APPLICATION NOTE

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A400GE-QDD RECOMMENDED TAP SETTINGS FOR LINK OPERATION

Table of Contents

Introduction

Ixia's A400GE-QDD test system makes the challenge of qualifying bit error rate (BER) on 400GE electronics easier and affordable. Whether validating chips, optical transceivers, or port electronics, the A400GE-QDD (A400) is a dedicated bit error rate test (BERT) and RS-544,514 forward error correction (FEC) test system with 56 Gigabit (Gb) electrical lane signaling per port that provides the ability to find a problem in minutes, not hours. It shows a system-level view of the BER and FEC performance of all the lanes, all at once, in real time.

The A400 is a compact BERT and FEC benchtop or rackmount test system. The chassis is provided with the Layer 1 BERT 400GE test software, KiOS. The Google® Chrome® browser-based user interface (UI) makes set up easy so you can start testing within minutes. An optional FEC test capability is available that makes FEC lanes testing just as easily as Layer 1 BERT. Ixia's FEC codeword error density distribution analysis (the FEC tail) shows the BER performance and other advanced measurements when it comes time to perform long-duration and stress tests—it cannot be made easier. This provides your development teams test capabilities to quickly pinpoint problems and to validate and qualify excellent BER performance.

This application note provides recommended transmit pre-emphasis tap settings for quad small form factor pluggable double density (QSFP-DD) multi-source agreement (MSA) compliant optical transceivers and passive copper direct attached cables (DAC) for the A400 test system. Specific examples are provided for the device under test (DUT) transmitter as well.

A few important facts about the A400 port set up.

- The A400 has facilities for adjusting transmit pre-emphasis settings.
- The A400 has default electrical and optical transmit pre-emphasis settings that will work with a wide range of optical transceivers and passive copper DACs. The purpose for the default settings is to establish a working environment to test and qualify optical transceivers and passive copper DACs beyond the specific ones shown in the tables that follow.
- The Decision Feedback Equalizer (DFE) in the receiver of the A400 is automatic. It dynamically adjusts the receive side of the port on the A400. There is no manual control or setting for the DFE in the A400. This is one reason there are examples of the A400 interfaced with the K400 and AresONE (Ixia's other QSFP-DD 400GE test systems) to show typical test system receiver settings from the DUT transmitter.
- Examples for the DUT are shown using Ixia's IxExplorer application so that when required, a known good optical transceiver or a passive copper DAC may be used to validate that the A400 port is working as designed for troubleshooting problem links or performance on un-tested devices.

Optical Transceivers

The A400 is designed to support all QSFP-DD MSA-compliant optical transceivers up to Power Class 7 with 14 watts of power consumption. This is within the range of the A400's capacity to power up the optical module in the port. For optical transceivers that require more power per port, please consult the Ixia factory support department for further information.

For optical transceiver modules, Ixia recommends the use of the *Optical Defaults* settings, which have been tested across a variety of vendor optics. The optics in the table below have been tested (i.e., qualified for use) with the A400 test system as of December 2019.

TECHNOLOGY TYPE	MANUFACTURER	FORM FACTOR
400GBASE-SR8	InnoLight	QSFP-DD
400GBASE-SR8	InnoLight	QSFP-DD AOC, 30 meters
400GBASE-FR4	InnoLight	QSFP-DD
400GBASE-SR4	Lumentum	QSFP-DD
400GBASE-LR8	Finisar	QSFP-DD
400GBASE-LR4	InnoLight	QSFP-DD

Table 1:Optical transceivers qualified for use with the A400

The table above does not explicitly rule out the use of different technology types or optics from other manufacturers. The following transmit pre-emphasis settings are provided as a guide for establishing a baseline for optical transceiver support beyond those mentioned in Table 1.

A400 SETTING	VALUE	UNIT
Pre-Cursor 2	0	dB
Pre-Cursor	-1.1	dB
Driver Amplitude	487	mV
Post-Cursor	0	dB

Table 2: Recommended A400 transmit pre-emphasis settings to establish a baseline for other optical tranceivers

