A Guide to
IP Systems

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A Guide to IP Systems Index

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 **GV'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 on offer.

1. IP Port Stream Capacities

1.1 General Information

Appendix A - Option Tables

Appendix B - IP Stream Switching

IP Port Speeds & Media Streams

GV offers **IP Routing Systems** capable of supporting **10GbE**, **25GbE**, **40GbE** and **100GbE** 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.

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

Appendix A to this document provides two sets of tables listing the maximum number of SMPTE 2022-6 and 2110 streams that can be supported for each port speed. Maximum stream numbers are stated for both 50Hz FPS and 59.94Hz 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 (frames per second) 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*.

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

Media Stream Type	Rate	Number of Streams per Port			
59.94Hz FPS Standards	Mbit/s	10GbE	25GbE	40GbE	100GbE
HD 1080i-59.94 SDI	1,484				
Uncompressed 2022	1,558	5	14	23	57
Uncompressed 2110	1,330	8	16	27	67
HD 1080P-59.94 SDI	2,970				
Uncompressed 2022	3,119	2	7	11	28
Uncompressed 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.

2. Connections & Cabling

2.1 Introduction

2.2 Copper Connectivity

2.3 Fiber Connectivity

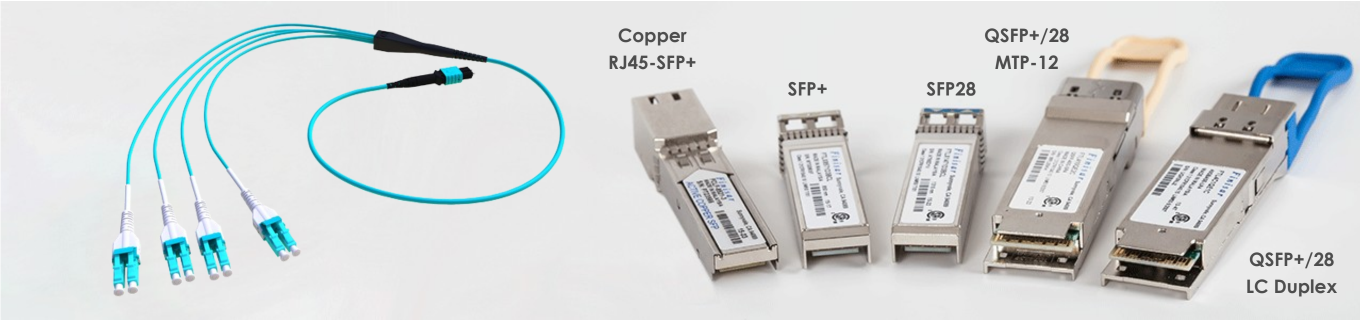
Fiber Cable
The SFP (Small Form-factor Pluggable)
The QSFP (Quad-SFP)
Fiber Breakout Cables

2.4 References

Section 2.1

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 centred around a single monolithic IP switch or a 'spine and leaf' arrangement of multiple switches.

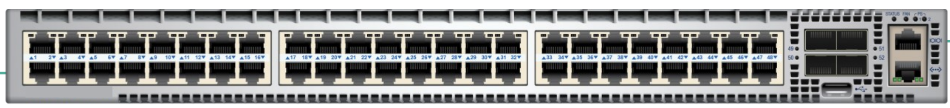
Early implementations for such LANs targeted the use of a 10GbE backbone, but advances in switch technology mean we are now seeing the deployment of 25GbE, 40GbE and 100GbE capable products.

Whilst a 10GbE 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 25GbE, 40GbE, and 100GbE necessitate the use of fiber cabling which not only provides almost unlimited bandwidth, but is immune to electromagnetic interference.

Section B2.2

Connections & Cabling

Copper Connectivity



RJ45 **10GbE IP switch with 48 'copper' RJ45 ports and 4 SFP ports** **Copper RJ45-SFP**

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

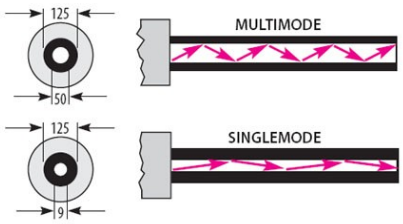
IEEE 802.3an specifies the minimum reach distances for 'Twisted-pair' CAT6 and CAT6A cables using RJ45 connectors. These are 30-40m (98-168ft) and 100m (328ft) respectively.

Whilst considered in earlier years, LAN networks based purely on copper connectivity for broadcast applications are highly restrictive and <u>very unlikely</u> to be adopted for 'Greenfield' systems!

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 so significant but MMF is considered easier to work with in terms of flexibility and robustness.
Both MMF and SMF are used in broadcast & media IP system applications.



All dimensions in microns (µm)

Link Distance/Reach

MMF is generally useful up to **300m** at10Gbit/s to 100Gbit/s data rates.
SMF is capable of **100km** and beyond. Most major vendors offer SFP variants with a reach of 80km.

MMF Grades (OM3 & OM4)

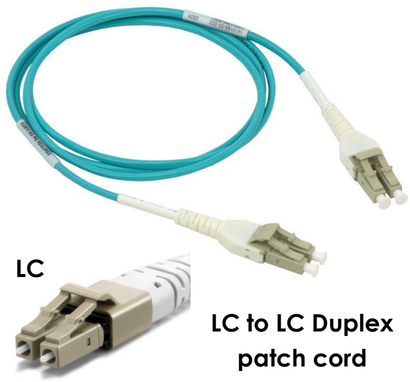
The designations **OM3** and **OM4** are often quoted for **50/125 µm MMF**. These are fabricated differently resulting in lower optical attention in OM4 (<3.0 dB/km) than in OM3 (<3.5 dB/km). Whilst OM3 is more widespread, OM4 is becoming more popular with the advent of 40GbE and 100GbE networks despite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

Cables and Connectors

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

1. 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.**

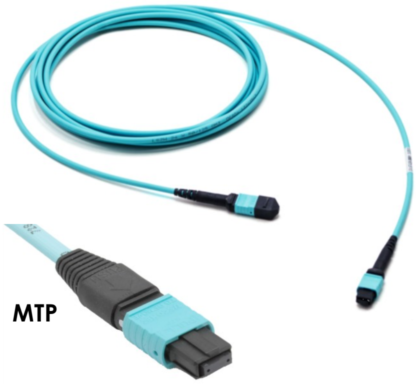


LC to LC Duplex patch cord

2. MPO/MTP Multi-core MMF or SMF cable

The MPO/MTP is the specified connector for 'short range' QSFP devices (see later) where the I/O comprises 4 sets of TX/RX data streams. MPO/MTP connectors can accommodate from 2 to 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 **M**ulti-fiber-**P**ush-**O**n. It is a multi-fiber 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.*



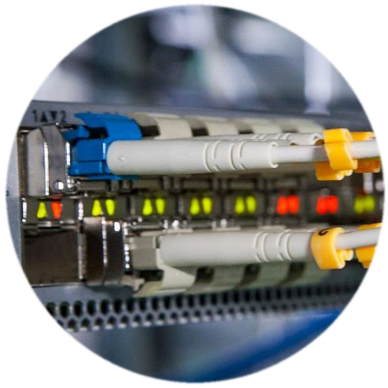
MTP to MTP Multi-core patch cord

Section 2.3
Connections & Cabling
Fiber Connectivity

The SFP

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 multi-source 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** (multi-mode) or **SMF** (single-mode) fiber.



SFP LC Duplex connection

SFP modules are available in several different categories:

SFP (100Mbit/s to 8 Gbit/s)
The 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 100MbE and 1GbE devices for system control networking.

SFP+ (10 Gbit/s)
The SFP+ is an enhanced version of the SFP that can support data rates up to 16 Gbit/s.
For broadcasting and media IP routing the SFP+ is an important building block for 10GbE connectivity. In time, it's usefulness may be surpassed by the SFP28 which enables 25GbE connectivity.

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

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

Some of the most common types are:

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

The suffices **-SR**, **-LR** and **-ER** stand for 'Short Range', 'Long Range' and 'Extended Range' respectively.
Typical maximum link lengths specified are **300m** over OM4 MMF (SR), **10km** (LR) and **40km** (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- 2km** 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 25GbE Link Distances
There are equivalent SFP28 types to the SFP+ stated above. Maximum link distances are essentially the same.

DDM/DOM

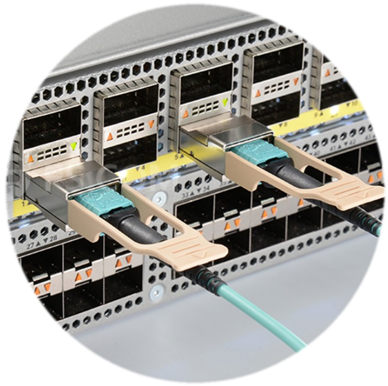
SFP and **QSFP** (see later) transceivers support standard diagnostics monitoring (**DDM**) or, as it's sometimes called, digital optical monitoring (**DOM**). This enables monitoring of parameters such as optical output power, optical input power, temperature, laser bias current, and transceiver supply voltage, in real time.
GV'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.

