D921

Power Module for 3-Phase Steppingmotors Product manual

V2.00, 12.2008

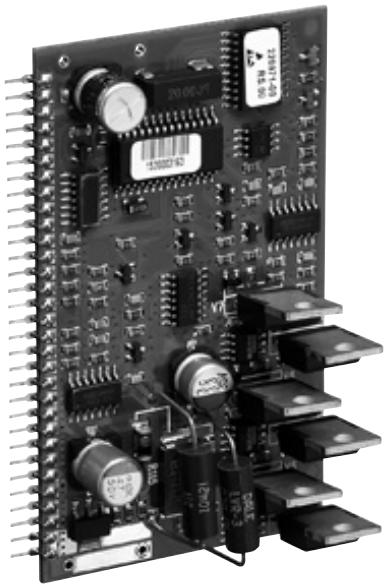

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Table of contents

1 Short Description

The D921 Power Module (hereinafter referred to as the "module") is a power amplifier with a so-called "pulse/direction" interface* for controlling a 3-phase stepping motor.

The module is intended to be integrated into a customer-specific electronics system (printed circuit board, mounted vertically with the aid of soldering pins).
Due to its small size (86.5mm wide x 52mm high x 23mm long), several modules can be placed side by side on a motherboard for multi-axis systems. The module length of 23mm results from the power transistors used (TO-220 housing, no heat sinks needed).

The maximum phase current (sinusoidal) is 5.8 A_{rms}. This gives a possible continuous peak current of 8.2 A DC when the motor is at standstill.

The voltage supply (= motor chopper voltage) can be from 18 V DC up to a maximum of 40 V DC. An external capacitor should be fitted.

An additional 5 V DC voltage supply is required for the module's internal logic.

The following 3-phase stepping motors can be controlled:

Motor Type	Rated torque	Rated current	
BRS 364	**0,45 Nm**	**5,2 A** $_{rms}$	7,3 A_{peak}
BRS 366	**0,90 Nm**	**5,8 A** $_{rms}$	8,2 A_{peak}
BRS 368	**1,50 Nm**	**5,8 A** $_{rms}$	8,2 A_{peak}
BRS 397	**1,70 Nm**	**5,8 A** $_{rms}$	8,2 A_{peak}
BRS 39A	**3,70 Nm**	**5,8 A** $_{rms}$	8,2 A_{peak}

For our 3-phase stepping motors and controls, rms values of the rated current are given in each case.

At lower speeds it is also possible to use a motor with a 130 V winding (BRS39B ; 6.0Nm; 5.0 A_{rms}).

** "Pulse / Direction" interface:*
In order to create rotational movement at the motor shaft, square wave clock pulses must be fed into the "Pulse" input. Every rising edge causes the shaft to rotate further by one angular increment. The sense of rotation is given by a defined signal at the "Direction" input.

2 Safety

This manual contains warnings which you must observe for your own personal safety and in order to avoid damage to equipment. The warnings are marked by a warning triangle and depending on the degree of danger are shown as follows:

2.1 Danger categories:

DANGER!
Warning of direct danger to persons which if not heeded can lead to serious injury resulting in death.

WARNING!
Warning of a recognisable danger.
If the warning is not heeded, the danger can lead to serious injury resulting in death, and the module or other parts of the system can be destroyed.

CAUTION!
Warning of a danger which if not heeded can lead to minor injury and to damage to the module or system.

2.2 Safety instructions:

DANGER!
Electric shock from high voltage!
Follow safety rules when working on electrical systems:

- Switch off the power to the unit
- Make sure the unit cannot be switched on again inadvertently
- Confirm that no voltage is present
- Cover or shield neighboring system parts which are live

ATTENTION!
Warning of a danger to the module or to system parts, possible danger to persons as a result

NOTE
Important or additional system-related information..

2.3 Use for the purpose intended

Before installing the Power Module, please read through this documentation carefully and pay attention to the following notes:

Intended use:

WARNING!
The D921 Power Module may only be used for controlling 3-phase stepping motors.
The motor must be approved by your local customer service for operation with the module.

ATTENTION!
The module is fitted with electronic components which can be destroyed by electrostatic discharges.
The Power Module may only be unpacked and installed in electrostatically protected working areas.

- The module must be fitted by qualified personnel.
  Local regulations on
  - accident prevention
  - installation of electrical and mechanical systems
  - spark protection

  must be observed.
- The power electronic system may not be started up or operated until it has been correctly installed to meet EMC requirements.
- The module's technical specifications, especially environmental conditions, must be observed.
- Arbitrary changes will lead to loss of warranty.
- The safety symbols and safety warnings on the module and in the documentation must be observed at all times.
- The original packaging should be kept in case the module has to be forwarded.

2.4 Qualification of the personnel

Work on or with te module may only be carried out by qualified personnel.

Qualified personnel can use their technical training, knowledge and experience to assess the work to be done and to recognize and avoid possible dangers.

