

Industrial Robot Webinar 工业机器人线上研讨会

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2019年11月28日

Agenda

- **Industrial robot overview 工业机器人概述**
 - Definition and classification of industrial robot 定义与分类
 - TI resource in industrial robot application TI在工业机器人应用丰富的线上资源
- **Industrial robot system analysis, design challenge and TI solution 工业机器人系统分析，设计挑战以及TI解决方案**
 - Major modules analysis 主要模块分析
 - Controller 控制柜/控制器
 - Manipulator/Robot arm 机器臂/本体
 - Sensors 传感器
 - System consideration 系统考虑
 - Power solution 电源
 - Functional safety solution 功能安全
 - Communication solution in different modules 通讯

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Definition and classification 定义与分类

Definition

ISO 8373:位置可以固定或移动，能够实现自动控制、可重复编程、多功能、多用途、末端控制的位置要在3个或3个以上自由度的工业自动化设备。

Classification

➤ by Mechanical Structure 按机械结构分:

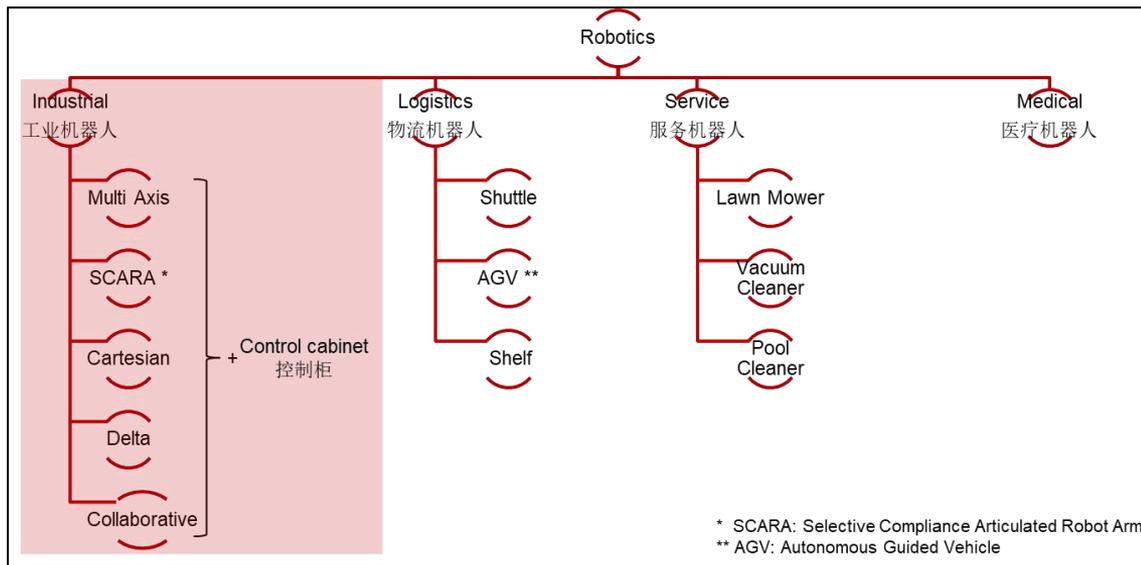
- Linear robots
- SCARA robots
- Articulated robots
- Parallel robots (delta)
- Cylindrical robots
- Others

➤ by Industries 按行业分:

- Automotive
- Electronics
- Metal
- Plastic and chemical products

➤ by Applications 按应用分:

- Welding
- Handling operations/ Machine Tending
- Processing



TI resource in industrial robot application

- End Equipment Block Diagram/Reference Design/Product Recommendation 系统框图/参考设计/产品推荐
 - [Factory automation & control](#) 工厂自动化控制
 - [Motor drives](#) 马达驱动
- Technical resources: application note, technical note, blog... 技术文档/应用文档 [Link](#)
- TI training & videos 培训/视频 [Link](#)

The screenshot displays a webpage layout with a sidebar on the left and a main content area on the right. The sidebar includes sections for 'Featured content' and 'Videos'. The main content area features three articles, each with a thumbnail image and a red arrow pointing to it from the Chinese text on the right.

Featured content

- How sensor data is powering AI in robotics**
From traditional industrial robotic systems to today's latest collaborative robots (or "cobots"), robots rely on sensors that generate increasingly massive volumes of highly varied data. Learn more...
[Download \(PDF, 1234KB\)](#)
- mmWave radar sensors in robotics applications**
Learn more about using complementary metal-oxide semiconductor (CMOS) millimeter-wave (mmWave) radar sensors in robotics.
[Download \(PDF, 1860KB\)](#)
- Optimizing control and design for industrial robotics**
An introduction to industrial robots, specifically robot control units. Covering some important applications and system technologies that can help understand how industrial robots control units are architected.
[Download \(PDF, 1251KB\)](#)

Videos

- ROBOTIC SENSE AND AVOID WITH MMWAVE SENSORS**
#CES2018
0:00 / 1:30
- Isolation in industrial robot systems**
0:00 / 23:30
- C2000™ MCU real-time control**
0:00 / 8:32

Reference design & products

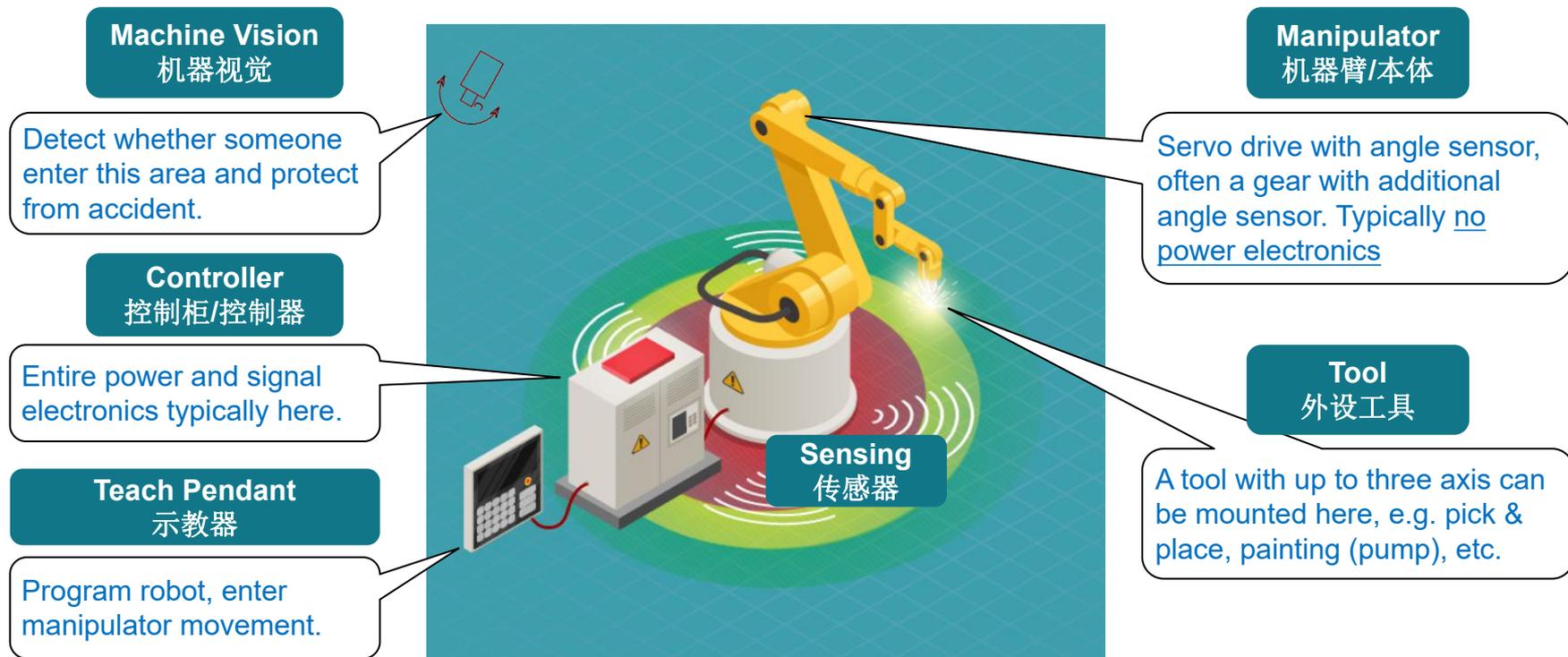
- Enabling the next-generation of service robots**
Date: April 6, 2019
Duration: 00:52
Modern service robots use various technologies such TI mmWave sensors to help them successfully navigate in their environment and optimize paths.
- Position and proximity sensors for industrial robots**
Date: May 6, 2019
Duration: 17:06
When designing a robot it is important to choose the correct sensors to enable it to be aware of its environment and perform the tasks required.
- Enabling the next generation of logistics robots**
Date: April 5, 2019
Duration: 01:01
TI enables designers to create highly efficient logistics robots that can accurately maneuver crowded logistic centers, campuses, retail stores and more.

Product Recommendation:
产品推荐:
时效性!
参考性!

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Industrial robot system analysis



Multi-Axis Industrial Robot System Example
多轴机器人系统

Industrial robot-TI system partitioning

Controller 控制柜/控制器



Industrial robot sensing module → LIDAR

Servo drive control module

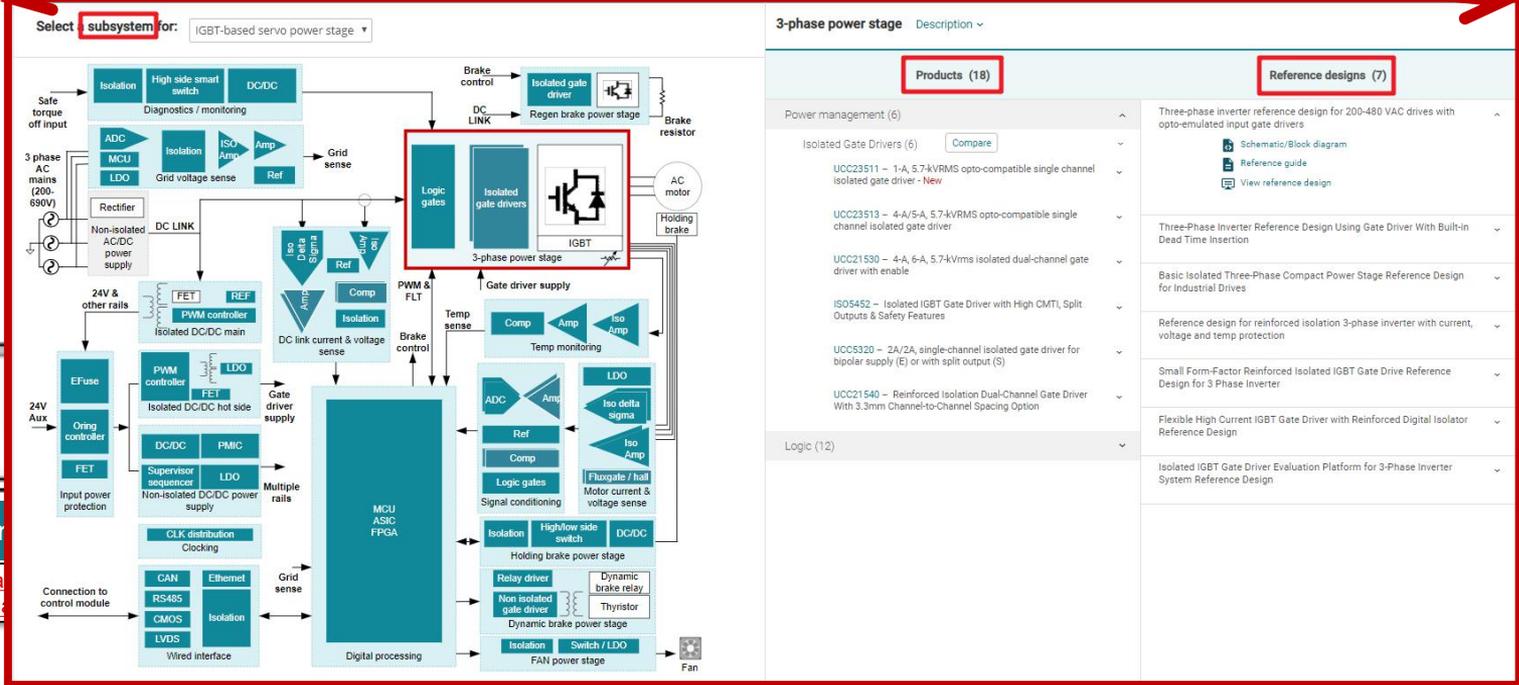
Welding machines

Industrial robot sensing module → mmWave

Servo drive position feedback

Laser

Teach Pen
Industrial pend



3-phase power stage Description

Products (18)

Reference designs (7)

Power management (6)

- Isolated Gate Drivers (6)
 - UCC23511 - 1A, 5.7-kVRMS opto-compatible single channel isolated gate driver - New
 - UCC23513 - 4-A/5-A, 5.7-kVRMS opto-compatible single channel isolated gate driver
 - UCC21530 - 4-A, 6-A, 5.7-kVrms isolated dual-channel gate driver with enable
 - ISO5452 - Isolated IGBT Gate Driver with High CMTI, Split Outputs & Safety Features
 - UCC5320 - 2A/2A, single-channel isolated gate driver for bipolar supply (6) or with split output (6)
 - UCC21540 - Reinforced Isolation Dual-Channel Gate Driver With 3.3mm Channel-to-Channel Spacing Option

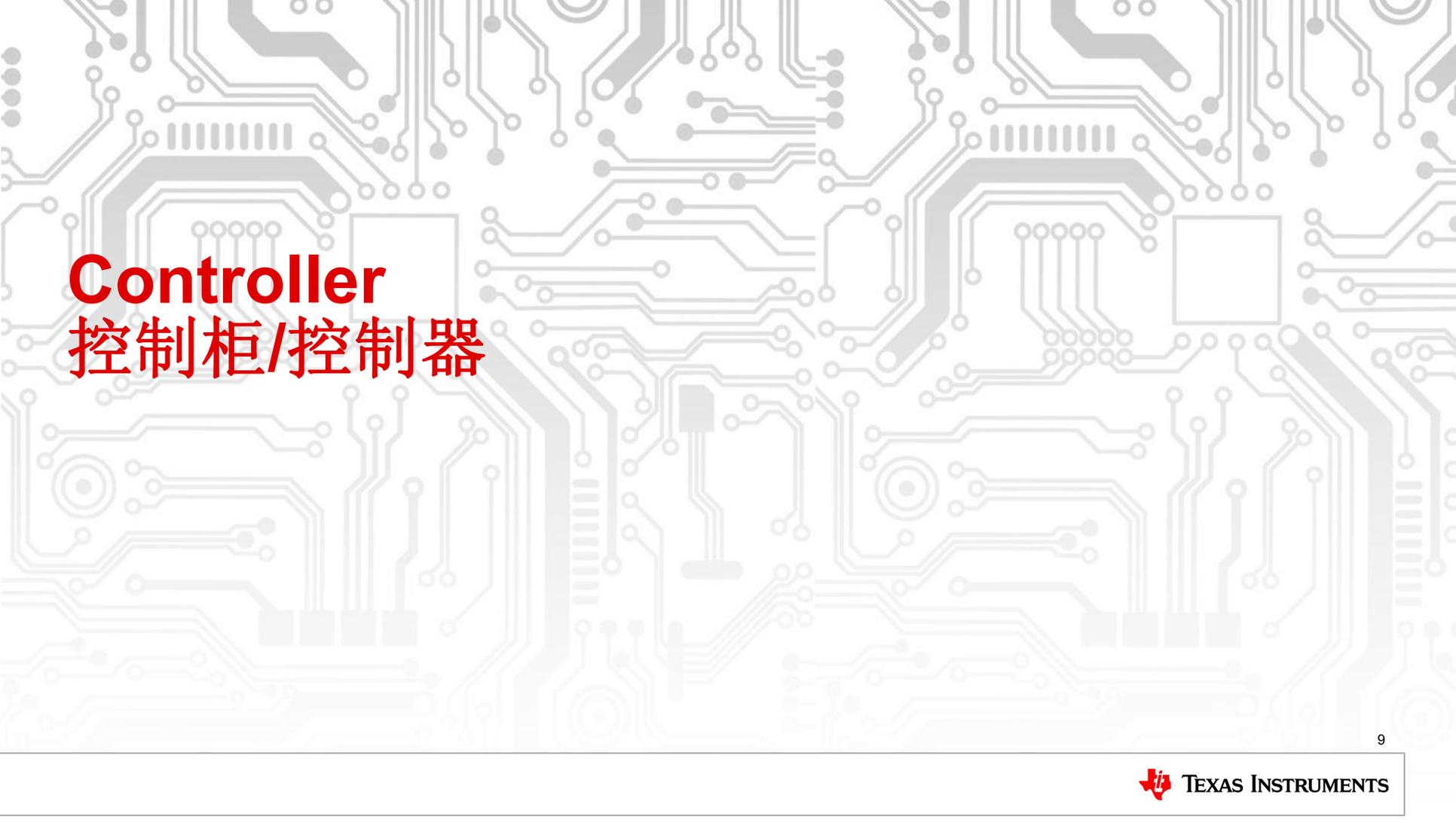
Logic (12)

- Three-phase inverter reference design for 200-480 VAC drives with opto-emulated input gate drivers
 - Schematic/Block diagram
 - Reference guide
 - View reference design
- Three-Phase Inverter Reference Design Using Gate Driver With Built-in Dead Time Insertion
- Basic Isolated Three-Phase Compact Power Stage Reference Design for Industrial Drives
- Reference design for reinforced isolation 3-phase inverter with current, voltage and temp protection
- Small Form-Factor Reinforced Isolated IGBT Gate Driver Reference Design for 3 Phase Inverter
- Flexible High Current IGBT Gate Driver with Reinforced Digital Isolator Reference Design
- Isolated IGBT Gate Driver Evaluation Platform for 3-Phase Inverter System Reference Design

