SUMITOMO ELECTRIC

Evaluation Results on Lock Performance of 10G and 25G CDRs

Sumitomo Electric Industries, LTD

D. Umeda

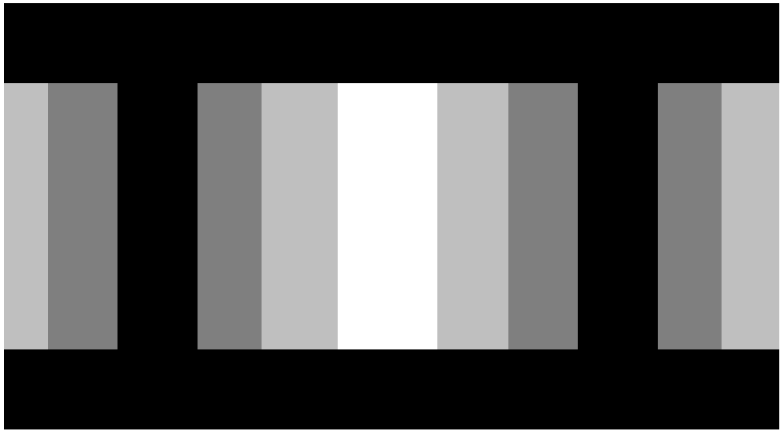
IEEE P802.3ca 100G-EPON Task Force meeting, New Orleans
23-25 May 2017

Motivation

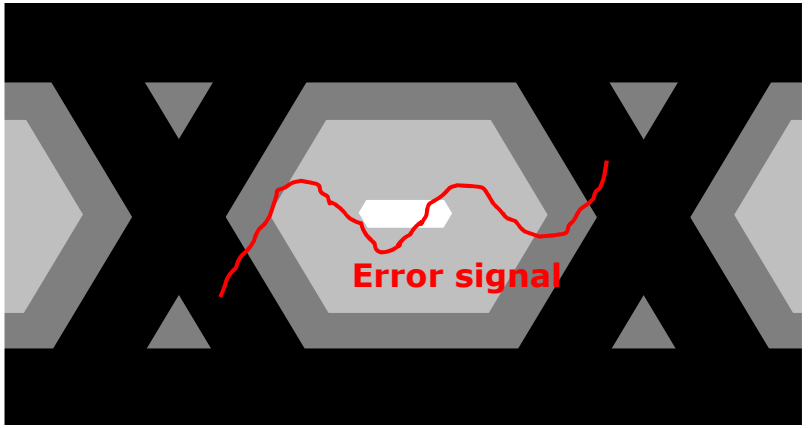
- Studying enhanced FEC to overcome the power budget problem.
- Before signal processing of FEC, we need to check whether a CDR can lock 25Gb/s signals in high BER condition like BER~10^{-2}.
- Evaluated some 10G and 25G CDRs.

Consideration of CDR Behavior

- CDR detects signal transitions (edges) between 0 and 1.
- Random jitter increases in high BER condition. Rj can be removed by averaging. While, the averaging time is determined by the loop bandwidth. The corner frequency is 4MHz for 10G and 10MHz for 25G. The number of edges we can average is same for 10G and 25G.
- Need to consider not only Rj but also errors. Actual input is like (B) at high BER. CDR counts a edge double or miss it with some probability. Too much false might cause the loss of lock (LOL). The judgement of Lock/Unlock is important.



(A) Ideal Jitter Signal



(B) Actual Jitter Signal with Errors

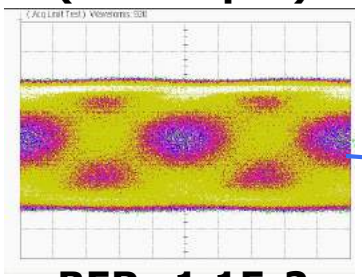
Samples

- Evaluated 8 samples as below.

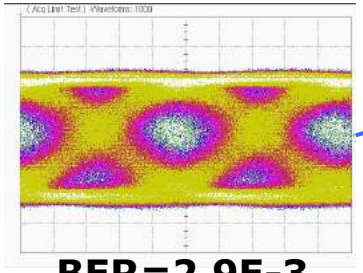
No.	Sample	Description	Slide
1	10G CM CDR	10G CM CDR on Evaluation Board	Slide.5
2	10G CM CR Module	10G CM CDR in Scope (Equipment)	
3	10G CM CDR Module	10G CM CDR in BERT (Equipment)	
4	10G-EPON ONU Transceiver	10G-EPON CM CDR in ONU Transceiver	Slide.6
5	10G-EPON OLT BM-CDR	10G-EPON BM CDR on Evaluation Board	Slide.7
6	10G-EPON OLT	10G-EPON BM CDR on 10G Line Card	Slide.8
7	25G SFP28	25G CM CDR in Transceiver	Slide.9
8	25G QSFP28 (CWDM, CH3)	25G CM CDR in Transceiver	

Example of 10G CM CDR Lock Performance

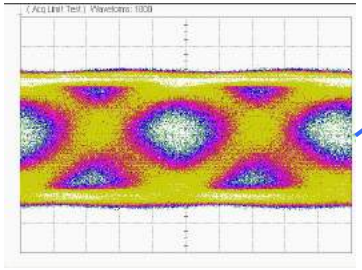
10G OLT Transceiver Output (CDR Input)



