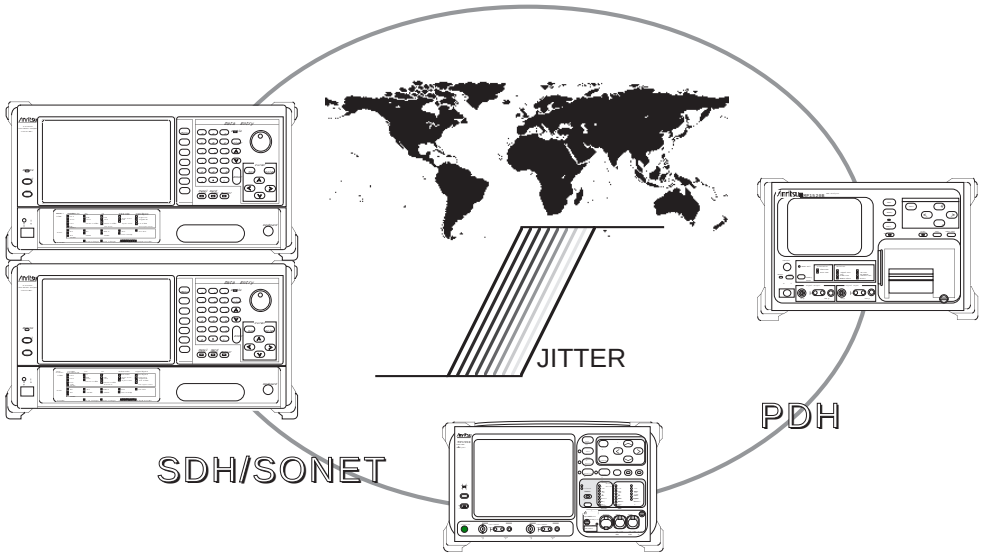
TECHNICAL NOTE

PDH/SDH Jitter & Wander Measurement

ME3520A/ME3620A SDH/SONET Analyzer
MP1550A/B PDH/SDH Analyzer
MP1520B PDH Analyzer



MEASUREMENT GROUP
ANRITSU CORPORATION

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1. Jitter Definition

1.1 What is Jitter and Wander?

In a digital network, the phenomenon where the noise in the transmission line and the transmission pattern that cause the transmission signal timing to be disrupted and the average position of the pulse phase to be offset is called jitter or wander (Refer to Figure 1-1). There is no difinition that clearly distinguish jitter from wander, but generally the boundary between the jitter and wander frequency (phase modulation frequency) is about 10 Hz, with frequencies below this being called wander and frequencies above this being called jitter. (Refer to Figure 1-2)

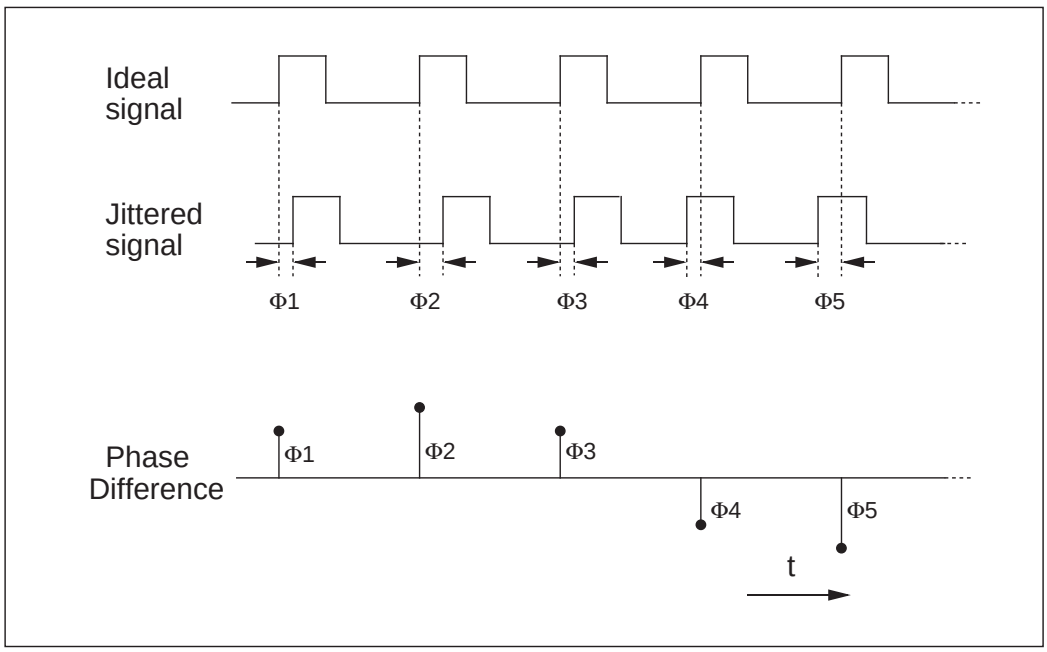

Figure 1-1 Jitter

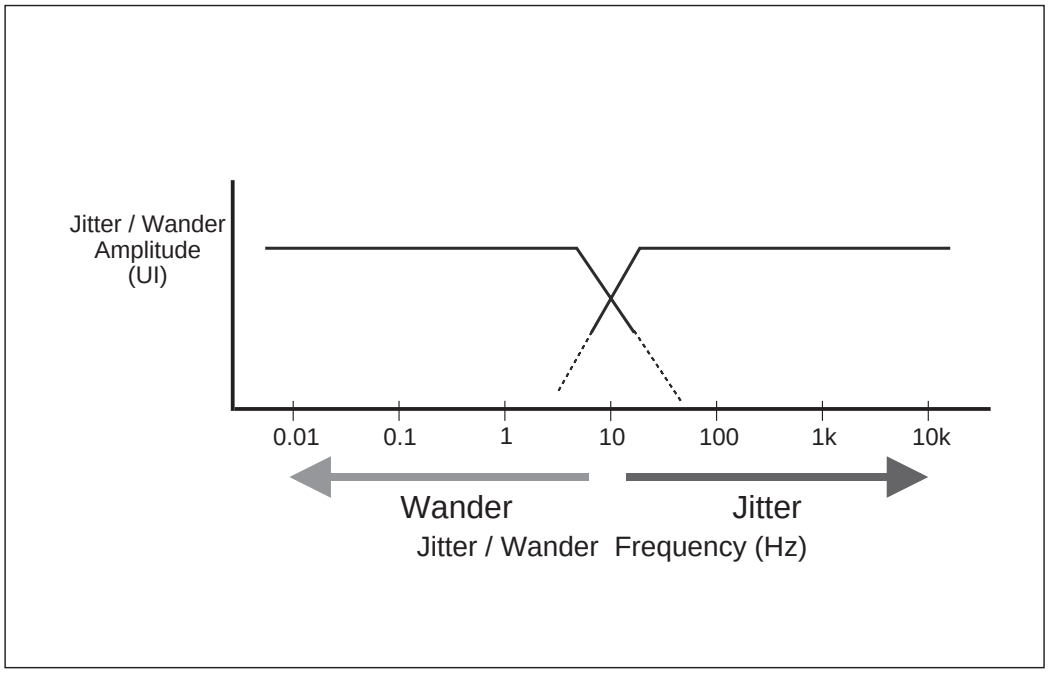

Figure 1-2 Jitter and Wander

1.2 Jitter Amount

The jitter amount is considered as the amount of phase variation between a measured signal and the reference signal. Figure 1-3 (a) and (b) shows the waveforms when a reference signal and the measured signal are observed using an oscilloscope. The blurred rising and falling edge in the jittered signal in Figure 1-3 (b) is the composite view of each instance of the delay or lead of the phase conditions between (c) and (d). This phase difference between (c) and (d) is the jitter amplitude and the reciprocal of the repeat period (Tm) is called the jitter frequency (fm).

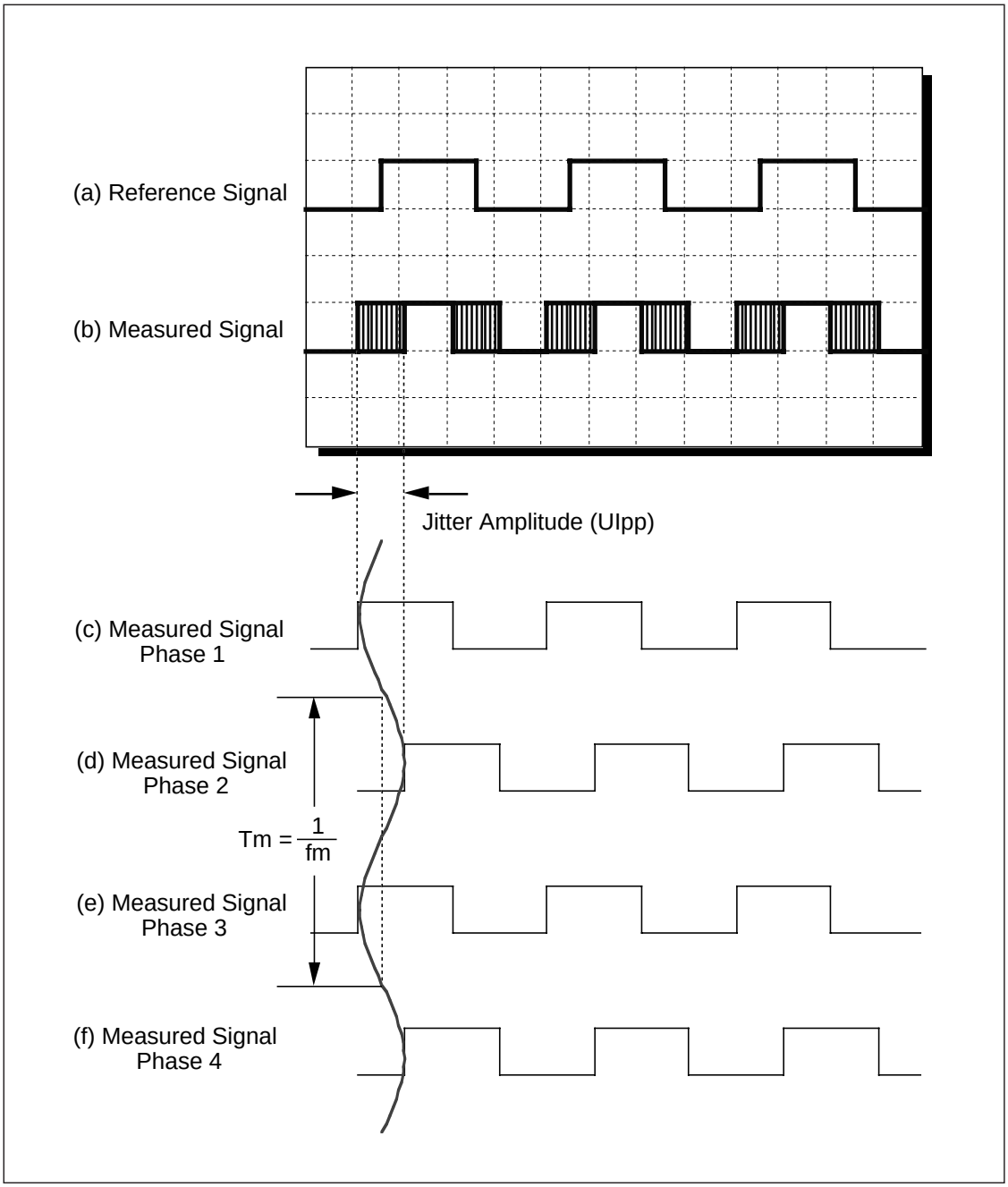

Figure 1-3 Jitter Wave Form

1.3 Jitter Units

Because jitter is the phase variation and its amount is an evaluation parameter for digital signal transmission quality, common units must be defined for all transmission codes. For this reason, "Unit Interval (UI)" is used as the unit for jitter amplitude, and 1 UI is defined as 1 cycle of the clock (Refer to Figure 1-4). The actual units consist of two types, UIpp (phase variation width peak-to-peak) and UIrms (phase variation width root mean square). Because these units are normalized parameters that do not rely on the bit rate, the jitter amplitude among different bit rates can be compared. (Refer to Figure 1-5)

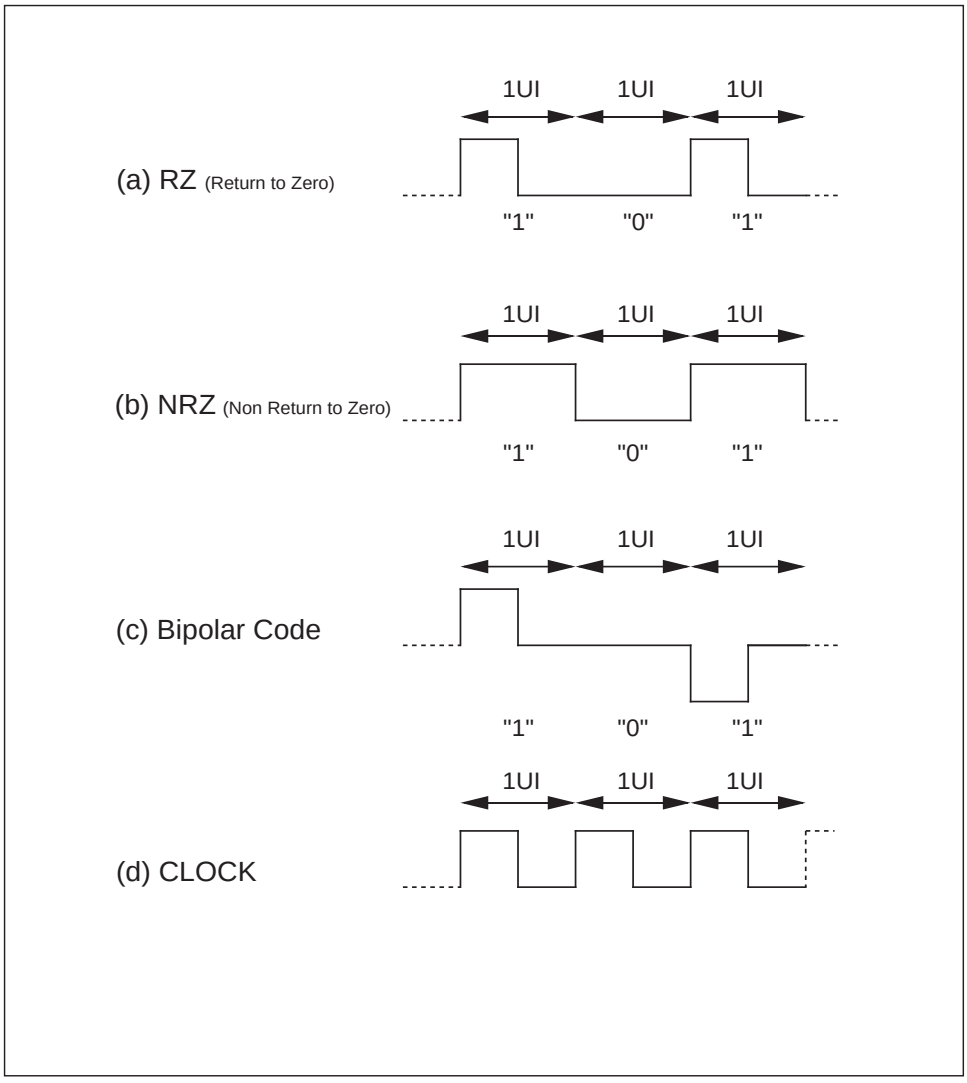

Figure 1-4 Jitter Unit (1)

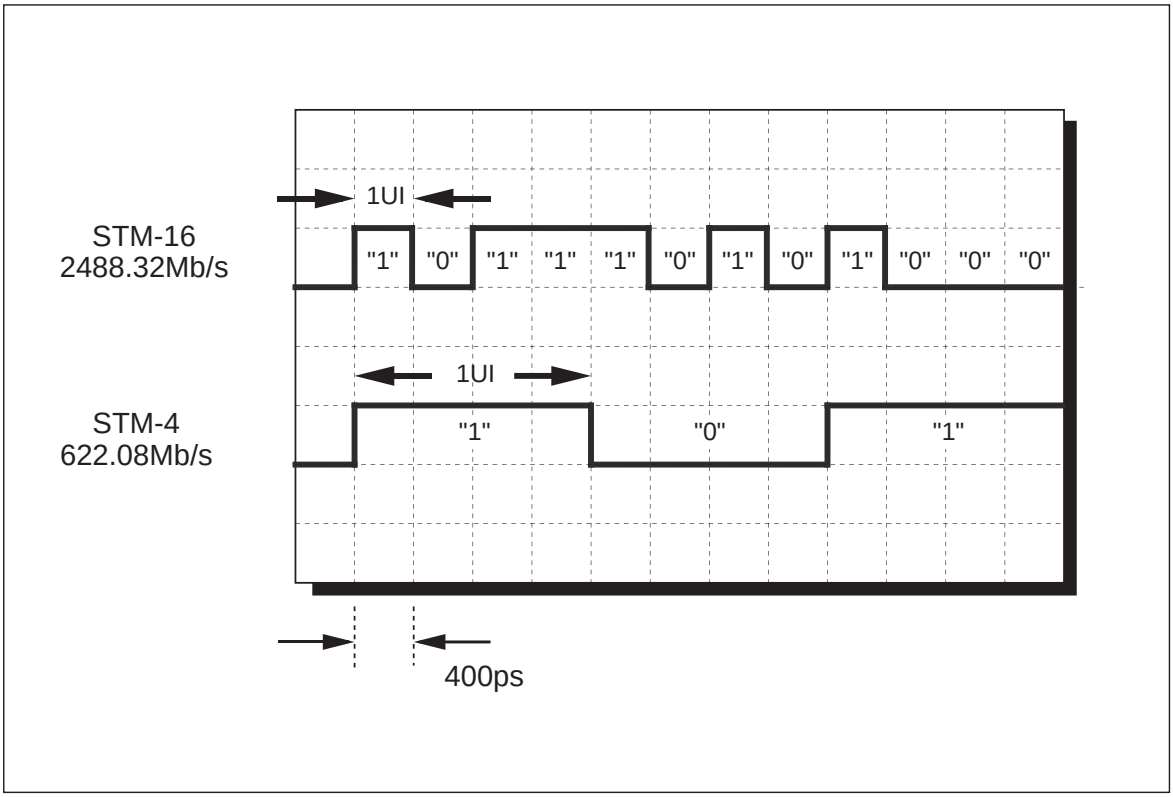

Figure 1-5 Jitter Unit (2)

1.4 Jitter Types

A variety of names are given to jitter depending on the generation mechanism and the cause. The following are the four representative types of jitter.

1. Systematic Jitter
2. Nonsystematic Jitter
3. Mapping Jitter
4. Pointer Jitter

1.4.1 Systematic Jitter

Systematic jitter occurs in relation to the transmission pattern and is also called pattern jitter. The cause of this jitter generation is the interference between the signals in each part of the equipment, AM/FM conversion, and clock recovering circuit detuning, etc. Because systematic jitter has the same trend in all repeater systems the cumulative effect becomes large and thus this jitter has a major impact on transmission quality.

1.4.2 Nonsystematic Jitter

The main cause of nonsystematic jitter is noise and because it occurs in individual repeaters, the cumulative effect is small and thus has a minor impact on transmission quality.

1.4.3 Mapping Jitter

Mapping jitter occurs when asynchronous signals are mapped in SDH or SONET frames. C-bit justification is performed to absorb the mismatch caused by the asynchronous signal frequency offset. This stuff bit called C bit (Justification control bit) causes jitter during demapping. The equipment reduces this mapping jitter using a PLL circuit, etc., and is required to meet the mapping jitter standards in ITU-T (International Telecommunication Union-Telecommunication) G.783 (for example, 139Mb/s f3-f4 0.075 UIpp or less). Figure 1-6 shows the VC-4 container configuration in the SDH frame. The asynchronous signal frequency offset can be absorbed by embeding information into the justification opportunity bit (S) in each row in the VC4 container and then maps these into the SDH/SONET frame.

