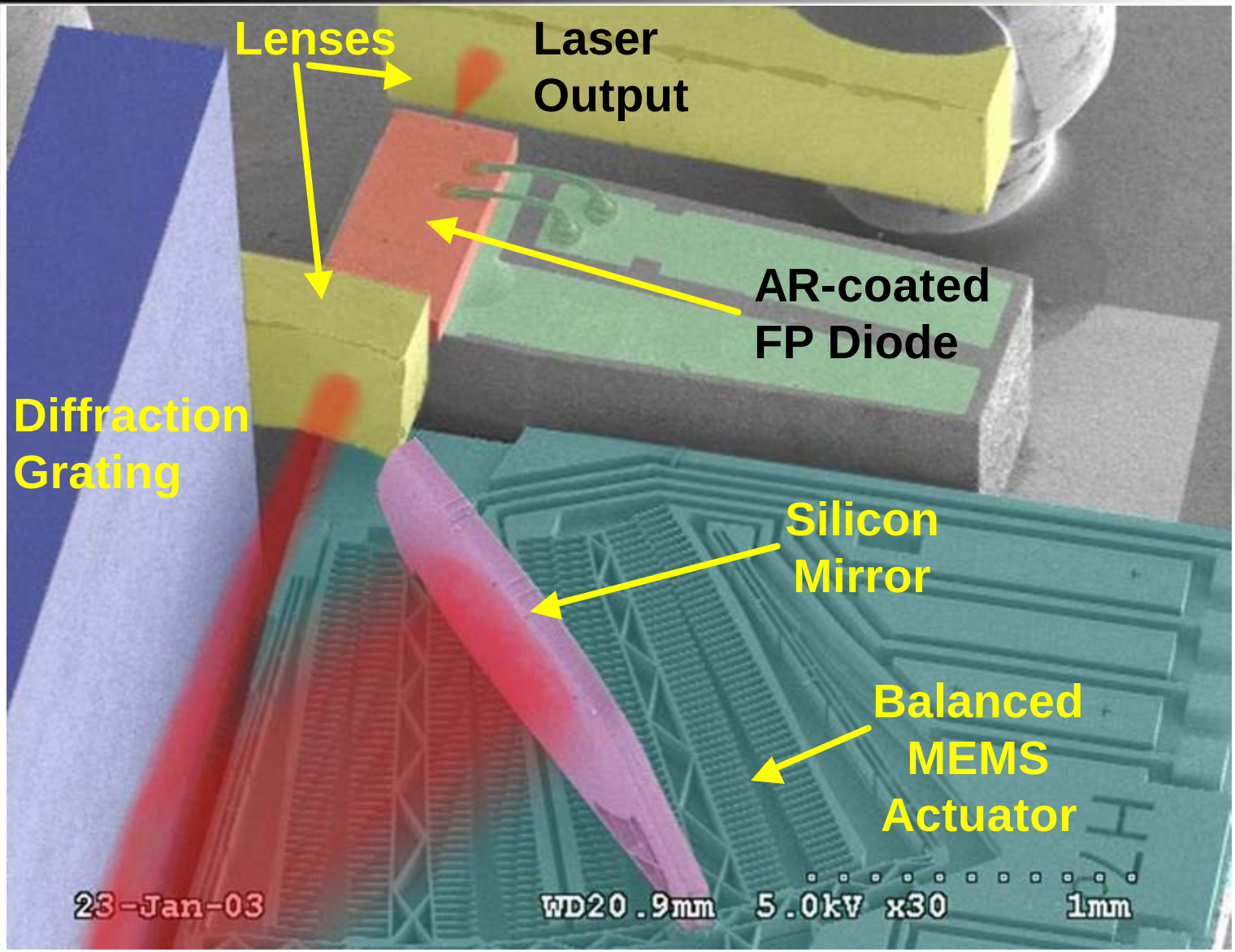
External Cavity Diode Laser Tuned with Silicon MEMS

MEMS-Tunable External Cavity Diode Laser



3 mm

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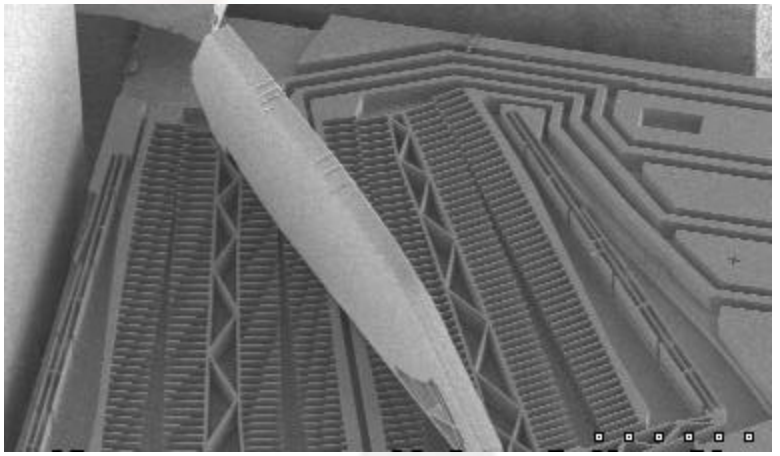
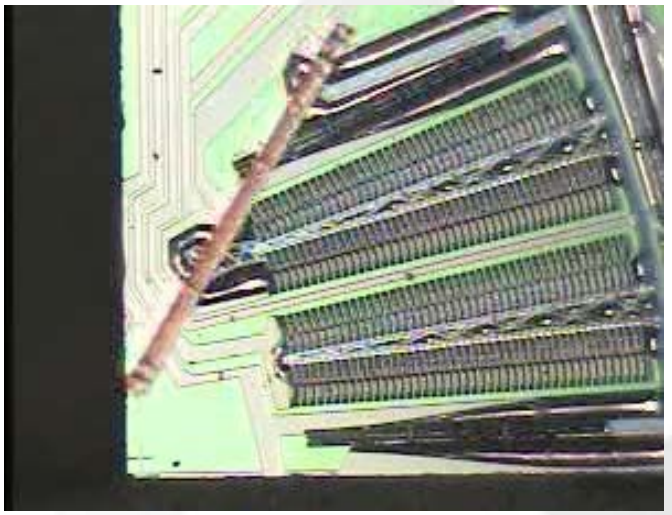
MEMS Technology

- Electrostatic comb drive actuator fabricated in single-crystal silicon by Deep Reactive Ion Etching (DRIE).
- High aspect ratio of combs provides high out-of-plane stiffness and high actuator force.
- Lithographically fabricated Si mirror attached to flexural rotary suspensions is rotated by applying up to 140 V to the comb drive.



