G.hn Access Multiplexer

GAM

Product Selection Guide

November 2020

GAM-12-M

GAM-24-M

GAM-12-C

GAM-24-C

Outdoor GAMs

GAM-4-MRX / GAM-4-MX
GAM-8-MRX / GAM-8-MX
GAM-4-CRX / GAM-4-CX
GAM-8-MVX
GAM-8-MDVX

G1001 Series
(Twisted pair (M), & Coax (C))

G1001-MP

G1001-MR

G1001-C

G1001-CR

Publication Information

Positron Access Solutions – GAM Product Selection Guide

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1   Introduction

"Fiber to the Home" is far from the only and most efficient technology to deliver Gigabit Internet access to subscribers. Retrofitting an existing (brownfield) Multi-Dwelling Unit (MDU) with fiber is complex and expensive. **With the G.hn Aggregation Multiplexer (GAM), Positron Access addresses the key challenge of delivering Gigabit Internet access to subscribers in MDUs as well as dense Single Family Unit (SFU) homes by leveraging the existing telephone or coaxial infrastructure to deliver near symmetrical Gigabit services at a fraction of the cost of alternatives.**

The ITU-T G.9960 G.hn Wave-2 standard is designed to leverage the existing telephone wiring (UTP, CAT-3 or CAT-5/5e) or RG-6/RG-59 coax cabling to deliver a Gigabit Internet service to each subscriber without the cost, complexity and delays associated with in-building fiber installation. G.hn is used as an Access technology by Operators looking to simplify their access network and backend infrastructure with an Ethernet-like technology that is highly scalable without some of the inherent complexity of DSL-related technologies. With G.hn, Operators deliver advanced services such as Gigabit High Speed Residential Internet and 4K IPTV without the high capital and operational expenses associated with a fiber retrofit. Each G.hn subscriber port supports up to 1.7 Gbps of dynamically allocated bandwidth for near symmetrical Gigabit services over the existing telephone wire or coaxial cable. The Positron GAM solution is MEF CE 2.0 compliant and is ideally suited to deliver Business Ethernet services in an MDU and/or MTU deployment.

This Product Selection Guide for GAM devices will help you select the right version and packaging for the type of building (MDU or MTU) or neighborhood you want to service.

2   GAM Use Cases

The G.hn technology is highly scalable and can serve several use cases that are usually deemed impossible to address.

This section covers the more popular use cases where the Positron GAM extends and distributes Gigabit services from Fiber/ xPON or Fixed Wireless Access uplinks over the existing in-building wiring. The "M" series operates over telephone (copper) pairs or better wiring while the "C" series operates over standard coaxial cabling and can leverage splitters to serve up to 16 devices per G.hn port of the GAM.

For each application, we provide an end-to-end network diagram as well as a high-level Bill of Materials (BOM) showing the correct models and quantities of GAMs, G1001 endpoints and accessories.

2.1 Best Effort HSI (MIMO) – Indoor AC Power

Best Effort High Speed Internet is the delivery of (up to) Gigabit services to residential (MDU) and Business (MTU) subscribers without a Service Level Agreement (SLA) but with solid performances and reliability.

The larger buildings usually have an indoor wiring closet where GAM-24-M (24 ports) and/or GAM-12-M (12 ports) can be installed with local power and connected to the existing telephone (copper) wiring. These GAM devices have two (2) SFP+ ports (10 Gigabit each) usable to terminate up to 20 Gbps of bandwidth. The 2nd SFP+ port is also convenient when stacking up multiple GAM devices to serve up to 96 subscribers in an MDU. G1001-M (data only) or G1001-MP (adds a POTS splitter) endpoint devices are installed inside each subscriber unit to convert the G.hn link to Gigabit Ethernet.

When operating over the telephone (copper) wiring, the GAM devices handle the VectorBoost function to mitigate crosstalk and optimize in real time the allocation of the spectrum and bandwidth in the downstream and upstream directions to match the demands from the subscribers. *Note that VectorBoost is covered in more details later in this document.*
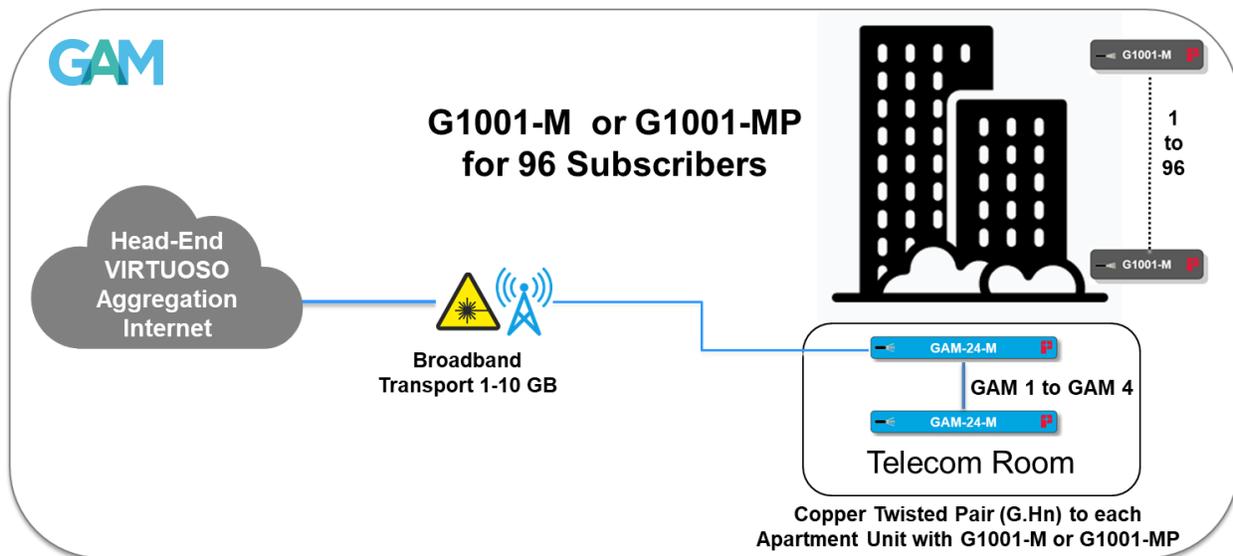
Figure 1: MIMO "M" GAM Application – Best Effort HSI, Indoor AC Powered

