General Description

Digital ADSL Regenerator (DAR)

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Content: Digital ADSL Regenerator (DAR)
General Description

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1 Preface

1.1 Highlight

This document describes the functions of Digital ADSL Regenerator the operational method and its configuration.

1.2 Structure

The following chapters can be found in this description:

1. Preface

   Basic information about the document contents.

2. General

   System overview and system elements.

3. Technical features

   Packet handling, transmissions, power, etc.

4. Device reference

   Electrical parameters, user interfaces, environmental conditions, etc.

5. DAR configuration

   NMS screens for DAR.

6. Safety requirements

   Remote power information.

1.3 Revisions

Release	Date	Comments
v3.2	15-02-2013	Local monitoring option
v3.1	20-06-2012	Revise of safety parameters
v3.0	25-04-2012	Re-structure of document adding NMS configuration
v2.0	16-12-2011	Extended version with technical data
v1.0	02-09-2011	Basic description of DAR

2 General

2.1 System overview

The DAR is a digital ADSL signal amplifier that provides transparent transmission between the exchange location and distant subscriber. The system can extend the signaling distance (or the bandwidth) of up to 4 individual subscribers over their existing copper pairs using the latest coding / decoding and remote power feeding solutions.

The target application of the system is to provide ADSL service for those subscribers who are:

- living too far from the exchange to get reasonable ADSL speeds – RURAL APPLICATION,
- cannot get high speed broadband for Triple Play service – IPTV APPLICATION.

The basic configuration of the system is shown below:

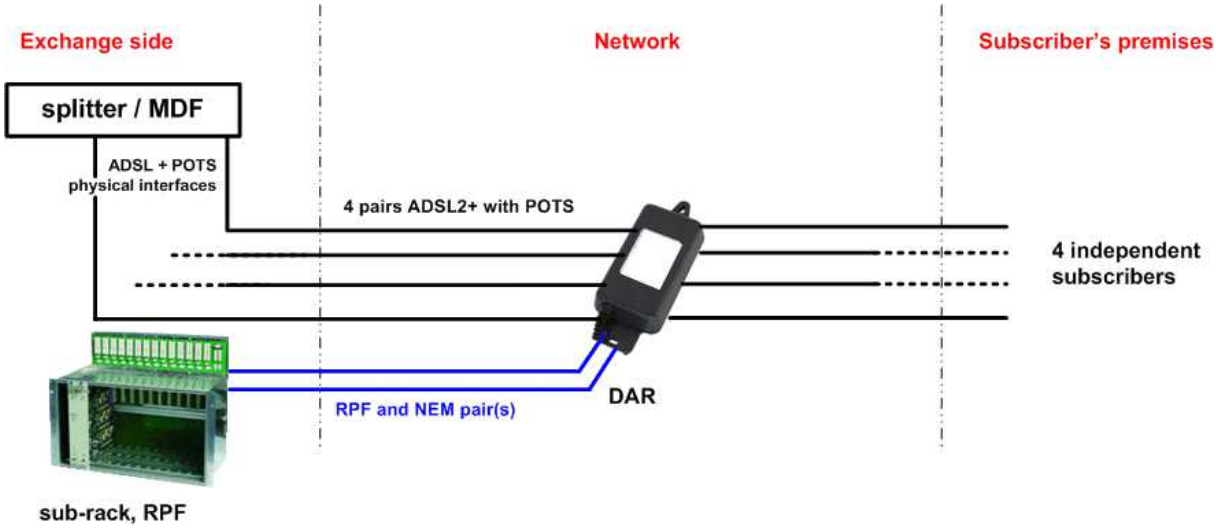

Figure 1. – Basic configuration

The system contains 2 main units:

- **RPF** – Remote Power Feeding unit, located at the Exchange which can provide the power for 4 Regenerators (*see document GenDesc RPF v1.0*),
- **DAR** – Digital ADSL Regenerator, located somewhere in the middle of the link which digitally regenerates the signal for up to 4 customers.

The DAR is house in heavy protected outdoor box and regenerates the ADSL signal for 4 different customers.

Operating distance

The operating distances on the 2 ADSL sections – Exchange–DAR, DAR–CPE – is determined by the attenuation of the ADSL lines. According to the installation location of DAR the system measures the parameters of the first section (Exchange–DAR) and use the frequency spectrum accordingly at the second ADSL section. This feature supports to avoid of any high noise introduction into the network which could destroy the signals in the neighborhood cables.