Reliable and Robust Devices

- Single-crystal Si flexure, no touching or rubbing parts = no material fatigue
- > 80 billion device cycles with zero failures
- Fast, durable, low-cost



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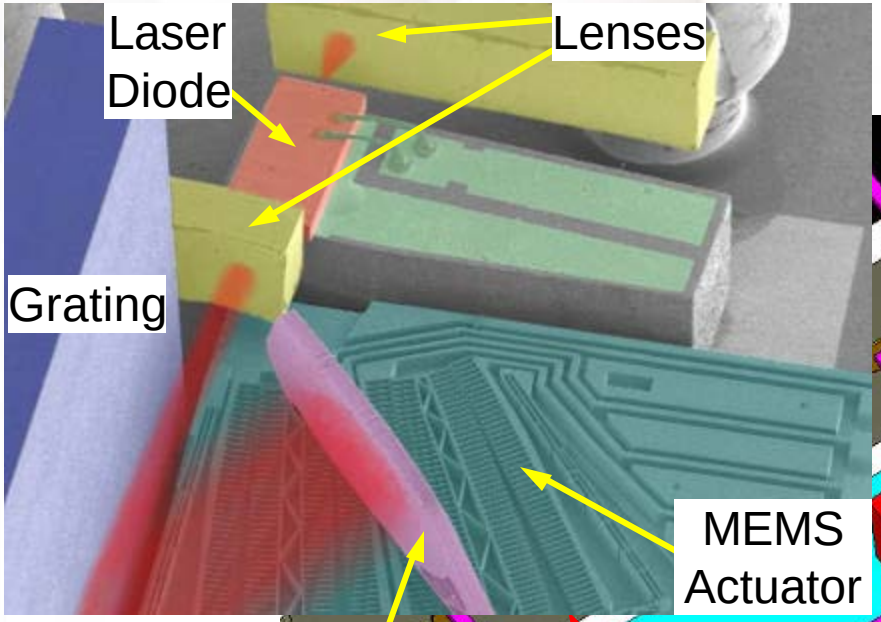
Integrated Laser, Wavelength Locker, & Shutter

External Cavity Laser



Mounted on a common TE cooler in an 18 pin hermetic package

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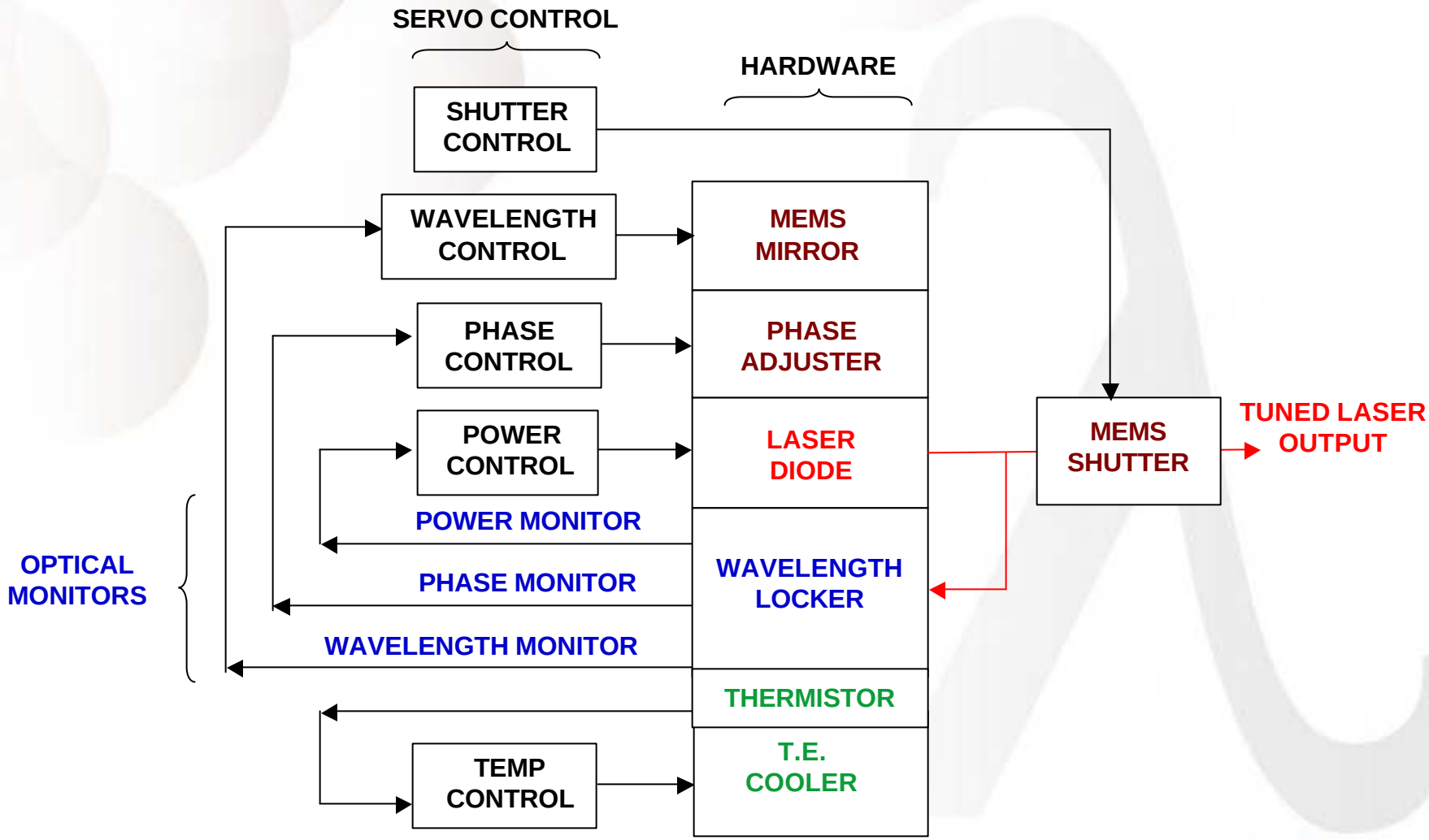
Tunable Laser Servo Block Diagram



