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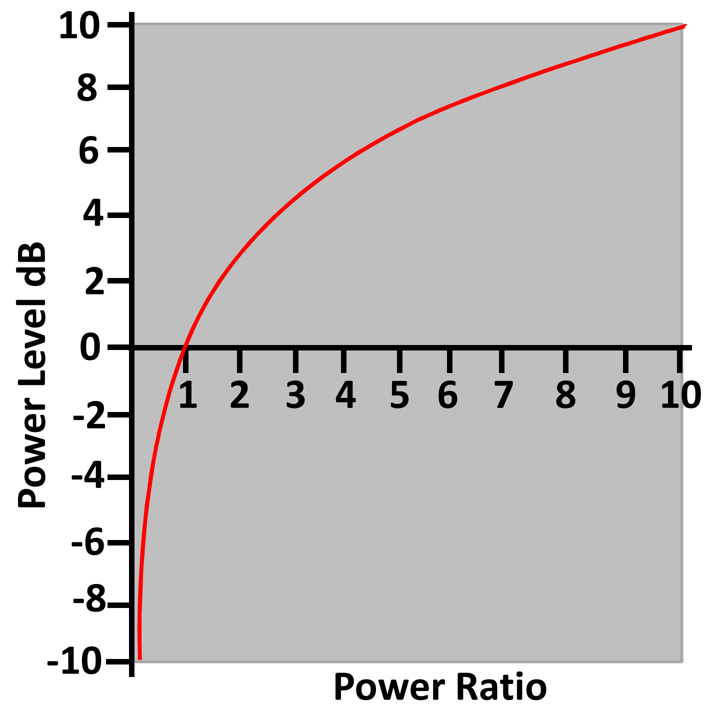
GPON