This DPBO frequency shaping requirement can vary country by country. The maximum allowed input power into the network is defined by the CAL (Cabinet Assigned Line) or the ESEL (Exchange Side Electrical Length) numbers that reflect the attenuation of the first ADSL section. Some operators handle this regulation very strictly some of them do not pay too much attention.

Taking the strongest limit into consideration the following distances can be achieved according to the installation position of the DAR:

ADSL ds rate (Kbps)	L1 (m)	L2 (m)	L (m)	added extra (%)
8192	2350	1550	3900	66
7648	2500	1650	4150	66
6764	2650	1750	4400	66
6040	2800	1900	4700	68
5272	3000	1950	4950	65
4036	3450	2350	5800	68
3276	3750	2550	6300	68
2564	4100	2750	6850	67

Table 1. – ADSL bandwidth vs distance

where:

ADSL ds rate	The measured ADSL downstream data rate
L1	The maximum distance which the measured ADSL downstream rate can reach in normal conditions – this is the location of DAR
L2	The extra distance which the DAR can add
L	Total distance with the measured ADSL stream
added extra	The percentage added by DAR

The above figures apply on ETSI compliant 0.4 mm diameter PE cable and with Stockholm noise model. The measurements were executed by ADSL2+ up to 8 Mbps downstream speed using line simulator with 50 m increments.

As a conclusion, it can be seen on the table that the **DAR can extend the distance** on certain ADSL bandwidth **by 60-70%** compared to the original one. During measurements DAR was set according to the strongest limitations by CAL, ESEL. In case of softer regulations the unit can extend the original distance by 100-120%.

The table contains the maximum capacity of ADSL distances (L1) where the DAR unit is installed. Besides, it is possible install the unit closer to the Exchange – the added extra distance (%) is guaranteed as well.

2.2 System components and accessories

One DAR can operate on maximum 4 twisted copper pairs between the Exchange and subscriber's premises. Additional link should be used for powering the unit. At the Exchange it is necessary to install the SBR sub-rack which provides the accommodation and cable connections for the RPF remote power unit.

2.2.1 Exchange

RPF	Remote Power Unit with 4 independent power interface towards DAR (*see document GenDesc RPF v1.0*)
SBR-14	Standard 19" sub-rack for up to 14 RPF with IDC connectors (*see document GenDesc SBR v1.0*)
NEM	Network Element Manager card for local/remote supervision (*see document GenDesc NEM v1.1*)

2.2.2 Remote

DAR	Digital ADSL Regenerator that extends the transmission distance of the ADSL services

The DAR is remotely powered equipment housed in outdoor box. It has the following functions:

- connects up to 4 POTS + ADSL subscriber lines and digitally amplifies the data signal,
- using filters connects the direct POTS channel between the Exchange the subscribers.

The DAR module can be fixed on mounting rails, to the wall or to the pole with the build-around outdoor box. Street cabinet installation is also possible with different boxes or rails.

It has a cable tail which should be connected to the suitable distribution boxes.

2.3 Network Management System

The Network Management System has 2 accesses to the devices: direct and remote.

The plug-in *Network Element Manager (NEM)* card is able to provide direct and remote supervision possibilities based on IP protocol. Both accesses require a client software installed on the PC or notebook called *Manager Monitor program*. It makes the real time monitoring, shows the electric and digital parameters of the connected systems, collects event logs and creates the visual view all of the measured parameters.

There is a 3rd option for monitoring: connecting the remotely installed equipment directly with an USB-serial converter. With this option the DAR located on the field can be configured immediately after the fixing without Exchange access, the NEM card is not necessary. With this process it is not possible to monitor the units installed at the Exchange (like RPF card).

3 Technical features

3.1 Subscriber interfaces

The subscriber interfaces of the DAR provide transparent transmission for POTS and ADSL services between the Exchange and the subscriber side.

3.1.1 POTS

Since the DAR contains filters removing the voice (POTS) from the data flow it provides direct link between the 2 sides.

Due to the filters at both ends the only addition compared to a direct link is the 1-2 dB extra attenuation and around 20-30 Ω extra impedance on the line. Considering the relatively low values it is obvious that the DAR doesn’t affect the voice transmission significantly.

The voice operation is uninterrupted in case of non-powered periods.

3.1.2 ADSL

The ADSL interfaces are implemented according to standards ITU-T G.992.1, G.992.3 and G.992.5 that are ADSL, ADSL2 and ADSL2+ both in Annex A and Annex B versions. In case of customer's request the implementations of Annex L, M are also possible. The system handles the data traffic on ATM level.

The system is totally transparent for the following functions:

- line connected, disconnected and the ADSL synchronization,
- the downstream and upstream ADSL speeds in case of fixed DSLAM profiles,
- the ATM traffic carried over the ADSL interfaces including the AOM F4/F5 cells,
- the system doesn't process the ATM cells, just passes forward as they arrive.

