



Configuring Redundancy for POS/APS

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Contents

[Introduction](#)

[Prerequisites](#)

[Requirements](#)

[Components Used](#)

[Conventions](#)

[Automatic Protection Switching](#)

[APS and Related Commands](#)

[Switching Modes](#)

[Bidirectional Mode \(Recommended\)](#)

[Unidirectional Mode](#)

[Basic Scenarios](#)

[Working Interface to ADM Fiber Fails](#)

[ADM to Working Interface Fiber Fails \(Bidirectional Mode\)](#)

[ADM to Working Interface Fiber Fails \(Unidirectional Mode\)](#)

[Both Tx and Rx Fibers Between Working Interface and ADM Links Fail](#)

[K1/K2 Bytes](#)

[Configure APS](#)

[Monitor and Maintain APS](#)

[Troubleshoot APS](#)

[NetPro Discussion Forums - Featured Conversations](#)

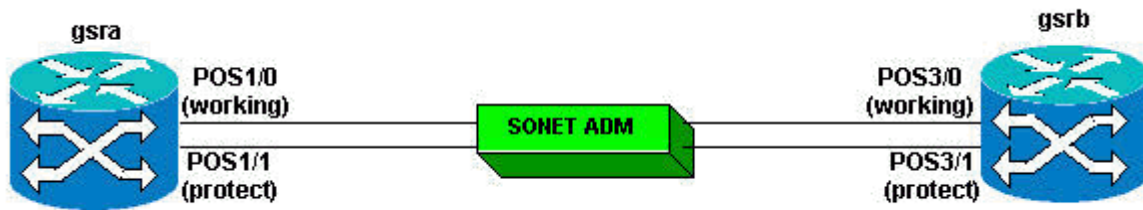
[Related Information](#)

Introduction

This document discusses the Automatic Protection Switching (APS) feature and provides an example of how to configure APS for Packet Over SONET (POS) redundancy.

This document enables you to understand how APS works, and helps you to configure and maintain APS on Cisco routers. The network topology in [figure 1](#) is the basis of this document:

Figure 1 – Network Topology



Prerequisites

Requirements

Cisco recommends that you have knowledge of these topics:

- Synchronous Optical Network (SONET) and POS technologies.
- Cisco router configuration basics.

Components Used

The information in this document is based on these software and hardware versions:

- Cisco IOS® Software Release 12.0(10)S.
- Cisco 12000 series hardware platforms.

Support for the APS feature is available on the Cisco 7500 and 12000 series hardware platforms, and on Cisco IOS Software Release 12.2(5) and later.

The information in this document was created from the devices in a specific lab environment. All of the devices used in this document started with a cleared (default) configuration. If your network is live, make sure that you understand the potential impact of any command.

Conventions

Refer to [Cisco Technical Tips Conventions](#) for more information on document conventions.

Automatic Protection Switching

The APS feature provides redundancy and allows for a switchover of POS circuits in the event of circuit failure. The implementation of APS allows you to configure a pair of SONET lines for line redundancy. When the Working (W) interface fails, the Protect (P) interface quickly assumes the traffic load. 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). SONET APS performs switchovers at Layer 1 (L1). Therefore, the switchover is significantly faster than at Layer 2 (L2) or Layer 3 (L3).

The protection mechanism that this feature uses has 1+1 architecture, as described in the Bellcore publication TR-TSY-000253, SONET Transport Systems, Common Generic Criteria, Section 5.3. SONET APS complies with GR-253 and ITU-T G.783. Therefore, SONET APS allows Cisco

routers to integrate seamlessly with SONET Add/Drop Multiplexers (ADMs). This feature allows configuration of either bidirectional or unidirectional switching, but bidirectional non-revertive switching is the default.

In the APS 1+1 architecture, each redundant line pair consists of a W interface and a P interface. The W and P interfaces are connected to a SONET ADM, which sends the same signal payload to the W and P interfaces. The W and P circuits can terminate in two ports of the same adapter, line card, or in two different routers. When a Signal Fail (SF) condition or a Signal Degrade (SD) condition occurs, the hardware switches from the W line to the P line. There is a revertive option. Upon detection of a SF condition, the hardware switches back to the W line automatically after the repair of the W line, and the elapse of a configured period. The in-band Protect Group Protocol (PGP) achieves coordination between the W line and the P line. In the non-revertive option, if an SF condition occurs, the hardware switches to the P line and does not automatically revert to the W line.