RF Budget Calculation

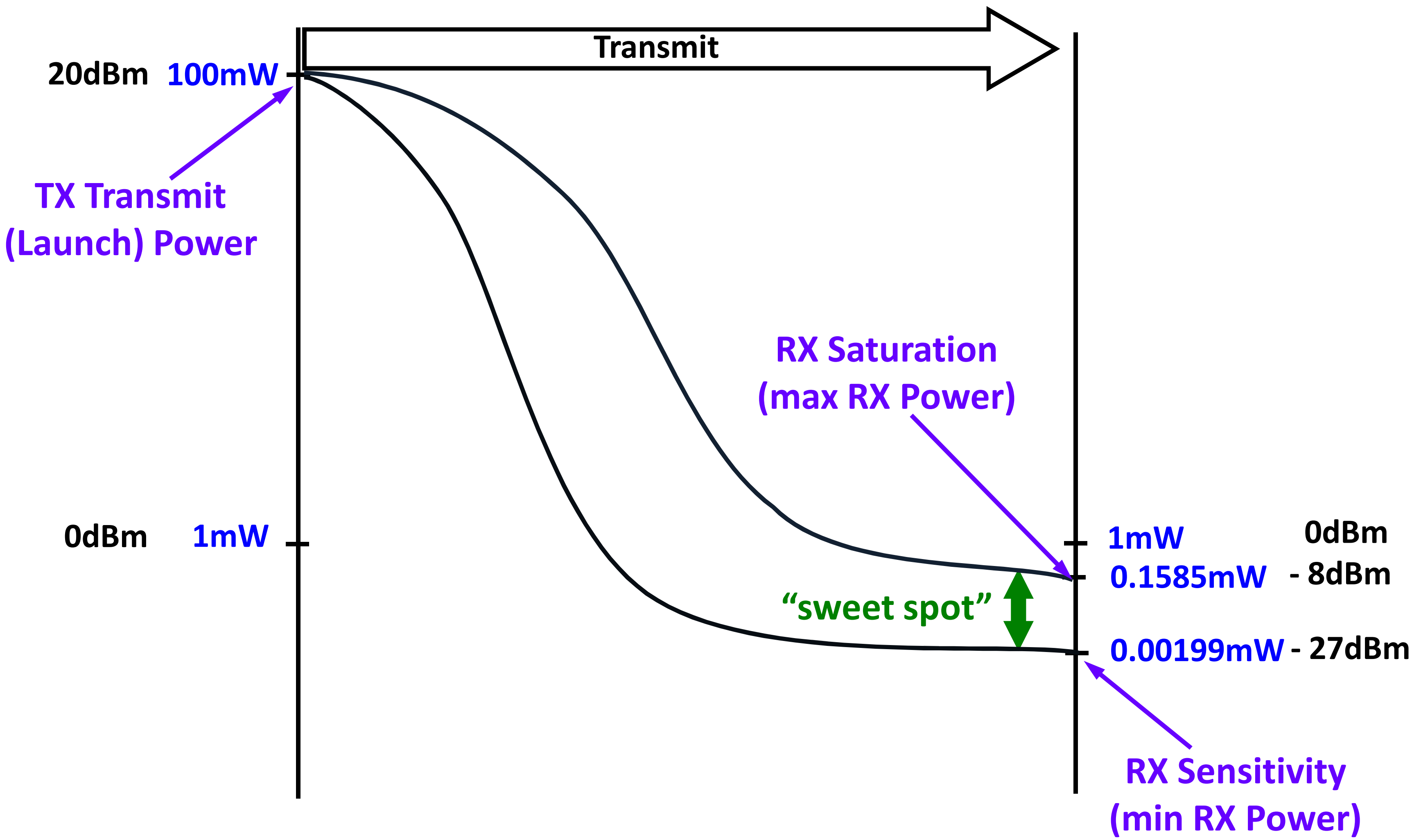
Using dBm

Signal to Noise Ratio

- SNR is a ratio expressed in dB logarithmically
- dB = $10Log_{10}$ (S/N)
- SNR is not linear
- Log_{10} (100) = 2
- If $y = Log_{10}(x)$
  - then $x = 10^{y}$



Terminology



Typical SNR values

-10dB	= 10 x Log_{10}(**0.1**)	reduce SNR by 1000% (-10 x)
<snip>		
-3dB	= 10 x Log_{10}(**0.50**)	reduce SNR by 50%
-2dB	= 10 x Log_{10}(**0.63**)	reduce SNR by 37%
-1dB	= 10 x Log_{10}(**0.79**)	reduce SNR by 21%
0dB	= 10 x Log_{10}(**1.00**)	
+1dB	= 10 x Log_{10}(**1.26**)	increase SNR by 26%
+2dB	= 10 x Log_{10}(**1.59**)	increase SNR by 59%
+3dB	= 10 x Log_{10}(**2.00**)	increase SNR by 200%
<snip>		
+10dB	= 10 x Log_{10}(10)	increase SNR by 1000% (10 x)

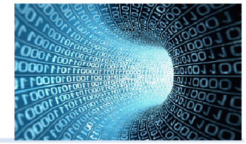
For example, an SNR increase of 3dB means a doubling of signal power whereas an SNR decrease of 3dB means halving the signal power

(Anti-Log Windows Calculator, dB ÷ 10 then press Inv and 10^x keys)

dB and dBm (dB milliwatt)

- dB and dBm are NOT the same thing
- dBm is a measure of dB with respect to a reference value of 1mW whereas dB is a ratio
- 0dBm = 1mW
- Convert Power in Watts to dBm (choose a formula)
  - $x\text{dBm} = (10\text{Log}_{10}\text{P})+30$ OR $x\text{dBm} = 10\text{Log}_{10}(1000\text{P})$
- Convert dBm to Power in Watts (choose a formula)
  - $P_W = 10^{(x\text{ dBm} - 30) / 10}$ OR $P = (10^{[x\text{ dBm} / 10]}) / 1000$

Demonstrate 0dBm = 1mW



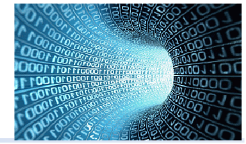
$$P_W = 10^{(\mathbf{0\ dBm} - 30)\ /\ 10}$$

$$P_W = 10^{(-30)\ /\ 10}$$

$$P_W = 10^{-3}$$

$$P_W = 0.001_W = 1mW$$

Sample Calculations



e.g. if P_W = 100,000W [100KW]

