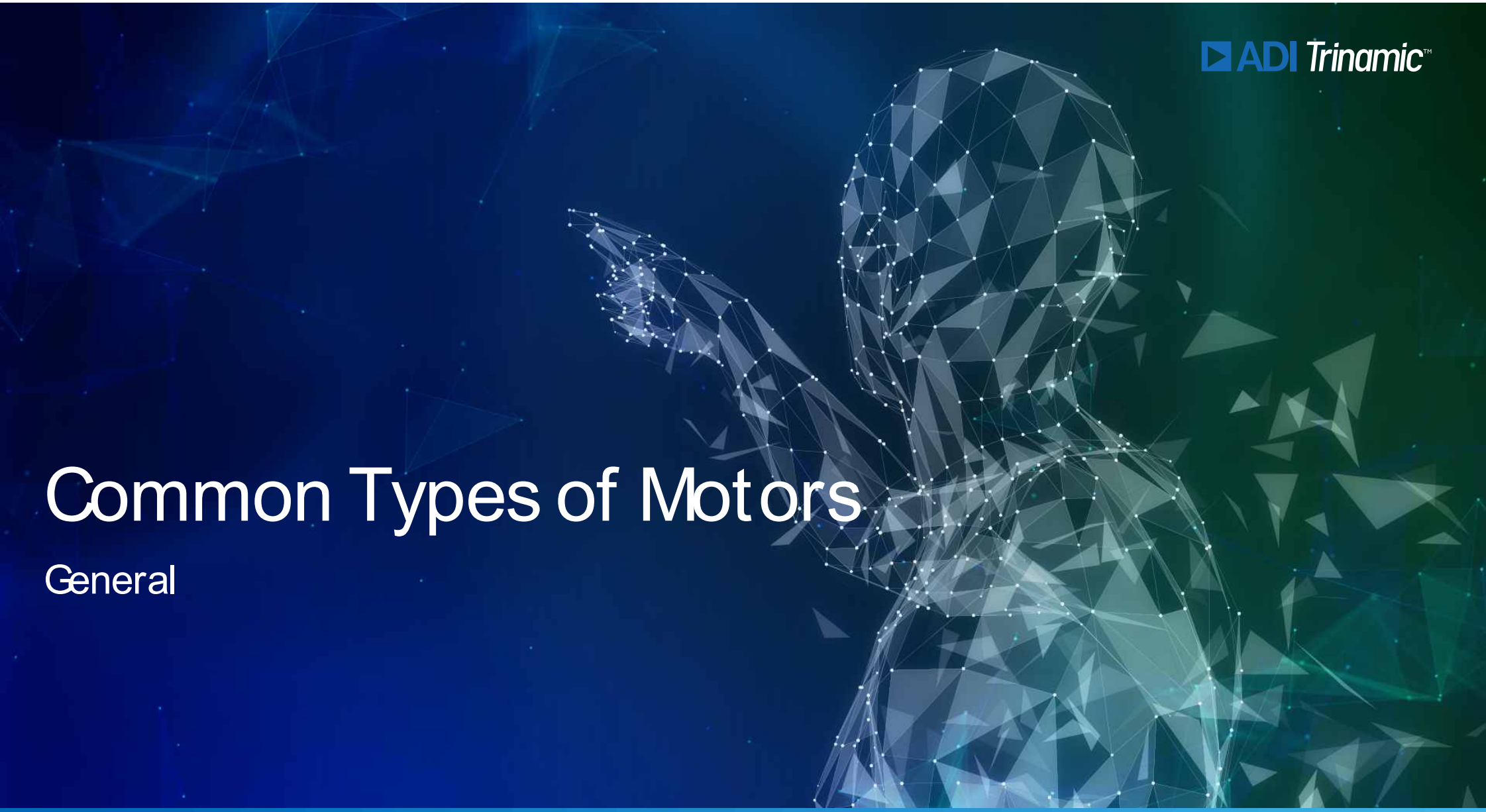
ADI Trinamic - ADI Trinamic Motion Control Solutions

What is the Impact of Motor Control?

52% of global electricity consumed by motors

Source: IEA Energy Efficiency Series, Paul Waide and Conrad U. Brunner, et al. . 2021



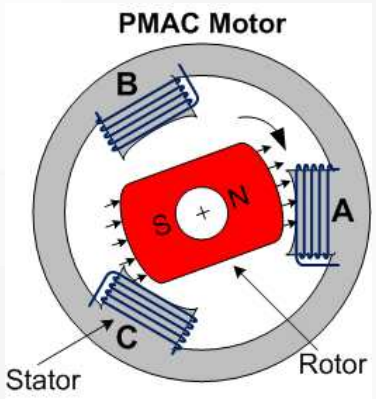
Common Types of Motors

General

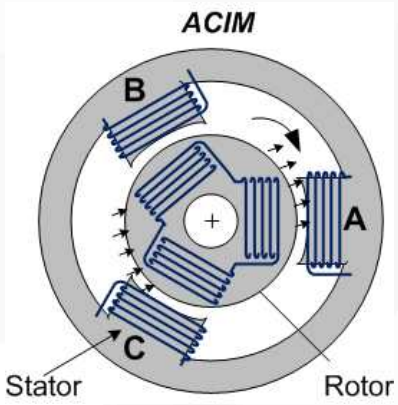
Common Types of Motors (HV>80V)

ADI Trinamic™

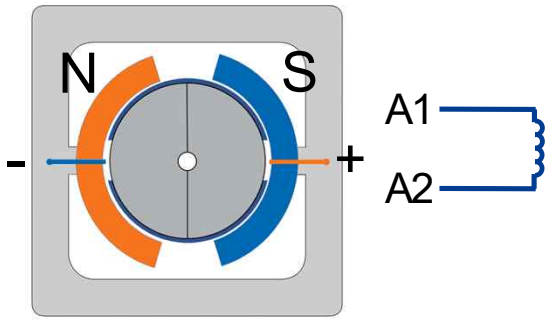
- Permanent Magnet AC Motor
  - Fixed windings on the outside - internal rotating magnets.
  - Stator windings current must be synchronized with the rotor magnet position
  - High torque and power density
  - Higher performance systems.



- AC Induction Motor
  - Fixed windings on the outside- internal rotating field induced by stator winding voltages.
  - Stator windings currents automatically synchronized with the rotor field position.
  - Industry workhorse

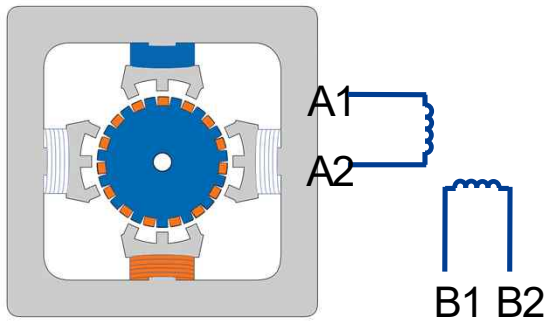


Common Types of Motor (LV<80V)



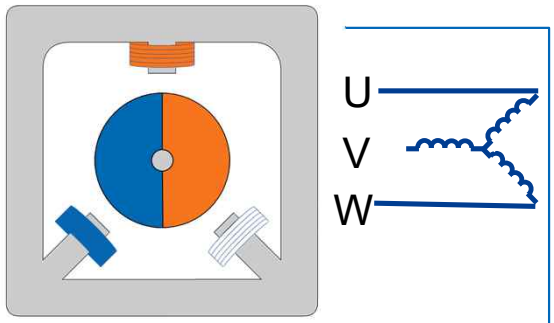
Brushed DC

Low requirements on precision, speed, position and efficiency.
Short lifetime high power density.



Stepper

Open loop positioning or velocity operation. High torque at low and mid-range velocities.



Brushless DC

Operates in closed loop or velocity controlled.
High velocities, long lifetime and high Efficiency.

Step-motor Control

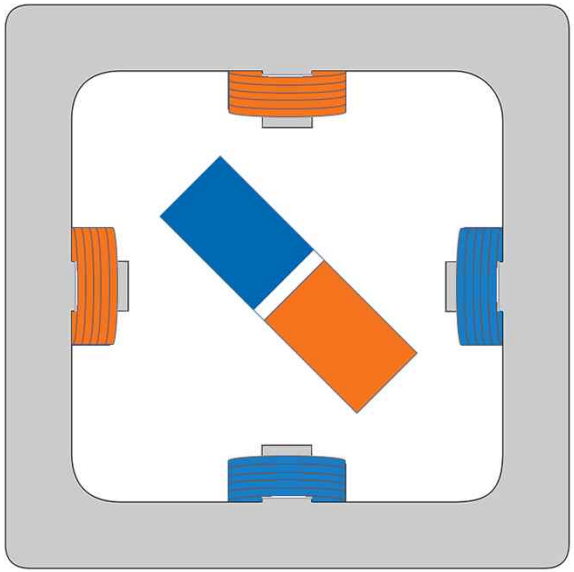
General

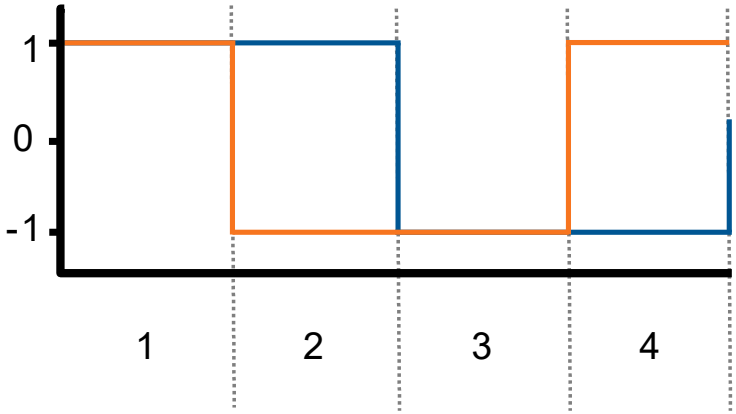
Step-motor Control Function

Pulsation in movement / vibrations High-resolution microstepping	SpreadCycle™
Dynamic load changes / overload and pot. position loss Sensorless load monitoring	StallGuard2/4™
Energy consumption / heat and power dissipation Current control based on sensorless StallGuard™ values	CoolStep™
Audible noise / mechanical resonances **Advanced current control**	StealthChop™
Jerky motion / position overshoot Advanced multi-segment / jerk-limiting acceleration ramps	EightPoint™

