

## ***Technical Description***

Edition 07/2002

File MAEDSM-E.xxx

Order Code: MAEDSM-E

# **Stepper Motor Controller**

## **DSM5-70-00X**



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# 1 DSM summary

## In this chapter

This chapter provides a summary of the functionality of the DSM stepper motor controller. It covers the following topics:

- General concept of DSM
- Other system components
- Block diagram
- Manual
- Guarantee

## 1.1 General concept of the DSM

### Summary

The DSM stepper motor controller accepts input signals as pulse frequency and direction information, and uses them to generate the power outputs for the motor currents to operate a 2-phase stepper motor.

The most important features of the DSM include:

- bipolar power output stages,
- micro-step capability, as well as
- a circuit to suppress resonance in the medium frequency range.

In the DSM, the motor currents can be set by DIL-switches within a range from 5 A<sub>eff</sub> (7.1 A peak current in micro-step mode) down to 0.625 A<sub>eff</sub> (0.88 A peak current in micro-step mode).

The controller produces regulated motor phase currents, operating off a supply voltage between 24 and 75 V DC. It is designed to drive a 2-phase hybrid stepper from the Bautz range of products. This can be either a standard hybrid stepper motor, or a high-performance hybrid stepper that uses the patented Sigmax principle.

**Note** *The output current from the DSM must match the rated current for the motor winding, or be adjusted accordingly.*

### Features

**Bipolar chopper output stage** - The patented, pulse-width modulated 4-phase chopper output stage controls the currents in the motor windings electronically, using a 20 kHz chopper frequency. It combines the advantages of recirculating and non-recirculating current control, thereby achieving a high level of suppression of the back-e.m.f., combined with low ripple in the inverter current.

Further advantages are:

- reduced heat dissipation
- low level of electrical interference
- improved current monitoring when braking the motor.

**Micro-steps** - can be set by switches, with micro-step sizes of 1/1, 1/2, 1/5, 1/10, 1/25, 1/50, 1/125 and 1/250 of a full step, when the decimal jumper is inserted, and 1/2, 1/4, 1/8, 1/16, 1/32, 1/64, 1/128 and 1/256 of a full step, if the decimal jumper is removed. (See Chapter 4.1.1 "Step size" Page 36.)

**Resonance suppression in the medium speed range** - A patented circuit suppresses such effects as torque weakening or pull-out of the motor in the medium speed range. These resonance effects usually occur with all stepper motor controllers that run on the principle of open-loop operation (i.e. without a feedback system and closed-loop control).

**Short-circuit/earth short protection circuit** - This switches off the controller if the motor outputs are short-circuited or shorted to earth. After the fault has been removed, the controller must be switched off and then on again to clear the fault status.

**MOSFET power transistors** – These make it possible to use a chopper frequency around 20 kHz, and so eliminate the noise that is often generated by inverters.

**Signal connections via optocouplers** - The signals applied to the pulse frequency, direction and enable inputs are fed to the input circuitry via optocouplers, so that they are electrically isolated from the supply voltage. The *Enabled* output is also brought out via an optocoupler. These measures increase the noise immunity of the signals to currents in the earthing/grounding conductors. The signal source for the pulse and direction signals does not require a ground reference on the DSM side.

This section is only intended to provide you with an overview. Details can be found in Chapter 3 – "Commissioning"

#### Settings with DIL-switch S1

**Motor current** – Sets the phase current in the motor to  
5.0 / 4.375 / 3.75 / 3.125 / 2.5 / 1.875 / 1.25 or 0.625  $A_{\text{eff}}$ .

**Step size** – Defines the step resolution, i.e. the amount by which the motor rotates per step pulse. A full step for the Pacific-Scientific stepper motors produces a rotation of 1.8 angular degrees.

If the decimal jumper is inserted, then the step sizes that can be selected are: 1/1, 1/2, 1/5, 1/10, 1/25, 1/50, 1/125 and 1/250 of a full step.

These are equivalent to 200, 400, 1000, 2000, 5000, 10,000, 25,000 or 50,000 micro-steps per turn.

If the decimal jumper is removed, then the step sizes that can be selected are: 1/2, 1/4, 1/8, 1/16, 1/32, 1/64, 1/128 and 1/256 of a full step.

These are equivalent to 400, 800, 1600, 3200, 6400, 12800, 25600 or 51200 micro-steps per turn.

**Resonance suppression in the medium speed range: switch ON or OFF** – The special patented circuit for preventing torque weakening and possible pull-out in the medium speed range of the motor can be switched on or off.

These resonance effects are caused by the combined electronic, magnetic and mechanical characteristics of a stepper motor system.

The compensation circuit damps oscillation in the medium speed range by advancing or retarding the instant of switching of the output current with respect to the incoming pulse signals.

**Idling current reduction (ICR)** - When the motor is idling (i.e. not stepping) the current in the winding can be reduced to 50 % of the preset value. This feature can be switched on or off.

The current reduction becomes effective 0.1 sec after the last step pulse. Jumpers can also be used to set this delay to 0.05 or 1 second.

**Note** *When the next step pulse arrives, the current returns to 100 % of the preset value.*

### Settings by jumpers

**Input filter for pulse signals** If this is active (jumper J6, pos. 1-2, is inserted), then interference pulses shorter than 500 nanoseconds on the pulse input will be filtered out. This is useful if the maximum pulse frequency is below 500 kHz.

**Configuration of the enable input** – This provides the option of inverting the sense of the enable signal. If the jumper J6 (pos. 5-6) is inserted, then the controller is *enabled* when current flows through the optocoupler. If the jumper is removed, then the controller is *inhibited* when current flows through the optocoupler.

### Typical applications

Typical applications for the DSM controller are, for example:

- X-Y coordinate tables and slides
- packing equipment
- industrial robot engineering
- special-purpose machinery
- material feeders
- labeling machines

## 1.2 Other system components

### Summary

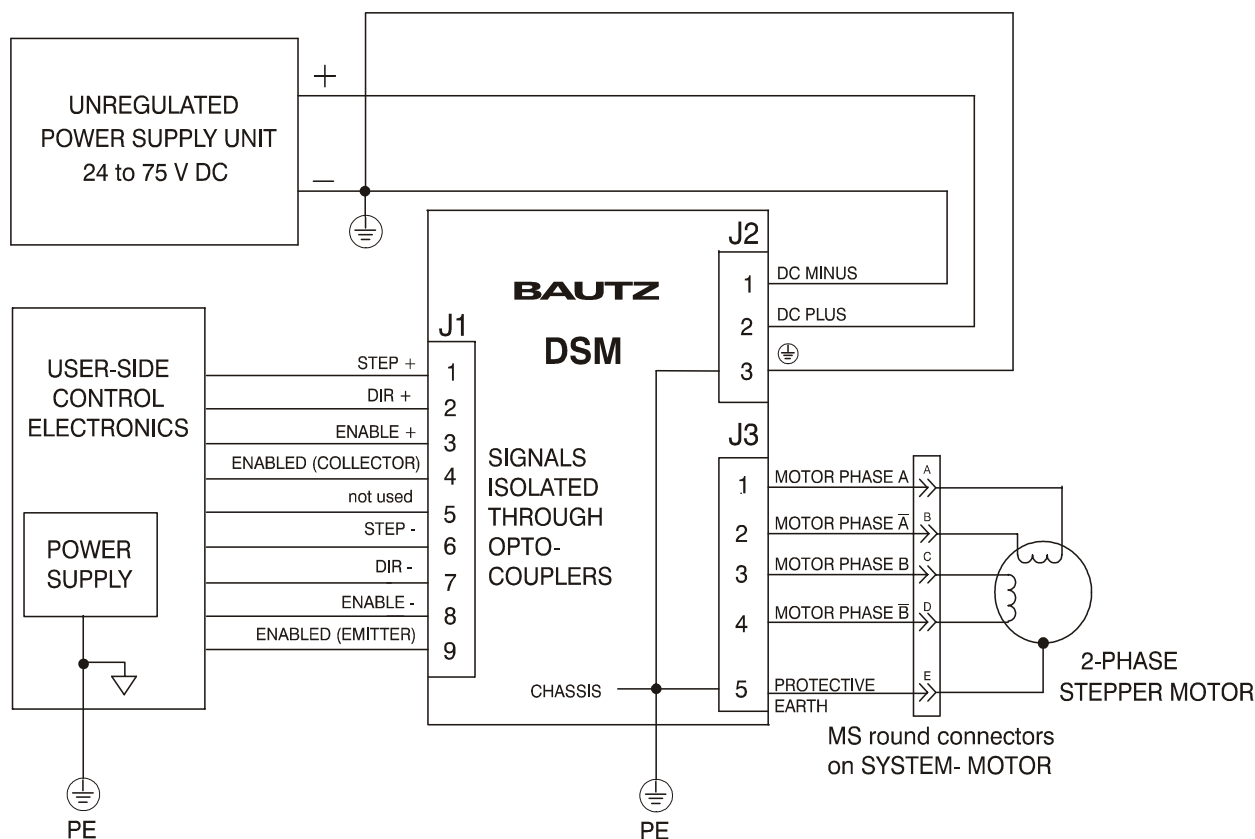
The other components that can be added to the DSM stepper motor controller to form a complete system are:

- Pulse or indexer
- Power generator supply unit for the 24 - 75 V DC supply voltage
- Stepper motor

The installation notes for these components can be found in Chapter 2 "Installation of the DSM stepper motor controller".

**Block diagram**

The following block diagram shows the basic connections for the drive in a typical system.



Please note: **Your system may look a bit different. Shielding is not shown!**

**1.3 About this manual**

This technical description contains information on connecting and setting up the DSM stepper motor controller, as well as notes on fault-finding and removal.

Please refer to the notes in the individual chapters and Appendix B (power supply unit) for planning the electrical installation, selecting/building a power supply unit, or installation and commissioning. This will help you to avoid the most common mistakes and difficulties.

**1.4 Guarantee**

Bautz provides a **one-year guarantee** for the DSM drives with respect to material or production faults. However, this guarantee does not cover equipment that has been modified by the customer, treated roughly, incorrectly handled or improperly used (e.g. incorrect wiring, wrong switch settings and the like).

## 2 Installation of the DSM stepper motor controller

### In this chapter

This chapter describes the installation of the DSM stepper motor controller. It covers the following topics:

- Checking goods received
- Safety information
- Selection of additional system components
- Mechanical installation of the DSM
- Electrical installation of the DSM

### 2.1 Check on receipt

#### Check

As soon as the goods are received, check the equipment and the packaging for possible transport damage. Any visible damage must be noted on the waybill by the transport driver when the goods are accepted.

If you discover any hidden or obvious damage, make records of it and inform your shipping agent at once (by post: within 24 hours of delivery).

1. Remove the DSM from the transport box.  
Remove all packaging material from the equipment.
2. Check the contents against the delivery note.  
There is a label attached to the inside of the chassis that states the instrument type, serial number and date code.

#### Storing the equipment

After checking, store the equipment in a clean, dry place. The storage temperature must be within the range from  $-55\text{ °C}$  to  $+70\text{ °C}$ . Pack the equipment back into the original box, to prevent damage in storage.

## 2.2 Safety rules

### Your responsibility

As the project engineer or user of this instrument, you are responsible for the decision that the product really is suitable for the intended application. In no circumstances will Bautz accept any responsibility or liability for indirect or consequential damage that may arise as a result of incorrect use of the product.

**Note** *Read the accompanying manual completely, so that you are able to operate the DSM effectively and safely.*



### **WARNING !**

***The voltages inside the DSM are high enough to give a dangerous electric shock to any persons that come into contact with them.***

***Observe the following safety rules in order to avoid such shocks.***

### Safety rules

To avoid the risk of personal injury, observe the following rules when working with the DSM.

- Never operate the stepper motor controller with a motor cover that is not earthed.  
**Note** *This is usually implemented by connecting the cover of the motor to terminal J3-5 of the DSM and connecting the protective earth (PE) to terminal J2-3 of the DSM.*
- Do not connect anything to the internal circuitry of the DSM. The input and output terminals or connectors are the only safe and permissible points of connection.
- Always disconnect the supply voltage before making or breaking any connections to the equipment.
- If the motor has been disconnected, be especially careful with the J3 terminals used for connecting the motor. If voltage is applied to the drive equipment while the motor is disconnected, then a very high voltage appears at these terminals.
- Switching off the *Enable* input to inhibit the drive does *not* count as safe disconnection in an emergency situation. For safe disconnection of the drive, always disconnect the supply voltage.

## 2.3 Selection of additional system components

### Selecting a pulse generator

Step pulse and direction signals must be applied to the DSM. Choose a pulse generator or an indexer that provides these signals as a minimum. A suitable indexer must be able to drive the input circuits as described in Chapter 3.2.3. Most applications that need speeds above 100 rpm require a pulse generator or indexer that is able to ramp up or down to the required pulse frequency.

### Selecting a motor

The DSM controller is designed to drive a 2-phase hybrid stepper motor from the Bautz product range. This can be either a standard hybrid stepper motor, or a high-performance hybrid stepper that uses the patented Sigmax principle. Most of the 2-phase stepper motors from other manufacturers will also be acceptable.

**Note** *The motor current from the DSM must match the rated current for the motor winding, or be adjusted accordingly.*

You can obtain characteristic torque/speed curves from your distributor on request. Contact your local Bautz distributor for advice on dimensioning drives and selecting motors.

### Selecting of the PSU

Operation of the DSM requires a power supply unit (PSU) with a single voltage output.

**Note** *For multi-axis applications, install a separate cable from the PSU via a fuse to each DSM. This is better than serial cabling of the supply voltage from one instrument to another.*

The permissible supply voltage must be in the range 24 to 75 V DC (max). Obtaining full power from the DSM requires a maximum current capacity of about 5 A. The power supply does not have to be a regulated PSU.



#### IMPORTANT NOTES

- ***The supply voltage must never go above 75 V, not even very briefly.***  
*Ignoring this limit can damage the equipment.*
- ***During braking, motors feed back energy into the PSU.***  
***This causes the supply voltage to rise.***
- ***Important information on the PSU can be found in Chapter 3.2.2 and Appendix B. Read both of these sections before choosing or building a power supply unit.***

## 2.4 Mechanical installation of the DSM

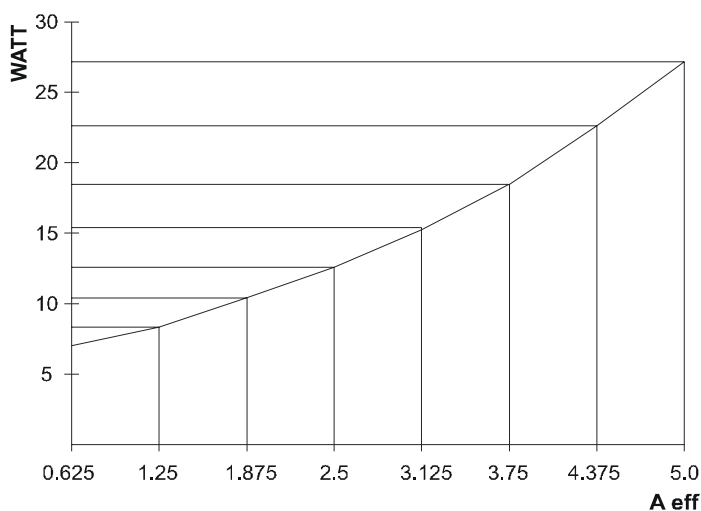
Rule for cooling:



The temperature of the DSM chassis must be kept below 60 °C.  
Ignoring this limit can damage the equipment.

Heat dissipation  
as a function of  
motor current

The heat generated by losses in the DSM depends on the motor current. The diagram indicates how much heat has to be removed. The installation must be implemented in such a way that the maximum chassis temperature of 60 °C is not exceeded. There are various ways of achieving this:



**Mounting on a cooling plate** The DSM chassis is built up from angles made out of thick sheet. The instrument is mounted by fixing the back to a heat sink or cooling plate. This is normally the mounting plate in a switchgear cabinet, an aluminium plate or heat sink with a thickness and surface that are sufficient to keep the chassis of the DSM controller below 60 °C at all times. Use the two openings in the chassis to fix the DSM in place with M4 bolts, and use a heat-conducting sheet or paste between the DSM and the mounting plate or heat sink.

If you use the mounting plate of a switchgear cabinet as a heat sink, then remove the paint from the mounting surface, to improve heat conduction and grounding.

