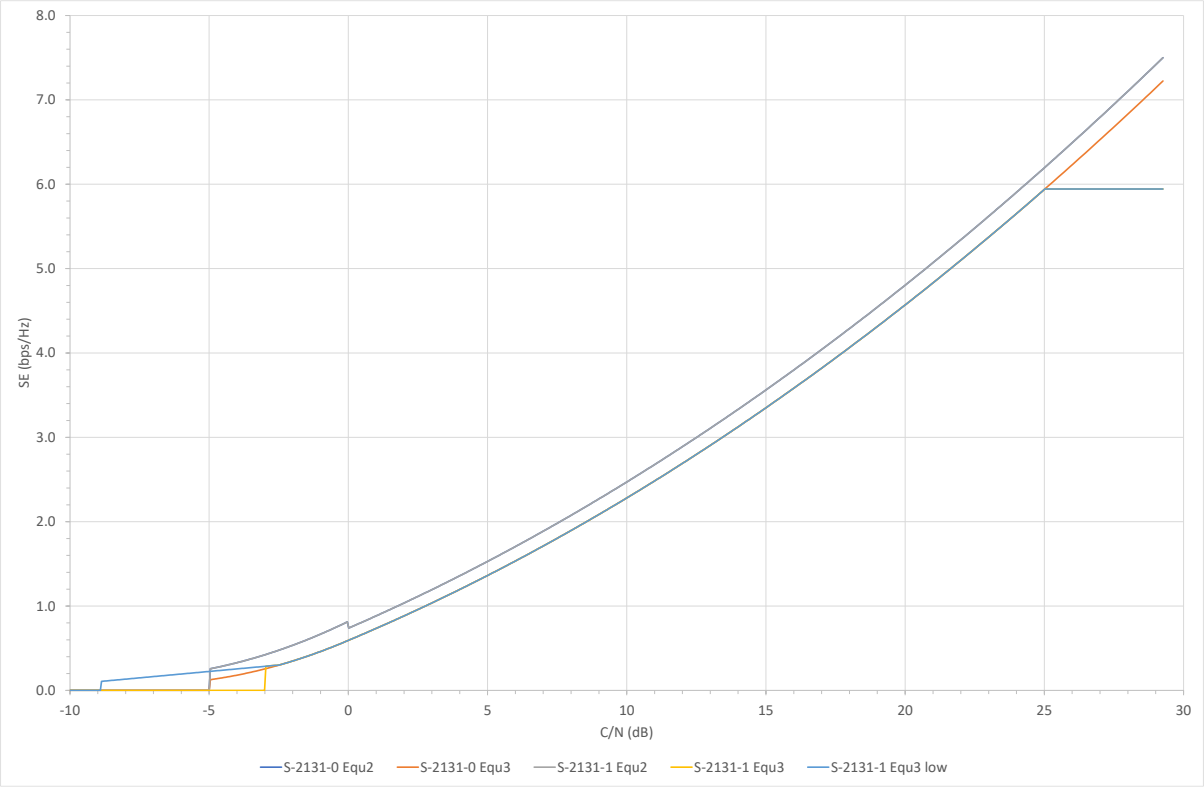
Spectrum Efficiency and Throughput Calculations

1. Introduction

Recommendation ITU-R S.2131 contains "Method for the determination of performance objectives for satellite hypothetical reference digital paths using adaptive coding and modulation". In particular, it gives equations that can be used to calculate the spectrum efficiency of a link in bits/second given an input C/N (dB) assuming the link is using adaptive coding and modulation (ACM). The equations were derived from values for the DVB-S2X standard.

A number of plots can be generated as shown below that take account of:

- There are two versions of the Recommendation, namely S.2131-0 and S.2131-1.
- These Recommendations give two curves, one for average spectrum efficiency and another for minimum spectrum efficiency
- Recommendation ITU-R S.2131-1 also gives an additional curve for systems that can process low C/Ns



The total throughput (TTP) over a run can be calculated using the following summation:

$$TTP = \sum_{i=1}^{i=N} SE_i BW_i T_{Step}$$

Where:

N = number of time steps

SE_i = spectrum efficiency for the i-th time step in bps/Hz

BW_i = bandwidth for the i-th time step in Hz

T_{step} = time step in seconds

The average throughput (ATP) is then:

$$ATP = \frac{TTP}{N.T_{Step}}$$

One of the metrics used in interference analysis is the percentage decrease in the ATP due to interference i.e.

$$\Delta ATP = 100 \cdot \frac{ATP\left(\frac{C}{N}\right) - ATP\left(\frac{C}{N+1}\right)}{ATP\left(\frac{C}{N}\right)}$$

Note that if the bandwidth and time step size are constant for all time steps, then the ΔATP can be calculated directly from the TTP using the simplified equations as follows:

$$\Delta ATP = 100 \cdot \frac{TTP_S\left(\frac{C}{N}\right) - TTP_S\left(\frac{C}{N+1}\right)}{TTP_S\left(\frac{C}{N}\right)}$$

