

SONET Automatic Protection Switching on the BPX 8600 Series

Introduction

SONET Linear Automatic Protection Switching (APS) is a new feature, enabled in hardware/software, that is available on the BPX 8600 series wide-area switches. APS offers superior redundancy for SONET equipment and provides a means to guard against card failures and fiber cuts. Implementation of APS on the BPX[®] 8600 series switches enhances the unmatched reliability and availability of this carrier-class switch, and is available today.

With software Release 9.2, APS is offered on the OC-3/STM1 and OC-12/STM4 versions of the Broadband Switch Modules (BXMs) in both the 1+1 and 1:1 modes. Both APS ITU-T G.783 Annex A and Annex B (1+1 bidirectional, Non-Revertive for Japan) are supported. APS improves the redundancy of the BXM cards by providing card/line redundancy and provides a faster and standards-compliant alternative to Y-cable redundancy. Because SONET APS complies with GR-253 and ITU-T G.783, it allows BPX 8600s to integrate seamlessly with SONET Add/Drop Multiplexers (ADMs). The implementation of APS allows a pair of SONET lines to be configured for line redundancy. In the event of a fiber cut, the active line switches automatically to the standby line within 60 milliseconds (10 millisecond initiation and 50 millisecond switchover).

With APS 1+1 or APS 1:1, each redundant line pair consists of a working line and a protection line. Once a signal fail condition or a signal degrade condition is detected, the hardware switches from the working line to the protection line. There is a revertive option, and upon detection of a

signal fail condition, the hardware switches back to the working line automatically after the repair of the working line, and a configured time period has elapsed. The coordination between the working line and the protection line is achieved using the in-band protocol. In the non-revertive option, if a signal fail condition is detected, the hardware switches to the protection line and does not automatically revert back to the working line.

Customer Benefits

APS performs switchovers with minimal loss of data, and time-consuming reroutes are avoided. With APS, there is no visibility that a failure has occurred beyond the network element in which it is residing; other nodes are not affected by the failure. Implementation of APS guards a network against complex restarts and resynchronizations since failures are isolated to a local device. With APS, the effect of a failure is greatly minimized, and a fast switchover guarantees minimal effect on the network. Point-to-point APS can be implemented with BPX 8600s for faster recovery from link failures.



SONET APS performs switchovers at Layer 1 which is significantly faster than at Layer 2 or Layer 3. For example, an APS switchover is accomplished in less than 60 milliseconds while a Y-cable redundancy switchover, done at the ATM layer, requires approximately 250 milliseconds. Fast switchovers are increasingly becoming more critical as traffic speeds approach OC-12/STM4 and higher.

The following example highlights the value of a fast switchover:

OC-12 = 622 Mb/second = 1,466,981 cells per second

250 millisecond switchover, using Y-cable redundancy results in over 350,000 cells lost

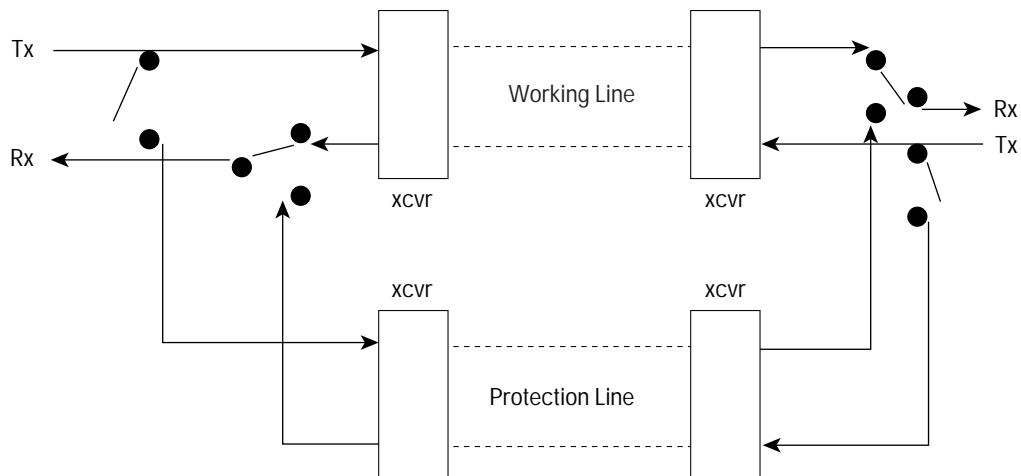
60 millisecond switchover, using SONET APS results in approximately 88,000 cells lost

Thus, APS saves approximately 260,000 cells from being lost

SONET Linear APS 1:1

SONET Linear APS 1:1 is a single card solution that guards against fiber cuts but not front card or back card failures. SONET APS 1:1 requires that for every working line, a protection line exists. Traffic protected by the redundancy is carried on the protection line only when a failure occurs on the working line. The protection line is not guaranteed to carry real traffic until the transmit end is informed of the failure and subsequent switchover.

