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25G/10G/1G triple-rate upstream receiver based on single 10G APD/TIA

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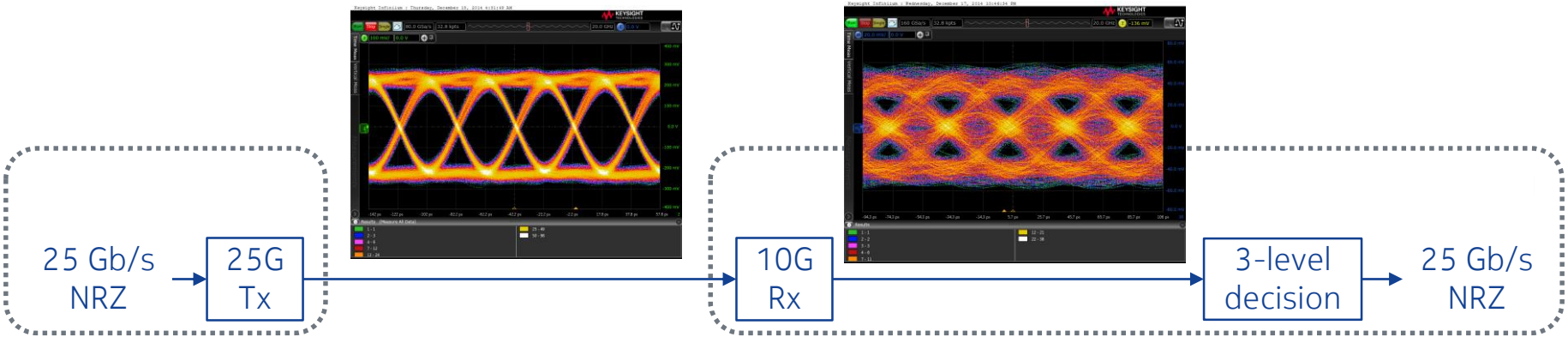
Summary Duobinary detection scheme



- Low pass filtering of NRZ creates ISI
- 10G filtering of 25G NRZ ISI creates a 3-level duobinary signal– which can be decoded at the receiver
- Duobinary detection is more tolerant to dispersion compared to NRZ
- Precoding is needed at the Tx to avoid error propagation at the duobinary decoder
- Dual-rate 25G/10G is very natural with this scheme because 25G is received with 10G Rx (Electronic equalizing of a 10G Rx to achieve 25G enables same dual-rate scheme)

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From: zhangdezhi_3ca_1_0317 “Multi-rate receiver survey and analysis”

Summary of survey

- **Technically triple-rate receiver design is feasible as many designs feedback in the survey**
- **Suggest more efforts on analysis of degradation of receiver sensitivities, to get recognized impact (estimation) and serve the wavelength discussion and PHY parameter calculation**
- **Some Triple-rate receiver designs need a rate_select signal from MAC to dynamically control the appropriate TIA/LA, doable but brings extra complexity in the OLT receiver**
- **The switch time of dynamic TIA trans-impedance seems not be a problem**

From: zhangdezhi_3ca_1_0317 “Multi-rate receiver survey and analysis”

Viewpoints from optical module vendor in the Survey

中国电信 CHINA TELECOM

Technical feasibility

- Generally, Triple-rate burst mode receiver design would be doable but challenging
- The margin of 1G sensitivity SPEC would be very tighter than dual-rate 10G/1G receiver, as usually 25G photo detector has smaller active region size, lower responsibility, larger dark current, less max. overload current, which results in worse RX performance than 10G photo detector under lower data rate
- Additional Rate_Sel input will be helpful to realize the Multi-rate TIA as Data rate variation ratio of 25G/10G/1G Multi-rate receiver is up to 25X

Industry support

- No 25G burst mode TIA/LA in the market yet
- Triple-rate test on same receiver means more test items, it would result in low yield
- 25G IC semiconductor process may be more expensive than 10G/1G due to different semiconductor processes and test platforms between 25G and 10G IC fabrication
- Two kinds of burst mode receivers existed in 100G EPON OLT (multi-rate, and pure 25G), which leads to scattered Burst mode RX ICs demand

