



EEEN 464 – DIGITAL COMMUNICATION

SYNCHRONOUS DIGITAL HIERARCHY (SDH) STUDY GUIDE

1. WHAT IS SYNCHRONOUS DIGITAL HIERARCHY (SDH)?

1. **Definition:** A standardized, synchronous optical fibre network technology for high-speed digital transmission.
2. **Purpose:** Transport voice, data, and video over long distances with high reliability.
3. **Key Idea:** All network elements lock to a **Primary Reference Clock (PRC)** for precise synchronization.
4. **Standard:** ITU-T G.707, G.783, G.784.

2. WHY SDH? (VS. PDH)

SDH solved the following PDH limitations:

1. **Synchronization:** Eliminated "bit stuffing" (no clock variations).
2. **Direct Add/Drop Multiplexing:** Access tributaries without full demultiplexing.
3. **Enhanced Operations Administration Maintenance (OAM):** Rich overhead for monitoring, alarms, and configuration.
4. **Global Standard:** Unified European (SDH), North American (SONET) systems.
5. **Built-in Resilience:** Automatic sub-50ms protection switching.

3. CORE SDH BUILDING BLOCKS

3.1 Frame Structure: STM-1

- **Size:** 9 rows × 270 columns = 2,430 bytes.
- **Duration:** 125 μs (8,000 frames/sec).
- **Bit Rate:**
 $9 \times 270 \times 8 \times 8000 = 155.52 \text{ Mbps}$
- **Sections:**
 - **Regenerator Section Overhead (RSOH):** First 3 columns (management between repeaters).
 - **Multiplex Section Overhead (MSOH):** Columns 4-9 (management between muxes).
 - **Payload:** Columns 10-270 (user data + Path Overhead).

3.2 Higher Rates (STM-N)

Level	Bit Rate	Equivalent SONET
STM-1	155.52 Mbps	STS-3 / OC-3
STM-4	622.08 Mbps	STS-12 / OC-12
STM-16	2.488 Gbps	STS-48 / OC-48
STM-64	9.953 Gbps	STS-192 / OC-192

4. SDH LAYERED ARCHITECTURE

a) Path Layer

- End-to-end connection (e.g., VC-12 for E1).
- **Path Overhead (POH):** Monitoring, error checking (B3 byte), trace (J1).

b) Multiplex Section (MS) Layer

- Between SDH multiplexers (e.g., STM-1 to STM-4).
- **MSOH:** Fault detection (K1/K2), data comms (D4-D12).

c) Regenerator Section (RS) Layer

- Between repeaters/regenerators.
- **RSOH:** Frame alignment (A1/A2), error monitoring (B1).

d) Physical (Optical) Layer

- Fiber, lasers, photodetectors (e.g., STM-64 over SMF).

5. VIRTUAL CONTAINERS (VCS): THE PAYLOAD ENVELOPE

- **VC Types:**
 - **Lower-Order VCs:** VC-11 (1.728 Mbps), VC-12 (2.304 Mbps), VC-3 (48.96 Mbps).
 - **Higher-Order VCs:** VC-4 (150.336 Mbps).
- **POH:** Added to each VC for end-to-end management.

6. MAPPING & MULTIPLEXING PROCESS

Example: Carrying E1 (2.048 Mbps) in SDH

1. **Mapping:** E1 → **C-12** (container) → **VC-12** (add POH).
2. **Alignment:** VC-12 → **TU-12** (add pointer for phase alignment).
3. **Multiplexing:**
 - 3 × TU-12 → **TUG-2**

- 7 × TUG-2 → **TUG-3**
- 3 × TUG-3 → **VC-4**
- VC-4 + AU-4 pointer → **AU-4** → **STM-1** payload.

7. POINTERS: SYNCHRONIZATION MAGIC

- **Function:** Locate VCs within STM frames despite minor clock drifts.
- **Key Pointers:**
 - **AU Pointer:** Finds VC-4 in STM-1.
 - **TU Pointer:** Finds VC-12 in TUG-3.
- **Bytes:** H1, H2 (offset value), H3 (phase adjustment).

8. KEY SDH FEATURES

- **Protection Mechanisms:**
 - **MSP (1+1/1:1):** Linear protection (e.g., fiber cuts).
 - **SNCP:** Path-level switching.
 - **MS-SPRING:** Ring protection (<50ms switch).
- **OAM Capabilities:**
 - Performance monitoring (BIP/B1-B3).
 - Fault localization (AIS, RDI).
 - Data comms (D1-D12 bytes).
- **Interoperability:**
 - Carries PDH (E1, E3), ATM, IP, Ethernet.
 - Compatible with SONET via mappings.

9. SDH VS. SONET: KEY DIFFERENCES

Parameter	SDH (ITU-T)	SONET (ANSI)
Base Signal	STM-1 (155.52 Mbps)	STS-1 (51.84 Mbps)
E1 Mapping	VC-12	VT-1.5
Overhead Terminology	MSOH, RSOH, POH	LOH, SOH, POH
Concatenation	VC-4-4c, VC-4-16c	STS-3c, STS-12c

10. WHERE IS SDH USED TODAY?

- **Legacy Core Networks:** Backbone transport.
- **Mobile Backhaul:** 3G/4G base station connectivity.
- **Hybrid Networks:** SDH + MPLS/IP for modern services.
- **Utilities:** Power grid SCADA systems.

11. STUDY TIPS

- **Memorize:** STM-1 frame structure, VC hierarchy, key bit rates.
 - **Visualize:** Draw multiplexing diagrams (E1 → VC-12 → TU-12 → ... → STM-1).
 - **Compare:** SDH vs. PDH limitations & solutions.
 - **Practice:** Calculate payload capacity (e.g., How many E1s in STM-1? *Answer: 63*).
 - **Key Questions:**
 - Why is SDH "synchronous"?
 - How do pointers solve timing issues?
 - Explain AU-4/TU-12 roles.
 - Contrast MSP vs. SNCP protection.
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12. FURTHER EXPLORATION

- **Standards:** ITU-T G.707, G.783.
- **Tools:** Wireshark SDH analysis, network simulators.
- **Evolution:** SDH → **OTN (Optical Transport Network)** for 100G+ speeds.