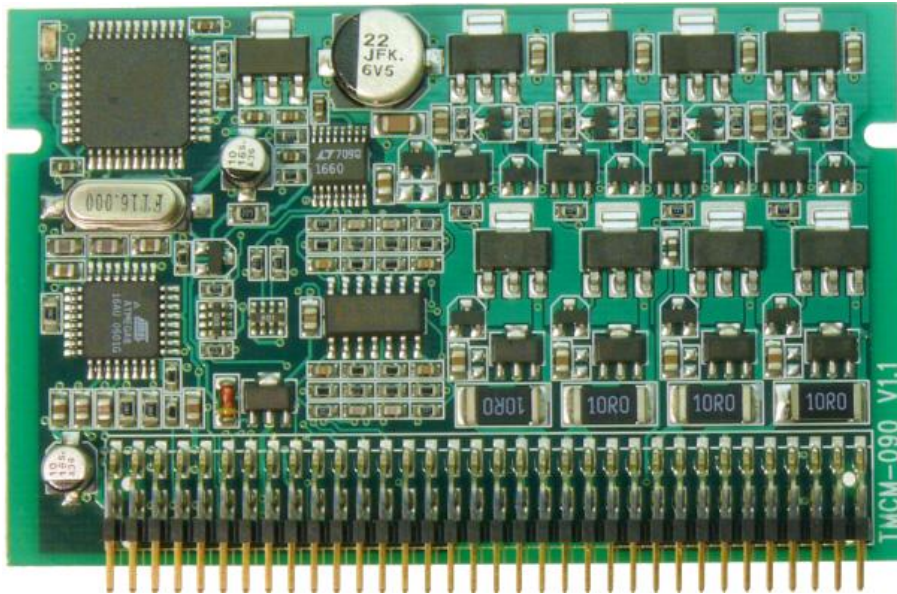


TMCM-090



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TRINAMIC

MOTION CONTROL

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1 Features

The TMC-090 is a compact piezo motor driver module for high precision and highly dynamic piezo axis. It is specially designed for four phase piezo motors, like the PIEZO MOTOR „Piezo Legs“. It can be combined with the driver-less modules TMC-301 or TMC-302 or with any step/direction controller. The TMC-323 can be added for encoder feedback. Its small size makes it an optimum solution for integration on any user board. The board can be connected to a baseboard or customized electronics with a pin connector. Applications are optical and analytical instruments. **Its high microstep resolution leads to a linear motor resolution of about 4nm per microstep.**

Applications

- highly precise positioning for optical and analytical instruments
- manufacturing equipment for semiconductor components
- high density multi axis drive electronics

Motor type

- Piezomotor PiezoLegs four phase Piezo motor

Highlights

- drives piezo legs' 0,5 μ F capacity inputs with up to 3kHz step frequency
- up to 2048 times microstepping using step / direction interface
- up to 64 times microstepping using SPI control with direct access to DACs
- step/direction control or SPI control
- Motor outputs protected against short to GND
- Overtemperature protection of driver stage
- pin compatible to TMC-035 stepper driver board – can be applied on the same application boards for driving by TMC-301 (SPI) or TMC-302 (Step-Dir)
- small credit card sized board

2 Order codes

Order code	Description
TMCM-090 (-option)	1-axis piezo LEGS motor driver
Related products	BB-301, TMCM-301, TMCM-302, BB-035
Option	
-H	horizontal pin connector (standard)
-V	vertical pin connector (on request)

Table 2.1: Order codes

3 Life support policy

TRINAMIC Motion Control GmbH & Co. KG does not authorize or warrant any of its products for use in life support systems, without the specific written consent of TRINAMIC Motion Control GmbH & Co. KG.

Life support systems are equipment intended to support or sustain life, and whose failure to perform, when properly used in accordance with instructions provided, can be reasonably expected to result in personal injury or death.

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Specifications are subject to change without notice.

