Application Note

Using DS90LV047-48EVM for Capturing DisplayPort AUX Channel

Harry Shin

ABSTRACT

The DisplayPort interface has an auxiliary (AUX) channel for bi-directional communication between the DisplayPort source and DisplayPort sink. The AUX channel is used for DP link training to optimize channel configuration. This application note is an introduction to monitor the DisplayPort AUX channel while link training. This assists in understanding the link training sequence and behavior between DisplayPort sink and source by extracting the discrete AUX transactions.

Table of Contents

Trademarks

All trademarks are the property of their respective owners.

1 Introduction

The DisplayPort Auxiliary (AUX) channel is a half-duplex, bidirectional channel consisting of one differential pair, as shown Figure 1-1. This channel supports about 1Mbps, or 675Mbps as FAUX.

The DisplayPort upstream device weakly pulls down the AUX+ line to GND and weakly pulls up the AUX- line to DP_PWR with resistors in the range of 10KΩ-105KΩ between the AC-coupling capacitors and the device connectors. This assists the DisplayPort upstream device in detecting the downstream device when connected. When both devices are connected, AUX+ line DC voltage becomes LOW level. This signal indicates that the DisplayPort upstream device detects that the downstream device is connected.

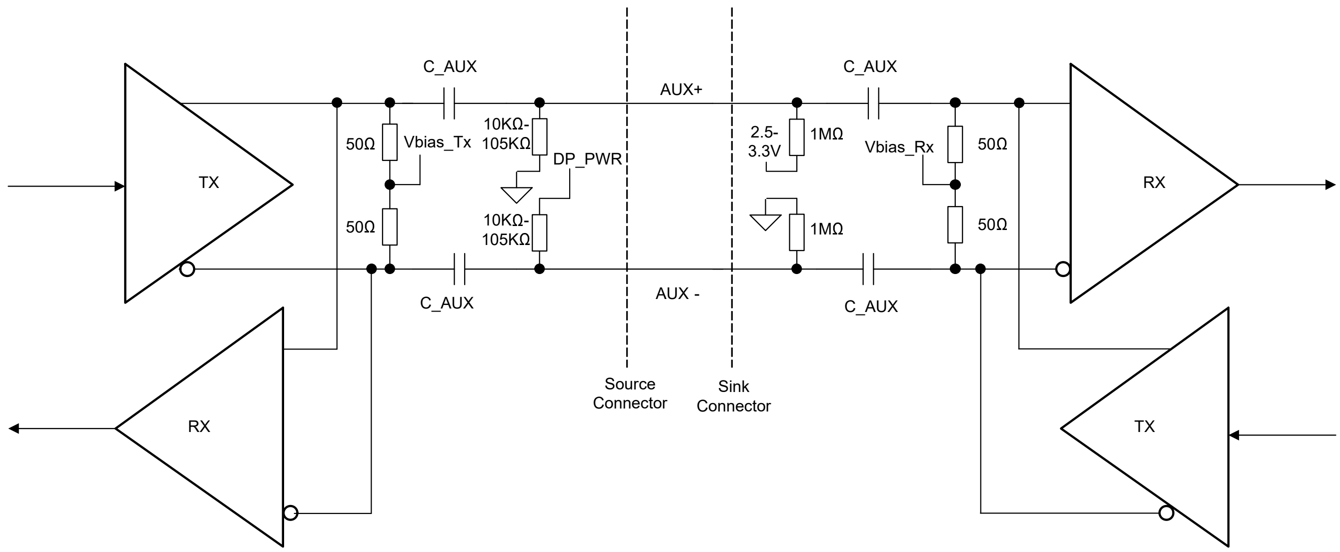

Figure 1-1. AUX Channel Differential Pair

The AUX channel specification supports Manchester II code transactions at 1Mbps. Figure 1-2 is an example of Manchester encoding.

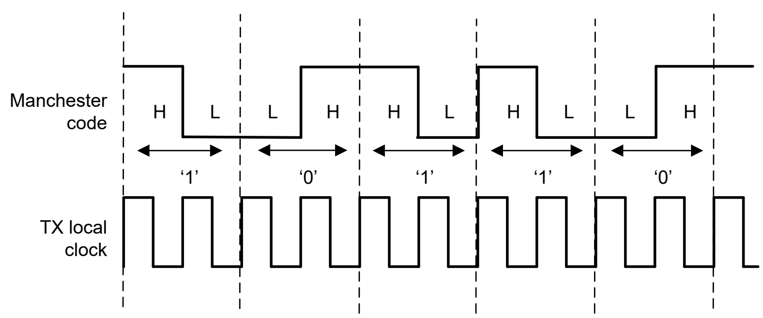

Figure 1-2. Manchester II Coding

2 DisplayPort Link Training Sequence

The DP link training sequence consists of clock recovery, channel equalization, and symbol lock stages. The status of these sequences is reported in the sink device's DPCD (Display Port Configuration Data) at address 0x00202h/0x00203h as shown in Table 2-1.