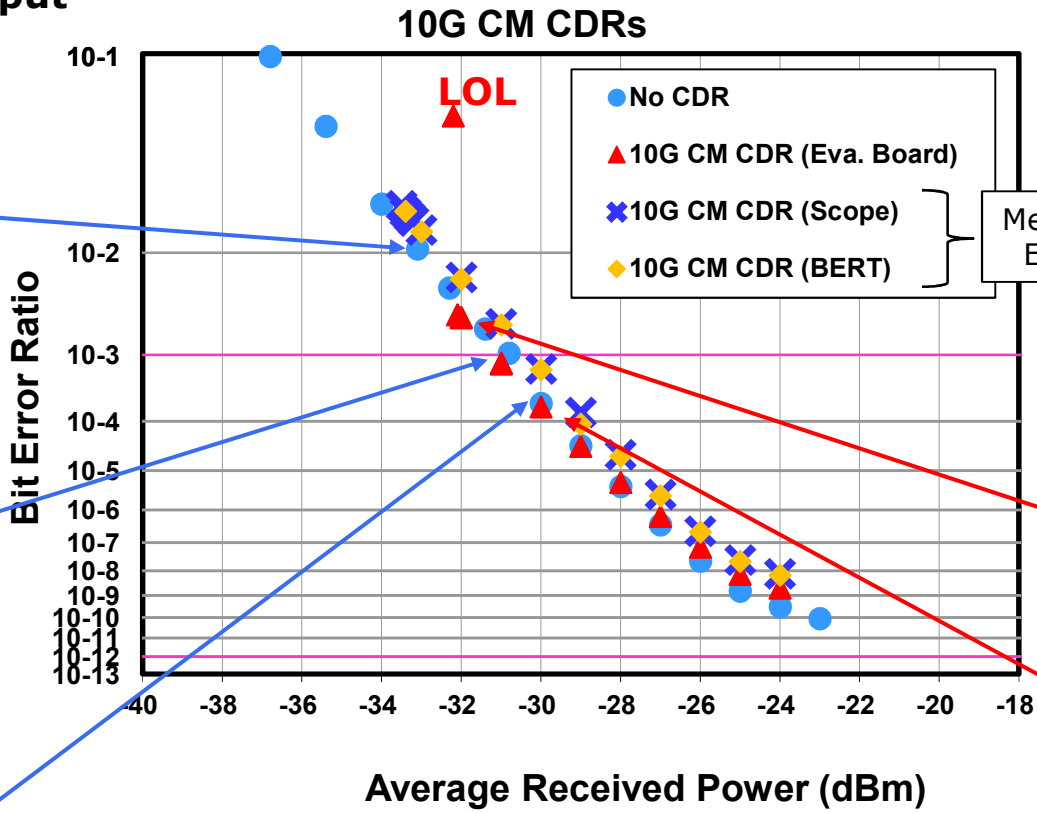
BER=1.1E-2



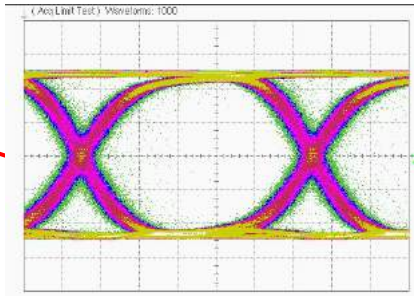
BER=2.9E-3



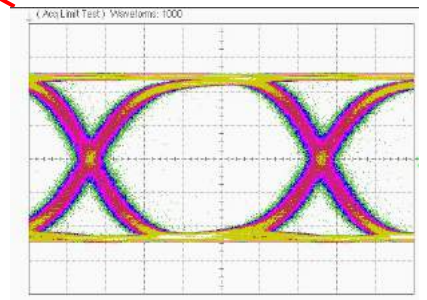
BER=7.8E-4



CDR Output ▲



Many dots are in the eye.



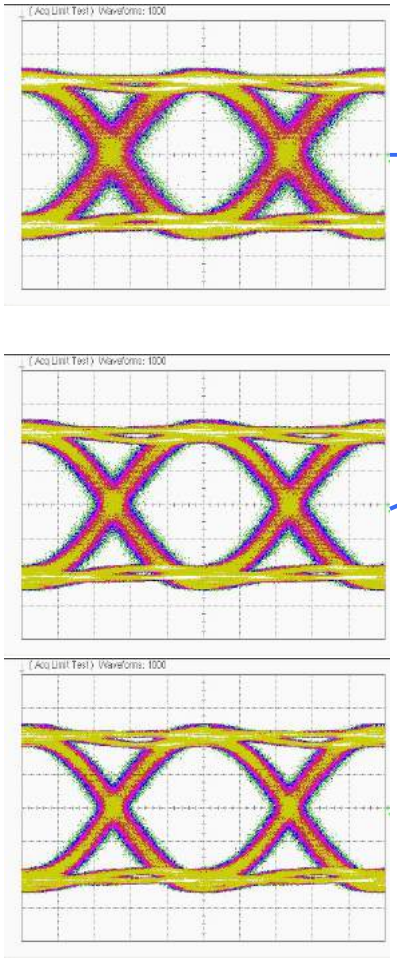
Some dots are in the eye.
Metastable?

