SIEMENS

FAQ for 6RA70 DC MASTER and SIMOREG CM

Question:
How do I perform diagnostics if a fault occurs?

Answer:
Several different ways of performing diagnostics on the SIMOREG 6RA70 are described below. You do not have to read the entire text, only the item relevant to your problem. This permits you to perform the necessary preliminary investigation, which you can then discuss with Technical Support (for contact address, see Section 14.1 of the Operating Instructions). For further documentation, please go to the following links:
http://support.automation.siemens.com/WW/view/en/10804967/133300
http://support.automation.siemens.com/WW/view/en/10804968/133300

Note: To perform initial start-up of a SIMOREG 6RA70, please work through Section 7.5 of the Operating Instructions before performing menu-driven start-up with DriveMonitor. Only here will you find the necessary information regarding correct parameterization and optimization of the closed-loop control!
First of all, set only the parameters described in Section 7.5 based on the device factory settings P051 = 21 and then perform optimization.
Only when you have completed this basic start-up procedure can you set the parameters for other functions such as technological closed-loop control and Profibus.
To protect the system, if necessary activate any fault messages suppressed in the factory settings with P820 - see "Fault messages".

⚠ **WARNING**

The units listed here contain dangerous electrical voltages and control rotating mechanical parts (drives). Failure to follow the relevant Operating Instructions may result in death, serious injury or considerable material damage.

Only qualified personnel who are familiar with all the safety information contained in the Operating Instructions, as well as the assembly, operating and maintenance instructions, should carry out work on these units.

Perfect, safe and reliable operation of the units is conditional upon them having been professionally transported, stored, mounted, and installed, and having been carefully operated and maintained.

The output of the power section for the armature and field is not electrically isolated from the input, which means that dangerous voltages will be present at the output when the supply voltage is applied to the input. Please also remember that dangerous voltages are also present on the power interface and field module.

The power supply for electronics modules CUD1, CUD2, and other electronic expansion modules is however electrically isolated from the line voltage. Their reference ground "M" is at ground potential.

About this document: This document will first deal with operations on the equipment, for example, using the operator panel, connectors, binectors, and then their relevance to control and setpoint inputs and diagnostics when fault messages occur. You will find basic theory on converters and procedures for performing measurements further on in the documentation to refresh you knowledge. This document is rounded off by an introduction to control engineering. Please use the index in the appendix to find the items you are require.

Device data and device standards:
Pxxx, Uxxx: Setting parameters; these parameters can be modified.
rxxx, nxxx: Display parameters; these parameters can be read only; they cannot be modified,
P053: Control word for the permanent memory (non-volatile storage of the parameters and some process data),
r070: Device code for MLFB (order number) of the device.
r060.01 and r065.01: Software version and software identifier of electronics board CUD1
r063.0x: Board code (x stands for the index number of the parameter)
P067: For adapting the rated device current based on the rating class, continuous current applies if P067 = 1, but if P067 > 1, the 100 % current applies as actual rated DC device current for the armature.
r068: Options acc. to the rating plate
r069.0x: Factory number of the SIMOREG, see further FAQs at
http://support.automation.siemens.com/WW/view/en/19869013
r071: Rated device connection voltage for armature
r072.01: Rated device DC current for armature acc. to the rating plate
r072.02: Actual rated DC device current for the armature after adaptation by means of P067 and P076.01; the smaller of the resulting values is active. Based on r072.02, the device can have a current load rating with a factor of up to 2.0x.
r073.01: Rated DC device current for the field acc. to the rating plate
r073.02: Actual rated DC device current for the field after adaptation with P076.02.
r074: Rated device connection voltage for the field
P075: Control word for overload capability for armature power section, where P075 = 1 or 2: Overload capability enabled, maximum 1.8x the rated device current acc. to rating plate (r072.01) possible.
P076.01: Adjustment of rated DC device current for armature to 10% to 100% rated current.
P076.02: Adjustment of rated DC device current for field to 10% to 100% of rated current
P077: Total thermal derating factor as a function of the ambient temperature and installation altitude of the device.
P078.01: Rated line voltage for converter armature
P078.02: Rated line voltage for converter field
P082: Operating mode for the field
Note: Always quote MLFB (r070), r063.0x: code of boards and software versions and IDs used (r060.0x and r065.0x) in communication with us. Ideally, e-mail a full parameter upload (.dnl file from DriveMonitor) to us: support.automation@siemens.com

Motor-related data:
P100: Rated motor current, armature
P101: Rated motor voltage, armature; for 1Q, set maximum line voltage x 1.2;
for 4Q, set maximum line voltage x 1.05.
P102: Rated motor current, field
P171: Positive current limit for armature with reference to P100 (set positive values)
P172: Negative current limit for armature with reference to P100 (set negative values)
P180: Positive torque limit with reference to rated motor torque (set positive values)
P181: Negative torque limit with reference to rated motor torque (set negative values)
P104 – P108: Settings for speed-dependent current limiting, see Section 9.16 of the Operating Instructions. For special applications, do not use speed-dependent current limiting for standard applications, set P109 = 0, parameter settings P104 - P108 will then not be evaluated.

Note: Notice/Danger; if positive values are set for P172 or P181 (or negative values are set for P171, P180), the motor will accelerate uncontrolled to its maximum possible speed limit.

PMU simple operator panel on the device door:
See Section 7.2 of the Operating Instructions. Seven-segment display with three keys.
Keep pressing the P key until a letter with a number is displayed, this is the parameter number display, which can be changed using the UP and DOWN keys. Upper case: modifiable parameters, Lower case: read-only parameters whose content cannot be changed.
The index of the parameter is displayed (if it exists) when P is pressed, e.g. ,002 for index 2, the index can now be increased or decreased with the UP and DOWN keys.
P820.10 = parameter P820, index 10
Pressing P again displays the parameter content.
Accelerating value adjustment: You can speed up the change in the displayed value by additionally pressing the opposite key while adjusting with the UP or DOWN key.
Before you can modify a parameter value, you must first set the key parameter P051 = 40.
In P927, you can set the interface in which a parameter can be modified.
Factory setting 6 = 2 (parameterization via PMU) + 4 (parameterization via interface G-SST1). To parameterize via Profibus, enter an odd number, for example, 7.
Not only the key parameter but also the operating status must be taken into account when changing the parameter value. Parameters designated "offline" in Chapter 11 of the Operating Instructions are OFF-line parameters, which means that their values can only be modified when pulses disable: operating status is o1.x or higher.
Set P052 = 3 for access to all parameters.
Only around 20 parameters have to be set for simple applications, for which the PMU is sufficient. After setting the system-specific parameters and making the optimizations, read out and note down all those parameters that deviate from the factory setting with P052 = 0 - done!
A separate FAQ exists for operations with the DriveMonitor (software requiring parameterization).
More at: http://support.automation.siemens.com/WW/view/en/24171248
You will find the parameter list in Chapter 11 of the Operating Instructions.

The function block diagrams:
To be found in Chapter 8 of the Operating Instructions.
In the following description, we refer to their sheet numbers, e.g. "Sheet G110 Binary Inputs".
The function block diagrams can be read like an analog circuit diagram and represent the entire controller structure with the parameters, connectors, and binectors used. The control loops are shown in the sequence in which they are calculated by the processor, reading from page 1 to the next, and from left to right.
If a function does not work correctly, the content of the connectors and binectors in the circuit diagrams starting from the signal source and the display of a read-only parameter rxxx, nxxx (xxx representing the number of the r-parameter or n-parameter) can be checked for measured values. This is a simple way of ascertaining up to which part of the circuit diagram the value is still OK. This procedure helps to localize the cause of an error and remedy it.
The parameter factory setting is always given in brackets next to the parameter numbers in the circuit diagram, e.g. on Sheet G112, P771 (0): Setting parameter P771 with a factory setting of 0, or for indexed parameters, the value under "FS".

Free function blocks: Technological software – Option S00
Sheet B100 to B216.
The S00 technological software (free function blocks) is enabled with a PIN code. The PIN code depends on the factory number of the device and is therefore device-specific. If the device is supplied with an enabled PIN (for orders with option S00), this PIN will be found on the adhesive label on the device. You can check whether it is enabled in parameter n978:
n978 = 0, S00 is not enabled and therefore disabled; the time for temporary enabling has elapsed.
n978 = xxx, S00 is not enabled, xxx time in operating hours still available for temporary enable. n978 = 1xxx, S00 is temporarily enabled,
xxx operating hours left for using S00.
n978 = 2000, S00 permanently enabled.
Temporarily enabled for 500 operating hours with parameter U977 = 1500. Temporary enabling can be interrupted with U977 = 500.
After the free operating hours for the S00 have expired, error message F059 is output.
Fault value 1: Time for S00 fully expired, the additional technological blocks are no longer available. Deselect S00 with U977 = 500 and, if still required, permanently enable the function by entering the PIN code from the order in U977.
Order number for ordering the PIN code: 6RX1700-0AS00, please quote the factory number of the device with your order.
See also parameters: U950 – U952; U960 – U962; U969.
PIN not accepted, see: http://support.automation.siemens.com/WW/view/en/19869013
Note: Without enabling (temporary or permanent), the free function blocks are not calculated and their connectors and binectors then have the value 0.
Note: To optimize the computing time after parameterizing the free blocks, always set U969 = 4 (value automatically jumps back to zero after the function has been executed). For further information see the description for U969 in the Operating Instructions.
See also: http://support.automation.siemens.com/WW/view/en/22041151

Note: The function descriptions are to be found in Chapter 9 of the Operating Instructions, a short-hand summary of the most frequently used functions is given below:
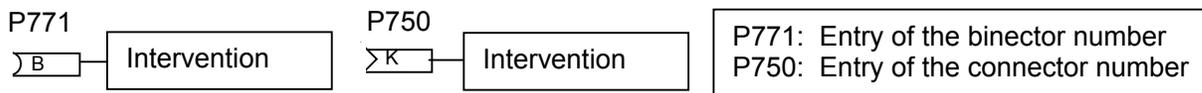

Connectors and binectors:
The device can be parameterized flexibly using the digital signals, the connectors Kxxxx: 16 bit or KKxxxx: 32 bit for indicating analog variables, such as actual current value or speed controller output, and the binectors Byyyy for indicating digital control signals/conditions with the value 0 or 1. The selection parameters are used to select at which intervention point the connector or binector in question will take effect.
Sheet G110: The status of terminal 36 is mapped in binector B0010 and the inverted signal of it in B0011.
Sheet G113: The value of the acquired analog signal of terminal 4/5 is mapped in connector K0011 and can be monitored with the display parameter r001 as a percentage.
Sheet G112: The binector number of the signal that is intended to change the status of terminal 46 is entered in parameter P771. n<nmin. This can be recognized by the B (for binector number) entered in the input path for the signal. When shown in the associated parameter above it, this means, enter the number of the binector to take effect at this intervention point.
Sheet G115: The number of the connector whose value is to be output via terminal 14 is entered in parameter P750, e.g. 167 for K0167: Actual speed value. This is identified by the K (for connector number) entered in the input field directly below the parameter number.

P771

| B |— Intervention

P750

| K |— Intervention

P771: Entry of the binector number
P750: Entry of the connector number

This permits intervention of the binectors in the open-loop control and intervention of the connectors in the closed-loop control.
For the connector - binector list see Chapter 12 of the Operating Instructions.
Fixed-value connectors and binectors, Sheet G120.

Display of connector and binector contents:
Sheet G121
Display of connector contents:
Entry of the connector numbers in P044.0x and display of their content in r043.0x (x stands for index number) as a percentage.
P042, r041: High-resolution connector displays as a percentage
U044, n045: Connector displays as a decimal value.
U046, n047: Connector displays as hexadecimal value.
Display of binector contents:
Entry of binector numbers in P046.0x and display of their value in r045.0x.

Standard normalization of connectors Kxxxx, KKxxxx:
16-bit value, 14 bit = 16384 decimal = 4000 hexadecimal corresponds to 100%
The MSB (16th bit, bit no. 15) is the sign,
MSB low for positive value, MSB high for negative value,
so -16384 decimal = C000 hexadecimal is minus 100 %.
7FFF hexadecimal = 32767 decimal = 199.993% (maximum representable positive number)
FFFF = -32767 = -199.993%
8000 = -32768 = -200% (minimum representable negative number)
Resolution: 0.0061%
Normalization double-word connectors KKxxxx:
32-bit value, MSB is the sign.
1073741824 decimal = 4000 0000 hexadecimal is 100 %
-1073741824 decimal = C000 0000 hexadecimal is minus 100%
Resolution: 9.3132E-8 %
Word read from right to left,
far right: bit zero, far left: bit 15 or bit 31.
For special normalization of other connectors, see Chapter 12 of the Operating Instructions.

Normalization of the closed-loop controller signals
Armature circuit.
Actual speed value: 100 % corresponds to the set maximum speed; speed setpoint normalization is analogous
Speed controller output K0152, Sheet G152: depends on P170, P170 = 0: 100 % corresponds to actual rated DC device current for armature (r072.02); P170 = 1: 100 % corresponds to torque of actual rated DC device current (r072.02) und 100 % flux PHI (is P102 for rated field current).
As from K0134, Sheet G160 and to the right of it, 100% corresponds to r072.02.
Actual armature current value K0152, Sheet G162: 100 % corresponds to r072.02
Firing angle K0110, K0121, K0102, Sheet G162; K0101, K0100, Sheet G163:
100 % corresponds to 0 degrees, 0% corresponds to 90 degrees, -100% corresponds to 180 degrees.
Field circuit:
Actual EMF value K0286, K0287, Sheet G165: 100 % corresponds to P078.01 * 1.35
Output EMF control loop, K0280, K0293, field current setpoint K0277 to K0268:
100 % corresponds to the actual rated DC device current, field (r073.02).
Output field current control loop (firing angle, field), Sheet G165:
K0260, K0271, K0252, K0250:
100% = 0 degrees, 0% = 90 degrees, -100 % = 180 degrees.

Fixed values:
Sheet G120
Fixed values in %, fixed values decimal, fixed control bits, constant fixed values and control bits.

Function and bico data sets:
Function data set FDS: 4 FDS (FDS1 to FDS4) exist, with which, for example, switchover to different controller settings is possible, for example, during alternating operation of different motors on the SIMOREG, for changing gear stage, or for switching to C axis operation on main spindle drives. See Sheet G175, switchover is performed with control word 2, Sheet G181; the parameters with FDS are identified in the parameter list.
E.g. P433.0x, x = index = number of FDS, identified in the function block diagrams with Pyyy.F.
Example: The source for the main setpoint can be switched via P433.F.
Control word 2, bit 16 = low, bit 17 = low: FDS1; bit 16 = high, bit 17 = L: FDS2; bit 16 = L, bit 17 = H: FDS3; bit 16 = H, bit17 = H: FDS4.
BDS Bico data sets: 2 BDS exist (BDS1 and BDS2), switchover is performed with control word 2. The parameters with BDS are identified in the parameter list.
E.g. P648.0x, x = index = number of BDS, identified in the function block diagrams with Pyyy.B.
Example: The source for control word 1 can be switched via P648.B.
Control word 2 bit30 = low: BDS1; bit30 = High: BDS2
FDS1 and BDS1 are always used for normal applications.
Procedure for assigning parameters:
First enter all parameters for FDS1, then copy the parameters of FDS1 to FDS2 using P055. Finally, make the parameter changes for FDS2.
Proceed in the same way for the BDS parameters. Copy BDS parameters via P057, see Sheet G175.

The operating status of the device:
The operating status of each device can be read from parameter r000 on the operating panal, or via r059 (can also be displayed via DriveMonitor). See parameter description for r000. The operating status is also available on connector K0800, for example, for transmission as PZD (process data) via a serial interface.
If the device does respond as required, always check the operating status. A relevant control signal might be missing. Check the signal status of the binary inputs (r010) and of control word 1 (r650).

Display of the signal states of the binary inputs and outputs:
r010: Display of the status of the binary inputs, see also connector K0020
r011: Display of the status of the binary outputs, see also connector K0021

Operation via bus (USS or Profibus, CAN bus, device net)
See Chapter 7.7.2 ff of the Operating Instructions
The data are transmitted serially via a bus connection.
PCD: Process data for transmission of connector contents Kxxxx (16-bit word), e.g., control word 1, main setpoint value as one PCD each.
For double-word connectors KKxxxx, the 32-bit word is transmitted to two subsequent positions of the PZD with 16 bits each. For this, the number of the double word connector is entered at two consecutive positions in parameterization of the transmission data.
The first PZD to be transmitted from the master to the SIMOREG must always be control word 1, and the 11th bit (bit number 10, counting starts from zero) in control word 1 must carry the high signal, otherwise the process data received by the SIMOREG will not be updated (no PZD transmission).
PKW: Parameter data: Parameter number, parameter index, parameter value.
For use of an interface module, for example a CBP2 for Profibus, see also Sheet Z110.

Parameter numbers: P, r, U, n, H, d, L, c – parameters: Operating Instructions, Section 7.2.2
Assigning parameters via Profibus: Set P051 = 40, P927 = 7; Operating Instructions, Section 7.7.2

Controlling via the binary signals of the converter or via control word 1 (STW1):
Terminal 37: On/Off1, starting from operating status o7.x, relay contact terminal 109/110 is closed (relay for controlling the main contactor). Then voltage must be applied to power section; otherwise F004 will occur.
P654, (factory setting = 1, recommended setting) caution! Sheet G130.
If Off1 is set (e.g. terminal 37 LOW signal), setpoint zero is set before the ramp-function generator and the drive slows down to zero speed along the deceleration ramp from the ramp-function generator.   On reaching n < nmin (P370), the current is reduced to zero, followed by pulse disable and the main contactor relay, terminal 109/110 drops out, then the supply voltage for the power section can be disconnected.
Note: To allow the device to respond to a switching command, "Ready to switch on": Operating status o7.x must be pending. When applying the supply voltage of the electronics supply, the ON command must not be set until the device is initialized (lasts approx. 3 seconds if no option modules exist) and subsequent status o.7x, otherwise the ON command will not be executed.
Exception: Restart parameterized and return of the supply voltage within the parameterized restart time in P086. –End of note-
Terminal 38: Operating enable (controller enable and pulse enable) operating status o1.x: Waiting for operating enable. If ON signal and operating enable are pending, the current converter goes into the "Run" state, operating status: -- (no torque direction engaged) or I (torque direction 1 pending) or II (torque direction 2 pending).
If operating enable is removed, Alpha W shift always occurs immediately without delay to reduce the current to zero followed by a pulse disable when current = zero is reached.
The source from which controlling is performed is parameterized in P648.0x, see Sheet G180. (enter the connector number of the source of the control word). Factory setting (9) means: bit-by-bit setting of the control commands, e.g., for controlling via terminals only, or if only individual bits are to be selected by the control word via bus.
Value 3001: Control via CB, e.g. Profibus.
Value 2001: Control via G-SST1, e.g. DriveMonitor
When controlling via bus make sure that bit 0 (On/Off1) and bit 3 (operating enable) of the control word from the bus are "ANDed" with terminal 37 and 38, i.e. a high signal must be pending at both sources for executing the control command.
If controlling is only required via bus, terminals 37 and 38 must be securely clamped to the High potential (e.g. connect terminal 34 to P24).
Control word 1: Sheet G180, display control word 1 via r650, see also connector K0030:
Status word 1: Sheet G182, display control word 1 via r652, see also K0032:
Note: If control is performed via bus only, e.g. Profibus, the time monitoring of the bus signal must be activated (for Profibus: Time monitoring for bus fault: set U722 > 0), otherwise if a bus fault occurs, the drive continues with the last signal values and cannot be switched off. If U722 = 0, an OFF signal must be implemented with terminals, e.g. Off2 via assignable-function terminals, or Off1 via terminal 37 or E-STOP via terminal 105/106.
For operation via Profibus, the 1st word of the PCD (control to SIMOREG) must always be control word 1 and the 11th bit (bit no. 10) must assume a High signal before process data transmission can take place.
Note: The ON signal and operating enable may also be performed simultaneously, the internal controller ensures that internal operation enable is delayed until the right conditions for line infeed and field supply are pending for transition to the Run state .
This allows efficient setting of P24 (24 V, e.g. of terminal 34) at terminal 38 so that the device can be controlled via terminal 37 only, for example.
If controlling via bit zero (1st bit) of control word 1, its bits 1 to 6, 10, 11, 12, and 15, must be set to high.

Off2, voltage enable
Bit 1 in Control Word 1. Sheet G180.
Bit 1 in Control Word 1 zero signal leads to Alpha W shift for reducing current to zero. On current zero, pulse is disabled and the main contactor relay terminal 109/110 opens.
The drive coasts down.

Off3, quick stop
Bit 2 in Control Word 1, Sheet G180.
Bit 2 in control word 1 low signal causes fastest possible deceleration of drive (4Q device required) to n < nmin (P370). When n < nmin is reached, current is reduced to zero current, and when zero current is reached, pulse disable occurs and main contactor relay terminal 109/110 opens. On fast stop, the ramp-down times of ramp-function generator P296, P297, P298 apply.

Priority of control signals
Cancellation of the operating enable (terminal 38, bit3 in Control Word 1) always causes immediate Alpha W shift irrespective of the other control signals, to current reduction to current = zero with subsequent pulse disable when current = zero is reached.
Operating status with a higher number (see r000),
e.g. o11 before o10 has a higher priority
o10 ...Off2 (voltage enable): High priority
o9 .....Off3 (fast stop): Average priority
o7 .....Off1 (shutdown) : Low priority
If several control signals are pending simultaneously, the command is executed with a higher priority, e.g. if Off2 and Off1 are set simultaneously, command Off2 is executed.
If a current actual value of zero cannot be reached for current reduction with Alpha W shift, the drive never enters pulse disable and the "Off" status can therefore not be reached. In such cases, only the setpoint "immediate pulse disable" via a binector settable in P177 can help.
The function "immediate pulse disable" via binector should be used with care. When applied during active regenerative feedback operation, for example, this function causes an overcurrent.
Note: Sequence of the control signals: Before setting the ON signal via bit 0 of the control word (e.g. terminal 37), the signals for Off2 (bit 1 Control Word 1) and Off3 (bit 2 Control Word 1) must have a high signal so that operating status o7 (ready to switch on) is pending; only then is it possible to switch on via Off1 (bit 0 Control Word 1).
If operating status o8 is pending (switch-on disable), set Off1 to enter operating state o7.

Controller structure for Off1 and Off3
To be able to execute Off1 and Off3 during current-controlled operation, the controller structure is adapted with a switch in the software. Sheets G152, G160, G161. With current-controlled slave devices, for example, in master-slave operation or in a 12-pulse parallel connection of devices, it is therefore important to ensure that signal Off1 or Off3 is not passed on to the slave devices until the master has completed the shutdown and is no longer in the Run state.

Setpoint setting:
P433.F: Select connector for setpoint before ramp-function generator, see Sheet G127 setpoint channel, in P433 the source of the setpoint is entered by input of the connector number.
P433.01 = 11 (function data set 1, FDS1: Factory setting 11: Setpoint via connector K0011, main setpoint via analog input, terminal 4/5, see Sheet G113).
P433.01 = 3002, setpoint via 2.PZD from Profibus.
Switchover of the setpoint source possible by switching over the FDS.
E.g. FDS1 from Profibus Word 2: P433.01 = 3002, for switchover to main setpoint from main setpoint input, use FDS2 P433.02 = 11.
Bit 11 and bit 12 of the control word high signal determine the direction of rotation of the motor by the polarity of the setpoint (applies to 4Q operation, both directions of current possible, see also below). Sheet G135.
Fixed setpoint: One/multiple fixed setpoints can be applied, Sheet G127. Only becomes active if the Run state is pending via the Off1 high signal (e.g. via terminal 37). The binector number of the source effective as the fixed setpoint precontrol is entered in P430.0x (x for the index, 8 indices exist, a separate fixed setpoint is available for use below each index), e.g. B0010 for terminal 36. The connector number of the setpoint is entered in P431.0x, e.g. K0401 as the setpoint source with P401 for setting the height of the setpoint.
Inching setpoint: Sheet G129. Inching has its own ON function for which Off1 must assume the low signal (e.g. terminal 37 Low), the ON function is implemented with the inching signal via control word 1 or via the binector defined by P435.0x. P436.0x defines the connector number for the setpoint. When the inching command is canceled, the delay parameterized in P085 is used as the delay time for the drop-out of the main contactor, to prevent drop-out of the main contactor between repeated inching commands.
Creeping setpoint. Sheet G130. Creeping has its own ON function for Off1 low signal and a fixed setpoint function when the creeping setpoint is used in the Run state.

Main contactor control terminal 109/110:
Control of the main contactor via terminal 109/110 ensures the correct switch-on and switch-off sequence of the main contactor, this is therefore the preferred method of implementation. Control for setting U619.0x = 124 (factory setting should be kept), see Sheet G117:
Terminal 109/110 is closed on ON command. Voltage must now be applied to the power section. If Off1, the setpoint before the ramp-function generator is set to zero, the drive decelerated to speed n<nmin (P370) along the ramp-function generator ramp, and then the current is reduced to zero and the controllers and pulses are disabled. Only then will 109/110 open to switch off the main contactor. The voltage on the power section can now be removed. For how to control the field supply, see Parameter P082. When the main contactor is controlled by an external contact, e.g. via the automation, the above conditions must be observed as otherwise F004 will occur.
Note: EMC requires that the contactor coil be connected to a suppression element:
For a coil with DC current excitation, with an anti-parallel diode, for AC current excitation, with an RC element.

E-STOP, terminal 105/106 (107/108):
No E-Stop, terminal 105/106 closed. If the function is not used, a jumper must be placed between jumper 105/106. See Sheet G117.
If E-STOP is pending the main contactor is switched off immediately via terminal 109/110, only a slight time delay of 15 ms takes effect to de-energize the drive before the main contactor drops out.
As the main contactor relay in SIMOREG has no forcibly guided contacts (in the worst case this means that the relay contact may be welded and therefore does not open), the failsafe contactor combination 3TK28 must be used if EMERGENCY STOP is implemented according to EN60204-1. 3TK2825 for immediate switch-off and 3TK2827 with delay via the integrated safe time element, e.g., to first execute the shutdown function in SIMOREG via fast stop. The normally closed contacts of 3TK28 are switched in series to the main contactor

relay terminal 109/110 to implement the safety functions. Approx. one contactor switching time should first be issued in the SIMOREG by the E-STOP so that the main contactor in the de-energized state and so that F004 does not occur. If the EMERGENCY-STOP function is used, a main contactor is required for the 6RA70 infeed or a contactor in the DC circuit. A pulse disable cannot prevent the current flow (motor torque) in case of a power section fault. See also our Safety Integrated Manual available on the Internet.
http://support.automation.siemens.com/WW/view/en/21729923

Brake control
Control logic has been implemented in the software to control the mechanical motor brake. See Sheet G140 and Section 9.9 of the Operating Instructions.

Automatic restart
If supply faults occur (F001, F004, F005, F006, F007, F008, F009), automatic restart is possible on return of the power supply for 1U1/1V1/1W1, 3U1/3W1, 5U1,5W1 within the time parameterized in P086. This is possible on condition that the ON signal for the SIMOREG is maintained for this duration.
P086 can be set between 0.00 (automatic restart deactivated) to 10.00 seconds, for which a maximum possible downtime of 2.00 seconds of the electronics power supply is permissible (5U1, 5W1) – if necessary, back up the electronics power for restart times of >2.00 s with a UPS.

Limit display:
The device limits the output of the SIMOREG as a function of the settable limits.
Firing angle limits Alpha G, Alpha W
Current limits, torque limits,
Ramp-function generator limit,
Maximum speed limit
When a limit it reached, this is indicated by a corresponding bit in parameter r040.
For diagnostics purposes, e.g. speed not reached or speed dip, motor does not energize, fluctuating current etc.

Diagnostics if Profibus or another serial interface for setpoint and control word setting is used:
Temporarily only parameterize control via terminals: Set 1 P648 = 9 for control word   1, P649 = 9 for control word 2 and assign the control commands via terminal 37 and terminal 38.
Temporarily set setpoint parameter assignments and parameter assignments of limits via connectors to factory setting:
P433.01 = 11 for setpoint via terminal 4/5 and
P433.01 = fixed setpoint connector for fixed setpoint assignment.
Alternately, maintain the necessary signals via bus if the values required are suitably assigned by the automation.

Thyristor test with P830:
Perform thyristor test using P830 = 3. After the ON command, a thyristor test is performed (operating state o3.x). If the device then starts operation without a fault, the thyristors are OK.
The load (motor) on the SIMOREG must be connected.
Note: The thyristor test does not give a clear result for 'Thyristor cannot be fired' for all load states, specially for high inductance load.
Additionally check current actual value with a Trace 2 recording by DriveMonitor, see below.

