

## White Paper

# Optical Amplifier Design Using Compact 70x90mm Building Blocks

## 1 Introduction

In today's competitive market environment, a key requirement for optical system designers is to decrease costs while maximizing the system flexibility, to address different applications and network segments. An important tool for achieving increased flexibility is to employ a flexible, modular design approach which allows different optical components to be mixed and matched on a line card according to the required system application.

For example, many systems now use standardized pluggable transceivers, where a single line card can support different applications (e.g. reach requirements) by simply replacing the transceiver component. A similar modular approach would also be beneficial with regards to optical amplifiers. However, currently, EDFAs are provided in different physical packages according to their specifications and applications, requiring specific line cards to be designed for each type of application. For a truly modular approach, it would be necessary to provide a basic EDFA building block in a standardized package, with sufficient functionality to allow all types of amplifiers to be constructed using this building block.

The Compact 70x90mm (70x90) optical amplifier package developed a few years ago is a good candidate for this purpose. However, until recently, the functionality of this package was limited to relatively simple fixed gain (FG) single stage amplifiers, which are not sufficient to support more complex variable gain applications.

Using a highly optimized space-saving design, and taking advantage of component miniaturization, RED-C has recently succeeded in integrating a fully functional VG EDFA in a 70x90 package. As we shall now show, this new development allows the entire spectrum of optical amplifier applications to be addressed using only these compact amplifiers as building blocks. This in turn allows a truly modular approach to amplifier design, where a single line card can support any mix of amplifiers that an optical system may require.

## 2 New 70x90 MSA Variable Gain EDFA

Figure 1 shows a mechanical outline of the Compact 70x90 package, which recently could only support a FG single stage EDFA. However, using a highly optimized and space-saving design, and taking advantage of component miniaturization, RED-C has launched an integrated, fully functional VG EDFA in this package, as shown in Figure 2. Besides the pump and two detectors found in a typical FG MSA EDFA, this new amplifier packs a Variable Optical Attenuator (VOA), up to 3 additional detectors, and all required passive components such as isolators, WDMs, couplers and splitters. The amplifier provides full control and communications capabilities, and contains fast transient suppression circuitry. The main features supported by the amplifier are:

- Full variable gain operation with up to 15dB dynamic gain range.
- Up to 20dBm output power.
- Low noise figure of <5.5dB over a large dynamic range.
- Fast transient suppression with <1dB overshoot/undershoot and <300µs setting time for input transient of 16dB with 1µs rise/ fall time.
- Can support FG amplifier with VOA placed at input for reduced cost and backward compatibility to older systems.
- I<sup>2</sup>C and RS232 communication, full set of control options and alarms