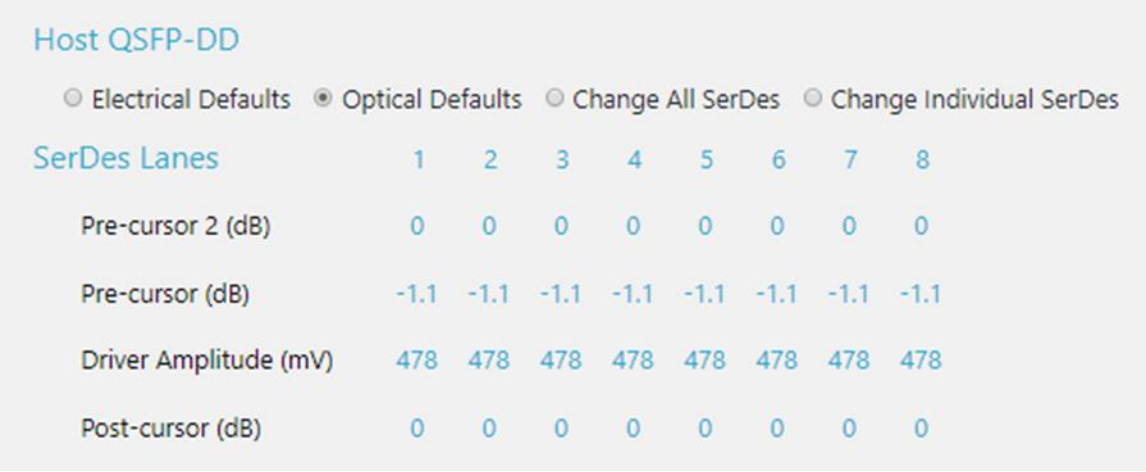

Figure 1: KiOS Host QSFP-DD settings screen for optical transceiver *Optical Defaults*

Passive Copper Direct Attached Cables (DACs)

The A400 is designed to support QSFP-DD form factor, passive copper direct attach cables (DACs). Passive DACs are supported from 1 meter to 3 meters in length. *Active* copper DACs are not restricted from use in the A400, however, as of December 2019, these have not been qualified for use with the A400.

For passive copper DACs, Ixia recommends the use of the *Electrical Defaults* settings, which have been qualified across a variety of vendor DACs. The DACs in the table below have been qualified for use with the A400 test system as of December 2019.

TECHNOLOGY TYPE	FORM FACTOR	MANUFACTURER	CABLE LENGTH
400GBASE-CR8	QSFP-DD	Molex	1.0 meter
		FIT	1.5 meters
		Molex	2.0 meters
			2.5 meters
			3.0 meters

Table 3: Passive copper DACs qualified for use with the A400

The *Electrical Defaults* have been established for the A400 and for copper DACs the default settings will meet most requirements. However, to reach the maximum capabilities of the A400, DACs may require more careful transmit equalization tuning.

There are two main scenarios described in this section:

1. Overall equalization tuning between A400 and a DUT, such as a vendor application-specific integrated circuit (ASIC) for a switch
2. Transmit tuning for back-to-back testing of a DAC within the same A400 tester

Transmit Equalization Tuning — A400 to DUT

This is typically a straightforward operation since the A400 *Electrical Defaults* were found to be useful to drive DAC lengths from 1m to 3m. However, there may be cases where a link between the A400 and a DUT has poor BER or FEC symbol error performance. If this happens, you can tune the A400 and the DUT to get the best BER results possible. Since every DUT has its own specific settings, you may find it useful to review examples that show different PHYs interoperating well. We've provided examples in Appendix A and Appendix B that pair the A400 to Ixia's K400 and AresONE QSFP-DD test systems acting as the DUT. This data will assist users of the A400 who want ideas on where to start tuning for their DUT.

Appendix A summarizes the A400 transmit (Tx) settings and AresONE receive (Rx) settings and Appendix B displays the A400 transmit (Tx) settings and K400 receive (Rx) settings to provide an idea of what Rx settings might be required on your DUT across cable lengths.

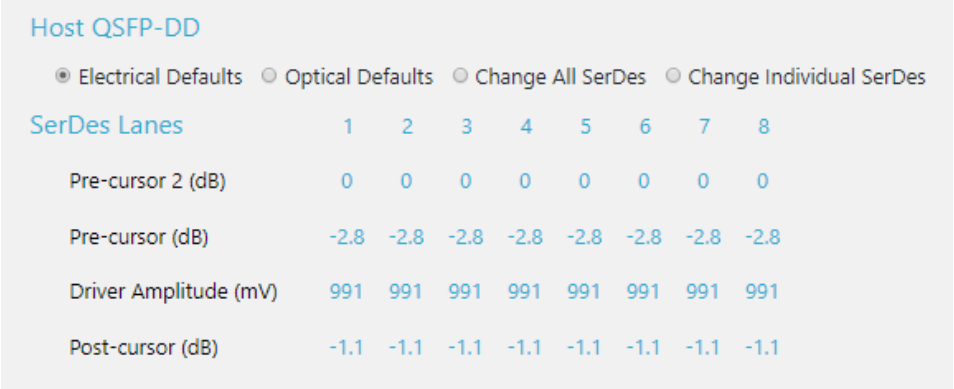

Figure 2: KiOS Host QSFP-DD settings screen for passive copper DAC *Electrical Defaults*