Table 2-1. DPCD Address for Link Training Sequence

	0x00202	0x00203
bit7	Reserved, Read 0.	Reserved, Read 0.
bit6	LANE1_SYMBOL_LOCKED	LANE3_SYMBOL_LOCKED
bit5	LANE1_CHANNEL_EQ_DONE	LANE3_CHANNEL_EQ_DONE
bit4	LANE1_CR_DONE	LANE3_CR_DONE
bit3	Reserved, Read 0.	Reserved, Read 0.
bit2	LANE0_SYMBOL_LOCKED	LANE2_SYMBOL_LOCKED
bit1	LANE0_CHANNEL_EQ_DONE	LANE2_CHANNEL_EQ_DONE
bit0	LANE0_CR_DONE	LANE2_CR_DONE

As part of the link training process, the source device accesses the sink device's DPCD (Display Port Configuration Data) to obtain information about the sink device's capabilities, such as the DP version and the maximum supported link rate and lane count. Overall, link training status or configuration between upstream device and downstream device is performed by the DisplayPort AUX channel. Please note that this can be different across different DisplayPort specifications.

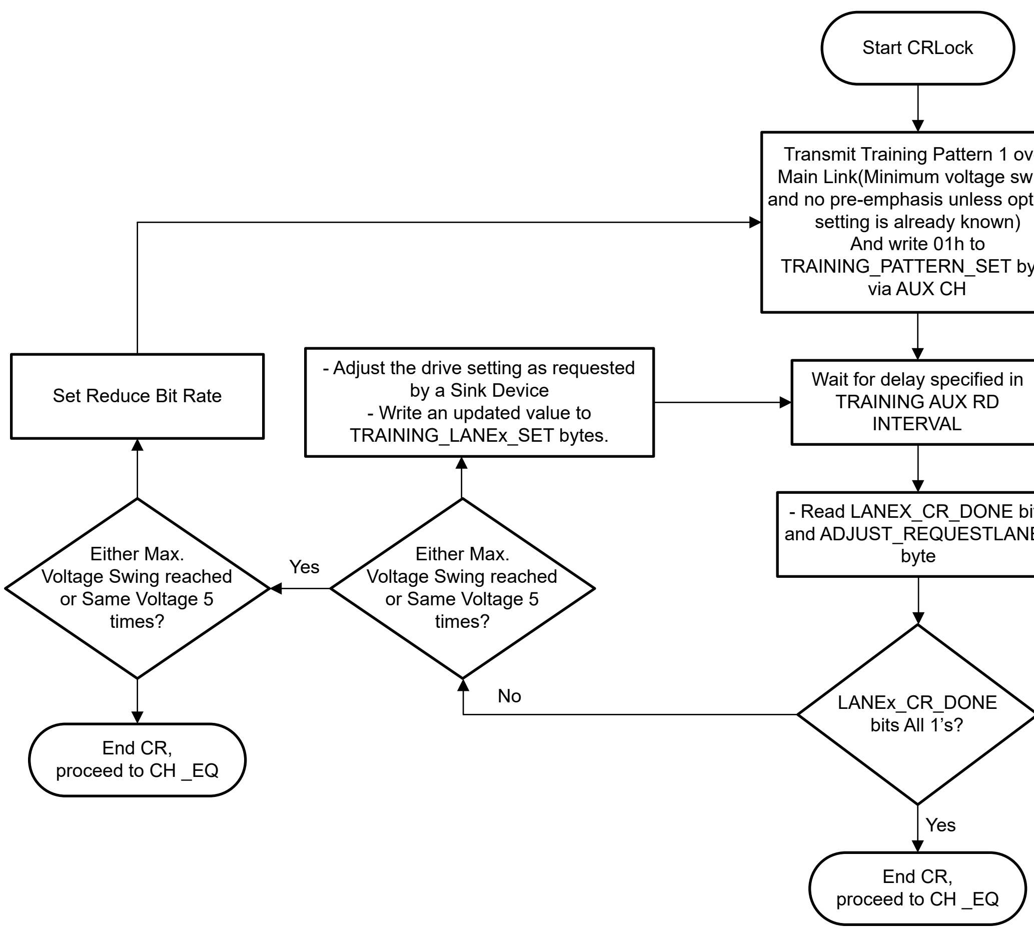

Figure 2-1. Clock Recovery Sequence of Link Training

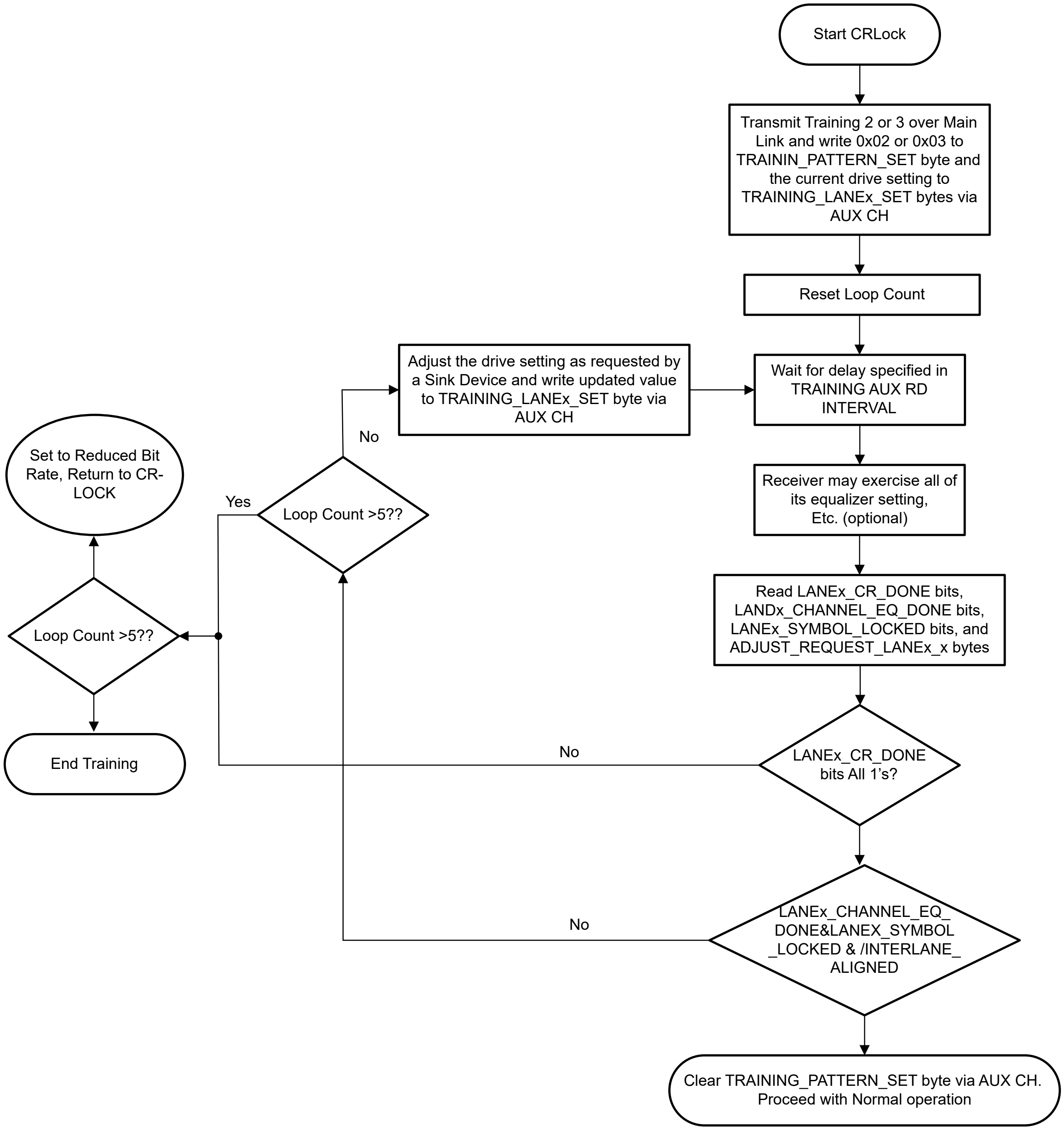

Figure 2-2. Channel Equalization Sequence of Link Training

3 AUX Transaction Syntax

The syntax of AUX transactions in Manchester format uses 1Mbps rate. There are two kinds of transaction as shown in the following.