Furthermore, the following parameters can be monitored via the Management System:

- actual ADSL mode and downstream/upstream speeds,
- actual Latency and INP settings,
- actual Signal Noise Margin and Signal Attenuation,
- resettable CRC, FEC and ATM cell counters,
- actual data rate performed in the last second,
- line and signal attenuation,
- maximum possible downstream/upstream speeds.

3.2 Remote power

The DAR is powered over additional copper pair using high voltage remote power feeding scheme from the connected RPF. The power connection can be realized over one or two copper pairs according to the national line voltage level regulations. All remote power feeding sources and sinks meet the safety requirements of EN 60950-1 and EN 60950-21 with the following specification:

circuit category:	RFT-V (optional RFT-C)
remote feeding voltage:	max ± 160 Vdc, software selectable
output capacity:	≤ 20 µF line to line
current limiting:	57 ± 1 mA
unbalance shut-down:	1.5 mA to Earth

The remotely fed DAR units also measure their input voltage and current in order to maintain their power budget. These results are also available on the management interface of the system. Using these data it is possible to estimate the resistance of the remote feeding loop and possible leakage currents.

Inversion of the voltage polarity of the power lines has no any impact on the operation of the system.

3.3 Alarm

The DAR provides alarm signal in several operational failures:

- ADSL synchronization problem,
- ADSL circuit hardware failure,
- POTS open loop,
- temperature related cases.

All kind of alarms can be notified in NMS GUI, described in paragraph 5.

4 Device Reference

The DAR is an active device that is used to either increase the distance that ADSL can be delivered to, or to boost the speed of ADSL for any set distance. Typical uses include rural broadband where traditionally the customers are too far from the Exchange to receive ADSL or IPTV services where the existing customer can receive ADSL but the line rate is insufficient for IPTV services.

It is in fully sealed house and installed on the POTS+ADSL line typically on the pole or at the street cabinet. The ADSL signal is then terminated, reshaped so as not to cause interference and then re-launched to the customer. By using the higher frequency bands on the customer side of the DAR, interference is minimized and extended reach can be achieved.

The DAR is line powered on spare pairs which are fed from the RPF located in the Exchange. By using this additional pairs, as well as remotely powering the DAR, management information about line speeds and performance data can be displayed.

The metallic bypass function works on both transmission lines, the POTS are through-connected directly by filters.

Figure 2. – DAR

4.1 Power consumption

The DAR module is remote power fed through the one or two power pairs with the following parameters:

input voltage:	up to ± 160 Vdc
max. power consumption:	15 W
max. power dissipation:	7 W

This consumption is covered by RPF consumption.

The remote power fed equipment consumes less than 57 mA current in normal operating modes.

4.2 PSD shaping

It is possible to set the output power spectrum density in order to avoid of crosstalk with the already existing digital cables. The output power level can be programmed by hardware or from the management software by considering its distance from the Exchange. This distance is defined in the CAL number (Cabinet Assigned Loss) of the installation position. In some countries the ESEL (Exchange Side Electrical Length) is preferred. Both of them reflect the line attenuation between the Exchange and the installation position of DAR. According to the set value the DAR unit transmits the signals at lower power level (DPBO – Digital Power Back Off) not to cause interference with other lines. Practically, on the second ADSL section the system carries the traffic at the unused frequency spectrum (over).

Hardware programming

The cable tail contains 2x 10 pairs. One of them is used for customer and power connections the other is for PSD shaping. Only 4 wires are used and 14 combinations make possible to set the CAL value between 26 and 52.

NMS programming

Using the monitoring platform it is possible to set the required CAL value between 2 and 52.

No programming

Selecting the “NORMAL” option at the monitor program the system doesn’t use any previously programmed frequency shaping.

4.3 Mechanical parameters

The mechanical properties of the unit are the followings:

Dimensions (H x W x D): 295 x 175 x 50 mm

Weight: 1100 g

Installation: wall/pole/pit installation

4.4 Environmental conditions

The DAR modules were designed and tested to meet the following environmental requirements of ETSI standards:

Operation:	ETSI ETS 300 019-1-3 class 3.3 ETSI ETS 300 019-1-4 class 4.1
Storage:	ETSI ETS 300 019-1-1 class 1.2
Transport:	ETSI ETS 300 019-1-2 class 2.2
Operational temperature:	-30 .. +70 °C
Relative humidity:	0 .. 100 %
Protection:	IP66

5 DAR configuration

All parameters of the connected DAR equipment are shown on different tabs selecting the unit at tree-view. The RPF port number where the power and the communication are done is also indicated on the top of the screen.

