Electronics for IoT

Sensor Interface Circuits

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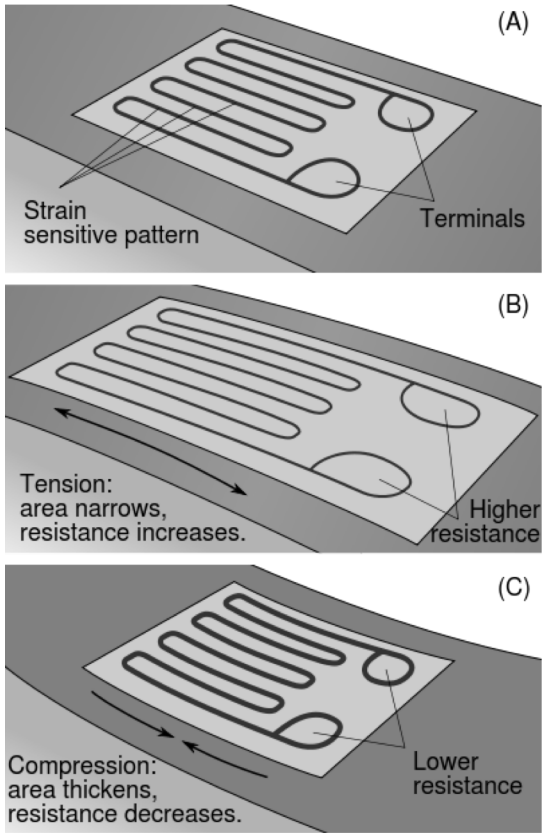
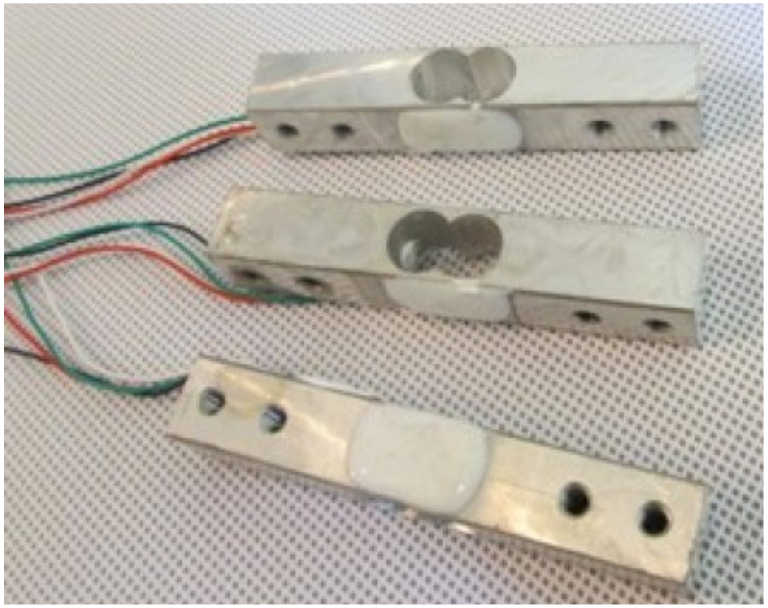
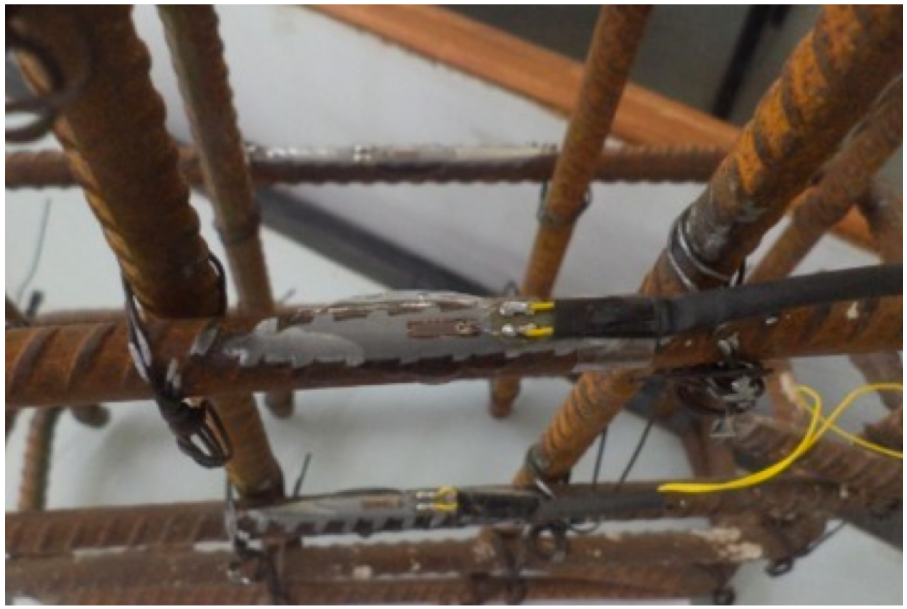
“Not” Smart Sensor

