

V 1.17

# HARDWARE MANUAL



## IDX 7507

1-axis stepper  
motor driver  
5A RMS (7A peak)  
12... 75V DC  
RS485

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# 1 Life support policy

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Specifications are subject to change without notice.



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## 2 Features

The TRINAMIC IDX 7505 is a small and rugged step/direction stepper motor driver system with a supply voltage of up to up to 75V and up to 5A RMS motor coil current. It can be controlled via an RS485 interface. Up to 256 micro steps are supported for either high accuracy or high speed. An update of the firmware is possible via the serial interface. The system features sensorless stall detection (StallGuard™) and full protection. The module is fully protected and comes with a stand-alone reference search feature.

The motor, switches and power supply can be connected easily with screw terminal connectors. The housing is based on a thick aluminum plate which is used as a heat sink.

### Applications

- Step/dir stepper driver for industrial applications
- Robotics
- Remote diagnostics / feedback allows for high-reliability drives
- Centralized motor driver mounted in switchboard
- Decentralized motor driver mounted near motor

### Motor types

- 0.5... 5.0A RMS / 7A peak
- 12... 75V DC nominal supply voltage

### Highlights

- Remote controlled diagnostics and parameterization (RS485)
- Reference move and turn CW / CCW via RS485
- Stand-alone operation, adjusted via RS485
- Fully protected drive
- Digital selection of motor current and standby current
- Local reference move using sensorless StallGuard™ feature or reference switch
- All setup parameters are stored in internal EEPROM, no bus system required in end application
- Micro step resolution can be changed to get high accuracy or high speed with the possibility to combine both
- Different chopper modes allow best adaptation to application / motor

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## 3 Order codes

| Order codes | Description          | Dimensions [mm]    |
|-------------|----------------------|--------------------|
| IDX 7505    | 75V, 5A RMS, 7A peak | 63.5 x 63.5 x 18.5 |

**Table 3.1: Order codes**

# 4 Electrical and mechanical interfacing

## 4.1 Pinning

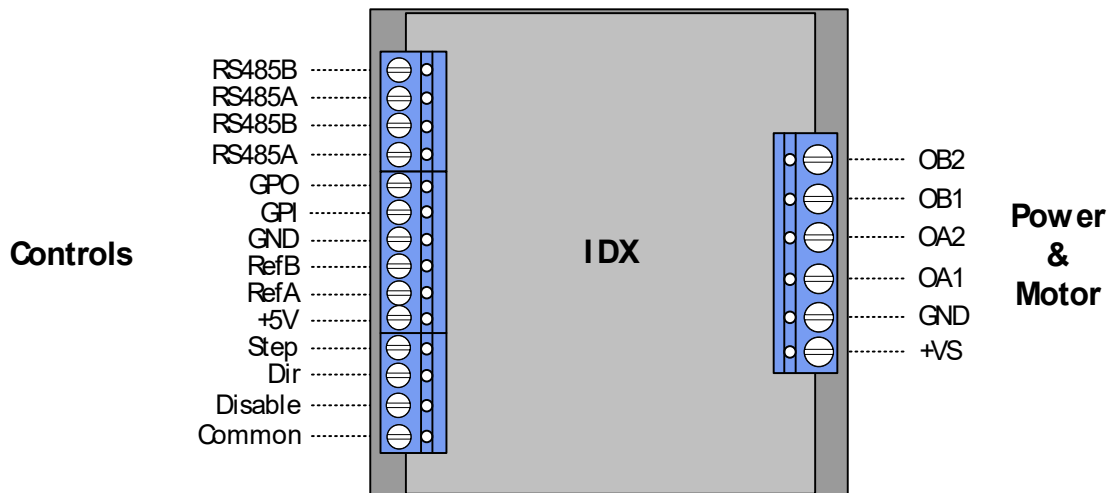


Figure 4.1: Pinning of IDX 7505

| Pin  | Label    | Description                   |
|------|----------|-------------------------------|
| 1, 2 | OB1, OB2 | Connections for motor coil B  |
| 3, 4 | OA1, OA2 | Connections for motor coil A  |
| 5    | GND      | GND, power                    |
| 6    | +VS      | Positive power supply voltage |

Table 4.1: Power and motor pinning

| Pin  | Label     | Description  |
|------|-----------|--|
| 1, 3 | RS485 -   | RS485 remote control access -, TTL input   |
| 2, 4 | RS485 +   | RS485 remote control access +, TTL input   |
| 5    | GPO       | General Purpose Output, for wiring scheme see Figure 7.2   |
| 6    | GPI       | General Purpose Input, for wiring scheme see Fehler!<br><b>Verweisquelle konnte nicht gefunden werden.</b>       |
| 7    | GND       | GND reference  |
| 8    | REF B     | Reference signal B (integrated 3.9 K pull up resistor to +5V)  |
| 9    | REF A     | Reference signal A (integrated 3.9 K pull up resistor to +5V)  |
| 10   | +5V       | Constant +5V output, reference   |
| 11   | Step      | Opto-decoupled input (negative terminal):<br>Each impulse causes one motor microstep                             |
| 12   | Direction | Opto-decoupled input (negative terminal):<br>Polarity determines motor direction                                 |
| 13   | Disable   | Opto-decoupled input (negative terminal):<br>Tie to opto-coupler negative supply voltage to disable motor driver |
| 14   | Common    | 5... 24V, optocoupler positive supply voltage  |

Table 4.2: Pinning for GPIOs, interfaces, and switches

## 4.2 Dimensions

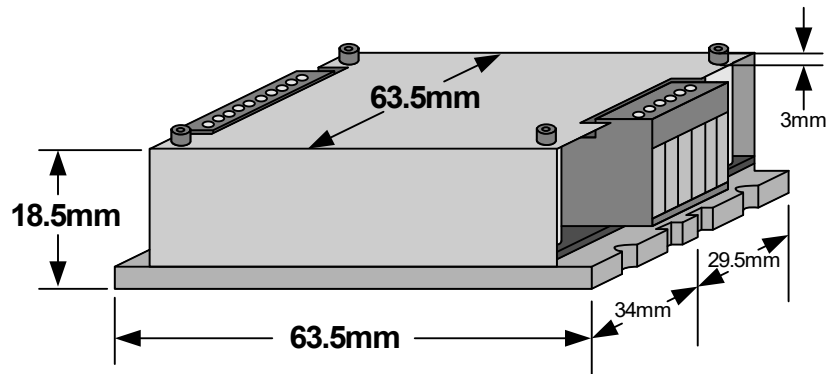


Figure 4.2: Dimensions of IDX

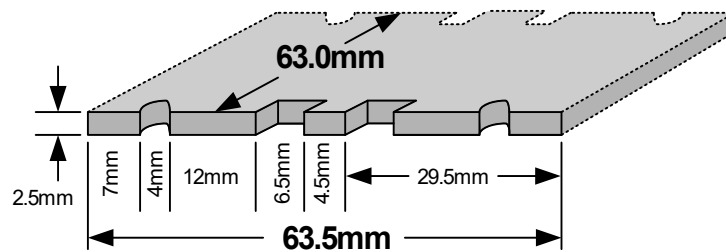


Figure 4.3: Base plate dimensions

## 4.3 Connectors

Power and motor: 6 pin connector RM 5.0 (07\_06\_RM5)  
 Control: Two 4 pin and one 6 pin connectors RM 3.5,  
 (2x 166\_04\_RM3.5, 1x 166\_06\_RM35)

*Both connectors are RIA connectors.*



## 5 Operational ratings

The operational ratings show the intended / the characteristic range for the values and should be used as design values. In no case shall the maximum values be exceeded.

