

Voltage References & Supervisors (VRS) New Product Update Broadcast

[TI.com/VREF](https://www.ti.com/VREF)

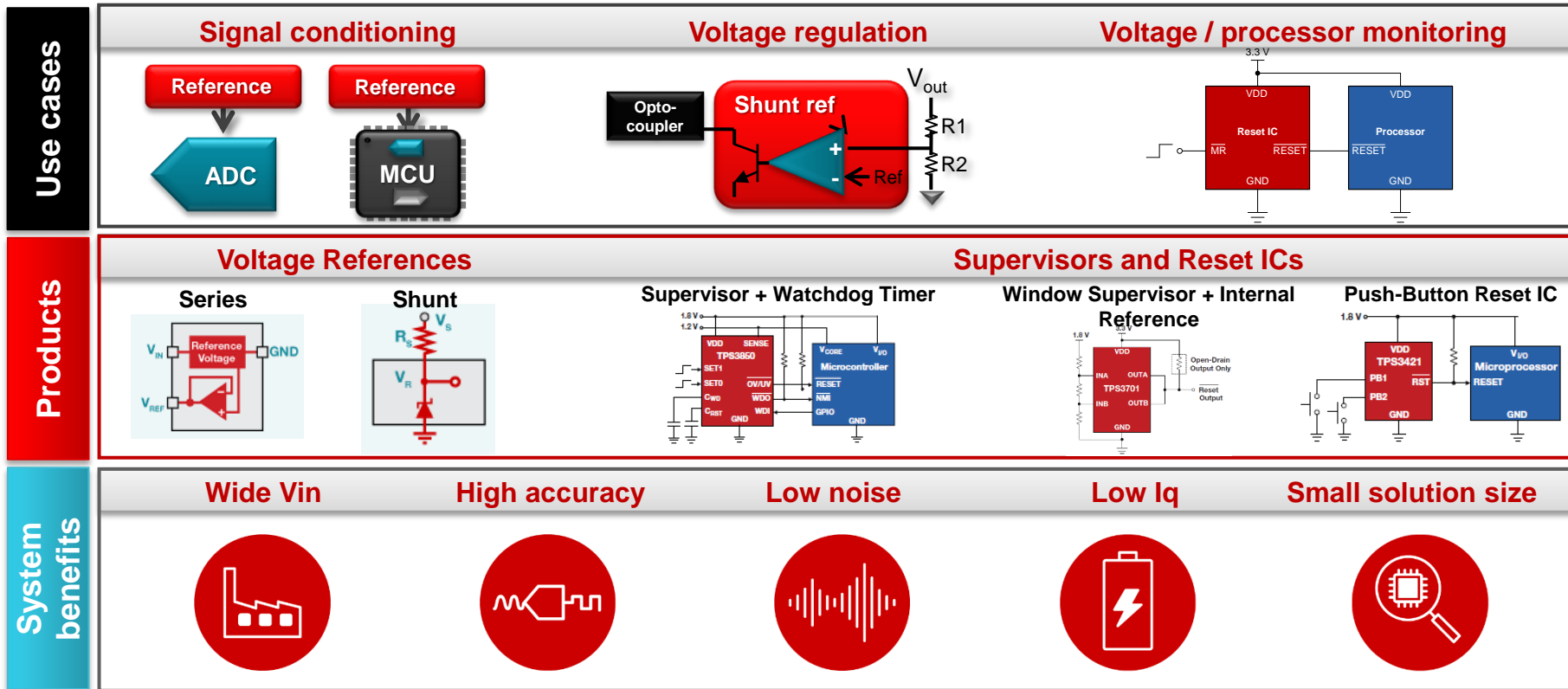
[TI.com/SVS](https://www.ti.com/SVS)

February 2019

Agenda

- Overview
- Voltage references
 - Use-cases and portfolio
 - *New series and shunt voltage references for higher accuracy and lower power*
- Supervisors
 - Use-cases and portfolio
 - *New standalone watchdog timers and upcoming low power supervisors*
- Technical resources

Voltage references & supervisors



Electricity meter

Select a subsystem for:

AC/DC Power Supply

- Line A, Line B, Line C, Neutral
- PWM Controller / Converter
- eFuse/ Load Switch
- Optocoupler
- Shunt Reference

Energy Storage

- Power Switch
- Battery Management

DC/DC Power Supply

- DC/DC
- Voltage Monitoring
- LDO
- Boost
- Protection

Metrology

- Line A/B/C, Neutral
- Current Sensor
- Protection
- Amp
- ADC
- VREF
- MCU/AFE
- SVS/WDT
- ISOLATION
- Clock
- Clock Buffer
- Isolated DC/DC
- ADC
- Amp
- Temp Sensor
- LDO

Anti-Tamper

- Case Open
- Inductive Switch
- Hall Sensor
- And Gate
- State Retention

Wired Communications

- PLC Modem
- Amp
- eFuse/ Current Limiter
- Isolation
- LDO
- RS-232/RS-485
- USB/Switch
- Wired MCU
- Protection

Applications

- Segment Display
- Protection
- Disconnect Switch
- LCD Controller
- Relay Driver
- MCU
- Crystal
- SVS/WDT
- Capacitive Touch
- EEPROM /FRAM
- RTC


Wireless Communications

- MCU
- Transceiver
- PA/LNA
- Antenna(s)
- Protection
- Amp
- RFID
- Level Translator
- Cellular Module
- Optical
- Amp

