DVB-S2 HOMS: EVM AND PSD SIMULATIONS IN NON-LINEAR CHANNEL

SLS-RFM_15-04

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OBJECTIVE OF THE DOCUMENT

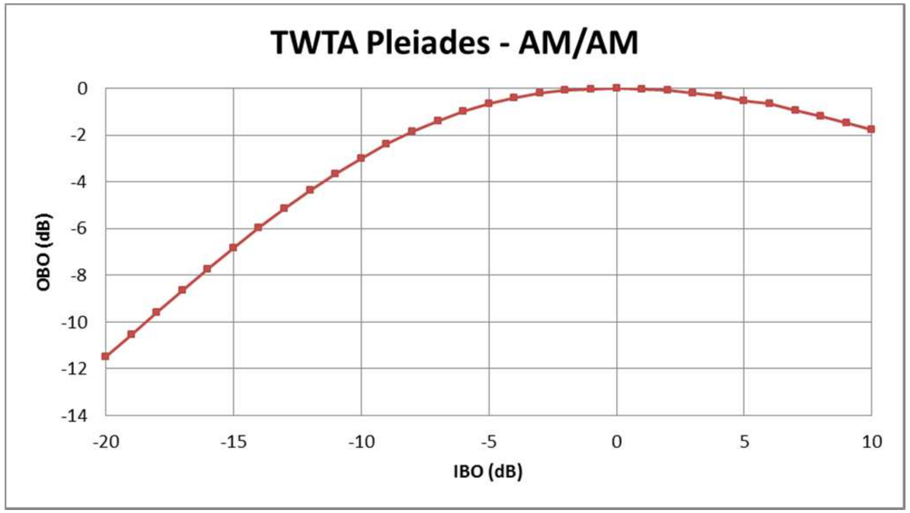
- to present some material towards a recommandation of an Error Vector Magnitude (EVM) requirement at the on-board High Data Rate Telemetry (HDRT) Power Amplifier (PA) output when using High Order Modulations (HOMs) of the DVB-S2 standard

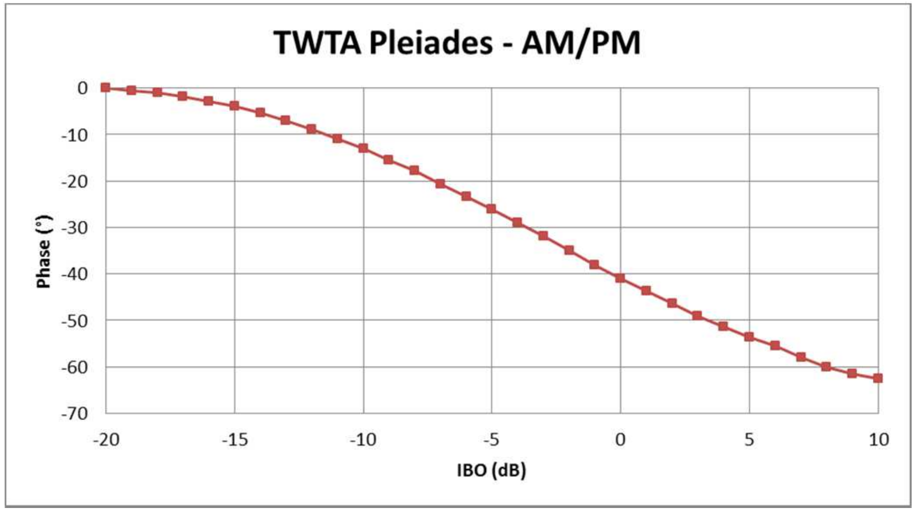
- to evaluate the possible improvement when using a very simple channel symbol Constellation Predistorsion (CP) of the PA non-linearity

- to evaluate possible constraints on the amplifier operating point related to the power spectrum density (PSD) at the PA output

METHODOLODY (1)

- model of non-linearity without memory (PA fully characterized by its AM/AM and AM/PM responses)
- X-band 35 W TWTA
- receiver synchronization assumed ideal (simple static amplitude and phase shift compensations to be able to measure EVM)





METHODOLODY (2)

- Value to be optimized (by modifying the PA operating point or the CP):

TD=OBO+DL (dB)