Fault indications: See Section 10 of the Operating Instructions:
If a fault occurs, Fxxx (xxx is the fault number) is displayed at the PMU and the "fault" LED lights up.
Fault messages can be suppressed via parameter P820.
Fault suppression: Enter the number of the fault to be suppressed as a value under any index of parameter P820.
In the case of a fault, bit 3 of status word 1 goes to high, Sheet G182.
B107: Inverted fault can be used for output to a binary output. For example, P771 = 107: If a fault message occurs, binary output terminal 46 has a low signal.
Note: The following fault messages are suppressed via P820 in the factory setting: F007, F018, F031, F035, F036, F037, these must be activated as required (recommended, for example, for F031, F036 for hoisting gear applications, or F035, F037 for motor monitoring). For this, enter 0 instead of the fault number entered in P820.xx.
Occurrence of a fault message results in current decay with Alpha W shift with subsequent pulse disable and deactivation of the main contactor with display of Fxxx on the operating panel. After elimination of the cause of the fault, the fault must be acknowledged, then OFF1 must be set in order to return to operating state o7.x "Ready to switch on".
The fault is acknowledged via bit 7 of the control word and pressing the P key on the PMU:
See also: http://support.automation.siemens.com/WW/view/en/23501277

Alarm messages: See Section 10 of the Operating Instructions:
If an alarm occurs, Axxx (xxx is the alarm number) is displayed on the PMU and the "fault" LED blinks.
Alarm messages can be suppressed via parameter P821.
Enter the number of the alarm to be suppressed as a value under any index of parameter P821.
The occurrence of an alarm indicates a special status of the device, but does not initiate a device response and has no effect on operation. The alarm message disappears automatically when its cause has been eliminated.

Note: Display of a fault message or alarm message prevents the PMU from assigning parameters. If the P key and the UP key are pressed simultaneously, the message is placed in the background and it is then possible to change parameters again. After that, the fault/alarm can be displayed again by pressing the P and DOWN key simultaneously while a parameter number is displayed on the PMU.

Note: Diagnostics parameter r047 (all indices) must be read out whenever a fault message occurs. The value in Index 1 (fault value) specifies the cause of the fault, in index 16 you will find the associated fault number (e.g. 30 for F030). See Chapter 10 of the Operating Instructions for diagnostics. See also parameters r947, r949, r049.
The fault number is transferred in the high byte of connector K0801 (as long as this fault message has not been acknowledged and is therefore still displayed on the PMU with Fxxx); the alarm number is transferred in the low byte of K0801.

Diagnostics for some fault/alarm messages

F004 occurs
F004 occurs whenever device is switched on:
Evaluate fault value of F004 acc. to Operating Instructions to locate the cause.
Check the following parameters:
P078.01: Rated voltage of supply network for the armature circuit (neither output voltage of SIMOREG nor rated motor voltage)
P353: Response threshold of phase failure monitoring as a percentage of P078.01.
P086: Duration of voltage failure on automatic restart
P089: Maximum waiting time for voltage on power section
P090: Stabilization time for line voltage
Observe setting instructions of parameter descriptions.

Check voltages of the armature circuit infeed:
Acknowledge pending fault messages, set shutdown by opening terminal 37
Switch off field supply with P082 = 0
Suppress F004 with P820.10 = 4
Switch on via terminal 37 but do not set operating enable via terminal 38
Operating status at r000 must be between o4 and o1 (check r000)
Operating status o4: Wait for voltage (armature)
Measure voltage with a voltmeter between all phases 1U1 / 1V1 / 1W1 direct at the device input
r015: Compare display of line voltage (armature) with measured voltage
If measured voltages are not OK:
Check line fuses
Measure voltage in front of and behind the main contactor
Measure voltage at the contactor coil.
Check output for the main contactor relay terminal 109/110.

If measured voltage is OK but operating status o4 and r015 is still not OK:
Line voltage sensed via the ignition cable for the thyristors, see Section 6.4 of the Operating Instructions, check connector X12, X14, X16.
On devices with arm fuses (> 900 A rated DC current), check arm fuses.
If all checks are OK but still operating status o4.
Fault on the power interface module or CUD1 of SIMOREG.
After diagnostics / repair, set P082 and P820.10 back to the original values.

F004 occurs sporadically:
Evaluate fault value of F004 acc. to Operating Instructions to locate the cause.
Check parameters as above. Check control of main contactor.
Perform trace recording with triggering in reponse to fault. Set zero for trace recording P086.
Activate error message. Pretrigger 95 %, set recording interval 1.
The cause of a fault can be derived from the Trace evaluation.

F005 occurs:
Evaluate fault value for F005 to delimit cause
For fault value 1 to 4 check following parameters:
P078.02: Rated voltage of supply network for field circuit (neither output voltage of SIMOREG nor rated motor voltage)
P353: Response threshold of phase failure monitoring as a percentage of P078.02.
P351: Check undervoltage threshold, refers to P078.02
P352: Check overvoltage threshold, refers to P078.02
P396: Check threshold for field current monitoring
P397:Time for field current monitoring, increase time for very high inductances.
P086: Duration of voltage failure on automatic restart

Observe setting instructions of parameter descriptions.
Check voltages of field circuit infeed 3U1 / 3W1:
Acknowledge pending faults; set shutdown by opening terminal 37
Set P082 = 1 for field supply
Perform trace recording with trigger for fault with error message activated. Set trace recording P086 = 0.
Suppress F005 with P820.10 = 5
Switch on via terminal 37 but do not set operating enable via terminal 38
Operating status at r000 must be between o5 and o1 (check r000)
Operating status o5: Wait for voltage (field)
Measure voltages with a voltmeter between all phases 3U1 / 3W1 and 3C /3D.
r016: Compare display of line voltage (field) with measured voltage

If measured voltages are not OK:
Check field input fuses, check cause of line voltage field supply fault.
If above is OK or fault value 5: Establish fault of field current:
Check P101 and P102, measure field current with ammeter.
Field current builds up slowly, this is due to the inductance of the field: Check P396, P397
Measure resistance of connected field coil, value should be approx. nominal field voltage divided by nominal field current as specified on rating plate of motor.
Perform diagnostics by means of parameters r034, r035, r036:
r036 shows setpoint, actual value r035 is zero, however field current is flowing and r034 shows delay angle zero, in which case a fault has occurred in the field current actual value acquisition of the SIMOREG.
Cause Field module or CUD1.
r036 and r035 deviate from one another, but field current is flowing: Check field coil.
Calculate output voltage from delay angle r034 and input voltage r016 (for calculation see below) and verify voltage at 3C-3D with voltmeter; if measured output voltage shows only approx. half the calculated value, this indicates that the power section or control is faulty.
Too little current flowing (but resistance of field circuit is OK), r034 = 0 and field output voltage is not greater than the line input voltage * 0.8, a thyristor does not fire (cause thyristor, field module or CUD1) or diode or thyristor in field power section is faulty.

F006 occurs:
Check parameter P078.01 and .02, correspond to rated line voltage
Check parameter P351(corresponds to P078).
P361: Observe delay time undervoltage monitoring as setting option.
Voltage dips due to high load with weak network supply?
Set P086 = 0 and trace recording, with triggering in response to fault, interval 1,
Perform pretrigger 95%.

F018/A018 occurs:
The terminal involved can be derived from r047.02.
Check P24 (24 V power supply) by measuring terminal 34 against terminal 35, voltage must be greater than 19 V. If voltage is OK, disconnect binary outputs; if fault message continues to occur, replace CUD1; if P24 not OK, fault might also be attributable to the power interface.

F030 occurs:
Check current controller optimization, perform current controller optimization run.
Perform trace recording with triggering in response to fault.
If fault value 1 or 2, set parameter U580 = 4 if necessary. See also description for U580 in the Operating Instructions.
See also: http://support.automation.siemens.com/WW/view/en/19868341
For fault value 3 overcurrent > 250% of r072.02 occurred. Possible cause during 4Q operation might be line undervoltage, brief line interruption during braking operation.
Check the motor for sparkfree commutation of the current. See also description for old motor.

Note: Error message F030 may only be suppressed with setting U580 = 0 (not with P820).

F031 / A031 occurs:
Check optimization of the controlled system. Set ramp-function generator times so that speed can follow setpoint. Load too high? Check current limits P171, P172 and torque limits P180, P181. Check parameter P590 and P591.
Check display parameters r040, shows which limitation responds and cause of the deviation:
Current limit / torque limit for armature responds: Drive requires more current which the limitation does not allow.
Firing angle limit Alpha G (P150: setpoint 5 degrees at 1Q, 30 degrees at 4Q) reached.
When the Alpha G limit is reached, firing angle limitation does not allow any further current increase with firing angle offset even though the current limit has not been reached. Cause: Line undervoltage or armature voltage too high. If armature voltage too high: Reduce P101, record field characteristic curve with P051 = 27 and
activate field weakening with P081 = 1.
When the current limit is reached, check P171, P172, observe permissible limit values for the motor when making settings.
Make trace recording.

F035 / A035 occurs:
See Operating Instructions,
Load for breakaway from standstill is too high. Current limit P171, P172 and torque limits P180, P181 too low. P355 setting too low. (observe permissible data for the motor). See also under 'Motor produces no torque'. Check Limitation r040 display.
Make trace recording.

F036 / A036 occurs:
Check fuses, load impedance. Check P150, P151.
Check r040
Check output voltage with voltmeter.
If the output voltage of the device is zero even though it indicates Run state, the device is faulty.
If the value of the output voltage is at its maximum, the cause is external. (Line voltage for possible armature voltage is too low, motor voltage too high, drive dragged along, motor field too high, armature circuit fuse faulty). See also F031.
Execute trace recording

F040 occurs:
If the electronics power supply is switched off before a pending fault message is acknowledged, F040 occurs when the supply voltage is switched on again. F040 cannot be acknowleged until the cause of the original fault message that triggered F040 is eliminated. In this case, read out the following parameters: r947.01 shows the current pending fault message: 40 for F040. The original error message that led to F040 can be read out of fault value r949.01. Now eliminate the cause of this message after which F040 can be acknowledged. If this is not successful, temporarily suppress F04 with P820 (see above).
See also: http://support.automation.siemens.com/WW/view/en/21781235

F042 occurs:
Fault value 1: Temporarily set device to operation without tachometer P083 = 3.
For analog tachometer, check the voltage for speed at terminal 103 / 104 and via connector K0013 or r002 the display parameter.
For pulse encoder, check speed via connector K0040 and the pulse encoder input using an oscilloscope. Check setting of parameters P140 and beyond. Check P142 as a reference of signal TTL (5V) or HTL (15 V).
Measure speed n and calculate expected EMF.
(with ud: r038, EMF: r037 and Id = r019);
EMF for rated motor speed = rated motor voltage – P110 * rated motor current.
EMF is proportional to n between n = 0 and n = nNom
If there is a larger deviation between the measured EMF and EMF to be calculated, the motor (field circuit or armature circuit) is faulty.
Possibly increase threshold of monitoring (P357).
For fault value 2 exchange terminal 103 / 104 with analog tacho, for pulse encoder, exchange input for both tracks.
Note: The pulse encoder is evaluated by means of a difference amplifier; if the inverted tracks are not used, the minus input of the difference encoder (terminals X173.29/31/33) must be wired to ground.

F043 occurs:
Usually field for current speed too high, possibly perform field weakening and reduce P101 (rated armature voltage of the motor).
Perform trace recording with triggering in reponse to fault.
Note: Triggering of this fault message can be suppressed by activating field weakening and setting P272 = 1, see parameter descripton for P272. As a result, the field current of the motor is reduced in order to lower the motor voltage to permissible values for a given speed. As a result of this necessary reduction of the field current, a delay time up until the torque direction switches over occurs as a result of the time constant of the field current reduction. This method can therefore not be used when a highly dynamic change in the torque direction is required or, for example, in hoisting applications with a suspended load, an overspeed could occur.
This setting can also be used if a higher maximum output voltage of the SIMOREG is required for 4Q operation. For P272 = 1, it is permissible to additionally set the firing angle Alpha G to smaller values than 30 degrees, e.g. 15 degrees.
If the SIMOREG is not used for the armature supply of a DC motor but, for example, to feed a motor field or a solenoid, suppress F043 via P820.

F048 occurs:
See detailed fault description in the Operating Instructions.
Note: If the fault message cannot be eliminated, it is permissible to suppress F048 via P820.xx, because F042 also provides monitoring.
Note: The pulse encoder is evaluated by means of a difference amplifier; if the inverted tracks are not used, the minus input of the difference encoder (terminals X173.29/31/33) must be wired to ground.

F050 occurs:
Fault message during the optimization run, see fault value in the fault description.

F052 occurs:
Additionally check settings of parameter P078.xx, the actual nominal line voltage is entered here. Evaluate the fault value according to the Operating Instructions.

F060/A060 occurs:
Set U969 = 4, see also:
http://support.automation.siemens.com/WW/view/en/22041151

F067/A067 occurs:
Fault value 1 or 2:
Check r013 and compare with actual heatsink temperature, see also K0050. The sensor is a thermistor, NTC: R100 (connector X6/X7 on the power interface module) has a nominal value of 6.8 kOhm, if resistance 6.8 kOhm is used instead of the sensor, r013 should indicate approx. 20 degrees.
Note: On devices with thyristor modules 6RA7013 to 6RA7091, the NTC measures the heatsink temperature, the response threshold is device specific.
On devices with disk-type thyristors 6RA7093 to 6RA7098, the NTC is on module A7004, i.e. the sensor is positioned in the device's air flow and is used for air flow monitoring, the heatsink temperature is then not acquired. Response threshold for A067 is 90 degrees, the response threshold for F067 is 95 degrees Celsius.
Fault value 3:
Can occur with 6RA7075 or 6RA7078
The power requirement for both fans is read independently on the field module and monitored with a comparator, if the value for a fan <89 mA or >230 mA (fan nominal current 130 mA) F067 is triggered, remedy: Replace both fans (use original spare parts; 2x 6RY1701-0AA07).
Diagnosis when both fans are running but fault message with fault value 3 occurs:
Temporarily suppress F067 with P820.10 = 67 and measure current for each individual fan.
Note: The internally supplied 24 V fans are only switched on via the electronics if operating state "Run" is pending on the SIMOREG. After leaving the Run state, a fan after-running time which can be set in P096 (factory setting 4 minutes) applies.

F080 occurs
If a technological supplementary module T300/ T400 is used.
Depending on the software configured for the module used, the supplementary module may take longer than 20 s to boot. The converter than switches off with F080. As a remedy, parameters U723.0x (timeout duration) should be set to higher values, e.g. 30 seconds.

F082 /A083 occurs:
Check first word of the process data from the automation to the SIMOREG.
First PZD must always be control word 1 (Control Word 1) and its bit 10 (11th bit because bits are counted from zero) must be set to H. The process data are only updated and evaluated with bit 10 of Control Word 1 High.

Note: When diagnostics is completed, reset all temporary parameter settings, e.g. fault suppression.

As soon as the voltage is applied to the power section, a fuse blows:
Armature infeed when fuse tripped without operation enable: Two or more thyristors of the power section broken down. Deenergize device infeed, disconnect motor and check resistance between all terminals 1U1 / 1V1 / 1W1 / 1C1 / 1D1, value must be greater than 100 kΩ. See also below as well as circuit diagram of power section, Section 6.4 of Operating Instructions.
Armature infeed, fuse tripped with controller enable: Resistance of load (including cable) 1C1, check against 1D1 and both against ground. No output short-circuit must be present. Perform insulation measurement of armature circuit (conductor plus motor). Perform

measurement on power section as described above to check whether a thyristor has broken down.

Perform thyristor test. Check current controller optimization.

Fuse tripped in the field infeed: Check resistance between 3U1 / 3W1 / 3C /3D with ohmmeter. See circuit diagram of power section Section 6.5 of the Operating Instructions. As diodes are also used here, the value between 3C/ 3D and between 3W1 – 3C / 3D is high resistance for the voltage polarity of the ohmmeter; for the others it is low resistance. See circuit diagram Section 6.5 of the Operating Instructions.

Fuse tripping of the armature infeed occurs sporadically:

Set P086 = 0 and perform trace recording with triggering in response to fault.

Note: If line undervoltage or line failure occurs during braking this can cause the conduction-through with a tripped fuse. In braking operations (4Q-SIMOREG or 1Q-SIMOREG with field switchover), the line supply voltage of the power section must be faultless, any short interruptions will cause a tripped fuse. If the voltage supply is made available via sliprings (material transport vehicle, hoisting drives), equip the sliprings with multiple contacts to guarantee an uninterruptible power supply throughout.

For an article on this physical effect (conduction-through), see:
http://support.automation.siemens.com/WW/view/en/24120447

As a remedy to bad lines and frequent brake operation, the product CCP (Converter Commutation Protector), which is also available, can be implemented.

More at: http://support.automation.siemens.com/WW/view/en/21688372

Display on the PMU is dark:

Check voltage at input according to circuit diagram:

230 V 1AC: Connection: 5U1+5W1 to 5N1, 400 V 2AC: Connection 5U1 – 5W1,

Check fuses F1 und F2; if all is OK but display is still dark, a fault has occurred on one of the following components: CUD1, power interface, device operator panel.

Irregular speed:

Temporarily set parameters to EMF control with P083 = 3, if speed is then regular check speed actual value with Trace (K0013 for analog tacho, K0040 for pulse encoder). Check whether encoder is correctly mechanically adjusted.

Check speed controller optimization, see also below: Notes about the optimization run: Depending on the drive mechanism it may sometimes be necessary to re-optimize the speed controller manually.

The following values can provide some orientation help:

Crane drives:

P225 = 7 - 11, P226 = 0.2 - 0.4 s

Drive with large masses (main drive printing machine, dry end on paper machine):

P225 = 20 - 30, P226 = 0.6 - 1.0 s

Cross cutter (good mechanical system is a requirement):

P225 = 25 - >30, P226 = 0.1 - 0.2 s

Extruder, rolling mills:

P225 = 5 - 10, P226 = 0.4 - 0.6 s

Positioning tasks (e.g. synchronized crane traveling gear):

P225 = 5 -10, P226 = 0.2 s

Constraint: Rated converter current = 1.5 * rated motor current.

If the converter/motor ratio is larger, Kp must be reduced proportionally.

On no account may the speed controller output exhibit periodic vibration or rattling in the gear unit. In this case, P225 must be reduced and possibly P226 increased.

If necessary, additionally set slight speed actual value smoothing of 0 - 50 ms for a pulse encoder or analog tachometer, approx. 40 ms for EMF control in P200.

Drive vibrates mechanically at a particular speed:
There is mechanical resonance in the system. As a remedy, a band filter can be inserted in the speed actual-value channel (two for suppressing two frequencies exist). Sheet G152. Set P623 = 178. Set the resonance frequency, quality depends on the width of the resonance band. Use of a band filter makes it possible to set a larger Kp for the speed controller without vibration occurring.

Irregular current:
Check current controller optimization, it is usually sufficient to perform a current controller optimization run with P051 = 25.
If non-linear load inductances are present, for example, if iron core smoothing inductors used, as recommended for 12-pulse parallel connections or for old motors, set P153 = 2. For supply of DC voltage links with smoothing capacitors, set P153 = 2.
If irregular current occurs close to current zero: Set P162 = 0 and P163 = 1.
Perform thyristor test.
The dynamic response of the current actual value during current control is usually due to the load and therefore normal, if the required speed is correctly controlled. Re-optimize the speed controller if the current actual value oscillates periodically.
Current peaks can also be caused by commutation problems on old motors. On old motors set P157 = 1 and P158 = approx. 0.04 seconds.
Even a weak network can cause current fluctuations if the undervoltage threshold P351 is reached when the automatic restart time P086 is set to a value greater than zero, see: http://support.automation.siemens.com/WW/view/en/19874412

Motor speed oscillates when stopping in the opposite direction via:
This is due to the I-component of the speed controller; because it must first integrate down toward zero, this must cause overshooting in the other direction of rotation.
Remedy: Activate automatic switchover to P control for low speeds. Setting:
Set switchover threshold P222 = 2 to 5 %. The content of the binector, the binector number set in P698 must be 1, e.g. set P698 = 1. You can selectively activate automatic switchover with this binector selection, for example, to suppress it during a positioning action.

Motor speed drifts when speed setpoint is zero
More at: http://support.automation.siemens.com/WW/view/en/26665312

The motor produces no torque although the necessary armature current is flowing:
Check the current load current with r019 and measure with an ammeter, any deviations may point to a fault in 6RA70. Check current controllers, load resistors (R75 phase U, R76 phase W, see Section 6.4 Operating Instructions) of the current measurement, check voltage drop at the load (device-specific and dependent on P076.01). Possible fault on the CUD1.
Perform trace recording and evaluate Trace 1 and Trace 2.
With r040 check whether a limit in SIMOREG responds.
Check field supply, measure field current and if existent, measure field voltage. If field current OK and field voltage not OK, an interturn fault in the field winding, which means that the motor flow is too small could be the cause.
Approx. 25% deviation from the rating plate data for the motor field as a function of the winding temperature is normal.
Any ground fault of the field winding can have a similiar effect.
Check armature circuit of motor.
Measure insulation resistance field circuit and armature circuit.

Motor does not reach voltage:
The SIMOREG device only generates so much output voltage that the current actual value does not exeed the set current limit.
The motor voltage is proportional to the product of speed and motor field (flow Phi: Φ). If the speed is low for the rated flux of the motor, a relatively low motor voltage will result. However, if the speed is high and practically no motor flux Φ exists, for example, because of a fault in the field winding, in this case, too, a low motor voltage will result. The physical relationship is explained below.

Motor turns several percent too slowly when an analog tachometer is used:
The high-resistance input for the analog tacho (terminal 103/104) may mean that the load on some tachometers is too low and so therefore output a voltage that is too high compared with the rating data. As a remedy, an additional base-load resistor can be placed parallel to the tacho output – observe the rating plate data on the tachometer.

Distribution of functions to the modules in the SIMOREG:

The purpose of this list is to show which modules are involved in the various actual-value acquisitions, to help ascertain which modules need to be replaced if a fault occurs. Ribbon cable and cable connections between the individual modules see Section 6.2 of the Operating Instructions. You will find the item number of the module in the screen print on the module, it is C98043-A.....
You will find the order number for spare part orders in spare part list DA21.1E
http://support.automation.siemens.com/WW/view/en/26996942
CUD1: Processor electronics for open-loop and closed-loop control; item number: C98043-A7001-L1 for software versions 1.0 to <3.0; C98043-A7001-L2 for software versions >3.0. Evaluation of analog and binary inputs and outputs, all inputs and outputs are referenced to ground. The electronics ground is at ground potential.
Serial interface G-SST1 (connection X300 at the PMU);
Serial interface G-SST2 (terminals 56 to 60)
Pulse encoder evaluation: For possible pulse encoders, see parameter description for P140.
Note: Evaluation of the tracks of the pulse encoder is performed by means of differential amplifier for evaluating the push-pull tracks of pulse encoders. A-A/, B-B/. If only signals A, B, and not cross-signals A/ and B/ exist, the negative signal inputs of the differential amplifiers, terminals: 29, 31, and 33 must be connected to electronics ground. --
AD converter (analog-to-digital converter) for: Line voltages armature and field, armature output voltage, load voltages of the current transformers and normalization of the rate armature current, temperature sensor on the heatsink and on the A7004, evaluation motor temperature sensor KTY84 / PTC
Analog inputs 4/5 and 6/7 via dual-slope AD converter, resolution and measuring time, see parameters P707 / P717.
Note: Terminals 4/5 and 6/7 lead to a differential amplifier, this means that the minus input of the amplifiers terminal 5 and terminal 7 must be connected to the ground of the measuring signal in question, i.e. with electronics ground terminal 1, using an internal reference voltage or with the ground of the external measuring signal that is fed via terminal 4 and terminal 6. – End of note-
DA converter (digital-to-analog converter) for analog outputs terminals 14 and 16
Analog output terminal 12 for the current actual value, 5 V for the rated device current acc. to r072.02, this is a realtime output for direct display of the shape of the current curve by means of oscilloscope or recorder.
Output reference voltages P10 and N10
Output P24, for controlling the binary inputs.
This is a pure output, feeding of external voltages at these terminals is not permitted.
Output P15, 200 mA for pulse encoder power supply
24 V binary outputs via transistor, each with 100 mA load rating, terminals 46 and 48
Frequency measurement of transducer for field current actual value acquisition and its normalization.

Generation of firing pulses for the thyristors of the armature and field power section.
Various monitoring modules for fans and fuses, sensing on additional modules, see below.
Calculation of all open-loop and closed-loop control functions for armature and field with
direct generation of the firing pulses for the thyristors using 2 microprocessors.
CUD2: Terminal expansion:
Item number: C98043-A7006-L1; Order number: 6RX1700-0AK00
Additional binary and analog inputs and outputs
Note: When using floating binary inputs, terminals 211 to 214, their reference ground,
terminal 216, with device ground, terminal 217, and when controlling the binary inputs from
an external control connect with their reference ground.
–End of note-
Additional RS485 interface G-SST3
Paralleling interface for parallel connection of SIMOREG 6RA70.
Evaluation, temperature sensor, KTY84 or PTC.
Power interface module:
Item number: C98043-A7002-Lx, C98043-A7003-Lx, x stands for the module variant, e.g. for
1Q/4Q and depending on the rated voltage of the 6RA70.
Input electronics power supply: 400 V: via 5U1/5W1, 5N1 open, or 230 V: connected via
5U1-5W1 and 5N1, fuses F1/F2 to protect the input
Terminals 105-107 for E-STOP
Terminals 103/104 for input-analog tachometer and 150 kOhm prescaler, signal conditioning
via operational amplifier on the CUD1
Relay output terminal 109/110 for main contactor control
Sensing of the line voltage armature infeed (synchronization for the armature gating unit is
also derived from this) and output voltage armature, related to ground potential via high-
resistance difference amplifier, total leakage resistance against ground
approx. 1 MOhm. The voltages are sensed via the firing pulse cables:
X12-2 (1W1), X14-2 (1U1), X15-2 (1C1), X16-2 (1V1), X25-2 (1D1).
Note: Direct sensing of the line voltage on the power section does not result in dependency
of the assignment of the phase angle for the power section with respect to the electronics
current supply. The electronics supply can therefore be provided by a UPS without
reservation.
The power infeed can have a clockwise and counter-clockwise rotating field (rotating field
synchronization is provided). –End of note-
Isolation of the firing pulses to the thyristors via pulse transformer.
Power transistors to control the pulse transfomers.
10 ohm load resistors for the current transformers (input X3) of the actual current sensing.
Connector X6/X7 for connecting temperature sensor NTC 6.8 kOhm, mounted on the
heatsink, for the heatsink temperature acquisition and for devices with 6RA70..-4 disk-type
thyristors mounted on the A7004 for air flow monitoring of the fan.
Field module:
Item number: C98043-A7014 + C98043-A7015 mounted perpendicularly to each other, both
supplied under a single order number as a spare part.
A7014: Gate pulses for field supply by electrical isolation provided by pulse transformers
Shunt resistors for current actual value acquisition for field supply and evaluation via voltage
frequency converters (V/Hz converters)
3U1/3W1 power terminals, infeed, field supply and output 3C/3D
A7015: Field current actual value measurement via V/Hz converter
Line voltage sensing, infeed, field supply via high-resistance differential amplifier with
reference to ground potential. The synchronization for the field gating unit is also derived
from this.
Note: Sensing directly at the field supply infeed means that any phase angle is possible.
Assignment to the phase angle of the infeed of the armature power section or the electronics
power infeed is immaterial. –End of note-

Fan monitoring and fan control for the 6RA7075 and 6RA7078,

X75: Connector for the fan connection.

C98043-A7004: Power connections 3U1/3W1 input line voltage, 3C, 3D DC voltage output

Gate pulse transformers for floating control of the thyristors of the field supply

Shunt resistors for field current actual value acquisition

V/Hz converter for actual field current measurement

Sensing of the line voltage, field, via high-resistantance differential amplifiers with reference to ground. The synchronization for the field gating unit is also derived from this.

Inputs for fuse monitoring XU1, XU2; XV1, XV2, XW1, XW2; these
are only for devices with installed arm fuses; (devices >850 A DC).

Power section 15 and 30 A devices:

Item number: C98043-A7010

Power section wiring and snubber circuits,

Gate pulse transformers for floating control of the thyristors of the field supply

Power terminals: Field supply.

Actual field current sensing via V/Hz converters and shunt resistors

Line voltage measurement, field infeed via high-resistance differential amplifiers, with reference to ground potential, also used for synchronization of the field gating unit.

PMU simple operator panel:

Item number: C98043-A7005, display via 7-segment displays and light-emitting diodes,
3 keys for operating the display, connector X300 for G-SST1, RS232 and RS485 for
USS protocol, for example for connecting a PC for operation via a DriveMonitor or an OP1S comfort operator panel.

Backplane module:

Item number C98043-A7009, provides the terminal connection to further modules

This module contains the EEPROM, the non-volatile memory for the device data, the PIN code for enabling the S00 technological software, and the device parameters.