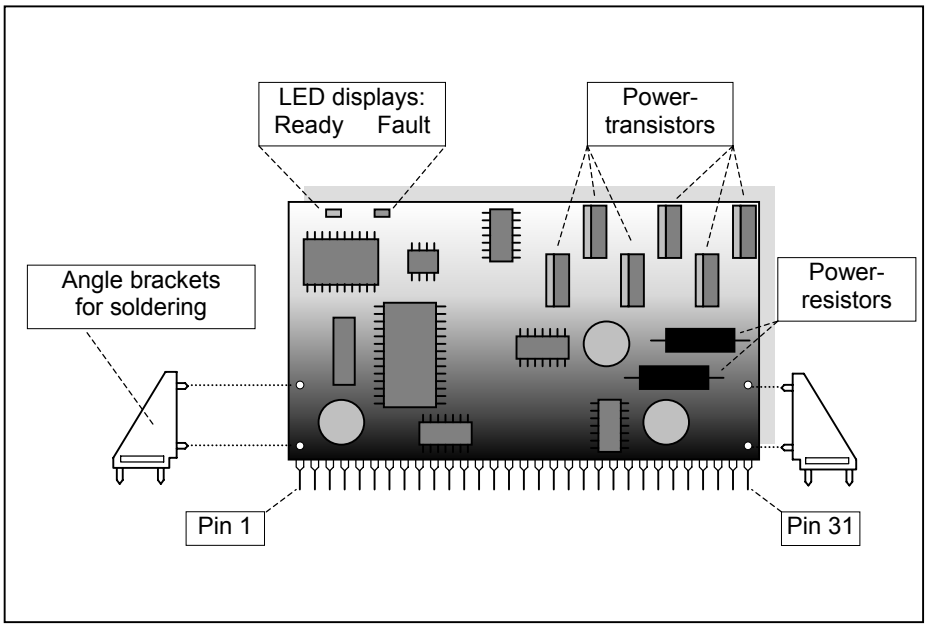
Qualified personnel will be aware of the current standards, regulations and accident prevention regulations which must be observed when working on the unit.

3 Function Description

The D921 Power Module has no setting or operating elements. All functions / parameters are controlled and set via SIL* soldering points (pins). A ready signal as well as various diagnostic signals are also available on the connection pins. Input and output wiring connections can be adjusted to suit the relevant requirements, and some suggestions are described in this documentation.

There are two LEDs on the module which display its operating status. The green LED denotes readiness for operation, and the red LED serves as a general fault display (it lights up as soon as one of the possible faults is detected or when the "ENABLE" signal is not present).

Two angle brackets provide lateral support for the module on the motherboard. They should first be soldered to the module itself and then together with the module to the customer-specific circuit board. The right-hand bracket (at pin 31) also serves as an additional heat sink and has the same potential as the voltage supply (18-40 V)!



Power Module

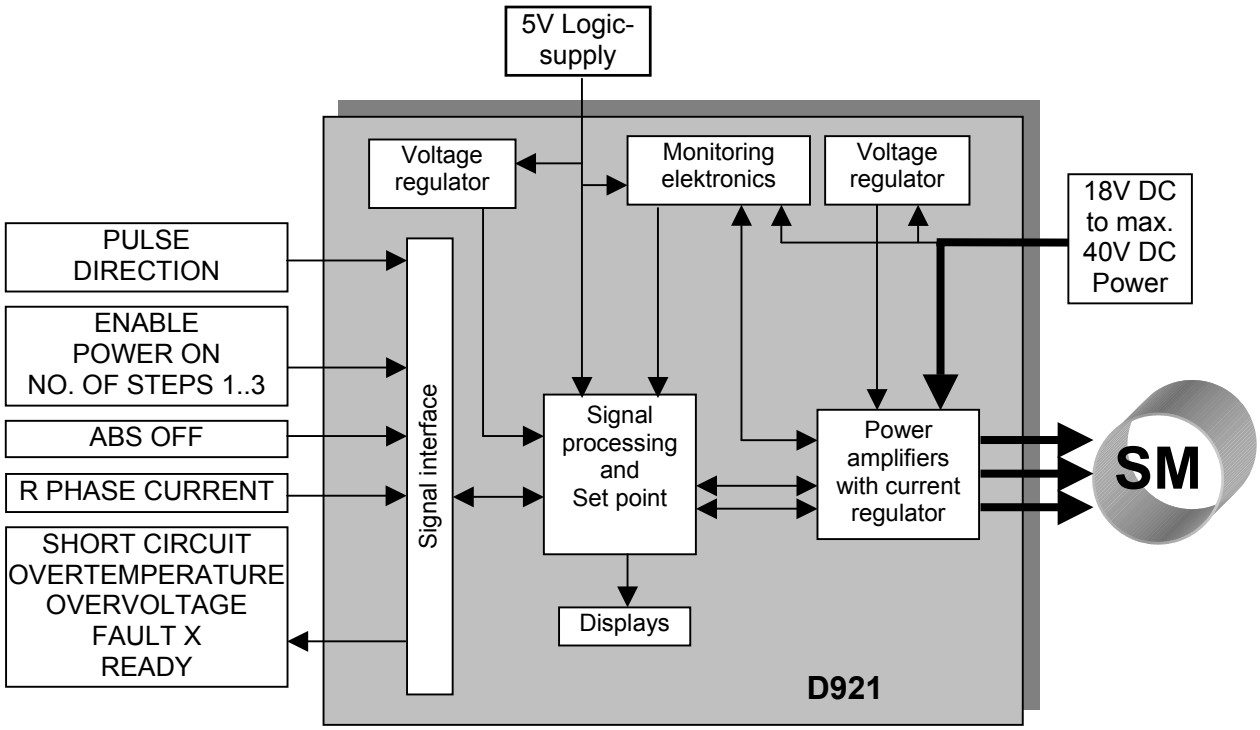
CAUTION!