- Transduce physical quantity into something “electrical”
- E.g. strain gauge:
  - Mechanical strain → resistance change
- User builds interface, e.g.
  - Convert resistance change to voltage
  - Voltage to digital (ADC)
  - Implement error correction, e.g. temperature compensation

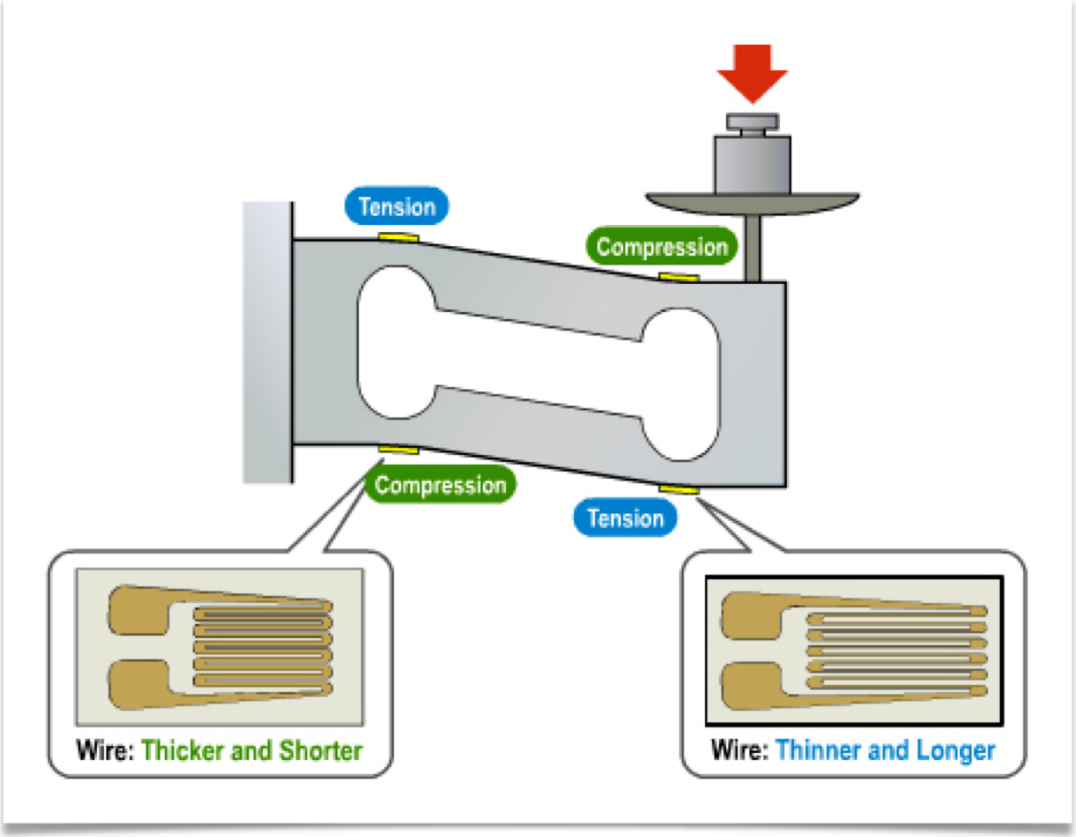