Optical Source: Commercial ONU Transceiver, PRBS2^{31}-1

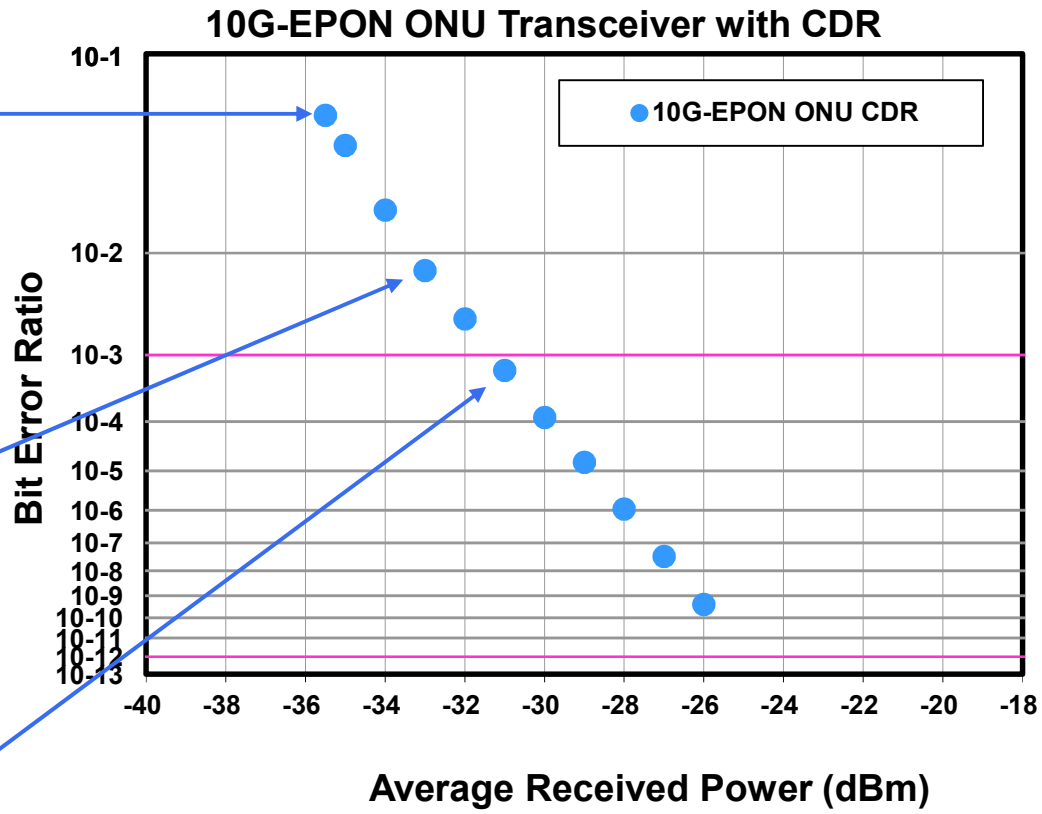
Loss of Lock (LOL) : BER=3x10^{-3} to 1.5x10^{-2} (BERT)

Example of 10G-EPON CDR Lock Performance

CDR Output



No dot is in the eye.

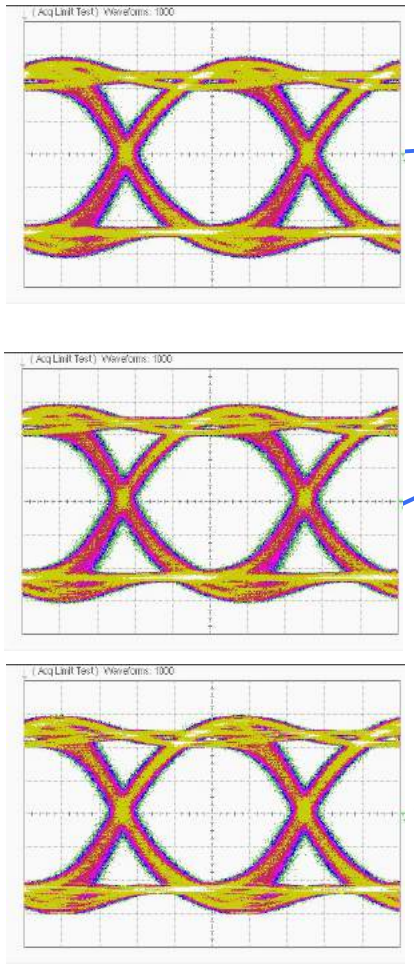


Optical Source: Commercial OLT Transceiver, PRBS2^{31}-1

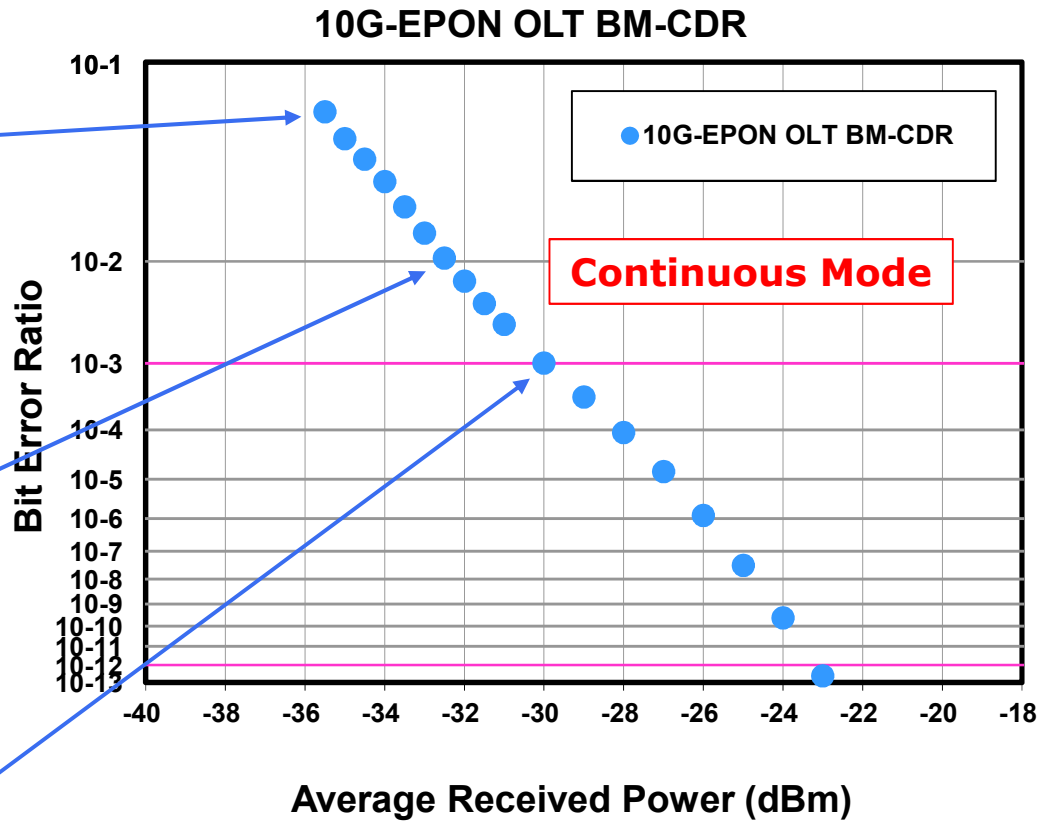
Loss of Lock (LOL) : BER=5.6x10^{-2}
10G-EPON ONU can lock to high BER signals.

