

New Product Update

Ultra low-drift ($0.8 \text{ } \mu\text{ppm}/^\circ\text{C}$)
Precision Low-Noise Voltage
Reference

Jackson Wightman

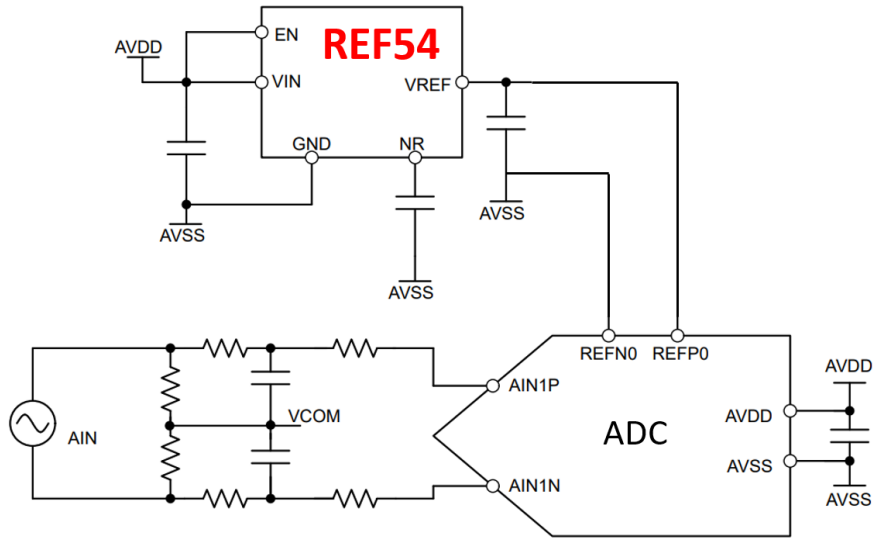
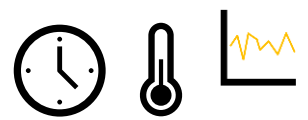
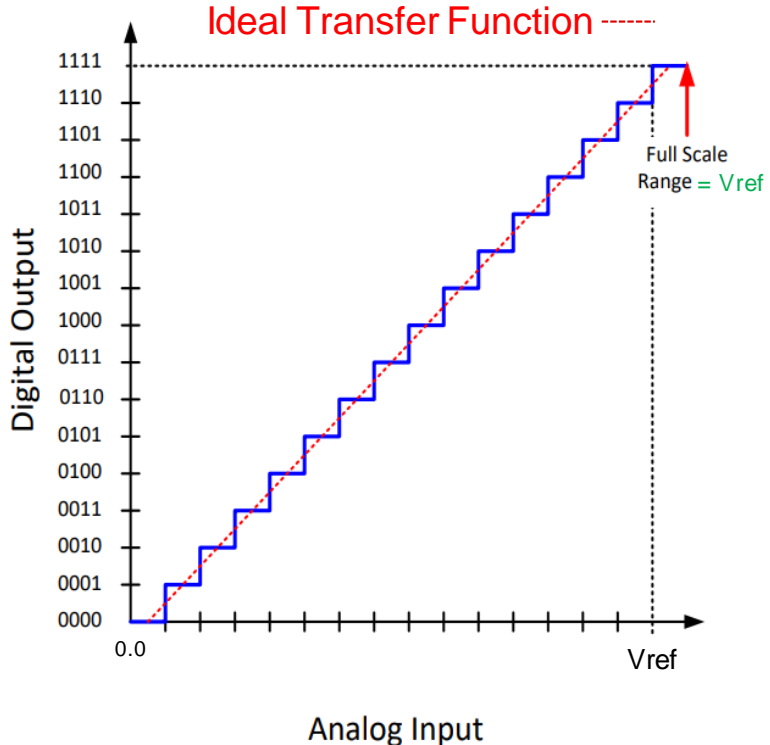
Voltage references applications engineer

Agenda

- Understanding voltage reference specifications
- Introducing REF54
- Applications examples
- TI's voltage references portfolio
- Conclusion and wrap up

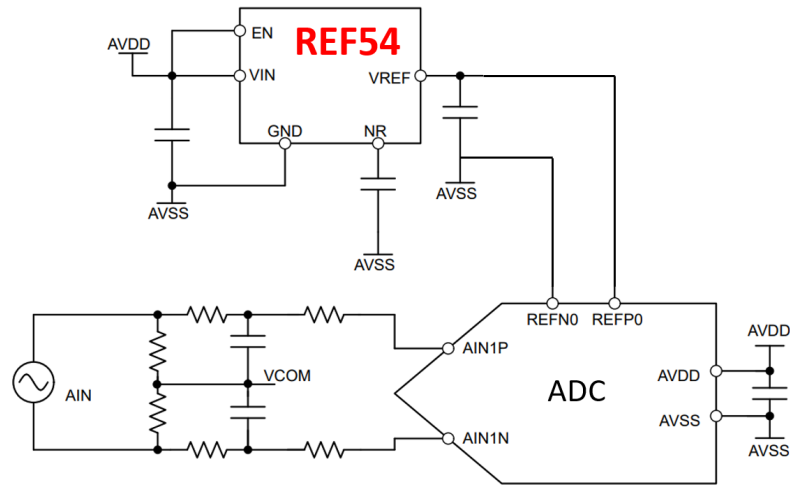
Understanding voltage reference specifications

