR-DOL:
NR-DOL is non-reversing direct on line starters.
In "Local" mode, the motor starts and stops when the respective I/O is activated (X13:12 for start and X13:14 for stop).

In "Remote" mode, the motor starts and stops when the respective command (telegram) is sent via the fieldbus.

When a “Start” command is given, the internal relay CCa remains closed until a stop command is given. The internal relay CCb has no function here.

With Latched contactor parameter "Yes", the “Start” command closes the internal relay CCa for 1 sec. Similarly, the internal relay CCc closes for 1sec with a stop command. The type of power contactor in the motor circuits can be either normal or mechanically latched. This starter type along with Latched contactor parameter "Yes" can be used for solenoid starters.

REV-DOL:
REV-DOL is reversing direct on line starters. The motor can be run both directions (clockwise and counter clockwise) and can be stopped.

In Local mode, the motor starts CW/CCW when the respective I/O is activated (X13:12 for CW and X13:13 for CCW). The motor stops when the Stop I/O is activated (X13:14).

In remote mode, the motor starts CW/CCW or stop when the respective command is given via the fieldbus. When “Start CW” command is given, the internal relay CCa remains closed until the stop command is given. The direction of the motor can be changed only after a stop. Similarly, when CCW start command is given, the internal relay CCb remains closed until a stop command. The relay CCc has no function.

With Latched contactor parameter "Yes", the “Start CW” and “Start CCW” command closes the internal relay CCa and CCb for 1sec respectively. The stop command will close relay CCc for 1 sec. The type of power contactor in the motor circuits can be either normal or mechanically latched.

NR-DOL/RCU:
The “Start CW” command closes the internal relay CCa 1sec respectively. The stop command will close relay CCc for 1 sec. The wiring of the self-auxiliary contact across the start command latches the contactor.

Removing the MCU from the starter will not prevent RCU operation depending however on the connection (external relay and/or switch is used for start and stop). The stop pulse issued by the MCU will override the RCU-switch start position.

3.3 Starter Type (MCU2)

Function	Starter configuration
MMI text	Starter type
Related MCU	2
Range	NR-DOL, REV-DOL, NR-DOL/RCU, REV-DOL/RCU, NR-S/D, NR-2N, Actuator and Autotrafo
Default setting	NR-DOL
Related parameters	Maintenance / CCx Cycles Preset, Alarm level Motor data / Failsafe status Starter configuration / Feedback supervision Starter configuration / N2 parameters (NR-2N) Starter configuration / External CT installed (NR-2N) Starter configuration / S/D parameters (NR-S/D) Starter configuration / Latched (NR-DOL, REV-DOL) Starter configuration / Softstart/stop ramp time (NR-DOL, REV-DOL) TOL protection / N2 parameters (NR-2N)
Description	see hereunder

The MCU2 supports more starter types than different kinds of motor connections. This parameter shall be set according to the type of control desired for the motor. For more details refer to Starter type (MCU1).

- NR-DOL: Non Reversing, Direct On Line.
- REV-DOL: Reversing, Direct On Line.
- NR-DOL-RCU: Non Reversing, Direct On Line; remote control of the contactor, bypassing the MCU.
- REV-DOL/RCU: Reversing Direct On Line; remote control of the contactor, bypassing the MCU.
- NR-S/D: Reduced voltage starting in star and running of the motor in delta after meeting the transition conditions.
- REV-S/D: Reversing reduced voltage starting in star and running of the motor in delta after meeting the transition conditions.
- NR-2N: Non-reversible two speed motor.
- REV-2N: Reversible two speed motor.
- ACTUATOR: Reversing starters for applications like valves, dampers, actuators etc.
- Autotrafo: Non-reversible motor starter based on reduced voltage via auto-transformer.

Note: Further details about the starter types are described in the MCU 3.0 Users Guide.

<u>REV-DOL/RCU:</u>
The “Start CW” and “Start CCW” command closes the internal relay CCa and CCb for 1sec respectively. The stop command will close relay CCc for 1 sec. The wiring of the self-auxiliary contact across the start command latches the contactor.
Removing the MCU from the starter will not prevent RCU operation depending however on the connection (external relay and/or switch is used for start and stop). The stop pulse issued by the MCU will override the RCU-switch start position.

Note! The internal relays CCa and CCb are electrically interlocked.

<u>NR-S/D:</u>
Star-delta starters are used mainly to restrict the starting current of a motor due to supply limitations. The motor is started with the winding connected in star and transferred to delta after the "Motor start-up time". The starting at a lower voltage also reduces shocks on the motor coupling, belts and the gear mechanisms. The starting current and the torque is reduced to 1/3 of the DOL value. However, it must be determined whether the reduced motor torque is sufficient to accelerate the load over the whole speed range.

The star to delta changeover can be done based on either “Time” or “Current”. When the changeover is based on “time”, the star to delta transition takes place after the parameterised *Motor start-up time*.

When the changeover is based on "current", the star to delta transition takes place if the current is below the parameterised value *S/D changeover level* for more than 1sec. The *Motor start-up time* is used as the timeout value.

The star to delta switchover is done with a transition time of maximum to ensure quenching of the arc in star operation before it changes over to delta to prevent short-circuit.

The contactor "Feedback Supervision" function must be enabled during star-delta starter type.

During the contactor transitions, the MCU 2 waits until the previous sequence is successfully completed. In case of any contactor failure the feedback supervision trip will open all the contactors.

NR-2N:
Two speed drives are used for applications requiring dual motor outputs. In case of two speed drives there are separate commands for the two speeds. When started by command 'speed1' the contactor CCa is closed and when started by command 'speed2' the contactor CCb is closed. The contactor CCc is used for stopping the motor. Two speed starter can be implemented either as "Dahlander" or "separate winding" starter. When "Dahlander" starter is implemented two contactor control outputs are used, thus one of the two contactors for speed N2 can be left out by masking the alarm from contactor feedback.

Current measurement for two-speed starter uses external current transformer with fixed transformation ratio.

Actuators:
Actuator starters are reversing direct on line starters where the limit switch inputs are used to stop the motor from running further after reaching the respective end positions. When one of the limit switch inputs is active, the motor can be started in another direction only.

Torque switch inputs are additionally used to signal the status of torque switch from the actuator unit and trip the motor. Torque switch provides the means to protect the actuator unit against mechanical damage caused by excessive force, i.e. due to mechanical jam.

Limit and torque switch functionality can be configured by selecting the *Actuator type*.

Autotrafo:
Autotransformer is used in order to reduce motor start current during start condition. While reduced voltage limits the starting current also usable torque is limited significantly. This must be considered carefully when designing starter based autotransformer.

Autotrafo starter uses three contactor control outputs but can be implemented as variant using two outputs, as well.

3.4 Number of Phases

Function	Starter configuration
MMI text	Number of phases
Related MCU	1 and 2
Range	1 phase / 3 phase
Default setting	3 phase
Related parameters	Starter configuration / Starter type Earth fault protection / Method Phase loss protection / Function enable, disable Unbalance protection / Function enable, disable
Description	see hereunder

MCU can handle a single or three phase AC motor. Based on the number of phases of the motor, 1 or 3 can be selected. For single-phase motors, the motor current lead or the CT secondary lead (for > 63 A) is passed through any of the phase window of the MCU internal current transformer. As an alternative, the current can be led through all the current transformer openings.

The phase loss protection is deactivated in MCU for single-phase selection. Single-phase application is practicable with NR-DOL starter type.

Note: Voltage measurement is not available for single-phase configuration.

Table 1. Functions not available for single phase applications.

Function	*MCU1*	*MCU2*
Phase loss protection	Function is disabled	Function is disabled
Unbalance protection	-	Function is disabled
Earth fault protection (Calculated)	-	Function is disabled

3.5 External CT Installed

Function	Starter configuration
MMI text	Ext.CT's installed
Related MCU	1 and 2
Range	No / 1 / 2
Default setting	No
Related parameter	Starter configuration / External CT secondary Motor data / Nominal current Motor data / Nominal current N2 Starter configuration / External CT1 primary Starter configuration / External CT2 primary
Description	see hereunder

The internal current transformer of the MCU can handle currents up to 63 A without an external transformer. However, INSUM allows using one or two external current transformer to handle motor current above 63 A to 6300A. While using external current transformers for Motor current > 63 A, this parameter is set to "1" or "2" thus indicating the number of installed current transformers. Else, the *External CT Primary* and the *External CT Secondary* parameters can not be set.

If *External CT installed* parameter is set to "No" inspite of an additional current transformer, the MCU will assume a false current. Value "1" indicates for one installed CT and transformation ratio is automatically calculated from *External CT1 Primary* and *External CT Secondary* values. For applications with two speed motors there is support by choosing value "2". This defines two separate external current transformers used for different motor windings, i.e. low-speed (N1) and high-speed (N2) with two-speed motors. The number of external CTs are defined with the following rules.

Parameter *External CT installed* value for one speed motor configuration
– is "0" when current in application <63 A
– is "1" when current in application >63 A.

Parameter *External CT installed* value for two speed configuration (NR-2N)
– is "0" when current is <63 A for both winding
– is "1" when current is <63 A for low and >63 A for high current winding
– is "2" when current is >63 A for both low and high current winding.

When two external CTs are selected there is an additional parameter *External CT2 primary* for the second current measurement. This provides possibility for different configurations with two speed starters.

The external current transformer should be of protection class with a composite error of maximum 5% and a saturation factor of at least 10. The secondary burden of the external CT shall be suitably selected based on the length and cross section of the secondary cable, and the CT secondary current rating.

3.6 External CT1 Primary

Function	Starter configuration
MMI text	Ext.CT1 primary
Related MCU	1 and 2
Range	10 (1) 6300 A
Default setting	150 A
Related parameters	Starter configuration / External CT installed Starter configuration / External CT secondary Motor data / Nominal current
Description	see hereunder

While using an external current transformer for motor nominal current > 63 A, the nominal primary current of the external current transformer is defined by this parameter.

Note! External current transformers are considered out of use if *External CT Primary* and *External CT Secondary* parameters has the same value or either has a value zero. That is even when *External CT Installed* is put to “Yes”.

3.7 External CT2 Primary

Function	Starter configuration
MMI text	Ext.CT2 primary
Related MCU	1 and 2
Range	10 (1) 6300 A
Default setting	150 A
Related parameters	Starter configuration / External CT installed Starter configuration / External CT secondary Starter configuration / External CT1 primary Motor data / Nominal current N2
Description	see hereunder

To support different two speed motor or star delta starter implementations MCU have additional parameter *External CT2 primary* for second external current transformer. Functionality of this parameter is according to *External CT1 primary* parameter.

With two speed motor applications and external transformers there are following considerations required between primary current settings.
- In case of one external current transformer, parameter *External CT1 primary* applies for high current measurement.
- In case of two external current transformers parameter *External CT1 primary* is for low and “External CT2 primary” is for high current measurement.

The other implementation, i.e. NR-S/D, using this parameter can utilize external current transformers, if enabled, always in configuration with two CT units.

3.8 External CT Secondary

Function	Starter configuration
MMI text	Ext.CT 1,2 secondary
Related MCU	1 and 2
Range	0.10 (0.01) 3.20 A or 2.0 (0.1) 63.0 A
Default setting	3 A
Related parameters	Starter configuration / External CT installed Starter configuration / External CT1 primary Starter configuration / External CT2 primary Motor data / Nominal current
Description	see hereunder

While using an external current transformer for motor nominal current >63 A, the nominal secondary current of the external current transformer is defined by this parameter.

For example: Motor rating 45 kW, In = 86A with an external current transformer 100/1.
Set *External CT installed* = 1,
Set *External CT primary* = 100A
Set *External CT secondary* = 1A
The range available in the MMI = 50…100 A
Set *Nominal current* = 86A

3.9 Latched Contactor

Function	Starter configuration
MMI text	Latched contactor
Related MCU	2
Range	Enabled / Disabled
Default setting	Disabled
Related parameter	Starter configuration/Starter type (NR-DOL, REV-DOL)
Description	see hereunder

Latched contactor is an extension to DOL starter type and is used when pulses drive the contactors. The start and stop is achieved by means of latching and unlatching of the contactor mechanically. The NR-DOL starters make use of relay CCA and CCC to give the start and the stop commands respectively. The REV-DOL starters make use of relay CCA, CCB and CCC for CW, CCW and Stop respectively. The length of the pulse is 1-sec duration. Solenoid starters can be handled as single phase DOL with normal or latched contactors.

3.10 Actuator type

Function	Starter configuration
MMI text	Actuator type
Related MCU	2
Range	Configuration 1 … Configuration 10
Default setting	1
Related parameter	Starter configuration / Starter type
Description	see hereunder

This parameter is used along with the actuator starter type.

Limit and torque switch operation is dedicated to the direction of an actuator unit. When a limit or torque input activates the corresponding direction of control is interlocked and function is stopped, tripped or started according to actual settings. See table below for functionality of actuator type.

Limit inputs 1and 2 are coupled from physical inputs X13:18 and X13:19. Limit switch shall be connected when actuator is controlled and functionality is selected by parameter.

Torque inputs 1 and 2 are coupled from physical inputs X13:20 (X14:9) and X13:21 (X14:10) correspondingly. If only a single torque switch for Open and Close direction is available, the switch has to be connected to CFC (torque 1) and Actuator type 10 must be selected.

Note: For actuator starter type recommended value for *Feedback delay* is < 150 ms. For very critical actuator unit stall protection shall be used as a backup torque supervision.

Table 2. Functionality according to limit and torque input(s).

Actuator Configuration	**Limit1** **X13:20**	**Limit2** **X13:19**	**Torque1** **X13:20 (X14:9)**	**Torque2** **X13:21 (X14:10)**	**Torque1** **X13:20 (X14:9)**	**Torque2** **X13:21 (X14:10)**
	Open position	Close position	Open position[1)]	Close position[1)]	Open travel[2)]	Close travel[2)]
1	Stop	Stop	Not relevant	Not relevant	Not relevant	Not relevant
2	Stop	Return[3)]	Not relevant	Not relevant	Not relevant	Not relevant
3	Return[3)]	Stop	Not relevant	Not relevant	Not relevant	Not relevant
4	Stop	Stop	Not relevant	Not relevant	Trip	Trip
5	Stop	Return[3)]	Not relevant	Not relevant	Trip	Trip
6	Return[3)]	Stop	Not relevant	Not relevant	Trip	Trip
7	TORQUE1[4)]	TORQUE2[4)]	Stop	Stop	Trip	Trip
8	Stop	TORQUE2[4)]	Not relevant	Stop	Trip	Trip
9	TORQUE1[4)]	Stop	Stop	Not relevant	Trip	Trip
10	TORQUE1[5)]	TORQUE1[5)]	Stop[5)]	Not relevant	Trip	Not relevant

[1)] Open (and close) position of torque switch is always indicated by the corresponding limit switch (when active).
[2)] Open (and close) position of torque in travel is always an activated torque switch alone, meaning actuator in the middle of transition area at the time of input actives.
[3)] Return is an automatic control function, which is activated when the tagged input has been activated.
[4)] If torque (1 or 2) is activated after corresponding limit switch only the limit switch position is indicated and actuator is stopped.
[5)] TORQUE1 reads the state of single torque switch output (combined open and close state).

3.11 Feedback Supervision

Function	Starter configuration
MMI text	Feedback supervision
Related MCU	1 and 2
Range	Enabled / Disabled / Trip only / Alarm only
Default setting	Enabled
Related parameter	Starter configuration / Feedback delay Starter configuration / Starter type I/O configurations
Description	see hereunder

This parameter helps to identify contactor faults such as welding of contacts or burn out of coil. If the parameter is set to ‘Disabled’, then the feedback signal from the contactors are ignored.

If the parameter is set to 'Enabled', the contactor signals are evaluated according to the starter type chosen. The feedback supervision cyclically checks the status of contactor auxiliary contact and if contactor transition is not fulfilled in time set by *Feedback delay*, an alarm or trip will be indicated. Only alarm and trip indication can be selected with this parameter. When alarm only is selected supervision will not give trip and respectively, if trip only is selected alarm indication is not issued but trip activates with indication, in a fault situation.

In case of a difference between the MCU control command and
- the contactor auxiliary status while current is detected, a 'Feedback alarm CFx' is issued
- the contactor auxiliary status while current is not detected, a 'Feedback trip CFx' is issued and the contactor tripping will occur.

If open command (stop) is given and (motor) current, inspite of that, can still be detected, the contactor watchdog will be activated and "Motor still running" trip is issued.

In case of MCU1 and MCU2 with starter type NR-DOL/RCU and MCU2 with starter type NR-S/D, NR-DOL/RCU, and REV-DOL/RCU, the feedback supervision must always be enabled.

Note: All RCU type starters use feedback supervision even being disabled by parameter. Feedback signalling from contactor auxiliary contacts shall be connected.

3.12 Feedback Delay

Function	Starter configuration
MMI text	Feedback delay
Related MCU	1 and 2
Range	100 (25) 5000 ms
Default setting	150 ms
Related parameter	Starter configuration / Feedback supervision
Description	see hereunder

This parameter defines the time for contactor to execute transition open to close or close to open. Feedback delay timer activates from the command to operate output relay and counts up to parameterised *Feedback delay* time. During that time contactor transition must be detected in respective feedback input (CFx), terminals X14:7 - X14:9, otherwise an alarm or trip indication occurs to inform of the control failure.

3.13 Feedback Reset Mode

Function	Starter configuration
MMI text	Feedback reset mode
Related MCU	1 and 2
Range	Auto / Remote / Local / Remote & Local
Default setting	Remote & Local
Related parameter	Starter configuration/Feedback supervision
Description	see hereunder

The 'Feedback trip CFx' can be reset from various locations.

Auto: The 'Feedback trip CFx' is reset automatically on restoration of normal condition.

Remote reset: Trip reset is only possible via the fieldbus (MMI, PCS via GW or OS).
Local reset: Trip reset is only possible via the device I/O. By operating "RESET" switch connected to terminal X13:15 resets the trip in the local mode. The local mode is activated with terminal X13:16.

3.14 Em-Stop Reset Mode

Function	Starter configuration
MMI text	Em-Stop reset mode
Related MCU	1 and 2
Range	Auto / Remote / Local / Remote & Local
Default setting	Remote & Local
Related parameter	---
Description	see hereunder

The emergency stop command to the MCU, terminal X13:17, will trip the motor with a message 'Em-Stop Activated'. With this reset mode parameter the required reset is selected.

Auto: The "Em-Stop Activated" trip is reset automatically on restoration of normal condition.

Remote: The "Em-Stop Activated" trip can be reset via the fieldbus (MMI, PCS via GW or OS) on restoration of normal condition.

Local: The 'Em-Stop Activated' trip reset is only possible via the device I/O. By operating "RESET" switch connected to terminal X13: 15 resets the trip in the local mode. The local mode is activated with terminal X13: 16.

Note: MCU Em-Stop inputs are only for annunciation. The primary protection function has to be realised according to national standards.

3.15 MCB Reset Mode

Function	Starter configuration
MMI text	Ext.trip reset mode
Related MCU	1 and 2
Range	Auto / Remote / Local / Remote & Local
Default setting	Auto
Related parameter	Starter configuration / External trip
Description	see hereunder

When the MCB input (Terminal no. X14:06) is activated, a "MCB trip" message is sent to the fieldbus and the contactor is tripped. This parameter defines the reset mode for MCB trip.

Auto: The "MCB trip" is reset automatically on closing the MCB.
Remote: The "MCB trip" can be reset via the fieldbus (MMI, PCS via GW or OS) on closing the MCB.

Local: The "MCB trip" reset is only possible via the device I/O. By operating "RESET" switch connected to terminal X13:15 resets the trip in the local mode. The local mode is activated with terminal X13:16.

3.16 External Trip Reset Mode

Function	Starter configuration
MMI text	Ext.trip reset mode
Related MCU	1 and 2
Range	Auto / Remote / Local / Remote & Local
Default setting	Auto
Related parameter	Starter configuration / External trip
Description	see hereunder

When the external trip input (Terminal no. X14:03) is activated, a "External trip" message is sent to the fieldbus and the contactor is tripped. The external trip reset mode parameter defines the way the trip is reset.

Auto: The “External trip” is reset automatically when input restores to normal condition.

Remote: The “External trip” can be reset via the fieldbus (MMI, PCS via GW or OS) after restoring to the normal condition.

Local: The “External trip” reset is only possible via the device I/O. By operating “RESET” switch connected to terminal X13:15 resets the trip in the local mode. The local mode is activated with terminal X13:16.

4 Analog output

MCU2 (Hardware –4) provides analog output for connection of an analog panel meter. Analog output is located on terminal X13:24. With this output the highest measured phase current can be indicated via panel meter.

Parameters involved with the analog output function are as below:

Function	Analog output
Available parameters	Range Full Scale

4.1 Range

Function	Analog output
MMI text	Range
Related MCU	2
Range	Disabled; 0…20 mA; 4…20 mA
Default setting	Disabled
Related parameter	Analog output/ Full scale
Description	See hereunder

The *Range* defines physical output current according to the full scale. If *Range* is disabled *Full scale* parameter is not available.

4.2 Full scale

Function	Analog output
MMI text	Full scale
Related MCU	2
Range	1.0 (0.1) 8.0 x In
Default setting	1.5
Related parameter	Analog output/ Range
Description	See hereunder

Full scale defines the maximum current provided by the analog output.
As an example:

The analog output *Range* is set either to 0...20 mA (equation 1) or 4...20 mA (equation 2) and analog output current (ANALOGOUT) can be calculated:

Equation 1. $$\mathrm{ANALOGOUT}[\mathrm{mA}] = \frac{\left(I_{Lmax}/In\right)}{\textit{Full scale}} \times 20\,\mathrm{mA}$$

Equation 2. $$\mathrm{ANALOGOUT}[\mathrm{mA}] = \left(\frac{\left(I_{Lmax}/In\right)}{\textit{Full scale}} \times 16\,\mathrm{mA}\right) + 4\,\mathrm{mA}$$

where ANALOGOUT is maximum 20 mA.

5 Motor data

Motor data consist of parameters related closely to motor protection settings. For example: Motor *Nominal current*, *Trip class* and *Ambient temperature* parameters of this function are used for calculating thermal capacity to protect the motor through TOL protection function.

Parameters involved with the motor data function are as below:

Function	Motor Data
Available parameters	Motor Identifier 1 Motor Identifier 2 Nominal Current Nominal Current N2 (NR-2N) Start-up I Ratio Start-up I Ratio N2 Motor Start-up Time Motor Start-up Time N2 (NR-2N) Autotrafo Start Time (Autotransformer) S/D Changeover Basis (NR-S/D) S/D Changeover Level (NR-S/D) Softstart Ramp Time (NR-DOL, REV-DOL) Softstop Ramp Time (NR-DOL, REV-DOL) Motor Ambient Temperature Failsafe Status

5.1 Motor Identifier 1

Function	Motor data
MMI text	Motor identifier 1
Related MCU	1 and 2
Range	SPACE ! " # $ % & ' ( ) * + , - . / 0… 9 : ; < = > ? @ A…Z [\ ] ^ _ ' a…z { | } ~
Default setting	MOTOR TAG NUMBER
Related parameter	---
Description	see hereunder

The user can assign 21 characters (ASCII) to describe the location or function of the motor.

5.2 Motor Identifier 2

Function	Motor data
MMI text	Motor identifier 2
Related MCU	1 and 2
Range	SPACE ! " # $ % & ' ( ) * + , - . / 0… 9 : ; < = > ? @ A…Z [\ ] ^ _ ' a…z { | } ~
Default setting	MOTOR DESCRIPTION
Related parameter	---
Description	see hereunder

The user can give 21 characters (ASCII) to further identify the motor.

INSUM allows four ways of identifying a motor; one starter identifier, two motor identifiers and by LON address of the device. The user can address the motor in relation to the process, switchgear, KKS number etc. with the help of these identifiers.

Example:	Conveyor belt	- Starter identifier
	KKS no....	- Motor identifier1
	MCC-19BFA	- Motor identifier2
	0/1/32...	- LON address (domain/subnet/node)

Additionally, the visualisation at the MMI, OS, and PCS can be done using any of these four alternatives.

