

A Guide to IP Systems

August 2019

Introduction

This Guide (together with the appendices) serves as an “IP Technology Reference” providing information on such things as fiber cabling, SFP devices, recommended and tested IP Ethernet switch types and system timing.

It provides an overview of Grass Valley’s **IP Routing System** with the intention of enabling the reader to define all the constituent elements required to supply any small to enterprise-wide system.

Although primarily directed at or sales staff and our re-sale partners, it is equally suited for technical personnel and others wishing to obtain a better understanding of the technologies and products we offer.

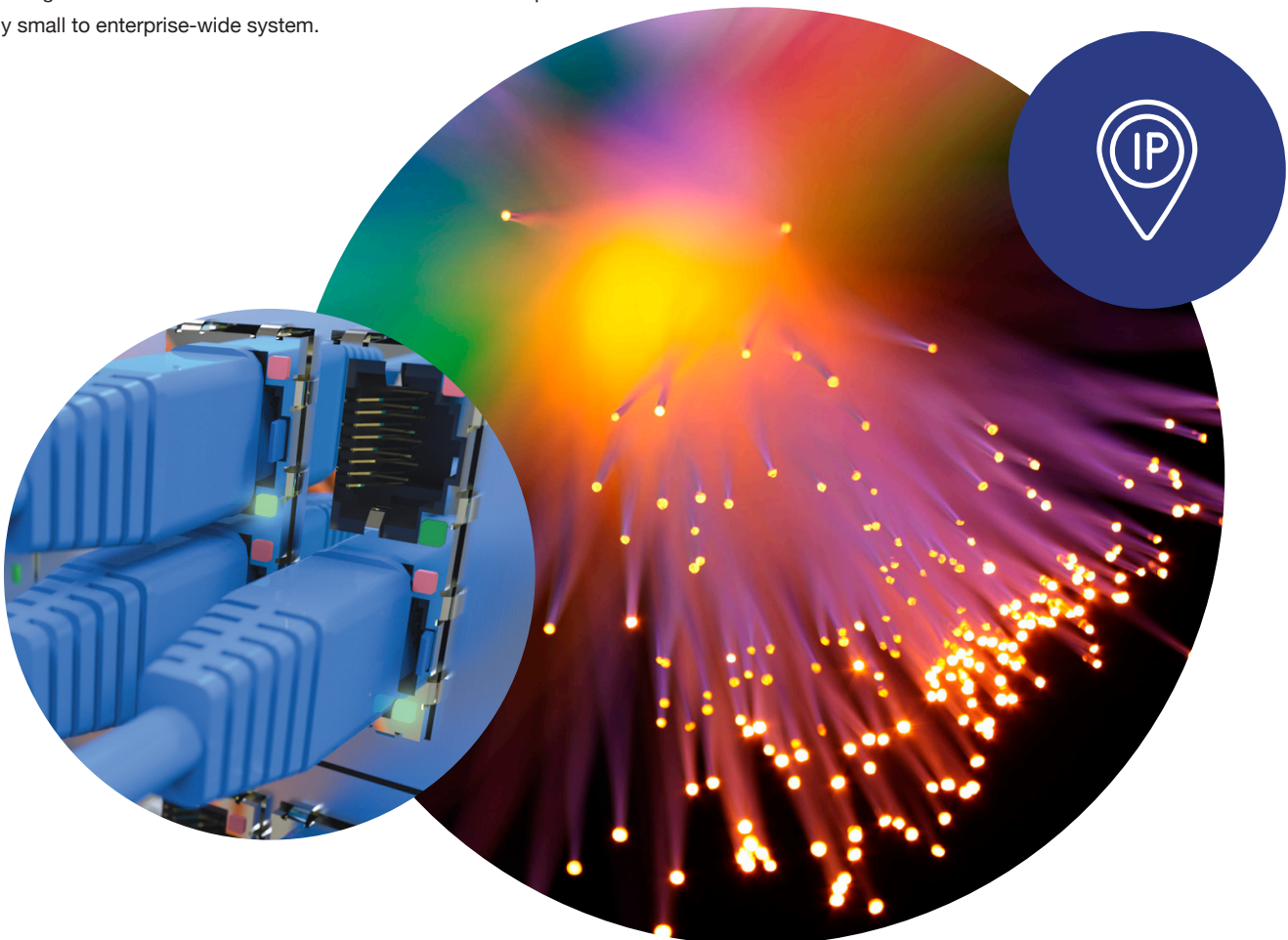


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IP PORT STREAM CAPACITIES — GENERAL INFORMATION

IP Port Speeds & Media Streams

Grass Valley offers IP Routing Systems capable of supporting **10 GbE, 25 GbE, 40 GbE and 100 GbE** network fabrics or combinations of these Ethernet port speeds. It works with multicast streams compliant with **SMPTE ST 2022-6, SMPTE ST 2110-10/20/30** or, indeed, a mix of these types simultaneously.

Appendix A to this document provides two sets of tables listing the maximum number of SMPTE ST 2022-6 and 2110 streams that can be supported for each port speed. Maximum stream numbers are stated for both 50 Hz fps and 59.94 Hz fps (frames per second) systems. Figures from Appendix A are used in the section titled **“COTS IP Switches”** to calculate the theoretical stream capacity for each of the example IP Switches depicted therein.

The tables below are samples of the information provided in Appendix A. They indicate the theoretical maximum number of streams per port (by Ethernet speed) for HD 1080i and 1080p for 50 fps and 59.94 fps systems respectively.

The samples are from the “Option 1” tables in Appendix A, which assume **“Break-before-make”*** or static switching. Any assumptions and conditions (including the addition of audio data) when compiling these figures are stated at the beginning of Appendix A.

* Please refer to **Appendix B** for more information.

The ability for any one of these Ethernet port speeds to support multiple media streams (in both directions) can yield a dramatic reduction in equipment cabling when compared with equivalent SDI systems.

Media Stream Type	Rate	Number of Streams per Port			
50 Hz fps Standards	Mb/s	10 GbE	25 GbE	40 GbE	100 GbE
HD 1080i-50 SDI	1,485				
Uncompressed SMPTE ST 2022	1,559	5	14	23	57
Uncompressed SMPTE ST 2110	1,114	8	20	32	80
HD 1080p-50 SDI	2,970				
Uncompressed SMPTE ST 2022	3,119	2	7	11	28
Uncompressed SMPTE ST 2110	2,202	4	10	16	40

Media Stream Type	Rate	Number of Streams per Port			
59.94 Hz fps Standards	Mb/s	10 GbE	25 GbE	40 GbE	100 GbE
HD 1080i-59.94 SDI	1,484				
Uncompressed SMPTE ST 2022	1,558	5	14	23	57
Uncompressed SMPTE ST 2110	1,330	8	16	27	67
HD 1080p-59.94 SDI	2,970				
Uncompressed SMPTE ST 2022	3,119	2	7	11	28
Uncompressed SMPTE ST 2110	2,635	3	8	13	34

Numbers stated in the tables are for guidance purposes only. They assume all streams at the port are the same picture format (e.g., 1080i or 1080p). In real systems there is likely to be a mixture of picture formats.

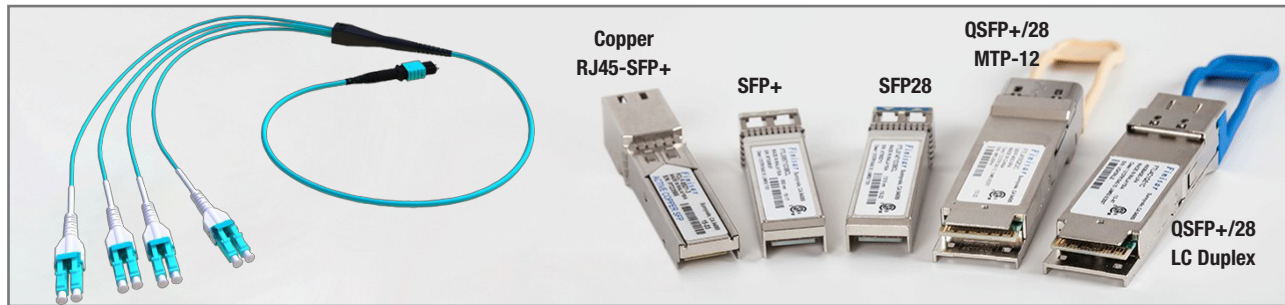
CONNECTIONS & CABLING

Introduction

The following sections are intended to provide a broad overview of the main interconnection components applicable to a modern broadcast and media IP LAN. Such networks are usually centered around a single monolithic IP switch or a “spine and leaf” arrangement of multiple switches.

Early implementations for such LANs targeted the use of a 10 GbE backbone, but advances in switch technology mean we are now seeing the deployment of 25 GbE, 40 GbE and 100 GbE capable products.

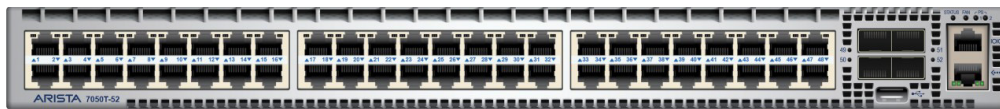
While a 10 GbE backbone can be implemented using copper only connections, link distances are limited and such networks aren’t future proof for higher speeds. The emergence of 25 GbE, 40 GbE, and 100 GbE necessitate the use of fiber cabling which not only provides almost unlimited bandwidth, but is immune to electromagnetic interference.



Copper Connectivity



RJ45



10 GbE IP switch with 48 “copper” RJ45 ports and 4 SFP ports



Copper RJ45-SFP

An all “copper” LAN with 10 GbE backbone can be implemented using CAT6 or CAT6A cabling with RJ45 connectors.

IEEE 802.3an specifies the minimum reach distances for “Twisted-pair” CAT6 and CAT6A cables using RJ45 connectors. These are 30-40m (98-168 ft.) and 100m (328 ft.) respectively.

While considered in earlier years, LAN networks based purely on copper connectivity for broadcast applications are highly restrictive and very unlikely to be adopted for “greenfield” systems!



CONNECTIONS & CABLING (CONT.)

Fiber Connectivity

Fiber Cable

Multimode (MMF) & Singlemode (SMF) cable

It is not within the scope of this document to explain all the differences between these two types of fiber cable. There is ample information on the web for the inquisitive mind. Briefly, the much greater cross-sectional diameter of the glass core in MMF (compared with SMF) leads to much greater modal dispersion over distance for the same light wavelength. The bandwidth and “reach” for MMF cable is therefore much less.

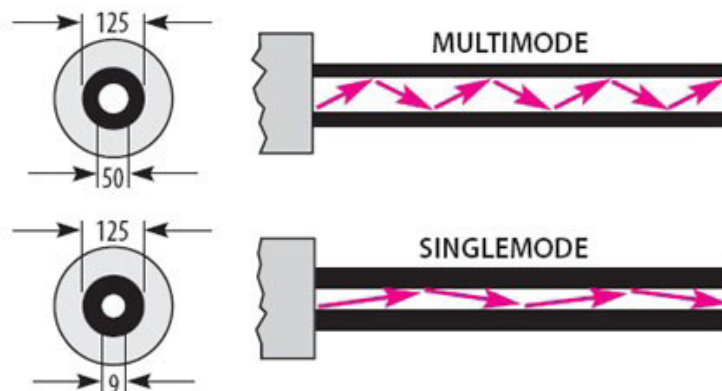
These days, the difference in cable cost is no longer as significant as it once was, but MMF is considered easier to work with in terms of flexibility and robustness.

Both MMF and SMF are used in broadcast and media IP system applications.

Link Distance/Reach

MMF is generally useful up to **300m** (984 ft.) at 10 Gb/s to 100 Gb/s data rates.

SMF is capable of **100 km** (62.1 mi.) and beyond. Most major vendors offer SFP variants with a reach of 80 km (49.7 mi.).



All dimensions in microns (μm)

MMF Grades (OM3 & OM4)

The designations **OM3** and **OM4** are often quoted for **50/125 μm MMF**. These are fabricated differently resulting in lower optical attenuation in OM4 (<3.0 dB/km) than in OM3 (<3.5 dB/km). While OM3 is more widespread, OM4 is becoming more popular with the advent of 40 GbE and 100 GbE networks — despite its higher cost.

Cables and Connectors

There are a multitude of different fiber connector types and cable formats (i.e., single, duplex and multistranded). *For broadcast and media systems, based on 10 GbE, 25 GbE, 40 GbE and/or 100 GbE, there are essentially two main fiber cable types used.* These are:

LC to LC Duplex MMF or SMF cable

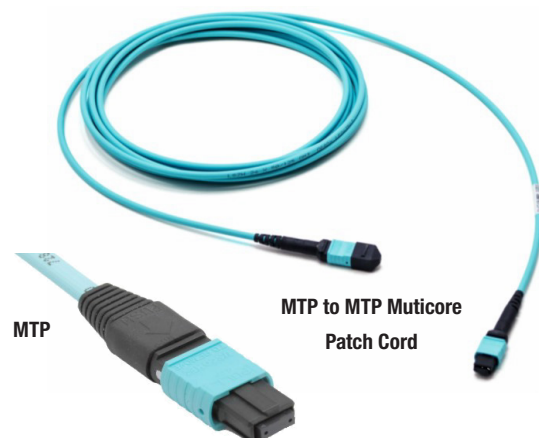
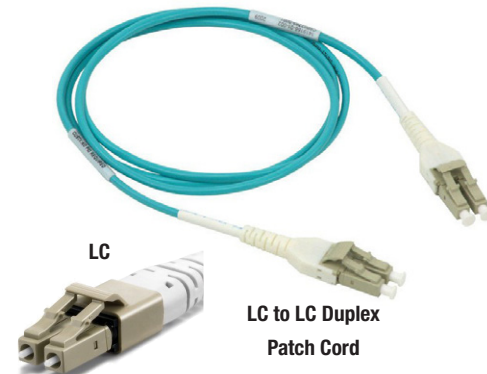
Ethernet at any speed requires a TX and RX path and hence duplex cabling is required. *Modern IP switches make extensive use of SFP, SFP+, SFP28 and QSFP-WDM pluggable devices (see later) which have dual LC receptacle ports.*

MPO/MTP Multicore MMF or SMF cable

The MPO/MTP is the specified connector for “short range” QSFP devices (see later) where the I/O comprises four sets of TX/RX data streams. MPO/MTP connectors can accommodate from 2-72 connections in one ferrule. The MTP-12 and MTP-24 (12 & 24-way) are the designated sizes for the QSFP.

MPO is an abbreviation for Multifiber-Push-On. It is a multifiber connector that is defined by IEC-61754-7. The term MTP is a registered trademark of US Conec. Their MTP product is fully compliant with the MPO standard.

Conec, however, claim certain improvements on the MPO standard including the ability to change gender and elliptical guide pins to provide for tight tolerance alignment.



CONNECTIONS & CABLING (CONT.)

The SFP — Small Form-factor Pluggable

The **SFP** is a compact, hot-pluggable transceiver used for both telecommunication and data communications applications. The form factor and electrical interface are specified by a multisource agreement (**MSA**) developed and supported by many network component vendors.

The SFP interfaces a network device motherboard (for a switch, router, media converter or similar device) to a fiber optic (or copper) networking cable.

SFP transceivers are available with a variety of transmitter and receiver types, allowing users to select the appropriate transceiver for each link to provide the required optical reach over **MMF** (multimode) or **SMF** (single-mode) fiber.

