# Performance and Implementation Updates to MB810

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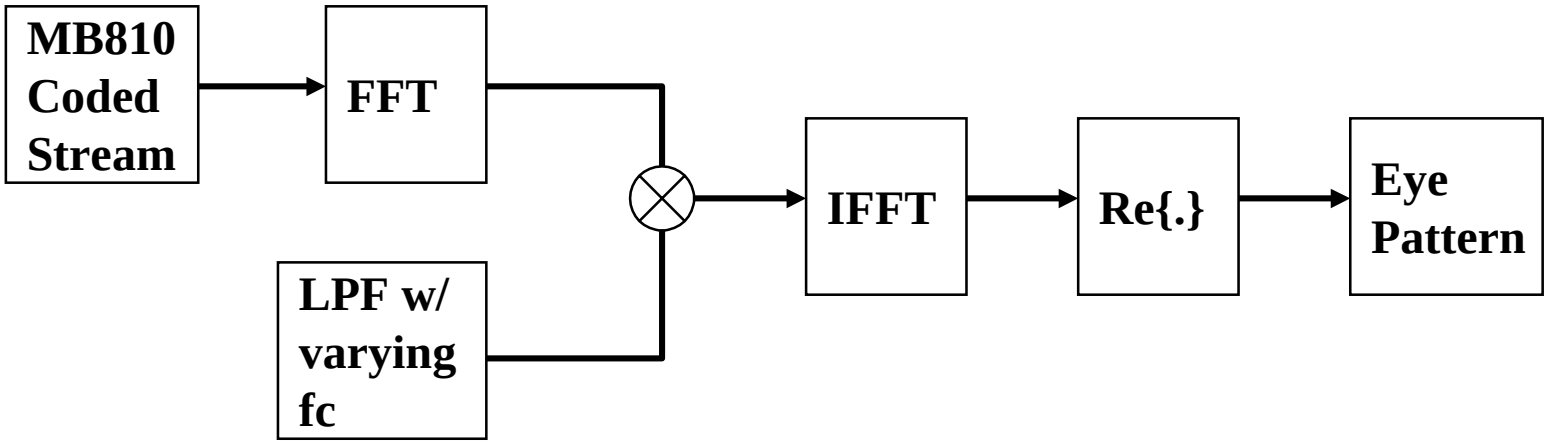
## Abstract

**We present simulation and experiments with MB810. By lowering the cutoff frequency of LPF, we confirmed superior survival capability of MB810 coded data over NRZ. We also confirmed the power spectral property by experiment. The BER test of MB810 coded data was done after passing through LPF of a Nyquist cutoff, which resulted in virtually error free transmission. We also give implementation and VHDL simulation results. The gate number required for MB810 encoder are estimated to be under the 20K.**

# CONTENTS

# Performance Simulation

- Eye pattern simulation of MB810 coded stream with a varying cutoff frequency of the Low Pass Filter




System model for simulation of the MB810 eye pattern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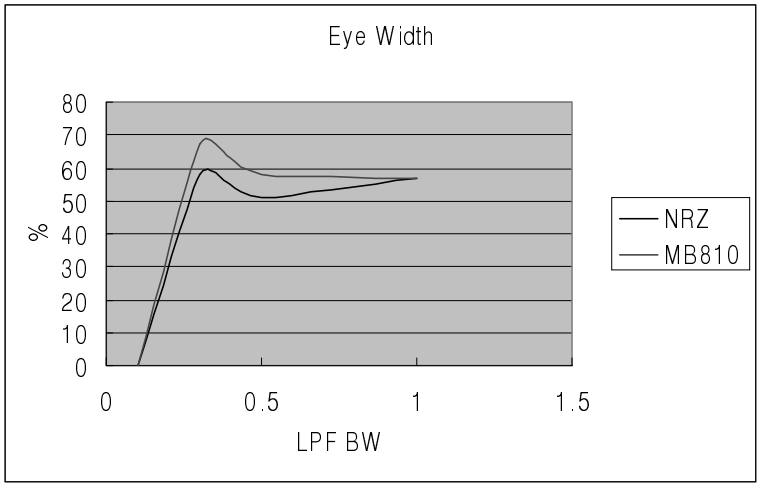
# Simulation Results: Excessive Drive