Contact danger through high component temperatures:
The power resistors can reach temperatures of up to 180°C!
The power transistors can reach temperatures of up to 150°C!
The module circuit board can reach a temperature of up to 110°C near the power components!

** SIL : Single in Line*

3.1 Block diagram

The following block diagram shows the most important function groups of the D921 Power Module.



3.2 Description of connections

PULSE

The Power Module can be controlled by means of square wave pulse signals from a master positioning unit at the PULSE input. The motor moves one step on every rising edge. The sense of rotation is determined via the DIRECTION input.

DIRECTION

This input is used to control the stepping motor's sense of rotation. If the signal at the input is high, rotation is clockwise. If the signal is low, rotation is anti-clockwise (looking at the motor shaft from the front). The sense of rotation can also be inverted by swapping two of the total of three motor leads (regardless of which ones).

ENABLE

The module's readiness for operation is controlled by the ENABLE input. As long as there is no ENABLE signal (input low), the red fault LED lights, the FAULT X and OVERVOLTAGE outputs are set, the amplifier is disabled and the error memory and ring counter are reset.
As soon as a high signal is present, the motor receives power (assuming the POWER ON input has been activated and there are no faults present), and the module switches to a state of readiness after approx. 500 ms (READY output high). Clock pulses can now be fed into the PULSE input.
(The ENABLE input can also be permanently set to high. The module is then automatically switched ready for operation as soon as the voltage supply is switched on.)

POWER ON

The power amplifier can be activated (input high) or deactivated (input low) via the POWER ON input. When the power amplifier is deactivated, the phase current is switched off and the standing motor has no more holding torque. This status is not displayed, the module remains ready for operation.
(The POWER ON input can also be permanently set to high.))

NUMBER OF STEPS 1...3

These 3 inputs (→ 3 bit = 8 possible status conditions) are used to set the stepping resolution of the motor. Numbers of steps which can be set are 200, 400, 500, 1000, 2000, 4000, 5000 and 10000 steps per revolution. It is only possible to switch resolutions when the motor is at a standstill.

Resolution:	No. of steps 1	No. of steps 2	No. of steps 3
200	0	0	0
400	1	0	0
500	0	1	0
1000	1	1	0
2000	0	0	1
4000	1	0	1
5000	0	1	1
10000	1	1	1

1 = input "high"

0 = input "low"

ABS OFF

This input can be used to switch off the automatic current reduction function (input low), i.e. the motor continues to receive 100% of the set current even when it is at a standstill.
When the automatic current reduction function is not switched off (input open), the motor phase current is reduced to approx. 60% approx. 100 ms after the last pulse edge. This function is used whenever the full holding torque is not required.
Advantage: motor and electronics heat up less
efficiency is improved.

R PHASE CURRENT

A ground resistor must be connected in order to set the motor phase current (minimum resistance: 22 kΩ, → gives max. current of 5.8A $_{rms}$).
A resistor network consisting of 4 resistors can also be used. In that case the current can be set at 16 different levels (see technical specifications).

ATTENTION!

The phase current selected may not be larger than the rated current given for the stepping motor!

NOTE

For our 3-phase stepping motors and controls, the rms values of the phase currents are given (peak value = rms value x 1.41).
It must be borne in mind that even when the motor is at a standstill the **peak value** of the set phase current may flow **continuously** (current reduction function switched off). This results in a maximum phase current of **8.2 A DC** (5.8 A $_{rms}$ × 1.41).

Diagnostic outputs

SHORT CIRCUIT:	low signal on short-circuit between motor phases (no protection against ground faults, earth contact); normal status: high signal
OVERTEMPERATURE:	high signal on overtemperature on the module; normal status: low signal
OVERVOLTAGE:	low signal on overvoltage in the power circuit (max. 40V); normal status: high signal
FAULT X:	low signal indicates further faults/status conditions in combination with other diagnostic outputs; normal status: high signal
READY:	high signal on module data set ready; low signal when a fault has occurred or ENABLE signal not present

These outputs can for example control external LEDs if the current is limited to 4 mA (external series resistor necessary, value approx. 560 Ω). However logic voltage levels cannot then be reached on account of the internal resistors (220 Ω).