Figure 1
SONET Linear APS 1:1



If the revertive option is enabled, the hardware switches back to the working line from the protection line after a configured time period (Wait to Restore) has elapsed. The revertive option is the default mode for APS 1:1.

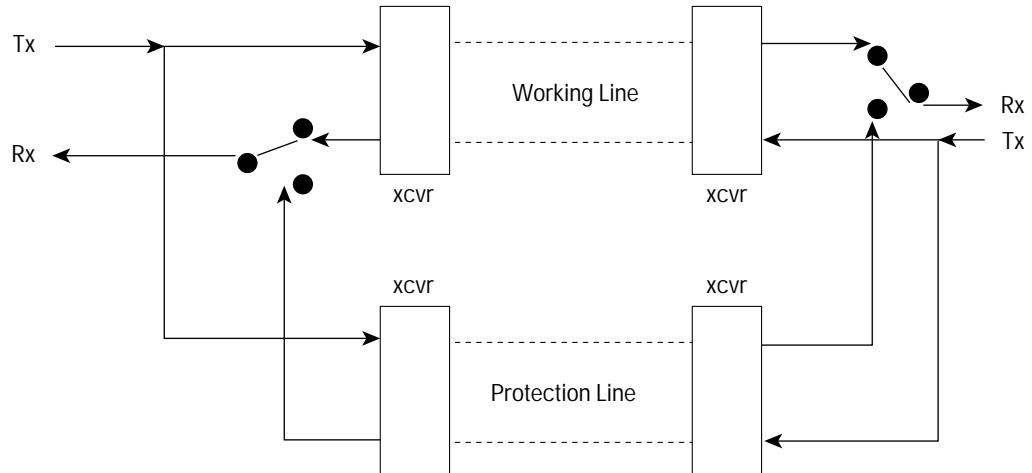
SONET Linear APS 1+1

SONET Linear APS 1+1 guards against both fiber cuts and front card or back card failures. APS 1+1 requires that for every working line, a redundant protection line exists. Traffic is carried simultaneously by the working and the protection lines. GR-253 and ITU-T G.783 require the bridging to be done at the electrical level; therefore, the same payloads are transmitted over the working and protection lines. Since traffic is carried simultaneously by the working



and protection lines, the receiver that terminates the APS 1+1 must select cells from either line and continue to forward one consistent traffic stream. The receiving ends can switch from working to protection line without coordinating at the transmit end since both lines transmit the same information.

Figure 2
SONET Linear APS 1+1

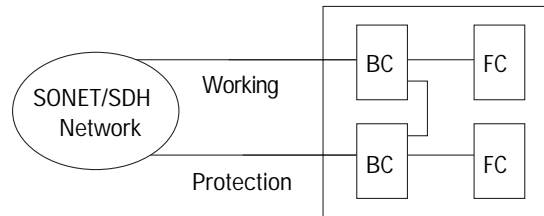


SONET APS 1+1 guards against the following types of failures: a fiber cut, a back card failure, or a front card failure. The type of failure that is encountered determines the switchover time. Referring to Figure 3:

- If a fiber cut occurs on the working line, the working front card remains active, and data is routed to the protection line. The switchover time is less than 60 milliseconds.
- If the working back card fails, the switchover time depends on the type of back card failure. If the failure involves power to the board, then data is switched to the protection back card and front card, and the switchover time is approximately 250 milliseconds. If the failure to the back card involves the optics and is isolated to the working line, data is switched to the protection line, and the switchover occurs in less than 60 milliseconds.
- In the third potential scenario, if the working front card fails, data is routed to the protection front card. In this case, the switchover time is approximately 250 milliseconds.