  - TD = Total Degradation
  - OBO = Output Back-Off
  - DL = Demodulation Loss

Remark: values kept negative

$$\mathrm{DL} = \frac{\mathrm{E_S}}{\mathrm{N_0}}\text{required at demodulation with PA} - \frac{\mathrm{E_S}}{\mathrm{N_0}}\text{ required at demodulation without non linearity}$$

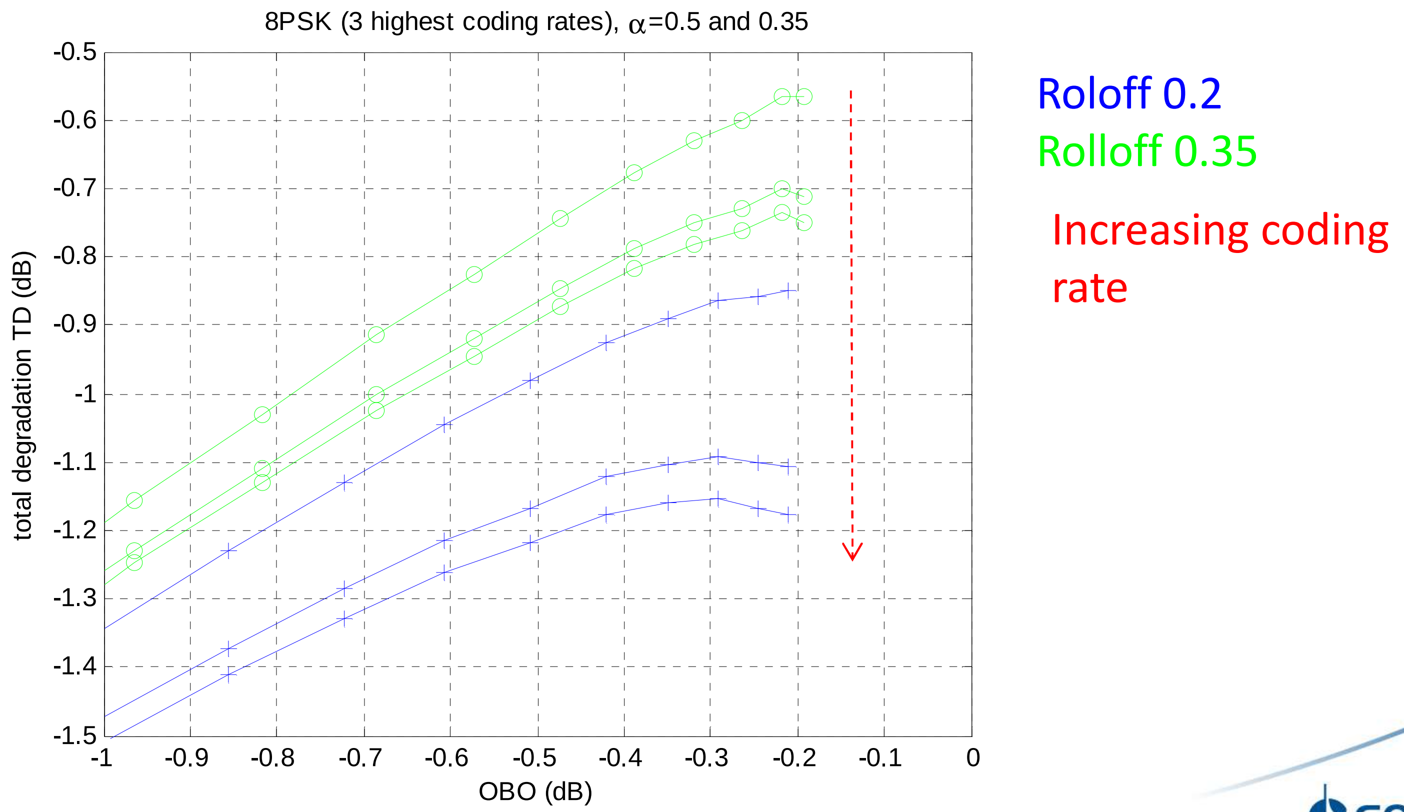
$$= 10\log 10\left(\left(\left(\text{theoretical } \frac{\mathrm{E_S}}{\mathrm{N_0}}\right)^{-1} - (\text{constellation SNR})^{-1}\right)^{-1}\right) - 10\log 10\left(\text{theoretical } \frac{\mathrm{E_S}}{\mathrm{N_0}}\right)$$

