
QAM VDSL – A tutorial

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Agenda

- What is a QAM modem
- Status of the EFM standard with respect to QAM VDSL
- Technology advancements during the past years
- Where we are going

QAM is simplicity

- QAM provides the best performance in the field, even though it is simple to design and simple to use
- New features are added every year to QAM modems ensure continued improvement in performance and excellence when compared to DMT
- Even though QAM is a simple and straightforward technology, we assure chip designers and the system developers that they will still enjoy making QAM products
- Fact: all the system management entity must do to bring a link up is set a profile for 2 carriers and all the rest of the bring up is done automatically, with no intervention from an external controller, does not impede the fast time to market of development efforts

Korea and Korea Telecom can confirm that QAM VDSL is in the field, in large numbers, with a fast learning curve



The advertisement features a man in a grey jacket and red pants playing a guqin (a traditional Chinese zither) in front of a large banner. The banner has Korean text: '최고는 다릅니다!' (The best is different!), '꿈의 속도! 메가패스 VDSL' (Dream speed! Megapass VDSL), and '메가매니아 24시간 자킴이' (Mega Mania 24-hour service). The banner also includes the KT logo and a '100' speed indicator. To the right of the banner are three speech bubbles. At the bottom left is a white speech bubble, and at the bottom center is a white box. To the right of the banner is a photograph of a server rack with multiple units, each with the KT logo and glowing green lights.

THE BEST IS DIFFERENT!

**Dream SPEED!
Megapass VDSL**

**Mega Mania
24 Hrs Service**

**Megapass helps
to DRIVE my
Internet Speed &
Services**

SLA

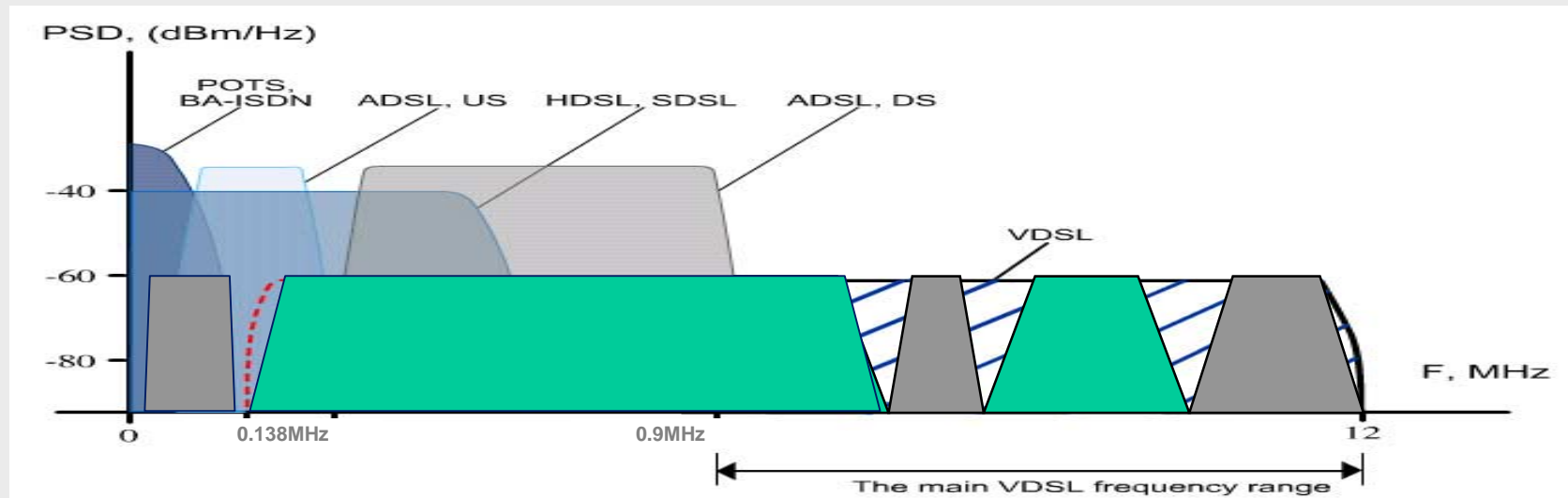
KT "The Value Networking Company"



What is a QAM VDSL PHY?

