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shaping tomorrow with you

Comment #36, #37: Autocorrelation of PRBS13Q

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Comment #36 (with updates)

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- When the waveform is captured, averaging multiple waveform captures was recommended in clause 85.8.3.3.4 that is referred from clause 94.3.12.5.2 that is referred from 120D.3.1.3 that is referred from 120D.3.1.6. Since averaging removes uncorrelated noise, it is not recommended to use averaging when capturing waveform for SNDR measurement.
- However, if we send PRBS31Q on the other lanes, such restriction of not to use averaging would mandate use of a realtime scope and exclude an option to use a sampling scope, because a sampling scope cannot capture asynchronous crosstalk correctly; limited-bandwidth noise is aliased to unlimited-bandwidth white noise.
- Alternatively, we may ~~permit to use averaging~~ use a sampling scope (without averaging), if we send PRBS13Q on the lanes not under test, because a sampling scope can capture synchronous crosstalk correctly.
- PRBS13Q on different lanes should be uncorrelated as much as possible.
- ~~However, PRBS13Q on different lanes are synchronous because the pattern length is same.~~
- ~~Therefore, averaging will not remove their effect of crosstalk.~~

Comment #36 Suggested Remedy (w/ updates)

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- Change the first ~~and second~~ paragraph~~s~~ of 120D.3.1.6 to:
- Signal-to-noise and distortion ratio (SNDR) is measured at the transmitter output using the following method, with transmitters on all lanes enabled, with identical transmit equalizer settings.
- Capture at least one complete cycle of the PRBS13Q test pattern (120.5.11.2.3) at TP0a per 85.8.3.3.4 excepting that averaging multiple waveform captures is not ~~recommended~~used. If ~~averaging is used, although it is not recommended~~a sampling scope is used, send PRBS13Q on the lanes not under test. ~~Otherwise~~If a realtime scope is used, send PRBS13Q, PRBS31Q, or a valid 200GBASE-R or 400GBASE-R signal on the lanes not under test.
- ~~Compute the linear fit to the captured waveform and the linear fit pulse response, p(k), and error, e(k), according to 120D.3.1.3. Denote the standard deviation of e(k) as σ_e.~~
- Also specify the minimum offset of 940 symbols between PRBS13Q patterns between any lane and any other lanes in Clause 120.5.11.2.3.

Comment #37

- Unlike PRBS31Q, PRBS13Q does not specify the seed for each lane or the minimum offset between PRBS13Q on different lanes. The Autocorrelation function of PRBS13Q has a strong peak at an offset of 452 symbols with correlation coefficient of 0.4. Lack of specification of seed for each lane or the minimum offset between lanes may result in strong correlation between test patterns on different lanes that is not desired for measurement accurately. It is also discouraged to reuse 4 seeds in Table 94-11 by adding 4 more seeds, because they will make the offset between Lane 1 and 2 only 827 symbols that is not sufficient to separate the strong peak between lanes. Autocorrelation function of PRBS13Q is almost flat for an offset between 470 symbols and 7720 symbols.

Background

- Unlike PRBS31Q, PRBS13Q is not specified with the seed for each lane or the minimum offset between PRBS13Q on different lanes.

- Lack of specification of seed for each lane or the minimum offset between lanes may result in strong correlation between test patterns on different lanes that is not desired for accurate measurement.

- We may reuse Table 94-11 that has 4 seeds by adding 4 more seeds, but it is not clear if we can get large enough offset using the seeds in Table 94-11.

- Hence, I studied the autocorrelation function of PRBS13Q and the offset with 4 seeds in Table 94-11.

Autocorrelation function of PRBS13Q (1/2)