5.3 Nominal current

Function	Motor data
MMI text	Nominal current / Nominal current N2
Related MCU	1 and 2
Range	0.10 (0.01) 3.20 A, 2.0 (0.1) 63.0 A, and 0.1 (0.1) 1.0 Iprim
Default setting	3.2 A
Related parameters	Starter configuration / External CT parameters
Description	see hereunder

This is the rated current (In) of the motor, at rated load, at rated voltage and frequency. The value is given on the motor rating plate. The MCU automatically detects which of the internal CTs is connected, and the range is displayed accordingly. The rated current can be set within this range.

In the case of starter with external current transformers, the range is dependent on the nominal primary current of the current transformer. The range varies from 0.1 to 1.0 of CT nominal primary current.

Example: In the case of an external current transformer of 100/*A, the range varies from 10 to 100 A. The nominal motor current can be set within this range.

5.4 Nominal Current N2

Function	Motor data
MMI text	Nominal current N2
Related MCU	2
Range	0.10 (0.01) 3.20 A, 2.0 (0.1) 63.0 A, and 0.1 (0.1) 1.0 Iprim
Default setting	3.2 A
Related parameters	Starter configuration / Starter type (NR-2N) Starter configuration / External CT parameters
Description	see hereunder

This parameter is used along with the two speed starter types. It is the rated current In of the motor for speed N2 (In2), at rated load, at rated voltage and frequency. The value is given on the motor rating plate. The current N2 shall be within the current range.

5.5 Start-up I Ratio

Function	Motor data
MMI text	Start-up I ratio / Start-up I ratio N1
Related MCU	1 and 2
Range	1.0 (0.1) 10.0
Default setting	2.0
Related parameter	Starter configuration / Starter type Motor data / Nominal current Motor data / Motor start-up time TOL protection / Trip class TOL protection / TOL alarm
Description	see hereunder

This parameter is a setting of the ratio between the start-up current and the nominal current (Is/In).

When a motor starts, it draws a high current of the order of 6 to 8 times the nominal current (In). The motor start-up current varies from one motor to another and may differ from manufacturer to manufacturer. This data along with *Motor start-up time* (ts) is essential for the relay, as this represents the design and construction of the motor largely, thereby deciding the thermal capacity required by the motor during start-up.

The *Start-up I ratio*, *Motor start-up time* and *Trip class* decide the start-up inhibit level; below which a successful start of the motor can be made.

The start-up inhibit level is a read only parameter in the Device Data section.

5.6 Start-up I Ratio N2

Function	Motor data
MMI text	Start-up I ratio N2
Related MCU	2
Range	1.0 (0.1) 10.0
Default setting	2.0
Related parameter	Starter configuration / Starter type (NR-2N) Motor data / Start-up I ratio TOL protection / TOL alarm
Description	see hereunder

This parameter allows setting of the start-up current ratio (Is2/In2) between the two-speed motor start-up current (Is2) and motor nominal current (In2).

Also refer to *Start-up I ratio*.

5.7 Motor Start-up Time

Function	Motor data
MMI text	Motor start-up time / Motor start-up time N1 / S/D changeover time
Related MCU	1 and 2
Range	1 (1) 600 s
Default setting	5.0 s
Related parameter	Starter configuration / Starter type (all) Motor data / Start-up I ratio Motor data / Nominal current Motor data / S/D changeover basis TOL protection / TOL alarm Unbalance protection / Function enable, disable Phase loss protection / Function enable, disable Rotation monitor / Function enable, disable Earth fault protection / Function enable, disable Stall protection / Function enable, disable Cosphi underload protection / Function enable, disable
Description	see hereunder

Motor start-up time (t_s) parameter is used to define the maximum start-up time for the motor. It is the time that is required for the motor to complete its starting sequence. The starting sequence is said to be complete, when the start-up current reaches 1.25 times the *Nominal current*.

This parameter along with the *Start-up I ratio* and *Trip class* decides the start-up inhibit level.

This parameter defines the length of time for the start-up phase of the motor during which a set of functions or protections are disabled. The disabled functions are listed in the table.

Table 3. Functions which are disabled during *Motor start-up time*.

Function	*MCU1*	*MCU2*
"O/L alarm" message	Alarm is not issued	Alarm is not issued
Stall protection	Protection is disabled	Protection is disabled
Phase loss protection [1]	Protection is disabled	Protection is disabled
Unbalance protection	-	Protection is disabled
Cosphi underload protection	-	Protection is disabled

[1]) If motor startup current is over 1.5 times of parameterised motor nominal current (Inom) in motor start up phase then Phase loss protection is not disabled (blocked out) by parameters Motor startup time / Motor startup time N2 / Softstart ramp time.

Please note:
The parameter is used as switching time for starter type NR-S/D.

5.8 Motor Start-up Time N2

Function	Motor data
MMI text	Motor start-up time N2
Related MCU	2
Range	1 (1) 600 s
Default setting	5.0 s
Related parameter	Motor data / Motor start-up time Starter configuration / Starter type (NR-2N) TOL protection / TOL alarm
Description	see hereunder

This parameter is like *Motor start-up time* (t_s) but dedicated for speed N2 (t_{s2}). During this time protection functions defined for *Motor start-up time* are disabled (see table 3 on page 23).

5.9 Autotrafo Start Time

Function	Motor data
MMI text	Autotrafo start time
Related MCU	2
Range	0 (1) 5 sec
Default setting	5.0 s
Related parameter	Starter configuration / Starter type (Autotransformer) Underload protection / Function enable, disable
Description	see hereunder

This parameter is used along with autotransformer starter type. It defines the time that motor is running with reduced voltage. When this time is elapsed motor is connected to direct line voltage.

Table 4. Functions not available during *Autotrafo start time*.

Function	*MCU2*
Underload protection	Function is disabled

5.10 S/D Changeover Basis

Function	Motor data
MMI text	S/D changeover basis
Related MCU	2
Range	Time / Current
Default setting	Current
Related parameter	Starter configuration / Starter type (NR-S/D) Motor data / S/D changeoverlevel Motor data / Motor start-up time
Description	see hereunder

The star to delta changeover can be done based on either "current" or "time". When the selected *S/D changeover basis* is "time", the star to delta transition takes place after a pre-parameterised motor start-up time. When the selected *S/D changeover basis* is "current", the star to delta transition takes place after the start-up current reaches a pre-defined value. Current must go down from higher (inrush) to lower current.

5.11 S/D Changeover Level

Function	Motor data
MMI text	S/D changeover level
Related MCU	2
Range	10 (10) 100%
Default setting	80 %
Related parameter	Motor data / S/D changeover basis Starter configuration / Starter type (NR-S/D) Motor data / Motor start-up time
Description	see hereunder

When the measured current is used as criteria for S/D switching condition, it is compared against the parameterised changeover current value. The switchover from star to delta is executed when the current remains below the parameterised value for a time longer than a fixed 1s delay. The current value is parameterised in proportion to the motor nominal current. The *Motor start-up time* is used as the timeout value after which the contactor opens with a message "Stall trip" indicating S/D changeover failure.

5.12 Softstart Ramp Time

Function	Motor data
MMI text	Softstart ramp time
Related MCU	2
Range	0 (1) 1200 s
Default setting	0 s
Related parameter	Starter configuration / Starter type (NR-DOL, REV-DOL) Motor data / Softstop ramp time Phase loss protection / Function enable, disable Unbalance protection / Function enable, disable Earth fault protection / Function enable, disable Underload protection / Function enable, disable Cosphi underload protection / Function enable, disable
Description	see hereunder

This parameter must be used when MCU is controlling motor via a softstarter unit. Softstarter unit is a separate unit limiting the voltage during motor start thus limiting also inrush current.
Softstarter unit has a set of parameters for the start and stop of the motor. MCU is adapted to start ramp time by setting the *Softstart ramp time* ≥ selected start ramp time of the motor.
Upon this parameter the listed protection functions are deactivated:

Table 5. Functions not available during *Softstart ramp time*.

Function	*MCU1*	*MCU2*
Phase loss protection [1]	Function is disabled	Function is disabled
Underload protection	Function is disabled	Function is disabled
Cosphi underload protection	-	Function is disabled

[1]) If motor startup current is over 1.5 times of parameterised motor nominal current (Inom) in motor start up phase then Phase loss protection is not disabled (blocked out) by parameters Motor startup time / Motor startup time N2 / Softstart ramp time.

MCU2 will give start/stop commands to the softstarter. The motor protection is done by the softstarter.

Please note:
MCU unit alone will not act as a softstarter unit when *Softstart ramp time* or *Softstop ramp time* parameters has been set. A softstarter is always needed for this functionality.
The accuracy of the current measurement is affected by the harmonics caused by the soft starters. This may harm especially the earth fault detection based on vector sum method (calculation).

5.13 Softstop Ramp Time

Function	Motor data
MMI text	Softstop ramp time
Related MCU	2
Range	0 (1) 1200 s
Default setting	0 s
Related parameter	Starter configuration / Starter type (NR-DOL, REV-DOL) Motor data / Softstart ramp time
Description	see hereunder

Softstarter unit has a parameter which is used to select the stop ramp time of the motor. MCU is adapted to this stop time by setting the *Softstop ramp time* ≥ selected stop ramp time of the motor.

Within the time defined by this parameter the listed functions are deactivated:
– “Motor still running” trip

5.14 Motor Ambient Temperature

Function	Motor data
MMI text	Motor ambient temp.
Related MCU	1 and 2
Range	+30 (5) 80 °C
Default setting	+40 °C
Related parameter	TOL protection / Thermal model Motor data / Nominal current TOL protection / Trip class TOL protection / Trip class te time TOL protection / TOL, and O/L Alarm
Description	see hereunder

Motors of basic design are intended for operation in a maximum ambient temperature (T_{AMB}) of 40°C. If a motor is to be operated in higher ambient temperature, it should normally be derated and should not be loaded to the same thermal capacity. Normally this reduction of output power is done automatically by MCU but it is also possible to do it manually which is instructed later in this chapter.

To calculate the thermal image of the motor being protected, the MCU needs to know the temperature of the environment in which the motor is running. Especially in industries, where the motors are located near the heat source, the maximum thermal capacity level of the motor is reduced based on the increased surrounding temperature.

Motors designed for EEx e applications are always rated and certified for a certain maximum ambient temperature, most commonly 40°C. If EEx e motor is designed for other temperature manufacturer will supply the motor rated data.

Because of the nature of EEx e motor the output power ratings are not reduced automatically according to ambient temperature by MCU. Instead of using ambient temperature parameter MCU uses fixed value 40°C, thus multiplier is one (1) when TOL EEx e model is selected.

Table 6. The MCU reduces the maximum permitted current by the multiplier as indicated in the table below (TOL standard model).

Ambient temp. °C	40	45	50	55	60	65	70	75	80	**Ambient temp. °C**
Permitted current = In x	1,00	0,96	0,92	0,87	0,82	0,74	0,65	0,58	0,50	**Permitted output, % of rated output**

For example: The thermal capacity level of the motor reduces from 100% at 40°C to 85% at 50°C. Therefore, the motor can be loaded maximum to 92% of its rated load at 50°C.

Manual reduction may be needed if other reduction multiplier than presented in the table above are required. Output power reduction is done by setting the value 40°C to parameter motor ambient temperature and calculating the temperature reduction directly to nominal current. When multiplier is calculated this way it must be applied to trip class time as well (Is/TFLC).

For example: Motor data sheet specifies that in 60°C motor can be loaded maximum of 75% of the nominal. Thus *Motor ambient temperature* is set to 40°C and when setting the *Nominal current* the rated motor current is derated,

Nominal current = 0.75xIn

When nominal current is derated *Trip class* parameter is defined with the same factor. It should also be considered that other parameter's, i.e. protection function trip and alarm levels, referring to *Nominal current* parameter are effected relatively.

5.15 Failsafe Status

Function	Motor data
MMI text	Failsafe status
Related MCU	1 and 2
Range	Start / Start CW / Start CCW / Stop / NOP (No operation)
Default setting	NOP
Related parameter	Starter configuration / Starter type System / Failsafe timeout ICU devices (MMI, OS, GW) / Failsafe heartbeat, Failsafe timeout
Description	see hereunder

INSUM offers a failsafe function where the user has the possibility to decide motor status after a failure either in MCU communication or PCS communication to INSUM.

If the communication to a PCS is disturbed the ICU devices will initiate the failsafe command and all MCU will execute the pre-parameterized command.

If the MCU detects a failure in communication, the command is executed after a pre-parameterised failsafe timeout.

Depending on the heartbeat parameterisation, a break in the communication shorter than Failsafe timeout is accepted with no activation of failsafe function.

Refer to 'INSUM Failsafe Guide' for more information.

6 Thermal Overload Protection (TOL)

INSUM MCU protects the motor by calculating the thermal image of the motor both during running and stop. This image is used to allow optimal performance of the motor with calculated time to restart and time to trip.

The thermal image is calculated based on the highest of the three measured phase currents and depends on the parameterised data such as *Trip class* (t6), *Motor ambient temperature* (T_{AMB}), *Motor start-up I ratio* (I_s/I_n), *Motor start-up time* (t_s) and *Cool down time factor* (Mt6).

Motor ambient temperature is taken into account for thermal image calculation by means of a device internal parameter TFLC. Where, TFLC is the highest of the measured three phase currents related to motor ambient temperature.

When the thermal capacity level reaches 100%, the thermal overload trip will occur. The TOL trip can be reset after the thermal image goes below the motor start-up inhibit level. The motor can be restarted only after TOL trip is reset.

The start-up inhibit level depends on the *Trip class* (t6), motor *Start-up I ratio* (I_s), and the *Motor start-up time* (t_s).

When the motor is being stopped, the thermal image calculation continues by using the background heat level and cooling down time factor until thermal capacity level decreases to zero. The thermal capacity decreases at a constant rate till it reaches the background heat level, after which it depends on the parameters *Trip class*, and *Cool down time factor.* Thus, simulating cooling down of the stator winding and the iron body of the motor.

During power failure, the thermal capacity level of the motor is stored in the memory and the cooling down calculation starts from this level after resumption of power.

TOL Protection conforms to IEC 947-4-1i.e with a motor current 1.05xTFLC running for 2 hrs will not cause TOL-trip and subsequent rise in current to 1.2xTFLC will cause trip within 2 hrs.

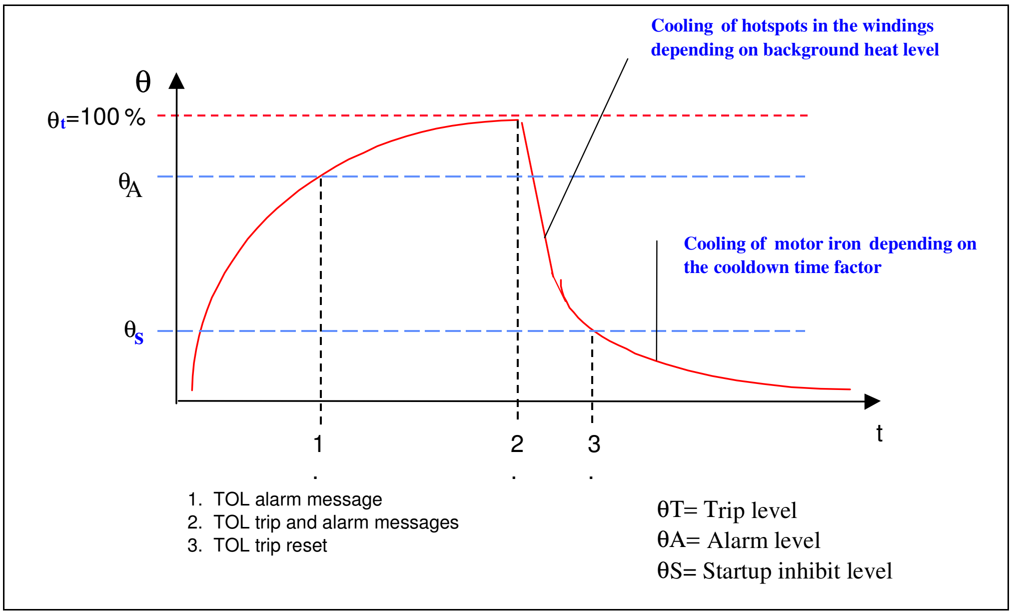
The time to trip calculation begin when the current is above 1.14xIn. The time to reset is calculated after TOL trip and is equal to zero when the thermal image reaches the start-up inhibit level.

In case of unbalance situation, the fictitious negative sequence current in remaining phases is taken into TOL calculation to trip early.

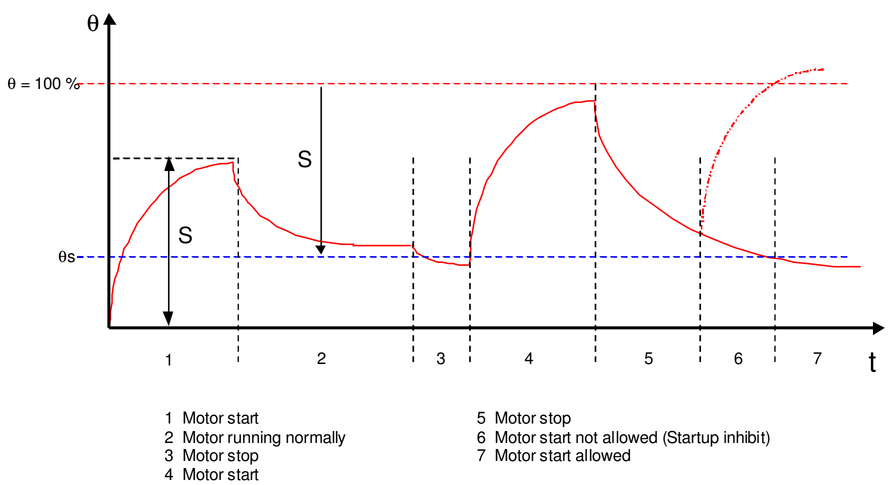
Parameters involved in TOL protection are as below:

Function	Thermal Overload Protection (TOL)	
Available parameters	Function Enable / Disable	
	Thermal Model	
	Trip Class (t6)	(Standard)
	Trip Classt (t6) Time N2	(Standard)
	Trip Class (te)	(EEx e)
	Trip Class (te) Time N2	(EEx e)
	Ia/In Ratio	(EEx e)
	Ia/In Ratio N2	(EEx e)
	Cool Down Time Factor	
	TOL Alarm Level	
	Trip Reset Mode	
	TOL Bypass Command	(Standard)

Picture 1. Illustration of motor thermal simulation behaviour.



Picture 2. Motor thermal simulation behaviour during repeated starts.



6.1 Function Enable, Disable

Function	TOL protection
MMI text	Function
Related MCU	1 and 2
Range	Enabled / Disabled / Trip only / Alarm only
Default setting	Enabled
Related parameter	TOL protection parameters
Description	see hereunder

TOL protection function can be disabled with this parameter. When disabled, all other parameters of the function (i.e. *Trip class*, *TOL alarm level*, *Trip reset mode* and *Cool down time factor*) do not have any functionality in the starter configuration unit (hidden in MMI and greyed out in OS).

6.2 Thermal Model

Function	TOL protection
MMI text	Thermal model
Related MCU	2
Range	Standard / EEx e
Default setting	Standard
Related parameter	TOL protection / Parameters Thermistor protection / Trip level, reset level Motor data / Motor ambient temperature
Description	see hereunder

The thermal model can be selected as either standard or EEx e. The standard model makes use of parameters *Trip class*, *Start-up I ratio* and *Motor start-up time* in TOL calculation. Parameter *Trip class* definition defines the trip time for 6x motor *Nominal current* (In) and it must be less than defined cold state maximum value for the motor.

The protection of explosion proof three-phase induction motors with type of protection 'increased safety' EEx e is done with two special parameters, the *Ia/In ratio* (stall/nominal current ratio) and *Te time*. The tripping time of the TOL protection from the cold state motor must be less than the te time rated for the motor.

For EEx e thermal model a set of parameters have fixed values or are not available in order to simplify parametering instructions and parametering process while providing a secured protection functionality. This should be carefully considered by the user since the given parameter value do not have effect to functionality in this case.

When EExe thermal model is selected the listed functions do have special functionality:

Table 7. Functions which are disabled when EEx e thermal model is selected.

Function	Parameter	Remarks
Starter configuration	Motor ambient temperature	Fixed 40°C value
Thermal protection	TOL bypass command	Command not allowed
Thermistor protection	Temperature protection enable, disable	'Alarm only' not allowed
Thermistor protection	Loop supervision enable, disable	'Alarm only' not allowed

6.3 Trip Class (t6)

Function	TOL protection
MMI text	t6 time / t6 time N1
Related MCU	1 and 2
Range	5 (1) 40 s
Default setting	10 s
Related parameter	TOL protection / Thermal model (standard) Motor data / Nominal current Motor data / Start-up I ratio Motor data / Motor ambient temperature
Description	see hereunder

Parameter *Trip class* (t6) is the basic setting of the thermal protection function. For user it provides the possibility to set the thermal model characteristic according to motor start-up requirements and characteristic. With *Trip class* (t6) parameter user defines the time that protection allows current of 6 x I_n from cold condition for protected motor.

Normally the *Trip class (t6)* value can be set according to one cold start, which allows easy setting of protection. However, when a requirement of one start for hot motor exists the setting is derived for the motor according to hot condition thermal protection time/current characteristic.

The *Trip class (t6)* time for protection is defined based on the motor maximum start time which is informed by the manufacturer.

Initial information required for *Trip class (t6)* definition.
– Motor start-up current ratio (rated motor data, Is/In), see parameter*Start-up I ratio*
– Maximum start time permitted for cold motor
– Maximum start time permitted for warm motor
– Motor ambient temperature, see parameter *Motor ambient temperature*.

Example 1. A thermal protection is set for a motor M2BA315SMC, 110 kW.

– Motor start-up current ratio (Is/In)	7,5
– Maximum start time for cold motor	30 s
– Maximum start time for warm motor	15 s
– Motor ambient temperature	40°C

With the initial information the protection characteristic can be defined by the following procedure. First, the motor start current is calculated according to the ambient temperature. Practically, with 40°C of ambient temperature, the following calculation for start current can be passed. For more information of ambient temperature coefficient see table of maximum permitted current in chapter "*Motor ambient temperature*".

Temperature coefficient is derived with the following routine. Since the motor ambient temperature in the example is 40°C, the TFLC is 1.00 x In.

Motor start-up current ratio is 7.5, thus motor rated start current (Is) is:

$$\mathrm{Is} = {}^{\mathrm{Is}}\!/_{\mathrm{In}} \times \mathrm{In}$$

The effect of ambient temperature is derived, when Is and TFLC are known:

$$\frac{\mathrm{Is}}{\mathrm{TFLC}} = \frac{7.5 \times \mathrm{In}}{1.00 \times \mathrm{In}} = 7.5 \;.$$

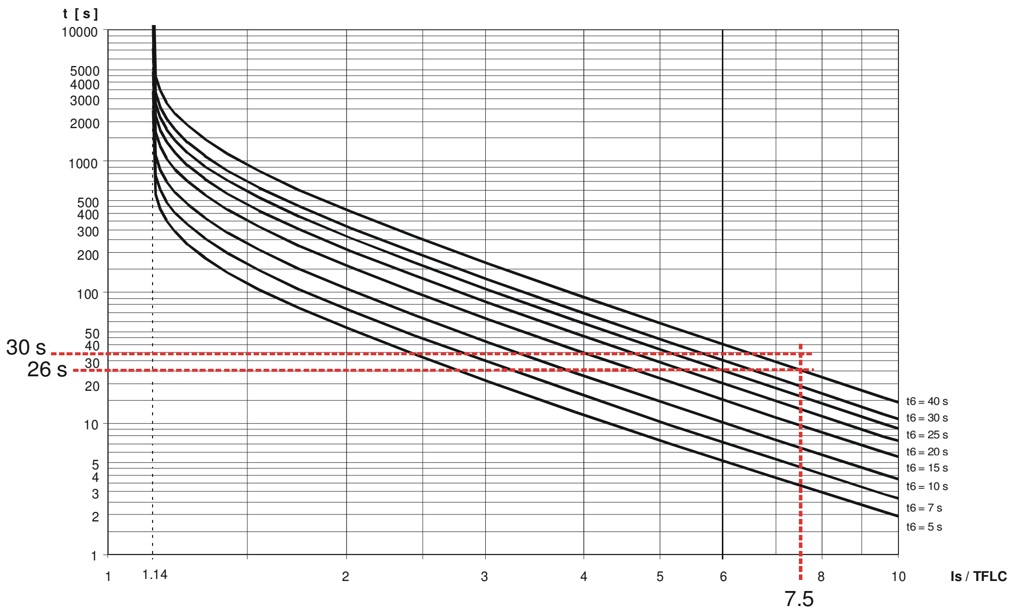
The calculated start current ratio (7.5) and motor maximum start time (30 second) are placed on the cold condition time/current characteristic diagram. Start current ratio is located on the horizontal axis, while the maximum permitted time for cold motor start is set on the vertical axis. The cross point of these constraints shows the maximum setting for *Trip class (t6)*.