- Eye opening versus low-pass cutoff frequency


**Conditions: Input data stream of 4096*5 bits.**

**BW normalized to input bit rate. Mark ratio of PRBS = 0.5**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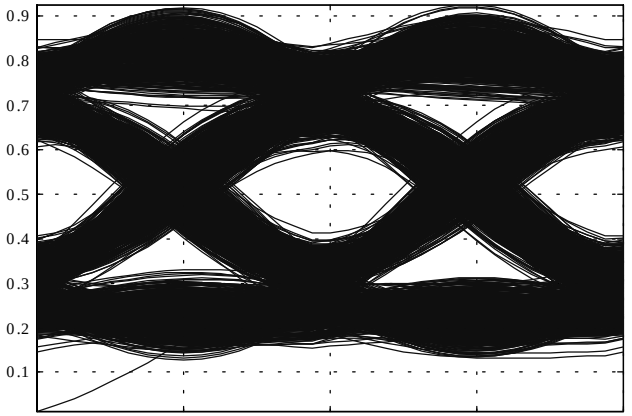
# Simulation Results

**NRZ**

**4096 samples**

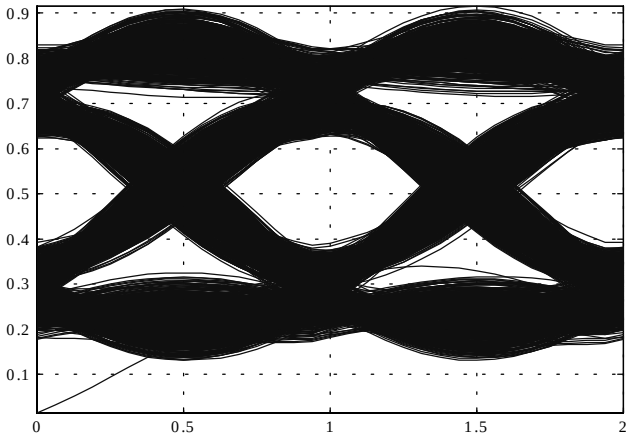
***f*c = 0.35*1/T**




**MB810 coded**

**4096 samples**

***f*c = 0.35*1/T**





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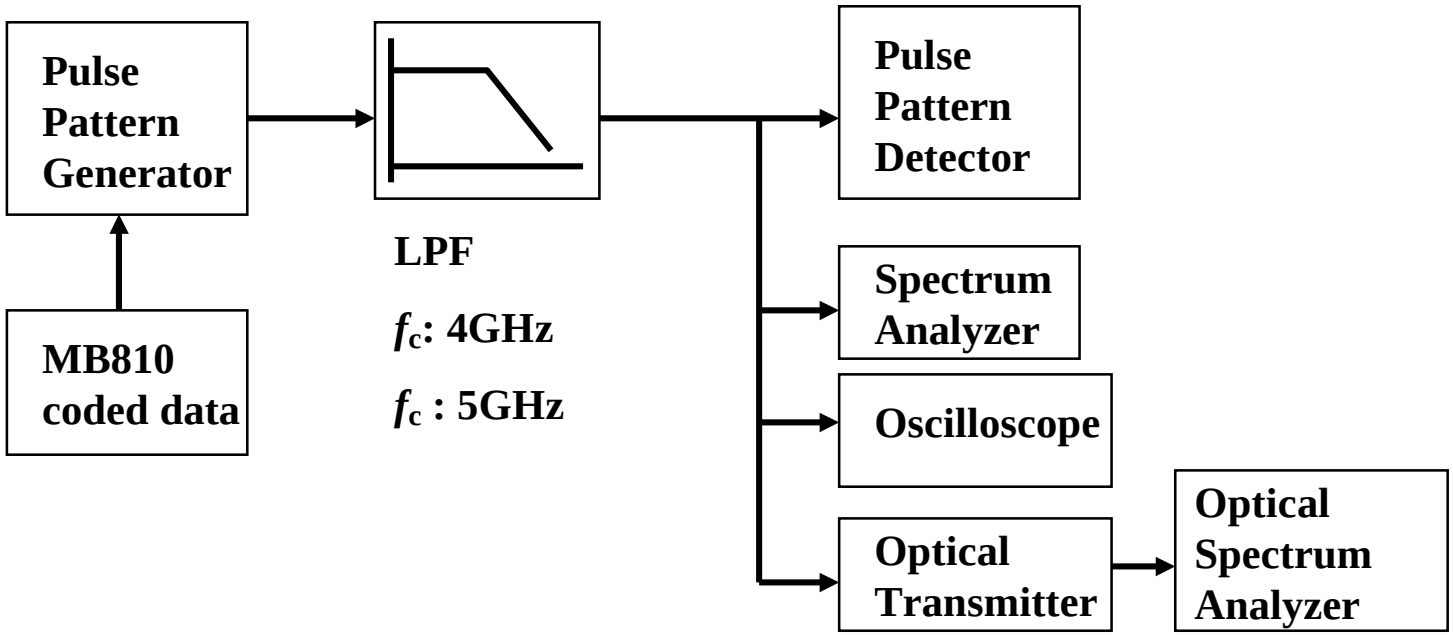
# Measurement Set-up for MB810 Coded Data




