TMC 423 – Datasheet
Serial Triple Incremental Encoder Interface


TMC423
TQFP-100 Package

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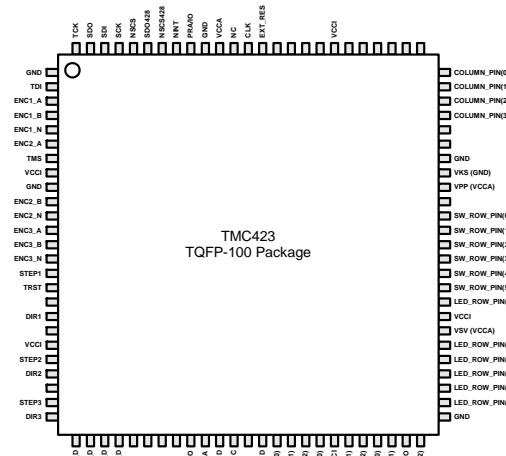
TMC423 Main Features

The TMC423 is a triple incremental encoder input chip, which interfaces to any SPI[TM] compatible controller. The TMC423 can especially be used in conjunction with the TMC428 triple stepper motor controller to provide position verification or stabilization using some additional software. It integrates 24 bit counters for each encoder to provide a high position resolution without CPU interaction. Further it allows dynamic resolution adaptation to allow direct comparison of encoder counters with motors using different micro step resolution. All encoder counters can be latched synchronously, or whenever a null channel event occurs, providing a position on strobe holding function. The TMC423 also provides a step / direction output with programmable signal shaping for the TMC428 as an optional function. A multiplexor function is also integrated for the TMC428 reference switches. Furthermore control and drive of a LED and switch matrix is implemented. All functions can also be used in conjunction.

Applications

- Stepper Motor Position Verification
- Position Maintenance
- Incremental Encoder Interface Readout
- Step / Direction conversion for TMC428 systems
- Control of LED 6 x 4 Matrix and Switch 6 x 4 Matrix

Features

- Supports 2 and 3 channel incremental encoders with a wide range of resolutions
- Allows step / direction signal extraction from TMC428 output data stream
- Programmable pulse shaping for step / direction interface
- 24 bit integrated position resolution
- Programmable prescaler for Incremental Encoder Interface
- 4-times evaluation of encoder signals
- Fast 32 bit SPI[TM] interface
- Can share SPI[TM] interface with TMC428 and supplies separate interrupt output
- Integrates Reference Switch Multiplexors
- Package: TQ100

Note: SPI is Trademark of Motorola, Inc.

Revision History

Version	Comment	Date	Name
Initial Version		November 22, 2002	Technical Department
0.4	Corrected Array Switching Frequency	January 23, 2003	Technical Department
0.5	First Customer Release	January 24, 2003	Technical Department
0.6	Minor corrections	March 11, 2003	Technical Department
0.6	Changes concerning new company TRINAMIC Motion	October 1st, 2004	Technical Department
0.7	Corrected Pinning: Position of CLK pin	December, 15th, 2004	Technical Department
1.0	Corrected Reset input in diagram, added supply spec	March, 15th, 2005	Technical Department

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1 <u>Pinout</u>

Figure 1: Pinout TMC423

1.1 Pin Description

Pin	Location	Dir	Description
GND	1, 9, 36, 51, 68, 69, 91	In	Ground
ENC1_A	3	In	Incremental Encoder Interface 1 Channel A
ENC1_B	4	In	Incremental Encoder Interface 1 Channel B
ENC1_N	5	In	Incremental Encoder Interface 1 Channel N (Connect to +5V if not used)
ENC2_A	6	In	Incremental Encoder Interface 2 Channel A
ENC2_B	10	In	Incremental Encoder Interface 2 Channel B
ENC2_N	11	In	Incremental Encoder Interface 2 Channel N (Connect to +5V if not used)
ENC3_A	12	In	Incremental Encoder Interface 3 Channel A
ENC3_B	13	In	Incremental Encoder Interface 3 Channel B
ENC3_N	14	In	Incremental Encoder Interface 3 Channel N (Connect to +5V if not used)
TDI	2		Connect to Ground
TMS	7		Connect to 5 Volt via Pull-Up Resistor
TRST	16		Connect to 5 Volt via Pull-Up Resistor
TDO	49		To be left open
TCK	100		Connect to Ground
VCCI	8, 20, 44, 58, 82	In	Positive Power Supply 5 Volt
VCCA	35, 57, 67, 90	In	Positive Power Supply 2.5 Volt
GND	39	In	Unused input: Connect to Ground
CLK	88	In	System Clock 16MHz
EXT_RES	87	In	External Reset Low Active
NC	37, 89	In	Connect to Ground
PRA / IO	92		To be left open
PRB / IO	34		To be left open
Step 1	15	Out	Step/Direction Interface – Step Output Motor 1
Dir 1	18	Out	Step/Direction Interface – Direction Output Motor 1
Step 2	21	Out	Step/Direction Interface – Step Output Motor 2
Dir 2	22	Out	Step/Direction Interface – Direction Output Motor 2
Step 3	24	Out	Step/Direction Interface – Step Output Motor 3
Dir 3	25	Out	Step/Direction Interface – Direction Output Motor 3
SDO_D	26	Out	Step / Direction SPI MISO
SDI_D	27	In	Step / Direction SPI MOSI
SCK_D	28	In	Step / Direction SPI SCK
NSCS_D	29	In	Step / Direction SPI NSCS
REF0	40	Out	Reference switch output 1
REF1	41	Out	Reference switch output 2
REF2	42	Out	Reference switch output 3
STOPR0	43	In	Right Stop Switch Motor 1
STOPR1	45	In	Right Stop Switch Motor 2
STOPR2	46	In	Right Stop Switch Motor 3
STOPL0	47	In	Left Stop Switch Motor 1
STOPL1	48	In	Left Stop Switch Motor 2
STOPL2	50	In	Left Stop Switch Motor 3
COLUMN_PIN0	75	Out	Column Drive Pin 0
COLUMN_PIN1	74	Out	Column Drive Pin 1
COLUMN_PIN2	73	Out	Column Drive Pin 2
COLUMN_PIN3	72	Out	Column Drive Pin 3
SW_ROW_PIN0	65	In	Switch Matrix Pin 0
SW_ROW_PIN1	64	In	Switch Matrix Pin 1
SW_ROW_PIN2	63	In	Switch Matrix Pin 2
SW_ROW_PIN3	62	In	Switch Matrix Pin 3

