CMA 5000

eXtended Transport Analysis Application

CMA 5000

The Field Portable Solution for Installation, Commissioning and Maintenance of SONET/SDH Networks (ready for NGN)

The compact size of the XTA Application module conveniently fits into the CMA 5000 Multi-Layer Network Test Platform using a small bay adapter - thus reducing cost and overall weight.

Ideal Solution for Any Test Scenario

As a part of the CMA 5000 Multi-Layer Network Test Platform, the eXtended Transport Analysis (XTA) Application is just one way to accelerate the deployment of services while reducing the cost of measurement. With test and measurement options ranging from OTDR, connector inspection, chromatic and polarization mode dispersion to optical spectral analysis, bit error rate test, SONET/SDH analysis and Gigabit Ethernet, the CMA 5000 Multi-Layer Network Test Platform is the ideal single-solution for all your testing needs.

[1] Technical descriptions are available in the datasheet of each options

Today's competitive environment demands that networks offer exceptional performance and reliability with minimal downtime. When characterizing and documenting such stringent performance levels, the CMA 5000 eXtended Transport Analysis (XTA) Application is the ideal single-solution for transmission system analysis. The CMA 5000 XTA Application increases your competitiveness in installing, maintaining, commissioning and monitoring high-speed SONET, SDH and DWDM transmission systems via an innovative and comprehensive test solution.

Increase revenue through maximized network efficiency and QoS:

- Minimize network downtime with a comprehensive set of test functions and powerful graphical event correlation
- Reduce user errors with an intuitive, easy-to-interpret user interface and on-line help
- Verify QoS with objective performance tests in compliance with ITU-T and Telcordia standards

Optimize network performance:

- Achieve comprehensive testing of PDH/ T-carriers and SONET/SDH networks up to 10 Gbps with only one instrument
- Produce APS measurement with 125 μs of resolution
- Obtain Round Trip Delay measurement with 100 ns of resolution
- Automatically detect network problems with Troublescan features

Reduce the cost of measurement:

- Generate professional test reports
- Reduce training and test time through targeted, user-friendly applications
- Protect your investment with a complete open architecture and future-proof technology

The CMA 5000 XTA Application enables installation and maintenance professionals to rely on one compact solution for testing DS1/E1 through OC-192/STM-64. An impressive list of options is also available[1]:

- Contiguous Concatenation
- Tandem Connection Monitoring
- Jitter and Wander generation/analysis from DS1/E1 up to OC-48/STM-16
- ATM over SONET/SDH
- Next Generation SONET/SDH (VCAT, LCAS, GFP, Eos)

All these possibilities of evolution protect your investment for the future.

Interfaces and Signal Specifications

SIGNALS				XTA MODULES			
SDH / PDH	SONET/ T-Carrier	Rate (Mb/s)	Interfaces	XTA 622	XTA 2.5	XTA 10-1310	XTA 10-1550
STM-64	OC-192	9953.280	Optical 1550 nm [1]	___	___	___	√
STM-16	OC-48	2488.320		___	√	√	√
STM-4	OC-12	622.080		√	√	√	√
STM-1	OC-3	155.520		√	√	√	√
STM-64	OC-192	9953.280	Optical 1310 nm [1]	___	___	√	___
STM-16	OC-48	2488.320		___	√	√	√
STM-4	OC-12	622.080		√	√	√	√
STM-1	OC-3	155.520		√	√	√	√
STM-1	STS-3	155.520	Electrical [2]	√	√	√	√
	STS-1	51.840		√	√	√	√
E4	___	139.264		√	√	√	√
E3	___	34.368		√	√	√	√
E1	___	2.048		√	√	√	√
___	DS3	44.736		√	√	√	√
___	DS1	1.544		√	√	√	√

Optical Transmitter	155.520 to 2488.320 Mb/s	9953.280 Mb/s
Wavelength		
1310 nm	1290-1330 nm	1290-1330 nm
1550 nm	1529-1570 nm	1530-1565 nm
Output Power		
1310 nm	-2 dBm to +2 dBm	+1 dBm to +5 dBm
1550 nm	-1 dBm to +2 dBm	-1 dBm to +2 dBm
Extinction Ratio	8.2 dB minimum	8.2 dB minimum (1550 nm) 6.0 dB minimum (1310 nm)

Optical Receiver	155.520 to 622.080 Mb/s	2488.320 Mb/s	9953.280 Mb/s
Wavelength	1270-1570 nm	1270-1570 nm	1527-1570 nm and 1290-1330 nm
Sensitivity (min)	-28 dBm (at 10^{-10} BER)	-28 dBm (at 10^{-10} BER)	-15 dBm (at 10^{-12} BER)
Saturation	-8 dBm	-8 dBm	-1 dBm

Clocks Synchronization	
Clock Reference	• Internal stratum 3 clock generation • External 2.048 MHz reference clock: 75 Ohms BNC connector, 0.5 to 4 Vpp signal amplitude • Timed from 2.048 Mbit/s received signal • External 1.544 MHz reference clock: 75 Ohms BNC connector, 0.5 to 4 Vpp signal amplitude • Timed from 1.544 Mbit/s received signal • External 10 MHz reference clock: 75 Ohms BNC connector, 0.5 to 4 Vpp signal amplitude • Timed from SDH/SONET received signal
Clock Output	• 155.520 MHz frequency signal synchronous with transmitted SDH/SONET signal, 50 Ohms connector, AC coupled, 600 mV amplitude

Key Features

- SDH/PDH and SONET/T-Carrier testing in one smart box
- Independant Tx and Rx

Notes:

[1] SC/PC connectors

[2] BNC 75 Ohms connectors (except for DS1 Bantam 100 Ohms)

Interfaces and Signal Specifications (continued)

Key Features

• PDH/T-Carrier Drop & I

• Concatenated payloads proposed as product op

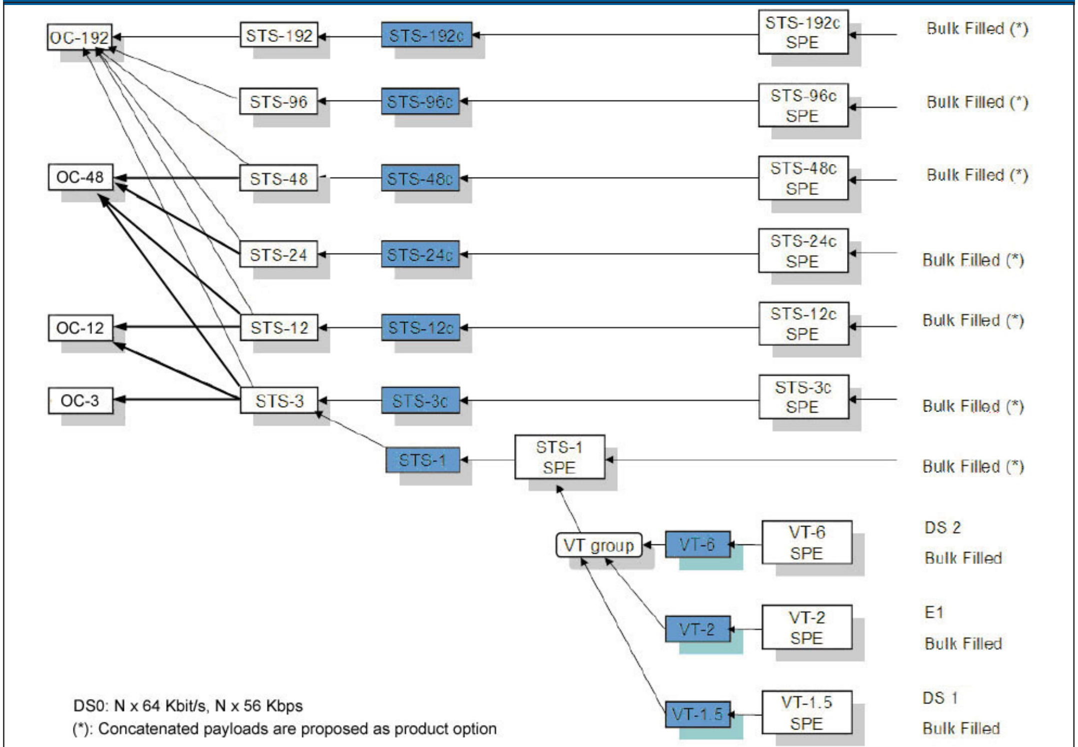
DCC Signals

The CMA 5000 XTA modules support the drop and insert of DCC channels from SONET/SDH.
Rates: D1-D3 DCC channels 192 Kb/s and D4-D12 DCC channels 576 Kb/s
Connector: DB 15

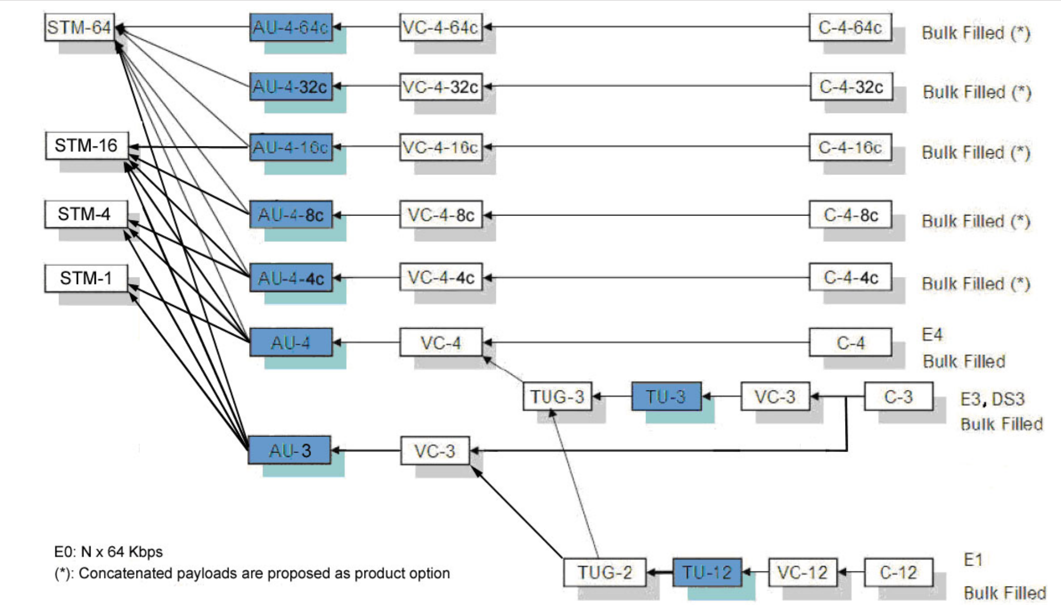
SONET/SDH Frame Formats and Mapping

SONET format	Telcordia GR-253
SDH format	ITU-T G.707

SONET Mappings



SDH Mappings



Interfaces and Signal Specifications (continued)

PDH/DSn Signal	Unframed Format	Framed Format
E1	PRBS	G.704 w/out CRC4 N x 64 Kbit/s
E3	PRBS	G.751
E4	PRBS	G.751
DS1	PRBS	ANSI T1.107 (SF and ESF) N x 64 Kbit/s, N x 56 Kbit/s
DS3	PRBS	ANSI T1.107 (C-bit and M-13)

T-Carrier MUX/DEMUX (Option)	
MUX/DEMUX	DS0 => DS1 => DS2 => DS3

Line Rate	Line Coding	Input Level	Output Level
E1 (2.048 Mbit/s)	HDB3 AMI	Short Haul: Terminate Monitor (-22 dB) Monitor (-26 dB) Monitor (-32 dB) High Z Long Haul: Terminate	G.703
E3 (34.368 Mbit/s)	HDB3	Terminate	G.703
E4 (139.264 Mbit/s)	CMI	Terminate/Monitor	G.703
DS1 (1.544 Mbit/s)	B8ZS AMI	Short Haul: Terminate Monitor (-22 dB) Monitor (-26 dB) Monitor (-32 dB) High Z Long Haul: Terminate	Short Haul: 0-133 feet 133-266 feet 266-399 feet 399-533 feet 533-655 feet Long Haul: 0 dB -7.5 dB -15 dB -22.5 dB
DS3 (44.736 Mbit/s)	B3ZS	Terminate Monitor	High DSX

Test Pattern	
PRBS Patterns	PRBS: 2^9-1, 2^{11}-1, 2^{15}-1, 2^{20}-1, QRSS, 2^{23}-1, 2^{29}-1, 2^{31}-1 inverted and non-inverted
Word Patterns	All “1” pattern, all “0” pattern, alternative “01” pattern, user-defined 2 bytes word pattern, 1 in 8, 2 in 8, 3 in 24, QRSS patterns for DS1 signal, T1 Daly

Key Features

- On-line help
- Automatic test

Network Emulation

Key Features

- Full range of I/O connectors
- Large color screen
- Almost unlimited storage capacity

SONET/SDH Overhead Editors	
SONET Frames:	
TOH Editor	All bytes of TOH (STS-1/STS-3) are programmable except B1/B2 and Z0 J0 (Trace Identifier): programmable 62 bytes ASCII sequence, CRLF added or programmable 15 bytes ASCII sequence, CRC (E.164) added or programmable byte
POH Editor (STS)	C2, G1, F2, H4, Z3, Z4, N1 J1 (Trace Identifier): programmable 62 bytes ASCII sequence, CRLF added or programmable 15 bytes ASCII sequence, CRC (E.164) added or programmable byte
POH Editor VT (POH)	V5, Z6, Z7 J2 (Trace Identifier): programmable 62 bytes ASCII sequence, CRLF added or programmable 15 bytes ASCII sequence, CRC (E.164) added or programmable byte
SDH Frames:	
SOH Editor:	All bytes of SOH (STM-1) are programmable except B1/B2 J0 (Trace Identifier): programmable 15 bytes ASCII sequence, CRC (E.164) added or programmable 62 bytes ASCII sequence, CRLF added or programmable byte
POH Editor	VC4 and VC3 POH: C2, G1, F2, H4, F3, K3, N1 J1 (Trace Identifier): programmable 15 bytes ASCII sequence, CRC (E.164) added or programmable 62 bytes ASCII sequence, CRLF added or programmable byte VC12 POH: V5, N2, K4 J2 (Trace Identifier): programmable 15 bytes ASCII sequence, CRC (E.164) added or programmable 62 bytes ASCII sequence, CRLF added or programmable byte

Error Addition	
SONET/DSn	A1/A2, B1, B2, REI-L, B3, REI-P, V5, REI-V, PRBS, Word, transmission errors, FAW (FAS), SFAW, FPS, CRC-6, MAW, Parity P, Parity CP, F-bit, M-bit, FEBE, Code Errors (BPV, EXZ)
SDH/PDH	A1/A2, B1, B2, MS-REI, B3, LP-B3, HP-REI, V5, LP-REI, PRBS, Word, transmission errors, FAW (FAS), CRC4, REI (E-bit or REBE), Code Errors (BPV, EXZ)
Error control	Programmable number or rate

Alarm Addition	
SONET/DSn	LOS, LOF, SEF, TIM-S, AIS-L, RDI-L, AIS-P, LOP-P, TIM-P, PLM-P, UNEQ-P, RDI-P, LOM-V, AIS-V, LOP-V, PLM-V, UNEQ-V, RDI-V, TIM-V, RFI-V, LSS, LPS, AIS, LOMF, LSF, OOF, RAI, IDLE
SDH/PDH	LOS, LOF, OOF, RS-TIM, MS-AIS, MS-RDI, AU-AIS, AU-LOP, HP-PLM, HP-TIM, HP-UNEQ, HP-RDI, TU-LOM, TU-AIS, TU-LOP, LP-PLM, LP-UNEQ, LP-TIM, LP-RDI, LP-RFI, LSS, LPS, AIS, LOMF, RDI
Alarm Control	On steady-state or programmable number of frames

Network Emulation (continued)

Voice Add/Drop (Option)	
SONET/DSn	Supports adding and dropping of a selected 64/56 kb/s voice channel (carried in a DSn signal) to an external handset (μ-Law)
SDH/PDH	NA