**Conditions;**

**- Data rates used in this measurement are 10Gbps.**

**- MB810 coded data is generated by program.**

**- Input random data has mark ratio of 0.5 and sequence period of 100K.**



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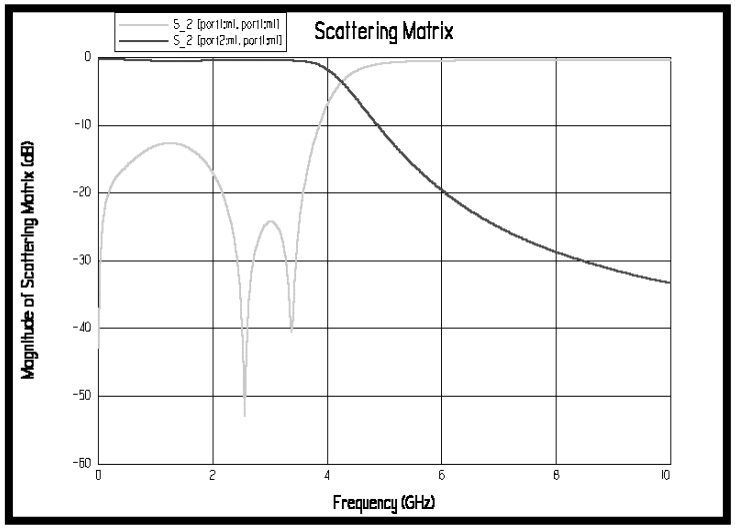
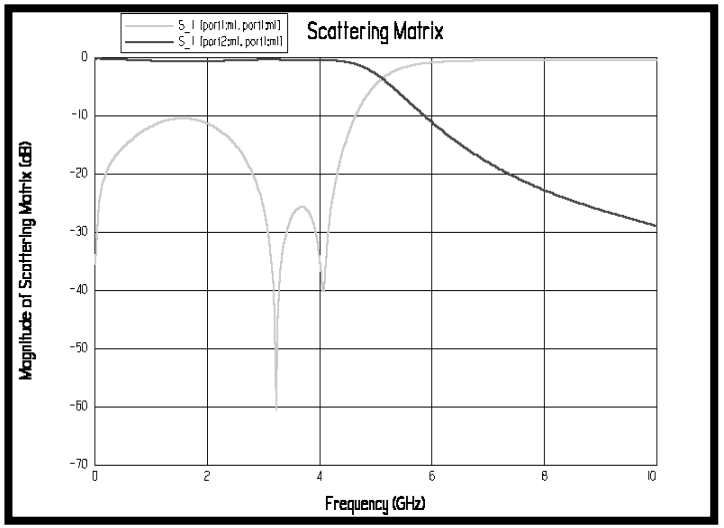
# Low Pass Filter Used in This Experiment

