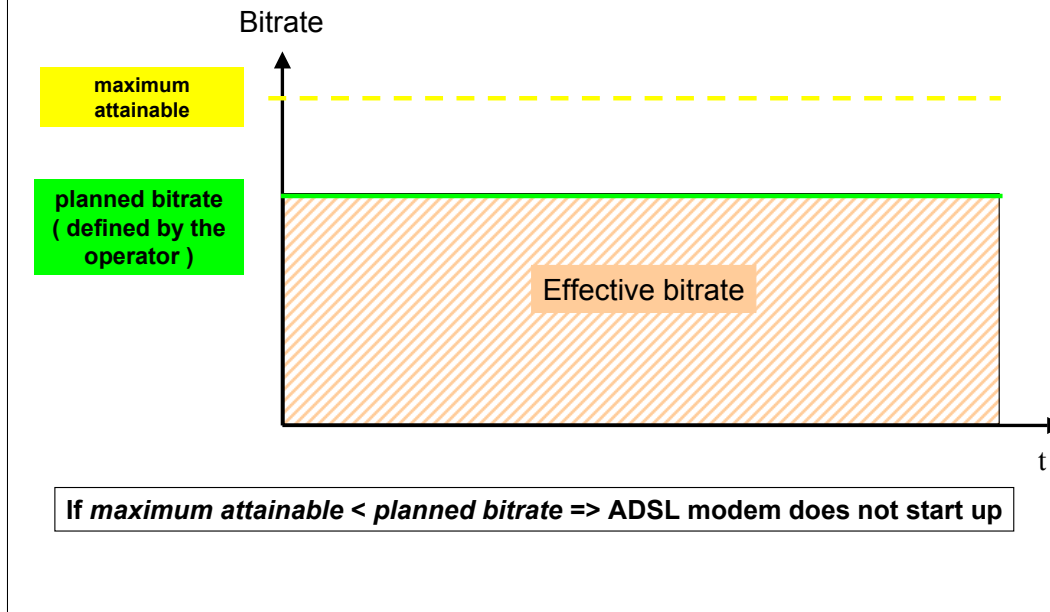


At what line speed do modems initialise?

(1) Operator Controlled Mode (RA mode 1)



Based upon Signal to Noise ratio measurements for each carrier frequency, a maximum attainable line speed can be calculated. This is the maximum amount of bps that can be transported over the UTP in between the ATU-C and the ATU-R. A maximum attainable ATM speed (shown above) is calculated out of the maximum attainable (measured) line speed!

Since the specified (planned) bit rate in the ADSL line profile is an ATM rate the modems will synchronise at a line speed slightly higher than the planned (ATM) bitrate.

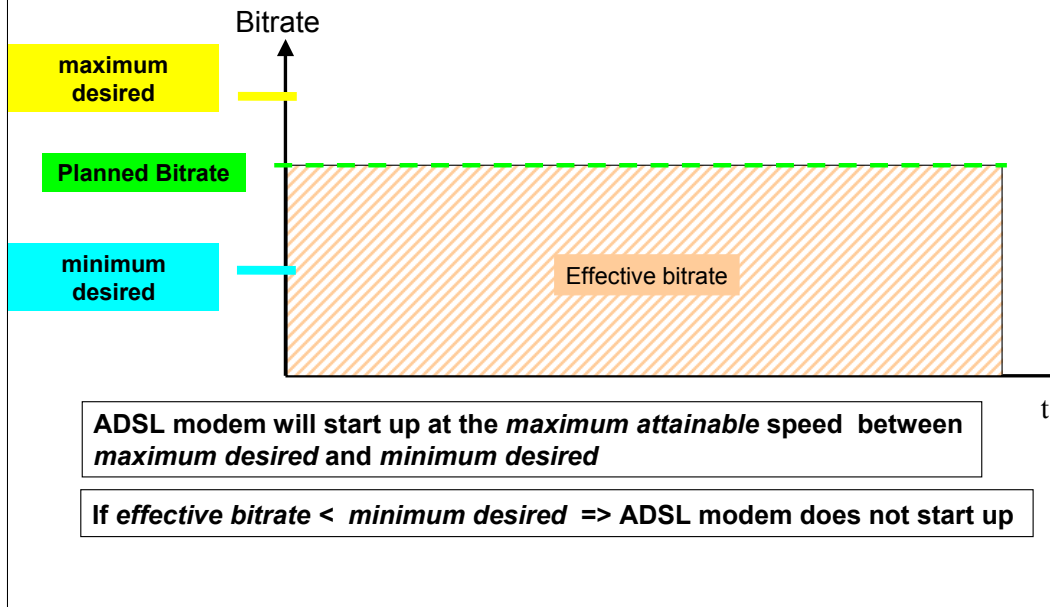
In other words, although ADSL line speed is to be specified in the ADSL line profile, ATM rates are assigned!

Thus a maximum attainable ATM speed (shown above) is calculated out of the maximum attainable (measured) line speed!

In operator controlled mode, the ATU-C & ATU-R will only synchronise whenever the requested (planned) bitrate is smaller than the maximum attainable bitrate. In this mode it is important not to set the requested bitrate too high since the modems will stay out of service (read will not synchronise)

At what line speed do modems initialise?

(2) Rate Adaptation Mode at startup (RA mode 2)



In rate adaptation mode at startup both modems will synchronise at a line speed (and thus ATM speed) in between a requested minimum and maximum bitrate.

The planned bitrate is the (real) requested value, just like in the operator controlled mode, but we will allow synchronisation at a speed slightly lower than this planned bitrate, the minimum bitrate! Indeed, sometimes a slightly lower value than the requested one is better than nothing!

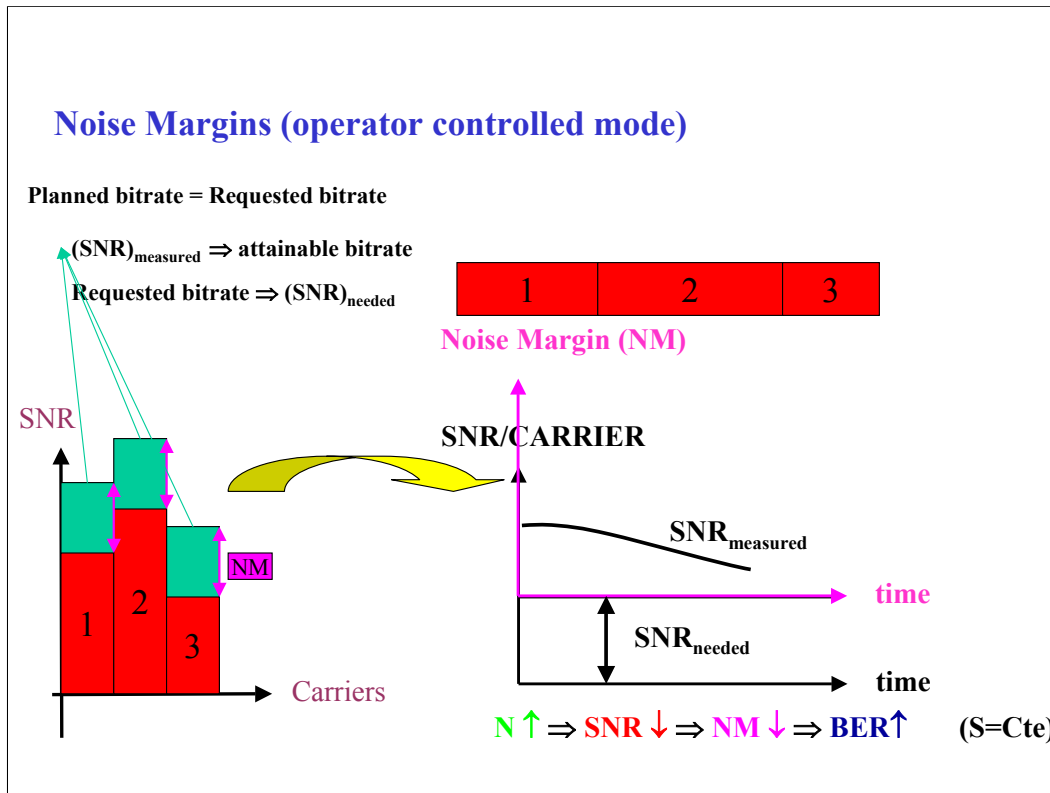
Why would synchronisation take place at a value higher than the requested one? To make the system more robust; compare it to a bus having 100 seats for only 90 passengers; a waste? Maybe, but if some of the seats are broken you will need the spare seats to cover up.

