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ADSL

Signal to Noise Ratio &
Seamless Rate Adaptation

ADSL types

ADSL Type	Standard	Up to D/S Speed	Up to U/S Speed	Max Freq.	U/S Tones	D/S Tones	No. of Bins
ADSL1	G.992.1	8Mbps	1.3Mbps	1.1MHz	6 – 31	33 – 255	256
ADSL2	G.992.3	12Mbps	1.3Mbps	1.1MHz	6 – 31	33 – 255	256
ADSL2+	G.992.5	24Mbps	1.3Mpbs	2.2MHz	6 – 31	33 – 511	512
Annex M	G.992.5	24Mbps	3.3Mbps	2.2MHz	6 – 56	60 – 511	512

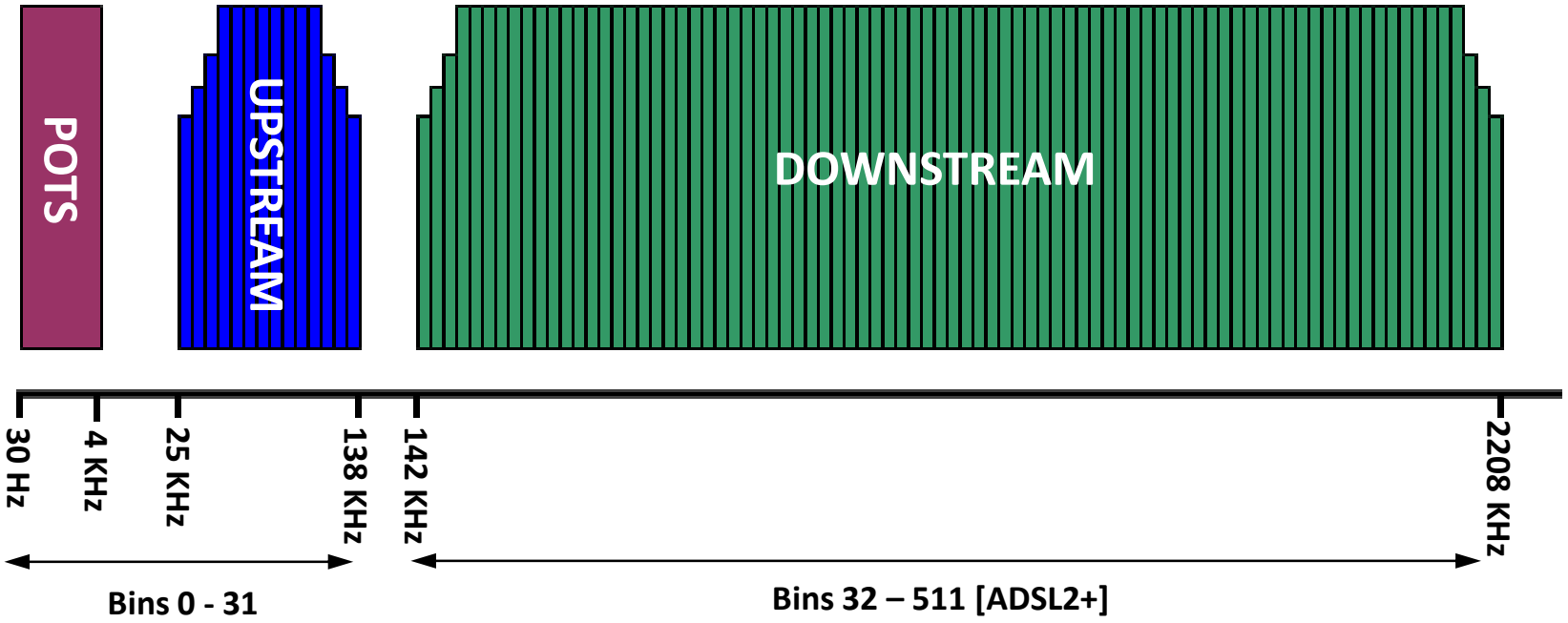
Note:

ADSL2 Annex J - 12Mbps D/S and 3.5Mbps U/S

ADSL2 Annex L - 5Mbps D/S and 0.8Mbps U/S [Reach DSL]

ADSL Discreet Multi Tone

Discreet Multi Tone [DMT] ADSL2+



Each bin = 4.3125KHz tone

Each bin carries bits [number of bits is dependent on SNR]