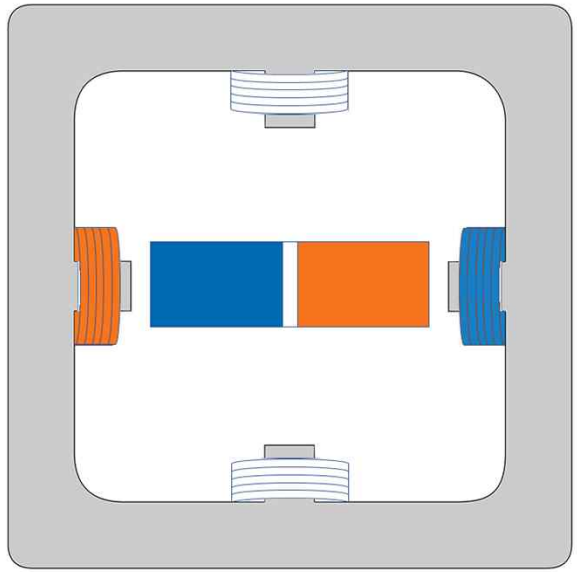
Micro Stepping

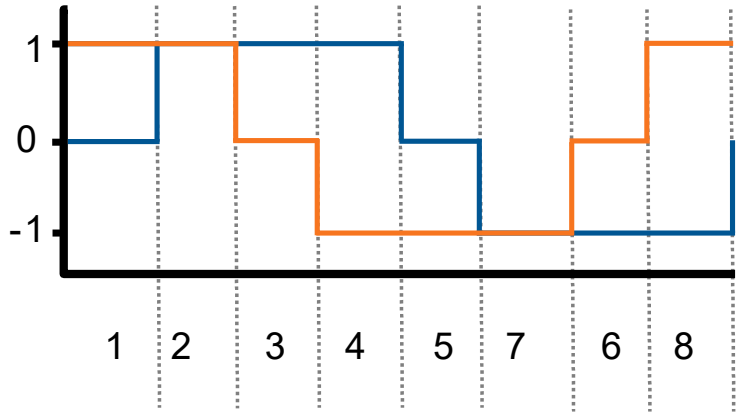
Fullstep



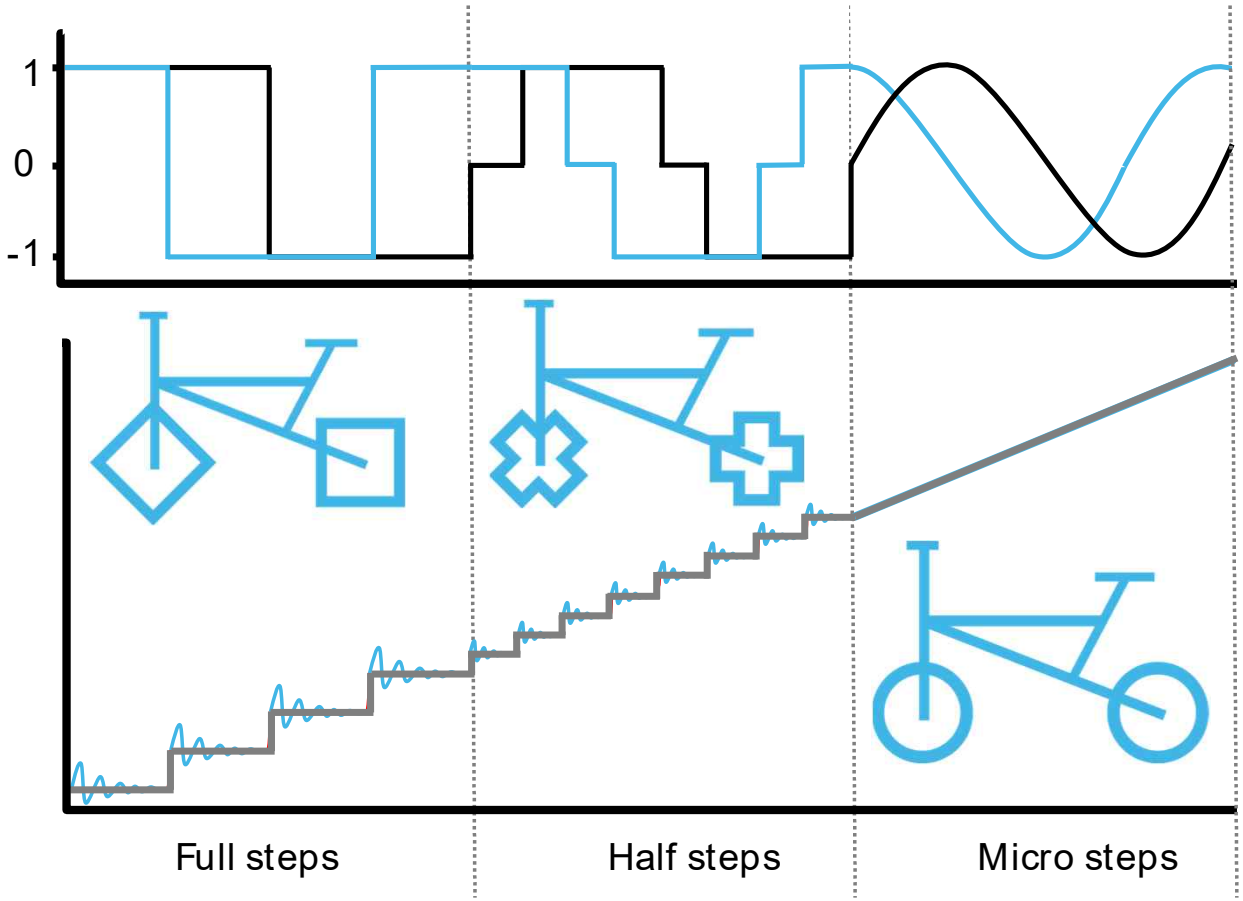


Halfstep





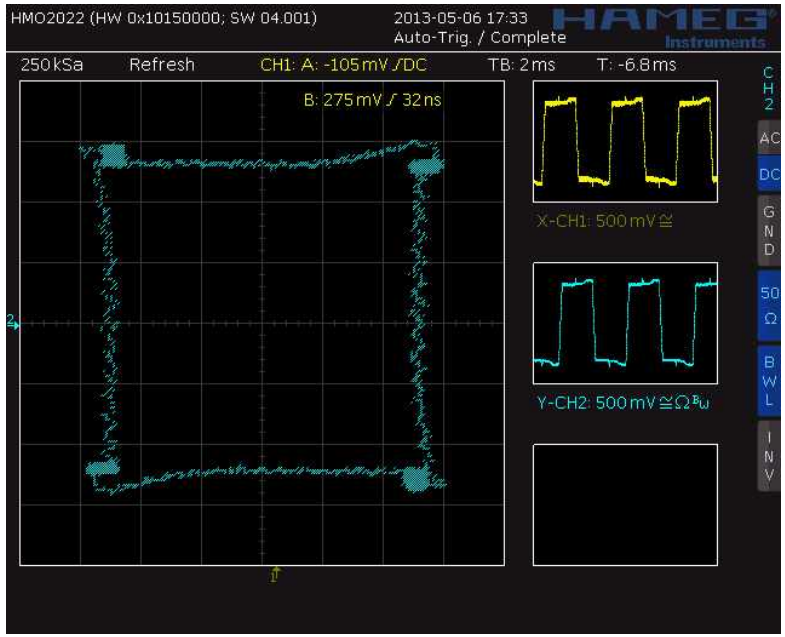
Micro Stepping



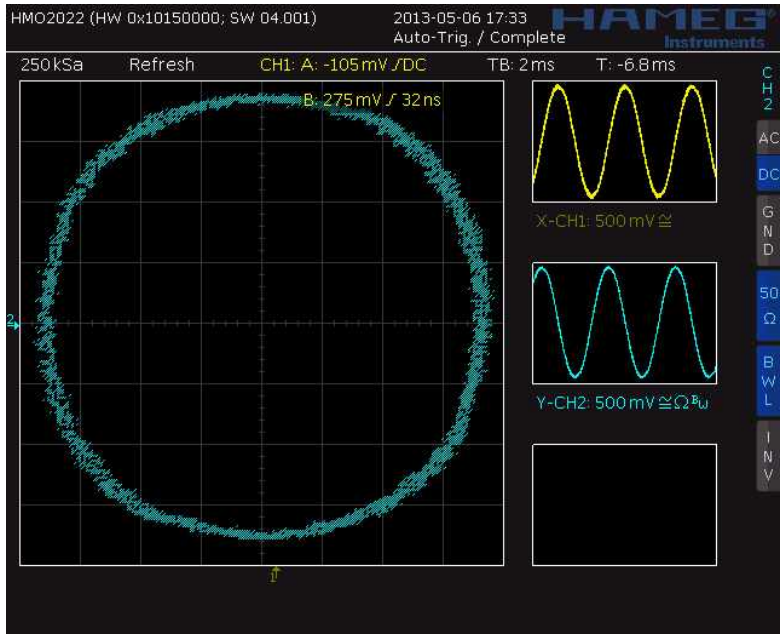
200 full-steps * 256 microsteps
= **51200 microsteps/ rotation**
Step resolution : 0.00703125°

If motor runs @1000rps =>
51,200,000
microsteps/ sec(5.12MHz)