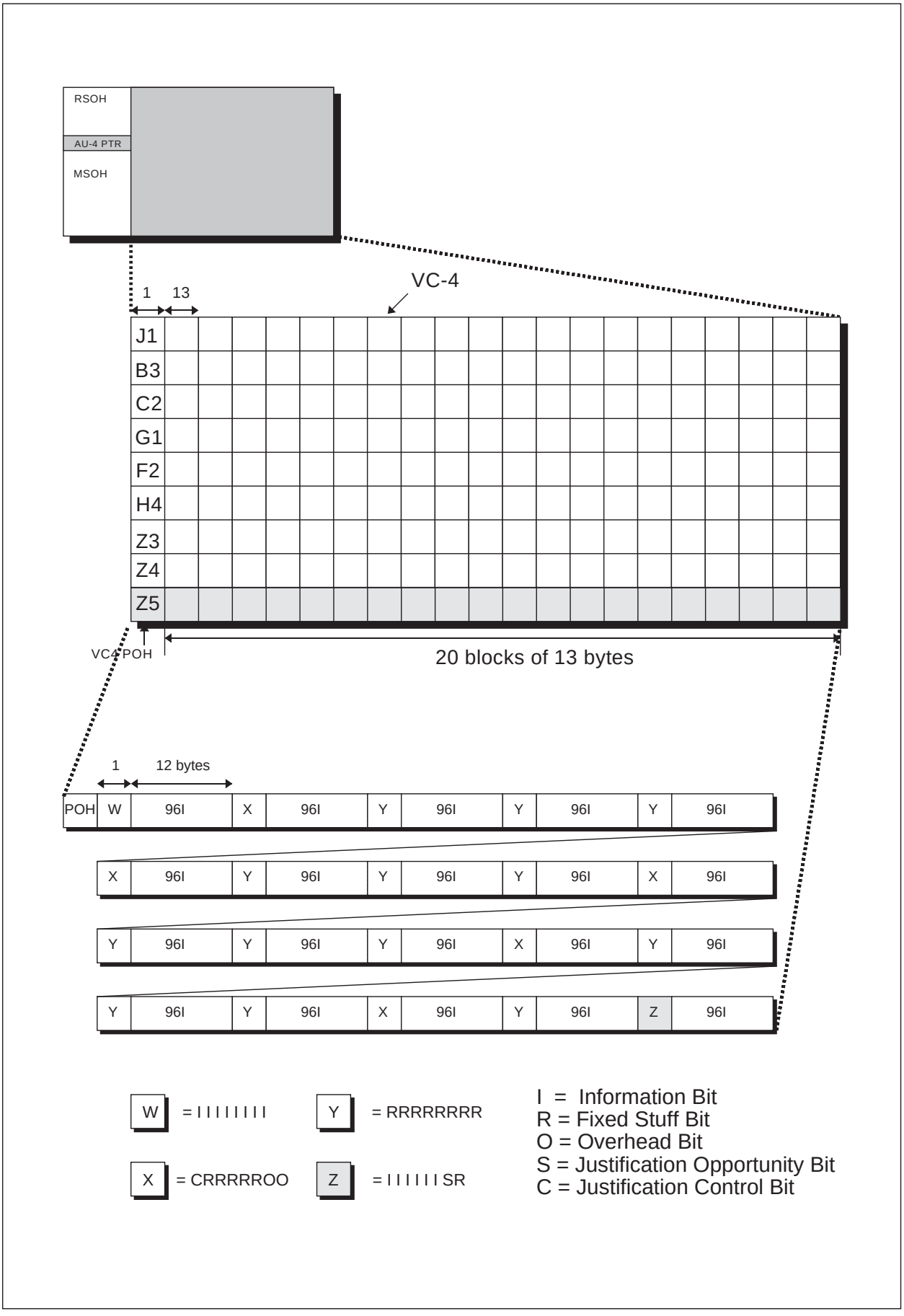

Figure 1-6 VC-4 Container Structure

1.4.4 Pointer Jitter

Pointer jitter is caused by the change of pointer, which is the mechanism that compensates for the frequency and phase difference between the SDH/SONET frame and container at the SDH/SONET mapping process. As shown in Figure 1-7, the pointer action is performed byte by byte. For this reason, a phase gap occurs in the tributary signal from the pointer action (value change) during demapping process. A single pointer action causes an 8-bit (H3 byte) x 3-byte = 24-bit phase gap and corresponds to a 24 UI jitter amount. Transmission equipment should smooth this phase gap caused by the pointer action and should meet the combined jitter standards in the ITU-T G.783. (For example, bit rate 139Mb/s, frequency range f3 to f4, under the pointer action conducted in sequence as shown in Figure 1-8, it shall be 0.075 UIpp or less. Refer to Item 2.6 combined jitter.)

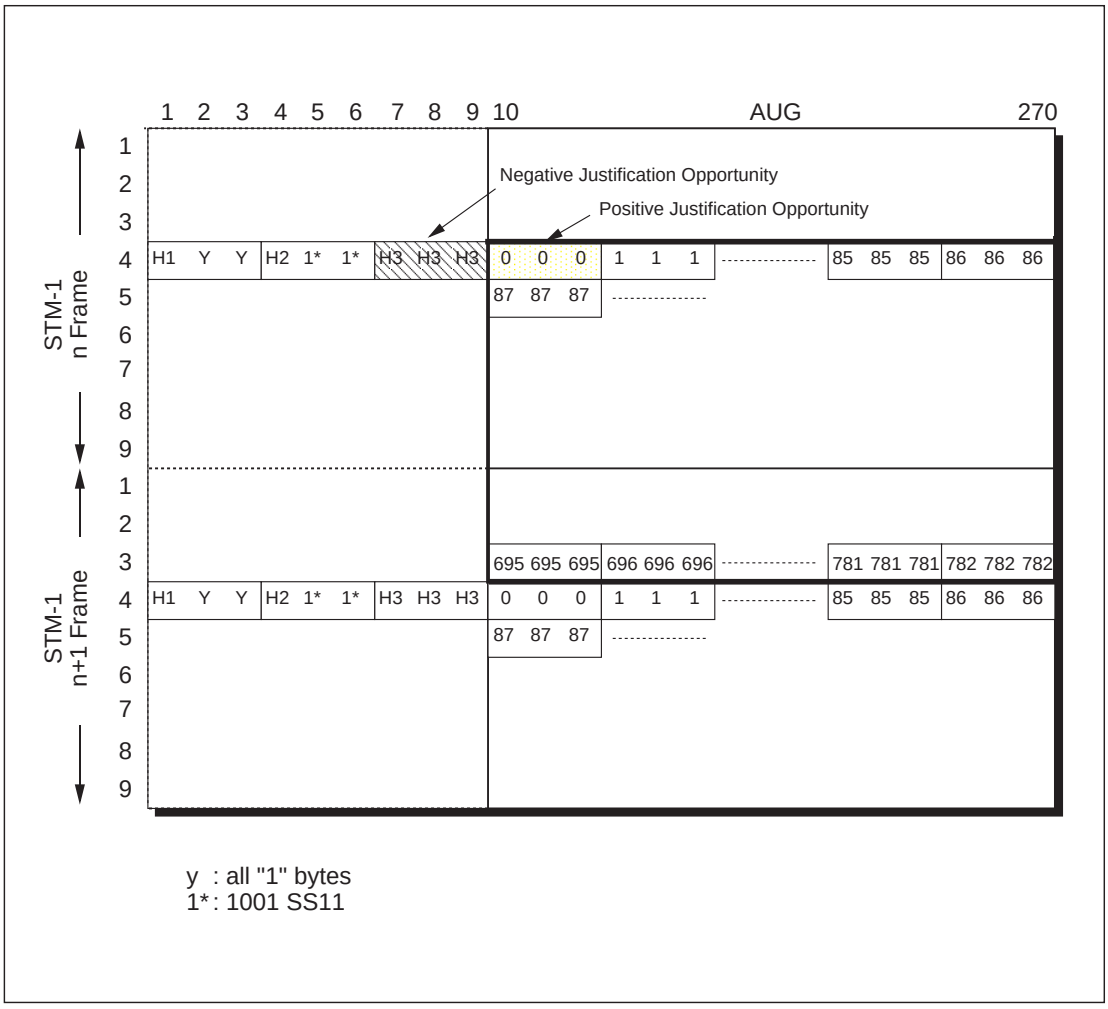

Figure 1-7 AU-4 Pointer

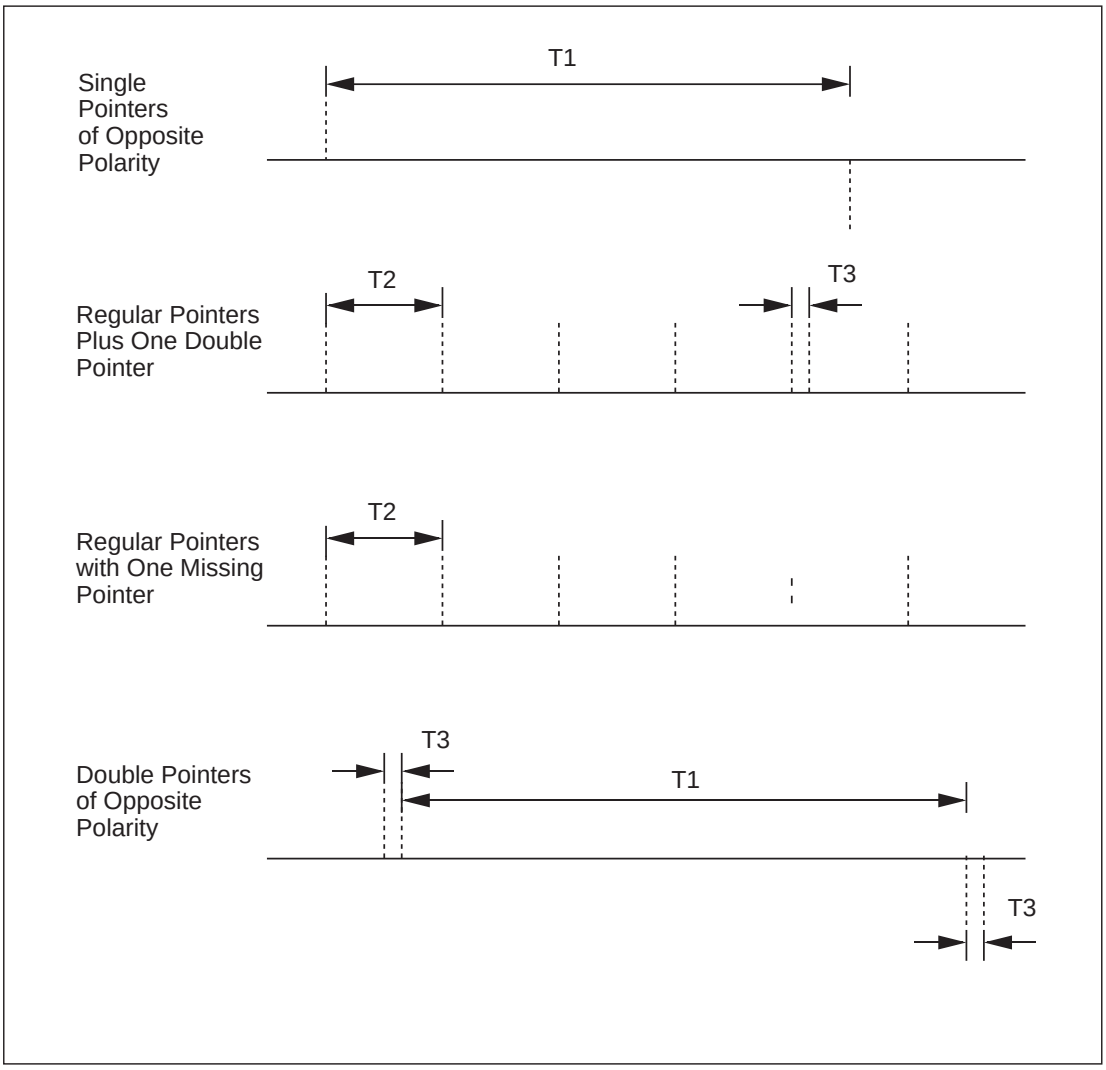

Figure 1-8 ITU-T G.783 Pointer Test Sequence

1.5 ITU-T Standards

The ITU-T (International Telecommunication Union-Telecommunication) standard recommendations are provided for controlling jitter and wander performance in digital networks. Representative ITU-T recommendations are shown in Table 1-1.

Table 1-1 ITU-T Standards

ITU-T No.	Title
G.783	Characteristics of Synchronous Digital Hierarchy (SDH) Equipment Functional Blocks
G.823	The Control of Jitter and Wander within Digital Networks Which Are Based on the 2048 kbit/s Hierarchy
G.824	The Control of Jitter and Wander within Digital Networks Which Are Based on the 1544 kbit/s Hierarchy
G.825	The Control of Jitter and Wander within Digital Networks Which Are Based on the Synchronous Digital Hierarchy (SDH)
G.958	Digital Line Systems Based on the Synchronous Digital Hierarchy for Use on Optical Fiber Cables
G.81s	Timing Characteristics of Slave Clocks Suitable for Operation in SDH Equipment's
G.811	Timing Requirements at the Outputs of Primary Reference Clocks Suitable for Plesiochronous Operation of International Digital Links
G.812	Timing Requirements at the Outputs of Slave Clocks Suitable for Plesiochronous Operation of International Digital Links

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2. Jitter Measurement

2.1 Basic Jitter Tests

Because jitter has a large impact on network transmission quality, a quantitative evaluation for jitter is required. The following five basic tests are used as jitter performance tests.

1. Jitter Tolerance
2. Jitter Transfer
3. Jitter Generation
4. Mapping Jitter
5. Combined Jitter

2.2 Jitter Tolerance

2.2.1 Jitter Tolerance

This evaluation is used to measure how tolerant the measured equipment will be without creating any error when the jitter amplitude is increased by sine wave jitter modulation (phase modulation) to the signal input to the measured equipment. This measurement evaluates the equipment total jitter tolerance by linking the measurement results at each point taken from repeatedly changing the jitter modulation frequency as shown in Figure 2-1.

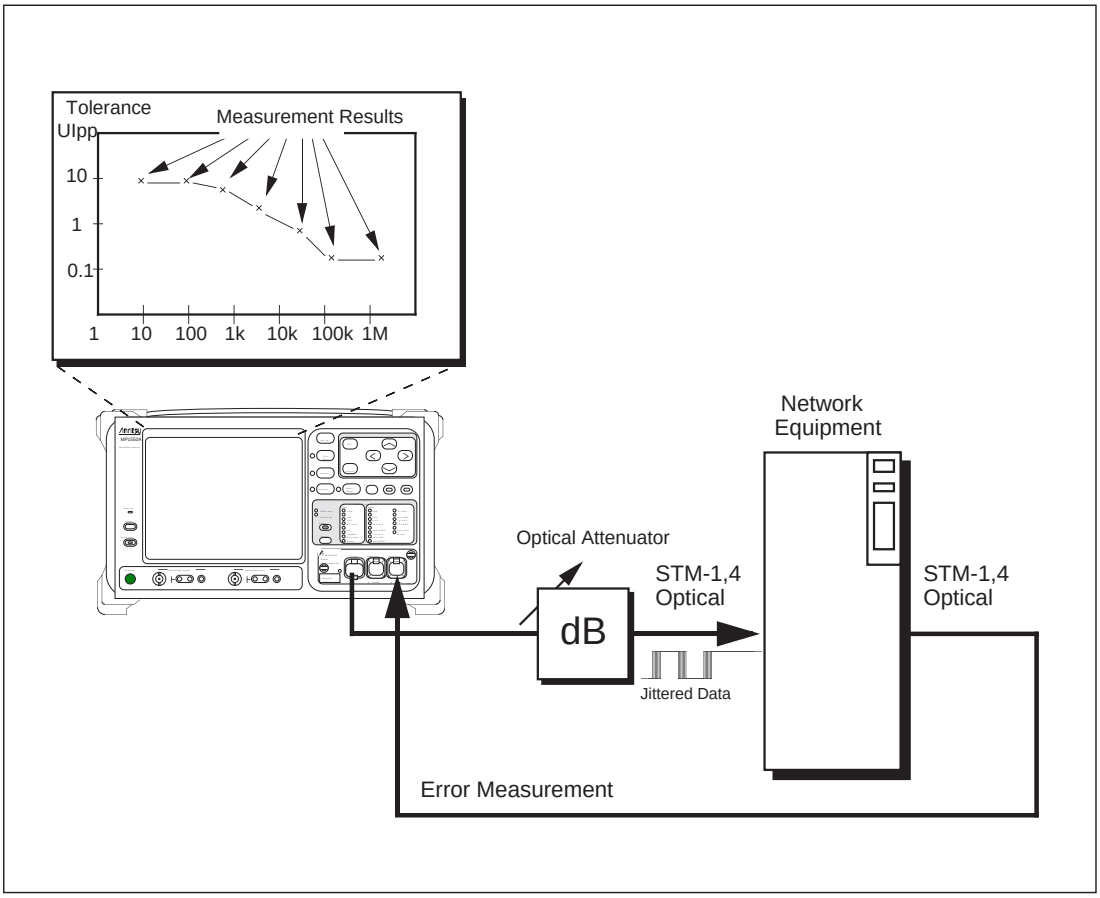


Figure 2-1 Jitter Tolerance

2.2.2 Jitter Tolerance Standards

The jitter tolerance masks recommended in ITU-T G.958 are shown in Figure 2-2. This recommendation includes two standards according to the difference of the internal retiming circuit configuration shown in Figure 2-3. Type A is applied to a low Q (quality factor) retiming circuit configured with a SAW filter, etc. Type B is applied to a high Q retiming circuit that uses a PLL circuit. The measured equipment must have a tolerance that exceeds the jitter tolerance mask for either of these circuit configurations.

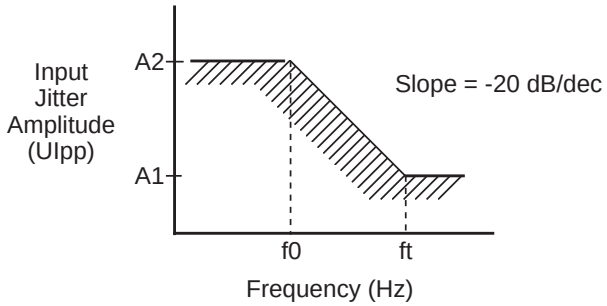


FIGURE 6.3/G.958 Jitter tolerance mask

STM level (Type)	ft (kHz)	f0 (kHz)	A1 (UIp-p)	A2 (UIp-p)
STM-1 (A)	65	6.5	0.15	1.5
STM-1 (B)	12	1.2	0.15	1.5
STM-4 (A)	250	25	0.15	1.5
STM-4 (B)	12	1.2	0.15	1.5
STM-16 (A)	1000	100	0.15	1.5
STM-16 (B)	12	1.2	0.15	1.5

Table 2/G.958 Jitter tolerance parameters

Figure 2-2 ITU-T G.958 Jitter Tolerance

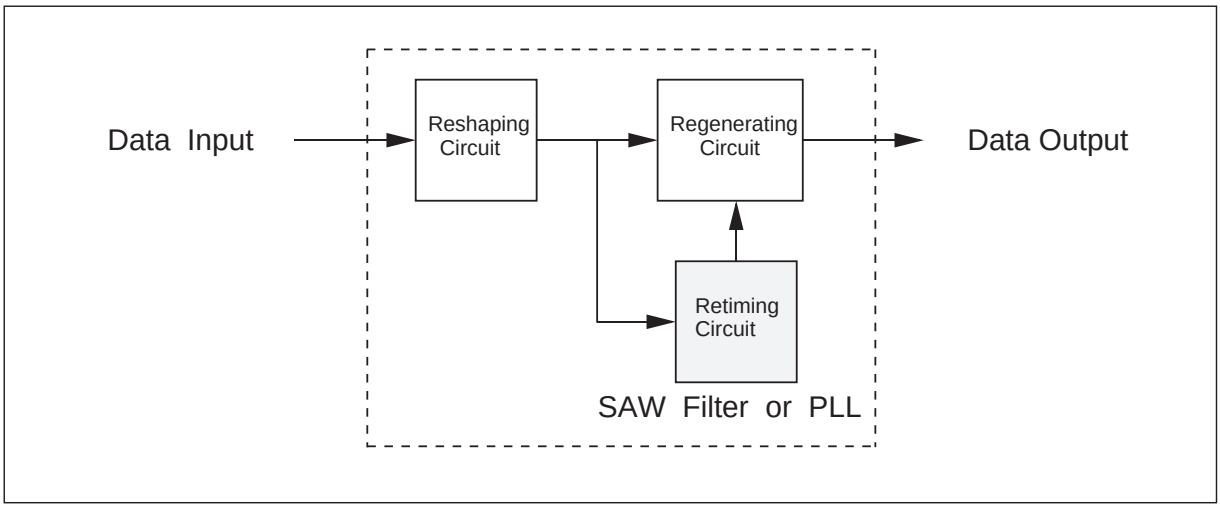


Figure 2-3 3R Repeater Configuration

2.2.3 Two Evaluation Methods

There are two measurement methods that are used to evaluate jitter tolerance depending on the DUT and the purpose of the evaluation.