Voltage reference in data converter applications



Voltage reference in data converter applications

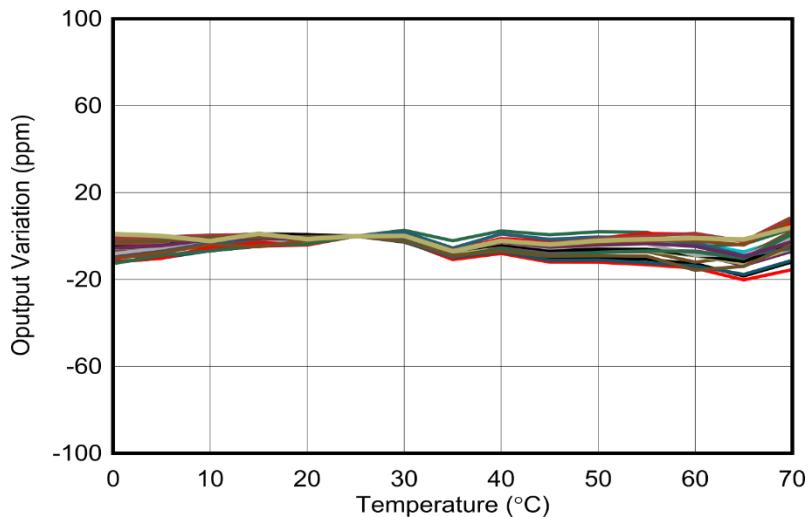
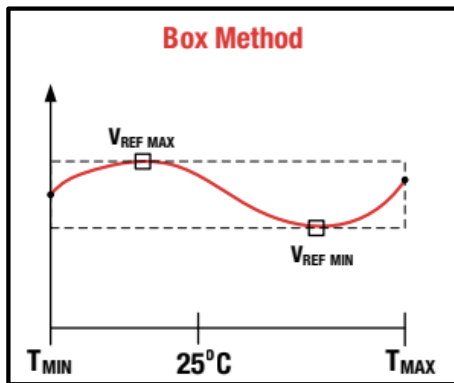
- Many data converters require or have an option for an external voltage reference.
- Precision voltage references are designed to be stable over:
 - Variation in input voltage
 - Temperature
 - Aging
 - Other factors
- Low flicker noise is very important for high precision applications.



$$\text{Voltage reference gain error} = \sqrt{(\text{Long term drift})^2 + (\text{Temp drift})^2 + (\text{Noise})^2 + \dots}$$

Temperature drift

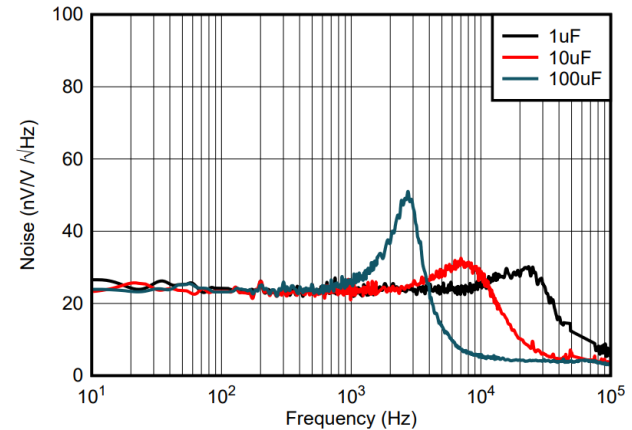
- Temperature drift impacts the gain error of data converter thus impacting system accuracy.
- REF54 provides a very low temperature drift calculated using the box method.



Flicker and broadband noise

- The internal noise of a voltage reference causes a dynamic error that degrades the signal-to-noise ratio (SNR) of a data converter and its ENOB.
- REF54 has exceptionally low noise and also offers a noise reduction (NR) pin to further minimize the flicker noise.

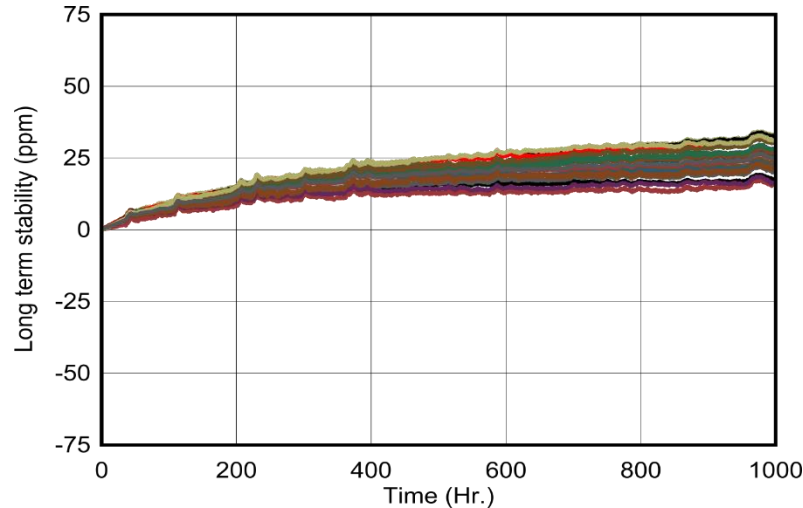
$$\text{SNR}_{\text{ADC}} = 20 \log \left(\frac{V_{\text{ref}}}{2\sqrt{2} * \text{Total ADC noise}} \right)$$



$$\text{Total ADC noise} = \sqrt{(\text{Inherent ADC noise})^2 + (\text{Buffer noise})^2 + (\text{Voltage Reference Noise})^2}$$