SW_ROW_PIN4	61	In	Switch Matrix Pin 4
SW_ROW_PIN5	60	In	Switch Matrix Pin 5
LED_ROW_PIN0	59	Out	LED Matrix Drive Pin 0
LED_ROW_PIN1	56	Out	LED Matrix Drive Pin 1
LED_ROW_PIN2	55	Out	LED Matrix Drive Pin 2
LED_ROW_PIN3	54	Out	LED Matrix Drive Pin 3
LED_ROW_PIN4	53	Out	LED Matrix Drive Pin 4
LED_ROW_PIN5	52	Out	LED Matrix Drive Pin 5
SDO	99	Out	SPI MISO
SDI	98	In	SPI MOSI
SCK	97	In	SPI SCK
NSCS	96	In	SPI NSCS
SDO428	95	In	SPI MISO Pin of TMC428
NSCS428	94	In	SPI NSCS Pin of TMC428
NINT	93	Out	NotInterrupt Output

Table 1: TMC423 Pinout

Note: Pins which are not marked in Figure 1: Pinout TMC423 on page 5 must be left open.

1.2 Recommended Operating Conditions

Parameter	Value	Unit
Clock Frequency [(1)]	16	MHz
Temperature	0 … + 70	°C
2.5 V Power Supply	2.25 … 2.75	V_{CCA}
5.0 V Power Supply	4.50 … 5.50	V_{CCI}

Table 2: Operating Conditions

1 – slower frequencies are also supported. Please take care about the timing information in this datasheet, since they are based on 16MHz Clock Frequency.

1.3 Electrical Characteristics

Parameter	Min	Max	Unit
Supply Current 2.5V		100	mA
Supply Current 5.0V (Output current = 0)		10	mA
LED driver current		20	mA
Input voltage level Low		0.8	V
Input voltage level High	2.4		V

Table 3: Operating Conditions

2 <u>Block Diagram</u>
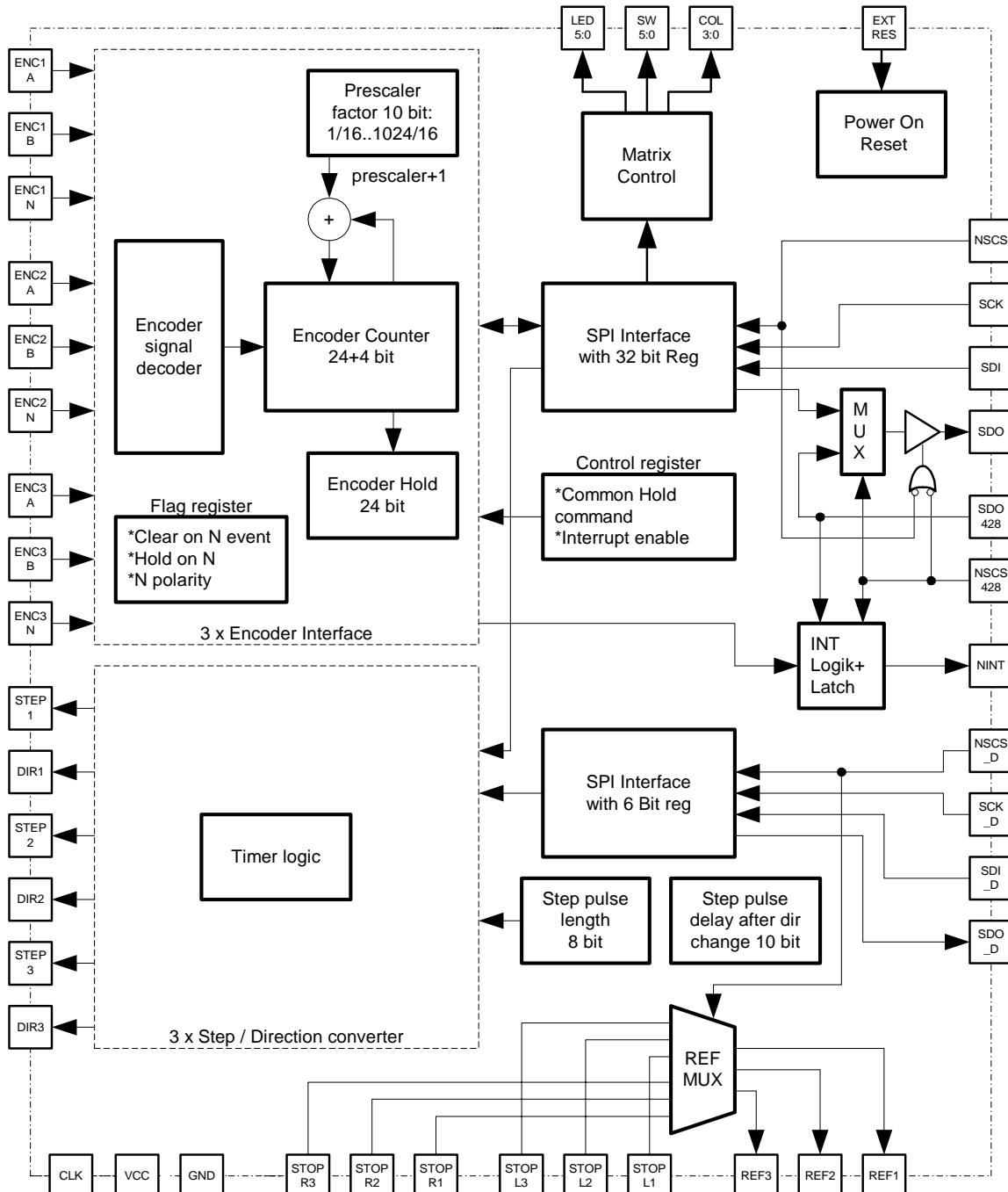
Figure 2: Block diagram of the TMC423

