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Part 1: The Six Subtleties of Accurate Singlemode Testing

I have observed some problems that occur when installers perform insertion loss testing of singlemode jumpers (aka, patch cords) and links. While investigating these problems, I identified six subtle, and critical steps which the tester must take. If the tester takes these steps, he will obtain the most accurate and the most repeatable singlemode loss measurements possible.

These six steps are:

qualify the reference leads

use singlemode barrels, not singlemode / multimode barrels

determine the directional effect of the barrels and use the barrels in their optimum directions

use a laser diode light source

clean, clean and re-clean

make multiple measurements for ST-compatible connectors

<u>Step 1: Qualify the Reference Leads</u> Regardless of whether you test according to Method A or Method B of TIA/EIA-526-14, you must have low loss connectors on your reference leads. Otherwise, all your test results will be higher than reality and you risk rejecting jumpers or links which are acceptable. You verify low loss connectors on your reference leads by qualifying those leads.

This qualification is simple, but a bit time consuming. See Figures 1 and 2 for the procedure. You will need two test leads, which we will label A and B. To qualify these two test leads, you will need to test each of these four connectors on the two reference leads against the other three. This testing must be done in both directions, since connectors do exhibit different losses on opposite directions (the directional effect). If all of the tests, x1...x8, produce values which are higher values than -0.50 dB (e.g., -0.35 dB), you can use these two leads as reference leads. The fact that you are qualifying two leads against each other means that reference leads are matched pairs. If one lead is damaged, you must requalify a potential new reference lead against the remaining good reference lead.

This qualification value of 0.50 dB is an arbitrary number, based on the field experiences of my associates and myself. If you use a qualification value worse than -0.50 dB, like -0.70 dB, you are likely to reject jumpers and links which are good, an undesirable decision.

If you use a qualification value better than -0.50 dB, like -0.30 dB, you will find yourself rejecting potentially good reference leads which will provide accurate loss measurements.

