MotStart Three-phase Start-Up Supervision for Motors

Contents

1. Introduction

1.1 Features

- Three-phase start-up protection for motors
- Thermal stress calculation (I^2 x t)
- Stall protection with a digital input for stall indication
- Cumulative start-up time counter protection
- Current measurement with conventional current transformers or Rogowski coils

1.2 Application

This document specifies the function of the three-phase start-up supervision function block MotStart used in products based on the RED 500 Platform.

Table 1 . Protection diagram symbols used in the relay terminal

ABB	IEC	ANSI
MotStart	**Is2t n<**	**48**

For IEC symbols used in single line diagrams, refer to the manual “Technical Descriptions of Functions, Introduction”, 1MRS750528-MUM.

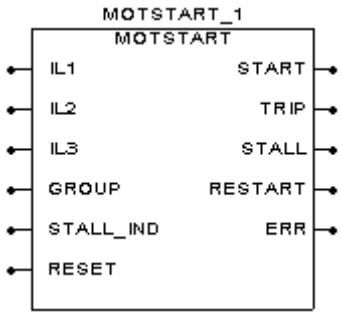

Figure 1. Function block symbol of MotStart

1.3 Input description

Name	Type	Description
IL1	Analogue signal (SINT)	Input for measuring phase current I_{L1}
IL2	Analogue signal (SINT)	Input for measuring phase current I_{L2}
IL3	Analogue signal (SINT)	Input for measuring phase current I_{L3}
GROUP	Digital signal (BOOL, active high)	Control input for switching between the setting groups 1 and 2
STALL_IND	Digital signal (BOOL, active high)	Input signal for motor stalling
RESET	Reset signal (BOOL, pos.edge)	Input signal for resetting the registers of MotStart

1.4 Output description

Name	Type	Description
START	Digital signal (BOOL, active high)	Start signal
TRIP	Digital signal (BOOL, active high)	Trip signal
STALL	Digital signal (BOOL, active high)	Stall signal
RESTART	Digital signal (BOOL, active high)	Restart enable signal
ERR	Digital signal (BOOL, active high)	Signal for indicating a configuration error

2. Description of Operation

2.1 Configuration

Phase currents can be measured via conventional current transformers or Rogowski coils. The measuring devices and signal types for the analogue channels are selected and configured in a special dialogue box of the Relay Configuration Tool. Digital inputs are configured in the same programming environment (the number of selectable analogue inputs, digital inputs and digital outputs depends on the hardware used).

When the analogue channels and digital inputs have been selected and configured in the dialogue box, the inputs and outputs of the function block can be configured on a graphic worksheet of the configuration tool. The phase currents I_{L1}, I_{L2} and I_{L3} are connected to the corresponding IL1, IL2 and IL3 inputs of the function block. Digital inputs are connected to the boolean inputs of the function block, and the outputs of the function block are connected to the output signals in the same way.

2.2 Setting the rated values of the protected unit

A separate scaling factor can be set for each analogue channel. The factors enable differences between the ratings of the protected unit and those of the measuring device (CTs, VTs, etc.). A setting of 1.00 means that the rated value of the protected unit is exactly the same as that of the measuring device. For more information, refer to the technical reference manual of the product in question.

2.3 Measuring mode

The calculation of the thermal stress (I^2 x t) for the motor is based on the TRUE RMS measuring principle. The start-up situation for the motor is detected by the PEAK measuring principle. Harmonics are not suppressed.

2.4 Operation mode

The setting parameter “Operation mode” is used for selecting one of the three operation modes available. Mode 0 (Not in use) sets the function out of use, whereas in mode 1 (IIt) MotStart calculates the thermal stress for the motor and in mode 2 (IIt & Stall) protects the motor against stalling during a motor start-up.

2.4.1 I^2 * t mode

The thermal stress during any single start-up is monitored by the start-up supervision MotStart, which calculates the product I^2 x t, i.e. the thermal stress, during a normal start-up of a motor.

The motor start-up situation is a sequence, where each of the initial three phase currents is less than 0.05 x I_n for 60 ms, i.e. the motor is at standstill, and where at least one phase current within the rising time (60 ms) rises from a value below 0.05 x I_n to a value higher than the start value (1.5 x I_n). If a phase current sample exceeds the current level within the rising time, the START signal is immediately set to TRUE, i.e. the START output can be activated before the rising time has elapsed.