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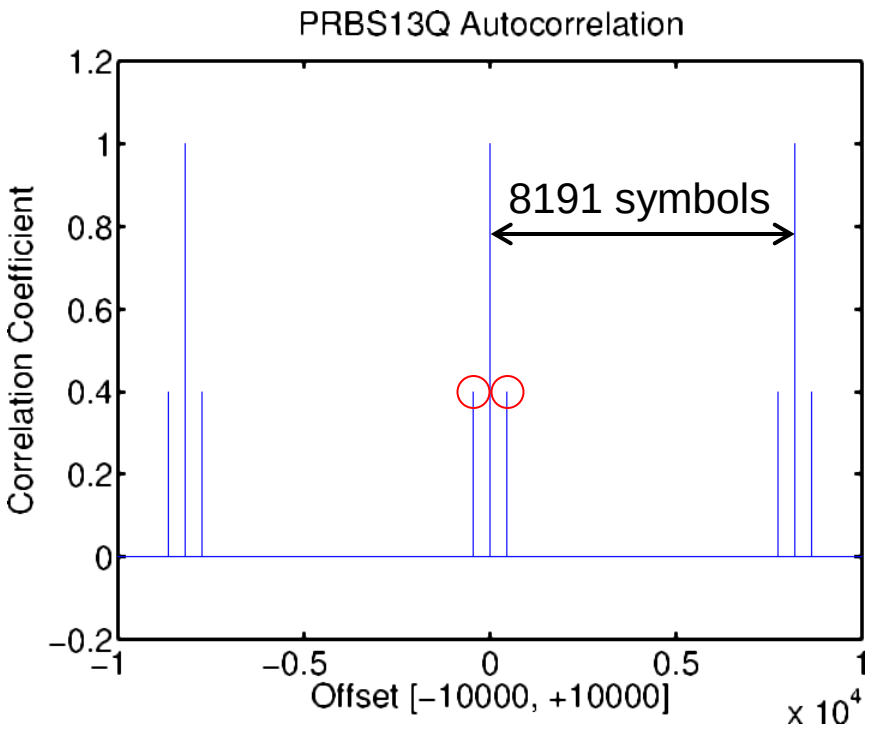
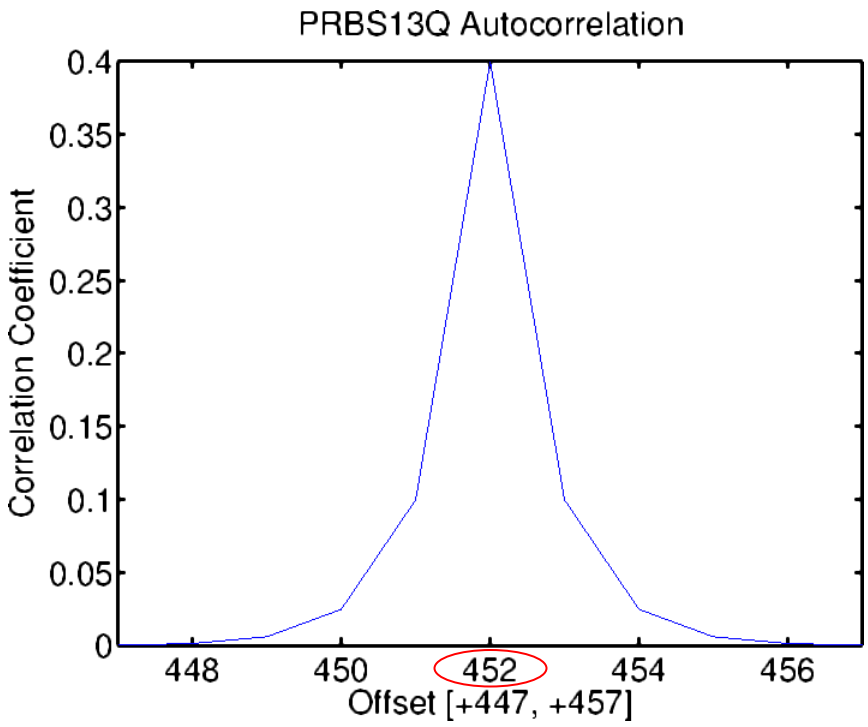
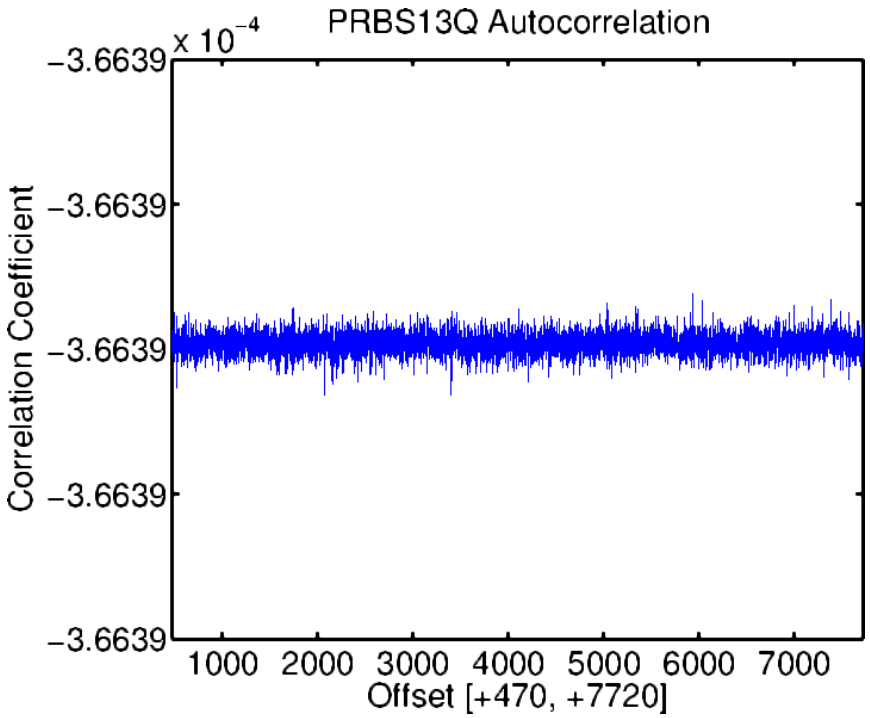
- Autocorrelation function of PRBS13Q is a periodic function with a cycle of 8191 symbols (i.e. length of PRBS13Q)
- It has a strong peak at an offset of ±452 symbols with correlation coefficient of 0.4.