Stress Function	
Pointer Movement	Pointer movement generation on SONET and SDH frames: • Pointer set to any value with or without NDF • Positive and negative movements • Pointer sequences (ITU-T G.783, Telcordia GR-253) **SDH** Single Alternating Regular + Double Regular + Missing Double Alternating Periodic 87.3 Periodic 87.3 with Add Periodic 87.3 with Cancel **SONET** Single Burst of 3 Periodic Periodic with Add Periodic with Cancel Periodic 87.3 Periodic 87.3 with Add Periodic 87.3 with Cancel Phase Transient
Frequency Shift	Programmable frequency offset: -100 ppm to +100 ppm in 0.1 ppm steps SONET/SDH -100 ppm to +100 ppm in 0.1 ppm steps for PDH/T-Carrier
APS (K1/K2)	Automatic Protection Switch messages (K1/K2) are user-programmable MSP Linear (ITU-T G783) and MSP-Ring (ITU-T G841) are supported
SDH Through Mode	SOH overwrite J0, A1, A2, K1, K2, S1, M0, M1 Error addition: A1 A2, B1, B2, MS-REI, Transmission errors Alarm addition: LOS, LOF, OOF, MS-AIS, MS-RDI
SONET Through Mode	TOH overwrite J0, A1, A2, K1, K2, S1, M0, M1 Error addition: A1 A2, B1, B2, REI-L, Transmission errors Alarm addition: LOS, LOF, SEF, AIS-L, RDI-L
DS1 Loop Codes	Loop Codes generation on DS1 frames: DS1 SF: Loop Up, Loop Down (CSU / NIU FAC1 /NIU FAC2) DS1 ESF: Line Loop Back Activate, Payload Loop Back Activate, Line Loop Back Deactivate, Payload Loop Back Deactivate, Universal Loop Back Deactivate Modes: In-Band, Out-of-Band Auto response to received loopback code

Key Features

- 64/56 Kb/s voice channel add/drop capability (option)
- Active Through Mode to simulate network problems
- Linear and Ring APS architectures supported

Key Features

- Summary, detailed and graphical results presentation
- Event Log for History Analysis
- Event Analysis with 125 μsec resolution

Measurement Capabilities

Path Analysis	
Signal Qualification	• Power meter • Frequency meter
Error Analysis	**SONET/DSn** A1/A2, B1, B2, REI-L, B3, REI-P, V5, REI-V, PRBS, Word, ERR, FAW (FAS), SFAW, FPS, CRC-6, MAW, Parity P, Parity CP, F-bit, M-bit, FEBE, Code Errors (BPV, EXZ) **SDH/PDH** A1/A2, B1, B2, MS-REI, B3, HP-REI, LP-B3, LP-REI, V5, PRBS, Word, ERR, FAW (FAS), CRC4, REI (E-bit or REBE), Code Errors (BPV, EXZ)
Alarms Analysis	**SONET/DSn** LOS, LOF, SEF, TIM-S, AIS-L, RDI-L, AIS-P, LOP-P, PLM-P, TIM-P, UNEQ-P, RDI-P, LOM-V, AIS-V, LOP-V, PLM-V, UNEQ-V, RDI-V, TIM-V, RFI-V, LSS, LPS, AIS, RAI, OOF, LSF, LOMF, IDLE **SDH/PDH** LOS, LOF, OOF, RS-TIM, MS-AIS, MS-RDI, AU-AIS, AU-LOP, HP-PLM, HP-UNEQ, HP-TIM, HP-RDI, TU-LOM, TU-AIS, TU-LOP, LP-PLM, LP-UNEQ, LP-TIM, LP-RDI, LP-RFI, LSS, LPS, AIS, LOMF, RDI
Pointer Movement Analysis	XTA modules track all the SONET/SDH pointers movements information: • Pointer value • Number of positive and negative pointer movements • Number of pointer movement with NDF
Quality Analysis	**SONET/DSn** Transmission quality is calculated each second as per GR-253 **SDH/PDH** Transmission quality is calculated each second in accordance with recommendations G.821, G.826, G.828, M.2100, M2101.1, M.2101, M.2110 for performance
Overhead Analysis	Realtime display of the following information: • J0, J1 and J2 Path Trace messages (ASCII sequence) • S1 (synchronization status) • C2/V5 (signal label) SONET/SDH: • Display of SOH/TOH and POH of the analyzed path channel • Capture capacity: 64 consecutive frames
Event Analysis	Alarms and Errors event analysis in temporal graphical display with 125 μs resolution

Measurement Capabilities (continued)

Round Trip Delay

- Measurement possible at each path level
- Resolution: 100 ns
- Range: 0 to 2 sec (depending on path level)
- Result: Tmax, Tmin, Tavr, Tcurrent and Errors/Alarms detection

Automatic Protection Switching Measurement

- Number of switches
- Switch duration (with 125 µs resolution)
- K1/K2 capture and interpretation

Performance Analysis

- Direct graphical presentation of performance and availability conformance test result
- Automatic calculation of acceptance thresholds according to ITU-T recommandations, such as M.2100, M.2101.1 and M.2101
- Automatic calculation of Performance Objectives according to ITU-T recommendations such as G.821, G.826, G.828

Structure Scan

- Complete signal mapping auto discovery (including Mix Payload)

Troublescan

- Continuous VC-4/SPEs scanning for alarms and errors detection

General Information

- The XTA hardware is a double size plug-in module compatible with the CMA 5000 Multi-Layer Network Test Platform (small, medium or large bay adapters).
- AC power: 100 to 250 VAC via CMA 5000 platform

Environmental specifications:	Operating Temperature: 0°C to +40°C Storage Temperature: -20°C to +70°C Humidity: 10% to 80%
Safety:	Electrical: EN 61010-1 Optical: Class I (21 CFR 1040) / Class 1M (60825-1)
EMC:	EN 300386 V1.3.2

- Warranty: 1 year standard
- CMA 5000 platform features are detailed in the CMA 5000 platform specifications sheet.

Key Features

- Trouble Scan function
- Automatic configuration with Structure Scan function

Key Features

- Future-proof solution with a complete list of upgrades to adapt to your evolving network requirements (contact your NetTest or Anritsu Representative for details)
- XTA modules have to be plugged into a CMA 5000 platform

Notes:

[1] A 1310 nm configuration is also available under reference 5663-000-XTA

[2] Each module is shipped with:

- One optical patchcord with SC/PC connectors
- One BNC 75 Ohms cable
- One optical 10 dB attenuator SC/PC connectors

[3] Module number

CMA 5000 XTA 10G-1550 Module [2]

Order Number	Description
5665-000-XTA	**CMA 5000 XTA 10G-1550 module** [1] Test module for T-Carriers/PDH and SONET/SDH technologies up to 10 Gbit/s. It provides: • Optical interfaces at 1550 nm for OC-192 and STM-64 • Optical interfaces at 1310 nm and 1550 nm for OC-3/12/48 and STM-1/4/16 • Electrical interfaces for DS1, DS3, STS-1, STS-3 and E1, E3, E4, STM-1

CMA 5000 XTA 2.5G Module [2]

Order Number	Description
5616-000-XTA	**CMA 5000 XTA 2.5G module** Test module for T-Carriers/PDH and SONET/SDH technologies up to 2.5 Gbit/s. It provides: • Optical interfaces at 1310 nm and 1550 nm for OC-3/12/48 and STM-1/4/16 • Electrical interfaces for DS1, DS3, STS-1, STS-3 and E1, E3, E4, STM-1

CMA 5000 XTA 622 Module [2]

Order Number	Description
5604-000-XTA	**CMA 5000 XTA 622 module** Test module for T-Carriers/PDH and SONET/SDH technologies up to 622 Mbit/s. It provides: • Optical interfaces at 1310 nm and 1550 nm for OC-3/12 and STM-1/4 • Electrical interfaces for DS1, DS3, STS-1, STS-3 and E1, E3, E4, STM-1 • Concatenation • Tandem Connection Monitoring • Jitter & Wander

List of options for XTA modules

Order Number	Description
XXXX[3]-101-XTA	Concatenation option (Full package)
XXXX[3]-151-XTA	T-Carrier package (T-Carrier MUX/DEMUX and voice add/drop (μ-Law))
XXXX[3]-201-XTA	Tandem Connection Monitoring (TCM) option
XXXX[3]-239-XTA	Remote Commands for XTA module (via Ethernet) *Remark: T-Carrier Package / ATM / VCAT Monitoring / Next-Gen options are not supported by remote commands*
XXXX[3]-301-XTA	Jitter & Wander full package option (*only available on XTA 2.5G and XTA 622 modules*)
XXXX[3]-351-XTA	“Tx only” Jitter package option (*only available on XTA 2.5G and XTA 622 modules*)
XXXX[3]-401-XTA	ATM option
XXXX[3]-501-XTA	VCAT Monitoring option (VCAT, LCAS, Diff. Delay) for High Order Path
XXXX[3]-601-XTA	Next Generation SONET/SDH Tx & Rx for High Order paths: VCAT, LCAS, GFP-F (-T), EoS

Anritsu

CMA 5000

eXtended Transport Analysis Application
Asynchronous Transfer Mode (ATM) Option[1]

Notes:

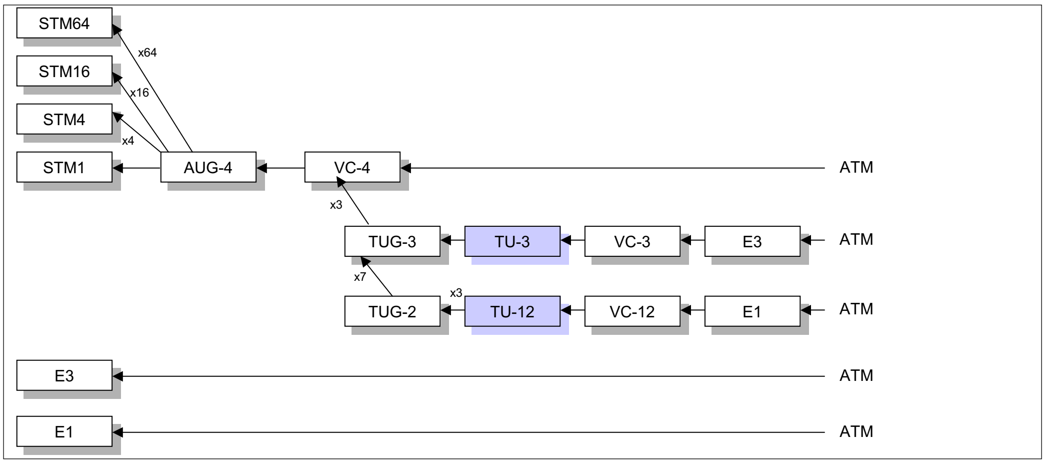
[1] All specifications are subject to change

Historically, SDH/SONET technology has been designed to carry voice traffic. But the changes in the telecommunications market for many years have brought new challenges for network operators and service providers. Data traffic becomes more and more important and today’s networks are evolving to meet these new multimedia communications challenges.
Asynchronous Transfer Mode (ATM) is a networking technology capable of accomodating the inherently bursty nature of data applications and the fixed bit rates of the historical synchronous networks.
ATM, coupled with SDH/SONET for transport, provides a very flexible solution and makes multimedia calls as easy, reliable and as secure as voice calls are today.
With the “ATM” option, the CMA 5000 XTA application provides all the functions needed to check the quality of ATM cell transport through the PDH/SDH and T-Carrier/SONET networks.
The “ATM” option is a software option of the main XTA software application.

Physical Layer

SONET/T -Carrier	SDH/ PDH	Rate (Mb/s)	Interfaces	XTA 622	XTA 2.5G	XTA 10G 1310	XTA 10G 1550
OC-192	STM64	9953.280	Optical 1550 nm	—	—	—	√
OC-48	STM16	2488.320		—	√	√	√
OC-12	STM4	622.080		√	√	√	√
OC-3	STM1	155.520		√	√	√	√
OC-192	STM64	9953.280	Optical 1310 nm	—	—	√	—
OC-48	STM16	2488.320		—	√	√	√
OC-12	STM4	622.080		√	√	√	√
OC-3	STM1	155.520		√	√	√	√
STS-3	STM1	155.520	Electrical	√	√	√	√
STS-1	—	51.840		√	√	√	√
—	E3	34.368		√	√	√	√
—	E1	2.048		√	√	√	√
DS3	—	44.736		√	√	√	√
DS1	—	1.544		√	√	√	√

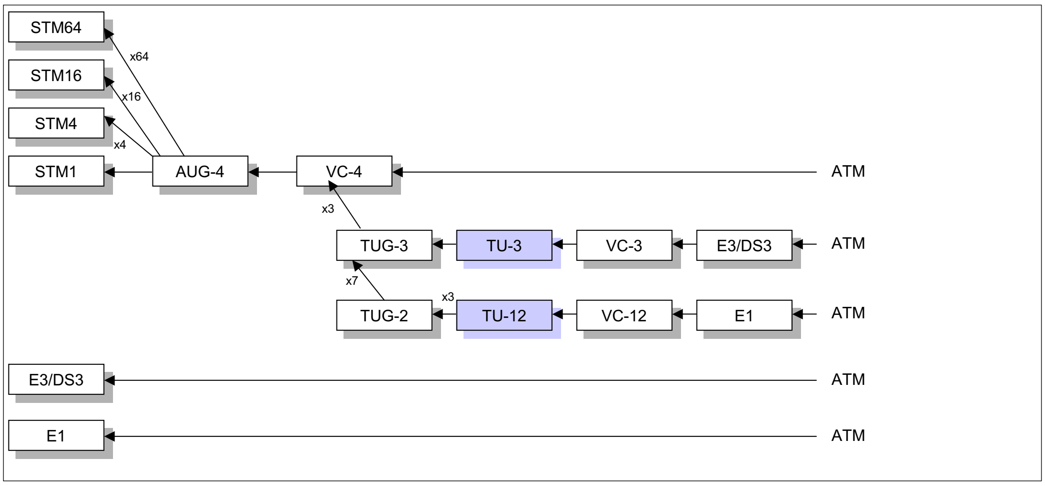
ATM Mapping



PDH/SDH Mappings

Notes:

[2] This document only describes functions at the ATM level. All the quality parameters analyzed at the transport layer by the base XTA Application software are still available



T-Carrier/SONET Mappings

ATM Transmit Functions[2]

Physical Adaptation Layer
• Scrambler and HEC calculation

ATM Layer	
Foreground Traffic	• One VP/VC channel for which the header, the payload and the traffic are programmable • Each field of the header is programmable: Type of interface (UNI or NNI), VPI, VCI, GFC, PTI, CLP • The payload is filled with PRBS (AAL0) • The average traffic level is user programmable
Background Traffic	• The number of backgound channels is programmable up to a maximum of 1000. • For each background channel, the header is fully programmable (manually or automatically): Type of interface (UNI or NNI), VPI, VCI, GFC, PTI, CLP • The payload is filled with a 16 bit user programmable word (AAL0) • For each background channel, the average traffic level is user programmable
Empty Cells	• Empty cells can be defined as idle or unassigned

Stress Functions	
Physical Adaptation Layer Error Injection	Single HEC, Multiple HEC Programmable number
Payload Error Error Injection	BER generated on the Foreground channel payload Programmable number or rate
OAM Alarms	AIS, RDI, Loss of Continuity for F4 and F5 flows of the Foreground channel
Alarm Injection	On steady-state

ATM Analysis Functions[3]

Physical Adaptation Layer	
Errors	Single HEC, Multiple HEC
Alarm	LCD

ATM Layer Performance	
Errors	BERT on the test VP/VC channel payload
Alarm	AIS, RDI, Loss of Continuity measured on the test VP/VC

Traffic
• Instantaneous and average traffic level of the total traffic
• Instantaneous and average traffic level of the selected VP
• Instantaneous and average traffic level of the selected VC

ATM Scan
• Automatic detection of the open ATM channels on the link with indication for each of: - Channel number: VPI, VCI - Average traffic

Notes:

[3] All ATM parameters can also be displayed graphically

All the ATM traffic parameters are available in one single window.

