Comparing ITU-T and IEEE Jitter Analysis Techniques in Synchronous Ethernet Networks

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Agenda

- Introduction
- Wander Aspects
- Jitter Aspects
- Measurement Examples
- Conclusion

Introduction

Synchronous Ethernet (SyncE)

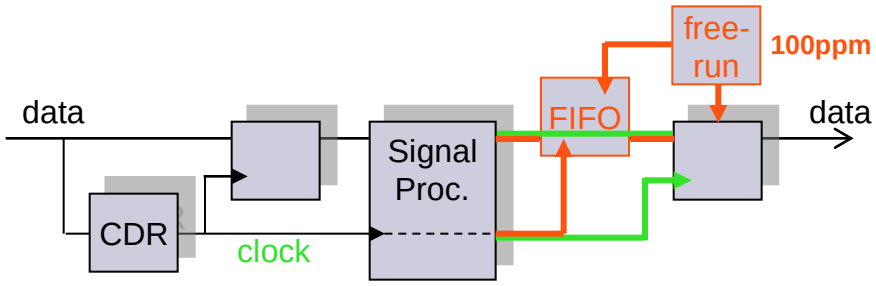
- Synchronous Ethernet (SyncE) enables frequency synchronization in packet (Ethernet) networks
- Provides frequency based timing over an Ethernet physical link by BITS/SSU or line-timed like SDH/SONET
- Direct replacement of SDH/SONET timing links with Ethernet (e.g. Mobile Backhaul)
- Replaces 100ppm Ethernet clock by 4.6ppm
- Does not impact any IEEE standards

G.8261
Network limits

G.8262
SyncE clocks

O.174
Test equipment

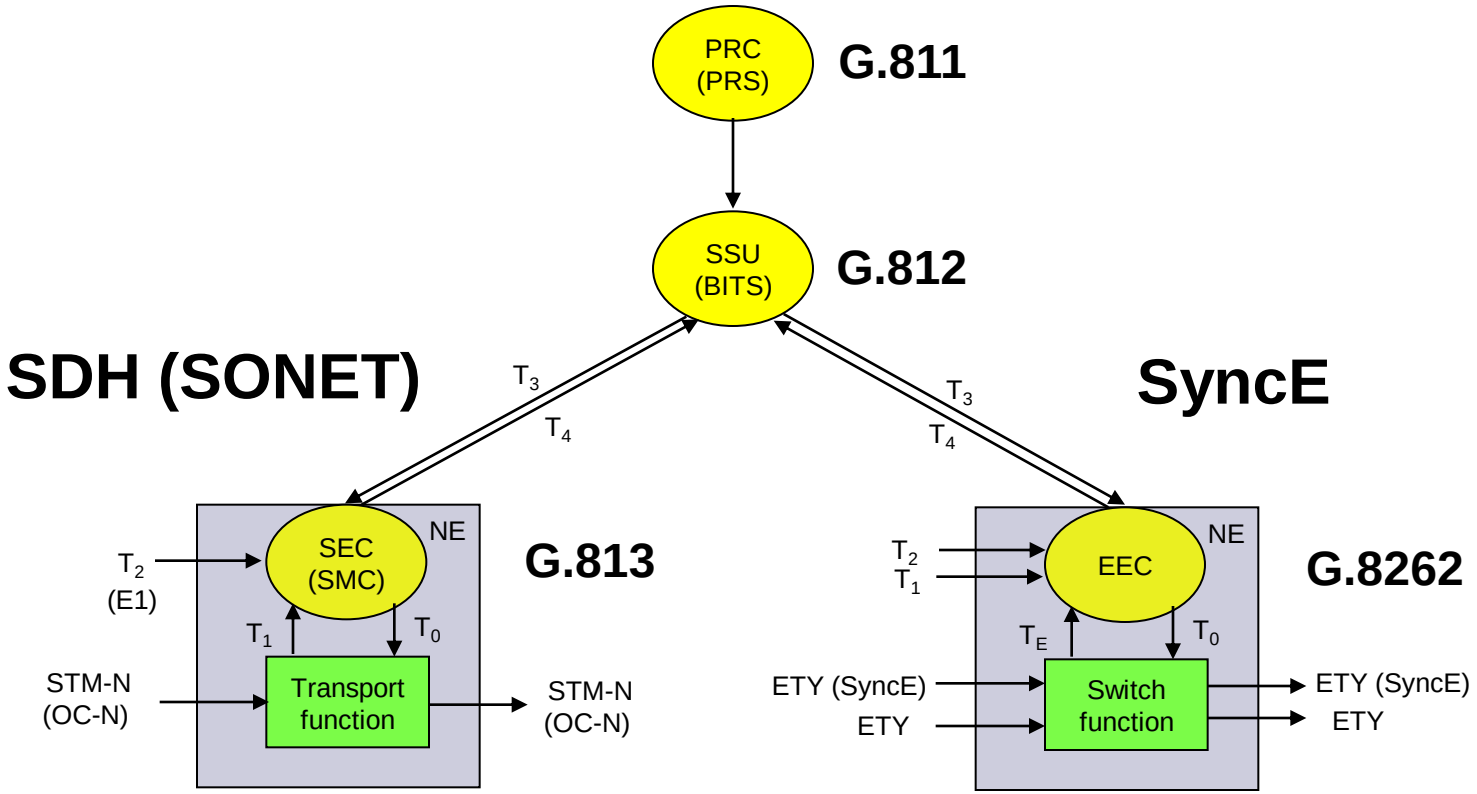
- Jitter test methodologies on Ethernet differ from those for SDH/SONET because of different timing methods



outgoing data is retimed with independent clock (±100ppm)