The received setting is the absolute maximum value without further considerations and a lower value can be selected. A longer start is not protected by thermal protection and additional protection against stalled rotor is necessary. In case of thermal protection trip at start, with the setting of maximum *Trip class (t6)* value, it is recommended to check the motor size for extreme start requirement.

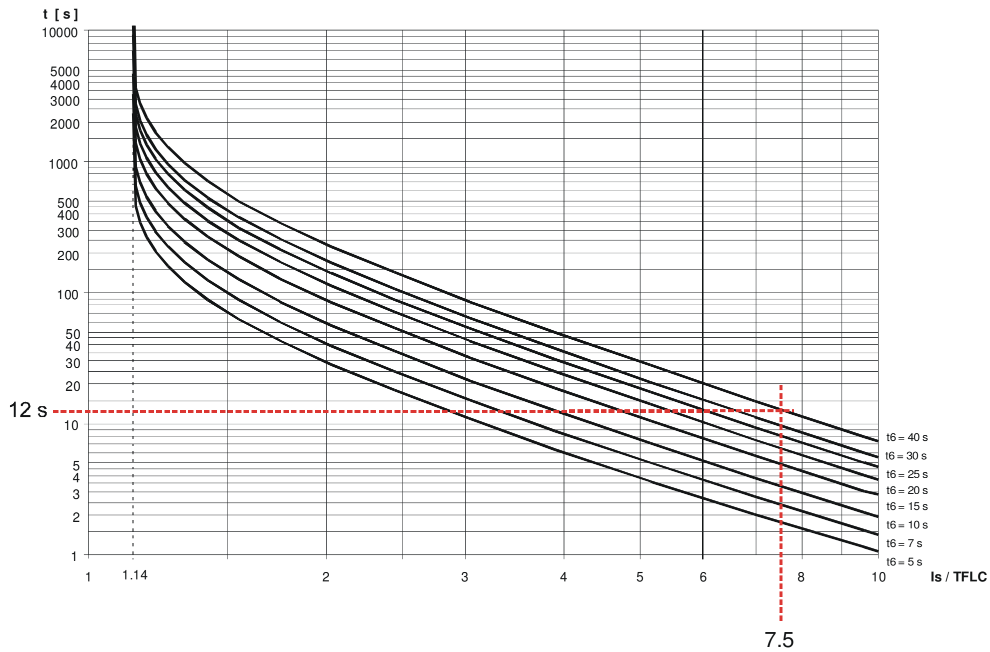
Now, the setting of 40 second is limited by the range of parameter. Value for *Trip class (t6)* is derived from the cold condition time/current diagram, see the picture. This setting allows start time up to approx. 26 second for cold motor, before a thermal protection trip occurs. The start time for a warm motor, with this parameter setting, can be read from the hot condition time/current diagram accordingly. The check routine is shown in the latter picture.

The warm condition start must be within motor ratings. In this case, the start time for a warm motor is approximated from the latter picture and must be shorter than 12 second, as read from the picture. In practise, start lasting longer than 12 second, will lead to trip from the thermal protection.

Picture 3. *Trip class (t6)* definition from cold condition time/current diagram.
Diagram presented in 40°C *Motor ambient temperature*.



Picture 4. Start time vs. *Trip class (t6)* definition from hot condition time/current diagram.
Diagram presented in 40°C *Motor ambient temperature*.



More optimized setting of thermal protection is needed in case of one start for warm motor is required. In this case the *Trip class (t6)* parameter is derived from the warm condition time/current diagram according to actual duration of motor start and motor start-up current.

The derived *Trip class (t6)* value is verified from the cold condition time/current diagram to ensure that thermal protection trip time is less than maximum allowed start time for a cold motor, i.e. the protection is well defined.

There is a need to arrange a separate protection for unsuccessful start, i.e. stalled rotor, if the thermal protection characteristic allows longer start before trip than is allowed for the motor. Then stall protection is utilised for a cold motor start supervision. By defining the operation of *Motor start-up time* and stall protection *Trip delay* the trip must be set before motor maximum start time is exceeded, in case of unsuccessful start.

6.4 Trip Class (t6) N2

Function	TOL protection N2
MMI text	t6 time N2
Related MCU	2
Range	5 (1) 40 s
Default setting	10 s
Related parameter	Starter configuration / Starter type (NR-2N) TOL protection / Trip class
Description	see hereunder

This parameter gives the user a possibility to set the maximum time that a motor can handle 6 times the nominal current (t6-time) for two speed motor second winding N2.

Thermal behaviour in two speed motors is simulated by calculating thermal level from the actual winding and its parameters. Thermal flow between winding is considered to be 100%.

For more details refer to parameter *Trip class (t6)*.

6.5 Trip Class (te)

Function	TOL protection
MMI text	te time
Related MCU	2
Range	5.0 (0.1) 30.0 sec
Default setting	5.0 s
Related parameter	TOL protection / Thermal model (EEx e) TOL protection / Ia/In ratio Motor data / Motor ambient temperature
Description	see hereunder

The safe locked rotor time (te) of a particular induction motor is the time necessary for the winding temperature to rise from its final operational value to a fixed maximum value determined by the corresponding temperature class of the motor during locked rotor. It is of particular significance when the overload protection is specified for motors destined for use in hazardous locations. The te-time is for EEx e motors to withstand Ia/In current.

The parameter value for *Trip class te time* is as rated for EEx e motor in the data book which represents the maximum value. Parameterised value for *Trip class te time* can be equal or less than motor rated te time. For a faster trip value less than rated is selected.

With *Ia/In ratio* this parameter makes it possible for MCU unit to calculate the trip time of the motor according to the load. MCU calculates the trip time for EEx e motor automatically, but the trip time for a certain current for further investigation can be defined as presented in this chapter.

Trip time can be defined with the help of following cold condition time/current diagram. Diagram is according to TOL standard model cold condition.

Initial information, as parameterised, is required.
– *Ia/In ratio* for EEx e motor
– *te time* for EEx e motor

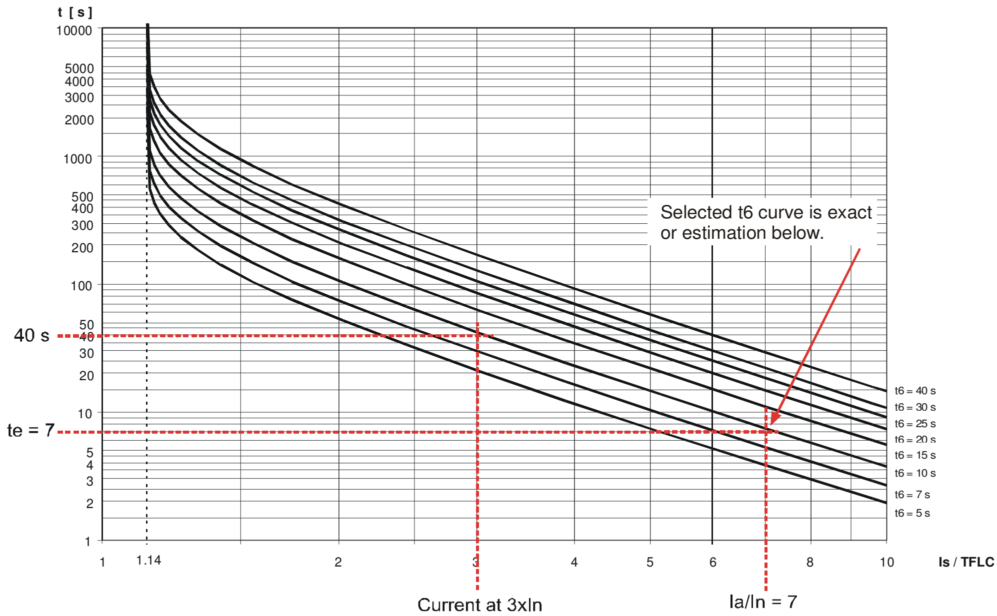
When *Ia/In ratio* is placed on the current (Is/TFLC) axis and te time is placed on the time (t) axis, the co-ordinate on which the lines drawn through these points cross each other is located on the t6 curve. According to defined t6 curve trip time vs. motor current are available from cold condition time/current diagram. The same t6 curve can be used for defining the trip time from a hot condition time/current diagram, as well.

<u>For example</u>: *Ia/In ratio* for an EEx e motor is 7 and parameter *te time* value is 7 seconds. By using the following cold condition time/current diagram t6 curve can be found. When t6 curve is defined other trip times vs motor current are available.

Motor ambient temperature is not observed because it does not have effect in TOL EEx e model usage, thus *Ia/In ratio* can directly be used (see parameter *Motor ambient temperature*).

The readout is t6 curve which is either existing in the diagram or is an estimation below the defined point. In this case *Trip class (t6)* = 9 seconds is estimated from the example picture below and is drawn to the diagram. Trip time for current 3 x In is estimated approx. 40 seconds.

Picture 5. Trip class definition for TOL/EEx e model from cold condition with time/current diagram. Diagram presented in 40°C *Motor ambient temperature*.



6.6 Trip Class (te) N2

Function	TOL protection N2
MMI text	te time N2
Related MCU	2
Range	5.0 (0.1) 30.0 sec
Default setting	5.0 s
Related parameter	Starter configuration / Starter type (NR-2N) TOL protection / Thermal model TOL protection / Trip class te time
Description	see hereunder

The parameter *Trip class (te) N2* defines the time second winding N2 for EEx e motor withstand Ia/In current. This information is rated for EEx e motor and available in motor data sheet.

For more details refer to parameter *Trip class (te)*.

6.7 Ia/In Ratio

Function	TOL protection
MMI text	Ia/In ratio / Ia/In ratio N1
Related MCU	1 and 2
Range	1.0 (0.1) 10.0
Default setting	5.0
Related parameter	TOL protection / Thermal model (EEx e) TOL protection / Trip class te time
Description	see hereunder

It is the ratio of stall current to the nominal current (Ia/In) for EEx e application. The motor shall withstand this current for the duration *Trip class te time*. This information is rated for EEx e motor and available in motor data sheet.

6.8 Ia/In Ratio N2

Function	TOL protection N2
MMI text	Ia / In ratio N2
Related MCU	2
Range	1.0 (0.1) 10.0
Default setting	5.0
Related parameter	Starter configuration / Starter type (NR-2N) TOL protection / Thermal model TOL protection / Trip class (te) N2
Description	see hereunder

This parameter defines the ratio between the stall current to the nominal current (Ia/In) of the second winding N2 for EEx e motor. This information is rated for EEx e motor and available in motor data sheet.

For more details refer to *Trip class (te)* parameter.

6.9 Cool Down Time Factor

Function	TOL protection
MMI text	Cooldown factor
Related MCU	1 and 2
Range	1 (1) 100
Default setting	4
Related parameter	---
Description	see hereunder

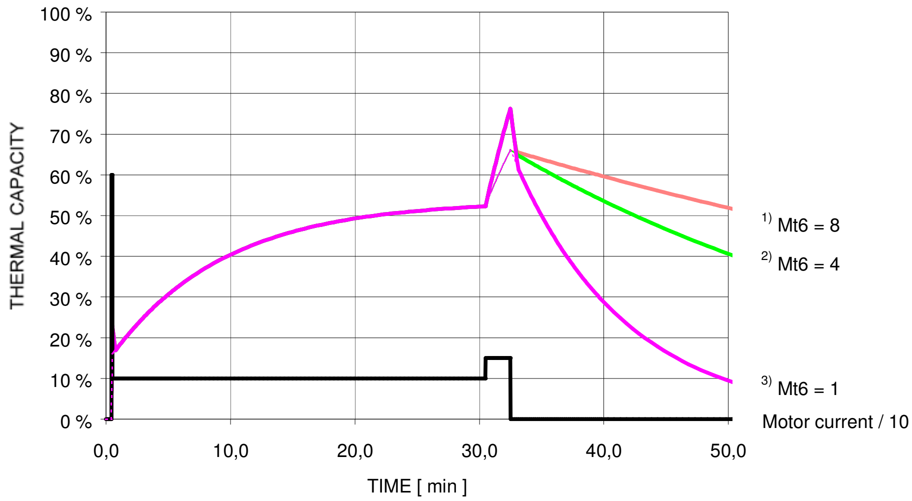
For an accurate thermal image of the motor, MCU needs to know the characteristics of the motor to be controlled. Different motors in different environments need different time periods to warm up and to cool down. Motor warming up is simulated via calculated function while cooling down is simulated by using *Cool down time factor* (Mt6). The cooling down period for a stopped motor is usually about four times longer than the warm up period and it certainly differs within the motor, e.g. in certain hot spots of the windings from the iron core. But this value can be different depending on dirt or other material covering the motor, motor body size, weight installation place, etc.

The normal value for the parameter is between 4…8 describing the slower cooling for a stopped motor [curve 1 and 2] than cooling of a running motor [curve 3]. In practise, this has been discovered as the normal rule for motors covering various applications.

However, if motor manufacturer gives recommendation for another value, it may be set to the protection.

For example: External cooling system is installed for improving the cooling down of a stopped motor. Furthermore, according to statement from motor manufacturer cooling time constants for a running and stopped motor are equal. Thus *Cooling down time* parameter can be set below recommended value 4 [curve 1].

Picture 6. *Cooling down time* (Mt6) parameter influence on stopped motor cooling (principle picture).



6.10 TOL Alarm Level

Function	TOL protection
MMI text	Alarm level
Related MCU	1 and 2
Range	50 (1) 100%
Default setting	90 %
Related parameter	---
Description	see hereunder

When the motor thermal level reaches thermal capacity level set by this parameter, the MCU sends a warning “TOL Alarm” to the fieldbus. When the thermal level reaches 100%, the motor will trip and a message “TOL Trip” is sent to the fieldbus. The TOL alarm is automatically reset when the thermal capacity reaches the parameterised *TOL alarm level* again.

An “O/L alarm” and the time to trip is reported to the fieldbus when the motor current exceeds 1.14 x In. The time to reset becomes zero when the start-up inhibit level is reached

6.11 Trip Reset Mode

Function	TOL protection
MMI text	Trip reset mode
Related MCU	1 and 2
Range	Auto / Remote / Local / Remote & Local / Autorestart
Default setting	Remote & Local
Related parameter	TOL protection / Enable, Disable
Description	see hereunder

TOL trip can be reset in multiple ways depending on the control philosophy. It is possible to reset the fault as desired by parameterisation.

Auto reset: Trip resets automatically after the calculated thermal capacity attains the start-up inhibit level (time to reset reaches 0).

Remote reset: Trip reset is only possible after the calculated thermal capacity attains the start-up inhibit level via the fieldbus (MMI, PCS via GW or OS). The terminal X13: 16 can be in position REMOTE or LOCAL).

Local reset: Trip reset is only possible after the calculated thermal capacity attains the start-up inhibit level via the device I/O. By operating "RESET" switch connected to terminal X13: 15 resets the trip in the local mode. The local mode is activated with terminal X13: 16.

6.12 TOL Bypass Command

Function	TOL protection
MMI text	TOL bypass
Related MCU	2
Range	Enabled / Disabled
Default setting	Disabled
Related parameter	TOL protection / Thermal model (standard)
Description	see hereunder

The operation of the TOL protection function can be prevented by a special 'TOL bypass' command given via the fieldbus when the thermal level rises over the *TOL alarm level*. With the TOL bypass feature the thermal level can be raised up to 200 % after which a trip will be executed. The possibility for execution of this command is enabled by this parameter.

If there is no trip, the TOL bypass command sent before is automatically deactivated when the thermal capacity decreases below the *TOL alarm level*.

An emergency restart is possible with the thermal capacity being above the start-up inhibit level by issuing a start command immediately after TOL-bypass command. TOL-bypass command cannot be enabled when the EEx e parameter is active. The time tag of the latest TOL-bypass command and the number of the commands will be stored and provided as statistical values (read only parameters in Device Data section).

7 Stall Protection

Stall protection is used to protect the driven mechanical system from jams and excessive overloads. Under such conditions, the motors have to be switched off in good time and reported to avoid undue mechanical and thermal stress on the motor and the installation.

This protection function is active only after the motor has successfully started or after parameterised *Motor start-up time* has elapsed and will cause relay activation in case of a motor stall while it is running.

The parameter can be set to a higher value for application experiencing overload as part of normal operation.

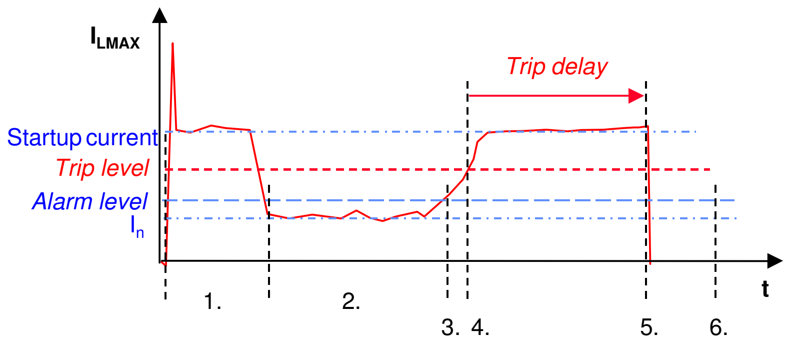
Note! Large low-voltage motors and those# having short admissible stalling time less than the start-up time are not protected by this function.

- Mixers, crushers, saw cutters etc.

Stall protection function consists of following parameters:

Function	Stall Protection
Available parameters	Function Enable, Disable Alarm Level Trip Level Trip Delay Trip Reset Mode

Picture 7. Stall protection function.



1. Motor startup time
2. Normal operation (Stalled protection active)
3. Alarm message
4. Trip delay active
5. Contactor trip and trip message
6. Reset according to reset mode

7.1 Function Enable, Disable

Function	Stall protection
MMI text	Function
Related MCU	1 and 2
Range	Enabled / Disabled / Trip only / Alarm only
Default setting	Enabled
Related parameter	Stall protection / Parameters Motor data / Motor start-up time Motor data / Motor start-up time N2
Description	see hereunder

Stall protection function can be disabled with the help of this parameter. When disabled, all other parameters of the stall function (*Alarm level*, *Trip level*, *Trip delay* and *Trip reset mode*) do not have any functionality in the starter configuration unit (hidden in MMI, greyed out in OS).

Stall protection activates after motor start-up when either of following condition is fulfilled:
– motor has successful start, i.e. current has decreased under 1,25 x In after current inrush
– time specified by *Motor start-up time* parameter has elapsed

7.2 Alarm Level

Function	Stall protection
MMI text	Alarm level
Related MCU	1 and 2
Range	100 (1) 800%
Default setting	300 %
Related parameter	Stall protection / Function enable, disable
Description	see hereunder

Stall function creates "Stall Alarm", when the motor current reaches the set value to inform the operator about the situation. A gradually approaching over stress such as bearing damage can be reported well in advance.

'Stall alarm' clears automatically on restoration of normal condition. In case of extensive change on motor load, the function may report unnecessary alarm messages due to high change in measured current. These nuisance alarm messages can be filtered by increasing the actual alarm level setting.

7.3 Trip Level

Function	Stall protection
MMI text	Trip level
Related MCU	1 and 2
Range	100 (1) 800%
Default setting	400 %
Related parameter	Stall protection / Function enable, disable Stall protection / Trip delay
Description	see hereunder

When the highest of the measured phase currents remains above the set value for a *Trip delay* time, the MCU will perform a trip with a message 'Stall trip'. If normal conditions are restored before the *Trip delay* elapses, the MCU will go back to normal operation.

The trip level referenced to In shall be set based on the motor technical data sheet supplied by the manufacturer and the requirements / restrictions of the application.

7.4 Trip Delay

Function	Stall protection
MMI text	Trip delay
Related MCU	1 and 2
Range	0.0 (0.1) 60.0 s
Default setting	5.0 s
Related parameter	Stall protection / Function enable, disable Stall protection / Trip level
Description	see hereunder

When the condition for a stall trip is present, the MCU will start a count down for the time specified in *Trip delay* parameter. The trip is followed with a message 'Stall Trip'. The *Trip delay* shall be set based on the requirements / restrictions of the application.

7.5 Trip Reset Mode

Function	Stall protection
MMI text	Trip delay
Related MCU	1 and 2
Range	Auto / Remote / Local / Remote & Local
Default setting	Remote & Local
Related parameter	Stall protection / Function enable, disable
Description	see hereunder

Stall trip can be reset in multiple ways depending on the control philosophy. It is possible to reset the trip as desired by parameterisation.

Auto reset: The trip resets automatically after the trip.

Remote reset: Trip reset is only possible via the fieldbus (MMI, PCS via GW or OS).

Local reset: Trip reset is only possible via the device I/O. By operating "RESET" switch connected to terminal X13: 15 resets the trip in the local mode. The local mode is activated with terminal X13: 16.

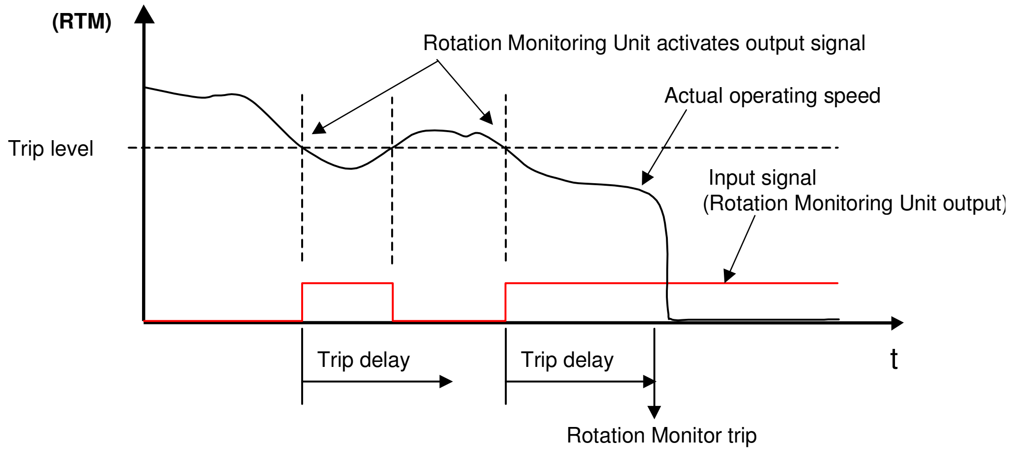
8 Rotation Monitor

Rotation monitor function (RTM) is used to protect the motor against locked rotor. It is especially useful for the protection of driven process where the rotation sensor can be used and already a slight decrease of rotation speed is very critical. Rotation monitor input is a binary input which activates when an external Rotation Monitoring Unit connected to this input activates.

Parameters involved in rotation monitoring protection are as below:

Function	Rotation Monitor
Available parameters	Function Enable, Disable Trip delay Trip Reset Mode

Picture 8. Rotation monitor function.



8.1 Function Enable, Disable

Function	Rotation monitor
MMI text	Function
Related MCU	2
Range	Enabled / Disabled / Trip only / Alarm only
Default setting	Disabled
Related parameter	Rotation monitor / Parameters Motor data / Motor start-up time Motor data / Motor start-up time N2
Description	see hereunder

The rotation monitor function can be disabled with the help of this parameter. When disabled, protection function does not have any functionality in the MCU and all other parameters of the function (*Trip delay and Trip reset mode*) are hidden in MMI and greyed out in the OS.

