High-Accuracy Jitter Measurement

T-BERD / MTS-8000

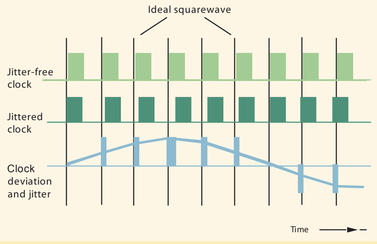
ONT-506 / ONT-512 / ONT-503

Views of Jitter

	SDH/SONET/OTN ITU-T/Telcordia	Ethernet IEEE
Jitter generation		BERT scan (bathtub curve) 
Jitter tolerance (MTJ)		Stressed eye 
Jitter transfer (JTF)		Not applicable

What is Jitter

Jitter is the term used to designate periodic or stochastic deviations of the significant instants of a digital signal from the ideal, equidistant values. Otherwise stated, the transitions of a digital signal invariably occur either too early or too late when compared to a perfect squarewave (reference clock).

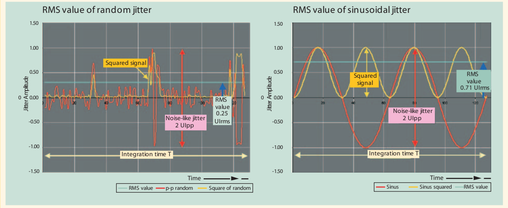


Peak-to-Peak and RMS Jitter

The root mean square (RMS) value of the jitter signal provides an indication of the jitter noise power. Peak values that cause bit errors are not recorded by an RMS measurement.

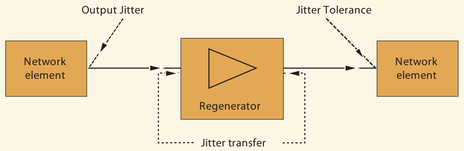
RMS jitter is defined for an integration period of T as: $J_{RMS} = \sqrt{\frac{1}{T}\int_0^T [j(t)]^2 \, dt}$

The square root is calculated over the mean value of the squared signal.



Jitter Measurements

Application	Device Under Test
Output jitter - intrinsic jitter	Network interfaces, equipment
Jitter tolerance (MTJ)	ADM, DXC, regenerator input ports
Jitter transfer (JTF)	Regenerator
Tributary jitter	Network interfaces, equipment
Pointer jitter	ADM, DXC, tributary output ports
SDH/SONET mapping jitter	ADM, DXC, tributary output ports
OTN mapping jitter	ADM, DXC, client output ports



Jitter Standards – Network Equipment

Aspect	Application	ITU-T	ANSI	Telcordia	ETSI
Output jitter	OTN	G.8251	–	–	–
Network interfaces	SDH	G.825	–	–	EN 302 084
	SONET	–	T1.105.03	GR-253	–
	1.5 Mb/s hierarchy	G.824	T1.102 T1.403 T1.404	GR-499	–
	PDH 2 Mb/s hierarchy	G.823	–	–	EN 302 084
	Synchronization	G.823	T1.101	–	EN 300 462-3-1
Output jitter	OTN	G.8251	–	–	–
Equipment	SDH/SONET (TM, ADM, DXC, etc.)	G.813	T1.105.03	GR-253	EN 300 462-5-1
	SDH/SONET regenerators	G.783	–	–	–
	PRC clock	G.811	–	–	EN 300 462-6-1
	SSU clock	G.812	–	–	EN 300 462-4-1 EN 300 462-7-1
	PDH/DSn	G.735 G.742 G.751	–	GR-499	–
Mapping/pointer (combined) jitter	SDH/SONET equipment	G.783	T1.105.03	GR-253	EN 300 417-1-1
Jitter tolerance	OTN	G.8251	–	–	–
	SDH/SONET	G.825	T1.105.03	GR-253	EN 302 084
	1.5 Mb/s hierarchy	G.824	–	GR-499	–
	PDH 2 Mb/s hierarchy	G.823	–	–	EN 302 084
Jitter transfer	OTN	G.8251	–	–	–
	SDH/SONET	G.783	T1.105.03	GR-253	–
	1.5 Mb/s hierarchy (MUXDEM)	–	–	GR-499	–
	PDH 2 Mb/s hierarchy (MUXDEM)	G.705	–	–	–
Definitions and terminology	Synchronization networks	G.810	–	–	EN 300 462-1-1

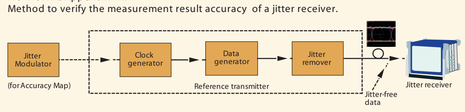
Jitter Standards – Test Equipment

Aspect	Application	ITU-T
Jitter test equipment	PDH systems	O.172
	SDH systems	O.173
	OTN systems	O.171

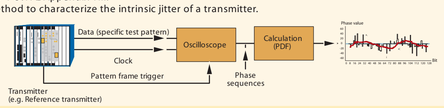
Total measurement error: ± *R* % of reading ± *W*
R = variable error
W = fixed error

Fixed Error (W) in UI pp	SDH/SONET/OTN f_1 - f_4	f_2 - f_4
STM-1	0.07	0.035
STM-4	0.1	0.035
STM-16/OTU1	0.1	0.035
STM-64/OTU2	0.1	0.035
STM-256	0.15	0.05
OTU3	0.2	0.05

ITU-T O.172 Appendix VII:
Method to verify the measurement result accuracy of a jitter receiver.