Autocorrelation function of PRBS13Q (2/2)

- Autocorrelation function of PRBS13Q has flat correlation coefficient about -3.6639E-4 with an offset from 470 symbols to 7720 symbols



Offset between lanes with seeds in Table 94-11

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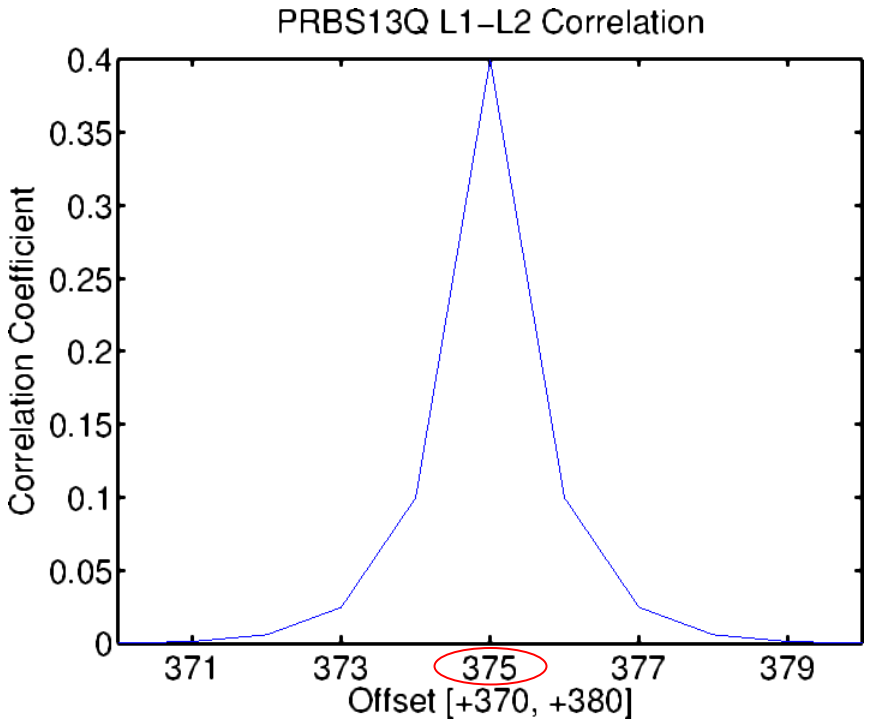
- Offset between L1 and L2 is only 827 symbols
  - It brings the strong peak of the adjacent lane closer than its own
    - The offset to the strong peak in the adjacent lane is 375 (=827-452) symbols
    - It is closer than its own peak at the offset of 452 symbols

Offset between lanes (# of symbols)

	Lane 3	Lane 2	Lane 1
Lane 0	1810	3259	4086
Lane 1	2267	827	
Lane 2	1449		



Conclusion

- It is recommended to specify PRBS13Q pattern has a minimum offset of 940 (=470x2) symbols between any lane and any other lane.

- It is discouraged to reuse 4 seeds in Table 94-11 by adding 4 more seeds, because they will make the offset between L1 and L2 only 827 symbols which brings the strong peak of the adjacent lane closer than its own.

Comment #37 Suggested Remedy

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- Add the following statement to the second paragraph in 120.5.11.2.3:
- To avoid correlated crosstalk, it is highly recommended that the PRBS13Q pattern is generated from different seeds for each lane so that the PRBS13Q pattern has a minimum offset of 940 symbols between any lane and any other lane.