Supply

A DC voltage of min. 18 volts to max. 40 volts is required as the power supply to the power circuit. This is available as a chopper voltage on the three phases of the stepping motor connected to it. For good dynamics, a power supply of 35 V is ideal (this voltage is also the basis for torque values given).
When less is required of the dynamics, a voltage of 24 V can be used to advantage (the power loss is smaller and the motor runs more quietly). Torque values are also available for this voltage.

An additional power supply of 5 volts is required for the control circuit (internal logic).

ATTENTION!
The ground connections of the power circuit and control circuit are galvanically connected on the module!

ATTENTION!
Before switching off the voltage supplies, it must be ensured that vertical shaft loads are secured against falling down (e.g. motor with brake).

Motor connection

The three stepping motor phases are each connected to two connection pins wired in parallel. Motor leads must be shielded. The shielding must be connected to power circuit ground over a large area. It must be applied on both sides (i.e. also on the motor).

NOTE
Motor leads and signal wires also motor- and signal tracks must be laid separately from each other!

4 Technical Specifications

4.1 Electrical Specifications

DANGER!
All module connections must be well separated from the mains!

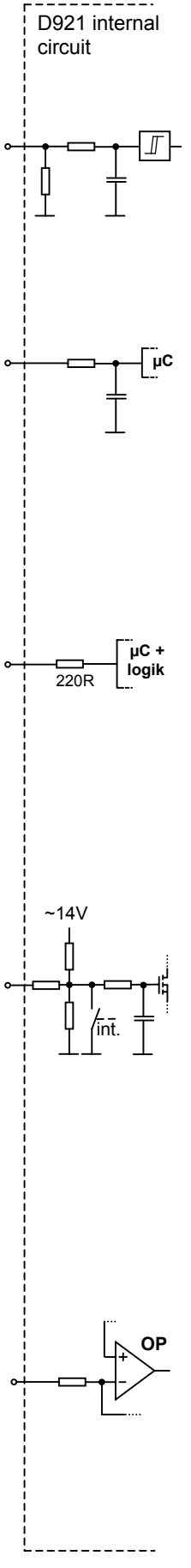
CAUTION!
The module has no internal protection against transient surges, no voltage breakdown bridging, no fuse and no reverse-polarity protection.

Power circuit	Supply voltage range	18 VDC - 40 VDC	(absolute limit values)
	Nominal supply voltage	35 V	(basis for torque data)
		24 V	(torque data available)
	Ripple	max. 3,6 V_{PP}	
	Current consumption	max. 5 A	(regardless of supply voltage, motor load and speed)
	Power loss maximum	15 W	
	External back-up fuse	10 A slow-acting	

An external capacitor (min. 1500µF/50V/2.5A ripple current at 20kHz) is required, it must be place near the Power Module on the motherboard.
When the motor is in braking mode, this capacitor (in addition to the capacitor of the power supply) must be capable of absorbing the energy feedback by the motor, otherwise an overvoltage fault will be triggered.

Control circuit	Supply voltage	5 V ± 5 %	(absolute limit values)
	Residual ripple	20 mV_{ss}	
	Input current	max. 100 mA	

Motor connection	Phase current, sinusoidal (at 60 rpm on the motor shaft)	1,45 A_{rms} - 5,8 A_{rms} (2,05 A_{peak} - 8,2 A_{peak})	
	Phase current (motor standstill)	max. 8,2 A DC	
	Motor chopper voltage	max. 40 V	
	Motor leads	length: cross-section: capacitance per unit length:	max. 10 m 1,5 mm², twin-shielded ≤ 10 nF/100 m
	Shield connection	both sides, over wide area	



CMOS inputs:

Signal voltage	U max.	5,25 V	(absolute limit values)
	U min.	0 V	

PULSE

(LSTTL compatible Schmitt trigger input with 10 kΩ pulldown resistor and RC filter, pulse frequency max. 500 kHz, the input levels must be actively connected → do not use Open Collector control)

Voltage controlled	U_{high} min.	2,1 V
	U low max.	0,5 V

DIRECTION, ENABLE, POWER ON, NUMBER OF STEPS 1...3

(Micro controller [µC] inputs with RC-filter)

Voltage controlled	U_{high} min.	2,0 V
	U low max.	0,8 V

CMOS outputs:

output current	I max.	± 4 mA	(absolute limit values)

SHORT-CIRCUIT, OVERTEMPERATURE, OVERVOLTAGE, FAULT X, READY
(diagnostic outputs, no permanent short-circuit protection!)

for I out = ± 1,6 mA	U low max.	0,8 V
	U high min.	3,5 V

FET input:

signal voltage	U max.	10 V	(absolute limit values)
	U min.	0 V	

ABS OFF

(field effect transistor [FET] input with RC filter, controlled in parallel by internal logic, threshold: ~7 V via voltage dividers 2 × 10 kΩ)

voltage controlled	U_{high} min.	6,5 V
	U low max.	0,8 V

The input should be left open (current reduction function active), or grounded (ABS off).
The function can also be controlled via an external Open Collector control (internal 7 V threshold: do not use external pull-up resistor!)