机器视觉

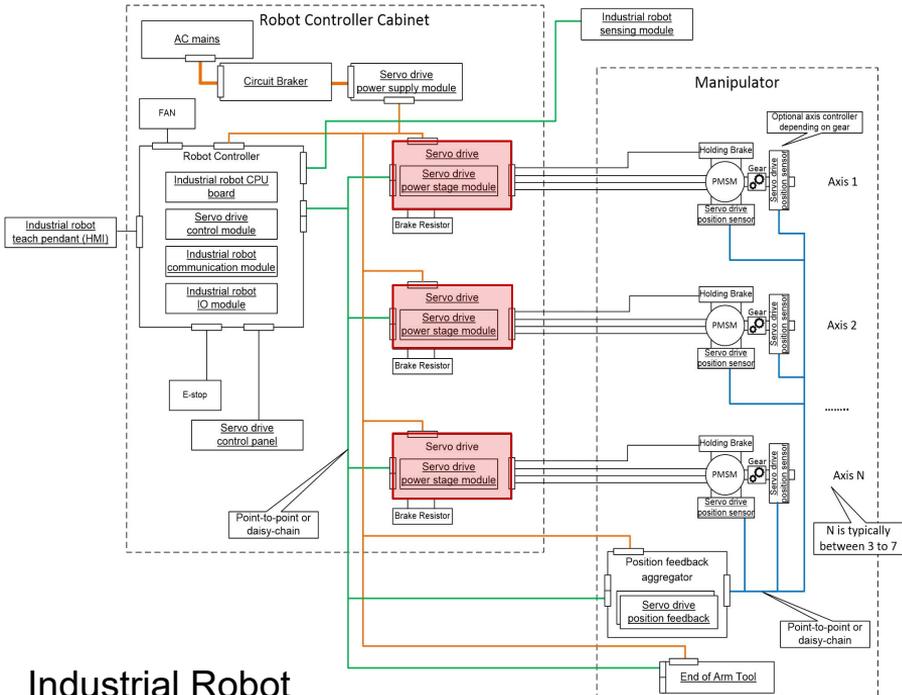
Camera

Stereo scope vision

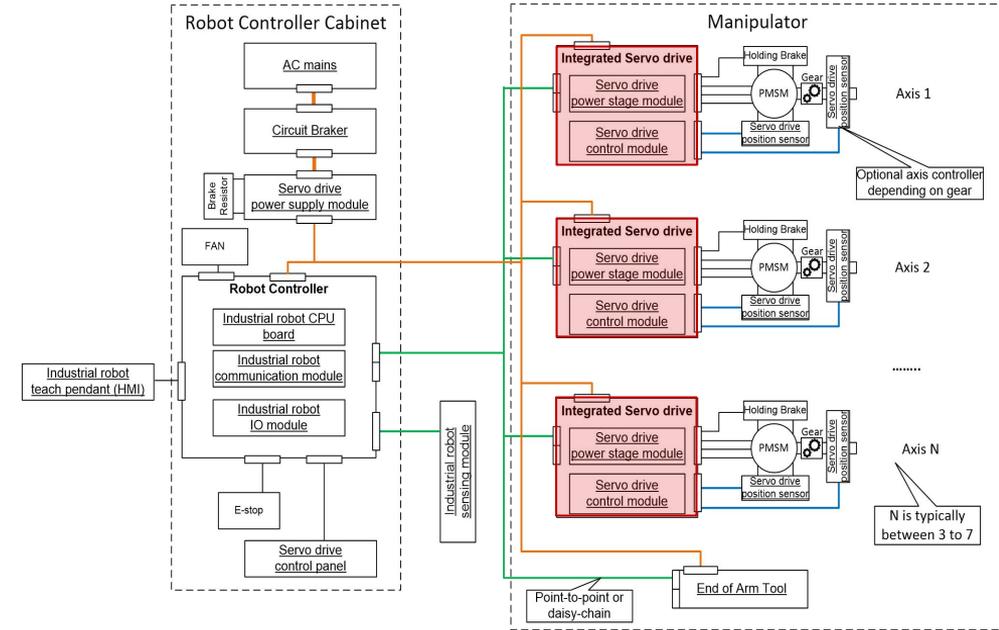


Controller 控制柜/控制器

Industrial robot controller system

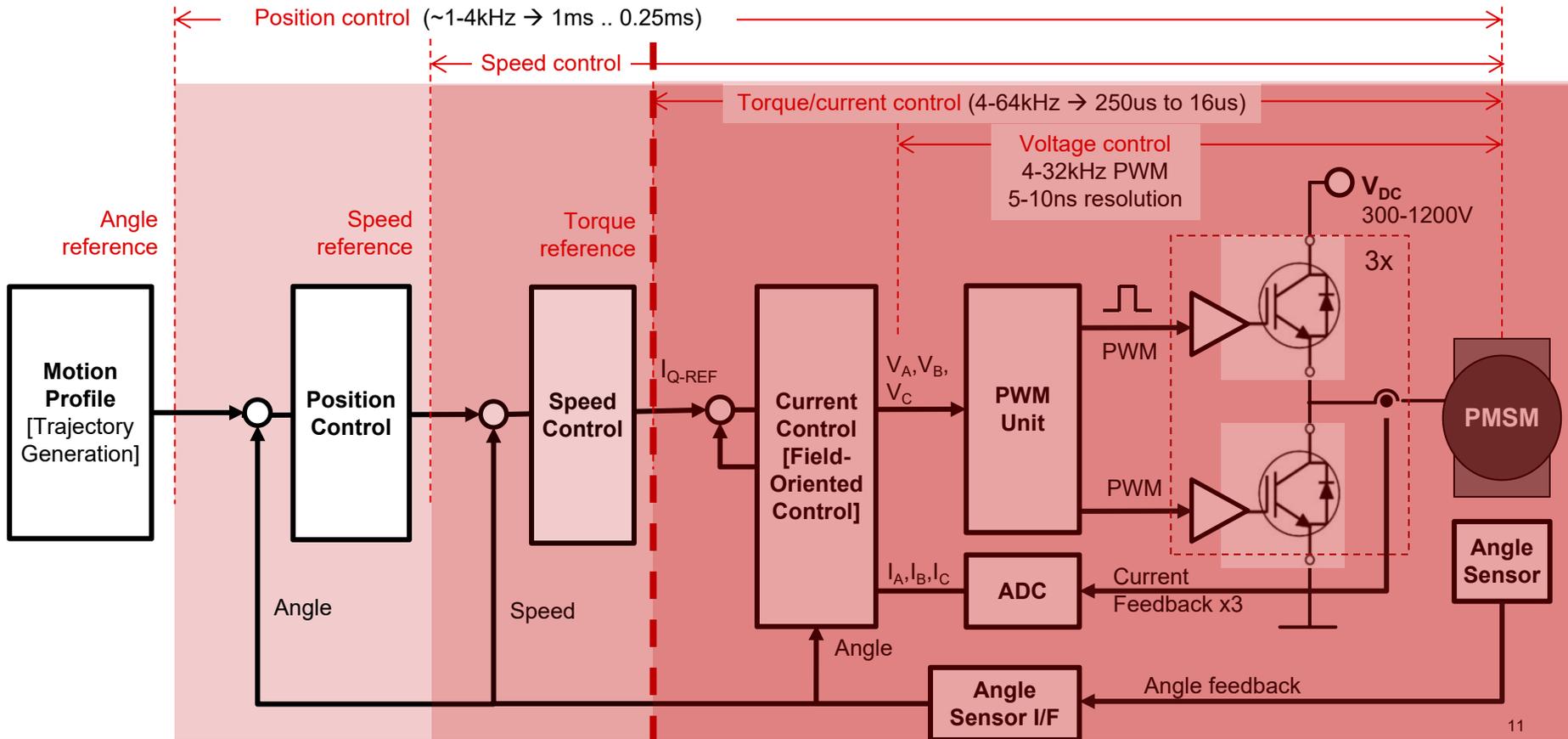


Industrial Robot
工业机器人

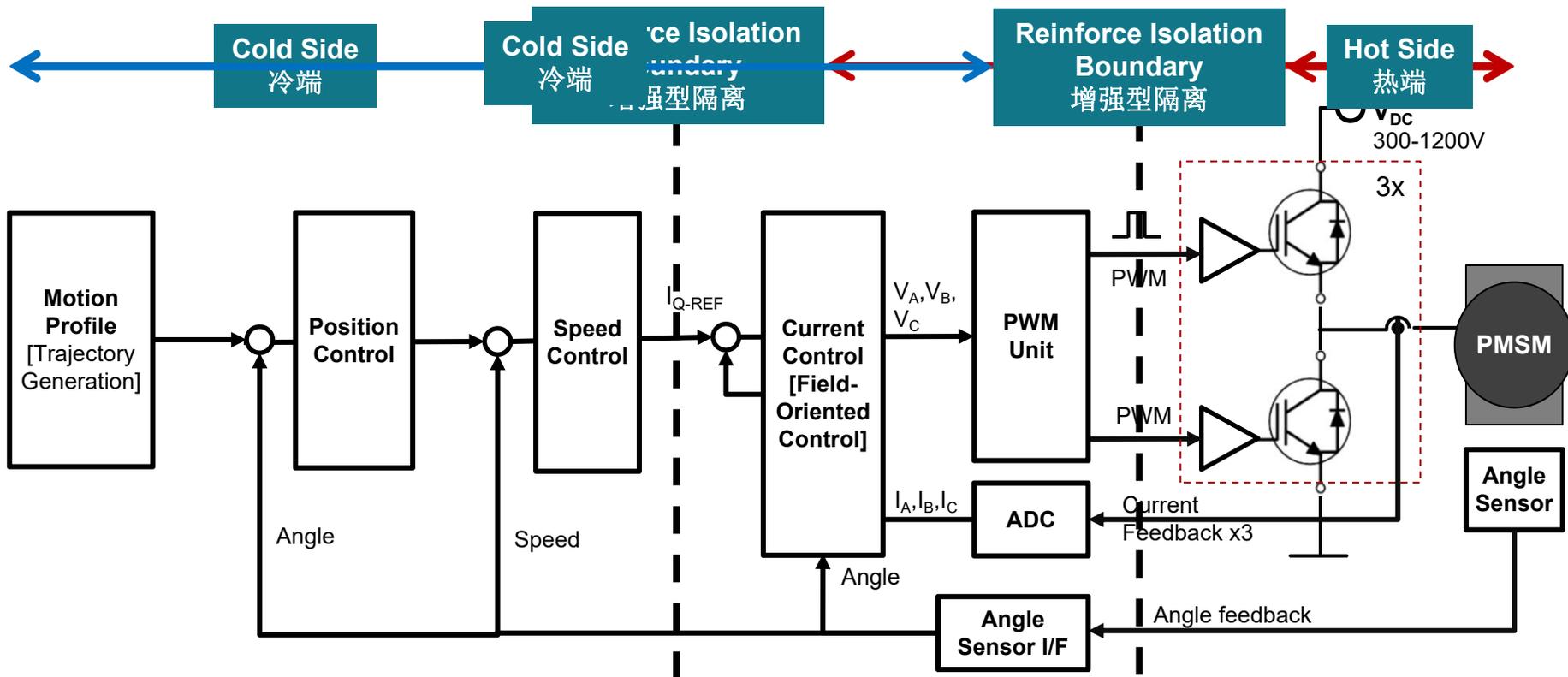


Collaborative Robot
协作机器人

Servo drive cascaded control topology 级联控制拓扑



Servo drive cascaded control topology 级联控制拓扑-隔离



Isolation: Why required? 为什么需要隔离?

功能方面: 区分电源域, 切断地环路以及减少共模噪声等; 没有特定的标准。

安全方面: SELV必须小于35VAC, 60VDC。有相关的行业国际标准 IEC 60747 或IEC 61800 。

End Equipment Safety Standards

Customer systems **MUST** pass. TI Isolators' safety, EMC/EMI performance enable

Application Organization	International IEC	Europe CENELEC (EN)	U.S. UL	Canada CSA	Germany DIN/VDE
Reference Equipment standard for Low-Voltage Systems	60664-1	-	-	-	-
Industrial	60204	50178	508	14-M91	-
Medical	60601	60601	2601-1	601	750
Telecom	6095	0 60950/41003	1459	225	804
IT Equipment	60950	60950	60950	60950	60950
Household	60065	60065	8730-1	-	860
Motor Drives	61800-5-1	-	-	-	-
Photo Voltaic Systems (Solar)	62109-1	-	-	-	-
Measurement and Control	61010-1	61010-1	1262	1010	0410/0411
EM Immunity	61000-4-x				
EM Emission	CISPR22B				

EE standard refers to EMC/EMI Immunity

against electric shock in

equivalent to Double

Semiconductor Component Safety Standards

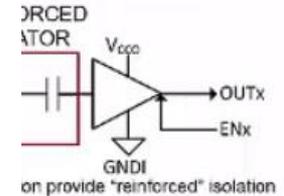
All isolators **MUST** pass. TI isolators have highest (30-70%) margin over competition

Isolator type Organization	International IEC	Europe CENELEC (EN)	U.S. UL	Canada CSA	Germany DIN/VDE
Magnetic/Capacitive Isolator Standards	60747-17 (DRAFT)				VDE-0884-10/11
Optoisolator Standards	60747-5-5	60747-5-5	1577	Component Acceptance Notice SA	DIN-EN-60747-5-5

TI isolators meet specs of current Opto-isolator Standards

TI isolators certified to Magnetic/Capacitive Isolator Standards

TI isolators certified to some Opto-isolator Standards



UCC23513

4A/5.7kVRMS 光耦兼容单通道隔离式栅极驱动器

概述

UCC23513是一个4A、5.7kVRMS光耦兼容单通道隔离式栅极驱动器，使用的是扩展性SO-6封装。该隔离式栅极驱动器的输入级采用了仿真二极管，隔离层采用了TI特有的电容隔离技术，具有更好的隔离特性和可靠性，高共模瞬态抗扰度可达100千伏每微秒 最大传播延时仅105纳秒。

特性

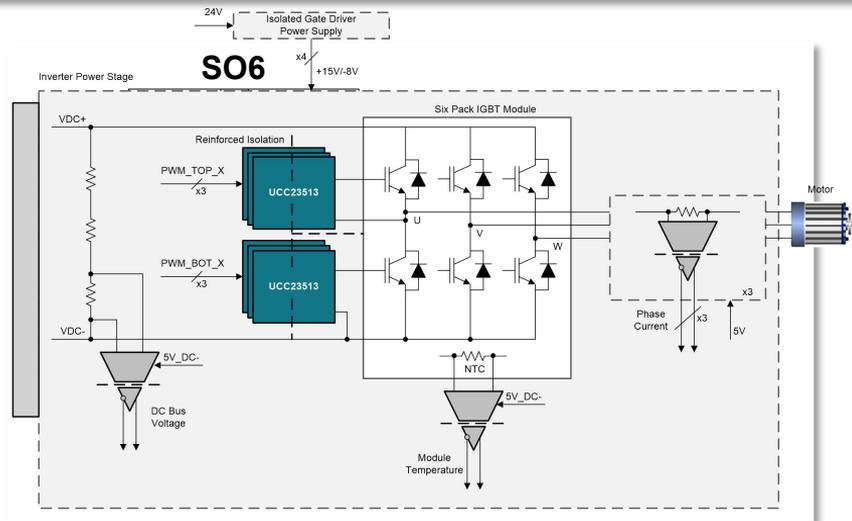
- 光耦容输入的 5.7kVRMS 单通道隔离式栅极驱动器 (IGBT/MOSFET/SiCs)
- 基于SiO₂的容隔技术
- 4A 最大峰值输出电流
- **扩展型 SO-6 封装，爬电距离和间隙大于 8.5mm**
- 105ns (最大值) 传播延迟, 25ns (最大值) 部件对部件延迟匹配度
- 150kV/ μ s 最小共模瞬态抗扰度 (CMTI)
- 12V 欠压锁定保护(UVLO)
- 输入引脚具有 7V 反极性电压处理能力
- 工作结温范围 (Tj): -40°C to 150°C

应用

- 工业电机控制驱动
- 工业电源、UPS
- 光伏逆变器
- 感应加热

优点

- 更小的传播延迟, 更小的部件对部件延迟匹配度
- 更高的共模瞬态完整性
- 更小的脉冲宽度失真
- 更高环境工作温度范围
- 耐高温, 耐老化, 可靠性高,
- 使用寿命长(> 50年)
- 模拟二极管正向压降具有更小的部件间变化和更小的温度变化。



ISO77xx

EMC 性能优异的增强型高速多通道数字隔离器

特性

- 集成的SiO₂的容隔技术
 - 最大数据速率100Mbps
 - 低传播延迟: 典型值为 10.7ns
 - 最大 Ch-Ch 偏移: 2.5ns
 - 最大 Part-Part-偏移: <5ns
 - 低功耗:
 - 1.5mA / channel 1Mbps典型值
 - 1mA/channel 默认状态
 - 0.5mA/channel 禁用状态
 - 错误中快速回复的能力
- 抗干扰性以及相关认证
 - 增强型隔离 (DIN V VDE V 0884-11)
 - CMTI: 100kV/μs 典型值 (85kV/us 最小值)

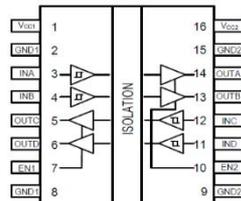
	ISO Rating	Surge	Working Voltage
SOIC-16 DW	5000 Vrms	12800 Vpk	1500 Vrms
SOIC-8 DWV	5000 Vrms	12800 Vpk	1500 Vrms
SOIC-8 D	3000 Vrms	8000 Vpk	450 Vrms
QSOP-16 DBQ	3000 Vrms	6400 Vpk	400 Vrms

供电与封装

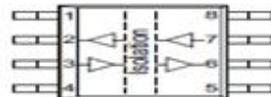
- 2.25V to 5.5V 宽输入电压范围
- 工作温度范围-55C to 125C
- SOIC-16W w/ 8 mm creepage / clearance (6, 4, 3, 2 and 1 channels)
- SOIC-8DWV w/ 8 mm creepage / clearance (2 channels)
- Small QSOP-16 package (6, 4 and 3 channels)
- Small SOIC-8 package (2 and 1 channels)

优点

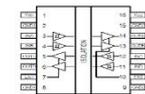
- 增强型隔离等级
- 高抗干扰性以及高稳定性
 - 系统级 ESD、EFT 和浪涌抗扰性
 - ±8kV IEC 61000-4-2 跨隔离栅接触放电保护
 - 低辐射
- 精准时序:
 - 低传播延迟, 低偏移和快速恢复错误的能力
 - 有利于开关式同步电源, 和SPI通信



