ACS 600

User's Manual

This manual includes:
- Safety
- Commissioning
- DSU Operation Basics
- DSU Hardware Description
- DSU Firmware Description

Diode Supply Sections
140 to 5200 kVA

ACS 600 MultiDrive Manuals (English Originals)

GENERAL MANUALS

***Safety and Product Information** EN 63982229
- Complete general Safety Instructions
- Technical data for DSU and TSU supplies and Drive Sections: ratings, power losses, dimensions, weights, fuses etc.

***System Description** EN 63700151
- General description of ACS 600 MultiDrive

***Hardware Manual E**N 63700118
- General Safety Instructions
- Hardware description of the Drive Section
- Cable selection
- ACS 600 MultiDrive mechanical and electrical installation
- Hardware commissioning of the Drive Section
- Preventive maintenance of ACS 600 MultiDrive

ACS 600 MultiDrive Control Electronics LED Indicators EN 64289721
- LED descriptions

****Modules Product Catalogue** EN 64104268
- Supply Unit components
- Drive Unit components
- Dynamic Braking Units
- Drive*Ware* information
- Dimensional drawings
- Single line diagrams
- Auxiliary power consumption
- Master component tables

****Modules Installation Manual** EN 64119010
- Cabinet assembly
- Wiring

****Grounding and Cabling of the Drive System** EN 61201998
- Grounding and cabling principles of a variable speed drive system

****EMC Compliant Installation and Configuration for a Power Drive System** EN 61348280

* Included with cabinet-assembled systems only
** Included in Modules deliveries only

SUPPLY SECTION MANUALS (depending on the supply type, one of these manuals is included in the delivery)

Diode Supply Sections User's Manual (DSU) EN 61451544
- DSU specific Safety Instructions
- DSU hardware and software descriptions
- DSU commissioning
- Earth fault protection options

Thyristor Supply Sections User's Manual (TSU) EN 64170597
- TSU operation basics
- TSU firmware description
- TSU program parameters
- TSU commissioning

IGBT Supply Sections User's Manual (ISU) EN 64013700
- ISU specific Safety Instructions
- Main components of ISU
- ISU ratings
- ISU power losses
- ISU dimensions and weights
- ISU fuses
- ISU program parameters
- Earth fault protection options

FIRMWARE MANUALS FOR DRIVE APPLICATION PROGRAMS (appropriate manual is included in the delivery)

System EN 63700177
- Commissioning of the System Application Program
- Control Panel use
- Software description
- Parameters of the System Application Program
- Fault tracing
- Terms

Application Program Template EN 63700185
- Commissioning of the Drive Section
- Control Panel use
- Software description
- Parameters
- Fault tracing
- Terms

Standard EN 61201441
- Control Panel use
- Standard application macros with external control connection diagrams
- Parameters of the Standard Application Program
- Fault tracing
- Fieldbus control

Note: a separate Start-up Guide is attached

Crane Drive EN 3BSE 011179
- Commissioning of the Crane Drive Application Program
- Control Panel use
- Crane program description
- Parameters of the Crane Drive Application Program
- Fault tracing

CONTROL SECTION MANUALS (delivered with optional Control Section)

Advant Controller 80 User's Manual EN 64116487
- AC 80 hardware and connections
- AC 80 software
- Programming
- Diagnostics

Advant Controller 80 Reference Manual PC Elements EN 64021737
- Description of PC and DB elements

Advant Controller 80 Reference Manual TC Elements EN 64331868
- Description of TC elements

BRAKING SECTION MANUAL (delivered with optional Braking Section)

ACA 621/622 Braking Sections User's Manual EN 64243811
- Installation, Start-up, Fault tracing, Technical data
- Dimensional drawings

MANUALS FOR OPTIONAL EQUIPMENT (delivered with optional equipment)

Fieldbus Adapters, I/O Extension Modules, Braking Choppers etc.
- Installation
- Programming
- Fault tracing
- Technical data

ACA 631/633 Diode Supply Sections 140 to 5200 kVA

User's Manual

This manual concerns six-pulse and twelve-pulse Diode Supply Sections ACA 631 and ACA 633 for ACS 600 MultiDrive and ACS/ACC 607/627 (units -0760-3, -0930-5, -0900-6 or above) frequency converters.

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EN
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Safety Instructions

Overview

The complete safety instructions stated in ACS 600 MultiDrive *Safety and Product Information* (EN 63982229) or *ACS/ACC 607 Installation & Start-up Manual* (ACS/ACC 607 units 630 to 3000 kW) (EN 61329005) must be followed when installing, operating and servicing the frequency converters. Study the complete safety instructions carefully.

General Safety Instructions

The general safety instructions are given below. These general instructions include only the main parts of the complete safety instructions. The general safety instructions are intended for all work on the ACS 600 MultiDrive and the ACS/ACC 607 (630 to 3000 kW) frequency converters. In the text below, they are collectively referred to as ACx 600. Neglecting these instructions can cause physical injury and death.

WARNING! All electrical installation and maintenance work on the ACx 600 should be carried out by qualified electricians.

Any installation work must be done with the power off, and power is not to be reconnected unless the installation work is complete. Dangerous residual voltages remain in capacitors when the disconnecting device is opened. Wait 5 minutes after switching off the supply before starting work. Always ensure that the measured voltage between terminals UDC+ and UDC- and frame is close to 0 V and that the supply has been switched off before performing any work on the equipment or making main circuit connections.

If the main circuit of the inverter unit is live, the motor terminals are also live even if the motor is not running!

Open the switch fuses of all parallel connected inverters before installation or maintenance work in any of them.

Check the cable connections at the shipping split joints before switching on the supply voltage.

If the auxiliary voltage circuit of the ACx 600 is powered from an external power supply, opening the disconnecting device does not remove all voltages. Control voltages of 115/230 VAC may be present on the digital inputs or outputs even though the inverter unit is not powered. Before starting work, check which circuits remain live after opening of the disconnecting device by referring to the circuit diagrams for your particular delivery. Ensure by measuring that the part of the cabinet you are working on is not live.

In ACx 600 frequency converters, control boards of the converter unit may be at the main circuit potential. Dangerous voltages may be present between the control boards and the frame of the converter unit, when the main circuit voltage is on. It is critical that the use of measuring instruments, such as an oscilloscope, and their connection to the ACx 600 frequency converters is done with caution and safety always a priority. The fault tracing instructions give special mention of cases in which measurements may be performed on the control boards, also indicating the measuring method to be used.

Live parts on the inside of doors are protected against direct contact. Special safety attention shall be paid when handling shrouds made of sheet metal.

Do not make any voltage withstand tests on any part of the unit while the unit is connected. Disconnect motor cables before making any measurements on motors or motor cables.

If an ACx 600 with the EMC Line Filter is installed to unearthed mains, the mains will be connected to earth potential through the EMC filter of the ACx 600. This may cause danger or damage the unit. Disconnect the EMC filter capacitors before connecting the ACx 600 to unearthed mains. For detailed instructions on how to do this, please contact your local ABB distributor.

WARNING! Close switch fuses of all parallel connected inverters before starting the frequency converter.

Do not open the drive section fuse switches when the inverter is running.

Do not use Prevention of Unexpected Start for stopping the drive when the inverter is running. Give a Stop command instead.

WARNING! Fans may continue to rotate for a while after the disconnection of the electrical supply.

WARNING! Some parts like heatsinks of power semiconductors inside of cabinet remain hot for a while after the disconnection of the electrical supply.

Starting DSU with a Braking Section

If the drive is equipped with a Braking Section, the following warning applies.

WARNING! Before power switch-on, make sure that a sufficient inverter power is connected to the intermediate circuit. Rules of thumb:

1. The sum power of the inverters connected must be at least 30% of the sum power of all inverters.
2. The sum power of the inverters connected must be at least 30% of the rated power of the braking section ($P_{br.max}$).

If the conditions mentioned above are not fulfilled, the DC fuses of the connected inverter(s) may blow or the braking chopper may be damaged.

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Chapter 1 – Introduction

Overview of the Manual

The Supply Section of ACS 600 MultiDrive and ACS/ACC 607 (units -0760-3, -0930-5, -0900-6 or above) frequency converters consist of Auxiliary Control Unit, Incoming Unit, Dynamic Braking Unit (optional) and Supply Unit. This manual covers:

- The commissioning of the Supply Section equipped with a Diode Supply Unit (DSU).
- System, hardware and software descriptions of the Diode Supply Unit. The descriptions provide the possibility to operate and optimize the unit for a particular system.

The Main Components of the Drive, Overall View

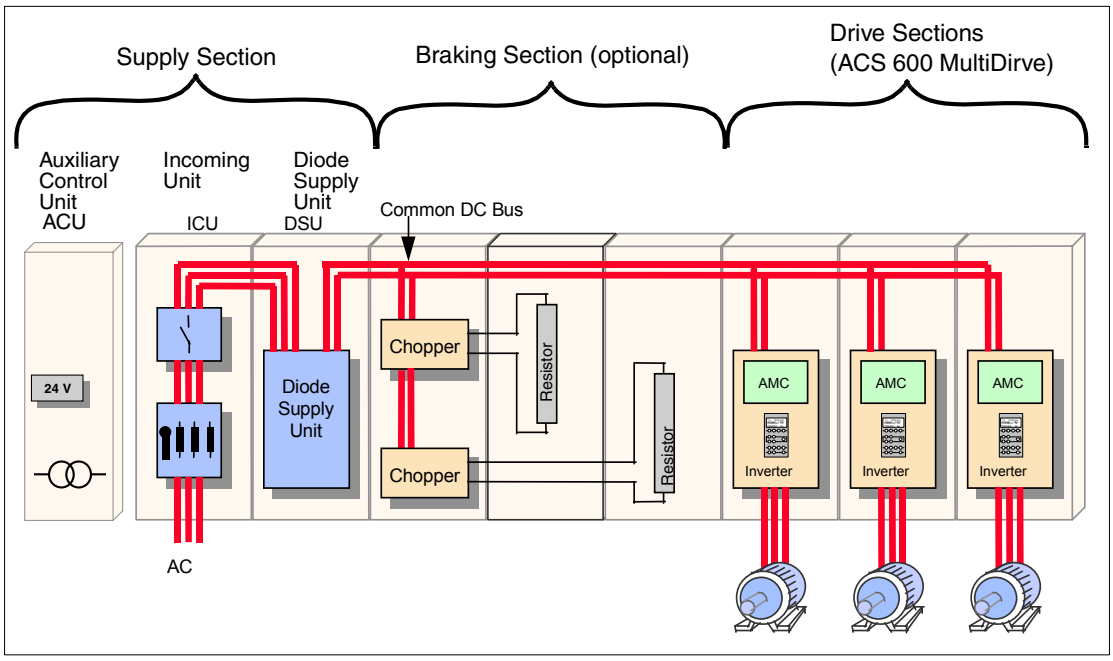


Figure 1-1 The main components of the drive

DSU Technical and Ambient Requirements

The Diode Supply Unit (DSU) can operate under following conditions:

- three-phase supply voltage
- voltage deviation ±10%
- frequency range 45 – 65 Hz
- rated frequency 50/60 Hz
- dynamic df/dt 17% / s
- permissible operational ambient temperature 0 – 40 °C
- storage temperature -40 – 55 °C
- relative humidity 5 – 95%, no condensation allowed

DSU Main Circuit Operation

The Diode Supply Unit (DSU) contains a 6 pulse, half controlled rectifier bridge with 3 thyristors in the upper leg and 3 diodes in the lower leg.

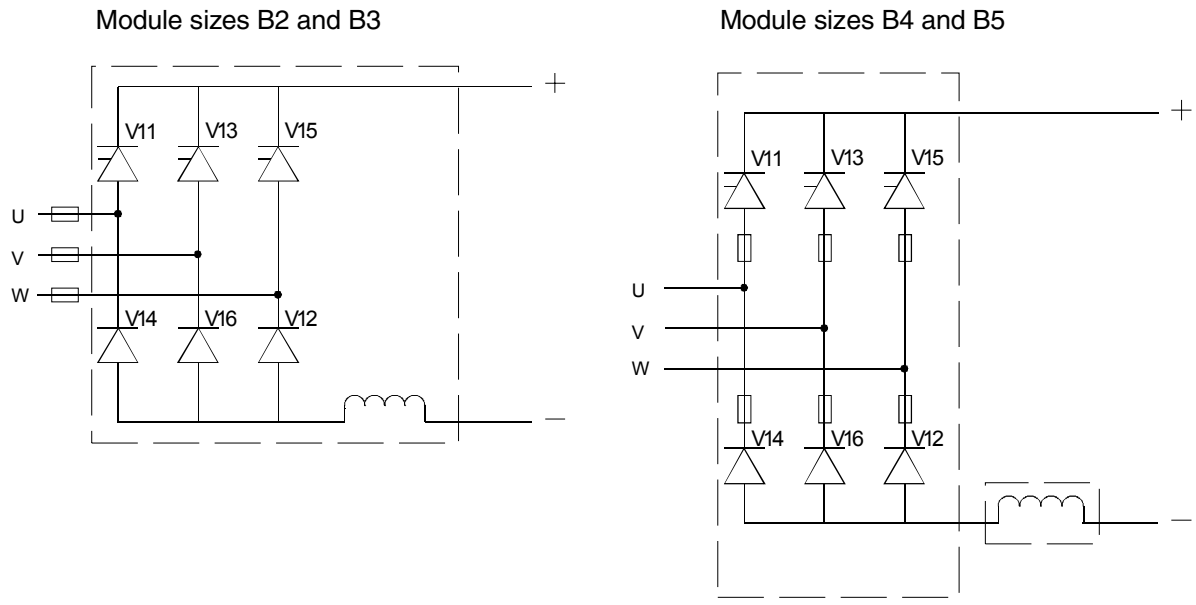


Figure 1-2 B2 and B3 have external AC fuses, while B4 and B5 have internal AC fuses)

In a three-phase bridge circuit, the commutations alternate between the power semiconductors in the upper and lower legs, so that six firing pulses are given during each period.

Thyristors 1, 3, and 5 connect the AC line terminals in cyclic sequence to the upper DC busbar (+). Diodes 2, 4, and 6 connect the AC terminals in cyclic sequence to the lower DC busbar (-). In the normal steady-state operation with continuous current, each thyristor in the upper leg and diode in the lower leg carries the current for a 120° period.

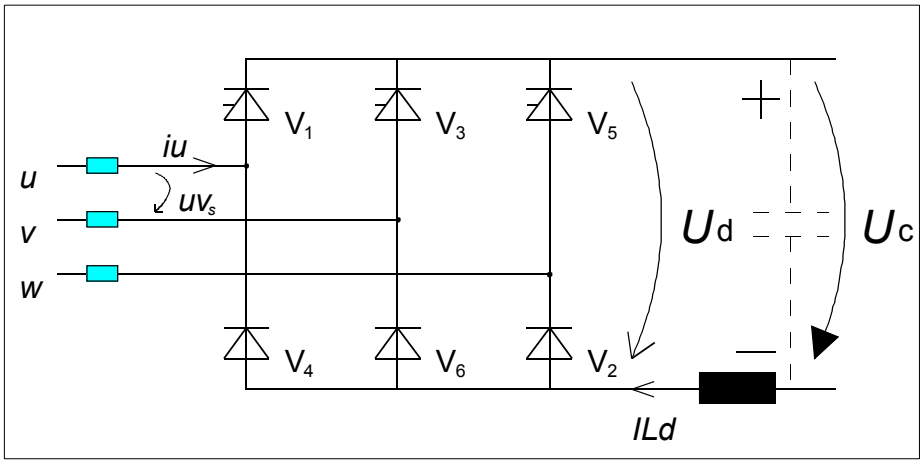


Figure 1-3 Half-controlled rectifier bridge

The conducting thyristors each carry the current for 120°. This period involves one upper-leg thyristor and one lower-leg diode, so the output voltage (U_d) consists of 60° sections of sequential line-to-line voltages.