4 Electrical and mechanical interfacing

4.1 Dimensions

The 68 pin connector has a 2.0mm pitch.

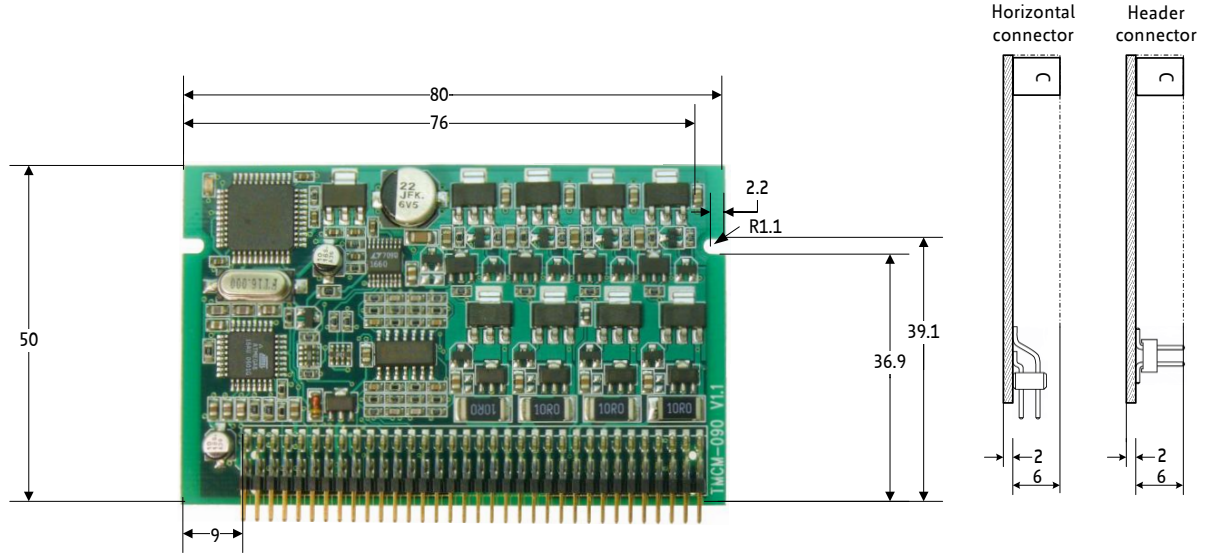


Figure 4.1: Dimensions

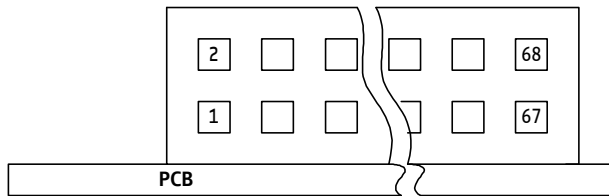


Figure 4.2: Enumeration of pins

4.2 Pinning

Pin	Number	Function
+5V	1, 3	5V logic power supply input (use +-2% or better tolerance regulator if possible) (max. 70mA)
GND	2, 4, 6, 8, 10, 61, 62	GND (Digital GND / Motor GND)
+VM	5, 7, 9	Motor supply voltage 48V +15% / -5% (The lower limit of -5% assumes an accurate +5V supply. It is reduced by the positive going tolerance of the +5V supply, i.e. the supply voltage requirement is higher with a higher 5V supply)
STEP_ENN	11	Digital Out: Pin 11 outputs the most significant bit of the microstep position. This serves for the decision to change or to keep the actual waveform.
SCK	12	Digital In: Serial clock for SPI operation. Do not connect in step/direction mode.
SCSN	13	Digital In: Serial chip select for SPI operation. Do not connect in step/direction mode.
SDO	14	Digital Out: Serial data output for SPI operation. Do not connect in step/direction mode.
SDI	16	Digital In: Serial data input for SPI operation. Do not connect in step/direction mode.
NRESET	17	Digital In: Module reset – leave open for normal operation
STEP	18	Digital In: Step input
DIR	20	Digital In: Direction input
MODE0	22	Digital In: Selection of wave form in Step/Direction mode
MODE1	24	Digital In: Selection of wave form in Step/Direction mode
RES0	25	Digital In: Step/direction microstep resolution 0
RES1	26	Digital In: Step/direction microstep resolution 1
MODE2	27	Digital In: Selection of operation mode: tie to GND for SPI mode
MOT4	37, 38, 39, 40	Motor phase 4 output
MOT3	41, 42, 43, 44	Motor phase 3 output
MOT2	49, 50, 51, 52	Motor phase 2 output
MOT1	53, 54, 55, 56	Motor phase 1 output