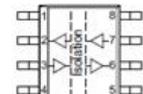
SOIC 16 pin
7.5mmx10.3mm



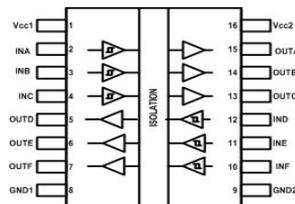
SOIC 8 pin DWV
7.5mmx5.85mm



QSOP 16 pin
3.9mmx4.9mm

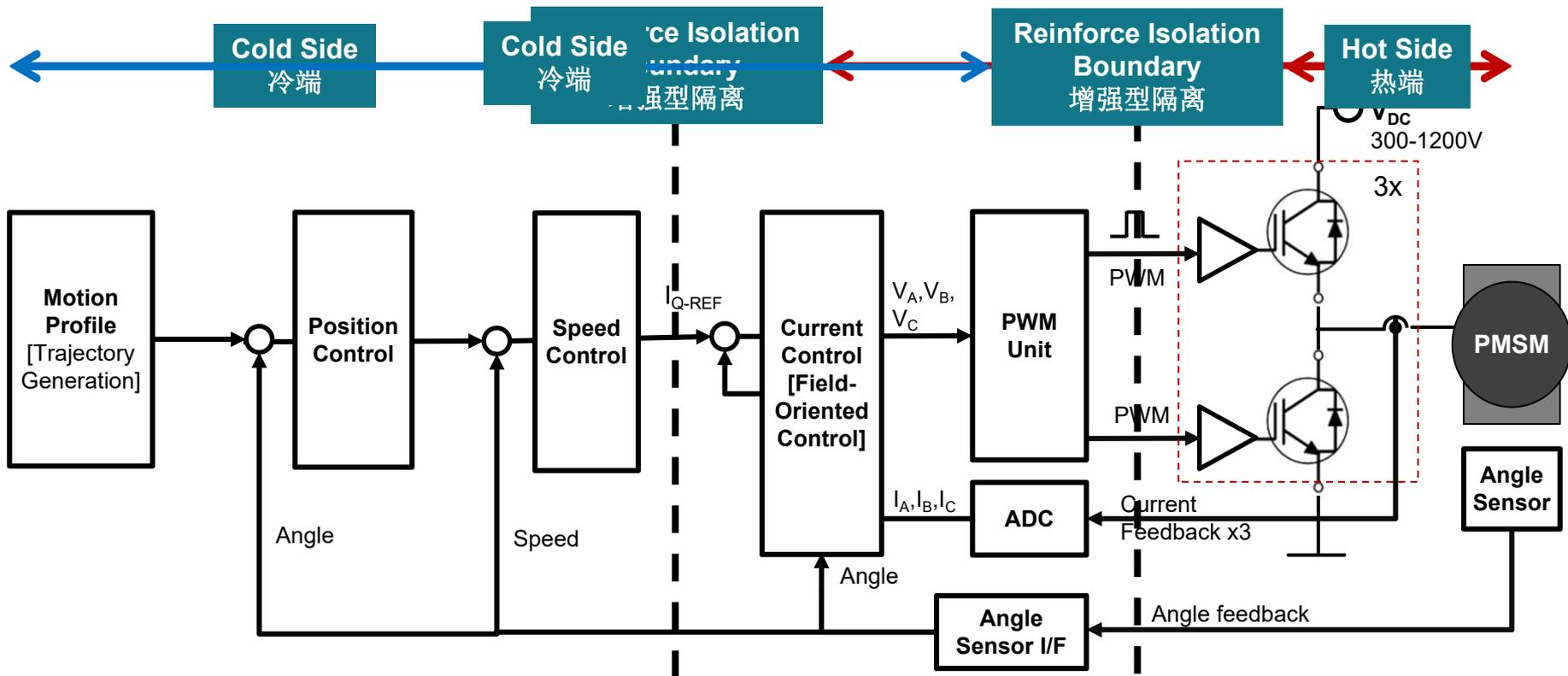


SOIC 8 pin
3.9mmx4.9mm

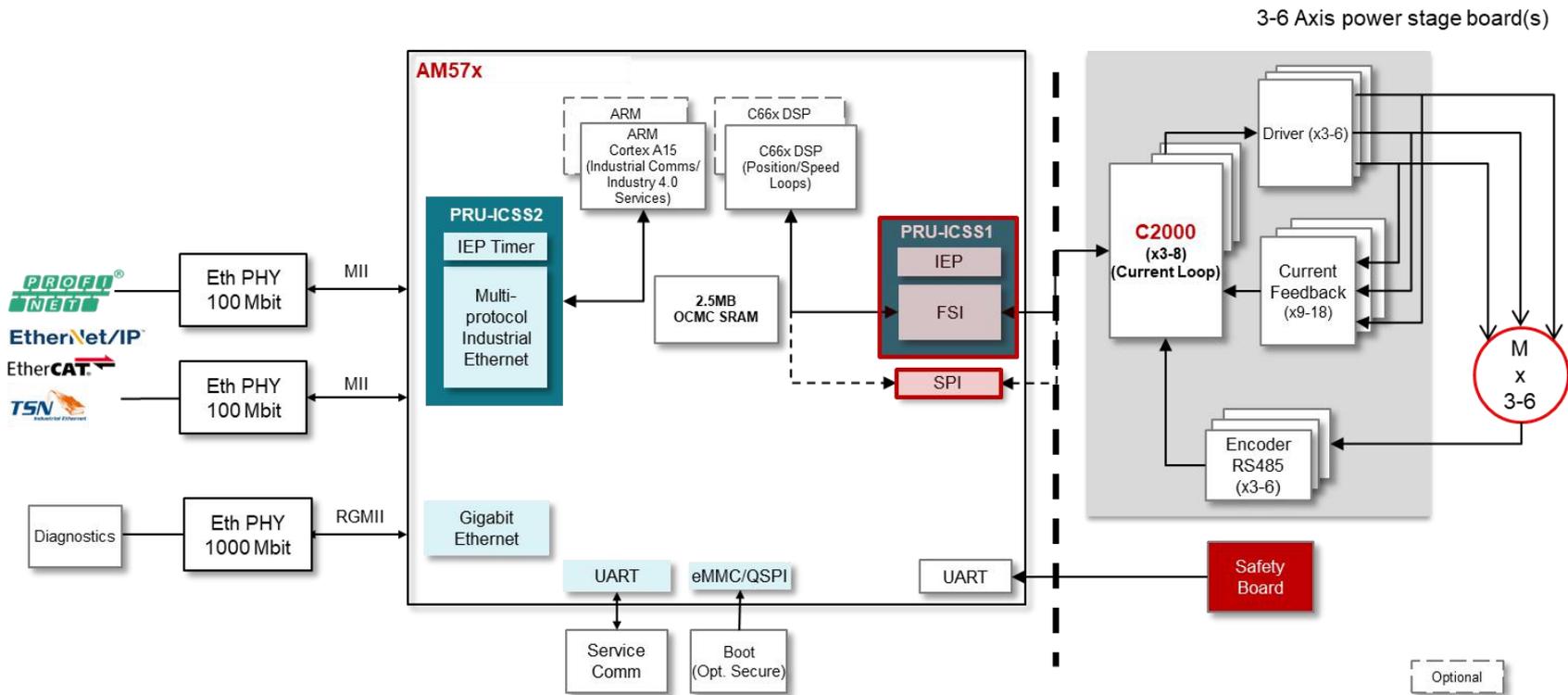


Q100 – 车规认证

Servo drive cascaded control topology 级联控制拓扑-隔离

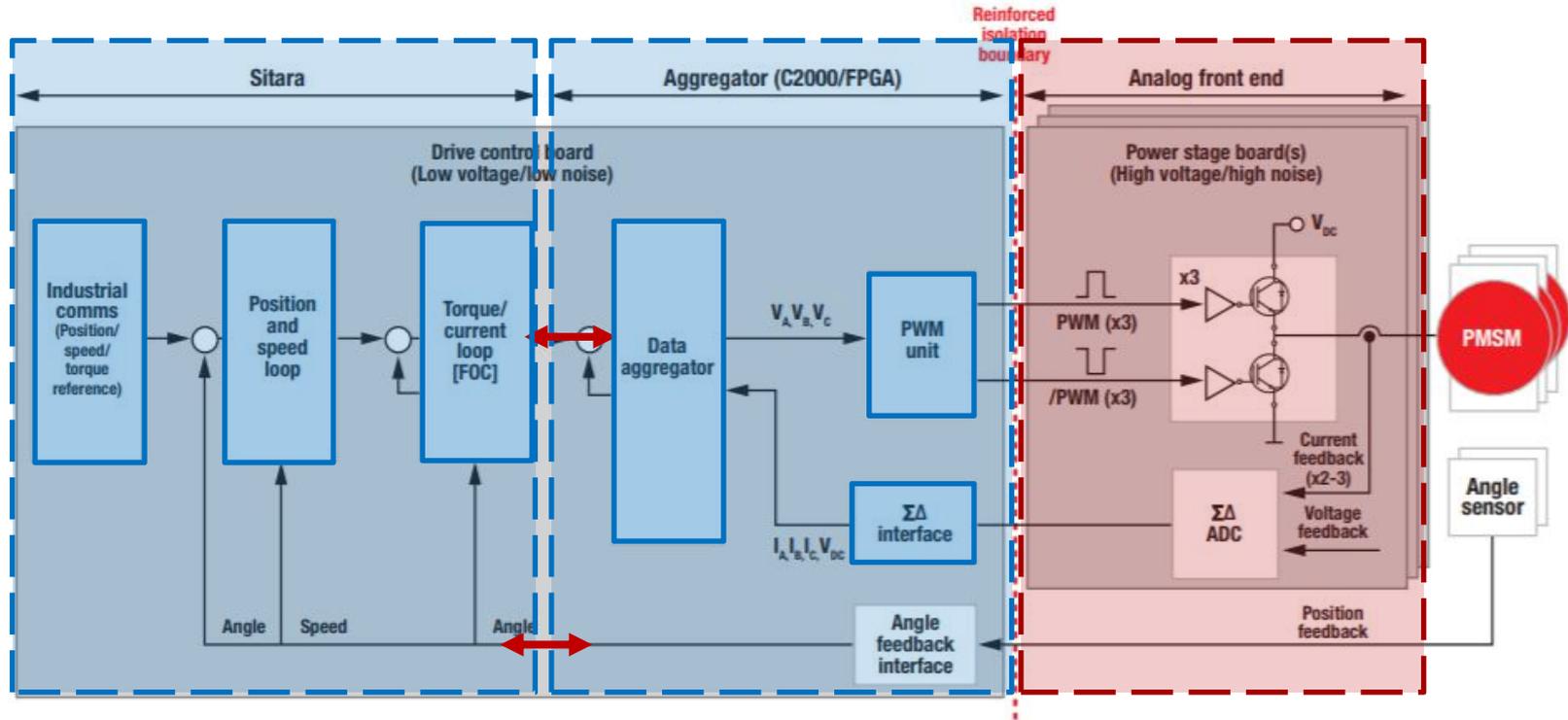


Structure1: Hot side control 热端控制

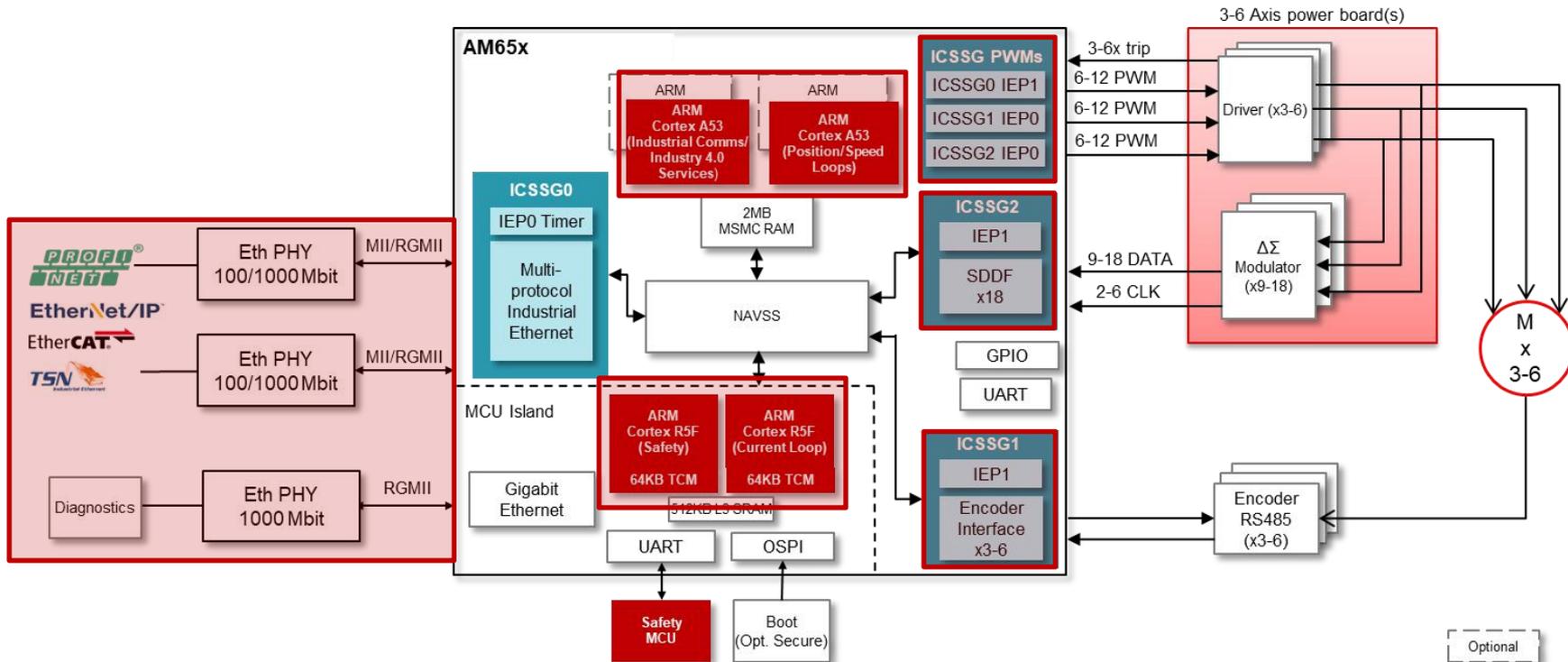


Decentralized Multi-Axis Servo & Robotics Drive

Structure2: Cold side control (data aggregator offload) 冷端控制



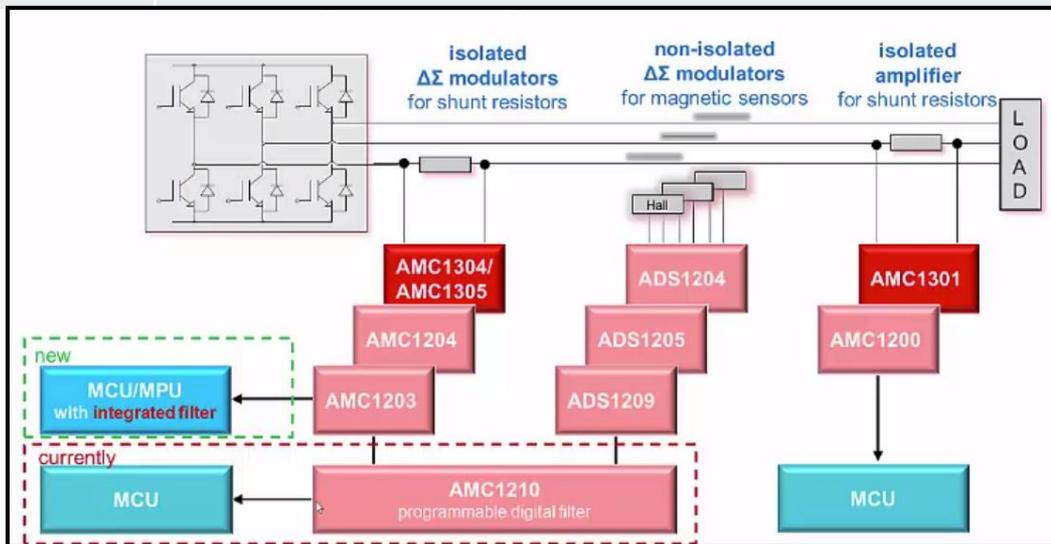
Structure3: Cold side control (Single-chip drive) 冷端控制（单芯片驱动）



Centralized Multi-Axis Servo & Robotics Drive

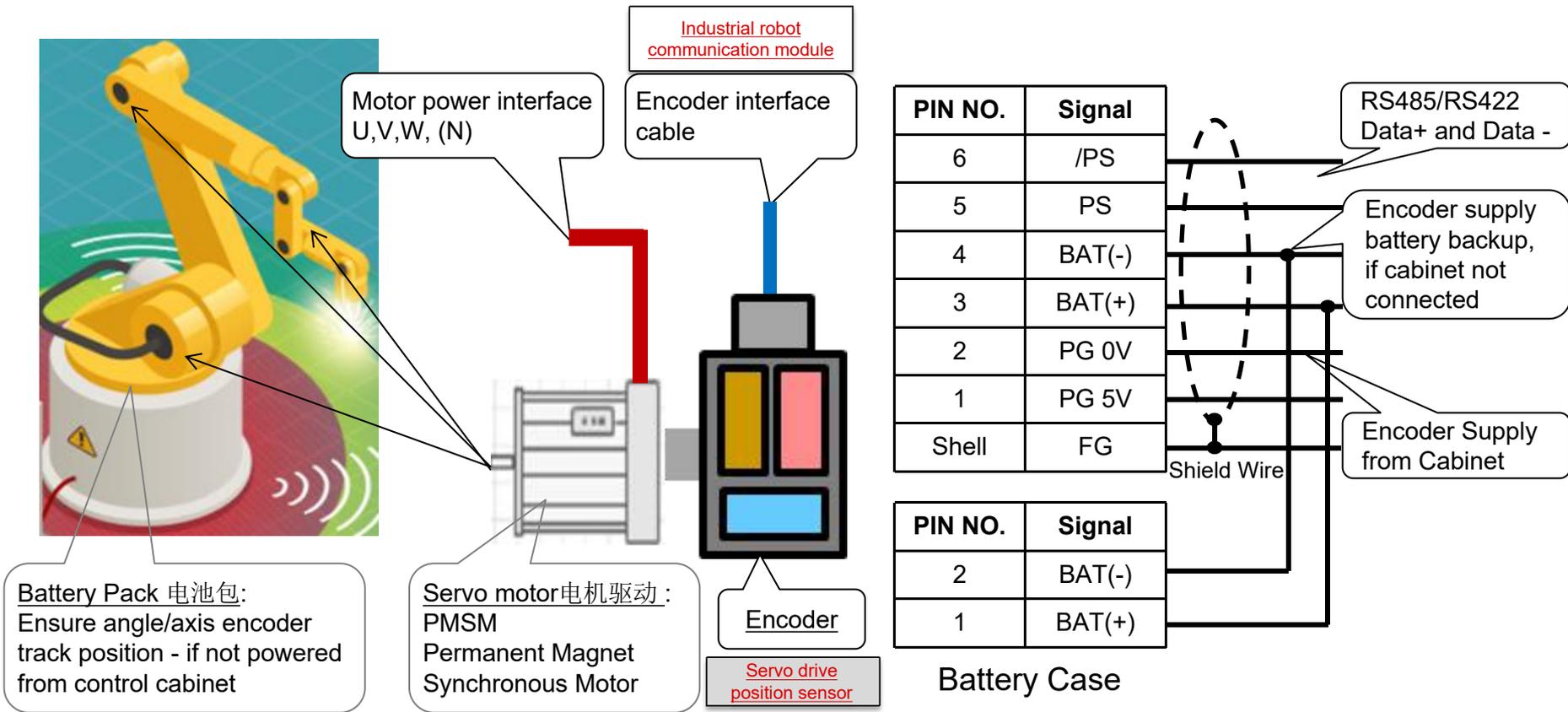
Other Information

Topic	Content type	Link to content or more details
电流电压采样	培训视频	http://edu.21dianyuan.com/index/course_video/vcid/1574 http://edu.21dianyuan.com/index/course_info/tree_id/5/cid/410
	参考设计	TIDA-01541 : 用于三相逆变器的高带宽相电流和 DC-Link 电压检测参考设计 TIDA-01455 : 用于高边开关瞬态三相逆变器的电流感应参考设计 TIDA-00914 : 采用小型 Δ - Σ 调制器的增强型隔离式相位电流感应参考设计 TIDA-00171 : 隔离式电流分流和电压测量参考设计
	产品推荐	隔离型 $\Delta\Sigma$ 调制器: AMC1305/6 ; 非隔离型 $\Delta\Sigma$ 调制器: ADS1204/5 ; 隔离型放大器: AMC1300/01 。



Manipulator 机器臂/本体

Manipulator: Servo motor & Encoder



Comparison of typical position feedback sensors in industrial drives

	Resolver	Incremental Encoder	Absolute Encoder
Sensor type	Inductive/transformer		
Absolute angle/position	Yes		
Multi-turn	No		
Angle accuracy (typ.)	medium (~0.1deg)		
Interface Open/public standards for encoder vendors marked green	Analog (I/O) 4V-7Vrms, 4-20kHz		
Latency	Medium		
Power supply	N/A		
Temperature	>150C ambient		
Electronics inside	No		
Design challenge	N/A		
Sensor cost	Low to medium		
Application examples	Robotics, harsh environment		

TIDA-00363

符合 EMC 标准的单芯片旋转变压器数字转换器 (RDC) 参考设计

方案特性

- 单芯片 RDC，具有优于 ± 0.2 度的典型精度
- 超过 IEC61800-3 EMC 抗扰度
 - $\pm 8\text{kV}$ ESD CD - 参考 IEC 61000-4-2 标准
 - $\pm 4\text{kV}$ EFT - 参考 IEC 61000-4-4 标准
 - $\pm 2\text{kV}$ 浪涌 - 按照 IEC 61000-4-5
- 具有 150mA 输出电流和可编程 (10 至 17V) 升压电源的集成式励磁放大器可减小 60% 的 PCB 尺寸
- 具有宽输入电压范围 (12 至 42V/60V) 和反极性保护功能的 24V 输入电压
- SPI (8MHz, 3.3V I/O)、并行和 ABZ/UVW 输出接口
- 提供使用外部 15V 励磁电源和外部励磁放大器的选项
- C2000 MCU 的示例固件可在 16kHz 采样速率下读取角度

目标应用

- 工业驱动产品
- 伺服驱动器
- 多轴机器人控制
- 工厂自动化与控制

工具与资源

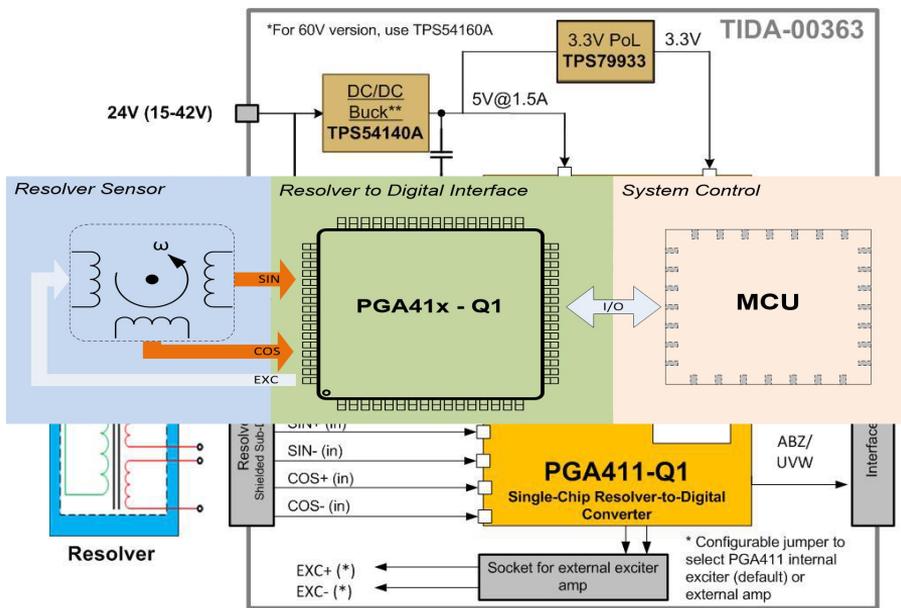
Board Image



- [TIDA-00363 and Tools Folder](#)
- [Design Guide](#)
- **Design Files:** Schematics, BOM, Gerbers, and more
- **Device Datasheets:**
 - [PGA411-Q1](#)
 - [TPS54140A](#)
 - [TPS79933](#)

优点

- PGA411减少了外部P/S和激励放大器，也减少了BOM和60% PCB尺寸
- 故障诊断覆盖范围:不需要外部监视、管控和保护。
- 易于与主机处理器连接
- **超过 IEC61800-3 EMC 抗扰度**



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Comparison of typical position feedback sensors in industrial drives

	Resolver	Incremental Encoder	Absolute Encoder
Sensor type	Inductive/transformer	Optical, magnetic, inductive, capacitive	
Absolute angle/position	Yes	No (Yes) Absolute angle possible with index signal, but not after power up and power cycle	
Multi-turn	No	No	
Angle accuracy (typ.)	medium (~0.1deg)	High (digital) to very high (Sin/Cos interpolation)	
Interface Open/public standards for encoder vendors marked green	Analog (I/O) 4V-7Vrms, 4-20kHz	Digital or Analog (O) <ul style="list-style-type: none"> Digital: 3.3V/5V TTL, 10-30V HTL or RS422, up to 10MHz pulse frequency Analog: Sin/Cos 1Vpp, up to 500kHz bandwidth 	
Latency	Medium	Very low (<1us)	
Power supply	N/A	5V, 10-30V, typ. <250mA	
Temperature	>150C ambient	70..100C ambient (outside case!)	
Electronics inside	No	Yes, simple	
Design challenge	N/A	Size, temp., AFE, power, EMC immunity	
Sensor cost	Low to medium	Medium	
Application examples	Robotics, harsh environment	AC inverter speed-variable drives (HTL/RS485), Servo/CNC Drives	

TIDA-00176

采用高分辨率位置插值的正弦/余弦编码器的接口

方案特性

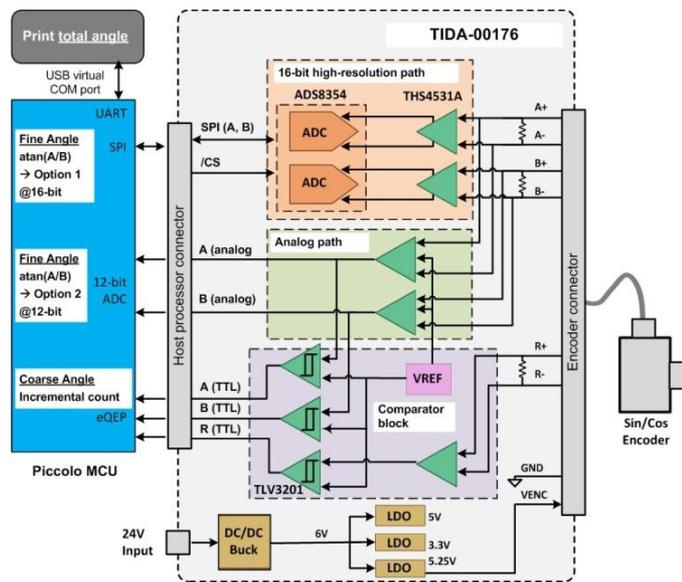
- 符合 EMC 标准的工业接口设计适用于带 1Vpp 差动输出（2.5V 偏移）以及高达 500kHz 输入频率的正弦/余弦编码器
- 高分辨率插值位置、高达 28 位的分辨率以及长达 70m 的实测电缆长度
- 可实现 16 位双路 SAR ADC 和 MCU 嵌入式 ADC 同步使用的双路模拟信号链可同时为路径和/或单路径的优化进行评估，从而提高防噪性能并降低带宽
- 可通过 SPI 和 QEP 接口轻松连接到 MCU，同时凭借插入式兼容 14 或 12 位 ADC 还可满足成本优化待决的分辨率要求
- 借助适用于 C2000 MCU 且带有 16kHz 算得的高分辨率角度以及通过 USB 虚拟 COM 端口实现的角度数据发送功能的示例固件，可轻松完成性能评估
- 经测试符合 IEC61000-4-2、4-4 和 4-5 要求（ESD、EFT 和浪涌 EMC 抗扰度要求）

应用

- AC 驱动器
- 精密变速驱动器
- 伺服驱动器

优点

- 测试接口与 Sin/Cos 编码器连接的电缆长度达 80m
- 高分辨率插值位置高达 25 位
- 14 位或 12 位 ADC 完全兼容，方便做成本优化的决策
- 可通过 SPI 和 QEP 接口轻松连接 MCU
- 通过 USB 虚拟 COM 端口实现的角度数据发送功能
- 测试符合 IEC61000-4-2、4-4 和 4-5 要求（ESD、EFT 和浪涌 EMC 抗扰度要求）



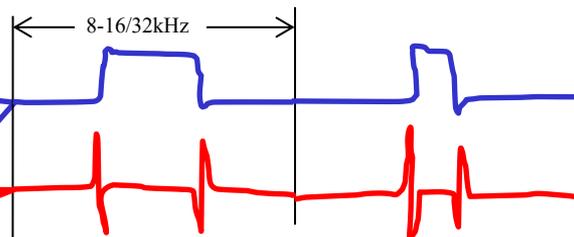
Comparison of typical position feedback sensors in industrial drives

	Resolver	Incremental Encoder	Absolute Encoder
Sensor type	Inductive/transformer	Optical, magnetic, inductive, capacitive	Optical, magnetic, inductive, capacitive
Absolute angle/position	Yes	No (Yes) Absolute angle possible with index signal, but not after power up and power cycle	Yes , provide speed feedback and more too
Multi-turn	No	No	Yes (pending model)
Angle accuracy (typ.)	medium (~0.1deg)	High (digital) to very high (Sin/Cos interpolation)	High to very high (up to 1 arc second or 0.00027 degree)
Interface Open/public standards for encoder vendors marked green	Analog (I/O) 4V-7Vrms, 4-20kHz	Digital or Analog (O) <ul style="list-style-type: none"> Digital: 3.3V/5V TTL, 10-30V HTL or RS422, up to 10MHz pulse frequency Analog: Sin/Cos 1Vpp, up to 500kHz bandwidth 	Digital (I/O) or Hybrid Analog+Digital (I/O) <ul style="list-style-type: none"> RS485/RS422 half- or full-duplex interface: <ul style="list-style-type: none"> Vendor proprietary: Tamagawa, EnDat2.2, ... Open standards: BiSS-C, BiSS-Line, OCS, SSI or fieldbus: PROFIBUS, Modbus-RTU CAN: CanOpen, DeviceNET 10/100MB Ethernet <ul style="list-style-type: none"> Vendor specific: DriveCLIQ (Siemens) Industrial Ethernet, like EtherCAT, Ethernet IP,... Hybrid: EnDat2.1 or HIPERFACE
Latency	Medium	Very low (<1us)	Low (10us and more, pending interface speed)
Power supply	N/A	5V, 10-30V, typ. <250mA	3.6V-14V, 5V, 10-30V and vendor specific, battery backup
Temperature	>150C ambient	70..100C ambient (outside case!)	70C...100C ambient
Electronics inside	No	Yes, simple	Yes, complex
Design challenge	N/A	Size, temp., AFE, power, EMC immunity	Size, temp., AFE, power, EMC immunity, interface protocol
Sensor cost	Low to medium	Medium	High to very high
Application examples	Robotics, harsh environment	AC inverter speed-variable drives (HTL/RS485), Servo/CNC Drives	Servo Drives, CNC, Robotics

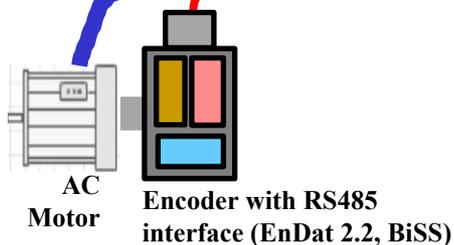
Why is EMC immunity critical? 为何EMC抗干扰性至关重要?

