

# TI's Space Grade Precision ADCs in Laser Communication Terminals



## Introduction

Space-based laser communication terminals integrate pointing, acquisition and tracking (PAT) systems that demand exceptional precision, reliability, and performance under harsh radiation environments. Texas Instruments' space-grade analog-to-digital converters (ADCs) provide critical functionality across multiple subsystems within these terminals. The [ADC168M102R-SEP](#) and [ADS1278QML-SP](#) help enable precise laser positioning, mirror feedback, and motor position monitoring in space-grade laser communication systems.

## Laser Communication Terminal Architecture

Modern laser communication terminals require precise control and position feedback across multiple positioning systems to establish and maintain optical links in space across large constellations. Three critical subsystems rely on high-performance ADCs:

1. **Laser Positioning:** Uses quadrant photodiodes to detect beam position for fine alignment
2. **Mirror Position Feedback:** Monitors mirror position through strain gauge bridges measurements
3. **Motor Position Feedback:** Tracks motor position through resolver and encoder feedback systems

Each subsystem presents unique signal processing challenges that TI's space-grade ADCs are uniquely qualified to address. The overall subsystem is shown in [Figure 1](#)

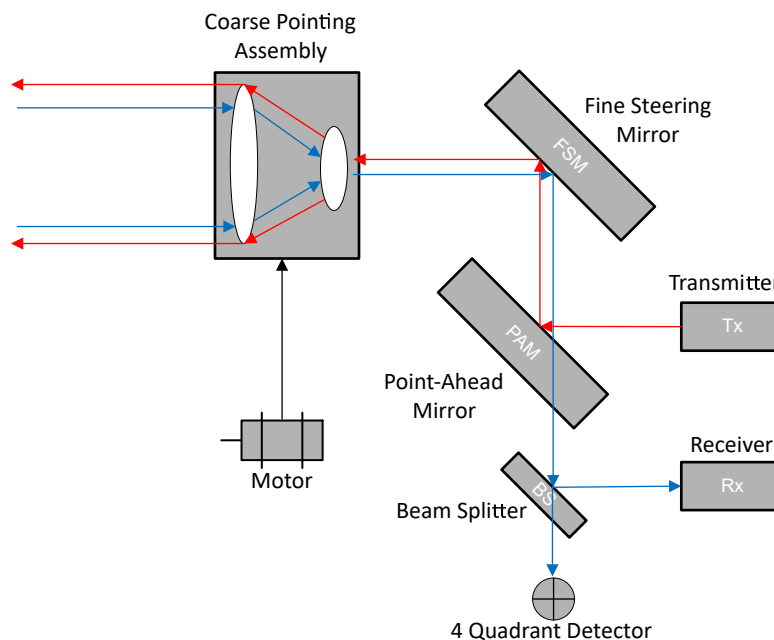
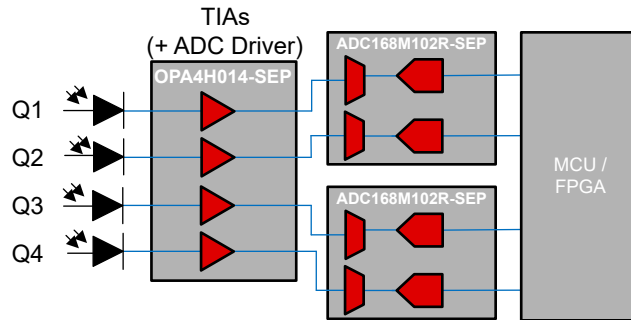


Figure 1. Laser Positioning System

## Laser Positioning

The laser positioning subsystem uses a 4-quadrant photodiode to precisely track the incoming laser beam position. The quadrant photodiode detector consists of four separate photosensitive quadrants (Q1, Q2, Q3, Q4) that generate currents proportional to the incident light on each segment. The position of the laser beam, relative to the center of the detector, is determined by comparing the output signals from each quadrant. The photodiode capacitance is typically in the range of 10s of pF to 100s of pF while the output current is in the range of 10s of nA to 100s of nA. This critical function verifies signal reception by providing position feedback for the alignment system when all four quadrants are measured simultaneously, as shown in [Figure 2](#).