Table 4.1: Power and motor pinning

4.3 Connectors

Connectors of the TMC-090 and possible socket board connectors:

Onboard connectors:	Samtec MMT-134-02-S-DH-K	horizontal pin connector (option H)
	Samtec TMM-134-01-S-D-SM	vertical pin connector (option V)
Socket board connector:	Samtec MMS-134-02-L-DV	straight
	Fischer Elektronik BLY4-068	right angle

5 Operational ratings

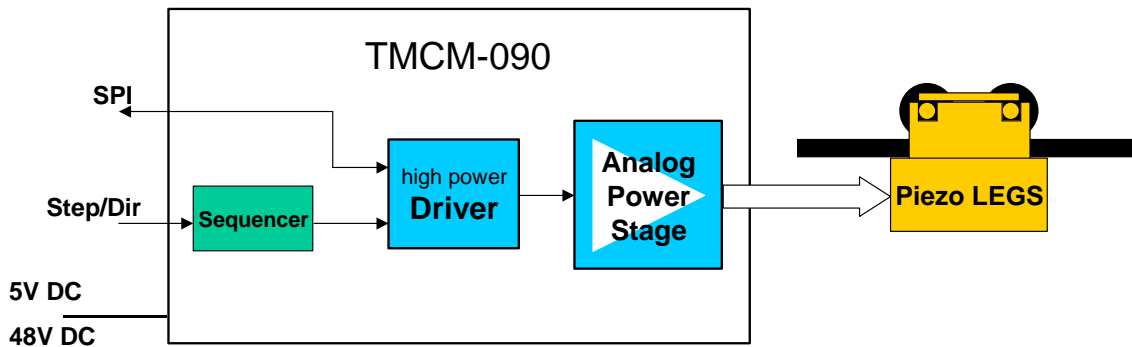
The operational ratings show the intended / the characteristic range for the values and should be used as design values. In no case shall the maximum values be exceeded.

Symbol	Parameter	Min	Typ	Max	Unit
V_S	Power supply voltage for operation (has to be above $9.12 * +5V$ input)	45.6	48	55	V
I_{COIL}	Motor current (short time)			1	A
I_{MC}	Continuous motor current (RMS) This additional current is seen on the power supply line when the motor is operating		0 .. 0.2		A
I_{+5}	Power supply current +5V		0.05		A
I_{STB}	Standby power supply current V_S		0.05		A
I_S	Power supply current V_S operational		0.06 .. 0.2	0.5	A
f_{Step}	Step frequency (step input)			384	kHz
t_h	Step pulse high time	100			ns
T_{S2D}	Direction hold time (Direction hold after step impulse)	2			μs
T_{D2S}	Direction change to step delay (direction setup time)	0			μs
T_{ENV}	Environment temperature	-25		85	$^{\circ}C$

Table 5.1: Operational ratings

6 Functional description

The TMC-090 module has got a step/direction interface mode, which provides a great number of resolutions and waveform settings, which are stored in internal ROM. An SPI mode is available, where the module is compatible to the SPI based TCM controller modules, after loading a special waveform table. However, the SPI mode only allows for a limited resolution of 64 microsteps.