(1) BER (Bit Error Ratio) Penalty Method

This method is used to evaluate the retiming capability of the clock recovery circuit. Attenuating the input signal level in advance with the jitter off, and set it to the 1 dB return state (1 dB power penalty) from the attenuation which the error occurred. (Refer to Figure 2-4 (a)) When conducting a measurement with a pre-defined error rate, set the 1 dB return state from the attenuation which pre-defined error rate or error count is obtained for the input signal. (Refer to Figure 2-4 (b))

The ITU-T standard O series recommends an example measurement for when the error count is 100/sec. But because the input level for BER has nearly linear characteristics, the same results will be obtained using either Figure 2-4 (a) or (b) method. In the case of the (b) measurement, the error rate is evaluated for each second, and the total measurement consequently takes more time than that in (a).

(2) Onset of Errors Method

This method is used to evaluate the asynchronous multiplexer justification capability. This method increases the jitter until an error occurs and then evaluates by means of error detection.

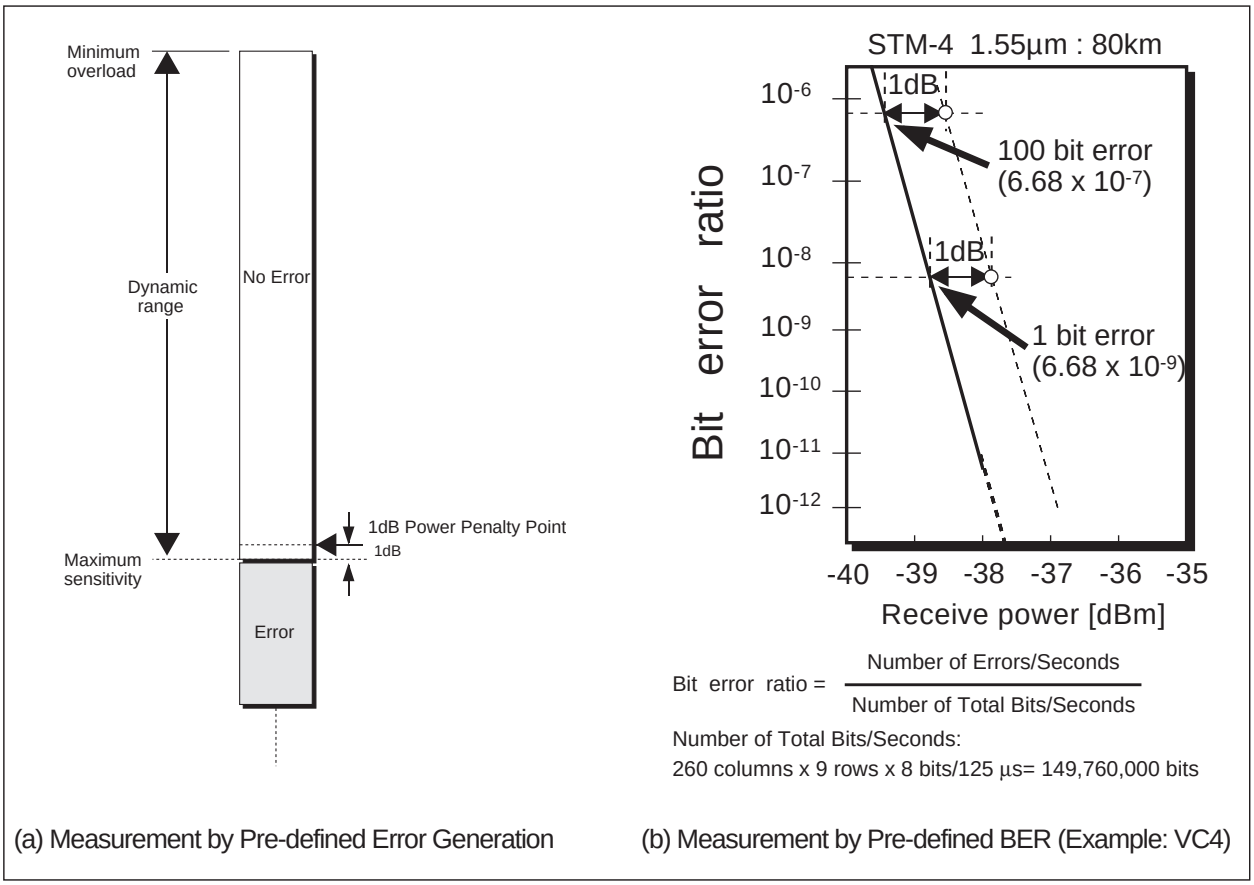


Figure 2-4 1 dB Power Penalty

2.2.4 Jitter Tolerance Measurement

Figure 2-5 shows an example measurement using the BER (Bit Error Ratio) penalty method with an MP1550A/B PDH/SDH analyzer.

A jittered signal is generated at the transmitter and the bit error is measured by the receiver. The input signal level is attenuated with the attenuator in advance in the jitter off state until an error is detected with the receiver. Then the attenuator is set with 1 dB return state from the attenuation which the error occurred, thereby setting the optical input level. This means an evaluation which is performed with the jitter amplitude corresponding to the 1 dB optical power penalty.

Note: • The ME3620A/ME3520A SDH/SONET analyzer can perform a jitter tolerance measurement according to the pre-defined error rate by installing system software Ver. 3.0 or later. (Refer to Item 6.4)

• The MP1550A/B PDH/SDH analyzer cannot perform the jitter tolerance measurement according to the pre-defined error rate.

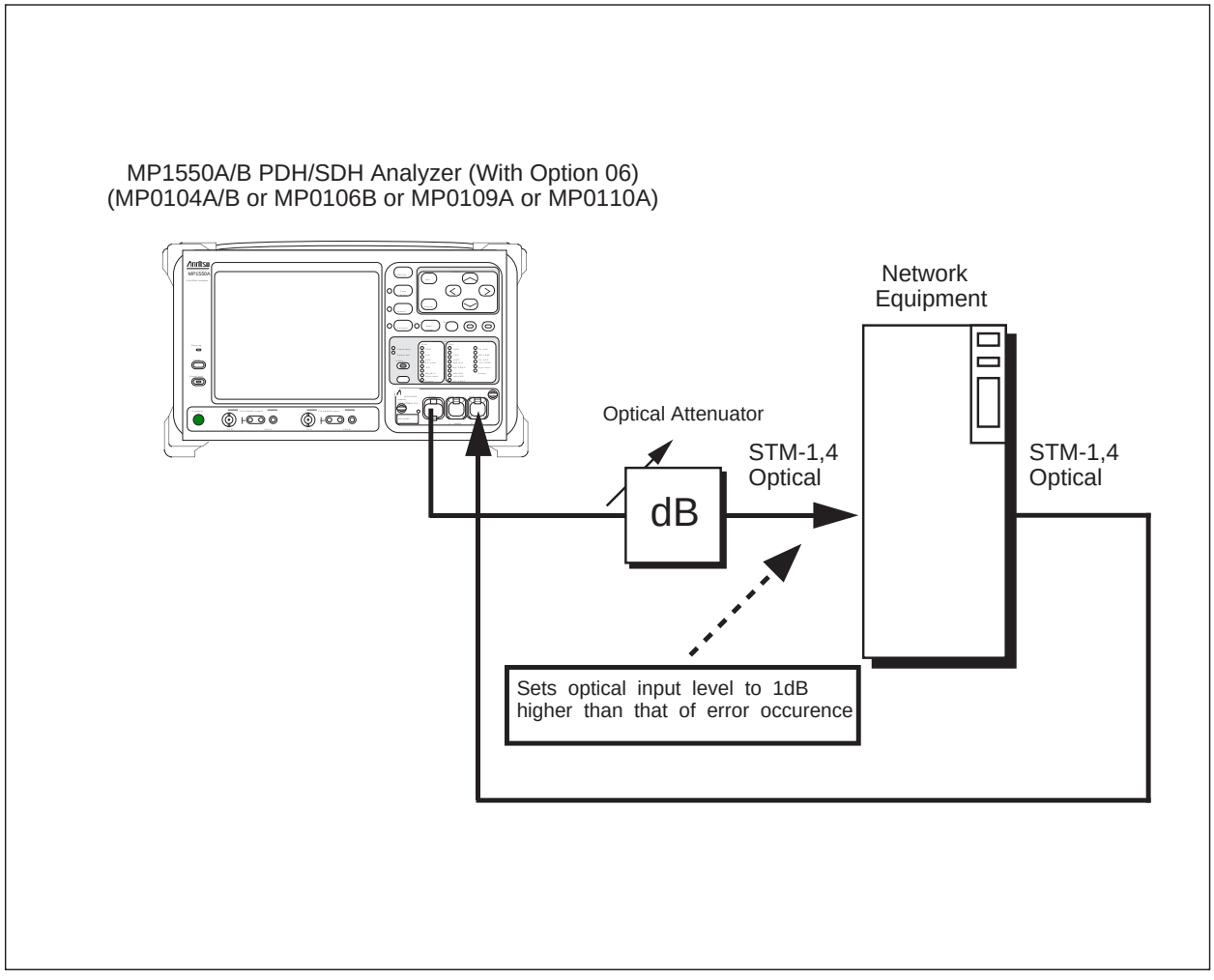


Figure 2-5 Jitter Tolerance Measurement

2.3 Jitter Transfer

2.3.1 Jitter Transfer

Jitter transfer is used to evaluate how much jitter amplitude is transmitted to the output side when sine wave jitter modulation (sine wave phase modulation) is applied to the measured device's input signal. The measurement results are derived from the jitter amount added to the input side (Jin) and the measured jitter amount on the output side (Jout) using formula (1). This measurement is a very important for eliminating jitter accumulation.

$$\text{Jitter Gain (dB)} = 20 \text{ LOG } \frac{\text{Jout}}{\text{Jin}} \quad \text{----------} (1)$$

2.3.2 Jitter Transfer Standards

The jitter transfer masks recommended in ITU-T G.958 are shown in Figure 2-6. This recommendation includes two standards with the difference of the measured internal retiming circuit configuration. Type A is a low Q retiming circuit configured with a SAW filter, etc. And Type B is a high Q retiming circuit that uses a PLL circuit, etc. The measured equipment is required to have jitter transfer characteristics that does not exceed the jitter transfer mask corresponding to either of these circuit configurations as shown in Figure 2-6.

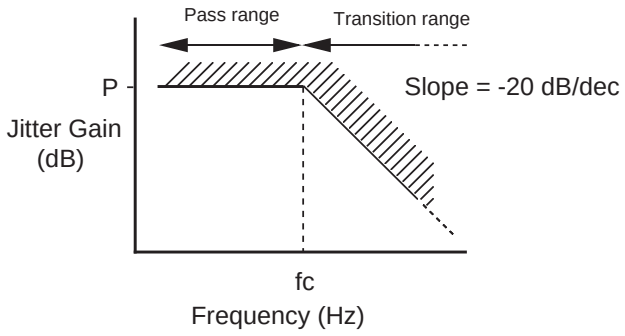


FIGURE 6.2/G.958 Jitter transfer mask

STM level (Type)	fc (kHz)	P (dB)
STM-1 (A)	130	0.1
STM-1 (B)	30	0.1
STM-4 (A)	500	0.1
STM-4 (B)	30	0.1
STM-16 (A)	2000	0.1
STM-16 (B)	30	0.1

Table 1/G.958 Jitter transfer parameters

Figure 2-6 ITU-T G.958 Jitter Transfer

2.3.3 Two Measurement Methods

(1) Broad-Band Method

As shown in Figure 2-7, this method detects broad-band jitter. (For example, up to 5 MHz for STM-4) This measurement is affected by the residual jitter and cannot keep a wide dynamic range.

Note: The input jitter amplitude for jitter transfer measurement is required to keep the measured equipment operating correctly without generating any error. For this reason the input jitter amplitude is limited to below the jitter tolerance. As shown in Figure 2-8, at a high modulation frequency range (measurements with 0.15 UIpp input), the dynamic range becomes 20 dB narrow because of the influence of noise, compared with that of the low frequency range (measurement with 1.5 UIpp input).

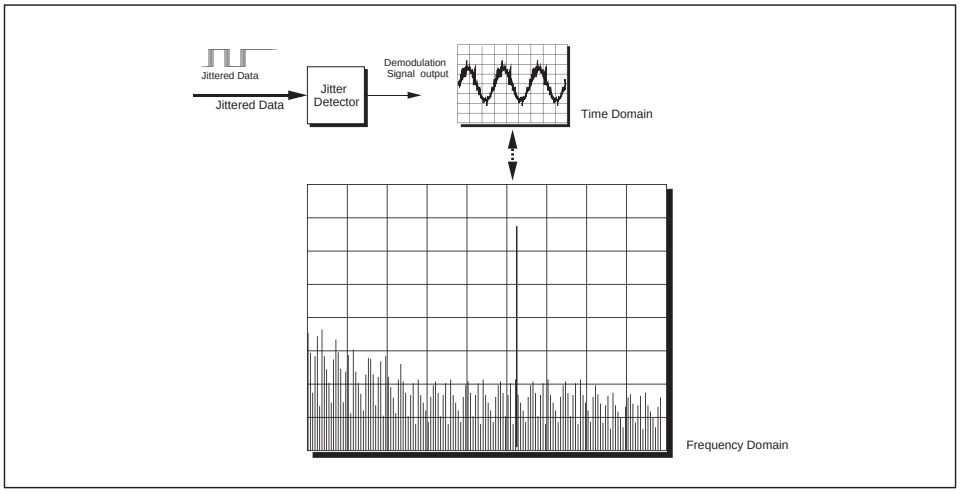


Figure 2-7 Jitter Spectrum of Demodulation Signal by Using Broad-Band Method

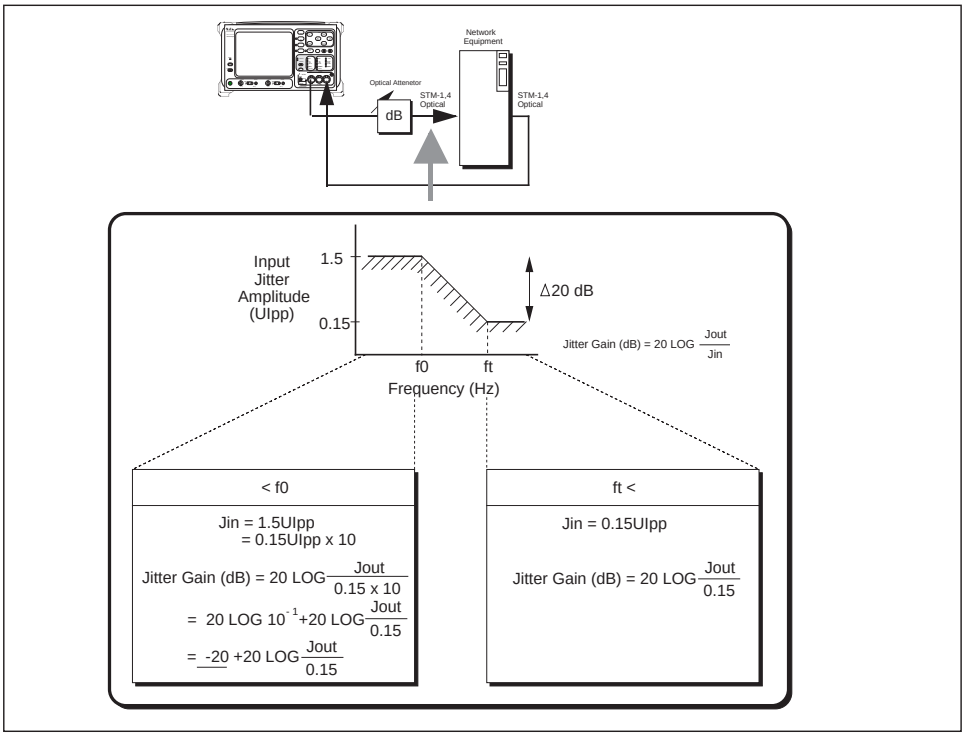


Figure 2-8 Limitation of Additional Jitter at Jitter Transfer Measurement

(2) Selective Method

With this method, the detector only measures the selected jitter frequency component (fm) added by the jitter generator (Refer to Figure 2-9) using a corporated selective filter. Because the effect of the residual jitter is small using this method, wide dynamic range measurement can be obtained.

Note: The actual jitter generated in the transmission line is not a single frequency but is composed of a variety of frequencies, so when conducting jitter transfer evaluation it is important to give consideration to the measurement results obtained from the broad-band method. (Refer to Item 2.3.4 Jitter Transfer Measurement). In addition, the selective method is an appropriate method for evaluating the filtering characteristics of the measured equipment's internal retiming circuit.

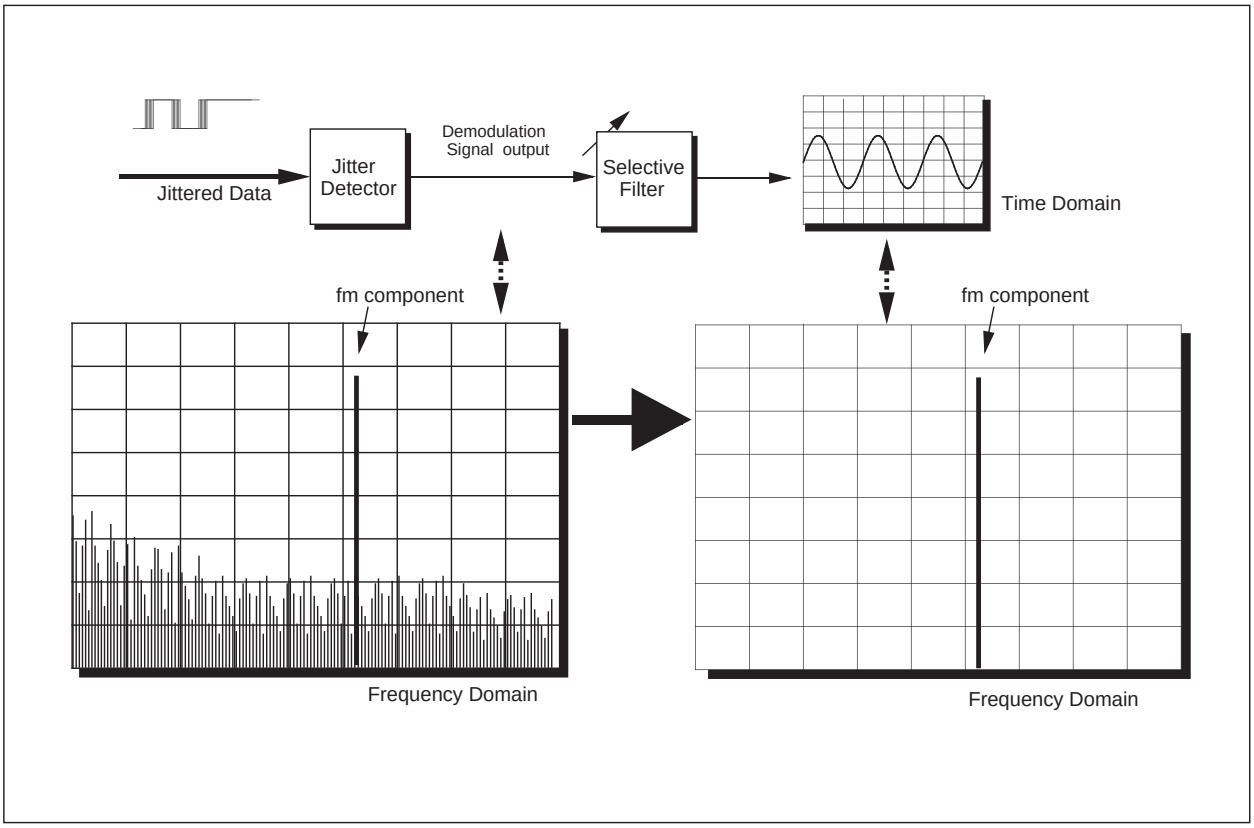


Figure 2-9 Jitter Spectrum of Demodulation Signal by Using Selective Method

2.3.4 Jitter Transfer Measurement

Figure 2-10 shows the above two method measurement results using the ME3620A SDH/SONET analyzer. Figure 2-10 (a) shows the broad-band method measurement results, where the jitter gain seems to be increasing between (A) and (B). Because the jitter gain is found using the 20 LOG (Jout/Jin) as shown in formula (1), while the Jout is keeping a constant value due to the residual jitter, the Jin is decreasing from 1.5 UIpp (A) to 0.15 UIpp (B), the calculated Jitter gain at the 0.15 UIpp measuring point seems 20 dB degraded than that of the 1.5 UIpp point.