If ordering this module as a spare part, specify the factory serial number and the MLFB (order number 6RA70...) of the device so that the manufacturer can load this data into the module before delivery.

Snubber circuits:

Various modules depending on the rated data: Voltage / current of the devices, see Section 6.4 of the Operating Instructions.

The thyristors are synchronized by means of an RC element, the snubber circuit. Transition from a conducting to a non-conducting thyristor state occurs with a fast current change. A fast current change in the current circuit results in overvoltages due to the presence of inductances ($u = L * di / dt$). The snubber circuit is dimensioned in such a way that any overvoltages resulting from commutation will be below the blocking voltage of the thyristors.

Note: A fault in the snubber circuit can cause thyristor failure due to overvoltage.

Signal assignment of the connectors:
X101: Line failure warning, overload P24, fan ON, fan OK, field current, fuse OK, analog tachometer, actual current value load armature, heatsink temperature, line voltage armature and field, armature voltage, power ON, firing pulses armature and field, E-STOP checkback signal, power supply monitoring: P24, M.
X102: Firing pulses field, current actual value field, monitoring power supply, line voltage field, fan ON, fan OK.
For connectors between the modules: see Operating Instructions Section 6.2.

Module Replacement:

Before installing the replacement module, compare its item number with the old number. C98043-Axxxx-Ly-zz; xxxx: Number of the module, e.g. 7001; y: L number.
The number must be identical up to the L Number, (exception CUD1: C98043-A7001-Ly, here only the software version to be used must be observed, this is already correctly loaded when the replacement module is delivered. L1: SW1.0 to <3.0, L2: SW 3.0 and higher possible).
The version zz of the module is irrelevant, all previously supplied versions of the module bearing an item number identical up to the L number, are compatible.
Replacement of the CUD1: If the replacement module has the same or a more recent software version (SW2.0 or higher), there is nothing to observe after module replacement (more recent parameter download not necessary), as the parameters are not stored on the CUD1 but in the non-volatile EEPROM on the backplane module. The software correctly sets the new parameters of the newer software version automatically, the old parameter settings are kept.
If the replacement module has an older software version, the factory setting must be restored with P051 = 21 and then the parameters downloaded. However, the latest version of the software should always be installed, irrespective of the hardware, available in the Internet under
http://support.automation.siemens.com/WW/view/en/22386444
The above advice also applies when replacing the software: Upgrading or downgrading the software.
Note: After updating the software to a later software version, no further measures, i.e. downloading the parameters, is necessary. The software correctly sets the parameters stored on the EEPROM automatically, and sets the new parameters of the later software version to the factory setting. After the software update, you are recommended to upload all the parameters again to have an up-to-date parameter file for a later download at your disposal.
Note: After replacing field module C98043- A7004; A7010, A7014+A7015, an offset adjustment must be performed with P051 = 22. This is needed for adjusting the zero point of the actual current sensing of the field current supply.
Once you have replaced the other modules, not more settings or adjustments are needed.
Note: Before replacing the modules, all the inputs and outputs of the 6RA70, including those of the electronics voltage supply, must be de-energized.

Replacing a device:

After you have replaced a SIMOREG device, you must enter the plant-specific parameters again.
In the simplest case, the parameters deviating from the factory setting are read out of the old devices with P052 = 0 and recorded. Implement factory settings on the replacement device with P051 = 21, then set parameters P051 = 40 and P053 = 3 and set the parameters from the list recorded above.
Exception: Parameter P825, adjustment of the actual current sensing, field, is device specific, do not change.
If parameter upload .DNL is available, this file can be imported into the new device with the DriveMonitor (see separate FAQ). If this file is from a device with an older software version,

some parameters might be rejected when downloaded into the new device. You will find the related parameter numbers under "Details". These parameters must be adjusted manually after the download.

The interface parameters such as, for example, the Profibus address, are not transferred during the download and must be set manually when downloading is completed.

Note: The following parameters are not transferred during the download with the DriveMonitor and must be entered manually afterward: P051, P055, P057, P781, P783, P786, P791, P793, P796, P801, P803, P806, P825, P826, P898, P918, P952, P971, U581. Do not change the original value of P825 in the device.

Note: When replacing the device you must ascertain whether the free function blocks, Option S00, were enabled on the old device and used. In this case, the free blocks (for description see above) must be released for use by entering the device-specific PIN code for the S00 in parameter U977 on the replacement device, too.

Controller structure of the 6RA70

The structure of the controller for the armature circuit:
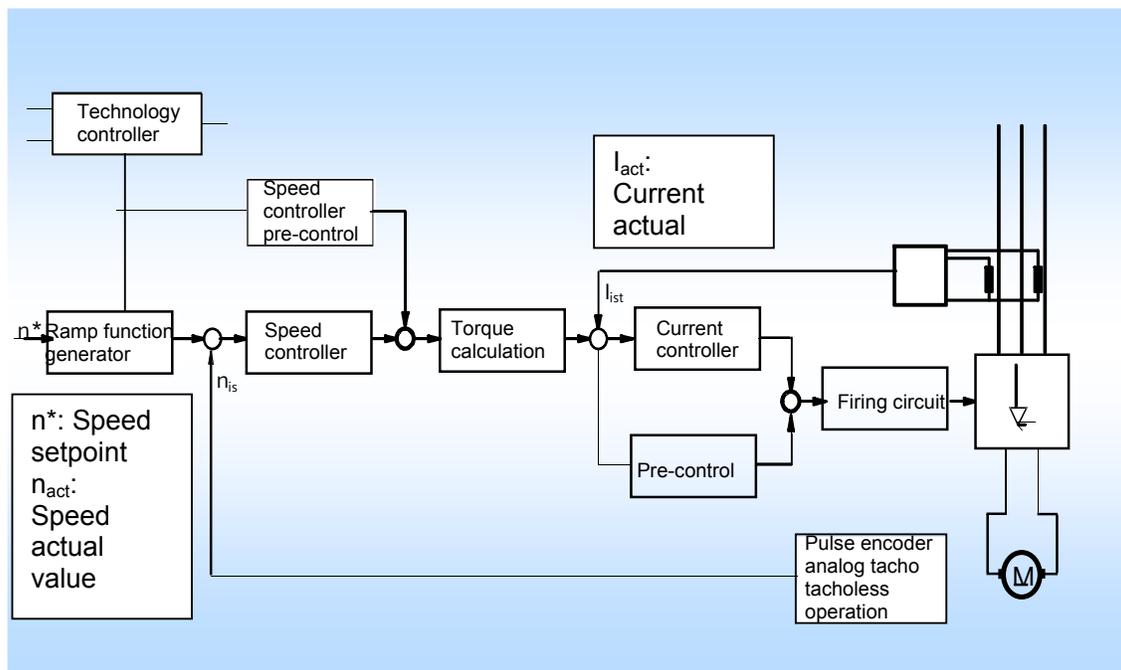
Ramp-function generator:

Sheet G136. The ramp-function generator changes speed setpoint that suddenly changes by means of an ascending ramp (ramp-up time P303) and a descending ramp (ramp-down time P304) In addition, a lower transition rounding (P305) at the beginning and an upper transition rounding (P306) at the end of the ramp-up function can be set. See also P611 to P614.

The ramp-up/ramp-down time should be set high enough that the speed actual value can follow the setpoint of the ramp-function generator output. This is the case if the set current/torque limit of the drive is not reached during the ramp-function generator action and the drive is still located in the possible control range.

the ramp-function generator times must be set to zero during positioning control with a higher-level automation.

Setting the ramp-function generator to the content of the connector number in P639:

P639.01, set for the ramp-function generator output on a high signal from the binector selected via P640

P639.02, setting the ramp-function generator output when Run state is no longer active (B104 = 0) and the content of the binector selected in P640 is low.

See also parameter P295, P302, P317, P318 and P636 to P641, P646 and P647

Display of active times: r315, display of ramp-function generator state: r316.

Speed setpoint:

At ramp-function generator input: r028; at ramp-function generator output: r027, at speed controller input: r026

Actual speed value:

Sheet G151;

Analog tachometer as the actual speed value (P083 = 1), K0013, Sheet G113. Normalization via P741;

Pulse encoder as actual speed value (P083 = 2), K0040, Sheet G145. Normalization via P143,

Pulse number of encoder P141; minimum speed/maximum speed that can be evaluated see Section 11.8 of the Operating Instructions; reduction of the minimum speed possible by a factor of 2 with P147 = 1, by a factor 4 with P147 = 2.

If a pulse encoder is used, the value can also be shown on the UPM: n024; K0048.

EMF as the actual speed value (P083 = 3). Sheet G165 top left, normalization P115. K0287

The EMF is the calculated induced motor voltage, generated from the measured device output voltage and the voltage dips I*R and L*di/dt of the motor.

The precision of this type of control is largely determined by the change in resistance of the armature winding of the motor via the temperature and amounts to approx. 5%.

For EMF control: Set speed actual value filtering P200 = approx. 40ms.

Freely selectable speed actual value source (P083 = 4), the number of the connector from which the actual speed value is derived is set in P609. Sheet G151.

If necessary, set a small filtering time for the actual speed value: P200 = approx. 5 to 40ms.

Actual speed value at speed controller input: K0166 as absolute value, K0167 as bipolar signal. Actual speed value display: r025

Irrespective of the signal used for the control and selected with P083, the other evaluated speed actual value quantities are also always available, e.g. for the required display of the EMF actual value when controlled with a pulse encoder or analog tachometer, or by using a second encoder for technological control.

Speed controller:

The output of the ramp-function generator is the speed setpoint value for the following speed controller, Sheet G152

It calculates the deviation between the speed setpoint and actual value and prescribes the setpoint for the following lower-level current controller after an intermediate torque calculation.

The speed controller is implemented as a PI controller (an additional D component can be connected via the derivative element P205 / P206). One characteristic of a PI controller is that it adjusts the error variable, in this case, between the setpoint and actual value for speed, to zero if the setpoint is constant.

The characteristic quantities of the controller, the gain Kp (P225) and the reset time Tn (P226) can be adjusted based on an additional variable, such as an actual speed value. Sheet G121. This permits stable operation within a broad control range even with special applications.

Used, for example, with low speeds on feed drives.

A droop function, Sheet G151, is also available. The droop function, for example, is used to achieve smooth load distribution for several drives coupled via the material. See also the description of applications about slave/master operation at:

http://support.automation.siemens.com/WW/view/en/9473023

Control method depends on the parameter assignment:
P224 = 1, P234 = 1, PI controller: Factory setting
P224 = 0; P234 = 1, P controller
P224 = 0; P234 = 1, I controller
For optimization, see below.
Speed controller as the voltage controller: Some applications require control to a constant output voltage of the SIMOREG.
Settings of the voltage actual value for control: P083 = 4; P609 = 292 (connector actual voltage value).
The speed control stability is specified in the technical data of the Operating Instructions. This is a long-term stability referred to a longer measuring time, e.g. 10 seconds. Deviations within a short monitoring period, e.g. as the result of a load surge, are higher than specified. Specific values cannot be given as these short-term deviations depend on the actual conditions of the system and optimizations. See also below.

Speed controller pre-control:
Sheet G153.
Compensation of the moment of inertia: The torque required for the speed change depends on the moment of inertia of the load and the desired speed rate of change. The necessary correcting quantity is calculated from the dv/dt of the ramp-function generator output (rate of change of speed) and is added to the speed controller output.
Friction compensation: The friction is speed dependent, the torque required to overcome the friction is derived and added to the speed controller output.
The above correcting quantities can be derived automatically with optimization run P051 = 28. These compensations offload the speed controller and permit a higher speed control dynamic response.
Selection of compensation via P223 = 1, Sheet G152.

Torque calculation:
Sheet G160. Depending on the setting for P170, the output of the speed controller indicates the torque setpoint or the current setpoint. The motor torque is determined using flow Phi of the motor. For theory, see below
Setting: P170 = 0, the speed controller output is the current setpoint that can be passed on to the current controller without any further calculation (except limitations).
P170 = 1, the speed controller output indicates the torque setpoint, the current setpoint for the current controller is determined by the next calculation M/ Φ. One advantage here is that the controlled system gain of the speed control loop is adapted suitably automatically within the field weakening range of the motor, producing a stable speed control response.
Torque setpoint before limitation: r022, after limitation: r021
The precision of the torque control dependent on the device is approx. 3%. (influence of actual current sensing, armature and field, taken into account and field characteristic curve recording performed, if there is field weakening). The influence of the motor is low for a fully compensated motor, but motor-related for a non-compensated motor.
Note: If the motor is only operated in the armature setting range (no field weakening), flux Φ is always 100% and setting P170 = 1 has no effect.
If P170 = 1, P169 = 0 must be set.

Current setpoint integrator / Reduced gearbox stressing
Sheet G162, P157 = 1, current setpoint integrator: The ramp-function generator for the current setpoint is effective for every current setpoint change of K120, recommended setting.
P157 = 0, reduced gearbox stressing: The ramp-function generator time is only effective for a change of torque direction.
P158 = Ramp-up time in seconds
On old motors, set P157 = 1 and P158 = approx. 0.04 s, required for good commutation of the current in the old motor.

Actual value of current
The armature current is sensed on the AC input side by one current transformer in each of the U and W phases. The current transformer load for each current transformer is on the power interface module and is 10 ohm. The load voltage is evaluated on the CUD1. The

rated DC current of the SIMOREG is adapted via the transformation ratio of the current transformer and electronically on the CUD1.

The DC actual value is formed from the two load voltages of the current transformers on the CUD1 with electronic rectification, which is fed to the analog-to-digital converter. This measured value for direct voltage as an image of the armature current is output to terminal 12/13 with normalization 5 V before analog-to-digital conversion as a realtime quantity according the actual rated device direct current (r072.02) after normalization via P076.01 and/or P067. P749 determines whether the voltage value +/-; +/- output is inverted, absolute, or absolute inverted. See Sheet G115.

The precision of the sensed armature current is 1% of the nominial value.

Note: Both of the current transformers must always be loaded with a load resistor, otherwise they will be damaged by internal overvoltage on current flow.

Current control loop

The current control loop adjusts any deviation of the current setpoint: r020 (100% correponds to the value of P100) and of the current actual value: r019 (100% corresponds to the value of P100) to zero. In the current control loop the current controller acts as the PI controller. Current controller precontrol is active at the same time. Sheet G162. The output of the current controller and the precontrol are added and the sum of the two quantities forms the delay angle.

Current controller: The current controller is a PI controller; its parameters for optimization are the Kp (P155) and the reset time Tn (P256). For optimization, see below.

Depending on the parameter settings can also be run as a P or I controller.

P154 = 1, P164 = 1; PI controller, factory setting

P154 = 0, P164 = 1; P controller

P154 = 1, P164 = 0; I controller

The current controller adjusts the setpoint/actual value difference of the current via its PI characteristic curve by forming the suitable delay angle for the gating unit.

Precontrol: The precontrol acts simultaneously with the current controller and ensures the dynamic response of the current control loop both for discontinuous and continuous current. Above all, the precontrol ensures that the delay angle for the existing non-linear control characteristic and the varying delay angle requirement for a change in the actual current value for discontinuous and continuous current is calculated and precontrolled to the correct extent.
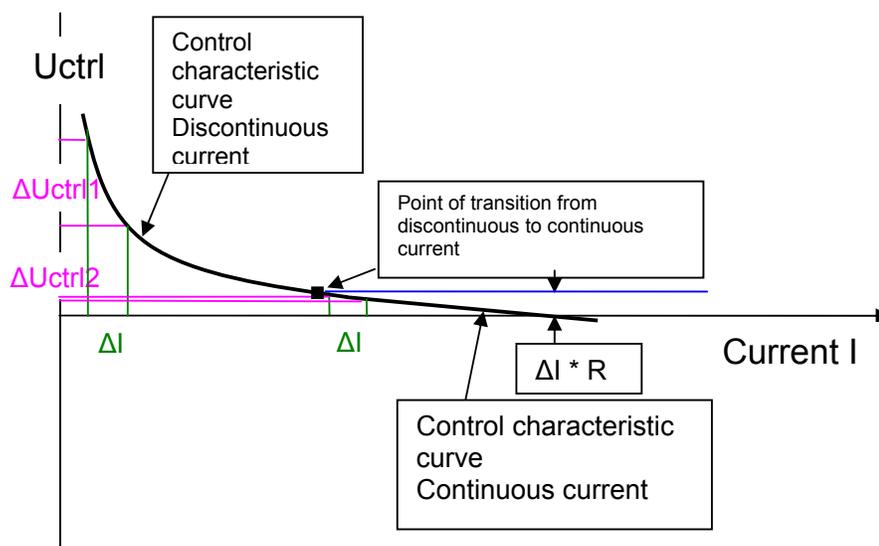
To effect a current change ΔI a firing angle change ΔUctrl must be applied. If ΔI is equal, the necessary control firing angle ΔUctrl1 in the discontinuous current range is much higher than ΔUctrl2 in the continuous current range. The firing angle change only has to take account of the armature-current-related linear voltage drop I * R in the continuous current range.

The point of transition from discontinuous to continuous current (see below) is determined by the inductance in the load circuit and the current motor EMF.

The control characteristic above applies to a particular motor EMF, the curve moves up or down depending on the current EMF.

The precontrol calculates the firing angle depending on the current setpoint and the EMF of the motor, uses it to compensate the above non-linearities and sets the required firing angle without delay for the following gating unit. The current controller now only has to correct by a small amount. This ensures that even for greater dynamic requirements such as cross-cutters, for example, the required dynamic response of the current control can be provided.

P150 = 0, The precontrol is not active

P153 = 1 Factory settings, precontrol dependent on current setpoint and EMF active

P153 = 2 Current-setpoint-dependent precontrol active, EMF influence not active, with torque direction change or on start via controller enable, the I component of the current controller is set to the delay angle component as a condition of the EMF. Recommended settings if non-linear smoothing reactors exist in the armature circuit, e.g. two-value reactor in 12-pulse operation or iron-cored reactors on applications for old motors.

P153 = 3 Precontrol assumes EMF zero, this is for applications that do not use EMF and for high inductance loads in field supply or solenoid applications.

Gating unit

The gating unit is the interface to the power section. The firing instant of the thyristors is defined by the offset of the firing angle from which an alternating variable direct voltage is formed. Phase control of the AC input voltage with suitable assignment of the thyristors to be fired is performed in such a way that a variable direct voltage occurs at the output, see below. The firing angle is calculated as a function of the zero crossing of the line voltage (voltage measurement of 1U1/1V1/1W1 on the power interface group).

The gate pulses are formed on the CUD1, the gate pulse transformers are located on the power interface module. The gate pulse transformer receives the chopped pulses, see below. The duration of the firing pulse burst is 0.89 ms for a short pulse setting of P079 = 0 (factory setting). For a long pulse setting of P079 = 1 the duration of the pulse burst is 0.1 ms before issue of the subsequent firing pulse.

The settings P079 = 2 and 3 are for the operation of SIMOREGs with 12-pulse series connection.

P079 = 2: Settings on the series master and series slave for 12-pulse series connection.

P079 = 3: Setting for 12-pulse series connection of parallel-connected SIMOREGs, only on the parallel units of the master.

Note: For normal applications always use short pulses with P079 = 0. P079 =1 Long pulses, intended for supplying large inductance to ensure that thyristors trigger. In the case of long pulses, the thyristors might not block on some network configurations, a Trace2 evaluation should therefore be performed for this setting showing that the thyristors will block, detailed support on this effect is available from Technical Support. When supplying large inductances with short pulses, a resistance must be implemented parallel to the load with a current of approx. 500 mA at nominal voltage for the load, to ensure that the thyristor attains the holding current of approx. 200 mA for the duration of the firing pulse. The thyristor will only remain conductive when the holding current is reached.

Example of parallel resistance: Nominal direct voltage 310 V / 0.5 A = approx. 680 ohm, load capability in watts: (line voltage * 1.35)^2 / resistance in ohms. In the above example, a 400 V line voltage and 680 ohms results in approx. 450 watts load capability for the resistance. – End of note-

Operation on weak networks (generator with diesel drive):

On weak-frequency networks, frequency changes of up to 10 Hz per second are permissible. For this, parameter P152 Line frequency correction armature (factory setting 20) must be set

to lower values. The correct setting depends on the system conditions and must be verified with trace recordings. The current measured with Trace 2 should exhibit a steady current without current peaks. Parameter P252 must be observed for the integrated field supply.
Note: A diesel generator cannot absorb regenerative current. In such a case, it is therefore important that load resistors on the AC infeed side of the SIMOREG are switched on during braking mode with a resistance value that is high enough to ensure that the generator always works generatively. Engineering support on request.

Delay angle limits
Sheet G163.
Control limit Alpha G: The setting of Alpha G (P150) determines the maximum possible output voltage of the SIMOREG. Smaller angle values mean higher voltage possible. For calculation see below. Factory setting 5 degrees for 1Q devices, and 30 degrees for 4Q devices and for 2Q with field switchover. 30 degrees for 4Q is required to ensure that the output voltage in motor operation is not too high and that on transition to braking mode with Alpha W 150 degrees enough back-EMF can be accumulated. If the output voltage of the device before transition into braking mode is too high, F043 is output in order to protect the drive from conduction-through. See also the descripton for F043.
Inverter stability limit Alpha W: Alpha W is set at P151, factory setting 150 degrees. Limit Alpha W is required to provide the necessary protection angle to allow the thyristor to block before commutation to the next thyristor. On weak power supply networks it may be necessary to reduce Alpha W, for example, set 145 degrees. For discontinuous current, the angle can be larger because the thyristor no longer carries current during commutation, so that Alpha W 165 degrees becomes active if zero current is signaled. This offset to 165 degrees can be prevented with P192 = 1, then P151 is always active.

Command stage
The command stage controls the torque direction change for 4Q drives.
Sheet G163. The requested torque direction is derived from the polarity of the current setpoint of connector K0119. If the requested torque direction does not correspond to that which is currently active, the torque direction is changed. The firing angle is pushed across the firing angle limitation to Alpha W in order to reduce the actual value for current to zero. The torque direction change is then performed 0.5 ms after the current zero is issued. The signal of the binector set on P165 (factory setting 220) is taken into account as an additional interlock. The interlock is required for 12-pulse parallel connections to ensure that both converter systems have the same active torque direction.   See also the description of applications for 12-pulse operation.
An additional number of Alpha W pulses can be set via P161 and P179, which are executed before the torque direction is changed, and which is required for supplying large inductances, see also the description of applications on field supplies and FAQ for the use of large inductances on the SIMOREG.
http://support.automation.siemens.com/WW/view/en/9472382
http://support.automation.siemens.com/WW/view/en/23480619
A torque-free pause can be set with P160.
Torque direction 1 set: Firing pulses for MI1 to MI6 present.
Torque direction 2 set: Firing pulses for MII1 to MII6 present.

Limits
Limits can be set between the control loops in order to adapt the maximum values to the system requirements.
Limitation before the ramp-function generator, Sheet G135
Limitation after the ramp-function generator, Sheet G137
Torque limitation, Sheet G160
Speed limitation controller, Sheet G160
Current limitation, Sheet G161
Firing angle limitation, Sheet G163

Example of limitation before ramp-function generator:
Positive limitation: The connector number is set at P642.0x, which acts as a positive limitation. Four values can be set via the four indices, of which the lowest value of the connector contents acts as the limitation.
Negative limitation: The connector is set at P643.0x, which acts as a negative limitation. Four values can be set via the four indices, of which the highest value of the connector contents acts as the limitation. Here, mathematically, minus 10 % is larger than minus 40 %, for example.

Controller structure for the field circuit
EMF control loop
Sheet G165. If P081 = 1, field weakening possible, the following applies: If the EMF actual value K=286 is higher than the EMF setpoint (K0288), the EMF control loop is activated and reduces its output variable, field current setpoint K0278, to reduce its EMF with field weakening of the motor.
EMF controller:
P274 = 1, P284 = 1 The controller acts as the PI controller, factory setting, recommended setting
P274 = 0, P284 = 1 The controller acts as the P controller
P274 = 1, P284 = 0 The controller acts as the I controller
Optimization variables for the controller: Gain Kp (P275) and reset time Tn (P276).
The EMF controller is responsible for the fine adjustment of the setpoint/actual-value difference; the precontrol functioning in parallel with this performs that main dynamic tasks.
The input variables of the precontrol are the EMF setpoint and the speed, the output is precontrolled depending on this by means of the recorded field characteristic curve. This means that a recorded field characteristic curve (motor-specific) is a requirement for P081 = 1. If a non-remediable fault occurs during recording of the field characteristic curve (P051 = 27), the field characteristic curve must be recorded manually.
In many practical cases, however, the following parameter settings are possible:
P081 = 1, P117 = 1, P253 = 0.
In this case, the precontrol of the EMF control loop is disabled and the field weakening control is only performed by the EMF controller, field characteristic curve recording is then not necessary.
If P081 = 0 no field weakening control is performed and the field current is input as a constant quantity, the EMF control loop is not active.
Field current setpoint limitation
After the output of the EMF control loop, a field current setpoint limitation takes effect.
The upper limit value is determined by r073.02, the rated field current for the motor.
Additionally, multiplying influence on the limit is possible by entering the required connector number in P613.
The field current setpoint lower limit is determined by P103 and a connector variable with a multiplying effect for the connector selected in P614.
Actual value for field current
The actual field current value is sensed by means of shunt resistors on the field module. The shunt resistance complement is dependent on the device data. The voltage drop of the shunt resistors is converted to a frequency by a V/Hz converter and measured by the CUD1.
100 % of r073.02 corresponds to the current field nominal current for a 100% actual field current value for the field current control. The rated device field current r073.01 results in the currently applicable rated device current, field after adjustment with R076.01 (10 to 100% in steps) for the field current control.
The precision of the actual value sensed for the field current is 1% of the nominal value.

Field current control loop

Sheet G166, field current controller:

P254 = 1, P264 = 1 The controller acts as the PI controller, factory setting, recommended setting

P254 = 0, P264 = 1, The controller acts as the P controller

P254 = 1, P264 = 0, The controller acts as the I controller

Optimization variables for the controller: Gain Kp (P255) and reset time Tn (P256).

the PI field current controller adjusts the field current to a setpoint/actual value difference of zero and provides the delay angle for the field current gating unit as the output.

A precontrol is active at the same time and has a different characteristic curve than the armature current control loop because it includes a half-controlled bridge circuit.

Firing angle limitation

The firing angle limitations in the factory settings are P250 = 0 degrees for Alpha G and P251 = 180 degrees for Alpha W.

If the field winding has a low nominal voltage, Alpha G can be set to higher values to limit the maximum output voltage in the case of a fault and thus protect the field winding of the motor from overload. For calculation, see below.

Gating unit

The gating unit synchronizes to the line voltage of the field supply (measured on 3U1/3W1 on the field module) and, according to the current delay angle, supplies the firing pulses for the thyristors for the generation of the variable output DC voltage to inject the required load current.

Optimizing the controller with optimization runs

Optimization runs provide effective support for controller optimization. See Section 7.5, item 8.4, of the Operating Instructions.

Possible faults during the optimization runs are F050 or F052. The causes are described in r047.01 (fault value) and Chapter 10 of the Operating Instructions.

Current controller optimization run P051 = 25: Optimization of precontrol and current controller armature and field. This optimization run must be executed whenever possible and results in nearly all cases in sufficient optimization of the current control loops. If a permanently excited DC motor (excitation via permanent magnets in the motor stator) is used, the rotor must be locked during current controller optimization.

Note: During current controller optimization the motor must be at standstill; if necessary, lock the motor shaft.

On highly dynamic drives, such as are used for cross cutters or feed drives, it may be necessary to manually optimize the armature current controller, for this, the controller is supplied with current setpoint step changes and the step response at the output of the controller is evaluated with the Trace (using the DriveMonitor), see below.

The optimization run optimizes the current controller based on the absolute value optimum.

Speed controller optimization run with P051 = 26. Supplies satisfactory results for many normal applications. In the case of high moments of inertia, a high Kp (P225) is often determined by the automatic optimization; if the mechanical system is not optimum, it may frequently be necessary to reduce this derived Kp by approx. a factor of 2.

Before performing the optimization run with P235, set the required extent of dynamic response of the speed control loop (100% corresponds to the highest dynamic response). Recommended values: 100% is possible for optimum mechanical systems. In practice, a setting of P236 = 30 is usually sufficient and suitable.

In the case of gearless motors: P236 = set approx. 30%. If the optimization is performed under load, both the centrifugal force of the motor and the load for the optimization is taken into account.

The optimization run optimizes the speed controller based on the symmetrical optimum.

If the motor is operated in field weakening, the field characteristic curve recording must be performed with P051 = 27. (If no field weakening is required, this optimization run need not be performed). After the optimization run, activate field weakening with P081 = 1.

Execute P051 = 28 if required,

P051 = 29 for a vibrating mechanical system (e.g. a belt drive), see below.