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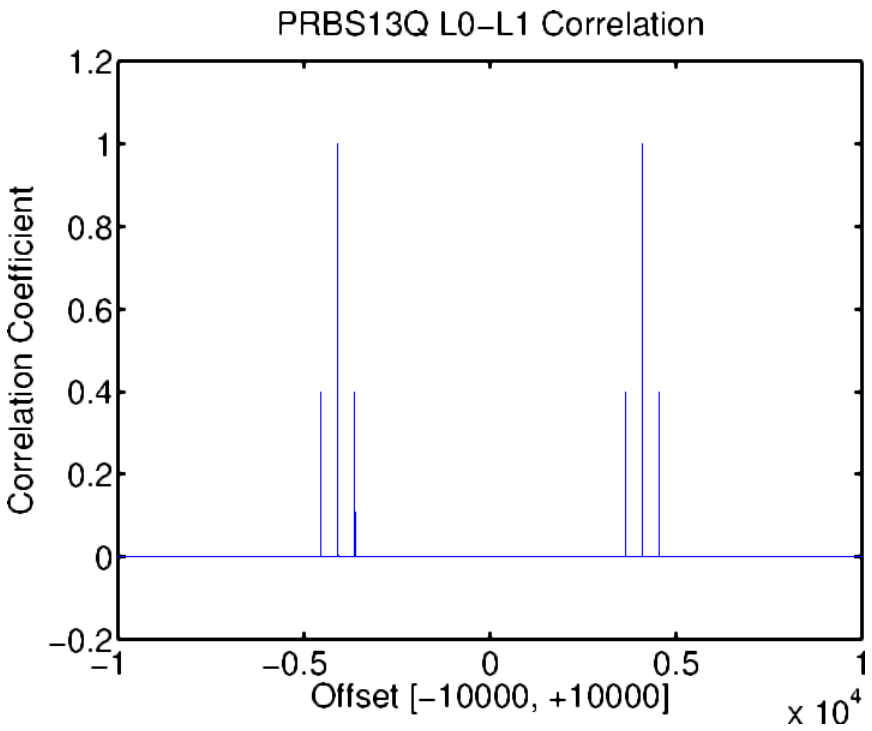
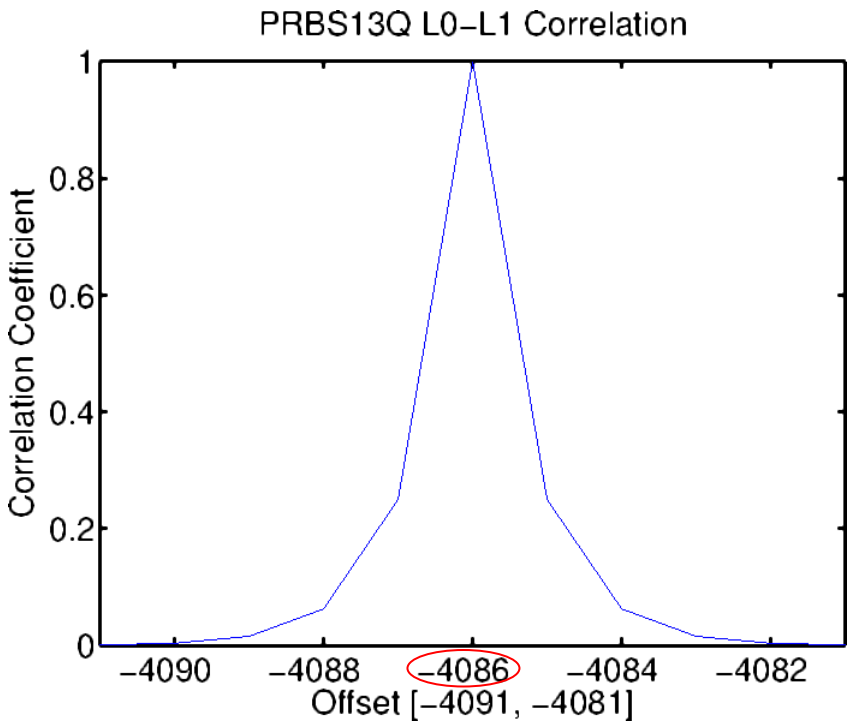
- Offset between lanes using seeds in Table 94-11

Offset between L0 and L1 using Table 94-11

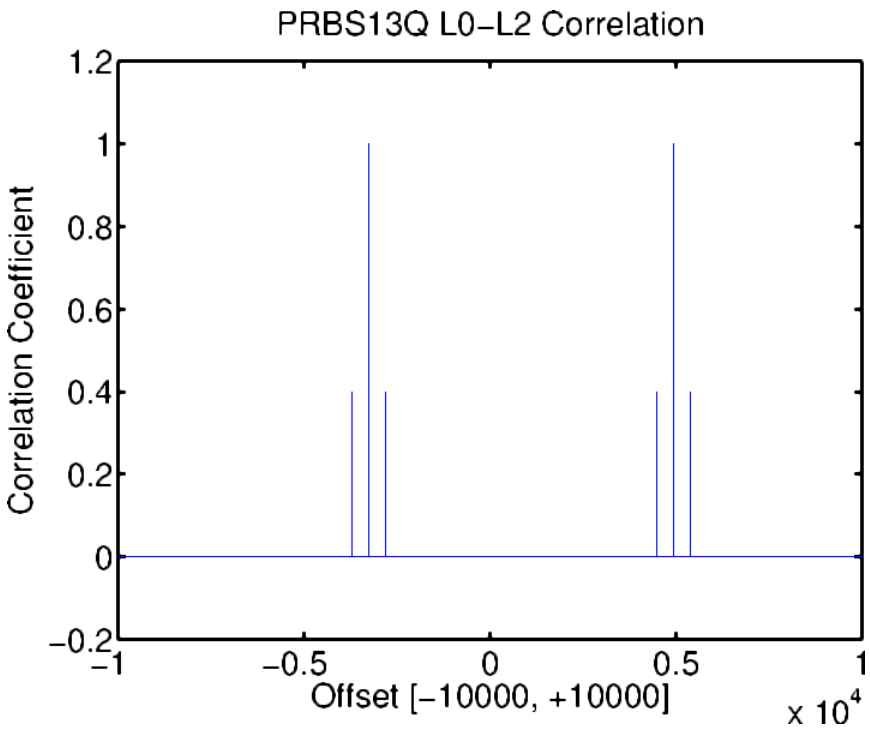
- The offset between Lane 0 and Lane 1 is 4086 symbols.

