



基于灵动**MM32SPIN**平台 的BLDC应用与技术发展介绍

08. Nov. 2019

Outline

- ◆ Company profile
- ◆ MM32SPIN Family
- ◆ Applications of Power
 - ▶ USB-PD CSM module in MM32SPIN MCU
 - ▶ Wireless Changer
 - ▶ BMS
 - ▶ Digital Power MCU
 - ▶ IoT Power Supply
- ◆ Applications of BLDC Motor
 - ▶ Theory and application of FOC and Observer
 - ▶ Test result and successful stories

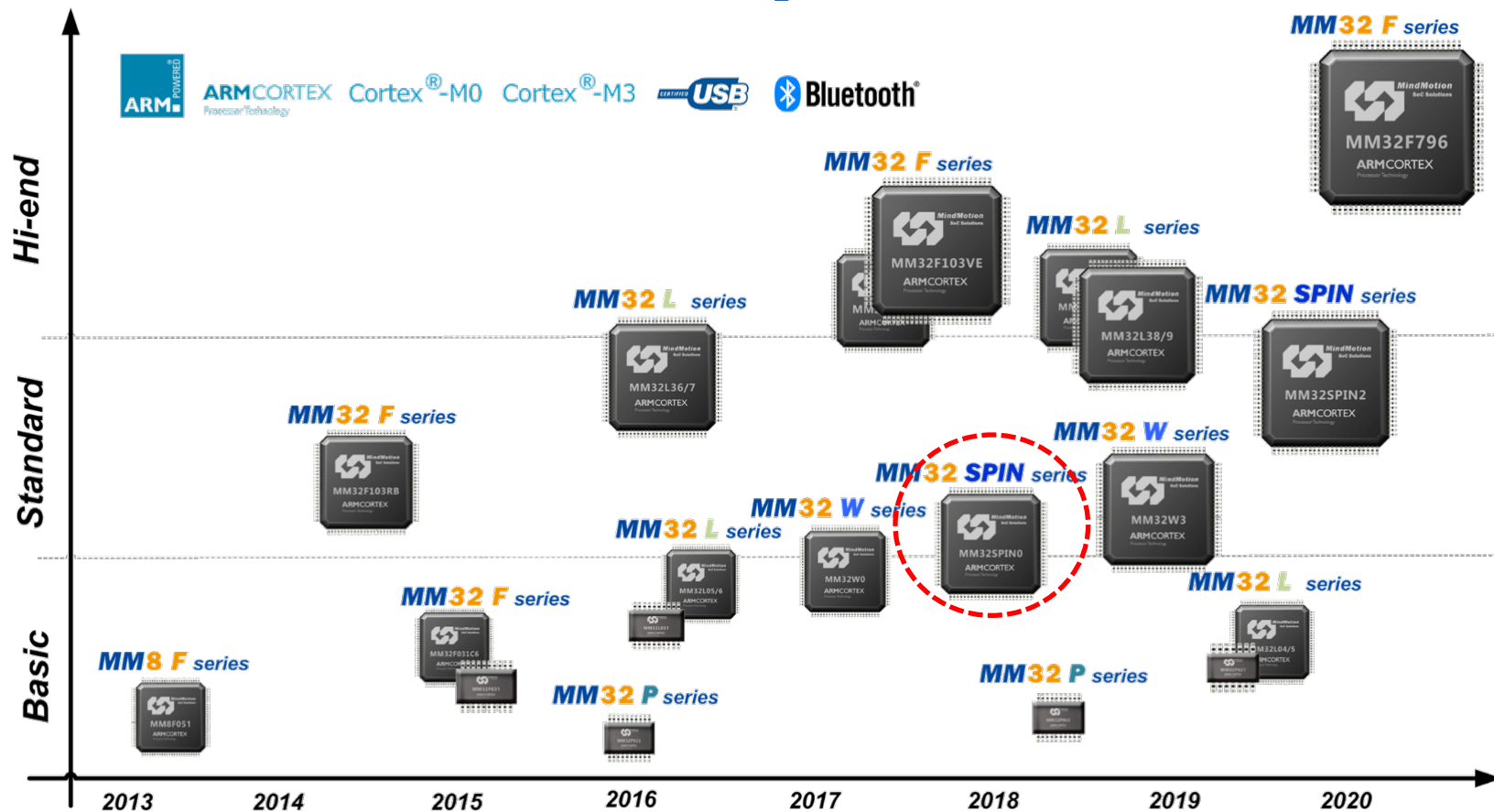
Where we are



MM32 MCU Market



MM32 MCU Roadmap



MM32 MCU Product Family

Over 200+
Part Numbers

MM32 MCU

MM32 F

General Purpose & High Performance

MM32 L

Low Power & High Safety

MM32 SPIN

Motor and Power

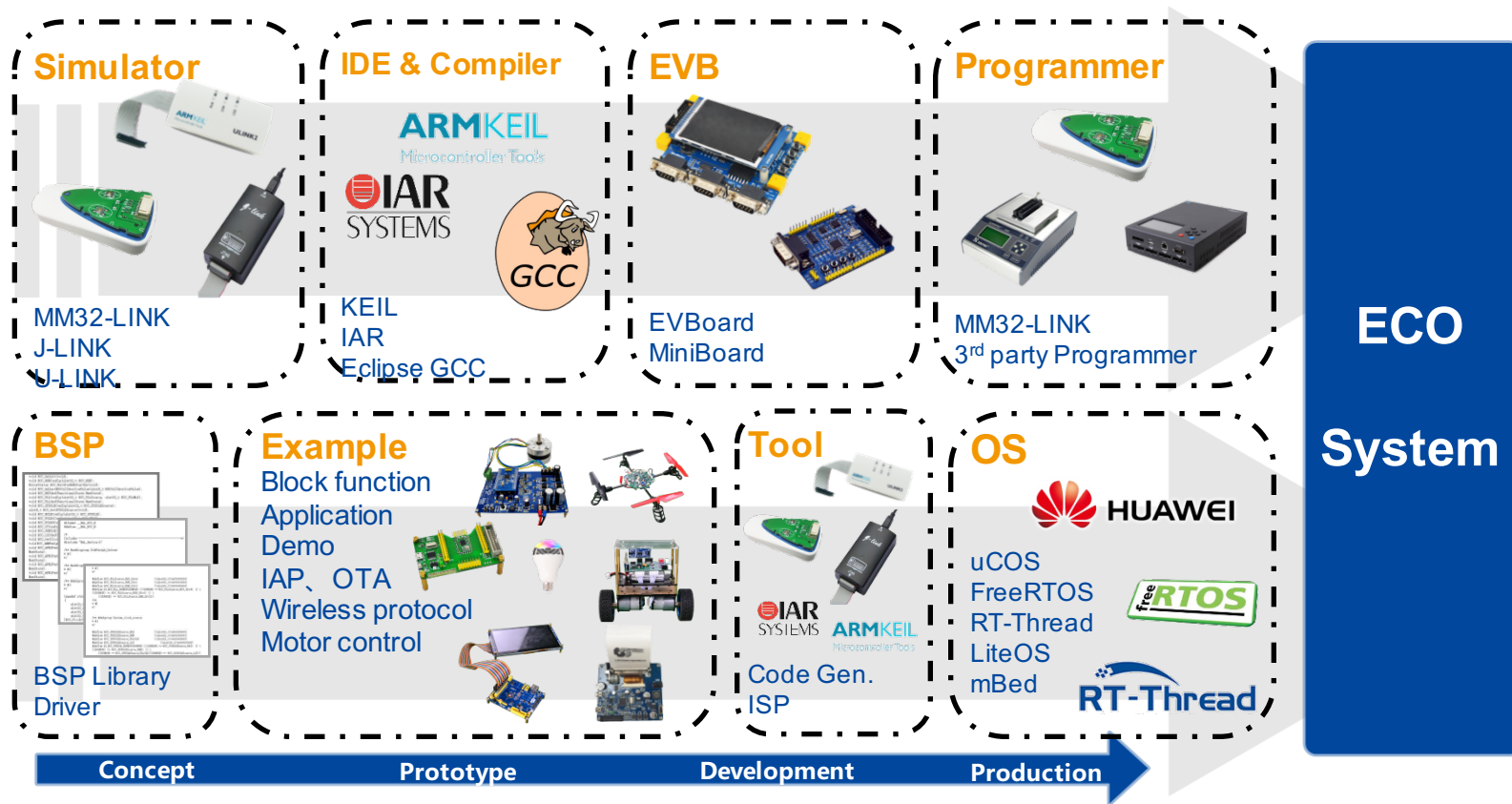
MM32 W

Wireless Connectivity

MM32 P

Tiny Package with OTP

MM32 ECO System



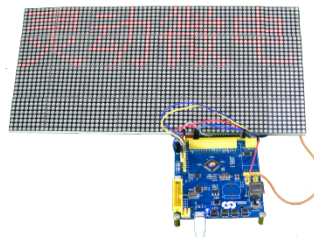
Successful Stories



Drone



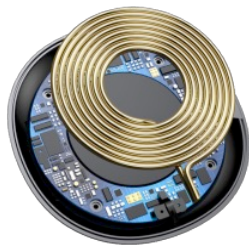
LCD Display



LED Display



E-tag



Wireless Charger



BLE Lighting



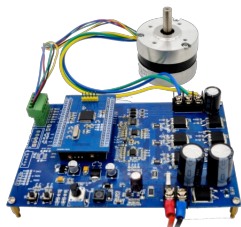
Smoke Detector



Thermal Printer



E-Cig



BLDC Motor



e Vehicle



Power Tool



Vacuum

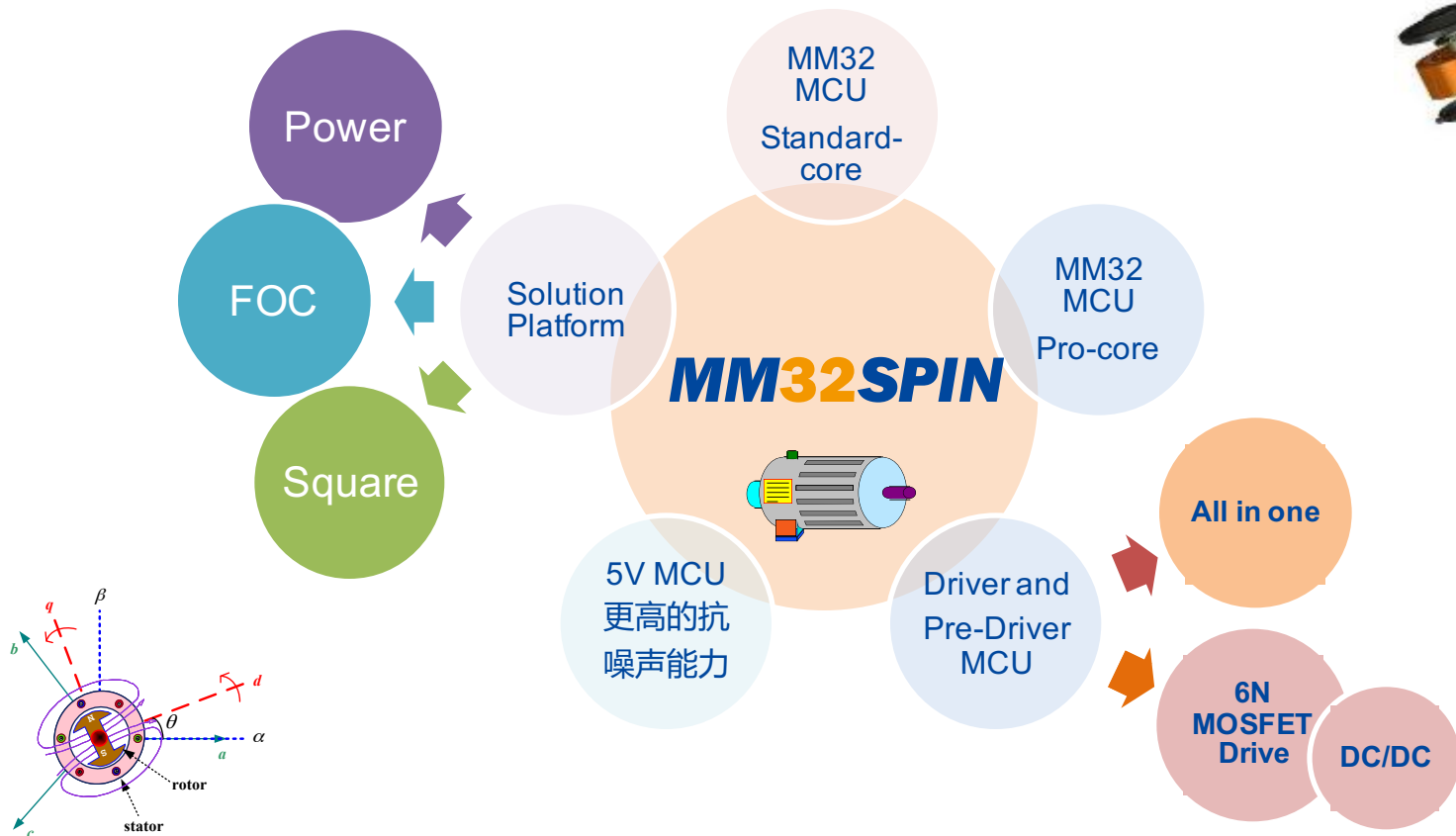


Servo



MM32SPIN FAMILY

What is **MM32SPIN** and it's advantage



The Smart and Green BLDC



Focus Market with Successful stories



SAM/TAM: 50 / 250 KK
MCU: MM32SPINx60C
MM32SPIN120B

Power
tool



SAM/TAM : 30 / 80 KK
MCU: MM32SPIN25/7 for FOC
MM32SPIN05 for Square
SPIN05PFX for 滑板车