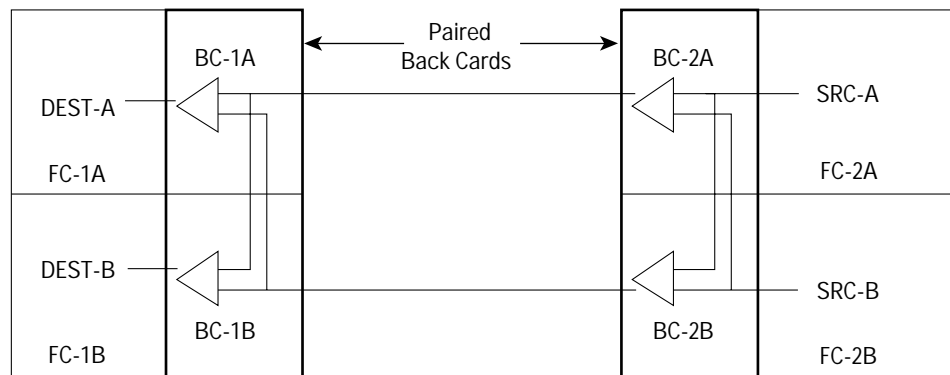


Figure 3
SONET Linear APS 1+1 Front Card and Back Card Schematic



As seen in Figure 4, the bridging requirement is satisfied by the cross-coupling of the transmit and receive signals between the two APS port pairs and is accomplished via the paired back cards. The cross-coupling is one-to-one for the same ports of each back card. Switching of the paired ports is done independently of the other paired ports; the paired back cards must occupy adjacent slots in the BPX nodes.

Figure 4
SONET Linear APS 1+1 Paired Back Card Schematic



APS 1:1 Configuration Requirements

For customers who prefer not to provide a full set of standby equipment, APS 1:1 provides redundancy without additional hardware. APS 1:1 is implemented on the following BXM cards:

Front Cards

BPX-BXM-155-4, BPX-BXM-155-4D, BPX-BXM-155-4DX

BPX-BXM-155-8, BPX-BXM-155-8D, BPX-BXM-155-8DX

BPX-BXM-622-2, BPX-BXM-622-2D, BPX-BXM-622-2DX



Back Cards

BPX-MMF-155-4-BC

BPX-SMF-155-4-BC

BPX-SMFLR-155-4-BC

BPX-STM1-EL-4-BC

BPX-MMF-155-8-BC

BPX-SMF-155-8-BC

BPX-SMFLR-155-8-BC

BPX-SMF-622-2-BC

BPX-SMFLR-622-2-BC

In addition to the BXM cards listed above, APS 1:1 requires new firmware, 9.2 software, and a Cisco WAN Manager (CWM) upgrade. Switching of the paired ports can be done independently of the other paired ports. The ports must be paired sequentially, for example, port 1 and port 2, port 3 and port 4, etc...

APS 1:1 Configuration Limits:

APS 1:1 cannot be configured on cards already configured for Y-cable redundancy.

APS 1:1 requires the user to add the APS configuration to a line prior to upping it.