Long-term stability

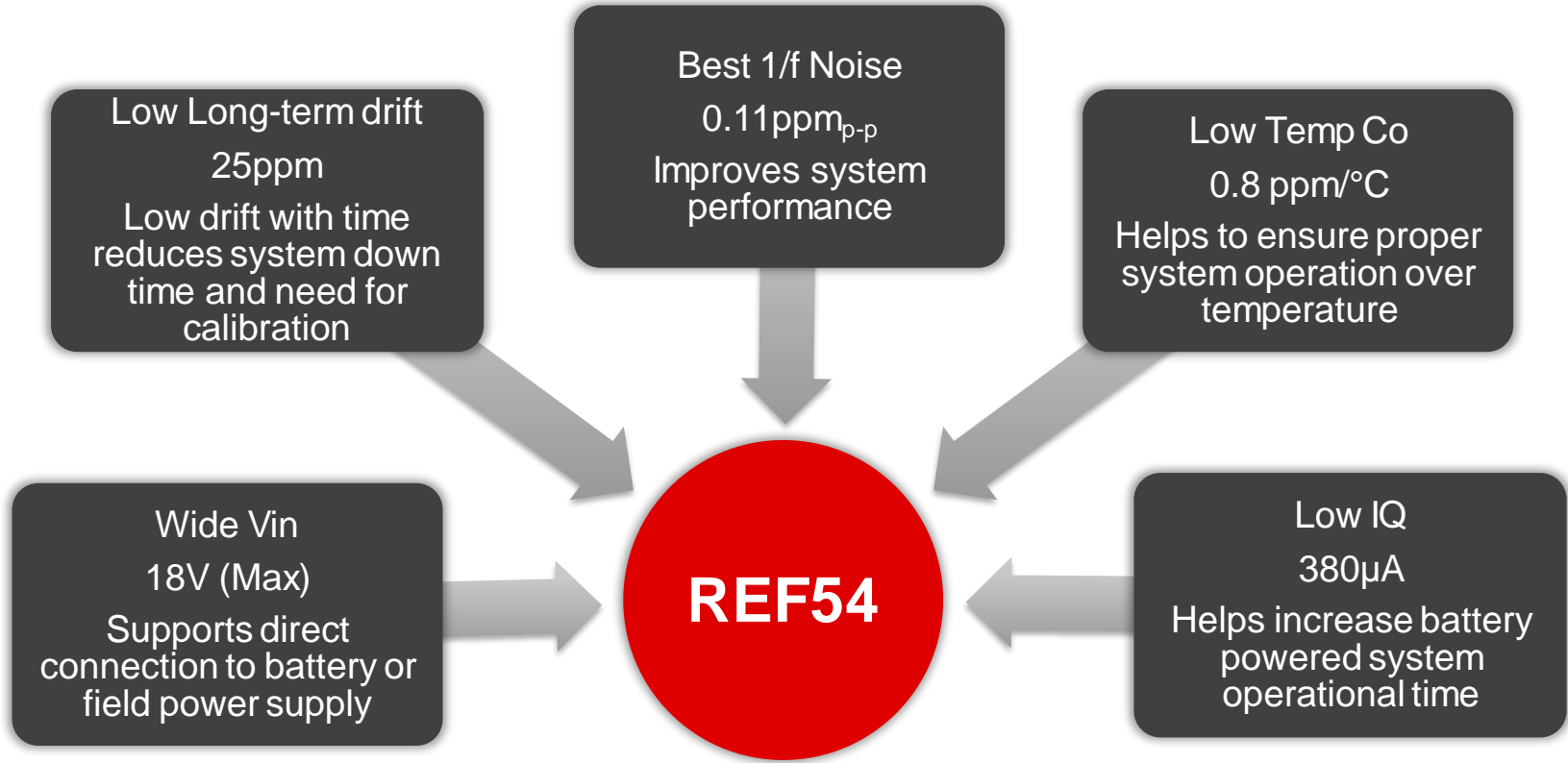
- Long-term stability (or drift) describes the shift in VREF after 1000 hours (6 weeks) of continuous operation under nominal conditions.
- REF54 provides an excellent long-term stability that can help to double time between necessary calibrations.



Introducing REF54

REF54

Next Generation Precision Voltage Reference



REF54 : Next Generation Precision reference

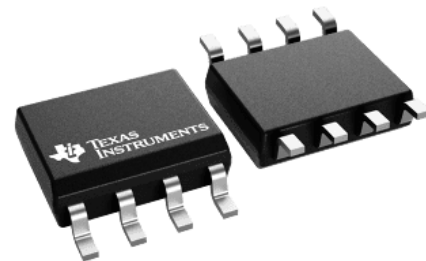
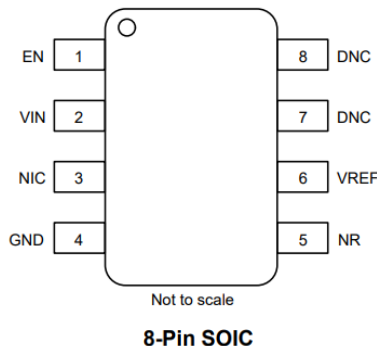
25PPM LTD, 0.8 ppm/°C, 0.11ppm_{p-p} Flicker Noise