Example of 10G-EPON CDR Lock Performance

CDR Output



No dot is in the eye.



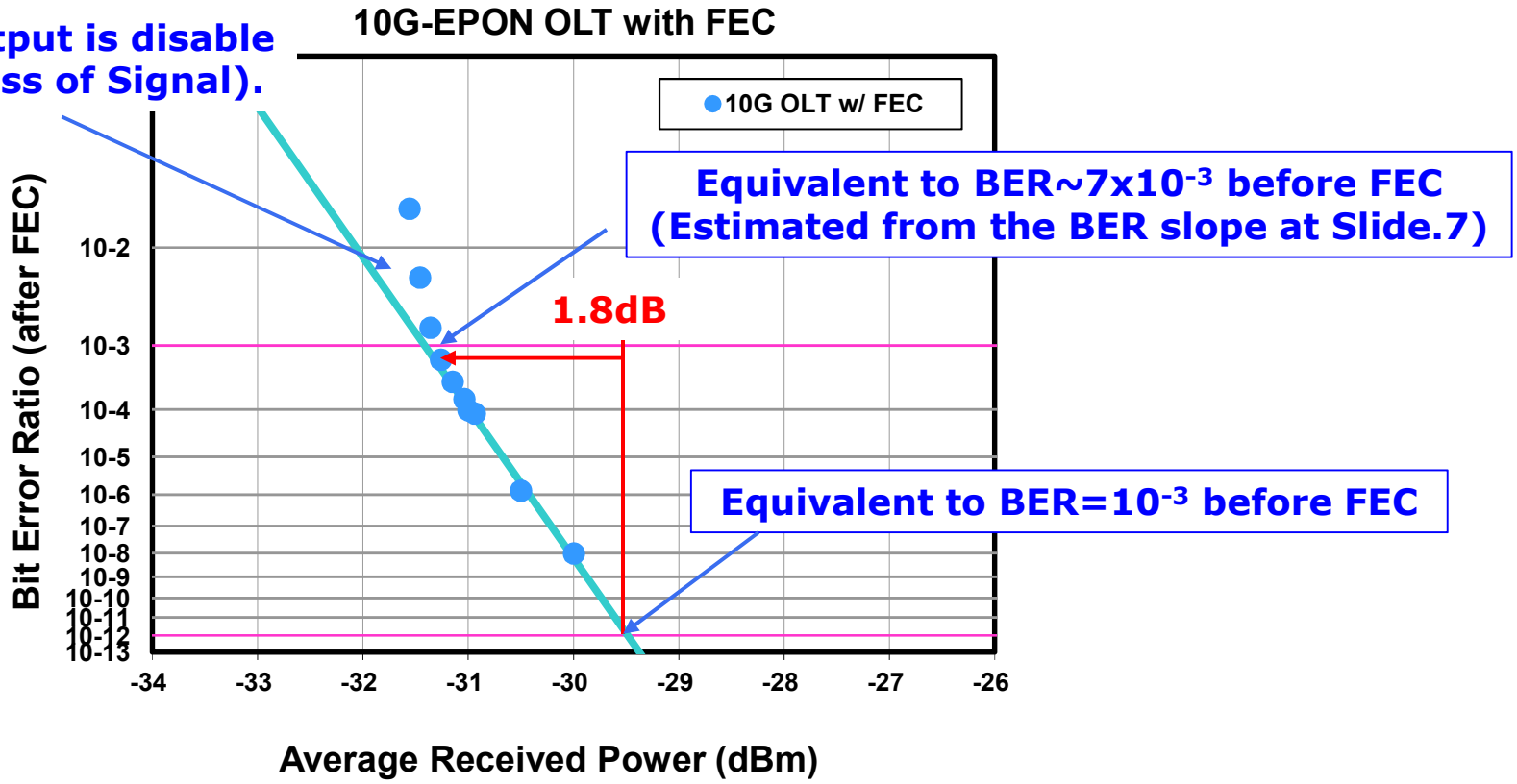
Optical Source: Commercial ONU Transceiver, PRBS2^{31}-1

Loss of Lock (LOL) : BER=5.9×10^{-2}
10G-EPON ONU can lock to high BER signals.

Example of 10G-EPON CDR Lock Performance

10G-EPON OLT with RS223/255 FEC
Measured Frame Error Ratio and converted to BER.

Transceiver output is disable due to LOS (Loss of Signal).