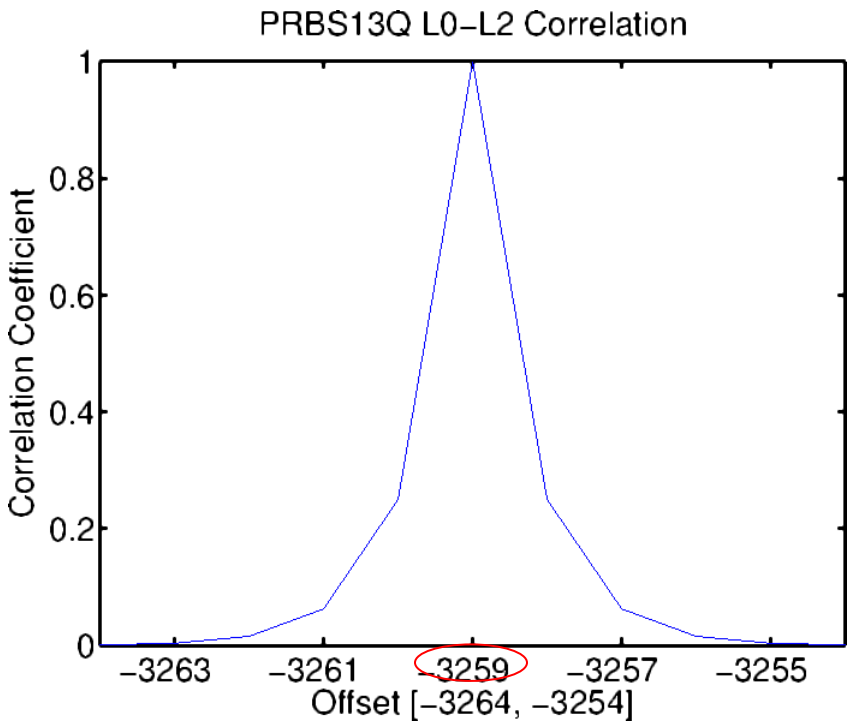




Offset between L0 and L2 using Table 94-11

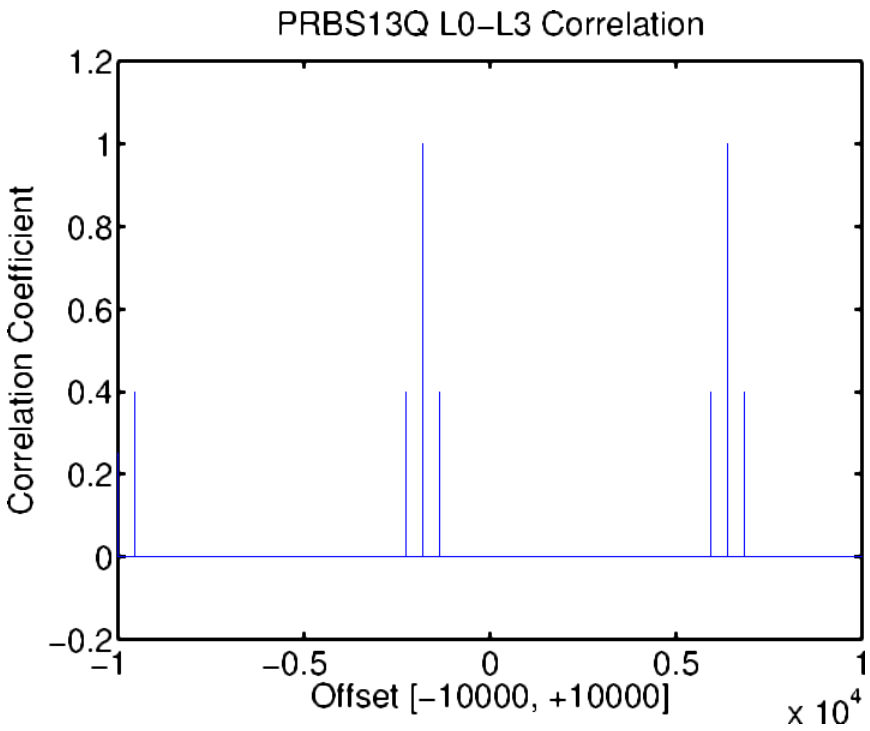
- The offset between Lane 0 and Lane 2 is 3259 symbols.