Features

- Long term drift: **25 ppm @1000hr for SOIC Package**
- Temp Drift (max): **0.8 ppm/°C (0°C to 70°C)**
 - **1.5 ppm/°C (-40°C to 125°C)**
- Ultra-low noise 0.1Hz to 10Hz (2.5V variant) :
 - **0.45ppm_{p-p} (w/o filtering)**
 - **0.11ppm_{p-p} (NR = 100 μF)**
- Quiescent current: **380uA (max)**
- Initial accuracy: **±0.02%**
- Dropout : **250mV**
- Supply voltage range : **2.75V to 18V**
- Output Voltage: **2.5 V, 3.0 V, 4.096 V, 4.5 V, 5 V**
- Cap-load stability : **1 – 100 μF**
- Output current Drive: **±10mA**

Benefits

- Best in class 1/f noise performance improves system performance
- Low drift with time enables use in high precision systems
- Low IQ helps increase battery powered system operational time
- Companion device for high-resolution data converters such as **ADS1285**, ADS8900B, ADS127L11, and DAC11001B



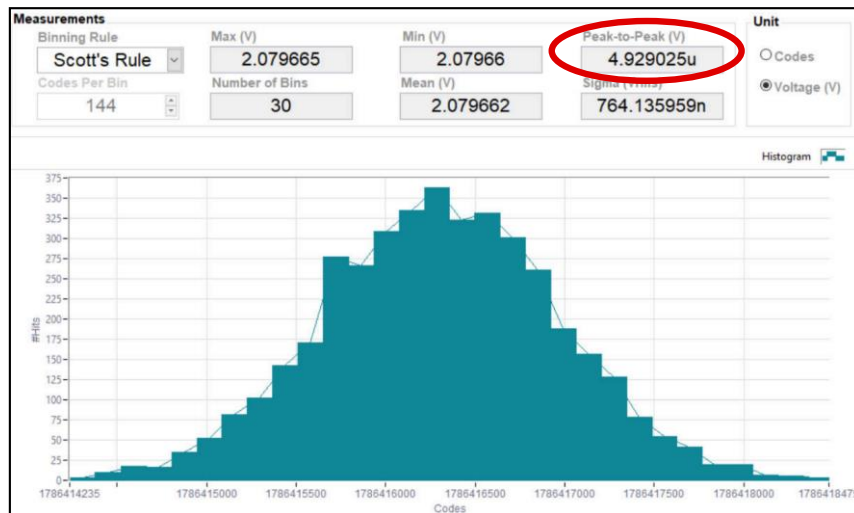
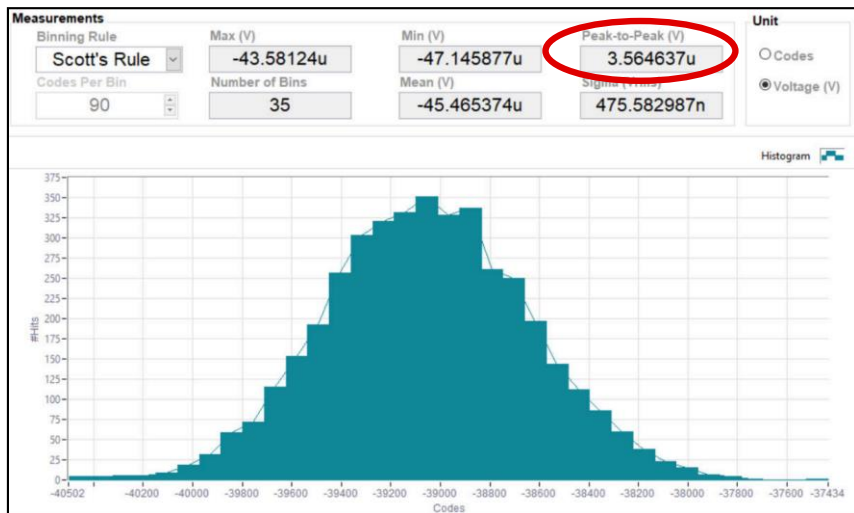
REF54 + ADS1285 Attach

ADS1285 Input = 0 V

REF54500 VREF = 5 V

ADS1285 Input = 2.08 V (FSR)

