

MPS Angular Sensor & Motor Driver Introduction

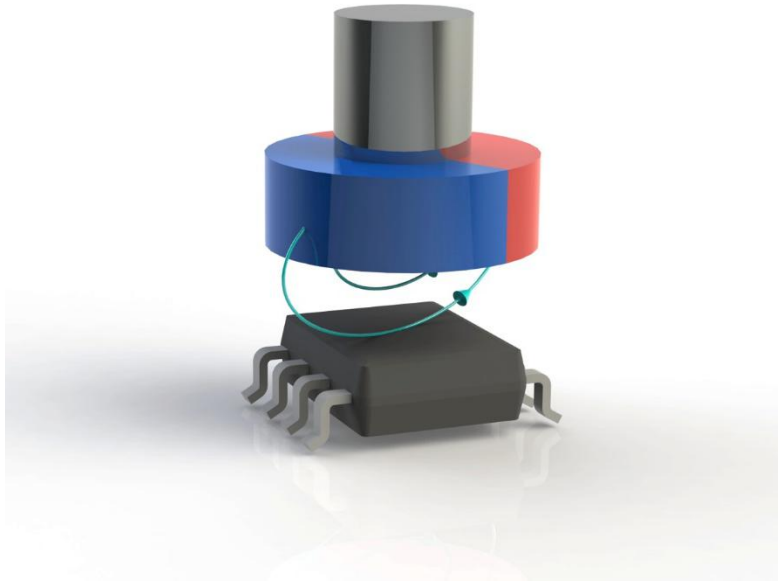
Vic.Huan

2019.10

Outline

- **MPS Angular Sensor Basic Introduction**
 - MagAlpha Application Background
 - MagAlpha Basic Function
 - Basic Principle
- **MPS Angular Sensor Application Share**
 - MA7XX Application
 - MA3XX Application
 - MA8XX Application
- **MPS Angular Sensor New Products Update**
 - MA780
 - MA731/2
 - MAQ430/470
- **MPS Angular Sensor Design Tool**
- **MPS Motor Driver Introduction**
 - BDC
 - Stepper
 - 3-phases BLDC
 - FOC

What is a MagAlpha?



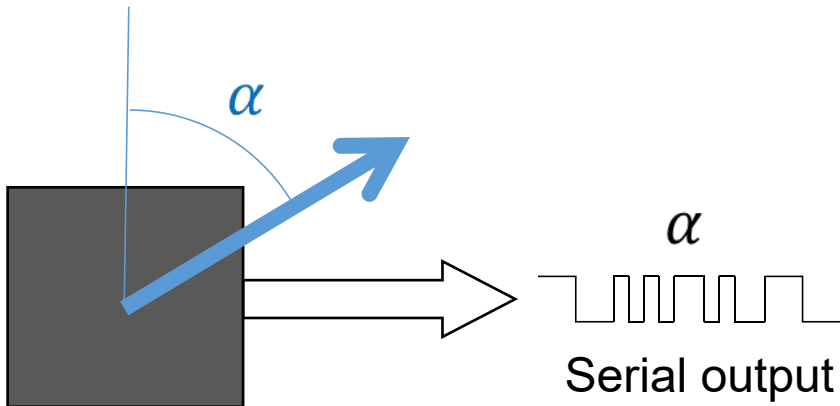
Sensor output:

Absolute direction of the magnetic vector in the die plane

➔ Contactless digital angle sensor

Where can it be used?

- Motor position control (servo)
- Speed control
- BLDC commutation
- Manual knobs and commands
- Etc.



MPS Angular Sensor Application

•Basic BLDC Motors



Hi-end Toys



Power Tools



Appliances



Industrial Automation

•Speed-Controlled Drives



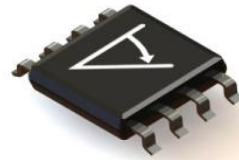
Machining



Servo Motor



Knobs



Interface Devices



Industrial Encoders



Automotive



Robotics



Drones



Gimbals

•Rotary Encoders

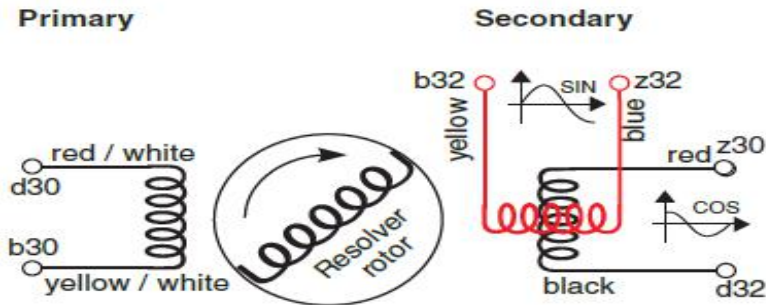
•Position-Controlled Drives

General Angular Sensors Comparison

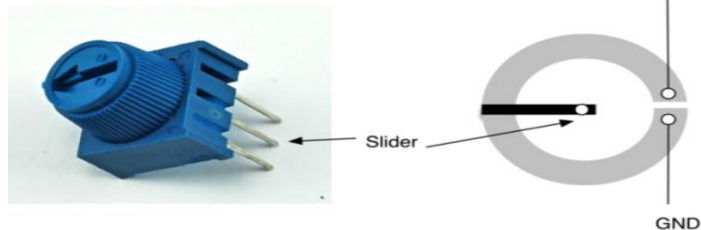
Optical Encoder



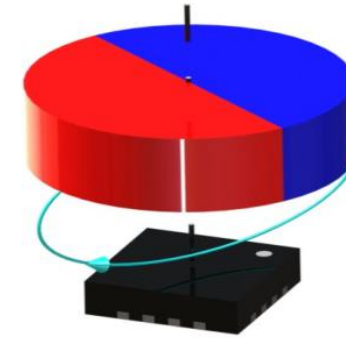
Resolver Generator



Potentiometer



Single Chip Magnetic Angle Sensor



VS.

- ✓ Low cost
 - ✓ High precision *
 - ✓ High speed *
 - ✓ Side-of-shaft ability *
 - ✓ Tiny system profile *
 - ✓ Extremely long life
 - ✓ Easy adjustable *
- * MPS Product Advantages**

Key Advantages of MPS Angular Sensors

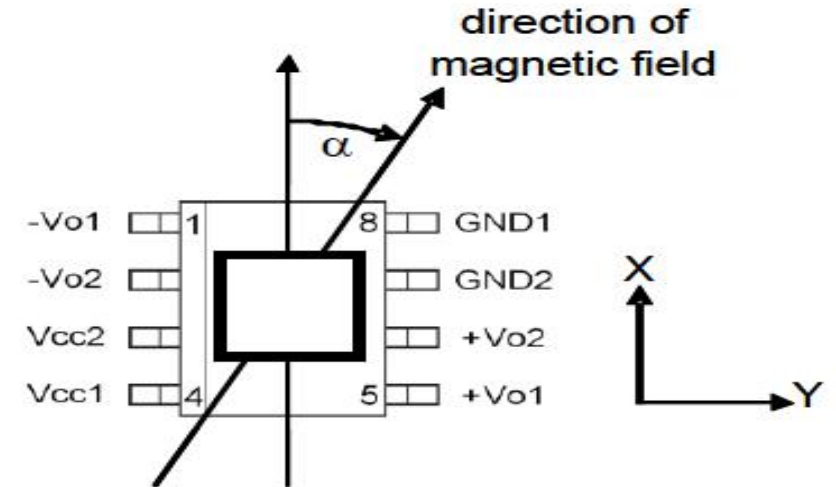
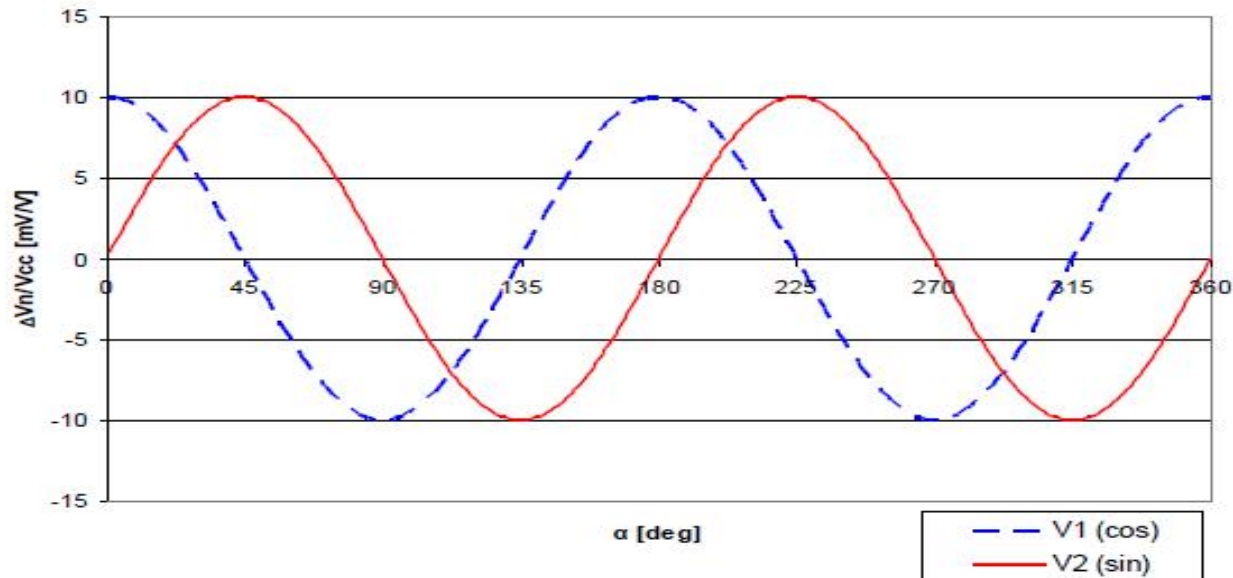
MagAlpha Key Advantages

- **Side-Shaft Mounting Possible**
- **High Sampling Frequency** **500k to 1000 kHz**
- **Ultra-Short Latency** **3 μ s**
- **Small Package** **QFN3mmx3mm**
- **Short Power-Up Time** **25 μ s**
- **Moderate Power Consumption** **7~12mA**

Traditional Magnetic Sensors

What is common in **competitors'** magnetic sensors?

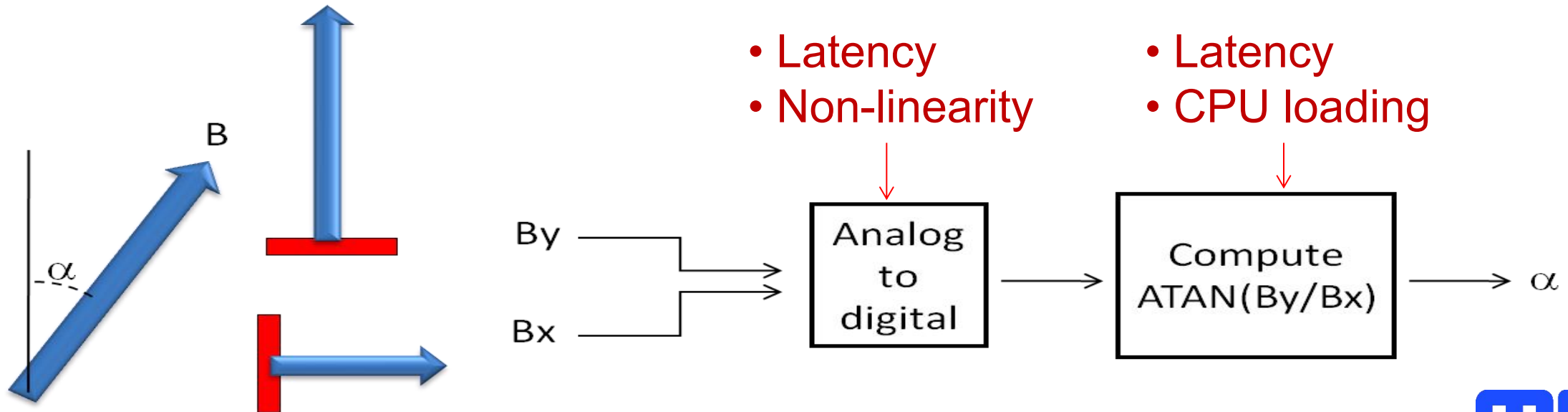
- Based on two component (X,Y) voltage measurement
- Voltage is converted to digital domain
- Angle is computed with complex arctan algorithm



Traditional Magnetic Sensors

Limitation of competitors' traditional solutions?

- Latency
- Non-linearity
- Size
- Current consumption

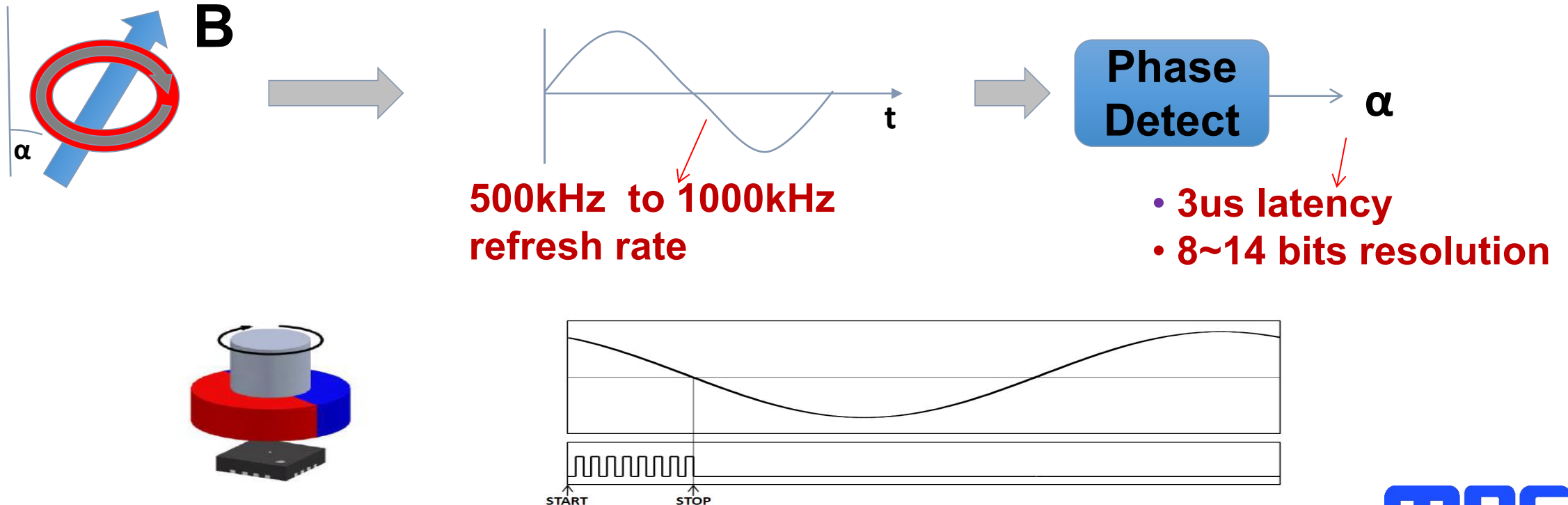


Basic Principle of MPS Angular Sensors

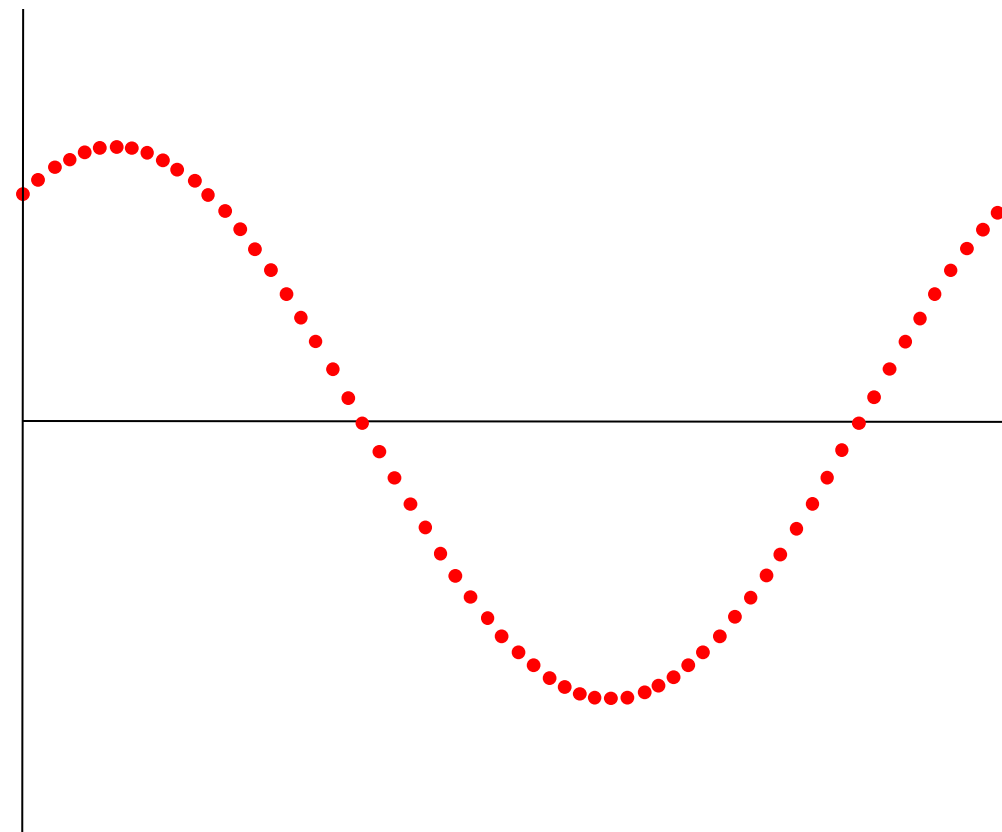
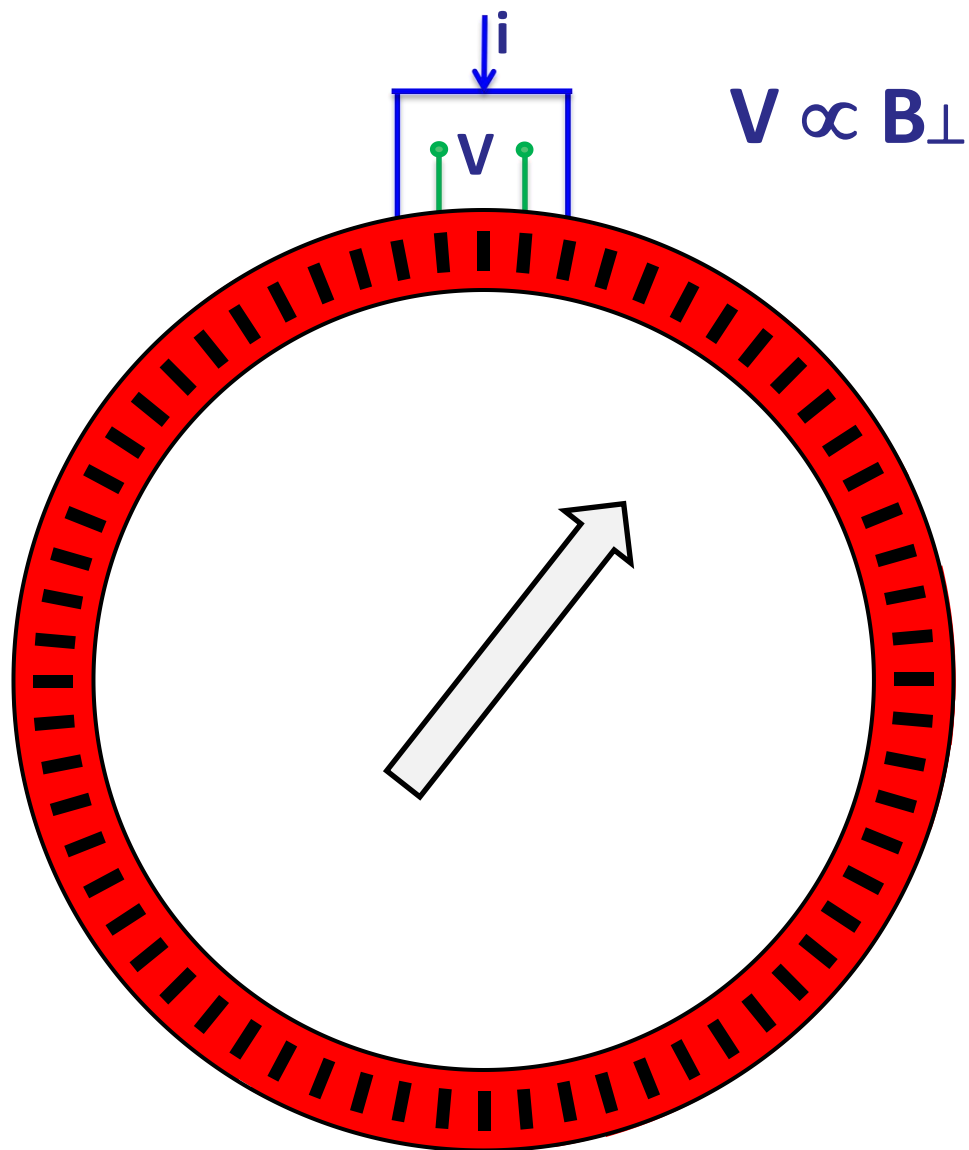
MPS unique solution of Spinaxis:

Instead of using digitized amplitudes.