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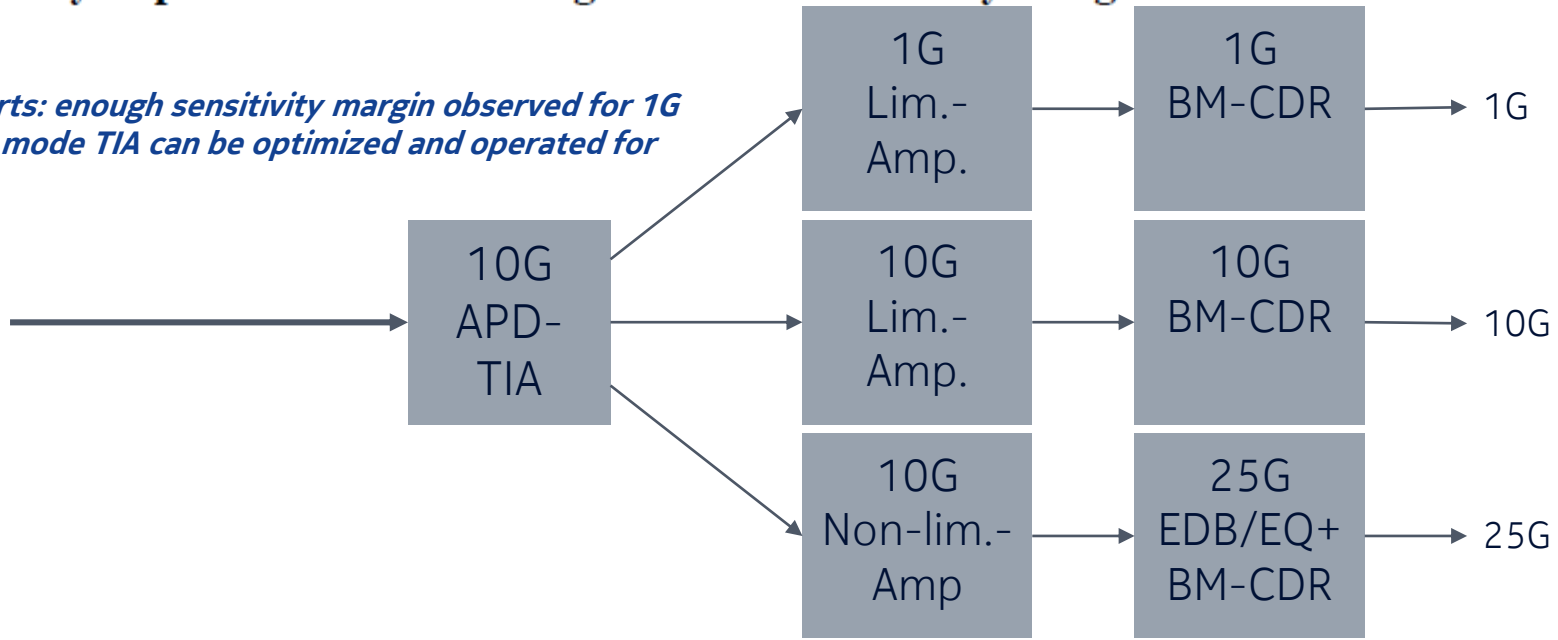
Feedback on zhangdezhi_3ca_1_0317 “Multi-rate receiver survey and analysis”

- **Technically triple-rate receiver design is feasible as many designs feedback in the survey**

“Real-life parts: enough sensitivity margin observed for 1G signal, burst mode TIA can be optimized and operated for 10G.”



We want to add another variation on a design of a triple-rate receiver:

A ”*Single APD/TIA triple-rate receiver design*”: 25G techniques based on 10G receivers (like duobinary (EDB) or electronic equalization (EQ)) enable a TDM-based 25G/10G/1G triple-rate receiver with no extra penalty for 10G/1G

Feedback on zhangdezhi_3ca_1_0317 “Multi-rate receiver survey and analysis”

- **Suggest more efforts on analysis of degradation of receiver sensitivities, to get recognized impact (estimation) and serve the wavelength discussion and PHY parameter calculation**

- The margin of 1G sensitivity SPEC would be very tighter than dual-rate 10G/1G receiver, as usually 25G photo detector has smaller active region size, lower responsibility, larger dark current, less max. overload current, which results in worse RX performance than 10G photo detector under lower data rate

Single APD/TIA design uses same optical front-end for 10G as well as 25G, so there is no degradation of 10G and 1G receiver sensitivity like in the case where you use a 25G receiver for all 3 rates

- **Some Triple-rate receiver designs need a rate_select signal from MAC to dynamically control the appropriate TIA/LA, doable but brings extra complexity in the OLT receiver**

- Additional Rate_Sel input will be helpful to realize the Multi-rate TIA as Data rate variation ratio of 25G/10G/1G Multi-rate receiver is up to 25X

Single APD/TIA design uses a single 10G APD/TIA for all 3 rates, so no additional rate_select signals are needed relative to a 10G/1G dual-rate receiver

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Feedback on zhangdezhi_3ca_1_0317 “Multi-rate receiver survey and analysis”