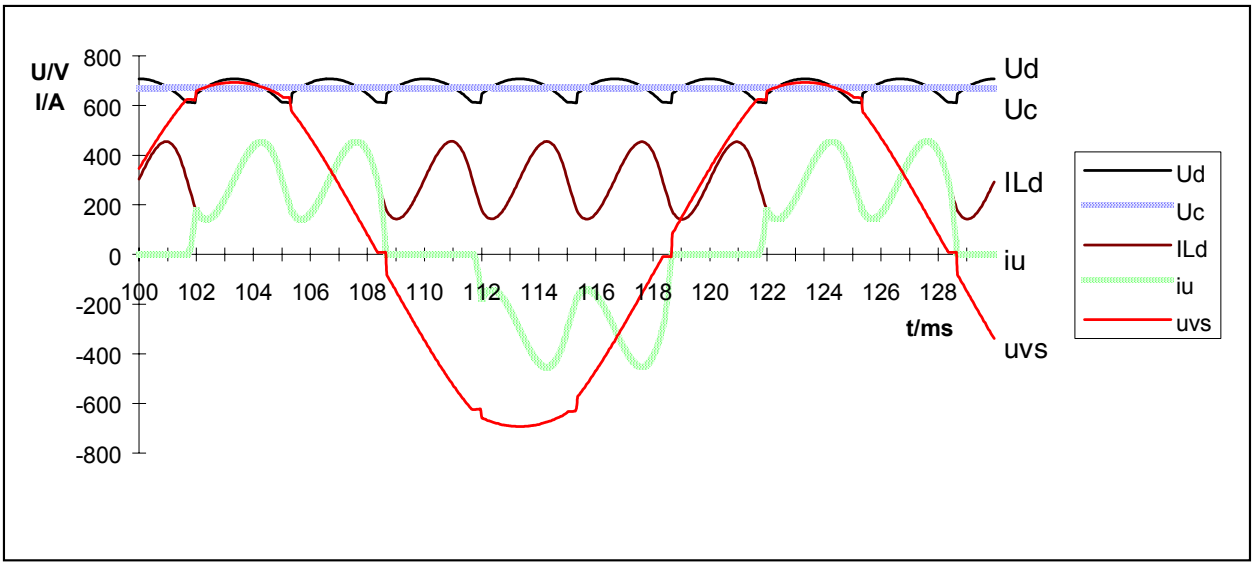


Figure 1-4 Diode Supply Unit voltages and currents in normal mode

The six-pulse function of a diode-thyristor bridge is different from a six-pulse thyristor bridge. The firing angle can be controlled only with low discontinuous current. This is why the charging is made with low steps starting from 170°. There are two modes in the firing pulse control: Charging mode and normal mode.

During charging mode, a single pulse is given during each 120° period. In normal mode, the thyristors are fired twice during each 120° period (see *Figure 1-5*). The firing angle is 0° in normal mode, meaning that

the bridge operates as a 6-pulse diode bridge.

The Diode Supply Unit is only rectifying the voltage. No braking power can be converted back to the network.

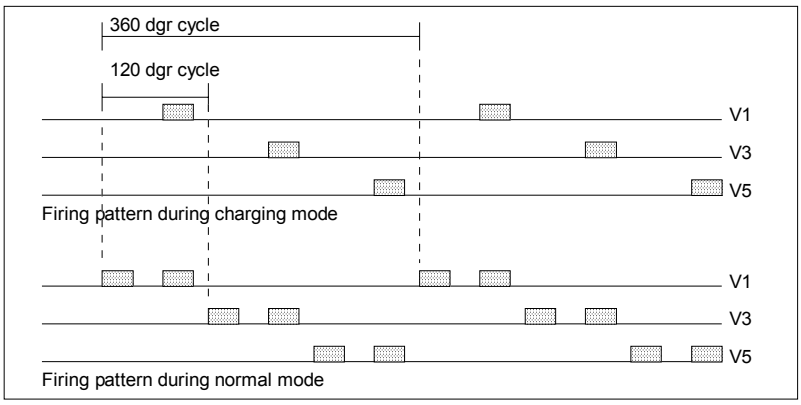


Figure 1-5 Firing pattern during charging and normal mode

With a half-controlled bridge and sweeping firing angle, neither charging resistors, - diodes nor - contactors are needed.

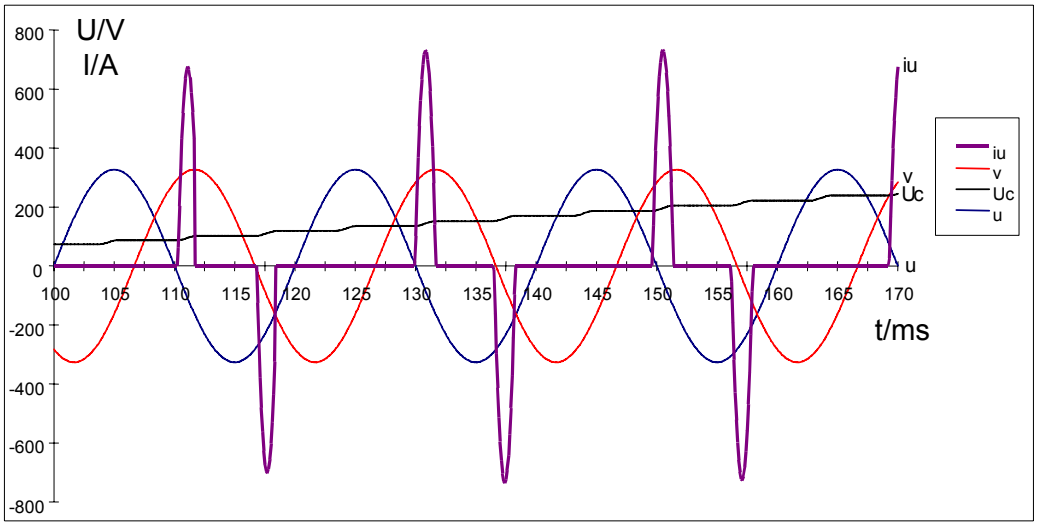


Figure 1-6 Line voltages, Uc voltage and one line current in charging mode

DSU System Configuration

The Diode Supply Unit is configured in each application by 8-way DIP switches S1 and S2 on the control board, NDSC. The meaning of each bit is described in *Chapter 2 – Commissioning the Supply Section with DSU*.

Non-Redundant 12-Pulse System

The Diode Supply Units can be configured in 6-, 12- or 24-pulse systems. If any of the parallel units fails, all units will trip. Typically, the fault signals are wired to each other by hardware or by software through an overriding control system.

Charging of DC link capacitors can be made with a single unit or by switching the ON signal to each parallel unit simultaneously.

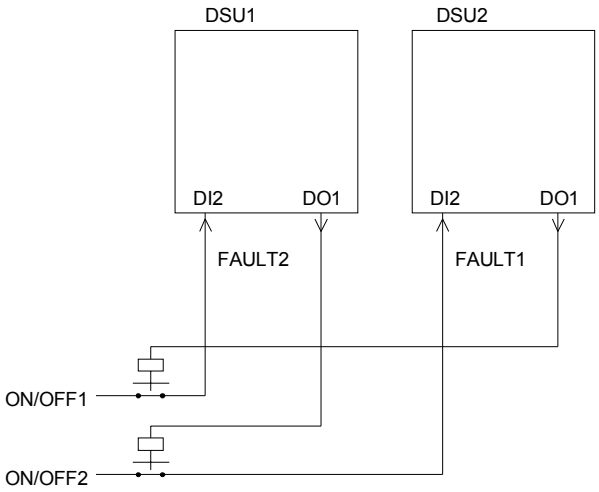


Figure 1-7 Example of a non-redundant 12-pulse Supply Unit with hardware tripping

Redundant 12-pulse Supply

The redundant 12-pulse supply enables the use of one half of the supply independently, thus minimising the process downtime in case of failure. Inspite of a failure in one of the unit, the other units will continue operating as a 6-pulse supply.

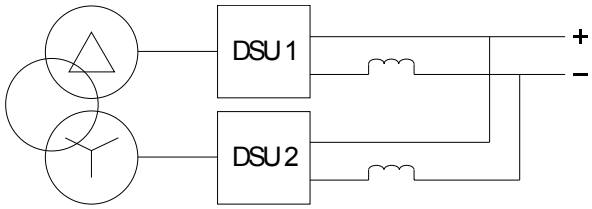


Figure 1-8 12-pulse supply equipped with DSU modules

Voltages from the Supply Section to the Control Devices

The inverter units convert auxiliary voltages (+24 V) from the DC busbar. The +24 V is required by the electronic boards, for example option modules and I/O.

Supply for the Diode Supply Unit cooling air fan(s) is taken from main AC circuit through contactor and circuit breaker.

The 230 VAC for the digital inputs of the DSU board is taken from a protection switch.

The emergency stop information to the drive sections goes from 24 VDC power supply through an emergency stop relay.

Chapter 2 – Commissioning the Supply Section with DSU

Overview

This chapter describes the commissioning of an ACx 600 Supply Section that is equipped with the Diode Supply Unit (DSU).

WARNING! The work described in this chapter must only be carried out by a qualified electrician. The *Safety Instructions* on the first pages of this manual and in the Safety and Product Information manual (EN 3AFY 63982229) must be followed. Negligence of the safety instructions can cause injury or death.

Installation Check-list

The installation must be checked before commissioning the Supply Section. The table below refers the more detailed instruction.

Action	Information
☐ Check that the mechanical and electrical installation of the frequency converter is inspected and OK. ☐ Ensure that the insulation resistance of the assembly is checked according to the instructions given in the installation manual.	For ACS 600 MultiDrive see *ACS 600 MultiDrive Hardware Manual (63700118).* For ACS/ ACC 607/627 see *ACS/ ACC 607/627 Hardware Manual (61329005).* Refer to *installation check-list, Insulation Checks.*
☐ Ensure that the surroundings and inside of the cabinet are free from dust and loose objects (like cable trimmings and other waste left from the installation).	After the start, the cooling air fans may suck nearby loose objects into the unit. This might cause failure and damage the unit.

Checks with No Voltage Connected

The table below is a commissioning check-list for the Supply Section with no voltage connected.

Action	Information
WARNING! Ensure that the disconnector of the supply transformer is locked to open position, i.e. no voltage is, or cannot be connected to the ACx 600 inadvertently. Check also by measuring that no voltage is connected.	
1. Air Circuit Breaker, Relays, Switches	
☐ If the Supply Section is equipped with an air circuit breaker, check the current trip levels of the air circuit breaker. **General rule** Ensure the selectivity condition is fulfilled i.e. the breaker trips at a lower current than the protection device of the supplying network, and that the limit is high enough not to cause unnecessary trips during the intermediate DC circuit load peak at start. **Long term current limit** Rule of thumb: Set to the rated AC current of the DSU module. **Peak current limit** Rule of thumb: Set to a value 3 - 4 times the rated AC current of the DSU module.	The trip levels have been preset at the factory. In most applications there is no need to change these settings.
☐ Check the settings of the relays for the emergency stop circuit.	See the circuit diagrams delivered with the device.
☐ Check the settings of the time relays.	See the circuit diagrams delivered with the device.
☐ Check the settings of other relays.	See the circuit diagrams delivered with the device.
☐ Check the settings of the breakers/switches of the auxiliary circuits.	See the circuit diagrams delivered with the device.
☐ Check that all breakers/switches of the auxiliary circuits are open.	
2. Power Supply Board SDCS-POW-1 (inside the Diode Supply Unit module)	
☐ Check that the position of switch SW1 corresponds to the right input voltage to the board (230 V or 115 V).	See the circuit diagrams delivered with the device: Auxiliary control voltage transformer.

Action | **Information**

3. Control Board NDSC-01 (inside the Diode Supply Unit module)

☐ Check the position of the DIP switch S1.

8-way DIP Switch S1 Positions (1 = ON, 0 = OFF)								Setting
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	
								Supply voltage
0	0	0						400 VAC
1	0	0						450 VAC
0	1	0						500 VAC
1	1	0						600 VAC
0	0	1						690 VAC
								Current transformer
			0	0				300 A
			1	0				600 A
			0	1				2000 A
			1	1				3000 A
								Charging time
					0			500 ms
					1			1000 ms
								DDCS-link
							0	No supervision
							1	Supervised

No. 1 to 3: Nominal supply voltage of the Diode Supply Unit.

No. 4 and 5: Rating of the transformer feeding the current measurement circuit of the NDSC board. Transformer is optional. See circuit diagrams or the transformer rating plate for the current rating.

No. 6: Charging time for the intermediate circuit DC capacitors. 500 ms is suitable for most applications.

No. 8: Supervision of communication break of the DDCS link between the NDSC board and the overriding system.

☐ Check the position of the DIP switch S2 if DDCS communication is in use between the NDSC-01 board and the overriding control system.

8-way DIP Switch S2 Positions (1 = ON, 0 = OFF)								Node Address
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	
0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	1
0	1	0	0	0	0	0	0	2
1	1	0	0	0	0	0	0	3
0	0	1	0	0	0	0	0	4
1	0	1	0	0	0	0	0	5
0	1	1	0	0	0	0	0	6
1	1	1	0	0	0	0	0	7
0	0	0	1	0	0	0	0	8
								to 255

S2 defines the address of the Diode Supply Unit in a communication system.

See the circuit diagrams delivered with the device for the address.

If the overriding control system is AC80, the node address is between 1 and 8 inclusive.

If the overriding control system is APC2, the node address is 1.

4. Supply Tripping Circuit

☐ Check the operation of the supply transformer tripping option.

This is an optional feature. See the circuit diagrams delivered with the device.

Action	Information
5. Auxiliary Control Voltage Transformer	
☐ Check the wirings to the primary and secondary side terminals of the auxiliary control voltage transformer.	See the circuit diagrams delivered with the device for the correspondence between the wirings and the voltage levels.

Connecting Voltage to Auxiliary Circuits

The table below describes how to connect voltage to the Supply Section input terminals and to the Auxiliary Control Unit (ACU) for the first time.

Action	Information
WARNING! When voltage is connected to the input terminals of the Supply Section, the voltage will also be connected to the Auxiliary Control Unit and to auxiliary circuits - also to the ones wired to drive sections. Make sure that it is safe to connect voltage to the input terminals. Ensure that while the voltage is connected: • Nobody is working on the unit or circuits that are wired from outside into the cabinets. • The cabinet doors are closed.	
☐ Disconnect the 230 VAC cables that lead from the terminal blocks to the outside of the equipment and have not yet been checked, and the connections which may not yet have been completed.	
☐ Make sure that the main contactor/air circuit breaker cannot inadvertently be closed by remote control, e.g. by temporarily opening some connection in its control circuit.	
☐ Be ready to trip the main breaker of the supply transformer in case anything abnormal occurs.	
☐ Ensure that all cabinet doors are closed.	
☐ Close the main breaker of the supply transformer.	
☐ Close the main disconnecting switch of the Supply Section.	
☐ Close the main disconnecting switch of the auxiliary circuit.	

