APPLICATION NOTE

MP1580A
Portable 2.5G/10G Analyzer

MEASUREMENT SOLUTIONS

ANRITSU CORPORATION

Contents

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1. Introduction

This application note describes jitter measurement for the components and transmission equipment that make up STM-64 /OC-192 (9.95328 Gbit/s) and STM16/OC-48(2,48832 Gbit/s) and submarine transmission system that are currently being extensively developed and installed. This application note explains jitter definition, what jitter measurement includes, and the features of jitter measuring instrument MP1580A, which conforms to latest ITU-T recommendation. It also describes examples of measurement using the MP1580A.

2. Jitter Definition

2.1 Jitter and Wander

In a digital networks, the symptom in which the noise and transmission pattern on the transmission line disturb the timing of signals to be transmitted and put pulse waveforms out of phase before and after the average position is called jitter or wander (see Fig. 2.1-1). There is no clear boundary between jitter and wander. However, generally, frequencies lower than a phase change frequency (Phase modulation frequency) of 10 Hz are called wander frequencies. Frequencies higher than 10 Hz are called jitter frequencies (see Fig. 2.1-2).

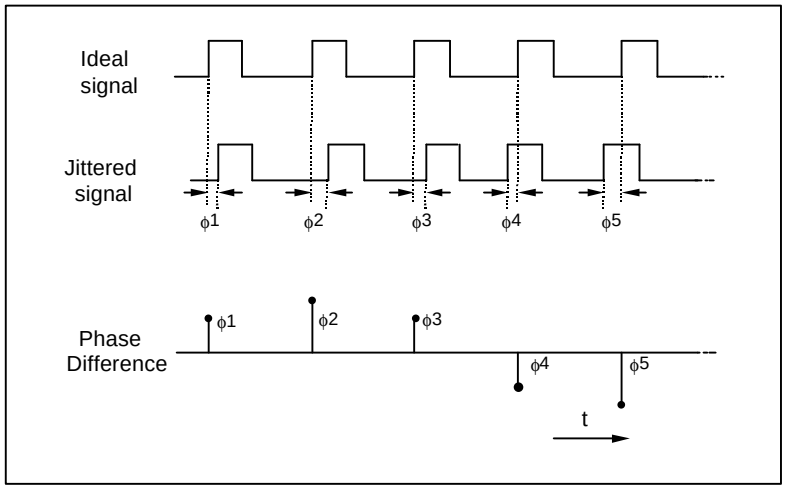


Fig. 2.1-1 Principles of Jitter

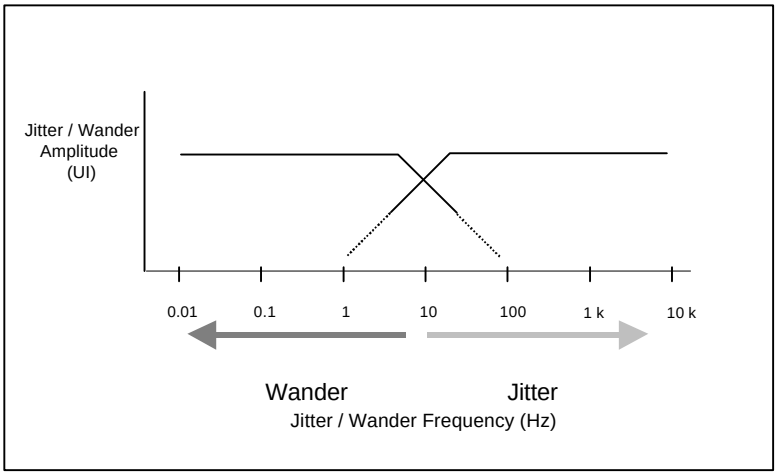


Fig. 2.1-2 What are Jitter and Wander

2.2 Jitter Amount

The quantity of jitter is represented as the amount of phase difference between the measured signal and reference signal. Fig. 2.2-1 (a) and (b) show the waveforms of a reference signal and measured signals observed using an oscilloscope. The shaded areas near the rising and falling edges of the jittered signal shown in (b) of Fig. 2.2-1 show the areas within which the edges momentarily fall as the signal enters and exits the phase states shown in (c) and (d) of Fig. 2.2-1. The jitter difference between (c) and (d) is called the jitter amplitude, and the reciprocal of repetitive cycle (Tm) is called the jitter frequency (fm).

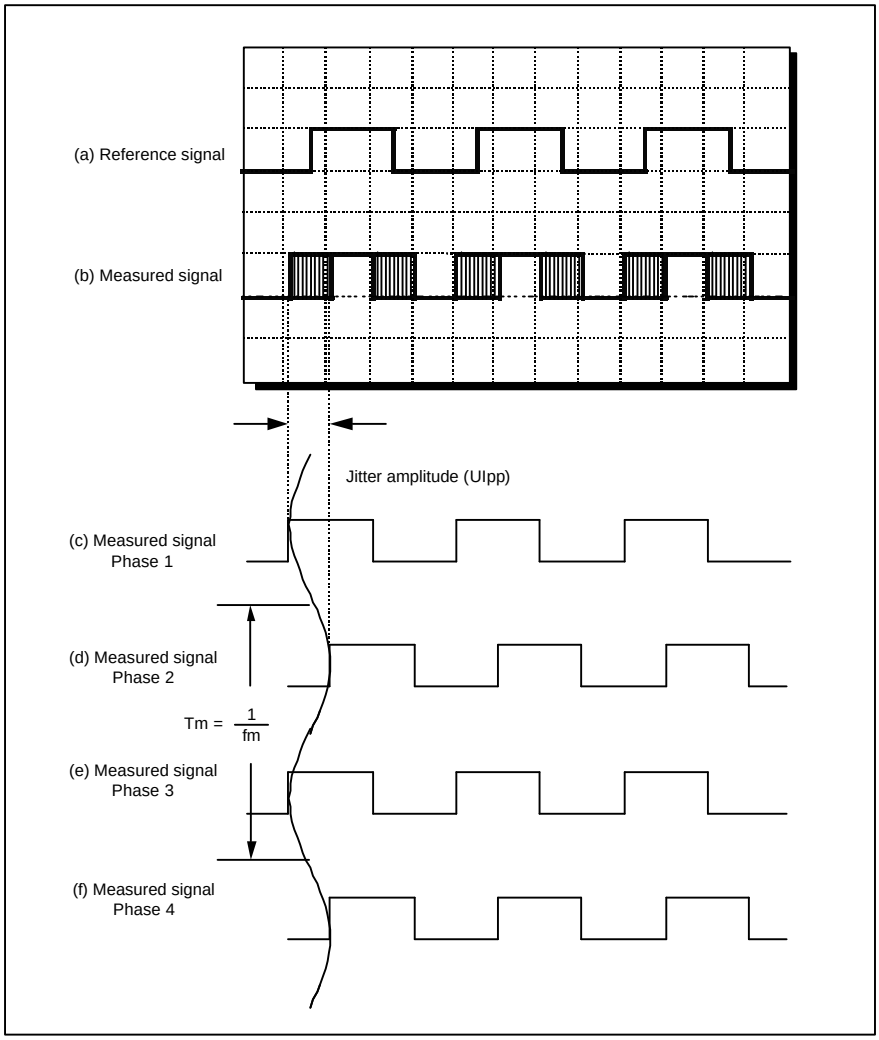


Fig. 2.2-1 Jitter Waveform

2.3 Unit of Jitter

Jitter is the phase change of a digital signal, and the quantity of jitter is an index for evaluating the transmission quality. All transmission codes require a common unit. Unit Interval (UI) is used as a unit that indicates the jitter amplitude. One UI is defined as one cycle of bit clock (see Fig. 2.3-1). Two types of units: Ulpp (peak to peak of phase change width) and Ulrms (effective value of phase change width) are actually used. Since these units are standardization parameters that are bit rate independent, the quantity of jitter can be compared at different bit rates (see Fig. 2.3-2).

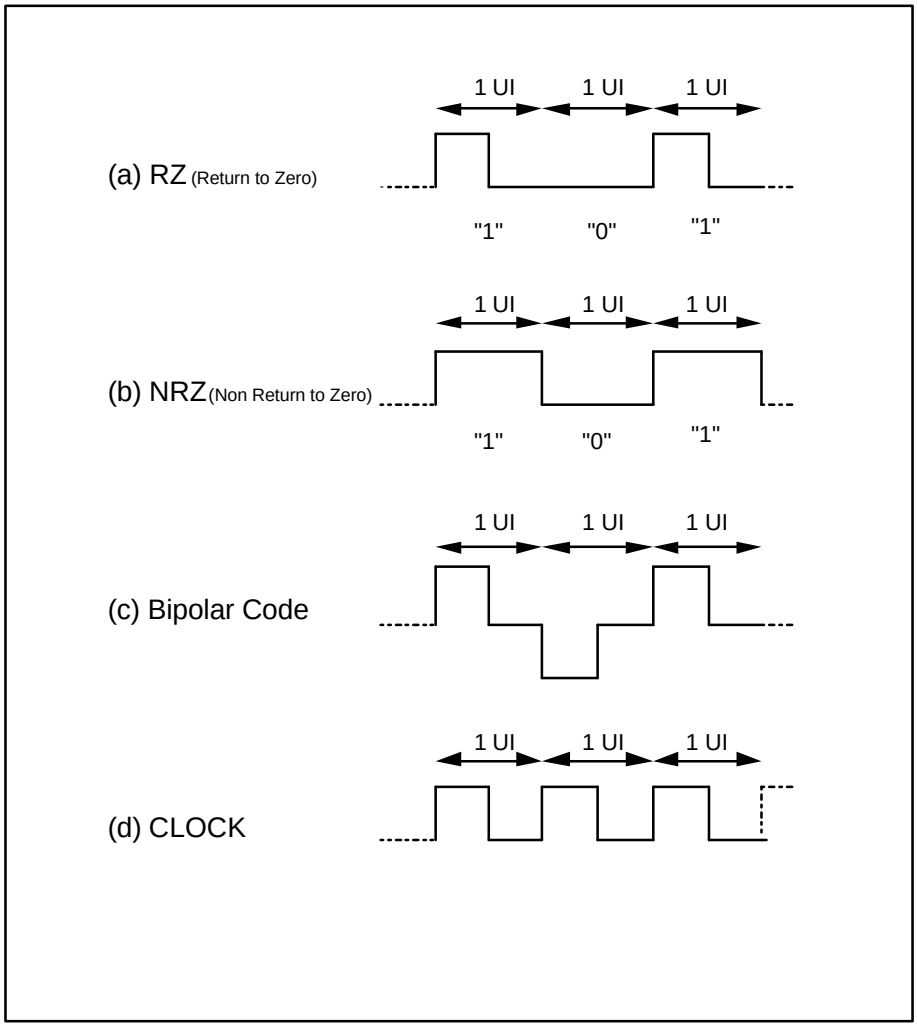


Fig. 2.3-1 Jitter Units (1)

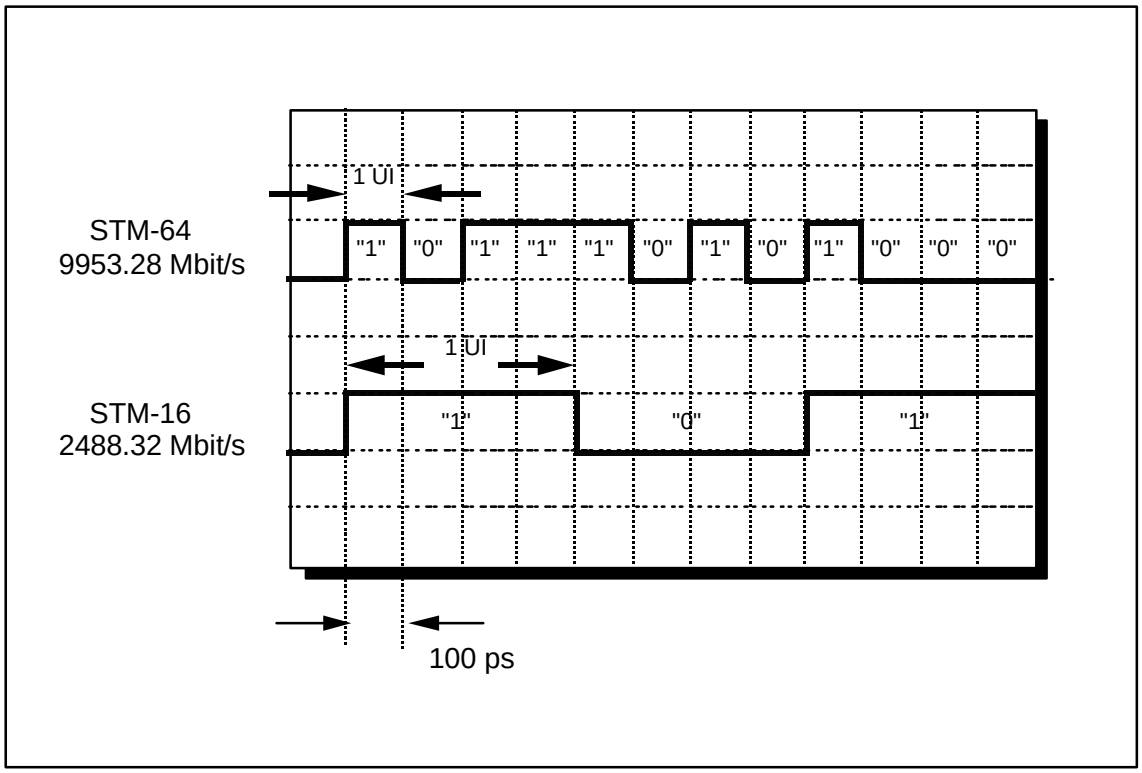


Fig. 2.3-2 Jitter Units (2)

3.Wander

3.1 What is Wander?

Wander is a slow phase shift at a frequency of DC to 10 Hz.

