Experimental Lab 2 Report

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Written in LaTeX

Aims

The aims of this experiemnt are to invesgiate the formation of eye diagrams based from digital signals. Eye diagrams can help to visualize SNR, Jitter, and timing error in a digital signal. We will be using a digital oscilloscope to visualize our outputs.

Method

We enabled infinite persistence and chose an appropriate trigger height on the oscilloscope and it produced an eye diagram as shown in Figure 1.

We then changed the frequency of the wave to 50Hz, 100Hz, 200Hz, and 300Hz respectively to analyse the effect this has on the shape of the eye. The output of this is shown in Figure 2.

We wrote a python script to generate 2 different types of array to be input into a picoscope for wave generation. Our script generated a wave that had 10 sample points per bit. We generated 2 different types of bit sequence: on-off keying and PAM-4. We generated 5 different waves each with a different SNR (6, 8, 12, 18, and 24dB). The output from the on-off keaying is shown in Figure 3 and the PAM-4 keying is shown in Figure 4.

We set the oscilloscope math function to low pass filter and gradually changed the frequency from 10MHz to 40kHz and analyzed the effect on our eye diagram. The output of this experiment is shown in Figure 5.

Conclusion

Eye diagrams are created by overlaying multiple segments of a digital signal to create a single graphical representation of the wave. They are used to measure the integrity of a digital signal. A "jittery" or "closed" (high signal interference) eye diagram means low integrity. Example (a) in Figure 1 shows a clear eye diagram whereas in example (b) the trigger is too low and therefore jitter is high.

We tested the eye diagram with multiple different frequencies. From the results produced we can see that at a low frequency the edges, or "lids" of the eye diagram will be further apart. At higher frequencies they will be closer together (with the distance roughly halving proportionally to a doubling of the frequency). We can also see that the eye becomes gradually more rounded or starts to "close" at higher frequencies. This shows that higher frequencies can lead to signal loss. This could be due to interference within close peaks within the signal and the fact that the signal may not have time to reach peak voltage with faster oscillations.

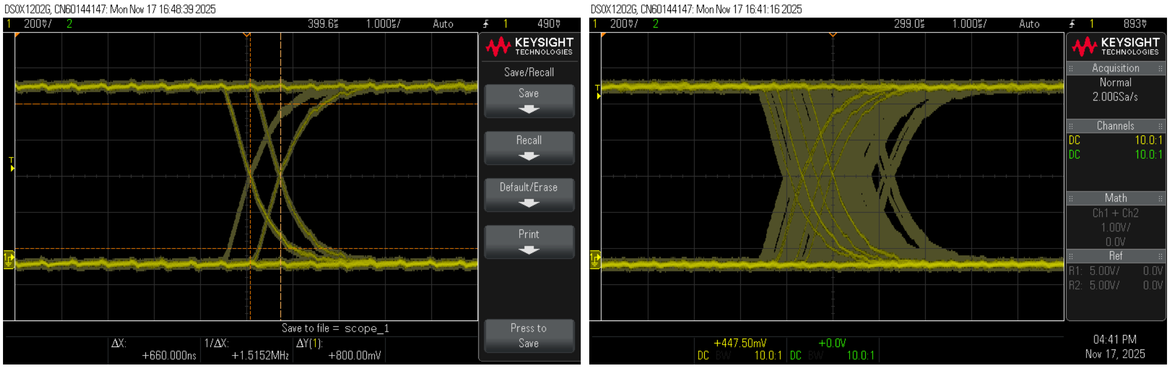
We can see that a low signal to noise ratio cause extreme jitter in the eye diagram which means low integrity in the signal. At (6-8:1)dB the eye diagram is almost unidentifiable due to jitter. At (12:1)dB we can begin to see an eye diagram forming. At (18:1)dB the diagram becomes much clearer and we can begin to identify the eyelids. At (24:1) the signal is clear and we can identify the eyelids. This shows that at signal to noise ratios below (12:1)dB have too much interference to produce a legible signal with on-off keying. We can also see that the signal narrows as noise decreases. This may be because the noise combines certain peaks in the signal which increases the amplitude.

