Raman C-Band Optical Amplifier for the Cisco ONS 15454 Multiservice Transport Platform

The Cisco® ONS 15454 Multiservice Transport Platform (MSTP) offers a Raman optical amplifier card (Figure 1) operating in the C-band region of the optical spectrum to extend the reach and capacity of a regional, long-haul, or ultra-long-haul optical network. The Raman optical amplifier cards are part of the Cisco ONS 15454 MSTP intelligent DWDM architecture engineered to reduce DWDM complexity and speed the deployment of next-generation networking solutions.

Figure 1. Raman C-Band Optical Amplifier (OPT-RAMP-C)

Background

The Cisco ONS 15454 Raman optical amplifier card (OPT-RAMP-C) is a plug-in module that takes advantage of the proven Cisco ONS 15454 carrier-class features. This card delivers the reach and optical performances to support a single DWDM channel all the way to 80 channels today, to meet the requirements of service provider and enterprise networks.

A Raman amplifier uses intrinsic properties of silica fibers to obtain signal amplification. This means that transmission fibers can be used as a medium for amplification, and hence that the intrinsic attenuation of data signals transmitted over the fiber can be combated within the fiber. An amplifier working on the basis of this principle is commonly known as a distributed Raman amplifier (DRA) or simply Raman amplifier.

The OPT-RAMP-C unit not only embeds efficient next-generation pump lasers to generate counter-propagating Raman effect in the span fiber but also a low-noise Erbium Doped Fiber Amplifier (EDFA) to optimize the overall Noise Figure of the Node.

Table 1 outlines the C-band optical amplifier plug-in card types available for the Cisco ONS 15454 MSTP with the applications they are designed to support.

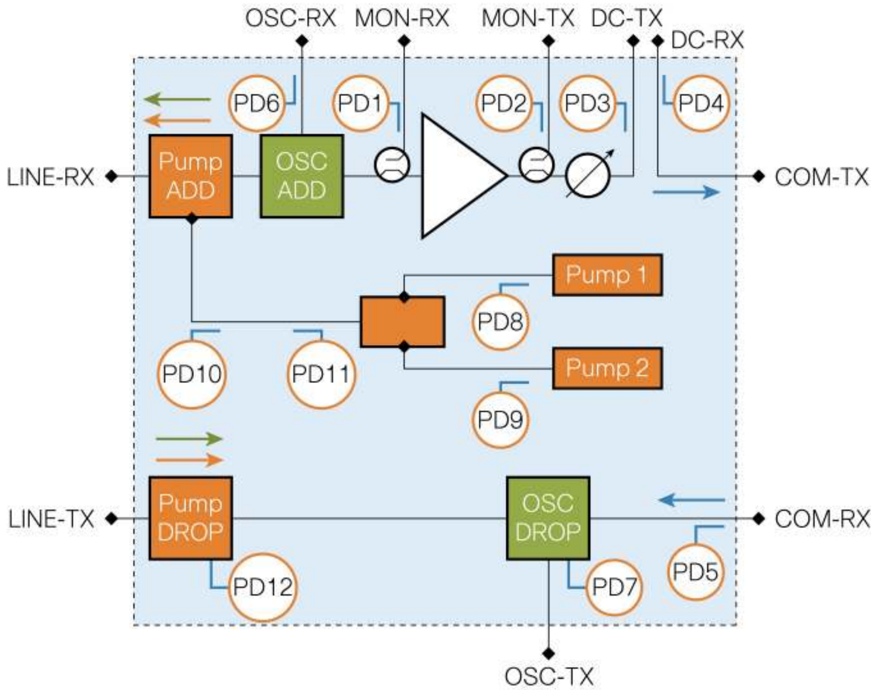
Table 1. C-Band Optical Amplifier Cards with Applications