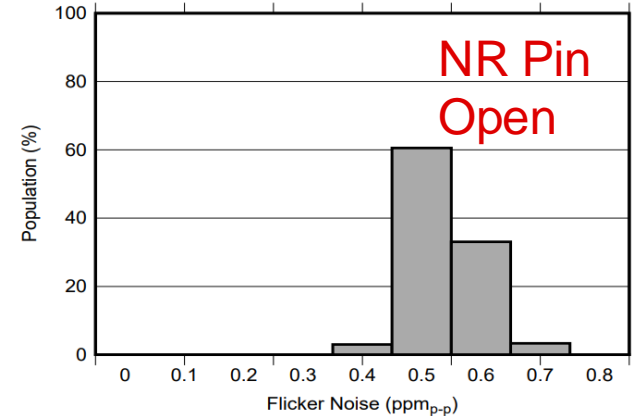
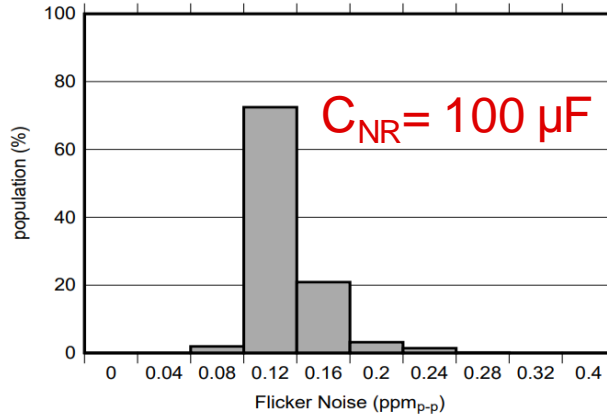
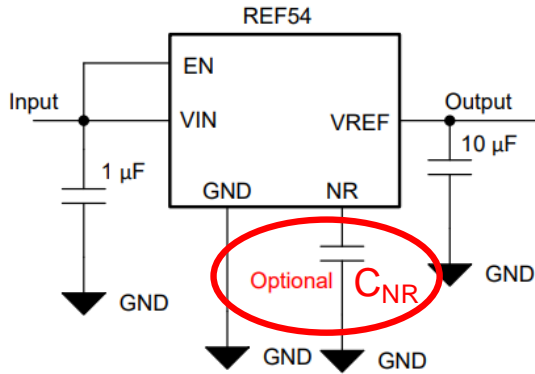
REF54500 VREF = 5 V



V_{p-p} scales by less than a factor of 1.5 once an input voltage is applied

REF54 – Flicker Noise

- REF54 offers $0.11 \text{ ppm}_{\text{p-p}}$ flicker noise with filtering and $0.45 \text{ ppm}_{\text{p-p}}$ flicker noise without filtering, while still keeping the quiescent current below $380\mu\text{A}$.



REF54 – best-in-class performance

Key Spec	REF54	Competitor #1	Competitor #2
Supply current	380 μ A	950 μ A	725 μ A
Temperature drift	0.8 ppm/ $^{\circ}$ C (0 $^{\circ}$ C to 70 $^{\circ}$ C) 1.5 ppm/ $^{\circ}$ C (-40 $^{\circ}$ C to 125 $^{\circ}$ C)	0.8 ppm/ $^{\circ}$ C (0 $^{\circ}$ C to 70 $^{\circ}$ C) 2 ppm/ $^{\circ}$ C (-40 $^{\circ}$ C to 125 $^{\circ}$ C)	3 ppm/ $^{\circ}$ C
Noise	0.45 ppm _{p-p} or 0.11 ppm _{p-p} with C _{NR}	0.5 ppm _{p-p}	0.58 ppm _{p-p}
Long-term drift	25 ppm SOIC	25 ppm SOIC	20 ppm SOIC

REF54 Device List

**Samples
available now.**

Find online at ti.com/product/REF54

REF54	VREF	Temp. Range
REF54250Q	2.5V	-40°C to 125°C
REF54250C	2.5V	0°C to 70°C
REF54300Q	3.0V	-40°C to 125°C
REF54300C	3.0V	0°C to 70°C
REF54410Q	4.096V	-40°C to 125°C
REF54410C	4.096V	0°C to 70°C
REF54450Q	4.5V	-40°C to 125°C
REF54450C	4.5V	0°C to 70°C
REF54500Q	5.0V	-40°C to 125°C
REF54500C	5.0V	0°C to 70°C

Application examples

REF54 – Target Applications

Medical

- X-rays
- CT
- Ultrasound
- MRI



Factory automation & control

- Battery test equipment
- Seismic/geothermal sensors
- Field transmitters



Grid

- Fault indicators
- Smart meter
- String inverter
- EV charging



Automotive

- Traction inverter
- 48 V to 12 V DC/DC Converter



Battery Test Equipment

Low long-term drift

Design Challenges

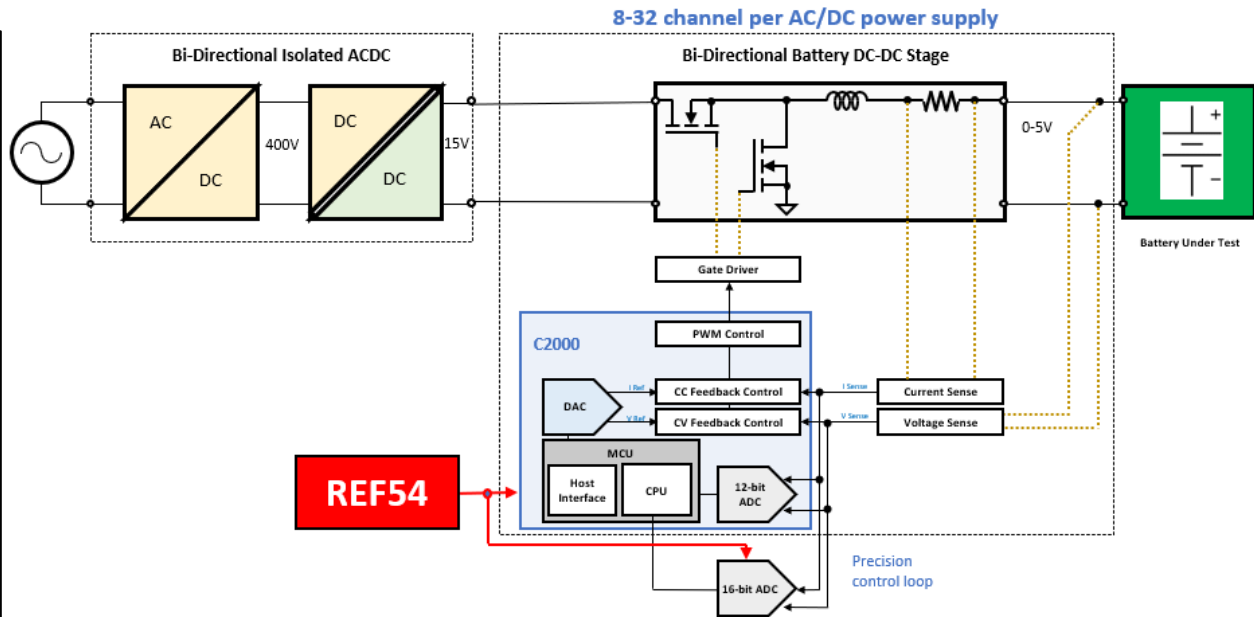
- Minimize the number of essential calibrations.
- Maintain system accuracy over wide temperature range.