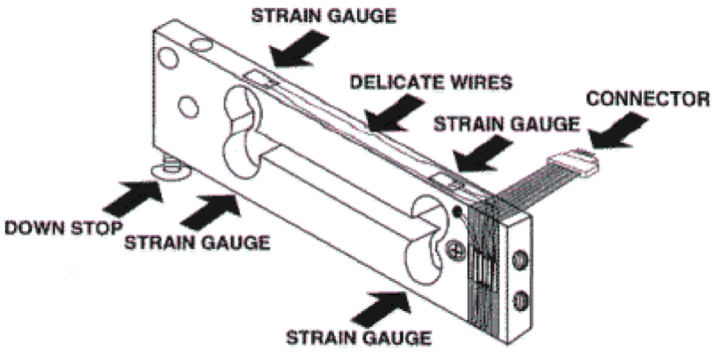
Strain Gauge Applications





Strain Gauge





https://learn.sparkfun.com/tutorials/getting-started-with-load-cells

Model: Strain → Resistance

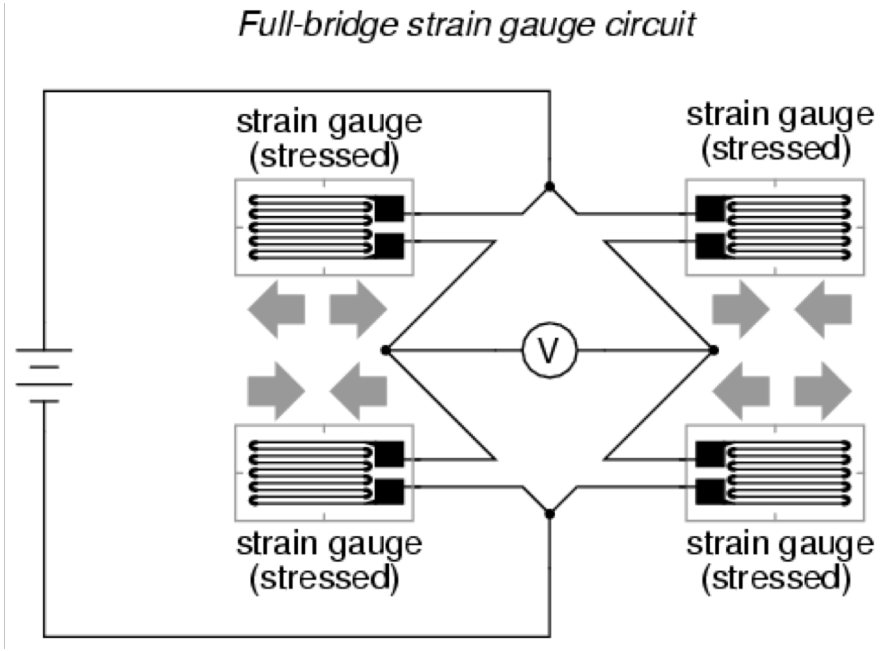
Gauge Factor

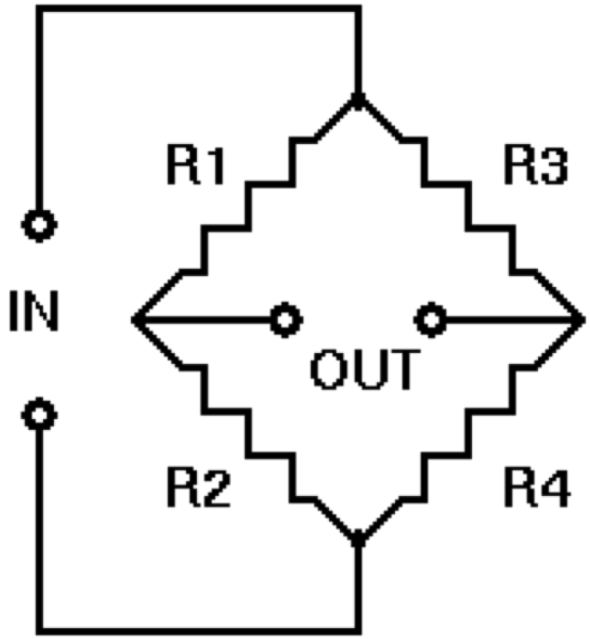
https://en.wikipedia.org/wiki/Gauge_factor

