
# DWDM Topologies

This chapter explains Cisco ONS 15454 dense wavelength division multiplexing (DWDM) topologies.

**Note** The terms "Unidirectional Path Switched Ring" and "UPSR" may appear in Cisco literature. These terms do not refer to using Cisco ONS 15xxx products in a unidirectional path switched ring configuration. Rather, these terms, as well as "Path Protected Mesh Network" and "PPMN," refer generally to Cisco's path protection feature, which may be used in any topological network configuration. Cisco does not recommend using its path protection feature in any particular topological network configuration.

There are two main DWDM network types, metro core, where the channel power is equalized and dispersion compensation is applied, and metro access, where the channels are not equalized and dispersion compensation is not applied. Metro Core networks often include multiple spans and amplifiers, thus making optical signal-to-noise ratio (OSNR) the limiting factor for channel performance. Metro Access networks often include a few spans with very low span loss; therefore, the signal link budget is the limiting factor for performance. The DWDM network topologies supported are: hubbed rings, multihubbed rings, meshed rings, linear configurations, and single-span links.

The DWDM node types supported are: hub, terminal, optical add/drop multiplexing (OADM), anti-amplified spontaneous emissions (ASE), and line amplifier. The hybrid node types supported are: 1+1 protected flexible terminal, scalable terminal, hybrid terminal, hybrid OADM, hybrid line amplifier, and amplified time-division multiplexing (TDM).

**Note** For information about DWDM cards, see Chapter 6, "DWDM Cards." For DWDM and hybrid node turn up and network turn up procedures, refer to the "DWDM Node Turn Up" chapter and the "DWDM Network Turn Up" chapter in the *Cisco ONS 15454 Procedure Guide*.

Chapter topics include:

# 12.1 DWDM Rings and TCC2 Cards

Table 12-1 shows the DWDM rings that can be created on each ONS 15454 node using redundant TCC2 cards.

*Table 12-1 ONS 15454 Rings with Redundant TCC2 Cards*

| Ring Type | Maximum Rings per Node |
|---|---|
| Hubbed rings | 1 |
| Multihubbed rings | 1 |
| Meshed rings | 1 |
| Linear configurations | 1 |
| Single-span link | 1 |
| Hybrid rings | 1 DWDM ring[1] |

1. The number of TDM bidirectional line switch rings (BLSRs) and path protection configurations depends on slot availability. See Table 11-1ONS 15454 Rings with Redundant TCC2 Cards, page 1 for more information about TDM ring capacity.

# 12.2 DWDM Node Types

The node type in a network configuration is determined by the type of amplifier and filter cards that are installed in an ONS 15454 DWDM node. The ONS 15454 supports the following DWDM node types: hub, terminal, OADM, anti-ASE, and line amplifier.

**Note** The MetroPlanner tool creates a plan for amplifier placement and proper node equipment.

## 12.2.1 Hub Node

A hub node is a single ONS 15454 node equipped with at least two 32-channel multiplexer (32 MUX-O) cards, two 32-channel demultiplexer (32 DMX-O) cards, and two TCC2 cards. A dispersion compensation unit (DCU) can also be added, if necessary. The hub node does not support both DWDM and TDM applications since the DWDM slot requirements do not leave room for TDM cards. Figure 12-1 shows a typical hub node configuration.

**Note** The OADM AD-xC-xx.x or AD-xB-xx.x cards are not part of a hub node because the 32 MUX-O and 32 DMX-O cards drop and add all 32 channels; therefore, no other cards are necessary.

*Figure 12-1 Hub Node Configuration Example*

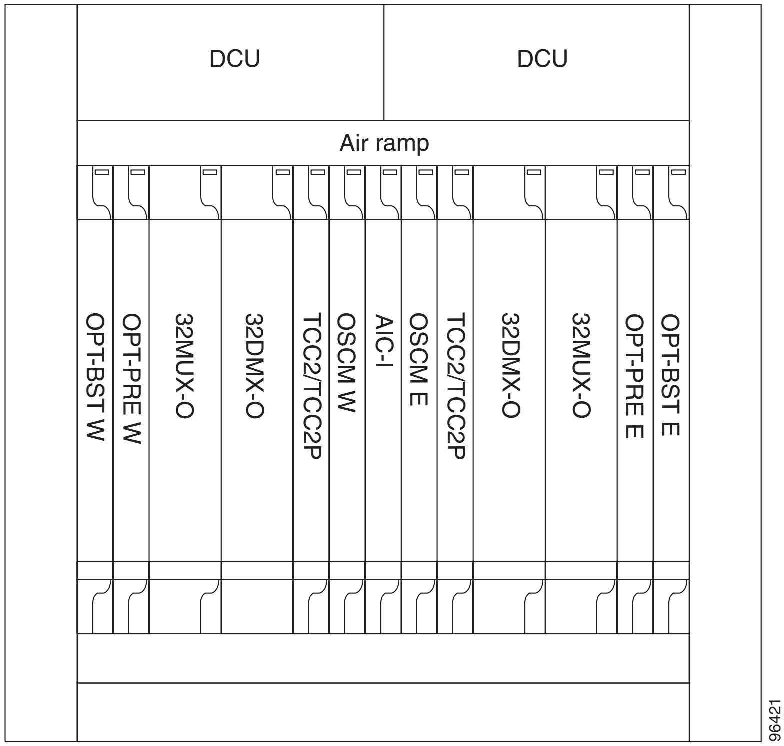
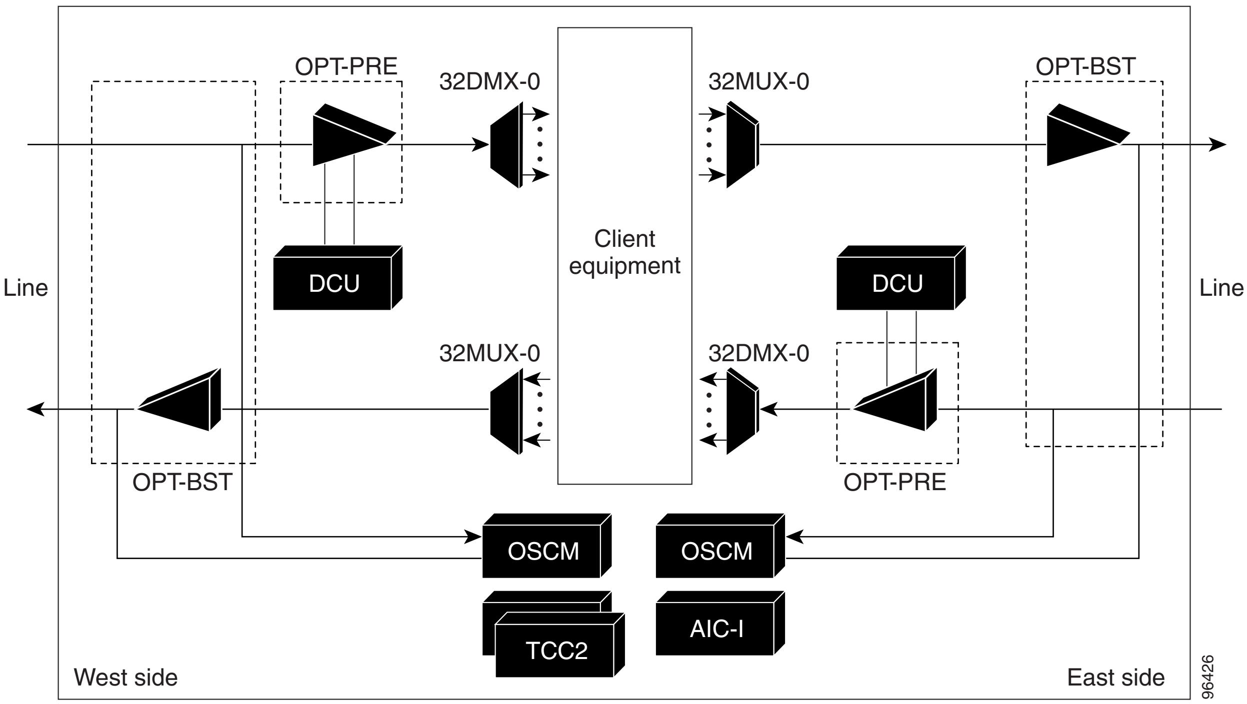



Figure 12-2 shows the channel flow for a hub node. Up to 32-channels from the client ports are multiplexed and equalized onto one fiber using the 32 MUX-O card. Then, multiplexed channels are transmitted on the line in the eastward direction and fed to the Optical Booster (OPT-BST) amplifier. The output of this amplifier is combined with an output signal from the optical service channel modem (OSCM) card, and transmitted toward the east line.

Received signals from the east line port are split between the OSCM card and an Optical Preamplifier (OPT-PRE). Dispersion compensation is applied to the signal received by the OPT-PRE amplifier, and it is then sent to the 32 DMX-O card, which demultiplexes and attenuates the input signal. The west receive fiber path is identical through the west OPT-BST amplifier, the west OPT-PRE amplifier, and the west 32 DMX-O card.

*Figure 12-2 Hub Node Channel Flow Example*

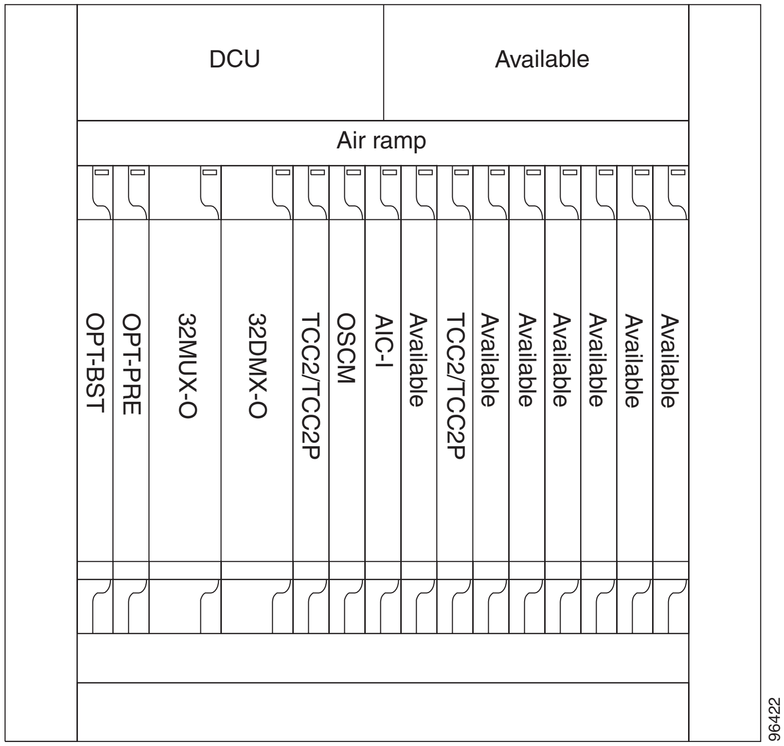



## 12.2.2 Terminal Node

A hub node can be changed into a terminal node by removing either the east or west cards. A terminal node is a single ONS 15454 node equipped with at least one 32 MUX-O card, one 32 DMX-O card, and two TCC2 cards. Figure 12-3 shows an example of an east terminal configuration. The channel flow for a terminal node is the same as the hub node (see Figure 12-2).

**Note** AD-xC-xx.x or AD-xB-xx.x cards are not part of a terminal node because pass-through connections are not allowed. However the AD-4C-xx.x card does support linear end nodes (terminals) in Release 4.6.

*Figure 12-3 Terminal Node Configuration Example*




## 12.2.3 OADM Node

An OADM node is a single ONS 15454 node equipped with at least one AD-xC-xx.x card or one AD-xB-xx.x card and two TCC2 cards. The 32 MUX-O or 32 DMX-O cards should not be provisioned. In an OADM node, channels can be added or dropped independently from each direction, passed through the reflected bands of all OADMs in the DWDM node (called express path), or passed through one OADM card to another OADM card without using a TDM ITU line card (called optical pass through).

Unlike express path, an optical pass-through channel can be converted later to an add/drop channel in an altered ring without affecting another channel. OADM amplifier placement and required card placement is determined by the MetroPlanner tool or your site plan.

There are different categories of OADM nodes, such as amplified, passive, and anti-ASE. For anti-ASE node information, see the "12.2.4 Anti-ASE Node" section on page 12-9.

Figure 12-4 shows an example of an amplified OADM node configuration.

*Figure 12-4 Amplified OADM Node Configuration Example*

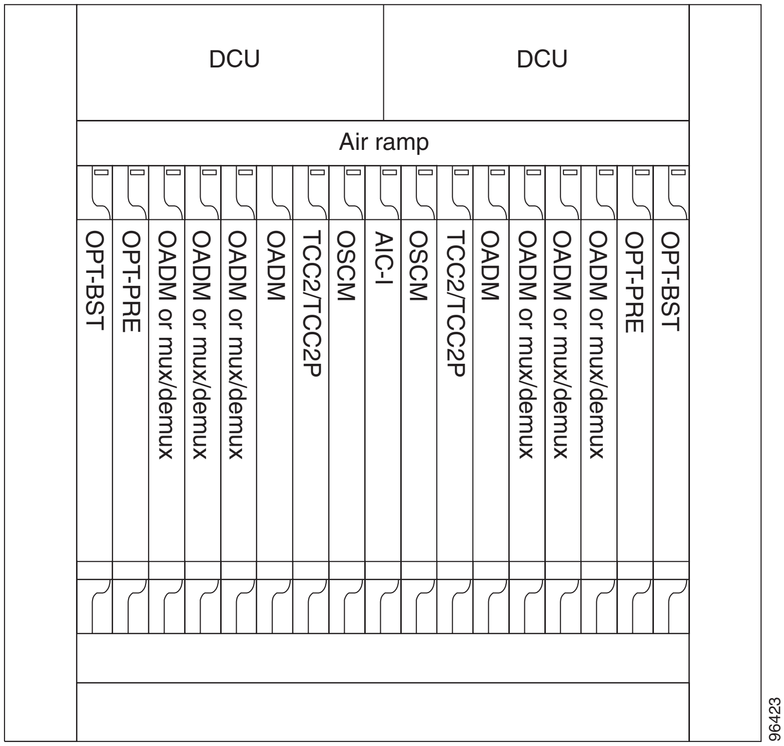



Figure 12-5 shows an example of a passive OADM node configuration.

*Figure 12-5 Passive OADM Node Configuration Example*

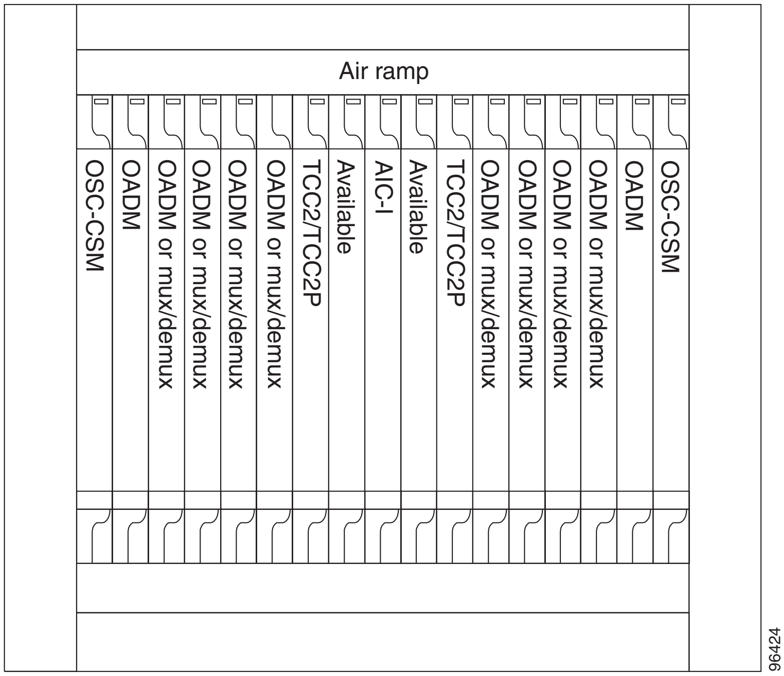



Figure 12-6 shows an example of the channel flow on the amplified OADM node. Since the 32-wavelength plan is based on eight bands (each band contains four channels), optical adding and dropping can be performed at the band level and/or at the channel level (meaning individual channels can be dropped). An example of an OADM node created using band or channel filters is shown in Figure 12-6. The OPT-PRE and the OPT-BST amplifiers are installed on the east and west sides of the node. Only one band, one four-channel multiplexer/demultiplexer, and one-channel OADMs are installed on the east and west sides of the node.

