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HIGH STABILITY, FAST TUNABLE SINGLE FREQUENCY LASER SOURCE FOR SPACE BASED LIDAR APPLICATIONS

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ABSTRACT

This paper describes the design and performance of the TESAT Reference Laser Head, acting as the frequency reference for the ALADIN Transmit Assembly (TXA) for the ESA AEOLUS satellite. First measurements of short time frequency stability (130 kHz rms over 360 sec) and digitally controlled coarse and fine step tuning functionality will be presented.

1. INTRODUCTION

Some applications in space based LIDAR system require high stability laser sources, that can be precisely tuned to perform sensor calibration. This paper describes the seed laser source approach used in the ALADIN instrument currently under development for the ESA ADM-AEOLUS mission (EADS Astrium as prime contractor for the satellite and the instrument). The direct detection Doppler wind LIDAR instrument incorporates a transmitter laser, made by an European consortium under the leadership of Galileo Avionica (It), in witch TESAT has the task to develop and qualify the Seeder Laser (so called Reference Laser Head, RLH), acting as the frequency reference for the Transmitter Laser (TxA). The baseline for the design is a set of two TESAT single frequency fiber coupled Nd:YAG ring lasers [1],[2].

2. THE TESAT LASERS

TESAT has currently developed two versions of this single frequency lasers, see figure 1. The right laser in figure 1 incorporates a high power non planar ring laser with up to 300 mW output power and 10 GHz continuos tuning range (60 GHz total).
The left laser includes a 30 GHz continuos tuning range laser x-tal, and a build-in Faraday Isolator. This type is able to emit > 50 mW of single frequency light and is foreseen for the RLH. Both laser in common have single mode polarization maintaining fiber coupling (free space beam optional), and internal power monitors. The lasers successfully passed a number on environmental tests (gamma radiation, launch vibration, thermal cycling, life test) to justify the robustness of this design, especially the long time frequency stability and single mode fibre coupling, that is stable to +- 10% over a temperature range of –40°C to + 40°C.
The lasers are remotely pumped by a redundant fiber coupled pump laser module.

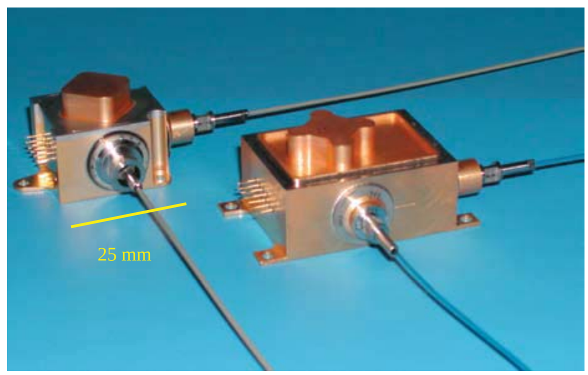

Fig. 1. TESAT single frequency Laser Heads

3. THE ALADIN REFERENCE LASER HEAD

The TESAT RLH serves as the seeder laser for the ALADIN TxA. Therefore the frequency stability and tunability of the TXA directly depends on the RLH performance.
In order to simultaneously fulfill the stringent requirements of absolute frequency stability, low frequency drift, and fast step tuning performance of the AEOLUS mission, the approach for the RLH is to separate tunability from frequency stabilization. The RLH internal setup is shown in figure 2.

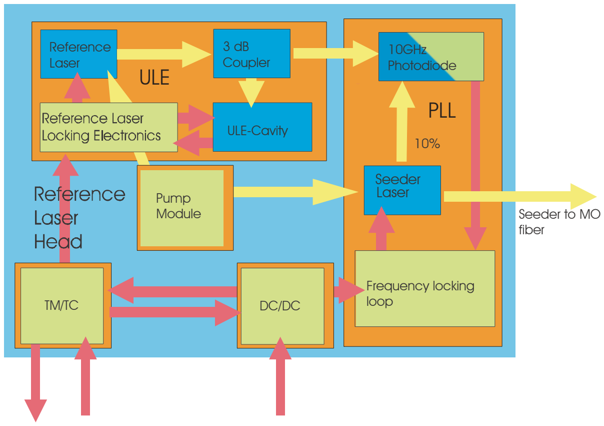

Fig. 2. Internal structure of RLH. Red arrows are electrical signals, yellow arrows are optical. Digital TM/TC is performed by a FPGA

3.1 Reference Laser

The RL is locked to a 3 GHz free spectral range cavity (see figure 3) made from ULE ™ (Corning) This special glass has a CTE of < 30 ppb near room temperature and is therefore ideally suited for low drift frequency stabilization cavities. The RL is locked to a resonance of this temperature stabilized cavity, and acts as the internal frequency normal for the Seeder Laser.