An additional heat sink can also be bolted onto the large side face of the instrument. The heat sink HSDSM is available as an accessory for this purpose (see next section). The diagram above shows the heat losses produced by the instrument, as a function of the motor current that is set. This diagram can be used as an aid for dimensioning the heat sink or cooling plate. If necessary, temperature measurements can be made during normal operation, in order to be able to adjust the area of the heat sink or the air flow over the cooling surfaces.

When making these temperature measurements, take into account the difference between the ambient temperature during the measurements and the worst-case ambient temperature that could arise in practise. The DSM can also be bolted onto a cooling surface by its large side face, using 4 M4 bolts, if the larger mounting surface that is required in this case is not a problem. The same considerations for heat conduction apply as for mounting on the back.

**Mounting with  
heat sink HS6410  
Limits:**

If a cooling plate has not been included in the design, then the Bautz HS6410 optional heat sink can be mounted on the side of the instrument. This unit can then be mounted by the back onto a mounting plate, as described above. Use two M4 bolts through the two openings in the back of the DSM.

With HS6410, note:

If a space of at least 10 cm is kept free above and below the instrument, and cooling is purely through natural convection (not forced convection), then the instrument can only be operated at a maximum current of 5 A<sub>eff</sub> with a maximum ambient temperature of 25 °C.

If the motor current is reduced to 2.5 A, the cooling will be adequate for an ambient temperature up to 45 °C. If a fan is used to provide forced convection for the heat sink, then the current can be set considerably higher.

But the limit always applies: The chassis temperature of the DSM must never rise above 60 °C.

It is best to check this by direct measurement, using a temperature probe in a system that is in operation. The difference between the ambient temperature during these measurements and the worst-case (maximum) ambient temperature that can be expected must be added to the chassis temperature that was actually measured. The sum must be below 60 °C.

**Mounting without  
a heat sink  
Limits:**

If the DSM is just fixed to a mounting plate, without an additional heat sink or cooling plate, then a space of 10 cm must be kept free above and below, as well as 2.5 cm at the sides, between the instrument and any other equipment.

If the cooling is exclusively through natural convection (not forced convection), then the instrument can only be operated at a maximum current of 2.5 A<sub>eff</sub> with a maximum ambient temperature of 25 °C.

It can be operated with maximum 1.25 A<sub>eff</sub> if the maximum ambient temperature is 45 °C.

In this case too, the permissible motor current of the DSM can be considerably larger if a fan is used to provide forced convection for the side face. The same temperature limits and considerations apply as for the previous section on the HS6410 heat sink.

**Installation tips**

Take care to observe the following points when installing the equipment:

Align the instrument so that it is vertical.

Mount the instrument on an even, solid surface, that is able to carry the weight of the instrument, about 0.5 kg.

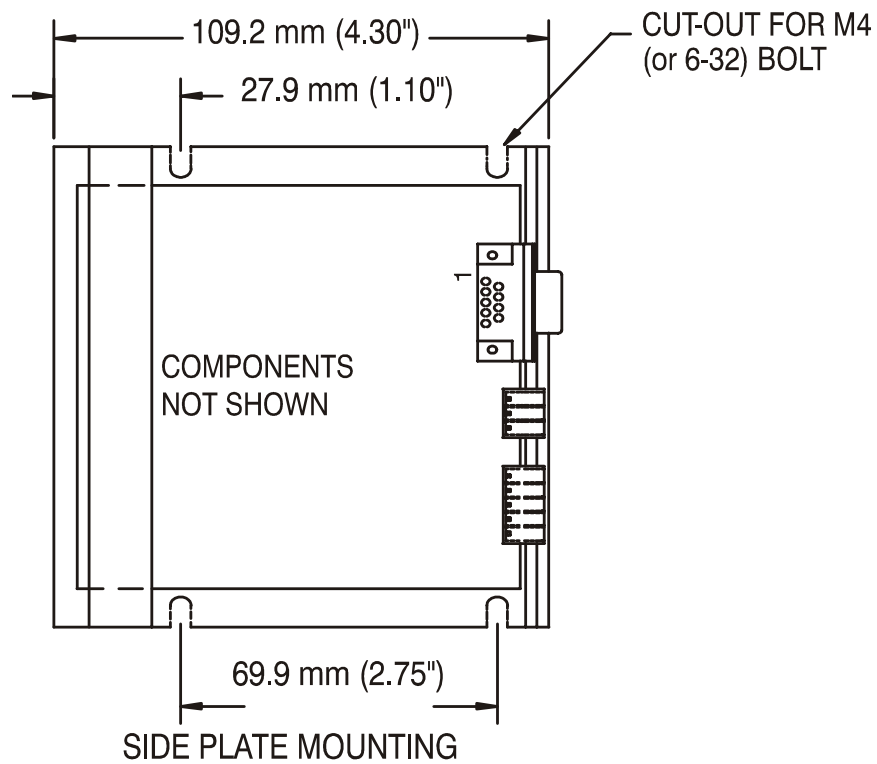
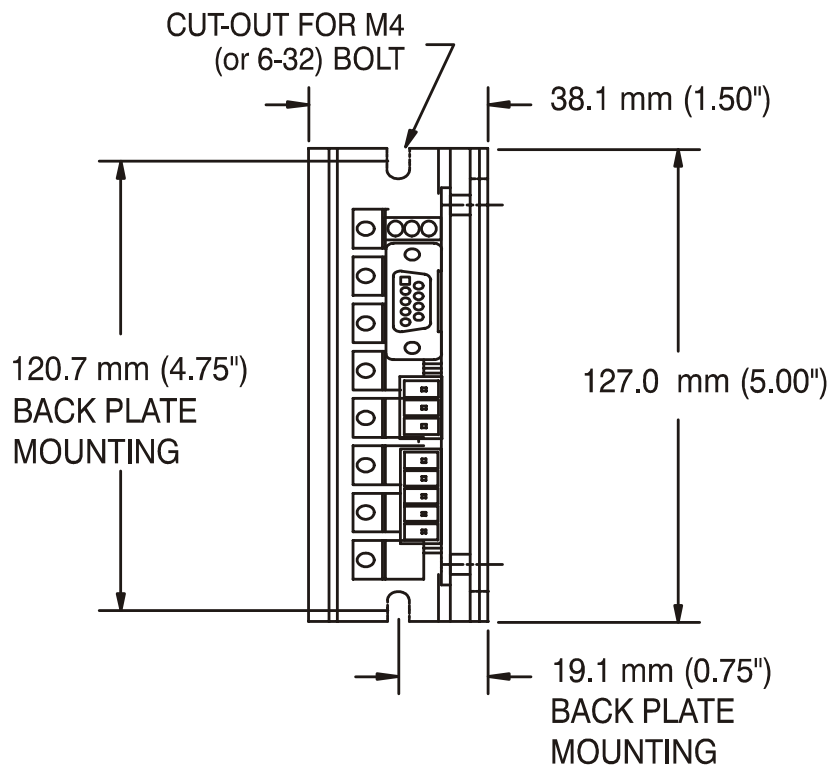
The installation site must be free from external shocks, vibration, or knocks.

There must be at least 10 cm of free space above and below the instrument.

The maximum chassis temperature (60 °C) and maximum ambient temperature (50 °C) for the instrument must not be exceeded.

**Dimensions**

The dimensions given below will help in mounting the DSM



### 3 Connections to the DSM

#### 3.1 CE conformity

The CE labeling confirms that our product DSM5-70-00X fulfills all the requirements of the relevant EC Directives.

The instrument cannot be operated without additional installation (cables, motor, etc.) The measurements specified for CE certification were carried out on a typical installation.

If your machine is wired up in a different way, or uses system components that are not shown here, then we cannot guarantee that interference limits will be maintained.

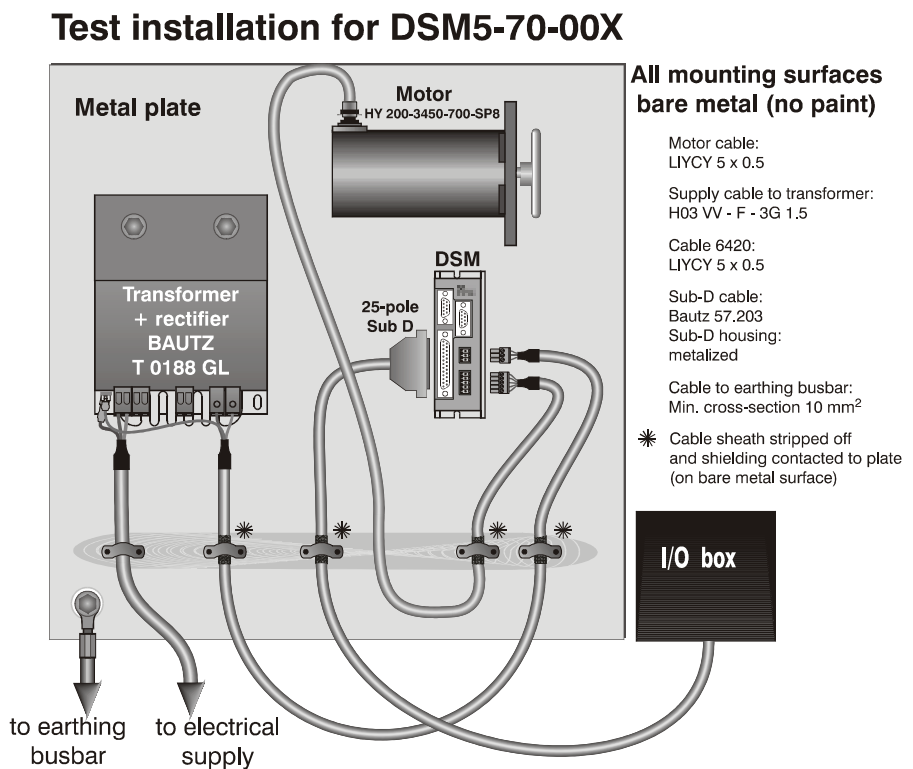
Our Declaration of Conformity confirms that the type DSM5-70-00X instruments meet the EMC Directive 89/336/EEC. The Low Voltage Directive 73/23/EEC is not applicable to these instruments, since their operating voltage is below 75 V<sub>DC</sub>.

When installing our product into a machine, commissioning (i.e. the starting of operation as directed) is prohibited until it has been proved that the final product conforms to the EC Directive 89/392/EEC (Machinery Directive) and the EMC Directive 89/336/EEC is fulfilled for the complete machine.

The manufacturer of the machinery bears the responsibility for proving that the complete system conforms to EC Directives.

The conformity of the product with the listed standards and directives is documented by the Declaration of Conformity on the next page.

The test installation that was used for this declaration is shown in the sketch:



**EC Declaration of Conformity**

The company

EDUARD BAUTZ GmbH & Co KG  
 Robert Bosch Straße 10  
 D-64331 Weiterstadt, Germany

hereby declares that the product

Designation	Stepper motor amplifier
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Type	DSM5-70-00X
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conforms to the following definitive regulations:

EC Directive	89/336/EEC	Electromagnetic Compatibility (EMC)
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Harmonized standards and regulations applied	EN 50081.2 Part 1.1 and 1.2 EN 50082.2 Parts 1.1., 1.2., 1.4., 5.1, 5.2.
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EC Type Examination	(not applicable for self-certification or Module A)
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Provided by	EDUARD BAUTZ GmbH & Co KG Dipl.-Ing. Norbert Witsch
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Place, date	Weierstadt, July 4th 2002
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Legally binding signature	
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### 3.2 Electrical installation of the DSM

#### Introduction

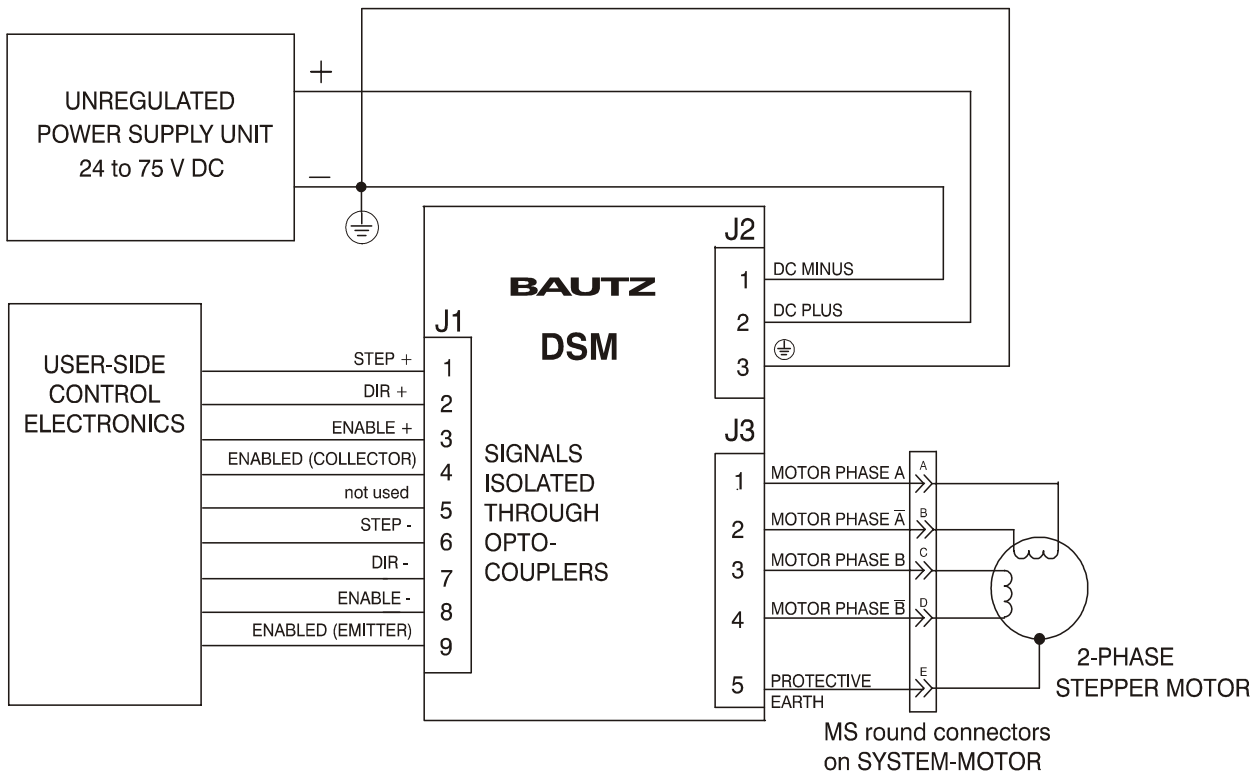
The following three input/output connectors are provided:

- J1 - Signal connector
- J2 - Supply voltage connector
- J3 - Motor connector

These inputs and outputs are described in the following section.

#### Block diagram

Shielding is not shown!



#### The cabling depends on the application

The conductor cross-sections and methods of connection described below, as well as the grounding and shielding measures, are in general use and are adequate for most applications.



**Note:**

**Unusual applications, special standards and regulations, specific operating conditions and system configurations, may make it necessary to deviate from the situation given here. Such requirements would then have priority over the information presented here.**

**It is therefore possible that you will have to connect up the drive in a different way to the one described.**

**Installation for CE conformity Earthing clamps**

Use twisted and shielded cables for the signal and power cables, as described below. These precautionary measures reduced electrical interference. Install a well-earthed busbar close to the DSM stepper motor controller, to which you can make large-area connections for the shielding of the cables, using cable clamps. Shielding should continue right up to the DSM. The length of cable between the earthing busbar and the DSM should not be more than 1 meter.

A number of manufacturers offer suitable components for earthing rails and cable clamps, such as Phoenix (SK14 terminals, NLS-Cu 3/10 rails, and the corresponding mounting stand-offs AB/SS-M) and Weidmüller (KLBÜ shielding terminals).

The DSM chassis should also have a large-area conductive connection to the protective earth (PE). The paint on the contact area must be removed, to provide a good electrical connection (and also good thermal conduction). (Use heat-conducting paste)

**Risk of electric shock**

See Chapter 2.2 for the safety rules that must be followed in order to reduce the risk of an electric shock.