8.2 Trip Delay

Function	Rotation monitor
MMI text	Trip delay
Related MCU	2
Range	1 (1) 60 sec
Default setting	10 sec
Related parameter	Rotation monitor / Function enable, disable
Description	see hereunder

This parameter defines the delay for the rotation monitor trip function.

When the rotation monitor input remains activated for a period longer than the *Trip delay*, the MCU will execute a contactor trip with a message 'Rotation trip'. With this delay a short fault situation can be filtered.

The trip state is reset according to the parameterisation of *Trip reset mode*.

8.3 Trip Reset Mode

Function	Rotation monitor
MMI text	Trip reset mode
Related MCU	2
Range	Auto / Remote / Local / Remote & Local
Default setting	Remote & Local
Related parameter	Rotation monitor / Function enable, disable
Description	see hereunder

Rotation trip can be reset in multiple ways. Depending on the control philosophy, it is possible to reset the trip as desired by suitable parameterisation.

Auto reset: "Rotation Trip" resets automatically after trip.

Remote reset: "Rotation trip" reset is only possible via the fieldbus (MMI, PCS via GW or OS).

Local reset: "Rotation trip" reset is only possible via the device I/O. By operating "RESET" switch connected to terminal X13: 15 resets the trip in the local mode. The local mode is activated with terminal X13: 16.

9 Phase Loss Protection

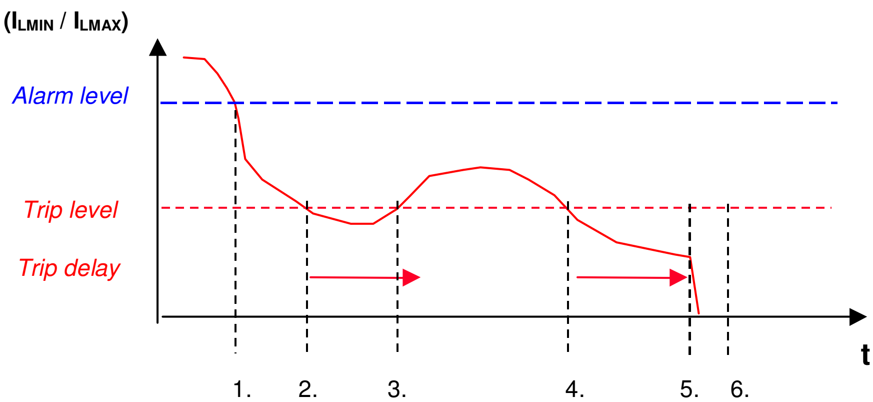
Phase loss in motor phase currents is a common phenomenon in industrial environment. It generally occurs because of pitted contacts in the contactor or SCPD, imbalance in the mains supply, loose connections, blown fuse, and faults within the motor. Phase loss is an extreme situation where a complete loss of phase occurs. This can be caused by a utility supply problem or by a blown fuse in one phase. Unbalanced phase currents are a major cause of motor thermal damage due to the nature of the current. The negative sequence current induced in the rotor is of double the power supply frequency and produces a counter torque to the desired motor output. For small unbalances, the overall output torque will remain same as motor develops a large positive sequence torque to overcome the negative sequence torque. This opposing torque and the high negative sequence current lead to an increased temperature rise in the rotor and stator.

Reasons for the phase loss are neither temporary nor self-covering, however phase loss protection may indicate a missing phase, according to actual settings, along with undervoltage protection. Although TOL protection performs an accelerated trip during phase loss and unbalance over 20%, there are no good reasons to wait for the trip to occur through TOL protection. By the use of phase loss protection a motor can be tripped without waiting for thermal calculation. Indeed, phase loss protection should be parameterised to trip in shorter time than TOL does.

Parameters involved in Phase loss protection are as below:

Function	Phase loss protection
Available parameters	Function Enable /Disable Alarm Level Trip Level Trip Delay Trip Reset Mode

Picture 9. Phase loss protection.



1. Alarm message
2. Trip delay active
3. Trip delay cleared
4. Trip delay active
5. Contactor trip and trip message
6. Reset according to reset mode

9.1 Function Enable, Disable

Function	Phase loss protection
MMI text	Function
Related MCU	1 and 2
Range	Enabled / Disabled / Trip only / Alarm only
Default setting	Enabled
Related parameter	Phase loss protection / Parameters Motor data / Motor start-up time Motor data / Softstart ramp time Starter configuration / Number of phases (3 phase applications)
Description	see hereunder

Phase loss protection function can be disabled with the help of this parameter. When disabled, protection function does not have any functionality in the MCU and all other parameters of the function (*Alarm level*, *Trip level*, *Trip delay* and *Trip reset mode*) are hidden in MMI and greyed out in the OS.

This function is disabled automatically during single-phase selection with *Number of phases* parameter, during *Motor start-up time* and *Softstart ramp time*.

Please note:
If motor startup current is over 1.5 times of parameterised motor nominal current (Inom) in motor start up phase then Phase loss protection is not disabled (blocked out) by parameters Motor startup time / Motor startup time N2 / Softstart ramp time.

9.2 Alarm Level

Function	Phase loss protection
MMI text	Alarm level
Related MCU	1 and 2
Range	5 (1) 90%
Default setting	80 %
Related parameter	Phase loss protection / Function enable, disable
Description	see hereunder

To avoid motor failure by phase loss, the MCU calculates the ratio between the lowest phase current to the highest phase current (I_{LMIN} / I_{LMAX}) from the measured currents of all three phases. If the condition set by this parameter is true, a 'Phase Loss Alarm Lx' warning message is sent to the fieldbus.

The 'Phase Loss Alarm Lx' clears automatically on restoration of normal condition. In case of extensive change on motor load, the function may report unnecessary alarm messages due to high change in measured current. These nuisance alarm messages can be filtered by decreasing the actual alarm level setting.

9.3 Trip Level

Function	Phase loss protection
MMI text	Trip level
Related MCU	1 and 2
Range	5 (1) 90%
Default setting	70 %
Related parameter	Phase loss protection / Function enable, disable Phase loss protection / Trip delay
Description	see hereunder

When the ratio I_{LMIN} / I_{LMAX} corresponds to the value set on *Trip level*, the MCU will trip after the elapse of *Trip delay* time with a message 'Phase Loss Trip Lx'. If normal conditions are restored before the trip, the MCU will go back to normal operation.

9.4 Trip Delay

Function	Phase loss protection
MMI text	Trip level
Related MCU	1 and 2
Range	0 (1) 60 s
Default setting	10 s
Related parameter	Phase loss protection / Function enable, disable Phase loss protection / Trip level
Description	see hereunder

After *Trip level* condition is reached, the MCU will delay the trip for the time defined by pre-parameterised *Trip delay*. A message 'Phase loss trip Lx' is generated. With this delay, a short phase current loss can be filtered. The MCU can be reset according to the *Trip reset mode* parameter.

9.5 Trip Reset Mode

Function	Phase loss protection
MMI text	Trip reset mode
Related MCU	1 and 2
Range	Auto, Remote, Local, Remote & Local
Default setting	Remote & Local
Related parameter	Phase loss protection / Function enable, disable
Description	see hereunder

Phase loss trip can be reset in multiple ways depending on the control philosophy. It is possible to reset the trip as desired by suitable parameterisation.

Auto reset: The "Phase Loss Trip" is reset automatically after the trip.

Remote reset: The "Phase loss trip" reset is only possible via the fieldbus (MMI, PCS via GW or OS).

Local reset: Phase loss trip reset is only possible via the device I/O. By operating "RESET" switch connected to terminal X13: 15 resets the trip in the local mode. The local mode is activated with terminal X13: 16.

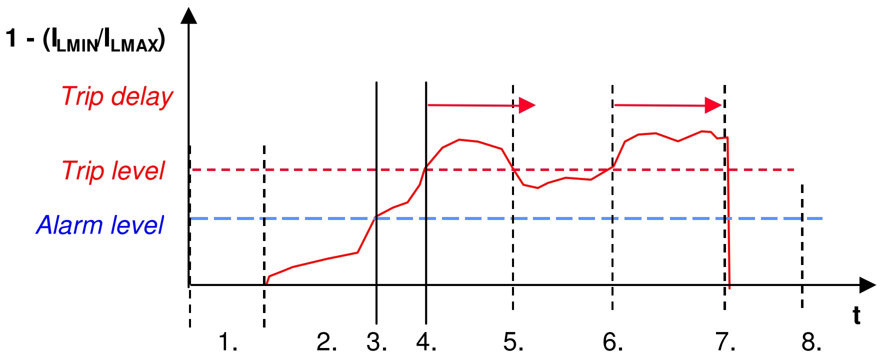
10 Unbalance Protection

Unbalance protection function protects the motor against a small degree of unbalance in the motor phases. The function monitors the ratio between 1-I_{LMIN}/I_{LMAX}. The calculation of the motor thermal capacity takes into account the unbalance for early tripping to prevent motor damage due to negative sequence currents. For more information refer to phase loss protection.

Parameters involved in unbalance protection are as below:

Function	Unbalance protection
Available parameters	Function Enable, Disable Alarm Level Trip Level Trip Delay Trip Reset Mode

Picture 10. Unbalance protection



1. Motor startup time
2. Normal operation
   (Unbalance protection active)
3. Alarm message
4. Trip delay active
5. Trip delay cleared
6. Trip delay active
7. Contactor trip and trip message
8. Reset according to reset mode

10.1 Function Enable, Disable

Function	Unbalance protection
MMI text	Function
Related MCU	2
Range	Enabled / Disabled / Trip only / Alarm only
Default setting	Enabled
Related parameter	Unbalance protection / Parameters Starter configuration / Number of phases (3 phase applications) Motor data / Motor start-up time Motor data / Motor start-up time N2 Motor data / Softstart ramp time
Description	see hereunder

The unbalance protection function can be disabled with the help of this parameter. When disabled, the protection function does not have any functionality in the MCU and all other parameters of the function (*Alarm level*, *Trip level*, *Trip delay* and *Trip reset mode*) are hidden in MMI and greyed out.

This function is disabled automatically during single-phase selection by using the *Number of phases* parameter and during time specified by *Motor start-up time* parameter, as well.

10.2 Alarm Level

Function	Unbalance protection
MMI text	Alarm level
Related MCU	2
Range	10 (1) 50 %
Default setting	20 %
Related parameter	Unbalance / Function enable, disable
Description	see hereunder

To avoid a motor failure by phase unbalance, the MCU calculates a ratio between the lowest phase current to the highest phase current ($1\text{-}I_{LMIN}/I_{LMAX}$) from the measured currents of all the three phases. If the condition set by this parameter is true, an ‘Unbalance Alarm’ warning message is sent to the fieldbus.

The “Unbalance alarm” clears automatically after normal status is attained. In case of extensive change on motor load, the function may report unnecessary alarm messages due to high change in measured current. These nuisance alarm messages can be filtered by increasing the actual alarm level setting.

10.3 Trip Level

Function	Unbalance protection
MMI text	Trip level
Related MCU	2
Range	10 (1) 50 %
Default setting	30 %
Related parameter	Unbalance / Function enable, disable Unbalance / Trip delay
Description	see hereunder

When the ratio '$1\text{-}I_{LMIN}/I_{LMAX}$' corresponds to the value set for this parameter, MCU will start a countdown set by *Trip delay* parameter after which a trip occurs with a message ‘Unbalance Trip’. If normal conditions are restored before the trip, the MCU will go back to normal operation.

10.4 Trip Delay

Function	Unbalance protection
MMI text	Trip delay
Related MCU	2
Range	1 (1) 60 s
Default setting	10 s
Related parameter	Unbalance / Function enable, disable Unbalance / Trip level
Description	see hereunder

After the *Trip level* level is reached, the MCU will delay the trip for the time set by this parameter. After the set *Trip delay*, the MCU will trip the motor and give a message ‘Unbalance trip’. With this delay, short phase unbalances can be filtered. The MCU can later be reset according to the *Trip reset mode* parameter.

10.5 Trip Reset Mode

Function	Unbalance protection
MMI text	Trip reset mode
Related MCU	2
Range	Auto / Remote / Local / Remote & Local
Default setting	Remote & Local
Related parameter	Unbalance protection / Function enable, disable
Description	see hereunder

A phase unbalance trip can be reset in multiple ways. Depending on the control philosophy, it is possible to reset the trip as desired by suitable parameterisation.

Auto reset: The “Unbalance Trip” is reset automatically after the trip.

Remote reset: Unbalance trip reset is only possible via the fieldbus (MMI, PCS via GW or OS).

Local reset: Unbalance trip reset is only possible via the device I/O. By operating “RESET” switch connected to terminal X13: 15 resets the trip in the local mode. The local mode is activated with terminal X13: 16.

11 Underload Protection

Underload protection function monitors the process against loss or decrease in motor load. This protection function is current based compared to cosphi measurement as in the case of "Underload Cosphi" protection. It is especially useful for indication of loss of suction for pumps, broken belt for conveyors, loss of air-flow for fans, broken tools for machines etc. Such states do not harm the motor but early diagnosis helps to minimise the extent of damage to the mechanical installation and subsequent loss of production.

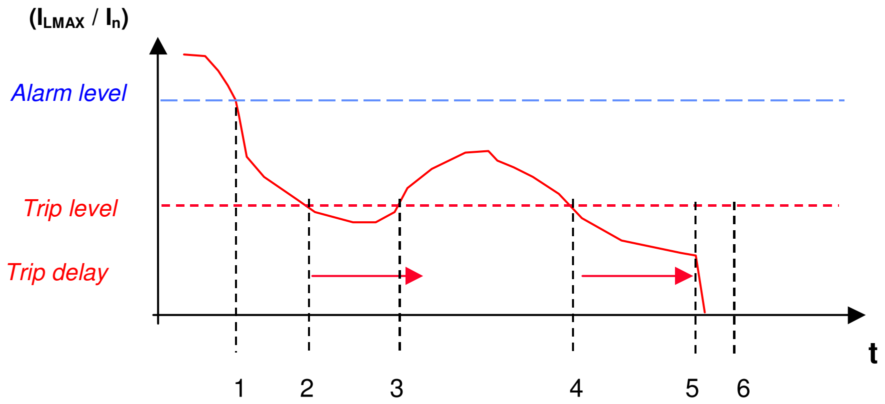
The motors on underload draw mainly the magnetising current and a small load current to overcome frictional losses. Therefore, the other reason to isolate the motors on underload is to reduce the reactive load on the power system network.

Underload protection function is based on the highest measured phase current.

Parameters involved in underload protection are as below:

Function	Underload protection
Available parameters	Enabled /Disable Alarm Level Trip Level Trip Delay Trip Reset Mode

Picture 11. Underload protection.



1. Alarm message
2. Trip delay active
3. Trip delay cleared
4. Trip delay active
5. Contactor trip and trip message
6. Reset according to reset mode

11.1 Function Enable, Disable

Function	Underload protection
MMI text	Function
Related MCU	1 and 2
Range	Enabled / Disabled / Trip only / Alarm only
Default setting	Enabled
Related parameter	Motor data / Softstart ramp time Motor data / Autotrafo start time
Description	see hereunder

Underload protection function can be disabled with the help of this parameter. When disabled, protection function does not have any functionality in the MCU and all other parameters of the function (*Alarm level*, *Trip level*, *Trip delay* and *Trip reset mode*) are hidden in MMI and greyed out in OS. Function is disabled during *Autotrafo start time and Softstart ramp time.*

11.2 Alarm Level

Function	Underload protection
MMI text	Alarm level
Related MCU	1 and 2
Range	15 (1) 90%
Default setting	30 %
Related parameter	Underload protection / Function enable, disable
Description	see hereunder

If the highest phase current (I_{LMAX}) of the measured three phase currents is detected below the *Alarm level*, then a warning message "U/L Alarm" is created to inform the operator of the underload condition.

'U/L Alarm' clears automatically after normal status is attained. In case of extensive change on motor load, the function may report unnecessary alarm messages due to high change in measured current. These nuisance alarm messages can be filtered by increasing the actual alarm level setting.

11.3 Trip Level

Function	Underload protection
MMI text	Trip level
Related MCU	1 and 2
Range	15 (1) 90%
Default setting	20 %
Related parameter	Underload protection / Function enable, disable Underload protection / Trip delay
Description	see hereunder

When current I_{LMAX} reaches the *Trip level*, the MCU trips the motor after elapse of *Trip delay* time. A message 'U/L Trip' is generated after the trip. If normal conditions are restored before the trip, the MCU will go back to normal operation.

11.4 Trip Delay

Function	Underload protection
MMI text	Trip delay
Related MCU	1 and 2
Range	0 (1) 600 s
Default setting	10 s
Related parameter	Underload protection / Function enable, disable Underload protection / Trip level
Description	see hereunder

The trip is delayed by the time set by this parameter. If underload condition is not back to normal before the elapse of *Trip delay* time, a trip is generated with a message. With this delay, short underload situations can be filtered.

11.5 Trip Reset Mode

Function	Underload protection
MMI text	Trip Reset Mode
Related MCU	1 and 2
Range	Auto / Remote / Local / Remote & Local
Default setting	Remote & Local
Related parameter	Underload protection / Function enable, disable
Description	see hereunder

Underload trip can be reset in multiple ways depending on the control philosophy. It is possible to reset the trip as desired by suitable parameterisation.

Auto reset: The “U/L Trip” is reset automatically after the trip.

Remote reset: The “U/L Trip” reset is only possible via the fieldbus (MMI, PCS via GW or OS).

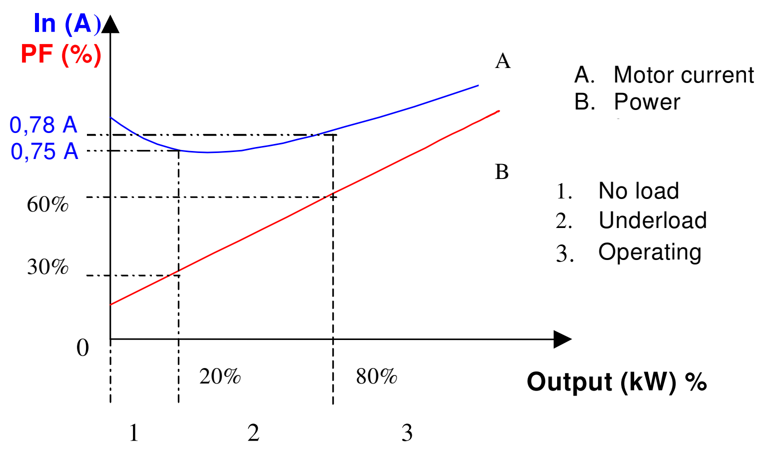
Local reset: The “U/L Trip” reset is only possible via the device I/O. By operating “RESET” switch connected to terminal X13: 15 resets the trip in the local mode. The local mode is activated with terminal X13: 16.

12 Cosphi Underload Protection

This function monitors the process against loss of load especially with small motors where current is not much related to low load. In contrast to the "Underload protection" that responds to the load current; the "Cosphi underload protection" is based on the power factor of the motor. During underload the reactive component of the current being fixed, the power factor reduces substantially along with the slight reduction of active current.

The figure below illustrates the necessity for Cosphi underload protection for small motors as power factor indicates better underload.

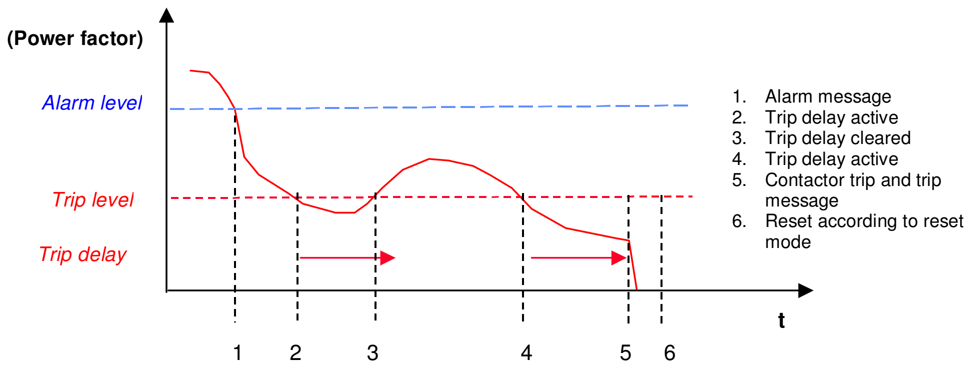
Picture 12. Load curve for motor 0.25/0.3 kW, 3*400VY, 50Hz, Type 3GAA072001-ASA.



Parameters involved in cosphi underload protection are as below:

Function	Cosphi underload protection
Available parameters	Function Enable, Disable Alarm Level Trip Level Trip Delay Trip Reset Mode

Picture 13. Cosphi underload protection.



12.1 Function Enable, Disable

Function	Cosphi underload protection
MMI text	Function
Related MCU	2
Range	Enabled / Disabled / Trip only / Alarm only
Default setting	Disabled
Related parameter	Underload cosphi / Parameters Motor data / Motor start-up time Motor data / Motor start-up time N2 Motor data / Softstart ramp time
Description	see hereunder

The Cosphi underload protection function can be disabled with the help of this parameter. When disabled, this protection function does not have any functionality in the MCU and all other parameters of the function (*Alarm level*, *Trip level*, *Trip delay* and *Trip reset mode*) are hidden in the MMI and greyed out in the OS.

Protection is disabled during
– the time defined by *Motor start-up time*
– the time defined by *Motor start-up time N2*
– the time defined by *Softstart ramp time*

12.2 Alarm Level

Function	Cosphi underload protection
MMI text	Alarm level
Related MCU	2
Range	0.01 (0.01) 1
Default setting	0.8
Related parameter	Cosphi underload protection / Function enable, disable
Description	see hereunder

If the power factor (cosphi) of phase L1 falls below the *Alarm level*, then a warning message ‘U/L cosphi alarm’ is created to inform the operator of the underload condition.

"U/L cosphi Alarm” clears automatically after normal status is attained.

12.3 Trip Level

Function	Cosphi underload protection
MMI text	Trip level
Related MCU	2
Range	0.01 (0.01) 1
Default setting	0.6
Related parameter	Cosphi underload protection / Function enable, disable Cosphi underload protection / Trip delay
Description	see hereunder

When the power factor (cosphi) of phase L1 reaches the *Trip level*, the MCU starts a countdown set by the *Trip delay* parameter after which a trip of the motor will follow.

12.4 Trip Delay

Function	Cosphi underload protection
MMI text	Trip delay
Related MCU	2
Range	0 (1) 60 s
Default setting	10 s
Related parameter	Cosphi underload protection / Function enable, disable Cosphi underload protection / Trip level
Description	see hereunder

The trip is delayed by the time set by this parameter. If underload cosphi condition is not back to normal before *Trip delay* time elapses, a trip along with the "U/L cosphi Trip" message is generated. With this delay, short underload cosphi situations can be filtered.

12.5 Trip Reset Mode

Function	Cosphi underload protection
MMI text	Trip reset mode
Related MCU	2
Range	Auto / Remote / Local / Remote & Local
Default setting	Remote & Local
Related parameter	Cosphi underload protection / Function enable, disable
Description	see hereunder

An Underload cosphi trip can be reset in multiple ways. Depending on the control philosophy, it is possible to reset the trip as desired by suitable parameterisation.

Auto reset: The "U/L cosphi trip" resets automatically after the trip.

Remote reset: The "U/L cosphi trip" reset is only possible via the fieldbus (MMI, PCS via GW or OS).

Local reset: The "U/L cosphi trip" reset is only possible via the device I/O. By operating "RESET" switch connected to terminal X13: 15 resets the trip in the local mode. The local mode is activated with terminal X13: 16.

13 No Load Protection

The no load protection function protects the process against sudden loss of load. Though this condition does not harm the motor, but requires a switch off to safe guard the process.