Noise Margins (operator controlled mode)

Bits/symbol	QAM	Signal/Noise ratio (dB) for BER<10 ⁻⁷
4	QAM-16	21,8
6	QAM-64	27,8
8	QAM-256	33,8
9	QAM-512	36,8
10	QAM-1.024	39,9
12	QAM-4.096	45,9
14	QAM-16.384	51,9

Another way to look at the MNM.

A minimum noise margin >0 results in rescaling the third column of above table. E.g., if QAM-64 is assigned at $SNR = SNR_{table} + NMN$, this means that the BER will decrease from 10^{-7} to a lower value.

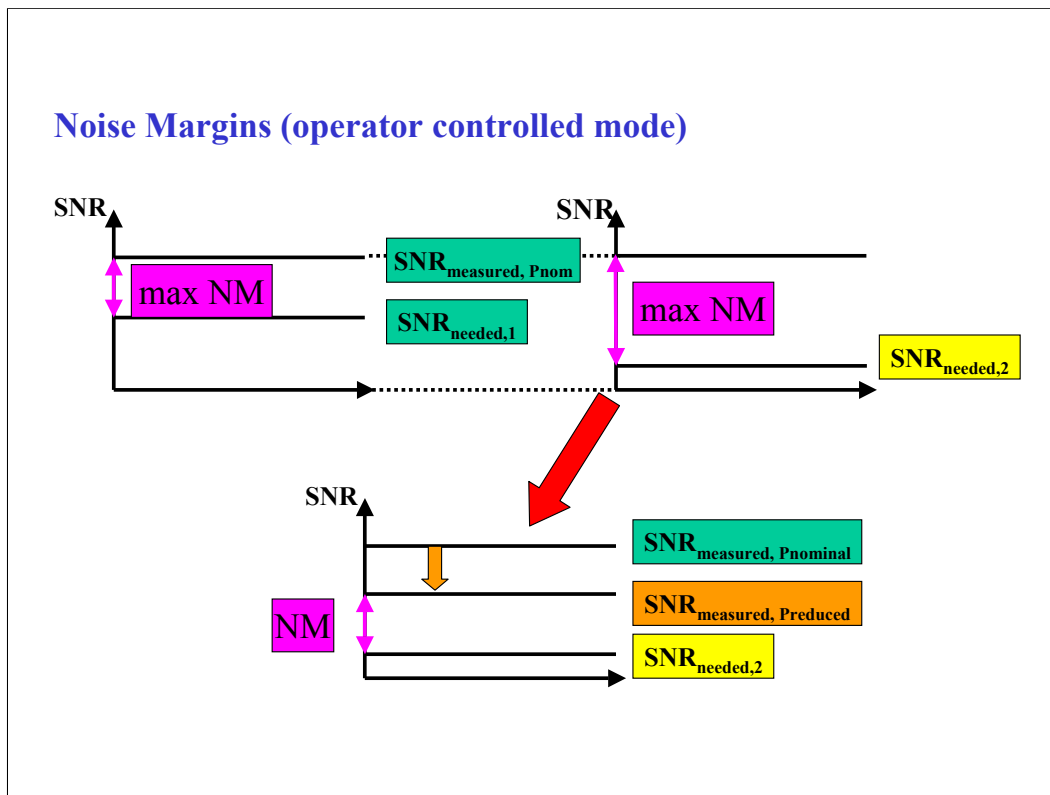


The 2 modems measure the SN ratios at the nominal power level. From these measurements an attainable bitrate can be calculated. Vice versa, the requested bitrate will result in a needed SNR for each carrier. How? The ATU tries to equalise the noise margin over all tones. The noise margin is nothing more but the difference between the measured SNR and the SNR needed for the particular carrier. More specifically the latter is called the maximum attainable noise margin.

It is clear that the measured SNR must be higher than the needed SNR, if not the modems will not accomplish in synchronising at the requested value.

What happens if the noise level (N) increases for $P=P_{nom}$ ($S=S_{nom}$)? The SNR decreases, the BER (Bit Error Rate) will increase. Indeed, if $(SNR_{measured} - SNR_{requested})$ decreases the difference between the number of assigned bits and the maximum number of bits that can be assigned will decrease; it becomes more likely to have an error!

As soon as $SNR_{measured}$ becomes smaller than SNR_{needed} the BER will surpass 10^{-7} . The latter will not be tolerated; the modem will reset (more details later regarding minimum noise margin)!