E Bike

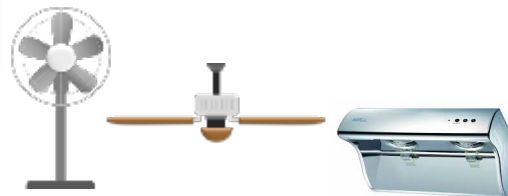
SAM/TAM : 30/ 100 KK
MCU: MM32SPIN22xC
MM32SPIN120B

Micro
motor



SAM/TAM : 10/ 100KK
MCU: MM32SPIN05/25
MM32SPINx60C

Fan



MM32SPIN05/06 Controller MCU Product Family

Frequency Up to 72/96Mhz

Build-in Divider and HW Break

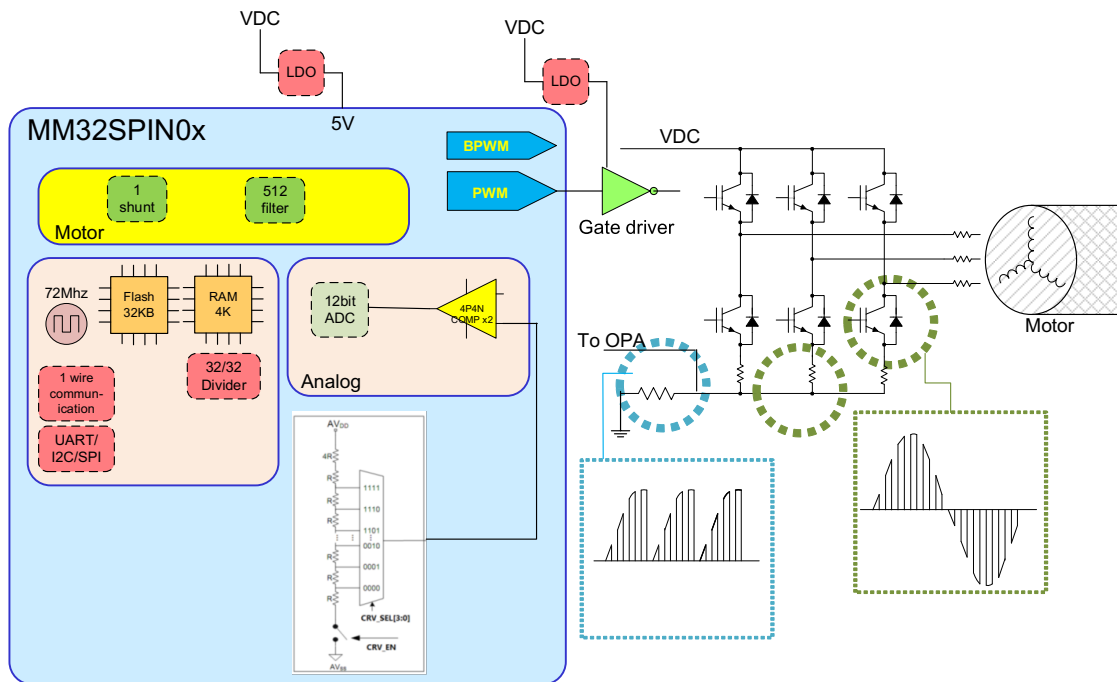
20PIN 3x PWM (SPIN05)

USB-PD CSM Module (SPIN06)

Support CAN Bus (SPIN06)

Motor Special Peripheral

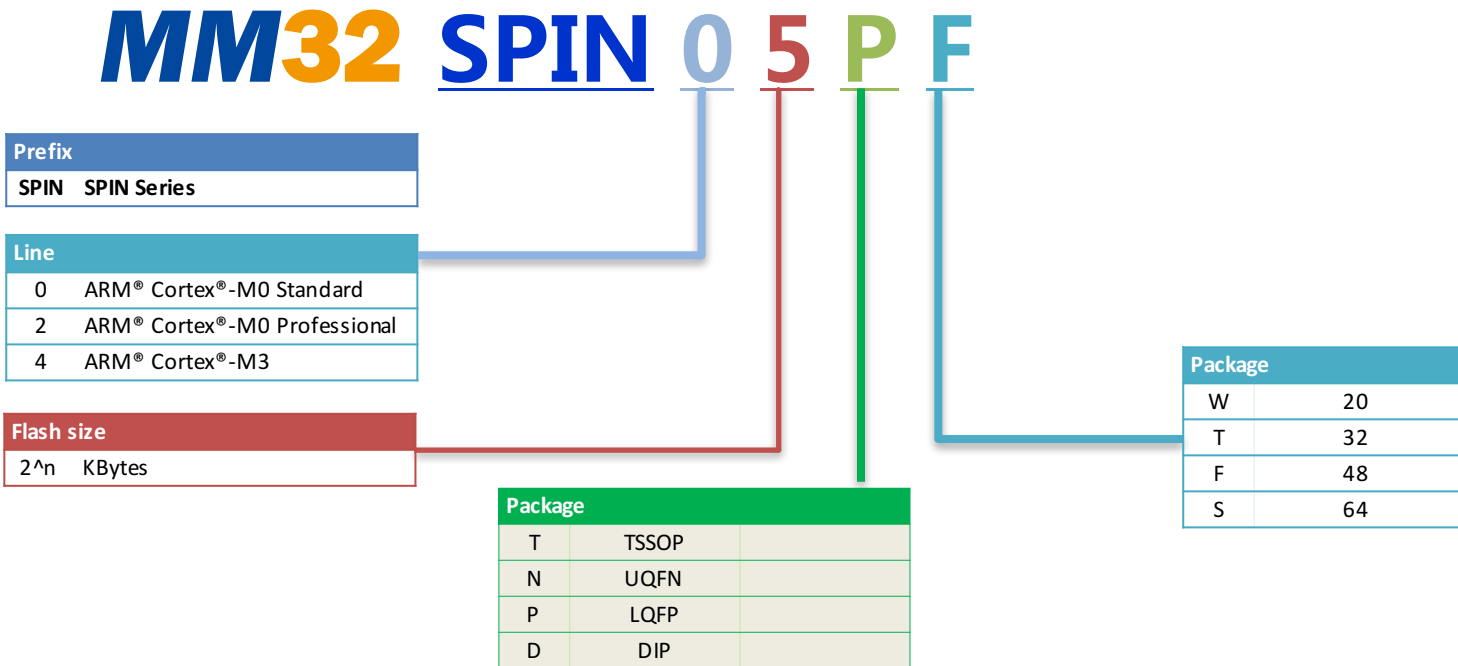
Support Single Line UART



Support IEC60730



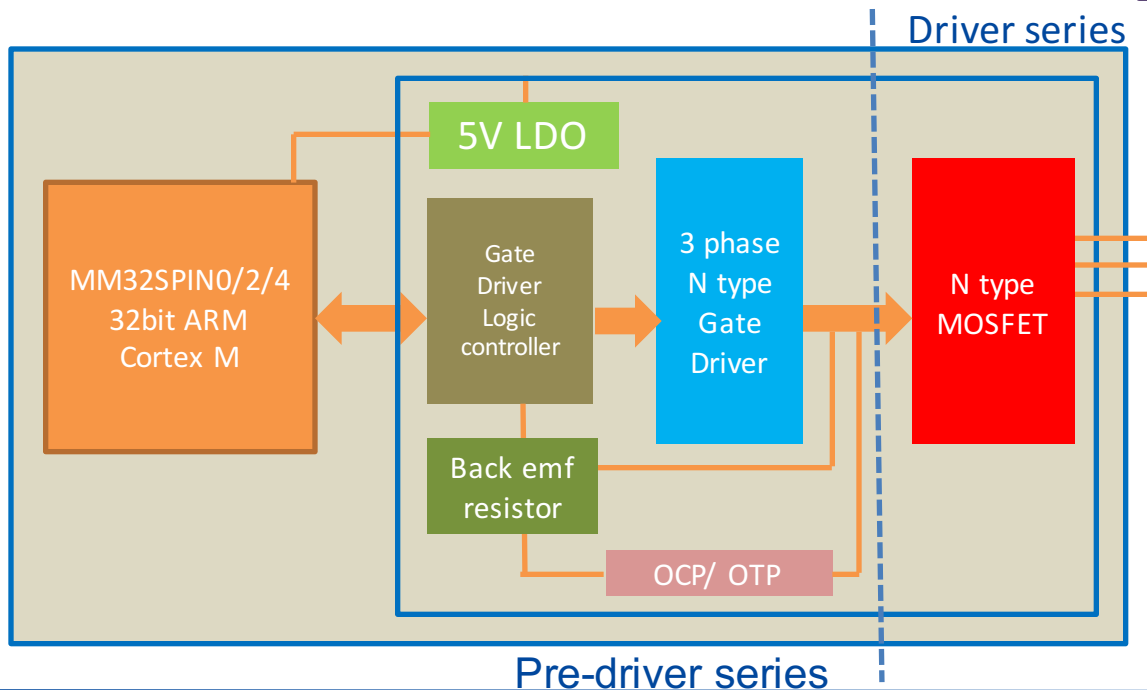
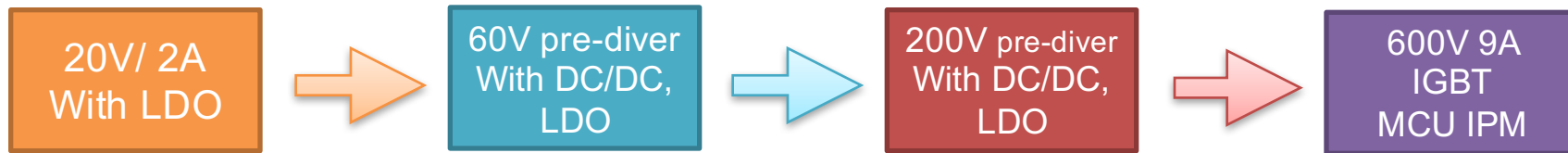
MM32SPIN Controller MCU Naming Rules



◆ More ...

- +Gate driver
- +Mosfet
- +DC DC converter

MM32SPIN Driver/Pre-driver MCU Product Family



MM32SPIN Driver/Pre-driver MCU Naming Rules

MM32 SPIN 2 2 2 C

Prefix	
SPIN	SPIN Series

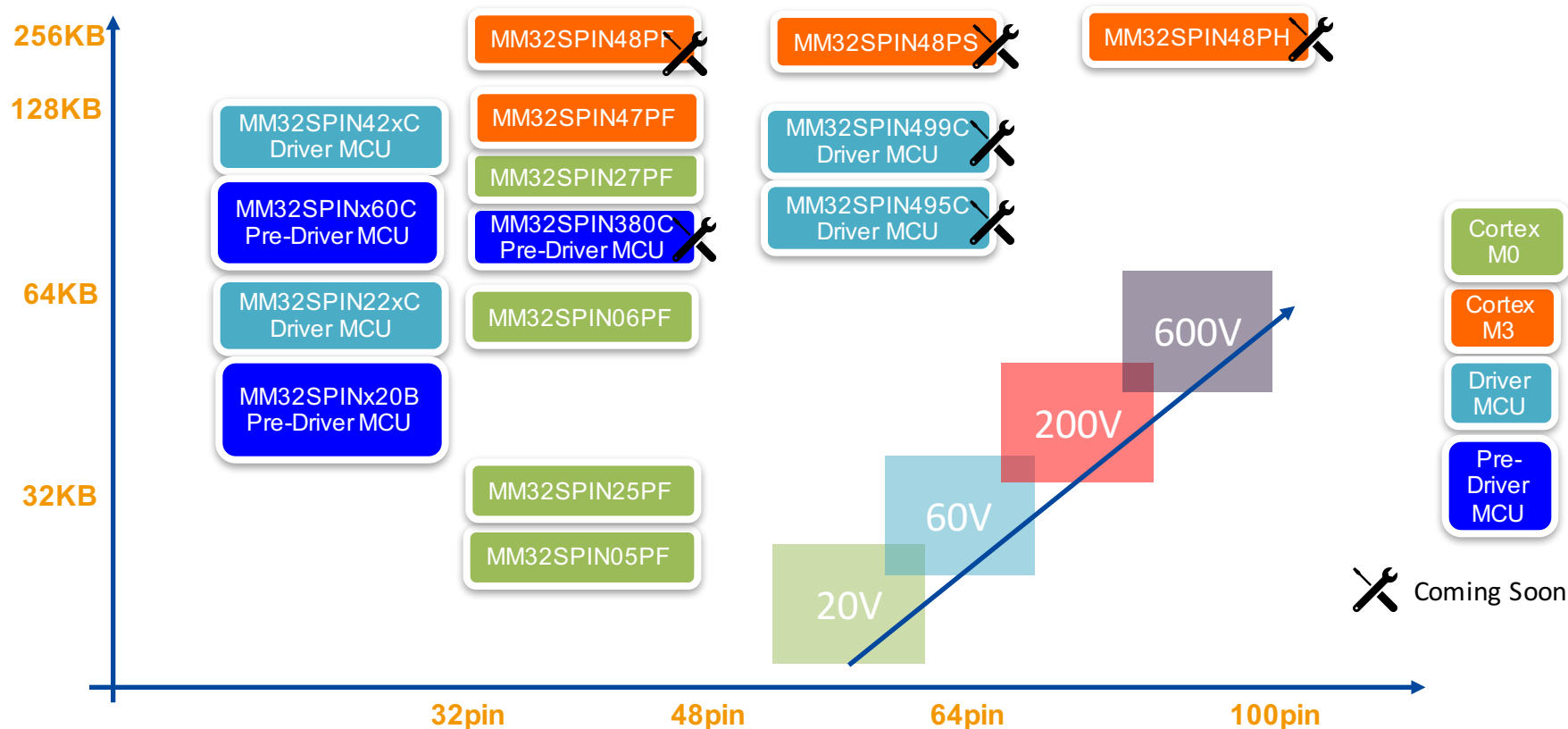
Line	
1	ARM® Cortex®-M0 Standard + Gate Driver
2	ARM® Cortex®-M0 Standard + Driver
3	ARM® Cortex®-M0 Professional + Gate Driver
4	ARM® Cortex®-M0 Professional + Driver
5	ARM® Cortex®-M3 Standard + Gate Driver