Transmit Equalization Tuning — DUT to A400

The A400 receiver has an adaptive receiver (DFE) that may benefit from tuned transmit equalization from the link partner. Appendix A shows the Tx parameters from AresONE and Appendix B show the Tx parameters from K400. This may help guide the user with their DUT's Tx equalization by looking at the patterns across cable lengths.

Back-to-Back Transmit Tuning — A400 to A400

The following are reasonable starting points for DAC characterization on back-to-back ports on the A400 tester. Note that small changes might be needed depending on the channel, with expected tweaks to the post-cursor and pre-cursor attenuation, and possibly the driver amplitude. The purpose here is to validate with known good DACs that the A400 is working as intended.

	A400 TRANSMIT			
DAC	**Pre-Cursor2 (dB)**	**Pre-Cursor (dB)**	**Driver Amplitude (mV)**	**Post-Cursor (dB)**
QDD Loopback	0	-2.3	819	-3.1
Molex 1.0m		-1.9	991	-4.6
Molex 2.0m		-1.5		-3.1
Molex 2.5m				
Molex 3.0m		0		-3.6
Electrical Defaults	**0**	**-2.8**	**991**	**-1.1**

Table 4: Optimal transmit settings for passive copper DAC interconnect in back-to-back set up on A400

Dealing with Difficult Lanes After Transceiver Insertion

Occasionally, after insertion or large equalization changes, one or two lanes on an A400 might measure with a higher BER than the others, which could also result in the port having trouble to gain lock. When this situation arises, the following steps are recommended:

a. Re-plug the transceiver or cable

b. On the link partner, apply a small transmit equalization tweak to the overall port or to the affected lanes

c. When the lane is not coming-up, wait an additional 30 seconds

A high-BER lane is easily seen in the per-lane statistic in either the BERT mode or the FEC mode. When attempting method b., a small change in the transmit post-cursor tap might be enough to make the A400 lane perform back to normal. Note that if there is a lane equalization problem in FEC mode that causes the port to lose lock, it is recommended to first switch to BERT mode to see which lane is problematic, apply the equalization change, and then switch back to the FEC mode.

Common Management Interface Specification

There are times when the common management interface specification (CMIS) may have to be consulted. For example, a transceiver that is programmed by the manufacturer as a CMIS 3.0 version may not work unless the A400 is set to CMIS 3.0 mode. The A400 CMIS mode must match the optical transceiver CMIS version. The A400 default is set to automatically detect the CMIS revision. It can be changed via the Auto-Detect option that is available under QSFP-DD Control / State Machine. Note that the A400 can override the incorrect version after insertion of the optical transceiver when desired. The A400 supports both versions 3.0 and 4.0.

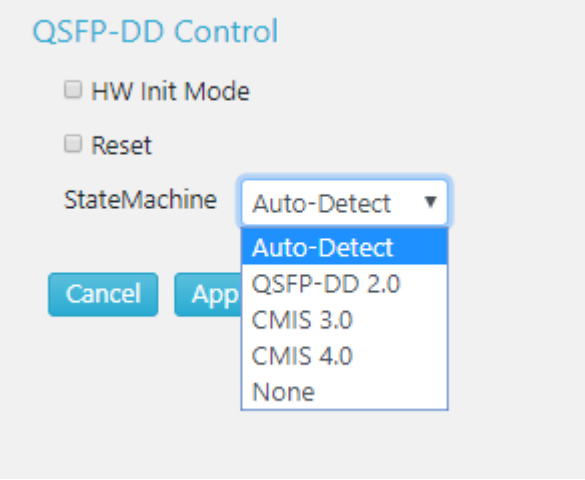

Figure 3: The KiOS QSFP-DD Control State Machine default is set to *Auto-Detect* the CMIS

If the selections in the A400 do not appear to apply properly to your transceiver, contact the transceiver manufacturer for identification of which version of the CMIS specification is installed on the device.