*Figure 12-6 Amplified OADM Node Channel Flow Example*

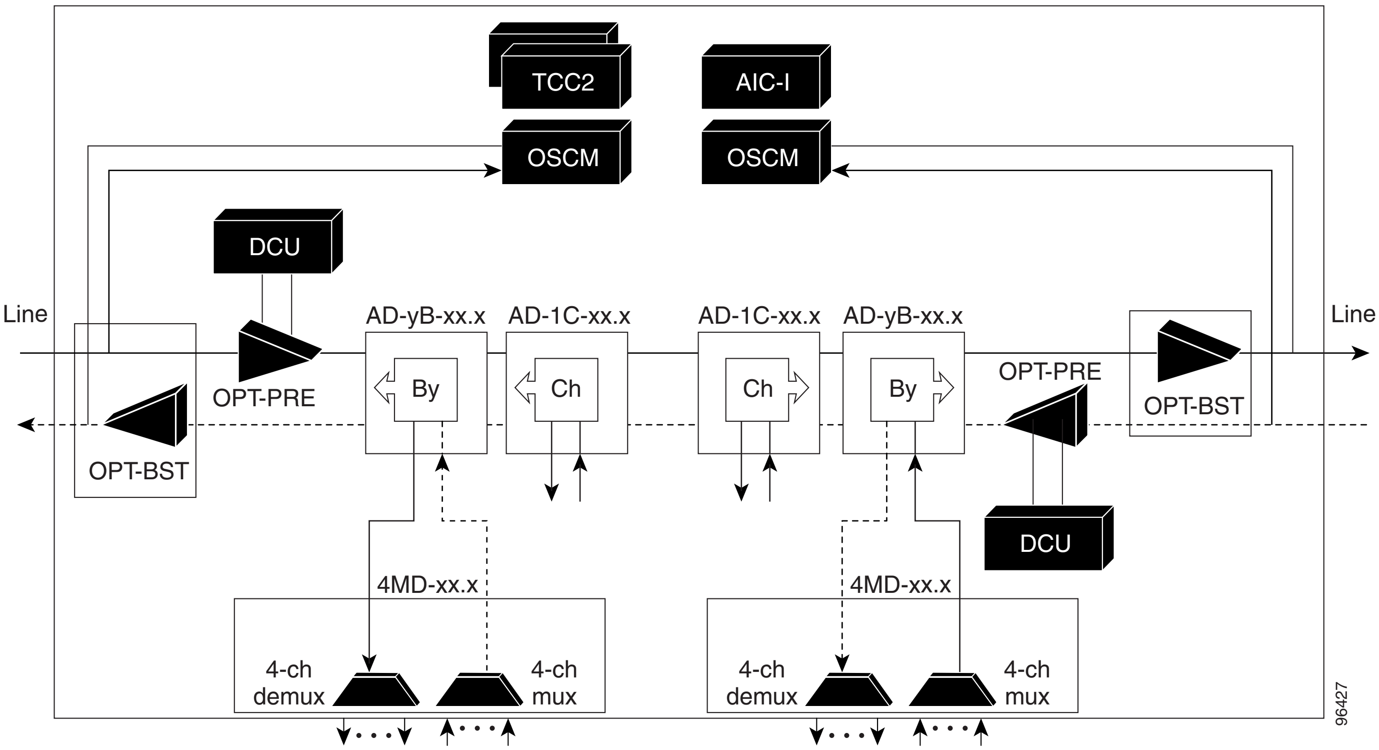
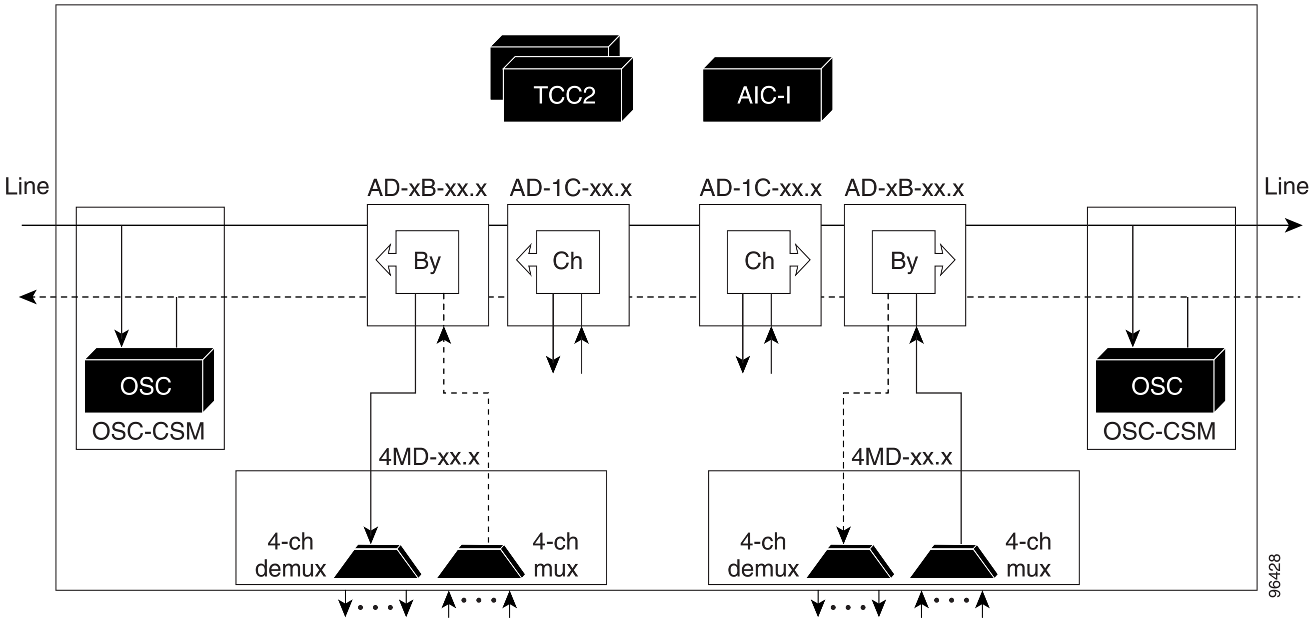



Figure 12-7 shows an example of traffic flow on the passive OADM node. The passive OADM node is equipped with a band filter, one four-channel multiplexer/demultiplexer, and a channel filter on each side of the node. The signal flow of the channels is the same as described in Figure 12-6 except that the Optical Service Channel and Combiner/Separator Module (OSC-CSM) card is being used instead of the OPT-BST amplifier and the OSCM card.

*Figure 12-7 Passive OADM Node Channel Flow Example*



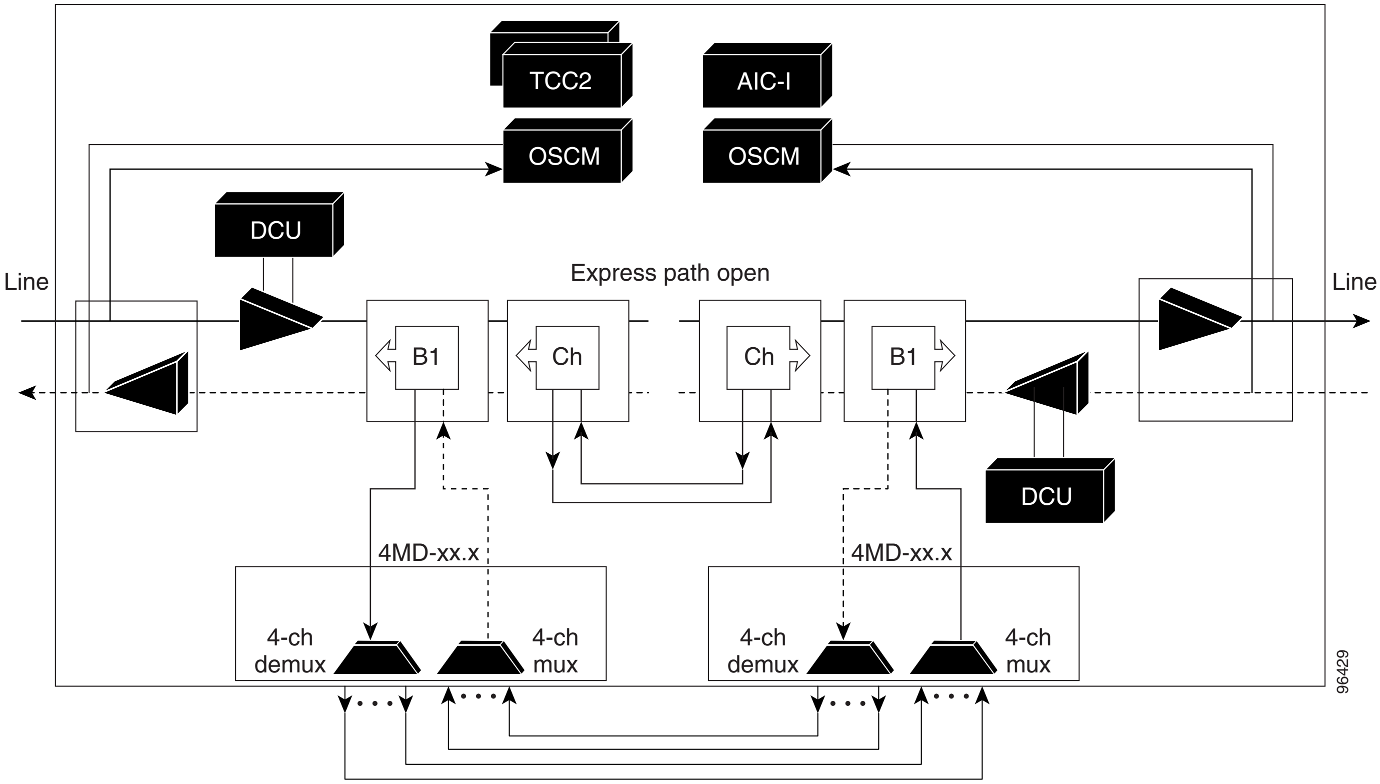

## 12.2.4 Anti-ASE Node

In a meshed ring network, the ONS 15454 requires a node configuration that prevents amplified spontaneous emission (ASE) accumulation and lasing. An anti-ASE node can be created by configuring a hub node or an OADM node with some modifications. No channels can travel through the express path, but they can be demultiplexed and dropped at the channel level on one side and added and multiplexed on the other side.

The hub node is the preferred node configuration when some channels are connected in pass-through mode. For rings that require a limited number of channels, combine AD-xB-xx.x and 4MD-xx.x cards, or cascade AD-xC-xx.x cards. See Figure 12-6 on page 12-8.

Figure 12-8 shows an anti-ASE node that uses all wavelengths in the pass-through mode. Use MetroPlanner or another network planning tool to determine the best configuration for anti-ASE nodes.

*Figure 12-8 Anti-ASE Node Channel Flow Example*

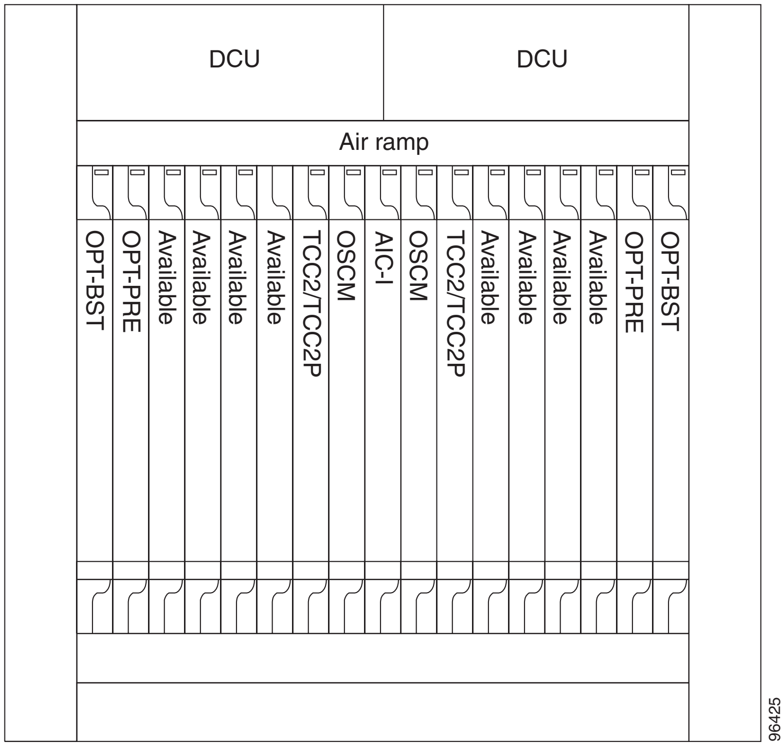



## 12.2.5 Line Amplifier Node

A line node is a single ONS 15454 node equipped with OPT-PRE amplifiers or OPT-BST amplifiers and TCC2 cards. Attenuators might also be required between each preamplifier and booster amplifier to match the optical input power value and to maintain the amplifier gain tilt value.

Two OSCM cards are connected to the east or west ports of the booster amplifiers to multiplex the optical service channel (OSC) signal with the pass-though channels. If the node does not contain OPT-BST amplifiers, you must use OSC-CSM cards rather than OSCM cards in your configuration. Figure 12-9 shows an example of a line node configuration.

*Figure 12-9 Line Node Configuration Example*




# 12.3 DWDM and TDM Hybrid Node Types

The node type in a network configuration is determined by the type of card that is installed in an ONS 15454 hybrid node. The ONS 15454 supports the following hybrid DWDM and TDM node types: 1+1 protected flexible terminal, scalable terminal, hybrid terminal, hybrid OADM, hybrid line amplifier, and amplified TDM.

**Note** The MetroPlanner tool creates a plan for amplifier placement and proper equipment for DWDM node configurations. Although TDM cards can be used with DWDM node configuration, the MetroPlanner tool does not create a plan for TDM card placement. MetroPlanner will support TDM configurations in a future release.

## 12.3.1 1+1 Protected Flexible Terminal Node

The 1+1 protected flexible terminal node is a single ONS 15454 node equipped with a series of OADM cards acting as a hub node configuration. This configuration uses a single hub or OADM node connected directly to the far-end hub or OADM node through four fiber links. This node type is used in a ring configured with two point-to-point links. The advantage of the 1+1 protected flexible terminal node configuration is that it provides path redundancy for 1+1 protected TDM networks (two transmit paths and two receive paths) using half of the DWDM equipment that is usually required. In the following example (Figure 12-10), one node transmits traffic to the other node on both east and west sides of the ring for protection purposes. If the fiber is damaged on one side of the ring, traffic still arrives safely through fiber on the other side of the ring.

***Figure 12-10 Double Terminal Protection Configuration***

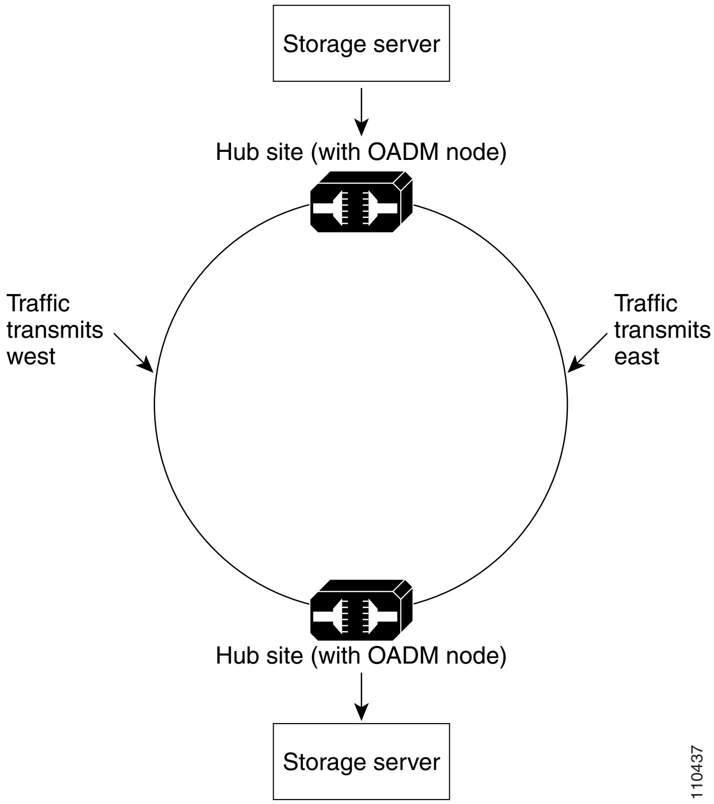


Figure 12-11 shows a 1+1 protected single-span link with hub nodes. This node type cannot be used in a hybrid configuration.