- **Filter is a 5-th order Chebyshev implemented in strip-line.**




**Cutoff Freq. 4GHz**




**Cutoff Freq. 5GHz**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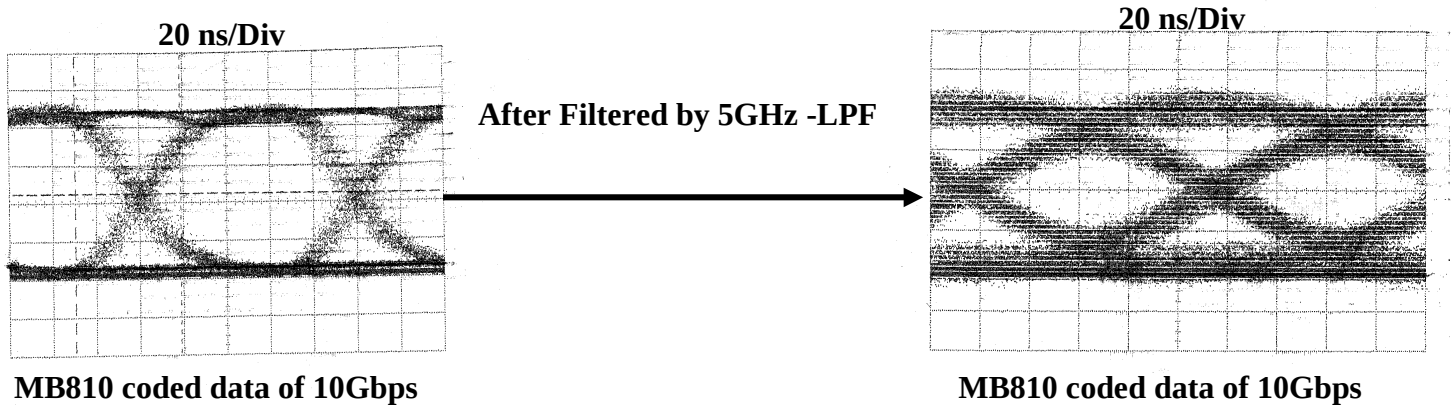
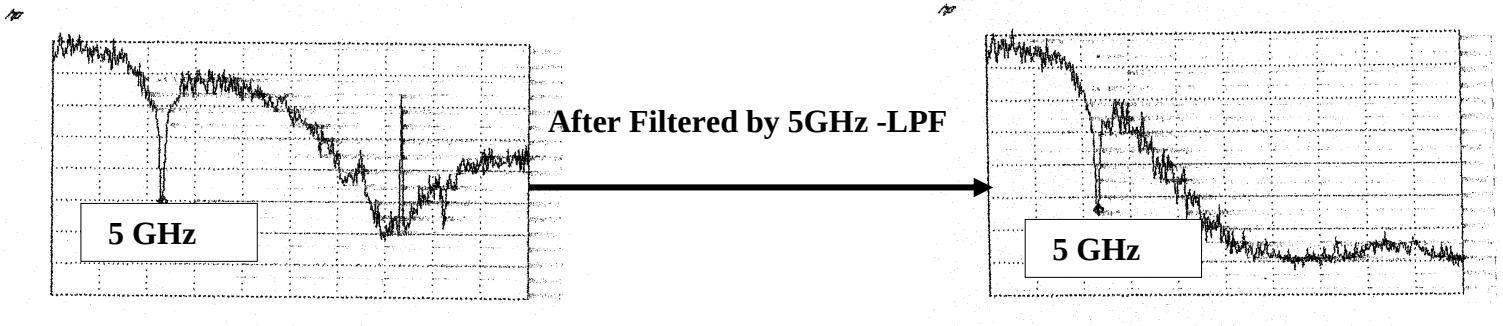
# Measurement Results With 5GHz-LPF




