Return loss measurement of fiber optic components

Solutions Brief 815-1

How the HP 8153A/HP 81534A measure return loss of fiber optic components?

The significance of return loss

The introduction of new technologies in optical transmission systems has created the need to adapt measurement techniques for component characterization.

In particular, this has been the case since the introduction of single-mode fiber to optical high-speed transmission systems. Special lasers with narrow linewidth have to be used for the transmission (these are known as Distributed Feedback Lasers DFBs). However, the smaller linewidth the more sensative the laser becomes with regard to backreflections.

If a system component, such as a connector, reflects too much light back to the transmitter, the modulation characteristics and the spectrum of the laser change. High-speed systems usually contain many components, hence there is a real danger that multiple reflections will lead to signal distortion and consequently to system failure.

In order to ensure the reliable performance of a system it is vital that all optical components are characterized, such as connectors, couplers, switches and detectors. In doing so it is especially important to measure how much light they will reflect back into the fiber. The parameter which quantifies this characteristic is called return loss.

In fiber optics, it is common to show optical signals, such as back reflections on a logarithmic scale. The ratio of the input power level and the power reflected by a component under test yields the return loss. High return loss values characterize components with minimum backreflections. These are most suitable for high speed transmission systems. Thus, to optimize the characteristics of optical components it is necessary to know how to measure return loss precisely.

The following will first give a description of how return loss measurements are performed and will then provide a dedicated HP solution.

Design of a return loss test setup

With increasing bit rates in high speed optical transmission systems there is more and more pressure to minimize backreflections from connectors and other system components. The following questions should be considered:

1) What return loss values of components are needed to meet the requirements of state-of-the-art transmission systems?

2) What is the measurement range we have to look at?

Straight contact connectors provide highly polished glass-to-glass connections which yield a return loss of between 30dB and 45dB. These return loss values are sufficient for digital transmission rates of up to 2.4 Gbit/s. Beyond this transmission rate and also for analog cable TV applications connectors with return loss values better than (larger than) 60dB may be required. These values can only be achieved using angled connectors. Their slanted finish at the fiber end forces backreflections to hit the cladding rather than being coupled back into the fiber core.

Because of this the test setup must be capable of measuring return loss values accurately at or beyond 60dB.

In order to perform return loss measurements on a device under test the test setup must consist of a laser source, a fiber optic coupler, and a detector (see Figure 1).

Configuring the HP 8153A multimeter with the HP 81534A return loss module and one of the laser source modules provides you with a complete solution in one single instrument. Additionally, built-in application software supports the return loss measurement.

Criteria for accurate return loss measurements

To achieve and ensure accurate measurements of return loss values better than 60dB several conditions have to be met:

Firstly, the output power of the laser source has to be highly stable as any power fluctuations will directly add to the measurement uncertainties.

Secondly, the laser source output power and the receiver sensitivity must offer enough dynamic range to keep the return loss signal well above the noise level and to display it with resolution good enough even for high return loss values.

Thirdly, the photodetector and the amplification circuits must show good linearity over all measurement ranges as linearity errors contribute directly to measurement uncertainty.

Movements of the fiber in the test setup change the polarization of the light signal. If the coupler which is used in the test setup shows polarization dependence a change in polarization will cause a changing coupling ratio. This results in a fluctuation of the return loss reading. So in order to optimize the test setup it is very important to use a coupler with a minimal polarization dependence.

Finally, unwanted contributions to the measurement results called parasitic reflections - should also be considered (see below).

All these requirements were taken into account when the HP 81534A return loss module was designed to meet highest performance expectations.

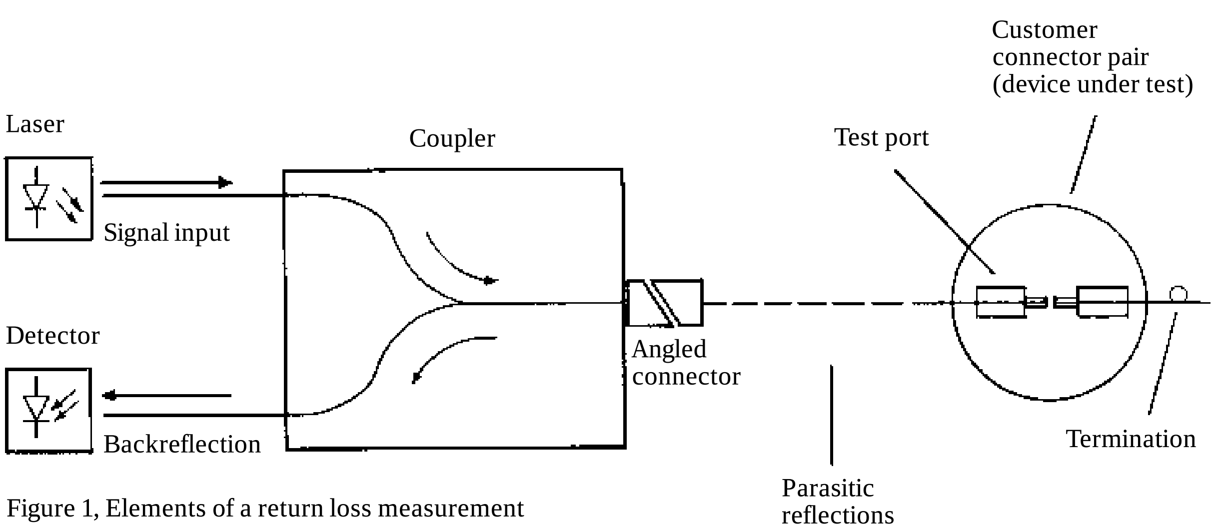

Figure 1, Elements of a return loss measurement

How to perform return loss measurements using the HP 8153A multimeter with the HP 81534 a return loss module?

