Precision Amplifiers

Roadmaps, XY Plots, and Technologies

TEXAS INSTRUMENTS

Precision Amplifiers
Technology and products diversification

Leading Process Technologies

- **1.8V to 180V** process capabilities
- Laser Trim **Thin-Film** Resistors
- Integrated 80V **Overvoltage Protection**
- **Burr-Brown™** for high fidelity audio
- 36V CMOS, Bipolar & JFET options
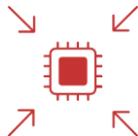
Manufacturing Footprint & Delivery

- **300mm** wafer capability
  - → HPA9 Precision CMOS
  - Best in class noise performance and voltage domain capability
- **Multi-fab** support to maintain supply continuity
- Proven track record of **on-time delivery**

Innovation

- Zero-drift
- E-Trim™
- Super beta
- Zero-crossover
- MUX-Friendly™
- JFET

High Quality & Reliability

- Rigorous testing to meet quality, reliability standards
- Max spec: > **5 sigma distribution**
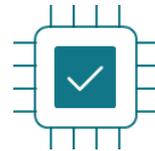
HPA9 Analog CMOS | Precision and lower Noise

Versatility

- Multiple voltage levels:
  - <48V, 48V, 85V, 120V, 200V
- Triple gate oxide:
  - 1.8V, 5V, 48V
- Widest component base:
  - CMOS, LDMOS, DECMOS, bipolar,
  - JFET, NVM (OTP, EEPROM, Efuse)
- Precision Capacitors
- Precision Resistors
- Thick Metal
- 300mm capability

30% Better matching

Input Offset Voltage (VOS) vs. Bandwidth (GBW)
5V, Linear (no Zero Drift/Chopper)

OPA392
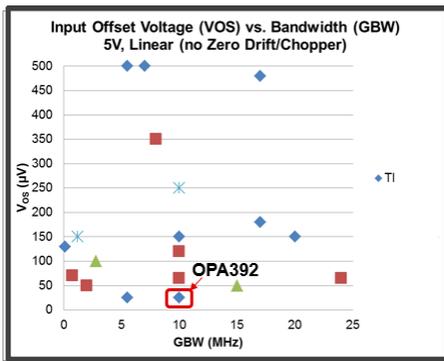
Lower 1/f noise

Small Footprint

DSBGA Package

OUTA	V+	OUTB
-INA	EN	-INB
+INA	V-	+INB

0.4mm (Typ)

1.3mm (Typ)

1.3mm (Typ)

dual precision amplifier

Ultra-low input bias current

<15 fA at 25°C

TEXAS INSTRUMENTS
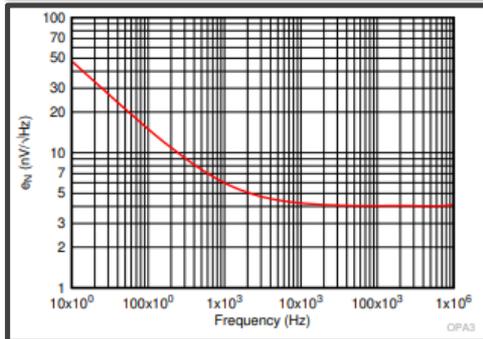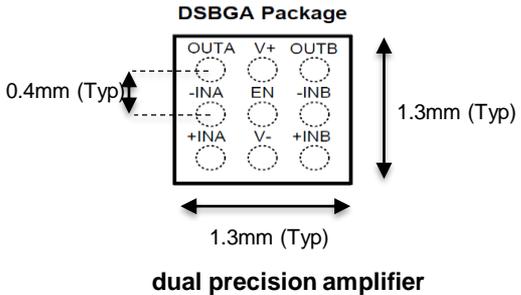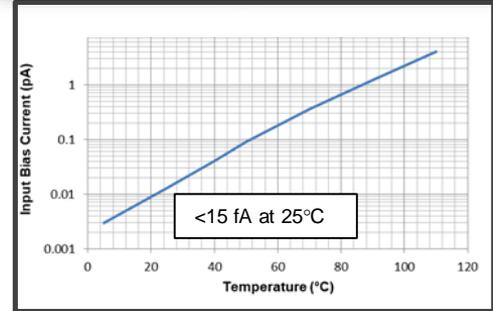
Precision Amplifiers Industry-leading technologies

- Enables µV offset and nV drift
- No Vos change over time/temperature
- No (1/f) noise

Zero-Drift

Super-Beta

- Low IB
- Ultra low current noise
- Higher Zin

- Eliminates parameter shifts
- Sub 25µV offset without calibration
- Allows miniature package sizes

E-trim™

PRAMPS Key Technologies

JFET

- Buried layer
- Low distortion
- High Zin
- Low 1/f corner

MUX Friendly™

Zero-Crossover

- True high-impedance differential input capability
- Fast-settling time
- No input diodes

- Ultra-high input linearity
- No input crossover distortion
- No dead band
- No transition

e-Trim™ Technology Overview

Differentiation

- Post assembly trim
- No Vos shift due to packaging stress
- No Vos, TCVos shift
- Low offset without self-calibration

System Benefits

- Stable Vos over CM
- Allows miniature package size
- Better long-term stability
- Versatile application use cases

Product Examples

Specifications	E-Trim OPA392	Laser trim OPA320
Input Offset (µV) (Typ, Max)	1, 10	40, 150
Input Offset Drift (µV/°C) (Typ, Max)	0.16, 0.8	1.5, 5

Specifications	E-Trim OPA2205	Laser trim OPA2277A
Input Offset (µV) (Typ, Max)	5, 25	35, 100
Input Offset Drift (µV/°C) (Typ, Max)	0.1, 0.3	0.15, 1

Input Offset Digital Trimming
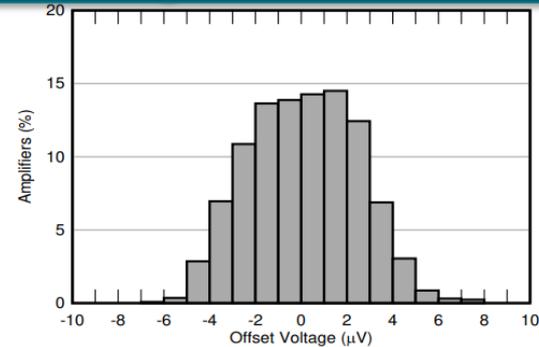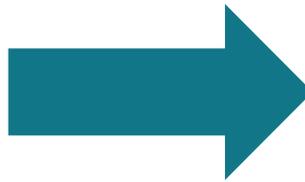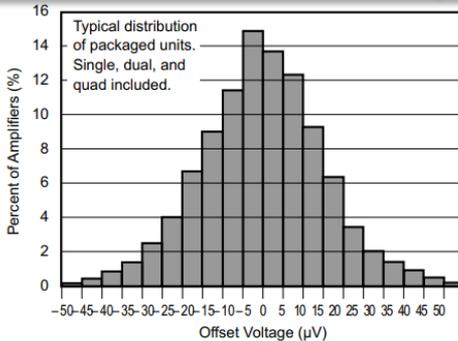
OPA2277 Laser-Trimmed Operational Amplifier Offset Voltage Distribution

