AN146

Analyzing dynamic Fiber Optic Components using the OP740: Optical Switches

Overview

The OP740 can be used to capture dynamic optical signals. In this example the OP740 will be used to monitor the switching behavior of two types of optical switches: mechanical and MEMs based.

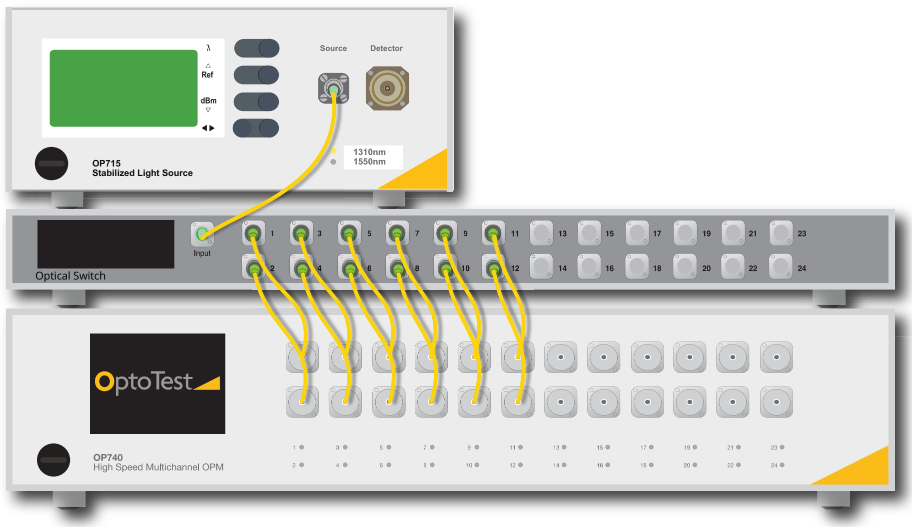

Figure 1: high-speed multichannel Optical Power Meter and two optical switches

Test Setup

To analyze an optical switch, the setup requires an optical source to be routed to the input of the optical switch and all outputs of the switch are routed to the OP740. The OP740 will be used to monitor the switching behavior.

Test Process and Results

Figure 2 shows what occurs when switching channels. When switching from one channel to the next channel, the first channel goes dark and then the channel that is being switched to becomes active for a short time, followed by periods of intermittent light on the destination channel. The switching takes roughly 90 to 100ms to complete.

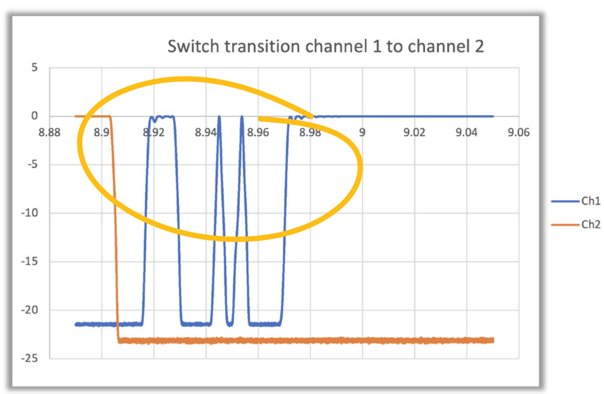

Figure 2: Channel Switch Transitions

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Analysis of Results

To understand what is happening, it is important to look at how mechanical switches are constructed and controlled. Typically, the common port is aligned with the active port. When the switch changes channels, the common port is moved into alignment with the destination channel. The motor driving the switch needs to move quickly to get to the channel. This speed causes the common to overshoot its position, then return to alignment.

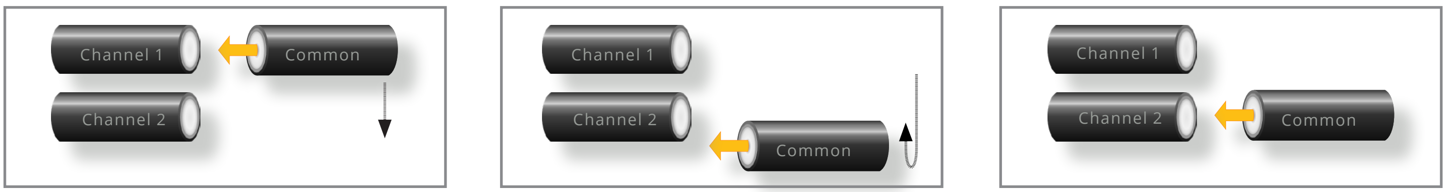

Figure 3: example of common overshooting the correct position and then coming back into alignment.