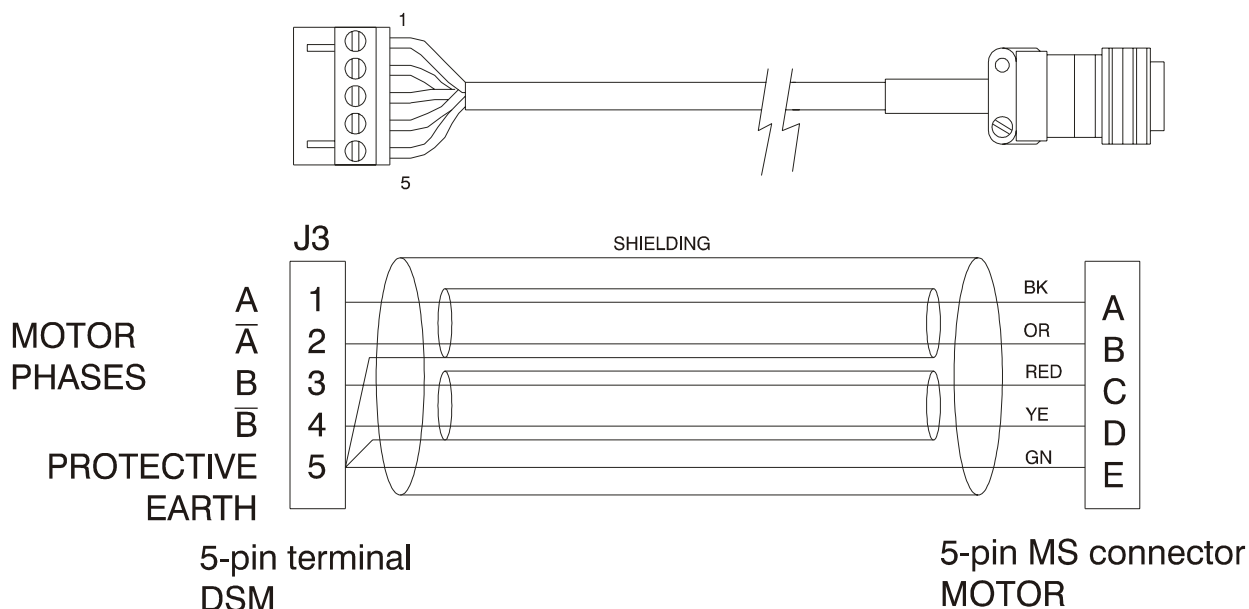
**3.2.1 Connector J3: Motor connection**

**Introduction**

The motor cable connects the controller, via J3, to the motor windings and housing. J3 is a plug-in screw terminal that enables easier installation and faster connections and disconnection of the connector.

**Bautz System Motors**

If you use Bautz System Motors (with MS round connectors) that are already fitted with the mating connectors, then connect them up as shown below.



**Assembling a motor cable**

If you want to make up a cable, please follow the instruction given below for the connections to the mating connector J3. Different sets of instructions are provided in this section for the connections to the different types of motor. For 8-wire motors, the windings for a particular phase are normally connected in parallel. If you connect the motor phase windings in series, then the rated current for the motors is halved. And, because of the increased inductance, the maximum speed that can be reached is also reduced.

**J3 connections**

OUTPUT	PIN	EXPLANATION
Motor phase A	J3-1	Excitation of motor phase A twisted pair of conductors
Motor phase $\bar{A}$	J3-2	
Motor phase B	J3-3	Excitation of motor phase B twisted pair of conductors
Motor phase $\bar{B}$	J3-4	
Protective earth	J3-5	Connection to the motor housing

**Mating connector**

The motor connector J3 on the DSM is a plug-in screw terminal connector from Phoenix, type MSTB 2,5-5-ST RM5.

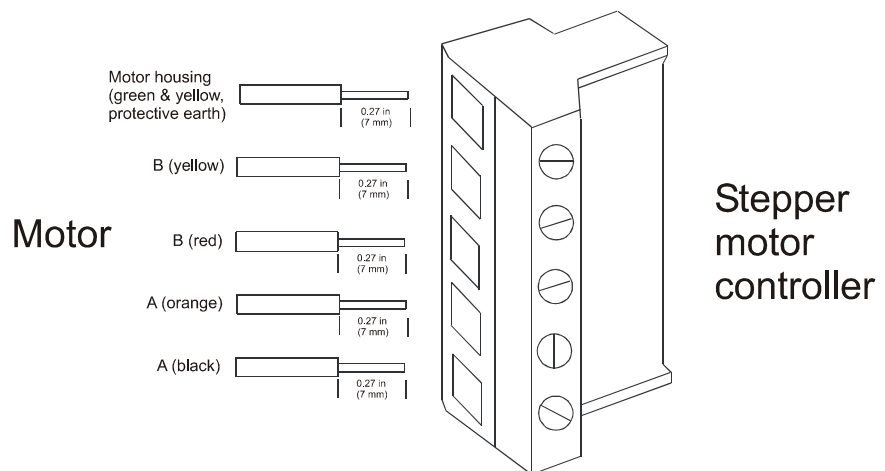
**Specification for the cable**

Stranded conductors up to 1,5 mm<sup>2</sup> cross-section will fit into the terminals of the mating connectors J2 J3.

It is better to use a more generous dimension for the conductor cross-section than the minimum required for the actual current, especially for long motor cables, as this reduces the voltage drop in the cable. It is important to use a shielded cable for the motor cable, with conductor cross-sections of at least 1.0 mm<sup>2</sup>, preferably 1.5 mm<sup>2</sup>. If the motor cable needs to be longer than 20 meters, please consult your distributor.

It is advantageous if the cable consists of two pairs of conductors, twisted with about 1 to 1½ turns per centimeter, with a fifth conductor for the earthing connection to the motor housing. There must be a shield around both phase pairs and the protective earth connection. With long cables, it is advantageous if the twisted pairs of the phase conductors have individual shielding for each pair. Connect the housing of the motor to Pin 5 of J3. **IMPORTANT:** Make a wide-area contact of the (outer) screen to the earthing busbar mentioned previously. Furthermore, the shielding must be connected as shown in the diagram on the previous page.

## J3 assignments



**Note:** The colors given in this diagram are those of the Bautz color code for stepper motors.

## Procedure

1. Strip off 7 mm of the stranded cores.
2. Connect the cores to the plug-in terminal strip as shown in the diagram.

**Note:** Make the terminal screws on J3 tight, for a good connection.

**CAUTION:**

**Do not solder the ends of the stranded cores. Cold solder flows under pressure, and therefore leads to a loose connection after some time.**

**Connection for motors  
with flying leads**

The 3 diagrams show how a Bautz motor with flying leads can be connected to the J3 connector on the DSM controller.

The first drawing shows how a 4-wire motor is connected.

The second drawing shows the connections for an 8-wire motor with windings wired in parallel.

The third drawing shows the connections for an 8-wire motor with windings wired in series.

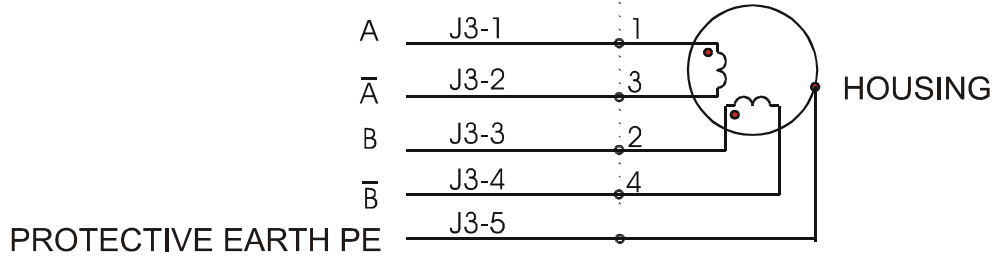
4 cores + earth + shielding are enough for the connections to the DSM.

The connections that are required for parallel or series wiring of the windings can be made at the motor, using a terminal block, for instance.

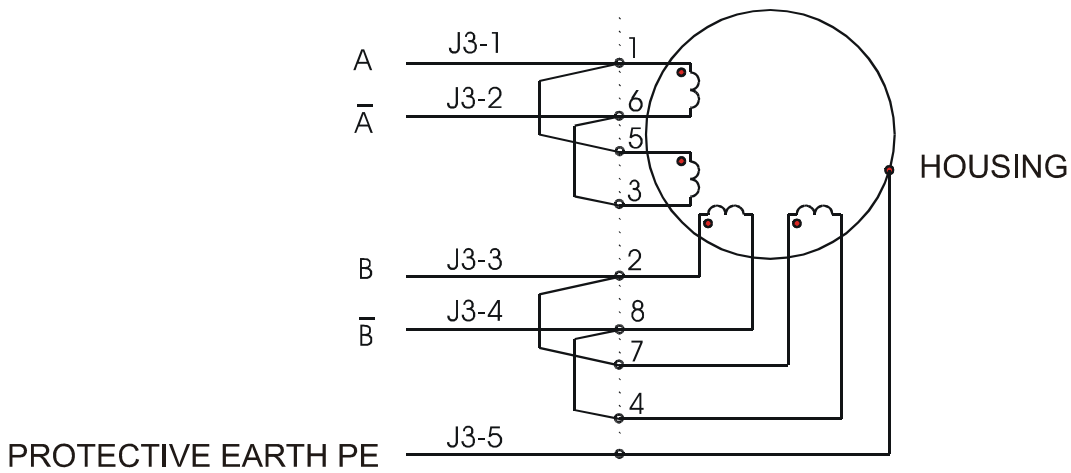
**Connection for motors with a terminal box**

The diagram below shows the connections that are required between connector J3 of the DSM and Bautz stepper motors with terminal boxes on the back end-shield. Connection examples are shown for 4-wire motors and 8-wire motors with parallel wiring of the windings, and 8-wire motors with series wiring.

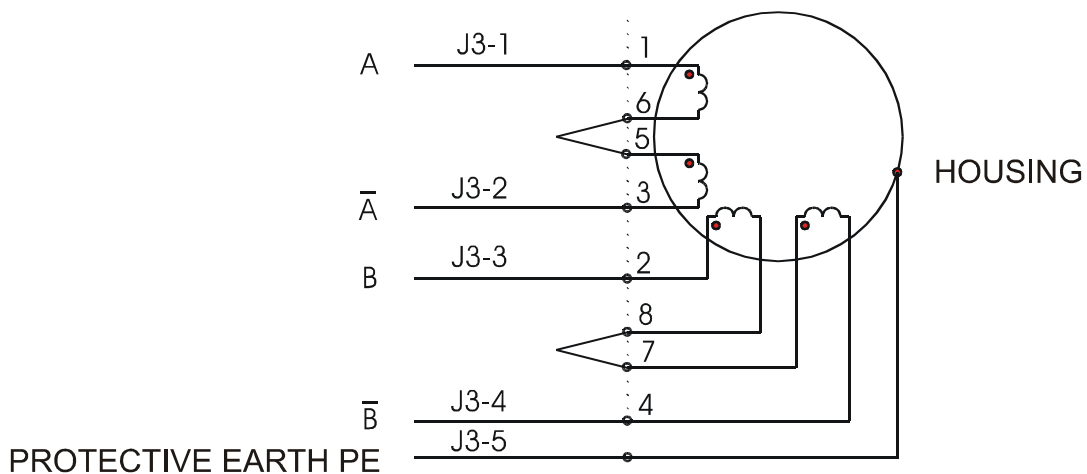
**J3 ASSIGNMENTS      TERMINALS**



**4-WIRE MOTOR**



**8-WIRE MOTOR, PARALLEL WIRING**

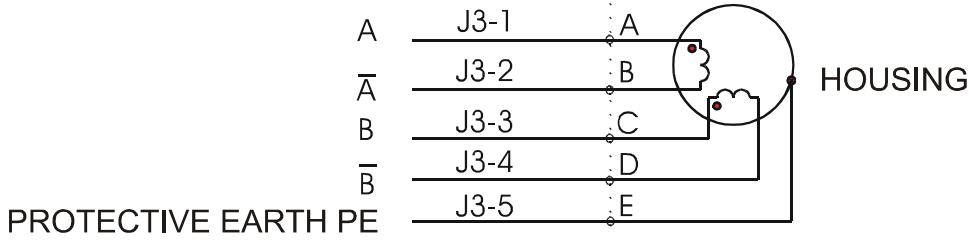


**8-WIRE MOTOR, SERIES WIRING**

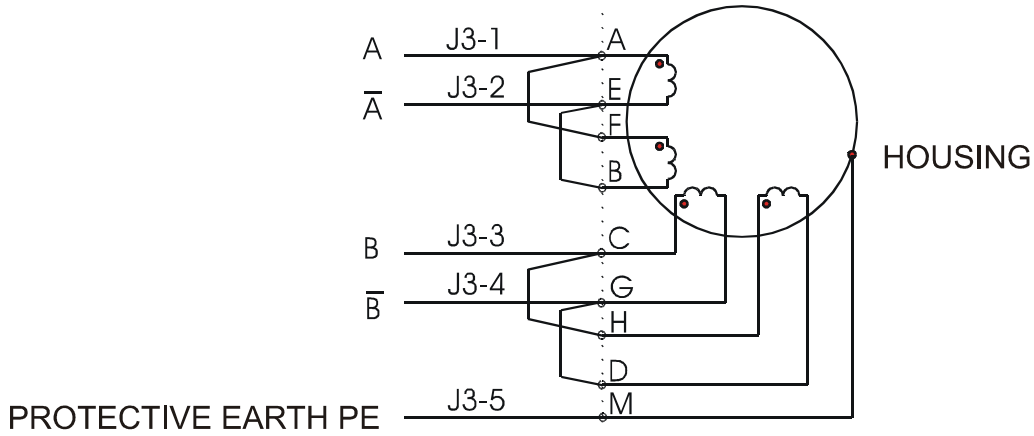
**Connection for System Motors with MS connectors**

The diagram below shows the connections required from the connector J3 on the DSM to Bautz stepper motors with MS round connectors. Connection examples are shown for: 4-wire motors and 8-wire motors with parallel wiring of the windings, and 8-wire motors with series wiring.