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 multi-core 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 de-multiplex 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 multi-core 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**) multi-channel transmission over multi-core **OM3** & **OM4 MMF** (multimode) cable. Typical maximum link lengths specified are **100m** for OM3 and **150m** for OM4.

The three most applicable QSFP MPO/MTP module types are:

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

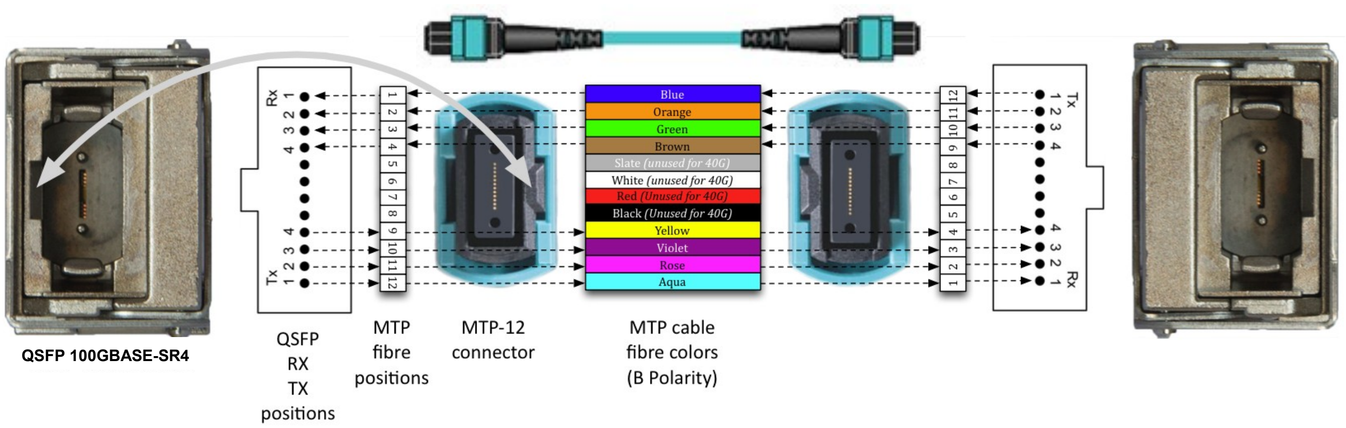
The 40G & 100G SR4 types connect **4x 10GbE** or **4x 25GbE** sets of media data respectively. They use 8 of the 12 lanes in an MTP-12 MMF cable.

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

View looking into QSFP

QSFP MPO/MTP Connection

The diagram below depicts a **Female-Female Type B MTP-12** cable for interconnecting two QSFP 100GbE-SR4 modules (..also for use with QSFP 40GbE-SR4 devices). '**Type B**' refers to the fact that this is a 'cross-over' cable. *(Other MTP cable types include '**Type A**' and '**Type C**' which are 'Straight-through' and 'Cross-pair' Trunk cables for fiber network patching qnd adapters or other links requiring alternative connector polarities.)*

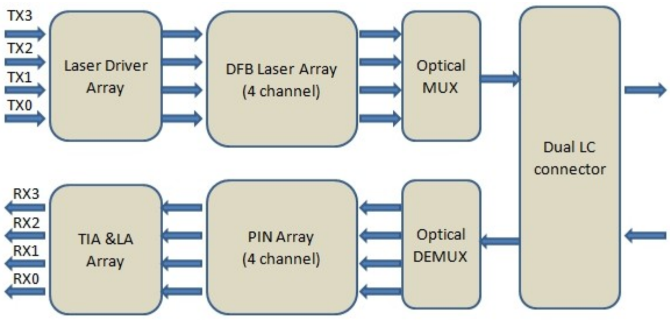


Interconnection of 2x QSFP 100GBASE-SR4 using MTP-12 (Type B) MMF cable

The QSFP (Quad-SFP) cont'd..

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 to 40km for SMF depending on the optical devices fitted. The LC Duplex (single TX+RX) connection is achieved by multiplexing and de-multiplexing the 4 sets of stream data using **WDM** (Wave-Division-Multiplex) blocks incorporated within the QSFP itself (see below).



QSFP 40/100GbE 4-lane optical MUX/DEMUX block

QSFP LC Duplex connection

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** (multi-source agreement) and/or are **IEEE 802.3ba** designated types.

Some of the most common types are:

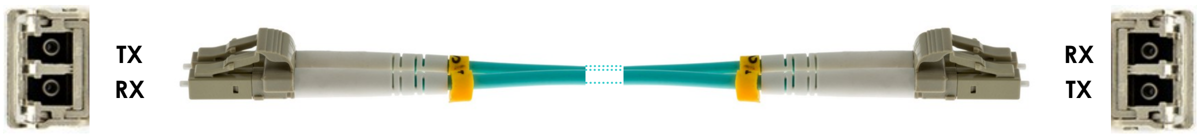
QSFP 40GbE-LR4; QSFP 40GbE-ER4; QSFP 100GbE-LR4; QSFP 100GbE-ER4

The 40G & 100G types connect **4x 10GbE** or **4x 25GbE** sets of media data respectively. All these types use DFB optical laser arrays with wavelength centred around **1300nm**.
(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 **10km** and **30-40km** 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- 2km** and is consequently a lower cost option. The - LRL4 is, to all intense 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 with simply adopt a maximum reach defined by the lower spec device.



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

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

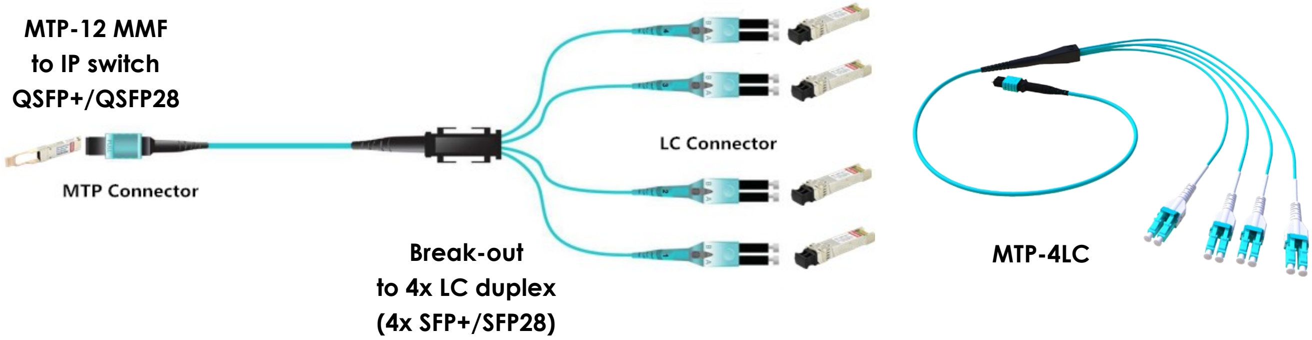
4x 10Gbe Channels = **QSFP+** 4x 25GbE Channels = **QSFP28**

Fiber Breakout Cables

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

40GbE and 100GbE 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 10Gbits or 25Gbit/s respectively. This is replicated for both the TX and RX paths (i.e. 4x TX & 4x RX).
In normal mode all the 40Gbit/s of data in a 40GbE 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 40GbE port.
An alternative mode is possible where, again taking the 40GbE port as an example, the four sets of 10Gbit/s data are intended for connection to four independent 10GbE 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 40GbE/100GbE port in the configuration file of the switch.

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

References

- **100GbE 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 Tranceivers 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

3. COTS IP Switches

3.1 General Information

3.2 Example Switch Types

GV Fabric Fixed Switches
Other Fixed Switches
Arista Modular Switches
Cisco Modular Switches

3.3 References

COTS IP Switch Parameters

GV'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 to 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 Tbits/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 **I**nternet **G**roup **M**anagement **P**rotocol is used by clients & adjacent routers on IPv4 networks to establish multicast group memberships

- Must support **PIM-SSM**
  Protocol **I**ndependent **M**ulticast - **S**ource **S**pecific **M**ulticast between routers & subnets.

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 GV has direct experience in both delivered systems and/or in-house test systems.

Consultation with GV is recommended when choosing your COTS Ethernet Switch.

Additional Considerations

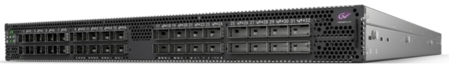
- **SDN** (Software Defined Network)
  Whilst all the switch types detailed are capable of operating in an SDN environment, GV's IP Routing system can be based on a topology that inherently does not require SDN control. In such cases it uses IGMPv3 in a non-blocking multi-cast design only for communication 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 like (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 or 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.

