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User Guide

OE325



LeCroy

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Application

The OE325 is a -35 dBm (300 nW) to 0 dBm (1 mW) optical probe, with a single-mode fiber light input. It is specifically designed for the measurement of telecommunication signals based on modulated 1310 nm-wavelength light. It is a straightforward plug-in probe that is compatible with all LeCroy instruments equipped with the ProBus™ intelligent probe interface. DC, AC, and impulse light intensities can be measured, with the oscilloscope automatically handling the conversion of units to Watts on the display, and when cursor or parameter measurements are being made.

Application as Optical Reference Receiver

It is, in addition, possible to filter the optical signal in a precise way, in accordance with ITU-T G.957 specifications, so that the scope and probe chain will constitute an Optical Reference Receiver as per Annex B of G.957. However, this capability is only present for a specific channel of a specific scope for which the probe is calibrated, and the vertical scale and sampling rate are limited. The vertical scale setting has to be between 0.7 mW/div and 0.01 mW/div. The sampling rate has to be either 4 GS/s or 8 GS/s. The list of scopes for which a OE325 will provide Optical Reference Receiver capability is currently LC564, LC584, and DDA-120.

Note that if you use the filter outside of the mask testing custom application, you should only use the filtered output after the first (complete) filtered transition, before that it might be different than reality due to lack of data before the start of the aquisition.

Quantity of Light

It must be understood that what the scope displays is actually the voltage resulting from the conversion of the light signal by an optical-to-electrical converter. The efficiency of this conversion (V/W) depends on the wavelength of the incident light. Furthermore, the space and angular distribution at the output of an optical fiber can vary considerably, depending, among other factors, on the characteristics of the light source. The probe is calibrated for light propagating in the single mode of a single-mode fiber, and for a wavelength of 1310 nm.

When using other sources of light, the power of the light, as displayed by the scope, has to be divided by the wavelength-dependent response factor, which amounts to typically about 1.15 at 1550 nm, and about 0.02 at 820 nm, to represent the actual power. In addition, the power actually present at the end of a fiber will be larger than what the scope displays if the fiber carries "multi-mode" signals, since only the "single-mode" energy is measured.

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Another factor affecting the measurement of power is the insertion loss of cables chained between the light source and the probe. Each optical connection will typically cost between 0.3 and 0.5 dB (7% to 12%) in terms of the light output. Probe users are reminded that the scope is calibrated in terms of light at the probe FC connector.

Measurements of Small Amounts of Light

Through "Enhanced Resolution" and "Averaging" mathematical functions, it is possible to measure very small signals that represent minute amounts of light. The offsets generated by temperature changes can become significant. If the absolute amount of light is to be measured, frequent scope re-calibrations should be planned, or temperature variations should be minimized. If the amplitude of a light modulation is to be measured, this is not critical.

Probe Informative Text

The probe provides Optical Reference Receiver characteristics for only one channel of one scope. This "matched channel" is indicated by a number combining the model, serial number, and channel number of the channel for which the accurate calibration has been done. The Matched Channel information can be read out by the "PRIT" remote command. It can also be read on the back side.

Optical Reference Receiver Background Information

An Optical Reference Receiver has a filter that implements the transfer function:

$$\frac{105}{105+105y+45y^2+10y^3+y^4}$$

where y is defined as $2.114\times\frac{2\Pi f}{2\Pi f_r}i$

f_r is the reference frequency, chosen as $0.75f_0$, and f_0 is the bit rate (either 622.08 MHz for OC12 or 155.52 MHz for OC3).

The form of the transfer function is the inverse of a Bessel Polynomial (see Krall, H. L. and Fink, O. "A New Class of Orthogonal Polynomials: The Bessel Polynomials." Trans. Amer. Math. Soc. 65, 100-115, 1948). Filters implementing Bessel polynomials as denominators of the transfer function are called Thompson filters–hence the name "Fourth order Thompson-Bessel" for the transfer function.

The order n Bessel polynomial is simply given by the formula:

$$\sum_{k=0}^{n}\times^k\frac{(2n-k)!}{2^{n-k}k!(n-k)!}$$

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The factor 2.1140 simply ensures that the norm squared of the transfer function reaches $^1/_2$ (the "-3 dB point") at the reference frequency.

The main property of the Bessel-Thompson filter is a minimal group delay distortion. The group delay is defined by the derivative of the phase delay with respect to the frequency of an input sine wave. When quoted in "UI" (as in annex B), this time, the group delay, is normalized to the bit rate's period. The group delay of the fourth-order Bessel Thompson filter at low frequencies is:

$$2.1140/(1.5\pi f_0) = 0.4486/f_0$$

The group delay diminishes monotonically, reaching 0.1512 UI at a frequency of two times the bit rate. The difference between the group delay at zero frequency and the group delay at a given frequency is called the group delay distortion and this is what is shown in the fourth column of table B.1 of annex B.

The conformity of the response to the specifications for the combination of the probe and the scope channel is checked in detail on a clean optical impulse at the factory.

Important note: if the scope channel is factory re-calibrated, it is thus advisable to request a recalibration of the optical probe at the same time.

SPECIFICATIONS

O/E CONVERTER CHARACTERISTICS

System Bandwidth (without Optical Reference Receiver Filtering): DC to 900 MHz (min)
Detector: InGaAs PIN photodiode
Wavelength Coverage: 950-1600 nm. Strongly reduced response 800-950 nm. Response vanishes at 1600-1650 nm.
Probe Bandwidth: 1.5 GHz (min)
Risetime (without Optical Reference Receiver Filtering): 500 ps (max)
Conversion Gain: 500 V/W (min), 600 V/W (typical)
Dynamic Range: -35 dBm to 0 dBm. Optimal operation between -35 dBm and -30 dBm will require attention limiting temperature changes during the measurement or insuring frequent re-calibrations.
Maximum Power Rating: Do not expose the photodiode to light power in excess of 5 mW.
Sensitivity: The mean launched power that would result in a less than 10^{-10} Bit Error Rate is −22 dBm (max), -26 dBm (typical).

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General Characteristics

Operating Temperature: 0° C to 50° C.
Optical Reference Receiver characteristics are provided over 15° C to 35° C ambient temperature.
Weight: 85 gr
Operating Altitude: 6000 m (max)
Relative Humidity: 85% (max), non-condensing
Warranty: Three years
Calibration: Certificate supplied. Check plots for Optical Reference Receiver available on demand.

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