1 Transmitter Parameters (from G.698.2)

1.1 Maximum and minimum mean channel output power

The mean launched power of each optical channel is the average power of a pseudo-random data sequence coupled into the DWDM link. It is given as a range (maximum and minimum) to allow for some cost optimization and to cover allowances for operation under the standard operating conditions, connector degradations, measurement tolerances and ageing effects.

1.2 Maximum spectral excursion

This is the maximum acceptable difference between the nominal central frequency of the channel and the –15 dB points of the transmitter spectrum furthest from the nominal central frequency. This is illustrated in Figure 1.

NOTE – The measurement of the –15 dB points of the transmitter spectrum should be performed with a nominal resolution bandwidth of 0.01 nm.

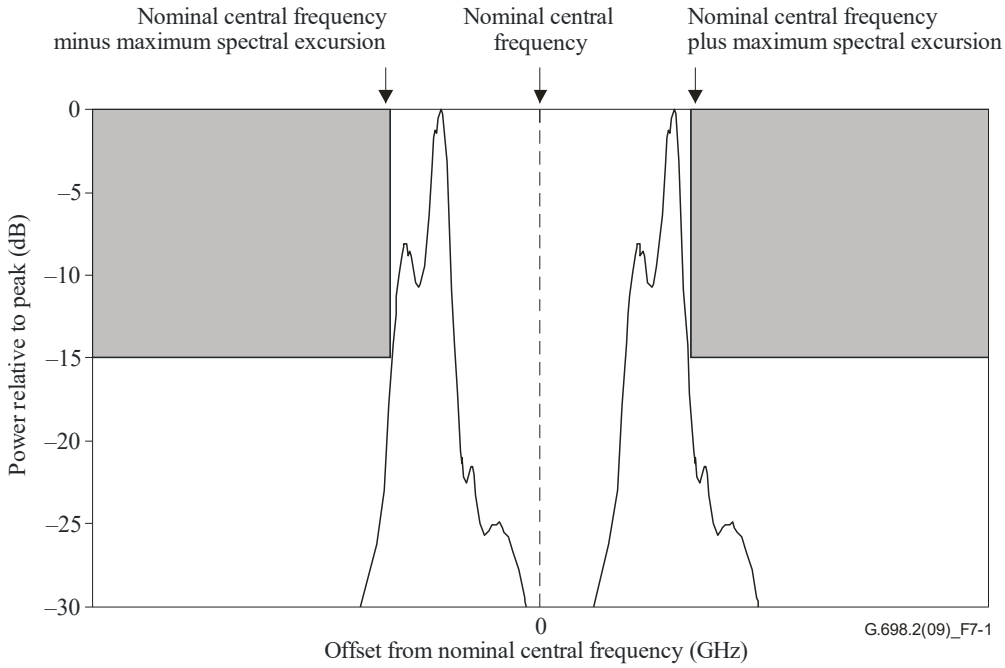

Figure 1 – Illustration of maximum spectral excursion

1.3 Minimum side mode suppression ratio

The minimum side mode suppression ratio is the minimum value of the ratio of the largest peak of the total transmitter spectrum to the second largest peak. The spectral resolution of the measurement shall be better than the maximum spectral width of the peak. The second largest peak may be next to the main peak, or far removed from it.

NOTE – Within this definition, spectral peaks that are separated from the largest peak by the clock frequency are not considered to be side modes.

1.4 Minimum channel extinction ratio

The extinction ratio (*EX*) is defined as:

$$EX = 10\log_{10}(A/B)$$

In the above definition of *EX*, *A* is the average optical power level at the center of a logical "1" and *B* is the average optical power level at the center of a logical "0". The convention adopted for optical logic levels is:

- emission of light for a logical "1";
- no emission for a logical "0".

1.5 Maximum transmitter (residual) dispersion OSNR penalty

The transmitter (residual) dispersion OSNR penalty is defined as:

Lowest OSNR with worst case (residual) dispersion – Lowest OSNR with no dispersion

Where:

- Lowest OSNR with no dispersion is the lowest OSNR that meets the maximum BER from a reference receiver at the transmitter at the minimum mean input power
- Lowest OSNR with worst case (residual) dispersion is the lowest OSNR that meets the maximum BER from a reference receiver at the transmitter with the chromatic dispersion applied which gives the highest OSNR penalty.