Section 3.2
COTS IP Switches
GV Fabric - Fixed Switches

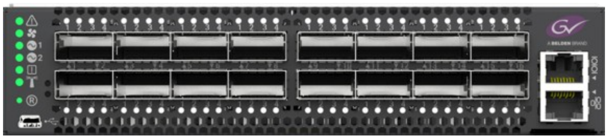
GVF-516-100G, GV-1032-100G



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

GV-516-100G - Ports: 16x 100GbE (QSFP) + 1x 10/100/1000Mb/s RJ45 ENET MGMT + 1x RJ45 Serial + 1x Mini USB
Flexible interface configurations: **16x 100GbE**, **16x 40GbE, 32x 50GbE, 64x 25GbE**, **64x 10GbE**

Front View



Rear View

GV-1032-100G - Ports: 32x 100GbE (QSFP) + 2x 10/100/1000Mb/s RJ45 ENET MGMT + 1x RJ45 Serial port + 1x USB
Flexible interface configurations: **32x 100GbE**, **32x 40GbE, 64x 50GbE, 64x 25GbE**, **64x 10GbE**

Front View

Rear View

GV Fabric Series Performance

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

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

Video Media 2110-20	GV-516- 100G				GV-1032- 100G			
	10GbE	25GbE	40GbE	100GbE	10GbE	25GbE	40GbE	100GbE
	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
UHD (50 fps)	64	128	64	160	64	128	128	320
UHD (59.94 fps)	0	128	48	128	0	128	96	256

Notes: (a). Each figure means no. 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 UHD). Hence numbers are for guideline only!

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 1U chassis.
It supports a combination of speeds of 10/25/40/50 & 100GbE.

CISCO Nexus 9236C

The **Nexus 9236C** is a high performance, high density 36-port QSFP switch housed in a 1U chassis.

It supports a combination of speeds of 10/25/40/50 & 100GbE.

CISCO Nexus 9272Q

The **Nexus 9272Q** is a high performance, high density 72-port QSFP switch housed in a 2U chassis.

It supports port speeds of 10GbE & 40GbE.

JUNIPER NETWORKS QFX5200-32C

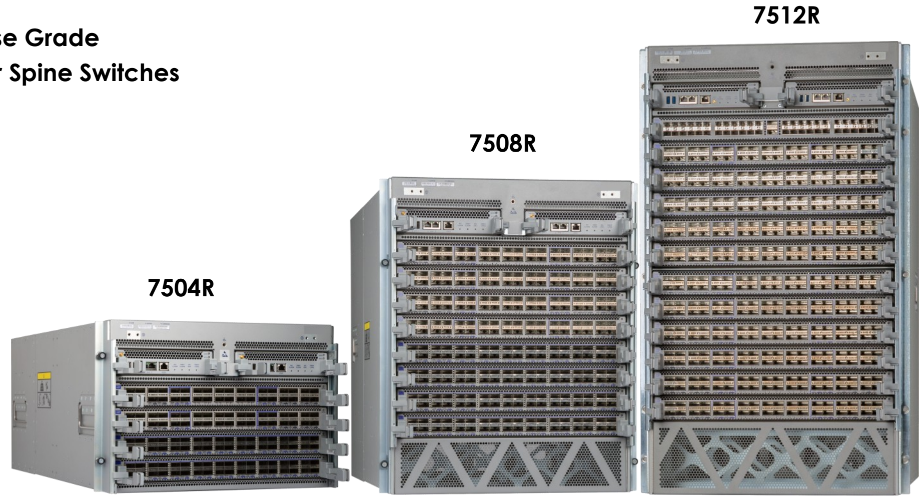
The **QFX5200-32C** is a high performance, high density 32-port QSFP switch housed in a 1U chassis.

It supports a combination of speeds of 10/25/40/50 & 100GbE.

ARISTA 7500R Series

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

Enterprise Grade
Modular Spine Switches



7500R Series System Performance

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

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

Video Media TR-03	7504R				7508R				7512R			
	10GbE	25GbE	40GbE	100GbE	10GbE	25GbE	40GbE	100GbE	10GbE	25GbE	40GbE	100GbE
	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
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
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 no. 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 only!

Scope of Supply

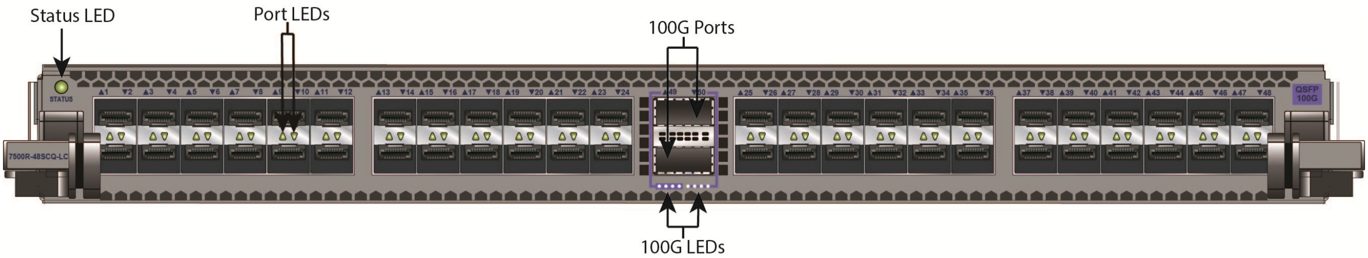
1. 7500R Series switches are supplied as a 'Chassis bundle' which includes the chassis, power supplies, cooling assemblies and switch fabric modules (5+1 redundancy). One 'Supervisor' control module is also included.
2. A second Supervisor module must be ordered separately if 1+1 redundant controllers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

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 10GbE, 25GbE, 40GbE or 100GbE 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).

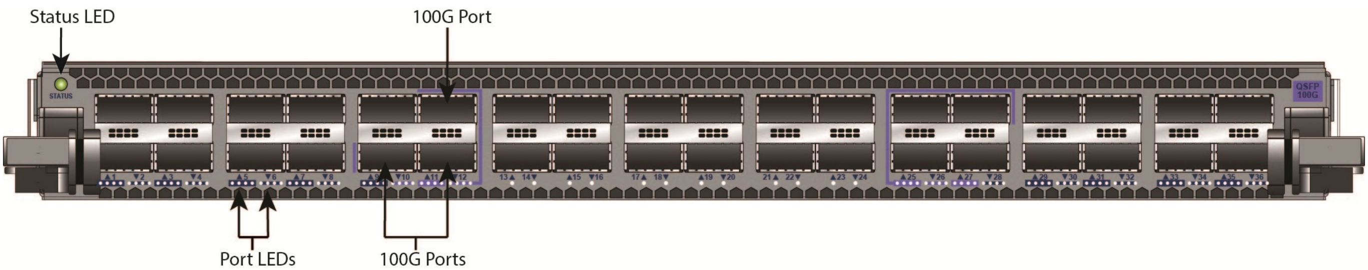
DCS-7500R-48S2CQ-LC

Up to 56x 10GbE ports <u>**or**</u> 48x 10GbE (SFP+) ports + 2x 100GbE (QSFP28) ports.
QSFP28 ports can be configured as **2x 100GbE** or **4x 25GbE** or **2x 40GbE** or **8x 10GbE**.



DCS-7500R-36Q-LC

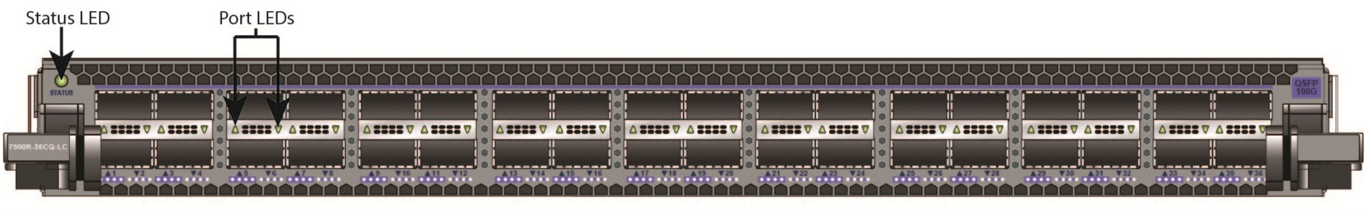
Up to 36 x 40GbE (QSFP+) ports <u>**or**</u> 24 x 40GbE (QSFP+) ports + 6 x 100GbE (QSFP28) ports.
24 x QSFP+ ports can be configured as **96x 10GbE** and/or **6x QSFP28** ports can be configured as **24x 25GbE ports**.



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

Preferred type!

36 x 100GbE (QSFP28) ports.
This is the <u>most flexible</u> and highest density line card with the greatest data throughput.
All QSFP28 ports can be independently configured as **100GbE** or **2x 50GbE** or **4x 25GbE** or **40GbE** or **4x 10GbE**.



