Application Note No. 8

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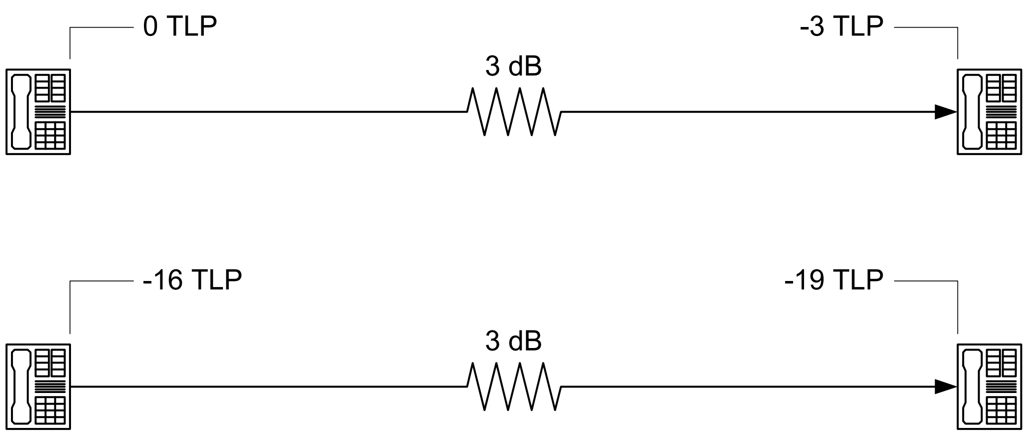
Transmission Level Point

1. Introduction

This application note covers the concept of the Transmission Level Point, or TLP. Another related application note covers the deciBel, or dB, which is fundamental to using Transmission Level Points.[1]

Transmission Level Point, or TLP, is simply one way of representing the gain or loss in a channel in dB. The simple circuits shown in Fig. 1 have 3 dB of loss. Therefore, if the input is at a TLP of 0 dB (stated another way, 0 TLP), then the output is at a TLP of -3 dB. Similarly, if the input is a -16 TLP, then the output is a -19 TLP.

Fig. 1
Basic Concept of the TLP



2. Application of the TLP

When referring to a transmission channel, it is necessary to describe the power of the signal, noise or test tones at a particular point and compare to power at other points

The power present at any point is dependent on the source power and the loss or gain in the channel. In Fig. 2, the input power (on the left) is -10 dBm. After passing through the 1.5 dB attenuator, the power level is -11.5 dBm. Similarly, the power level at each point depends on the total gain or loss from the input point to the point of measurement.

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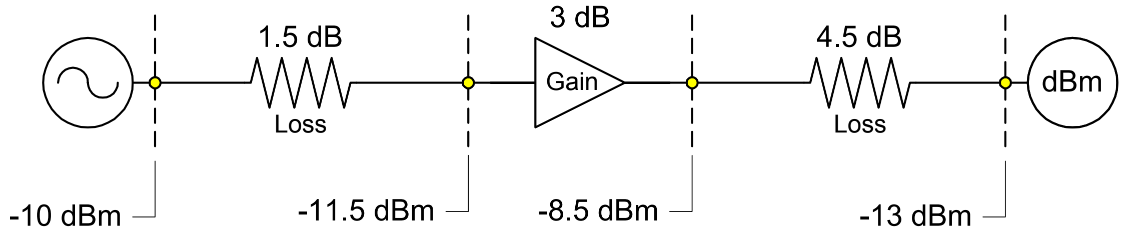
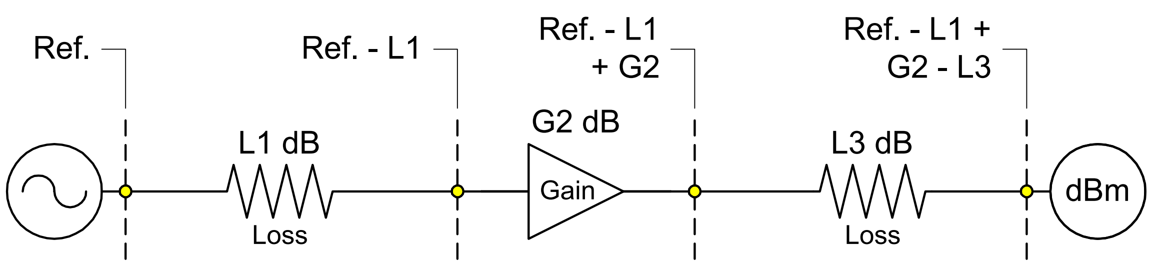
[1] See Application Note No. 7, *The DeciBel.*

Fig. 2
Circuit Losses and Gains



Since the source power level and loss or gain are not always available, it is convenient to describe the power at a measurement point by relating it to some standard reference point. In Fig. 3, which is similar to Fig. 2, the input point on the left is labeled as a Reference. The first attenuator has a loss, L1. Therefore, at the point after the attenuator, the power level is Reference level minus L1. A gain block also is shown in this illustration. The measured power at the point immediately after the gain block is Reference level minus L1 plus G2, where G2 is the gain, in dB, of the gain block.