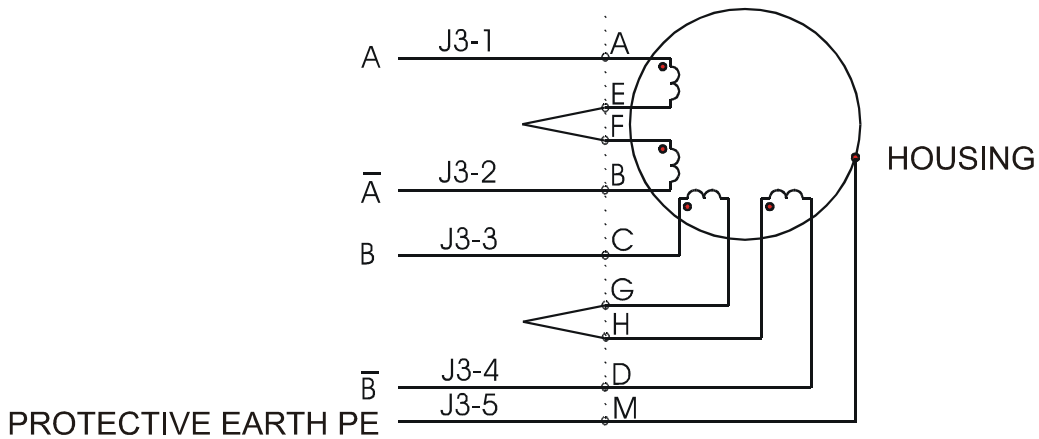
**J3 ASSIGNMENTS MS CONNECTOR**



**4-WIRE MOTOR**



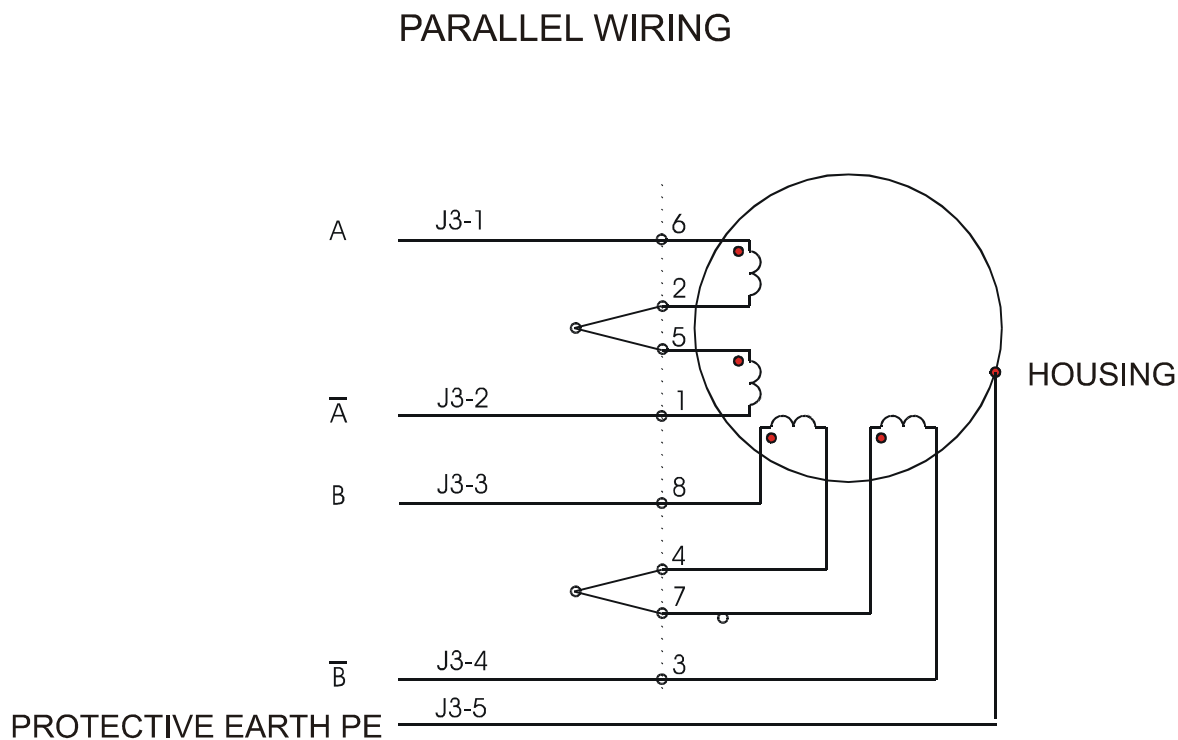
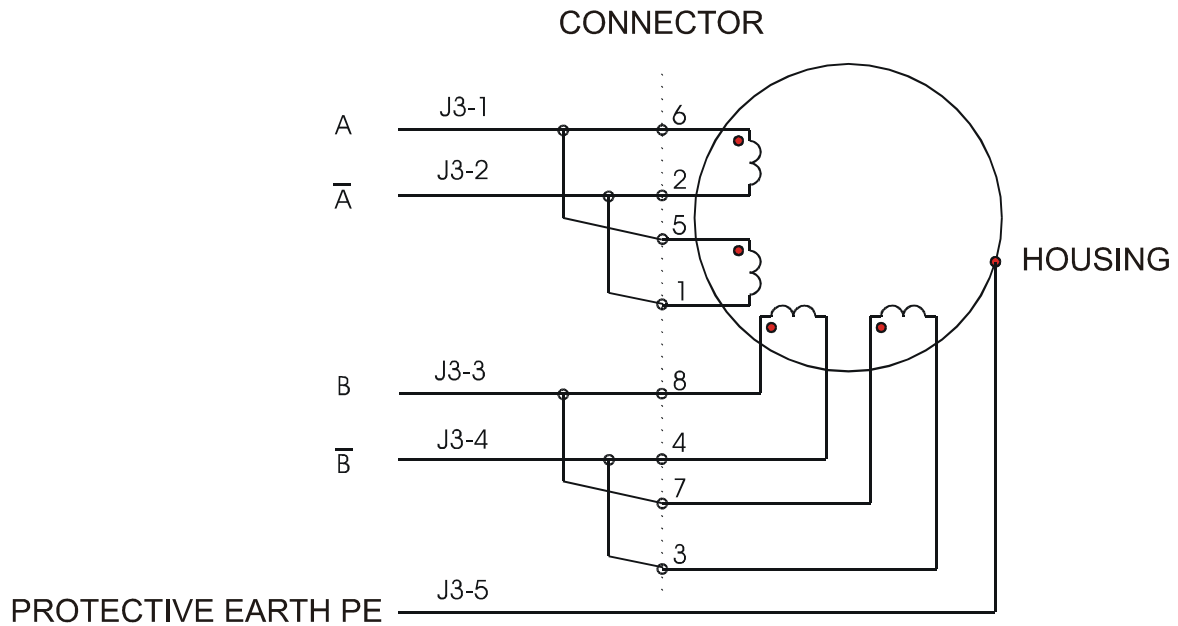
**8-WIRE MOTOR, PARALLEL WIRING**



**8-WIRE MOTOR, SERIES WIRING**

**Connection for Power-Max motors**

The diagram below shows the connections required between the DSM and Bautz Power-Max motors. Power-Max motors have an 8-pole connector. As shown, the windings for a phase can be wired up either in series or in parallel.




### 3.2.2 Connector J2: Supply voltage

#### Introduction

The supply voltage from the PSU is fed to the DSM via J2. See Appendix B for the power supply requirements. There you can find information about the dimensioning and building or selection of a power supply.

#### Connector J2:

(See also the diagram of the J2 connector later in this section)

Input	Pin	Explanation
DC –	J2-1	Supply is +24 to max. +75V DC, max. 5A The negative connection of the supply must be joined externally to PE (protective earth). There is no internal connection in the DSM between J2-1 (DC–) and J2-3 (PE).
DC +	J2-2	
	J2-3	Protective earth connection for the DSM chassis, internally joined to the PE terminal of the motor connector J3-5.

#### Voltage supply

The block diagram on the next page shows the connections between the power supply unit and the instrument. In this example, a simple unregulated power supply is used.

Install a slow-blow 10A fuse (not a circuit-breaker) between the power supply and the storage capacitor.

If several DSM controllers are in the same installation, please **do not** join them all up with wire links to the same DC supply. Instead, install a separate fuse and cable connection from the PSU to the storage capacitor of each DSM.

#### Cable requirements

You can use ordinary shielded cable to connect the PSU to the fuse and capacitor. Ground the shield with a large-area earthing clamp.

The capacitor (storage capacitor type) between DC+ and DC– must be wired in circuit close to the DSM. The connection between the capacitor and the DSM must have a twisted pair for DC+ and DC–. The cores must be twisted with 1 to 1½ turns per centimeter. The core for the protective earth should not be twisted together with this pair. The connection must not be longer than 1 meter. The 3 cores must be covered by a shielding braid. Use cables with a 1.5 mm² core cross-section for the supply voltage.



**IMPORTANT NOTE**

The supply voltage must never go above 75 V, not even very briefly.  
Voltage spikes in the supply voltage are the most frequent cause of equipment failure.  
The PWM-modulated chopper controller does not draw a constant current, but a pulsed current. That is why it is important that the inductance of the cable between the external capacitor and the DSM is kept down. To achieve this, the connecting cable must not be longer than 1 meter, and must be a twisted and shielded pair.

**Wiring diagram**

Note: Shielding is not shown.

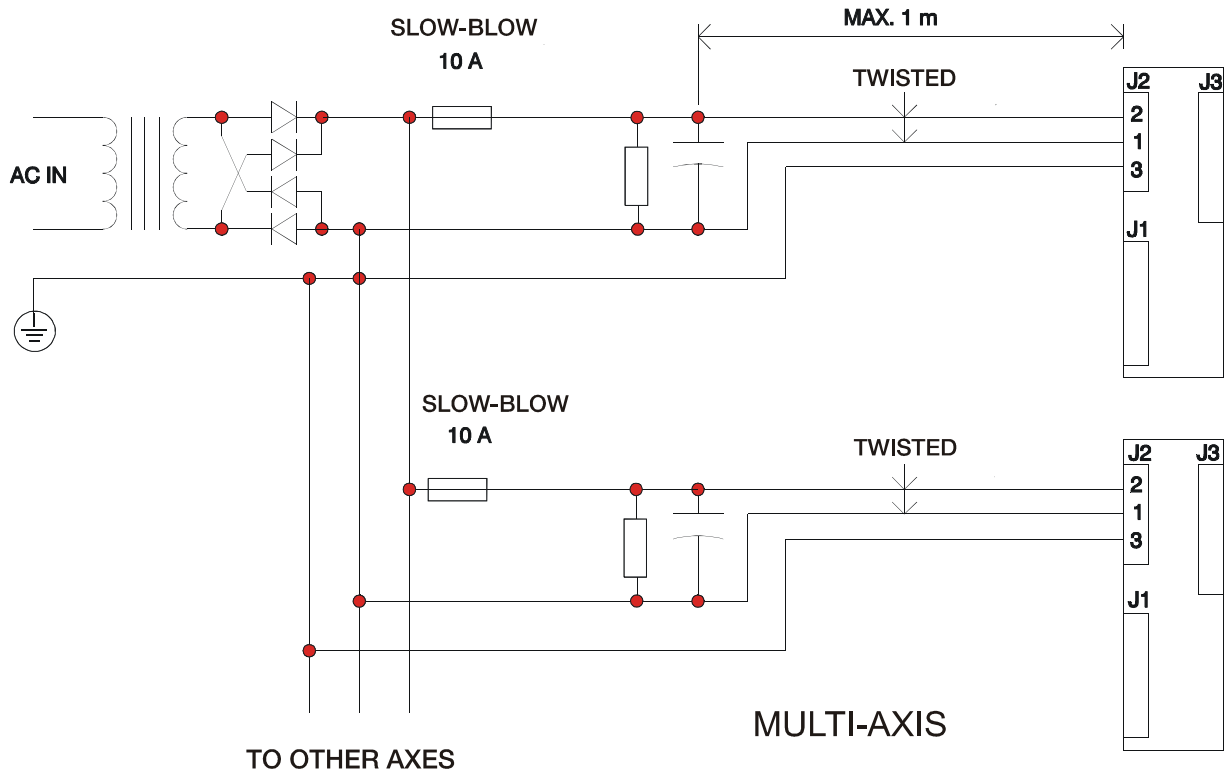
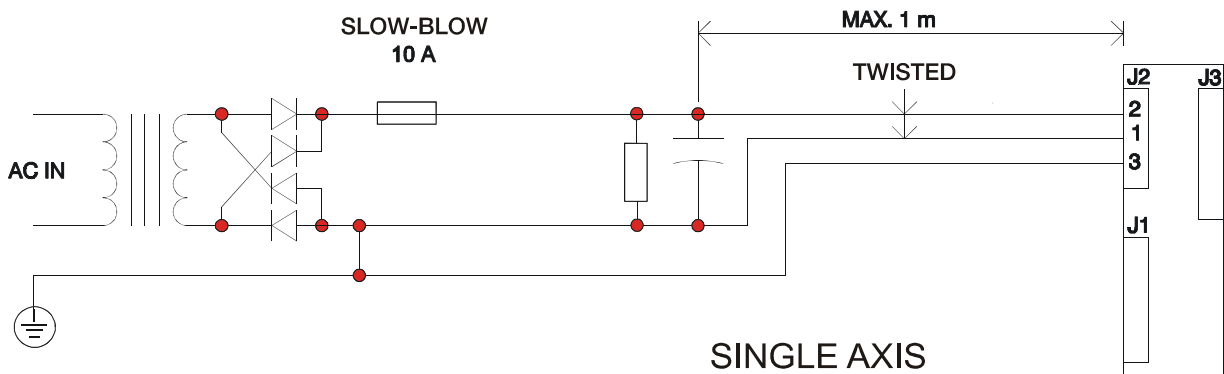
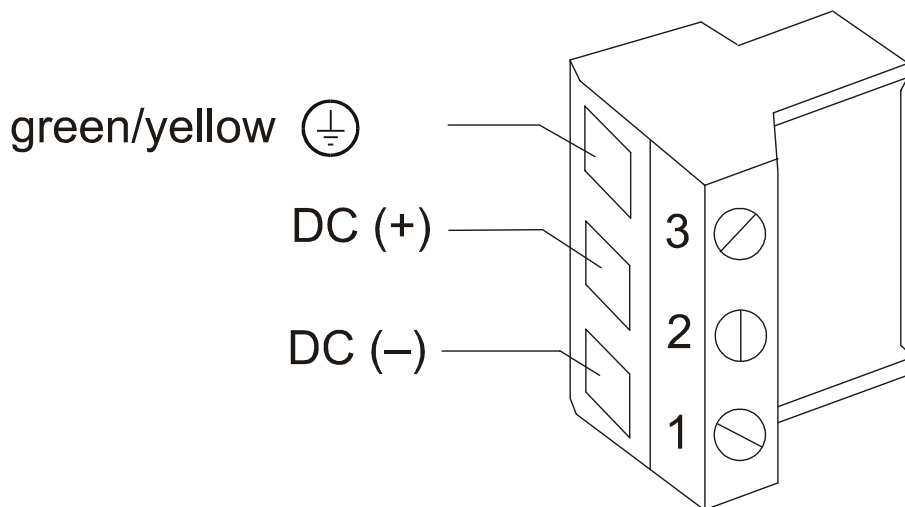


Diagram:  
Connector J2:



**Procedure**

1. Strip off 7 mm of the stranded cores.
2. Connect the cores to the plug-in terminal connector as shown in the diagram.

**Note:** Make sure that the screws on the plug-in terminal are really tight, to ensure a good connection to the stranded cores.



**CAUTION:**  
*Do not solder the ends of the stranded cores. Cold solder flows under pressure, and therefore leads to a loose connection after some time.*

### 3.2.3 Connector J1: Signal connections

#### Introduction

The step pulse and direction signals from an external indexer or pulse generator, together with the enable signal, are wired up to the signal connector J1. The *Enabled* output of the DSM can also be accessed here. It indicates that the motor windings are being driven.

#### J1: signal connector assignment

**Note:** *All inputs and outputs are isolated via optocouplers*

Input / output	Pin	Explanation
<b>STEP+ (pulse +)</b>	J1-1	Step pulse input to create a rotation of the motor. See the following diagram for information on the circuitry and timing.
<b>DIR + (rotation +)</b>	J1-2	Rot. direction input to select direction of rotation of the motor. With the standard motor wiring, the motor rotates clockwise when the optocoupler is <i>not</i> activated, i.e. when no current flows from DIR+ to DIR-. The polarity of the DIR (direction of rotation) input can be reversed by swapping the core pair to <b>one</b> motor phase (not both) on the motor connector (i.e. A swapped with $\bar{A}$ or B swapped with $\bar{B}$ ). See the following diagram for information on the circuitry and timing.
<b>ENABLE +</b>	J1-3	This input is used to enable or inhibit the motor current. If the jumper J6 (pos. 5-6) is removed (factory default setting), then the output stage is enabled when <b>no</b> current flows through the optocoupler. The output stage is inhibited if current is flowing through the optocoupler. If jumper J6, pos. 5-6, is inserted, then the function of this input is reversed. See the following diagram for circuit information. There is a delay of roughly 500 $\mu$ sec between applying the drive enable to the input and the activation of the power output stage.
<b>Enabled collector (Enabled output) – collector output –</b>	J1-4	Collector output. The transistor is switched on as soon as the output stage of the DSM is enabled. See the following diagram for information on the circuitry and timing.
	J1-5	unused

## Continuation of the table

Input / output	Pin	Explanation
STEP- (pulse -)	J1-6	Step pulse input to create a rotation of the motor. See the following diagram for information on the circuitry and timing.
DIR - (rotation -)	J1-7	Rot. direction input to select direction of rotation of the motor. With the standard motor wiring, the motor rotates clockwise when the optocoupler is <b>not</b> activated, i.e. when no current flows from DIR+ to DIR-. The polarity of the DIR (direction of rotation) input can be reversed by swapping the core pair to <b>one</b> motor phase (not both) on the motor connector (i.e. A swapped with $\bar{A}$ or B swapped with $\bar{B}$ ). See the following diagram for information on the circuitry and timing.
ENABLE -	J1-8	This input is used to enable or inhibit the motor current. If the jumper J6 (pos. 5-6) is removed (factory default setting), then the output stage is enabled when <b>no</b> current flows through the optocoupler. The output stage is inhibited if current is flowing through the optocoupler. If jumper J6, pos. 5-6, is inserted, then the function of this input is reversed. See the following diagram for circuit information. There is a delay of roughly 500 $\mu$ sec between applying the drive enable to the input and the activation of the power output stage.
Enabled emitter (Enabled output) - emitter connection -	J1-9	Emitter connection. The transistor is switched on as soon as the output stage of the DSM is enabled. See the following diagram for information on the circuitry and timing.