Component	Deployment Application
Raman optical amplifier (OPT-RAMP-C)	This product injects counter-propagating optical power to generate Raman effect in the span fiber and features an embedded Erbium Doped Fiber Amplification (EDFA) to help guarantee low noise. It integrates an optical service channel splitter/combiner to allow the optical supervisory channel (OSC) to be sent to and received from the optical service channel module (OSCM) card. It allows insertion of dispersion-management devices (DCUs) to compensate for pulse spreading at higher multiplexer speeds. Deployment locations include any configuration where very long unregenerated spans or low latency is required.
Enhanced optical amplifier (OPT-AMP-C)	This flexible amplifier can be used as a preamplifier or as a booster amplifier, providing a total output power of 20 dBm. It integrates an optical service channel splitter/combiner to allow the optical supervisory channel (OSC) to be sent to and received from the optical service channel module (OSCM) card. It employs a two-stage amplifier design to allow insertion of dispersion-management devices (DCUs) to compensate for pulse spreading at higher multiplexer speeds. Deployment locations include any site where high per-channel power or high optical gain is required.
Enhanced optical booster amplifier (OPT-BST-E)	This product amplifies the outgoing composite DWDM signal to overcome the attenuation of the fiber network, providing a total output power of 20 dBm. It integrates an optical service channel splitter/combiner to allow the OSC to be sent to and received from the OSCM card. Deployment locations include any site where high per-channel power is required to hit the fiber span.
Optical booster amplifier (OPT-BST)	This product amplifies the outgoing composite DWDM signal to overcome the attenuation of the fiber network, providing a total output power of 17 dBm. It integrates an optical service channel splitter/combiner to allow the OSC to be sent to and received from the OSCM card. Deployment locations include any site where amplification of the DWDM signals is required before hitting the fiber span.
17 dB gain optical amplifier (OPT-AMP-17C)	This flexible amplifier can be used as a preamplifier or as a booster amplifier, providing a total output power of 17 dBm. It integrates an optical service channel splitter/combiner to allow the OSC to be sent to and received from the OSCM card. It employs a single-stage amplifier design to optimize the noise figure and operates with a fixed gain of 17 dB. Deployment locations include any site where fixed gain amplification can be used to optimize node gain figure and dispersion-management devices are not needed.
Optical preamplifier (OPT-PRE)	This product amplifies the incoming composite DWDM signal to allow a sufficient optical power level to optical receivers on dropped wavelengths and to overcome the insertion losses of the reconfigurable or fixed optical filters in the node. It employs a two-stage amplifier design to allow insertion of dispersion-management devices (DCUs) to compensate for pulse spreading at higher multiplexer speeds, providing a total output power of 17 dBm. Deployment locations include any site where variable gain amplification and/or dispersion-management devices are required in the receive direction.

Product Overview and Applications

The OPT-RAMP-C takes advantage of the latest in amplifier technology, variable optical attenuators, photo diodes, and extensive software to facilitate a high degree of automation for simplified operations. The OPT-RAMP-C features an embedded low-noise EDFA gain block for C-band optical amplification and optimized system performances with Raman amplification. The Raman pumps embedded in the unit use on the latest laser technology, enabling up to 500 milliwatts (mW) of power combining just two pump lasers, thus obtaining very high efficiency and low power consumption (Figure 2).

Figure 2. OPT-RAMP-C Block Diagram



When deployed in any node configuration, the OPT-RAMP-C unit faces both the span fibers and thus can use the embedded OSC's splitting and combining capabilities to provide visibility and manageability of all the nodes of the network. If the OSC is not used, it is possible to use the Data Communication Network (DCN) Extension capabilities of the Cisco ONS 15454 MSTP to help ensure the correct operation and support of all the intelligent optical applications, such as Wavelength Path Provisioning (WPP), Automatic Power Control (APC), Network Topology Auto-discovery, or Network-Level Alarm Correlation (NLAC).

The OPT-RAMP-C also provides an embedded fast Gain Control for transient suppression to respond quickly to network changes without impairments and degradation of existing wavelengths. In addition to this, the unit features an embedded Gain Flattening Filter (GFF) for the compensation of the ripple generated by the cascaded Raman and EDFA stages.