ITU-T O.172 Appendix VIII:
Method to characterize the intrinsic jitter of a transmitter.



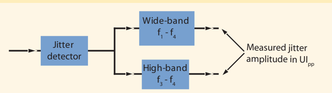
Output Jitter – Intrinsic Jitter – Jitter Generation

Network interface	Standard	Bit rate	Jitter limits Wide-band jitter/Ulpp	Jitter limits High-band jitter/Ulpp
OTN	ITU-T G.8251	OTU1	1.5	0.15
		OTU2	1.5	0.15
		OTU3	6.0	0.15
SDH transport	ITU-T G.825 ETSI EN 302 084	STM-1e	1.5	0.075
		STM-1	1.5	0.15
		STM-4	1.5	0.15
		STM-16	1.5	0.15
		STM-64	1.5	0.15
		STM-256	tbd	tbd
SONET transport	ANSI T1.105.03 Telcordia GR-253	OC-1	1.5	0.15
		OC-3	1.5	0.15
		OC-12	1.5	0.15
		OC-48	1.5	0.15
		OC-192	1.5	0.15
		OC-768	6.0	0.15
PDH/DSn transport	ITU-T G.823 ETSI EN 302 084	2048 kb/s	1.5	0.2
		8448 kb/s	1.5	0.2
		34368 kb/s	1.5	0.15
		139264 kb/s	1.5	0.075
	ANSI T1.102 Telcordia GR-499	1544 kb/s	5	0.1
		6312 kb/s	3(1)	0.1
	ITU-T G.824	44736 kb/s	5	0.1
Synchronization	ITU-T G.823 ETSI EN 300 462-3-1	2048 kb/s PRC	0.05	–
		2048 kb/s SSU	0.05	–
		2048 kb/s SEC	0.5	0.2
		2048 kb/s PDH	1.5	0.2
	ANSI T1.101	1544 kb/s	5	0.1

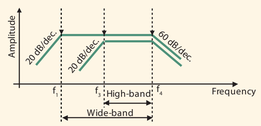
(1) In revised G.824 (02/00): 5 Ulpp

Equipment	Standard	Bit rate	Jitter limits Wide-band jitter/Ulpp	Jitter limits High-band jitter/Ulpp
OTN	ITU-T G.8251	OTU1	0.3	0.1
		OTU2	0.3	0.1
		OTU3	1.2	0.1
OTN (SDH interfaces)	ITU-T G.8251	STM-16	1.0	0.1
		STM-64	1.0	0.1
		STM-256	1.0	0.1
SDH (TM, ADM, DXC, etc.)	ITU-T G.783	STM-1	0.5	0.1
	ITU-T G.813	STM-4,	0.5	0.1
	ETSI EN 300 462-5-1	STM-16	0.5	0.1
		STM-64	0.5	0.1
	ANSI T1.105.03	OC-1	0.01 UIrms (12 kHz)	–
		OC-3	0.01 UIrms (12 kHz)	–
		OC-12	0.01 UIrms (12 kHz)	–
		OC-48	0.01 UIrms (12 kHz)	–
		OC-192	0.3	0.1
	Telcordia GR-253	OC-1	0.1 (0.01 UIrms)	–
		OC-3	0.1 (0.01 UIrms)	–
		OC-12	0.1 (0.01 UIrms)	–
		OC-48	0.1 (0.01 UIrms)	–
		OC-192	0.3	0.1
		OC-768	1.2	0.1
SDH regenerators	ITU-T G.783	STM-1	0.3	0.1
		STM-4 S	0.3	0.1
		TM-16	0.3	0.1
		STM-64	0.3	0.1
		STM-256	tbd	0.1
PRC clock	ITU-T G.811 ETSI EN 300 462-6-1	2048 kb/s	0.05	–
		1544 kb/s	0.015	–
SSU clock	ITU-T G.812 ETSI EN 300 462-4-1	STM-1e	0.5	0.075
		STM-1	0.5	0.1
		STM-4	0.5	0.1
		STM-16	0.5	0.1
		2048 kb/s	0.05	–
		1455 kb/s	0.05	–
PDH/DSn	ITU-T G.735	2048 kb/s	0.05	–
	ITU-T G.742	84448 kb/s	0.05	–
	ITU-T G.751	34368 kb/s	0.05	–
		139264 kb/s	0.05	–
	Telcordia GR-499	1544 kb/s	1.0 (0.3 UIrms)	–
		6312 kb/s	1.0 (0.3 UIrms)	–
		44763 kb/s	1.0 (0.3 UIrms)	–