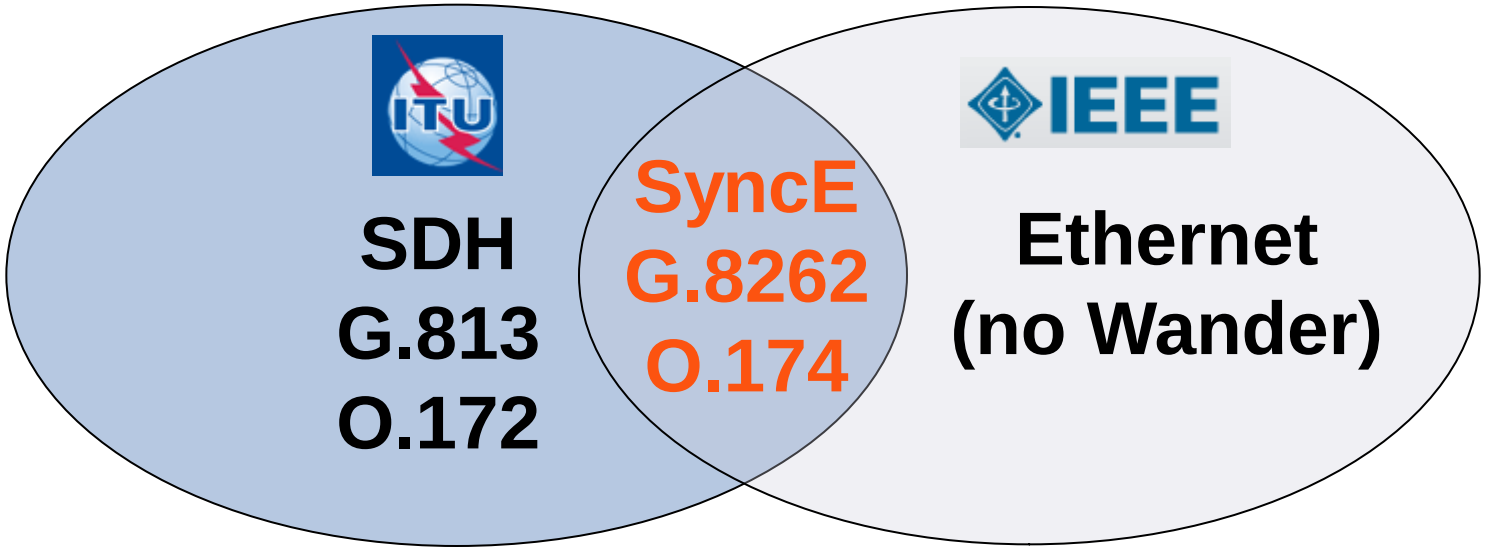
outgoing data is retimed with recovered clock of incoming data

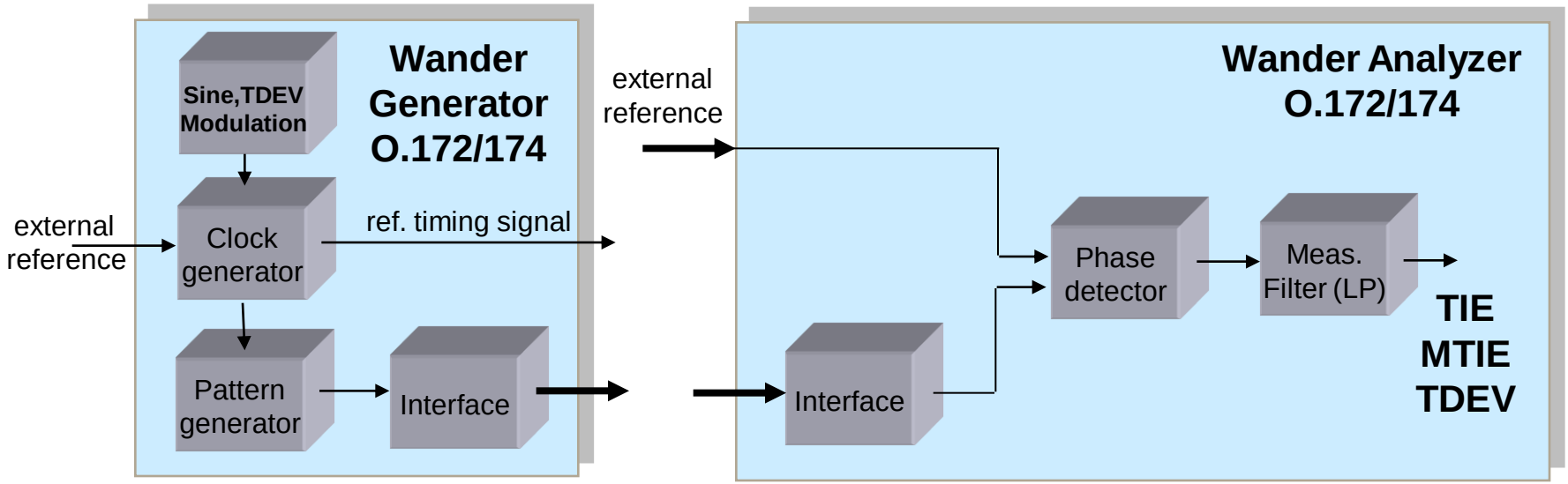
Synchronization Architecture for SDH and SyncE



