TMC428 – Application Note

Parallel Stepper Motor Drivers LMD18245 on TMC428

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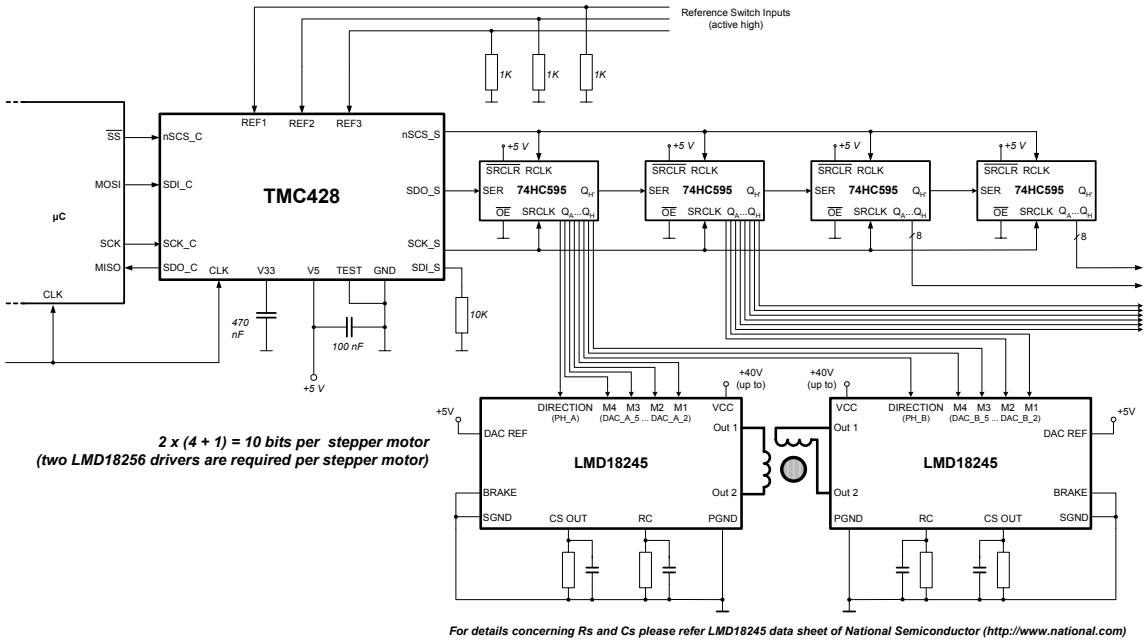
The TMC428 is a miniaturized stepper motor controller with two synchronous serial 4-wire interfaces (Serial Periphery Interface, SPI™ is Trademark of Motorola, Inc.), controlling up to three 2-phase stepper motors. Although, the TMC428 is designed to control integrated stepper motor drivers with serial interface (e.g. TMC235, TMC288, TMC289), it is simple to use traditional stepper motor drivers without SPI as the LMD18245 from National Semiconductor together with the TMC428. Two LMD18245 are required to drive one stepper motor.



2 x (4 + 1) = 10 bits per stepper motor
(two LMD18256 drivers are required per stepper motor)

For details concerning Rs and Cs please refer LMD18245 data sheet of National Semiconductor (http://www.national.com)

Two chained 74HC595 are sufficient to form the SPI interface as required to control two LMD18245 by the TMC428. The 74HC595 contains an 8 bit shift register together with an 8 bit buffer register. The TMC428 synchronously shifts stepper motor control bits (called ***primary signals*** within the TMC428 data sheet) into the shift registers of the 74HC595. After all control bits are transferred the content of the shift register is copied into the buffer register of the 74HC595. The content of the buffer registers is available in parallel. The ***primary signals*** of the TMC428 enfold signals to control the phase current polarity, the DAC current amplitude, fast decay option, a constant 0 and a constant 1 signal, and a step and direction signal is available.

The TMC428 automatically updates the buffer register by sending an SPI datagram if necessary. So, the content of the buffer register of the 74HC595 is always up to date. For micro stepping two 4 bit digital-to-analog-converters (DACs) are integrated within the LMD18245 for current control.

Once initialized, the TMC428 generates all signals necessary to control up to three 2-phase stepper motors including velocity profiles. Simply writing a target position into the register associated to on stepper motor, causes the TMC428 to move the stepper motor to that target position automatically taking motion parameter limits into account. Similar, a target velocity can be defined.

The control signals (***primary signals***) generated by the TMC428 are internally available in parallel. These control signals have to be available in parallel for the stepper motor driver. So, just the transmission of the stepper motor control signals from TMC428 to the driver logic is serial. The datagram configuration defines the order of the signals. Each ***primary signal*** of the TMC428 has its mnemonic and code. The sending order of ***primary signals*** is defined by the order of ***primary signals codes*** stored within the stepper motor driver datagram configuration RAM area (for details please refer the TMC428 data sheet). The order of control signals is individually programmable for each stepper motor driver. In case of this application note only one stepper motor is driven.

The schematic shows the connections from the parallel outputs Qa, ..., Qh of the two 74HC595 to the digital control inputs DIRECTION, M4, M3, M2, M1, DIRECTION, M4, M3 and M2, M1 of the two LMD18245. So, the serial stepper motor driver interface of the TMC428 has to be configured that the primary signals map to the parallel outputs Qa, ..., Qh of the two 74HC595 which are mapped to the control signals of the two LMD18245. Within the following table, indices 1 an 2 are used to distinguish the outputs of the two 74HC595 and the inputs of the two LMD18245.