We measure the angle by phase detection.

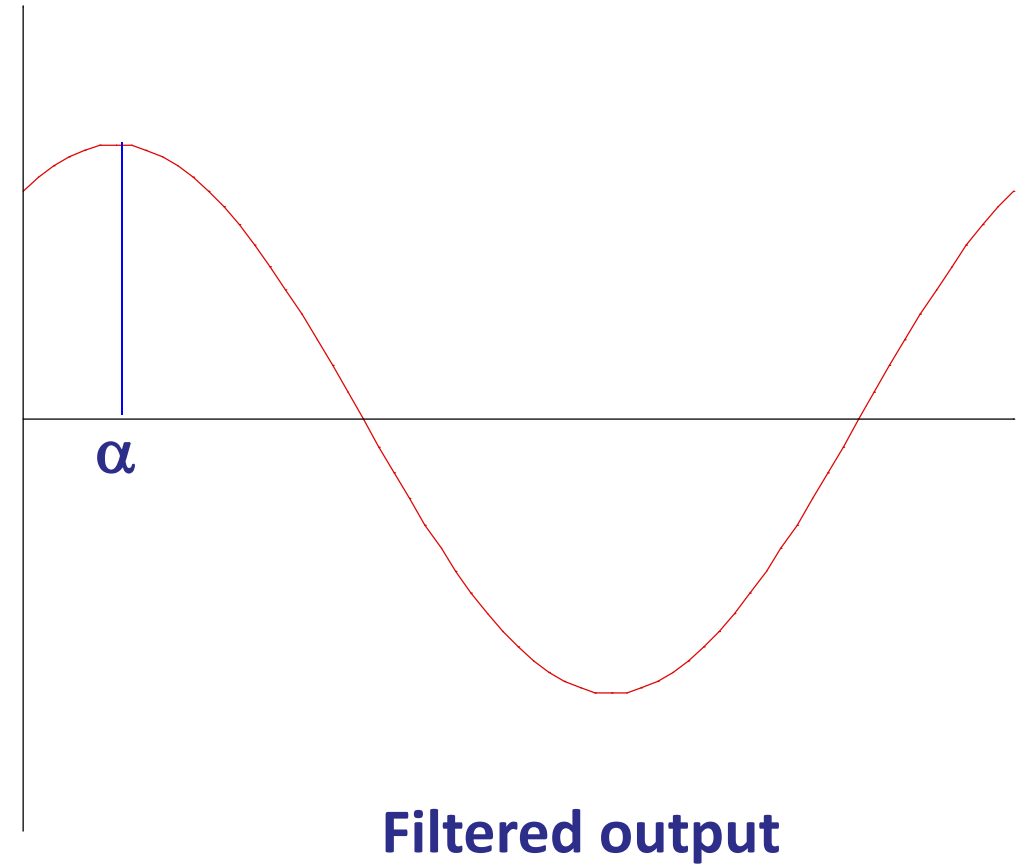
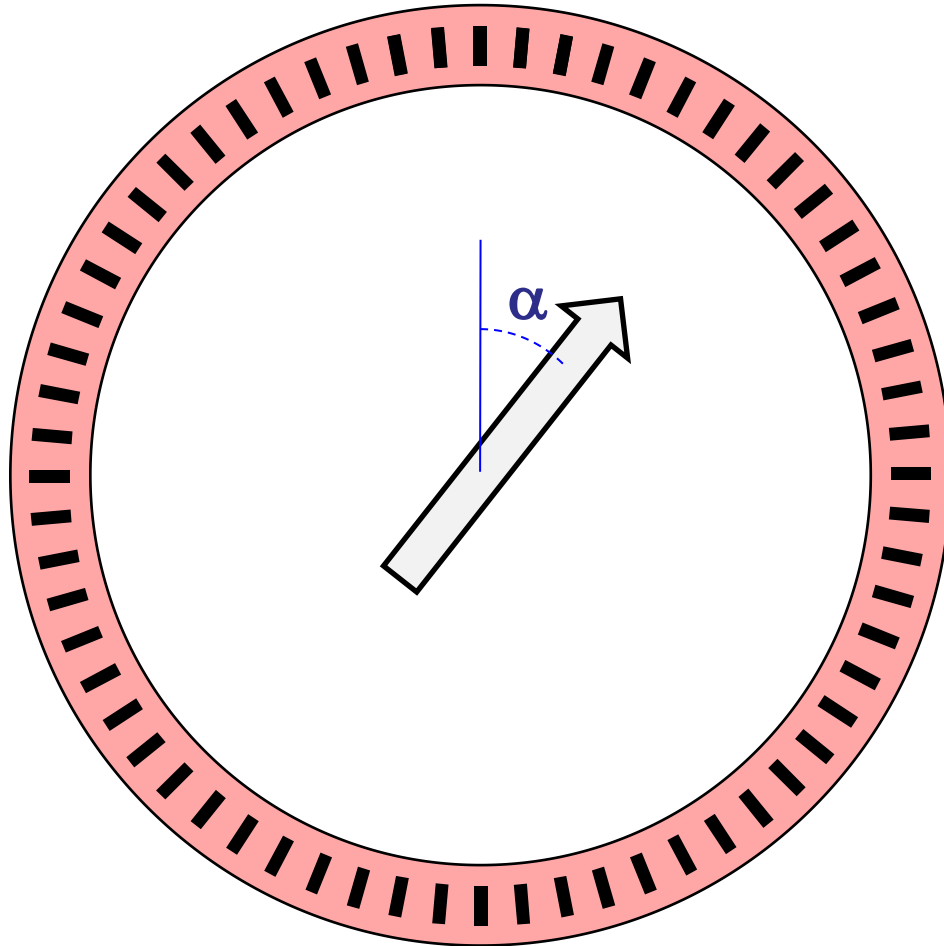


Basic Principle of MPS Angular Sensors



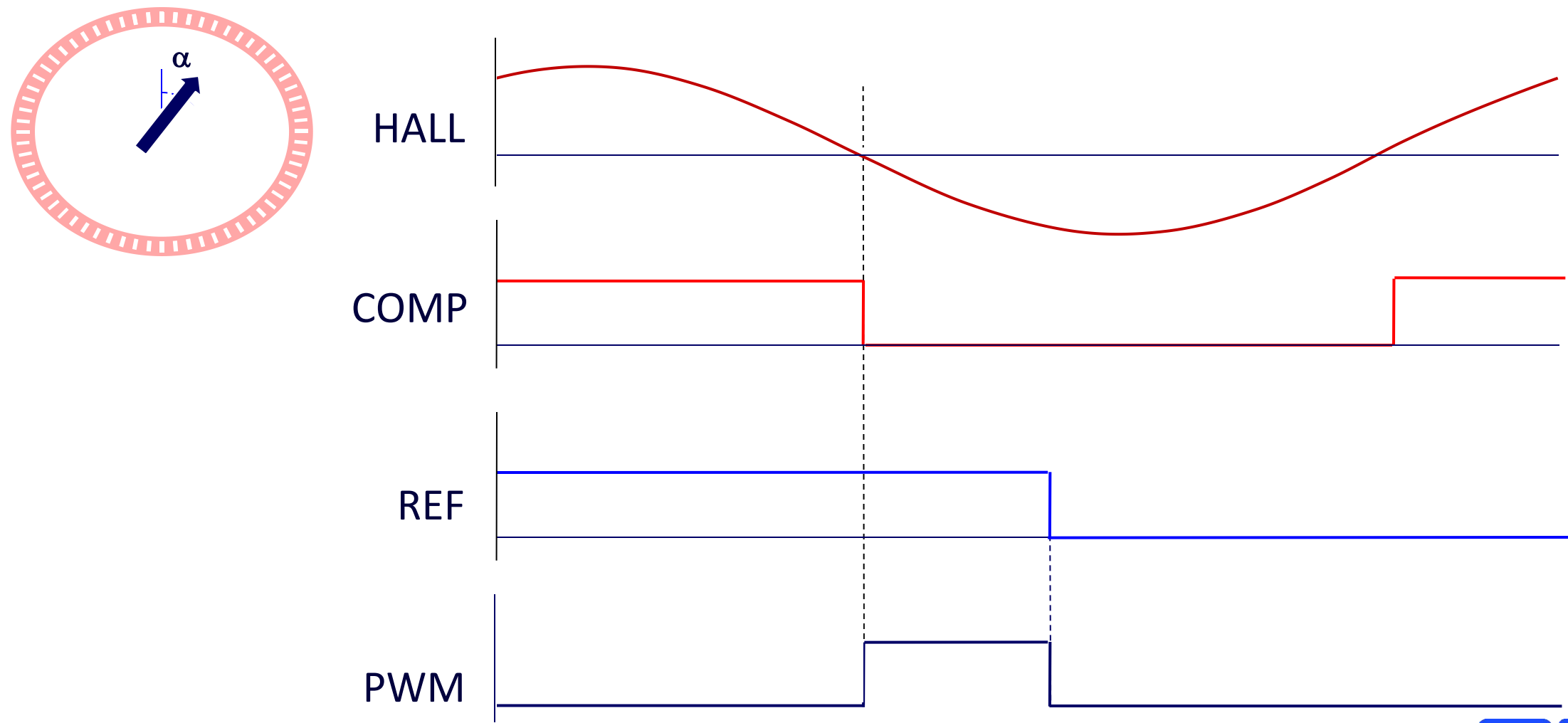
Basic Principle of MPS Angular Sensors

How does *Spinaxis* work?

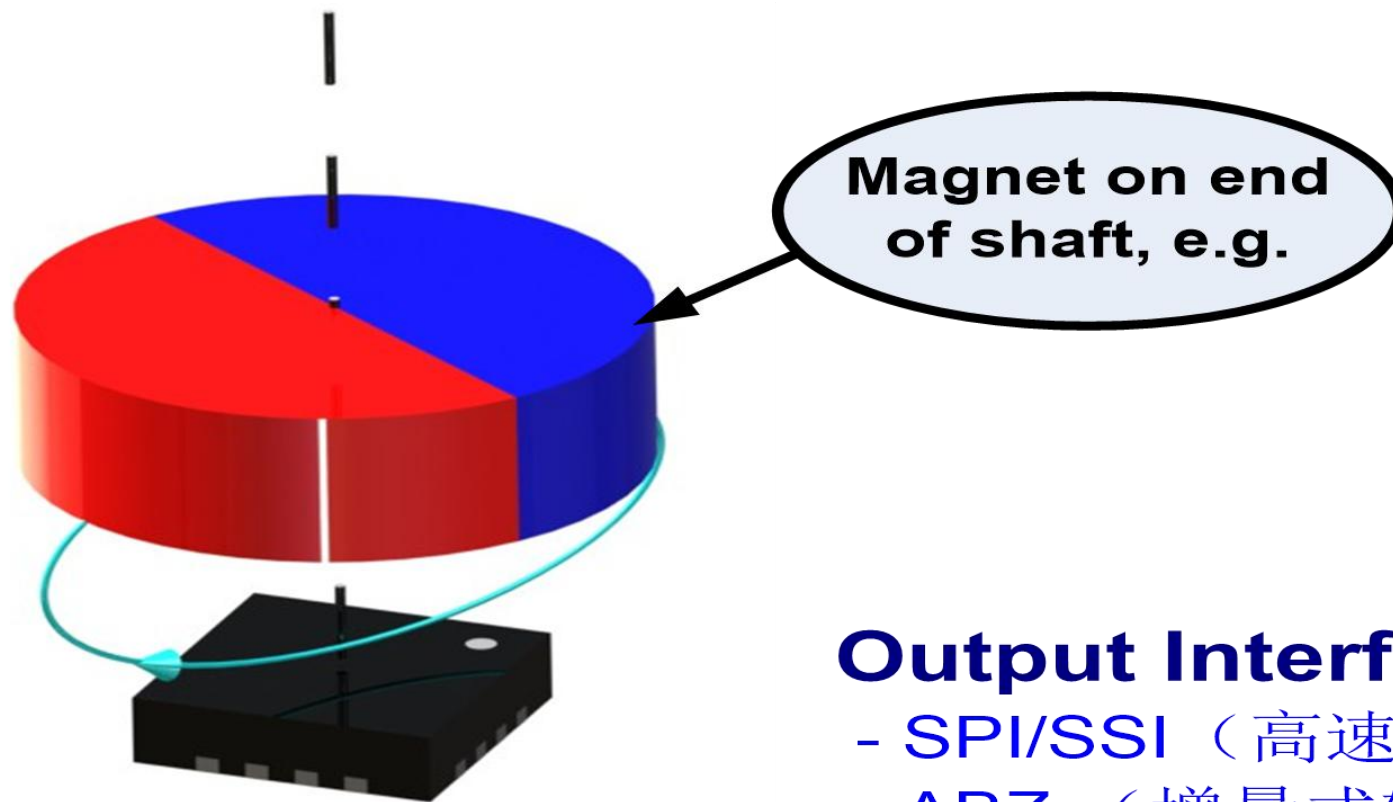


Basic Principle of MPS Angular Sensors

How does *Spinaxis* work?



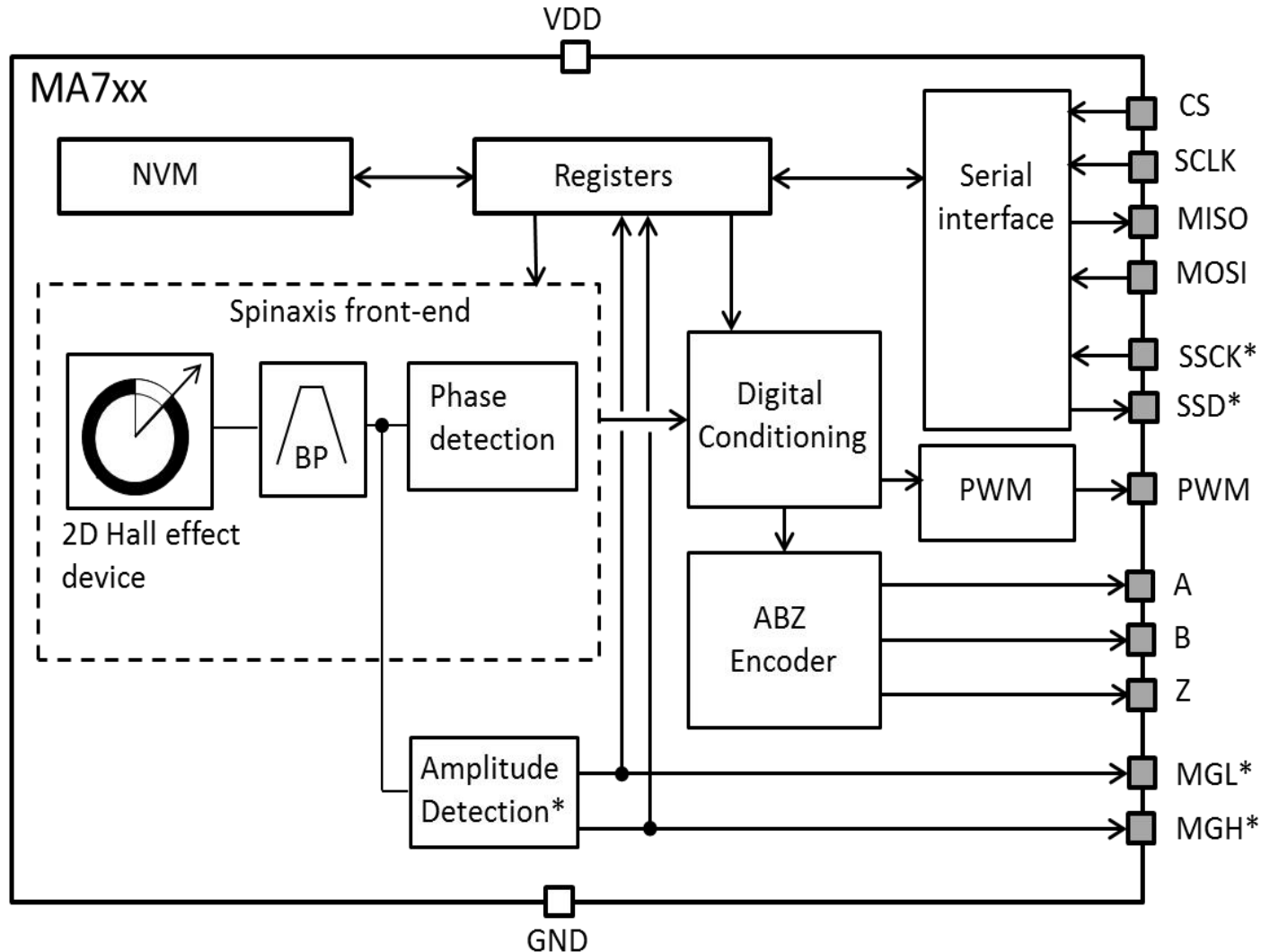
Output Interface of MPS Angular Sensors



Output Interface:

- SPI/SSI (高速串行数字绝对值输出)
- ABZ (增量式输出)
- UVW (无刷电机换向信号输出)
- PWM (脉宽输出接口)
- MGH/MGL (磁场强/弱阈值检测)

MA730/MA710/MA702 Introduction



SPI & SSI

Absolute angle 12-14 bit resolution

PWM

12-14 bit resolution

ABZ Incremental

10-12 bit

Prog. 1-1024 pulses per channel

Prog. 4-4096 edges per turn

Field Strength Detection

High/low thresholds

Programmable

P2P Compatible

MPS Sensors for Encoder Applications

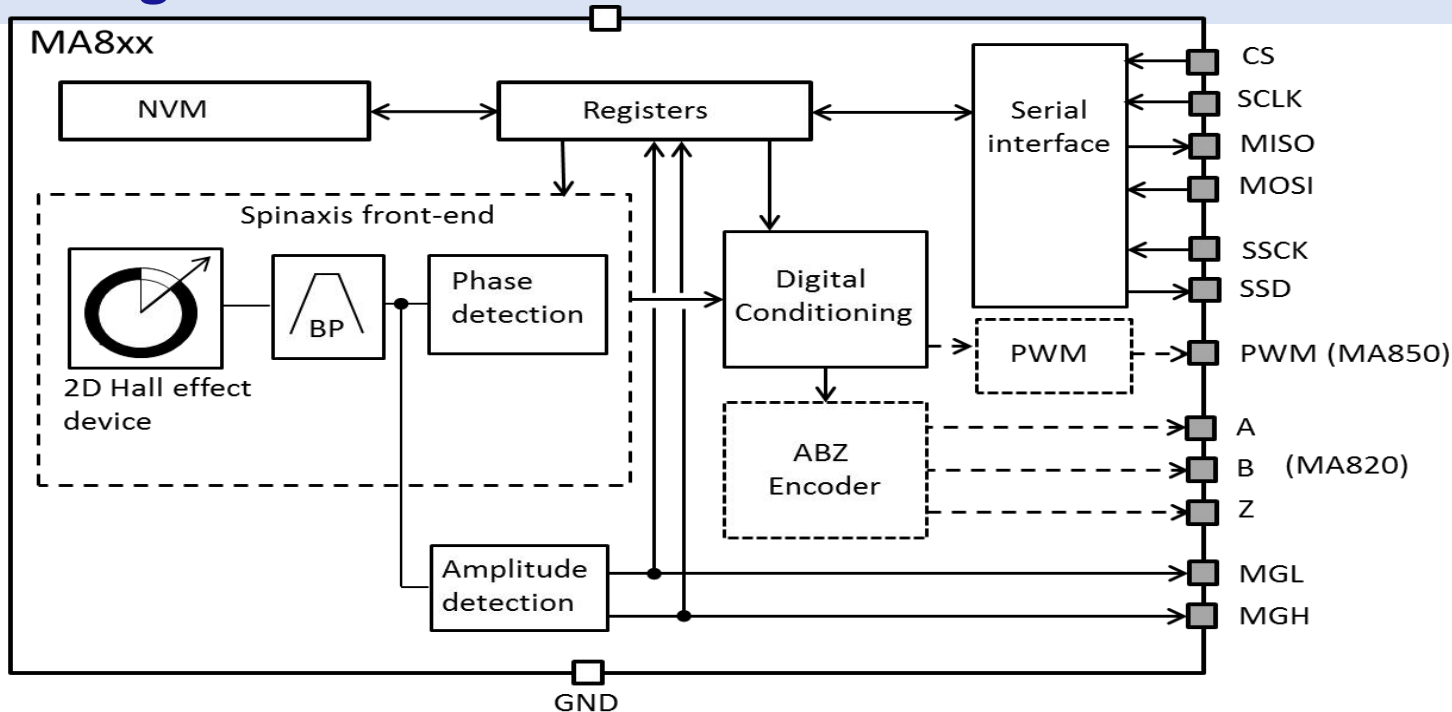
Features by Part		Rotary Angular Sensors			
		MA700 Digital & ABZ	MA702 Digital & ABZ	MA710 Side-shaft Optimized Digital & ABZ	MA730 High-resolution Digital & ABZ
Effective angle resolution	bit	11	12	12	14
Dynamic response		Fast	Fast	Medium	Medium
Magnetic field range	mT	30 .. 150mT	30 .. 150	15 .. 150	40 .. 150
Zero setting		✓	✓	✓	✓
Side-shaft compensation		✓	✓	✓	✓
Adjustable direction			✓	✓	✓
SPI register configuration		✓	✓	✓	✓
Absolute angle on SPI	bit	11	12	12	14
Absolute angle on SSI	bit		12	12	14
ABZ incremental		✓	✓	✓	✓
ABZ resolution	PPR	256	1 .. 256	1 .. 256	1 ..1024
Adjustable Z pulse			✓	✓	✓
PWM output			✓	✓	✓
PWM resolution	bit		12	12	14
Magnetic field detection			✓	✓	✓