Micro Stepping

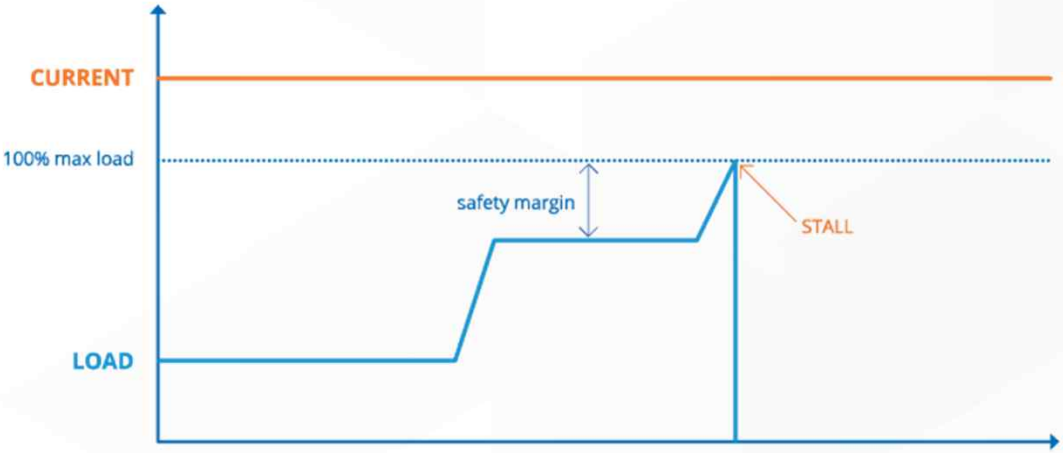


From Full Step



To 256 Microstep

StallGuard & CoolStep

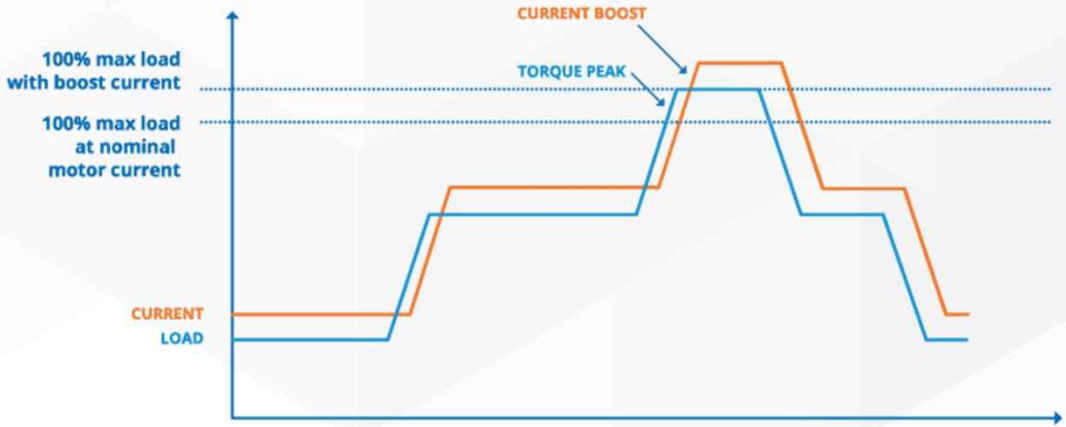


StallGuard™

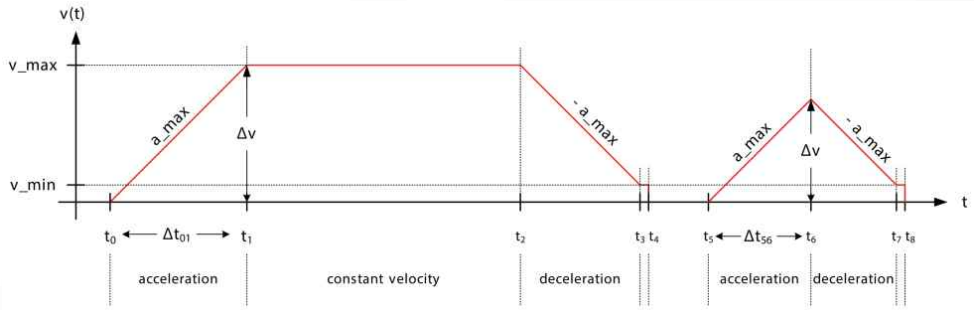
- Sensorless Load Angle Detection
  - Blocking Detection
  - Referencing
  - System Check

CoolStep™

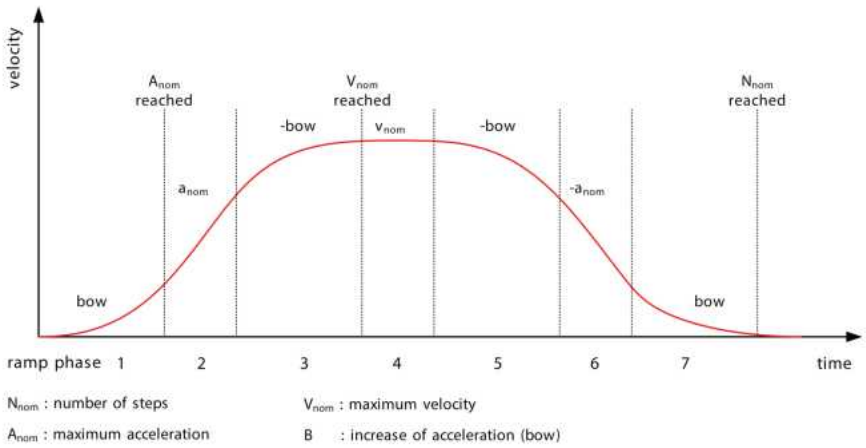
- Load dependent Current Control
- Saves up to 70% Energy



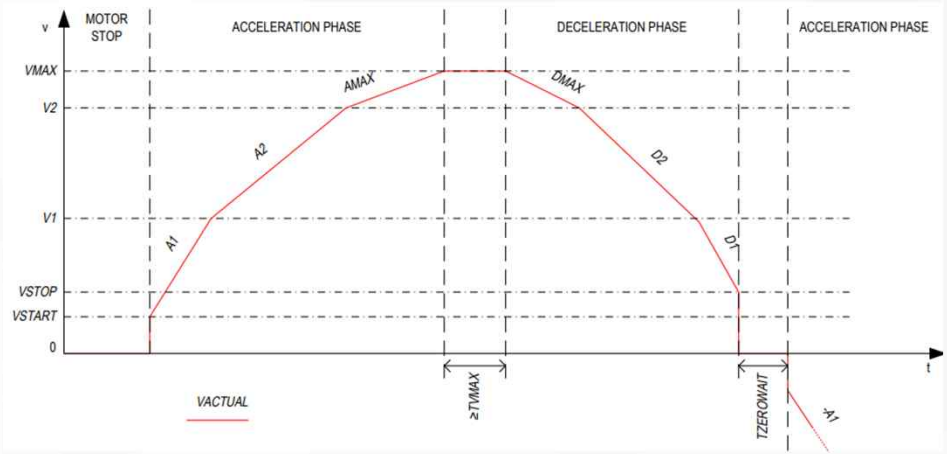
Advanced Ramping



1st generation Motion Controller



2nd generation motion controller

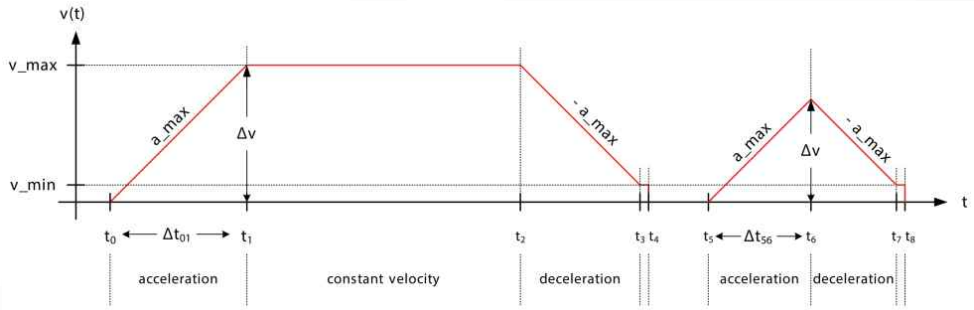


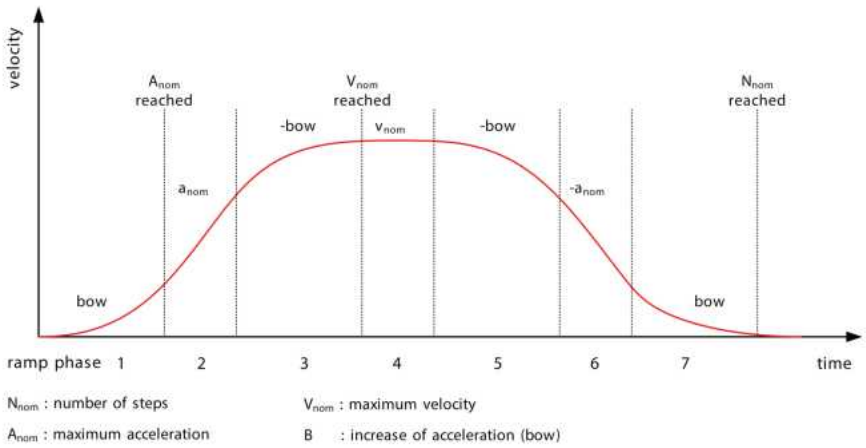
3rd gen. motion controller – multi point

Advantages:

- Proven Hardware Blocks
- Offloading the Processor
- Parameter Change on the Fly
- Reference Switch input (Hard- / Soft-Stop)

