Some useful formulas

- Fourier series: $s(t) = C_0 + \sum_{n=1}^{\infty} C_n \cdot \sin(2\pi nft + \varphi_n)$

- Sampling frequency f_s for a signal of maximum frequency f_{max}: $f_s \geq 2 f_{\max}$

- Relation between levels L of a digital modulation and number of bits n used

$$L = 2^n \ , \ \mathrm{n} = \log_2 L$$

Some useful formulas

- Relation between bit rate (R) and symbol rate (S) for a multi-level signal (modulated or baseband)

$$R = S \cdot \log_2 L \ , \ R = S \cdot n$$

- Bit rate for a **baseband** multi-level modulation, where B is the bandwidth

$$R = 2 \cdot B \cdot \log_2 L \ , \ R = 2 \cdot B \cdot n$$

- Bandwidth of **modulated** M-ASK, M-PSK, M-QAM, where L is the number of levels and d accounts for non-ideal conditions

$$B = (1+d) \cdot S \ , \mathrm{B} = (1+d) \cdot \frac{R}{\log_2 L} \cdot$$

Some useful formulas

- Bandwidth of **modulated** M-FSK, where L is the number of Levels and d accounts for non-ideal conditions

$$B = S \cdot (L + d)$$

- Decibel calculation for power loss

$$L_{dB} = 10 \log_{10} \left(\frac{P_{in}}{P_{out}} \right)$$

- Decibel calculation for launch power (dBm)

$$P_{dB} = 10 \log_{10} \left(\frac{P_{in}}{1mW} \right) = 10 \log_{10} \left(\frac{P_{in}}{0.001W} \right)$$

Some useful formulas

- Power budget threshold for a transmission line, where G_{ampl} is the gain of the amplifier if present**. Everything is in dB**:

  P_{tx} – Loss - M >= Rx_{sens}, (Receiver sensitivity threshold)

  Where Loss= $lenth_{[km]}$ x Loss_coeff ($\alpha_{[dB/km]}$)

  When amplifiers are present, with M gain of all amplifiers and Loss is the loss of all spans:

  P_{tx} - Loss + Gain -M>= Rx_{sens}

- SNR threshold for a transmission line, where Nf_{ampl} is the noise figure of amplifiers if they are present, Nf_{rec} the noise figure of the receiver**. Everything is in dB:**

  If there is only one amplifier:

  $OSNR_{recv}=P_{launch[dBm]} - \alpha_{[dB/km]} \times L_{span[km]} - NF_{ampl[dB]} + 58_{[dB]} - M >= OSNR_{threshold}$

  With a chain of n amplifiers:

  $OSNR_{recv}=P_{launch[dBm]} - \alpha_{[dB/km]}\ L_{span[km]} - NF_{ampl[dB]} - 10\log_{10}(n) + 58_{[dB]} - M >= OSNR_{threshold}$