On the P circuit, the K1/K2 bytes from the Line OverHead (LOH) of the SONET frame indicate the current status of the APS connection, and convey any requests for action. The two ends of the connection use this signaling channel to maintain synchronization. The W and P circuits themselves, within the router or routers in which they terminate, are synchronized over an independent communication channel (using APS PGP), isolated from the W and P circuits. This independent channel can be a different SONET connection, Ethernet, or a lower-bandwidth connection. In a router configured for APS, the configuration for the P interface includes the IP address of the router (normally and recommended to be the loopback address) that has the W interface.

The APS PGP, which runs on top of the User Datagram Protocol (UDP), provides communication between the process that controls the W interface and the process that controls the P interface. The process that controls the P circuit uses this protocol to direct the process that contains the W circuit, on whether to activate or deactivate the W circuit, in the case of degradation, loss of channel signal, or manual intervention. If the two processes lose communication with each other, the W router assumes full control of the W circuit as if no P circuit existed.

APS and Related Commands

Here are the APS triggers categorized hierarchically (from lowest priority to highest priority):

- Manual switch request.
- SD condition (Bit Error Rate (BER) exceeding the SD threshold).
- SF condition (Loss of Frame (LOF), Loss of Signal (LOS), Alarm Indication Signal-Line(AIS-L), and a Line BER that exceeds 10⁻³/or user-provisionable).
- Forced switch request.

Here are the IOS options to configure APS:

```
GSR(config-if)# aps ?
authentication  Authentication string
force          Force channel
group         Group association
lockout       Lockout protection channel
manual       Manually switch channel
protect       Protect specified circuit
reflector     Configure for reflector mode APS
```

```

revert          Specify revert operation and interval
signaling       Specify SONET/SDH K1K2 signaling
timers          APS timers
unidirectional  Configure for unidirectional mode
working         Working channel number

```

In addition to the new IOS commands for the APS feature, the POS interface configuration commands **POS threshold** and **POS report** have been added to support user configuration of the BER thresholds and reporting of SONET alarms. Here is a sample output:

```

GSR(config-if)# POS threshold ?
  b1-tca  B1 BER threshold crossing alarm
  b2-tca  B2 BER threshold crossing alarm
  b3-tca  B3 BER threshold crossing alarm
  sd-ber  set Signal Degrade BER threshold
  sf-ber  set Signal Fail BER threshold

GSR(config-if)# POS report ?
  all      all Alarms/Signals
  b1-tca  B1 BER threshold crossing alarm
  b2-tca  B2 BER threshold crossing alarm
  b3-tca  B3 BER threshold crossing alarm
  lais    Line Alarm Indication Signal
  lrldi   Line Remote Defect Indication
  pais    Path Alarm Indication Signal
  plop    Path Loss of Pointer
  prdi    Path Remote Defect Indication
  rdool   Receive Data Out Of Lock
  sd-ber  LBIP BER in excess of SD threshold
  sf-ber  LBIP BER in excess of SF threshold
  slof    Section Loss of Frame
  slos    Section Loss of Signal

```

Switching Modes

In bidirectional mode, the Receive (Rx) and Transmit (Tx) channels are switched as a pair. In unidirectional mode, the Tx and Rx channels are switched independently. For example, in bidirectional mode, if the Rx channel on the W interface has a loss of channel signal, both the Rx and Tx channels are switched.

Bidirectional Mode (Recommended)

The W router recognizes failure and notifies the P router (through local interconnect PGP). The P router instructs the W router to deselect the W interface (through local interconnect PGP). The P router requests the ADM to switch Tx and Rx to P (through K1/K2 bytes on the P interface that go to the ADM). The P router selects the P interface and the ADM complies with the switch request and signals compliance (through K1/K2 bytes on ADM to the P interface fiber).

Unidirectional Mode

When there is a LOS/LOF alarm (failure) on the W Rx, the W router recognizes the failure and notifies the P router (through local interconnect PGP). The P router instructs the W router to deselect the W interface (through local interconnect PGP). The W router asserts a Line Alarm Indication Signal (LAIS) for as long as the W interface is deselected to force the ADM to switch the Rx to the P interface. The P router requests the ADM to switch to the P interface (through K1/K2 bytes on the P

interface to ADM fiber). The P router selects the P interface and the ADM complies with the switch request.