Section 3.2
COTS IP Switches
Cisco Modular Switches

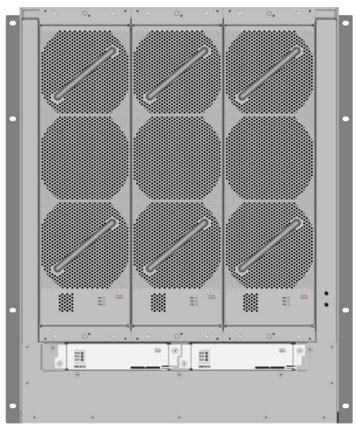
Nexus 9508

Enterprise Grade
Modular Spine Switch

x8 Line Card capacity

Front to back airflow

Rear View



Nexus 9508 Series System Performance

				Recommended by GV			
Model Number	**Switching Capacity**	**Linecard Capacity**	**10GbE Ports**	**25GbE Ports**	**40GbE Ports**	**100GbE Ports**	**Rack Units**
N9K-C9508	75Tbps	8 x 9.6Tbps	1,152	1,152	288	288	13

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

Video Media TR-03	9508 10GbE 1,152	25GbE 1,152	40GbE 288	100GbE 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
UHD (50 fps)	1,152	2,304	1,152	2,880
UHD (59.94 fps)	0	2,304	864	2,304

Notes: (a). Each figure means no. 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 only!

Scope of Supply

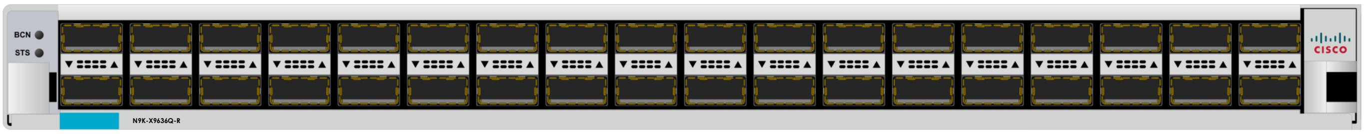
1. The 9508 switch is supplied as a 'Chassis bundle' which includes the chassis, power supplies (x3), system controllers (x2), Supervisor/SUP-B control module (x1), cooling trays and switch fabric modules (x6).
2. A second Supervisor/SUP-B module must be ordered separately if 1+1 redundant controllers 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)

Section 3.2
COTS IP Switches
Cisco Modular Switches - Line Cards

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

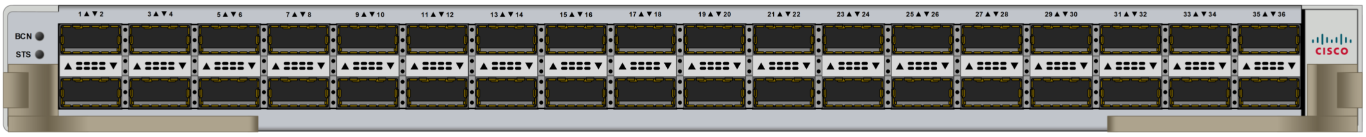
* The maximum number of 10GbE, 25GbE, 40GbE or 100GbE ports for the chassis (see tables on the previous page) is derived assuming line card **N9K-X9636C-R** is fitted in all slots (see bottom of page).

N9K-X9636Q-R
36x 40GbE (QSFP+) ports.
All **QSFP+** ports can be independently configured as **40GbE** or **4x 10GbE**.



N9K-X9636C-R **(Highest Data Capacity)***
36x 100GbE (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 **100GbE** or **4x 25GbE** or **40GbE** or **4x 10GbE**.

Preferred type!



References

- **GV Fabric 1U 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

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4. Edge Devices

4.1 General Information

4.2 GV Products

GV Portfolio
Licensing

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.

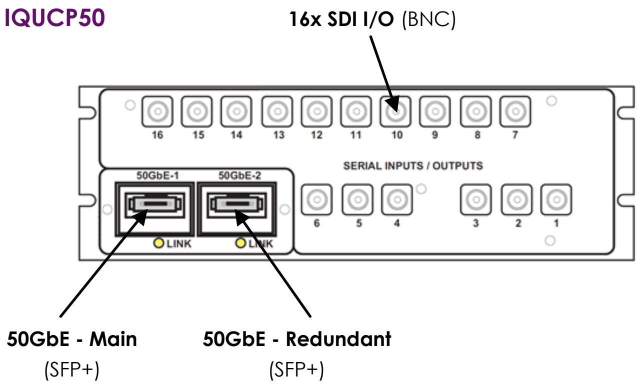
GV Edge Devices

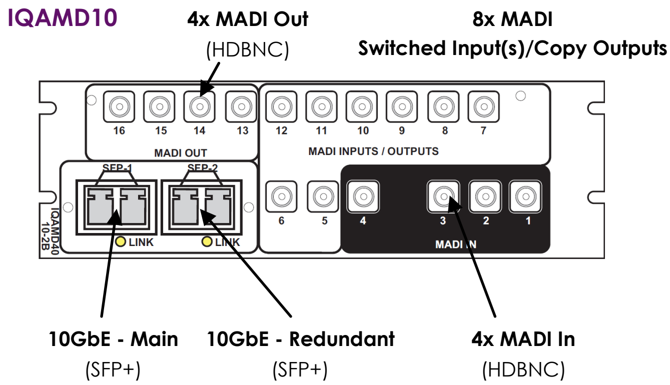
The majority of GV products now feature IP ports either as standard or as optional interfaces facilitating their use as Edge Devices in an IP network. A list of GV IP products is given on the next page. Datasheets are available for all the products giving details of their respective GbE interfaces and available data rates.
All products feature dual Ethernet ports for implementing SMPTE 2022-7 signal redundancy for hitless switching.

Third-Party Edge Devices

GV 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 GV Sales.

Examples - GV Edge Device Connectivity

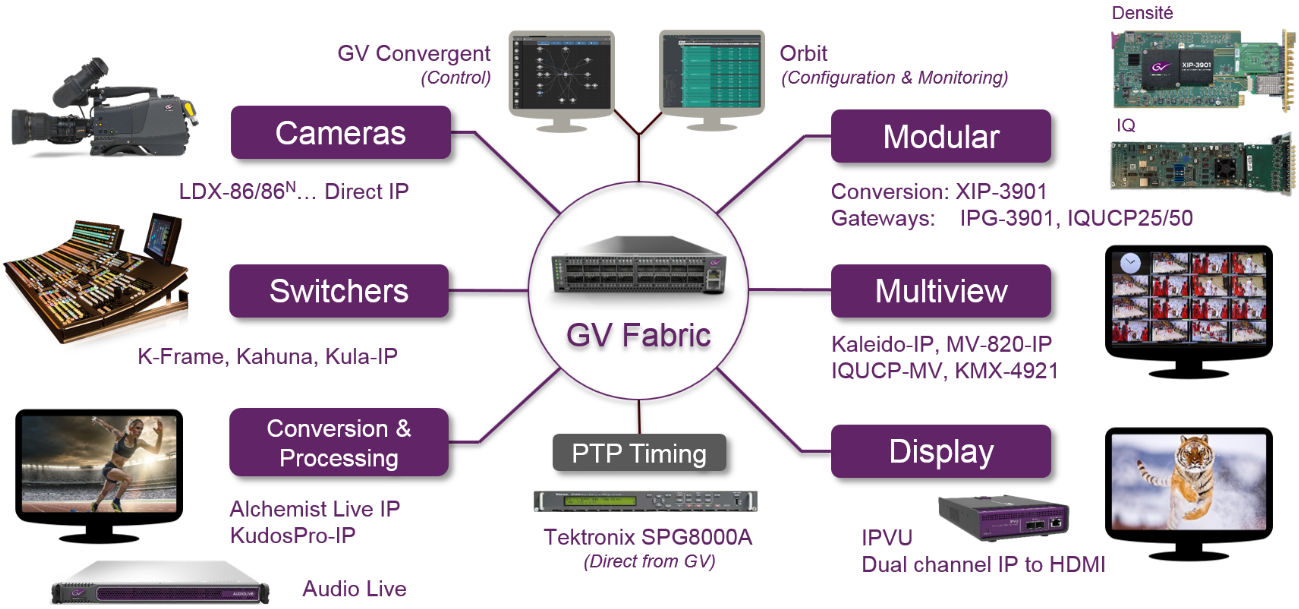




Section 4.2
Edge Devices
GV Products

GV Portfolio

GV can supply all the key components for your IP Routing system including the COTS Ethernet Switch(es).