Figure 3. – NMS – unit identification

On *Figure 3.* the DAR (AREP0012) is monitored by NEM (called test) and connected to the port 3 of RPF card which is installed in the slot 6 of the sub-rack (06). The NEM card monitors the RPF on the first communication line at sub-rack 4 (104).

At the upper part of the Component panel the user can select the configuration access (Config ON-OFF). These parameters belong to the supervision hierarchy. The main reason of its function is to avoid of more modifications from different remote locations at the same time.

Enable the configuration access the name of the actual user will appear after the button. During one's configuration period the other users has no access for any configuration.

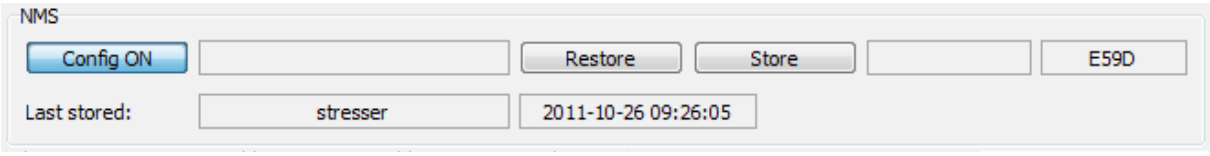

Figure 4. – NMS – configuration

Restore (*button*)	The user can load back the parameters last stored in the Eeprom.
Store (*button*)	Save the modified parameters into the Eeprom. Leaving the device without pushing this button the executed modifications will be lost.

During modification by any user a “MODIFICATION” (blue) signal appears after the buttons.

Enable the configuration access the name of the actual user will appear after the button. During one's configuration period the other users have no access for any configuration.

Note: In order to save the modifications it is necessary to push the 'Store' button. Leaving the surface of the modified system without using this button the configuration changes will be lost.

5.1 System

On the system tab the user can monitor the basic parameters there are the general inventory information like serial number, software/hardware date, hardware type, software checksum, operational time or element internal temperature.

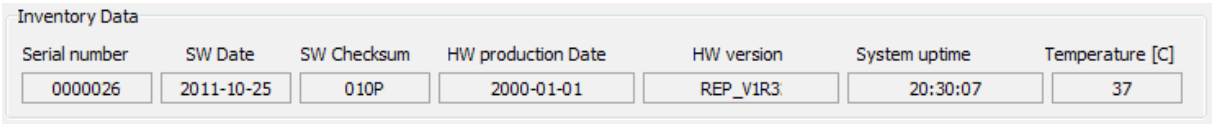

Figure 5. – NMS – inventory data

On the lower part the user can check the connected remote devices and the general status of the system.

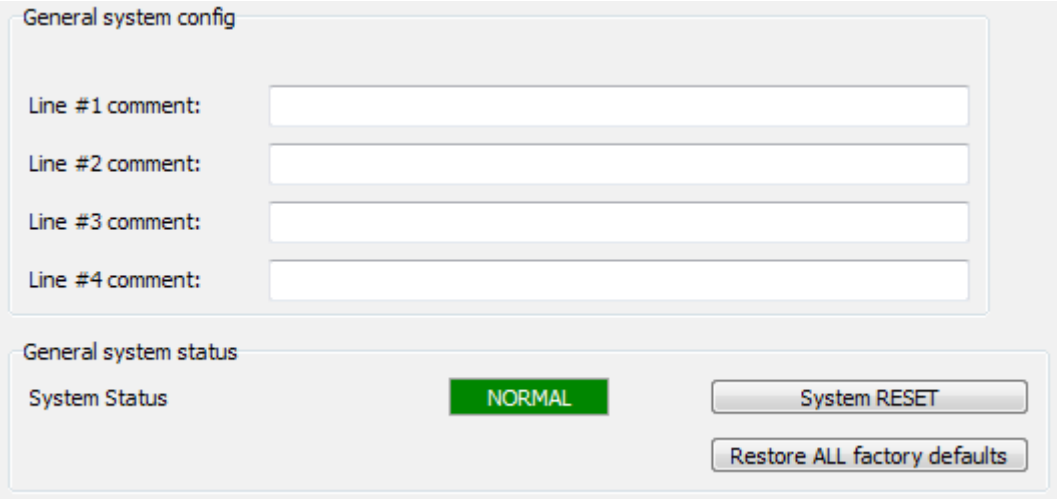

Figure 6. – NMS – general system status

General system config

Line #x comment	The user can make notes about the installed DAR (pe.: the location of the device).