Checks with Voltage Connected to Auxiliary Circuits

The table below is a commissioning check-list for the Supply Section with voltage connected to the input terminals, and Auxiliary Control Unit (ACU).

Action	Information
WARNING! This section includes instructions for checking/measuring circuits under voltage. Only a qualified person is allowed to do the work. Appropriate and approved meter must be used. **IF IN DOUBT, DO NOT PROCEED!**	
☐ Ensure the actions described in section *Connecting Voltage to Auxiliary Circuits* are completed.	
☐ Measure phase voltages by using the switch and volt meter on the cabinet door.	This is an optional feature. See the circuit diagrams delivered with the device if included.
☐ Check the secondary side voltage of the auxiliary voltage transformer. Close the protection switch on the secondary side.	See the circuit diagrams delivered with the device.
☐ Close the breakers of the auxiliary circuits one by one. Check each circuit by • measuring correct voltage in terminal blocks • checking the operation of the devices connected to the circuit.	***Note:*** The cooling fan of the Diode Supply Unit (DSU) will start only after the voltage is connected to the DSU, and the DSU is operating.
☐ Check for the correct connection from an external auxiliary voltage source (e.g. from an Uninterrupted Power Supply, UPS) to the Auxiliary Control Unit.	This is an optional feature. See the circuit diagrams delivered with the device, if included.

Connecting Voltage to Diode Supply Unit

The table below describes how to connect voltage to the Diode Supply Unit and the DC busbars for the first time.

	Action	Information
	If the drive is equipped with a Braking Section, the following warning applies. **WARNING!** Before switching on power, make sure that sufficient inverter power is connected to the intermediate circuit. Rules of thumb: 1. The sum power of the connected inverters must be at least 30% of the sum power of all inverters. 2. The sum power of the connected inverters must be at least 30% of the rated power of the braking section ($P_{br.max}$). If the conditions above are not fulfilled, the DC fuses of the connected inverter(s) may blow or the braking chopper may be damaged.	
	**WARNING!** When connecting voltage to the Diode Supply Unit, the DC busbars will become live, as will all the inverters connected to the DC busbars. Make sure that it is safe to connect voltage to the Diode Supply Unit. Ensure that: • Nobody is working on the unit or circuits that are wired from outside into the cabinets. • All cabinet doors are closed.	
1.	First Voltage Switch-on for the Diode Supply Unit	
☐	If the Supply Section is equipped with an air circuit breaker, set the air circuit breaker current settings to 50% of the on-load values.	It is recommended to set relatively low current values at the first voltage switch-on.
☐	Ensure all cabinet doors are closed.	
☐	Be ready to trip the main breaker of the supply transformer if anything abnormal occurs.	
☐	Close the main disconnecting switch of the Supply Section. Close the main contactor/air circuit breaker of the Supply Section.	***Note:*** Keep the starting switch of the air circuit breaker in START position for at least 2 s to ensure that the cooling fan accelerates to nominal speed.
2.	Air Circuit Breaker Current Settings	
☐	Increase the air circuit breaker current settings to the on-load values.	

Checks with Voltage Connected to Diode Supply Unit

The table below is a commissioning check-list for the Supply Section after voltage is connected to the Diode Supply Unit and DC busbars.

	Action	Information
1.	Basic Checks	
☐	Check that the cooling fan in the Supply Section rotates freely in the right direction, and the air flows upwards.	A paper sheet set on the lower gratings stays.The fan runs noiselessly.
2.	Earth Fault Protection Based on an Insulation Monitoring Device	
☐	Check the tuning of the insulation monitoring device for the earth fault protection (Bender). The insulation monitoring device is tuned at the factory. If further tuning is required, see the *IRDH265 Operating Manual* by Bender (code: TGH1249).	This is an optional feature. See the circuit diagrams delivered with the device, if included (IRDH 265-x).
3.	Earth Fault Protection Based on a Summation Current Transformer	
☐	Check the tripping level of the earth fault protection summation current transformer. The current limit is set to 4 A at the factory. It can be changed via DDCS link. For more information on the limit setting see *Chapter 5 – Software Description*.	This is an optional feature. See the circuit diagrams delivered with the device, if included.

On-load Checks

The table below is a commissioning check-list for the loaded Supply Section.

	Action	Information
☐	Check the correct operation of the current meters.	This is an optional feature. See the circuit diagrams delivered with the device.
☐	Check the correct operation of the emergency-stop circuits.	This is an optional feature. See the circuit diagrams delivered with the device.

Chapter 3 – Earth Fault Protection (option)

Overview

This chapter contains the description of the earth fault protection solutions available for ACS 600 MultiDrive and ACS/ACC 607/627 (units -0760-3, -0930-5, 0900-6 or above) frequency converters. The settings required at the start-up are given in *Chapter 2 – Commissioning the Supply Section with DSU*.

Check from the circuit diagrams delivered with the unit if the Earth Fault Protection option is included and on which equipment the protection is based:

- overvoltage relay
- summation current transformer
- insulation monitoring device

Note: With other commercial Earth Fault Protection solutions, see the manufacturers description.

Overvoltage Relay, Floating Network

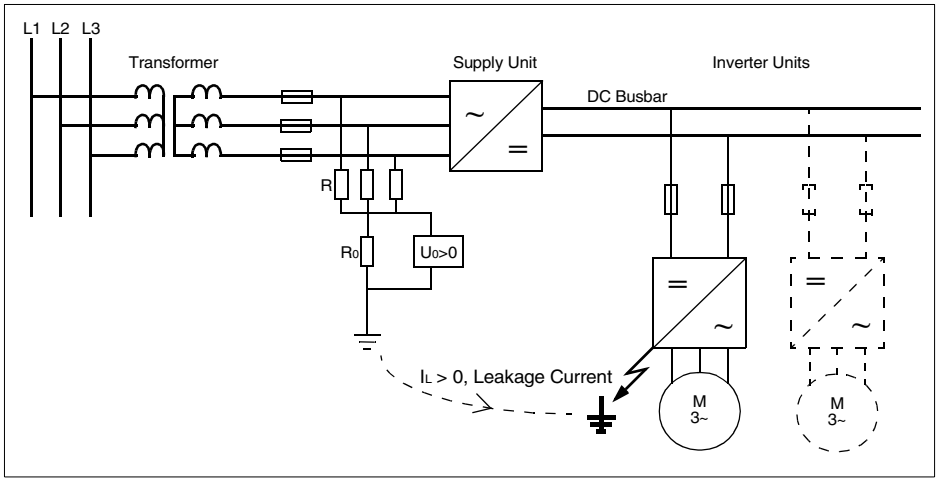


Figure 3-1 Overvoltage relay, floating network

Description

If the neutral point of the transformer is not available, earth fault supervision is implemented by means of an artificial neutral point achieved with three resistors R, connected to the 3-phase system at one end and together at the other end (see *Figure 3-1*). This resistor assembly is installed inside the ACx 600.

An overvoltage relay is used to detect an earth current through resistance R_0 that is connected between the artificial neutral point and earth.

In Case of an Earth Fault In case of an earth fault, a LED on the overvoltage relay illuminates. Depending on the connection, the overvoltage relay controls the main contactor or air circuit breaker open or generates a warning via the control board NDSC.

Insulation Monitoring Device, Floating Network

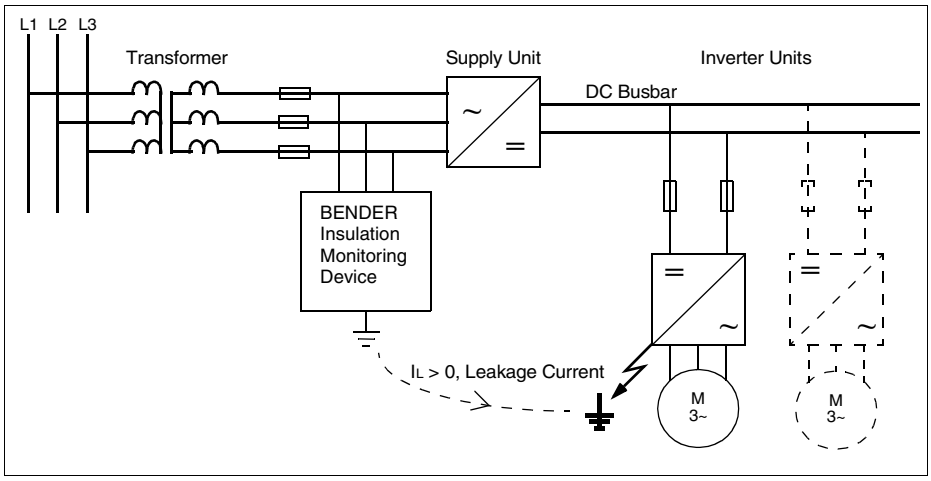


Figure 3-2 Insulation monitoring device, floating network

Description The monitoring device is connected between the unearthed system and the equipotential bonding conductor (PE).

A pulsating AC measuring voltage is superimposed on the system (measuring principle *Adaptive Measuring Pulse, AMP* is developed by BENDER, patent pending). The measuring pulse consists of positive and negative pulses of equal amplitude. The period depends on the respective leakage capacitances and the insulation resistance of the system to be monitored.

The setting of the response values and other parameters can be carried out via the function keys. The parameters are indicated on the display and stored in a non-volatile memory after setting.

By using Bender's insulation monitoring device, it is possible to set up two response values, ALARM1 and ALARM2. Both values have their own alarm LED, which illuminates if the reading is below these selected response values.

In Case of an Earth Fault An earth fault closes the measuring circuit. An electronic evaluation circuit calculates the insulation resistance which is indicated on an LC display or an external ohmmeter after the response time.

The alarm actions depend on the electric connection: for example ALARM1 may only give a warning and ALARM2 may trip the device.

Further Information

Further information about the insulation monitoring device is available in the *IRDH265 Operating Manual (code TGH1249)* published by the manufacturer, BENDER companies.

Current Transformer, System-Earthed Network

In a system-earthed network, the neutral point of the supply transformer is earthed solidly.

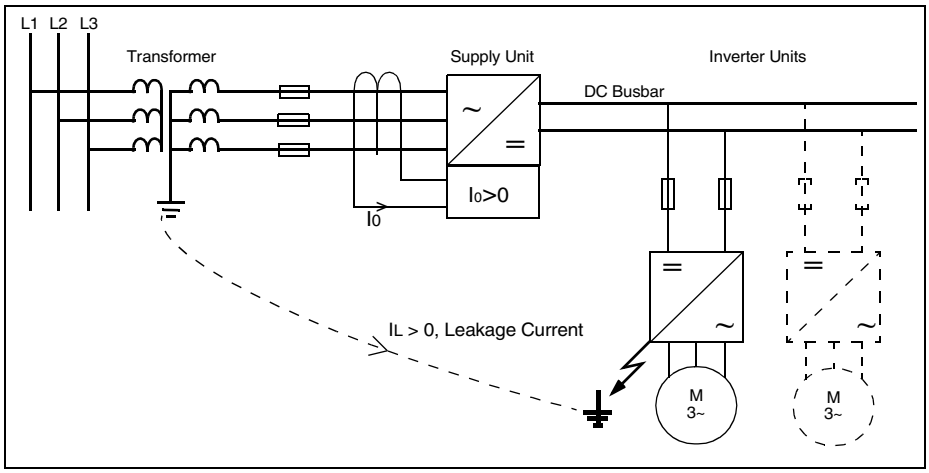


Figure 3-3 Current transformer, system-earthed network

Description

The earth fault protection in a system-earthed network is based on a summation current transformer, monitoring the sum of the three-phase supply currents. The transformer output is connected to the supply section Control Board NDSC.

In Case of an Earth Fault

In normal operation, the current sum is approximately zero. An earth fault leads to an unbalance in the 3-phase system and therefore to a current sum which is greater than zero. This current induces a current I_o in the current transformer. If I_o exceeds the tripping limit set in the software of the converter, the device is tripped. The fault signal F05 appears on the 7-segment display.

Chapter 4 – DSU Hardware Description

DSU Control Unit

The figure below shows the control unit connections.

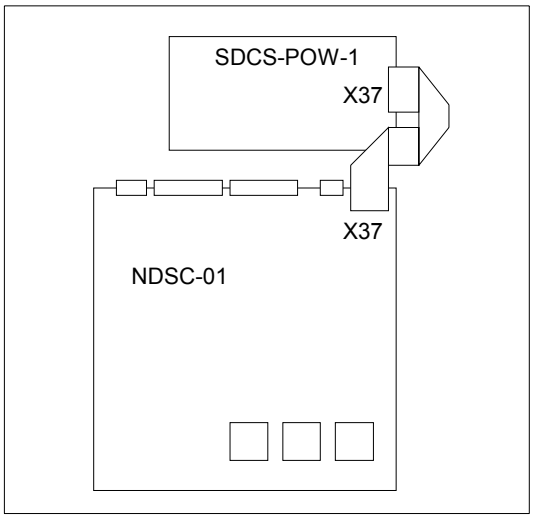


Figure 4-1 Control unit connections for DSU

Power Supply Board SDCS-POW-1

The SDCS-POW-1 is a power supply board for the DSU control unit. It provides all necessary DC voltages for the NDSC-01 board. The input voltage can be selected either to 230 VAC or 115 VAC (or to 190 ... 350 VDC). The figure below shows the instructions for the selection of the AC input voltage.