The difference from jitter is the necessity for a long period. In addition, the units of wander measurement are nanoseconds (ns).

3.2 Wander Measurement

Fig. 3.2-1 shows an example of the setup for measuring wander using the MP1580A and MP1570A.

Wander measurement is based on the phase of two signals (wander reference signal and measured signal) when measurement is started (Fig. 3.2-2). TIE (Time Interval Error) expresses the phase difference at the measurement start where +Peak and -Peak are the positive maximum phase shift and negative maximum phase shift, respectively, compared to the phase at the start of measurement.

In addition, peak-to-peak expresses the peak-to-peak phase shift compared to the measured signal reference signal.

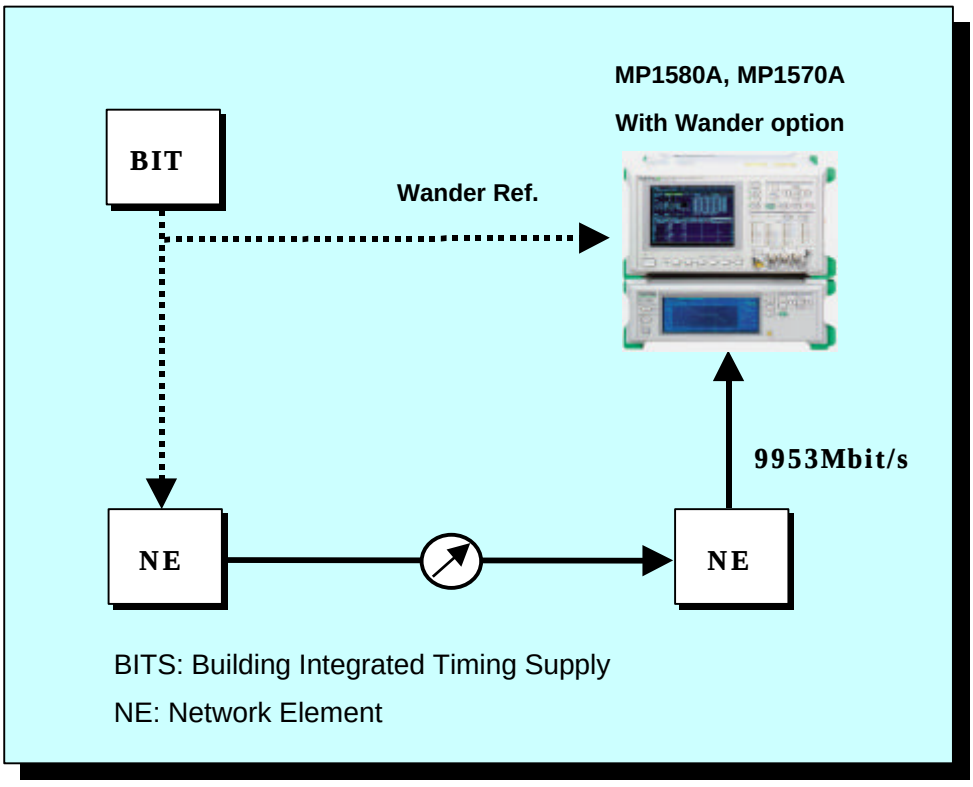


Fig. 3.2-1 Wander Measurement Setup

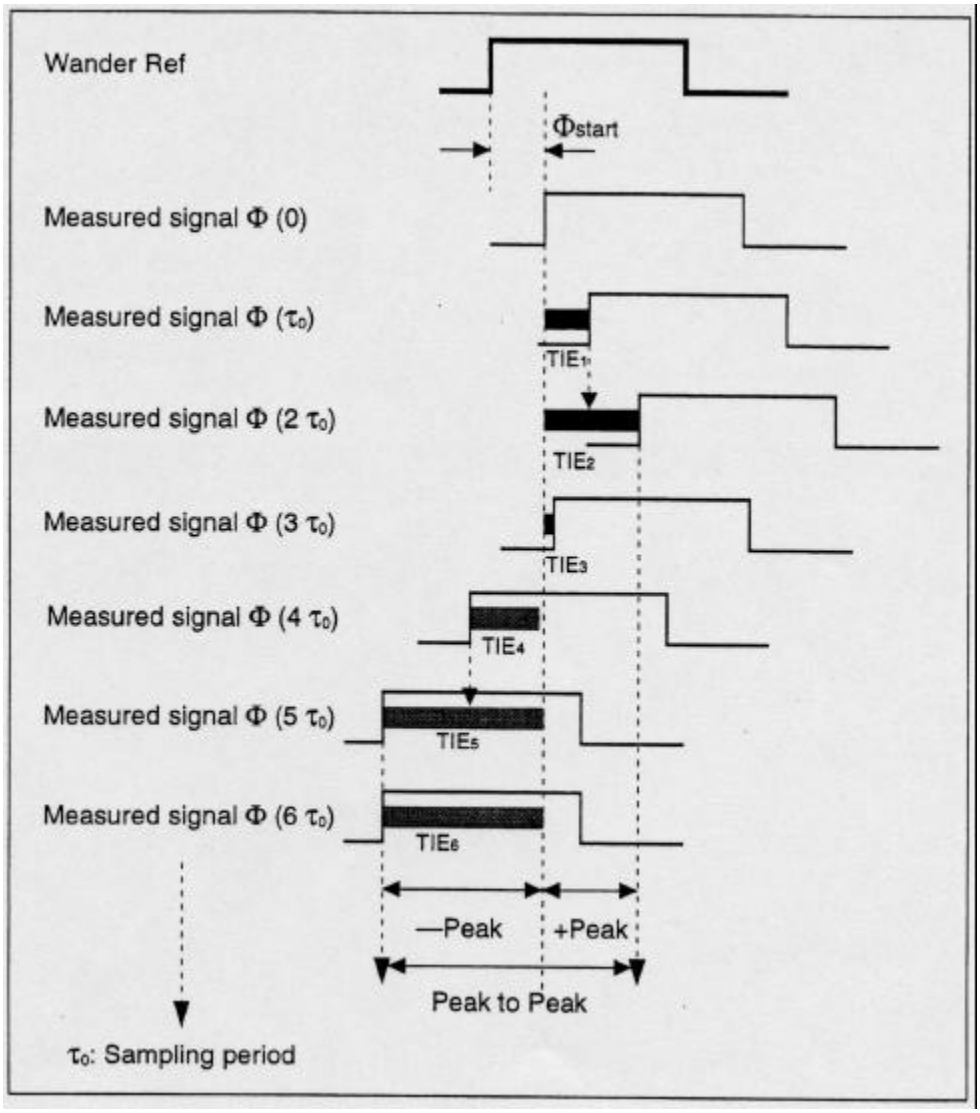


Fig. 3.2-2 TIE (Time Interval Error)

3.3 MTIE (Maximum Time Interval Error) Measurement

MTIE is measured by calculation from equation (1) based on the TIE data. When this measurement result is plotted as a graph, observation time ($\tau = n\,\tau_0$) is plotted on the x-axis (Fig. 3.3-1).

$$MTIE(\tau) \cong \max_{1 \le K \le N-n} \left(\max_{K \le i \le K+n} - \min_{K \le i \le K+n} \right) \quad \text{.....(1)}$$

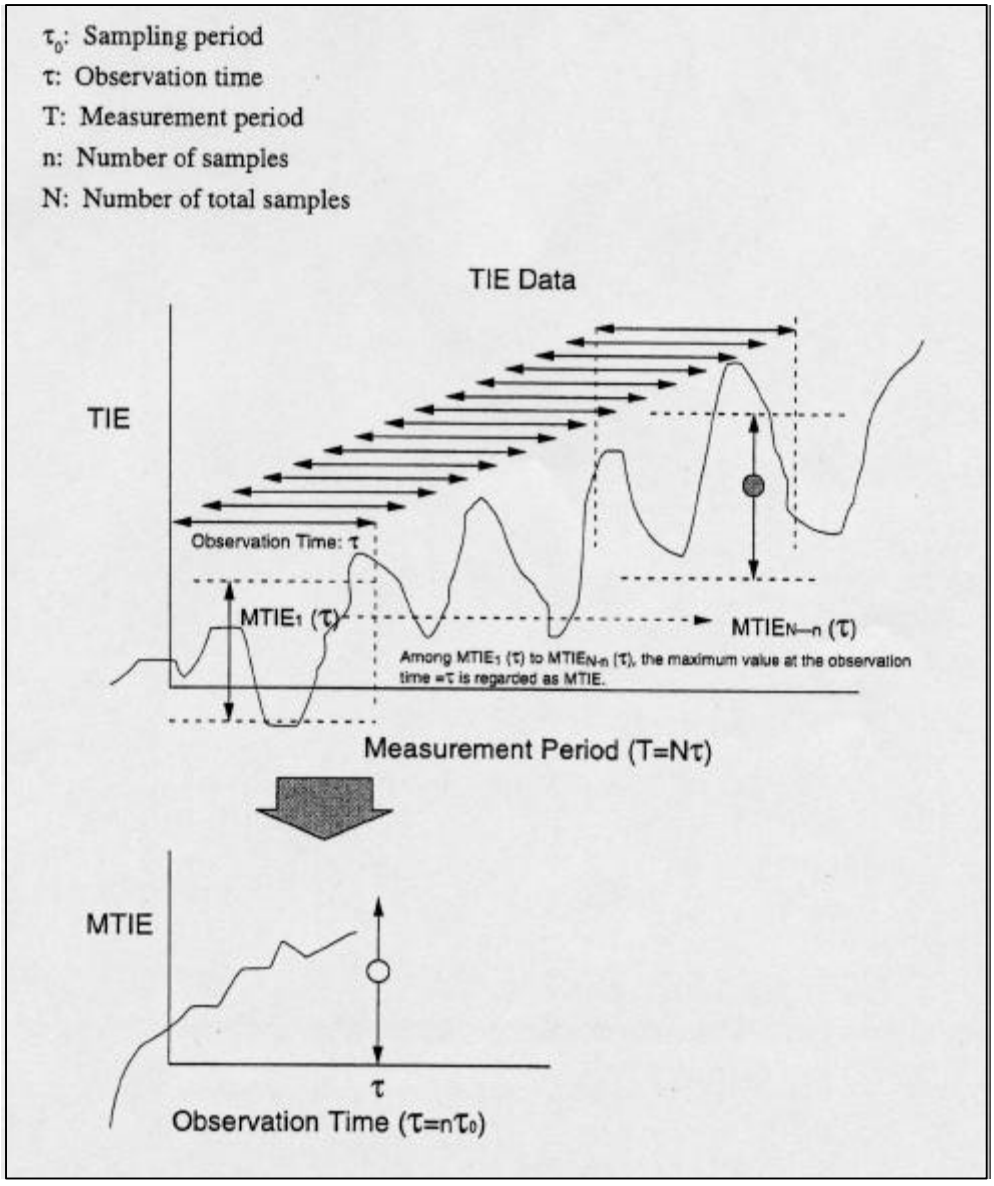


Fig. 3.3-1 TIE and MTIE

4. Jitter Measurement

4.1 Basic Jitter Test

Since jitter has a large impact on the network transmission quality, jitter must be evaluated quantitatively. The jitter performance test is based on the following four measurements:

1. Jitter tolerance
2. Jitter transfer characteristics
3. Jitter generation
4. Output Jitter

4.2 Jitter Tolerance Measurement

In this measurement, the signal input to the DUT is modulated by a sine wave (sine wave phase modulation) and the ability of the DUT to operate without generating errors as the jitter amplitude is gradually increased is measured as the jitter tolerance. The jitter modulation frequency is changed and the measurement is repeated and the measurement results at each measurement point are plotted as shown in Fig. 4-1 expressing the DUT jitter tolerance.

