Product Guide 2018

Integrated Circuits

We transform
digital information
into **physical motion**

TRINAMIC
MOTION CONTROL

About Us

Decades of experience embodied in dependable building blocks.

Trinamic is the global leader in embedded motor and motion control. Our ICs and microsystems connect the digital and physical worlds. Our engineers are experts in solving real world problems, their decades of experience are embodied in each of our products. Trinamic is synonymous with precision, reliability and efficiency.

Amplify your product with Trinamic technologies

"Electric motors are such an essential part of everyday life that consumption of these devices has continued to rise in recent years. The growing expanse of the middle class, coupled with increases in household automation and the number of electric motor-driven products around the home, are major drivers of growth."

Bryan Turnbough, analyst with IHS.
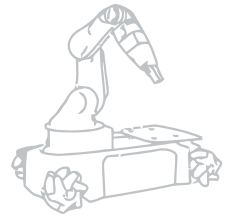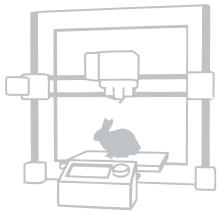
The trend towards automating all aspects of the human environment has resulted in an explosion in the deployment of controlled motion systems. Product developers must deal with increasingly complex systems and can no longer be experts in all aspects of the underlying technology. Trinamic addresses this issue through an API-based approach that reduces time to market, saves money and ultimately delivers better products with superior performance.

Trinamic is an established player with a range of products serving multiple markets. These include laboratory and factory automation, semiconductor manufacturing, textiles, robotics, ATMs and vending machines – wherever reliable positioning is required.

Our latest products set the performance standard for high-growth, emerging markets like 3D printing, medical pumps and liquid handling.

Why do the most forward-thinking companies on the planet repeatedly choose Trinamic?

Of course some choose us because of superior product features. However, the majority of our customers select us because our sole focus on motion control provides access to deep application knowledge and enables our customers to innovate faster in their specific areas.

Innovation made by Trinamic

Trinamic is an innovative company with over 20 years of experiences in design and marketing of motion control chips, modules, and mechatronic drives.

Within its history, Trinamic engineers have been granted many patents including Dual Interface Control, and Automatic Mixed Decay.

Integrated solution with motion controller and driver in a single device. It combines a flexible hardware ramp generator for automatic target positioning with the industries most advanced stepper motor driver.

cDriver™

High integration, high energy efficiency and a small form factor enable miniaturized and scalable systems for cost effective solutions. The complete solution reduces the learning curve to a minimum while giving best-in-class performance.

A sensorless load measurement for stepper motors. It gives cost effective realtime feedback on the load angle. It is the world's first sensorless load detection implemented in a standard stepper motor driver.

StallGuard™

StallGuard™ eliminates the need for reference or end switches. This reduces cost and complexity of applications, where a precise referencing is required. The high resolution feedback of StallGuard2™ allows for a continuous condition monitoring of the system.

CoolStep™ sensorless load-dependent current control using the StallGuard2™ load values. It always drives the motors at their optimum current and therefore enables to drive the motors in an energy-efficient way.

CoolStep™

Without the need for any sensors, coolStep™ eliminates the security current margin, boosts the motor, avoids stall and step loss to improve the reliability of the entire system.

StealthChop™ delivers exceptionally quiet stepper motor performance. Motors operating at low speed exhibit a phenomenon known as magnetostriction, which causes an audible high pitch noise.

StealthChop™

Based on the current feedback, the chip regulates the voltage modulation to minimize current fluctuation. StealthChop™ applications have achieved noise levels of 10dB and more below classical current control.

Using SpreadCycle™ the microstep current sinewave is always well formed with a smooth zero crossing. Drivers with SpreadCycle eliminate the spike in the current waveform caused by the motors back EMF.

SpreadCycle™

Stepper motors can be driven very fast without resonance effects. This reduces vibrations and improves the efficiency, as no energy is fed to the resonances.

The SixPoint™ ramping profile allows for faster positioning by adding a free configurable start/ stop frequency to a linear motion profile plus adding a reduced acceleration value at high velocity.

SixPoint™

SixPoint™ reduces the jerk at the end of standard acceleration ramp. For high-speed positioning as well as for handling jerk-sensitive goods or objects with extensive inertia, (S-Shaped) ramping profiles might be necessary.

The Trinamic Motion Control Language is a programming language dedicated to motion control. It uses simple commands for positioning and setting all relevant parameters of the motion controller accelerate application development.

TMCL™

Used as a protocol, it is very easy to control actuators with any programming language. It is supported by the TMCL-IDE – a PC based integrated development environment.

Digital technologies are making a dramatic impact on manufacturing. Technologies like 3D printing, CNC-milling and Laser Cutting become mature and accessible. Real-world products can now be manufactured directly from the design software.

Small Motors are ubiquitous!