**Mating connector**

The signal connector J1 is a 9-pole Sub-D socket. The mating connector can be obtained from ITT, among others.

ITT ordering details:

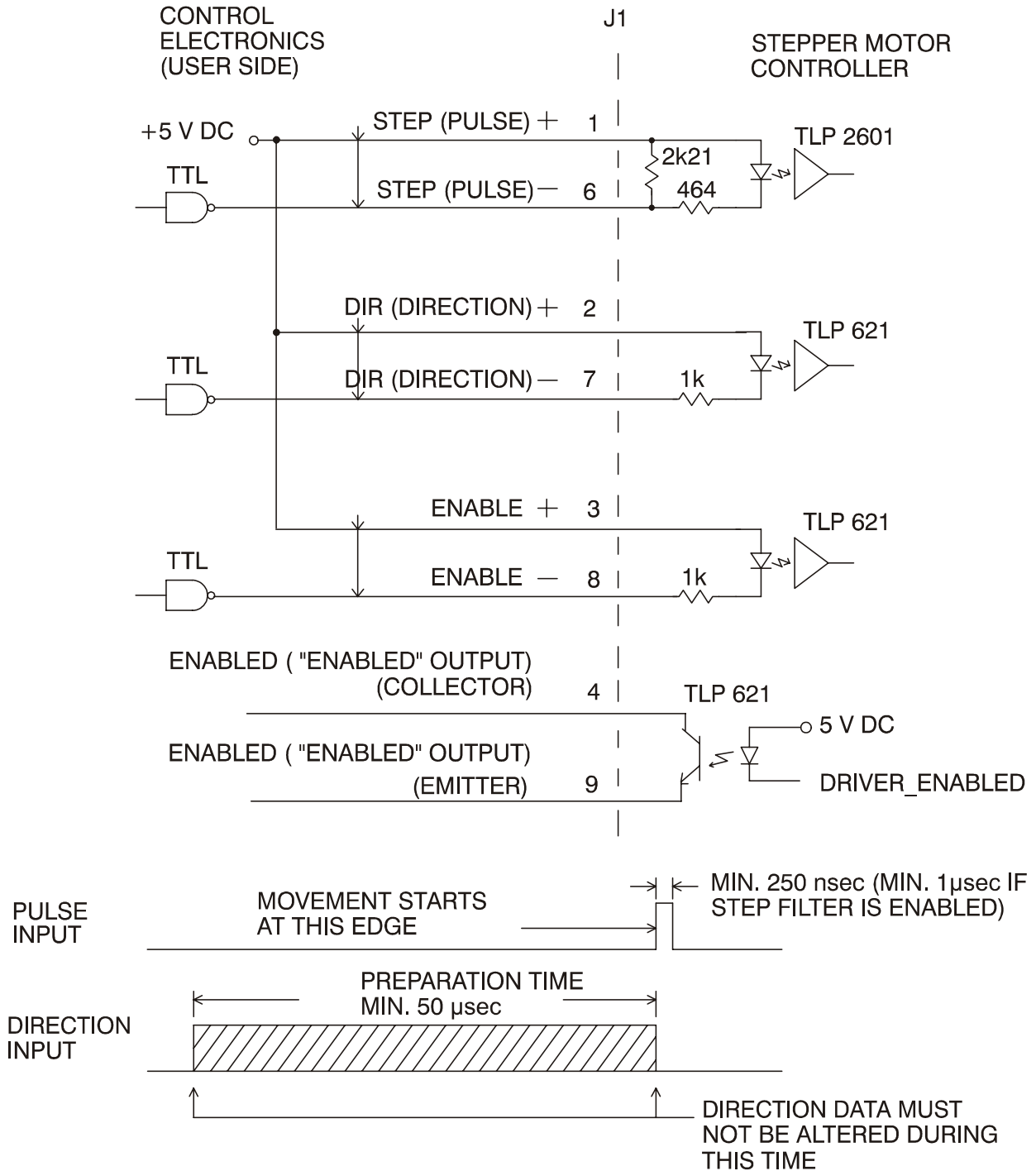
Sub-D plug DE-9P with hood Sub-D DE110963 and strain relief D20419.

**Typical wiring**

The circuit diagrams on the following pages show typical implementations of the wiring between an external indexer and DSM controllers. The TTL gates should have differential driver outputs, and be able to sink at least 10.0 mA at a max. output ON-state voltage of 0.4V.

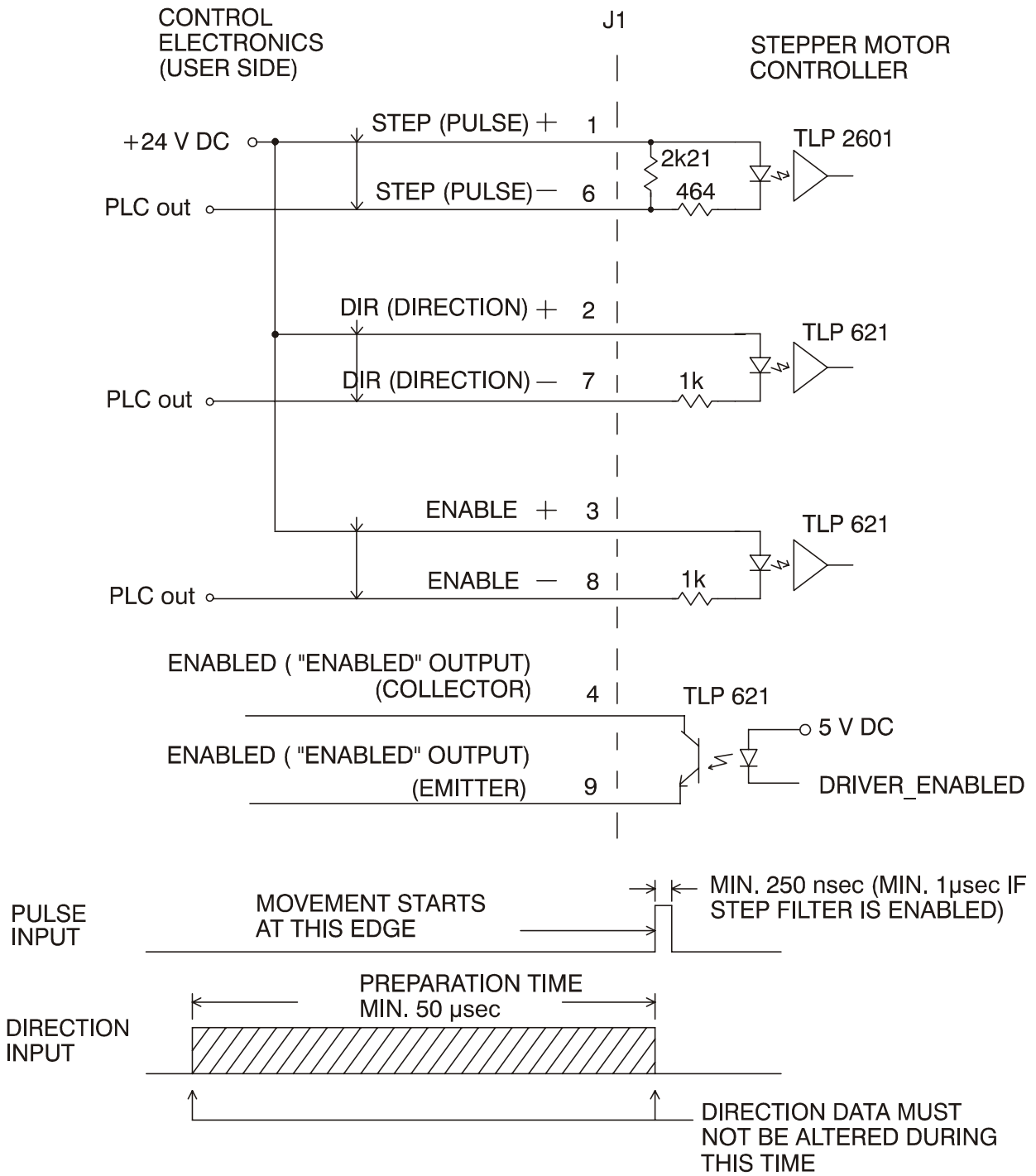
**Circuitry and timing**

**5VTTL DSM5-70-003**



Circuitry and timing

24V/SPS DSM5-70-001



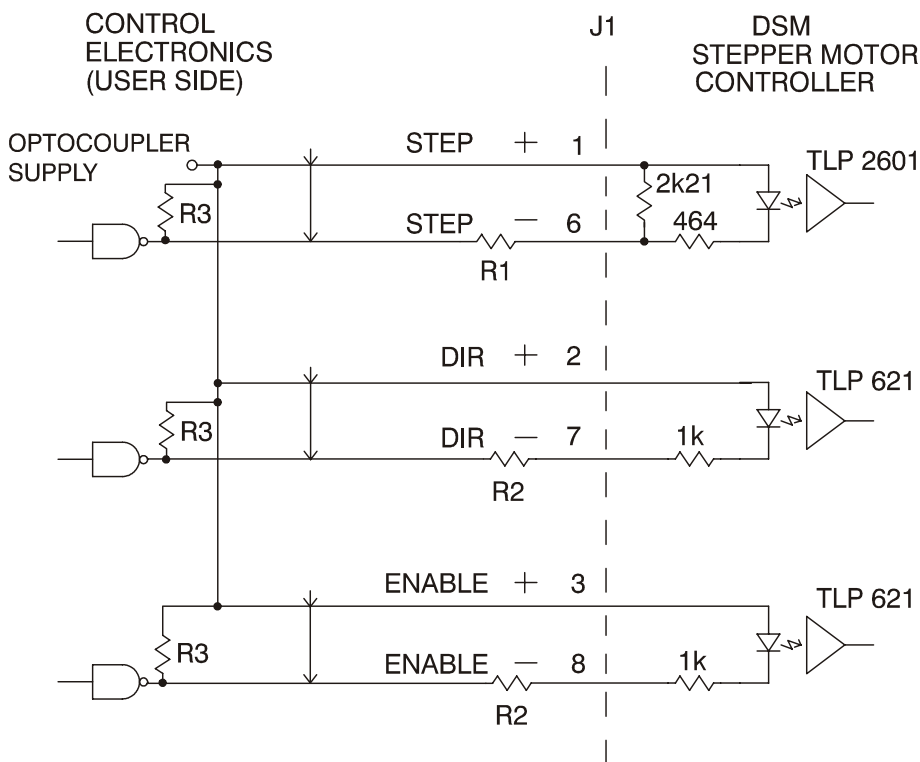
**Signals with higher voltage**

For the signals fed to the optocouplers in the DSM controller, an input of up to 30V is permissible. However, a resistor must be wired in series with the optocoupler diode, as shown below.

If your pulse generator or indexer produces output signals with a level above 5 V, then you can find the value for the series resistance for various voltages in the following table.

If the indexer or pulse generator does not have drivers with a differential output, but open-collector transistor outputs, then you should include pull-up resistors (R3) as shown. A typical value for R3 would be 2k7.

Optocoupler series resistance	R1 (ohms)	R2 (ohms)
+ 12 V DC	1 k	1k5
+ 15 V DC	1k5	2k2
+ 24 V DC	2k4	4k7
+ 30 V DC	3k3	6k8



## 4 Commissioning the DSM drive

### In this chapter

This chapter explains how the DSM drive is commissioned after it has been installed. The following points are covered:

- Using the switch S1 and jumper J6 to set up functions.
- Testing the system

This chapter will make the user familiar with the settings that are required for commissioning and operation of the DSM drive.

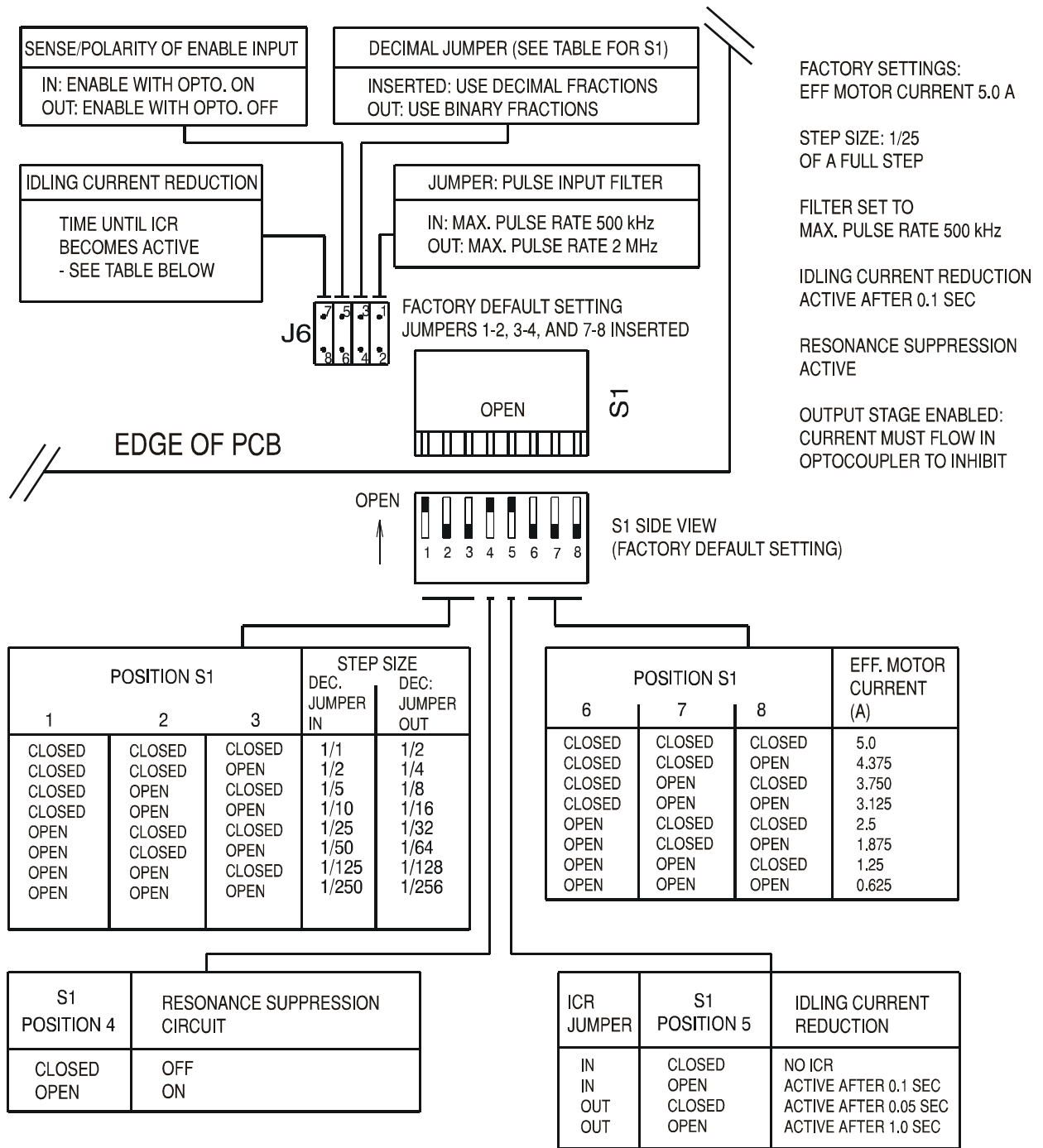
### 4.1 Settings for switch S1 and jumper J6

#### Introduction

The DIL-switch S1 and jumper J6 are used to set:

- the step size
- the motor current
- the resonance suppression
- idling current reduction (ICR)
- the effective polarity of the enable input
- the pulse input filter

**Settings for switch S1 and jumpers**



### 4.1.1 Step size

**Definition**

The step size defines the amount by which the motor rotates for each step pulse on the input. In the following table, this rotation is given as a fraction of a full step.

As a result of their design, all Pacific-Scientific and all 1.8° stepper motors have these features:

One full step rotates the motor shaft by 1.8°.

For such motors, the value is given in steps per revolution.

15 different step sizes are available, by combining the settings of jumper block J6, position 3-4, and the DIL-switch S1, positions 1–3, as shown below.

