IIT MADRAS
Indian Institute of Technology Madras

Technology Transfer Office
TTO – IPM Cell

Industrial Consultancy & Sponsored Research (IC&SR)

Repetition rate Independent Stabilization of Active Harmonic mode-Locked Fiber Laser

IITM Technology Available for Licensing

PROBLEM STATEMENT

- **Mode locked lasers** have revolutionized various technologies, producing ultrashort optical pulses with pulse repetition rates between **50 MHz and a few gigahertz (GHz).**
- **Active mode locking techniques** can generate GHz repetition rates without shortening the optical cavity length, while harmonic mode locking aims for higher pulse repetition rates using an RF source.
- However, **these lasers can be unstable in the long term** due to continuous fluctuations in the **cavity's FSR due to environmental disturbances, temperature fluctuations, and vibrations**.
- **A control system is needed to stabilize active harmonic mode-locked lasers**, maintain long-term operation, and enhance performance reliability, particularly for applications **like photonic analog-digital converters, optical clock distribution, and microwave signal generation**.

TECHNOLOGY CATEGORY/ MARKET

Technology: Stabilization of Active Harmonic mode-Locked Fiber Laser
Category: Electronics & Circuits /Photonics
Industry: Electronic System & Design Manufacturing (ESDM)
Application: Mode-locked lasers, Photonic analog to digital converter, optical communications
Market: The global market size valued at **USD 3.86 Billion in 2022** and is poised to grow from **USD 4.31 Billion in 2023 to USD 10.36 Billion by 2031**, at a **CAGR of 11.6%** during the forecast period **(2024-2031).**

INTELLECTUAL PROPERTY

IITM IDF Ref. 2862 ,Patent No: IN 545507

TRL (Technology Readiness Level)

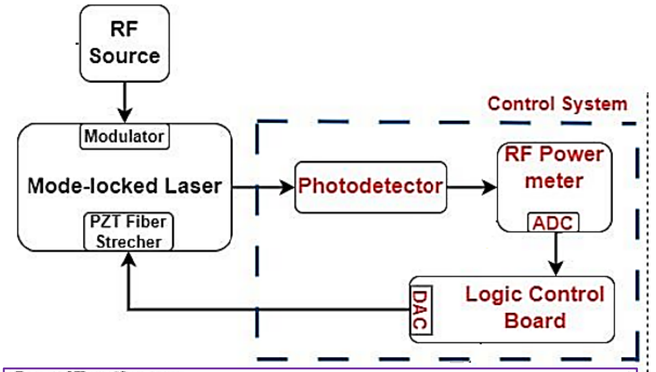
TRL- 3, Experimental Proof of concept

Research Lab

Prof. Deepa Venkitesh & Prof. Balaji Srinivasan, **Dept**. of Electrical Engineering

TECHNOLOGY

System for stabilization of the AHML



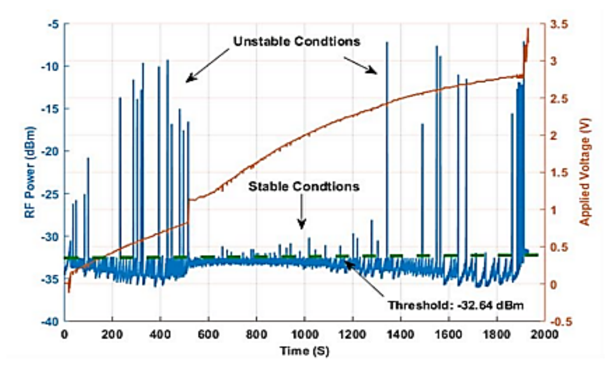
Specifications:

InGaAs PIN Photodetector
Bandwidth: DC - 400 MHz
Conversion Gain: 9×10^3 V/W

RF Power meter
RF range: 1 MHz- 8GHz
Dynamic range: -58 dBm to - 1dBm
ADC - 12 bit with SPI interface

Logic Control Board
CPU: 1.2GHz Broadcom BCM2837 64bit, 40 GPIO pins
DAC: 16 bit with SPI interface

The below graph shows a variation in RF power levels at the ADC as a function of time when a cumulative applied voltage is supplied to the PZT fiber stretcher under stable and unstable operative conditions of the AHML.