OP input:

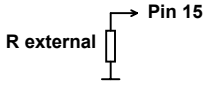
external resistor	R min.	22,0 kΩ	(absolute limit values)
	tolerance	max. ± 1 %	

R PHASE CURRENT
(Operational amplifier [OP] input to external connections)

resistance range	R min.	22,0 kΩ	
	R max.	any value	(input open)

4.2 Current settings

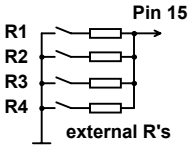
Connection suggestion 1 Table for external resistor connections (to control circuit ground) in order to set stepping motor phase current.



Connection suggestions for 16 current settings:

Phase current	ext. Resistor	Phase current	ext. Resistor
1,45 A_{rms}	---	3,75 A_{rms}	41,2 kΩ
1,75 A_{rms}	330 kΩ	4,05 A_{rms}	36,6 kΩ
2,05 A_{rms}	165 kΩ	4,35 A_{rms}	33 kΩ
2,30 A_{rms}	110 kΩ	4,60 A_{rms}	30 kΩ
2,60 A_{rms}	82,5 kΩ	4,90 A_{rms}	27,5 kΩ
2,90 A_{rms}	66 kΩ	5,20 A_{rms}	25,4 kΩ
3,20 A_{rms}	55 kΩ	5,50 A_{rms}	23,5 kΩ
3,50 A_{rms}	47 kΩ	5,80 A_{rms}	22,0 kΩ

Connection suggestion 2 A further possibility is to use a resistor network, consisting of four resistors. The resistors selected can be used to set the phase current via switches to 16 different levels (specially suited for a hexadecimal switch).



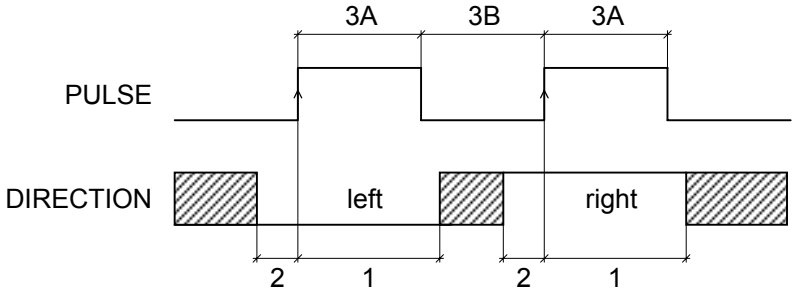
Phase current	R1	R2	R3	R4	Phase current	R1	R2	R3	R4
1,45 A_{rms}	0	0	0	0	3,75 A_{rms}	0	0	0	1
1,75 A_{rms}	1	0	0	0	4,05 A_{rms}	1	0	0	1
2,05 A_{rms}	0	1	0	0	4,35 A_{rms}	0	1	0	1
2,30 A_{rms}	1	1	0	0	4,60 A_{rms}	1	1	0	1
2,60 A_{rms}	0	0	1	0	4,90 A_{rms}	0	0	1	1
2,90 A_{rms}	1	0	1	0	5,20 A_{rms}	1	0	1	1
3,20 A_{rms}	0	1	1	0	5,50 A_{rms}	0	1	1	1
3,50 A_{rms}	1	1	1	0	5,80 A_{rms}	1	1	1	1

R1 = 330 kΩ
R2 = 165 kΩ
R3 = 82,5 kΩ
R4 = 41,2 kΩ

1 denotes ground resistor connected
0 denotes resistance open

The phase current can also be controlled by using field effect transistors instead of individual switches (or the hexadecimal switch).

4.3 Signal Timing Diagram



1	Hold time	≥	25µs	undefined area
2	Set-up time	≥	0 µs	
3A	Pulse width minimum	≥	1 µs	
3B	Pulse interval minimum	≥	1 µs	

4.4 Pin Assignment

Pin No.	Signal / Connection	
1	**+ 5 V DC Supply to control circuit**	
2,3	**Control circuit ground**	
4	PULSE	
5	DIRECTION	
6	ENABLE	
7	POWER ON	
8	NUMBER OF STEPS 1	
9	NUMBER OF STEPS 2	
10	NUMBER OF STEPS 3	
11	OPTION 1	(may not be connected)
12	OPTION 2	(may not be connected)
13	OPTION 3	(may not be connected)
14	ABS OFF	
15	R PHASE CURRENT	
16	SHORT CIRCUIT	
17	OVERTEMPERATURE	
18	OVERVOLTAGE	
19	FAULT X	
20	READY	
21,22,23	**Power circuit ground**	
24,25	**Motor phase U**	
26,27	**Motor phase V**	
28,29	**Motor phase W**	
30,31	**+ 18-40 V DC Supply to power circuit**	