MPS Sensors for Motor Applications

Features by Part		Motor Commutation		Position Controlled Drivers		
		MA100 High Speed	MA102 High Speed	MA300 High Speed	MA302 High Speed	MA310 Side-shaft opt
Absolute angle on SPI	bit	8	8	11	12	12
Dynamic response		high	high	high	high	medium
Magnetic field range	mT	30 .. 150	30 .. 150	30 .. 150	30 .. 150	15 .. 150
Zero setting		✓	✓	✓	✓	✓
Side-shaft compensation		✓	✓	✓	✓	✓
Adjustable direction			✓		✓	✓
SPI register configuration		✓	✓	✓	✓	✓
ABZ incremental				✓	✓	✓
ABZ resolution	PPR			256	1 .. 256	1 .. 256
Adjustable Z pulse					✓	✓
UVW output		✓	✓	✓	✓	✓
UVW pp per rev.		1	1 .. 8	1	1 .. 8	1 .. 8
Differential UVW			✓			
Magnetic field monitoring			✓		✓	✓

MPS Sensors for Turning Knobs

- Potentiometer Replacement / Rotary User Interfaces with optional push button
- White Goods / Industrial Man-Machine interface / Automotive Infotainment, etc.
- 8-bit angle resolution via SPI/SSI + programmable ABZ (1-64)
- Field Strength detection for Push Button applications
- Programmable zero offset

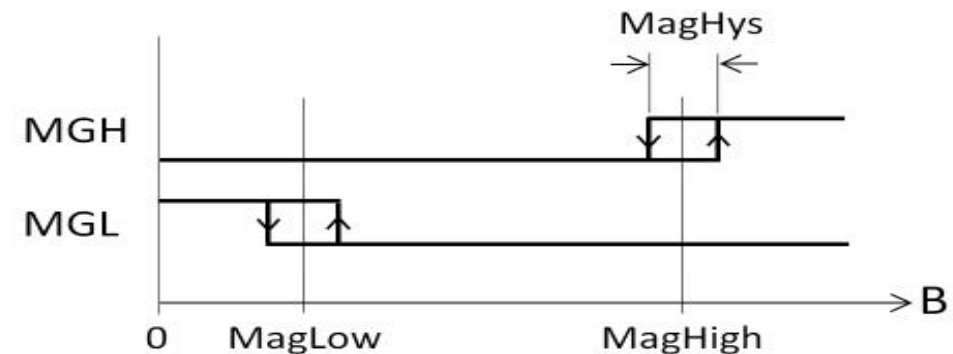
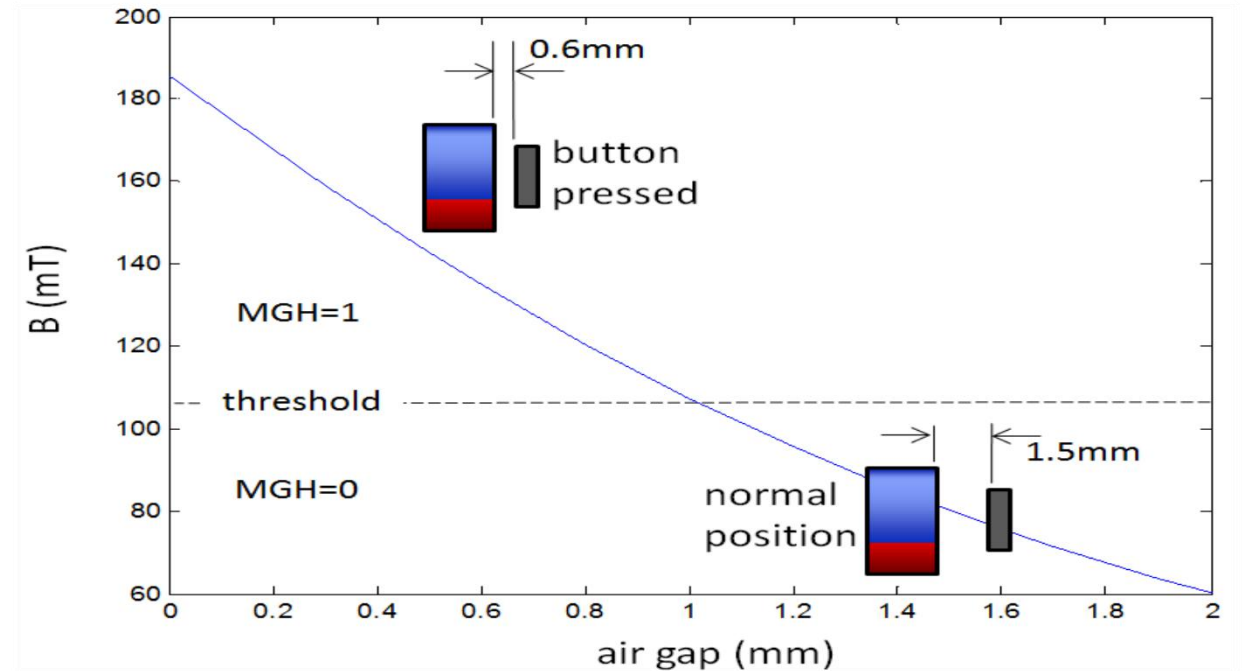
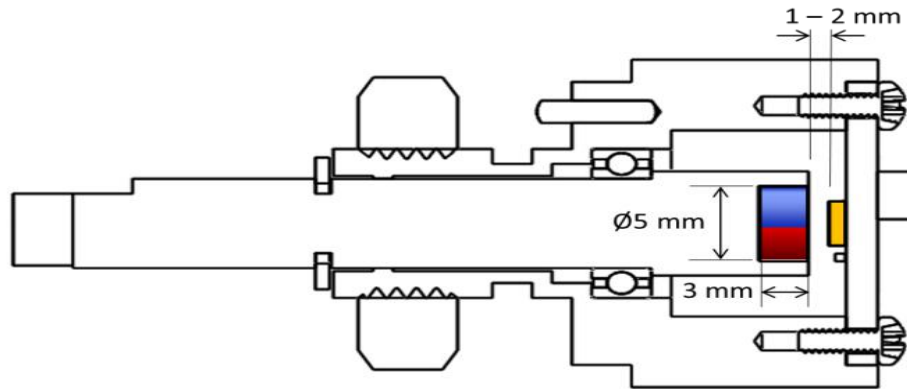


MPS Sensors for Turning Knobs

Features by Part		Turning Knob Applications		
		MA800	MA820	MA850
	Unit	Digital Out	ABZ Incremental Out	PWM Out
Effective angle resolution	bit	8	8	8
Magnetic field range	mT	30 .. 150	30 .. 150	30 .. 150
Zero setting		✓	✓	✓
SPI register configuration		✓	✓	✓
Absolute angle on SPI	bit	8	8	8
Absolute angle on SSI	bit	8	--	--
ABZ incremental			✓	
ABZ resolution	PPR		1 .. 64	
PWM output		.	.	✓
PWM resolution	bit			8
Magnetic field detection		✓	✓	✓

Field Strength Detection

- Two independent detection thresholds
- Thresholds configurable between 15 ... 150mT
- Output pins and register flags

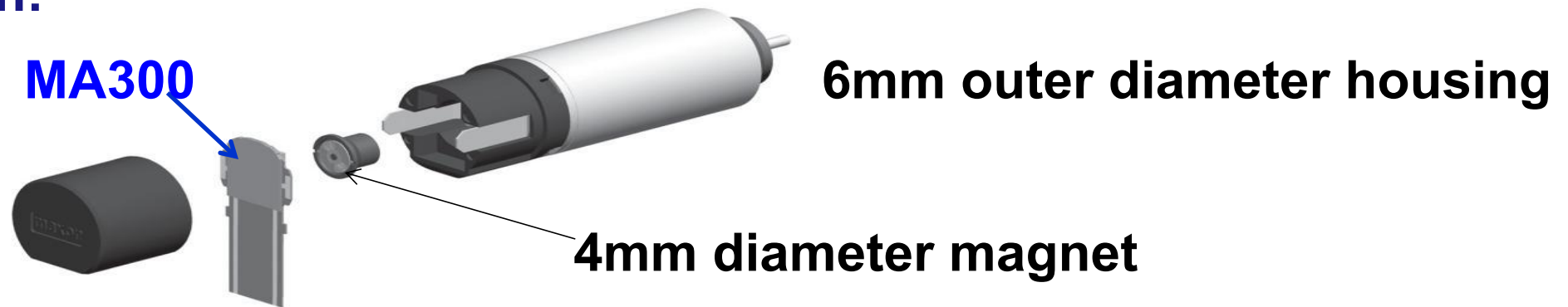


Application Stories Share--MA300 for Mini Motors

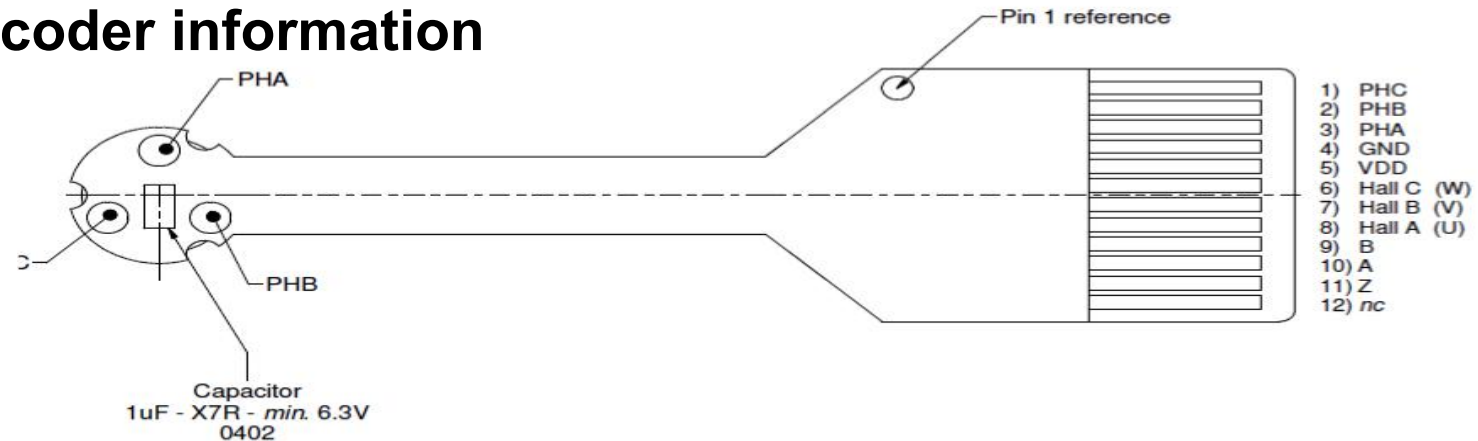
Customer's problem:

Motor diameter is too small for hall switches.

MPS Solution:

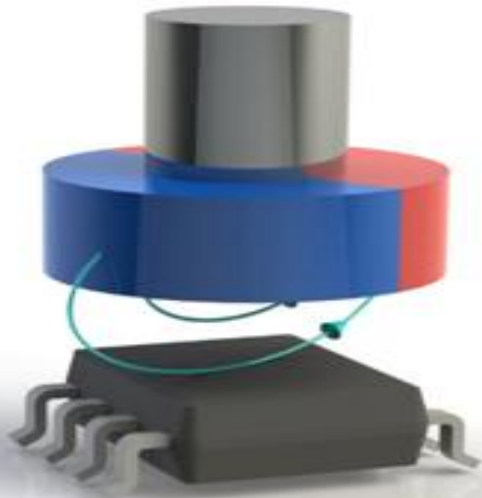


In addition: provide encoder information

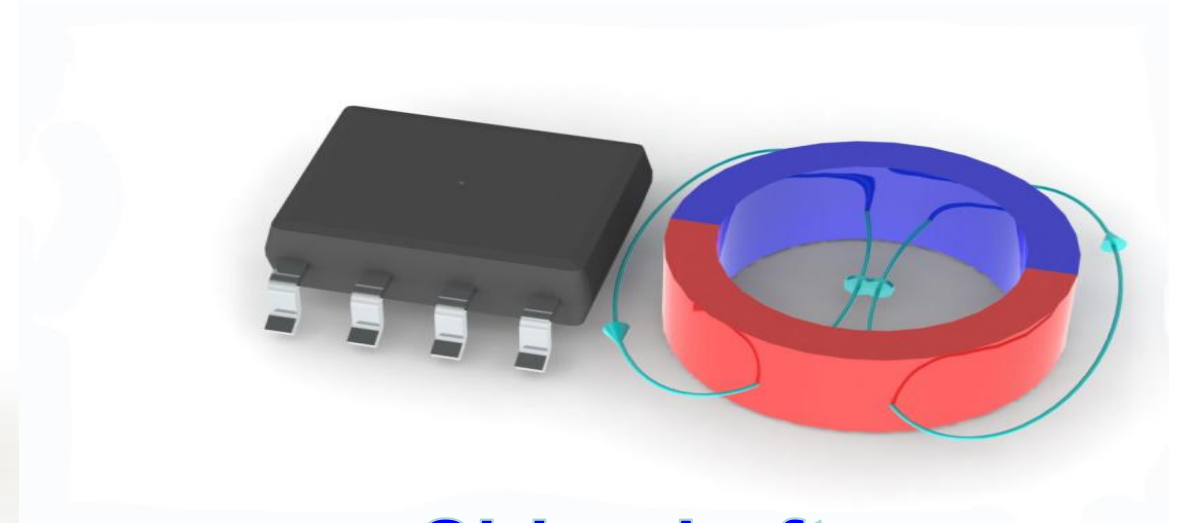


MPS Magnetic Angular Sensors

Feasible mechanism with the same device!~

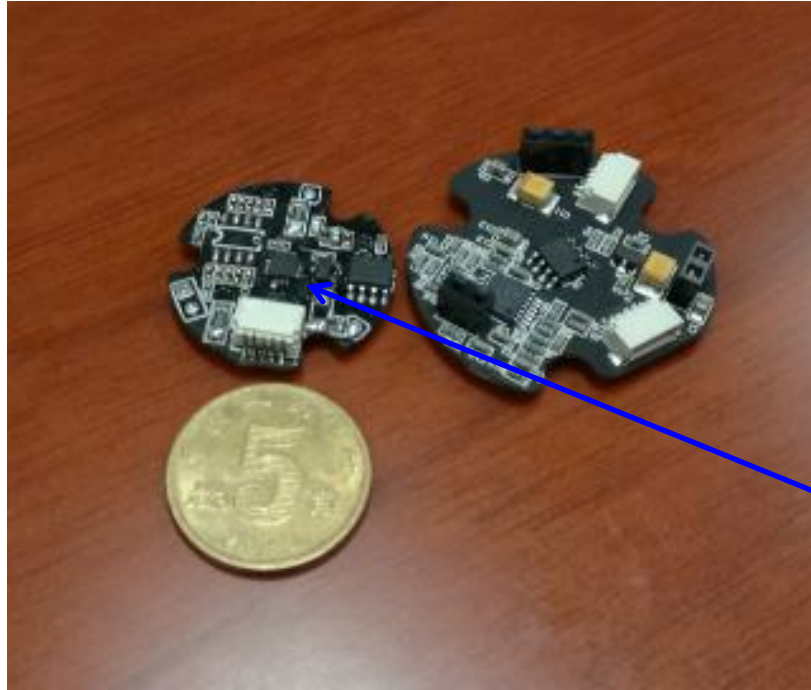


End-of-shaft

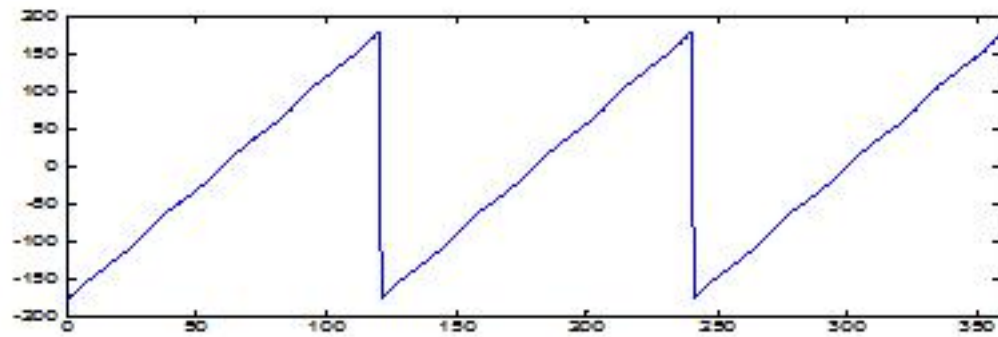
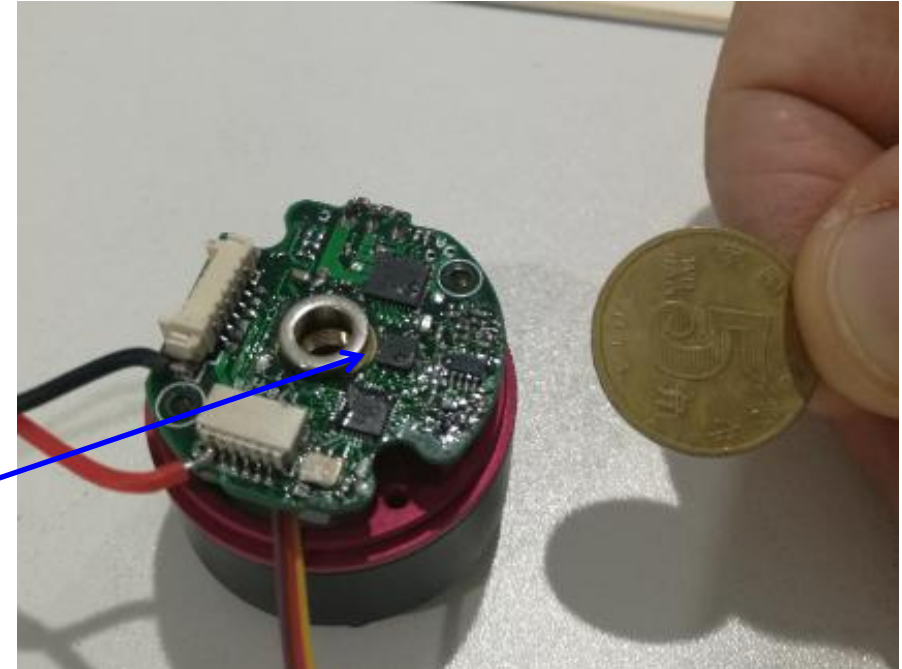


Side-shaft

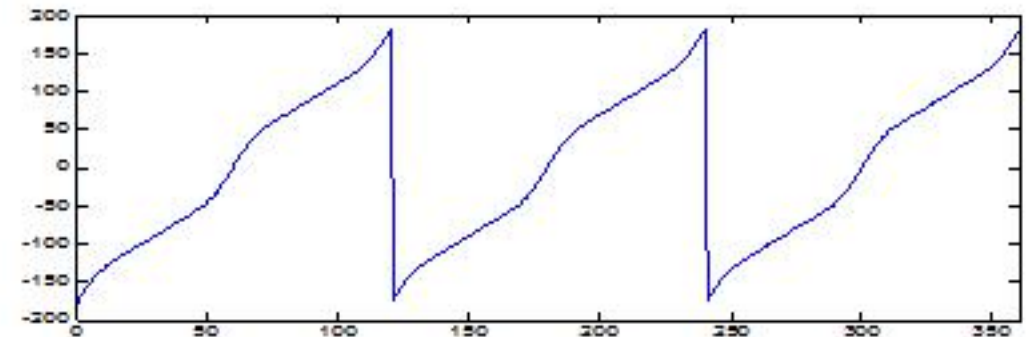
Application Stories Share--MA730 for Gimbals