Resistance to Voltage

“Single-Ended” Readout

Bridge Circuit





ADC

Reference

Supply Voltage Sensitivity

Supply Voltage Accuracy

ANALOG DEVICES

Precision, Micropower LDO Voltage References in TSOT

ADR121/ADR125/ADR127

FEATURES

- Initial accuracy
  - A grade: ±0.24%
  - B grade: ±0.12%
- Maximum temperature coefficient
  - A grade: 25 ppm/°C
  - B grade: 9 ppm/°C
- Low dropout: 300 mV for ADR121/ADR125
- High output current: +5 mA/−2 mA
- Low typical operating current: 85 µA
- Input range: 2.7 V to 18 V for ADR127
- Temperature range: −40°C to +125°C
- Tiny TSOT (UJ-6) package

APPLICATIONS

- Battery-powered instrumentation
- Portable medical equipment
- Data acquisition systems
- Automotive

PIN CONFIGURATION

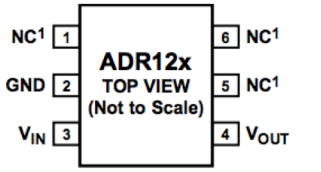


Figure 1.

ADC

Product Folder | Order Now | Technical Documents | Tools & Software | Support & Community

TEXAS INSTRUMENTS

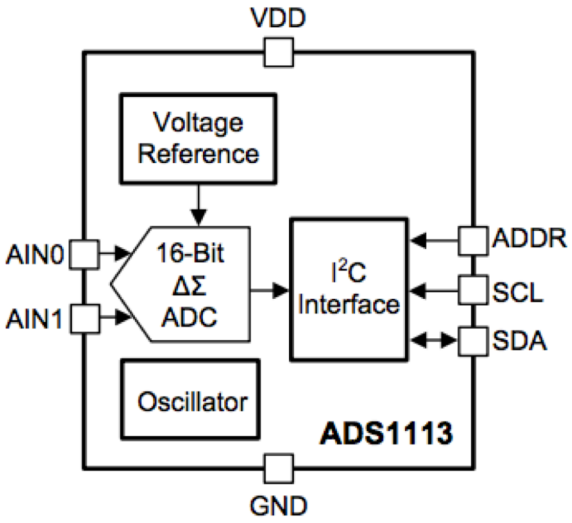
ADS1113, ADS1114, ADS1115

SBAS444D – MAY 2009 – REVISED JANUARY 2018

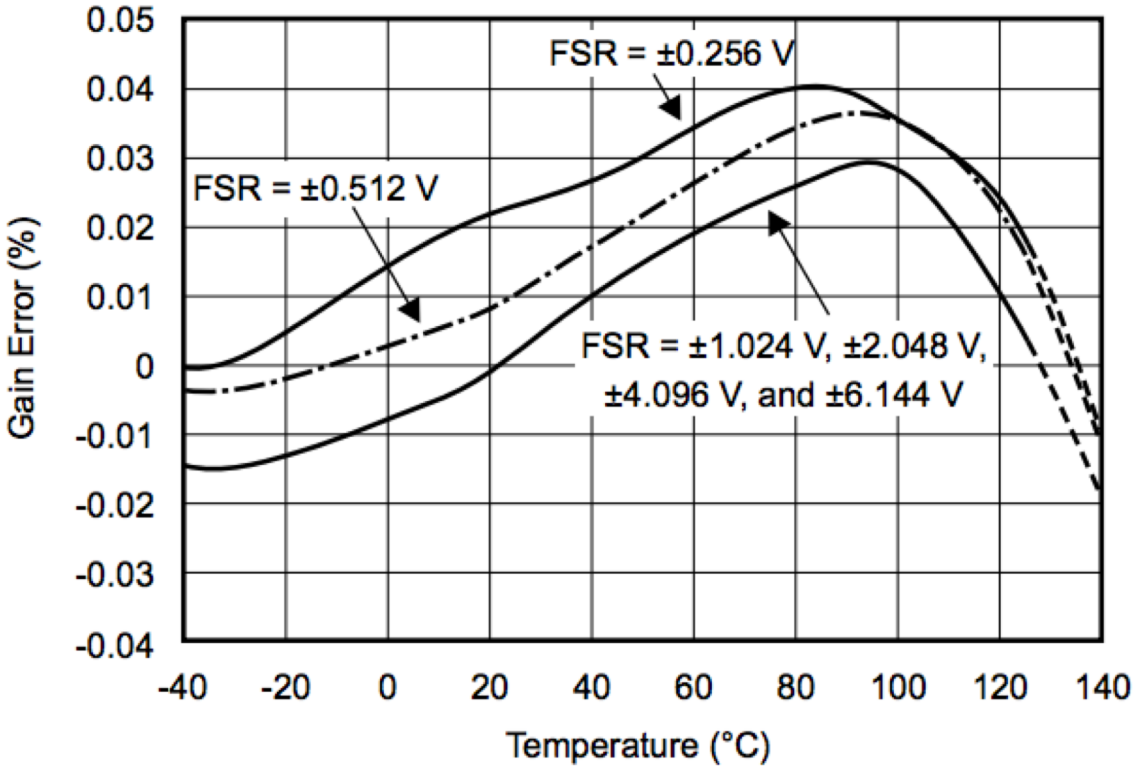
ADS111x Ultra-Small, Low-Power, I²C-Compatible, 860-SPS, 16-Bit ADCs With Internal Reference, Oscillator, and Programmable Comparator