Tones not used for data

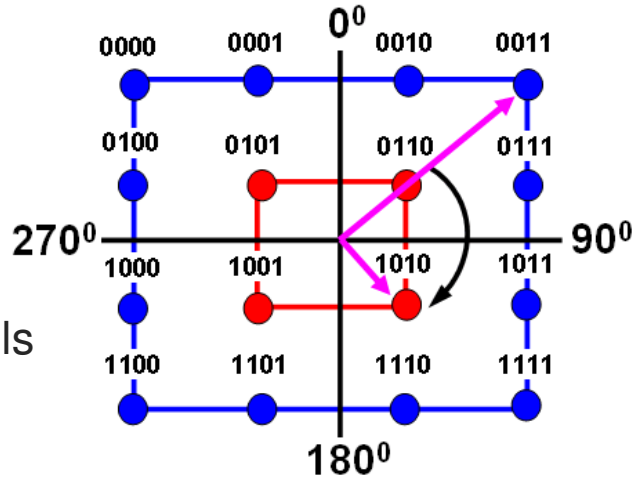
- DC (first tone) - Tone 0
- Guard Band - Tones 1 to 5 [< 25.875 kHz]
  - Tone 1 POTS
  - Tones 2-5 prevents cross talk between POTS + ADSL
- Guard Band Tone 32 [138kHz] - prevents cross-talk between upstream and downstream data
- Nyquist frequency (final frequency tone)
- Upstream Pilot Tone - 16 [69kHz]
- Downstream Pilot Tone - 64 [276kHz]
- Annex-M Stop Band - Tone 59 [254kHz] ADSL2+ Annex-M only
- DSLAM specific tones e.g. Tones 476 - 499 [2053kHz-2156kHz]
- Any bins that DSLAM marks as having SNR too low

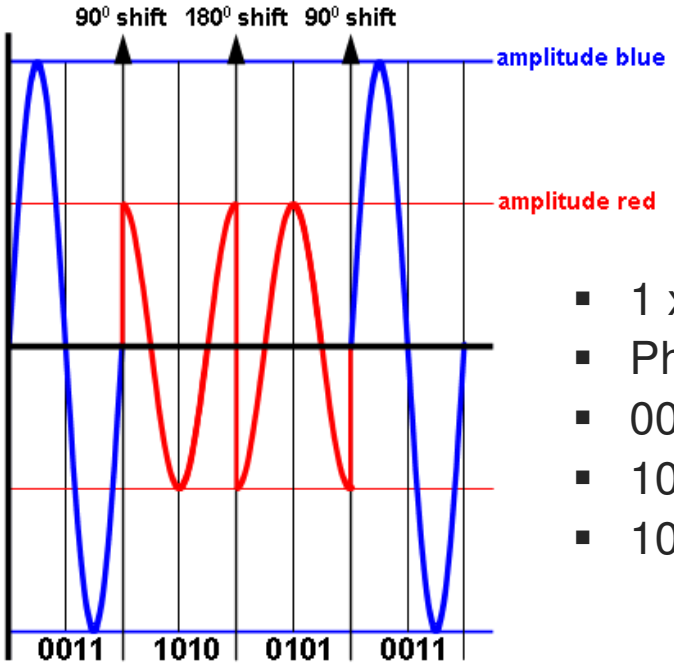
Bins & bits

- No. of bits per bin is dependent on SNR at bin's frequency
- 15 x bits maximum per tone bin
- Minimum of 2 x bits per bin for tone to be useable
  - ADSL2 & ADSL2+ support 1 x bit per tone minimum
- QAM used to modulate the bits onto carrier signal per frequency
- Higher frequency bins carry fewer bits due to poorer SNR
- Bit Error Rate [BER] used to measure quality

QAM illustration

- Quadrature Amplitude Modulation
- 2 x amplitudes – red & blue
- 16 x symbols [0000 – 1111]
- 12 x phase shifts in blue
- 4 x phase shifts in red
- Amplitude & phase shift defines the symbols