General system status

“NORMAL”/green	Normal operation.
“TEST/MODIF”/blue	Data under modification.
“ALARM”/red	System under alarm.
“ACK. ALARM”/yellow	Acknowledged alarm.
System reset (*button*)	DAR system re-start.
Restore ALL factory defaults (*button*)	Re-set the factory default values of the DAR.

5.2 ADSL

This tab offers the configuration for the ADSL sections.

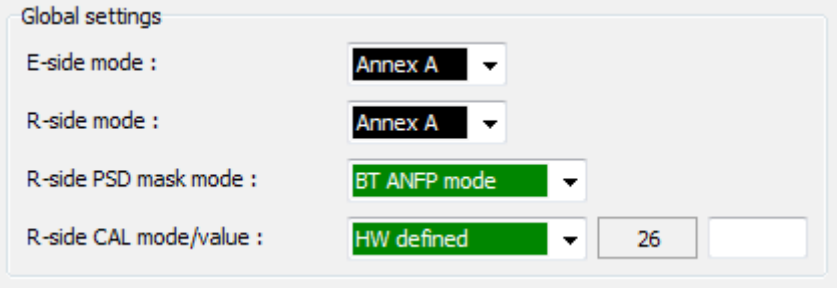

Figure 7. – NMS – global settings

Normal operating mode settings *(buttons)*

E-side mode (*roll window*)	The user can set the required ADSL Annex (A, B, M, J, I) at Exchange-DAR section.
R-side mode (*roll window*)	The user can set the required ADSL Annex (A, B, M, J, I) at DAR-Remote section.
R-side PSD mask mode (*roll window*)	Power Spectrum Density mask – adjustable used frequency range. It is possible to use pre-defined masks according to national definitions. NORMAL = no mask used.
R-side CAL mode / value (*roll window*)	DAR settings referring to the CAL, Cabinet Assigned Loss (or ESEL, Exchange Signal Electric Length).
HW defined	Connecting the suitable cables at DAR's RPF connector it is possible to pre-set the DAR's CAL by hardware (26 .. 52, see Installation Manual).
NMS configure	Selecting this option the user can define the CAL value (0 .. 52).

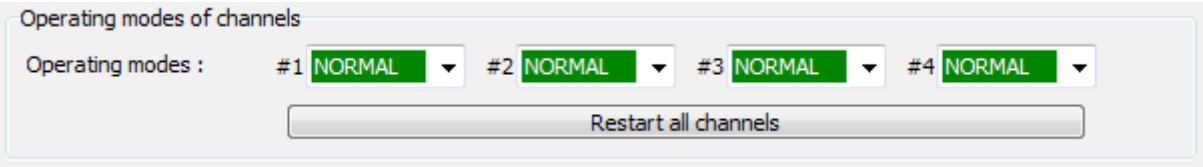

Figure 8. – NMS – ADSL operating modes

Operating modes of ADSL channels

NORMAL/green	Normal operation mode, the DSLAM ADSL section synchronizes according to the DSLAM's settings and the DAR forces the same speed profile to CPE section.
TEST/blue	Test mode, the two ADSL sections synchronize separately on the highest possible downstream and upstream speed.
OFF/yellow	Disable the ADSL traffic on the channel.
Restart All ADSL channels (*button*)	Manually re-start the ADSL channels.

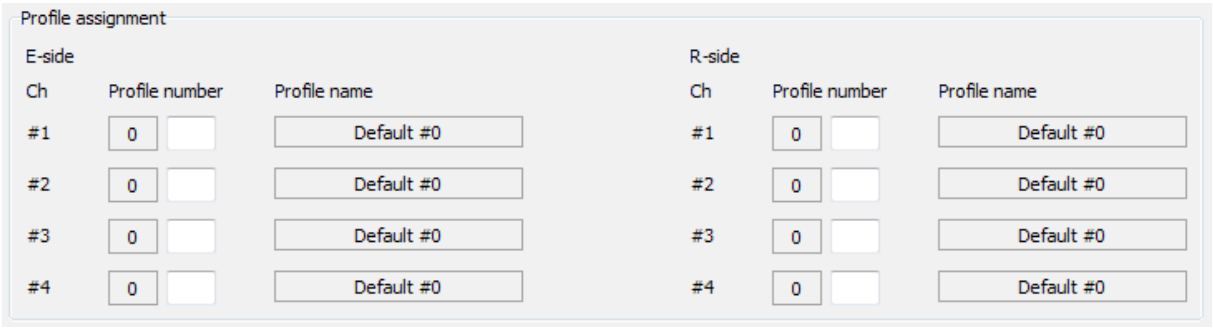

Figure 9. – NMS – profile assignment

The user can associate pre-defined ADSL profiles to each ADSL link (E-side: Exchange side; R-side: Remote side). It is possible to create 8-8 different profiles for the Exchange links and the Remote links, too. The settings of these profiles can be done in the ADSL Profiles tab, see details in Par. 5.3