1. Native AUX transaction.
2. I2C over AUX transaction.

AUX transactions must start with a preamble *SYNC* for synchronizing the requester and the replier, and must end with a *STOP* condition. AUX transactions consist of command, address and data.

3.1 Request Command Definition of AUX Transaction

Bit 3 = Native AUX or I2C over AUX.

1b'1 = DisplayPort transaction.

1b'0 = I2C transaction.

- When bit3 = 1 (Native AUX transaction).
- Bits 2:0 = Request type.
  - 000 = Write
  - 001 = Read

- When Bit 3 = 0 (I2C over AUX transaction).
- Bit2 = MOT (Middle of Transaction) bit.
- Bits 1:0 = I2C_Command.
- 00 = Write.
- 01 = Read.
- 10 = Write_Status_Update_Request.
- 11 = Reserved.

3.2 Reply Command Definition of AUX Transaction

Bits 1:0 = Native AUX reply field.

- 00 = AUX_ACK.
- 01 = AUX_NACK.
- 10 = AUX_DEFER.
- 11 = Reserved.

Bits 3:2 = I2C over AUX reply field.

- 00 = I2C ACK.
- 01 = I2C NACK.
- 10 = I2C DEFER.

11 = Reserved

4 Introduction of DS90LV047-48AEVM

The DS90LV048 device is a differential line receiver which supports up to 200MHz bandwidth. This device can help to convert AUX differential signals to single ended signals for capturing transactions easily. The DS90LV047-48AEVM is shown in Figure 4-1.

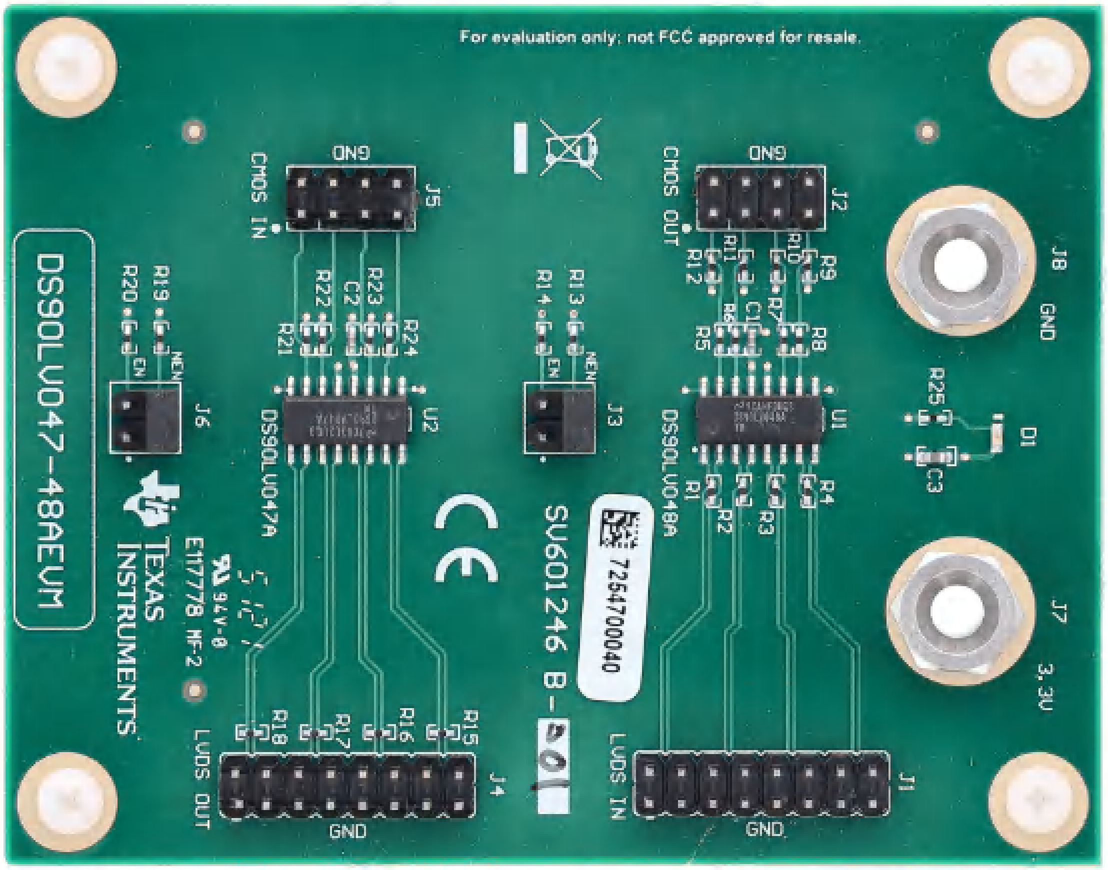

Figure 4-1. DS90LV047-48AEVM

5 Configuration of Measuring AUX CH With DS90LV047-48AEVM and Logic Analyzer

Figure 5-1 shows the hardware configuration to measure AUX transactions. This setup includes the DS90LV048A-EVM and a logic analyzer to capture the waveforms.