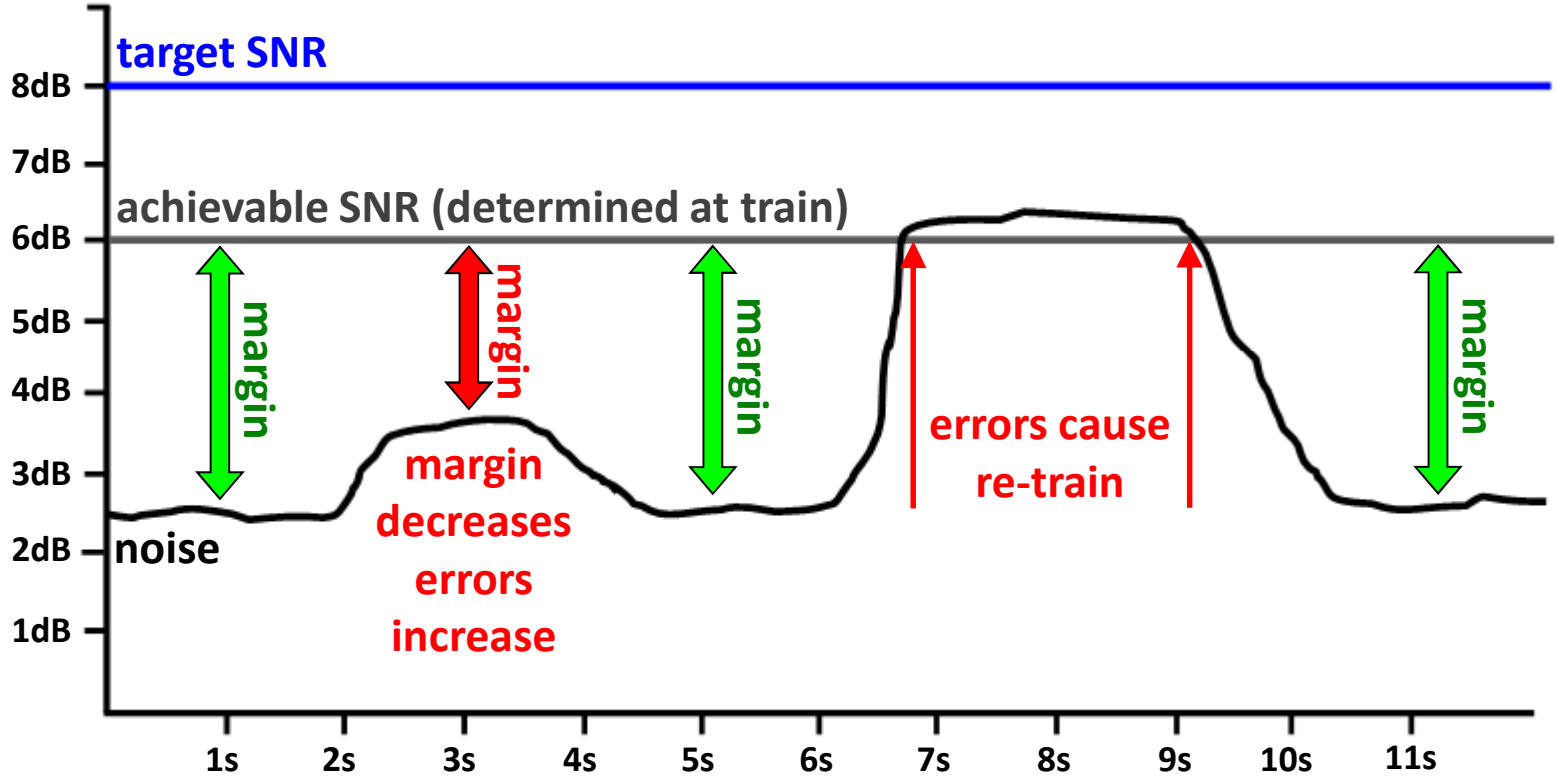




- 1 x error correction bit + 3 x data bits
- Phase shift is relative to previous phase
- 0011 blue 90^0 phase shift to red = 1010
- 1010 red 180^0 phase shift to red = 0101
- 10101 red 90^0 phase shift to blue = 0011

Signal to Noise Ratio

The achievable SNR of a non-SRA line remains at the level attained during training – unless a re-train occurs due to errors