Note: If the controller structure has been changed by reparameterization of the connector interventions, the optimization runs may not work. Remedy: Use the controller structure as defined in the factory settings, i.e. perform the optimization runs at the beginning of start-up before the controller structure is changed.

Manual optimization
See Section 7. of the Operating Instructions.
Settings for armature circuit resistance and armature circuit inductance, P110, P111, Section 7.6.1
Setting of field circuit resistance, P112, Section 7.6.2
Manual recording of the field characteristic curve, see:
http://support.automation.siemens.com/WW/view/en/27006004

Manual controller optimization using the square-wave generator
Step changes in the setpoint can be defined for the controllers using the square-wave generator, Sheet G128. The controllers can be adapted manually by suitably setting the controller variables, the gain Kp and the reset time Tn, and analysis of the step response.
The setpoint step change and the step response of the controller can be recorded and evaluated using the Trace function of the DriveMonitor.
The setpoint step change should only be high enough to keep the controller within the control range, i.e. so that the controller does not reach a limit, e.g. the current limit.
Extent of step change approx. 2% to 5%, depending on the system configuration.
Setting of the square-wave generator:
P480.F: Higher value of the setpoint step change
P482.F: Lower value of the setpoint step change, e.g. 2% lower than P480
P481.F: Duration for the setpoint as per P480, e.g. 0.1 seconds
P483.F: Duration for the setpoint as per P482, e.g. 0.1 seconds
Activation of the output of the square-wave generator of connector K0208, by setting the binector number in P485.B; e.g. P485.01 = 1 (permanently "Oscillation On").
Setpoint step change for current control loop:
P601.05 = 208, couple output of square-wave generator with input of current control loop (current controller plus current controller precontrol). Sheet G162.
Operate motor at standstill. Switch off field with P082 = 0 and enter an ON signal plus operation enable via terminal 37 and 38.
Check effects of settable filters P191.F and P190.F.
Step reponse for discontinous current, e.g. P480 = 15% and continuous current
check e.g. P480 = 40%. The point of transition from discontinuous to continuous current is influenced by the inductance in the load circuit and is approx. 30 % of the rated motor current (test for any system-related deviations). Perform controller optimization with Kp, P155 and Tn, P156 in the continuous current range.
Optimization is performed based on the absolute value optimum.
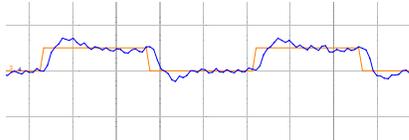
Automatic current controller optimization
Setpoint step-change from 40 to 50 % current setpoint (orange);
Actual current value (blue)

Automatic current controller optimization
Setpoint step change from 40 to 50 % with current setpoint filtering
P191 = 9 ms

Setpoint step change for the speed controller:
P625.F = 208, couple output of square-wave generator with input of speed controller.
Sheet G152.
Activate field with P082, enter ON command and operating enable via terminal 37 and 38.
Record step response.
E.g. step response from 15% to 18% speed setpoint.
Perform controller optimization with Kp, P225 and Tn, P226.
Optimization is performed based on symmetrical optimum, see below.
Test affect of filtering on P228, optimum conditions (only slight overshooting) occur when the filter time P228 is equal to the reset time Tn (P226) of the speed controller.
Notice: The setting for P226 is in s, the setting for P228 is in ms.
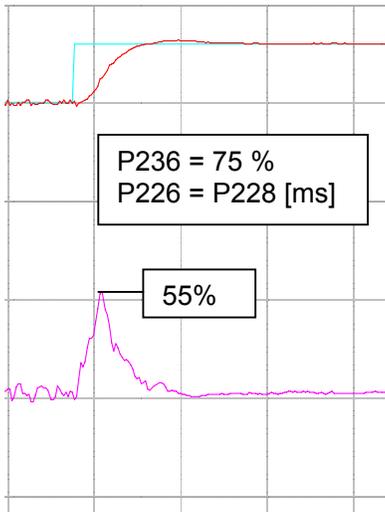
P236 = 75 %
P226 = P228 [ms]

55%
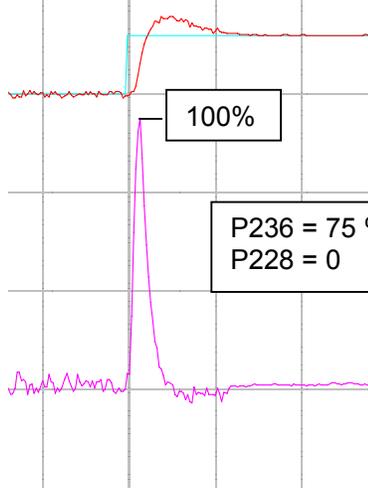
100%

P236 = 75 %
P228 = 0
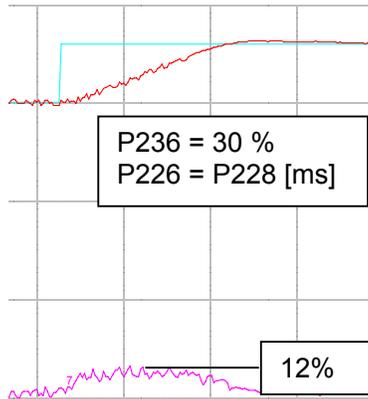
P236 = 30 %
P226 = P228 [ms]

12%

Setpoint step change from 15 % to 18 %
n-set
n-act
i-act

Automatic speed controller optimization
where P236 = 75 % and P236 = 30 %
n-set filtering P228 equal to reset time P226
reduces overshooting of n-act

32

Open-Loop Controlled operation
For test purposes it is possible to operate the device in open-loop controlled mode.
The resulting device output voltage can be calculated, see below.
Note: The current limits have no affect in controlled operation, only the set firing angle limits for Alpha G and Alpha W have an effect. – End of Note.
The firing angle offset can be changed in fine increments from -100 % to positive values, the resulting current r019 for the armature actual value: 100% actual current from P100 or r035 for the field curent actual value: 100 % actual current from P102, must be checked.
-100 % corresponds to 180 degrees, 0% corresponds to 90 degrees, and 100% corresponds to 180 degrees.
Delay angle in degrees = K100[%] * 180 / (-200) + 90 for the armature circuit, see parameter r018
Delay angle in degrees = K250[%] * 180 / (-200) + 90 for the field circuit, see parameter r034
Additional measurement of current actual value by means of an ammeter necessary!
Open-Loop Controlled operation for the armature circuit:
Sheet G162 and G163. With P601.05 = 401 fixed value connector K0401, its value can be set on the P401. (set P601.06 = 0). P401 = +10% for positive torque direction, M1, set as current setpoint. The polarity of its output, K0119, specifies the torque direction
(P401 = -10% for a negative torque direction, set M2).
See also above under Command stage.
P600.01 = 402, fixed value connector K0402, its content can be set via P402 and corresponds to the firing angle.
Procedure: Set P402 = -100%, the result is Alpha W, value from P151 (factory setting 150 degrees) as the control angle.
Set P082 = 0, field supply not active, motor at standstill on SIMOREG, if motor starts to rotate due to remanence, lock the rotor.
Define ON signal via terminal 37 and operating enable via terminal 38.
The drive must be in "RUN" mode.
If P151 = 150 degrees, no armature current flow will be selected.
Set delay angle P402 from -100% to larger values,
r018 shows delay angle in degrees after limitation with P150 and P151.
A current flow will build up as of 120 degrees (approx. -32%).
The device output voltage Ud at 1C1/1D1 is:
Unetwork * 1.35 * cos(firing angle in degrees) = r015 * 1.35 * cos(r018).
Open –Loop Controlled operation for the field circuit: Sheet G166.
Set P610 = 403 for K0403, the value for K0403 is set as a percentage in P403.
Set P403 = -100 % for delay angle 180 degrees
Set P082 = 3, field permanently "On", an initial ON signal at terminal 37 may be required to start the field firing pulses.
The drive must be in operating mode o7.x or a lower number.
Set higher percentage values in P403, the field delay angle is displayed in r034 (field firing angle after firing angle limitation P250, P251), check field current flow with r035 and an ammeter in the field current circuit. Motor field as load must be connected.
The output voltage Ud at 3C/3D is:
Unetwork * 0.9 * (1 + cos(firing angle in degrees)) / 2 = r016 * 0.9 * (1+ cos(r034)) / 2.

Fundamentals of line-commuted converters

Requirements of the supply system

The line voltage must be sinusoidal, supply of a line-commuted converter via a DC voltage source is not possible.

$U_{Netz} = Û * \sin(ω*t)$, Û: Peak voltage of the supply network

$ω = 2 * π * f$: Angular frequency, f: Frequency of the line voltage, $1 / f = T$: Period

At 50 Hz line, $T = 1 / 50 = 0.02 = 20$ ms

At 60 Hz line, $T = 1 / 60 = 0.0167 = 16.7$ ms

The rms value U_{RMS} of the line voltage is measured with the voltmeter.

$Û = U_{RMS} * \text{root}(2) = U_{RMS} * 1.41421$, at 400 $V_{RMS} = 400 * 1.41421 = 566$ V

Line voltage at 50 Hz and V_{RMS} = 400 V

One line period:
360 degrees electrical
= 2π

Time in [ms]
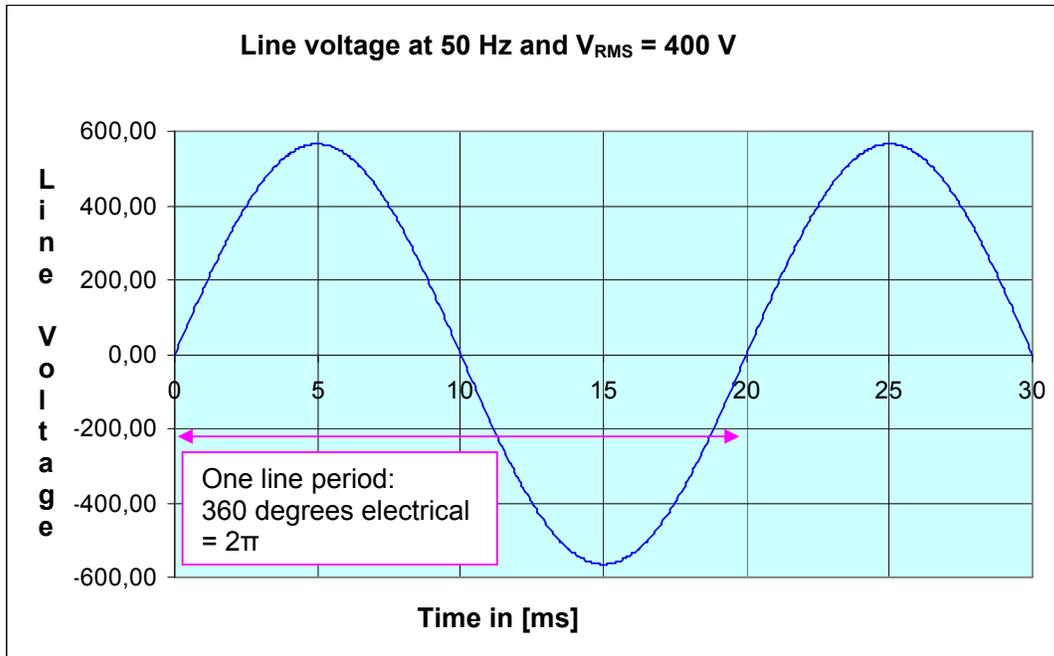
Three-phase system:
A three-phase system comprises three individual phases (U, V, W) of the same voltage and a phase shift by 120 degrees.

Phase voltage, e.g. U_U: The voltage of an individual phase is the line-to-neutral voltage, single voltage measured against the neutral point of the transformer.

Phase-to-phase voltage, e.g. U_{UV}: This is the voltage measured between two phases.

The phase-to-phase voltage is the phase voltage times the root (3).

e.g.: $U_U = 230$ V $\rightarrow$ $U_{UV} = U_U * \text{root}(3) = 230 * 1.732 = 400$ V

The phase-to-phase voltage is always specified on the technical data and on the rating plate of the SIMOREG.

U

V

W

U_{UV}

U_W

Neutral point transformer

Phases U, V, W with the line-to-neutral voltage and the line-to-line voltage

Transformer secondary winding
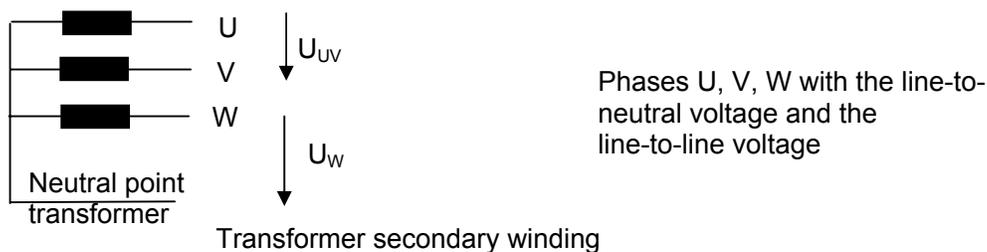
Converter for armature supply using
a fully controlled three-phase bridge connection

B6C connection (6RA70..-..S22-0): Operation in one electric current direction and two voltage directions. Fully controlled three-phase bridge connection, 1Q device acc. to catalog. As this is a fully controlled connection, the output voltage can accept negative values by operation in the inverter range (see formula for calculating the output DC voltage of the converter). This is actually a 2Q device. This 2Q device allows driving in the speed forward direction and braking in the speed reverse direction without any further measures, simply by offsetting the firing angle. With this characteristic, negative output voltage in the converter range, it is possible by switching over the motor field to implement braking operation in the forward rotation direction and driving operation in the reverse rotation direction. By reversing the polarity of the field current in the motor the induced motor voltage assumes negative values and the motor outputs a negative torque (braking torque) with constant positive current direction and negative motor voltage. So field reversal makes operation in all four quadrants possible. Please note that motor field reversal can only be performed within a few seconds, demanding a 4Q device for transition to braking operation in dynamic operations. However, field reversal can be used to permit braking of large masses in one direction of rotation or if operation in the opposite direction of rotation is required. The control progression for field reversal is described in Section 9.18 of the Operating Instructions, see also Sheet G200.
Note: For field reversal, an overvoltage protective circuit must be configured at the output of the field converter. This protective circuit must be able to absorb the energy content of the field winding $W[Ws] = L[H] * I^2[A] / 2$.
Any resulting overvoltages must not exceed the value of the blocking voltage of the valves of the field converter.
Connection (B6)A(B6)C (6RA70..-..V62-0): Circulating-current-free inverse-parallel connection of two fully controlled three-phase bridge rectifiers: 4Q device, operation in both current directions and both voltage directions possible. Circulating-current-free means that the current must be reduced to zero in the one current direction before the opposite current direction is enabled. By implementing suitable current actual value acquisition in 6RA70, fast reversal of the torque direction is possible (typically 3.3 ms at 50 Hz), allowing the retrofitting of old circulating-current-carrying converters with 6RA70 with almost no significant disadvantages. With this 4Q device, driving and braking in both motor directions of rotation is possible with high dynamic response of the control without any additional measures. Motor operation on the converter, speed n and torque M:

B6C one current
direction

(B6)A(B6)C or B6C
with field reversal
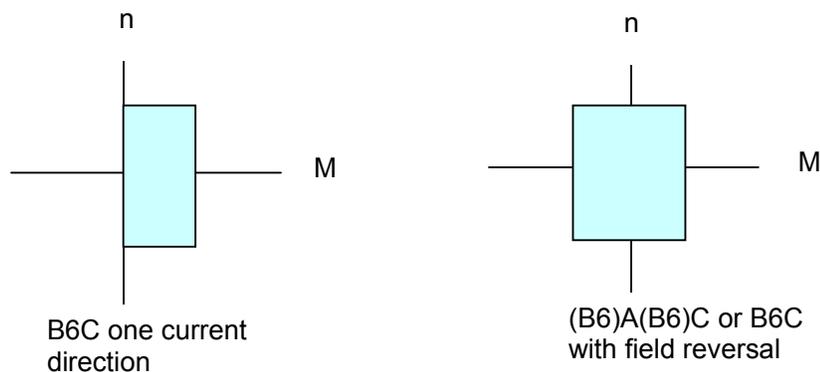
The converter generates a variable direct voltage a function of a variable firing angle by rectification of the line voltage. The firing angle determines the firing time of the thyrister and thus the magnitude of the variable output direct voltage.

The figure below shows the system line-to-neutral voltages and the magnitude of the converter output voltage Ud.

The number defines the firing sequence for the thyristors (valve), 1 - 6, if a clockwise rotating field exists for the line supply.

One valve must always be conducting in two phases for each to permit current flow in the DC circuit.

The figure shows: At the first instance, valve 5 and 6 are conducting, then valve 6 is conducting and 1 is fired; at the next firing instant, valve 1 is still conducting and valve 2 is fired etc. As is shown, each valve must remain conducting for two subsequent firing instances.

A thyristor remains conducting as long as there is a current flow, on current zero, it returns to the off state. Therefore suitable measures are needed to ensure that the valve, i.e. the first thyristor to be fired, remains conducting for continued current flow now via the next thyristor. For this, the firing pulse duration of the thyristor must be greater than 60 degrees, because when stationary, the next thyristor is fired every 60 degrees. Because the firing pulse duration on the 6RA70 is however only 0.89 ms (60 degrees correspond to 3.3 ms at 50 Hz line frequency), to keep the first valve to be fired conducting for a further 60 degrees, another firing pulse, the second pulse is triggered from it. This is above all necessary for discontinuous current.

Figure applies to the clockwise rotating field of the network
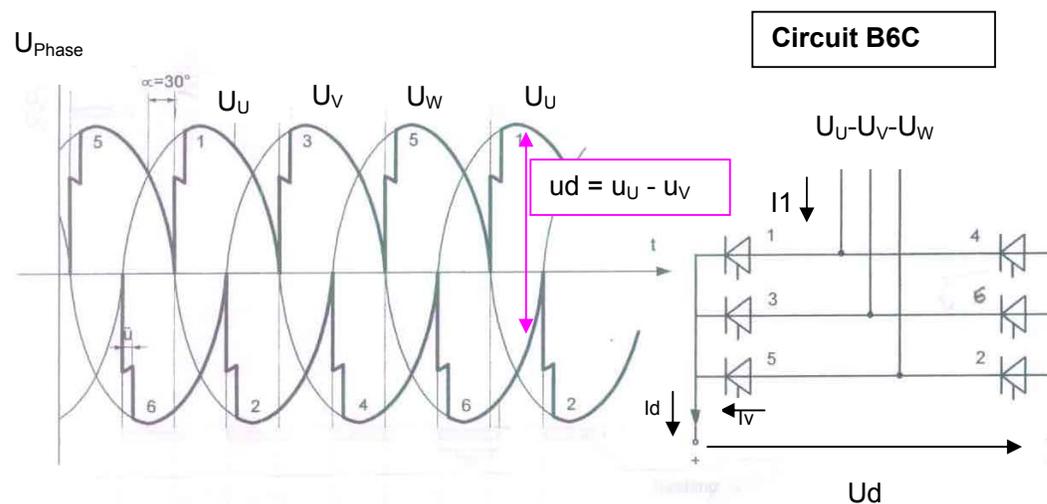
The momentary value of the output direct voltage can be read from the voltage characteristic above for the delay angle α = 30 degrees.
See example: Arrow of direct voltage magnitude Ud in pink.

An overlap o occurs during commutation, i.e. on transfer of current conducting from one valve to the next. At this point in time both thyristors involved are conducting at the same time (commutation short circuit). o lasts longer for longer commutation inductance. o results in a loss of the voltage-time area and thus a loss in the mean direct voltage.
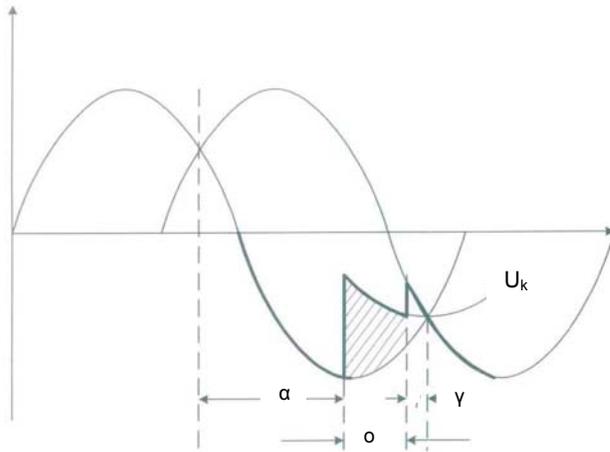
The figure shows the response during converter operation.
α is the firing angle that determines the firing instant,
o: overlap,
γ: protection angle.
U_k: voltage during commutation

In inverter operation, the firing angle must be limited by α_W so that the following valve can take over the current. Commutation is then possible if the voltage at the next valve has a more positive value than that of the valve currently conducting the current.

After overlap o, a safety angle γ must be observed, which takes account of the critical hold-off interval of the thyristors. The thyristor commutating onward must be free of current and able to take up reverse voltage and the next thyristor must have taken over the current before the voltage on the next thyristor has a more negative value then the previous one. The protection angle γ is typically 10 degrees.

On the 6RA70 α_W is set to 150 degrees in the factory setting (P151), with discontinuous current the delay angle is offset to 165 degrees as then no more current has to be commuted. Offset to 165 degrees can be suppressed with control parameter P192.

P192 = 0: When continuous current α_W = P151; when discontinous current α_W = 165 degrees.

P192 = 1: α_W always acc. to P151.

In the case of very weak power systems (large o) it may be necessary to set α_W less than 150 degrees e.g. to 145 degrees.

Maximum firing-angle setting α_G : The maximum firing-angle setting is set in P150. Factory setting 5 degrees for 1Q devices. For 4Q devices or for 1Q devices with braking by means of field reversal the firing angle must be symmetrically to α_W. That is for α_W = 150 degrees to 30 degrees (factory setting for 4Q). This is caused by the fact that α_G defines the maximum possible motor voltage during operation; if this is too high, the required back-EMF is not reached on transition to braking mode with α_W, resulting in conduction-through. This is monitored on the 6RA70 and deactivated with fault message F043 if the effect described above occurs, to prevent an overcurrent on transition into braking operation.

For remedy and alternatives to the above rule, see the description for F043 in this description. See also Operation Instructions Chapter 10, fault description for F043 and Chapter 11, description for parameter P272.

Note: When braking with field reversal on 1Q devices, a fuse must be implemented in the direct current circuit like for 4Q devices (for type see comparable 4Q device). Devices with a rated current greater than 900 A, have installed branch fuses which replace both the line fuses as well as the fuse in the DC circuit for semi-conductor protection.

 Note: Some of the following formulas are only approximations, but precise enough for practical use.

Formulas:

Ideal direct voltage Udi: This is the direct voltage that is calculated with a firing angle of zero degrees (full firing-angle setting).

Udi = Uv * 1.35,

Uv: Line-to-line input voltage at converter, at 400 V: Udi = 540 V
Variable direct voltage Ud depending on delay angle:
Ud = Udi * cos α, (in practical applications an additional voltage loss resulting from overlap o
also applies here; this is subtracted so that the resulting measured voltage is slightly lower
than that calculated)
α: Firing angle in degrees, cos(α) can be read from the graph below to calculate the output
direct voltage.

Control characteristics for B6C und (B6)A(B6)C
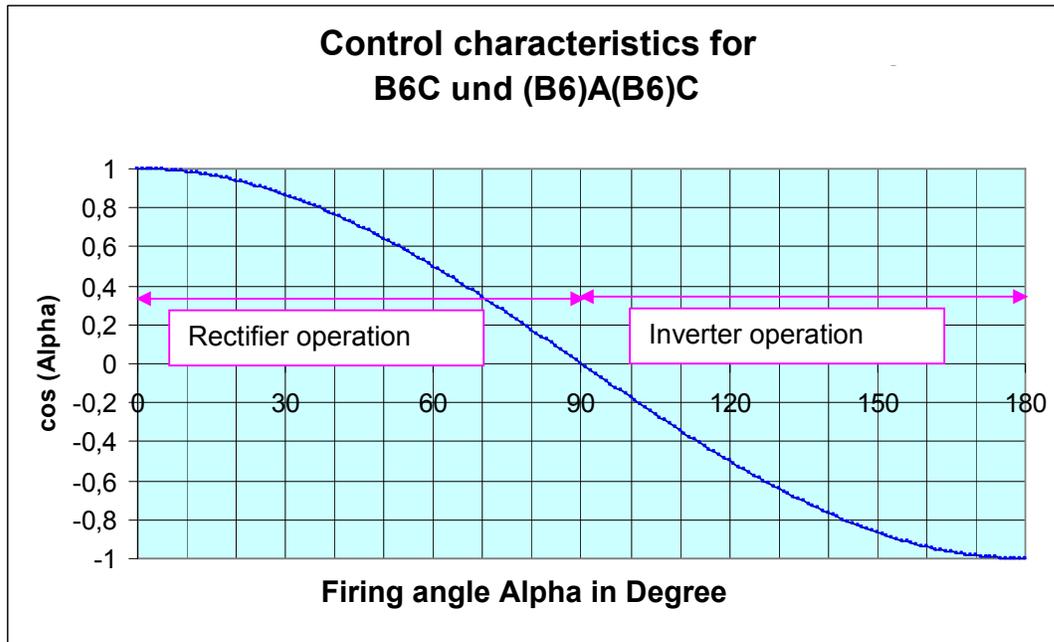
Line current I1: I1[A] = Id[A]* root (2/3) = Id * 0.817, where Id: Direct Current
Current in thyristor: Iv [A]= Id * root (1/3) = Id * 0.58
Direct current power: P[W] = Ud[V] * Id
Active power Line: P = 1.05 * Ud * Id
Ideal current power:
Pdi[W] = Udi [V] * Id, use for peak power maximum direct current
Required apparent power of the line transformer:
S_T [VA]= Udi * 1.05 * Id
Phase control reactive power:
Q[Var] = 1.05 * Udi * Id * sin α, at firing angle α
cos φ in the line infeed: cos φ = Ud / Udi
cos φ is zero on motor speed zero,
at rated motor speed and rated motor voltage adjusted to the line voltage, it has the following
values: 1Q: 0.9; 4Q: 0,75.
Maximum output voltage for SIMOREG at 5% undervoltage of the nominal line voltage:
1Q device: Ud_{max} = Uv * 1.2;   4Q device: Ud_{max} = Uv * 1.05;
Set P101 to maximum Ud_{max}
Note: The output voltage of the SIMOREG depends on the voltage of the supply system, not
on the rated line-side voltage of the SIMOREG.
The minimum permissible nominal line voltage (set P78.01 nominal voltage for line) is 85 V
up to rated device voltage. For voltage range 15 – 85 V, order device with option L04.
(option L04 available for 400 / 460 / 575 V devices). Order L04 ex works, a retrofit involves a
lot of work.

