



# TMC32NPx and TMC401 Evaluation Kit



## Features:

The TMC32NP and TMC401 allows to evaluate the performance of different stepper driver configurations, using a two or a four layer layout and different SMD package types. The three driver sections are: TMC32NP-SM8 with TMC249A-SA, TMC32NP-MLP with TMC249-LA and TMC34NP-PSO with TMC249A-LA. The board also allows to explore the TMC401 step-/direction to SPI converter. This chip allows to operate the SPI driver chips from a step-/direction input signal. The diagnostic features of the TMC249 like overtemperature pre-warning and StallGuard motor stall detection are displayed via LEDs. The related signals can be accessed via pins. One driver can be operated at a time. Driver selection is done by the power supply connector and a jumper.

The kit contains the TMC32NPx evaluation board and a cable to connect the on-board SPI connectors or to control it via an TMC428 evaluation board, as well as a power supply connector. Please visit our website (<http://www.trinamic.com>) for additional documentation.

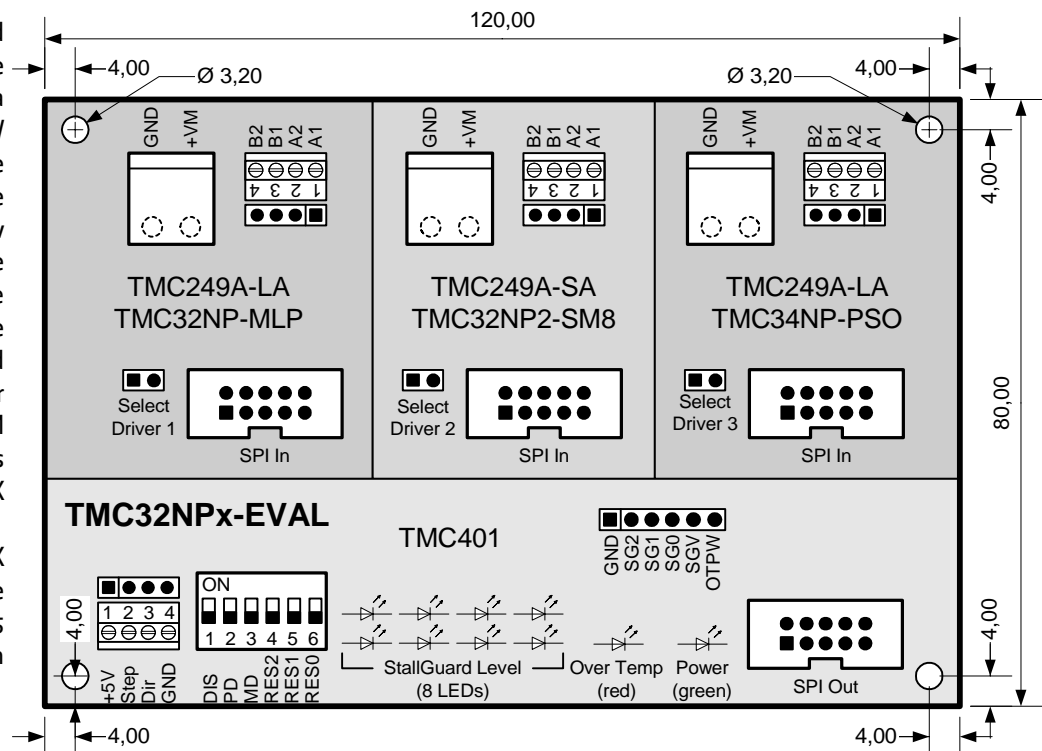
## Precautions:

1. **Never reverse the power supply since the module is not protected against wrong polarity!**
2. Do not connect or disconnect a motor while the evaluation board is powered, as this could damage the TMC249 driver chip!

## Connectors and Dimensions:

Board Dimensions: 80 x 120 mm  
Power supply (+VM) is 7...28.5 Volts.

All connectors and jumpers except the power connectors have a 2.54mm pitch. For step-/direction inputs and the motor coil outputs there are easy to use screw connectors. The electrically identical line of 4 pins next to these connectors can be used alternatively. The power connectors are 2 pole RM 5.08mm connectors (onboard: PHOENIX MSTBA2.5/2-G-5.08, Counterpart: PHOENIX MSTB 2,5/2-ST-5,08). The SPI connectors are 2x5 pole RM 2.54mm connectors (Din 41651).



**Motor connection:**

**Warning: Never connect or disconnect a motor while the unit is powered on! This may damage the motor drivers due to high induction voltage!**

Supported motors are two-phase bipolar stepper motors with min. 1.4A respectively 2.8A (TMC32NP-PSO) coil current. Connect one coil of the motor to the pins "A1" and "A2" and the other coil to the pins "B1" and "B2".