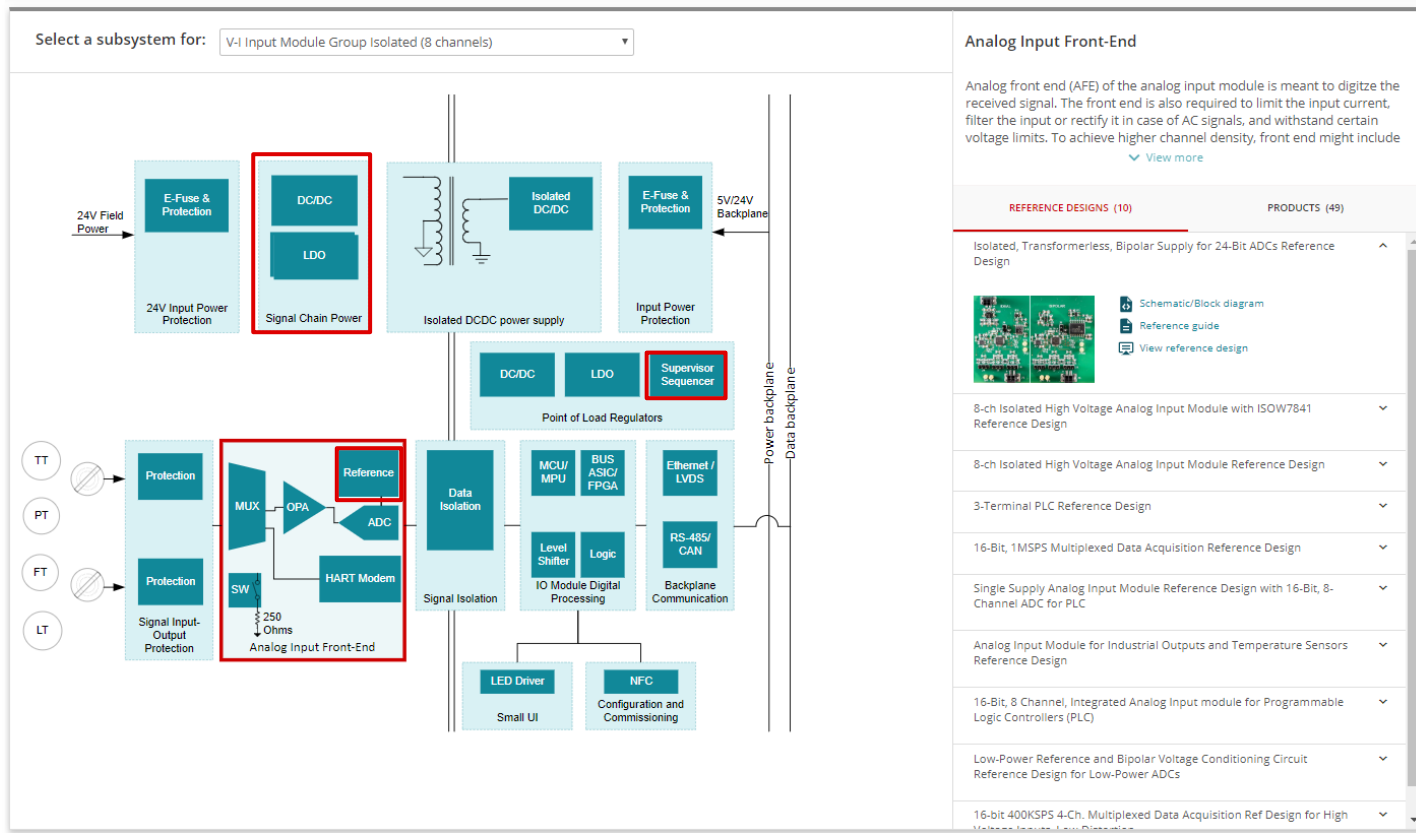
Applications

Smart meters use embedded processors to calculate energy usage based upon current and voltage sampling. Most processors are also used to run meter applications, drive the user display, and execute communications protocols among many other applications.

[View more](#)

REFERENCE DESIGNS (4)	PRODUCTS (38)
Nano power, wide VIN (12 V max) supervisor reference design used as comparator or power sequencer	 <ul style="list-style-type: none">Schematic/Block diagramReference guideView reference design
Magnetically Immune Transformerless Power for Isolated Shunt Current Measurement Reference Design	
Multi-Phase Power Quality Measurement with Isolated Shunt Sensors Reference Design	
Reference Design for Segment LCD Control Using GPIO Pins to Increase System Flexibility	

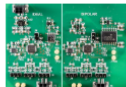
PLC Analog Input Module



Analog Input Front-End

Analog front end (AFE) of the analog input module is meant to digitize the received signal. The front end is also required to limit the input current, filter the input or rectify it in case of AC signals, and withstand certain voltage limits. To achieve higher channel density, front end might include

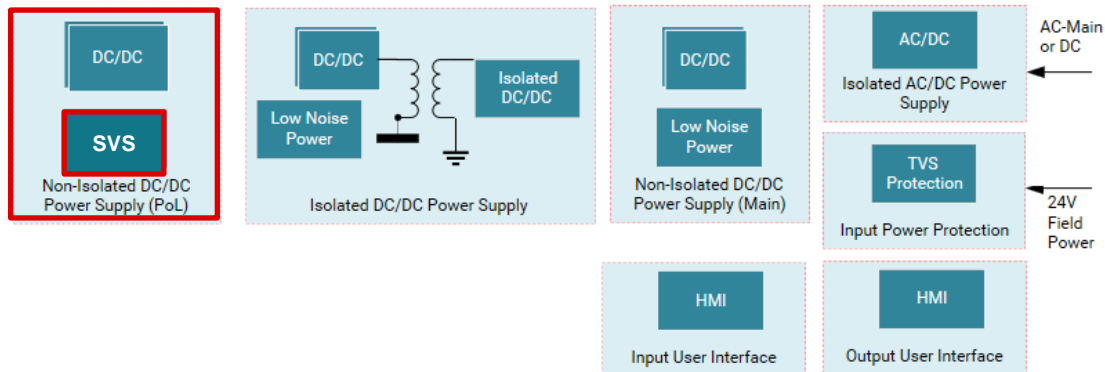
[View more](#)

- | REFERENCE DESIGNS (10) | PRODUCTS (49) |
|--|---------------|
| <p>Isolated, Transformerless, Bipolar Supply for 24-Bit ADCs Reference Design</p>  <p>Schematic/Block diagram
Reference guide
View reference design</p> | |
| 8-ch Isolated High Voltage Analog Input Module with ISOW7841 Reference Design | |
| 8-ch Isolated High Voltage Analog Input Module Reference Design | |
| 3-Terminal PLC Reference Design | |
| 16-Bit, 1MSPS Multiplexed Data Acquisition Reference Design | |
| Single Supply Analog Input Module Reference Design with 16-Bit, 8-Channel ADC for PLC | |
| Analog Input Module for Industrial Outputs and Temperature Sensors Reference Design | |
| 16-Bit, 8 Channel, Integrated Analog Input module for Programmable Logic Controllers (PLC) | |
| Low-Power Reference and Bipolar Voltage Conditioning Circuit Reference Design for Low-Power ADCs | |
| 16-bit 400KSPS 4-Ch, Multiplexed Data Acquisition Ref Design for High Voltage Inputs, Low Distortion | |