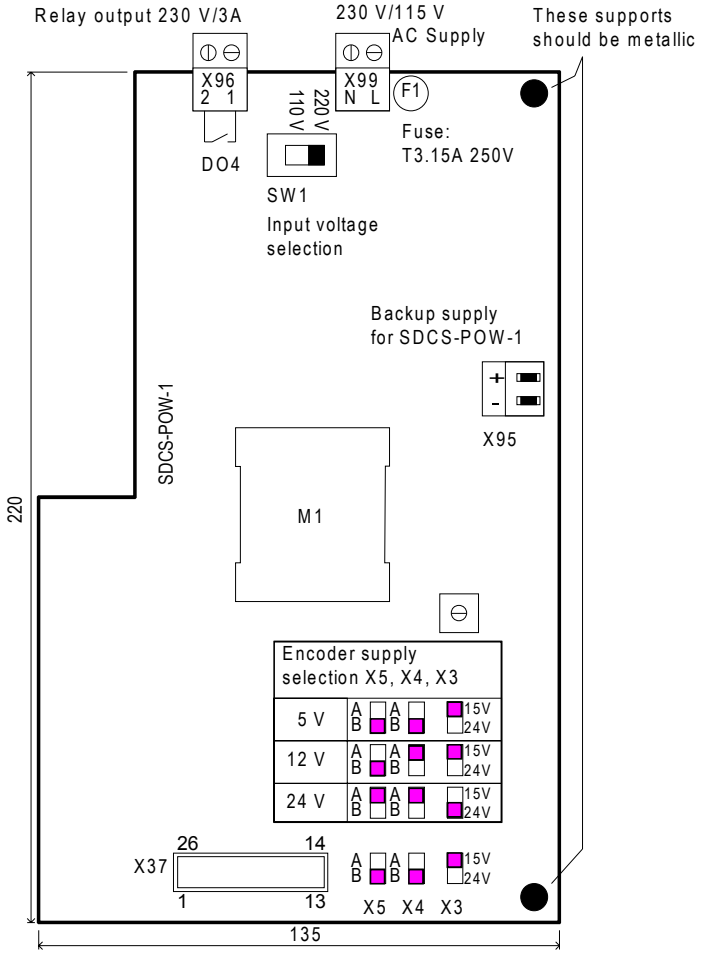


Figure 4-1 Layout of the power supply board SDCS-POW-1 (revision B or later) and jumper coding instructions

Control Board NDSC-01 The control board NDSC-01 comprises:

- 3 digital inputs (LED indication)
- 3 + 1 digital outputs (LED indication)
- DDCS communication link (LED indication)
- +24 VDC (500 mA) to supply auxiliary equipment (LED indication)
- isolated firing pulses
- voltage measurements; Uc (DC busbar voltage), Uac (supply voltage), synchronisation
- heatsink temperature measurement
- current measurement
- earth fault current measurement
- 7-segment display
- two 8-way DIP switches for application specific configuration

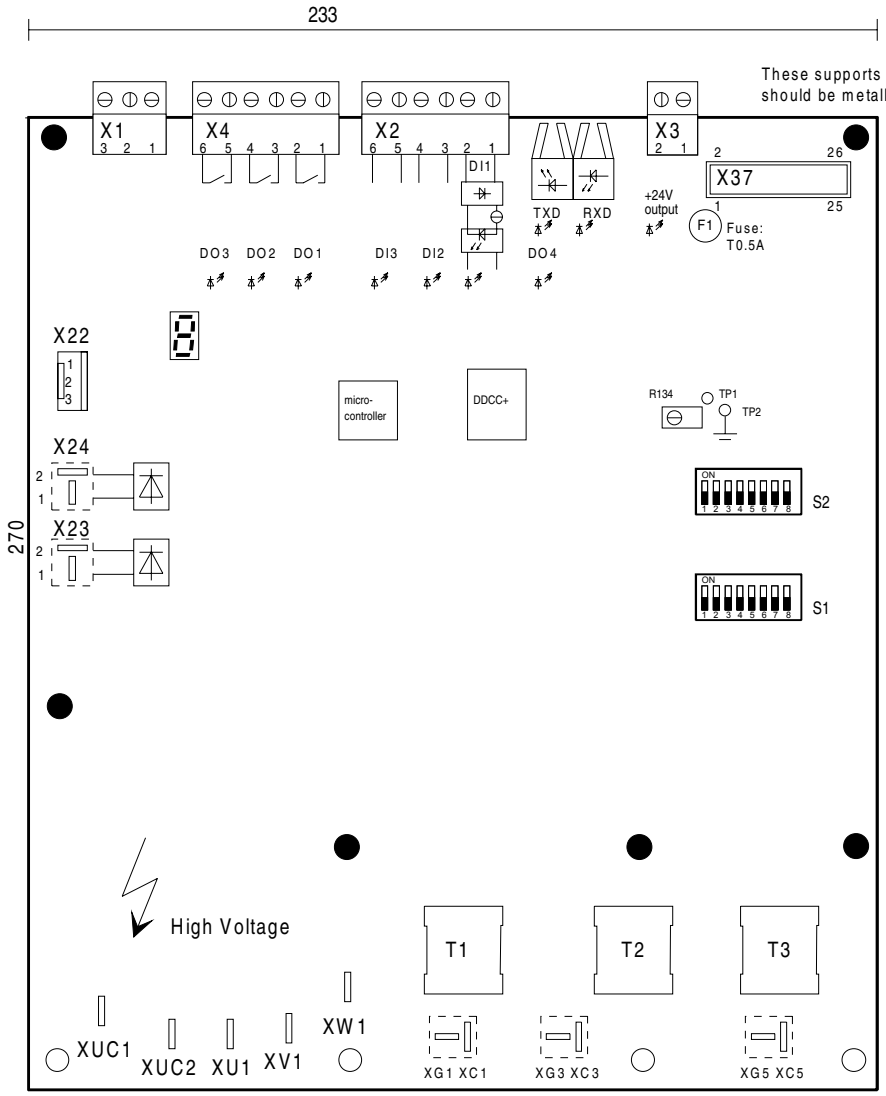


Figure 4-1 Layout of the control board NDSC-01

Digital Inputs and Outputs

The control board contains three digital inputs which are self-adaptive for voltage range 24 VDC ... 230 VAC. The channels are galvanically isolated from each other and the rest of the board. The filtering time constant for digital inputs is 10 ms. The status of each channel is indicated by LED's. The digital outputs are relays. The test voltage between the channels is 1500 VAC. The starting sequence through digital inputs/outputs is described in the *Chapter 5 – Software Description* see *Control Logic and Status*.

Connector X3 is an output of 24 VDC voltage (500 mA), which can be used for digital inputs or power supply for AMC or APC2 boards. This voltage is fuse protected and the status of the fuse is indicated by a LED.

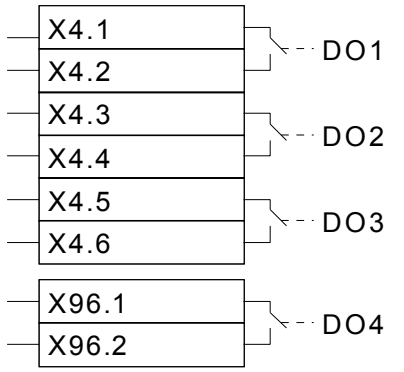
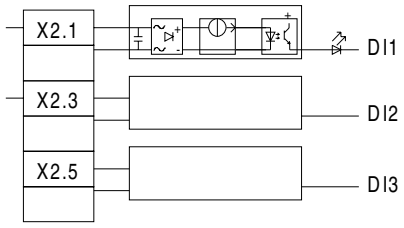
	Fault Running Main contactor on Alarm	3 digital outputs on NDSC: galvanically isolated with relays, contact rating 250 VAC/8 A 1 digital output on power supply board SDCS
	Main cont. and FAN ack. ON/OFF control Reset	3 digital inputs Input voltage: 24VDC...230 VAC

Figure 4-1 Definition of digital inputs (DI) and digital outputs (DO)

Measurements The control board contains high ohmic voltage measurements for supply voltages and DC-link voltage. The voltage level is lowered to an acceptable level with a 7 MΩ resistor chain.

Note: The main circuit actual voltage signals U1, V1, W1, Uc1 and Uc2 are not galvanically isolated.

The heatsink temperature is measured with an NTC sensor. Current measurement is optional as this information is not needed in control. The current transformer ratio for the software is defined by 8-way DIP switch S1.

Earth fault measurement is optional. A current transformer with transformation ratio 400/1 A is to be connected to X1 pins 1 and 2. If an other type of earth fault indication is used (Bender), a digital signal of 24VDC can be connected to X1 pins 1 and 3.

Gate Pulses The gate pulses for the three thyristors of the DSU bridge are generated through pulse transformers.

Communication The communication to the overriding system is handled via a DDCC+ ASIC. The board contains one communication channel. The status of the channel is indicated by LEDs (TXD, RXD).

7-Segment Display The status of the NDSC-1 board is shown on the 7-segment display one digit at a time. See *Fault and Alarm Table* in *Chapter 5 – Software Description*.

Chapter 5 – Software Description

Program Revision

This software description is compatible with the Diode Supply Unit program revision 1.02 or later. The Diode Supply Unit control program is stored in the PROM of the microcontroller on the NDCS-01 board. Parameters cannot be changed. The program revision code is visible on microcontroller chip.

Software Functions

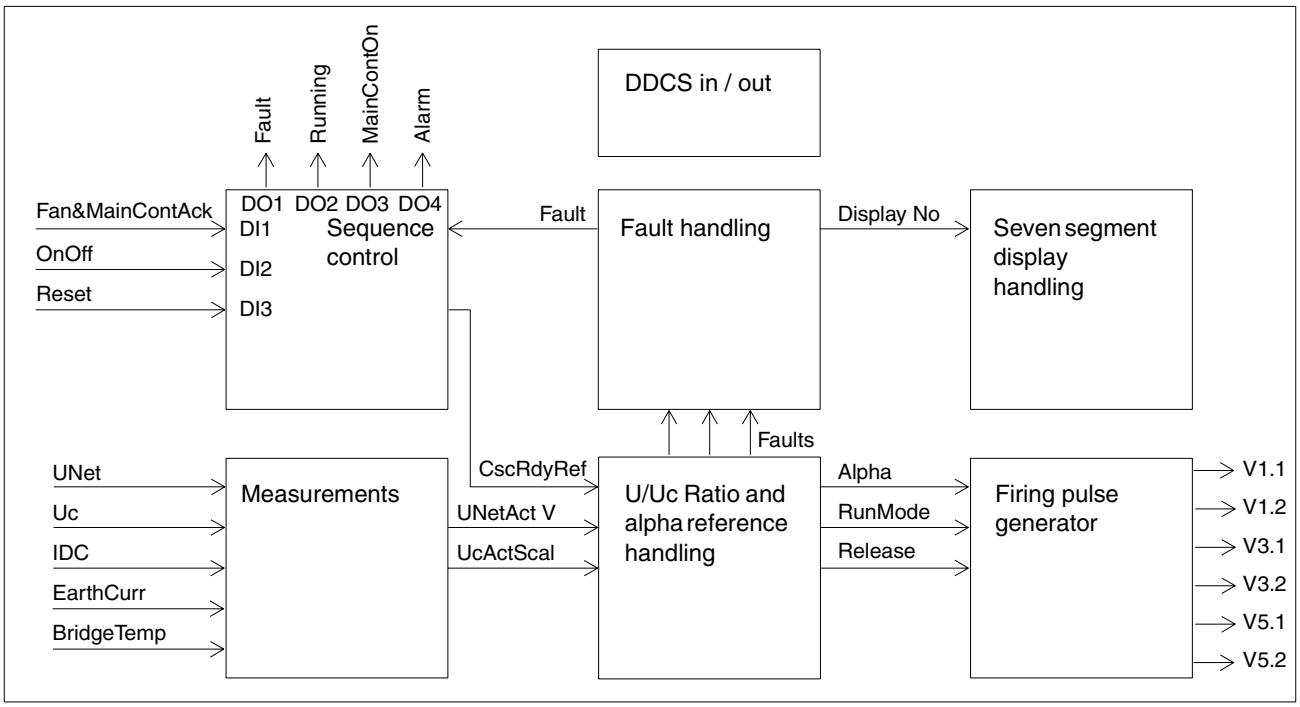


Figure 5-1 Block diagram of DSU software

Measurements

AC Voltage Measurement

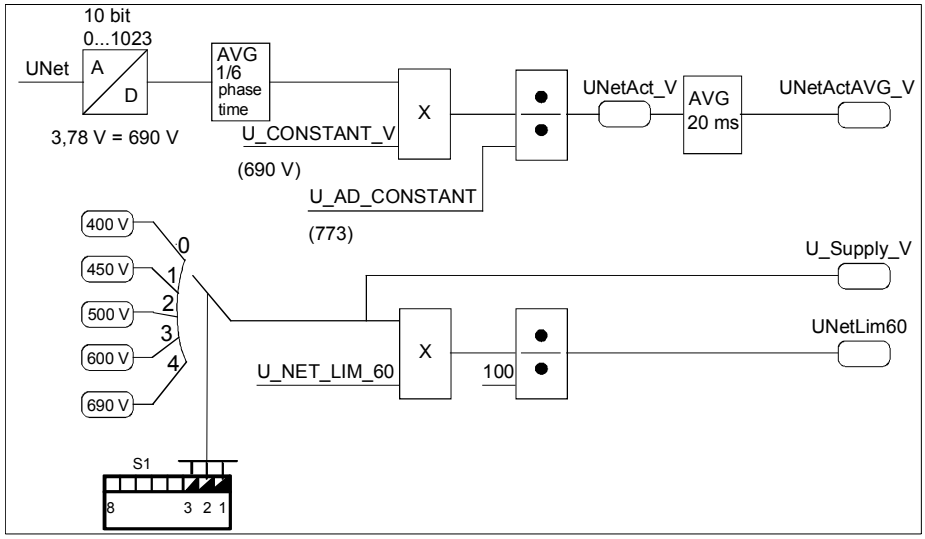


Figure 5-2 AC voltage measurement

Nominal AC voltage is chosen by 8-way DIP switch S1 on the control board NDSC (see *Checks with No Voltage Connected* in *Chapter 2 – Commissioning the Supply Section with DSU*). Low voltage alarm is 60% of the network nominal voltage.

Uc Voltage Measurement

Uc is the DC busbar voltage, see *Figure 1-3* in *Chapter 1 – Introduction*. The scaling is in accordance with the AC voltage.

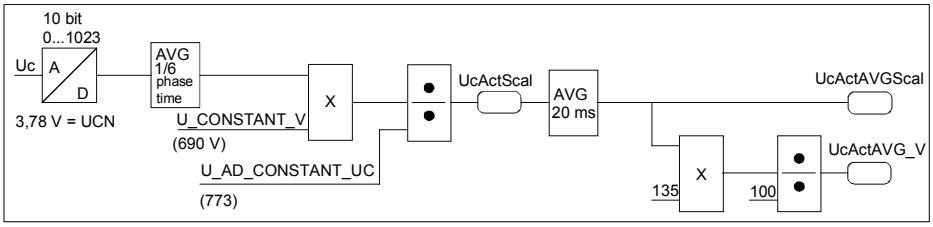


Figure 5-3 Uc voltage measurement

DC Current Measurement

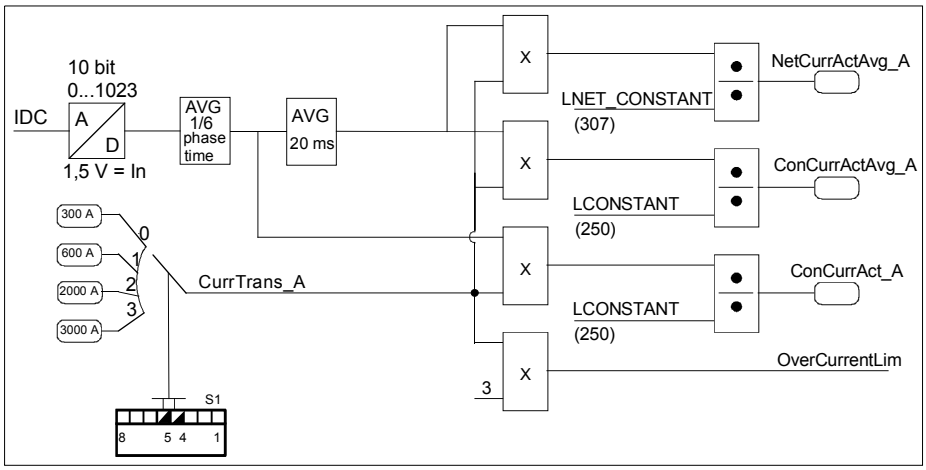


Figure 5-4 DC current measurement

DC current measurement is optional. The control does not need this function. If the current transformers are connected, the DC current can be measured and the DC power calculated. The nominal current is set by 8-way DIP switch S1 on the control board NDSC (see *Checks with No Voltage Connected* in *Chapter 2 – Commissioning the Supply Section with DSU*). The overcurrent tripping limit is three times the nominal value of the current transformer (= 300%).