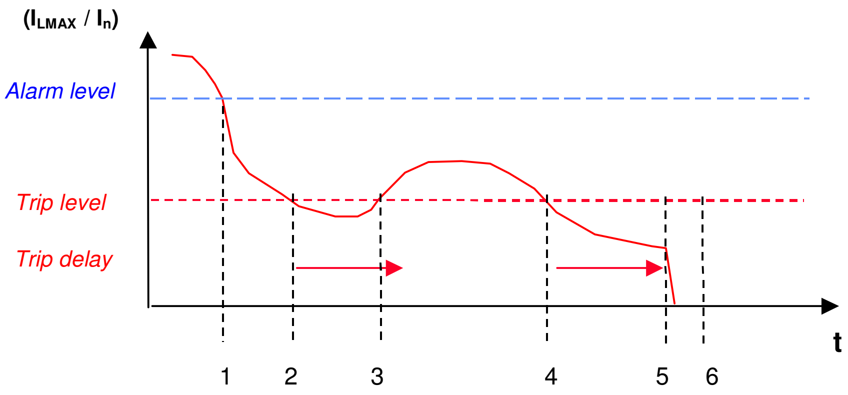
The no load current is of the order of 0.2 to 0.6 I_n depending on the size and speed of the motor. The no load current of slow speed motors is high and that of large motors is low.

The no load protection function is based on the highest phase current measured by the current measurement unit. The no load protection function detects missing current with respect to the contactor and the main switch ON feedback and executes actions as parameterised.

Parameters involved in no load protection are as below:

Function	No load protection
Available parameters	Enabled / Disable Alarm Level Trip Level Trip Delay Trip Reset Mode

Picture 14. No load protection.



1. Alarm message
2. Trip delay active
3. Trip delay cleared
4. Trip delay active
5. Contactor trip and trip message
6. Reset according to reset mode

13.1 Function Enable, Disable

Function	No load protection
MMI text	Function
Related MCU	1 and 2
Range	Enabled / Disabled / Trip only / Alarm only
Default setting	Enabled
Related parameter	No load / Parameters Motor data / Softstart ramp time
Description	see hereunder

No load protection function can be disabled with the help of this parameter. When disabled, protection function does not have any functionality in the MCU and all other parameters of the function (*Alarm level*, *Trip level*, *Trip delay* and *Trip reset mode*) are hidden in the MMI and greyed out in the OS. Function is disabled during *Autotrafo start time and Softstart ramp time*.

13.2 Alarm Level

Function	No load protection
MMI text	Alarm level
Related MCU	1 and 2
Range	15 (1) 50 %
Default setting	20 %
Related parameter	No load protection / Function enable, disable
Description	see hereunder

If the highest phase current (I_{LMAX}) of the measured three phase currents is detected below the *Alarm level*, then a warning message 'N/L Alarm' is created to inform the operator of the no load condition.

'N/L Alarm' clears automatically on restoration of normal condition. In case of extensive change on motor load, the function may report unnecessary alarm messages due to high change of measured current. These nuisance alarm messages can be filtered by increasing the actual alarm level setting.

13.3 Trip Level

Function	No load protection
MMI text	Trip level
Related MCU	1 and 2
Range	15 (1) 50 %
Default setting	15 %
Related parameter	No load protection / Function enable, disable No load protection / Trip delay
Description	see hereunder

If the highest phase current (I_{LMAX}) of the measured three phase currents falls below the *Trip level* for longer than the time period set by the *Trip delay*, the MCU trips the motor with a 'N/L Trip' message.

13.4 Trip Delay

Function	No load protection
MMI text	Trip delay
Related MCU	1 and 2
Range	0 (1) 600 s
Default setting	5 s
Related parameter	No load protection / Function enable, disable No load protection / Trip level
Description	see hereunder

When the current I_{LMAX} reach the no load *Trip level*, the MCU trips the motor after elapse of *Trip delay* time. A message 'N/L Trip' is generated after the trip. If normal conditions are restored before the trip, the MCU will go back to normal operation. With this delay, a short noload situations can be filtered.

13.5 Trip Reset Mode

Function	No load protection
MMI text	Trip reset mode
Related MCU	1 and 2
Range	Auto / Remote / Local / Remote & Local
Default setting	Remote & Local
Related parameter	No load protection / Function enable, disable
Description	see hereunder

The no load trip can be reset in multiple ways depending on the control philosophy. It is possible to reset the trip as desired by suitable parameterisation.

Auto reset: The 'N/L Trip' is reset automatically after the trip.

Remote reset: No Load trip reset is only possible via the fieldbus (MMI, PCS via GW or OS).

Local reset: No Load trip reset is only possible via the device I/O. By operating "RESET" switch connected to terminal X13: 15 resets the trip in the local mode. The local mode is activated with terminal X13: 16.

14 Earth Fault Protection

The earth fault protection function protects the motor and the network against ground current flow. During earth fault, the motors can reach a dangerous potential above the ground level thus posing safety hazard to personnel. The earth faults are mainly caused due to ageing of the insulation, deterioration of insulation due to sustained or cyclic overloading, moisture or conductive dust. Most insulation faults result in leakage to the frame of the motor. The monitoring of the earth faults is done with current measurement via residual current transformer.

The residual current transformer method is normally employed for either isolated systems or for systems earthed with high impedance. The sensitive protection against earth faults is possible. The low current threshold helps to protect the stator winding from earth faults at the neutral end. The sensitivity of the earth fault current measurement can vary depending on the resistance across the secondary of the transformer. In general, measurement through residual current transformer provides higher sensitivity compared to vector sum method, introduced below.

Table 8. The values of resistances are as given below.

Sensitivity	Burden
0.1 - 1.0 A	330.0 Ohm
1.1 - 5.0 A	68.0 Ohm
5.5 - 50.0 A	7.5 Ohm

The power rating of the burden shall be 0.5W, the accuracy ±1% or better. The standard split core toroidal current transformer P/N 701143/801 by ABB Sace is to be used. The split core current transformer facilitates connections on to the cables or busbars even after termination / assembly.

Table 9. The RCT toroidal transformer types.

Name	Type	Diameter
Closed	1SDA 037394R0001	60 mm
Closed	1SDA 037395R0001	110 mm
Riped	1SDA 037396R0001	110 mm
Riped	1SDA 037397R0001	180 mm
Riped	1SDA 037398R0001	230 mm

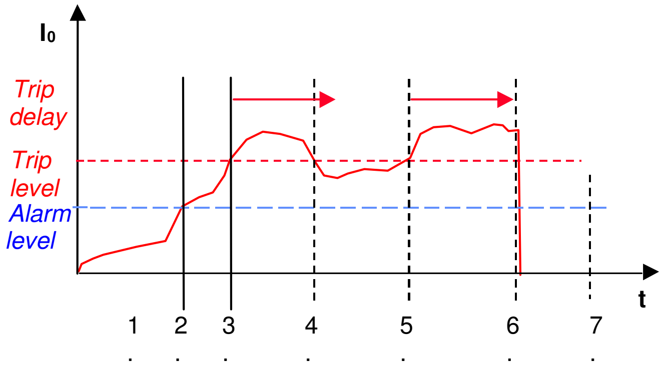
Selectable with parameters but not supported due to the low accuracy is the calculation of the earth fault current by means of the vector sum method. This method is normally employed for solidly earthed systems or for systems earthed through low impedance. This method uses the phase current transformers for measuring the earth fault current and does not require an additional residual current transformer. In a balanced healthy system, the summation of three phase currents is zero. During the earth fault, the neutral current corresponding to the earth current flow executes the trip command. This method is also called as Holmgreen. With this option earth fault protection can be used to indicate extensive earth fault current min. 15% of *Nominal current* setting.

Note! Calculated earth fault option is not supported for common use.

Parameters involved in the earth fault protection are as below:

Function	Earth fault protection
Available parameters	Function Enable, Disable Method Residual CT Primary Alarm Level Trip Level Trip Delay Trip Reset Mode

Picture 15. Earth fault protection.



1. Startup / Normal operation (Earth fault protection active)
2. Alarm message
3. Trip delay active
4. Trip delay cleared
5. Trip delay active
6. Contactor trip and trip message
7. Reset according to reset mode

14.1 Function Enable, Disable

Function	Earth fault protection
MMI text	Function
Related MCU	2
Range	Enabled / Disabled / Trip only / Alarm only
Default setting	Disabled
Related parameter	Earth fault / Parameters
Description	see hereunder

Earth fault protection function can be disabled with the help of this parameter. When disabled, the protection function does not have any functionality in the MCU and all other parameters of the function (*Method*, *Residual CT primary*, *Alarm level*, *Trip level*, *Trip delay*, and *Trip reset mode*) are hidden in MMI and greyed out in OS.

14.2 Method

Function	Earth fault protection
MMI text	Method
Related MCU	2
Range	Calculation / Measurement
Default setting	Calculation
Related parameter	Earth fault / Residual CT primary Starter configuration / Number of phases (3 phase applications)
Description	see hereunder

The earth fault protection function is based either on the vector sum of the measured currents (calculation) or residual current transformer (measurement) measurement. When single phase application is implemented only *Measurement method* can be chosen.

The sensitive earth fault protection is possible by the *Measurement method*. In this method an additional residual current transformer is provided to measure the earth leakage current. The 10 V p-p maximum voltage output of the residual current transformer is connected to terminal I_0A and I_0B of MCU2 wired either to connectors X14: 13,14 when RCT is located inside the drawer unit or to connector X13: 33,34 if RCT is located outside the drawer unit. This method can detect minor insulation fault leading to alarm or trip at an early stage.

The protection can be bypassed during starting with the help of *Trip delay* to avoid nuisance tripping due to saturation of the current transformers.

Note! See restrictions for the use of calculated earth fault functionality in the paragraph "Earth Fault protection".

14.3 Residual CT Primary

Function	Earth fault protection
MMI text	Residual CT range
Related MCU	2
Range	1 A / 5 A / 50 A
Default setting	1 A
Related parameter	Earth fault protection / Measurement method
Description	see hereunder

The parameter defines the maximum primary current of the RCT. This parameter is active when 'measurement' method is selected.

14.4 Alarm Level

Function	Earth fault protection
MMI text	Alarm level
Related MCU	2
Range	0.1 (0.1) < *Residual CT primary*, max. 50 A
Default setting	0.8
Related parameter	Earth fault protection / Function enable, disable Earth fault protection / Residual CT primary Motor data / Motor start-up time
Description	see hereunder

When the earth fault current exceeds the pre-set *Alarm level*, an alarm "Earth fault alarm" is generated. The earth fault alarm is automatically reset when the current falls below the *Alarm level*.

14.5 Trip Level

Function	Earth fault protection
MMI text	Trip level
Related MCU	2
Range	0.1 (0.1) < *Residual CT primary*, max. 50 A
Default setting	1 A
Related parameter	Earth fault protection / Function enable, disable Earth fault protection / Trip delay
Description	see hereunder

When the earth fault current remains above the *Trip level* for a pre-set *Trip delay* time, the MCU will generate a trip command with a message 'Earth fault trip'. If normal conditions are restored before the *Trip delay* time elapses, the MCU will go back to normal operation.

14.6 Trip Delay

Function	Earth fault protection
MMI text	Trip delay
Related MCU	2
Range	0.2 (0.2) 60.0 s
Default setting	10.0 s
Related parameter	Earth fault protection / Function enable, disable Earth fault protection / Trip level
Description	see hereunder

When the earth fault current rises above the *Trip level*, the MCU will execute a trip command after elapse of the time specified in the *Trip delay* parameter. The trip is followed with a message "E/F Trip". The count down is reset if the earth fault current goes below the *Trip level* before the pre-set *Trip delay*. The trip is reset depending on the parameterisation of the *Trip reset mode*.

14.7 Trip Reset Mode

Function	Earth fault protection
MMI text	Trip reset mode
Related MCU	2
Range	Auto / Remote / Local / Remote & Local
Default setting	Remote & Local
Related parameter	Earth fault protection / Function enable, disable
Description	see hereunder

An earth fault trip can be reset in multiple ways depending on the control philosophy. It is possible to reset the trip as desired by parameterisation.

Auto reset: The "Earth fault trip" resets automatically after the trip.

Remote reset: The trip reset is only possible via the fieldbus (MMI, PCS via GW or OS).

Local reset: The trip reset is only possible via the device I/O. By operating "RESET" switch connected to terminal X13: 15 resets the trip in the local mode. The local mode is activated with terminal X13: 16.

15 Thermistor Protection

PTC thermistors are semiconductor elements with a very high positive temperature coefficient. PTC temperature detectors are used extensively in the protection of motors against excessive temperature rise. They are embedded directly between the phase windings on the overhang of the stator winding normally during manufacture.

In contrast to the *Trip class* (t6) and TOL protection that responds to the load current, the Thermistor protection responds to the change in thermistor resistance due to temperature rise in the windings. The Thermistor protection is also sensitive to fall in temperature in order to make it possible to reset the trip.

The thermistors are selected to have a rated operating temperature (TNF) to correspond with the insulation class, type and construction of the motor. It's resistance increases sharply in the range of its rated operating temperature (TNF). For a temperature change of 10°C, the resistance changes ten times.

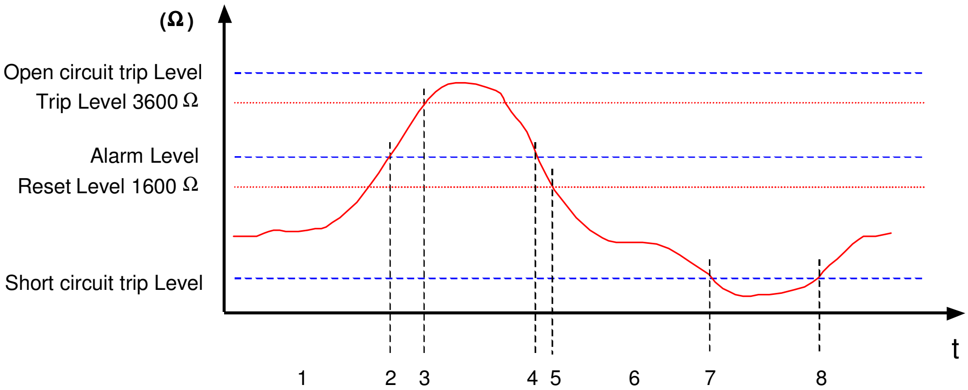
The MCU senses this abrupt change in the resistance to execute a trip command. A trip will follow when 3600 Ω resistance is detected by the measurement and reset is allowed when resistance is under 1600 Ω. These limits can not be changed.

When thermistor protection is activated there is an internal supervision which detectes open or short circuit faults from thermistor circuit. With thermistor resistance values above 12 kΩ there is indication and trip for open circuit protection as selected by parameters. Short circuit level can be selected within given range by the user.

Parameters involved in thermistor protection are as below:

Function	Thermistor protection
Available parameters	Temperature protection Enable, Disable Loop supervision Enable, Disable Alarm Level Short circuit trip level Temperature protection Trip Reset Mode Loop supervision Trip Reset Mode

Picture 16. Thermistor protection.



1. Motor running
2. Alarm message
3. Contactor trip and alarm message
4. Alarm message cleared
5. Trip reset allowed
6. Reset according to reset mode parameter
7. Short circuit trip and trip message
8. Reset according to reset mode parameter

15.1 Temperature Protection Enable, Disable

Function	Thermistor protection
MMI text	Temperature protect.
Related MCU	2
Range	Enabled / Disabled / Trip only / Alarm only
Default setting	Disabled
Related parameter	TOL protection / Thermal model Thermistor protection / Temperature protection parameters Thermistor protection / Loop supervision enable, disable
Description	see hereunder

The Thermistor protection function can be disabled with the help of this parameter. When disabled, the protection function does not have any functionality in the MCU and all other parameters of the function are hidden in MMI and greyed out in the OS.

The functionality of the PTC is limited by the *Thermal model* selection, i.e. standard or EEx e thermal model. For available settings refer to table below.

Table 10. Different Thermistor protection options available.

Parameter	Value	Thermal model	
		Standard	EEx e
Temperature protection enable, disable	Enabled	Yes	Yes
	Disabled	Yes	Yes
	Trip only	Yes	Yes
	Alarm only	Yes	No

15.2 Loop Supervision Enable, Disable

Function	Thermistor protection
MMI text	Loop supervision.
Related MCU	2
Range	Enabled / Disabled / Trip only / Alarm only
Default setting	Disabled
Related parameter	Thermistor protection / Temperature enable, disable Thermistor protection / Loop supervision parameters
Description	see hereunder

This parameter activates and defines the indication for thermistor loop protection. Protection supervises the loop integrity for loosen screw contacts and for short circuit faults between thermistor wires. There are separate indications for open circuit and short circuit faults.

Open circuit trip indication activates when resistance in thermistor circuit exceeds fixed burden level. Short ircuit level is selected with a dedicated parameter.

Table 11. Different options available for loop supervision.

Parameter	Value	Thermal model	
		Standard	EEx e
Loop supervision enable, disable	Enabled	Yes	Yes
	Disabled	Yes	Yes
	Trip only	Yes	Yes
	Alarm only	Yes	No

15.3 Alarm Level

Function	Thermistor protection
MMI text	Alarm level
Related MCU	2
Range	1.0 (0.1) 12.0 kOhm
Default setting	1.6 KOhm
Related parameter	Thermistor protection / Temperature protection enable, disable
Description	see hereunder

This parameter defines the alarm level for the Thermistor protection function. The limit causes a message "PTC temperature alarm" to be issued to the fieldbus when the measured temperature is higher than the alarm level. The temperature is measured via the PTC thermistors.

Usually, three PTC thermistors in series are built into the overhang of the stator winding at the coolant air exhaust end of the motor. The thermistors are selected to have a rated operating temperature (TNF) to correspond with the insulation class, type and construction of the motor. If the resistance corresponding to the high temperature at one or more of the thermistors exceeds this value, an 'PTC temperature alarm' will be generated.

The PTC temperature alarm clears automatically on reaching the normal condition, i.e. resistance restores below *Alarm level*.

15.4 Short Circuit Trip Level

Function	Thermistor protection
MMI text	Short circuit level
Related MCU	2
Range	55 (1) 1000 Ohm
Default setting	55
Related parameter	Thermistor protection / Loop supervision enable, disable
Description	see hereunder

This parameter defines the short circuit resistance of the sensor loop for PTC short circuit trip. The limit causes a message 'PTC short circuit trip' and trips when the result of the loop integrity test for thermistor connection is below the given level.

15.5 Temperature Protection Trip Reset Mode

Function	Thermistor protection
MMI text	Temp. trip reset mode
Related MCU	2
Range	Auto / Remote / Local / Remote & Local
Default setting	Remote & Local
Related parameter	Thermistor protection / Temperature protection enable, disable
Description	see hereunder

A PTC trip can be reset in multiple ways depending on the control philosophy. It is possible to reset the trip as desired by parameterisation.

Auto reset: The 'PTC temperature trip' resets automatically after the sensor loop resistance goes below the threshold set for the trip-reset level.

Remote reset: Trip reset is only possible via the fieldbus (MMI, PCS via GW or OS) after the PTC loop resistance reaches the trip reset level.

Local reset: Trip reset is only possible via the device I/O. By operating "RESET" switch connected to terminal X13: 15 resets the trip in the local mode. The local mode is activated with terminal X13: 16.

15.6 Loop Supervision Trip Reset Mode

Function	Thermistor protection
MMI text	Loop trip reset mode
Related MCU	2
Range	Auto / Remote / Local / Remote & Local
Default setting	Remote & Local
Related parameter	Thermistor protection / Loop supervision enable, disable Thermistor protection / Short circuit trip level
Description	see hereunder

A loop supervision trip can be reset in multiple ways depending on the control philosophy. It is possible to reset the trip as desired by parameterisation.

Auto reset: The 'short circuit trip' or 'open circuit trip' resets automatically after the sensor loop resistance goes above the threshold set for the trip.

Remote reset: Trip reset is only possible via the fieldbus (MMI, PCS via GW or OS) after the PTC loop resistance reaches the trip reset level.

Local reset: Trip reset is only possible via the device I/O. By operating "RESET" switch connected to terminal X13: 15 resets the trip in the local mode. The local mode is activated with terminal X13: 16.

16 Undervoltage Protection

The undervoltage protection function protects the motor against overload during voltage dips. During a mains undervoltage, the electrical energy required to drive the rotor remains same for some period owing to its inertia.

According to the energy conservation law,

Mechanical energy = Electrical energy

$$= V_L * I_L * \text{cosphi}$$

Equation 1

Where, V_L is the motor line voltage, I_L is the motor line current and Cosphi is the power factor.

From equation 1, the motor draws more current during voltage dips to deliver the same mechanical energy.

The motors switched off during voltage dip or power failure can be restarted on power resumption sequentially to prevent simultaneous switch-on of the motors and thus prevent another mains failure on the network. The tripping of motors due to undervoltage of short duration can be bypassed. The feature also would help to restart the process on power resumption by sequentially starting the motors (staggered start).

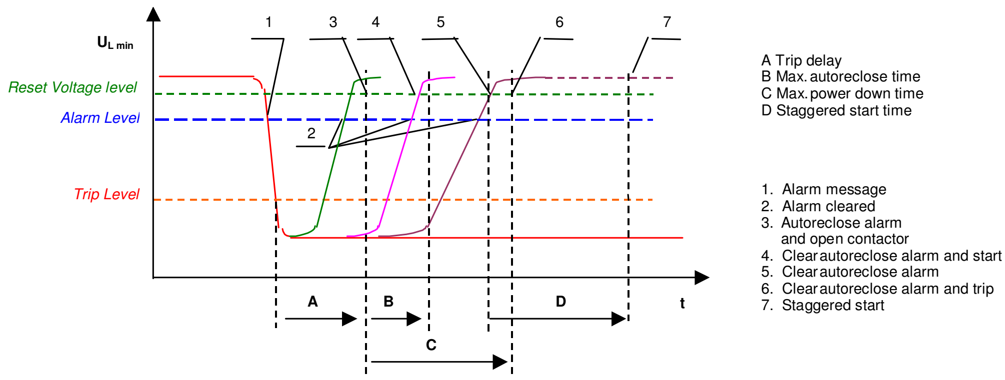
The Undervoltage protection also prevents start-up of the motor if the voltage is not high enough and indicates phaseloss before switching ON the motor.

Note! The voltage unit needs to be connected to the MCU2 and uses lowest of the measured phase voltages.

Parameters involved in undervoltage protection are as below:

Function	Undervoltage protection
Available parameters	Function Enable, Disable External VT Installed External VT Primary External VT Secondary Nominal voltage Alarm Level Trip Level Trip Delay Reset Voltage Level Max. Autoreclose Time Max. Powerdown Time Staggered Start Time Trip Reset Mode

Picture 17. Undervoltage protection.



If the voltage restores above the start level, following conditions apply:

If timing < A, motor not stopped
If timing > A and < A+B, motor immediate start applies
If timing > A+B and < A+C, staggered start appl ies

16.1 Function Enable, Disable

Function	Undervoltage protection
MMI text	Function
Related MCU	2
Range	Enabled / Disabled / Trip only / Alarm only
Default setting	Disabled
Related parameter	Undervoltage / Parameters
Description	see hereunder

The undervoltage protection function can be disabled with the help of this parameter. When disabled, the protection function does not have any functionality in the MCU and all other parameters of the function (A*larm level*, *Trip level*, *Trip delay*, *Reset voltage level*, *Max. autoreclose time*, *Max. power down time*, *Staggered start time*, and *Trip reset mode*) are hidden.

16.2 External VT Installed

Function	Undervoltage protection
MMI text	Ext. VT installed
Related MCU	2
Range	No / Yes
Default setting	No
Related parameter	Starter configuration / External VT primary Starter configuration / External VT secondary Starter configuration / Nominal voltage
Description	see hereunder

The voltage measurement in MCU2 unit can measure voltages up to 690 V with voltage unit. If voltages above 690 V should be measured an external voltage transformer is required and with this parameter primary and secondary values for voltage transformer can be activated.

Note! External voltage transformer is considered out of use if *External VT Primary* and *External VT Secondary* parameters has the same value or either has a value zero. That is even when *External VT Installed* is set to “Yes”.