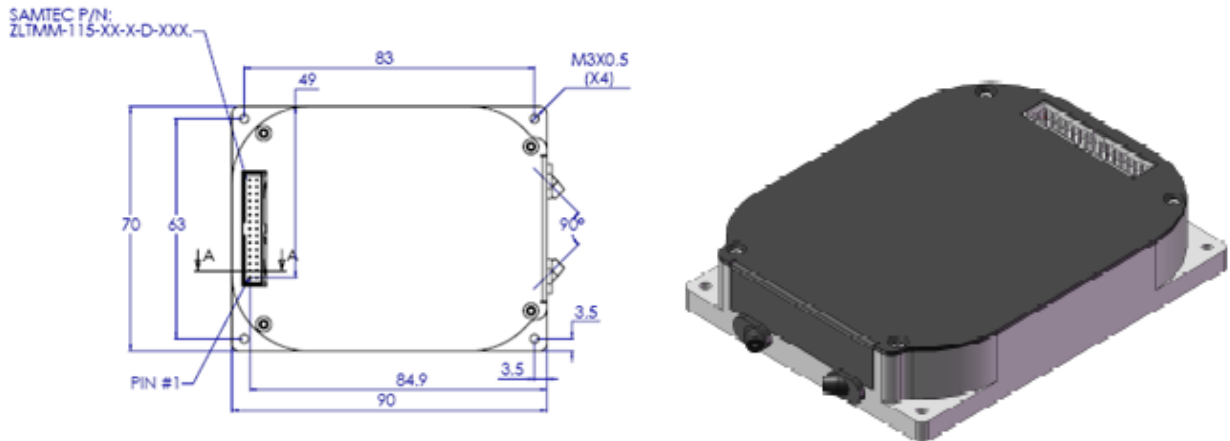


Figure 1: Mechanical outline of the 70x90mm package

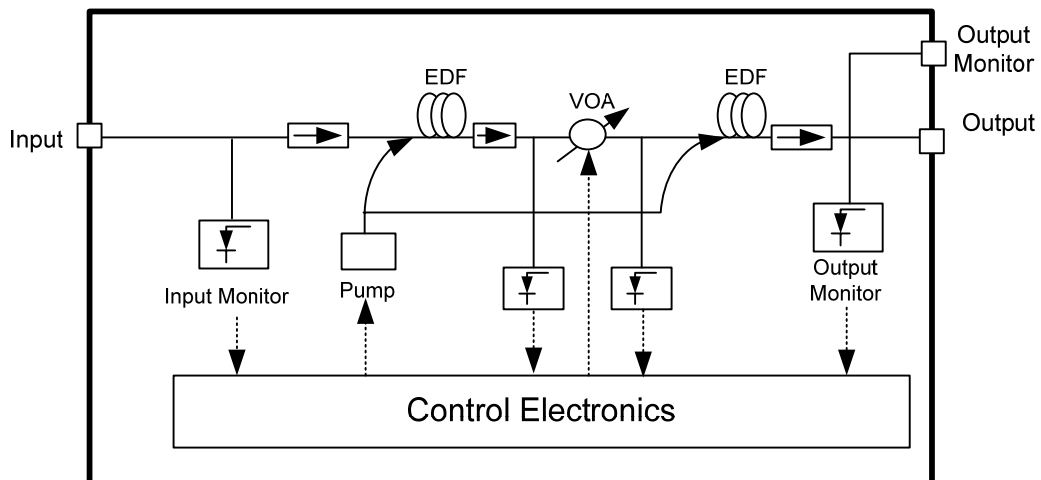


Figure 2: Block diagram of single stage VG EDFA in 70x90mm package

### 3 Modular Designs Based on 70x90 EDFAs

The basic building block for all EDFA applications is either a FG or VG single stage EDFA. Now that both these basic building blocks are available in a compact 70x90 package, a simple modular design approach for amplification can be adopted. In a typical implementation of this modular approach, a single line card supporting two 70x90 EDFAs would be designed. Since either of these two EDFAs can be either FG or VG, this single line card can support all possible network applications.

The various possible configurations of the line card are shown in Figure 3. Bi-directional configurations (a)-(c) support two separate single stage EDFA for each of East/ West directions, whereas uni-directional configuration (d) supports a dual-stage EDFA with mid-stage access.

In some cases, mainly for cost reduction and/or backward compatibility purposes, a VG EDFA can be substituted by an FG EDFA preceded by a VOA. This cost-effective design can also be supported by the compact 70x90 package, without the need for an external VOA, as was previously the case.

Figure 4 shows two examples of how multiple line cards can be used to support complex amplification nodes, such as nodes with dispersion compensation (Figure 4a) and ROADMs with East/ West separation (Figure 4b). Clearly, any type of nodes can be constructed using the configurations shown in Figure 3.

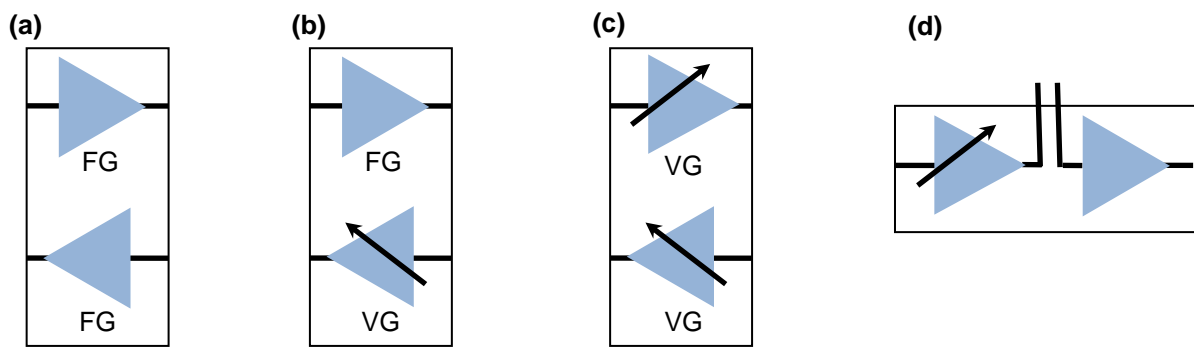


Figure 3: Possible configurations of a line card supporting two MSA EDFAs

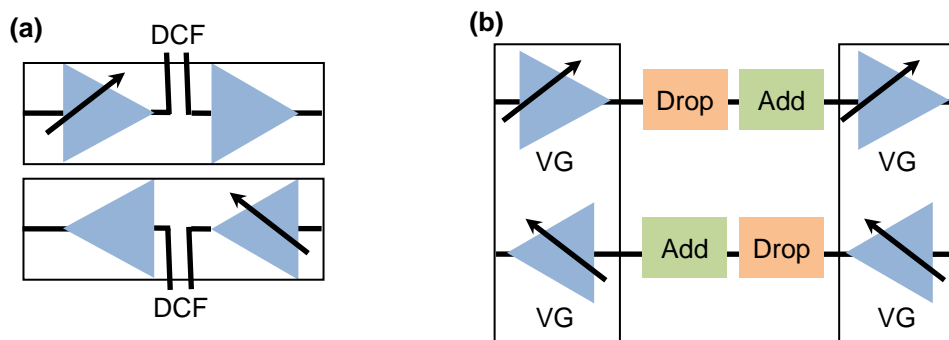


Figure 4: Using multiple line cards to support complex amplification nodes

### 4 Conclusions

In this paper we discussed a modular design approach to optical amplification using FG and VG single stage EDFAs as a basic building block. This approach is enabled by the recent introduction of a VG EDFA in a compact 70x90mm package, meaning that a single line card designed to support two compact packages can be used to address all amplification requirements.

The use of a single line card together with a few selected FG and/or VG single stage EDFA building blocks allows maximum design flexibility on the one hand, while requiring a minimum number of part numbers on the other. This in turn allows:

- Direct system cost reduction by allowing the most appropriate amplifier design to be used for each application.
- Simpler and more cost-effective supply chain management for system vendors.
- Reduced sparing requirement for operators and carriers.

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