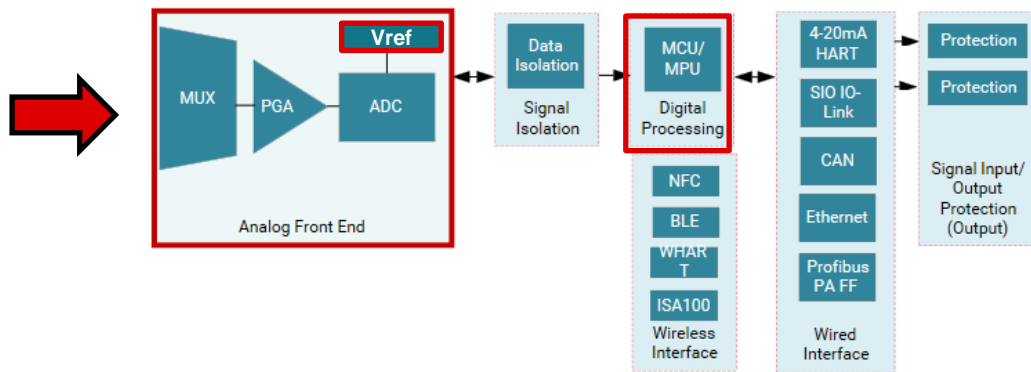
Field Transmitters

Application Needs

- Low-power <math><100\mu\text{A}</math>
- Low-noise <math><8\mu\text{Vpp/V}</math>
- Thermal hysteresis
- Long term stability



Pressure
Flow
Temperature
Level
Displacement



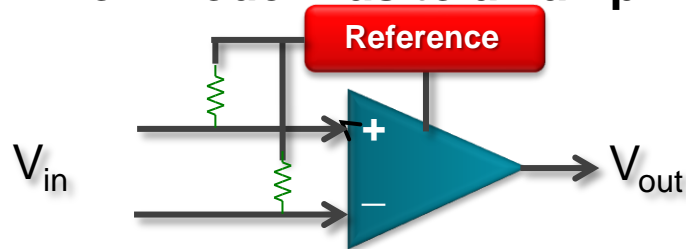
Voltage references

Voltage reference example use cases

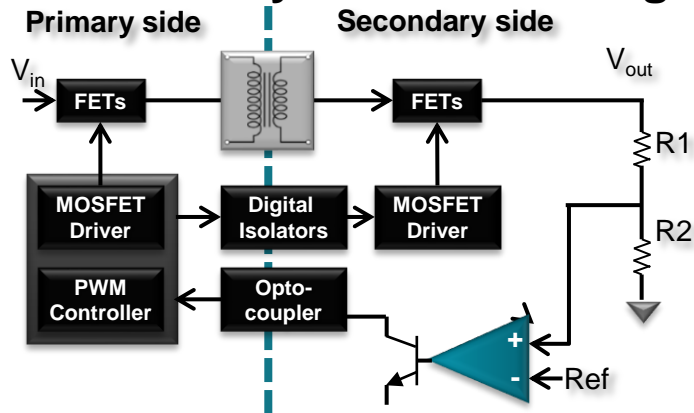
Precision reference for data converter



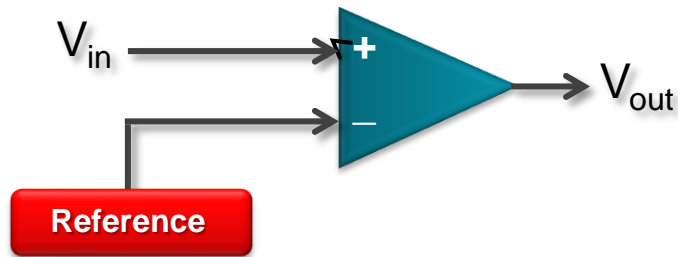
Common Mode Bias to an amplifier



Secondary side monitoring

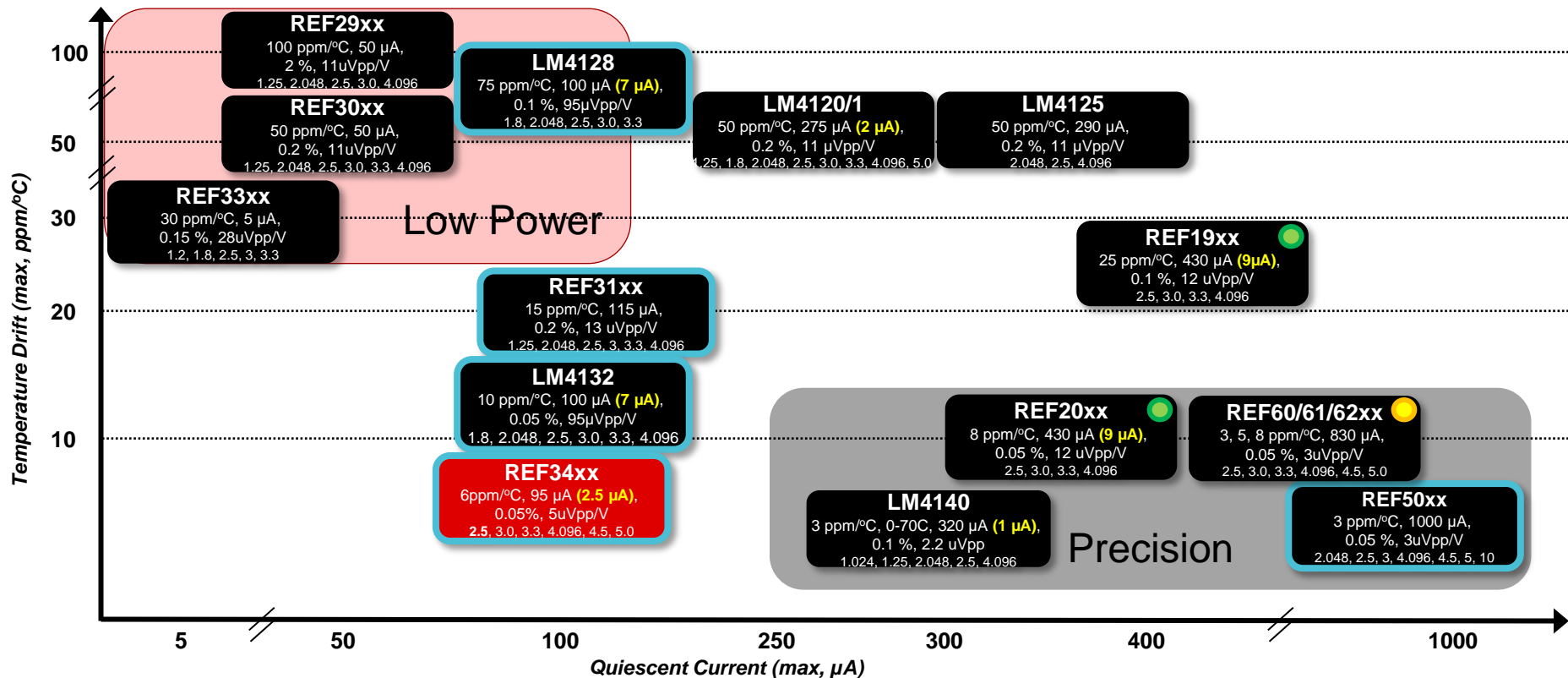


Accurate reference to a comparator



Series voltage references

Need more? See TI.com/VREF



Q-100 Automotive Qualified



Dual outputs



Integrated ADC Drive Buffer

(shutdown Iq)