*Figure 12-11 1+1 Protected Single-Span Link with Hub Nodes*

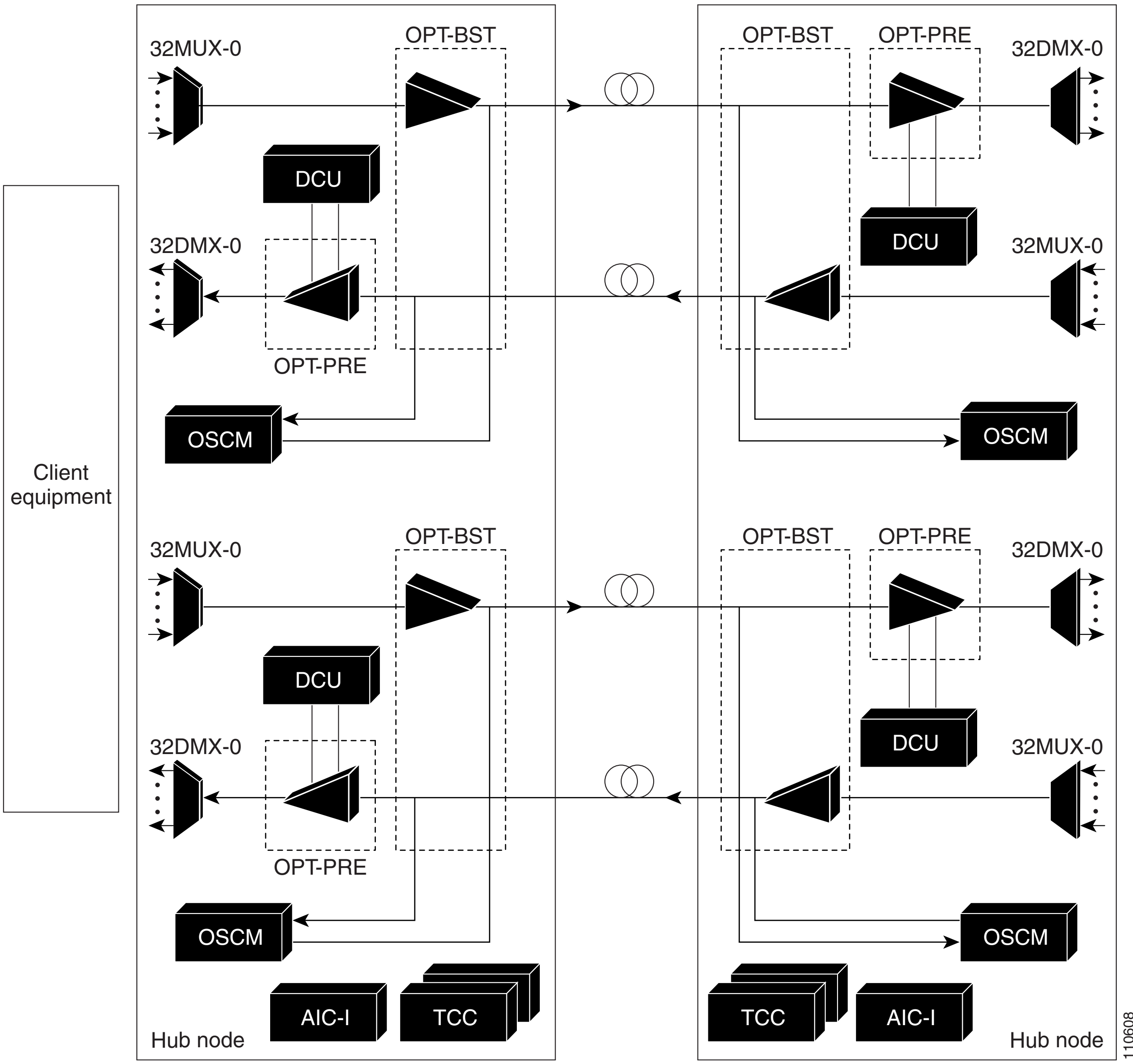


Figure 12-12 shows a 1+1 protected single-span link with active OADM nodes. This node type can be used in a hybrid configuration.

***Figure 12-12 1+1 Protected Single-Span Link with Active OADM Nodes***

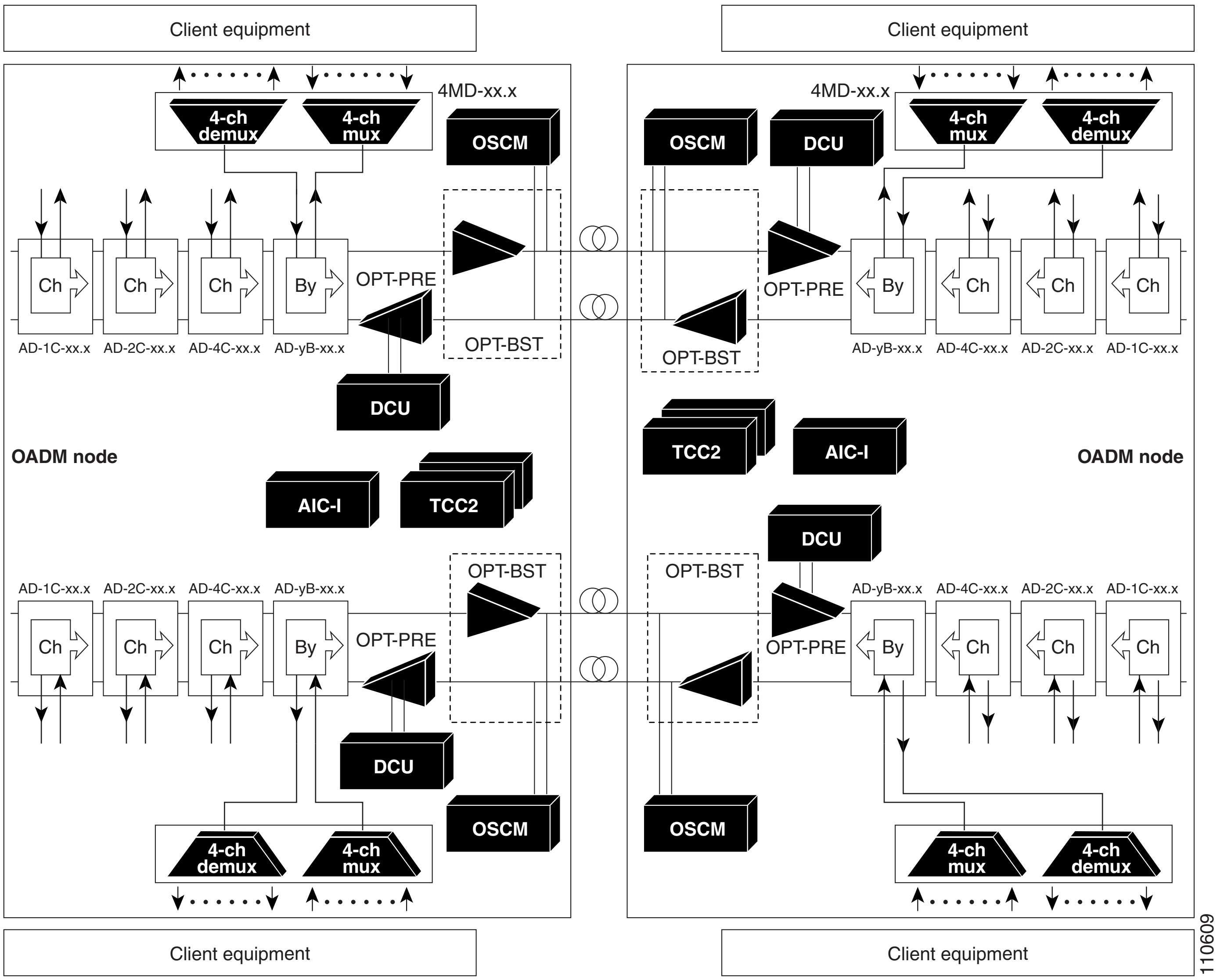
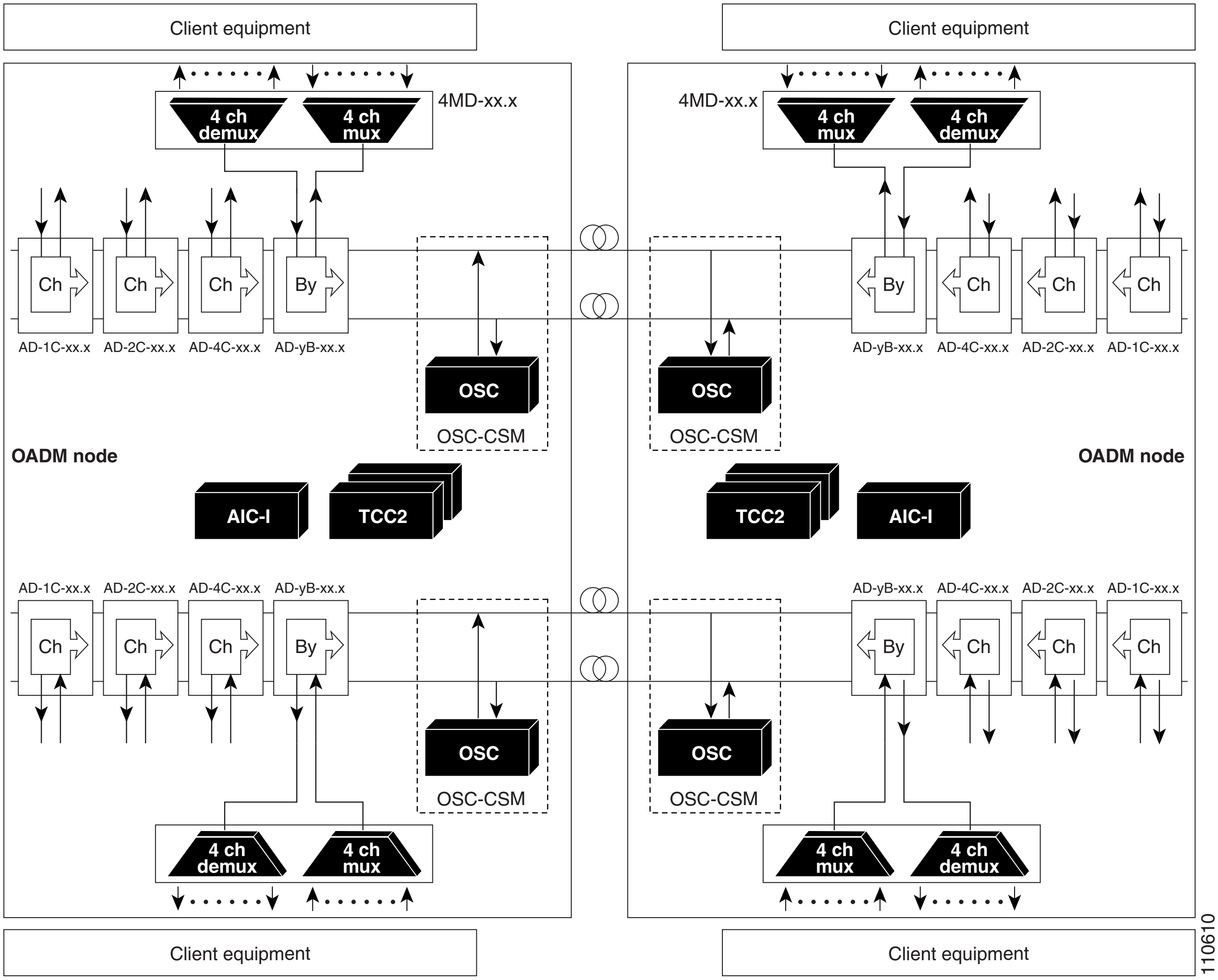


Figure 12-13 shows a 1+1 protected single-span link with passive OADM nodes. This node type can be used in a hybrid configuration.

***Figure 12-13 1+1 Protected Single-Span Link with Passive OADM Nodes***




## 12.3.2 Scalable Terminal Node

The scalable terminal node is a single ONS 15454 node equipped with a series of OADM cards and amplifier cards. This node type is more cost effective if a maximum of 16 channels are used (Table 12-2). This node type does not support a terminal configuration exceeding 16 channels because the 32-channel terminal site is more cost effective for 17 channels and beyond.

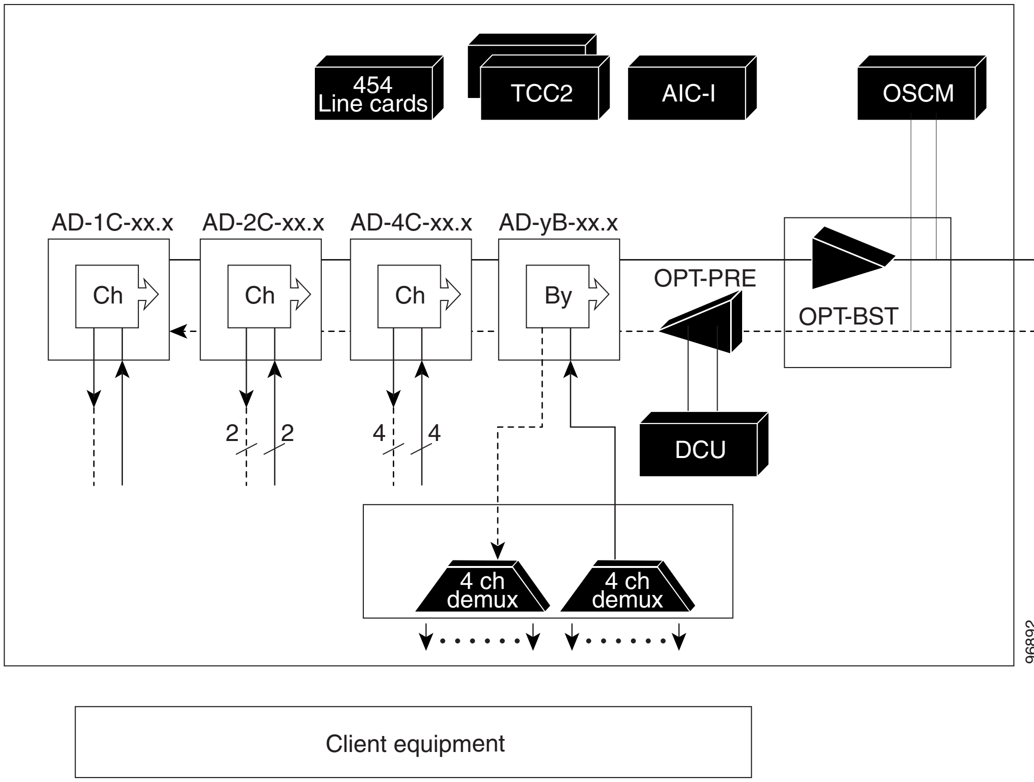
**Note** The dash (—) in the table below means not applicable.