Ordering Information

CMA 5000 XTA 10G-1310 Module

Order Number	Description
5663-401-XTA	ATM option for XTA 10G-1310 module

CMA 5000 XTA 10G-1550 Module

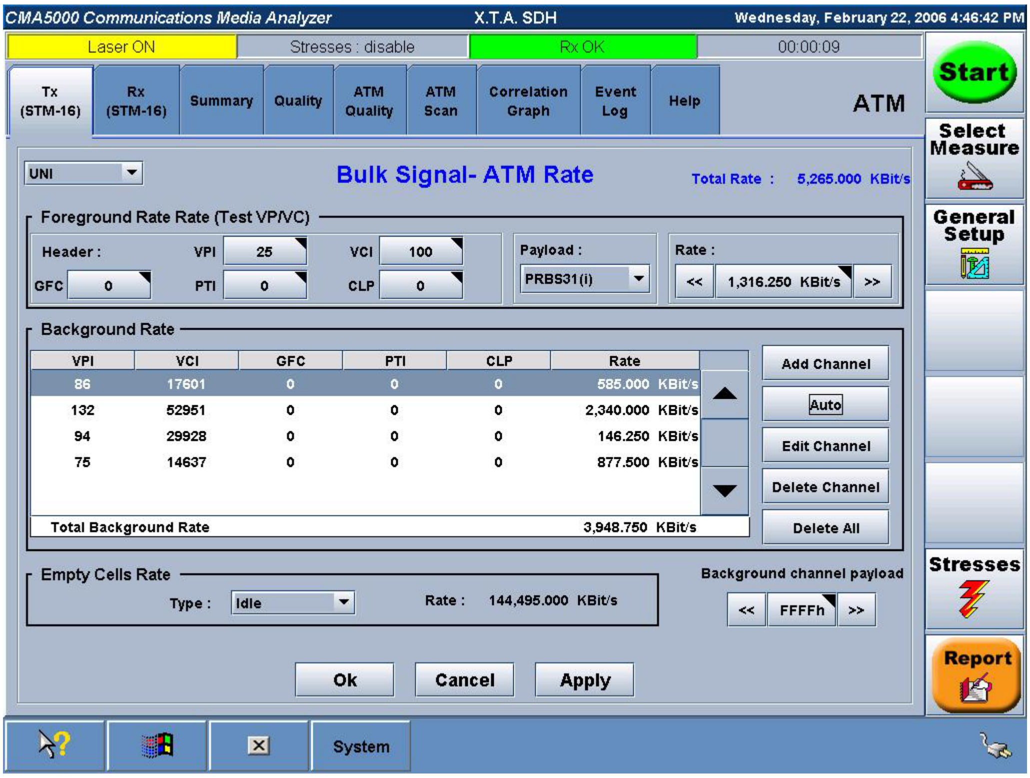
Order Number	Description
5665-401-XTA	ATM option for XTA 10G-1550 module

CMA 5000 XTA 2.5G Module

Order Number	Description
5616-401-XTA	ATM option for XTA 2.5G module

CMA 5000 XTA 622 Module

Order Number	Description
5604-401-XTA	ATM option for XTA 622 module



The Quality measurement screen provides all the alarms, errors and quality information at the ATM layer for fast measurement interpretation.

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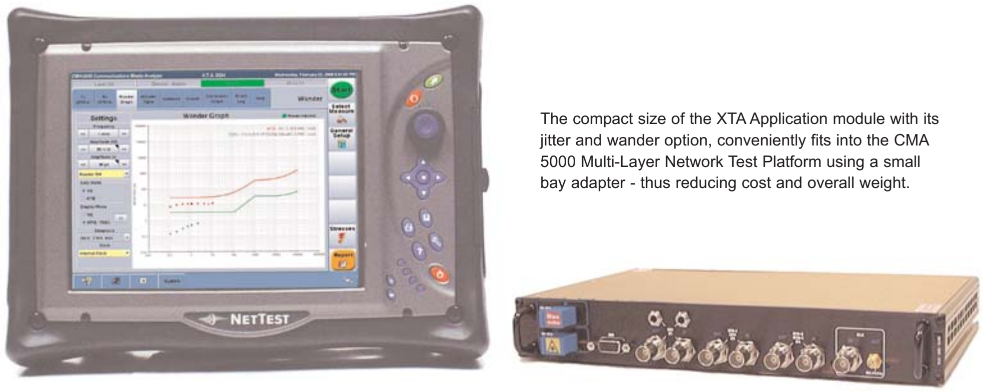
NetTest is Now a Member of the Anritsu Group

Anritsu Corporation is a global provider of innovative communications solutions for more than 110 years. With offices throughout the world, Anritsu with the recent acquisition of NetTest provides solutions for existing and next-generation wired and wireless communication systems and operators. The company's measurement solutions include wireless, optical, microwave/RF, and digital instruments, operations support systems and solutions that can be used during R&D, manufacturing, installation, and maintenance. Anritsu also provides precision microwave/RF components, optical devices, and high-speed devices for design into communication products and systems. The recently combined companies sell in over 90 countries worldwide and approximately 4000 employees.

CMA 5000

eXtended Transport Analysis Application
Jitter and Wander Option



The compact size of the XTA Application module with its jitter and wander option, conveniently fits into the CMA 5000 Multi-Layer Network Test Platform using a small bay adapter - thus reducing cost and overall weight.

Key Features

- Ideal tool for jitter and wander analysis in a field environment
- Intuitive graphical user interface. Never have jitter and wander tests been so easy to set up and interpret
- Jitter generation and measurement at all interface rates from 1.5 Mbit/s to 2.5 Gbit/s

Modern networks need to be fine-tuned to the highest possible level to maintain the best quality of service. Synchronization problems, jitter and wander are very real potential threats for network operators and must be thoroughly evaluated and assessed during installation, commissioning and operation.

The CMA 5000 Multi-Layer Network Platform enables you to identify potential sources of trouble quickly and easily using the Jitter and Wander option for our eXtended Transport Analysis (XTA) Application.

The ability to accurately measure network elements intrinsic jitter, as well as de-mapping and pointer adjustment induced jitter on tributaries, is a key feature of this option that will allow you to securely assess the compliance of your synchronous network with international standards.
Jitter tolerance and transfer test results are readily displayed and compared with industry standard pass/fail masks.

This option’s testing and measuring capabilities cover the whole spectrum of applications from asynchronous tributaries 1.5, 2, 34, 45 and 140 Mbit/s up to synchronous rates 52, 155, 622 Mbit/s and 2.5 Gbit/s.

With jitter and wander analysis specifications well over ITU-T 0.172 standard on tester requirements, our module guarantees you can safely maximize network QoS and save precious time pinpointing any causes of trouble.

Interfaces and Signal Specifications[1]

Jitter/Wander Generation and Analysis Interfaces				XTA Modules	
Interfaces	SONET/DSn	SDH/PDH	Rate (Mb/s)	XTA 622	XTA 2.5G
Optical	OC-48	STM16	2488.320	____	√
1550 nm &	OC-12	STM4	622.080	√	√
1310 nm [2]	OC-3	STM1	155.520	√	√
Electrical [3]	STS-3	STM1e	155.520	√	√
	STS-1	____	51.840	√	√
	____	E4	139.264	√	√
	____	E3	34.368	√	√
	____	E1	2.048	√	√
	DS3	____	44.736	√	√
	DS1	____	1.544	√	√

Key Features

- The characteristics of jitter measurements meet or exceed the requirements of ITU-T 0.171 & 0.172 and Telcordia GR.253 standards
- Easily upgradable option for XTA Module

Jitter Generation

Jitter Generation Characteristics	
Tx Signals	Sinusoïdal jitter generation at all bit rates included in the XTA module configuration
Amplitude Range	Up to 240 000 UI [4]
Frequency Range	0.1 Hz to 20 MHz [4]
Frequency Shift	Programmable frequency offset -100 ppm to +100 ppm in 0.1 ppm steps For PDH/T-Carrier and SONET/SDH

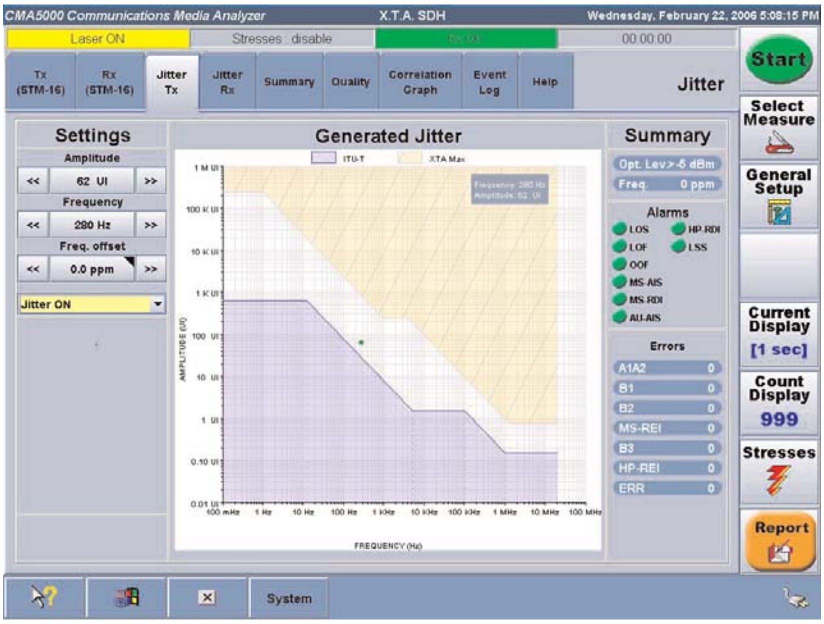
Notes:

[1] All the general specifications of the XTA modules are described in the CMA 5000 eXtended Transport Analysis Application datasheet

[2] SC/PC connectors

[3] BNC 75 Ohms connectors (except for DS1 Bantam 100 Ohms)

[4] Depending on the XTA module configuration



Graphical display of the generated jitter (frequency and amplitude) compared to the recommended maximum tolerable jitter mask of the equipment under test

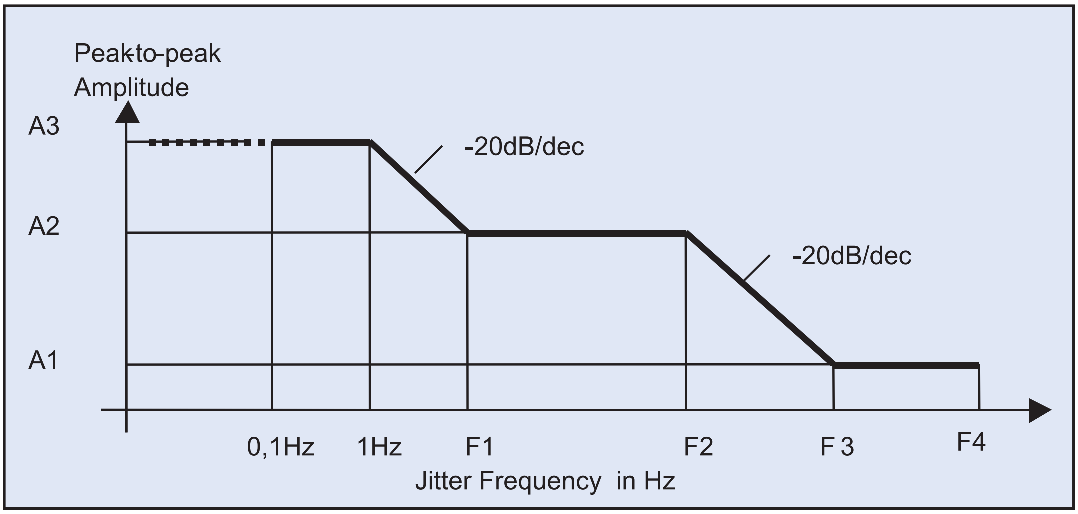
SONET/SDH Jitter Generation Characteristics							
	Amplitude(UI)			Frequency (KHz)			
Interfaces	A3	A2	A1	F1	F2	F3	F4
OC-48/ STM16	240000	240	0.75	1	4	1300	20000
OC-12/ STM4	60000	60	0.75	1	16	1300	5000
OC-3/ STM1	15000	15	0.75	1	65	1300	___[1]

Key Features

- Built-in maximum tolerable jitter masks
- Extended frequency range for jitter (starting from 0.1 Hz)

Notes:

[1] Not defined



Jitter frequency and amplitude can be programmed within the range specified above

PDH/T-Carrier Jitter Generation Characteristics							
	Amplitude(UI)			Frequency (Hz)			
Interfaces	A3	A2	A1	F1	F2	F3	F4
STS-3/ STM1e	15000	150	0.75	100	500	100K	1300K
STS1	5200	52	1	100	10000	520K	1000K
E4	15000	150	0.75	100	500	100K	3500K
E3	3500	35	1	100	10000	350K	800K
E1	200	20	1	10	1000	20K	100K
DS3	4500	45	1.12	100	10000	400K	____
DS1	160	16	1	10	1000	16K	40K

Jitter Measurement

Key Features

- Simultaneous analysis of jitter peak +, peak -, peak to peak and RMS in each measurement band
- Graphical presentation of jitter amplitude results versus time
- Professional reports

Notes

[1] RMS: Root Mean Square

[2] At 20 dB/dec

Jitter Analyzer Characteristics	
Rx Signals	Jitter measurement at all bit rates included in the XTA module configuration Signal Qualification ensures that the incoming signal is in acceptable operating range before starting a jitter measurement, by checking: • Optical/electrical power • Frequency shift (up to 100 ppm)
Alarms and Errors Analysis	Alarms and errors are analyzed in real time during the jitter measurement: • SDH alarm events: LOS, LOF, OOF, MS-AIS, MS-RDI, AU-AIS, HP-RDI, TU-AIS, LP-RDI, AIS, LSS, HITS • SONET alarm events: LOS, LOF, OOF, AIS-L, RDI-L, AIS-P, RDI-P, AIS-V, RDI-V, AIS, LSS, HITS • SDH error events: B1, B2, MS-REI, B3, V5, HP-REI, LP-REI, LSS • SONET error events: B1, B2, REI-L, REI-P, V5, REI-V, LSS
Optical Sensitivity	The optical input power must be in the range of -8 to -13 dBm for accurate measurement
Measurement Ranges	Amplitude: • Peak to Peak: 0 to 128 UI p-p • RMS[1]: 0 to 64 UI rms Maximum resolution: • Peak to Peak: 0.001 UI p-p • RMS[1]: 0.001 UI rms
Built-in Filters	Range from 10 Hz to 20 MHz • High-Pass filters at 20 dB/dec for HP1, HP2 and HPrms • Low pass filters at 60 dB/dec for LP
Amplitude Results	• Positive Peak, Negative Peak, Peak to Peak, RMS[1] • Current and maximum values are displayed in numerical or graphical form

Jitter Measurement Filters Characteristics

Interfaces	HP1 Hz (20dB/dec)	HP2 KHz (20dB/dec)	LP KHz (60dB/dec)	HPrms KHz (20dB/dec)
OC-48/STM16	5000	1000	20000	12
OC-12/STM4	1000	250	5000	12
OC-3/STM1	500	65	1300	12
STS-3/STM1e	500	65	1300	12
STS-1	100	20	400 [2]	12
E4	200	10	3500	12
E3	100	10	800	12
E1	20	18	100	12
DS3	10	30	400 [2]	12
DS1	10	8	40 [2]	12

Filters with frequency break points

Jitter Hits	
The jitter measurement counts the number of seconds with hits (jitter exceeding a user specified threshold)	
Results	'Hit second' count is displayed numerically Each second with a jitter hit is recorded in the 'Event Log' file

Jitter Tolerance

An optimized algorithm increases jitter amplitude until occurence of an error in the received signal. A fast tolerance mode is also available. It allows a more rapid assessment of the jitter performance of the system under test.

