Application Note

Precision Temperature Sensing for ITLA Wavelength Stability

Saminah Chaudhry

Abstract

Coherent optical modules used in AI-driven, high-speed data-center and data-center-interconnect (DCI) networks rely on Integrated Tunable Laser Assemblies (ITLAs) to maintain a precise, stable optical wavelength. Because laser wavelength is highly sensitive to temperature, ITLAs use an RTD and thermoelectric cooler (TEC) in a closed thermal-control loop to hold the laser at the optimal operating point. This application note describes how the Texas Instruments ADS122C14, a 24-bit delta-sigma ADC with integrated PGA, precision IDAC excitation current sources, and I^2C interface, enables the high-resolution, ultra-low-noise temperature measurement needed to stabilize this loop. The small WQFN and DSBGA package options of the ADS122C14 also address the shrinking form factor of next-generation nano-ITLA designs. Intended for hardware and systems engineers designing coherent optical transceivers for hyperscale data-center and DCI applications, this document explains how the ADS122C14 simplifies the signal chain while improving wavelength stability, accuracy, and space efficiency.

Table of Contents

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1 Introduction

Increasing bandwidth requirements in AI-driven hyperscale data centers are driving the transition toward 800G, 1.6T, and higher-speed optical architectures. Coherent optical modules and their integrated tunable laser assemblies (ITLAs) are critical components in these high-capacity data-center and data-center-interconnect (DCI) links.

2 Detailed Description

2.1 Thermal Stability Requirements in ITLAs

An ITLA provides a tunable laser with a precisely controlled optical wavelength and frequency. Laser temperature affects the optical characteristics, and changes in temperature can cause wavelength and frequency drift. As optical data rates increase, maintaining a stable optical carrier becomes increasingly important for reliable coherent communication.

To maintain a stable laser operating point, the ITLA uses a thermoelectric cooler (TEC) together with an RTD temperature sensor positioned near the laser. The RTD continuously monitors the laser temperature, while the TEC heats or cools the laser to maintain the desired operating temperature.

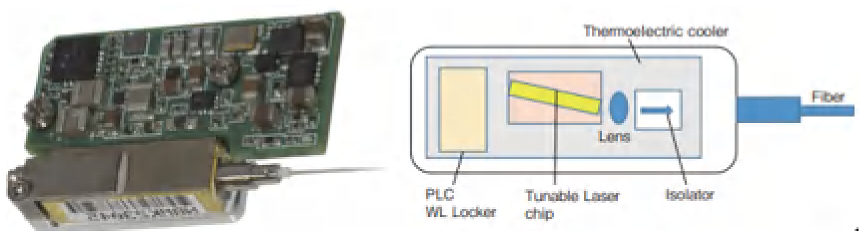

Figure 2-1. Integrated Tunable Laser Assemblies (ITLA)

This configuration forms a closed-loop thermal-control system, as shown in Figure 2-2. The RTD measures the change in resistance based on the laser temperature, and the ADS122C14 converts the small RTD resistance change into high-resolution digital temperature data. The module controller compares the measured temperature to the setpoint and adjusts the TEC using a TEC driver. The resulting thermal correction is captured by the RTD, allowing the controller to continuously stabilize the laser operating point.

To maintain wavelength stability, the system must resolve the minimal resistance changes characteristic of RTDs. This requires an analog front end with high resolution and ultra-low noise and offset errors. Inadequate precision in the temperature feedback loop causes TEC control instability, resulting in temperature oscillations and wavelength drift.

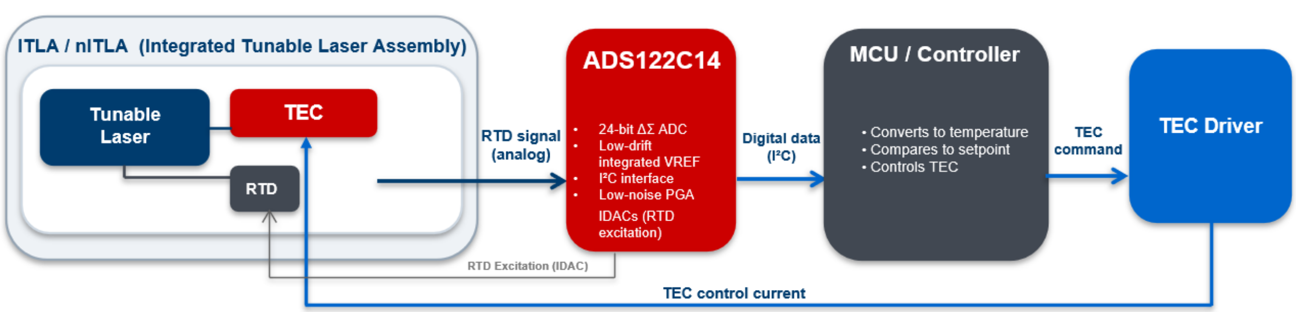

Figure 2-2. ITLA Temperature Sensing Signal Chain

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The loop relies on the integrated, matched current sources (IDACs) of the ADS122C14 to supply precise excitation current to the RTD element. The resulting small analog voltage signal is conditioned by an internal low-noise PGA before being digitized by the high-resolution 24-bit delta-sigma (ΔΣ) ADC. This digitized data is transmitted through an I^2C interface to the MCU or controller. The MCU processes this data to calculate the actual temperature. To compensate for RTD non-linearity, the MCU applies linearization algorithms to the digitized data. This provides a precise temperature reference, enabling the TEC driver to maintain the tight thermal stability required for wavelength control.

