Application Note

TDP1204 HDMI 2.1 Compliance Guide

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ABSTRACT

Depending upon the intended application, the TDP1204 acts as either a linear or limited HDMI 2.1 redriver to assist in passing HDMI 2.1 compliance testing by improving signal integrity of the high-speed signals. However, both board-level design and misconfiguring the TDP1204 device registers present potential challenges in passing the HDMI 2.1 compliance testing. This document provides qualitative and quantitative data to show how modification of the TDP1204 device registers adjusts the signal waveform to overcome the potential failures within HDMI 2.1 compliance testing.

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Trademarks

1 Introduction

This document explores the effects on the HDMI 2.1 waveforms by experimentation of the different receiver equalization (EQ), differential output voltage (VoD) and termination register settings. The effects that the TDP1204 control registers have on the eye diagram differ depending on whether the device is in the linear or limited redriver mode. This document provides the resulting waveforms and waveform measurements to show the effects of the modifications of those register settings in either redriver mode.

2 TDP1204 Controls for HDMI Compliance Testing

This section explores the effects on the HDMI 2.1 waveforms by experimenting with the different receiver EQ, VoD and termination register settings. While performing these register changes, the different effects on the waveforms are provided for both linear and limited redriver modes.

The effects that the TDP1204 controls have on the eye diagram differ between linear and limited mode. The selection between the redriver modes is done by setting the most significant bit (MSB) of the GBL_CTRL1 Register (Offset = 0xDh). If the GLOBAL_LINR_EN is set to 0 then the redriver functions in limited mode. If the GLOBAL_LINR_EN is set to 1 then the redriver functions in the linear mode. The two least significant bits of the GBL_CTRL1 Register are used to control the termination settings of the device. The TDP1204 TX termination can be set to one of four settings: No termination (TERM = 0x0), 300-ohms (TERM = 0x1), Automatic based HDMI mode (TERM = 0x2) or 100-ohms (TERM = 0x3).

The EQ and VoD settings can be modified for each lane independently. Therefore, there are four registers that can be modified for each of the four HDMI 2.1 FRL data lanes.

To choose between the receiver EQ settings, set the least four significant bits of the following registers: CLK_CONFIG2 Register (Offset = 0x13h), D0_CONFIG2 Register (Offset = 0x15h), D1_CONFIG2 Register (Offset = 0x17h) and D2_CONFIG2 Register (Offset = 0x19h).

To choose between the VoD settings for HDMI 2.1 FRL, set the least three significant bits of the following registers: CLK_CONFIG1 Register (Offset = 0x12h), D0_CONFIG1 Register (Offset = 0x14h), D1_CONFIG1 Register (Offset = 0x16h) and D2_CONFIG1 Register (Offset = 0x18h). The CLK_CONFIG registers map to the D3 data lane of HDMI 2.1 FRL.

Please refer to *TDP1204 12-Gbps, DC/AC-Coupled to HDMI™ 2.1 Level Shifter Hybrid Redriver*, data sheet for more information on these registers.

2.1 Adjusting Equalization for the Short Cable Model

This section provides eye diagrams and eye diagram measurements as receiver EQ increases for both linear and limited modes using the Category 3 Short Cable Model (SCM3) Eye Mask Test. The three different EQ settings, no equalization (0x0h), mid-range equalization (0x8h) and the highest equalization (0xFh) samples how EQ affects the waveform's eye diagram. There were no modifications between the results provided in this section with respect to the test setup or register settings. The VoD and termination settings for these tests were set at 0x3h and 0x2h, respectively.

Figure 2-1 and Figure 2-2 show the eye diagrams when TDP1204 is operating in limited mode and linear mode without signal equalization under the HDMI 2.1 Short Cable Model, respectively.

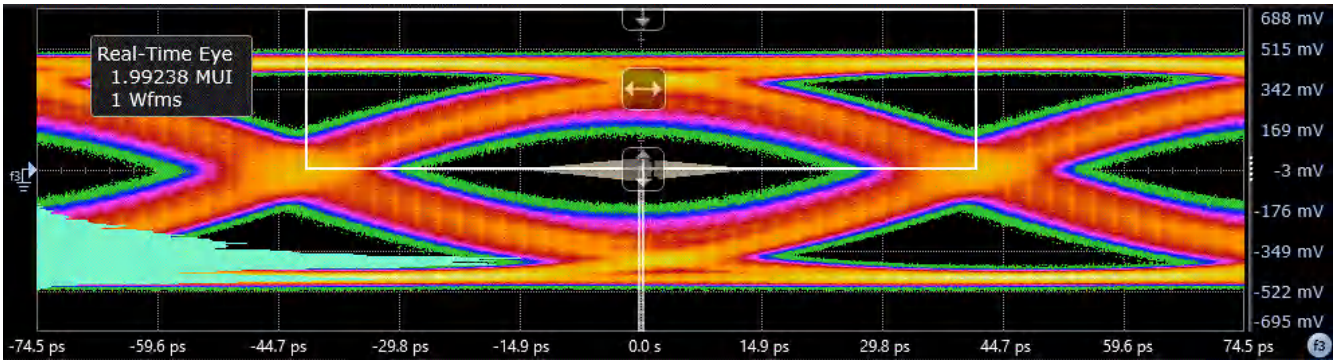

Figure 2-1. Short Cable Model with TDP1204 in Limited Mode (EQ = 0)

