EV/HEV中车载充电机（OBC），DC/DC以及电机驱动（INVERTER）设计优化

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Nov 2017

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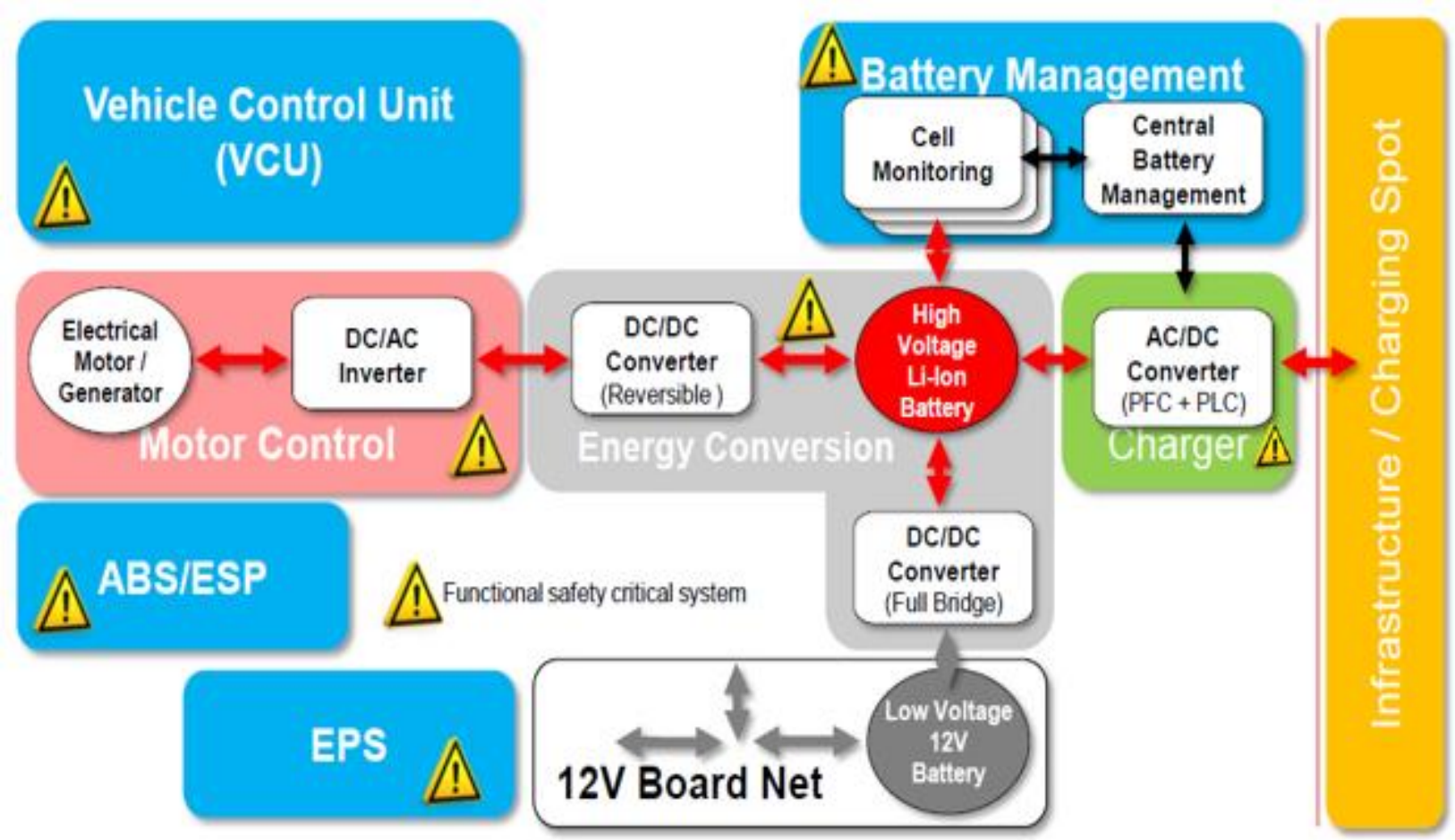
Reach Further™

Automotive EV/HEV Architecture Overview



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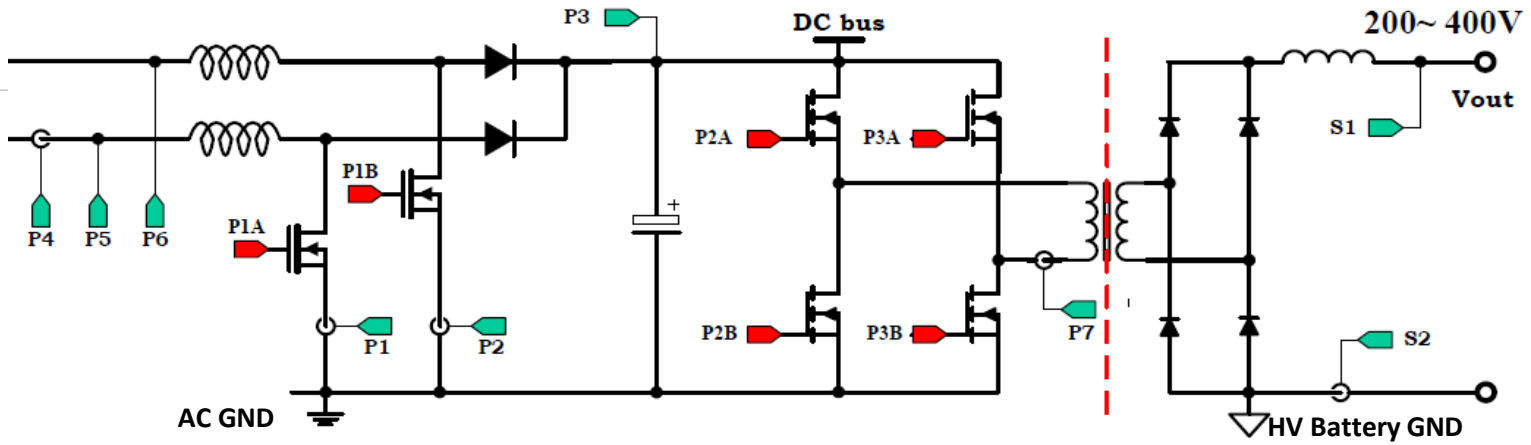
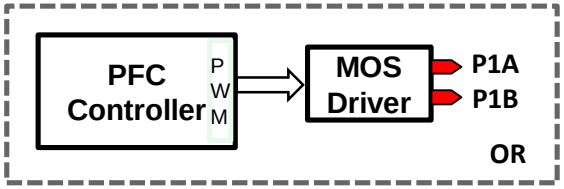
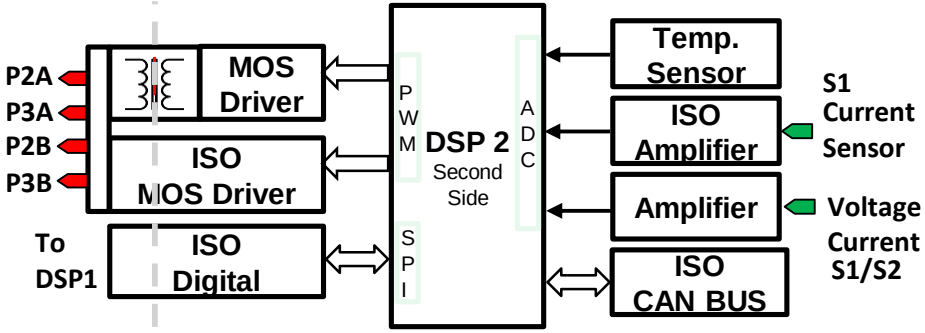
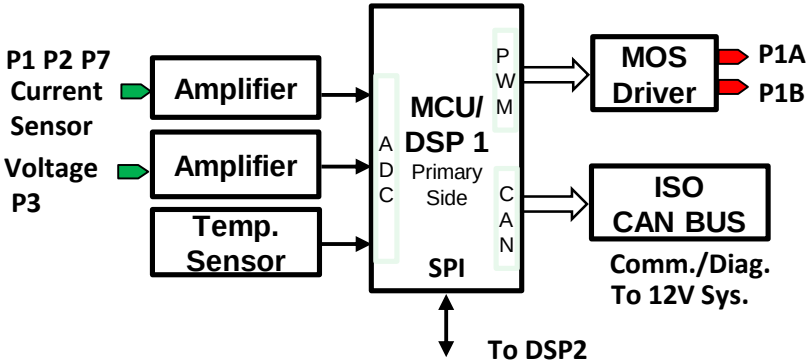
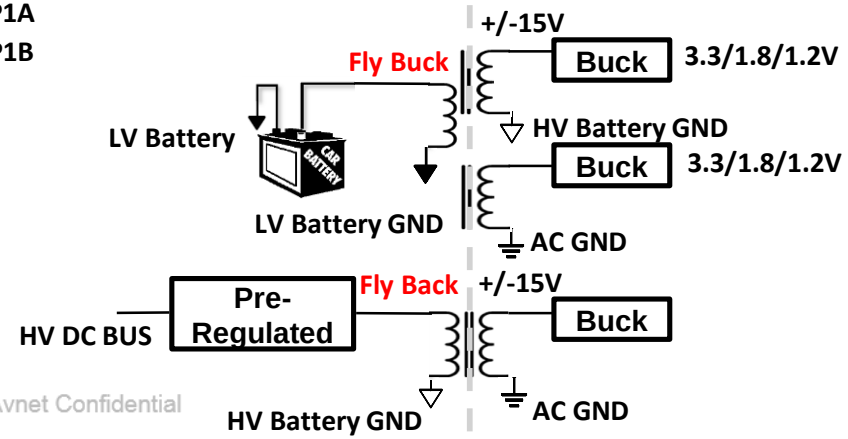
HEV/EV - OBC板载充电机