Control, Configuration & Monitoring	
GV Convergent	Control: IP Routing System Controller - Single or dual redundant turnkey server options. GUI & LED/LCD panels.
Orbit	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 & 100GbE Two variants: 32-Port 100GbE QSFP 1RU, 16-Port 100GbE QSFP 1/2 width 1RU
Cameras	
LDX 86 & LDX86N	High-speed, 4K-capable cameras. Uses XF Transmission Direct IP connection - *4x 10GbE interfaces*
Production Switchers (IP I/O)	
Kayenne K-Frame	K-FRM-IO-10GE IP I/O card, TICO compression for 4K/12G - *10GbE interface*
Karrera K-Frame	K-FRM-IO-10GE IP I/O card, TICO compression for 4K/12G - *10GbE interface*
GV Korona K-Frame	K-FRM-IO-10GE IP I/O card, TICO compression for 4K/12G - *10GbE interface*
Kahuna	I/O cards (fins) for Kahuna 9600/6400/4800 'High End' switcher - *40GbE/50GbE interfaces*
Kula	I/O cards (fins) for Kula switcher - *40GbE/50GbE interfaces*
Processing & Conversion	
Alchemist Live IP	Motion-compensated Framerate Conversion for Live Media Streams, SD to 4K UHD & 4K DCI - *100GbE interface*
KPRO-IPLC410	'Utility' quad channel frame/format converter. Includes video & audio processing - *10GbE interface*
KPRO-IPSV410	'International' quad channel format converter. Includes video & audio processing - *10GbE interface*
KPRO-IPMC210	Dual channel motion compensated frame rate converter. Includes video & audio processing - *10GbE interface*
Audio Live	Multi-channel audio routing (2,048 x 2048) & processing software for Live Multi-stream IP - *10GbE/40GbE interfaces*

Section 4.2
Edge Devices
GV Products

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 -*10GbE interface*
XIP-3901	Agile SDI<>IP Processing Platform, Up/Down/Cross & HDR, 4K UHD 3G/HD/SD-SDI, 8 inputs/8 outputs –*25GbE interface*

IQ Modular System

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

Multiviewers

MV820-IP	IP '2U Boxed' Multiviewer. Up to 48 inputs, Up to 12x UHD 4K SDI/IP outputs - *4x 100GbE QSFP interfaces*
MV800-DT	Desktop software IP Multiviewer - *H.264 streams @25Mbit/s max. interface*
Kaleido-IP	SD, HD and 4K UHD IP Video Multiviewer -*10/25GbE SFP, 40/100GbE QSFP interfaces*
IQUCP-MV	IQ Modular multiviewer card. Up to 12 inputs/4 outputs - *25GbE SFP/50GbE QSFP interfaces*

Display

IPVU	Compact Dual Channel IP to HDMI converter. Vesa mounting bracket - *10GbE/25GbE SFP interfaces*

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

GV 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 GV and third-party devices.
In addition, there is a license fee levied for each 'clean switch' control at a logical destination.

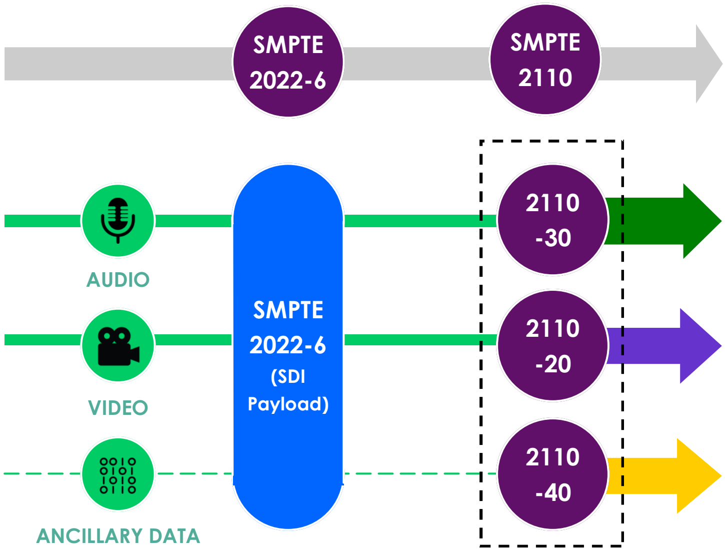
The license types are listed below:

IP Stream Video Output Licences

GVC-OUT-IP	License for control of 1 IP switch output video stream (Note: 2022-07 redundancy requires 2 licenses)
GVC-IP-CS	License for IP Clean Switch Control of 1 logical destination in GV-Convergent (Requires sufficient GVC-OUT-IP license to support 'make-before-break' workflow and is hardware dependent.

5. System Timing

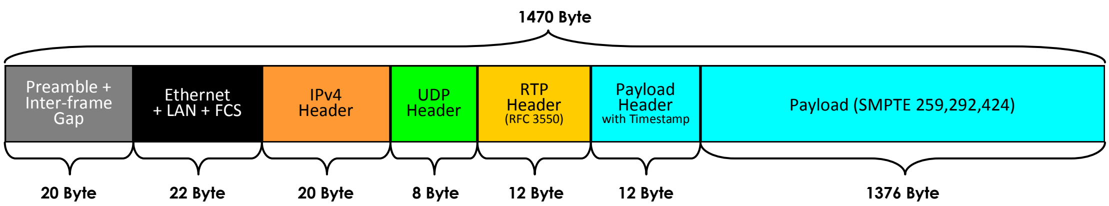
System timing is a critical aspect of any IP routing system. In traditional SDI systems, video and audio signals are synchronised to a continuous reference source and 'delay blocks' added to correct for lipsync errors. In 'packetized' IP systems data must be continually time-stamped for re-alignment downstream.



The diagram above summarises two 'packetizing' options used for multicast streamed media data.

With **SMPTE 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 (Lipsync) is maintained. Multicast SMPTE 2022-6 packets from a source could simply be accumulated at a receiver, de-capsulated 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 2022-7** redundancy switching. This mechanism can be applied to all types of streams and not just SMPTE 2022-6.

With **SMPTE 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 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 .



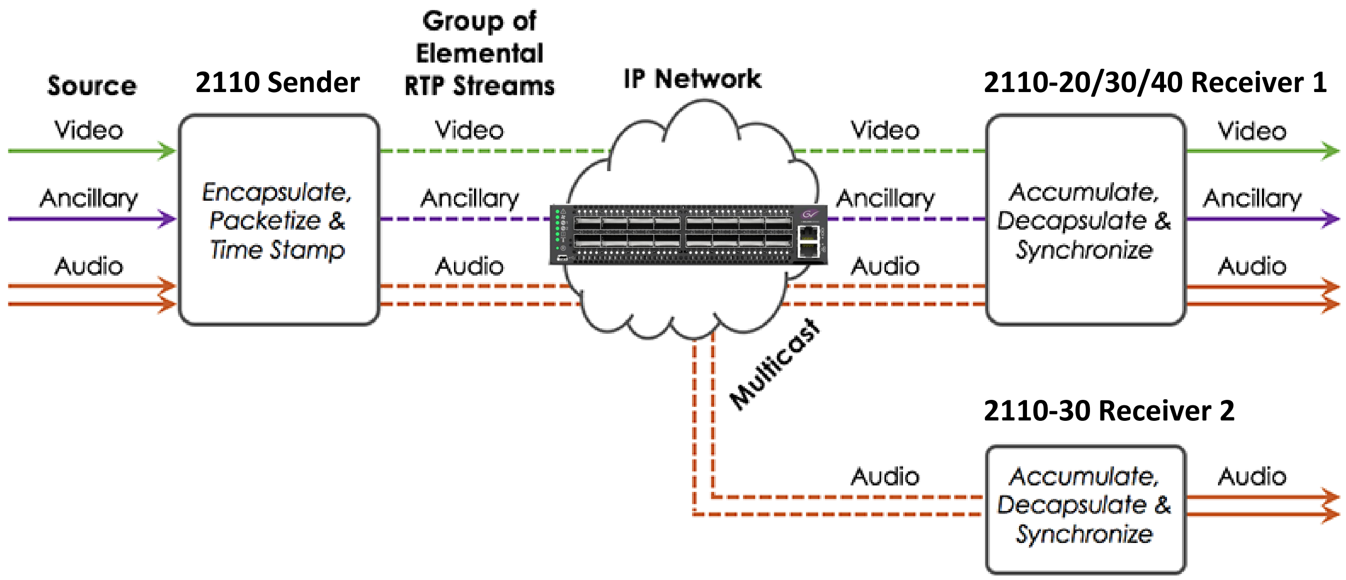
The relevant item in the packet structure is the inclusion of timestamp data in the payload header.
The remaining parts of this section show how the timestamp is used and how it's implemented in a real system.

Basic Concept

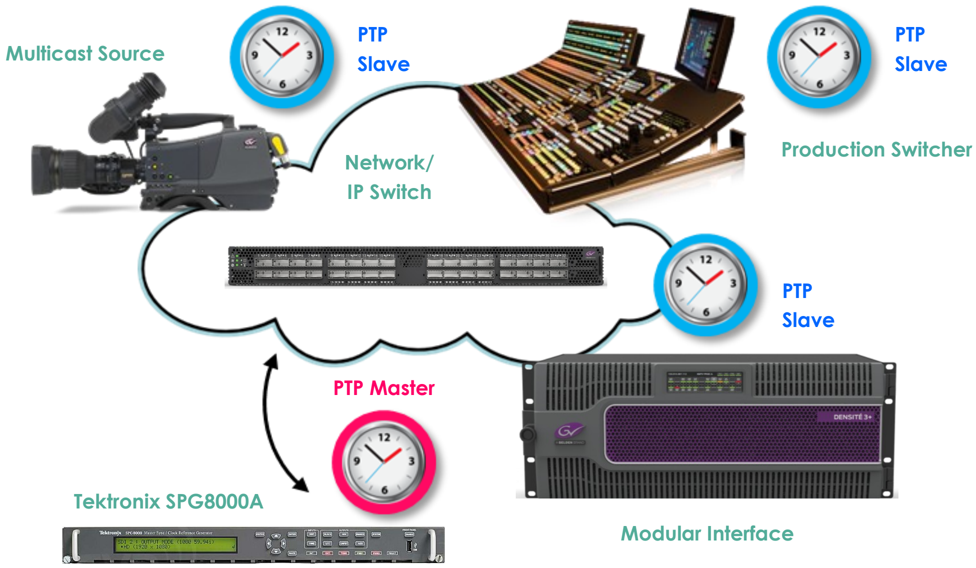
The diagram below outlines the basic concept whereby timestamps are used to re-align media data.
Baseband video, ancillary data and audio are encapsulated and packetized in the '**2110 Sender**' into separate (elemental) multicast RTP streams. Each '**2110 Receiver**' then 'declares' (to the IP switch) 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.