1 Features

- Ultra-Small X2QFN Package: 2 mm × 1.5 mm × 0.4 mm
- Wide Supply Range: 2.0 V to 5.5 V
- Low Current Consumption: 150 μA (Continuous-Conversion Mode)
- Programmable Data Rate: 8 SPS to 860 SPS
- Single-Cycle Settling
- Internal Low-Drift Voltage Reference
- Internal Oscillator



ADC Reference



Precision References

MAX6126

Ultra-High-Precision, Ultra-Low-Noise, Series Voltage Reference

General Description

The MAX6126 is an ultra-low-noise, high-precision, low-dropout voltage reference. This family of voltage references feature curvature-correction circuitry and high-stability, laser-trimmed, thin-film resistors that result in 3ppm/°C (max) temperature coefficients and an excellent ±0.02% (max) initial accuracy. The proprietary low-noise reference architecture produces a low flicker noise of 1.3µV_{P-P} and wideband noise as low as 60nV/$\sqrt{Hz}$ (2.048V output) without the increased supply current usually found in low-noise references. Improve wideband noise to 35nV/$\sqrt{Hz}$ and AC power-supply rejection by adding a 0.1µF capacitor at the noise reduction pin. The MAX6126 series mode reference operates from a wide 2.7V to 12.6V supply voltage range and load-regulation specifications are guaranteed to be less than 0.025Ω for sink and source currents up to 10mA. These devices are available over the automotive temperature range of -40°C to +125°C.