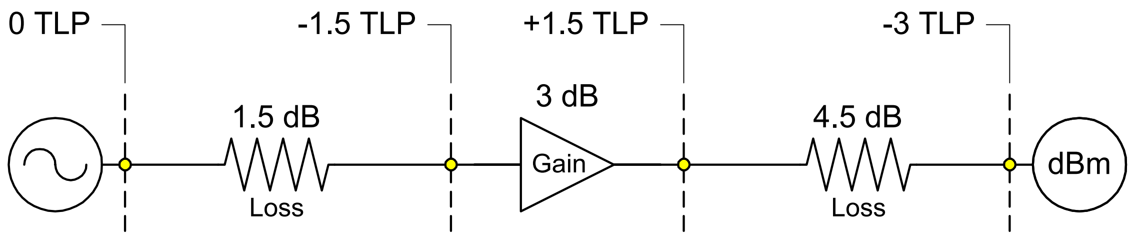
Fig. 3
Use of a Reference



The standard reference point is called the Zero Transmission Level Point, or 0 TLP. A convenient physical location for 0 TLP is not always available (nor necessary). It simply is some predefined, sometimes arbitrary, point. In an end office switching system, the reference point, or 0 TLP, is the center of the switch, which is physically inaccessible. The 0 TLP can be defined at any, arbitrary, point in a circuit that is convenient for the tests to be performed.

A given physical point in a circuit may have different transmit and receive TLPs. For example, in Fig. 4, the input on the left is defined as the 0 TLP. Therefore, the transmit TLP is 0 dB. At the right, the circuit output, or receive, has a TLP of -3 dB. If the signal generator is moved to the right and assuming the circuit is bi-directional and symmetrical, the transmit TLP at this point could be defined as 0 dB. Therefore, either end of this particular bi-directional circuit has a 0 dB transmit TLP and -3 dB receive TLP. A twisted metallic cable pair with 3 dB of loss is an example of a bi-directional and symmetrical circuit. Such a circuit could be defined to have 0 dB transmit TLP at each end. Then, each end would have a -3 dB receive TLP.

Fig. 4
0 TLP as the Reference

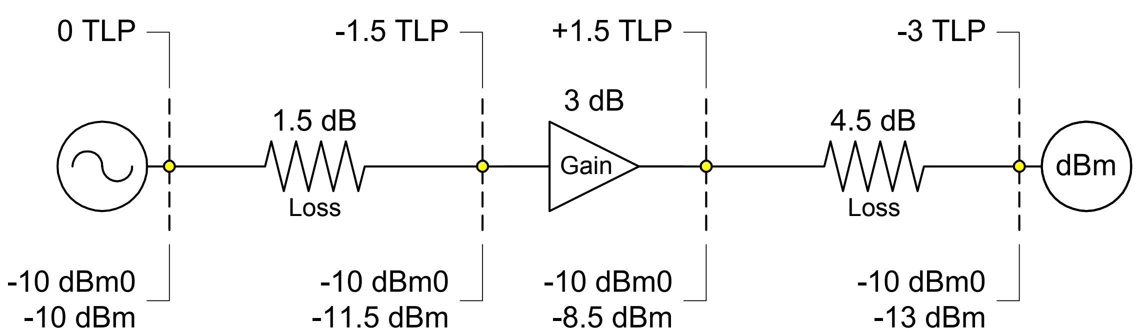


For convenience, the input, or transmit, TLP of a line circuit in an end office switching system is considered to be at 0 TLP. The output, or receive, TLP of the same line circuit will depend on the type of call. For example, a call terminating on the line circuit from an interexchange carrier will be at a -6 TLP and from another end office within 200 miles area will be at a -3 TLP.[2]

Once the 0 TLP is established, it is possible to describe the power present anywhere in a channel by stating what this power would be if it was measured at the 0 TLP. The notation used to indicate the power with respect to the 0 TLP is dBm0.

> Example:
>
> -10 dBm0 means the power at the 0 TLP is -10 dBm. In Fig. 5, a signal level of -10 dBm is applied at a 0 TLP. The signal level, with respect to the 0 TLP, is -10 dBm0. After passing through the 1.5 dB attenuator, the power level is -11.5 dBm. However, the power level referred to the 0 TLP is still -10 dBm0. In fact, the power level referred to the 0 TLP, in dBm0, is the same everywhere in the circuit, regardless of circuit losses, gains or TLP.