4.5 Mechanical Specifications

Dimensions

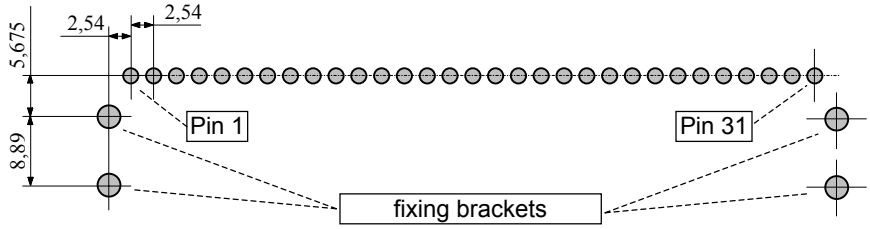
Module width × height:	86,5 mm × 52 mm	(height above motherboard)
Module length:	approx. 23 mm	(→ TO-220 housing)
Weight (with bracket):	approx. 45 g	

Solder points

Grid pitch:	2,54 mm
Contacts:	31 Pins

Hole diameter and arrangement on the customer-specific circuit board (motherboard):

31 holes for solder pins	Ø = 0,9 mm + 0,15 mm
4 holes for brackets	Ø = 1,3 mm + 0,15 mm



Motherboard insertion side, data in mm

4.6 Ambient Conditions

Ambient temperature in operation:	0°C bis 50°C *	(supply voltage 35V)
	0°C bis 55°C *	(supply voltage 35V, current reduction function active)
Transport and storage temperature:	-40°C bis 70°C	

** Convection cooling sufficient as long as module is mounted vertically.*

NOTE

Care must be taken that air can flow unhindered through and around the board. Modules must also not warm up each other on multi-axis systems. If the installation site and ambient conditions lead to insufficient convection (heat build-up), the module must be ventilated. If an overtemperature fault is triggered, the module must definitely be externally ventilated!

Type of protection: IP00
Condensation not permitted

5 Norms, Regulations, Laws

The module is operated off extra low safety voltage, and conformity to relevant regulations must be ensured by means of external connections.

NOTE
An isolating transformer must be used conforming to DIN Norm VDE 0551, Part 1/09.89 or EN 60742:1989 (safe electrical isolation).

NOTE
The module represents a component. Conformity to the EMC guideline and the low voltage guideline must be ensured with additional measures such as mains filters, covers, etc.!
Only then can conformity to machinery directives be ensured.

6 Fault Conditions, Displays

Fault or Signal status:	Signal change on the following diagnostic outputs:	
Short circuit between motor phases:	**SHORT-CIRCUIT**	**on "low"**
Overtemperature on module circuit board:	**OVERTEMPERATURE**	**on "high"**
(The OVERTEMPERATURE output and the red fault LED are triggered approx. 15-20 seconds before the amplifier is switched off. The module remains ready for operation during this time)		
Overvoltage (power circuit):	**OVERVOLTAGE**	**on "low"**
(Overvoltage can also be caused by feedback from the stepping motor in braking mode or if it falls out of step at high speeds.)		
ENABLE input on "low":	**FAULT X** **OVERVOLTAGE**	**on "low"** **on "low"**
Internal watchdog fault *(e.g. if the quartz oscillator fails)*	**FAULT X** **OVERVOLTAGE** **SHORT-CIRCUIT**	**on "low"** **on "low"** **on "low"**
Timing pulse fault *(pulse frequency too high or error pulses present))*	**FAULT X** **OVERVOLTAGE** **SHORT-CIRCUIT** **OVERTEMPERATURE**	**on "low"** **on "low"** **on "low"** **on "high"**

For all above-mentioned cases, the following applies:
Motor de-energized, fault stored, READY output on low, green LED not lit, red LED lit.
Reset fault by off/on cycle or via ENABLE input (low / high cycle > 5 seconds).

ATTENTION!
When a fault occurs, the motor is deenergized. A deenergized motor no longer has any holding torque. This can lead to unintended movement of motor and system parts (especially Z-axis).

Further fault and signal status conditions:

Module is ready for operation:

READY output on "high"
green LED lit, red LED not lit

all other diagnostic outputs are in their normal status:

SHORT-CIRCUIT	on "high"
OVERTEMPERATURE	on "low" !
OVERVOLTAGE	on "high"
FAULT X	on "high"

In the event of undervoltage in the power circuit (<18 V), the amplifier is disabled, both LEDs are off, µC-I/O high Impedance. If the control circuit voltage is still present (5 V), the diagnostic outputs are set as follows:

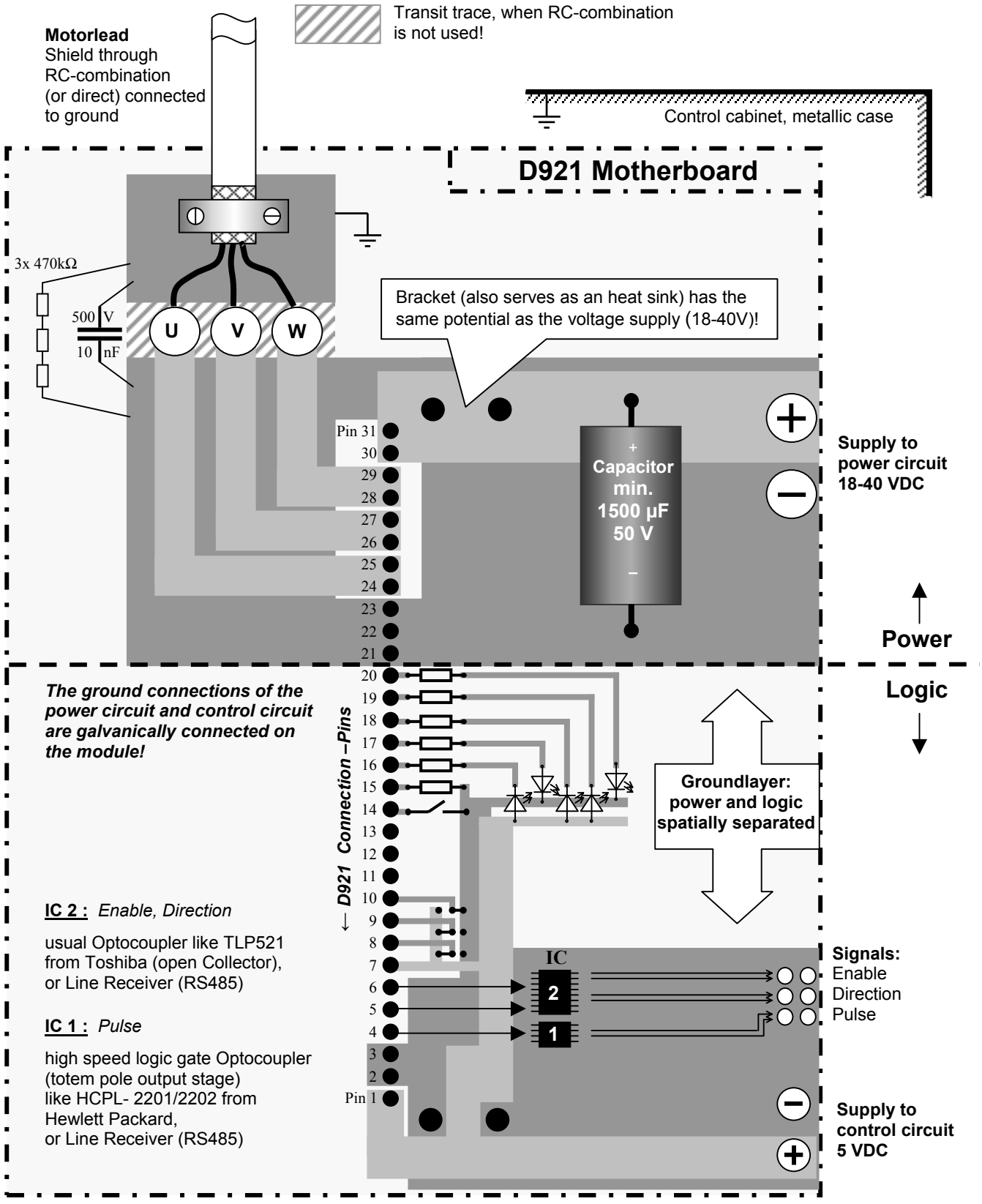
SHORT-CIRCUIT	on "high"
OVERTEMPERATURE	on "low"
OVERVOLTAGE	over 10 kΩ pull-up on "high"
FAULT X	over 10 kΩ pull-up on "high"
READY	over 10 kΩ pull-down on "low"

In the event of undervoltage in the control circuit (<4.75 V), the amplifier is also disabled (motor deenergized), both LEDs are off. The diagnostic outputs are in an undefined status.

ATTENTION!
Destruction of the module!
In case of an untervoltage in the control circuit (<4,75 V) the OVERVOLTAGE protecting circuit cannot work. If then energy feedback from the motor occures, the module will be destroyed by an overvoltage (>50 V at Pin 30/31).

It is not allowed that in case of an untervoltage (<4,75 V) the stepping motor is driven by external sources. Also it is not allowed to switch off the control circuit power, while the motor is still running at medium and higher speeds. (dependend of ext. capacitor size)
This can made sure as the control circuit power (5 V) is generated out of the power circuit voltage.