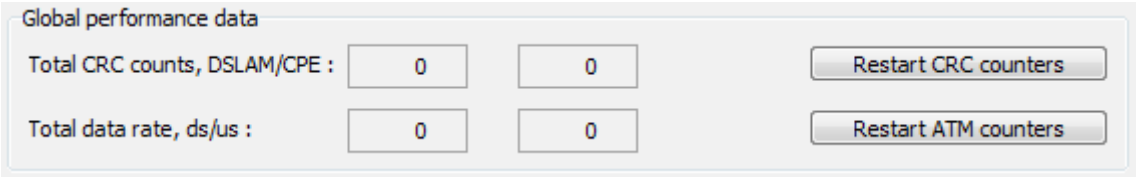

Figure 10. – NMS – ADSL operating modes

Global performance data

Total CRC counts, DSLAM/CPE	Total number of CRC errors in the ADSL sections at DSLAM-DAR and DAR-CPE sections.
Total data rate, ds/us	Sum of the data rate of all ADSL channels downstream and upstream.
Restart CRC counters (*button*)	Re-set the CRC and FEC counters to zero on the ADSL sections.
Restart ATM counters (*button*)	Re-set the ATM counters to zero.

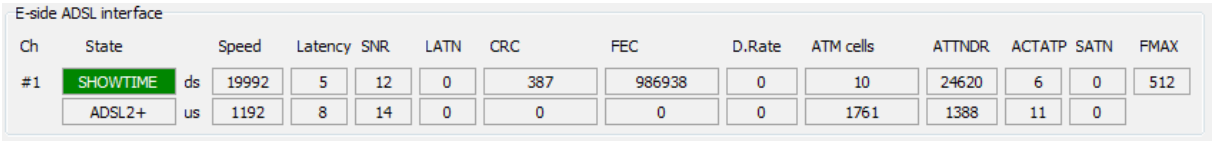

Figure 11. – NMS – ADSL channel statuses

All channels have separated indicator windows for both DSLAM and CPE sections. The difference only is in the ACTATP (DSLAM part) – ACTPSD (CPE part) column.

State (upper row)	Channel ADSL performance.
„OFF”	Channel is restricted.
„FAIL”	Sync failed.
„IDLE”	No ADSL compatible device (DSLAM, CPE) connected.
„HANDSHAKE”	Standard sync phase.
„TRAINING”	Standard sync phase (ONLY CPE side).
„ANALYSIS”	Standard sync phase (ONLY CPE side).
„EXCHANGE”	Standard sync phase (ONLY CPE side).
„SHOWTIME”	Sync ready.
„DYING GASP”	No sync, the CPE is OFF (ONLY CPE side).
„HW ERROR”	Hardware problem at the ADSL channel.
State (lower row)	Channel ADSL mode.
„ADSL”	Standard G.992.1 mode.
„ADSL2”	Standard G.992.3 mode.
„ADSL2+”	Standard G.992.5 mode.
„RATESET”	ds and us re-sync according to the other side.
„OTHERSIDE”	Loose sync because of the other ADSL side.
„EXCEPTION”	Refusing of the connected CPE.
Speed	Downstream and upstream sync speeds (Kbps).
Latency	Latency (error correction) value.
SNR	Signal Noise Rate (dB).
LATN	Line attenuation (dB).
CRC	Cyclic Redundancy Check errors.
FEC	Forwarded Error Correction.
D. Rate	Net actual data rate which occurred in the last second (Kbps).
ATM cells	Transferred ATM cells in both directions.
ATTNDR	Attainable Net Data Rate. The maximum theoretical bandwidth which can be achieved on the ADSL sections (Kbps).
ACTATP (DSLAM)	Actual Aggregate Transmit Power (dB).
ACTPSD (CPE)	Actual Power Spectrum Density (dB).
SATN	Signal attenuation (dB).
FMAX	The upper limit of used frequency spectrum at DSLAM-DAR section.

