Application Note 034 – Comparison of Optical and RF Splitters for Multi-Point Distribution

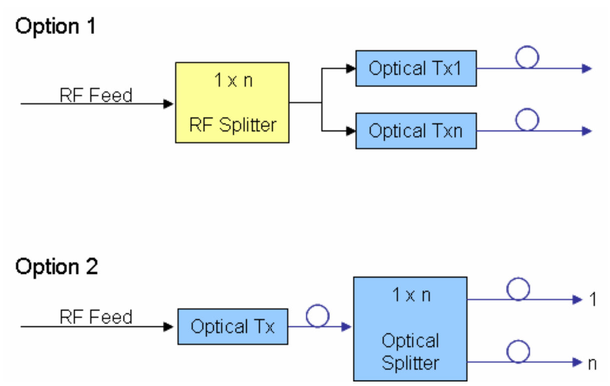
This document compares the effect on the performance of an analogue fibre optic link of splitting (or combining) a signal for distribution to more than one optical receiver.

Introduction

Splitting signals that are carried by fibre optic links may be implemented in one of two ways (figure 1):-

1. In the electrical domain, while the signal is still RF (i.e. over copper), prior to the optical transmitter (i.e. before RF to optical conversion occurs), or;
2. After the signal has been converted to the optical domain, which would be immediately following the optical transmitter.

Figure 1



The use of optical splitters for distributing a signal to more than one optical receiver (for example in DVB-T services) can degrade the overall RF performance of the analogue fibre optic link. However, it does offer the advantage of a reduction in the number and therefore cost of optical transmitters. Conversely, the use of RF splitters for distributing a signal from a single source to multiple destinations offers a significant performance advantage over the use of optical splitters.

Optical Signal Splitting

Optical splitters are available in a number of split ratios. They are characterised by the inherent loss associated with the split ratio (10logN), added to an excess loss that depends on the design and construction of the splitter. The optical splitters themselves are very compact – typically 65mm x 15mm x 15mm. In the following examples, split ratios of 1:2 up to 1:16 are examined and compared with a straight-through 1:1 system. The optical losses quoted are typical of readily available optical splitters.

In table 1 the effect on a typical fibre optic link of losses associated with typical splitters is shown.

Table 1

Optical Splitter Losses

Split Ratio	Optical Loss (dB)	Link Gain (dB)	Link Noise Figure (dB)	Link Input P1dB (dBm)
1:1	0	0	25	0
1:2	4	-8	30	0
1:4	7	-14	35	0
1:8	11	-22	43	0
1:16	15	-30	51	0

Clearly, the link gain and noise figure are affected by the optical loss. The link gain may be compensated for by the use of a post-amplifier at the optical receiver output. The post amplifier effectively compensates for the degradation in link gain due to the optical losses. However, there are still significant degradations in the link noise. This situation may be improved by the use of a pre-amplifier at the input of the optical transmitter, as shown in table 2.

Table 2

Noise Figure Reduction of a Distributed Network

Split Ratio	Optical Loss (dB)	Link Gain (dB)	Link Noise Figure (dB)	Link Input P1dB (dBm)
1:1	0	0	25	0
1:2	4	0	22	-8
1:4	7	0	21	-14
1:8	11	0	21	-22
1:16	15	0	21	-30

However, it is now evident that the input P1dB (and hence IP3) of the link degrades as the gain of the transmitter pre-amplifier is increased.

Finally, as shown in table 3, a compromise may be made, by sharing the required gain increase between the optical transmitter and the optical receiver. In this particular example, the required gain increases (to compensate for optical path losses) are equally shared between the transmitter and receiver. Depending on whether there is margin within either the noise figure or the linearity in a particular system, the gain balance between transmitter and receiver may be altered.

Table 3

Optimising Gain of a Distributed Network Using Pre- and Post Fibre Optic Link Amplification

Split Ratio	Optical Loss (dB)	Link Gain (dB)	Link Noise Figure (dB)	Link Input P1dB (dBm)
1:1	0	0	25	0
1:2	4	0	26	-4
1:4	7	0	28	-7
1:8	11	0	32	-11
1:16	15	0	36	-15

RF Signal Splitting

Alternatively, RF signal splitting could be undertaken prior to the input to the optical transmitter. The RF splitter insertion loss may be compensated for by increasing the optical transmitter gain. This would ensure that end-to-end gain remained at 0dB. Here we make a distinction between reactive RF and resistive RF splitting. Resistive splitters have approximately twice the loss of reactive splitters, but have a much wider bandwidth.

Table 4 shows the losses for the cases where ***reactive*** RF splitters are used. If ***resistive*** RF splitters are chosen, then in each split ratio case the performance data for the next split ratio should be taken. For example, if a 1:8 ***resistive*** splitter is chosen, use the predicted performance of the 1:16 ***reactive*** splitter.

Table 4

Reactive RF Splitter Loss

Split Ratio	Reactive RF Splitter Insertion Loss (dB)	Link Gain (dB)	Link Noise Figure (dB)	Link Input P1dB (dBm)
1:1	0	0	25	0
1:2	4	0	25	0
1:4	7	0	25	0
1:8	11	0	27	0
1:16	15	0	29	0

Conclusions

When using fibre optic links it is sometimes required to split the signal carried. The systems designer has the choice of splitting either in the optical or RF domain. The technical implications of both of these methods have been outlined. Either optical or RF splitters and combiners are offered as part of the ViaLite product range.

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