| Symbol                | Parameter   | Min  | Typ                  | Max                     | Unit |
|-----------------------|---|------|----------------------|-------------------------|------|
| V <sub>S</sub>        | Power supply voltage  |      | 12... 75             | 78.5                    | V    |
| I <sub>COIL</sub>     | Motor peak coil current   |      | 0.7... 6.4           | 7.1                     | A    |
| I <sub>MC</sub>       | Nominal motor current   |      | 0.5... 4.5           | 5                       | A    |
| f <sub>CHOP</sub>     | Motor chopper frequency (actual frequency depends on operation mode)  |      | 20 or 36             |                         | kHz  |
| t <sub>SLP</sub>      | Coil output slope   |      | 300                  |                         | ns   |
| I <sub>S</sub>        | Power supply current  |      | << I <sub>COIL</sub> | 1.4 * I <sub>COIL</sub> | A    |
| V <sub>ISO</sub>      | Isolation voltage of optocoupler  |      | ± 42                 | ±100                    | V    |
| V <sub>COM</sub>      | Supply voltage for step, direction and disable; (inputs have negative logic)  |      | 5... 24              | 30                      | V    |
| V <sub>OPTON</sub>    | Signal active voltage at disable, step and direction input (optocoupler on, measured from U <sub>COM</sub> to input)    | 3.5  | 4.5... 24            | 30                      | V    |
| V <sub>OPTOFF</sub>   | Signal inactive voltage at disable, step and direction input (optocoupler off, measured from U <sub>COM</sub> to input) | -5.5 | 0                    | 2                       | V    |
| I <sub>OPT</sub>      | Optocoupler current (internally regulated)  |      | 4                    | 8                       | mA   |
| t <sub>STEPLO</sub>   | Step impulse low time (optocoupler on)  | 0.7  |                      |                         | µs   |
| t <sub>STEPHI</sub>   | Step impulse high time (optocoupler off)  | 2.0  |                      |                         | µs   |
| t <sub>DIRSETUP</sub> | Direction setup time to rising edge of step input   | 0    |                      |                         | µs   |
| t <sub>DIRHOLD</sub>  | Direction hold time after rising edge of step input   | 3.0  |                      |                         | µs   |
| V <sub>REF</sub>      | Input low voltage on REFA / REFB  | -2   | 0                    | 0.8                     | V    |
| V <sub>REF</sub>      | Input high voltage on REFA / REFB   | 2.4  | 5                    | 30                      | V    |
| V <sub>GPI</sub>      | Input voltage on GPI  | -2   | 0... 5               | 30                      | V    |
| V <sub>GPO</sub>      | Output voltage on GPO (open collector)  | -1   |                      | 100                     | V    |
| I <sub>GPO</sub>      | Output current on GPO (open collector)  |      |                      | -150                    | mA   |
| T <sub>ENV</sub>      | Environment temperature   | -25  |                      | 70                      | °C   |
| T <sub>C</sub>        | Temperature of case back (cooling plate)  | -25  |                      | 85                      | °C   |

Table 5.1: Operational ratings

## 5.1 Practical maximum motor current ratings

The IDX 7505 uses eight high power 80V transistors with low internal on resistance of only 15mOhm to drive the motor. Due to this, power loss is just a few watts at maximum current. In order to avoid EMV problems and to keep electromagnetic emission low, the transistors are switched smoothly on and off with 300ns transitions. On the other hand, this produces dynamic losses and thus additional power dissipation. The resulting power dissipation has to be cooled away by air convection and via the metal base plate, in order to keep transistor and board temperature well below 125°C (Integrated thermal limit). This becomes a limiting point, because of its high voltage capability. The following table gives some examples for the current capability in a typical mounting situation, where the module is mounted to a metal base plate (heat sink with fins, overall dimensions 100\*50\*15mm<sup>3</sup>). In this situation the base plate was always kept at maximum 60°C. However, the actual motor type and velocity setting also influences power dissipation of the module.

| Chopper mode | Supply voltage | Maximum I <sub>COIL</sub> RMS for continuous operation | Maximum duty cycle for full current |
|--------------|----------------|--|-------------------------------------|
| 0, 1         | 75V            | 3.5A   | 50%                                 |
| 0, 1         | 70V            | 4A   | 60%                                 |
| 0, 1         | 60V            | 4.5A   | 80%                                 |
| 0, 1         | ≤50V           | 5A   | 100%                                |
| 2            | 15V ... 75V    | 4A *)  | n/a                                 |

**Table 5.2.1: Practical motor current limitations for IDX 7505**

\*) This limit is due to the higher current ripple in chopper mode 2, which allows a maximum of 75% to 90% of the maximum current setting. It is not a thermal limit.

## 5.2 Step, direction and disable inputs

The inputs *disable*, *dir* and *step* are electrically isolated from the module. The inputs are related to  $V_{COM}$ . In a typical application,  $U_{COM}$  shall be tied to the positive supply voltage of the master and the inputs are driven by open collector or push/pull outputs.  $V_{OPTOFF}$  and  $V_{OPTON}$  must not exceed  $V_{COM}$  to avoid reverse polarity for the optocouplers.

OFF:  $V_{COM} - V_{IN} < 1.0V$

ON:  $V_{COM} - V_{IN} \geq 3.5V$

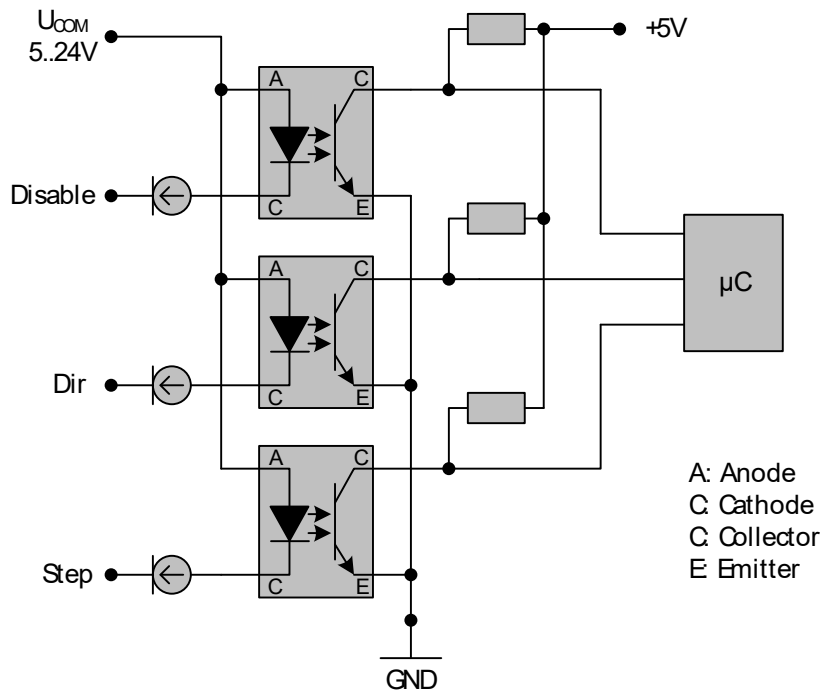
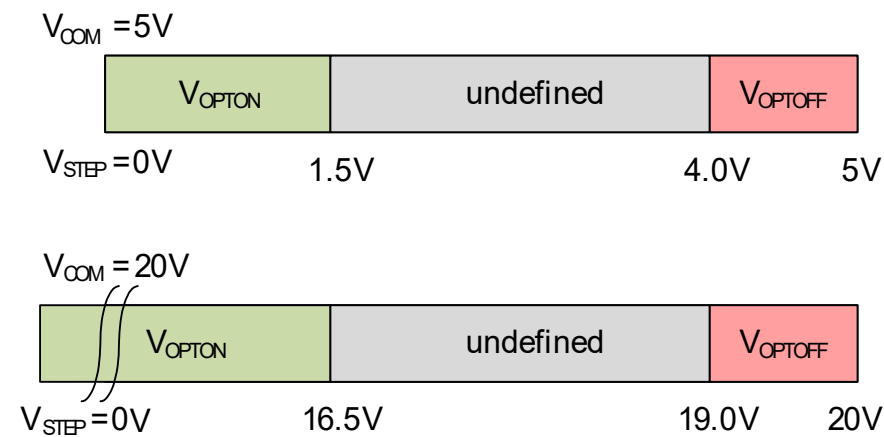


Figure 5.1: Step, Direction and Disable Inputs

Examples:



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## 6 Getting started

### 6.1 Motor

Attention:

- *Do not connect or disconnect the motor while power on. Damage to the module may occur.*
- *A too high motor current setting can damage you motor! If in doubt, start with a low current setting and check motor temperature.*
- *If the motor heats up very quickly, check all settings. The motor shall never reach a temperature above 100°C under any circumstances.*
- *Some stepper motors need contact to metallic parts to allow continuous operation. Mind the default settings, when you operate in step/direction mode the first time! (You can store your own settings in the module permanently.)*

#### 6.1.1 Motor choice

Care has to be taken concerning the selection of motor and supply voltage. In the different chopper modes different criteria apply.

Attention:

*Modes 0 and 1 are quite insensitive to the motor choice, while mode 2 is very sensitive, because it uses a different motor current regulation scheme.*

This chapter gives some mathematical information on the motor choice, but you can skip it if you want to experiment with a given motor. Normally, best results will be achieved when operating the given motor in a range of 50 to 100% of nominal motor current (see motor data sheet).

Mode 2 and mode 1 are mainly intended for slow, smooth and very exact movements, due to the high micro stepping resolution. For most dynamic operation choose mode 0 or the combined modes 3 and 4 which use mode 1 or 2 for slow movements and switch to mode 0 at a defined velocity.

##### 6.1.1.1 Motor velocity

Whenever it is desired to maximize the motor velocity in a given application, it is important to understand limitations due to supply voltage and motor inductivity. Please consult your motor data sheet for this, as well as the choice of the chopper mode. Chopper mode 0 allows maximum motor velocity.