The amplifier integrates a software-controllable variable optical attenuator (VOA) to provide gain tilt control capabilities and to optimize and control the per-channel power at the input of the mid-access loss for dispersion compensation units (DCUs).

The OPT-RAMP-C provides parallel, low Failure-In-Time (FIT) optical safety functionalities, which allow the classification of the unit into Class 1M as defined by IEC/EN 60825-1. The embedded detection devices and control mechanisms allow to shut down the amplifier (lowering its transmit optical power below the level defined in the recommendation mentioned above) if any of the following situations occur:

- Raman pump back-reflection, which may be caused by bad connections or similar problems with the span fiber
- Detection of open connectors
- Detection of broken fiber up to a few tens of kilometers from the node

The optical Raman amplifier card is supported by the integrated Cisco Transport Controller (CTC) craft manager on the Cisco ONS 15454, which provides the user access to operations, administration, maintenance, and provisioning (OAM&P) of the system.

A dedicated software application has been incorporated in Cisco Transport Controller to allow a fully automatic and simple configuration and tuning of the optical Raman amplifiers along a DWDM link. This software application, called Raman Tuning Wizard, can take advantage of tunable Transponder or Muxponder units to evaluate the physical characteristics of the span's fiber, determine the optimal mix of Raman pump wavelengths, and define the contribution of Raman versus EDFA for the overall optical amplification of the unit. At the end of the process it is possible to export the data retrieved during the tuning for design validation or tracking purposes.

Selection and deployment of the Cisco ONS 15454 Raman C-Band Optical Amplifier depend on the requirements of the network. The Cisco TransportPlanner optical design tool is available to assist in the engineering, bill-of-material development, and deployment of the DWDM network.

The OPT-RAMP-C card incorporates faceplate-mounted LEDs to provide a quick visual check of the operational status at the card. Printed on each of the faceplates is an icon, an orange circle, which is mapped to shelf-slot icons indicating the shelf slot where the card can be physically installed.

Using the OPT-RAMP-C, the Cisco ONS 15454 MSTP can support a number of applications, including the following.

Ultra Long-Haul Unregenerated Transmission

The OPT-RAMP-C can be used in addition to the EDFA-based optical amplification to extend the unregenerated reach of DWDM systems, using the distributed amplification that can be obtained in the span fiber. Up to 2,000 miles (3,200 km) can be supported for systems equipped with 0.4 Tbps capacity and using 10-Gbps wavelengths.

Support for Very Long Spans

The OPT-RAMP-C can be used to guarantee high capacity over very long fiber spans where intermediate amplification or regeneration cannot be supported (such as submarine links or festoon/repeater-less applications). Up to 130 miles (200 km) can be supported for systems equipped with 0.2 Tbps capacity and using 10-Gbps wavelengths.

Improved Transmission Reach and Capacity for Networks with Long Spans

A large number of DWDM networks in the world happen to be deployed in locations where some unamplified spans exist, due to the geography of the region. EDFA-based systems suffer a high Optical Signal-to-Noise Ratio (OSNR) degrade when the wavelengths cross these long spans due to the extra loss and tilt. Selectively using Raman amplification, it is possible to lower the overall insertion loss of these spans and improve the overall unregenerated distance and/or system capacity.

Upgrade of Transmission Systems to Higher Per-Channel Bit Rate

Increasing the bit rate of the wavelengths in the system normally drives the need to guarantee a higher OSNR for these wavelengths. The market is currently transitioning to 40-Gbps wavelengths and Raman amplification can be selectively used to improve overall system performance and allow the upgrade of deployed systems to higher per-wavelength bit rates, which directly results in an extension of the system lifecycle.

Reduced Latency of SAN Services

The higher OSNR that can be achieved by selectively using OPT-RAMP-C in the DWDM network allows the possibility to avoid using Forward Error Correction (FEC) or Enhanced FEC (E-FEC) for wavelength carrying SAN services and this directly improves the end-to-end latency.