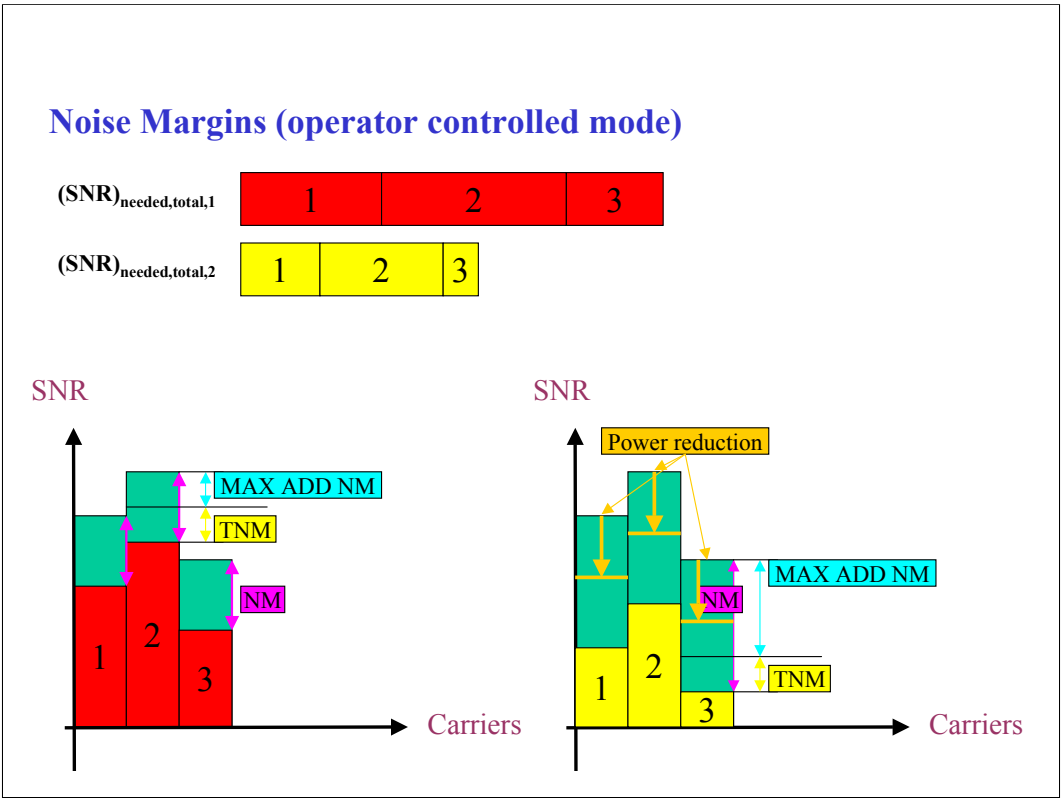


Conclusion: the higher the attainable SNR the more robustness against noise increase (higher attainable noise margin)!

But in some cases the requested bitrate is very low, such that $SNR_{measured} \gg SNR_{requested}$. Since this corresponds with a lot of wasted energy ($P=P_{nom}$), we might prefer to work at lower power level (P and thus S). This results in a trade off; robustness versus energy!

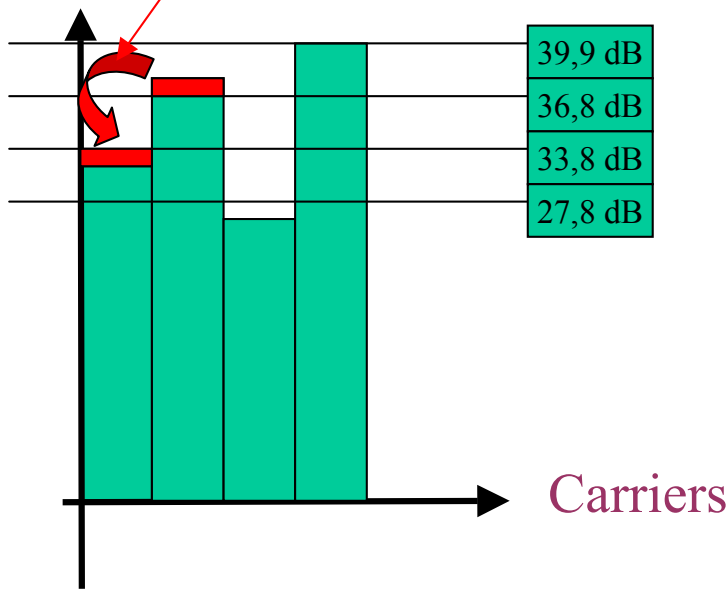
Instead of synchronising at $P=P_{nom}$ we will ask the modems to synchronise at a power level corresponding with a fixed noise margin (NM), smaller than the maximum attainable noise margin. This means that the higher the requested bit rate (SNR) is, the higher the power level will be; since a fixed level of NM (= robustness) is kept!

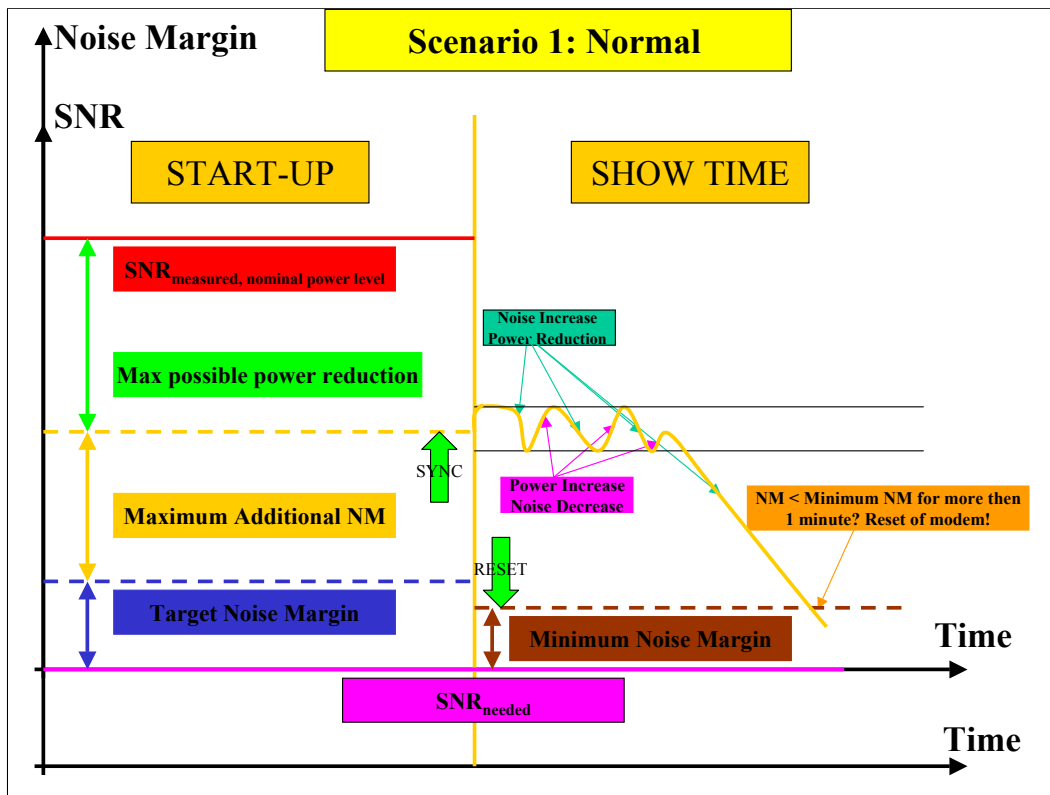
In case you set the noise margin to the same value for all different planned bitrates, the same amount of noise can be taken by before resetting.



The rule is : the ATU tries to equalise the noise margin over all tones, what could lead to bits being moved from one tone to another, and even tones to disappear or to appear. Margins are "analog" where bits are "digital". As you need 3 dB for 1 bit, a margin of 4.7 dB over all tones can not be translated into bits.

Modem does not calculate with bits. It measures the available SNR, then subtracts the Target Noise Margin, and then checks to what constellation it would fit. There is also the possibility to increase (or decrease) the gain of each tone (+ -2.5 dB, but sum over all tones must be 0) for those tones which have just a little bit shortage to have 1 bit more loaded. A gain change results directly in signal change, so also SNR change.