SFP modules are available in several different categories:

SFP (100 Mb/s to 8 Gb/s)

There are multiple applications for SFP devices running in this speed range. None are applicable to IP routing of multicast video streams for broadcast other than perhaps 100 MbE and 1 GbE devices for system control networking.

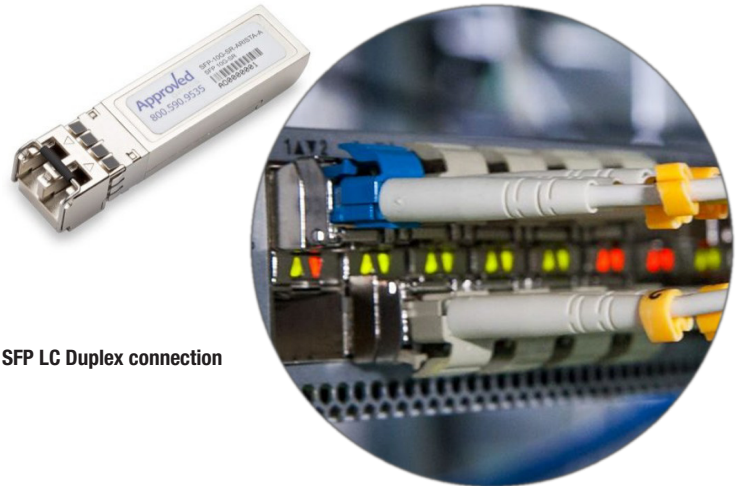
SFP+ (10 Gb/s)

The SFP+ is an enhanced version of the SFP that can support data rates up to 16 Gb/s.

For broadcasting and media IP routing, the SFP+ is an important building block for 10 GbE connectivity. In time, its usefulness may be surpassed by the SFP28 which enables 25 GbE connectivity.

SFP28 (25 Gb/s)

The SFP28 is a 25 GbE interface having evolved from 100 GbE, which is typically implemented with 4 × 25 Gb/s data lanes. (SFP28 implements one 28 Gb/s lane (25 Gb/s + error correction).



SFP LC Duplex connection

SFP+ 10 GbE Link Distances

There are multiple different variants (and vendors) of SFP+ types for 10 GbE. They are not all interoperable so it is wise to select products compliant with the **SFP MSA** (multisource agreement) and/or are **IEEE 802.3ae** designated types.

Some of the most common types are:

SFP+ 10 GbE-SR; SFP+ 10 GbE-LR; SFP+ 10 GbE-ER

The suffixes **-SR**, **-LR** and **-ER** stand for “Short Range,” “Long Range” and “Extended Range” respectively. Typical maximum link lengths specified are **300m** (984 ft.) over OM4 MMF (SR), **10 km** (6.2 mi.) (LR) and **40 km** (24.8 mi.) (ER) over SMF.

One variant of the above types has the suffix **-LRL**. It meets all the same specifications as the -LR but is only rated for link distances/reach of up to **1- 2 km** (0.62 – 1.24 mi.) and is consequently a lower cost option. The -LRL is, to all intense and purposes, an -LR device that has not passed the minimum reach test.

SFP28 25 GbE Link Distances

There are equivalent SFP28 types to the SFP+ stated above. Maximum link distances are essentially the same.

DDM/DOM

SFP and **QSFP** (see later) transceivers support standard diagnostics monitoring (**DDM**) or, as it's sometimes called, digital optical monitoring (**DOM**). This enables monitoring of parameters such as optical output power, optical input power, temperature, laser bias current, and transceiver supply voltage, in real time. *Grass Valley's Control and Monitoring system supports reporting of DOM parameters on all Edge Device SFP/QSFP ports and the IP switch SFP/QSFP ports via SNMP.*

CONNECTIONS & CABLING (CONT.)

The QSFP (Quad-SFP)

The name QSFP or Quad-SFP exactly describes this device (i.e., four standard SFP type devices integrated in a single “pluggable” package). Hence the QSFP contains four pairs of transmitters and receivers [4x (TX + RX)].

The *QSFP is physically wider than a standard SFP* and is available in two basic forms:

- 1. Incorporates an **MPO/MTP** female receptacle for interconnection using multicore optical fiber cables. This is the preferred (more cost effective) approach for short runs using multimode cable.
- 2. Incorporates two **WDM** (Wave Division Multiplex) blocks. Different optical wavelengths are used in the QSFP for each of the four transmitters. Their outputs are then multiplexed in one of the integrated WDM blocks to produce a single TX optical output. The second WDM block is used to demultiplex the complementary received RX signal. Since the I/O for this type of QSFP is a single TX/RX pair, it can use low cost LC to LC duplex cables. The WDM QSFP is usually intended for longer links where the increased cost of multicore cables (using MPO connectors) is less attractive if not impractical.

The QSFP – MPO/MTP Connection

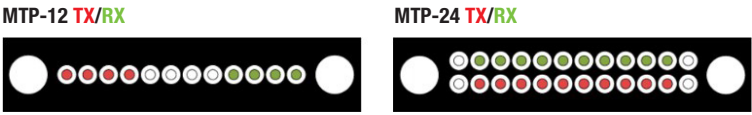
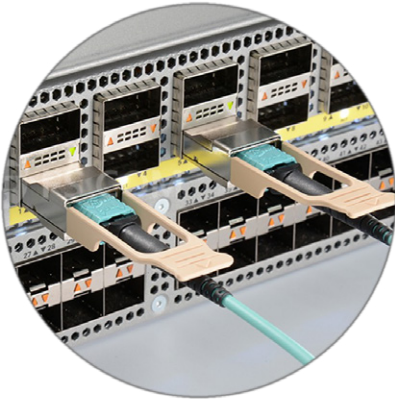
The QSFP with MPO/MTP connectivity is generally used for short range (**SR**) multichannel transmission over multicore **OM3 & OM4 MMF** (multimode) cable.

Typical maximum link lengths specified are 100m (328 ft.) for OM3 and 150m (492 ft.) for OM4. The three most applicable QSFP MPO/MTP module types are:

QSFP 40 GbE-SR4; QSFP 100 GbE-SR4; QSFP 100 GbE-SR10

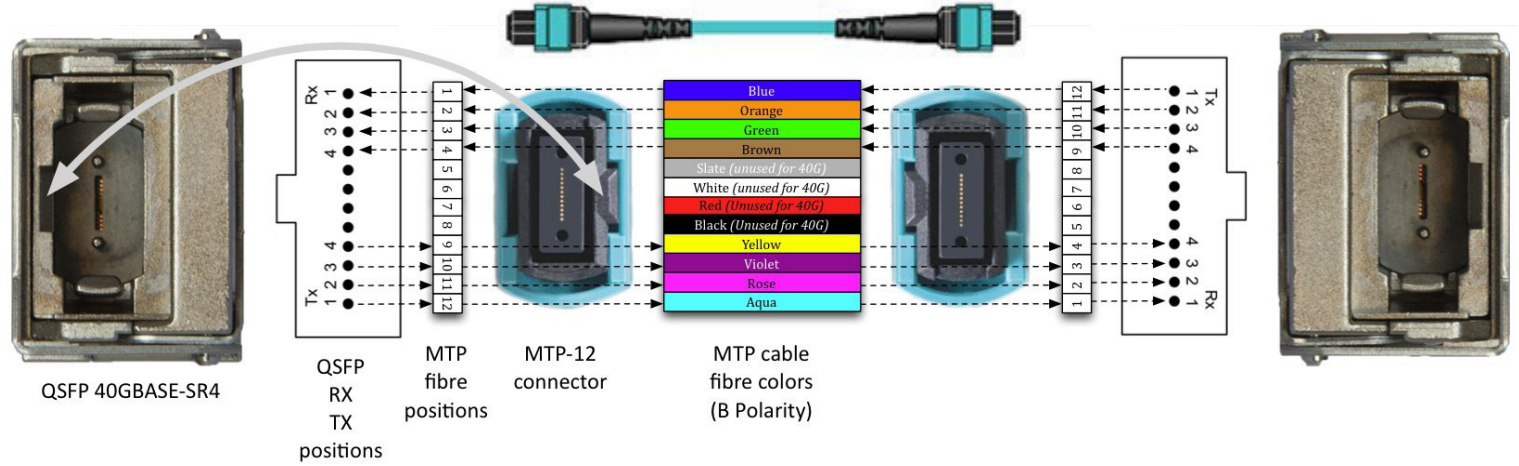
The 40G & 100G SR4 types connect **4x 10 GbE** or **4x 25 GbE** sets of media data respectively. They use 8 of the 12 lanes in an MTP-12 MMF cable.

The 100G SR10 type (less common) connects **10x 10 GbE** sets of media data respectively. It uses 20 of the 24 lanes in an MTP-24 MMF cable.



View looking into QSFP

The diagram below depicts a **Female-Female Type B MTP-12** cable for interconnecting two QSFP 100 GbE-SR4 modules (also for use with QSFP 40 GbE-SR4 devices). “**Type B**” refers to the fact that this is a “crossover” cable. (Other MTP cable types include “**Type A**” and “**Type C**,” which are



“Straight-through” and “Crosspair” trunk cables for fiber network patching and adapters or other links requiring alternative connector polarities.)

CONNECTIONS & CABLING (CONT.)

Interconnection of 2x QSFP 100GBASE-SR4 using MTP-12 (Type B) MMF cable

The QSFP – Duplex LC Connection

The QSFP with Duplex LC connectivity is generally intended for longer links over duplex SMF (singlemode) cable. Typical maximum link lengths range from 1km (0.6 mi.) to 40km (24.8 mi.) for **SMF** depending on the optical devices fitted. The LC Duplex (single TX+RX) connection is achieved by multiplexing and demultiplexing the four sets of stream data using **WDM** (Wave Division Multiplex) blocks incorporated within the QSFP itself (see below).

There are multiple different variants (and vendors) of WDM QSFP types. They are not all interoperable, so it is wise to select products compliant with the **QSFP MSA** (multisource agreement) and/or are **IEEE 802.3ba** designated types.

Some of the most common types are:

QSFP 40 GbE-LR4; QSFP 40 GbE-ER4; QSFP 100 GbE-LR4; QSFP 100 GbE-ER4

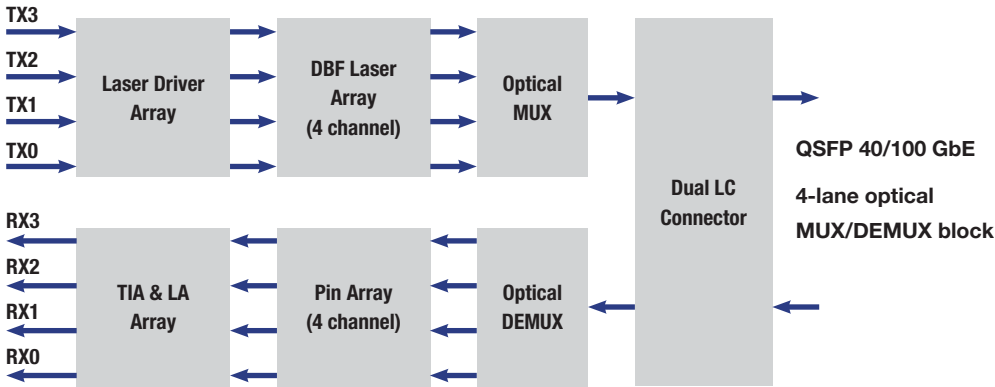
The 40G & 100G types connect **4x 10 GbE** or **4x 25 GbE** sets of media data respectively. All these types use DFB optical laser arrays with wavelength centered around 1300 nm.

(The four wavelengths are specified in IEEE 802.3ba and are: 1295.56 nm, 1300.05 nm, 1304.59 nm, 1309.14 nm).

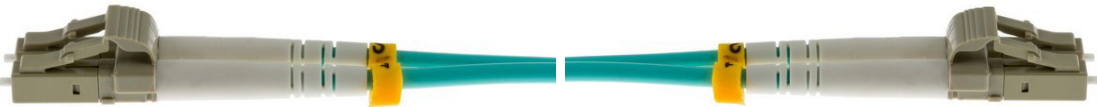
The suffices: **-LR4** and **-ER4** stand for “Long Range” and “Extended Range” respectively. Typical maximum link lengths/reach specified are **10 km (6.2 mi.)** and **30-40km (18.6-24.8 mi.)** over SMF respectively.

One variant of the above types has the suffix **-LRL4**. It meets all the same specifications as the - LR4 but is only rated for link distances/reach of up to **1- 2 km (0.6-1.2 mi.)** and is consequently a lower cost option. The - LRL4 is, to all intents and purposes, an –LR4 device that has not passed the minimum reach test.

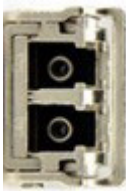
Note: It is generally expected that links will use the same QSFP types at both ends. It is possible, however, to mix types. A link using one –LR4 and one – LRL4 will simply adopt a maximum reach defined by the lower spec device.



TX
RX



Interconnection of 2x QSFP (WDM) using LC to LC Duplex SMF cable



RX
TX

QSFP+LC

QSFP naming convention (for both MPO/MTP & LC Duplex connections)

4x 10 GbE Channels = QSFP+

4x 25 GbE Channels = QSFP28

CONNECTIONS & CABLING (CONT.)

Fiber Breakout Cables

QSFP 40 GbE & 100 GbE to 4x 10 GbE & 25 GbE

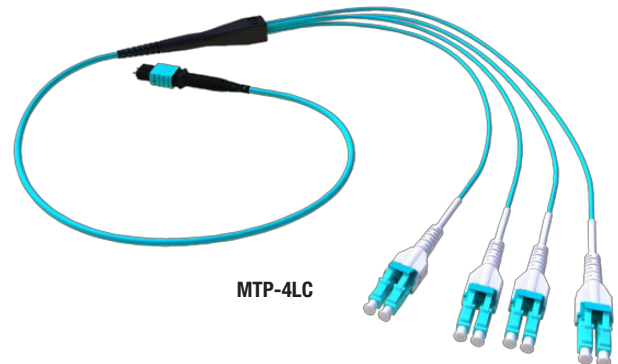
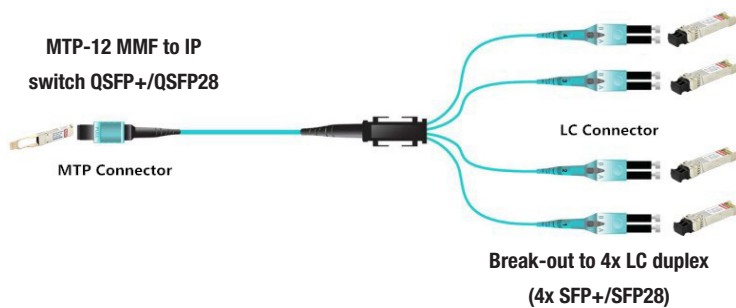
40 GbE and 100 GbE IP switch ports can be configured in alternative modes. In each case the motherboard (or IP switch line card) presents the data to a QSFP in four lanes of 10 Gb/s or 25 Gb/s respectively. This is replicated for both the TX and RX paths (i.e., 4x TX & 4x RX).

In **normal mode** all the 40 Gb/s of data in a 40 GbE port, for example, can be aggregated across all four lanes on a “best fit” basis (for lowest latency) as decided by the switch hardware/firmware. This mode assumes the client/edge devices is likewise a dedicated 40 GbE port.