- No 25G burst mode TIA/LA in the market yet

  The single APD/TIA triple-rate receiver uses 10G burst mode APD/TIA parts for 10G as well as 25G, so a 25G BM TIA is not needed

- 25G IC semiconductor process may be more expensive than 10G/1G due to different semiconductor processes and test platforms between 25G and 10G IC fabrication

  In the single APD/TIA triple-rate receiver design the analog front-end ICs can be 10G for the 25G rate

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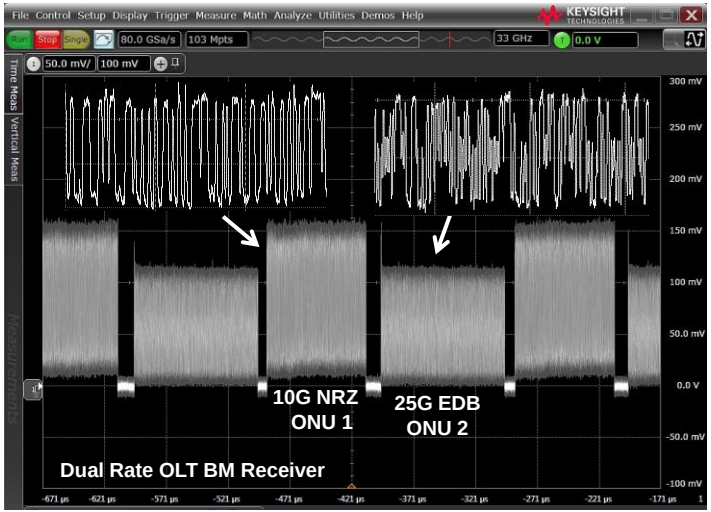
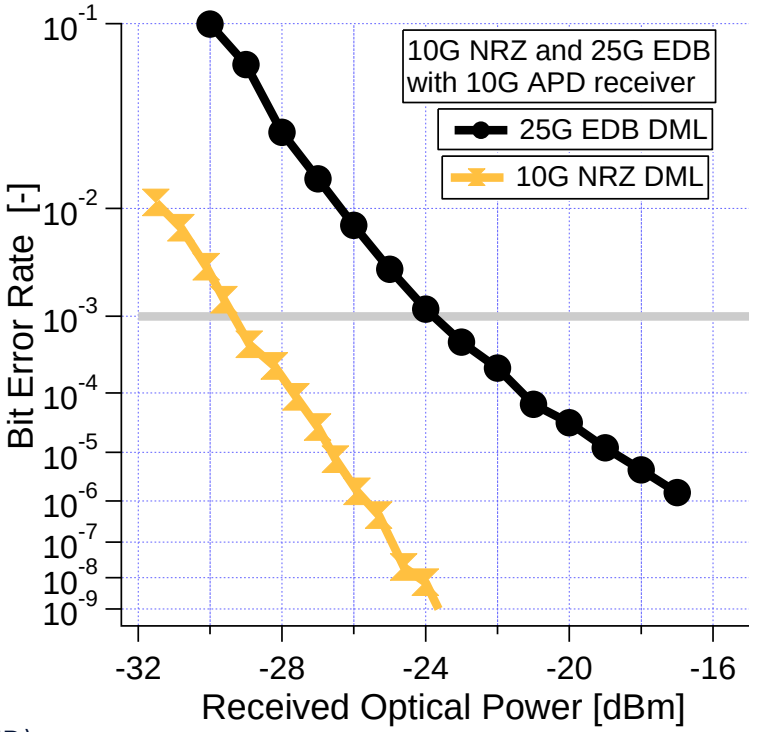
25G/10G dualrate OLT receiver
Experimental results





- ER_10G = ~6 dB
- ER_25G = ~4.9 dB
- 5.5 dB penalty for 25G EDB (~0.5 dB due to ER)

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Conclusions

- We proposed a triple-rate receiver based on one 10G APD/TIA to be added to the listed schemes in zhangdezhi_3ca_1_0317 presented at the Vancouver meeting
- A dual-rate 25G/10G receiver is very natural with EDB because the 25G rate is also received with the 10G analog frontend (Electronic equalizing of a 10G Rx to achieve 25G enables same dual-rate scheme)
- Also a triple-rate 25G/10G/1G receiver can be implemented using duobinary or equalization of a 10G receiver without extra sensitivity penalty relative to a dual-rate 10G/1G receiver
- 10G analog burst mode front-end parts can be reused for 25G, no 25G BM TIA is needed
- We measured 5 dB penalty (assuming same ER) between 10G NRZ and 25G EDB for a 25G/10G dual-rate receiver based on 10G APD/TIA, illustrating that no extra penalty occurs for 10G
- No extra rate_select signal is needed to switch bandwidth for 25G, because it can use same analog frontend as 10G

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