Both rapid prototyping and digital manufacturing require precise and dependable motion control. With excessive experience in 3D printing and manufacturing Trinamic provides solutions for the manufacturing of the future.
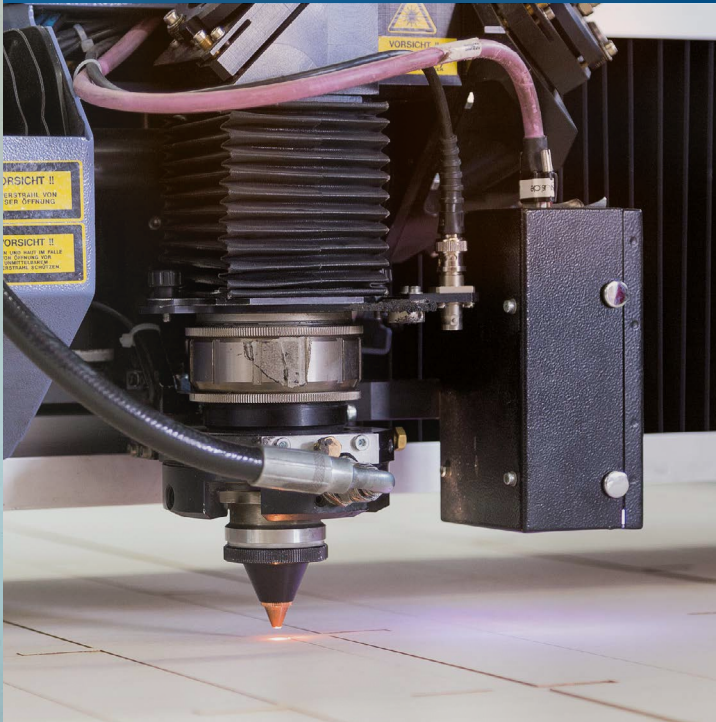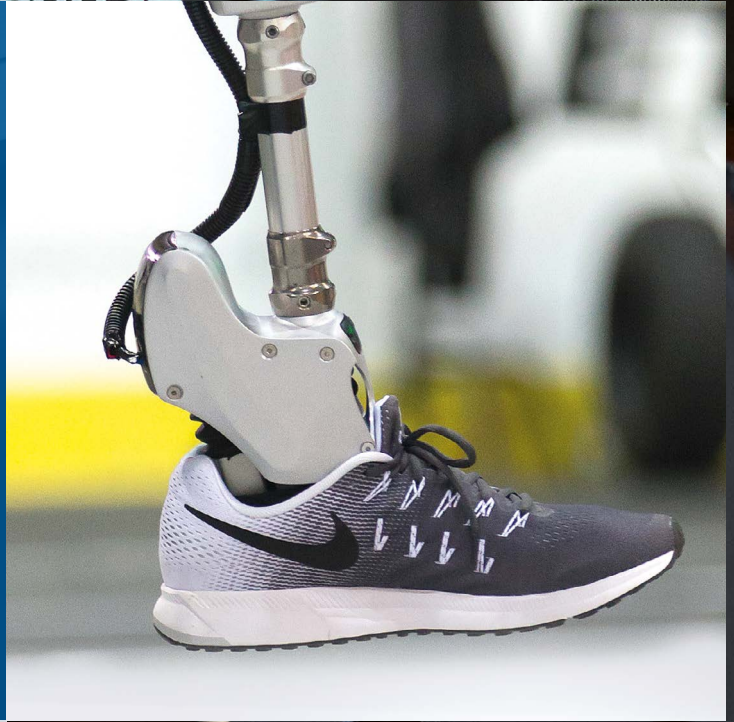
Wherever reliable positioning is required, Trinamic's dependable hardware building blocks form the systems foundation.

What is your Application?

Trinamic's microsystems are suitable for all applications requiring controlled motion. Our products set the performance standard for applications like digital manufacturing, medical devices and laboratory automation.
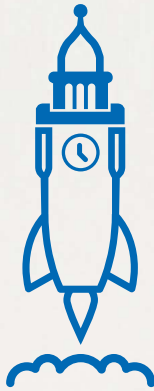
Evaluation Boards

Get started with your design with a Landungsbrücke Evaluation Kit and choose from a variety of motor and motion control evaluation boards.