Decimal step sizes		Binary step sizes	
fraction of full step	?steps/rev	fraction of full step	?steps/rev
1/1 full step	200	1/2 half step	400
1/2 half step	400	1/4	800
1/5	1.000	1/8	1.600
1/10	2.000	1/16	3.200
1/25	5.000	1/32	6.400
1/50	10.000	1/64	12.800
1/125	25.000	1/128	25.600
1/250	50.000	1/256	51.200

**Advantages**

If you select a micro-step of 1/4 or smaller, then you get:

- higher resolution
- smoother operation at low speed
- the option of operating the drive at low speeds in regions that would otherwise suffer from resonance.

**Requirement**

Your indexer or pulse generator must be able to produce the considerably higher pulse rates that are required.

## 4.1.2 Resonance suppression circuit

### Definition

In every stepper drive, resonances appear in the medium frequency range that result in a loss of torque, because the back-e.m.f. of the motor modulates the current in the motor windings at certain speeds. Resonances in the medium speed range can be seen as a region of potential instability that occurs as a result of the electronic, magnetic and mechanical parameters of every stepper motor system. The patented circuit that is used to suppress this effect works by delaying or advancing the switching of the output current in a manner that depends on the incoming step pulse rate. As a user, you should take this into account if you want to apply a step-by-step pulse control method.

The resonance suppression circuit is activated by setting the DIL-switch S1, position 4, to OPEN, as shown in the diagram. This is the default setting, and is favorable for most applications, particularly if your application reveals any resonance or loss of torque in the medium speed range.

If you want to make use of a step-by-step pulse control method, deactivate the resonance suppression circuit by setting the DIL-switch S1, position 4, to CLOSED.

### Advantages

This special circuit avoids loss of torque in the medium frequency range. If it is switched on, the motor maintains its torque during operation in the medium speed range.

### 4.1.3 Idling current reduction (ICR)

**Definition**

The idling current reduction (ICR) reduces the motor phase current when the motor is at idling, i.e. just holding its position. The motor phase current is reduced as soon as the controller has not received any step signals for a preset length of time. This time can be 0.05 sec, 0.1 sec, or 1 second. The current that flows through both halves of the motor winding is reduced by 50 %.

The ICR function can be switched off, so that the idling current is the same as the current for a moving motor. This is unfavorable, because of the heat that is produced. If the function is enabled, then a time delay can be set between the last step pulse signal and the activation of the current reduction. A long delay makes sense for loads with an overshoot. This time delay can be set to 0.05 sec, 0.1 sec, or 1.0 second. 4 different options are available, by combining the settings of the DIL-switch S1, position 5, and the jumper block J6, position 7-8.

The reduction to 50 % always refers to the motor current as set.

Jumper J6, pos. 7-8 Idling current reduction	DIL-switch S1 position 5	Idling current reduction
inserted	closed	Function switched off
inserted	open	active after 0.1 sec <sup>1)</sup>
removed	closed	active after 0.05 sec
removed	open	active after 1.0 sec

1) Factory setting

**Note:**  
*If the ICR function is switched on, then both the motor holding torque and the motor stiffness are reduced by 50 % when the motor is idling/holding.*

**Advantages**

The idling current reduction function reduces heating of the motor and drive when the motor is idling and the output stage is enabled.

#### 4.1.4 Setting the motor current

The motor current must be set by the DIL-switch S1, positions 6,7, and 8. The current that is set must correspond to the motor current rating.

If you use an 8-wire motor in a series connection, please note that the halved motor current in a parallel-connected motor would have the same heating effect. The inductance of a series connection of the windings is four times larger.

A table with the switch settings for various values of current can be found in the diagram *Settings for switch S1 and jumpers* on page 34.

**Notes:**

- 1.) *The heat loss in the DSM controller increases with the output current, so that a higher motor current will require better cooling.*
- 2.) *Relevant information on cooling for the DSM can be found in Chapter 2.4 – Mechanical installation of the DSM –*

#### 4.1.5 Configuration of the enable input

The polarity of the enable input action can be reversed by jumper J6, position 5-6.

If the jumper is inserted, then the controller is enabled when current flows through the optocoupler.

Putting it another way: If the jumper J6 (position 5-6) is inserted, then an external enable signal must be applied (i.e. current flows through the optocoupler) in order for the output stage to supply current to the motor.

If the jumper is removed, then the controller is inhibited when current flows through the optocoupler.

With this setting, the DSM controller can be operated without having to use the enable input. (Factory setting)

#### 4.1.6 Pulse input filter

A digital filter can be switched into the pulse input circuit, to reduce the noise sensitivity, but this will reduce the maximum pulse rate that can be used. If the jumper J6 (position 1-2) is inserted (factory setting), then the filter is active, and the step pulses must be at least 1  $\mu$ sec wide. Pulses (and interference) shorter than 0.5  $\mu$ sec will be suppressed. If the filter is switched off, i.e. Jumper J6, position 1-2 is removed, then the step pulses must be at least 0.25  $\mu$ sec wide. For this reason, the max. step pulse rate is 500 kHz if the filter is in circuit, and 2 MHz if the filter is switched off.

### 4.2 Testing the system

#### Background

The test steps described below are used to check that there is no hidden transport damage to the DSM controller, and it has been properly installed.

#### Procedure

After the DSM has been installed, as described in Chapter 2, check your system as follows.



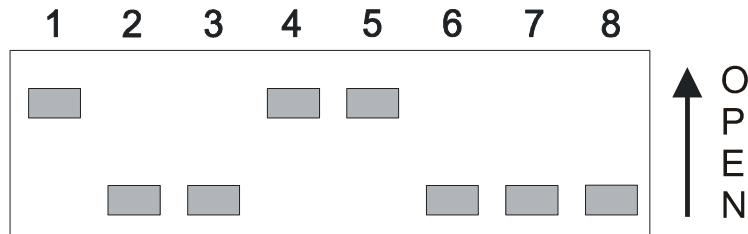
**WARNING !**

**Faults may cause the motor to move unexpectedly.  
For this reason:**

- **When switching on for the first time, the motor shaft must be free, i.e. no load coupled to it.**
- **Fix the motor in such a way that it cannot fall over or cause any damage if it makes jolting movements.**
- **Disconnect the supply voltage if any unexpected movements occur.**

#### Check connections

- 1) Check that the mounting and cooling of the equipment is correct, and check all cable connections, earthing and shielding, to be sure that you have a correct installation.
- 2) *With the equipment switched off*, check that the DIL-switch S1, positions 1 to 8, are all set properly. The factory setting is shown below.



Interpretation of the factory setting:

- Step size: 1/25 of a full steps
- resonance suppression is ON
- idling current reduction is ON
- motor current is 5 A<sub>eff</sub>.



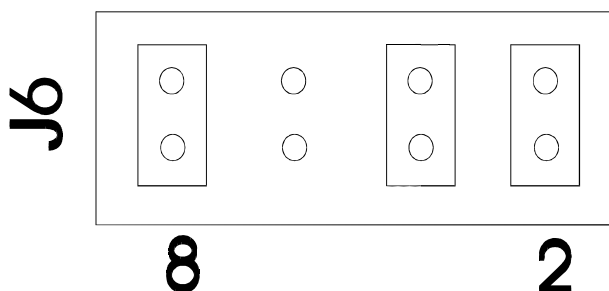
**CAUTION:**

***If the rated motor current is less than 5 A<sub>eff</sub> , set the positions 6, 7 and 8 accordingly.***

**WARNING !**

*Before continuing, check that no voltage is applied to the system.*

2. Check that the jumper block J6 is set correctly. The factory setting is shown here.



Interpretation of the factory setting:

- Idling current reduction is active (with 0.1 sec delay)
  - DSM is enabled when the enable input is unused
  - decimal step sizes are selected
  - pulse input filter is ON
4. Switch on the supply voltage.

**Signal test**

1. Test whether the motor has a holding torque, by trying to turn the motor shaft by hand. A current-carrying motor cannot be turned by hand, or only with great difficulty.
2. Apply step pulses, and see if the motor rotates.
3. Reverse the polarity of the direction signal (DIR) and apply step pulses to the motor. The motor must now rotate in the other direction.

**Help, if required**

If you need further support for your application, please contact your distributor.

## 5 Maintenance / Fault-finding

**In this chapter** This chapter describes maintenance and fault-finding for the DSM stepper motor controller.

### 5.1 Cleaning the DSM controller

The DSM controller does not require any regular maintenance. However, to prevent problems being caused by deposits of dust and dirt, it can be cleaned if required, as follows.

**Procedure** Clean off surface dust and dirt from the instrument, by using clean, dry compressed air, at a low pressure.

### 5.2 Status LEDs

**Green LED** When the controller is enabled (motor is carrying current), the green LED lights up on the front panel of the instrument, and the DSM is ready for operation.

**Yellow LED** The yellow LED shows that step pulse signals are being received by the controller.

**Red LED** This shows that the fault detection (see below) has been triggered.

### 5.3 Fault-finding in a DSM drive

**Introduction** The DSM controller has an *Enabled* transistor output that is electrically isolated, via an optocoupler. It is conducting if the drive is enabled, i.e. the motor is carrying current. It is non-conducting if the controller has been inhibited by the appropriate signal on the enable input, or if it has been de-activated for its own protection, because the internal protection circuit has detected one of the following faults:

- current overload of the output (short-circuit between two motor phases, or between a phase and earth)
- 
- overheating
- overvoltage on the supply voltage, input connector J2
- undervoltage on the supply voltage input on connector J2
- If one of the above protection circuits has been triggered, then the fault condition is immediately indicated by the red status LED on the front panel.

Use the following fault-finding table and the *Enable* output for diagnosis, as shown in the list. These two aids make it possible to solve most problems. If it is still not possible to operate the controller after this, please contact your Bautz distributor.

**IMPORTANT NOTE**

***If you come to the conclusion that the DSM controller is faulty, do NOT just replace it by another and then switch on again.***

***Instead, check:***

- ***the PSU dimensioning***  
You can find important tips about this in Appendix B, towards the end of this manual.
  - ***the wiring of the supply voltage***  
You can find important tips about this in Chapter 3.2.2 - Connector J2: Supply **voltage** s(on page 25).
- ***whether the chassis temperature was kept below 60 °C***  
Important notes on thermal dimensioning can be found in Chapter 2.4 – Mechanical installation of the DSM – on page 12.

***Supply voltage faults are the most frequent cause of controller failures.***

## Fault-finding table

SYMPTOMS	CORRECTIVE MEASURES
<p>Motor has no (holding) torque and: green LED is off Red LED is on</p>	<p>State: Enable is missing, or an internal protection circuit has been triggered and has removed the enable.</p> <p>Check that the jumper J6 (position 5-6) is removed, or, if it is inserted, that at least 3 mA current is flowing through the optocoupler for the <i>Enable</i> input.</p> <p>Switch off the supply voltage, detach the motor cable from connector J3, and switch the supply on again. If the <i>Enabled</i> output is now LOW, disconnect the motor at the motor end of the cable. Check the motor cable for continuity, and for short circuits between the cores, or between the cores and the shielding. Check that J3 is correctly wired up. Check the detached motor for continuity of the individual phases, and for short circuits between the phases, or between the phases and the motor housing. Reconnect the motor, in accordance with the appropriate circuit diagram, as shown in Chapter 3.2.1 from page 19 onwards.</p> <p>Check that the supply voltage on connector J2 lies between 24 V and 75 V DC. If possible, check this with an oscilloscope, and look for any short overvoltage spikes or voltage drop-outs.</p>
<p>Motor has no torque, and the green LED is on Red LED is off</p>	<p>State: Controller is enabled, but the motor current is too low, or there is no motor current at all.</p> <p>Check that the DIL-switch S1, positions 6, 7 and 8 (current setting), are all set properly.</p> <p>Check, as described above, that the motor cable is correctly wired up and properly plugged in to the drive.</p>
<p>Motor has a holding torque, but does not rotate Green LED is on Yellow LED is off</p>	<p>State: No step pulses are being detected at the step pulse input.</p> <p>Test the pulse input, for instance by applying a 4.5 V battery (with the right polarity). Unless an extremely small step size was selected, repeated on/off contacting of the battery must produce a visible movement of the motor shaft. Make sure that the step pulse input is wired up correctly, and the pulse source fulfills the electrical and timing/frequency requirements.</p>
<p>Motor rotates in the wrong direction</p>	<p>State: You need to reverse the sense/polarity of the direction input.</p> <p>Switch off the supply voltage. Swap the connections to one motor phase (not both) on J3. This will reverse the default direction of rotation.</p>
<p>Motor does not respond to the direction input</p>	<p>Test the direction input, for instance by applying a 4.5 V battery (with the right polarity).</p> <p>Make sure that the direction input is wired up correctly, and the signal fulfills the electrical and timing requirements.</p>

Fault-finding table, continued

SYMPTOMS	CORRECTIVE MEASURES
<p>Motor does not reach the expected position</p>	<p>Check whether the step size that has been set for the DSM controller matches the step size parameter setting for the indexer.</p> <p>Check whether the motor stops or loses steps because it is overloaded (required load or acceleration torque is too high) or because it is working in a resonance region. The noise made in operation is often a clue to such effects.</p> <ol style="list-style-type: none"> <li>1. Check the drive dimensioning once more. Please note that the torque curve of a stepper motor depends on                     <ul style="list-style-type: none"> <li>- the DC-bus voltage used for the controller (in the case of the DSM, this is the supply voltage)</li> <li>- (if it is an 8-wire motor) whether the motor phases have a series or parallel connection.</li> </ul> </li> <li>2. Use a smaller step size, to avoid resonance problems at low speed (below about 120 rpm)</li> <li>3. Activate the circuit for resonance suppression in the medium speed range (switch S1, position 4, to CLOSED).</li> <li>4. Consider the switchable filter for the step pulse input. When using small step sizes, you have to switch off the filter in the pulse input, so that the higher frequencies required can pass through. When using large step sizes, it makes sense to use the filter (see Chapter 4.1.6 on page 38).</li> <li>5. To avoid small step errors that accumulate when the drive moves backwards and forwards, make a special check whether the indexer maintains the necessary waiting time of at least 50 µsec for the direction signal, before it produces the first step pulse for a new movement.</li> <li>6. Check that the signals at the step pulse and direction inputs fulfill all the specified electrical and timing requirements, and are not being falsified by interference.</li> </ol>

**Returning items  
for repair or  
exchange**

If you come to the conclusion that the DSM controller and/or the stepper motor is faulty, then proceed as follows:

If you are the customer of a machinery manufacturer in whose machine Bautz-products are being used, then first contact the machinery manufacturer, and not the nearest Pacific-Scientific distributor. Machinery manufacturers often make small alterations, especially to motors, which the distributor does not know about, so that replacement equipment or motors from a distributor are no longer compatible, in spite of having the same type number.

If you acquired the product directly from a distributor, then please contact precisely this particular distributor. He will know the fastest way for repairs and exchange.

## 6 Operation with a Profibus interface

This manual (MAEDSM-E) describes the operation of the DSM output stage with step pulse and direction inputs. If you are using it with the Profibus interface, these signals are generated by the add-on card of the indexer.

**In this case, please note the following:**

When using the Profibus Stepper 6410-PBX, the connector J1 of the DSM has no function, and must not be connected.

On the jumper block J6, the jumpers 1-2 (inserted) and 5-6 (removed) must not be altered.