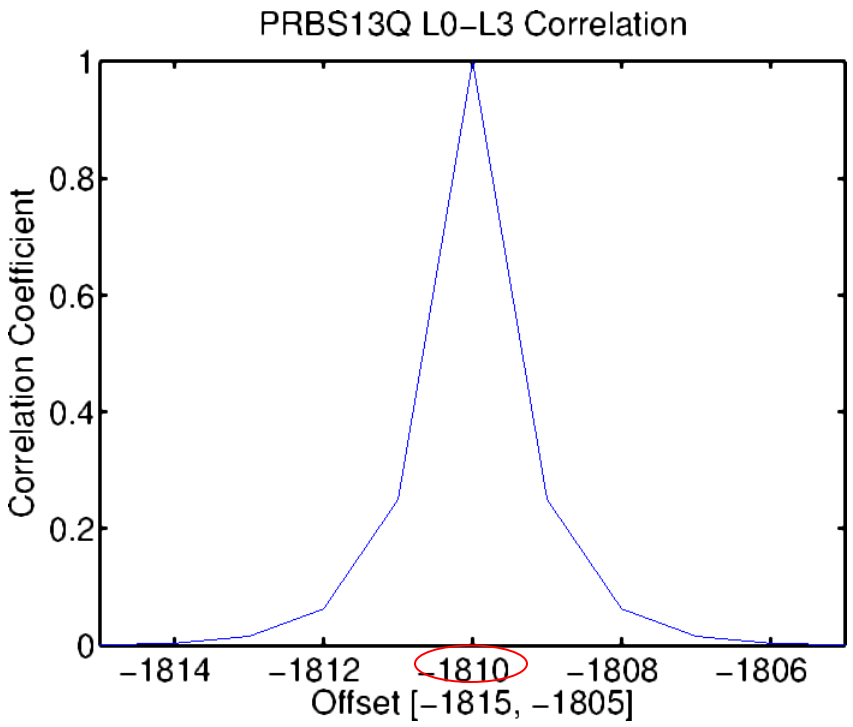




Offset between L0 and L3 using Table 94-11

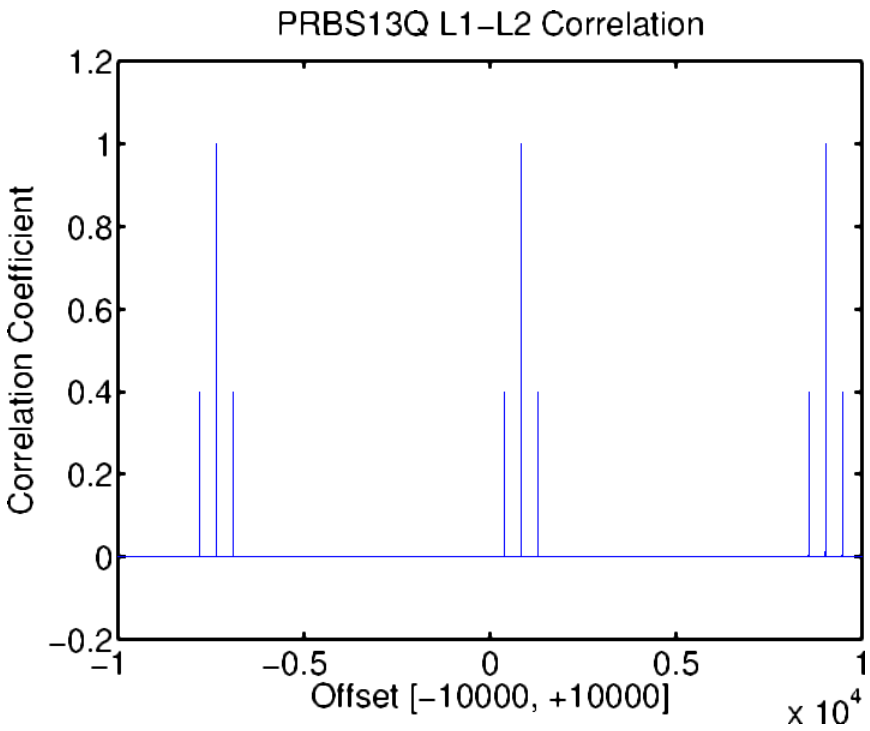
- The offset between Lane 0 and Lane 3 is 1810 symbols.