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 synchronise 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 lipsync.

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 synchronise 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.

PTP Clock Types

A PTP network is made up of PTP-enabled devices. There are 4 mains types of PTP Clock:

Grandmaster Clock: The primary source of time for clock synchronization using PTP. It usually has a very precise time source, such as a 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.

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 look out 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.

PTP Reference Generators

The Tektronix **SPG8000A** Master Sync/Master Clock Reference Generator (see Figure 1) provides multiple video reference signals such as black-burst, HD tri-level sync plus SDI and analog test patterns.
For IP installations it supports Precision Time Protocol (PTPv.2) IEEE 1588.

Figure 1 **Tektronix SPG8000A**

Multi-format SDI references, 1x PTP (RJ45), 1x PTP(SFP), Free-run, Genlock or GPS

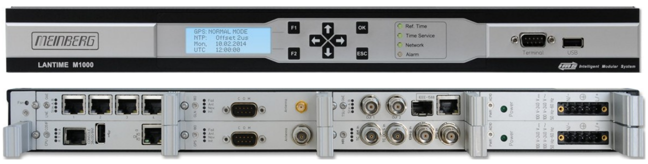


Figure 2 **Meinberg LANTIME M1000**

Modular (No SDI) , Up to 4 PTP ports/modules, Free-run or Genlock or GPS

Other PTPv2 Generators

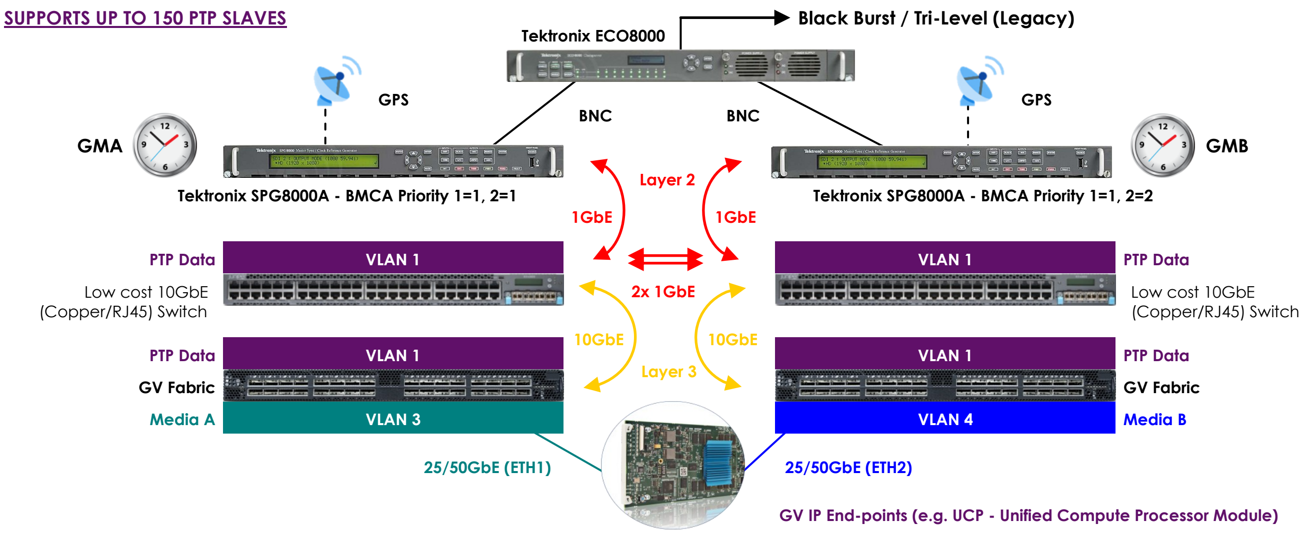
In very large systems a generator dedicated to PTP systems (slave count up to 500+) can be slaved to the SPG8000A. An example of this is the **Meinberg LANTIME 1000** depicted in Figure 2.

Section 5.4
System Timing
PTP Example Configurations

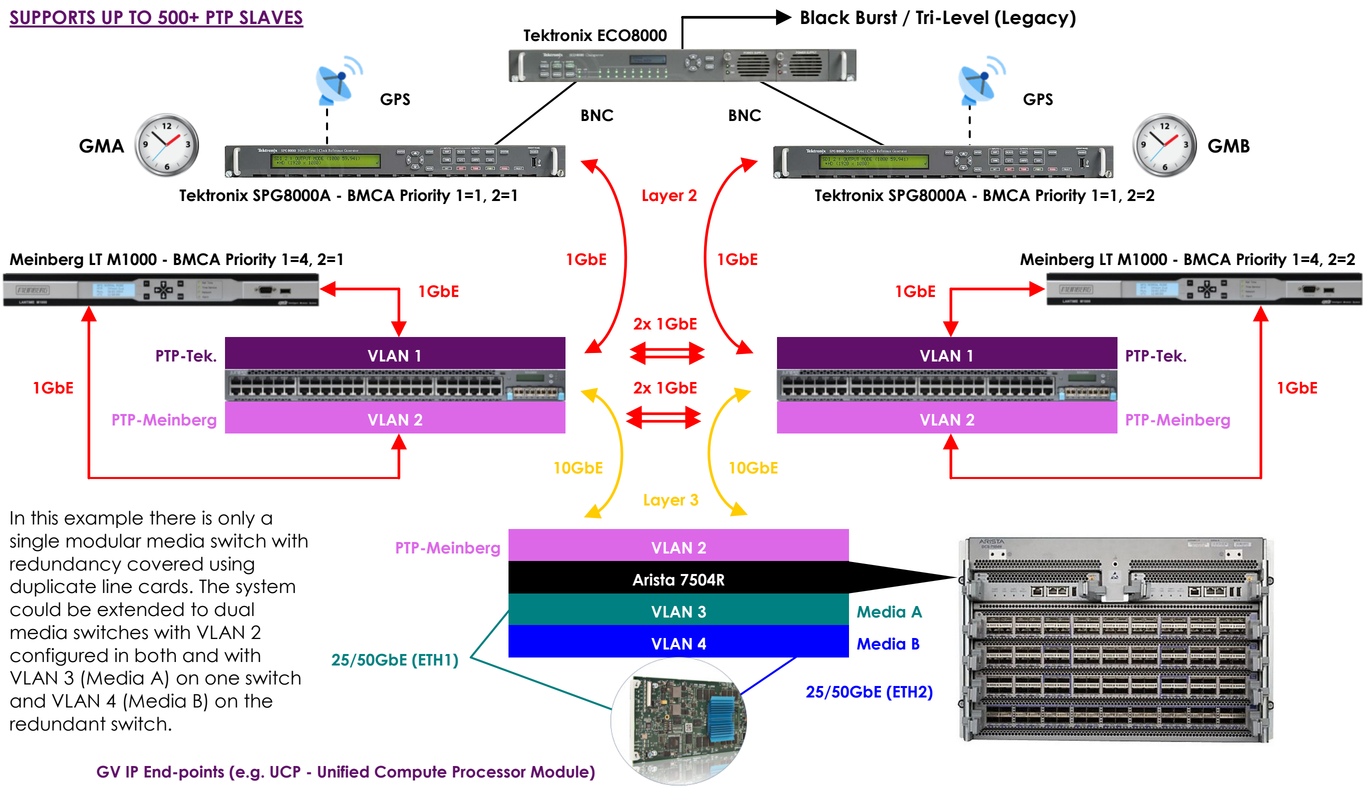
Guide to IP Systems

Examples using Ordinary Clocks

The following examples use two Tektronix **SPG8000A** master sync generators configured for redundancy with the **ECO8000** 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).