Landungsbrücke

Whatever your application is, start your design easily using the Landungsbrücke. Test and compare different drive options in your application. Making something new is easier than ever before.
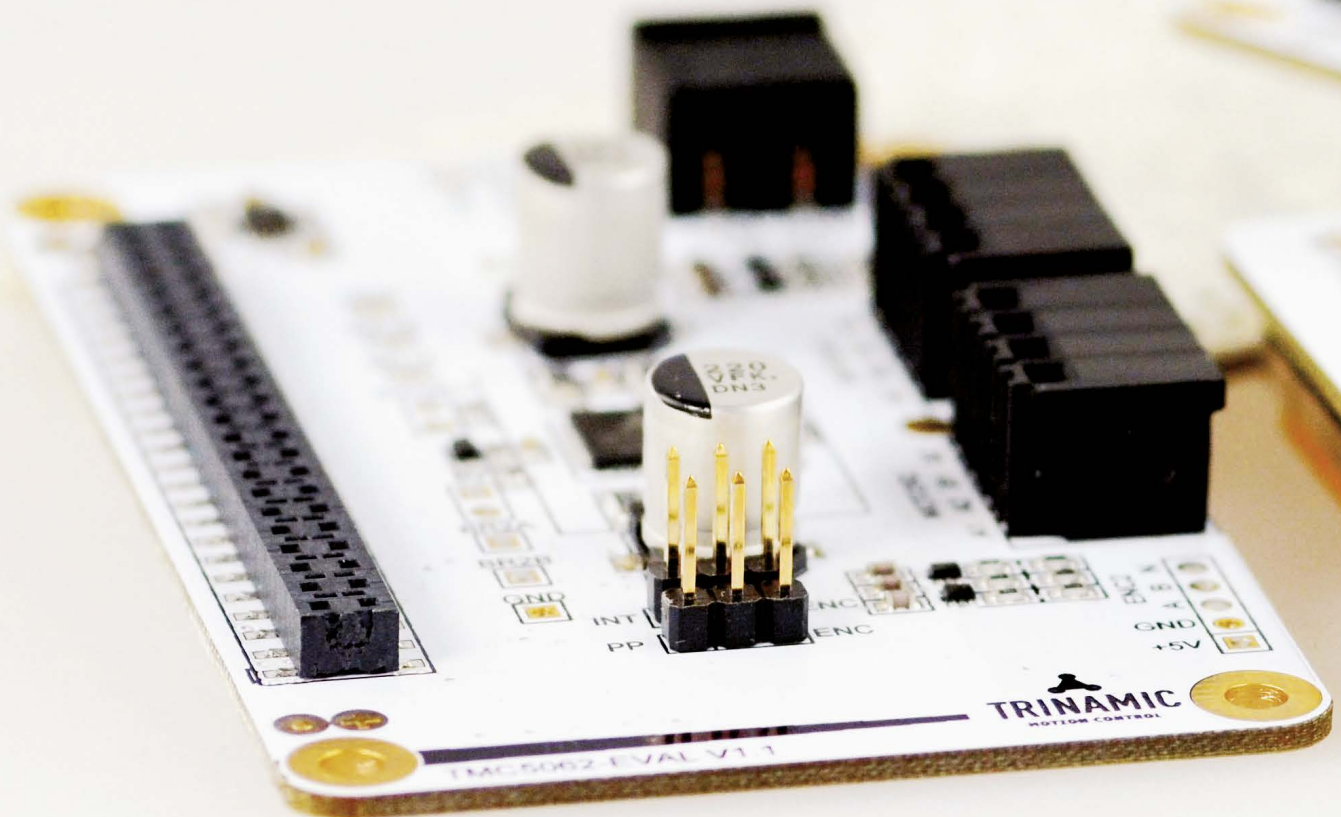
Shorter time to markets require reduced design cycles. With an increased complexity it is important to have dependable, proven building blocks as a foundation for your design.

From Prototype to Production

Rapid technological improvments leads to increasingly complex development. Well-designed ICs with a comprehensive design package including proven reference designs, CAD symbols and sample code build the foundation of your design.

The software is the key bringing hardware to life. All boards from the Landungsbrücke evaluation system are supported by the TMCL-IDE. From a register browser to parameterization assistants the IDE is the tool to get started. Just connect motors and a computer, start the TMCL-IDE and with a few mouse clicks the motor is running.

Software

Regardless of your MCU and programming style a comprehensive API package guides the way to your own firmware. Routines from low level register access to kinematic calculations pave your way to controlled motion.

Open source hardware shares much of the principles and approach of free and open-source software. We believe, that people should be able to study our designs, to understand how they work, make changes to it, and use the designs in own projects.
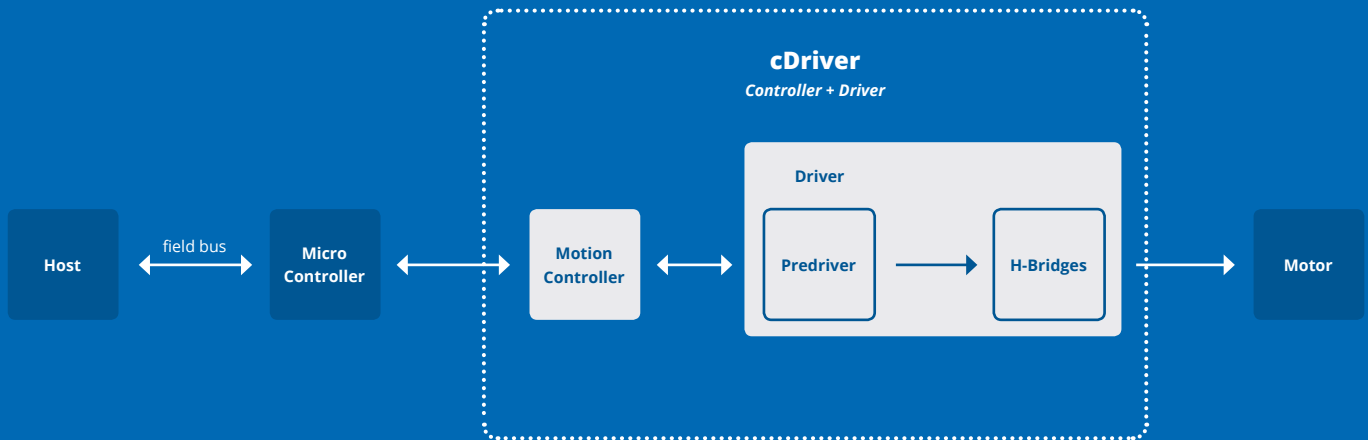
Open Source Hardware