3　Application Environment

TMC423 as Incremental Encoder Interface　　　　　　　**TMC423 as Step / Direction converter and Incremental Encoder Interface**
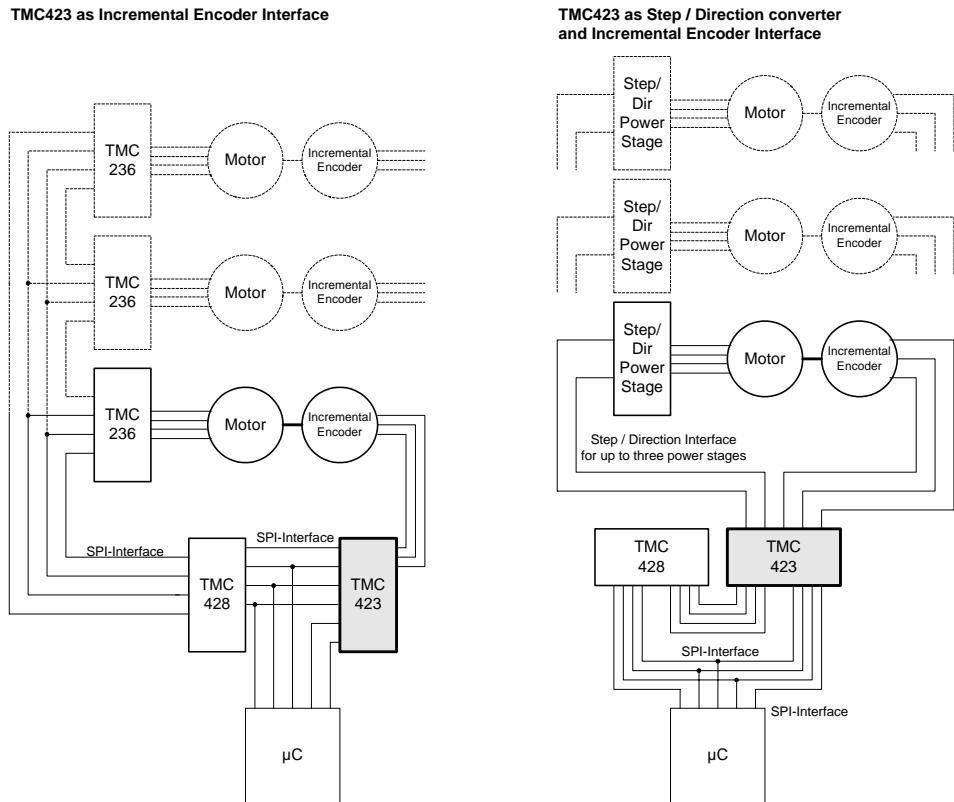
Figure 3: Application Environment

3.1　Application Description

3.1.1　Application with TMC236 Stepper Motor Driver

A complete close-loop motion control system consists of the TMC428 three-axis motion controller, the powerfull TMC236 stepper motor driver and the TMC423 Encoder Interface. The system is controlled by an inexpensive microcontroller.
The main advantage of the system is that time critical communication to the TMC236 driver is performed by the TMC428. The main purpose of the inexpensive microcontroller is to parametrize the TMC428 and TMC423 and to send motion parameters like maximum speed or target position to the TMC428. Position validation is done by reading the actual position of the TMC428 and the TMC423.

3.1.2　Application with Step / Direction Power Stage

Another possibility to built a close loop motion control system is to use the TMC423 as encoder interface and also as a step direction converter. Thereto the TMC423 converts the SPI^{TM} datagrams sent by the TMC428 into parameterizeable step and direction pulses. For parameterizing both the TMC428 and TMC423 have to be connected via SPI^{TM} interface to an inexpensive microcontroller.

4   Dynamic Resolution Adaption

The dynamic resolution adaption is needed to link stepper motors and encoders with different resolutions. The characteristics of the connected hardware must provided to the TMC423 by sending the corresponding SPI telegram. (See 5.3.1 Overview on page 12 in this issue). The TMC423 multiplies the encoder counter by a user selectable value in the range 1..1024, and then divides it by 16. When using incremental encoders with N channel it is also possible to select between different behaviors when the N channel is triggered.