*Table 12-2 Typical AD Configurations for Scalable Terminal Nodes*

| Number of Channels | Terminal Configuration | |
|---|---|---|
| | Option 1 | Option 2 |
| 1 | AD-1C-xx.x | — |
| 2 | AD-2C-xx.x | — |
| 3 | AD-4C-xx.x | AD-1B-xx.x + 4MD-xx.x |
| 4 | AD-4C-xx.x | AD-1B-xx.x + 4MD-xx.x |
| 5 | AD-1C-xx.x + AD-4C-xx.x | AD-1C-xx.x + AD-1B-xx.x + 4MD-xx.x |
| 6 | AD-2C-xx.x + AD-4C-xx.x | AD-2C-xx.x + AD-1B-xx.x + 4MD-xx.x |
| 7 | 2 x AD-4C-xx.x | 2 x (AD-1B-xx.x + 4MD-xx.x) |
| 8 | 2 x AD-4C-xx.x | 2 x (AD-1B-xx.x + 4MD-xx.x) |
| 9 | AD-1C-xx.x + (2 x AD-4C-xx.x) | AD-1C-xx.x + 2 x (AD-1B-xx.x + 4MD-xx.x) |
| 10 | AD-2C-xx.x + (2 x AD-4C-xx.x) | AD-2C-xx.x + 2 x (AD-1B-xx.x + 4MD-xx.x) |
| 11 | 3 x AD-4C-xx.x | AD-4B-xx.x + (3 x 4MD-xx.x) |
| 12 | 3 x AD-4C-xx.x | AD-4B-xx.x + (3 x 4MD-xx.x) |
| 13 | AD-4B-xx.x + (3 x 4MD-xx.x) + AD-1C-xx.x | AD-4B-xx.x + (4 x 4MD-xx.x) |
| 14 | AD-4B-xx.x + (3 x 4MD-xx.x) + AD-1C-xx.x | AD-4B-xx.x + (4 x 4MD-xx.x) |
| 15 | — | AD-4B-xx.x + (4 x 4MD-xx.x) |
| 16 | — | AD-4B-xx.x + (4 x 4MD-xx.x) |

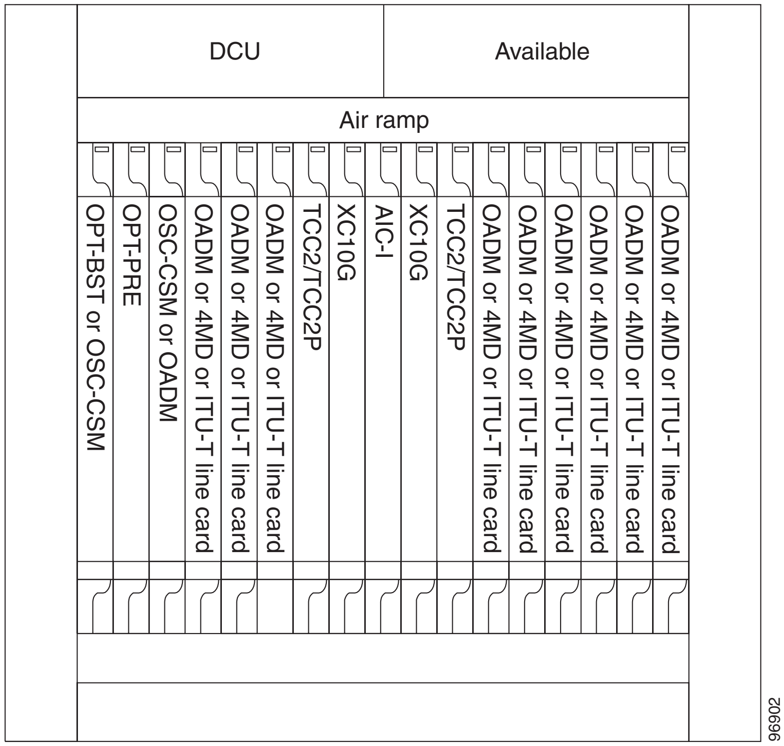
The OADM cards that can be used in this type of node are: AD-1C-xx.x, AD-2C-xx.x, AD-4C-xx.x, and AD-1B-xx.x. You can also use AD-4B-xx.x and up to four 4MD-xx.x cards. The OPT-PRE and/or OPT-BST amplifiers can be used. The OPT-PRE or OPT-BST configuration depends on the node loss and the span loss. When the OPT-BST is not installed, the OSC-CSM must be used instead of the OSCM card. Figure 12-14 on page 12-17 shows a channel flow example of a scalable terminal node configuration.

*Figure 12-14 Scalable Terminal Channel Flow Example*




A scalable terminal node can be created by using band and/or channel OADM filter cards. This node type is the most flexible of all node types because the OADM filter cards can be configured to accommodate node traffic. If the node does not contain amplifiers, it is considered a passive hybrid terminal node. Figure 12-15 shows an example of a scalable terminal node configuration. This node type can be used without add or drop cards.

*Figure 12-15 Scalable Terminal Example*




## 12.3.3 Hybrid Terminal Node

A hybrid terminal node is a single ONS 15454 node equipped with at least one 32 MUX-O card, one 32 DMX-O card, two TCC2 cards, and TDM cards. If the node is equipped with OPT-PRE or OPT-BST amplifiers, it is considered an amplified terminal node. The node becomes passive if the amplifiers are removed. The hybrid terminal node type is based on the DWDM terminal node type described in the "12.2.2 Terminal Node" section on page 12-4. Figure 12-16 shows an example of an amplified hybrid terminal node configuration.

*Figure 12-16 Amplified Hybrid Terminal Example*

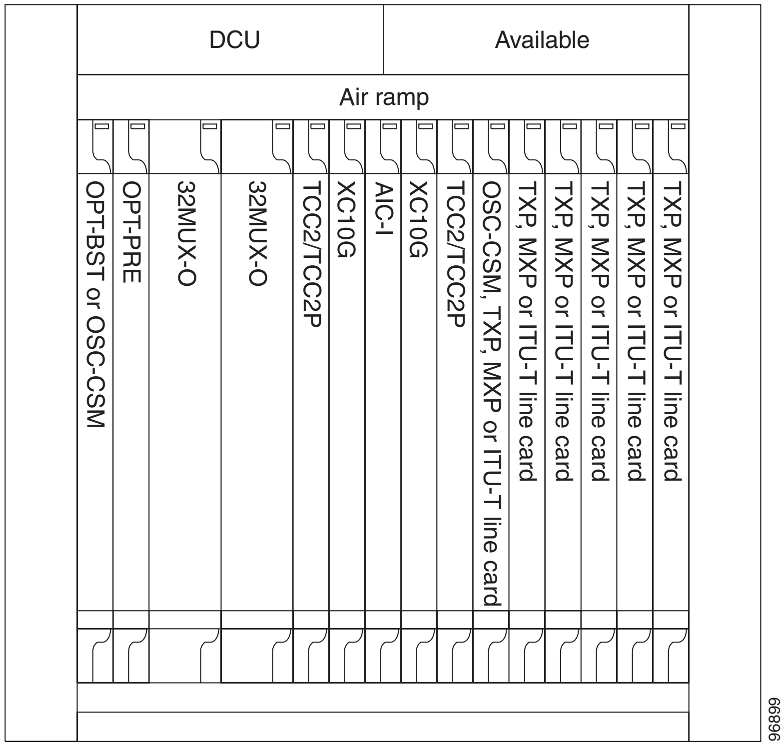
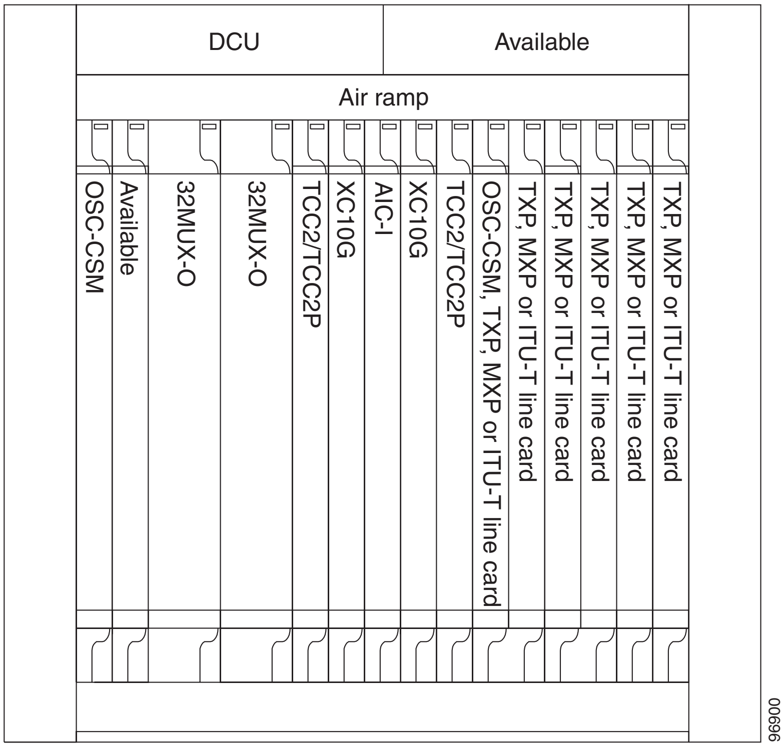


Figure 12-17 shows an example of a passive hybrid terminal node configuration.

***Figure 12-17 Passive Hybrid Terminal Example***

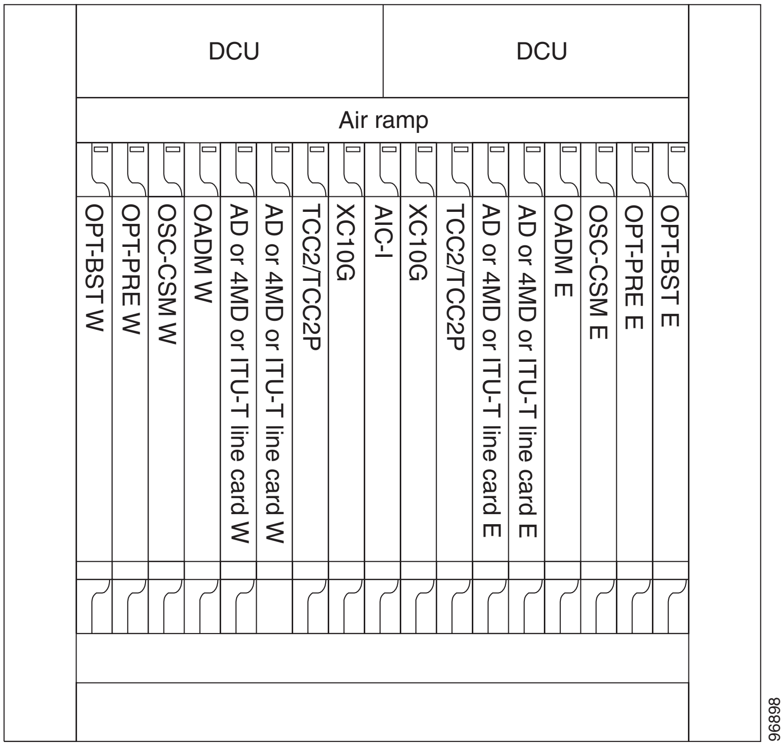



## 12.3.4 Hybrid OADM Node

A hybrid OADM node is a single ONS 15454 node equipped with at least one AD-xC-xx.x card or one AD-xB-xx.x card, and two TCC2 cards. The hybrid OADM node type is based on the DWDM OADM node type described in the "12.2.3 OADM Node" section on page 12-5. TDM cards can be installed in any available slot. Review the plan produced by MetroPlanner to determine slot availability.

Figure 12-18 shows an example of an amplified hybrid OADM node configuration. The hybrid OADM node can also become passive by removing the amplifier cards.

*Figure 12-18 Hybrid Amplified OADM Example*




## 12.3.5 Hybrid Line Amplifier Node

A hybrid line amplifier node is a single ONS 15454 node with open slots for both TDM and DWDM cards. Figure 12-19 shows an example of an hybrid line amplifier node configuration. Figure 12-20 on page 12-23 shows a channel flow example of a hybrid line node configuration. Since this node contains both TDM and DWDM rings, both TDM and DWDM rings should be terminated even if no interactions are present between them.

**Note** For DWDM applications, if the OPT-BST is not installed within the node, the OSC-CSM card must be used instead of the OSCM card.

*Figure 12-19 Hybrid Line Amplifier Example*

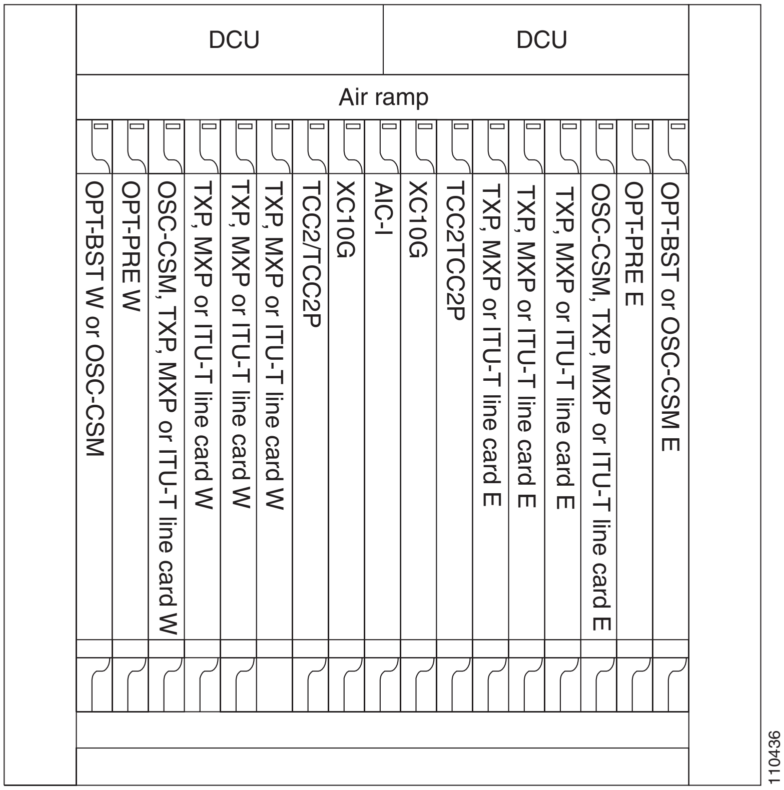
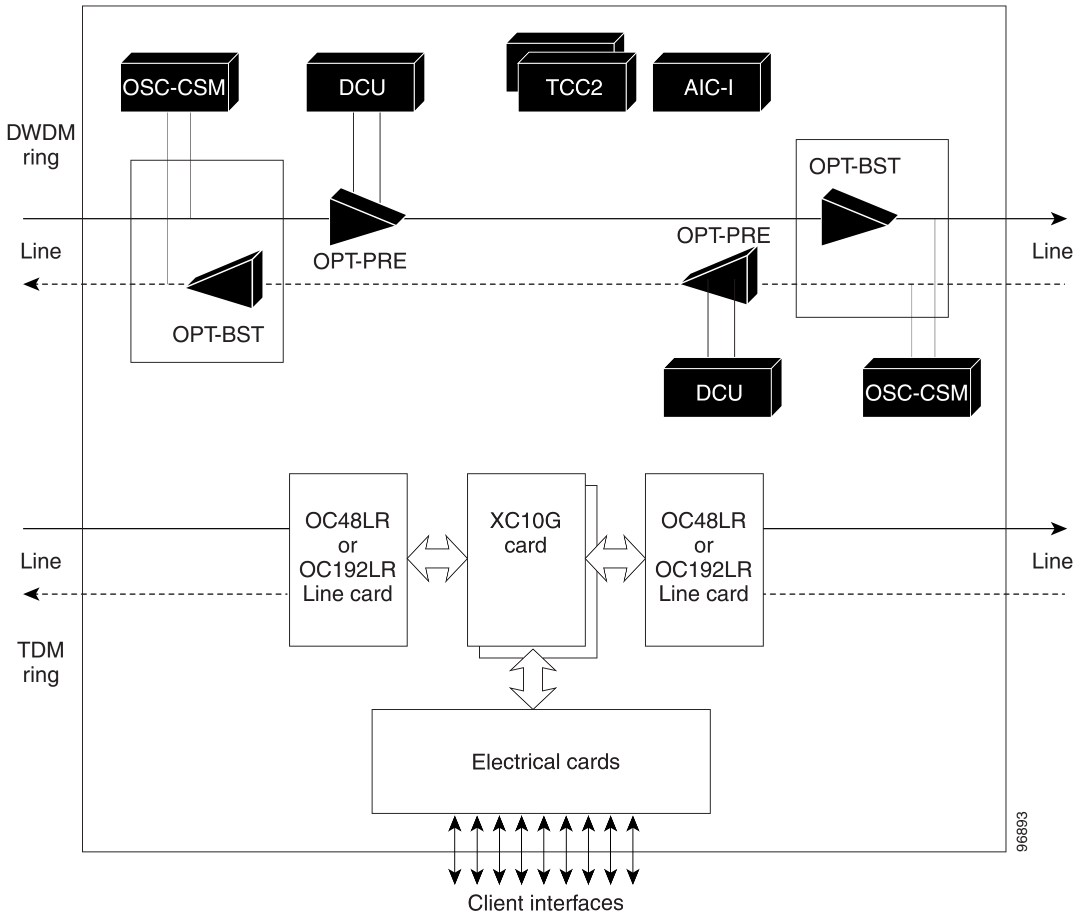


*Figure 12-20 Hybrid Line Amplifier Channel Flow Example*




A hybrid line node is another example of the hybrid line amplifier OADM node. A hybrid line node is single ONS 15454 node equipped with OPT-PRE amplifiers, OPT-BST amplifiers, and TCC2 cards for each line direction. Both types of amplifiers can be used or just one type of amplifier. Attenuators might also be required between each preamplifier and booster amplifier to match the optical input power value and to maintain the amplifier gain tilt value. TDM cards can be installed in any available slot. Review the plan produced by MetroPlanner to determine slot availability.

## 12.3.6 Amplified TDM Node

An amplified TDM node is a single ONS 15454 node that increases the span length between two ONS 15454 nodes that contain TDM cards and optical amplifiers. There are three possible installation configurations for an amplified TDM node. Scenario 1 uses client cards and OPT-BST amplifiers. Scenario 2 uses client cards, OPT-BST amplifiers, OPT-PRE amplifiers, and FlexLayer filters. Scenario 3 uses client cards, OPT-BST amplifiers, OPT-PRE amplifiers, AD-1C-xx.x cards, and OSC-CSM cards.