MA730

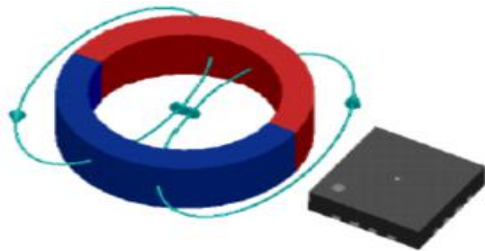


Sensor output with BCT trimming

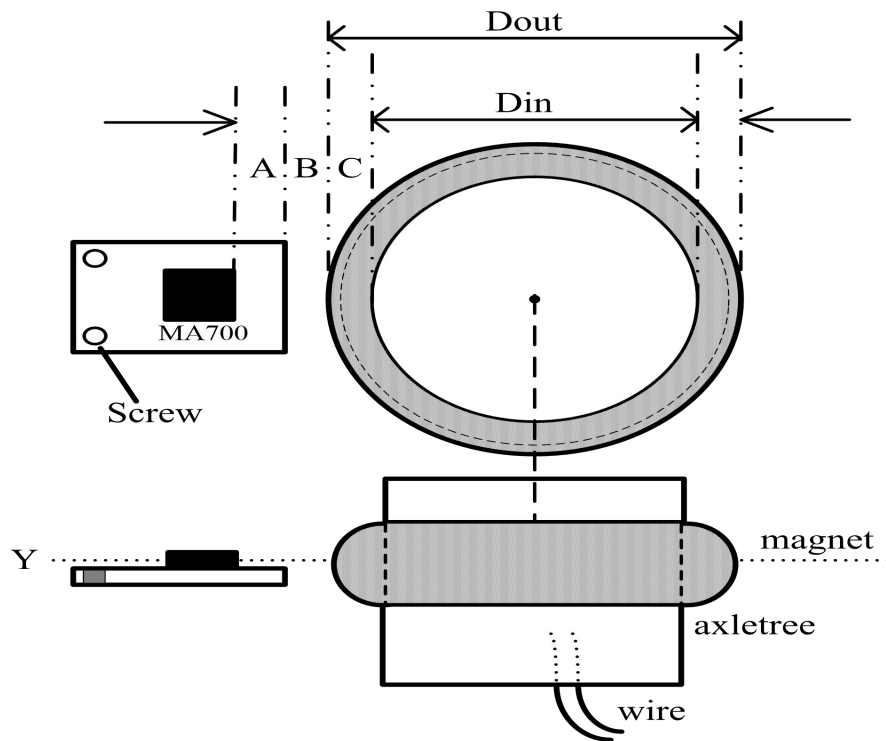


Sensor output without BCT trimming

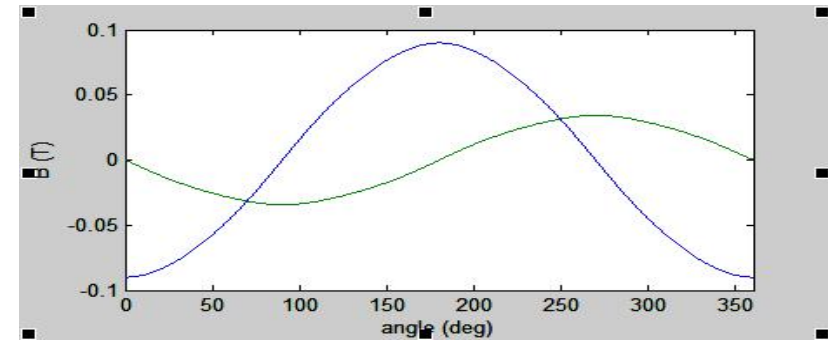
Application Stories Share--MA730 for Side-shaft Gimbals



Customer dimensions:



Simulation results of magnetic field:



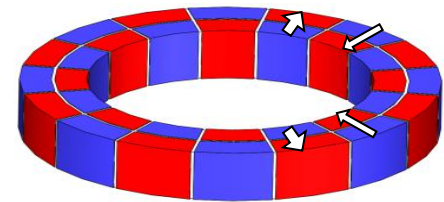
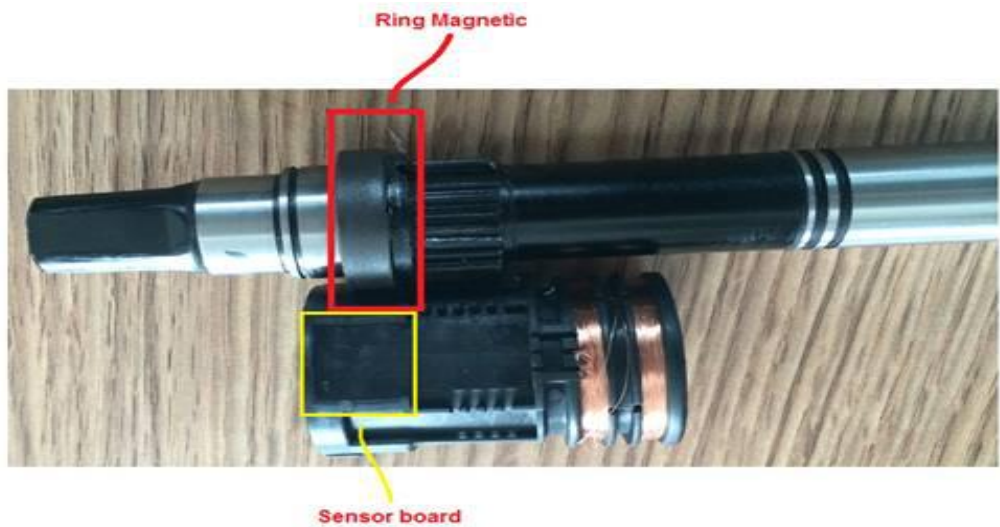
Bmin (mT)	Bmax (mT)	k
34	90	2.6

MagAlpha setting:

$$BCT(7:0) = \frac{255}{0.667} \left(1 - \frac{1}{k} \right)$$

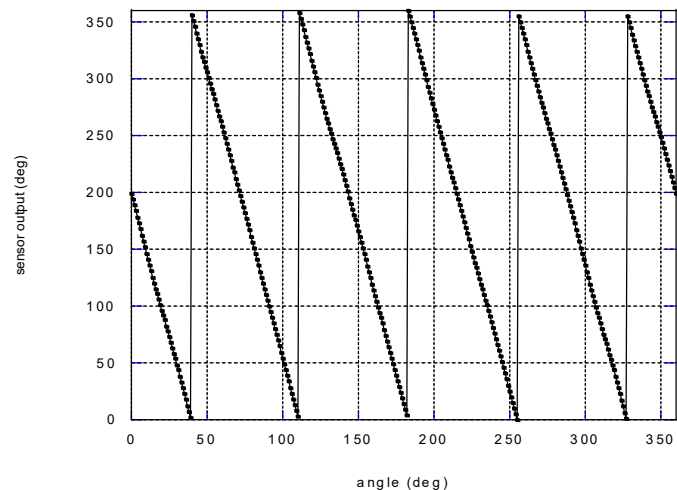
BCT=235

Application Stories Share--Multi-pole Side-shaft for E-bike

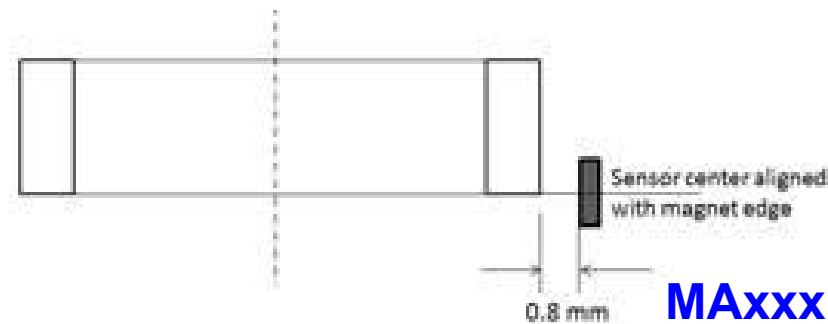


Radial magnet

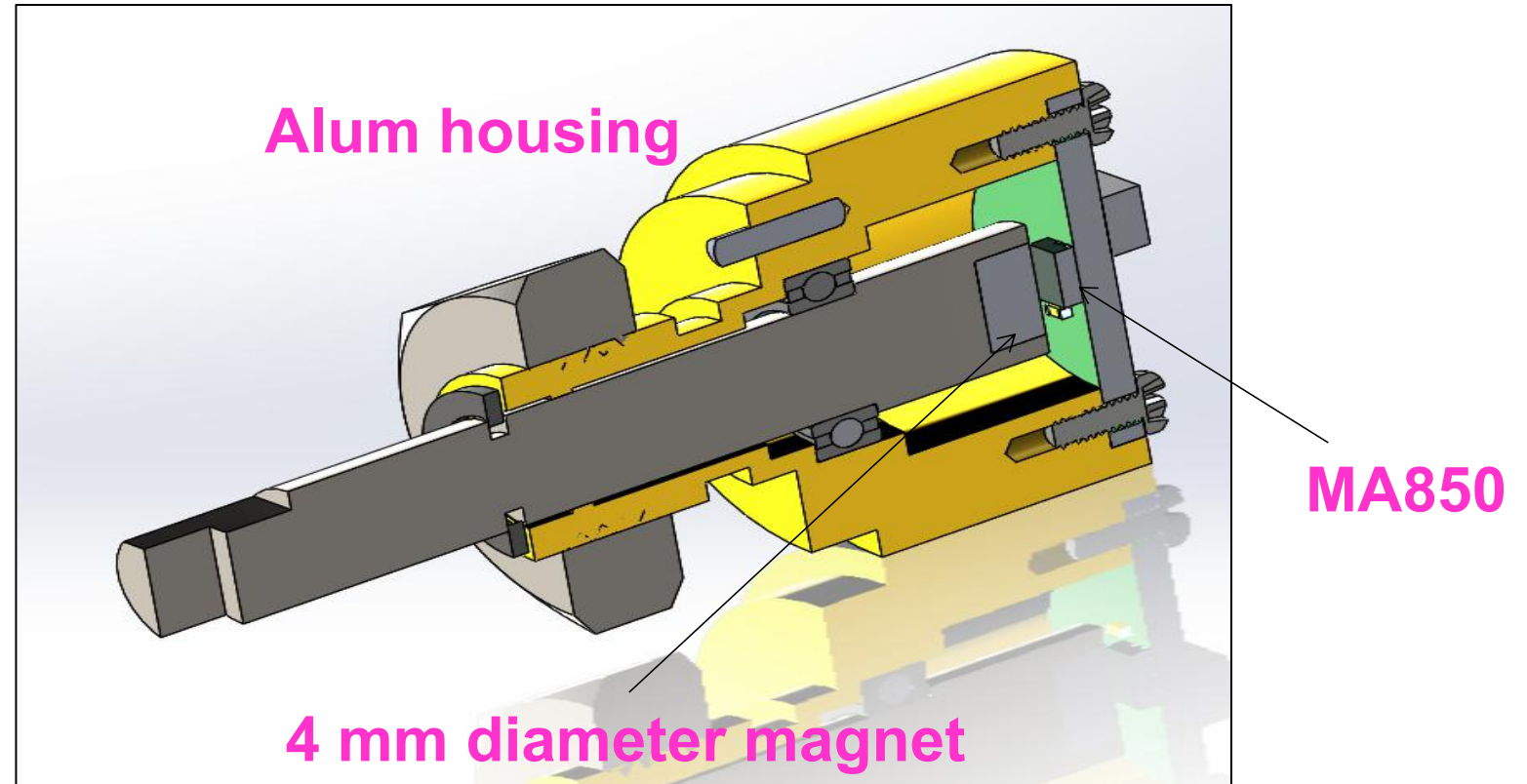
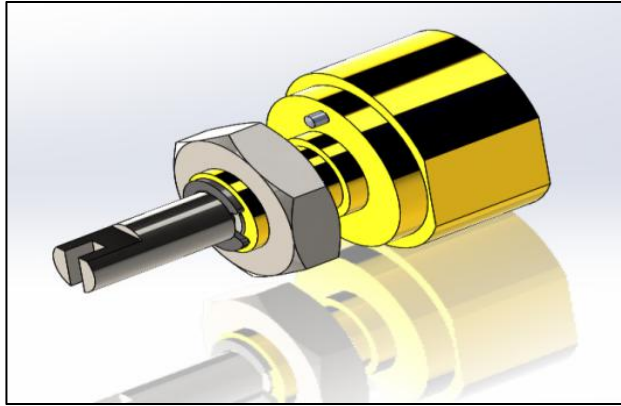
Results with 5-pp magnet:



non-linearity of
 ± 0.4
mechanical
degrees

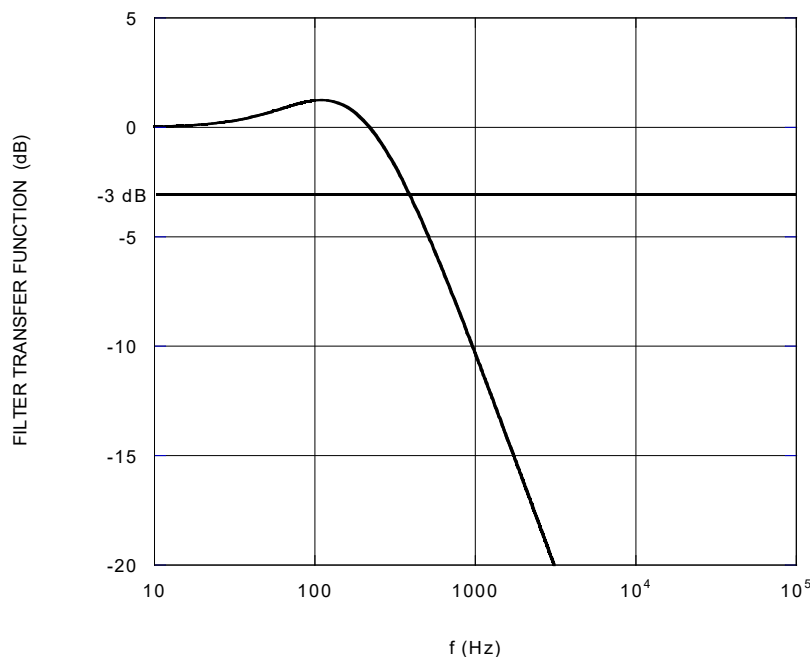
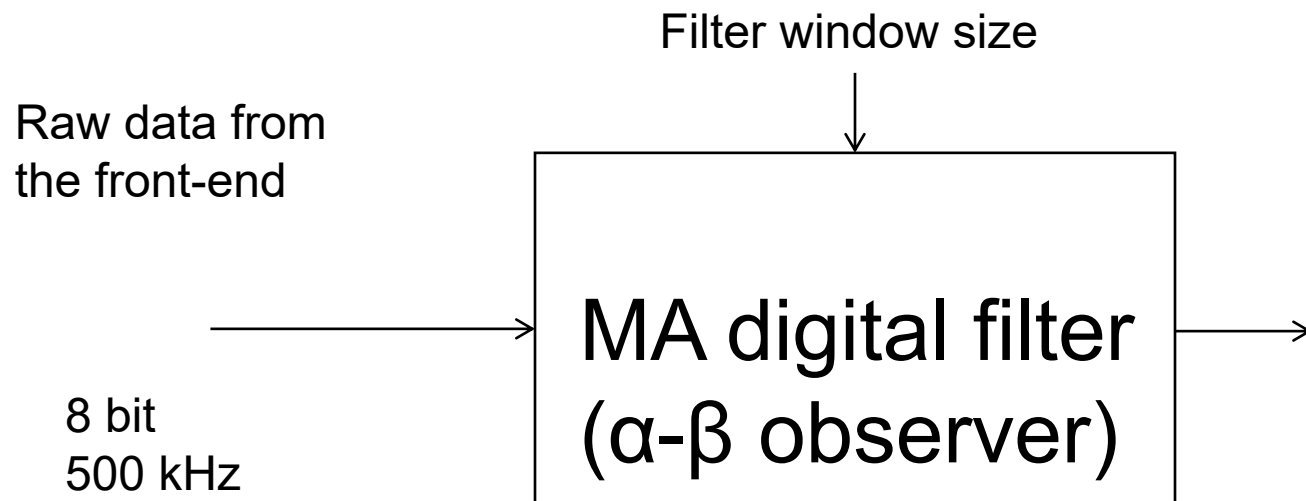


Application Stories Share--MA850 for Turning Knobs



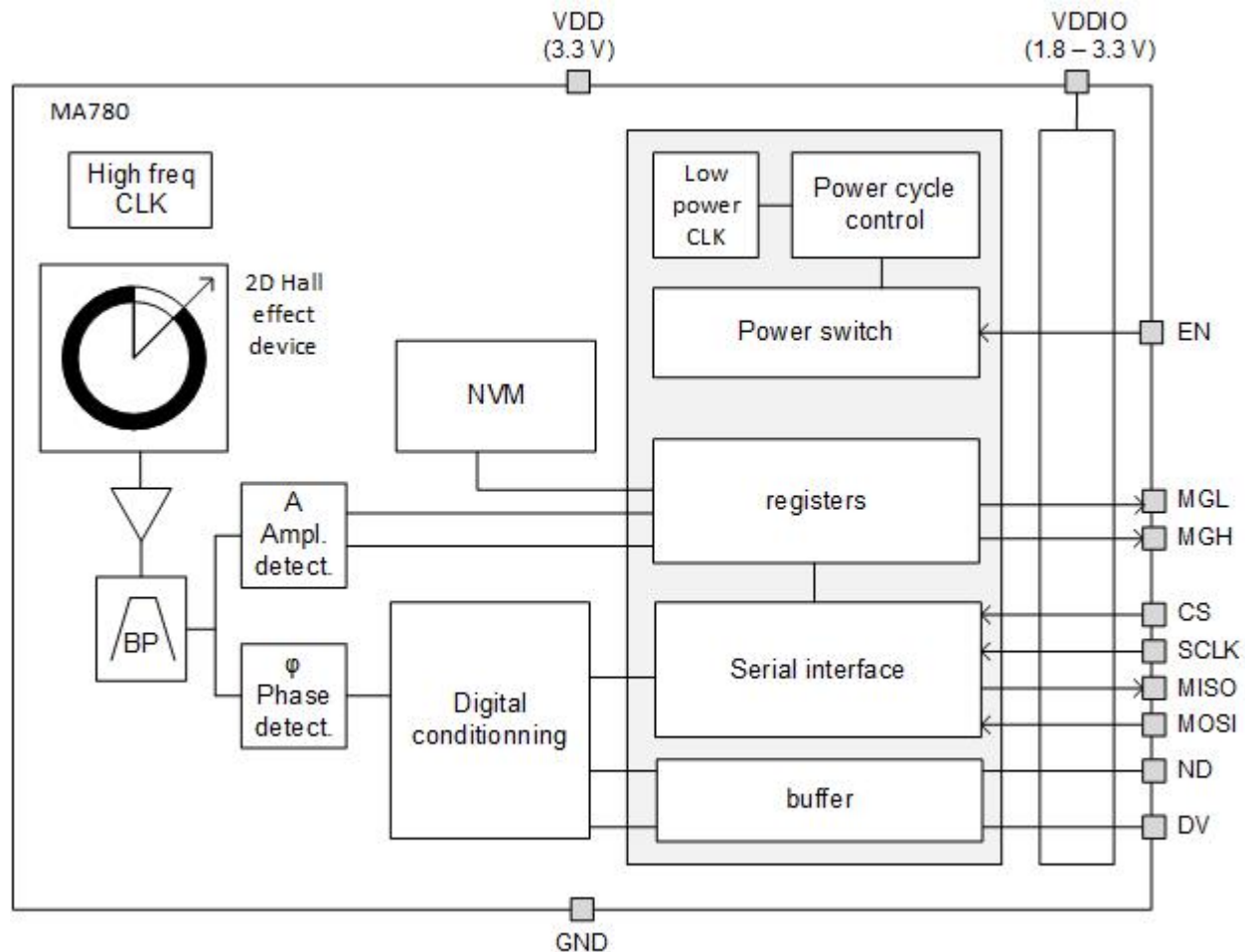
- MA850 for potentiometer/low-end rotate encoder replacement
- Low cost, longer life, better performance, higher reliability

New Product: MA731/2 – Adjustable Filter



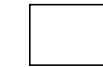
FW(7:0)	Effective Resolution at 45 mT (Bit)	Fcutoff (Hz)
51	9.5	6000
68	10	3000
85	10.5	1500
102	11	740
119 (default)	11.5	370
136	12	185
153	12.5	93
170	13	46
187	13.5	23

New Product--Low Power MA780



Always on

10mA



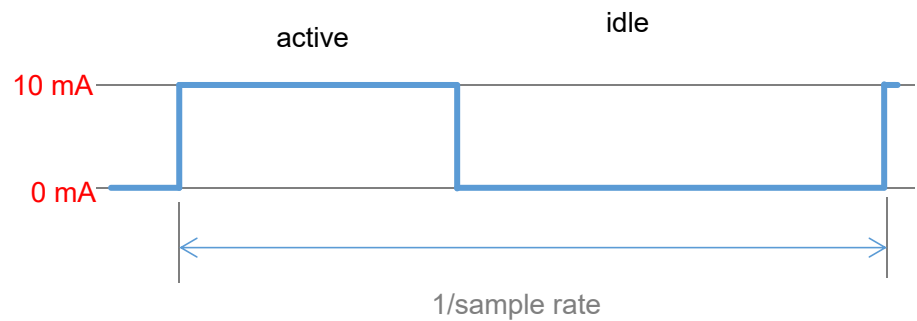
Only on when sensor active 2 μ A

New Product--Low Power MA780

Power Cycling

- 3.3V Supply
- IO Supply : 1.8V to 3.3V.
- 70 mT

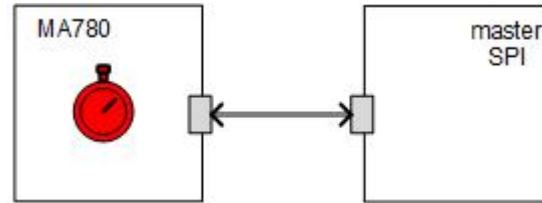
Window size FW(0:3)	Time constant τ (μ s)	Filter settling time (μ s)
0	1	1
1	2	3
2	4	7
3	8	15
4	16	31
5	32	63
6	64	127
7	128	255
8	256	511
9	512	1023
10	1024	2047
11	2048	4095
12	4096	8191
13	8192	16383
14	16384	32767
15	32768	65535