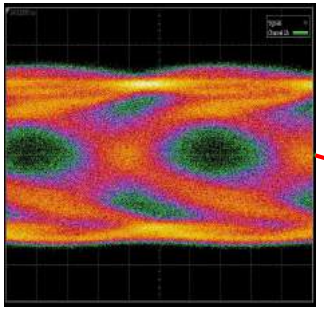


Optical Source: Commercial ONU, 128Byte Frame
The OLT/ONU transceivers are different from the samples at Slide.7

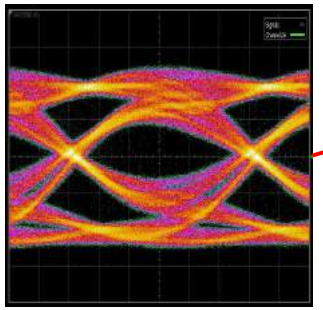
Loss of Lock (LOL) : BER > 7×10^{-3}

Example of 25G CM CDR Lock Performance

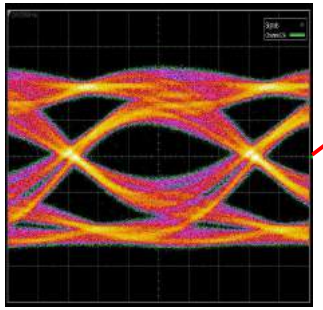
25G Transceiver Output
(CDR Output)



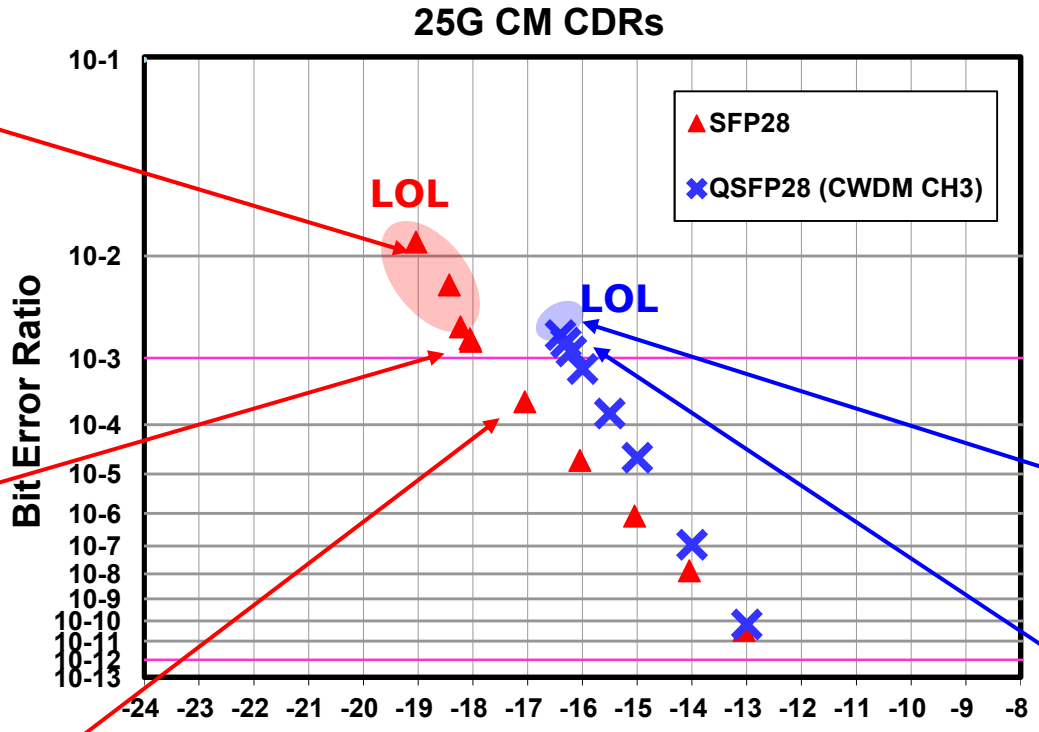
CDR is bypassed due to LOL.
25G BERT can lock this.



Many dots are in the eye.



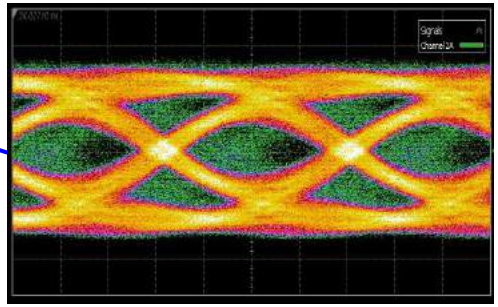
Dots are in the center of eye.
Metastable?

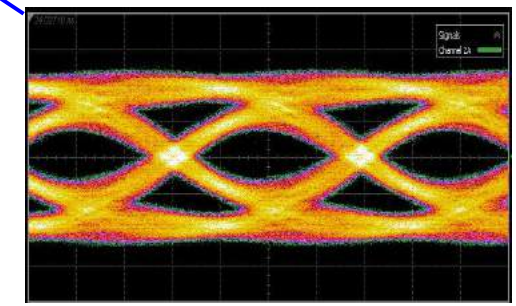


Optical Source: SFP28 Transceiver (uncooled DML), PRBS2^{31}-1

Loss of Lock (LOL) : BER~1.5x10^{-3}

25G Transceiver Output
(CDR Output)





A few dots are in the center of eye.
Metastable?

Jitter Specification

- TP8 (CDR Input Jitter) for 10G-EPON OLT

	TJ	DJ	RJ	1-TJ	
BER=10^{-3}	0.76	0.53	0.23	0.24	UIp-p
1UI=96.97ps				23.27	ps

- How is TP8 for 25G-EPON OLT?

  In case that the jitter spec. is same as 10G in UI.