In unidirectional mode, the router coerces the ADM to switch. In order to do so, the router asserts LAIS (persistently, if on W; momentarily, if on P). Therefore, the unidirectional that you see is quite real, in that the unidirectional mode complies with GR-253. However, what the unidirectional also does is, to force a second unidirectional switch, which makes the switch appear to be bidirectional. This is the result of constraints that are deeply embedded in routing mechanisms (IP), which at every level assume traffic must have Rx and Tx on the same interface. In summary, the router complies with the unidirectional protocols in GR-253, but forces the switching into a model that supports IP. Hence, the router does not support Tx and Rx on different fiber pairs.

Note: A major deviation of the Cisco 12000 Series from GR-253 is that the Cisco 12000 Series does not bridge transmits to W and P, but keeps one interface active at a time.

Basic Scenarios

Working Interface to ADM Fiber Fails

The ADM sees the fiber failure and sends SF SWITCH REQUEST to the P router (through K1/ K2 bytes on P interface fiber), and requests a switch to the P interface. The P router instructs the W router to deselect (deactivate) the W interface (through local interconnect). The P router selects (activates) the P interface. The P router informs the ADM of the compliance with the switch request (through K1/ K2 bytes on the P interface ADM fiber).

ADM to Working Interface Fiber Fails (Bidirectional Mode)

The W router recognizes failure and notifies the P router (through local interconnect). The P router instructs the W router to deselect the W interface (through local interconnect). The P router requests ADM to switch Tx and Rx to P (through K1/K2 bytes on the P interface to the ADM fiber). The P router selects the P interface and ADM complies with the switch requests and signals compliance (through K1/K2 bytes on ADM to the P interface fiber).

ADM to Working Interface Fiber Fails (Unidirectional Mode)

The W router recognizes failure and notifies the P router (through local interconnect). The P router instructs the W router to deselect the W interface (through local interconnect). The W router asserts a LAIS for 100 ms to force the ADM to switch the Rx to the P interface. The P router requests ADM to switch to the P interface (through K1/K2 bytes on the P interface to ADM fiber). The P router selects the P interface and the ADM complies with the switch request.

Both Tx and Rx Fibers Between Working Interface and ADM Links Fail

Both sequences begin. Whether the P router first initiates the switch to P, or the ADM initiates the switch does not matter, because the result is the same.

POS-equipped Cisco routers act as Terminal Equipment (TE) for SONET/Synchronous Digital Hierarchy (SDH) section, line, and path segments of a link, and can detect and report these SONET/SDH errors and alarms:

- **Section:** LOS, LOF, and Threshold Crossing Alarms (TCA) (B1)

- **Line:** AIS (line and path), Remote Defect Indication (RDI) (line and path), Remote Error Indication (REI), TCA (B2)
- **Path:** AIS, RDI, REI, (B3), New Pointer Events (NEWPTR), POSitive Stuffing Event (PSE), Negative Stuffing Event (NSE)

Other reported information includes:

- SF-ber
- SD-ber
- C2 - signal label (payload construction)
- J1 - path trace byte

B1, B2, and B3 are categorized as performance-monitoring parameters, while others such as LOS, LOF, and LAIS fall under alarms. Performance monitoring pertains to advance alerts, while alarms indicate failures. K1/K2 byte status is also reported for SONET APS or SDH Multiservice Switching Path (MSP).

K1/K2 Bytes

When you discuss APS, you first need to understand how SONET uses K1/K2 bytes in the LOH.

Each Synchronous Transport Signal-1 (STS-1) consists of 810 bytes, which includes 27 bytes for the Transport Overhead (TOH) and 783 bytes for the Synchronous Payload Envelope (SPE). [Table 1](#) illustrates the format of an STS-1 frame and the 9 rows by 90 columns.

Table 1 – Format of an STS-1 Frame

				Path Overhead
Section Overhead	A1 Framing	A2 Framing	A3 Framing	J1 Trace
	B1 BIP-8	E1 Orderwire	E1 User	B3 BIP-8
	D1 Data Com	D2 Data Com	D3 Data Com	C2 Signal Label
Line Overhead	H1 Pointer	H2 Pointer	H3 Pointer Action	G1 Path Status
	B2 BIP-8	K1	K2	F2 User Channel
	D4 Data Com	D5 Data Com	D6 Data Com	H4 Indicator
	D7 Data Com	D8 Data Com	D9 Data Com	Z3 Growth

	D10 Data Com	D11 Data Com	D12 Data Com	Z4 Growth
	S1/Z1 Sync Status/Growth	M0 or M1/Z2 REI-L Growth	E2 Orderwire	Z5 Tandem Connection

The K1/K2 bytes form a 16-bit field. [Table 2](#) lists the usage of each bit.