The above picture is valid for each carrier. We should distinguish two phases:

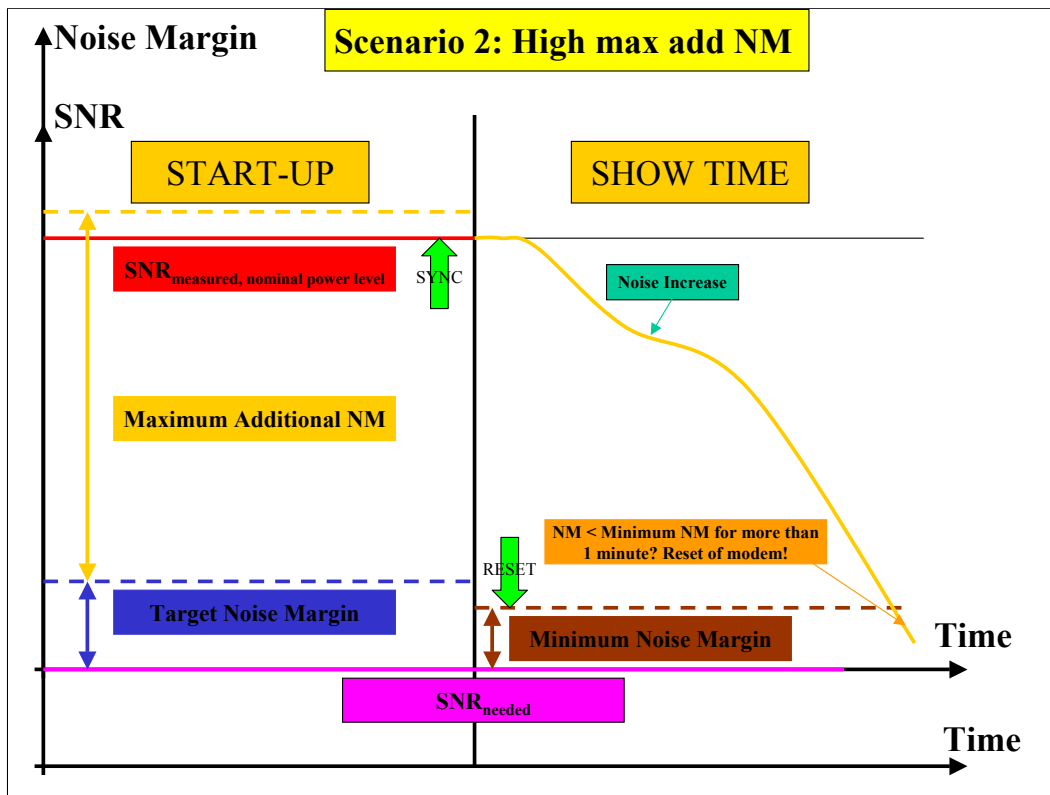
START-UP

ANT & ADLT will measure the quality of the transmission line by determining the SNR; they do this at nominal power level.

An SNR_{needed} can be calculated for a particular carrier; this is done such that each carrier operates at the same Noise Margin (if possible) and that the planned bitrate is reached (see above). The higher the planned bitrate the higher the needed SNR and thus the smaller the noise margin. The modem is able (allowed) to synchronise as soon as the measured SNR is bigger then the needed SNR + the target noise margin. However if a maximum additional noise margin is specified the modem will try to synchronise at needed SNR + target noise margin + maximum additional noise margin. A power reduction is possible if the SNR measured at P_{nom} is higher then needed SNR + target noise margin + maximum additional noise margin (see below for additional examples).

SHOWTIME

When the noise increases the SNR will decrease; as soon as the threshold value is reached (very small) the modem will increase the power. Indeed since the modem synchronised at reduced power level it can increase the power (to compensate for the noise increase and thus to restore the original SNR). In other words, the modems try to keep up the maximum additional noise margin at all times! Once the nominal power level is reached the power cannot be increased anymore; in other words a noise increase cannot be compensated anymore by means of a power increase. If even more noise appears on the line the SNR will drop below the minimum noise margin. The modem will reset as soon as the SNR drops below the minimum noise margin for more then 1 minute. A high minimum noise margin corresponds with an reset (a lower BER before resetting).



This set-up corresponds with the default settings in the ADSL Line Profile; where the maximum additional noise margin is close to infinity. This is not interesting since the the possible power reduction is limited!

However a high value for the maximum additional value will not prevent the modem from synchronising.

Notice that the modem will operate at nominal power level and no power reduction is possible; maximum additional noise margin is not attained! If the noise increases during show time no power increase is possible anymore.

When the noise increases the SNR will decrease and the modem will reset as soon as the SNR becomes smaller then the minimum noise margin (for more then 1 minute).

Especially in case the planned bitrate is small it does not make sense to use a high maximum additional noise margin, since the possible power reduction is substantial for small bitrates.

Advantages of using low values for the Maximum Additional Noise Margin:

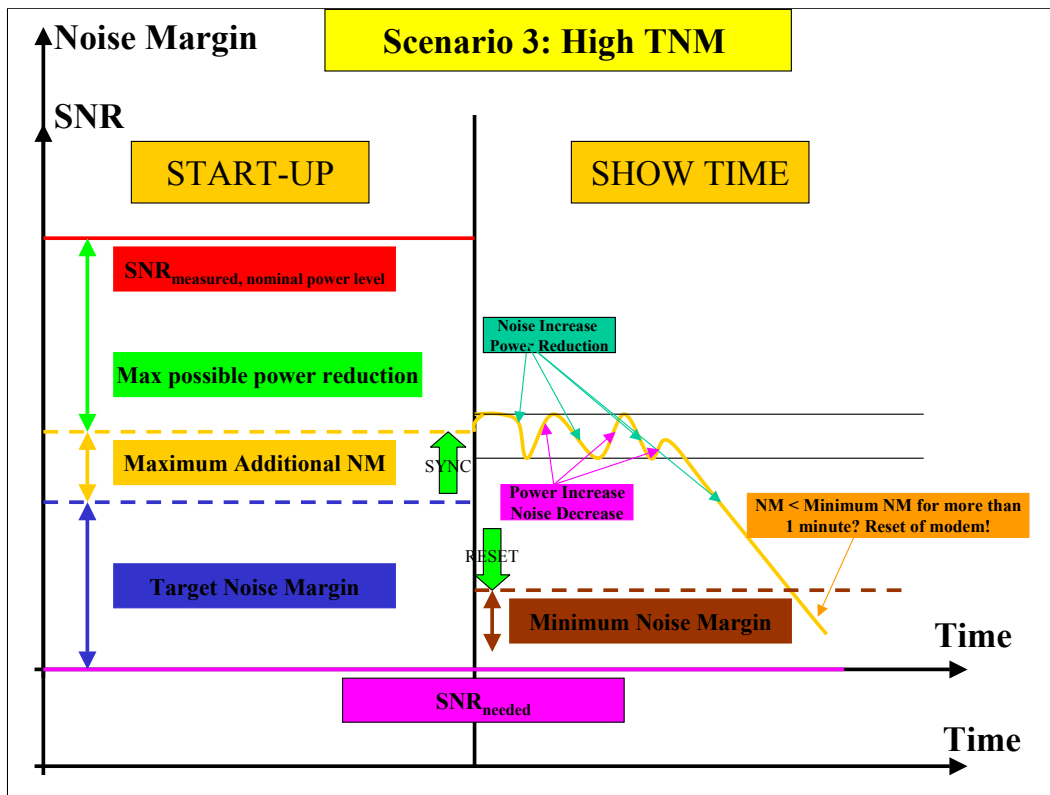
A reduction in the LT board power consumption; up to a possible 0.8 W per line.