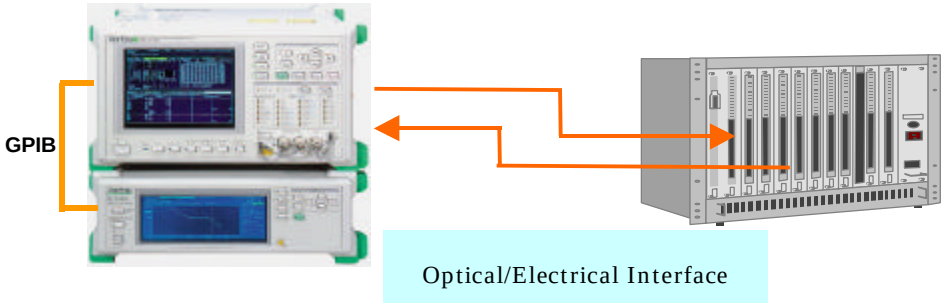
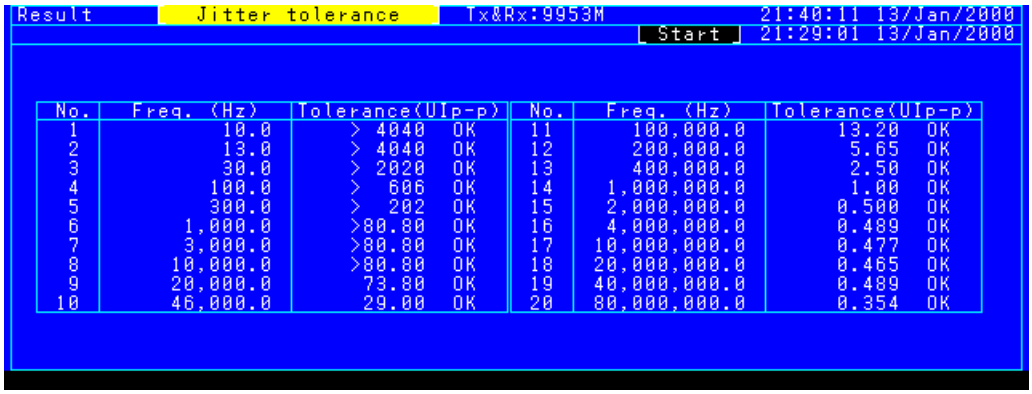


Fig.4.2-1 Example of Jitter Tolerance Measurement Setup

Example of Jitter Tolerance Measurement Results (graph display)



No.	Freq. (Hz)	Tolerance(UIp-p)		No.	Freq. (Hz)	Tolerance(UIp-p)	
1	10.0	> 4040	OK	11	100,000.0	13.20	OK
2	13.0	> 4040	OK	12	200,000.0	5.65	OK
3	30.0	> 2020	OK	13	400,000.0	2.50	OK
4	100.0	> 606	OK	14	1,000,000.0	1.00	OK
5	300.0	> 202	OK	15	2,000,000.0	0.500	OK
6	1,000.0	>80.80	OK	16	4,000,000.0	0.489	OK
7	3,000.0	>80.80	OK	17	10,000,000.0	0.477	OK
8	10,000.0	>80.80	OK	18	20,000,000.0	0.465	OK
9	20,000.0	73.80	OK	19	40,000,000.0	0.489	OK
10	46,000.0	29.00	OK	20	80,000,000.0	0.354	OK

Example of Jitter Tolerance Measurement Results (numeric display)

4.3 Jitter Transfer Measurement

In this measurement, a sine-wave jitter modulated (jittered) signal (sine wave phase modulation) is input to the DUT and the degree to which the jitter amplitude is transferred to the output side of the DUT is evaluated. The measurement results are found from the jitter impressed at the input side (Jin) and the jitter measured at the output side (Jout) using formula (1). This result is a very important item in controlling cumulative jitter.

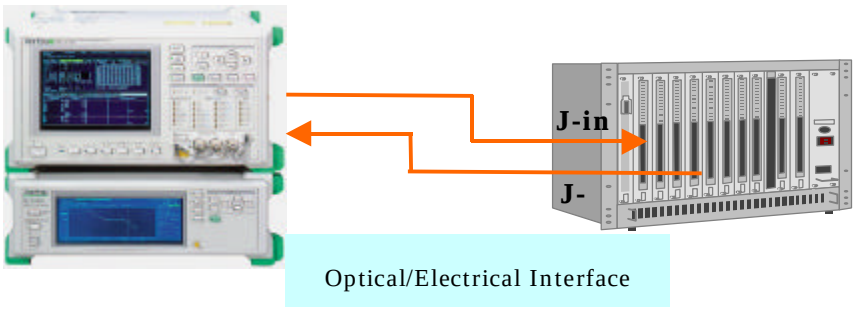
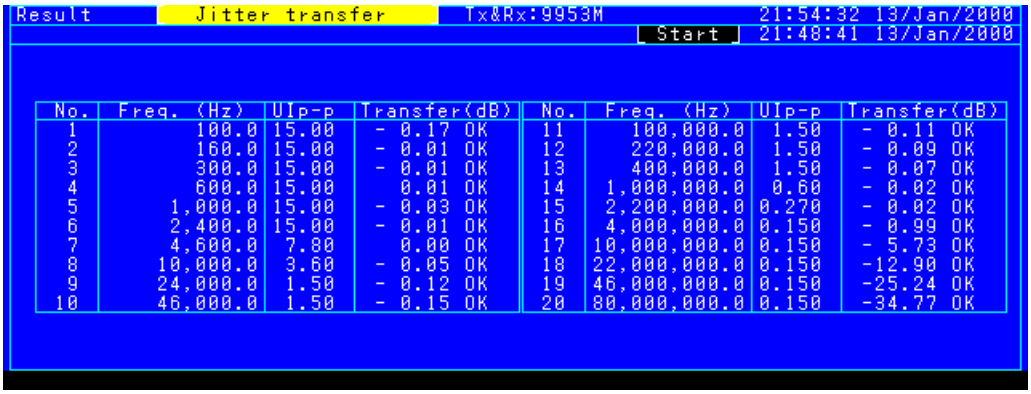


Fig. 4.3-1 Example of Jitter Transfer Measurement Setup

Jitter Gain (dB) = 20 LOG (J out / J in) ----------(1)

Example of Jitter Transfer Measurement Results (graph display)



No.	Freq. (Hz)	UIp-p	Transfer(dB)	No.	Freq. (Hz)	UIp-p	Transfer(dB)
1	100.0	15.00	- 0.17 OK	11	100,000.0	1.50	- 0.11 OK
2	160.0	15.00	- 0.01 OK	12	220,000.0	1.50	- 0.09 OK
3	300.0	15.00	- 0.01 OK	13	400,000.0	1.50	- 0.07 OK
4	600.0	15.00	0.01 OK	14	1,000,000.0	0.60	- 0.02 OK
5	1,000.0	15.00	- 0.03 OK	15	2,200,000.0	0.270	- 0.02 OK
6	2,400.0	15.00	- 0.01 OK	16	4,000,000.0	0.150	- 0.99 OK
7	4,600.0	7.80	0.00 OK	17	10,000,000.0	0.150	- 5.73 OK
8	10,000.0	3.60	- 0.05 OK	18	22,000,000.0	0.150	-12.90 OK
9	24,000.0	1.50	- 0.12 OK	19	46,000,000.0	0.150	-25.24 OK
10	46,000.0	1.50	- 0.15 OK	20	80,000,000.0	0.150	-34.77 OK

Example of Jitter Transfer Measurement Results (numeric display)

4.4 Jitter Generation Measurement

This measurement finds the DUT jitter generation at the OC-192/STM-64 bit rate, and the generated jitter must be less than 0.30 UIp-p (HP: 20 kHz, LP: 80 MHz) and 0.10 UIp-p (HP: 4000 kHz, LP: 80 MHz) (G.783 draft version)

Previously, it should have been less than 0.01 UIrms at all bit rates, but a change to peak-to-peak measurement is under investigation.

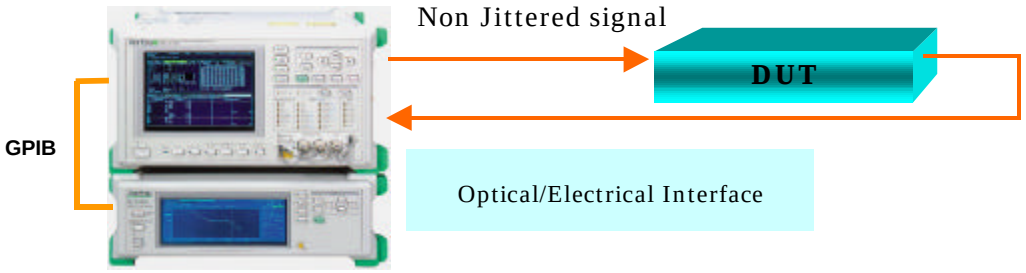
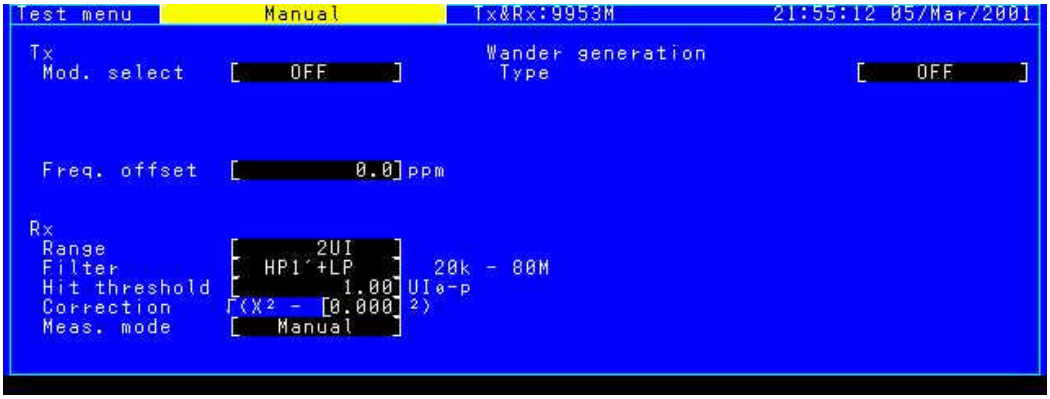


Fig. 4.4-1 Example of Jitter Generation Measurement Setup



Example of Jitter Generation Measurement Condition

Example of Jitter Generation Measurement Results

4.5 Output Jitter Measurement

In this measurement, the amount of jitter that is output from the DUT must be less than 1.5 UIp-p (HP: 20 kHz, LP: 80 MHz) and 0.15 UIp-p[*1] (HP: 4 MHz, LP: 80 MHz).

(*1: The effect of dispersion and non-linearity on the eye opening and on the choice of this value is under further study.)

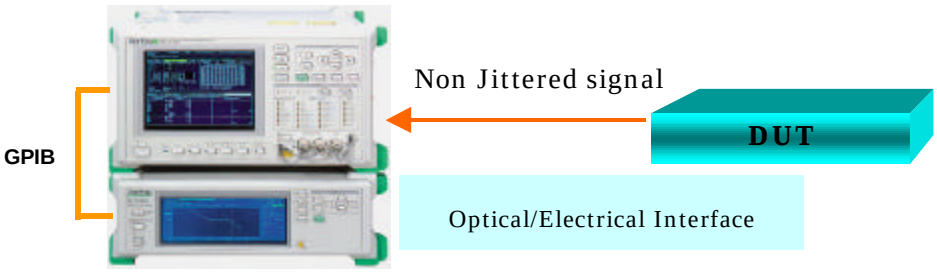
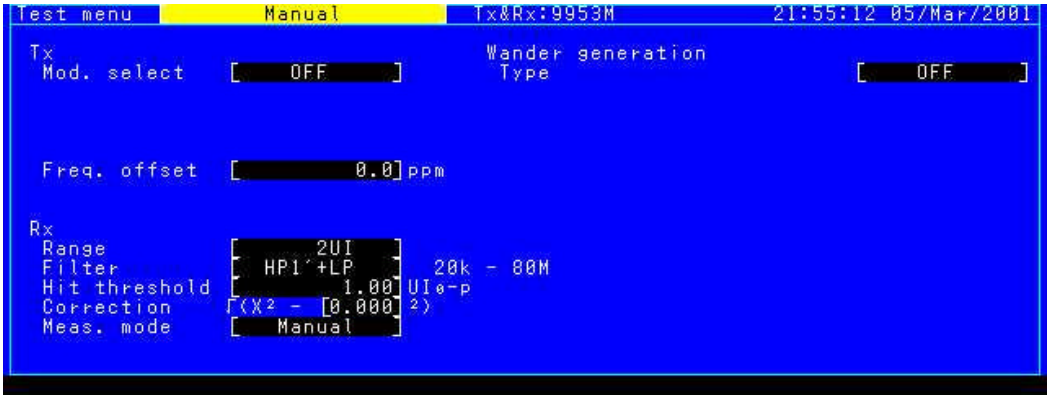


Fig. 4.5-1 Example of Output Jitter Measurement Setup



Example of Output Jitter Measurement Condition

Example of Output Jitter Measurement Results (numeric display)

5. MP1580A Portable 2.5G/10G Analyzer

The MP1580A Portable 2.5G/10G Analyzer is a Jitter measuring instrument for measuring 2.5G and 10G jitter with conforms to the ITU-T recommendations 0.172 (Measuring Instruments for Measuring SDH Jitter).