Voltage	
2	20V
6	60V
7	100V
8	200V
9	600V

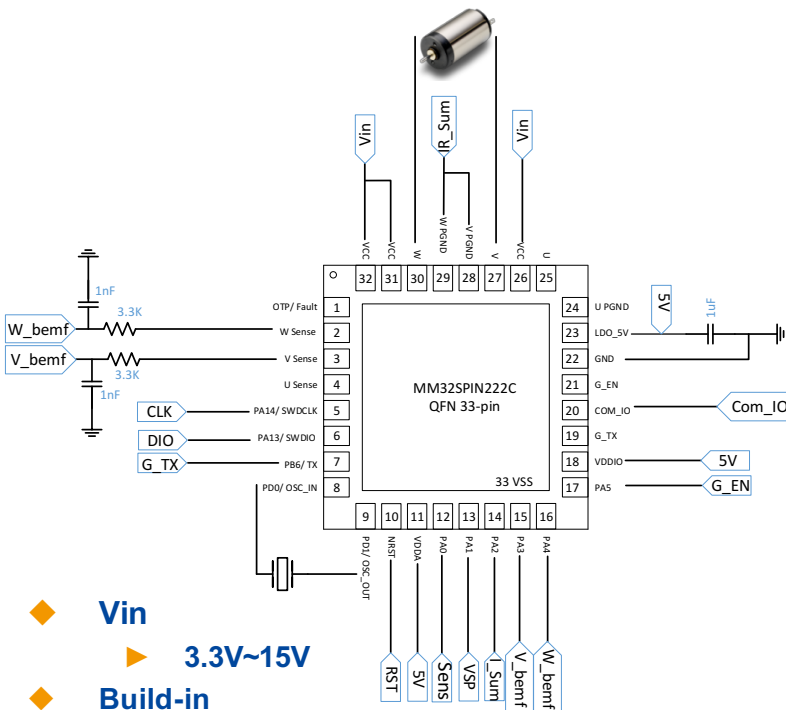
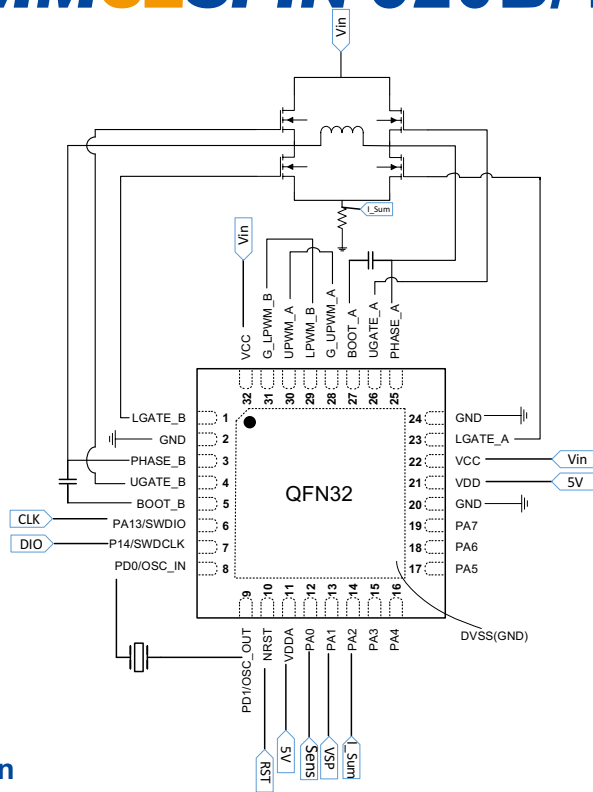
Phase	
A	1-phase
B	2-phase
C	3-phase
D	4-phase

Current		
1~9	1~9 Amp	

MM32SPIN MCU Roadmap



MM32SPIN 320B/120B/222C



- ◆ **Vin**
 - ▶ 7V~15V
- ◆ **Build-in**
 - ▶ Two half bridge N type gate driver

- ◆ **Vin**
 - ▶ 3.3V~15V
- ◆ **Build-in**
 - ▶ 5V LDO with low drop voltage
 - ▶ 2Amp 3P+3N Mosfet
 - ▶ Back-emf sense resistor
 - ▶ OTP (Over temperature protection)

MM32SPIN x60C

◆ Vin

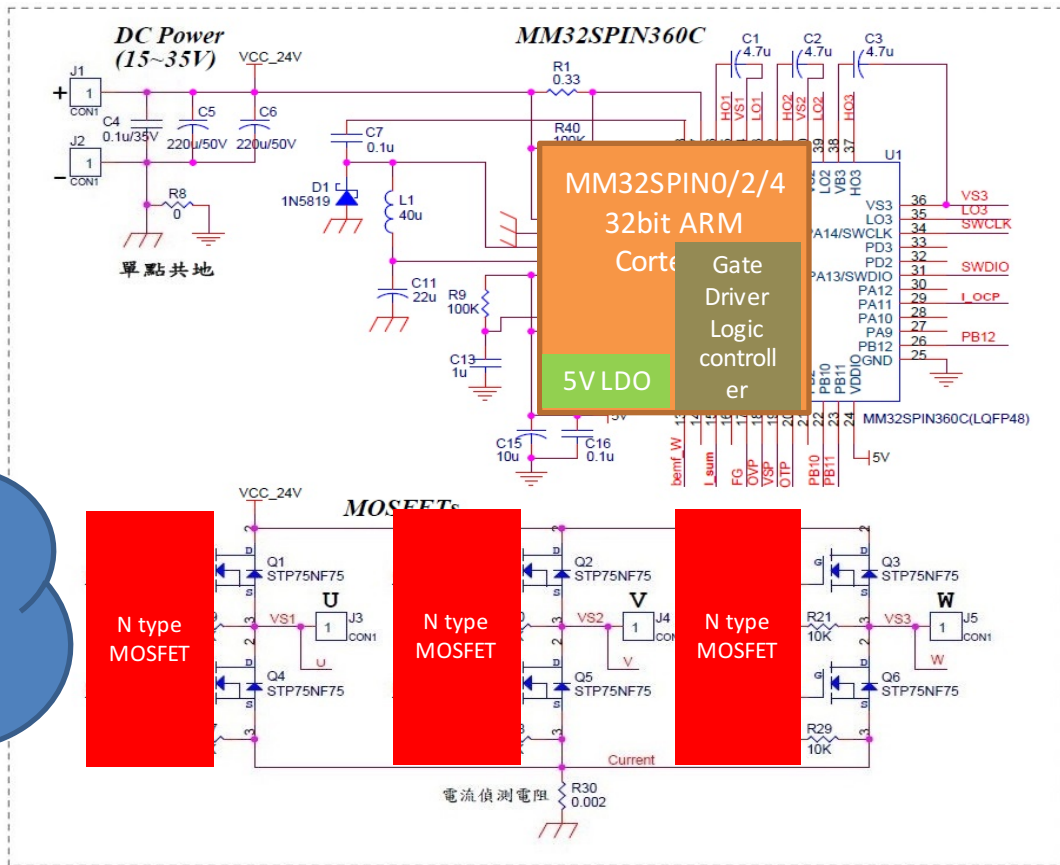
▶ 7V~36V

◆ Build-in

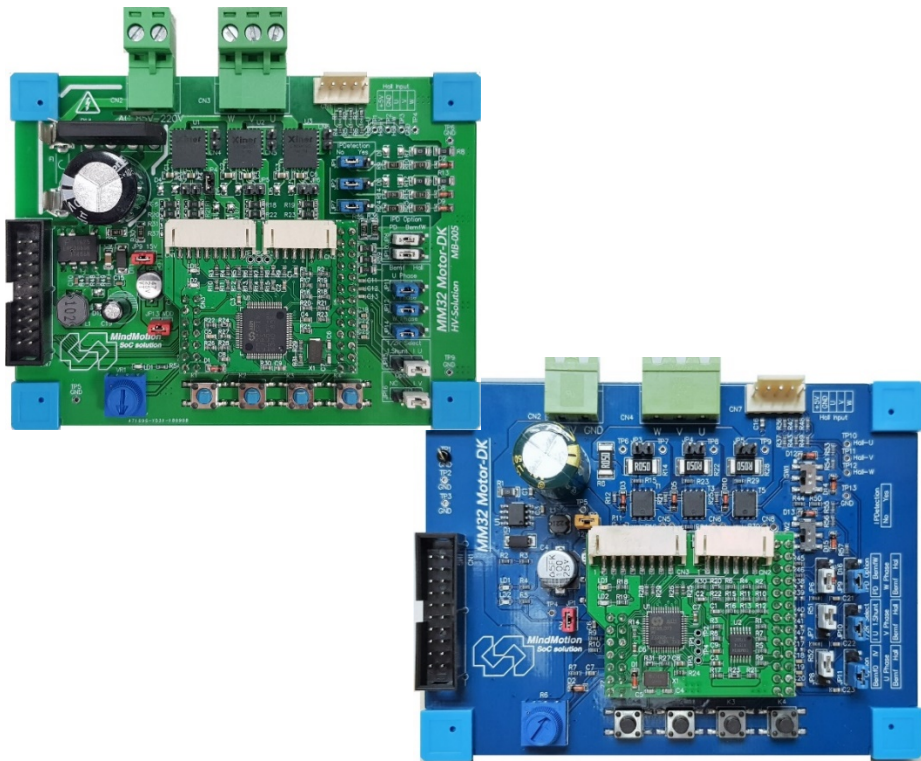
- ▶ Three half bridge N type gate driver
- ▶ Buck/Boost type DC/DC converter
- ▶ Low drop voltage 5V LDO
- ▶ 3x OPA
- ▶ 4x Comparator

优势

节省PCBA面积
节省2颗OPA IC
节省3个HVIC
节省1个LDO
节省1个DCDC IC
节省1~2个比较器IC



MM32SPIN0 Motor-DK (Develop Kits)



Support All MM32SPIN MCUs

Low Voltage Protection and

Reverse connection protection

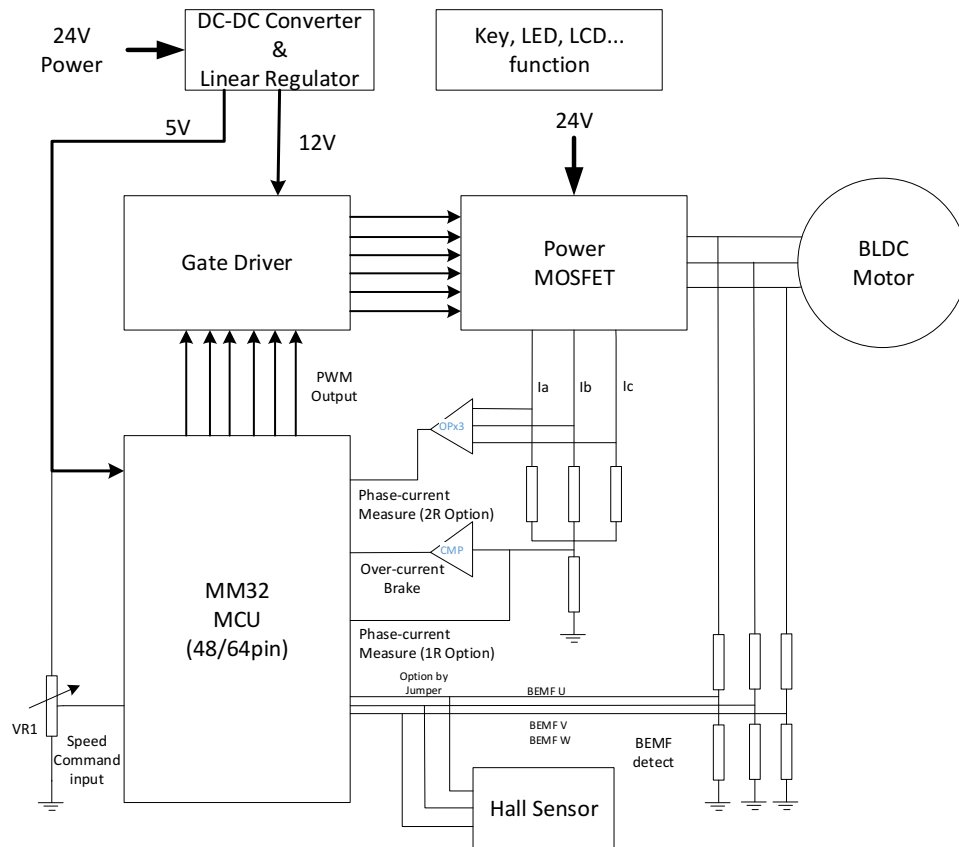
Various Resistance Sampling Modes

Support MM32SPIN Algorithm Lib

Easy to Use

Easy to Obtain

MM32SPIN Motor-DK (Develop Kits)