OPA2205 e-trim™ Operational Amplifier Offset Voltage Distribution

OPAx39x: TI's Low Voltage e-trim™ Op Amps Family

Features

- **True-RRIO** allows for use of the full dynamic range
- **Lowest offset linear amp:** 10uV of max offset (OPAx392)
- **Low input bias current** provide low noise with high impedance sensor interface
- **e-Trim™** - no parameter shifts due to packaging stress
- **Highest speed to power ratio** in its class

Package Options

Packages**: (Released / Sampling / Preview) :**

OPA391 (SC-70-5, SOT553-5, VSSOP-8, WCSP) | OPA2391 (RUG, VSSOP-8, WCSP)

Packages**: (Released / Sampling / Preview) :**

OPA392 (SOT23-5, SC70, WCSP) | OPA2392 (SOIC-8, VSSOP-8, QFN, WCSP) | OPA4392 (TSSOP-14, QFN)

Specifications	Low Iq: 22uA		Low Bias: 1pA	
	OPA391	OPA396	OPA392	OPA397
Vos (max)	45 µV	100 µV	10 µV	60 µV
Vos Drift (typ)	0.1 µV/°C	0.1 µV/°C	0.1 µV/°C	0.1 µV/°C
Ibias (max)	0.8 pA	10 pA	0.8 pA	0.8 pA
Voltage noise	50 nV/√Hz	50 nV/√Hz	6 nV/√Hz	6 nV/√Hz
1/f Noise	4.3 µVp-p	4.3 µVp-p	1.7 µVp-p	1.7 µVp-p
GBW (G=1)	1 MHz	1 MHz	13 MHz	13 MHz
I_Q (max)	21 µA	22 µA	1.22 mA	1.22 mA
Price (1K) (Single)	$0.83	$0.59	$0.92	$0.59

OPA391/6 Applications

- Process automation
- Process control
- Medical Instrumentation
- Batter-power instrumentation
- Power monitoring

OPA392/7 Applications

- Optical Modules
- Pulse Oximeter
- Medical Instrumentation
- Blood Glucose Monitors
- Low Power Instrumentation

TI TechNotes — *Offset Correction Methods: Laser Trim, e-Trim ™, and Chopper*

TEXAS INSTRUMENTS

Super Beta Technology Overview

Differentiation

- Lower Ib
  - Lower current noise
  - Higher Zin
- Better transistor matching
 - Lower Vos

System Benefits

- Enables higher system accuracy
- Versatile use cases
  - Ideal for interfacing with high source impedances
- Maintains signal integrity

Product Examples

	Device		I_B (nA)	V_{os} (µV)	V_{os} Drift (µV/°C)
Op Amps	OPA2210 Superbeta	max	±2	35	0.6
	OPA2209 Traditional	max	±4.5	150	3
INAs	INA818 Superbeta	max	±0.5	35	0.5
	INA118 Traditional	max	±5	50	1

Improving industry standard

Superbeta vs. Traditional BJT
Ib Comparison

Traditional (INA118)

Suberbeta (INA818)
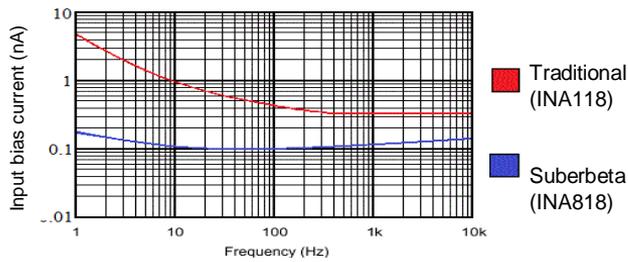
Lower current noise
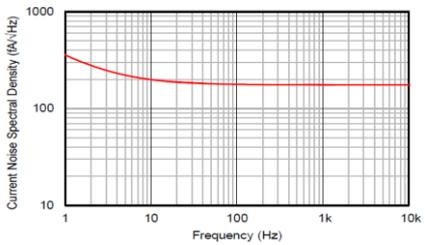
Superbeta vs. Traditional BJT
Offset Voltage Drift Production Distribution

OPA2210 Superbeta

OPA2209 Traditional

TEXAS INSTRUMENTS
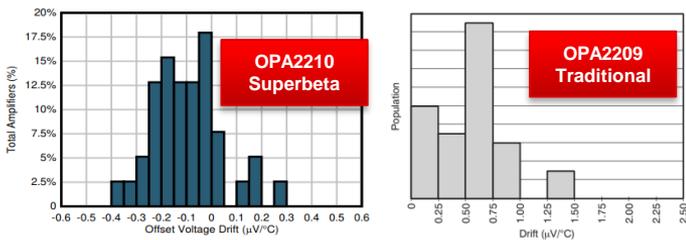
Improved Superbeta (SNPN) transistors

Better matching

New SNPN
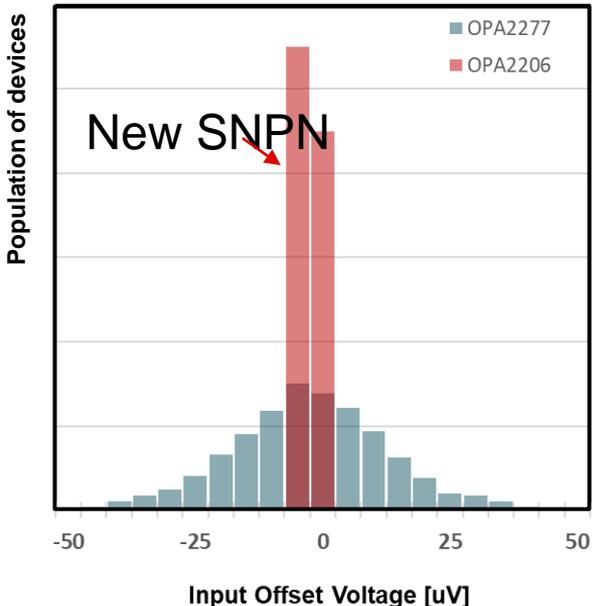
Amplifier examples: THP210 | INA821 | INA819 | INA818
OPA2206 | INA849 | INA848 | OPA2205