$$= 10\log 10\left(1 - \left(\text{theoretical } \frac{\mathrm{E_S}}{\mathrm{N_0}}\right)(\text{constellation SNR})^{-1}\right)$$

$$\text{constellation SNR} = -20\log 10(\text{measured EVM})$$

QPSK AND 8PSK

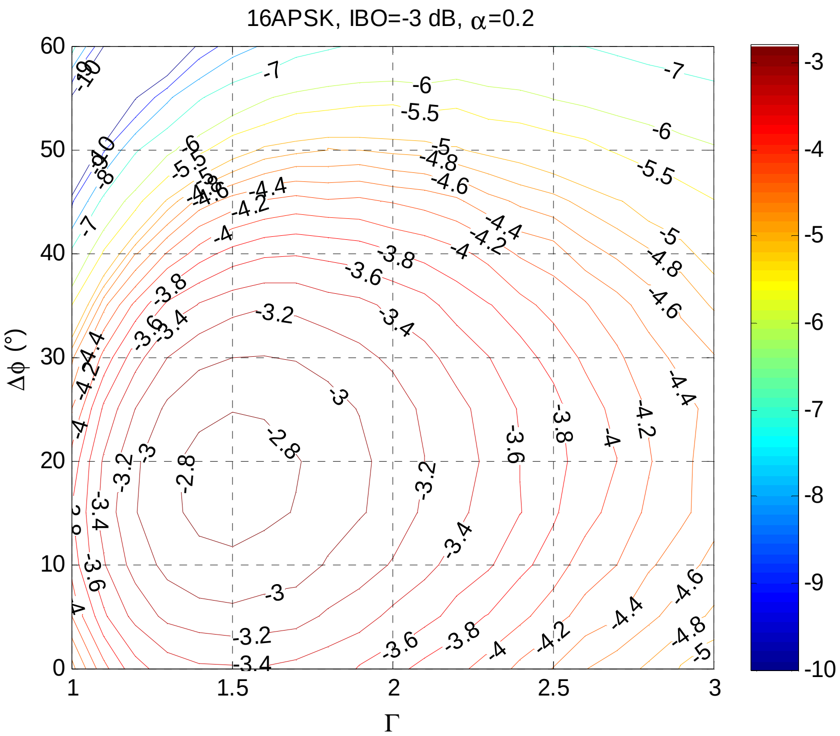
- optimization only performed on the PA operating point
- whatever the roll-off is, best operating point found very close to the PA saturation



16APSK (1)

- optimization performed on
  - the amplifier operating point
  - the increase of the radius ratio wrt the nominal constellation ($\Gamma=\gamma_{CP}/\gamma_{nominal}$)
  - the phase shift of the second ring wrt the nominal constellation ($\Delta\varphi$)
- for each IBO, optimal couple (Γ, $\Delta\varphi$)

TD (in dB) as a function of Γ and Δϕ for a fixed IBO=-3 dB



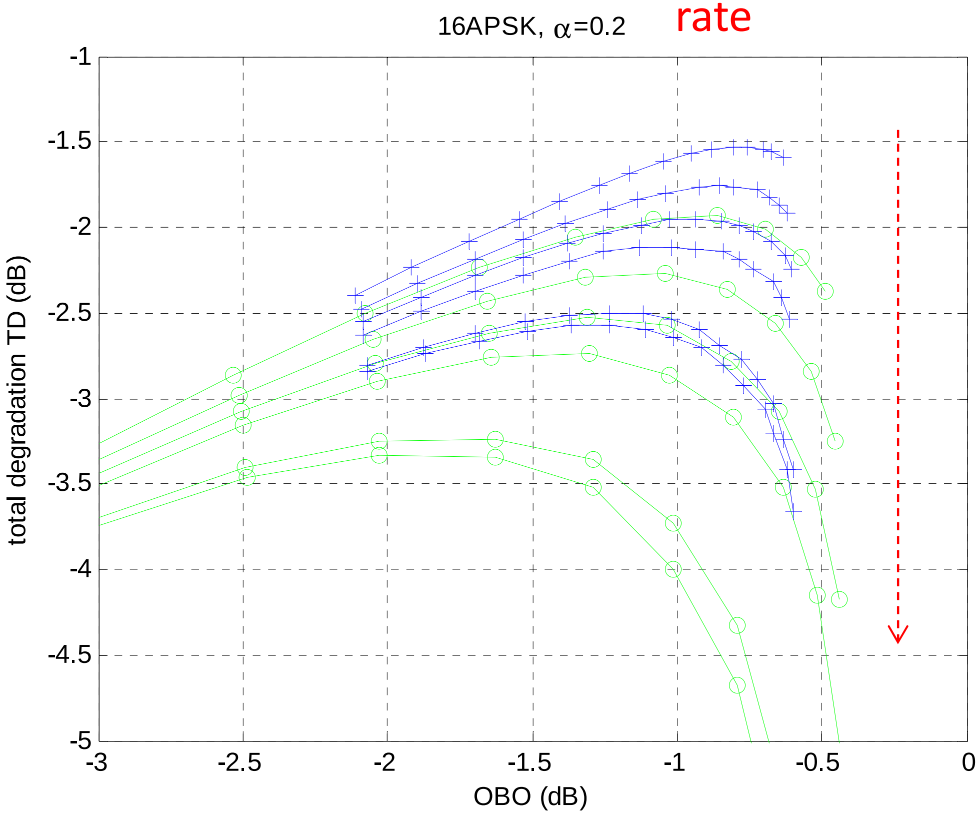
16APSK (2)