##### 6.1.1.2 Chopper modes 0 (SPI / default mode) and 1 (PWM)

In these two modes the maximum supply voltage ( $V_S$ ) of the motor must not exceed 22-25 times the nominal motor voltage ( $V_N$ ), regarding the multiplication of  $I_{COIL, MAX}$  and  $R_{MOTOR}$ . A higher value would lead to an excess of motor rating.

The minimum supply voltage has to be above two times the nominal motor voltage.

$$2 \cdot V_N \leq V_S \leq 22 \dots 25 \cdot V_N$$

$$V_N = I_{\text{COIL,MAX}} \cdot R_{\text{MOTOR}}$$

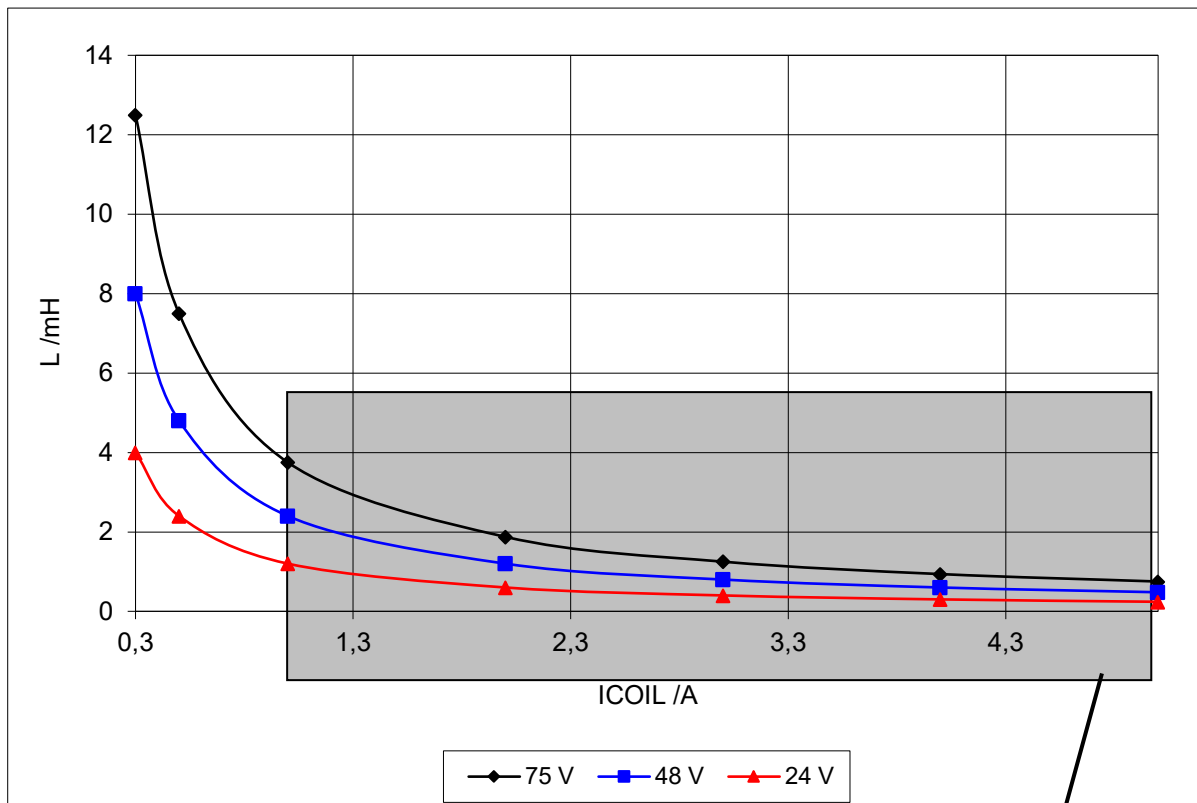
### 6.1.1.3 Chopper Mode 2 (PHASE)

In Table 6.1 and Figure 6.1 examples of maximum power supply voltages regarding current  $I_{\text{COIL}}$  and inductivity of your motor are specified.

For further information, including a formula and description how to calculate the maximum voltage for your setup, refer to 7.2.2.3

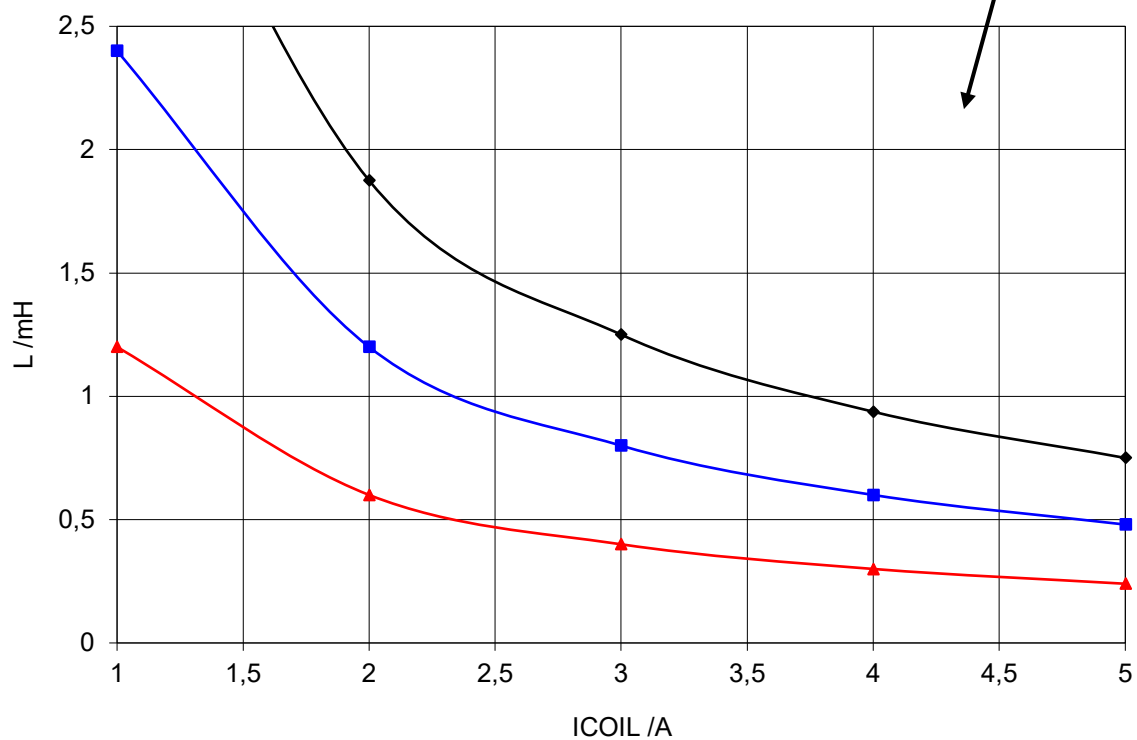
| $I_{\text{COIL}}$ (RMS) | L (min.) | $V_S$ (max.) |
|-------------------------|----------|--------------|
| 5.0 A                   | 0.75 mH  | 75 V         |
|                         | 0.48 mH  | 48 V         |
|                         | 0.24 mH  | 24 V         |
| 4.0 A                   | 0.94 mH  | 75 V         |
|                         | 0.6 mH   | 48 V         |
|                         | 0.3 mH   | 24 V         |
| 3.0 A                   | 1.25 mH  | 75 V         |
|                         | 0.8 mH   | 48 V         |
|                         | 0.4 mH   | 24 V         |
| 2.0 A                   | 1.875 mH | 75 V         |
|                         | 1.2 mH   | 48 V         |
|                         | 0.6 mH   | 24 V         |
| 1.0 A                   | 3.75 mH  | 75 V         |
|                         | 2.4 mH   | 48 V         |
|                         | 1.2 mH   | 24 V         |
| 0.5 A                   | 7.5 mH   | 75 V         |
|                         | 4.8 mH   | 48 V         |
|                         | 2.4 mH   | 24 V         |
| 0.3 A                   | 12.5 mH  | 75 V         |
|                         | 8 mH     | 48 V         |
|                         | 4 mH     | 24 V         |

**Table 6.1: Maximum voltage regarding motor current and inductivity**



**Figure 6.1: Maximum voltage regarding motor current and inductivity**

Any combination of motor coil current and inductivity which is above the curve for maximum supply voltage ( $V_s$ ) is possible to drive the motor in this mode.