Solution

- Low long-term drift can nearly double time between calibrations (6 months to approximately 1 year).
- Avoid large DC error that affects ADC gain and DAC output because of low temperature drift and low long-term drift.

Companion ADCs

- ADS131M08, ADS9817, ADS8668



Field Transmitters

Low quiescent current for 4-20mA loops

Design Challenges

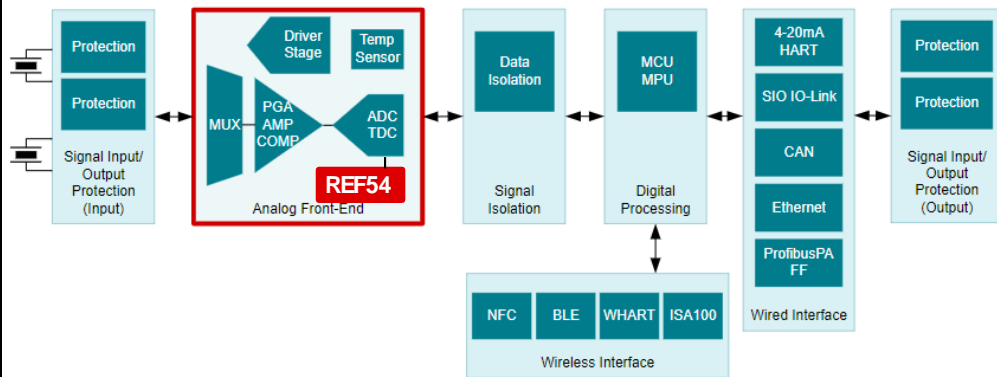
- Maintain accurate measurement over a large range of temperatures.
- Increase battery life without sacrificing accuracy.
- Minimize the number of calibrations.

Solution

- Low quiescent current being paired with high accuracy allows for precise battery powered devices while possibly increasing battery life by 20%.
- Ultra low temperature coefficient helps ensure accurate measurements in large temperature ranges.
- Low long-term drift can decrease the number of calibrations.

Companion ADCs

- ADS1220, ADS1120



EV Charging

Low temperature drift requirement

Design Challenges

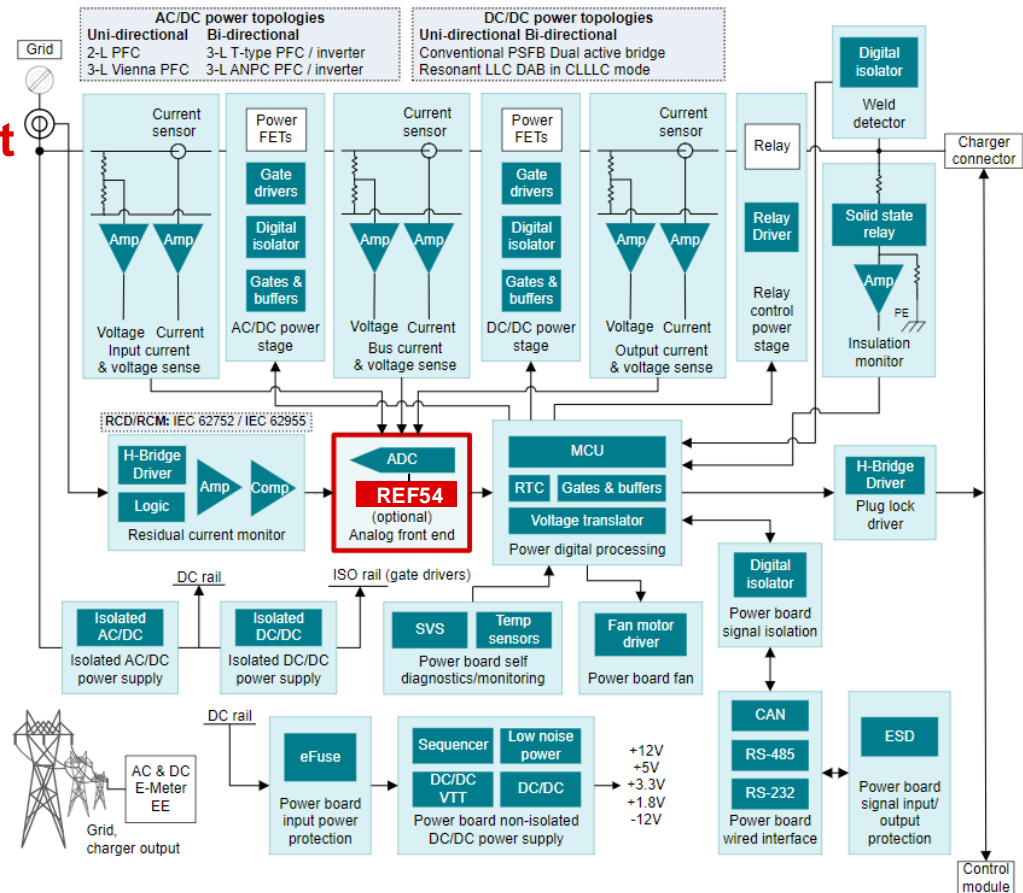
- Accurate measurements over a wide temperature range.
- Charge the consumer an accurate amount for amount of electricity used.