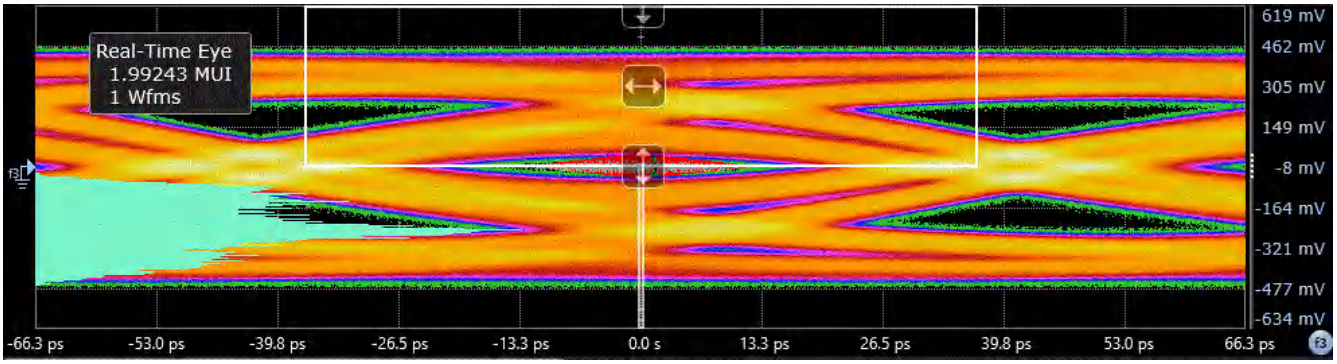

Figure 2-2. Short Cable Model with TDP1204 in Linear Mode (EQ = 0)

Figure 2-3 and Figure 2-4 show the eye diagrams when TDP1204 is operating in limited mode and linear mode with signal equalization set to 8 under the HDMI 2.1 Short Cable Model, respectively.

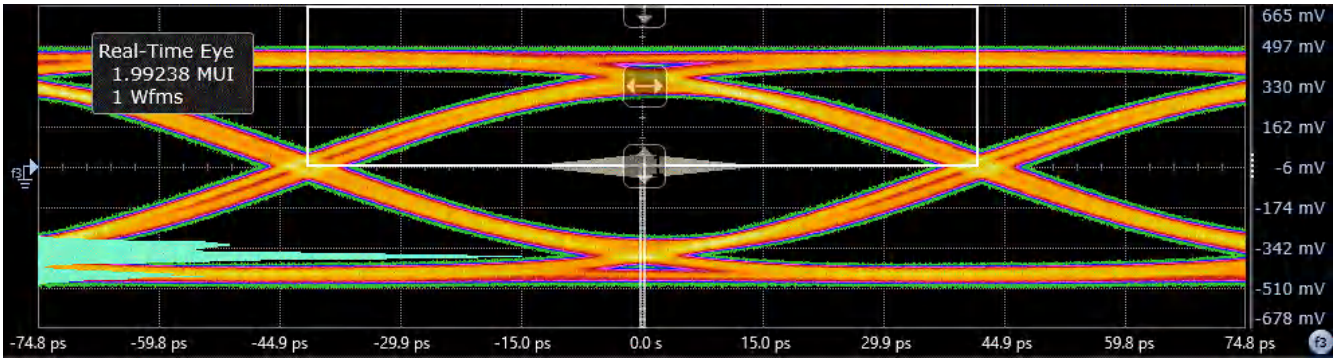

Figure 2-3. Short Cable Model with TDP1204 in Limited Mode (EQ = 8)

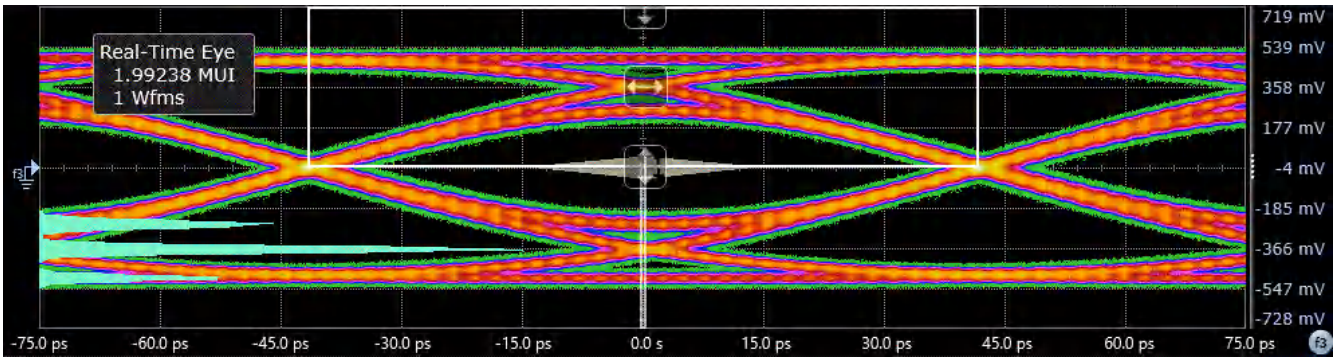

Figure 2-4. Short Cable Model with TDP1204 in Linear Mode (EQ = 8)

Figure 2-5 and Figure 2-6 show the eye diagrams when TDP1204 is operating in limited mode and linear mode with signal equalization set to the highest equalization setting under the HDMI 2.1 Short Cable Model, respectively.