Next Figure 2-10 (b) shows the measurement results when more unnecessary jitter components (appropriate to 0.3 UIpp) are included in the measured equipment's output signal. Of note here is that the jitter gain at a jitter frequency higher than that at point (C) is over 0 dB (This is an extreme example but was obtained from an actual evaluation).

Because many unnecessary jitter components were included in the measured equipment's output signal, the total output jitter exceeds the input jitter and the measurement results is therefore obtained as strange phenomenon that the calculated jitter gain exceeds 0 dB at the frequencies where the measurement is performed with a small input jitter — i. e. around point (c) or higher frequencies.

Figure 2-10 (c) shows the measurement results using the selective method for the same measurement as in (b). Although an unnecessary jitter component is included in the measured equipment's output, the effect of the unnecessary jitter component does not show up in the measurement results. From this fact, it is important to refer to the broad-band measurement results for the evaluation of jitter accumulation which is the purpose of jitter transfer measurement.

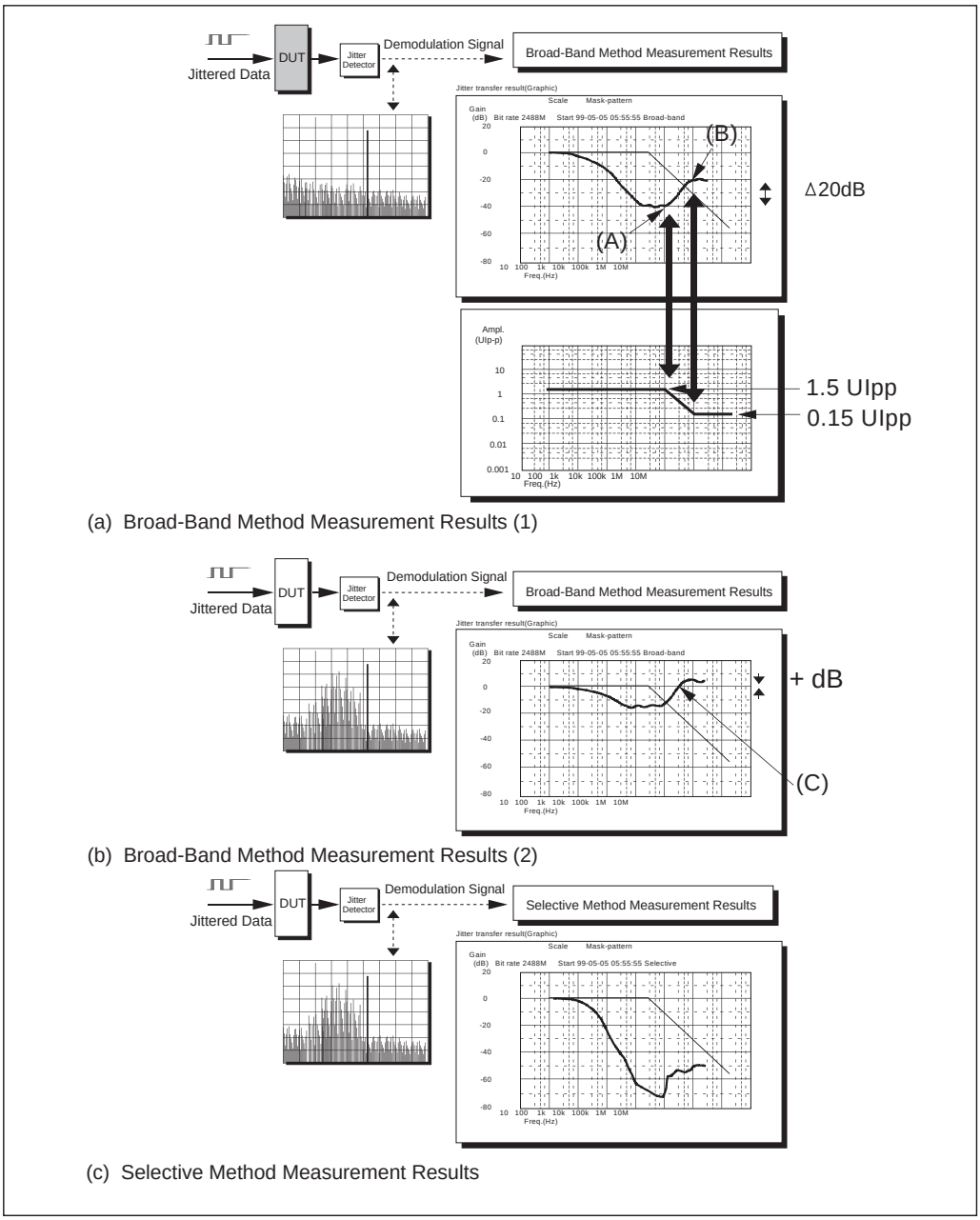


Figure 2-10 Jitter Transfer Results

2.3.5 Selective Method Principles

Following is an explanation of the selective method, which is one of the jitter transfer measurement methods. Figure 2-11 shows a measurement block diagram of the selective method. The jitter generator applies jitter modulation to the source signal at a specified modulation frequency (fm). While, the jitter demodulator demodulates the jitter component (demodulation signal) from the input signal. At this point all other residual (unnecessary) noise components are included in the demodulation signal in addition to the original modulation frequency (fm). Passing through the central frequency (fm)'s BPF, such unnecessary components are removed from the demodulated signal. Taking this BPF output signal as the measured jitter makes it possible to measure the jitter transfer without the influence of the residual jitter.

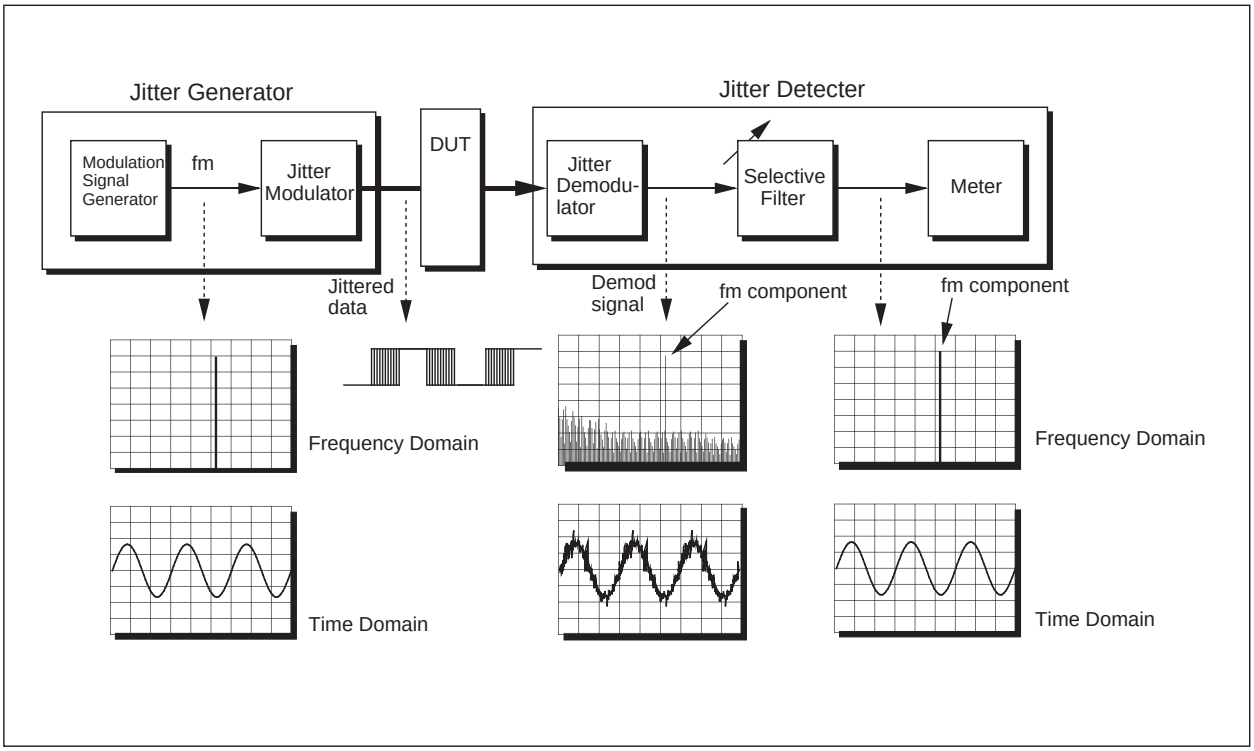


Figure 2-11 Block Diagram of Selective Method

2.3.6 Selective Method Realization

Following is given two representative examples of the selective method realization.

(1) Method Using an External Network Analyzer

Currently, the ITU-T standards O series contains a measurement guide for the jitter transfer measurement selective method which is shown in Supplement 3.8. It does not specify the BPF bandwidth for measuring the jitter frequency mentioned in Item 2.3.5. Here alternatively it recommends using a network analyzer or a spectrum analyzer which can freely change the measuring bandwidth. Figure 2-12 shows a measurement configuration that uses an ME3620A with an MS3401A network analyzer.

Note: When evaluating jitter transfer according to ITU-T G.958 using the configuration in Figure 2-12, especially in the pass range (jitter gain +0.1 dB or less; cf. P.20) the tolerance mask value jitter should be input for an accurate measurement.

When conducting this evaluation, use the MN2402A jitter transfer equalizer shown in Figure 2-12. The MN2402A is an adapter that applies a jitter modulation amount that matches the jitter tolerance mask for the network analyzer's output signal level (constant level).

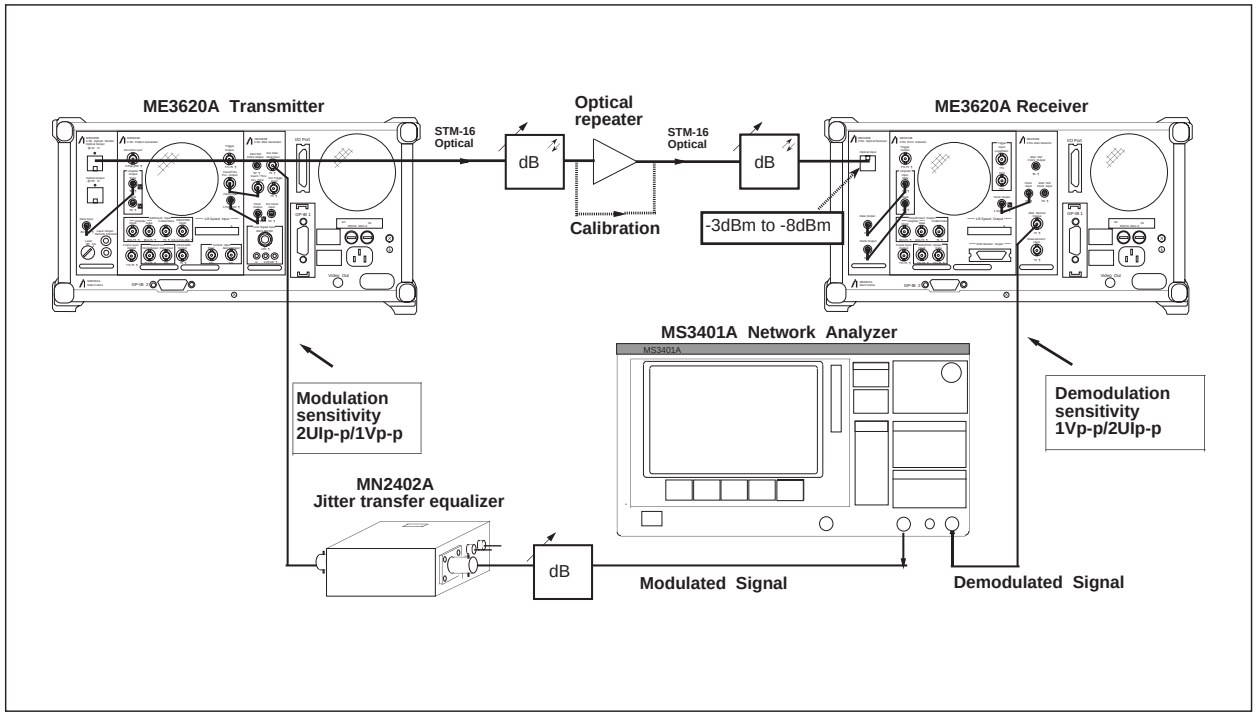


Figure 2-12 Jitter Transfer Measurement by Network Analyzer

(2) ME3520A/ME3620A Jitter Transfer Measurement

(Possible Only with the combination of the ME0303C/D and the ME0313C/D)

The ME3520A/ME3620A SDH/SONET analyzer can measure jitter transfer using the selective method in addition to the broad-band method. Figure 2-13 shows the ME3620A's jitter transfer measurement block. The measurement method is the same as that described in Item 2.3.5. Provided that the bandwidth is 40 Hz when the modulation frequency is 1 kHz or more. When the modulation frequency is less than 1 kHz then the bandwidth is limited as follows:

$0.1\ \text{Hz} \leq \text{BW} \leq 200\ \text{Hz}$ (at $10\ \text{Hz} \leq \text{fm} < 100\ \text{Hz}$)

$20\ \text{Hz} \leq \text{BW} \leq 2\ \text{kHz}$ (at $100\ \text{Hz} \leq \text{fm} < 1\ \text{kHz}$)

BW: Bandwidth (Refer to Figure 2-14)

Note: 1. When measurement error is likely to occur at a measuring frequency of 1 kHz or lower owing to many unnecessary jitter components included in 2 kHz or lower frequency ranges, measurement has to be conducted using an external network analyzer.

2. The MP1550A/B PDH/SDH analyzer and the MP1520B PDH analyzer introduce only the selective method to measure jitter transfer.

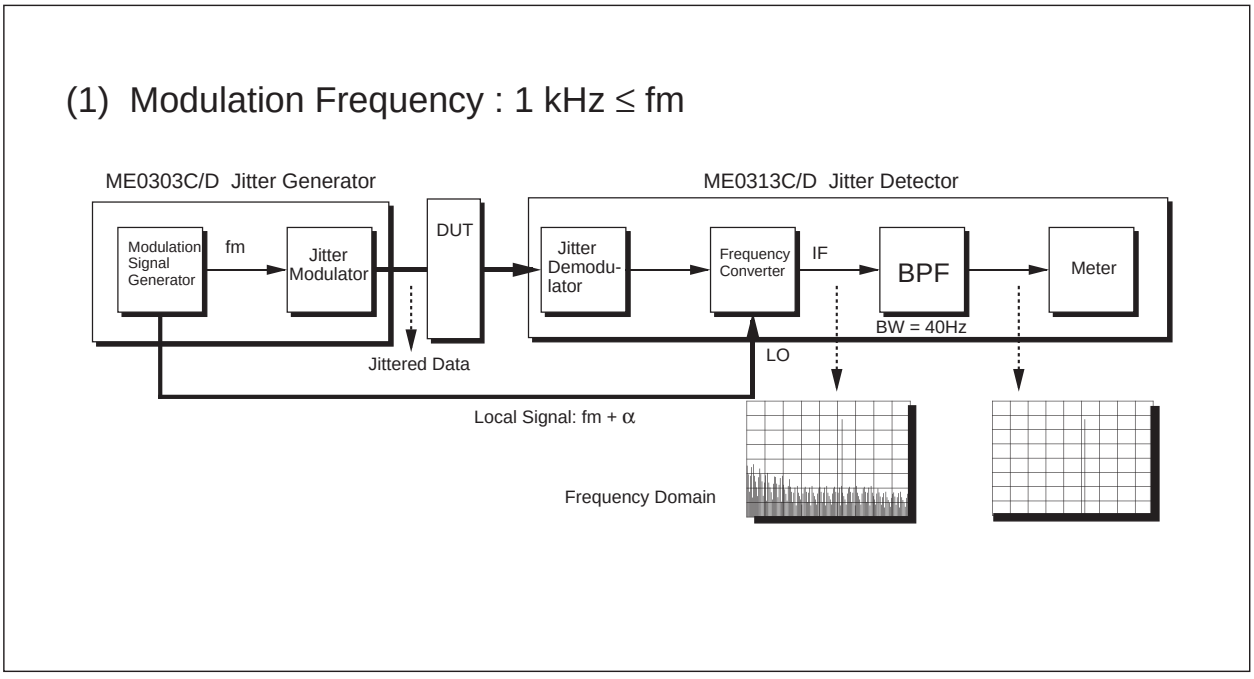
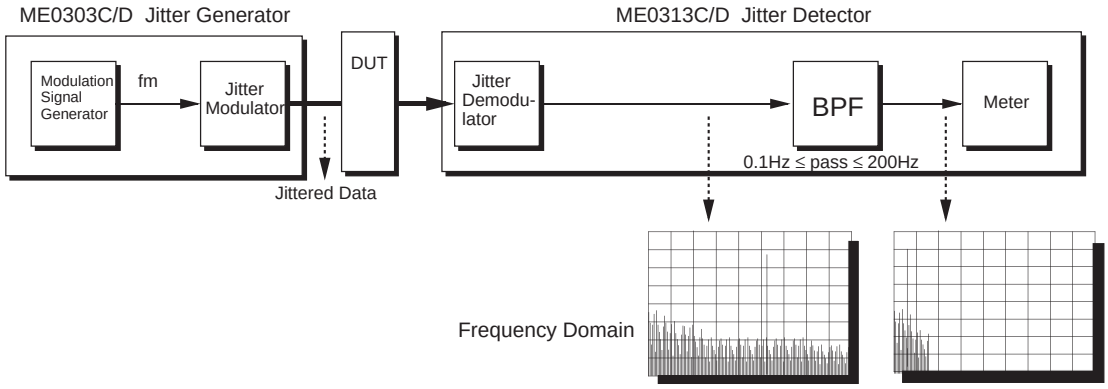


Figure 2-13 Jitter Transfer Measurement Block 1

(2) Modulation Frequency : 10 Hz ≤ fm < 100 Hz



(3) Modulation Frequency : 100 Hz ≤ fm < 1 kHz

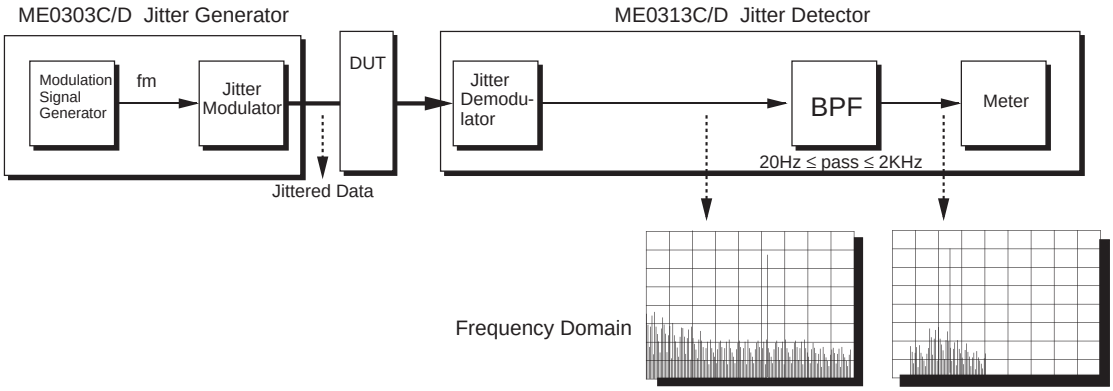


Figure 2-14 Jitter Transfer Measurement Block 2

2.4 Jitter Generation

2.4.1 Jitter Generation

Jitter generation is defined as the jitter amount generated by the measured equipment itself when a signal containing no jitter is input. For SDH/SONET equipment, it is required that the jitter generation be 0.01 UIrms or less when measuring through 12 KHz HPF.