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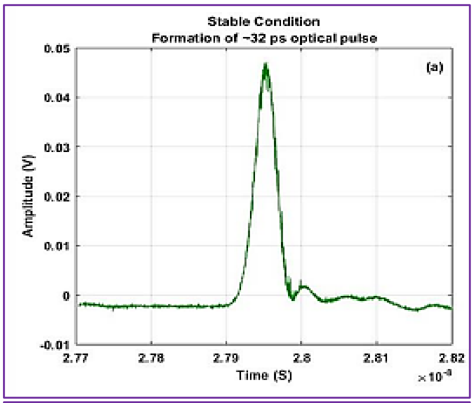
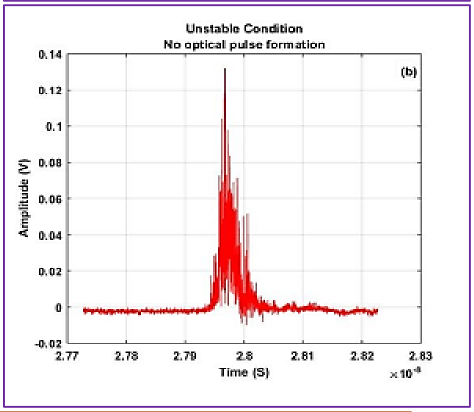
Process flow for stabilization of the AHML

- Monitoring an integrated optical power in the lower-order longitudinal cavity modes
- Determining a threshold integrated power of the lower-order longitudinal cavity modes as an indicator of pulse stability
- Converting the integrated optical power of the lower-order longitudinal cavity modes into an electrical signal
- Receiving the converted electrical signal and determining an instantaneous RF power level at the RF power meter
- Digitizing the instantaneous RF power level output of the RF power meter by the ADC
- Generating a DAC correction voltage based on the instantaneous RF power level and a control logic
- Generating a DAC output voltage as a feedback correction signal based on the control logic
- Sending the DAC output voltage to a piezo electric transducer (PZT) fiber stretcher of the AHML
- Controlling a cavity length of the PZT based fiber stretcher to achieve a longitudinal mode spacing as an integral multiple of a desired pulse repetition rate
- Minimizing the integrated optical power of lower-order longitudinal cavity modes of the AHML

The below two graph shows the optical pulse generated by the AHML when mode-locked, under stable operative conditions of the AHML





Key Features / Value Proposition

- **Active Harmonic Mode-Lock Laser Operation**
  - Minimize integrated optical power of lower-order longitudinal cavity modes.
  - Ensure reliable, stable operation for longer, uninterrupted duration.
  - Maintain stability without performance impact from environmental disturbances.
- **Stabilizing Active Harmonic Mode-Locked Fiber Laser**
  - Functions regardless of repetition rates.
  - Eliminates need for reconfiguration.
  - Avoids cavity length and FSR variations.
- **Configuring ADC for RF Power Levels**
  - Receives instantaneous RF power levels.
  - Determines desired RF power level.
- **Maintaining RF Power Level Threshold at ADC**
  - Maintains desired threshold for **1800s**.
- **RF Power Level Measurement**
  - Measures difference between instantaneous and desired levels.
  - Determines desired RF power level threshold.
  - Maintains instantaneous RF power level at determined threshold.
- **RF Power Level Monitoring**
  - Controls DAC output voltage and integrated optical power.
- **Terminates DAC correction voltage generation**
  - if ADC voltage reaches PZT limit.
- **Photodetector operates at**
  - bandwidth **of less than 400MHz.**

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