User Selectable Mask	The jitter Tolerance measurement is automatically performed and compared with predefined standard masks: • PDH: ITU-T G.823 low and high Q masks • T-Carrier: ITU-T G.824 and Telcordia GR.499 masks, category 1 and 2 • SDH: ITU-T G.825 masks • SONET: Telcordia GR.253 masks Independent transmit and receive tributaries can be selected
Results	The results are displayed in a graph with masks or a table with a clear PASS/FAIL message

Jitter Transfer

Jitter Transfer measurement defines the ratio between the output jitter amplitude and the input jitter amplitude versus the jitter frequency for a given bit rate

Jitter Transfer Pass Masks	Jitter Transfer measurement is automatically performed and compared with ITU-T G.741, G.742, G.783 and Telcordia GR.253, GR.499 specifications
Frequency	Up to 20 MHz
Results	The results are displayed in tabular format or plotted on a graph showing the gain versus frequency. The pass mask is displayed on the graph as well as the results

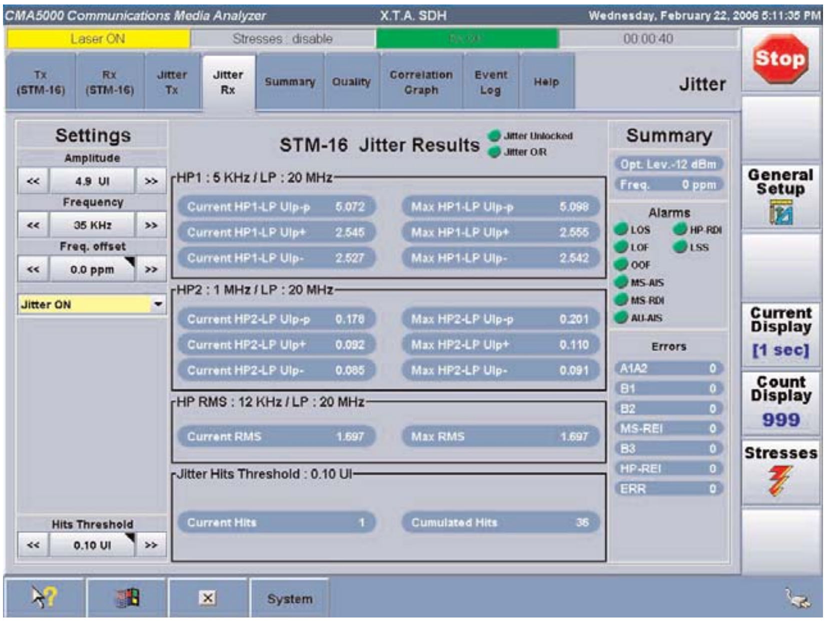
Jitter Pointer Analysis

Compliance with recommendation ITU-T G.783. Pointer sequences are programmable

Results	The unit generates pointer sequences and simultaneously analyzes the output jitter of the device under test. Results are displayed in a numerical or graphical form

Key Features

- Automatic jitter tolerance and transfer function measurements
- Graphical results are displayed according to ITU-T / Telcordia templates
- User programmable or ITU-T G.783 pointer movement sequences to analyse pointer and mapping jitter
- Quick appraisal of jitter spectral content



All errors, alarms and jitter information are presented simultaneously on one easy to read display

Wander Generation

Key Features

- Built-in wander masks
- Wander generation at all implemented bit rates

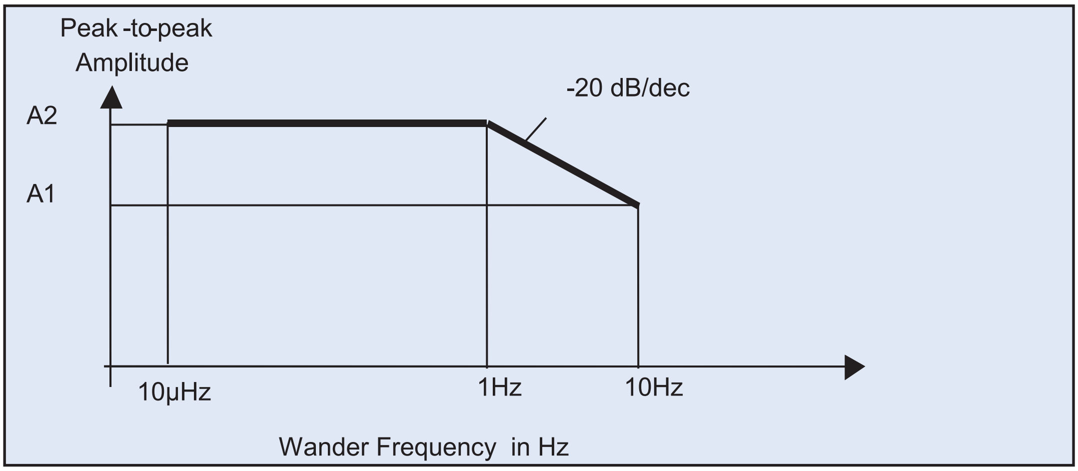
Note:

[1] Depending on the XTA module configuration

Wander Generation Characteristics	
Tx Signals	Sinusoïdal wander generation at all bit rates included in the XTA module configura tion
Amplitude Range	Up to 100 μs [1]
Frequency Range	10 μHz to 10Hz [1]
Frequency Shift	Programmable frequency offset (only with internal clock reference) -100 ppm to +100 ppm in 0.1 ppm steps For PDH/T-Carrier and SONET/SDH

SONET/T-Carrier Wander Generation Characteristics

Interfaces	Bit Rate Mbit/s	A2 in UI From 10μHz to 1Hz	A1 in UI at 10Hz
OC-48	2488.320	240 000	24 000
OC-12	622.080	60 000	6000
OC-3	155.520	15 000	1500
STS-3	155.520	15 000	1500
STS-1	51.840	5200	520
DS3	44.736	4500	450
DS1	1.544	160	16



Wander amplitude mask for SONET/SDH

SDH/PDH Wander Generation Characteristics

Interfaces	Bit Rate Mbit/s	A2 in UI From 10μHz to 1Hz	A1 in UI at 10Hz
STM16	2488.320	240 000	24 000
STM4	622.080	60 000	6000
STM1	155.520	15 000	1500
STM1e	155.520	15 000	1500
E4	139.264	15 000	1500
E3	34.368	3500	350
E1	2.048	200	20

Wander Measurement

Wander Analyzer Characteristics	
Rx Signals	Wander measurement at all bit rates in SONET/SDH included in the XTA module configuration Signal Qualification ensures that the incoming signal is in acceptable operating range before starting a wander measurement, by checking: • Optical/electrical power • Frequency shift (up to 100 ppm)
Alarms and Errors Analysis	Alarms and errors are analyzed in real time during the jitter measurement • SDH alarm events: LOS, LOF, OOF, MS-AIS, MS-RDI, AU-AIS, HP-RDI, TU-AIS, LP-RDI, AIS, LSS • SONET alarm events: LOS, LOF, OOF, AIS-L, RDI-L, AIS-P, RDI-P, AIS-V, RDI-V, AIS, LSS • SDH error events: B1, B2, MS-REI, B3, V5, HP-REI, LP-REI, LSS • SONET error events: B1, B2, REI-L, REI-P, V5, REI-V, LSS
TIE (Time Interval Error)	Sample rate up to 100/s Low pass filter at 10 Hz
MTIE (Maximum Time Interval Error)	Measurement range: from 1μs up to 1s Resolution: 0.1 ns
MRTIE (Maximum Relative Time Interval Error)	If the reference clock is unavailable when analysing wander signals, the MTIE analysis may have a superimposed frequency offset. This offset is removed in MRTIE analysis.
TDEV (Time DEViation)	Measurement range: 10^5 ns Resolution: 0.01 ns
Reference Clock Signal	• External: for wander analysis with XTA modules, it is recommended to provide a reference clock with very high accuracy [1 & 2] • Internal frequency: stratum 3 (10MHz)
Results	TIE, MTIE, MRTIE, TDEV are displayed in a graphical and tabular result presentation Calculation of MTIE and TDEV are in real time Frequency offset is displayed Graphical mode is user adjustable with zoom In/Out

Key Features

- Built-in calculation and presentation of the MTIE, TDEV and MRTIE wander performance parameters
- Internal stratum 3 clock used when no external reference available

Note:

[1] No external reference clock source is required for jitter measurement

[2] External clock - 75 Ohms BNC connector: 2MHz, 1.5MHz or 10MHz. Received E1 or DS1 if the analyzed signal is different

Real-time graphical presentation of MTIE/TDEV results

Ordering Information

Key Features

- Future-proof solution with a complete list of
  - module upgrades and
  - module options

  to adapt to your evolving network requirements (contact your NetTest or Anritsu Representative for details)

Notes:

[1] Must be ordered with the 5616-000-XTA

Each module is shipped with:

- One optical patchcord with SC/PC connectors
- One BNC 75 Ohms cable
- One optical fix 10 dB attenuator SC/PC connectors

General Information

- CMA 5000 platform information is detailed in the CMA 5000 platform specifications sheet
- XTA module information is detailed in the eXtended Transport Analysis (XTA) Application
- Warranty option: 1 year standard
- Calibration cycle: 1 year

CMA 5000 XTA 2.5G Module

Order Number	Description
5616-000-XTA	**CMA 5000 XTA 2.5G module** Test module for T-Carriers/PDH and SONET/SDH technologies up to 2.5 Gbit/s. It provides: • Optical interfaces at 1310 nm and 1550 nm for OC-3/12/48 and STM1/4/16 • Electrical interfaces for DS1, DS3, STS1, STS3 and E1, E3, E4, STM1
5616-101-XTA	Concatenation software for XTA 2.5G module
5616-301-XTA	Option Jitter and Wander full package Tx (generation) & Rx (analysis) Jitter and Wander package up to 2.5 Gbit/s [1]
5616-351-XTA	Tx (generation) only Jitter package up to 2.5 Gbit/s [1]

CMA 5000 XTA 622 Module

Order Number	Description
5604-000-XTA	**CMA 5000 XTA 622 module** Test module for T-Carriers/PDH and SONET/SDH technologies up to 622 Mbit/s. It provides: • Optical interfaces at 1310 nm and 1550 nm for OC-3/12 and STM1/4 • Electrical interfaces for DS1, DS3, STS1, STS3 and E1, E3, E4, STM1 • Concatenation software for XTA 622 module • Tandem Connection Monitoring • Tx (generation) & Rx (analysis) Jitter and Wander package up to 622 Mbit/s

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Technical Note

Understanding Jitter in Transport Networks

CMA5000

XTA module (e**X**tended **T**ransport **A**nalysis)

Introduction

Modern Telecommunication networks will still be running in the years ahead with the classical machinery of the synchronous SONET/SDH infrastructure throughout the world. While great care is devoted to warrant a very high quality of transport (at the physical level), in the real world of day-to-day installation, commissioning and maintenance activities things are not necessarily running smooth. Network clock synchronization, wander and timing instabilities are only a few examples of recurrent phenomenons likely to pester network engineers in charge of these broadband networks. Fast timing instabilities in the clocks and data lines are commonly designated by the term Jitter, while the term Wander addresses the slower fluctuations affecting these elements.
The object of this technical note is to explain jitter phenomenon and present the common techniques used to qualify and control it. Another technical note elaborates in more details on wander problematic.

What is jitter, what are its causes and its consequences

Jitter: what is it?

Jitter represents the time fluctuations in the rising and falling edges of digital pulses. While we generally mentally assume that, say, the rising edges in a 2,5G clock occur exactly every 400 ps, various phenomenons blur this ideal picture and fluctuations (phase variations) of several ps around the "official" rising times happen. The question then is to constrain these timing imperfections within specific limits in order to avoid trouble.

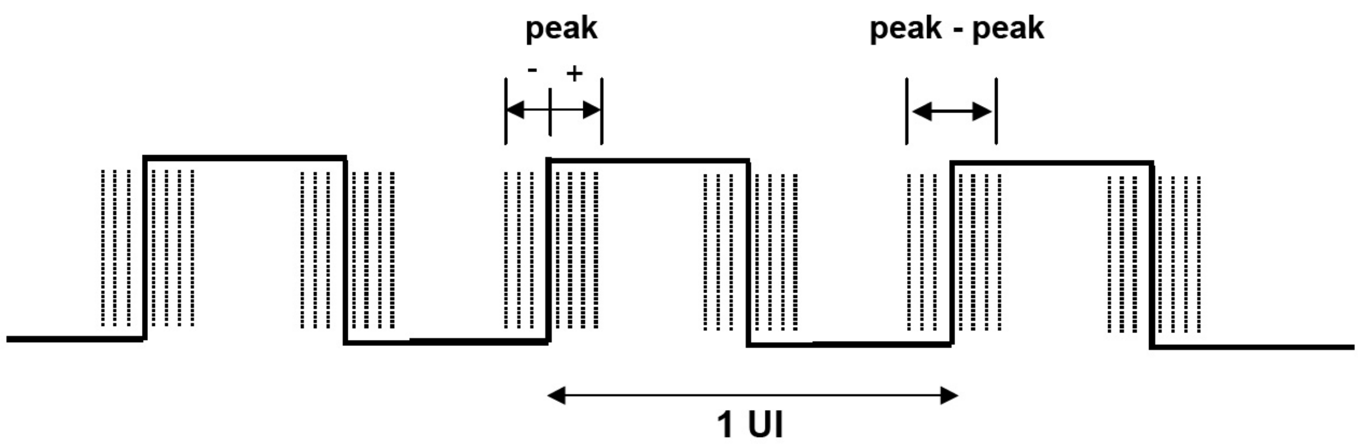

Figure 1. Jittered clock signal

What are the causes of jitter?

Impulsive noise or cross talk on transmitted signals usually causes high frequency jitter. The same applies for thermal noise in a clock circuitry. The regular repetition of digital patterns causes what is called pattern-dependent systematic jitter. A good example of that are the A1/A2 framing bytes in SONET/SDH streams: these bytes are not scrambled and the same pattern therefore occurs at 8kHz frequency thereby creating some form of jitter.

There are other causes in SONET/SDH networks, like mapping-demapping jitter and pointer induced jitter. When we insert for instance into a VC12 an E1 signal that runs 10 ppm faster than the SDH node, E1 chunks are encapsulated into VC12 multi-frames in a way to cope with the rate difference between the tributary and the network. Most chunks will be 1024 bit long but one out of 100 will have 1025 bits. In another words the information stream is not constant. Upon retrieving this E1 these time discontinuities in the E1 info will inevitably generate jitter on the extracted E1: this is called mapping-demapping jitter.

Pointer-induced jitter is more serious. SONET/SDH networks with bad network synchronization must proceed to what is called pointer adjustments. These pointer movements generate gaps in the information flow and when tributaries are extracted from the synchronous network they again inevitably pick up some jitter fluctuations.

What are the consequences of jitter?

May be the easiest way to understand why jitter is dangerous is to imagine that these time fluctuations occur randomly and change very quickly in time. The digital detection process on such an input port will use a sampling clock that will look very much like the dark regular line on Figure 1. This is so because the internal clock circuitry will filter out these high frequency fluctuations. So the sampling instants (for the detection) will fall very regularly but they won't fall right in the middle of the data (jittered) pulses. If their jitter is too high this situation will likely cause bit errors.

Another way to look at it is to imagine how this high frequency jitter will affect the eye diagram of reception process. It will look as shown on the Figure 2, with a narrowed eye opening, something likely to create errors.

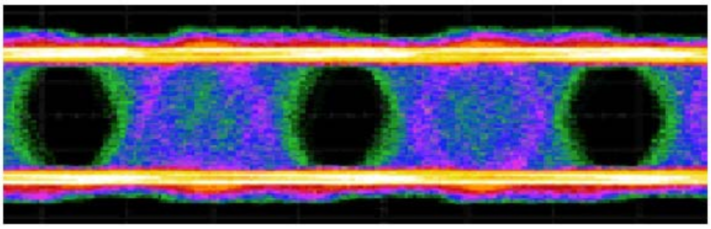

Figure 2. Jittered eye diagram

This example was focused on a high frequency case but a large low frequency jitter is just as dangerous as it may destabilize the reception circuitry. Furthermore, large jitter bursts on tributaries are liable to cause a loss of framing (for example on a DS1 signal), thereby triggering a loss of information and impacting the quality of service. Examples of services that typically suffer from severe jitter are: encrypted text, Facsimile, Video, voice band data, compressed Audio and cellular trunk lines.