Higher input impedance and lower noise

INA118

INA818

New SNPN
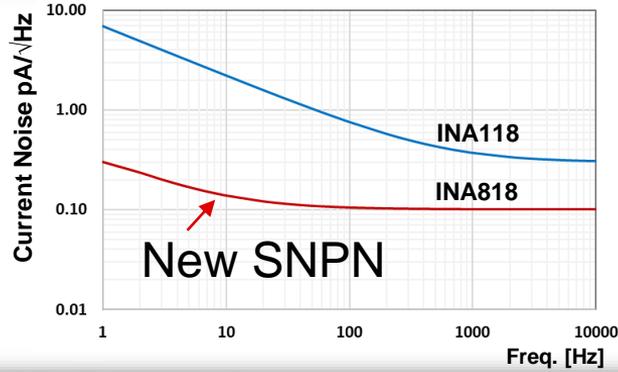
Product Examples

OpAmps

Device		I_B (nA)	V_os (µV)	V_os Drift (µV/°C)
OPA2206 Superbeta	max	±0.4	15	0.2
OPA2227 Traditional	max	±10	75	0.6

INAs

Device		I_B (nA)	V_os (µV)	V_os Drift (µV/°C)
INA818 Superbeta	max	±0.5	35	0.4
INA118 Traditional	max	±5	50	1

TEXAS INSTRUMENTS

8

OPAx205- 36V e-Trim™, Super Beta op amp (250 µA/ch)

Bipolar, high precision, low power, low noise, low input bias current

Features

- Input Offset Voltage: **25 µV** (max)
- Offset Voltage Drift: **0.3 µV/°C** (max)
- Input Bias Current: **0.75 nA** (max)
- Input Voltage Noise: **7.2 nV/√Hz** at 1kHz
- Output Current: **25 mA** (Short Circuit)
- Gain Bandwidth: **3.6 MHz**
- Slew Rate: **4 V/µs**
- Supply Current: **250 µA** (max)
- Wide Supply Range: **4.5V to 36V**

Released / Sampling / Preview)
OPA205 (**SOIC, MSOP, SOT-23**) | OPA2205 (**SOIC, MSOP, QFN**) |
OPA4205 (**TSSOP, SOIC, QFN**)

Applications

- Industrial Automation
- Test and Measurement
- Sensors and control
- Multi-channel Data Acquisition
- Flow meters
- Analog Input Modules

Benefits

- **e-Trim™ technology** eliminates parameter shifts due to packaging
- **Industry-leading precision** (25 µV max) and drift (0.3µV/°C max), decreases need for external calibration
- **Super beta inputs** helps reduce the device's input bias current and input bias current drift over temperature
- **Low system noise** and **low power**, suitable for portable designs with small error budgets

TI TechNotes *Offset Correction Methods: Laser Trim, e-Trim ™, and Chopper*
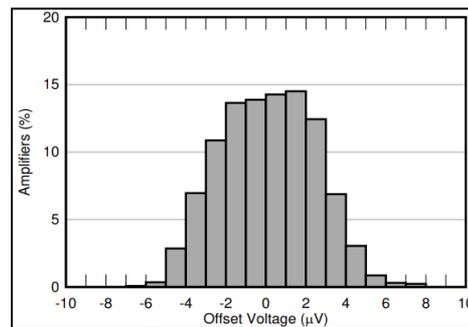
Low Offset Voltage
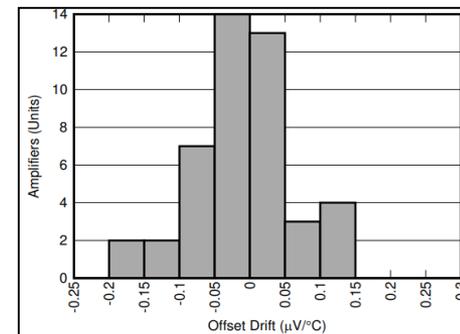
Low Offset Drift

TEXAS INSTRUMENTS

OPAx206- **36V** e-Trim™, Super Beta op amp (250 µA/ch)

Bipolar, high precision, low power, low noise, low input bias current

e-Trim Super Beta

Features

- Input Offset Voltage: **25 µV** (max)
- Offset Voltage Drift: **0.3 µV/°C (max)**
- Input Bias Current: **0.75 nA** (max)
- Input Voltage Noise: **8 nV/√Hz** at 1kHz
- Output Current: **25 mA** (Short Circuit)
- Gain Bandwidth: **3.6 MHz**
- Slew Rate: **4 V/µs**
- Supply Current: **250 µA** (max)
- Wide Supply Range: **4.5V to 36V**

Released / Sampling / Preview)
OPA206 (SOIC, MSOP, SOT-23) | OPA2206 (SOIC, MSOP, QFN) |
OPA4206 (TSSOP, SOIC, QFN)

Applications

- Industrial Automation
- Test and Measurement
- Sensors and control
- Multi-channel Data Acquisition
- Flow meters
- Analog Input Modules

Benefits

- **e-Trim™ technology** eliminates parameter shifts due to packaging
- **Industry-leading precision** (25 µV max) and drift (0.3µV/°C max), decreases need for external calibration
- **Super beta inputs** helps reduce the device's input bias current and input bias current drift over temperature
- **Low system noise** and **low power**, suitable for portable designs with small error budgets
- **Integrated input overvoltage protection** (OVP) increases system robustness

TI TechNotes *Offset Correction Methods: Laser Trim, e-Trim ™, and Chopper*
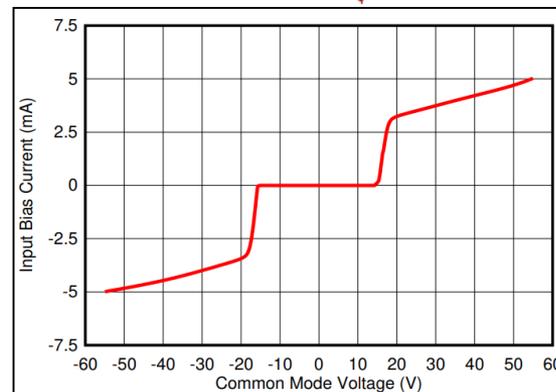
Integrated input overvoltage protection (OVP) protects the system from fault conditions, even when unpowered

TEXAS INSTRUMENTS

OPAx210- 36V Super Beta input Op Amp (2.2 nV/√Hz)
High precision, low drift, ultra low noise, small packages

Super Beta

Features

• Voltage noise:	**2.2 nV/√Hz** at 1kHz
• Voltage noise 0.1 to 10 Hz:	**90 nVpp**
• Current Noise	**400 fA/√Hz**
• Offset voltage:	**35 µV** (max)
• Offset voltage drift:	**0.5 µV/ºC** (max)
• Bias current	**0.3 nA** (typ)
• Gain bandwidth:	**18 MHz**
• Slew Rate:	**6.4 V/µs**
• Low supply current:	**2.5 mA** (max)
• Wide Supply Range:	**4.5V to 36V**

(Released / Sampling / Preview)

OPA210 (SOIC-8, MSOP-8, SOT-23)

**OPA2210 (SOIC-8, MSOP-8, QFN 3mmX3mm)**

Applications

|	
• Ultrasound scanners	• Semiconductor test equipment
• Medical instrumentation	• PLL loop filters
• Merchant network PSU	• Audio preamplifier
• High-performance ADC drivers	• Lab instrumentation