An **alternative mode** is possible where, again taking the 40 GbE port as an example, the four sets of 10 Gb/s data are intended for connection to four independent 10 GbE enabled clients or edge devices. In this mode, the switch must be configured to treat the four groups of data as separate distinct entities. The mode can be set independently for each 40 GbE/100 GbE port in the configuration file of the switch.

When operating a 40 GbE or 100 GbE switch port in the alternative mode (as described above) a mechanism is required to “break-out” the MTP-12 fiber connection from the relevant QSFP into its four constituent SFP+ (10 GbE) elements. An example breakout cable is depicted below. This cable may be connected directly to the QSFP or after an MTP “patch-box” used to truncate the connection from the QSFP in the switch.

Important note: All 40 GbE and 100 GbE ports on Grass Valley edge devices are set to normal mode. They intentionally cannot be split into the four constituent 10 GbE or 25 GbE data sets. Setting the alternative modes is a function of the IP switch only. A Grass Valley (or third-party) 10 GbE or 25 GbE enabled edge device can, of course, be connected to one of the “broken-out” elements from a 40 GbE or 100 GbE IP switch port.



References

100 GbE Information

https://en.wikipedia.org/wiki/100_Gigabit_Ethernet

Small Form-factor Pluggable Transceiver

https://en.wikipedia.org/wiki/Small_form-factor_pluggable_transceiver

Arista Transceivers and Cables

<https://www.arista.com/en/products/transceivers-cables>

MTP-12 Cheat Sheet for QSFP 40G SR4 Optical Cabling

<https://eos.arista.com/mtp12-cheat-sheet-for-qsfp-40g-sr4-optical-cabling>

US Conec MTP Fiber Connectors

<http://www.usconec.com/products/connectors/mtp.htm>

COTS IP SWITCHES

General Information

Grass Valley's IP Routing System is agnostic with respect to IP COTS switch type. Nevertheless, there are a number of basic criteria that should be considered when selecting a suitable device. Here are some of the main requirements:

COTS IP Switch Parameters

► Must have very large bandwidth

Some of the largest enterprise-grade IP spine switches exhibit throughput capacity up to 115 Tb/s (51 Bpkts/s).

► Ideally be non-blocking

Router internal bandwidth must handle all the port bandwidths at the same time & at full capacity.

Note: The use of SDN (Software Defined Networking) can be used in cases where an IP switch does not meet the above criteria.

► Must be IGMPv3 compliant

The Internet Group Management Protocol is used by clients & adjacent routers on IPv4 networks to establish multicast group memberships.

► Must support PIM-SSM

Protocol Independent Multicast — Source Specific Multicast between routers & subnets.

Additional Considerations

► SDN (Software Defined Network)

While all the switch types detailed are capable of operating in an SDN environment, Grass Valley's IP routing system can be based on a topology that inherently does not require SDN control. In such cases it uses IGMPv3 in a non-blocking multicast design only for communication with the switch fabric. Systems using SDN, however, can also be implemented as it is often requested as a means of defining "secure paths" (connections) in IP networks.

For SDN deployments, a smaller subset of these switches and their control systems need to be designed into the IP fabric.

► Redundant IP Switches

When deploying a fully redundant system (i.e., dual IP switches) it is possible to deploy different switches from alternative vendors. This approach hopes to avoid potential issues (affecting both switches) caused during a firmware upgrade or such (It is unlikely two switch vendors would release upgrades at the same time).

► IP Switch Stream Capacity

In the following pages, theoretical figures are stated for the maximum stream capacities for each switch type and size. These, however, assume a single stream format (i.e., HD, 3G, etc.). It is most likely that any system would have a mix of formats and so these figures should only be used as "finger-in-the-air" guidelines.

The IP Switches detailed in the following pages is by no means a complete list of compliant equipment. They are, however, examples of some of the types with which Grass Valley has direct experience in both delivered systems and/or in-house test systems.

Consultation with Grass Valley is recommended when choosing your COTS Ethernet switch.

COTS IP SWITCHES (CONT.)

GV Fabric — Fixed Switches

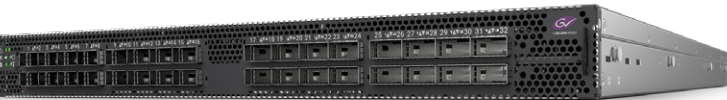
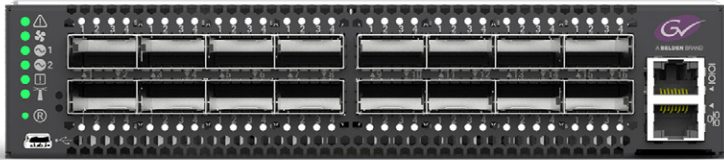
GVF-516-100G, GV-1032-100G

The **GV-516-100G** and **GV-1032-100G** are high-performance, high-density switches housed in a 1/2 width and full width 1 RU chassis with flexible combination of speeds from 1 GbE to 100 GbE.

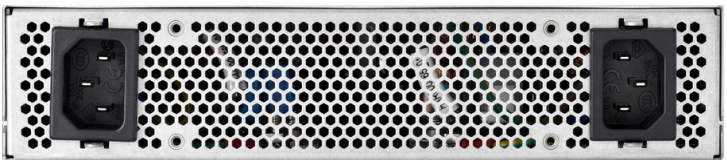
GV-516-100G — Ports: 16x 100 GbE (QSFP) + 1x 10/100/1000 Mb/s RJ45 ENET MGMT + 1x RJ45 Serial + 1x Mini USB

Flexible interface configurations: 16x 100 GbE, 16x 40 GbE, 32x 50 GbE, 64x 25 GbE, 64x 10 GbE

Front View



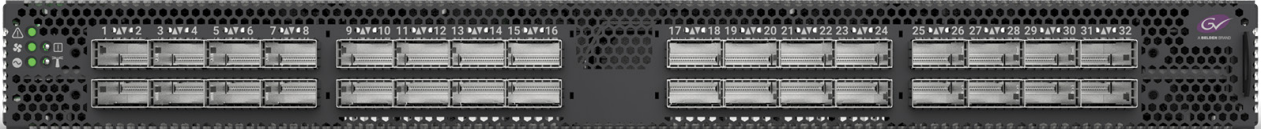
Rear View



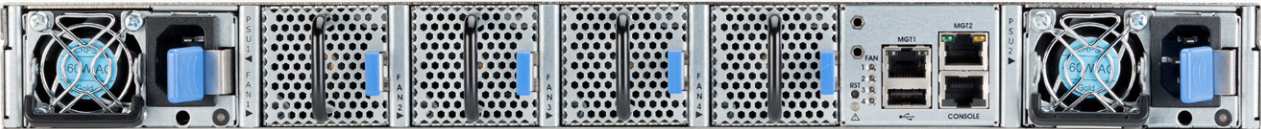
GV-1032-100G — Ports: 32x 100 GbE (QSFP) + 2x 10/100/1000 Mb/s RJ45 ENET MGMT + 1x RJ45 Serial port + 1x USB

Flexible interface configurations: 32x 100 GbE, 32x 40 GbE, 64x 50 GbE, 64x 25 GbE, 64x 10 GbE

Front View



Rear View



GV Fabric Series Performance

Model Number	Throughput (Max.)	Packets/Sec (Max.)	10 GbE Ports	Recommended by Grass Valley			Rack Units
				25 GbE Ports	40 GbE Ports	100 GbE Ports	
GV-516-100G	3.2 Tb/s	2.38 Bp/s	64	64	16	16	1 1/2 Width
GV-1032-100G	6.4 Tb/s	4.76 Bp/s	64	64	32	32	2

Video Signal Channel Capacity — Based on SMPTE ST 2110 streams each with 16-Channel SMPTE ST 2110-30 audio data

Video Media	GV-516-100G				GV-1032-100G			
	10 GbE	25 GbE	40 GbE	100 GbE	10 GbE	25 GbE	40 GbE	100 GbE
SMPTE ST 2110-20	64	64	16	16	64	64	32	32
HD (50 fps)	512	1,280	512	1,280	512	1,280	1,024	2,560
HD (59.94 fps)	384	1,024	432	1,072	384	1,024	864	2,144
3G (50 fps)	256	640	256	640	256	640	512	1,280
3G (59.94 fps)	192	512	208	544	192	512	416	1,088
4K UHD (50 fps)	64	128	64	160	64	128	128	320
4K UHD (59.94 fps)	0	128	48	128	0	128	96	256

Notes: (a). Each figure means number of channels "In" & "Out" (e.g., 2,560 means 2,560 TX and 2,560 RX (SDI equiv. 2560 x 2560))
(b). Assumes full bandwidth of switch with no contingency/additional capacity (i.e., "break-before-make" switching).
(c). Numbers based on switch using single format (i.e., all HD or all 3G or all 4K UHD). Hence numbers are for guideline use only!

COTS IP SWITCHES (CONT.)

Other Fixed Switches

Listed below are examples of alternative fixed switch types to GV Fabric that have been tested and successfully deployed in broadcast and media facilities for routing uncompressed video (and audio) signals up to 4K UHD.

ARISTA 7060CX2-32S



The **7060CX2-32S** is a high-performance, high-density 32-port QSFP switch housed in a 1 RU chassis. It supports a combination of speeds of 10, 25, 40, 50 and 100 GbE.



Nexus 9236C



The **Nexus 9236C** is a high-performance, high density 36-port QSFP switch housed in a 1 RU chassis. It supports a combination of speeds of 10, 25, 40, 50 and 100 GbE.



Nexus 9272Q



The **Nexus 9272Q** is a high-performance, high density 72-port QSFP switch housed in a 2 RU chassis. It supports port speeds of 10 and 40 GbE.



QFX5200-32C



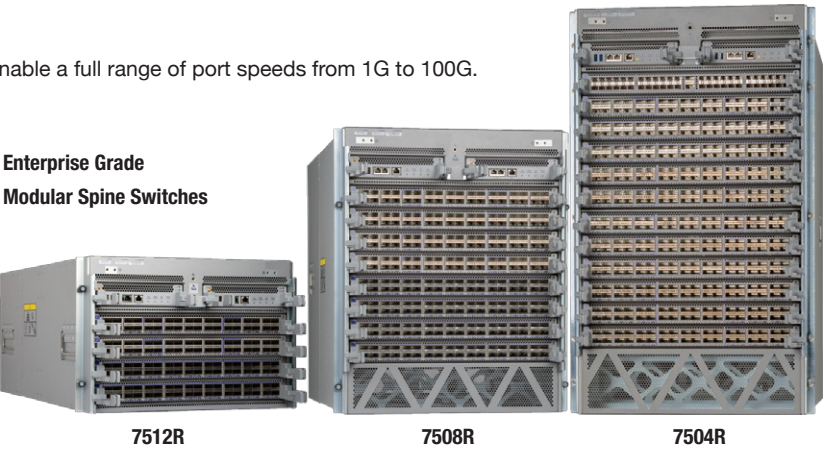
The QFX5200-32C is a high-performance, high density 32-port QSFP switch housed in a 1 RU chassis. It supports a combination of speeds of 10, 25, 40, 50 and 100 GbE.

COTS IP SWITCHES (CONT.)

Arista Modular Switches

ARISTA 7500R Series

The 7500R Series of universal spine switches enable a full range of port speeds from 1G to 100G.



7500R Series System Performance

Model Number	Switching Capacity	Linecard Capacity	10 GbE Ports	Recommended by Grass Valley			Rack Units
				25 GbE Ports	40 GbE Ports	100 GbE Ports	
7504R	38 Tb/s	4 x 9.6 Tb/s	576	576	144	144	7
7508R	75 Tb/s	8 x 9.6 Tb/s	1,152	1,152	288	288	13
7512R	115 Tb/s	12 x 9.6 Tb/s	1,728	1,728	432	432	18

Video Signal Channel Capacity — Based on SMPTE ST 2110 streams each with 16-Channel (25 Mb/s) audio data

Video Media	7504R				7508R				7512R			
	10 GbE	25 GbE	40 GbE	100 GbE	10 GbE	25 GbE	40 GbE	100 GbE	10 GbE	25 GbE	40 GbE	100 GbE
VSF TR-03	576	576	144	144	1,152	1,152	288	288	1,728	1,728	432	432
HD (50 fps)	4,608	11,520	4,608	11,520	9,216	23,040	9,216	23,040	13,824	34,560	13,824	34,560
HD (59.94 fps)	3,456	9,216	3,888	9,648	6,912	18,432	7,776	19,296	10,368	27,648	11,664	28,944
3G (50 fps)	2,304	5,760	2,304	5,760	4,608	11,520	4,608	11,520	6,912	17,280	6,912	17,280
3G (59.94 fps)	1,728	4,608	1,872	4,896	3,456	9,216	3,744	9,792	5,184	13,824	5,616	14,688
4K UHD (50 fps)	576	1,152	576	1,440	1,152	2,304	1,152	2,880	1,728	3,456	1,728	4,320
4K UHD (59.94 fps)	0	1,152	432	1,152	0	2,304	864	2,304	0	3,456	1,296	3,456

Notes: (a). Each figure means number of channels "In" & "Out" (e.g., 9,216 means 9,216 TX and 9,216 RX (SDI equiv. 9216 x 9216))
(b). Assumes full bandwidth of switch with no contingency/additional capacity i.e. "break-before-make" switching.
(c). Numbers based on switch using single format (i.e., all HD or all 3G or all UHD). Hence numbers are for guideline use only!

Scope of Supply

- 7500R Series switches are supplied as a "chassis bundle," which includes the chassis, power supplies, cooling assemblies and switch fabric modules (5+1 redundancy). One "Supervisor" control module is also included.
- A second Supervisor module must be ordered separately if 1+1 redundant controllers are required.
- A "Monitoring & Provisioning" license must be purchased (ZTP, LANZ, API, TapAgg) — see Arista datasheet(s).
- Line cards are purchased separately but shipped in the chassis (see next section for optional types).

COTS IP SWITCHES (CONT.)

Line Cards

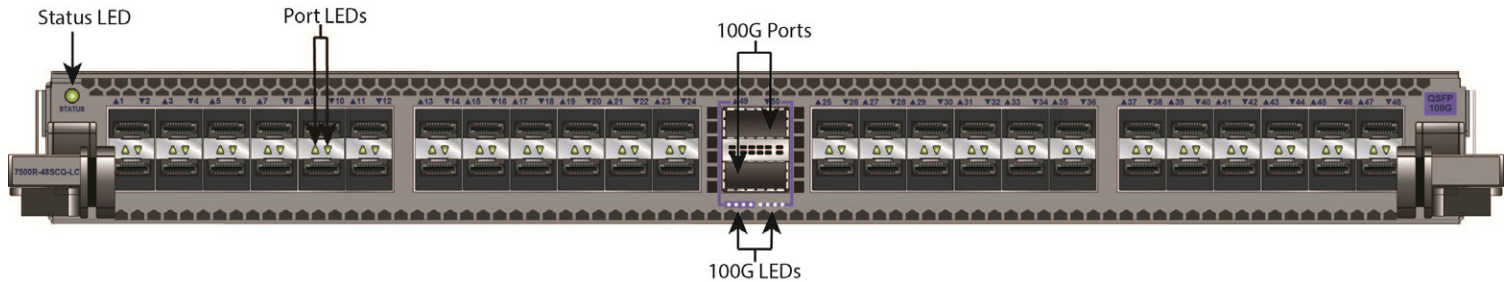
Four, Eight or Twelve of any mix of the line cards below can be fitted in the 7504R, 7508R or 7512R chassis respectively.