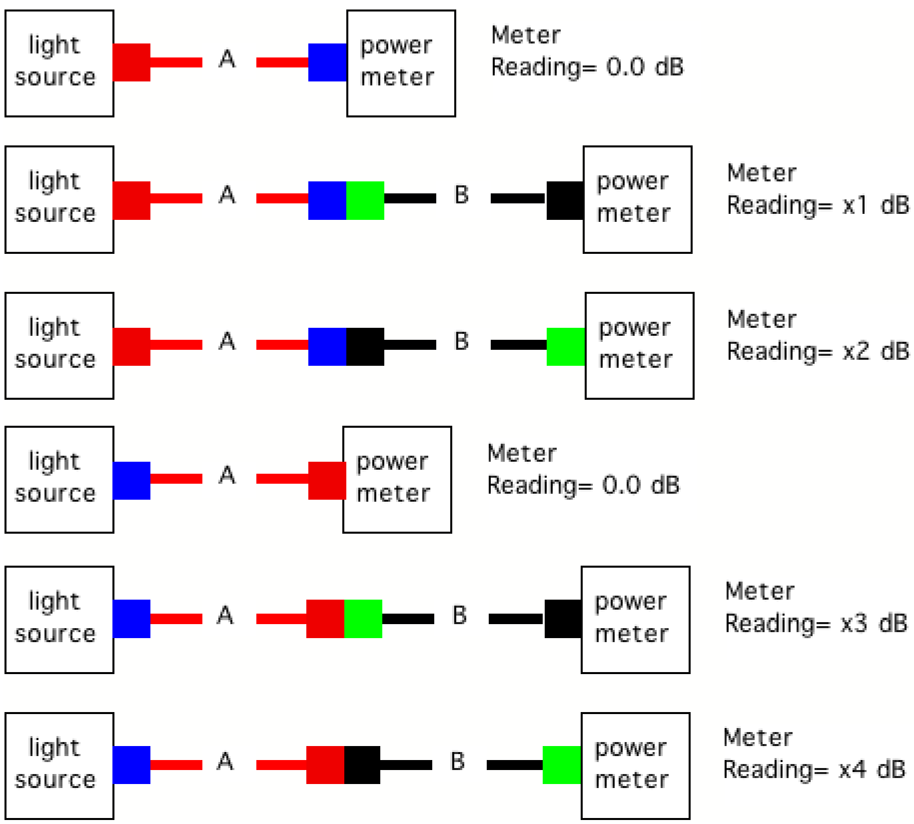

Figure 1: Qualification of Lead B Against Lead A

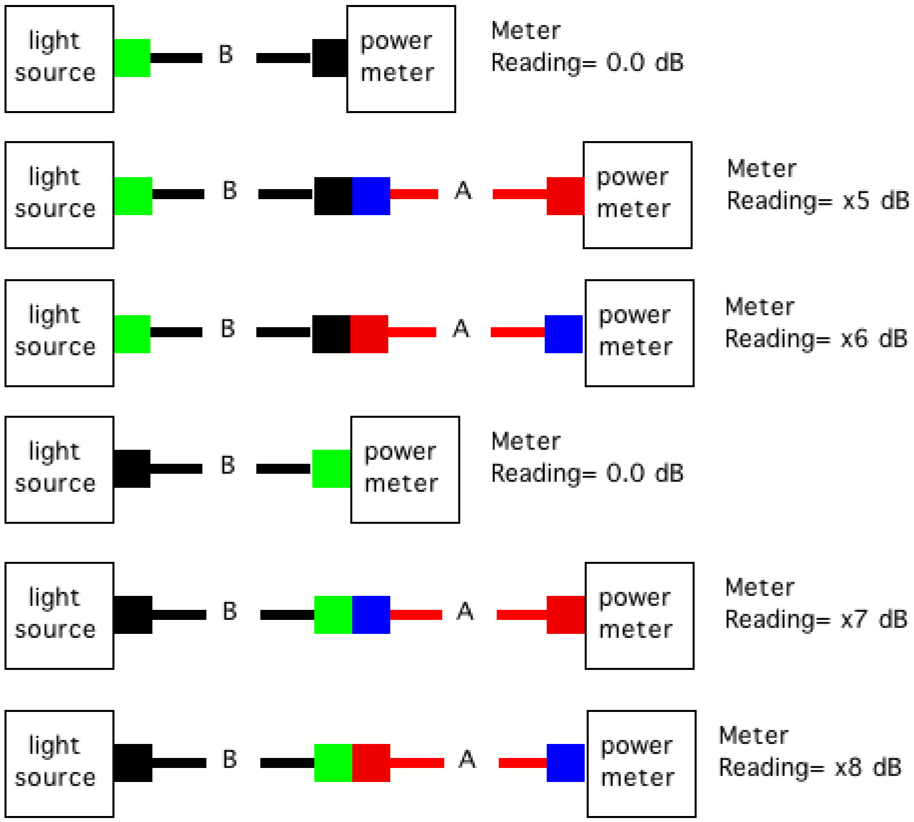

Figure 2: Qualification of Lead A Against Lead B

Recently, we recertified four singlemode reference leads from two of our test kits. The results are in Tables 1 and 2 (in dB). Since all of the values in Table 1 were lower than 0.50 dB, these two reference leads can be used. Since all of the values in Table 2 were not lower than 0.50 dB, these two reference leads can not be used.

Table 1: Qualification Results for Reference Leads 4 and 19

x1	x2	x3	x4	x5	x6	x7	x8
-0.42	-0.04	-0.01	-0.13	-0.21	-0.10	-0.03	-0.34

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Table 2: Qualification Results for Reference Leads 11 and 9

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x1	x2	x3	x4	x5	x6	x7	x8
-0.59	-0.17	-0.67	-0.38	-0.48	-0.28	-0.23	-0.66

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Step 2: Use Singlemode Barrels Three types of barrels are available: multimode, singlemode/multimode, and singlemode. Obviously, you do not want to test singlemode cables with multimode barrels. You might think that singlemode / multimode barrels will work. However, preliminary test results suggest that singlemode barrels will provide lower insertion loss values and better repeatability. All our current and future singlemode testing will be done with barrels designated singlemode.

Step 3: Determine Barrel Directional Effects While it may not be obvious, singlemode barrels do not provide the same loss when the barrel is reversed. There is a small, but significant directional effect. This directional effect becomes significant because it is about the same value of the low loss of singlemode connectors available at this time.

When tested by the procedure in Figure 3, which is called the single end loss test, the singlemode barrels Pearson Technologies uses exhibited the directional effects in Table 4. This table indicates an average directional effect of almost 0.10 dB. While this average may seem small, insertion loss testing by Method A or B of TIA/EIA-526-14 requires two barrels. If both barrels are used in the direction providing the higher loss, then the test results could be biased 0.20 dB higher than reality. For relatively long outdoor links, this bias will be insignificant. However, for short distance indoor links, this bias could cause rejection of properly installed links.