Bill of Materials (BOM)

Product Code	Product Description	Quantity
GAM-24-M	G.hn Access Multiplexer (GAM) with 24 dual-pair (MIMO) copper ports and 2 x 10Gbps SFP+ ports. AC 110-220V Power Input	4
G1001-M	G.hn (MIMO) to Gigabit Ethernet Bridge. AC Wall Adapter included	96

NOTE: The GAM-12-M may be utilized for smaller applications of this nature. GAM-12-M and GAM-24-M can be combined to fit the number of doors to serve in an MDU.

2.2 Best Effort HSI (MIMO) – Outdoor Installation, Reverse Power Feed

When serving small to medium building without a wiring closet, access to the copper pairs is typically limited to a nearby pedestal or from the edge or back of the building. In this case, there is rarely a nearby power source and GAM devices need to be installed outdoors and reverse powered from the subscribers. The GAM-8-MRX (8 ports) and GAM-4-MRX (4 ports) are purposely designed to handle this demanding environment. In this case, the G1001-MR (data only) provides the reverse power feed (RPF / 48Vdc) to the outdoor GAM and converts the G.hn link to Gigabit Ethernet.
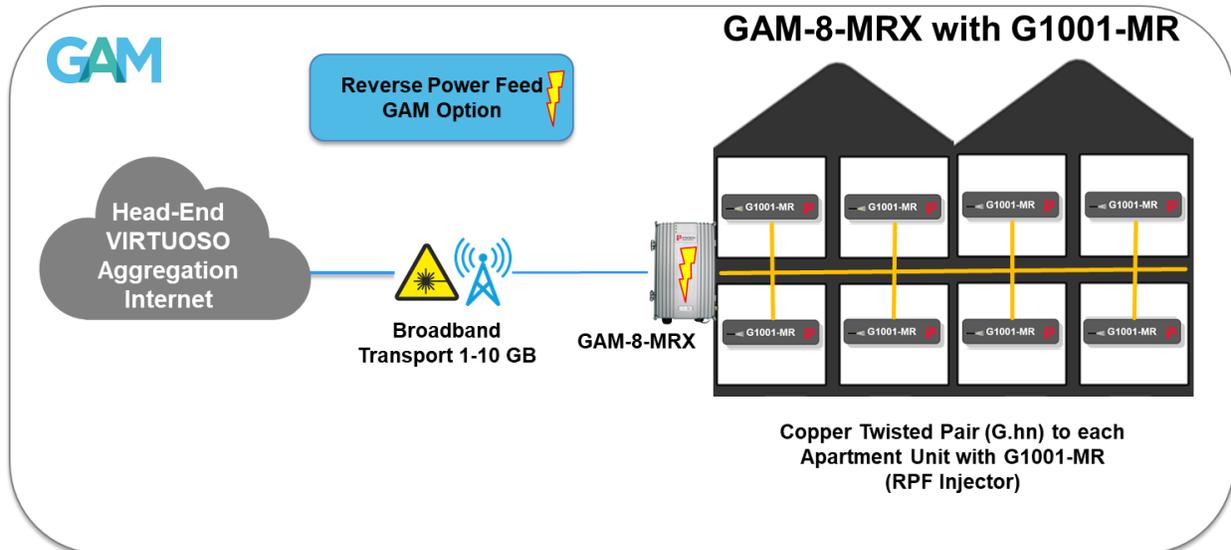
Figure 2: MIMO "M" GAM Application – Best Effort HIS, Outdoor Hardened, RPF

Bill of Materials (BOM)

Product Code	Product Description	Quantity
GAM-8-MRX	OUTDOOR G.hn Access Multiplexer (GAM) with 8 MIMO ports and 1 x 10Gbps SFP+ port. Reverse Power Feed	1
G1001-MR	G.hn (MIMO) to Gigabit Ethernet Bridge. AC Wall Adapter included. RPF Support, acts as PSE.	8

Please refer to section 3 for a summary of the key features of the Positron G.hn devices in the above diagrams.

NOTE: the GAM-8-MX and GAM-4-MX outdoor devices operate over local power (110-220Vac to 12 Vdc) when there is an existing source nearby. In this case, the G1001-M or G1001-MP endpoint devices are used since there is no need to reverse power the GAM.

2.3   Best Effort HSI (COAX) – Indoor AC Power

Best Effort High Speed Internet is the delivery of (up to) Gigabit services to residential (MDU) and Business (MTU) subscribers without a Service Level Agreement (SLA) but with solid performances and reliability.

The larger buildings usually have an indoor wiring closet where GAM-24-C (24 ports) and/or GAM-12-C (12 ports) devices are installed and connected to the existing coaxial cabling. Each G.hn port of a GAM can serve up to 16 subscribers, meaning that a GAM-24-C can serve up to 384 subscribers while a GAM-12-C can serve 192 subscribers. These GAM devices have two (2) SFP+ ports (10 Gigabit each) usable to handle up to 20 Gbps of uplink bandwidth. The 2nd SFP+ port is also convenient when stacking up multiple GAM devices in a larger MDU. G1001-C endpoint devices (with a built-in coax splitter) are installed inside each subscriber unit to convert the G.hn link to Gigabit Ethernet and deliver other services such as Satellite TV via the coax splitter.