P_{DC} Calculation

The DC power can be calculated only if the optional current transformers are connected. The power is calculated by multiplying the actual DC current and actual DC voltage as follows

$$P\_kW = \frac{ConCurrActAVG\_A \cdot UcActAVG\_V}{1000}$$

(See *Figure 5-3* and *Figure 5-4 .)*

The power calculation has 100 ms filtering.

Firing Angle Calculation

The firing angle calculation is based on the relation between Uc voltage and AC voltage; Uc/Unet (see *Figure 5-7)*. This relation is converted to firing angle, Alpha, using a conversion table. In DC-link charging mode Alpha is changing along a preset ramp. After the charging, in normal mode, Alpha is locked to 0° and the DSU acts as a diode bridge.

Charging

Charging is carried out by changing the URatioRef, see *Figure 5-7* . When 87% of the nominal Uc voltage is reached (= 1.35 · nominal supply voltage), the DSU changes from charging mode to normal mode. If UcRef reaches 89% before UcAct is 87%, the DSU forces the transition to normal mode. The charging time is set by 8-way DIP switch S1 (see *Checks with No Voltage Connected* in *Chapter 2 – Commissioning the Supply Section with DSU*) on the control board.

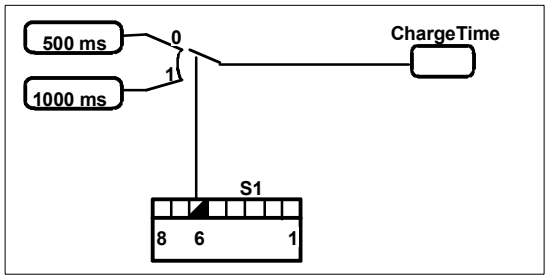


Figure 5-5 Charging time selection

The DSU changes to charging mode every time a UNET UNDER-VOLTAGE ALARM occurs (60% of nominal UNET) or when stop command OFF is set. During charging mode, RUNNING is not set.

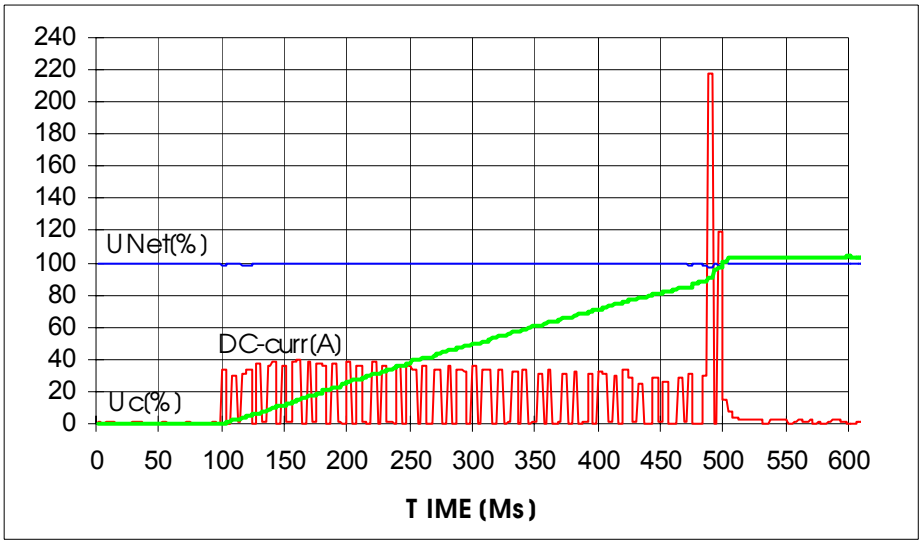


Figure 5-6 Charging the DC link

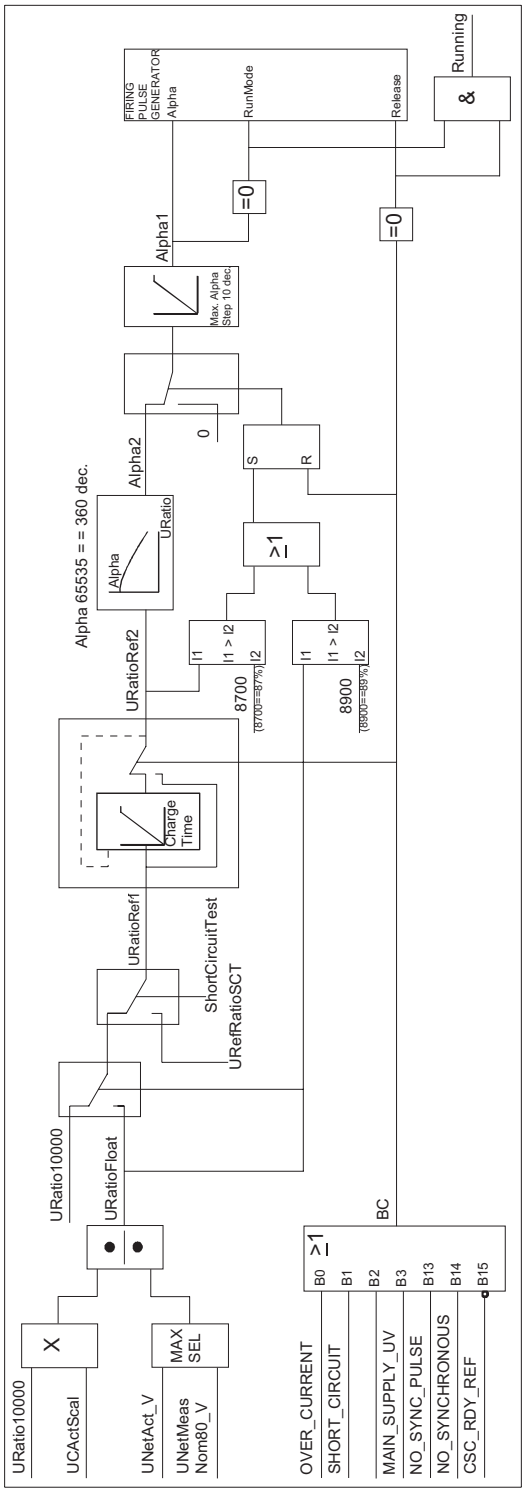


Figure 5-7 Firing angle generation

Control Logic and Status

The DSU is controlled through digital inputs. The rising edge of the signal activates the commands.

Local/Remote Control

The Remote Control can be set by 8-way DIP switch S1 (see *Checks with No Voltage Connected* in *Chapter 2 – Commissioning the Supply Section with DSU*) on the control board. The overriding system can enable or disable the ON command given from digital I/O. The RESET command can be given for the overriding system via the DDCS link.

Digital Inputs

DI1 **FAN&MAIN_CONT_ACK**

0 Fan is not ON, or main contactor is open

1 Fan is ON and main contactor is closed

DI2 **ON/OFF**

0 STOP command

1 RUN command on the rising edge

DI3 **RESET**

1 Fault RESET on the rising edge

Digital Outputs

DO1 **FAULT**

0 No FAULT

1 FAULT is ON

DO2 **RUNNING**

0 DSU is stopped or it is in charging state

1 DSU operates as a diode bridge

DO3 **MAIN_CON_ON**

0 Main Contactor open

1 Main Contactor closed

DO4 **ALARM** (this relay output is on the power supply board)

0 No ALARM

1 ALARM

RDY_ON

0 FAULT is on

1 No FAULT

RDY_RUN

0 ON command, Main Contactor is open

1 ON command, Main Contactor closed

RUNNING

0 STOP or charging

1 Normal Mode

ALARM

0 No ALARM

1 ALARM is active

FAULT

0 No FAULT

1 FAULT

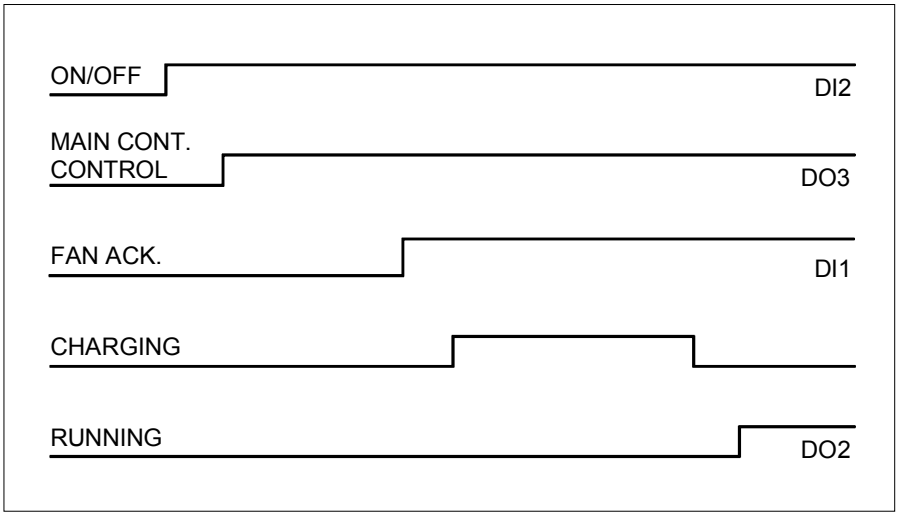


Figure 5-8 DSU starting sequence

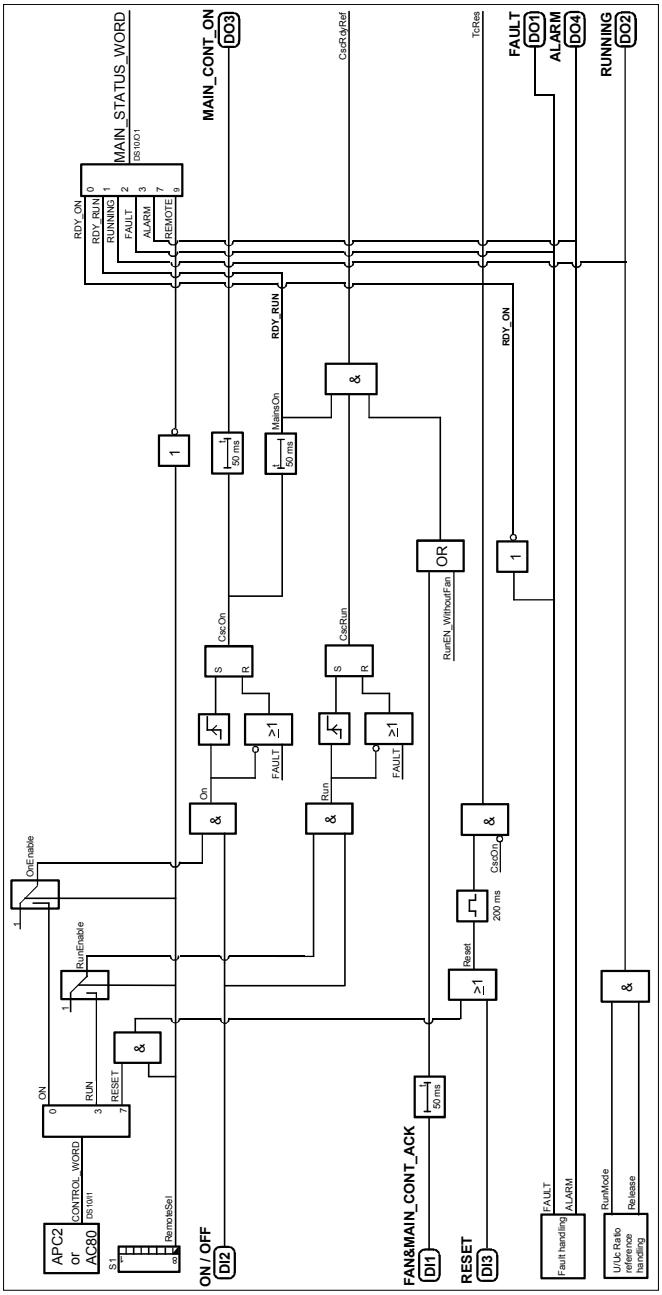


Figure 5-9 Control logic and status

Fault Diagnostics

The fault signals can be identified with the 7-segment display and fault and alarm words on the DDCS link. If no fault is active, the decimal point in the 7-segment display is ON. Any fault sets DO3 high.

Note: There is no Fault Logger on the board. If the power supply for the board trips, the current fault is lost.

Fault and Alarm Table

Table 5-1 Fault signals

Definition of the faults	Display code	Fault word bit No.
Short circuit	F 12	0
Over current	F 02	1
Auxiliary under voltage	F 01	2
Converter overtemperature	F 04	3
Earth-fault	F 05	4
No converter fan acknowledge	F 50	5
Type coding fault	F 17	8
DDCS link communication error	F 20	10
Not in sync	F 31	13

Table 5-2 Alarm signals

Definition of alarms	Display code	Alarm word bit No
Converter overtemp alarm	A 105	4
DDCS link communication alarm	A 120	5
Mains under-voltage alarm	A 118	10
Net asymmetry alarm	A 117	11
Aux. Under-voltage alarm	A 132	14
Uc ripple alarm	A 116	15
* Current asymmetry alarm	A119	13

(* in REV. C and later)

Fault and Alarm Logic

Net Supply Undervoltage

The firing pulses are inhibited when supply voltage is <60% of nominal voltage. The nominal voltage level is chosen with the 8-way DIP switch S1 (see *Checks with No Voltage Connected* in *Chapter 2 – Commissioning the Supply Section with DSU*) on the board. No Undervoltage Alarm is indicated if the ON/OFF status is OFF.

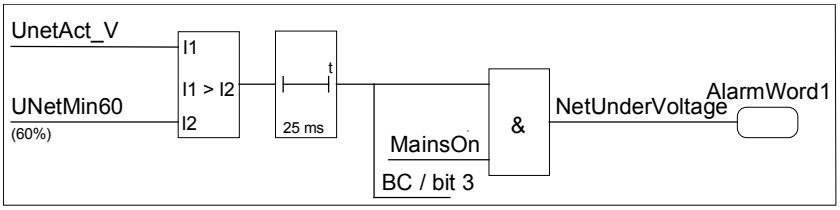


Figure 5-10 Uac undervoltage alarm

Auxiliary Voltage Supervision

The control system supervises two auxiliary voltage signals.

MPFS is the signal that indicates the status of the auxiliary voltages on the control board NDSC. When this signal is low, a fault is generated and the DSU trips.

MPFP is the supervision signal of the power supply board SDCS-POW-1. When mains supply to the board fails, the MPFP bit is set. If DSU is running when MPFP is set, a fault is generated and the DSU trips. If the DSU is not running when MPFP is set, only an alarm is indicated.