Solution

- Low temperature drift allows for accurate measurements despite outdoor temperature changes.
- High accuracy leads to fair price calculation for consumer.

Companion ADCs

- ADS131M08, AMC130M03



Seismic Data Acquisition

Low quiescent current

Design Challenges

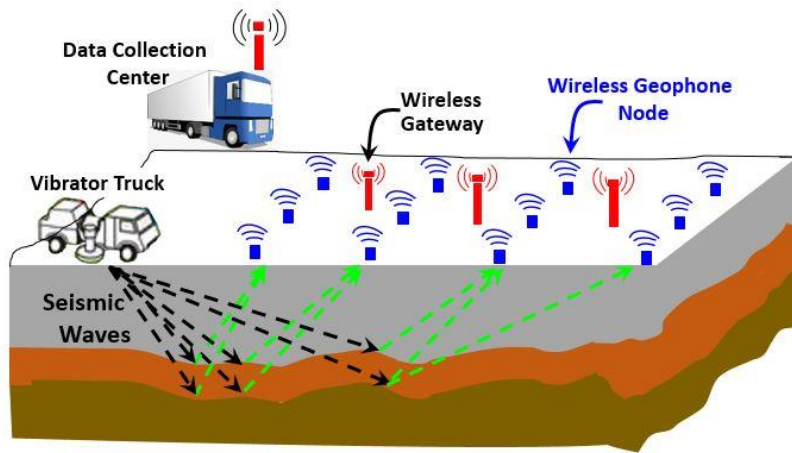
- Maintain system accuracy while increasing battery life.
- Maintain quality signal at low frequencies.

Solution

- Low quiescent current with high accuracy can help provide for accurate measurements while potentially increasing battery life by 20%.
- Low flicker noise helps maintain low frequency signal integrity.

Companion ADCs

- ADS1285



Source :- <https://faculty.kfupm.edu.sa/EE/hattia/Senior%20projects.htm>

X-Ray Imaging

Low noise for increased image resolution

Design Challenges

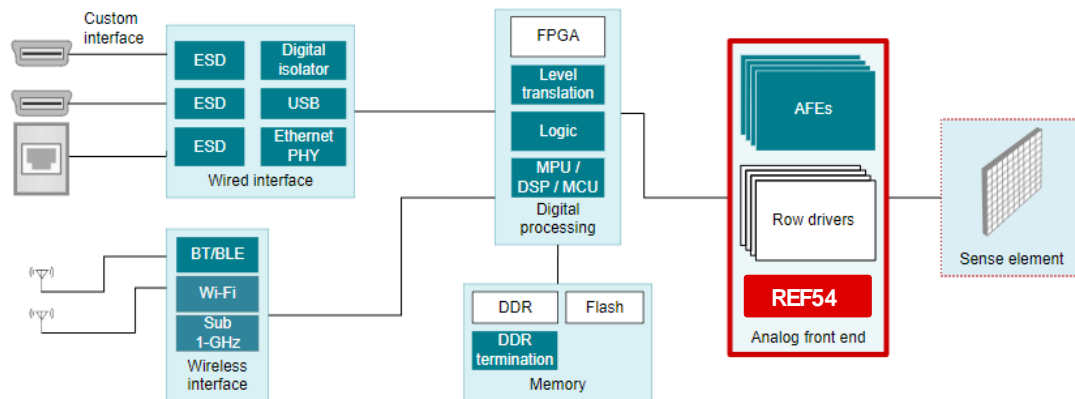
- Improve final image resolution.
- Increase battery life for mobile systems.

Solution

- Low flicker noise to increase the SNR of the ADC will lead to increased image resolution.
- Low quiescent current for less power consumption in mobile systems.