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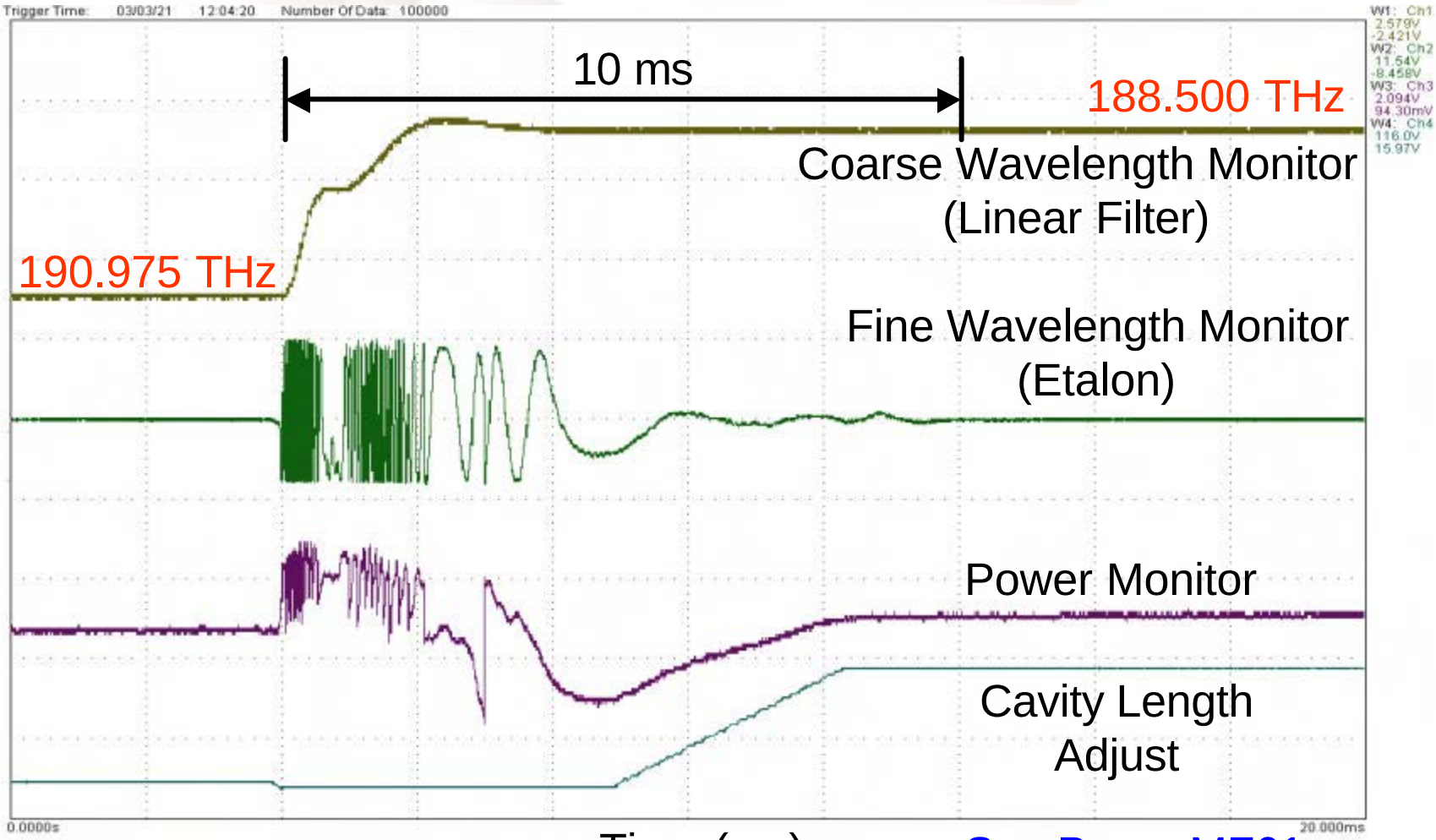
10 ms Wavelength Tuning and Locking Across 100 Channels at 25 GHz



Time (ms)