Encoder:
Resolution: e.g.: 1000 steps / rotation

Stepper motor

TMC423

SPI Interface

Stepper Motor:
Resolution: e.g.: 12800 steps / rotation

TMC423:
Prescaler = 3.2 -> 1000* 4 * 3.2 = 12800
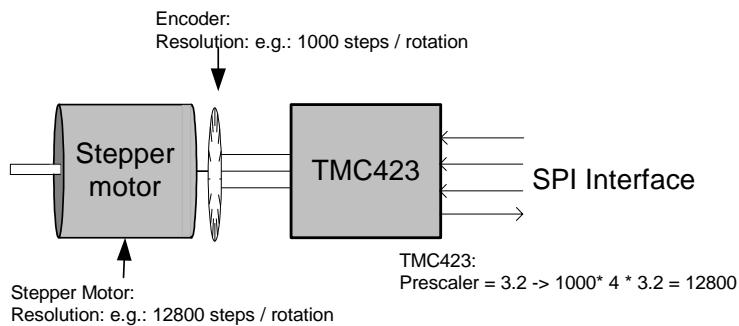
Figure 4: TMC423 Application

Table 4 Prescaler factors for different motors and encoders shows the prescaler factors for possible combinations of micro step resolution and encoder resolution. Note: The given number of pulses have to be multiplied by four since 4-times encoder signal evaluation is used. (See Figure 8: Encoder Output and Evaluation on page 13).

Microsteps	Encoder Resolution [Pulses / Rotation]									
	1024	1000	512	500	256	250	200	125	50	25
12800	3.125	3.2	6.25	6.4	12.5	12.8	16	25.6	64	----
6400	1.5625	1.6	3.125	3.2	6.25	6.4	8	12.8	32	64
3200	----	----	1.5625	1.6	3.125	3.2	4	6.4	16	32
1600	----	----	----	----	1.5625	1.6	2	3.2	8	16
800	----	----	----	----	----	----	1	1.6	4	8
400	----	----	----	----	----	----	----	----	2	4

Table 4: Prescaler factors for different motors and encoders

5   Serial Peripheral Interface (SPI) with 32-bit Register

5.1   Description and Specification

Four pins named nSCS, SCK, SDI and SDO form the serial peripheral interface from a microcontroller to the TMC423. The communication between the microcontroller and the TMC423 takes place via datagrams with a fixed length of 32 bit. The microcontroller acts always as master and the TMC423 as slave.

The SPI^{TM} of the TMC423 behaves like a simple 32-bit shift register. Incoming serial data at pin SDI is shifted with the rising edge of the clock signal SCK into the 32-bit register. The content of this register is copied after 32-bits with the rising edge of the selection signal nSCS into a buffer register of 32-bit length. The SPI^{TM} of the TMC423 sends back data read from registers immediately via the SDO signal. It processes serial data synchronously to the clock signal CLK.

Because of on-the-fly processing of the input data stream, the serial microcontroller interface of the TMC423 requires the serial data clock signal SCK to have a minimum low / high time of three clock cycles. The data signal SDI driven by the microcontroller has to be valid at the rising edge of the serial data clock input SCK. The maximum duration of the serial data clock period is unlimited.

A complete serial datagram frame has a fixed length of 32 bit. While the data transmission from the microcontroller to the TMC423 is idle, the low active serial chip select input nSCS and also the serial data clock signal SCK are set to high. The serial data input SDI of the TMC428 has to be driven by the microcontroller. Like other SPI compatible devices, the SDO signal of the TMC423 is high impedance 'Z' as long as nSCS is high.

The signal nSCS has to be high for at least three clock cycles before starting a datagram transmission. To initiate a transmission, the signal nSCS has to be set to low. Three clock cycles later the serial data clock may go low. The most significant bit (MSB) of a 32 bit wide datagram comes first and the least significant bit (LSB) is transmitted as the last one. A data transmission is finished by setting nSCS high three or more CLK cycles after the last rising SCK slope. nSCS and SCK change in opposite order from low to high at the end of a transmission as these signals change from high to low at the beginning. The timing of the serial microcontroller interface is outlined in Figure 5: Timing diagram of the Serial Interface.
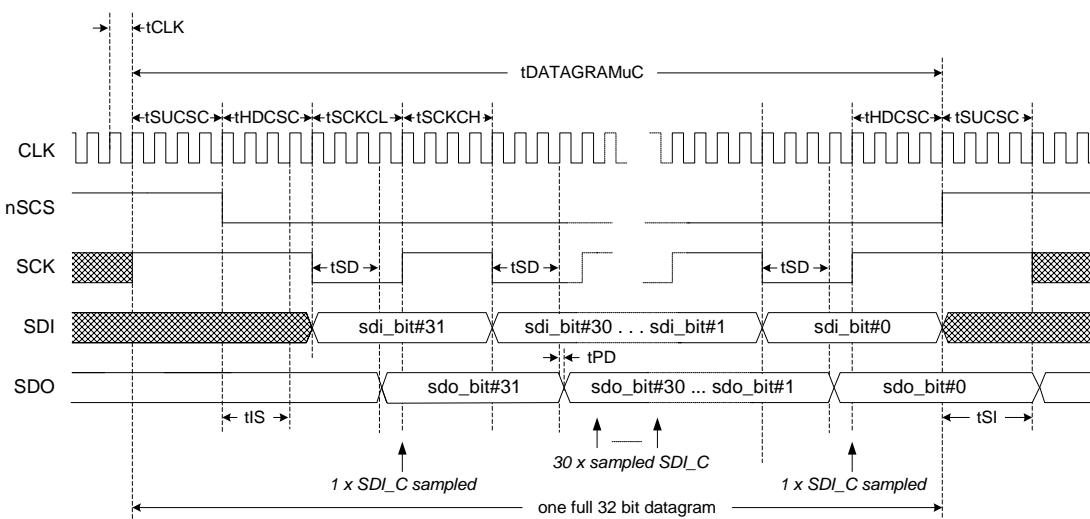