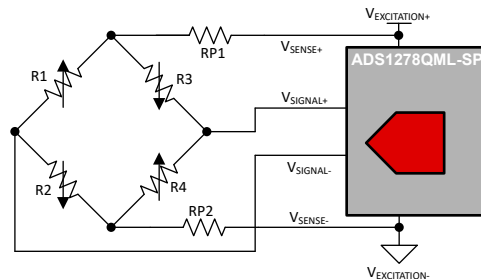


**Figure 2. Laser Positioning Signal Chain**

To accomplish this, each quadrant connects to one channel of the [OPA4H014-SEP](#) quad-channel op-amp configured as a transimpedance amplifier (TIA). The TIA outputs connect directly to the inputs of the [ADC168M102R-SEP](#). The 1MSPS sampling rate of the [ADC168M102R-SEP](#) allows for simultaneous sampling of all four quadrants, enabling real-time beam position tracking with microsecond-level responsiveness. The 93dB of signal-to-noise ratio (SNR) allows the [ADC168M102R-SEP](#) to detect a wide range of currents, weak signals and subtle position changes.

## Mirror Position Feedback

Fine steering mirrors (FSMs) are high-precision, optical devices that rapidly adjust the directional path of reflected light beams with exceptional accuracy. In laser communication terminals, FSMs are used to center the beam onto the 4-quadrant photodiode which requires accurate position feedback. The [ADS1278QML-SP](#) shown in [Figure 3](#) offers a design for monitoring the strain gauge bridge sensors attached to these mirrors.

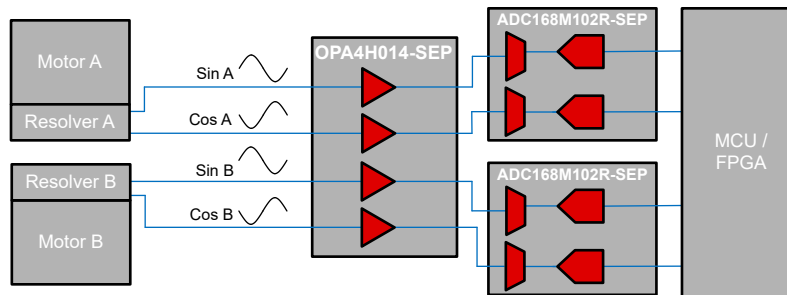


**Figure 3. Mirror Position Feedback Signal Chain**

Each mirror axis uses a full Wheatstone bridge configuration for temperature compensation. The 8-channel simultaneous sampling architecture of the [ADS1278QML-SP](#) allows monitoring of both X and Y axes for up to four separate mirrors, verifying accurate relative position data across all axes. The high resolution of this ADC allows for detection of mirror movements in the microradian range.

## Motor Position Feedback

The coarse pointing assembly uses motors with resolvers or encoders to provide initial beam alignment. The [ADC168M102R-SEP](#)'s architecture shown in [Figure 4](#) provides capabilities for the position feedback from an encoder or a resolver. The dual-channel simultaneous sampling feature allows for the sine and cosine signals to be digitized at the same time while the 1MSPS sampling rate allows for oversampling of the input signals.



**Figure 4. Motor Position Feedback Signal Chain**

Encoders and resolvers output sine and cosine signals that represent the actual speed of the motor and position and measuring both signals at the same time allows for the most accurate data. The [ADC168M102R-SEP](#) can be used with the [OPA4H014-SEP](#) to simultaneously measure the sine and cosine outputs of two different resolvers or encoders.

## Conclusion

Texas Instruments' space-grade ADCs provide the precision, performance, and reliability required for advanced laser communication terminals. The [ADC168M102R-SEP](#) excels in both laser positioning and motor feedback applications where simultaneous sampling and 16-bit precision are critical. The [ADS1278QML-SP](#) delivers the extreme resolution required for fine steering mirror position feedback.

Together, these ADCs enable the precise control required for establishing and maintaining optical links in space-based laser communication systems. Their radiation tolerance, performance specifications, and reliability make the ADCs preferred choices for mission-critical space applications where failure is not an option.

By implementing TI's space-grade ADCs in these three key subsystems, designers can create laser communication terminals capable of precise beam steering, rapid acquisition, and reliable data transmission across vast distances in the challenging environment of space.

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