Companion data converters

- AFE2256, AFE3256, ADS9218, ADS8861



Electronic Lab and Field Test Equipment

High accuracy for good measurements

Design Challenges

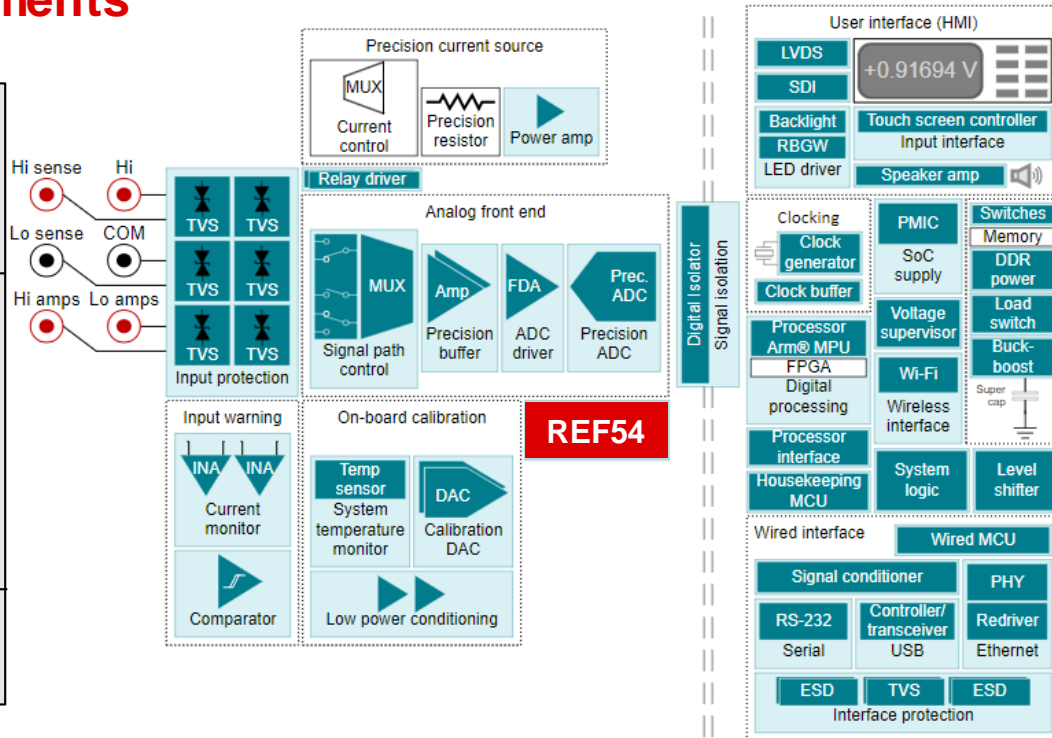
- Accurate and precise measurements across a wide temperature range.
- Decrease the number of calibrations.

Key care-about specifications

- Low flicker noise improves the SNR of the ADC.
- Low temperature coefficient can keep stable measurements in a variety of temperature conditions.
- Low long-term drift can increase time between calibrations.

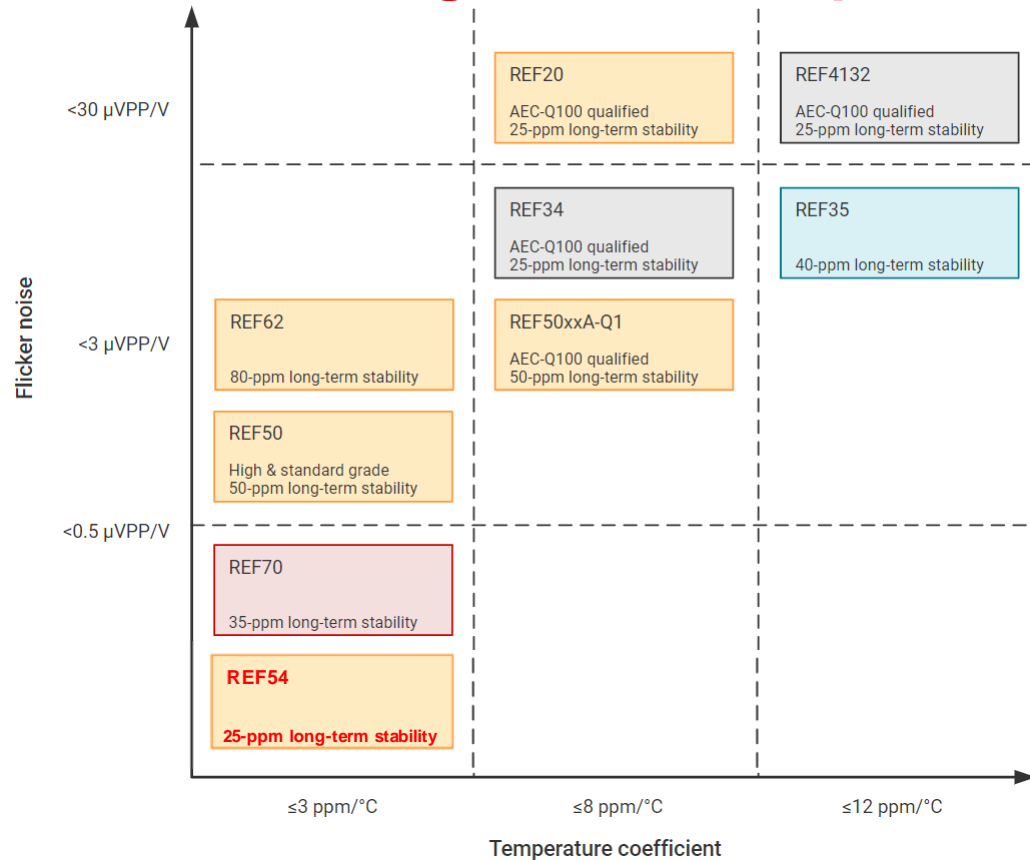
Companion ADCs

- ADS1675, ADS8910B, ADS1259



TI's voltage references portfolio

TI's series voltage reference portfolio



Getting started

Learn more at
ti.com/product/REF54

Find the REF54 evaluation module at
www.ti.com/lit/ug/snau289/snau289.pdf

Visit www.ti.com/npu

For more information on the New Product Update series, calendar and archived recordings



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