**Eye pattern and spectrums are measured in error free condition**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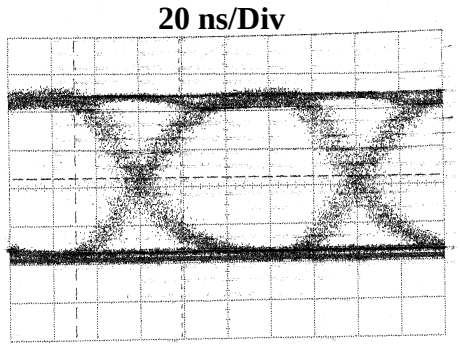
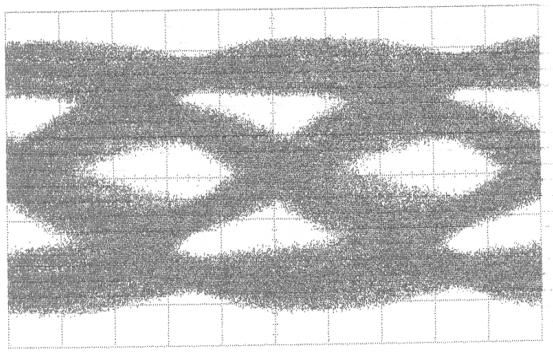
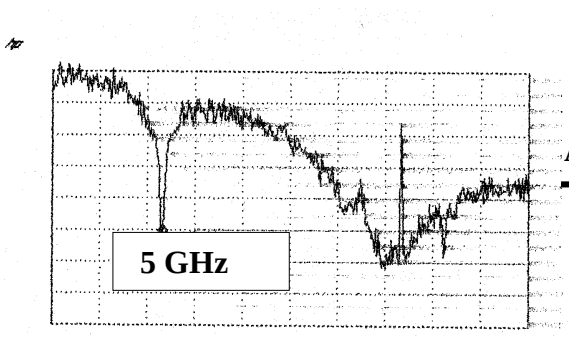
# Measurement Results With 4GHz-LPF