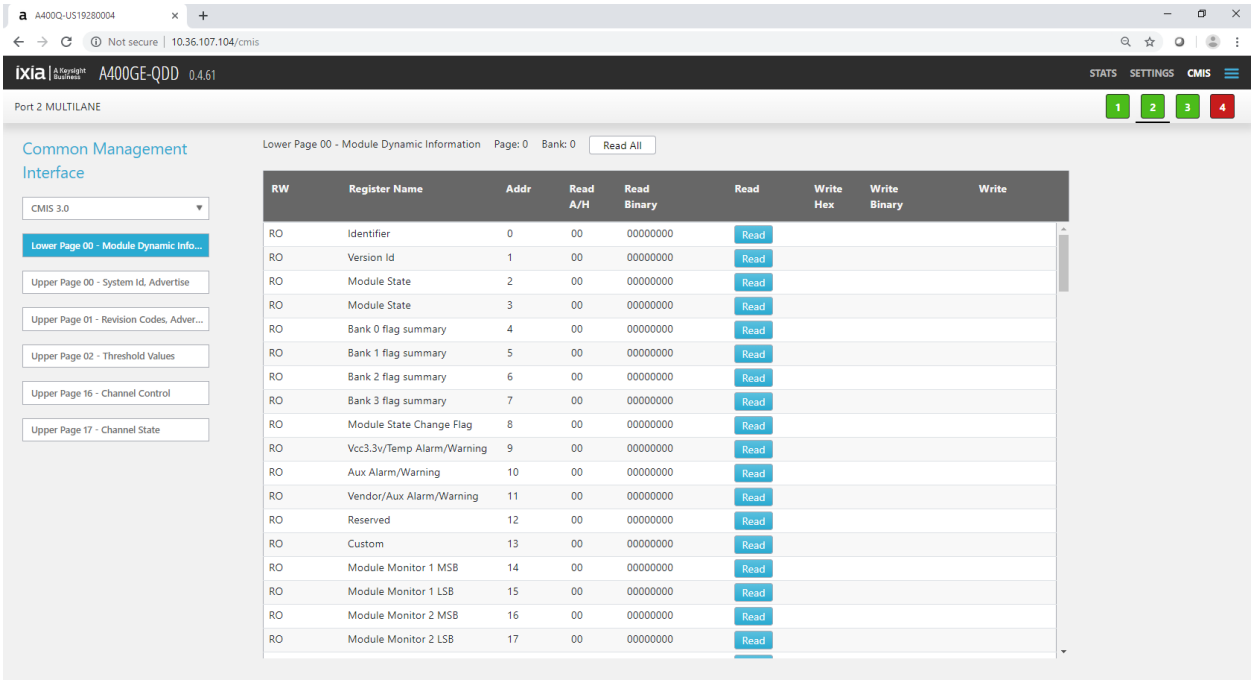

Figure 4: KiOS CMIS 3.0 interface display

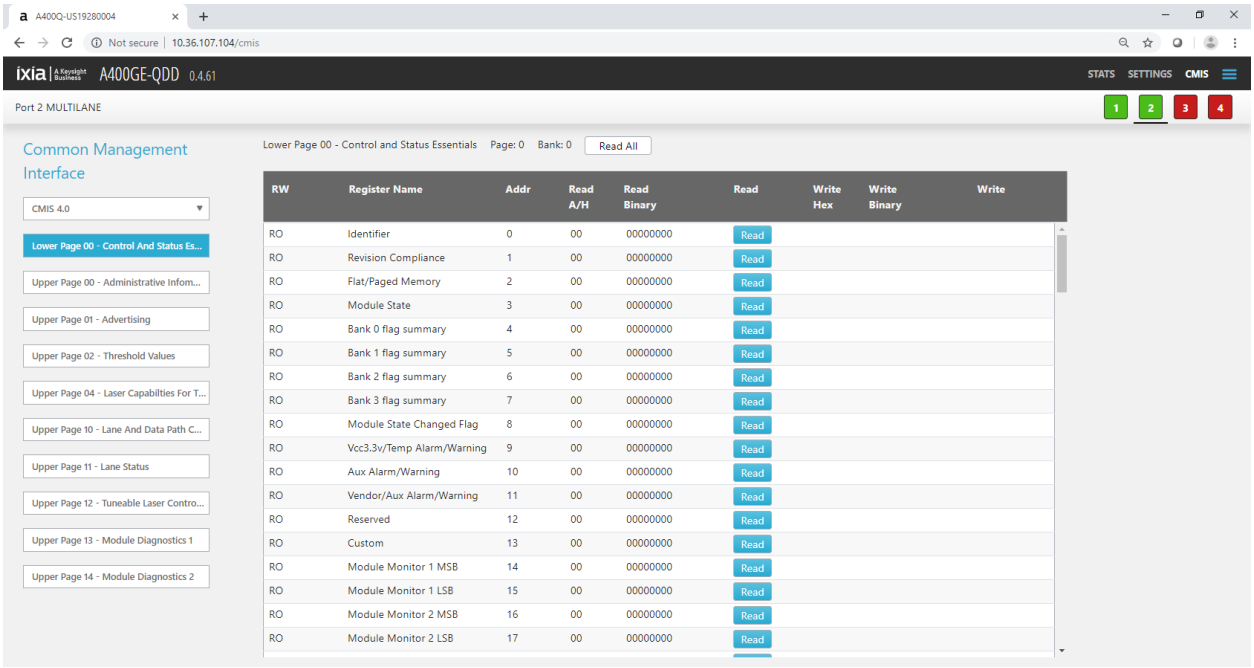

Figure 5: KiOS CMIS 4.0 interface display

Conclusion

The A400 is designed to operate with difficult and problematic optical transceivers and copper DACs. The default link settings are tuned for the most common interconnects qualified for use with the A400, giving users immediate access to many testing scenarios. However, some optical transceivers and DACs will require careful transmit equalization tuning to reach the maximum capabilities of the A400.

In many cases it is beneficial to the user to start with known good optical transceivers and copper DACs to see how the pre-emphasis adjustments affect the BER results. This provides a starting point for working with new optical transceivers and copper DACs where the results are not initially known. Once you are familiar with the adjustments available on the A400, it then becomes much easier to zero in on the most optimal settings for validating new interconnect media.

Appendix A: AresONE QSFP-DD as DUT Examples

Transmit Equalization Tuning — A400 to DUT

The following table summarizes the A400 transmit (Tx) settings and AresONE receive (Rx) settings to provide an idea of what Rx settings might be required on your DUT across cable lengths.

A400 to AresONE (DUT) Recommendations for DACs

	A400 TRANSMIT				ARESONE RECEIVE	
DAC	**Pre-Cursor2 (dB)**	**Pre-Cursor (dB)**	**Driver Amplitude (mV)**	**Post-Cursor (dB)**	**Rx CTLE**	**DSP Mode**
Molex 1.0m	0	-2.8	991	-1.1	12	Short Channel