A reduction in the mean overall ADSL cross talk level; by reducing the Tx power on good ADSL lines, this provides a reduction in the overall levels of cross talk.

Disadvantages of using low values for the Maximum Additional Noise Margin:

A risk of the cocktail party effect:

The initial situation is that all modems use a reduced Tx power since they have excessive margin. A new modem comes on line, generates extra cross talk. Its neighbours react by increasing their power and now generate more cross talk. The modems which have increased their power now generate more cross talk on some others, and so on....Ultimately, some modems on the worst loops could run out of margin and re-initialise.



The cocktail party effect can, in a worst case scenario reduce the stability of service that is offered to customers.

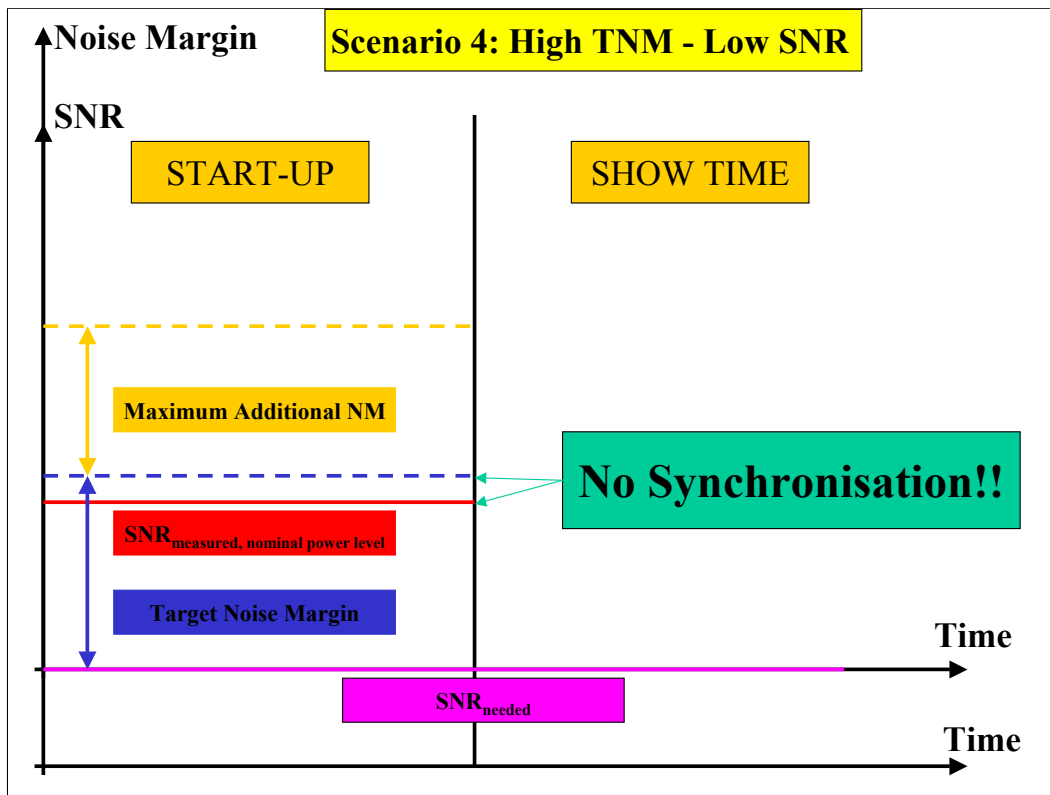
A reduction in the link robustness for impulsive noise; bitswap mechanism is too slow to react to this. For slow noise / channel attenuation increase, no loss of robustness occurs; bitswap mechanism will slowly increase the power level back to the nominal PSD value.

Compared to scenario 1 there are only 2 changes: a reduced maximum additional noise margin and an increased target noise margin; let us focus on the latter since it has serious implications. It was told above that a high maximum additional noise margin will not prevent the modem from synchronising; a high target noise margin will inhibit synchronisation!

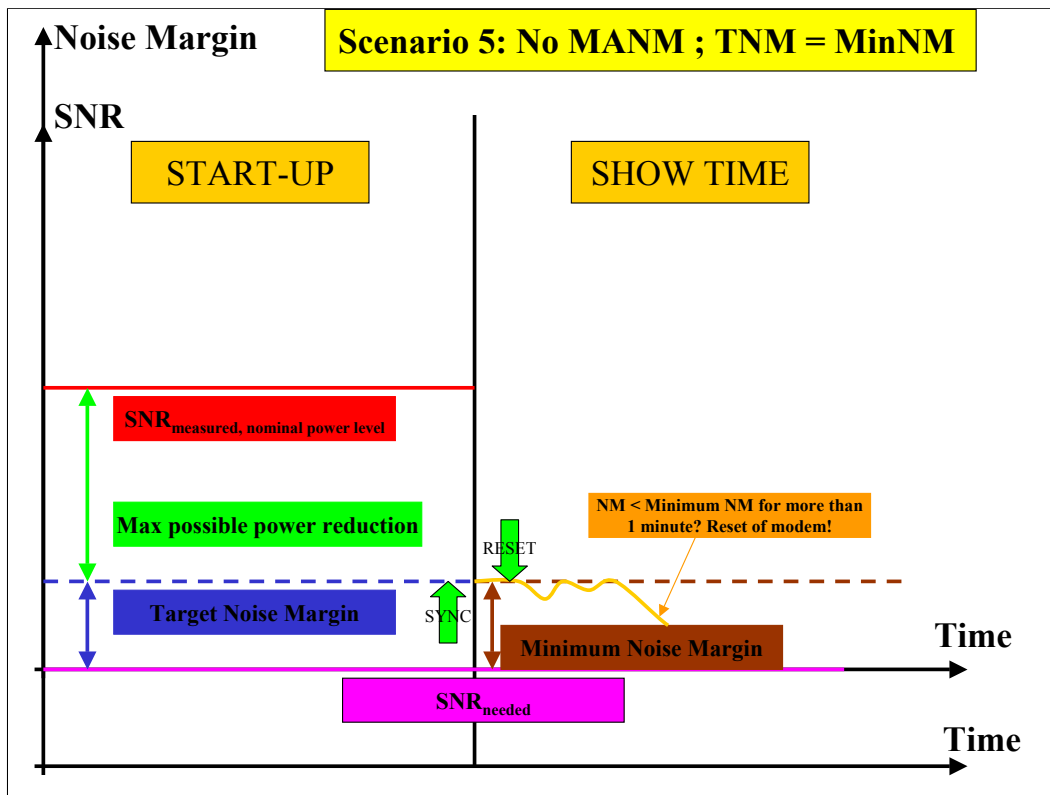
Indeed, the measured SNR should be higher than the SNR needed + the target noise margin. There is no problem in above picture but there might be whenever the measured SNR is not too good!

Notice that reset takes place at SNR needed + minimum noise margin; it does not make sense to use a target noise margin that is too high.