Jitter terminology

Timing fluctuations are analysed with a jitter detector, whose circuitry continually yields the evolution of the phenomenon.

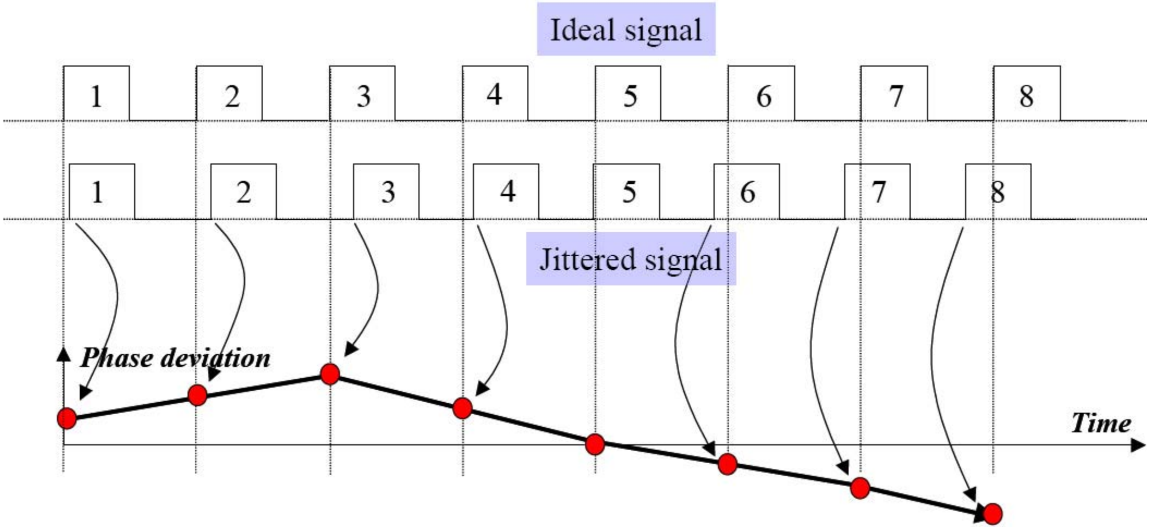

Figure 3. Output of jitter detector circuit

In order to characterize jitter the detector output is pass-band filtered and a peak-to-peak or rms measurement is carried out on the resulting output. The jitter unit is called Unit Interval (UI). A UI is simply a bit period for the considered rate.

Peak-to-peak jitter is written UI pp and root mean square jitter UI rms. Both quantities are used in jitter tests. UI pp gives a measure of worst case jitter while UI rms is helpful when one wants to cumulate jitter in a chain of network elements.

Network interface	Bit Rate	UI (Unit Interval)	Network Interface	Bit Rate	UI (Unit Interval)
PDH / T-Carrier	1.5 M (DS1)	0.65 µs	SDH / SONET	STS-1	19.29 ns
	2 M (E1)	0.49 µs		STM-1/OC-3	6.43 ns
	34 M (E3)	29.10 ns		STM-4/OC-12	1.61 ns
	45 (DS3)	22.35 ns		STM16/OC-48	401.9 ps
	140 (E4)	7.18 ns		STM-64/OC-192	100.5 ps

Figure 4. Unit Interval (UI) values per bit rate

The reason why each jitter measurement is associated to a filter is that jitter's spectrum is quite broad and not at all confined to a small frequency band, as reminded in figure 5. Figure 6 shows the 2 filters used for UIpp characterization.

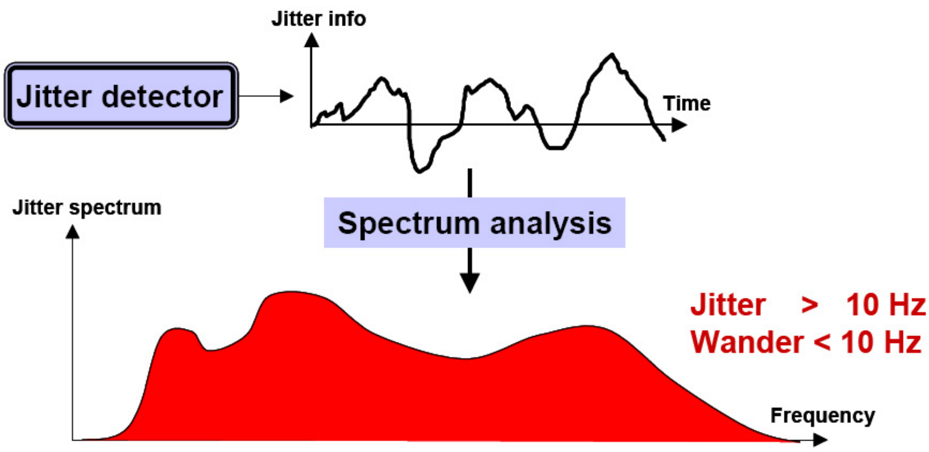

Figure 5. Phase deviation amplitude spectrum

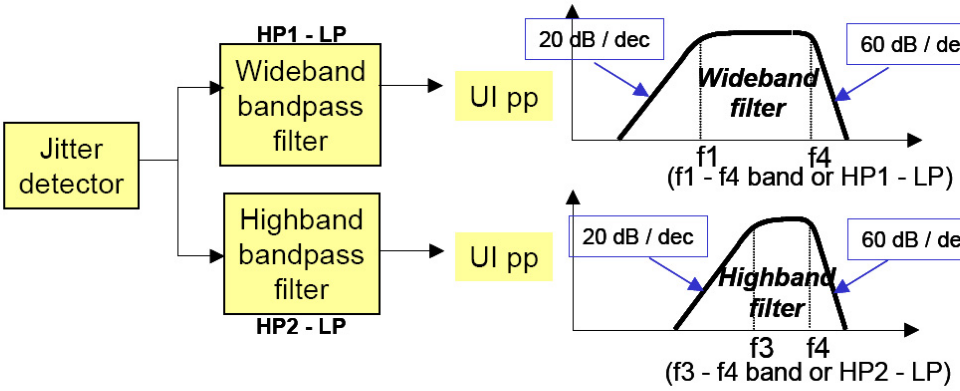

Figure 6. Wide band and High band pass filters used for measuring jitter

Each interface rate has normalized HP1-LP & HP2-LP filters. Here HP stands for high pass and LP for low pass. The standard procedure to characterize peak-to-peak jitter is to record the two UIpp values after 60 seconds. For UI rms measurements another pass band filter is applied with 12 kHz high pass and the same LP low pass filter.

For example, at STM16 – OC-48 level, UI pp is gauged in the bands [5 kHz, 20 MHz] and [1MHz , 20 MHz] and UI rms in the band [12 kHz , 20 MHz]. These values appear in the CMA5000 XTA GUI jitter analysis screen as shown on figure 7.

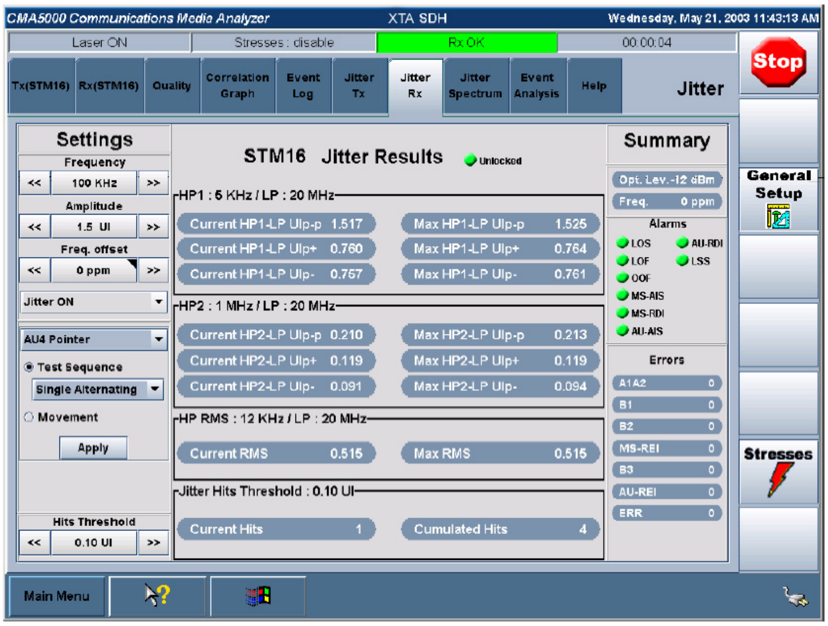

Figure 7. Simultaneous jitter results through HP1 and HP2 filters with CMA5000-XTA

Standard jitter measurements and associated limits / templates

There are a few basic tests that need to be carried out if one wants to warrant full compliance of interfaces and networks as far as jitter is concerned. These are presented below:

Intrinsic jitter

Nothing being perfect, any output interface is jittery. At the output of a circuit pack we must make a distinction between two different cases: either this unit is running with a very stable clock or this clock is itself likely to be jittery. Obviously the first case represents the jitter floor level and this is called “intrinsic jitter”.

When units are validated, their "intrinsic jitter" is measured and compared to the standard limits. As outlined above, this means running them in free mode or slaved by any very stable independent clock and registering the UI pp data after one minute. The standard limits as per ITU-T are as displayed in Table 1. For instance at STM16 level limits are 500 mUI pp in the [5 kHz, 20 MHz] wideband and 100 mUI pp in the [1 MHz, 20 MHz] high band. Any interface with results above these figures would not be compliant.

Bit Rate	Wideband UI pp	Wideband limit	High band UI pp	High band limit
2M	0.05	20 Hz - 100 KHz	x	18 KHz - 100 KHz
34M	0.05	100 Hz - 800 KHz	x	10 KHz - 800 KHz
140M	0.05	200 Hz - 3,5 MHz	x	10 KHz - 3,5 MHz
STM-1 (opt)	0.5	500 Hz - 1,3 MHz	0.1	65 KHz - 1,3 MHz
STM-4	0.5	1 KHz - 5 MHz	0.1	250 KHz - 5 MHz
STM-16	0.5	5 KHz - 20 MHz	0.1	1 MHz - 20 MHz
STM-64	0.5	20 KHz - 80 MHz	0.1	4 MHz - 80 MHz

Table 1. Standard intrinsic jitter limits as per ITU-T

Maximum permissible output jitter

In real world network interfaces are not necessarily run with a jitter less clock. As a matter of fact many telecom facilities usually derive their clocking from one incoming high speed line and therefore pick up jitter in the process. The ITU-T has defined upper limits for jitter, ones that must never be exceeded whatever the network details. These are shown in the Table 2.

Network Interface	Standard	Bit rate	Wideband UI pp	Wideband limit	High band UI pp	High band limit
PDH	ITU-T G.823	2M (E1)	1.5	20 Hz - 100 KHz	0.2	18 KHz - 100 KHz
		8M	1.5	20 Hz - 400 KHz	0.2	3 KHz - 400 KHz
		34M (E3)	1.5	100 Hz - 800 KHz	0.15	10 KHz - 800 KHz
		140 (E4)	1.5	200 Hz - 3,5 MHz	0.075	10 KHz - 3,5 MHz
SDH	ITU-T G.825	STM-1 (opt)	1.5	500 Hz - 1,3 MHz	0.15	65 KHz - 1,3 MHz
		STM-4	1.5	1 KHz - 5 MHz	0.15	250 KHz - 5 MHz
		STM-16	1.5	5 KHz - 20 MHz	0.15	1 MHz - 20 MHz
		STM-64	1.5	20 Khz - 80 MHz	0.15	4 MHz - 80 MHz

Table 2. Maximum permissible output jitter

For instance at STM16 level these network limits are 1500 mUI pp in the [5 kHz, 20 MHz] and 150 mUI pp in [1 MHz , 20 MHz]. As usual, these measurements are carried out in one minute. Any situation violating these limits would be cause for concern and would require searching the cause of the problem (circuit pack, local clock unit, clock distribution, etc…).

Jitter tolerance

All input port circuitries must be able to function in the presence of jitter on the received signals. One says that they must tolerate jitter (up to a certain point). This minimum tolerance has been standardized. Unfortunately ITU and North America specifications are different on this and other issues. We show here (figure 8) a 2.5 G level tolerance measurement and the associated Bellcore standard (in red).

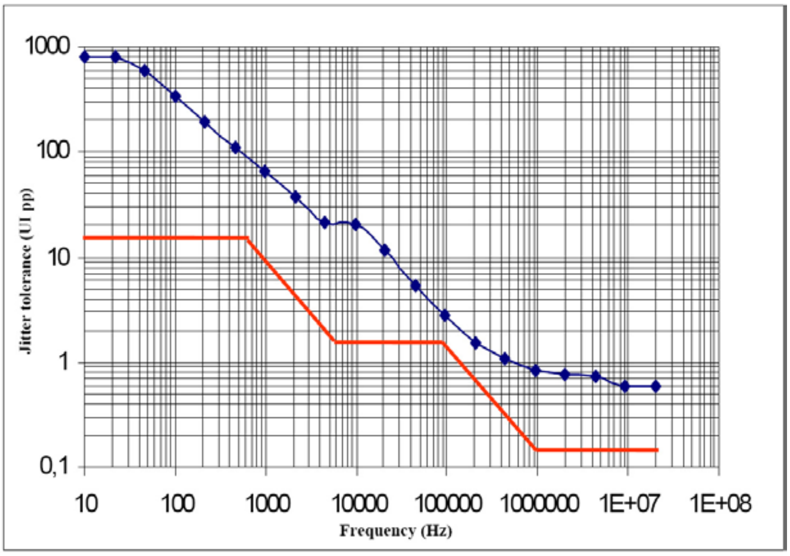

Figure 8. Example of 2.5G jitter tolerance measurement compare to Bellcore mask (in red)

Its meaning is quite straightforward:
The port accepts up to 60 UI pp jitter with 1000 Hz frequency, 20 UI pp at 10 kHz, 2.5 UI pp at 100 kHz, 0.9 UI pp at 1 MHz and 0.6 UI pp at 20 MHz, for instance. In all cases this is better than the template data and therefore the corresponding ports are compliant. That sort of jitter tolerance checking must be done at least during manufacturing.

The tolerance measurement is best carried out automatically. The tester generates jitter frequency stresses (applied to the DUT device under test) and searches the amplitude limit beyond which the DUT input port starts experiencing errors. For instance in the example above, when the tester reaches 0.6 UI pp at 20 MHz the OC-48 receiver identifies B2 errors, which are signalled in the outgoing OC-48 line with the REI-L counter SONET scheme. The tester only needs to analyse this return line to know the jitter limit has been reached. It then proceeds to stress the DUT at another frequency (see figure 9).

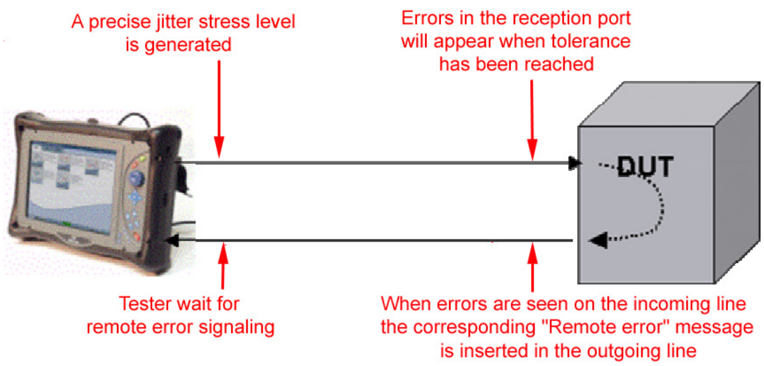

Figure 9. Automatic jitter tolerance measurement

Jitter transfer

Jitter transfer basically concerns regenerators. These equipments lock themselves onto the incoming signal but their PLL circuitry does not phase out jitter altogether. Its internal filter effectively attenuates only the high frequency content. On the other hand, low frequency jitter may be slightly amplified, which will show in the outgoing line. This “jitter transfer” (from incoming to outgoing line) must be limited because a chain of regenerators could otherwise amplify jitter in an uncontrollable way.