	TJ	DJ	RJ	1-TJ	
BER=10^{-x}	0.76	0.53	0.23	0.24	UIp-p
1UI=38.79ps				**9.31**	ps

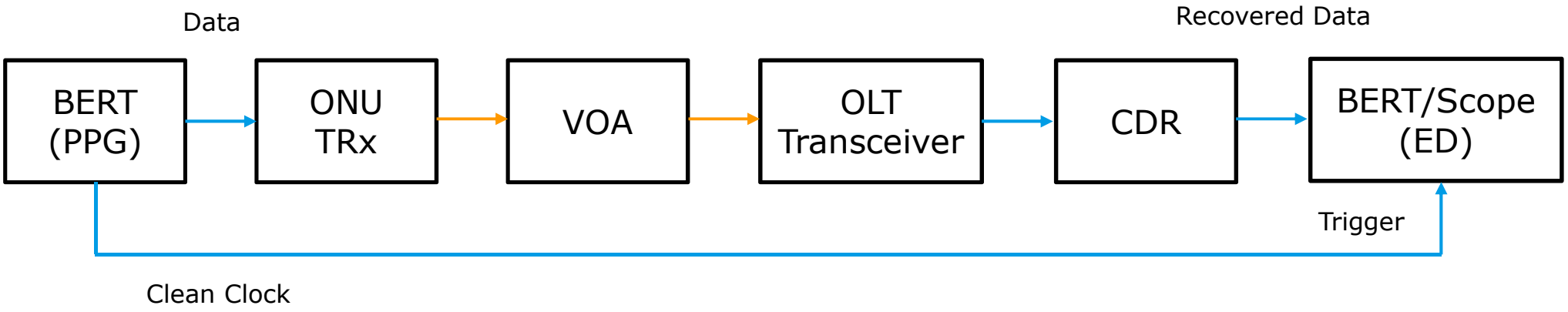
Jitter budget for CDR is less than 10 ps.

Summary

- LOL of 25G CM CDRs we evaluated here were around $1.5x10^{-3}$. The CDRs were not designed for the operation under high BER condition. The lock performance of 25G/100G-EPON CDR would be tuned and improved like 10G-EPON.
- However, 25G jitter budget is severe and BER~$1x10^{-2}$ is risky. The target BER would be $1x10^{-3}$ to $2x10^{-3}$ and further study by CDR vendors is needed.

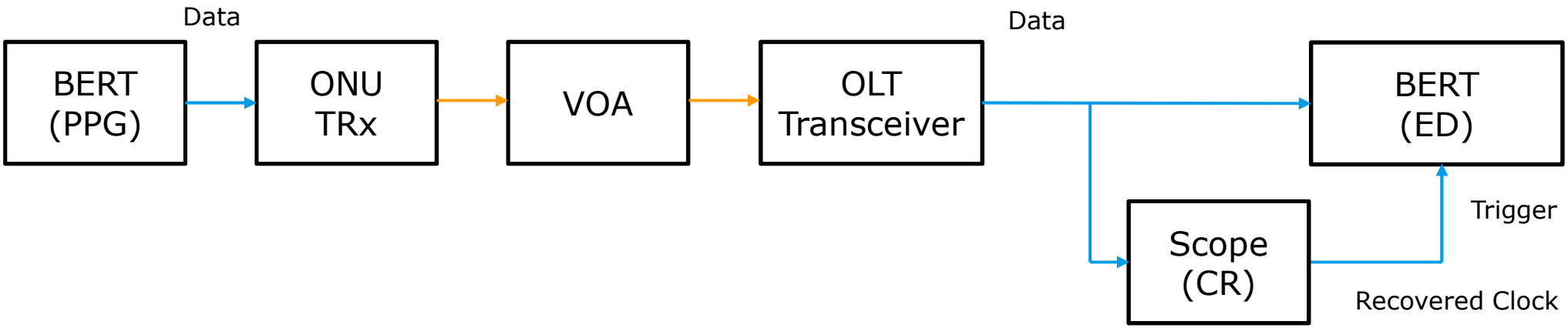
Thank you!

Setup 1



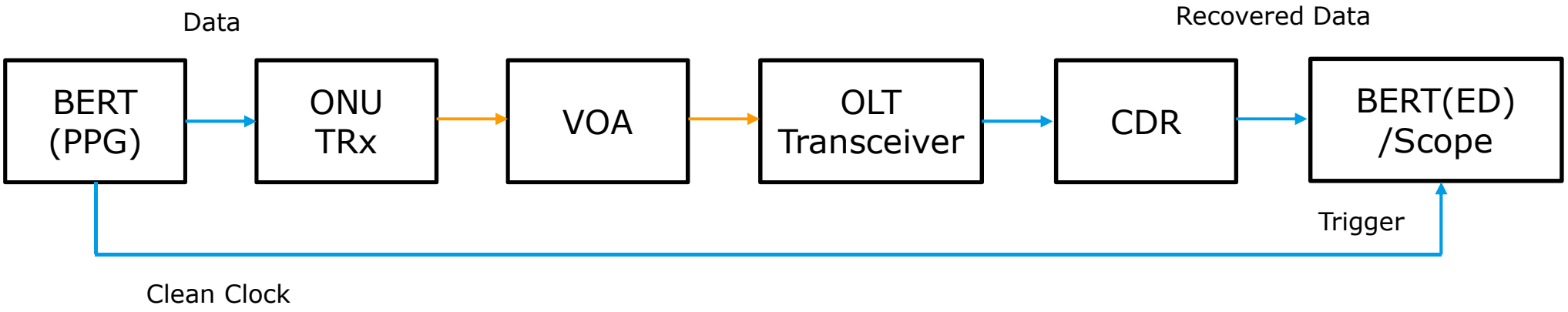
No.	Sample	Description	Slide
1	**10G CM CDR**	**10G CM CDR on Evaluation Board**	Slide.5
2	10G CM CR Module	10G CM CDR in Scope (Equipment)	
3	10G CM CDR Module	10G CM CDR in BERT (Equipment)	
4	10G-EPON ONU Transceiver	10G-EPON CM CDR in ONU Transceiver	Slide.6
5	10G-EPON OLT BM-CDR	10G-EPON BM CDR on Evaluation Board	Slide.7
6	10G-EPON OLT	10G-EPON BM CDR on 10G Line Card	Slide.8
7	25G SFP28	25G CM CDR in Transceiver	Slide.9
8	25G QSFP28 (CWDM, CH3)	25G CM CDR in Transceiver	