FIT 1.5m					16	
Molex 2.0m					16	
Molex 2.5m					20	
Molex 3.0m					28	
			AresONE Rx EQ Defaults		**8**	**Short Channel**

Table 5: Optimal transmit settings for passive copper DAC interconnect of AresONE to A400

Transmit Equalization Tuning — DUT to A400

The following table shows the Tx parameters from AresONE to help guide the user with their DUT's Tx equalization by looking at the patterns across cable lengths.

AresONE (DUT) to A400 Recommendations for DACs

	ARESONE TRANSMIT		
DAC	**Pre-Cursor**	**Main Cursor**	**Post-Cursor**
Molex 1.0m	4	120	24
FIT 1.5m			
Molex 2.0m			32
Molex 2.5m		128	
Molex 3.0m		140	12
Tx EQ Defaults	**4**	**140**	**12**

Table 6: Optimal transmit settings for passive copper DAC interconnect of AresONE to A400

Appendix B: K400 as DUT Examples

Transmit Equalization Tuning — A400 to DUT

The following displays the A400 transmit (Tx) settings and K400 receive (Rx) settings to provide an idea of what Rx settings might be required on your DUT across cable lengths.

A400 to K400 (DUT) Recommendations for DACs

	A400 TRANSMIT				K400 RECEIVE	
DAC	**Pre-cursor2 (dB)**	**Pre-cursor (dB)**	**Driver Amplitude (mV)**	**Post-Cursor (dB)**	**Rx CTLE**	**DSP Mode**
Molex 1.0m	0	-2.8	991	-1.1	5	"Non-strenuous links with strong reflections" - or - "Strenuous optical links with strong reflections"
FIT 1.5m						
Molex 2.0m						
Molex 2.5m						
Molex 3.0m					6	
			K400 Rx EQ Defaults		**5**	"Non-strenuous links with strong reflections"

Table 7: Optimal transmit and receive settings for interoperation of A400 and K400 with passive copper DACs