	Pin	Function
A1	1	Motor coil A1
A2	2	Motor coil A2
B1	3	Motor coil B1
B2	4	Motor coil B2

**Power supply:**

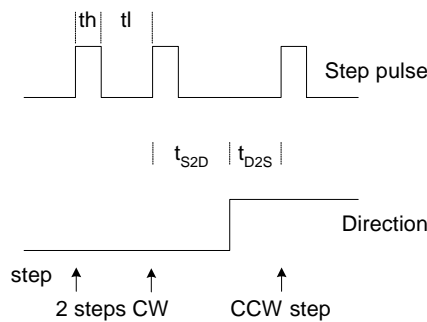
The power supply is minimum 7V and maximum 28.5V DC. Three power connectors are provided to power each driver separately. They can be connected simultaneously. A voltage of +5V is produced onboard at the TMC401 section. Thus no additional +5V supply is needed at the step-/direction signal input if at least one driver section is supplied with power. The power lines (7..28.5 and back +5V) are the only connections between the driver and TMC401 sections (except SPI). The green LED indicates power on.

Top view	Pin	Function
	+VM	Power supply: 7..28.5V DC (not protected)
	GND	Ground

**Step-/Direction signal:**

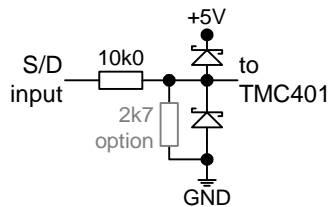
Step-Direction signal timing:

	Min	Max
$T_{S2D}$	2 $\mu$ s	
$T_{D2S}$	0 $\mu$ s	
th	0.125 $\mu$ s	
$f_{STEP}$		245 kHz

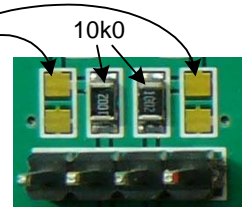


	Pin	Function
+5V	1	+5V (optional supply)
Step	2	Step input
Dir	3	Dir input
GND	4	Ground

The step-/direction levels are TTL levels (0 and 5V). Signals of 24 V can be used if two 2k70 (0805) resistors are soldered to the free pads next to the step-/direction connector.



for 24V signals only: solder two additional 2k7 resistors to this free pads



**TMC401 Functionality:**

The TMC401 generates out of a given step-/direction signal a SPI datagram which directly controls TRINAMIC TMC249A drivers. Additional settings are available via a number of inputs. A set of diagnostic features is implemented also. The IC gives a warning upon high driver temperature and the motor load is detected with the patented StallGuard feature. These functions are explained later on. For further information please refer to the TMC401 manual and for StallGuard to the TMC249 manual.

**DIP Switches:**

The DIP switches set the inputs of the TMC401. The inputs are low active and have internal pull-ups. A switch turned ON pulls the input to ground. There are six DIP switches on this board:

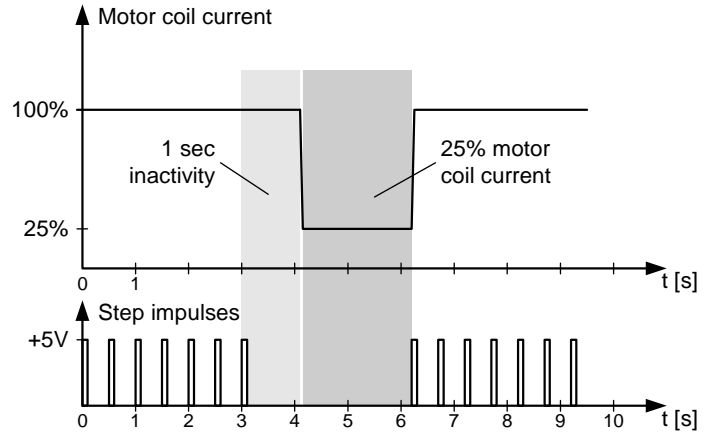
	Pin	Function
1	1	Disables the TMC401 by tri-stating all four SPI pins.
2	2	Activates "Power Down" feature
3	3	Activates Mixed Decay
4	4	Sets $\mu$ step resolution (bit 2)
5	5	Sets $\mu$ step resolution (bit 1)
6	6	Sets $\mu$ step resolution (bit 0)

**Mixed Decay:**

The MD pin controls the use of the Mixed Decay feature of the TMC249A. Mixed decay is enabled when the MD pin is pulled low. The mixed decay setting especially at rotation velocities in the range of a few 10 steps per seconds to several 100 steps per second improves motor behavior (less resonance). However, the actual performance depends on the motor and mechanics. For supply voltages above 24V and for low inductivity motors, best microstep behavior is reached when mixed decay setting is continuously on.

**Power Down:**

The PD pin controls the automatic power down feature. If this pin is low the motor current will be lowered to approx. 25% of the actual current after there has been no step pulse for at least one second. The current will be raised to 100% again as soon as the next step pulse occurs. When the PD pin is high (or open, as the PD pin has an internal pull-up resistor) the current will always stay at 100%.