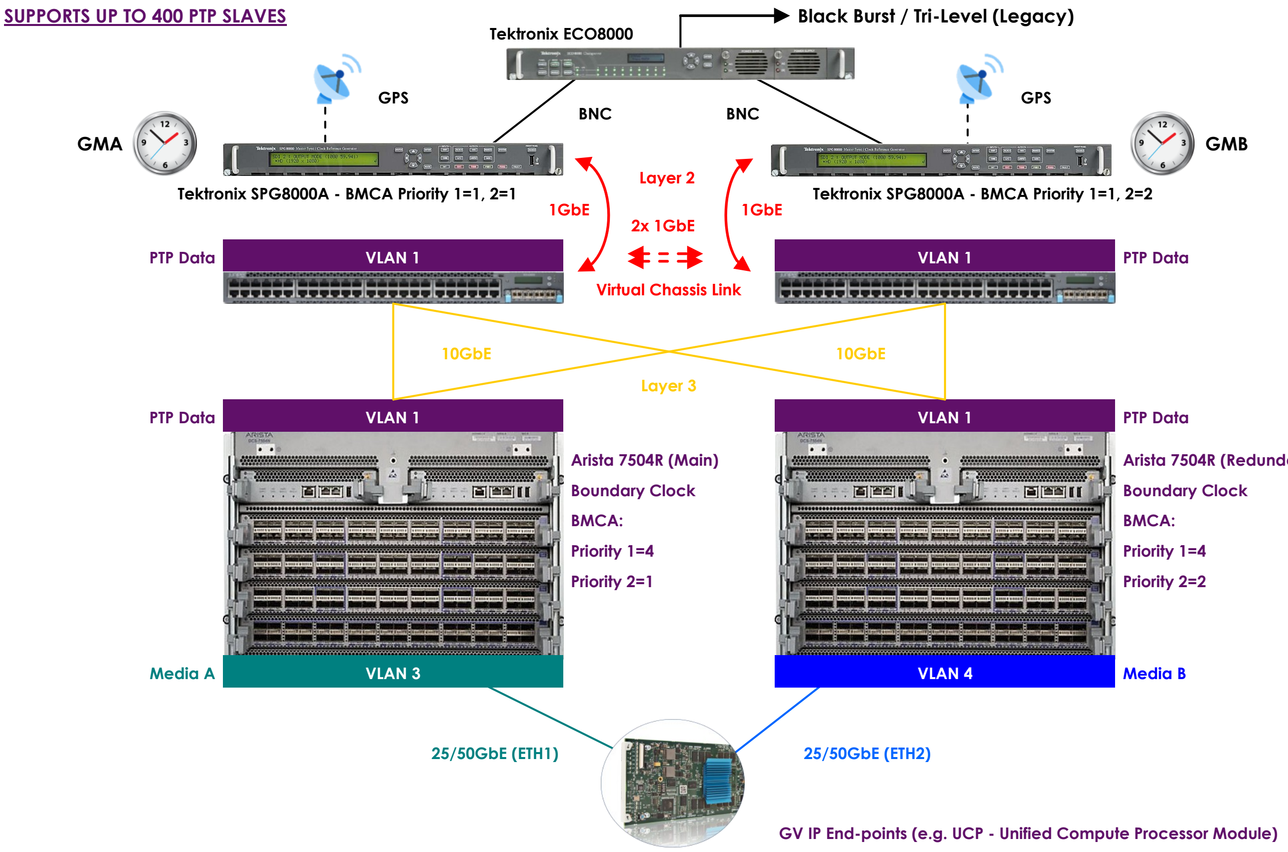
The example below also uses ordinary clocks but utilises Meinberg PTP boxes (slaved to the Tek. Grandmasters) to extend the edge device capability to over 500. PTP communication between the grandmasters and Meinberg slave ports are confined to VLAN 1 and the Meinberg downstream PTP communications to 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.

Examples using Boundary Clocks

The following example uses the same set up as the previous examples with respect to the grandmaster clock(s) but utilises the boundary clocks contained within the Media switches for synchronising 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. It's remaining ports become 'masters' for synchronising 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 GV technical staff.

- **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/
  http://www.tek.com/spg8000a-master-sync-master-clock-reference-generator

6. Control & Monitoring

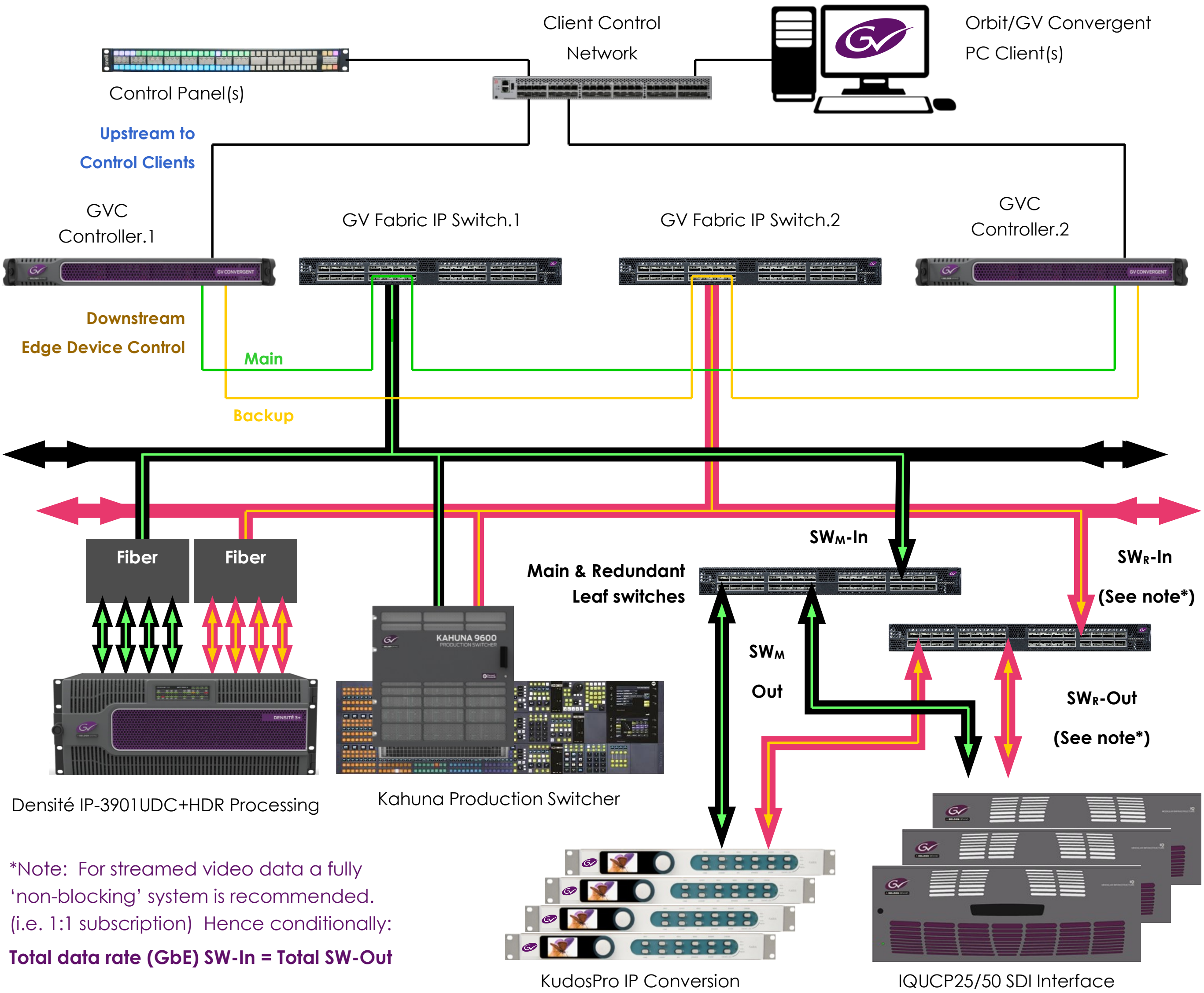
6.1 General Information

6.2 System Elements

IP Routing System Controller
Standard Router Control clients
Third-Party Control

6.3 GV Convergent - The Complete System

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 GV's IP Routing controllers.

IP Routing System Controller(s)

The hub of GV's IP System is the **GVC-CONTROLLER** of which there are two variants.
These are: **GVC-CONTROLLER-800** & **GVC-CONTROLLER-802** for single or dual redundant systems respectively.
Whilst the GVC-CONTROLLER-800 physical server has dual redundant power supplies, a fully redundant system requires two servers operating in parallel as offered by the -802 option.

The GVC-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 the GVC 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 & 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 software component, the **IP Network Monitor**, is provided for installation on a PC/Terminal for configuration (& mapping) of the IP Router Adapter.

Standard Router Control Clients

The GVC-CONTROLLER is fully compatible with **GV Convergent** and **Orbit** PC control clients including GV's extensive range of 1U and 2U LED and LCD control panels. These are configured in the normal way and connect to the GVC-CONTROLLER over Ethernet.