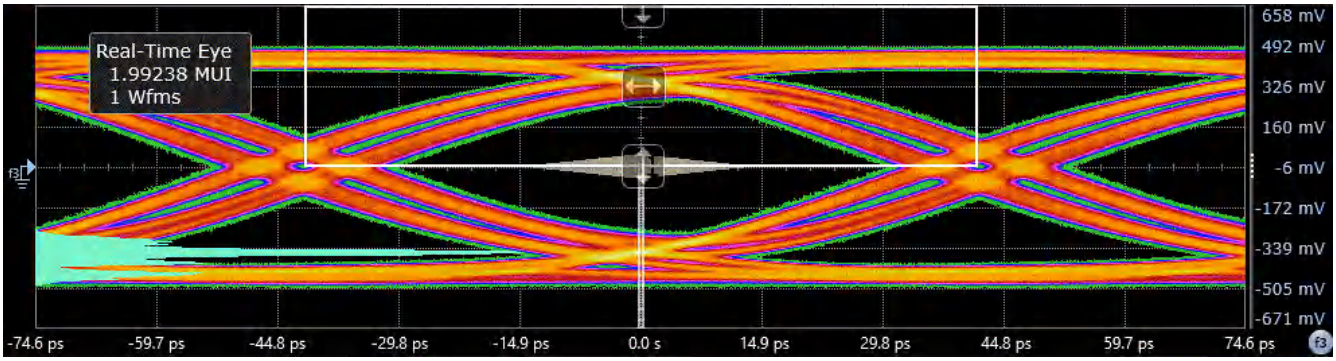

Figure 2-5. Short Cable Model with TDP1204 in Limited Mode (EQ = F)

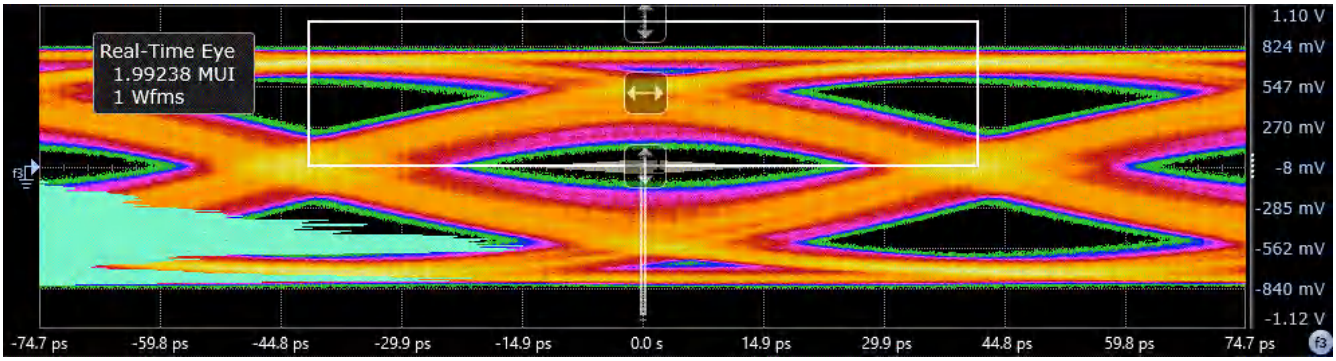

Figure 2-6. Short Cable Model with TDP1204 in Linear Mode (EQ = F)

Table 2-1 summarizes the performance of the TDP1204 when modifying the receiver equalization for the Short Cable Model. For the EQ = 8 condition, the eye heights and eye widths provide the most vertical and horizontal margins for both redriver modes, respectively. However, the limited mode gives greater vertical and horizontal margins over the linear mode. Although the eye width and height vary based on EQ setting, the results for all EQ settings in the Short Cable Model show that tests pass without HDMI 2.1 mask violations for all case except when EQ is set to 0 in linear mode.

Table 2-1. Receiver Equalization Modification for Short Cable Model (SCM3) Result Summary

EQ Setting	Mode	Result
0	Limited	No Mask Failures Eye Width: 50.746 ps Eye Height: 281 mV
	Linear	approximately 7k Mask Failures Eye Width: 10.874 ps Eye Height: 42 mV
8	Limited	No Mask Failures Eye Width: 72.185 ps Eye Height: 579 mV
	Linear	No Mask Failures Eye Width: 68.996 ps Eye Height: 393 mV
F	Limited	No Mask Failures Eye Width: 60.271 ps Eye Height: 521 mV
	Linear	No Mask Failures Eye Width: 40.151 ps Eye Height: 223 mV

2.2 Adjusting Equalization for the Worst Cable Model

This section provides eye diagrams and eye diagram measurements as receiver EQ increases for both linear and limited modes using the Category 3 Worst Cable Model (WCM3) Eye Mask Test. The three different EQ settings, no equalization (0x0h), mid-range equalization (0x8h) and the highest equalization (0xFh) samples how EQ affects the waveform's eye diagram. There were no modifications between the results provided in this section with respect to the test setup or register settings. The VoD and termination settings for these tests were set at 0x3h and 0x2h, respectively.

Figure 2-7 and Figure 2-8 show the eye diagrams when TDP1204 is operating in limited mode and linear mode without signal equalization under the HDMI 2.1 Worst Cable Model, respectively.