- Results
  - gain in using CP
    - 0.4 to 0.76 dB with α=0.2
    - 0.55 to 1.1 dB with α=0.35
  - gain slightly higher for the highest roll-off
    - PAPR increase induced by the pulse shaping filter not mitigable by the CP

With CP

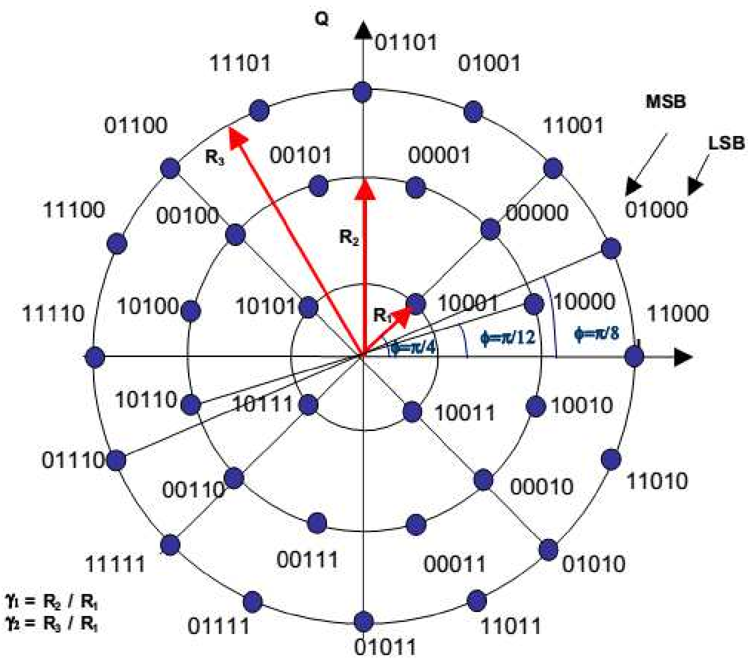
Without CP

Increasing coding rate



32APSK (1)

- (suboptimal) optimization performed on
  - the amplifier operating point
  - the increase of the second radius ratio wrt the nominal constellation ($\Gamma_2 = \gamma_{2,CP}/\gamma_{2,nominal}$)
  - the phase shift of the third ring wrt the nominal constellation ($\Delta\varphi_2$)