To facilitate this, we release all of the original design files (Eagle CAD) of our evaluation boards. Embedding Trinamic reference design in commercial products does not require you to disclose or open-source your design.
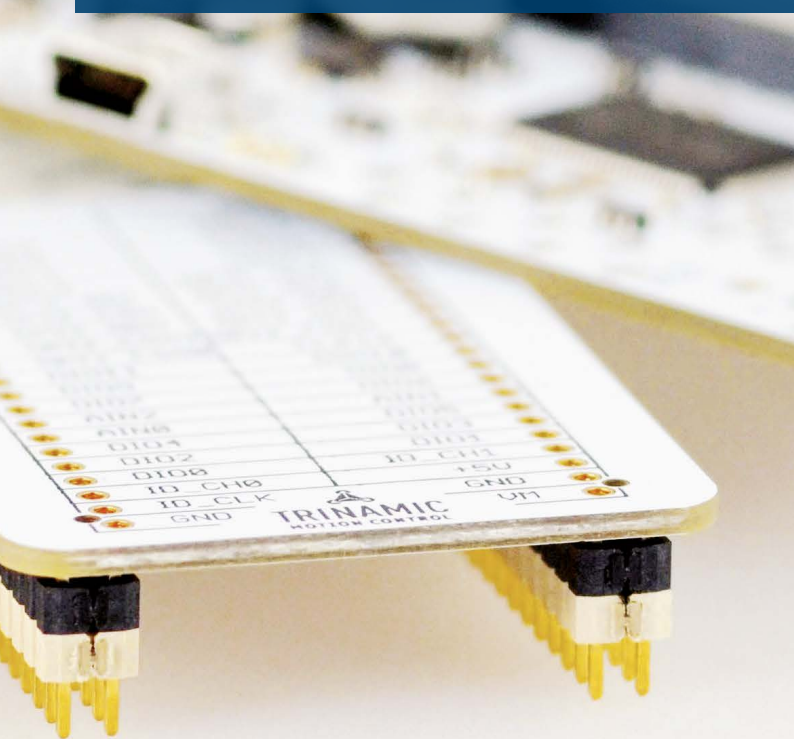
Stepper Motor System Architecture

Controller

Microcontroller: The usage of integrated motion controllers reduces the requirements to the MCU. Only a serial interface as SPI is needed.

Motion Controller: Integrated logic unit, that calculates ramping and positioning in safe and integrated hardware. Dedicated motion controllers offload real time calculations from the MCU. Motion controllers for SPI chipset may also incorporate microstep sequencing units.

Motor Driver

Predriver: Integration of predrivers, sensing and protection circuitry. The predriver may also include microstep sequencing or commutation logic.

Driver: Single chip solution including predriver and power bridges in a single board-space saving package.

cDriver: Integrated solution with motion controller, predriver and driver in one single device.

Trapezoidal Ramping

Driving a stepper motor at velocities higher than its physical start stop frequency requires a defined acceleration.

For the great majority of positioning applications, linear ramping profiles are sufficient.

Trinamic's motion controllers with linear ramping allow for fast and accurate positioning of one or several axes and offload the MCU from time-consuming real-time tasks.
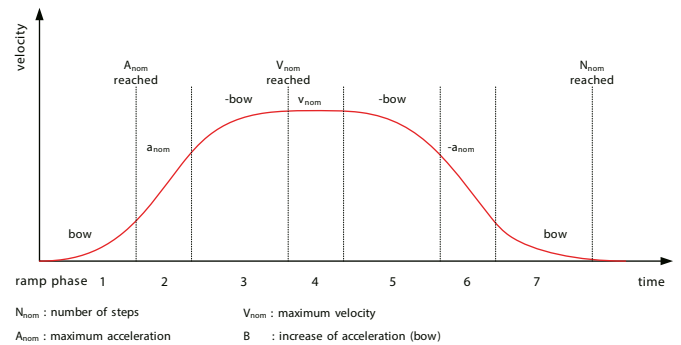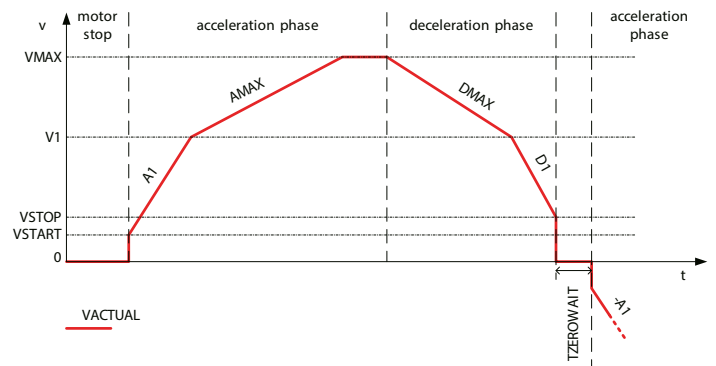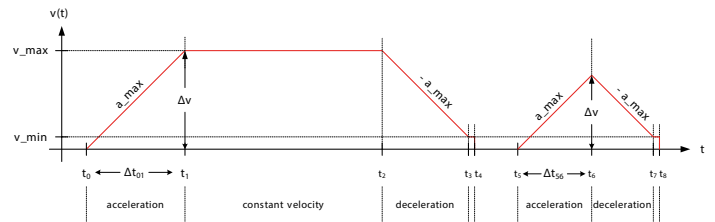
Advanced Ramping

Trinamic's advanced SixPoint™ ramping profile allows for faster positioning by adding a freely configurable start/stop frequency to a linear motion profile plus adding a reduced acceleration value at high velocity to reduce the jerk at the end of a standard acceleration ramp.