It is ideal for jitter measurement in various fields, especially R&D, manufacturing and maintenance of transmission equipment and optical modules for the very active markets in submarine cable transmission systems and terrestrial network backbones.

5.1 Features

- Supports ITU-T O.172 recommendations

  Supports 80-MHz jitter band with and jitter modulation amplitude of 4,000 UIp-p recommended by jitter measurement standards of OC-192/STM-64

- Support 10GHz wander measurement (option)

  The recommendations for generating and measuring 10-GHz wander have not yet been published (January 2001) but the MP1580A can generate and measure various types of wander. It can generate a wander signal with a modulation frequency range of 10 μHz to 10Hz up to a maximum of 400,000 UIp-p.

  In addition, when the optional MX150002A application software is installed in an externally connected PC, MTIE/TDEV can be measured in real time.

- Both 2.5G and 10G supported in one cabinet

  The MP1580A can perform jitter generation and analysis at both 2.5G and 10G. When the MU150000A, MU150001A, and MU150017A are installed in the MP1570A, the jitter tolerance and jitter transfer characteristics, etc., of SONET/SDH signals at an optical I/F can be measured easily and automatically.

- Small and lightweight for superior portability

5.2 External View

Fig. 5.2-1 Front View of MP1580A

Fig. 5.2-2 External View of MP1580A and MP1570A

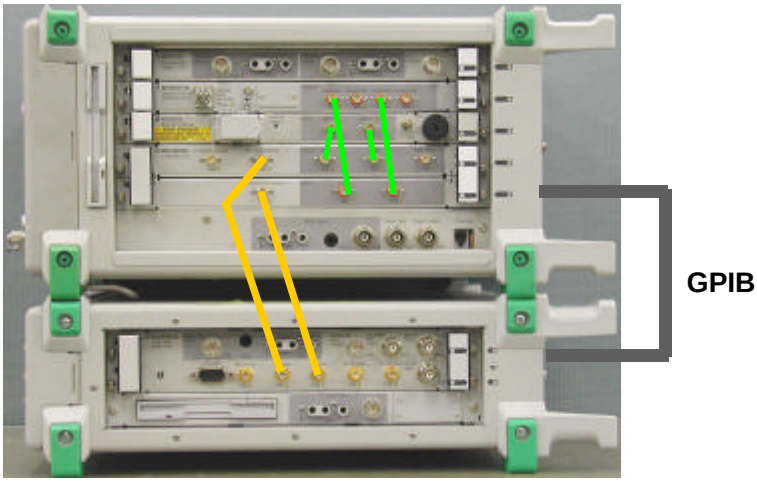


Fig. 5.2-3 Connections between MP1580A and MP1570A

6. Jitter Measurement Items and Setup Configuration

6.1 Measurement Items

(1) STM-64/OC-192 Clock Regeneration Module Jitter Tolerance Measurement
(2) STM-64/OC-192 Clock Regeneration Module Jitter Transfer Measurement
(3) STM-64/OC-192 Clock Regeneration Module Jitter Generation Measurement
(4) SDH/SONET Transmission Device Jitter Sweep Measurement
(5) SDH/SONET Transmission Device Frequency Tolerance Measurement

6.2 Jitter Measurement Items and Setup Configuration

	Measurement Items				
	(1)	**(2)**	**(3)**	**(4)**	**(5)**
MP1580A	√	√	√	√	√
Option 01 RS-232C					
Option 02 GPIB					
Option 03 Ethernet					
Option 04 VGA					
MU150018A	√	√	√	√	√
MU150018A Option 02	√	√	√	√	√
MP1570A	√	√	√	√	√
MU150000A	√	√	√	√	√
MU150001A/B	√	√	√	√	√
MU150017A	√	√	√	√	√
MX150002A MTIE/TDEV Application Software	√	√		√	√

7. Measurement Examples

7.1 Example of Jitter Tolerance for STM-64/OC-192 Clock recovery module

This jitter tolerance measurement measures the jitter tolerance point at which an error occurs when a jitter-modulated data signal is input to an STM-64/OC-192 clock recovery module.

There are two jitter measurement methods using the MP1580A with the MP1570A: 1. The actual jitter tolerance point can be observed and measured (Jitter Tolerance measurement), and 2. A preset jitter amplitude can be added to the signal to check the error generation (Jitter Sweep method). The first method (Jitter Tolerance measurement) is commonly used in R&D to evaluate the actual DUT performance and the second method (Jitter Sweep measurement) finds applications in manufacturing divisions for shipping inspection of production lots.

7.1.1 Measurement Setup Examples

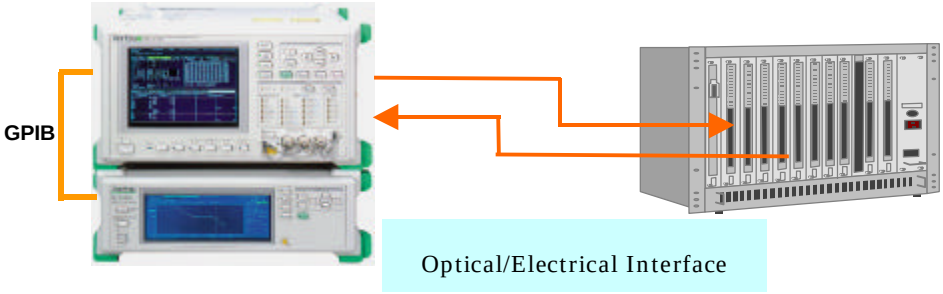


Fig.7.1.1-1 Example of Jitter Tolerance Measurement Setup

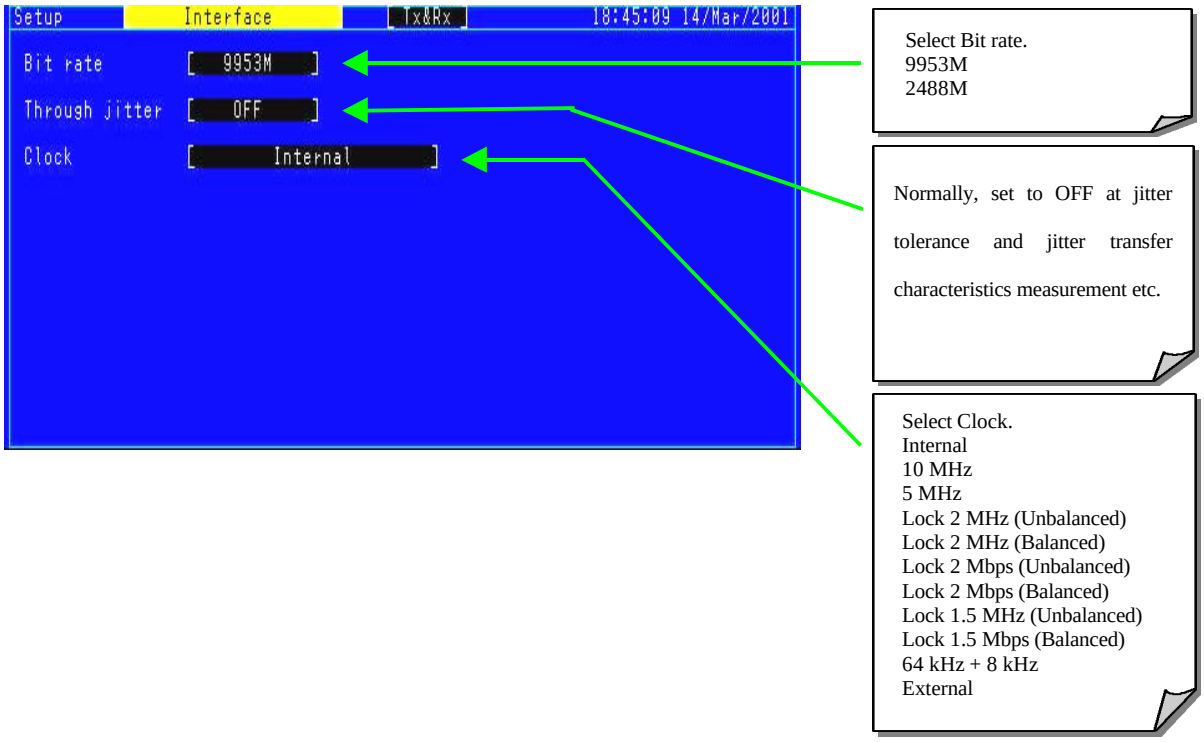
Note: The connection shown in Fig. 5.2-3 on page 17 is required when using with the MP1570A. Set GPIB and reference clock I/O as well as “Tracking” at the MP1580A “Setup” “System” screen. Next, move the marker to “Tracking” on the “Test Menu” screen and press the “Set” key to execute automatic tracking between the MP1580A and MP1570A.

7.1.2 Measurement Procedures

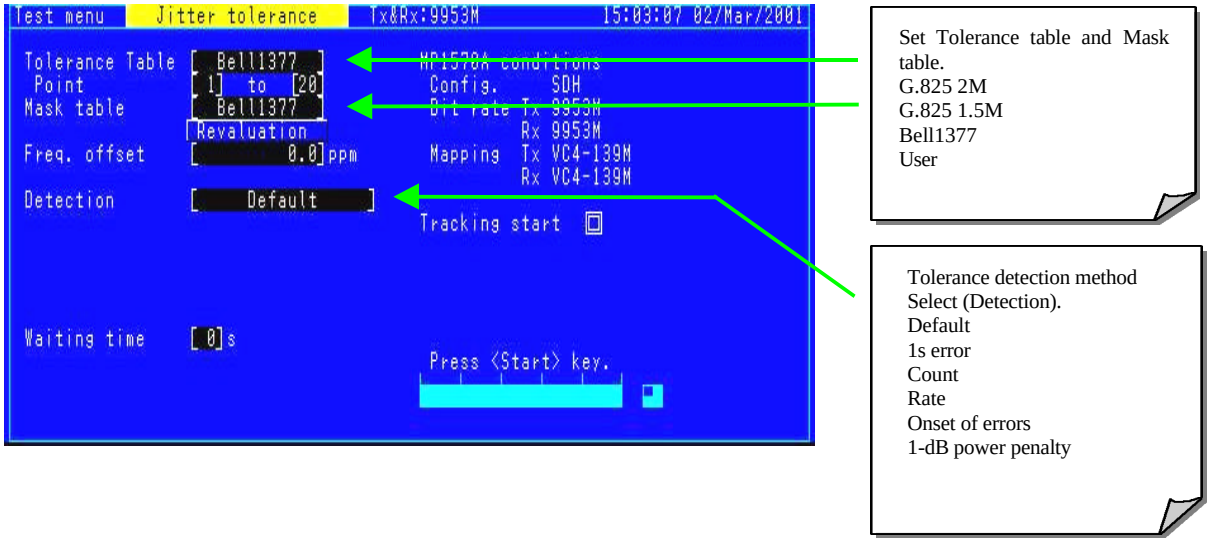
The following procedure describes how to observe and evaluate the actual jitter tolerance point (Jitter Tolerance measurement).