Why do we need a target noise margin? If not, the modem might synchronise at a SNR which is only slightly higher than the needed SNR; if during showtime the noise increases just a little bit (even if minimum noise margin is 0) the modem will reset. A high target noise margin will ensure that when you enter show time lots of noise might appear on the line before resetting.



Since the target noise margin is too high, or the measured SNR is too low the modems will not synchronise. Worst case scenario? Imagine the requested planned bitrate is very small, e.g. 200 kbps. If the attainable bitrate is 2000 kbps but the target noise margin is set unreasonably high the modem will synchronise! You might (wrongly) conclude that the transmission line quality is not good enough to support 200 kbps.

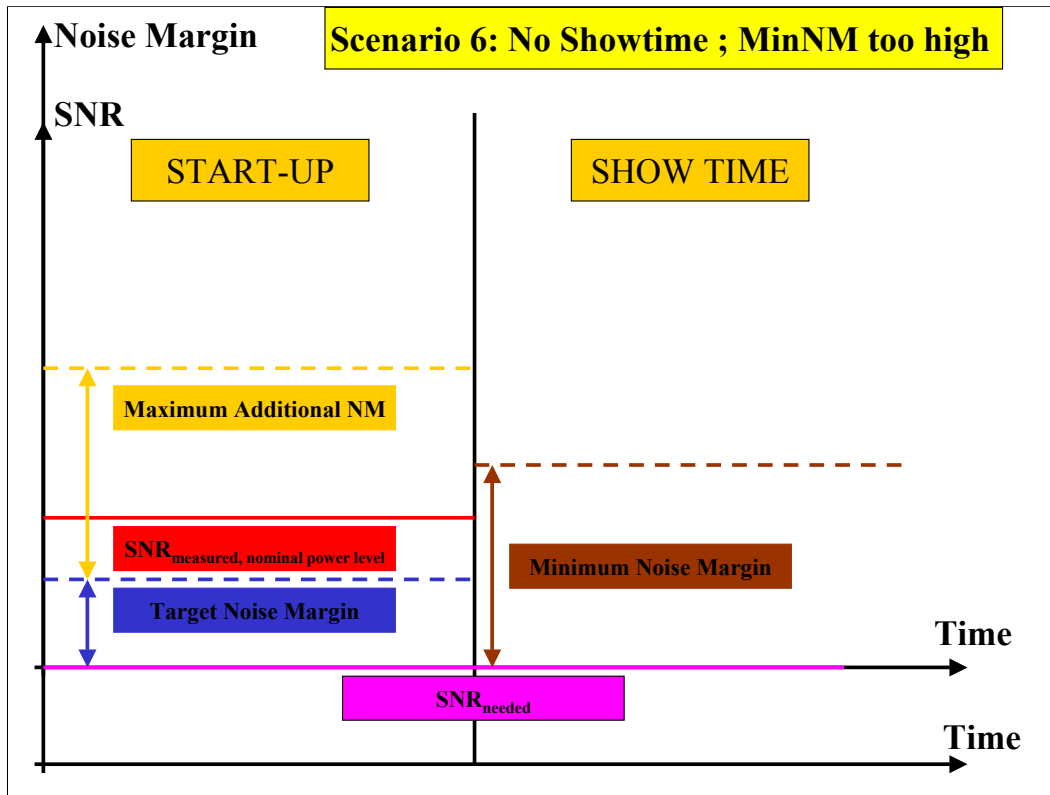


In case of a sudden noise increase the modem will reset as soon as the SNR becomes smaller then the minimum noise margin for more then a minute. Especially when no power reduction was available.

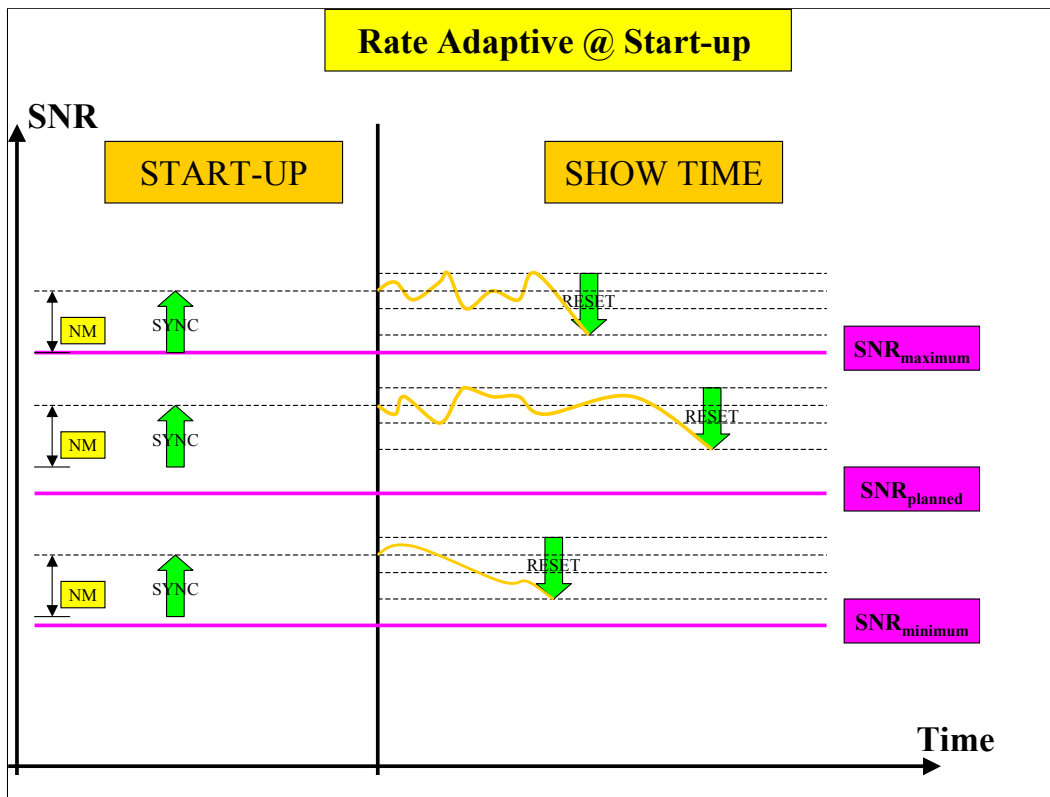
Is it therefore wise to set the target noise margin to a higher value then the minimum noise margin! Indeed, it will allow the line to accept more noise before resetting.

If the minimum noise margin would be higher then the target the noise margin the modem might reset as soon as it enters showtime.

It is clear that a high minimum noise margin will result in an earlier reset in case of noise increase! Therefore a higher noise increase results in operating at a lower BER (less errors).



The modems will enter show time only briefly since the requested noise margin during show time is bigger than the requested NM (target noise margin; not the maximum additional noise margin since this does not prevent the modem from synchronising) during start-up.



Lets summarise:

When initialising (START-UP PHASE), the modem takes following priorities:

1. Highest possible bitrate
2. Highest possible Margin
3. Lowest possible power

Practically, following process is running:

-Measure and calculate the maximum attainable ATM rate taking into account specified TNM and specified power budget (for downstream in maximum DS PSD)

-When the maximum attainable ATM rate is lower then minimum requested bitrate (mimumum bitrate in RA mode 2; planned bitrate in RA mode 1) then halt initialisation.