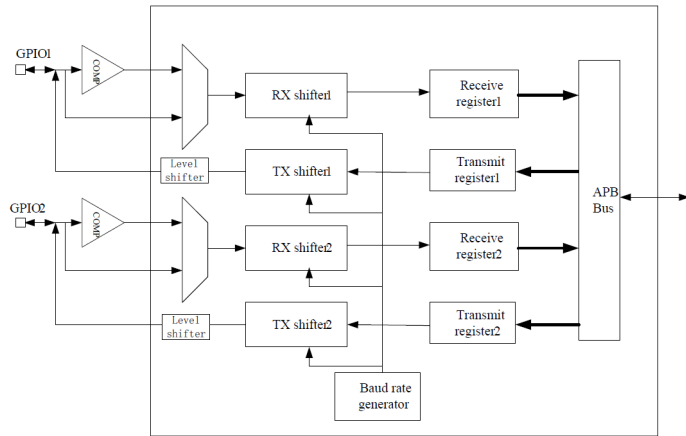
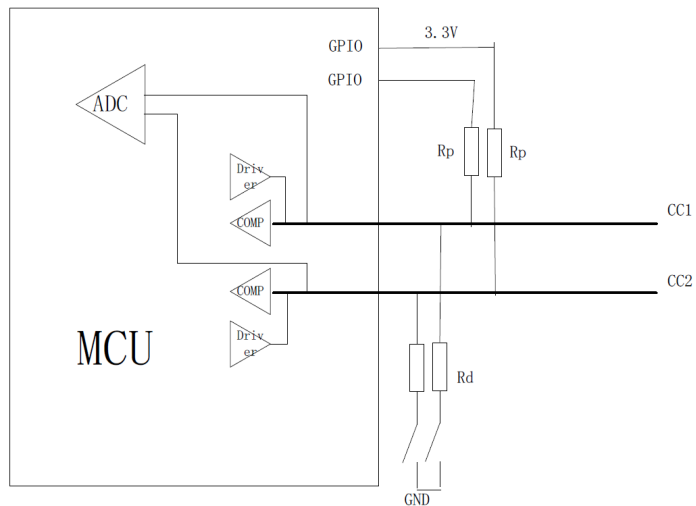




APPLICATIONS OF POWER

Block Diagram of CSM Module

- ◆ 串行收发模块主要用于串行数据的接收和发送，数据可以选择比较器或者GPIO输入，通过内部设置的波特率采样后转换为32位数据，可用CPU或者DMA保存在存储器，再通过软件分析接收的数据。



MM32SPIN25

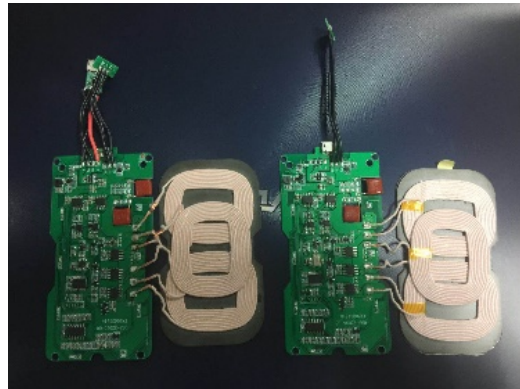
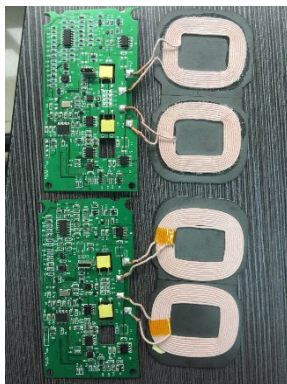
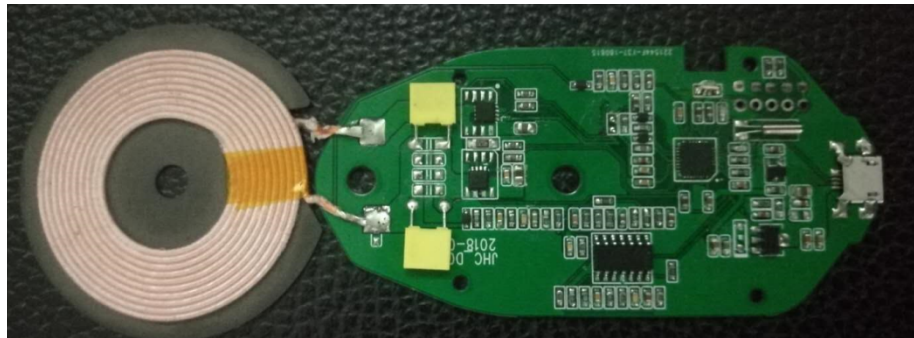
-
- The schematic diagram illustrates the bootstrap switch control circuit. It includes the following components and connections:
- Inputs:** CC, UI, and LI.
 - Outputs:** BOOT, UGATE, and PHASE.
 - Power Supply:** VCC and GND, with a 12K resistor connected to VCC.
 - Logic Blocks:**
 - UVLO:** UVLO block connected to CC.
 - LEVEL SHIFT:** LEVEL SHIFT block connected to UI and LI.
 - Adaptive Shoot-Through Protection:** Two blocks, one connected to UI and LI, and another connected to UGATE and PHASE.
 - Bootstrap Switch Control:** Bootstrap Switch Control block connected to UGATE and PHASE.
 - Resistors:** Two 200K resistors connected to UI and LI, and a 12K resistor connected to VCC.

The diagram shows the timing of a 1-bit full adder. It includes four signals: UI (blue), LI (blue), UGATE (red), and LGATE (red). UI and LI are inputs, while UGATE and LGATE are control signals. The diagram illustrates the propagation delays for the carry-out signal (COUT) and the sum output (SOUT). The carry-out signal (COUT) is shown as a red signal that transitions from low to high when the carry-in (CIN) is high and the sum output (SOUT) is high. The sum output (SOUT) is shown as a blue signal that transitions from low to high when the carry-in (CIN) is high and the sum output (SOUT) is high. The propagation delays are labeled as follows: T_{UIRUGR} (UI to UGATE), T_{LIRLGR} (LI to LGATE), T_{TRUG} (UGATE to COUT), T_{TRLG} (LGATE to COUT), T_{UIFGF} (UI to SOUT), T_{LIFLGF} (LI to SOUT), T_{PDHLG} (COUT to SOUT), and T_{PDHUG} (SOUT to COUT).

-

Wireless Charger

- ◆ WPC Qi V1.2.4
- ◆ FOD 运算
- ◆ 搭配USB-PD
 - ▶ 20W以上
 - 5/9/12/20 V
- ◆ 支持NTC\风扇、蜂鸣器等各种附加功能。
- ◆ 车充
- ◆ 无线充电宝

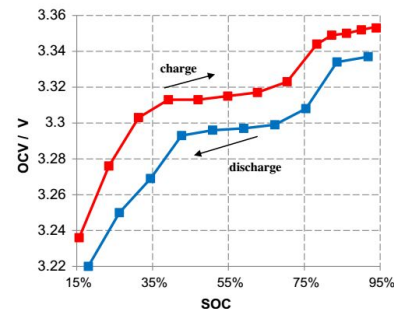
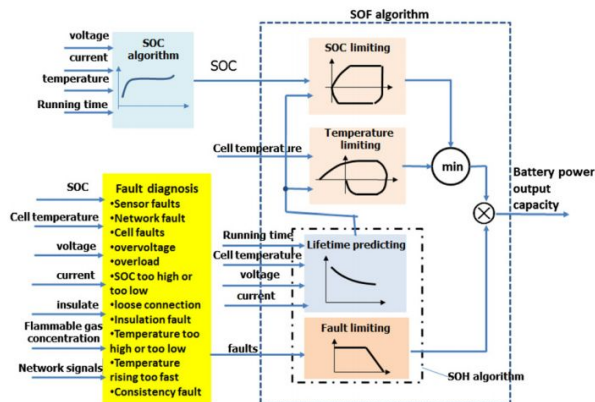
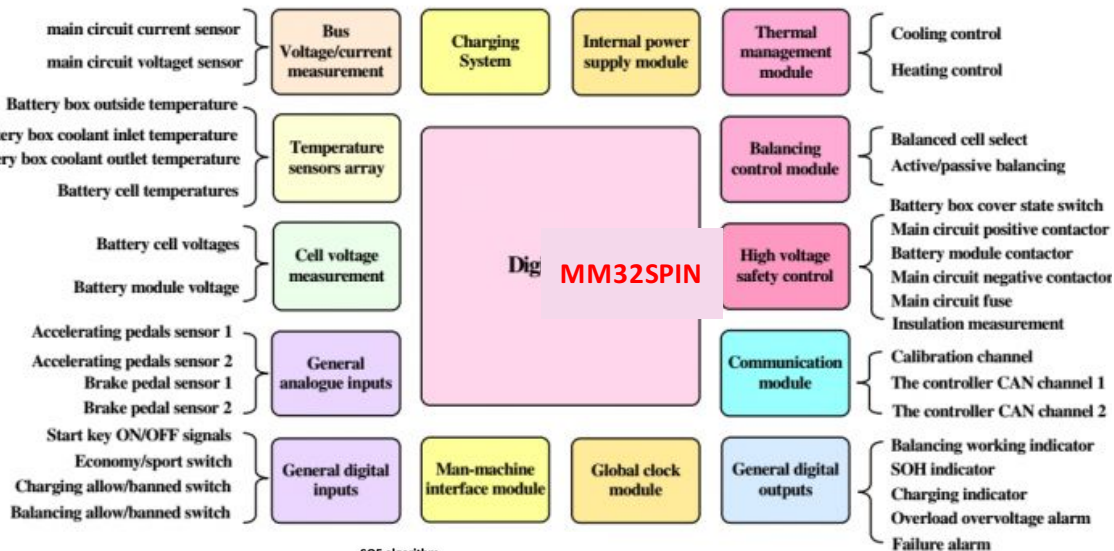


BMS

◆ MM32SPIN06

- ▶ 13ch 12bit ADC
- ▶ 96Mhz M0 with DIV
- ▶ 2 Comparator
- ▶ CAN 2.0b

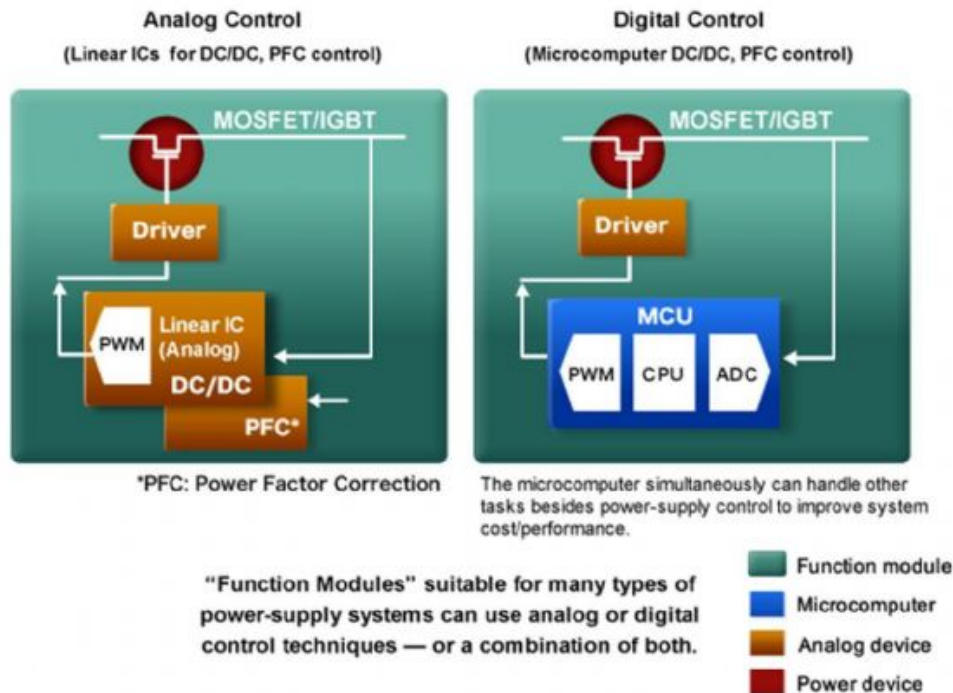
◆ SOC algorithm



Digital Power MCU

◆ MM32SPIN25/27

- ▶ 192Mhz PWM, 3phase inter-leave PWM control
- ▶ DSP aux-core
- ▶ 128K flash
- ▶ 4x OPA
- ▶ 5x Comparator
- ▶ Cycle by cycle protection