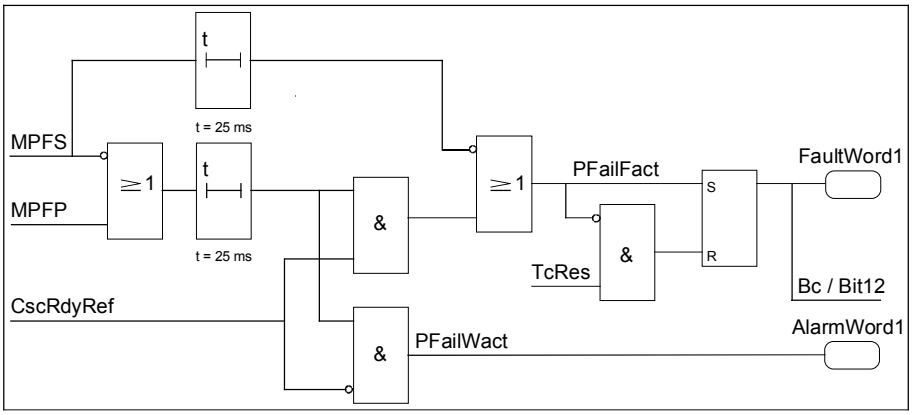


Figure 5-11 Auxiliary voltage fault, alarm and tripping

Table 5-3 Auxiliary voltage monitoring

Supply voltage	Undervoltage limit
+5V	+4.55V
+15V	+12.4V
-15V	-12.0V
+24V	+19V
+48V	+38V

DC Link Short Circuit Test

A short circuit test is carried out in the beginning of the charging. In the test, the thyristors are fired with 170° angle, 15 times. If the Uc voltage does not rise above the 2% limit during the short circuit test, a fault is generated and the Diode Supply Unit trips.

Note: Short circuit test does not necessarily prevent fuses from blowing.

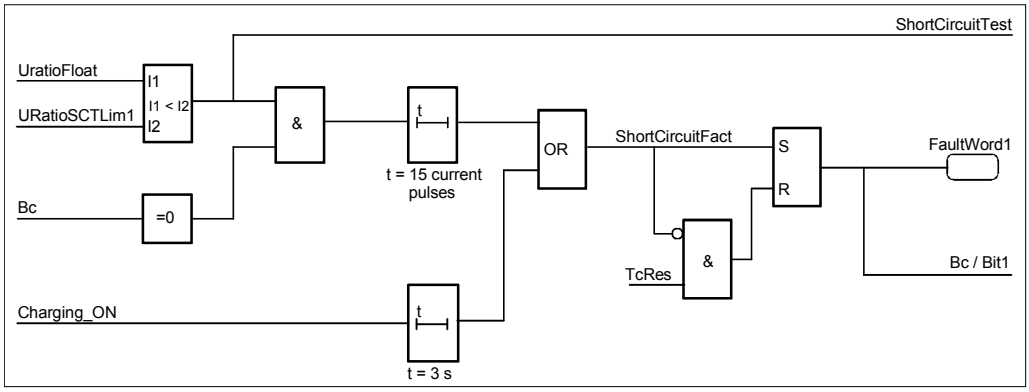


Figure 5-12 DC link short circuit in the start of charging

Contactor Acknowledge

The status of the main contactor or air circuit breaker and the fan contactor is supervised. In high power units the air flow and fan status are supervised with a pressure detector instead of the fan contactor.

When the main contactor is closed, the acknowledgement from the main contactor and the fan must be received within 12 seconds. The firing pulses are inhibited as long as the signal FAN&MAIN_CONT_ACK = 0. If the signal is still 0 after 12 seconds or if the signal is reset during running, the firing pulses are inhibited and a fault is generated and the DSU trips.

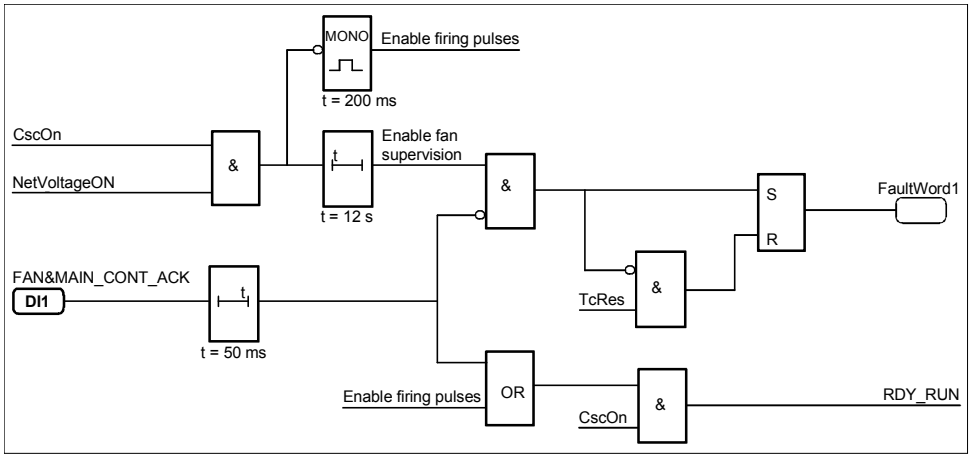


Figure 5-13 Supervision of the main contactor and fan

Temperature Supervision

The bridge heatsink temperature is measured with a NTC sensor. The tripping limit is 95°C and the alarm limit is 85°C.

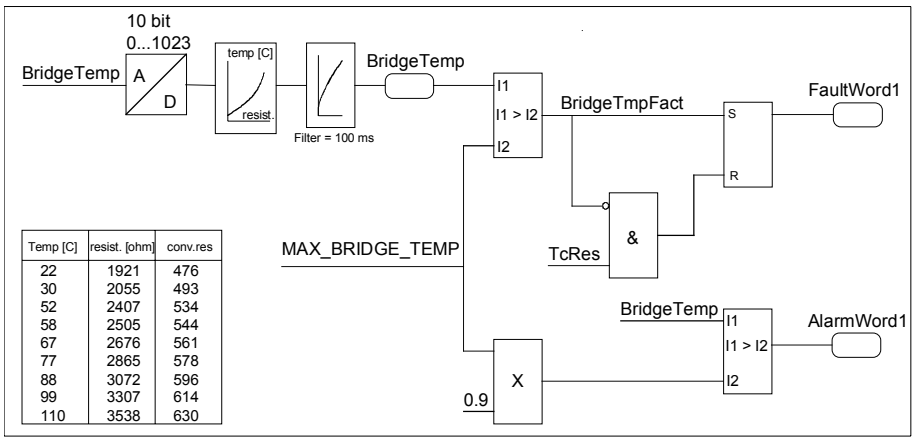


Figure 5-14 Temperature supervision

Earth Fault Current

The transformation ratio of the current transformer is 400/1 A. The measuring circuit is tuned so that 4 A current in the primary side of the transformer generates 0.5 V voltage in the input of the A/D-converter.

If the DSU is connected to an overriding system (APC2/AC80), the tripping limit (**EarthFaultLvl**) and delay time (**EarthFaultDly**) can be changed.

Limits

EarthFault	Lvl = 4...30	(== 4...30 A)
EarthFault	Dly = 10...10 000	(== 10...10 000 ms)

Initial values

EarthFault	Lvl = 4	(==4 A)
EarthFault	Dly = 20	(== 20 ms)

Note: This function is highly sensitive to the capacitive currents generated by ACS 600 MultiDrive inverters!

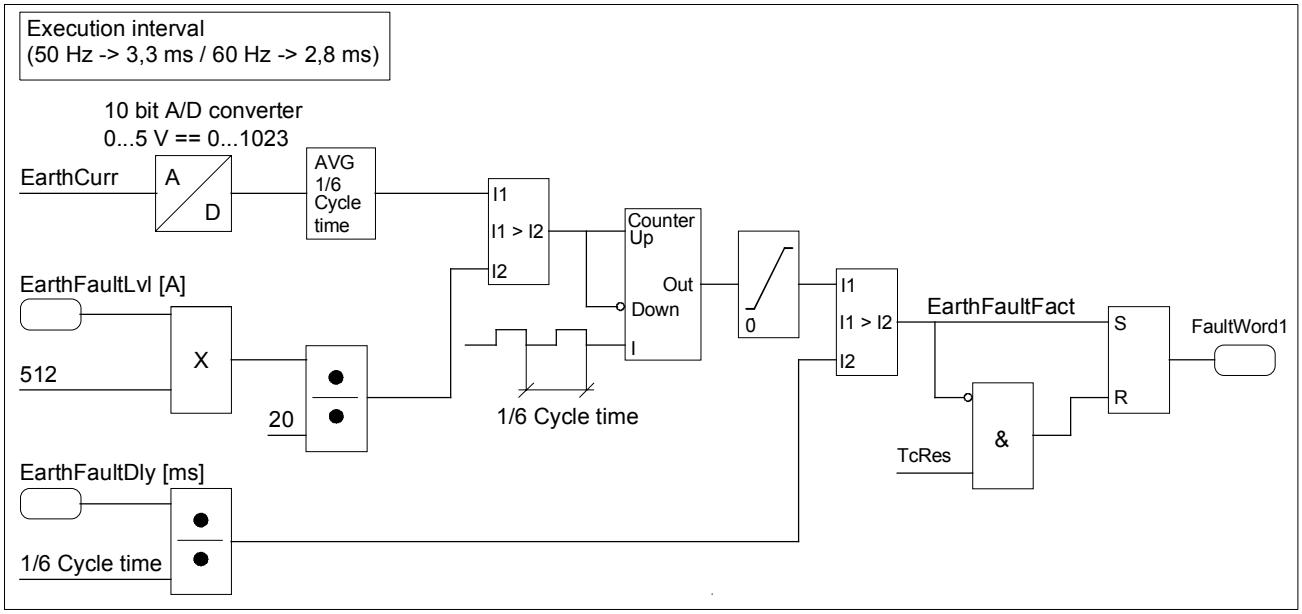


Figure 5-15 Earth fault current supervision

Synchronisation

The three line voltages are measured through high ohmic resistors. The measured signals pass filters of 60° and 120°, and the synchronisation is wired to the NMI input of the processor. The principle is capable to identify the phase sequence of the network. The synchronisation interrupt is inhibited when the network is not connected.

The software is supervising the synchronisation signals and the length of the cycle.

1. If synchronisation is failing during the OFF state, the firing pulse release is inhibited (Bc / Bit14 = 1)
2. If synchronisation is failing during RUNNING, the firing pulses are inhibited after 100 ms delay. This keeps the DSU running during short network breaks (Bc / Bit13 and Bit14 = 1)
3. If four consecutive cycle length measurements differ more than 8°, the firing pulses are inhibited.
4. The actual Synchronisation Fault is generated, when one of the conditions above is active, the main contactor is closed and there is no Main_Supply_Undervoltage (see *Figure 5-16*).

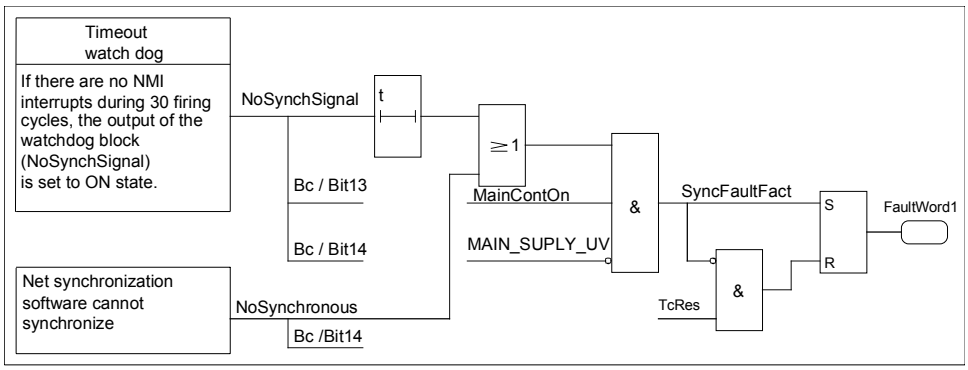


Figure 5-16 Synchronisation supervision

Net Asymmetry Alarm

The average network voltage is measured between two consecutive firings. If there is more than 10% difference between the two measurements and this difference has been measured more than 5 times during a 200 ms cycle, a net asymmetry alarm is generated.

Uc Ripple Alarm

The average Uc voltage is measured between two consecutive firings. If there is more than 10% difference between the two measurements and this difference has been measured more than 5 times during 200 ms cycle, Uc Ripple Alarm is generated. The Uc Ripple Alarm is generated under the following conditions:

1. DSU is RUNNING
2. Uc ripple more than 10%
3. No Net Asymmetry Alarm

One possible reason for the Uc Ripple Alarm is that a branch fuse in one leg of the supply bridge has blown.

Current Asymmetry Alarm (In REV. C or later)

The purpose of this function is to indicate the blowing of a branch fuse in the supply bridge in 12-pulse configurations. The indication is based on the asymmetry of the rectified line current (current bubbles). When a branch fuse blows in one leg of the bridge, there is a 120° “hole” in the rectified total line current (see *Figure 5-17*). In DSU, the DC-current is measured as an average of 1/6 of the net cycle (ConCurrAct_A) and the whole net cycle (ConCurrActAVG_A).

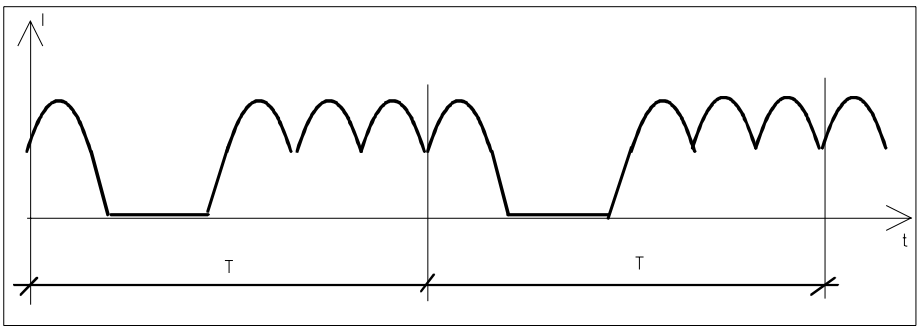


Figure 5-17 DC current when one branch fuse has blown, two current bubbles are missing

Conditions for the Current Asymmetry Alarm

- DSU is in Normal Mode (RUNNING)
- the actual average current (ConCurrActAVG_A) is > 25% of the nominal current of the used current transformer
- one of the current bubbles (1/6) falls below 5% of the nominal value of the used current transformer 6 times during a 200 ms cycle.

DDCS Communication

Communication supervision is activated by an 8-way DIP switch S1 (see *Checks with No Voltage Connected* in *Chapter 2 – Commissioning the Supply Section with DSU*) on the control board NDSC.

Communication Fault is generated, when the Diode Supply Unit has received the first valid DataSet message and if no valid DataSet messages have been received in 2 seconds after that.

Communication Alarm is generated if

1. the initialisation of the DDCC+ASIC has not been successful after switched on power to the board.
2. Supervision is activated and no DataSet message has been received.

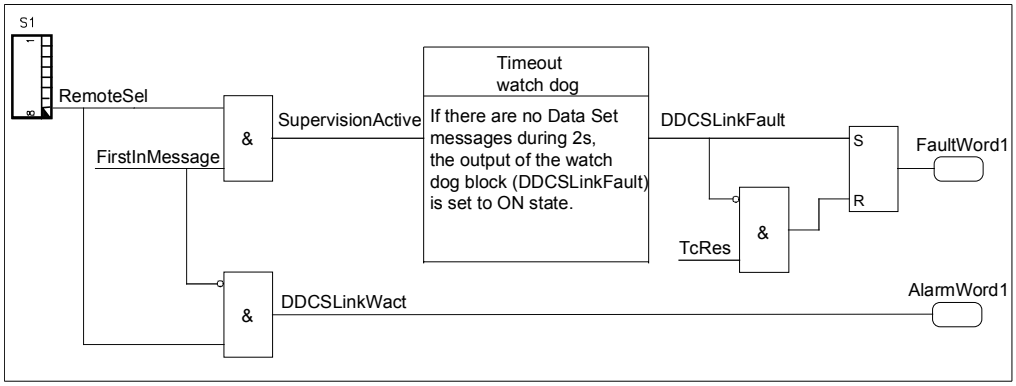


Figure 5-18 DDCC communication supervision

Overcurrent Fault

Current measurement is optional. The control system does not need the current value. The nominal value of the transformers is set by the 8-way DIP switch S1 on the control board NDSC. Overcurrent Fault is generated, when the current value is three times the nominal value of the transformer.