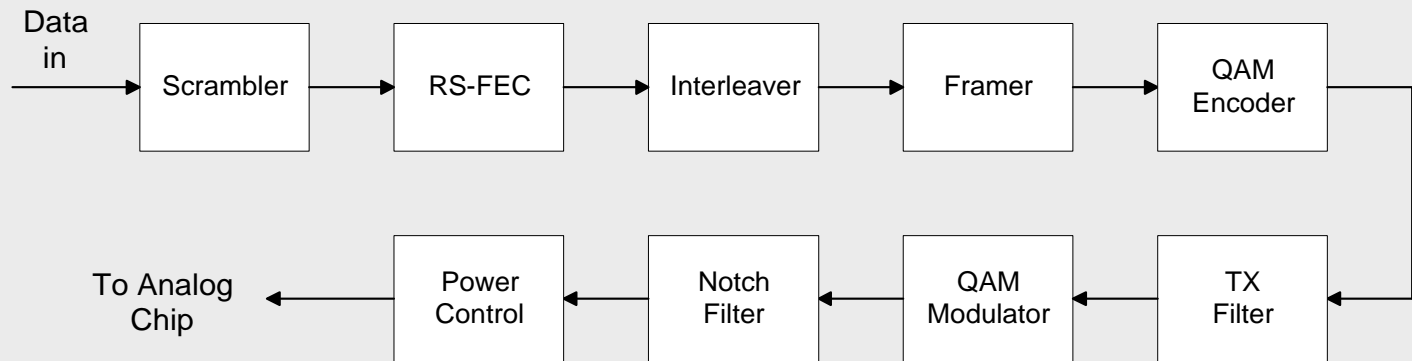
The most advanced VDSL technology available.

- QAM symbols are transmitted in each carrier
- A wideband signal is transmitted at a high bit rate
- The receiver equalizes the signal with a multi-stage blind receiver
- Blind equalization – only carrier configuration is needed, the blind equalizer performs signal decoding automatically, with no need for information exchange



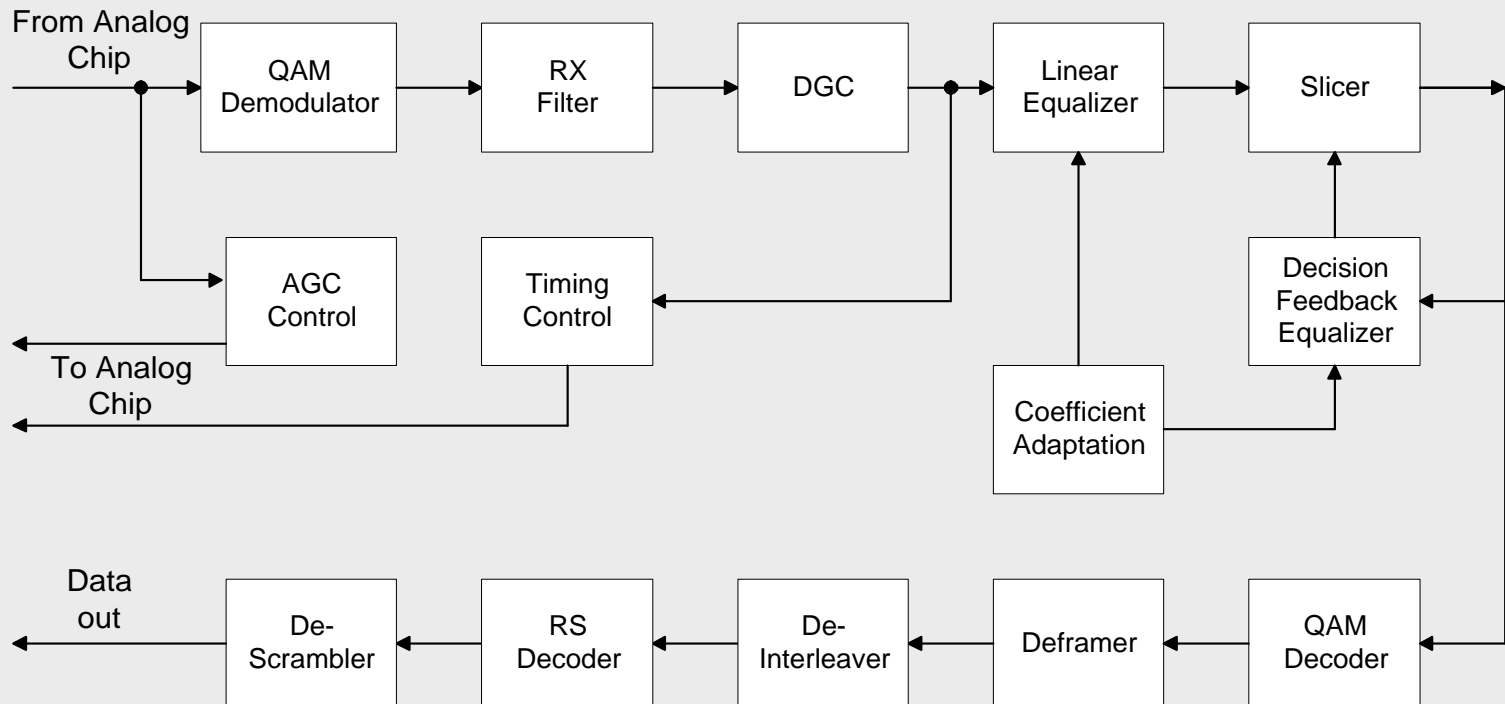
QAM – focus on simplicity and robustness