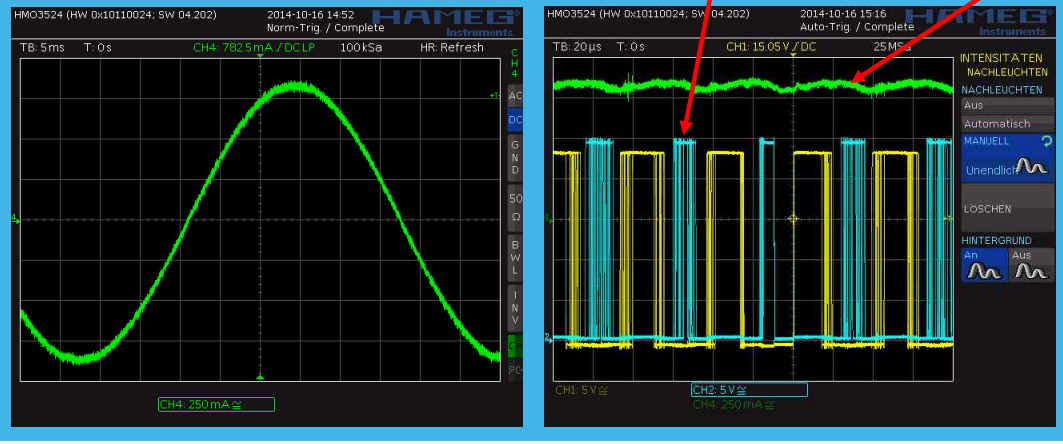
Advanced Ramping





Current Controller - SpreadCycle™ vs. StealthChop™

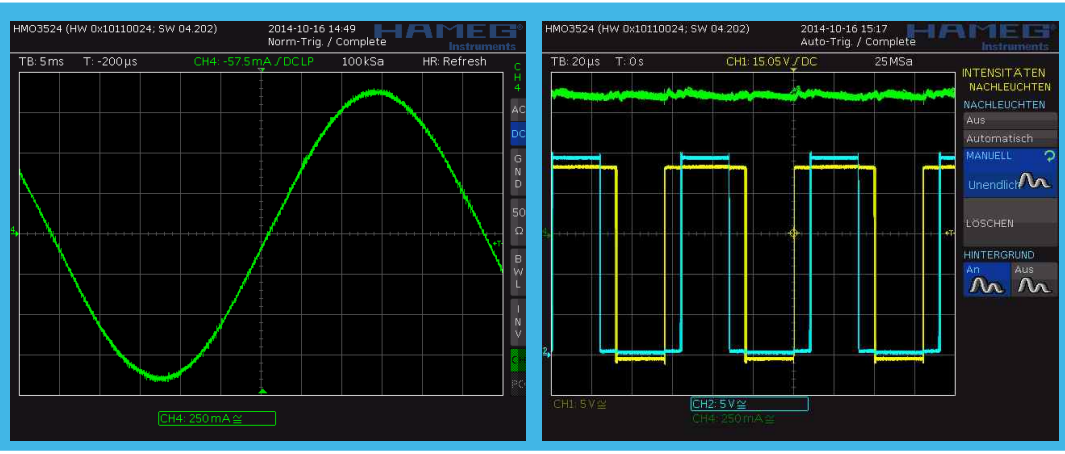
Coil Voltage Motor Current



Strict and fast Current Control leads to continuous readjustment of Chopper Pulses

= highest dynamics

SpreadCycle™



PWM output enables jitter-free output while mean current is maintained

= noiseless operation

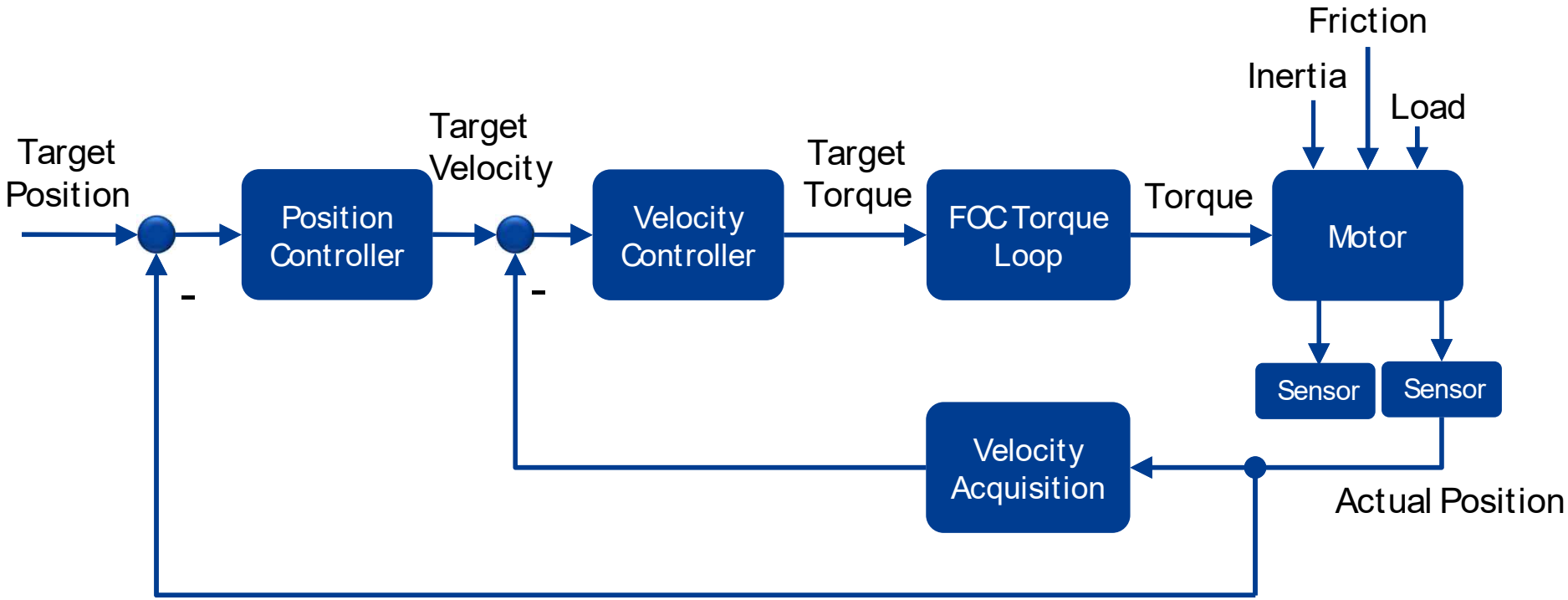
StealthChop™

FOC Control (Field Oriented Control)

General

Complete Controller Cascade

FOC = Field Oriented Control

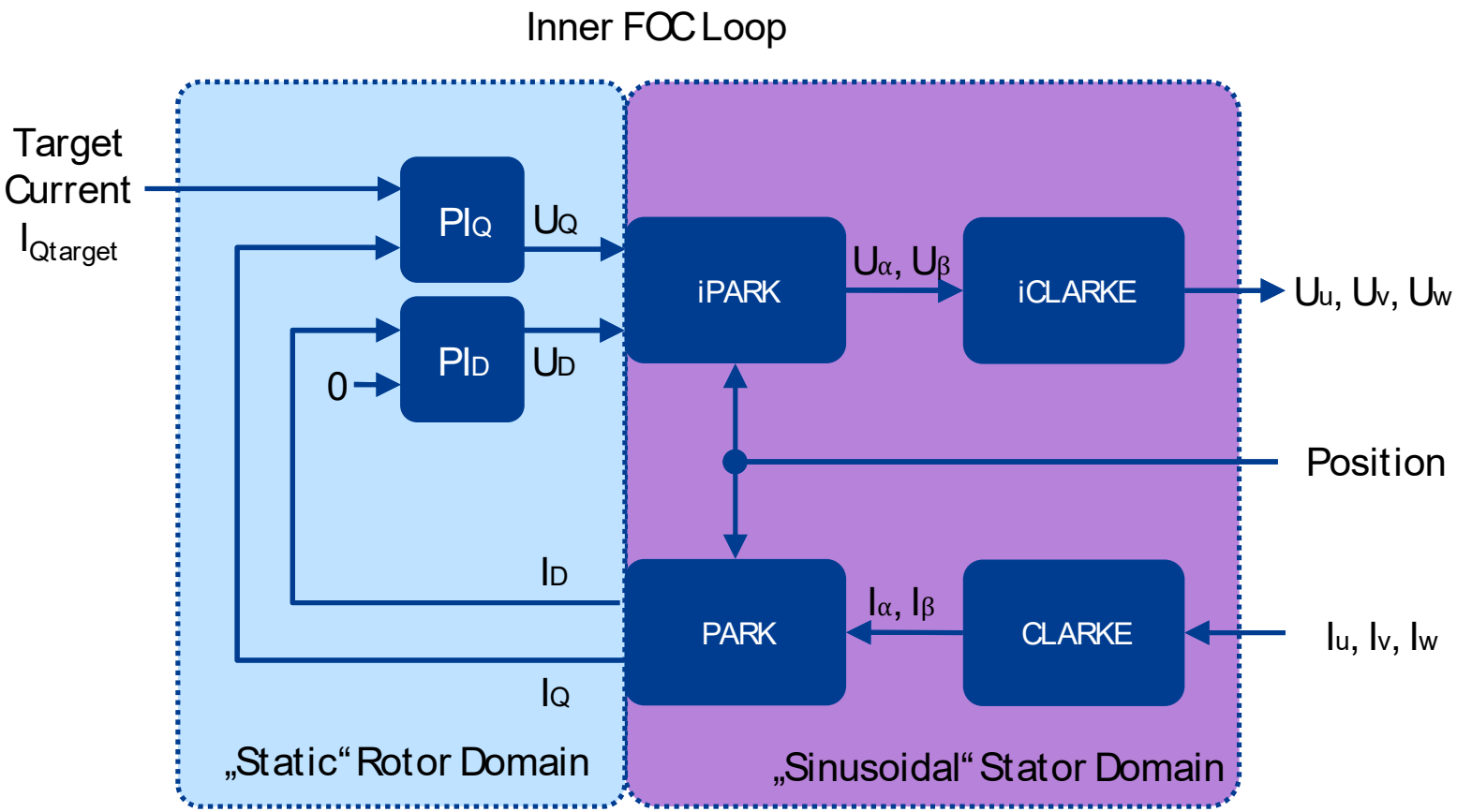


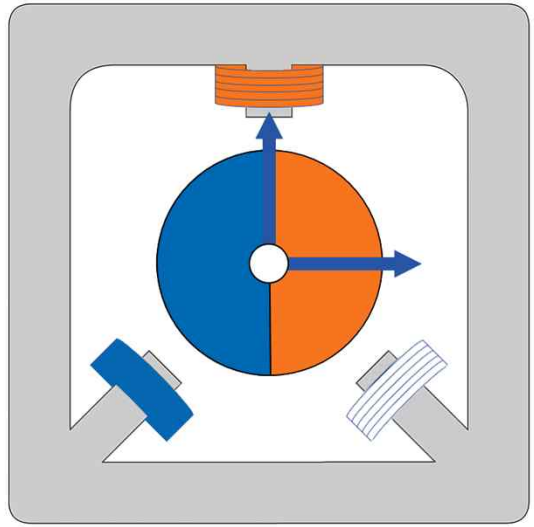
TMC4671 Classic PI
Current Loop: PWM Frequency, 100kHz max.
Velocity and Position Loop: 4kHz fixed