2.4.2 Jitter Generation Measurement

This measurement result must be below 0.01 UIrms for all the bit rates of STM-1 to 16 and OC-1 to 48. However, the jitter measurement upper limit frequency depends on the bit rate (Refer to Figure 2-15) because the amount of jitter influence from the transmitted pattern differs depending on the bit rate. Also, it is necessary to subtract the residual jitter in the transmission pattern from the measurement results. The accumulation differs depending on the type of jitter, but there is no need to consider the accumulation since the jitter generation measurement is carried out for one device. Figure 2-16 and the following procedure shows the compensation of residual jitter arising from the transmitting pattern under this assumption.

(1) Measure the residual jitter of the data output with the configuration in Fig 2-16 (b) with the transmitter jitter modulation off and define the measured value as Y_0.

(2) Change the configuration to the clock interface as shown in Fig 2-16 (a) and generate 1 kHz jitter with the transmitter so that the measured value comes to 0.001 UIrms, then define this value (0.001 UIrms) as X1.

(3) Return to the former configuration in Fig 2-16 (b) keeping the jitter generation unchanged and define the measured value as Y_1.

(4) Continue this operation in the same manner for X2 = 0.002 UIrms, X3 = 0.003 UIrms, ..., and X20 = 0.020 UIrms.

Figures 2-17 and 2-18 show the results of the two types of correction methods for the residual jitter from the pattern. The first method is a simple subtraction using formula (2), and the other is a correction method comparing the pattern jitter to noise using formula (3).

When making corrections using formula (2), the error is large between the results after correction and added jitter (Xn), when n is other than 1, whereas by making corrections using formula (3) we can see that the error is corrected within a maximum of ±0.002 UIrms. In other words, when measuring jitter generation we can obtain the amount of pure jitter generated in a measured device by compensating the residual jitter arising from transmitting pattern using formula (3).

However, this theory is based on the assumption that the cause of the residual jitter is in the measurement side and that the effects from the transmission side are very small.

$$X_{r1n} = Y_n - Y_0 \quad \text{---------- (2)}$$

$$X_{r2n} = \sqrt{Y_n^2 - Y_0^2} \quad \text{---------- (3)}$$

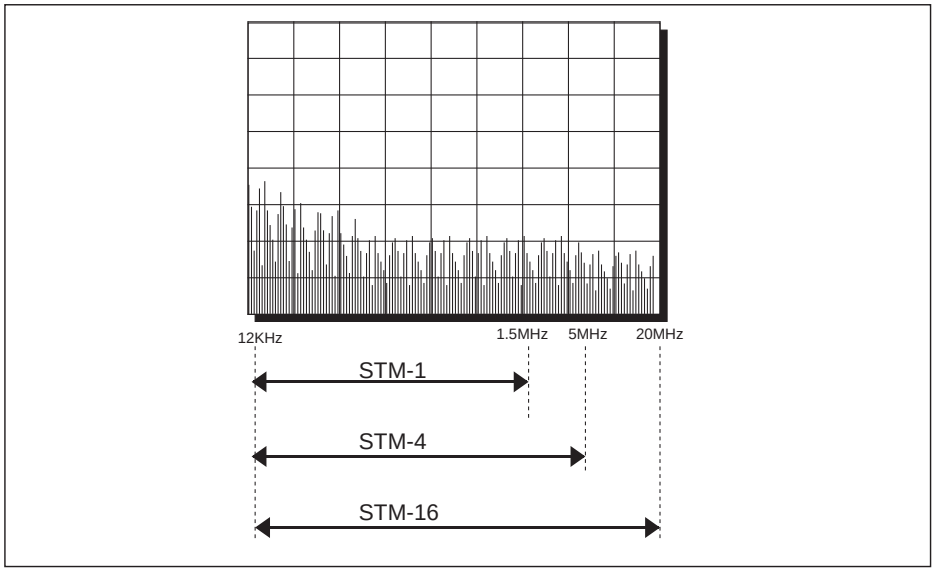


Figure 2-15 Jitter Measurement Bandwidth

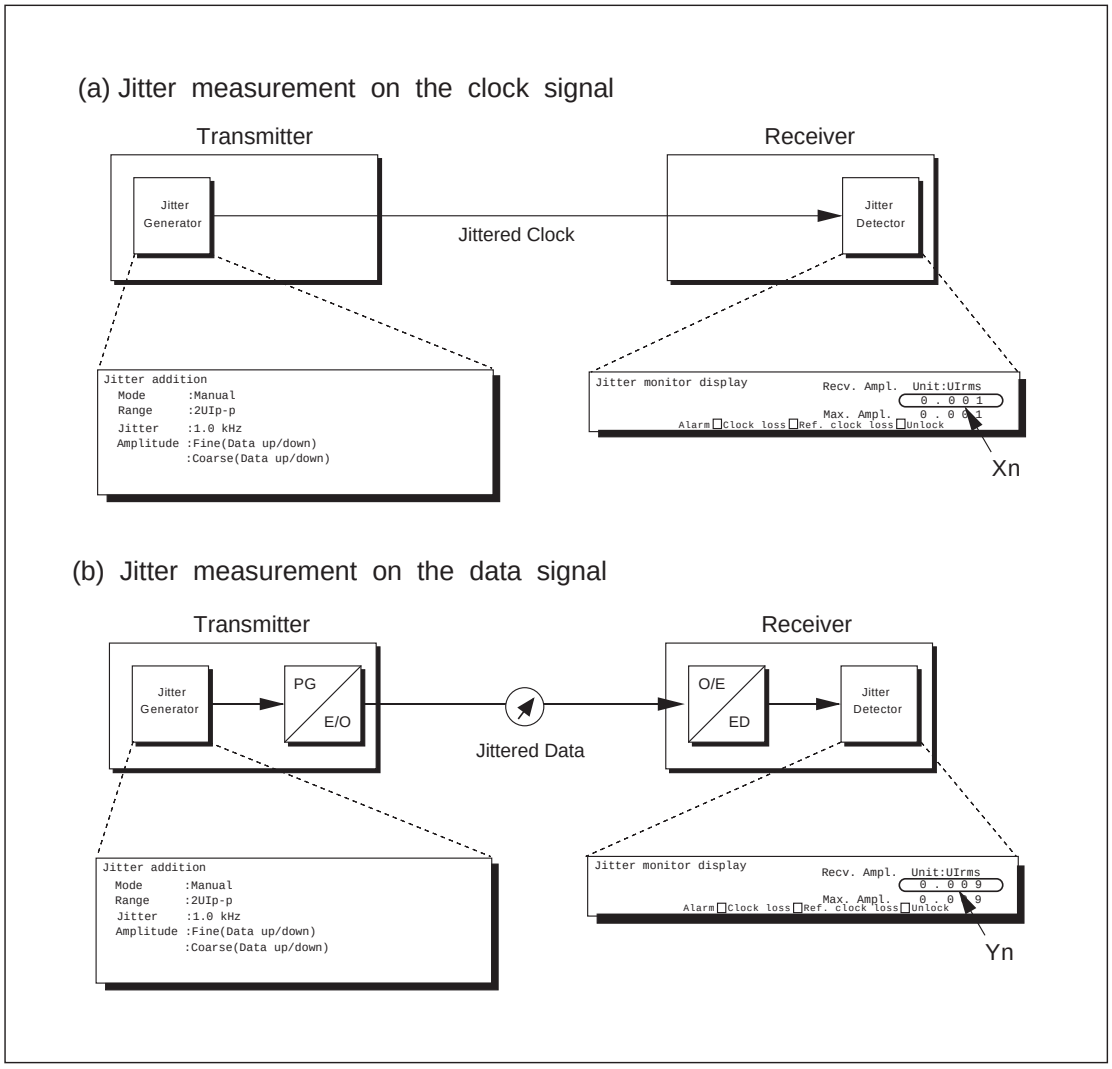


Figure 2-16 Jitter Test Configuration

n	Xn (UIrms)	Yn (UIrms)	$Xr1n = Y_n - Y_0$ (UIrms)	$Xr2n = \sqrt{Y_n^2 - Y_0^2}$ (UIrms)
1	0.001	0.009	0.0000	0.0000
2	0.002	0.009	0.0000	0.0000
3	0.003	0.010	0.0010	0.0044
4	0.004	0.010	0.0010	0.0044
5	0.005	0.010	0.0010	0.0044
6	0.006	0.011	0.0020	0.0063
7	0.007	0.011	0.0020	0.0063
8	0.008	0.012	0.0030	0.0079
9	0.009	0.013	0.0040	0.0094
10	0.010	0.014	0.0050	0.0107
11	0.011	0.014	0.0050	0.0107
12	0.012	0.015	0.0060	0.0120
13	0.013	0.016	0.0070	0.0132
14	0.014	0.017	0.0080	0.0144
15	0.015	0.017	0.0080	0.0144
16	0.016	0.019	0.0100	0.0167
17	0.017	0.019	0.0100	0.0167
18	0.018	0.020	0.0110	0.0179
19	0.019	0.021	0.0120	0.0190
20	0.020	0.022	0.0130	0.0201

Bit rate : STM-16
SDH Internal VC3 Bulk
Y0 = 0.009UIrms

Figure 2-17 Jitter Generation Measurement Data (example)

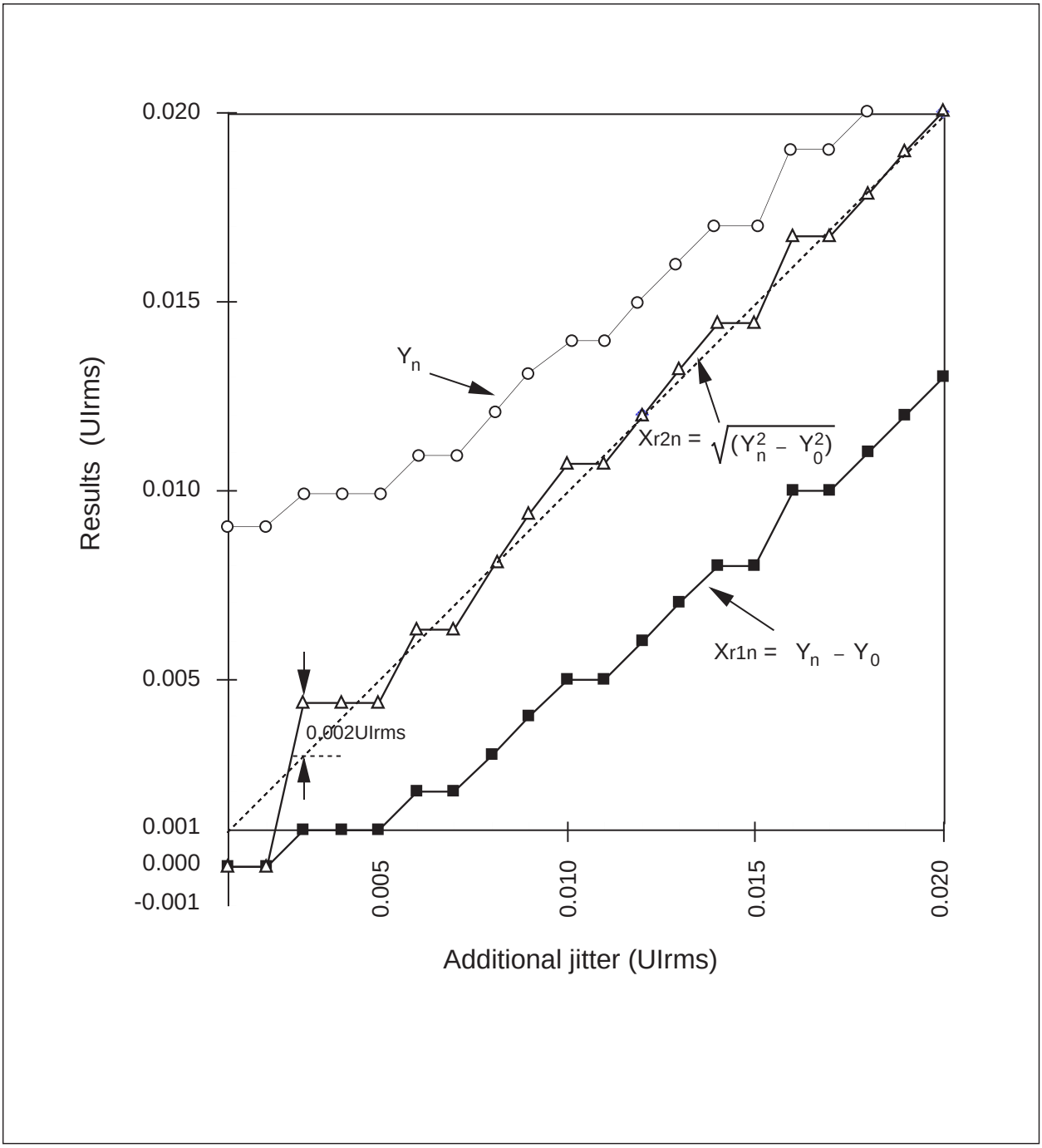


Figure 2-18 Results

2.4.3 ME3520A/ME3620A's rms Jitter Measurement

Figure 2-19 shows the ME3520A/ME3620A's rms jitter measurement block.

The filter limits the measurement frequency band of the demodulated signal coming from the jitter demodulator. The rms (route mean square) measurement circuit measures this filter output using a thermocouple. Here, care must be taken because the average value and the rms value will differ for an AC voltage measurement. In other words, an AC voltmeter measures rms values but the measurement accuracy will vary depending on the distortion of measured waveforms. For example, using the AC voltmeter, the rms values are calculated by multiplying the average value from the detected waves using a sine wave form factor of 1.11, so it is impossible to measure the correct rms value for distorted waveforms, such as rectangular and saw-toothed waves. Figure 2-20 shows several examples of the difference between the rms value and the average value caused from the waveform differences.

Otherwise, a calculation can be made following the rms value definition shown in formula (4). In this case, the sampling data E (t) processing method corresponding to each waveform is required for correct measurement, or else the measurement becomes discontinuous depending on the methods and measurement error therefore may occur.

$$\text{rms Value} = \sqrt{\frac{1}{T}\int_0^T E(t)^2 dt} \quad \text{----------} \quad (4)$$

E (t): Waveform

In short, which method is used to measure the rms value is important in conducting accurate rms jitter measurement.

Anritsu's rms jitter measurement performs accurate and continuous rms value measurement via heat using a thermocouple.

Note: The MP1550A/B PDH/SDH analyzer's rms jitter measurement also uses the measurement method via heat.

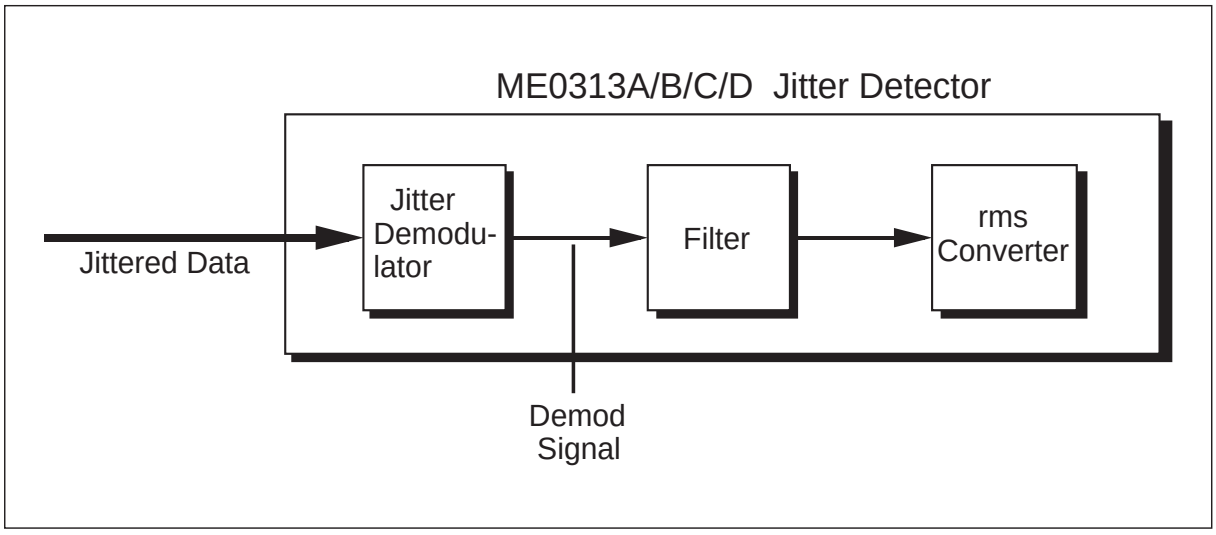


Figure 2-19 rms Jitter Measurement Block

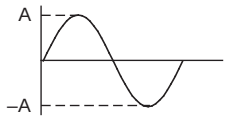
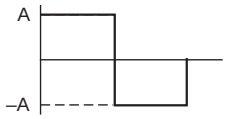
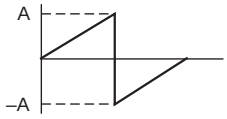
Type	Wave Form	rms Value	Average Value	Form Factor $\left(=\frac{\text{rms Value}}{\text{Average Value}}\right)$
Sine Wave		$\frac{A}{\sqrt{2}}=0.707A$	$\frac{2}{\pi}A=0.637A$	1.11
Rectangular Wave		A	A	1
Saw-toothed Wave		$\frac{A}{\sqrt{3}}=0.577A$	$\frac{A}{2}=0.5A$	1.15

Figure 2-20 rms Values and Average Values

2.5 Mapping Jitter

2.5.1 Mapping Jitter Standards

Figure 2-21 shows the ITU-T G.783 mapping jitter standards. The jitter arising from mapping of the measured device must be below the values shown in the ITU-T G.783 Table 6-1 Maximum Mapping Jitter.

Note: Tributary mapping jitter is measured in the absence of pointer adjustments.

Table 6-1/G.783 Mapping jitter generation specification

G.703 interface	Filter characteristics			Maximum pk-pk jitter	
	f1 high pass	f3 high pass	f4 low pass	mapping	
				f1-f4	f3-f4
2 048 kbit/s	20Hz	18kHz	100kHz	(Note 1)	0.075
34 368 kbit/s	100Hz	10kHz	800kHz	(Note 1)	0.075
139 264 kbit/s	200Hz	10kHz	3.5MHz	(Note 1)	0.075

Note 1-For further study.

Figure 2-21 ITU-T G.783 Mapping Jitter

2.5.2 Mapping Jitter Measurement

Figure 2-22 shows the mapping jitter measurement configuration using the MP1550A/B PDH/SDH analyzer. Turn off the jitter generation function of the transmitter and input the test signal into the ADM (Add Drop Multiplexer). Then measure jitter in the desynchronized output signal using the receiver.