Wander Aspects

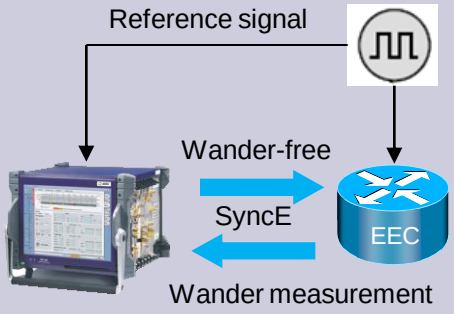
Wander Aspects

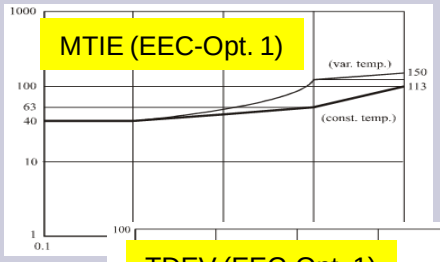


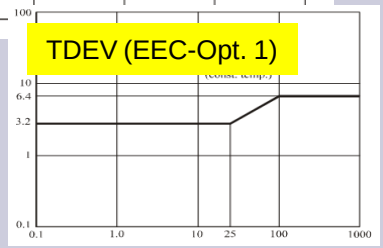


SyncE: Wander applications acc. to G.8262

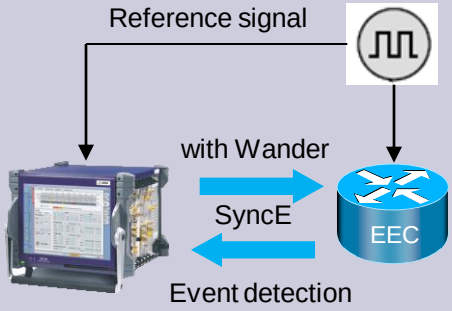
Wander Generation

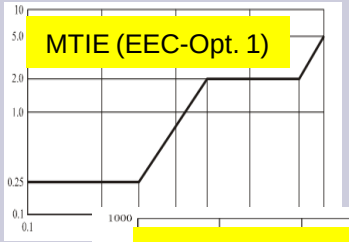


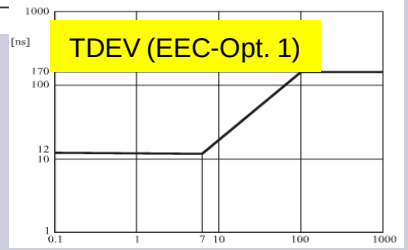




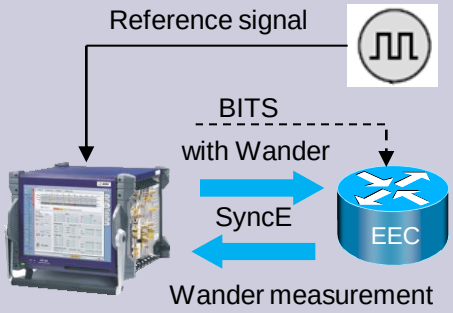
Wander Tolerance

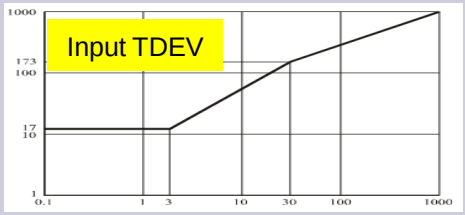


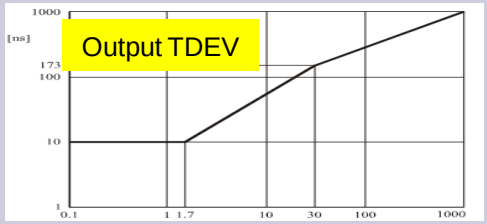




Wander Transfer

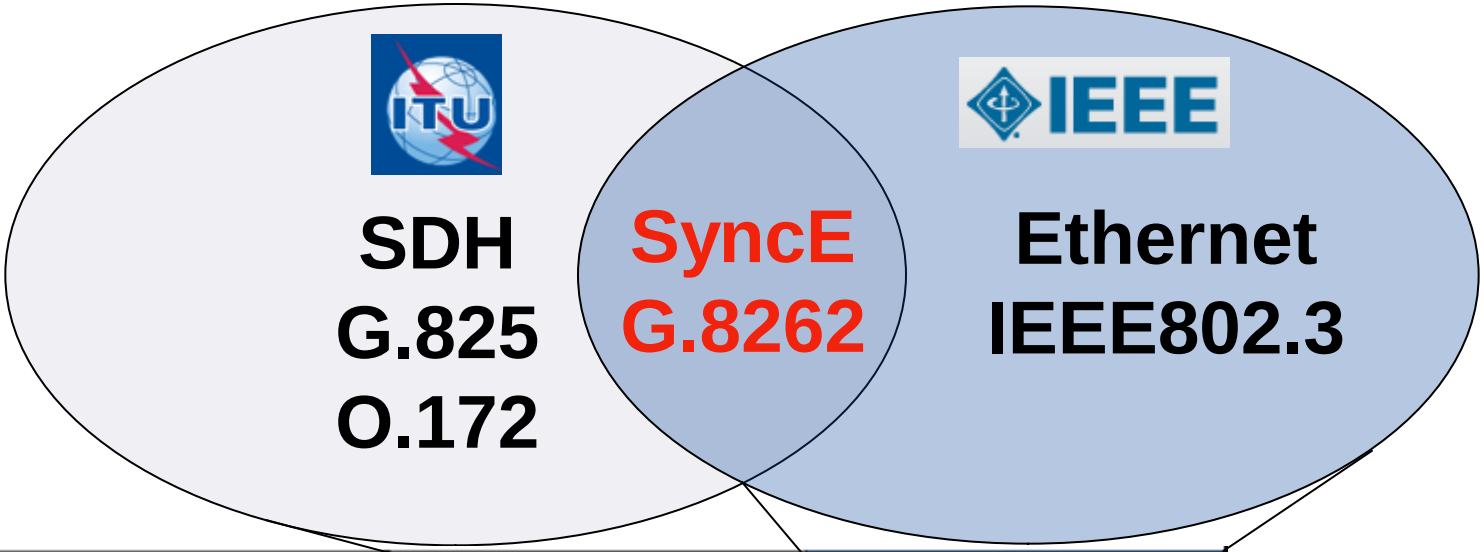






Jitter Aspects

Jitter Aspects

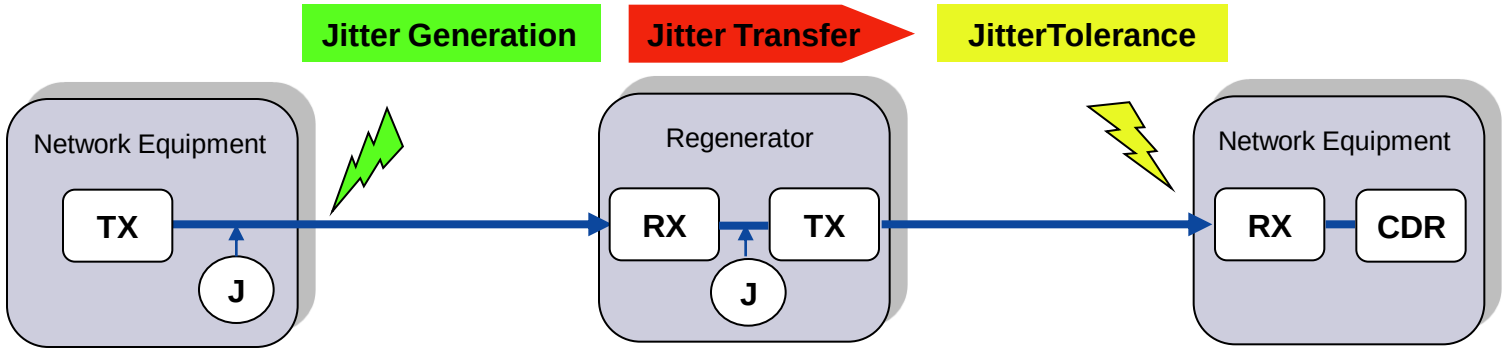


Jitter Generation	Peak-Peak-Jitter measurement Gen. → DUT → Jitter Analyzer Generation	e.g. BERT scan (Bathtub curve) Gen. → DUT → BERT Generation
Jitter Tolerance Amplitude / Frequency	Jitter injection → Error detection Jitter Gen. → DUT → BERT Tolerance	Impairment injection → Error detection Stressed Eye → DUT → BERT SRS
Jitter Transfer Gain in dB / Frequency	Jitter injection → Transfer → Select. Jitter measurement Jitter Gen. → DUT → Jitter Analyzer for calibration	not applicable DUT Device Under Test