FOC Torque Loop – Field Oriented Control

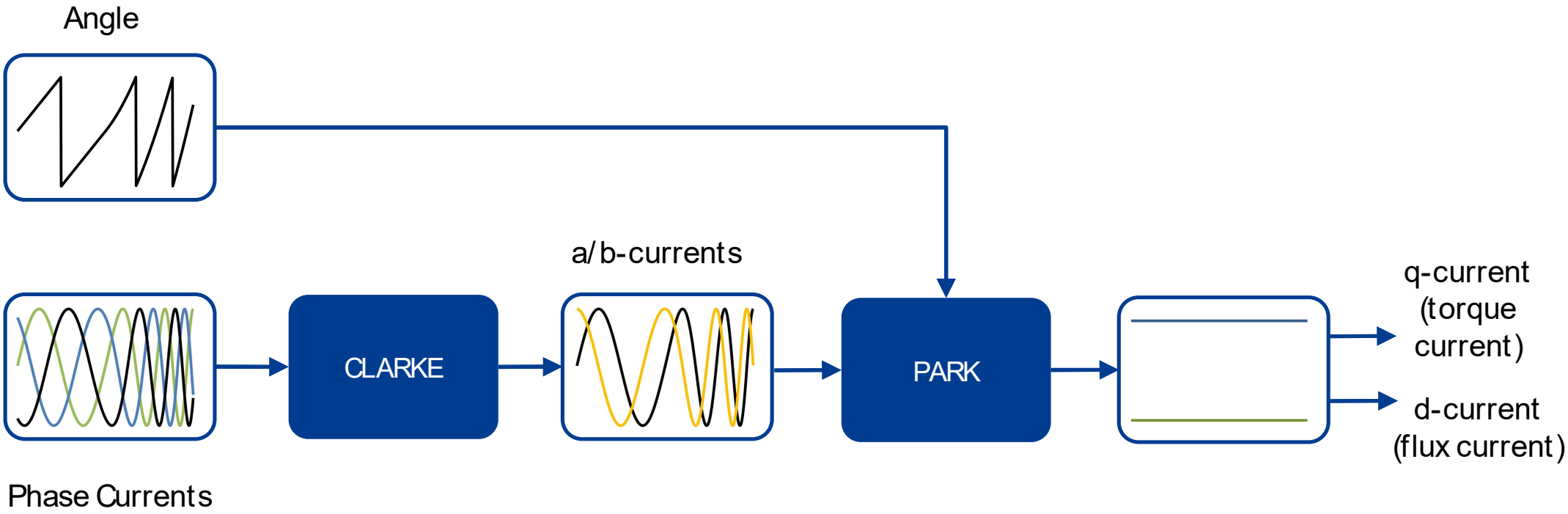
Servo

ADI Trinamic™



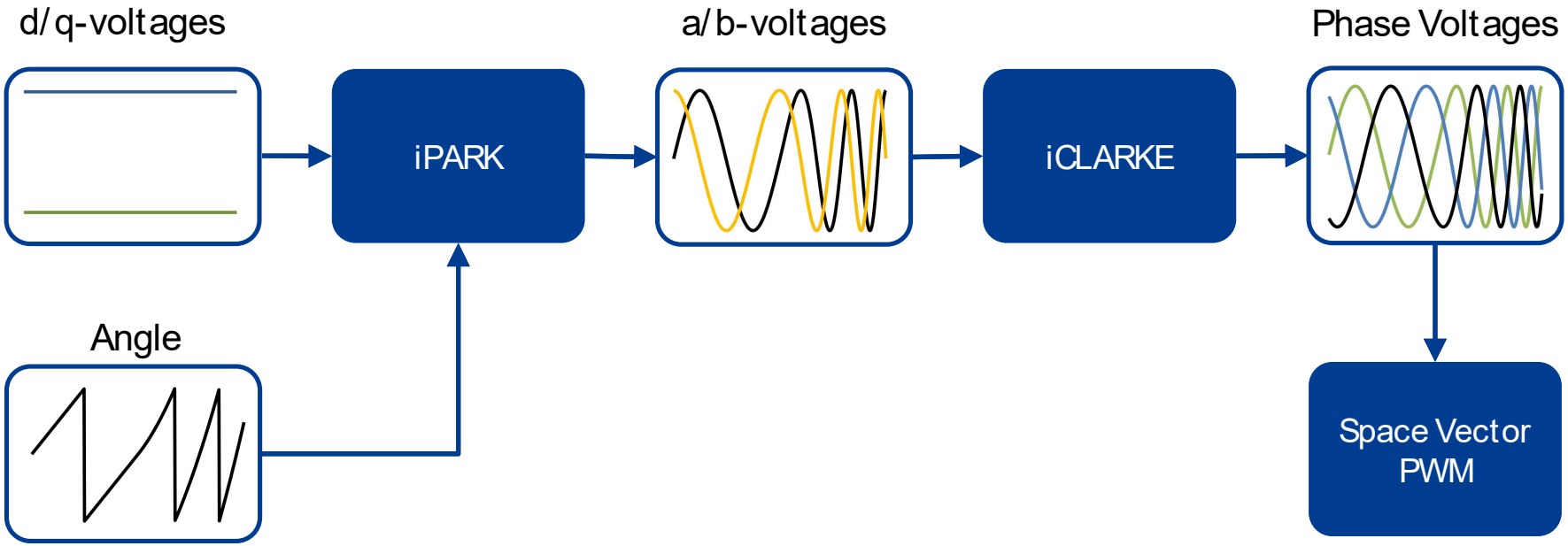


Transformations I



If d-current is zero q-current is proportional to torque!
→ d-current = zero
→ control torque with q-current

Transformations II



Interfaces

General

Interfaces

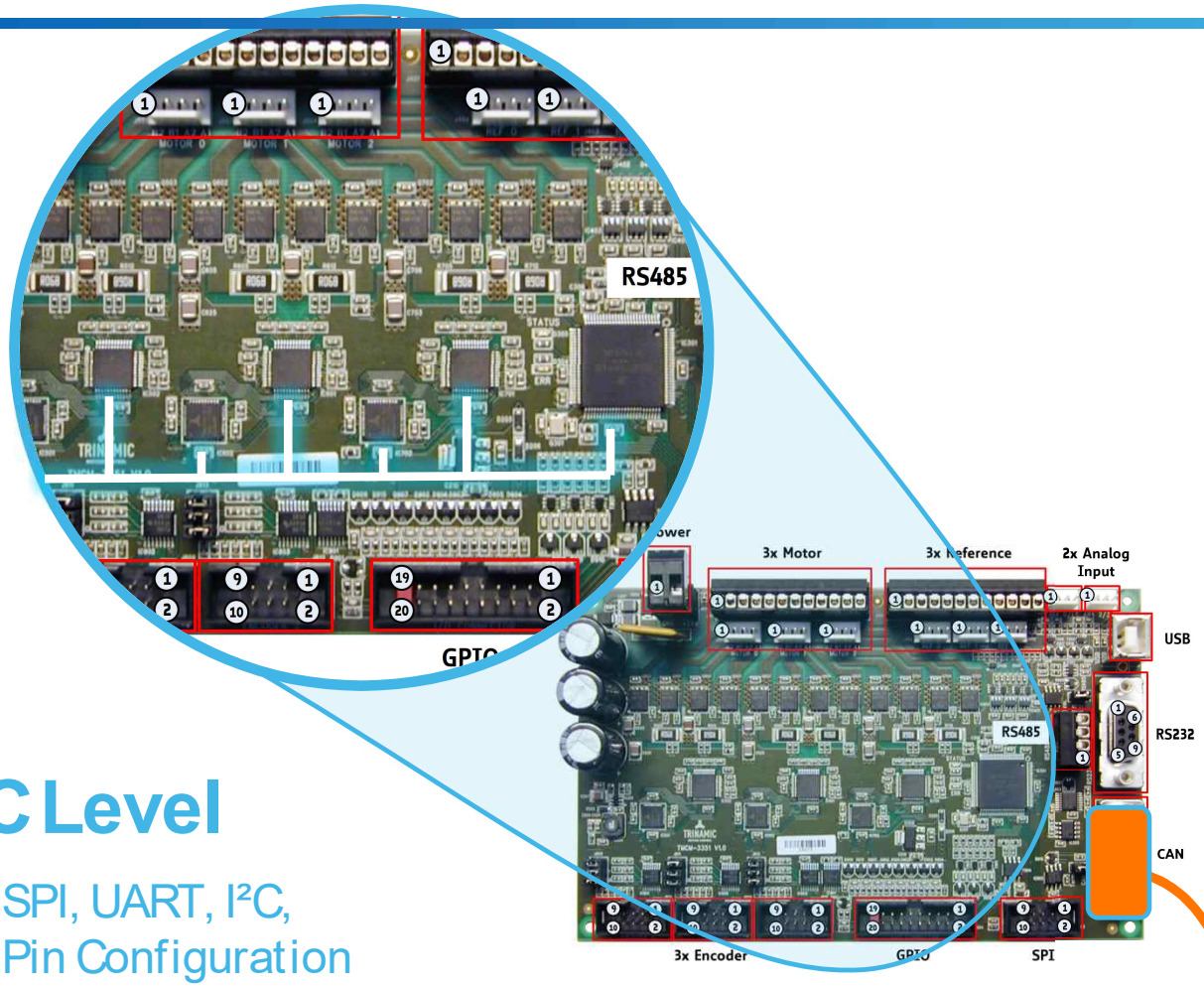
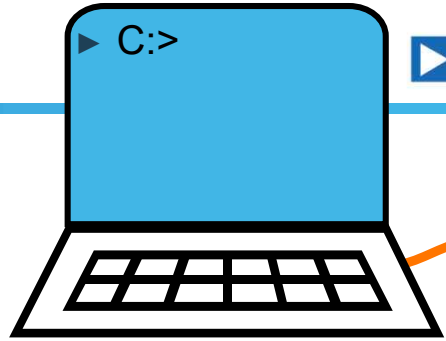