NEW

EXISTING

REF3425/30/33/40/50(-Q1)

2.5ppm/C Low-Drift, Low-Power, Small-Package Precision Voltage Reference

Features

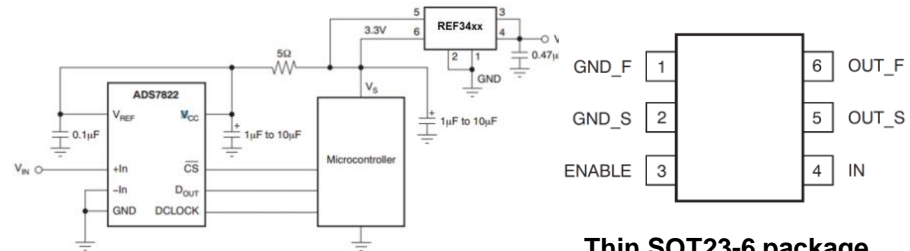
- Initial Accuracy: $\pm 0.05\%$ (max)
- Temperature Drift: **6 ppm/°C (max)**
- 0.1-10Hz Noise: $5 \mu\text{V}_{\text{p-p}}/\text{V}$
- Quiescent current: 95 μA (max)
- Line Regulation: 2 ppm/V
- Load Regulation (sourcing): 20 ppm/mA
- Output Voltages: 2.5V, 3.0V, 3.3V, 4.096, 5.0
- Supply Voltage Range: $V_{\text{OUT}} + \text{Dropout} - 12\text{V}$
- Long Term Drift: 30ppm/1000hrs

Applications

- Industrial automation and sensing
- 4-20mA loop sensor
- Field transmitters
- Test and measurement
- Medical equipment
- Ratio-metric instrumentation

Benefits

- Low reference noise enable design in noise sensitive applications such as PLC and 4-20mA loop sensor
- Low temperature coefficient enables better accuracy over the full industrial temp range
- Low power enables use in loop powered applications
- DDC package enables Thermal Hysteresis <60ppm
- Ideal for low power and noise sensitive systems

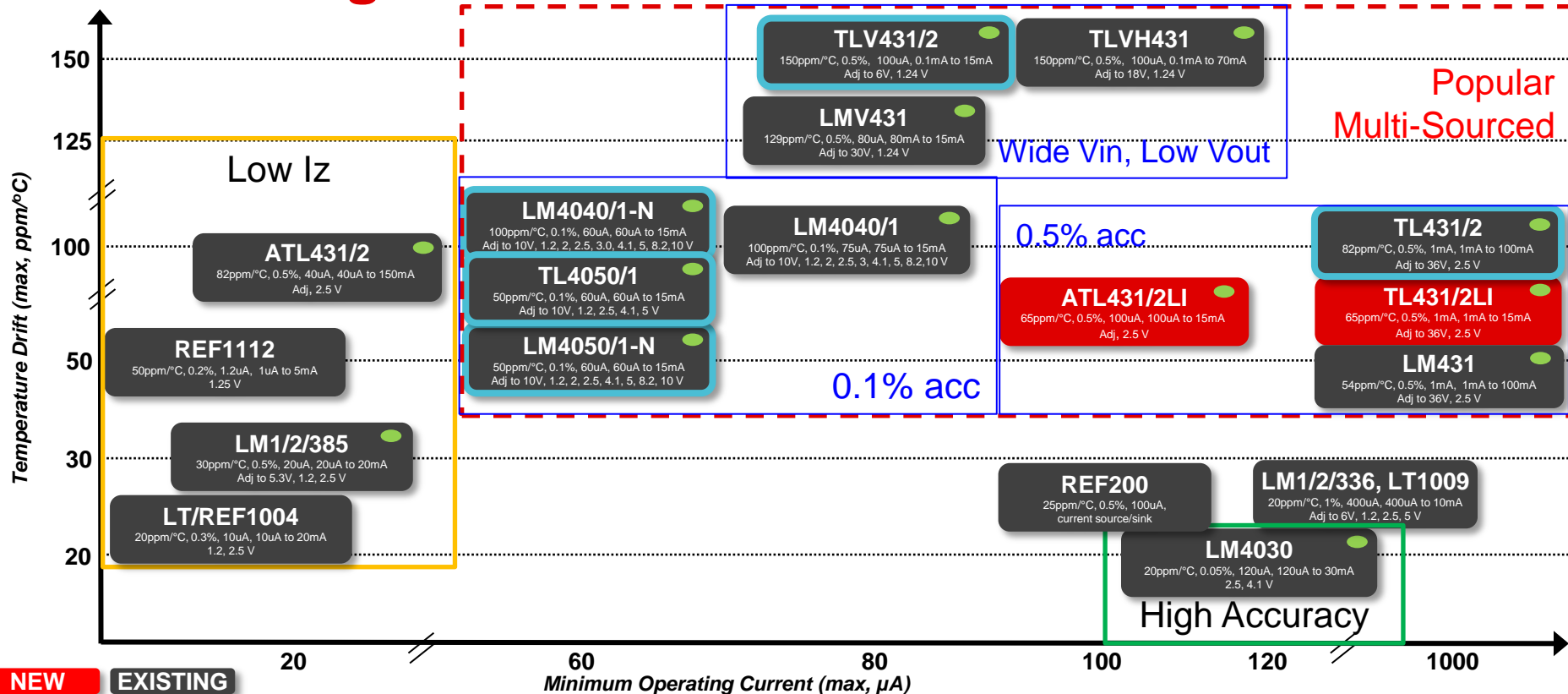


For AEC-Q100, REF34-Q1 is better performance/cost than REF50xA-Q1!