*Check your motor data sheet, please. If in doubt, please start with a lower supply voltage and check motor heating when raising the voltage.*

## 6.2 Connecting motor and power supply

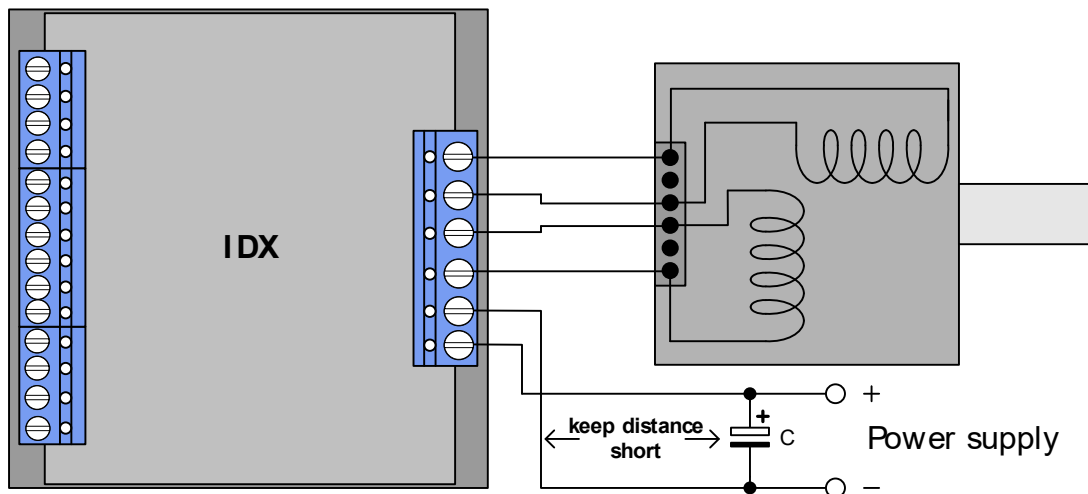


Figure 6.2: Connecting motor and power supply

## 6.3 Power supply requirements

The power supply voltage shall be in the limits as given in the chapter 0 under operational ratings. Please note that there is no protection against reverse polarity or too high voltage. The power supply typically should be within a range which fits the motor requirements, as described in chapter 6.1.1. When using supply voltages near the upper limit, a regulated power supply becomes a must. Please ensure, that enough power filtering capacitors are provided in the system (1000 $\mu$ F for each ampere of RMS motor current or more recommended), in order to absorb mechanical energy fed back by the motor in stalling conditions. In larger systems a zener diode circuitry might be required, when motors are operated at high velocities.

The power supply should be designed in a way, that it supplies the nominal motor voltage at the desired maximum motor power. In no case shall the supply value exceed the upper or lower voltage limit. To ensure reliable operation of the unit, the power supply has to have a sufficient output capacitor and the supply cables should have a low resistance, so that the chopper operation does not lead to an increased power supply ripple directly at the unit. Power supply ripple due to the chopper operation should be kept at a maximum of a few 100mV.

### Therefore we recommend to

- keep power supply cables as short as possible
- use large diameter for power supply cables
- if the distance to the power supply is large (i.e. more than 2-3m), use a robust 4700 $\mu$ F or similar additional filtering capacitor located near to the motor driver unit. Choose the capacitor voltage rating fitting to the maximum operating voltage.

The overall power rating mainly depends on the motor used and on the mechanical output power, i.e. the motor velocity and desired torque. As a thumb rule, a 42mm class motor will require a 10W (short motor) to 20W (long motor) power supply, while a 57mm motor will require 15W to 30W, when operated at maximum rated current and low velocities. Operation at very high velocities will increase the power demand up to the double value.

### 6.3.1 EMV considerations

Due to the small form factor of the unit, it is not completely protected against electromagnetic emissions resulting from switching operation. If your system is subject to CE testing and shows EMV problems, i.e. due to some parts of the housing/cabling not being shielded, provide ferrite filters for the positive power supply line and for the motor outputs near to the unit. A 470pF to 1nF (100V) capacitor to GND then should be added externally to each ferrite filter.

## 6.4 Connections for step/dir mode

The step-direction-mode is enabled if the acceleration is set to 0 (default) using the RS485 interface. The example input signals of Figure 6.3 are schematically (see chapter 5.2 for more information):

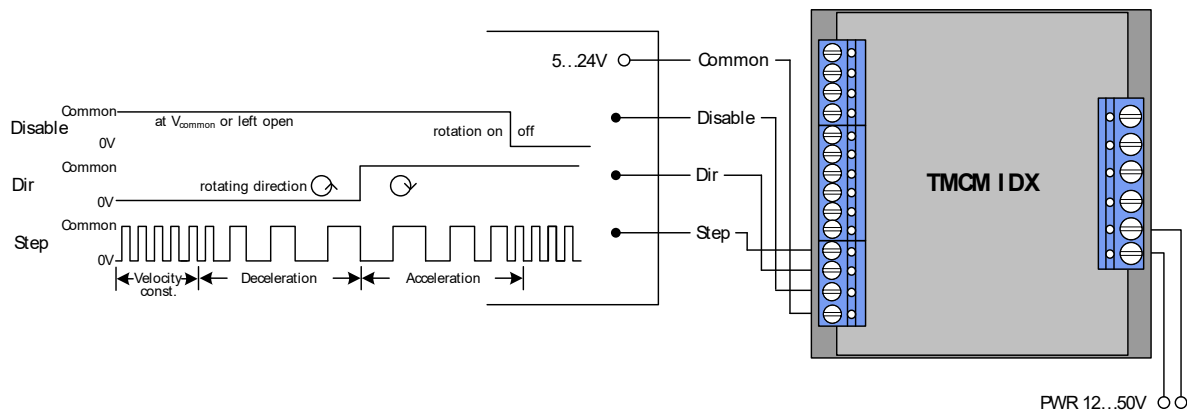


Figure 6.3: Contacts for step/dir

The maximum step frequency is 350 kHz (limited by the optocouplers).

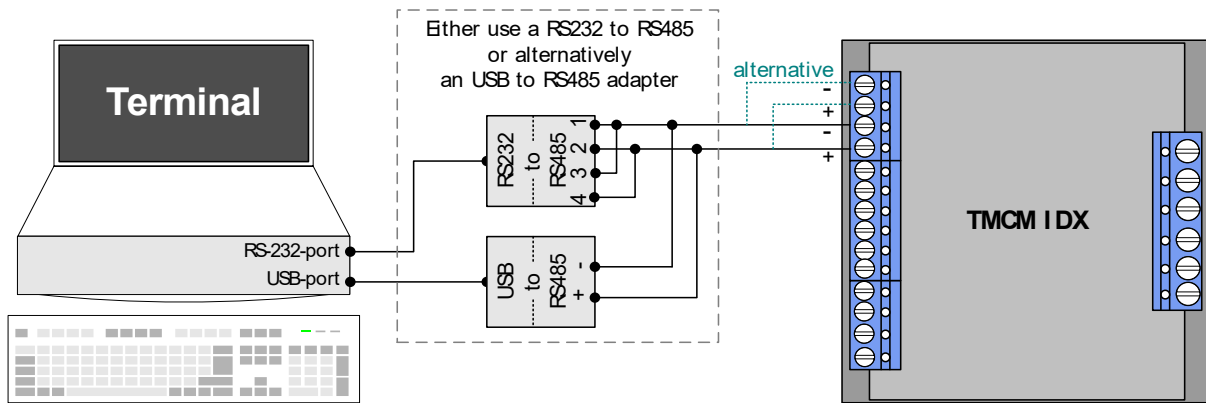
## 6.5 Connections for RS485 interface

The RS485-mode allows for configuration of motor parameters as well as remote control of the motor.

### 6.5.1 Interface installation

To connect the module to a PC a RS485 interface is required, for example TRINAMIC’s new USB-2-485 or any other RS485 adapter, like the standard RS232 to RS485-converters. Input A has to be connected to RS485A of the IDX and Input B with RS485B.



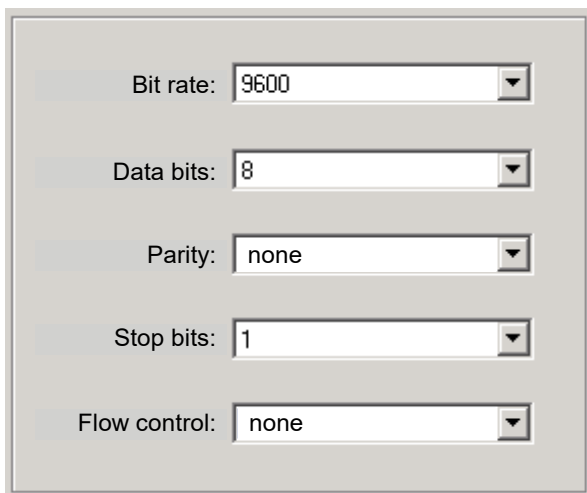


**Figure 6.4: Contacts for RS485 with an adapter**

### 6.5.2 Control with terminal program

Having installed the hardware, the IDX can be controlled with any terminal program, like HyperTerminal that comes with MS-Windows. Following steps are described for HyperTerminal but are similar for the other terminal programs:

1. Start HyperTerminal
2. A window for a new connection opens. Fill in a name and press OK.
3. Select the appropriate COM-port and press OK.
4. Fill in the values like in Figure 6.5 and confirm with OK.