Cisco ONS 15454 Raman C-Band Optical Amplifier Card Specifications

Tables 2 and 3 list the regulatory compliance and system requirements for the OPT-RAMP-C card. Tables 4 and 5 list product and optical specifications, and Table 6 provides ordering information.

Regulatory Compliance[1]

Table 2. Regulatory Compliance

SONET/ANSI System	SDH/ETSI System
Countries Supported	
• Canada • United States • Mexico • Korea	• European Union • Australia • New Zealand • Singapore • China • Mexico • Hong Kong • Korea • Japan
EMC (Class A)	
• ICES-003 Issue 4 (2004) • GR-1089-CORE, Issue 4 (Type 2 and Type 4 equipment) • GR-1089-CORE - Issue 03 (Oct 2002) (Objective O3-2 – Section 3.2.1 - Radiated Emissions requirements with all doors open) • FCC 47CFR15, Class A subpart B (2006)	• EN 300 386 v1.3.3 (2005) and v1.4.1 (2007) • CISPR 22 - Fifth edition (2005-04) Class A and the amendment 1 (2005-07) • CISPR 24 - First edition (1997-09) and amendment 1 (2001-07) and amendment 2 (2002-10) • EN 55022:1998 Class A - CENELEC Amendment A2:2003 • EN 55024:1998 - CENELEC Amendment A1:2001 and Amendment A2:2003
Safety	
• CAN/CSA-C22.2 No.950-95, 3rd Edition • GR-1089-CORE , Issue 4 (Type 2 and Type 4 equipment)	• UL/CSA 60950 -1 First Edition (2003) • IEC 60950-1 (2001/10) / Amendment 11:2004 to EN 60950-1:2001, 1st Edition (with all country deviations)
Optical Safety	
• EN or IEC-60825-2 Third edition (2004-06) • EN or IEC 60825-1 Consol. Ed. 1.2 - incl. am1+am2 (2001-08) • 21CFR1040 (2004/04) (Accession Letter and CDRH Report) • IEC-60825-2 Third edition (2004-06) • ITU-T G.664 (2006)	
Environmental	
• GR-63-CORE, Issue 3 (2006)	• ETS 300-019-2-1 V2.1.2 (Storage, Class 1.1) • ETS 300-019-2-2 V2.1.2 (Transportation, Class 2.3) • ETS 300-019-2-3 V2.1.2 (Operational, Class 3.1E) • EU WEEE regulation • EU RoHS regulation
Optical	
• GR-253-CORE - Issue 04 • ITU-T G.691	• ITU-T G.709 • ITU-T G.975

[1] All compliance documentation may not be completed at the time of product release. Please check with your Cisco sales representative for countries outside of Canada, the United States, and the European Union.

SONET/ANSI System	SDH/ETSI System
Quality	
• TR-NWT-000332, Issue 4, Method 1 calculation for 20-year mean time between failure (MTBF)	
Miscellaneous	
• AT&T Network Equipment Development Standards (NEDS) Generic Requirements, AT&T 802-900-260, Issue 3, December 1999 • SBC TP76200MP, May 2003	• Verizon SIT.NEBS.NPI.2002.010, October 2002 • Worldcom ESD requirement

Table 3. System Requirements

Component	Cisco ONS 15454 ANSI	Cisco ONS 15454 ETSI
Processor	TCC2P/TCC2	TCC2P/TCC2
Cross-connect	All (not required)	All (not required)
Shelf assembly	15454-SA-HD or 15454-SA-HD-DDR shelf assembly with CC-FTA fan-tray assembly	15454-SA-ETSI shelf assembly with CC-FTA fan-tray assembly
System software	Release 9.0 ANSI or later	Release 9.0 ETSI or later
Slot compatibility	1–6, 12–17	1–6, 12–17