Figure 3: COAX "C" GAM Application – Best Effort HSI, Indoor AC Powered

Bill of Materials (BOM)

Product Code	Product Description	Quantity
GAM-24-C	G.hn Access Multiplexer (GAM) with 24 Coax ports and 2 x 10Gbps SFP+ ports. AC 110-220V Power Input	1
G1001-C	G.hn (COAX) to Gigabit Ethernet Bridge. AC Wall Adapter included	384

2.4   Best Effort HSI (COAX) – Outdoor Installation, Reverse Power Feed

When serving small to medium building without a wiring closet, access to the coax cabling is typically limited to a nearby pedestal or from the edge or back of the building. In this case, there is rarely a nearby power source and the GAM devices need to be installed outdoors and reverse

powered from the subscribers. The GAM-4-CRX (4 ports) is purposely designed to handle this demanding environment. In this case, the G1001-CR provides the (RPF / 48Vdc) reverse power feed to the outdoor GAM and converts the G.hn link to Gigabit Ethernet.

These GAM devices optimize in real time the allocation of the spectrum and bandwidth in the downstream and upstream directions to match the demands from the subscribers.
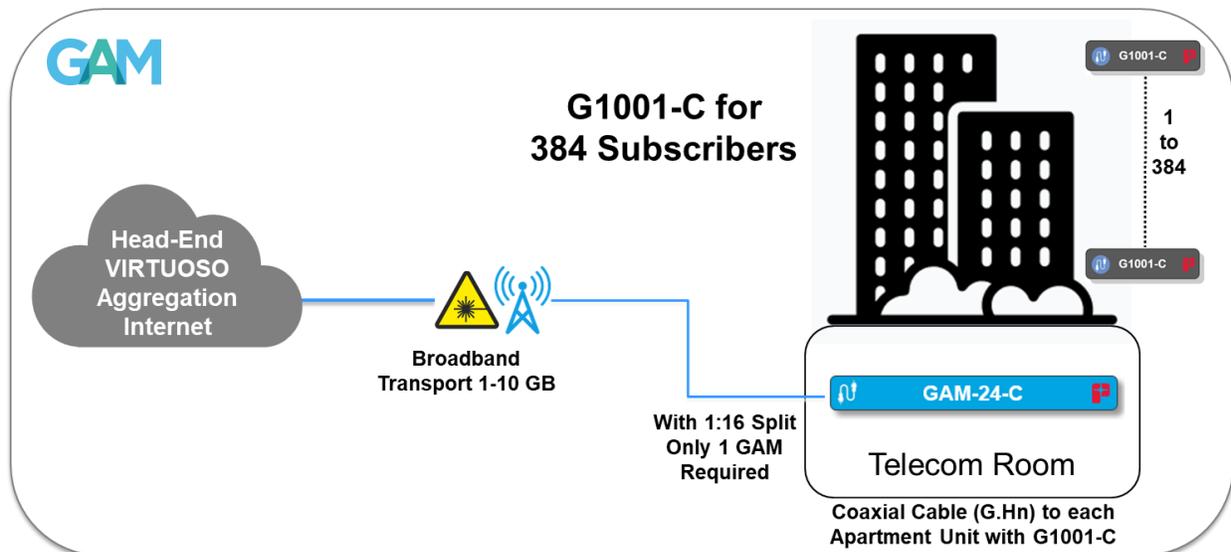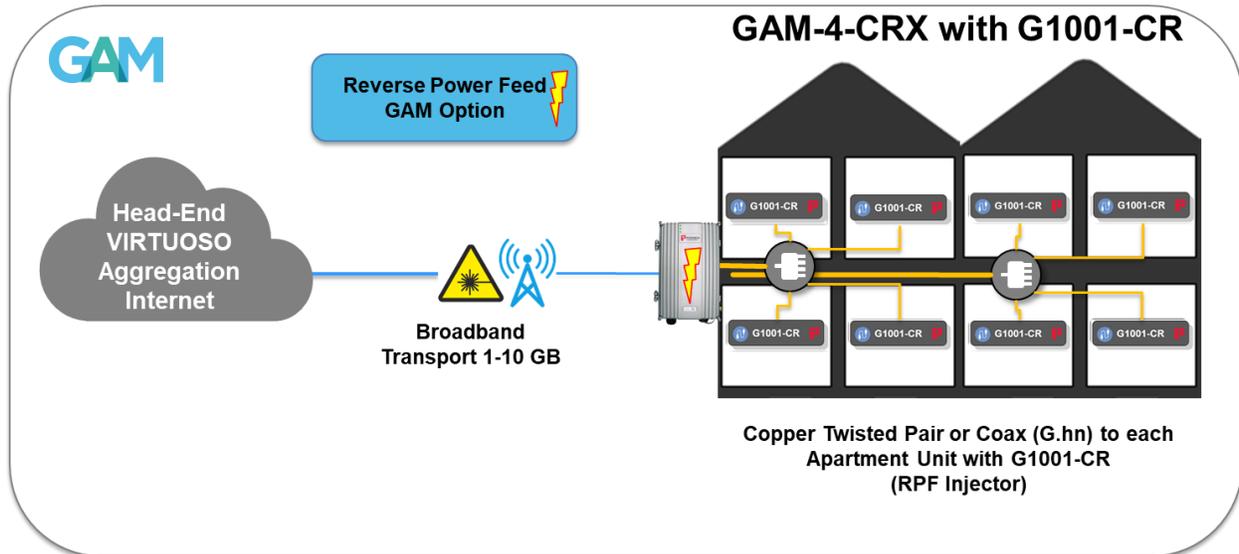

Figure 4: COAX "C" GAM Application – Best Effort HSI, Outdoor Hardened, RPF

Bill of Materials (BOM)

Product Code	Product Description	Quantity
GAM-4-CRX	OUTDOOR G.hn Access Multiplexer (GAM) with 4 COAX ports and 1 x 10Gbps SFP+ port. Reverse Power Feed	1
G1001-CR	G.hn (MIMO) to Gigabit Ethernet Bridge. AC Wall Adapter included. RPF Support, acts as PSE.	8

Please refer to section 4 for a summary of the key features of the Positron G.hn devices in the above diagrams.