See Paper MF61

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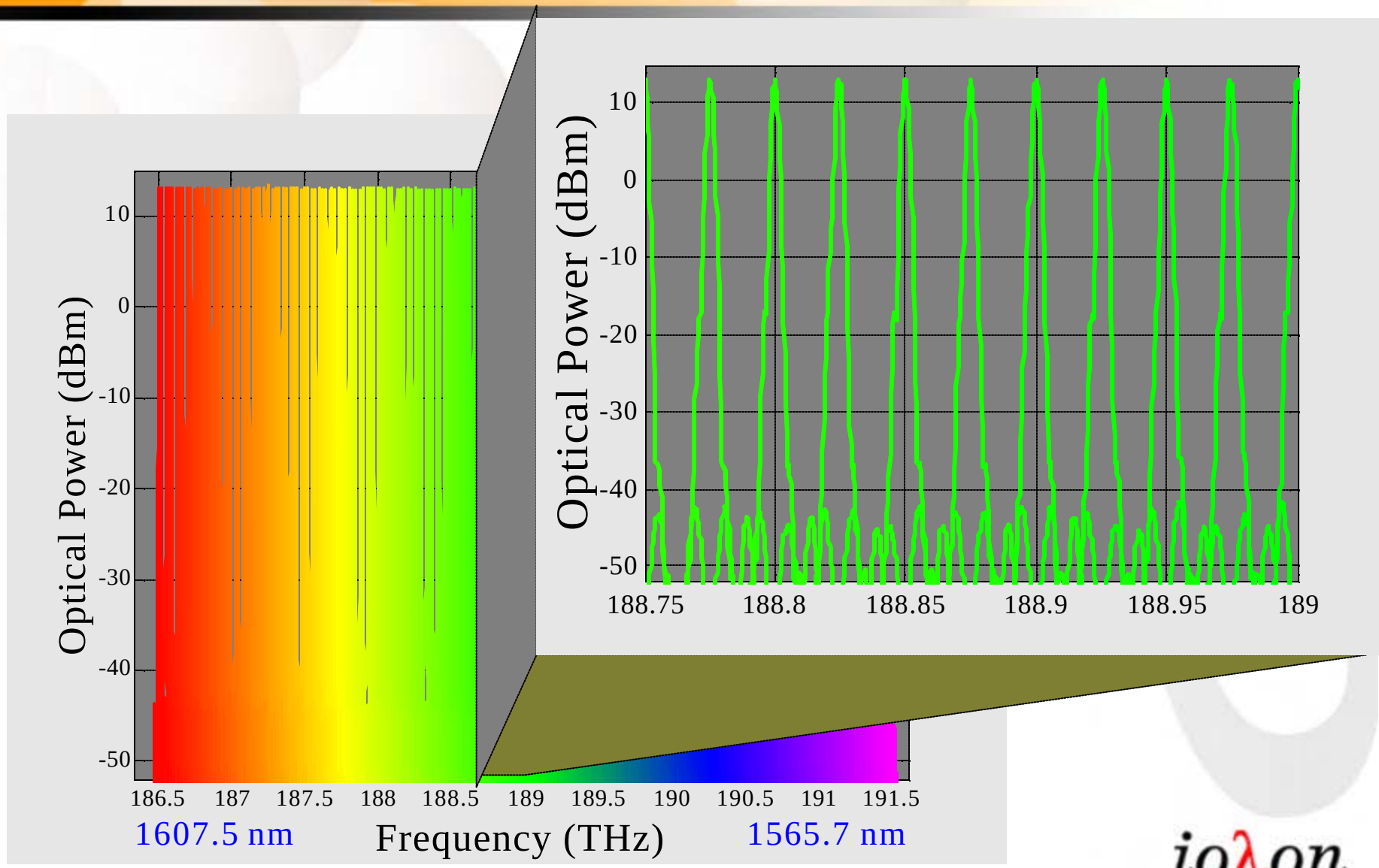
200 Channels at 25 GHz, L-band
>20 mW Output Power



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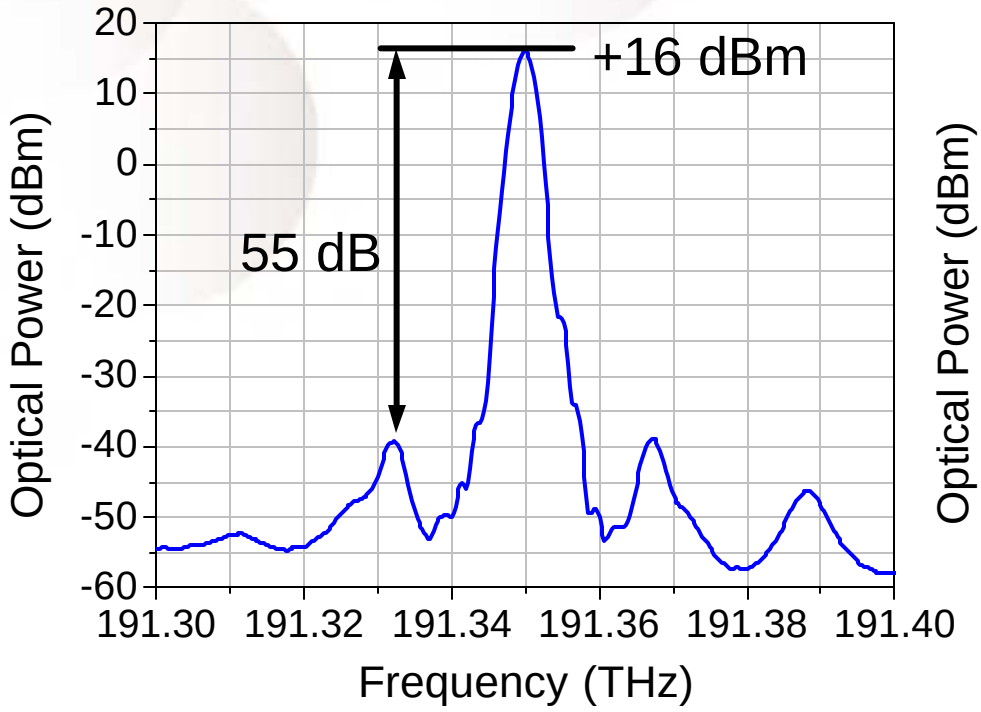
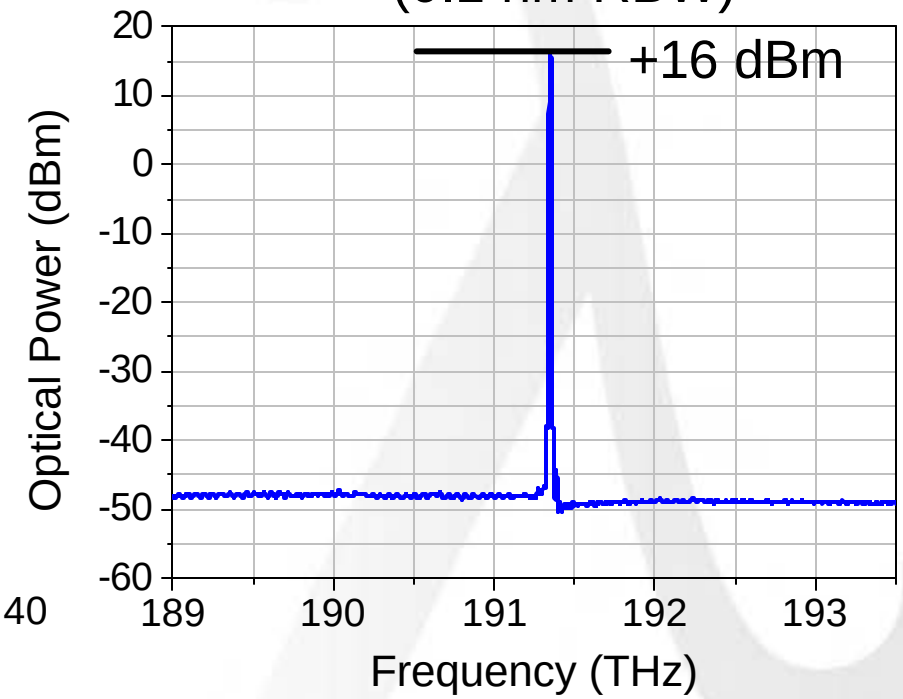
Optical Performance: Power, SMSR, SSE