APPLICATIONS OF MOTOR

MM32SPIN Solution Planform – Fan

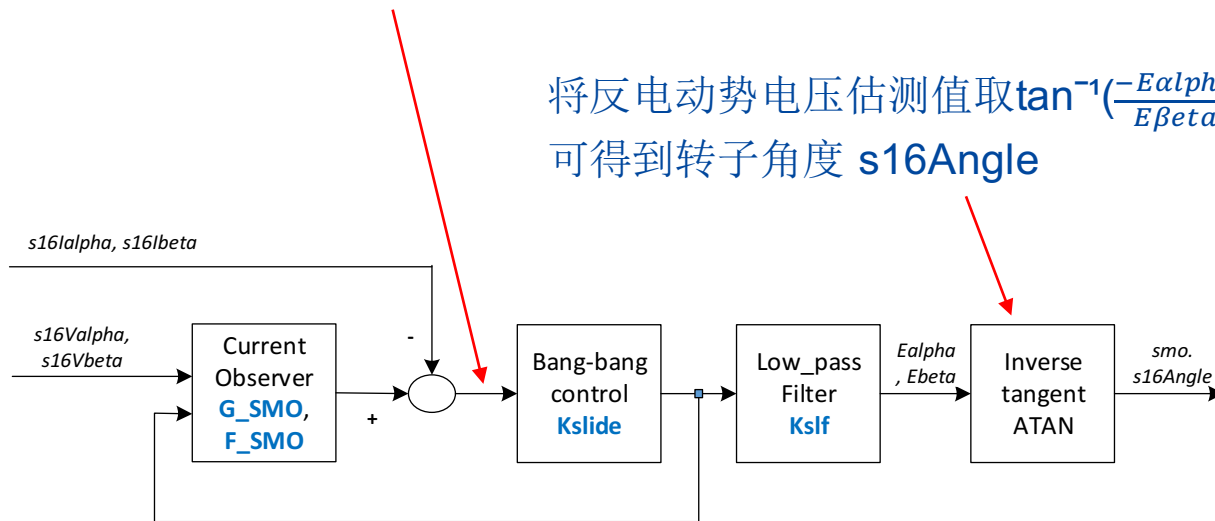
- ◆ FOC
- ◆ Square
- ◆ Single Phase using Sinewave

滑模估测(SMO)转子角度估测软件框图

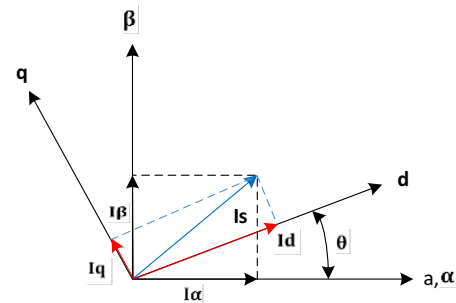
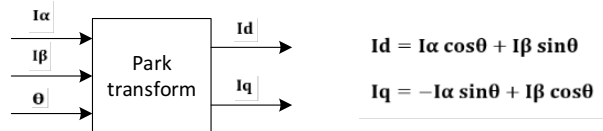
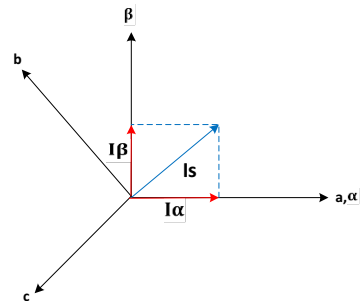
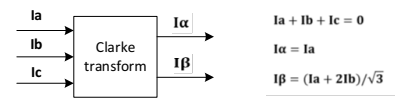
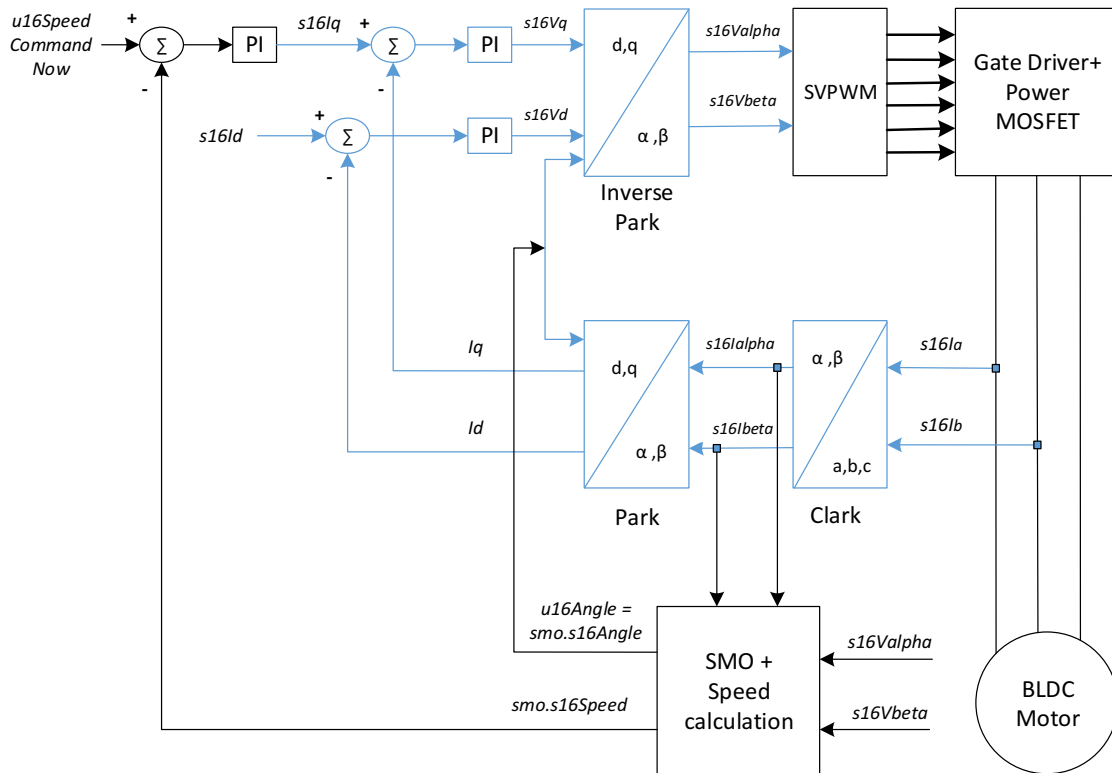
$l\alpha_error = l\alpha_esti - s16l\alpha$

$l\beta_error = l\beta_esti - s16l\beta$

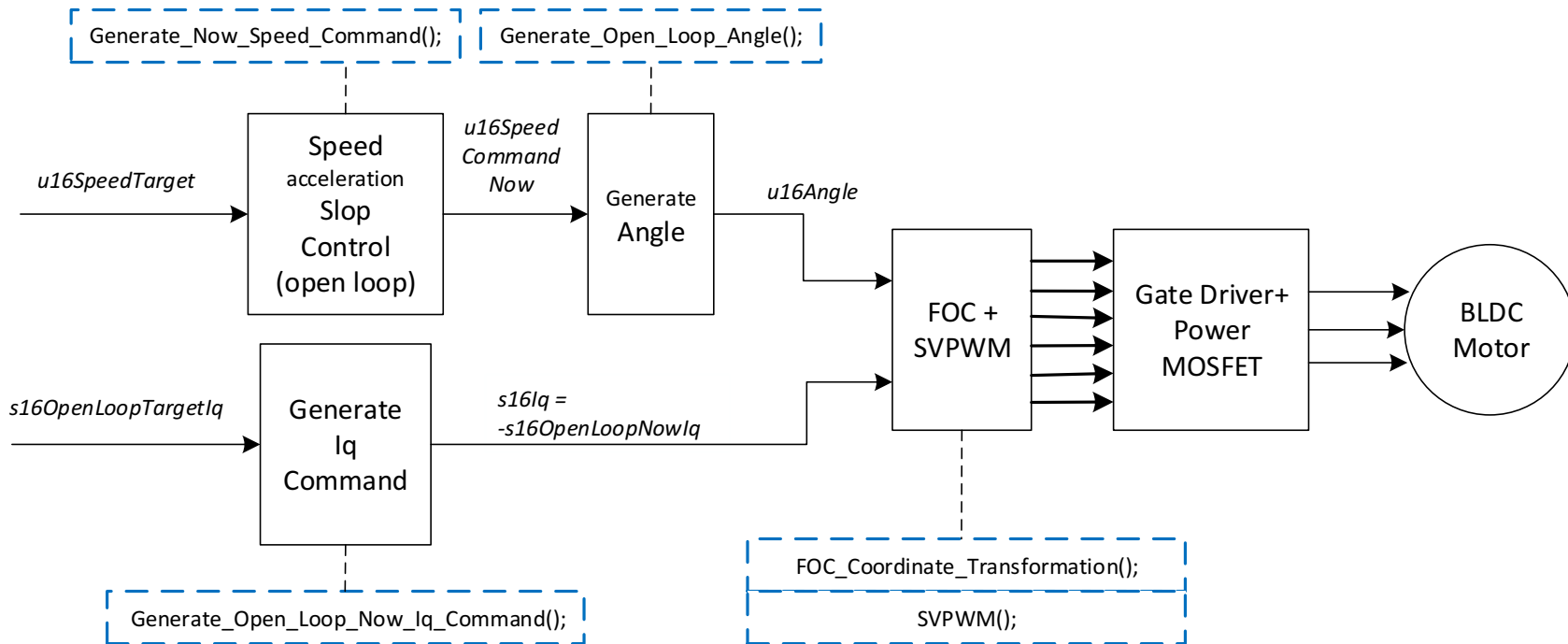
将反电动势电压估测值取 $\tan^{-1}(-\frac{E\alpha}{E\beta})$,
可得到转子角度 $s16Angle$