Benefits

• **Low input voltage** and **current noise** which makes the OPA2210 suitable for circuits with a high source impedance

• **Better transistor matching** and **better temperature stability** (than traditional bipolar devices) which yields high precision across all industrial temperature range

• **Super beta technology** helps reduce the device's input bias current and input bias current drift over temperature

• **High bandwidth** and **slew rate** enables linearity

• **Rail-to-rail output swing** maximizes dynamic range

• **Fast settling** time to 16-bit accuracy for 10 V output swings

OPA2210 0.1-Hz to 10-Hz Noise
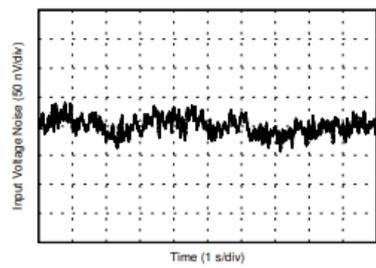
OPA2210 Offset Voltage Drift Distribution

TEXAS INSTRUMENTS
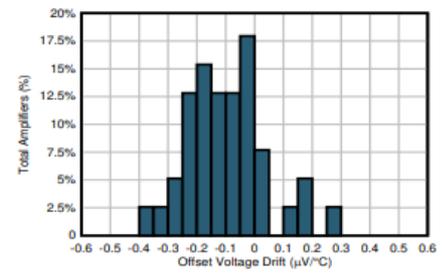
INA849- 36V Instrumentation amp (15 MHz)

Industry leading ultra-low noise, high bandwidth, high precision

Features

• Voltage noise:	**1 nV/√Hz** at 1kHz
• Gain bandwidth:	**28 MHz**
• Slew rate:	**35 V/µs**
• Voltage offset:	**35 µV** (max)
• Offset voltage drift:	**0.4 µV/ºC** (max)
• CMRR (high gain):	**120 dB** (min)
• Bias current	**20 nA** (max)
• Gain error:	**0.05 %** (max)
• Supply current:	**6 mA** (typ)
• Wide Supply Range:	**8V to 36V**

Released| Sampling| Preview

**SOIC|8 [APL], DGK [APL], , QFN**

Applications

- Optical networking
- Ultrasound scanners
- Gas detectors
- Battery testers
- Oscilloscopes
- Bearing failure detection

Benefits

- **Industry's lowest noise** instrumentation amplifier with low distortion enables the highest resolution for data acquisition systems such as ultrasound scanners and vibration analysis
- **Industry's highest bandwidth** instrumentation amplifier with better quiescent current to bandwidth ratio than competitors
- **Low input offset and drift** enable extremely accurate measurements for battery testers and oscilloscopes
- Device variant with fixed gain (G=2,000) available: **INA848**

$$V_O = G(V_{+IN} - V_{-IN}) + V_{REF}$$

$$G = 1 + \frac{6\ k\Omega}{R_G}$$

TEXAS INSTRUMENTS
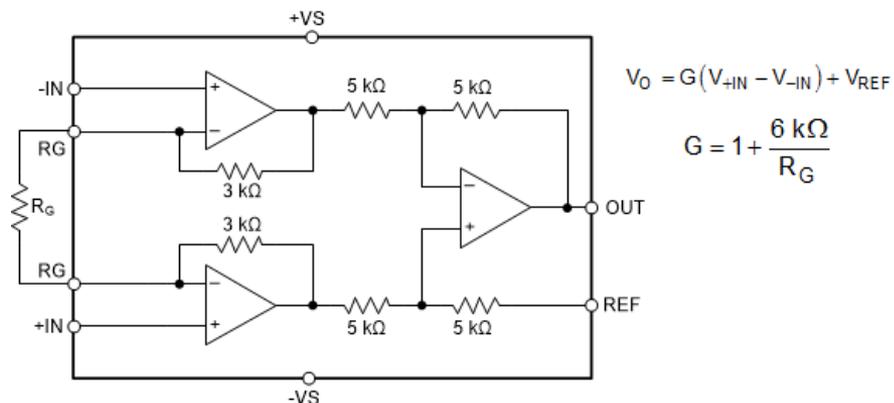
INA823- Precision Instrumentation Amplifier

Low Power | High Precision | 2.7 V - 36 V| Tiny Package MSOP-8, DFN 3x3

Low IQ

Features

- **High DC Precision**
  - **Offset Voltage**   **150 µV** (max) (G > 100)
  - Gain Drift   1 ppm/°C (G = 1)
                                  35 ppm/°C (G > 1)

- **AC Performance**
  - Low Noise   18 nV/√Hz, G ≥ 100
  - Wide Bandwidth   900 kHz (G = 1),
                                 60 kHz (G = 100)
  - **CMRR**   **120 dB, Min (G = 100)**
  - PSRR   140 dB, Min (G = 100)

- **Rail-to-Rail Output Swing**
  - Supply Range   **2.7 V** to 36 V
  - **Supply Current**   **250 µA (typ)**
  - Input Common Mode Range   Down to −150 mV
                                 below (V−)

  Input Protection Up to ± 60 V (± 80 V for short transient)

Applications

- Factory Automation (PLC)
- Circuit Breakers
- Battery Testing
- Power Automation
- Bio- Medical Instrumentation

Benefits

- Low input voltage down to **2.7 V** enables operation in portable battery applications
- Reduction in power supply consumption **to 250 µA** over competition maximizes battery life time
- Tiny package allows for high density design and higher channel count
- Integrated filter optimizes for best **EMI** performance
- Input overvoltage protection up to **± 60 V DC** and **± 80 V** for short transients

(Released / Sampling / Preview)
   INA823 (**MSOP-8, D**

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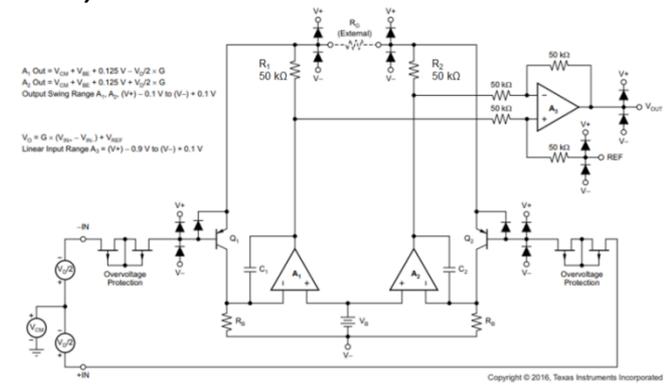
THP210- 36V Fully differential amp (950-µA)

High precision, low noise, RRO, Super Beta inputs

Features

•	Gain bandwidth:	**9.2** MHz
•	Slew rate:	**15** V/µs
•	Voltage noise:	**3.7 nV/√Hz** at 1kHz
•	Current noise:	**300 fA/√Hz** at 1kHz
•	THD+N:	**-120 dB** (@ 10KHz)
•	Voltage offset:	**40 µV** (@ 25ºC, max)
•	Offset voltage drift:	**0.35 µV/ºC** (max)
•	Bias current	**2 nA** (@ 25ºC, max)
•	Cap Load Drive:	**50** pF
•	Supply current:	**950 µA** (typ)
•	Wide Supply Range:	**3V to 36V**