## 7 Technical data

### 7.1 Electrical data

**Supply voltage** 24 - 75 V DC, 5.0 A

**Output currents from the controller (motor-phase currents)** with the setting:

5 A	5 A ± 0.25 A
4.375	4.375 ± 0.2 A
3.75	3.75 ± 0.2 A
3.125	3.125 ± 0.15 A
2.5	2.5 ± 0.15 A
1.875	1.875 ± 0.125 A
1.25	1.25 ± 0.125 A
0.625	0.625 ± 0.1 A

**Type of control** bipolar 2-phase chopper control

**Chopper frequency** nominal 20 kHz

**Step size**

<u>Can be set by switches</u>	<u>steps/rev</u> <u>(for 1.8° stepper motor)</u>
1/1 <b>(1/2)</b>	200 <b>(400)</b>
1/2 <b>(1/4)</b>	400 <b>(800)</b>
1/5 <b>(1/8)</b>	1,000 <b>(1,600)</b>
1/10 <b>(1/16)</b>	2,000 <b>(3,200)</b>
1/25 <b>(1/32)</b>	5,000 <b>(6400)</b>
1/50 <b>(1/64)</b>	10,000 <b>(12,800)</b>
1/125 <b>(1/128)</b>	25,000 <b>(25,600)</b>
1/250 <b>(1/256)</b>	50,000 <b>(51,200)</b>

**Signal inputs** (See circuit diagram in Chapter 2.5.3)

Signal inputs are isolated via optocouplers

Input	min. current to switch the optocoupler	max. current through the optocoupler	max. reverse voltage
J1-1, J1-6 step pulse	5.5 mA	10 mA	5 V
J1-2, J1-7 direction	3.0 mA	4.5 mA	5 V
J1-3, J1-8 enable	3.0 mA	4.5 mA	5 V

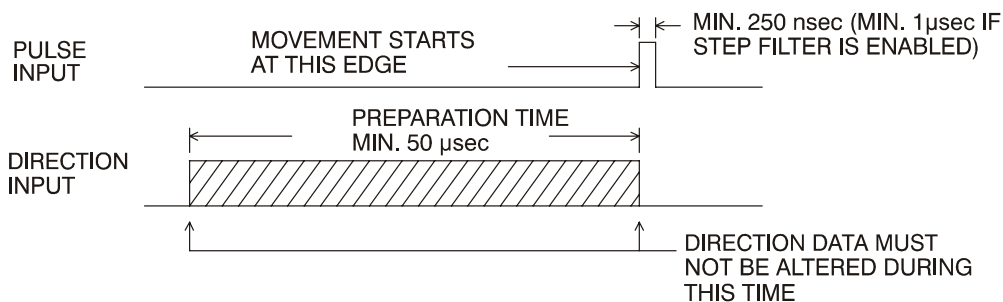
**Features of the signal output** (See diagram in Chapter 3.2.3)

J1-4, J1-9  
Enabled output

Optocoupler with an *npn* transistor in the output, open collector and open emitter  
Maximum voltage drop in the ON (=LOW) state: 0.5 V, at 2 mA load current.

**Maximum pulse frequency on the pulse input** 2 MHz, if the switchable filter in the step pulse input is off.  
500 kHz, if the filter is active.

**Preparation time for direction input** The following diagram shows the timing relationships that are required between the step pulse and the direction input:



**Min. ramp duration for pulse frequency ( accel./braking)** 50 msec (this limit only applies if the resonance suppression circuit is activated for medium speeds).

**Delay between pulse and motor step**

1. If resonance suppression is activated for medium speeds, the the delay for step pulse rates lower than 500 full steps per second is less than 500  $\mu$ sec. At pulse rates above 500 full steps per second, the delay is less than 270° of one period of the frequency (=pulse rate).
2. If resonance suppression for medium speeds is de-activated, then the delay is less than 10  $\mu$ sec at all pulse rates.

**7.2 Ambient conditions**

**Operating temperature**

The permissible ambient temperature is 0 °C to 50 °C, with or without a housing, provided that the chassis is properly mounted and cooled, so that the maximum permissible chassis temperature of 60 °C is not exceeded. Details on thermal dimensioning can be found in Chapter 2.4 .

**Storage temperature**

-55 °C to +70 °C

**Maximum chassis temperature**

60 °C

**Note:** *Mount the DSM chassis (using the back or side panel) on a cooling plate or a heat sink, to ensure the best possible heat transfer. Use a heat-conducting sheet or paste between the DSM and the mounting plate or heat sink. The temperature of the DSM chassis must be kept below 60 °C in all circumstances. A fan can be installed to ensure this. If ICR is used, then the waste heat that is generated will be reduced.*

**Humidity**

10 to 90 %, no condensation permitted

**Convection cooling**

(These details apply if the DSM is not mounted on a cooling plate.)

With optional heat sink HS6410

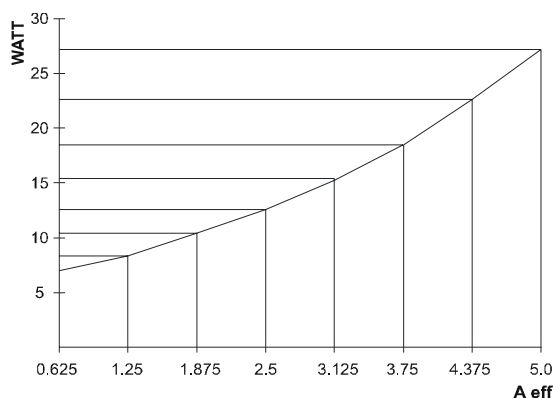
Full motor current (5 A) at +25 °C ambient temperature  
max. motor current 2.5 A at +45 °C ambient temperature

Without heat sink

max. motor current 2.5 A at +25 °C ambient temperature  
max. motor current 1.25 A at +45 °C ambient temperature

The curve for waste heat generated against the set motor current helps in thermal dimensioning. See Fig. 1 below.

**Fig. 1**



### 7.3 Mechanical data

**Dimensions**                    see Chapter 2.4

**Weight**                         approx. 0.5 kg

#### Connectors and mating connectors

Supply voltage                 Phoenix Contact MSTBT 2,5/3-ST RM5

Signal                            9-pole Sub-D socket. Suitable mating connector: ITT Sub-D DE-9P  
with hood ITT Sub-D DE110963 and strain relief D20419

Motor                             Phoenix Contact MSTBT 2,5/5-ST RM5

## Appendix A - Ordering details

### Background

This appendix provides the type codes and ordering numbers for the DSM controller and accessories.

### For the DSM:

Designation	Ordering number	Comment
Stepper motor controller	DSM5-70-003	5V inputs
Stepper motor controller	DSM5-70-001	24V inputs
Connector set	CK-DSM	5-pole plug from PCD
		3-pole plug from PCD
Optional heat sink to screw to the chassis side panel	HS6410	with fixing material and heat-conductive sheet
DSM technical description in German	MAEDSM-D	MAEDSM-D.pdf
DSM technical description in English: Installation & Hardware Reference Manual	MAEDSM-E	MAEDSM-E.pdf

## Appendix B PSU considerations

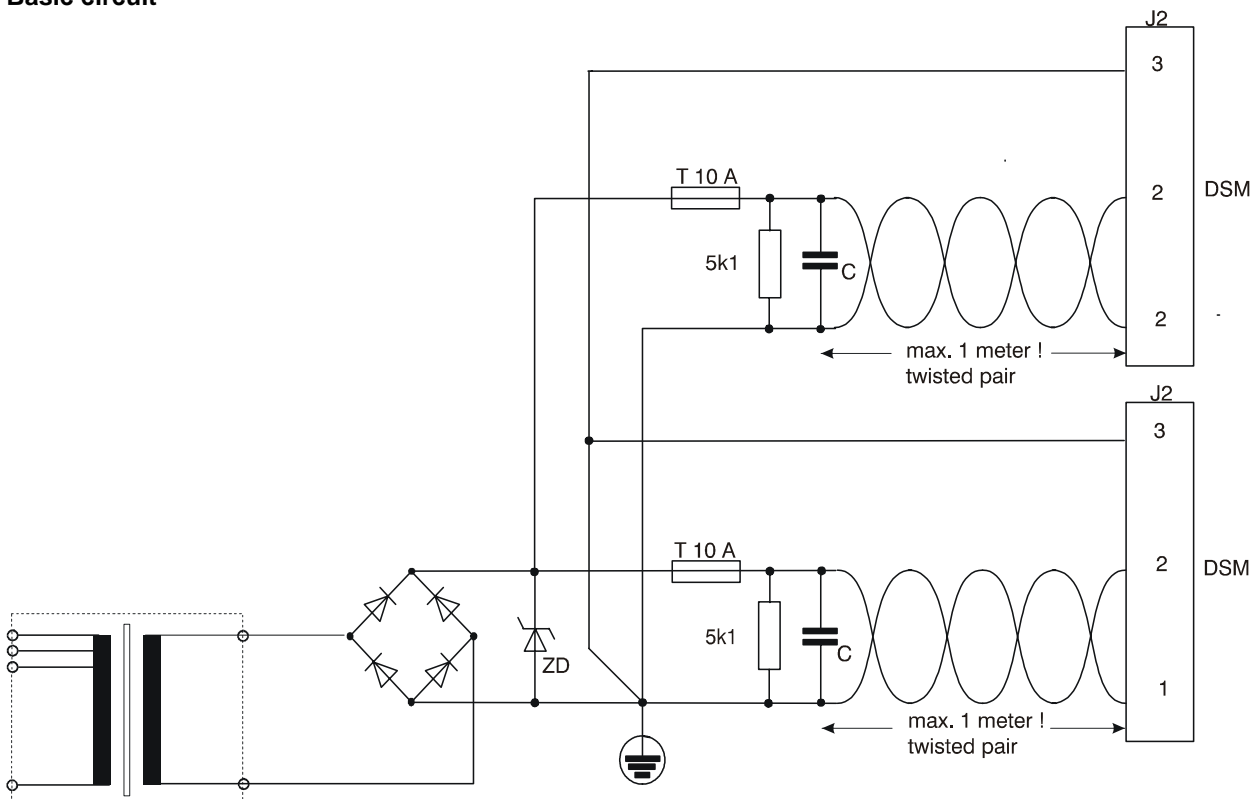
### B1 PSU with a bridge rectifier and capacitor

The circuit diagram below shows a layout using a transformer, bridge rectifier and capacitor. This is the type of power supply most frequently used to supply one or more DSM controllers.

An isolating transformer converts the voltage from the electrical supply to a level that, when rectified, produces the required DC-bus voltage. At the same time, it provides electrical isolation from the electrical supply network. An individual fuse must be provided between the rectifier and each of the smoothing/storage capacitors used to feed each DSM from the DC-bus. To provide optimum protection, each fuse must be dimensioned for the current required by a single DSM. The capacitors must be installed close to their respective DSMs. The connection between the capacitor and the DSM terminals for DC+ and DC- must be made by a twisted pair cable (shielded, if possible). The cable must not be longer than 1 meter. This reduces the effect of lead inductance.

In many cases, a ballast circuit must be included to limit the rise in voltage caused by feedback from the motor during braking. In this Appendix (B) you can find guidelines for the dimensioning of power supply components.

#### Basic circuit



This diagram serves only to show the basic circuit elements. In a practical implementation, shielded cables should be used.

Details on shielding and installation to conform to CE requirements can be found in Chapter 3.2. A wide-area contact of the shielding to the earthing busbar is vitally important.

**CAUTION**

*The power supply must be so dimensioned that the voltage between J2-2 and J2-1 never rises above 75 V, regardless of the operating conditions – not even for a very short time. Such operating conditions include: the maximum possible electrical supply voltage, variations in the secondary voltage from the transformer (caused by load variations), voltage spikes arising from the pulsed current drawn by the DSM, as well as voltage fed back from the motor during braking. If these factors are not taken into account, the DSM controller may suffer lasting damage.*

## B1.1 Supply transformer dimensioning

### Electrical supply: voltage and frequency

When dimensioning the transformer, make allowance for the maximum possible voltage and the lowest possible frequency of the electrical supply network. Otherwise, the core may saturate, resulting in an enormous rise in current and damage to the windings.

### Considerations for the secondary voltage

The motor produces the maximum power when fed with the maximum voltage, but this must never go above 75 V DC. Of course, you can also use a lower voltage, as long as it is above the minimum level of 24 V DC. The available motor torque falls off faster with increasing speed if the voltage fed to the motor is lower.

The maximum voltage for the DC supply can be approximately calculated (without taking account of the voltage spikes produced by the pulsed current consumption of the DSM):

$$(1.414 \times \text{actual r.m.s. secondary voltage}) - 1.5$$

**Note:** *This assumes a voltage drop of 0.75 V across each rectifier diode. To achieve the above value, and to discharge the capacitors when the AC supply is switched off, we recommend wiring a discharge resistor across each capacitor, (See basic circuit diagram)*

### Example

If the secondary voltage is, for example, 40 V AC (r.m.s.) then the maximum DC voltage is  $1.414 \times 40 - 1.5 = 55$  V.

Under normal supply conditions and rated load, a transformer with a 230 V AC primary winding, and a 40 V AC secondary winding would produce a maximum rectified DC voltage of 55 V.

However, if the electrical supply voltage increases by 10 %, the peak voltage of the DC output (at rated transformer load) will rise to:

$$(1.414 \times 1.1 \times 40) - 1.5 = 60.7 \text{ V.}$$

**Transformer rigidity**

The rigidity of the transformer secondary voltage must also be taken into account. Transformer as dimensioned so that they produce the specified secondary voltage at the rated load current.

**If the actual current is lower than the rated current, the output voltage will rise.**

Typical values can be seen below, for the output rigidity of the transformers manufactured by the "Signal Transformer" company:

Apparent transformer power	Off-load rise in secondary voltage, in %
1 – 100 VA	+10 %
100 – 350 VA	+8 %
> 500 VA	+5 % or less

This means that the off-load secondary voltage of a 100 VA transformer will be about 10 % higher than the nominal rated voltage. Since the increase when the transformer is unloaded can cause the DSM controller(s) to switch off, because this is detected as an overvoltage fault, the dimensioning of the transformer must take account of the transformer rigidity, as well as the maximum possible primary voltage. As a precautionary measure, you should use a transformer that has primary taps for 0 – 230 V – 240 V – 250 V (for single-phase transformer).

**Determining the nominal secondary voltage rating**

The following table has been derived by taking these factors into consideration: for the maximum nominal secondary voltage with an electrical supply tolerance of +10%:

Apparent transformer power <sup>1</sup>	Max. rated secondary voltage
1 – 100 VA	44.7 V AC
100 – 350 VA	45.5 V AC
> 500 VA	46.8 V AC

**Determining the nominal secondary current rating**

The maximum current drawn by the DSM controller depends primarily on the power output to the motor. The best method is to measure the current drawn by the DSM at maximum motor power, using an ammeter in circuit in front of the capacitor.

Or make an estimate: The DC current consumption will not be larger than (approximately) the current for the motor phases that is set by the DIL-switch. If more than one DSM used on one transformer, add the resulting currents together. Make an allowance for the degree to which they are simultaneously active.

Axes that are at standstill have a relatively low current consumption.

**Example**

A transformer that is to be used to feed three DSM controllers with 5 A<sub>eff</sub> each must be dimensioned for a secondary current rating of

$$(5 + 5 + 5) = 15 \text{ A}$$

**Note:** Crude overdimensioning of the transformer is not a good idea, since the inrush current of the capacitors will be larger, thus placing an increased stress on the rectifier diodes.

<sup>1</sup> Apparent transformer power in VA = rated secondary current x rated secondary voltage.

## B1.2 Selecting a rectifier diode

### Design and layout

The  $I_{FSM}$  (max. permissible one-off peak current) for the rectifier diode must be larger than the inrush current that charges up the capacitors (capacitor load). The usual method is: select a diode with a max. continuous current rating  $I_{FAV}$  that is about twice as large as the rated secondary current of the transformer.

### Example

with 3 controllers, each drawing 5 A from the transformer, as above:

Max. continuous current  $I_{FAV} = 2 \times 3 \times 5 \text{ A} = 30 \text{ A}$

Inverse voltage rating: higher than  $1.5 \times (\text{DC-bus voltage } 70 \text{ V}) = 105 \text{ V}$

select a bridge rectifier such as: type KBPC3504 F/W from

Diotec, Heitersheim

with the data

$I_{FAV} = 35 \text{ A}$  (resistive),  $28 \text{ A}$  (capacitive),  $I_{FSM} = 400 \text{ A}$ ,  $V_{RRM} = 400 \text{ V}$   
or a similar type.

## B1.3 Selecting a capacitor

The following capacitors are required for each individual DSM, to achieve approx. 10 % voltage ripple on a 50 Hz electrical supply network:

Motor phase current	DC-bus 30 V <sub>DC</sub>	DC-bus 50 V <sub>DC</sub>	DC-bus 70 V <sub>DC</sub>
5.0 A	18,000 µF	10,000 µF	7,500 µF
4.375 A	15,000 µF	9,100 µF	6,800 µF
3.75 A	12,000 µF	8,200 µF	5,600 µF
3.125 A	11,000 µF	6,800 µF	4,700 µF
2.5 A	9,100 µF	5,600 µF	3,600 µF
1.875 A	6,800 µF	3,900 µF	2,700 µF
1.25 A	4,700 µF	2,700 µF	1,800 µF
0.625 A	2,200 µF	1,200 µF	910 µF

The capacitors can be dimensioned about 20 % smaller when using a 60Hz supply.

### Ripple current

The ripple current rating of the capacitors should be as high as (or higher than) the current that is set for the DSM.