Setup 2



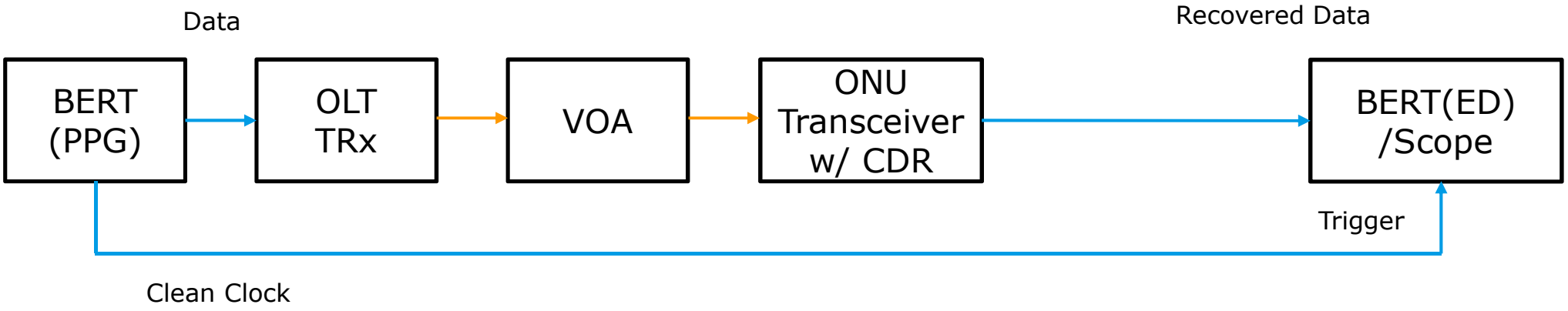
No.	Sample	Description	Slide
1	10G CM CDR	10G CM CDR on Evaluation Board	Slide.5
2	**10G CM CR Module**	**10G CM CDR in Scope (Equipment)**	
3	10G CM CDR Module	10G CM CDR in BERT (Equipment)	
4	10G-EPON ONU Transceiver	10G-EPON CM CDR in ONU Transceiver	Slide.6
5	10G-EPON OLT BM-CDR	10G-EPON BM CDR on Evaluation Board	Slide.7
6	10G-EPON OLT	10G-EPON BM CDR on 10G Line Card	Slide.8
7	25G SFP28	25G CM CDR in Transceiver	Slide.9
8	25G QSFP28 (CWDM, CH3)	25G CM CDR in Transceiver	

Setup 3



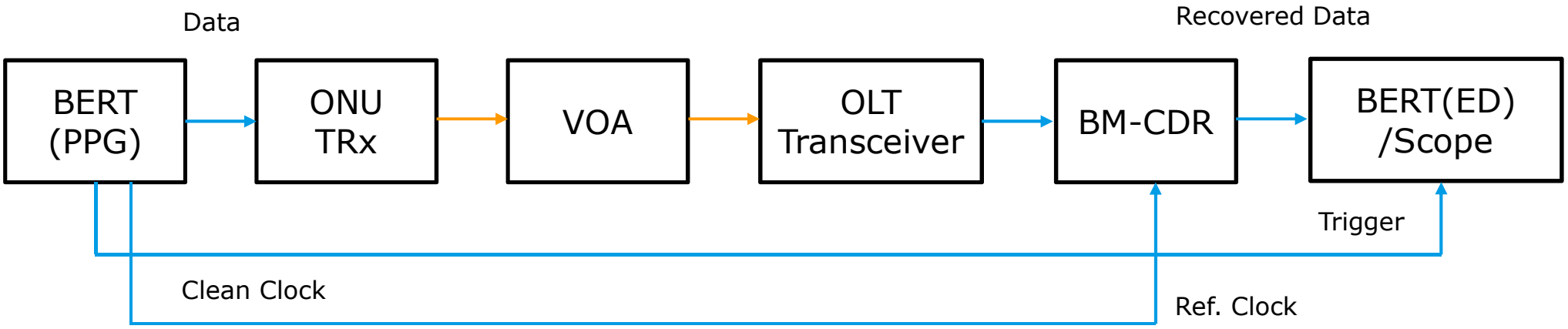
No.	Sample	Description	Slide
1	10G CM CDR	10G CM CDR on Evaluation Board	Slide.5
2	10G CM CR Module	10G CM CDR in Scope (Equipment)	
3	**10G CM CDR Module**	**10G CM CDR in BERT (Equipment)**	
4	10G-EPON ONU Transceiver	10G-EPON CM CDR in ONU Transceiver	Slide.6
5	10G-EPON OLT BM-CDR	10G-EPON BM CDR on Evaluation Board	Slide.7
6	10G-EPON OLT	10G-EPON BM CDR on 10G Line Card	Slide.8
7	25G SFP28	25G CM CDR in Transceiver	Slide.9
8	25G QSFP28 (CWDM, CH3)	25G CM CDR in Transceiver	