-When the maximum attainable ATM rate is lower or equal then maximum allowed bitrate (maximum bitrate in RA mode 2; planned bitrate in RA mode 1) then set up that bitrate.

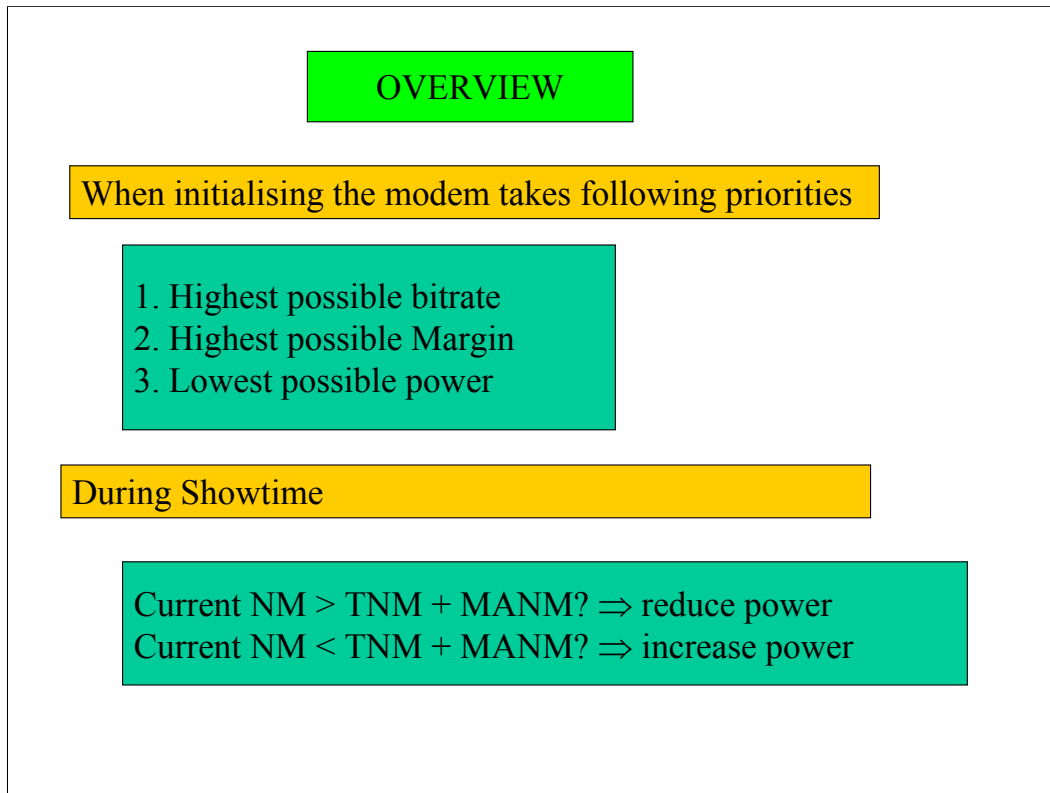
-When the maximum attainable ATM rate is higher then maximum allowed bitrate (maximum bitrate in RA mode 2; planned bitrate in RA mode 1) then:

-the excess ATM rate (= maximum attainable - maximum allowed) is translated into increased noise margin on top of the TNM

-limit additional noise margin

-if new noise margin is larger then target NM + maximum additional NM then reduce the transmit power to get below that threshold.

-when the power cannot be reduced anymore to get below that threshold, then NM stays higher then threshold.



During SHOWTIME:

When the current noise margin gets above the target noise margin + the maximum additional noise margin, the ATU attempts to reduce the far-end output power to get the noise margin below this limit.

When the current noise margin gets below the target noise margin + the maximum additional noise margin, the ATU attempts to increase the far-end output power to get the noise margin above this limit.

RA mode 2 (Rate Adaptive @ start-up)

The modem tries to synchronise at the highest bitrate possible. Assuming that the initial conditions are very good, the modem will synchronise at the maximum bitrate. When the noise level increases/decreases the modem will try to increase/decrease power. Assuming that noise continues to increase the SNR will drop below the minimum noise margin and the modem will reset. In RA mode 1 (operator controlled) the modem will not resynchronise until the line conditions have improved. In RA mode 2 we allow the modem to synchronise between minimum and maximum bitrate. So, if the modem resets he will resynchronise at a bitrate in between the minimum and maximum bitrate. In the above picture the second situation. If the noise still increases the modem will reset again and resynchronise at an even lower value. Finally the measured SNR will drop below the minimum SNR + TNM; the modem resets and does not synchronise until the SNR gets above minimum SNR + TNM.

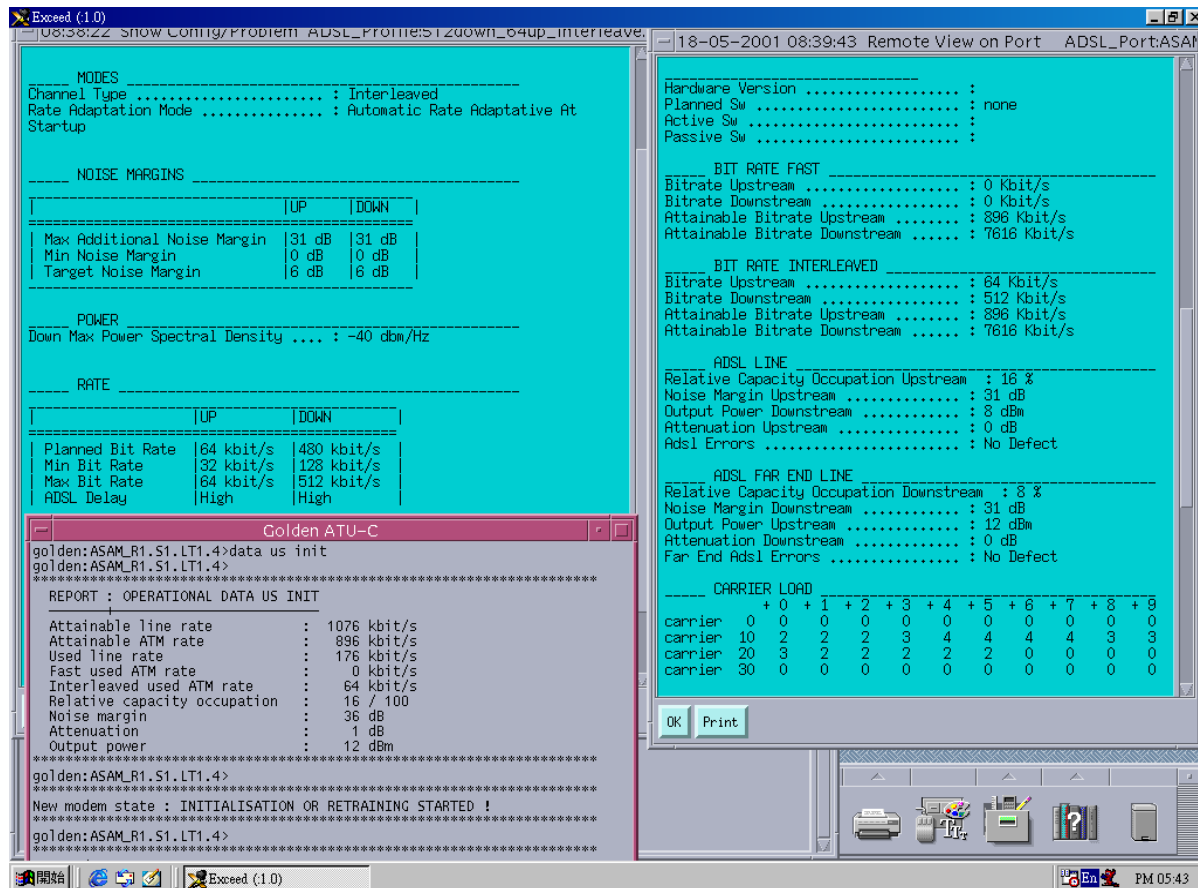
The modem does not support RA mode 3; i.e. if the modem is synched at a bitrate in between the minimum and maximum bitrate he will not resynchronise at a higher bitrate as soon as the line conditions improve; to achieve the latter one should reset the modem manually.