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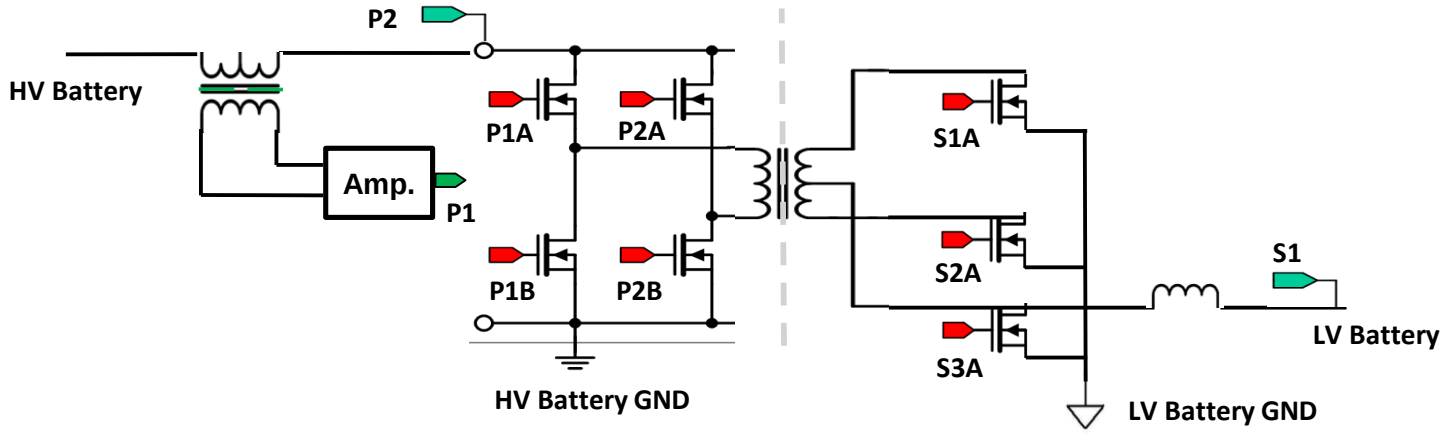
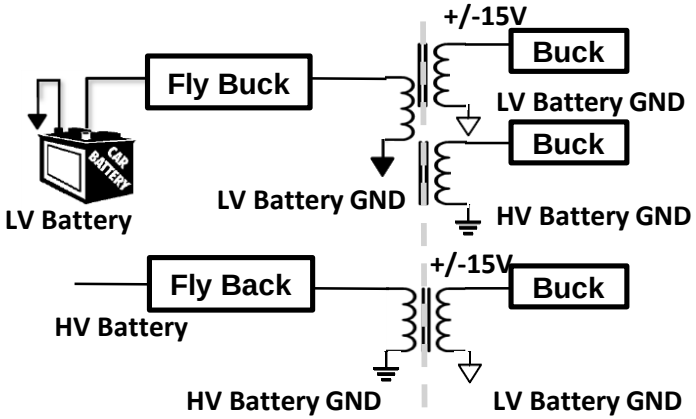
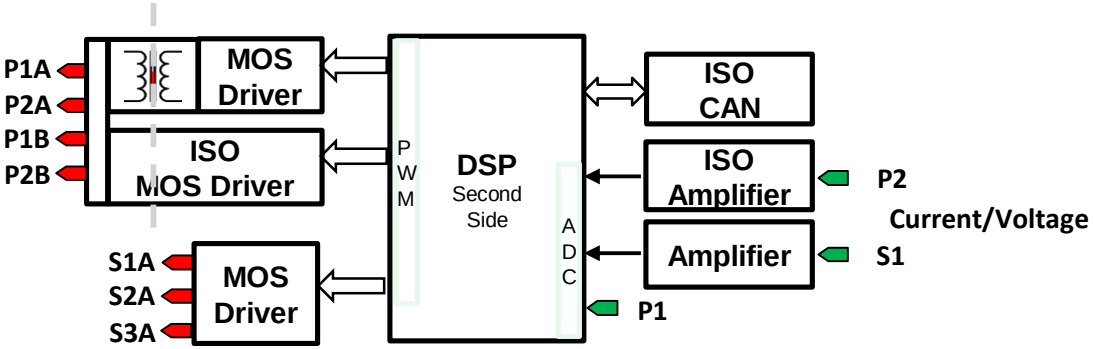
HEV/EV - DC/DC 转换器







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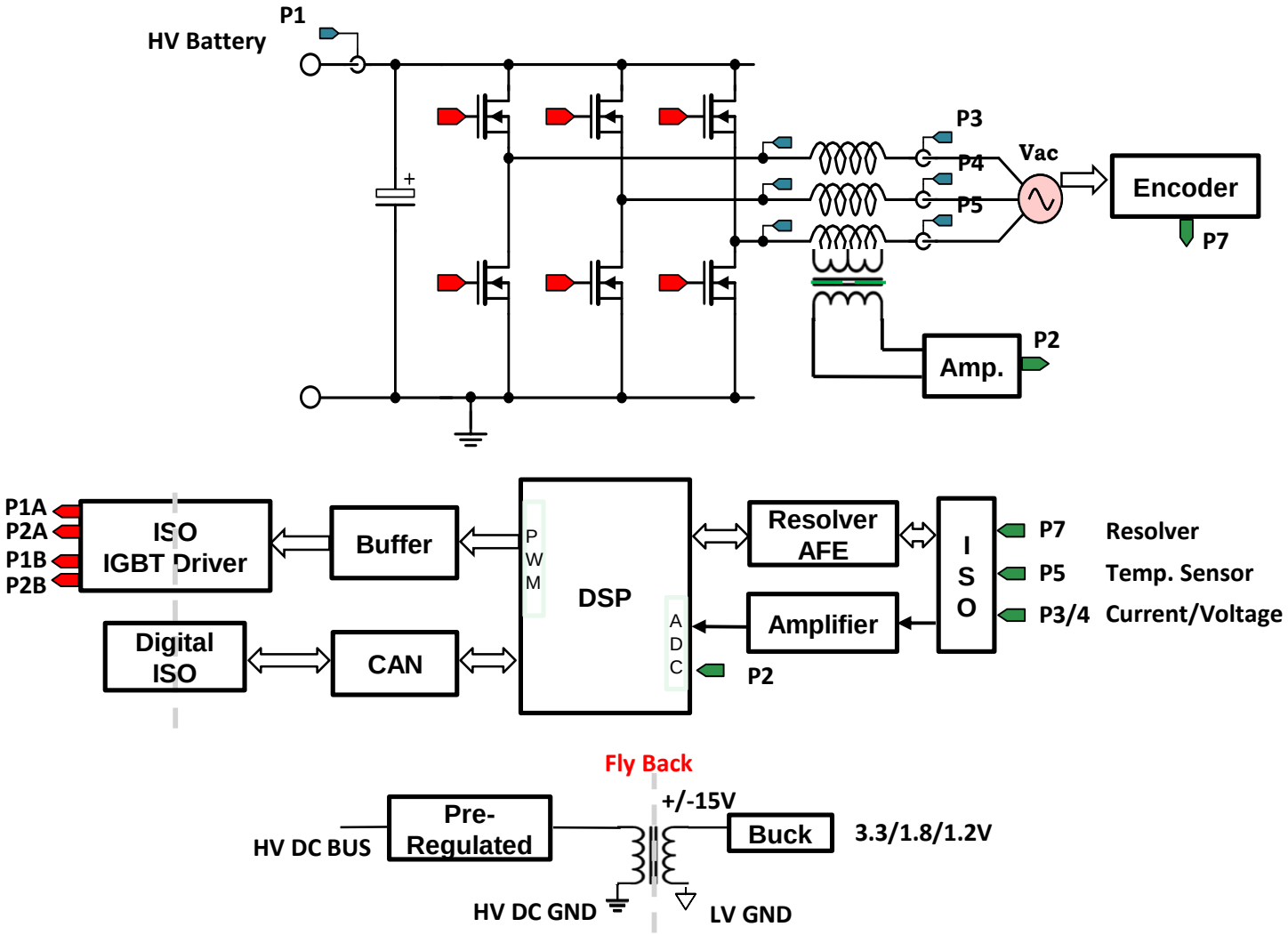
HEV/EV - 逆变器和电机驱动