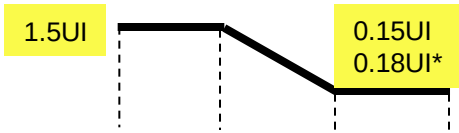
Jitter Aspects - ITU

Jitter Measurements required in SDH Networks

SDH	f1(HP1)	f3(HP2)	f4(LP)	f1-f4	f3-f4
STM-1	0.5k	65k	1.3M	1.5UI	0.15UI
STM-4	1k	250k	5M	1.5UI	0.15UI
STM-16	5k	1M	20M	1.5UI	0.15UI
STM-64	20k	4M	80M	1.5UI	0.15UI
STM-256	80k	16M	320M	1.5UI	0.18UI

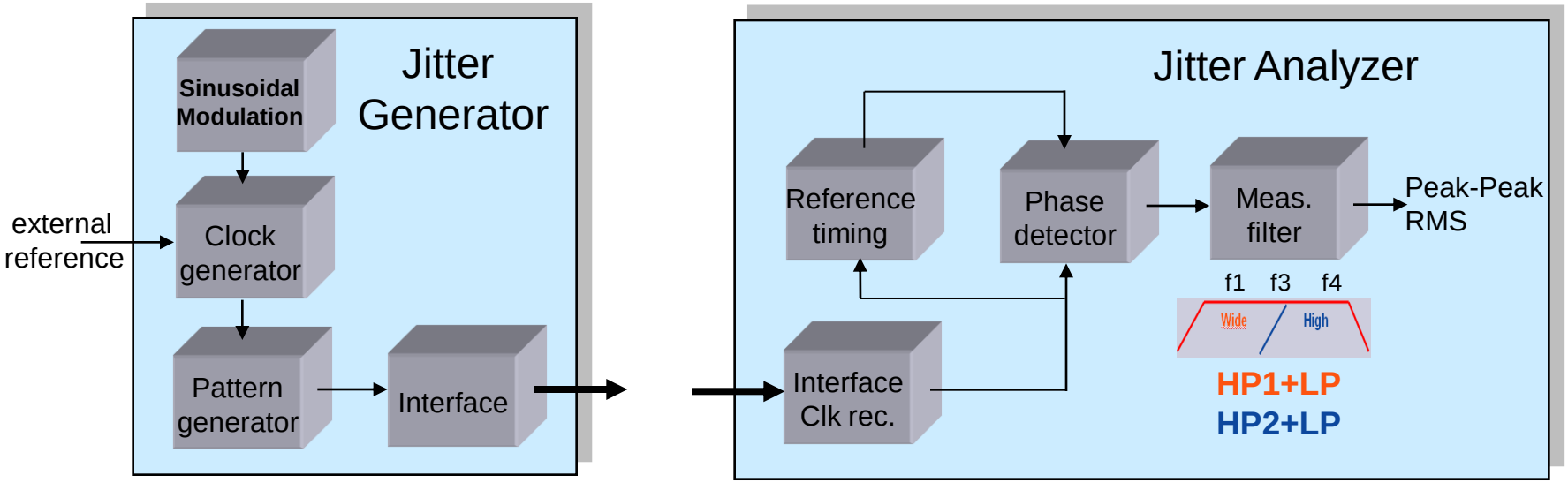


SDH	fL	fc	fH
STM-1	1.3k	130k	1.3M
STM-4	5k	500k	5M
STM-16	20k	2M	20M
STM-64	10k	1M	80M
STM-256	40k	4M	320M



SDH	f1	f2	f3	f4
STM-1	0.5k	6.5k	65k	1.3M
STM-4	1k	25k	250k	5M
STM-16	5k	100k	1M	20M
STM-64	20k	400k	4M	80M
STM-256*	80k	1.92M	16M	320M

Jitter Measurement acc. to ITU-T O.172



- Jitter can change with pattern, mapping, scrambling, and framing
- Bulk payload with longest PRBS generates the largest peak-to-peak jitter
- Real time jitter measurement in the defined frequency-band
- Transient peaks are measured (may be missed by sampling oscilloscope)
- Measuring more than 1UIpp (eye diagram is limited)

Jitter Aspects - IEEE

G.8262 App.III: Interfaces applicable to SyncE

IEEE 802.3

Fast Ethernet (125Mb/s)

PHY	Description	Clause
100BASE-BX10	100 Mb bidi fiber	58, 66
100BASE-FX	100 Mb fiber	24, 26
100BASE-LX10	100 Mb fiber	58, 66
100BASE-TX	100 Mb TP copper	24, 25

Gigabit Ethernet (1.25Gb/s)

PHY	Description	Clause
1000BASE-LX	1 Gb SM/MM fiber	38
1000BASE-SX	1 Gb MM fiber	38
1000BASE-BX10	1 Gb bidi fiber	59, 66
1000BASE-CX	1 Gb twinax	39
1000BASE-KX	1 Gb backplane	70
1000BASE-PX	1 Gb PON, unidir	38
1000BASE-T	1 Gb TP copper, unidir	40

10Gigabit Ethernet WAN (9.95328Gb/s)

PHY	Description	Clause
10GBASE-EW	10 Gb fiber	50, 52
10GBASE-LW	10 Gb fiber	50, 52
10GBASE-SW	10 Gb fiber	50, 52

10Gigabit Ethernet LAN (10.3125Gb/s)

PHY	Description	Clause
10GBASE-ER	10 Gb SM fiber	49, 52
10GBASE-LR	10 Gb SM fiber	49, 52
10GBASE-SR	10 Gb MM fiber	49, 52
10GBASE-LX4	10 Gb 4x3.125G fiber	50, 52
10GBASE-LRM	10 Gb fiber	68
10GBASE-CX4	10 Gb 4x3.125G twinax	54
10GBASE-T	10 Gb 4x3.125G TP, unidir	55
10GBASE-KR	10 Gb backplane	72
10GBASE-KX4	10 Gb 4x backplane	71
10/1GBASE-PR	10 G/1 G PON, unidir	76
10GBASE-PR	10 G PON, unidir	76