Table 2 – K1 Bit Descriptions

Bits (hex)	Description
K1 Bits 12345678	
Bits 5 through 8	
nnnn	Channel number associated with the command code.
Bits 1 through 4	
1111 (0xF)	Lockout of protection request.
1110 (0xE)	Forced switch request.
1101 (0xD)	SF - high priority request.
1100 (0xC)	SF - low priority request.
1011 (0xB)	SD - high priority request.
1010 (0xA)	SD - low priority request.
1001 (0x9)	Not used.
1000 (0x8)	Manual switch request.
0111 (0x7)	Not used.
0110 (0x6)	Wait to restore request.
0101	Not used.

(0x5)	
0100 (0x4)	Exercise request.
0011 (0x3)	Not used.
0010 (0x2)	Reverse request.
0001 (0x1)	Do not revert request.
0000 (0x0)	No request.

Note: Bit 1 is the low-order bit.

Table 3 – K2 Bits Descriptions

Bits	Description
K2 Bits 12345678	
Bits 1 through 4	
nnnn	Channel number associated with the command code.
Bit 5	
1	One to n (1:n) architecture.
0	One plus one (1+1) architecture.
Bits 6 through 8	
111	Line AIS.
110	Line RDI.
101	Bidirectional operation mode.
100	Unidirectional operation mode.
Other	Reserved.

Note: In K2 (12345678):

- K2[1-4] – Currently bridged channel number.
- K2[5] – Architecture (always 0 for 1+1).
- K2[6-8] – Provisioned operating mode (4 = unidir; 5 = bidir).

- K2[6-8] – Also carries the alarm code 6=LRDI and 7=LAIS.

Note: In SDH, K2[6-8] carries only the alarm codes. The operating mode is not sent.

Note: For example, what are the values for K1 and corresponding K2 on the W if the router receives an SF? On the P side?

Note: Answer: Only the P transmits and reads K1/K2, never the W. In bidirectional mode, if the W receives an SF, and no higher request preempts it, the code from P to the ADM is:

```
K1= 0xC1 (switch request, SF on 1=working, low priority)
K2 = 0x05 (protect bridged [working bridge is incomplete];bidirectional)
```

Note: After the ADM answers:

```
K1 = 0x21 (Reverse request, channel 1)
K2 = 0x15 (Working bridged; bidirectional)
```

Note: The protect router's txk1k2 will be:

```
K1=0xC1 (switch request, SF on 1=working, low priority)
K2 = 0x15 (working bridged; bidirectional)
```

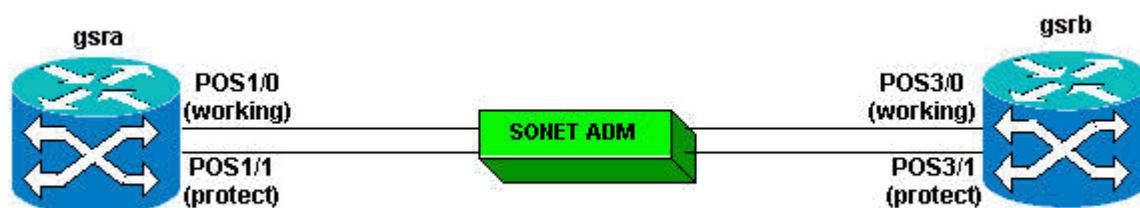
Note: At this point, the switch is complete.

Configure APS

[Figure 2](#) shows a basic APS 1+1 configuration from a GSR to an ADM (ONS 15454) in bidirectional mode, non-revertive (default on Cisco 12000 Series). APS is linear switched, and is done on the line level (between the Cisco 12000 Series and ADM versus path or end-to-end).

Note: This example does not have an independent channel for PGP because both the W and P interfaces are on the same router.

Figure 2 – A Basic APS 1+1 Configuration



```
gsrA# show running-config
!
interface Loopback0
ip address 100.1.1.1 255.255.255.0
no ip directed-broadcast
!
interface POS1/0
ip address 10.1.1.1 255.255.255.0
no ip directed-broadcast
```

```
crc 16
aps group 10
aps working 1
!
interface POS1/1
ip address 10.1.1.3 255.255.255.0
no ip directed-broadcast
no keepalive
crc 16
aps group 10
aps revert 1
aps protect 1 100.1.1.1
!
router ospf 100
network 10.1.1.0 0.0.0.255 area 0
network 100.1.1.0 0.0.0.255 area 0

gsrB#show running-config
!
interface Loopback0
ip address 200.1.1.1 255.255.255.0
!
interface POS3/0
ip address 10.1.1.2 255.255.255.0
no ip directed-broadcast
crc 16
aps group 10
aps working 1
!
interface POS3/1
ip address 10.1.1.4 255.255.255.0
no ip directed-broadcast
no keepalive
crc 16
aps group 10
aps revert 1
aps protect 1 200.1.1.1
!
router ospf 100
network 10.1.1.0 0.0.0.255 area 0
network 200.1.1.0 0.0.0.255 area 0
!
```