Relations between various operating points of the motor:

Example:

Line voltage: 400 V, 50 Hz;

Voltage drop commutating reactor: 4% → voltage at SIMOREG input: 384 V

Motor: 1GG6208-0NH40-1VV3; 2020 UPM; 183 kW

U_N: 420 V, I_N: 466 A, η: 91%, Ra: 43.8 mΩ, La: 0.94 mH

Calculation with motor rating data; no smoothing reactor n_N, I_N, U_N → α = 36 degrees, the resulting current ripple is 11.5 % rms
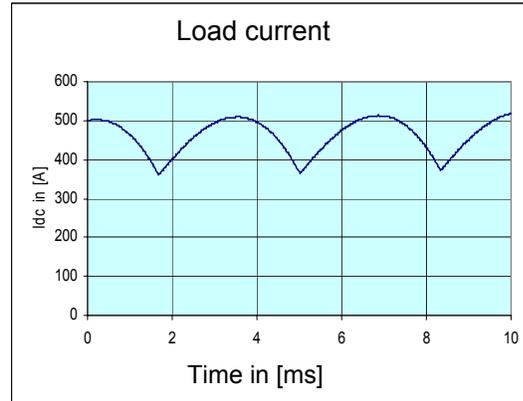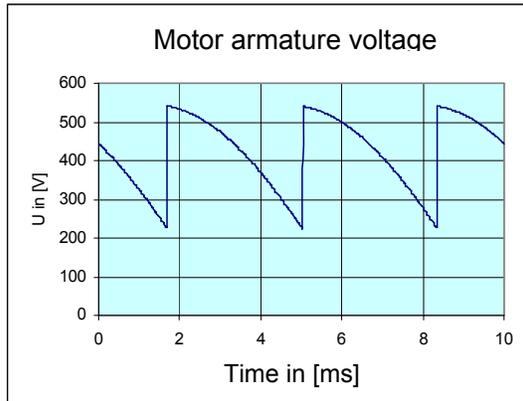
As above for smoothing reactor 1.5 mH, the resulting current ripple is 4.5 % rms
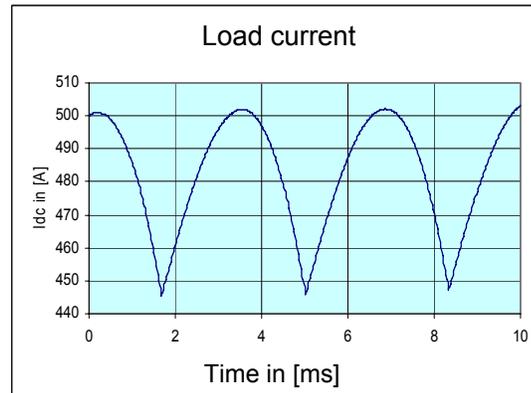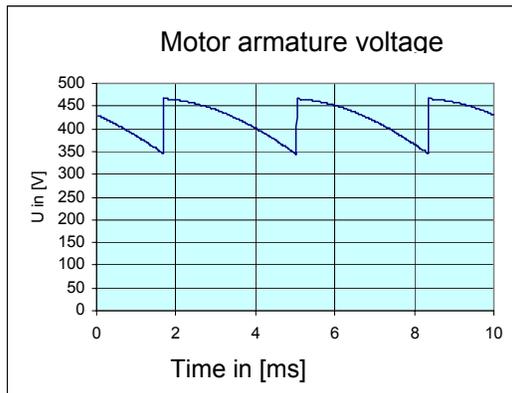
Half the rated motor speed, without smoothing reactor, I_N, → α = 65 degrees

39
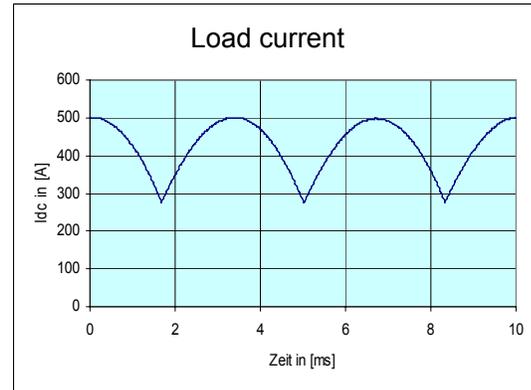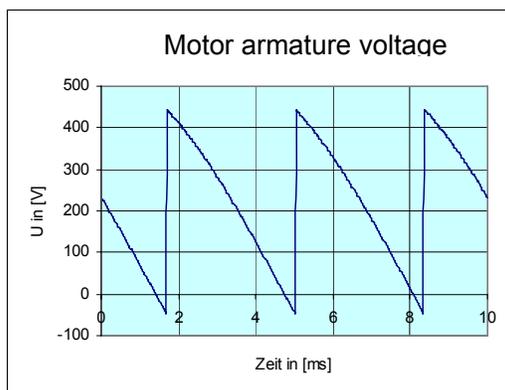
When motor speed is zero, I_N, $\rightarrow$ α = 88 degrees; the resulting current ripple is 19% rms
No smoothing reactor

Motor armature voltage

U in [V] vs Time in [ms]

Load current

Idc in [A] vs Time in [ms]
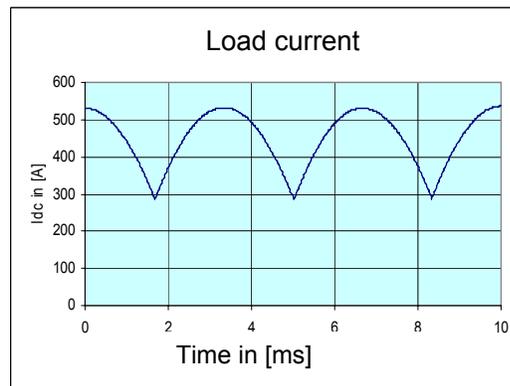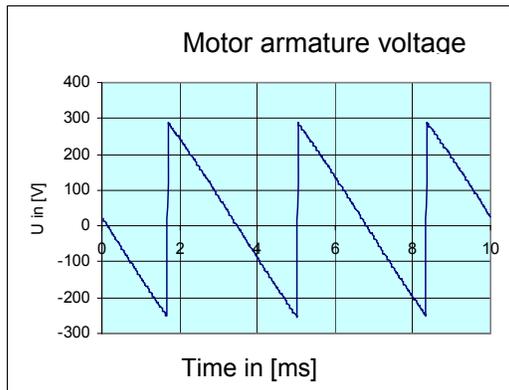
Without smoothing reactor, current at point of transition from discontinuous to continuous current, i.e. current maximum values just touch the zero line; point of transition from discontinuous to continuous current (example half motor nominal speed) is 31 % of I_N.
No figure, as above, 1.5 mH smoothing reactor, transition from discontinuous to continuous current is 12 % I_N.

Motor armature voltage

U in [V] vs Time in [ms]

Load current

Idc in [A] vs Time in [ms]
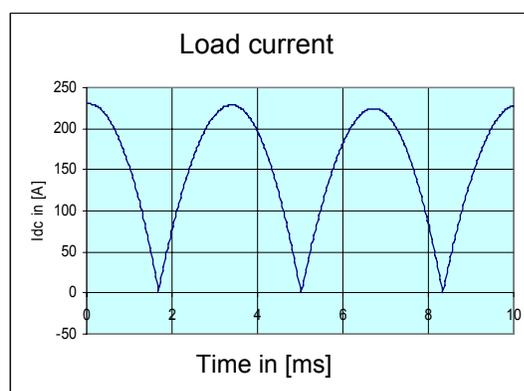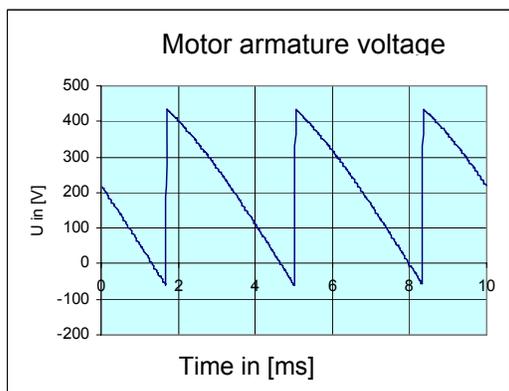
Discontinous current, half rated motor speed, without smoothing reactor

Motor armature voltage

U in [V] vs Time in [ms]

Load current

Idc in [A] vs Time in [ms]
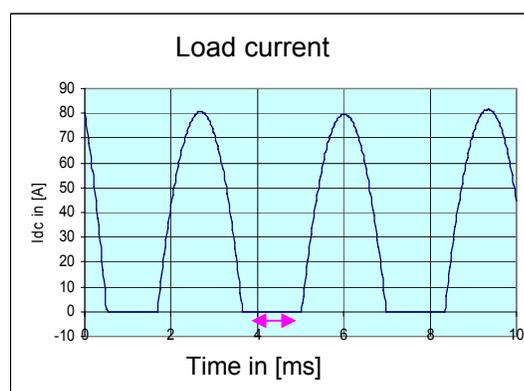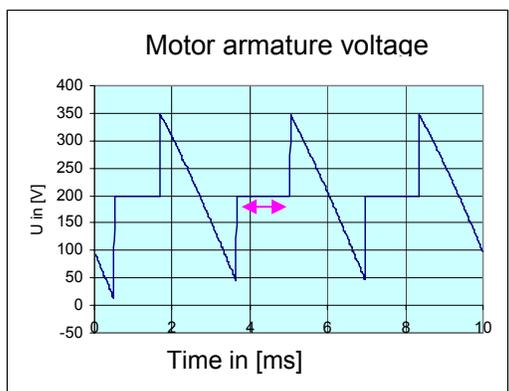
◄─►: Period of discontinuous current
the motor voltage is the motor EMF, here 200 V

40

In braking operation (voltage and current have different signs), with negative rated motor speed, positive current, discontinuous current operation, without smoothing reactor; Firing angle 143 degrees.

Motor armature voltage

Load current
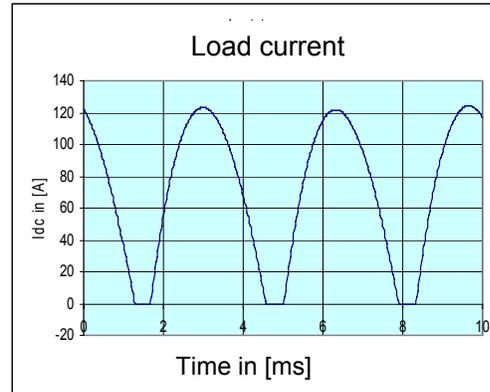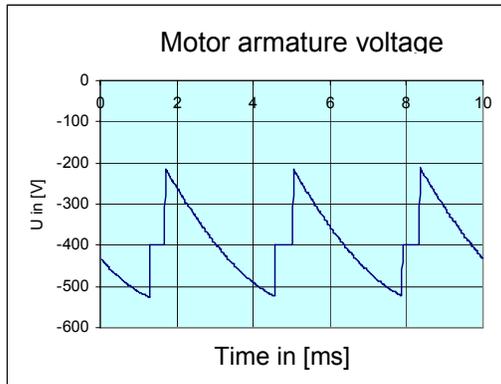
Measurement of current characteristic of line-side current: During the positive half-wave of the line-to-line line voltage, two positive current peaks occur, then a pause for the duration of the current maximum value, then two negative current maximum values during the negative half-wave of the line voltage. If the two positive or negative current maximum values are missing, the thyristor does not fire.

The advantage of current measurement on the infeed side is that an AC probe can be used for current measurement with the oscilloscope or recorder, which is more readily available than a DC probe for measurement in the DC circuit.

The measurement can also be performed on the R75 load resistors (for current converters in line phase U) and R75 (for current converters in line phase W) of the current converters on the power interface module (module C98043-A7002 or C98043-A7003) with an oscilloscope (measurement of voltage drop at the load resistor). The base point of the load resistors is then at frame potential, this can be derived by resistance measurement using an ohmmeter in order to avoid a short circuit of the load voltage when measuring with a grounded oscilloscope.

Example below: Measurement current at point of transition from discontinous to continuous current
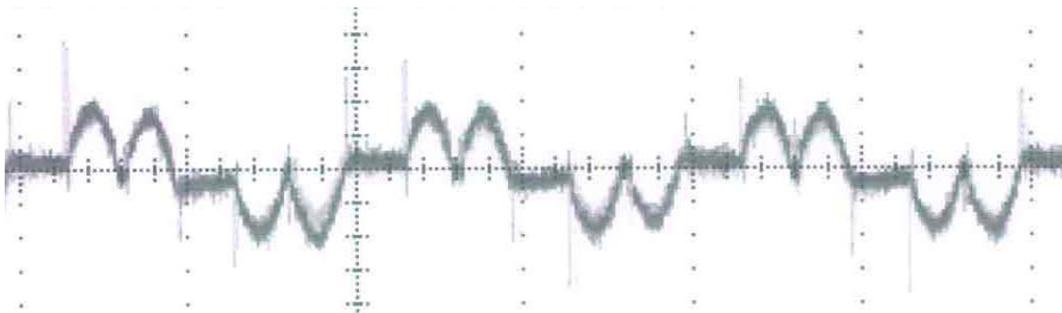
Current converter for field supply with 2-pulse half-controlled bridge circuit in a B2Hz connection

The line connection is either single-phase or two-phase: e.g. 1AC230 V, 2AC400 V.
This is an asymmetrical half-controlled bridge circuit B2Hz.
In the 6RA70, this circuit is installed for the motor field supply.
The bridge circuit comprises two controlled valves (thyristors) and two uncontrolled valves (diodes). By changing the firing angle, the firing instance of the thyristors, a positive variable direct voltage from zero up to the maximum possible value is reached at the output of the converter.
The field supply device is current controlled, i.e. the required field current is adjusted to the constant value depending on the rated value P102, irrespective of line fluctuations or changes to the resistance of the field winding , the required voltage sets itself automatically (no parameter input required for this).
In the case of nominal field voltages 3C/3D <=180 V, infeed via 3U1/3W1 with
1AC 230 V is recommended. Possible minimum value of the nominal voltage for the infeed is 85 V, see P078:02:nominal value of line voltage for the field infeed.
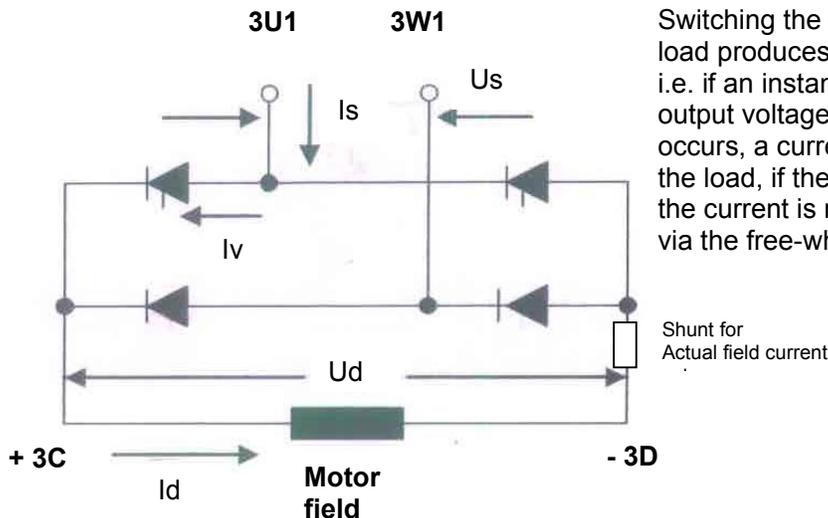
Switching the diodes parallel to the load produces a free-wheeling arm, i.e. if an instantaneous value of the output voltage greater than zero occurs, a current flow builds up via the load, if the output voltage is zero, the current is reduced toward zero via the free-wheeling arm.

Formulas:
Us: Line-to-line alternating voltage at the input
Ideal output direct voltage: Udi[V] = 0.9 Us[V]
Is[A] ~ Id[A], where Is: Input alternating current, Id: Output direct current
Valve current Iv[A] ~ 0.707 * Id;
Current load of diodes higher than thyristors because the diodes additionally carry the free-wheeling current
Output direct voltage Ud[V]:   Ud = Udi * (1 + cos α) / 2
Line power rating / nominal transformer power: P[W] = 1.11 * Udi * Id
The factor (1+ cos α) / 2 for calculating the Ud can be taken from
the control characteristic.

Control Characteristic
Two-pulse half-controlled Bridge B2Hz

[1 + cos (Alpha)] / 2 (y-axis)

Firing Angle in Degree (x-axis)
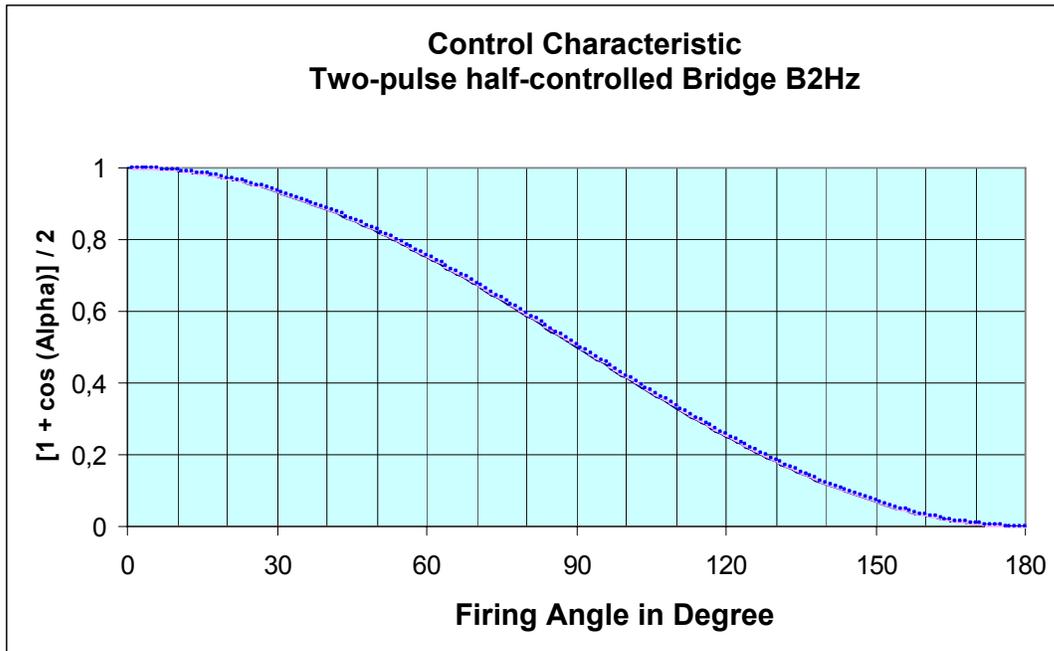
Voltage and current characteristic:

Us = 400 V, 50 Hz, Id = 0.21 A, L_F = 10 H, R_F = 1475 Ω, Udc = 310 V at α = 45 degrees

Udc-SIMOREG

Udc in [V]

Time in [ms]

Load current

Idc in [A]

Time in [ms]
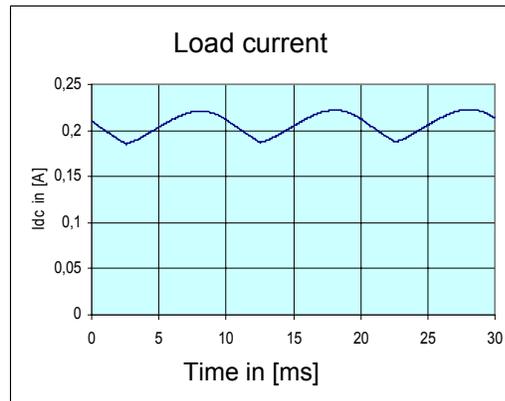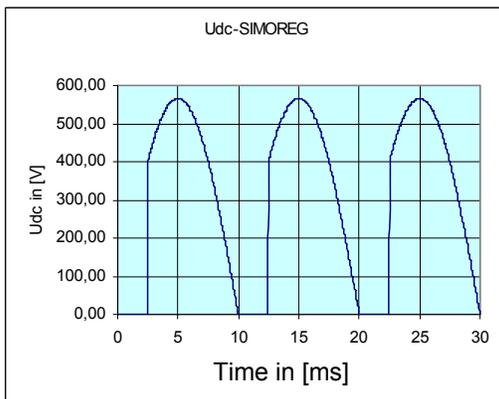
Measurement with current probe.

Output direct current

Neutral

Line current

Neutral
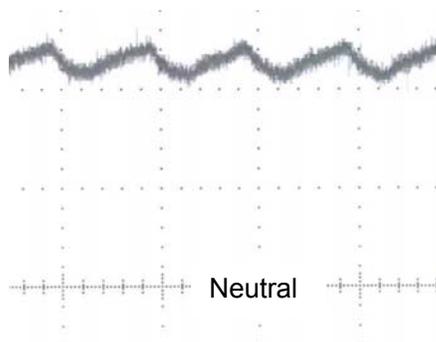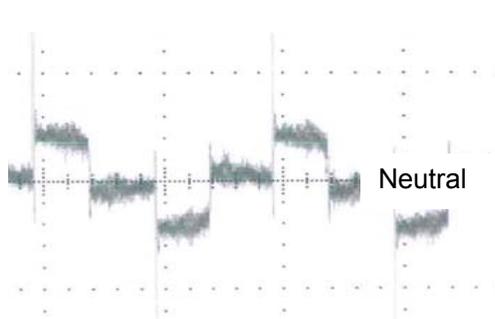
Measurements that can be performed on the 6RA70

In normal conditions a multimeter can be used as the measuring instrument, because measured value recordings can be performed with the trace function, where
Trace 2 is most advantageous, as it can be used to record the variables: line voltage supply, armature and field circuit, output direct voltage armature circuit, armature current with its curve characteristic. The trace function is part of the DriveMonitor installation and diagnostic software. See also: http://support.automation.siemens.com/WW/view/en/24171248
If an oscilloscope or recorder is also available, more in-depth measurement evaluations will not pose a problem; however, special knowledge is required to handle these devices.

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> ⚠ **WARNING**
>
> The warning notices at the beginning of this document and in the instructions of the devices used must be observed to avoid hazards to people.
>
> If the monitoring, limitation or control features implemented in the device are deactivated, for example, by operating the device in controlled operation, this can result in additional danger for the system.
>
> A source of particular danger are the dangerous voltages on the devices, the loads and their power supply cables, as well as the rotating and moving parts, such as the web.

Measurement of electrical variables
Electrical variables that can be measured with a multimeter:
Alternating and direct voltage; voltage U in volts: [V]
Alternating voltage: Preset measuring device to V-AC or V~,
Direct voltage: Preset measuring device to V-DC or V=,
Alternating or direct current; current I in amperes: [A]
Alternating current: Preset measuring device to A-AC or A~
Direct current: Preset measuring device to A-DC or A=
Resistance in ohms: [Ω], the resistance is equal to U divided by I; 1 V / 1 A = 1 Ω
Preset measuring device to Ω
Electrical variables measurable with special measuring devices:
Apparent power S in [VA], or [kVA];
Active power P in watts, [W], or [kW]; $P = S * \cos \varphi$
Reactive power Q in [Var], or [kVar]; $Q = S * \sin \varphi$
Power factor: $\cos \varphi = P / S$;
In the case of direct current cos φ is always equal to 1 (no reactive component, no effective components)
Kilo, k is a factor of 1000; 1 kW = 1000 W.
Milli, m is a thousandth, 1 mA = 0.001 A

Note: Before a measurement can be performed, the measuring device must be set to the required measuring method (voltage, current, resistance) and the measuring range expected for the measurement. Incorrect settings could damage the measuring device.

Measuring the resistance of power semi-conductors

The resistance of the power semi-conductors can be measured at the power terminals: input and output. Please refer to the circuit diagrams of the power section in the Operating Instructions; Section 6.4 for the armature circuit and Section 6.5 for the field circuit.

Note: The following precautions must be taken before measuring the resistance:
1) Clear the line-side supply voltage of the power section
2) Check safe isolation from supply on the input and output of the power section of the current converter
3) Disconnect the load at the output of the current converter

When measuring the power semi-conductor ensure that they are equipped with an RC element (snubber circuit). For this, first charge (or reverse-charge if reversing the poles of the ohmmeter) capacitor C of the circuit via the voltage source of the ohmmeter, this means that for a certain initial time, a low-resistance display will result before the display shows the actual high-resistance value. This resulting charging process is also an indication that the snubber circuit is OK, so the manifestation of this effect can also be used to check the snubber circuit.

Measurements at the power section for the armature supply:
Measure between all phases of infeed 1U1/1V1/1W1 and
between all phases of the infeed and ututs 1C1/1D1, and
between outputs 1C1/1D1 in both polarities of the ohmmeter.
Ideally, all measurements must show a high-resistance value of > 100 kΩ.

Measurements at the power section for the armature supply:
Between infeeds 3U1/3W1, measurements must be high resistance in both polarities.
Between 3U1 and 3C and subsequently 3 D; measurements must be high resistance in both polarities.
Between 3W1 and 3C and subsequently 3 D, measurement must be high polarity in one polarity of the ohmmeter and low resistance in the other.

The diode:

Anode +

Cathode -

Technical current direction
from + to -

The thyristor:

Anode +

Gate G

Cathode -

Technical current direction
from + to -
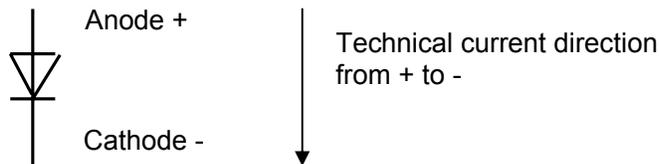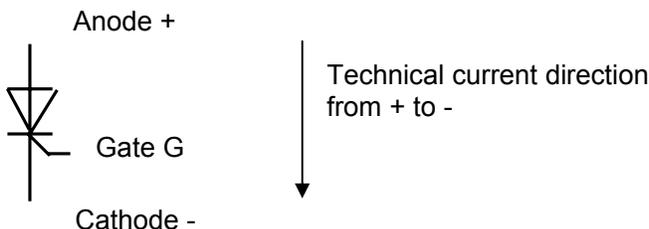
Measurement at the diode:
Perform with measuring range "Diode", approx. 0.5 V voltage drop is displayed in the
conducting direction on the diode. Anode diode connected to plus pole, cathode diode
connected minus pole of the measuring device: Diode in conducting direction means approx.
0.5 V voltage drop for 1 diode.
Measurement with polarity reversal of measurement device produces high resistance
measurement, infinite displayed.

Measurement at thyristor, between anode and cathode: for both polarities of the ohmmeter,
High-resistance measurement result: Setpoint > 100 kOhms.

Measurement at thyristor gate:
Gate G connected to plus pole of ohmmeter and cathode connected to minus pole
conducting direction and then poles reversed:
Conducting direction and non-conducting direction low resistance result approx. 15 Ohms,
with measuring range "diode" approx. 20 to 30 mV voltage drop (measured with a digital
measuring device)
The forward direction of the semi-conductor, approx 100 Ohms, clearly differs from a short
circuit that produces zero Ohms.
The non-conducting direction differs from an interruption with the value infinite. This depends
on the maximum value that can be displayed by the ohmmeter in question.

Measurement of the firing pulses
Pulse during operation:
Short pulses at P079 = 0, pulse duration 0.89 ms with pulse chopping
Long pulses at P079 = 1, pulse duration up to 0.1 ms before the next pulse with pulse
chopping
Pulse chopping: First pulse 50 μs and 55 μs pause, following pulse 35 μs and 70 μs pause
Measurement at output of pulse transformer:
No-load voltage approx. 8 V, short-circuit current approx. 1.2 A
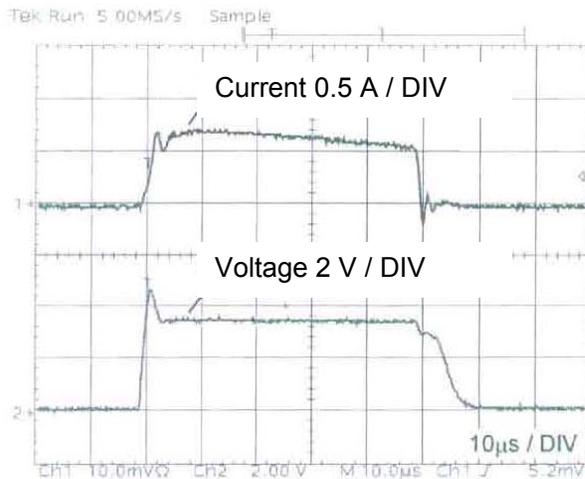
Check the firing trigger:
A dummy load of 4 diodes in series and 20
ohms parallel to it is connected at the
pulse transformer output,
Measuring result: Pulse with 3.5 V; 0.7 A
Figure left applies to the initial pulse of 50
μs.
Test with connected thyristor:
The result is a pulse current, depending on
the thyristor used in SIMOREG, of
approx. 0.3 A.

The individual trigger pulses can also be tested in simulation mode, with settings in
parameter U840.
The number of the thyristor that receives a firing pulse is set in U840. U840 = 11 firing line
X11, thyristor 1 from torque direction 1; U840 = 21, firing line X21, thyristor 1 from torque
direction 2 etc. receives firing pulses. For more detailed information see description on U840,
Chapter 11 of the Operating Instructions.
Firing lines: E.g. X25-1, to gate of thyristor 5 from torque direction 2,

See circuit diagram Section 6.4 of the Operating Instructions. The thyristor number defines the firing sequence when there is a clockwise rotating field in the infeed.

Checking the firing capability of the thyristors by means of a Trace 2 recording using the DriveMonitor:

This is done when the motor is at standstill. Switch off field via P082 = 0.
Specify current setpoint via fixed value connector.
P601.05 = 401 (connector 401 as current setpoint at current controller input)
P401 = 10% (10% for K0401) as current setpoint
Start drive via terminal 37 and terminal 38 high signal.
Start trace recording with command "Go" and when recording is complete, read out Trace 2 and store.
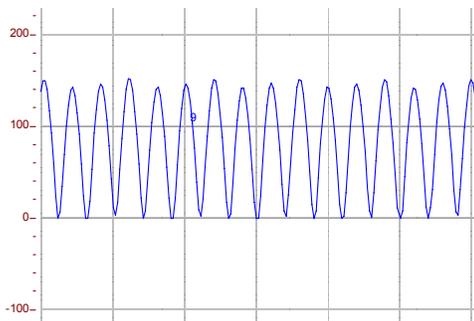
Blue: Curve of current actual value
All current maximum values exist without a gap, all thyristors are fired correctly and carry current
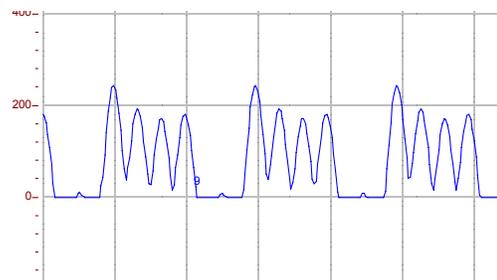
Curve of current actual value
Torque direction M1
(P401 = 10%), after 4 positive current maximum values, 2 maximum values are missing, i.e. one thyristor does not fire
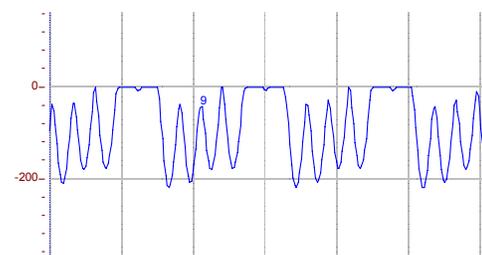
Curve of current actual value
Torque direction M2
(P401 = -10%), after 4 negative current maximum values, 2 maximum values are missing, i.e. one thyristor does not fire

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Testing the current converter without load:

The current converter can be tested without a connected motor with variable voltage. Set P083 = 3, adjust maximum output voltage via P115. However, this will not work without at least some base load. This is because no control is possible without a slight load current in the thyristors and the output voltage jumps between zero and the maximum possible value. So a current of at least the magnitude of the holding current of the thyristor, approx. 0.25 A, must be flowing. We suggest connecting a load with a current load greater than 1% of the drive nominal current (armature r072.02, field circuit r073.02), however, no less than approx. 0.3 A at the output. For devices with a higher rated current, the rated drive current should be adjusted via P076 (armature circuit P076.01, field circuit P076.02).