For high-speed positioning as well as for handling jerk-sensitive goods or objects with extensive inertia sinusoidal (S-Shaped) ramping profiles might be necessary.
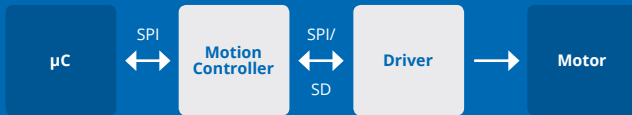
Dedicated Motion Controller

Ramping Profiles

N_{nom} : number of steps

A_{nom} : maximum acceleration

V_{nom} : maximum velocity

B : increase of acceleration (bow)

Dedicated Motion Controller

Trapezoidal and Multiaxis

SPI Chipset

A single bidirectional interface for both motion commands and diagnostics keep the count of required lead traces low. Only one low-speed SPI interface from the microcontroller enables extremely miniaturized and lean designs.

The SPI chipset allows full control over microstepping tables and a seamless change of microstep resolutions on the fly is possible. For optimized motor requirements the microstepping tables are adaptable in the motion controller.

| PRODUCT	TMC4210-I	TMC429-I	TMC429-LI	TMC429-PI24
Number of axes	1	3	3	3
Motor type	Stepper	Stepper	Stepper	Stepper
Operating voltage	3.3V…5V	3.3V…5V	3.3V…5V	3.3V…5V
Microstep resolution	S/D	64 (SPI)	64 (SPI) , S/D	64 (SPI) , S/D
Controller interface	SPI	SPI	SPI	SPI
Driver interface	S/D	SPI	SPI, S/D	SPI
Encoder interface	-	-	-	-
Closed-loop control	-	-	-	-
ChopSync™	-	-	-	-
DcStep™	-	-	-	-
Trapezoidal ramp generator	✓	✓	✓	✓
Advanced ramp generator	-	-	-	-
Ref. inputs	2	3 x 2	3 x 2	3 x 2
Package	SSOP16	SSOP16	QFN32 (5x5)	SOP24
Product status	active	active	active	active

Step and Direction Chipset

Step and direction (S/D) drivers and motion controllers simplify the control of stepper motors.

Step and direction interfaces are widespread in industry and thus allow for compatible solutions. Especially at high microstep resolutions and high step frequencies S/D architectures reduce required bandwidth compared to SPI or PWM interfaces. SPI is used for setup and feedback channel for diagnostics down to the power stage.
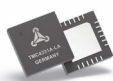
Dedicated Motion Controller

Advanced Ramping and Closed Loop

μC	SPI	Motion Controller	SPI/ SD	Driver		Motor

Position Feedback
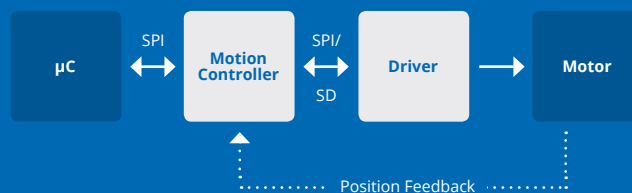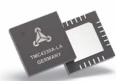
TMC457-BC	TMC4330A-LA	TMC4331A-LA	TMC4361A-LA	PRODUCT
1	1	1	1	**Number of axes**
Stepper, Piezo	Stepper	Stepper	Stepper	**Motor type**
1.5V + 3.3V	3.3V + 5V	3.3V + 5V	3.3V + 5V	**Operating voltage**
2048 , S/D	S/D	256 , S/D	256 , S/D	**Microstep resolution**
SPI	SPI	SPI	SPI	**Controller interface**
SPI, S/D	S/D	SPI, S/D	SPI, S/D	**Driver interface**
ABN	ABN, SPI, SSI	-	ABN, SPI, SSI	**Encoder interface**
-	✓	-	✓	**Closed-loop control**
✓	✓	✓	✓	**ChopSync™**
-	-	✓	✓	**DcStep™**
✓	✓	✓	✓	**Trapezoidal ramp generator**
S-Shaped	SixPoint™, S-Shaped	SixPoint™, S-Shaped	SixPoint™, S-Shaped	**Advanced ramp generator**
2	3	3	3	**Ref. inputs**
FBGA144	QFN32 (4x4)	QFN32 (4x4)	QFN40 (6x6)	**Package**
active	active	active	active	**Product status**

Stepper Motor Drivers

Step/ Direction Chipset

Minimized Boardspace

Trinamic's monolithic stepper motor drivers build powerful integrated systems integrating a state of the art microstepping sequencer, and power drivers. By reducing the count of required external components, Trinamic's stepper drivers allow for smallest systems.

With the latest current control technologies you can create silent, efficient, precise and cost efficient products.