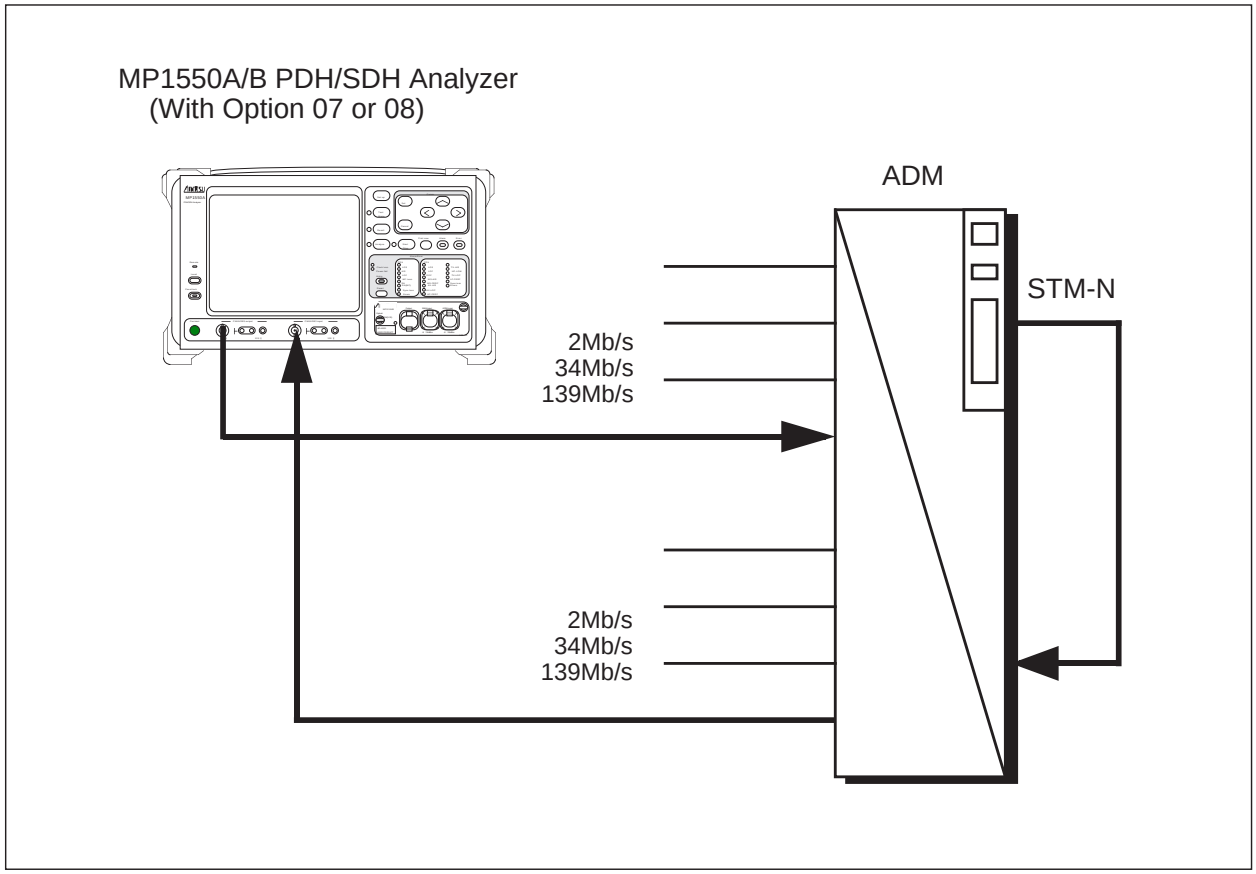


Figure 2-22 Mapping Jitter Measurement

2.6 Combined Jitter

2.6.1 Combined Jitter Standards

Figure 2-23 shows the ITU-T G.783 combined jitter standards. The jitter arising from the pointer action of the measured equipment must be below the ITU-T G.783 Table 6-2 Maximum Combined Jitter values.

Table 6-2/G.783 Combined jitter generation specification

G.703 interface	Sequence (Note 1)	Time Interval			Filter characteristics			Maximum pk-pk jitter	
					f1 high pass	f3 high pass	f4 low pass	combined	
		T1	T2	T3				f1-f4	f3-f4
2 048 kbit/s	B,D,E	10s	750ms	2ms	20Hz	18kHz	100kHz	0.4	0.075
34 368 kbit/s	B,D,E	10s	34ms	0.5ms	20Hz	10kHz	800kHz	0.4	0.075
	C	10s	34ms	0.5ms	100Hz	10kHz	800kHz	0.75	0.075
139 264 kbit/s	B,D,E	10s	34ms	0.5ms	200Hz	10kHz	3.5MHz	0.4	0.075
	C	10s	34ms	0.5ms	200Hz	10kHz	3.5MHz	0.75	0.075

Note 1 :

B : Single Pointers of Opposite Polarity

C : Double Pointers of Opposite Polarity

D : Regular Pointers with One Missing Pointer

E : Regular Pointers Plus One Double Pointer

Figure 2-23 ITU-T G.783 Combined Jitter

2.6.2 Pointer Test Sequence for Combined Jitter Measurement

The pointer action sequence used to evaluate combine jitter is as follows. (Refer to Figure 2-24)

(B) Single Pointers of Opposite Polarity

(C) Double Pointers of Opposite Polarity

(D) Regular Pointers with One Missing Pointer

(E) Regular Pointers Plus One Double Pointer

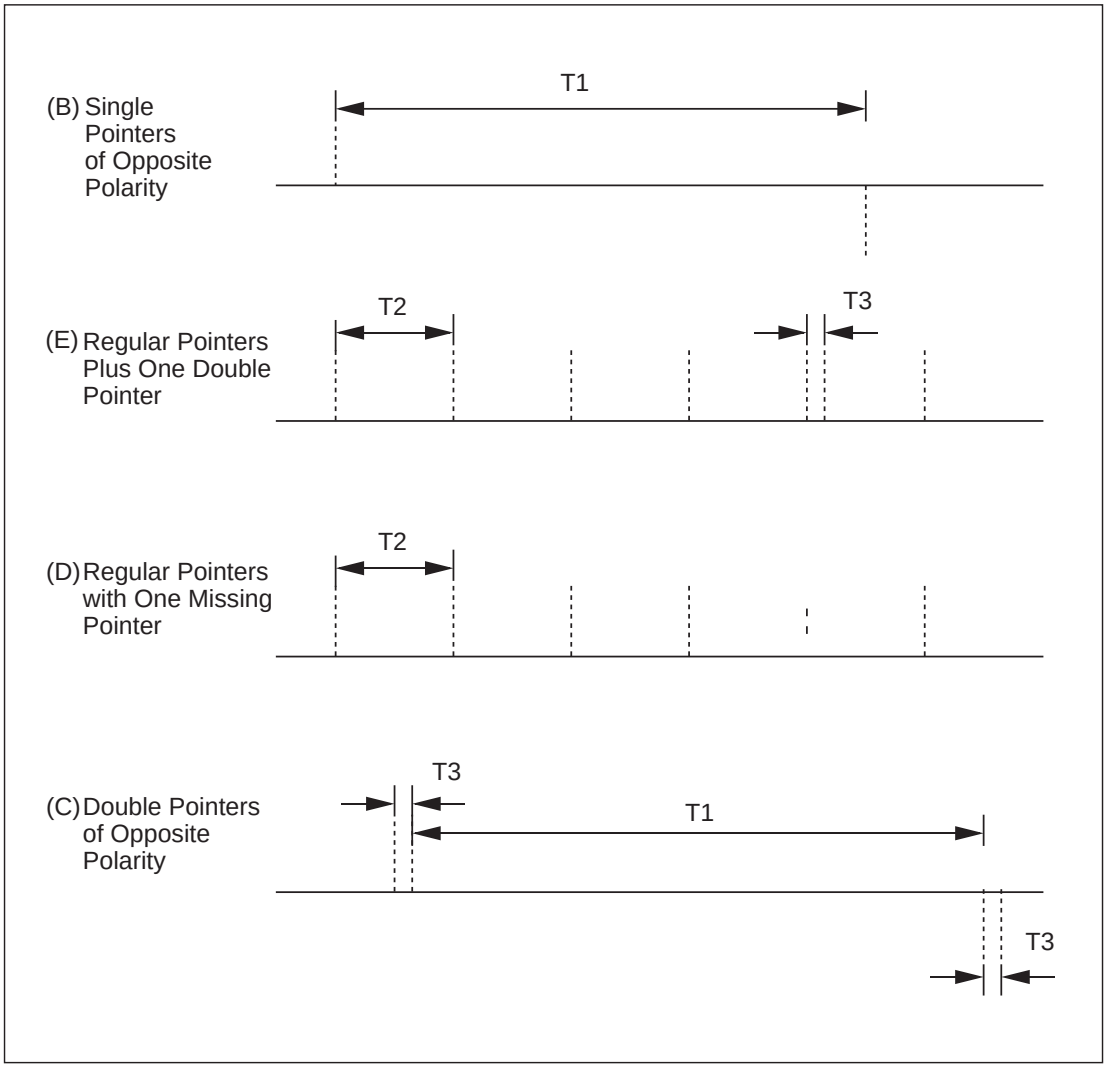


Figure 2-24 ITU-T G.783 Pointer Test Sequence

2.6.3 Combined Jitter Measurement

Figure 2-25 shows the combined jitter measurement configuration using an MP1550A/B PDH/SDH analyzer. Turn off the jitter generation function of the transmitter and input the test signal into the ADM (Add Drop Multiplexer) while measuring jitter in the tributary signal using the receiver. Where, setting the instrument to coupled function on makes the jitter measurement synchronized with the pointer sequence cycle. In addition, make the ADM and the MP1550A/B synchronized to the 2 MHz DCS signal in order to prevents any pointer adjustment generation other than that of by the MP1550A/B.

Note: 1. The phase relation between the pointer action cycle and the jitter measurement cycle when coupled measurement is on is as shown in Figure 2-26.

2. The jitter on the tributary signal arising from the pointer action differs in the phase change direction depending on the positive justification and the negative justification as shown in Figure 2-26. The jitter measurement instrument must correctly measure these phase changes.

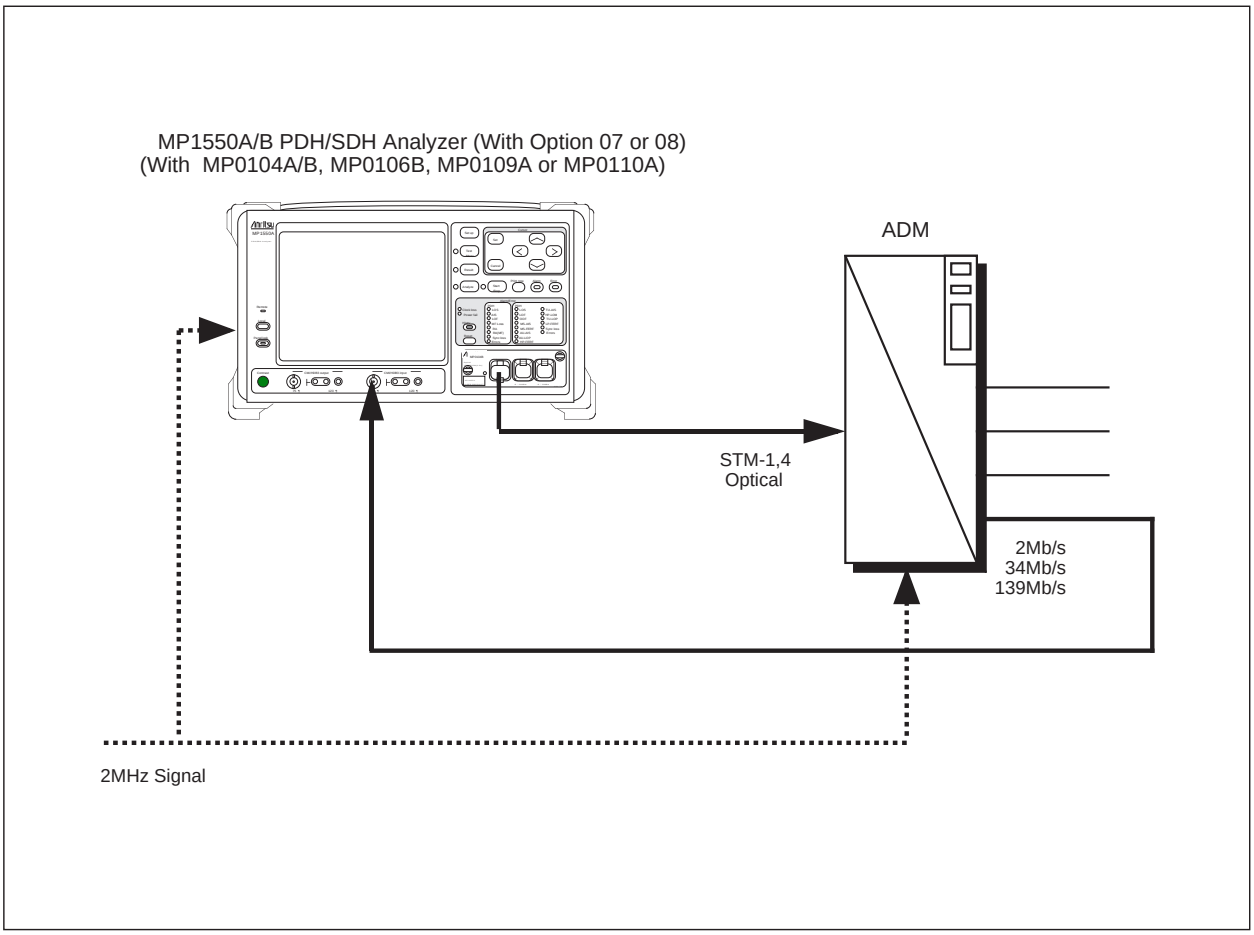


Figure 2-25 Combined Jitter Measurement

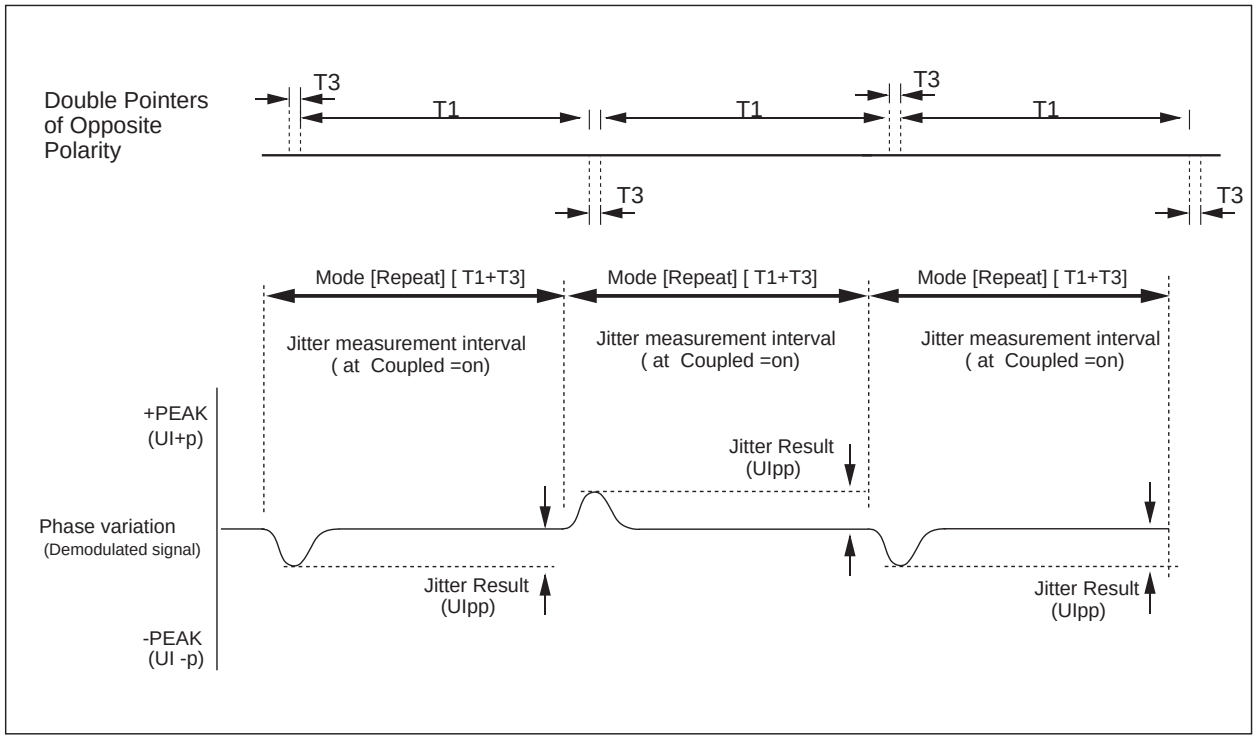


Figure 2-26 Measurement Timing

3. Jitter Calibration

3.1 Jitter Generator Calibration

Generally the calibration for the phase modulation (PM) makes use of a Bessel null point. This method uses the characteristic that when a sine wave phase modulation deviation varies, the output carrier level changes according to the deviation as the function curve shown in Fig. 3-1. Using a spectrum analyzer, it calibrates the jitter modulation deviation at the function curve zero (Bessell null point). It allows accurate calibration for large jitter modulations that exceed 1 UI without any effect on the spectrum analyzer's linearity. Figure 3-2 shows an actually observed spectrum at the Bessel null point. In addition, Figure 3-3 shows the jitter amount for a Bessel null of 1 to 20 (carrier signal).

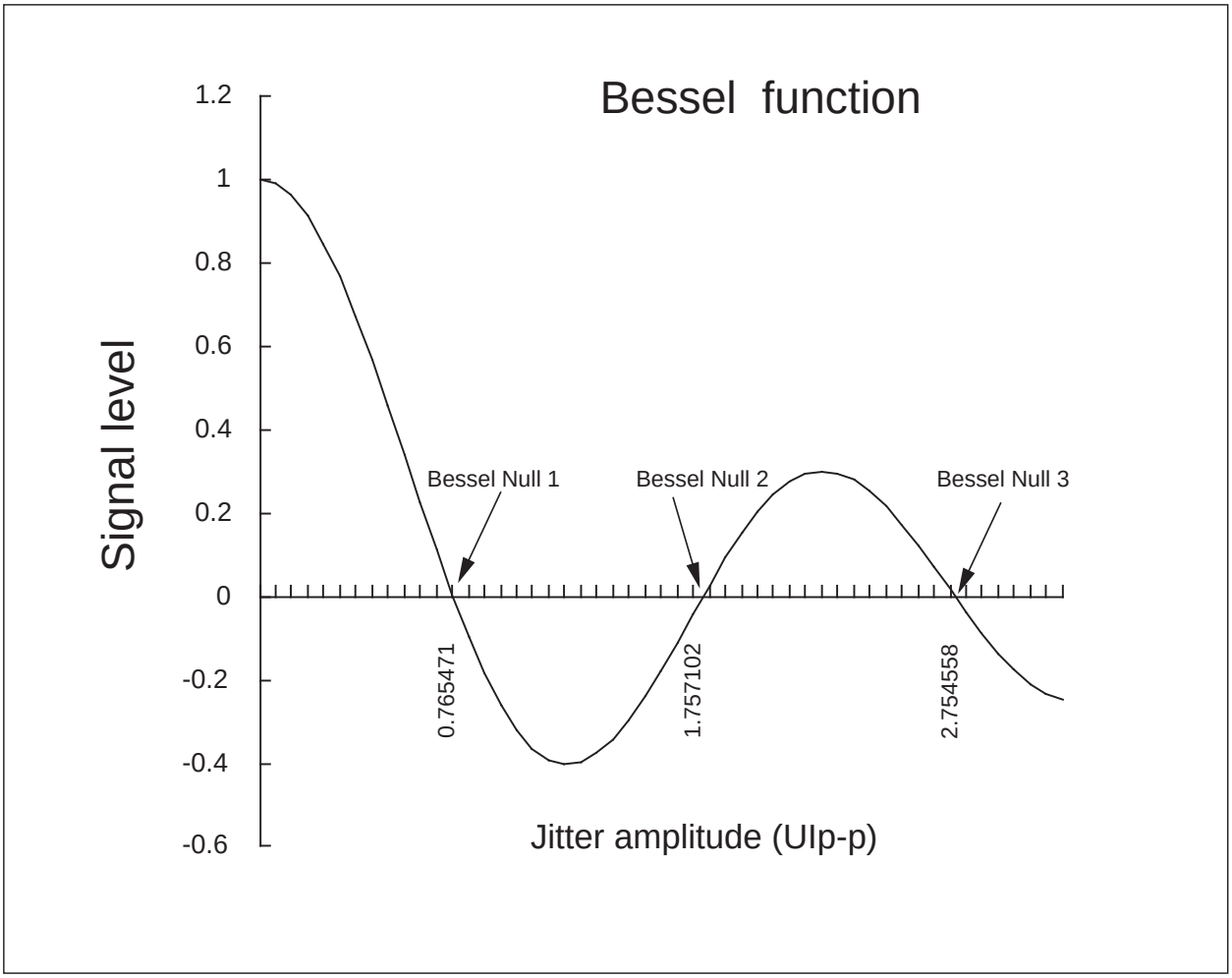


Figure 3-1 Bessel Function

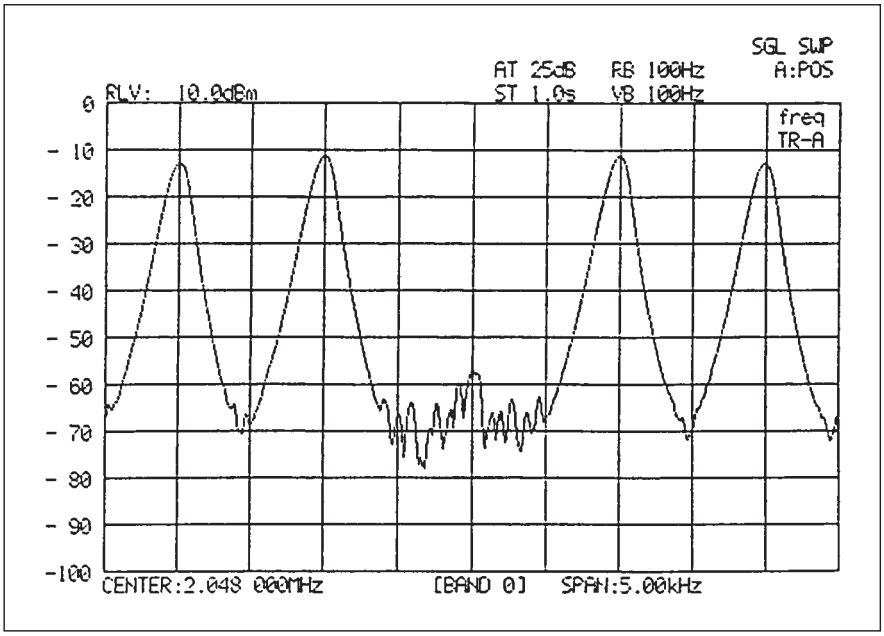


Figure 3-2 Bessel Null Spectrum

Bessel Null No.	Modulation index (rad)	Jitter amplitude (UIpp)
1	2.4048	0.76547161
2	5.5201	1.75710240
3	8.6537	2.75455826
4	11.7915	3.75335102
5	14.9309	4.75265308
6	18.0711	5.75220978
7	21.2116	6.75186198
8	24.3525	7.75164150
9	27.4935	8.75145286
10	30.6346	9.75129604
11	33.7758	10.75117105
12	36.9171	11.75107790
13	40.0584	12.75098474
14	43.1998	13.75092342
15	46.3412	14.75086210
16	49.4826	15.75080077
17	52.6240	16.75073945
18	55.7655	17.7507996
19	58.9070	18.75068047
20	62.0485	19.75065097

Figure 3-3 Bessel Null 0 to 20 (Carrier Signal)

3.2 Jitter Detector Calibration

The jitter generator calibrated using the method in Item 3.1 can be used for detector calibration. Where, a clock signal is used to prevent the influence of the pattern.