Figure 2: TMCM-3351 Connectors

IC Level

- SPI, UART, I²C, Pin Configuration



ADI Trinamic™

bus

Board Level

- RS232, RS485, USB, CAN, IO-Link, EtherCAT

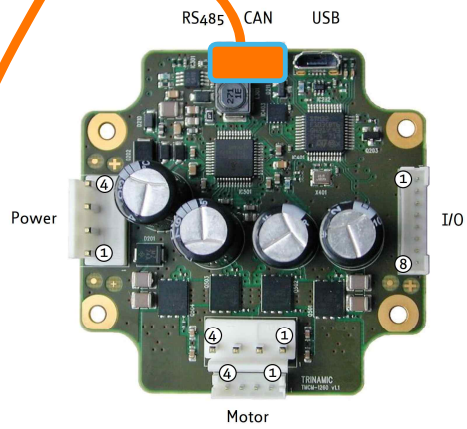


Figure 2: TMCM-1260 connectors

Protocol

00110110
01011010

BOARD-LEVEL INTERFACE

ADI Trinamic™

Parameter/Product	TMCM-1638	3-PHASE BRD	TMCM-1617	TMCM-1633	TMCM-1636-24V	TMCM-1636-48V	TMCM-1640	STD STEP BRD	TMCM-1070 / PD-1070	TMCM-1076 / PD-1076	MOTION STEP BRD	TMCM-1021 / PD-1021	TMCM-1110-StepRocker	TMCM-1111-StepRocker	TMCM-1140 / PD-1140	TMCM-1141 / PD-1141	TMCM-1160 / PD-1160	TMCM-1161 / PD-1161	TMCM-1180 / PD-1180	TMCM-1210 / PD-1210	TMCM-1211-StepRocker	TMCM-1230	TMCM-1231	TMCM-1240 / PD-1240	TMCM-1241 / PD-1241	TMCM-1260 / PD-1260	TMCM-1270 / PD-1270	TMCM-1276 / PD-1276	TMCM-1278 / PD-1278	CLOSED LP STEP BRD	TMCM-1310	TMCM-1311	TMCM-1316-StepRocker	TMCM-1321	3x MOTION STEP. BRD	TMCM-3110	TMCM-3212	TMCM-3230	TMCM-343	TMCM-351	3x CLOSED LP STEP. BRD	TMCM-3351	6x MOTION STEP. BRD	TMCM-6110	TMCM-6212	TMCM-6214
BLDC DRIVER FEATURES		^						^			^																			^					^						^		^			
INTERFACES & PROTOCOLS		^						^			^																			^					^						^		^			
TMCL Protocol		^						^			^																			^					^						^		^			
SPI		^						^			^																			^					^						^		^			
UART		^						^	k	k	^																			^					^						^		^			
CAN	k	^	k	k	k	k		^			^				k		k		k			k	k	k	k	k	k	k	k	^		k			^	k	k	k	k	k	^	k	^	k	k	k
CANopen	k	^	k	k	k	k		^			^				k		k		k			k	k	k	k	k	k	k	k	^					^	k	k	k	k	k	^	k	^		k	k
RS485	k	^	k				k	^			^	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k				^		k	k	k	^	k	k	k	k	k	^	k	^	k	k	k
USB		^					k	^			^		k	k	k	k	k	k	k		k			k	k	k				^	k	k	k		^	k	k	k		k	^	k	^	k	k	k
RS232		^		k				^			^							k	k											^					^			k	k	k	^	k	^			k
EtherCAT		^	k					^			^																			^	k				^						^		^			
CoE		^	k					^			^																			^	k				^						^		^			

- ADI Trinamic's board-level products and PANdrive smart motors offer a range of commonly used bus interfaces and communication protocols to ease the design in of these turnkey solutions.
- These interfaces are used to access single devices or a large number of nodes in a shared industrial field bus

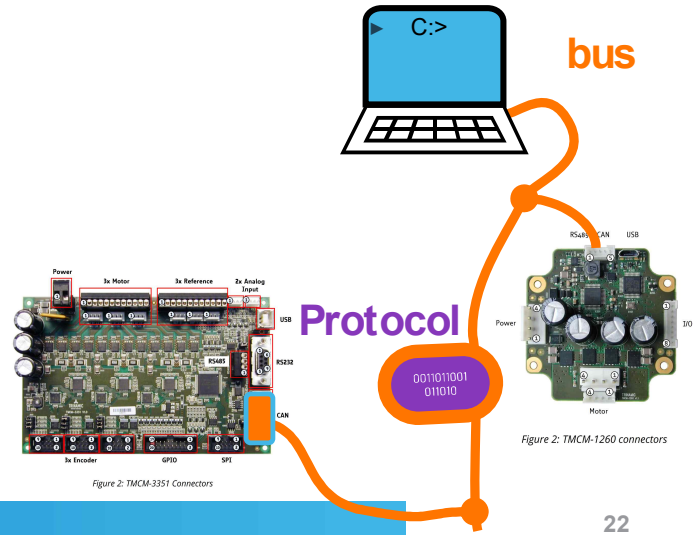


Figure 2: TMCM-3351 Connectors

Figure 2: TMCM-1260 connectors

Up the Stack

General

Trinamic Motion Control - Product Offering

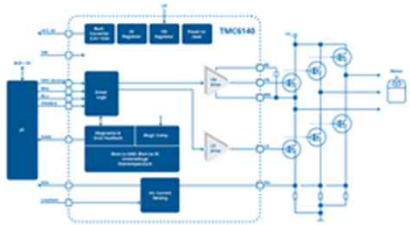
ADI Trinamic™

Solution proposition

PANdrives (Motor + Module)

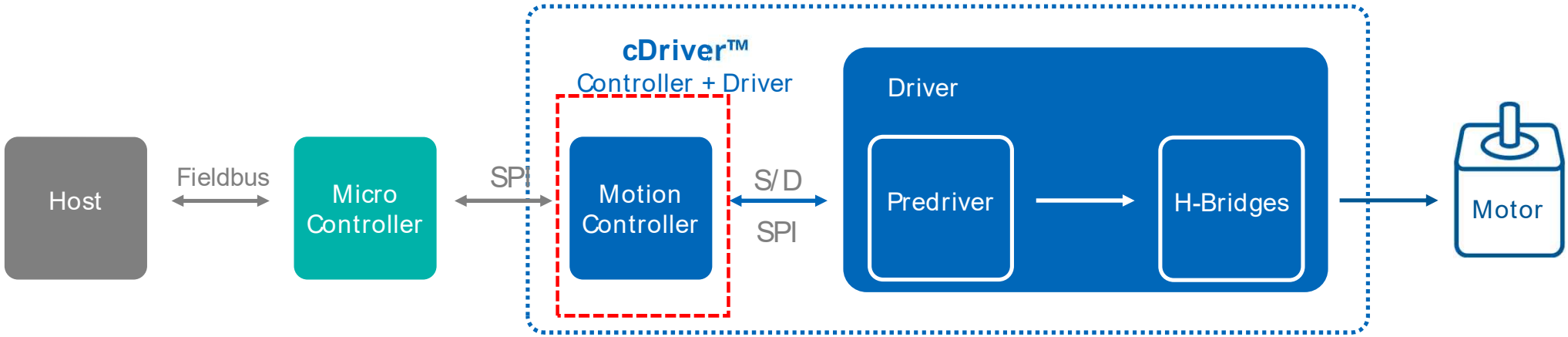
Boards (Module)

ICs



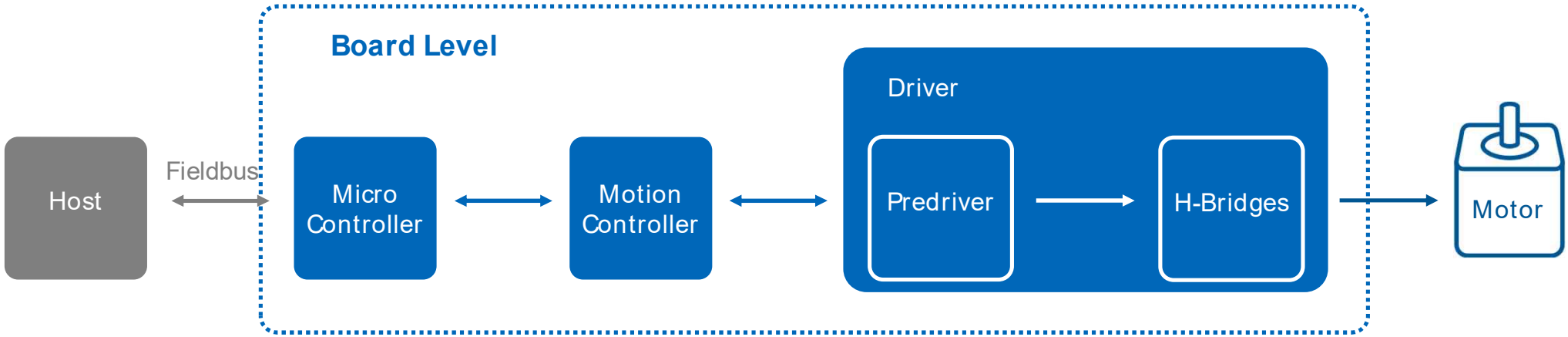
IC Level Solutions

Product	Motor Type / Feature	Product Type	Motor Supply	Phase Current (RMS)	Package
NEW TMC5240	2-Phase Stepper Motor	cDriver™	4,75 – 36 V	2.1A	TQFN32
TMC5130A	2-Phase Stepper Motor	cDriver™	4.75 – 46 V	1.4 A	eTQFP48
TMC5160	2-Phase Stepper Motor	cDriver™	8 – 60 V	Ext. MOSFETs	eTQFP48 / QFN56
TMC4361	S-Shaped Ramping / Closed loop	Motion Controller	digital	-	QFN40
TMC4671	FOC / Closed loop	Motion Controller	digital	-	QFN76



