

Contents

| | |
|---|------|
| Special Report Notice of Disclaimer | iii |
| List of Figures | vii |
| List of Tables | ix |
| 1 Introduction to Automatic Protection Switching for SONET | |
| 2 Definitions | |
| 3 1:n Protection Switching | |
| 3.1 Protection Switching Commands | 3-3 |
| 3.1.1 Manually Initiated Commands (OS and/or Craftsperson) | 3-4 |
| 3.1.2 Automatically Initiated Switch Commands | 3-6 |
| 3.1.3 Automatically Initiated State Indicators for 1:n | 3-7 |
| 3.2 State Transitions for 1:n Protection Switching | 3-8 |
| 3.2.1 State Transitions for 1:n Bidirectional Protection Switching | 3-8 |
| 3.2.1.1 General State Transition Process | 3-8 |
| 3.2.1.2 Internal State Transitions and the Bit-Oriented Protocol for 1:n Bidirectional Protection Switching System | 3-12 |
| 3.2.1.2.1 Rules and Protocols for the APS Bytes K1 and K2 | 3-12 |
| 3.2.1.2.2 Internal State Transitions for 1:n Bidirectional Protection Switching Architectures Based on the Bit-Oriented Protocol of the K1 and K2 Bytes | 3-17 |
| 3.2.2 State Transition for 1:n Unidirectional Protection Switching | 3-29 |
| 3.2.2.1 General State Transition Process | 3-29 |
| 3.2.2.2 Internal State Transitions and the Bit-Oriented Protocol for 1:n Unidirectional Protection Switching System | 3-30 |
| 3.2.2.2.1 Rules and Protocols for the APS Bytes K1 and K2 | 3-30 |
| 3.2.2.2.2 Internal State Transitions for 1:n Unidirectional Protection Switching Architecture Based on the Bit-Oriented Protocol of the K1 and K2 Bytes | 3-30 |
| 3.2.3 1:1 Protection Switching (Special Case of 1:n) | 3-33 |
| 4 1+1 Protection Switching | |
| 4.1 1+1 Protection Switching Commands | 4-1 |
| 4.1.1 Manually Initiated 1+1 Architecture APS Commands | 4-2 |
| 4.1.2 Automatically Initiated 1+1 Architecture APS Commands | 4-2 |
| 4.1.3 Automatically Initiated State Indicators for 1+1 Architecture | 4-3 |
| 4.2 State Transitions for 1+1 Protection Switching | 4-3 |
| 4.2.1 State Transitions for 1+1 Bidirectional Protection Switching | 4-3 |
| 4.2.1.1 General State Transition Process | 4-3 |

| | |
|---|------|
| 4.2.1.2 Internal State Transitions and the Bit-Oriented Protocol for a 1+1 Bidirectional Protection Switching System | 4-4 |
| 4.2.1.2.1 Rules and Protocols for the K1 and K2 APS Bytes (1+1) | 4-6 |
| 4.2.1.2.2 Internal State Transitions for 1+1 Bidirectional Protection Switching Architecture Based on the APS Bit-Oriented Protocol | 4-7 |
| 4.2.2 State Transitions for 1+1 Unidirectional Protection Switching | 4-21 |
| 4.2.2.1 General State Transition Process | 4-21 |
| 4.2.2.2 Internal State Transitions and the Bit-Oriented Protocol for 1+1 Unidirectional Protection Switching Systems | 4-21 |
| 4.2.3 Interworking of 1+1 and 1:1 Protection Switching | 4-22 |

Appendix A: Summary of BER Threshold-Crossing Detection Times and Rules

Appendix B: References

| | |
|---|-----|
| Note | B-1 |
| To Contact Telcordia Customer Service or to Order Documents | B-1 |
| To Order Documents From Within Telcordia (Employees Only) | B-1 |

Appendix C: Acronyms

List of Figures

| | | |
|-------------|--|------|
| Figure 1-1 | Overhead Byte Locations in an STS-1 Frame | 1-2 |
| Figure 3-1 | 1:n APS Architecture Example | 3-1 |
| Figure 3-2 | 1:n APS Switch Protecting Channel K | 3-2 |
| Figure 3-3 | 1:n APS Switch in Released Position (With Extra Traffic on Line 15) | 3-3 |
| Figure 3-4 | General State Transitions for 1:n Bidirectional APS Architectures | 3-9 |
| Figure 3-5 | State Transitions for the Protection Channel of a 1:n Bidirectional Protection Facility | 3-11 |
| Figure 3-6 | Internal State Transition Diagram for 1:n Bidirectional Protection Switching System | 3-18 |
| Figure 3-7 | Sequence of Events for Completing a Bidirectional Switch | 3-20 |
| Figure 3-8 | Simultaneous Failures on Different Lines | 3-23 |
| Figure 3-9 | Simultaneous Failures for the Same Line | 3-24 |
| Figure 3-10 | Clearing of Simultaneous Switch Orders at One End | 3-26 |
| Figure 3-11 | Clearing of Simultaneous Switch Orders at Both Ends | 3-27 |
| Figure 3-12 | Signaling When There Is Extra Traffic Input – SF | 3-29 |
| Figure 3-13 | Signaling for Unidirectional 1:n Protection Switching | 3-32 |
| Figure 4-1 | 1 + 1 APS with the Protection Line Used in Both Directions | 4-1 |
| Figure 4-2 | State Transitions for the Protection Channel of a 1+1 Revertive Bidirectional Protection Facility | 4-5 |
| Figure 4-3 | State Transitions for the Protection Channel of a Nonrevertive Bidirectional Protective Facility | 4-6 |
| Figure 4-4 | Sequence of Events for Completing 1+1 Bidirectional Nonrevertive Switch | 4-9 |
| Figure 4-5 | Sequence of Events for Pre-emption (Local) | 4-10 |
| Figure 4-6 | Sequence of Events Pre-emption (Remote) | 4-11 |
| Figure 4-7 | Sequence of Events for Lockout of Protection (while on line 1, Local) | 4-12 |
| Figure 4-8 | Sequence of Events for Lockout of Protection (while on line 0, Local) | 4-13 |
| Figure 4-9 | Restoration for Revertive Bidirectional 1+1 Systems | 4-14 |