SNR is usually expressed in dB as a logarithmic function: $dB = 10Log_{10}(S/N)$

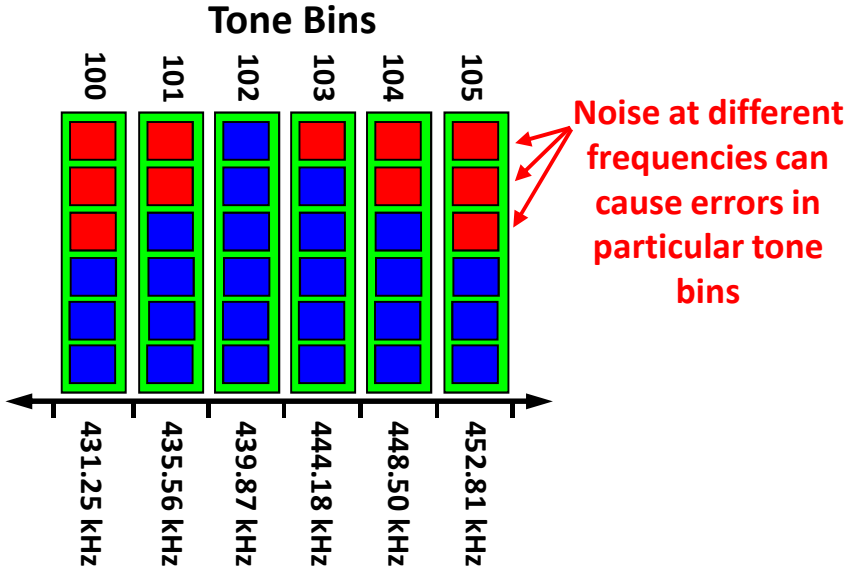
Signal to Noise Ratio

- A small decrease in SNR margin results in a large reduction in signal quality - for example, if margin decreases by 3dB signal quality halves

  10Log_{10} (S/N) = - 3dB

  Log_{10} (0.5019) = - 0.3dB

- Noise may affect different frequencies [tone bins] at different times
- Therefore, the affect of a reduction in SNR is unpredictable
- SNR can also be thought of as the ratio of transportable to non-transportable bits



Signal to Noise Ratio

- SNR margin varies over time depending on the causes of the noise e.g. external interference
- Reducing bit rate can improve SNR to give stability – stability must be the main goal
- Balance is needed – SNR too high means unnecessary reduction in bit rate, SNR too low means errors
- Other techniques are available to reduce errors on poor quality lines e.g. bit swapping and/or interleaving

Signal to Noise Ratio

- The Zhone MKX DSLAM trains at an appropriate SNR value to ensure a bit error rate of 10^{-7} or less
- Having trained at a particular rate there is no dynamic bit rate tuning to improve SNR – lines with high error rates re-train
- ADSL2+ can be configured to support Seamless Rate Adaptation [SRA] to provide dynamic bit rate tuning

Zhone MKX – SNR & SRA

- The DSL chip-sets handle error detection & correction
- The MXK line cards use two different chip-sets:
  - Conexant Octane G24
  - Broadcom BCM6411 (ADSL Bond Cards only)
- The Conexant chip-set supports only downstream SRA
- The CPE controls Downstream SRA (adsl-cpe-profile)
- The DSLAM controls Upstream SRA (adsl-co-profile)
- The Broadcom chip-sets also support PHYR

Zhone MKX – SNR parameters

```
adsl-co-profile x/y/z
targetSnrMgn: ------------->  {60}  Training only (DSLAM)
maxSnrMgn: ---------------->  {150} Re-train unless SRA (DSLAM)
minSnrMgn: ---------------->  {30}  Re-train unless SRA (DSLAM)

adsl-cpe-profile x/y/z
targetSnrMgn: ------------->  {60}  Training only (modem)
maxSnrMgn: ---------------->  {150} Re-train unless SRA (modem)
minSnrMgn: ---------------->  {30}  Re-train unless SRA (modem)
```

The DSLAM and modems exchange status and statistics information using ATU-C/R messages