In order to determine the return loss of a device under test three power levels have to be measured:

- the power of the backreflection of a known reference reflector attached to the test port (reference measurement)

- the power of the backreflections caused by parasitic reflections of the test setup itself

- the power of the backreflections when the device under test is attached to the test port

The following paragraphs describe and explain the entire measurement procedure in greater detail (see Figure 2).

1) The HP 81000BR is the accessory used to calibrate the setup for return loss measurements. It provides a stable 96% reflection with only 2% uncertainty. An open connector is not a good reference, because its return loss may vary more than ldB (25%) of the 14.6dB reflection, due to the influence of the polishing process.

The HP 81000BR reflector has to be attached to the return loss module at the test port, as seen in Figure 2. Then, the appropriate reference value (0.18dB for the HP 81000BR/ 14.6dB when a cleaved fiber is used as a reference) has to be entered as PARAM R by pressing DISP to REF.

2) For the most accurate measurements all additional backreflections caused by the fiber cable or a patchcord in the test set up (called
parasitic reflections) must be eliminated. This can be done by terminating the cable close to the front of the test port. Termination can be achieved by bending the fiber into several tight fiber loops. Again, a measurement is made and this value has to be stored as PARAM T by pressing DISP to REF.

3) Finally, the device under test can be connected to the test port. The return loss value of the device under test is automatically calculated and shown on the display.

If the device under test is a pigtailed component, then the test port of the return loss module must also be a bare fiber (Option 001). To calibrate this setup, the bare fiber end of the return loss module can be cleaved to provide a 14.6dB reflection. A cleaved fiber end is a precise, repeatable reference for return loss measurements on pig-tailed components. A pigtail output extends the measurement range from > 60dB to 65dB (Option 001). The measurement procedure remains the same.

To save time during testing and to minimize errors, recalibration should only be repeated if the setup is physically altered i.e. if a patchcord is removed or exchanged.

For more information on return

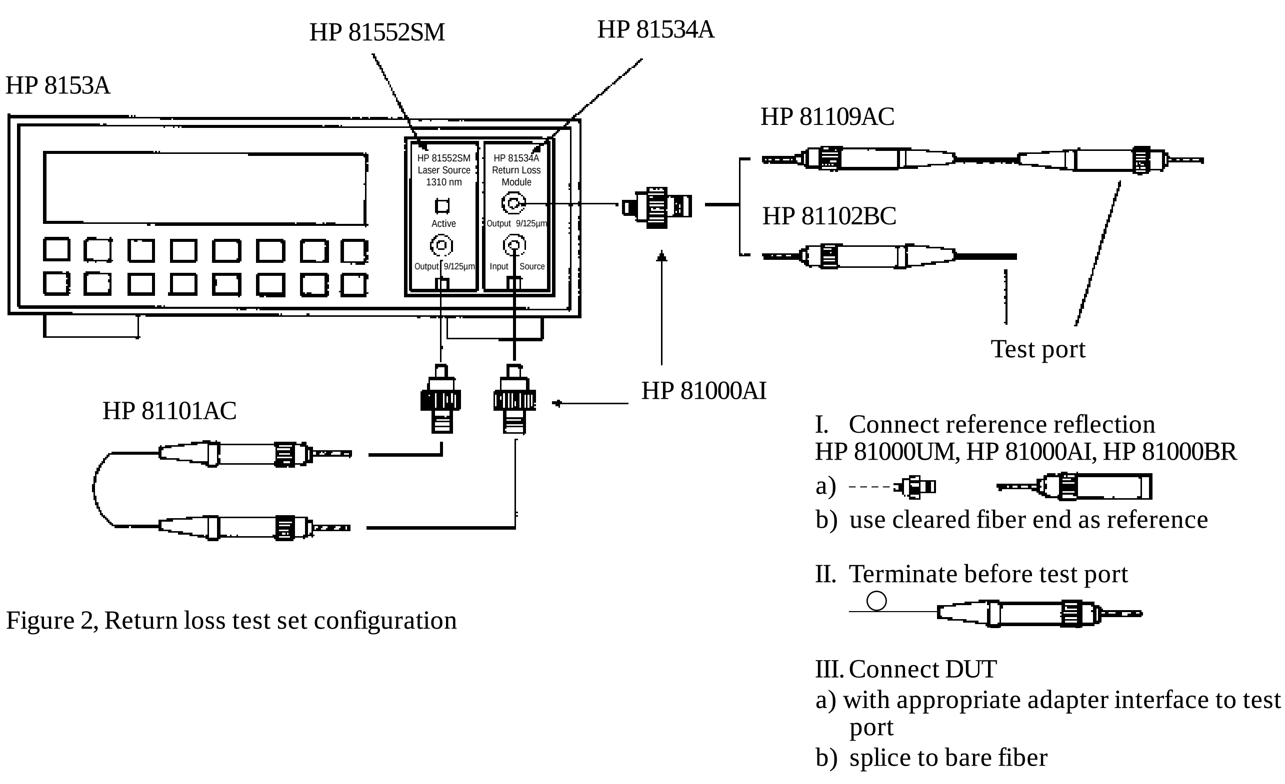

Figure 2, Return loss test set configuration

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