NOTE: the GAM-4-CX outdoor device operates over local power (110-220Vac to 12 Vdc) when there is an existing source nearby. In this case, the G1001-C endpoint device is used since there is no need to reverse power the GAM.

2.5 Managed Business Ethernet (CE 2.0) over Copper

The Positron GAM devices are all compliant with the MEF CE 2.0 specification and offer comprehensive support for E-LINE and E-LAN modes of operation. With hardware based NID capabilities (Y.1731, 802.3ah and 802.1ag), these GAM devices are ideal to extend Business Ethernet services supported with SLAs over the existing in-building copper (telephone) wiring.

G.hn transports Ethernet frames with full support for EVCs, 802.1q (Double-tagging) and comprehensive QOS. Each G.hn port is made up of 8 hardware queues with extensive traffic and rate limiting just like a native Carrier Ethernet switch.

GAM-24-M and GAM-12-M are ideal for larger buildings.

Figure 5: Managed Business Ethernet (CE 2.0) over Copper (Indoor AC)

Bill of Materials (BOM)

Product Code	Product Description	Quantity
GAM-24-M	G.hn Access Multiplexer (GAM) with 24 dual-pair (MIMO) copper ports and 2 x 10Gbps SFP+ ports. AC 110-220V Power Input	4
G1001-M	G.hn (MIMO) to Gigabit Ethernet Bridge. AC Wall Adapter included	96

NOTE: The GAM-12-M may be utilized for smaller applications of this nature. GAM-12-M and GAM-24-M can be combined to fit the number of doors to serve in an MDU.

Reverse powered GAM-8-MRX and GAM-4-MRX cater to smaller buildings.

Figure 6: Managed Business Ethernet (CE 2.0) over Copper (Outdoor RPF)

Bill of Materials (BOM)

Product Code	Product Description	Quantity
GAM-8-MRX	OUTDOOR G.hn Access Multiplexer (GAM) with 8 MIMO ports and 1 x 10Gbps SFP+ port. Reverse Power Feed	1
G1001-MR	G.hn (MIMO) to Gigabit Ethernet Bridge. AC Wall Adapter included. RPF Support, acts as PSE.	8

Please refer to section 3 for a summary of the key features of the Positron G.hn devices in the above diagrams.

NOTE: the GAM-8-MX and GAM-4-MX outdoor devices operate over local power (110-220Vac to 12 Vdc) when there is an existing source nearby. In this case, the G1001-M or G1001-MP endpoint devices are used since there is no need to reverse power the GAM.

2.6 Managed Business Ethernet (CE 2.0) over COAX

The Positron GAM-24-C, GAM-12-C and GAM-4-CRX are compliant with the MEF CE 2.0 specification and offer comprehensive support for E-LINE and E-LAN modes of operation. With hardware based NID capabilities (Y.1731, 802.3ah and 802.1ag), GAM devices are ideal to extend Business Ethernet services supported with SLAs over the existing in-building coaxial cabling. G.hn transports Ethernet frame with full support for EVCs, 802.1q (Double-tagging) and comprehensive QOS. Each G.hn port is made up of 8 hardware queues with extensive traffic and rate limiting just like a native Carrier Ethernet switch.
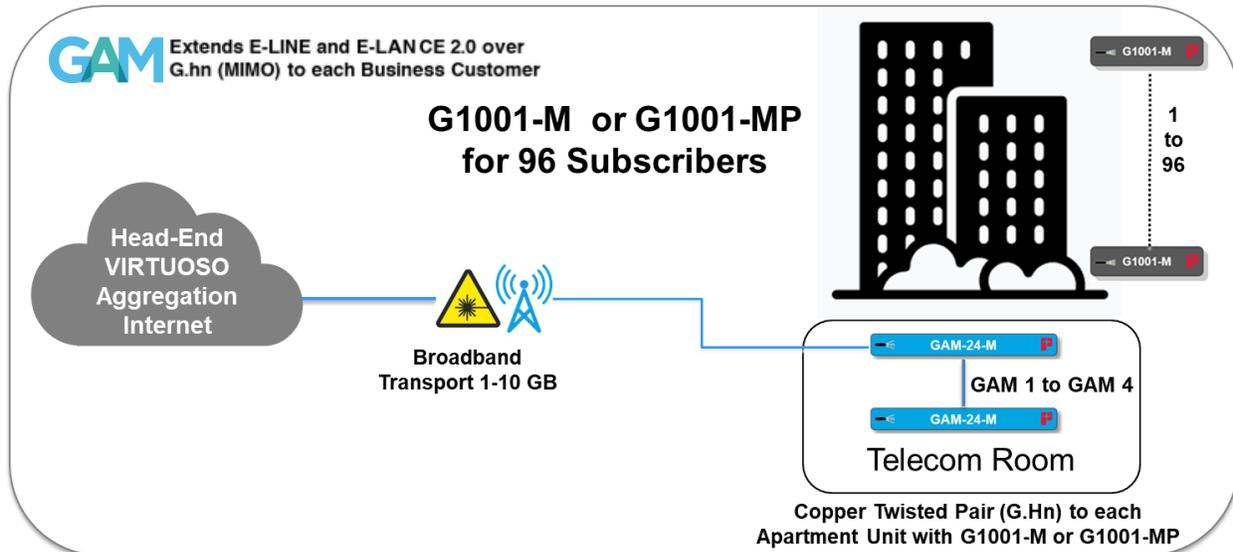
GAM-24-C and GAM-12-C are ideal for larger buildings.