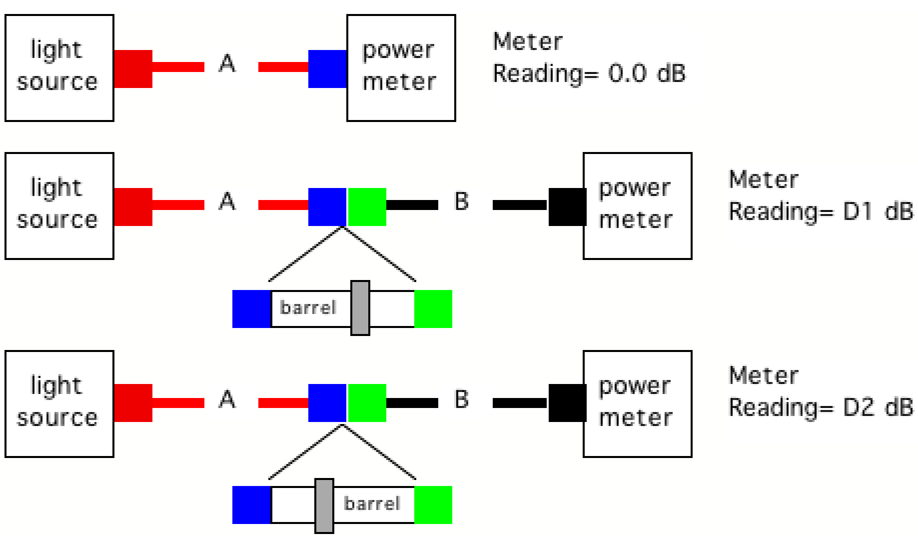

Figure 3: Qualification of Lead A Against Lead B

Table 4: Directional Effects of ST-Compatible Singlemode Barrels

Barrel #	Loss, D1, in dB	Loss, D2, in dB	Directional Effect, in dB
6	-0.15	-0.13	0.02
7	-0.16	-0.23	0.07
8	-0.08	-0.15	0.07
9	-0.20	-0.05	0.15
10	-0.09	-0.20	0.11
11	-0.06	-0.20	0.14
12	-0.03	-0.13	0.10

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Step 4: Use a Laser Source   The goal of insertion loss testing is the simulation of operating conditions. The more closely the testing conditions simulate the operating conditions, the closer the insertion loss values will be to the loss experienced by the transmitter-receiver pair. Such simulation requires use a laser diode light source. While the 1300 nm multimode testing source may seem similar enough to the 1310 nm singlemode source to use the former to test the latter, the similarity is not close enough. Use of a multimode source to test singlemode links can produce loss values which are higher than reality. While such a situation makes for conservative testing conditions, it also can result in rejecting good links due to high loss. We investigated this effect in order to quantify the difference.

We tested singlemode samples by Method A, the two lead method, of TIA/EIA-526-14. We tested the samples with a singlemode, 1310 nm laser source and with a multimode, 1300 nm LED source with the same reference leads. The results are in Table 5. The bold values highlight the general trend of higher loss values from the multimode source than from the singlemode source. Note that the positive loss measurements in Table 5 are an intrinsic problem of Method A and do not represent measurement errors.

Table 5: 1300 nm vs. 1310 nm Loss Values

	Forward loss	Forward loss	Difference,	Reverse loss	Reverse loss	Difference,
Sample	1300	1310	dB	1300	1310	dB
4	-.06	-0.18	+0.12	-0.07	-0.19	+0.12
7	-0.32	-0.03	**-0.29**	-0.26	+0.04	**-0.22**

8	-0.28	-0.05	**-0.23**	-0.05	-0.00	**-0.05**
9	-0.40	-0.40	0.00	-0.56	-0.18	**-0.38**
10	+0.20	+0.19	+0.01	0.00	+0.10	**-0.10**
11	-0.09	+0.43	**-0.52**	-0.19	0	**-0.19**
12	-0.06	-0.01	**-0.05**	-0.13	+0.06	**-0.19**

Step 5: Clean, Clean and Reclean While cleaning is important for low loss multimode connectors, it is critical for singlemode connectors. If not properly cleaned, acceptable low loss, low reflectance connectors can be rejected. Table 6 has examples of the reduction or improvement in loss after cleaning.

Table 6: Insertion Loss Improvement After Cleaning

Loss before cleaning	Loss after cleaning	Improvement, dB
-0.35	-0.07	0.28
-0.40	-0.13	0.27
-0.13	+0.08	0.21
-0.17	-0.01	0.16

Cleaning can be done with acetone or a connector cleaner, such as Electro-Wash Px from Chemtronics (www. Chemtronics.com). We use both, since our informal testing reveals no significant difference between Electro-Wash and acetone.