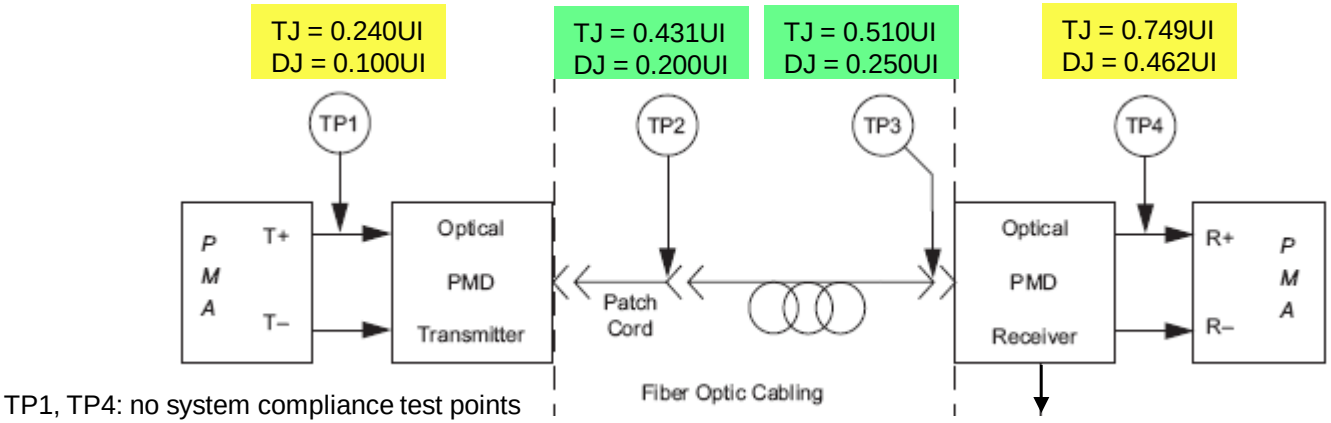
40Gb/s and 100Gb/s Ethernet

PHY	Description	Clause
40GBASE-KR4	40 G 4x backplane (1m)	84
40GBASE-CR4	40 G 4x twinax (10m)	85
40GBASE-SR4	40 G 4x MM fiber (100m)	86
40GBASE-LR4	40 G 4λSM fiber (10km)	87
100GBASE-CR10	100 G 10x twinax (10m)	85
100GBASE-SR10	100 G 10xMM fiber (100m)	86
100GBASE-LR4	100 G 4λ SM fiber (10km)	88
100GBASE-ER4	100 G 4λSM fiber (40km)	88

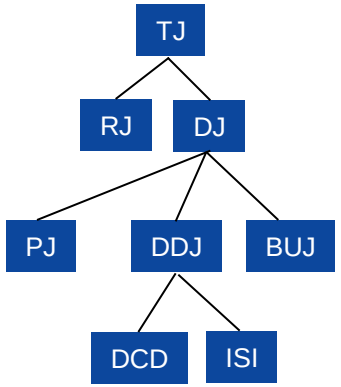
JDSU

Jitter Specifications for 1000BASE-SX/LX

High frequency jitter above 637kHz:



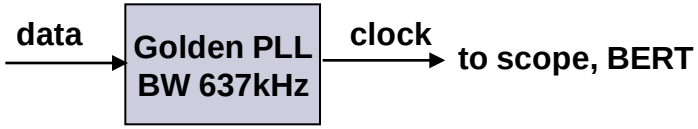
TP1, TP4: no system compliance test points



Jitter measurement acc. to ANSI X3.230-1994 Annex A:

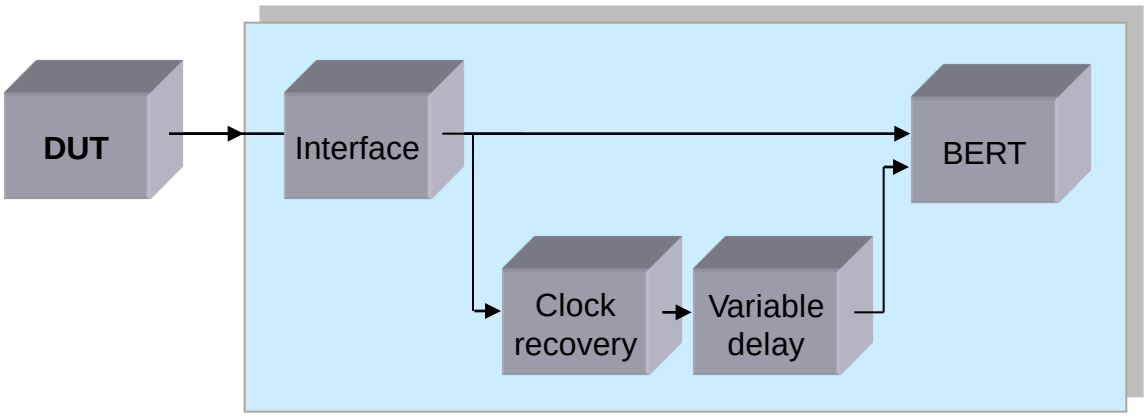
- TJ at TP2: using a mixed frequency test pattern and a BERT
- TJ at TP4: using the conformance test signal at TP3
- DJ: using a mixed frequency test pattern and a sampling scope

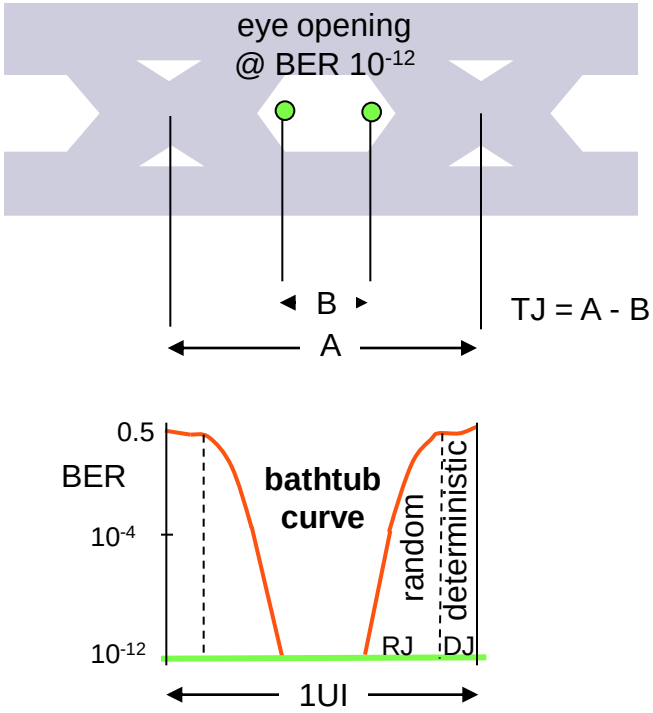
- Golden PLL removes low frequency jitter