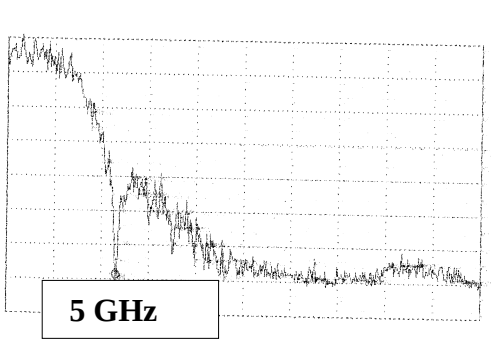

After Filtered by 4GHz -LPF



**MB810 coded data of 10Gbps**




After Filtered by 4GHz -LPF




**Eye pattern and spectrums are measured in error free condition**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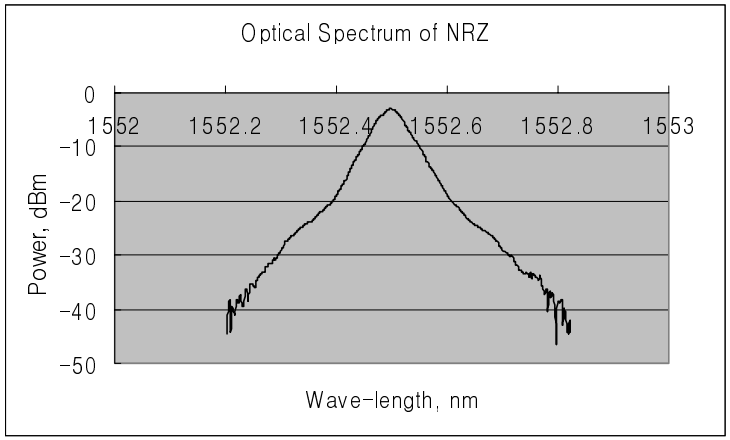
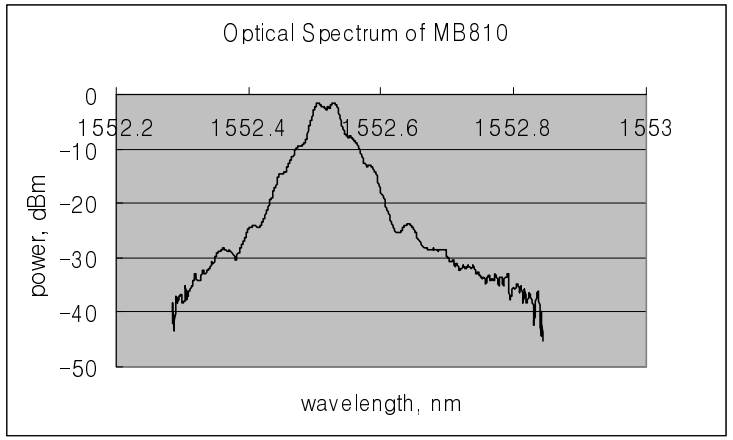
# More Measurement - Optical Spectrum




- Measured optical power spectrum of NRZ and MB810.
- The optical spectrum width @ -30dBm of MB810 is decreased by 0.197nm compared to NRZ. [MB810 coded stream passed through 5 GHz LPF are used]
- There is a valley at the center of MB810 spectrum, which contributes to the reduction optical line spectrum.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# Hints from Measurement Results

- MB810 is stable when cut off set at the Nyquist frequency; 50% of the line rate and 60% of the data rate. A wide eye opening.
- Even driven by 20% more, MB810 maintained near error-free transmission while NRZ did not. A fair-quality eye opening.
- In case of 10GbE, we need only 5GHz channel bandwidth; 40% of the line rate and 50% of the data rate.


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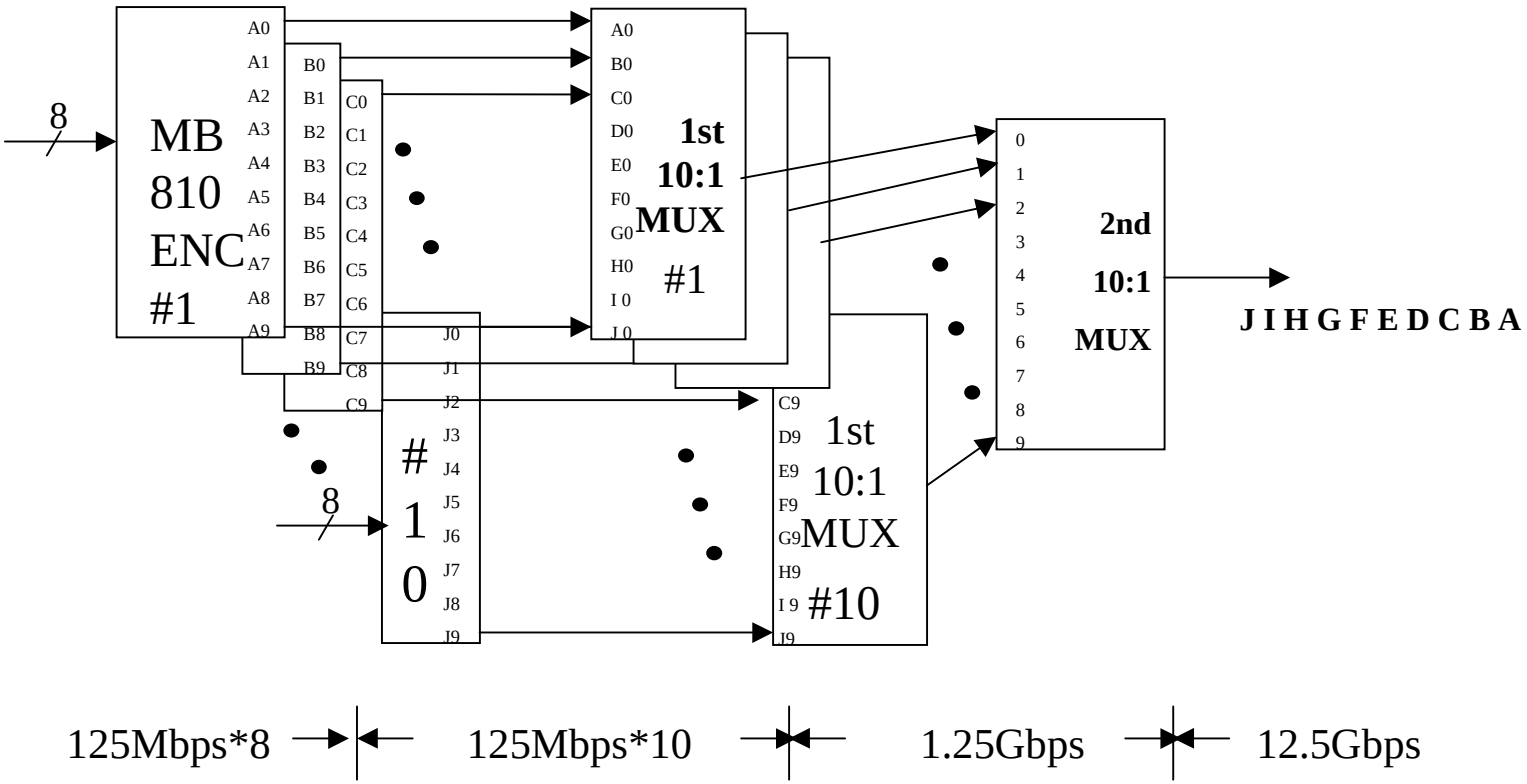
# Implementation: Double Multiplexing