Fig. 3: ULE cavity in comparison with a FC/APC connector

Figure 4 shows the first results for the frequency stability (measured by heterodyning the locked laser with a Iodine stabilized laser on a fast photo diode, and analyzing the beat frequency).
The measurements showed a drift of less than 1 kHz / sec, and a random jitter of ~130 kHz.

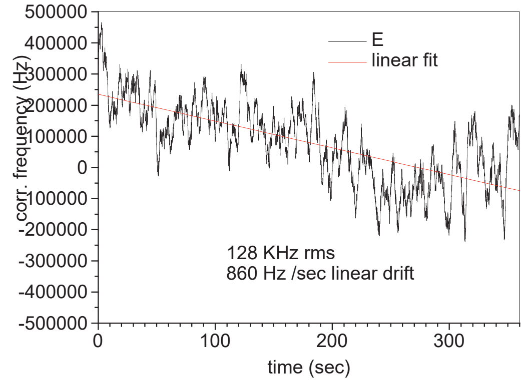

Fig. 4: First measurements of frequency stability of a RL locked to a cavity resonance.

3.1 Seeder Laser PLL

For frequency tuning, the light from the frequency stabilized RL is mixed on a photo diode with the light from a second laser, the so called seeder laser (SL). The SL delivers the seeding signal to the TxA Master Oscillator.
The emission frequency of the SL controlled by a high frequency (> 10GHz) digital phase locked loop (PLL) enabling the system to perform small frequency steps (8.333 MHz) with kHz accuracy in < 100 msec. Larger frequency steps (83.33 MHz) can be performed in less than 1 sec. Even sequences of steps differing in step size and step direction are possible. Figure 5 shows a coarse and fine frequency tuning sequence.

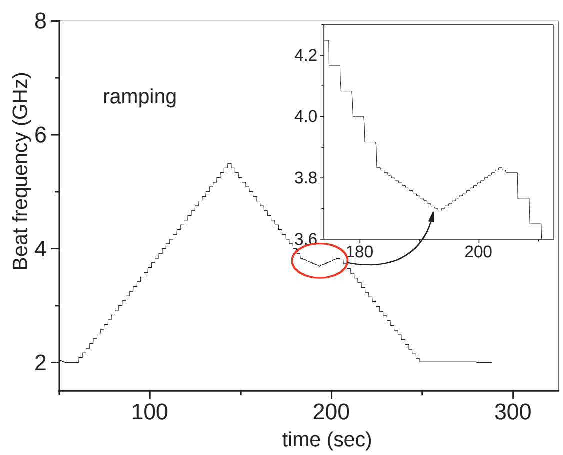

Fig. 5: Frequency tuning sequence, the insert shows the transition from coarse (83.33 MHz) to fine (8.333 MHz) frequency tuning steps (and reverse)

The key parts of the PLL setup are already space qualified, optics and lasers are currently in the qualification process .

4. RLH DESIGN

The RLH is fitted into housing with isostatic mounts (see fig. 6). The weight of the RLH is ~ 2 kg, dimensions are approx. 140mm*200mm*90mm. The power consumption is ~ 20 W, supply voltages are + - 15 V DC. 25 mW tunable single frequency light is delivered to an AVIM single mode polarization maintaining fiber, that is detachable from the RLH. The TM/TC interface of the RLH is a FPGA and can by adapted to different customers requirements regarding protocol, timing, and step size. The RLH accepts digital frequency commands.

Fig. 6: RLH housing, showing isostatic mounts and connector interface.

5. SUMMARY

The paper describes the design and performance of the Reference Laser Head, used as Seeder Laser for the ALADIN Transmitter laser in the ESA AEOLUS mission. First performance measurements are given regarding frequency stability and tunability.

6. REFERENCES

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