A suitable load at 400 V line voltage would be, for example, two 100 watt 230 V light bulbs in series. For higher device nominal currents, implement load with a lower resistance.

Testing the current converter with a short-circuited output:

Testing the current converter with a short-circuited output is not permissible and in the best case (stiff power system) leads to a blown fuse.

It is however possible to insert a smoothing reactor behind the direct voltage output of the SIMOREG with an inductance value of the magnitude of the armature inductance of a direct current motor of similar current or higher and short-circuit it to test the current yield of the SIMOREG.

Additional components on the current converter

Additional components (catalog DA21.1) are required for operation of built-in devices 6RA70. If cubicle-mounted device 6RM70 (Catalog DA22) is used, it already contains all the necessary components and can thus be connected directly to the line supply. The following section seeks to aid checking for correct rating of the additional components in case of a fault. Catalog:
http://www.automation.siemens.com/ld/dc-stromrichter/html_00/dc-master/kataloge.html

See also the description of application note: "Tips for configuration":
http://support.automation.siemens.com/WW/view/en/9466880

Protection with fuses:
Semi-conductor protective fuses are mandatory for protection semi-conductors. Types other than those specified in the catalog/Operating Instructions may only be used if the rated voltage is larger or equal and the I^2t value is less than or equal to the prescribed type. The fuse protects the semi-conductor if the current shows a particular rate of rise during a fault. The fuse may not be able to protect the semi-conductor under the following conditions:
On a bolted short-circuit at the current converter output if a very slight commutation induction is pending (current rise too steep: very high line short-circuit output and commutation reactor too small), or if the current rises too slowly (very weak network or inductance in load circuit too large). In both cases, a smaller fuse type could provide a solution, if the system allows it. In any case, protection is provided by the additional CCP (see below).
Note: Semi-conductor protective fuses of duty class "aR" cannot assume additional protection of the line; in this case, extra precautions must be taken. Semi-conductor protective fuses of duty class "gR" (e.g. 3NE1..) give additional line protection cover. The I^2t value of the 3NE1 type usually means that the prescribed fuses cannot be replaced directly by this type.

Commutation reactor, Catalog LV60:
If line-commutated current converters are used, commutation induction is always required in the supply circuit. In the simplest case, a commutation reactor is used.
To protect the current converter, a commutation inductance is required that produces a 4% voltage drop at the rated current of the converter; Vimp = 4%. A separate commutation reactor or separate transformer winding with 4 % Vimp must be used for every current converter used on one power system. The permissible Vimp of the reactor/transformer winding for the current converter is 4% to 10% (worst case 15%).
According to VDE0160, voltage dips of up to 20% are permissible during commutation.
The following applies: If the short-circuit power of the power system is higher than the connected load of the current converter by at least a factor of 100, commutation notches of maximum 20 % of the peak voltage of the network will occur if a 4% commutation reactor is used.
If several current converters are installed on the same power system, it can be assumed that these will not commutate at exactly the same time, so the reactor can be dimensioned for each current converter individually as a function of its power, as described above. Normally the commutation reactor is dimensioned as a function of the rated motor current; this saves costs as the rated current of the device is usually higher. If high acceleration currents are required on the motor, the reactor should be designed for a
peak current / 1.6 due to the saturation that occurs during high currents.
The alternating current of the reactor for the armature circuit infeed is:
direct current Id * 0.816
Help with calculation of the commutation notches:
$\Delta U[\%] = (x_N + x_T)/ (x_N + x_T + x_D) * 100\%$;
where $(x_N + x_T) = U_N^2 / S'_{k2}$; $x_D = L_D * 2 * \pi * f$; x_D: Reactor reactance, f = line frequency, L_D: Inductance of the reactor; S'_{k2}: Short-circuit power at connecting point of current converter; U_N: Line-to-line nominal line voltage at connecting point of current converter;

X_N: Line reactance; x_T :transformer reactance related to the connecting point of the current converter,

ΔU: Commutation notch power system at current converter connecting point (line side directly before the commutation reactor) as a percentage.

If only the short-circuit power S'_{k1} on the high-voltage side of the line transformer is known, S'_{k2} can be calculated as follows:

$S'_{k2} = S_T / (u_k + S_T / S'_{k1})$; S_T: Transformer apparent power, u_k: Short-circuit power transformer in p.u. e.g. 0.06 for 6% uk.

Effects of the commutation notchs on loads in the same power system:

If several 6RA70 are operated in the same network, they do not usually affect each other, so long as the voltage dip is not higher than that defined by the threshold of the phase-failure monitoring in parameter P353 (factory setting 40% means 60% dip permissible).

However, it cannot be ruled out that these steep-edged voltage dips might damage other loads. Examples of this are switched-mode power supplies for supplying power to automation units, computers and their monitors, but also loads such as fluorescent lamps with electronic starters and power-factor correction capacitors for low-voltage motors.

That is one of the reasons why higher performance current converters are usually supplied via a separate converter transformer, fed from the high-voltage side of the power system. If problems arise with consumers on the same network with line-commuted current converters, the lower-cost solution is usually to provide a separate transformer for the weak network loads rather than implement additional measures on the high-power current converter.

See Catalog LV60 under:

http://www.siemens.de/lowvoltage/kataloge

Note: Overcurrent or thyristor damage can occur if a 6RA70 is operated in a power system without sufficient commutating reactance in its infeed.

The commutating reactance is the sum of all reactances in the incoming circuit of the SIMOREG: Line reactance plus transformer reactance plus reactance of the commutating reactor.

RFI suppression filter:

RFI suppression filters reduce conducted radio frequency interference from the power system (RF interference).

The filters listed in Catalog DA21.1 / Operating Instructions are used to maintain radio interference level A1. If these requirements are specified by the plant operator, RFI suppression filters must be installed. As RF interference is lower on DC drives than on AC drives with frequency converters, filters are only implemented on the former if the customer makes a special request.

Note: The filters specified in the catalog are intended for grounded power systems. Alternative special filters for use in IT systems are available on request.

The filters must be installed on the line side in front of the commutation reactor (mandatory if using filters). If the filter and commutation reactor are installed in the wrong sequence, this will cause a fuse to blow in the current converter infeed.

Interference suppression filters do reduce RF interference but not the level of the harmonics on the line side.

Smoothing reactor in the DC circuit:

See "DC Motor" – "Old motor"

Reactive-power compensation, series-resonant circuits for harmonics:

These supplementary components with capacities parallel to the power system must be implemented with an inductor to prevent unacceptable resonance levels in the line infeed. See "Cosine Phi" for reactive power levels.

If capacitors are used at the SIMOREG input, e.g. for power factor compensation, commutation reactors of at least 2% uk must be implemented in front of the SIMOREG input to prevent overcurrents occurring in the SIMOREG.

A calculation of the line-side harmonics can be performed by Siemens advisory services on request. In complex converter installations, the harmonics must be measured on the infeed network.

Note: High line-side harmonics can cause damage to other consumers on the same network, for example, to power factor correction capacitors of low-voltage motors.

Line-side overvoltage protection 7VV3002:

If the SIMOREG is connected directly to the winding of a converter transformer without there being an open isolating point in front of the SIMOREG (e.g. open main contactor) when the transformer is disconnected in the primary circuit, an overvoltage protection module 7VV3002 must be implemented on the infeed side of the current converter. Siemens technical advisers will support you with configuration. More at:
http://support.automation.siemens.com/WW/view/en/19338566

Direct-voltage-side overvoltage protection, SIOV, E89110-... or 7VV3003...

If a direct current motor is used as the load, no overvoltage protection is required on the direct voltage output to protect the converter.

If a high load inductance occurs, for example, when feeding a motor field or a solenoid with a 6-pulse converter (output of armature voltage output terminals of 6RA70), overvoltage protection parallel to the direct voltage output is always required. This must be configured for the given current and induction of the load. See also the description of applications for field supply with 6RA70.
http://support.automation.siemens.com/WW/view/en/9472382

Converter transformer:

In the case of higher power converters, a separate converter transformer is recommended (connection on high voltage side at the medium voltage level), to prevent overloading and/or damage of weak system consumers by system perturbation from the converter(s) (commutation notches, harmonics).

The transformer apparent power is:

S_T = Unetwork* 1.35 * 1.05 * Id

S_T: Required apparent power of transformer, Uline: Line-to-line network voltage at converter input; Id: Direct Current

Converter Commutation Protector, CCP:

The additional component CCP is available from Siemens for protection against the effects of conduction-through.
http://support.automation.siemens.com/WW/view/en/21688372

This CCP can be used with 6RA70 with a nominal direct current (actual value acc. to r072.02) from 300 to 2000 A (if 6RA70 is connected in parallel, use, CCPs in parallel) and nominal line voltages from 400 to 690 V.

Siemens technical advisers will support you with configuration.

Conduction-through is a physical effect of the line-commutated converter and is an effect that can occur during braking operation (regenerative feedback, 4Q or 2Q with field reversal) with a blown fuse.

See also the detailed article in the Internet, at the following address:
http://support.automation.siemens.com/WW/view/en/24120447

High-speed DC circuit-breaker:

Besides the CCP, implementation of a high-speed DC circuit-breaker is the only way of protecting the converter against the effects of conduction-through. The CCP is the preferred solution for new systems if the given current and voltage range is adequate. Older systems being retrofitted frequently have a high-speed DC circuit-breaker. We recommend keeping this. The high-speed circuit-breaker should trigger a fault during a current rise in order to prevent a fuse blowing. An air smoothing reactor is usually required in the direct current circuit to limit the rate of rise of the current on a fault. The required induction of the reactor depends on the system size and the type of semi-conductor protective fuse used. When retrofitting the old converter with 6RA70, check the design of these reactors; Siemens advisory services will help you with this.

Main contactor in the 6RA70 infeed:

This is dimensioned for maximum current I_{AC} for AC1 operation.

I_{AC} = 0.816 * Id_{max}. Id_{max} = maximum operational direct current. See Catalog LV1.
http://www.siemens.de/lowvoltage/kataloge

Retrofitting an old current converter by implementing 6RA70:

When retrofitting an old current converter in a B6C / (B6)A(B6)C connection (for other types/circuit types please consult us) with 6RA70, the following procedure is possible: Replace the converter and insert the new semi-conductor fuses prescribed for 6RA70. Other existing components such as the converter transformer or an existing commutation reactor and overvoltage protection can be kept. Any existing smoothing reactor in the direct current circuit should also be kept.

As the old converters did not usually include a closed-loop controlled field device, which made a commutation reactor superfluous, a commutation reactor must be retrofitted for the field circuit if the field supply is used in 6RA70. Its rated alternating current should be equal to the rated current of the motor field; if this is not known, dimension it for the rated current of the field power supply unit.

New 6RA70 converters emit no higher radio interference than older products used previously, which means it is not necessary to retrofit the interference suppression filter when retroftting with 6RA70, as long as the plant operator does not make higher demands than for the old device.

See also: http://support.automation.siemens.com/WW/view/en/26117006

The separately excited direct current motor

Motor armature and motor field are supplied from separate voltage sources.

The windings in the motor:
The armature winding: The armature winding is located in the movable motor armature and armature current flows through it. The number of turns of the armature winding determines the EMF of the motor.
The commutating winding: This is used to keep the area below the carbon brushes field-free, to ensure good commutation.
The compensation winding: An anchor current causes the distortion of main flux Φ and therefore a reaction that corresponds to a field weakening. As this is dependent on the magnitude of the armature current, for higher motor powers in particular direct current motors are implemented with a compensation winding in the stator to compensate for this effect. Without a compensation winding the following formulas can only be approximations. If, for example, the motor torque is to be determined very precisely as a function of the armature current, or operation without a tachometer with speed control via the EMF is to be performed, a compensation winding is mandatory.
The compound winding: This winding is a stabilizing series winding and strengthens the motor flux proportionally with the armature current. This increases the motor torque. Stabilizing series windings are frequently to be found in old motors. See our FAQ on series motors and motors with compound windings for special features in this context in combination with the 6RA70.
http://support.automation.siemens.com/WW/view/en/22503789
Armature winding, commutating winding, and compound winding are arranged in series and then led outwards via terminals A1 and A2 for the customer connection. The effective value for resistance Ra and induction La applies to all four windings collectively.
The field winding: Motor flux Φ is applied via the current of the field winding, which produces the EMF as a function of the speed and the torque of the motor as a function of the armature current.
The commutator: The current to the rotating motor armature with its armature winding is led to a commutator via carbon brushes. The commutator supplies the armature winding in the correct polarity (electromechanical commutation) so that a torque is generated in the motor as a function of the armature current using the flux in the torque.
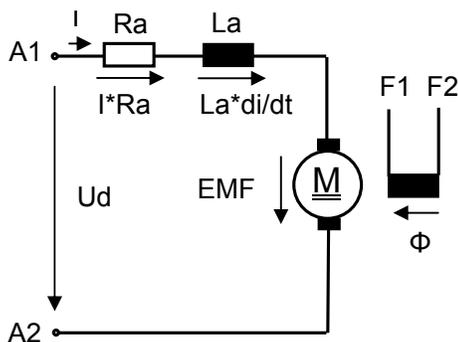
M: DC motor
A1, A2: Terminals, motor armature
F1, F2: Terminals, motor field
Φ: Motor flux
I: Armature current, motor
EMF: Voltage induced in the motor
Ra: Armature resistance, motor
La: Armature inductance, motor
Ud: Terminal voltage, motor armature

The formula for the voltage is as follows:

$$Ud = EMF + I * Ra + La * di / dt$$

I * Ra: Voltage drop at armature resistance of the motor as a function of the armature current

La * di / dt: Induced voltage in the armature induction of the motor that occurs on a current change Δi during the time Δt.

For example, Δi = 500 A during time interval Δt = 10 ms, at an La of 1 mH:

La * Δi / Δt = 0.001 * 500 / 0.01 = 50 V

For stationary state of the motor: Δi = 0,

In this case, only the voltage drop due to the resistance of the armature resistor of the motor has an effect.

EMF (electromotive force):

This is the internal motor voltage which is induced as a function of the speed n and flux Φ of the motor.

EMF = k1 * Φ * n,

The EMF is thus proportional to the flux Φ and the speed n.

Contant k1 depends on the number of pole pairs and the number of armature windings of the motor.

During nominal operation with rated motor speed and nominal flow, a nominal EMF is established, on speed zero the EMF is zero and the required motor voltage is I * Ra.

Motor flux Φ:

Flux Φ is applied to the field winding via the field current. As the result of saturation occurring in the magnetic circuit of the motor, the relationship between the field current and the flux Φ resulting from it is non-linear, i.e. as the excitation current increases the flow increases less than proportionally due to the saturation of the iron core. This relationship is determined by the field characteristic recording with P051 = 27 in the SIMOREG.

Field current:

The field supply unit in the SIMOREG regulates to a constant field current irrespectively of the temperature-dependent field resistance and the line voltage (assumed to be sufficiently high), the required direct voltage sets itself automatically.

The motor torque:

Motor flux Φ and armature current I determine the torque M of the motor,

M = k2 * Φ * I, M = motor torque in [Nm]

The motor torque is thus proportional to the product of flux Φ and armature current I.

Constant k2 is dependent on the number of armature windings and the dimensions of the machine.

Accelerating torque M_B:

M_B = J * dω / dt,

with moment of inertia J in [kgm^2], ω = 2 * π * f, f = n / 60,

n in revolutions per minute [RPM]

M_B = J * (2 * π / 60) * dn / dt.

M is constant for a constant dn/dt, so differential quantities are to be expected. For example, a speed change of 0 to 1500 RPM results in a Δn of 1500; used in the formula above, it can be used to determine the acceleration time Δt.

The motor torque M required for acceleration is the sum of the load torque M_L to be surmounted and acceleration torque M_B:

M = M_L + M_B

Relationship between torque and power:

M[Nm] = P[kW] * 9550 / n[RPM]

The rated motor power P acc. to the motor rating plate and the rated motor speed equals rated motor torque M.

The electrical/mechanical power:

P_{el} = Ud * I is the electrical power of the motor. Multiplied with efficiency η of the motor it yields mechanical motor power P_{mech}, which is stated on the rating plate of the motor.

$P_{mech} = P_{el} * η$

Relationship:

n_n: Rated speed
n_{Fmax}: Maximum field weakening speed where P_n = constant
n_{mech}: Highest permissible operating speed
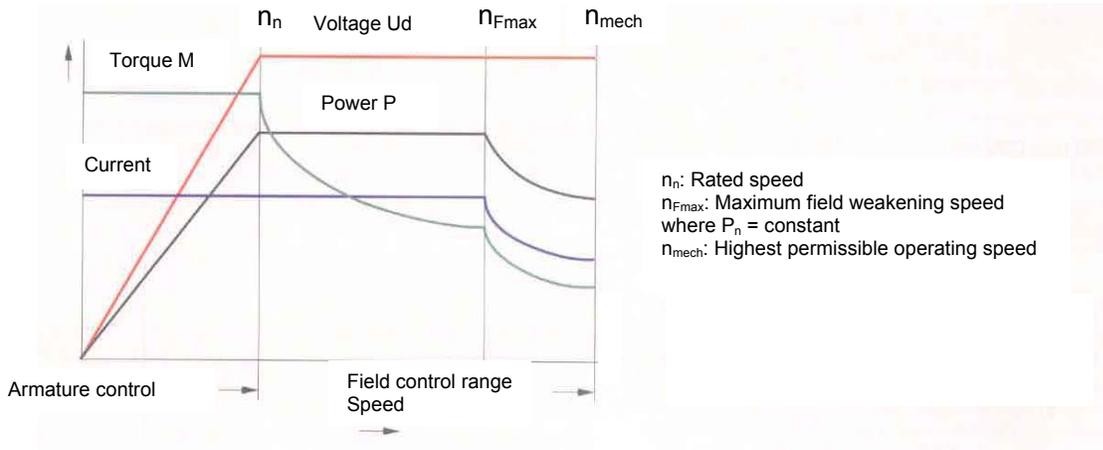
Armature control range: The armature and the power at constant current increase proportionally to the speed. The rated motor voltage is reached when the rated speed is at nominal flux.

Field control range: To increase the speed beyond the rated speed and to prevent the voltage from increasing beyond the rated value, the motor field must be weakened. A constant current and constant voltage therefore results in a constant power and a torque that is reduced inversely proportional to the speed.

Field weakening at constant power is possible up until the maximum field weakening speed n_{Fmax} is reached. At even higher speeds, the current must be reduced while taking account of the commutation (brush sparking!). This is done in the SIMOREG by setting the speed-dependent current limitation, see Section 9.16 of the SIMOREG Operating Instructions. Due to the necessary current reduction in this range, an additional power reduction and as a result an even greater torque reduction will result at constant voltage.

Protection of the motor winding from overtemperature:

A thermal motor protection can be approximated with the I^2*t monitoring implemented in SIMOREG. The resulting winding temperature is calculated with the help of a thermal model of the motor and a warning and fault message are output depending on that result. A thermal equivalent time constant is entered as the required setting value in parameter P114. The curve depicted in Section 9.14 of the Operating Instructions for P114 applies to all Siemens direct current motors of type 1G.5/6/7 1H.5/6/7. Please contact the motor manufacturer if non-Siemens motors are to be used.

It is important to remember that this I^2*t monitoring does not provide full motor protection. A temperature sensor is required for that.

The 6RA70 can evaluate the following temperature sensors: PTC thermistor Warning, or switch off, no temperature display possible. KTY84 temperature display possible, temperature threshholds for warning and switch-off can be set.

(see parameters P490 to P494 of the 6RA70).

If sensors are installed in the motor NTC thermistor - or PT100 – the motor winding temperature can be evaluated with the following external evaluation device: 3RS1041-1GW50.

The temperature thresholds for warning and switch-off (required for KTY; PT100) are motor specific, for which a request for quotation is required, please give the entire order number and factory number of the motor.

Example of a motor power plate / rating plate:

Order No.: MLFB

Serial number/
Factory serial

Armature control

Field control range

Exciter data

Construction

Power

```
            ┌──────────────────────────────────────────────────┐
            │  ○  _____  SIEMENS          C E   ○         │
            │  DC - Motor        1GG6286-0NG40-1VV1-Z           │
            │  No. N  R7  1145783 010 001 / 2004     EN 60034   │
            │  Wärmekl./Th.Cl.  H    IP23 / IC 06  IM B3  Gew./Wt. 1,56 t │
            │     V       A       1/min        kW              │
            │  20 ... 420  985   10 ... 1410  2,76 ... 390      │
            │   420       990   1410 ... 1620     390           │
            │  Fremderr./Separate excit.: 310 ... 210 V, 14,5 ... 11,5 A │
            │  Fremdkühlung/Separate cooling: 0,75 m³/s   Luftrichtung/ │
            │                                             Dir. of Ventilation │
            │                                             NDE-DE │
            │                                                  │
            │  ○  ⊳⊢ B6C, 400 V, 50 Hz                    ○    │
            │         MADE IN GERMANY                          │
            └──────────────────────────────────────────────────┘
```

Rated motor voltage: 420 V, rated motor current 985 A
Rated motor speed: 1410 RPM, maximum field weakening speed: 1620 RPM
Field data: 310 V / 14.5 A at speed zero to rated speed 1410 RPM,
at a maximum field weakening speed of 1620 RPM: 210 V / 11.5 A
Field resistance when winding is warm: 310 V / 14.5 A = 21.4 Ω
And 210 V / 11.5 A = 18.3 Ω

Note: The field resistance for a warm winding is approx. 25% higher than in the cold state, the controlled field device in the SIMOREG compensates for this effect with constant current regulation. The lower resistance at 11.5 A results because the field winding does not heat up so much with a low field current.

The gearing
Gears are used to adapt the speed of the motor to a particular system speed.
Relationships:
Motor speed / load speed = gear ratio i
Convert load variables to the motor side:
$M_L / i = M_{LM}$,
M_L: Torque on the load side, M_{LM}: Load-side torque converted to the motor side.
$J_L / i^2 = J_{LM}$
J_L: Moment of inertia on the load side, J_{LM}: Load-side inertia converted to motor side.
$P_L = P_M$, the power on the load side corresponds to the power on the motor side.

Operation

SIMOREG:

The SIMOREG must be operated within the specification according to the technical data in the Operating Instructions (line voltage, current, ambient conditions).

The maximum ambient temperature is the temperature directly at the air inlet of the heatsink on the SIMOREG and not the room temperature outside the control cabinet.

The rated current printed on the rating plate is the permissible continuous current of the device. If the current is lower than the rated current, the device can be loaded with a higher current for a particular cycle duration but no more than 1.8 x the value of rated current r072.01. The possible overload duration is calculated with a thermal model and monitored. See also the overload curves in Chapter 9 of the Operating Instructions. The response of the device after consumption of the thermal reserves in the devices can be set in parameter P075.

DC motor:

The current specified on the rating plate is the continuous current (S1 operation), in intermittent operation a higher current is possible.

Operation at partial load (< 50% I) over a longer period results in heavy brush wear and commutation problems and must be avoided.

(Consultation necessary).

Stationary DC motors may be loaded with armature current only for short periods to prevent thermal overload of individual commutator segments. Please ask about permissible values. Low speeds (>0) are permissible.

When the motor is operated with its nominal field current the motor fan must be in operation to avoid overheating of the field winding.

According to the rating plate, the maximum field weakening speed n_{Fmax} or n_2 (when motor is operated in the speed-dependent current limit range) should not be exceeded, as the motor can only be tested for balance and commutation response up to this speed.

Maintenance

The maintenance instructions given in the operating instructions of the components used must be observed.

SIMOREG:

Dirt and contamination: Depending on the degree of contamination, the device must be cleaned at regular intervals, but at least every 12 months, with compressed air at maximum 1 bar or with a vacuum cleaner.

The ribs of the heatsink must be free of dirt to ensure that they can dissipate heat without obstruction.

Dirt on modules reduces the air and creepage distances, this can cause arcing and damage. The modules must always be free of conductive dust.

Depending on their contamination with dirt from the environment, filters in the control cabinet must be replaced at certain time intervals.

Condensation: Condensation on the modules is not permissible. If condensation occurs, the device may not be reconnected to the line voltage until the modules are completely dry.

Where equipment is used in tropical countries, we recommend equipping the control cabinet with cabinet heating to prevent condensation.

If the device is in operation, condensation is prevented by its own heat dissipation. The cabinet heating should therefore be activated when the device is not in operation.

Environmental requirements, see:

http://support.automation.siemens.com/WW/view/en/23585684

Fan: Devices with a current of 210 A or more are equipped with a fan. These fans should be replaced every 30,000 operating hours to ensure the availability of the SIMOREG.

DC motor:
Maintenance intervals: The direct current motor must be maintained at regular intervals. The maintenance intervals and extent are stated in the operating instructions of the motor.
Dirt and contamination: The cooling-air passages to the motor ventilation must be cleaned regularly depending on the extent of contamination. When replacing the brushes, free the inside of the motor from abraded brush material (brush dust), the brush equipment and insulating parts of the commutator must be cleaned. After a protracted operating time, the motor must be dismantled and the winding also freed from brush dust.
Condensation: Condensation inside the motor is not permissible. Possible remedial measures: Use an air-condensation heater, or as an alternative, supply the motor field with approx. 30% of the nominal exciter current without operating motor fan in order to heat up and dry the inside of the motor.
Brushes: The current is fed to the commutator of the motor via carbon brushes. The brush life depends on such plant conditions as diameter of the commutator, motor speed, current level, and environmental conditions. The continuous current of the motor should be greater than 50% of the rated current of the motor, a lower armature current, so-called operation at partial load, results in higher brush wear, which can be partially compensated for with special brush materials. Control of minimum armature current see under:
http://support.automation.siemens.com/WW/view/en/32006599
The carbon brushes must rest well on the commutator and the brushes must be able to move freely in the brush-holder. Brushes must not be worn down below the permissible residual brush height (see marking on brushes). When replacing carbon brushes ensure that the original type is inserted according to the printing on the brush.
Brush rocker: The brush rocker must be set to the line mark on the end shield and brush rocker, if positioned incorrectly, brush sparking will result and could damage the brush and the commutator.
Commutator: Keep the slots between the commutator segment clean by cleaning them. Contaminated slots could cause flashovers and arcing on the commutator. Ribbing and burn marks on the commutator must be removed by grinding.
If necessary, remove the rotor and skim the commutator on the lathe, then the slots, for example, must be reworked with a special saw. The minimum permissible commutator diameter is stated in the operating instructions.
Insulation test: Before being installed or after long storage or shutdown periods, the insulation resistance of the windings must be measured to ground with direct voltage. Measurement should be performed when the winding is cooled (20 – 30 degrees room temperature). Please observe the operating instructions of the insulation resistance meter, if the converter is connected, first check that its input is safely isolated from the supply. 500 V is the maximum permissible measuring voltage. When making the measurement, you must wait approx. one minute until the final resistance value is reached.
Measuring circuit voltage: 100 V to 500 V direct voltage, minimum insulation resistance of new or repaired windings: 10 MΩ. Critical insulation resistance: 0.5 MΩ / kV rated voltage of the motor.
Example of 500 V rated voltage: 0.5 kV * 0.5 MΩ / kV = 0.25 MΩ = 250 kΩ
Remedy if insulation resistance of winding is too low: Clean and dry winding.
Note: If the SIMOREG is connected during measurement, its leakage resistance of approx. 1 MΩ against ground as a result of voltage measurement with high-resistance difference amplifiers must be observed. This means that this leakage resistance is connected in parallel to the insulation resistance of the winding. The formula for the parallel connection of resistances is: 1/ Rges = 1 / R1 + 1 / R2.
In the above example, the resulting measured insulation resistance Rges must be at least 1 / Rges = 1 / 1 MΩ + 1 / 0.25 MΩ = 5, therefore 1/5 = 0.2 MΩ. Disconnect the cable between the SIMOREG and the motor to precisely determine the insulation resistance. --
Motor bearing: The motor bearing is subject to wear, which is dependent on system conditions such as the motor speed and the magnitude of the resulting lateral forces on the bearing. The bearing life is typically between 30,000 to 40,000 operating hours.