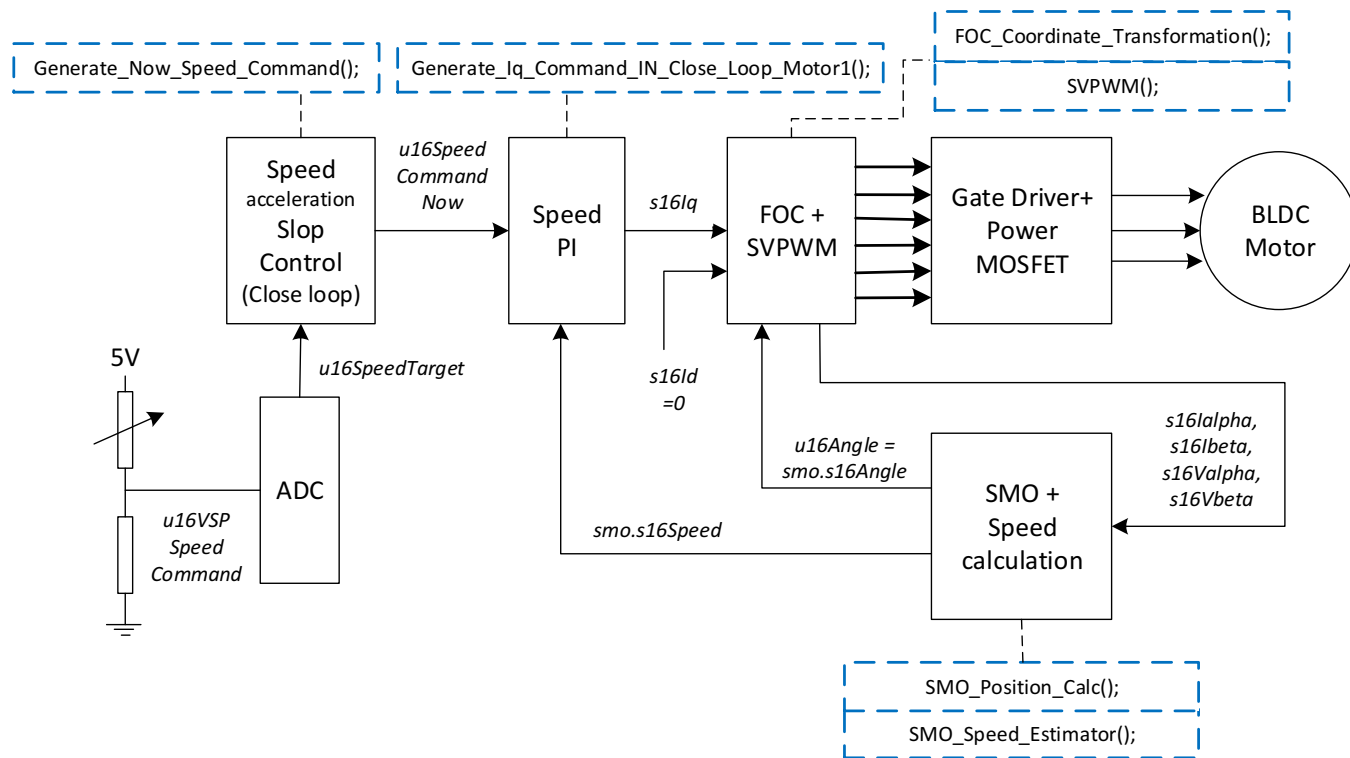
FOC Block Diagram



Sensorless FOC- Open Loop

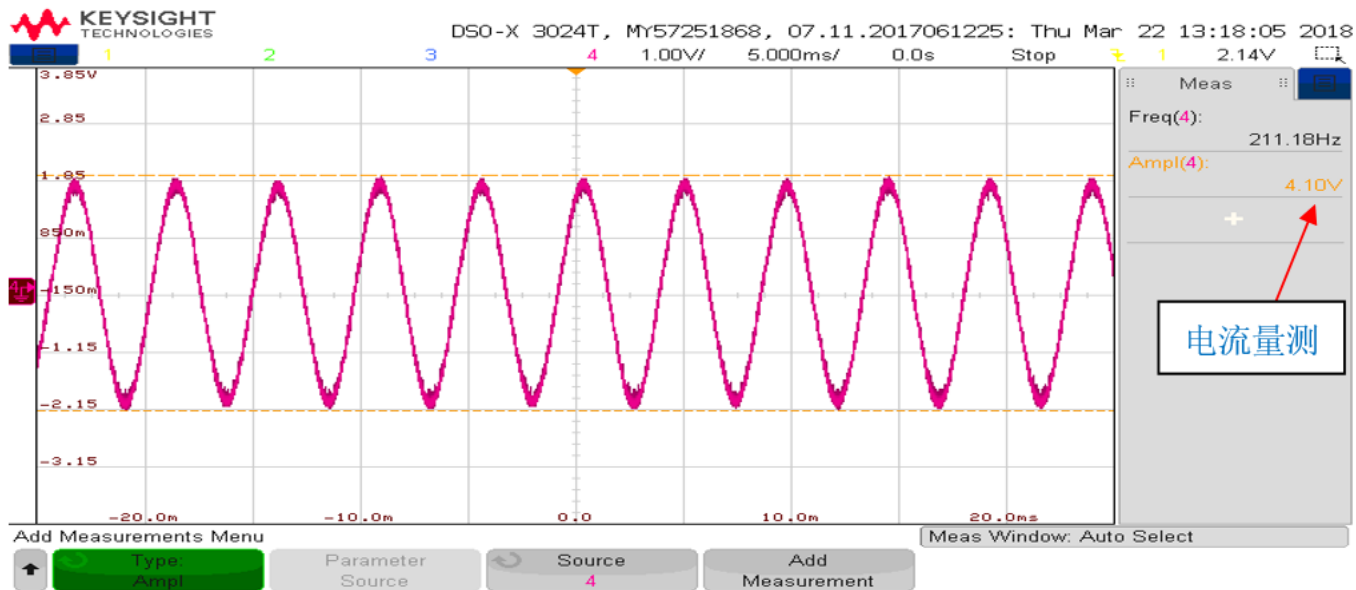


Sensorless FOC- Close Loop

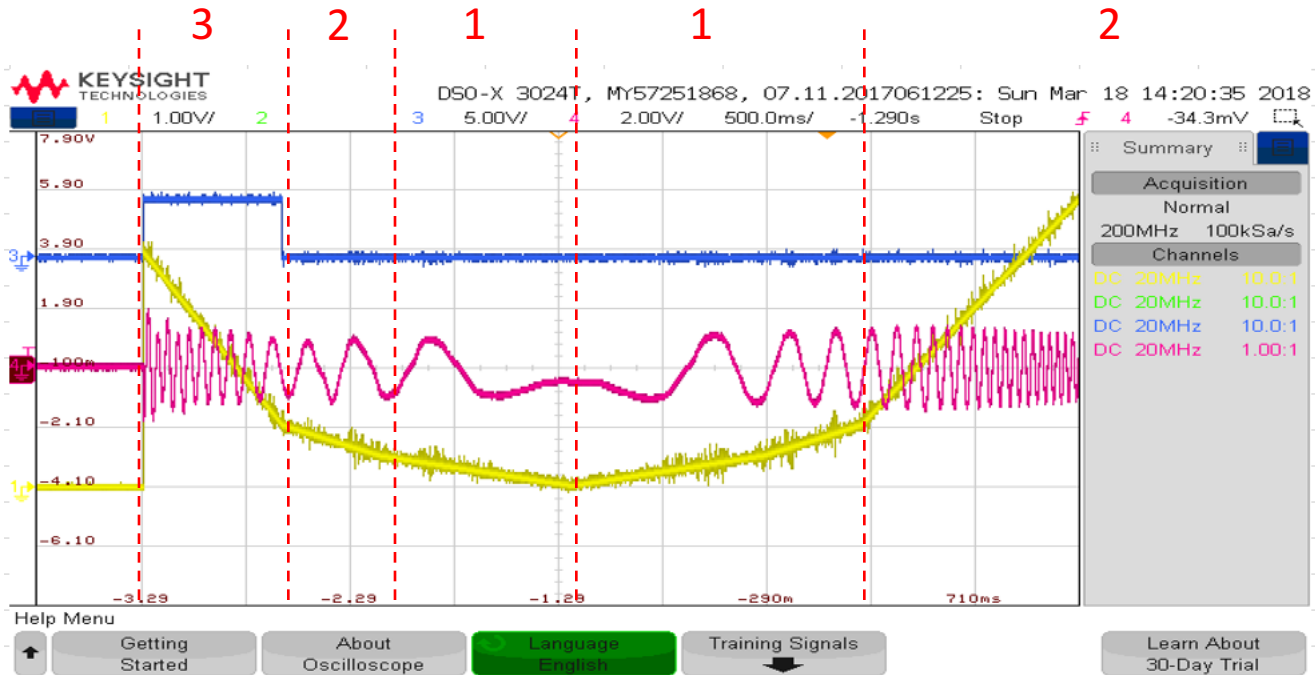


Current Loop Control

◆ 电流命令2A下的V相电流波形, 实际量测结果为 $\pm 2.05\text{A}$



逆风启动开回路三段减速度波形



藍色：高電平 表在降速斜率三區間，降速斜率三設定為 200RPM/Sec 減速度，速度由200RPM 下降至50RPM

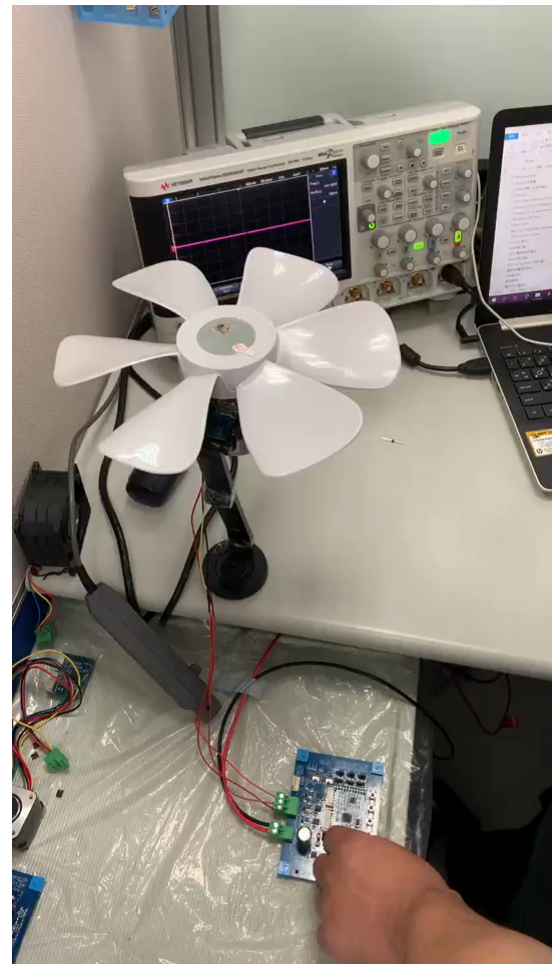
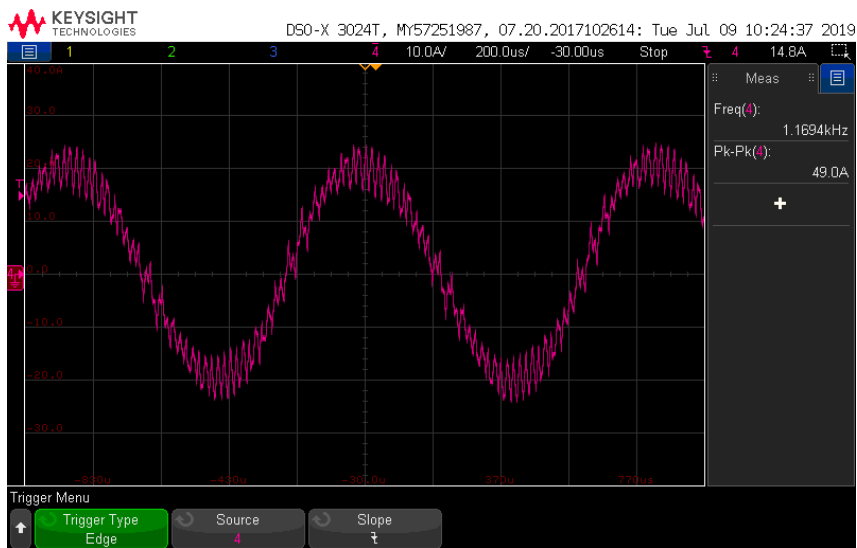
紅色：W相電流 (電流探棒 1A/1V)

黃色：開環速度 (10RPM/0.20V)(由DAC 輸出至示波器上)

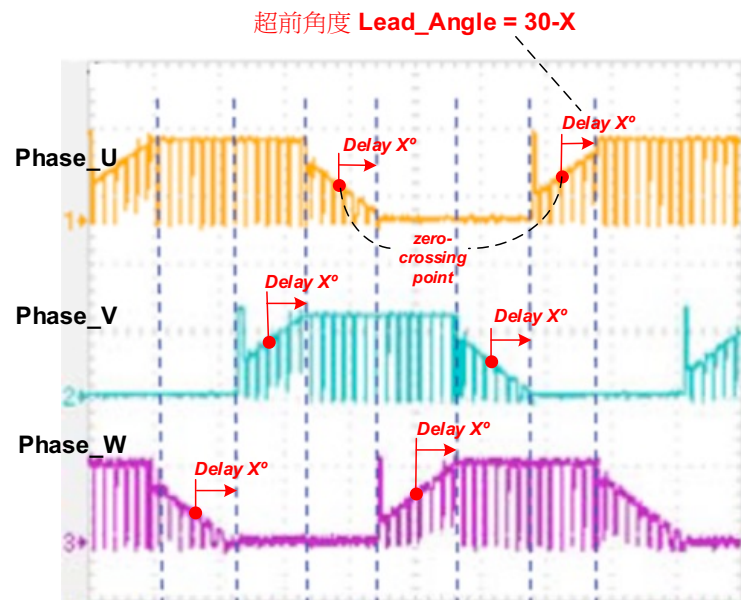
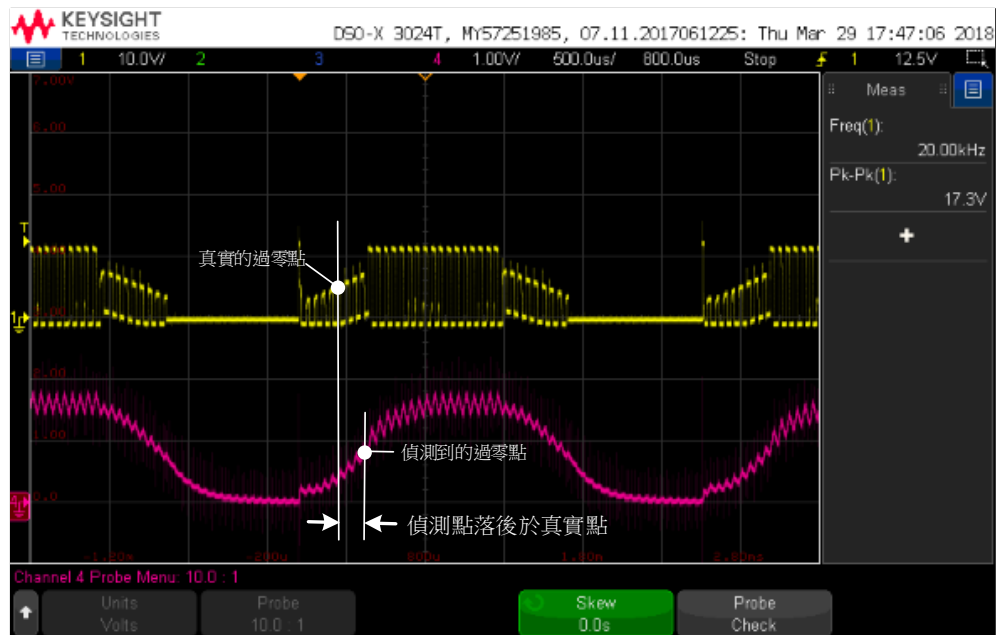
測試結果：PASS

The test result of high speed

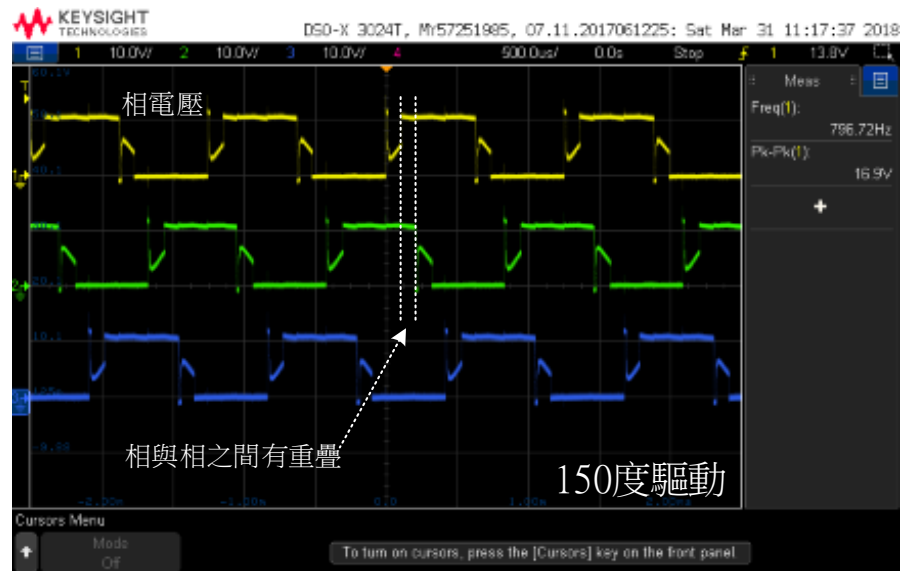
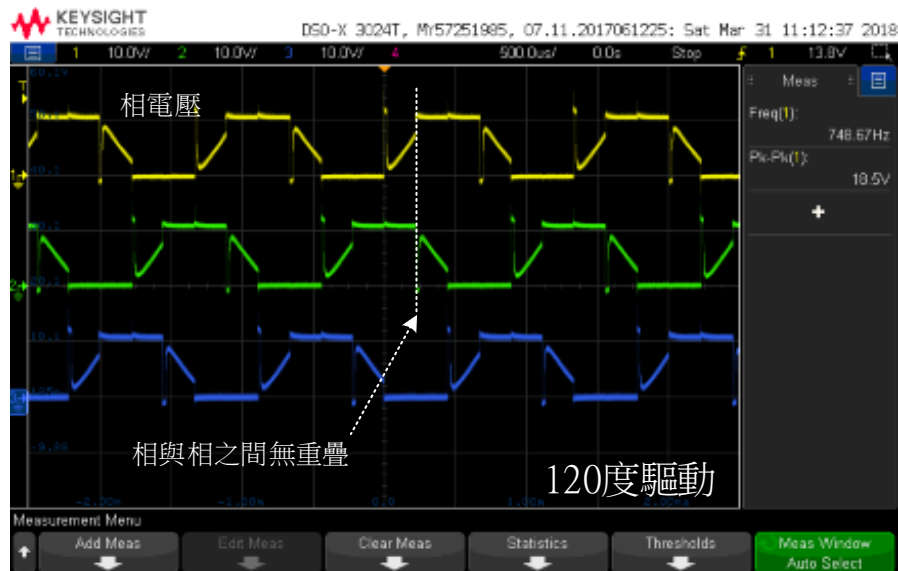
- ◆ FOC , 90,000~120,000 (Dyson level)
 - ▶ Start up at zero speed