Many use 98% isopropyl alcohol for cleaning connectors. There is not question that isopropyl is acceptable for cleaning fibers prior to connector installation or to splicing. We have found that this alcohol can be acceptable for cleaning multimode connectors if the connectors are wiped with a dry lens grade tissue immediately after being wiped with a tissue moistened with isopropyl.

However, isopropyl alcohol is consistently unacceptable for cleaning singlemode connectors. It is impossible to achieve both consistent low loss and low reflectance with alcohol as a connector cleaning liquid.

Step 6: Make Multiple Measurements We have observed that singlemode ST-compatible connectors do not always seat fully or immediately. Usually, this behavior is not troublesome for multimode connectors. However, this behavior forces a change in the testing procedure and in an increase in the testing time of singlemode connectors. We present typical results in Table 7. The average for the range values in Table 7 is 0.07 dB.

We have not tested singlemode SC connectors to determine whether they behave in a manner similar to that of the singlemode ST-compatible connectors.

Table 7: Variation of Insertion Loss Values During Range/Repeatability Testing

Sample	Direction	Meas. 1	Meas. 2	Meas. 3	Range, dB
6	forward	0.20	0.20	0.23	0.03
6	reverse	0.23	0.17	0.08	0.15
7	forward	0.12	0.16	0.19	0.07
7	reverse	0.23	0.24	0.22	0.02
8	forward	0.03	0.13	0.07	0.10
8	reverse	0.14	0.12	0.20	0.08
9	forward	0.18	0.18	0.23	0.05
9	reverse	0.09	0.00	0.07	0.09
10	forward	0.07	0.10	0.09	0.03
10	reverse	0.20	0.20	0.20	0.00
11	forward	0.04	0.11	0.04	0.07
11	reverse	0.21	0.18	0.22	0.04
12	forward	0.05	0.00	0.03	0.05
12	reverse	0.13	0.11	0.15	0.04

During some of our recent evaluations, we adopted a procedure for making three measurements for loss of singlemode ST-compatible connectors. We would test according to the following procedure:

install both ST-compatible connectors into a barrel, record the loss,

remove and reinstall one of the connectors, record the loss

remove and reinstall the second connector, record the loss

For the purposes of our testing, we averaged these three losses to simulate the loss which would be obtained from a single measurement.

In summary: singlemode testing requires a significant attention to detail. When you follow the six steps outlined in this article, you will avoid erratic results, excessively high losses and excessive testing time.

Part 2: Unstable Power Measurements?

Do Not Blame the Test Equipment!

If you get unstable power loss measurements, do not blame the test equipment. By unstable, I mean that the power meter is exhibiting significant changes in the power level, even when left connected to the cable system under test. By significant, I mean more than ±0.15 dB. With some test equipment, such as the Fotec products, significant means more than ±0.10 dB.

If you are powering the light source or power meter from a 110 VAC power cube, disconnect the cube and use the internal batteries. If the line power exhibits large variations, these variations may be the cause of your problem.

This July, during a training program in downtown New York City, I experienced this problem in a relatively new skyscraper!

Some locations have dirty power with such a large voltage fluctuations that the voltage delivered to the light source fluctuates beyond the ability of the source to stabilize.

If the line power is not the problem, If operation of the source and meter with batteries exhibits the same problem, replace the batteries. Batteries near the end of their useful life will create the same problem.

My thanks to Dominick Tambone of Crystal Tech for sharing this tip with me several months ago.

Part 3: A Personal Perspective

It is obvious that we are in the worst recession that the fiber optic industry has ever experienced. The other one, 1986-88, occurred when the long distance telephone companies reduced their purchases because they had completed their backbones. Our industry did not have other segments to make up for this lost volume. In that case, all of us in fiber were concerned, but we knew the market would pick up soon, since there were other segments growing to fill the volume.

Today we have a different situation. While I am very concerned about our near term future, I am not concerned for the usual reason of timing of the recovery. I am extremely concerned about the reputation of our industry when the economy recovers. Most companies have laid off many of their personnel, from executives to machine operators. When the recovery occurs, production volumes will increase. Who will sell and make this increased volume?

My concern is that the new, relatively inexperience personnel involved in the processes of selling and manufacturing will make errors. These errors will give our industry a bad reputation. We do not need this. With lack of the correct information, copper biases, beliefs in myths and anti fiber inertia restricting the growth in use of fiber, we do not need the development of a bad reputation.

Already I am seeing some limited, subtle signs of problems with companies, which had been trouble free for the last ten to fifteen years. I am hoping that fiber optic companies recognize and address this potential before it becomes major problem.

A bad reputation is easy to develop, because it takes no effort. But recovering from a bad reputation is often impossible.

Pearson Technologies

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