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HEV/EV 应用主推荐物料

Block description	Part recommendation	Key features
Processor	TMS320F28xx	C2000 family of High-Efficiency 32-Bit CPU
Flyback	UCC287xx	Constant Voltage, Constant Current PWM
	LM34XX	Isolated Power
CAN Transceiver	ISO1050	Isolated Can
	TCAN1042-Q1	Automotive Fault Protected CAN Transceiver With Flexible Data-Rate
Isolators	ISO7xx-Q1	TI's integrated SiO2 isolation barrier technology provides the fastest, highest precision, highest temperature, high EMI immunity, and longest life isolation product solutions
Dual FET Gate Driver Low Side	UCC27524/8-Q1	Dual channel high speed gate drivers
Dual FET Gate Driver Hi-Side/Low Side	UCC21520	4A/6A Dual Iso Driver 5KV RMS I/O, 1.5KV ch-ch 30ns prop delay, 5ns matching SOWB -16
	UCC27714D	600V/4A High-Speed, High/Low-side Gate Driver
Isolated Amplifier	AMC1301-Q1	4.25kV peak Isolated Amplifier for Current Shunt Measurements
Op Amp	OPA365-Q1	Automotive Catalog 2.5V, 200MHz GBW, CMOS Single Op Amp
Current Shunt Monitor	INA21X-Q1	High/Low-Side Measurement, Bi-Directional Zero-Drift, Current Shunt Monitor
Amplifier	LM290X-Q1	Dual Operational Amplifier
Temperature sensor	TMP101-Q1/TMP411-Q1/TMP300-Q1	Local temperature sensor with digital output, remote temperature sensor, temperature switch

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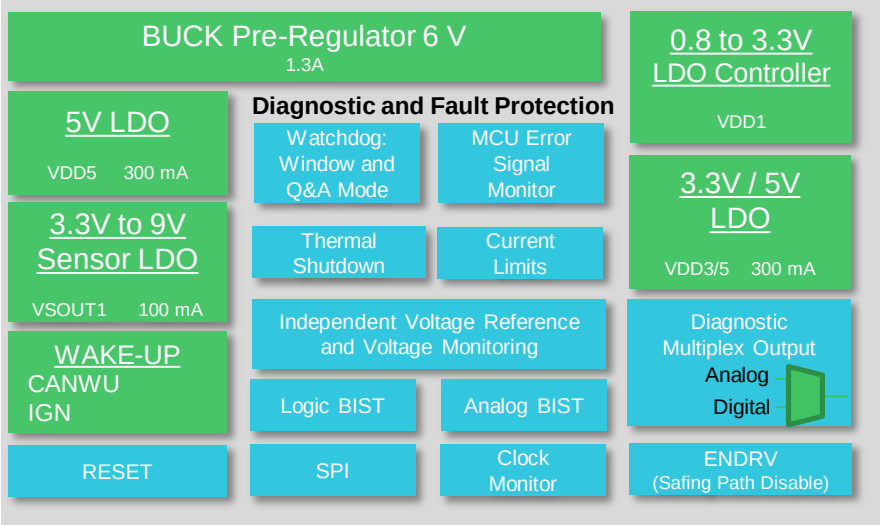
TPS65381A-Q1

PMIC for safety-critical applications powering lock-step MCUs

Features

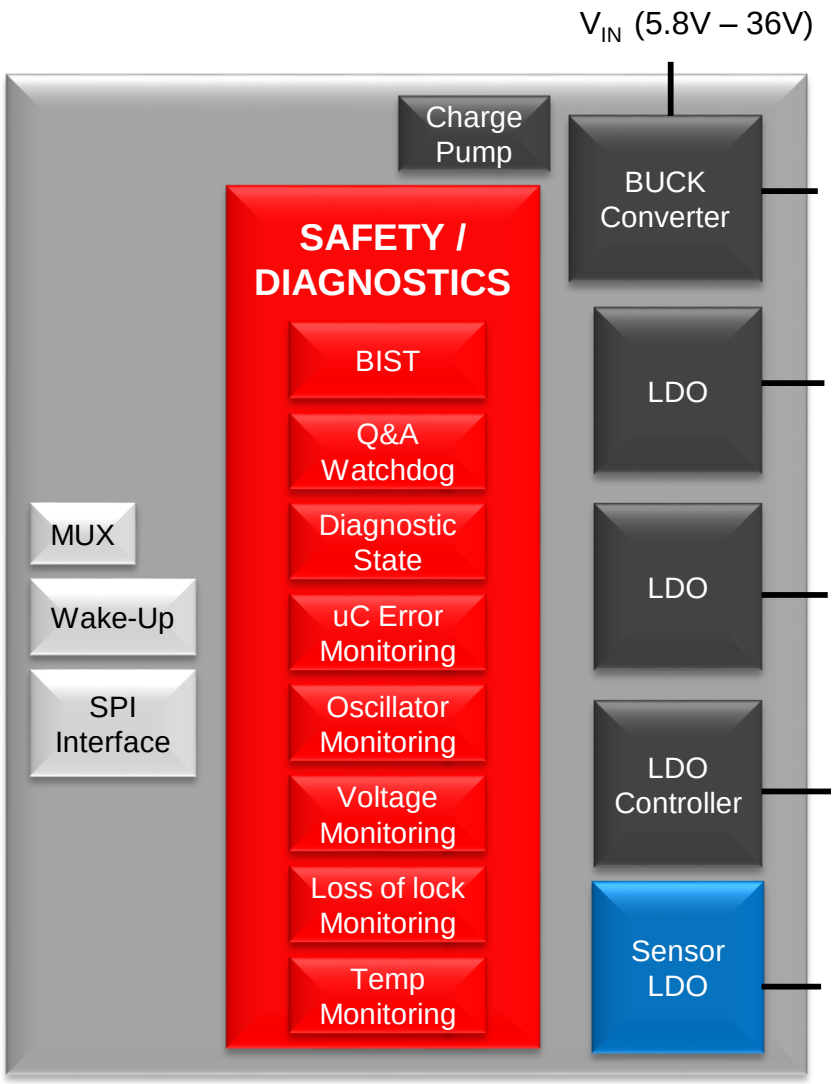
1 HV Asynchr. Buck Conv 440KHz (1.3A)
2 LDO (300mA)
1 Sensor LDO (100mA)
1 LDO controller (external FET)
Window/Q&A Watchdog
Lock-Step MCU Error Signal Monitor
Enhanced Diagnostics, BIST
Supports up to ISO 26262 ASIL-D Systems



Applications

- Safety-critical applications like EV Motor Driver, EPS, Braking, Transmission, Industrial Safety
- Supports a variety of safety architecture MCUs for safety-critical applications
- Supports TI TMS570/Hercules and C2000 Families

