

CT's QAM TECH GUIDE

August 2009

INSIDE THIS ISSUE

Overview, Glossary	page 1
Vendor Table,	page 3
Narrowcast, UK Birth	page 4
QAM Basics	page 7
SDV Elements,	page 8

QAM Tactics and Technology: Toward greater density and more flexibility

by Monta Hennon, Contributing Editor

The cry of more HD, more VOD has grown to a roar.

While there isn't a one solution fits all answer, trends include switched digital video (SDV) and analog reclamation. No matter which direction an operator heads, however, one thing is clear: More content means a need for more quadrature amplitude modulation (QAM) channels.

The same 6 Mhz that held one analog channel supports 10-15 SD channels or two HD channels. Yet, if it's more HD content an operator wants, then it's more QAM channels the operator needs, even considering technology that can squeeze up to four HD streams into a QAM channel.

"The efficiency on the Edge QAM network is less (for HD) than standard definition," said Rick Swiderski, CTO, RCN, which is migrating to an all-digital platform.

More HD means more QAM channels for VOD as well, but take rates are also increasing as subscribers become more comfortable with the concept.

"A few years ago when (we were) selling QAMs for VOD,

it was pretty much four QAM channels per service group... Now we are seeing, two or three years later, that number (has) grown from four to somewhere between six and eight channels," Ramin Farassat, vice president, marketing, RGB, said.

This growing need for QAM channels will continue so long as operators are still using coax. "In an HFC world, QAM modulation will be the predominant vehicle for a while to propagate signals over that type of network," Jeff Winn, RCN, director of video engineering said.

Customer premise equipment is a factor too. "Until you get rid of QAM demodulation in the set-top and cable modem, you still need a modulator...If you have an Ethernet receiver or Ethernet modem or set-top you wouldn't need (it)," Tony Pierson, vice president business development, LiquidStream, said.

SWITCHING TACTICS

Analog reclamation may have superseded the buzz about SDV, with a few larger operators making a decided push to go all digital, but SDV is still being implemented. With SDV, pro-

grams are transmitted only upon request for switched channels. Bandwidth is not congested with rarely watched video.

"(Analog reclamation) does not preclude (using) a switched architecture to increase bandwidth... Even when you reclaim channels, when you pump in more content in the digital domain (you) might want to switch that. Content is infinite these days," Charles Cheevers, ARRIS VP, product line management, multimedia, and CTO, Europe, said.

For competitive reasons, operators may want to use SDV to provide a more personalized and unicast service. "That is the experience you get when you do over the top," Nimrod Ben-Natan, vice president, product marketing, solutions and strategy, Harmonic Inc. said.

In any case, SDV requires a high channel count. "(For) all companies running SDV, channel counts go to eight to 16 per f-connector (output)," Cheevers said.

For SDV, an edge QAM also needs to be able to copy programming in real time for multiple viewers without

continued on page 5

QAM Glossary

BIT ERROR RATE (BER)

The number of bits in error expressed as a portion of transmitted bits. A measurement of transmission accuracy. It is a ratio of bits received in error vs. bits sent.

CARRIER

An RF or optical wave used to transport (carry) video, audio or data signals over various media such as coaxial cable, microwave, broadcast TV, radio, or optical fiber employing various modulation techniques.

EDGE QAM

A multi-purpose QAM modulator, as opposed to one dedicated to a particular purpose, such as digital broadcast video. They are distinguished by Gigabit Ethernet interfaces (1 and 10) and flexibility—many edge QAMs can accommodate switched digital video (SDV) and video on demand (VOD) in addition to broadcast digital video. Universal edge QAMs are designed to add data to that mix. The term "edge" refers to the somewhat amorphous logical edge of the network, as opposed to a physical location.

continued on page 8

500,000 QAMs shipped. And still counting.



Talk about a blockbuster! With over 500,000 QAMs shipped to date, and deployed by over 60 service providers worldwide, our BigBand Edge QAM platform (including the current BEQ™ 6000) continues to outpace the competition.

What sets the BigBand BEQ™ 6000 apart?

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- ▶ Delivers the lowest total cost of ownership with the highest reliability
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And the BEQ6000 supports SDV, VOD, broadcast video, vIP PASS™ and DOCSIS®3.0/CMTS, giving you the ability to manage today's services requirements, and the flexibility to address future demands as your network evolves.