* The maximum number of 10 GbE, 25 GbE, 40 GbE or 100 GbE ports for each chassis size (see tables on the previous page) is derived assuming line card DCS-7500R-36CQ-LC is fitted in all slots (see bottom of page).

DCS-7500R-48S2CQ-LC

Up to 56x 10 GbE ports or 48x 10 GbE (SFP+) ports + 2x 100 GbE (QSFP28) ports.

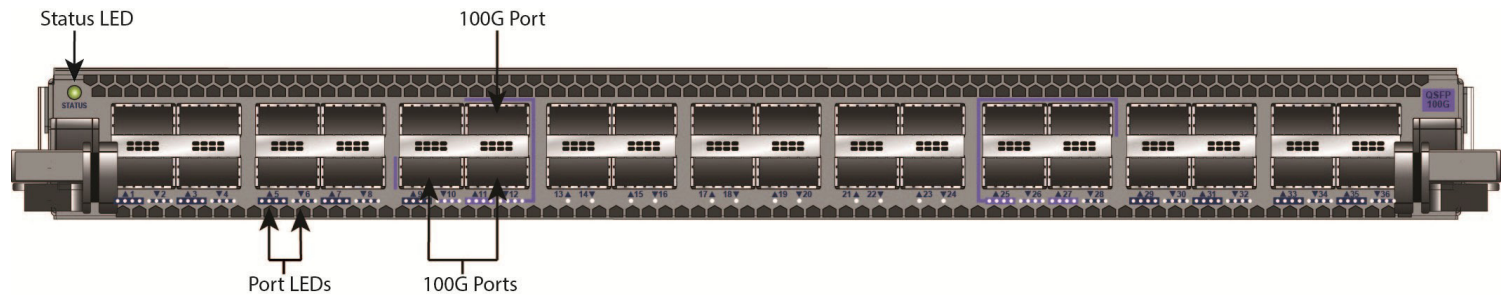
QSFP28 ports can be configured as 2x 100 GbE or 4x 25 GbE or 2x 40 GbE or 8x 10 GbE.



DCS-7500R-36Q-LC

Up to 36 x 40 GbE (QSFP+) ports or 24 x 40 GbE (QSFP+) ports + 6 x 100 GbE (QSFP28) ports.

24x QSFP+ ports can be configured as 96x 10 GbE and/or 6x QSFP28 ports can be configured as 24x 25 GbE ports.



DCS-7500R-36CQ-LC (Highest Data Capacity)*

36x 100 GbE (QSFP28) ports.

This is the most flexible and highest density line card with the greatest data throughput.

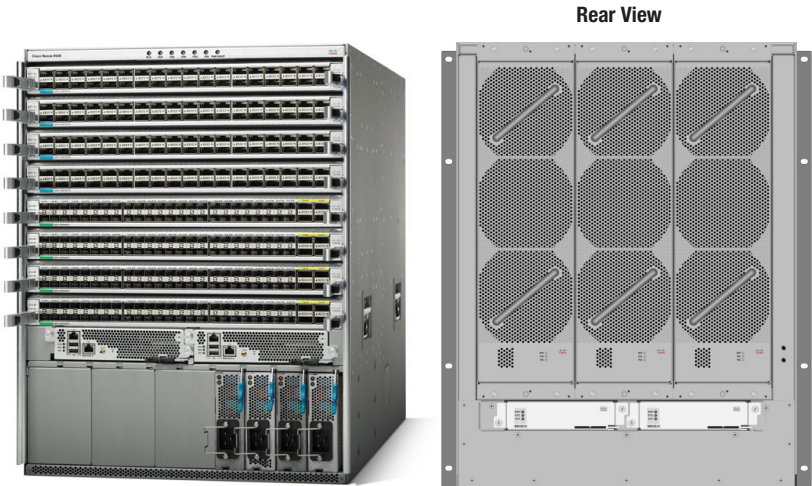
All QSFP28 ports can be independently configured as 100 GbE or 2x 50 GbE or 4x 25 GbE or 40 GbE or 4x 10 GbE.



Cisco Modular Switches



Enterprise Grade Modular Spine Switch
x8 Line Card capacity
Front to back airflow



Nexus 9508 Series System Performance				Recommended by Grass Valley			
Model Number	Switching Capacity	Linecard Capacity	10 GbE Ports	25 GbE Ports	40 GbE Ports	100 GbE Ports	Rack Units
N9K-C9508	75 Tb/s	8 x 9.6 Tb/s	1,152	1,152	288	288	13

Video Signal Channel Capacity — Based on SMPTE ST 2110 streams each with 16-channel (25 Mb/s) audio data

Video Media	9508			
	10 GbE	25 GbE	40 GbE	100 GbE
VSF TR-03	1,152	1,152	288	288
HD (50 fps)	9,216	23,040	9,216	23,040
HD (59.94 fps)	6,912	18,432	7,776	19,296
3G (50 fps)	4,608	11,520	4,608	11,520
3G (59.94 fps)	3,456	9,216	3,744	9,792
4KUHD (50 fps)	1,152	2,304	1,152	2,880
4K UHD (59.94 fps)	0	2,304	864	2,304

Notes: (a). Each figure means number of channels "In" & "Out"(e.g., 9,216 means 9,216 TX and 9,216 RX (SDI equiv. 9216 x 9216))
(b). Assumes full bandwidth of switch with no contingency/additional capacity (i.e., "break-before-make" switching).
(c). Numbers based on switch using single format (i.e. all HD or all 3G or all UHD). Hence numbers are for guideline use only!

Scope of Supply

1. The 9508 switch is supplied as a "Chassis bundle" which includes the chassis, power supplies (x3), system controllers (x2), Supervisor/SUP-B control module (x1), cooling trays and switch fabric modules (x6).
2. A second Supervisor/SUP-B module must be ordered separately if 1+1 redundant controllers are required.
3. A LAN Enterprise & a DCNM for LAN (Advanced Edition) licenses must be purchased — see 9508 datasheet(s).
4. Line cards are purchased separately but shipped in the chassis (see next section for optional types).

COTS IP SWITCHES (CONT.)

Line Cards

Eight of any mix of the line cards below can be fitted in the **Nexus 9508** chassis.

* The maximum number of 10 GbE, 25 GbE, 40 GbE or 100 GbE ports for the chassis (see tables on the previous page) is derived assuming line card **N9K-X9636C-R** is fitted in all slots (see bottom of page).

N9K-X9636Q-R

36x 40 GbE (QSFP+) ports.

All **QSFP+** ports can be independently configured as **40 GbE** or **4x 10 GbE**.



N9K-X9636C-R (Highest Data Capacity)*

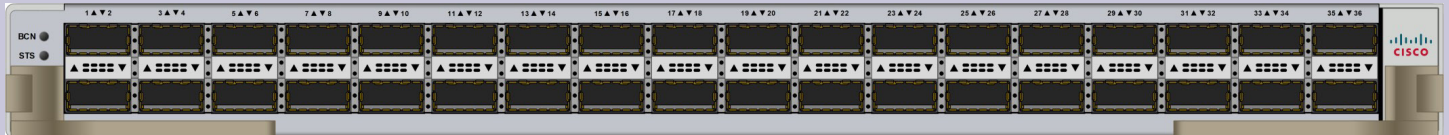
36x 100 GbE (QSFP28) ports.

This is the most flexible and highest density line card with the greatest data throughput.

All **QSFP28** ports can be independently configured as **100 GbE** or **4x 25 GbE** or **40 GbE** or **4x 10 GbE**.



Preferred type!



References

GV Fabric 1 RU Fixed Ethernet Switches

https://www.grassvalley.com/products/gv_fabric/

Arista 7500R Series Modular Ethernet Switches

<https://www.arista.com/en/products/7500r-series>

Cisco Nexus 9508 Modular Ethernet Switch

<https://www.cisco.com/c/en/us/products/switches/nexus-9508-switch/index.html>

EDGE DEVICES

General Information

What is an Edge Device?

An Edge Device is any piece of equipment, software- or hardware-based, that is connected to a network but is not part of the backbone infrastructure, which typically comprises the IP switch(es), cabling and network controllers. An Edge Device can be a “Source” (unicast or multicast) or a “Destination” (receiver) or both. It can be a “Processing” and/or an “Interface” device. Edge Devices are sometimes referred to as “End-point” Devices.

Grass Valley Edge Devices

The majority of Grass Valley products now feature IP ports either as standard or as optional interfaces facilitating their use as Edge Devices in an IP network. A list of Grass Valley IP products is given on the next page. Datasheets are available for all the products giving details of their respective GbE interfaces and available data rates.

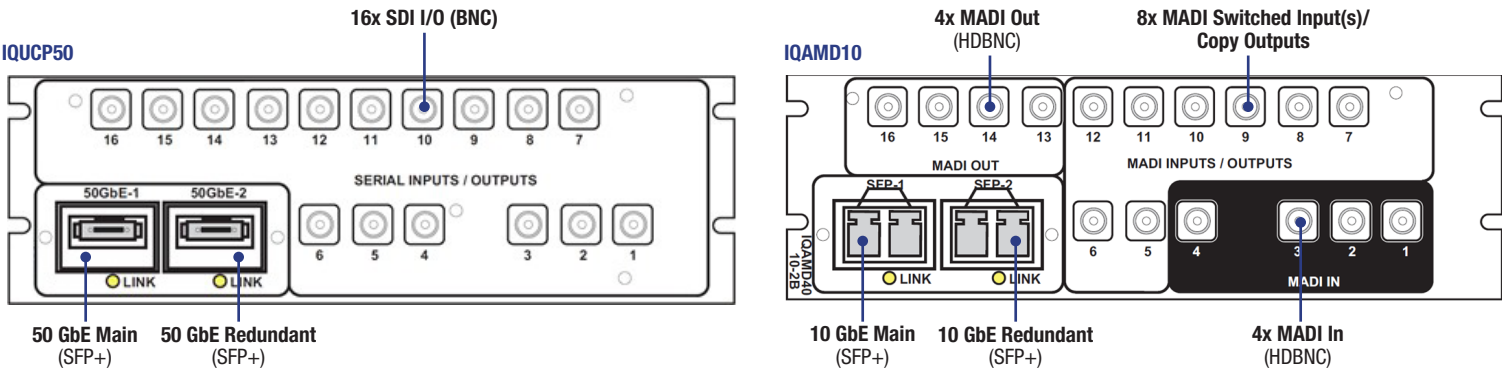
All products feature dual Ethernet ports for implementing SMPTE ST 2022-7 signal redundancy for hitless switching.

Third-Party Edge Devices

Grass Valley is able to write third-party drivers to allow inclusion of alternative vendors’ equipment in its IP routing system. If a driver is not available within an existing library, a development charge may be requested for the required work.

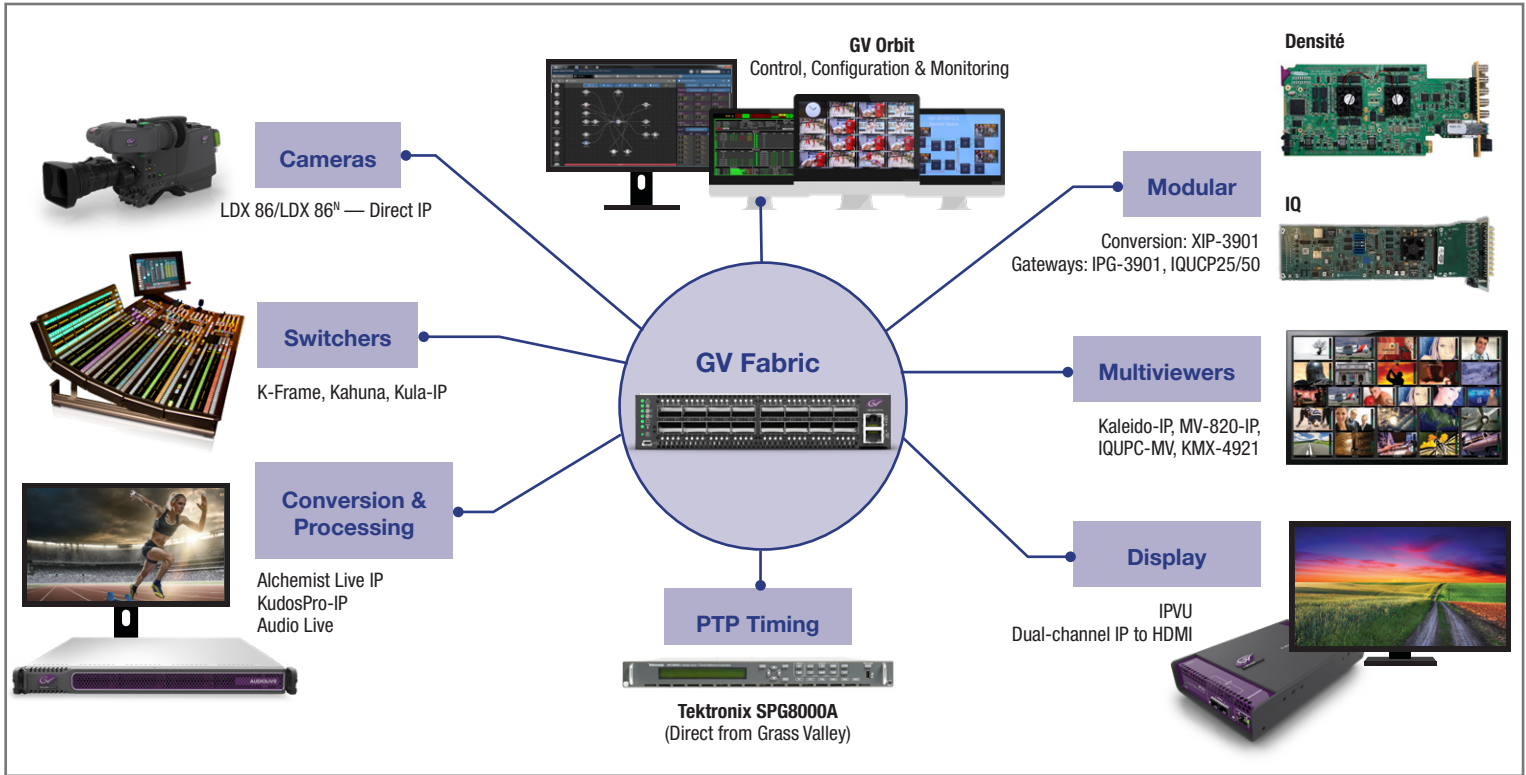
Information on existing drivers and/or quotations for new drivers can be obtained from Grass Valley Sales.

Examples — GV Edge Device Connectivity



Grass Valley Portfolio

Grass Valley can supply all the key components for your IP routing system including the COTS Ethernet switch(es).



Control, Configuration & Monitoring

GV Orbit

Control: IP Routing System Controller — Single or dual redundant turnkey server options. GUI & LED/LCD panels.
Configuration & Monitoring: System setup, device configuration & addressing. Comprehensive monitoring tools.