- 编码器通过对瞬态电压有极高抗干扰性的RS485与控制柜通讯，可以减低误码率，极大地提高伺服系统的性能以及降低故障时间。
- 越来越多的供应商在EFT过程中提出了零错误RS485传输。

三相电源电缆: PWM的瞬变电压可能会达到10kV/us甚至更高, 这种信号, 尤其是共模瞬变噪声, 非常容易耦合到编码器的数据传输线。



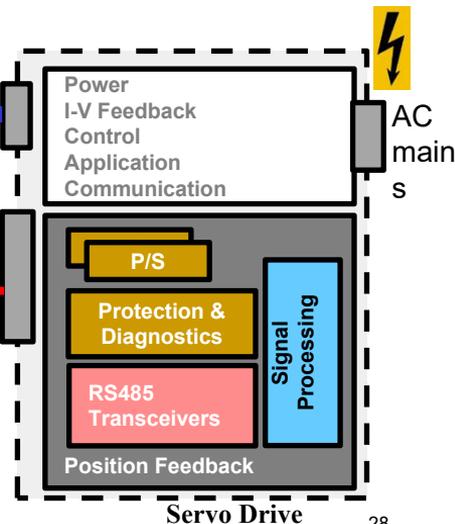
共模噪声通过PWM输出电压耦合至数据传输线端。可达+/-20V, 脉宽<1us。



Shielded encoder cable up to 100m and more

EMC immunity requirements for industrial drives by standard body: IEC 61800-3 or NECA (Japan) Industrial Drives: Injection of **external** over-voltage transients at the encoder interface cable and AC mains

EFT
ESD
Surge



TIDA-01401

用于绝对编码器的高 EMC 抗扰度 RS-485 接口 参考设计

方案特性

- 带 16kV IEC-ESD 和 4kV EFT 的 50 兆波特 5V 半双工 RS-485 收发器 (THVD1550) 可省去外部 ESD组件的成本。
- 设计实现了业界最高的 IEC 61000-4-4 快速电气瞬变抗扰度
- 支持 4 线制 RS-485 接口标准 (如 EnDat 2.2 和 BiSS) 或 2 线制接口标准 (如 Tamagawa)
- 由于可配置时钟方向, 硬件可用作驱动器和编码器接口
- 3.3V C2000 LaunchPad 接口, 用于使用编码器协议轻松进行系统评估
- 设计符合 IEC 61800-3 EMC 抗扰度要求

优点

- 符合 IEC61800-3 标准 B 的电磁兼容性要求
- 基于 RS485 的位置通信在 EFT 和 INS 脉冲噪声注入过程中具有高的位错抗扰度, 使伺服驱动性能和可靠性达到最高
- 强大的 5V RS485, 内置 ESD/EFT 保护, 当使用带有屏蔽电缆的编码器时, 无需使用 TVS 二极管。
- 支持同步和异步数据通信高达 50Mbps 的低延迟通信。
- 验证符合标准数据率高达 100 米电缆长度每 EnDat 2.2 和 BiSS。

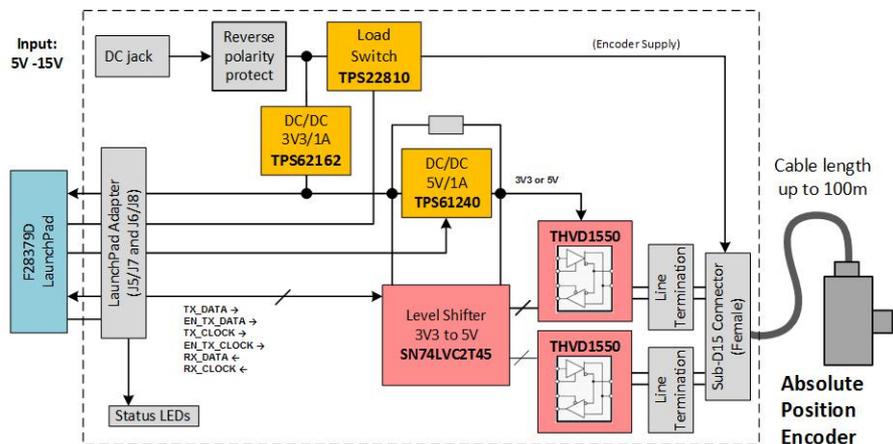
目标应用

- 伺服 CNC 和机器人
- 交流逆变器和 VF 驱动器
- 位置传感器 (编码器)
- 工业机器人

工具与资源

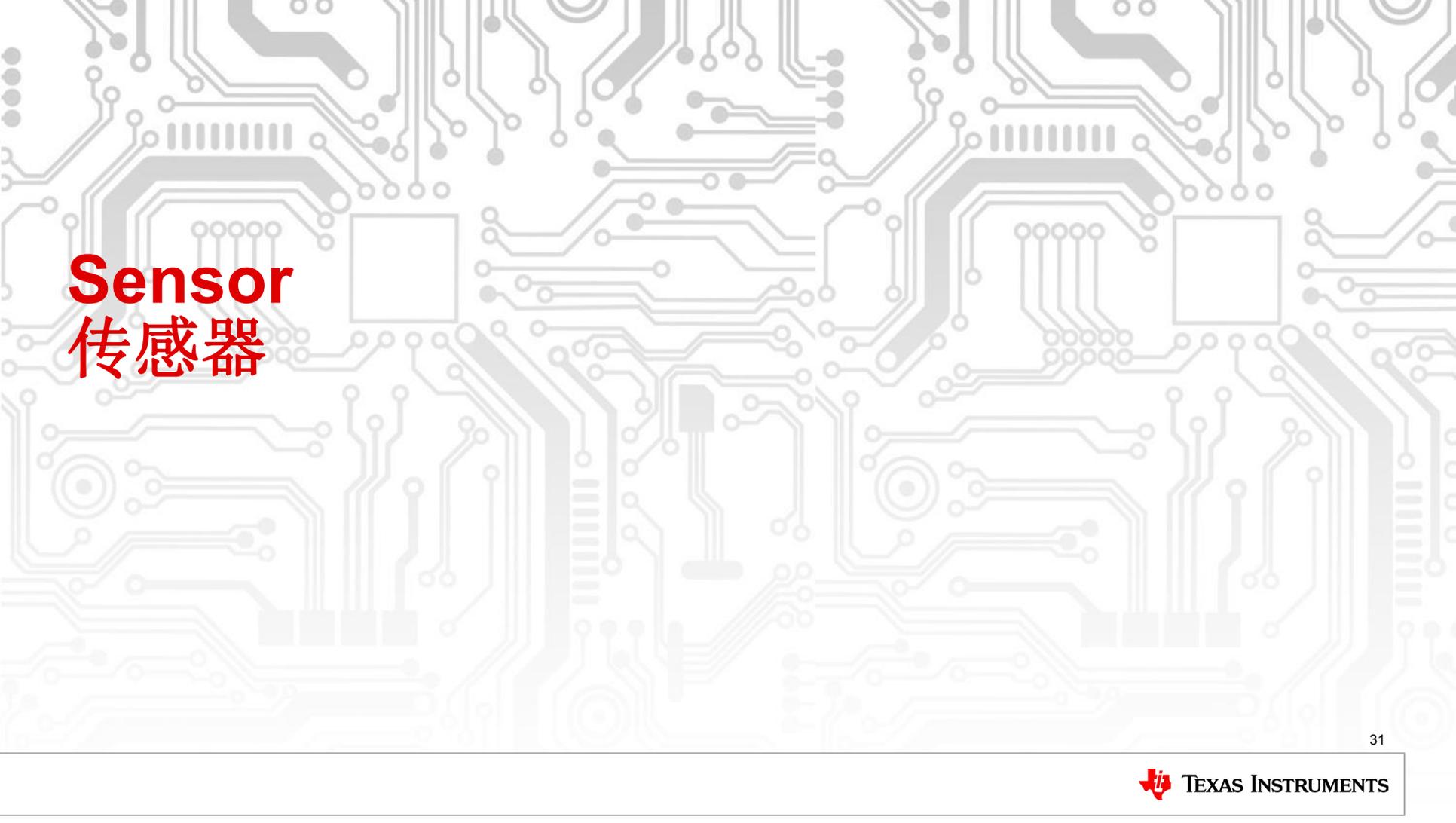


- [TIDA-01401 and Tools Folder](#)
- [Design Guide](#)
- Design Files: Schematics, BOM, Gerbers, and more
- Device Datasheets: THVD1550



Comparison of typical position feedback sensors in industrial drives

	Resolver	Incremental Encoder	Absolute Encoder
Sensor type	TIDA-00363	Optical, magnetic TIDA-00176	Optical, magnetic TIDA-01401
Absolute angle/position	Yes	No (Yes) Absolute angle possible with index signal, but <u>not after power-up</u> TIDA-00178	Yes, provides speed feedback and more features TIDA-00172 Sitara AM437x IDK
Multi-turn	No	No	Yes (pending) TIDA-00175 TIDEP-0022
Angle accuracy (typ.)	medium (~0.1deg)	High (digital) to very high (Sin/Cos interpolation)	High to very high (up to 0.00027 degree) TIDA-00177
Interface Open/public standards for encoder vendors marked green	Analog (I/O) 4V-7Vrms, 4-20kHz	Digital or Analog (O) <ul style="list-style-type: none"> Digital: 3.3V/5V TTL, 10-30V HTL or RS422, up to 10MHz pulse frequency Analog: Sin/Cos 1Vpp, up to 500kHz bandwidth 	Digital (I/O) or Hybrid Analog+Digital (I/O) <ul style="list-style-type: none"> RS485/RS422 half- or full-duplex interface: <ul style="list-style-type: none"> Vendor proprietary: Tamagawa, EnDat2.2, ... Open standards: BiSS-C, BiSS-Line, OCS, SSI or fieldbus: PROFIBUS, Modbus-RTU CAN: CanOpen, DeviceNET 10/100MB Ethernet <ul style="list-style-type: none"> Vendor specific: DriveCLIQ (Siemens) Industrial Ethernet, like EtherCAT, Ethernet IP, ... Hybrid: EnDat2.1 or HIPERFACE
Latency	Medium	Very low (<1us)	Low (10us and more, pending interface speed)
Power supply	N/A	5V, 10-30V, typ. <250mA	3.6V-14V, 5V, 10-30V and vendor specific, battery backup
Temperature	>150C ambient	70..100C ambient (outside case!)	70C...100C ambient
Electronics inside	No	Yes, simple	Yes, complex
Design challenge	N/A	Size, temp., AFE, power, EMC immunity	Size, temp., AFE, power, EMC immunity, interface protocol
Sensor cost	Low to medium	Medium	High to very high
Application examples	Robotics, harsh environment	AC inverter speed-variable drives (HTL/RS485), Servo/CNC Drives	Servo Drives, CNC, Robotics



Sensor 传感器

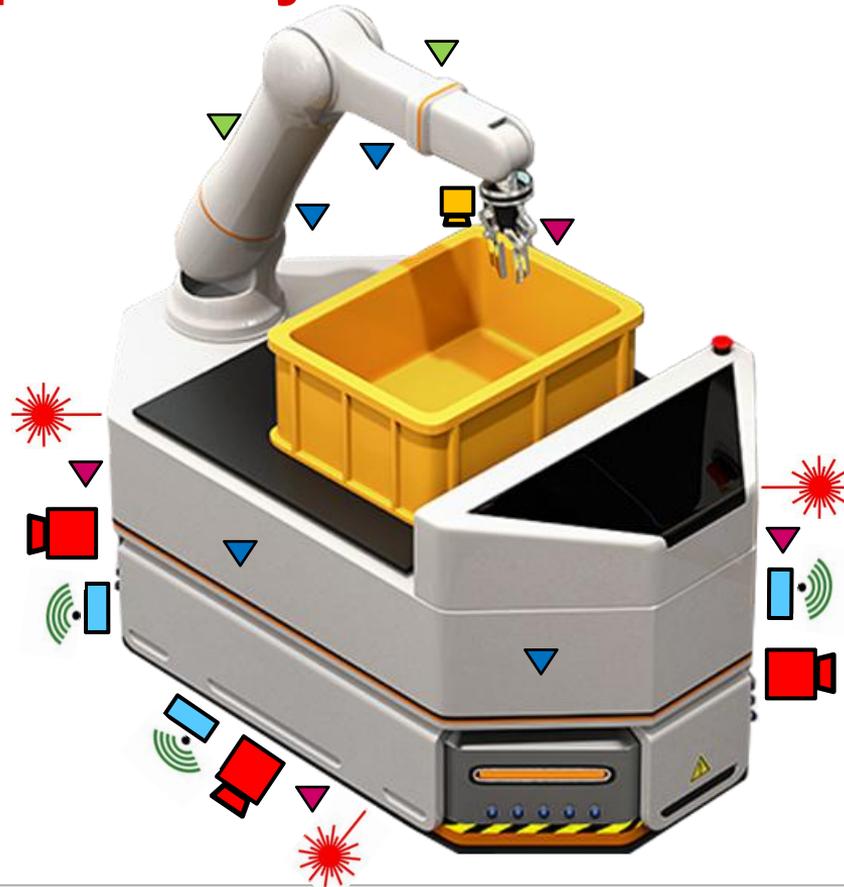
Position and proximity sensors in robots

 Camera
Target object
surround view

 Ultrasound
Detect transparent
objects

 Force
Detect contact

 Capacitive
Detect proximity



 RADAR
Blind spot detection
Navigation

 LIDAR
Collision avoidance
Emergency braking

 Camera
Collision warning
Object detection
Surround view

TI position and proximity sensor technologies



Ultrasonic

Radar

Light

Capacitive

Force

Magnetic

Inductive

+low power
+noise immunity:

+high accuracy
+long range

+Long range
+EMI immune
+Electrical isolation

+high resolution
+Rugged & can be subject to intense vibrations

+contact sensing
+robust technology

+High resolution
+Semiconductor based
+Easy to package

+low cost sensor
+Electrical isolation
+detects all conductive elements

Range: up to few m

Range: hundreds of m

Range: Up to km

Range is small < 1m

Range: 0

Range: few cm

Range few cm

-dynamic range between close and far range

-Cost
-SW complexity

-No blocking object
-reflectivity from object

-Highly non-linear
-Fringing effects
-Clean surface

-need mechanical design

-Need a magnet
-Difficult to calibrate
-Sensitive to interference

-Need metal objects
-Range proportional to sensor size

TDC1xxx
PGA4x

IWR1xxx

OPT3xxx
TDC72xx

FDC
MSP430

ADC

DRV5xxx
DRV4x

LDC

Ultrasonic



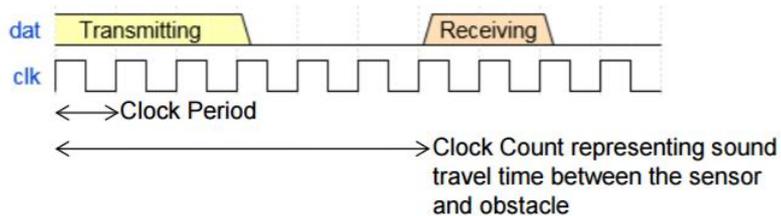
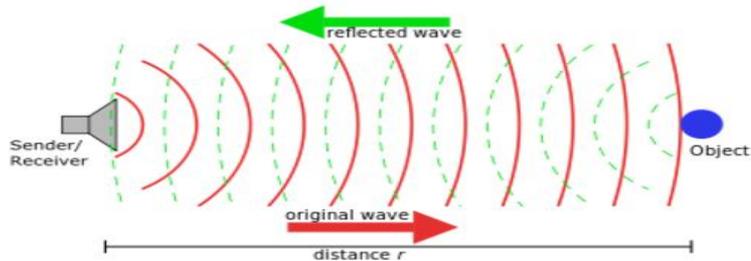
Ultrasonic

+low power
+noise immunity:

Range: up to few
m

-dynamic range
between close
and far range

TDC1xxx
PGA4x



$$ToF(s) = \text{Clock Period} \cdot \text{Clock Count}$$

$$r(m) = \frac{ToF \cdot \text{Speed of Sound}}{2}$$

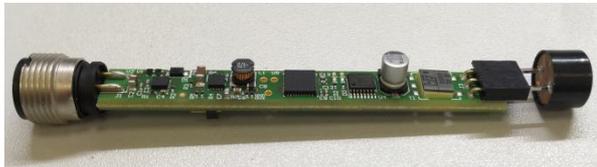
TIDA-01386

具有 IO-Link 的超声波距离传感器参考设计

方案特性

- 外形小巧: M12
- IO-Link 接口
- 距离范围:
 - ✓ 10cm 至 30cm (300kHz)
 - ✓ 30cm 至 5m (58kHz)
- 分辨率:
 - ✓ 约 1mm (300kHz)
 - ✓ 约 1cm (58kHz)
- 非接触式检测与测量

工具与资源



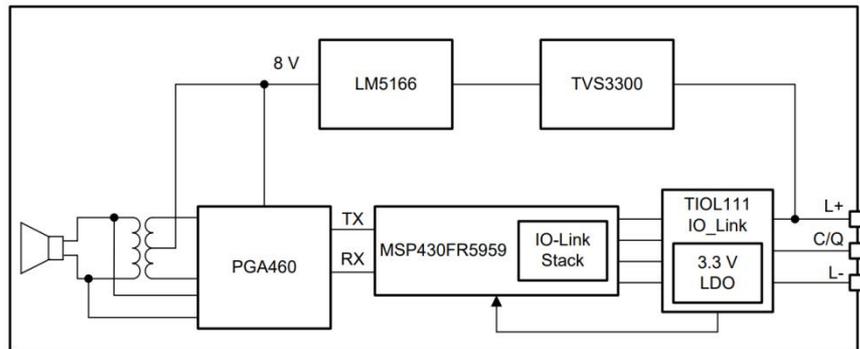
- **TIDA-01386**
 - [Design Guide](#)
 - [Design Files](#)
- **Datasheets:**
 - [PGA460](#)
 - [MSP430](#)
 - [TIOL111](#)
 - [LM5166](#)
 - [TVS3300](#)

优点

- 高集成度, 体积小
- 非接触检测, 与它们的颜色、透明度或表面特性无关。
- 使用相同硬件实现更宽频率范围

目标应用

- 物流机器人
- 工业机器人
- 无人机



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PGA460

超声波信号处理器和传感器驱动器

方案特性

- 距离: 15cm - 11m
- 频率范围: 30kHz - 80kHz, 180kHz - 480kHz
- 工作温度: -40 - 105°C
- 接口: 单线UART或时间命令接口(TCI)
- 封装: 16-pin TSSOP
- 有车规级版本Q100
- 集成温度传感器