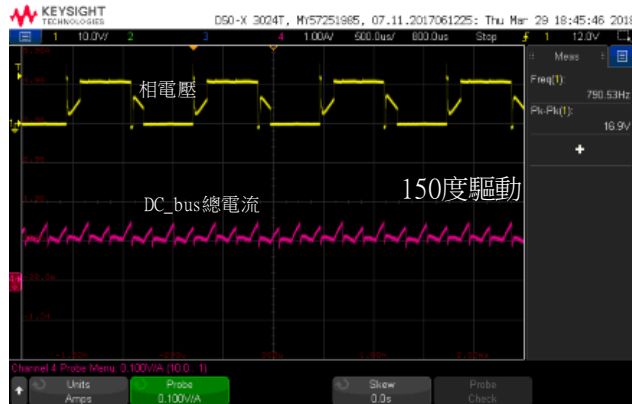
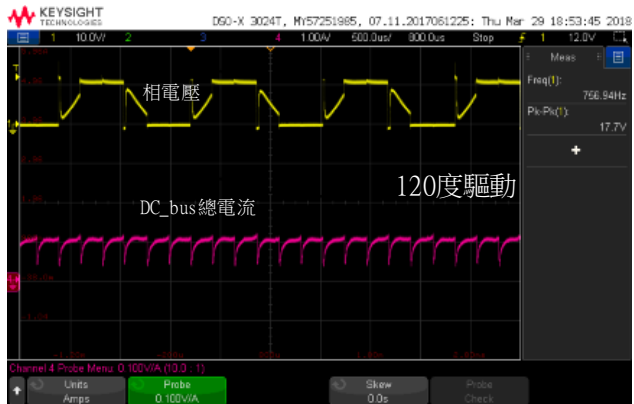
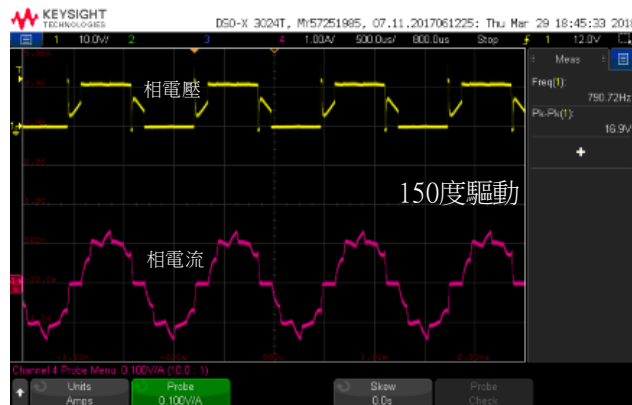
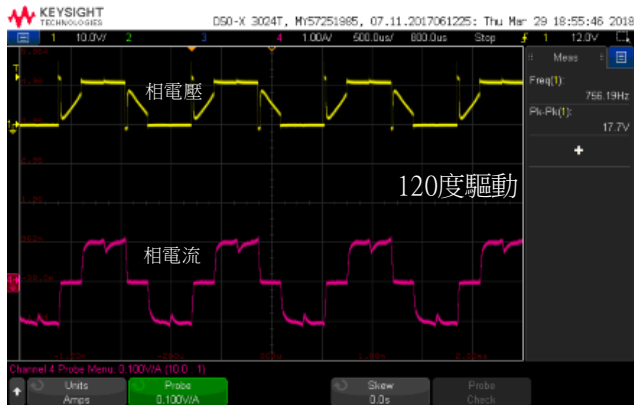
Square wave solution- 120 degree



Square wave solution- 120/ 150 degree

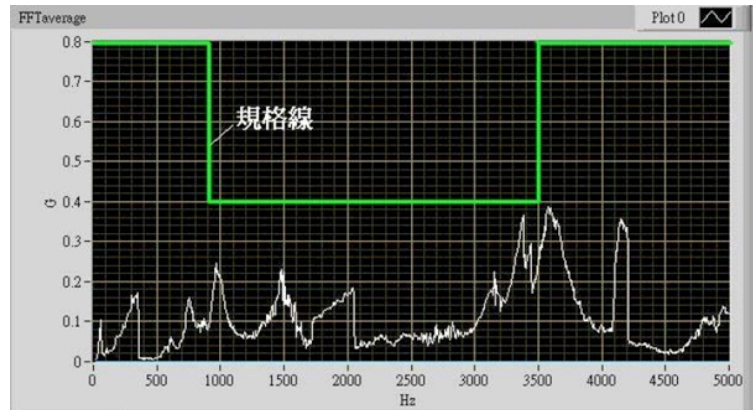
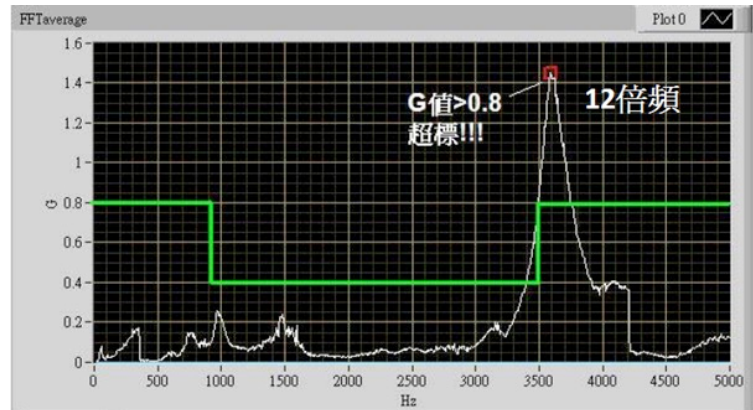


Square wave solution- 120/ 150 degree



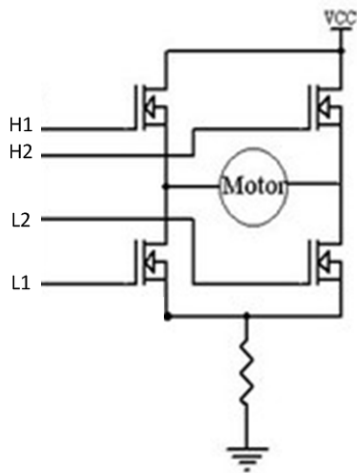
Square wave solution- 120/ 150 degree

- ◆ Example:
- ◆ Server Fan
- ◆ Vibration improvement: 12x frequency
 - ▶ 6 slots 4 poles
 - ▶ Rated speed: 21,000 rpm
- ◆ Upper:
 - ▶ Big vibration on 12x
 - ▶ =3600Hz
 - ▶ =18000rpm
- ◆ Lower:
 - ▶ Lower vibration on 12x

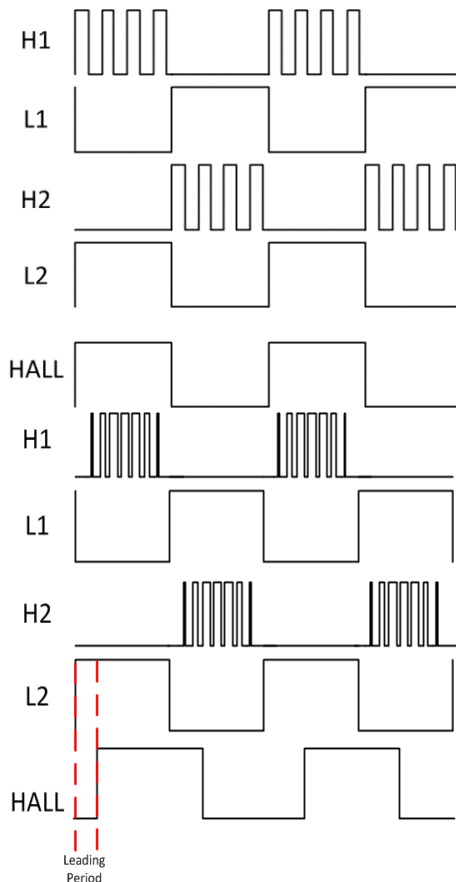


MM32 Single phase theory

- ◆ Conventional
 - ▶ Square wave

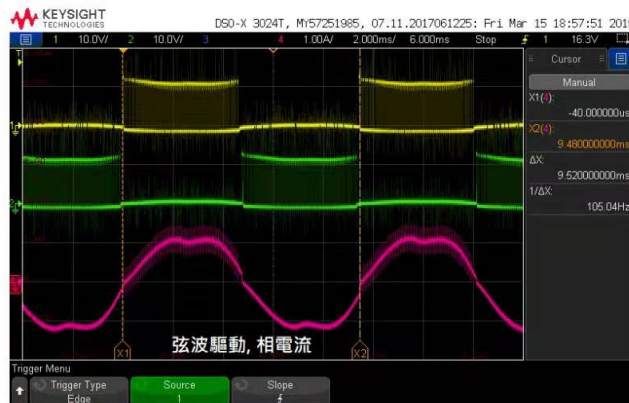
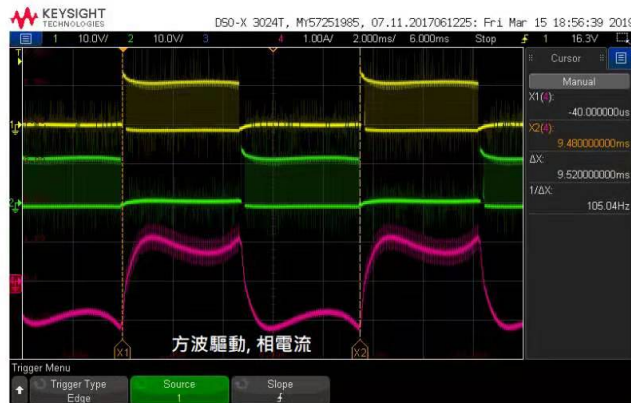
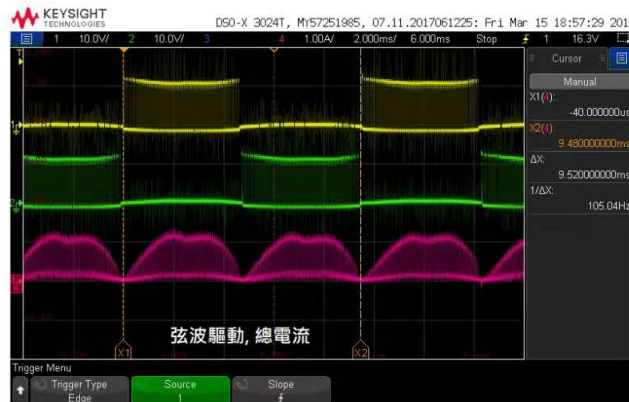
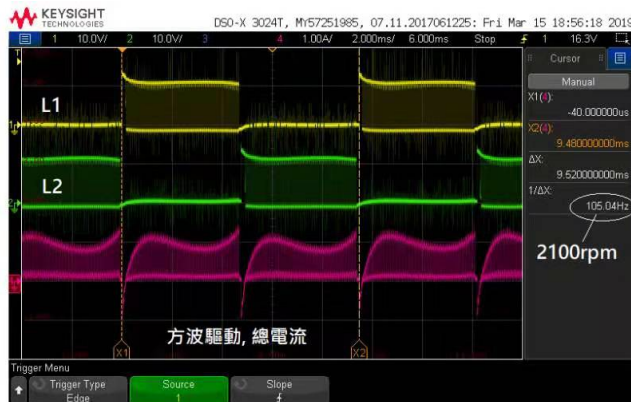


- ◆ New model
 - ▶ Sine wave



- ◆ Advantage
 - ▶ Soft-switching PWM
 - ▶ Lower vibration
 - ▶ Lower noise
 - ▶ Higher efficiency
 - ▶ Lock rotor
 - ▶ Current limit
 - ▶ Over current
 - ▶ Over/under voltage
 - ▶ Duty/ speed control