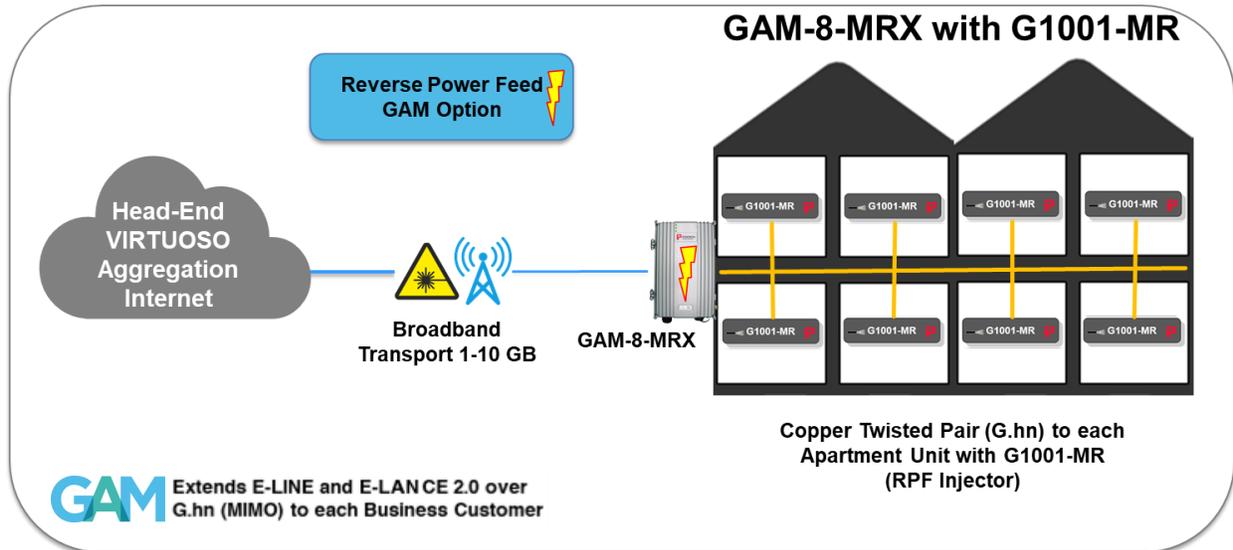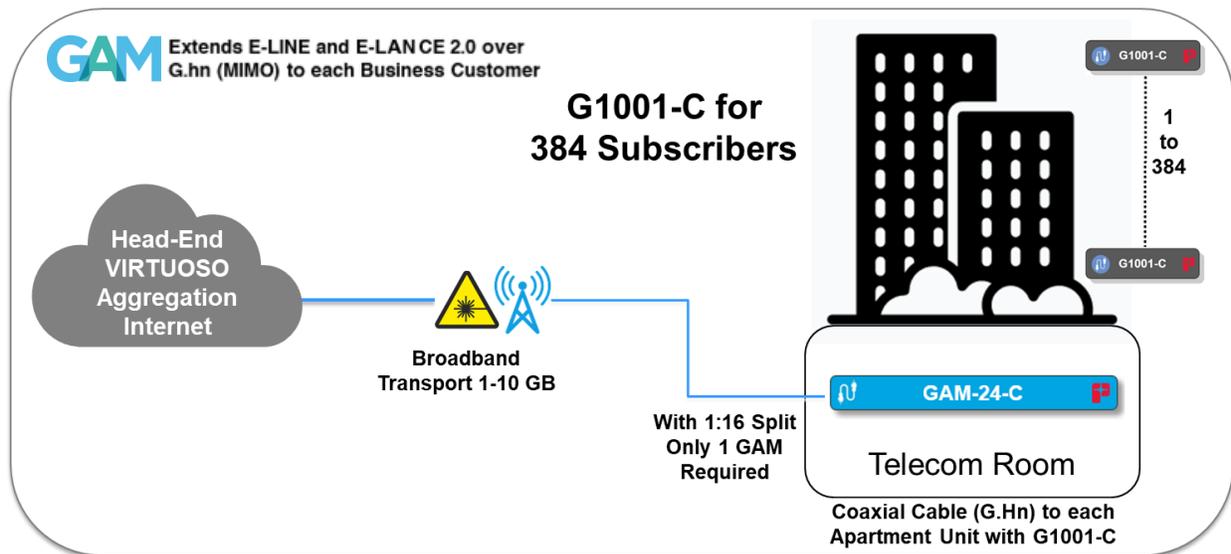Figure 7: Managed Business Ethernet (CE 2.0) over COAX (Indoor AC)

Bill of Materials (BOM)

Product Code	Product Description	Quantity
GAM-24-C	G.hn Access Multiplexer (GAM) with 24 Coax ports and 2 x 10Gbps SFP+ ports. AC 110-220V Power Input	1
G1001-C	G.hn (COAX) to Gigabit Ethernet Bridge. AC Wall Adapter included	384

