# High-power optical amplifier with enhanced wall-plug efficiency for 10-channel WDM satellite laser communication systems

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As part of the ARTES ScyLight framework programme (SeCure and Laser communication Technology), ESA envisages the establishment of a high throughput optical network in the sky called HydRON [1]. This next generation of optical satellite communication technology foresees the employment of all-optical payloads, targeting for a seamless extension of terrestrial fiber networks with terabit per second capacity.

In this context, we present the development of a fiber-based high-efficiency laser amplifier (HELA). The system is designed to simultaneously amplify 10 narrow-linewidth optical channels (< 15 MHz) at wavelengths around 1064 nm. For input powers ranging between 1 and 10 mW per channel, the targeted output power is up to 10 W per channel (minimum requirement: 5 W), i.e., up to 100 W in total. Considering the strict electrical power restrictions for satellite payloads, a focus was placed on enhancing the wall-plug efficiency of the system.

An in-house developed fiber laser setup combining 10 optical channels (1060 nm to 1069 nm, approx. 1 nm spacing) in a single-mode fiber serves as a seed source. The HELA system is designed as an all-fiber setup which is illustrated in Fig. 1a). It comprises two amplifier stages based on $Yb^{3+}$-doped polarization maintaining (PM) double-clad fibers. In-house manufacturing technology for fiber optical components enables the integration of pump-combiners (PC) [2], cladding light strippers (CLS) [3] and end caps directly into the active fibers. Therefore, additional splices within the amplifier chain are avoided in favour of preserving the optical properties of the input signal. In between both amplifier sections, two fiber-based optical isolators are employed in order to decouple the booster stages from each other.

With this design, an amplification up to a total output power of 100 W has been demonstrated while employing the aforementioned fiber-based 10-channel seed source. In Fig. 1b) the corresponding amplifier output power is plotted as a function of the current applied to the pump diodes. With respect to the optical power emitted by the two wavelength-stabilized pump diodes of the main amplifier stage, a slope efficiency of around 63% has been achieved. Ongoing development efforts include fiber cut-back experiments in order to optimize the performance of the system. The lengths of the active fibers used in each of the two amplifier stages are a key parameter in defining the amplifier efficiency as well as the achieved gain flatness across the 10-channel seed spectrum.

Considering its intended application in space, irradiation tests have been performed with several components of the HELA system. The in-house manufactured fiber components and the optical isolator have been subjected to gamma irradiation, whereas the employed fiber-coupled pump diodes have been characterized before and after proton irradiation.

While this development is driven by the needs and specifications of the HydRON mission concept, it can also benefit other space applications in the domain of lidar and scientific metrology.

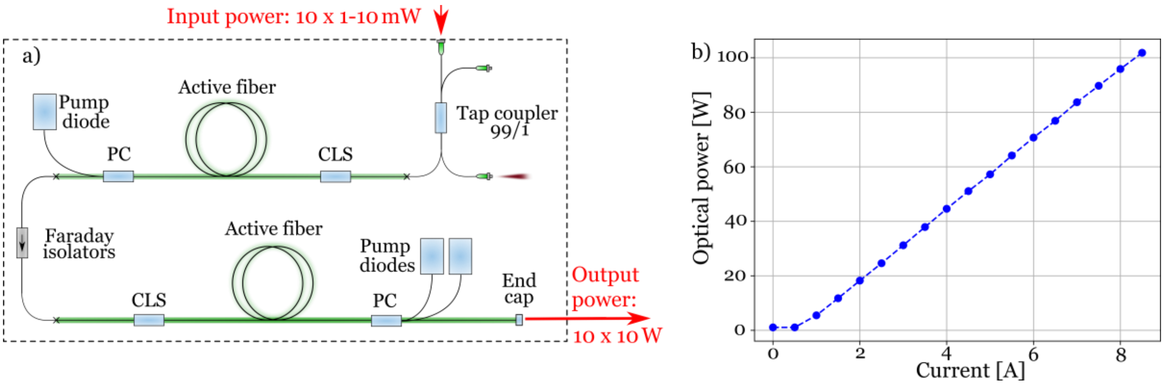


**Fig. 1** a) Setup of the HELA system designed as an all-fiber architecture comprising two amplifier stages. PC: pump combiner, CLS: cladding light stripper, x: splice. b) Optical slope of the HELA system up to an output power level of 100 W, plotted as a function of the current applied to the wavelength-stabilized high-power pump diodes.

## References

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