Figure 10 shows a jitter transfer measurement done at OC-48 level along with the Telcordia template for regenerators (in red). We see that above 2 MHz the template has a 20 dB per decade slope while low frequencies template is flat (at 0.1 dB). This measurement is a good example of a typical good jitter transfer case. In all cases the transfer curve must be below the template. This measurement is always carried out automatically but requires a pre calibration to guarantee accurate results.

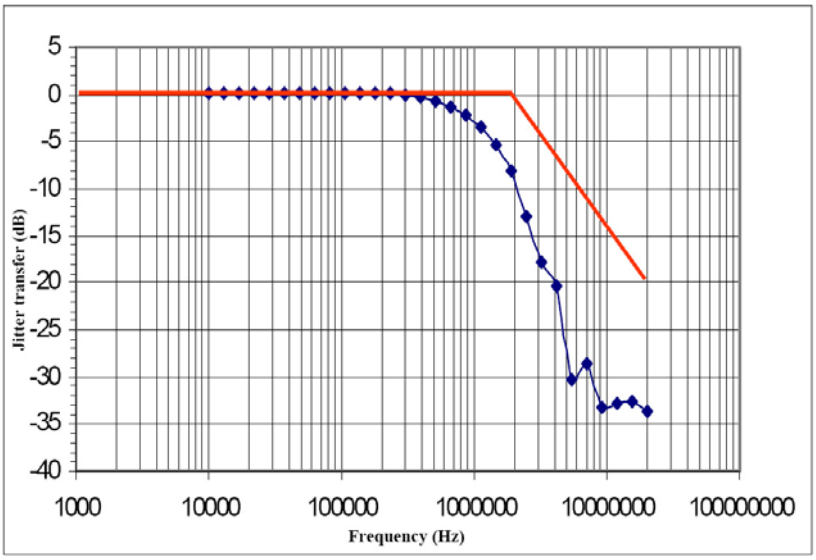

Figure 10. OC-48 jitter transfer measurement.

Jitter on tributaries travelling on SDH/SONET networks

SDH & SONET technology is great but it actually does not always treat its payload fairly! Even with a jitterless synchronous line you may end up extracting, say, a 2M tributary trunk line with jitter. Why? Because of pointer activity within the SDH/SONET network. Extracting (dropping) a 2M from a VC12 with pointer movements will inevitably render this 2M jittery. This is called pointer-induced jitter. Note that there is also another jitter type called mapping-demapping jitter but it is usually less severe. Pointer-induced jitter is attenuated as much as possible by a circuit called "desynchroniser" in the extracting unit. In order to make sure that this phenomenon is acceptable, it is best to try it, if at all possible. This is always done generating pointer activity with a few normalized pointer sequences. These create a stress on the tributary extraction process and the corresponding tributary jitter is analysed and compared to standard limits (as defined in G.783 in the SDH case).

CMA5000 XTA jitter screens

The CMA5000 XTA graphical user interface is particularly handy to carry out the jitter measurements. This section outlines its features.

Manual Tx/Rx jitter window

The jitter generation (Tx) and jitter analysis (Rx) windows are respectively shown in Fig. 11 and 7. The left column (present in Tx and Rx) shows the jitter stress generation parameters (frequency, amplitude UI pp) as well as the rate offset in ppm. The lower part is used for pointer sequence activity in the SDH/SONET cases, something important when testing the pointer-induced jitter on the embedded tributaries. The hit threshold is used mainly to monitor high UI pp jitter occurrence.

The central part of Tx window displays the applied jitter stress. It appears clearly on the frequency / amplitude graph superimposed with the relevant tolerance template for the interface under test. This is a useful guideline since applying a jitter stress only makes sense if one knows what minimum stress the DUT is supposed to handle. Here it shows as a blue line and the current stress corresponds to the green dot (100 kHz @ 1.5 UI pp on Figure 11). Another information, the maximum stress capability of the tester, is also displayed: this is the upper curve in the Tx window.

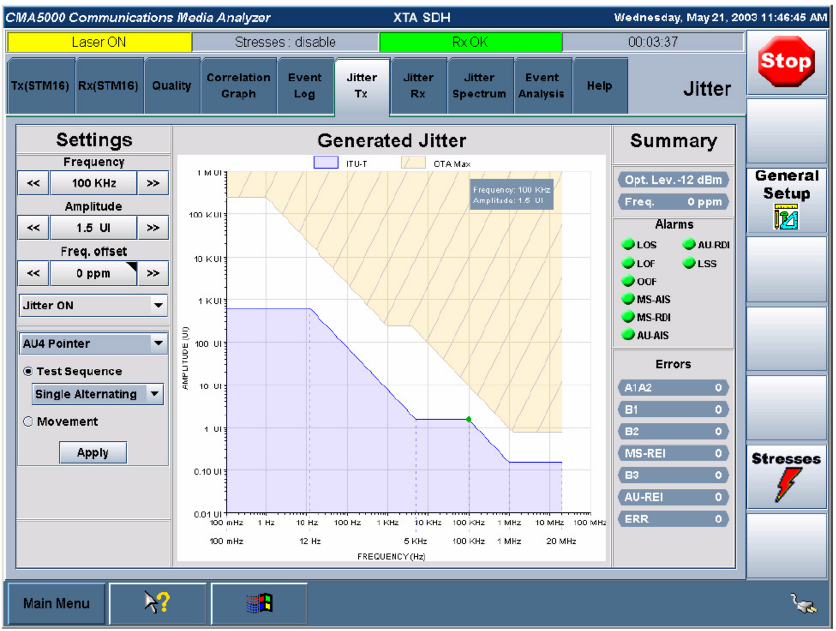

Figure 11. Jitter generation configuration with CMA5000 XTA

The central part of the analysis (Rx) window (refer to Fig.7) displays all the important information at the same time, which spares the trouble of having to change windows and menus in order to understand what’s going on or capture the analysis again after changing the analysis filter. Here all is available at a single glance.

The analysis in all three bands (HP1-LP, HP2-LP and 12kHz-LP) yields the UI pp and UI rms info in the current second and the maximum data recorded since starting the measurement.

The right column is also common to Tx and Rx windows. It displays the situation at the interface alarm and error levels in order to render the appraisal of the situation easier for the operator.

Jitter tolerance windows

Figures 12 and 13 respectively show the full and fast tolerance windows. Both have a common left column displaying the relevant jitter tolerance settings.

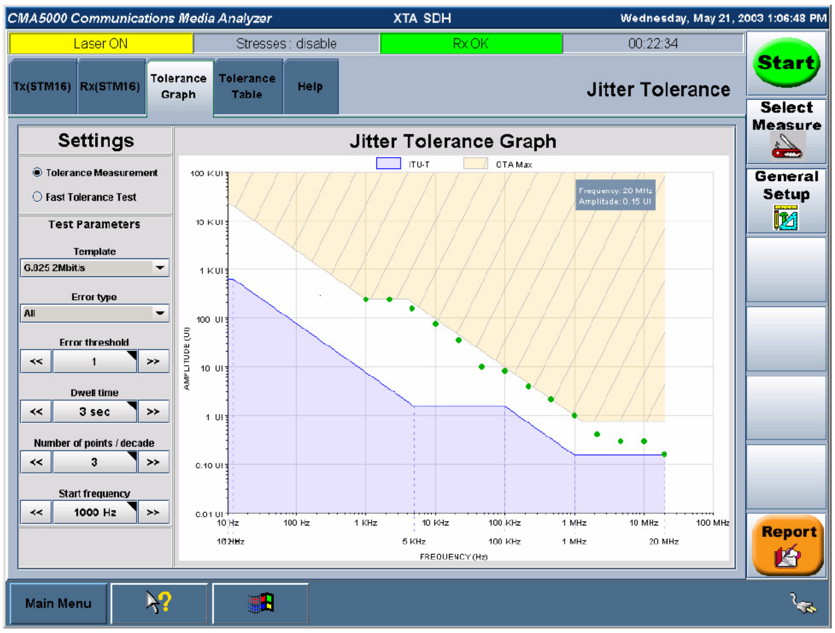

Figure 12. Full jitter tolerance measurement with CMA5000 XTA.

The error type indicates the signalling used to track the onset of errors during the tolerance measurement. In most cases the error type would be typically a remote signalling like MSREI.

In each stress trial the equipment waits a certain time (commonly called gate time or dwell time). If during this interval no error was signalled at the DUT input, the applied stress is deemed below the tolerance. The same applies too as long as the number of errors is below the parameter “error threshold” within this dwell time.

In the full tolerance search, the software must then go on probing the DUT with a higher stress in order to find out the onset of errors. This is done at different frequencies. In Fig. 12 just 3 jitter points were scanned in each decade. The green dots show the maximum jitter stimuli that the DUT accepted in this instance.

The only problem with full tolerance is that it takes time : if you scan 3 decades with 3 points per decade, with an average of 5 iterations on each frequency and 5 seconds waiting at each trial (dwell time) you need almost 6 minutes altogether.

A more pragmatic approach consists in doing a fast tolerance (as per Fig. 13). The software will not try and find the real jitter limit but will only do one trial per frequency: with a fast tolerance parameter set to 0% , it will actually follow the selected template and try it on the DUT. The idea here is just checking that the DUT passes the test. It is also good practice to introduce a margin here, say 50 % above the template. The stresses will be 50 % higher (compared to the 0 % case) and if the DUT passes the test, so much the better.

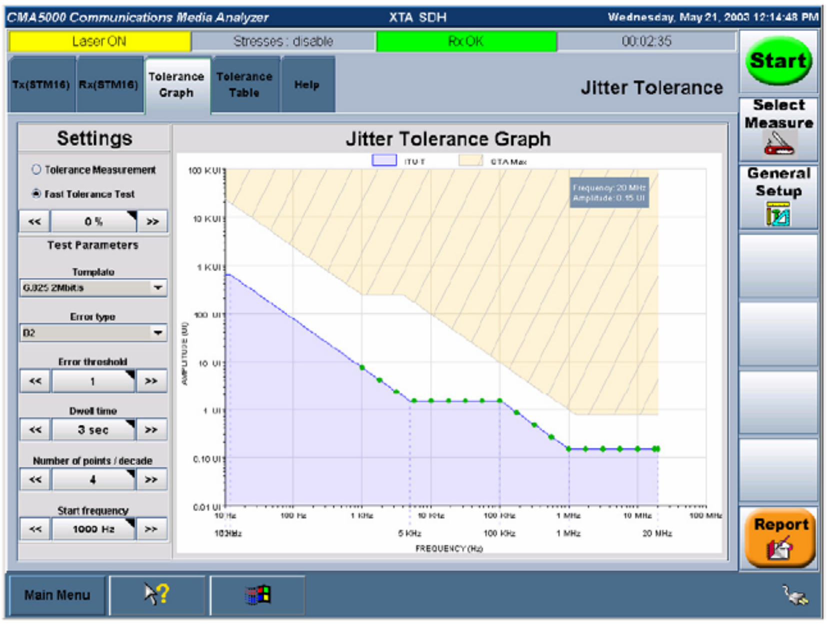

Figure 13. Save time with the fast tolerance test of the CMA5000 XTA

Jitter transfer windows

The Figures 14 and 15 show the user interface on jitter transfer. The calibration phase (Fig. 14) means we first perform jitter measurements looping the tester on itself. This will allow accurate jitter transfer after inserting the DUT in-between. Here the “dwell time” parameter is the time dedicated to each jitter measurement. Its setting is a matter of trade-off: a large interval will give very accurate transfer data but after a long time.

After running the measurements the transfer data (in dB) are displayed with the relevant background template. The green dots on the left in Figure 15 correspond to data close to 0 dB and below the 0.1 dB template limit in the flat band area.

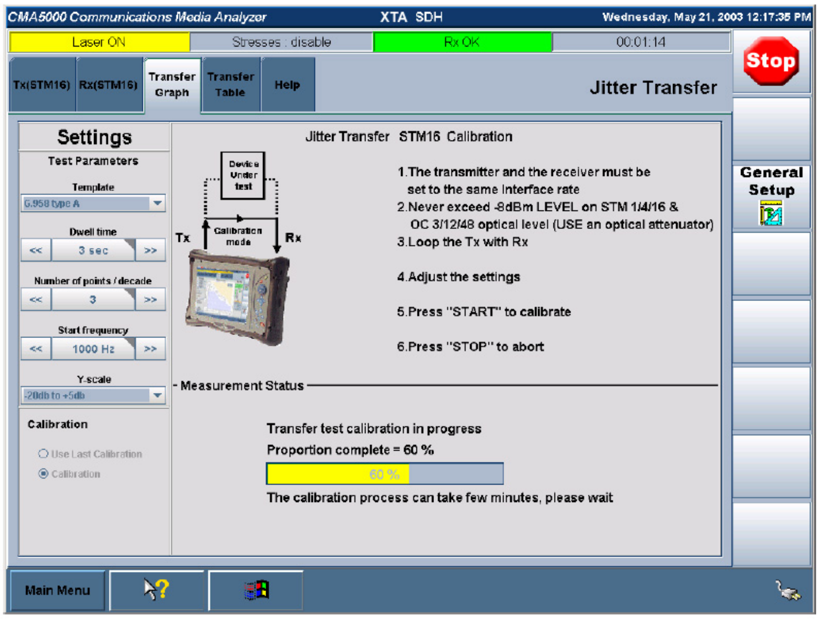

Figure 14. Calibration phase before measuring jitter transfer

Figure 15. Jitter transfer graph on CMA5000 XTA

Conclusion

This note presented the main features of Anritsu XTA jitter generation and analysis option. It first gave a background on the problematic of jitter and then illustrated them with the application's GUI windows. Jitter measurements are usually considered quite tedious but with this new solution many potential users should and certainly will change their mind on that issue.

Specifications are subject to change without notice.

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Technical Note

Understanding Wander in Transport Networks

CMA5000

XTA module (e**X**tended **T**ransport **A**nalysis)

Introduction

Synchronous SDH/SONET networks are the powerhouse of modern long haul backbones. As their name implies, they are supposed to run on synchronous clocks, that is to say, clocks that all derive from a common source and supposedly fairly identical.

While this requirement is, to some extent, indeed respected in most cases, these networks have to handle occasional losses of perfect synchronization. SDH & SONET indeed have enough internal provision to do that but the impact of bad synchronization must be appreciated at the payload level. This is because transported tributaries within synchronous streams may sometimes be badly hit in such cases while everything looks fine at SDH/SONET level. This can lead to loss of frames at tributary level and therefore create a serious degradation of the services carried by these circuits.

Synchronization problems mean low frequency phase fluctuations at clock and signal level and are commonly called Wander. The object of wander analysis is therefore to characterize these clocking fluctuations. This application note addresses this issue, explaining first what wander is, presenting the classical background behind it and the techniques used to characterize it.

What is Wander, its causes and consequences

As mentioned above wander is the generic term for the slow and very slow timing fluctuations affecting transmission networks. Transmission streams are supposed to arrive at exchange nodes regularly, but what if they don't?

If one or several incoming streams accumulate important (many μs) phase differences (wander) between one another we may get problems: signals are bufferized before processing and the node processes them with a common clock. If the wander gets too large, buffers will either loose a whole frame (buffer overflow) or repeat one twice (buffer underflow) in order to keep control. This is called a "controlled frame slip". In all cases the internal data carried within these streams will be corrupted, resulting in a quality of service degradation. The only service that would not suffer from a frame slip is the case of uncompressed voice transmission. In all other cases (data, video, signalling, etc...) excessive wander is a real threat.