The START signal remains active until all the three phase currents fall below 0.9 x Start current (0.9 x 1.5 x I_n = 1.35 x I_n) and remain below that level for 150 ms, i.e. until the start-up situation is over.

During the motor start-up MotStart measures the start current, raises the value to a power of 2 and multiplies it by the running time, i.e. calculates the product I^2 x t. If the calculated value exceeds the set value, the function block trips immediately.

Note! The set I^2 x t comes from the value set for the “Start current” parameter raised to a power of two and multiplied by the value set for the “Start time” parameter.

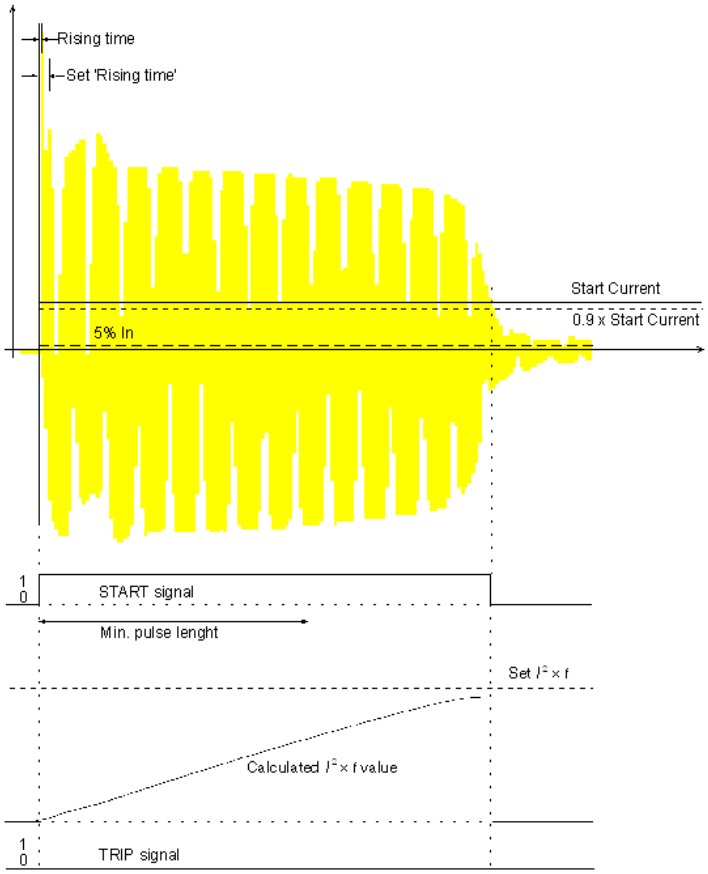

Figure 2. Functionality of start-up supervision based on I^2 x t

2.4.2 $I^2 * t$ & stall mode

In this mode, stall protection operates in parallel to the I^2 x t function. The function stalls during the motor start-up (STALL active) if the stall indication input signal (STALL_IND) remains active longer than set stall time. An active STALL signal is indicated by a steady trip LED (red) on the MMI.

Note! The trip and stall functions will both continue protecting the motor even though the other function has operated.

2.5 Start-up counter

Every time the motor is started, the start-up time is added to a register. If the contents of the register exceed the preset level, i.e. the value set for the “Time limit” parameter, the signal “Output RESTART” is deactivated. When the start-up situation is over, the value of the register decreases at a certain speed, which is set via the parameter “Countdown rate”. When the value of the register falls below the set time limit, the signal “Output RESTART” is activated again. Note that the RESTART output is normally activated, i.e. a new start is possible, even though its default value is zero.

For example, the motor manufacturer may state that three starts at the maximum are allowed within 8 hours and the start-up situation time is 20 s. By initiating three successive starts we reach the situation illustrated below. As a result, the value of the register adds up to a total of 60 seconds. Right after the third start has been initiated, the RESTART output is deactivated and the fourth start will not be allowed, provided the time limit has been set to 41 seconds.

Furthermore, the maximum of three starts in 8 hours means that the value of the register should reach the set time limit within 8 hours to allow a new start. Accordingly, the countdown rate should be 20 seconds in 8 hours and should thus be set to 20 s / 8 h = 2.5 s / h.