Fig. 5
Using dBm0 to Represent Signal Level



Once the power at the 0 TLP is described, it is easy to describe the power (from the same source) at any other point in the channel. If the signal power is X dBm at the 0 TLP, it is X dB above (if X is +) or below (if X is -) the numeric value of any TLP on the channel when measured at that TLP. It is important to remember that dB is implied in the transmission level point. For example, the

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[2] These TLPs are described in the Fixed Loss Plan applicable to North America.

statement that the receive TLP at point X is -3 means that the receive level is 3 dB lower than the 0 TLP.

A simple formula to remember is:

TLP = dBm - dBm0

Example:

If a signal is specified as -13 dBm0 at a particular point and - 6 dBm is measured at that point, the TLP is

TLP = -6 dBm - (-13 dBm0) = +7 TLP

Example:

If a signal is -13 dBm at the 0 TLP (-13 dBm0), then at the +7 TLP the signal level in dBm is

(+7 TLP) + (-13 dBm0) = -6 dBm

Example:

A -13 dBm0 signal measured at the -16 TLP is

(-16 TLP) + (-13 dBm0) = -29 dBm

It is important to remember that the numeric value of the TLP does not describe the power present at that point. To know the power present at a given TLP, it is necessary to know the power present at some other TLP in the channel. Once the power is known at one TLP, it can be determined at any other TLP.

Example:

If a -29 dBm signal is measured at a -16 TLP, the signal level referred to the 0 TLP is

(-29 dBm) - (-16 TLP) = -13 dBm0

The power at the -16 TLP is 16 dB lower than the power at the 0 TLP. In this example, the power at the 0 TLP is -13 dBm and the power at the -16 TLP is -29 dBm.

The use of the 0 TLP reference allows transmission objectives and measurements to be stated independent of any specific TLP. That is, a separate set of objectives are not required for each TLP encountered in the field.

TLP applies to noise levels as well as signal levels. The same TLP is used for both signal and noise measurements. Therefore, when referred to the 0 TLP, noise is given in dBrnC0. The values in dBrnC0 are the values published in industry standards. They may be converted to actual measured values at any TLP by making use of the following expression:

TLP = dBrnC - dBrnC0

Example:

Say the impulse noise threshold objective is 71 dBrnC0. For measurements at a -3 TLP receive terminal, -3 dB should be added to the objective (in dBrnC0) to determine the absolute threshold in dBrnC, or

(71 dBrnC0) + (-3 TLP) = 68 dBrnC

For measurements at a +7 TLP, 7 dB should be added to the objective, or

(71 dBrnC0) + (+7 TLP) = 78 dBrnC

The TLP at the MOD IN jack of an analog carrier transmission system always is -16 TLP and the DEMOD OUT jack always is +7 TLP. Although these TLPs originally were developed for analog carrier transmission systems, they also apply to any digital carrier transmission system with analog voice frequency channel units that are set to these TLPs.

The standard data test level is -13 dBm0 and the standard voice test level is -16 dBm0. Absolute test levels for data and voice are -29 dBm and -32 dBm at the MOD IN and -6 dBm and -9 dBm at the DEMOD OUT of analog carrier systems or analog channels in digital carrier systems using these TLPs.

0/0 TLP means a circuit has zero gain (loss). If a channel is designed for 0 dB net loss, then the transmit TLP (TLP-T) and receive TLP (TLP-R) are equal and the power levels in dBm and dBm0 are equal. Whatever signal level is injected into the near-end is measured at the same level at the far-end.

Example:

A -13 dBm0 test tone has a measured level of -13 dBm at both ends of the channel. This can be verified from

TLP = dBm - dBm0, or

0 dB = -13 dBm - (-13 dBm0)

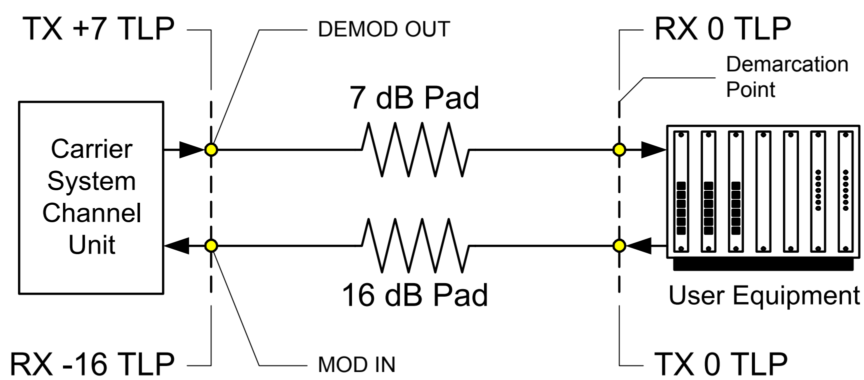
A 0/0 TLP on a channel consisting only of twisted pair cable requires gain devices to compensate for the loss inherent to outside plant cabling and office wiring. When a 0/0 TLP is derived from a carrier transmission system having -16/+7 TLP, loss pads are required to adjust the TLP.