But why should this happen in the first place, anyway? Basically, if all network clocks were perfectly stable (no clock noise) and fully synchronized, this would never happen. Unfortunately clocks, even if they are driven by a nice synchronization source, add up some internal wander of their own. Their intrinsic wander amplitude may individually exceed 100 ns over a few hours.

Clocks within a network are usually all driven from a common source called a Primary Reference (PRC or PRS) but we have to consider that interconnected networks may run on different PRCs that will show relative wander to one another. Each PRC may build a wander of 1 μs per day. Then, due to micro interruptions or change of reference clocking source (consecutive to a failure) at the input of PLL circuits, clocking signals in Network Elements experience random phase changes.

In the end, especially in the unfavourable cases of PDH / T-carrier streams travelling along several SDH/SONET networks, there exists the possibility of large wander accumulations that may lead to several frame slips per day.

Additionally, SDH & SONET networks add their own peculiar contribution to this issue. Their equipments "transparently" accommodate synchronization differences with what is called pointer adjustments. A 2Mbit/s trunk line crossing SDH networks with serious timing problems would actually travel in a TU12 container with frequent pointer movements. It turns out that each occurrence of these movements induces a non negligible jitter on the extracted 2M line. If this "pointer-induced" jitter is not well smoothed out (by a circuit called desynchronizer) this impairment may well "knock off" the terminating equipment, say, a PABX or a mobile base station, in the sense that the equipment may then temporarily loose synchronization and data.

Normally pointer movements are scarce but they occur when a failure in the synchronization distribution forces a node to run on its internal clock or when a dc offset in the PLL clock circuitry causes a clock drift.

Figure 1 sums up these issues.

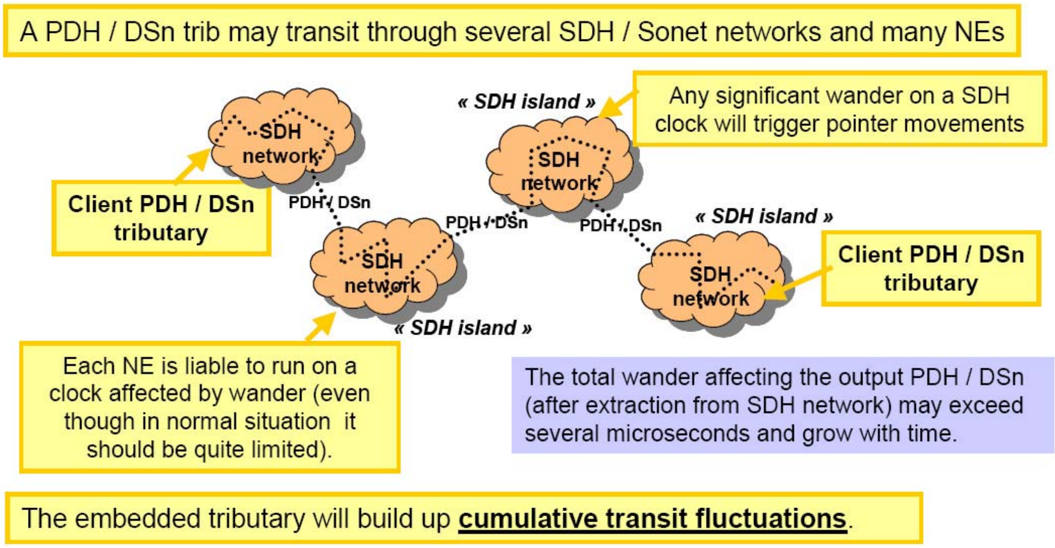

Figure 1. Why wander may accumulate?

Synchronization and wander

Network synchronization is very important. Synchronization is commonly distributed in a chain through different clock units with different levels of quality, as illustrated in Figure 2. It also shows the difference in terminology in SDH and SONET worlds.

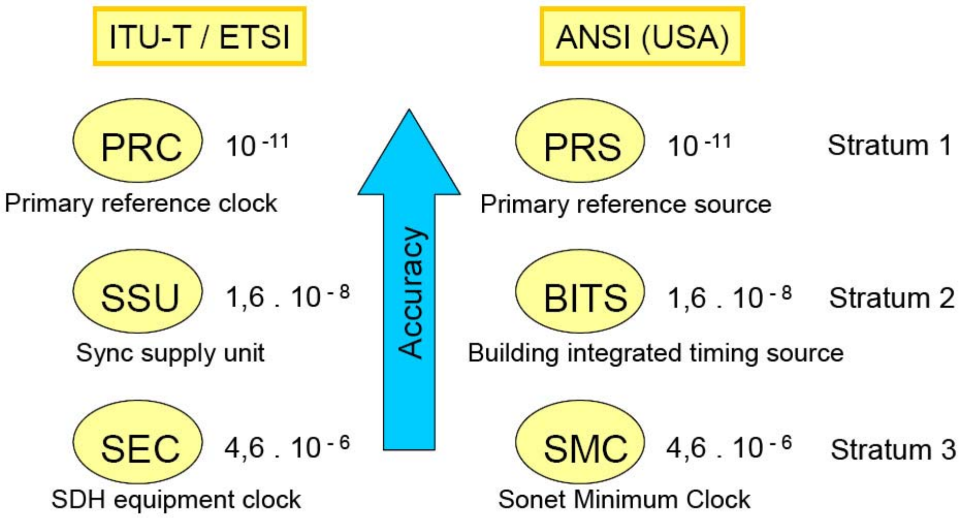

Figure 2. Two clocks hierarchies in the synchronous world

Stratum 1 clocks are by definition clocks with the best long term accuracy. For instance Cesium beam oscillators are Stratum 1. Stratum 2 and 3 refer to the next levels below Stratum 1, with long term accuracy decreasing from Stratum 1 to Stratum 2 and finally Stratum 3. Stratum 3E (enhanced) is a particular case whose quality is intermediary between Stratum 2 and 3.

In ITU-T parlance the highest level is called PRC or Primary Reference Clock. The second level is the SSU or Synchronization Supply Unit and the third one is the SEC or SDH equipment clock. One difference between SSU and SEC is that SSUs have a narrower bandwidth and different intrinsic wander limit specifications.

Similar terms are used in SONET and the corresponding long term accuracy is listed in Fig. 2. Most common PRC units use GPS satellite timing signals as a synchronization source, whenever reception conditions are correct, but switch to alternative sources like a Rubidium clock if GPS reception is not satisfactory. On the other hand, SEC clocks are typically made with quartz crystal oscillators.

The job of a SSU is to select one of several available timing sources and distribute it locally to the different SEC units. But in general we may encounter the distribution chain shown in Figure 3 (see also Fig. 8 for more details).

One way to appraise the quality difference between clocks is to look at Table 1. It displays their maximum number of (125 µs) frame slip occurrences assuming they run in free mode after having lost their normal reference. However these figures do not include the impact of their own intrinsic wander and of clock distribution. They are just an illustration.

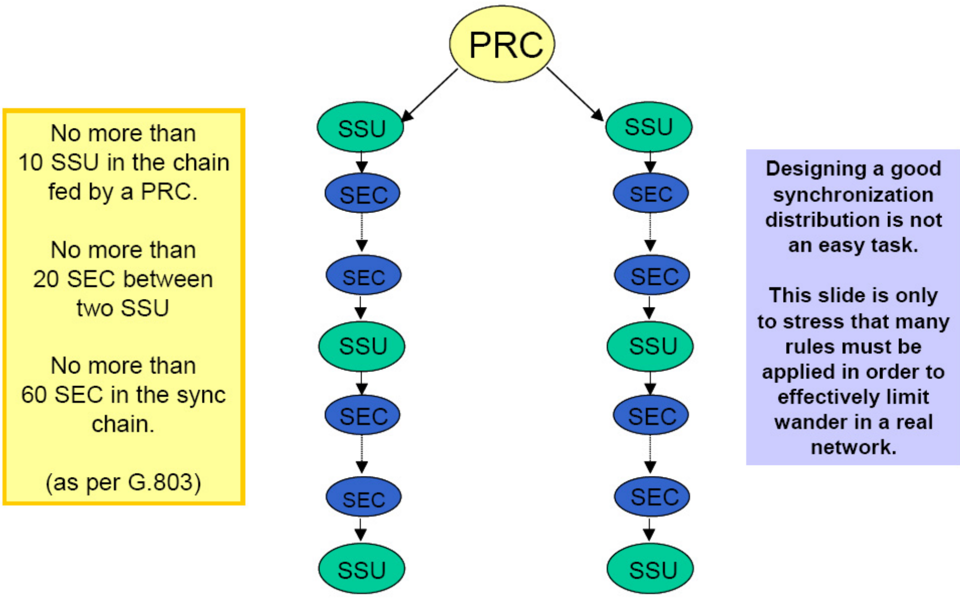

Figure 3. Synchronization distribution in SDH terms (Master – Slave type)

Stratum level	Free run accuracy	Holdover accuracy (first day)	Number of 125 µs periods
1	10^{-11}	NA	<1 slip in 72 days
2	$1.6 \cdot 10^{-8}$	$1 \cdot 10^{-10}$	<1 slip in 13 days
3E	$4.6 \cdot 10^{-6}$	$1 \cdot 10^{-8}$	<7 slips in 1st day
3	$4.6 \cdot 10^{-6}$	$3.7 \cdot 10^{-7}$	<255 slips in 1st day

Table 1. Quality differences between clocks (in free mode)

The wander recommendations (eg. ITU-T G.810, 811, 812, 813, 822, 823 and Telcordia GR-253, 1244) have been conceived to constrain wander to reasonable limits even in the case of information streams crossing many synchronous networks and assuming worst case situations. These standard limits come in the form of templates that measurements must not exceed, but we must first explain what these measurements are.

Wander measurements

Figures 4 and 5 show two important cases:

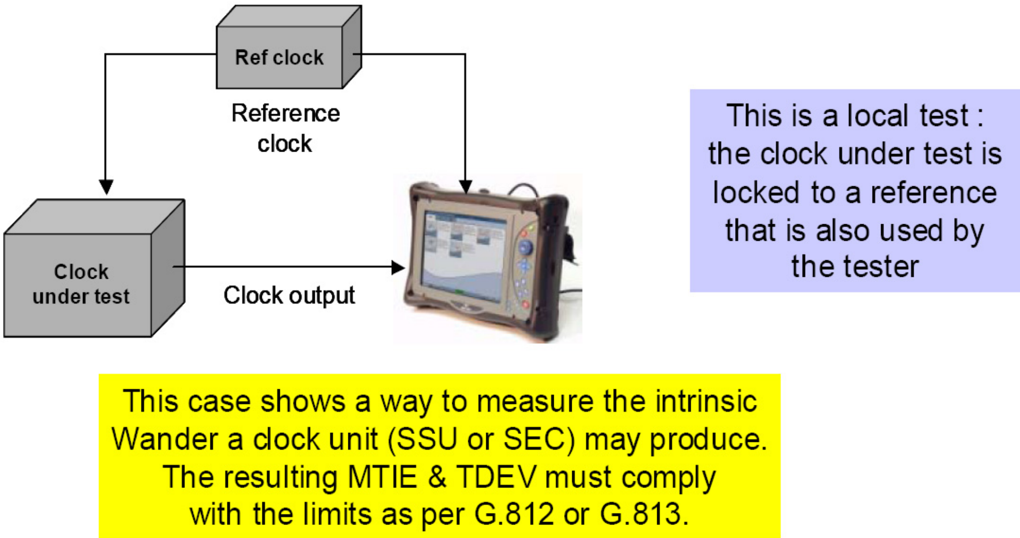

Figure 4. Example of intrinsic wander measurement

As discussed above, any clock contributes to wander accumulation with its own intrinsic low frequency phase variations. With the test shown in Fig 4 this intrinsic wander may be gauged. This test is called “locked mode” or “synchronized clock” wander measurement. The analysis of the wander data must comply with the relevant standard. If clock quality were not strictly bounded intrinsic wander could be a serious cause of wander accumulation in networks.

Figure 5 is more focused directly on measuring a network wander. In this case wander at point of measure (a clock unit or a data line) depends on the whole chain of synchronization, that is to say, it is not a local test. Since the outcome may involve a broad wander accumulation (imagine you are actually measuring a 2M trunk line that went through several SDH sub networks) the standard limits on maximum tolerable wander in networks are more relaxed, as will be seen later. This test is called “independent clock” wander measurement.

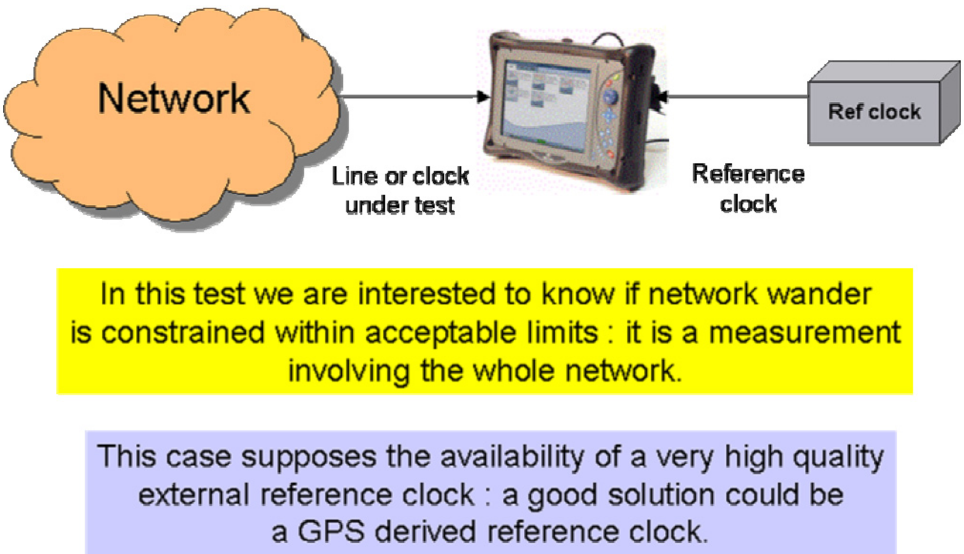

Figure 5. Network wander measurement

But what does the tester record during a wander measurement and how long should it last? The tester periodically measures the phase difference between the reference and the signal under test and stores the data. These data are called Time Interval Error or TIE and are usually displayed in ns.

TIE sampling periodicity is user-settable but depends on the application, and the same applies to the total wander measurement time. Table 2 shows a list of application examples. If one wants to, say, observe the wander induced by pointer movements the total observation time is short (less than 10s) but in order to track quick phase variations it is best to have 30 or 100 TIE samples per second.

On the other hand, if one wants to characterize a network wander long term fluctuations it is advisable to run the test during several days. This is because wander build-up in networks may not be seen with a simple 24 hrs run. In such cases it is most advisable to lower the sampling rate to 1 per second or 1 every 10s. A one week run with 0.1 TIE per second would already collect a bit more than 60.000 TIE.

Figure 6 shows a TIE recording done with the CMA5000 XTA application, with the horizontal scale in seconds and the TIE vertical scale in ns. It shows a TIE wander of 10 µs peak-to-peak fluctuation, first with a period of 100s (10 mHz) then a period of 50s (20 mHz).