PRODUCT	TMC2100-LA	TMC2130-LA	TMC2100-TA	TMC2130-TA	TMC2041-LA	TMC2208-LA	TMC2224-LA
Number of axes	1	1	1	1	2	1	1
Stepper motor type	2-Phase	2-Phase	2-Phase	2-Phase	2-Phase	2-Phase	2-Phase
Phase current (RMS)	1.2A	1.2A	1.4A	1.4A	1.1A	1.4A	1.4A
Motor supply voltage	5V…46V	5V…46V	5V…46V	5V…46V	5V…26V	5V…36V	5V…36V
Max. microstep resolution	256	256	256	256	256	256	256
Controller interface	S/D + digital	SPI + S/D	S/D + digital	SPI + S/D	SPI + S/D, UART	S/D + UART	S/D + UART
ChopSync™	-	✓	-	✓	-	-	-
StallGuard™	-	-	-	-	-	-	-
StallGuard2™	-	✓	-	✓	✓	-	-
CoolStep™	-	✓	-	✓	✓	-	-
SpreadCycle™	✓	✓	✓	✓	✓	✓	✓
StealthChop™	✓	✓	✓	✓	-	✓*	✓*
MicroPlyer™	✓	✓	✓	✓	✓	✓	✓
Package	QFN36 (5x6)	QFN36 (5X6)	eTQFP48	eTQFP48	QFN48 (7x7)	QFN28 (5x5)	QFN28 (5x5)
Product status	active	active	active	active	active	active	active

* StealthChop2™

Low Power Dissipation

Using the lowest RDSon TrenchFET switches Trinamic's multichip stepper drivers reduce power loss and do not require heatsinks in their full specified current range, this decreases both the system power consumption and the total system cost.

Advanced diagnostic functions provide continuous system condition monitoring.

Stepper Motor Drivers

SPI Chipset

TMC236B-PA	TMC246B-PA	TMC260A-PA	TMC2660-PA	TMC261-PA	PRODUCT
1	1	1	1	1	**Number of axes**
2-Phase	2-Phase	2-Phase	2-Phase	2-Phase	**Stepper motor type**
1.1A	1.1A	1.4A	2.8A	1.4A	**Phase current (RMS)**
7V...34V	7V...34V	9V...40V	9V...30V	9V...60V	**Motor supply voltage**
16, 64	16, 64	256	256	256	**Max. microstep resolution**
analog, SPI	analog, SPI	SPI + S/D	SPI + S/D	SPI + S/D	**Controller interface**
✓	✓	-	-	-	**ChopSync™**
-	✓	-	-	-	**StallGuard™**
-	-	✓	✓	✓	**StallGuard2™**
-	-	✓	✓	✓	**CoolStep™**
-	-	✓	✓	✓	**SpreadCycle™**
-	-	-	-	-	**StealthChop™**
-	-	✓	✓	✓	**MicroPlyer™**
QFP44	QFP44	QFP44	QFP44	QFP44	**Package**
active	active	active	active	active	**Product status**

Integrated Motion Controller and Driver

Single Axis

Digital to Physical

Trinamic's cDriver is an integrated solution with a motion controller and driver in a single device. It combines a sophisticated ramp generator for automatic target positioning with the industries most advanced stepper motor driver.

High integration, high energy efficiency and a small form factor enable miniaturized and scalable systems for cost effective solutions. Trinamic's cDrivers translate digital information to physical motion.

| PRODUCT	TMC5130A-TA	TMC5160-TA	TMC5160-WA
Number of axes	1	1	1
Stepper motor type	2-Phase	2-Phase	2-Phase
Phase current (RMS)	1.4A	>10A (ext. FET)	>10A (ext. FET)
Motor supply voltage	5V...46V	8V...60V	8V...60V
Max. microstep resolution	256	256	256
Controller interface	SPI, UART	SPI + S/D, UART	SPI + S/D, UART
Encoder interface	✓	✓	✓
StallGuard2™	✓	✓	✓
CoolStep™	✓	✓	✓
SpreadCycle™	✓	✓**	✓**
StealthChop™	✓	✓*	✓*
Ramp generator	SixPoint™, trapezoidal	SixPoint™, trapezoidal	SixPoint™, trapezoidal
DcStep™	✓	✓	✓
Package	eTQFP48 (9x9)	TQFP48 (9x9)	QNF56 (8x8)
Product status	active	active	preview

** SpreadCycle2™

* StealthChop2™

Compact Multiaxis

For all applications, like surveillance cameras, office automation equipment or infusion pumps, that require multiple dependable motors but small build volume, dual axis cDrivers are the perfect solution.

A high level of integration at a low-cost-per-axis, reduces system cost. Integrated advanced ramp controllers shorten development cycles and minimize cost of ownership.

