

GPON Frame used on FTTP

GPON (Gigabit Passive Optical Network) is a fibre-optic technology used to deliver high-speed internet directly to homes and businesses.

Here is a simple breakdown of how it structures data using precise time, byte counts, and headers.

The Master Frame Blueprint

GPON operates like a continuous, perfectly timed conveyor belt. Every single second, exactly 8,000 master frames are sent down the fibre. This strict timing creates a fixed frame duration.

- **125 Microseconds:** The exact duration of one master frame. Both downstream and upstream transmission loops reset every 125 microseconds to keep the entire network perfectly synchronized.

Downstream vs. Upstream Allocation

GPON allocates different amounts of data (bytes) and different wavelengths of light depending on the direction of travel to prevent collisions on a single fibre strand.

- **Downstream (Central Office to User):**
 - **38,880 Bytes:** The total capacity of one 125-microsecond downstream master frame. This equates to a total bandwidth of 2.488 Gbps.
 - **1490 nm Wavelength:** The specific colour of infrared laser light used to broadcast data down to all users.
- **Upstream (User to Central Office):**
 - **19,440 Bytes:** The total capacity available across one 125-microsecond upstream window. This equates to a total bandwidth of 1.244 Gbps.
 - **1310 nm Wavelength:** The specific colour of infrared laser light used by individual users to share the fibre when sending data back.

GEM Frames: The Cargo Containers

Inside each 125-microsecond master frame sits a variable number of **GEM (GPON Encapsulation Method) frames**. Think of the master frame as a large delivery truck, and GEM frames as individual cardboard boxes inside it.

Because user data (like an Ethernet packet or web page) fluctuates in size, a master frame will pack in as many variable-length GEM frames as can fit into its byte allocation.

The 5-Byte GEM Header Breakdown

Every GEM frame begins with a strict **5-byte (40-bit) header** that acts as the shipping label. It tells the equipment who the data belongs to and how big the container is.

- **PLI (Payload Length Indicator):**
 - **Size:** 12 bits.

- **Purpose:** Specifies the exact size of the data payload following the header, up to 4,095 bytes.
- **Port ID:**
 - **Size:** 12 bits.
 - **Purpose:** The unique address targeting the specific user or service instance. It ensures your router only opens your data and ignores your neighbour's data.
- **PTI (Payload Type Indicator):**
 - **Size:** 3 bits.
 - **Purpose:** Identifies the type of data inside the sub-frame (e.g., user data vs. network management commands).
- **HEC (Header Error Correction):**
 - **Size:** 13 bits.
 - **Purpose:** A mathematical checksum. It detects and fixes transmission errors within the header itself to prevent data from being delivered to the wrong user.

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