The following table summarizes the mapping required:

74HC595	***LMD18245***	***TMC428***	
		primary signals	***primary codes***
Qa_1	DIRECTION	PH_A	***$06***
Qb_1	M4	DAC_A_5 (MSB)	***$05***
Qc_1	M3	DAC_A_4	***$04***
Qd_1	M2	DAC_A_3	***$03***
Qe_1	M1	DAC_A_2	***$02***
Qf_1	DIRECTION	PH_B	***$0E***
Qg_1	M4	DAC_B_5 (MSB)	***$0D***
Qh_1	M3	DAC_B_4	***$0C***
Qh_1‘ Ser_2	***serial shift register output connected to serial shift register input of the 2nd 74HC595***		
Qa_2	M2	DAC_B_3	***$0B***
Qb_2	M1	DAC_B_2	***$0A***
Qc_2	***n.c.***		
Qd_2	***n.c.***		
Qe_2	***n.c.***		
Qf_2	***n.c.***		
Qg_2	***n.c.***		
Qh_2	***n.c.***		
Qh_2‘	serial shift register output for connection of additional 74HC595		

The corresponding RAM configuration of the TMC428 is:

```
0A,0B,0C,0D,0E,02,03,04,05,26,00,00,00,00,00,00
00,00,00,00,00,00,00,00,00,00,00,00,00,00,00,00
00,00,00,00,00,00,00,00,00,00,00,00,00,00,00,00
00,00,00,00,00,00,00,00,00,00,00,00,00,00,00,00
00,01,03,04,06,07,09,0A,0C,0E,0F,11,12,14,15,17
18,19,1B,1C,1E,1F,20,22,23,24,26,27,28,29,2A,2C
2D,2E,2F,30,31,32,33,34,35,36,36,37,38,39,39,3A
3B,3B,3C,3C,3D,3D,3E,3E,3E,3F,3F,3F,3F,3F,3F,3F
```

Here, the upper 64 hexadecimal data words represent the configuration of the serial driver interface of the TMC428. The order of the primary signal codes (`$0A,$0B,$0C,$0D,$0E,$02,$03,$04,$05,`**`$26`**) represents the order how the primary signals (***DAC_B_2, DAC_B_3, DAC_B_4, DAC_B_5, PH_B, DAC_A_2, DAC_A_3, DAC_A_4, DAC_A_5, PH_A)*** are serially transferred to the 74HC595 shift register. These control signals are available at the parallel outputs (Qa_1, Qb_1, Qc_1, Qd_1, Qe_1, Qf_1, Qg_1, Qh_1, Qa_2, Qb_2) of the 74HC595. The value **`$26`** (= **`$20`** + **`$06`**) instead of **`$06`** results from the so called NxM bit (***Ne**x*t ***M***otor bit) which terminates a logical datagram block associated to one stepper motor driver. A datagram transmission is complete if the control signals for all stepper motor drivers are sent. This is controlled by

a TMC428 parameter called LSMD (last stepper motor driver). The parameter LSMD has to be set 0 here for one stepper motor driver (please refer the TMC428 data sheet for details).

To transfer these 10 primary signal codes (`$0A, $0B, $0C, $0D, $0E, $02, $03, $04, $05, **$26**`) into the stepper motor driver configuration RAM area the micro controller has to sent 5 data 32 bit wide datagrams to TMC428. This is because two successive configuration RAM cells are commonly accessed. The datagrams to initialize the micro step look-up table (LUT) are described in detail within the TMC428 data sheet. The 5 datagrams for the serial stepper motor driver interface configuration are:

```
$ 80 00 0B 0A
$ 82 00 0D 0C
$ 84 00 02 0E
$ 86 00 04 03
$ 88 00 26 05
```

By chaining up to four 74HC595 one could control up to three LMD18245 stepper motor drivers. A combination with SPI™ stepper motor drivers (e.g. TMC235, TMC288, TMC289) is also possible.
The reference switch inputs REF1, REF2, REF3 are high active. So, with pull-up resistors, the reference switches have to be opening-switches. With pull-down resistors, the reference switches have to be closing-switches. The switches can be configured as automatic stop-switches (for details see TMC428 data sheet).

Literature

- 74HC595 – Data Sheet, Texas Instruments,
  (on-line **http://www.ti.com/**)
- LMD18245 – Data Sheet, National Semiconductor,
  (on-line **http://www.national.com/**)
- TMC428 – Data Sheet (v. 1.02 / November 22, 2001), TRINAMIC Microchips GmbH,
  (on-line **http://www.trinamic.com/**)

Revision History

Version	Date	Comment
1.00	March 19, 2002	First complete version published in printed form
1.00	October 1st, 2004	Changes concerning new company TRINAMIC Motion Control GmbH & Co. KG

Please refer to** www.trinamic.com **for updated data sheets and application notes.

***The TMCtechLIB CD-ROM including data sheets, application notes, schematics of evaluation boards, software of evaluation boards, source code examples, parameter calculation spreadsheets, tools, and more is available from TRINAMIC Microchips GmbH by request to** info@trinamic.com*

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