6.1 Power supply requirements

The motor supply voltage of the TMC-090 is 48V DC $\pm 15\%$ / -5% . The lower limit of -5% assumes an accurate +5V supply. It is reduced by the positive going tolerance of the +5V supply, i.e. the supply voltage requirement is higher with a higher 5V supply. It has to be above 9.12 times the +5V input. The module is not protected against wrong polarity. Also a +5VDC supply for module functionality is needed (use $\pm 2\%$ or better tolerance regulator if possible, max. 70mA). Please use all listed pins for the power supply inputs and ground in parallel.

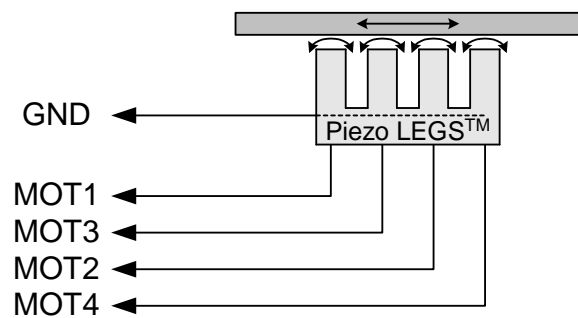
6.2 Bus interfaces

The TMC-090 has two different interfaces to fit in all applications. There is a SPI and step / direction interface available. The step/direction interface mode provides a great number of resolutions and waveform settings. With SPI interface the module is compatible to the SPI based TCM controller modules. However, this mode only allows for a limited resolution of 64 microsteps. Refer to "6.4 SPI mode operation" and "6.5 Step/dir mode operation" for further information.

6.3 Motor connection

The Module is specially designed and programmed for Piezomotor's Piezo Legs 4 phase motor.

Connect the motor to the MOTx pins. Always use all the pins for each "leg"! Connect one "leg" of the motor to MOT1 (53, 54, 55, 56), MOT2 (49, 50, 51, 52), MOT3 (41, 42, 43, 44) and MOT4 (37, 38, 39, 40) pins. Connect GND for example to pin 61 or 62. **Never connect or disconnect the motor while the module is under power as this may damage the module.**



The 4 "piezo-legs" move depending on the voltage of the MOTx inputs. A coordinated movement of all 4 legs causes a linear motion of the upper bar. Rotating systems with the same mechanism are available also.

Figure 6.1: How to connect the motor

6.4 SPI mode operation

To use the SPI interface you will have to make the following connections:

Signal name	Pin number	Connection
MODE2	27	Digital In: Selection of operation mode: tie to ground for SPI
SCK	12	Digital In: Serial clock for SPI operation.
SCSN	13	Digital In: Serial chip select for SPI operation.
SDO	14	Digital Out: Serial data output for SPI operation.
SDI	16	Digital In: Serial data input for SPI operation.

Table 6.1: SPI interface connections

6.4.1 TMCM-090 in conjunction with TMCM-301

The SPI interface is mainly to be used to connect the TMCM-090 module to a [TMCM-301] module. This way, up to three TMCM-090 modules can be connected to one TMCM-301. The microstep resolution is limited to 64, which corresponds to the TMCM-301's capabilities.

TMCM-090 pin number	TMCM-301 pin number	Signal name (TMCM-090)
1, 3	1, 3	+5V
2, 4, 6, 8, 10	2, 4, 6, 8, 10	GND
12	30	SCK
13	20	SCSN
14	28	SDO
16	26	SDI

Table 6.2: Connecting a TMCM-090 to a TMCM-301 (Motor o)

Since the TMCM-090 is pin compatible to the TMCM-035 the baseboard BB-301 can be used for an easy setup. Please refer to the [BB-301] manual for more information.

The TMCM-301 has to be prepared for operation with the piezo motor, by loading a special driver chain configuration ("TMCM-301_config.dvc"), which is available on the TMCM-090 website / TechLib CD. To do this open *Setup/Configure Module* in the TMCL IDE, go to tab *Drivers (TMCM-301)* and load the driver configuration TMCM-301_config.dvc. Finally download the table to the TMCM-090 by pressing *Set*.