Reverse powered GAM-4-CRX caters to smaller buildings.
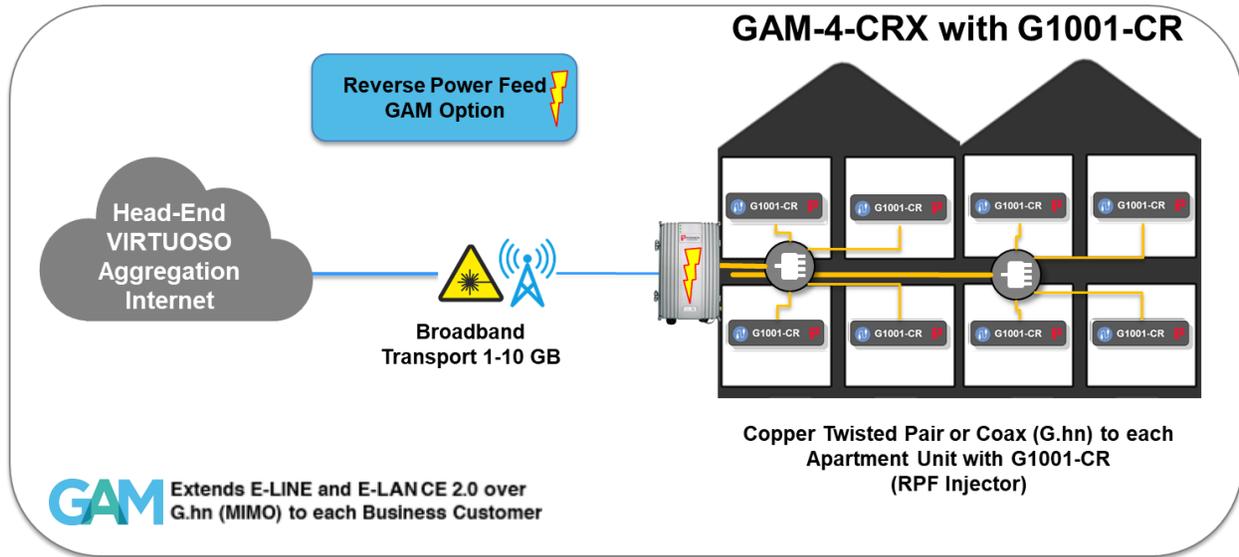
Figure 8: Managed Business Ethernet (CE 2.0) over COAX (Outdoor RPF)

Bill of Materials (BOM)

Product Code	Product Description	Quantity
GAM-4-CRX	OUTDOOR G.hn Access Multiplexer (GAM) with 4 COAX ports and 1 x 10Gbps SFP+ port. Reverse Power Feed	1
G1001-CR	G.hn (MIMO) to Gigabit Ethernet Bridge. AC Wall Adapter included. RPF Support, acts as PSE.	8

Please refer to section 4 for a summary of the key features of the Positron G.hn devices in the above diagrams.

NOTE: the GAM-4-CX outdoor device operates over local power (110-220Vac to 12 Vdc) when there is an existing source nearby. In this case, the G1001-C endpoint device is used since there is no need to reverse power the GAM.

2.7 Maximizing low density / rural fiber Gigabit coverage with GAM devices

GPON is progressively used (or being considered) to deliver Gigabit speeds to subscribers in low density neighborhood and even in rural areas. Since GPON is optimized for higher density markets, the cost and complexity of covering the last 500-800 feet (150-250 meters) is an area where G.hn can certainly help eliminate construction cost and delays and reduce truck rolls.

The copper (MIMO) outdoor GAM devices cost effectively complement the GPON fiber build along the road by taking care of the extension of the Gigabit services over the existing copper pairs already reaching each home. In addition, the reverse powered GAM-8-MRX and GAM-4-MRX devices do not require the installation of an outdoor power source, further simplifying the design and maintenance of the access network infrastructure.
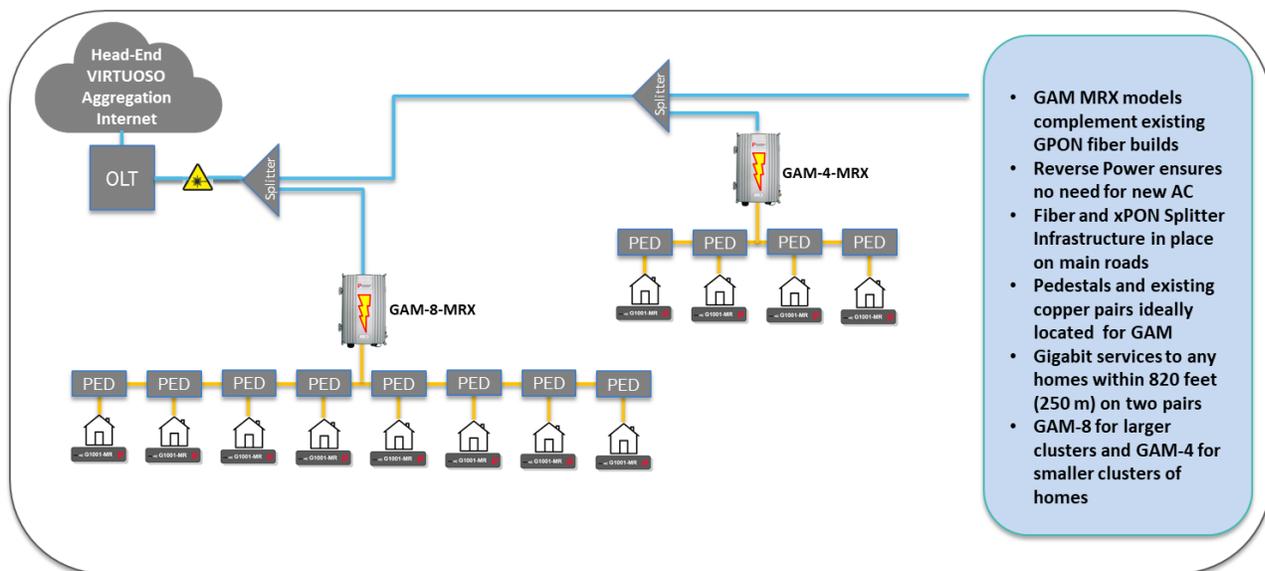
Figure 9: Maximizing low density / rural fiber Gigabit coverage with GAM devices