Waveform Comparison



Reference and successful stories

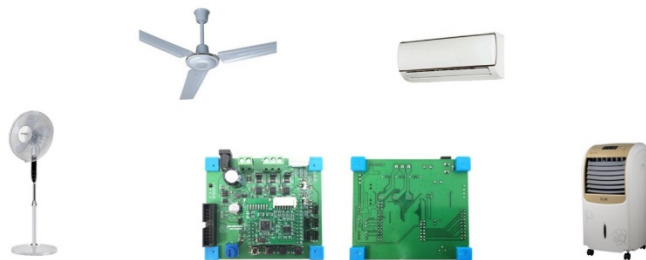
- ◆ Low voltage fan
- ◆ Range hood
- ◆ Server fan
- ◆ Power tool
- ◆ E vehicle
- ◆ E motor-cycle

MM32SPIN Sample Application : Low Voltage Fan

MM32 MCU

MINDMOTION MICROELECTRONICS

Low Voltage Fan 风扇



MM32 MCU型号

MM32SPIN05

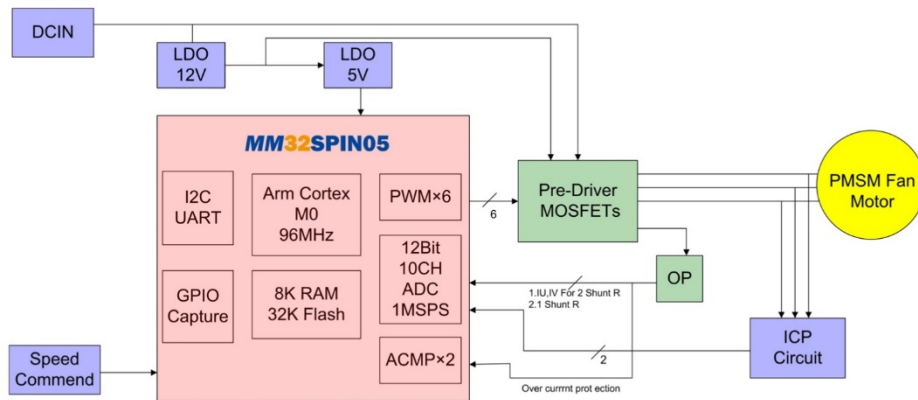
方案特色

- 高效率，静音控制
- 无段变频，恒功率控制

方案规格

- ARM Cortex M0 最高可运行至 96MHz
- 无传感磁场导向控制
- 使用滑模观测器估测转子角度
- 支援单/双电阻三相电流采样
- 具初始位置侦测功能
- 支持顺逆风启动, 有无负载启动
- 保护功能：过流, 过压, 堵转保护
- 电压范围：16~28V
- 转速范围：100~28800RPM (2poles)

系统框图



MM32SPIN Sample Application : Range Hood

MM32 MCU

MINDMOTION MICROELECTRONICS

Range Hood 油烟机

系统框图



MM32 MCU型号

MM32SPIN05

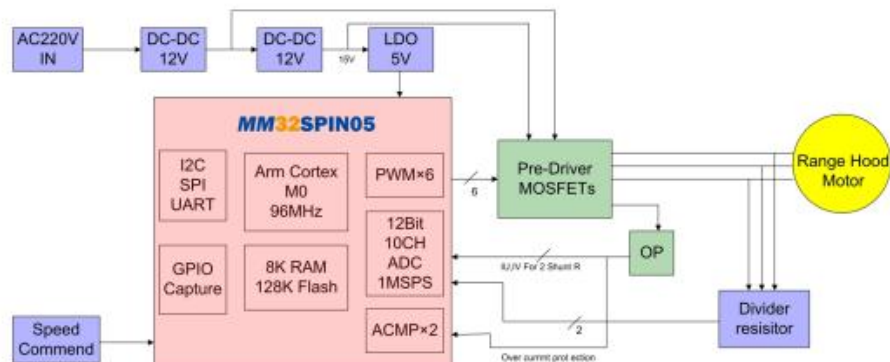
方案特色

- FOC高效率, 静压启动控制
- 恒功率控制

方案规格

- ARM Cortex M0 最高可运行至 96MHz
- 无传感磁场导向控制
- 使用滑模观测器估测转子角度
- 双电阻三相电流采样

- 支持顺逆风启动, 有无负载启动
- 保护功能: 过流, 过压, 堵转保护
- 电压范围: 180~260VAC
- 转速范围: 300~1800RPM (8poles)



MM32SPIN Sample Application : Server Fan

MM32 MCU

MINDMOTION MICROELECTRONICS

PC/Server Fan 服务器散热风机



MM32 MCU型号

MM32SPIN222C

方案规格

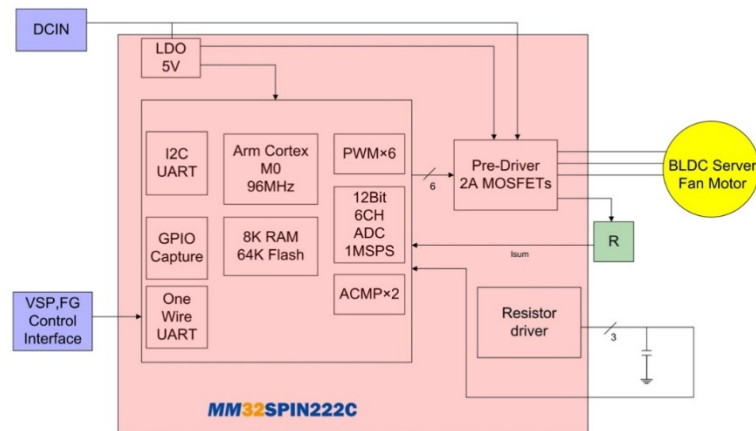
- ARM Cortex M0 最高可运行至 96MHz
- 内建 Gate driver 及 20V/2A MOS管*6
- 内建 5V LDO
- 无传感器方波驱动控制
- 支援 120/150 度驱动
- 支持顺逆风启动, 有无负载启动

方案特色

- 高效率, 集成度高
- 一体化

- 可接受 PWM Direct-in 的速度命令输入
- 超前角控制
- 支持软件震动抑制
- 保护功能: 过流, 过压, 堵转保护
- 电压范围: 5~15V
- 转速范围: Up to 72000 RPM (2 Poles)

系统框图



MM32SPIN Sample Application : Power Tool

MM32 MCU

MINDMOTION MICROELECTRONICS

Power Tool 电动工具



MM32 MCU型号

MM32SPIN05

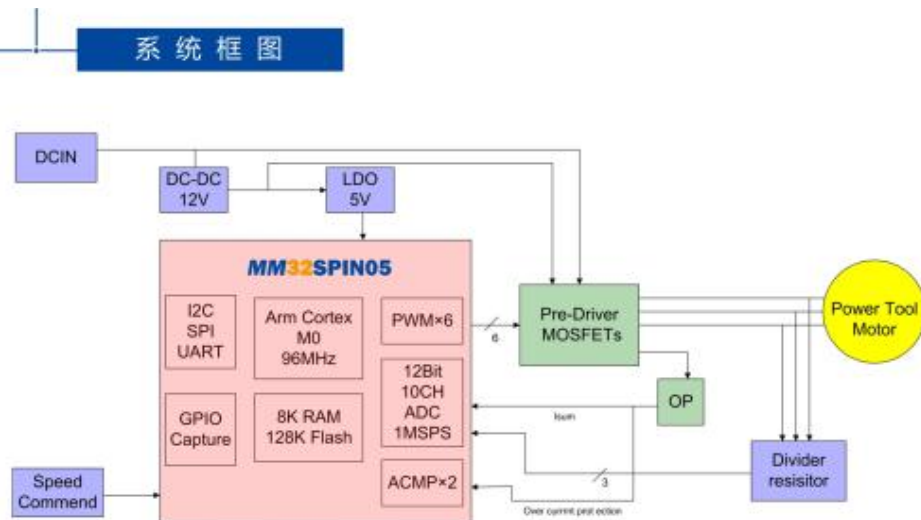
方案特色

- 超高转速, 内建比较器控制
- 启动快速

方案规格

- ARM Cortex M0 最高可运行至 96MHz
- 无传感器方波驱动控制
- 保护功能: 过流, 欠压, 堵转保护
- 电压 : 24V

系统框图



MM32SPIN Sample Application : RC Servo Motor

MM32 MCU

MINDMOTION MICROELECTRONICS

RC Servo 机器人舵机



MM32 MCU型号

MM32SPIN222C

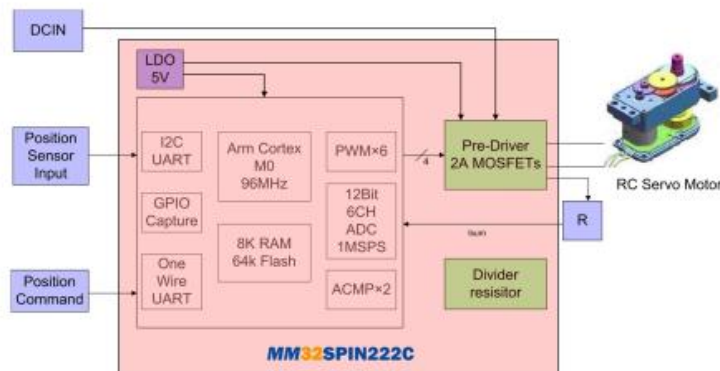
方案规格

- ARM Cortex M0 最高可运行至 96MHz
- 内建 Gate driver 及 20V/2A MOS管*6
- 内建 5V LDO
- 内建单线半双工 UART 通讯功能

方案特色

- 高效率, 集成度高
- 一体化
- 位置/速度控制
- 保护功能: 过流保护
- 电压范围 : 5~15V

系统框图



MM32SPIN Sample Application : E-Vehicle

MM32 MCU

MINDMOTION MICROELECTRONICS

E-Vehicles 电动车



MM32 MCU型号

MM32SPIN27

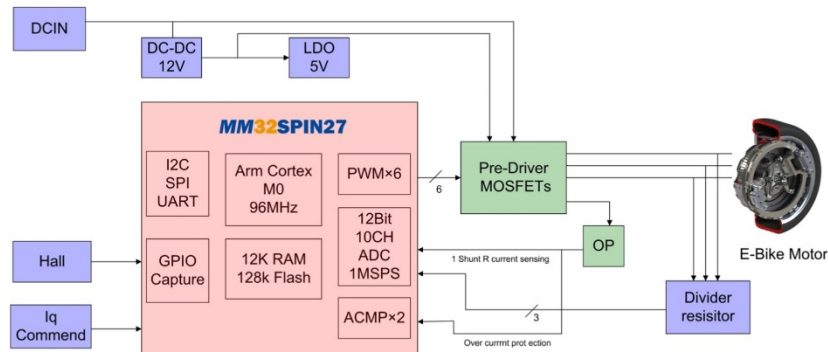
方案规格

- ARM Cortex M0 最高可运行至 96MHz
- 支持三模驱动
- 单电阻三相电流采样
- 限速, 限流, 防盗功能

方案特色

- 三模FOC高效率
- 支持霍尔启动与运动控制
- 定速巡航
- 保护功能: 过流, 欠压, 堵转保护
- 电压 : 48V

系统框图



MM32SPIN Sample Application : E-Motorcycle

MM32 MCU
MINDMOTION MICROELECTRONICS

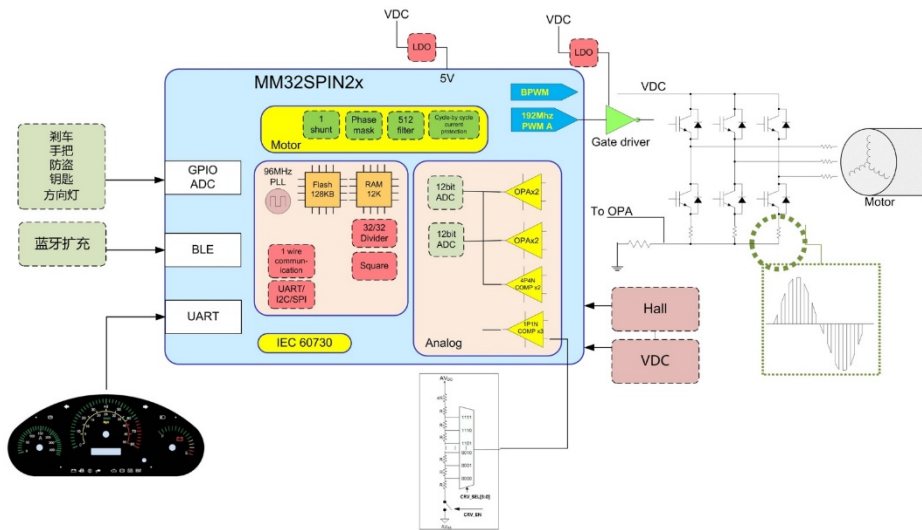
高性能电动摩托车

车辆特点

- 极速: 100km/h
- 起步加速性能: 0~100km 17秒
- 控制器与仪表板采用高性能32位MM32 MCU主控核心
- 高扭力中置电机
- Full LCD液晶仪表板
- 水冷与气冷: 不需要
- 高性能倒立前插与高制动力双碟煞设计

控制器参数

- MCU: MM32SPIN27PS
- MOSFET: 18 x 100A N type
- 64V, 72V 电压配置
- 防盗功能
- 支持三模驱动
- ABS刹车控制方案
- 霍尔故障运行及其故障诊断
- 限速, 限流, 过流, 欠压, 堵转保护
- 单电阻, MOS内阻形式三相电流采样
- 矢量弦波(FOC)控制方案与无霍尔运行





灵动**MM32**MCU

Thank you !

Please Visit: www.mm32mcu.com