Monitor and Maintain APS

In order to provide information about system processes, the IOS software includes an extensive list of EXEC commands that begin with the word **show**. When you execute these **show** commands, detailed tables of system information appear. Here is a list of some of the common **show** commands for the APS feature, along with sample outputs:

- **show aps**
- **show controllers POS**
- **show interface POS**

```
!
gsrA# show aps
POS1/1 APS Group 10: protect channel 0 (inactive)
```

```

bidirectional, revertive (1 min)
SONET framing; SONET APS signaling by default
Received K1K2: 0x20 0x05
Reverse Request (protect)
Transmitted K1K2: 0xE0 0x05
Forced Switch (protect)
Working channel 1 at 100.1.1.1 (Enabled)
Pending local request(s):
0x0E (No Request, channel(s) 0 1)
Remote APS configuration: working
POS1/0 APS Group 10: working channel 1 (active)

```

!--- Verify whether the working channel is active.

```

SONET framing; SONET APS signaling by default
Protect at 100.1.1.1
Remote APS configuration: working

```

```

gsrA# show controllers POS 1/0
POS1/0
SECTION
LOF = 0          LOS      = 0                      BIP(B1) = 0
LINE
AIS = 0          RDI      = 0          FEBE = 0          BIP(B2) = 0
PATH
AIS = 0          RDI      = 0          FEBE = 0          BIP(B3) = 0
LOP = 0          NEWPTR = 0          PSE  = 0          NSE      = 0
Active Defects: None
Active Alarms:  None
Alarm reporting enabled for: SF SLOS SLOF B1-TCA B2-TCA PLOP B3-TCA
Framing: SONET
APS
working (active)

```

!--- Ensure that the working channel is active.

```

COAPS = 0          PSBF = 0
State: PSBF_state = False
ais_shut = FALSE
Rx(K1/K2): 00/00  S1S0 = 00, C2 = CF
Remote aps status working; Reflected local aps status working
CLOCK RECOVERY
RDOOL = 0
State: RDOOL_state = False
PATH TRACE BUFFER : STABLE
Remote hostname : 12012
Remote interface: POS3/0
Remote IP addr  : 10.1.1.2
Remote Rx(K1/K2): 00/00  Tx(K1/K2): 00/00
BER thresholds:  SF = 10e-3  SD = 10e-6
TCA thresholds:  B1 = 10e-6  B2 = 10e-6  B3 = 10e-6
!
```

```

gsrA# show controllers POS 1/1
POS1/1
SECTION
LOF = 0          LOS      = 0                      BIP(B1) = 0
LINE
AIS = 0          RDI      = 0          FEBE = 0          BIP(B2) = 0
PATH
AIS = 0          RDI      = 0          FEBE = 0          BIP(B3) = 0
LOP = 0          NEWPTR = 0          PSE  = 0          NSE      = 0
Active Defects: None

```

```

Active Alarms:  None
Alarm reporting enabled for: SF SLOS SLOF B1-TCA B2-TCA PLOP B3-TCA
Framing: SONET
APS
protect (inactive)
COAPS = 0          PSBF = 0
State: PSBF_state = False
ais_shut = FALSE
Rx(K1/K2): 20/05 Tx(K1/K2): E0/05
Signalling protocol: SONET APS by default
S1S0 = 00, C2 = CF
Remote aps status working; Reflected local aps status working
CLOCK RECOVERY
RDOOL = 0
State: RDOOL_state = False
PATH TRACE BUFFER : STABLE
Remote hostname : 12012
Remote interface: POS3/0
Remote IP addr  : 10.1.1.2
Remote Rx(K1/K2): 00/00 Tx(K1/K2): 00/00
BER thresholds:  SF = 10e-3  SD = 10e-6
TCA thresholds:  B1 = 10e-6  B2 = 10e-6  B3 = 10e-6
!
gsrA# show interface p1/0
POS1/0 is up, line protocol is up  (APS working - active)