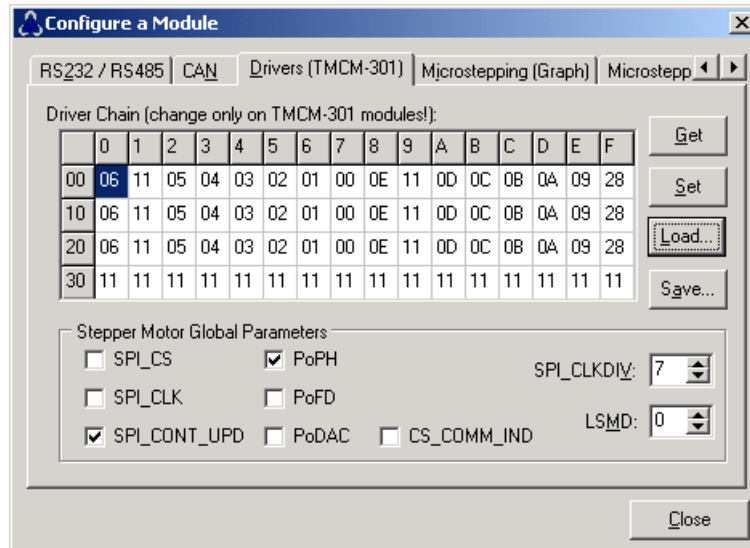


Figure 6.2: Driver configuration chain using TMCM-301

For the step table, a sine step table can be used. Any symmetrical waveform would be possible. At tab *Microstepping (Table)* and *Microstepping (Graph)* in the TMCL IDE calculate the microstepping table. Use Sigma=0 for a sine step table. Refer to [TMCL] reference for more information. Finally download the table to the TMCM-090 by pressing *Set*.

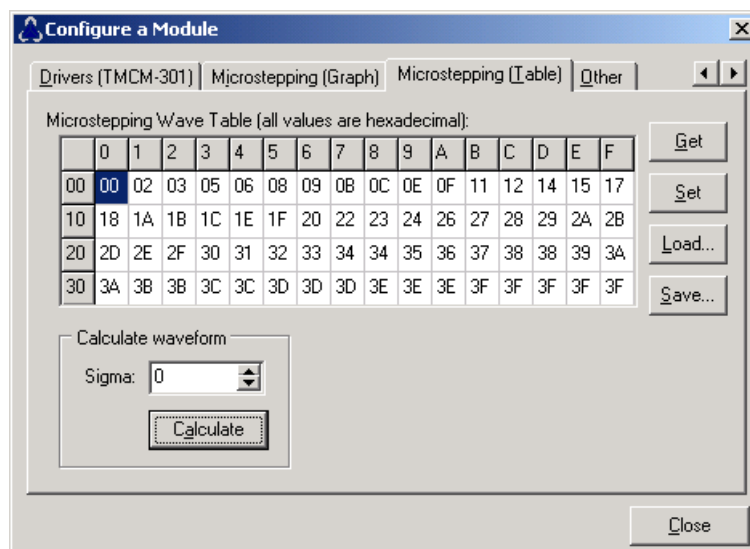


Figure 6.3: Microstep calculation for sine step table

Further, there is a special setting for mixed decay which is not valid for the TMCM-090: Please set SAP 203,0,2048 and STAP 203,0 to disable mixed decay and store this setting in the TMCL environment.

Attention: Resetting the TMCM 301 to default values restores the driver configuration table and some other parameters for stepper motor drivers, and these do not fit for the 090 module.

6.5 Step/dir mode operation

In Step/Direction mode the full capabilities of the module can be used, e.g. different waveforms and highest step resolution. However, the motor velocity which can be achieved depends on the mode, because the clock frequency which can be accepted by the module is quite limited.