Board Level Turnkey Solutions

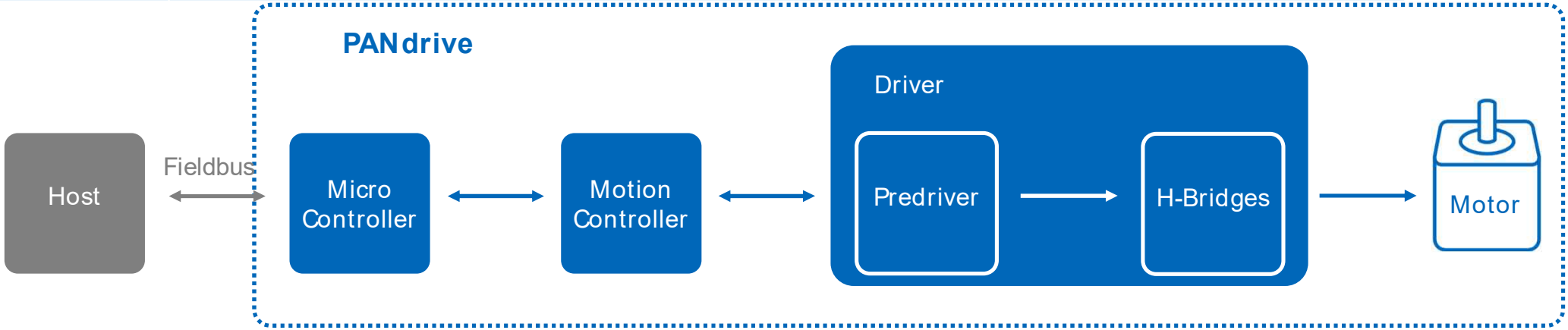
Product	Motor Type	Product Type	Motor Supply	Phase Current (RMS)	Size	Interface
TMCM-1260	2-Phase Stepper Motor	Single Axis Open Loop	12 – 48V	6A	60mm x 60mm 2.36“ x 2.36“	CAN, RS485, USB, GPIO, Encoder
TMCM-3351	2-Phase Stepper Motor	3 Axis S-Ramps Closed loop	12V – 24V max 28V	3A	160mm x 100mm 6.2“ x 3.9“	CAN, RS485, RS232, USB, GPIO, Encoder
TMCM-1640	3-Phase BLDC / EC	Single Axis Board	12V – 24V	5A	42mm x 42mm 1.7“ x 1.7“	RS485, USB, HALL, Encoder
TMCM-1636	3-Phase BLDC / EC	Single Axis Board	12V - 24V 12V – 60V	30A 20A	45mm x 90mm 1.8“ x 3.5“	CAN, HALL, ENCODER



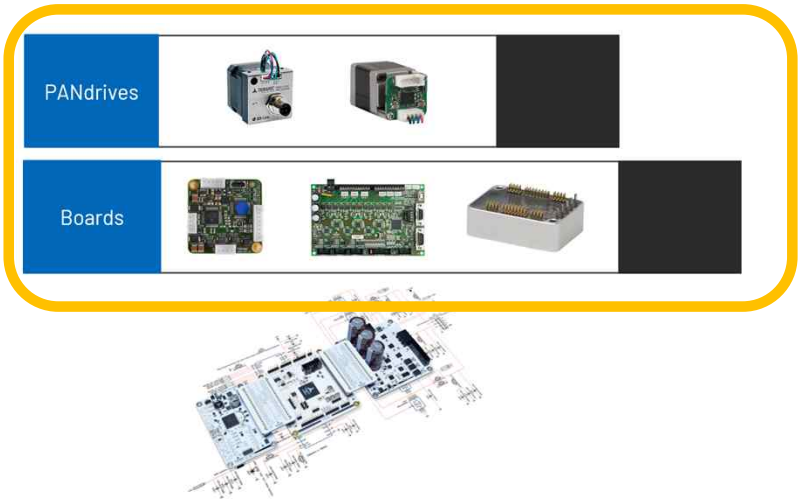
Smart Motor Turnkey Solutions

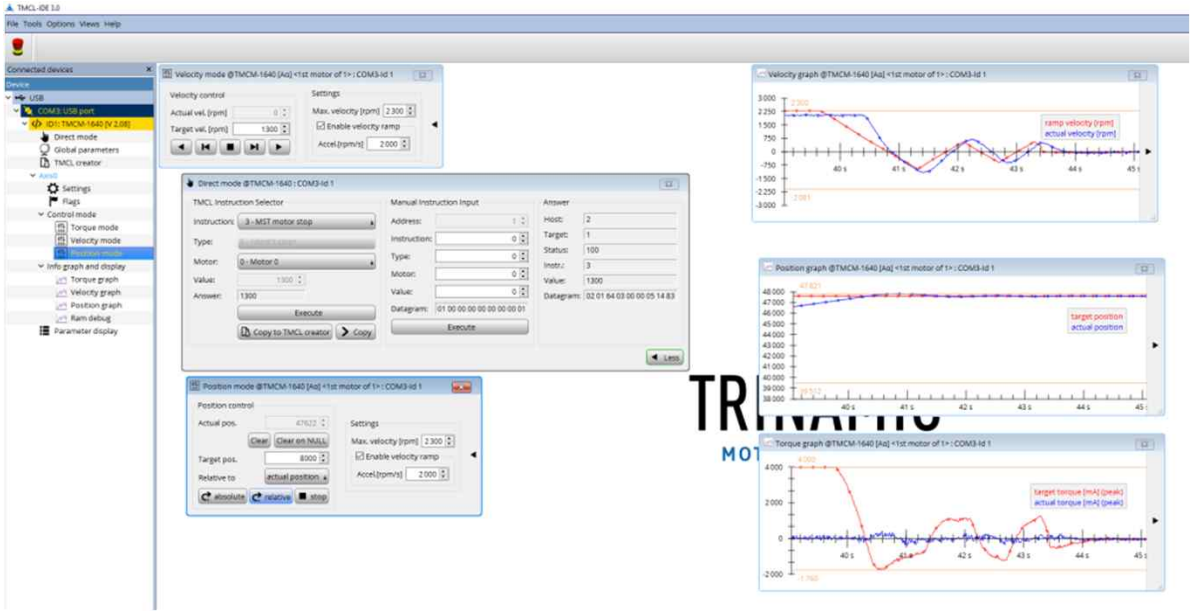
ADI Trinamic™

Product	Motor Type	Product Type	Motor Supply	Phase Current (RMS)	Size	Interface
PD42-X-1140 -TMCL -CANopen	2-Phase Stepper Motor	Open Loop	12V – 24V	22Ncm - 70Ncm	42mm x 42mm (NEMA17)	CAN, RS485, USB, GPIO,
PD57/60-X-1378 -TMCL -CANopen	2-Phase Stepper Motor	Closed loop	12V – 48V	55Ncm - 310Ncm	57mm x 57mm 60mm x 60mm NEMA23 / NEMA24	CAN, USB, GPIO, Ref
PD42-1-1243 -IOLINK	2-Phase Stepper Motor	Open loop	12V – 24V	27Ncm	42mm x 42mm (NEMA17)	IOLINK
PD42-X-1670 -TMCL -CANopen	BLDC / EC	FOC Servo	12V – 24V	6.25Ncm - 18.5Ncm	42mm x 42mm (NEMA17)	CAN , GPIO, Ref