The ADS122C14 directly addresses the aggressive form-factor constraints of shrinking optical transceivers. As industry standards transition from traditional ITLAs to ultra-compact nano-ITLA (nITLA) architectures, PCB real estate has become a critical bottleneck. By integrating excitation sources, a low-noise PGA, and a 24-bit converter into a single device, the ADS122C14 reduces both system cost and component count. To maximize these spatial advantages, the device is available in ultra-small packages, including a 3.00mm × 3.00mm WQFN and a 1.87mm × 1.97mm DSBGA (Figure 2-3) enabling the implementation of the high-precision temperature sensing required for stable wavelength control in ultra-dense layouts.

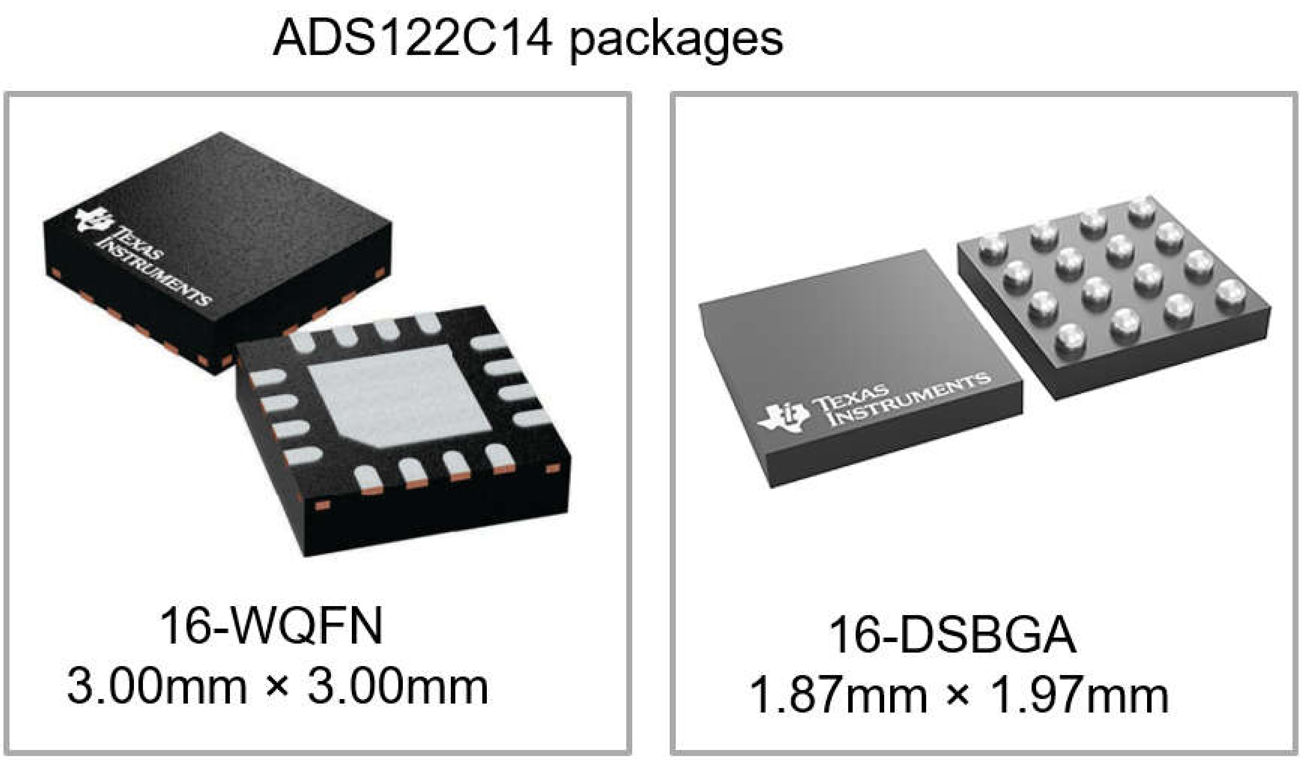

Figure 2-3. ADS122C14 Package

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3 Summary

As data rates scale toward 800G, 1.6T, and beyond, precise thermal control of the laser becomes essential to preventing wavelength drift and providing reliable coherent transmission. The ADS122C14 meets this need by pairing accurate RTD excitation and low-noise signal conditioning with high-resolution digitization in a single, ultra-compact device allowing designers to achieve tight thermal-loop performance without the added cost, complexity, or board space of a discrete implementation.

4 References

1. Texas Instruments, ADS122C14 Eight-channel 24-bit 64kSPS delta-sigma ADC with PGA, VREF, two IDACs and I^2C, product page
2. Texas Instruments, ADS122C04 24-bit, 2-kSPS, 4-ch, low-power, small-size delta-sigma ADC with PGA, VREF, 2x IDACs & I^2C interface, product page
3. Texas Instruments, *A Basic Guide to RTD Measurements*, application note
4. Furukawa Electric, *The Development of a Nano-ITLA for Digital Coherent Datacenter Interconnects*, Furukawa Electric Review No. 52, 2021

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