The client cards that can be used in an amplified TDM node are: TXP_MR_10G, MXP_2.5G_10G, TXP_MR_2.5G, TXPP_MR_2.5G, OC-192 LR/STM 64 ITU 15xx.xx, and OC-48 ELR/STM 16 EH 100 GHz.

Figure 12-21 shows the first amplified TDM node scenario with an OPT-BST amplifier.

*Figure 12-21 Amplified TDM Example with an OPT-BST Amplifier*

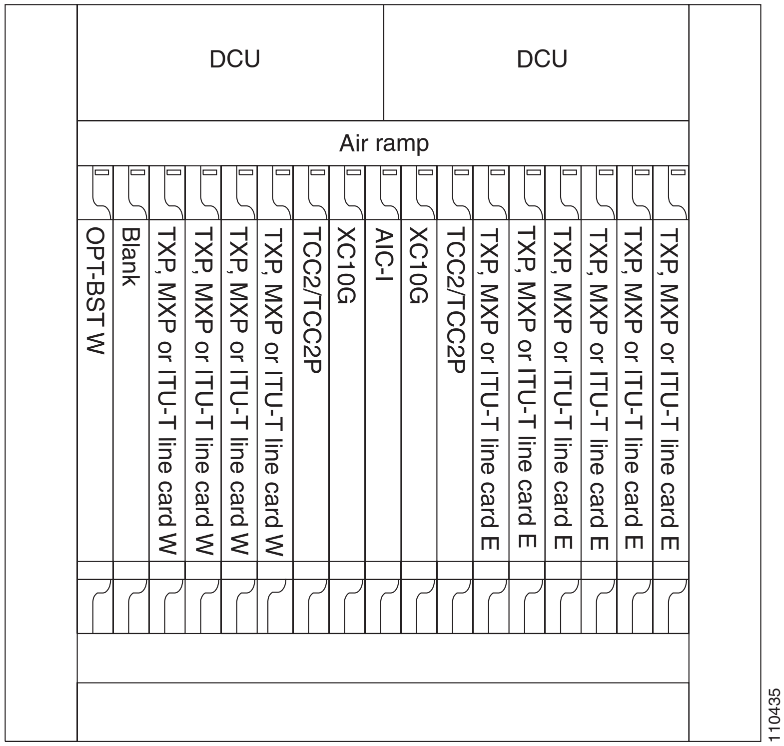



Figure 12-22 shows the first amplified TDM node channel flow scenario configured with OPT-BST amplifiers.

*Figure 12-22 Amplified TDM Channel Flow Example With OPT-BST Amplifiers*

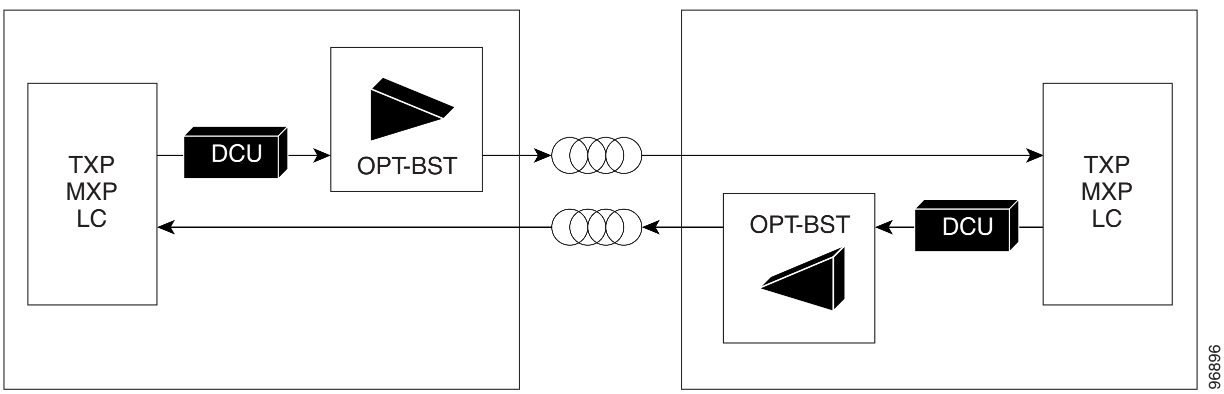


Figure 12-23 shows the second amplified TDM node configuration scenario with client cards, AD-1C-xx.x cards, OPT-BST amplifiers, OPT-PRE amplifiers, and FlexLayer filters.

***Figure 12-23 Amplified TDM Example with FlexLayer Filters***

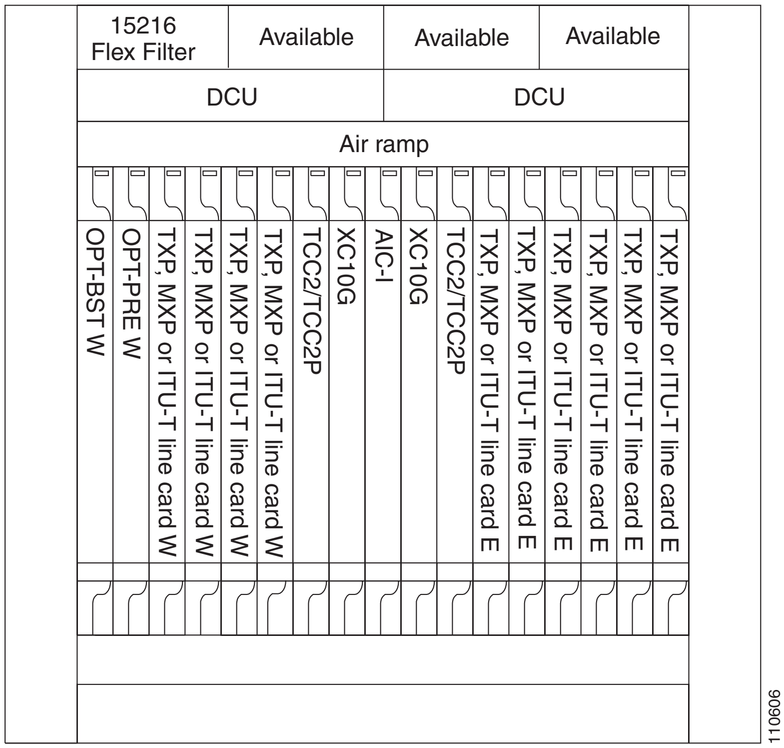



Figure 12-24 shows the second amplified TDM node channel flow configuration scenario with client cards, OPT-BST amplifiers, OPT-PRE amplifiers, and FlexLayer filters.

***Figure 12-24 Amplified TDM Channel Flow Example With FlexLayer Filters***

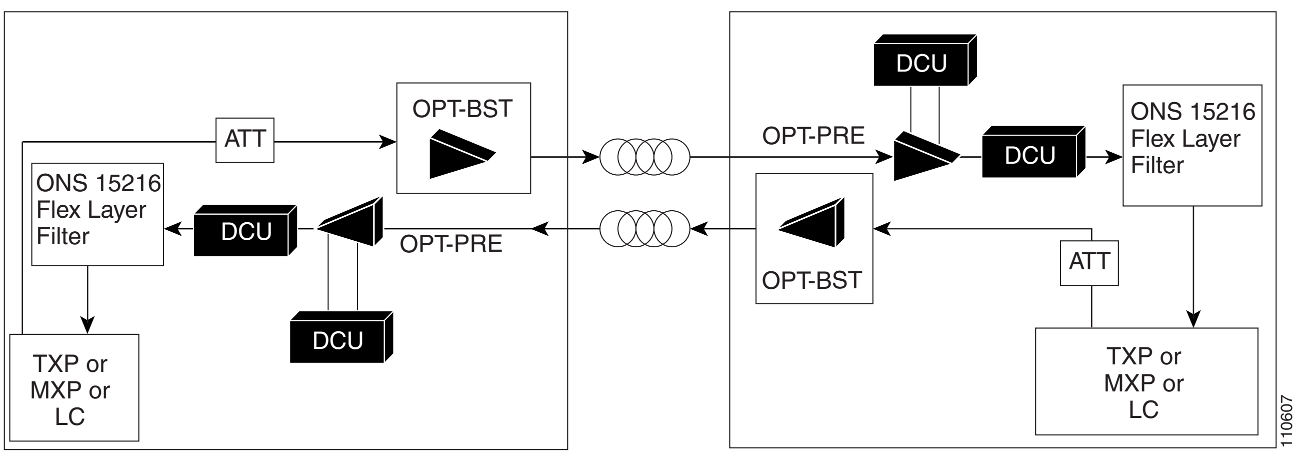
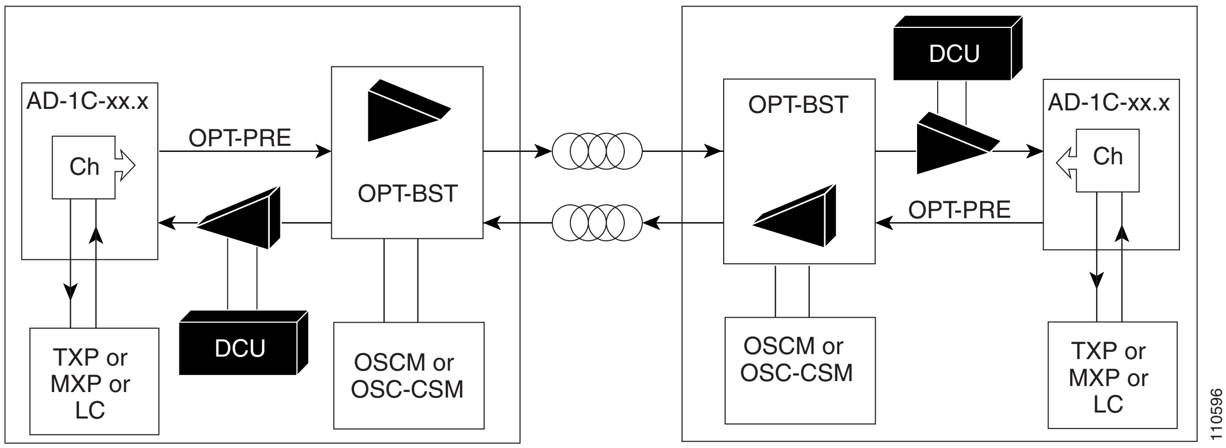


Figure 12-25 shows the third amplified TDM channel flow configuration scenario with client cards, OPT-BST amplifiers, OPT-PRE amplifiers, AD-1C-xx.x cards, and OSC-CSM cards.

***Figure 12-25 Amplified TDM Channel Flow Example With Amplifiers, AD-1C-xx.x Cards, and OSC-CSM Cards***




# 12.4 Hubbed Rings

In the hubbed ring topology (Figure 12-26), a hub node terminates all the DWDM channels. A channel can be provisioned to support protected traffic between the hub node and any node in the ring. Both working and protected traffic use the same wavelength on both sides of the ring. Protected traffic can also be provisioned between any pair of OADM nodes, except that either the working or the protected path must be regenerated in the hub node.

Protected traffic saturates a channel in a hubbed ring, that is, no channel reuse is possible. However, the same channel can be reused in difference sections of the ring by provisioning unprotected multihop traffic. From a transmission point of view, this network topology is similar to two bidirectional point-to-point links with OADM nodes.

*Figure 12-26 Hubbed Ring*

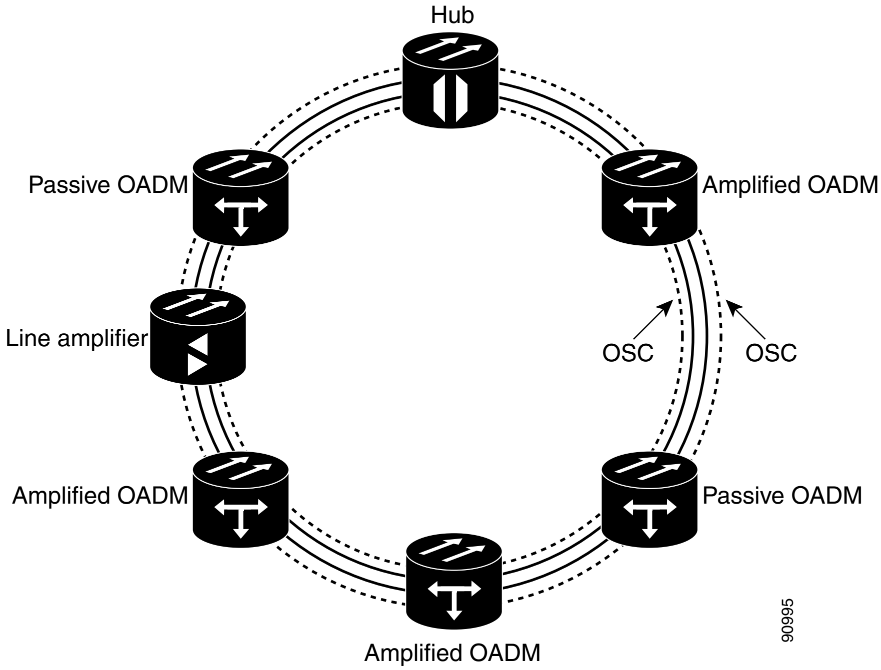



Table 12-3 lists the span loss for a hubbed ring. This applies to metro core networks only.

**Note** The dash (—) in the table below means not applicable.

*Table 12-3 Span Loss for a Hubbed Ring, Metro Core Network*

| Number of Spans[1, 2] | Class A[3] | Class B[3] | Class C[3] | Class D[3] | Class E[3] | Class F[3] | Class G[3] |
|---|---|---|---|---|---|---|---|
| | Classes A through C are 10-Gbps interfaces | | | Classes D through G are 2.5-Gbps interfaces | | | |
| 1 | 30 dB | 23 dB | 24 dB | 34 dB | 31 dB | 28 dB | 29 dB |
| 2 | 26 dB | 19 dB | 19 dB | 28 dB | 26 dB | 23 dB | 26 dB |
| 3 | 23 dB | — | — | 26 dB | 23 dB | 21 dB | 23 dB |
| 4 | 21 dB | — | — | 24 dB | 22 dB | 18 dB | 21 dB |
| 5 | 20 dB | — | — | 23 dB | 20 dB | 13 dB | 20 dB |
| 6 | 17 dB | — | — | 22 dB | 18 dB | — | 17 dB |

*Table 12-3 Span Loss for a Hubbed Ring, Metro Core Network (continued)*

| Number of Spans[1, 2] | Class A[3] | Class B[3] | Class C[3] | Class D[3] | Class E[3] | Class F[3] | Class G[3] |
|---|---|---|---|---|---|---|---|
| 7 | 15 dB | — | — | 21 dB | 16 dB | — | 15 dB |

1. The optical performance values are valid assuming that all OADM nodes have a loss of 16 dB and equal span losses.
2. The maximum channel count allowed for the link budget is 32.
3. The following class definitions refer to the ONS 15454 card being used:

Class A—10-Gbps multirate transponder with forward error correction (FEC) or 10-Gbps muxponder with FEC

Class B—10-Gbps multirate transponder without FEC

Class C—OC-192 LR ITU

Class D—2.5-Gbps multirate transponder both protected and unprotected with FEC enabled

Class E—2.5-Gbps multirate transponder both protected and unprotected without FEC enabled

Class F—2.5-Gbps multirate transponder both protected and unprotected in regenerate and reshape (2R) mode

Class G—OC-48 ELR 100 GHz

Table 12-4 lists the maximum ring circumference and maximum number of amplifiers in each subnetwork for a hubbed ring. This applies to metro access networks only. Metro Planner supports the same interface classes (Classes A through G) for both Metro Access and Metro Core networks. Each card class has a limit to the fiber length before chromatic dispersion occurs as shown in the SMF fiber field of Table 12-4. In Classes A, B, and C, the maximum link length is limited by the interface's chromatic dispersion strength. In Classes D, E, F, and G, the maximum link length is limited by the interface's receive sensitivity and not by the chromatic dispersion; therefore, you will see that the maximum chromatic dispersion allowed is significantly lower than the maximum interface strength. For DWDM card specifications, see Chapter 6, "DWDM Cards."