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networks

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ARRIS

Product Name	Product Type	Features
D5	Universal Edge QAM Modulator	The compact and scalable D5 UEQ is a feature-rich modular device fully compatible with existing VOD, SDV and Broadcast standards worldwide. It enables M-CMTS and DOCSIS 3.0 with complete DTI, DEPI-MPT and DRFI features with capacity for 6 QAM modules for up to 192 channels in a two-rack unit.

BigBand Networks

Product Name	Product Type	Features
BEQ 6000	Universal Edge QAM Modulator	Universal Edge QAM platform that meets service providers' needs for reliable and cost effective digital video delivery. Widely deployed platform with 500,000+ shipments. Supports SDV, vIP PASS™, VOD, broadcast, modular CMTS and low cost IP video delivery. Superior performance, scalability, and reliability. Lowest total cost of ownership with low power consumption. Dynamic bandwidth and network resource utilization

Blankom

Product Name	Product Type	Features
EQM100	EdgeQAM Modulator	Modular unit generating up to 24 QAM channels from unicast or multicast MPEG transport streams encapsulated in UDP supplied over IP networks. Through the use of direct digital frequency conversion an RF-Signal is generated for a local CATV network. Features: web server, SNMP, GigE, jitter correction, null packet insertion.
EQM008	EdgeQAM Modulator	Provides 8 QAM channels from unicast or multicast MPEG transport streams encapsulated in UDP supplied over IP networks. A small form factor design allows to install the unit remotely in the local loop, or multiple EQM008 modules in a 19" chassis. Features: web server, SNMP, GigE, jitter correction, null packet insertion.
AMA299	QAM Modulator	Multinorm frequency agile ASI-to-QAM modulator suitable for large networks and high quality QAM signal distribution. Features: null-packet insertion, PSI- and SI processing with NIT generation, PID filtering, web server, SNMP, ASI input, jitter correction, 63dBmV output, alarm contacts.
AMC406	QAM Modulator	Modular dual channel frequency agile QAM Modulator/Upconverter. Features: multi norm (Annex A/B/C) null-packet stuffing, Integrated transport stream processing capabilities (NIT, CAT-Filter, Operator-ID, PID-Filter, Network-ID, dual ASI inputs, integrated output combiner. Modular design allows installation of up to 16 modules in a 9RU subrack (32 QAM channels)

Casa Systems

Product Name	Product Type	Features
C2150	Multi-purpose Edge-QAM Modulator	Designed to meet the DOCSIS multi-channel RF and modular CMTS Edge QAM spec. Can deliver both video-over-IP and MPEG services concurrently. Enables provisioning high-bandwidth IP services in addition to traditional broadband access and VoIP services. Integrated MPEG video processing capability provides flexibility to offer MPEG or DVB-based switched digital video, VOD, and interactive TV services.



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Cisco Systems		
Product Name	Product Type	Features
RF Gateway 1	Universal Edge QAM Modulator	Fourth-generation QAM product that enhances SDV support, higher density (48 QAMs per RU), improved reliability, superior RF performance, 1 GHz RF output, and DOCSIS 3.0/M-CMTS capability. Integrated and tested as part of Cisco uBR10012 M-CMTS. Enables converged next-gen cable access network by offering comprehensive video and DOCSIS functions in a single platform.

Harmonic		
Product Name	Product Type	Features
NSG9000	Narrowcast Services Gateway	High-density (72 QAM in 2-RU) system that offers leading RF performance and serves as highly integrated digital video gateway, capable of performing multiplexing, scrambling, QAM modulation, encryption and RF upconversion for on-demand content streamed over an IP network. Solution for broadcast, on-demand, SDV and M-CMTS. DOCSIS 3.0-ready and designed to support direct-to-edge apps.

Motorola		
Product Name	Product Type	Features
APEX 1000	Universal Edge QAM Modulator	Power-efficient multiplexing, encryption, and QAM/RF upconversion in a high-density 1 RU platform. Universal and open standards-based. Can be used in VOD, SDV and M-CMTS configurations and broadcast encryption applications. Dual-power supplies and up to three removable and hot-swappable QAM modules. Delivers up to 48 QAM channels across 6 RF ports.
REM1000	RF Switch Device	Used in conjunction with the APEX1000 EQAM product to support RF port level redundancy for narrow-cast applications. Total of 22 RF ports (12 inputs and 10 outputs), supporting up to two directly connected APEX1000 devices. Each connected APEX1000 provides 5 primary RF inputs and 1 backup RF input.