16.3 External VT Primary

Function	Undervoltage protection
MMI text	Ext. VT primary
Related MCU	2
Range	1000 (100) 12000 V
Default setting	6600 V
Related parameter	Starter configuration / External VT installed Starter configuration / External VT secondary Starter configuration / Nominal voltage
Description	see hereunder

While using an external voltage transformer for motor nominal voltages > 690 V, the nominal primary voltage of the external voltage transformer is defined by this parameter.

16.4 External VT Secondary

Function	Undervoltage protection
MMI text	Ext. VT secondary
Related MCU	2
Range	200 (1) 690 V
Default setting	380 V
Related parameter	Starter configuration / External VT installed Starter configuration / External VT primary Starter configuration / Nominal voltage
Description	see hereunder

While using an external voltage transformer for motor nominal voltages > 690 V, the nominal secondary voltage of the external voltage transformer is defined by this parameter.

For example: Rated Un = 10 kV and external current transformer 12 kV / 690 V.

Set *External VT installed* = Yes,
Set *External VT primary* = 12 kV
Set *External VT secondary* = 690 V
Set *Nominal voltage* = 10 kV

16.5 Nominal Voltage

Function	Undervoltage protection
MMI text	Nominal voltage
Related MCU	1 and 2
Range	230 (1) 400 V 230 (1) 690 V 600 (1) 12000 V
Default setting	380 V
Related parameter	Starter configuration / External VT parameters
Description	see hereunder

This is the rated voltage (Un) of the mains supply for motor. The rated voltage can be set within this range.

In the case of external voltage transformer is installed the range is from 0.6 to 12.0 kV.

16.6 Alarm Level

Function	Undervoltage protection
MMI text	Alarm level
Related MCU	2
Range	50 (1) 100 %
Default setting	80 %
Related parameter	Undervoltage / Function enable, disable
Description	see hereunder

This parameter defines the voltage level for an undervoltage alarm. The undervoltage protection is based on the lowest of the measured phase voltages. An alarm 'Undervoltage alarm' is generated when the lowest of the measured voltages is below the parameterised *Alarm level* (refer figure 13, point 1).

16.7 Trip Level

Function	Undervoltage protection
MMI text	Trip level
Related MCU	2
Range	50 (1) 100 %
Default setting	65 %
Related parameter	Undervoltage / Function enable, disable Undervoltage / Trip delay
Description	see hereunder

This parameter defines the trip level for the undervoltage protection function. When the lowest of the measured phase voltages goes below the *Trip level*, the MCU will start counting a *Trip delay*.

16.8 Trip Delay

Function	Undervoltage protection
MMI text	Trip delay
Related MCU	2
Range	0.2 (0.1) 5.0 s
Default setting	1.0 s
Related parameter	Undervoltage / Max. power down time
Description	see hereunder

This parameter defines the time from the undervoltage *Trip level* to the execution of the trip command. When the lowest of the measured phase voltages goes below the *Trip level* for a time specified in the *Trip delay*, the MCU will open the contactor. An alarm message "Autoreclosure alarm" is generated and the counting of *Maximum power down time* begins.

Note: When starter types NR DOL/RCU or REV DOL/ RCU are used trip delay shall be set to zero (0).

16.9 Reset Voltage Level

Function	Undervoltage protection
MMI text	Reset voltage level
Related MCU	2
Range	50 (1) 100 %
Default setting	90 %
Related parameter	Undervoltage / Trip delay Undervoltage / Max. autoreclose time Undervoltage / Max. power down time Undervoltage / Staggered start time
Description	see hereunder

The *Reset voltage level* is a voltage limit for restarting the motor after an undervoltage trip. The motor will start immediately or after a delay depending on the time during which the *Reset voltage level* is reached (refer figure).

16.10 Max. Autoreclose Time

Function	Undervoltage protection
MMI text	Reclosure enable time
Related MCU	2
Range	0.0 (0.1) 5.0 s
Default setting	0.2 s
Related parameter	Undervoltage / Function enable, disable Undervoltage / Trip reset mode Undervoltage / Trip delay Undervoltage / Reset voltage level Undervoltage / Max. powerdown time
Description	see hereunder

Max. autoreclose time is the time after the undervoltage *Trip delay* during which the motor immediately re-starts on restoration of voltage above the *Reset voltage level*.

16.11 Maximum Power Down Time

Function	Undervoltage protection
MMI text	Restart enable time
Related MCU	2
Range	0 (1) 1200 s
Default setting	5 s
Related parameter	Undervoltage / Function enable, disable Undervoltage / Trip reset mode Undervoltage / Trip delay Undervoltage / Reset voltage level Undervoltage / Max. autoreclose time Undervoltage / Staggered start time
Description	see hereunder

The *Max. powerdown time* starts after the *Trip delay* time has elapsed. It is the maximum waiting time of the MCU for the power resumption. The motor would restart after *Staggered start delay* on voltage restoration above the *Reset voltage level* between end of *Max autoreclose time* and *Max. power down time*. The MCU issues an undervoltage trip message if the voltage recover above the reset voltage level after the *Max. powerdown time*.. The trip can be reset based on the parameterisation of the *Trip reset mode*.

16.12 Staggered Start Time

Function	Undervoltage protection
MMI text	Staggered start time
Related MCU	2
Range	0 (0.1) 1200 s
Default setting	5.0 s
Related parameter	Undervoltage / Function enable, disable Undervoltage / Trip reset mode Undervoltage / Trip delay Undervoltage / Reset voltage level Undervoltage / Max. autoreclose time Undervoltage / Max. power down time
Description	See hereunder

This parameter defines the time from the voltage rise above the *Reset voltage level* to the time when the start command is executed. It is applicable to the motors if the voltage restores above the *Reset voltage level* between the delay “C-B” (refer figure 13). This parameter can be used to start the motors sequentially after resumption of power to prevent voltage dip caused by simultaneous starting of several motors.

16.13 Trip Reset Mode

Function	Undervoltage protection
MMI text	Trip reset mode
Related MCU	2
Range	Auto / Remote / Local / Remote & Local
Default setting	Remote & Local
Related parameter	Undervoltage / Function enable, disable
Description	see hereunder

An undervoltage trip can be reset in multiple ways depending on the control philosophy. It is possible to re-set the trip as desired by parameterisation.

Auto reset: ‘Undervoltage trip’ resets automatically after the voltage goes above the reset voltage level

Remote reset: Trip reset is only possible via the fieldbus (MMI, PCS or OS) after the voltage goes above the reset voltage level.

Local reset: Trip reset is only possible via the device I/O. By operating “RESET” switch connected to termi-nal X13: 15 resets the trip in the local mode. The local mode is active with terminal X13: 16 kept low.

Note: When undervoltage protection function is activated with Remote & Local or Remote reset mode, the reset command can be given via fieldbus even though product is in local control mode. This feature allows fast start of process after voltage break.

17 Start Limitation Protection

Start limitation helps to protect the motor and also the process against excess number of starts in a given interval. When the number of starts is reached and the motor is switched off, a new start is prevented. The time interval starts from the first start. After the elapse of the time interval the counter is reset to the pre-set value. The permissible motor starts per hour can be obtained from the manufacturers motor and apparatus data sheet. However, the minimum waiting time between two starts shall be complied.

The parameterisation of the protection function can be the number of starts per time interval or the time between two consecutive starts. In the first case the user must wait after the trip for the reset to take place before making a start. The time to reset after start limitation trip is provided to the fieldbus.

Independent of this function, the motor is protected by TOL function and a start is possible only if the thermal capacity is below the start-up inhibit level. If motor data specifies the number of starts during a certain time span the advantage of this protection function can be taken of supervising the number of starts. On some other cases process may put requirements for the motor start number thus this protection can be employed.

As an example: The following picture presents the start limitation protection functionality. Allowed maximum number of starts, *Number of starts,* is 3 within *Time interval*.

1. Normal situation, after stop command motor can be started normally, “Start 2”. Every start activates an internal timer for the time defined by *Time interval* parameter. The number of active timers are reviewed after every stop command and compared to value of *Number of starts* parameter. Stop command can thus exist during active or elapsed timer.

2. Two timers are still active, thus stop command generates alarm message and one more start is allowed, “Start 3”.

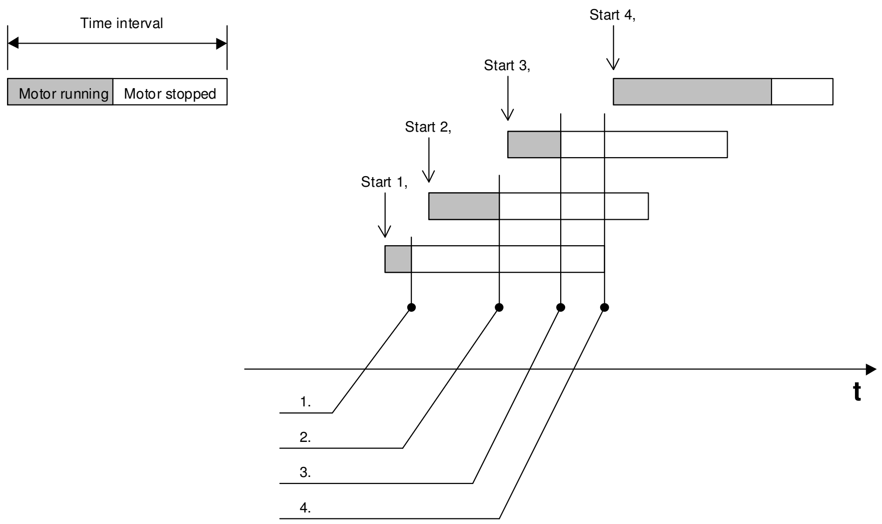
3. The 3rd start has been executed. A contactor trip and trip message will follow when motor is stopped while there are two active timers, here starting from “Start 1”.

4. Trip can be reset when the first timer from “Start 1” is finished. Motor start is possible when all pending trips are reset. Supervision continues with a new timer from “Start 4”.

The parameters involved with the protection function are,

Function	Start limitation protection
Available parameters	Function Enable, Disable Time interval Number of starts Trip reset mode

Picture 18. Start limitation protection.



17.1 Function Enable, Disable

Function	Start limitation protection
MMI text	Function
Related MCU	2
Range	Enabled / Disabled / Trip only / Alarm only
Default setting	Disabled
Related parameter	Start limitation / Parameters
Description	see hereunder

The start limitation protection function can be disabled with the help of this parameter. When disabled, the protection function does not have any functionality in the MCU and all other parameters of the function (*Time interval*, *Number of starts*, and *Trip reset mode*) are hidden.

17.2 Time Interval

Function	Start limitation protection
MMI text	Time interval
Related MCU	2
Range	0 (1) 600 min
Default setting	60 min
Related parameter	Start limitation / Number of starts
Description	see hereunder

During this *Time interval* the number of starts is limited by setting the parameter *Number of starts*.

17.3 Number of Starts

Function	Start limitation protection
MMI text	Number of starts
Related MCU	2
Range	1 (1) 100
Default setting	3
Related parameter	Start limitation / Time interval
Description	see hereunder

This parameter defines the number of allowed starts during a predefined time window set by the parameter *Time interval*. If this value is set to one, the parameterised time interval will define the time between two consecutive starts.

17.4 Trip Reset Mode

Function	Start limitation protection
MMI text	Trip reset mode
Related MCU	2
Range	Auto / Remote / Local / Remote & Local
Default setting	Remote & Local
Related parameter	Start limitation / Function enable, disable.
Description	see hereunder

This parameter defines the trip reset modes for the start limitation protection trip.

Auto: The 'Start limitation trip' is reset automatically after trip.

Remote: The 'Start limitation trip' can be reset via the fieldbus (MMI, PCS or OS).

Local: The 'Start limitation trip' is only possible via the device I/O. By operating "RESET" switch connected to terminal X13: 15 resets the trip in the local mode. The local mode is active with terminal X13: 16 kept low.

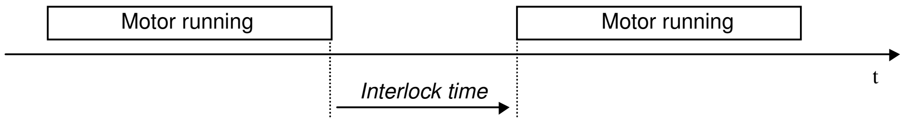
18 Start Interlock Protection

Start interlock protection is available to help the intelligent control of the delay between previous stop command and new start command. With this function user can define the delay during which the unit will not allow to start motor but gives an indication to the user. Trip and alarm functionality are selectable.

The parameters involved with the protection function are,

Function	Start interlock protection
Available parameters	Function Enable, Disable Interlock time Trip reset mode

Picture 19. Start interlock protection principle.



18.1 Function Enable, Disable

Function	Start interlock protection
MMI text	Function
Related MCU	2
Range	Enabled / Disabled / Trip only / Alarm only
Default setting	Disabled
Related parameter	Start interlock / Parameters
Description	see hereunder

The start interlock protection function can be disabled with the help of this parameter. When disabled, the protection function does not have any functionality in the MCU and all other parameters of the function (*Interlock time* and *Trip reset mode*) are hidden.

18.2 Interlock Time

Function	Start interlock protection
MMI text	Interlock time
Related MCU	2
Range	1 (1) 600 min
Default setting	10 min
Related parameter	Start interlock / Function enable, disable
Description	see hereunder

The *Interlock time* starts from the last stop command and makes the unit to discard the start command until the time has elapsed.

18.3 Trip Reset Mode

Function	Start interlock protection
MMI text	Trip reset mode
Related MCU	2
Range	Auto / Remote / Local / Remote & Local
Default setting	Remote & Local
Related parameter	Start interlock / Function enable, disable
Description	see hereunder

This parameter defines the trip reset modes for the start interlock protection trip.

Auto: The 'Start interlock trip' is reset automatically after trip.

Remote: The 'Start interlock trip' can be reset via the fieldbus (MMI, PCS or OS).

Local: The 'Start interlock trip' is only possible via the device I/O. By operating "RESET" switch connected to terminal X13: 15 resets the trip in the local mode. The local mode is active with terminal X13: 16 kept low.

19 Maintenance Functions

Preventive maintenance is the best way to have long service life for any equipment. Maintenance function can be configured suitably as a reminder for preventive maintenance. This would reap high benefits to the user in terms of reduced process down time and loss due to stoppage of production.

Maintenance function indicates the operation of the motor in terms of hours run and the usage of contactor in the form of operating cycles. Number of hours run helps to assess the bearing life and it's lubrication or replacement, whereas the number of operating cycles help in deciding replacement of worn-out power contacts or the contactor itself.

Maintenance alarm can be activated after lapse of the set counter. The counters can be set after maintenance according to two different principles depending of course on normal routine of the user.

– *Preset CCx cycles* can be set to zero after maintenance and keep the current alarm level (hours or cycles)
– *Preset CCx cycles alarm* can be increased to a new value that fulfils the next required service conditions (hours or cycles)

Parameters under ‘Maintenance function’ are as below:

Function	Maintenance
Available parameters	Preset Hours Run Motor Hours Run Alarm Preset CCa Cycles Preset CCa Cycles Alarm Preset CCb Cycles Preset CCb Cycles Alarm Preset CCc Cycles Preset CCc Cycles Alarm

19.1 Preset Hours Run

Function	Maintenance
MMI text	Preset hours run
Related MCU	1 and 2
Range	0 (10) 10’000’000 h
Default setting	0 h
Related parameter	Maintenance function / Preset hours run alarm
Description	see hereunder

Preset hours run parameter can be used to set up a value to a counter, which calculates the motor running time in hours. Preset hours run parameter is possible to be reset after maintenance, as an example.

19.2 Motor Hours Run Alarm

Function	Maintenance
MMI text	Motor hours run alarm
Related MCU	1 and 2
Range	0 (10) 10’000’000 h
Default setting	10'000 h
Related parameter	Maintenance function / Preset hours run NV heartbeat base
Description	see hereunder

The user can set a period after which a preventive maintenance is desired. When the 'Preset Hours Run' counter exceeds the *Preset hours run alarm* level a message 'Maintenance hours run' is generated for the corresponding MCU. This helps to lubricate and maintain the bearings of the motor within the correct service interval.

19.3 Preset CCa Cycles

Function	Maintenance
MMI text	Preset CCa cycles
Related MCU	1 and 2
Range	0 (10) 10'000'000
Default setting	0
Related parameter	Maintenance function / Preset CCa cycles alarm
Description	see hereunder

Preset CCa cycles can be used to set up a value to a counter, which calculates the operating cycles of contactor 1. The counter can be reset to zero after maintenance.

Each cycle consists of a close-open operation of a contactor.

19.4 CCa Cycles Alarm Level

Function	Maintenance
MMI text	Ca cycles alarm level
Related MCU	1 and 2
Range	0 (10) 10'000'000
Default setting	10'000
Related parameter	Maintenance function / Preset CCa cycles NV heartbeat base
Description	see hereunder

When contactor CCa has run trough the set value of cycles in *preset CCa cycles alarm* counter, the corresponding MCU generates a message 'Maintenance CCa'. This helps in carrying out preventive maintenance of power contacts for the contactor to control output CCa. The electrical life# of the contactor can be set to this parameter in terms of control cycles.

19.5 Preset CCb Cycles

Function	Maintenance
MMI text	Preset CCb cycles
Related MCU	1 and 2
Range	0 (10) 10'000'000
Default setting	0
Related parameter	Maintenance function / Preset CCb cycles alarm Starter configuration / Starter type
Description	see hereunder

Preset CCb cycles can be used to set up a value to a counter, which calculates the operating cycles of contactor connected to control output CCb. It is possible to be reset this counter to zero after maintenance.

This parameter is disabled during non-reversible starter type selection under starter configuration function

19.6 CCb Cycles Alarm Level

Function	Maintenance
MMI text	CCb cycles alarm level
Related MCU	1 and 2
Range	0 (10) 10'000'000
Default setting	10'000
Related parameter	Maintenance function / Preset CCb cycles Starter configuration / Starter type NV heartbeat base
Description	see hereunder

When contactor CCb has run through the set value of cycles in *preset CCb cycles alarm* counter, the corresponding MCU generates a message 'Maintenance CCb'. This help in carrying out preventive maintenance of power contacts for the contactor connected to control output CCb.

Also refer to parameter *Preset CCa cycles alarm* for more details.

19.7 Preset CCc Cycles

Function	Maintenance
MMI text	Preset CCc cycles
Related MCU	2
Range	0 (10) 10'000'000
Default setting	0
Related parameter	Maintenance function / Preset CCc cycles alarm Starter configuration / Starter type
Description	see hereunder

Preset CCc cycles can be used to set up a value to a counter, which calculates the operating cycles of contactor connected to control output CCc. It is possible to be reset this counter to zero after maintenance.

This parameter is disabled during non-reversible starter type selection under starter configuration function.

19.8 CCc Cycles Alarm Level

Function	Maintenance
MMI text	CCc cycles alarm level
Related MCU	2
Range	0 (10) 10'000'000
Default setting	10'000
Related parameter	Maintenance function / Preset CCc cycles Starter configuration / Starter type NV heartbeat base
Description	see hereunder

When contactor CCc has run through the set value of cycles in *preset CCc cycles alarm* counter, the corresponding MCU generates a message 'Maintenance CCc'. For more details refer to parameter preset CCa cycles alarm. This helps in carrying out preventive maintenance of power contacts for the contactor connected to control output CCc.

20 Control Access

There are different stations like PCS (via INSUM Gateways), MMI, INSUM OS or Motor Control Panels from where the motor can be started or stopped or trips can be reset.

With the Control Access functionality it can be decided which one of these *stations* is allowed to control a MCU/motor at a given time. When Control Access is used each MCU "knows" which *station* momentarily has the authority to control it. Commands coming from an unauthorised *station* will not be passed to the motor.

To use Control Access a hierarchy has to be defined between the *stations* in an INSUM system. These priorities determine the "rules" for passing Control Access between *stations*. Passing of Control Access is done with a dedicated set of telegrams. In most cases the GW will receive the highest priority because it is the *station* connecting the INSUM system to a PCS.

For one INSUM system (comprising up to 128 MCU's and its *stations*) one "Control Access setting" has to be defined. Then Control Access parameters in all MCU's and all *stations* belonging to the system have to be set accordingly.

Stations are devices connected to the ICU (INSUM Communication Unit devices such as Gateways, MMI) and also the INSUM OS. ICU devices are referred here as 'SU'-devices (SU = Switchgear Unit).

In addition to those devices controlling the MCU's via bus, each MCU can be controlled via its hardware inputs if Terminal X13: 16 = Local. The Local control has automatically the highest priority in the system.

Note! The setting of reset mode parameters and usage of Control Access can interfere with each other.

For example: GW (PCS) have CA for MCU 2/5.
In MCU 2/5 TOL Protection / Trip Reset mode: Local
-> Reset command from GW is accepted by MCU because GW has "CA", but as the Reset mode is only "Local" and not "Bus", the Reset will not be performed and TOL trip remains.

Please refer to 'INSUM Control Access Guide' document for further information.

The parameters under Control Access function are as below:

Function	Control Access
Available parameters	Function Enable / Disable SU Lifelist Timeout Station Priority

20.1 Function Enable /Disable

Function	Control Access
MMI text	Enabled / disabled
Related MCU	1 and 2
Range	Enabled / Disabled
Default setting	Disabled
Related parameter	Control access / Parameters System / SU lifelist timeout
Description	see hereunder

Control Access function can be disabled with the help of this parameter. When disabled, all other parameters of the function (*Station priority*, *Station Lifelist Timeout*) are hidden in MMI, greyed out in OS.

When disabled only the "simple" way of Control Access is used:
If terminal X13: 16 is set to Local, only commands via binary inputs will be accepted by the MCU. If terminal X13: 16 is set to bus (remote), only commands via the fieldbus inputs will be accepted by the MCU. The MCU does not differentiate from which station (GW, MMI or OS) a control command is sent.

When enabled the full Control Access functionality is used. If terminal X13: 16 is set to bus (remote) the MCU only accepts control commands from the station "owning" CA at that time. Control commands can be Start, Stop, Reset.

20.2 SU Lifelist Timeout

Function	Control Access
MMI text	SU lifelist timeout
Related MCU	1 and 2
Range	1 (1) 255 s
Default setting	20 s
Related parameter	Control access parameters in MCU, GW, MMI, OS SU devices – SU lifelist heartbeat
Description	see hereunder

All SU devices connected to the backbone bus send cyclically "Lifesign heartbeats" to each other. Each SU device is supervising these Lifesigns and creates a "SU LifeList" telling which of the SU devices is "alive" on the bus. The SU device having the highest station priority is sending this "SU LifeList" down to all MCU's with the cycle time defined by the "SU lifelist heartbeat".

When the time defined by *SU lifelist timeout* expires and the actual "CA-owner" is not marked "alive" any-more the Control Access will be set to "release" state for that MCU. When the time defined by *SU lifelist timeout* expires until a new "SU LifeList" is received, the Control Access will be set to "release" state for that MCU. "Release" state means that any station regardless its priority can take over Control Access for that MCU.

Note!: *SU lifelist timeout* of MCU's should be at least 2-3 times "SU lifelist heartbeat" of SU devices.

20.3 Station Priority

Function	Control Access
MMI text	Address priority 1:…16:
Related MCU	1 and 2
Range	Subnet 0(1)255 / Node 0(1)127
Default setting	0, 0
Related parameter	Control access parameters in MCU, GW, MMI, OS SU devices - CA priority
Description	see hereunder

This list of parameters defines the priorities between the stations controlling a MCU.

The hierarchy defined should be the same for all MCU's in one INSUM system. To give a station a certain priority its LON subnet/node address has to be filled in at the respective priority entry.

Priority 1 is automatically occupied by the local control (hardware inputs of MCU).

21 System

INSUM relies on event driven messages. This means: Each time a change in status or a change of an analogue value above a predefined hysteresis occurs, the telegram carrying the specific information is immediately updated by the MCU. In addition, all data sent to SU devices (GW, MMI, and OS) are updated in a slow background cycle. The cyclic update serves to give newly hooked up SU devices an image of the system. It is also used to supervise MCU communication towards SU devices (detection of communication loss).