Ethernet Switches

GV Fabric

Compact, High-Speed Ethernet Switches. Configurable port speeds of 1, 10, 25, 40, 50 and 100 GbE
 Two variants: 32-port 100 GbE QSFP 1 RU, 16-Port 100 GbE QSFP 1/2 width 1 RU

Cameras

LDX 86 & LDX 86N

High-speed, 4K-capable cameras. Uses XF Transmission Direct IP connection — 4x 10 GbE interfaces

Production Switchers (IP I/O)

Kayenne K-Frame

K-FRM-IO-10GE IP I/O card, TICO compression for 4K/12G — *10 GbE interface*

Karrera K-Frame

K-FRM-IO-10GE IP I/O card, TICO compression for 4K/12G — *10 GbE interface*

GV Korona K-Frame

K-FRM-IO-10GE IP I/O card, TICO compression for 4K/12G — *10 GbE interface*

GV K-Frame X

Video processing frame — *10 GbE or 25 GbE interfaces*

GV K-Frame XP

4K UHD/HD IP and SDI video processing frame — *10-25 GbE interfaces*

Kahuna

I/O cards (fins) for Kahuna 9600/6400/4800 “high-end” switcher — *50 GbE interfaces*

Kula

I/O cards (fins) for Kula switcher — *50 GbE interfaces*

Processing & Conversion

Alchemist Live IP

Motion-compensated Framerate Conversion for Live Media Streams, SD to 4K UHD & 4K DCI — *100 GbE interface*

KPRO-IPLC410

“Utility” quad channel frame/format converter. Includes video & audio processing — *10 GbE interface*

KPRO-IPSV410

“International” quad channel format converter. Includes video & audio processing — *10 GbE interface*

KPRO-IPMC210

Dual-channel motion compensated frame rate converter. Includes video & audio processing — *10 GbE interface*

Audio Live

Multichannel audio routing (2,048 x 2048) & processing software for Live Multi-stream IP — *10 GbE/40 GbE interfaces*

EDGE DEVICES (CONT.)

Modular Gateways, Processing & Conversion

Densité 3+ Modular System

IPG-3901	Multichannel SDI<>IP Gateway, 4K UHD 3G/HD/SD-SDI, 2 inputs/2 outputs + 7 configurable in/out — 10 GbE interface
XIP-3901	Agile SDI<>IP Processing Platform, Up/Down/Cross & HDR, 4K UHD 3G/HD/SD-SDI, 8 inputs/8 outputs — 25 GbE interface

IQ Modular System

IQMIX10	Multichannel SDI<>IP Gateway, 3G/HD/SD-SDI — 10 GbE interface
IQUCP25	Universal Compute Processor, SDI<>IP, 4K UHD 3G/HD/SD-SDI, 16x HDBNC/Optional configs — 25 GbE interface
IQUCP50	Universal Compute Processor, SDI<>IP, 4K UHD 3G/HD/SD-SDI, 16x HDBNC/Optional configs — 50 GbE interface
IQAMD40	Multichannel MADI<>IP Gateway — 10 GbE interface
IQTIC00	Third-party IP Control Interface Module

Multiviewers

MV820-IP	IP “2 RU Boxed” Multiviewer. Up to 48 inputs, up to 12x UHD 4K SDI/IP outputs — 4x 100 GbE QSFP interfaces
MV800-DT	Desktop software IP Multiviewer — H.264 streams @ 25 Mb/s max. interface
Kaleido-IP	SD, HD and 4K UHD IP Video Multiviewer — 10/25 GbE SFP, 40/100 GbE QSFP interfaces
IQUCP-MV	IQ Modular Multiviewer Card. Up to 12 inputs/4 outputs — 25 GbE SFP/50 GbE QSFP interfaces

Display

IPVU	Compact Dual-channel IP to HDMI Converter. Vesa mounting bracket — 10 GbE/25 GbE SFP interfaces
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PTP Timing

SPG800A*	Tektronix Master Sync/Master Clock Reference Generator. Blackburst, HD tri-level sync, SMPTE ST 2059-1/2 (PTPv2)
ECO8000*	Tektronix Automatic Changeover Unit. Required for redundancy schemes using 2x SPG8000A

* Grass Valley is an approved reseller for Tektronix® Reference Generators.

Licensing

Grass Valley levies “one-time” license fees at the “point of purchase” for its IP routing system. These are distinct from any installation and commissioning costs which are treated separately.

The total fee is based on the number of IP switch video output streams to both Grass Valley and third-party devices. In addition, there is a license fee levied for each “clean switch” control at a logical destination.

The license types are listed below:

IP Stream Video Output Licenses

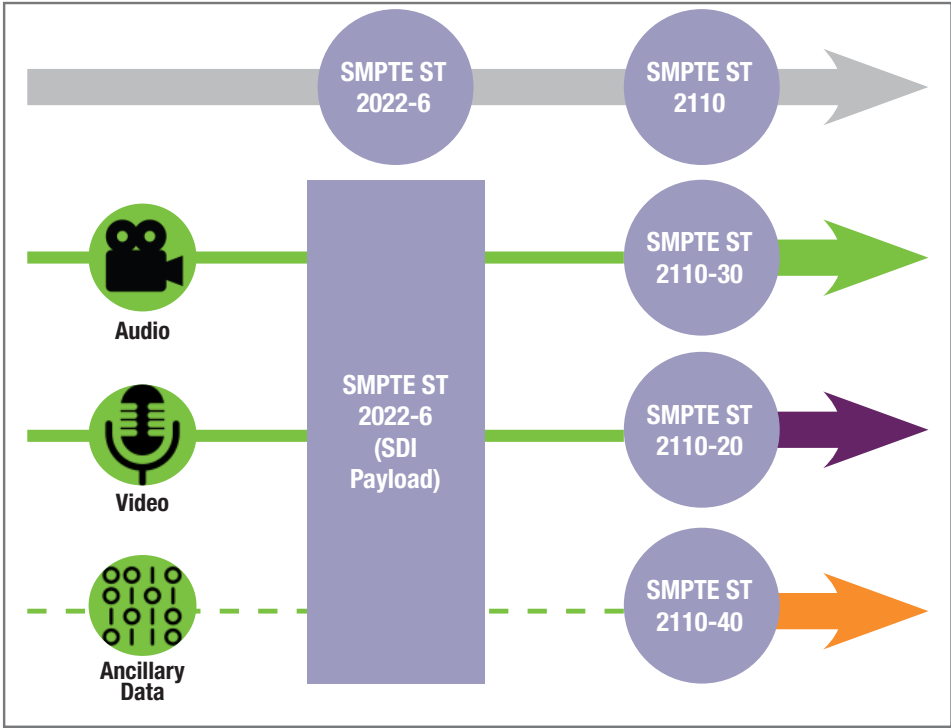
GVC-OUT-IP	License for control of one IP switch output video stream (Note: SMPTE ST 2022-07 redundancy requires two licenses)
GVC-IP-CS	License for IP Clean Switch Control of one logical destination (Requires sufficient GVC-OUT- IP license to support “make-before-break” workflow and is hardware dependent)

SYSTEM TIMING

Introduction

System timing is a critical aspect of any IP routing system. In traditional SDI systems, video and audio signals are synchronized to a continuous reference source and “delay blocks” added to correct for lip-sync errors.

In “packetized” IP systems, data must be continually time-stamped for re-alignment downstream.



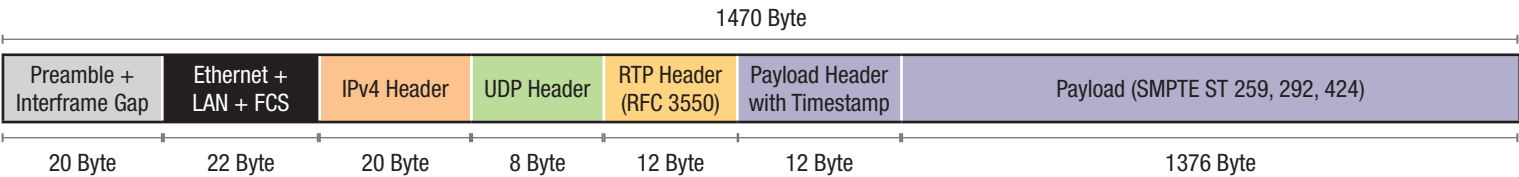
The diagram above summarizes two “packetizing” options used for multicast streamed media data.

With **SMPTE ST 2022-6** streams, all the SDI payload data including video, embedded audio and ancillary data is encapsulated within each streamed packet. The necessity for a data packet timing mechanism is not immediately obvious since grouping of the data types ensures their original timing relationship (lip-sync) is maintained. Multicast SMPTE ST 2022-6 packets from a source could simply be accumulated at a receiver, decapsulated and then reconstituted as an SDI signal. A potential scenario, however, could occur where packets experience different delays through a network resulting in disruption of the packet sequence — e.g., a packet arrives at a receiver before the one that was originally transmitted ahead of it! The argument for a packet timing mechanism is more apparent when considering redundant streams.

A method of “hitless” or uninterrupted switching between two identical streams is a major requirement in broadcast systems. Such systems obviate the need to have streams absolutely time-aligned which can only be achieved in IP networks by individually time stamping every packet. This forms the basis for implementing **SMPTE ST 2022-7** redundancy switching. This mechanism can be applied to all types of streams and not just SMPTE ST 2022-6.

With **SMPTE ST 2110** streams, audio and ancillary data is streamed separately from the video data. Time stamping of packets for these stream types is mandatory to allow realignment of the data types at the receiving host.

The diagram below depicts the high level structure of a single **SMPTE ST 2022-6** data packet. The number of packets per second or packet rate is determined by the video format. Similar packet structures exist for the other formats.



The relevant item in the packet structure is the inclusion of timestamp data in the payload header.

The remaining parts of this section show how the timestamp is used and how it’s implemented in a real system.

Basic Principles

Basic Concept

The diagram below outlines the basic concept whereby timestamps are used to re-align media data.

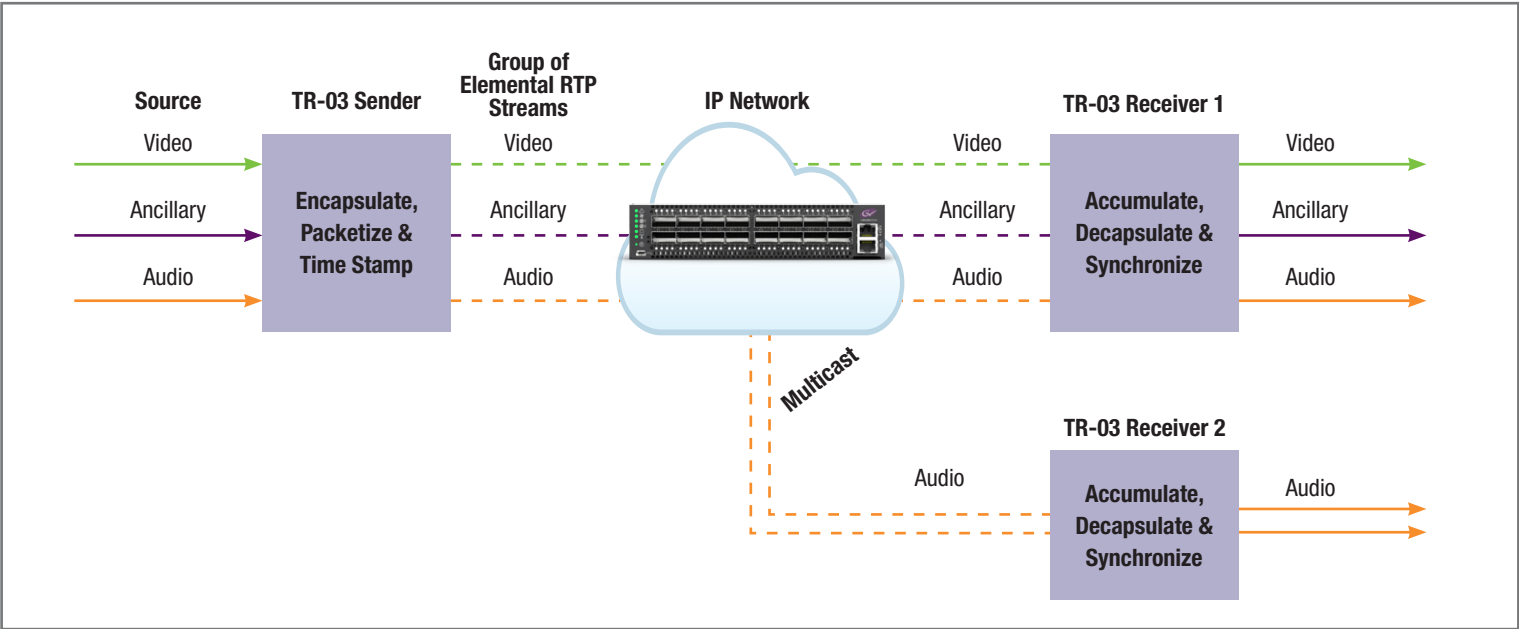
Baseband video, ancillary data and audio are encapsulated and packetized in the “2110 Sender” into separate (elemental) multicast RTP streams. Each “2110 Receiver” then “declares” (to the IP switch) all the streams it wishes to receive and only then will the switch forward the requested streams to that receiver. In this case, Receiver 1 has requested all streams and Receiver 2 has prescribed to the audio stream only. In a real system, the audio from Receiver 2 might be an alternative language channel to the video and audio channel from Receiver 1. Each receiver accumulates, de-encapsulates and then synchronizes all the streams to its internal clock which it does by

comparing all the packet timestamps with its own local time.

Furthermore, if it is desired that the audio output at Receiver 2 is co-timed with that of Receiver 1, then clearly a mechanism is required to ensure that both receivers internal clocks are also synchronous.

The next page in this section describes just such a system. *In fact, it enables all device clocks on a network (Senders, Receivers and, if desired the IP Switch itself) to be co-timed with microsecond accuracy.*

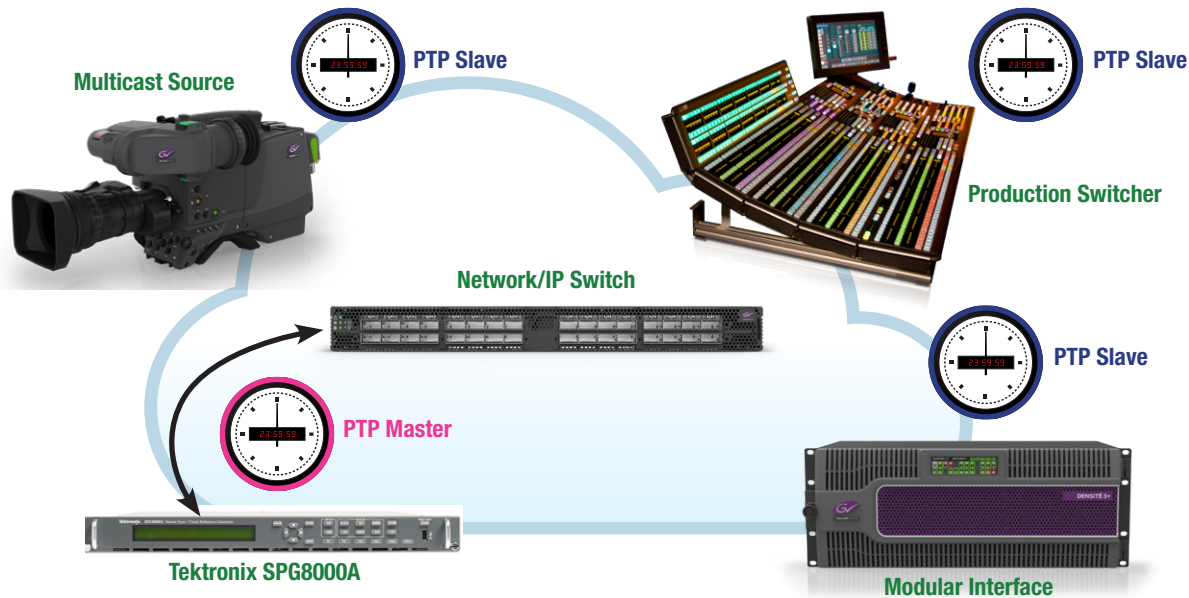
The same mechanism described above is also good for aligning redundant streams for “hitless” changeover.