40 mW (+16 dBm) Fiber Output Power

SMSR = 55 dB



SSE = -54 dBc/nm
(0.1 nm RBW)



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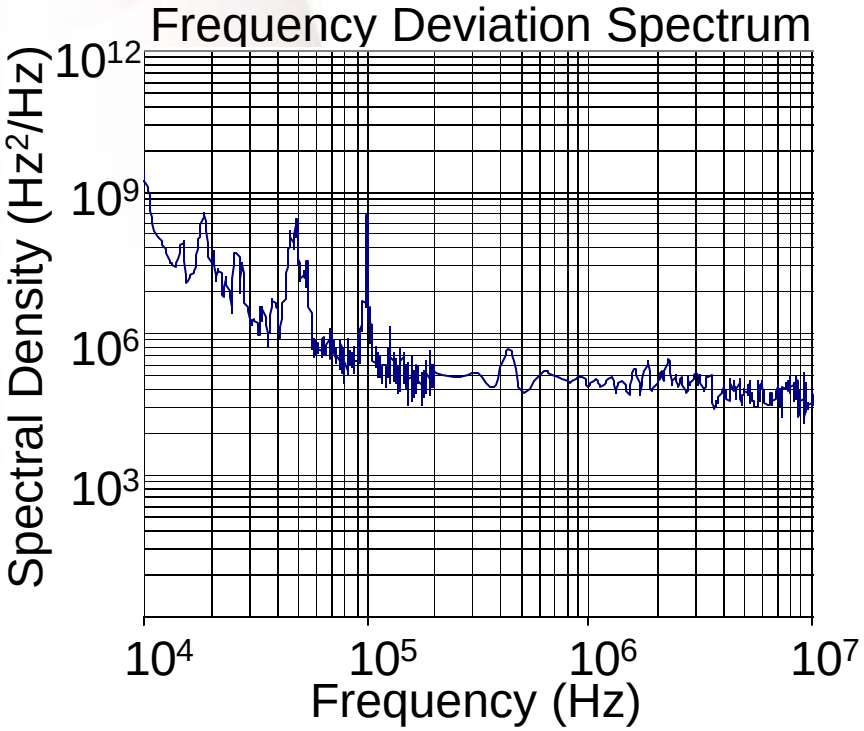
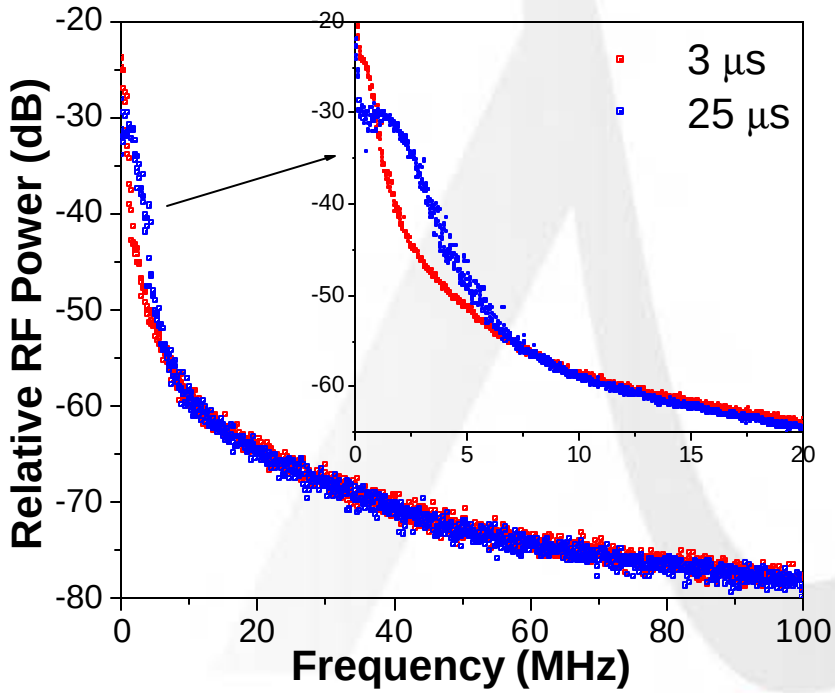
Optical Performance: Linewidth

- Instantaneous Linewidth ~ 125 kHz from phase noise spectrum
- Time-Averaged Linewidth ~ 2 MHz due to low-frequency actuator motion
- SBS Suppression Linewidth ~ 200MHz using 200 kHz current dither