Figure 5: Timing diagram of the Serial Interface

5.2   32-bit SPI Datagram Structure

Datagram from TMC423 send to µC

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
INT				0	0	0	0	Data																							

Datagram send from µC to TMC423

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Address							R/W	Data																							
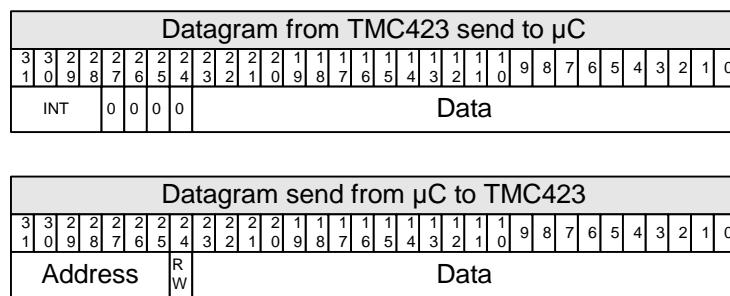
Figure 6: Structure 32-Bit Interface

Interrupt Flags [Bit]	Name	Description
31	INT_ext	external Interrupt, e.g. TMC428
30	INT_enc1	N Signal of Encoder Interface 1 detected
29	INT_enc2	N Signal of Encoder Interface 2 detected
28	INT_enc3	N Signal of Encoder Interface 3 detected

Table 5: Interrupt Flags

5.3   SPI 32-bit Datagram Specification

5.3.1   Overview

Byte #		Byte 3								Byte 2								Byte 1								Byte 0							
Bit #	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
				Address				R/W																								
Control	0	0	0	0	0	0	0	1	Encoder 1 Prescaler								N Polarity	N Hold	N Clear	N Trigger					Direction	Reserved						
	0	0	0	0	0	0	1	1	Encoder 2 Prescaler								N Polarity	N Hold	N Clear	N Trigger					Direction	Reserved						
	0	0	0	0	0	1	0	1	Encoder 3 Prescaler								N Polarity	N Hold	N Clear	N Trigger					Direction	Reserved						
	0	0	0	0	0	1	1	1	Encoder 1, 2, 3 Prescaler - set all commonly								N Polarity	N Hold	N Clear	N Trigger					Direction	Reserved						
Data	0	0	0	0	1	0	0		Encoder 1 Position Register																							
	0	0	0	0	1	0	1		Encoder 2 Position Register																							
	0	0	0	0	1	1	0		Encoder 3 Position Register																							
Step /Dir	0	0	0	0	1	1	1	1	Step Pulse Length								Step Pulse Delay								Reserved							
INT	0	0	0	1	0	0	0	1	Reg Hold	INT EN	Clear Flags	Reserved																				
Matrix	0	0	0	1	0	0	1	0	Switch Row 3				Switch Row 2				Switch Row 1				Switch Row 0											
	0	0	0	1	0	1	0	1	LED Row 3				LED Row 2				LED Row 1				LED Row 0											

Figure 7: Overview TMC423 Registers

6   Incremental Encoder

Incremental Encoders are translating the rotary motion of a shaft into a two-channel digital quadrature output. The light emitted from a LED is focused onto a reflective code wheel. As the shaft moves, the code wheel rotates, reflecting light from an alternating bright and dark pattern.

The TMC423 samples the incoming signals *ENCx_a* and *ENCx_B* from the incremental encoder. A internal algorithm block counts the amount of edges generated by the encoder. A prescaler value can be used to adapt the incremental encoder resolution to the stepper motor resolution.

For high resolution the TMC423 evaluates the encoder signals 4-times during each encoder step. This has to kept in mind when choosing the prescaler value.
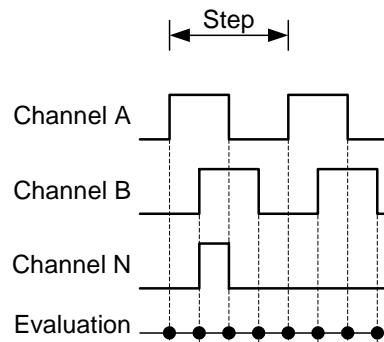

Figure 8: Encoder Output and Evaluation

Note: It is possible that the encoder signals ENCx_A, ENCx_B and ENCx_N are polluted with crosstalk noise. Crosstalk could influence the internal logic, to overcome this problem internal filters are applied to ensure correct functionality. Furthermore is saves the need for external analog filters.
e.g.: Figure 9: Crosstalk on Encoder Wire shows crosstalk from channel A to channel B.
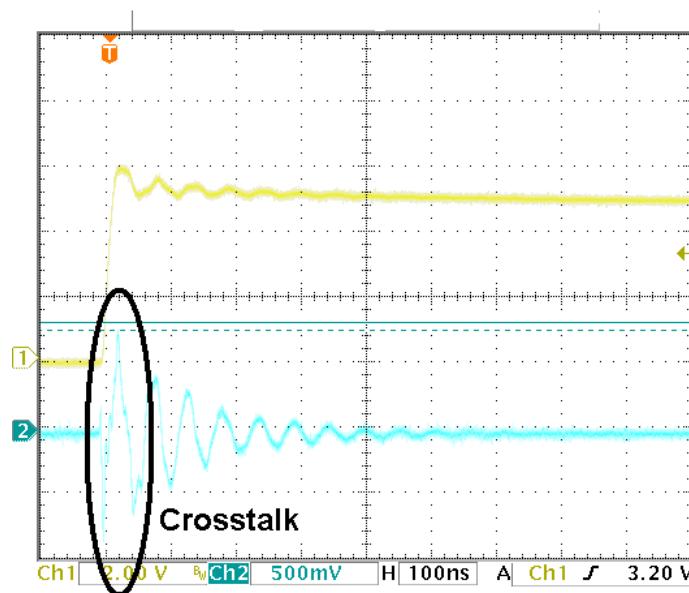
Figure 9: Crosstalk on Encoder Wire

7   Configuration Datagrams

7.1   Encoder Interface Prescaler and Null Event Configuration

The Encoder Interface Initialization datagram is mainly used for the parameterizeable encoder prescaler to adapt the TMC423 for different incremental encoders. Furthermore the TMC423 behavior concerning the N channel can be selected.