- The transmitter is the simplest function in the PHY.
- Notch filters exist so that power reduction in HAM bands is supported.
- Power control and PSD shaping is performed to meet Power Back Off (PBO) needs.



QAM receiver

- The receiver is composed of a demodulator and filter, control of the AGC and timing loop, equalization, decoding and framer.
- In the EFM spec, we added the Ethernet encapsulation to this PMD and PMA function



What are the impairments that a modem deals with?

- Interference from non-VDSL systems in the bundle
- Interference from other VDSLs in the bundle
- Problems with the telephone circuit impulse (on/off hook, ringing, tax signals etc...)
- Impulse noise
- Near Far issues (Power Back Off - PBO)
- HAM radio
- AM radio
- Bridged taps, Cable gauge mixes

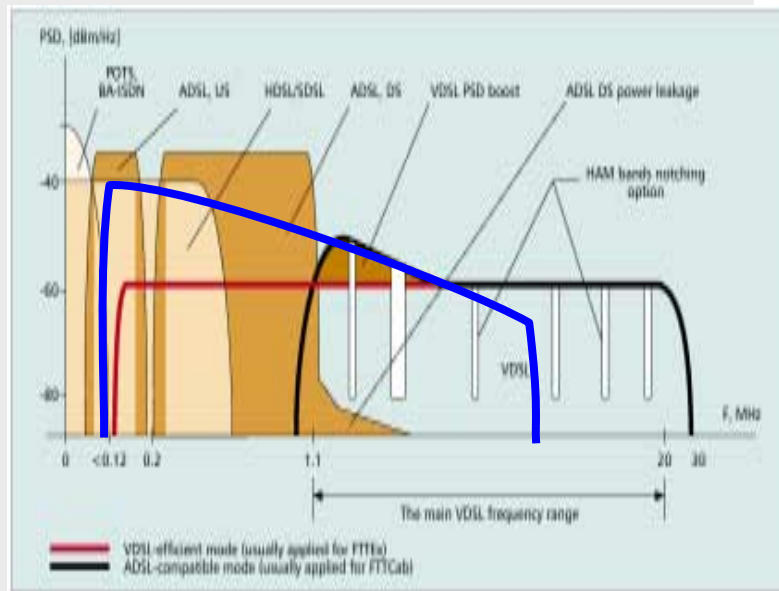
How does a QAM modem set up a link?

- Management system configured for the band plan in use in the country (according to regulation)
 - Target profile of operation is set (rate, notches)
 - Transmitter goes on
 - Equalizer at far end performs blind equalization and brings up link
 - Power Back Off is performed automatically, together with rate adaptation, if needed.
 - In QAM, all configuration can be done by internal message channel (VOC). Handshake is redundant yet supported.
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- Just set the profile and the modem sets up the link

QAM is rate adaptive and can work with non-standard interferers

■ Example: T-LAN interference in Korea

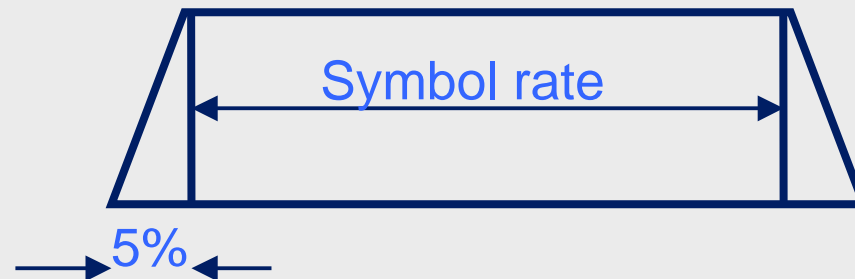
- In addition to standard ADSL, a system called T-LAN is deployed in the network and creates cross talk in to the VDSL frequency range



- QAM rate adaptive algorithm detects the noise and shifts the carrier frequency and symbol rate to work around the T-LAN

Excess bandwidth – 10% overhead

- The digital QAM signal is transmitted through a finite length filter. This creates a shaped signal with “excess bandwidth”.
 - First generation QAM had 20% excess (overhead)
 - EFM spec and current deployments/implementations have 10% overhead