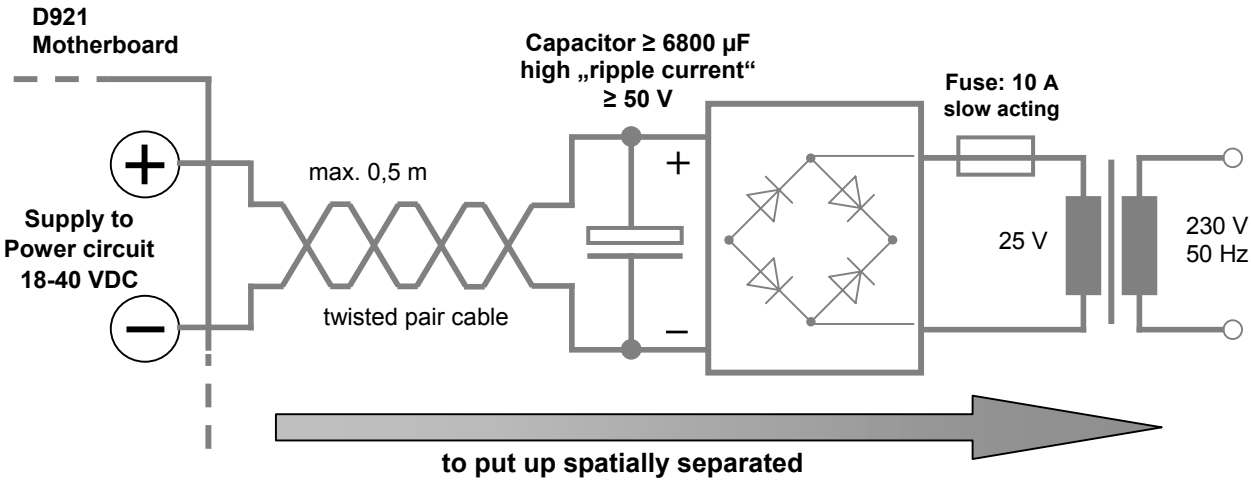
7 Layout-Sample and Design Notes



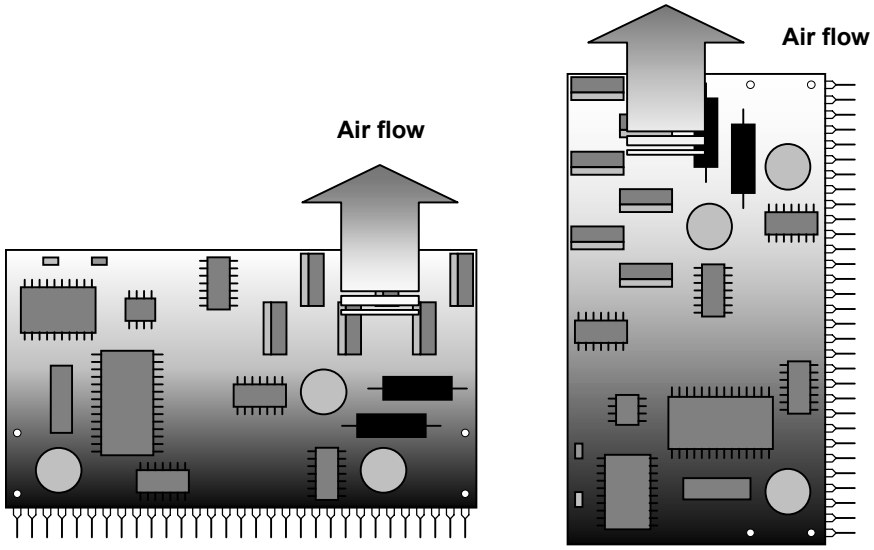
7.1 Example of an unsmoothed Power Supply (power circuit)

DANGER!
Electric shock from high voltage!
Follow safety rules when working on electrical systems:

- Switch off the power to the unit
- Make sure the unit cannot be switched on again inadvertently
- Confirm that no voltage is present
- Cover or shield neighboring system parts which are live



7.2 Installation



Convection cooling sufficient as long as module is mounted vertically.

It is important that the 6 Power-Transistors always to be located at the top!

7.3 Electromagnetic compatibility, EMC

Motherboard

- When no high Pulse-frequencys are used (e.g. < 200 kHz), it is possible to put a **RC-filter directly beside the Pulse-input of the D921.** Thereby the use of an open collector Optocoupler is allowed (e.g. 6N136 or HCPL2531 from Hewlett Packard)
- When there is any control electronics on the motherboard of the D921, it is possible to connect a TTL-signal directly to the Pulse-input (short trace).
  In this case a **groundlayer** for the control electronics is strictly recommed **(spatially separated from the power side)**

Cabling

- Lay the cables spatially separated from each other:
  Signal cables - power cables - Mains - motor cables - Mains filter input and output cables
- Ground a large surface area of the shields of digital signal cables at each end or via sub-D housing
- Use only shielded motor cables with copper braiding and at least 85% covering, ground a large surface area of the shield at each end. Only use motor cables recommended by your local customer service
- If the motor and machine are not conductively connected, for example by an insulated Flange or a non-flat connection, ground the motor with a grounding wire or ground strap

Control cabinet setup

- Use cable clamps to connect a large surface area of the shield from all shielded cables to the mounting plate at the control cabinet entry
- Use zinc or chrome-plated mounting plates, make large contact surface connections for metal parts, remove paint from bearing surfaces
- Fit switching devices such as contactors, relays or solenoids with interference suppressors or spark suppressors
  (e.g. diodes, varistors, RC elements)