Trinamic Software – TMCL-IDE

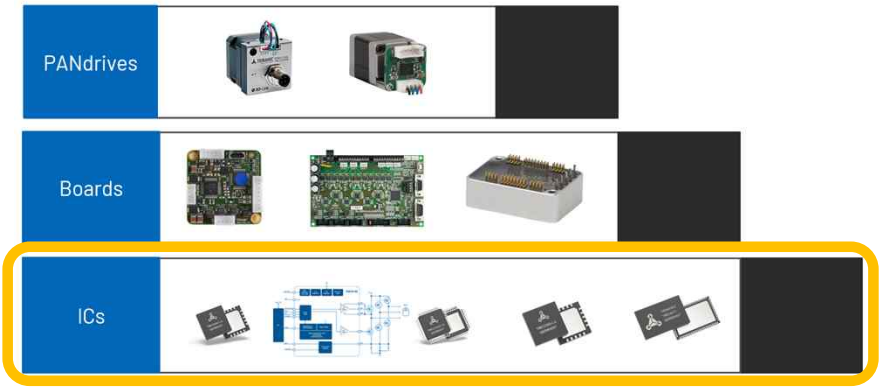


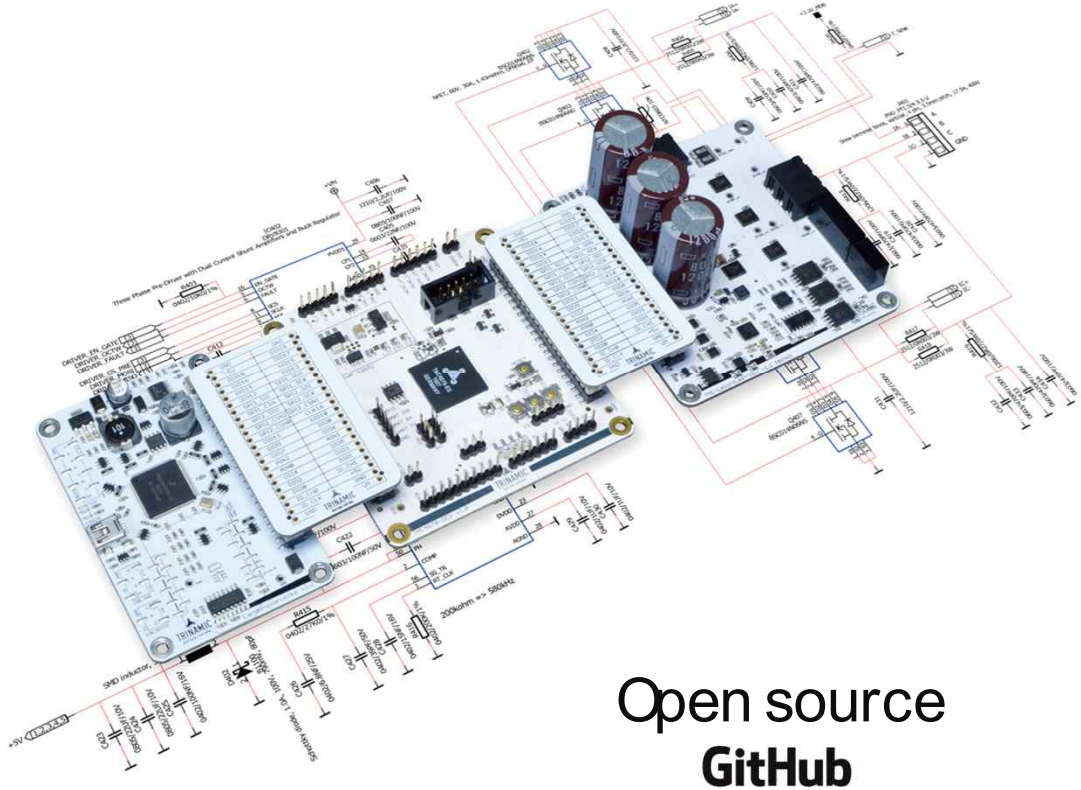


Free Software

- TMCL-IDE

Trinamic Software – Eval-System



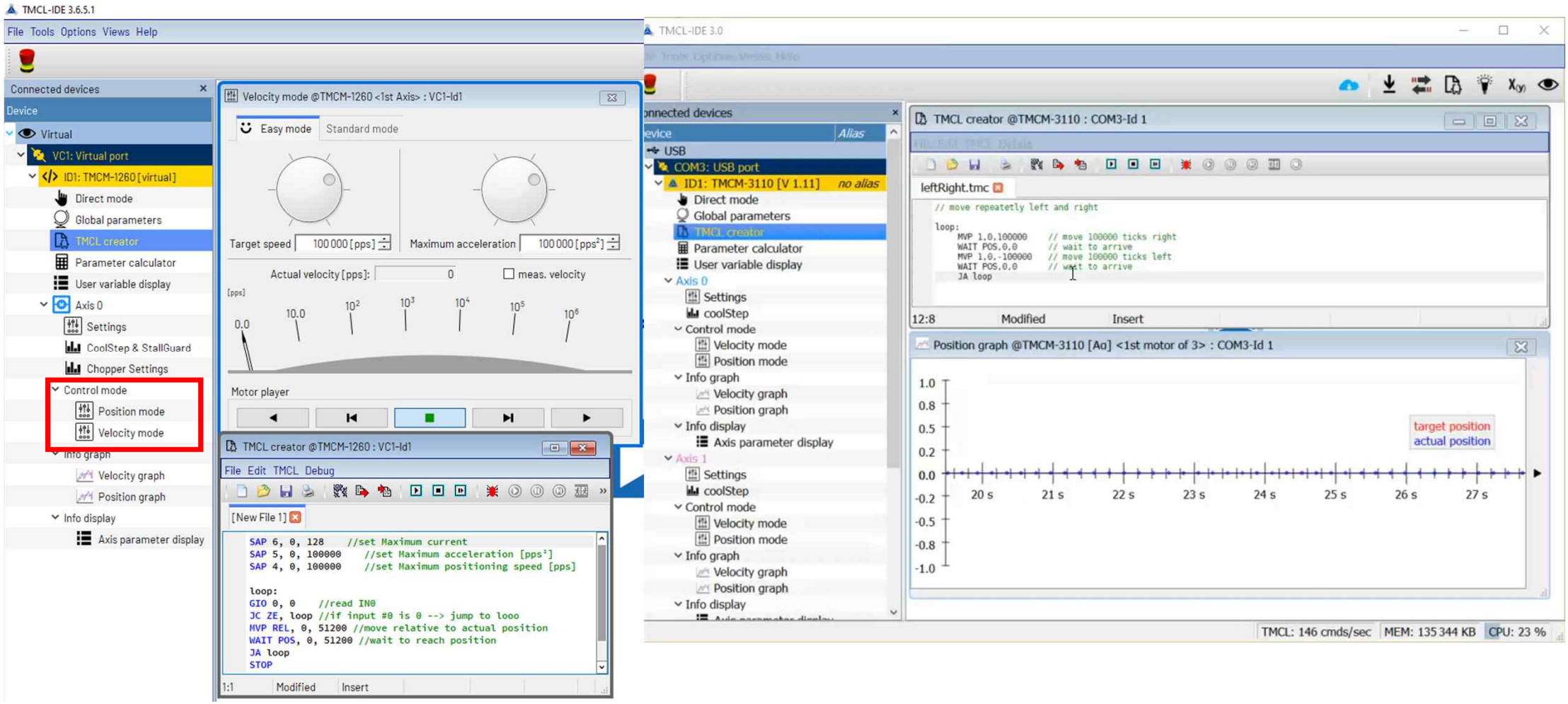


Open source

GitHub

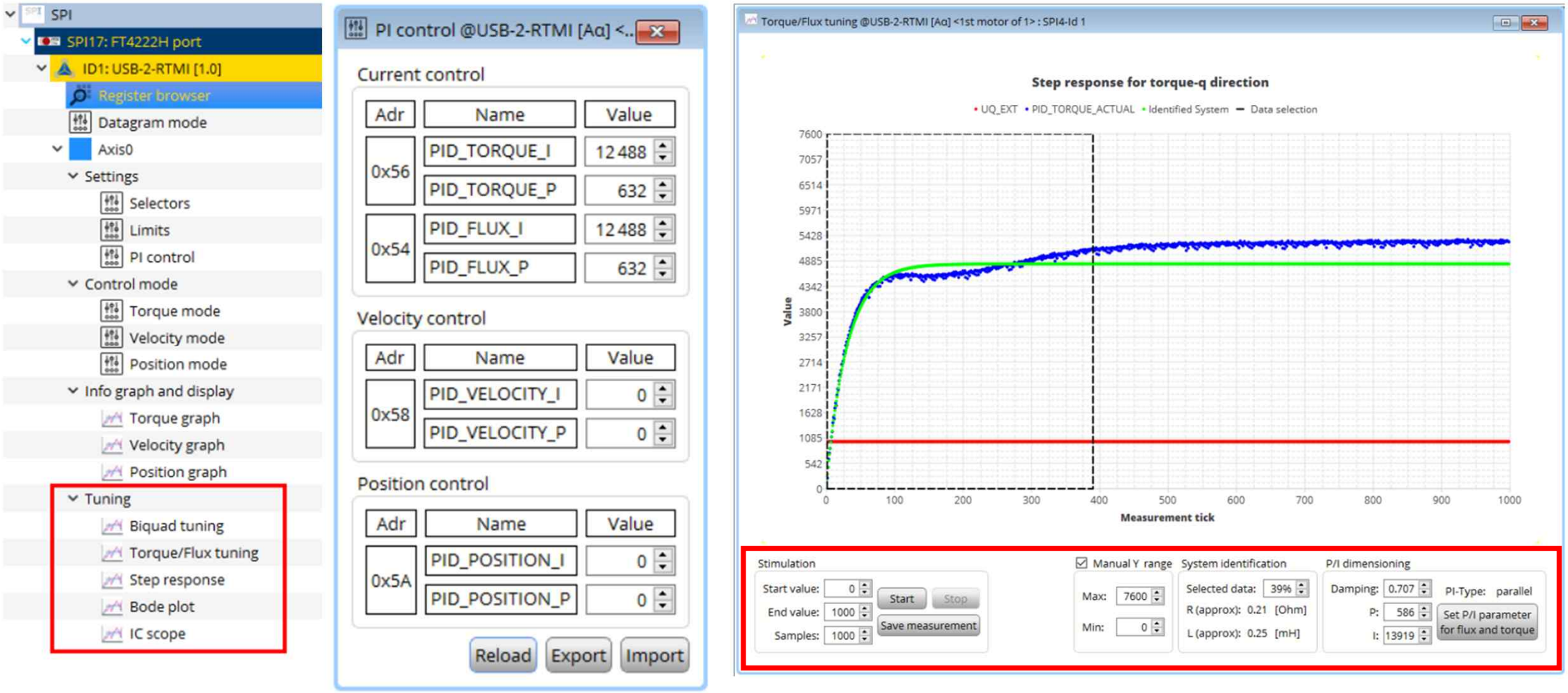
- TMC-EvalSystem

TMCL-IDE (Step-motor)



https://www.analog.com/en/resources/evaluation-hardware-and-software/motor-motion-control-software/tmcl-ide.html

TMCL-IDE(BLDC-motor)



https://www.analog.com/en/resources/evaluation-hardware-and-software/motor-motion-control-software/tmcl-ide.html

Actual application

General