**Figure 6.5 : Connection settings for RS485**

Type into the terminal window commands like *AV 50000*, *AA 300* or *Ac* and execute each with ENTER. Pay attention to the spaces between command and value. With standard RS485 adapters the typed value may be echoed and lines like *AAVV 5500000000* for the typed *AV 50000* appear. If this happens best is to pay no attention to the screen and just type in the commands and press ENTER. The value sent to the module is only the typed and not the displayed. An acceleration differing from zero is required to get velocities in RS485 mode. Setting or storing this value to the EEPROM disables step/direction control until acceleration is set to zero again (and eventually stored) or the board is reset to factory default.

# 7 Functional description

The IDX module offers three different possibilities to control a stepper motor: step-dir, RS485, and stand alone. With the RS485 it is possible to change parameters and save them to the EEPROM of the module to have all options in any mode. Therefore there are different settings like microstep resolution possible in step-dir mode also.

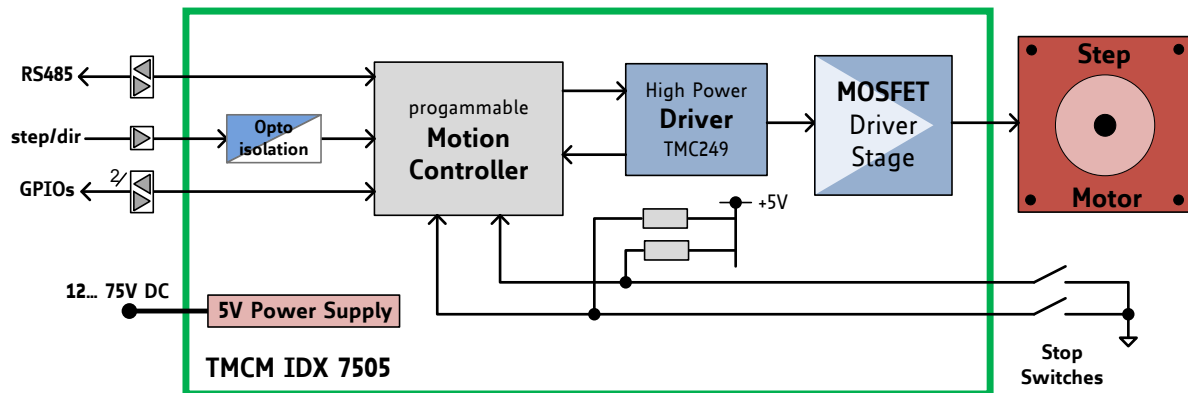


Figure 7.1: Main parts of the IDX 7505

## 7.1 Disable function

The disable works as an emergency shutdown. Connected to ground all power to the motor will shut down independent of the current settings.

*Please stop the step impulses or set the velocity to zero before enabling the motor again. It starts abrupt otherwise.*

### Function Table:

| V <sub>OPTON</sub> | open wire     | V <sub>OPTOFF</sub> |
|--------------------|---------------|---------------------|
| motor disabled     | motor enabled |                     |

## 7.2 RS485 interface

The RS485 interface can control all functions of the IDX. It is possible to change parameters, with this interface which are also valid in the other modes like max. velocity or acceleration. The parameters can be written to the EEPROM to obtain the changes after a restart.

A Reset to factory default is possible. Default address byte is A, and default baud rate is 9600 baud. This mode can only be used with an appropriate RS485 interface. Commands are sent with a terminal program, refer 6.5.

### 7.2.1 RS485 Commands

For RS485 commands write the address byte (default is A) first, followed by an command from the following list. A small command letter provides the actual setting. All values are ASCII.

| Command | Function                   | Description   | Range                         | Factory Default |
|---------|----------------------------|---|-------------------------------|-----------------|
| A, a    | Acceleration               | Acceleration: $v = 28.96 * a$   | 0... 2500000                  | 0               |
| C, c    | Set Motor Current          | Motor current in percentage of maximum current (0... 100% * IDX max. current). Refer 7.2.1.2  | 0... 100                      | 50              |
| E       | Failure readout            | Provides failure readout. Refer 7.2.1.3   | 8 Bit (SPI)<br>1 Bit (others) |                 |
| G, g    | StallGuard                 | In mode 0 (SPI) the stallGuard™ feature is functional. <i>g</i> provides the actual StallGuard value, not the setting. Refer 7.2.1.4  | -7... 0... +7                 | 0               |
| L, l    | Limit switch               | Used to switch on and off reference run values. Refer 7.2.1.5   | byte                          | -               |
| M, m    | Select Mode                | Select chopper mode: 0:SPI (default), 1:PWM, 2:PHASE, 3 & 4: Combinations, refer to 7.2.2   | 0, 1, 2, 3, 4                 | 0               |
| O, o    | Set Output                 | Output adjustments, refer to 7.2.1.6  | 2 bit                         | 0               |
| P       | Set Position               | Set position without moving the motor   | 32 bit                        |                 |
| Q       | Read I/Os                  | Provides out of the I/O the values of the ports GPI, REF_A, REF_B, GPO and ALARM. Refer to 7.2.1.7  |                               |                 |
| R       | Read Current Position      | Provides the current position of the motor  | 32 bit                        |                 |
| S       | Changes address byte       | Capital letter followed by the command 'S' makes this letter the new address byte<br>Example: <i>BS</i> makes <i>B</i> the new address byte   |                               | A               |
| T, t    | RS485-Timeout              | Sets the RS485-Timeout  |                               |                 |
| U, u    | Set baud rate              | Sets baud rate for RS485 communication. Refer to 7.2.1.8  | 0... 7                        | 0               |
| V, v    | Velocity for Rotation      | Velocity for rotation / reference run<br>$v = n * 0.149157 \mu\text{steps/s}$<br>Additional Parameter is 0 or missing: Carriage Return (CR) comes after acceleration phase<br>Additional Parameter is 1: no delay of CR | +/- 2500000,<br>0 or 1        | 0               |
| W       | Store parameters to EEPROM | Stores different parameters to the EEPROM to restart with the same performance. Refer 7.2.1.9   |                               |                 |
| X       | Version number             | Provides version number of implemented Software   |                               |                 |
| Y, y    | Standby current            | Sets 0... 100% of maximum current after 1 second motor inactivity. For no standby current use the same value as for <i>Set motor current</i> .  | 0... 100                      | 20              |

|      |                      |  |        |   |
|------|----------------------|--|--------|---|
| Z, z | Microstep Resolution | Sets the maximum microstep resolution (0: max; 6: min), Refer 7.2.1.11 | 0... 6 | 0 |
|------|----------------------|--|--------|---|

**Table 7.1: RS485 commands**

**Examples:**

1. Set chopper mode to SPI Mode:  
AM 0 ⇒ ENTER
2. Read out the actual mode  
Am ⇒ ENTER

**7.2.1.1 Examples for test move**

- **Different accelerations and velocities**  
AA 500, AV 50000, AV -50000 ⇒ try other AA 100... 8000, AV 0... 400000
- **Max. current – test of torque**  
AA 500, AV 50000, AC 255 ⇒ test torque manually ⇒ AC 50 ⇒ test torque
- **Read and set position**  
AR, AP 0, AR, AA 500, AV 50000, AR

**7.2.1.2 Motor current (C)**

The motor current can be set by the user. To do this use the RS485 command “AC” in addition with a percent value. To calculate the actual setting, please use the 100% values as shown in the table. Internally the current is regulated by two independent parameters for the best module/motor performance possible.