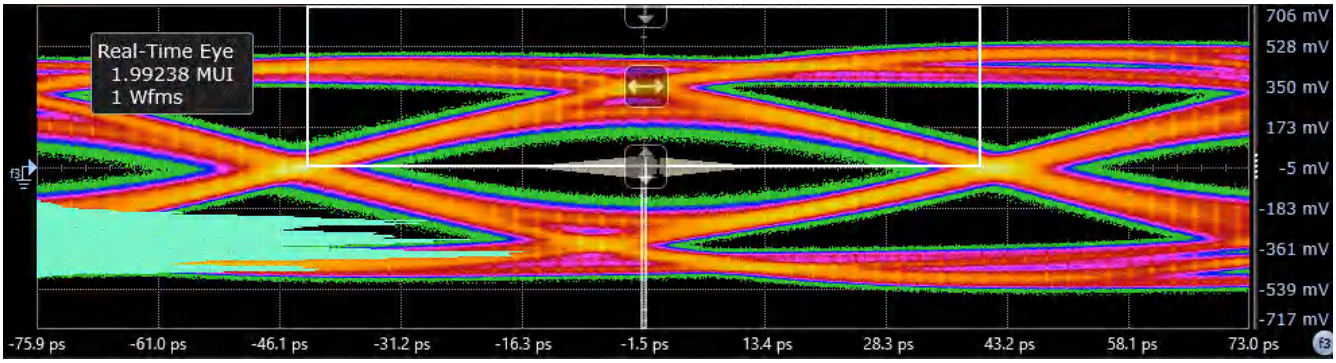

Figure 2-7. Worst Cable Model with TDP1204 in Limited Mode (EQ = 0)

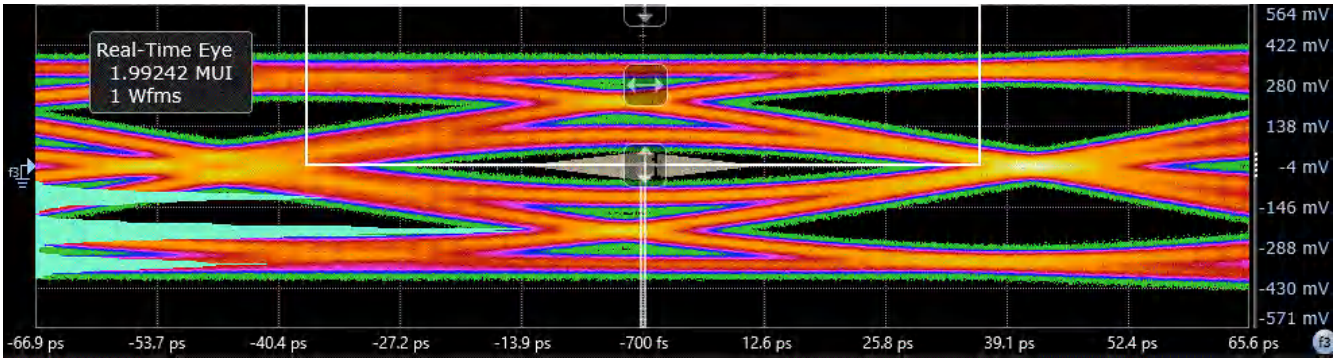

Figure 2-8. Worst Cable Model with TDP1204 in Linear Mode (EQ = 0)

Figure 2-9 and Figure 2-10 show the eye diagrams when TDP1204 is operating in limited mode and linear mode with signal equalization set to 8 under the HDMI 2.1 Worst Cable Model, respectively.

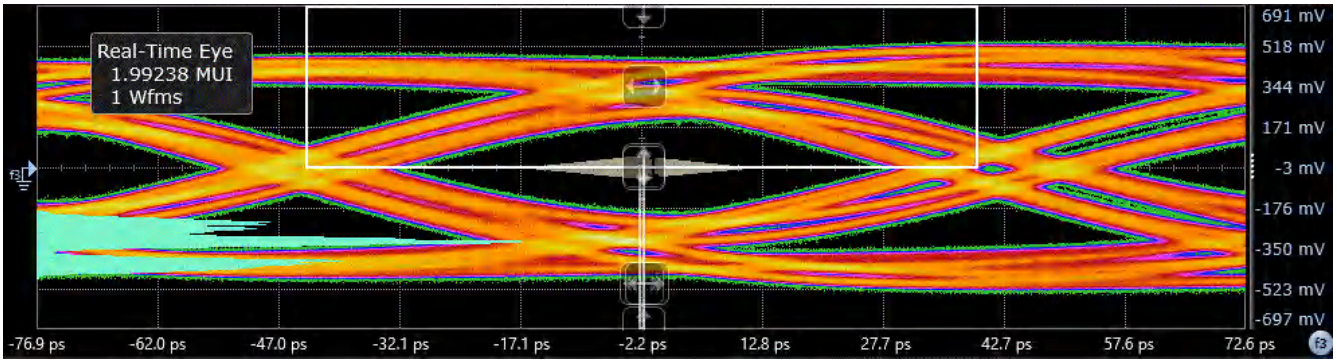

Figure 2-9. Worst Cable Model with TDP1204 in Limited Mode (EQ = 8)