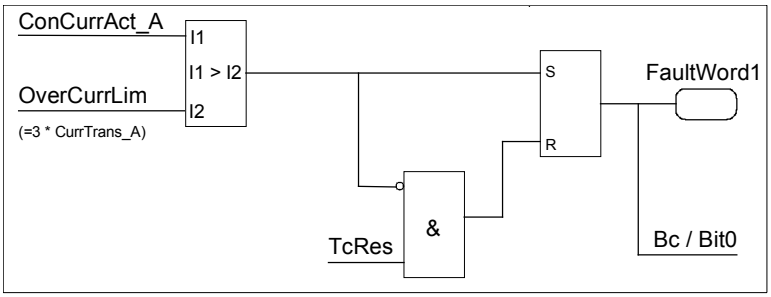


Figure 5-19 Overcurrent fault and tripping

Type Code Fault

The 8-way DIP switches S1 and S2 on the control board NDSC are configuring the control unit to the whole supply. The 8-way DIP switches must be set during power off state. The codes are read during the initialisation in power up. The reading procedure is repeated until five successive readings are similar. If the reading procedure is repeated more than 50 times, the recording is interrupted and Type Code Fault is generated.

DDCS Communication

The DDCS (Distributed Drives Communication Circuit) protocol employs datasets. The program of the Diode Supply Unit uses the datasets as described below. The node address is defined with DIP switch S2 on the NDSC board (see *Checks with No Voltage Connected* in *Chapter 2 – Commissioning the Supply Section with DSU*).

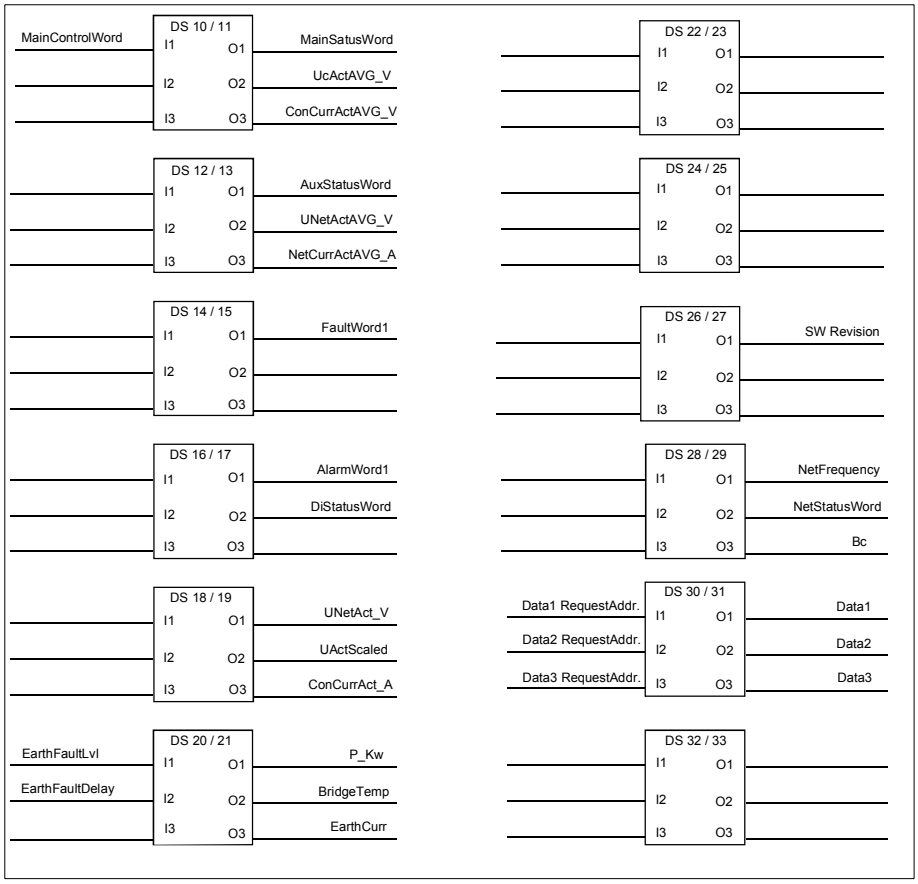


Figure 5-20 DDCS data sets

Signals to DSU

Table 5-4 Signals from overriding system to DSU

Signal name	Unit	DataSet No	DataSet I / O No	Description
MainControlWord		10	I1	Control word Bit 0 ON 1...2 Not in use 3 RUN 4...6 Not in use 7 RESET 8...15 Not in use
EarthFaultLvl	A	20	I1	Earth Fault tripping limit
EarthFaultDly	ms	20	I2	Earth Fault delay time

Signals from DSU

Table 5-5 Signals from DSU to overriding system

Signal name	DataSet No	DataSet I/O No	Description
MainStatusWord	10	O1	DSU Status Word Bit 0 RDY_ON 1 RDY_RUN 2 RUNNING 3 FAULT 4...6 Not in use 7 ALARM 8 Not in use 9 REMOTE (0==remote) 10...15 Not in use
AuxStatusWord	12	O1	Status of S1, S2 Bit 0...7 Switch S1 8...15 Switch S2
FaultWord1	14	O1	DSU Fault Word Bit 0 SHORT-CIRCUIT 1 OVER_CURRENT 2 AUX_UNDER_VOLTAGE 3 BRIDGE_OVER_TEMP 4 EARTH_FAULT 5 NO_C_FAN_ACK 6...7 Not in use 8 TYPE_CODING_FAULT 9 Not in use 10 DDCS_LINK_COM_ERROR 11...12 Not in use 13 NOT_IN_SYNCHRONISM 14...15 Not in use

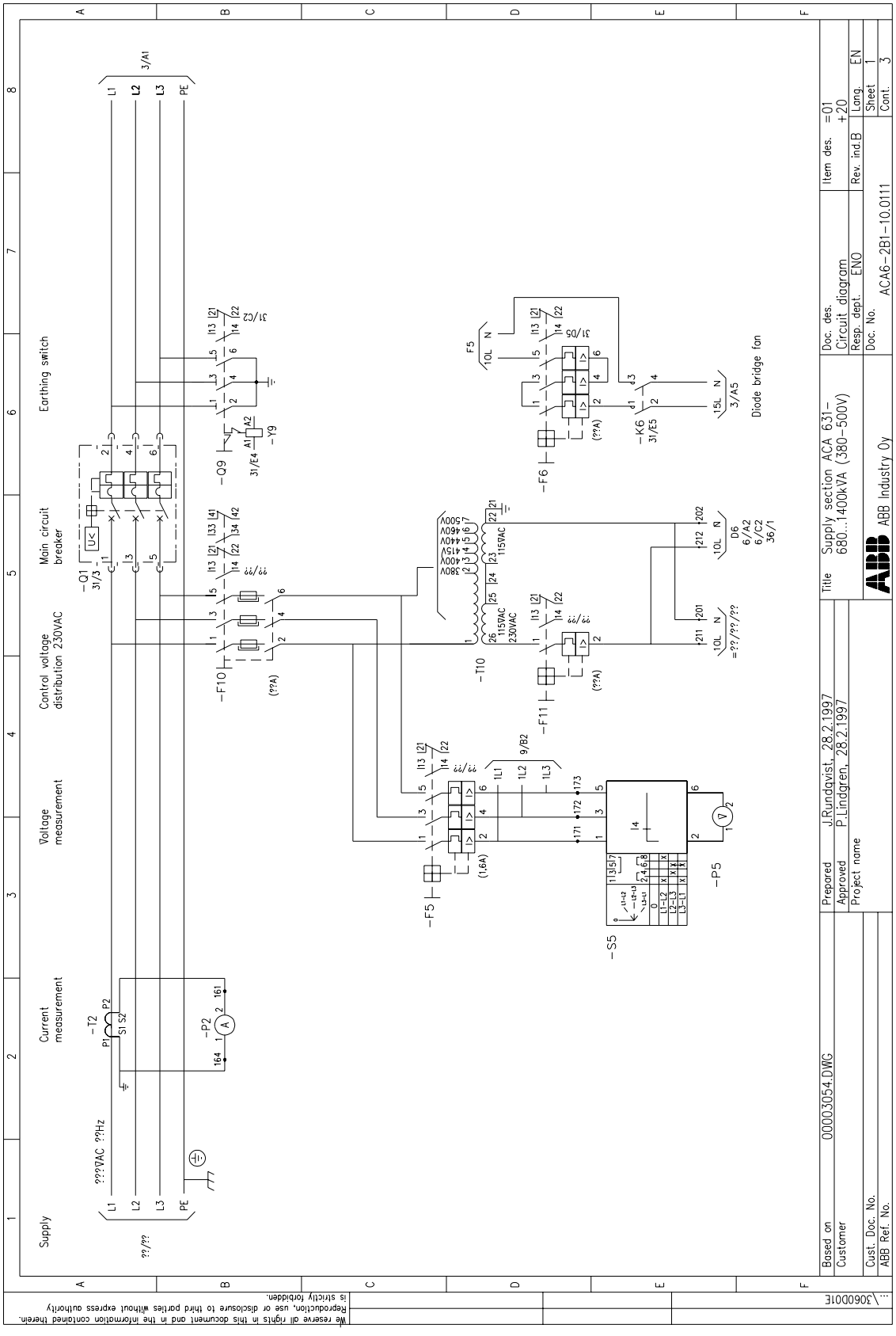
Signal name	DataSet No	DataSet I/O No	Description
AlarmWord1	16	O1	DSU Alarm Word Bit 0...3 Not in use 4 BRIDGE_OVER_TEMP_ALARM 5...9 Not in use 10 MAINS_UNDER_VOLT_ALARM 11 NET_ASYMMETRY_ALARM 13 CURRENT_ASYMMETRY_ALARM 14 AUX_UNDER_VOLTAGE 15 UC_RIPPLE_ALARM
DI_StatusWord	16	O2	Digital Input Status Bit 0 DI1 1 DI2 2 DI3 3...15 Not in use
Bc	28	O3	Internal Status Word 0 firing pulses released >0 pulses inhibited Bit 0 OVER CURRENT 1 SHORT CIRCUIT 2 Not in use 3 MAIN SUPPLY UNDERVOLT 4...11 Not in use 12 POWER FAIL 13 NO SYNC PULSE 14 NO SYNCHRONOUS 15 CONTROL RELEASE
NetStatusWord	28	O2	Status of synchronization 1 = direction not identified 2 = direction identified, not in sync. 4 = direction clockwise, sync. OK 8 = direction anticlockwise, sync. OK

Appendix A – Circuit Diagrams

Overview

The following pages include circuit diagrams of a supply section equipped with a Diode Supply Unit.

The circuit diagrams help in understanding the function of DSU. The diagrams do not necessarily match the actual wiring of each delivery. The wiring varies depending on power rating and the selected equipment. The circuit diagrams valid for each Supply Section are included in the delivery.