Thin SOT23-6 package
P2P Replacement for
MAX6070/71 & ADR3425

Shunt voltage references

Need more? See TI.com/VREF



TL431/2LI

Precision Programmable Shunt Regulator

Features

- Wide supply voltage range: $V_{KA}=2.495\text{V}$ to 36V
- V_{ref} tolerance @ 25C: A Grade: 1%, B Grade: 0.5%
- I_{ka} min: 1mA
- I_{ref} max: 0.4uA
- Max variation over temperature:
 - 11mV (0°C to 70°C) (C Grade)
 - 17mV (-40°C to 85°C) (I Grade)
 - 27mV (-40°C to 125°C) (Q Grade)
- Package: DBZ (Body size 2.9x1.3 SOT23-3)

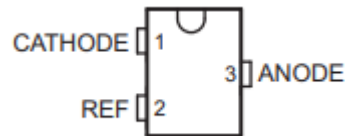
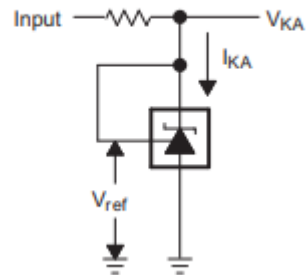
Applications

- Power Supply
- LED Lighting
- Factory Automation
- Building Automation

Benefits

- High voltage operation enables flexibility
- Accurate reference voltage
- Low operating power
- Low input leakage
- Small footprint

Simplified Schematic



ATL431/2LI

Precision Programmable Shunt Regulator

Features

- Wide supply voltage range: $V_{KA}=2.5V$ to 36V
- V_{ref} tolerance @ 25C: A Grade: 1%, B Grade: 0.5%
- I_{ka} min: 100uA
- I_{ref} : 0.4uA
- Package: DBZ (Body size 2.9x1.3 SOT23-3)

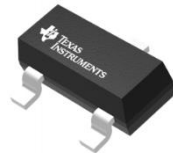
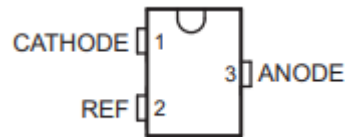
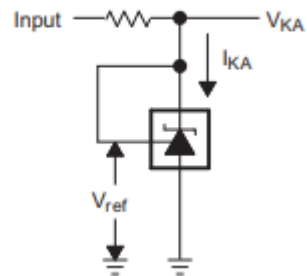
Applications

- Low standby power power supply
- LED Lighting
- Factory Automation/Building Automation

Benefits

- High voltage operation enables flexibility
- Accurate reference voltage
- Low operating power
- Low input leakage
- Small footprint

Simplified Schematic



xTL431 2.5V options

	**TL431/2LI	TL431/2	LM431	ATL431/2	**ATL431/2LI
Vref (typ)	2.5V	2.5V	2.5V	2.5V	2.5V
Vka (max)	36V	36V	36V	36V	36V
Ika (min)	1mA	1mA	1mA	35uA	100uA
Ika (max)	15mA	100mA	100mA	100mA	15mA
Iref (max)	0.4uA	4uA	4uA	0.15uA	0.4uA
I _(dev) (max)	0.3uA	2.5uA	1.2uA	0.05uA	0.3uA
Accuracy Grade Versions	A: 1% B: 0.5%	Blank: 2% A: 1% B: 0.5%	A: 2% B: 1% C: 0.5%	A: 1% B: 0.5%	A: 1% B: 0.5%
Operating Temp. Range	C: 0 to 70C I: -40 to 85C Q: -40 to 125C	C: 0 to 70C I: -40 to 85C Q: -40 to 125C	C: 0 to 70C I: -40 to 85C	I: -40 to 85C Q: -40 to 125C	I: -40 to 85C Q: -40 to 125C
Packages	DBZ: 3SOT-23	D: SOIC DBV: 5SOT-23 DBZ: 3SOT-23 DCK: SC-70 LP: TO-92 P: PDIP PK: SOT-89 PS: SO PW: TSSOP	M: SOIC M3: 3SOT-23 Z: TO-92	DBZ: 3SOT-23	DBZ: 3SOT-23
Reel	T: tape/small reel R: large reel	T: tape/small reel R: large reel	No "X": tape/small reel X: large reel	T: tape/small reel R: large reel	T: tape/small reel R: large reel
AEC-Q100	"Q1" suffix	"Q1" suffix	Unavailable	Unavailable	Unavailable

Example: ATL431LIADBZR

- ATL431LI core
- A / 1% accuracy
- I / -40 to 85C temp. range
- DBZ package
- R / large reel

AC/DC or DC/DC with optocoupler:

System accuracy comparison

	TL431AI 1% grade with 0.5% resistors	TL431BI 0.5% grade with 0.5% resistors	*NEW* TL431LIAI 1% grade with 0.5% resistors
Vref (V)	2.495	2.495	2.495
Vref deviation over temp range (dev)(mV)	34	34	17
R1 (kΩ)	10	10	10
R2 (kΩ)	10	10	10
Iref (μA)	4	4	0.4
II(dev) (μA)	2.5	2.5	0.3
Error due to Iref and II(dev) (V)	0.06565	0.06565	0.007
Total output voltage (V)	5.198	5.173	5.106
Total Error	3.35%	2.85%	2.25%

Total output voltage =
 $(V_{ref} + V_{I(dev)}) * (1 + R1/R2) + (I_{ref} + I_{II(dev)}) * R1$
 V_{ref} , R1, R2 have errors referred in percentages in the table

TL431LIAI (1%) grade is *more accurate* than TL431AI (1%) grade by over 1% and TL431BI (0.5%) by 0.5%. The TL431LI is more accurate as you increase the resistors R1 and R2 to save power.

ATL431LI class 6 power supply power budgets

System requirements with no load condition:

European COC	75mW	Adaptor power <49W
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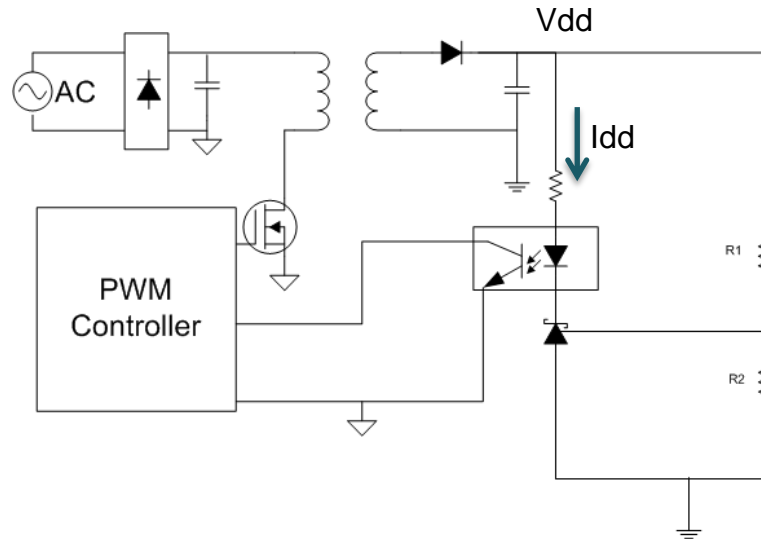
Power consumed by TL431 branch = $V_{dd} * I_{dd}$

TL431LI Example: $V_{dd} = 20V$, $I_{dd} = 2mA$ given a practical design scenario using the **TL431LI** and a regular optocoupler.

