

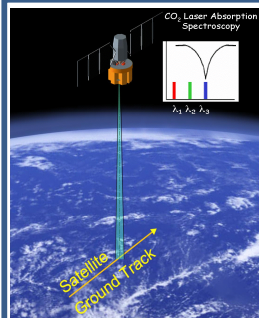


Recent Progress in Low SWaP Semiconductor Laser Transmitter Module Development for ASCENDS Applications



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The National Research Council's (NRC) Decadal Survey (DS) of Earth Science and Applications from Space has identified the Active Sensing of CO₂ Emissions over Nights, Days, and Seasons (ASCENDS) as an important atmospheric science mission. The CO₂ mixing ratio needs to be measured to a precision of 0.5 percent of background or better (slightly less than 2 ppm) at 100-km horizontal resolution overland and 200-km resolution over oceans. To meet this goal, the ASCENDS mission requires simultaneous laser remote sensing of CO₂ and O₂ in order to convert CO₂ column number densities to average column CO₂ mixing ratios (XCO₂). As such, the CO₂ column number density and the O₂ column number density will be utilized to derive the average XCO₂ column.

NASA Langley Research Center, working with its partners, is developing fiber laser architecture based intensity modulated CW laser absorption spectrometer for measuring XCO₂ in the 1.57 micron spectral band. In support of this measurement, sensor technology for remote sensing of O₂ in the 1.26 μ m band for surface pressure measurements is being developed. Currently, NASA LaRC is developing Global Hawk platform compatible Laser Absorption Spectrometer under NASA ROSES Instrument Incubator Program (IIP) known as ACES.

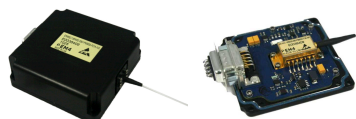
Significant strides have been made in developing highly stable, narrow linewidth, Low SWaP seed laser modules for CO₂ and O₂ sensing

Active Sensing of CO₂ Emissions over Nights, Days, & Seasons (ASCENDS)

- Goal:** Enhanced understanding of the presence of CO₂ in the global carbon cycle by quantifying global spatial distribution of terrestrial and oceanic sources and sinks of during day/night over all seasons.
- Priority:** Medium class mission recommended by NRC for implementation in the 2019 timeframe.
- How:** Global laser-based measurements of XCO₂ to a precision of 0.5 percent on horizontal scales of 100-km over land and 200-km over oceans
- Measurements:** CO₂ number density tropospheric column, O₂ number density column (surface pressure to obtain XCO₂), Temperature profile to improve CO₂ accuracy, Altimetry & CO profiles

Design Goals

- Narrow Laser Linewidth:
- Low-noise current source via novel architecture
- Stable Laser Line Position:
 - Linear temperature control
- Tunability of Laser Line Position and Output Power
 - Coarse tuning via temperature and fine tuning via chirp
 - Large adjustments to power also achievable with correspondingly large adjustments to frequency
- Lowest Possible SWaP
 - Linear temperature control is inefficient so DFB itself was redesigned to be more thermally efficient and require less current
- Immunity to Electromagnetic Interference
- Commercial Viability with Path to a Space Qualifiable Design

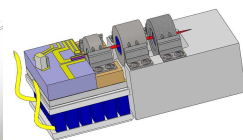
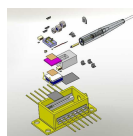


EM650 is a DFB laser integrated OEM style package with: (a) novel low-noise laser current source, (b) novel temperature control circuit and (c) back facet monitor photodiode amplifier

Design Configuration with associated Driver PCB

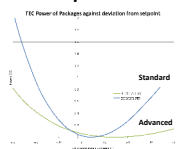
Transmitter Development

Exploded view of EM527 prototype design for thermally improved "Configuration 1" NASA ASCENDS DFB laser master-oscillator



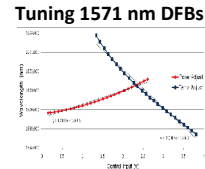
Internal component view of EM527 prototype package design for "Configuration 1."

Effi. Improvements



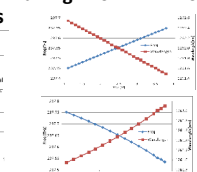
power versus temperature delta for example standard and "Configuration 1" devices

Tuning 1571 nm DFBs



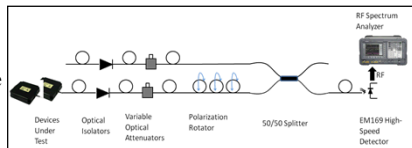
Wavelength tuning produced using the temperature and power adjust inputs of the EM650. The black lines and associated equations are a linear regression of the measured data.

Tuning 1262nm DFBs



Top: Temperature Adjust
Bottom: Power Adjust

Stability Measurements using Heterodyne Measurement Technique



Stability Measurements

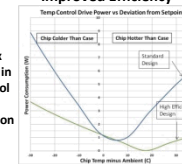
- Commercial measurement systems are not capable of measuring line stability <200MHz (1.6pm at $\lambda=1550$ nm)
- The simple heterodyne technique provides a semi-quantitative measure of line positional stability and a qualitative comparison of linewidth



Commercial Drivers w/ EM4 DFBs
Stability Over 30s Intervals

The peak of the waveforms shown can be monitored to determine the drift of the difference frequency over time under the assumption that the drift is due to uncorrelated random sources in the two lasers generating the difference frequency. The EM650 varies by 4MHz pk-pk (0.032pm) and the commercial controllers vary by 31MHz (0.248pm)

New Integrated Design Improved Efficiency



Up to 5x reduction in TEC control power consumption

10 x Improved COP (Coefficient of Performance) over Standard Design