### Voltage rating

The rated voltage of the capacitors must be higher than the maximum possible DC voltage. Select a capacitor that is rated for at least 1.3 x the intended DC supply voltage.

### Layout

The capacitor for each DSM must be connected via a cable that is not longer than 1 meter, and is a twisted (and preferably shielded) pair.

### Discharge resistor

For the discharge resistor, use a power type, such as: 5k1, 2 W, across the capacitor for the feed to each controller.

## B 1.4 Fuse selection

### In front of the DSM

If the motor current is set to 5 A<sub>eff</sub>, install a slow-blow 10A fuse in front of each DSM. If the motor current is less than 5 A, then the fuse rating can be proportionally lower.

### In front of the transformer

The supply transformer draws a heavy current at the moment of switching on. So select an appropriate slow-blow fuse characteristic for the fuse in front of the transformer.

## B1.5 Generator mode

When a motor is braked, it becomes a generator which converts the mechanical energy stored in the rotating motor and load, and converts it back into electrical energy. The DSM controller can feed this energy, as a regenerative voltage, back into the DC supply.

If the mechanical energy is less than the losses in the controller and motor, then the DC voltage will not increase. However, if the mechanical energy is larger than the losses, the DC voltage will increase and charge up the capacitors, this increase being larger if the coupled inertia and the speed are higher.

The mechanical energy of a rotating body is given by the following equation:

$$W_{\text{kin}} = \frac{1}{2} J \omega^2$$

where  $W_{\text{kin}}$  = kinetic energy in watt-seconds = joules

$$\omega = \pi \times (n / 30) \quad (= \text{the angular speed in rads/sec})$$

$n$  = rpm

$J$  = rotary moment of inertia in kg-meter<sup>2</sup>

### Resulting voltage

If this energy is converted into electrical energy, in the form of a charge on the DC-bus capacitors, then the voltage can be derived as follows:

$$U = \sqrt{U_0^2 + \frac{2W_{\text{kin}}}{C}}$$

where  $U$  = voltage  
(after the energy has been transferred to the capacitors)

$U_0$  = initial voltage

$C$  = total capacitance in Farads

$W_{\text{kin}}$  = initial kinetic energy, in joules

### Example

If an unloaded E34 motor (inertial moment of the rotor =  $0.247 \times 10^{-3}$  kgm<sup>2</sup>) is running at a speed of 1500 rpm, then the stored energy is:

$$0.5 \times 0.247 \times 10^{-3} \times (1500 / 30)^2 = 3.0 \text{ joules}$$

If all this energy is loaded into a 6.800  $\mu$ F capacitor that had an initial voltage of 70 V, then the capacitor voltage will rise to 76 V.

**Note:** *This is above the maximum permissible voltage for the DSM drive.*

In practise, most (or even all) of the kinetic energy is dissipated in the motor or in the control circuitry, so that the regenerative voltage is often not a problem. However, where high speeds are used with a high moment of inertia for the load, the voltage can increase considerably, and extra circuitry must be provided to ensure that the voltage never rises above the 75 V limit.

**Note:** *The regenerative voltage can become critical if the variation in the electrical supply voltage are also near the upper tolerance limit.*

To find out whether regenerated energy is a problem, monitor the DC-voltage on a storage oscilloscope. You can also use a peak-voltage detector, consisting of a diode and capacitor connected to the DC voltage, and measure the peak value with a digital voltmeter.

Bring the motor up to speed, and then brake is gently, to see if the DC voltage rises during braking. Repeat this several times, braking harder each time. Observe the DC voltage. If the regenerated energy makes the DC voltage rise above a peak value of 75 V DC, then a ballast circuit is needed.

**Note:** *Do not forget to allow for the highest possible electrical supply voltage when making this test.*

### Ballast circuit

The simplest form of a ballast circuit is a power zener diode, as shown in the basic circuit diagram (above). The ballast circuit must clamp the voltage to below 75 V.



#### CAUTION

***If a zener diode or other kind of ballast circuit is used, then the secondary voltage from the transformer must be checked again, to be sure that the ballast circuit is not already clamping when the maximum supply voltage is reached and the transformer is off-load.***

***This situation would overheat the zener diode or any other ballast circuit, and cause it to fail.***

### Zener diode

Use zener diodes rated for at least 5 W. Use a high-power type of zener diode, with a zener voltage below 75 V, but above the maximum possible DC-bus voltage.

Zener diodes can also be wired in series, whereby the overall zener voltage is the sum of the individual voltages.

*Recommendation: 2 diodes, type 1N5365B727 (36V zener, 5 W) wired in series. The zener threshold is then 72 V, and the current is about 100 mA at 75 V, which is sufficient for most applications.*

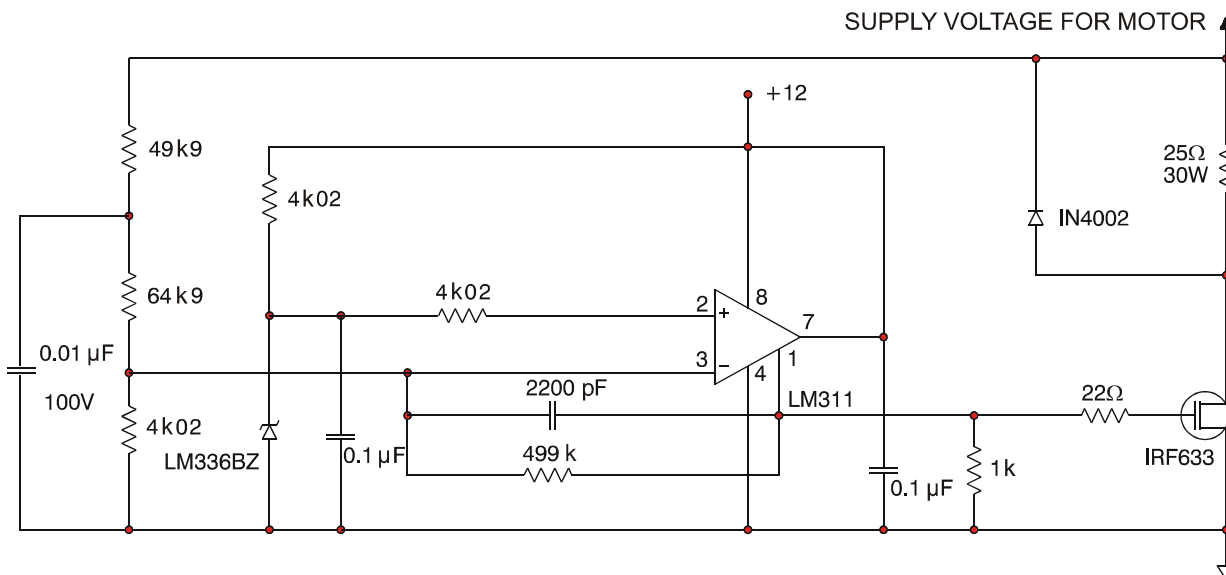


#### WARNING !

***The zener diodes can get hot! Make sure there is enough space around them!***

**Active ballast circuit**

If the average power is so high that it cannot be safely dissipated in zener diodes, then the following active ballast circuit can be used. If the DC voltage for the motor tries to rise above 75 V, the power is dissipated in 25 ohm / 30 W resistors.



**B2 Supplying the DSM controller from an electronically regulated PSU**

The current drawn by the DSM controllers is in the form of pulses with fast edges. Many regulated DC power supply units are not suitable for such a load. If there are any problems, wire a 470 μF smoothing capacitor into the supply leads to the DSM, between DC+ and DC-.

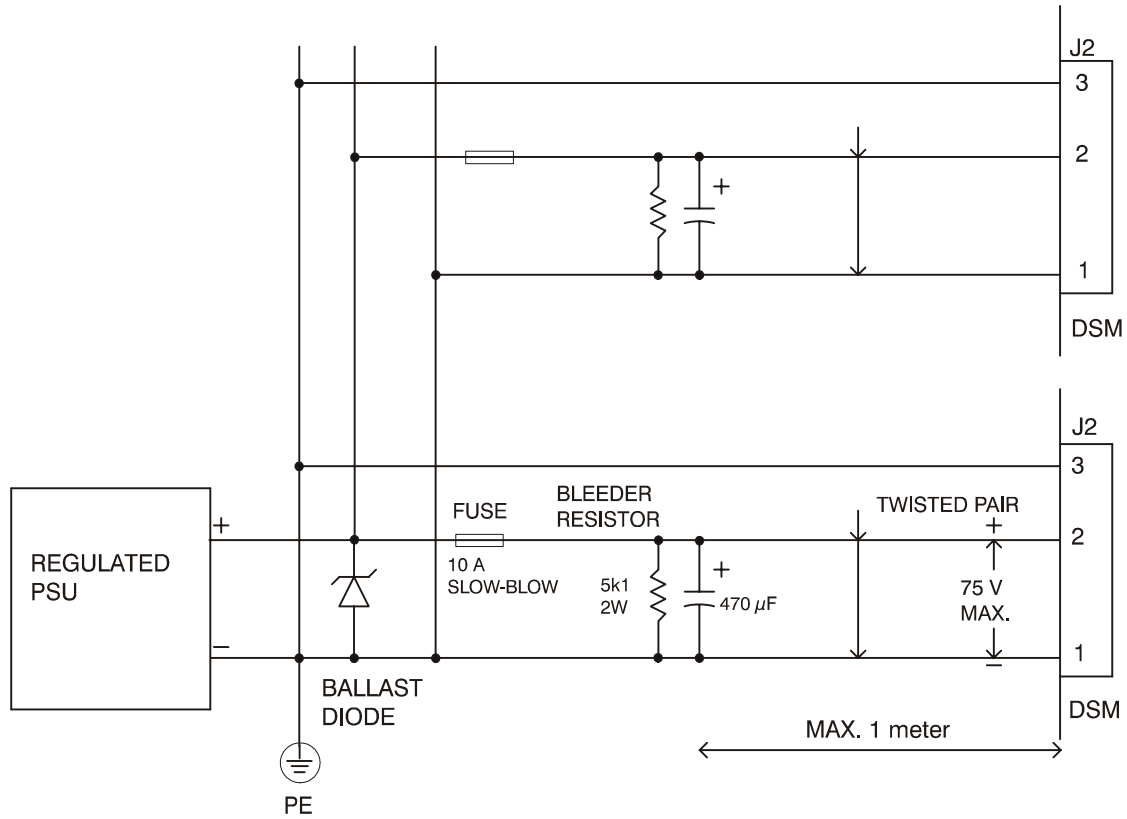
This capacitor must be able to smooth out a 20 kHz ripple current. The rated voltage of this capacitor must be at least 1.3 x the max. DC-bus voltage.

A capacitor must be fitted as close as possible to each DSM, via a cable that is no longer than 1 meter, and is a twisted (and preferably shielded) pair.

Regulated power supplies are normally unable to feed back energy to the electrical supply. So the energy regenerated by the braking of the motor will increase the DC-bus voltage and damage the power supply, or the DSM. In this case you will also have to fit a suitable power zener diode. And for high powers, an active ballast circuit will be needed.

**Regulated power supply for the DSM**

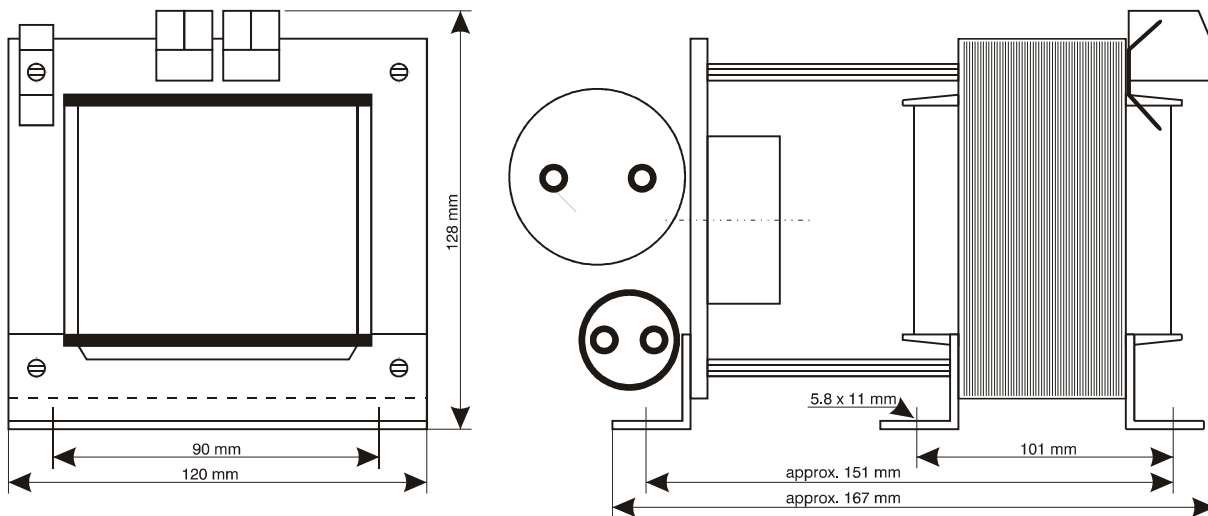
The following circuit illustrates the method of supplying the DSM from a regulated PSU, whereby both an external capacitor and a ballast circuit are required. The fusing is also shown.



### B 3 Ready-made PSUs available

BAUTZ offers power supply units in two sizes, for experiments and test rigs. These consist of transformers with an attached angle plate, that carries the rectifier and capacitor. These power supply units provide a nominal  $52.5 V_{DC}$  unregulated, smoothed DC voltage. The DC-bus voltage is low enough that a ballast circuit is normally not necessary

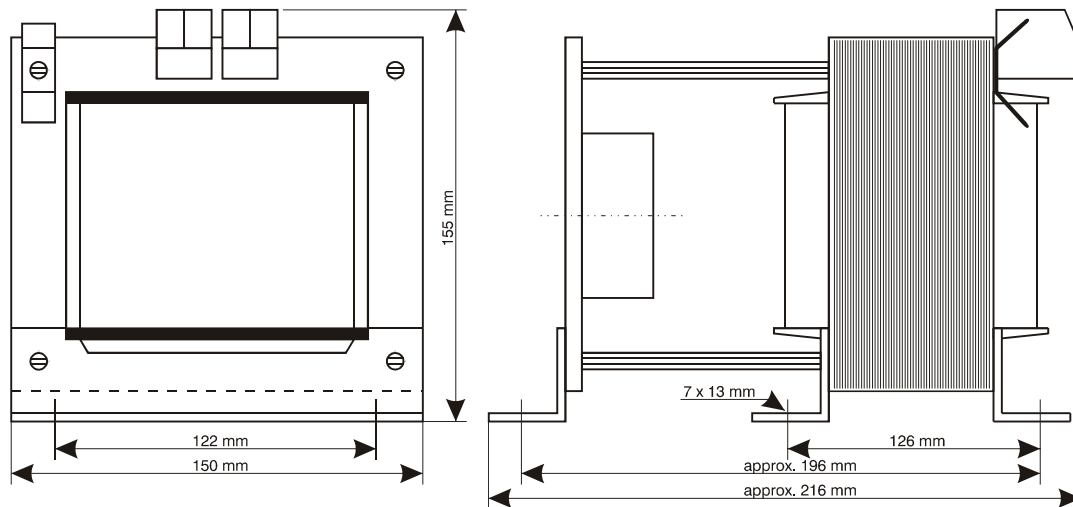
#### B 3.1 PSU for 0.386 kVA - designation for ordering: T0188-GL



#### Technical data for T0188-GL:

Primary:	0 - 230 - 240 - 250 V?
Secondary 1:	wired with bridge rectifier and capacitor 6900 $\mu$ F, 100 V <b>to produce 52.5 V<sub>DC</sub>, 5.1 A</b>
Secondary 2:	19 V / 2.0 A
Power:	0.86 kVA
Protection:	IP 00
Frequency:	50 / 60 Hz
As per VDE	0551

### B 3.2 PSU for 0.741 kVA - designation for ordering: T0189-GL



#### Technical data for T0189-GL:

Primary:	0 - 230 - 240 - 250 V?
Secondary 1:	wired with bridge rectifier and capacitor 6900 $\mu$ F, 100 V <b>to produce 52.5 V<sub>DC</sub>, 10.3 A</b>
Secondary 2:	19 V AC / 2.0 A
Power:	0.741 kVA
Protection:	IP 00
Frequency:	50 / 60 Hz
As per VDE	0551

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