Released / Sampling / Preview)

THP210 (VSSOP-8, SOIC-8)

Applications

- Vibrational analysis
- Modal analysis
- Acoustics
- Power quality analysis
- GP data acquisition

Benefits

- **Wide bandwidth and high speed** allows the device to be used with high resolution 24-bit Delta-Sigma ADCs
- **Super beta** inputs provide very low noise levels for maximum accuracy at low power
- **Low THD** reduce front end error contribution and provide extremely accurate analog-to-digital conversions
- **High-precision** reduces need for calibration and improves accuracy
- **Wide supply range** improves dynamic range for a variety of signal sources
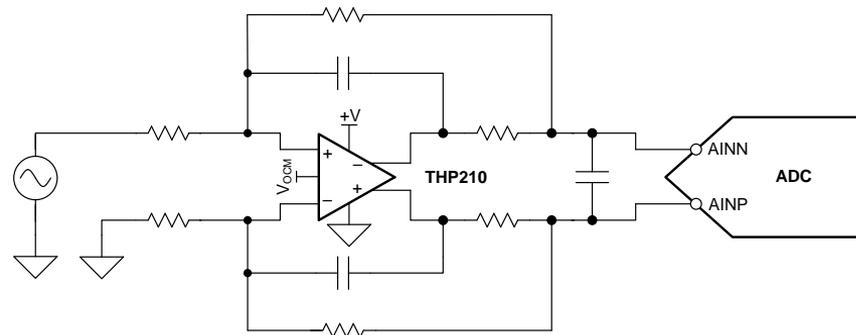
36V Op Amps and INAs with Super beta Inputs

NEW!

Specifications	OPAx202	OPA2205	OPA2206	OPAx210
Vos (µV) (max)	200	25	25	35
Vos Drift (µV/°C) (typ)	0.5	0.1	0.1	0.1
Ibias (nA) (max)	2	0.75	0.75	2
Input Current Noise (fA/$\sqrt{\text{Hz}}$) (typ)	76	200	200	400
Voltage Noise (nV/$\sqrt{\text{Hz}}$) (typ)	9	7.2	8	2.2
1/f Noise (µV$_{pp}$) (typ)	0.2	0.15	0.15	0.09
Overvoltage Protection	No	No	± 40V	No

NEW!!

Specifications	INA818/ INA819	INA821	INA828
Vos (µV) (max)	35	35	50
Vos Drift (µV/°C) (max)	0.4	0.4	0.5
Ibias (nA) (max)	0.5	0.5	0.6
Input Current Noise (fA/$\sqrt{\text{Hz}}$) (typ)	130	130	170
Voltage Noise (nV/$\sqrt{\text{Hz}}$)	8	7	7
GBW (MHz) (typ)	2	4.7	2
Iq (mA) (typ)	0.35	0.6	0.6
Overvoltage Protection	± 60V	± 40V	± 40V

Op Amp Applications Examples

- Semiconductor Test
- DAQ
- High-End Medical Instrumentation
- Ultrasound Equipment
- Analog Input Modules

INAs Applications Examples

- Biopotential Measurements
- Bridge Sensing Elements
- Current Leakage Detection
- Field Transmitters
- Battery Test Equipment

INA819 and INA821 QFN offerings !!

WSON (8Pin) Package

3 mm x 3 mm

TEXAS INSTRUMENTS

Zero-drift Technology Overview

Operation

- Self correcting technology to achieve:
  - Ultra-low input offset voltage
  - Near-zero input offset voltage drift
- Input offset voltage averages to zero
- Chopper stabilized or auto-zero

Differentiation

- Best in class DC performance
- No 1/f noise
- More practical than continuous-time amps
  - Development time, cost and board space

System Benefits

- Eliminates calibration
- Very low p-p noise for higher resolution
- Allows for very high gain circuits
- Reduces errors due to Aol, CMRR and PSRR

DC and AC performance for precision measurements

Vos distribution
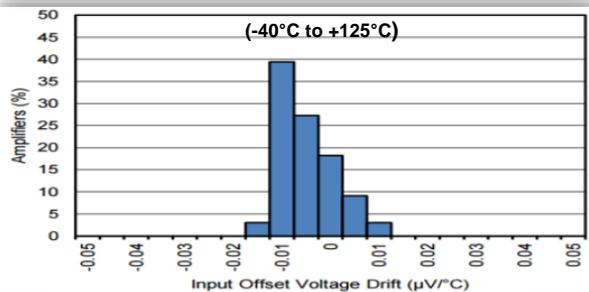
No 1/f
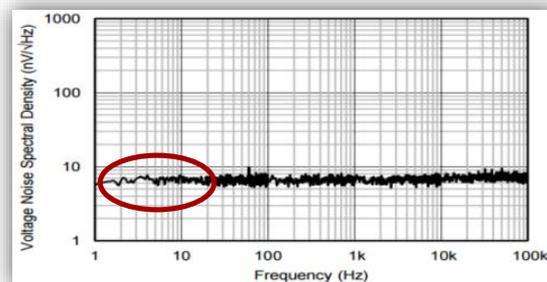
Product Examples

Specifications	Zero Drift OPA189	E-trim OPA192
Input Offset (µV) (Typ, Max)	3	25
Input Offset Drift (µV/°C) (Max)	0.02	0.5

Specifications	Zero Drift OPA388	E-trim OPA376
Input Offset (µV) (Typ, Max)	5	25
Input Offset Drift (µV/°C) (Max)	0.05	0.5

TI's **High Voltage Zero-drift** Op Amps Family

Features

- **Industry's lowest offset drift op amps**
  - OPAx182: **45%** lower drift vs competition

- **24 V Zero-drift amp with RRIO**
  - TLVx186: only one in its class with RRIO

- **Wide gain-bandwidth options:** 0.55 – **14MHz**
  - Wideband operation enables fast settling and increased throughput in multiplexed / multi-channel systems

- **Low power options for portable applications**
  - Reduce system power without compromising performance: TLVx186 (**90µA**) & OPAx187 (**100µA**)
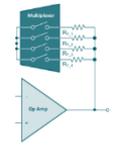
- **p2p package family options**
  - **Single**: SOIC-8, VSSOP-8, SOT-23-5
  - **Dual**: SOIC-8, VSSOP-8
  - **Quad**: SOIC-14, TSSOP-14, WQFN-16

- **MUX-Friendly Inputs**
  - OPAx189, OPAx182, TLV2186

Device	Supply Voltage (V)	Bandwidth (MHz)	Vos (µV)(max)	Vdrift (µV/°C) (max)	Iq (mA) (typ)
OPAx189	4.5-36	14	3	0.050	1.3
OPAx182 **NEW!**	4.0-36	5	4	0.012	0.85
OPAx188	4.0-36	2	25	0.085	0.385
OPAx180	4.0-36	2	75	0.350	0.45
TLVx186 **NEW!!**	4.5-24	0.75	250	0.100	0.09
OPAx187	4.5-36	0.55	10	0.015	0.10