Smaller motors are equipped with bearings with permanent lubrication, bearings must be replaced as soon as their useful life has elapsed. Larger motors are equipped with a relubricating device. A lubrication instruction plate is located next to the rating plate of the motor. It provides details of lubrication type, lubrication quantity and relubrication intervals. It also gives details of the bearing type installed in the motor. After the bearing useful life has elapsed, these bearings, too, must be replaced. The bearing cover contains a used lubrication compartment, which must be freed from lubricant after relubrication has been performed several times. Remember that the fan motor is also equipped with bearings to which the above instructions apply.

Measurements on the motor

Measurement of field current, field voltage, field current with display parameters in the SIMOREG: r035
Field voltage by means of an external voltmeter and comparison with the calculated voltage, see above.
Measurement of the armature voltage, armature current through display parameters in the SIMOREG:
Current: r019, voltage: r038
It may be necessary to check by measurement with an additional measuring instrument.
Field resistance: with ohmmeter, desired result: rated field voltage / rated field current according to the motor rating plate, measured value is approx. 25% lower than calculated for a cold winding.
Armature resistance, several milliohms to ohms depending on motor size, milliohmmeter required.

Precautions when operating the 6RA70 on an old motor

By old motor, we mean a motor that is at least 20 years old that was not originally designed for operation on the converter, e.g. retrofit replacement of motor power supply through a Ward-Leonard generator set by a converter.
Because the old motor was usually designed to have a power margin, no special precautions are usually required with regard to additional losses due to converter operation. However, the current commutation with greater current ripple due to converter operation must be taken into account. The current ripple of the direct current (rms value of the current ripple) is calculated. This should not be greater than 10 % of the rated current of the motor in the worst case.
Siemens technical advisers will support you in calculating the smoothing reactor required in the DC circuit to comply with the above current ripple data. Please state the nominal line voltage and the rating plate data of the motor.
It is helpful to specify the armature resistance and the armature inductance of the motor. If this data is no longer available, we will estimate it and allow a margin in the reactor rating.
If the motor was already being operated with a converter and a smoothing reactor is in use, this must be retained when the 6RA70 is retrofitted.
Lower rates of current change are permissible on old motors than on modern DC motors. High rates of current change on the old motor can result in the occurrence of overcurrent peaks in the armature current (due to communication problems). Therefore activate the current setpoint integrator in the SIMOREG: Set P157 = 1, P158 = approx. 0.04 s.
If an iron-cored smoothing reactor is used, set P153 = 2.

Special applications of the 6RA70

The normal application is operation of a separately excited DC motor on the 6RA70. However, the 6RA70 can be used for many special applications in addition to this.

Operation of a permanent-magnet DC motor, e.g. 1HU3... on the 6RA70 :
A permanent-magnet DC motor has permanent magnets for the motor excitation field. These types of motor can also be used on the 6RA70. The 1HU3 motor has a rated voltage of 160 V. If a 6RA70 is operated in a 400 V 3AC power system, a peak voltage of 560 V occurs at the output. The commutator of the motor is not rated for such a high peak voltage and may be damaged. For that reason, a 150 V 3AC to 230 V 3AC matching transformer is required at the input of the 6RA70 1U1/1V1/1W1. The nominal line voltage is set in parameter P078.01.
To perform current controller optimization, the motor shaft must be blocked. (The motor must remain stopped during current controller optimization.)

Operation of a series-wound motor or a motor with a stabilizing series winding (compound winding) on the 6RA70:
See under: http://support.automation.siemens.com/WW/view/en/22503789

Input of a high inductance via 6RA70:
For operation of a high inductance (field power supply of a DC motor, field power supply of a synchronous generator, solenoid application, eddy-current brake) on the 6RA70, fault-free operation on the standard 6RA70 is possible of the following documents are complied with. More at:
http://support.automation.siemens.com/WW/view/en/9472382
http://support.automation.siemens.com/WW/view/en/23480619
Note: An overvoltage protection must be always configured at the direct voltage output of the 6RA70 to protect the thyristors in the 6RA70. This must be suitable for reducing the energy content of the inductive load: $W[Ws] = L[H] * I[A]^2 / 2$ in case of a fault.

Closed-loop control of a generator set using 6RA70:
More at: http://support.automation.siemens.com/WW/view/en/21401620

12-pulse parallel connection with 6RA70:
More at:
http://support.automation.siemens.com/WW/view/en/9448785
http://support.automation.siemens.com/WW/view/en/25495243
http://support.automation.siemens.com/WW/view/en/26041969

6-pulse or 12-pulse series connection of 6RA70:
You can obtain extensive documentation on this from your local Siemens office.

Parallel connection or series connection of motors on a shared 6RA70:
http://support.automation.siemens.com/WW/view/en/23516054

DC link infeed from pulse-controlled converters through 6RA70:
Possible, if required: A DC smoothing reactor is recommended for this application. Siemens technical advisers will support you with configuration.
1Q: For DC link voltage up to approx. line voltage * 1.2
4Q: Maximum controlled DC link voltage up to line voltage * 1.05 possible.
Set P153 = 2.

Charging batteries with 6RA70:
Siemens technical advisers will support you with configuration of this application.

Electrolytic applications with 6RA70:
Siemens technical advisers will support you with configuration of these applications.

Retrofit replacement of the control of old power sections with
6RA70 control via SIMOREG CM:
More at: http://support.automation.siemens.com/WW/view/en/10804968/133300

A little control engineering (for those who are interested)

This summary is no substitute for study the theory of closed-loop control but is intended to provide information on some relationships and help with practical application.

Time equation and frequency response

Every linear system can be described by one or more coupled linear differential equations. The solution to a non-homogeneous linear differential equation is composed of a homogeneous and a non-homogeneous partial solution.

If the input variable of a linear system is a harmonic oscillation in a particular case, the non-homogeneous partial solution that characterizes the steady state is also a harmonic oscillation.

Time equation:

Input variable: $x_e = \hat{x}_e * \sin(\omega t)$ $\hat{x}$ = peak value of x

Solution method for the output variable: $x_a = \hat{x}_a * \sin(\omega t + \varphi)$

Or, in complex notation: $x_e = \hat{x}_e * e^{j\omega t}$; $x_a = \hat{x}_a * e^{j(\omega t + \varphi)}$

For an nth-order linear differential equation, the following applies:

$x_a + a_1 * dx_a / dt + a_2 * d^2 x_a / dt^2 + ... + a_n * d^n x_a / dt^n = k * x_e$

Where $d / dt \rightarrow j\omega = p$, $d^2 / dt^2 \rightarrow (j\omega)^2 = p^2$ etc applies:

$x_a * e^{j(\omega t + \varphi)} * (1 + pa_1 + p^2 a_2 + ... + p^n a_n) = k\hat{x}_e e^{j\omega t}$

Further substitution and transformation then yields the following:

$G(p) = x_a / x_e = k / (1 + pa_1 + p^2 a_2 + ... + p^n a_n)$

G(p) is termed the frequency response.

The frequency response of a linear system is the relation between the non-homogeneous partial solution of the output variable to that of the input variable, where the input variable is a harmonic oscillation.

As can be seen above, the frequency response is obtained from the differential equation by substituting p.

The advantage of the frequency response is that only the fundamental operation of arithmetic: addition, subtraction, multiplication and division have to be applied, unlike solving differential equations.

Frequency response and transfer function

The frequency response equation describes the response of a system for a harmonic oscillation. It is therefore a special case of an equation, similar to the differential equation, that describes the response of a system for any input variables. Such an equation can be obtained by applying the Lapace transform to the system equations.

By means of the integral F(s):

$$F(s) = \int_0^\infty f(t) * e^{-st} * dt$$

a time-dependent function f(t) is tranformed into a function F(s) depending on the complex variable

$s = \delta + j\omega$.

In this case, f(t) is the original function and F(s) is the Laplace transform. Applying the Laplace function to an original function in the form of a linear differential equation results in a Laplace transform in the form of a linear algebraic equation. By solving this algebraic

equation and re-transformation to the original, this solution can be calculated as a differential equation. Please refer to the extensive literature on this topic.

Using an example of a second-order linear differential equation:

$$x_a + a_1 * d/dt * x_a + a_2 * d^2/dt^{2} * x_a = k * x_e$$

and the addition rule:

$$a_1 f_1(t) + \ldots + a_n f_n(t) \rightarrow a_1 f_1(s) + \ldots + a_n f_n(s)$$

and the differential rule:

$$d_n/dt^n * f(t) \rightarrow s^n * f(s) + s^{n-1} * f(0) + s^{n-2} * f'(0) + \ldots + f^{(n-1)}(0)$$

f'(0): Value of the first derivation of f(t) at time t = 0

f''(0): Value of the second derivation of f(t) at time t = 0

With the initial values at t = 0, this results the following Laplace transform:

$$x_a + a_1 s x_a + a_2 s^2 x_a = k * x_e$$

This yields the transfer function: $G(s) = x_a / x_e = k / (1 + a_1 s + a_2 s^2)$.

So, instead of solving closed-loop control problems with differential equations, the Laplace transform is used to calculate the transfer function. With this transfer function it is possible to obtain information about the stability of the system using suitable methods, for example, the root locus method (see the relevant literature).

In drive control loops, frequency response analyses are often the route to success that requires the least effort. The transfer function can be obtained at any time by substituting p = jω by the complex expression s.

Proportional transfer element

There is no time delay between input and output, only the amplitude of the output is less than or greater than the input.

Kp is the gain of the P element.
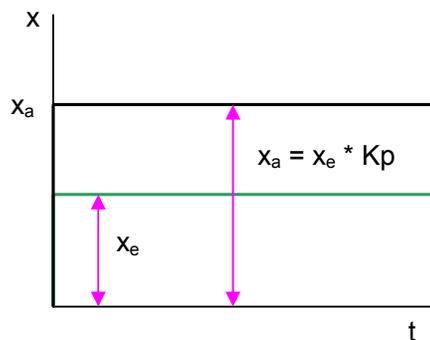
Transfer function,
Time equation:
$F(t) = x_a(t) / x_e(t) = Kp$
Frequency response:
$F(p) = x_a(p) / x_e(p) = Kp$

First-order lag element

Example: Series connection of the resistance and inductance, e.g. in the armature circuit of the motor

This element results in a sluggish time response of the control loop, large time constants having a greater effect. The aim is therefore to compensate for this response with a suitable controller.
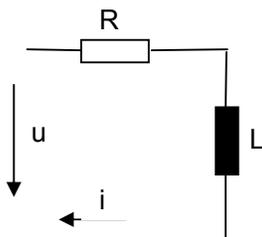
u: voltage, i: current, R: resistance, L: inductance
$u(t) = R * i(t) + L * di(t) / dt$; time constant $T = L / R$
$R * i(t) = U * (1 - e^{-t/T})$; $V_P = U / R$
Time equation: $f(t) = x_a(t) / X_e = V_P * (1 - e^{-t/T})$
Frequency response: $F(p) = V_P / (1 + pT)$
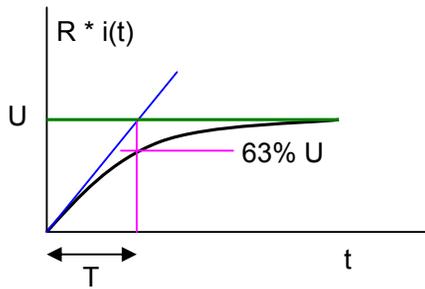
U: step change in voltage at the input

Step response: R * i(t)

Transfer element with dead time
If the output variable follows the input variable, resulting in a time offset, this is termed a dead time response.
The time constant T_t is the dead time.
You can image the dead-time element as composed of an infinite number of 1st-order lags.
If the dead time is sufficiently small, it can be treated like a first-order lag element for calculation purposes.
Let us take the current converter as an example because the output for a control voltage U_{st} on the trigger set can only have a delaying effect depending on the trigger delay angle on the output depending on the instantaneous phase angle of the line voltage. The signal for a phase angle change is only acted upon after a dead time of the output voltage U_a.
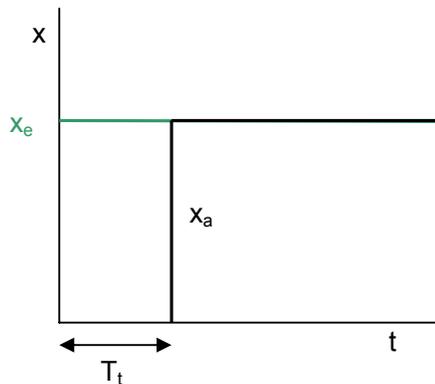
Dynamic response:
$x_a(t) = x_e(t - T_t)$
Frequency response:
$F(p) = e^{-pT_t}$

Integral-action transfer element
Example: Speed ramp-up of a motor with a constant motor and load torque in the armature setting range.
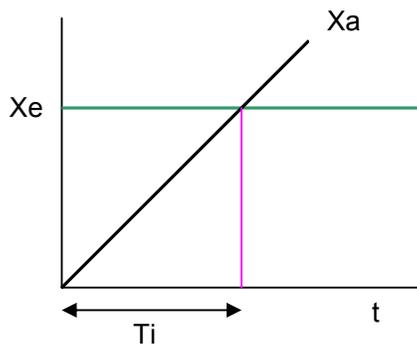
Xe: input variable; Xa: output variable
Transfer function: $f(t) = Xa(t) / Xe = t / Ti$
Frequency response: $F(p) = 1 / (p * Ti)$
In the case of a step change in the input variable, the output variable increases

Proportional-plus-integral controller; PI controller

Frequency response: $G_R = Kp * (1 + p * Tn) / (p * Tn)$

With the factor $(1 + p * Tn)$ it is possible to compensate for a time constant of the control loop here. This always compensates for the greatest time constant.

Kp: gain; Tn: reset time; Xe: input variable; Xa: output variable

The output initially responds with a step change in voltage corresponding the the factor Kp and then with integration of the input voltage over time.

Tn: Time required to reach a magnitude of change corresponding to the Xe *Kp.

Ti: Integral-action time to reach a change in magnitude of the value of Xe.

Transfer function:
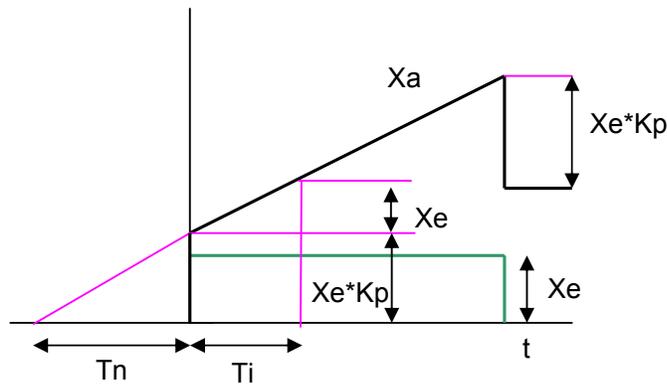
Proportional-plus-integral-plus-derivative controller, PID-controller

Frequency response:

$G_R = Kp * (1+ p*Tn) * (1+ p*Tv) / (p*Tn)$

If there are two larger time constant in the control loop, the greater of the two is compensated by $(1 + p*Tn)$ and the smaller, by $(1 + p*Tv)$.

Kp: P gain, Tn: reset time, Tv: rate time

Transfer function:

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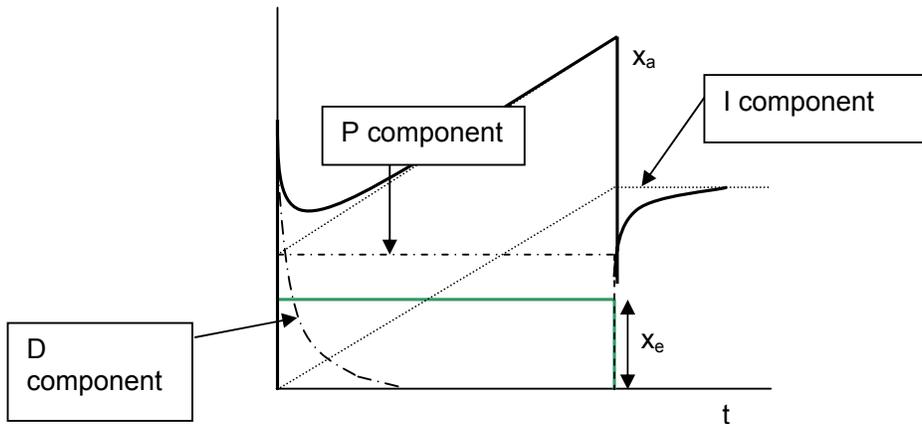
Controller optimization
The control equipment must be adjusted to output a manipulated variable y that has the controlled variable x follow a reference variable w or to compensate for a change in disturbance variable z as precisely as possible and with as little oscillation as possible. An ideal controller therefore as the relation x(t) / w(t) = 1 or x(t) / z(t) = 0, which would mean that you do not notice any change in the disturbance variable.
However, the lag effect of the controlled system through all its transfer elements is an obstacle to this ideal response of a control loop.

Settling of a control loop on a step change in input:
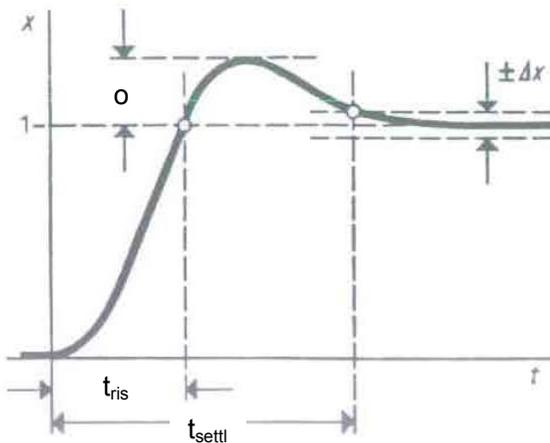
t_{rise}: The rise time characterized by the first moment the reference input reaches the set value.
t_{settle}: Settling time, time that elapses before the new settled final state is reached. This is deem reached when the controlled variable disappears within the tolerance band Δx.
Δx: e.g. 2% of the step change in the reference variable.
The overshoot o is stated as a percentage of the total step change in the reference variable.

Optimization of the PI controller according to the absolute value optimum
The absolute value optimum is used if there is no integral-action element in the controlled system. Approximation of the absolute value of the frequency response to the optimum value 1 is performed for the largest possible frequency range.
If, among multiple small lag elements in the controlled system, there is one that has a greater time constant (e.g. the armature time constant of the motor in relation to the current controller) than the sum of all the other lag elements, this time large time constant must be compensated for to speed up the control process. To avoid a static control error, the controller must have an integral character. To achieve compensation of the large lag using the integral-action controller, a proportional action is required in addition.
To compensate for the large time constant T1 it is necessary for the reset time Tn of the controller to correspond to this T1. Reset time Tn = T1
The Kp of the control is calculated from Kp = T1 / (2 * Vs * σ).
Vs is the controlled-system gain and σ is the sum of the small time constants of the lag elements.
The rise time is t_{rise} = 4.7 * σ; the settling time is t_{settle} = 8.4 * σ for a Δx of 2%.
The overshoot is 4.3%.
If, not one but two especially large lag elements are in a series of the first-order lag, a proportional-plus-integral-plus-derivative-action controller, i.e. a PID controller, is more

suitable. The reset time Tn must always be set to the the larger time T1 of the two; Tv, to the smaller time constant T2 in the control loop.

Tn = T1, Tv = T2, Kp = T1 / (2 * Vs * σ).

The frequency response of the PID controller is: F(p) = Kp * (1+p*Tn) * (1+p*Tv) / (p*Tn)

Because 2 larger time constants are compensated for, the remaining σ is smaller, meaning that faster rise times can be achieved.

Optimization of the PI controller according to the symmetrical optimum

If a controlled system contains not only 1st-order lags, proportional-action elements and dead-time elements, but also elements with an integral character, optimization must be performed by a method other than the absolute value optimum to avoid controller oscillation due to series connection of the integral controller and the integral of the controlled system. A differing optimization rule must therefore be found for the reset time Tn. This is achieved by adjustment according to the symmetrical optimum.

If the controlled system contains an integral-action element and also a number of first-order lag element whose time constants can be grouped together into a total time constant σ, you can provide the controller with a PI action.

The frequency response of the open loop $F_0(p) = Kp * Vs * (1 + Tn) / [(pTn) (pT_0) (1+pσ)]$

The control parameters are set as follows:

$Kp = T_0 / (2*Vs*σ)$; Tn = 4*σ;

Vs is the controlled-system gain and σ the sum of the small time constants.

T_0 is the integral-action time of the integral-action element.

The rise time t_{rise} is 3.1*σ; the settling time t_{settle} is 16.5*σ; the overshoot is 43.3% for a Δx of 2%. This also applies of the controlled system contains an integral.

If, among the small lags, there is one with the constant T2 that exceeds the other, this must be compensated for with a derivative-action element, i.e. a PID controller must be used.

The frequency response of the open loop is therefore:

$F_0(p) = Kp *Vs * (1+pTn) *(1+ pTv) / [(pTn)*(1+ pT_2)* (1+pσ)]$.

If $T_2 = Tv$, the following results:

$F_0(p) = Kp * Vs * (1 + pTn) / [(pTn) *(pT_0) * (1 + pσ)]$, the same expression as above, resulting in the following for the optimization: $Kp = T_0 / (2*Vs*σ)$ and Tn = 4*σ.

If the controlled system consists of first-order lags among which one T_1 is more than four times greater than the sum of the others, the effect of this variable is approximately integral, which should result in optimization according to the symmetrical optimum in this case, too.

The set values are therefore: $Kp = T_1 / (2*Vs*σ)$; Tn = 4σ.

If the controlled system contains two especially large lags, a PID controller must be used with an integral-action time corresponding to the smaller of the two.

Setpoint smoothing

Overshoots of 43.4% are only permitted in very rare cases. Measures must be taken to reduce these.

Setpoint smoothing with t_{ss} = 4σ, i.e. with the magnitude of the Tn of the controller provides the suitable results, if Ti >=1

The rise time is then 7.6σ, the settling time with reference to a tolerance band of +/- 2% is 13.6σ, and the overshoot is 8.1%, with reference to a change to the settled state of 100%.

If the overshoots of the controlled variable are to disappear completely on a step change in the setpoint channel, stronger setpoint smoothing with t_{ss} = 6σ can be connected in front of the symmetrically optimized control loop, that only contains first-order lags in the controlled system.

If you want to avoid the disadvantage of a slower control due to smoothing of the setpoint and still achieve a steeper rise, the smoothing element must be bypassed in the setpoint channel by a derivate-action element t_{g1} = 4σ.

**Comparison of the absolute value optimum
and the symmetrical optimum**

If you attempt to adjust a control loop according to the absolute optimum or the symmetrical optimum, you will not always succeed in sensing the data of the controlled system correctly, especially as some elements in the controlled system are non-linear, i.e. their characteristic values change on being controlled, inaccuracy in measurement will occur that results in a certain degree of error in adjustment of the control. This can be seen in the transfer function recorded using a recorder or trace function.

The response of the controlled variable to a step change in the reference variable usually reveals the error clearly.

The step responses shown below reveal the response at the optimum and with the characteristic values of the optimum maladjusted by a factor of 2. This show the direction in which the characteristic values have to be change to approach the optimum.

Setting of the correct rate time Tv of a PID controller according to the compensation method described above.

The diagrams for the absolute value optimum show that as the gain of the controller increases, the steepness of the response also increases, causing the overshoot to grow.

As the reset time increases, settling to the final value is performed with more and more pronounced tracking. However, if the reset time is smaller than the optimum value, the controller tends to oscillate more and more as the integral-action time is reduced.

If the gain is reduced by a factor of two, but the reset time has the correct value according to the absolute value optimum, the setting corresponds to the 'linear optimum'. The linear optimum is adjustment to the aperiodic limit case.

With a smaller reset time, the form of the transfer function approximates to that of the symmetrical optimum
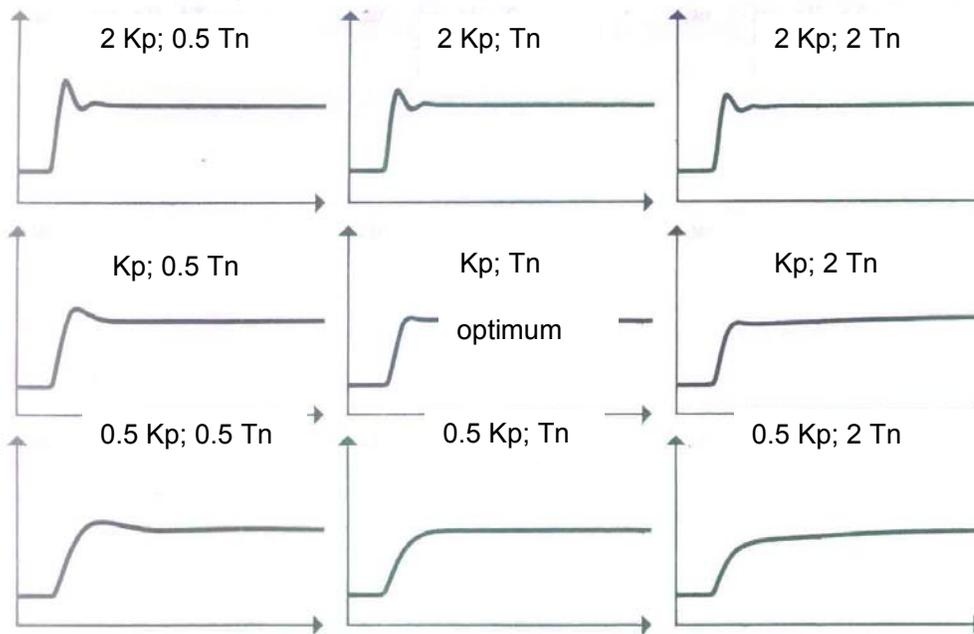
Adjustment to the absolute value optimum

The transfer functions of the symmetrical optimum exhibit similar tendencies.
As the gain increases, the rise time decreases. An excessively large Kp results in more pronounced hunting, as does an excessively small Tn. If the reset time is too large, this results in a degree of settling, if the Kp is correctly set. If the Kp is too small or too large, the overshoot increases and if Tn is too small, pronounced oscillations whose frequency grows with the gain occur for every Kp.
Moreover, at the symmetrical optimum, the phase offset from critical positive feedback is smaller than for the absolute value optimum. While the absolute value optimized control loop can become more and more stable by reducing the gain, this is only possible for the symmetrically optimized loop by increasing the reset time at the same time as having correct gain.

2 Kp; 0.5 Tn	2 Kp; Tn	2 Kp; 2 Tn
Kp; 0.5 Tn	Kp; Tn optimum	Kp; 2 Tn
0.5 Kp; 0.5 Tn	0.5 Kp; Tn	0.5 Kp; 2 Tn
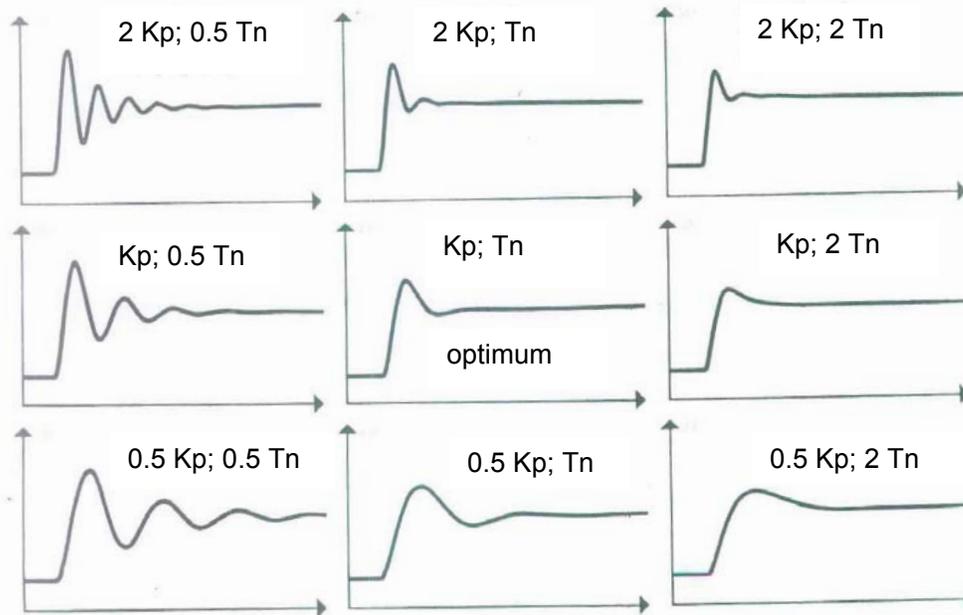
Adjustment according to the symmetrical optimum

Equivalent time constant of the optimized control loop
A controlled system often contains not just two but more time constants and integrals. This sometimes results in impermissibly slow settling.
For example, a drive not only has the speed control as a main controlled variable but also the armature current as an auxiliary variable.
In this case, the current control is therefore subordinate to the speed controller. For the higher-level control loop, the lower-level control must therefore be considered part of the controlled system. To be able to represent the frequency response of the higher-level loop as simply as possible, it is useful to use a first-order function for the lower-level loop.
For a lower-level controller optimized according to the absolute value optimum, the equivalent time constant $t_{eBO} = 2\sigma$ applies.
For a lower-level control loop optimized according to the symmetrical optimum, the following applies:
Equivalent time constant is $t_{eSO} = 4\sigma$

Avoiding overshooting of the controlled variable in an overdriven controller

So far we have assumed that none of the controllers is being overdriven. However, overdrive can be expected in response to large or fast changes in the reference variable. Because the manipulated variable cannot reach the necessary amplitude during the settling process, the controlled variable can only change more slowly. In the case of a controller with an integral-action component, the controller is overdriven and the integral-action component can only integrate back when the sign of the reference variable is inverted. This results in overshoots in the controlled variable. Such overshoots are not desired and can easily result in an unstable response of the control loop.