*Table 12-4 Span Loss for a Hubbed Ring, Metro Access Network*

| Parameter[1] | Class A[2] | Class B[2] | Class C[2] | Class D[2] | Class E[2] | Class F[2] | Class G[2] |
|---|---|---|---|---|---|---|---|
| | Classes A through C are 10-Gbps interfaces | | | Classes D through G are 2.5-Gbps interfaces | | | |
| Maximum dispersion | 680 ps/nm | 750 ps/nm | 750 ps/nm | 2000 ps/nm | 2000 ps/nm | 2000 ps/nm | 2000 ps/nm |
| Maximum link length with G.652 fiber (SMF) | 40 km | 45 km | 45 km | 120 km | 120 km | 120 km | 120 km |
| Maximum ring circumference | 120 km | | | | | | |
| Maximum number of amplifiers for each subnetwork | 5 amplifiers | | | | | | |
| Average per channel power at the amplifier output[3] | 5 dBm | | | | | | |
| Maximum per channel power at the amplifier output | 8 dBm | | | | | | |
| Minimum per channel power at the amplifier output | -7 dBm | | | | | | |

1. The optical performance values are valid assuming that all OADM nodes have a loss of 16 dB and equal span losses.
2. The following class definitions refer to the ONS 15454 card being used:

Class A—10-Gbps multirate transponder with FEC or 10-Gbps muxponder with FEC

Class B—10-Gbps multirate transponder without FEC

Class C—OC-192 LR ITU

Class D—2.5-Gbps multirate transponder both protected and unprotected with FEC enabled

Class E—2.5-Gbps multirate transponder both protected and unprotected without FEC enabled

Class F—2.5-Gbps multirate transponder both protected and unprotected in 2R mode

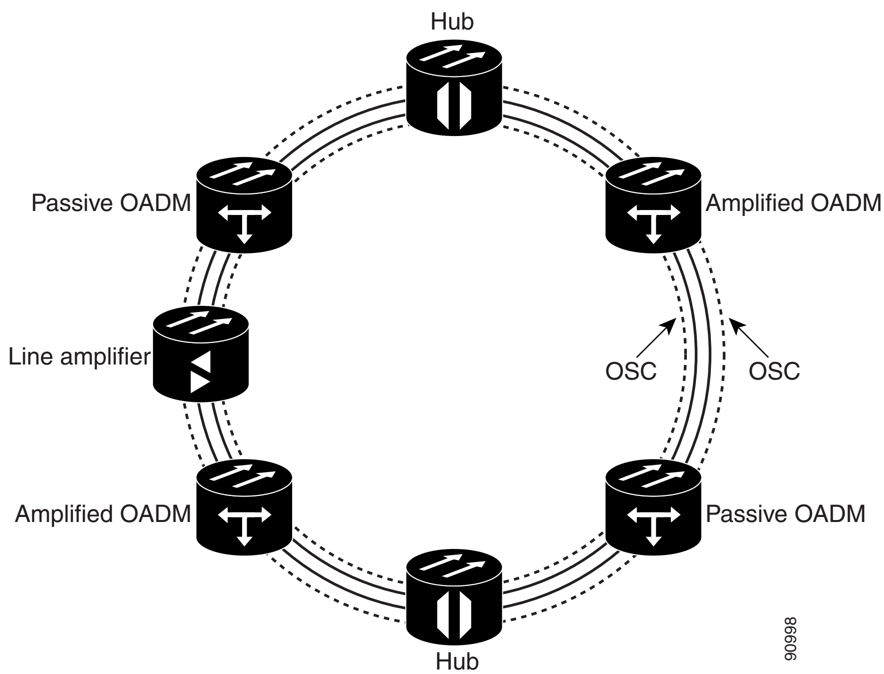
Class G—OC-48 ELR 100 GHz

3. The maximum average power per channel at the amplifier output is set as indicated to avoid saturating the total output power from the amplifiers.

# 12.5 Multihubbed Rings

A multihubbed ring (Figure 12-27) is based on the hubbed ring topology, except that two or more hub nodes are added. Protected traffic can only be established between the two hub nodes. Protected traffic can be provisioned between a hub node and any OADM node only if the allocated wavelength channel is regenerated through the other hub node. Multihop traffic can be provisioned on this ring. From a transmission point of view, this network topology is similar to two or more point-to-point links with OADM nodes.

***Figure 12-27 Multihubbed Ring***




For information on span losses in a ring configuration, see Table 12-3 on page 12-27. This applies to metro core networks only.

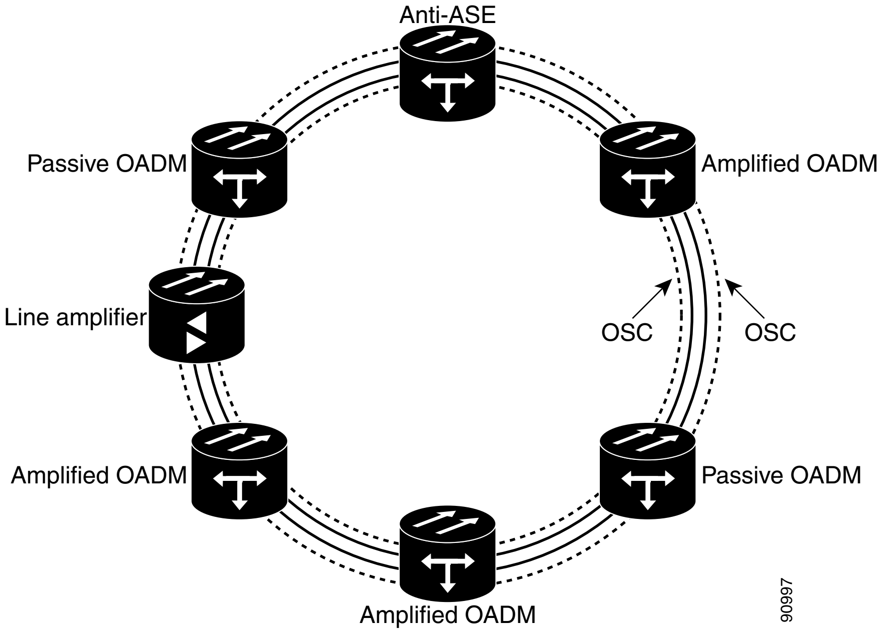
# 12.6 Meshed Rings

The meshed ring topology (Figure 12-28) does not use hubbed nodes; only amplified and passive OADM nodes are present. Protected traffic can be provisioned between any two nodes; however, the selected channel cannot be reused in the ring. Unprotected multihop traffic can be provisioned in the ring. A meshed ring must be designed to prevent ASE lasing. This is done by configuring a particular node as an anti-ASE node. An anti-ASE node can be created in two ways:

- Equip an OADM node with 32 MUX-O cards and 32 DMX-O cards. This solution is adopted when the total number of wavelengths deployed in the ring is higher than ten. OADM nodes equipped with 32 MUX-O cards and 32 DMX-O cards are called full OADM nodes.
- When the total number of wavelengths deployed in the ring is lower than ten, the anti-ASE node is configured by using an OADM node where all the channels that are not terminated in the node are configured as “optical pass-through.” In other words, no channels in the anti-ASE node can travel through the express path of the OADM node.

For more information about anti-ASE nodes, see the “12.2.4 Anti-ASE Node” section on page 12-9.

*Figure 12-28 Meshed Ring*




For information on span losses in a ring configuration, see Table 12-3 on page 12-27. For information on span losses in a ring without OADMs, see Table 12-6 on page 12-33. The tables apply to metro core networks only.

# 12.7 Linear Configurations

Linear configurations are characterized by the use of two terminal nodes (west and east). The terminal nodes must be equipped with a 32 MUX-O card and a 32 DMX-O card. OADM or line amplifier nodes can be installed between the two terminal nodes. Only unprotected traffic can be provisioned in a linear configuration. Figure 12-29 shows five ONS 15454 nodes in a linear configuration with an OADM node.

*Figure 12-29 Linear Configuration with an OADM Node*

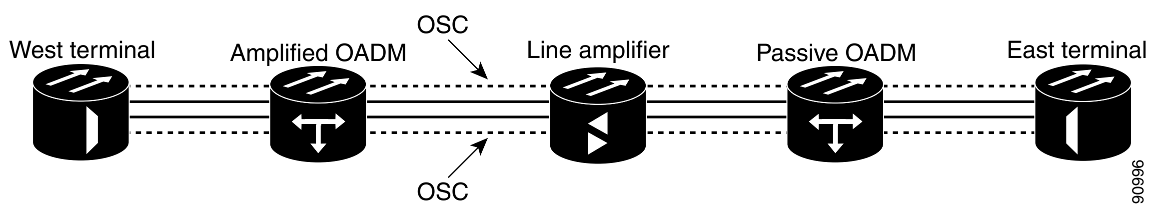



Table 12-5 on page 12-32 lists the span loss for a linear configuration with OADM nodes for metro core networks only.

**Note** The dash (—) in Table 12-5 means not applicable.

*Table 12-5 Span Loss for Linear Configuration with OADM Nodes*

| Number of Spans[1, 2] | Class A[3] | Class B[2] | Class C[2] | Class D[2] | Class E[2] | Class F[2] | Class G[2] |
|---|---|---|---|---|---|---|---|
| | Classes A through C are 10-Gbps interfaces | | | Classes D through G are 2.5-Gbps interfaces | | | |
| 1 | 30 dB | 23 dB | 24 dB | 34 dB | 31 dB | 28 dB | 29 dB |
| 2 | 26 dB | 19 dB | 19 dB | 28 dB | 26 dB | 23 dB | 26 dB |
| 3 | 23 dB | — | — | 26 dB | 23 dB | 21 dB | 23 dB |
| 4 | 21 dB | — | — | 24 dB | 22 dB | 18 dB | 21 dB |
| 5 | 20 dB | — | — | 23 dB | 20 dB | 13 dB | 20 dB |
| 6 | 17 dB | — | — | 22 dB | 18 dB | — | 17 dB |
| 7 | 15 dB | — | — | 21 dB | 16 dB | — | 15 dB |

1. The optical performance values are valid assuming that all OADM nodes have a loss of 16 dB and equal span losses.
2. The maximum channel count allowed for the link budget is 32.
3. The following class definitions refer to the ONS 15454 card being used:

Class A—10-Gbps multirate transponder with FEC or 10-Gbps muxponder with FEC

Class B—10-Gbps multirate transponder without FEC

Class C—OC-192 LR ITU

Class D—2.5-Gbps multirate transponder both protected and unprotected with FEC enabled

Class E—2.5-Gbps multirate transponder both protected and unprotected without FEC enabled

Class F—2.5-Gbps multirate transponder both protected and unprotected in 2R mode

Class G—OC-48 ELR 100 GHz

Figure 12-30 shows five ONS 15454 nodes in a linear configuration without an OADM node.

*Figure 12-30 Linear Configuration without an OADM Node*

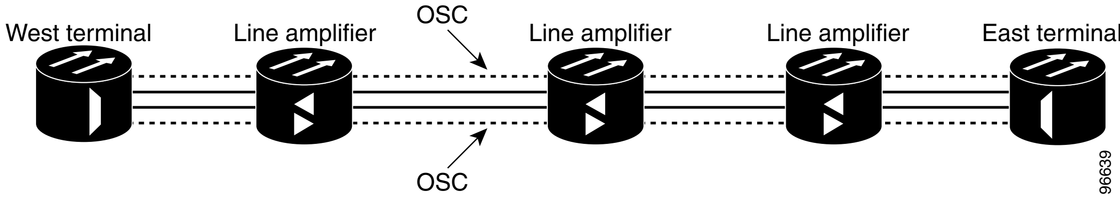



Table 12-6 lists the span loss for a linear configuration without OADMs.

**Note** The dash (—) in Table 12-6 means not applicable.

*Table 12-6 Span Loss for a Linear Configuration without OADM Nodes*

| Number of Spans | Class A[1] | Class B[1] | Class C[1] | Class D[1] | Class E[1] | Class F[1] | Class G[1] |
|---|---|---|---|---|---|---|---|
| | Classes A through C are 10-Gbps interfaces | | | Classes D through G are 2.5-Gbps interfaces | | | |
| 1 | 30 dB | 23 dB | 24 dB | 34 dB | 31 dB | 28 dB | 29 dB |
| 2 | 26 dB | 19 dB | 20 dB | 28 dB | 26 dB | 23 dB | 25 dB |
| 3 | 24 dB | 16 dB | 17 dB | 25 dB | 24 dB | 21 dB | 22 dB |
| 4 | 22 dB | 14 dB | 14 dB | 24 dB | 22 dB | 20 dB | 21 dB |
| 5 | 21 dB | — | — | 23 dB | 21 dB | 19 dB | 20 dB |
| 6 | 20 dB | — | — | 22 dB | 20 dB | 15 dB | 19 dB |
| 7 | 20 dB | — | — | 21 dB | 20 dB | 14 dB | 18 dB |

1. The following class definitions refer to the ONS 15454 card being used:

Class A—10-Gbps multirate transponder with FEC or 10-Gbps muxponder with FEC

Class B—10-Gbps multirate transponder without FEC

Class C—OC-192 LR ITU

Class D—2.5-Gbps multirate transponder both protected and unprotected with FEC enabled

Class E—2.5-Gbps multirate transponder both protected and unprotected without FEC enabled

Class F—2.5-Gbps multirate transponder both protected and unprotected in 2R mode

Class G—OC-48 ELR 100 GHz

# 12.8 Single-Span Link

Single-span link is a type of linear configuration characterized by a single-span link with pre-amplification and post-amplification. A span link is also characterized by the use of two terminal nodes (west and east). The terminal nodes are usually equipped with a 32 MUX-O card and a 32 DMX-O card; however, it is possible to scale terminal nodes according to site requirements. Software R4.6 also supports single-span links with AD-4C-xx.x cards. Only unprotected traffic can be provisioned on a single-span link. For more information, see the "12.3.6 Amplified TDM Node" section on page 12-23.

Figure 12-31 shows ONS 15454s in a single-span link. Eight channels are carried on one span. Single-span link losses apply to OC-192 LR ITU cards. The optical performance values are valid assuming that the sum of the OADM passive nodes insertion losses and the span losses does not exceed 35 dB.

*Figure 12-31 Single-Span Link*

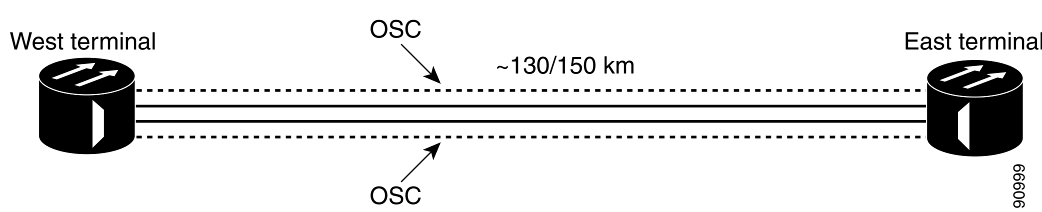


Table 12-7 lists the span loss for a single-span link configuration with eight channels. The optical performance for this special configuration is given only for Classes A and C. This configuration assumes a maximum channel capacity of eight channels (8-dBm nominal channel power) used without any restrictions on the 32 available channels.

**Note** The dash (—) in Table 12-7 means not applicable.

*Table 12-7 Single-Span Link with Eight Channels*

| Node Configuration | Number of Spans | Class A[1] | Class B[1] | Class C[1] | Class D[1] | Class E[1] | Class F[1] | Class G[1] |
|---|---|---|---|---|---|---|---|---|
| | | Classes A through C are 10-Gbps interfaces | | | Classes D through G are 2.5-Gbps interfaces | | | |
| With OSCM card | 1x | 37 dB | — | 37 dB | — | — | — | — |
| With OSC-CSM card | 1x | 35 dB | — | 35 dB | — | — | — | — |

1. The following class definitions refer to the ONS 15454 card being used:
Class A—10-Gbps multirate transponder with FEC or 10-Gbps muxponder with FEC
Class B—10-Gbps multirate transponder without FEC
Class C—OC-192 LR ITU
Class D—2.5-Gbps multirate transponder both protected and unprotected with FEC enabled
Class E—2.5-Gbps multirate transponder both protected and unprotected without FEC enabled
Class F—2.5-Gbps multirate transponder both protected and unprotected in 2R mode
Class G—OC-48 ELR 100 GHz

Table 12-8 lists the span loss for a single-span link configuration with 16 channels. The optical performance for this special configuration is given only for Class A and Class C. This configuration assumes a maximum channel capacity of 16 channels (5-dBm nominal channel power) used without any restrictions on the 32 available channels.