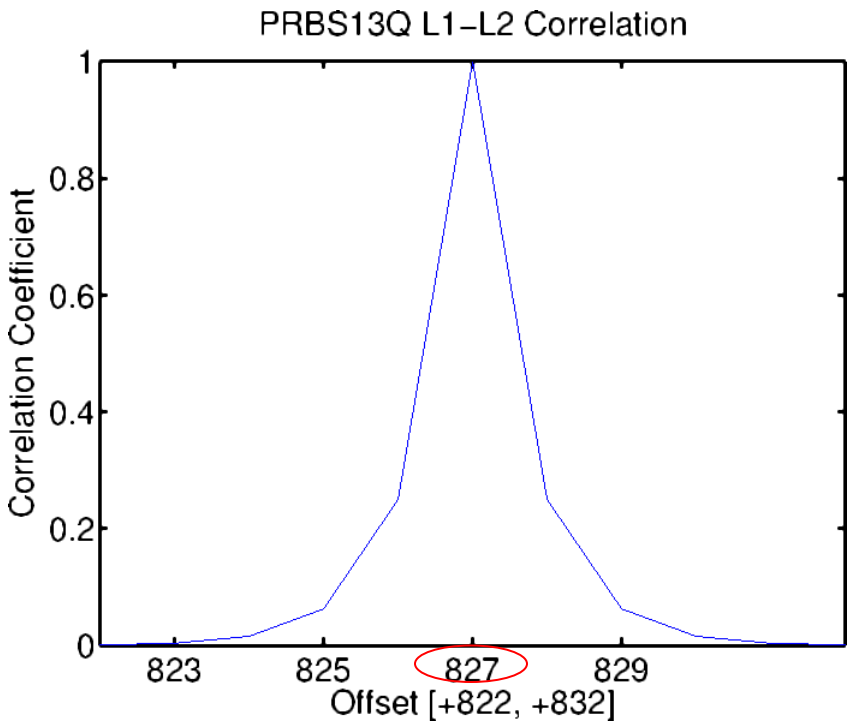




Offset between L1 and L2 using Table 94-11

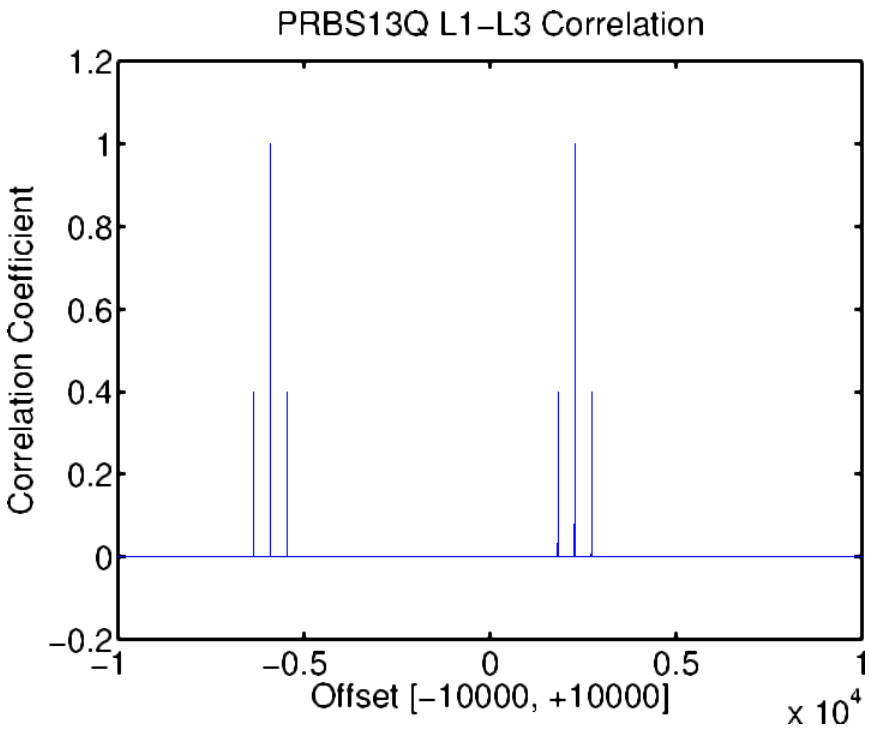
- The offset between Lane 1 and Lane 2 is 827 symbols.