For chopper mode 2, the maximum setting is about 75% to 90% - at higher settings, motor microstep behavior may become harsh. The actual maximum depends upon the actual motor. This is to avoid the motor coil current raising above the 100% setting at any time. Not all currents can be continuously driven at all supply voltages / cooling circumstances. Please refer to motor current limitations.

| AC  | I <sub>COIL,PP</sub> | I <sub>COIL,RMS</sub> | % to max. I <sub>COIL</sub> |
|-----|----------------------|-----------------------|-----------------------------|
| 100 | 7.1A                 | 5.0A                  | 100% *)                     |
| 75  | 5.3A                 | 3.8A                  | 75%                         |
| 66  | 4.7A                 | 3.3A                  | 66%                         |
| 50  | 3.5A                 | 2.5A                  | 50%                         |
| 33  | 2.4A                 | 1.7A                  | 33%                         |
| 25  | 1.8A                 | 1.26A                 | 25%                         |
| 10  | 0.71A                | 0.50A                 | 10%                         |

**Table 7.2: Motor Current Examples for IDX**

\*) except chopper mode 2

**7.2.1.3 Failure readout (E)**

The IDX provides a full driver failure analysis in SPI mode (8 Bit). The returned bit assignments are as follows:

| Bit | Name | Function                      | Remark   |
|-----|------|-------------------------------|--|
| 7   | OT   | overtemperature               | 1 = driver chip off due to overtemperature         |
| 6   | OTPW | temperature pre-warning       | 1 = driver chip prewarning temperature exceeded    |
| 5   | UV   | driver undervoltage           | 1 = undervoltage on VS – does not cover all cases  |
| 4   | OCHS | overcurrent high side         | (not available in current hardware implementation) |
| 3   | OLB  | open load bridge B            | Open load detection can occur at fast motion also. |
| 2   | OLA  | open load bridge B            | Open load detection can occur at fast motion also. |
| 1   | OCB  | overcurrent bridge B low side | Short circuit detected. Please check motor wiring. |
| 0   | OCA  | overcurrent bridge A low side | Short circuit detected. Please check motor wiring. |

**Table 7.3: Failure readout in SPI mode**

In the other two modes the failure analysis consists of only one bit:

- 1: short circuit or overtemperature
- 0: no failure

### 7.2.1.4 StallGuard™ (G)

The StallGuard™ feature is available in the default mode 0 (SPI) only. It is a sensorless load measurement and stall-detection. Overload is indicated before steps are lost. The command letter ‘g’ provides the actual StallGuard value of the motor so easy calibration is possible. To use StallGuard in an actual application, some manual tests should be done first, because the StallGuard level depends upon the motor velocities and on the occurrence of resonances. When switching on StallGuard, the motor operation mode is changed and microstep resolution may be worse. Thus, StallGuard should be switched off when not in use.

| Value    | Description  |
|----------|--|
| -7... -1 | Motor stops when stallGuard™ value is reached and position is set zero (useful for reference run). |
| 0        | StallGuard function is deactivated (default).  |
| 1... 7   | Motor stops when stallGuard™ value is reached and position is <b>not</b> set zero.                 |

**Table 7.4: StallGuard™**

The StallGuard™ function can also be activated when using step/dir mode. In step/dir mode the motor will not be stopped when the StallGuard value is reached, but the general purpose output will be controlled by the StallGuard™ value: when the actual load value is greater than the stallGuard™ value, the GPO will be switched on, and when the actual load value is lower or equal to the StallGuard™ limit, the GPO will be switched off. This can be used to signal a stall to the step/dir controller. When the StallGuard™ function is de-activated (0, default) the GPO will not be changed by StallGuard™.

### 7.2.1.5 Limit switch (L)

The parameter ‘L’ defines the different reference entrances of the module. The motor stops when the defined position is reached.

| Bit | Motor stops at |
|-----|----------------|
| 0   | REF_B = 0      |
| 1   | REF_A = 0      |
| 2   | GPI = 0        |

|   |   |
|---|---|
| 3 | REF_B = 1   |
| 4 | REF_A = 1   |
| 5 | GPI = 1   |
| 6 | 0: soft stop, 1: hard stop                            |
| 7 | 0: sets position zero<br>1: sets position not to zero |

**Table 7.5: Limit switch**

To activate a reference switch set the appropriate bit to 1. When motor stops the position counter is set to zero.

**Example:**

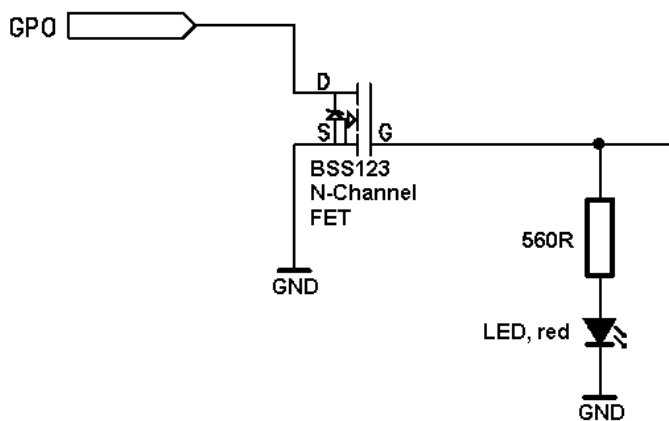
AL 8 ⇒ ENTER: Activates REF\_B = 1. When destination reached, motor stops and position counter is set to zero.

**7.2.1.6 Output setting (O)**

The bit settings are as follows:

| Bit | Description                                  |
|-----|--|
| 0   | 0: GPO is inactive (LED off)                 |
|     | 1: GPO is active (LED on)                    |
| 1   | 1: Output is changed at end of reference run |

**Table 7.6: Output adjustment**



**Figure 7.2: GPO wiring scheme**

**7.2.1.7 I/Os readout (Q)**

**Command:**

AQ ⇒ ENTER

|      |   |   |   |     |       |       |     |       |
|------|---|---|---|-----|-------|-------|-----|-------|
| Bit  | 7 | 6 | 5 | 4   | 3     | 2     | 1   | 0     |
| Port | 0 | 0 | 0 | GPI | REF_B | REF_A | GPO | ALARM |

**Table 7.7: I/Os readout****7.2.1.8 Baud rate (U)**

The parameter  $U$  changes the baud rate of the module for RS485 communication.

| Parameter U | Baud rate   |
|-------------|-------------|
| 0           | 9600 baud   |
| 1           | 14400 baud  |
| 2           | 19200 baud  |
| 3           | 28800 baud  |
| 4           | 38400 baud  |
| 5           | 57600 baud  |
| 6           | 76800 baud  |
| 7           | 115200 baud |

**Table 7.8: Baud rate****7.2.1.9 Velocity mode (V)**

The velocity mode allows rotation of the motor without external signals. In order to rotate the motor, please set an acceleration value different from zero. The velocity is given by the following equation, when parameter  $AV n$  is used:

$$\begin{aligned}
 v[\text{microsteps / s}] &= n \cdot 0.149157 \text{ [microsteps / s]} \\
 v[\text{steps / s}] &= \frac{n \cdot 0.149157}{\text{Microstep resolution}} \text{ [steps / s]} \\
 v[\text{rotations / s}] &= \frac{n \cdot 0.149157}{\text{Microstep resolution} \cdot \text{Fullsteps of motor}} \text{ [rotations / s]}
 \end{aligned}$$

For a 200 step motor at 64 microsteps, this gives

$$v[\text{rotations / s}] = \frac{n}{85815} \text{ [rotations / s]}$$

A practical limit with most stepper motor types is about 20 rotations / second in chopper mode 0 and 5 rotations / second in chopper mode 2.

As a second parameter, value 0 or 1 is optional. Standard is 0 and sends back the Carriage Return character at once. If it is set to 1 sending back of the Carriage Return character is delayed until the target velocity is reached.

**Example:**

AV -50000 ⇒ ENTER: Accelerates motor to given velocity

AV 0 1 ⇒ ENTER: Accelerates motor to velocity zero (standstill) and delays echoing of carriage return until target velocity has been reached

**7.2.1.10 Store parameters to EEPROM (W)**

This command stores the actual parameters to the EEPROM to restart with the same performance after power down.

Stored parameters are:

- Current setting (set by command C)
- Selected Mode (set by command M)
- Output adjustment (set by command O)
- RS485 parameters (set by command U)
- Microstep resolution (set by command Z)

**Example:**

AW ⇒ ENTER: All actual parameters from list above are stored to EEPROM.

**7.2.1.11 Microstep resolution (Z)**

The microstep resolution can be set by the user. It depends on the maximum resolution which differs in the three different chopper modes (see 7.2.2).

The maximum resolution is set by the parameter Z.

| Parameter Z |                | Microstep resolution |     |                 |
|-------------|----------------|----------------------|-----|-----------------|
|             |                | SPI                  | PWM | Phase (default) |
| 0           | max resolution | 64 *)                | 64  | 256             |
| 1           | 1/2 max        | 32 **)               | 32  | 128             |
| 2           | 1/4 max        | 16                   | 16  | 64              |
| 3           | 1/8 max        | 8                    | 8   | 32              |
| 4           | 1/16 max       | 4                    | 4   | 16              |

**Table 7.9: Adjustment of microstep resolution**

\*) Simulated microsteps, the actual microsteps of the motor are not improved compared to Z = 1.

\*\*\*) Simulated microsteps, the actual microsteps are improves but do not reach 32 microsteps.

**Example:**

AZ 2 ⇒ ENTER: Sets the microstep resolution to a quarter of the maximum resolution.