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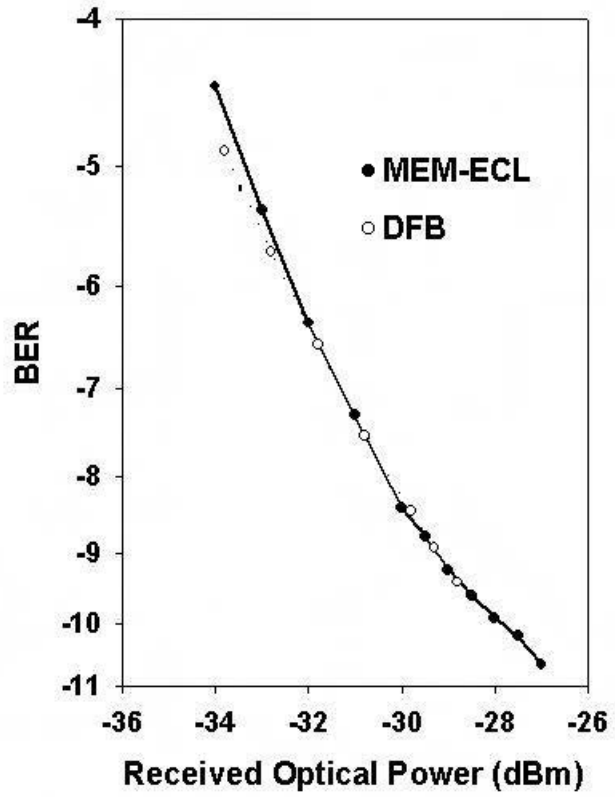
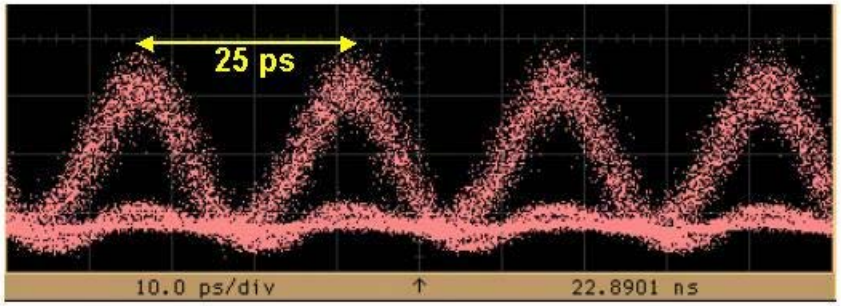
System Performance, MEM-ECL vs. DFB





Nearly identical BER and transmitted eye diagrams in a 500 km amplified link at 40 Gb/s

Similar DFB-like eye diagrams and BER seen at:

2.5 Gb/s
10 Gb/s
40 Gb/s

Link lengths up to 3000 km

Data courtesy of Lucent Technologies

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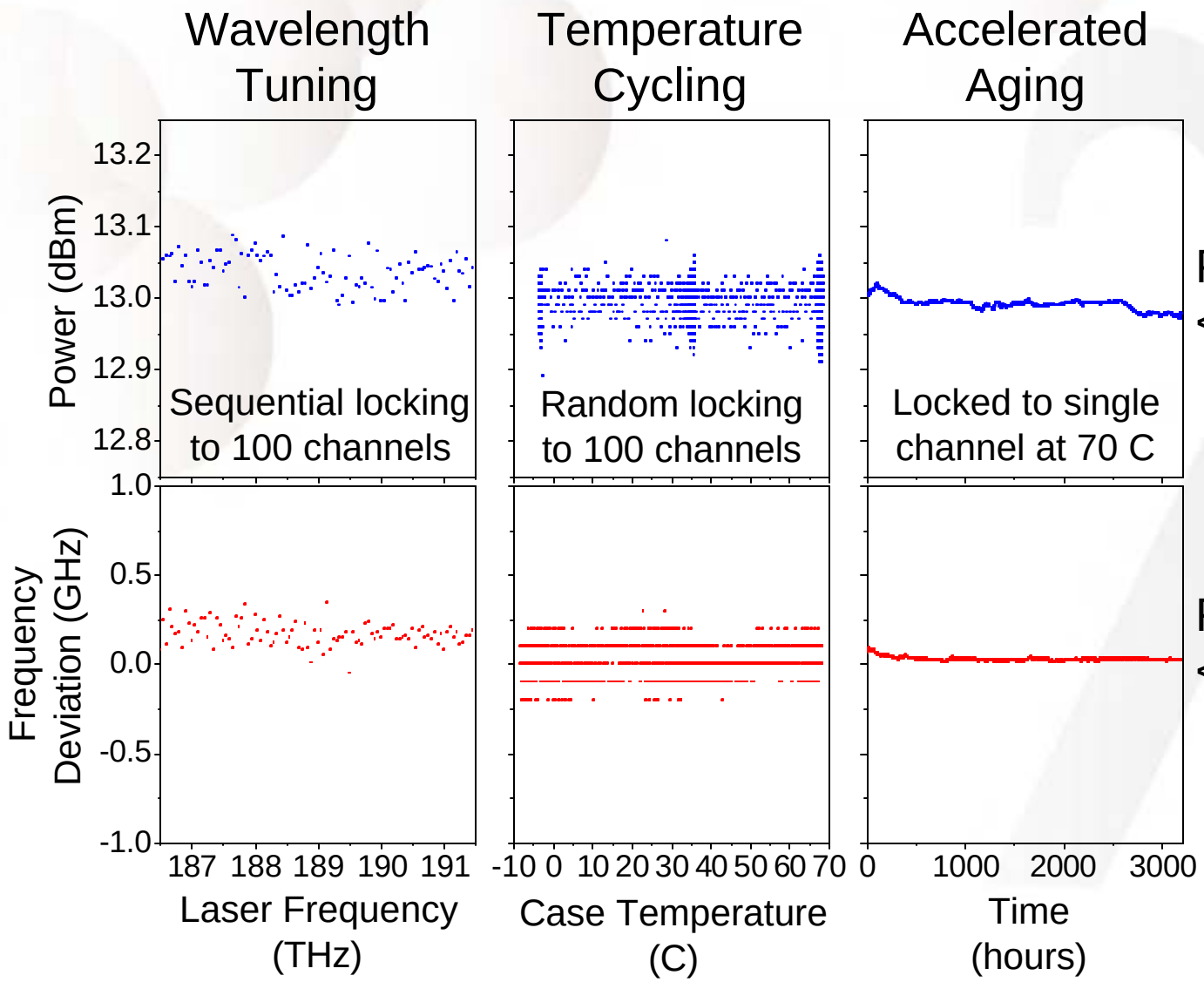
Environmental Stability and Reliability



