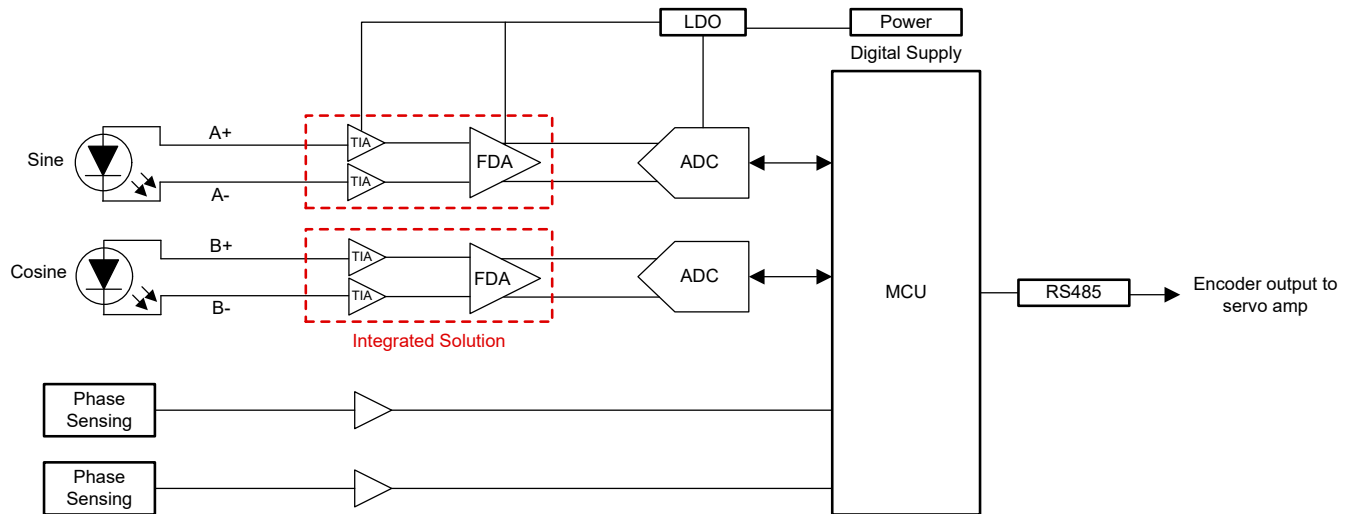


# High Speed Amplifiers for Motor Encoders and Position Sensing



**Example: Optical Motor Encoder Block Diagram with Discrete and Integrated Solutions**

## What are the Key Specifications for Transimpedance Amplifiers (TIA) in Motor Encoders?

- **Gain-Bandwidth Product:** The signal-chain bandwidth required by the encoder is determined by the resolution (periods per revolution) and speed (revolutions per minute). The wider the signal-chain bandwidth, the larger the gain-bandwidth product needed to maintain linearity across a wide range of gain values.
- **Offset Voltage and Input Bias Current:** A higher precision amplifier improves total dynamic range received from the output of the photodiode. The smaller the output current value that is detectable from the photodiode, the more precise the motor encoder positioning.
- **Voltage Noise and Total Harmonic Distortion:** Lower noise and distortion performance amplifiers enable maximum performance of the selected ADC. For more information on ADC selection, see [Precision ADCs for Motor Encoders and Position Sensing](#).
- **Size:** Encoders are typically located on a PCB mounted on the motor; therefore, a small form factor amplifier is required.

## What are the Key Specifications for Fully Differential Amplifiers (TIA) in Motor Encoders?

- **Fully Differential Architecture:** A fully-differential amplifier allows the input signal to be converted into a differential signal if using a single ended transimpedance amplifier in an optical path, or remain a fully-differential signal while setting the output common mode voltage if a TIA is not required.
- **High Gain-Bandwidth Product:** Add additional gain and active filtering onto the amplifier while maintaining signal-chain bandwidth linearity.
- **Low Offset Voltage and Drift:** Improve precision performance for minimal DC shift impact on the system.
- **Rail to Rail Output:** Maximize the full scale range available on the output to maintain signal integrity.

Need additional assistance? Ask our engineers a question on the TI [E2E™ Amplifiers Support Forum](#).