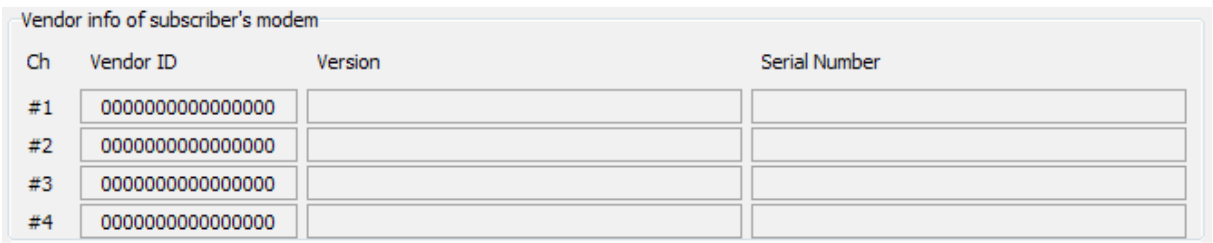

Figure 12. – NMS – CPE's vendor information

In this window the system collects the connected modem's information like vendor ID, version and serial number.

5.3 ADSL Profiles

It is possible to pre-define significant ADSL profiles which can be easily used by selecting them at ADSL tab. These profiles are useful in both operating modes to control the broadband profiles.

Some of the setting options are only available at DAR-Remote side since the Exchange-DAR section is strictly defined by the DSLAM.

The profile #0 is the factory default the others are free for creating customized profiles.

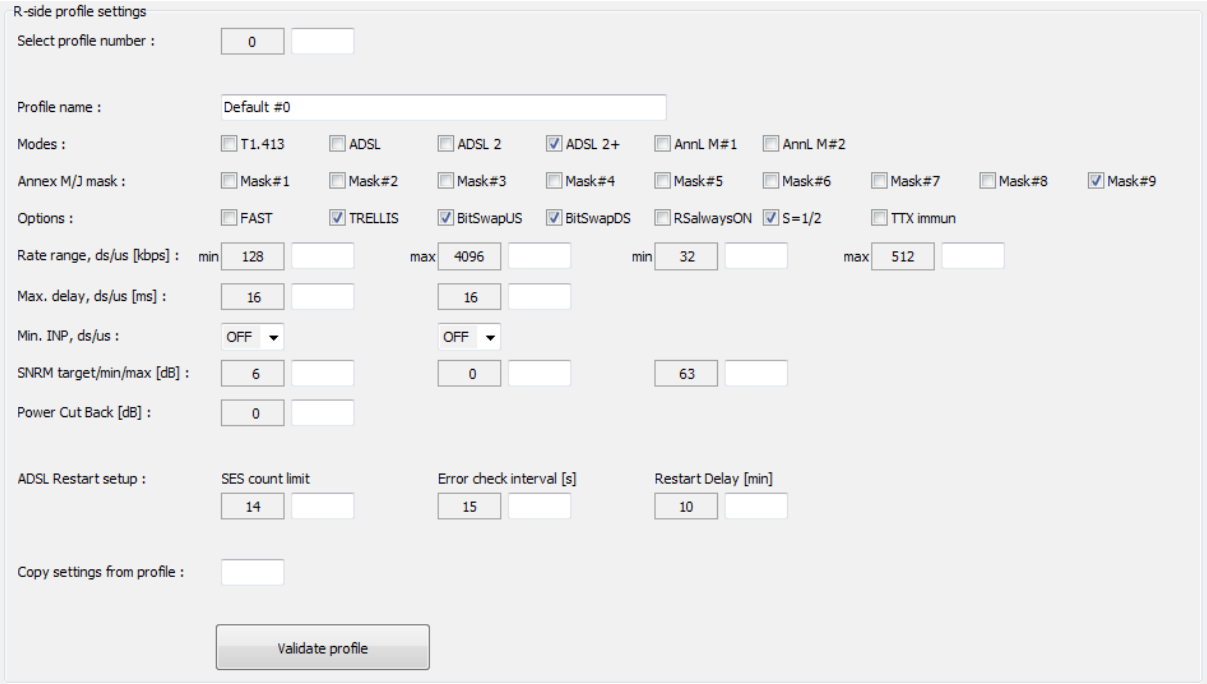

Figure 13. – NMS – profile settings

Select profile number	The user can choose a profile identification number (0 .. 7) and all the below settings will belong to this profile number.
Profile name	Any name can be related to the profile.
Modes (*buttons*)	The user can set the ADSL modes.
T1.413	Technical standard which defines the interaction of network and modem in the telecommunication network.
ADSL	ADSL standard according to ITU-T G.992.1
ADSL2	ADSL2 standard according to ITU-T G.992.3
ADSL2+	ADSL2+ standard according to ITU-T G.992.5
AnnM #1	ADSL2 and ADSL2+ optional standard with boosted upstream speed.
AnnM #2	ADSL2 and ADSL2+ optional standard with boosted upstream speed.
Note: The systems recognize automatically the environment's mode and acts accordingly. The factory setting is Annex A or Annex B depending on the national standards.	
Annex M/J mask	Power Spectrum Density mask – adjustable used frequency range.
DAR-remote side only	It is possible to use pre-defined masks according to national definitions.
Options	Fine tunings for ADSL modes.
DAR-Remote side only	