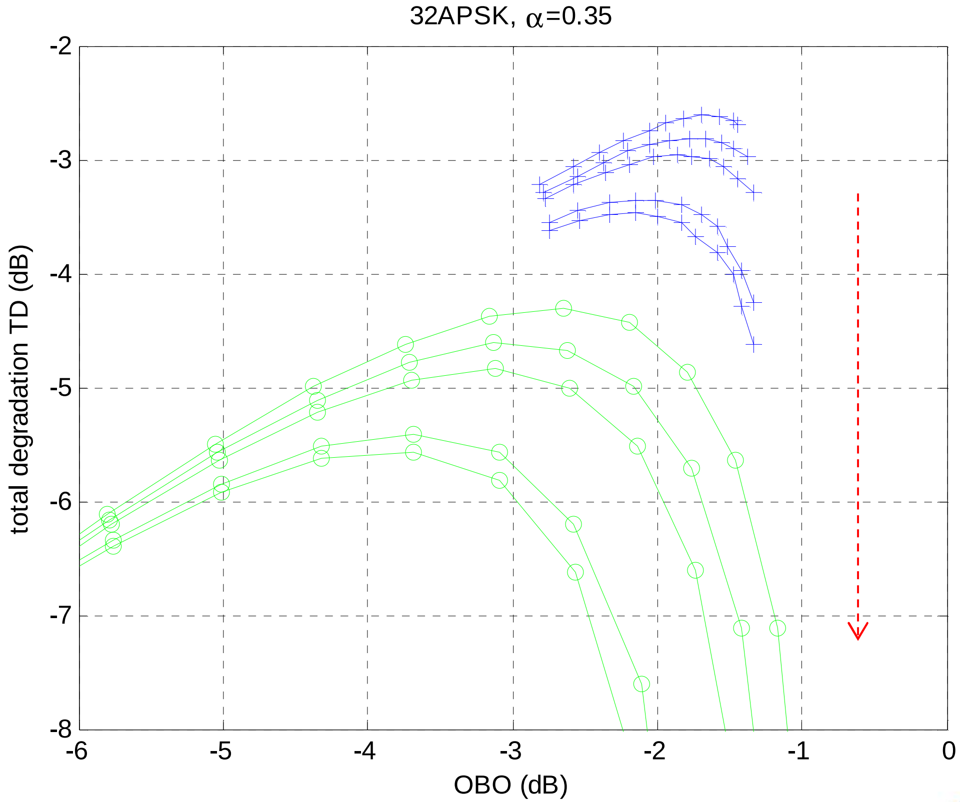
32APSK (2)

- Results
  - gain in using CP
    - 1.25 to 1.46 dB with α=0.2
    - 1.69 to 2.11 dB with α=0.35
  - Same trend than for 16APSK concerning the roll-off