Applications

- Weigh scales
- Test Equipment
- Medical instrumentation
- Precision multichannel systems
- Field Transmitters
- Sensor interfaces (infrared, bridge, thermopile)

TEXAS INSTRUMENTS

OPAx182- 36V Zero-Drift, MUX-friendly Op-Amp (5 MHz)
CMOS, ultra-high precision, fast settling, low noise, RRO

Features

- Input Stage Offset Voltage: **3.5 µV** (max)
- Offset Voltage Drift: **0.02 µV/°C** (max)
- Gain Bandwidth: **5 MHz**
- Slew Rate: **10 V/µs**
- Fast Settling: **10-V 0.01% in 1.7 µs**
- Input Stage Voltage Noise: **5.7 nV/√Hz** at 1kHz
- 0.1-Hz to 10-Hz Noise: **0.12 µVpp**
- Quiescent Current: **0.85 mA** (typ,/ch)
- Supply Range: **4.5V to 36V**
- **MUX-Friendly and RFI/EMI Filtered Inputs**

Packages**: (Released / Sampling / Preview) :**

OPA2182 (SOIC-8, VSSOP-8)

OPA182 (SOIC-8, SOT23-5, VSSOP-8) | OPA4182 (TSSOP-14, SOIC-14)

Applications

- Flow Transmitters
- DC Power Supply, AC Source, Electronic Load
- Data Acquisition
- Test and Measurement Equipment

Benefits

- **Zero-drift** architecture provides ultra-low input offset voltage and near-zero input offset voltage drift over the entire industrial temperature range avoiding the need of calibration

- **Low broadband noise** and **zero flicker noise** enable maximum signal integrity through the signal chain

- **Rail-to-rail output** enables sensing of signals close to supply/ground and maximizes the dynamic range and improved SNR of the signal chain

- **Wide supply range** allows maximum versatility of industrial rails

- **MUX-friendly input** prevents inrush current when applying large input differential voltages which improves settling performance

Offset Voltage (µV) vs Temperature (°C)

TEXAS INSTRUMENTS
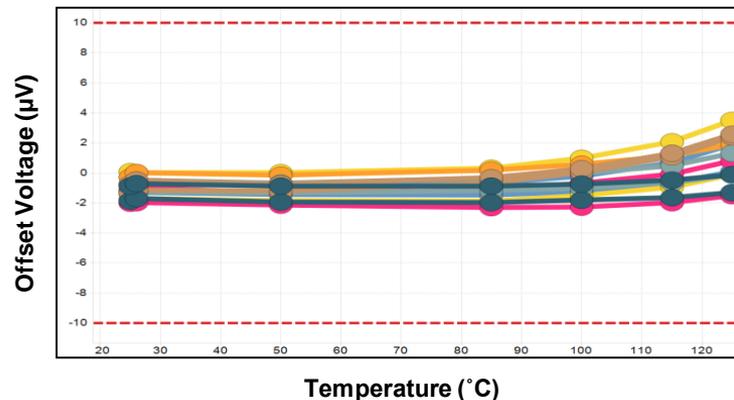
TI's Low Voltage Zero-drift Op Amps Family

Features

- **OPA388: First and only zero-drift and zero-crossover op amp & now Q-100 Qualified!**

- Ultra **low offset and drift**
  - Removes need for calibration and increases DC precision

- **Wide-bandwidth operation: up to 10MHz**
  - Enables high gain configurations
  - Ability to support equipment from precision weigh scales to heart-rate monitors

- **Low power options for portable applications**
  - LPV821 (**650nA**)
  - TLVx333 (**17µA**)

- **p2p package family options***
  - **Single**: SOIC-8, VSSOP-8, SOT-23-5, SC70-5
  - **Dual**: SOIC-8, VSSOP-8, SON-8, WSON-8
  - **Quad**: SOIC-14, TSSOP-14, RUM-16, VQFN-14

*Not all devices listed have all of the package options, refer to the device ds for specific package types

Device	Supply Voltage (V)	Bandwidth (MHz)	Vos (µV) (max)	Vdrift (µV/°C) (typ)	Iq (mA) (typ)	Ibias (pA) (max)
OPA2387 **NEW!!**	1.7	5.7	2	0.003	0.57	135
OPAx388	2.5-5.5	10	5	0.005	1.7	350
OPAx333	1.8-5.5	0.35	10	0.02	0.017	200
OPAx330	1.8-5.5	0.35	50	0.02	0.021	500
LPV821	1.7-3.6	0.008	10	0.02	0.00065	--
OPAx335	2.7-5.5	2	5	0.02	0.285	200
LMP2021	2.2-5.5	5	5	0.004	0.95	100
OPA2333P	1.8-5.5	0.35	10	0.02	0.017	200

Applications

- IR Sensors
- Medical Instrumentation
- Temperature Measurements
- Precision Sensor Applications
- Battery-Powered Instruments
- Current Sensing

TEXAS INSTRUMENTS

OPAx387- 5.5V Zero-Drift Op-Amp (3 µV)

TI's lowest offset voltage, low power, low noise, EMI filtered, RRIO

Features

- Input Stage Offset Voltage: **2 µV** (max)
- Offset Voltage Drift: **0.012 µV/°C** (max)
- Quiescent Current: **570 µA** (typ,/ch)
- Gain Bandwidth: **5.7 MHz**
- Slew Rate: **2.8 V/µs**
- Input Stage Voltage Noise: **8.5 nV/√Hz** at 1kHz
- Input Bias Current: **135 pA** (max)
- Supply Range: **1.7V to 5.5V**
- **Rail-to-rail input and output**
- **EMI filtered**

Packages**: (Released / Sampling / Preview) :**

OPA387 (SOIC-8, SOT23-5, VSSOP-8) | OPA2387 (SOIC-8, VSSOP-8) | OPA4387 (TSSOP-14, SOIC-14)

Benefits

- **Lowest offset voltage** in portfolio and **low drift** removes need for calibration
- **Low Power** for battery-powered and high channel count applications
- **RRIO** increases dynamic Range
- **Low 1.7V supply** suitable for portable applications
- **Integrated EMI filters** reduced interference related offset errors

Applications

- Process automation and control
- Medical Instrumentation
- Photodiode Amplifiers
- Precision Data Acquisition
- Automated Test Equipment
- Battery-powered Instrumentation