xdBm = (10 x Log_{10}100,000) + 30

xdBm = (10 x 5) + 30

xdBm = 80dBm

e.g. if **x** = 80dBm convert back to Watts

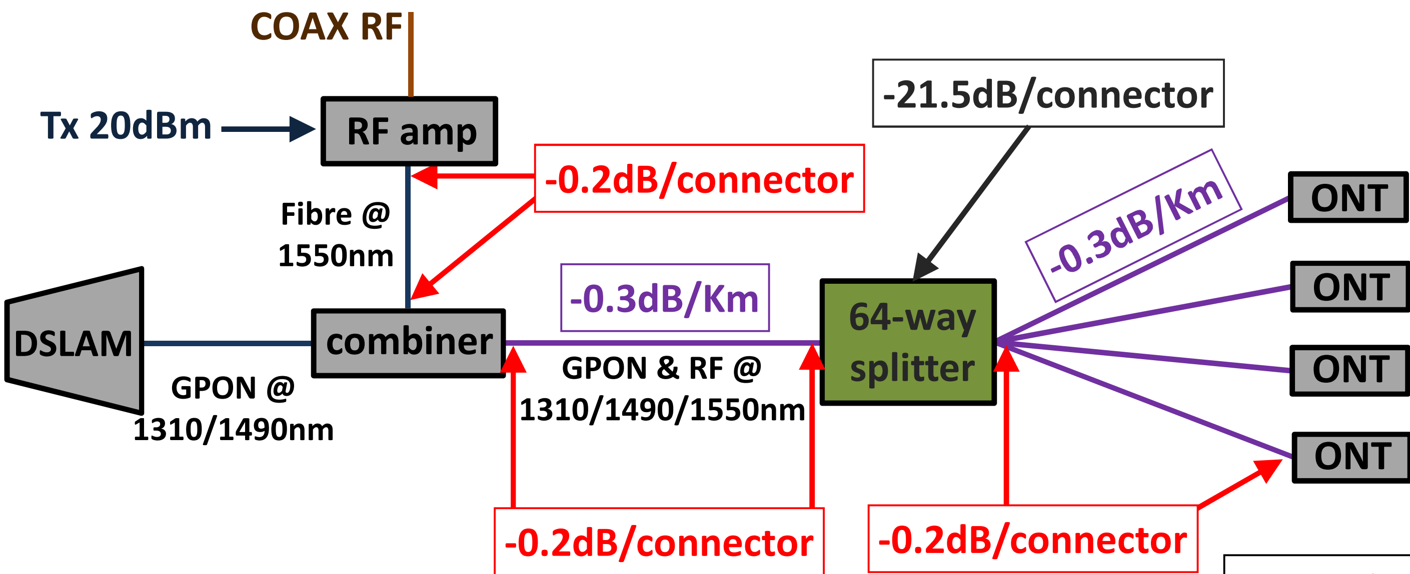
$P_W = 10^{(x - 30) / 10}$

$P_W = 10^{(80 - 30) / 10}$

$P_W = 10^{5}$

P_W = 100,000 Watts

RF Amplifier to ONT



No. Splits	Max Loss
2	-4.0dB
4	-7.5dB
8	-11.0dB
16	-14.0dB
32	-18.0dB
64	-21.5dB

Assumptions:
- Splitter is 1Km from combiner
- ONT is 1kM from splitter
- Splitter is 64-way
- -3dB contingency loss added

P_{Tx} = 20dBm (RF amplifier)

P_{Rx} = -27dBm [0.00199mW] (ONT min Rx power)

Loss = (6 x -0.2dB) + (2 x -0.3dB) – 21.5dB -3dB = -26.3dB

Note 1: A contingency of -3dB is added to the calculation

Note 2: Calculation for 1500nm over SM fibre (loss varies for different fibres)

Note 3: Tx and Rx are in dBm, loss is in dB (they are not the same)

Calculate loss in mW

AMPLIFIER / TRANSMITTER (Convert to mW)

Launch power = 20dBm

$P_W = 10^{(20dBm - 30) / 10}$

$P_W = 10^{-1}$

P_W = 0.1W = 100mW

ONT 2543 (Convert to mW)

Receive Saturation (max) = -8dBm

$P_W = 10^{(-8dBm - 30) / 10}$

$P_W = 10^{-3.8}$

P_W = 0.0001585W = 0.1585mW

ONT 2543 (Convert to mW)