LiquidStream		
Product Name	Product Type	Features
LxS-3616	Universal Edge QAM Modulator	576 QAMs per chassis; up to 36 QAMs per RF Port; 16 RF Ports per chassis. Redundancy on all modules, including N+1 RF module redundancy. Frequency plan flexibility: Place each QAM anywhere in the digital band. Connect-Once RF: No need to disconnect the coax for future upgrades or modifications.

RGB Networks		
Product Name	Product Type	Features
USM	Universal Scalable Modulator	Fully redundant, single rack unit chassis supports up to 128, 6 Mhz QAM channels, saving nearly 5 times the rack space and power required by lower-density QAMs. Supports multiple apps and services and can multiplex 1280 programs for a 'pay-as-you-grow' licensing model so users only pay for QAM channels as needed.

TANDBERG Television		
Product Name	Product Type	Features
EQ8096	Universal Edge QAM Modulator	Runs broadcast, VOD, SDV and HSD simultaneously. Full functionality for all apps from a single, highly integrated, low power, 96 QAM channel 2RU unit. Open standards interface. Dual AC or DC power supply. Supports full DOCSIS 3.0 specs. Hot-swap modulator cards. Advanced de-jittering. Up to 1 GHz output frequency.

Vecima Networks		
Product Name	Product Type	Features
HyperQAM	Universal Edge QAM Modulator	High-density universal edge QAM that offers simultaneous support for triple-play video, voice and data services. Ideal for cable operators requiring cost-effective solutions for their digital video services, the HyperQAM is software upgradeable to support next gen services such as DOCSIS 3.0 and M-CMTS.

continued from page 1

dropping packets or losing information. "It needs to do it at the speed of a channel change," Doug Jones, BigBand Networks chief architect, cable, said.

MORE FOR LESS

Buckeye CableSystem is in the deployment stage of an SDV rollout. The plan is to switch 110 channels, which should gain back approximately seven QAM channels of spectrum. The company has purchased 70 BigBand BEQ Chassis for SDV.

Buckeye takes into account the cost per QAM. "We are not going to pay double the cost for something that is not double the value," Jim

Brown, director of engineering, said, noting density also is important.

There are so-called ultrahigh density modulators on the market. LiquidStream 's LxS 3616, for example, offers 36 QAM channels per port, but says it is the density that drives functionality. (For more on density, see sidebar on BroadLogic's chip, page 7.)

"If you lit up certain services (like) SDV, and want to add DOCSIS 3.0 or more VOD capacity, you don't have to roll a truck. You don't have to do anything. You can sit at a local terminal and turn them on," Pierson said.

Alternatively, using a stack of four-channel per port QAM modulators need combining

networks, which take up rack space and are harder to manage, Pierson said. "This is all alleviated if all the QAMs you need forever are coming from the same coax port."

Ben-Natan talked about

than an RF network.

"We are shaping octal-based QAMs, but we still have customers that buy quad-based QAMs," Ben-Natan said when asked about the timing of the HectoQAM. "Our goal is to have

“
In an HFC world, QAM modulation will be
the predominant vehicle for a while.
”

— Jeff Winn, RCN

generating up to 100 QAMs on a single RF port to a specific network region. The HectoQAM would combine voice, video and data services in an IP rather

the right density that is required at the right time for the market."

The market for higher channel counts depends in part on digital conversion, Jones, said.

ARRIS D5™ Universal Edge QAM

- ◆ **Video** - Feature rich and fully compatible with existing VOD, SDV, and Broadcast standards world wide – a drop-in replacement for existing QAMs
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DIRECT DIGITAL SYNTHESIS

In the "old" days (some four years ago), modulators outputted an intermediate frequency, which was then upconverted with resistors and capacitors. This changed with the advent of very dense FPGAs, Charles Cheevers, ARRIS vice president, product line management, multimedia, and CTO, Europe, said.

The QAM signal now is generated digitally. "When (the signal) is created digitally, you can cancel artifacts, or shape it any way you want and improve its characteristics," Cheevers said.

"In the analog domain, it cost you signal level to shape the signal and make it perfect. In the digital domain, you can just add to it or subtract (from) it," Tony Pierson, vice president business development, LiquidStream, said.

The next step is to feed the direct digital synthesis output into a digital to analog converter into the 1GHz frequency range. "The only thing you need to do is amplify," Cheevers said.