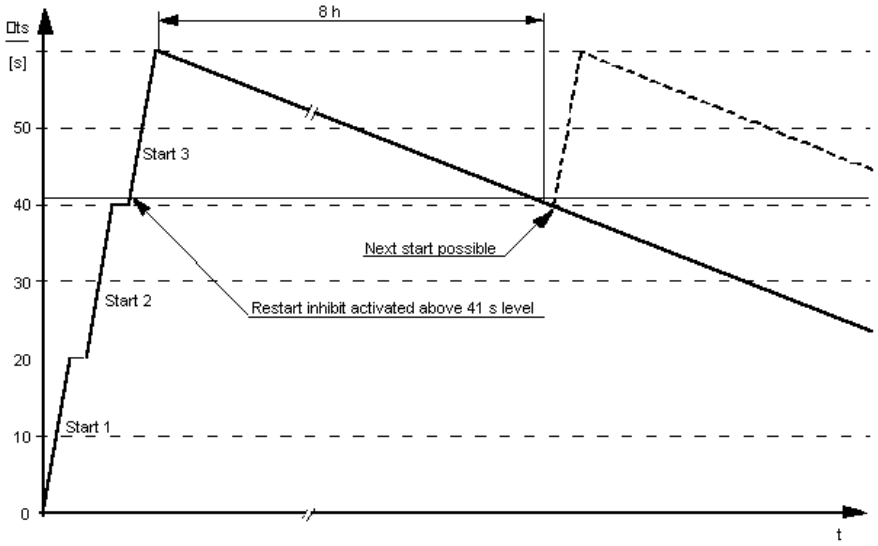

Figure 3. Operation of the start-up time counter

The parameter “Time to restart” estimates in minutes the time remaining to the moment when the next start is possible. The parameter is updated when the motor is not running, i.e. all the phase currents are below 0.05 x I_n. The parameter “Start counter” calculates the number of motor start-ups and is updated at the rising edge of the START signal.

2.6 Setting groups

The two different groups of setting values, group 1 and 2, are available for the function block. Switching between the two groups can be done in the following three ways:

1 Locally via the control parameter “Group selection”[1)] of the MMI

2 Over the communication bus by writing the parameter V1[1)]

3 By means of the input signal GROUP when allowed via the parameter “Group selection” (i.e. when V1 = 2[1)]).

[1)] Group selection (V1): 0 = Group 1; 1 = Group 2; 2 = GROUP input

The control parameter “Active group” indicates the setting group valid at a given time.

2.7 Test mode

The digital outputs of the function block can be activated with separate control parameters for each output either locally via the MMI or externally via the serial communication. When an output is activated with the test parameter, an event indicating the test is generated.

The protection functions operate normally while the outputs are tested.

2.8 START, TRIP and STALL outputs

The minimum pulse width of the corresponding output signal is set via a separate parameter on MMI (control setting) or serial communication. If the start situation is longer than the set pulse width, the START signal stays active until the start situation is over. The output signal TRIP may have a non-latching or latching feature. When the latching mode has been selected, the TRIP signal remains continuously active though the operation criteria have reset, until the output is reset.

Note! The values set for the control parameters “Trip signal” (non-latching or latching) and “Trip pulse” (minimum pulse width) apply to both the TRIP output and the STALL output.

An active STALL signal is indicated by a steady trip LED (red) on the MMI. Active TRIP and START signals are indicated as normally, i.e. TRIP with a steady trip LED (red) and START with a steady start LED (yellow).

2.9 Resetting

The TRIP output signal and the registers can be reset either via the RESET input, over the serial bus or via the local MMI.

The operation indicators, latched trip signal and recorded data can be reset as follows:

	Operation indicators	Latched trip signal	Recorded data
RESET input of the function block [1)]		X	X
Parameter F054V013 [1)]		X	X
General parameter F001V011 [2)]	X		
General parameter F001V012 [2)]	X	X	
General parameter F001V013 [2)]	X	X	X
Push-button C [2)]	X		
Push-buttons C + E (2 s) [2)]	X	X	
Push-buttons C + E (5 s) [2)]	X	X	X

[1)] Resets the latched trip signal and recorded data of this particular function block.
[2)] Affects all function blocks.