To use the Step / Direction interface connect the inputs as follows:

Signal name	Pin number	Connection
MODE2	27	Digital In: Selection of operation mode: set high for step/direction
STEP_ENN	11	Digital Out: Pin 11 outputs the most significant bit of the microstep position. This serves for the decision to change or to keep the actual waveform.
STEP	18	Digital In: Step input
DIR	20	Digital In: Direction input
MODE0	22	Digital In: Selection of wave form in Step/Direction mode
MODE1	24	Digital In: Selection of wave form in Step/Direction mode
RES0	25	Digital In: Selection of step/direction microstep resolution
RES1	26	Digital In: Selection of step/direction microstep resolution

Table 6.3: Step / direction interface connections

Note: Pins 12, 13, 14 and 16 must not be connected in this mode!

6.5.1 Step / direction signal timing

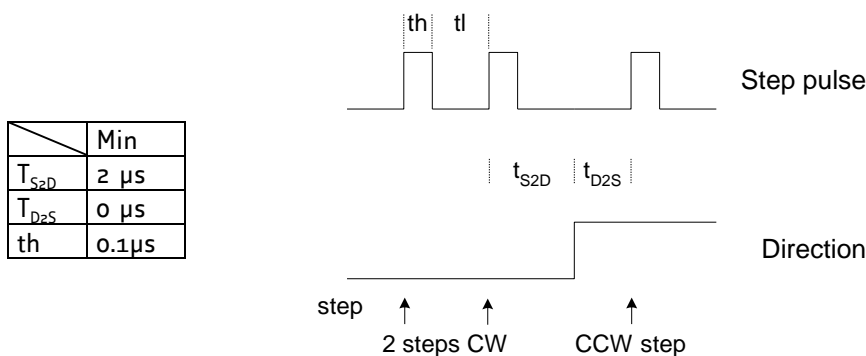


Figure 6.4: Step / direction signal timing

6.5.2 Resolution and waveform settings

The different waveforms and resolutions stored in the internal ROM are selected by digital inputs. MODE₀ and MODE₁ set the waveforms and RES₀ and RES₁ the microstep resolutions. See Table 6.4 for bit settings and chapter 6.5.3 for waveform examples. The modes with *128 microsteps or less* allow usage of the maximum possible motor velocity of 3kHz. Please be careful not to exceed the maximum allowed motor velocity in these modes, in order not to damage the motor.

Wave mode	Microstep resolution	RES ₁	RES ₀	MODE ₂	MODE ₁	MODE ₀
omega564 smoothwalking	2048	1	1	1	1	1
omega564 smoothwalking	1024	1	0	1	1	1
omega564 smoothwalking	512	0	1	1	1	1
omega564 smoothwalking	256	0	0	1	1	1
sine1s85 standard sine low noise	512	1	1	1	1	0
sine1s85 standard sine low noise	256	1	0	1	1	0
sine1s85 standard sine low noise	128	0	1	1	1	0
sine1s85 standard sine low noise	64	0	0	1	1	0
Rhomb	256	1	1	1	0	1
Rhomb	128	1	0	1	0	1
Rhomb	64	0	1	1	0	1
Rhomb	32	0	0	1	0	1
Rhomb F maximum force	256	1	1	1	0	0
Rhomb F maximum force	128	1	0	1	0	0
Rhomb F maximum force	64	0	1	1	0	0
Rhomb F maximum force	32	0	0	1	0	0
Module controlled by SPI interface	SPI	x	x	0	x	x

Table 6.4: Microstep resolution setting in step-direction modes

6.5.3 Changing the resolution or wave mode

For some applications it will be optimum to switch between different operation modes and resolutions. The microstep resolution can be changed any time, but when changing the wave mode, it has to be considered that a change at any point in the waveform would produce a jerk in the motor. In order to minimize this jerk, the TMC090 switches only at one point in the wave. This has to be considered when programming the motor controller.