Setup 4



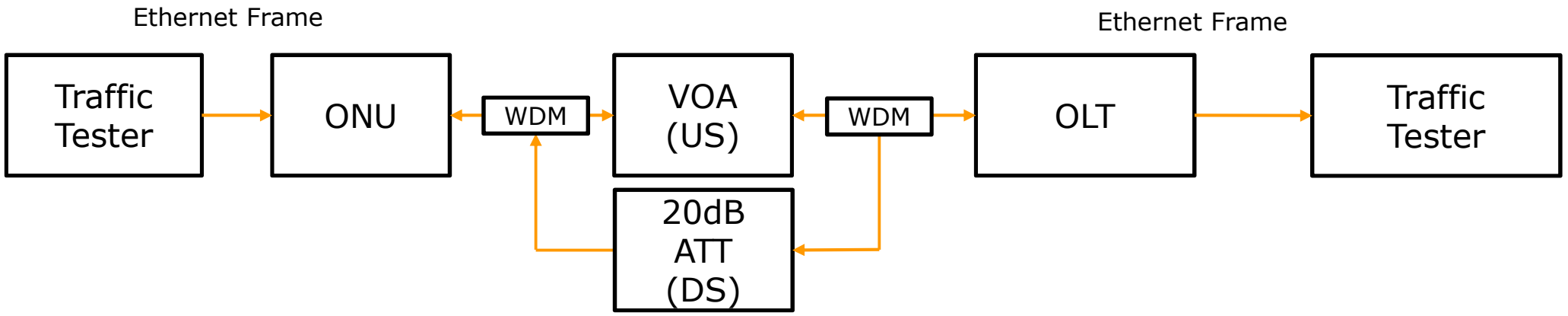
No.	Sample	Description	Slide
1	10G CM CDR	10G CM CDR on Evaluation Board	Slide.5
2	10G CM CR Module	10G CM CDR in Scope (Equipment)	
3	10G CM CDR Module	10G CM CDR in BERT (Equipment)	
4	**10G-EPON ONU Transceiver**	**10G-EPON CM CDR in ONU Transceiver**	Slide.6
5	10G-EPON OLT BM-CDR	10G-EPON BM CDR on Evaluation Board	Slide.7
6	10G-EPON OLT	10G-EPON BM CDR on 10G Line Card	Slide.8
7	25G SFP28	25G CM CDR in Transceiver	Slide.9
8	25G QSFP28 (CWDM, CH3)	25G CM CDR in Transceiver	

Setup 5



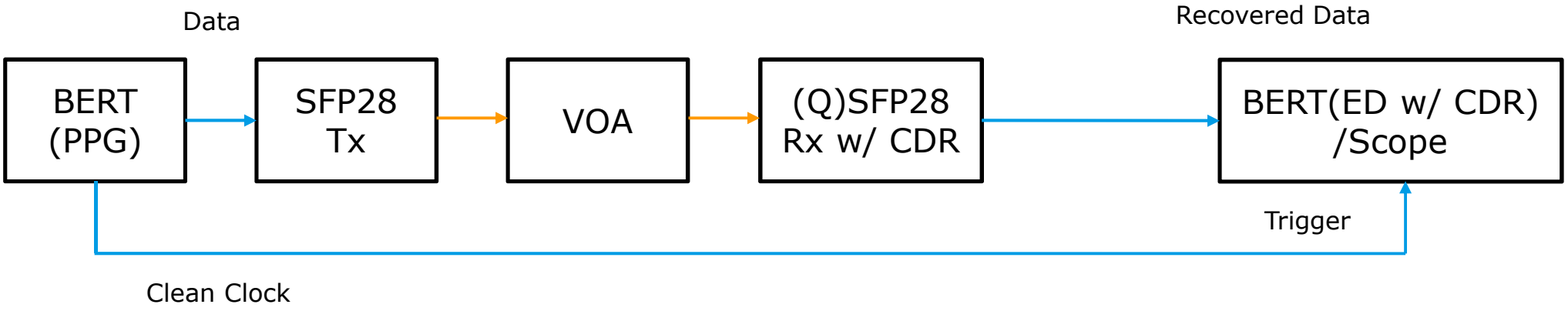
No.	Sample	Description	Slide
1	10G CM CDR	10G CM CDR on Evaluation Board	Slide.5
2	10G CM CR Module	10G CM CDR in Scope (Equipment)	
3	10G CM CDR Module	10G CM CDR in BERT (Equipment)	
4	10G-EPON ONU Transceiver	10G-EPON CM CDR in ONU Transceiver	Slide.6
5	**10G-EPON OLT BM-CDR**	**10G-EPON BM CDR on Evaluation Board**	Slide.7
6	10G-EPON OLT	10G-EPON BM CDR on 10G Line Card	Slide.8
7	25G SFP28	25G CM CDR in Transceiver	Slide.9
8	25G QSFP28 (CWDM, CH3)	25G CM CDR in Transceiver	

Setup 6



No.	Sample	Description	Slide
1	10G CM CDR	10G CM CDR on Evaluation Board	Slide.5
2	10G CM CR Module	10G CM CDR in Scope (Equipment)	
3	10G CM CDR Module	10G CM CDR in BERT (Equipment)	
4	10G-EPON ONU Transceiver	10G-EPON CM CDR in ONU Transceiver	Slide.6
5	10G-EPON OLT BM-CDR	10G-EPON BM CDR on Evaluation Board	Slide.7
6	**10G-EPON OLT**	**10G-EPON BM CDR on 10G Line Card**	Slide.8
7	25G SFP28	25G CM CDR in Transceiver	Slide.9
8	25G QSFP28 (CWDM, CH3)	25G CM CDR in Transceiver	

Setup 7,8



No.	Sample	Description	Slide
1	10G CM CDR	10G CM CDR on Evaluation Board	Slide.5
2	10G CM CR Module	10G CM CDR in Scope (Equipment)	
3	10G CM CDR Module	10G CM CDR in BERT (Equipment)	
4	10G-EPON ONU Transceiver	10G-EPON CM CDR in ONU Transceiver	Slide.6
5	10G-EPON OLT BM-CDR	10G-EPON BM CDR on Evaluation Board	Slide.7
6	10G-EPON OLT	10G-EPON BM CDR on 10G Line Card	Slide.8
7	**25G SFP28**	**25G CM CDR in Transceiver**	Slide.9
8	**25G QSFP28 (CWDM, CH3)**	**25G CM CDR in Transceiver**	