**7.2.2 Chopper modes**

**7.2.2.1 Chopper mode 0 (SPI) / default mode**

In this mode, the motor coil current is regulated on a chopper-cycle-by chopper-cycle bias. This is the standard operation mode for most motor drivers. It brings a medium microstep resolution of 16 microsteps and typically works well with most motors and a high range of supply voltage and motor current settings. A resolution of up to 64 microsteps can be simulated but the motor precision is only slightly improved compared to 16 microsteps and the same as with 32 microsteps.

The maximum supply voltage ( $V_S$ ) of the motor must not exceed 22-25 times the nominal motor voltage ( $V_N$ ), regarding the multiplication of  $I_{COIL, MAX}$  and  $R_{MOTOR}$ . A higher value would lead to an excess of motor rating.

The minimum supply voltage has to be above two times the nominal motor voltage.

$$2 \cdot V_N \leq V_S \leq 22 \dots 25 \cdot V_N$$

$$V_N = I_{COIL, MAX} \cdot R_{MOTOR}$$



It uses a chopper frequency of about 36kHz.

### 7.2.2.2 Chopper mode 1 (PWM)

This mode is identical to the chopper mode 0 (SPI) mode, but it increases the microstep resolution at low velocities / stand still.

$$2 \cdot V_N \leq V_S \leq 22 \dots 25 \cdot V_N$$

$$V_N = I_{\text{COIL,MAX}} \cdot R_{\text{MOTOR}}$$

### 7.2.2.3 Chopper mode 2 (PHASE)

This mode uses a different chopper scheme, which provides a very high microstep resolution and smooth motor operation. However motor dynamics and maximum velocity are quite limited. Care has to be taken concerning the selection of motor and supply voltage:

The motor is chopped with 20kHz, and the coil sees a 50% duty cycle at full supply voltage when the coil current is meant to be zero. This is only true for the average, but the motor still sees an alternating current and thus an alternating magnetic field. Now, care has to be taken in order to keep this current to a value which is significantly lower than the motor maximum coil current. If it is too high, the motor has significant magnetization losses and coil power dissipation, and would get much too hot, even with zero average current. The only possibility to limit this effect is to operate with a comparatively low supply voltage. The following calculation is based on the assumption that full motor current is set.

#### Check list:

1. Take the motor inductivity  $L$  [mH] and motor rated full step coil current  $I_{\text{COIL}}$  [A] from the motor's data sheet.
2. Now choose a supply voltage for the module to fulfill the following comparison:

$$\frac{V_S \cdot 25\mu\text{s}}{L} \leq I_{\text{COIL}} \cdot 0.5$$

$$\Leftrightarrow V_S \leq I_{\text{COIL}} \cdot 20 \cdot L[\text{mH}]$$

3. If your parameters do not fulfill the equation, i.e. you calculate a supply voltage which is below the modules' operation specs or which does not fit your system requirements, try the following:

#### **Calculate x:**

$$x = \frac{V_S}{I_{\text{COIL}}} \cdot \frac{0.025}{L[\text{mH}]}$$

If  $x$  is below 0.5, everything is OK.

If x is in the range 0.5 to 1.0, try operating your motor and check if motor or driver gets too hot.

If x is above 1.0, choose one of the other chopper modes.

See also 6.1.1.3 for graphical demonstration.

### 7.2.2.4 Chopper mode 3 (phase and SPI)

This mode combines the modes 2 (phase) and 0 (SPI) in order to provide highest accuracy at lower velocities and also the possibility for faster movements. Through the switching between modes some microsteps may be lost. Microstep resolution must not be higher than 64. It is set according to Phase mode, so possible values for Z (microstep resolution) are 2, 3 or 4.

| μsteps | Phase to SPI |          | SPI to phase |          |
|--------|--------------|----------|--------------|----------|
|        | V-value      | Rounds/s | V-value      | Rounds/s |
| 64     | 192000       | 2.24     | 25000        | 0.29     |
| 32     | 96000        | 2.24     | 12500        | 0.29     |
| 16     | 48000        | 2.24     | 6250         | 0.29     |

**Table 7.10: Chopper mode 3 switching velocities**

Conversion of values above to motors with different fullstep resolutions:

$$v_{\text{motor}} (\text{rounds/s}) = \frac{v_{\text{table}} (\text{rounds/s})}{200} \cdot \text{motors fullsteps per revolution}$$

### 7.2.2.5 Chopper mode 4 (PWM and SPI)

This mode combines the modes 1 (PWM) and 0 (SPI) in order to provide higher accuracy (up to 64 microsteps) at lower velocities and also the possibility for faster movements. For higher velocities in SPI mode the microstep resolution is always 16, but set resolution is simulated. Through the switching between modes some microsteps may be lost. Microstep resolution must not be higher than 64. It is set according to Phase mode, so possible values for Z (microstep resolution) are 2, 3 or 4. This mode should only be used in very special occasions and mode 3 should be preferred if a combination of high accuracy at slow movements and high speed is needed.

## 7.3 Step/dir

Additional parameters can be set by RS485 i.e. to set a maximum velocity or microsteps per round.

The step/dir controls are as follows:

| Motor   | Velocity       | Acceleration               | Rotate right  | Rotate left                   |
|---------|----------------|----------------------------|---|-------------------------------|
| Control | Step frequency | Increase of step frequency | Direction open wired or connected to V <sub>COM</sub> | Direction connected to ground |

**Table 7.11: External signals and motor reactions**

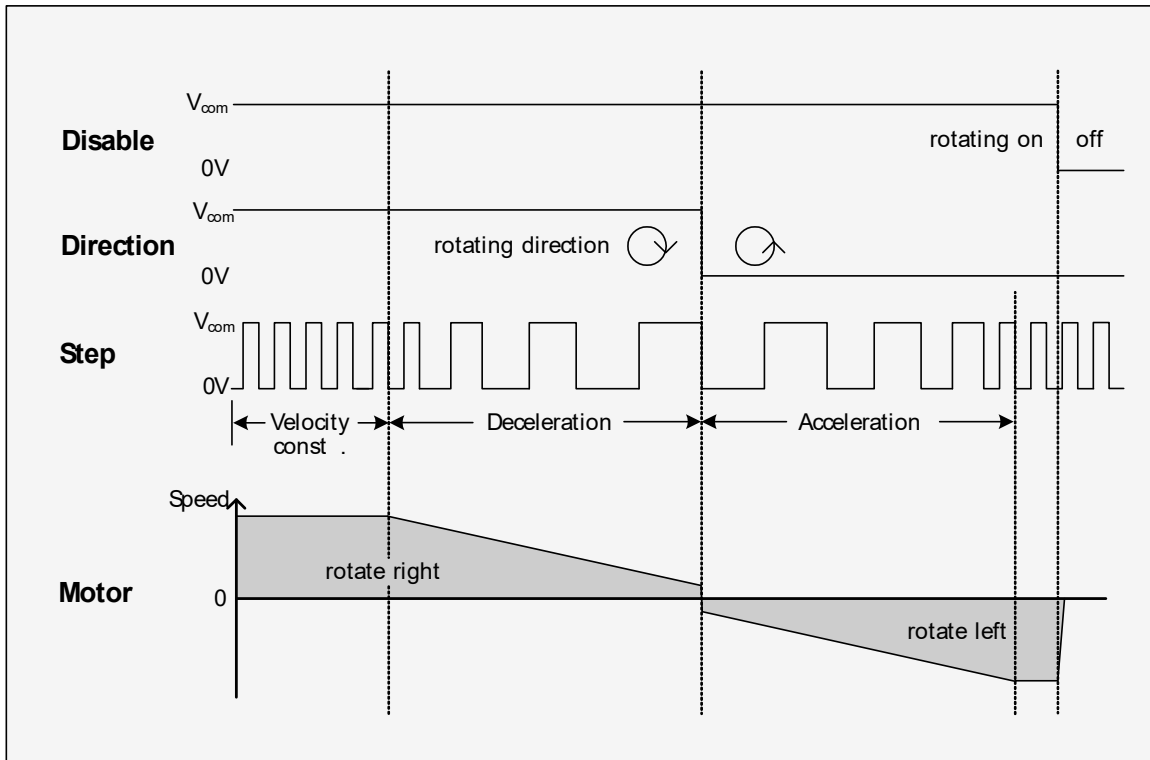


Figure 7.3: Step/dir signals and motor reactions

### 7.3.1 Direction

The Direction signal changes the motors rotation from clockwise (CW) to counterclockwise (CCW) and vice versa.

Function table:

| GND      | open wire | $V_{COM} = 5... 24V$ |
|----------|-----------|----------------------|
| motor CW | motor CCW |                      |

### 7.3.2 Step

**Description:** The Step signal controls the velocity and acceleration of the motor. The velocity depends on the frequency, the acceleration on the change of the frequency. One step impulse represents one microstep.