The main difference between PAM-4 keying and on-off keying is that PAM-4 uses 4 bit levels whilst on-off uses 2 (binary). The way noise effects these signals is very similar. From (6-8:1)dB there is not distinguashable shape. From (12-18:1)dB the eye diagram begins to form. At (24:1)dB the signal becomes clear and the eyelids are identifiable. One of the main differences we can see is that at lower SNR the PAM-4 signal shrinks whereas the on-off signal widens. This may be because with high noise the 4 levels in PAM-4 interfer deleteriously which reduces signal amplitude.

At a 10MHz bandwidth the output is a basic square wave. There is no identifiable curvature or eye formation. At 1MHz the corners begin to smooth. At 40kHz the eyes become clear. This is beacuse as the bandwidth shrinks the high frequencies of the signal become attenuated (Their peaks are cut) which leads to sloping at the edges of the square wave.

This lab has taught us the effect that SNR, bandwidth, frequency, and trigger point has on the integrity of signals. We have learned how to create, read, and adjust eye diagrams.

Results



(a) (b)

Figure 1: Eye Diagram - High and Low Trigger

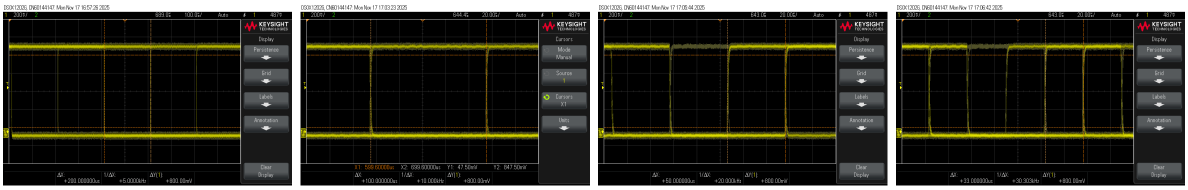


Figure 2: Frequencies [50, 100, 200, 300]Hz

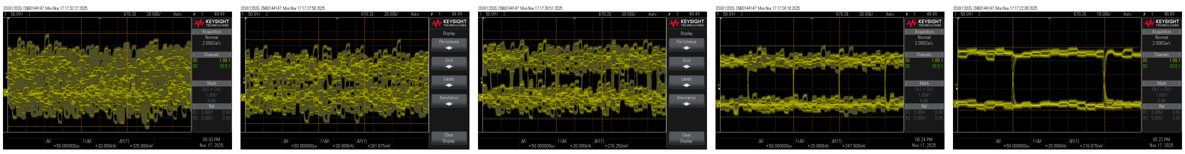


Figure 3: On-off keying SNR ratios [6, 8, 12, 18, 24]dB

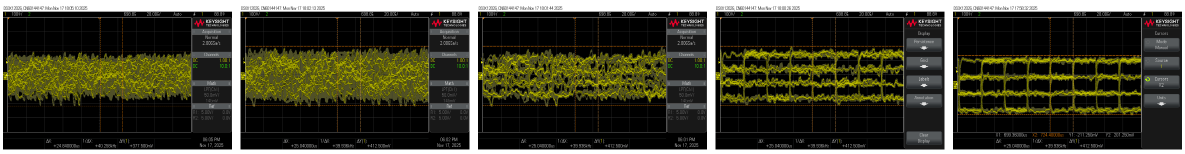


Figure 4: PAM-4 SNR ratios [6, 8, 12, 18, 24]dB

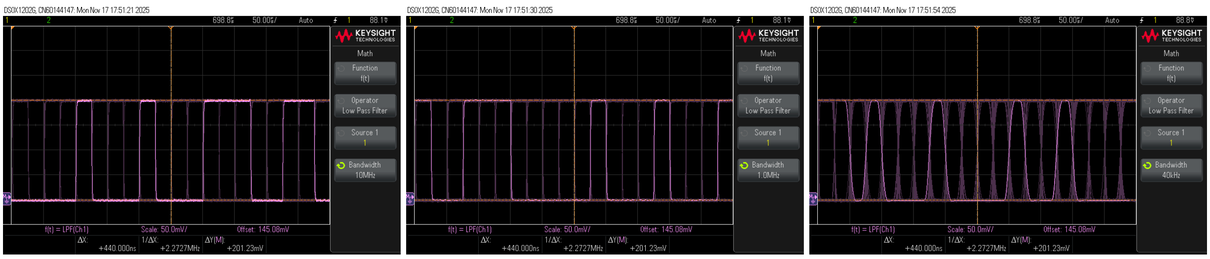


Figure 5: Low-Pass Filter Bandwidth [10MHz, 1MHz, 40kHz]