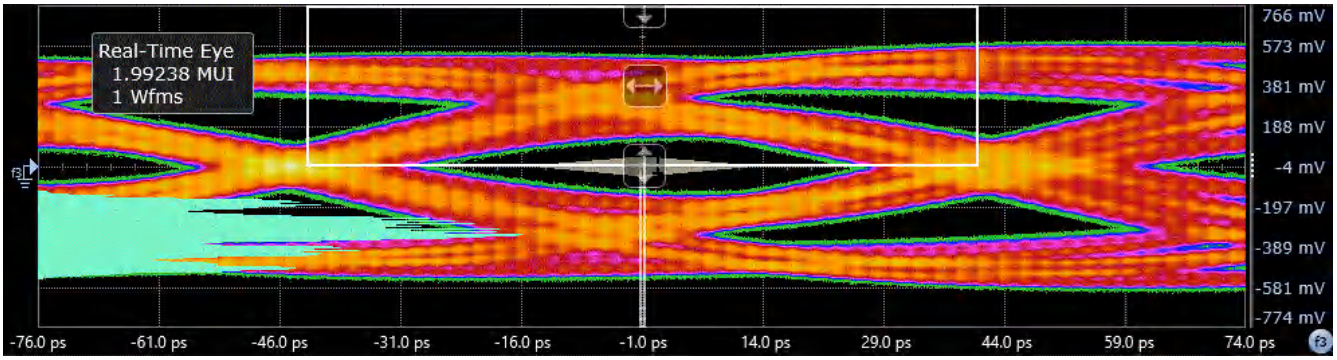

Figure 2-10. Worst Cable Model with TDP1204 in Linear Mode (EQ = 8)

Figure 2-11 and Figure 2-12 show the eye diagrams when TDP1204 is operating in limited mode and linear mode with signal equalization set to the highest equalization setting under the HDMI 2.1 Worst Cable Model, respectively.

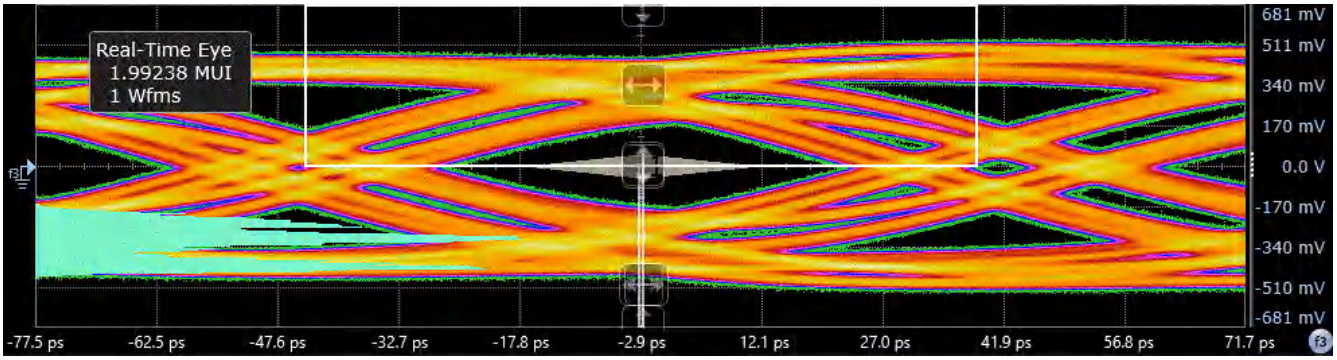

Figure 2-11. Worst Cable Model with TDP1204 in Limited Mode (EQ = F)

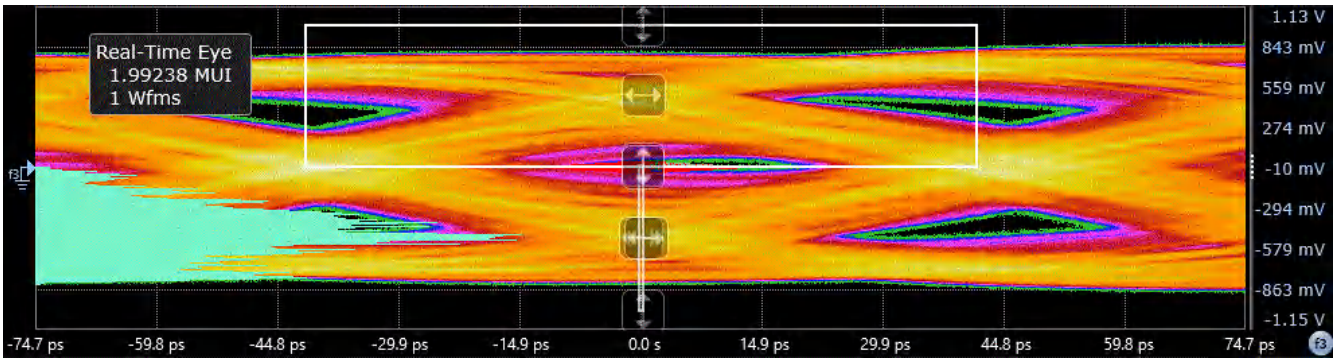

Figure 2-12. Worst Cable Model with TDP1204 in Linear Mode (EQ = F)

Table 2-2 summarizes the performance of the TDP1204 when modifying the receiver equalization for the Worst Cable Model. Similar to the Short Cable Model data, the limited mode gives greater vertical and horizontal margins over the linear mode for all sampled EQ settings. When EQ = 0 or EQ = F the linear redriver experiences HDMI mask violations. The EQ = 8 condition provides the most vertical and horizontal margins for the linear redriver mode which illustrates the importance of selecting the correct EQ setting to avoid eye mask violations.