Integrated Motion Controller and Driver

Dual Axis cDriver
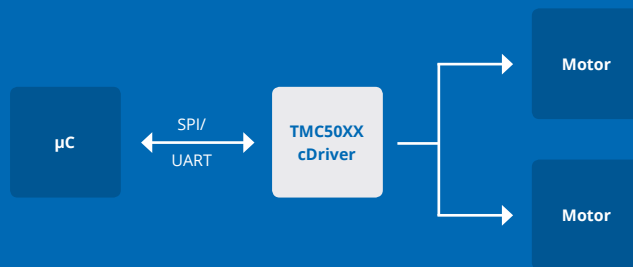
TMC5031-LA	TMC5041-LA	TMC5062-LA	TMC5072-LA	PRODUCT
2	2	2	2	**Number of axes**
2-Phase	2-Phase	2,3-Phase	2-Phase	**Stepper motor type**
1.1A	1.1A	2x 1.1A/ 1x 2.2A	2x 1.1A/ 1x 2.2A	**Phase current (RMS)**
5V...16V	5V...26V	5V...20V	5V...26V	**Motor supply voltage**
256	256	256	256	**Max. microstep resolution**
SPI	SPI + S/D	SPI, UART	SPI, UART	**Controller interface**
-	-	✓	✓	**Encoder interface**
✓	✓	✓	✓	**StallGuard2™**
✓	✓	✓	✓	**CoolStep™**
✓	✓	✓	✓	**SpreadCycle™**
-	✓	-	✓	**StealthChop™**
SixPoint™, trapezoidal	SixPoint™, trapezoidal	SixPoint™, trapezoidal	SixPoint™, trapezoidal	**Ramp generator**
-	-	✓	✓	**DcStep™**
QFN48 (7x7)	QFN48 (7x7)	QFN48 (7x7)	QFN48 (7x7)	**Package**
active	active	active	active	**Product status**

Stepper Motor Predrivers

Predrivers

Powerful Drives

Designs with predriver and external MOSFETs allow powerful flexible designs for high or highest current designs perfectly matched to your motors.

All Trinamic predrivers provide full diagnostics via SPI. With Trinamic's unique advanced current control capabilities all Trinamic stepper drivers and predrivers provide precise and smooth microstepping.

| PRODUCT	TMC248-LA	TMC249A-SA	TMC262-LA	TMC389-LA	TMC5160-TA	TMC5160-WA
Number of axes	1	1	1	1	1	1
Stepper motor type	2-Phase	2-Phase	2-Phase	3-Phase	2-Phase	2-Phase
Gate current	30mA	30mA	40mA	40mA	>10A	>10A
Motor supply voltage	7V...34V	7V...34V	9V...60V	9V...60V	8V...60V	8V...60V
Max. microstep resolution	16, 64	16, 64	256	171	256	256
Controller interface	analog , SPI	analog , SPI	SPI + S/D	SPI + S/D	SPI, S/D, UART	SPI, S/D, UART
ChopSync™	✓	✓	-	-		
StallGuard™	✓	✓	-	-	-	-
StallGuard2™	-	-	✓	✓	✓	✓
CoolStep™	-	-	✓	✓	✓	✓
SpreadCycle™	-	-	✓	✓	✓**	✓**
MicroPlyer™	-	-	✓	✓	✓	✓
MOSFET type	N + P	N + P	N + P	N + P	N + N	N + N
Package	QFN28 (5x5)	SO28	QFN32 (5x5)	QFN32 (5x5)	TQFP48 (9x9)	QNF56 (8x8)
Product status	active	active	active	active	active	preview

** SpreadCycle2™

Realtime Communications

EtherCAT is a high-performance, low-cost, easy to use Industrial Ethernet technology with a flexible topology. EtherCAT is the fastest Industrial Ethernet technology, but it also synchronizes with nanosecond accuracy.

Trinamic slave controllers connect peripherals optimized for embedded motion and motor control applications to the fast fieldbus and allow for accurate synchronisation of distributed drives.
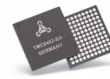
Fieldbus Interfaces

EtherCAT Slave Controller
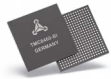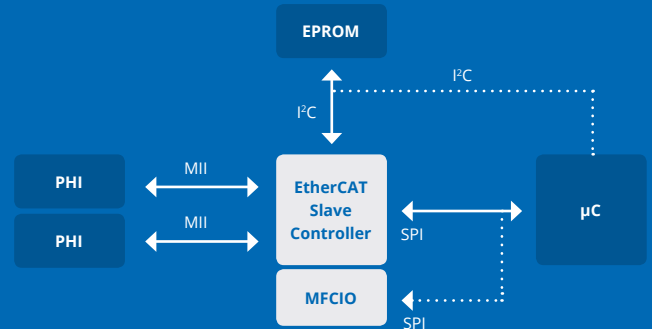
| TMC8460-BI	TMC8461-BA	TMC8462-BA	PRODUCT
1.2V + 3.3V	3.3V, 5V...24V	3.3V, 5V...24V	**Operating voltage**
SPI (30Mbit/s)	SPI (30Mbit/s)	SPI (30Mbit/s)	**Controller interface**
2x MII	2x MII	2x int. Phy	**Bus interface**
✓	✓	✓	**Encoder interface**
16K	16K	16K	**Process data memory**
6	8	8	**Sync manager**
6	8	8	**Fieldbus memory management unit**
64bit	64bit	64bit	**Distributed clock**
8	24 (incl. 8x HV)	24 (incl. 8x HV)	**Multi-function I/Os**
-	2x 500mA	2x 500mA	**Integrated DC/DC regulator**
✓	✓	✓	**Step/Direction output**
✓	✓	✓	**SPI master**
-	✓	✓	**I²C master**
BGA VFGG400 (17x17)	BGA144 (10x10)	BGA121 (9x9)	**Package**
active	active	active	**Product status**

BLDC Predrivers

3-Phase Predrivers
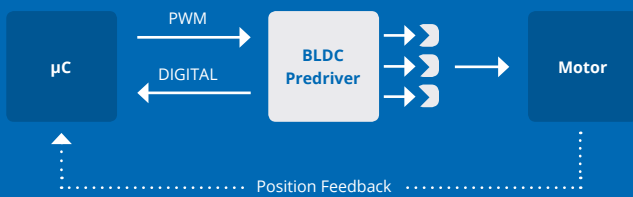
Powerful Servos

The use of BLDC motors as replacement for brushed DC motors is increasing both in EMC-critical applications and in applications with the highest requirements on energy efficiency.