With CP

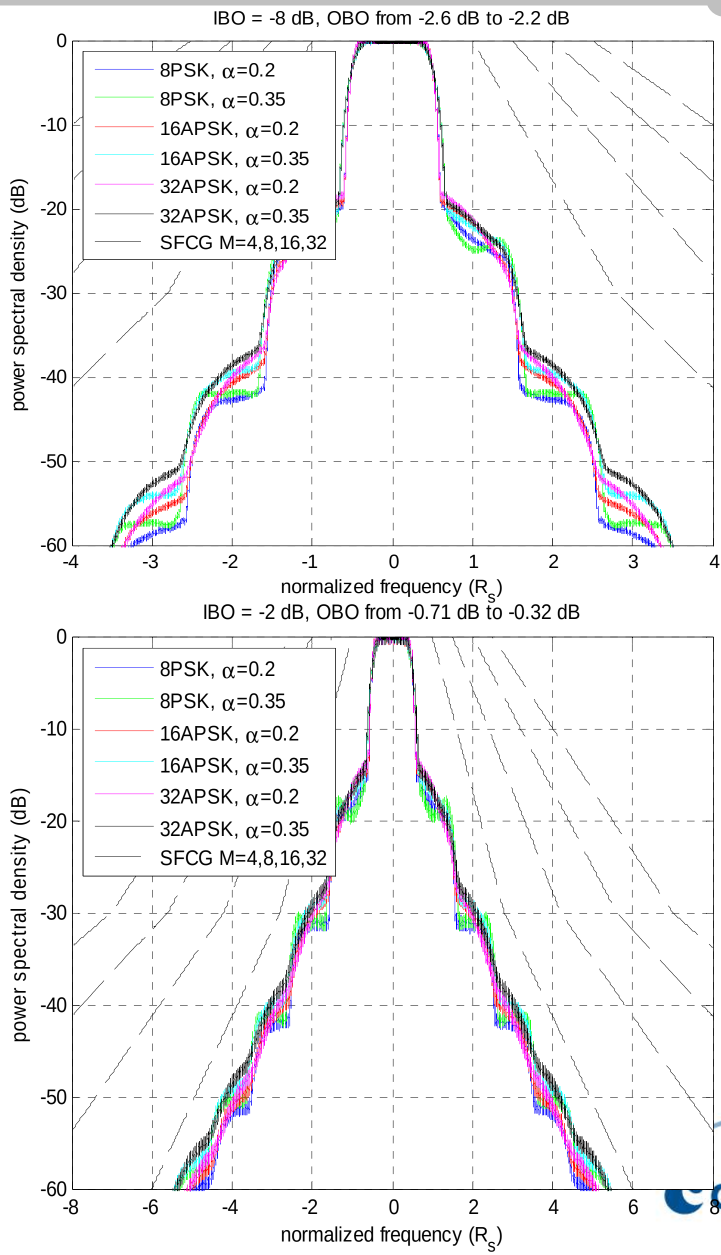
Without CP

Increasing coding rate



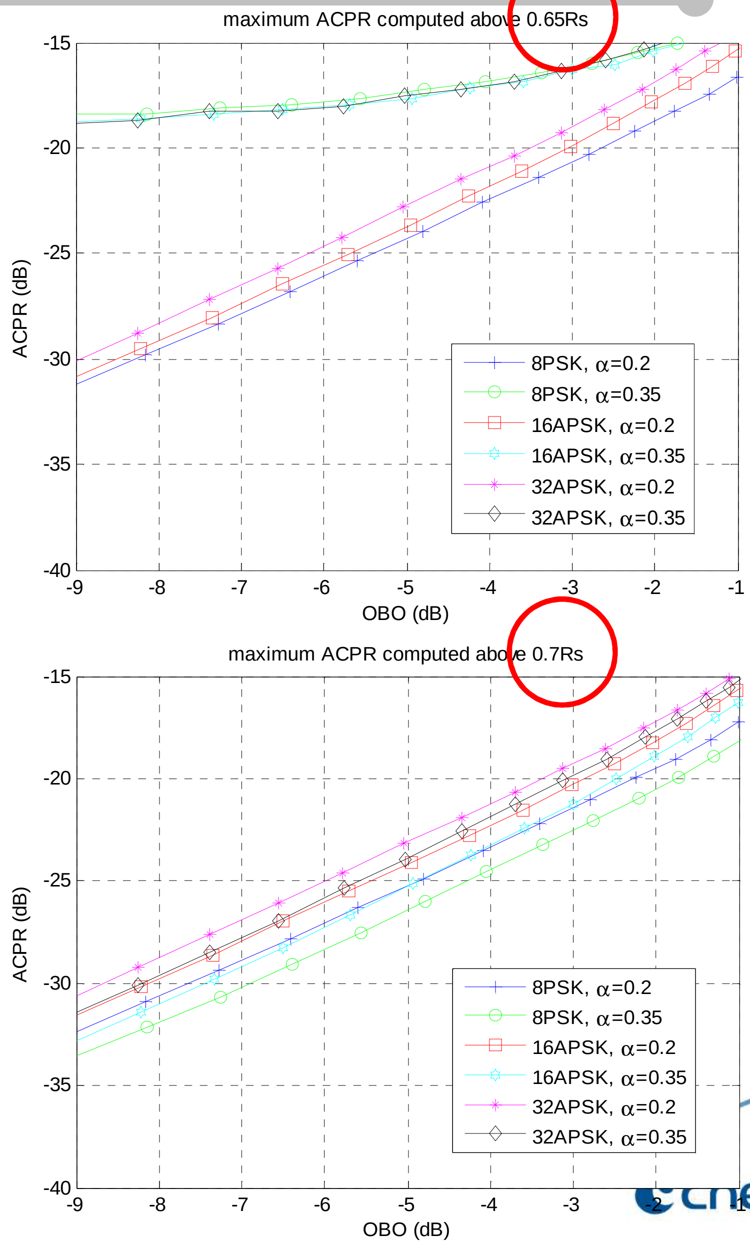
PSD AND ACPR (1)

- PSD (Power Spectrum Density) at the PA output (but SFCG PSD mask applicable at the satellite output after a RF output filter)
- PSD normalized at the carrier center
- Remark: SFCG PSD mask depends on the constellation



PSD AND ACPR (2)

- ACPR (Adjacent Channel Power Ratio) designs here the ratio in natural value between
  - the PSD at the carrier center
  - the maximum PSD above a given frequency offset from the carrier center



CONCLUSION

- Optimization of the operating point in the PA amplifier for the highest coding rate leads to the following constellation SNR
  - 8PSK : ~20.4 dB
  - 16APSK : ~20.3 dB
  - 32APSK : ~21.9 dB

- No particular criticity found at the PSD level to respect the SFCG PSD mask

- Remark: technical material added to the “DVB-S2 Green Book”