Table 2-2. Receiver Equalization Modification for Worst Cable Model (WCM3) Result Summary

EQ Setting	Mode	Result
0	Limited	No Mask Failures Eye Width: 61.105 ps Eye Height: 278 mV
	Linear	18 Mask Failures Eye Width: 47.946 ps Eye Height: 102 mV
8	Limited	No Mask Failures Eye Width: 57.117 ps Eye Height: 375 mV
	Linear	No Mask Failures Eye Width: 50.604 ps Eye Height: 237 mV
F	Limited	No Mask Failures Eye Width: 46.981 ps Eye Height: 316 mV
	Linear	approximately 24.9k Mask Failures Eye Width: 0 ps Eye Height: 0 mV

2.3 Adjusting Differential Output Swing

Figure 2-13 to Figure 2-15 shows the VoD of the TDP1204 while operating in linear mode. Although, there is no voltage swing difference between VoD settings for linear mode the VoD is higher than the VoD of the limited redriver mode.

Note, the link training pattern 4 (LTP4) is the waveform used in this section for ease of examining the VoD.

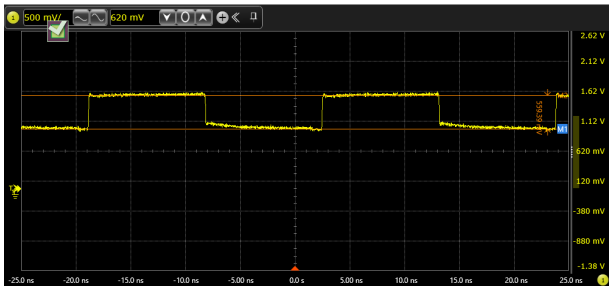

Figure 2-13. TDP1204 operating in Linear Mode (VoD = 0)

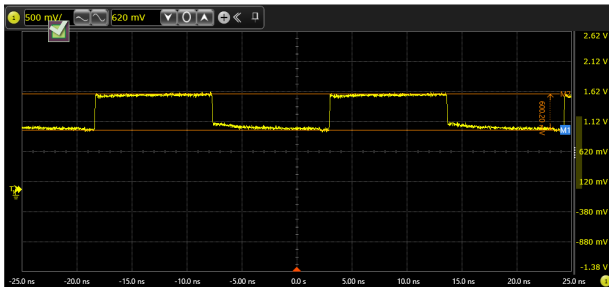

Figure 2-14. TDP1204 operating in Linear Mode (VoD = 1)

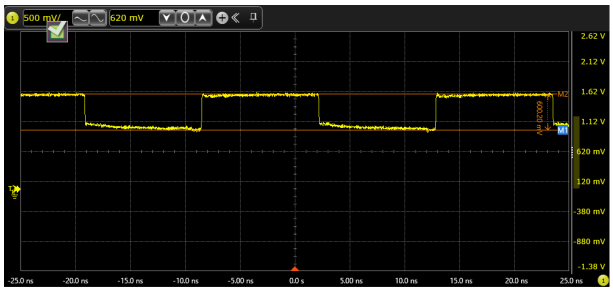

Figure 2-15. TDP1204 operating in Linear Mode (VoD = 3)

Figure 2-16 to Figure 2-18 shows that in limited mode the differential output swing increases as the VoD setting in the VoD register increases in value. The VoD increases more going from VoD = 0 setting to VoD = 7 setting then it does for VoD = 0 to VoD = 3.

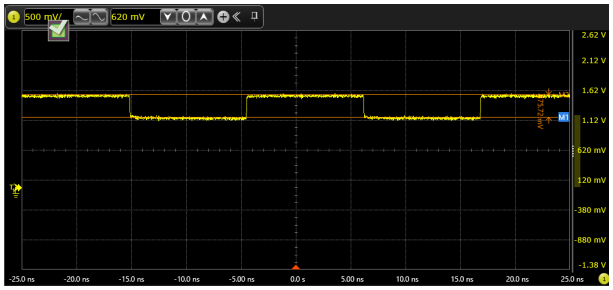

Figure 2-16. TDP1204 operating in Limited Mode (VoD = 0)

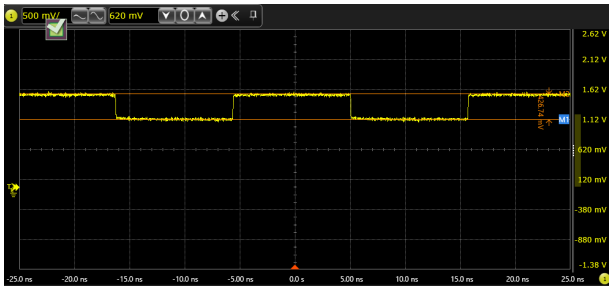

Figure 2-17. TDP1204 operating in Limited Mode (VoD = 3)

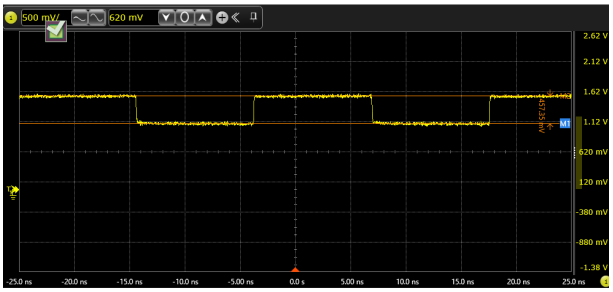

Figure 2-18. TDP1204 operating in Limited Mode (VoD = 7)

Table 2-3 summarizes the performance of the TDP1204 when modifying the swing voltage between linear and limited redriver modes.