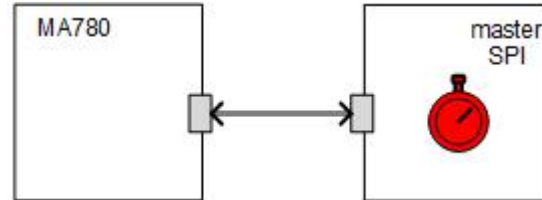
sample rate	avg. current (mA)	
	8-bit (FW=2) 35+7 μ s	10-bit (FW=7) 35+255 μ s
1 kHz	0.4	3
300 Hz	0.13	0.9
100 Hz	0.04	0.3
20 Hz	0.009	0.06
5 Hz	0.003	0.05

New Product: MA780 – Different Power Modes

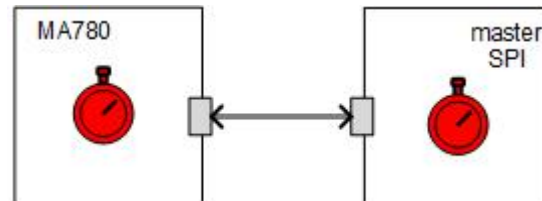
Automatic Cycling



Externally controlled



Mixed



New Product: MAQ430 and MAQ470(Automotive)

AECQ Grade 1

-40 to +125 °C T_j operation

Wettable Flank 3x3mm QFN (GQE)

MTP non-volatile parameter storage

MAQ430GQE-AEC1 12-bit Angle Sensor with SPI, ABZ, UVW

- For Brushless DC motor applications
 - Provides Commutation, and Angle Position
 - ABZ encoder for speed and direction information

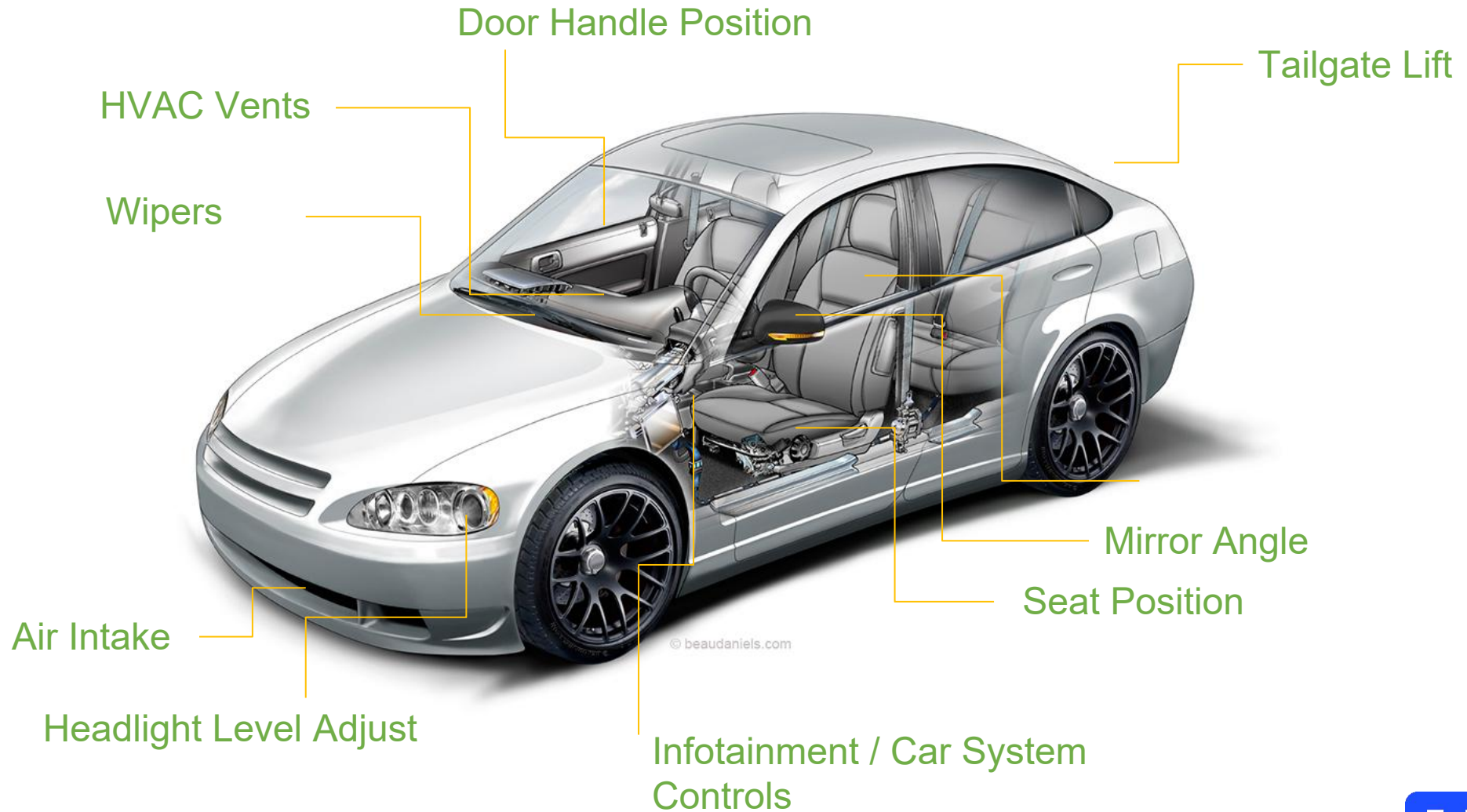
MAQ470GQE-AEC1 12-bit Angle Sensor with SPI, ABZ, PWM

- For Rotary position sense applications
 - Rotary knobs with/without push detect feature
 - Angle measurement : e.g. in a headlight adjuster, or HVAC vent
 - Can replace unreliable potentiometers that are used currently

PART	Op Temp (C)	SPI	Resolution	ABZ	UVW	PWM	Zero Set	EEProm
MAQ430	-40 to +125	Yes	12 bit	Yes	Yes	No	Yes	Yes
MAQ470	-40 to +125	Yes	12 bit	Yes	No	Yes	Yes	Yes

New Product: MAQ430 and MAQ470 (Automotive)

ASIL A or B rated or below



MA family

Application	Part	Distinct features
Replacement of 3 Hall switches (BLDC)	MA102	UVW output
Human/machine interface. Speed < 200 rpm	MA800	SPI output
	MA820	ABZ output
	MA850	PWM output (to make an analog output)
All purpose encoder	MA704	10 bit High bandwidth (3 kHz) - suitable for closed loop control
	MA702	12 bit Medium Bandwidth (390 Hz) - suitable for slow closed loop control
	MA710	12 bit at low field, Low bandwidth (90 Hz)
	MA730	14 bit Low bandwidth (20 Hz)
	MA732	10-14 bit selectable, 1024 PPT , low INL
	MAQ470	Like MA702, AECQ-100
All purpose encoder for BLDC (UVW output)	MA302	Same as 702 but with UVW
	MA310	Same as 710 but with UVW
	MA330	Same as MA732 with UVW
	MAQ430	Like MA302, AECQ-100
Low power	MA780	Options for cycling the power

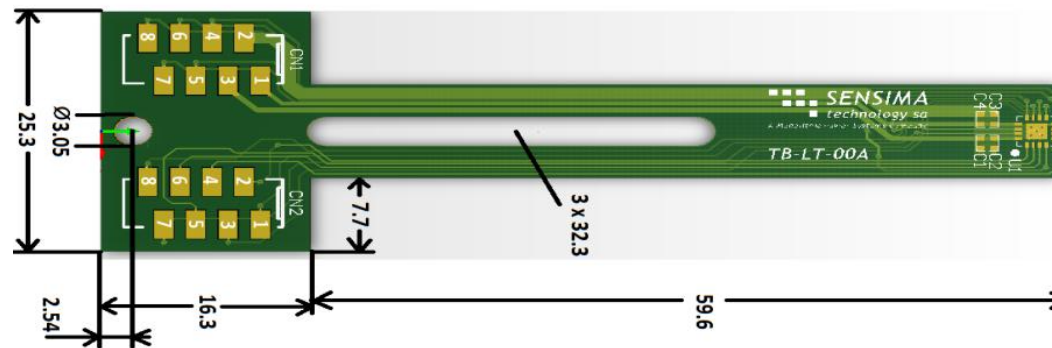
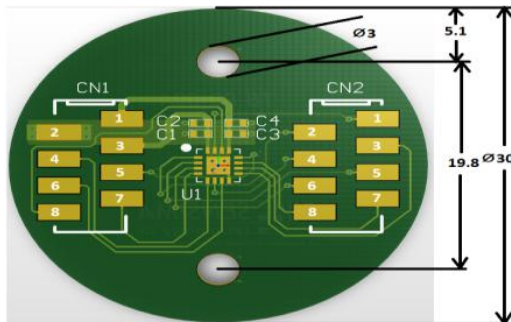
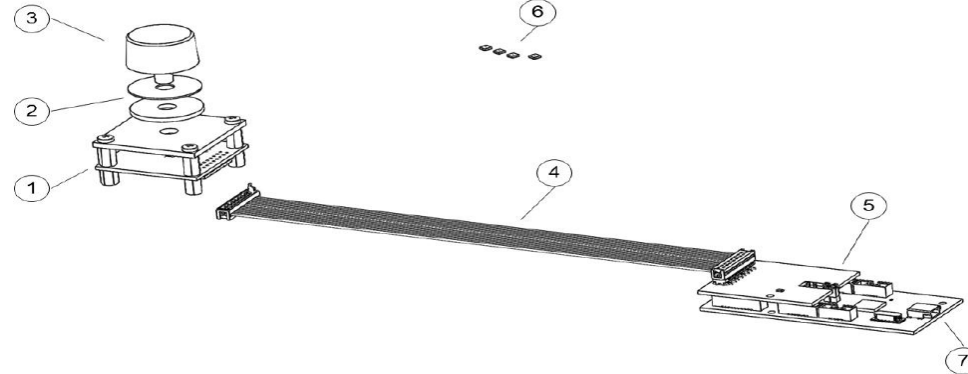
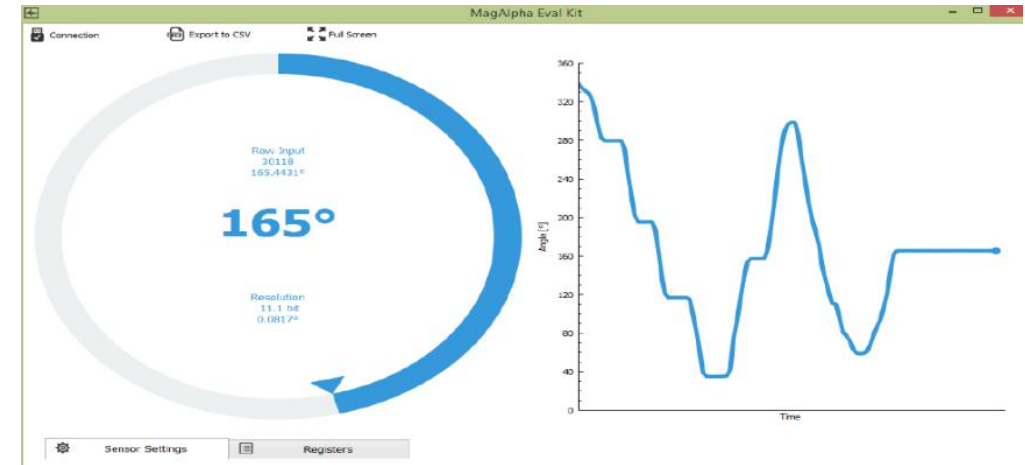
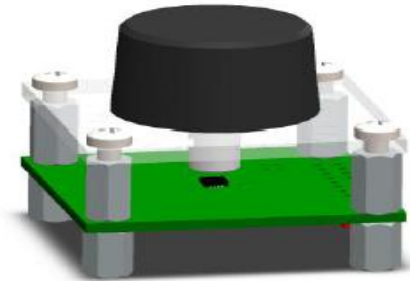
EVB & Test Boards

Rotary Knob Front End Demo kit

Test boards for direct embedded via SPI:

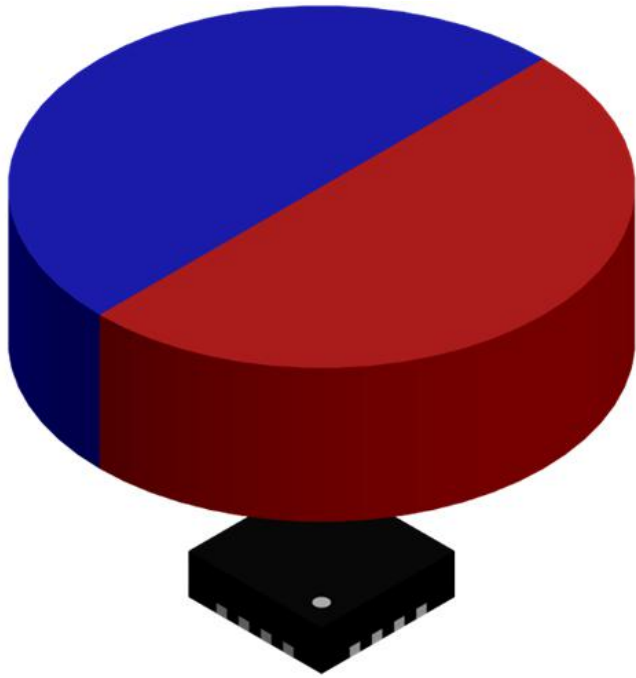
TBMAxxx-LT-Q-00A (stick shape)

TBMAxxx-RD-Q-00A (round shape)

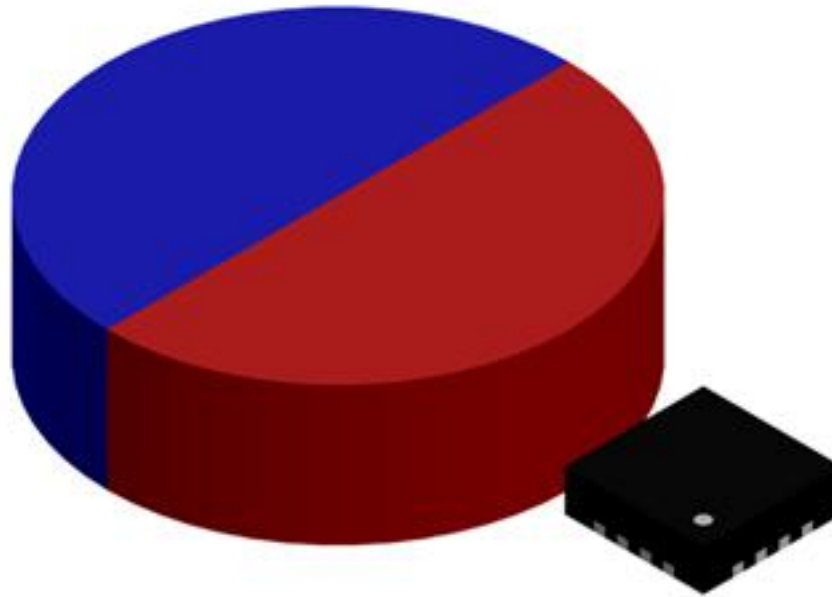


Online Magnetic Design Tool

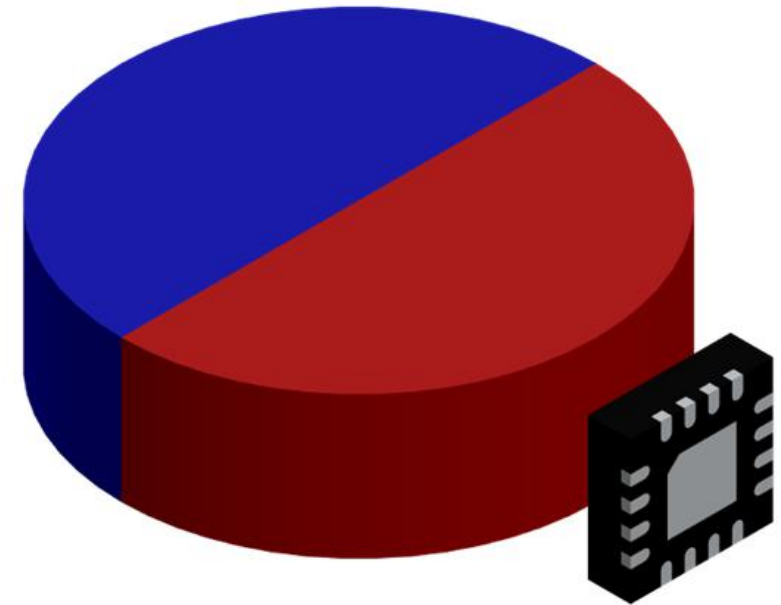
<http://sensors.monolithicpower.com/>



End-of-shaft



Side-shaft



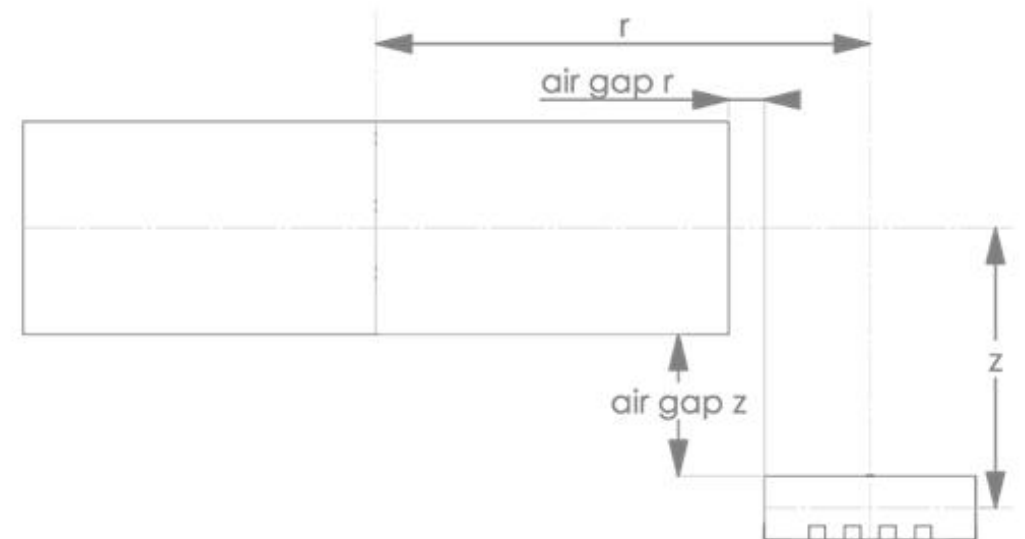
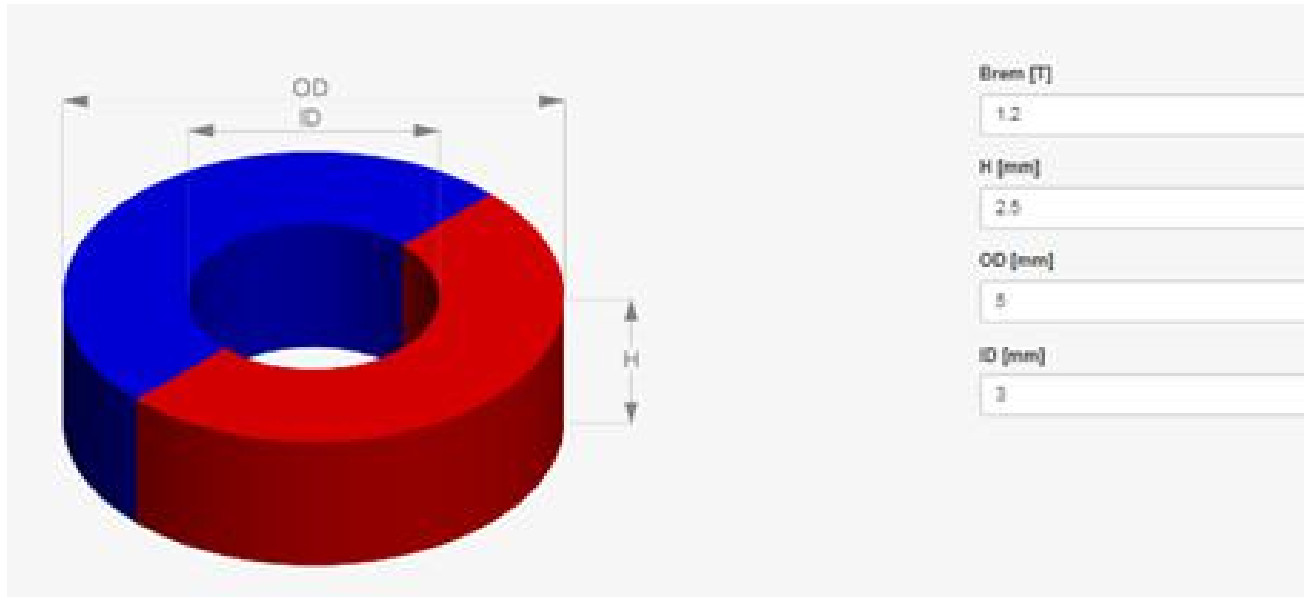
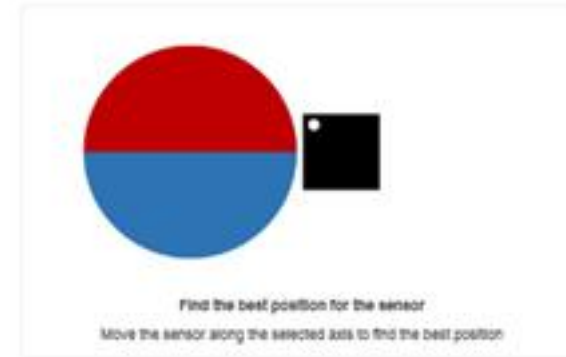
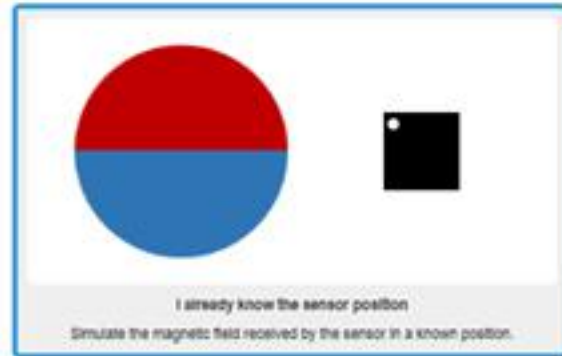
Orthogonal Side-shaft