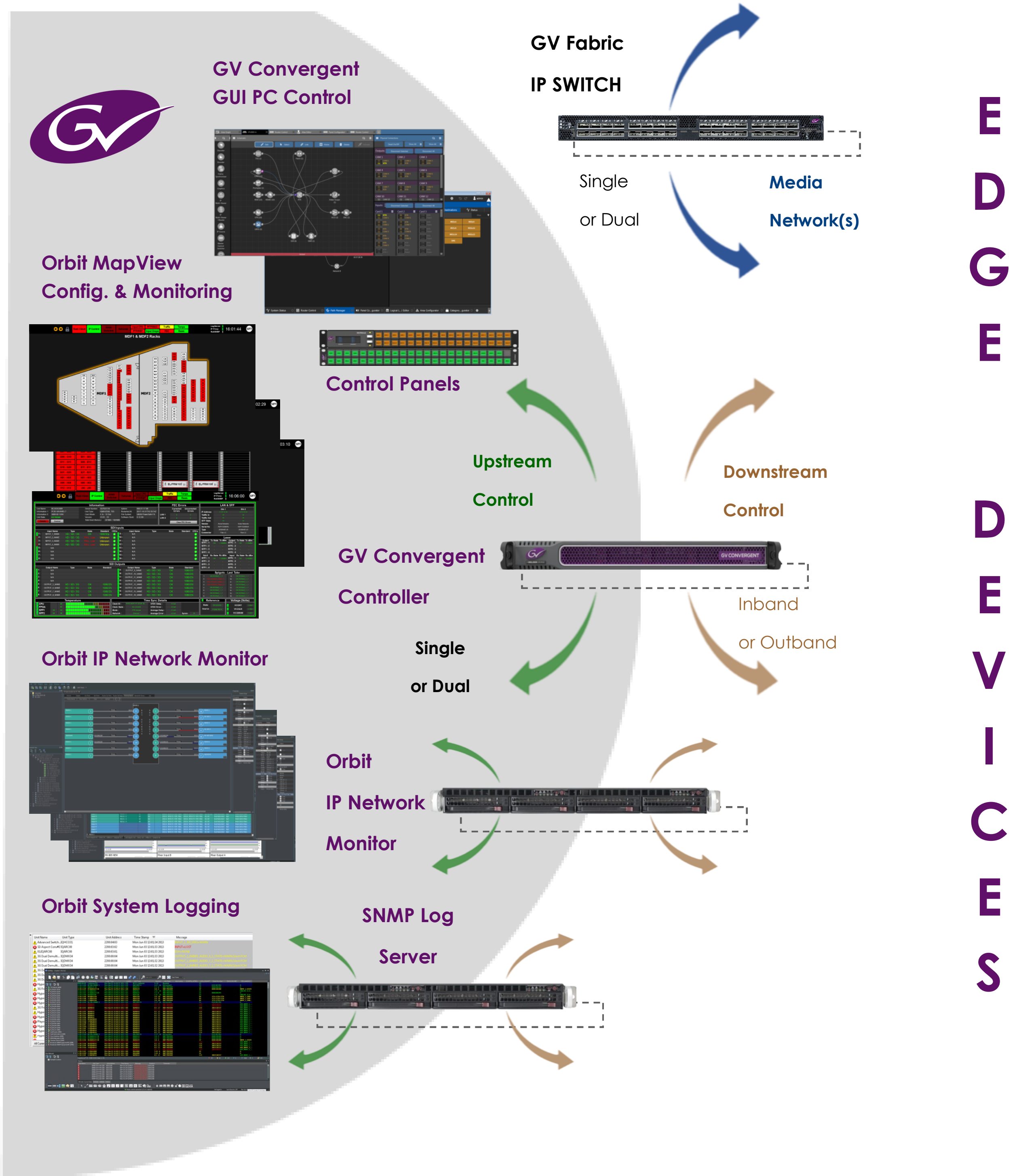
Third-Party Control

The **GVC-CONTROLLER** exposes **SW-P-02** & **SW-P-08** router control protocols over Ethernet for control by third-party clients.

GV Convergent & Orbit Overarching Control & Monitoring

Grass Valley can provide a complete IP Control, Configuration and Monitoring system. The GV 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.

GV Convergent/Orbit - Overarching C&M



Appendices

Appendix A

IP Port Stream Capacities

General Information

IP Port Speeds & Media Streams

GV's IP Routing System is compatible with **10GbE**, **25GbE**, **40GbE** and **100GbE** network fabrics or any combination of these Ethernet port speeds. It works with stream formats compliant with **SMPTE 2022-6** and **SMPTE 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 50Hz FPS and 59.94Hz FPS (frames per second) 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.

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 UHD). In real systems there is likely to be a mixture of picture formats.

Notes on table values for stream data rates:

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

Adjustments to IP port stream capacities dependant on switch mechanism

- GV'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 table(s) 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.

Key Features

Multiple Stream types
GV's IP Routing System works with multicast stream formats compliant with SMPTE 2022-6 /7 and SMPTE 2110-20/30/40 standards.
The system operates seamlessly when utilising any mix of these different stream types concurrently on the same network system.

40GbE and 100GbE Ports
With 40GbE and 100GbE ports on an IP switch, it is often assumed that media streams must be grouped into four 10GbE or four 25GbE 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 40Gb or 100Gb Ethernet transport bandwidth.** It is only necessary to group datagrams of a particular stream together (in one of the four 10GbE or 25GbE paths) if the port speed of a connected device is 10Gbe or 25GbE.

Appendix A

IP Port Stream Capacities

Option Tables 1 & 2

Option 1

Maximum possible channel capacity, packing the Ethernet fully with streams.
Usable with static switching; **or** break-before-make (constant bandwidth) dynamic switching.

Option 2

Channel capacity packing the Ethernet 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: No. of Option 2 channels = No. of Option 1 channels minus 1]

Option 1 (Option 2) - IP Port Capacities for 50Hz FPS standards

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

Option 1 (Option 2) - IP Port Capacities for 59.94Hz FPS standards

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

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 50Hz FPS standards

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

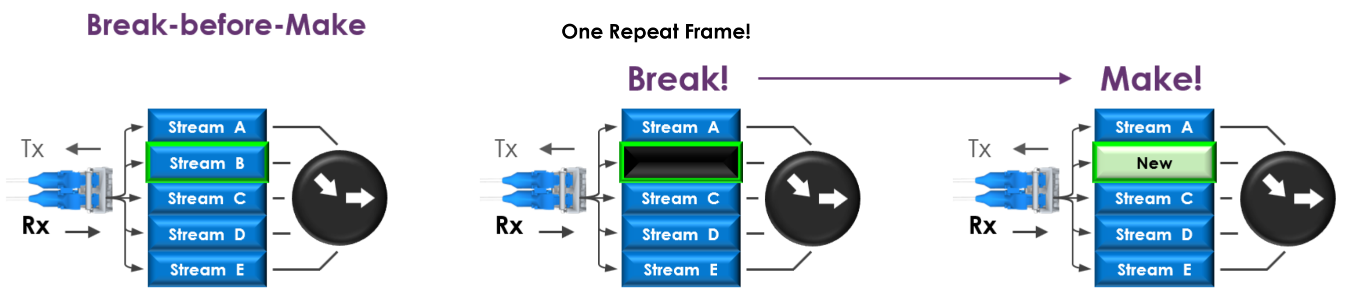
Option 3 - IP Port Capacities for 59.94Hz FPS standards

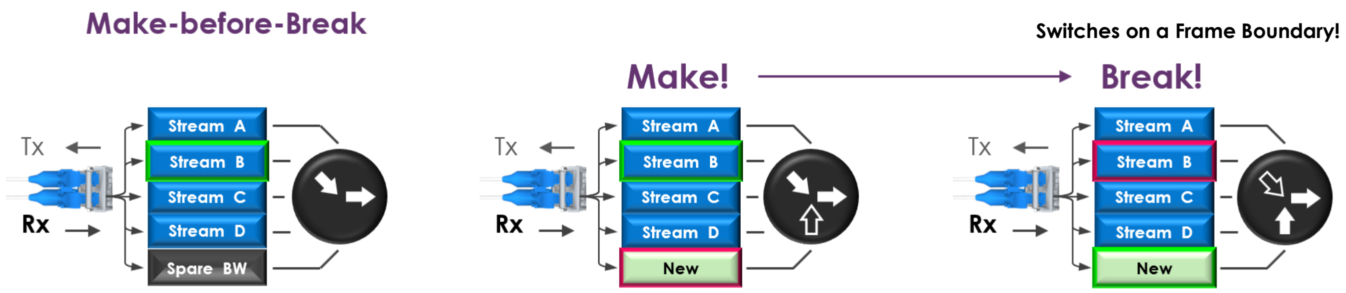
Media Stream Type	Rate	Number of Streams per Port				
59.94Hz FPS Standards	Mbit/s	1GbE	10GbE	25GbE	40GbE	100GbE
SD 625i-59.94 SDI	270					
*** Uncompressed 2022**	284	1	15	39	63	158
*** Uncompressed 2110**	246	1	18	45	73	182
*** Compressed 2042-1**	125	3	36	90	144	361
HD 1080i-59.94 SDI	1,485					
***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

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 synchroniser, then the disturbance will be minimal with a single blank/black frame displayed during the switch or 'break'. A **clean, very fast & 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 whilst the '**New**' stream is 'called'. A **completely clean switch is made on the synchronised 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-breaking switching.

Salvos - What happens when dynamically switching multiple streams simultaneously?
In multi-channel make-before-break switching there must be adequate spare bandwidth to accommodate all the new streams simultaneously. If this is not the case or is impractical, then the host will 'ripple through' each channel switch using the available spare bandwidth.