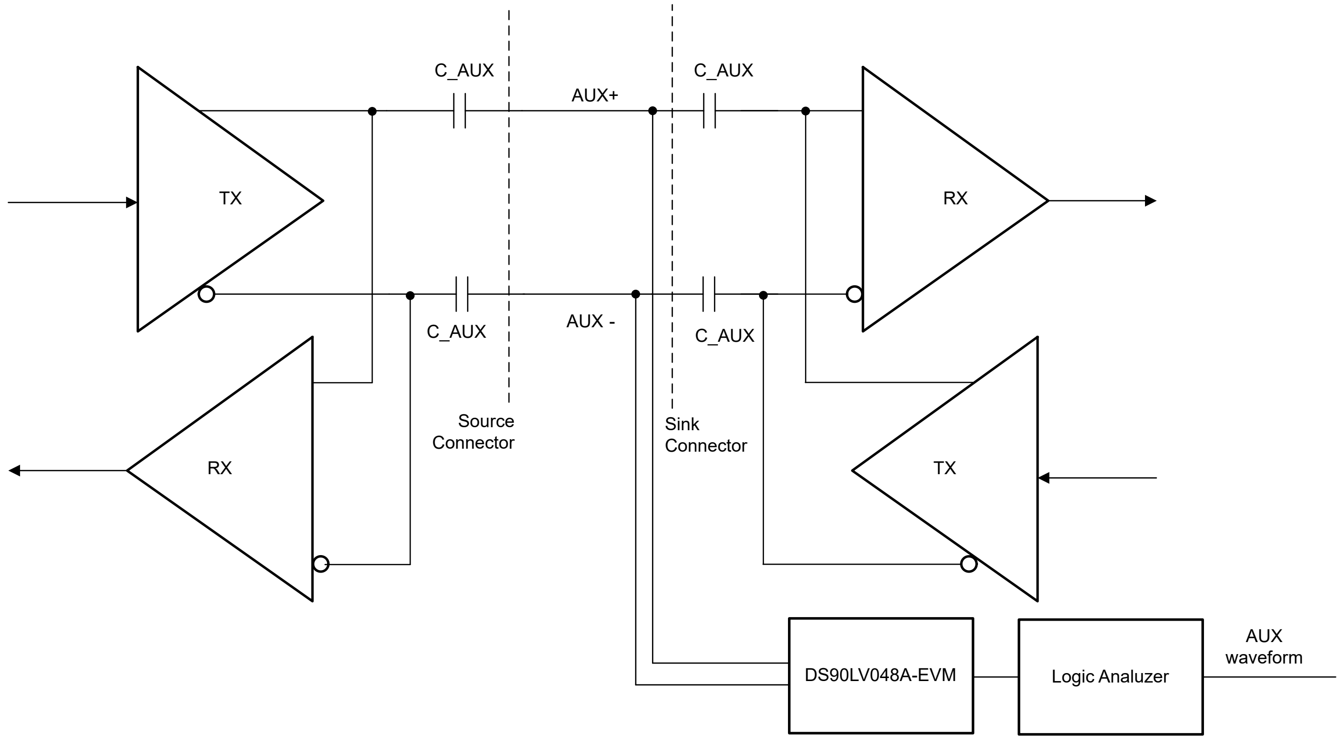

Figure 5-1. Diagram for Measuring AUX Transaction Using DS90LV048A-EVM

The measured waveform using an oscilloscope is shown in Figure 5-2. Oscilloscopes are unable to provide a long-time measurement, and also have difficulties accurately capturing the waveforms.