Example: A 1000 steps per rotation encoder is to connect at a stepper motor with 12800 microsteps per rotation. When the next event at the high active N channel is found, the position register must set to zero. Only Encoder Interface 1 is connected.
The following datagram performs this task:

- Bits 31 downto 24 have to be set to 01_{HEX} to select encoder interface 1
- The prescaler value has to set to 12800 / (1000*4) = 3.2. Therefore bits 23 downto 12 must set to 831_{HEX}.
- The N channel is set up correctly when bits 11 downto 0 are set to $A0_{HEX}$.

Bit	Encoder Interface Initialization
31…28	"0000" Register Address
27…25	Interface Selection 000 = Interface 1 001 = Interface 2 010 = Interface 3 011 = Interface 1, 2 and 3
24	'1'
23…12	External Encoder Resolution and Corresponding Prescaler Factor Encoder: 1024 $(032)_h$ for 12800 micro steps (prescaler 3.125) $(019)_h$ for 6400 micro steps (prescaler 1.5625) Encoder: 1000 $(831)_h$ for 12800 micro steps (prescaler 3.2) $(813)_h$ for 6400 micro steps (prescaler 1.6) Encoder: 512 $(064)_h$ for 12800 micro steps (prescaler 6.25) $(032)_h$ for 6400 micro steps (prescaler 3.125) $(019)_h$ for 3200 micro steps (prescaler 1.5625) Encoder: 500 $(862)_h$ for 12800 micro steps (prescaler 6.4) $(831)_h$ for 6400 micro steps (prescaler 3.2) $(813)_h$ for 3200 micro steps (prescaler 1.6) Encoder: 256 $(0C8)_h$ for 12800 micro steps (prescaler 12.5) $(064)_h$ for 6400 micro steps (prescaler 6.25) $(032)_h$ for 3200 micro steps (prescaler 3.125) $(019)_h$ for 1600 micro steps (prescaler 1.5625) Encoder: 250 $(8C4)_h$ for 12800 micro steps (prescaler 12.8) $(862)_h$ for 6400 micro steps (prescaler 6.4) $(831)_h$ for 3200 micro steps (prescaler 3.2) $(813)_h$ for 1600 micro steps (prescaler 1.6) Encoder: 200 $(100)_h$ for 12800 micro steps (prescaler 16) $(080)_h$ for 6400 micro steps (prescaler 8) $(040)_h$ for 3200 micro steps (prescaler 4) $(020)_h$ for 1600 micro steps (prescaler 2)

	(010)$_h$ for 800 micro steps (prescaler 1) Encoder: 125 (993)$_h$ for 12800 micro steps (prescaler 25.6) (8C4)$_h$ for 6400 micro steps (prescaler 12.8) (862)$_h$ for 3200 micro steps (prescaler 6.4) (831)$_h$ for 1600 micro steps (prescaler 3.2) (813)$_h$ for 800 micro steps (prescaler 1.6) Encoder: 50 (400)$_h$ for 12800 micro steps (prescaler 64) (200)$_h$ for 6400 micro steps (prescaler 32) (100)$_h$ for 3200 micro steps (prescaler 16) (080)$_h$ for 1600 micro steps (prescaler 8) (040)$_h$ for 800 micro steps (prescaler 4) (020)$_h$ for 400 micro steps (prescaler 2) Encoder: 25 (400)$_h$ for 6400 micro steps (prescaler 64) (200)$_h$ for 3200 micro steps (prescaler 32) (100)$_h$ for 1600 micro steps (prescaler 16) (080)$_h$ for 800 micro steps (prescaler 8) (040)$_h$ for 400 micro steps (prescaler 4) (020)$_h$ for 200 micro steps (prescaler 2) (010)$_h$ for 100 micro steps (prescaler 1) (default value after PON)
11	N Polarity for Selected Interface (can be ignored if not used) 0 = active low (default) 1 = active high
10	Hold on N for Selected Interface (can be ignored if not used) 0 = no hold (default) 1 = active
9	Clear on N Event for Selected Interface (can be ignored if not used) 0 = no clear (default) 1 = active
8	N Trigger Selection (can be ignored if not used) 0 = only at next N signal (default) 1 = always at N signal
7	add or sub register for each step (CW = looking onto the axis) 0= add for CW, sub for CCW (default) 1= add for CCW, sub for CW
6…0	Reserved

Table 6: SPI Datagram Prescaler

7.2 Encoder Interface Hold Register Operation

To read the actual contents of the position register to preset the position register the following command is to be used:

Bit	Encoder Interface Control (Read/Preload Encoder Hold Register)
31…28	"0000" Register Address
27…25	Select Encoder Hold Register 100 = Hold register in encoder interface 1 101 = Hold register in encoder interface 2 110 = Hold register in encoder interface 3
24	Read or Preload Selection 0 = Read encoder hold register 1 = Preload encoder hold register
23…0	Encoder Hold Register Data

Table 7: SPI Datagram Hold Register

7.3 Timer Logic Step Pulse Length and Delay

To parameterize the step length and delay the next datagram is to be used:

Bit	Write Step Pulse Length / Delay
31…25	"0000111" Register Address
24	'1'
23…16	Step Pulse Length (default value = 48$_{(10)}$ after PON)
15…6	Step Pulse Delay after Direction Change (default value = 160$_{(10)}$ after PON)
5…0	Reserved

Table 8: SPI DatagramTimer logic

7.4 Control Register and Interrupt Control

This datagram configures the interrupt control of the TMC423. When enable the N channel pulse is fed to the NINT pin.