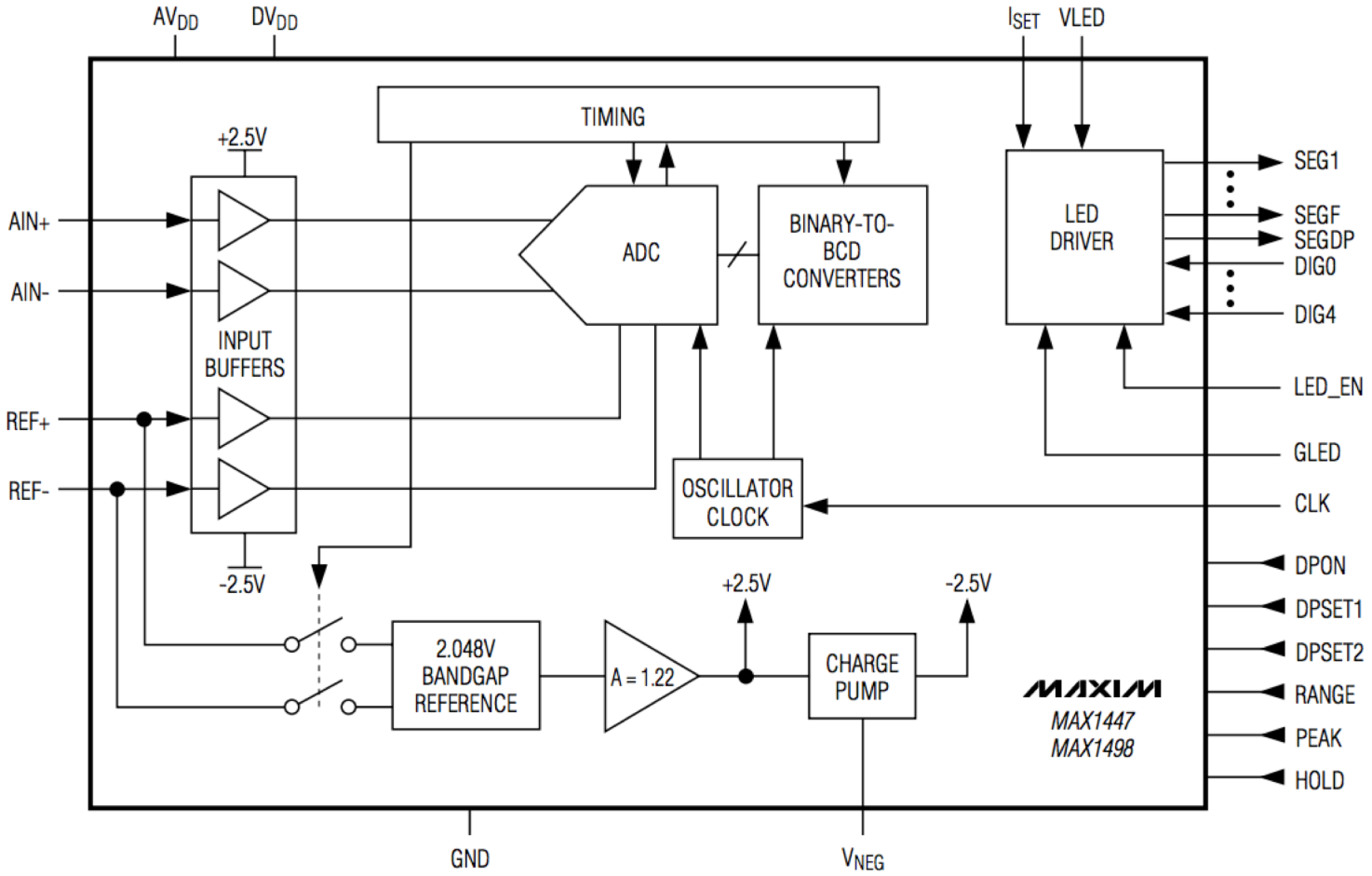
Benefits and Features

- Ultra-Low 1.3µV_{P-P} Noise (0.1Hz to 10Hz, 2.048V Output)
- Ultra-Low 3ppm/°C (max) Temperature Coefficient
- ±0.02% (max) Initial Accuracy
- Wide (V_{OUT} + 200mV) to 12.6V Supply Voltage Range
- Low 200mV (max) Dropout Voltage
- 380µA Quiescent Supply Current
- 10mA Sink/Source-Current Capability
- Stable with C_{LOAD} = 0.1µF to 10µF
- Low 20ppm/1000hr Long-Term Stability
- 0.025Ω (max) Load Regulation
- 20µV/V (max) Line Regulation
- Force and Sense Outputs for Remote Sensing

Reference Mismatch

Ratiometric Measurement

ADC with external Reference



https://datasheets.maximintegrated.com/en/ds/MAX1447-MAX1498.pdf

Signal Range

Voltage Amplifier

Amplification

ANALOG DEVICES

3 nV/√Hz, Low Power Instrumentation Amplifier

Data Sheet **AD8421**

FEATURES

- **Low power**
  - **2.3 mA maximum supply current**
- **Low noise**
  - **3.2 nV/√Hz maximum input voltage noise at 1 kHz**
  - **200 fA/√Hz current noise at 1 kHz**
- **Excellent ac specifications**
  - **10 MHz bandwidth (G = 1)**
  - **2 MHz bandwidth (G = 100)**
  - **0.6 µs settling time to 0.001% (G = 10)**
  - **80 dB CMRR at 20 kHz (G = 1)**
  - **35 V/µs slew rate**