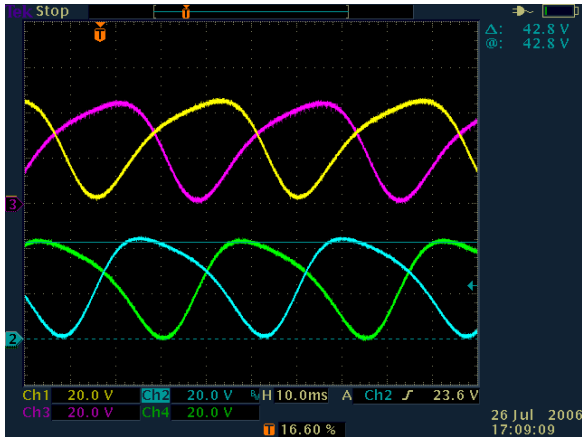
For changing the wave mode, the following procedure is recommended for the controller:

1. Change to a microstep resolution value which is available in the actual and in the new mode.
2. After minimum 0.5ms, change the wave mode to the new setting and switch the resolution to give the same microstep resolution in the new mode as before
3. After minimum "resolution" steps, the wave mode becomes changed and you may change the resolution again any time. During phase 3, the motor should not move faster than with a microstep rate of about 3kHz, so that the processor does not miss the first possible switching point.

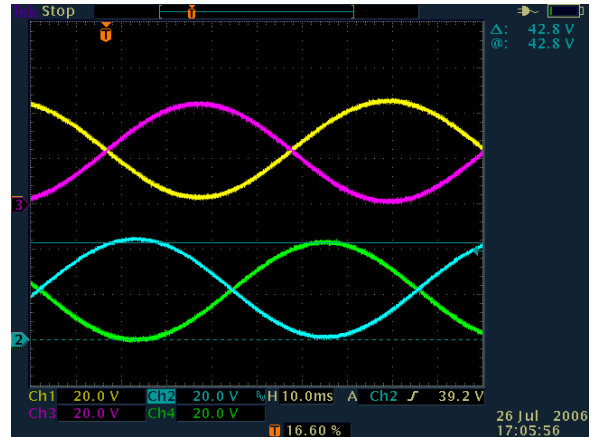
6.5.3.1 Waveform examples

The following scope screen shots show examples of the motor control patterns.

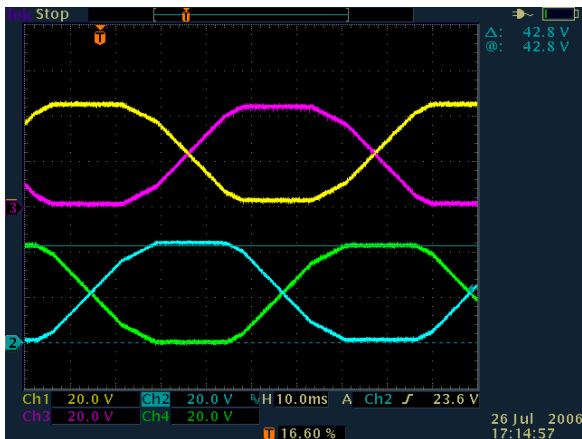
Waveform: Omega564, microstep resolution: 2048



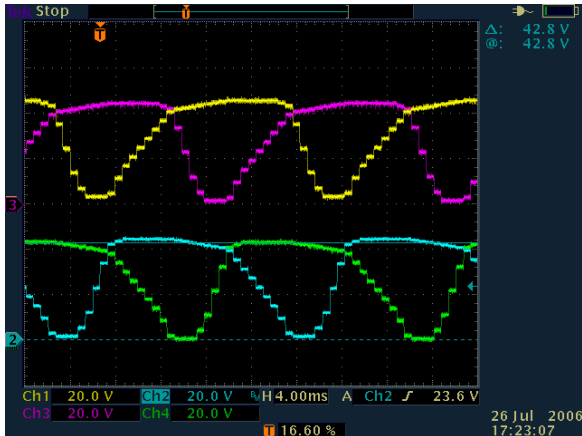
Waveform: sine1s85, microstep resolution:256