Bit	Control Register
31…25	"0001000" Register Address
24	'1'
23	Set Common Hold for Encoder Hold Registers 0 = no hold (default) 1 = freeze encoder hold registers
22	Encoder Interrupt Enable, if Null signal 0 = interrupt disable (default) 1 = interrupt enable
21	Clear Interrupt Flags 0 = no clear (default) 1= clear flags
20…0	Reserved

Table 9: SPI Datagram Control Register

7.5 Switch Matrix Read

Bit	Control Register
31…25	"0001001" Register Address
24	'0'
23…18	Switch Matrix Register Row 3
17…12	Switch Matrix Register Row 2
11…6	Switch Matrix Register Row 1
5…0	Switch Matrix Register Row 0

Table 10: Switch Matrix Read

7.6 LED Matrix Write

Bit	Control Register
31…25	"0001010" Register Address
24	'1'
23…18	LED Matrix Register Row 3
17…12	LED Matrix Register Row 2
11…6	LED Matrix Register Row 1
5…0	LED Matrix Register Row 0

Table 11: LED Matrix Write

8 SPI-Protocol for Interface with 6-bit Register

The 6-bit SPI Interface is used to receive step / direction information from the TMC428. The TMC423 processes the data and issues the corresponding step / direction signals via the step / direction pins. Bit0 (Pulse 1) have to be sent first to the TMC423.

Bit	Step / Direction Converter
0	Pulse 1
1	Direction 1
2	Pulse 2
3	Direction 2
4	Pulse 3
5	Direction 3

Table 12: SPI Datagram Step / Direction Converter

8.1 Step and Direction Pulse conversion

Step pulses can be modified in their pulse width and delayed after an direction change was done. The corresponding datagram (See 7.3) on page 16) is used to parameterize the Step / Dir interface.
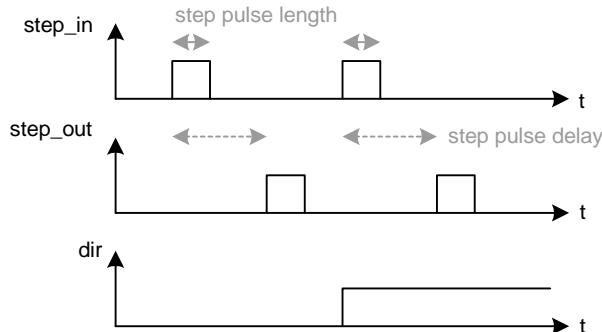

Figure 10: Step Direction conversion

9   LED and Switch Matrix

The TMC423 can be used to drive a LED matrix or to get information from a switch matrix, whether the switches are on or off. LEDs or switches are only active when the corresponding column is selected by setting it to zero. The switch frequency of the column pins is fixed to 500 Hz. The LEDs are driven with a maximum current of 20mA.

The following Table 13: TMC423 LED Matrix Pins shows how the LED Matrix Write register is mapped to the corresponding TMC423 pins to drive the LEDs.

TMC423 Pin: COLUMN_PIN [3:0]				TMC423 Pin: LED_ROW_PIN [5:0]					
Bit 3	Bit 2	Bit 1	Bit 0	LED_Matrix_Write [23:0]					
0	1	1	1	23	22	21	20	19	18
1	0	1	1	17	16	15	14	13	12
1	1	0	1	11	10	9	8	7	6
1	1	1	0	5	4	3	2	1	0

Table 13: TMC423 LED Matrix Pins

For correct external connection of the matrix please refer to the following Figure 11: Connection to the matrix. If distortions causes by long PCB traces are to expect, then filter capacitors C_{filter} of 100pF have to be added.
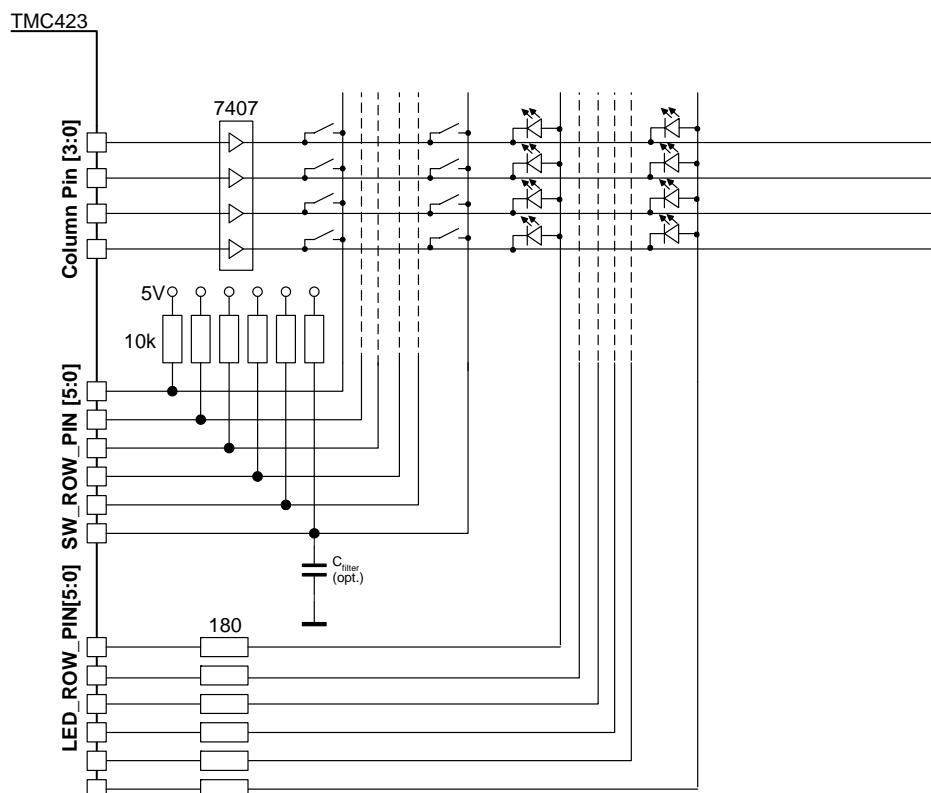