Jitter Generation Measurement Method

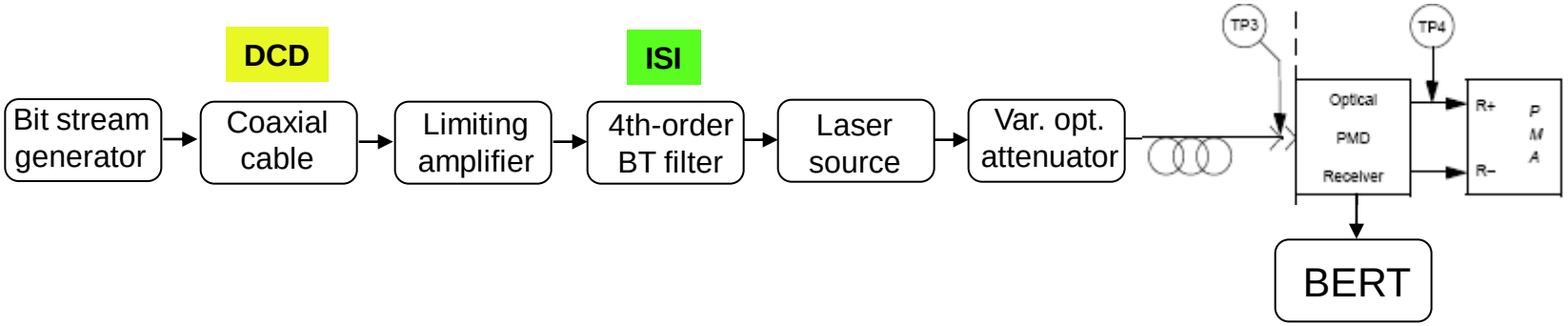
- BERT scan: Time domain jitter measurement by moving the data sampling point within the data eye from the centre to the crossing points
- Bathtub curve: BER (Bit Error Ratio) is recorded as a function of decision circuit time position varied over one Unit Interval (= one bit period)
- Common practice to save time: measuring up to 10^{-6} and then extrapolate to the eye opening at a 10^{-12} probability

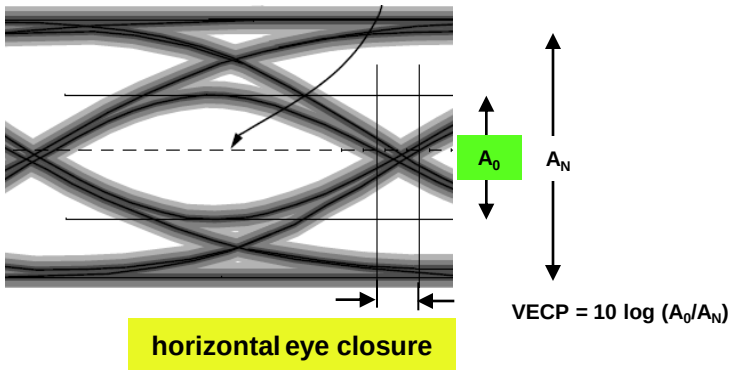




Stressed Receive Sensitivity for 1000BASE-SX/LX

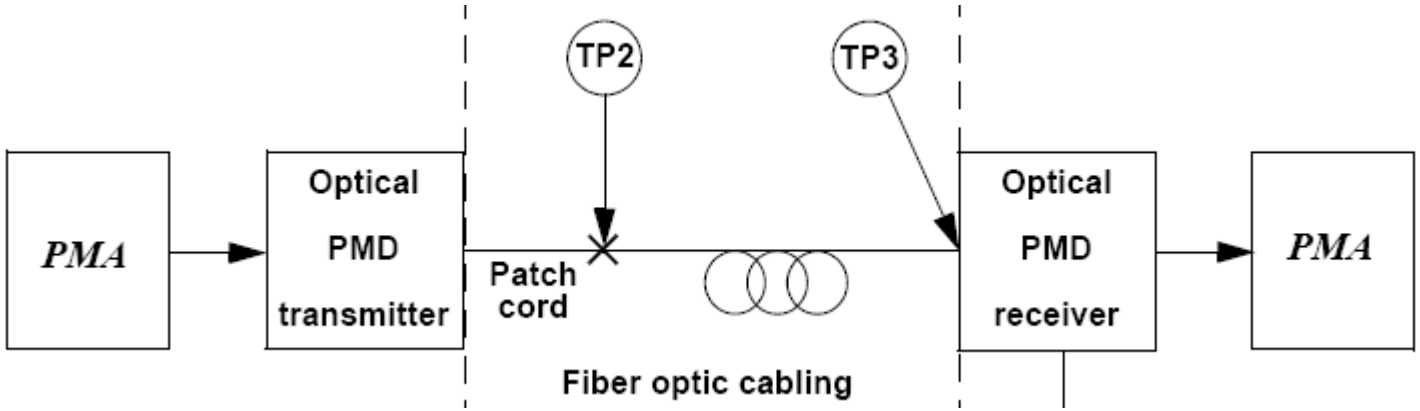
- Receiver test: using conformance test signal at TP3 for BER < 10^{-12}



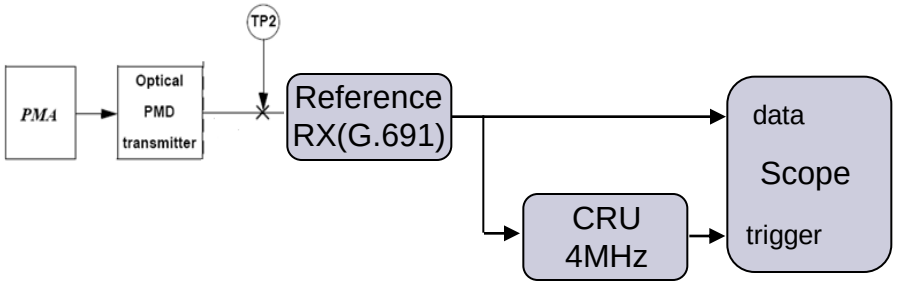


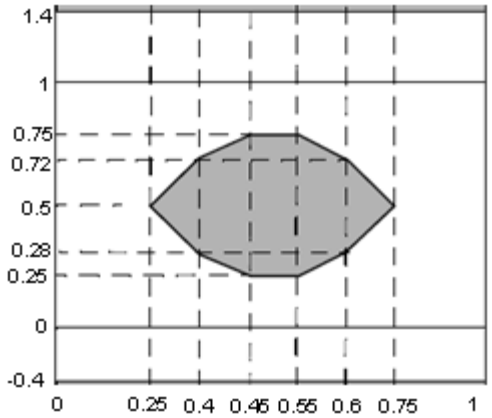
Test condition 1000BASE-X	SX 850n/62.5	SX 850n/50	LX 1310n
ER (dB)	9	9	9
VECP (dB)	2.6	2.2	2.6
Jitter (ps)	65	65	65
SRS (dBm)	-12.5	-13.5	-14.4