3. Parameters and Events

3.1 General

- Each function block has a specific channel number for serial communication parameters and events. The channel for MotStart is 54.
- The data direction of the parameters defines the use of each parameter as follows:

Data direction	Description
R, R/M	Read only
W	Write only
R/W	Read and write

- The different event mask parameters (see section “Control settings”) affect the visibility of events on the MMI or on serial communication (LON or SPA) as follows:

Event mask 1 (FxxxV101/102)	SPA / MMI (LON)
Event mask 2 (FxxxV103/104)	LON
Event mask 3 (FxxxV105/106)	LON
Event mask 4 (FxxxV107/108)	LON

For example, if only the events E3, E4 and E5 are to be seen on the MMI of the relay terminal, the event mask value 56 (8 + 16 + 32) is written to the “Event mask 1” parameter (FxxxV101).

In case a function block includes more than 32 events, there are two parameters instead of e.g. the “Event mask 1” parameter: the parameter “Event mask 1A” (FxxxV101) covers the events 0...31 and “Event mask 1B”(FxxxV102) the events 32...63.

3.2 Setting values

3.2.1 Actual settings

Parameter	Code	Values	Unit	Default	Data direction	Explanation
Operation mode	S1	0...2 [1)]	-	1	R/M	Selection of operation mode
Start current	S2	1.0...10.0	x I_n	2.0	R/M	Starting current for motor
Start time	S3	0.3...250.0	s	5.0	R/M	Starting time for motor
Time limit	S4	1.0...500.0	s	10.0	R/M	Time-based restart inhibit limit
Countdown rate	S5	2.0...250.0	s/h	60.0	R/M	Countdown rate for the time counter
Stall time	S6	2.0...120.0	s	10.0	R/M	Permitted stalling time for rotor

[1)] Operation mode 0 = Not in use; 1 = IIt; 2 = IIt & Stall

3.2.2 Setting group 1

Parameter	Code	Values	Unit	Default	Data direction	Explanation
Operation mode	S41	0...2 [1)]	-	1	R/W	Selection of operation mode
Start current	S42	1.0...10.0	x I_n	2.0	R/W	Starting current for motor
Start time	S43	0.3...250.0	s	5.0	R/W	Starting time for motor
Time limit	S44	1.0...500.0	s	10.0	R/W	Time-based restart inhibit limit
Countdown rate	S45	2.0...250.0	s/h	60.0	R/W	Countdown rate for the time counter
Stall time	S46	2.0...120.0	s	10.0	R/W	Permitted stalling time for rotor

[1)] Operation mode 0 = Not in use; 1 = IIt; 2 = IIt & Stall

3.2.3 Setting group 2

Parameter	Code	Values	Unit	Default	Data direction	Explanation
Operation mode	S71	0...2 [1)]	-	1	R/W	Selection of operation mode
Start current	S72	1.0...10.0	x I_n	2.0	R/W	Starting current for motor
Start time	S73	0.3...250.0	s	5.0	R/W	Starting time for motor
Time limit	S74	1.0...500.0	s	10.0	R/W	Time-based restart inhibit limit
Countdown rate	S75	2.0...250.0	s/h	60.0	R/W	Countdown rate for the time counter
Stall time	S76	2.0...120.0	s	10.0	R/W	Permitted stalling time for rotor