TPS65381-Q1 Safety Companion PMIC



Functional safety architecture features

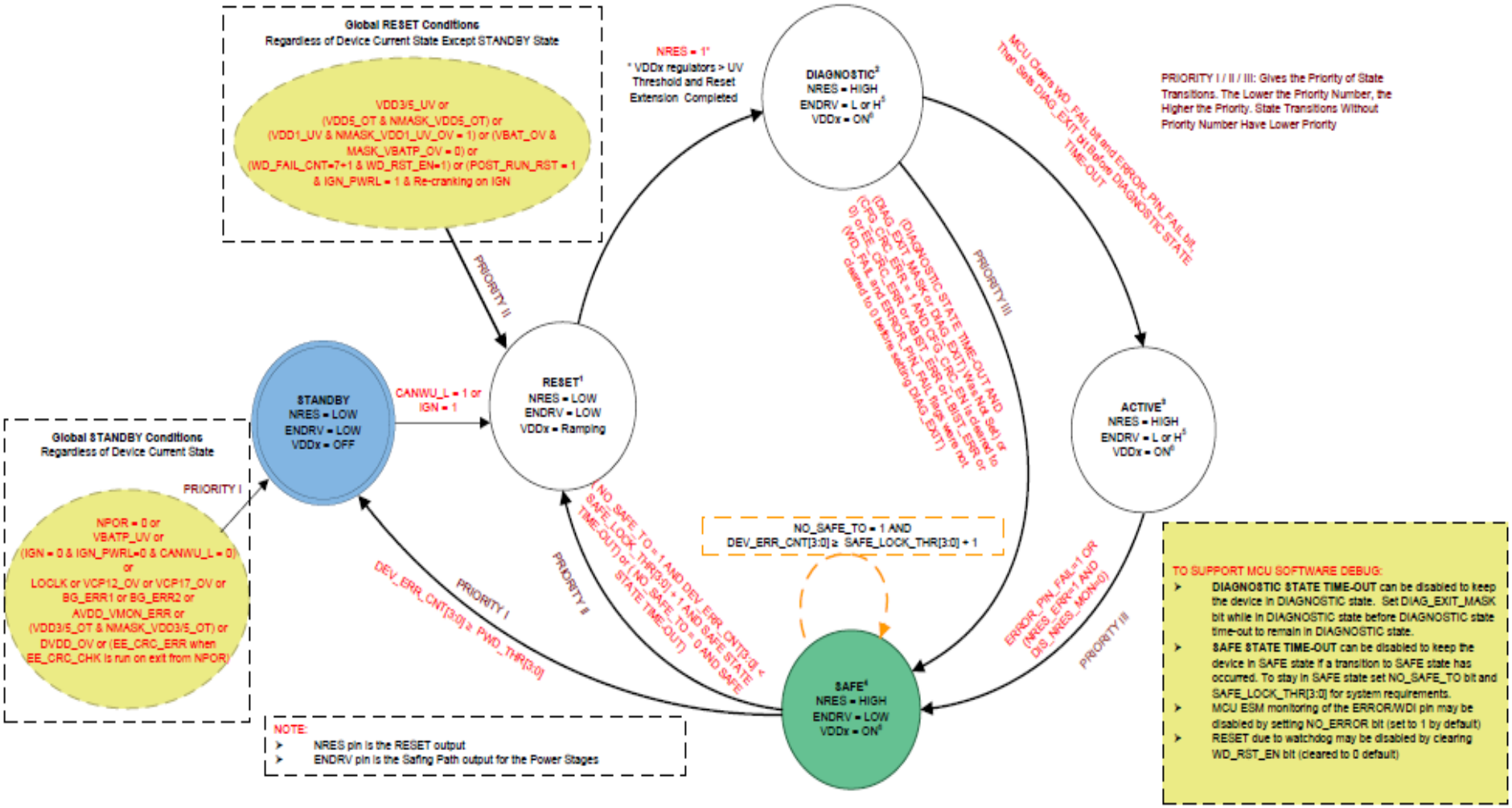
Includes multiple power supply rails in a single device

Additional sensor supply built-in

Diagnostic interfaces

AEC 100 qualified and temperature grades to 125 C°

TPS65381-Q1 Functional safety architecture features



TPS65381A-Q1 Advantages and Support

Advantages:

- Reduce complexity for safety compliance on system level and shorten design time (functional Safety documentation and support)
- Significantly smaller board size
- Lower BOM count and cost
- Less solder points
- Saves glue logic and discrete components
- Easier power system design
- Easy implementation of power supplies for MCUs in Safety critical applications
- Suitable for safety-critical applications (ISO26262, IEC61508), helps to obsolete second safing MCU in application
- High-efficiency, low cost, flexible output power (only one inductor)
- Suitable for sensor connection outside ECU without external protection

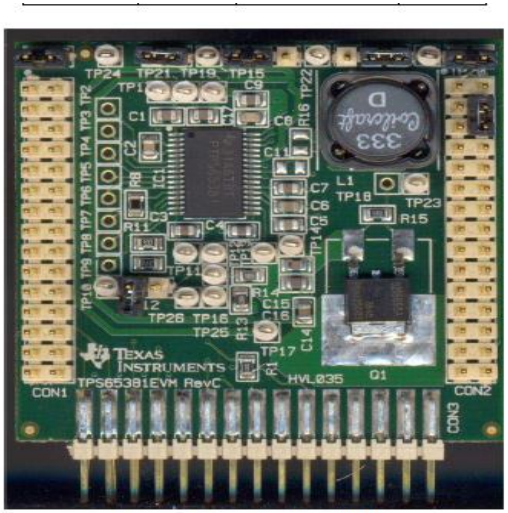


Figure 1. EVM Top Board View

What are Resolver sensors?

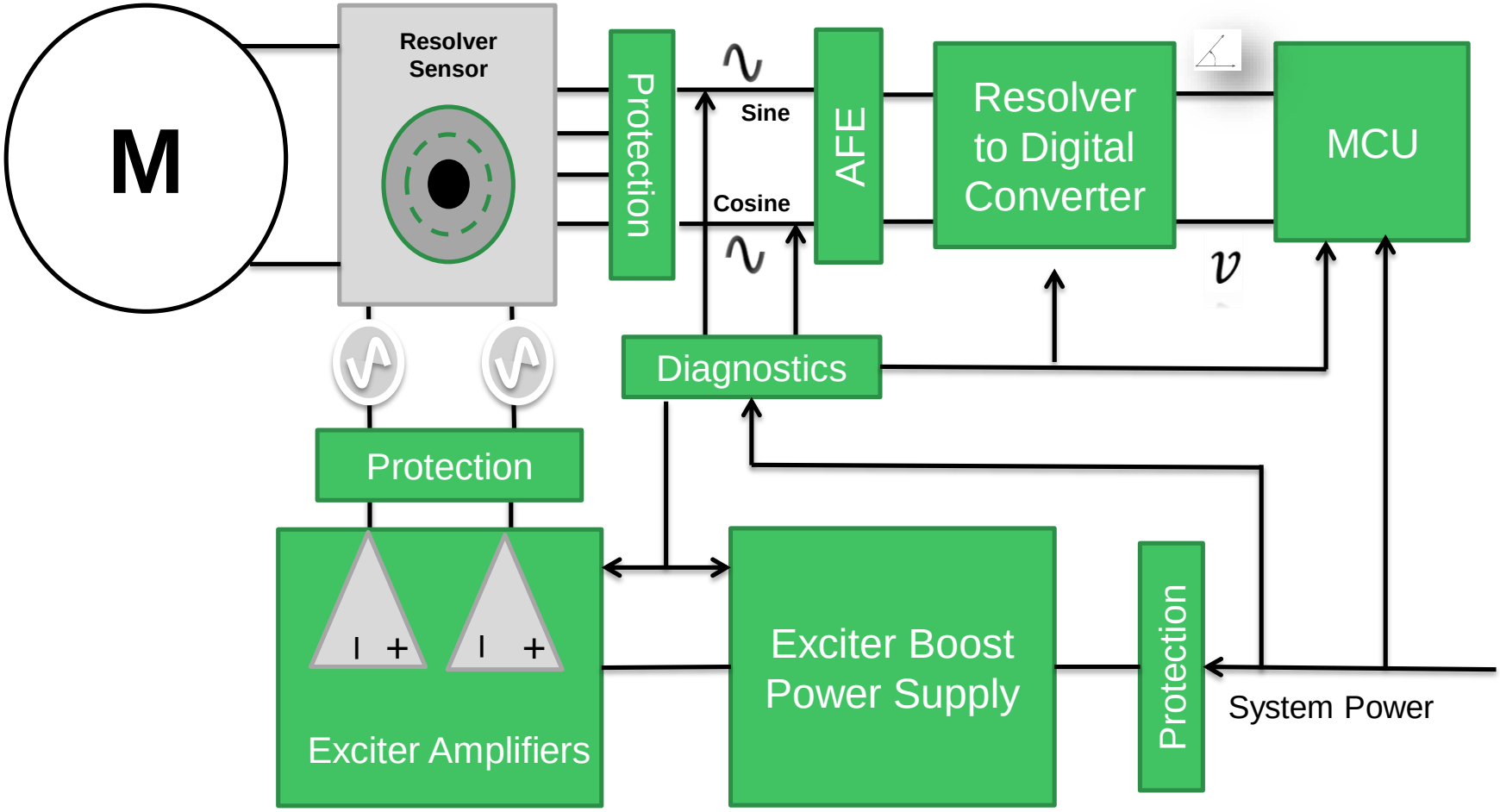
A type of rotatory position sensor that is made up of coil windings which require a powered sine wave to generate a cosine and sine wave

Primary winding in the rotor and two secondary windings in the stator

6 wires are used to connect the stator of the resolver to the motor control board

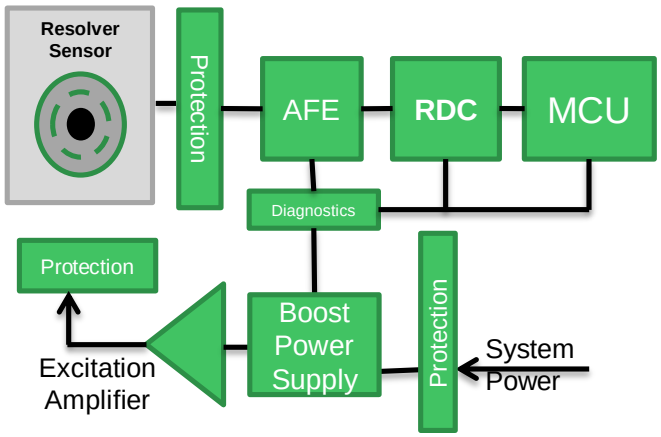
Resolvers perform well in harsh environments due to their lack of electronics inside