Noise Margins:Conclusions

Target Noise Margin \Rightarrow minimum robustness against noise increase

Maximum Additional Noise Margin \Rightarrow possible operation at reduced power level

Minimum Noise Margin \Rightarrow operation at a reduced BER



Question?

ADSL Line Profile 1: TNM=6 MANM=31 => NM=37

ADSL Line Profile 2: TNM=6 MANM=3 => NM=34

Remote VOP1: NM=31 ; Remote VOP2: NM=31

Are these the Max Attainable Noise Margins? That would explain that there is no change!

I was told that if Noise is artificially increased, the NM in the RVOP drops. This supports my supposition.

Golden ATU-C2: NM=21? Why not 9. Is that because there is a limit to the power reduction? Yes!

Exceed (1.0) 08:52:29 Show Config/Problem ADSL_Profile:testing_brian.nw 18-05-2001 08:53:12 Remote View on Port ADSL_Port:ASAM_R1

```

MODES
Channel Type ..... : Interleaved
Rate Adaptation Mode ..... : Automatic Rate
Adaptative At Startup

-----
NOISE MARGINS
-----


|                             | UP   | DOWN |
|-----------------------------|------|------|
| Max Additional Noise Margin | 3 dB | 3 dB |
| Min Noise Margin            | 0 dB | 0 dB |
| Target Noise Margin         | 6 dB | 6 dB |



-----
POWER
-----
Down Max Power Spectral Density .... : -40 dbm/Hz

-----
RATE
-----


|                  | UP        | DOWN       |
|------------------|-----------|------------|
| Planned Bit Rate | 64 kbit/s | 480 kbit/s |
| Min Bit Rate     | 32 kbit/s | 128 kbit/s |
| Max Bit Rate     | 64 kbit/s | 512 kbit/s |
| ADSL Delay       | High      | High       |


```

Golden ATU-C

```

Attainable line rate : 1076 kbit/s
Attainable ATM rate : 896 kbit/s
Used line rate : 176 kbit/s
Fast used ATM rate : 0 kbit/s
Interleaved used ATM rate : 64 kbit/s
Relative capacity occupation : 16 / 100
Noise margin : 26 dB
Attenuation : 1 dB
Output power : 2 dBm
*****
golden:ASAM_R1.S1.LT1.4>
*****
New modem state : INITIALISATION OR RETRAINING STARTED !
*****
golden:ASAM_R1.S1.LT1.4>
*****
New modem state : SHOWTIME STATE STARTED !
*****
golden:ASAM_R1.S1.LT1.4>
*****

```

```

-----
ANT STATES
-----
Availability State ..... : available

-----
ANT HW AND SW VERSIONS
-----
Hardware Version ..... :
Planned Sw ..... : none
Active Sw ..... :
Passive Sw ..... :

-----
BIT RATE FAST
-----
Bitrate Upstream ..... : 0 Kbit/s
Bitrate Downstream ..... : 0 Kbit/s
Attainable Bitrate Upstream ..... : 928 Kbit/s
Attainable Bitrate Downstream ..... : 7616 Kbit/s

-----
BIT RATE INTERLEAVED
-----
Bitrate Upstream ..... : 64 Kbit/s
Bitrate Downstream ..... : 512 Kbit/s
Attainable Bitrate Upstream ..... : 928 Kbit/s
Attainable Bitrate Downstream ..... : 7616 Kbit/s

-----
ADSL LINE
-----
Relative Capacity Occupation Upstream : 16 %
Noise Margin Upstream ..... : 31 dB
Output Power Downstream ..... : 0 dBm
Attenuation Upstream ..... : 0 dB
Adsl Errors ..... : No Defect

-----
ADSL FAR END LINE
-----
Relative Capacity Occupation Downstream : 7 %
Noise Margin Downstream ..... : 31 dB
Output Power Upstream ..... : 2 dBm
Attenuation Downstream ..... : 0 dB
Far End Adsl Errors ..... : No Defect

-----
CARRIER LOAD
-----
+ 0 + 1 + 2 + 3 + 4 + 5 + 6 + 7 + 8 + 9

```

OK Print

開始 | Exceed (1.0) | PM 05:55

Enabling Power Back-off

- An additional Operator-defined power back-off can be configured for the Down Stream (DS) direction...
 - The parameter “Nominal DS PSD” is used to define power back-off
 - Values between -40 and -52 dBm/Hz can be configured to enable the feature

Putting it into perspective

- The “Nominal DS PSD” parameter for power back-off
 - fixed
 - always active during initialization and showtime
- The “Maximum Additional Noise Margin” parameter
 - automatic power reduction during init and showtime
 - power reduction only activated if noise margin in excess of the maximum noise margin
 - power reduction relative to the nominal PSD

Combining Power Back-Off & Maximum Additional Noise Margin

- The absolute minimum figures for the PSD-levels are a combination of both the power backoff on the Nominal PSD and the Maximum Additional Noise Margin...
 - Min PSD in Down Stream = -64.5 dBm/Hz
 - -52dBm/Hz (minimal Nominal DS PSD)
 - minus up to 10 dB due to Maximum Additional Noise Margin settings
 - minus up to 2.5 dB Fine Tune Gain
 - Min PSD in Up Stream = -52.5 dBm/Hz
 - -38 dBm/Hz (minimal Nominal US PSD)
 - minus up to 12 dB due to Maximum Additional Noise Margin settings
 - Minus up to 2.5 dB Fine Tune Gain

Recommended Settings

- The recommended settings are...
 - -40 dB for the “Nominal DS PSD” (which is standards compliant)
 - 6 dB for the Target Noise Margin
 - 6 dB for the Maximum Additional Noise Margin
 - 0 dB for the Minimum Noise Margin
- The values above provide maximum power saving coupled with low levels of crosstalk, and margin against increasing crosstalk from other lines.
- In the case where a system is affected by heavy impulse noise, a further margin of improvement can be obtained by setting...
 - 31db for the Maximum Additional Noise Margin