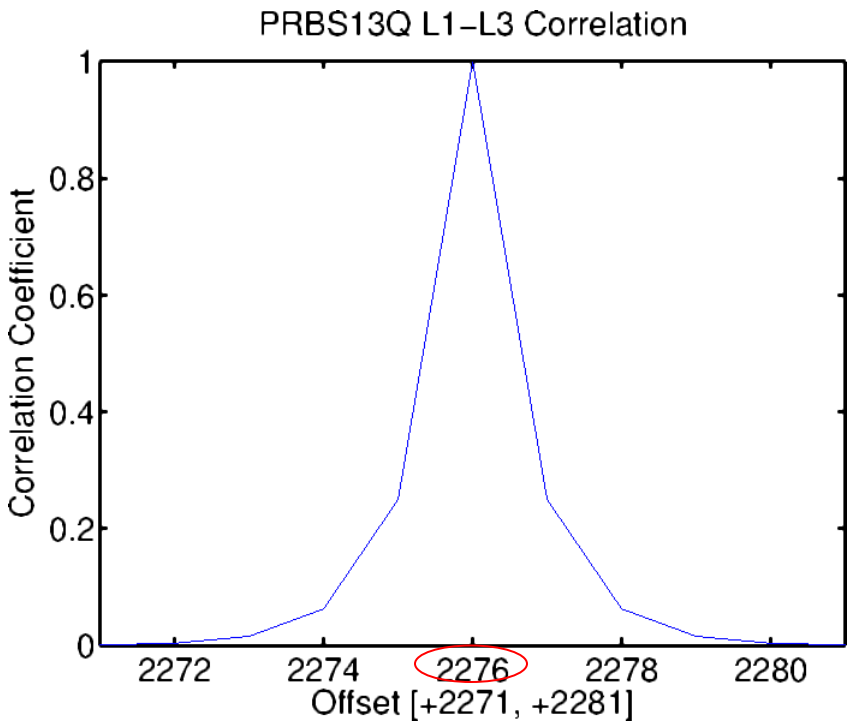




Offset between L1 and L3 using Table 94-11

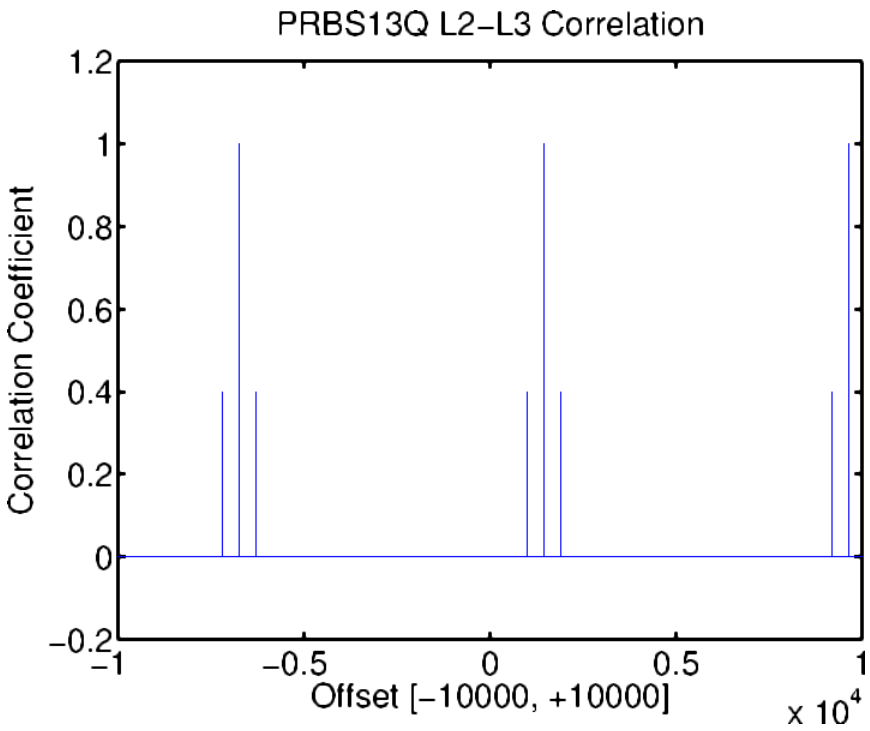
- The offset between Lane 1 and Lane 3 is 2267 symbols.

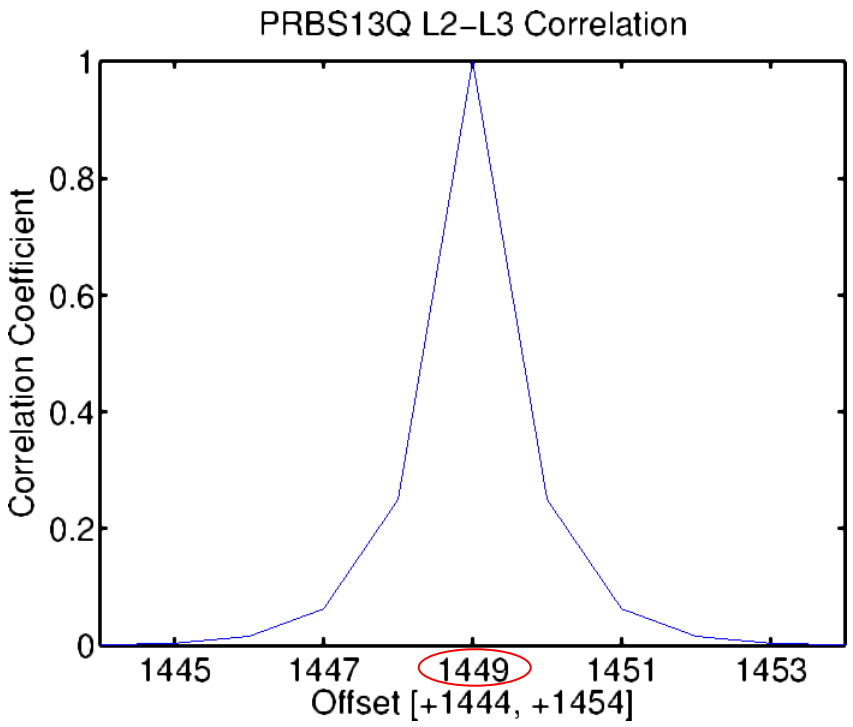




Offset between L2 and L3 using Table 94-11

- The offset between Lane 2 and Lane 3 is 1449 symbols.





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Thank you