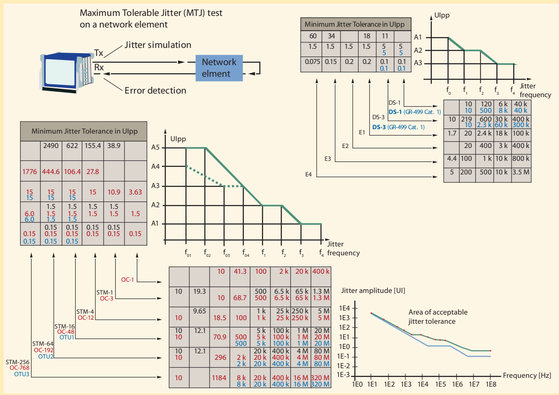
Jitter Measurement Filters for SDH/SONET/OTN



	High-pass 1	High-pass 2	Low-pass
STM-1/OC-3	500 Hz	65 kHz	1.3 MHz
STM-4/OC-12	1 kHz	250 kHz	5 MHz
STM-16/OC-48/OTU1	5 kHz	1 MHz	20 MHz
STM-64/OC-192/OTU2	20 kHz	4 MHz 1	80 MHz
STM-256	80 kHz	6 MHz	320 MHz
OC-768/OTU3	20 kHz	16 MHz	320 MHz



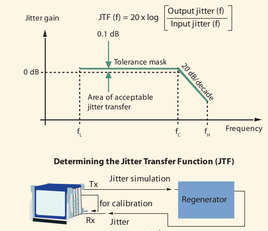
Jitter Tolerance (MTJ)



Jitter Transfer (JTF)

	Type	f_1	f_2	f_4
OC-1	–	400 Hz	40 kHz	400 kHz
STM-1/ OC-3	A	1.3 kHz	130 Hz	1.3 MHz
	B	300 kHz	30 kHz	1.3 MHz
STM-4/ OC-12	A	5 kHz	500 kHz	5 MHz
	B	300 Hz	30 kHz	20 MHz
STM-16/ OC-48	A	20 kHz	2 MHz	20 MHz
	B	300 Hz	30 kHz	3 MHz
STM-64/ OC-192	A	10 kHz	1 MHz	80 MHz
	*	–	120 kHz	–
OTU1	–	2.5 kHz	250 kHz	20 MHz
OTU2	–	10 kHz	1 MHz	80 MHz
OC-768/ OTU3	–	40 kHz	4 MHz	320 MHz

* Telcordia GR-1377-Core

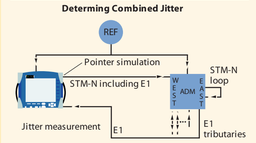


Combined Jitter

Limits for Combined Jitter (pointer & mapping jitter)

G.783, GR-253 EN 300 417-1-1	Max. jitter (Ulpp)	High-pass cutoff	Low-pass cutoff
1544 Mb/s (DS1)	1.3 ... 1.9 0.1	10 Hz 8 kHz	40 kHz 40 kHz
2048 Mb/s (E1)	0.4 0.075	20 Hz 18 kHz	100 kHz 100 kHz
34366 Mb/s (E3)	0.4 ... 0.75 0.075	100 Hz 10 kHz	800 kHz 800 kHz
44736 Mb/s (DS3)	1.3 0.1	10 Hz 30 kHz	400 kHz 400 kHz
139264 Mb/s (E4)	0.4 ... 0.75 0.075	200 Hz 10 kHz	3500 kHz 3500 kHz

Determing Combined Jitter

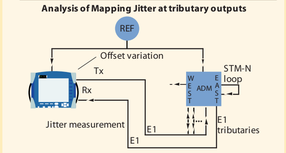


SDH/SONET Mapping Jitter

Maximum Mapping Jitter as per ITU-T G.783

Bit rate	Max. offset	Max. jitter (p-p)	High pass	Low-pass
1544 Mb/s (DS1)	± 50 ppm	0.1 UI	8 kHz	40 kHz
2048 Mb/s (E1)	± 50 ppm	0.075 UI	18 kHz	100 kHz
34368 Mb/s (E3)	± 30 ppm	0.075 UI	10 kHz	800 kHz
44736 Mb/s (DS3)	± 20 ppm	0.1 UI	30 kHz	400 kHz
139264 Mb/s (E4)	± 15 ppm	0.075 UI	10 kHz	3500 kHz

Analysis of Mapping Jitter at tributary outputs

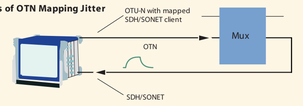


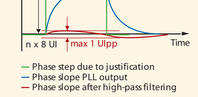
OTN Mapping Jitter

Maximum OTN Mapping Jitter as per ITU-T G.8251

Bit rate	Max. offset OTU-N	Max. jitter for f_1 - f_4	Max. jitter for f_2 - f_4
STM-N/OC-N	± 20 ppm	1.0 Ulpp	0.1 Ulpp

Analysis of OTN Mapping Jitter





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