PIN CONNECTION DIAGRAM

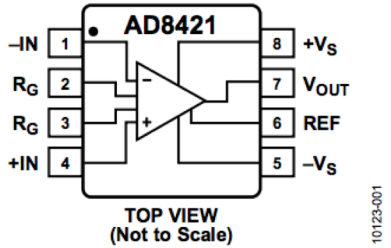
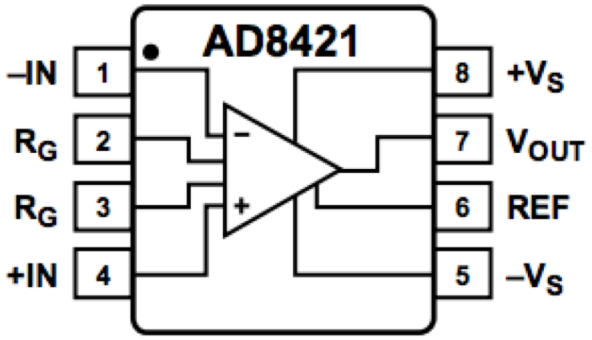


Figure 1.

Gain

Table 6. Gains Achieved Using 1% Resistors

1% Standard Table Value of R_G	Calculated Gain
10 kΩ	1.99
2.49 kΩ	4.98
1.1 kΩ	10.00
523 Ω	19.93
200 Ω	50.50
100 Ω	100.0
49.9 Ω	199.4
20 Ω	496.0
10 Ω	991.0
4.99 Ω	1985



Supply Voltage

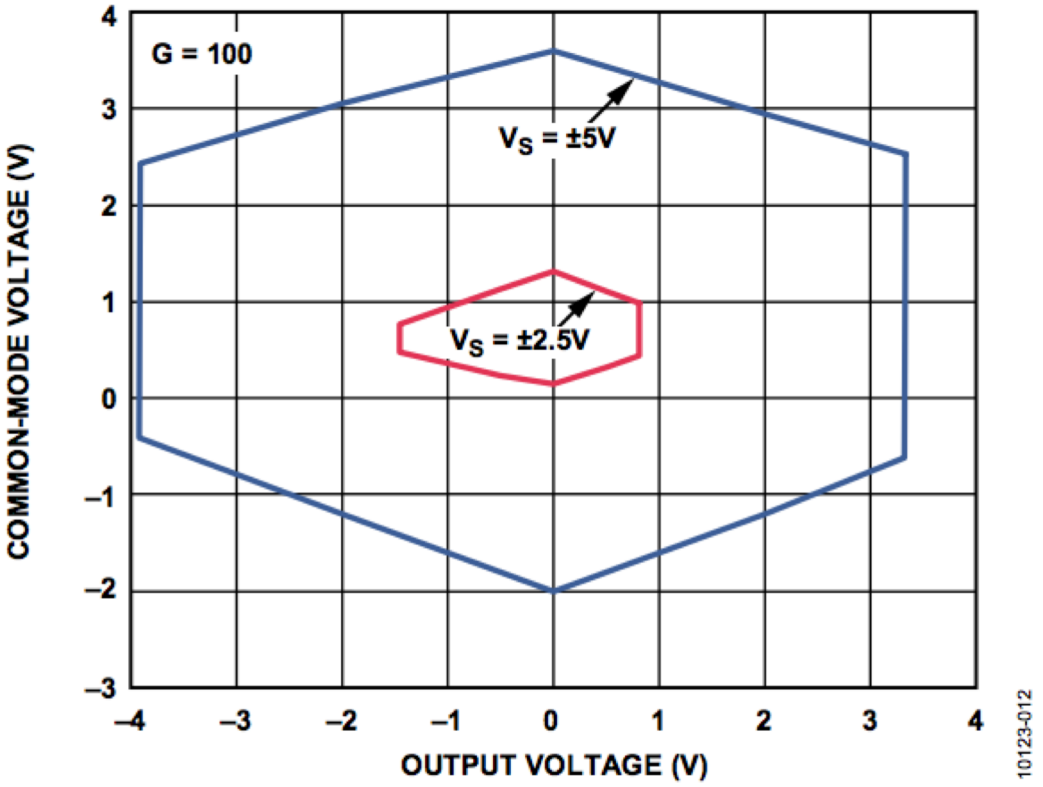
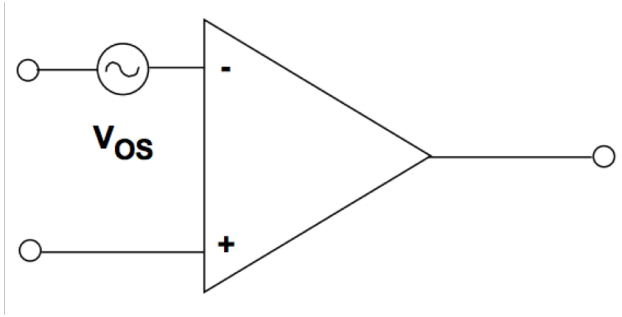