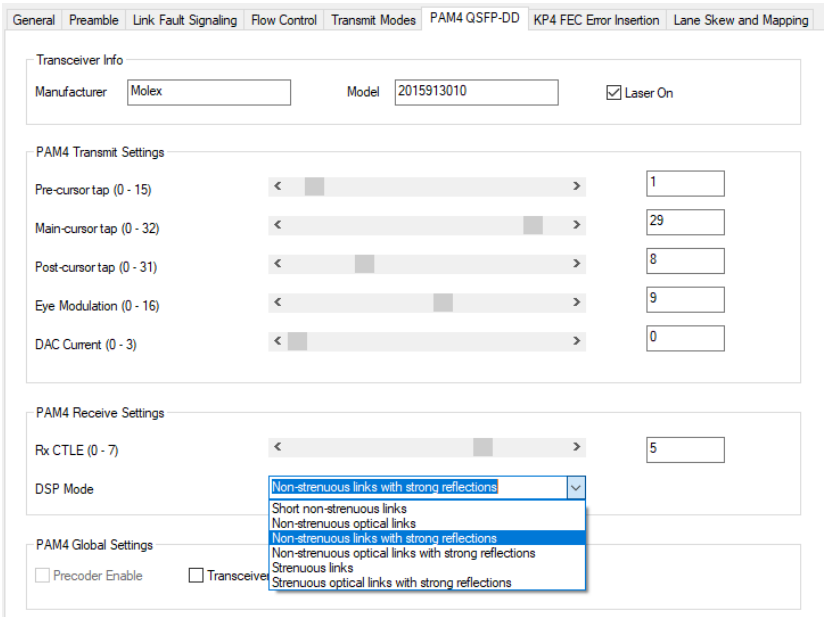

Figure 6: IxExplorer PAM4 QSFP-DD optical settings for "Non-strenuous links with strong reflections"

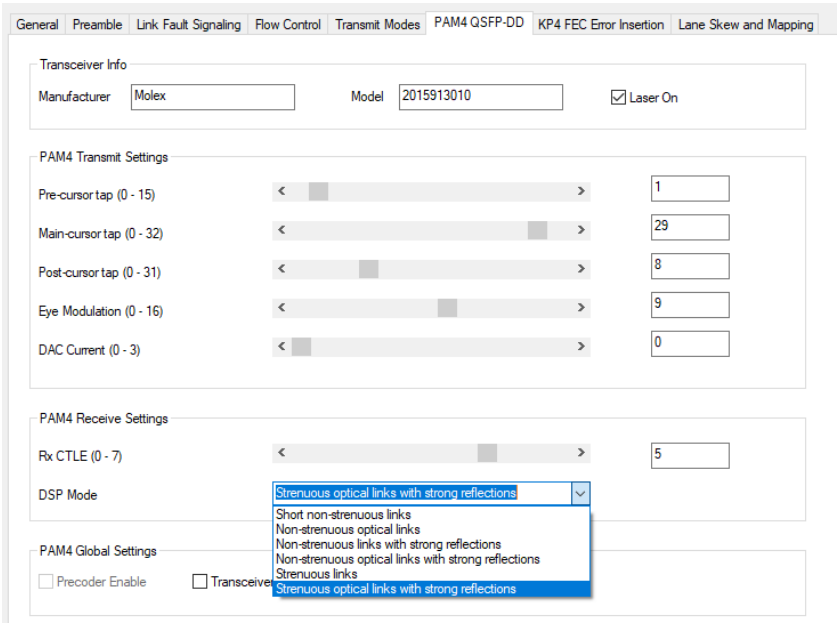

Figure 7: IxExplorer PAM4 QSFP-DD optical settings for "Strenuous optical links with strong reflections"

Transmit Equalization Tuning — DUT to A400

The following table shows the Tx parameters from K400 to help guide the user with their DUT's Tx equalization by looking at the patterns across cable lengths.

K400 (DUT) to A400 Recommendations for DACs

	K400 TRANSMIT			
DAC	**Pre-Cursor**	**Main Cursor**	**Post-Cursor**	**DAC Current**
Molex 1.0m	1	29	8	0
FIT 1.5m	2	30	9	
Molex 2.0m		31		
Molex 2.5m		28	10	1
Molex 3.0m		30	4	
Tx EQ Defaults	**4**	**30**	**2**	**0**

Table 8: Optimal transmit settings for passive copper DAC interconnect of K400 to A400

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