Supply
Current measurement
Voltage measurement
Control voltage distribution 230VAC
Main circuit breaker
Earthing switch
Diode bridge fan
Supply section ACA 631-680...1400kVA (380-500V)
ABB Industry Oy
ACA6-2B1-10.0111
Circuit diagram
Prepared J.Rundqvist, 28.2.1997
Approved P.Lindgren, 28.2.1997
Project name
00003054.DWG
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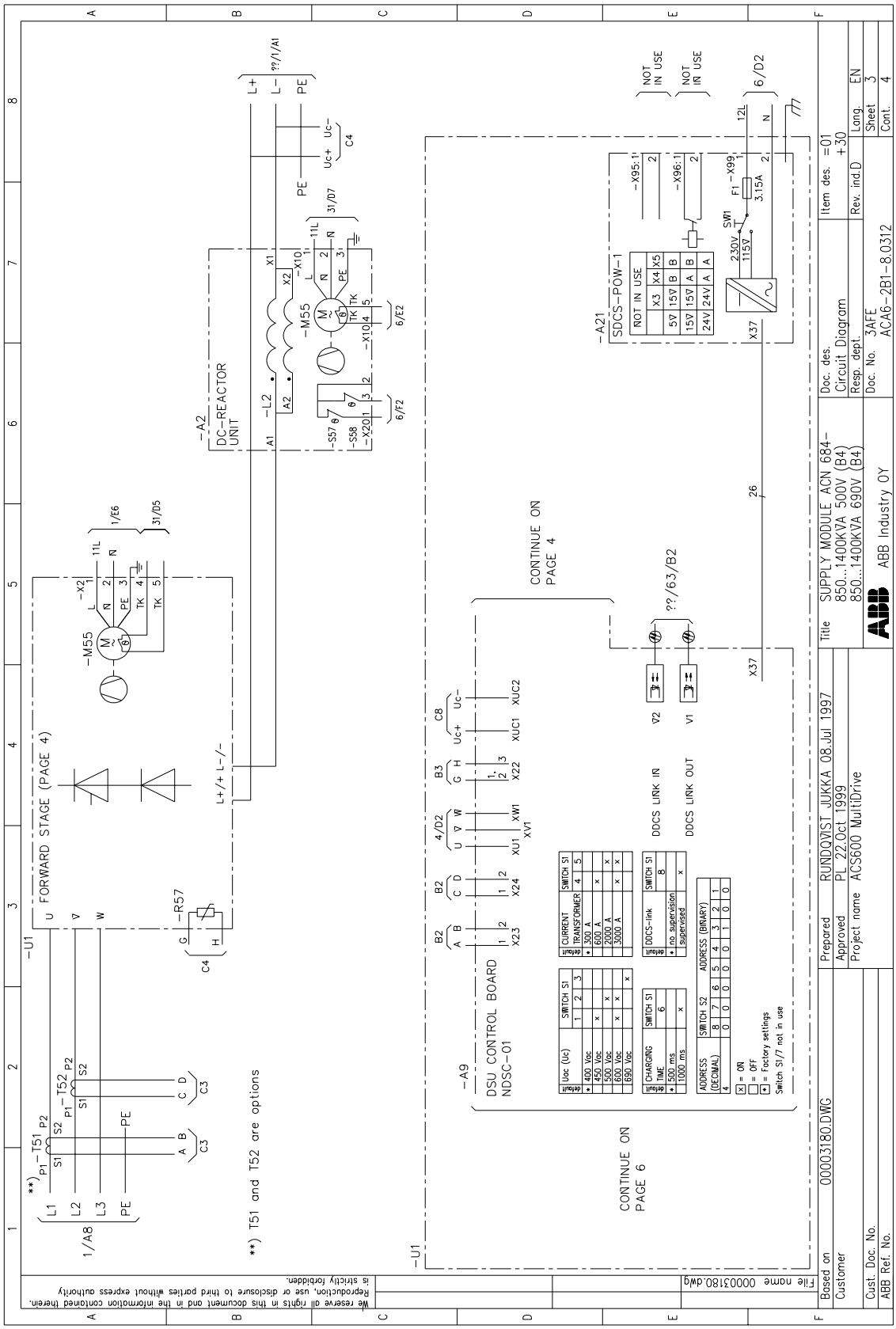
-U1
FORWARD STAGE (PAGE 4)
-A2
DC-REACTOR UNIT
-L2
-M55
-R57
-A9
DSU CONTROL BOARD NDSC-01
-A21
SDCS-POW-1
CONTINUE ON PAGE 4
CONTINUE ON PAGE 6
DDCS LINK IN
DDCS LINK OUT
SUPPLY MODULE ACN 684-
850...1400KVA 500V (B4)
850...1400KVA 690V (B4)
ABB Industry OY
ACA6-2B1-8.0312
**) T51 and T52 are options
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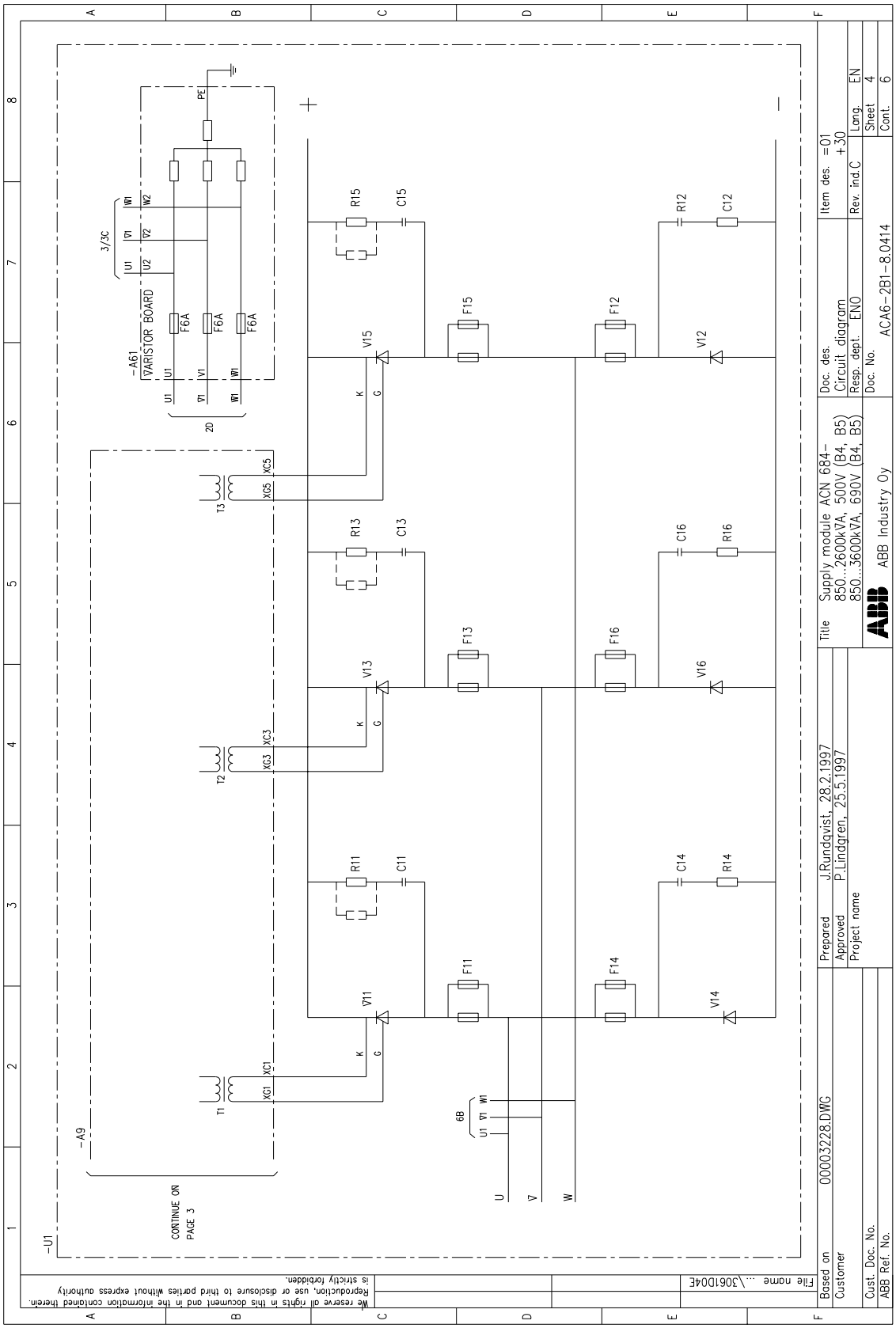
Supply module ACN 684-
850...2600kVA, 500V (B4, B5)
850...3600kVA, 690V (B4, B5)
ABB Industry Oy
ACA6-2B1-8.0414
Item des. =01 +30
Circuit diagram
Resp. dept. ENO
Rev. ind.C
Lang. EN
Sheet 4
Cont. 6
Prepared J.Rundqvist, 28.2.1997
Approved P.Lindgren, 25.5.1997
Project name
Based on 00003228.DWG
Customer
Cust. Doc. No.
ABB Ref. No.
File name ...\3061D04E
-A61 VARISTOR BOARD
F6A
-A9
CONTINUE ON PAGE 3
-U1
T1
T2
T3
V11
V12
V13
V14
V15
V16
F11
F12
F13
F14
F15
F16
R11
R12
R13
R15
R16
C11
C12
C13
C14
C15
C16
U
V
W
PE
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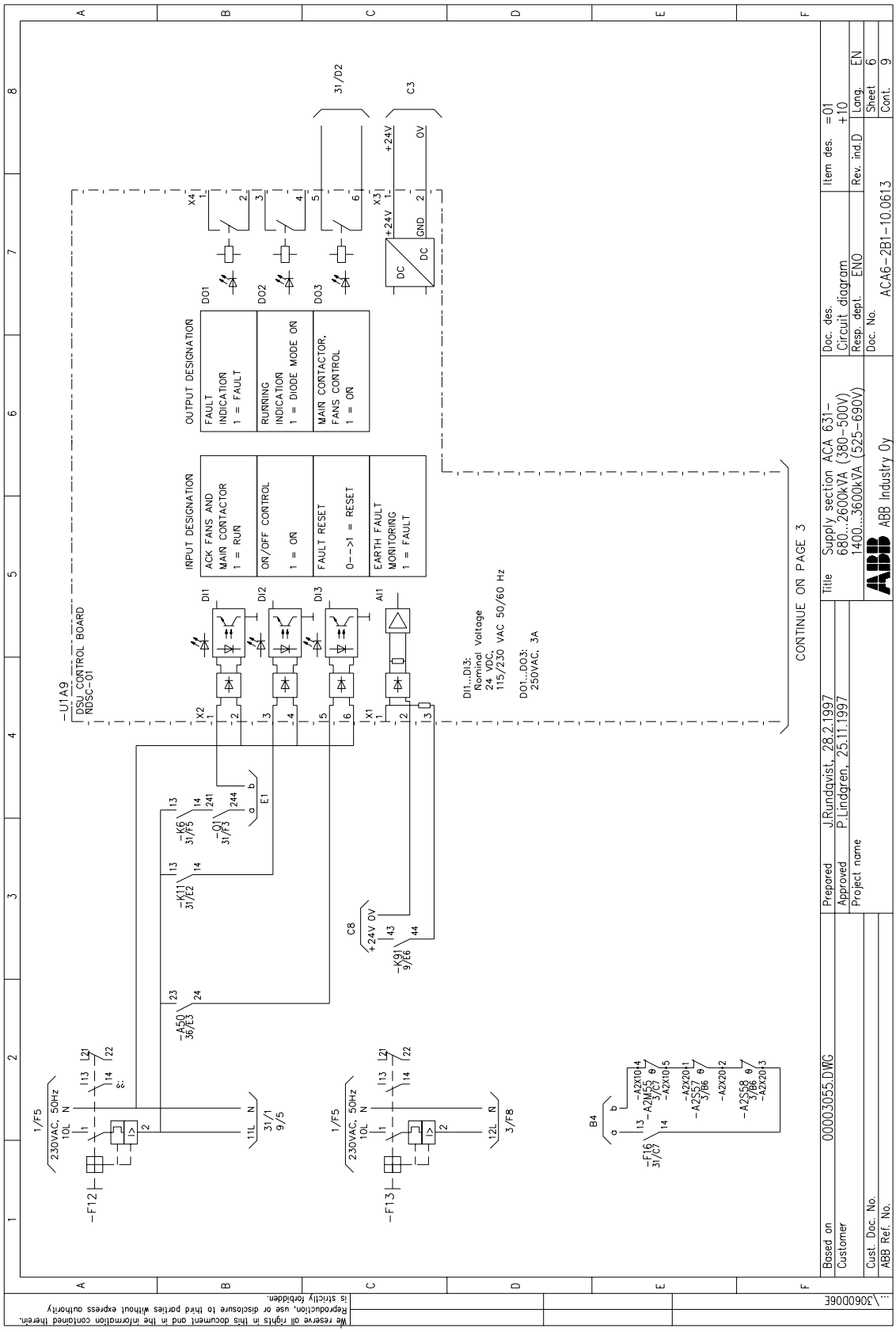
-U1A9
DSU CONTROL BOARD
RDSC-01
OUTPUT DESIGNATION
FAULT INDICATION 1 = FAULT
RUNNING INDICATION 1 = DIODE MODE ON
MAIN CONTACTOR, FANS CONTROL 1 = ON
INPUT DESIGNATION
ACK FANS AND MAIN CONTACTOR 1 = RUN
ON/OFF CONTROL 1 = ON
FAULT RESET 0-->1 = RESET
EARTH FAULT MONITORING 1 = FAULT
DI1...DI3: Nominal Voltage 24 VDC, 115/230 VAC 50/60 Hz
DO1...DO3: 250VAC, 3A
CONTINUE ON PAGE 3
Supply section ACA 631- 680...2600kVA (380-500V) 1400...3600kVA (525-690V)
ABB Industry Oy
ACA6-2B1-10.0613
Prepared J.Rundqvist 28.2.1997
Approved P.Lindgren 25.11.1997
Project name
Based on 000003055.DWG
Customer
Cust. Doc. No.
ABB Ref. No.
Item des. =01 +10
Rev. ind. D
Lang. EN
Sheet 6
Cont. 9
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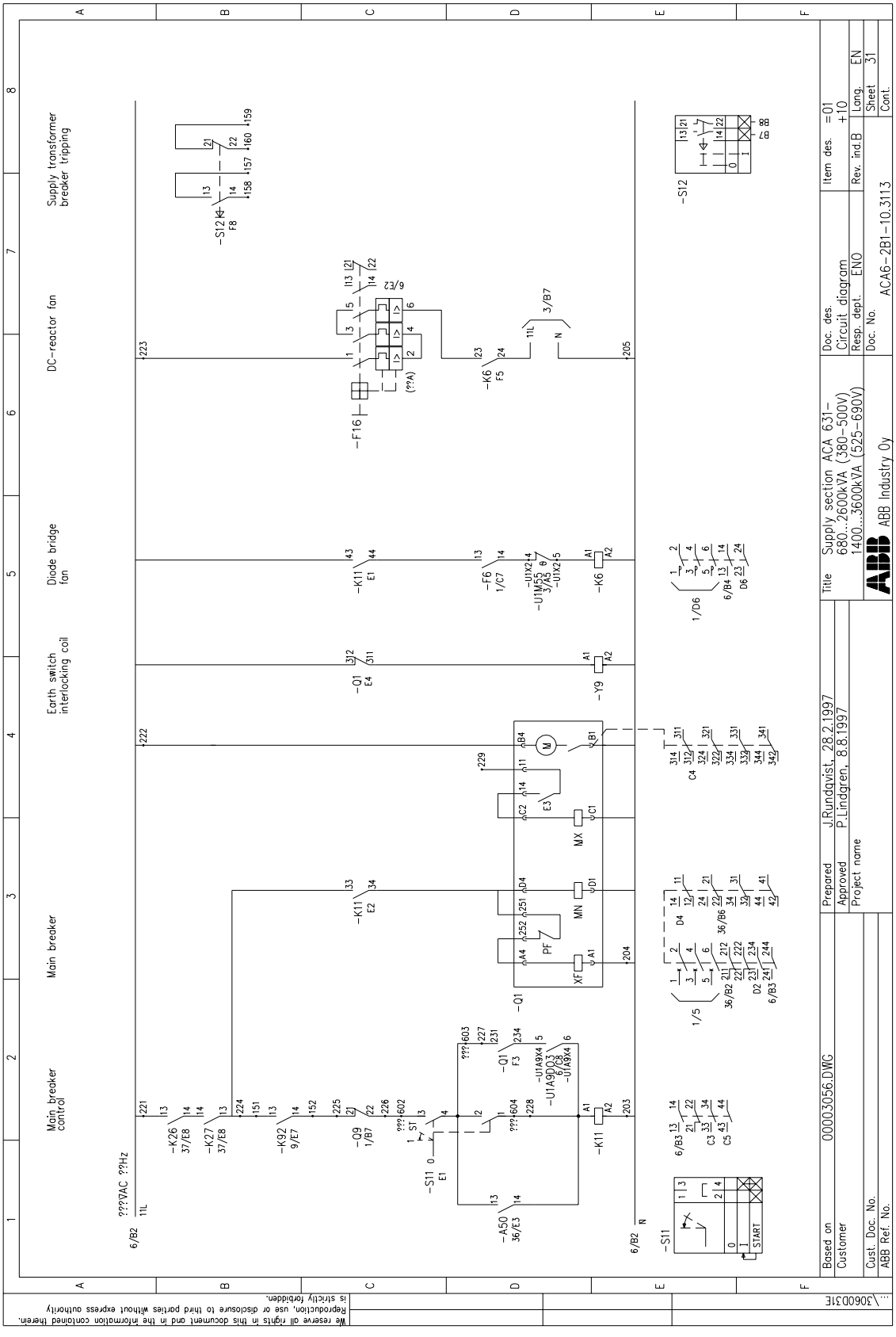
3060D06E


Supply transformer breaker tripping
DC-reactor fan
Diode bridge fan
Earth switch interlocking coil
Main breaker
Main breaker control
-S12 K4 F8
-F16
-K6 F5
-K11 E1
-F6 1/C7
-Q1 E4
-Y9
-K6
-K11 E2
-Q1 F3
-Q1
-K11
-A50 36/E3
-S11 E1
-S11
-K26 37/E8
-K27 37/E8
-K92 9/E7
-Q9 1/B7
-S12
1/D6
6/B4 D6
1/5
36/B6
6/B3
36/B2
6/B2
Supply section ACA 631-
680...2600kVA (380-500V)
1400...3600kVA (525-690V)
ABB Industry Oy
ACA6-2B1-10.3113
Prepared J.Rundqvist 28.2.1997
Approved P.Lindgren 8.8.1997
Project name
Based on 00003056.DWG
Customer
Cust. Doc. No.
ABB Ref. No.
Doc. des.
Circuit diagram
Resp. dept. ENO
Doc. No.
Item des. =01 +10
Rev. ind. B
Lang. EN
Sheet 31
Cont.
3060D31E
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