FUNDAMENTALS OF TELECOMMUNICATION

Lab. 5. Passive Fiber Components

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Introduction

This exercise looks at passive fiber parts like isolators and couplers in telecom systems. We test them to understand how they work and contribute to signal quality in fiber networks.

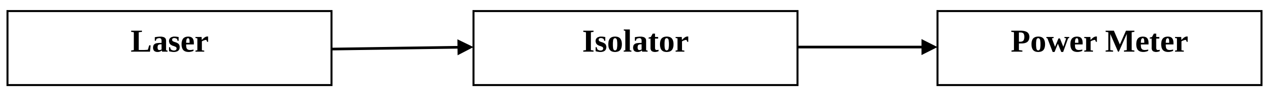
Task 5.2

We measured the optical laser power as: 9.77 mW and 9.9dBm

5.3

We measured the power transmitted, from port 1 to port 2 and from port 2 to port 1

Output port/Input port	1	2
1	x	8.94dBm
2	-47.57	x



We can calculate the insertion loss in this direction:

Insertion Loss = 10log (Pout/Pin) = 10log (-47.57/9.77) = -6.874 dBm

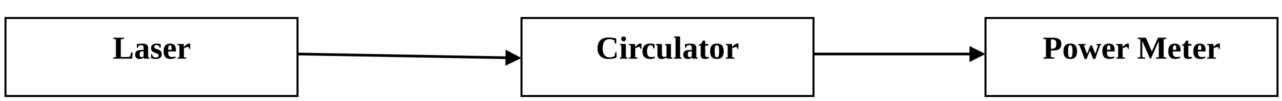
10log (Pout/Pin) = 10log (8.94/9.77) = -0.386 dBm

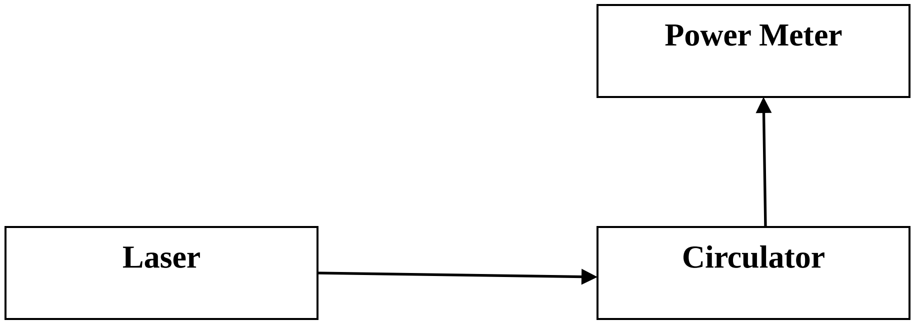
The insertion loss of -0.386 dBm is minimal, indicating that the isolator introduces little attenuation to the signal. Additionally, the isolation of -6.874 dBm effectively prevents signal reflections and reverse propagation. These parameters collectively indicate that the isolator performs well, minimizing signal loss and providing effective isolation between input and output ports.

5.4

Measurements of the power transmitted changing input and output ports.

O/I	**1[dBm]**	**2[dBm]**	**3[dBm]**
1	x	0	0
2	7.55dBm	x	0
3	-42.66	6.59	x





Based on the power levels we observed, it seems that light goes from port 1 to port 2, then from port 2 to port 3. However, it doesn't go directly from port 1 to port 3 or backward from a later port to an earlier one.

5.5

Coupler 1

I/0	1	2	3	4
1	X	0	4.03	7.9
2	0	X	-29.3	-19.95
3	-21.14	3.89	X	0
4	6.72	-0.54	0	X

IL1-2=10log (Pout/Pin) = 10 log (0/9.77) = 0

IL2-3=10log (Pout/Pin) = 10 log (3.89/9.77) = -3.999

IL3-4=10log (Pout/Pin) = 10 log (0/9.77) = 0

Isolation2-1 = 10log (Pout/Pin) = 10 log (0/9.77) = $-\infty$ dBm

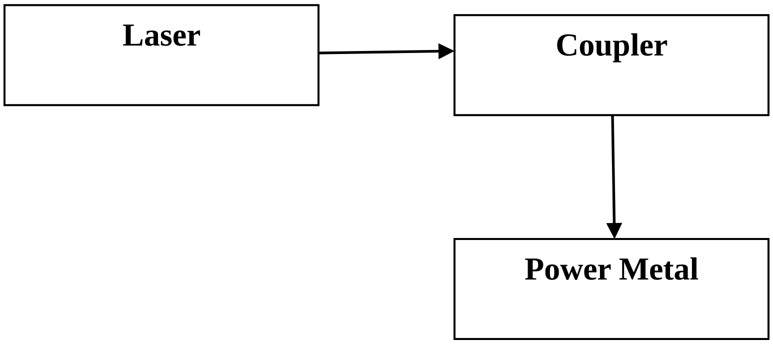
Isolation3-2 = 10 log (Pout/Pin) = 10 log (-29.3/9.77) = -4.77 dBm