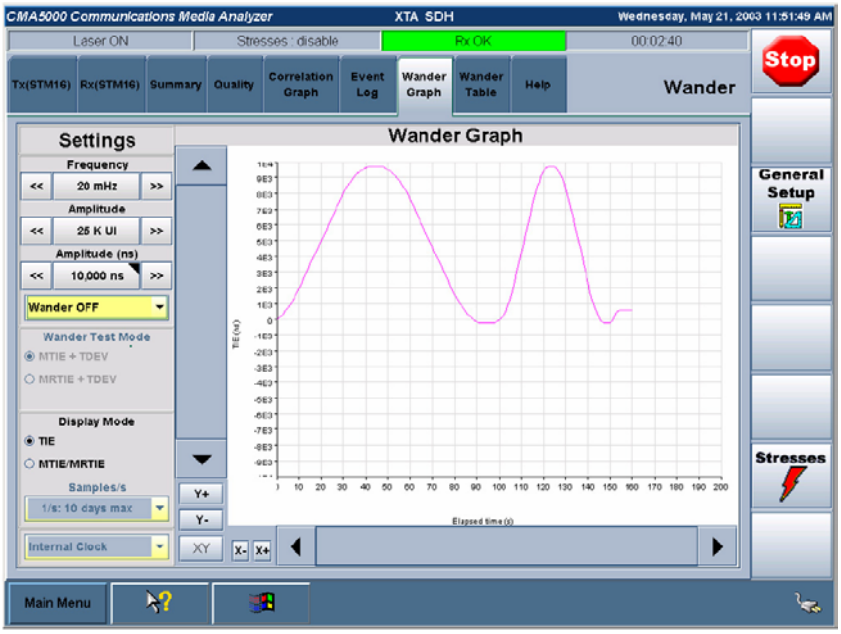

Figure 6. Time Interval Error (TIE) measurement with CMA5000 XTA

In long wander measurements, setting a fast sampling rate is unnecessary since we are then mainly interested in tracking very low frequency phase fluctuations. Setting, say, the rate to one TIE every 10s (100 mHz) basically prohibits any wander analysis on frequencies above 50 mHz but is perfectly fine to focus on the 10 µHz – 10 mHz wander range.

In other words, if you run a one week test with 10 TIE / second you will end up with 6 million TIEs (that is, if the tester can handle that). Better do that at 0.1 TIE / second: you get only 60.000 data but that's more than you need.

Then, if one wants to focus later on higher frequencies it is a simple matter to rerun the test with a faster sampling rate and a much smaller measurement time.

Rec	Type	Analysis	Observ. window	Freq.	Measurement time
G.783	Impact of pointer sequences on DS1 & DS3	MTIE	Up to 10 s	x	10 s
G.812	Transient analysis on clocks at 2M and STM-n level	MTIE	Up to 240 s	x	4 min
G.823	Network limits for PDH signals (section 5.2)	MRTIE	Up to 1000 s	x	20 min
G.823	Network limits (absolute meas. with PRC ref clock)	TDEV	42,000 sec	10 µHz	5,8 days

Table 2. Examples of wander measurement types with associated measurement time

Wander terminology

Most templates defining wander limits refer to the terms MTIE and TDEV. They both characterize the nature of the raw TIE wander data. To analyse wander you normally don't want to see the TIEs. They are only a lot of raw data and we need to extract from them something that really allows network engineers to decide quickly if they are in a Pass or a Fail situation.

What is MTIE? Imagine you find in the TIE sequence a TIE transition of 0.5 µs between measurement times t = 20s and t = 30s, that is to say, during a 10s interval. Imagine that nowhere else in the TIE sequence can you find a larger transition (500 ns) occurring during **any** 10s interval (you slide a 10s window along the whole TIE record). Then you have found the MTIE (10s) value of your wander measurement.

You then do that for other intervals like 1s, 2s, 5s, 10s, 20s, 50s, 100s and so on and you end up with values like : MTIE (1s) , MTIE (2s) , MTIE (5s) , MTIE (10s) , MTIE (20s) , MTIE (50s) , MTIE (100s) , etc… This is the essence of MTIE analysis. The parameter (here the sliding window width) is often called "observation window".

MTIE is very useful to pinpoint peak-to-peak wander phase fluctuations or identifying a shift in frequency.

What is TDEV now? TDEV is used to characterize more precisely the "randomness" or the degree of phase instability present in the TIEs. For instance it is not affected by any rate shift (unlike MTIE). It is more like a spectral density analysis.

What is basically done to compute TDEV (10s) when TIE rate is 1 per second? The TIE data are band pass filtered and roughly speaking the frequency content around 20 mHz and 70 mHz is extracted. Then the root mean square (rms) of these filtered data is computed. That is exactly TDEV (10s).

Similar computations are done to get the other TDEVs: the parameter is also called "observation window". To compute TDEV (τ) the band pass filtering is about centred around 0,42 / τ . That's why TDEV is a spectral analysis. Table 3 gives the correspondence between the observation window and the central frequency. The larger τ the smaller the frequency band analysed by TDEV (τ).

τ	1s	10s	100s	1,000s	10,000s	100,000s
Frequency	420 mHz	42 mHz	4 mHz	420 µHz	42 µHz	4 µHz

Table 3. Correspondence between TDEV observation windows (τ) and central frequency of band pass filter

MTIE and TDEV analysis is very useful: it gives a good synthesis of the recorded TIE data. Once they are computed MTIE and TDEV data are displayed in ns unit vertically with the observation window parameter on the horizontal scale in second unit. Figure 7 shows such a MTIE / TDEV analysis window. In this figure MTIE template and data are shown in red while TDEV template and data are in green.

What is fundamental in MTIE / TDEV wander analysis is that the computed curves are generally compared to the relevant templates. All points must be below the template in order to be in a PASS situation.

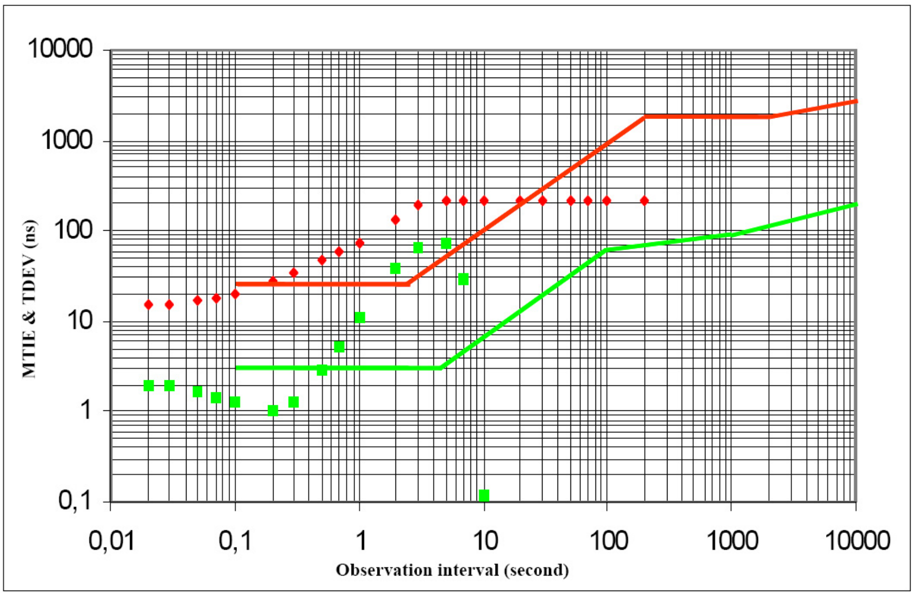

Figure 7. MTIE/TDEV data compared to corresponding templates for PASS/FAIL results

Note: there is a useful relationship between the minimum τmin parameter one wants to investigate and the TIE sampling rate (see ETSI EN 300-462-3 Annex A.2) : **(TIE rate) x (τmin) ≥ 3**

In order to avoid aliasing problems this in turn normally requires that the TIE data be first low-pass filtered with a cut-off frequency around: $(\tau min)^{-1}$.

For example, if one plans to do a long measurement and is basically interested in τ values above 30s one may set the TIE rate to at least: 3 / 30s = 0.1 TIE/s (one every 10s). But then the data must have been first processed by a low pass filter of cut-off frequency around 33 mHz (through hardware and/or software).

Standard limits on wander

Once MTIE / TDEV analysis is through we must display the relevant templates. There are many templates corresponding to very different situations and standard bodies (ITU-T, ETSI, ANSI and Bellcore). Table 4 mentions but a few, applying to networks built on the European hierarchy.

Measurement type	Reference	Level
Locked mode	ITU G.812 / ETSI EN 300-462-4	SSU type I
Locked mode	ITU G.813 / ETSI EN 300-462-5	SEC option 1
Network limit	ITU G.823 / ETSI EN 300-462-3	SSU clock output
Network limit	ITU G.823 / ETSI EN 300-462-3	SEC clock output
Network limit	ITU G.823 / ETSI EN 300-462-3	PDH clock output
Transient response	ITU G.812	SSU type I at E1
Transient response	ITU G.812	SSU type I at STM-n
Transient response	ITU G.812	SSU type I - phase discontinuity

Table 4. Examples of ITU-T recommendations containing MTIE/TDEV templates

Figure 9 shows the MTIE templates that define the maximum permissible limit on networks This supposes however that the network is not running in an abnormal way (for instance with one or several clocks in holdover) but on the contrary with all clocks deriving their synchronization from a common master clock.

Figure 8 reminds the condition under which we are running such a test. A master PRC is used at the start of the synchronization distribution chain in the network. Suppose we want to know if some SSU output in the network is complying with the standard. This SSU output is then fed into the wander tester (using another PRC as tester reference since usually it is not possible to use the network master PRC at point of measure). The MTIE obtained must lie below the SSU limit of figure 9. Figure 8 shows for all 4 levels (PRC, SSU, SEC, PDH) where the tests should be applied.

Why consider here PDH? This is because PDH interfaces may be used for synchronization distribution. In such case a 2M path is used to carry sync to the next SSU. In this case the point of measure is the PDH line fed into the SSU clock. The most relevant cases in Fig. 8 / 9 / 10 however are for SSU and SEC output (SDH regular clock feeding).

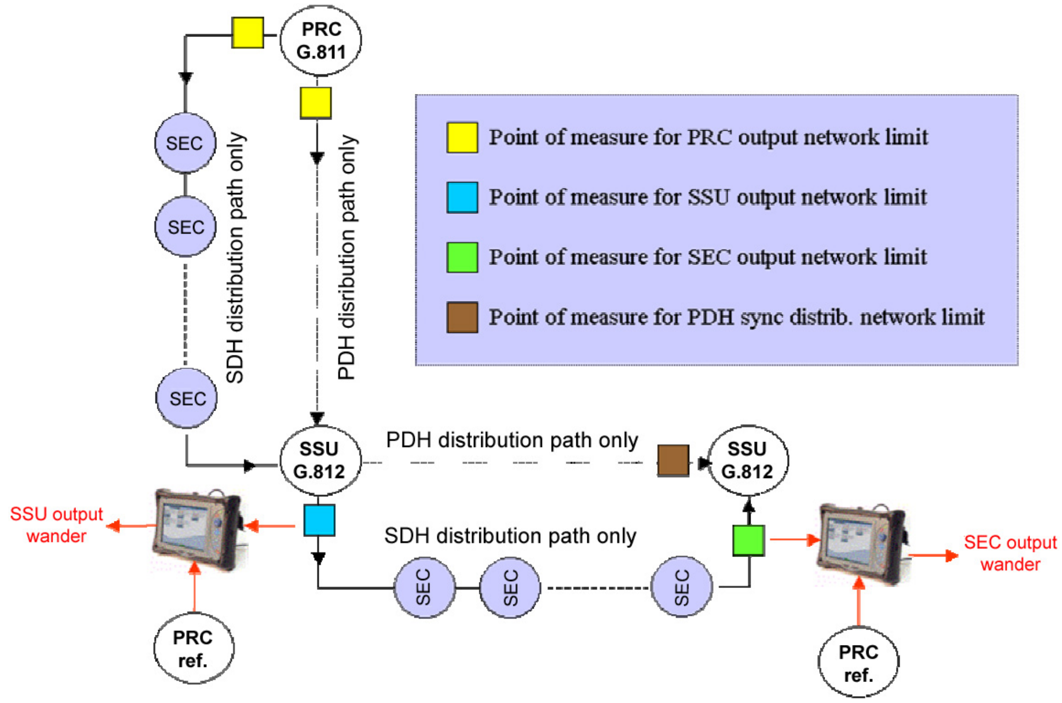

Figure 8. Points of test to measure the maximum permissible MTIE limit on a network

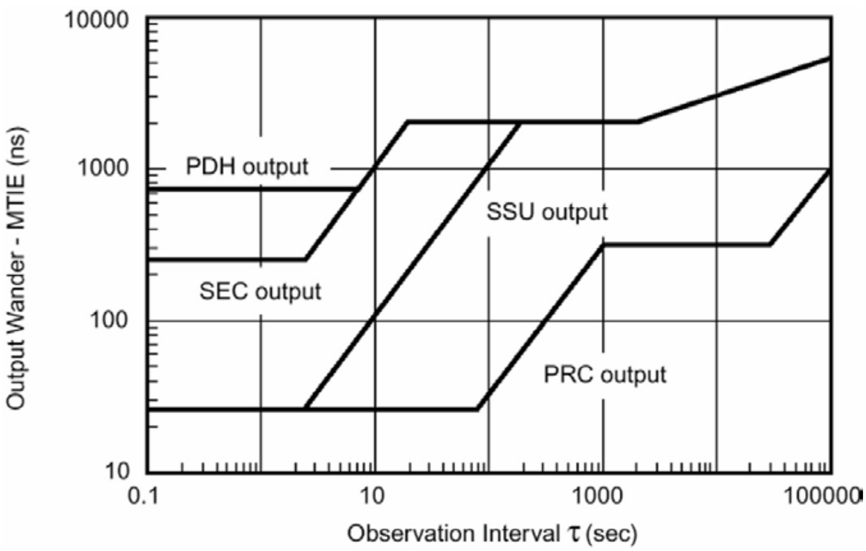

Figure 9. MTIE templates for PRC, SSU, SEC and PDH levels

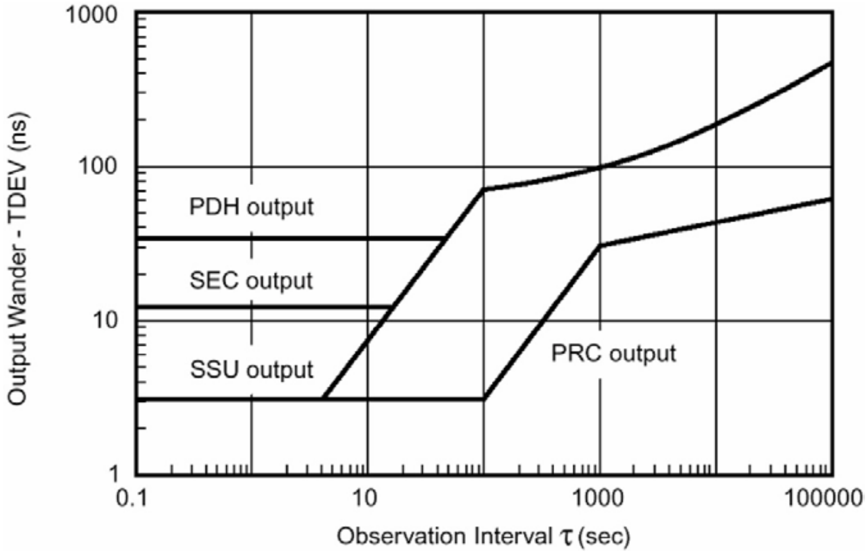

Figure 10. MTIE templates for PRC, SSU, SEC and PDH levels

Figure 10 displays the corresponding TDEV limits. As may be seen from these graphs the MTIE and TDEV limits are more relaxed when you move from PRC to SSU to SEC then to PDH. The important thing here is that the corresponding wander test is simple: you run the data recording, get the MTIE/TDEV curves and compare them to these templates. Any situation where the templates would be exceeded would be a serious source of concern and would require a serious synchronization distribution checking.

Conclusion

This note gave some background on the problematic of wander and network synchronization distribution and monitoring. It also illustrated these issues with the XTA application's GUI windows. Wander measurements are very important. If a clock unit (SSU or SEC) stops working in an adequate way, gets out of control and no warning is available at the network monitoring system level, a serious wander case may be triggered, which could lead to frame slip occurrences and/or large pointer movement activity.

In order to avoid potentially disastrous quality degradation, it is good practice to run wander tests at least at the SSU and SEC clock output level (as illustrated in Fig. 8) as a preventive action. These tests can be carried in an unobtrusive way whenever a clock output monitoring point and a good Stratum 1 reference clock are available.

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Specifications are subject to change without notice.

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