NOTE – The measurement of the transmitter (residual) dispersion OSNR penalty therefore requires filtered ASE noise to be added to the signal.

This penalty is not part of the system budget directly (since it is included as part of the optical path OSNR penalty defined in 2.7) but rather provides an upper bound on the OSNR penalty due to dispersion alone, thereby ensuring that some of the optical path OSNR penalty is available to cover the other impairments listed.

2 Black Link Parameters (from G.698.2)

2.1 Maximum ripple

For any optical channel, the maximum ripple is the peak-to-peak difference in insertion loss between the input and output ports of the black link for that channel in the frequency range of the central frequency of the channel ± the maximum spectral excursion. This is illustrated in Figure 2.

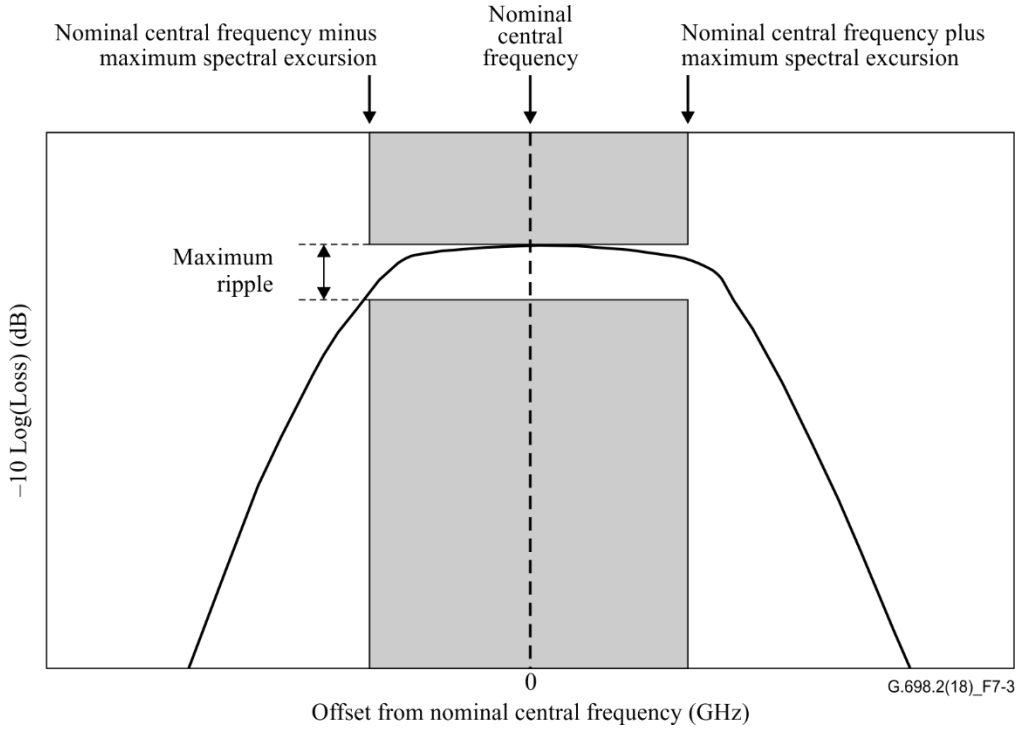

Figure 2 – Illustration of maximum ripple

2.2 Maximum and minimum (residual) chromatic dispersion

These parameters define the maximum and minimum value of the optical path end-to-end chromatic dispersion that the system shall be able to tolerate. These are the worst-case dispersion values of the optical path. In the case that the black link contains dispersion compensation between these two points, its effect is included.

These parameters contain the word "residual" in brackets because, in the case of links which include dispersion compensators, these are the maximum and minimum residual chromatic dispersion, and in the case of links that do not include any dispersion compensators, these parameters are simply the maximum and minimum chromatic dispersion.