Power Variation
< ± 0.1 dB

Frequency Error
< ± 0.5 GHz

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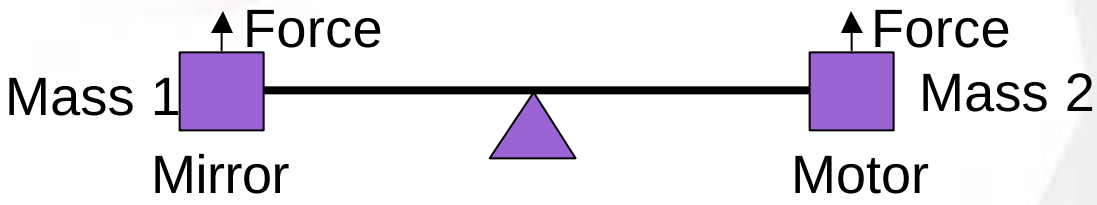
Balanced MEMS Actuator

- Mechanically balanced actuator is resistant to shock and vibration.
  - Pivoting lever is balance mechanism; similar to a see-saw.



- Servo system actively controls laser to ITU wavelength to further reduce shock and vibration sensitivity.
- Lasers exhibit < 2.5 GHz wavelength error with a 35 g half-sine shock.
  - Card slams and fan tray insertions produce up to 20 g shock to an operating line card.
  - GR468 does not specify operating shock.

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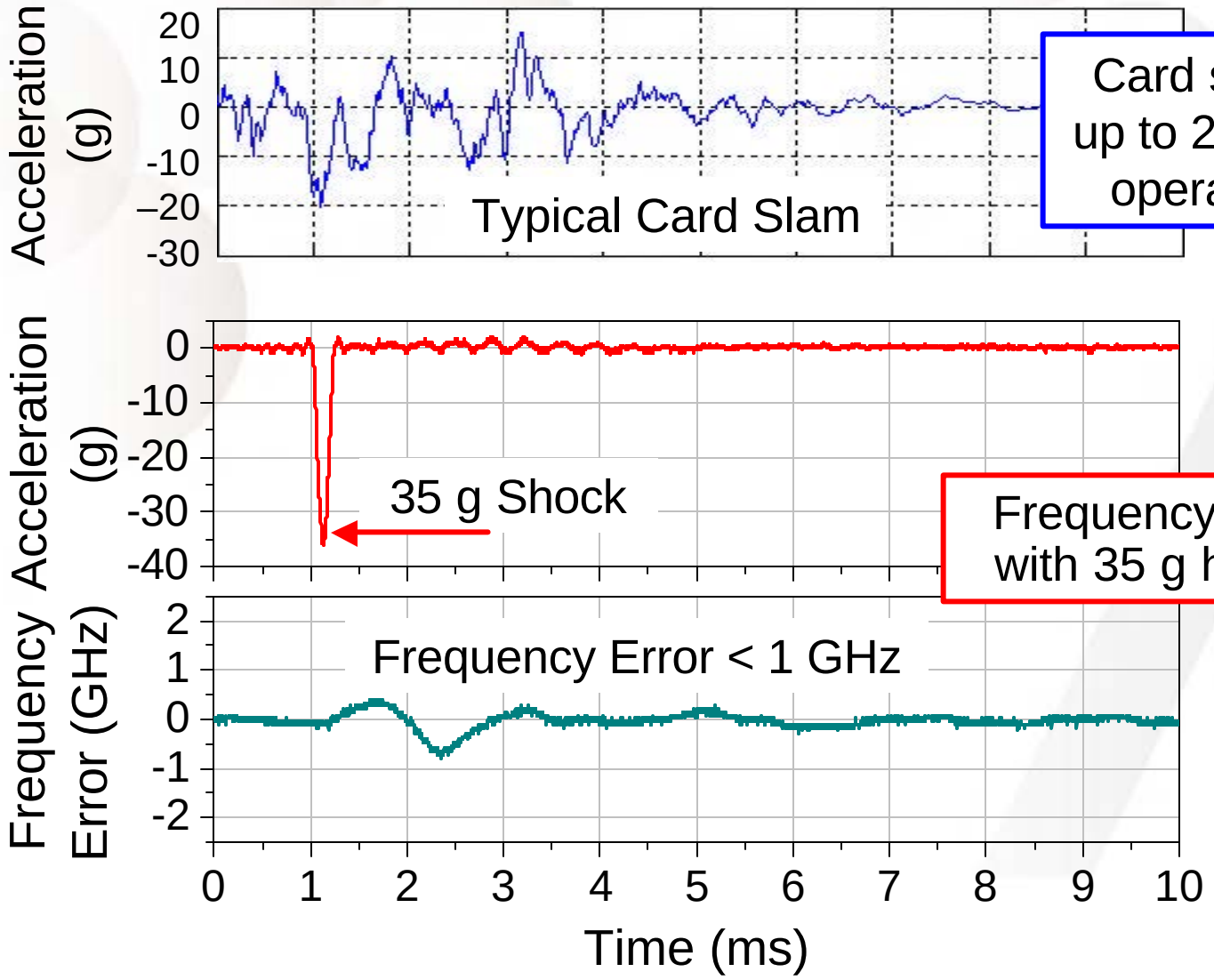
Shock and Vibration Immunity