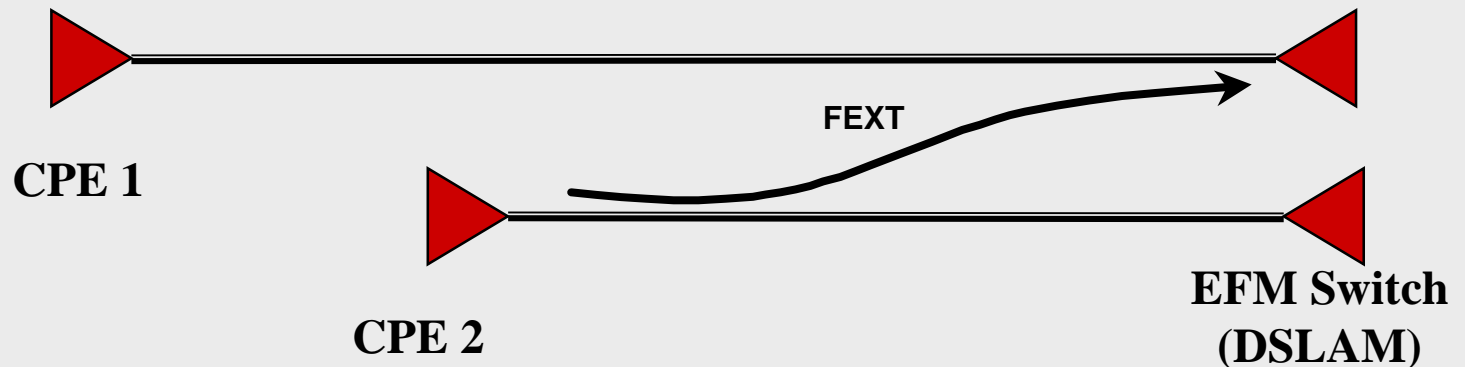


- With new QAM filter-less designs, the total overhead goes down to 10% since no guard band is required.

Power back off

The FEXT interference from short to long lines

- Power Back Off (PBO) is required to reduce crosstalk from CPE devices that are close to the Switch and can “hide” the signal of a CPE that is farther away
- A mask defines the PSD at the receiver so that all signals are received equally at the receiver.
- The transmit PSD has the slope of $\sqrt{\text{frequency}}$
- Shaped PSD in QAM modems enhances performance.



Status of SCM 10PASS –TS standard

- Clause 30
 - Layer Management Specification exists
- Clause 45 – Registers
 - All the registers required for OAM and configuration of a SCM PHY are included in clause 45.
- Clause 61 – PCS
 - MAC-PHY rate matching, PMI aggregation, TPS-TC (Ethernet Encapsulation over the VDSL data pump), G.hs
- Clause 62 – 10PASS-TS PMA and PMD
- Clause 62.3 – SCM PMA
 - Taken from VDSL standards
- Clause 62.5 – SCM PMD
 - Taken from VDSL standards,
 - Includes all link state machines

Configuring an SCM PHY is covered entirely in the standard

Simplicity. No confusing options

- Annex 62A - PMD Profiles for 10PASS-TS
 - The rate, band plan, PSD mask and notches are chosen from this annex.
 - The clause 45 registers to be configured for each profile will be defined in this annex
- Clause 45 registers are used to set the configuration of the PHY
 - Rate, band plan, carrier, symbol rate, notch state etc.. Are configured through clause 45 registers
- SCM PMD performs link activation state machine including blind training and equalization.
- Annex 62B - Performance guidelines for 10PASS-T PMD profiles (these verify performance)
- If a configured profile is not achievable, the management entity can reconfigure a new profile

QAM developments over the last 4 years

- Filterless – no duplexing filters
- Multi-Band – From fixed 2 band to flexible 4 band
- Support for band 0
- Ham radio notching
- Advanced blind equalization
 - Simple, fast, automatic and autonomous – Ethernet like
- Rate adaptive solutions for the field
- Low power, low cost – Our Ethernet based VDSL links provide better price/performance than ADSL!!!
- Multi-port solutions
- Single chip solutions

QAM is committed to the EFM vision & schedule

- QAM VDSL is as simple as Ethernet
- The buying market has chosen QAM as the de-facto solution
- Korea and Japan have moved to Ethernet over VDSL for their next generation of access networks. Others are following.
- The vision of Ethernet in the access is prevailing. The simplicity and performance of QAM meet that vision
- Every new standard chooses a more modern solution. VDSL QAM is the modern flavor of DSL.
- EFM can move ahead..