Bill of Materials (BOM)

Product Code	Product Description	Quantity
GAM-8-MRX	OUTDOOR G.hn Access Multiplexer (GAM) with 8 MIMO ports and 1 x 10Gbps SFP+ port. Reverse Power Feed	1
GAM-4-MRX	OUTDOOR G.hn Access Multiplexer (GAM) with 4 MIMO ports and 1 x 10Gbps SFP+ port. Reverse Power Feed	1
G1001-MR	G.hn (MIMO) to Gigabit Ethernet Bridge. AC Wall Adapter included. RPF Support, acts as PSE.	12

3   GAM Copper (MIMO) Solutions

When operating over copper pairs, each port of a GAM device can be connected to either 1 pair (Single Input Single Output – SISO) or 2 pairs (Multiple Input Multiple Output – MIMO). When in SISO mode, up to 200 MHz of spectrum is used over that pair to deliver up to 1.7 Gbps of aggregate bandwidth. When operating in MIMO mode, the 200 MHz of spectrum is evenly split with 100 MHz of spectrum per pair to deliver up to 1.7 Gbps to reduce the impact of the signal attenuation and achieve higher bandwidth and longer reach.

GAM devices operate over copper pairs leverage an innovative crosstalk mitigation known as VectorBoost. It allows each G.hn port to operate with a basic level of spectrum to reduce crosstalk. VectorBoost actively monitors the bandwidth requirements of each G.hn user and will boost the spectrum allocation to those that need more bandwidth when they need it.

The GAM monitors the bandwidth requirements of each G.hn port, and dynamically balances the total bandwidth between the downstream and upstream directions in real time for each subscriber. This is achieved via a process called Collaborative Dynamic Time Allocation or cDTA. It always ensures a fair allocation of the spectrum while mitigating the inherent crosstalk between each pair in the copper cable.

The currently available GAM products operating over copper (telephone) pairs are summarized in the following table:

Ordering Code	Description		Picture
GAM-24-M	**Number of G.hn Ports**	24 MIMO	
	Number of SFP+	2	
	Management Ports	GigE / Serial	
	Power Source	110-220Vac	
	Operating Temp Range	0°C to +40°C	
	Dimensions	17.4" W x 1.73" H x 10.0" D / 442 mm W x 44 mm H x 254 mm D	
	Enclosure rating	IP40	
GAM-12-M	**Number of G.hn Ports**	12 MIMO	
	Number of SFP+	2	
	Management Ports	GigE / Serial	
	Power Source	110-220Vac	
	Operating Temp Range	0°C to +40°C	
	Dimensions	17.4" W x 1.73" H x 10.0" D / 442 mm W x 44 mm H x 254 mm D	
	Enclosure rating	IP40	

GAM-8-MRX	Number of G.hn Ports	8 MIMO
	Number of SFP+	1
	Management Ports	GigE / Serial
	Power Source	Reverse Power Feed (48Vdc) from G1001-MR (Optional 12Vdc for initial activation)
	Operating Temp Range	-40°C to +65°C
	Dimensions	8" W x 12" H x 3" D / 200 mm W x 300 mm H x 75 mm D
	Enclosure rating	IP67
GAM-8-MX	Number of G.hn Ports	8 MIMO
	Number of SFP+	1
	Management Ports	GigE / Serial
	Power Source (requires protective enclosure for power source)	110-220Vac to 12Vdc @ 4 Amps
	Operating Temp Range	-40°C to +65°C
	Dimensions	8" W x 12" H x 3" D / 200 mm W x 300 mm H x 75 mm D
	Enclosure rating	IP67
GAM-4-MRX	Number of G.hn Ports	4 MIMO
	Number of SFP+	1
	Management Ports	GigE / Serial
	Power Source	Reverse Power Feed (48Vdc) from G1001-MR (Optional 12Vdc for initial activation)
	Operating Temp Range	-40°C to +65°C
	Dimensions	8" W x 12" H x 3" D / 200 mm W x 300 mm H x 75 mm D
	Enclosure rating	IP67
GAM-4-MX	Number of G.hn Ports	4 MIMO
	Number of SFP+	1
	Management Ports	GigE / Serial
	Power Source (requires protective enclosure for power source)	110-220Vac to 12Vdc @ 4 Amps
	Operating Temp Range	-40°C to +65°C
	Dimensions	8" W x 12" H x 3" D / 200 mm W x 300 mm H x 75 mm D
	Enclosure rating	IP67

Table 1: GAM Copper (MIMO) Solutions

3.1 G.hn End-Point devices Solutions for copper (telephone) pairs

A G.hn End-Point device handles the conversion of the G.hn signals to Gigabit Ethernet and allows a simple and efficient connection to the Wi-Fi Router, Residential Gateway, and similar devices.

When connected to an outdoor GAM (GAM-8-MRX or GAM-4-MRX), the G1001-MR device further acts as a Power Supply Device (PSD) to provide the Reverse Power Feed (RPF) to the outdoor GAM.