Note! The parameter *Status heartbeat* and *Nv heartbeat base* are to be selected carefully to reduce unnecessary bus loading.

The parameters involved with "system" are as below:

Function	System
Available parameters	Failsafe Timeout Status Heartbeat Nv Heartbeat base I Report Deadband External memory

21.1 Failsafe Timeout

Function	System
MMI text	Failsafe timeout
Related MCU	1 and 2
Range	1 (1) 100 s
Default setting	5 s
Related parameter	---
Description	see hereunder

If communication failure between PCS, SU and MCUs is longer than the time period defined in this parameter, the MCU failsafe functionality is activated. MCU continuously monitor communication with SUs by receiving 'heart beat' from them. This parameter allows setting the time period in which the MCUs should expect the 'heartbeat' signal from the SU.

Note! This parameter must be synchronised with the 'heart rate' of the SU to avoid problems. (As a general rule, *Failsafe timeout* > 3 x heart rate).

21.2 Status Heartbeat

Function	System
MMI text	Status heartbeat
Related MCU	1 and 2
Range	1.0 (0.1) 60.0 s
Default setting	2.0 s
Related parameter	ICU devices - Field device timeout
Description	see hereunder

This parameter sets the interval at which the most important data the motor status (nvoMotorStateExt), is to be sent repeatedly by the MCU. *Status heartbeat* must correspond with the parameter "Field device timeout" in SU devices (GW, MMI, and OS).

21.3 NV Heartbeat Base

Function	System
MMI text	NV heartbeat base
Related MCU	1 and 2
Range	1.0 (0.1) 60.0 s
Default setting	2.0 s
Related parameter	---
Description	see hereunder

All data (nv's – network variables) sent from the MCU towards the SU devices (GW, MMI, OS) is periodically updated in a slow background cycle. The "nv heartbeat base" parameter defines the base timer for different time slots used for sending different groups of data. The assignment of the data to the time slots is defined as follows:

Table 12. *NV heartbeat base* reported network variables.

Cycle		Network variable name	Unit	NV index	MCU2
4x *NV heartbeat base*	Actual Control Access owner	nvoActualCA1	--	45	
	Alarm bit field	nvoAlarmReport	--	51	
	Current report	nvoCurrRep	--	17	
	Phase currents	-	A	-	
	Phase currents	-	%	-	
	Earth fault	-	A	-	
12x *NV heartbeat base*	Voltage report	nvoVoltRep	--	55	X
	Phase voltages	-	V	-	
	Frequency	-	Hz	-	
	Power report	nvoPowRep	--	56	X
	Active power	-	W	-	
	Reactive power	-	Var	-	
	Power factor	-	--	-	
	Apparent power	nvoAppPwr	kVA	67	X
72x *NV heartbeat base*	CCc switching cycles	nvoNbrOfOp3	--	39	X
	CCa switching cycles	nvoNbrOfOp1	--	41	
	CCb switching cycles	nvoNbrOfOp2	--	43	
	Motor run hours	nvoCumRunT	Hour	33	
	Thermal capacity	novCalcProcValue	%	19	
	GPI1 feedback	nvoGpIn1	--	74	X
	GPI2 feedback	nvoGpIn2	--	75	X
	GPO1 feedback	nvoGPOut1Fb	--	71	X
	GPO2 feedback	nvoGPOut2Fb	--	73	X
	Configuration CRC	nvoParFileCRC16	--	76	
	Time to trip	nvoTimeToTrip	sec	20	
	Time to reset	nvoTimeToReset	sec	21	

21.4 I Report Deadband

Function	System
MMI text	I Report Deadband
Related MCU	1 and 2
Range	1 (1) 100 %
Default setting	10 %
Related parameter	---
Description	see hereunder

INSUM uses an event driven mechanism and sends new analogue data when a certain change in hysteresis occurred. The MCU sends all current related data (nvoCurrRep) when changes in measured values are detected beyond the dead band defined by this parameter.

Note! Changing this parameter causes large changes in the busload.

21.5 External memory

Function	System
MMI text	External memory
Related MCU	2
Range	No / Yes
Default setting	No
Related parameter	---
Description	**Note: This function is not used!**

22 Device Data

This group provides the internal data of the MCU and other relevant data of the INSUM system. The parameters belonging to this group are read only and no parameterisation is possible.

The parameters involved with “Device Data” are as below:

Function	Device Data
Available parameters	Software ID Parameter file version Start inhibit level Current unit (CU) Voltage unit (VU) TOL trip reset count TOL bypass counter Diagnostics

22.1 Software ID

The firmware version momentarily loaded in the MCU is indicated by this read only parameter. Display of firmware version is to simplify assistance in case of technical questions related to MCUs.

The format of software ID is construed according to following table.

Software ID example: M3 430a Apr 29 2002 08:55:25

Information	MCU type	HW ID	SW ID	Date of create	Time of create
Example	M3	4	30a	Apr 29 2002	08:55:25
Explanation	M1 = MCU1 type M3 = MCU2 type (relates to HW -4)	4 = MCU-4	3.0 (main release) a (version)	month day year	hour:minute: second

22.2 Parameter file version

All parameter values are stored in one "binary file" inside the MCU. MMI, OS and GW can upload and download this file and interpret it. In case of changes in the structure/format of this file the file version number will be incremented. So interpretation can be adapted.

22.3 Start inhibit level

Based on the parameter setting of *Start-up I ratio*, *Motor start-up time*, and *Trip class (t6)*, the MCU calculates the Start Inhibit Level which also represents the reset level for TOL trip. It can be read from this parameter.

22.4 Current unit (CU)

The internal current transformer range is automatically detected by the MCU and then stored in this read only parameter.

22.5 Voltage unit (VU)

The internal voltage transformer range is automatically detected by the MCU and then stored in this read only parameter.

22.6 TOL trip reset count

The number of TOL trip reset is stored into this read only parameter.

22.7 TOL bypass counter

The number of TOL bypass commands is stored into this read only parameter.

22.8 Diagnostics

Diagnostic counters 1...4. For internal use only.

23 I/O Configuration

The binary inputs are fed to the MCU either to control or for supervision of the starter. These binary inputs can be parameterised to normally open (NO) or normally closed (NC). This increases the flexibility of the I/O configuration and reduction of additional auxiliary relays.

The actual input state in default

Table 13. Following are the inputs that can be parameterised:

Input name	Terminal	Default configuration	Available
Start 1	X13:12	Normally open	MCU1&2
Start 2	X13:13	Normally open	MCU1&2
Stop	X13:14	Normally closed	MCU1&2
Reset	X13:15	Normally open	MCU1&2
Local	X13:16	Normally open	MCU1&2
Em-stop	X13:17	Normally closed	MCU1&2
Test/service	X14:1	Normally open	MCU1&2
Main switch	X14:2	Normally open	MCU1&2
MCB	X14:6	Normally open	MCU1&2
CFa	X14:7	Normally open	MCU1&2
CFb	X14:8	Normally open	MCU1&2
CFc / Torque 1	X14:9 or X13:20	Normally open	MCU2
External trip input	X14:3	Normally open	MCU1&2
Limit 1	X13:18	Normally open	MCU2
Limit 2	X13:19	Normally open	MCU2
Rotation monitor	X13:23	Normally open	MCU2

24 General purpose I/O

MCU2 unit can be used to read in or control I/O external device. This is achieved via configurable general purpose I/O interface. This interface consists of two input interface and two relay output interface. Practically general purpose I/O implementation requires logical bindings over fieldbus interface in order to transfer read data or execute control according to received data.

An exception for general purpose interface use is with some of the starter types utilizing the general purpose inputs by default. In these cases general purpose connections can not be used. These starter types are:
- REV-2N
- REV-S/D
- Actuator

Parameters in MCU2 involved with general purpose I/O configuration are as follows:

Function	General purpose I/O
Available parameters	GPO1 ON value GPO1 OFF value GPO2 ON value GPO2 OFF value GPI1 ON value GPI1 OFF value GPI2 ON value GPI2 OFF value

Note: Whenever a parameter value is changed for any GPO or GPI parameter, the new value ia active after change in control input!

24.1 GpO1 ON Value

Function	General purpose I/O
MMI text	GpO1 contact open
Related MCU	2
Range	0 (1) 255
Default setting	4
Related parameter	General purpose output / GpO1 OFF value
Description	see hereunder

This parameter defines the value that will activate the general purpose output relay 1 (terminal X13:3) when received through network interface.

24.2 Gp O1 OFF Value

Function	General purpose I/O
MMI text	GpO1 contact closed
Related MCU	2
Range	0 (1) 255
Default setting	0
Related parameter	General purpose output / GpO1 ON value
Description	see hereunder

This parameter defines the value that will deactivate the general purpose output relay 1 (terminal X13:3) when received through network interface.

24.3 GpO2 ON Value

Function	General purpose I/O
MMI text	GpO2 contact open
Related MCU	2
Range	0 (1) 255
Default setting	4
Related parameter	General purpose output / GpO2 OFF value
Description	see hereunder

This parameter defines the value that will activate the general purpose output relay 2 (terminal X13:5) when received through network interface.

24.4 GpO2 OFF Value

Function	General purpose I/O
MMI text	GpO2 contact closed
Related MCU	2
Range	0 (1) 255
Default setting	0
Related parameter	General purpose output / GpO2 ON value
Description	see hereunder

This parameter defines the value that will deactivate the general purpose output relay 2 (terminal X13:5) when received through network interface.

24.5 GpI1 ON Value

Function	General purpose I/O
MMI text	GpI1 ON value
Related MCU	2
Range	0 (1) 255
Default setting	4
Related parameter	General purpose input / GpI1 OFF value
Description	see hereunder

This parameter defines the value that will be issued to fieldbus through output variable when general purpose input 1 (terminal X13:21 or X14:10) is activated.

24.6 GpI1 OFF Value

Function	General purpose I/O
MMI text	GpI1 OFF value
Related MCU	2
Range	0 (1) 255
Default setting	0
Related parameter	General purpose input / GpI1 ON value
Description	see hereunder

This parameter defines the value that will be issued to fieldbus through output variable when general purpose input 1 (terminal X13:21 or X14:10) is deactivated.

24.7 GpI2 ON Value

Function	General purpose I/O
MMI text	GpI2 ON value
Related MCU	2
Range	0 (1) 255
Default setting	4
Related parameter	General purpose input / GpI2 OFF value
Description	see hereunder

This parameter defines the value that will be issued to fieldbus through output variable when general purpose input 2 (terminal X13:22 or X14:11) is activated.

24.8 GpI2 OFF Value

Function	General purpose I/O
MMI text	GpI2 OFF value
Related MCU	2
Range	0 (1) 255
Default setting	0
Related parameter	General purpose input / GpI2 ON value
Description	see hereunder

This parameter defines the value that will be issued to fieldbus through output variable when general purpose input 2 (terminal X13:22 or X14:11) is deactivated.

Appendix A. MCU trip curves

Table 1. Look-up table of trip time from cold condition, balanced network. T_{AMB} = 40°C.

I / In	t6 = 5 s	t6 = 7 s	t6 = 10 s	t6 = 15 s	t6 = 20 s	t6 = 25 s	t6 = 30 s	t6 = 35 s	t6 = 40 s
1.15	552 s	772 s	1103 s	1655 s	2207 s	2758 s	3310 s	3861 s	4413 s
1.16	459 s	643 s	918 s	1377 s	1837 s	2296 s	2755 s	3214 s	3673 s
1.17	406 s	568 s	812 s	1217 s	1623 s	2029 s	2434 s	2840 s	3246 s
1.18	368 s	516 s	737 s	1105 s	1473 s	1842 s	2210 s	2578 s	2947 s
1.19	340 s	476 s	679 s	1019 s	1359 s	1699 s	2038 s	2378 s	2718 s
1.20	317 s	443 s	633 s	950 s	1266 s	1583 s	1900 s	2216 s	2533 s
1.40	148 s	207 s	296 s	444 s	592 s	740 s	888 s	1036 s	1184 s
1.60	96.5 s	135 s	193 s	289 s	386 s	482 s	578 s	675 s	771 s
1.80	69.9 s	97.8 s	140 s	209 s	279 s	349 s	418 s	488 s	558 s
2.00	53.6 s	75.0 s	107 s	160 s	214 s	267 s	321 s	374 s	428 s
2.20	42.7 s	59.7 s	85.2 s	128 s	170 s	213 s	255 s	298 s	340 s
2.40	34.9 s	48.8 s	69.7 s	104 s	139 s	174 s	209 s	244 s	278 s
2.60	29.2 s	40.8 s	58.2 s	87.3 s	116 s	145 s	174 s	203 s	232 s
2.80	24.8 s	34.7 s	49.5 s	74.1 s	98.7 s	123 s	148 s	173 s	197 s
3.00	21.4 s	29.9 s	42.6 s	63.8 s	85.0 s	106 s	127 s	149 s	170 s
3.20	18.6 s	26.0 s	37.1 s	55.5 s	74.0 s	92.4 s	111 s	129 s	148 s
3.40	16.4 s	22.9 s	32.6 s	48.8 s	65.0 s	81.2 s	97.5 s	114 s	130 s
3.60	14.5 s	20.3 s	28.9 s	43.3 s	57.6 s	72.0 s	86.4 s	101 s	115 s
3.80	13.0 s	18.1 s	25.8 s	38.6 s	51.5 s	64.3 s	77.1 s	89.9 s	103 s
4.00	11.7 s	16.3 s	23.2 s	34.7 s	46.2 s	57.8 s	69.3 s	80.8 s	92.3 s
4.20	10.6 s	14.7 s	21.0 s	31.4 s	41.8 s	52.2 s	62.6 s	73.0 s	83.4 s
4.40	9.6 s	13.4 s	19.1 s	28.5 s	38.0 s	47.4 s	56.9 s	66.3 s	75.8 s
4.60	8.8 s	12.2 s	17.4 s	26.0 s	34.6 s	43.3 s	51.9 s	60.5 s	69.1 s
4.80	8.1 s	11.2 s	16.0 s	23.8 s	31.7 s	39.6 s	47.5 s	55.4 s	63.3cs
5.00	7.4 s	10.3 s	14.7 s	21.9 s	29.2 s	36.5 s	43.7 s	51.0 s	58.2 s
5.20	6.9 s	9.5 s	13.6 s	20.3 s	27.0 s	33.7 s	40.3 s	47.0 s	53.7 s
5.40	6.4 s	8.8 s	12.6 s	18.8 s	25.0 s	31.2 s	37.4 s	43.6 s	49.8 s
5.60	5.9 s	8.2 s	11.7 s	17.4 s	23.2 s	28.9 s	34.7 s	40.4 s	46.2 s
5.80	5.5 s	7.7 s	10.9 s	16.2 s	21.6 s	26.9 s	32.3 s	37.7 s	43.0 s
6.00	5.2 s	7.2 s	10.2 s	15.2 s	20.2 s	25.2 s	30.2 s	35.2 s	40.2 s
6.20	4.8 s	6.7 s	9.5 s	14.2 s	18.9 s	23.5 s	28.2 s	32.9 s	37.6 s
6.40	4.5 s	6.3 s	8.9 s	13.3 s	17.7 s	22.1 s	26.5 s	30.9 s	35.2 s
6.60	4.3 s	5.9 s	8.4 s	12.5 s	26.6 s	20.8 s	24.9 s	29.0 s	33.1 s
6.80	4.0 s	5.6 s	7.9 s	11.8 s	15.7 s	19.5 s	23.4 s	27.3 s	31.2 s

I / In	t6 = 5 s	t6 = 7 s	t6 = 10 s	t6 = 15 s	t6 = 20 s	t6 = 25 s	t6 = 30 s	t6 = 35 s	t6 = 40 s
7.00	3.8 s	5.3 s	7.5 s	11.1 s	14.8 s	18.4 s	22.1 s	25.7 s	29.4 s
7.20	3.6 s	5.0 s	7.1 s	10.5 s	14.0 s	17.4 s	20.9 s	24.3 s	27.8 s
7.40	3.4 s	4.7 s	6.7 s	10.0 s	13.2 s	16.5 s	19.8 s	23.0 s	26.3 s
7.60	3.3 s	4.5 s	6.3 s	9.4 s	12.5 s	15.6 s	18.7 s	21.8 s	24.9 s
7.80	3.1 s	4.3 s	6.0 s	9.0 s	11.9 s	14.8 s	17.8 s	20.7 s	23.7 s
8.00	2.9 s	4.1 s	5.7 s	8.5 s	11.3 s	14.1 s	16.9 s	19.7 s	22.5 s
8.20	2.8 s	3.9 s	5.5 s	8.1 s	10.8 s	13.4 s	16.1 s	18.7 s	21.4 s
8.40	2.7 s	3.7 s	5.2 s	7.7 s	10.3 s	12.8 s	15.3 s	17.9 s	20.4 s
8.60	2.6 s	3.5 s	5.0 s	7.4 s	9.8 s	12.2 s	14.6 s	17.0 s	19.4 s
8.80	2.5 s	3.4 s	4.8 s	7.1 s	9.4 s	11.7 s	14.0 s	16.3 s	18.6 s
9.00	2.4 s	3.2 s	4.6 s	6.8 s	9.0 s	11.2 s	13.4 s	15.6 s	17.8 s
9.20	2.3 s	3.1 s	4.4 s	6.5 s	8.6 s	10.7 s	12.8 s	14.9 s	17.0 s
9.40	2.2 s	3.0 s	4.2 s	6.2 s	8.2 s	10.2 s	12.2 s	14.3 s	16.3 s
9.60	2.1 s	2.9 s	4.0 s	6.0 s	7.9 s	9.8 s	11.7 s	13.7 s	15.6 s
9.80	2.0 s	2.8 s	3.9 s	5.7 s	7.6 s	9.4 s	11.3 s	13.1 s	15.0 s
10.00	1.9 s	2.7 s	3.7 s	5.5 s	7.3 s	9.1 s	10.8 s	12.6 s	14.4 s

Picture 1. Trip curve from cold condition, balanced network. T_{AMB} = 40°C.

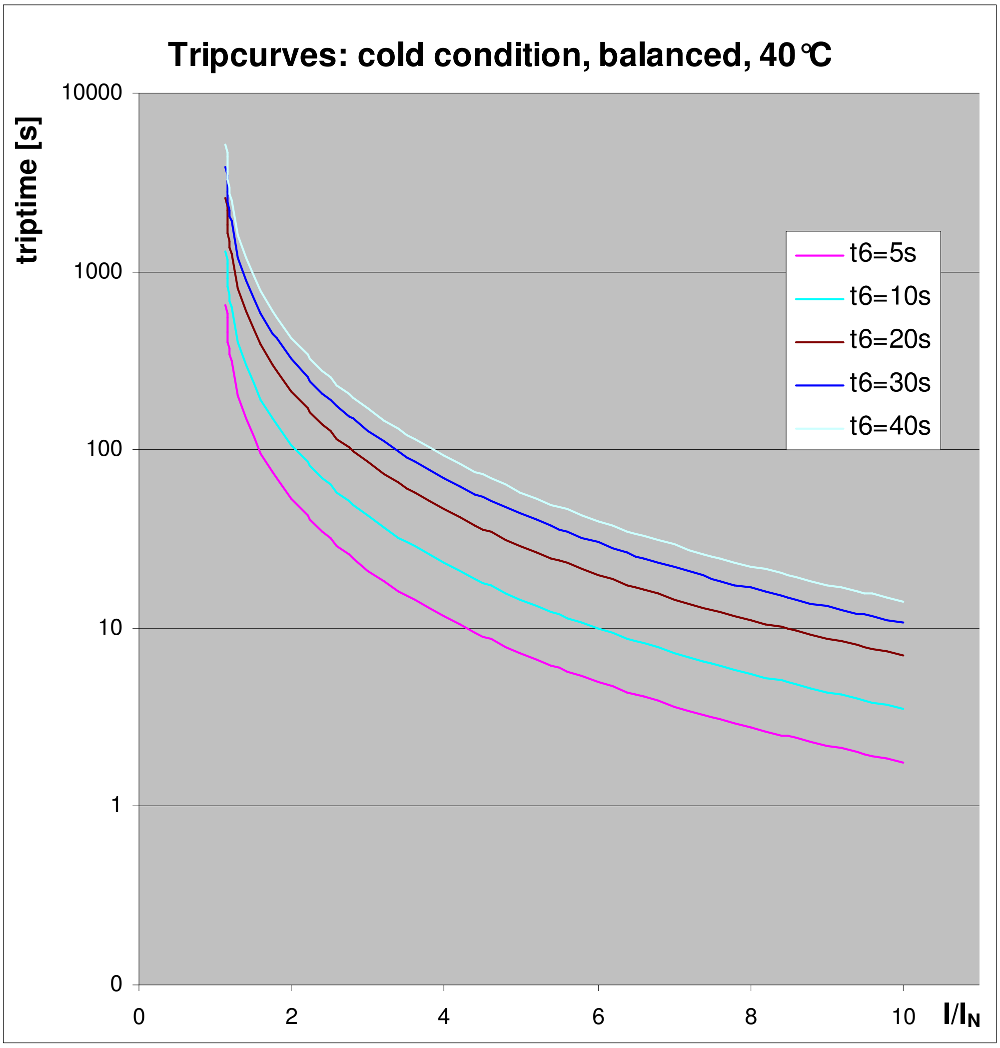


Table 2. Look-up table of trip time from cold condition, 100% of phase loss. T_{AMB} = 40°C.