## Recommended Discrete Components

**Table 1. Transimpedance Amplifier (TIA)**

Parameter	OPA607	OPA836	OPA814
Supply Voltage Range (V)	2.2 - 5.5	2.5 - 5.5	6 - 12.6
Gain Bandwidth Product (MHz)	50	118	250
Quiescent Current, $I_Q$ (typ) (mA)	0.9	1	16
Slew Rate (typ) (V/ $\mu$ s)	24	560	750
Rail-to-Rail	In to V-, Out	In to V-, Out	No
Input Offset Voltage, $V_{OS}$ (max) (mV)	0.6	0.4	0.25
Offset Voltage Drift (typ) ( $\mu$ V/ $^{\circ}$ C)	0.3	1.1	1
Voltage Noise at Flatband (typ) (nV/ $\sqrt{\text{Hz}}$ )	3.8	4.6	5.3
Operating Temperature Range ( $^{\circ}$ C)	-40 to 125	-40 to 125	-40 to 85
Channel Count Variants	OPA2607	OPA2836	---

**Table 2. Fully Differential Amplifier (FDA)**

Parameter	THS4531A	THS4561	THS4551
Supply Voltage Range (V)	2.5 - 5.5	2.85 - 12.6	2.7 - 5.4
Gain Bandwidth Product (MHz)	27	60	135
Quiescent Current, $I_Q$ (typ) (mA)	0.25	0.78	1.35
Slew Rate (typ) (V/ $\mu$ s)	220	230	220
Rail-to-Rail	In to V-, Out	In to V-, Out	In to V-, Out
Input Offset Voltage, $V_{OS}$ (max) (mV)	00.4	0.25	0.175
Offset Voltage Drift (typ) ( $\mu$ V/ $^{\circ}$ C)	3	0.5	0.45
Voltage Noise at Flatband (typ) (nV/ $\sqrt{\text{Hz}}$ )	10	4	3.3
Operating Temperature Range ( $^{\circ}$ C)	-40 to 125	-40 to 125	-40 to 125

## Recommended Integrated Components

**Table 3. Integrated Differential TIA + ADC Driver**

Parameter	THS4567
Supply Voltage Range (V)	3.3 - 6
Gain Bandwidth Product (MHz)	220
Quiescent Current, $I_Q$ (typ) (mA)	2
Slew Rate (typ) (V/ $\mu$ s)	500
Rail-to-Rail	Out
Input Bias Current, $I_{BIAS}$ (max) (pV)	750
Input Offset Voltage, $V_{OS}$ (max) (mV)	10
Offset Voltage Drift (typ) ( $\mu$ V/ $^{\circ}$ C)	1
Voltage Noise at Flatband (typ) (nV/ $\sqrt{\text{Hz}}$ )	4.2
Operating Temperature Range ( $^{\circ}$ C)	-40 to 125
Features	Independent input and output common mode control, shutdown

## Learn More

- [\*Interface to Sin/Cos Encoders with High-Resolution Position Interpolation Reference Design\*](#)
- [\*Interface to a Sin/Cos Encoder with Sitara AM437x Reference Design\*](#)
- [\*Interface to a HIPERFACE Position Encoder Reference Design\*](#)
- [\*Dual-channel data acquisition reference design for optical encoders, 12 bits, 1MSPS\*](#)
- [\*Current sensing with <1 \$\mu\$ s settling for 1-, 2-, & 3-Shunt FOC in 3-Phase Inverter Reference Design\*](#)
- [\*Improving response time and accuracy in autonomous robots with wideband SAR-ADCs\*](#)
- [\*Maximizing signal chain distortion performance using high speed amplifiers\*](#)
- [\*Transimpedance amplifier circuit design calculator\*](#)

## Key Applications

- [\*Servo drive position sensor\*](#)
- [\*Servo drive position feedback\*](#)
- [\*AC drive position feedback\*](#)
- [\*Linear motor position sensor\*](#)

## IMPORTANT NOTICE AND DISCLAIMER

TI PROVIDES TECHNICAL AND RELIABILITY DATA (INCLUDING DATA SHEETS), DESIGN RESOURCES (INCLUDING REFERENCE DESIGNS), APPLICATION OR OTHER DESIGN ADVICE, WEB TOOLS, SAFETY INFORMATION, AND OTHER RESOURCES "AS IS" AND WITH ALL FAULTS, AND DISCLAIMS ALL WARRANTIES, EXPRESS AND IMPLIED, INCLUDING WITHOUT LIMITATION ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF THIRD PARTY INTELLECTUAL PROPERTY RIGHTS.

These resources are intended for skilled developers designing with TI products. You are solely responsible for (1) selecting the appropriate TI products for your application, (2) designing, validating and testing your application, and (3) ensuring your application meets applicable standards, and any other safety, security, regulatory or other requirements.

These resources are subject to change without notice. TI grants you permission to use these resources only for development of an application that uses the TI products described in the resource. Other reproduction and display of these resources is prohibited. No license is granted to any other TI intellectual property right or to any third party intellectual property right. TI disclaims responsibility for, and you will fully indemnify TI and its representatives against, any claims, damages, costs, losses, and liabilities arising out of your use of these resources.

TI's products are provided subject to [TI's Terms of Sale](#) or other applicable terms available either on [ti.com](https://www.ti.com) or provided in conjunction with such TI products. TI's provision of these resources does not expand or otherwise alter TI's applicable warranties or warranty disclaimers for TI products.

TI objects to and rejects any additional or different terms you may have proposed.

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265  
Copyright © 2025, Texas Instruments Incorporated