ATL431LI Example: $V_{dd} = 20V$, $I_{dd} = 200\mu A$ given a practical design scenario using the **ATL431LI** and an advanced optocoupler.

230V AC input	TL431LI	*Components	ATL431LI	*Components
Power (mW)	40	40	4	40
Total (mW)	80		44	

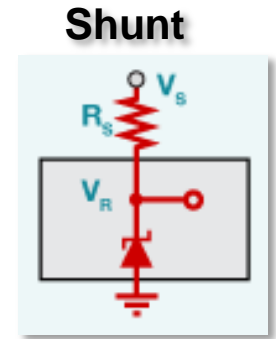
*Components consist of: MOSFETs, controllers, etc



ATL431LI saves standby power budget by at least 36mW given practical opto-coupler biasing conditions.

Shunt references as Zener diodes

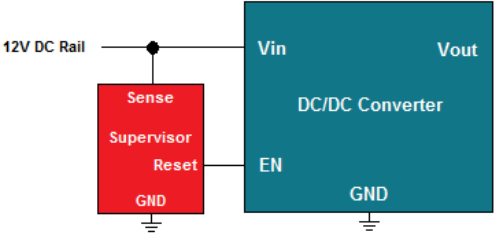
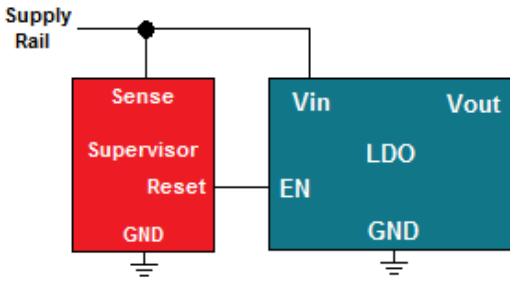
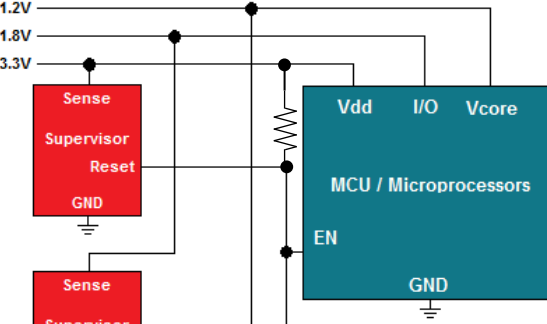
- Zener diodes are often used as low-cost overvoltage protection and voltage references/regulators, but have two limitations:
 - The I_z current for regulation is high for battery applications (typ. $I_z = 3\text{-}5\text{mA}$)
 - Typ. high error from initial accuracy and temp deviation
- Shunt references can offer Zener functionality with lower I_z and higher accuracy
 - [TL431LI](#) ($I_{ka,min}=1\text{mA}$)
 - [LM4040-N/-Q1](#) ($I_{ka,min}=60\mu\text{A}$, $V_{ref}=2.048/2.5/3/4.096/5\text{ V}/8.192/10\text{V}$)
 - [LM4041-N/-Q1](#) ($I_{ka,min}=60\mu\text{A}$, $V_{ref}=1.24\text{V}$)
- Blog: [How to use a voltage reference as a voltage regulator](#)



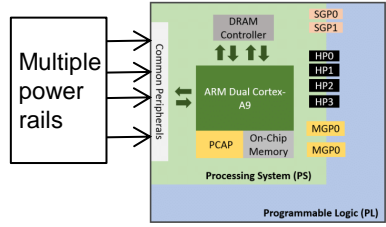
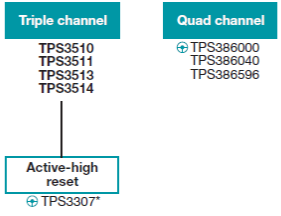
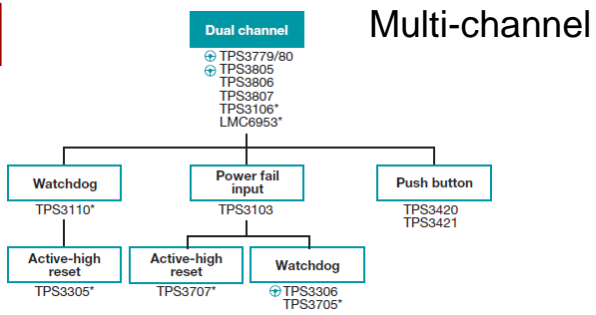
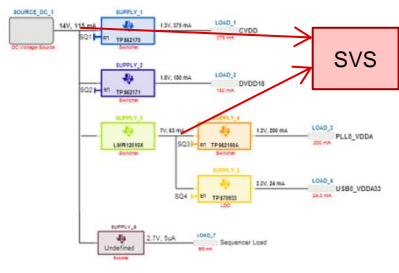
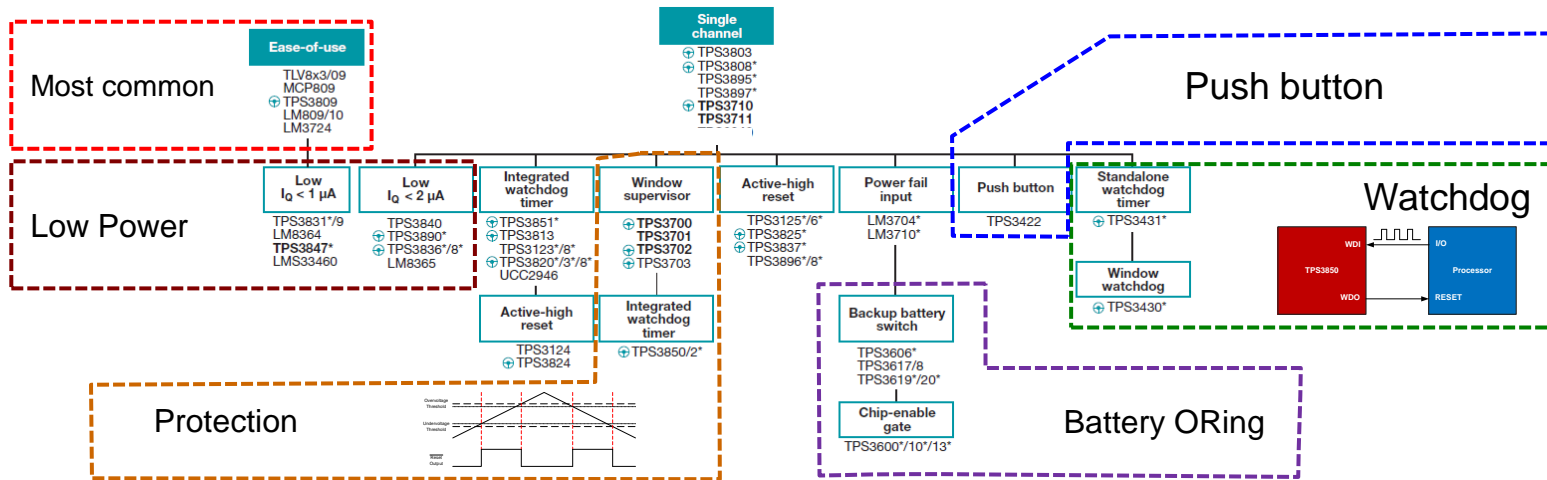
Supervisors