Card slam produces up to 20 g shock to an operating line card

Frequency error < 1 GHz with 35 g half-sine shock

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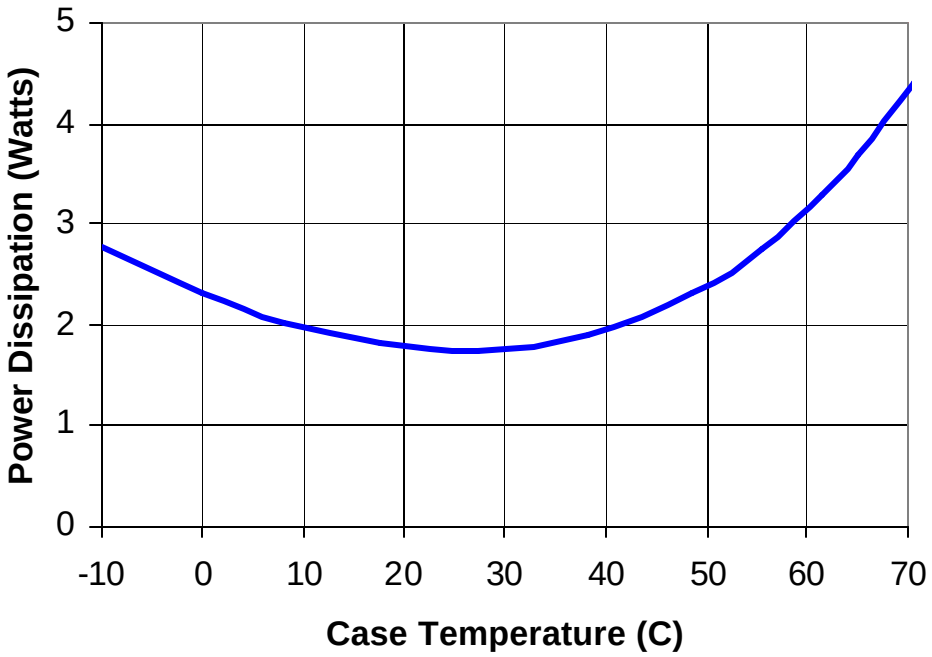
Laser Module Power Dissipation



Measured Power Dissipation for 20 mW output at Vcc = 3.3V is:

1.75 W at 25 °C
4.4 W at 70 °C

Power dissipation is nearly constant over 5 THz tuning range (no channel-to-channel variation)

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iolon Tunable Laser Summary

- C-band or L-band
- Tuning Range up to 44 nm
- 25 GHz or 50 GHz Channels
- Integrated Wavelength Locker
- Tuning Time < 15 ms
- Power Dissipation < 4.4 W at 70 C
- Output Power up to 40 mW
- Power Variation < ± 0.25 dB
- Frequency Error < ± 1 GHz
- SMSR > 50 dB
- Linewidth < 200 kHz
- Dither for SBS Suppression
- RIN < -145 dB/Hz to 22 GHz
- Dark Tuning

- Butterfly and control electronics with 40-pin serial connector in 70×50×13mm module.
- Compliant with OIF (Optical Internetworking Forum) and Tunable Laser MSA (Multi-Source Agreement) between iolon, Bookham, GTRAN, Intel, QDI, Santur, and Vitesse.
- Telcordia Qualified

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2.5 Gb/s Directly Modulated Tunable Laser Transmitter

- Direct modulation at 2.5 Gb/s using a low-capacitance laser diode in the ECL provides a cost-effective widely tunable transmitter for metro applications.

- < 2 dB transmission penalty over 250 km at 2.5 Gb/s

- Dynamic chirp is 5X lower than standard DFB due to the free-space cavity length of the ECL.
  - Laser chip length is only 20% of total cavity length.

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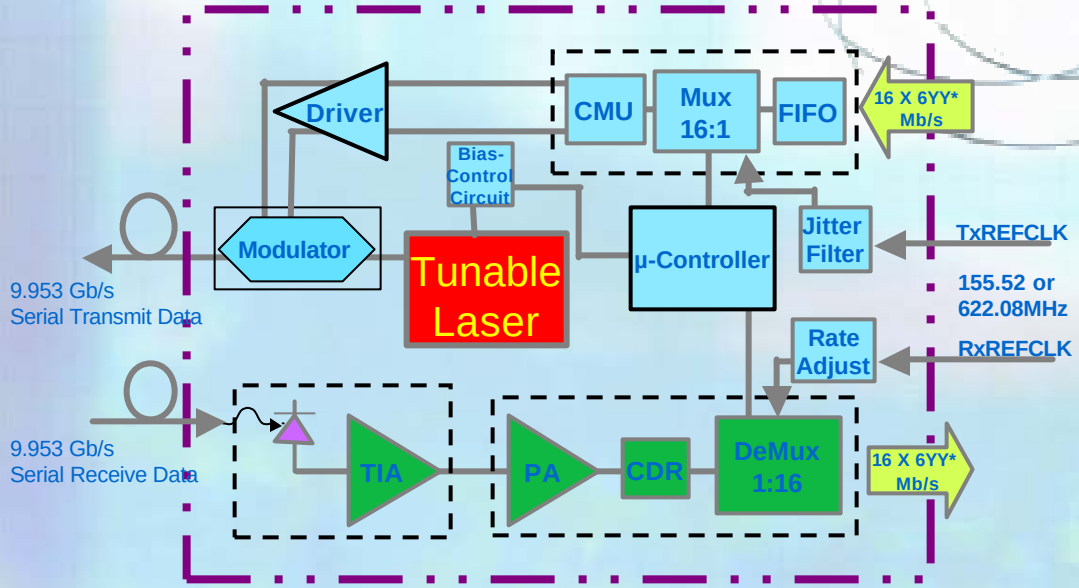
10G Long Reach $LiNbO_3$ Transponder

300 pin MSA Compliant

Tunable laser supplied by iolon



Full band wavelength (40 nm) tunability

C and L Bands

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Optium

Tunable Lasers for Optical Networks

- Tunable lasers are network-ready
  - Match performance of fixed-wavelength DFBs
  - Meet reliability criteria for 99.999% network deployment
  - Supplied by multiple vendors under multi-source agreements
- Replacement of fixed-wavelength lasers with tunables is economically justified today
  - Costs of tunable transmitters are increasingly competitive with costs of fixed-wavelength transmitters
  - … In legacy fixed-wavelength networks, for the cost savings of inventory reduction and sparing.
  - … In new wavelength-agile optical networks that provide for bandwidth re-provisioning, streamlining of traffic patterns, and new services, creating lower operating costs and higher revenues.

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Thank You

For more information …

Demos:

- iolon # 4312
- Optium # 6114
- OIF # 7620
- Fiberbyte # 7356
- Luna # 4212

Papers:

- MF61 – Tunable Laser Frequency and Mode Control
- TuN2 - Tunable Filter

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