4. Wander

4.1 Wander

Wander is a slow phase variation at a variation frequency (wander frequency) of DC to about 10 Hz. Unlike jitter it requires a wide measurement range (20 UIpp or more). In addition, "nsec" is used for the wander measurement unit.

4.2 Wander Measurement

Figure 4-1 shows the 2 Mb/s wander measurement configuration with an MP1550A/B PDH/SDH analyzer. As shown in Figure 4-2, wander measurement is based on the phase between two signals when measurement is begun. The TIE (Time Interval Error) shows the phase difference from the measurement start time and is shown as the + peak and the - peak which represent the plus maximum phase variation amount and the minus maximum phase variation amount for the phase when measurement is begun. In addition, peak to peak is the peak to peak fluctuation amount for the base signal of the measured signal.

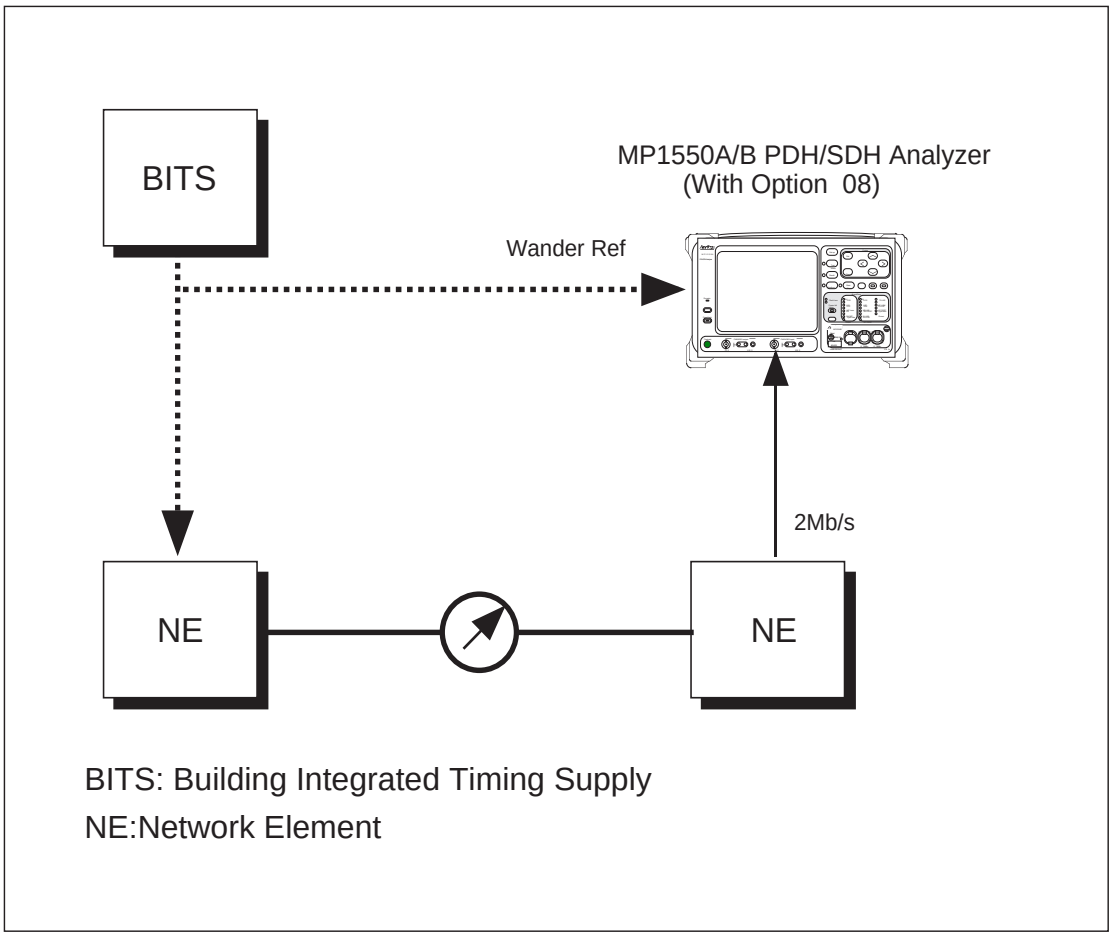


Figure 4-1 Wander Measurement

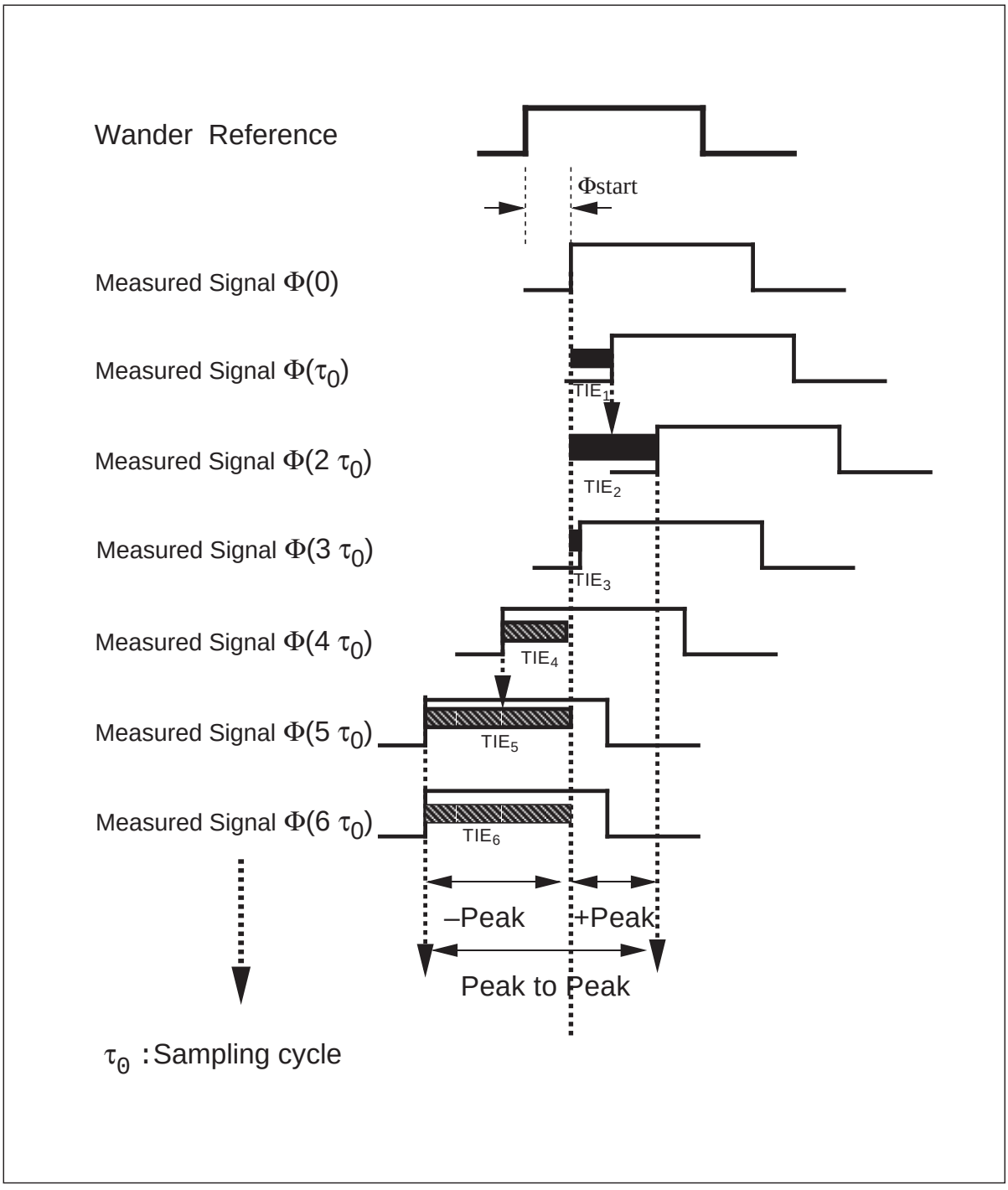


Figure 4-2 TIE (Time Interval Error)

5. Jitter/Wander Measuring Instrument

5.1 Jitter/Wander Measuring Instrument

As shown in Figure 5-1, Anritsu supplies jitter and wander measuring instruments that cover the complete range from PDH to SDH/SONET.

(1) When only PDH is required : MP1520B PDH analyzer

(2) When PDH/SDH are required : MP1550A/B PDH/SDH analyzer

(3) When SDH/SONET are required : ME3620A/ME3520A SDH/SONET analyzer

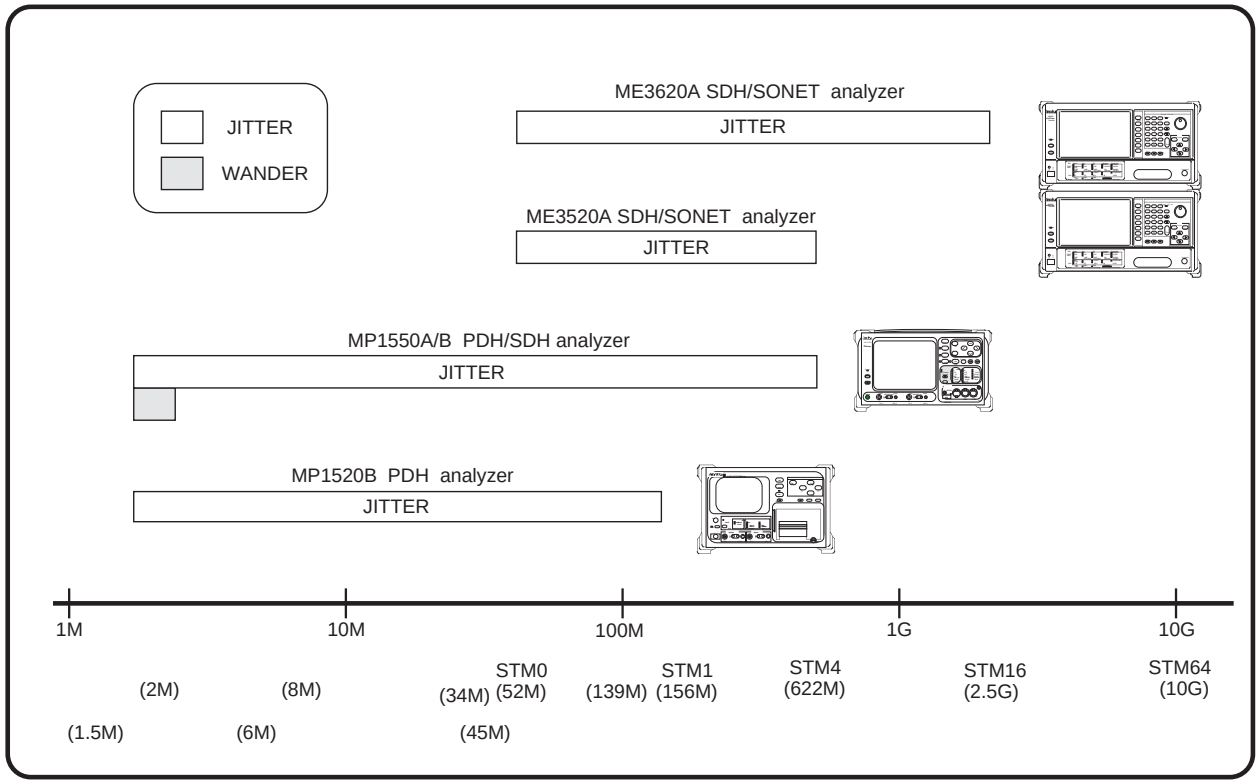


Figure 5-1 PDH/SDH Jitter/Wander Measuring Instruments

6. Jitter Measurement Guide for ME3520A/ME3620A

● Connection The connection is as follows:

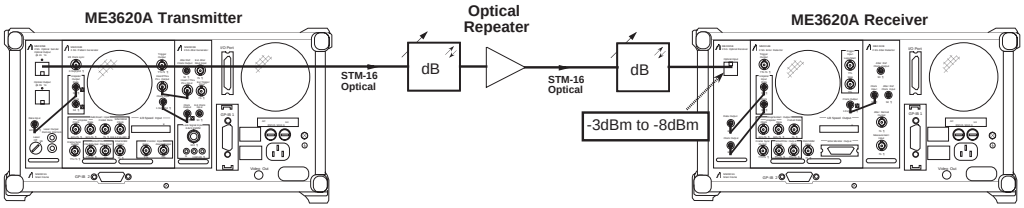


Fig. 6-1-1 Cable Connection

Note: Make sure that the optical input/output power of the equipment matches that of the transmitter/receiver.

● Settings ◇ The setting of transmitter is as follows:

- Sets the Jitter to "OFF".

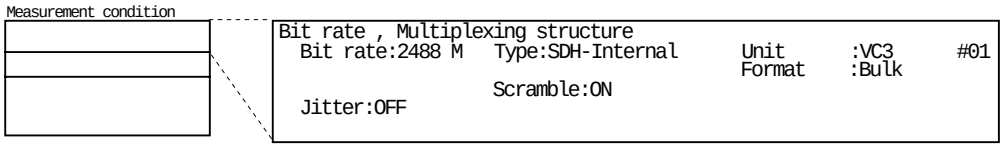


Fig. 6-1-2 Transmitter Setting

◇ The setting of receiver is as follows:

- Sets the optical band width to "Wide"

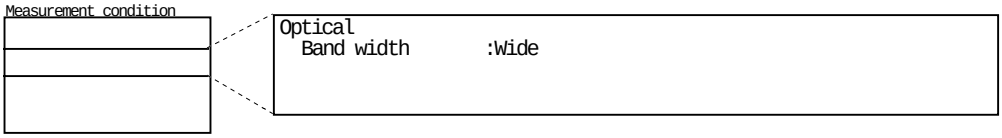


Fig. 6-1-3 Receiver Setting

- Sets the mode of jitter condition to "Amplitude".
- Sets the internal filter of jitter condition to "12kHz<pass".
- Sets the unit of jitter monitor to "UIrms".

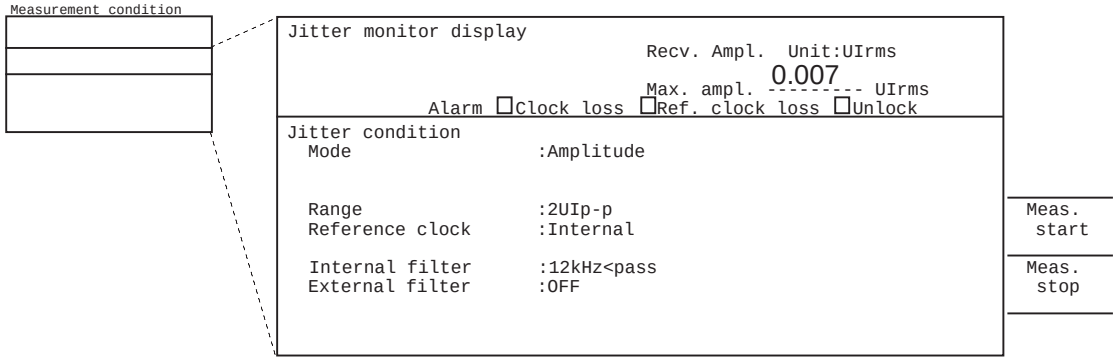


Fig. 6-1-4 Receiver Setting

● Measurement ◇ The measured result is displayed in the following screen.

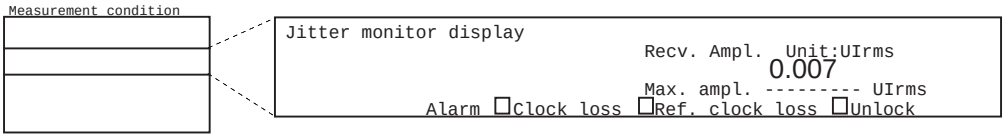


Fig. 6-1-5 Monitor Screen

Reference Standard ITU-T G.958

Jitter Generation: ≤ 0.01 UIrms

6.2 Output Jitter (ITU-T G.825) Measurement Example (1/2)
(for optical interface)

● Connection The connection is as follows:

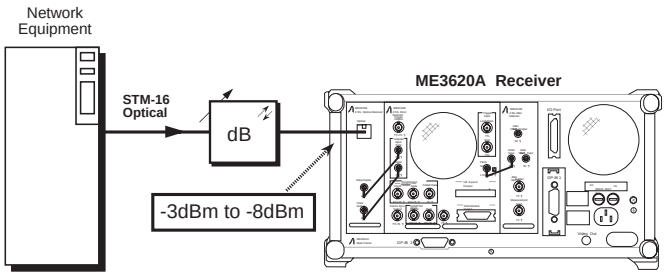


Fig. 6-2-1 Cable Connection

Note: Make sure that the optical output power of the equipment matches that of the input power range of the receiver.

● Setting ◇ The setting of the receiver is as follows:

- Sets the optical band width to "Wide".

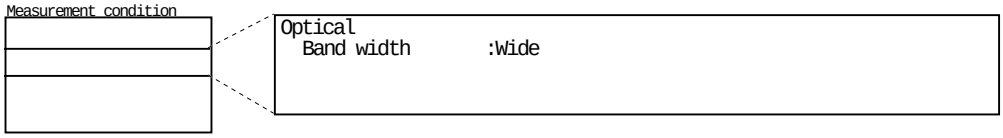


Fig. 6-2-2 Receiver Setting

- Sets the mode of jitter condition to "Amplitude".
- Sets the internal filter of jitter condition to "5kHz<pass<20MHz" or "1.0MHz<pass<20MHz".
- Sets the unit of jitter monitor to "UIp-p".