The overshoot and alignment are shown in the optical signal by the intermittent light on the port. The OP740 captures and accurately represents this dynamic optical signal.

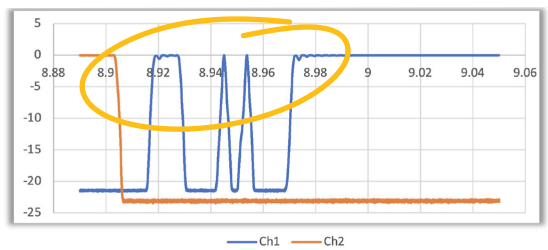

Figure 4: switch transition channel 1 to channel 2

Full Channel Step-Through

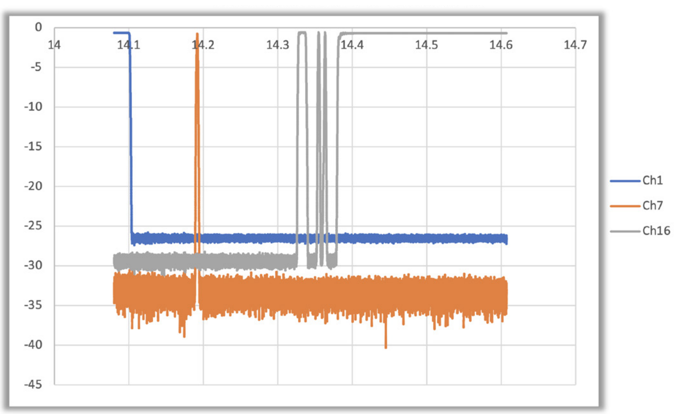

Figure 5: Switch Transition Channel 1 to Channel 16

Now we look at a "worst case" scenario where the 16-channel switch is switched from channel 1 directly to channel 16. Channels 1, 7, and 16 are monitored. The data shows that it takes about 300ms to fully transition from channel 1 to channel 16, but it is also seen that channel 7 briefly lights up. As channel count of the switch increases, the time to get to channels that are far away gradually increases.

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Full Channel Step-Through

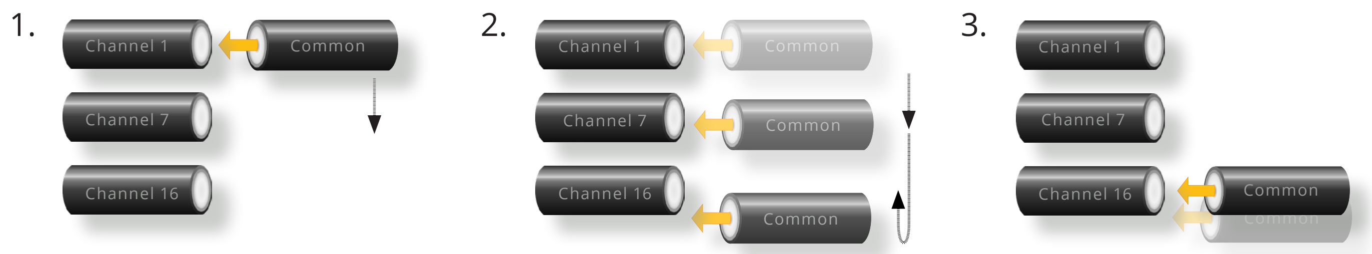

Figure 6: Switch Transition Channel 7 briefly lights up as it is passed going to Channel 16

As the channel changes from 1 to 16, the common port briefly passes by channel 7 on its path to channel 16. This "pass by" causes a brief power spike on channel 7 The high-speed data capture of the OP740 allows the signal to be seen, where sampling at a lower data rate would likely miss this event.