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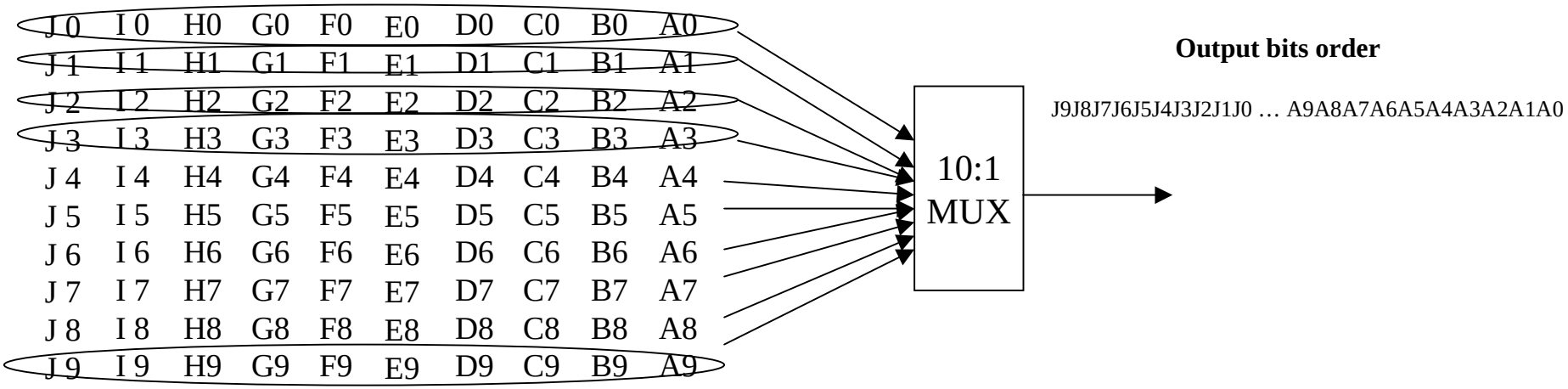
# Implementation - Word Mux by Bit-Interleaving