**Note** The dash (—) in Table 12-8 means not applicable.

*Table 12-8 Single-Span Link with 16 Channels*

| Node Configuration | Number of Spans | Class A[1] | Class B[1] | Class C[1] | Class D[1] | Class E[1] | Class F[1] | Class G[1] |
|---|---|---|---|---|---|---|---|---|
| | | Classes A through C are 10-Gbps interfaces | | | Classes D through G are 2.5-Gbps interfaces | | | |
| With OSCM or OSC-SCM cards | 1x | 35 dB | — | 35 dB | — | — | — | — |

1. The following class definitions refer to the ONS 15454 card being used:

Class A—10-Gbps multirate transponder with FEC or 10-Gbps muxponder with FEC

Class B—10-Gbps multirate transponder without FEC

Class C—OC-192 LR ITU

Class D—2.5-Gbps multirate transponder both protected and unprotected with FEC enabled

Class E—2.5-Gbps multirate transponder both protected and unprotected without FEC enabled

Class F—2.5-Gbps multirate transponder both protected and unprotected in 2R mode

Class G—OC-48 ELR 100 GHz

Table 12-9 lists the span loss for a single-span link configuration with one-channel, AD-1C-x.xx cards, OPT-PRE amplifiers, and OPT-BST amplifiers. The single-span link with a flexible channel count is used both for transmitting and receiving. If dispersion compensation is required, a DCU can be used with an OPT-PRE amplifier. The optical performance for this special configuration is given for Classes A through G (8-dBm nominal channel power) used without any restrictions on the 32 available channels.

*Table 12-9 Single-Span Link with One Channel, AD-1C-xx.x Cards, OPT-PRE Amplifiers, and OPT-BST Amplifiers*

| Node Configuration | Number of Spans | Class A[1] | Class B[1] | Class C[1] | Class D[1] | Class E[1] | Class F[1] | Class G[1] |
|---|---|---|---|---|---|---|---|---|
| | | Classes A through C are 10-Gbps interfaces | | | Classes D through G are 2.5-Gbps interfaces | | | |
| With OSCM cards[2] | 1x | 37 dB | 31 dB | 31 dB | 37 dB | 37 dB | 37 dB | 37 dB |
| Hybrid with OSC-CSM cards[3] | 1x | 35 dB | 31 dB | 31 dB | 35 dB | 35 dB | 35 dB | 35 dB |

1. The following class definitions refer to the ONS 15454 card being used:

Class A—10-Gbps multirate transponder with FEC or 10-Gbps muxponder with FEC

Class B—10-Gbps multirate transponder without FEC

Class C—OC-192 LR ITU

Class D—2.5-Gbps multirate transponder both protected and unprotected with FEC enabled

Class E—2.5-Gbps multirate transponder both protected and unprotected without FEC enabled

Class F—2.5-Gbps multirate transponder both protected and unprotected in 2R mode

Class G—OC-48 ELR 100 GHz

2. OSCM sensitivity limits the performance to 37 dB.
3. OSC-CSM sensitivity limits the performance to 35 dB when it replaces the OSCM in a hybrid node.

Table 12-10 lists the span loss for a single-span link configuration with one channel and OPT-BST amplifiers. The optical performance for this special configuration is given for Classes A through G. Classes A, B, and C use 8-dBm nominal channel power. Classes D, E, F, and G use 12-dBm nominal channel power. There are no restriction on the 32 available channels. That is, a line card, transponder, or muxponder wavelength can be extracted from the 32 available wavelengths. Also, the optical service channel is not required.

*Table 12-10 Single-Span Link with One Channel and OPT-BST Amplifiers*

| Number of Spans | Class A[1] | Class B[1] | Class C[1] | Class D[1] | Class E[1] | Class F[1] | Class G[1] |
|---|---|---|---|---|---|---|---|
| | Classes A through C are 10-Gbps interfaces | | | Classes D through G are 2.5-Gbps interfaces | | | |
| 1x | 20 to 30 dB | 17 to 26 dB | 17 to 28 dB | Unprotected from 29 to 41 dB<br>Protected from 25 to 41 dB | Unprotected from 28 to 37 dB<br>Protected from 24 to 40 dB | Unprotected from 21 to 34 dB<br>Protected from 18 to 34 dB | From 23 to 36 dB |

1. The following class definitions refer to the ONS 15454 card being used:

Class A—10-Gbps multirate transponder with FEC or 10-Gbps muxponder with FEC

Class B—10-Gbps multirate transponder without FEC

Class C—OC-192 LR ITU

Class D—2.5-Gbps multirate transponder both protected and unprotected with FEC enabled

Class E—2.5-Gbps multirate transponder both protected and unprotected without FEC enabled

Class F—2.5-Gbps multirate transponder both protected and unprotected in 2R mode

Class G—OC-48 ELR 100 GHz

Table 12-11 lists the span loss for a single-span link configuration with one channel, OPT-BST amplifiers, OPT-PRE amplifiers, and ONS 15216 FlexLayer filters. ONS 15216 FlexLayer filters are used instead of the AD-1C-xx.x cards to reduce equipment costs and increase the span length since the optical service channel is not necessary. The optical performance for this special configuration is given Classes A through G. Classes A, B, and C use 8-dBm nominal channel power. Classes D, E, F, and G use 12-dBm nominal channel power. There are no restriction on the first 16 available wavelengths (from 1530.33 to 1544.53 nm).

*Table 12-11 Single-Span Link with One Channel, OPT-BST Amplifiers, OPT-PRE Amplifiers, and ONS 15216 FlexLayer Filters*

| Number of Spans | Class A[1] | Class B[1] | Class C[1] | Class D[1] | Class E[1] | Class F[1] | Class G[1] |
|---|---|---|---|---|---|---|---|
| | Classes A through C are 10-Gbps interfaces | | | Classes D through G are 2.5-Gbps interfaces | | | |
| 1x | 38 dB | 30 dB | 30 dB | 44 dB | 40 dB | 38 dB | 40 dB |

1. The following class definitions refer to the ONS 15454 card being used:

Class A—10-Gbps multirate transponder with FEC or 10-Gbps muxponder with FEC

Class B—10-Gbps multirate transponder without FEC

Class C—OC-192 LR ITU

Class D—2.5-Gbps multirate transponder both protected and unprotected with FEC enabled

Class E—2.5-Gbps multirate transponder both protected and unprotected without FEC enabled

Class F—2.5-Gbps multirate transponder both protected and unprotected in 2R mode

Class G—OC-48 ELR 100 GHz

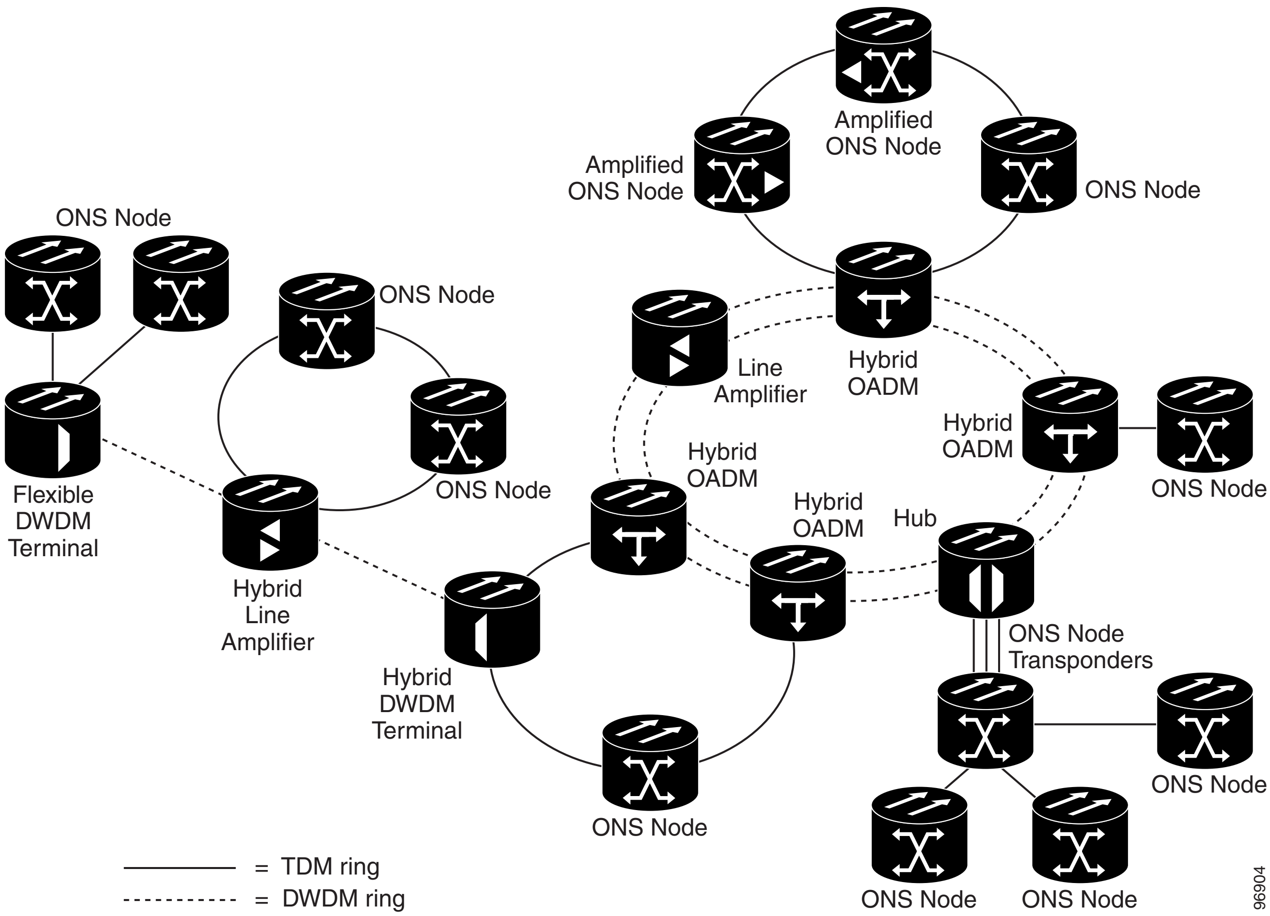
# 12.9 Hybrid Networks

The hybrid network configuration is determined by the type of node that is used in an ONS 15454 network. Along with TDM nodes, the ONS 15454 supports the following hybrid node types: 1+1 protected flexible terminal, scalable terminal, hybrid terminal, hybrid OADM, hybrid line amplifier, and amplified TDM. For more information about hybrid node types see the "12.3 DWDM and TDM Hybrid Node Types" section on page 12-11. For hybrid node turn-up procedures and hybrid network turn-up procedures, refer to the "DWDM Node Turn Up" chapter and the "DWDM Network Turn Up" chapter in the *Cisco ONS 15454 Procedure Guide*.

**Note** The MetroPlanner tool creates a plan for amplifier placement and proper equipment for DWDM node configurations. Although TDM cards can be used with DWDM node configuration, the MetroPlanner tool does not create a plan for TDM card placement. MetroPlanner will support TDM configurations in a future release.

Figure 12-32 shows ONS 15454s in a hybrid TDM and DWDM configurations.

*Figure 12-32 Hybrid Network Example*



DWDM and TDM layers can be mixed in the same node; however they operate and are provisioned independently. The following TDM configurations can be added to a hybrid network: point-to-point, linear add/drop multiplexer (ADM), BLSR, and path protection.

Figure 12-33 shows ONS 15454s in a hybrid point-to-point configuration.

***Figure 12-33 Hybrid Point-to-Point Network Example***

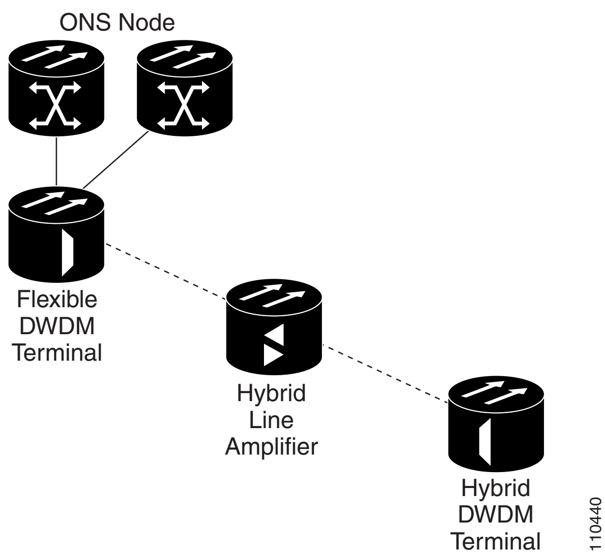



Figure 12-34 shows ONS 15454s in a hybrid linear ADM configuration.

***Figure 12-34 Hybrid Linear ADM Network Example***

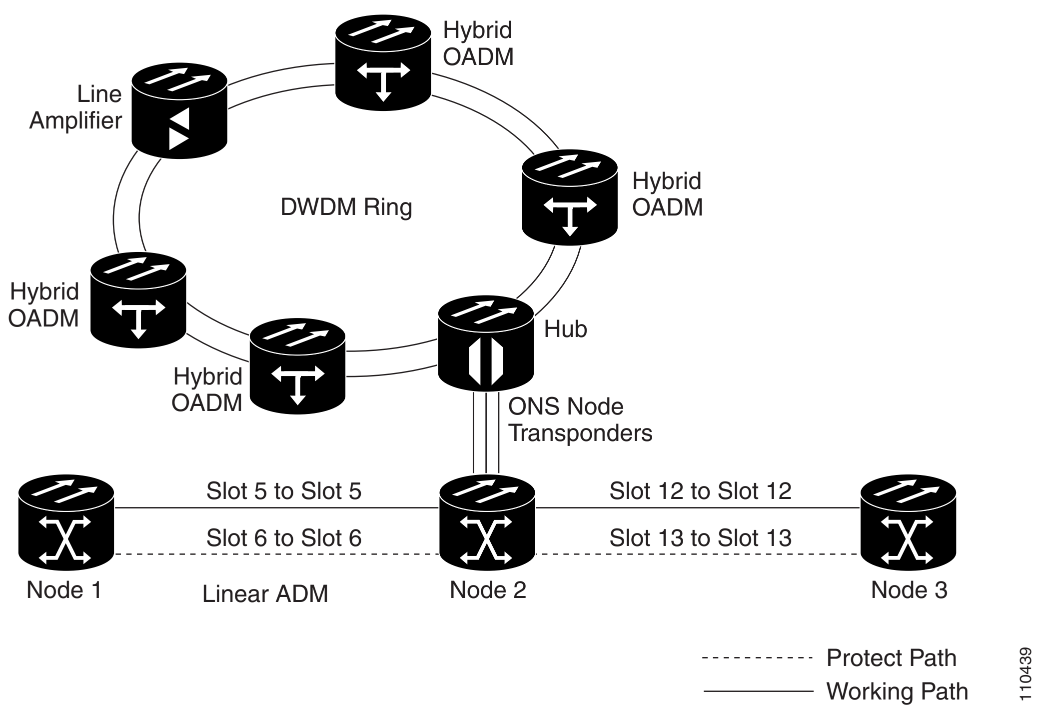


Figure 12-35 shows ONS 15454s in a hybrid BLSR configuration.