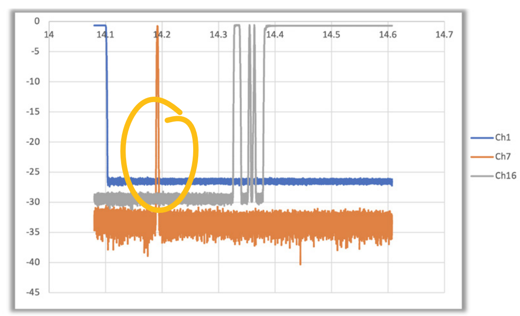

Figure 7: "pass by" power spike on channel 7

High Speed MEMs Switch Analysis

MEMs Switch Structure

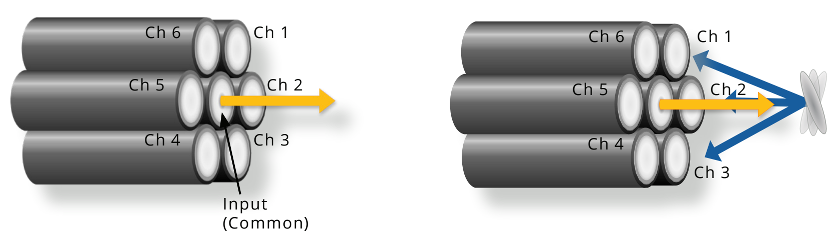

Figure 8: Common MEMs Switch Structure. Mirror steers the input beam to output fibers.

To understand the optical behavior of MEMs switches, it helps to understand their internal structure. Not all MEMs switches have the same internal structure but figure 8 shows a common structure. The switch has a bundle of fibers that are incident on a small mechanical mirror. In the center of the bundle is the common fiber known as the input fiber. Situated around the common fiber are the fibers for the switch channels. The switch steers the input beam to the fibers depending on which channel is selected. When incrementing through channels, the mirror steers the beam to each channel.

Unlike with mechanical switches, the mirror does not need to travel on a fixed path. This means that the switch can change channels and the mirror can move the beam directly to the appropriate output channel without needing to pass the intermediate channels.

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Test Process and Results

Now we look at the performance of a MEMs switch that is switching from one channel to another and skipping intermediate channels. In this case, when the switch is on channel one and channel three is selected the switch goes directly to channel three. The MEMs mirror does not need to travel on a fixed path like the mechanical switch. The total transition time from channel one to three is about 10ms.

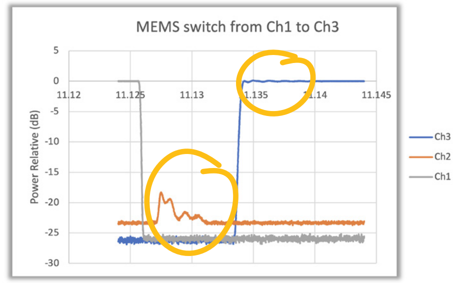

Figure 9: brief low power detected on channel two while switching Ch 1 to Ch 3

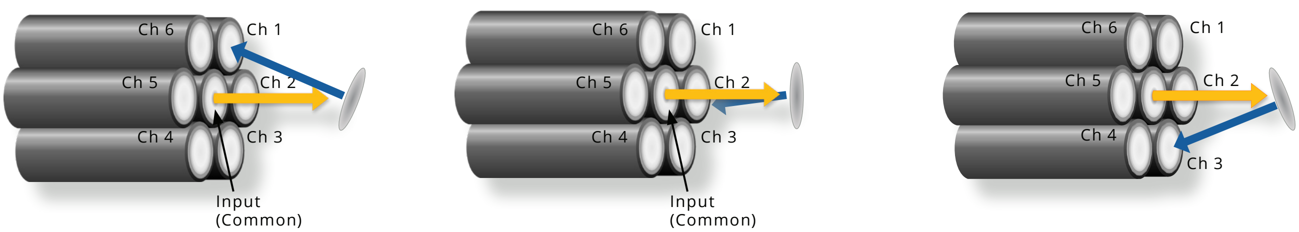

Figure 10: Common MEMs Switch Structure. Mirror steers the input beam to output fibers.

With the system switching from channel one to channel three, there is brief low power detected on channel two. The beam passes by channel two only partially on its way to channel three, resulting in the small power blip on channel two that is observed. This blip is much smaller than what is seen with mechanical switches. The OP740 can capture the fine details of this power blip as well as the transition between the active channel and the destination channel. Even the damped transition to the destination channel is captured by the OP740. The result of this MEMs structure is a much more uniform response time when navigating across channels.

Conclusion

Optical switches are dynamic systems that re-direct an optical signal from on channel to another. To analyze such behavior in a switch the OP740 is uniquely qualified. It has a wide dynamic range to accommodate the large shift in optical power from a dark signal to a bright signal and it has a fast response and fast sampling rate to yield highly resolved traces of the optical signal during its transient behavior.

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