Table 2-3. Swing Voltage Modification Result Summary

VoD Setting	Mode	Result
0, 1, and 3	Linear	No voltage swing difference between VoD settings
0, 3, and 7	Limited	Increase in voltage swing as VoD setting increases. Limited mode voltage swing is less than the voltage swing provided in linear mode.

2.4 Adjusting Termination

The transmitter termination can be adjusted as well for the TDP1204. However, when the termination register is set to 0x2h the termination setting automatically adjusts based on HDMI mode providing robustness to the end application. All other eye diagrams in this document have been using 0x2h to set the termination automatically. Furthermore, the register settings for EQ and VoD in this section are 0x8h and 0x3h, respectively.

In Figure 2-19 and Figure 2-20, the TDP1204 is configured in linear mode for the Worst Cable Model with a termination setting of 0 and 1, respectively.

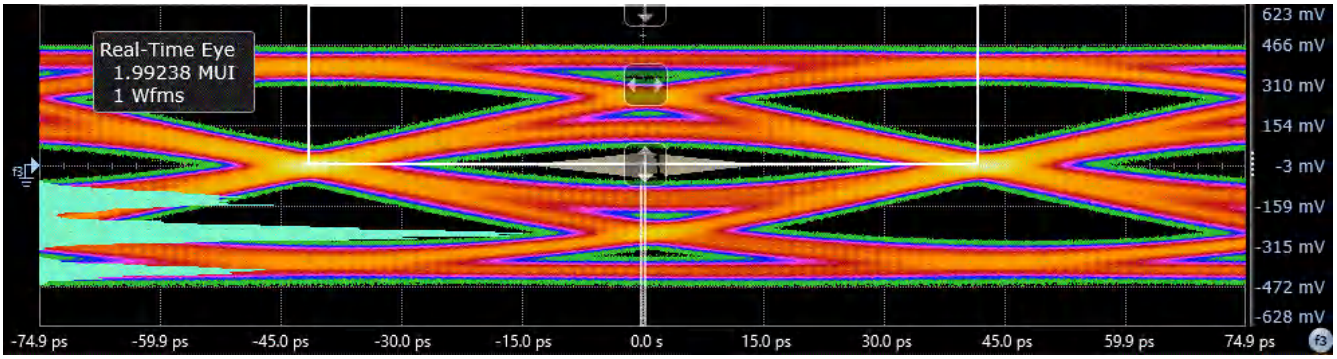

Figure 2-19. Linear Mode for the Worst Cable Model (TERM = 0)

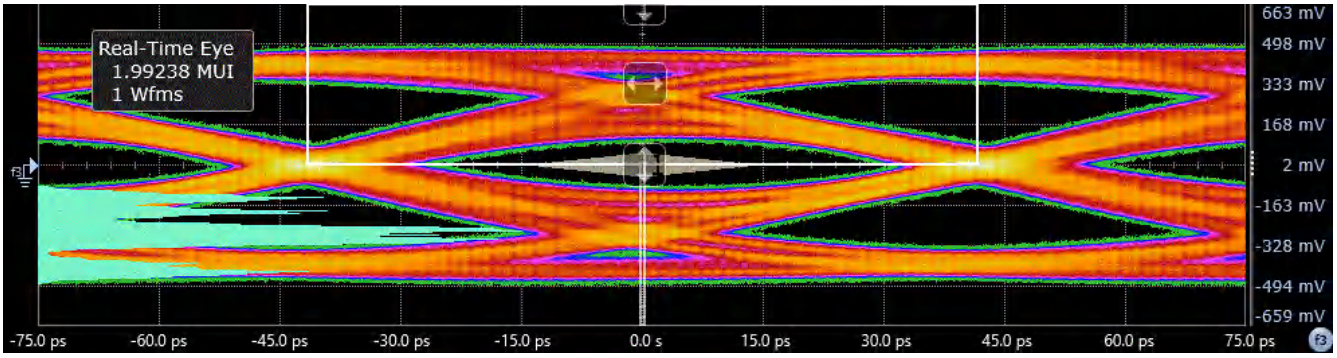

Figure 2-20. Linear Mode for the Worst Cable Model (TERM = 1)

In Figure 2-21 and Figure 2-22, the TDP1204 is configured in limited mode for the Worst Cable Model with a termination setting of 0 and 1, respectively.