Figure 13. Input Common-Mode Voltage vs. Output Voltage; V_S = ±2.5 V and ±5 V (G = 100)

Offset Voltage



- Chopper Stabilized Op Amps: <1μV
- General Purpose Precision Op Amps: 50-500μV
- Best Bipolar Op Amps: 10-25μV
- Best JFET Input Op Amps: 100-1,000μV
- High Speed Op Amps: 100-2,000μV
- Untrimmed CMOS Op Amps: 5,000-50,000μV
- DigiTrim™ CMOS Op Amps: <100μV-1,000μV

http://www.analog.com/media/en/training-seminars/tutorials/MT-037.pdf

AD8421 Input Offset Voltage

Parameter	Test Conditions/ Comments	AR Grade Min	AR Grade Typ	AR Grade Max	BR Grade Min	BR Grade Typ	BR Grade Max	Unit
VOLTAGE OFFSET[2]								
Input Offset Voltage, V_{OSI}	V_S = ±5 V to ±15 V			60			25	µV
Over Temperature	T_A = −40°C to +85°C			86			45	µV
Average TC				0.4			0.2	µV/°C

Selection Tables

Instrumentation Amplifiers

Choose Parameters | All | I | Reset Table | Maximize Filters | Sort by Newest | Download to Excel | Share | Quick Tips

Filter parts

60 parts

Part Number	# of Amps 3 Values Selected HIDE	Vos *max	V* 10u - 3.5m HIDE	Vos TC *max	V/°C* 50n - 8u HIDE	Gain Set 5 Values Selected HIDE	Gain *min	V/V* 0.1000 - 2000 HIDE	Gain *max	V/V* 5.000 - 1.000e- HIDE	BW - low gain *typ	Hz* 250 - 35M HIDE
AD8233	-	-		-		-	100		100		-	
AD8422	1	25µ		300n		Resistor	1		1000		2.2M	
AD8232	-	-		-		-	100		100		-	
AD8237	1	75µ		200n		Resistor	1		1000		200k	
AD8421	1	25µ		200n		Resistor	1		1000		10M	
AD8420	1	150µ		1µ		Resistor	1		1000		250k	
AD8428	1	25µ		300n		Fixed Gain	2000		2000		3.5M	
AD8426	2	150µ		1.5µ		Resistor	1		1000		1.5M	
AD8429	1	50µ		300n		Resistor	1		10000		15M	
AD8229S	-	-		-		-	-		-		-	
AD8229	1	100µ		1µ		Resistor	1		1000		15M	
AD8235	1	2.5m		700n		Resistor	5		200		23k	
AD8227	1	100µ		1µ		Resistor	5		1000		250k	
AD8236	1	3.5m		-		Resistor	5		200		23k	
AD8226	1	50µ		1µ		Resistor	1		1000		1.5M	
AD8295	1	60µ		300n		Resistor	1		1000		1.2M	

Temperature Sensitivity

Temperature Sensitivity