I / In	t6 = 5 s	t6 = 7 s	t6 = 10 s	t6 = 15 s	t6 = 20 s	t6 = 25 s	t6 = 30 s	t6 = 35 s	t6 = 40 s
0.73	533 s	747 s	1067 s	1600 s	2133 s	2666 s	3200 s	3733 s	4266 s
0.74	419 s	586 s	837 s	1255 s	1674 s	2092 s	2510 s	2929 s	3347 s
0.75	359 s	503 s	718 s	1077 s	1436 s	1795 s	2154 s	2513 s	2872 s
0.76	319 s	447 s	638 s	958 s	1277 s	1596 s	1915 s	2234 s	2553 s
0.77	290 s	405 s	579 s	869 s	1158 s	1447 s	1737 s	2026 s	2316 s
0.78	266 s	373 s	532 s	798 s	1064 s	1330 s	1596 s	1862 s	2128 s
0.79	247 s	345 s	493 s	740 s	987 s	1233 s	1480 s	1727 s	1973 s
0.80	230 s	323 s	461 s	691 s	921 s	1152 s	1382 s	1612 s	1843 s
1.00	101 s	140 s	201 s	301 s	402 s	502 s	603 s	703 s	804 s
1.20	61.4 s	85.9 s	123 s	184 s	245 s	307 s	368 s	429 s	490 s
1.40	42.3 s	59.2 s	84.5 s	127 s	169 s	211 s	253 s	295 s	337 s
1.60	31.2 s	43.6 s	62.2 s	93.3 s	124 s	155 s	186 s	217 s	248 s
1.80	24.1 s	33.6 s	48.0 s	71.9 s	95.8 s	120 s	144 s	168 s	191 s
2.00	19.2 s	26.8 s	38.2 s	57.2 s	76.3 s	95.3 s	114 s	133 s	152 s
2.20	15.7 s	21.9 s	31.2 s	46.8 s	62.3 s	77.8 s	93.3 s	109 s	124 s
2.40	13.1 s	18.3 s	26.0 s	38.9 s	51.9 s	64.8 s	77.7 s	90.7 s	104 s
2.60	11.1 s	15.5 s	22.0 s	33.0 s	43.9 s	54.8 s	65.8 s	76.7 s	87.6 s
2.80	9.5 s	13.3 s	18.9 s	28.3 s	37.7 s	47.0 s	56.4 s	65.8 s	75.2 s
3.00	8.3 s	11.5 s	16.4 s	24.6 s	32.7 s	40.8 s	48.9 s	57.1 s	65.2 s
3.20	7.3 s	10.1 s	14.4 s	21.5 s	28.6 s	35.8 s	42.9 s	50.0 s	57.1 s
3.40	6.4 s	9.0 s	12.7 s	19.0 s	25.3 s	31.6 s	37.9 s	44.2 s	50.5 s
3.60	5.8 s	8.0 s	11.3 s	16.9 s	22.5 s	28.1 s	33.7 s	39.3 s	44.9 s
3.80	5.2 s	7.2 s	10.2 s	15.2 s	20.2 s	25.2 s	30.2 s	35.2 s	40.2 s
4.00	4.7 s	6.5 s	9.2 s	13.7 s	18.2 s	22.7 s	27.2 s	31.8 s	36.3 s
4.20	4.2 s	5.9 s	8.3 s	12.4 s	16.5 s	20.6 s	24.7 s	28.8 s	32.9 s
4.40	3.9 s	5.4 s	7.6 s	11.3 s	15.0 s	18.8 s	22.5 s	26.2 s	29.9 s
4.60	3.6 s	4.9 s	7.0 s	10.4 s	13.8 s	17.2 s	20.6 s	24.0 s	27.4 s
4.80	3.3 s	4.5 s	6.4 s	9.5 s	12.6 s	15.8 s	18.9 s	22.0 s	25.1 s
5.00	3.0 s	4.2 s	5.9 s	8.8 s	11.6 s	14.5 s	17.4 s	20.3 s	23.1 s
5.20	2.8 s	3.9 s	5.5 s	8.1 s	10.8 s	13.4 s	16.1 s	18.7 s	21.4 s
5.40	2.6 s	3.6 s	5.1 s	7.5 s	10.0 s	12.5 s	14.9 s	17.4 s	19.8 s
5.60	2.4 s	3.4 s	4.7 s	7.0 s	9.3 s	11.6 s	13.9 s	16.1 s	18.4 s
5.80	2.3 s	3.1 s	4.4 s	6.5 s	8.7 s	10.8 s	12.9 s	15.1 s	17.2 s
6.00	2.1 s	2.9 s	4.1 s	6.1 s	8.1 s	10.1 s	12.1 s	14.1 s	16.1 s
6.20	2.0 s	2.8 s	3.9 s	5.7 s	7.6 s	9.5 s	11.3 s	13.2 s	15.0 s

I / In	t6 = 5 s	t6 = 7 s	t6 = 10 s	t6 = 15 s	t6 = 20 s	t6 = 25 s	t6 = 30 s	t6 = 35 s	t6 = 40 s
6.40	1.9 s	2.6 s	3.7 s	5.4 s	7.1 s	8.9 s	10.6 s	12.4 s	14.1 s
6.60	1.8 s	2.5 s	3.4 s	5.1 s	6.7 s	8.4 s	10.0 s	11.6 s	13.3 s
6.80	1.7 s	2.3 s	3.2 s	4.8 s	6.3 s	7.9 s	9.4 s	11.0 s	12.5 s
7.00	1.6 s	2.2 s	3.1 s	4.5 s	6.0 s	7.4 s	8.9 s	10.4 s	11.8 s
7.20	1.5 s	2.1 s	2.9 s	4.3 s	5.7 s	7.0 s	8.4 s	9.8 s	11.2 s
7.40	1.5 s	2.0 s	2.8 s	4.1 s	5.4 s	6.7 s	8.0 s	9.3 s	10.6 s
7.60	1.4 s	1.9 s	2.6 s	3.9 s	5.1 s	6.3 s	7.6 s	8.8 s	10.0s
7.80	1.3 s	1.8 s	2.5 s	3.7 s	4.9 s	6.0 s	7.2 s	8.4 s	9.5 s
8.00	1.3 s	1.7 s	2.4 s	3.5 s	4.6 s	5.7 s	6.8 s	8.0 s	9.1 s
8.20	1.2 s	1.6 s	2.3 s	3.3 s	4.4 s	5.5 s	6.5 s	7.6 s	8.6 s
8.40	1.2 s	1.6 s	2.2 s	3.2 s	4.2 s	5.2 s	6.2 s	7.2 s	8.2 s
8.60	1.1 s	1.5 s	2.1 s	3.1 s	4.0 s	5.0 s	5.9 s	6.9 s	7.9 s
8.80	1.1 s	1.4 s	2.0 s	2.9 s	3.8 s	4.8 s	5.7 s	6.6 s	7.5 s
9.00	1.0 s	1.4 s	1.9 s	2.8 s	3.7 s	4.6 s	5.4 s	6.3 s	7.2 s
9.20	1.0 s	1.3 s	1.8 s	2.7 s	3.5 s	4.4 s	5.2 s	6.1 s	6.9 s
9.40	1.0 s	1.3 s	1.8 s	2.6 s	3.4 s	4.2 s	5.0 s	5.8 s	6.6 s
9.60	0.9 s	1.2 s	1.7 s	2.5 s	3.3 s	4.0 s	4.8 s	5.6 s	6.3 s
9.80	0.9 s	1.2 s	1.6 s	2.4 s	3.1 s	3.9 s	4.6 s	5.4 s	6.1 s
10.00	0.9 s	1.2 s	1.6 s	2.3 s	3.0 s	3.7 s	4.4 s	5.1 s	5.9 s

Picture 2. Trip curve from cold condition, 100% phase loss. T_{AMB} = 40°C.

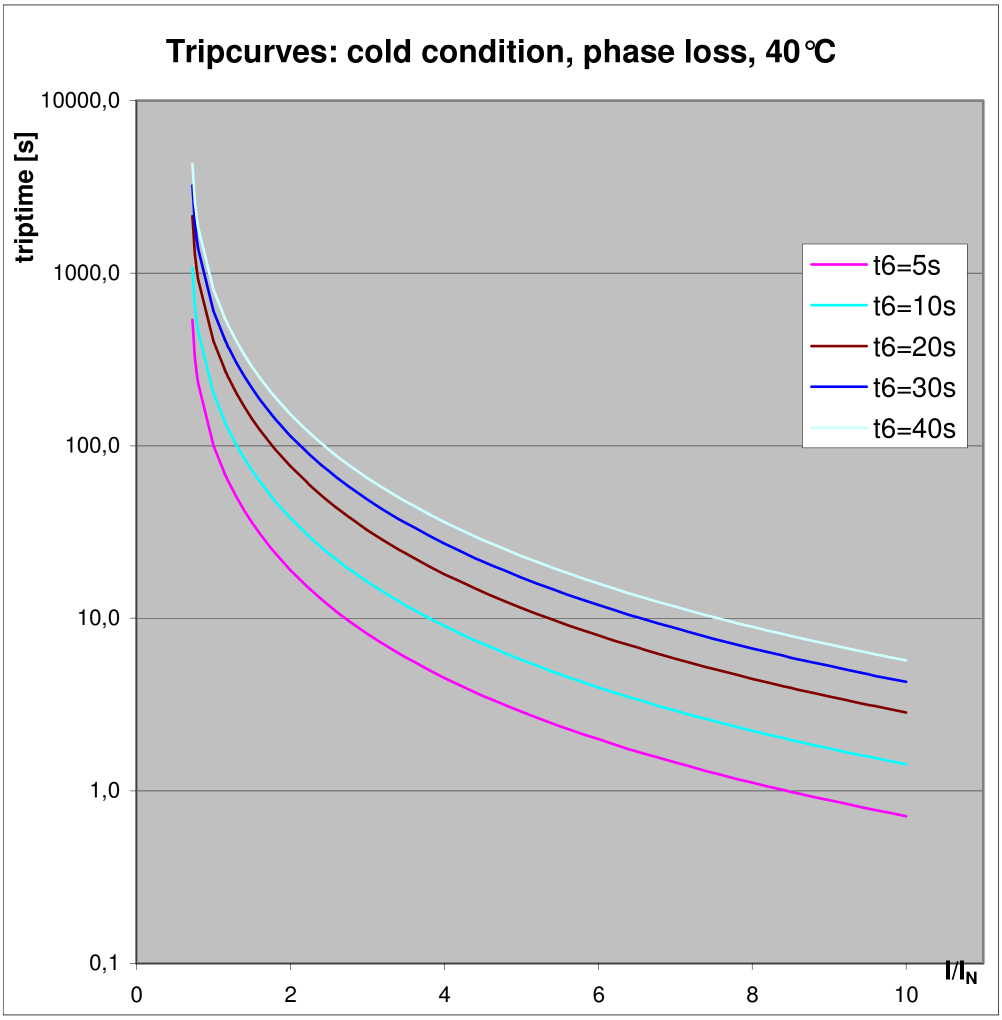
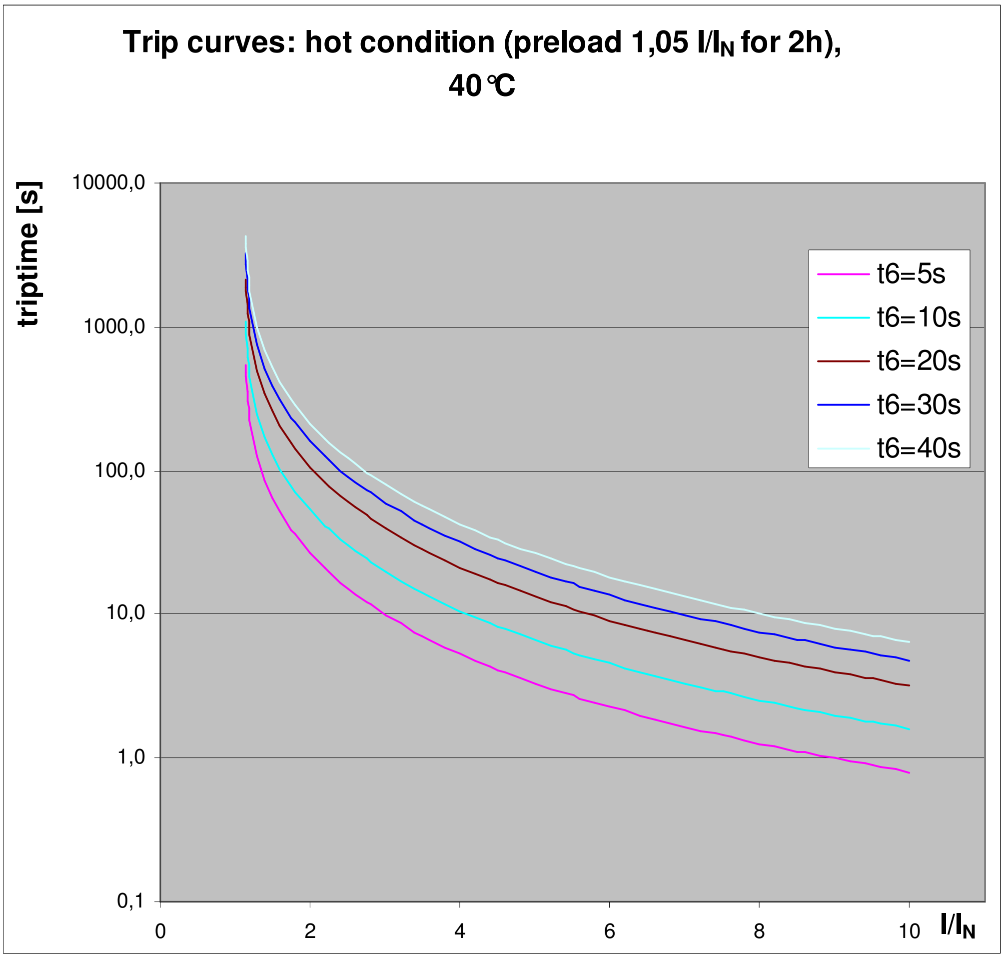


Table 3. Look-up table of trip time from hot condition (1,05xIn preload for 2 hours), balanced network. T_{AMB} = 40°C.

I / In	t6 = 5 s	t6 = 7 s	t6 = 10 s	t6 = 15 s	t6 = 20 s	t6 = 25 s	t6 = 30 s	t6 = 35 s	t6 = 40 s
1.15	446 s	624 s	891 s	1336 s	1782 s	2227 s	2673 s	3119 s	3565 s
1.16	356 s	498 s	712 s	1067 s	1423 s	1779 s	2134 s	2490 s	2847 s
1.17	305 s	427 s	610 s	915 s	1220 s	1525 s	1830 s	2135 s	2441 s
1.18	270 s	378 s	540 s	810 s	1080 s	1350 s	1620 s	1891 s	2162 s
1.19	244 s	341 s	488 s	731 s	975 s	1219 s	1463 s	1707 s	1952 s
1.20	223 s	312 s	446 s	669 s	892 s	1115 s	1338 s	1561 s	1785 s
1.40	86.2 s	121 s	172 s	258 s	344 s	430 s	517 s	603 s	689 s
1.60	51.9 s	72.5 s	104 s	155 s	207 s	259 s	310 s	362 s	414 s
1.80	35.9 s	50.2 s	71.6 s	107 s	143 s	179 s	215 s	250 s	286 s
2.00	26.7 s	37.4 s	53.3 s	79.9 s	107 s	133 s	160 s	186 s	213 s
2.20	20.9 s	29.2 s	41.6 s	62.3 s	83.1 s	104 s	125 s	145 s	166 s
2.40	16.9 s	23.5 s	33.6 s	50.3 s	67.0 s	83.7 s	100 s	117 s	134 s
2.60	14.0 s	19.5 s	27.7 s	41.50 s	55.3 s	69.1 s	82.9 s	96.8 s	111 s
2.80	11.8 s	16.4 s	23.4 s	35.0 s	46.6 s	58.2 s	69.8 s	81.5 s	93.2 s
3.00	10.1 s	14.1 s	20.0 s	29.9 s	39.9 s	49.8 s	59.7 s	69.7 s	79.7 s
3.20	8.8 s	12.2 s	17.3 s	25.9 s	34.5 s	43.1 s	51.7 s	60.3 s	69.0 s
3.40	7.7 s	10.7 s	15.2 s	22.7 s	30.2 s	37.7 s	45.3 s	52.8 s	60.4 s
3.60	6.8 s	9.4 s	13.4 s	20.1 s	26.7 s	33.3 s	40.0 s	46.6 s	53.3 s
3.80	6.1 s	8.4 s	12.0 s	17.9 s	23.8 s	29.7 s	35.6 s	41.5 s	47.5 s
4.00	5.4 s	7.6 s	10.7 s	16.0 s	21.3 s	26.6 s	31.9 s	37.2 s	42.5 s
4.20	4.9 s	6.8 s	9.7 s	14.5 s	19.2 s	24.0 s	28.8 s	33.6 s	38.4 s
4.40	4.5 s	6.2 s	8.8 s	13.1 s	17.4 s	21.8 s	26.1 s	30.4 s	34.8 s
4.60	4.1 s	5.7 s	8.0 s	12.0 s	15.9 s	19.8 s	23.8 s	27.7 s	31.7 s
4.80	3.8 s	5.2 s	7.4 s	11.0 s	14.6 s	18.2 s	21.8 s	25.4 s	29.0 s
5.00	3.5 s	4.8 s	6.8 s	10.1 s	13.4 s	16.7 s	20.0 s	23.3 s	26.6 s
5.20	3.2 s	4.4 s	6.3 s	9.3 s	12.3 s	15.4 s	18.4 s	21.5 s	24.6 s
5.40	3.0 s	4.1 s	5.8 s	8.6 s	11.4 s	14.2 s	17.1 s	19.9 s	22.7 s
5.60	2.8 s	3.8 s	5.4 s	8.0 s	10.6 s	13.2 s	15.8 s	18.5 s	21.1 s
5.80	2.6 s	3.6 s	5.0 s	7.4 s	9.9 s	12.3 s	14.7 s	17.2 s	19.6 s
6.00	2.4 s	3.3 s	4.7 s	7.0 s	9.2 s	11.5 s	13.8 s	16.0 s	18.3 s
6.20	2.3 s	3.1 s	4.4 s	6.5 s	8.6 s	10.7 s	12.9 s	15.0 s	17.1 s
6.40	2.1 s	2.9 s	4.1 s	6.1 s	8.1 s	10.1 s	12.1 s	14.1 s	16.1 s
6.60	2.0 s	2.8 s	3.9 s	5.7 s	7.6 s	9.5 s	11.3 s	13.2 s	15.1 s
6.80	1.9 s	2.6 s	3.7 s	5.4 s	7.2 s	8.9 s	10.7 s	12.4 s	14.2 s

I / In	t6 = 5 s	t6 = 7 s	t6 = 10 s	t6 = 15 s	t6 = 20 s	t6 = 25 s	t6 = 30 s	t6 = 35 s	t6 = 40 s
7.00	1.8 s	2.5 s	3.5 s	5.1 s	6.8 s	8.4 s	10.1 s	11.7 s	13.4 s
7.20	1.7 s	2.3 s	3.3 s	4.8 s	6.4 s	8.0 s	9.5 s	11.1 s	12.7 s
7.40	1.6 s	2.2 s	3.1 s	4.6 s	6.1 s	7.5 s	9.0 s	10.5 s	12.0 s
7.60	1.6 s	2.1 s	3.0 s	4.4 s	5.7 s	7.1 s	8.5 s	9.9 s	11.4 s
7.80	1.5 s	2.0 s	2.8 s	4.1 s	5.5 s	6.8 s	8.1 s	9.4 s	10.8 s
8.00	1.4 s	1.9 s	2.7 s	3.9 s	5.2 s	6.5 s	7.7 s	9.0 s	10.2 s
8.20	1.4 s	1.8 s	2.6 s	3.8 s	4.9 s	6.1 s	7.3 s	8.5 s	9.8 s
8.40	1.3 s	1.8 s	2.4 s	3.6 s	4.7 s	5.9 s	7.0 s	8.1 s	9.3 s
8.60	1.2 s	1.7 s	2.3 s	3.4 s	4.5 s	5.6 s	6.7 s	7.8 s	8.9 s
8.80	1.2 s	1.6 s	2.2 s	3.3 s	4.3 s	5.3 s	6.4 s	7.4 s	8.5 s
9.00	1.2 s	1.5 s	2.1 s	3.1 s	4.1 s	5.1 s	6.1 s	7.1 s	8.1 s
9.20	1.1 s	1.5 s	2.1 s	3.0 s	4.0 s	4.9 s	5.8 s	6.8 s	7.8 s
9.40	1.1 s	1.4 s	2.0 s	2.9 s	3.8 s	4.7 s	5.6 s	6.5 s	7.4 s
9.60	1.0 s	1.4 s	1.9 s	2.8 s	3.6 s	4.5 s	5.4 s	6.3 s	7.1 s
9.80	1.0 s	1.3 s	1.8 s	2.7 s	3.5 s	4.3 s	5.2 s	6.0 s	6.8 s
10.00	1.0 s	1.3 s	1.8 s	2.6 s	3.4 s	4.2 s	5.0 s	5.8 s	6.6 s

Picture 3. Trip curve from hot condition (1,05xIn preload for 2 hours), balanced network. T_{AMB} = 40°C.



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Appendix C. Terms and Abbreviations

Abbreviation	Term	Explanation / Comments
	Alarm	Alarm is defined as status transition from any state to abnormal state. Status transition to abnormal state can be data crossing over the predefined alarm limit.
	Backplane	INSUM backbone, holds following INSUM devices: router, gateways, clock, power supply. Part of the INSUM Communication Unit, see ICU
CA	Control Access	A function of INSUM system that allows definition of operating privileges for each device level (e.g. PCS, gateway, field device)
CAT	Control Access Table	Table containing control access privileges
CB	Circuit Breaker	Circuit breaker unit (here: ABB SACE Emax with electronic release PR112-PD/LON)
CT	Current Transformer	Current Transformer
DCS	Distributed Control System	see also PCS
Eth	Ethernet	Layer 1 of the ISO layer model for networks, describing the physical properties (cable, connectors etc.) using TCP/IP protocol
	Event	An event is a status transition from one state to another. It can be defined as alarm, if the state is defined as abnormal or as warning as a pre-alarm state.
FD	Field Device	Term for devices connected to the LON fieldbus (e.g. motor control units or circuit breaker protection)
FU	Field Unit	see Field Device
GPI	General Purpose Input	Digital input on MCU for general use
GPO	General Purpose Output	Digital output on MCU for general use
GPS	Global Positioning System	System to detect local position, universal time and time zone, GPS technology provides accurate time to a system
GW	Gateway	A gateway is used as an interface between LON protocol in INSUM and other communication protocols (e.g. TCP/IP, Profibus, Modbus)
HMI	Human Machine Interface	Generic expression for switchgear level communication interfaces to field devices, either switchboard mounted or hand held
ICU	INSUM Communications Unit	INSUM Communications Unit consists of devices such as backplane, gateways, routers, system clock and power supply. It provides the communication interface within INSUM and between INSUM and control systems. Formerly used expressions: SGC, SU
INSUM	INSUM	Integrated System for User optimized Motor Management. The concept of INSUM is to provide a platform for integration of smart components, apparatus and software tools for engineering and operation of the motor control switchgea
INSUM OS	INSUM Operator Station	Tool to parameterise, monitor and control devices in the INSUM system
ITS	Integrated Tier Switch	The Intelligent Tier Switch is an ABB SlimLine switch fuse with integrated sensors and microprocessor based electronics for measurement and surveillance
LON	Local Operating Network	LON is used as an abbreviation for LonWorks network. A variation of LON is used as a switchgear bus in the INSUM 2 system

Abbreviation	Term	Explanation / Comments
LonTalk	LonTalk protocol	Fieldbus communication protocol used in LonWorks networks
LonWorks	LonWorks network	A communication network built using LonWorks network technology, including e.g. Neuron chip and LonTalk protocol
MCU	Motor Control Unit	Motor Control Unit is a common name for a product range of electronic motor controller devices (field device) in INSUM. A MCU is located in a MNS motor starter, where its main tasks are protection, control and monitoring of motor and the related motor starter equipment.
MMI	Man Machine Interface	The switchgear level INSUM HMI device to parameterize and control communication and field devices.
MNS	MNS	ABB Modular Low Voltage Switchgear
	Modbus, Modbus RTU	Fieldbus communication protocol
NV,nv	LON Network Variable	Network variable is a data item in LonTalk protocol application containing max. 31 bytes of data.
Nvi, nvi	LON Network Variable input	LON bus input variable
Nvo, nvo	LON Network Variable output	LON bus output variable
OS	Operator Station	see INSUM OS
PCS	Process Control System	High level process control system
PLC	Programmable Local Controller	Low level control unit
PR	Programmable Release	Circuit breaker protection/release unit (here: ABB SACE Emax PR112-PD/LON)
	Profibus DP	Fieldbus communication protocol with cyclic data transfer
	Profibus DP-V1	Fieldbus communication protocol, extension of Profibus DP allowing acyclic data transfer and multi master.
PTB	Physikalisch-Technische Bundesanstalt	Authorized body in Germany to approve Ex-e applications.
PTC	Positive Temperature Coefficient	A temperature sensitive resistor used to detect high motor temperature and to trip the motor if an alarm level is reached.
RCU	Remote Control Unit	Locally installed control device for motor starter, interacting directly with starter passing MCU for local operations.
	Router	Connection device in the LON network to interconnect different LON subnets. Part of the INSUM Communications Unit.
RTC	Real Time Clock	Part of the INSUM System Clock and and optionally time master of the INSUM system
SCADA	Supervisory Control and Data Acquisition	
SGC	Switchgear Controller	Former term used for INSUM Communications Unit
SU	Switchgear Unit	Former term used for INSUM Communications Unit
	System Clock	INSUM device providing time synchronisation between a time master and all MCUs. Part of the INSUM Communication Unit, see ICU
TCP/IP	Transmission Control Protocol / Internet Protocol	Transmission protocol used for data transmission via Ethernet
TFLC	Thermal Full Load Current	See MCU Parameter Description for explanation

Abbreviation	Term	Explanation / Comments
TOL	Thermal Overload	See MCU Parameter Description for explanation
	Trip	A consequence of an alarm activated or an external trip command from another device to stop the motor or trip the circuit breaker.
VU	Voltage Unit	Voltage measurement and power supply unit for MCU 2
	Wink	The Wink function enables identifcation of a device on the LON network. When a device receives a Wink-message via the fieldbus, it responds with a visual indication (flashing LED)

ABB Automation Products GmbH
Wallstadter Str. 59
D - 68526 Ladenburg / Germany

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