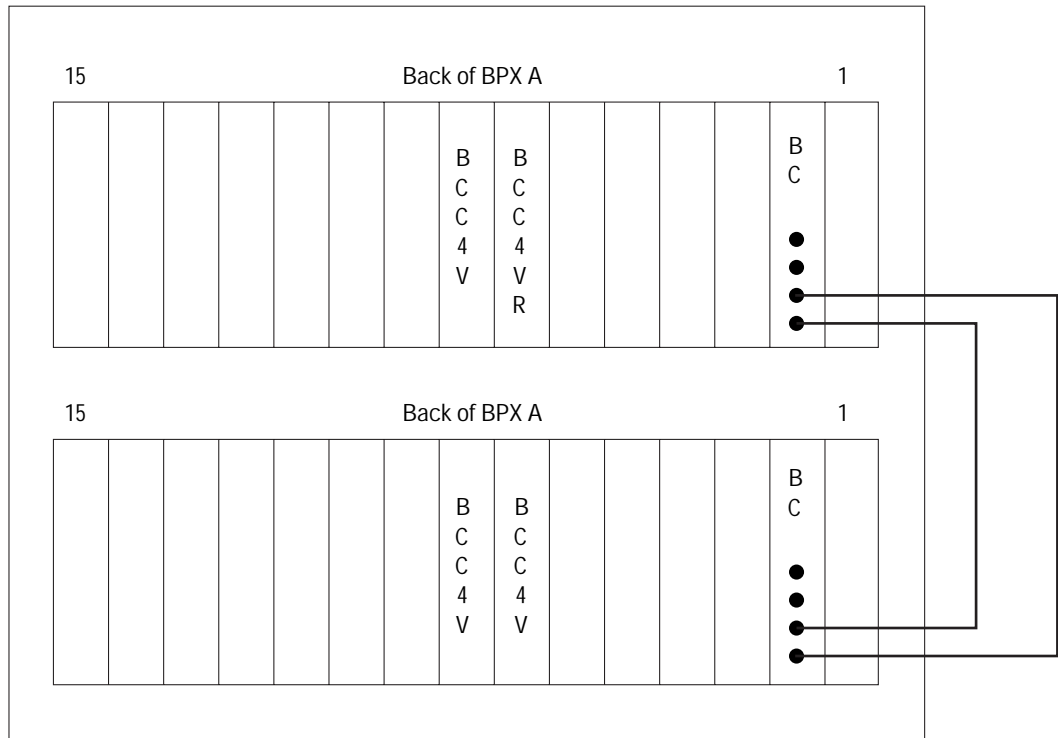
APS 1:1 requires the user to down a line prior to deleting the APS configuration on that line.

APS 1:1 can only be configured for bidirectional operation and revertive switching.

With APS 1:1, available connections are reduced by half since the standby line's port shares resources with the working line's port; using the BXM-enhanced cards (to be released in 2H'99), the number of available connections is not decreased.



Figure 5
SONET Linear APS 1:1 BPX 8600 Configuration



BC = Back Card

APS 1+1 Configuration Requirements

APS 1+1 redundancy is available on the BXM-155 and BXM-622 (SMF and SMFLR) cards. This feature is implemented with card redundancy via new (redundant) BXM back cards, and redundant OC3/OC12 lines. The following items are required for APS 1+1: BXM-155 or BXM-622 and new back cards (SMF or SMFLR), 9.2 SW, 9.2 compatible BXM FW, CWM upgrade.



The new back cards implemented in APS 1+1 incorporate an LED that indicates whether the card should be removed for service replacement. For example, all the lines on a given card may be working, except for one. Therefore, the cards should be removed and replaced. The LED functions are as follows:

BXM Back Card Display

Table 1 BXM Back Card Display

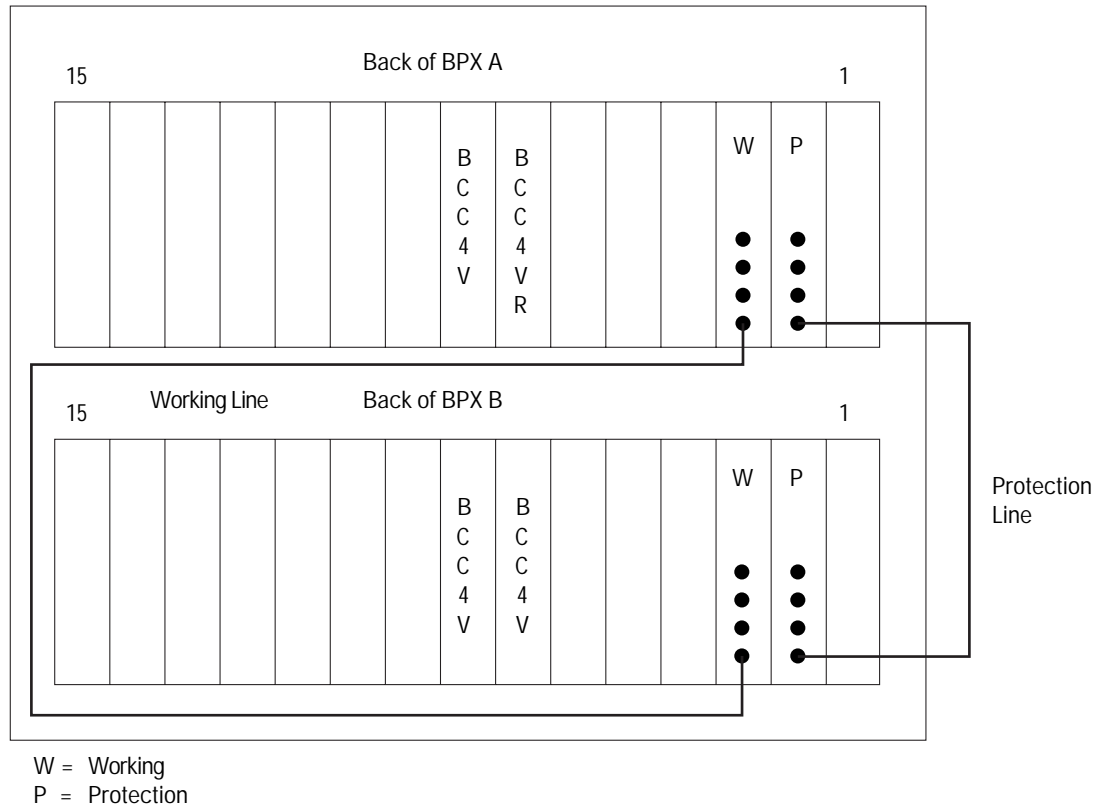
LED	Description
Green	The card has at least one active line and cannot be removed w/out affecting service
Yellow	The card has no active lines and may be removed
Red	N/A