Table 4. Card Specifications

Specification	
Management	
Card LEDs Failure (FAIL) Active/standby (ACT/STBY) Signal fail (SF)	 Red Green/yellow Yellow
Power	
Typical Maximum	44W 55W
Physical	
Dimensions	Occupies two slots
Weight	2.1 Kg (4.6 lbs)
Reliability and Availability	
Mean Time Between Failures (MTBF)	319,014 hrs
Environment Conditions	
Storage temperature	–40 to 70ºC (–40 to 158ºF)
Operating temperature Normal Short term[1]	 0 to 55ºC (32 to 131ºF) –5 to 55ºC (23 to 131ºF)
Relative humidity Normal Short term[1]	 5 to 85%, noncondensing 5 to 90% but not to exceed 0.024 kg water/kg of dry air

[1] Short-term refers to a period of not more than 96 consecutive hours and a total of not more than 15 days in 1 year. (This refers to a total of 360 hours in any given year, but no more than 15 occurrences during that 1-year period.)

Table 5. Optical Specifications

Specification	Value
Unit	
Signal wavelength range	1529.0 nm to 1562.5 nm
OSC wavelength range	1500 nm to 1520 nm
Insertion loss • LINE-TX to OSC-TX (OSC wavelength) • LINE-TX to COM-RX (signal wavelengths) • OSC-RX to LINE-RX (OSC wavelength)	 1.5 dB (typical) 0.6 dB (typical) / 1 dB (worst case) 0.7 dB (typical) / 1.7 dB (worst case)
Gain flatness (EDFA + Raman)	+/–0.2 dB (typical) / +/–0.5 dB (maximum)
Polarization Dependent Loss (PDL) – COM-RX to LINE-TX	0.2 dB (maximum)
Polarization Mode Dispersion (PMD) – COM-RX to LINE-TX	0.15 ps (maximum)
Optical connectors back reflection	40 dB (minimum)
Raman Section	
Pump wavelengths	1425 nm and 1452 nm (typical)
Total Raman pump power	500 mW (maximum)
Operating range Raman pump power	100 mW to 450 mW
Pump power precision	+/–2%
Optical power settling time	1s (maximum)
Typical Raman gain • SMF Fiber (G.652) • E-LEAF Fiber (G.655) • TW-RS (G.655)	 8.5 dB 10 dB 13.5 dB
EDFA Section	
Gain • Nominal • Settable range • Control accuracy • Set resolution	 14 dB (0 dB VOA attenuation) 8 dB to 20 dB +/–0.5 dB 0.1 dB (maximum)
Channel addition/removal (transient) gain response • Maximum • Typical	 0.1 ms (3 dB input power excursion, maximum undershoot and overshoot < 0.8 dB) 0.08 ms (3 dB input power excursion, maximum undershoot and overshoot < 0.8 dB)
Output power • Maximum (full channel load) • Minimum (single channel) • Set resolution	 17 dB –10 dB 0.1 dB (maximum)
VOA attenuation range	0 dB to 25 dB
Noise figure (0 dB VOA attenuation – nominal gain) • Full channel load • Single channel	 5.7 dB (typical) / 7 dB (maximum) 6.7 dB (typical) / 7.5 dB (maximum)
Polarization Mode Dispersion (PMD)	0.5 ps (maximum)
Chromatic Dispersion (CD)	+/–5 ps/nm (maximum)

Table 6. Ordering Information

Part Number	Description
15454-OPT-RAMP-C=	Optical Raman amplifier with embedded EDFA, 500mW total counter-propagating Raman pump power, 17dBm EDFA Output Power, C-band, 80 channel, 50-GHz compatible, LC connectors, midstage access, includes one LC/LC loopback (to be used if DCU is not required) and two 2-meter LC/LC fiber-optic cables

Service and Support

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For more information about Cisco Services, refer to Cisco Technical Support Services or Cisco Advanced Services.

For More Information

For more information about the Cisco ONS 15454 Raman C-Band Optical Amplifier and ONS 15454 Multiservice Transport Platform, contact your local account representative or visit Cisco at: www.cisco.com/go/optical or www.cisco.com/go/IPoDWDM.

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