Design Note:

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Optimizing the MAX3656 Output Network for Long Laser Leads in GPON / GEPON ONT Application

MAXIM High-Frequency/Fiber Communications Group

Maxim Integrated Products

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1 Introduction

The MAX3656 (Reference 1) is designed for burst-mode laser driver operation in various ONT/ONU PON applications such as GPON, EPON, BPON or GEPON. The majority of optical subassemblies (Diplexers / Triplexers) used in these applications come with leaded signal connections (TO-Header style pin connections). It is common to mount the optical devices to the top of the PCB and bend the pins down to the PCB making trough-hole connections (Figure 1). While this type of assembly is often chosen for cost and manufacturing reasons, the long leads of the connection can have a severe impact on the signal quality at gigabit data rates.

This applications note discusses the impact of the increased inductance in more detail and illustrates by simulation and lab measurements a compensation network that provides excellent gigabit operation with large amounts of lead inductance.

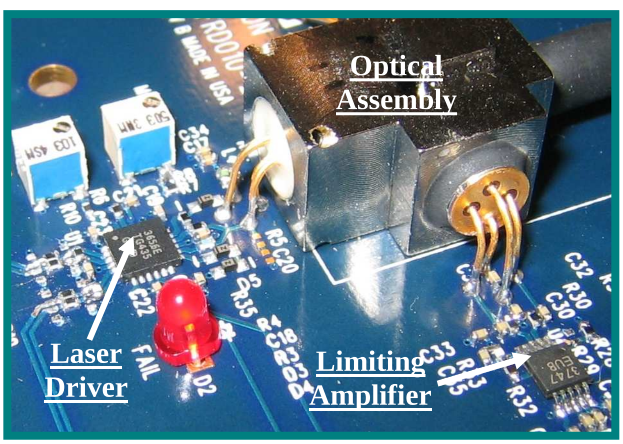

Figure 1. PCB Top Mount Laser Assembly (HFRD 10.2 Shown)

2 Detailed Explanation

2.1 Typical Connection Diagram

Figure 2 illustrates the typical schematic connections of a laser diode to the MAX3656 laser driver. As seen in Figure 1 and Figure 3 the PCB top mount laser assembly results in long lead connections from the laser diode to the laser driver. The long leads of the assembly create a significant amount of inductance (not desired for high-speed applications) and are represented schematically in Figure 4.