Online Magnetic Design Tool

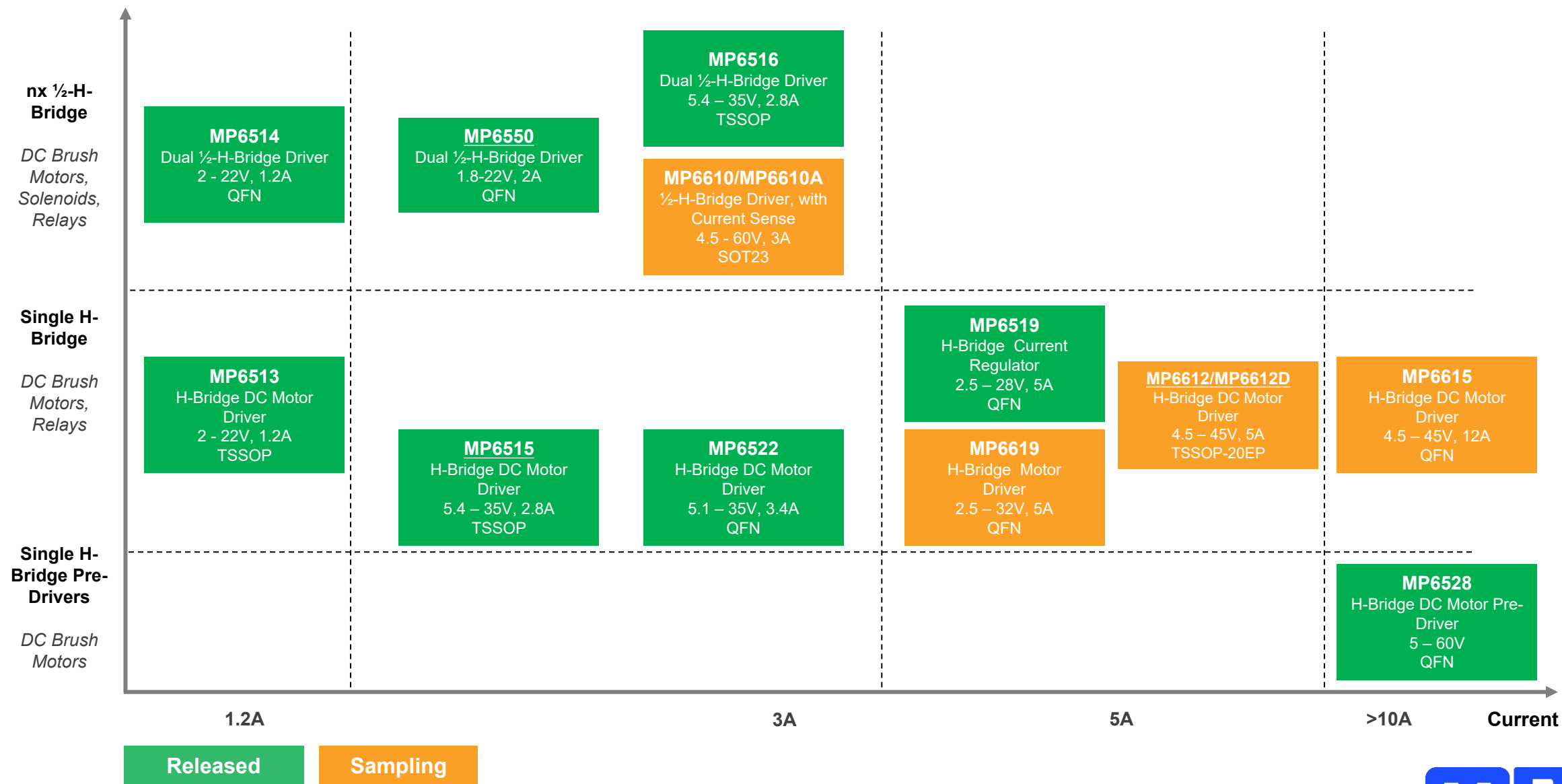
<http://sensors.monolithicpower.com/>



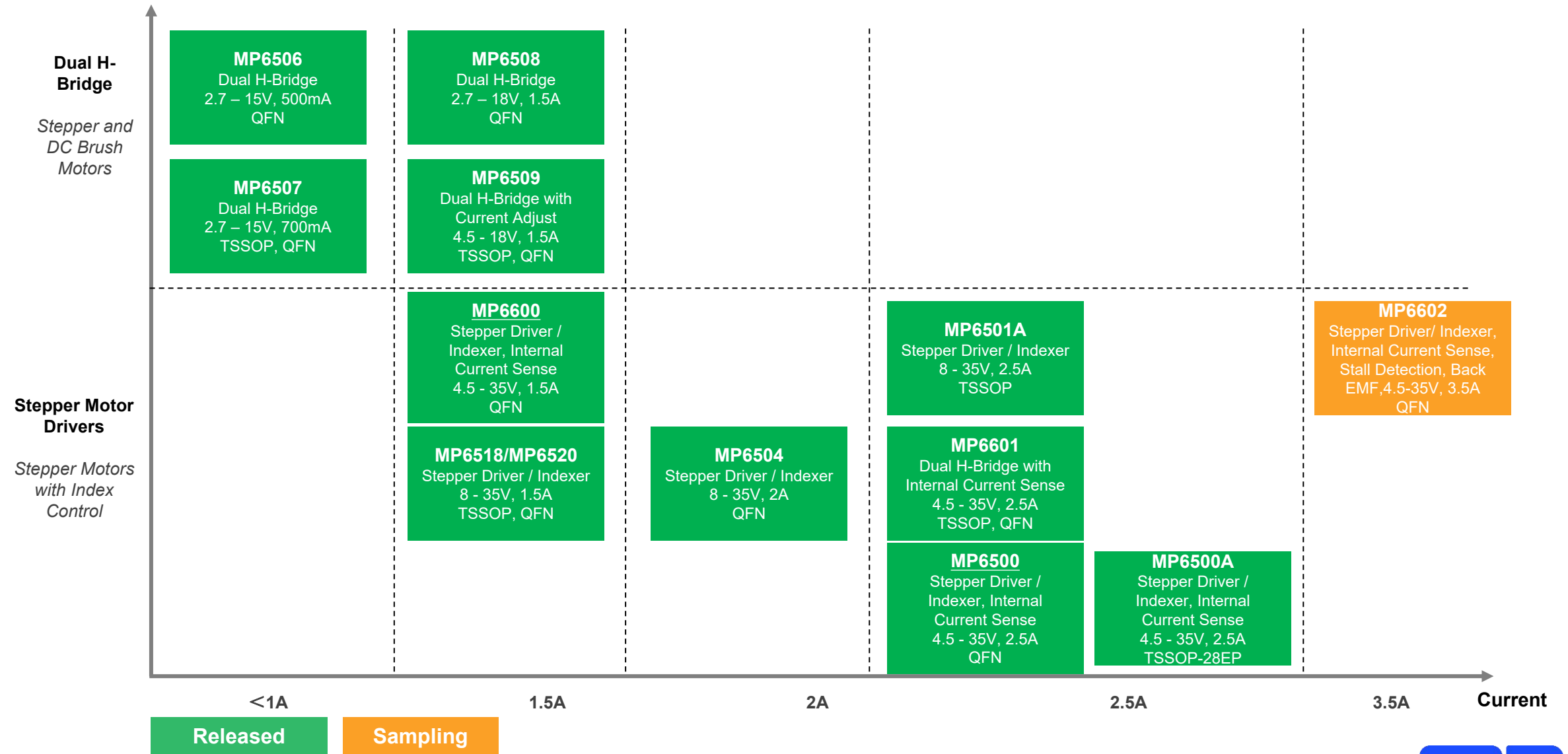
Microsoft Word
Document



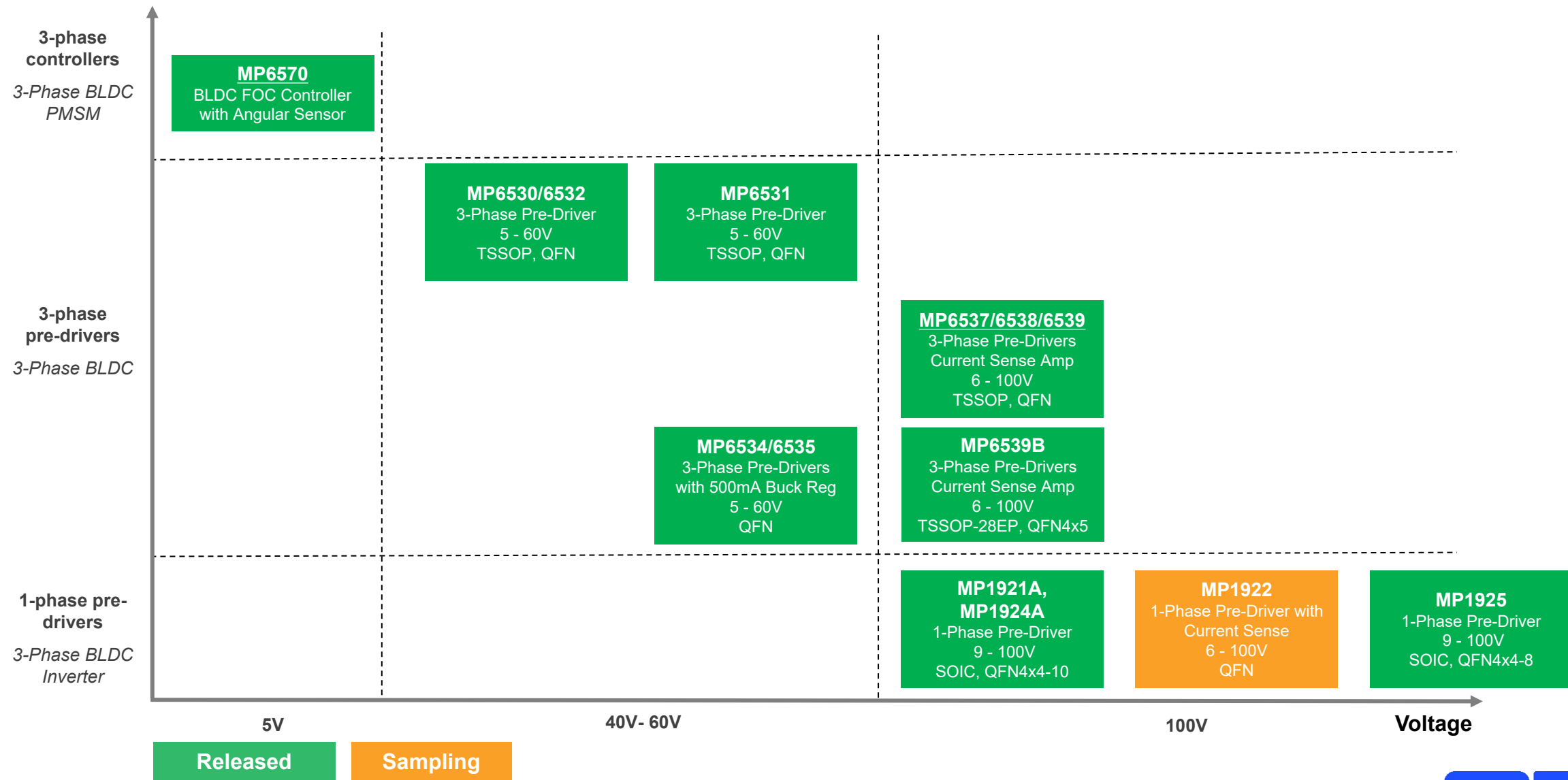
H-Bridges (DC Brush, Solenoid, Relays)