The currently available GAM products operating over copper (telephone) pairs are summarized in the following table:

Ordering Code	Description		Picture
G1001-M	**G.hn Port**	MIMO	
	Gigabit Ethernet	RJ-45	
	Power Source	12Vdc from 110-220Vac adapter	
	Operating Temp Range	0°C to +40°C	
	Dimensions	2.36" W x 1" H x 4" D / 60 mm W x 27 mm H x 103.4 mm D	
	Enclosure rating	IP40	
G1001-MP	**G.hn Port**	MIMO	
	Gigabit Ethernet	RJ-45	
	Power Source	12Vdc from 110-220Vac adapter	
	POTS Splitter	Integrated	
	Operating Temp Range	0°C to +40°C	
	Dimensions	2.36" W x 1" H x 4" D / 60 mm W x 27 mm H x 103.4 mm D	
	Enclosure rating	IP40	
G1001-MR	**G.hn Port**	MIMO	
	Gigabit Ethernet	RJ-45	
	Power Source	12Vdc from 110-220Vac adapter	
	RPF PSD	48Vdc to GAM	
	Operating Temp Range	0°C to +40°C	
	Dimensions	3.7" W x 1.35" H x 6.7" D / 95 mm W x 34.3 mm H x 169.5 mm D	
	Enclosure rating	IP40	

Table 2: G.hn End-Point devices Solutions for copper (telephone) pairs

4 GAM COAX Solutions

When operating over coaxial cabling, each port of a GAM device delivers up to 1.7 Gbps and can serve up to sixteen (16) subscribers using standard coax splitters commonly used for DOCSIS. **Note:** when using coax splitters, the up to 1.7Gbps of bandwidth is shared by all of subscribers served by a specific GAM port under the control of the subscriber profiles defined for the GAM.

The GAM monitors the bandwidth requirements of each G.hn port, and dynamically balances the total bandwidth between the downstream and upstream directions in real time for each subscriber of each port. This is achieved via a process called Interactive Dynamic Time Allocation or iDTA. It always ensures a fair allocation of the spectrum while making sure each subscriber gets fair access to the bandwidth.

The currently available GAM products operating over coaxial cabling are summarized in the following table:

Ordering Code	Description		Picture
GAM-24-C	Number of G.hn Ports	24 COAX	
	Number of SFP+	2	
	Management Ports	GigE / Serial	
	Power Source	110-220Vac	
	Operating Temp Range	0°C to +40°C	
	Dimensions	17.4" W x 1.73" H x 10.0" D / 442 mm W x 44 mm H x 254 mm D	
	Enclosure rating	IP40	
GAM-12-C	Number of G.hn Ports	12 COAX	
	Number of SFP+	2	
	Management Ports	GigE / Serial	
	Power Source	110-220Vac	
	Operating Temp Range	0°C to +40°C	
	Dimensions	17.4" W x 1.73" H x 10.0" D / 442 mm W x 44 mm H x 254 mm D	
	Enclosure rating	IP40	
GAM-4-CRX	Number of G.hn Ports	4 COAX	
	Number of SFP+	1	
	Management Ports	GigE / Serial	
	Power Source	Reverse Power Feed (48Vdc) from G1001-MR (Optional 12Vdc for initial activation)	
	Operating Temp Range	-40°C to +65°C	
	Dimensions	8" W x 12" H x 3" D / 200 mm W x 300 mm H x 75 mm D	
	Enclosure rating	IP67	

GAM-4-CX	Number of G.hn Ports	4 COAX
	Number of SFP+	1
	Management Ports	GigE / Serial
	Power Source (requires protective enclosure for power source)	110-220Vac to 12Vdc @ 4 Amps
	Operating Temp Range	-40°C to +65°C
	Dimensions	8" W x 12" H x 3" D / 200 mm W x 300 mm H x 75 mm D
	Enclosure rating	IP67

Table 3: GAM COAX Solutions

4.1　G.hn End-Point devices Solutions for COAX

A G.hn End-Point device handles the conversion of the G.hn signals to Gigabit Ethernet and allows a simple and efficient connection to the Wi-Fi Router, Residential Gateway, and similar devices.

When connected to an outdoor GAM (GAM-4-CRX), the G1001-CR device further acts as a Power Supply Device (PSD) to provide the Reverse Power Feed (RPF) to the outdoor GAM.

The currently available GAM products operating over coaxial cabling are summarized in the following table:

Ordering Code	Description		Picture
G1001-C	G.hn Port	COAX – F-type	
	Gigabit Ethernet	RJ-45	
	COAX Splitter	Integrated	
	Power Source	12Vdc from 110-220Vac adapter	
	Operating Temp Range	0°C to +40°C	
	Dimensions	2.36" W x 1" H x 4" D / 60 mm W x 27 mm H x 103.4 mm D	
	Enclosure rating	IP40	
G1001-CR	G.hn Port	COAX – F-type	
	Gigabit Ethernet	RJ-45	
	COAX Splitter	Integrated	
	Power Source	12Vdc from 110-220Vac adapter	
	RPF PSD	48Vdc to GAM	
	Operating Temp Range	0°C to +40°C	
	Dimensions	3.7" W x 1.35" H x 6.7" D / 95 mm W x 34.3 mm H x 169.5 mm D	
	Enclosure rating	IP40	

Table 4: G.hn End-Point devices Solutions for COAX

4.2 GAM and Endpoint Accessories

The outdoor GAM devices are shipped with a versatile mounting bracket:

- Wall-mount
- Pole-mount
- Pedestal-mount

This GAM mounting bracket can be fitted with a GAM-STRAND-KIT for installation on a strand wire between telephone poles.
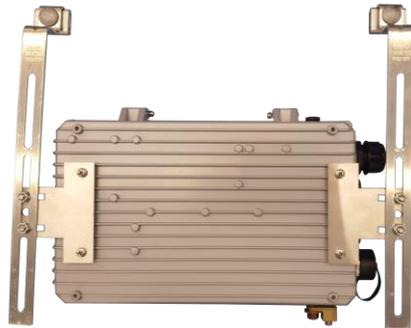
Ordering Code	Description	Picture
GAM-STRAND-KIT	Strand-mounting kit for the - GAM-4-MRX - GAM-8-MRX - GAM-4-CRX	

Table 5: GAM and Endpoint Accessories