目标应用

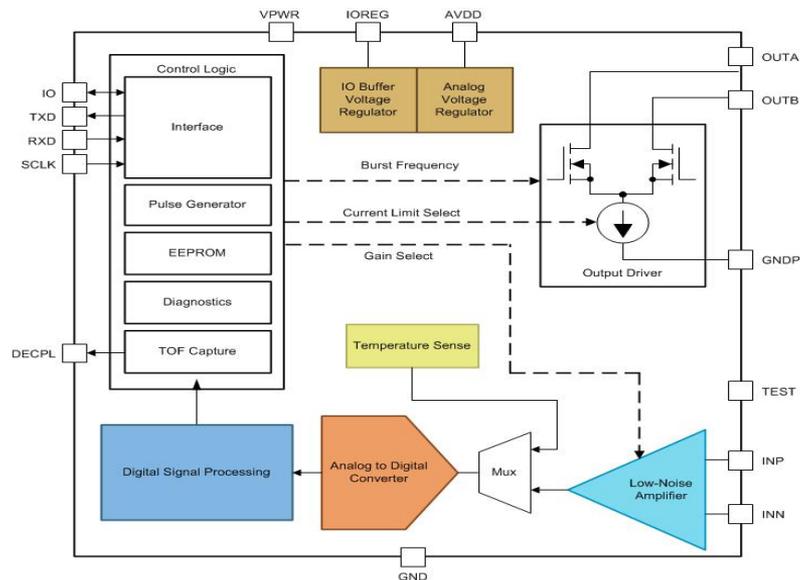
- 超声波雷达
- 物体距离和位置感应
- 存在和接近检测

工具与资源

- <http://www.ti.com/product/PGA460-Q1/technicaldocuments>
- <http://www.ti.com/product/PGA460-Q1/toolssoftware>

优点

- 优化范围内的目标的检测
- 允许设备驱动和接收更广频率的超声波换能器
- 行业领先的成本竞争力



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Radar



Ultrasonic

+low power
+noise immunity:

Range: up to few m

-dynamic range between close and far range

TDC1xxx
PGA4x

Radar

+high accuracy
+long range

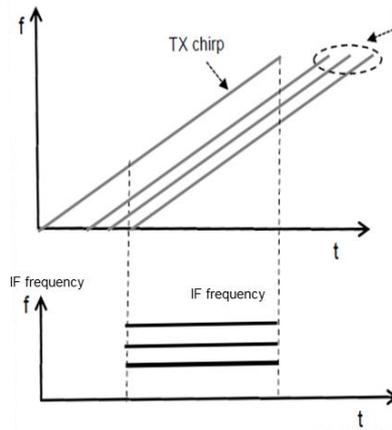
Range: hundreds of m

-Cost
-SW complexity

IWR1xxx

Basics of FMCW

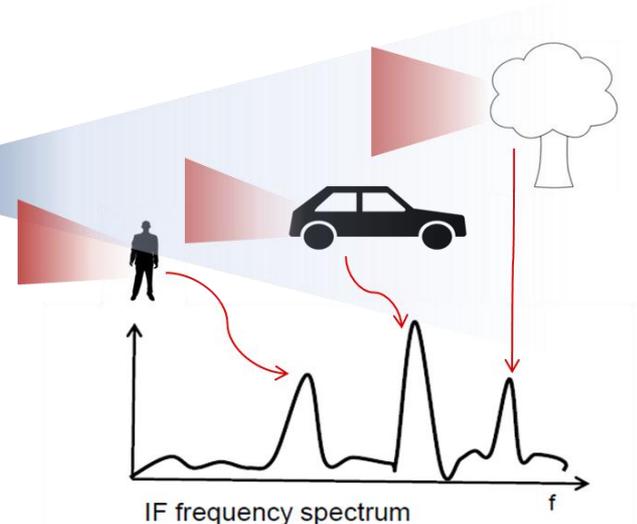
Distance Measurement



IF frequency = Tx frequency - Rx frequency

Distance of object is proportional to frequency of IF signal

Reflection from multiple objects. (Rx chirps)



IF frequency spectrum

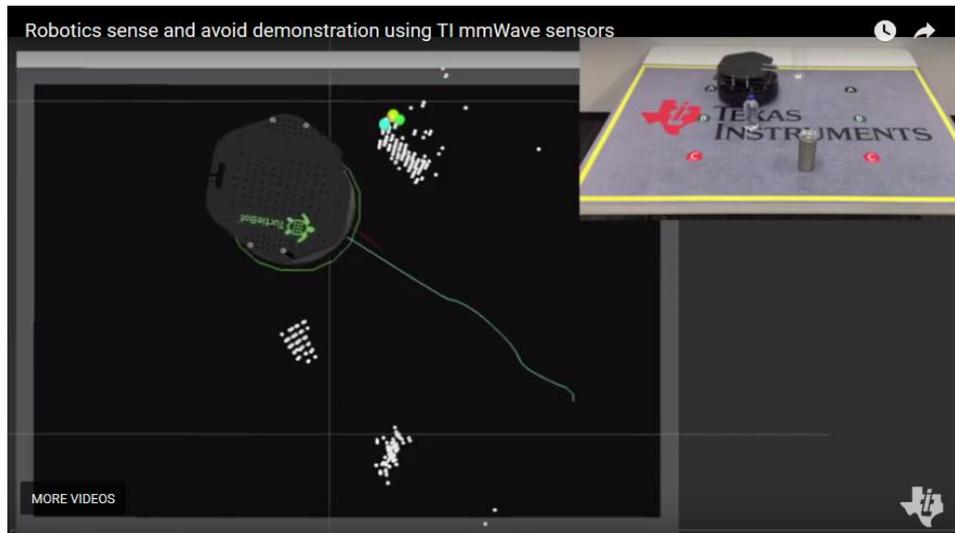
Frequencies in above plot are proportional to distance of objects. For objects far away the frequency of IF signal is higher.

TIDEP-01006

在 Sitara™ MPU 和封装天线毫米波传感器上使用 ROS 的自主机器人参考设计

Environmentally robust point cloud for robotics navigation and obstacle sensing

	Available
HW / EVM	IWR6843ISK+MMWAVEBOOSTIC + AM57x EVM
视场角	120° 水平, 30° 垂直
最大测量距离 (分辨率)	10m (0.047m)
性能标准	<ul style="list-style-type: none">•具有丰富的携带速度信息的点云，可以分辨静态与动态的物体。•Lidar或TOF相比，成本相对较低。•可检测物体材料属性，并且可穿透塑料、玻璃以及干墙等。•具有悬崖检测的能力。



1. Discover mmWave offering for robotics page [here](#)
2. Evaluate the performance
 1. IWR6843EVM : [IWR6843ISK](#) + [MMWAVEICBOOST](#)
 2. [Sense and Avoid Lab](#)
 3. [Detecting walls of different materials experiment](#)
3. Design custom boards with IWR6843 silicon
 1. [Online datasheet](#)
 2. [Hardware design checklist](#)

Lidar



Ultrasonic

Radar

Light

+low power
+noise immunity:

Range: up to few m

-dynamic range between close and far range

TDC1xxx
PGA4x

+high accuracy
+long range

Range: hundreds of m

-Cost
-SW complexity

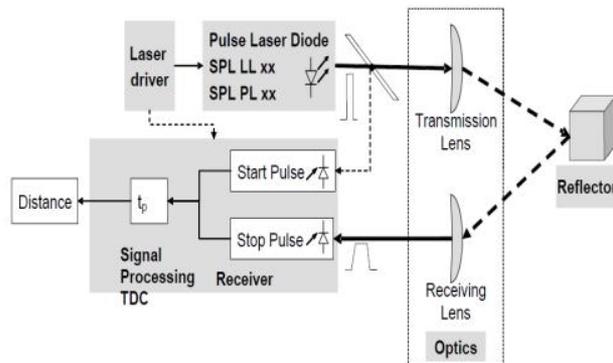
IWR1xxx

+Long range
+EMI immune
+Electrical isolation

Range: Up to km

-No blocking object
-reflectivity from object

OPT3xxx
TDC72xx



Technology	LIDAR Pulsed w/TDC Few pixel	LIDAR Pulsed w/HS-ADC few pixel	LIDAR Continuous wave Few pixel	LIDAR Continuous wave Pixel matrix (aka 3D ToF)
Principle	A sharp pulse is sent and time measured with TDC between TX and RX	A sharp pulse is sent and HSADC measures RX until RX edge detected	Modulated IR light (AM), correlation between RX and TX for ToF	Modulated IR light (AM), correlation between RX and TX for ToF
Strengths	<ul style="list-style-type: none"> ✓ Very long range ✓ Best for eye safety ✓ Simple ✓ Best cost structure 	<ul style="list-style-type: none"> ✓ Very long range ✓ Best for eye safety ✓ Well know and understood 	<ul style="list-style-type: none"> ✓ Long range ✓ Higher amount of samples can lead to increased distance accuracy 	<ul style="list-style-type: none"> ✓ Point cloud output ✓ Long range ✓ Built-in multi-sensor operation
Weaknesses	<ul style="list-style-type: none"> • Poor understanding of math needed to increase SNR (slyt706) 	<ul style="list-style-type: none"> • Expensive HS-ADC 	<ul style="list-style-type: none"> • Discrete solutions: <ul style="list-style-type: none"> • Expensive HS-ADC • Expensive HS-DAC • Integrated solutions: <ul style="list-style-type: none"> • Cross-talk TX to RX • Lower range due to eye safety 	<ul style="list-style-type: none"> • Expensive solution when only a few pixel needed
Key TI Designs	<ul style="list-style-type: none"> • TIDA-00663 • TIDA-01573 	<ul style="list-style-type: none"> • TIDA-01187 	<ul style="list-style-type: none"> • OPT3101EVM 	<ul style="list-style-type: none"> • TIDA-01173
Key TI ICs	<ul style="list-style-type: none"> - LMG1020 - OPA857 - TDC720x 	<ul style="list-style-type: none"> - ADC3244 - DAC5682Z - OPA857 - THS4541 	<ul style="list-style-type: none"> - ADC3244, DAC5682Z - OPA857, THS4541 - OPT3101 	<ul style="list-style-type: none"> - OPT8341 - OPT9221 - AM4379 - TPS659122

TIDA-00663

LIDAR 脉冲TOF参考设计

方案特性

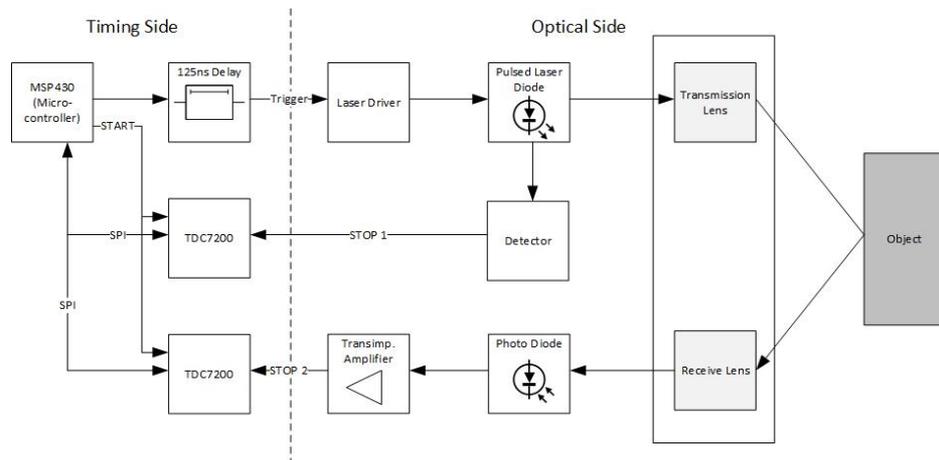
- LIDAR 脉冲飞行时间测量
- 系统级距离分辨率 <math><1\text{cm}</math>
- TDC 分辨率 1.65cm, 白噪声 1.05cm RMS
- TX 能量: 40 ns 时间内的峰值为 70W

优点

- 利用TI独特的TDC提供低成本, 高精度的解决方案
- 可应用于户外测量

应用

- 工厂自动化光学接近传感器
- 工厂自动化光学液位传感器
- 工厂自动化体积扫描仪
- 无人机



TDC7200

适用于测量激光雷达TOF应用的时间数字转换器（TDC）

方案特性

- 分辨率: 55ps
- 标准偏差: 35ps
- 测量范围:
 - ✓ 模式 1: 12ns 至 500ns
 - ✓ 模式 2: 250ns 至 8ms
- 低功耗: 0.5 μ A (2SPS)
- 最多支持 5 个 STOP 信号
- 自主多周期平均模式, 可实现低功耗
- 电源电压: 2V 至 3.6V
- 工作温度范围: -40°C 至 85°C
- 用于配置和寄存器访问的 SPI 主器件接口

工具与资源

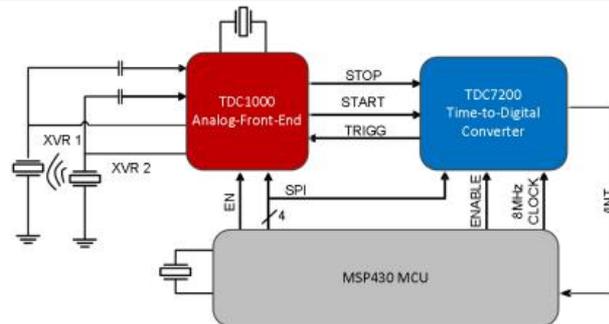
- [TIDA-00663](#): LIDAR 脉冲TOF参考设计
- [TIDM-ULTRASONIC-FLOW-TDC](#): 超声波流量计设计
- [TDC7200 EVM](#)
- [TDC1000-GASEVM](#): 超声波q气体流量计设计
- [TDC1000-TDC7200EVM](#): 超声波水流量/液面/浓度测量

优点

- 检测零或低流量时计时精度可达ps级别
- 低功耗提高系统电池寿命
- 与模拟前端TDC1000可无缝对接使用
- SPI接口允许无缝集成到现有系统

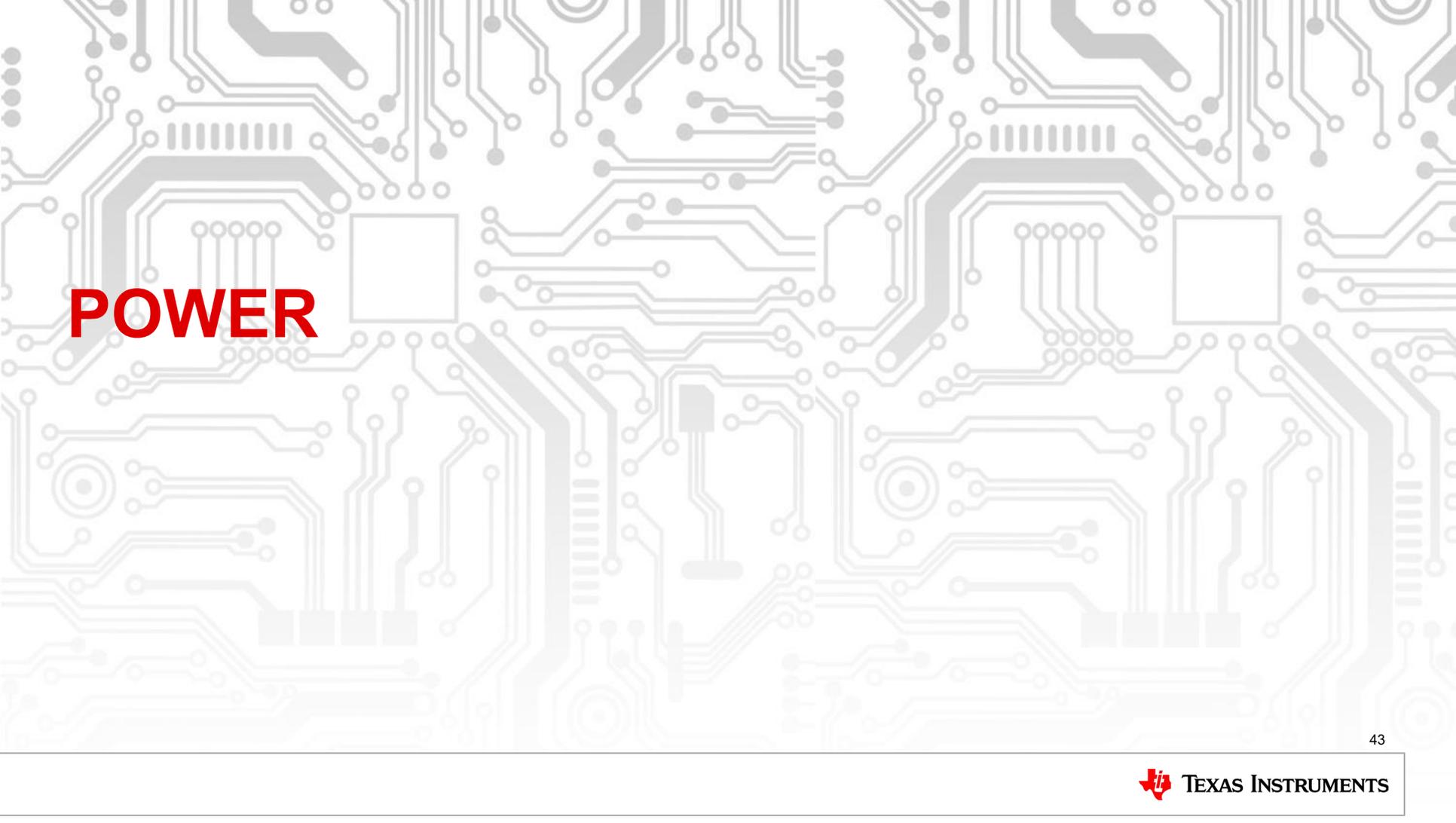
目标应用

- 流量计: 水表、燃气表和热量计
- 磁致伸缩位置/液位感测
- 无人机(激光雷达和声纳)的飞行时间、计量设备和投影仪
- 热量分配表



Agenda

- **Industrial robot overview 工业机器人概述**
 - Definition and classification of industrial robot 定义与分类
 - TI resource in industrial robot application TI在工业机器人应用丰富的线上资源
- **Industrial robot system analysis, design challenge and TI solution 工业机器人系统分析，设计挑战以及TI解决方案**
 - Major modules analysis 主要模块分析
 - Controller 控制柜/控制器
 - Manipulator/Robot arm 机器臂/本体
 - Sensors 传感器
 - System consideration 系统考虑
 - Power solution 电源
 - Functional safety solution 功能安全
 - Communication solution in different modules 通讯



POWER

Power in industrial robots

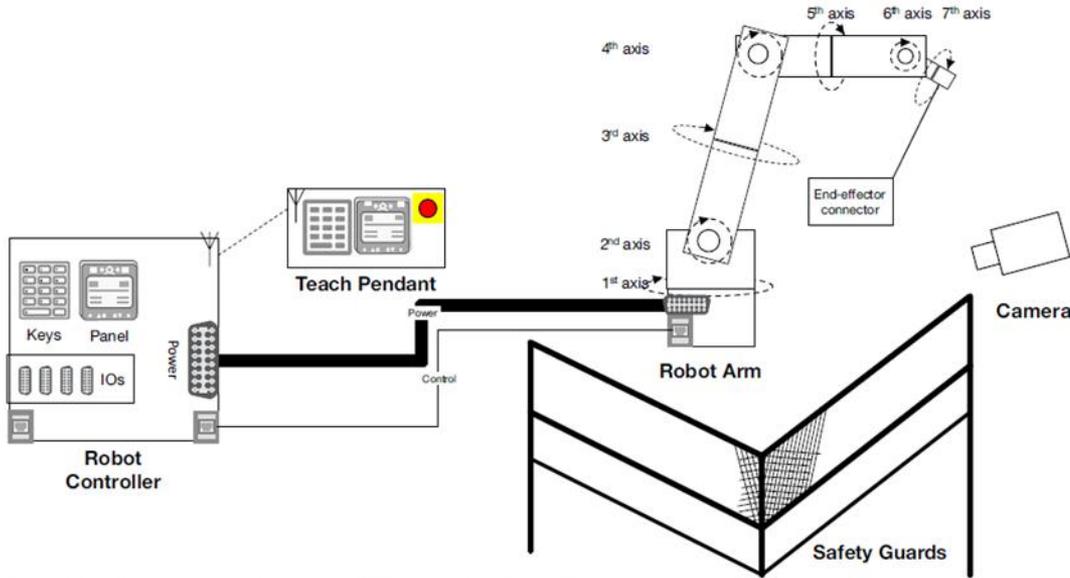


Figure 1: Typical system components in an industrial robot system.