MB810 coded stream, with each column being output of the 1st 10:1 MUX.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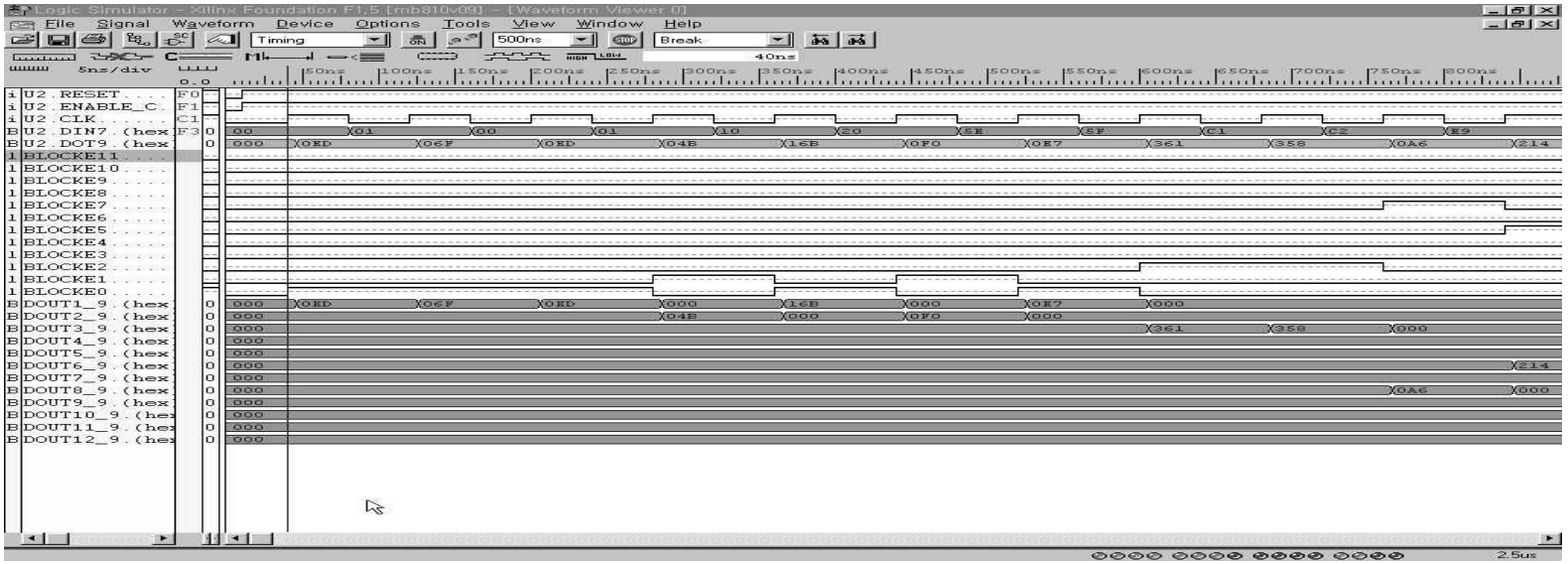
# Implementation - VHDL Simulation Results

**We reduced the data speed down to a 10th for implementation with FPGA, and simulated with VHDL**




- MB810 encoder implemented with hardwire only.
- Estimated gate number is under **20K** in VHDL simulation.
- The 10 to 1 MUX of 1.25Gbps used is the existing chip for GbE.
- The 10 to 1 MUX of 12.5Gbps needs to be implemented in a separate single chip for 10GbE.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# Conclusion

- MB810 persisted healthy (no appreciable error) even with a LFP cutoff at 40% the line rate frequency. Needs only a 5GHz BW for 10GbE.
- Considerable reduction in channel bandwidth.
- A MB810 encoder was successfully implemented with FPGA, suggesting feasibility of high-speed and low-cost custom chips. ASIC implementation is underway.
- More facts about MB810 code including theoretical papers, programs, experimental results, and implementations are being updated at:
  http://routertech.etri.re.kr/English/Standard/
  http://ccl.chungnam.ac.kr/LineCoding/.
- Hope our results could contribute to the success of 10GbE.