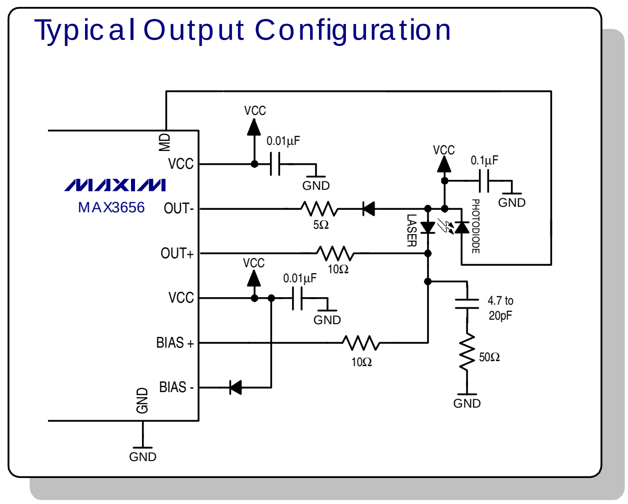

Figure 2. Typical Output Configuration

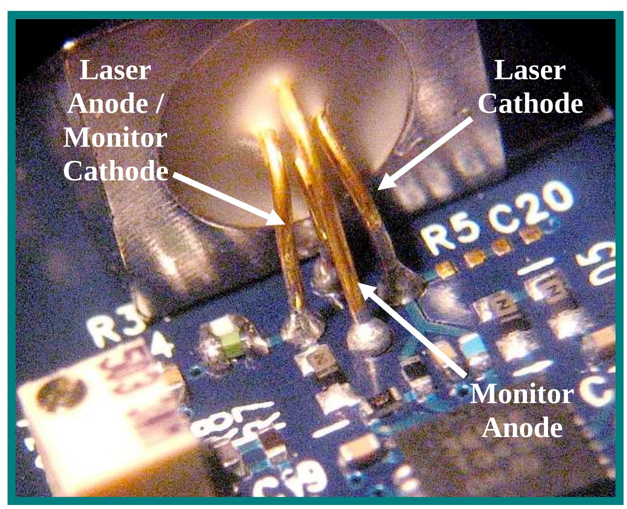

Figure 3. PCB Top Mount Laser Assembly (Laser Connection Detail)

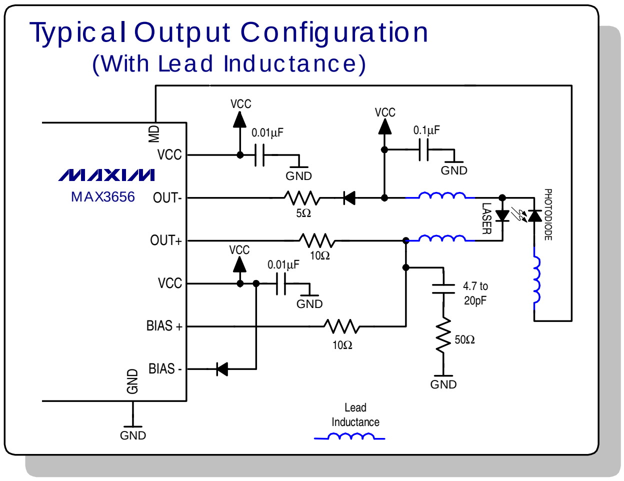

Figure 4. Typical Output Configuration (With Lead Inductance).

2.2 Approximation of Lead Length / Increased Inductance

Using HFRD 10.2 (Reference 4) as an example, a simple mechanical drawing (Figure 5) is used to approximate the lead lengths of the laser connections. From the drawing, the anode and cathode lead connections of the laser are approximately 7.2mm each (14.4mm total lead length).

Depending on the mechanics and pin out of the triplexer, each lead connection of the critical pins (Laser Anode/Cathode) can range between 2mm and 10mm. The combined length of both leads will vary between 5mm and approximately 17mm. Using the rule of thumb that 1mm of a lead results in approximately 0.5nH of inductance, between **2.5nH** and **8.5nH** of inductance is typically added to the high-speed signal path when using a PCB top mount laser assembly. Combined with other parasitic values in the signal path, these large values of inductance can severely affect signal quality at gigabit transmission rates.

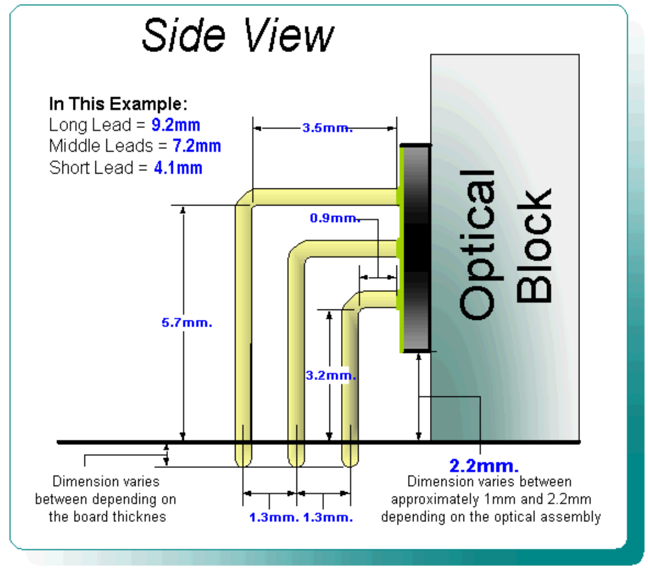

Figure 5. Lead Length Diagram (HFRD 10.2)

3 LR Compensation Network

Conventionally differential drive networks are used to overcome increased signal path inductance and to improve overall edge speed of the laser output (References 2, 3). In burst mode applications, these methods are generally not acceptable because they use AC-coupling capacitors and / or ferrite beads. These two components introduce a low frequency cut-off that can cause significant baseline wander, burst on overshoot / ripple, and turn-on delay when used in bursting PON applications.