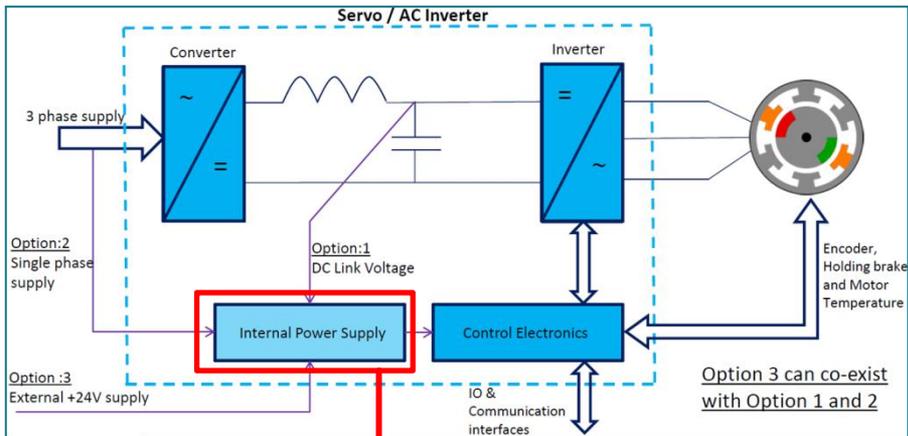
工业机器人的组成	供电要求
工业机器人通讯模块	+5Vdc ISO
工业机器人CPU模块	+5/3.3/1.8Vdc
伺服控制模块	VAC 到 VDC 高直流环节电压 到低直流电压 (通常24V)
工业机器人传感模块	+5/10Vdc
工业机器人人机界面 (HMI)	+5Vdc (通常)
工业机器人IO模块	+24Vdc ±12/15Vdc
(功能安全模块)	—

<http://www.ti.com.cn/zh-cn/applications/industrial/factory-automation/overview.html>

44

Power supply architectures

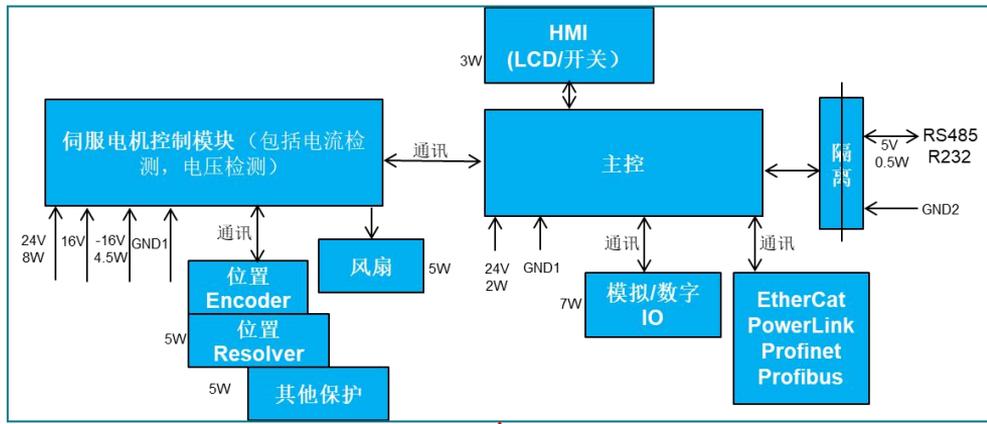
1. 伺服电机部分的供电



AC/DC

- 高效
- 低待机功耗
- 良好的功率因素
- 低谐波失真(THD)
- OVP, OCP, CBC, OTP等
- 低噪声

2. 其他部分的供电



隔离 DC/DC

- 控制方式的选择
- 低噪声
- 高效
- 输出滤波器的设计

非隔离 DC/DC

- 高效
- 纹波要求
- 可控时序
- 小体积

TIDA-010009 适用于伺服驱动器且具有紧凑结构和较高效率的 24V 输入辅助电源参考设计

方案特性

- 由 24V $\pm 20\%$ 的外部保护性超低电压 (PELV) 电源 供电
- 电源输入端的工业电子保险丝可提供可编程 UV/OV 保护、反极性保护、输出过载保护和 SC 保护
- 经过优化且具有集成开关的同步降压直流/直流转换器，可实现高于 90% 的效率和紧凑的尺寸
- 具有集成开关的 PSR 反激式，可为通信和数字 I/O 生成隔离式电压轨
- 可编程电压输出，支持多种编码器类型
- 输出电压轨：24VISO、5VISO、 $\pm 12V$ 、5V、3.3V、2.5V、1.2V，具有小于 $\pm 1\%$ 的负载和线路调 解率
- 系统效率 > 90%
- 负载调整率和线性调整率: < $\pm 1\%$
- 工作温度范围: -25°C 到 85°C

TI.com 中的资源

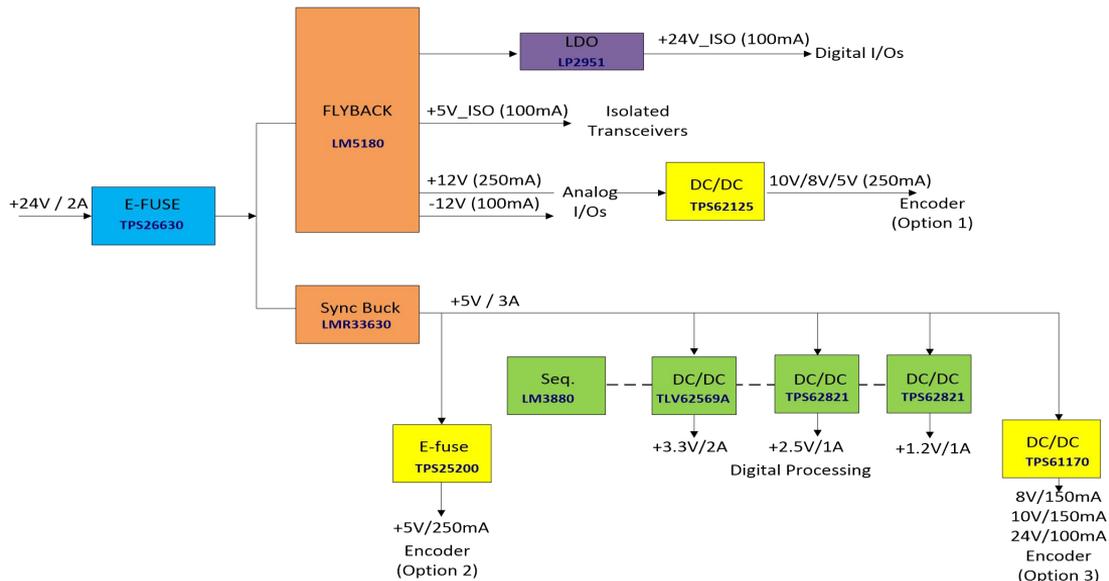


- [TIDA-010009 and Tools Folder](#)
- [Design Guide](#)
- 设计文件: 原理图, BOM, Gerbers, 等等.
- 芯片数据手册:

TPS26630	TPS62821
LM5180	TPS61170
LMR33630	LP2951
TPS62569	TPS25200

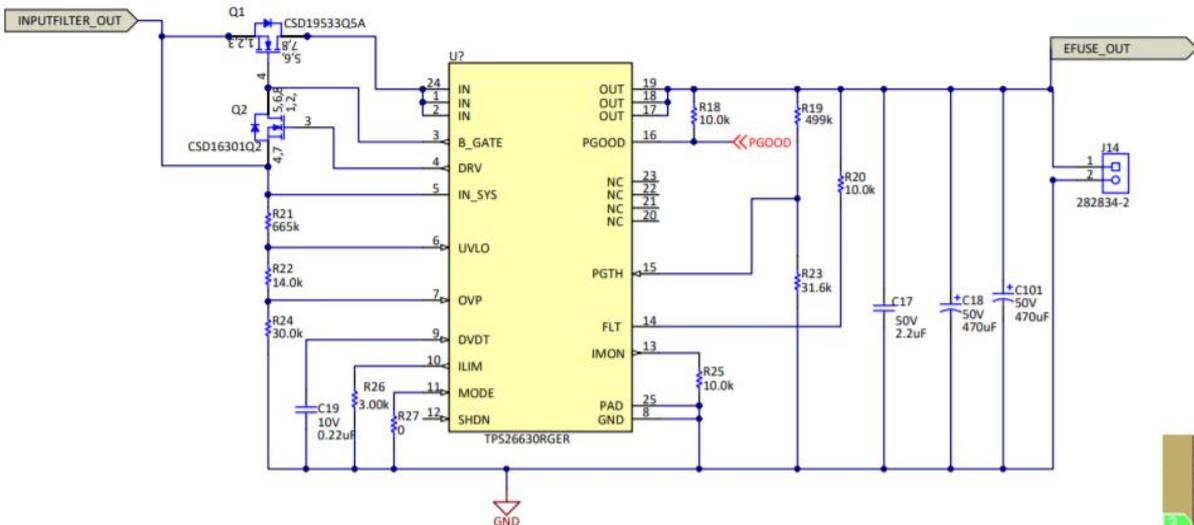
优化

- PSR Fly-back 结构省去了光耦合器和辅助绕线,节省了BOM中元器件的数量
- 低成本且紧凑的电源方案
- 实现电涌负载保护时 (IEC 61000-4-5) 所使用的外围元件数量减少
- 通过PG和EN管脚进行时序的调整
- 若系统设计时, 负载电流改变, 可灵活地使用P2P芯片来实现



Protection at input by eFuse

- 软启动和浪涌电流
- 反极性保护
- 欠压锁定和过压保护



TPS2663 60V、6A 功率限制浪涌保护EFUSE

- 工作电压为 4.5V 至 60V，绝对最大值为 62V
- 具有 $31\text{m}\Omega$ R_{ON} 的集成式 60V 热插拔 FET
- 通过外部 N 沟道 FET 提供反极性保护和反向电流阻断支持
- 0.6A 至 6A 可调节电流限制（6A 时精度为 $\pm 8\%$ ）
- 热插拔时，浪涌电流可被控制（ $dV/dt = \text{开路}$ ）支持大型电容器充电
- 具有可调节检测阈值 (PGTH) 的电源正常输出 (PGOOD)

图 9. Hot Plug In and Inrush Current Control at 24-V Input

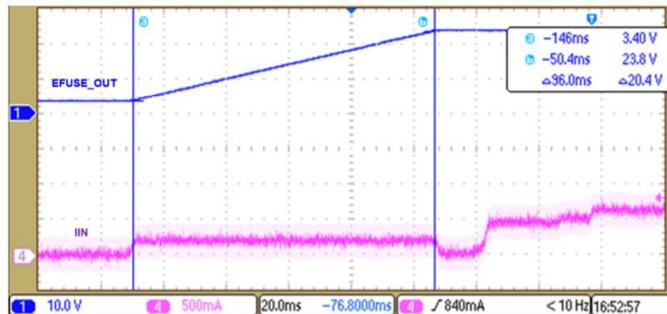
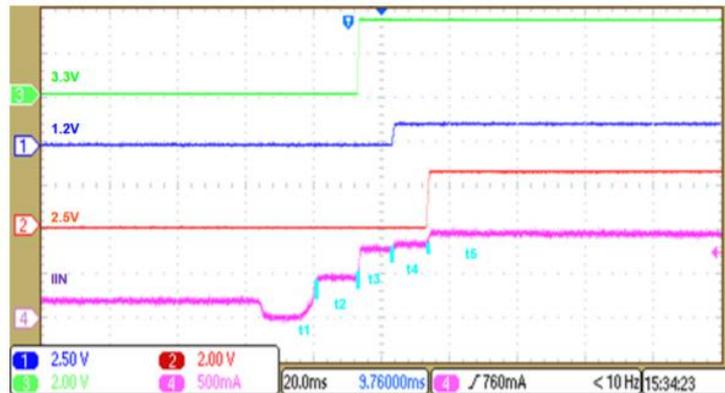


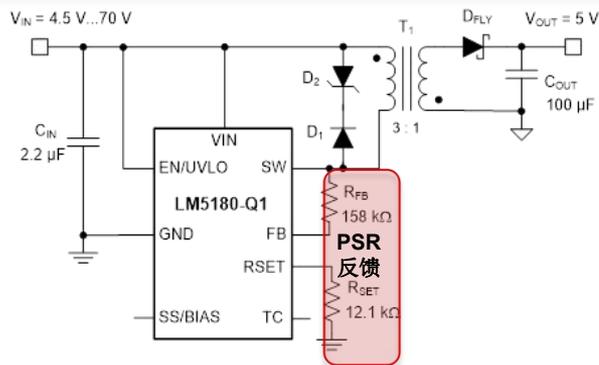
图 10. Input Current During Power Up of Power Supplies



Devices selected in PSR flyback power supply

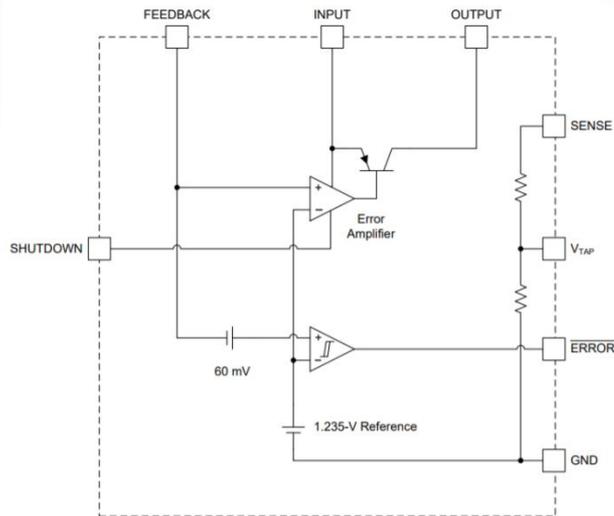
LM5180

- 具有 100V、1.5A 集成功率 MOSFET 的 65VIN PSR 反激式转换器
- 4.5V 至 65V 的宽输入电压范围
- 通过采用边界导电模式 (BCM) 开关可实现紧凑的磁解决方案以及优于 $\pm 1.5\%$ 的负载和线路调节性能
- 集成的 100V 功率 MOSFET 能够提供高达 7W 的输出功率并提高应对线路瞬变的余量
- 内部环路补偿
- 低 EMI 运行, 符合 CISPR 32 标准



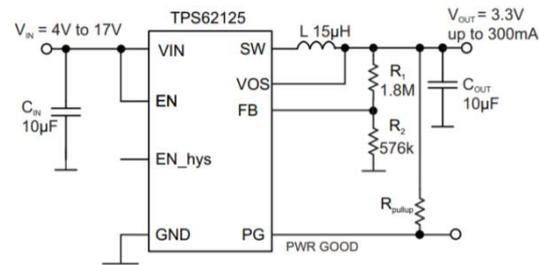
LP2951

- 单路输出100mA、可调节电压的 LDO
- 宽输入电压范围, 最大可达30V
- 低Dropout: 380mV (Typ) 在100mA
- 低静态电流: 75uA (Typ)
- 线性调整率: 0.03%
- 负载调整率: 0.04%

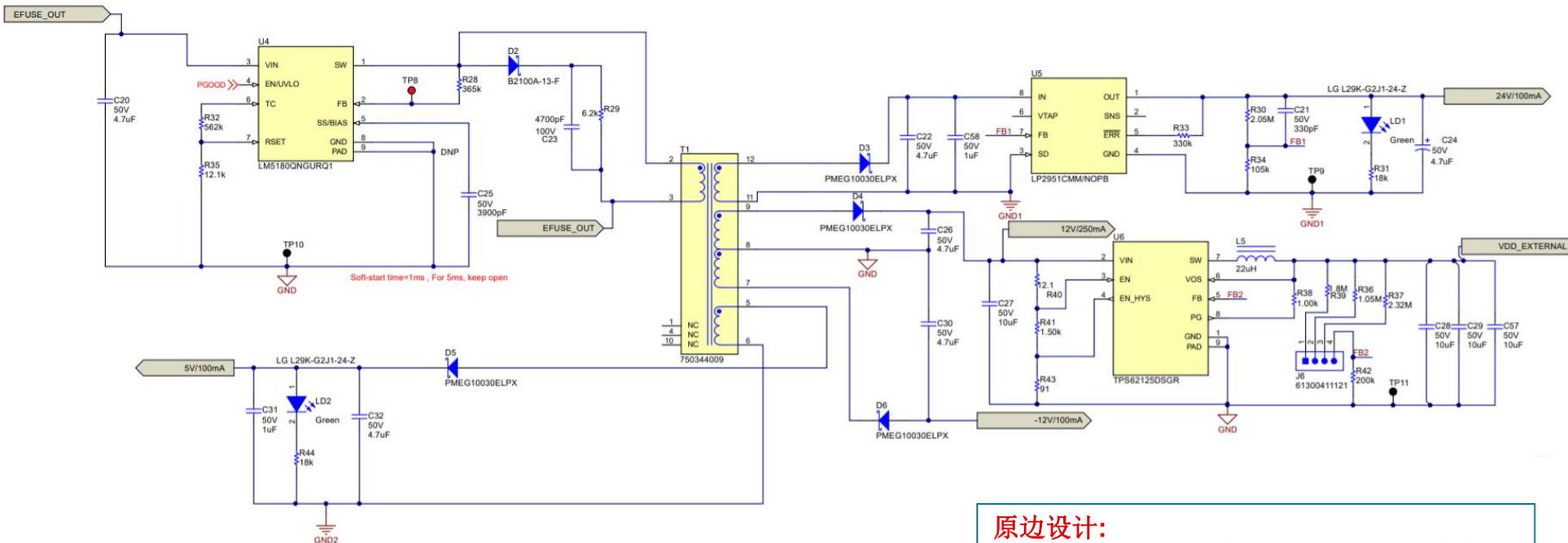


TPS62125

- 使能阈值和迟滞可调节的 3V 至 17V、300mA 降压转换器
- 1.2V 至 10V 宽输出电压范围
- 静态电流典型值为 13µA
- 低输出纹波电压 (20mVpp)
- 高达 1MHz 的开关频率



PSR flyback power supply



PSR Flyback 的优点:

- 省去了光耦合器和额外的反馈绕线
- 通过避免来自变压器DCR, 漏感和副边二极管的误差实现了更好的负载调节
- 相比于传统Flyback, 尺寸更小
- 工作在DCM和BCM模式下

原边设计:

变压器的设计 (绕线匝数, 电感, 漏能...), 漏能的控制 (原边齐纳钳位, RC阻尼), 输入电容, 反馈电阻等

副边设计:

Flyback二极管, 输出电容

LM5180 quickstart tool: 15V & -7.5V dual outputs at 150mA

WIDEV_{IN} DC/DC Power Solutions
Reliable Power for Demanding Systems

LM5180 PSR Flyback Converter Design Tool

Terms Of Use

About = Input Box

Step 1: Operating Specifications

Input Voltage - Min. $V_{IN(min)}$	10 V
Input Voltage - Nom. $V_{IN(nom)}$	24 V
Input Voltage - Max. $V_{IN(max)}$	60 V
Single Output or Dual Outputs	DUAL
Output Voltage, V_{OUT1}	15 V
Rated Output Current, I_{OUT1}	0.15 A
Output Voltage, V_{OUT2}	-7.5 V
Rated Output Current, I_{OUT2}	0.15 A

Step 3: Input & Output Capacitors

Minimum Input Capacitance	2.2 μ F
Input Capacitance, C_{IN}	4.7 μ F
Input Capacitor ESR	10 m Ω
Resulting Input Voltage Ripple	87 mV _{pk-pk}
Minimum Output Capacitance, Output #1	1.1 μ F
Output Capacitance, C_{OUT1}	22 μ F
Output Capacitor ESR	3 m Ω
Resulting Output Voltage Ripple, Output #1	32 mV _{pk-pk}
Minimum Output Capacitance, Output #2	2.3 μ F
Output Capacitance, C_{OUT2}	47 μ F
Output Capacitor ESR	3 m Ω
Resulting Output Voltage Ripple, Output #2	15 mV _{pk-pk}

Step 5: Power Losses & Thermals

Flyback Diode Voltage Drop, $V_{D(no-load)}$	0.25 V
Flyback Diode Voltage Drop, $V_{D(full-load)}$	0.35 V
Estimated Thermal Impedance, θ_{JA}	60 $^{\circ}$ C/W
Ambient Temperature, T_A	85 $^{\circ}$ C
LM5180 Power Dissipation at Full Load, P_D	148 mW
LM5180 Junction Temperature at Full Load, T_J	94 $^{\circ}$ C

Step 2: Flyback Transformer

Recommended Magnetizing Inductance	22 μ H
Magnetizing Inductance, L_M	22 μ H
Primary Winding DC R	100 m Ω
Secondary Winding #1 DC R	200 m Ω
Secondary Winding #2 DC R	200 m Ω
Turns Ratio, PRI : SEC1	1 : 2
Turns Ratio, SEC1 : SEC2	0.51
Duty Cycle at $V_{IN(min)}$	43.4 %
Max Output Power at $V_{IN(min)}$	3.0 W

Step 4: Feedback, Soft-start, TC, UVLO

Recommended Feedback Resistor	76.3 k Ω
Selected Feedback Resistor, R_{FB}	158 k Ω
Soft-Start Configuration	Adjustable
Soft-Start Time	5 ms
Soft-Start Capacitance, C_{SS}	22 nF
VOUT Thermal Compensation	YES
Diode Voltage Drop Thermal Coefficient	-1.3 mV/ $^{\circ}$ C
Thermal Compensation Resistor, R_{TC}	732 k Ω
Input UVLO Configuration	Adjustable
Input UVLO Turn-On Threshold	9.5 V
Input UVLO Turn-Off Threshold	6.5 V
Upper UVLO Resistor, R_{UV1}	536 k Ω
Lower UVLO Resistor, R_{UV2}	100 k Ω

PSR flyback test results

图 56. Switch Node of LM5180 at Full Load



测试环境:
输入 = 24V/2A
时间 = 15 分钟
环境温度 = 25°C

图

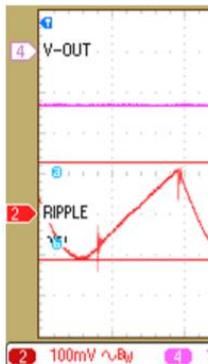
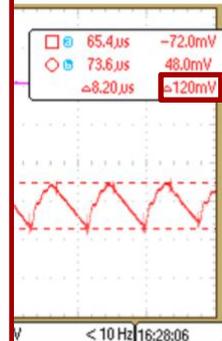
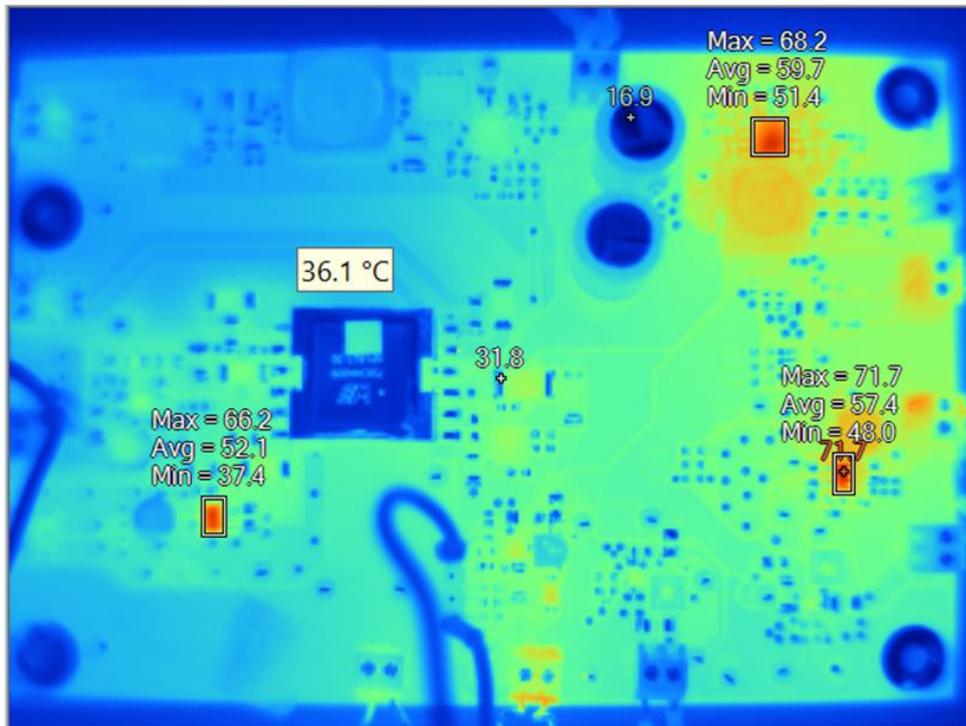
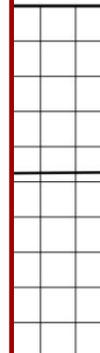