Voltage supervisor, monitor, detector, reset IC....

Supervisor/reset IC common use cases

Main Supply Rail	LDO - Vin	Processors / MCUs
		
<p>A DC/DC converter has a main supply rail that needs to be above a certain threshold voltage before it can power up correctly.</p> <p>A supervisor is used to monitor this rail to ensure it is online before asserting a high signal to the converter's enable pin allowing the converter to power up.</p>	<p>A LDO has a main supply rail that needs to be above a certain threshold voltage before it can power up correctly.</p> <p>A supervisor is used to monitor this rail to ensure it is online before asserting a high signal to the enable pin allowing the LDO to power up.</p>	<p>Processors and microcontrollers have multiple supply rails with a tight window of accuracy and require accurate supervisors to disable the processor in the case UV to prevent brownout conditions.</p>

TI's broad supervisor portfolio



TPS3431

Stand Alone Watchdog with Programmable Timeout Period

Features

- Input Voltage Range: VDD = 1.8 V to 6.5 V
- One pin (SET1) factory programmed timeout period selector
- **User-Programmable Timeout** period via external capacitor
- **15% timeout accuracy**
- Watchdog Disable Feature
- Low Supply Current: 10 μ A (Typ.)
- Open-Drain Active low Output
- Junction Operating Temperature Range: -40°C to +125°C
- Available in 3mmx3mm DFN-8 (DRB)

Applications

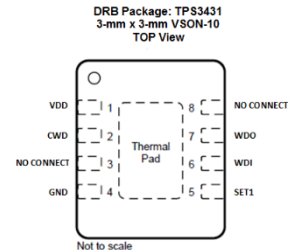
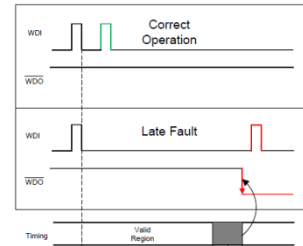
- Automotive Gateways
- Automotive Radar
- Automotive body control
- Protection Relay
- Video Surveillance
- Grid Automation
- HVAC Systems
- Grid Automation

Benefits

Stand alone watchdog improve system reliability eliminating single point failures. Detect late pulses outside of the WD timeout period

The WD keep the system from lockout by monitoring the processor or microcontroller periodical pulses (WDI), when the processor fails to send the pulse before the programmed timeout period the watchdog will assert an interrupt (WDO) to reset the processor.

TPS3431 also have a disable feature to avoid nuisance timeouts during prototyping / debugging.



TPS3430

Stand Alone Window Watchdog with programmable timeout period

Features

- Input Voltage Range: $V_{DD} = 1.6\text{ V to }6.5\text{ V}$
- Two pin (SET1/2) factory programmed timeout period selector
- **User-Programmable Timeout** period via external capacitor
- **15% timeout accuracy**
- Watchdog Disable Feature
- Low Supply Current: $10\mu\text{A (Typ.)}$
- Open-Drain Active low Output
- Junction Operating Temperature Range: $-40^{\circ}\text{C to }+125^{\circ}\text{C}$
- Available in 3mmx3mm DFN-10 (DRC)

Applications

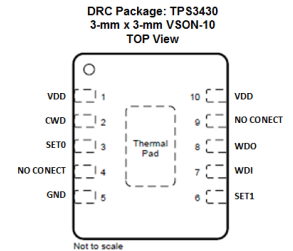
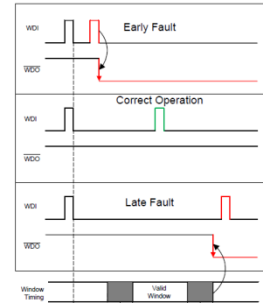
- Automotive Gateways
- Automotive Radar
- Automotive body control
- Protection Relay
- Video Surveillance
- Grid Automation
- HVAC Systems
- Grid Automation

Benefits

Window watchdog improve system reliability eliminating single point failures. Detects early and late pulses

The WD keep the system from lockout by monitoring the processor or microcontroller periodical pulses (WDI), when the processor fails to send the pulse within the programmed time window the watchdog will assert an interrupt (WDO) to reset the processor.

TPS3430 also have a disable feature to avoid nuisance timeouts during prototyping / debugging.



TPS3840

VIN=10V, IDD=0.35uA, Manual Reset, Programmable Reset Time, -40C to 125C

Samples available now!