SYSTEM TIMING (CONT.)

Precision-Timing-Protocol (PTPv.2)

The **IEEE 1588-2008** precision time protocol (specifically **PTP v.2**) provides a standard method to synchronize multiple devices on a network. It is used extensively in both LAN and WAN IT networks where measurement and automation applications, for example, require synchronization of multiple events with sub-microsecond accuracy. Although PTP is widely deployed in many sectors, **SMPTE ST 2059-1** and **SMPTE ST 2059-2** describe a specific media-based PTP profile required to use PTP-based equipment in the professional broadcast and media industry.



The diagram above depicts a simple system with a number of edge devices connected via an IP switch.

Each edge device includes its own internal clock. *The goal of the PTP timing system is to synchronize all the clocks such that the absolute time difference between any two clocks (i.e., their accuracy) is within a specified limit.*

This is typically about one microsecond, which is more than adequate for broadcast and media applications that are primarily interested in maintaining audio/video lip-sync.

► So how does it work?

A “Master” Sync Pulse Generator (e.g., Tektronix SPG8000A) multicasts sync packets across the network. Each “Slave” (Edge) device communicates periodically with the master to best determine the transmission delay associated with the sync data. Each then re-aligns its local clock accordingly. A more in-depth look at the process is provided in the “PTP Slide Presentation” (Courtesy of Microsemi) listed in the “References” page of this section.

► Data Timestamps

Each multicast source can now timestamp all transmitted data packets with the exact time they exit the device. Likewise a receiving host can buffer and synchronize the time-stamped packets to its local clock. If the receiving device is a video format converter, for instance, it will then convert the video signal and re-transmit new stream packets with their timestamps effectively reflecting the processing delay.

► Timestamp Format

The actual timestamp is a 64-bit number. The first 16 bits define the “epoch” (reference start time and date of the timescale) which is 00:00, January 1, 1970 (This is the default epoch for PTP, but can be changed to other scales). The next 32 bits defines the number of seconds from this date and the last 32 bits provides sub-second resolution. *PTP thus provides for timestamp resolution down to sub-nanoseconds. This is not be confused with system accuracy (approximately one microsecond) which is the maximum offset between device clocks.*

► Master SPG Failure

One advantage of PTP over other network timing systems (such as NTP) is that it has built-in support for redundancy and failover. If a PTP grandmaster node fails, the next-best node will automatically take over as grandmaster.

SYSTEM TIMING (CONT.)

PTP Clock Types

A PTP network is made up of PTP-enabled devices. There are four main types of PTP clocks:

Grandmaster Clock: The primary source of time for clock synchronization using PTP. It usually has a very precise time source, such as GPS but can “free-run” if the GPS signal is lost (effectively a “super” Ordinary Clock — see next).

Ordinary Clock: A PTP clock with a single PTP port. It functions as a node in a PTP network and the **BMCA** (see below) determines whether it’s a “master” or “slave” within a sub-domain.

Boundary Clock: A boundary clock has more than one PTP port. Each port provides access to a separate PTP communication path. Boundary clocks provide an interface between PTP domains. They intercept and process all PTP messages, and pass all other network traffic. The boundary clock uses the BMCA to select the best clock seen by any port. The selected port is then set as a slave. All other ports are in master state, which synchronize the clocks connected downstream (e.g., edge devices), while the slave port synchronizes with the upstream master clock.

Transparent Clock: This clock type in a PTP network updates the time-interval field in the PTP event message. It compensates for switch delay with an accuracy of less than one picosecond.



Figure 1. Tektronix SPG8000A

Multiformat SDI references, 1x PTP (RJ45), 1x PTP(SFP), free-run, genlock or GPS

PTP Reference Generators

The Tektronix SPG8000A Master Sync/Master Clock Reference Generator (see Figure 1) provides multiple video reference signals such as blackburst, HD tri-level sync plus SDI and analog test patterns.

For IP installations it supports Precision Time Protocol (PTPv.2) IEEE 1588.

Best Master Clock Algorithm (BMCA)

A key to the resiliency of PTP is the “Best Master Clock Algorithm,” or BMCA. The BMCA allows a clock to automatically take over the duties of Grandmaster when the previous Grandmaster loses its GPS or gets disconnected. In essence a clock “makes announcements” and “listens for announcements” from other clocks.

The first thing a clock does after power up is listen for announce messages from the PTP general multicast address. An announce message contains the properties of the clock which sent it. If the Ordinary Clock sees an announce message from a better clock, it goes into a slave state (or passive if not slave capable). If the Ordinary Clock does not see an announce message from a better clock within the “Announce Time Out Interval,” then it takes over the role of Grandmaster. Master capable devices are constantly on the lookout for the loss of the current master clock. It’s important that the *“Announce Time Out Interval” is set longer than the “Announce Interval” in the network!*

So what makes one master better than another? The decision is based on a number of parameters (with defined precedence) including “Clock Class,” “Clock Accuracy,” etc. There are two “Priority Fields.” **Priority 1** is an 8-bit user-settable value where the lowest number wins! It can be used to establish any pecking order required. **Priority 2** is at the low end of the decision tree, allowing system integrators to identify primary and backup clocks among identical redundant Grandmasters.

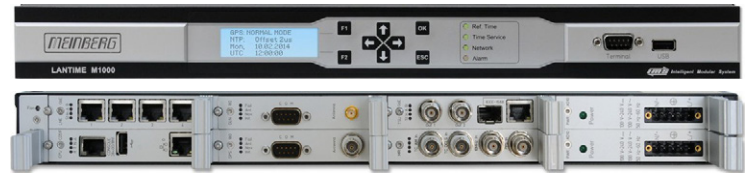


Figure 2. Meinberg LANTIME M1000

Modular (No SDI). Up to 4 PTP ports/modules, free-run, genlock or GPS

Other PTPv2 Generators

In very large systems, a generator dedicated to PTP systems (slave count up to 500+) can be slaved to the SPG8000A. An example of this is the **Meinberg LANTIME 1000** depicted in Figure 2.

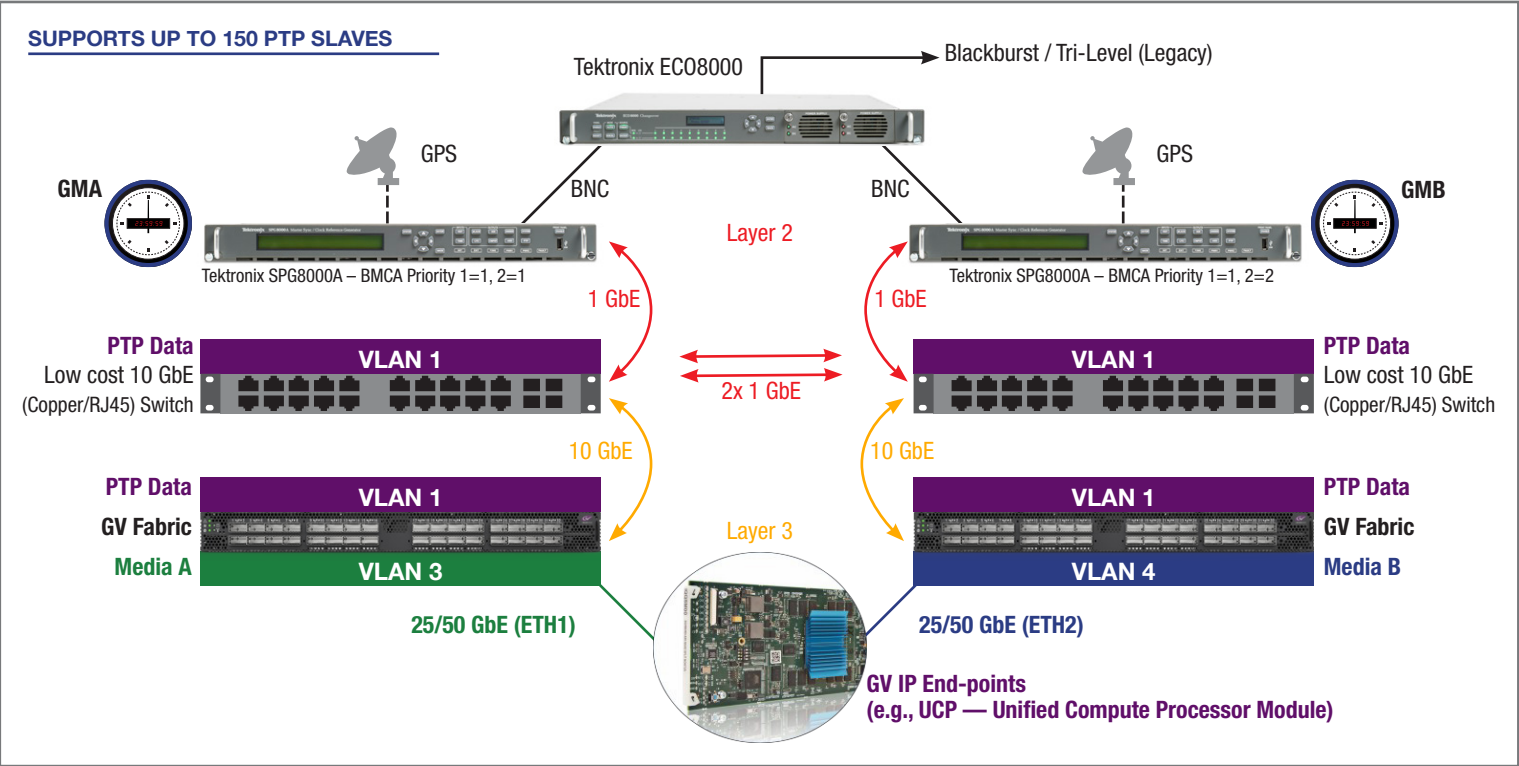
SYSTEM TIMING (CONT.)

PTP Example Configurations

Examples Using Ordinary Clocks

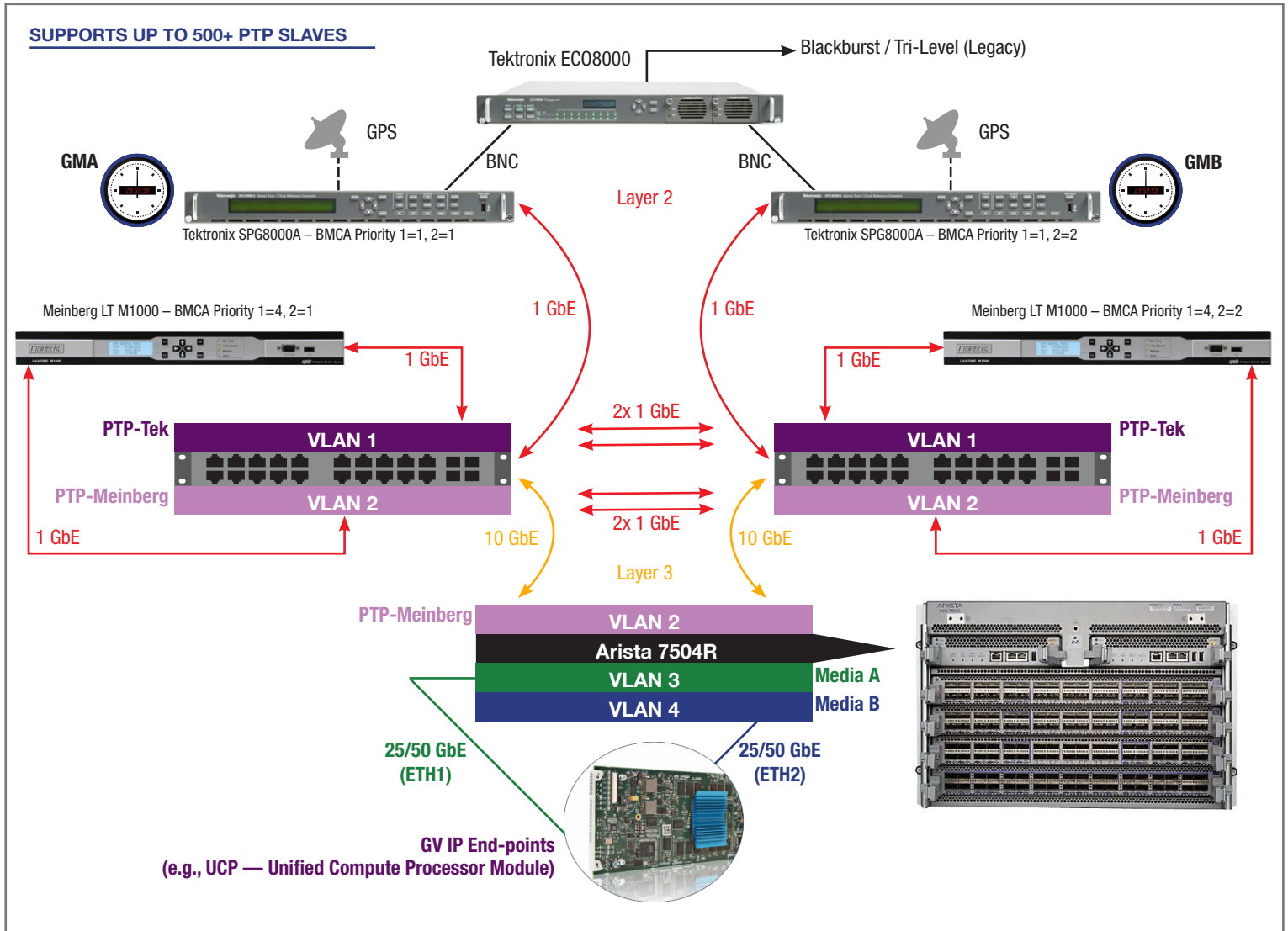
The following examples use two Tektronix **SPG8000A** master sync generators configured for redundancy with the **EC08000** changeover unit for supporting switchover of legacy reference signals. Both units are available directly from Grass Valley. The generators are effectively Ordinary Clocks but use the BMCA to decide which one assumes the role of “Grandmaster.” PTP communication between the Grandmaster and the IP End-points/Slaves (up to 150) is constrained to VLAN 1. Media data is confined to VLAN 3 (Main Switch) and VLAN 4 (Redundant Switch).

The example below also uses Ordinary Clocks but utilizes Meinberg PTP boxes (slaved to the Tektronix Grandmasters) to extend the edge device capability to over 500. PTP communication between the Grandmasters and Meinberg Slave ports are confined to VLAN 1 and the Meinberg downstream PTP communications to VLAN 2.



SYSTEM TIMING (CONT.)

The example below also uses Ordinary Clocks but utilizes Meinberg PTP boxes (slaved to the Tektronix Grandmasters) to extend the edge device capability to over 500. PTP communication between the Grandmasters and Meinberg Slave ports are confined to VLAN 1 and the Meinberg downstream PTP communications to VLAN 2.