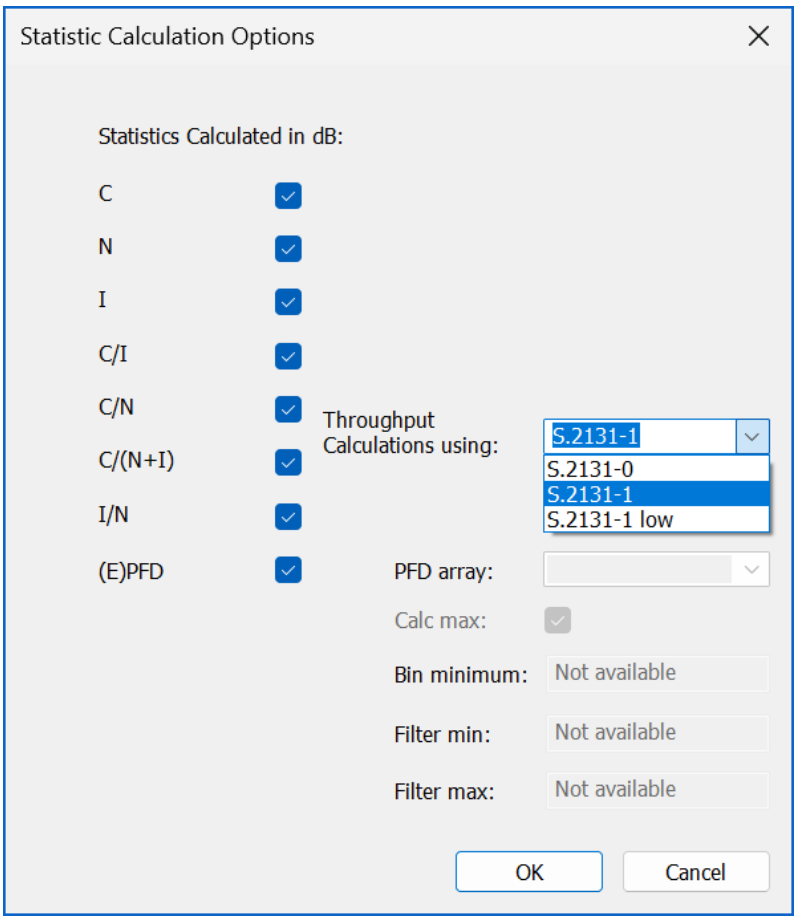
Where:

$$TTP_S = \sum_{i=1}^{i=N} SE_i$$

Here the units of TTP_S are bits/time steps/Hz.

2. Implementation in Visualyse

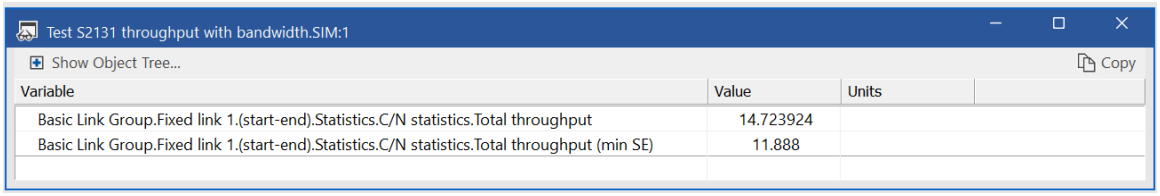
Visualyse includes the ability to calculate throughput using the equations in Recommendation ITU-R S.2131. The version can be selected using the “Calculations Options” on the “Statistics Collection Options” dialog:



The drop-down list gave the options as:

- S.2131-0
- S.2131-1
- S.2131-1 low

These options are used in Visualyse with the simplified TTP_S equations above from which the ΔATP can be derived in units of bits/time steps/Hz. The TTP_S is visible in the Link Status dialog or can be shown in the Watch Window as follows:



These are given for both the average and minimum spectrum efficiency equations.

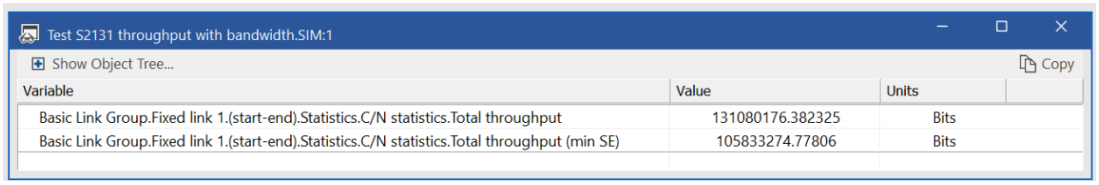
3. Visualyse Update

Visualyse Professional (V7.10.10.2) and Visualyse Interplanetary (V0.0.19.2) have been updated to include two new options, making five in total, namely:

- S.2131-0
- S.2131-1

- S.2131-1 low
- S.2131-1 (bits)
- S.2131-1 (bits) low

These last two new options calculate the TTP rather than the TTP_S. Hence the units are in bits rather than bits/time step/Hz. The units are now shown in the watch window, as can be seen below:



Note that the throughput is also calculated in the Link Groups using the following rules:

Method	**Rule**
Best link	Uses the link with the highest C/N
Best link by	Uses the link with the best metric
Worst link	Uses the link with the lowest C/N
Worst link by	Uses the link with the worst metric
Thermal addition	Uses the bandwidth of the last link with the C/N or C/(N+I) calculated using thermal addition
Maximum power combining	Uses the bandwidth of the last link with the C/N or C/(N+I) calculated using maximum power combining