[Measurement Procedure]

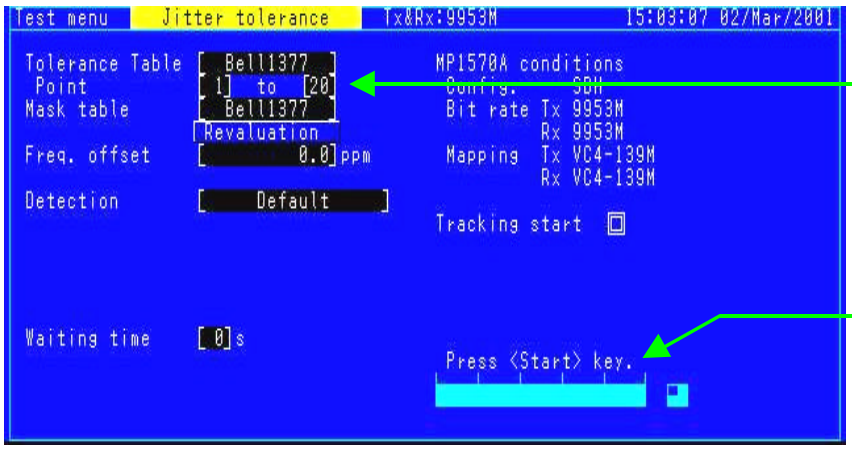
(1) Set the Bit rate, Clock conditions, etc., at the MP1580A “Setup” ”Interface” screen.



(2) At the “Test menu” screen, set the measurement point (Tolerance table) and applicable standard (Mask table).



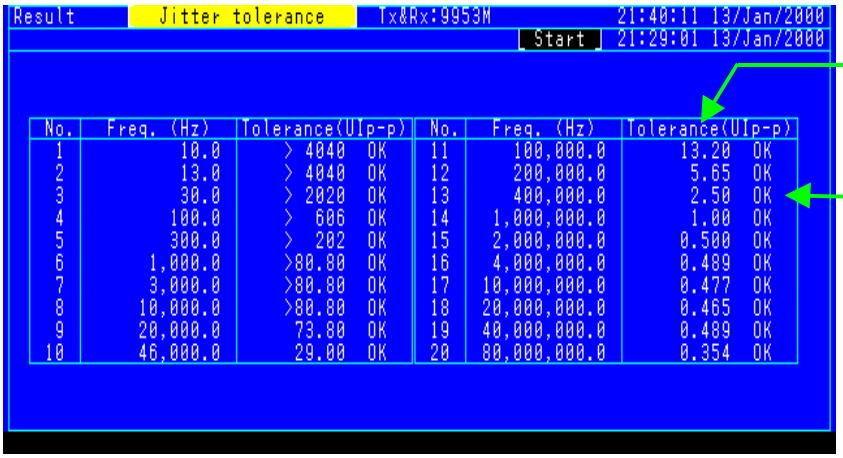
(3) Start measurement by pressing the ”Start/Stop” key (green) underneath the cursor keys on the front panel.



The number of measurement points (between measurement start and stop) can be set.

The measurement progress is indicated by a bar graph.

(4) When the Result key on the front panel is pressed, the tolerance measurement results are displayed numerically. The OK/NG indication at the right side of each measurement point indicates whether or not the result satisfies the Mask (standard value) set at the ”Test menu” screen—OK means passed and NG means failed.

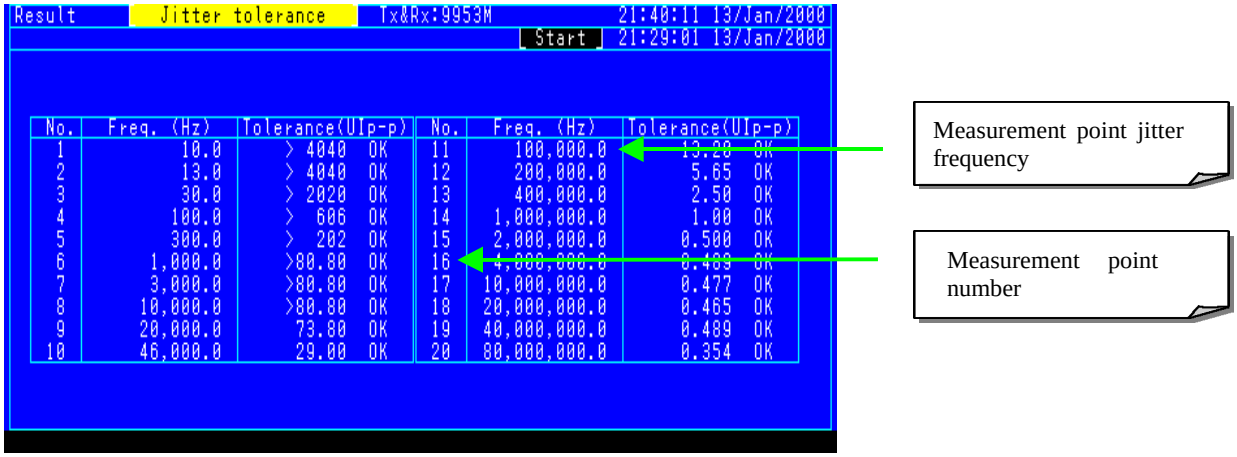


No.	Freq. (Hz)	Tolerance(UIp-p)		No.	Freq. (Hz)	Tolerance(UIp-p)	
1	10.0	> 4040	OK	11	100,000.0	13.20	OK
2	13.0	> 4040	OK	12	200,000.0	5.65	OK
3	30.0	> 2020	OK	13	400,000.0	2.50	OK
4	100.0	> 606	OK	14	1,000,000.0	1.00	OK
5	300.0	> 202	OK	15	2,000,000.0	0.500	OK
6	1,000.0	>80.80	OK	16	4,000,000.0	0.489	OK
7	3,000.0	>80.80	OK	17	10,000,000.0	0.477	OK
8	10,000.0	>80.80	OK	18	20,000,000.0	0.465	OK
9	20,000.0	73.80	OK	19	40,000,000.0	0.489	OK
10	46,000.0	29.80	OK	20	80,000,000.0	0.354	OK

The progress of the OK/NG evaluation is indicated by a numeric.

The progress of the OK/NG evaluation compared to the set jitter tolerance standards is indicated by OK or NG.

Note:
Measurement results with an appended “>” symbol have no DUT error even at the MP1580A maximum jitter generation.



(5) The measurement results are displayed as graphic data at the Analyze screen. The solid line indicates the measurement results and the dotted line indicates the standard values (Mask).

7.2 Example of Jitter Transfer characteristic Measurement for STM64/OC/92 clock recovery module.

This jitter transfer characteristics measurement measures to what extent a DUT attenuates the jitter component of a jitter-modulated data signal at each jitter frequency when a signal is input to an STM-64/OC-192 clock recovery module.

The jitter transfer can be measured by combination with the MP1580A and MP1570A and also the MP1580A itself (Electrical interface only).

The MP1580A enables Jitter transfer measurement at 20 points for about 5 minutes, and suitable for the in R&D, manufacturing and inspection section.

7.2.1 Measurement Setup Examples

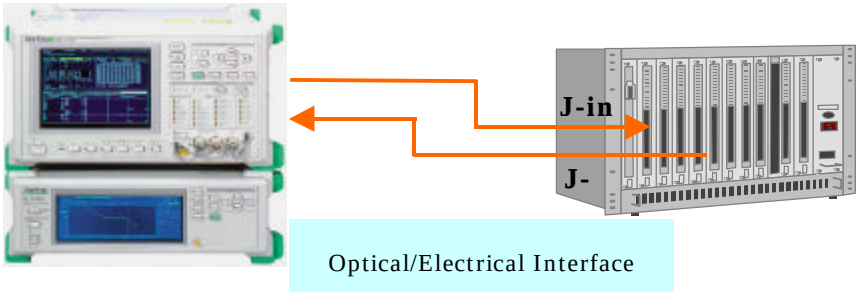


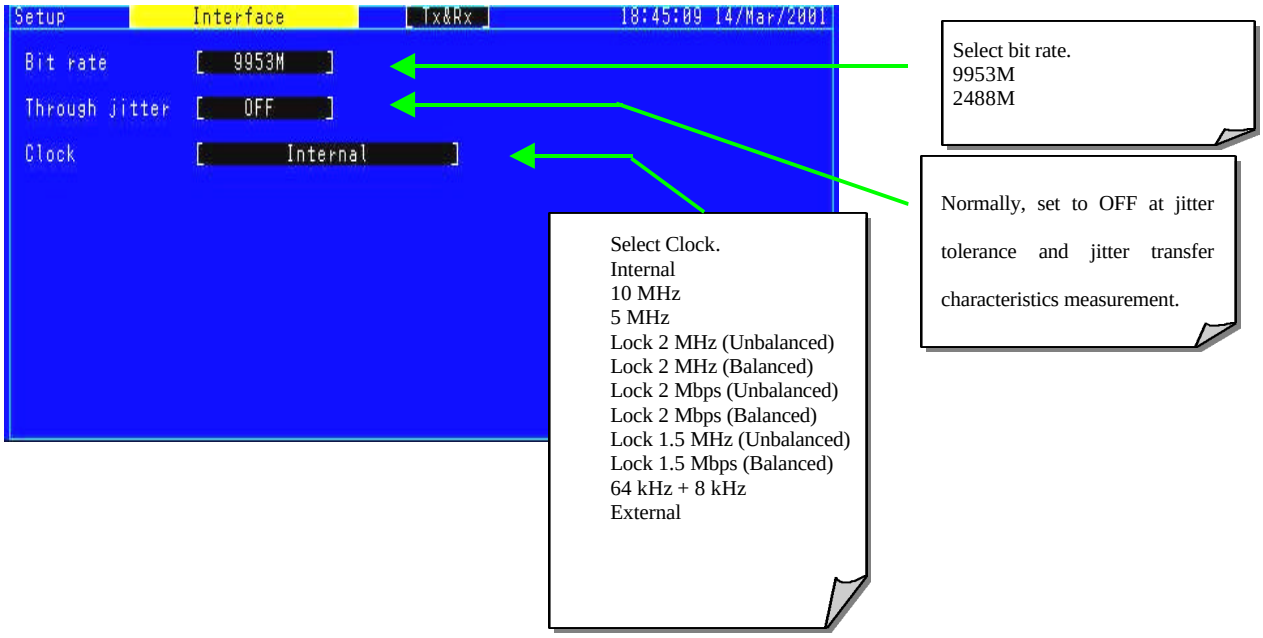
Fig. 7.2.1-1 Setup for Jitter Transfer Characteristics

7.2.2 Measurement Procedure

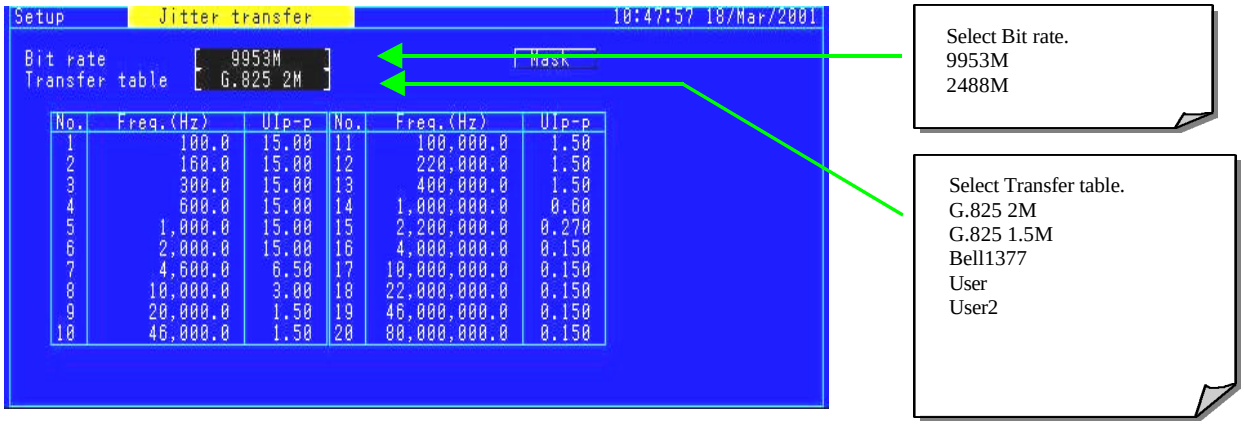
The following procedure explains jitter transfer measurement of an STM-64/OC-192 clock recovery module.