List of Tables

| | | |
|------------|--|------|
| Table 3-1 | Current State Versus Allowed Next State for Various Switch Actions | 3-10 |
| Table 3-2 | APS Byte K1, Bits 1 through 4 Switch Pre-emption Priority | 3-13 |
| Table 3-3 | APS Byte K1, Bits 5 through 8 Assignment Rules | 3-14 |
| Table 3-4 | Lockout of Protection to No Request | 3-34 |
| Table 3-5 | Forced Switch to Lockout of Protection | 3-35 |
| Table 3-6 | Forced Switch to No Request | 3-36 |
| Table 3-7 | Signal Failure (Low Priority Channel) to Lockout of Protection (Remote) | 3-37 |
| Table 3-8 | Signal Failure (Low Priority Channel) to Forced Switch (Local) | 3-38 |
| Table 3-9 | Signal Failure (Low Priority Failure (High Priority) | 3-39 |
| Table 3-10 | Signal Failure (Low Priority Channel) to Wait to Restore | 3-40 |
| Table 3-11 | Signal Degrade (Low Priority) to Lockout of Protection (Local) | 3-40 |
| Table 3-12 | Signal Degrade (Low Priority) to Forced Switch (Remote) | 3-41 |
| Table 3-13 | Signal Degrade (Low Priority) to Signal Failure (Low Priority) | 3-42 |
| Table 3-14 | Signal Degrade (Low Priority) to Signal Degrade (High Priority) | 3-43 |
| Table 3-15 | Signal Degrade (Low Priority) to Wait to Restore | 3-44 |
| Table 3-16 | Manual Switch to Lockout of Protection | 3-44 |
| Table 3-17 | Manual Switch to Forced Switch | 3-45 |
| Table 3-18 | Manual Switch to Signal Failure (Low Priority) | 3-46 |
| Table 3-19 | Manual Switch to Signal Degrade (Low Priority) | 3-47 |
| Table 3-20 | Manual Switch to No Request | 3-48 |
| Table 3-21 | Wait to Restore to Lockout of Protection (Remote) | 3-49 |
| Table 3-22 | Wait to Restore to Forced Switch (Local) | 3-50 |
| Table 3-23 | Wait to Restore to Signal Failure (Local) | 3-51 |
| Table 3-24 | Wait to Restore to Signal Degrade (Remote) | 3-52 |
| Table 3-25 | Wait to Restore to Manual Switch (Remote) | 3-53 |
| Table 3-26 | Wait to Restore to No Request | 3-54 |
| Table 3-27 | Exercise to Lockout of Protection | 3-55 |
| Table 3-28 | Exercise to Forced Switch | 3-56 |
| Table 3-29 | Exercise to Signal Failure (Low Priority) | 3-57 |
| Table 3-30 | Exercise to Signal Degrade (Low Priority and Same Line) | 3-58 |
| Table 3-31 | Exercise to Manual Switch (Same Line) | 3-59 |
| Table 3-32 | Exercise to No Request | 3-60 |
| Table 3-33 | No Request to Lockout of Protection | 3-61 |
| Table 3-34 | No Request to Forced Switch | 3-62 |
| Table 3-35 | No Request to Signal Failure (Low Priority) | 3-63 |
| Table 3-36 | No Request to Signal Degrade (Low Priority) | 3-64 |
| Table 3-37 | No Request to Manual Switch | 3-65 |
| Table 3-38 | No Request to Exerciser | 3-66 |
| Table 3-39 | Simultaneous Failures on Different Lines (Both Lines Low Priority) | 3-67 |
| Table 3-40 | Simultaneous Failures for the Same Line | 3-68 |
| Table 3-41 | Clearing of Simultaneous Switch Orders at One End | 3-69 |

| | | |
|------------|--|------|
| Table 3-42 | Clearing of Simultaneous Switch Orders at Both Ends | 3-70 |
| Table 3-43 | Signaling When There Is Extra Traffic Input – SF | 3-72 |
| Table 3-44 | Signaling for Unidirectional 1:n Protection Switching | 3-73 |
| Table 4-1 | Sequence of Events for Completing 1+1 Bidirectional Nonrevertive Switch | 4-15 |
| Table 4-2 | Sequence of Events for Pre-emption (Local) | 4-16 |
| Table 4-3 | Sequence of Events for Pre-emption (Remote) | 4-17 |
| Table 4-4 | Sequence of Events for Lockout for Protection (while on line 1, Local) | 4-18 |
| Table 4-5 | Sequence of Events for Lockout of Protection (while on line 0, Local) | 4-19 |
| Table 4-6 | Restoration for Revertive Bidirectional 1+1 Systems | 4-20 |
| Table A-1 | Maximum Detection Time Requirements | A-1 |