With a sinewave commutation BLDC motors build silent and efficient drives for heating and ventilation. Equipped with a high-resolution feedback system and field oriented control they are the optimum solution for powerful servo drives.
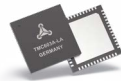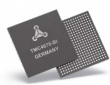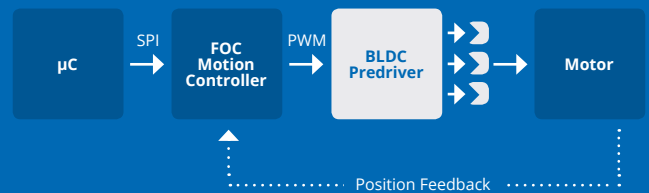
PRODUCT	TMC603A-LA	TMC6130-LA
Number of axes	1	1
Motor type	3-Phase BLDC	3-Phase BLDC
Gate current	150mA	1A
Motor supply voltage	12V...50V	4.5V...28V
Controller interface	PWM	PWM, (SPI)
Shunt amplifier	dual	single
Current sensing via MOSFET	✓	-
Short to GND protection	✓	✓
Switching regulator	12V	-
Linear regulator	5V	12V
Break before make logic	✓	✓
Slope control	✓	-
MOSFET type	N	N
Package	QFN52 (8x8)	QFN32 (5x5)
Product status	active	active

Outstanding Dynamics

Servo controllers play a key role in modern motor control technology for synchronous machinery. Field oriented control has long been the state of the art, but implementation requires a lot of time.

Trinamic's servo controller chips significantly reduce development time for three-phase synchronous motors and two-phase stepper motors and allow for outstanding dynamics.

### Dedicated Motion Controller
Embedded Servo Controller

| TMC4670-BI	TMC8670-BI	PRODUCT
1	1	**Number of axes**
2,3-Phase	2,3-Phase	**Motor type**
SPI	-	**Controller interface**
-	2x MII for EtherCAT	**Bus interface**
-	CANopen over EtherCAT (CoE)	**Bus protocol**
1.2V + 2.5V + 3.3V	1.2V + 3.3V	**Operating voltage**
Incremental ABN, Digital Hall, Analog Hall, Analog SinCos	Incremental ABN, Digital Hall, Analog Hall, Analog SinCos	**Encoder interface**
✓	✓	**Dual encoder support**
✓	✓	**Field oriented control**
25kHz...200kHz	25kHz...100kHz	**Current loop frequency**
4kHz	4kHz	**Velocity loop frequency**
4kHz	4kHz	**Position loop frequency**
-	-	**Ramp generator**
BGA256 (17x17)	FCSG325 (11x11)	**Package**
active	active	**Product status**

MotionCookie™ system in a package

Servo Controller Microsystem
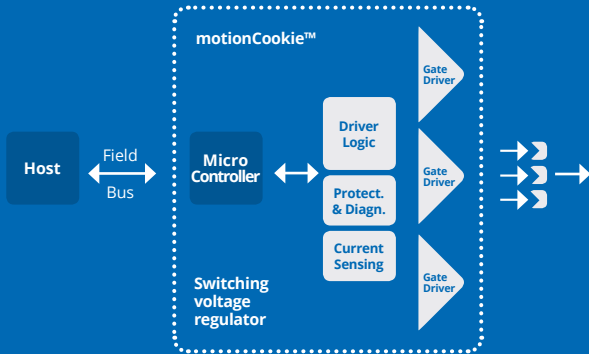
Rapid Development

TMCC160-MotionCookie™ integrates a powerful gate driver and a Cortex-M4 microprocessor with an integrated field oriented control (FOC) firmware.

To keep hardware-design as simple as possible and keep component count low, the SMT microsystem TMCC160-MotionCookie™ contains all the core components of an embedded motion control system.
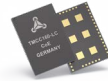
PRODUCT	TMCC160-LC TMCL	TMCC160-LC CANopen	TMCC160-LC CoE
Number of axes	1	1	1
Motor type	BLDC/PMSM	BLDC/PMSM	BLDC/PMSM
Controller interface	SPI	-	-
Bus interface	CAN, RS485	CAN	SPI to ESC
Bus protocol	TMCL	CANopen	CoE
Operating voltage	4.5V...28V	4.5V...28V	4.5V...28V
Encoder interface	✓	✓	✓
Hall sensor support	✓	✓	✓
Field oriented control	✓	✓	✓
Current loop frequency	2kHz...20kHz	2kHz...20kHz	2kHz...20kHz
Velocity loop frequency	1kHz...20kHz	1kHz...20kHz	1kHz...20kHz
Position loop frequency	1kHz...20kHz	1kHz...20kHz	1kHz...20kHz
Ramp generator	trapezoidal	trapezoidal	trapezoidal
Package	LGA	LGA	LGA
Product status	active	active	active

TRINAMIC

MOTION CONTROL

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