Figure 11: Connection to the matrix

10 Package dimensions
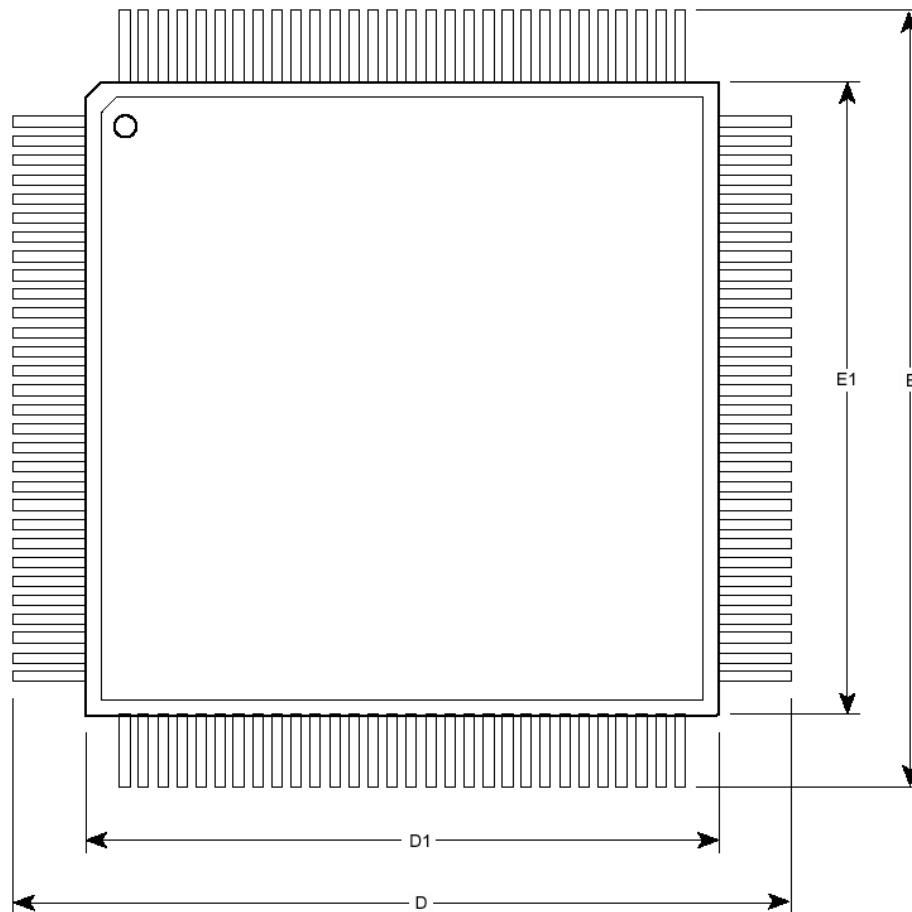

Figure 12: 100-Pin TQFP Top View
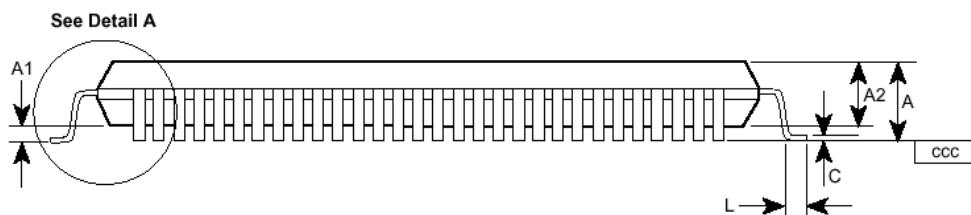
Figure 13: 100-Pin TQFP Side View
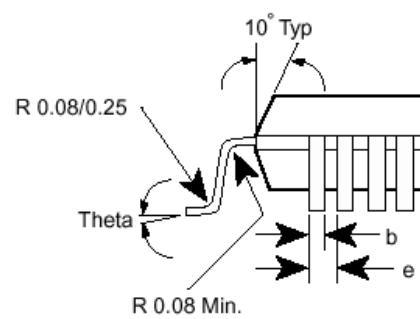

Figure 14: 100-Pin TQFP Side View Detail A

JEDEC Equivalent	TQFP100 MS-026 VAR BED		
Dimension	Min	Nom	Max
A			1.60
A1	0.05		0.15
A2	1.35	1.40	1.45
b	0.17	0.22	0.27
c	0.09		0.20
D/E		16.00 BSC	
D1/E1		14.00 BSC	
e	0.50 BSC		
L	0.45	0.60	0.75
ccc	0.08		
Theta	0	3.50 deg	7 deg

Table 14: TQFP Dimensions

Notes :
- all dimensions are in millimeters
- BSC Basic Spacing between Centers

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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