Jitter Specifications for 10GBASE-R/W



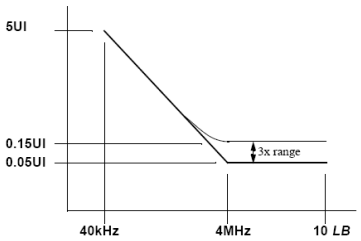
- **Transmitter optical waveform measurement (eye mask) acc. to IEC 61280-2-2**

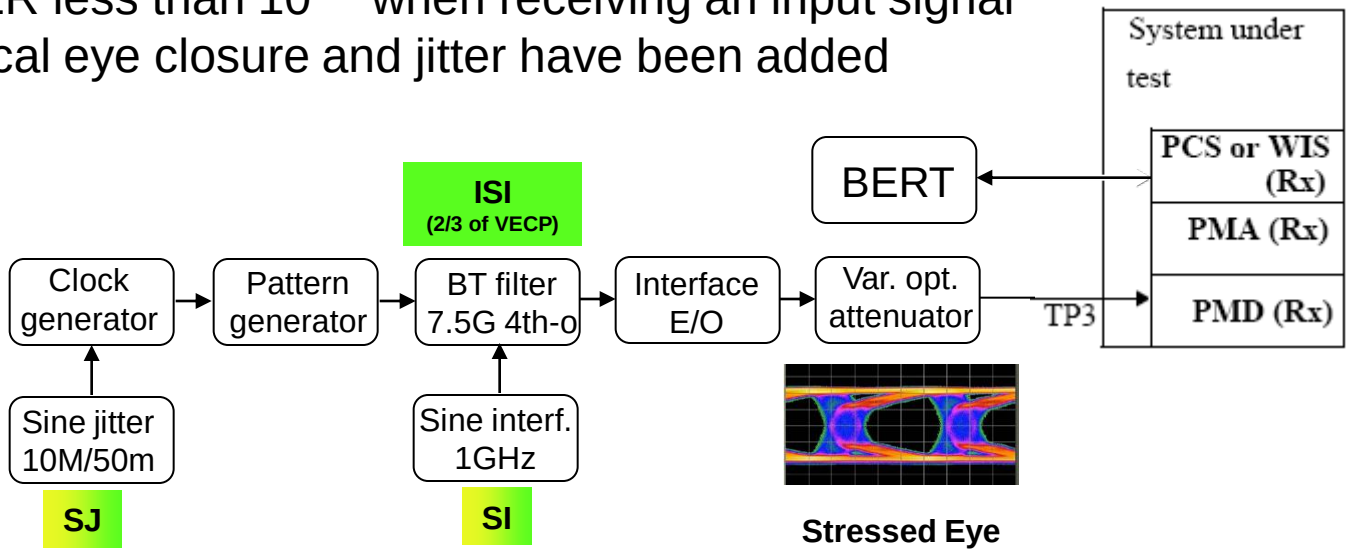


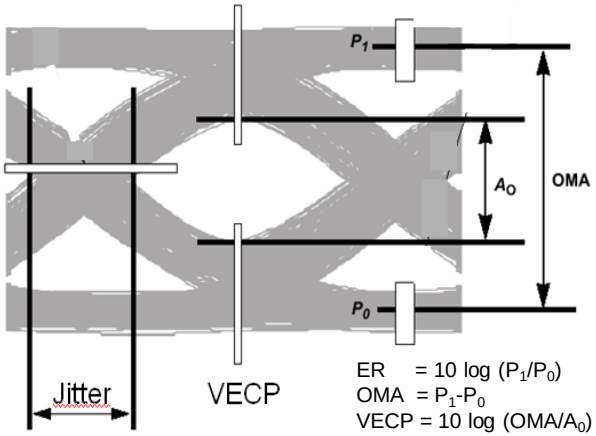


Stressed Receiver Conformance Test (SRCT)

- Stressed receiver sensitivity (SRS) verifies that a receiver operates at a BER less than 10^{-12} when receiving an input signal where both vertical eye closure and jitter have been added



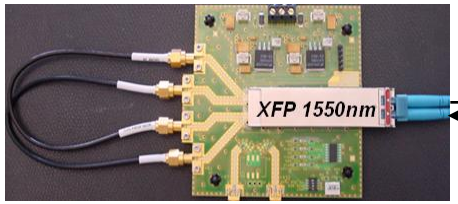




Test conditions 10GBASE-R/W	S 850	L 1310	E 1550
ER (dB)	3	3.5	3
OMA (dBm)	-7.5	-10.3	-11.3
VECP (dB)	3.5	2.2	2.7
Jitter (Ulpp)	0.3	0.3	0.3

Measurement Examples

Measurement Examples: XFP 10G Ethernet

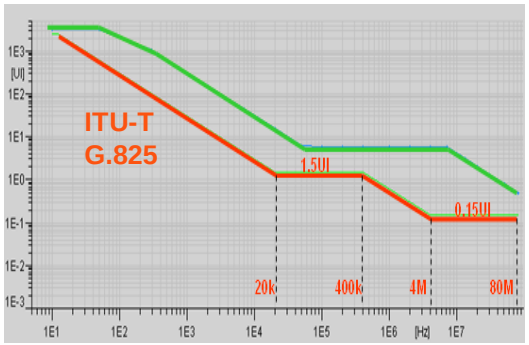
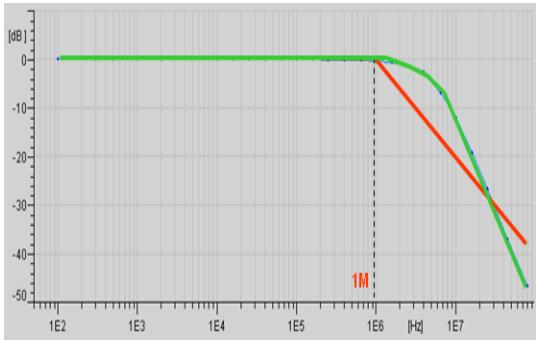
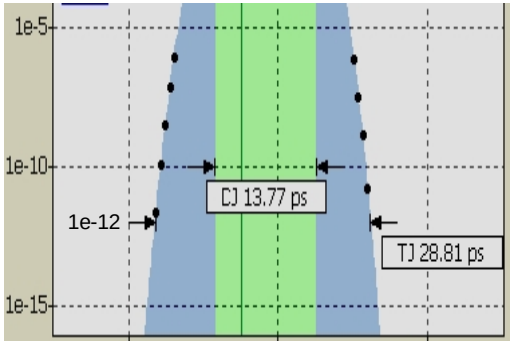
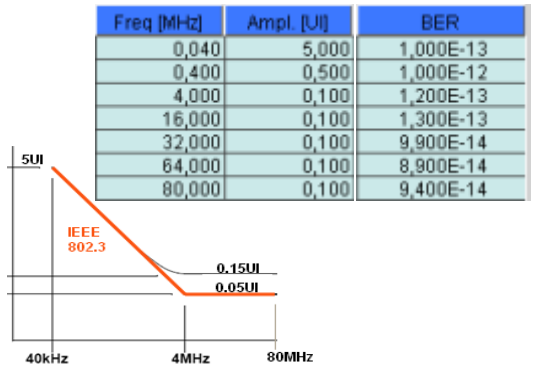