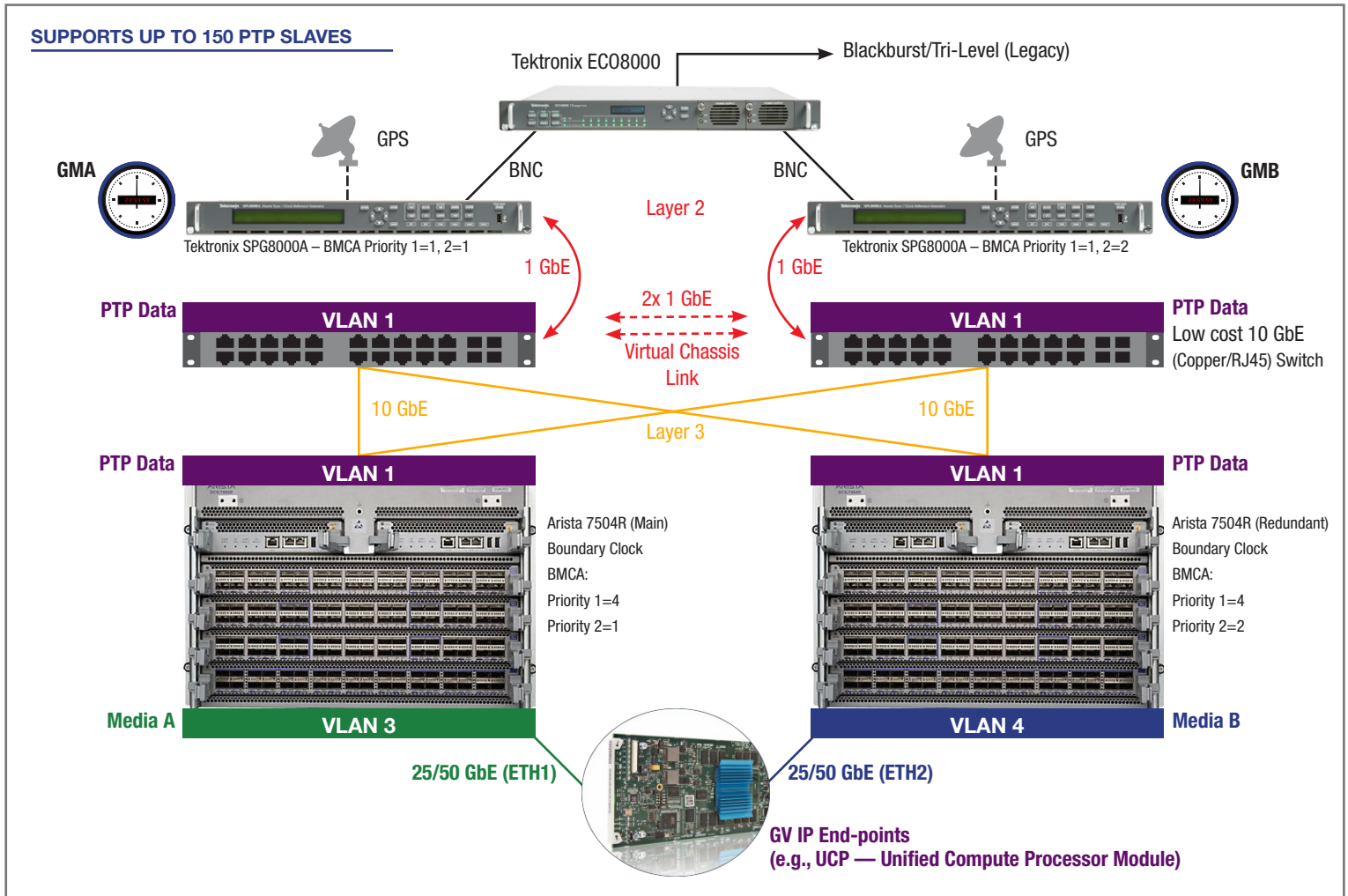


In this example, there is only a single modular media switch with redundancy covered using duplicate line cards. The system could be extended to dual media switches with VLAN 2 configured in both and with VLAN 3 (Media A) on one switch and VLAN 4 (Media B) on the redundant switch.

SYSTEM TIMING (CONT.)

Examples using Boundary Clocks

The following example uses the same set up as the previous examples with respect to the Grandmaster Clock(s) but utilizes the boundary clocks contained within the Media switches for synchronizing end-point timing. Each switch can accommodate up to 400 end-point slaves. The BMCA in each switch detects the higher priority grandmaster PTP multicast and sets the associated receiving port as a slave. Its remaining ports become “masters” for synchronizing the end-point slaves. Note the priority 1 and priority 2 BMCA settings for PTP hierarchy.



PTP System Timing Design

The PTP timing configuration will depend on system size amongst other parameters. It is advised that the proposed design and choice of equipment is checked and verified with the appropriate Grass Valley technical staff.

SYSTEM TIMING (CONT.)

References

1588-2008 – IEEE Standard

Precision Clock Synchronization Protocol for Networked Measurement and Control Systems

<http://ieeexplore.ieee.org/document/4579760/?reload=true>

ST 2059-1:2015 – SMPTE Standard

Generation and Alignment of Interface Signals to the SMPTE Epoch

<http://ieeexplore.ieee.org/document/7291827>

ST 2059-2:2015 – SMPTE Standard

SMPTE Profile for Use of IEEE-1588 Precision Time Protocol in Professional Broadcast Applications

<http://ieeexplore.ieee.org/document/7291608>

Microsemi PTP Slide Presentation

http://www.microsemi.com/document-portal/doc_view/133481-ptp-telecom-profiles-for-frequency-phase-and-time-synchronization

Qulsar PTP White Paper

https://qulsar.com/Resources/Whitepapers/1588_Ordinary_Clock.html

Tektronix PTP Reference Generator

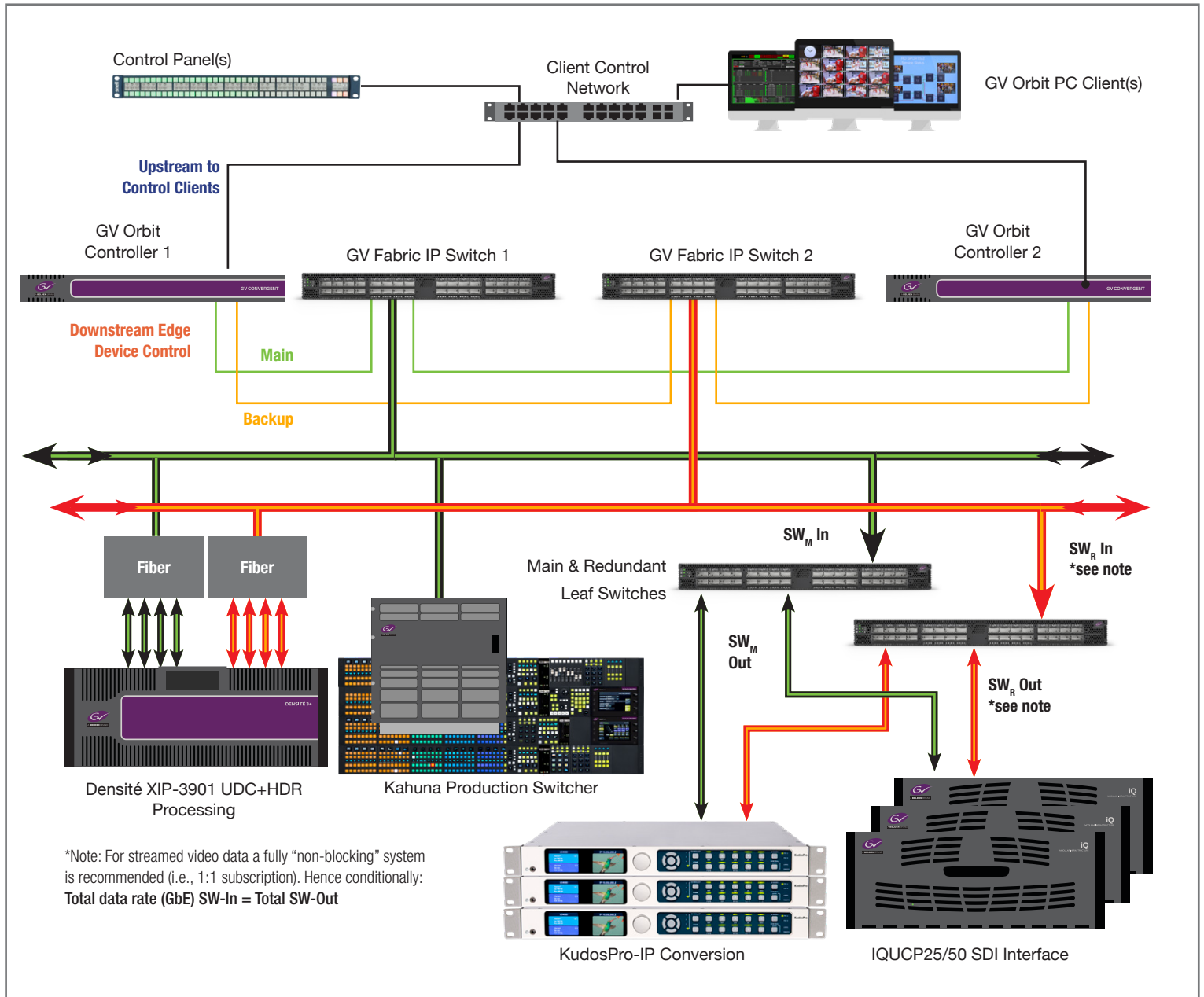
<https://www.grassvalley.com/products/spg8000a/>

<https://www.grassvalley.com/products/eco8000/>

<https://www.telestream.net/video/sync-and-reference-generators.htm>

CONTROL & MONITORING

General Information



IP Routing System Block Diagram — Fiber (SFP/QSFP) connectivity

The diagram above depicts two monolithic IP switches (in redundant configuration) with the addition of “Fiber Breakout” and “Leaf Switch” options for signal distribution and fan-out to multiple edge devices.

Overview

This section is intended to provide an overview of the constituent components required to implement a system based on Grass Valley’s IP Routing controllers.

CONTROL & MONITORING (CONT.)

System Elements

IP Routing System Controller(s)

The hub of Grass Valley's IP System is the GV Orbit Controller housed in a 1 RU COTS server. It can be deployed as a single or as dual units for redundant systems. While each physical server has dual redundant power supplies, a fully redundant system requires two servers operating in parallel.

The GV Orbit Controller is supplied with all system software pre-installed. Optional functions are license enabled. The system software consists of two main elements:

The first is the **Standard Router Controller**, based on Grass Valley traditional SDI router control software, allowing control using existing PC clients and/or hardware control panels. The second is an **IP Router Adapter** package that maps and interfaces all the IP Edge Devices to the Standard Router Controller. All the transmitted and received signals (audio, video and data) to and from all ports on the IP Edge Devices are mapped to source and destination ports named (in the normal way) in the controller.

A third component, the **IP Network Monitor**, provides configuration (and mapping) of the IP Router Adapter.

Standard Router Control Clients

The GV Orbit Controller can accommodate a virtually unlimited number of PC control clients and is fully compatible with Grass Valley's extensive range of 1 RU and 2 RU LED and LCD control panels. These are configured in the normal way and connect to the GV Orbit Controller over Ethernet.

Third-Party Control

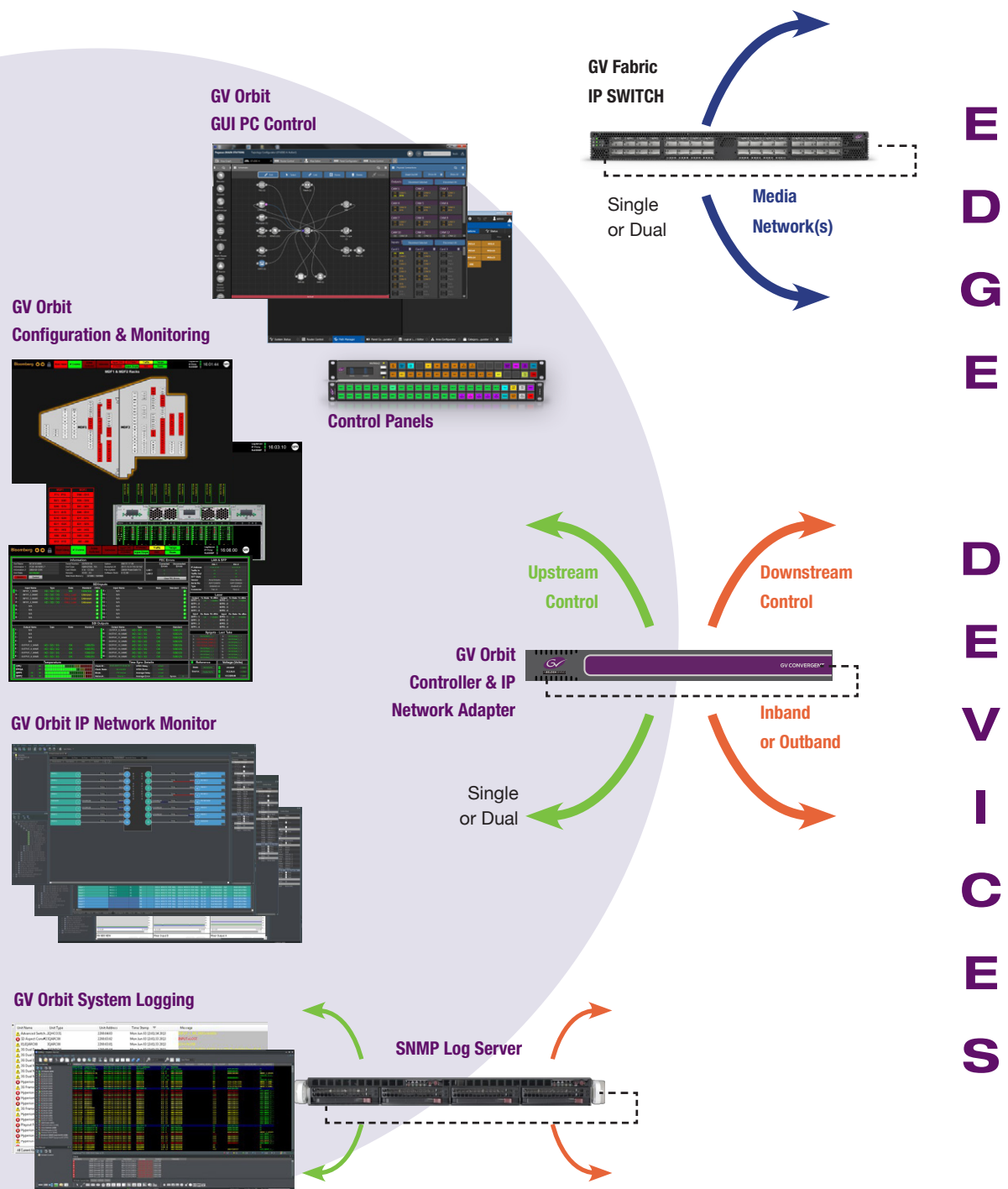
The GV Orbit Controller exposes **SW-P-02** and **SW-P-08** router control protocols over Ethernet for control by third-party clients.

CONTROL & MONITORING (CONT.)

