TECH NOTE

Connecting Your Laser to the LDP-3830

OVERVIEW

The LDP-3830 Precision Pulsed Current Source solves most impedance matching problems by generating the pulses in the LPB-386 Pulse Board. If the laser is mounted on the LPB-386, or connected with a low impedance cable shorter than 10 inches, error free performance can be expected. For a longer connection, most low impedance cables can be used, but the resistance at the diode will need to match the cable resistance.

IMPEDANCE AND DISTANCE

Pulses at the load can differ from those at the source. The pulse shape discrepancy is caused by a combination of the distance between the source and the load, and the impedance of the source, connecting cable, and load.

Transmission line impedance matching is necessary when the one-way propagation delay of the cable is equal to or greater than one-half the applied signal rise/fall time (whichever edge is faster). In general, most differential cables will have a propagation delay of approximately 1.5 ns/ft. A good rule of thumb is for each nanosecond of rise time, you can allow two inches of cable before impedance matching is necessary. The LDP-3830 specifies a 10ns rise time; therefore cables over 20 inches will require impedance matching.

LOAD-LINE MATCHING

The most important requirement of proper impedance matching is matching the impedance of the load to the impedance of the transmission line. Since the LDP-3830 dynamically adjusts for load impedance, source matching is not necessary. If the load impedance matches the cable impedance, then the LPB-386 Pulse Board will have a consistent pulse shape between the source and the laser.

LOW IMPEDANCE CABLES FOR PULSING DIODES

Most cables made for high frequency signal transmission are designed for low current. Common impedance standards for transmission lines are 50, 75, 100, 300, 600 ohm. The LDP-3830 can deliver up to 5A at 20V and using most off the shelf cables will not work because the characteristic impedance will cause the LDP-3830 to go over the compliance voltage. In most cases, the cable must be custom made. There are two common methods for making a cable.

The easiest cable to make is a coupled copper foil transmission line; however impedance matching this cable to the load is more difficult. The impedance (Z_O) for this cable will be similar to the equation below for a lossless parallel plate.

$$Z_0 = \frac{120\pi}{\sqrt{\varepsilon_r}} \cdot \frac{d}{w}$$

Where ε_r is the relative permittivity of the insulator, w is the width of the plate, and d is the separation between plates. These cables can be made by placing copper tape on either side of a polyimide or acrylic tape. An assembly of ½ inch wide copper tape (3M™ 1126) attached to 5 mil Kapton® tape (3M™ 5413) has a characteristic impedance of approximately 4Ω

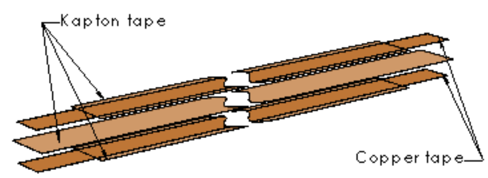

Figure 1: Diagram of coupled copper foil transmission line.

The other cabling method, which is harder to build, but allows for easier changes in impedance is to use a flat ribbon cable. These cables are consistently manufactured such that impedances are consistent between conductors. The impedance of a typical IDC ribbon cable is approximately 95Ω to 110Ω. This impedance is based on a signal surrounded by ground on adjacent conductors (Ground / Signal / Ground.) When used for pulsing, this cable will be used in a differential configuration (Anode+ / Cathode-). If this cable was wired in the (G / A+ / G / C- / G) configuration, the impedance would be double that of the ribbon cable, due to the combined impedance down and then back. When wired (A+ / C-) the impedance decreases due to a virtual ground between the two signal lines. This makes the differential impedance around 1.6x the ribbon cable impedance.

To further reduce the impedance, the cabling configuration (A+ / C- / A+ / C- / . . .), alternating between anode and cathode on each conductor, should be continued. This is the most effective way of reducing impedance due to the virtual ground created between each signal pair. Due to slight imbalances between each conductor, cable impedance will be reduced by a little less than half each time you double the number of conductors. To achieve a 5 ohm impedance cable it is estimated that at least 40 conductors will be need to be used. Using a ribbon cable has an added advantage in that adjusting impendence is as simple as adding or removing additional conductors.

Figures 2 through 4 are examples of different connections. The top signal was the electrical signal from the current monitor port on the LPB-386, while the bottom signal was the detected optical signal. The cable impedance mismatch was evident in both the copper foil cable (Figure 3) and the flat ribbon cable connection (Figure 4) in the electrical response. This ripple is not evident in the optical signal due to the lower bandwidth of the detector. The additional cable inductance created by spreading wires at the LPB-386 has affected the rise time in both cable instances.