```

!--- Verify whether the working channel is active.

```

gsrA# show interface p1/1
POS1/1 is up, line protocol is down (APS protect - inactive)

```

!

```

gsrB# show aps
POS3/1 APS Group 10: protect channel 0 (inactive)
bidirectional, revertive (1 min)
SONET framing; SONET APS signaling by default
Received K1K2: 0x00 0x05
No Request (Null)
Transmitted K1K2: 0x00 0x05
No Request (Null)
Working channel 1 at 200.1.1.1 (Enabled)
Remote APS configuration: working
POS3/0 APS Group 10: working channel 1 (active)

```

!--- Verify whether the working channel is active.

```

SONET framing; SONET APS signaling by default
Protect at 200.1.1.1
Remote APS configuration: working

```

!

```

gsrB# show controllers p 3/0
POS3/0
SECTION
LOF = 11          LOS      = 11          BIP(B1) =
46701837
LINE
AIS = 10          RDI      = 11          FEBE = 1873          BIP(B2) = 8662
PATH
AIS = 14          RDI      = 27          FEBE = 460909       BIP(B3) =
516875
LOP = 0           NEWPTR = 11637        PSE   = 2           NSE     = 16818
Active Defects: None

```

```

Active Alarms:  None
Alarm reporting enabled for: SF SLOS SLOF B1-TCA B2-TCA PLOP B3-TCA
Framing: SONET
APS
working (active)

```

!--- Verify whether the working channel is active.

```

COAPS = 103          PSBF = 0
State: PSBF_state = False
ais_shut = FALSE
Rx(K1/K2): 00/00  S1S0 = 00, C2 = CF
Remote aps status working; Reflected local aps status working
CLOCK RECOVERY
RDOOL = 11
State: RDOOL_state = False
PATH TRACE BUFFER : STABLE
Remote hostname : hswan-gsr12008-2b
Remote interface: POS1/0
Remote IP addr  : 10.1.1.1
Remote Rx(K1/K2): 00/00  Tx(K1/K2): 00/00
BER thresholds:  SF = 10e-3  SD = 10e-6
TCA thresholds:  B1 = 10e-6  B2 = 10e-6  B3 = 10e-6
!
gsrB# show controllers p 3/1
POS3/1
SECTION
LOF = 10          LOS      = 10          BIP(B1) =
250005115
LINE
AIS = 11          RDI      = 8          FEBE = 517          BIP(B2) = 5016
PATH
AIS = 14          RDI      = 25          FEBE = 3663          BIP(B3) = 7164
LOP = 0           NEWPTR = 184          PSE  = 1            NSE   = 247
Active Defects:  None
Active Alarms:   None
Alarm reporting enabled for: SF SLOS SLOF B1-TCA B2-TCA PLOP B3-TCA
Framing: SONET
APS
protect (inactive)
COAPS = 538          PSBF = 0
State: PSBF_state = False
ais_shut = FALSE
Rx(K1/K2): 00/05  Tx(K1/K2): 00/05
Signalling protocol: SONET APS by default
S1S0 = 00, C2 = CF
Remote aps status working; Reflected local aps status working
CLOCK RECOVERY
RDOOL = 10
State: RDOOL_state = False
PATH TRACE BUFFER : STABLE
Remote hostname : hswan-gsr12008-2b
Remote interface: POS1/0
Remote IP addr  : 10.1.1.1
Remote Rx(K1/K2): 00/00  Tx(K1/K2): 00/00
BER thresholds:  SF = 10e-3  SD = 10e-6
TCA thresholds:  B1 = 10e-6  B2 = 10e-6  B3 = 10e-6
!
gsrB#show interface p3/0
POS3/0 is up, line protocol is up  (APS working - active)

```

!--- Verify whether the working channel is active.

```

gsrB#show interface p3/1
POS3/1 is up, line protocol is down (APS protect - inactive)
!
```

Troubleshoot APS

In order to troubleshoot problems with APS, collect the output from these **show** and **debug** commands:

- **show ver**
- **show run**
- **show ip int b**
- **show contr POS**
- **debug aps**
- **show aps**

Perform the necessary actions to recreate the problem. Issue these commands to collect the final output and turn off the debug:

- **show aps**
- **no debug aps**

Note: Under normal conditions, the **debug aps** command produces no output. When an abnormal condition occurs, this command reports the condition.

Note: If the W and P fibers are in different routers (as they usually are), you must collect the command outputs on both routers.

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Updated: Jan 09, 2006

Document ID: 14680