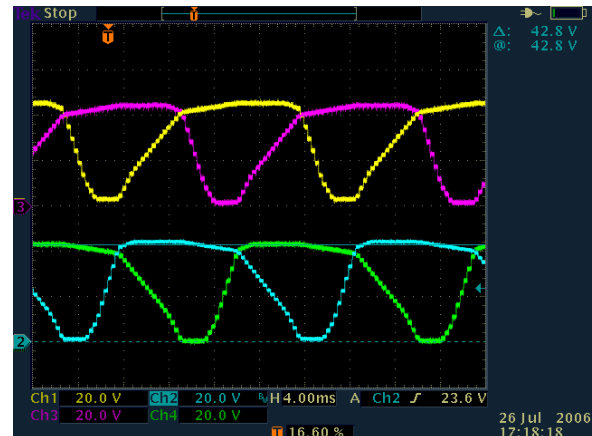
Waveform: Rhomb, microstep resolution: 256



Waveform: Rhomb F, microstep resolution: 32



Waveform: Rhomb F, microstep resolution: 64



6.5.4 Baseboard BB-035 for easy adaptation

The baseboard BB-035 was designed for the stepper motor driver module TMCM-035. Nonetheless, since the TMCM-090 is pin compatible it is the perfect solution for an easy adaptation of the TMCM-090 in step/direction mode. Power supply, step / direction input and motor are connected via screw terminals.

Jumpers INAB should be open and the mode selection pin MODE2 can be set high for step / direction by the jumper u64. The +5V supply voltage is provided by the baseboard, so only the motor supply voltage is needed, step / direction signals are connected to the STEP/DIR IN connector by screw connectors. Inverted inputs are also provided. The microstep resolution and waveform settings can be done by the jumpers labeled SDE (Mode0), S16 (Mode1), UMD (RES1) and ANN (RES0). SPE shall not be used. See Table 6.5 and Table 6.4. For more details refer to the [BB-035] Manual.

Pin	Number	BB-035 jumper
MODE0	22	SDE
MODE1	24	S16
RES0	25	ANN
RES1	26	UMD
MODE2	27	u64

Table 6.5: Resolution and waveform settings with BB-035

6.5.5 TMCM-090 in conjunction with TMCM-302

The Step / Direction interface can be used to connect the TMCM-090 module to a [TMCM-302] module:

TMCM-090 pin number	TMCM-302 pin number	Signal name (TMCM-090)
1, 3	1, 3	+5V
2, 4, 6, 8, 10	2, 4, 6, 8, 10	GND
27	--	MODE2, set high
18	31	STEP
20	33	DIR

Table 6.6: Connecting a TMCM-090 to a TMCM-302 (step / direction)

7 Revision history

7.1 Documentation revision

Version	Comment	Description
0.95	Initial Release	
1.00	Module 1.1	Updated initial version for Module V1.1
1.01	Revision	
1.02	Update	Added BB-035 information for step / direction
1.03	Added	Added firmware V1.2 information, Added 2.0mm pitch connector info
1.04	Pin 11	Pin 11 corrected, minor changes
1.05	Dimensions	Figure of dimensions corrected (2011-SEP-13)

Table 7.1: Documentation revisions

7.2 Firmware revision

Version	Comment	Description
0.95	Initial Release	
1.1	1.Jul.06	Initial V1.1 release.
1.2	27. Sep. 06	Improved microstep update rate (from 10kHz to 37kHz), microstep rate up to 384kHz, synchronous change between waveforms / resolutions

Table 7.2: Firmware revisions

8 References

[TMCL]	TMCL manual (see http://www.trinamic.com)
[TMC-301]	TMC-301 manual (see http://www.trinamic.com)
[TMC-302]	TMC-302 manual (see http://www.trinamic.com)
[BB-035]	BB-035 manual (see http://www.trinamic.com)
[BB-301]	BB-301 manual (see http://www.trinamic.com)