Rate range, ds/us	The user can set a range for downstream and upstream direction in every link where the synchronization speed must fit in. The system will be synchronized on the possible maximum speed in the defined range.
Max. delay, ds/us	Adjustable latency (error correction) value at CPE side (0 .. 63).
Min. INP (*roll windows*) **DAR-Remote side only**	Adjustable Impulse Noise Protection against various interferences at CPE side (OFF or 0,5 .. 16).
SNRM target/min/max **DAR-Remote side only**	The target, minimum and maximum acceptable signal-noise rate margin can be adjusted at CPE side. The DAR-CPE ADSL synch will be proceeded accordingly (-8 .. +31 dB).
Power Cut Back **DAR-Remote side only**	The DAR can vary the transmit power on all ADSL channels in order to introduce less noise into the network (-9 .. +31 dB).
ADSL Restart setup	The system restarts the ADSL line if the number of digital errors reaches the adjusted value (*SES count limit*, max 31) within the adjusted time period (*Error check interval*, max 31 s). Avoiding of continuous restarts on poor lines the user can set a delay for restarting (*Restart Delay*, max 99 min).
Copy settings from profile	It is possible to copy previously adjusted profile to a new one.
Validate profile (*button*)	After finishing all necessary adjustment of the new profile the user should use this button to make the profile effective. As a further step, the modification shall be stored at System tab, too.

5.4 Performance of ADSL

This tab contains the performance of the downstream and upstream ADSL sections at both sides. The parameters belong to the last 15 minutes.

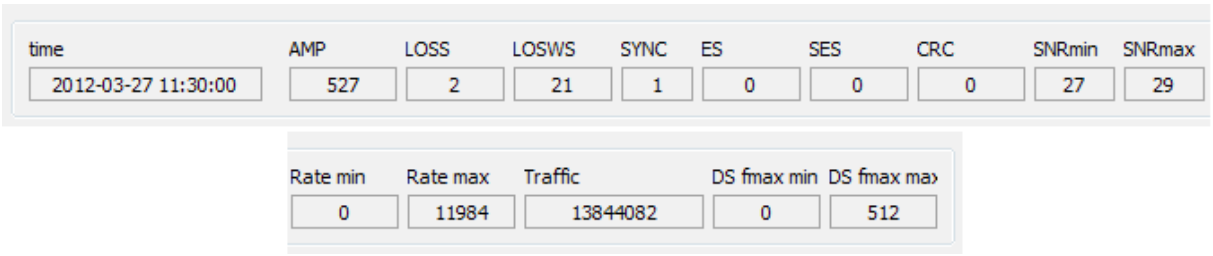

Figure 14. – NMS – ADSL parameters

time	Last date when the data was recorded (yyyy-mm-dd, hh-mm-ss).
AMP	Actual measured period (s).
LOSS	Loss of signal (s).
LOSWS	Loss of sync word (s). ADSL sync in progress.
SYNC	ADSL sync is ON (s).
ES	Number of seconds having error.
SES	Number of seconds having severly error.
CRC	Number of CRC errors.
SNRmin	Minimum Signal Noise Ratio (dB).
SNRmax	Maximum Signal Noise Ratio (dB).
Rate min	Available minimum ADSL speed (Kbps).
Rate max	Available maximum ADSL speed (Kbps).
Traffic	Forwarded ATM cells (pcs).
DS fmax min	Minimum level of used frequency spectrum (kHz).
DS fmax max	Maximum level of used frequency spectrum (kHz).

6 Safety requirements

a) The remote feeding system of DAR has been classified as a RFT-C circuit according to the EN 60950-1 and 60950-21. The RPF provides up to 330 Vdc nominal voltage line to line (± 165 Vdc nominal voltage line to earth).

b) Effective capacitances of interfaces

- between the connection points for the conductors of the Telecommunication Network is less than 1.5 µF

- between the connection point for one conductor of the Telecommunication Network and Earth is less than 1.0 µF

c) At the time of installation it shall be checked that the voltage rating of the wiring of the Telecommunication Network is adequate for the normal RFT circuit voltage together with the transients. The installed GDAs also must be considered.