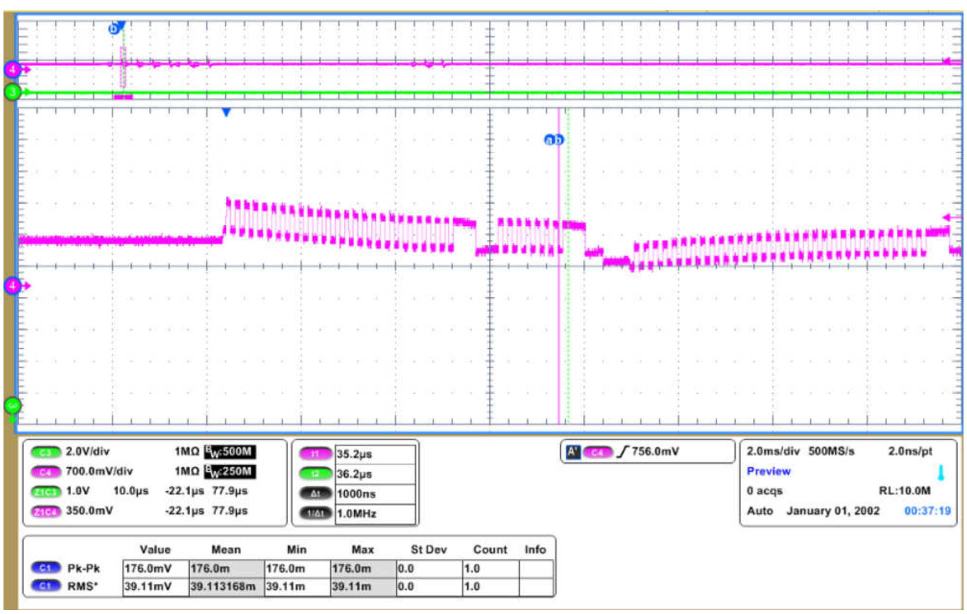

Figure 5-2. AUX Waveform by Oscilloscope

Figure 5-3 shows the measurement from a logic analyzer. The logic analyzer capture shows better visibility for long time measurements, which provides more efficiency when analyzing the AUX transactions.

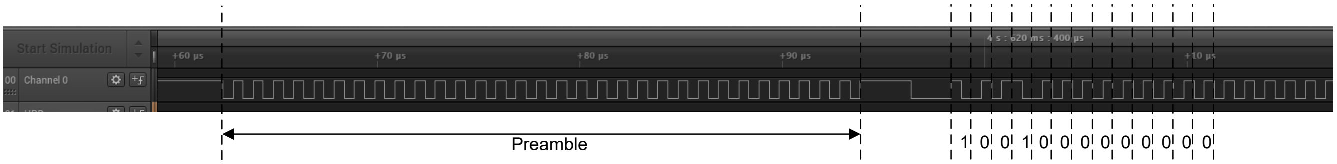

Figure 5-3. AUX Waveform by Logic Analyzer

Figure 5-4 shows the logic analyzer capture with a plug-in extension to interpret and display AUX transactions above the waveforms. This helps with understanding the DisplayPort source and Sink behavior and AUX transactions quickly, particularly the link training period.

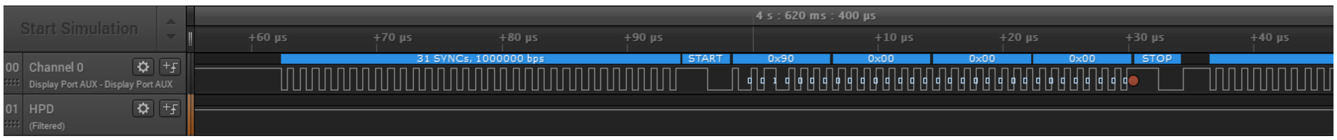

Figure 5-4. AUX Waveform by Logic Analyzer With Extension

6 Summary

The auxiliary channel of DisplayPort distinguishes it from other display interfaces like OLDI or HDMI because it supports bidirectional communication between DisplayPort source and sink devices. This brings many benefits to DP link training conditions with optimized link rates and voltage swing or pre-emphasis levels. However, the AUX channel can also have issues across the TX and RX of the system when incorrectly matched or implemented. This application note provides an approach to verifying the DisplayPort link training AUX transactions for debugging purposes.

7 References

- Vesa *About DisplayPort - VESA - Interface Standards for The Display Industry*.
- Texas Instruments *DS90LV047-48AEVM Evaluation Board* user's guide.
- Saleae logic analyzer *Saleae Logic Analyzers*.
- GitHub, *GitHub - Alex-the-Smart/DPAUXAnalyzer: Display Port AUX Analyzer for Saleae Logic*.
- Tektronix, *DPO7000*, oscilloscope.