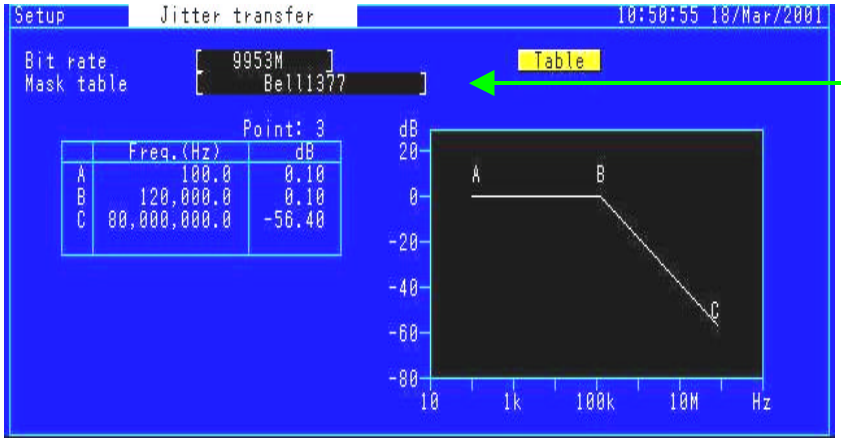
[Measurement Procedure]

(1) Set the Bit rate, Clock conditions, etc., at the MP1580A ”Setup” ”Interface” screen.



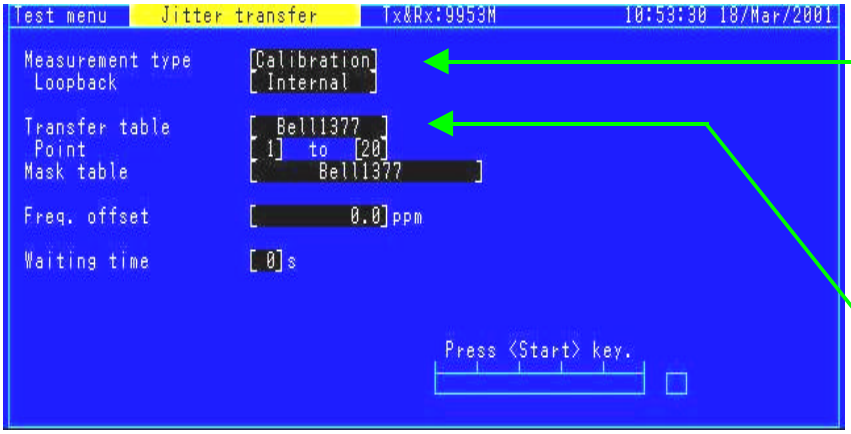
(2) Display the Setup Jitter transfer. At the “Set up” screen, set the measurement points (Transfer table) and the applicable standard (Mask table).





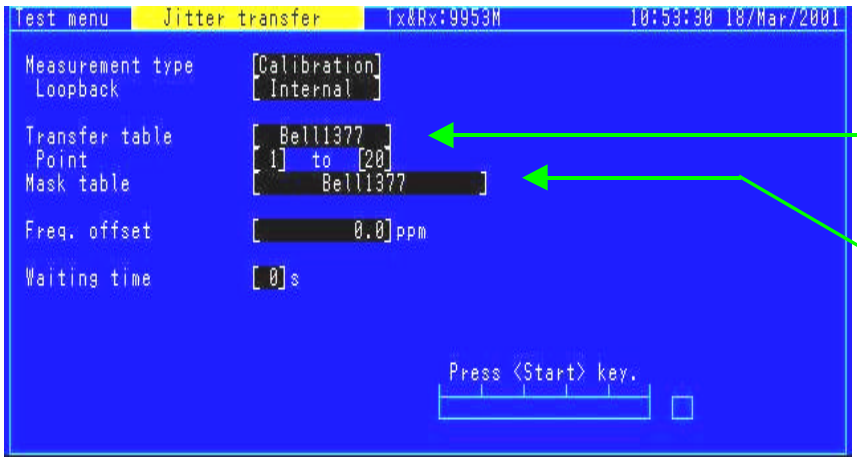
Select Mask table for Jitter transfer.
G.825 2M
G.825 1.5M
Bell1377
User
User2

(3) After completed the settings at the “Test menu” screen, press the “Start/Stop” key on the front panel to start calibration of the measurement system excluding the DUT.



Check that the Measurement type is Calibration and press the Start/Stop to start. The Measurement type changes automatically to Measurement after calibration is completed and measurement starts.

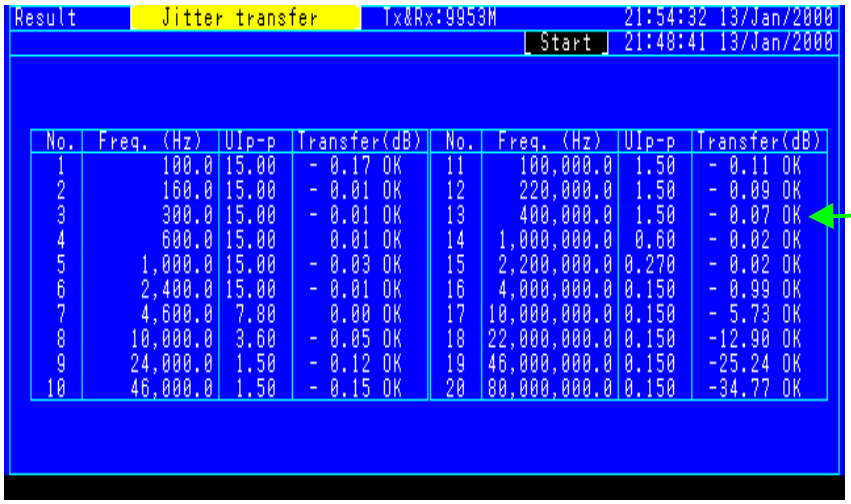
Select Transfer table.
G.825 2M
G.825 1.5M
Bell1377
User
User2



Set the number of measurement points (from 1 to 20).

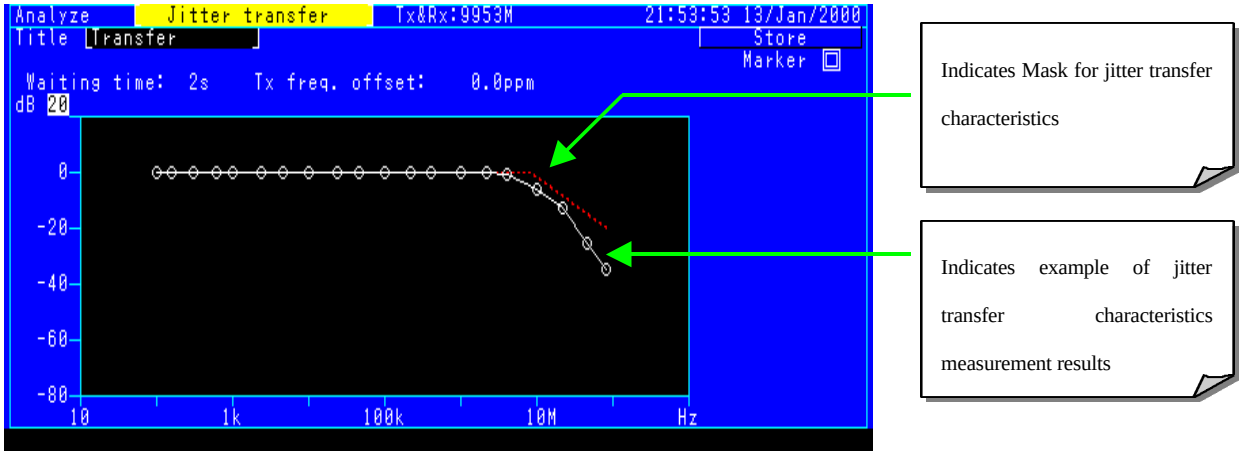
Set Mask table.

(4) Check the measurement results at the “Results” screen. The OK/NG indication indicates whether or not the result satisfies the Mask (standard value) set at the “Setup menu” screen—OK means passed and NG means failed.



No.	Freq. (Hz)	UIp-p	Transfer(dB)	No.	Freq. (Hz)	UIp-p	Transfer(dB)
1	100.0	15.00	- 0.17 OK	11	100,000.0	1.50	- 0.11 OK
2	160.0	15.00	- 0.01 OK	12	220,000.0	1.50	- 0.09 OK
3	300.0	15.00	- 0.01 OK	13	400,000.0	1.50	- 0.07 OK
4	600.0	15.00	0.01 OK	14	1,000,000.0	0.60	- 0.02 OK
5	1,000.0	15.00	- 0.03 OK	15	2,200,000.0	0.270	- 0.02 OK
6	2,400.0	15.00	- 0.01 OK	16	4,000,000.0	0.150	- 0.99 OK
7	4,600.0	7.80	0.00 OK	17	10,000,000.0	0.150	- 5.73 OK
8	10,000.0	3.60	- 0.05 OK	18	22,000,000.0	0.150	-12.90 OK
9	24,000.0	1.50	- 0.12 OK	19	46,000,000.0	0.150	-25.24 OK
10	46,000.0	1.50	- 0.15 OK	20	80,000,000.0	0.150	-34.77 OK

(5) The measurement results are displayed as graph data at the “Analyze” screen. The solid line indicates the measurement results and the dotted line indicates the standard values (Mask).



7.3 Example of Jitter Generation for STM-64/OC-192Clock Recovery Module

The Jitter generation measurement measures the jitter of a DUT when a data signal without jitter (Jitter = OFF) is input to an STM-64/OC-192 clock recovery module.

At jitter generation measurement, the generally used measurement units are Ulrms. However ITU-T has recently reviewed jitter generation measurement and requires UIp-p units.
The MP1580A enables jitter measurement in both UIrms and UIp-p at jitter bandwidths of 80 MHz.

7.3.1 Measurement Setup Examples

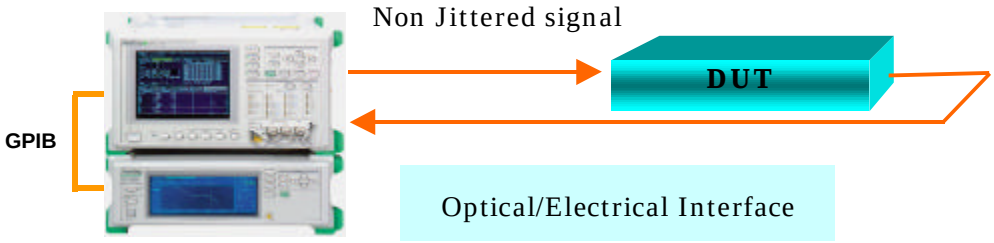


Fig. 7.3.1-1 Setup for Jitter Generation Measurement

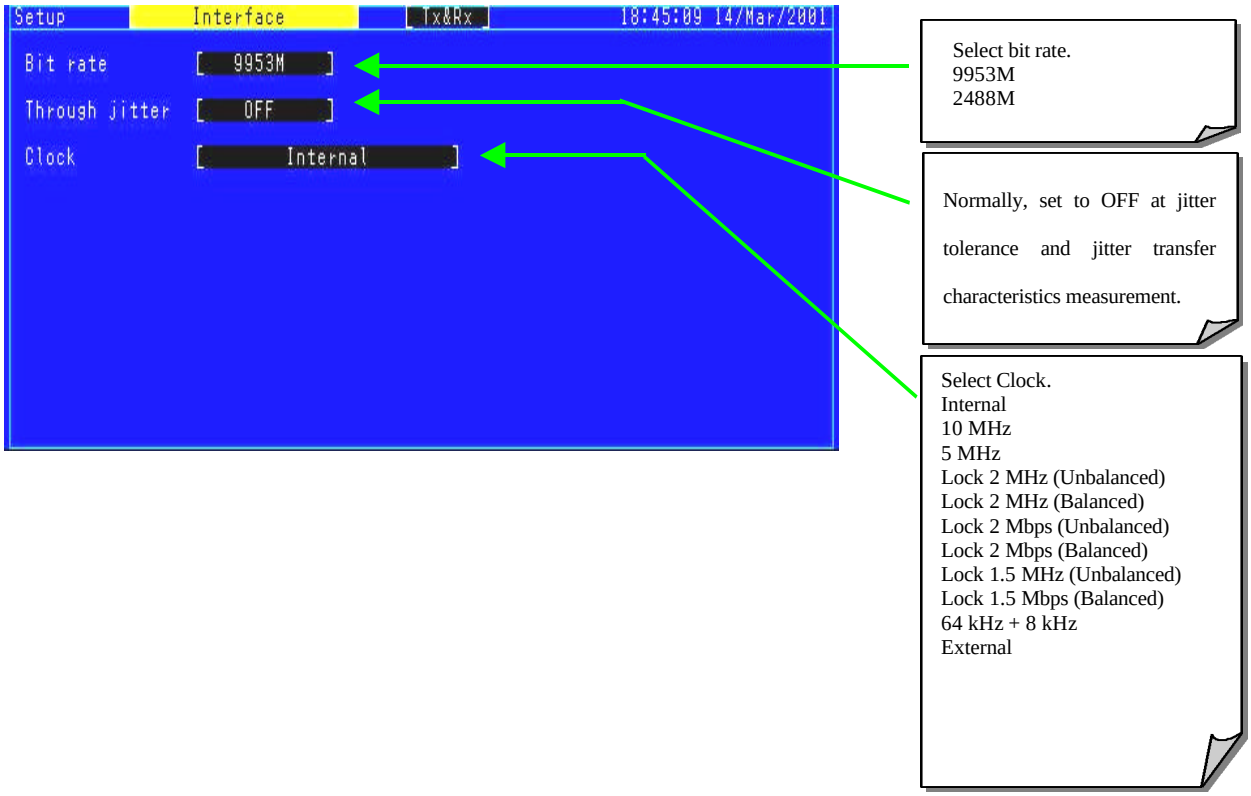
Note: The connection shown in Fig. 5.2-3 on page 17 is required when using with the MP1570A. Set GPIB and reference clock I/O as well as “Tracking” at the MP1580A “Setup” “System” screen. Next, move the marker to “Tracking” on the “Test Menu” screen and press the “Set” key to execute automatic tracking between the MP1580A and MP1570A.