Calculation of rotations per second (refer to 7.2.1.11):

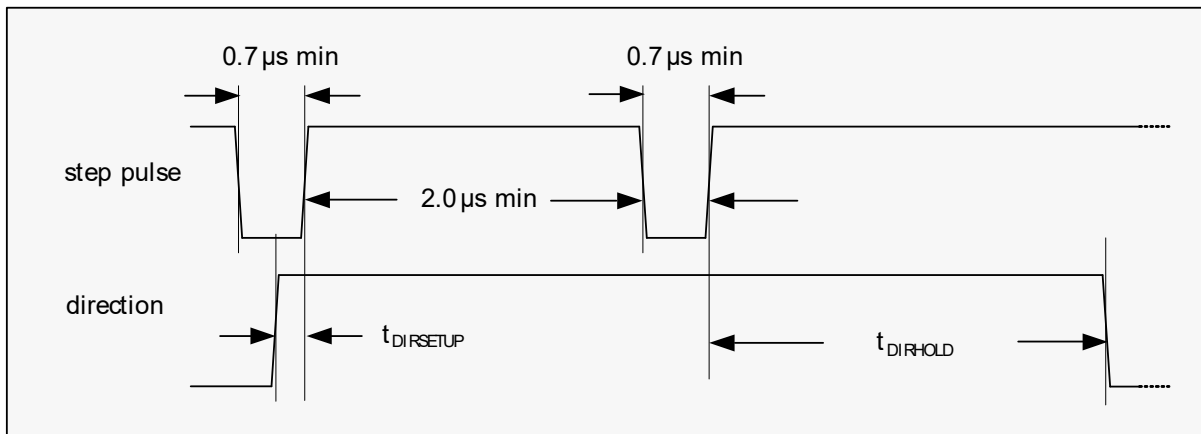
$$v[\text{rotations / s}] = \frac{\text{Step input frequency}}{\text{Fullsteps} \cdot \text{Microstep resolution}} [\text{rotations / s}]$$

Frequency:

- The maximum Step input frequency is 350 kHz, aligned to the Direction signal. The minimum logic 0 time is 0.7  $\mu\text{s}$  and the minimum logic 1 time is 2.0  $\mu\text{s}$ .
- A step is triggered by the positive going edge of the signal (switching off of opto coupler).
- Maximum frequency at a duty cycle of 1 (0 time is 2.0  $\mu\text{s}$  and 1 time is 2.0  $\mu\text{s}$ ) is 250 kHz.

**Function table:**

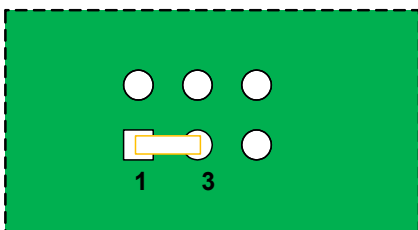
| Extern | GND  | open wire | $V_{COM} = 5... 24V$ |
|--------|------|-----------|----------------------|
| Intern | HIGH | LOW       |                      |



**Figure 7.4: Step and direction signal**

### 7.4 Reset to factory default

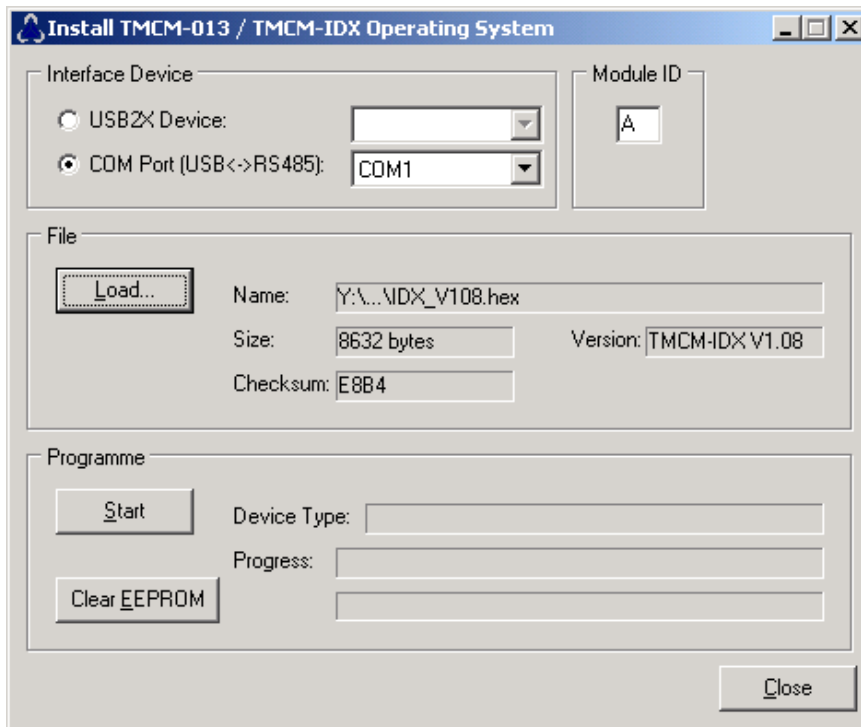
Switch off the module and short-circuit pin 1 and pin 3 of the free contacts for a 6-pin connector on the backside of the module. See Figure 7.5. Turn on the module and switch it off again to remove the short-circuit. All settings are now at factory default.



**Figure 7.5: Reset to factory default**

### 7.5 Firmware update

For Firmware update start the program TMCM013boot.exe contained in the IDX-Folder of your TMCTechLibCD or at [www.trinamic.com](http://www.trinamic.com):



**Figure 7.6: Firmware update tool**

1. Choose your RS485 connection.
2. Select your module ID (default is A).
3. Load the new firmware file (e.g. IDX\_V1.08.hex), to download from [www.trinamic.com](http://www.trinamic.com).
4. Start the update process.

At the end of the update process check your firmware version with command AX.

## 8 Revision history

### 8.1 Document revision

| Version | Comment/Date  | Author | Description   |
|---------|---------------|--------|---|
| 1.00    | First Release |        | Full functionality for Firmware V1.05   |
| 1.01    | Limit switch  |        | Added limit switch to documentation   |
| 1.02    | Additions     |        | stallGuard™ added with RS485 command 'G', formerly used for output setting (LED) now command 'O'. Switched default mode to SPI.                           |
| 1.04    | Updates       |        | Added / modified some details   |
| 1.05    | Updates       |        | RS485 connection documentation revised  |
| 1.06    | Updates       |        | Corrected current default value, included IDX 7505 information  |
| 1.07    | Updates       |        | Modes 3, 4 and GPO, GPI wiring scheme included  |
| 1.08    | Updates       |        | Firmware update included  |
| 1.09    | Corrections   |        | Step / direction timing   |
| 1.10    | Corrections   |        | 6.1.1.3 Chopper Mode 2 – Inductivities, 7.2.1.11 Microstep Resolution   |
| 1.11    | Update        |        | EMV / optocoupler reverse voltage   |
| 1.12    | New style     |        |   |
| 1.13    | Nov 7, 2007   | HC     | Ground plate height has changed from 3mm to 2.5mm (see 4.2)   |
| 1.14    | Nov 28, 2007  | HC     | RS485 command 'W' clarified, Figure 6.3 corrected (disable)   |
| 1.15    | Sep 16, 2008  | OK     | New feature of firmware 1.12 added  |
| 1.16    | Dec 3, 2008   | OK     | Address setting procedure corrected   |
| 1.17    | 2011-APR-11   | SD     | New front page, new design, minor changes. Special information about outdated IDX with less performance deleted. Figure 7.1 new (functional description). |

**Table 8.1: Document revision**

### 8.2 Firmware revision

| Version  | Comment                | Description  |
|----------|------------------------|--|
| Pre 1.07 | Please update          |  |
| 1.07     | First Release          | Full functionality (except DC-Motor) with some possibilities to expand   |
| 1.08     | Bug fix, new options   | Added chopper modes 3 and 4, modified V command, corrected RS485 bug (always echoing of CR at earlier versions)  |
| 1.09     | Bug fix                | 'E' command corrected (output was shifted by four bits)  |
| 1.10     | New options            | 'X' command can also be given as a lower case letter<br>Option 2 for command 'O' added<br>Mixed decay automatically disabled when stallGuard™ enabled<br>Mixed decay can be disabled without turning on stallGuard™ using G8 |
| 1.11     | Improvement            | stallGuard™ improved by filtering  |
| 1.12     | New option             | stallGuard™ also usable in step/direction mode (controls GPO then)   |
| 1.13     | Improvement<br>Bug fix | Motor powered (with stand by current) directly after enabling in all modes<br>Stand by current in step/dir mode 0 corrected  |
| 1.14     |                        |  |

**Table 8.2: Firmware revision**