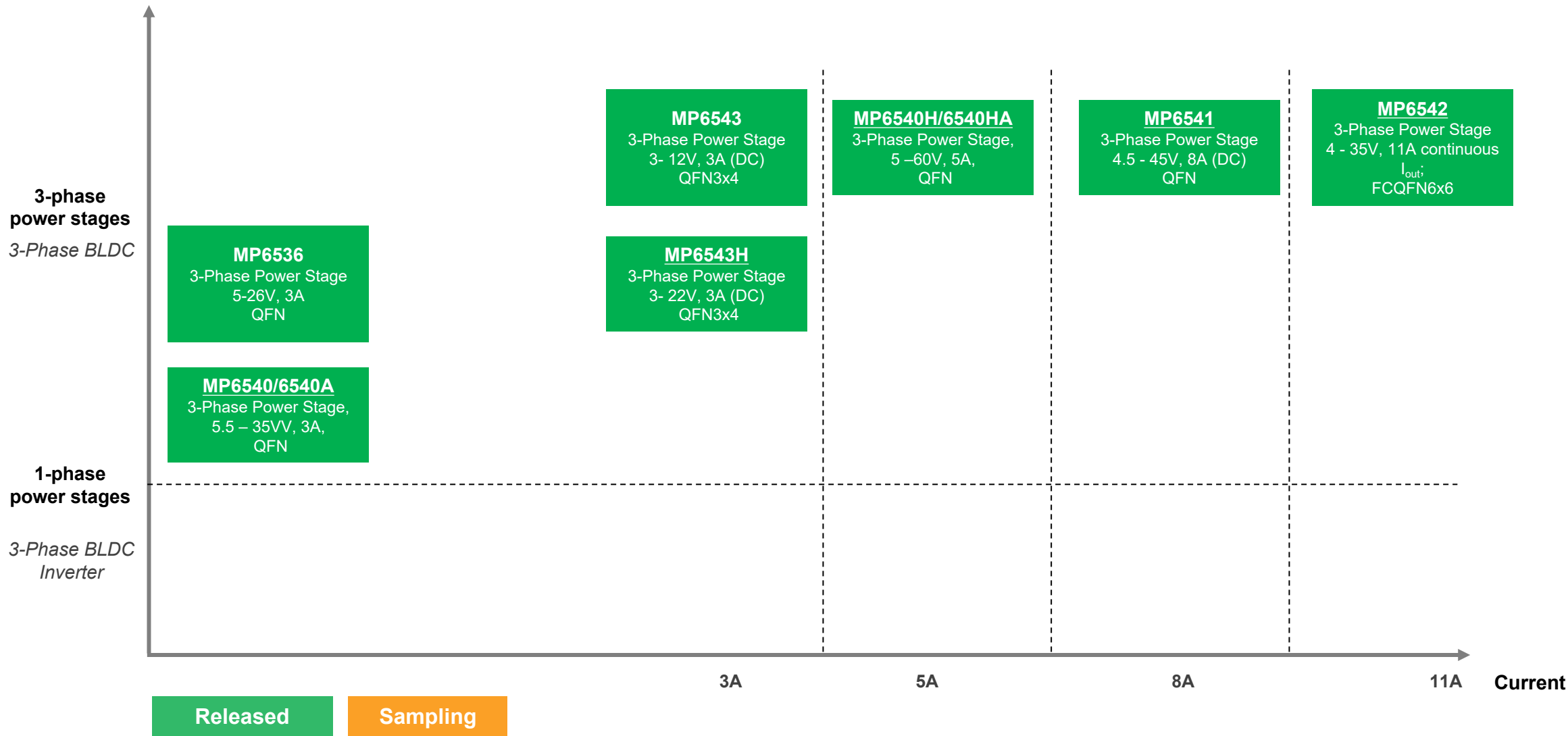
Dual H-Bridge & Stepper Motors



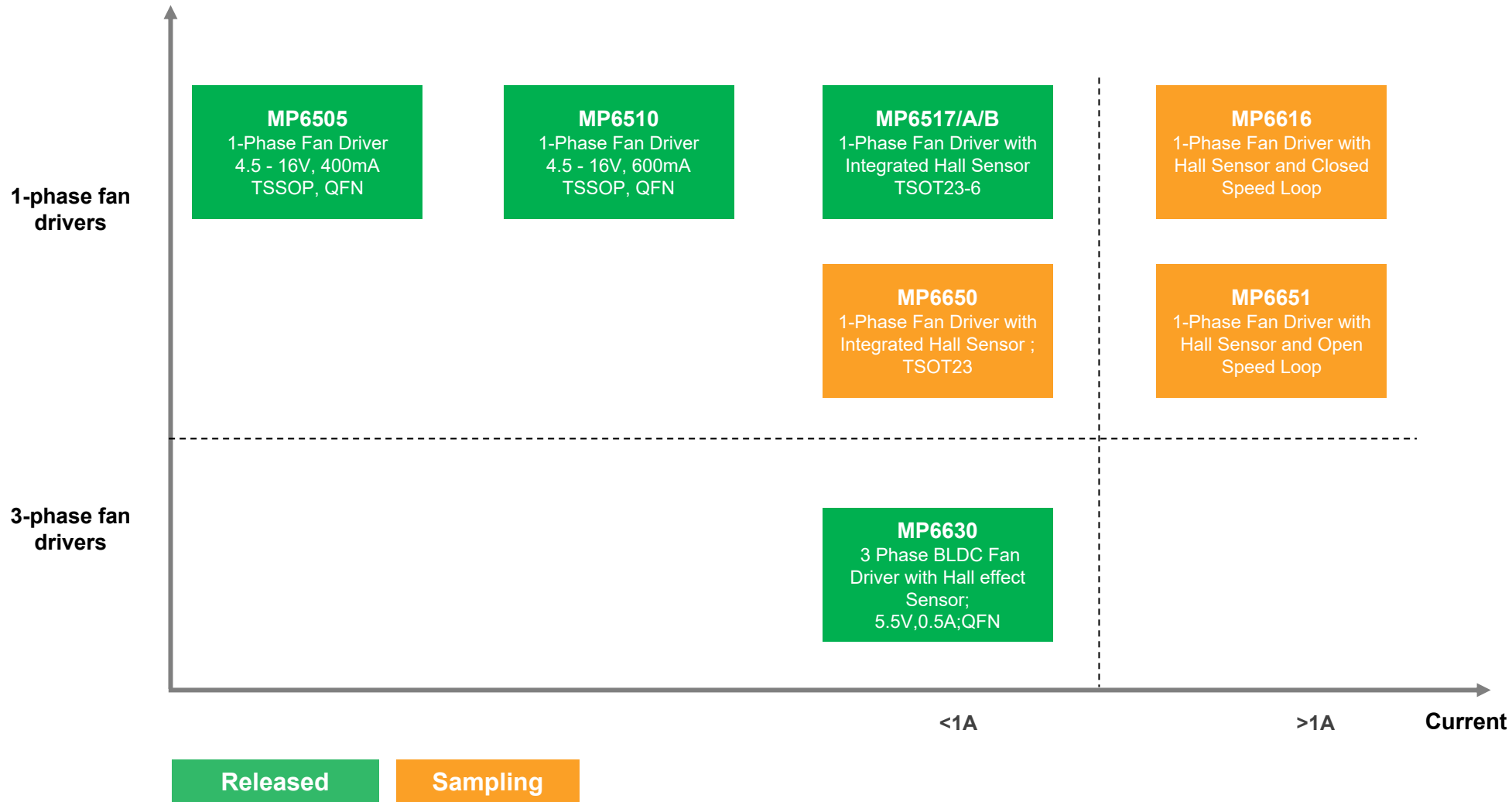
Brushless DC Motor Pre-Driver



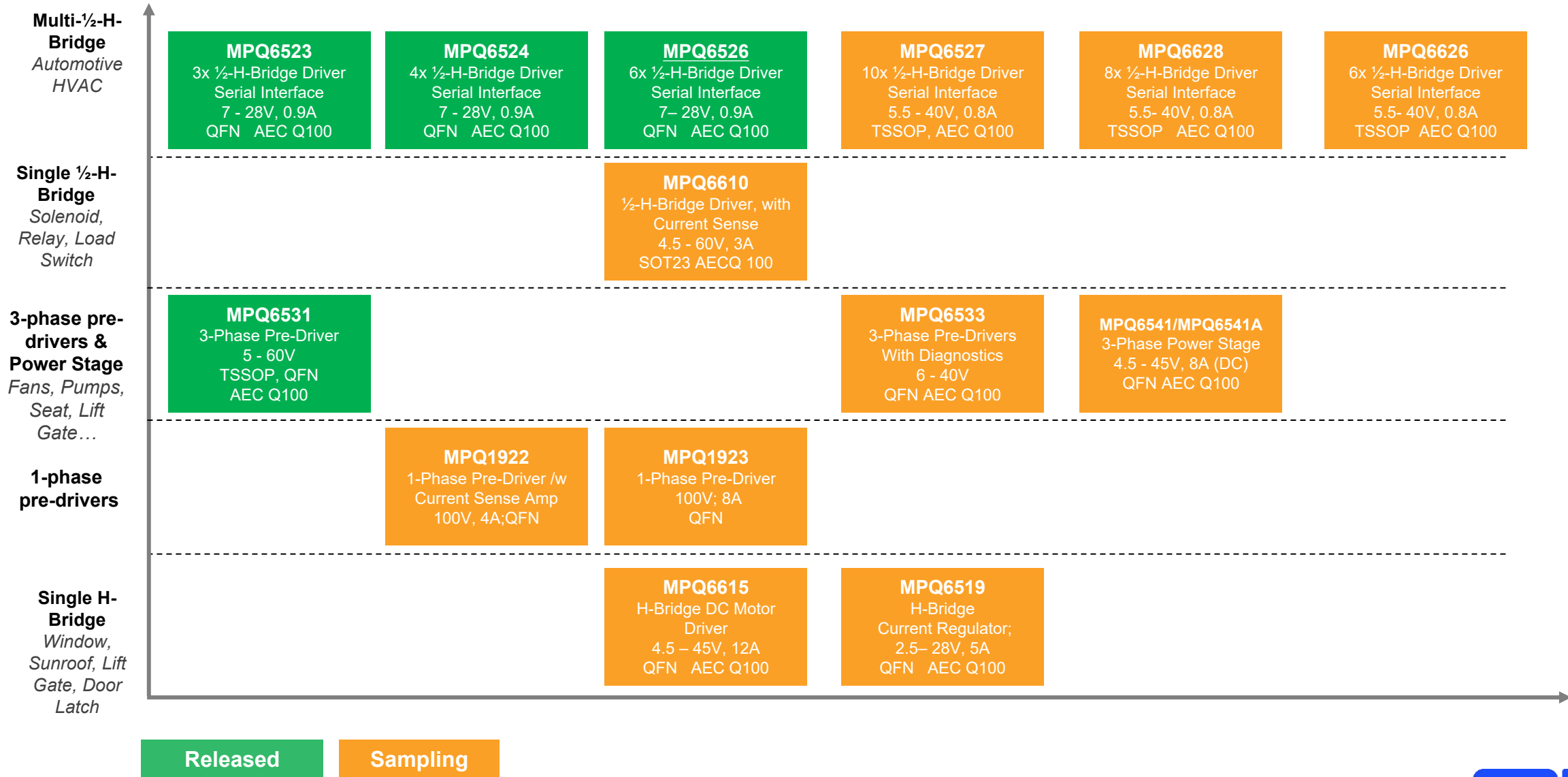
Brushless DC Motor Driver Power Stage



Brushless DC Fan Drivers



Automotive Motor Drivers



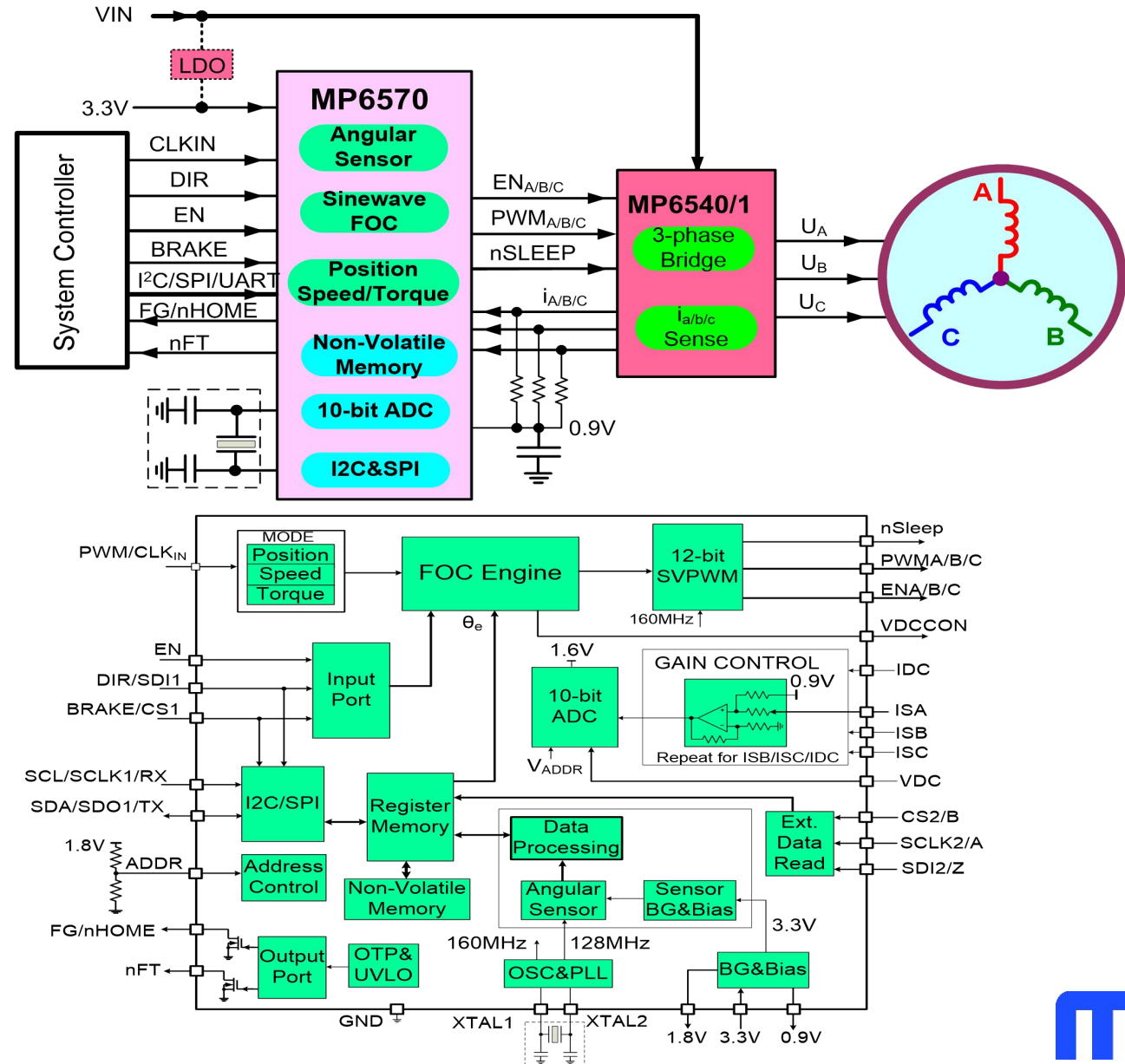
Motor Driver--FOC Controller MP6570

Features

- 3-Phase PMSM Servo Motor Controller
- **FOC Control**
- **Integrated Rotor Angular Sensor**
- **Internal Non-Volatile EEPROM**
- **Three PI Control Loops:**
 - Torque Control
 - Speed Control
 - Position Control
- Flexible Configuration
- I²C, SPI, and Serial Interfaces
- PWM and Clock Inputs
- Supports 1, 2, or 3 Current Sensors
- Direct Interface to Power Stages or Pre-Drivers
- Low-Power Standby Mode
- Locked Rotor Detection and Restart
- Braking with Supply Voltage Clamp
- Integrated OCP/OVP/OTP Protection
- Available in **QFN4x4-28** Package

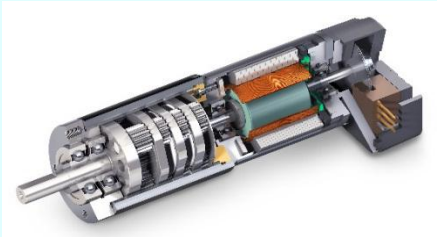
Applications

- 3-Phase BLDC motors
- PMSM Servo motors
- Robotics
- Electric Vehicle
- Power Tools

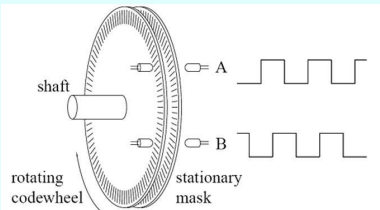


MPS Smart Motor Solution

Current Solution



Motor



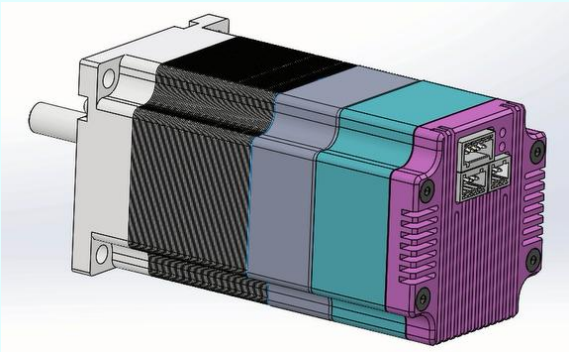
Encoder



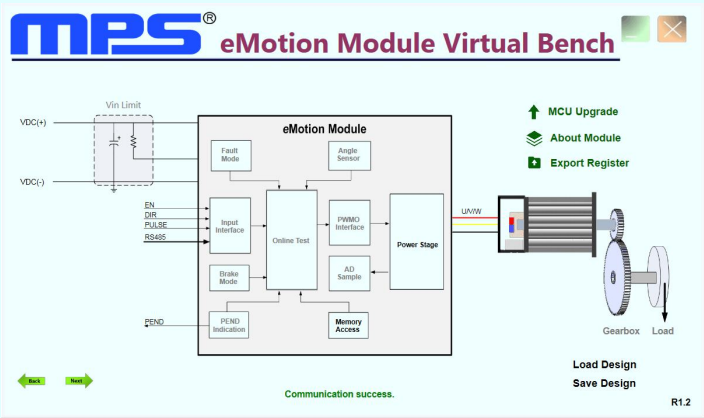
Driver



MPS Smart Motor



Easy Use GUI



Power Spec for Module

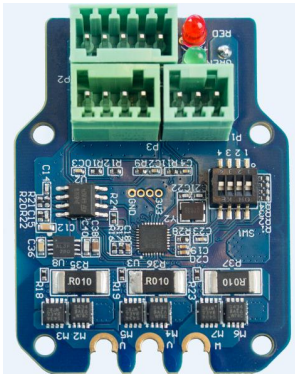
42mm



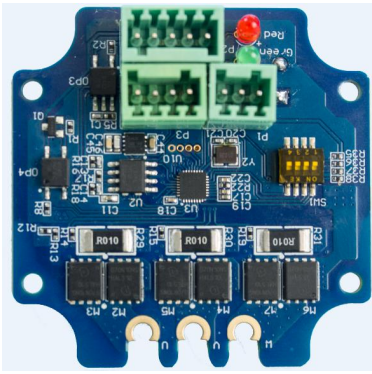
57mm



42 PCBA



57 PCBA



Series	Smart Motor Part Number	Vin Spec	Rated RPM	Rated Torque (Nm)
42mm	MSM942038-24-C-R	(18V, 24V, 36V)	3000	0.12
	MSM942052-24-C-R		4000	0.125
	MSM942077-24-C-R			0.185
	MSM942105-24-C-R			0.25
57mm	MSM957094-36-C-R	(18V, 36V, 70V)	3000	0.3
	MSM957141-36-C-R		3000	0.45
	MSM957188-36-C-R		3000	0.6

Series	Smart Motor Part Number	Vin Spec	Rated Power(W)
42mm	MMP942038-24-C	(18V, 24V, 36V)	38
	MMP942052-24-C		52
	MMP942077-24-C		77
	MMP942105-24-C		105
57mm	MMP957094-36-C	(18V, 36V, 70V)	94
	MMP957141-36-C		141
	MMP957188-36-C		188

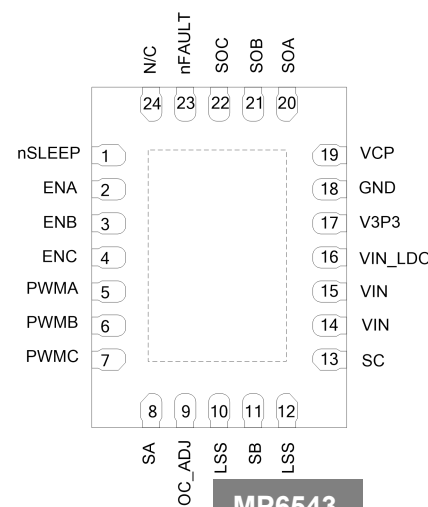
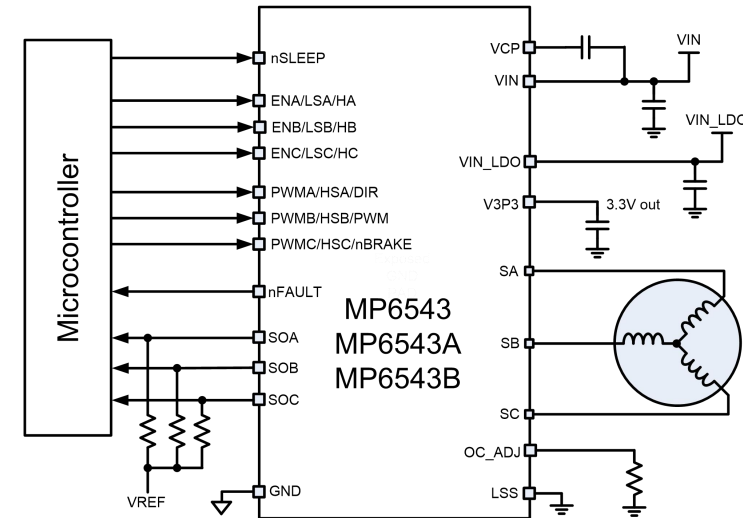
MP6543H:22V 2A 3-Phase Power Stage

Features

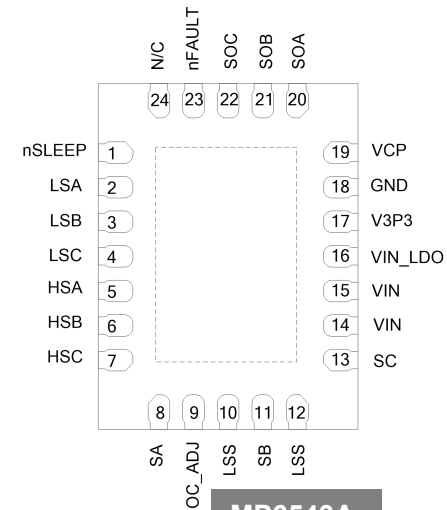
- 5V to 22V Operating Supply Voltage
- Three integrated half-bridge drivers
- 2A Continuous Output Current
- MOSFET On-Resistance: 110mΩ per FET
- **MP6543H**: PWM & ENBL inputs (QFN3x4-24)
- **MP6543HA**: HS & LS inputs (QFN3x4-24)
- **MP6543HB**: Hall Signal Interface(QFN3x4-24)
- Built-In 3.3-V, 100-mA LDO Regulator
- Internal Charge Pump for 100% Duty Cycle
- Automatic Synchronous Rectification
- Integrated Bi-directional Current Sense Amp

Applications

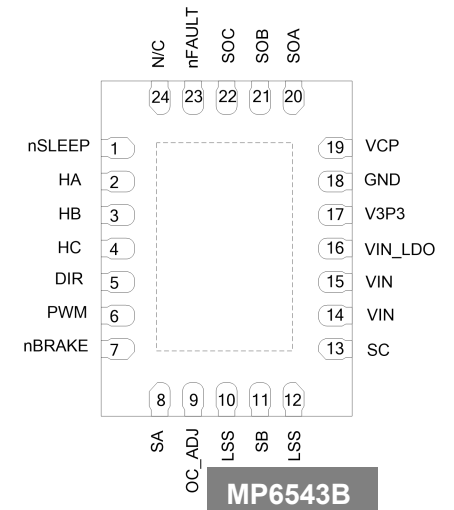
- 3-Phase Brushless DC Motors and Permanent Magnet Synchronous Motors



MP6543



MP6543A



MP6543B

MP6540/H/MPQ6541/MP6542:3-Phase Power Stages

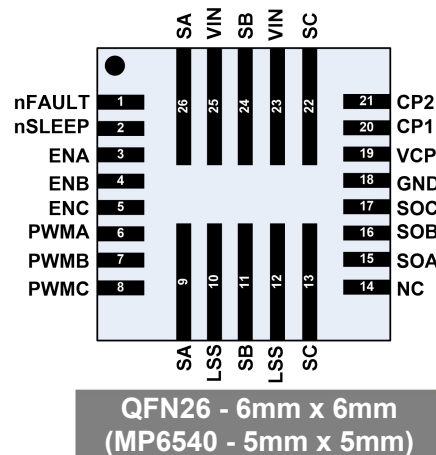
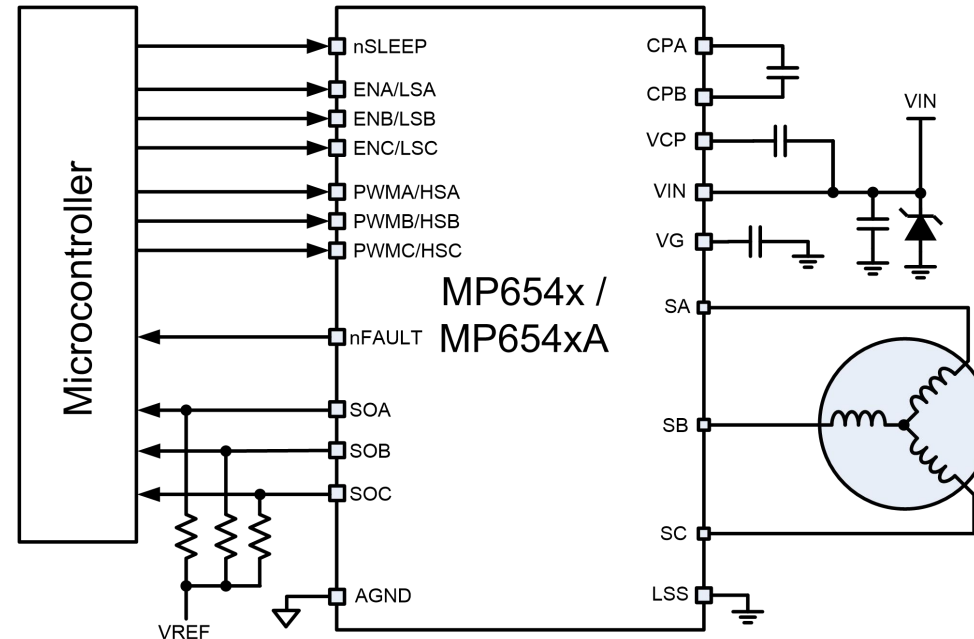
Features

Three integrated half-bridge drivers

- **MP6540**: 4.5V to 29V, 3A Continuous Current
- **MP6540H**: 7V to 60V, 5A Continuous Current
- **MPQ6541**: 4.5V to 45V, 8A Continuous Current ; 13mΩ /FET R_{ds} (on)
- **MP6542**: 4 to 35V, 11A Continuous Current 10mΩ /FET R_{ds}(on)
- EN/PWM Logic Inputs (MP654x)
- HS/LS Logic Inputs (MP654xA)
- Internal Charge Pump Supports 100% Duty Operation
- UVLO and Thermal Shutdown Protection
- Over current Protection
- Integrated Bi-directional Current Sense Amp
- Available in 5x5 or 6x6mm FCQFN packages