7.3.2 Measurement Procedure

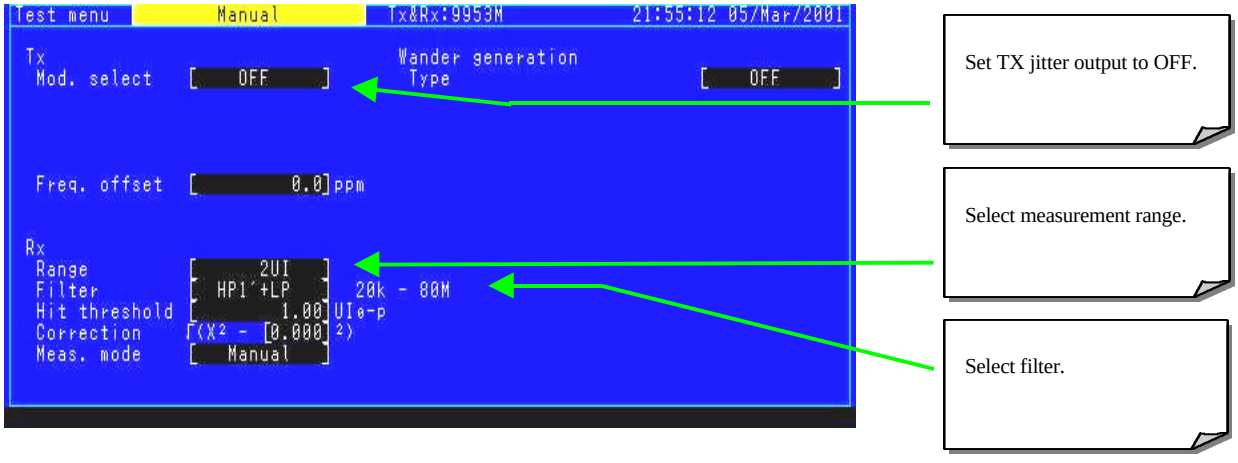
The following procedure describes measurement of the jitter generation of an STM-64/OC-192 clock recovery module. (Refer to Bellcore GR1377 standards.)

[Measurement Procedure]

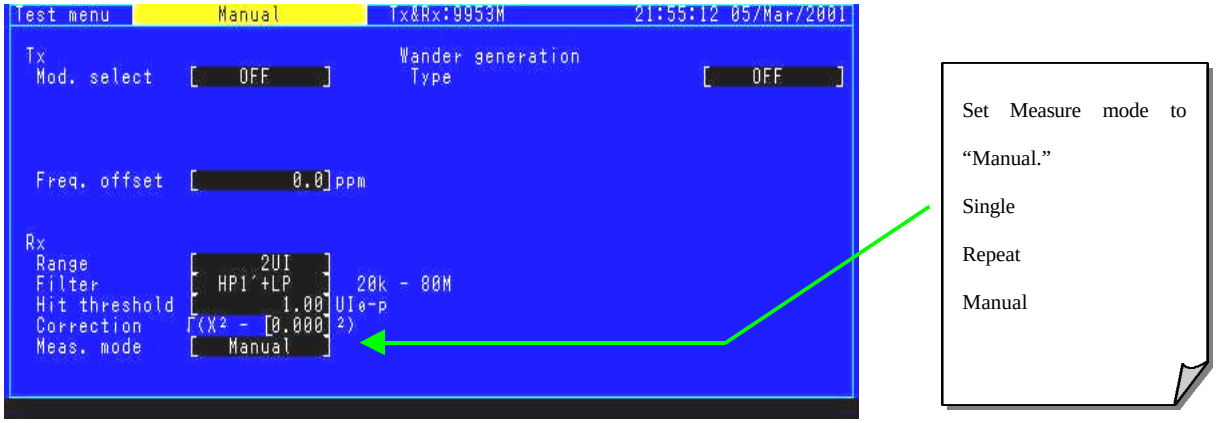
(1) Set the Bit rate, Clock conditions, etc., at the MP1580A “Setup” “Interface” screen.



(2) At the “Test menu” screen, set the TX jitter output setting of the measurement range and filter.



Example of Setting of Jitter Generation Measurement Condition



Example of Setting of Jitter Generation Measurement Condition

(3) After completing the settings at the "Test menu" screen, press the" Start/Stop" key on the front panel to start the measurement. The numeric measurement results are displayed on the "Results "screen.

Example of Jitter Generation Measurement Results

7.4 Example of Jitter Sweep Measurement for Clock recovery Module for SDH/SONET Transmission System

This jitter sweep measurement checks whether an error occurs when a jitter-modulated data signal is input to a clock recovery module for submarine transmission systems.

The MP1580A enables use of a measurement method (jitter tolerance measurement) that finds and evaluates the jitter tolerance point, and also enables use of a measurement method (jitter sweep measurement) that adds a preset jitter value to check only whether an error occurs. The former method (jitter tolerance measurement) is suitable for the application such as performance evaluation for the DUT in research and development departments. The latter method (jitter sweep measurement) is suitable for the application such as shipment during mass production of the DUT in the manufacturing departments.

7.4.1 Measurement Setup Examples

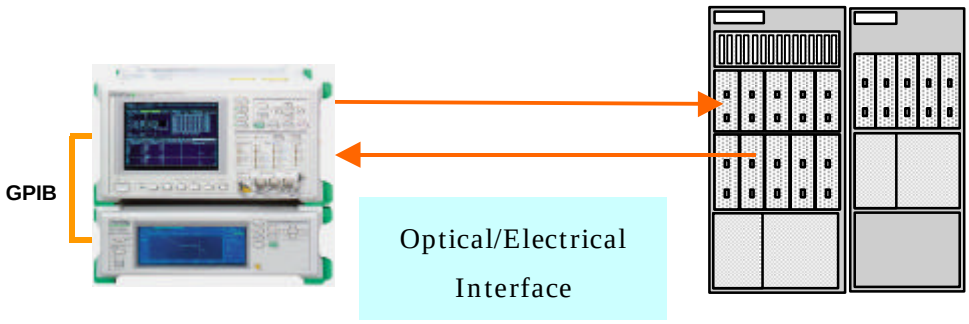


Fig. 7.4.1-1 Setup for Jitter Sweep Measurement

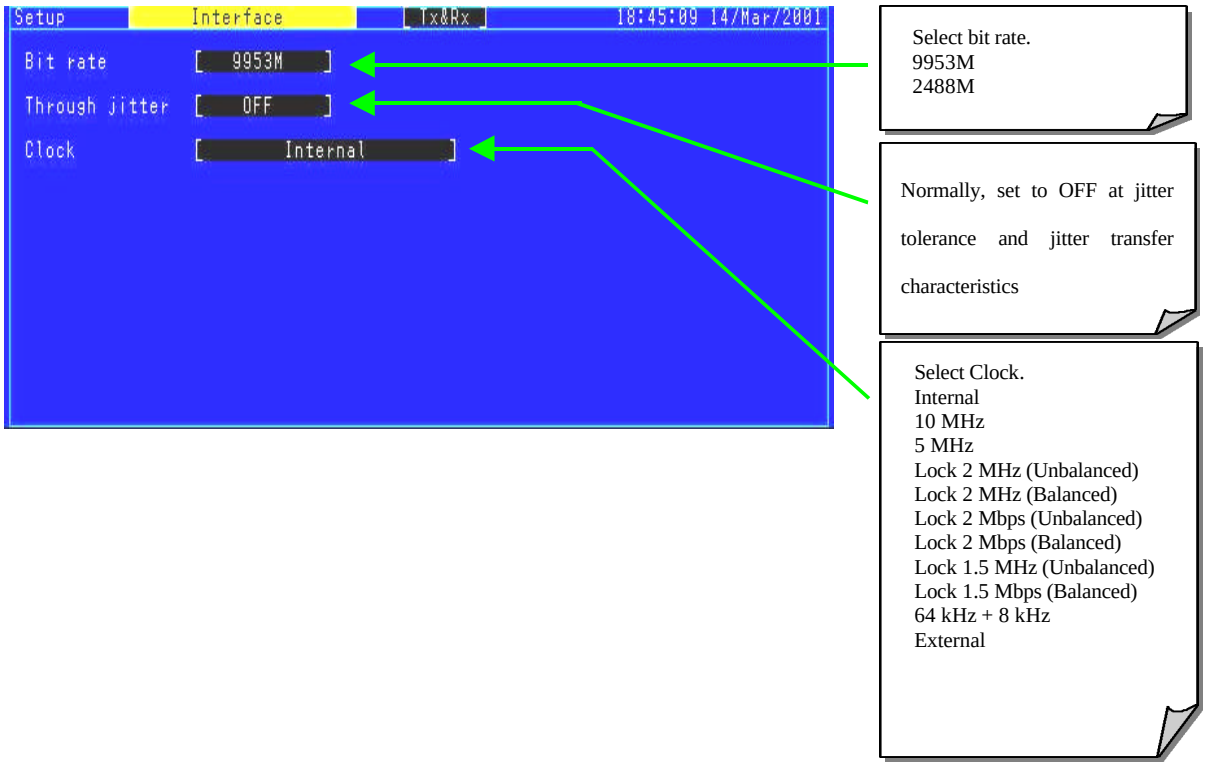
Note: The connection shown in Fig. 5.2-3 on page 17 is required when using with the MP1570A. Set GPIB and reference clock I/O as well as “Tracking” at the MP1580A “Setup” “System” screen. Next, move the marker to “Tracking” on the “Test Menu” screen and press the “Set” key to execute automatic tracking between the MP1580A and MP1570A.

7.4.2 Measurement Procedure

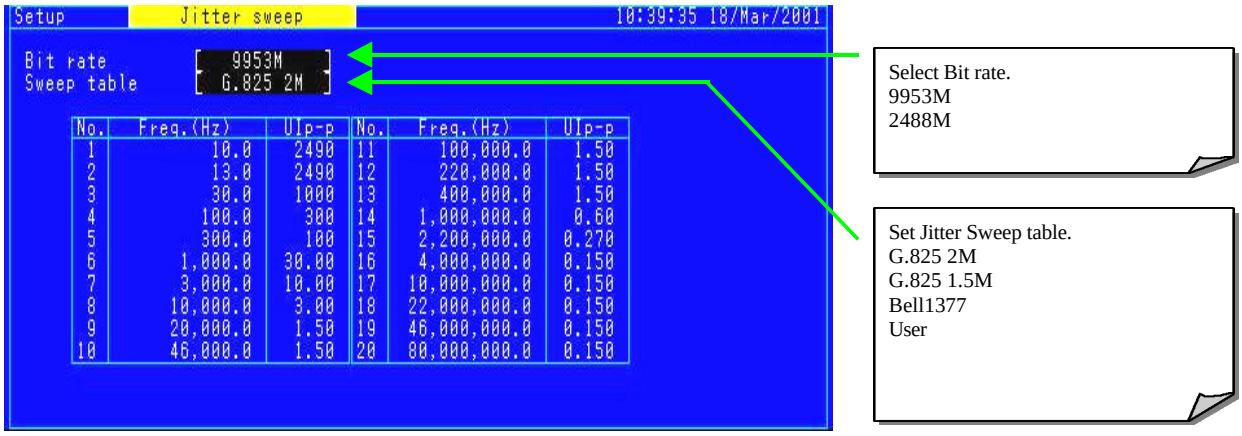
The following procedure describes how to measure the jitter sweep of an STM-64/OC-192 transmission system

[Measurement Procedure]

(1) Set the Bit rate, Clock conditions, etc., at the MP1580A “Setup” “Interface” screen.