[1)] Operation mode 0 = Not in use; 1 = IIt; 2 = IIt & Stall

3.2.4 Control settings

Parameter	Code	Values	Unit	Default	Data direction	Explanation
Group selection	V1	0...2 [1)]	-	0	R/W	Selection of the active setting group
Active group	V2	0 or 1 [2)]	-	0	R/M	Active setting group
Start pulse	V3	0...1000	ms	0	R/W	Minimum pulse width of START signal
Trip signal	V4	0 or 1 [3)]	-	0	R/W	Selection of latching feature for TRIP and STALL outputs
Trip pulse	V5	40...1000	ms	40	R/W	Minimum pulse width of TRIP and STALL
Start counter	V6	0...99999	-	0	R/M	Start counter
Time to restart	V7	0...99999	min	0	R/M	Time to restart enable
Reset registers	V13	1=Reset	-	0	W	Resetting of latched trip signal and registers
Test START	V31	0 or 1 [4)]	-	0	R/W	Testing of START
Test TRIP	V32	0 or 1 [4)]	-	0	R/W	Testing of TRIP
Test STALL	V33	0 or 1 [4)]	-	0	R/W	Testing of STALL
Event mask 1	V101	0...255	-	63	R/W	Event mask 1 for event transmission (E0 ... E7)
Event mask 2	V103	0...255	-	63	R/W	Event mask 2 for event transmission (E0 ... E7)
Event mask 3	V105	0...255	-	63	R/W	Event mask 3 for event transmission (E0 ... E7)
Event mask 4	V107	0...255	-	63	R/W	Event mask 4 for event transmission (E0 ... E7)

[1)] Group selection 0 = Group 1; 1 = Group 2; 2 = GROUP input
[2)] Active group 0 = Group 1; 1 = Group 2
[3)] Trip signal 0 = Non-latching; 1 = Latching
[4)] Testing 0 = Do not activate; 1 = Activate

3.3 Measurement values

3.3.1 Input data

Parameter	Code	Values	Unit	Default	Data direction	Explanation
Current IL1	I1	0.0...60.0	x I_n	0.0	R/M	Phase current IL1
Current IL2	I2	0.0...60.0	x I_n	0.0	R/M	Phase current IL2
Current IL3	I3	0.0...60.0	x I_n	0.0	R/M	Phase current IL3
Input GROUP	I4	0 or 1 [1)]	-	0	R/M	Signal for switching between groups 1 and 2
Input STALL	I5	0 or 1 [1)]	-	0	R/M	Signal for motor stalling indication
Input RESET	I6	0 or 1 [1)]	-	0	R/M	Signal for resetting the output signals and registers of MotStart

[1)] Input 0 = Not active; 1 = Active

3.3.2 Output data

Parameter	Code	Values	Unit	Default	Data direction	Explanation
Output START	O1	0 or 1 [1)]	-	0	R/M	Status of start signal
Output TRIP	O2	0 or 1 [1)]	-	0	R/M	Status of trip signal
Output STALL	O3	0 or 1 [1)]	-	0	R/M	Status of stall signal
Output RESTART	O4	0 or 1 [2)]	-	0	R/M	Restart enable signal

[1)] Output 0 = Not active; 1 = Active
[2)] Output RESTART 0 = Disabled; 1 = Enabled

3.3.3 Recorded data

3.3.3.1 General

The information required for later fault analysis is recorded at the rising and falling edge of start or when the function block trips. Tripping can be caused by either the I^2 x t function or the stalling function. In case both the I^2 x t function and the stalling function operate, only the first one is recorded.

The data of the last three events are stored into Recorded data 1...3, beginning from Recorded data 1. These registers are updated in a cyclical manner, where the values of the most recent event overwrite the oldest recorded data. If recorded data has been reset or the relay has been restarted, the first event is again stored to Recorded data 1.

3.3.3.2 Date and time

The time stamp indicates the rising edge of the START signal and will be updated in case the function block trips or stalls.

3.3.3.3 Duration and Start time

The duration of the start-up situation is recorded both in seconds and as a percentage of the set operate time. The duration is updated for both IIT and STALL either at the falling edge of the START signal i.e. when the motor start-up situation is over, or when the TRIP or STALL output becomes active.

3.3.3.4 Currents

An average for each of the phase currents I_{L1}, I_{L2} and I_{L3} is calculated during the start situation, that is, the time from the rising edge of the START signal until its falling edge or until the function block trips or stalls. The values of the phase currents I_{L1}, I_{L2} and I_{L3} are recorded as multiples of the rated current I_n.

3.3.3.5 Status data

The status data of the “Active group” parameter, which indicates the setting group valid for the recorded data, is recorded at the moment of triggering.