***Figure 12-35 Hybrid BLSR Network Example***

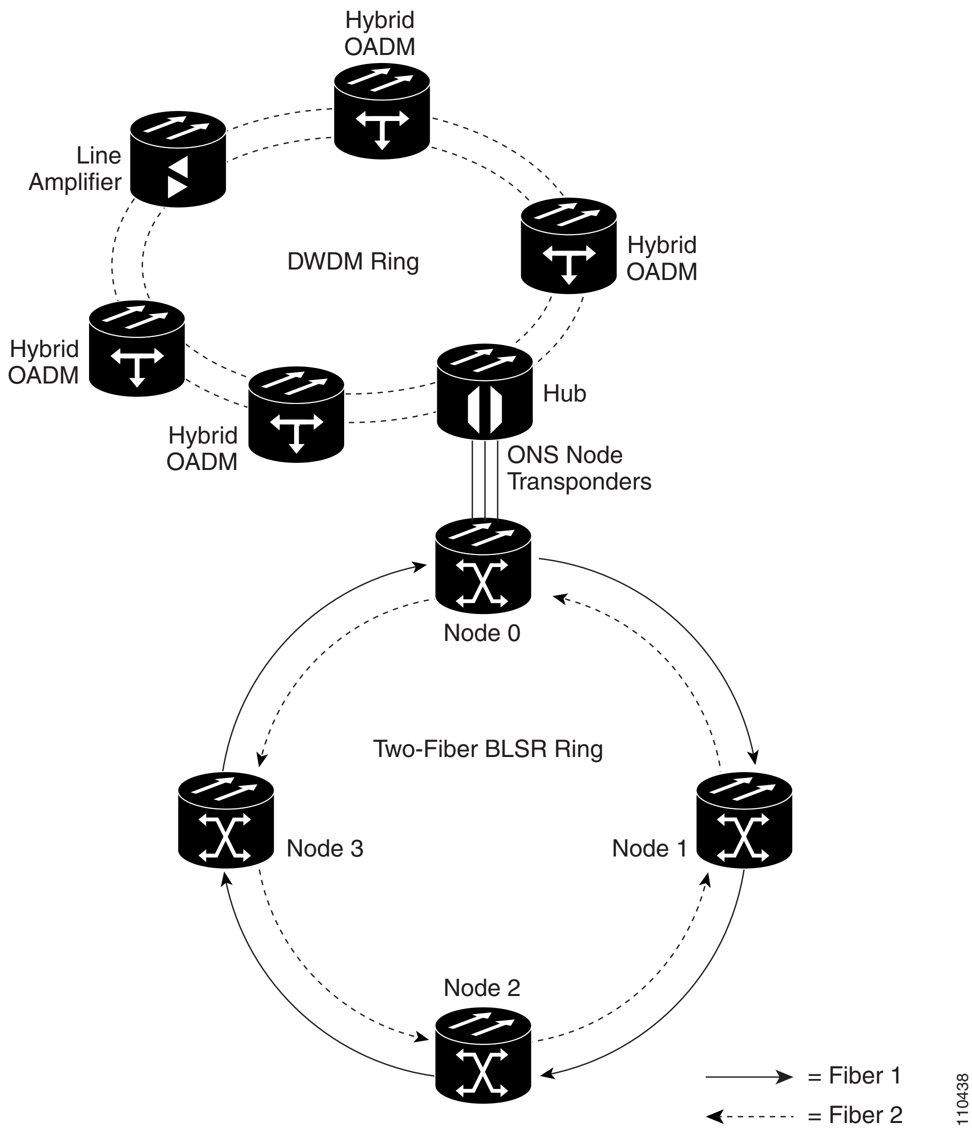
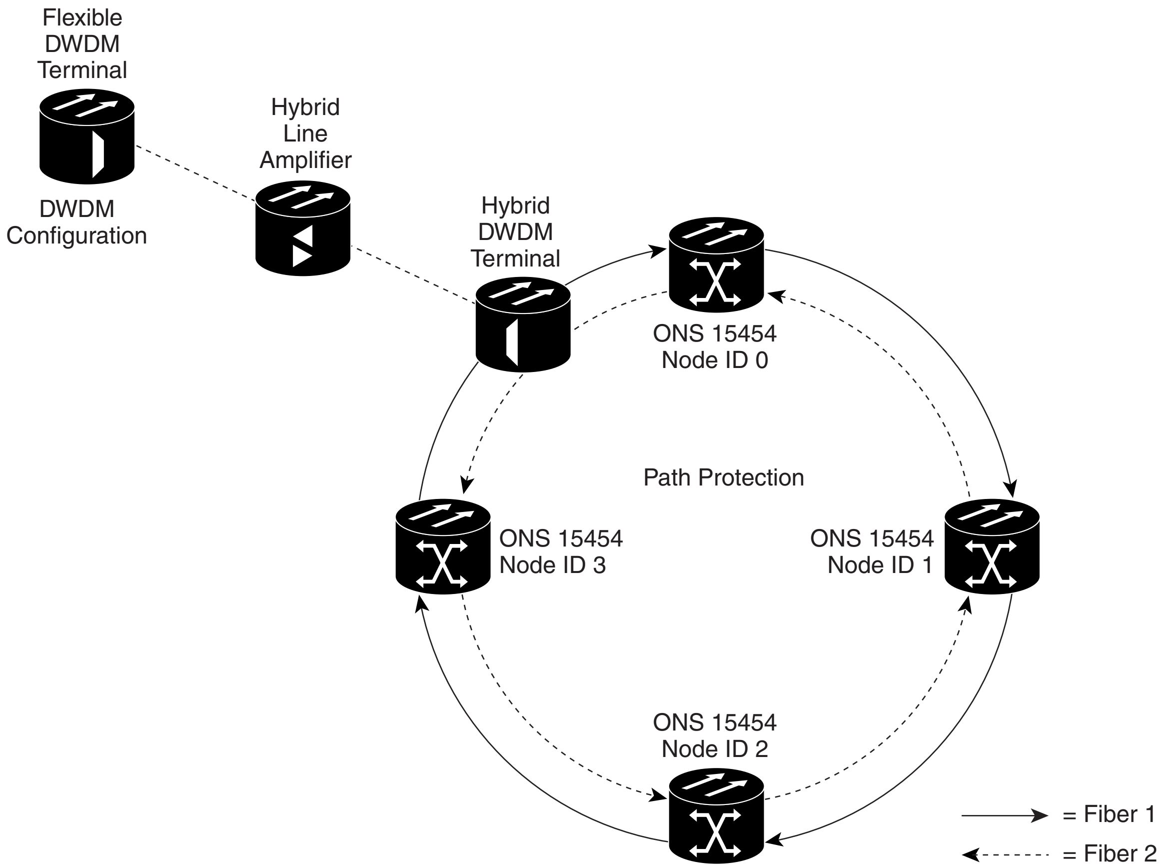


Figure 12-36 shows ONS 15454s in a hybrid path protection configuration.

*Figure 12-36 Hybrid Path Protection Network Example*




# 12.10 Automatic Power Control

The ONS 15454 automatic power control (APC) feature performs the following functions:

- Maintains constant per-channel power when changes to the number of channels occur.
- Compensates for optical network degradation (aging effects).
- Simplifies the installation and upgrade of DWDM optical networks by automatically calculating the amplifier setpoints.

**Note** APC functions are performed by software algorithms on the OPT-BST, OPT-PRE, and TCC2 cards.

Amplifier software uses a control gain loop with fast transient suppression to keep the channel power constant regardless of any changes in the number of channels. Amplifiers monitor the changes to the input power and change the output power according to the calculated gain setpoint. The shelf controller software emulates the control output power loop to adjust for fiber degradation. To perform this function, the TCC2 needs to know the channel distribution, which is provided by a signaling protocol, and the expected per-channel power, which you can provision. The TCC2 compares the actual amplifier output power with the expected amplifier output power and modifies the setpoints if any discrepancies occur.

## 12.10.1 APC at the Amplifier Card Level

In constant gain mode, the amplifier power out control loop performs the following input and output power calculations, where G represents the gain and t represents time.

Pout (t) = G * Pin (t) (mW)

Pout (t) = G + Pin (t) (dB)

In a power-equalized optical system, the total input power is proportional to the number of channels. The amplifier software compensates for any variation of the input power due to changes in the number of channels carried by the incoming signal.

Amplifier software identifies changes in the read input power in two different instances, t1 and t2 as a change in the carried traffic. The letters m and n in the following formula represent two different channel numbers. Pin/ch represents the per-channel input power:

Pin (t1)= nPin/ch

Pin (t2) = mPin/ch

Amplifier software applies the variation in the input power to the output power with a reaction time that is a fraction of a millisecond. This keeps the power constant on each channel at the output amplifier, even during a channel upgrade or a fiber cut.

Amplifier parameters are configured using east and west conventions for ease of use. Selecting west provisions parameters for the preamplifier receiving from the west and the booster amplifier transmitting to the west. Selecting east provisions parameters for the preamplifiers receiving from the east and the booster amplifier transmitting to the east.

Starting from the expected per-channel power, the amplifiers automatically calculate the gain setpoint after the first channel is provisioned. An amplifier gain setpoint is calculated in order to make it equal to the loss of the span preceding the amplifier itself. After the gain is calculated, the setpoint is no longer changed by the amplifier. Amplifier gain is recalculated every time the number of provisioned channels returns to zero. If you need to force a recalculation of the gain, move the number of channels back to zero.

## 12.10.2 APC at the Node and Network Levels

The amplifier adjusts the gain to compensate for span loss. Span loss changes due to aging fiber and components, or changes in operating conditions. To correct the gain or express variable optical attenuator (VOA) setpoints, APC calculates the difference between the power value read by the photodiodes and the expected power value. The expected power values is calculated using:

- Provisioned per-channel power value
- Channel distribution (the number of express, add, and drop channels in the node)
- ASE estimation

Channel distribution is determined by the sum of the provisioned and failed channels. Information about provisioned wavelengths is sent to APC on the applicable nodes during circuit creation. Information about failed channels is collected through a signaling protocol that monitors alarms on ports in the applicable nodes and distributes that information to all the other nodes in the network.

ASE calculations purify the noise from the power level reported from the photodiode. Each amplifier can compensate for its own noise, but cascaded amplifiers cannot compensate for ASE generated by preceding nodes. The ASE effect increases when the number of channels decreases; therefore, a correction factor must be calculated in each amplifier of the ring to compensate for ASE build-up.

APC is a network-level feature. The APC algorithm designates a master node that is responsible for starting APC hourly or every time a new circuit is provisioned or removed. Every time the master node signals for APC to start, gain and VOA setpoints are evaluated on all nodes in the network. If corrections are needed in different nodes, they are always performed sequentially following the optical paths starting from the master node.

APC corrects the power level only if the variation exceeds the hysteresis thresholds of +/– 0.5 dB. Any power level fluctuation within the threshold range is skipped since it is considered negligible. Because APC is designed to follow slow time events, it skips corrections greater than 3 dB. This is the typical total aging margin that is provisioned during the network design phase. After you provision the first channel or the amplifiers are turned up for the first time, APC does not apply the 3 dB rule. In this case, APC corrects all the power differences to turn up the node.

**Note** Software R4.6 does not report corrections that are not performed and exceed the 3 dB correction factor to management interfaces (Cisco Transport Controller [CTC], Cisco Transport Manager [CTM], and Transaction Language One [TL1]).

To avoid large power fluctuations, APC adjusts power levels incrementally. The maximum power correction is +/– 0.5 dB. This is applied to each iteration until the optimal power level is reached. For example, a gain deviation of 2 dB is corrected in four steps. Each of the four steps requires a complete APC check on every node in the network. APC can correct up to a maximum of 3 dB on an hourly basis. If degradation occurs over a longer time period, APC will compensate for it by using all margins that you provision during installation.

When no margin is available, adjustments cannot be made because setpoints exceed ranges. APC communicates the event to CTC, CTM, and TL1 through an APC Fail condition. APC will clear the APC fail condition when the setpoints return to the allowed ranges.

APC automatically disables itself when:

- A HW FAIL alarm is raised by any card in any of the network nodes.
- A Mismatch Equipment Alarm (MEA) is raised by any card in any of the network nodes.
- An Improper Removal alarm is raised by any card in any of the network nodes.
- Gain Degrade, Power Degrade, and Power Fail Alarms are raised by the output port of any amplifier card in any of the network nodes.
- A VOA degrade or Fail alarm is raised by any of the cards in any of the network nodes.

## 12.10.3 Managing APC

The APC state (Enable/Disable) is located on every node and can be retrieved by the CTC or TL1 interface. If an event that disables APC occurs in one of the network nodes, APC will be disabled on all the others and the APC state will be shown as DISABLE. On the contrary, the APC DISABLE condition is raised only by the node where the problem occurred to simplify troubleshooting.

APC DISABLE is a reversible state. After the error condition is cleared, signaling protocol will enable APC on the network and the APC DISABLE condition will be cleared. Since APC is required after channel provisioning to compensate for ASE effects, all optical channel network connection (OCHNC) circuits that a user provisioned during the disabled APC State will be kept in OOS-AINS status until APC is enabled. OCHNC will automatically go into the IS state only when APC is enabled.

# 12.11 Automatic Node Setup

Automatic node setup (ANS) is a TCC2 function that adjusts values of the VOAs on the DWDM channel paths to equalize the per-channel power at the amplifier input. This power equalization means that at launch, all the channels have the same amplifier power level, independent from the input signal on the client interface and independent from the path crossed by the signal inside the node. This equalization is needed for two reasons:

- Every path introduces a different penalty on the signal that crosses it.
- Client interfaces add their signal to the ONS 15454 DWDM ring with different power levels.

To support ANS, the integrated VOAs and photodiodes are provided in the following ONS 15454 DWDM cards:

- OADM band cards (AD-xB-xx.x) express and drop path
- OADM channel cards (AD-xC-xx.x) express and add path
- 4-Channel Terminal Multiplexer/Demultiplexer (4MD-xx.x) input port
- 32-Channel Terminal Multiplexer (32 MUX-O) input port
- 32-Channel Terminal Demultiplexer (32 DMX-O) output port

Optical power is equalized by regulating the VOAs. Knowing the expected per-channel power, ANS automatically calculates the VOA values by:

- Reconstructing the different channels paths
- Retrieving the path insertion loss (stored in each DWDM transmission element)

VOAs operate in one of three working modes:

- Automatic VOA Shutdown—In this mode, the VOA is set at maximum attenuation value. Automatic VOA shutdown mode is set when the channel is not provisioned to ensure system reliability in the event that power is accidentally inserted.
- Constant Attenuation Value—In this mode, the VOA is regulated to a constant attenuation independent from the value of the input signal. Constant attenuation value mode is set on the following VOAs:
  - OADM band card VOAs on express and drop paths (as operating mode)
  - OADM channel card VOAs during power insertion startup
  - The multiplexer/demultiplexer card VOAs during power insertion startup
- Constant Power Value—In this mode, the VOA values are automatically regulated to keep a constant output power when changes occur to the input power signal. This working condition is set on OADM channel card VOAs as “operating” and on multiplexer/demultiplexer card VOAs as “operating mode.”

In the normal operating mode, OADM band card VOAs are set to a constant attenuation, while OADM channel card VOAs are set to a constant power. ANS requires the following VOA provisioning parameters to be specified:

- Target attenuation (OADM band card VOA and OADM channel card startup)
- Target power (channel VOA)

To allow you to modify ANS values based on your DWDM deployment, provisioning parameters are divided into two contributions:

- Reference Contribution (read only)—Set by ANS.
- Calibration Contribution (read and write)—Set by user.

The ANS equalization algorithm requires knowledge of the DWDM transmission element layout:

- The order in which the DWDM elements are connected together on the express paths
- Channels that are dropped and added
- Channels or bands that have been configured as pass through

ANS assumes that every DWDM port has a line direction parameter that is either West to East (W-E) or East to West (E-W). ANS automatically configures the mandatory optical connections according to following main rules:

- Cards equipped in Slots 1 to 6 have a drop section facing west.
- Cards equipped in Slots 12 to 17 have a drop section facing east.
- Contiguous cards are cascaded on the express path.
- 4MD-xx.x and AD-xB-xx.x are always optically coupled.
- A 4MD-xx.x absence forces an optical pass-through connection.
- Transmit (Tx) ports are always connected to receive (Rx) ports.

Optical patch cords are passive devices that are not autodiscovered by ANS. However, optical patch cords are used to build the alarm correlation graph. ANS uses Cisco Transport Controller (CTC) and TL1 as the user interface to:

- Calculate the default connections on the NE.
- Retrieve the list of existing connections.
- Retrieve the list of free ports.
- Create new connections or modify existing ones.
- Launch ANS.

Optical connections are identified by the two termination points, each with an assigned slot and port. ANS checks that a new connection is feasible (according to embedded connection rules) and returns a denied message in the case of a violation.

ANS requires provisioning of the expected wavelength. When provisioning the expected wavelength, the following rules apply:

- The card name is generically characterized by the card family, and not the particular wavelengths supported (for example, AD-2C for all 2-channel OADMs).
- At the provisioning layer, you can provision a generic card for a specific slot using CTC or TL1.
- Wavelength assignment is done at the port level.
- An equipment mismatch alarm is raised when a mismatch between the identified and provisioned value occurs. The default value for the provisioned attribute is AUTO.

# 12.12 DWDM Network Topology Discovery

Each ONS 15454 DWDM node has a network topology discovery function that can:

- Identify other ONS 15454 DWDM nodes in an ONS 15454 DWDM network.
- Identify the different types of DWDM networks.
- Identify when the DWDM network is complete and when it is incomplete.

ONS 15454 DWDM nodes use node services protocol (NSP) to automatically update nodes whenever a change in the network occurs. NSP uses two information exchange mechanisms: hop-by-hop message protocol and broadcast message protocol. Hop-by-hop message protocol elects a master node and exchanges information between nodes in a sequential manner simulating a token ring protocol:

- Each node that receives a hop-by-hop message passes it to the next site according to the ring topology and the line direction from which the token was received.
- The message originator always receives the token after it has been sent over the network.
- Only one hop-by-hop message can run on the network at any one time.

NSP broadcast message protocol distributes information that is to be shared by all ONS 15454 DWDM nodes on the same network. Broadcast message delivery is managed in an independent way from delivery of the two tokens. Moreover, no synchronization among broadcast messages is required; every node is authorized to send a broadcast message any time it is necessary.