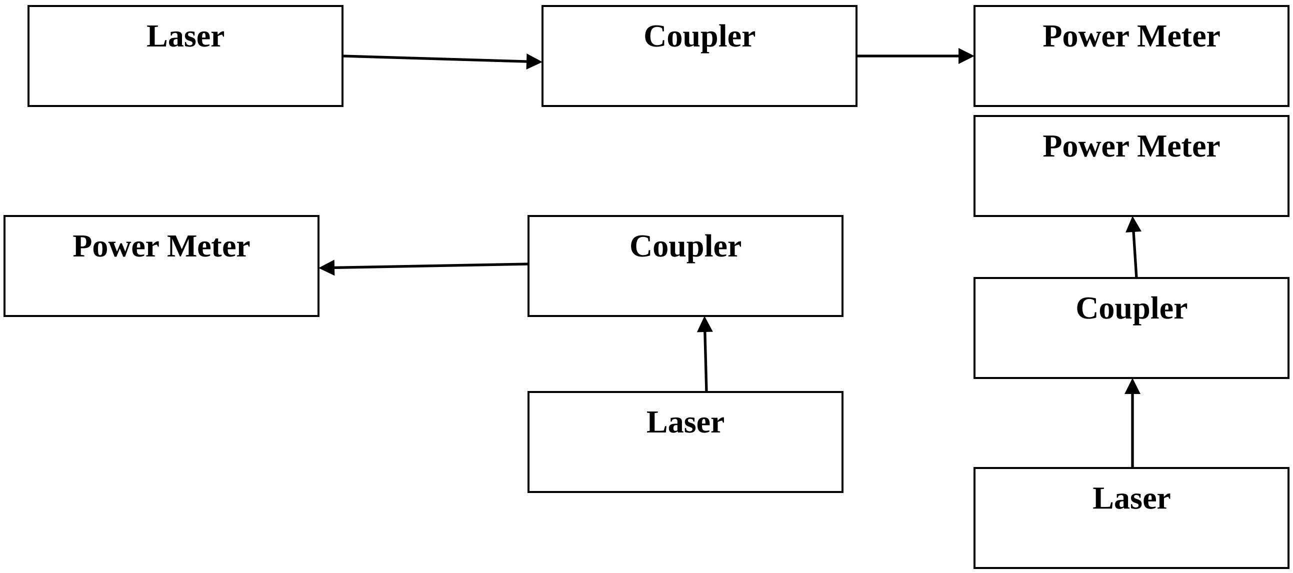
Isolation3-1 = 10 log (Pout/Pin) = 10 log (4.03/9.77) = -3.846 dBm

Isolation4-1 = 10 log (Pout/Pin) = 10 log (7.9/9.77) = -0.923 dBm

Isolation1-4 = 10 log (Pout/Pin) = 10 log (6.72/9.77) = -1.625 dBm

The insertion losses (IL12 and IL23) are low, indicating minimal signal attenuation through the circulator. Complete isolation is ensured between port 2 and port 1, as well as between port 3 and port 1, preventing signal reflections. Although there's slight signal leakage from port 3 to port 2 and from port 1 to port 3, the isolation values remain significant, ensuring effective isolation between most port pairs.





We can calculate the coupling ratios for input port 1:

$CR = P3 / (P3 + P4) * 100\% = 21.14 / (21.14 + 6.72) * 100\% = 75.9\%$

$CR = P4 / (P4+P3) * 100\% = 6.72/ (21.14+6.72) * 100\% = 24.1\%$

And also, for input port 2:

$CR=P3/(P3+P4) *100\% = 0.54 / (3.89 + 0.54) * 100\% = 12.2\%$

$CR=P4/(P4+P3) *100\%= 3.89 / (3.89 + 0.54) * 100\% = 87.8\%$

So, the split ratio of our coupler is approximately 88/12.

Now we can calculate directivity, first when input port is 1:

$\text{Directivity} = -10 \log (P2/P1) = -10\log (0.1 / 9.77) = 19.899$ dBm

And when input port is 2:

$\text{Directivity}= -10 \log (P1/P2) = -10 \log (0.1 / 9.77) = 19.899$ dBm

Finally, we can calculate insertion losses when input port is 1:

$IL1\text{-}2=10\log (Pout/Pin) = 10\log ((21.14 + 6.72) / 9.77) = 4.551$ dBm

And when input port is 2:

IL1-2=10log (Pout/Pin) =10log ((4.61+2.16)/8.57) = -3.435 dBm

5.6

We utilized an optical circulator to gauge the reflection coefficients of APC and PC connectors. This arrangement enabled us to precisely control and measure reflected light, underscoring the circulator's function in reducing signal loss. We noted that reflected light was minimal for both connectors. However, it was even smaller for the APC connector. This is due to the angled surface design in APC connectors, which is engineered to minimize back reflections, enhance signal performance, and improve return loss in fiber optic systems.

APC to PC result -9.05dBm

PC to APC result -14.38dBm

APC to APC result -36.66dBm

5.7

3.69 dBm through circulator

-17.81 dBm through coupler

These measurements were vital for assessing the fiber loop mirror setup's efficiency in our experiment. Once more, we noted very low values of reflected light.

CONCLUSION

In this lab session, we explored standard passive optical fiber components, like fiber couplers, circulators, and isolators, by measuring key parameters such as insertion loss, isolation, and coupling ratio. Fiber couplers split or combine signals in fiber optic systems, while circulators route signals in one direction and prevent reflections, finding use in telecommunications and fiber optic sensors. Isolators are vital for maintaining signal integrity by reducing reflections and safeguarding optical sources, making them essential in optical amplifiers, fiber lasers, and high-speed communication systems. Understanding these components' characteristics and applications is crucial for designing and deploying efficient and reliable fiber optic systems across various industries.