QAM and the MDU

How best to serve multiple dwelling units (MDUs)?


At the Broadband Properties conference in Dallas in April, Verizon SVP Technology Mark Wedleitner extolled the virtues of fiber all the way to each unit. Property developers and managers, however, pointed out certain problems with bringing one particular provider's equipment all the way into a resident's apartment or condominium.

For its part, the cable industry has several possible QAM-based answers to that question.

Vecima Networks has developed an MDU Gateway, which eliminates the need for a set-top box for each subscriber in an MDU.

Using integrated CableCards for program decryption, the platform provides a single point of control for remote management of all services running through the unit and involves minimal installation for the main service, plus three ports for local content insertion.

As for local content, in April Motorola introduced the QUE100 QAM MicroEncoder, designed to migrate video content generated and consumed within MDUs and commercial buildings from analog to digital. A common application is on-site security feeds.

The DVISm from ATX Networks likewise aims for cost-effective QAM channel insertion of security camera or local advertising as MPEG-2 video. It well suited for spectrum reclamation or MDUs provisioned with digital only set-top boxes or DTA adapters, the company says. 

“**One edge QAM serving more applications at once. I would love for that to be the case.**”

— Jim Brown, Buckeye CableSystem

For example, with a 750MHz cable plant, there would be approximately 116 channel slots, but thirty of those might still be analog for local off-air channels. "That leaves 80 odd slots that could be converted to QAM."


"It really depends on operators' strategy for reclaiming analog channels," Jones added, noting channel counts would be higher if a plant is 850 MHz or 1GHz.

and or M-CMTSs even though we don't have those at this time," Al Kuolas, CTO, said. However, he isn't sure that integrating the CMTS functionality into the modulator makes sense for smaller operators where all equipment is in a single headend facility.

UNIVERSAL UNIVERSE

While current models of edge QAMs can support various applications, it's not done concurrently. That is changing, Farassat explained. "All call (their products) universal modulators, but operators buy multiple (devices) for different applications," he said, noting that before the end of the year, RGB will announce a new architecture to address this.

BigBand's Jones said his company also is planning to have this functionality in a QAM modulator by the end of the year. "Operators (will) not longer (be) tied to buying one QAM (modulator) for each service... There are operational efficiencies to moving toward a universal edge QAM. That will be the trend over the next three years."

"One edge QAM serving more applications at once. I would love for that to be the case," Brown said, adding, however that Buckeye probably would not be an early adopter. "That would be putting a lot of eggs in one basket." 

MODULARITY

Many of the Edge QAMs on the market today can support broadcast television, VOD, SDV, DOCSIS 3.0 and a modular-CMTS architecture (M-CMTS). QAM modulation can be removed from the CMTS with the edge QAM acting as a downstream device.

"If you strip down the functionality (of the CMTS), put it in the edge QAM, and run IPTV through the edge QAM...the economics might be available to let that work," Pierson said.

The market hasn't adapted the concept of the M-CMTS as fast as expected, Farassat said. "The architecture is complex. It also does require competitors to work with each other—the vendor building the QAM modulator and the one selling the CMTS."

When Atlantic Broadband purchased edge QAMs recently, it went with Harmonic. "We wanted to ensure some ability to upgrade (and) support both SDV

Denser QAM Chip Costs Less

BroadLogic, a San Jose, CA, maker of video-processing semiconductors, announced in June an ultra-dense quadrature amplitude modulation (QAM) chip for video, voice and data transport.

The TeraQAM chip will be available in 16-channel and 32-channel versions, thus doubling and quadrupling QAM chip density from the standard eight-channel chip most commonly shipped today.

The going rate for eight-channel QAM modulators is around \$200, according to BroadLogic.

The vendor expects to

manufacture production quantities of its TeraQAM chips by the end of 2009. BroadLogic anticipates the denser chips will allow QAM manufacturers to approach the \$100/QAM watermark.

"Operators consider \$100 per QAM to be the Holy Grail," said BroadLogic's president and CEO Danial Faizullahoy.

While the cost of QAM modulators has declined dramatically in the past few years, the subject is still of keen interest to cable operators and plays into the debate over whether to deliver IP

video through the CMTS or bypass the CMTS in favor of edge QAM modulators. Proponents of bypass point out that stand-alone edge QAM modulators are a lot cheaper than downstream CMTS ports.