10.3125Gb/s
PRBS31

ITU Jitter

IEEE BERTscan

IEEE SRS

	Jitter Generation	Jitter Tolerance	Jitter Transfer
ITU	HP1+LP (20kHz – 80MHz) HP2+LP (4MHz – 80MHz)		
IEEE			N/A

HP1+LP (20kHz – 80MHz)

No	+Peak [UI]	-Peak [UI]	Peak-Peak [UI]
1	0,047	0,048	0,095
2	0,042	0,048	0,091
3	0,045	0,050	0,095
4	0,045	0,049	0,094
5	0,043	0,048	0,091

HP2+LP (4MHz – 80MHz)

No	+Peak [UI]	-Peak [UI]	Peak-Peak [UI]
1	0,031	0,035	0,066
2	0,031	0,034	0,065
3	0,030	0,035	0,065
4	0,034	0,034	0,068
5	0,030	0,034	0,064

Freq [MHz]	Ampl. [UI]	BER
0,040	5,000	1,000E-13
0,400	0,500	1,000E-12
4,000	0,100	1,200E-13
16,000	0,100	1,300E-13
32,000	0,100	9,900E-14
64,000	0,100	8,900E-14
80,000	0,100	9,400E-14

JDSU

Conclusion

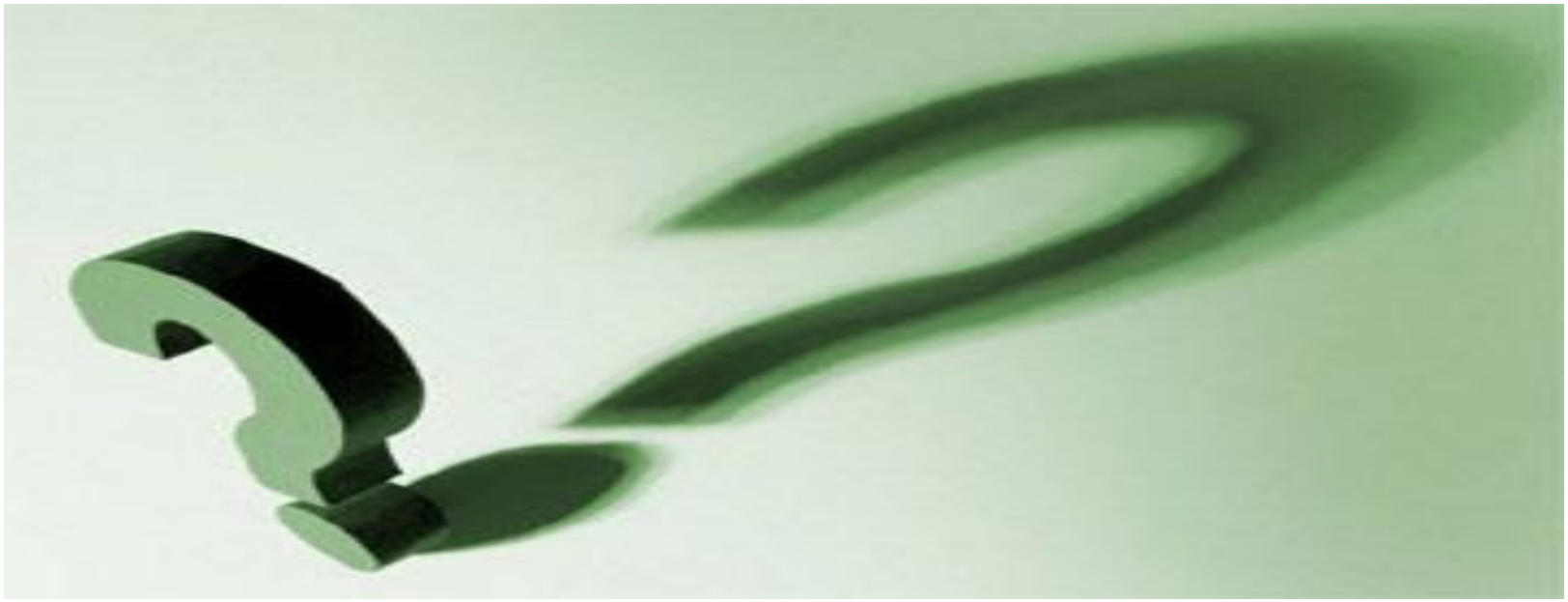
Conclusion

- **The specifications and test methodologies for jitter on Ethernet differ from those for SDH(SONET)**
- **Ethernet traffic interfaces have to fulfil high-band jitter specifications and SRS test methods defined by IEEE802.3**
- **Synchronization interfaces have to fulfil wide-band and high-band jitter specifications, sinusoidal input jitter tolerance and jitter transfer methods defined by ITU-T**
- **There is no comparability of the jitter measurement methods**

	SDH	SyncE	Ethernet
Clock function	ITU-T G.813 (SEC)	ITU-T G.8262 (EEC)	IEEE802.3 (free running)
Network standard	ITU-T G.825, G.783	ITU-T G.8261	IEEE802.3
Jitter applications and related test equipment standard	Generation Tolerance Transfer ITU-T O.172	ITU-T O.174 IEEE 802.3	BERT scan SRS N/A IEEE 802.3
Wander applications and related test equipment standard	Generation Tolerance Transfer ITU-T O.172	Generation Tolerance Transfer ITU-T O.174	N/A N/A N/A

Q & A

Thank you
for your attention



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