Resolver Sensing Solution Based on RDC IC

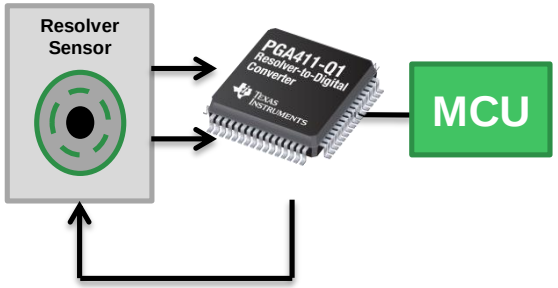


PGA411-Q1: Simplify the system

Improve system stability and accuracy through device architecture



Current Solution



TI Solution

- **Advanced stability is created by positioning the high current and voltage IP blocks away from other parts of the device, like the AFE, which are highly susceptible to damage.**
- **Comparators in the AFE remove the need for an external ADC, improving accuracy by reducing the effects of quantization noise on the input signals from the sensor.**

PGA411-Q1

Resolver-to-Digital Converter w/ Integrated Exciter Amp and Power Supply

Features

- Integrated exciter amplifier (10-20 kHz) with short protection and integrated exciter boost power supply
- Programmable fault detection thresholds and filters and Analog & Logic BIST for functional safety**
- AFE Resolver to Digital Converter
- *Enables systems to meet requirements up to ASIL-D. Documentation available for IS0 26262*

Applications

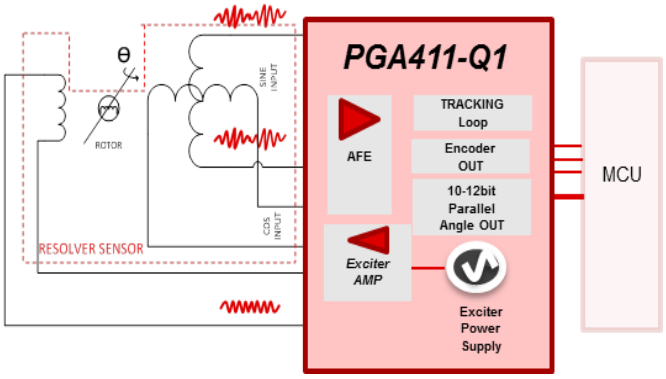
- HEV/EV Inverters
- Start-Stop Alternators
- AC Servo Drive/Motors
- Building Lifts
- HVAC Pump Motor
- Electric Power Steering
- Robotics

Tools & Resources

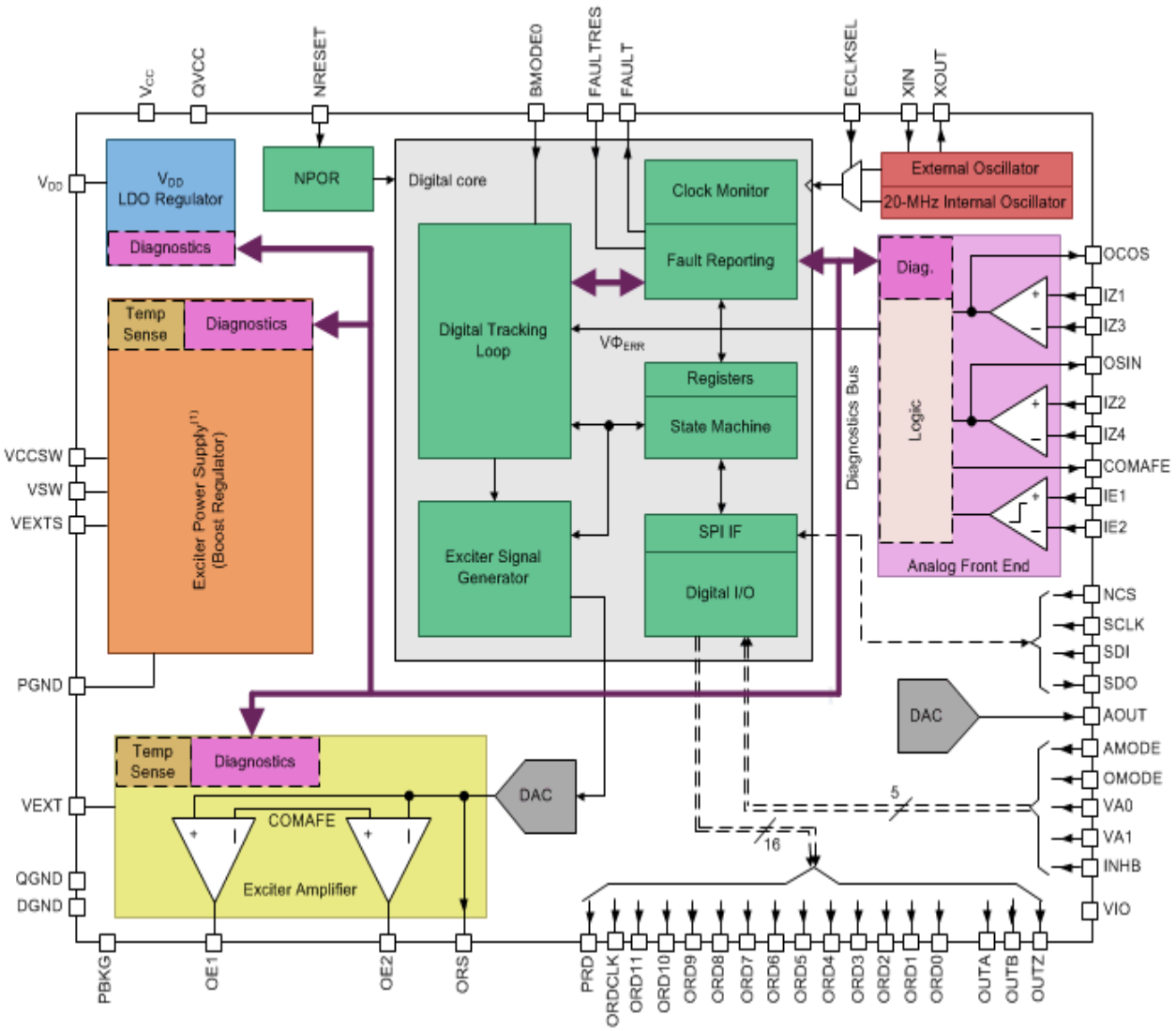
- PGA411-Q1 Datasheet (Chinese version)
- PGA411-Q1 EVM
- TIDA-00796
- TIDA-00363

Benefits

- **10 bit and 12 bit modes:** Enables customers to choose the mode that best fits their applications. 200,000 rpm max in 10 bit mode and 72,000 rpm max in 12 bit mode
- **Enables BOM cost and PCB savings:** Cost savings by integrating an exciter amplifier and boost power supply with protections
- **Functional safety and diagnostics:** Provides extensive diagnostic coverage for functional safety; enables customer to meet ISO 26262 standards
- **Analog and Logic BIST for functional safety**: Built-in-Self-Test for functional safety enables better latent fault coverage
- **Better system accuracy and stability:** AFE comparator architecture eliminates the effects of quantization noise