Applications

- 3-Phase Brushless DC Motors and Permanent Magnet Synchronous Motors



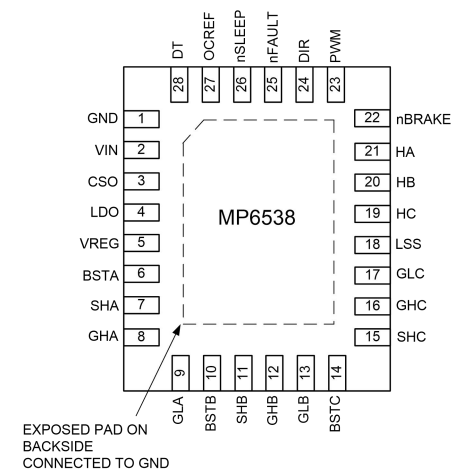
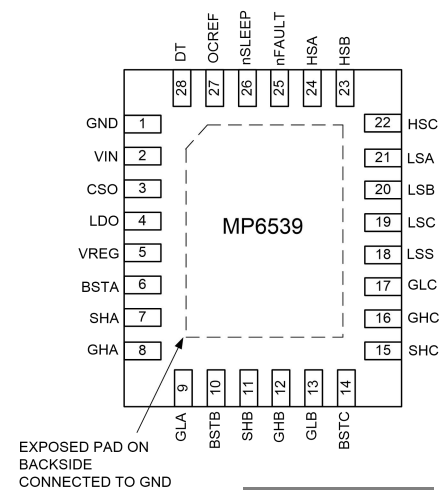
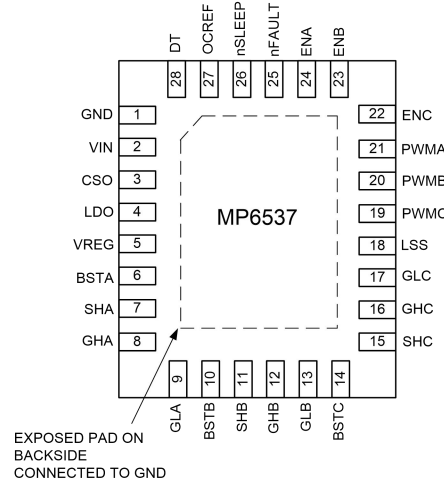
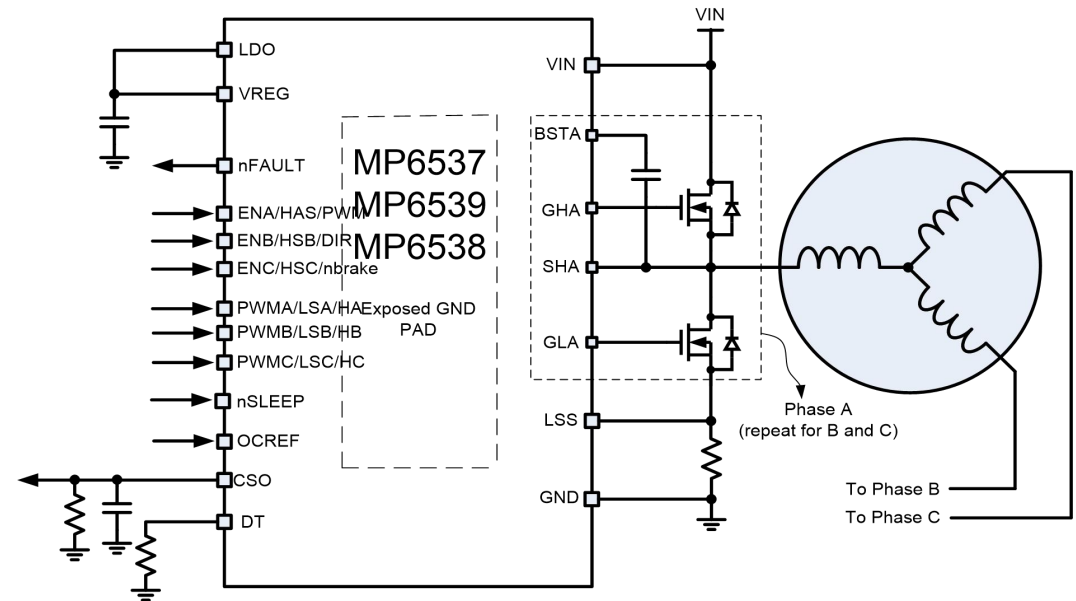
MP6537/MP6539/MP6538: 100V, 3-Phase BLDC Motor Pre-Drivers

Features

- Three 1/2-H-Bridge MOSFET Pre-Drivers
- Supports 100V Supply Voltage
- 120V Max Vboost Voltage
- 6V – 15V Gate Drive Supply
- Internal Current Sense Amp
- 800mA Source, 1A Sink Current
- **MP6537**: PWM & Enable inputs for each phase
- **MP6539**: Independent HS/LS inputs
- **MP6538**: Hall Sensor Inputs
- Low Power Sleep Mode
- Programmable Over-current Protection of External MOSFETs
- Adjustable Dead Time Protection to Prevent Shoot Through
- Thermal Shutdown and UVLO Protection
- Fault Indication Output
- Thermally Enhanced QFN Package

Applications

- 3-Phase Brushless DC Motors and Permanent Magnet Synchronous Motors
- Fans
- Power Drills
- Impact Drivers
- E-Bike



QFN4X5-28

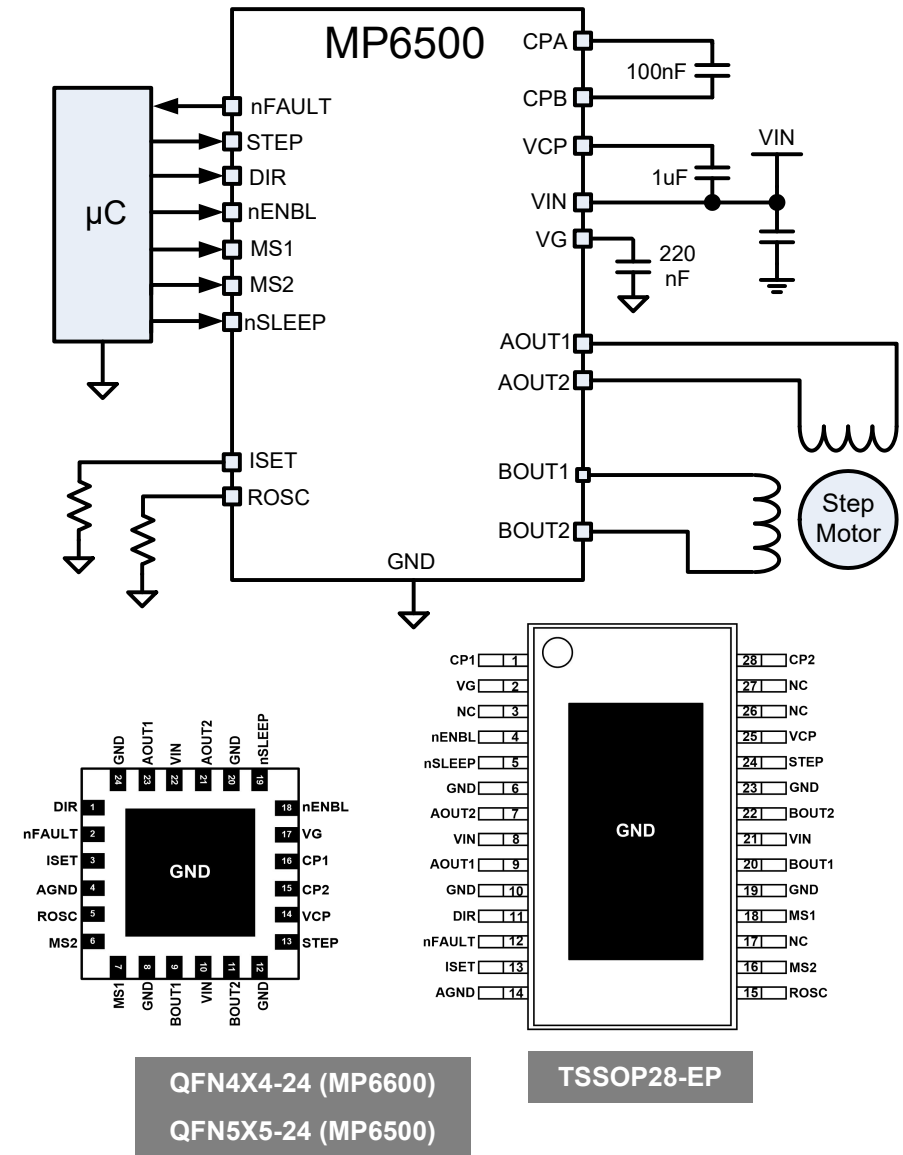
MP6500 / MP6600:Stepper Motor Driver

Features

- Dual Internal Full Bridge Driver
- 4.5V - 35V Supply Voltage Range
- 2.5A Output Current (MP6500, TSSOP & 5mm x 5mm QFN)
- 1.5A Output Current (MP6600 , 4mm x 4mm QFN)
- Internal Current Sensing and Regulation
- Indexer supports up to 1/8-step
- Low On Resistance (HS:170mΩ;LS:150mΩ)
- Automatic Current Decay
- Low Power sleep mode
- Overcurrent and overtemperature protection
- Undervoltage lockout
- Fault indication output

Applications

- General bipolar stepper motor drives
- Printers
- Industrial control
- Automated machinery
- Vending machines



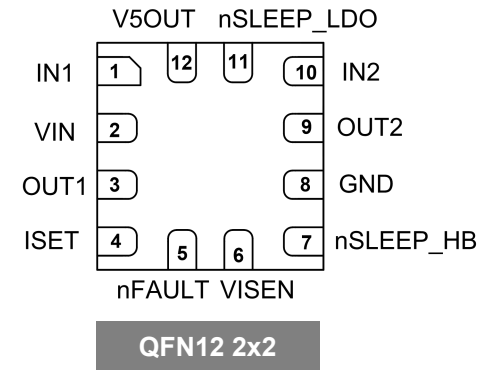
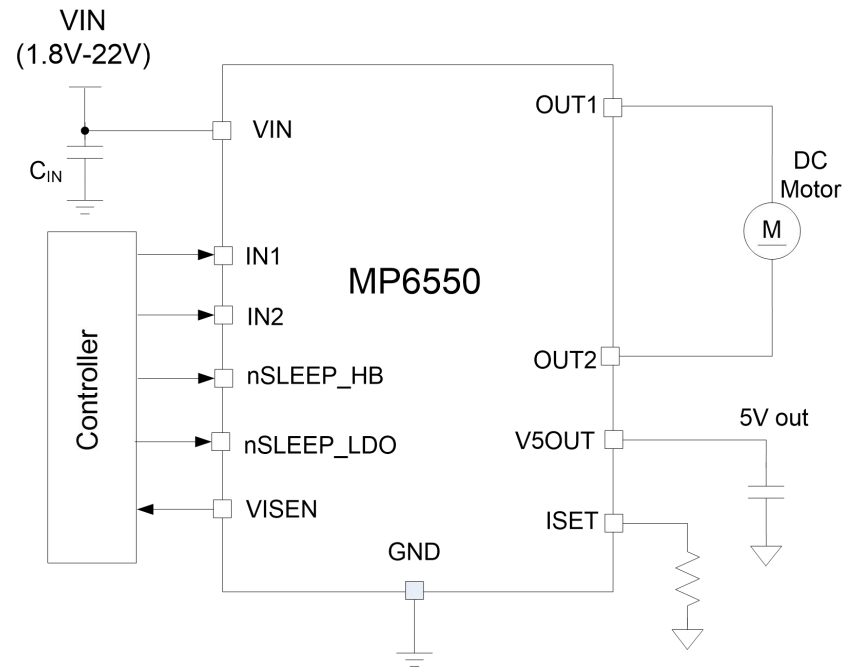
MP6550: Dual Half-Bridge Driver

Features

- Internal Dual ½-H-Bridge Driver
- 1.8V – 22V Supply Voltage Range
- 2A Continuous Output Current (3A Peak)
- 100nA Sleep Mode Supply Current
- Internal Lossless Current Measurement
- Integrated LDO Voltage Regulator
- Individual Control Inputs
- MOSFET On-Resistance: 100mohm / FET
- Overcurrent, Short-Circuit, Overtemperature protection
- Undervoltage lockout
- Small 2.5mm x 3mm QFN package

Applications

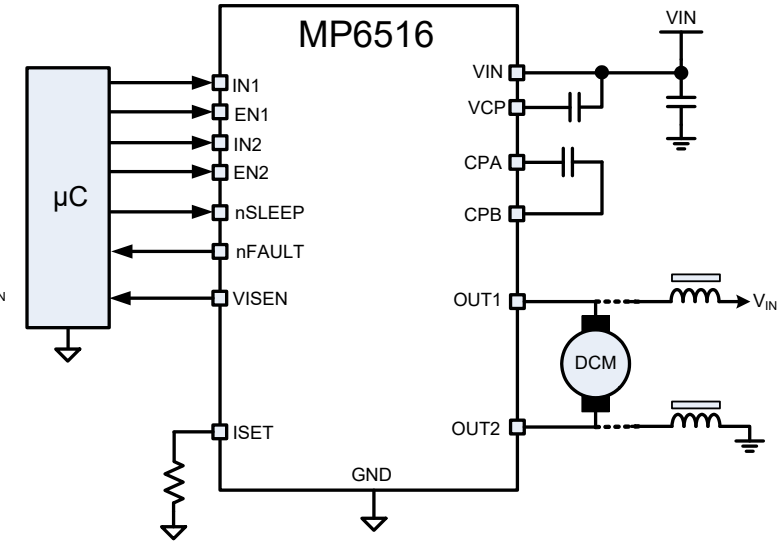
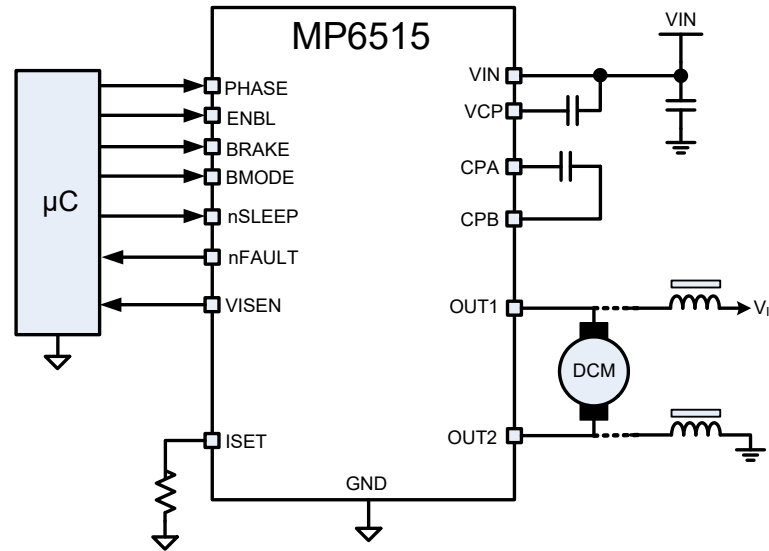
- Robotics
- Toys
- Cameras
- Medical Devices



MP6515 / MP6516:H-Bridge Driver

Features

- Wide 8V to 35V Input Voltage Range
- 2.8A Maximum Output Current
- Internal Full H-Bridge Driver
- Cycle-by-cycle Current Limit
- No Control Power Supply Required
- Simple, Versatile Logic Interfaces
- 3.3 and 5 V Compatible Logic Supply
- Overcurrent Protection
- Overvoltage Protection
- Shutdown
- Undervoltage Lockout
- Fault Indication Output
- Thermally Enhanced TSSOP Package



Applications

- Coffee Machines
- Printers
- Currency Handling Equipment
- Solenoid Drivers



MPQ6526: Hex Half Bridge Driver

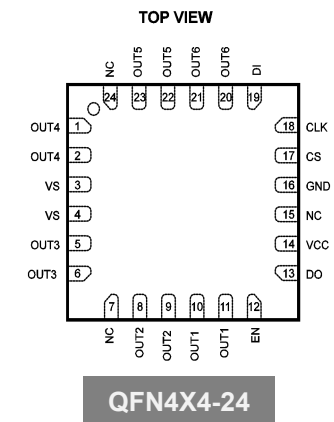
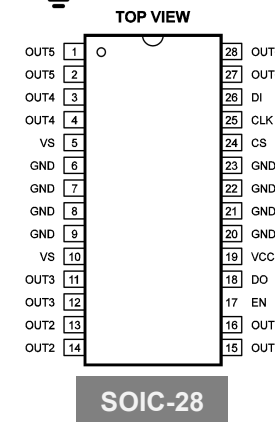
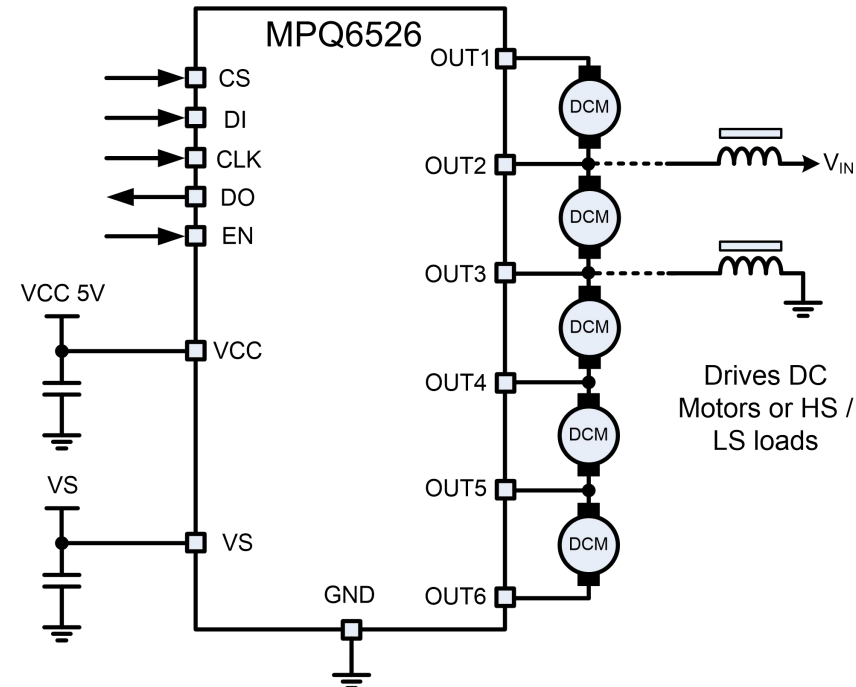
Features

- Hex 1/2-H-bridge Motor Driver
- 7V - 40V Supply Voltage Range
- 1A Output Current
- Serial Interface
- Individual 1/2-H-Bridge Control
- MOSFET on-Resistance: HS + LS 650mohm
- Controlled Slew Rate
- Open Load Detection
- Diagnostic Feedback
- SOIC & QFN Packages

Applications

- Automotive HVAC Controls
- Solenoid Drivers

**AEC Q100
Available**



MP6612 / MP6612D / MPQ6612 / MPQ6612A:45V, 5A, H-Bridge DC Motor Driver with Current Sense

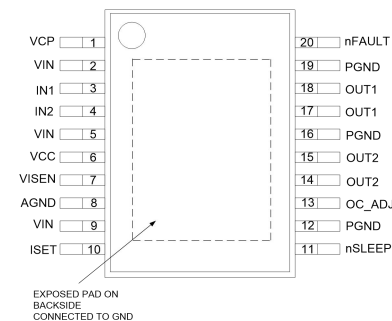
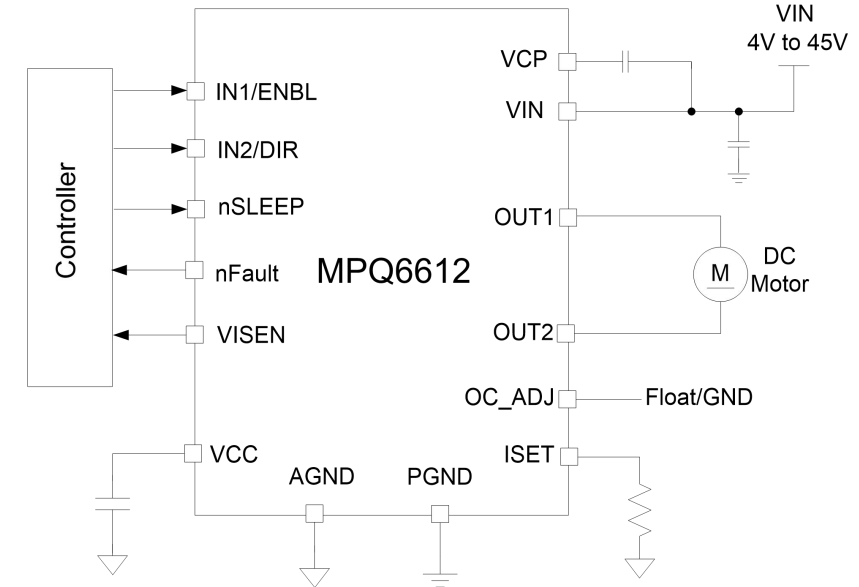
FEATURES

- Wide 4V to 45V Operating Input Range
- Internal Full H-Bridge Driver support 100% duty cycle with Internal charge pump
- Internal Current Sense with $\pm 10\%$ accuracy
- 5A Continuous Output Current
- 120mohm $R_{DS(ON)}$ (HS + LS)
- Programmable Cycle-by-cycle Current Regulation / Limit
- IN1/IN2 or ENBL/DIR inputs
- Low Iq Brake Mode
- Fault Indication Output for OCP/OTP/OVP
- TSSOP-20 EP (MP6612 / MP6612D / MPQ6612) and FCQFN-18 packages(MPQ6612A)
 - MP6612: IN1 and IN2 inputs
 - MP6612D: ENBL and DIR inputs

Applications

- DC Brush Motor Drivers
- Solenoid Drivers
- Door lock / Latch

AEC Q100
Available



TSSOP20-EP

Thank You!

Q&A