Receive Sensitivity (min) = -27dBm

$P_W = 10^{(-27dBm - 30) / 10}$

$P_W = 10^{-5.7}$

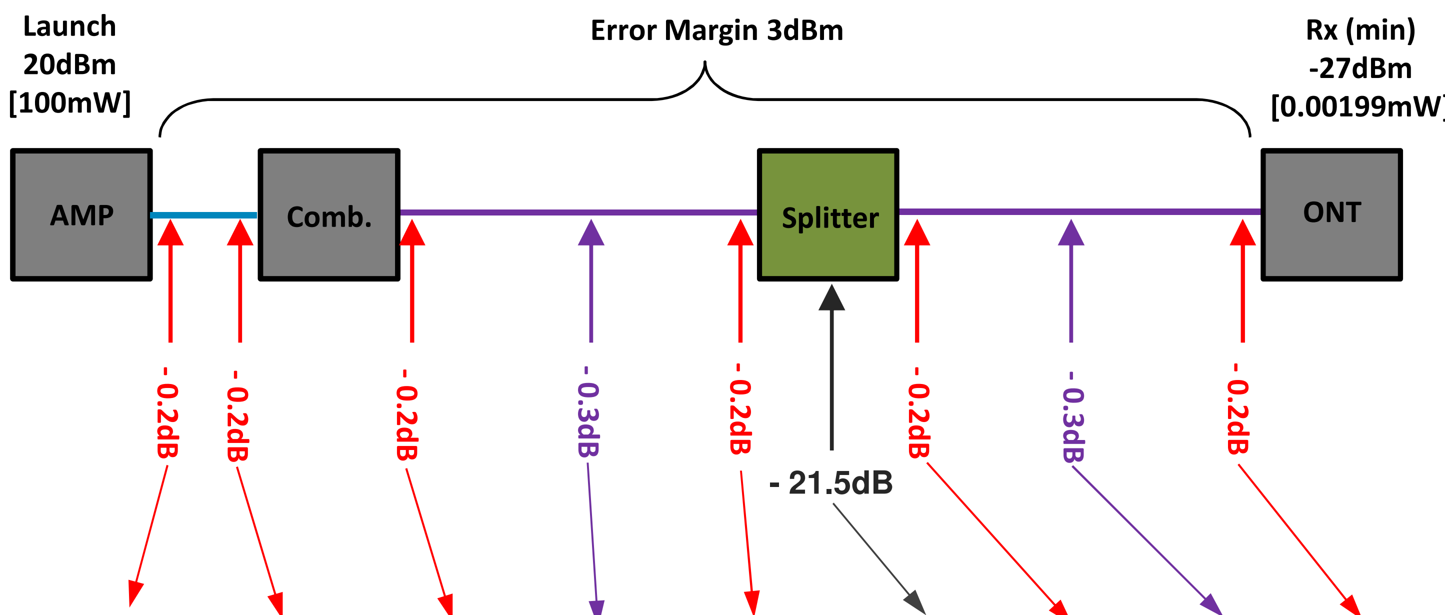
P_W = 0.000001995W = 0.001995mW

The signal "window" for the ONT to receive is between 0.1585mW and 0.00199mW. Therefore, the dB loss ratio along the path must not degrade the signal strength from 100mW to below the value of 0.00199mW.

Calculate budget method #1

Find the LOSS RATIOS per Component

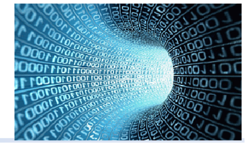
- Connector = -0.2 dB = $10Log_{10}(0.9545)$
- Per Km = -0.3 dB = $10Log_{10}(0.9333)$
- Splitter = -21.5 dB = $10Log_{10}(0.0071)$
- Safety Margin = -3.0 dB = $10Log_{10}(0.5012)$



3dBm

Ratio	0.9545	0.9545	0.9545	0.9333	0.9545	0.0071	0.9545	0.9333	0.9545	0.5012
mW	95.45	91.1070	86.9616	81.1613	77.4685	0.5500	0.5250	0.4900	0.4677	0.2344

Calculating budget method #2



Find the overall, end-to-end LOSS RATIO

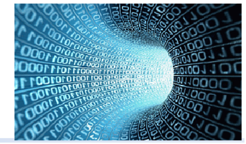
Rather than take the 100mW launch power and multiply it by the loss ratio at each hop, take the cumulative path loss from Slide 6 and apply the total dB loss ratio to the 100mW launch power:

Cumulative Loss Ratio:

- 26.3dB = $10\text{Log}_{10}(0.002344)$
- Receive P_W = 100mW x 0.002344
- Receive P_W = 0.2344mW (same answer as for Method #1)

Therefore, with a 20dBm transmitter at 100mW and an estimated total path loss of -26.3dBm the ONT will still receive a signal strength of 0.2344mW. This is much higher than its minimum receive sensitivity of 0.00199mW but is also higher than the saturation maximum power so additional attenuation may be needed.

Considerations



- Different component manufacturers have different loss values
- Different cable types (SM/MM) have different loss per Km
- The above calculation assumes the connectivity in Slide 8
- The above calculation assumes the distances in Slide 8
- Different topologies will have different power budgets
- The above calculation is for the RF 1550nm signal only
- The ONT receive power range for data is -8dBm to -27dBm (where -8dBm is overload and -27dBm is sensitivity)

Thank You!

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