This can be counter-acted by a PI controller and a D-action component in the actual-value channel with Tv = 4σ (controller optimized according to the symmetrical optimum).

Overdrive of the controller can also be reduced by a ramp function generator in the setpoint channel with a suitable choice of ramp time.

Overview tables for optimization

The following tables are used to define optimization method for the control loop according to the time constants of the controlled system and the characteristics of the controller.

Controlled system						Controller	Optimization	Time constant of the setpoint smoothing t_{gs}
Large time constants			Small time constants					
T_0	T_1	T_2	$4\sigma >= T$	$4\sigma <= T$	$4\sigma << T$			
			X	X	X	I	BO	-
	X		X			PI	BO (SO)	-
	X			X		PI	SO (BO)	$0 < t_{gs} < 4\sigma$
	X				X	P (PI)	BO (SO)	(4σ)
x	X	X				PID	BO (SO)	-
x	X			X		PID	SO (BO)	$0 < t_{gs} < 4\sigma$
x	X				X	PD (PID)	BO (SO)	(4σ)
X			X			PI	SO	4σ
X				X		PI	SO	4σ
X					X	P (PI)	BO (SO)	(4σ)
X		X	X			PID	SO	4σ
X		X		X		PID	SO	4σ
X		X			X	PD (PID)	BO (SO)	(4σ)

BO: absolute value optimum; SO: symmetrical optimum

The optimization state in brackets results in slower compensation

σ: sum of the small time contants;

T: largest first-order lag or integral-action time T_0

T_1: larger of the two large time constants

T_2: smaller of the two large time constants

Calculation of the controller parameters

Optimi-zation	Controller	Controller parameters					Transfer function on step change in setpoint			Equivalent time constant of the optimized control loop
		T_I	Tn	Tv	Kp Only lag	Kp With integral	t_{an}	t_{aus}	o %	
Linear optimum	I	$4V_s\sigma$	-	-	-	-	-	12σ	0	4σ
	P	-	-	-	$T_1/(4V_s\sigma)$	$T_i/4\sigma$				
	PI	$4V_s\sigma$	T_1	-	$T_1/(4V_s\sigma)$	-				
	PD	-	-	T_2	$T_1/(4V_s\sigma)$	$T_i/4\sigma$				
	PID	$4V_s\sigma$	T_1	T_2	$T_1/(4V_s\sigma)$	-				
Absolute value optimum	I	$2V_s\sigma$	-	-	-	-	4.7σ	8.4σ	4,3	2σ
	P	-	-	-	$T_1/(2V_s\sigma)$	$T_i/2\sigma$				
	PI	$2V_s\sigma$	T_1	-	$T_1/(2V_s\sigma)$	-				
	PD	-	-	T_2	$T_1/(2V_s\sigma)$	$T_i/2\sigma$				
	PID	$2V_s\sigma$	T_1	T_2	$T_1/(2V_s\sigma)$	-				
Only lag SO	PI	$V_s8\sigma^2/T_1$	4σ	-	$T_1/(2V_s\sigma)$	-	$>3.1\sigma$	$<16.5\sigma$	$<43,4$	$2\sigma+0.5t_{gs}$
	PID	$V_s8\sigma^2/T_1$	4σ	T_2	$T_1/(2V_s\sigma)$	-	$<7.6\sigma$	$<13.3\sigma$	$<8,1$	
SO with Integral	PI	$8\sigma^2/T_i$	4σ	-	-	$T_i/2\sigma$	3.1σ	16.5σ	43,4	4σ
	PID	$8\sigma^2/T_i$	4σ	T_2	-	$T_i/2\sigma$	7.6σ	13.3σ	8,1	

t_{rise}: rise time; t_{settle}: settling time, o: overshoot as a percentage
$T_i = T_0/V_s$: integral-action time of the controlled system; T_0: integral-action time, V_s: Controlled system gain
SO: symmetrical optimum

Compensation of disturbance variables
A controlled system is also subject to disturbance variables, such as a load surge on a variable-speed drive.
This load surge results in a system deviation that is corrected by the controller.
The constancy of the control stated in the Operating Instructions refers to a long period of, for example, 10 seconds. It therefore does not take a transient system deviation caused by a disturbance variable into account. This can therefore be greater than the value stated as the constancy.
We do not intend to look at formal derivation of the response to precontrol here. Suffice it to say that a controller adjusted according to the symmetrical optimum is more advantageous than one adjusted according to the absolute value optimum in such cases.

Symmetrical optimum with an integral in the controlled system

Optimized according to: symmetrical optimum

Transfer function on a step response of the disturbance variable: Optimized according to absolute value optimum
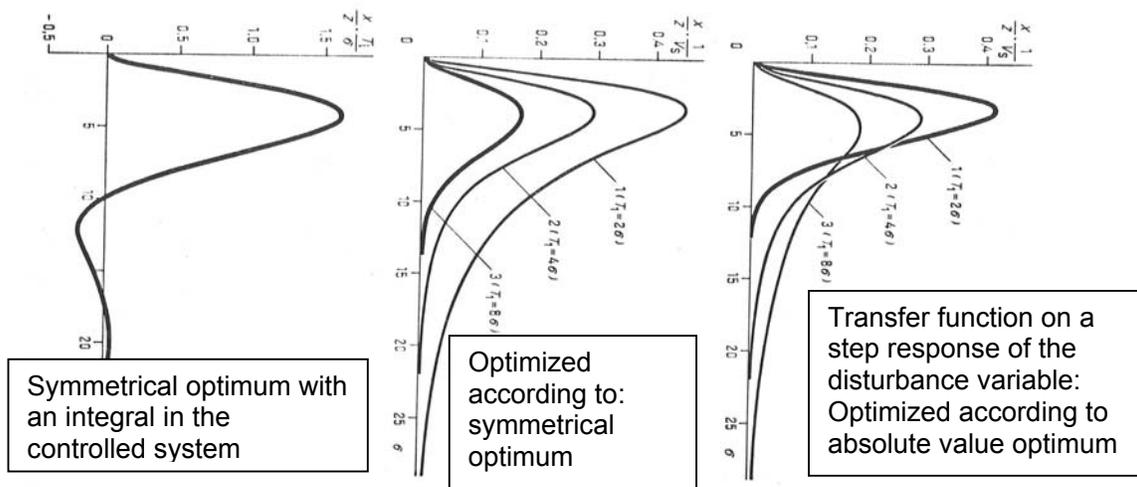
Structure diagram of the entire armature control loop with an example
Speed controller with a lower-level current controller and DC motor as the load.
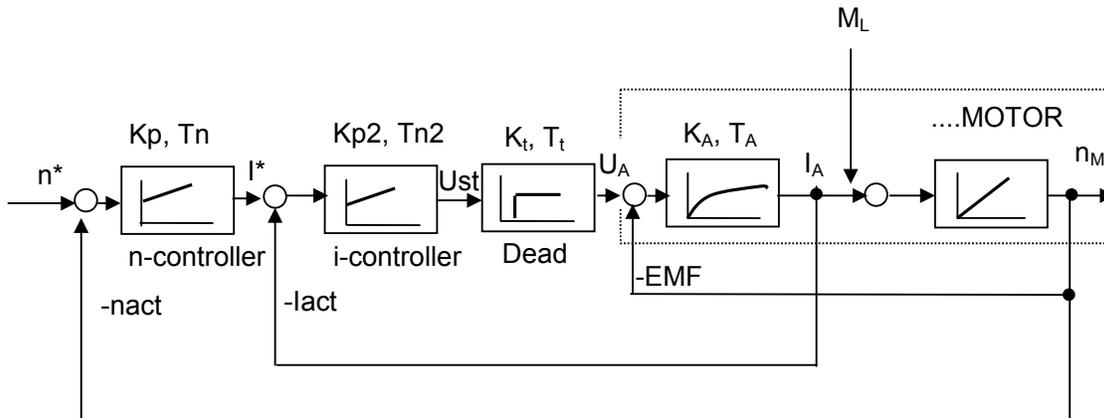
n*: speed setpoint, nact: speed actual value, I*: current setpoint, Iact: actual current value;
Ust: control voltage, U_A: armature voltage, EMF: induced motor voltage,
I_A: armature current motor, T_t: dead time due to power system cycles,
T_M: mechanical ramp-up time constant; M_L: load torque, n_M: the motor speed
n-controller: speed controller, i-controller: current controller
K_A, T_A: PT1 element due to armature circuit inductance and armature circuit resistance;
Kp: controller gain, Tn: controller reset time

Example:
B6C circuit, line voltage Us:3AC400 V, armature circuit inductance motor L_M: 0.5 mH,
Armature circuit resistance motor R_M: 0.02 ohm, inductance of smoothing reactor L_G: 1 mH,
resistance of smoothing reactor R_G: 5 mOhm, cable deemed negligible.
Voltage drop commutating reactor: Vimp = 4%,
Line frequency: 50 Hz, rated armature current I_{AN}: 600 A, rated armature voltage U_{AN}: 420 V,
firing angle range $\Delta\alpha$ = 90 degrees for 100% in the calculation of the software

Parameters of the dead-time element:
Ideal no-load direct voltage = Udi = Us * 1.35 = 540 V
The trigger firing angle for rated armature voltage α_2 is derived from the cosine function of
the control characteristic: $\cos \alpha_2$ = U_{AN} / Udi = 420 / 540 = 0.778 yields α_2 approx. 39 degrees
$K_t = \Delta\alpha / (\alpha_1 - \alpha_2) = 90 / (90 - 39) = 1.76$
Mean (statistical) dead time for 6-pulse bridge connection (p=6) and 50 Hz:
T_t = 20 ms / p = 20 / 6 = 3.33 ms, half of which is postulated as the statistical dead time:
T_t = 1.66 ms
Parameters of the lag element:
$R_A = R_M + R_G + R_S$, d_x = 0.5 * Vimp = 0.02; $R_S = d_x$ * Udi / I_{AN} = 0.02 * 540 / 600 = 0.018
R_A = 0.02 + 0.005 + 0.018 = 0.043
Armature circuit inductance $L_A = L_M + L_G$ = 1.5 mH
Armature circuit gain:
$K_A = U_{AN} / (I_{AN} * R_A)$ = 440 / (600*0.043) = 16.3
Armature time constant = $L_A / R_A = 1.5*10^{-3} / 0.043 = 0.0349$ s = 34.9 ms = T_1

If the set current limit is greater than I_{AN}, this peak current must be substituted in the formulas. This also applies to the torque M_{MN} for the mechanical ramp-up time constant T_M.

Current controller optimization according to the absolute value optimum with a PI controller:
$V_s = K_t * K_A = 1.76 * 16.3 = 28.7$
$\sigma = 1.66$ ms,
$Tn = T_1 = 34.9$ ms
$Kp = T_1 / (2V_s\sigma) = 0.0349 / (2 * 28.7 * 0.00166) = 0.37$
The rise time of the current controller is $4.7\sigma = 4.7 * 1.66 = 8$ ms
The settling time of the current controller is $8.4\sigma = 14$ ms
Equivalent time constant of the lower-level current controller:
$\sigma = 4\sigma$(current control loop) = 4 * 1.66 = 6.64 ms (more suitable than the theoretical 2σ for the digital control 4σ used in this case).

Speed controller optimization according to the symmetrical optimum with a PI controller:
$Tn = 4\sigma = 4 * Tn$ current controller = 4 * 34.9 ms = 0.14 s.
Let the integral-action time T_0 (mechanical ramp-up time of motor, e.g. measured in a ramp-up experiment) be 4000 ms.
$T_i = T_0 / V_s = 4s / 28.7 = 4000$ ms / 28.7 = 139 ms
$Kp = T_i / (2\sigma) = 139 / (2*34.9$ ms) = 1.9
The rise time of the speed controller is $3.1\sigma = 3.1 * 34.9 = 0.109$ s
Values measured for the 6RA70 were typically > 40 ms
The settling time is $16.5\sigma = 16.5 * 34.9 = 0.9$ s

Speed control with an oscillating mechanical system
The mechanical part of the drive is characterized by an I-element with the mechanical time constant T_M. T_M contains the motor inertia and the inertias of the coupled load, including the shaft, gearing, coupling, etc. In real cases, elastic connecting elements, such as couplines, long flexible torsion shafts or elastic belts, often have an effect. In this case, it is a damped multiple-mass oscillator. For this reason, the rise times calculated above can only rarely be achieved in practice. The structure diagram of the control will also deviate if the mechanical system is approximated to a two-mass oscillator.

$M_M = M_{BM} + M_F$
where M_M: motor torque, M_{BM}: accelerating torque of motor, M_F: torque of the springs

$M_{BM} = J_M * dn / dt * 2\pi / 60$; J_M: inertia of motor in m^2kg, n: speed in RPM
$M_{BM} = J_M * 2\pi /60 * p * N_M$; $n_M = 1 / (pT_M) * m_{BM}$, $T_M = J_M * 2\pi * N_{MN} / (M_{MN} * 60)$

$M_F = C_F * 2\pi * (N_M – N_L) / (p * 60)$; C_F: spring rate in Nm / rad
$m_F = (n_M – n_L) / (pT_F)$ where $T_F = 60 * M_{MN} / (2\pi * N_{MN} * C_F)$

The torque transmitted by the spring is used to accelerate the load: $m_F = m_{BL}$
load speed: $n_L = m_{BL} / (pT_L)$ where $T_L = J_L * 2\pi * N_{MN} / (60* M_{MN})$; J_L: Load inertia

In the case of gearing, the load inertia converted to the motor speed is used.

The structure diagram shows a cascade connection of I-elements, which would result in undamped oscillation once the system had been excited. The damping of the springs must therefore also be considered.

Structure diagram of the DC motor with elastically coupled flywheel and damping
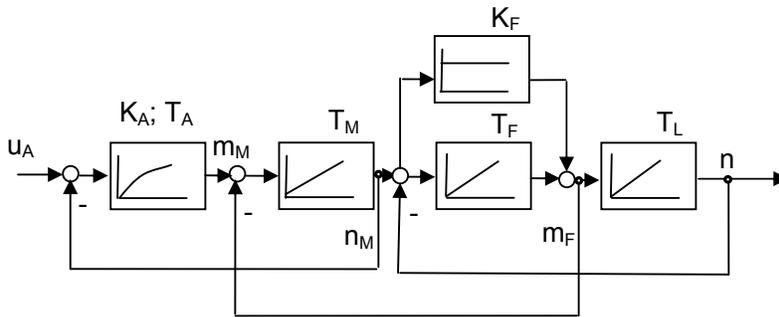
With damping, $m_F = (n_M - n_L) / (pT_F) + k_F * (n_M - n_L)$
With k_F of the gain of the damping element $k_F = d * 2\pi * N_{MN} / (60 * M_{MN})$ and d as the damping.

The characteristic values can be determined experimentally:
T_M: due to acceleration of the uncoupled motor at the current limit up to the rated speed of the motor.
$T_M + T_L$: due to acceleration of the motor with a coupled flywheel.
The natural frequency ω_e of the flexible mechanical system can be calculated by recording the speed with an oscillograph while the couple drive is ramping up at the current limit.

So, you can see that this is a complex issue.
On the SIMOREG 6RA70, the frequency response of the controlled system is calculated with P051 = 29 as part of optimization of the drives with oscillating mechanical system and the parameters P225, P226, and P228 required for the speed control loop are automatically set. We will therefore not look any further into this issue because the topic of frequency characteristics has not been dealt with in this document.

Adaptation of the controllers
Speed controllers: The characteristic values of the speed controllers can be adapted depending on an influencing variable (any connector variable), for example, to the actual current value or the speed actual value, see Sheet G151. For gear stage changing (change of the T_M depending on the gear stage) or C-axis operation on main spindle drives, the function data set switchover (FDS1 to FDS4) can be used.
The current controller characteristics values can be adapted; each multiplied by one connector variable. The change in delay angle required for a change in current of a certain magnitude is different for discontinuous and continuous current. Thos non-linearity is compensated for by the current controller precontrol. Sheet G162
In the case of weak-field operation, division by PHI is performed after the speed controller (torque calculation can be selected). In this way, the speed controller output is the torque setpoint to adapt the controlled system accordingly. Sheet G160.
The relationship between the field current and the motor flux PHI is non-linear because of the magnetization characteristic (non-linearity due to core saturation). The precontrol of the EMF controller takes this into account depending in the magnetization characteristic of the motor (recorded by field characteristic recording by means of P051 = 27).
Sheet G165.

If the controlled variable reaches a limit, the integral-action component of the PI controller is stopped so as not to integrate away too much which could only be triggered to integrated down again by an input variable with a negative sign. This reduces possible overshooting of the output variable.

In this implementation, the digital 6RA70 can make use of its advantages over older analog controls.

Technological controls with 6RA70

For 6RA70, various options for technological controls can be implemented.

In the simplest case, the technology software (free function blocks)

option S00 is used in the basic unit.

Technology modules T300 and T400 can be used as freely configurable additional modules.

Furthermore, terminal expansion modules and serial communication modules (e.g. CBP2 Profibus interface) are available for connecting to the automation.

See Catalog DA21.1 Chapter 4:

http://www.automation.siemens.com/ld/dc-stromrichter/html_00/dc-master/kataloge.html

Current / torque limitation control:

There is sometimes a requirement to limit to a certain speed and torque at the same time. This cannot be implemented without further complications.

The following options for closed-loop control exists: Speed control, with the speed kept constant at a certain speed setpoint and the current / torque is set to a suitable value, so that the speed is kept constant.

Torque control, with the motor torque kept constant and the speed set to a precisely the value that compensates for this torque while remaining constant.

The current limitation control or torque limitation control is a possible compromise. In the armature setting range (no field weakening), the variables for the current and the torque are equal (100% of field current). In the weak field range, the torque is kept constant and the current setpoint necessary to maintain the constant torque in the weak field range is calculated by division of the torque setpoint by the flux Φ. See parameters P169 and P170, Sheet G160.

For this type of control, the speed setpoint is overdriven by a small percentage, say, 5% of the additional speed setpoint. The drive would like to rotate faster but the speed is kept at the somewhat lower actual value by the web. The speed controller goes to the torque limit. This torque limit can now be set to the desired torque limit value by an external variable.

Sheet G135. Input of the additional speed setpoint via the connector number set in P645.01.

Sheet G160. Input of the desired torque limit setpoint via the connector number set in P605.01.

This type of control is often used for axial winder and tension controls.

With this torque limit at the overdriven speed controller output, control now results in precisely the desired torque value.

If the material now tears, the speed controller will depart from the torque limit because of the missing load torque of the web and the driver will not turn faster than the speed setpoint plus the, for example, 5% additional overdrive setpoint. This prevents a high overspeed and the resulting damage to the winder reel.

No additional option is required for this type of control.

Master-slave switchover
Depending on the application, Option S00 may be necessary, for example, if adjustment via an additional multiplier are required.
With this type of control, a variable-speed master drive and one or more torque-controlled slave drives are used.
The possible applications are motors on a common shaft, e.g., for line shafts of printing machines or DC motors with a common shaft (tandem drive) or if multiple drives are inputting to a common transmission.
More at: http://support.automation.siemens.com/WW/view/en/9473023

Load sharing control
If drives are coupled via a common web and they are to be controlled to a specific load distribution across the motors, e.g. S roll drives on a foil plant or to implement a converter tilting drive, load sharing control is used instead of master-slave switchover. Option S00 is required for this. You will find a description of applications for this application at:
http://support.automation.siemens.com/WW/view/en/26502614

Load sharing via the droop function of the speed controller
A typical application example for this are roller conveyer drives for conveying material. The speed controllers of the 6RA70 are given the same speed setpoint (master setpoint), so that the motors turn at the same speed in principle. However, the speed controller has P-feedback in addition to the PI characteristic. As the controller output variable (torque setpoint) increases, this causes via this P-feedback a subtraction variable in the speed setpoint channel, which in turn causes the speed actual value to collapse at a higher load torque, which in turn automatically causes a reduction in the torque output. This results in an even distribution of the load over multiple drives in which this droop function is parameterized without any load sharing control. No further connections between the various devices are required except for the common speed setpoint.
No Option is required for this droop function.
More at: http://support.automation.siemens.com/WW/view/en/9473023

Analog circuit diagram of the droop function:

Settable droop

PI controller
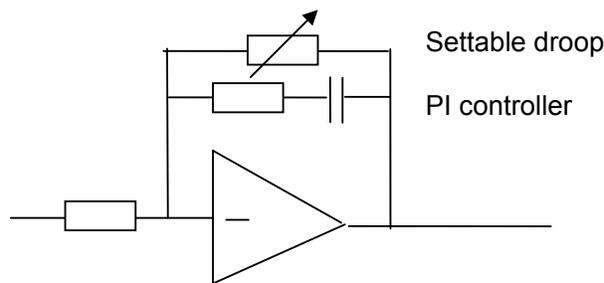
Axial winder
There are several ways of implementing an axial winder in the 6RA70
1) Implementation using S00
2) Implementation using the technology module T300
3) Implementation using the technology module T400
In most cases 1) implementation with S00 is sufficient and also the lowest-cost solution.
An axial winder characterized that fact that the diameter of the wound material varies as winding progresses.
There are various methods of implementating the winding function, such as indirect tension control, direct tension control, dancer roll control and v-constant control. One of these methods is used both for taking up and paying out the material.
The drive is given the web velocity v as the setpoint. The diameter D is calculated by the formula $n * D = v$. This diameter is used to convert the web velocity setpoint to a speed setpoint to obtain the motor speed n as a function of D. The speed controller then receives a correction setpoint via the tension controller (for dancer control or v-constant control) or it is overdriven to control the tension via the torque limitation (for direct and indirect tension control). In addition, the compensation of the inertia and the friction is taken into account and the reeling hardness is open-loop-controlled.
For more on axial winders using the S00 Option, see:
http://support.automation.siemens.com/WW/view/en/9716319
A parameter download file .DNL is located on the CD supplied with the 6RA70.

Tension control with constant roll diameter
For this tension control with constant roll diameter, the software for the axial winder above can be used in principle. The only difference is that the diameter is not variable but a constant value. This is taken into account as a constant in the web-velocity-to-speed conversion.
http://support.automation.siemens.com/WW/view/en/9716319

Machine tool drives
Main spindle drive
A main spindle drive can be implemented using 6RA70.
Perform current controller optimization, speed controller optimization (possibly, manually re-optimize for the speed controller) and field characteristic recording (P051 = 25, 26, 27).
In the case of belt drives, it is sometimes necessary to perform the optimization for an oscillating mechanical system (P051 = 29).
A main spindle drive requires additional monitoring functions. For that reason, the CUD2, Option K00, terminal expansion is usually required.
Messages:
B0107: No error message
B0164: n < nmin (P370) for zero-speed message
B0172: Setpoint-actual difference 2 as nset = nact monitoring; for parameterization see Sheet G187 and http://support.automation.siemens.com/WW/view/en/23595539
If Ia > Ix monitoring is desired, it can be implemented using a limit comparator of Option S00.
C-axis mode with main spindle drives
For normal main spindle operation, FDS1 is used. On selection of
C-axis mode, FDS2 is used (see above under Function data sets).
Procedure: after complete parameterization and optimization of the main spindle drive in FDS1, copy FDS1 to FDS2 using P055 (Sheet G175) and then perform optimization of C-axis mode in FDS2.
Define the maximum speed for the C-axis mode (usually approx. 10 to 15 % of the main spindle operation); perform optimizations. The current controller optimization usually provides suitable settings; manual re-optimization of the current controller only necessary in border-line cases. Optimizations of the speed control that are found (should exhibit the most rigid response possible) can usually be improved by manual re-optimization.
If necessary, perform speed controller adaptation Sheet G151.

Spingle positioning for main spindle drives
With 6RA26 and 6RA27, there was a separate additional module for spindle positioning.
6RA70 no longer has this.
If 6RA70 is used, spindle positioning can be implemented in the following ways.
Spindle positioning via a NC (SINUMERIK)
Use of technology module T300 with the standard configuration for positioning
Use of technology module T400 with a customized configuration.

Feed drives
Old thyristor controllers as the feed drive can be replaced by 6RA70 if the time is taken to perform optimization carefully.
Automatic current controller optimization sometimes has to be improved by manual re-optimization. Always manually re-optimize the speed optimization,
If necessary, perform speed controller adaptation Sheet G151.
If transistor choppers were used because of high dynamic requirements, retrofitting with AC servo technology (AC servo motor plus converter) is almost always necessary.

Angular synchronous control
For angular synchronous control, the technology module T400 can be used with the standard angular synchronous control configuration loaded.
Order number module, including software angular synchronization; 6DD1842-0AB0
Order number of Operating Instructions: 6DD1903-0BA0
See Catalog DA21.1 Chapter 4:
http://www.automation.siemens.com/ld/dc-stromrichter/html_00/dc-master/kataloge.html

Cross-cutter/shear control
For cross-cutter/shear control, the technology module T400 can be used with the relevant standard configuration loaded.
Order number of module, including software cross-cutter/shear control:
6DD1842-0AD0; order number of Operating Instructions: 6DD1903-0DA0
See Catalog DA21.1 Chapter 4:
http://www.automation.siemens.com/ld/dc-stromrichter/html_00/dc-master/kataloge.html

Technology control for hosting gear applications
For technological hoisting gear applications, technology module T300 with special standard software can be used. Six software modules are available for this to control the luffing gear, holding gear, closing gear, slewing gear, traversing gear and traversing gear slave drive.
The following standard functions have been implemented:
Load-dependent field weakening, non-linear master controller setpoint, heavy-load control, position control, prelimit switching, inching mode, starting pulse, switchover of ramp function generator on field weakening and heavy load, zero-speed message, control monitoring, speed actual value monitoring using two speed actual value encoders, synchronous control master-slave operation, current distribution monitoring for master-slave operation, constant field weakening, slack rope control, grab position control, grab adjustment, synchronous control for traversing operation, current balancing control, Polyp grab operation, reach-dependent ramp-up time, influence of the ramp-up and ramp-down times depending on the error variable, reach-dependent speed of rotation, synchronous control for master-slave operation.
With these, almost any hoisting gear application can be implemented. Other functions can be implemented on request.

HIPAC swing control:
HIPAC is an electronic open and closed-loop control system that can be integrated as an added element into any crane control that has variable-speed drives.
HIPAC permits almost swing-free movement of crane loads for:
Time-optimized conveying of loads, reduction of time for pick-up and set-down of loads with swing-free approach to the target position, perfect crane operation, also by inexperienced crane operators, reduced wear on drives and mechanical parts due to optimized torque progressions and crane automation with low effort.
The handling performance and safety of cranes are enhanced.
The system consists of swing angle sensors and computer hardware for the control.
For more on hoisting gear technology applications, please contact
Siemens AG, A&D MC CR.

References:

1...See Internet for specific product documentation 6RA70 and SIMOREG CM:

http://support.automation.siemens.com/WW/view/en/10804967/133300
http://support.automation.siemens.com/WW/view/en/10804968/133300

2...."Einführung in die elektronische Regelungstechnik"; by Friedrich Fröhr and Fritz Orttenburger; in German; published by: Siemens Aktiengesellschaft Berlin-Munich 1970.

3...."Berechnung von Regelkreisen der Antriebstechnik"; by Arne Buchsbaum and Klaus Schierau; in German; AEG-Telefunken-Handbücher; Volume 16; Elitera Verlag Berlin; 2nd edition 1976

4....SIMOREG catalogs:
http://www.automation.siemens.com/ld/dc-stromrichter/html_00/dc-master/kataloge.html

5….Catalog DC motors:

http://www.automation.siemens.com/ld/dc-motor/html_00/allg/kataloge.html

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