PGA411-Q1 Block Diagram



PGA411-Q1 Block Diagram 升压电源部分

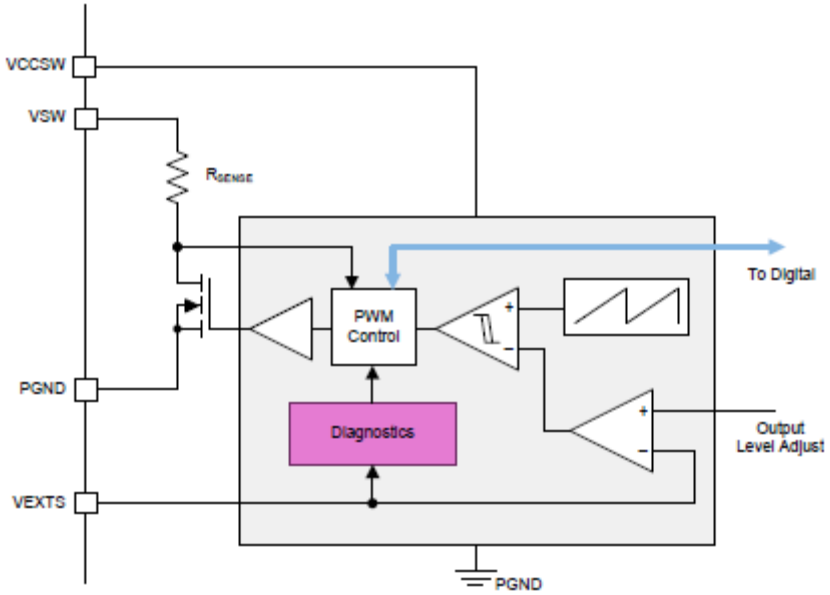


图 11. 激励电源框图

PGA411-Q1 Block Diagram激励信号生产电路

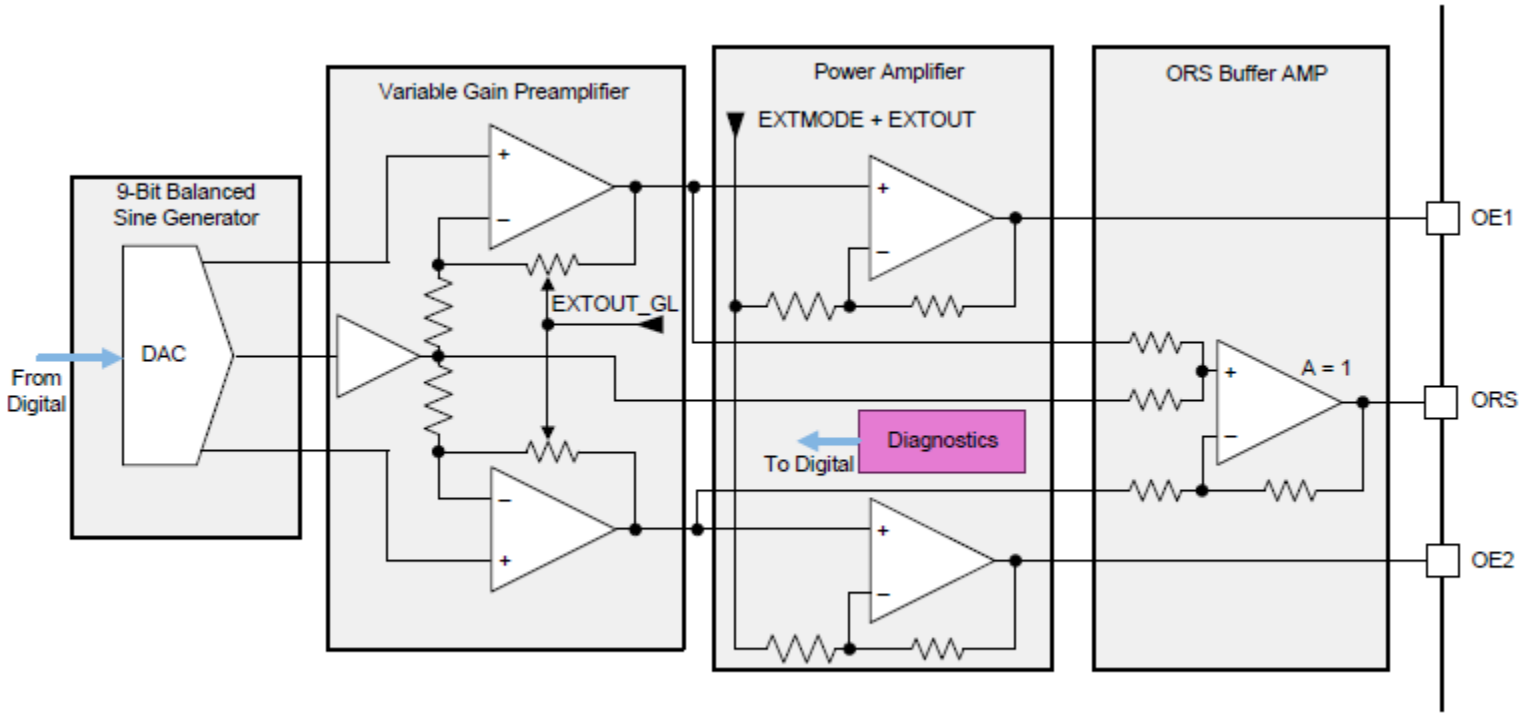
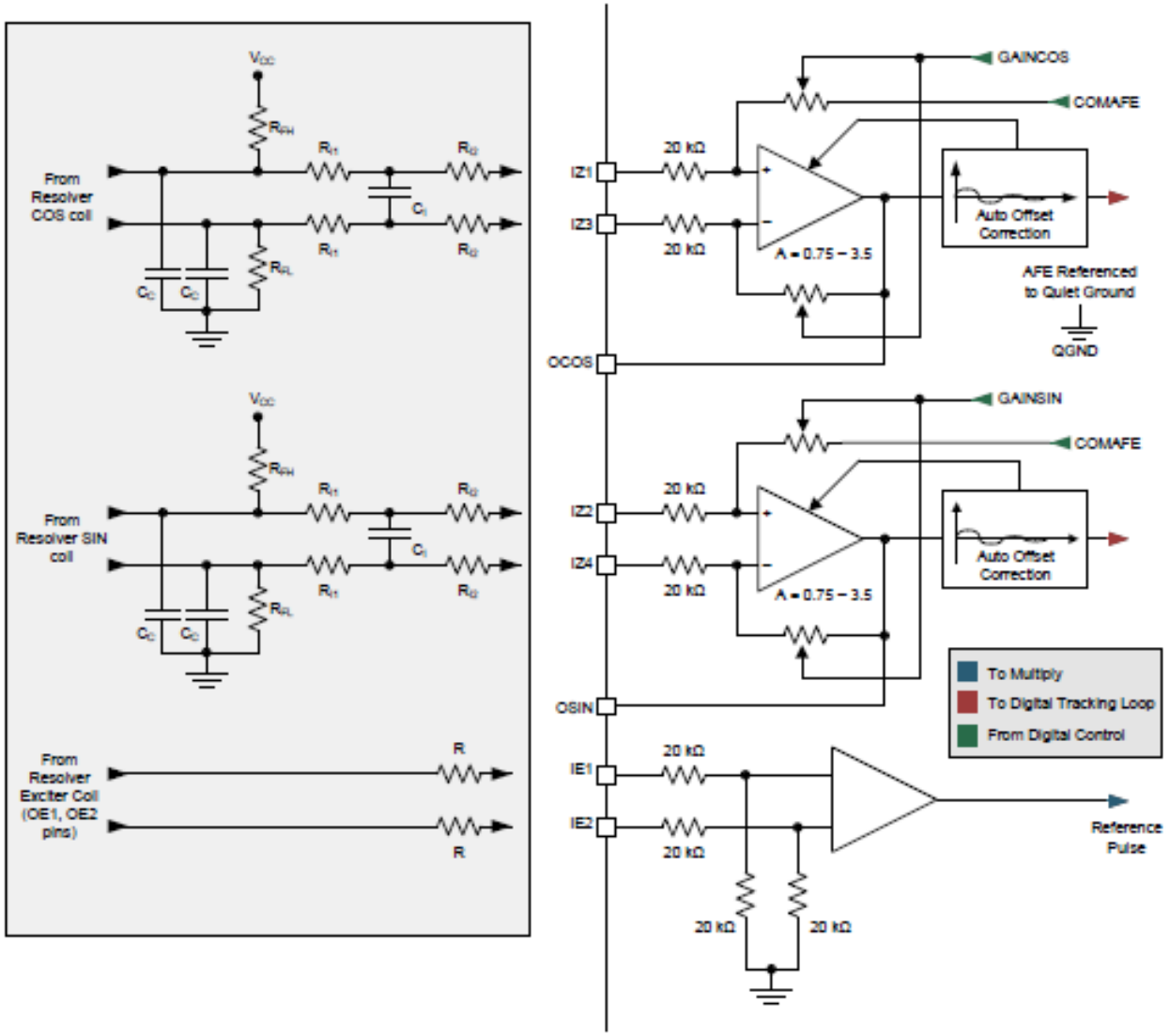
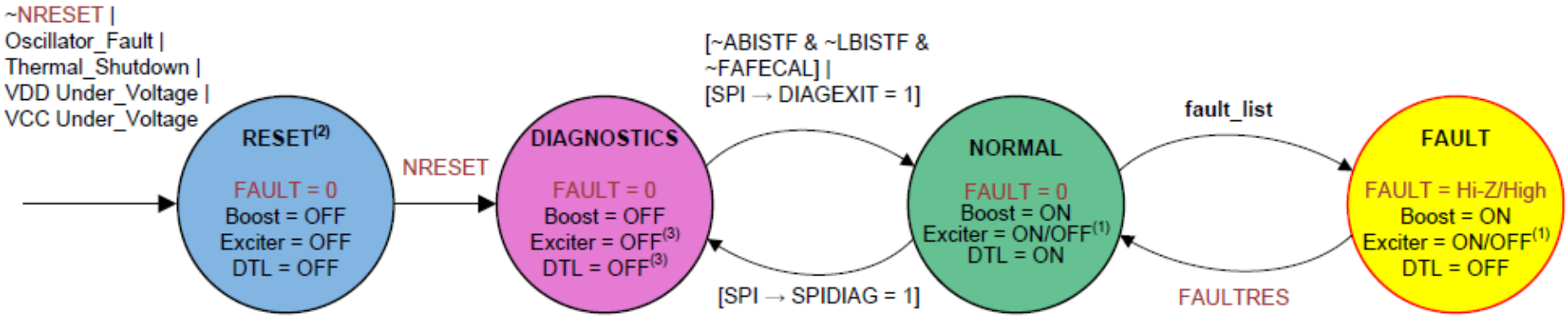