图 57. Output Ripple on Isolated 5-V Rail at Full Load



0-mA Rail



27 28

D030

SBVA059 工业相机或视觉传感器中高性能CMOS图像传感器的供电方案

设计难点

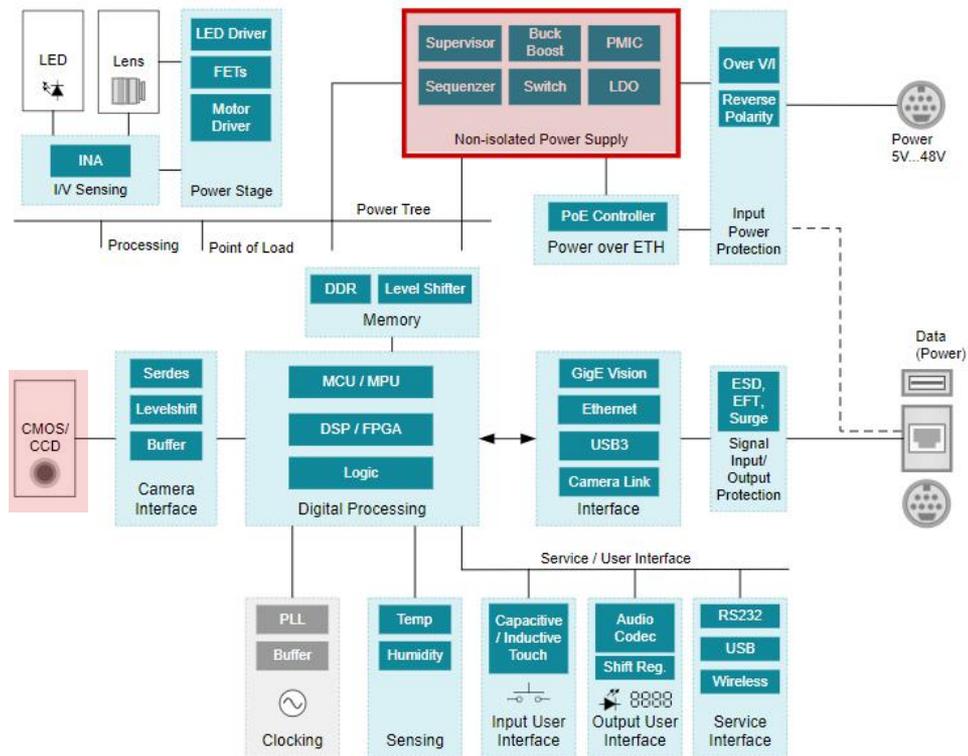
- CMOS图像传感器需要多路电源轨
- CMOS图像传感器各路电源轨供电要求不同：
 - 模拟电源轨对噪声敏感
 - 有些电源轨挂有大容值bypass电容
- 体积限制和热表现之间的平衡

方案特性

- 输入电压: 12V / 24V, 瞬态电压可高达 60V
- 4V中转电压
- 3 路低噪声且高 PSRR 的电源轨(典型值可从1.2V 到3.3V)
- 输出电流最大可达500mA
- 输出容值可高达250uF
- 控制有序的上电和掉电时序
- 主动输出放电

优化

- 功率损耗减小
- 低噪, 小纹波, 高PSRR
- 可承载高达250uF的输出电容
- 体积小
- 符合CMOS图像传感上下电时序要求



<http://www.ti.com.cn/solution/cn/machine-vision-camera?variantid=484&subsystemid=23983>

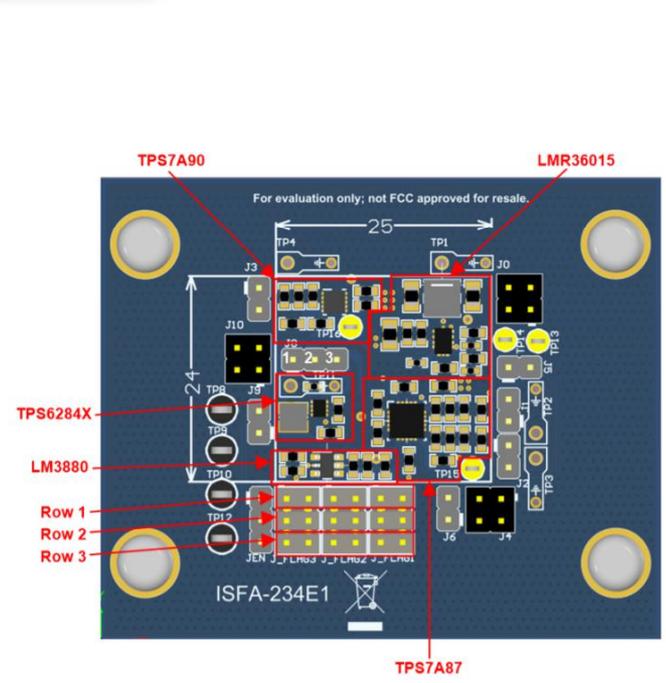
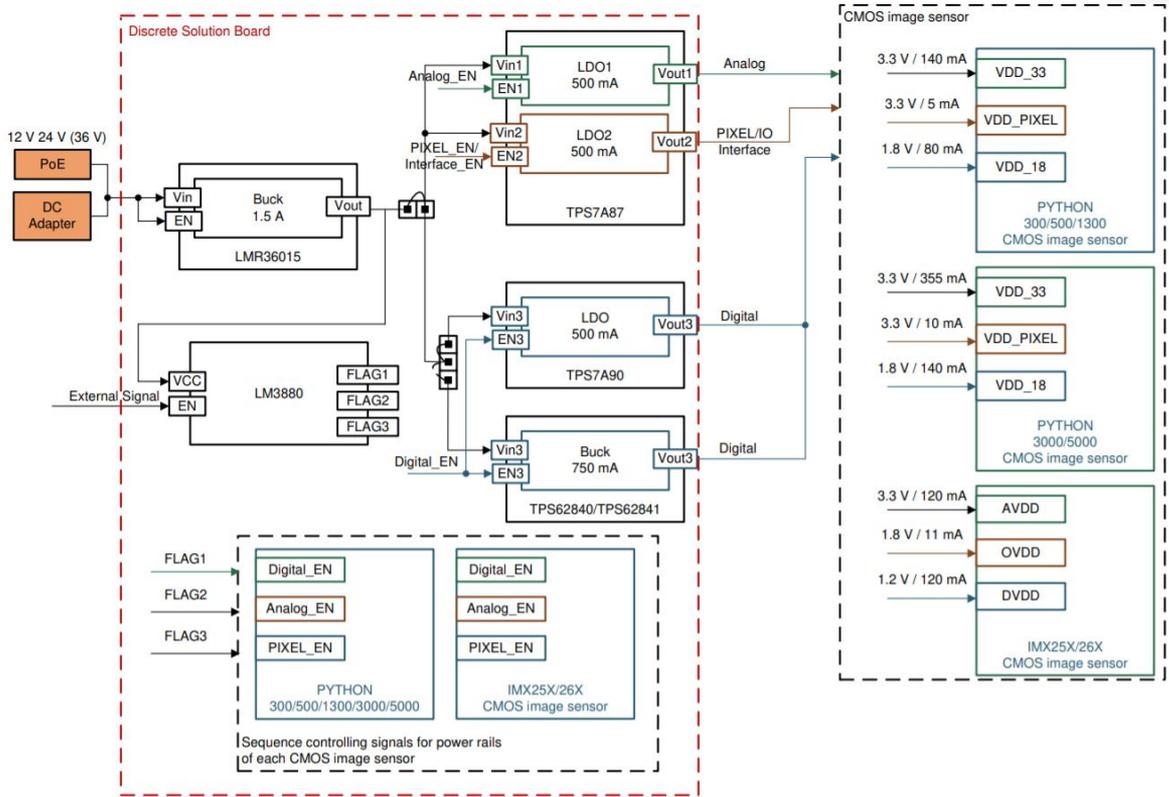
Solutions overview

1. 分离式方案

- Discrete Solution**
- LMR36015
 - TPS7A87
 - TPS7A90
 - TPS62840/TPS62841
 - LM3880

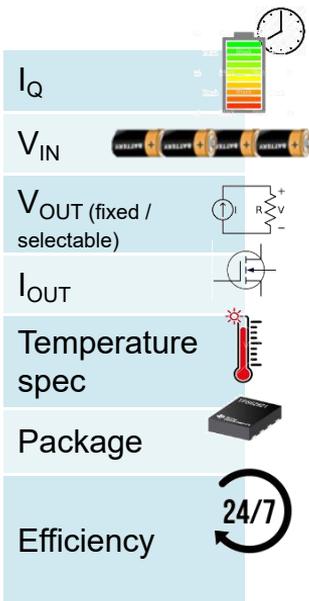
- TPS65000 Solution**
- LMR36015 EVM
 - TPS65000 EVM
 - LM3880 EVM

- TPS650330-Q1 Solution**
- TPS650330-Q1 EVM



Device selected in discrete solution

TPS62840



- I_Q
- V_{IN}
- V_{OUT} (fixed / selectable)
- I_{OUT}
- Temperature spec
- Package
- Efficiency

old solution

TPS62 740

I_Q	360nA
V_{IN}	2.2V to 5.5V
V_{OUT} (fixed / selectable)	1.8V to 3.3V
I_{OUT}	300mA
Temperature spec	-40 to +85°C
Package	2x3 QFN
Efficiency	82% @ 10 μ A I_{OUT} 50% @ 1 μ A I_{OUT}

new solution

TPS62 840 Marathon

I_Q	60nA
V_{IN}	1.8V to 6.5V
V_{OUT} (fixed / selectable)	0.8V to 3.3V
I_{OUT}	750mA
Temperature spec	-40 to +125°C
Package	1.5x2 QFN
Efficiency	90% @ 10 μ A I_{OUT} 85% @ 1 μ A I_{OUT}

业界最低IQ

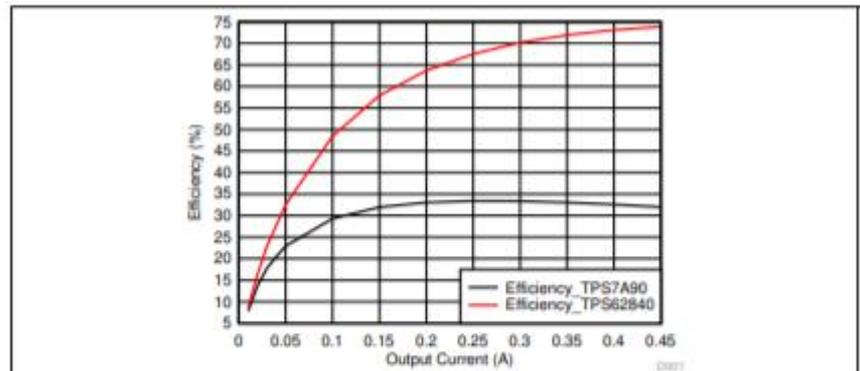
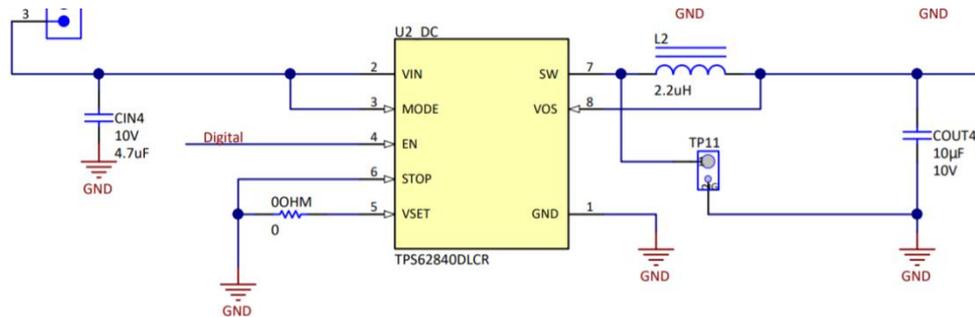


Figure 17. Efficiency of the Digital Rail Supplied by TPS7A90 or TPS62840 in PYTHON 300/500/1300 CMOS Image Sensors

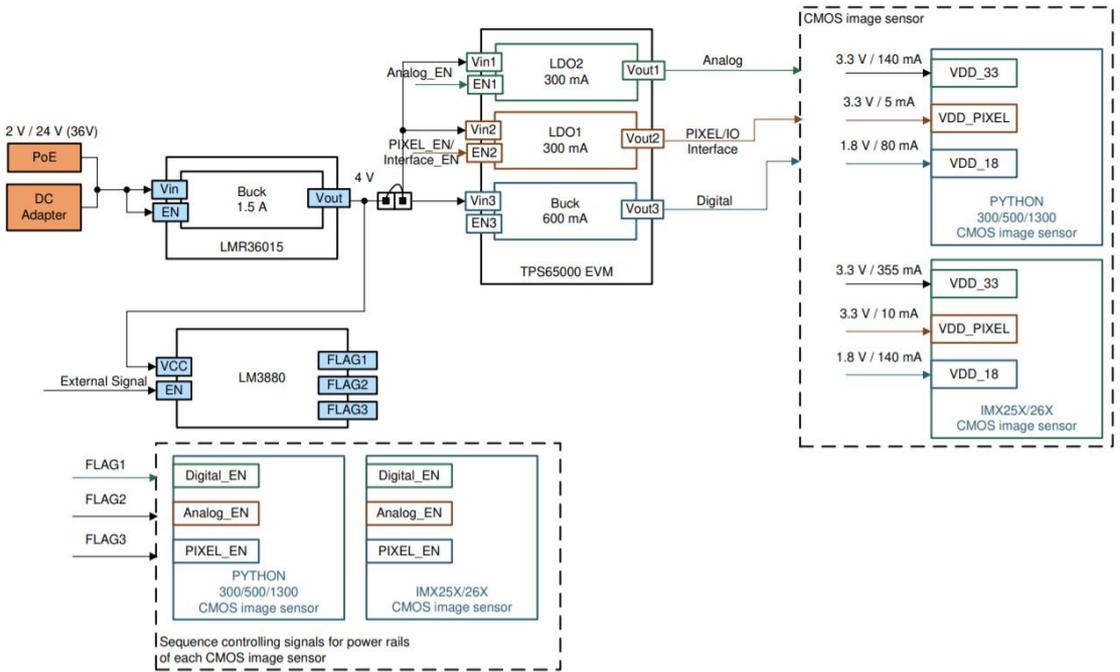
Two PMIC solutions

2. TPS65000 集成式方案

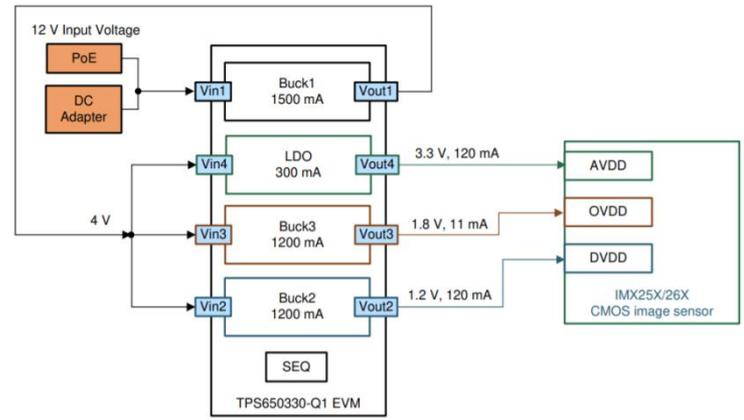
- Discrete Solution**
- LMR36015
 - TPS7A87
 - TPS7A90
 - TPS62840/TPS62841
 - LM3880

- TPS65000 Solution**
- LMR36015 EVM
 - TPS65000 EVM
 - LM3880 EVM

- TPS650330-Q1 Solution**
- TPS650330-Q1 EVM



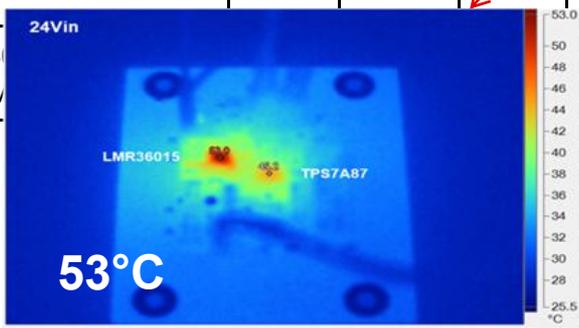
3. TPS650330-Q1 集成式方案



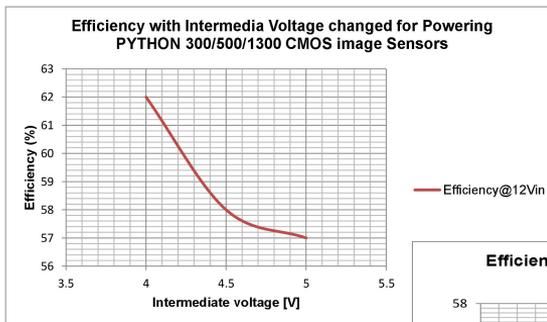
Efficiency

三种方案（分离式方案，TPS65000集成式方案和TPS650330-Q1集成式方案）的效率比较：

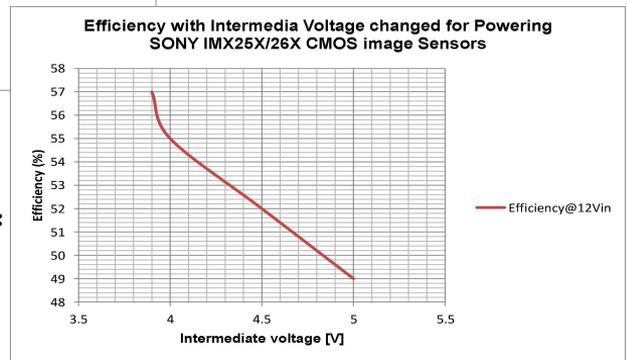
三种方案给同一种CMOS图像传感器供电			
方案	效率		
	5Vin	12Vin	24Vin
方案1: 分离式方案 (LMR36015+TPS7A87+TS62841+LM3880)	71%	62%	50%
方案2: TPS65000 集成式方案 LMR36015 (方案PCB板上的第一级电源)+TPS65000EVM+LM3880EVM	72%	63%	53%
方案2: TPS650330 TPS650330-Q1 EV			



多级电源轨的中间电压选值对系统效率的影响



第一个CMOS图像传感器：多级电源轨中间电压改为4.5V和5V时所呈现的系统效率。



第二个CMOS图像传感器：多级电源轨中间电压改为3.9V, 4.5V和5V时所呈现的系统效率。

多级电源轨的中间电压选值约低，系统的效率越高。但是还需要具体系统具体分析。

Low V_{IN} (<7V) buck (step-down) DC/DC converter

Care-about's

更低的Core电压



数字处理中高精度的VREF
全温度范围内1%，固定VOUT, I2C接口

多路电源轨



时序 / 跟踪
Power Good, 可调软起动, 精准EN, 同一家族芯片P2P

高密度PCB



更小的PCB面积
小封装, 简单的外围电路, 简单的PCB布局和走线

热性能



效率高
省电模式, 低静止电流, HotRod™ 套装

安静的供电

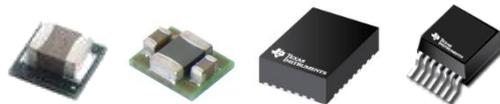
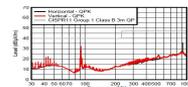
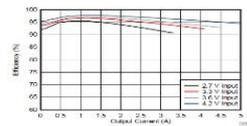
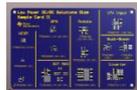


低噪声
DCS-控制技术, FPWM 模式可选, 固定/同步的频率

可缩短上市时间



模块
集成电感/电容



Low V_{IN} (<7V) buck (step-down) DC/DC converter

Portfolio highlights

I_{OUT}	高效/ 小体积 Automatic Power Save Forced-PWM (optional)		固定频率 with f_{SW} synchronization	超低 I_Q nano I_Q	模块 Integrated Inductor
0.3A		TPS62240 TPS62230		TPS62740	TPS82740 LMZ10500
0.6A	TPS62840	TPS62260 TPS62808 TPS62290 TPS62802		TPS62840	TPS82670
1A	TPS62821 TLV62568	TLV62568A	TPS62811		LMZ10501 TPSM82821 TPS82680
2A	TPS62822 / 5 TLV62569 TPS62088	TLV62569A	TPS62812 TPS54218		TPS82084 TPSM82822
3A	TPS62823 / 6 TLV62585		TPS62813 TPS54318		TPS82085 TPSM82813
4A	TPS62827 TLV62095	TPS62864	TPS62810 TPS52418		TPSM82810
5A			TPS54519		
6A		TPS62480 TPS62866	TPS54618		TPSM82480
7A			TPS54719		
9A					

Preview products in [light teal](#)