Example:

The carrier DEMOD OUT is +7 TLP, so a 7 dB loss pad is required for a 0 TLP-R

The carrier MOD IN normally is -16 TLP, so a 16 dB loss pad is required to reduce the 0 TLP-T to a -16 TLP at the carrier system. See Fig. 6.

Fig. 6
Carrier Transmission System TLPs



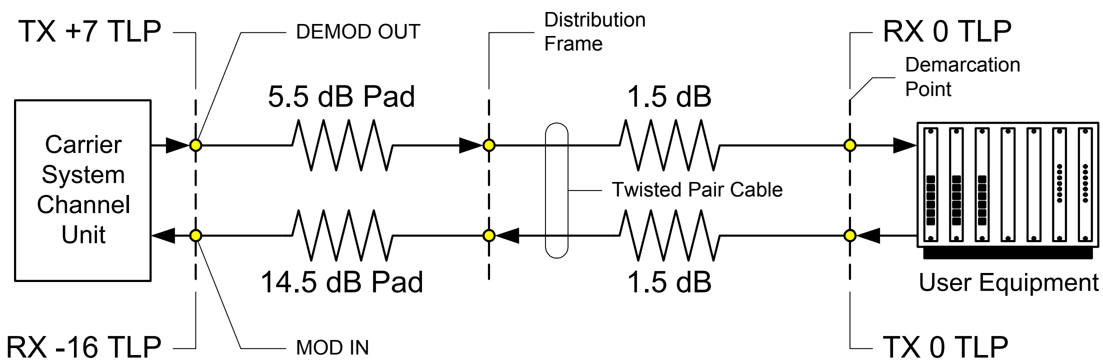
If there are cable losses between the input/output of the carrier system and the point at which the 0/0 TLP is required, the pad values must be adjusted to compensate for these losses.

<u>Example</u>:

Cable losses are 1.5 dB as shown in the illustration below. The receive pad would be adjusted from 7 dB to 5.5 dB and the transmit pad from 16 dB to 14.5 dB to compensate for the cable loss as shown in Fig. 7.

Note that the Transmission Level Point at the input to the twisted pair cable at the distribution frame would be at +1.5 TLP in this example. Normally, the input to twisted pair exchange cables is limited to 0 TLP for analog circuits to minimize problems due to crosstalk. Positive TLPs are used only after consideration of their effects. In an actual circuit, the pad would be set to 7 dB at the DEMOD OUT. This would provide a more suitable 0 TLP at the input to the cable pair. However, a gain device (such as a Data Station Termination, or DST) would be required at the demarcation point to deliver the required 0 TLP to that point.

Fig. 7
Compensating for Circuit Losses to Deliver 0/0 TLP



All digital loop carrier transmission systems, multiplexers and channel banks have adjustable pads and amplifiers in the analog channel units that allow adjusting the TLP to any practical desired value.

For digital applications, a Digital Reference Signal (DRS) is used to establish an analog TLP reference. The Zero Decode Level Point (0 DLP) is a point at which the DRS would be decoded into an analog 1013 Hz sinewave of 0 dBm.

Although the above discussion focused on the application of TLP to analog voice frequency circuits or channels, the same concept can be applied to digital transmission circuits or channels. However, industry practice does not use digital TLPs to any meaningful extent.

The TLP concept is still useful with digital transmission systems. Most digital systems carry digitally encoded analog voice frequency signals, and the TLP concept is most naturally applied to this signal before it is encoded or after it is decoded. If the digital system does not alter the encoded signal in any way, say by use of digital attenuators (pads) or digital signal processing (DSP), the TLP of the encoded analog signal is the same everywhere in the digital channel regardless of the level of the digital signal itself. Alteration by digital pads would change the TLP, as one would expect. Alteration by DSP possibly would change the TLP depending on what is accomplished by the processing.

3. References

[1] Reeve, W., Subscriber Loop Signaling and Transmission Handbook: Analog, IEEE Press, 1992.

Availability: IEEE Press books are available from IEEE Press by calling 1+800-678-IEEE.

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