Due to these, a compensation network is used instead of differential drive to overcome the increased inductance in the signal path. The compensation network is accomplished using an LR circuit as shown in Figure 6. The values are chosen so that the impedance is large (in comparison to the laser diode) at very high frequencies and very low impedance at all frequencies less than the operating rate. The network dampens overshoot and ringing caused by the increased inductance while maintaining a fast edge speed at the laser output.

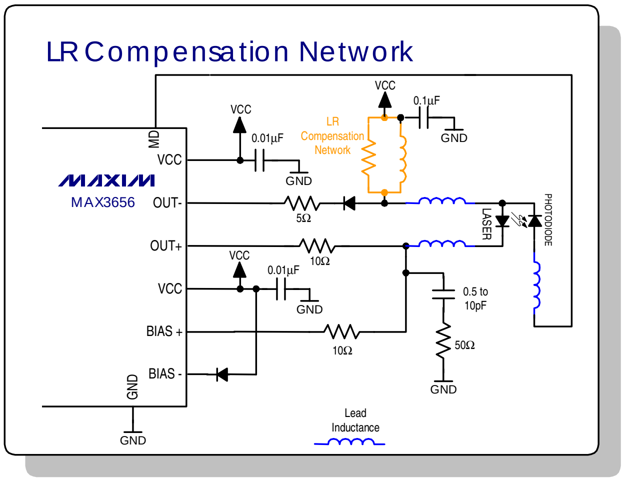

Figure 6. LR Compensation Network

The final values should be determined experimentally due to variation in each PCB design and assembly. In a 1.25Gbps application, the values of inductance (L) will range from 15nH to 30nH and the resistance (R) values are typically between 15Ω and 30Ω. Note: The burst-on wave shape should also be considered when selecting these values as excessive inductance and resistance may cause overshoot when the output bursts on.

4 Simulations

The effectiveness of the compensation network was simulated using a laser driver output model and a simplified LR model for the laser (Figure 7). The inductance of the two laser leads (about 4.1nH per lead) was lumped into one inductor (8.2nH) and the laser was modeled as an 8Ω resistor for simplicity.

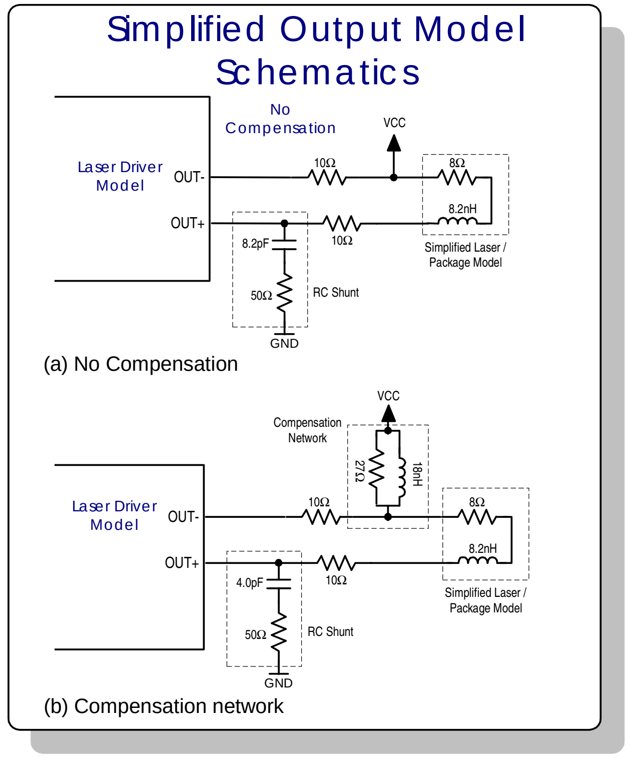

Figure 7. Simplified Output Model Schematics

A 1.25Gbps K28.5 test pattern was used for the simulations. The output signal represents the current through the laser (differential voltage across the resistor in the model). The RC shunt values were optimized to reduce the overshoot to less than 10%.