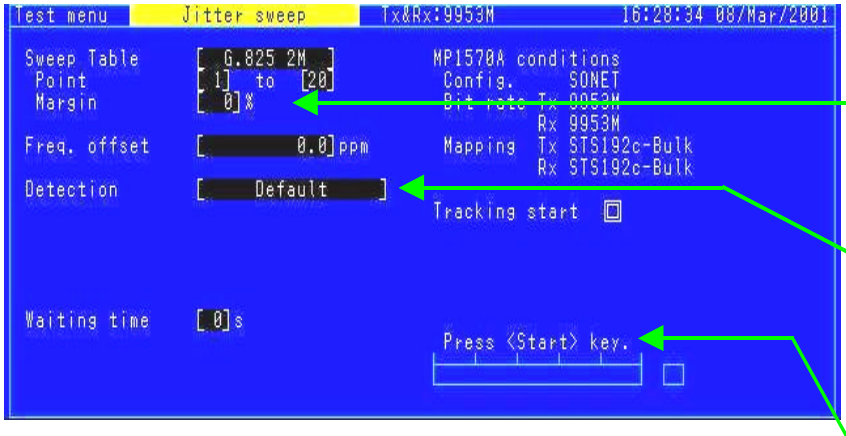
(2) Set the Bit rate and Sweep table the “Setup” “Jitter Sweep” screen.



(3) After completing the settings at the Test menu screen, press the Start/Stop key on the front panel to start the measurement.

Set Jitter Sweep table.
G.825 2M
G.825 1.5M
Bell1377
User

Set the number of measurement points (Can be set measurement start a stop points.)

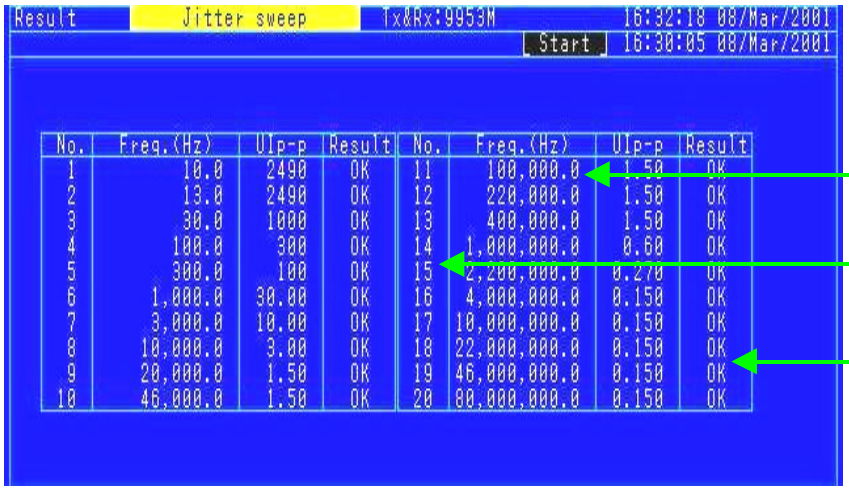


The jitter margin can be set from 0% to 100%.

Select Jitter Sweep detection method.
Default
1s error
Count
Rate
Onset of errors
1-dB power penalty

The measurement progress is displayed by a bar graph

(4) Press the Results key on the front panel to display the jitter sweep measurement results as a numeric value. The OK/NG indication at the right side of each measurement point indicates whether or not the result satisfies the Mask (standard value) set at the Test menu screen—OK means passed and NG means failed.

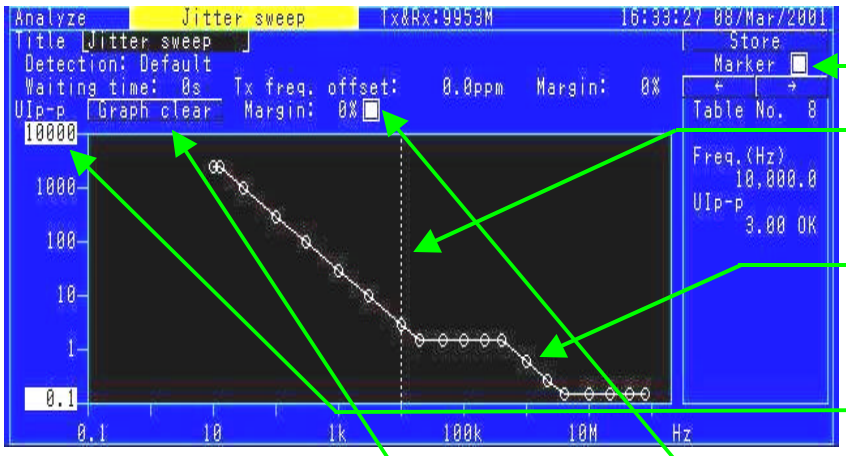


Measurement point to jitter frequency

Measurement point number

Displays Pass/Fail(OK/NG) compared to set Jitter Sweep standard as numeric value

(5) The measurement results are displayed graphically at the “Analyze” screen.



Press the Set key after moving the reverse marker to here to display a broken line marker on the screen.

Jitter Sweep measurement result (graph)

Max. scale value:

9953M:4000UI
2488M:1000UI

Displays margin set at Test menu screen

Press the Set key after moving the reverse cursor to here to clear the graph display.

7.5 Example of Frequency Tolerance Measurement for Submarine Transmission Equipment

This frequency tolerance measurement checks whether an error occurs when a frequency-offset data signal is input to the SDH/SONET transmission equipment.

The MP1580A can be adjusted to a 100 ppm frequency offset in steps of 0.1ppm. This function enables checking of the frequency tolerance of transmission equipment.

7.5.1 Measurement Setup Examples

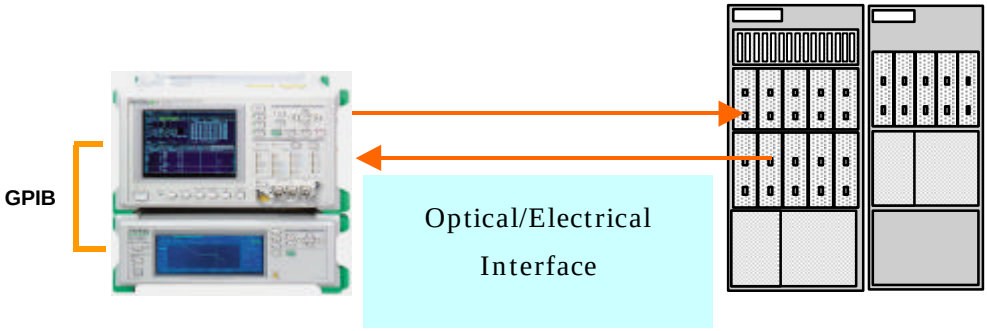


Fig. 7.5.1-1 Setup for Frequency Tolerance Measurement

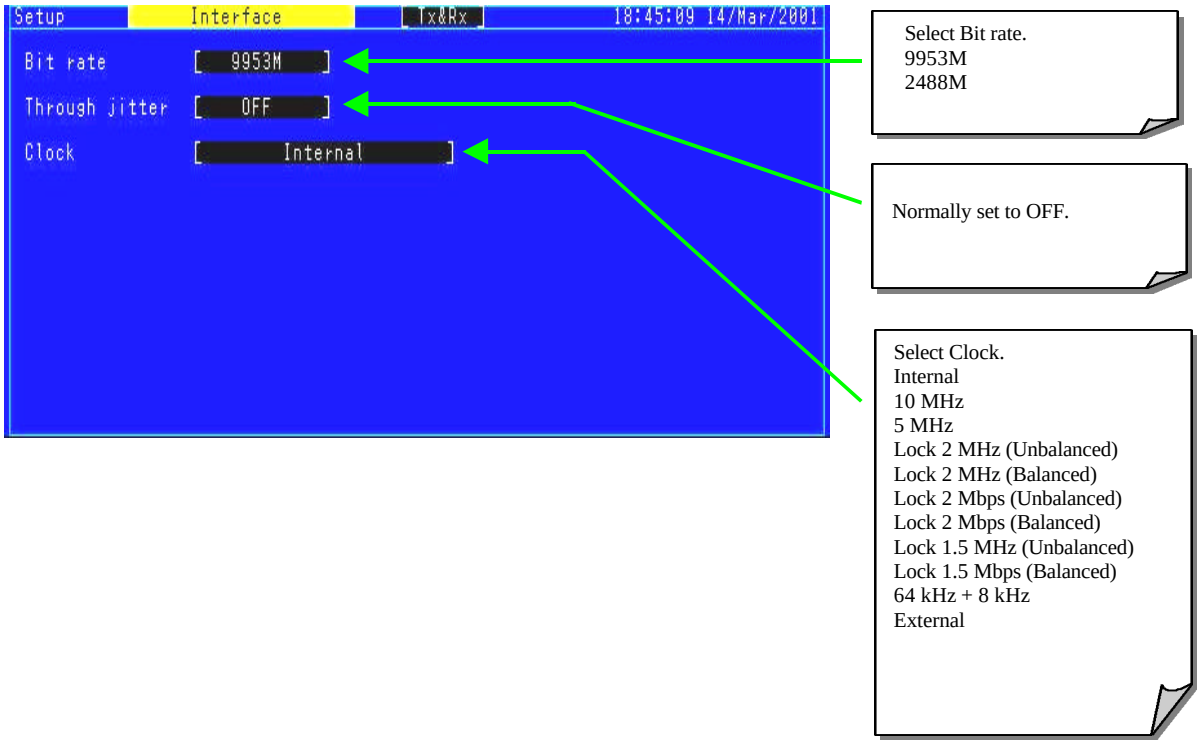
Note: The connection shown in Fig. 5.2-3 on page 17 is required when using with the MP1570A. Set GPIB and reference clock I/O as well as “Tracking” at the MP1580A “Setup” “System” screen. Next, move the marker to “Tracking” on the “Test Menu” screen and press the “Set” key to execute automatic tracking between the MP1580A and MP1570A.

7.5.2 Measurement Procedures

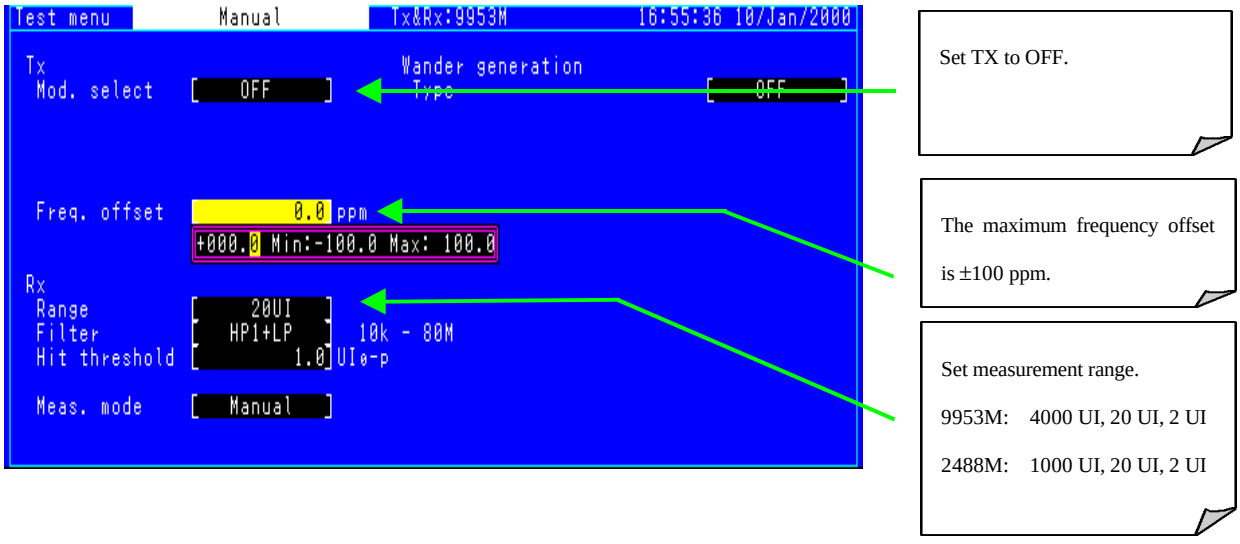
The following procedure describes how to input a frequency-offset signal to a SDH/SONET transmission equipment and check for error generation, and shows the frequency tolerance measurement results.

[Measurement Procedure]

(1) Set the Bit rate, Clock conditions, etc., at the MP1580A Setup Interface screen.



(2) Change the frequency offset manually at the Test menu and check for errors on the MP1570A.



Anritsu

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