图 12. 激励信号生成电路

PGA411-Q1 Block Diagram具模拟前端



PGA411-Q1 Block Diagram诊断和保护



Symbol Legend:

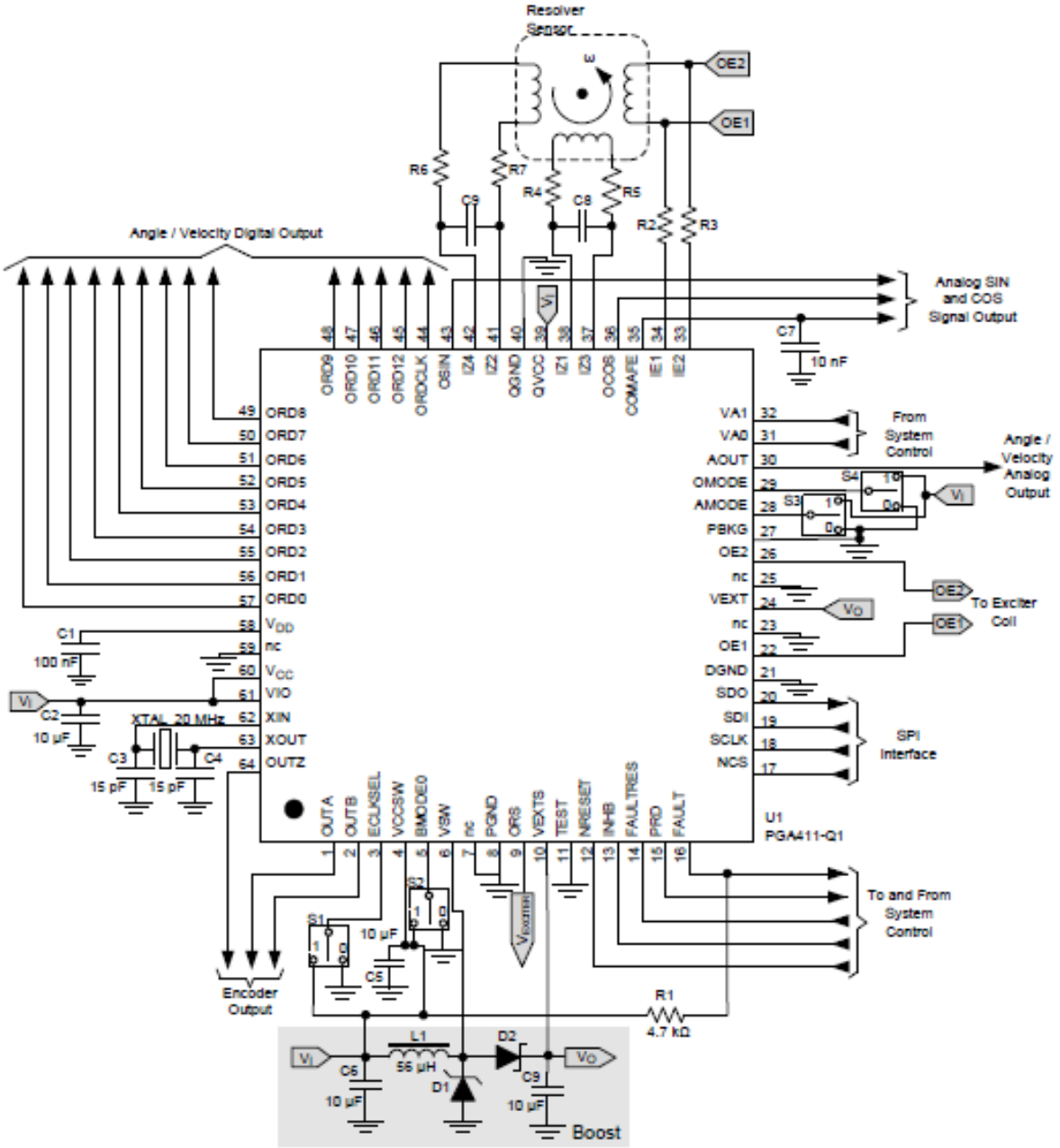
~	Logical NOT		Internal Signal
&	Logical AND		Device Pin
|	Logical OR		
→	SPI Value change		

- **Boost** refers to the Exciter Power Supply (Boost Regulator).
- **Exciter** refers to the Exciter Signal Power Amplifier.
- **DTL** refers to the integrated Digital Tracking Loop.

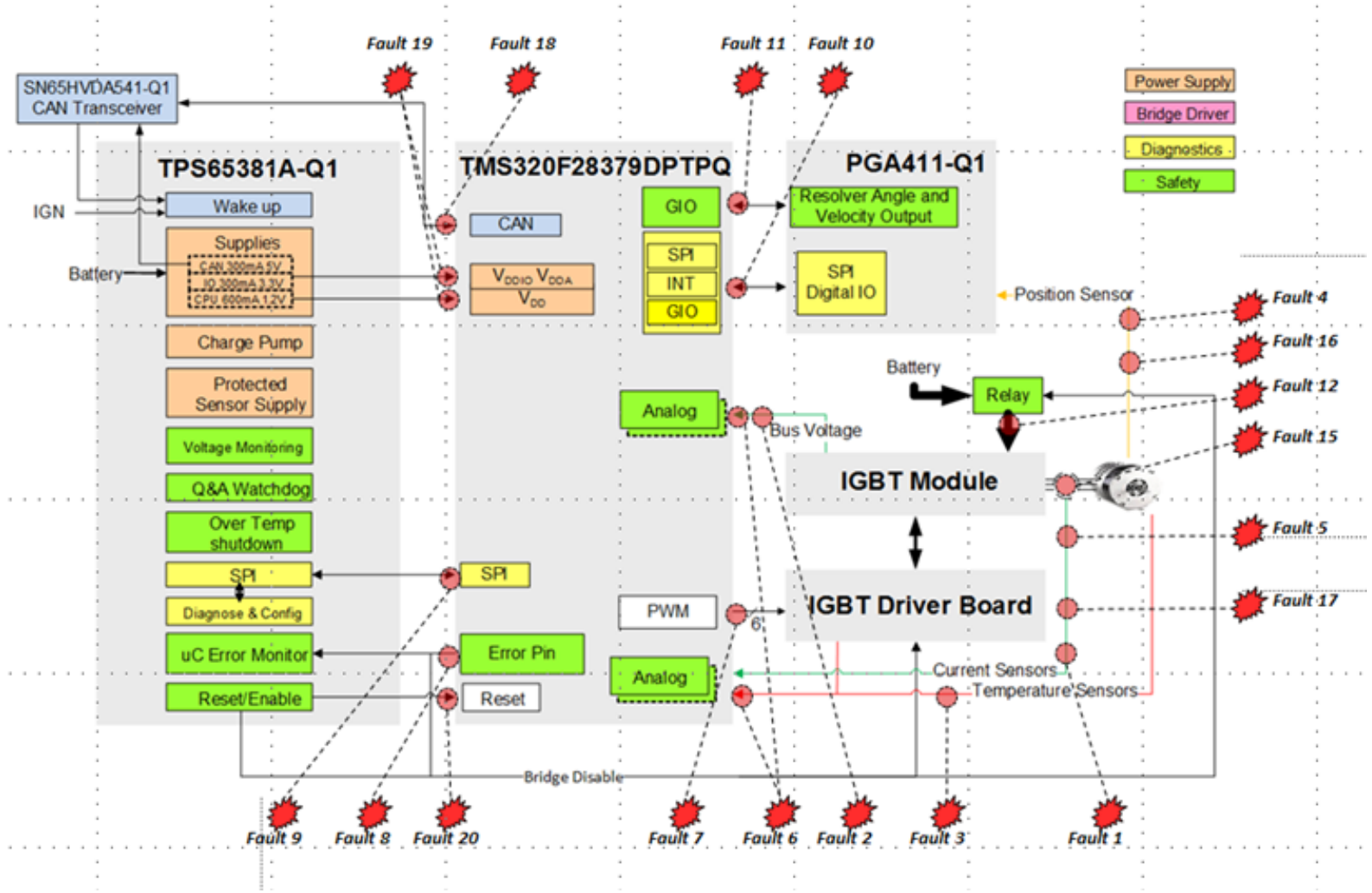
fault_list:

[EXTMODE = 00 | EXTMODE = 11] |	FBSTOV |
[EXTOV & ~MEXTOV] |	FVCCOV |
[EXTUV & ~MEXTUV] |	FVDDOV |
[(FEXTMONH | FEXTMONL) & ~MEXTMON] |	FVDDOC |
[FIZHx & ~MIZOVx] |	FTSD2 |
[FIZLx & ~MIZUVx] |	FGOPEN |
[FOSHORT & ~MFOSHORT] |	FRCRC |
[FOSINOPH & ~MFOSINOPH] |	FCECRC |
[FOCOSOPH & ~MFOCOSOPH] |	FTECRC |
[FOSINOPL & ~MFOSINOPL] |	SPI_ERR |
[FOCOSOPL & ~MFOCOSOPL] |	ABISTF |
[FLOOPE & ~ MFLOOPE] |	LBISTF

PGA411-Q1 Block Diagram典型应用原理图



Application Example:TPS65381A+F28379+PGA411



TI PGA4xx Family: Save Development Time

Reduce a complex stage of the industrial drives development cycle

Scalability across development platforms and resolver sensor flexibility

Reduces software development for RDC conversion

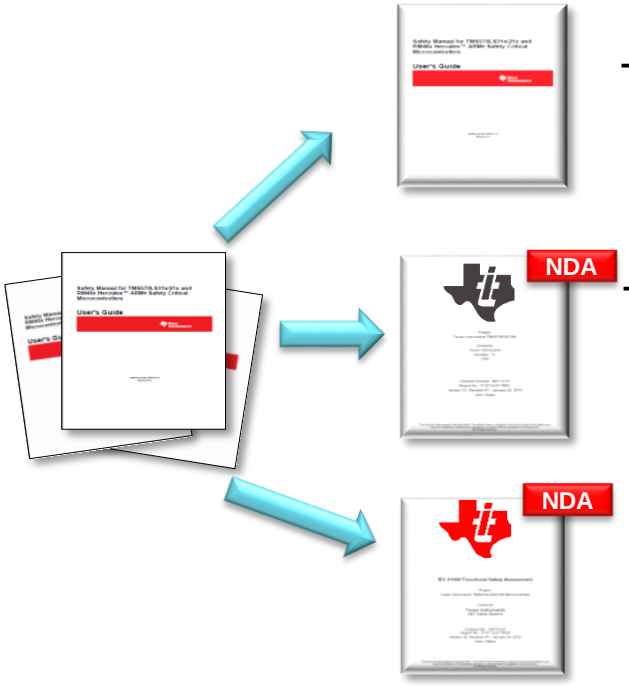
Reduces discrete analog design because of high integration

PGA411-Q1: Solve functional safety challenges

Facilitate design to help meet functional safety standards up to ASIL D (ISO 26262)

On-board functional safety and diagnostic capabilities:

- Analog and logic built-in self-tests (BIST)
- Enhanced latent fault coverage
- On-board diagnostic and protection features



– Device Safety Manual

Details product safety architecture and recommended usage

– Safety Analysis Report*

Summary of FIT rate and FMEDA at DEVICE level for ISO 26262

– Safety Case Report*

Summary of compliance to ISO 26262

*Safety reports available to customers who sample the PGA411-Q1

PGA411Q1EVM

PGA411-Q1 Evaluation Module

EVM Features

- User-friendly GUI Interface
- Connectors for 1 resolver sensor
- Fast access to various signals to help with prototype design on AFE

Benefits

- Easy-to-use GUI interface with various features such as:
  - GUI offers demo mode for customer visits
  - Ability to plot angle and velocity
  - Clickable SBD with quick drop-down options when configuring parameter settings
- Multiple test points for quick and easy analysis
- Regional demo available in EU, AM, and China for field and customer demonstrations

Application Notes/Collateral

- PGA411-Q1 Evaluation Module Quick Start Guide (also in Chinese)
- PGA411-Q1 EVM User's Guide
- PGA411-Q1 EVM GUI Software
- Software Developer Guide for PGA411-Q1
- PGA411-Q1 Step-by-step Initialization with Any Host System
- Troubleshooting Guide for PGA411-Q1

TIDA-00796

Automotive Resolver Front End

Design Features

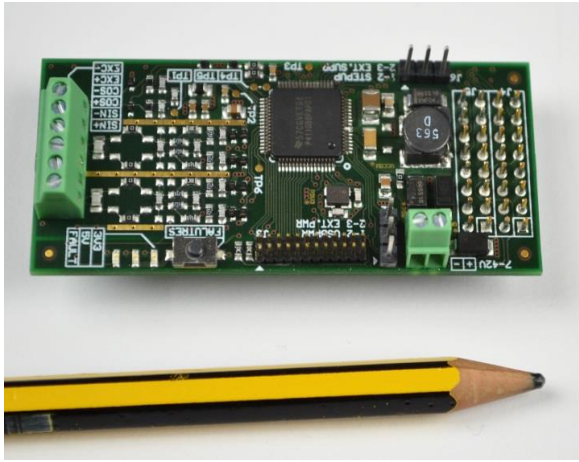
- PGA411-Q1 Automotive Resolver Front End with SPI and Optional Parallel Interface for Automotive Safety Applications
- 4 Vrms or 7 Vrms, 10 - 20 kHz Excitation Signal
- Integrated Step-up Converter for the Exciter Amplifier
- Wide Single Supply Operation … 5 V or 7 V to 42 V
- Reverse Polarity and Transient Protection
- Programmable Fault Detection Thresholds and Filters
- Plug-and-Play Compatibility with F28069 ™ controlSTICK
- Interfacing with F28069 ™ controlSTICK and F28069M LaunchPAD Development Kits
- Compact 30 x 70 mm Four Layer PCB
- AEC-Q100 Components

Tools & Resources

- **TIDA-00796 Tools Folder**
- **Test Data / Design Guide**
- **C2000™ controlSTICK or F28069M LaunchPAD**
- **Design Files:** Schematics, BOM, Design Files, Source Code, Binary Files

Design Benefits

- Easy to Use All-In-One Solution with In-built Diagnostics and Fault Detection
- Smaller and More Flexible PCB Footprint than its Discrete Counterpart
- Reduced Analog Signal Toolchain Simplifies Host System Interfacing
- Reduces Host MCU Execution Time
- Easy Firmware Implementation



TIDA-00363

EMC Compliant Single-Chip Resolver-to-Digital Converter (RDC) Reference Design

Design Features

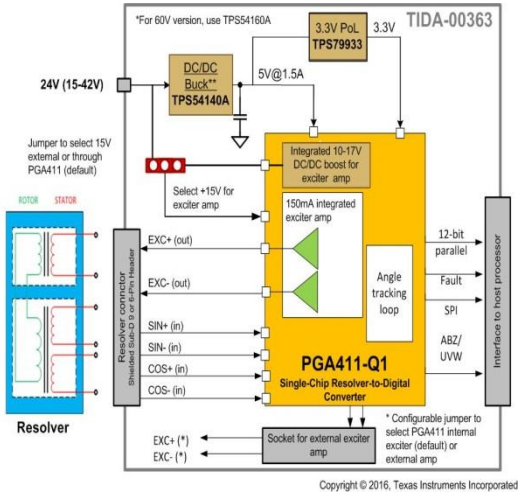
- Single-Chip Resolver-to-Digital Converter (RDC) with typical accuracy better than ±0.2 degree
- Exceeds IEC61800-3 EMC Immunity
  - ±8-kV ESD CD per IEC 61000-4-2
  - ±4-kV EFT per IEC 61000-4-4
  - ±2-kV Surge per IEC 61000-4-5
- Integrated Exciter amplifier with 150mA Output Current and Programmable (10-17V) Boost power supply enables 60% PCB size reduction
- 24V input with wide input voltage range (12-42V/60V) and reverse polarity protection
- SPI Interface (8MHz, 3.3V I/O), Parallel and ABZ/UVW Output Interface
- Option to Use External 15-V Exciter Supply and/or External Exciter Amplifier
- Example Firmware with C2000 MCU to read angle at 16kHz sample rate

Tools & Resources

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

Design Benefits

- PGA411 Eliminates Need for External P/S and Exciter Amp and Reduce BOM and PCB, ~60% Size Reduction
- Fault Diagnostic Coverage : Eliminates Need of External Monitoring, Supervisor, and Protection.
- Easy to Connect to Host Processor
- Exceeds IEC61800-3 EMC immunity (ESD,EFT, Surge) requirements



Thank you