Note that a smaller capacitor in the shunt network was needed for the circuit with the compensation network because there was less overshoot, and that the simulations were completed to illustrate the affect of the peaking network, but not the exact component values.

Figure 8 is the simulation result of the standard configuration. Figure 9 is the simulation of the output signal when applying the compensation network to the output (Figure 7(b)). As seen in the figures, the edge speed was decreased by approximately 60ps when using this network.

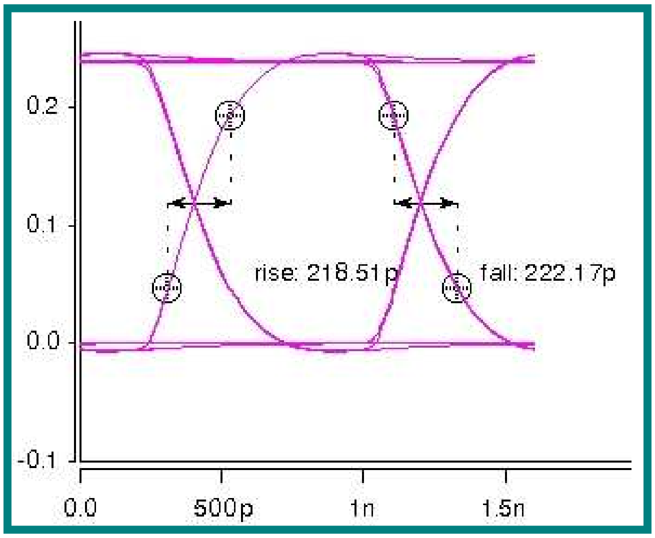

Figure 8. Simulation Result with No Compensation Network

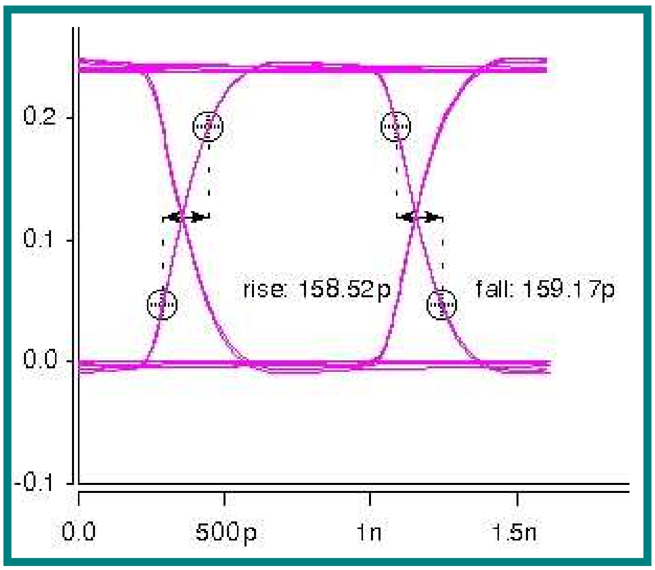

Figure 9. Simulation Result with Compensation Network

5 Lab Measurement / Example

The compensation network described has been implemented on the Maxim HFRD 10.2 GPON ONT reference design. For details regarding the schematic connections, layout and additional test data, please see Reference 4.

5.1 Test Data

With no peaking, the response shown in Figure 10 was obtained. Applying the compensation network, improved results were obtained as shown in Figure 11. Figure 12 illustrates the minimal affect of the peaking network on the output response during a burst-on sequence.