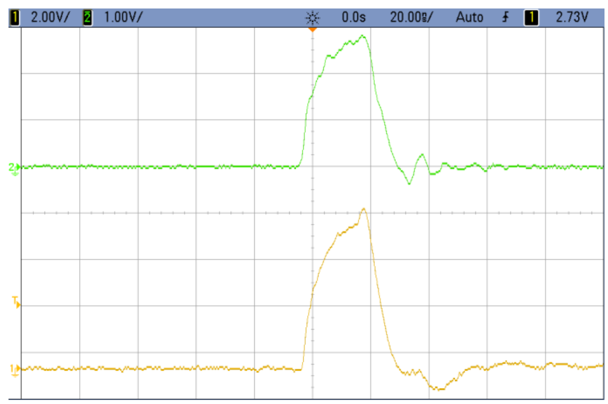

Figure 2: Direct Connection

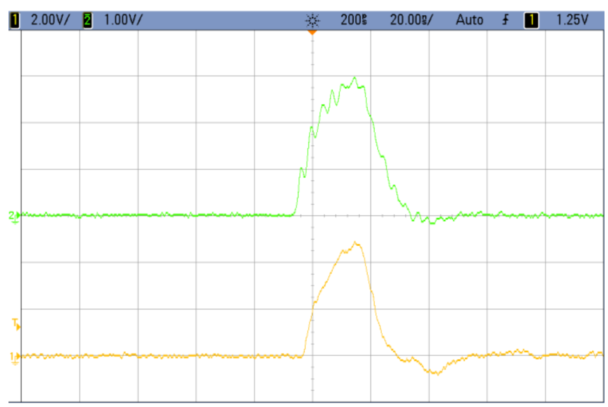

Figure 3: Coupled Copper Foil Cable

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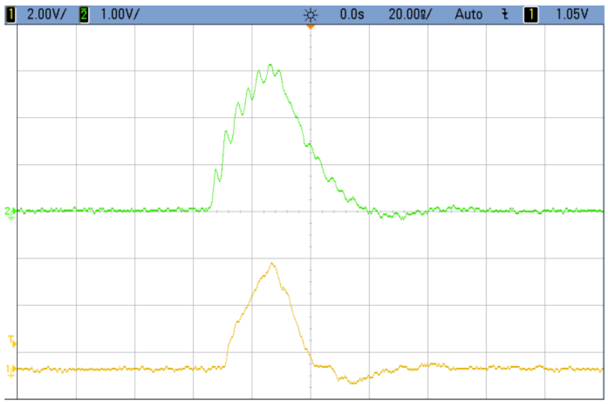

Figure 4: 34-Pin Ribbon Cable Connection

DETERMINING MATCH

The current probe on the LPB-386 can be used to determine if the cable is correctly matched to the load. Since this port is located at the source, the initial part of the waveform will first respond to the impedance of the transmission cable and then it will respond to the impedance of the load.

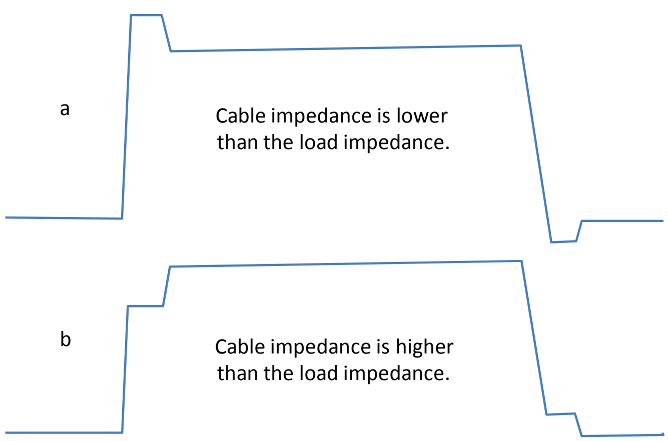

Figure 5: Examples of Impedance Mismatch

Prolonged overshoot on the rising and falling edge of the signal (Figure 5a) indicates the cable impedance is less than the load. The cable impedance should be increased by decreasing the width, or reducing the number of wires in the cable. Pronounced undershoot at the rising and falling edges (Figure 5b) indicates the impedance of the cable is greater than that of the load. The impedance of the cable should be reduced by increasing the width of the strip line or adding more conductors. Alternatively a series resistor at the laser can be used to increase the impedance of the load.

Note: The LDP-3830 is sensing the same current measurements as available on the current sense port. These offsets in current due to reflections of mismatched cable and load do affect the controlled current.

CONCLUSION

In summary for best performance a direct connection is recommended however this is not always practical and an interconnection cable maybe necessary. When using a cable, low characteristic impedance cables should be used. When the length of the differential cable exceeds 20 inches, matching the cable impedance to the load is necessary.

REFERENCES

Buhler, R., *Flat Cable Characteristic Impedance Reduction and Measurement Techniques,* Paper for the 11th Annual regional Symposium on Electromagnetic Compatibility, Wednesday October 3, 2011, Rocky Mountain Chapter of the IEEE EMC Society, at the Radisson Inn, Northglenn, Colorado USA.