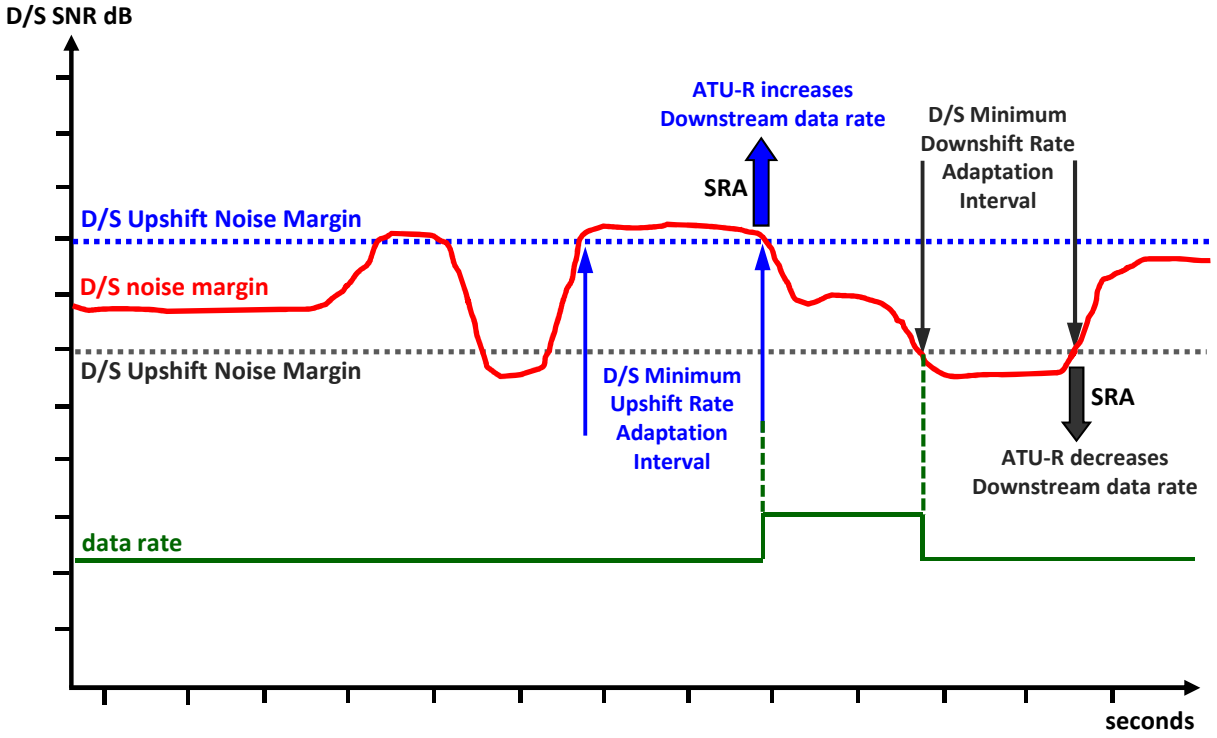
MXK main ADSL parameters

```
adsl-profile x/y/z
adslTransmissionMode: ----------->  {autonegotiatemode} ✓
adslChannelMode: ---------------->  {fastonly} Consider interleave if errors

adsl-co-profile x/y/z
rateMode: ----------------->  {adaptatruntime} ✓
rateChanRatio: ------------>  {50}  Ratio between fast & interleave (if using)
fastMinTxRate: ------------>  {32000}    32Kbps
interleaveMinTxRate: ------>  {32000}    32Kbps
fastMaxTxRate: ------------>  {24000000} 24Mbps
maxInterleaveDelay: ------->  {4}        4ms (byte spacing - needs tuning)
interleaveMaxTxRate: ------>  {24000000} 24Mpbs

adsl-cpe-profile x/y/z
rateMode: ----------------->  {adaptatruntime} ✓
rateChanRatio: ------------>  {50}  Ratio between fast & interleave (if using)
fastMinTxRate: ------------>  {32000}    32Kbps
interleaveMinTxRate: ------>  {32000}    32Kbps
fastMaxTxRate: ------------>  {1024000}  1Mbps
maxInterleaveDelay: ------->  {4}        4ms (byte spacing - needs tuning)
interleaveMaxTxRate: ------>  {1024000}  1Mpbs
```

MXK SRA operation



MXK SRA parameters

adsl-co-profile

- ***downshiftSnrMgn** – U/S SNR at which SRA adjustment starts
- ***upshiftSnrMgn** – U/S SNR at which SRA adjustment starts
- **minUpshiftTime** – U/S & D/S time period for SRA adjustment
- **minDownshiftTime** – U/S & D/S time period for SRA adjustment

adsl-cpe-profile

- **donwshiftSnrMgn** – D/S SNR at which SRA adjustment starts
- **upshiftSnrMgn** – D/S SNR at which SRA adjustment starts
- **minUpshiftSnrMgn** – D/S time period for SRA adjustment
- **minDownshiftSnrMgn** – D/S time period for SRA adjustment

*** Not Conexant chip-set**

MXK SRA parameters

```
adsl-co-profile x/y/z
downshiftSnrMgn: ----------->   {0} Upstream SRA (not Conexant)
upshiftSnrMgn: ------------>    {0} Upstream SRA (not Conexant)
minUpshiftTime: ----------->    {30} Recommended 30 seconds
minDownshiftTime: --------->    {30} Recommended 30 seconds

adsl-cpe-profile x/y/z
downshiftSnrMgn: ----------->   {50} Downstream SRA - Target SNR -1 to -3dB
upshiftSnrMgn: ------------>    {70} Downstream SRA - Target SNR +1 to +3dB
minUpshiftSnrMgn: --------->    {30} Recommended 30 seconds
minDownshiftSnrMgn: ------->    {30} Recommended 30 seconds
```

- CPE controls downstream SRA [adsl-cpe-profile]
- DSLAM controls upstream SRA [adsl-co-profile]
- Conexant chip-set supports only downstream SRA
- SRA often only applied in the downstream direction

Thank You!

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