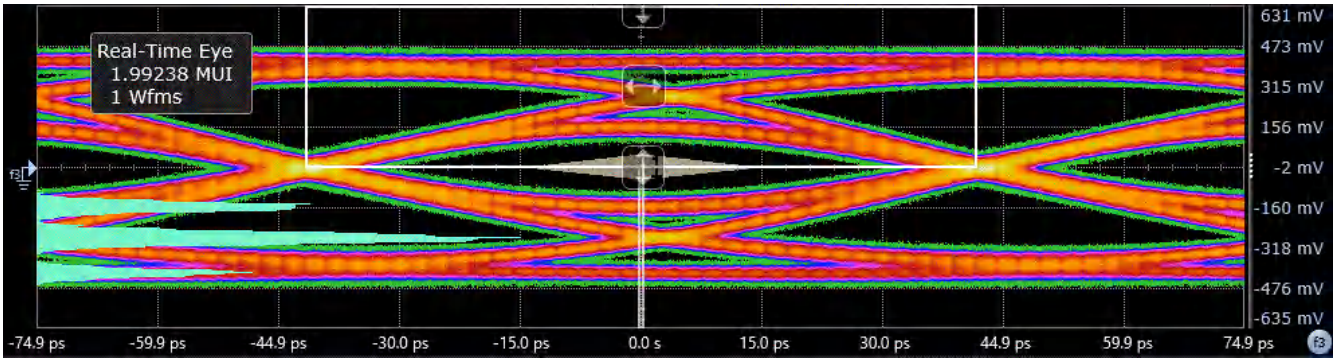

Figure 2-21. Limited Mode for the Worst Cable Model (TERM = 0)

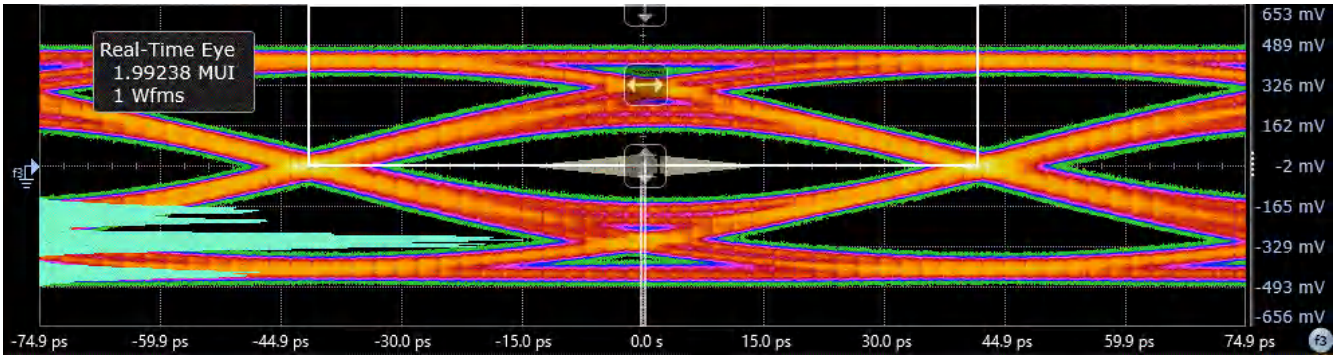

Figure 2-22. Limited Mode for the Worst Cable Model (TERM = 1)

Table 2-4 summarizes the performance of the TDP1204 when modifying the termination control between linear and limited redriver modes. The eye width and eye height both increase when using TERM = 1 or a 300 Ω termination rather than when TERM = 0 or no termination. When TERM = 2 and other register settings are unchanged, as shown inTable 2-4, the eye width is marginally smaller than when the termination setting is set to 1. However, the eye height increase continues the trend shown between the transition between TERM = 0 and TERM = 1.

Table 2-4. Termination Modification for Worst Cable Model (WCM3) Result Summary

Termination Setting	Mode	Result
TERM = 0 or No Termination	Limited	No Mask Failures Eye Width: 60.134 ps Eye Height: 188 mV
	Linear	No Mask Failures Eye Width: 51.986 ps Eye Height: 130 mV
TERM = 1 or 300 Ω Termination	Limited	No Mask Failures Eye Width: 64.116 ps Eye Height: 274 mV
	Linear	No Mask Failures Eye Width: 55.060 ps Eye Height: 176 mV

3 Transmitter Emphasis Control

The TDP1204 supports both linear and limited redriver modes. However, the transmitter pre-emphasis and de-emphasis control is only supported in limited mode for HDMI 1.4 or HDMI 2.0. When the TDP1204 is operating as an HDMI 2.1 redriver pre-emphasis implementation is not available and only the de-emphasis is modified by the device based upon the DDC TXFFE snooped value. Since the pre-emphasis implementation is not available when operating as an HDMI 2.1 redriver, care must be taken while running HDMI 2.1 compliance testing to make sure that the pre-emphasis tests are not inadvertently selected. Therefore, running the pre-emphasis tests while using TDP1204 as an HDMI 2.1 redriver causes HDMI 2.1 compliance testing to report failures.

4 Summary

The register settings chosen depend upon each individual application, but this document demonstrates the effects that the receiver EQ, VoD, termination and redriver mode registers have on the HDMI 2.1 FRL waveform. The EQ settings in linear and limited mode need to be carefully selected to avoid HDMI mask violations and signal integrity issues. The VoD settings are utilized to control the output voltage swing in limited mode if a higher or lower voltage swing is needed to meet HDMI test requirements. While termination settings can be modified the recommendation is to set this register to 0x2h to take advantage of the automatic TX termination control based upon HDMI mode.

5 References

- Texas Instruments, *TDP1204 12-Gbps, DC/AC-Coupled to HDMI™ 2.1 Level Shifter Hybrid Redriver*, data sheet

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