3.3.3.6 Recorded data 1

Parameter	Code	Values	Unit	Default	Data direction	Explanation
Date	V201	YYYY-MM-DD	-	-	R/M	Recording date
Time	V202	hh:mm:ss.mss	-	-	R/M	Recording time
Start time	V203	0.0...300.0	s	0.0	R/M	Duration of start-up situation in seconds
Duration(IIT)	V204	0.0...100.0	%	0.0	R/M	Duration of start-up situation (IIT)
Duration(STALL)	V205	0.0...100.0	%	0.0	R/M	Duration of start-up situation (STALL)
Average IL1	V206	0.0...60.0	x In	0.0	R/M	Filtered value of IL1
Average IL2	V207	0.0...60.0	x In	0.0	R/M	Filtered value of IL2
Average IL3	V208	0.0...60.0	x In	0.0	R/M	Filtered value of IL3
Active group	V209	0 or 1 [1)]	-	0	R/M	Active setting group

[1)] Active group 0 = Group 1; 1 = Group 2

3.3.3.7 Recorded data 2

Parameter	Code	Values	Unit	Default	Data direction	Explanation
Date	V301	YYYY-MM-DD	-	-	R/M	Recording date
Time	V302	hh:mm:ss.mss	-	-	R/M	Recording time
Start time	V303	0.0...300.0	s	0.0	R/M	Duration of start-up situation in seconds
Duration(IIT)	V304	0.0...100.0	%	0.0	R/M	Duration of start-up situation (IIT)
Duration(STALL)	V305	0.0...100.0	%	0.0	R/M	Duration of start-up situation (STALL)
Average IL1	V306	0.0...60.0	x In	0.0	R/M	Filtered value of IL1
Average IL2	V307	0.0...60.0	x In	0.0	R/M	Filtered value of IL2
Average IL3	V308	0.0...60.0	x In	0.0	R/M	Filtered value of IL3
Active group	V309	0 or 1 [1)]	-	0	R/M	Active setting group

[1)] Active group 0 = Group 1; 1 = Group 2

3.3.3.8 Recorded data 3

Parameter	Code	Values	Unit	Default	Data direction	Explanation
Date	V401	YYYY-MM-DD	-	-	R/M	Recording date
Time	V402	hh:mm:ss.mss	-	-	R/M	Recording time
Start time	V403	0.0...300.0	s	0.0	R/M	Duration of start-up situation in seconds
Duration(IIT)	V404	0.0...100.0	%	0.0	R/M	Duration of start-up situation (IIT)
Duration(STALL)	V405	0.0...100.0	%	0.0	R/M	Duration of start-up situation (STALL)
Average IL1	V406	0.0...60.0	x In	0.0	R/M	Filtered value of IL1
Average IL2	V407	0.0...60.0	x In	0.0	R/M	Filtered value of IL2
Average IL3	V408	0.0...60.0	x In	0.0	R/M	Filtered value of IL3
Active group	V409	0 or 1 [1)]	-	0	R/M	Active setting group

[1)] Active group 0 = Group 1; 1 = Group 2

3.3.4 Events

Code	Weighting coefficient	Default mask	Event reason	Event state
E0	1	1	START signal from MotStart	Reset
E1	2	1	START signal from MotStart	Activated
E2	4	1	TRIP signal from MotStart	Reset
E3	8	1	TRIP signal from MotStart	Activated
E4	16	1	STALL signal from MotStart	Reset
E5	32	1	STALL signal from MotStart	Activated
E6	64	0	Test mode of MotStart	Off
E7	128	0	Test mode of MotStart	On

4. Technical Data

Operation accuracies	At the frequency range f/f_n = 0.95...1.05: Current meas.: ±2.5% of set value or ±0.01 x I_n		
Stall time accuracy	±2% of set value or ±20 ms		
Start time	f/f_n = 0.95...1.50	internal time	< 22 ms
		total time [1]	< 30 ms
	f/f_n = 0.50...0.95	internal time	< 32 ms
		total time [1]	< 40 ms
Reset ratio	Typ. 0.95 (range 0.95...0.98)		
Retardation time	Total retardation time when the current drops below the start value [2]		< 50 ms
Frequency dependence of the settings and operate times	The frequency dependence is described above.		
Configuration data	Task execution interval (Relay Configuration Tool): 10 ms at the rated frequency f_n = 50 Hz		

[1] Includes the delay of the signal relay
[2] Includes the delay of the heavy-duty output relay

Technical revision history	
Technical revision	**Change**
D	-
E	Setting range of the parameter “Start time” changed: 0.3…80.0 s → 0.3…250.0 s
F	-
G	-