Whether operators choose to bypass the CMTS for video transport or not, Faizullahoy anticipates a need for more QAM modulators in cable operators' HFC networks to meet the demand for personalized video content such as VOD, interactive applications and advanced advertising.

In addition to increased

density and lower cost of its new chip, BroadLogic is also touting TeraQAM's lower power usage, claiming a reduction in power consumption of up to 85 percent.

BroadLogic, which was founded in 2002, counts Time Warner, Comcast and Cisco among its investors.

Canadian QAM vendor LiquidStream Systems makes its own chip, which can support 36 QAM channels per port, but the company does not sell its chip to other QAM manufacturers. ➡

—Linda Hardesty

A truly universal edgeQAM



Harmonic's market-leading NSG™ 9000 delivers superior RF performance and is the only proven platform that can support VOD, nPVR, cable IPTV, broadcast, M-CMTS, SDV and edge encryption.

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Long(er) Live QAM!

How much life is left in QAM technology?

Some 20 months ago, at Paul Kagan's "QAM Before the Storm" event that preceded the SCTE Conference on Emerging Technologies (ET) in Los Angeles, one proponent of universal edge QAM devices noted "wistfully" (to borrow the bon mot used by Heavy Reading Senior Analyst Alan Breznick) that given the fundamental economics of the two technologies, RF is in a losing battle against photonics.

In other words, the shift from RF over coax to IP over fiber is inevitable. If that is the case, then RF over glass (RFoG) looks like an intermediate step.

At this year's Cable Connection week, however, two technical papers revived RF's standing as a contender. As it happens, they both had the same author, Dr. Robert Howald, customer systems architect in

Motorola's office of the CTO.

In "Fueling the Last Coaxial Mile," a paper presented during the ET portion of the April event, Howald explored unused capacity of the HFC plant. As an "interesting reference point," he

“**Operators can start netting themselves that extra 25 percent of bandwidth efficiency.**”

— Robert Howald, Motorola

made this observation: "Note that 1 GHz of ideal 1024-QAM bandwidth, at 10 bits/s/Hz efficiency, adds up mathematically to 10 Gbps."

That's a lot of throughput, comparable to what's promised with emerging 10Gig passive optical networking (PON) recommendations from the IEEE and ITU-T. But 1024-QAM? Didn't Howald explain the challenges of

deploying 1024-QAM in a Cable-Tec Expo paper back in 2002?

Yes, he did. Which is why it's important to digest "New Megabits, Same Megahertz: Plant Evolution Dividends," the paper that Howald (and col-

here, an awareness of the key drivers to link performance, and a modeling approach that can be used to assess HFC readiness to accept 1024-QAM signals, operators can start netting themselves that extra 25 percent of bandwidth efficiency that is currently going unused in already occupied spectrum."

To some, this may sound like QAMunism, i.e. the theory and practice of constantly moving to ever-higher orders of modulation. One reality check, for instance, are ongoing challenges that operators have with 64-QAM in the upstream. (For more, stay tuned for next month's webcast on the topic.)

Yet it's pretty hard to dismiss the author of that memorable paper from 2002, who returned with two more brilliant ones this year. [↪](#)

—Jonathan Tombes

GLOSSARY *continued from page 1*

MODULATION ERROR RATIO (MER)

A ratio (expressed in dB) of average power in error vectors compared to the average power in ideal vectors of a QAM constellation, with the error vector being the resultant between the ideal and actual power vectors.

MODULATOR

A device that places video, audio or data signals onto a carrier.

QUADRATURE AMPLITUDE MODULATION (QAM)

A technique that uses two amplitude-modulated carriers with a 90-degree phase angle between them to produce a signal with an amplitude and phase angle that can vary continuously. A digital frequency modulation technique that is a combination of both amplitude modulation (AM) and phase modulation (PM). By combining phase and amplitude

modulation, it is possible to transmit significantly more bits per symbol, increasing spectral efficiency. Despite their high susceptibility to interfering signals, QAM carriers are increasingly being used in the return path.

QUADRATURE COMPONENT

The vertical axis (amplitude) that is shifted 90 degrees from the horizontal axis (or in-phase component) of QAM.

QAM CONSTELLATION

A graphic representation of the phase and polarity of individual digital signal components plotted as coordinate points on an x and y axis.

QAMMUNISM

The theory and practice of constantly moving to ever higher orders of modulation. Its advocates are, of course, QAMmies. (See above, Motorola Customer Systems Architect Robert Howald.) [↪](#)