TEXAS INSTRUMENTS
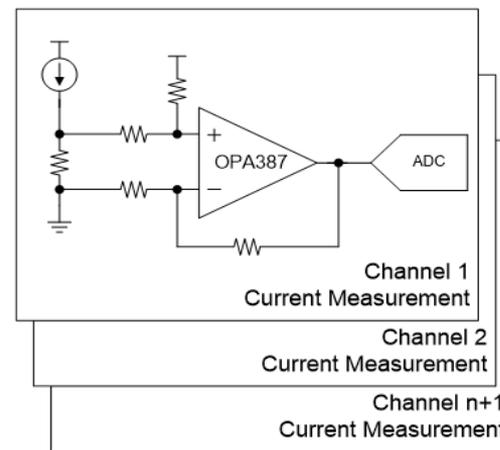
MUX-friendly input Technology Overview

Differentiation

- TI's proprietary input protection circuitry eliminates need for anti-parallel diodes between the inputs

- Large steps from multiplexed systems are handled by patented control block

System Benefits

- Faster settling times while slewing

- No increase in input bias or decrease in input impedance due to conducting diodes

- Fast MUX channel switching without compromising precision

Product Examples

Device	Description
OPAx189 Zero-drift	Only zero-drift HV 14MHz op amp in the market, **2.5-µV** offset
OPAx182 Zero-drift	Lowest offset drift (12nV/C) HV op amp, 5MHz
OPAx191 e-trim™	**25-µV** offset, 2.5-MHz, 200-µA Iq
OPAx192 e-trim™	**25-µV** offset , 10-MHz, 1.2-mA Iq

Technology in Action

Switching Timing Diagram
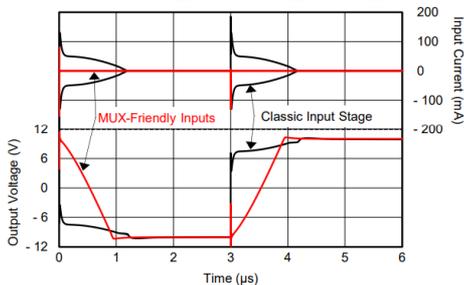
MUX-friendly scheme
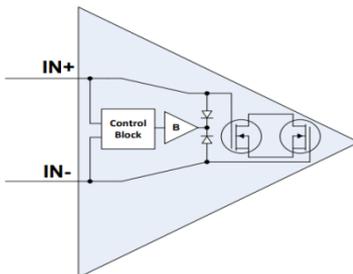
Settling time comparison

TEXAS INSTRUMENTS
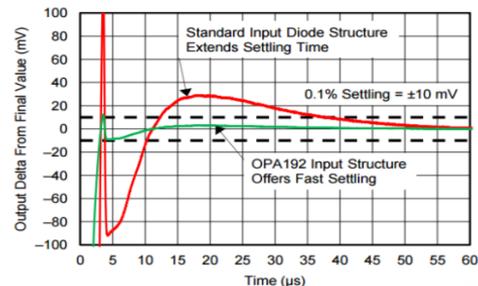
Precision Amps MUX Friendly Devices

	OPAx189	OPAx182	TLV2186	OPAx192	OPAx197
Supply Voltage (V)	4.5-36	4.5-36	4.5-24	4.5-36	4.5-36
Vos (µV)(max)	3	3.5	250	25	25
Vos Drift (typ) (µV/ºC)	0.005	0.003	0.1	0.1	0.8
GBW (MHz)	14	5	0.75	10	2.5
Slew Rate (typ) (V/µs)	20	10	0.35	20	7.5
Settling Time (µs)	0.8	1.3	7.5	0.25	1.4
I_Q (max) (mA)	1.3	0.85	0.09	1.2	0.2
Complementary Technology	Zero-Drift	Zero-Drift	Zero-Drift	e-Trim™	e-Trim™

Features

- **36V CMOS inputs that do not require antiparallel diodes**
- Able to maintain **robustness** while also improving **settling time** for switched systems
- **Wideband operation** enables fast settling and increased throughput in multiplexed / multi-channel systems
- **Low Power Options:**
  - TLV2186 (90µA) & OPAx197/1 (200µA)
- **Complementary Technology: Zero-Drift & e-Trim™**

Multiplexed Inputs with External MUX for Analog Input Modules

INPUT 1
INPUT 2
INPUT N
MUX
ADC
ISO
OPAx189
MUX36S08 **Companion**
MUX36D04 **Devices**

TEXAS INSTRUMENTS
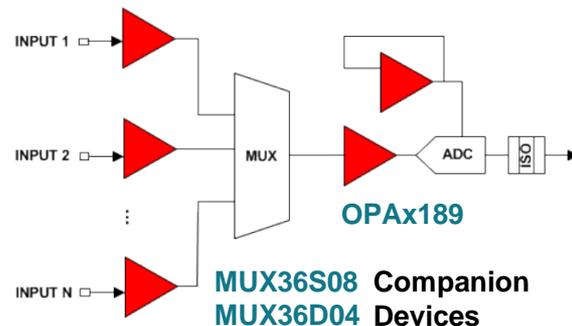
Zero-crossover Technology Overview

Differentiation

- Regulated charge pump
  - Reduced noise
  - Maximizes dynamic range
- Swings below ground
- No transition region

System Benefits

- No input crossover distortion
- Better Linearity
- Increased dynamic range
- Compatibility with precision ADCs

Product Examples

Device	Advantage
OPA320	Fast settling CMOS
OPA325 e-trim™	10MHz precision CMOS
OPA388 Zero-drift	High precision, wide BW
OPA369	Ultra-low power

Rail to rail without compromise

No distortion
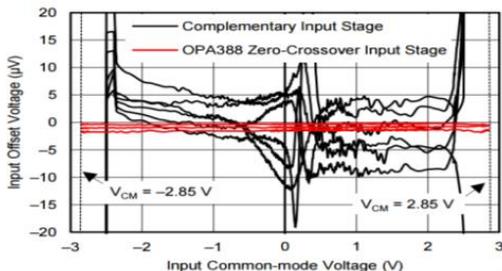
One diff pair
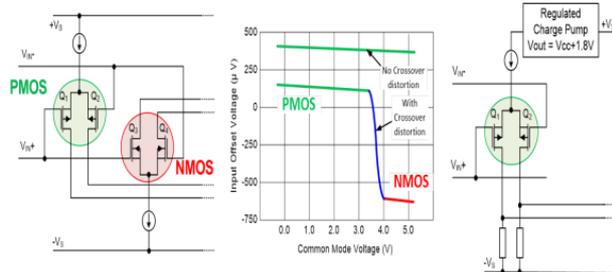
Flatter Vos vs. CM
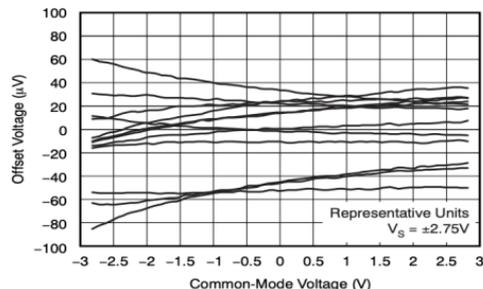
OPA3S328- 5.5V TIA with integrated switches(40 MHz)