APS 1+1 Configuration Limits:

1. When card redundancy is implemented, the two BXM front cards must reside in the same two adjacent slots as the APS back cards which must be inserted into the APS two-slot redundant frame assembly.
2. APS 1+1 Annex B can only be configured for bidirectional operation and non-revertive switching on a line.



Figure 6
SONET Linear APS 1+1 BPX 8600 Configuration



Appendix: Upgrade Procedure

For an existing BPX 8600 customer, the procedure for upgrading to APS 1+1 card and line redundancy is detailed below. There are separate upgrade procedures for existing Y-cable redundancy cards and non-Y-cable redundancy cards. APS back card model numbers are:

BPX-RDNT-SM-155-4

BPX-RDNT-SM-155-8

BPX-RDNT-LR-155-8

BPX-RDNT-SM-622

BPX-RDNT-SM-622-2

BPX-RDNT-LR-622-2

Required Components for APS 1+1:

1. New paired back card
2. BXM-155 Rev C or higher
3. BXM-622 Rev E or higher

4. Release 9.2 SW
5. Release 9.2 compatible BXM FW
6. Release 9.2 Cisco WAN Manager

For existing Y-cable redundancy cards, the upgrade procedure is as follows:

1. Upgrade FW, SW, and CWM to Release 9.2
2. Move all active lines to a third standby card (slot C) via Y-red
3. Upgrade all BXM front cards/back cards (slots A and B) for APS 1+1
4. Move all active lines to slot A (or B) via Y-red
5. Connect cables for second line to slot B (or A)
6. Cable slot A/B ports for redundancy as required
7. Activate APS feature on A/B slots

These upgrade procedures are dependent on Y-cable redundancy, and traffic is affected for less than 250 ms for each switch.

To minimize disruption to the network, the FW upgrade should be done only when a card is not active.

For existing non-Y-cable redundancy cards, the upgrade procedure is as follows:

1. Reroute trunk traffic if there is bandwidth available
2. Remove the existing BXM back card
3. Install the APS back card pairs and cable
4. After traffic is up, configure the cards and ports for APS
5. Restore traffic as necessary

These upgrade procedures require that traffic be disrupted while the new APS back cards are installed. To minimize disruption, traffic should be re-routed and be restored before APS is activated on the switch.

Required Components for APS 1:1

1. Release 9.2 SW
2. Release 9.2 compatible BXM FW
3. Release 9.2 CWM

For existing Y-cable redundancy cards, the upgrade procedure is as follows:

1. Apply the following commands to the existing BXM card:
delcon, dnln, dnport
2. Upgrade SW, FW, and CWM to Release 9.2
3. Configure the new card for APS 1:1
4. Cable active lines to only one of the APS paired ports
5. Cable standby lines
6. Activate APS for adjacent ports
7. Add ports, lines, and conns as required

Note that these upgrade procedures result in substantial outage of traffic. For a trunking application, this outage can be avoided if the customer can provide extra bandwidth through other trunks and then re-route the connections. If extra bandwidth is not available, all the connections must be deleted and re-added to activate APS. This situation also exists when adding APS 1:1 (same card) to an existing slot.



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