**Microstep Resolution:**

The microstep resolution can be set to a number of different values. Thus each sent step impulse is interpreted accordingly. The resolution selection inputs have internal pull-up resistors.

RES <sub>2</sub>	RES <sub>1</sub>	RES <sub>0</sub>	Microstep resolution
0	0	0	1/32 (effective microsteps: 24 different)
0	0	1	1/16
0	1	0	1/8
0	1	1	1/4
1	0	0	1/2
1	0	1	1/1
1	1	0	Full step with matched current
1	1	1	Full step with full current

**Overtemperature:**

The red LED labeled "Over Temp" indicates the state of the OTPW bit of the TMC249. The OTPW pin is an output pin that shows this state also. It lights or is high when the OTPW bit is set (that means, there is an overtemperature pre-warning). The OTPW pin could be directly connected to the enable input of the TMC249 when the motor shall be switched off automatically if there is an overtemperature pre-warning.

The pre-warning temperature is min.: 135°C, typical: 145°C and max.: 155°C. When the OTPW flag becomes active, the user could decide to switch off the motor / switch the motor to standby in order to protect the power transistors against overheating.

**SPI Out:**

The SPI data word sets the current and polarity for both motor coils. By applying consecutive values, describing a sine and a cosine wave, the motor can be driven in microsteps. Every microstep is initiated by its own telegram. For more information about the SPI datagram please refer to the TMC249 documentation chapter "Control via the SPI-Interface". For normal operation of the TMC32NPx-Eval board the SPI connectors are not needed since all these signals are connected to the driver sections directly. The pin assignment of the connector is as follows:

Pin	Function	Pin	Function
1	MISO	2	DIS: For use with TMC428-Eval board (disables TMC401)
3	MOSI	4	GND
5	CS	6	GND
7	SCK	8	GND
9	Not connected	10	+5V output to drivers

**StallGuard:**

The load detection bits LD2..LDo of the TMC249 are input to the StallGuard output pins SG2..SGo. Every time the StallGuard bits become valid a low pulse of approx. 4µs is generated on the SGValid output. At this times the StallGuard value can be read out. Please see TMC249 Manual for further information. The StallGuard level is shown by the 8 LEDs labeled "StallGuard value". The StallGuard value depends on the torque, velocity and resonances of the motor. Thus a stall can be detected. The "StallGuard level" bits SG2..SGo and the "StallGuard valid" bit SGV are directly accessible by the output pins labeled accordingly.

**Driver functionality:**

The drivers are controlled via a 12 bit SPI datagram generated by the TMC401 or for example by the TMC428-Eval board. All driver sections can be separated from the TMC401 section (sawed off) in order to simulate the thermal conditions on a smaller PCB. In this case, or when the TMC428-Eval board is used, a bypass cable connects the SPI output of the TMC401 or TMC428 to the desired driver/transistor configuration. For this reason all driver sections have their own power supply connector.

Be careful to saw at the lines only and not into the inner copper layers to avoid a short circuit between the layers. However, please be aware that Trinamic can take no warranty for modified boards.

**SPI In:**

Please refer to SPI Out of the TMC401 section for the pinout of this connector. This connector is for use with SPI telegram generating modules, mainly the TMC428-Eval board.

If the TMC401 section is sawed off, the SPI connectors are used to control the modules. In this case the +5V power supply has to be externally connected to the step-/direction connector. The drivers get the necessary +5V voltage via the SPI connector.

**Jumper:**

The SPI interfaces of the drivers are all connected in parallel. They all use the same signal generated by the TMC401. To select a driver, the jumper on the active driver section has to be set (closed). The jumper connects the MISO line to the TMC401 section. All other jumpers should be left open.

**Driver differences:**

The three driver sections of the TMC32NPx-Eval board have different characteristics with respect to current capability. The application performance differs in dependence of board size, environment temperature and mounting orientation, thus the values given in the table are just indications. For a conservative design, we suggest that the transistor packages should not exceed 100°C under normal conditions (125°C under maximum conditions). This gives enough headroom for eventual effects which may occur in the end application (absolute maximum temperature is 150°C). Reduced duty cycle allows for higher current. Please also refer to the respective transistor datasheets and TMC249 datasheet.

No.	Driver	Transistor	Current capability	Characteristics
1	TMC249A-LA	TMC32NP-MLP	1.4A RMS, 2A peak continuous 2A RMS, 2.8A peak (limited duty cycle) eight transistors: ca. 1.8x current	very compact, 4 layer layout
2	TMC249A-SA	TMC32NP2-SM8	1.1A RMS, 1.5A peak continuous 1.8A RMS, 2.5A peak (limited duty cycle)	only two transistor packages, 2 layer layout
3	TMC249A-LA	TMC34NP-PSO	2.8A RMS, 4A peak continuous	4 layer layout

**Documentation Revision:**

Version	Date	Author	Description
1.01	11-May-2007	HC	Initial Release
1.02	27-Jun-2007	DW	Minor updates, added TMC34NP-PSO info