High precision, low power, high speed, RRIO log amp replacement

Zero Crossover

Features

- Gain bandwidth: **40 MHz**
- Slew Rate: **25 V/µs**
- Bias current: **10 pA** (@ 25ºC, max)
- Voltage noise: **6.2** nV/√Hz at 1KHz
- Voltage offset: **25 µV** ((@ 25ºC, max)
- Offset voltage drift: **1.5 µV/ºC** (max)
- CMRR: **114 dB** (typ)
- Low supply current: **4 mA** (typ/ch)
- Wide Supply Range: **2.7V to 5.5V**

Packages**: (Released / Sampling / Preview) :**

OPA3S328: (3.5 x 3.5 mm WSON-20), (2.5 x 2.0 mm WCSP-20**)**

Applications

- Optical Power Monitors
- Test and Measurement Equipment
- Photodiode Monitoring
- Communications
- Wide dynamic range current measurements

Benefits

- **Integrated low-resistance switches** provides selectable gain and reduces system size
- **Wide bandwidth** maximizes dynamic range current measurements for optical power monitors and communications equipment
- **Low input bias** enables high precision photodiode current measurements
- **Rail-to-rail** capability enables measurements near the supply and ground, and improves the SNR of the design

JFET Technology Overview
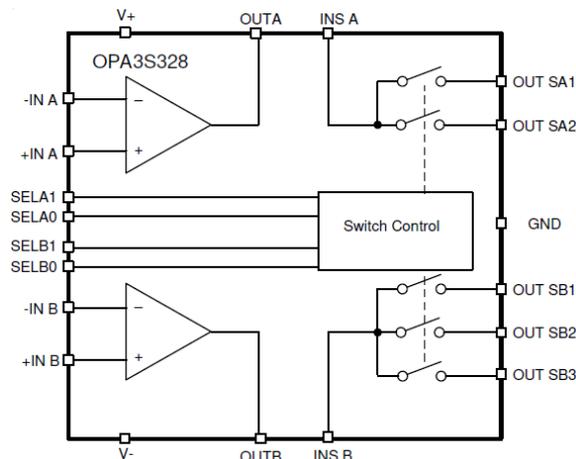
Differentiation

- Lower offset and drift vs. competition
- No thermal tail
- Dielectric isolation

System Benefits

- Lower total cost
- Faster settling, better acquisition
- Premium sound quality

Product Examples

Device	Description
OPA828	45MHz, 120ns 14bit settling
OPA145	5.5MHz, 0.8 fA current noise density
OPAx140	11 MHz, low noise, QFN packages available

Superiority in sound and sight

DiFet process
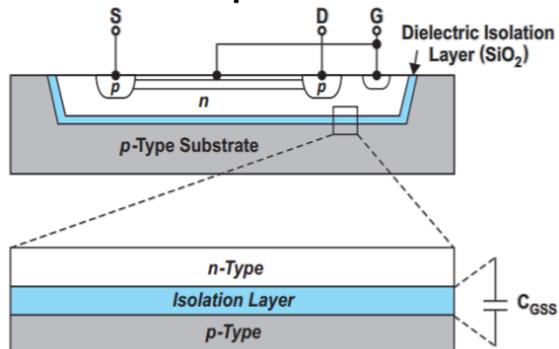
Flat Ib over CM
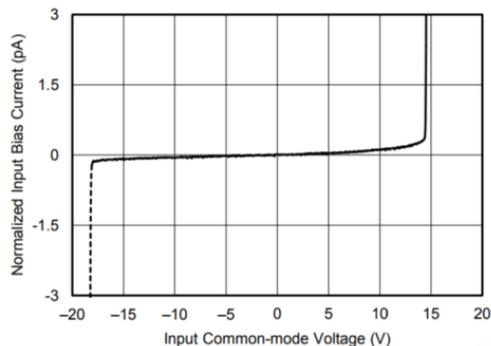
Better noise performance
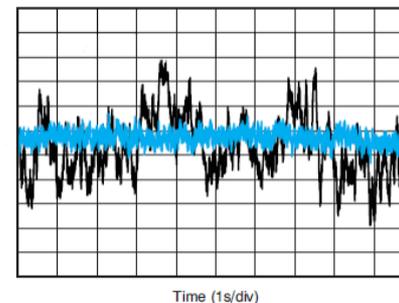
Precision Amplifiers **JFET** Op Amps Devices

Features

- **Maximum Full Power Bandwidth:**
  - Bandwidth of up to 45MHz
  - Slew Rates of up to 150 V/µs
- **Fast Settling** for better acquisition
- **High Precision** for systems requiring accurate measurements
- **Highest SNR:** Low voltage and current noise
  - Ex. OPA828 has a voltage noise density of 4nV/$\sqrt{\text{Hz}}$ and a current noise density of 1.2 fA/$\sqrt{\text{Hz}}$

Spec	OPA828	OPAx140	OPAx145
Vos (µV)(typ)	50	30	40
Vos Drift (µV/°C) (max)	1.3	1	1.5
Slew Rate (V/us)	150	20	20
Settling Time (ns)	110	880	1600
Bandwidth (MHz)(typ)	45	11	5.5

- **OPAx145 package family options**
  - **Single**: SOIC-8, VSSOP-8, SOT-23-5
  - **Dual**: SOIC-8
- **OPA828 package family options**
  - **Single**: SOIC-8
- **OPAx140 package family options**
  - **Single**: SOIC-8, VSSOP-8, SOT-23-5
  - **Dual**: SOIC-8, VSSOP-8, QFN 3x3mm
  - **Quad**: SOIC-14, TSSOP-14
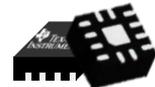
Applications

- Test and Measurement
- Data Acquisition
- High End Medical Instrumentation
- High Resolution ADC Driver
- DAC Output Buffer
- Pro Audio
- I-V Conversion
- Optical Modules

TI's Power Amplifier Family

Features

- **OPA462:**
  - Very high voltage and high current drive
  - Wide supply range and output swing
  - Unity gain stable and wide bandwidth

- **OPA455:**
  - Wide supply range and output swing
  - Unity gain stable and wide bandwidth
  - High slew rate

- **OPA454:**
  - Wide supply range and output swing
  - Unity gain stable
  - Low cost

- **OPA593:**
  - Upcoming power amplifier
  - High precision, very low offset voltage
  - High slew rate

Device	Supply Voltage (V)	Bandwidth (MHz)	Vos (mV)(max)	Vdrift (µV/°C) (max)	Slew Rate (V/µs)
OPA462	12-180	6.5	3.4	20	32
OPA455	12-150	6.5	3.4	20	32
OPA454	10-100	2.5	4	10	13
OPA593 UPCOMING!	4.5-85	10	0.1	2	40

Applications

- Automated test equipment
- Optical modules
- Medical instrumentation
- Display panels
- Semiconductor test equipment
- Lab and field instrumentation

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