TLV62 568 / 569 / 585

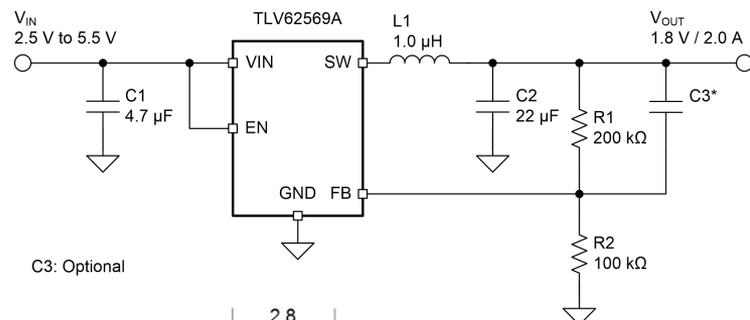
1A / 2A / 3A Buck converter family in **SOT-package**

特性

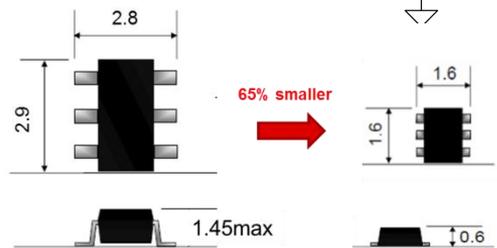
- 2.5V to 5.5V 输入电压范围
- 低 开关电阻 $R_{DS(ON)}$: 150m Ω / 100m Ω (1A)
100m Ω / 60m Ω (2A), 56m Ω / 32m Ω (3A)
- 0.6-V 至 V_{IN} 可调节输出电压
- 100% 占空比时, dropout能达到很低
- I_Q : 35 μ A
- 内置软起动
- 轻载高效节能模式
- FPWM 运作方式来实现更低的纹波电压 (TLV62568A/TLV62569A)
- PGOOD 功能可选 (TLV6256xP)
- 1A / 2A 的SOT23 和SOT563封装都有
- 3A 有2x2 QFN 和SOT563封装

优点

- 成本优化
- 工业中常见的引脚封装



C3: Optional



SOT23
Package size: 8.1mm²

SOT563
Package size: 2.6mm²

TPSM82 821/822

1A / 2A Buck converter module with integrated inductor

In development
samples now

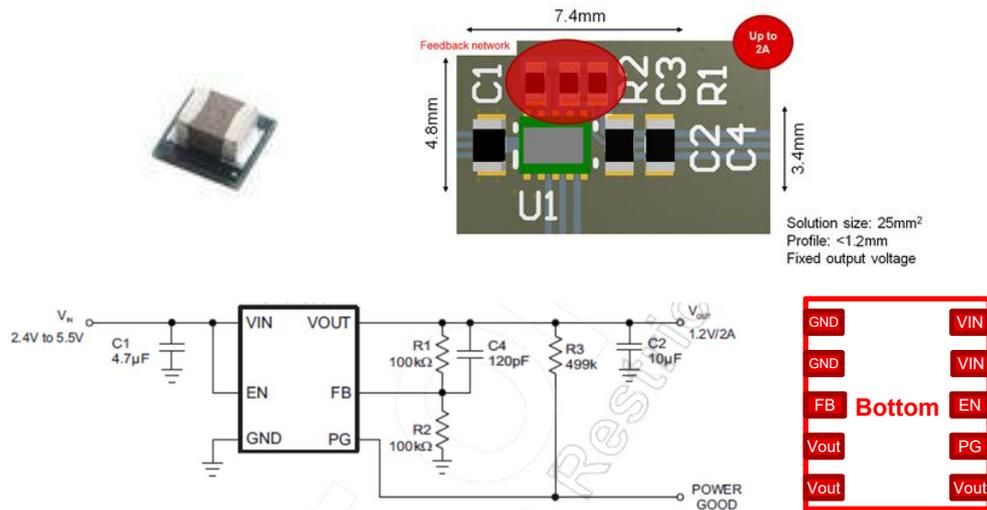
特性

• 2.0 x 2.5 x 1.1mm SIL 封装，内集成电感

- $V_{IN} = 2.4V$ to $5.5V$
- $V_{OUT} = 0.6V$ to V_{IN} (可调)
- $V_{OUT} = 1.2V, 1.8V, 2.5V, 3.3V$ (TPSM82821是固定的输出电压值)
- $4\mu A$ 静态电流
- 高达95% 的效率
- DCS-Control™ 拓扑
- 轻载高效节能模式
- $V_{REF} = 0.6V$ 有着 1% 精确度
- 打嗝模式短路保护
- 主动输出放电还有PGOOD
- 内置软起动

优点

- 适用于对体积有要求的设计当中
- 方便使用
- **25mm²** 的尺寸
- DCS-Control 拓扑 在快速的线性响应时，维持了精准的输出电压并且保证了在瞬态响应时，PWM模式和节能模式的无缝切换。



FUNCTION SAFETY

Functional safety content

- I/O模块/电源模块的功能安全等
 - [参考设计TIDA-010049](#) “适用于 IEC 61508 (SIL-2) 且经 TUV 评估的数字输入参考设计”
 - [参考设计TIDA-00548](#) “适用于安全应用的 4mA-20mA 模拟输入模块参考设计”
 - [TechNote](#) “带有诊断的电压监视器”
 - [TechNote](#) “隔离24 V 电源窗口监视器选项”

工业

从工业 4.0 到机器人和电机驱动器，工业系统正在变得更为智能、安全和高效。设计更安全的工业系统、减少制造停机时间和最大化设备寿命的需求提升了功能安全设计要求，以满足 IEC 61508、ISO 13849、IEC 61800 和 IEC 60730 等标准。找到能够满足您最严苛的工业系统设计难题所需的产品和资源。

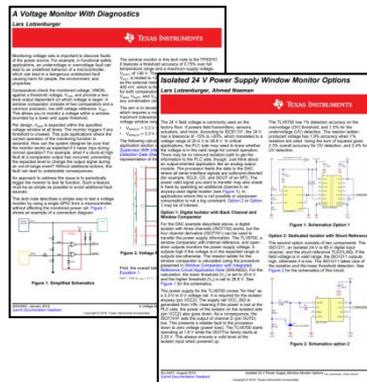


- 模拟输入模块
- 模拟输出模块
- 数字输出模块
- 安全区域扫描仪
- 安全光幕
- 门禁
- 伺服驱动器功能安全模块
- 伺服驱动器功率级模块
- 交流驱动器功率级模块
- DIN 轨电源

- SafeTI™

<http://www.ti.com.cn/zh-cn/technologies/functional-safety/overview.html>

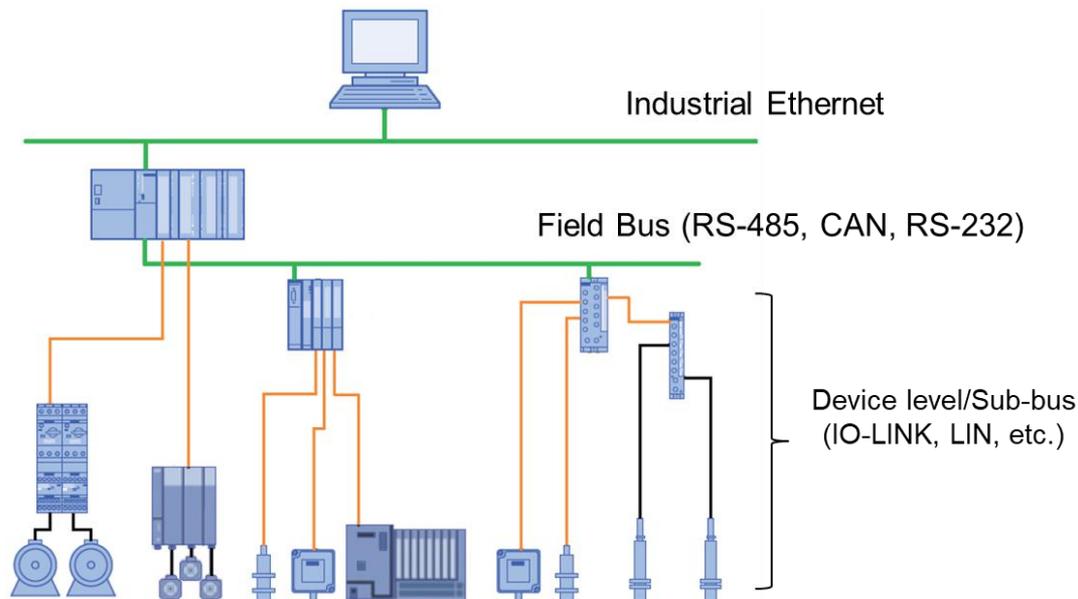
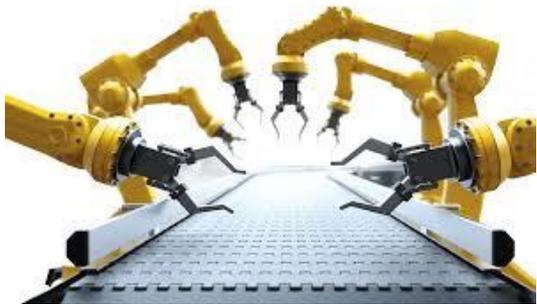
<http://www.ti.com.cn/zh-cn/microcontrollers/hercules-safety-mcus/design-development.html>



COMMUNICATION

Communication hierarchy

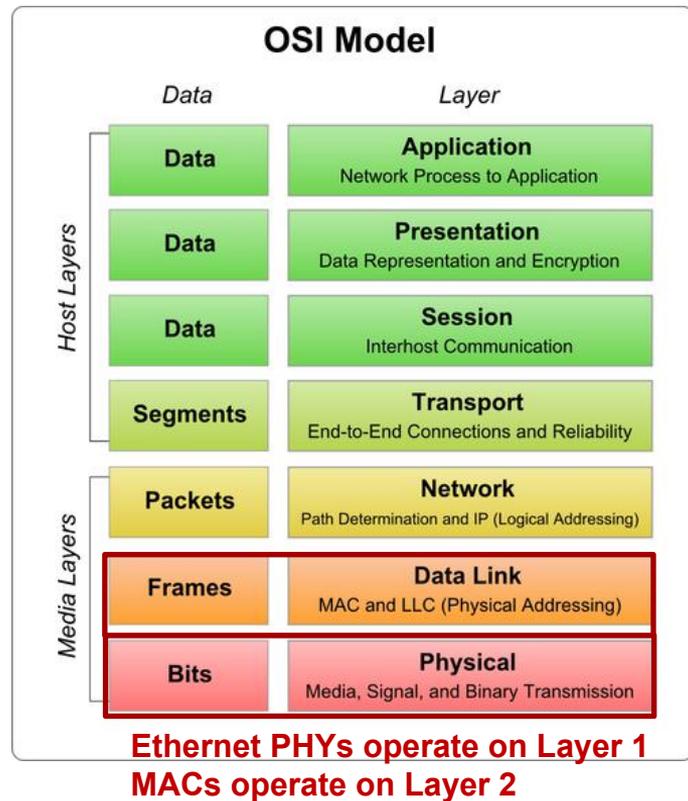
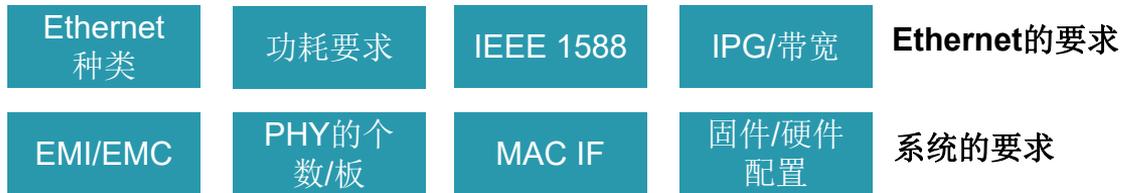
- RS-485 和 CAN 可作为模块，旋变传感器，编码器与扭矩传感器之间的通讯接口
- 工业机器人通讯协议之间，最为常见的有 RS-485 / RS-422 和 Ethernet
- 一些系统也会用 CAN 和 RS-232
- RS-485和Ethernet 用作电机/伺服控制模块之间的通讯接口



Ethernet PHYs

- 100Mbps 全双工
 - 100BASE-TX (或100BASE-FX) 是现场总线中常用的
- 延迟必须被减少
 - 每个总线定义了它自己的节点个数
 - 更多的节点=增加延迟
- 在IRT的应用中，延迟抖动需保持在最小
 - 大多数抖动需要低于100ns，甚至更低，却决于所需的精度
 - 单MII时钟周期为40ns。
- 快速链接丢失反应时间

一般从链接丢失到指示链接丢失的时间不能超过15微秒



EtherCAT从属设备和多协议工业以太网参考设计 TIDA-00299 (TIDEP0032的更新)

方案特点

- EMC兼容, 工业温度双端口的EtherCAT从属设备 具有SPI接口
- 5-V 供电电源, 为整板供电. 包括可选DDR3 内存(不需要 EtherCAT 与堆栈外部)
- AMIC110 被配置从SPI Flash 或SPI host processor 引导
- 主平台如C2000, 通过SPI 从属接口(16MHz), SPI 主机 或McASP 串行接口(48MHz) 来运行EtherCAT 从属堆栈
- 当EtherCAT从属堆栈运行额外的主平台时, 不需要额外的RAM
- TI LaunchPad 兼容 带3.3V TTL逻辑的BoosterPack 格式

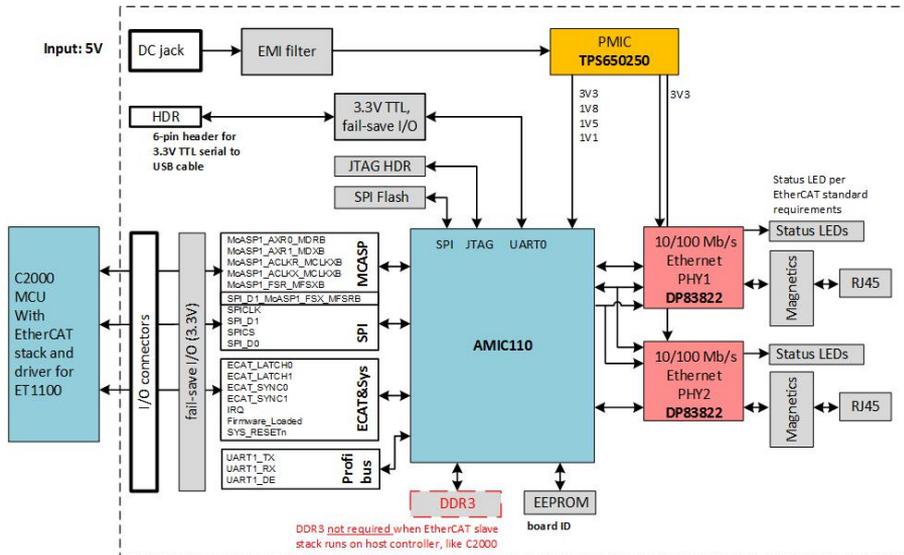
Ti.com中的资源



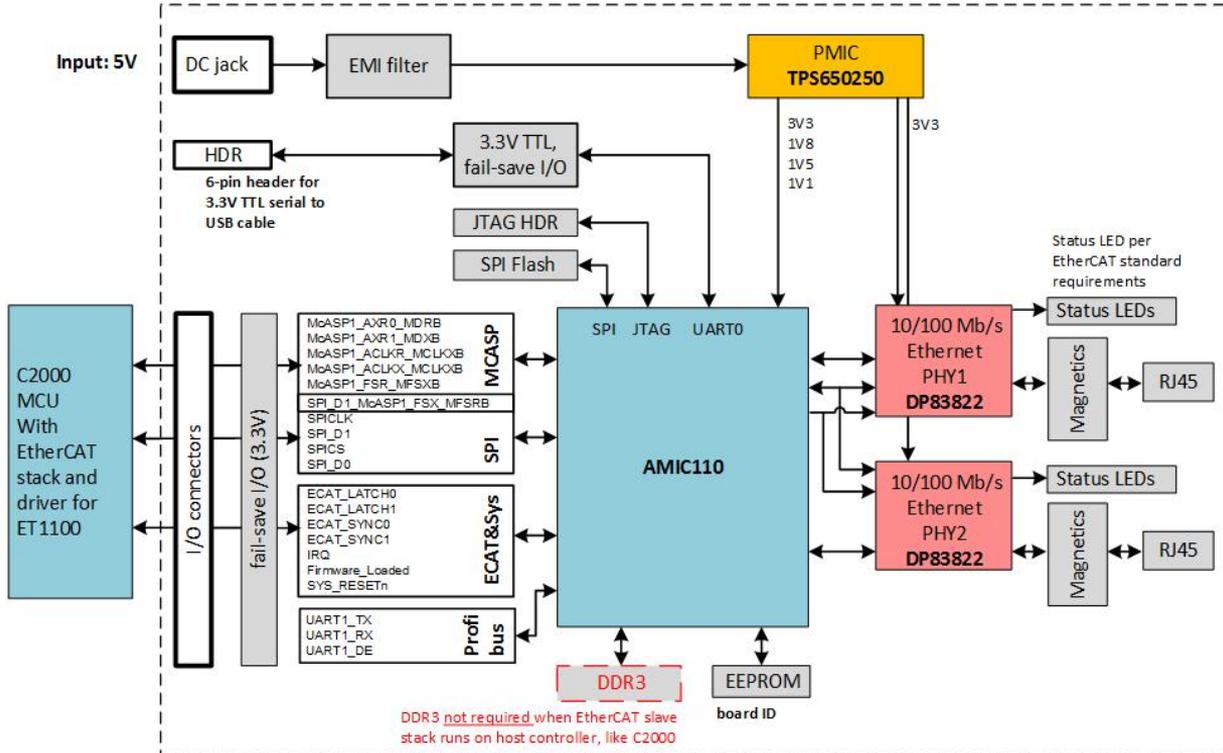
- [TIDA-00299 and Tools Folder](#)
- [Design Guide](#)
- 设计文件: 原理图, BOM, Gerbers, 等等.
- 芯片数据手册
 - [DP83822H](#),
 - [AMIC110](#),
 - [TPS650250](#)

Benefits

- 成本优化的双端口EtherCAT 从属设备 (PROFIBUS 和 多协议RT Ethernet可供选择)
- TPS650250 PMIC 给所有电源轨进行供电
- DP83822, 低延迟, 耐用的10/100 PHY, EtherCAT 测试和认证
- 设计符合IEC61000-4-2, 4-4, 4-5 电磁兼容抗扰性要求



EtherCAT从属设备和多协议工业以太网参考设计 框图



DP83822

- 在100Mbps时，100%利用率的最低功率<120mW (1.8V), 且主动睡眠模式功率<50mW
- 低延迟允许在精度至关重要的应用中进行实时响应
- DP83822可直接替换TLK105L (P2P兼容)
- 多种MAC接口:MII/RMII/RGMII

AMIC110

45nm

ARM® Cortex A8
300 MHz

32K/32K L1

256K L2 w/ECC

64K RAM

64KB L3 Shared RAM

LPDDR1/ DDR2/ DDR3/ DDR3L

PRU-ICSS

Industrial Communication Subsystem

EtherCAT®, PROFINET®, EtherNET/IP™, PROFIBUS, HSR/PRP, and more

System Services

EDMA
JTAG/ETB
Timers x8
WDT
RTC
12-bit ADC⁽¹⁾

Connectivity and I/Os

USB2 OTG +PHY x2

CAN x2

PWM x3

SPI x2

I2C x3

McASP x2

GPIO

UART x6

GPMC / NAND / NOR (16bit ECC)

MMC / SD / SDIO x3

TI RS-485/422 portfolio overview

Standard Transceivers

Products

- Broad offer of 3.3-V to 5-V Half-duplex and Full-duplex transceivers optimized to meet the needs of cost-sensitive applications with data rates up to 50Mbps

Hero Products

- SN65HVD308xE
- SN65HVD485E
- SN65HVD1x
- SN65HVD3x
- SNx5176/x5176B
- SN65LBC180



ESD/EFT/Surge Protected

Products

- Devices with protection in mind
- Up to +30kV IEC 61000-4-2 Contact Discharge protection
- > +30kV HBM protection

Hero Products

- **THVD14x9** Surge + ESD + EFT
- **THVD15xx** ESD + EFT, 5V VCC
- **THVD14xx** ESD + EFT, 3.3 to 5V VCC
- SN65HVD82
- SN65HVD7x



Bus-Fault Protected

Products

- Rugged devices designed for harsh industrial environments
- High bus standoff voltage up to $\pm 70V$
- Wide common mode voltage

Hero Products

- **THVD24xx** +/-70V Bus-fault & +/-25V common mode voltage + ESD + EFT
- SN65HVD178x
- SN65HVD179x
- SN65HVD2x



Special Features

Products

- Automatic and μP controlled Polarity
- Extended Modes of Operation
- Extended distance/High Output

Hero Products

- **THVD1505** Automatic polarity correction
- SN65HVD2x Receiver Equalization Extends Cable Length
- SN65HVD1794 Cable Invert Function Allows Correction for Reversed Bus Pins
- SN65HVD01 1.65-V to 3.6-V Supply for Data and Enable Signals



RS422 Transceivers

Products

- Transceivers and multi-channel receivers/drivers
- High data-rates, High ESD protection

Hero Products

- AM26LV32E 4*TX + IEC
- SN65C1168E 2*TX+2*RX+IEC
- AM26C31 4*TX
- AM26C32 4*RX



Collateral

Content title	Content type	Link to content or more details
TI 与工业机器人有关的网页界面	网站链接	http://www.ti.com.cn/zh-cn/applications/industrial/robotics.html www.ti.com/automation www.ti.com/motordrive
TI 参考设计	TI 参考设计	接口 TIDA-00012 TIDA-01401 TIDA-00982
使机器人实现新的水平的工厂自动化	白皮书	http://www.ti.com/lit/pdf/slyy115
工业机器人的兴起。在工厂自动化中克服安全人机交互的挑战	博客	http://e2e.ti.com/blogs/b/industrial_strength/archive/2016/11/08/rise-of-the-industrial-robots-overcoming-the-challenges-of-safe-robot-human-interaction-in-factory-automation

Thanks!
Q&A

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