GV Orbit Control, Configuration & Monitoring

Grass Valley can provide a complete IP control, configuration and monitoring system. The Grass Valley suite of software packages includes customizable PC screens for operational control, hardware control panels and IP network monitor for setting “source flows,” monitoring “Spigots” and device/channel bandwidths and routing status.

Full “System Logging” can be implemented on a separate SNMP server.



APPENDIX A — IP PORT STREAM CAPACITIES

General Information

IP Port Speeds & Media Streams

Grass Valley’s IP Routing System is compatible with 10 GbE, 25 GbE, 40 GbE and 100 GbE network fabrics or any combination of these Ethernet port speeds. It works with stream formats compliant with SMPTE ST 2022-6 and SMPTE ST 2110-20/30/40.

This section provides two sets of tables listing the recommended maximum number of such streams that can be supported for each of these port speeds. Maximum stream numbers are stated for both 50 Hz (fps) and 59.94 Hz (fps) systems. The table figures are used in the section titled “COTS IP Switches” to calculate the theoretical stream capacity for each of the example IP Switches depicted therein.

Notes on table values for stream data rates:

- SDI signal data rates are stated in Mb/s for SD, HD, 3G and 4K UHD
- Each Ethernet port assumes a maximum utilization factor of 90%
- A packet overhead factor is applied to the SDI data rates to obtain the uncompressed SMPTE ST 2022 and 2110 rates in Mb/s. It includes headers for the Ethernet, IP, UDP & RTP layers, plus high level stream format for SMPTE ST 2022.
- The data rate stated for compressed VC-2 HQ (SMPTE ST 2042) streams uses a nominal 2:1 compression ratio.
- For each uncompressed SMPTE 2110 and each SMPTE ST 2042 compressed stream an additional 25Mb/s is added representing 16 audio channels and metadata.

Numbers stated in the tables are for guidance purposes only. They assume all streams at the port are the same picture format (e.g., HD or 4K UHD). In real systems there is likely to be a mixture of picture formats.

Key Features

Multiple Stream Types

Grass Valley’s IP routing system works with multicast stream formats compliant with SMPTE ST 2022-6 /7 and SMPTE ST 2110-20/30/40 standards.

The system operates seamlessly when utilizing any mix of these different stream types concurrently on the same network system.

Adjustments to IP Port Stream Capacities Dependent on Switch Mechanism

Grass Valley’s IP Routing System uses “destination-timed switching.” For “break-before-make” switching, no additional port bandwidth is required and the stream capacities are as defined in “Option 1” in the following tables.

For a “make-before-break” switch, bandwidth equivalent to one spare channel/stream must be reserved to achieve an “entirely clean” frame boundary switch. Stream capacities are then modified as per “Option 2.” Option 2 assumes a single make-before-break switch at any one time. If multiple make-before-break switches are commanded at the same time, they will “ripple through” in sequence on a frame-by-frame basis.

If multiple concurrent make-before-break switches are required, then spare bandwidth must be reserved that is equivalent to the group size of the streams to be switched. The tables for “Option 3” reflect the extreme case where all streams at the port are to be switched using make-before-break on the same frame boundary.

40 GbE and 100 GbE Ports

With 40 GbE and 100 GbE ports on an IP switch, it is often assumed that media streams must be grouped into four 10 GbE or four 25 GbE distinct blocks respectively (i.e., all packets relating to a particular stream are contained in one of the four blocks). This is not the case unless specifically defined in the IP switch during configuration! Datagrams from different streams may be spread across the full 40 Gb or 100 Gb Ethernet transport bandwidth. It is only necessary to group datagrams of a particular stream together (in one of the four 10 GbE or 25 GbE paths) if the port speed of a connected device is 10 GbE or 25 GbE.

APPENDIX A — IP PORT STREAM CAPACITIES (CONT.)

Option 1

Maximum possible channel capacity, packing the Ethernet network fully with streams.

Usable with static switching or break-before-make (constant bandwidth) dynamic switching.

Option 2

Channel capacity packing the Ethernet network almost fully with streams, leaving one spare stream worth of bandwidth. Usable with static switching or break-before-make (constant bandwidth) switching or true-clean make-before-break switching, with a maximum of one destination changed at a time.

(Note: Number of Option 2 channels = Number of Option 1 channels minus 1)

Option 1 (Option 2) — IP Port Capacities for 50 Hz (fps) standards

Media Stream Type	Rate	Number of Streams per Port				
50 Hz (fps) Standards	Mb/s	1 GbE	10 GbE	25 GbE	40 GbE	100 GbE
SD 625i-50 SDI	270					
Uncompressed SMPTE ST 2022	284	3 (2)	31 (30)	79 (78)	126 (125)	317 (316)
Uncompressed SMPTE ST 2110	243	3 (2)	37 (36)	92 (91)	148 (147)	370 (369)
Compressed SMPTE ST 2042-1	123	7 (6)	73 (72)	182 (181)	292 (291)	731 (730)
HD 1080i-50 SDI	1,485					
Uncompressed SMPTE ST 2022	1,559	0	5 (4)	14 (13)	23 (22)	57 (56)
Uncompressed SMPTE ST 2110	1,114	0	8 (7)	20 (19)	32 (31)	80 (79)
Compressed SMPTE ST 2042-1	515	1 (0)	17 (16)	43 (42)	69 (68)	174 (173)
HD 1080p-50 SDI	2,970					
Uncompressed SMPTE ST 2022	3,119	0	2 (1)	7 (6)	11 (10)	28 (27)
Uncompressed SMPTE ST 2110	2,202	0	4 (3)	10 (9)	16 (15)	40 (39)
Compressed SMPTE ST 2042-1	1,005	0	8 (7)	22 (21)	35 (34)	89 (88)
4K UHD 2160p-50 SDI	12,000					
Uncompressed SMPTE ST 2022	12,600	0	0	1 (0)	2 (1)	7 (6)
Uncompressed SMPTE ST 2110	8,734	0	1 (0)	2 (1)	4 (3)	10 (9)
Compressed SMPTE ST 2042-1	3,944	0	2 (1)	5 (4)	9 (8)	22 (21)

Option 1 (Option 2) — IP Port Capacities for 59.94 Hz (fps) standards

Media Stream Type	Rate	Number of Streams per Port				
59.94 Hz (fps) Standards	Mb/s	1 GbE	10 GbE	25 GbE	40 GbE	100 GbE
SD 625i-59.94 SDI	270					
Uncompressed SMPTE ST 2022	284	3 (2)	31 (30)	79 (78)	126 (125)	317 (316)
Uncompressed SMPTE ST 2110	246	3 (2)	36 (35)	91 (90)	146 (145)	365 (364)
Compressed SMPTE ST 2042-1	125	7 (6)	72 (71)	180 (179)	289 (288)	722 (721)
HD 1080i-59.94 SDI	1,484					
Uncompressed SMPTE ST 2022	1,558	0	5 (4)	14 (13)	23 (22)	57 (56)
Uncompressed SMPTE ST 2110	1,330	0	8 (7)	16 (15)	27 (26)	67 (66)
Compressed SMPTE ST 2042-1	612	1 (0)	14 (13)	36 (35)	58 (57)	146 (145)
HD 1080p-59.94 SDI	2,970					
Uncompressed SMPTE ST 2022	3,119	0	2 (1)	7 (6)	11 (10)	28 (27)
Uncompressed SMPTE ST 2110	2,635	0	3 (2)	8 (7)	13 (12)	34 (33)
Compressed SMPTE ST 2042-1	1,200	0	7 (6)	18 (17)	30 (29)	75 (74)
UHD 2160p-59.94 SDI	12,000					
Uncompressed SMPTE ST 2022	12,600	0	0	1 (0)	2 (1)	7 (6)
Uncompressed SMPTE ST 2110	10,466	0	0	2 (1)	3 (2)	8 (7)
Compressed SMPTE ST 2042-1	4,723	0	1 (0)	4 (3)	7 (6)	19 (18)

APPENDIX A — IP PORT STREAM CAPACITIES (CONT.)

Option 3

Channel capacity using no more than half the Ethernet bandwidth, leaving 50% spare bandwidth for clean switching. Usable with static switching, or break-before-make (constant bandwidth) switching; or true-clean make-before-break switching, with every destination able to be changed on the same frame.

Option 3 — IP Port Capacities for 50 Hz (fps) standards

Media Stream Type	Rate	Number of Streams per Port				
50 Hz (fps) Standards	Mb/s	1 GbE	10 GbE	25 GbE	40 GbE	100 GbE
SD 625i-50 SDI	270					
Uncompressed SMPTE ST 2022	284	1	15	39	63	158
Uncompressed SMPTE ST 2110	243	1	18	46	74	185
Compressed SMPTE ST 2042-1	123	3	36	91	146	365
HD 1080i-50 SDI	1,485					
Uncompressed SMPTE ST 2022	1,559	0	2	7	11	28
Uncompressed SMPTE ST 2110	1,114	0	4	10	16	40
Compressed SMPTE ST 2042-1	515	0	8	21	34	87
HD 1080p-50 SDI	2,970					
Uncompressed SMPTE ST 2022	3,119	0	1	3	5	14
Uncompressed SMPTE ST 2110	2,202	0	2	5	8	20
Compressed SMPTE ST 2042-1	1,005	0	4	11	17	44
4K UHD 2160p-50 SDI	12,000					
Uncompressed SMPTE ST 2022	12,600	0	0	0	1	3
Uncompressed SMPTE ST 2110	8,734	0	0	1	2	5
Compressed SMPTE ST 2042-1	3,944	0	1	2	4	11

Option 3 — IP Port Capacities for 59.94 Hz (fps) standards

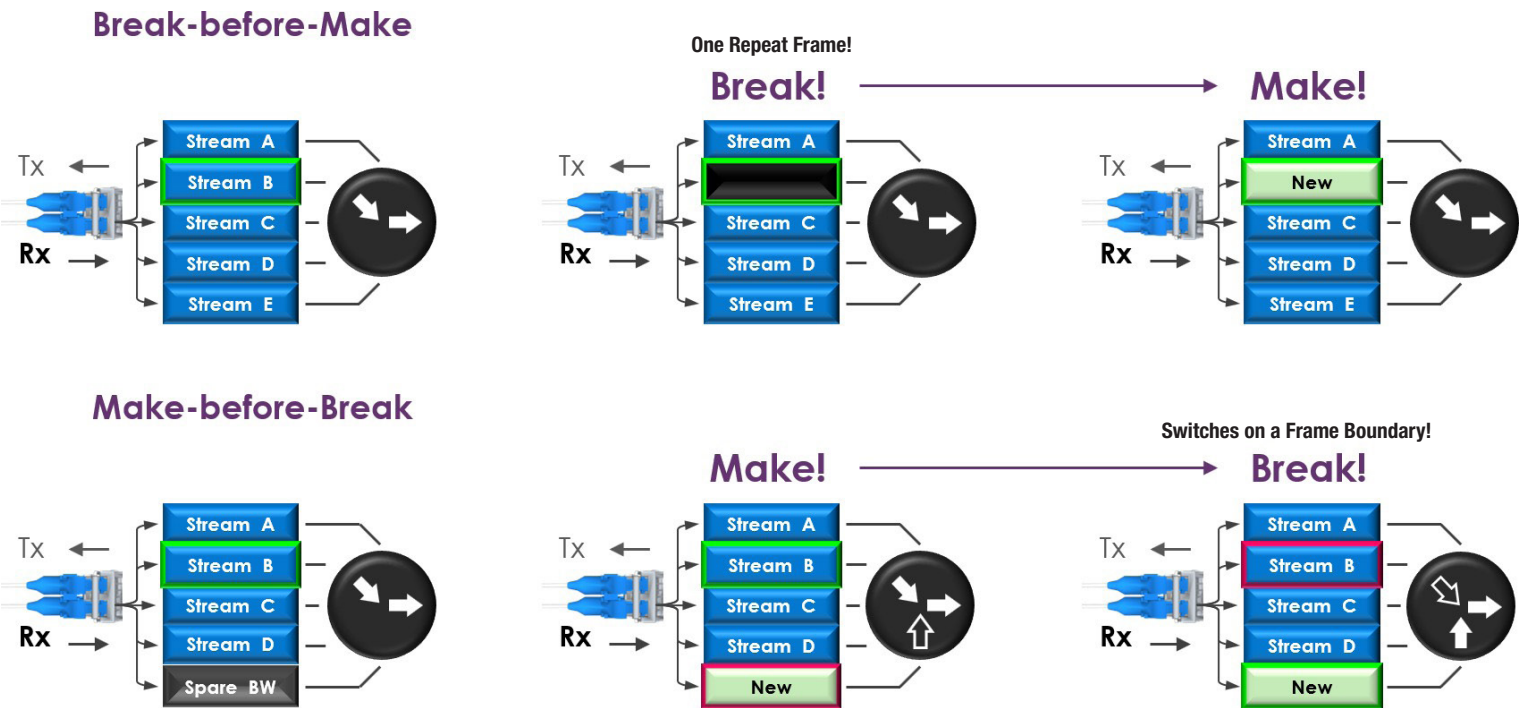
Media Stream Type	Rate	Number of Streams per Port				
59.94 Hz (fps) Standards	Mb/s	1 GbE	10 GbE	25 GbE	40 GbE	100 GbE
SD 625i-59.94 SDI	270					
Uncompressed SMPTE ST 2022	284	1	15	39	63	158
Uncompressed SMPTE ST 2110	246	1	18	45	73	182
Compressed SMPTE ST 2042-1	125	3	36	90	144	361
HD 1080i-59.94 SDI	1,485					
Uncompressed SMPTE ST 2022	1,558	0	2	7	11	28
Uncompressed SMPTE ST 2110	1,330	0	4	8	13	33
Compressed SMPTE ST 2042-1	612	0	7	18	29	73
HD 1080p-59.94 SDI	2,970					
Uncompressed SMPTE ST 2022	3,119	0	1	3	5	14
Uncompressed SMPTE ST 2110	2,635	0	1	4	6	17
Compressed SMPTE ST 2042-1	1,200	0	3	9	15	37
4K UHD 2160p-59.94 SDI	12,000					
Uncompressed SMPTE ST 2022	12,600	0	0	0	1	3
Uncompressed SMPTE ST 2110	10,466	0	0	1	1	4
Compressed SMPTE ST 2042-1	4,723	0	0	2	3	9

APPENDIX B –IP STREAM SWITCHING

Alternative Switch Mechanisms

In “**break-before-make**” or static switching, an IP stream (e.g., **Stream B**) is “dropped” by the host device and a “**New**” stream is “called.” If the host device includes a synchronizer, then the disturbance will be minimal with a single blank/black frame displayed during the switch or “break.” A **clean, very fast and visibly undetectable switch** can be implemented by repeating the last picture frame from the dropped stream.

In “**make-before-break**” or dynamic switching, additional link bandwidth is required for the duration of the switch. The IP stream to be replaced (e.g., Stream B) is retained while the “**New**” stream is “called.” A **completely clean switch is made on the synchronized frame boundaries**. There are no repeated picture frames.



FAQ

How do I select Static or Dynamic switching?

Each signal channel path can be independently set/configured in the host device for break-before- make or make-before-break- ing switching.

Salvos — What happens when dynamically switching multiple streams simultaneously?

In multichannel make-before-break switching, there must be adequate spare bandwidth to accommodate all the new streams simultaneously. If this is not the case or it is impractical, then the host will “ripple through” each channel switch using the available spare bandwidth.