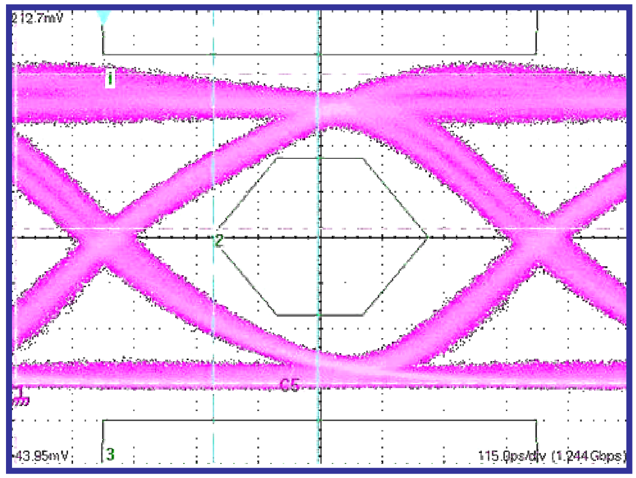

Figure 10. Filtered 1244Mbps Output Without Compensation Network

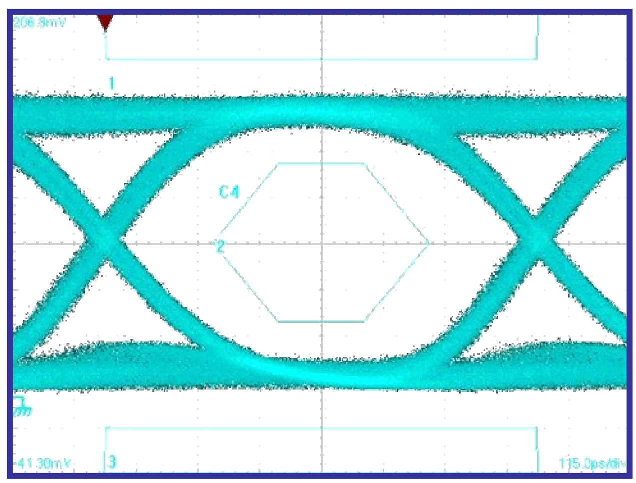

Figure 11. Filtered 1244Mbps Output With Compensation Network (>30% Margin to Standard Mask)

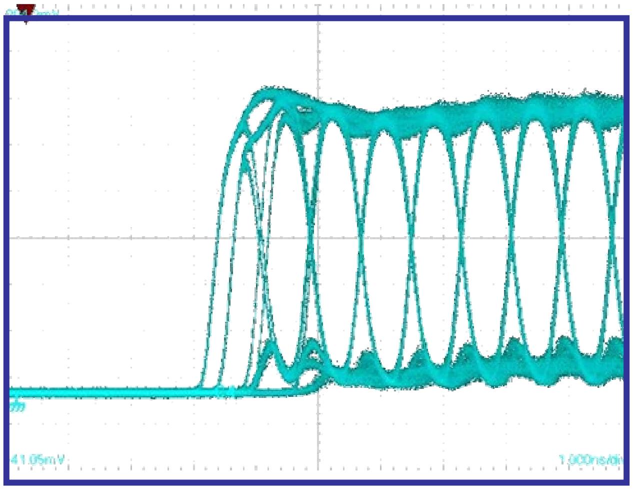

Figure 12. Burst-On Diagram with Peaking Network

6 Conclusion

The long leads on the laser associated with PCB top-mount triplexer / diplexer assemblies can cause signal distortion in gigabit PON applications. An LR compensation network added to the output provides a significant performance improvement of the optical output signal.

References:

1. Data Sheet: "MAX3656: 155Mbps to 2.5Gbps Burst-Mode Laser Driver" - Maxim Integrated Products, November 2004.

2. Application Note: "MAX3735A Output Configurations, Part 3: Differential Drive" – HFDN-26.2, Maxim Integrated Products, September, 2003

3. Application Note: "Single-Ended vs. Differential Methods of Driving a Laser Diode" – HFDN-02.5.0, Maxim Integrated Products, May, 2004

4. Reference Design Note: "622Mbps / 1244Mbps GPON ONT" – HFRD-10.2, Maxim Integrated Products, March, 2005