2.3 Minimum optical return loss at transmitter

Reflections are caused by refractive index discontinuities along the optical path. If not controlled, they can degrade system performance through their disturbing effect on the operation of the optical source, or through multiple reflections which lead to interferometric noise at the receiver. Reflections from the optical path are controlled by specifying the:

- minimum optical return loss of the cable plant at the transmitter, including any connectors; and
- maximum discrete reflectance between transmitter and receiver.

2.4 Maximum discrete reflectance between transmitter and receiver

Optical reflectance is defined to be the ratio of the reflected optical power present at a point, to the optical power incident to that point. The maximum number of connectors or other discrete reflection points which may be included in the optical path (e.g., for distribution frames, or WDM components), must be such as to allow the specified overall optical return loss to be achieved.

2.5 Maximum differential group delay

Differential group delay is the time difference between the fractions of a pulse that are transmitted in the two principal states of polarization of an optical signal.

The maximum differential group delay is defined to be the value of differential group delay that the system must tolerate with a maximum OSNR penalty of 2 dB.

2.6 Maximum inter-channel crosstalk

This parameter places a requirement on the isolation of a link conforming to the "black link" approach such that under the worst-case operating conditions the inter-channel crosstalk at the receiver is less than the maximum inter-channel crosstalk value.

Inter-channel crosstalk is defined as the ratio of total power in all of the disturbing channels to that in the wanted channel, where the wanted and disturbing channels are at different wavelengths.

Specifically, the isolation of the link shall be greater than the amount required to ensure that when any channel is operating at the minimum mean output power at the transmitter and all of the others are at the maximum mean output power, then the inter-channel crosstalk at the receiver is less than the maximum inter-channel crosstalk value.

2.7 Maximum optical path OSNR penalty

The optical path OSNR penalty is defined as:

$$\text{Lowest OSNR at receiver} - \text{Lowest OSNR at transmitter}$$

where:

– Lowest OSNR at transmitter is the lowest OSNR that meets the maximum BER from a reference receiver *before* transmission through the black link.
– Lowest OSNR at receiver is the lowest OSNR that meets the maximum BER from a reference receiver *after* transmission through the black link.

NOTE – Measuring the optical path OSNR penalty therefore requires filtered ASE noise to be added to the signal.

The effects that contribute to the optical path OSNR penalty include:

– transmitter (residual) dispersion penalty for NRZ signal classes;
– non-linear effects within the black link;
– inter-channel crosstalk;
– interferometric crosstalk;
– reflections from the optical path;
– polarization dependent loss.

The transmitter/receiver combination is required to tolerate an actual differential group delay of 0.3-bit period with a maximum optical path OSNR penalty of 2 dB (with 50% of optical power in each principal state of polarization). For a well-designed receiver, this corresponds to an OSNR penalty of 0.2 – 0.4 dB for a differential group delay of 0.1-bit period.

3 Receiver Parameters (from G.698.2)

3.1 Maximum and minimum mean input power

The maximum and minimum values of the average received power at the receiver.

3.2 Minimum optical signal-to-noise ratio (OSNR)

The minimum optical signal-to-noise ratio (OSNR) is the minimum value of the ratio of the signal power in the wanted channel to the highest noise power density (referred to 0.1 nm) in the range of the central frequency plus and minus the maximum spectral excursion. For the purposes of this definition, the noise is defined to be that which would be present if the signal in the wanted channel were removed from the black link while keeping all other black link conditions the same (e.g., the gain and noise figure of all amplifiers).

3.3 Receiver OSNR tolerance

The receiver OSNR tolerance is defined as the minimum value of OSNR at the receiver that can be tolerated while maintaining the maximum BER of the application. This must be met for all powers between the maximum and minimum mean input power with a transmitter with worst-case values of:

– transmitter eye mask;
– extinction;
– optical return loss at the transmitter,
– receiver connector degradations;
– measurement tolerances.

The receiver OSNR tolerance does not have to be met in the presence of chromatic dispersion, non-linear effects, reflections from the optical path, polarization mode dispersion, polarization dependent loss, or optical crosstalk; these effects are specified separately in the allocation of maximum optical path OSNR penalty.

3.4 Maximum reflectance of receiver

Reflections from the receiver back into the DWDM link are specified by the maximum permissible reflectance of the receiver measured at the receiver.