RTM early 2Q 2019

Features

- Wide V_{IN} operational range: 1.5 V – 10V (12V max)
- Temperature range -40°C to 125°C T_J range
- 1% typical accuracy, 2.5% over temperature
- Fixed threshold Voltage (100mV step): 1.6V to 4.9V
- Capacitor programmable reset time delay
 - Fast reset time with no capacitor at C_D pin
 - 30% delay time accuracy
- Low I_q: 350nA typical, 1uA max over temp (125C)
- Manual Reset: active low logic, can be left open when not in use
- Output topology: Open Drain and Push Pull
- Package: SOT23-5 (DBV)

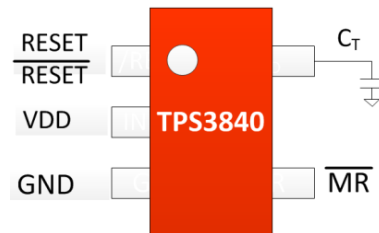
Benefits

- Wide Vin enable operation from high voltage rail or multi cell battery supply
- High voltage threshold accuracy and time delay accuracy to improve system reliability
- Low power consumption to extend battery life and minimize power consumption in self-power systems
- Time delay programmability for sequencing or meeting system power up requirements
- Extended temperature range for industrial applications

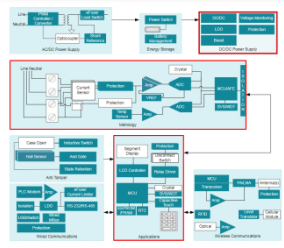
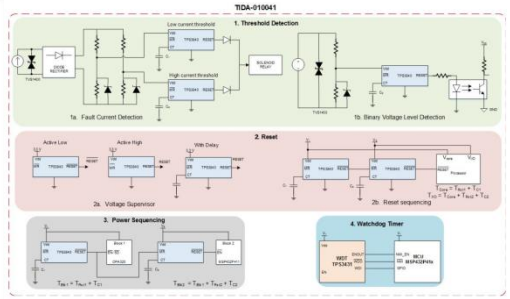
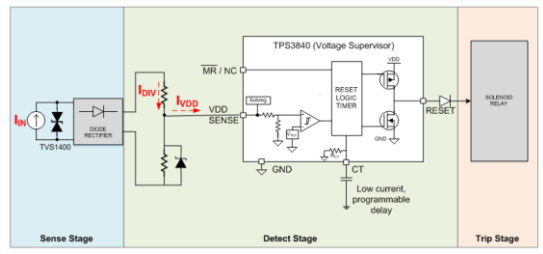
Applications

- Field Transmitters & PLCs
- Circuit Breakers & E-meters
- Low Battery Detection – multi cell applications
- μ P and μ C Voltage Monitoring
- Portable Industrial Control Systems

- **TPS3840DL**
Open Drain Active Low
- **TPS3840PH**
Push-Pull Active High
- **TPS3840PL**
Push Pull Active Low



TPS3840 technical docs and reference designs



- [Blog: Improve circuit breaker leakage current response with a voltage supervisor](#)
 - Use [TPS3840](#) in a leakage current detector circuit, taking advantage of the device's 200 μ s startup time, I_Q of 350 nA, and 300 mV V_{POR} !
- [TI Design: TIDA-010041 - Nano power, wide VIN \(12 V max\) supervisor reference design used as comparator or power sequencer](#)
- [Blog: Voltage supervisor requirements for e-meter applications](#)

TPS3703-Q1

Samples available now!

RTM early 2Q 2019

Precise monitoring OV/UV monitoring to assist on safety solution

Features

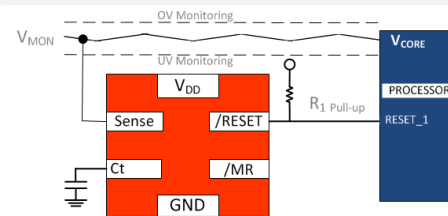
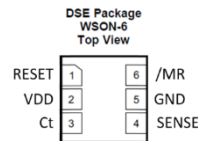
- Operating Voltage: 1.7 to 5.5V
- OV/UV accuracy: 0.25% (Typ.) , 0.9% across temp -40°C to +125°C
 - Nominal monitoring rails: 50mV steps from 0.5V to 1.3V and 1.5V, 1.8V, 2.5V, 2.9V, 2.8V, 3.3V, 5V.
 - OV and UV trip point from nominal rails 3%, 4%, 5% ,6%, 7%,
- Built-in 0.5% hysteresis and built-in Glitch immunity
- Fixed and programmable reset time delay
 - Fixed rest time delay: 50us, 1ms, 5ms, 10ms, 20ms, 100ms, 200ms
- Integrated RESET latching feature clear with external pulse
- MR active low reset: sequencing assist, AND logic, force reset.
- Low Supply Current: 6µA (Typical)
- Open Drain Active low output topology

Applications

- Automotive ADAS Systems: CMOS imager monitoring, MCU monitoring
- Automotive Cluster and infotainment processor monitoring
- Industrial Motor Drivers control unit
- Automated Machinery
- Avionics system
- FPGA and ASIC Applications

Benefits

- Combination of High Accuracy & Precision Hysteresis provide maximum useable bus voltage.
- Fixed thresholds with internal resistor divisor permits high precision monitoring without external resistor tolerance error.
- Programmable and fixed time delay to meet power up timing requirements and also provides sequencing.
- Built-in hysteresis minimizes nuisance trips due to supply voltage ripple
- Open drain topology allows AND-wiring the RESET output with various devices; Open drain also provides level shifting



Technical resources on TI.com

Getting Started:

- www.ti.com/VREF
- www.ti.com/SVS

Training Series:

- [Vref training videos](#)
- [Voltage Supervisors 101](#) video series

TI Designs:

- Analog I/O module ([TIPD164](#))
- Monitoring voltage rails ([TIDA-00392](#))
- Isolated current measurement ([TIDA-00912](#))
- AC/DC power adapter ([TIDA-01622](#))
- Nano power supervisor used as comparator or power sequencer ([TIDA-010041](#))
- ADAS power design with improved voltage supervision ([TIDA-050008](#))

Selection Guides:

- [SVS quick reference guide](#)
- [How to select a Vref topology](#)
- [Data Converter Brochure](#)

Application Notes (PDF):

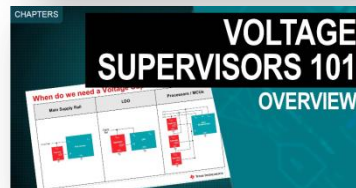
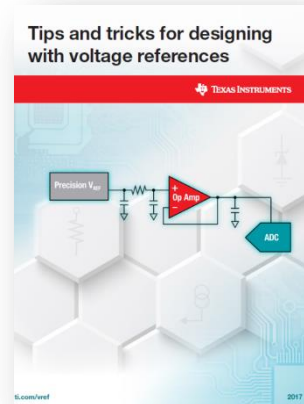
- [Voltage reference application e-book](#)
- [Power-down sequencing for FPGAs](#)
- [Designing with ATL431](#)
- [Choosing appropriate pull-up/pull-down resistor for open-drain outputs](#)

TI Blogs:

- Selecting voltage detectors, supervisors, & reset ICs for system safety ([Part 1](#); [Part 2](#))
- [Tips and tricks for optimizing your voltage supervisor](#)
- [What is a watchdog timer and why is it important?](#)

White Papers (PDF):

- [Voltage reference selection basics](#)



Thank you