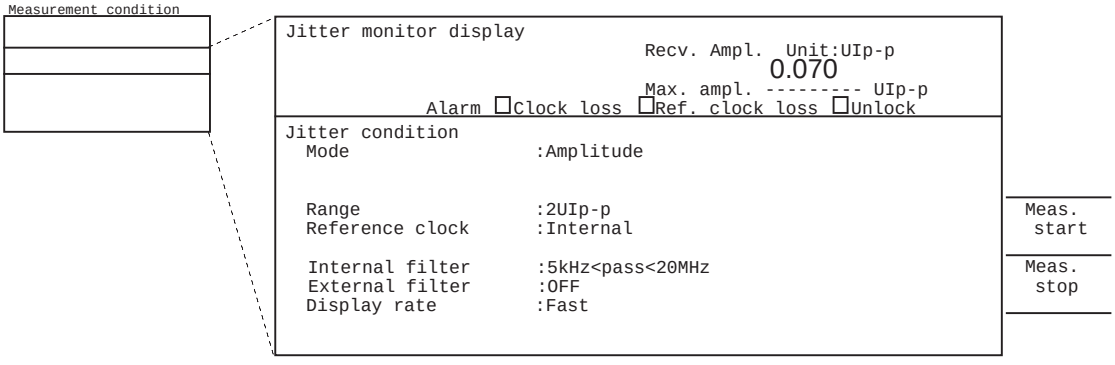


Fig. 6-2-3 Receiver Setting

- Sets the meas. time of measurement setting to "00-00:01:00".

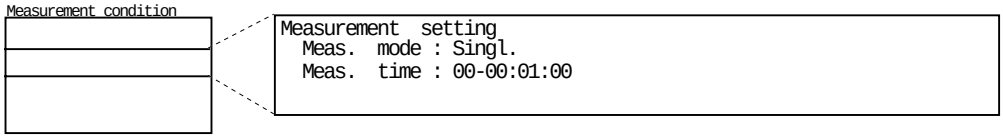


Fig. 6-2-4 Receiver Setting

6.2 Output Jitter (ITU-T G.825) Measurement Example (2/2)
(for optical interface)

● Measurement The measurement is started by pressing the Meas. start function key.

The measured result is displayed as Max. ampl. in the jitter monitor screen after a measurement period.

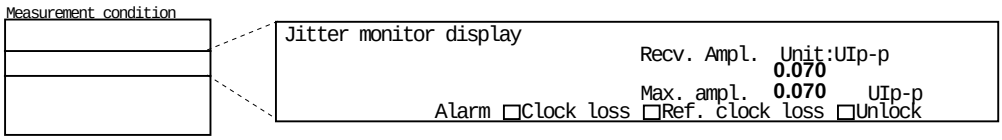


Fig. 6-2-5 Monitor Screen

Reference Standard ITU-T G.825

Table-1/G.825 SDH Network Interface Output Jitter Specification Parameters

STM Level	Bandpass filter cut-off f1-f4	Bandpass filter cut-off f3-f4
STM-1	500Hz<pass<1.3MHz	65kHz<pass<1.3MHz
STM-4	1kHz<pass< 5MHz	250kHz<pass<5MHz
STM-16	5kHz<pass<2	1MHz<pass<20MHz
Output Jitter	≤ 1.5 UIp-p	≤ 0.15 UIp-p

6.3 Output Jitter (ITU-T G.825) Measurement Example (1/2) (for electrical interface)

● Connection The connection is as follows:

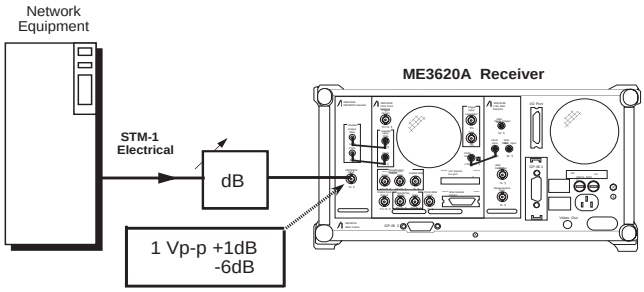


Fig. 6-3-1 Cable Connection

● Setting ◇ The setting of the receiver is as follows:

- Sets the bit rate to "156M".
- Sets the input code to "CMI" .

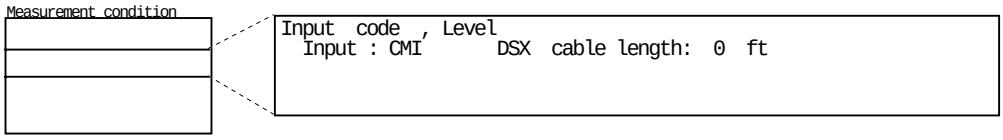


Fig. 6-3-2 Receiver Setting

- Sets the mode of jitter condition to "Amplitude".
- Sets the internal filter of jitter condition to "500Hz<pass<1.3MHz" or "65kHz<pass<1.3MHz".
- Sets the unit of jitter monitor to "UIp-p".

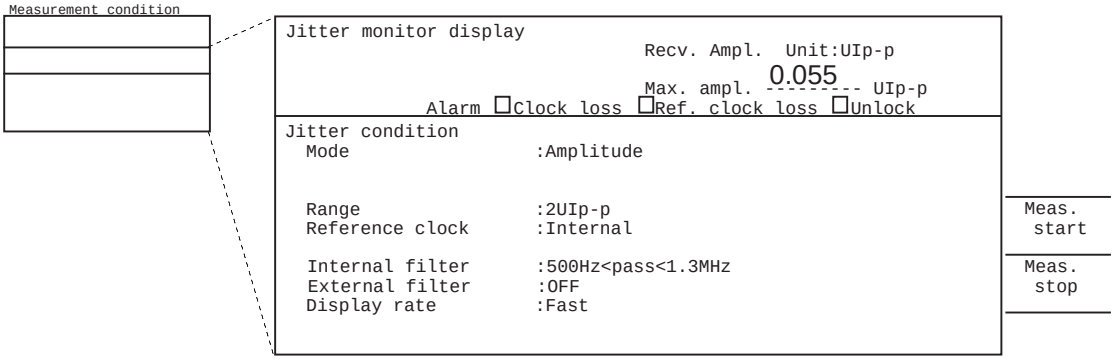


Fig. 6-3-3 Receiver Setting

- Sets the meas. time of measurement setting to "00-00:01:00".

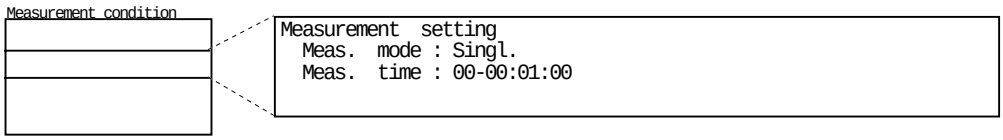


Fig. 6-3-4 Receiver Setting

6.3 Output Jitter (ITU-T G.825) Measurement Example (2/2) (for electrical interface)

● Measurement The measurement is started by pressing the Meas. start function key.

- The measured result is displayed as Max. ampl. in the jitter monitor screen after a measurement period.

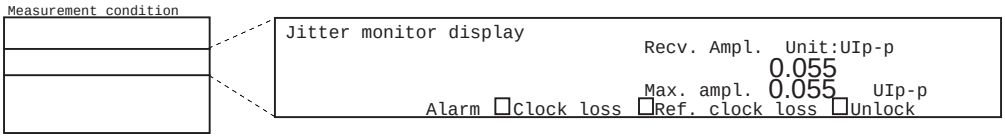


Fig. 6-3-5 Monitor Screen

Reference Standard ITU-T G.825

Table-1/G.825 SDH Network Interface Output Jitter Specification Parameters

STM Level	Bandpass filter cut-off f1-f4	Bandpass filter cut-off f3-f4
STM-1	500Hz<pass<1.3MHz	65kHz<pass<1.3MHz
Output Jitter	≤ 1.5 UIp-p	≤ 0.15 UIp-p

6.4 Jitter Tolerance (ITU-T G.958) Measurement Example (1/3)
(Measurement with errors specified)

● Connection The connection is as follows:

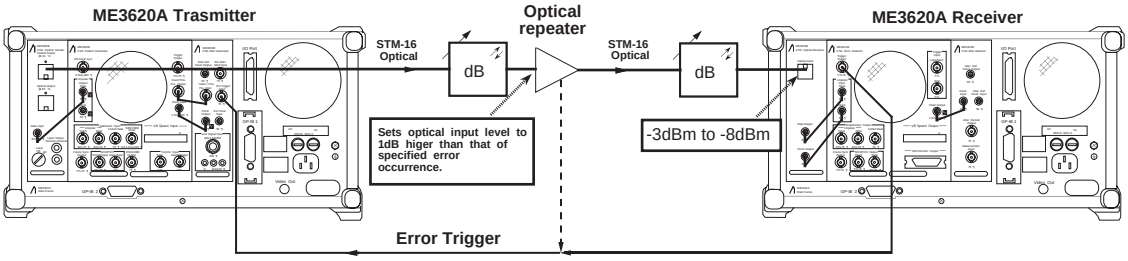


Fig. 6-4-1 Cable Connection

Note: Input an optical output power that is attenuated by an attenuator to the device from the transmitter. Set the optical input level to a 1dB higher level than the minimum level of specified error occurrence.

● Setting ◇ The setting of the transmitter is as follows:

- Sets the Jitter to "ON".
- Sets the mode of jitter addition to "Jitter tolerance".

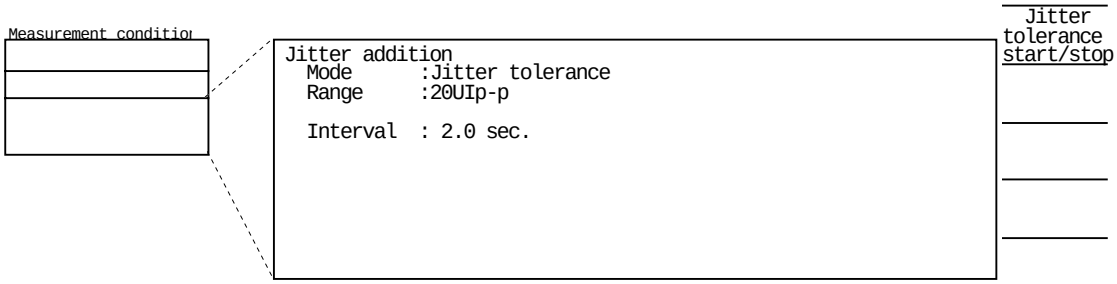


Fig. 6-4-2 Transmitter Setting

Note: Set an interval of 2 seconds or more to effect measurement with errors specified. An interval setting of less than 2 seconds would disable the correct measurement.

- Sets the jitter tolerance table.

Jitter tolerance table

Bit rate:2488 M Decade-point-set Print-out
Range :20UIp-p Decade point : 9
Number of table:49

No	Hz	No	Hz	No	Hz	No	Hz
1	10.0	19	1.0 k	37	100.0 k	55	2.0 M
2	13.0	20	1.3 k	38	130.0 k	56	2.0 M
3	17.0	21	1.7 k	39	170.0 k	57	2.0 M
4	22.0	22	2.2 k	40	220.0 k	58	2.0 M
5	28.0	23	2.8 k	41	280.0 k	59	2.0 M
6	36.0	24	3.6 k	42	360.0 k	60	2.0 M
7	46.0	25	4.6 k	43	460.0 k	61	2.0 M
8	60.0	26	6.0 k	44	600.0 k	62	2.0 M
9	77.0	27	7.7 k	45	770.0 k	63	2.0 M
10	100.0	28	10.0 k	46	1.0 M	64	2.0 M
11	130.0	29	13.0 k	47	1.3 M	65	2.0 M
12	170.0	30	17.0 k	48	1.7 M	66	2.0 M
13	220.0	31	22.0 k	49	2.0 M	67	2.0 M
14	280.0	32	28.0 k	50	2.0 M	68	2.0 M
15	360.0	33	36.0 k	51	2.0 M	69	2.0 M
16	460.0	34	46.0 k	52	2.0 M	70	2.0 M
17	600.0	35	60.0 k	53	2.0 M	71	2.0 M
18	770.0	36	77.0 k	54	2.0 M	72	2.0 M

Fig. 6-4-3 Transmitter Setting

6.4 Jitter Tolerance (ITU-T G.958) Measurement Example (2/3)
(Measurement with errors specified)

◇ The setting of the receiver is as follows:

• Sets the optical band width to "Wide".

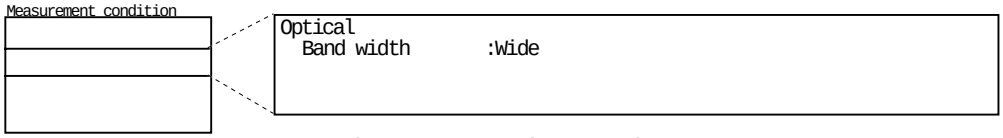


Fig. 6-4-4 Receiver Setting

• Sets the Output trigger to "1 sec error" for example "Info. bit" and the threshold "Error count >100".

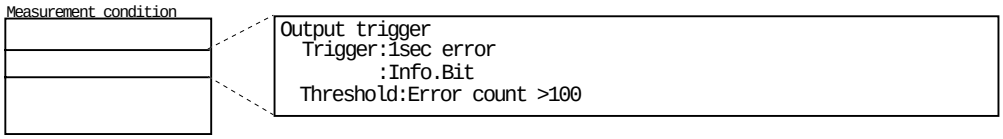


Fig. 6-4-5 Receiver Setting

Note:
1. When an error signal occurs in the device, this error signal can be connected to the external trigger input on the ME0303A/B/C/D. However, verify that the error signal output of the device matches the interface of the trigger signal input.
2. When the error signal response is delayed, a longer interval for the transmitter jitter addition screen is required.
3. The output trigger of 1 sec errors is possible using system-soft Ver. 3.0 or later.

● Measurement The measurement is started by pressing the Jitter tolerance start/stop function key.

Such jitter output and position can be monitored in the following screen.

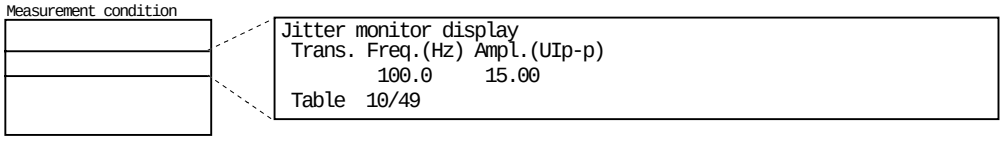
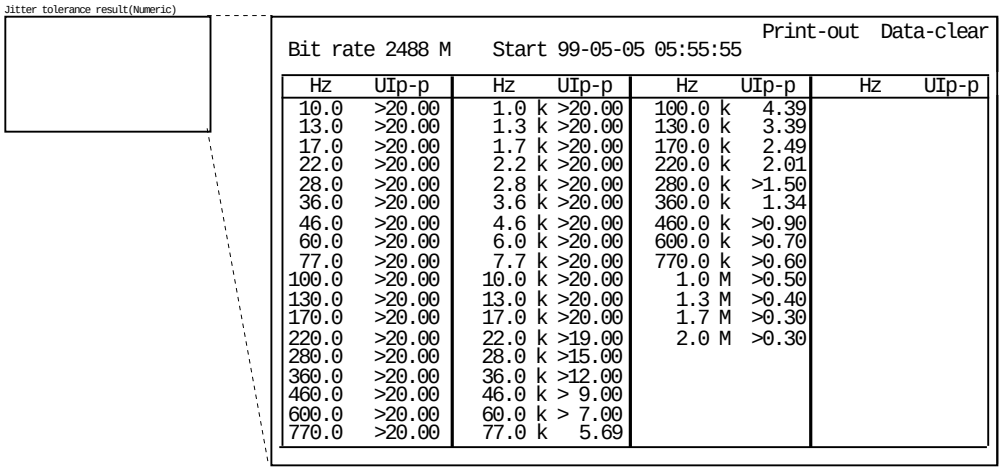


Fig. 6-4-6 Transmitter Setting

In addition, the tolerance result can be checked using the following screen.



Hz	UIp-p	Hz	UIp-p	Hz	UIp-p	Hz	UIp-p
10.0	>20.00	1.0 k	>20.00	100.0 k	4.39		
13.0	>20.00	1.3 k	>20.00	130.0 k	3.39		
17.0	>20.00	1.7 k	>20.00	170.0 k	2.49		
22.0	>20.00	2.2 k	>20.00	220.0 k	2.01		
28.0	>20.00	2.8 k	>20.00	280.0 k	>1.50		
36.0	>20.00	3.6 k	>20.00	360.0 k	1.34		
46.0	>20.00	4.6 k	>20.00	460.0 k	>0.90		
60.0	>20.00	6.0 k	>20.00	600.0 k	>0.70		
77.0	>20.00	7.7 k	>20.00	770.0 k	>0.60		
100.0	>20.00	10.0 k	>20.00	1.0 M	>0.50		
130.0	>20.00	13.0 k	>20.00	1.3 M	>0.40		
170.0	>20.00	17.0 k	>20.00	1.7 M	>0.30		
220.0	>20.00	22.0 k	>19.00	2.0 M	>0.30		
280.0	>20.00	28.0 k	>15.00				
360.0	>20.00	36.0 k	>12.00				
460.0	>20.00	46.0 k	> 9.00				
600.0	>20.00	60.0 k	> 7.00				
770.0	>20.00	77.0 k	5.69				

Fig. 6-4-7 Result (Numeric) Screen

Furthermore, the tolerance result can be checked using the following screen.

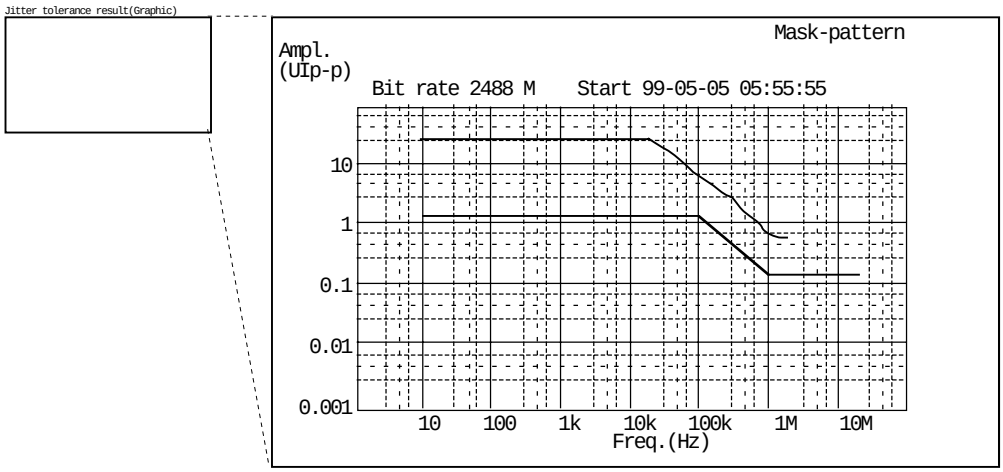


Fig. 6-4-8 Result (Graphic) Screen

Reference Standard ITU-T G.958

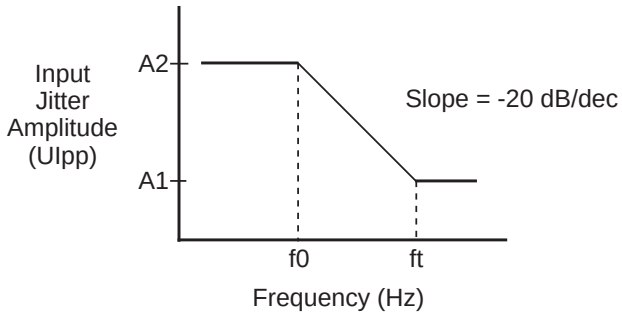


Figure 6.3/G.958 Jitter Tolerance Mask

STM level (Type)	ft(kHz)	f0(kHz)	A1(UIp-p)	A2(UIp-p)
STM-1 (A)	65	6.5	0.15	1.5
STM-1 (B)	12	1.2	0.15	1.5
STM-4 (A)	250	25	0.15	1.5
STM-4 (B)	12	1.2	0.15	1.5
STM-16 (A)	1000	100	0.15	1.5
STM-16 (B)	12	1.2	0.15	1.5

Table 2/G.958 Jitter Tolerance Parameters

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6.5 Jitter Transfer (ITU-T G.958) Measurement Example (1/4)

Jitter transfer measurement by using the selective method.

● Connection The connection is as follows:

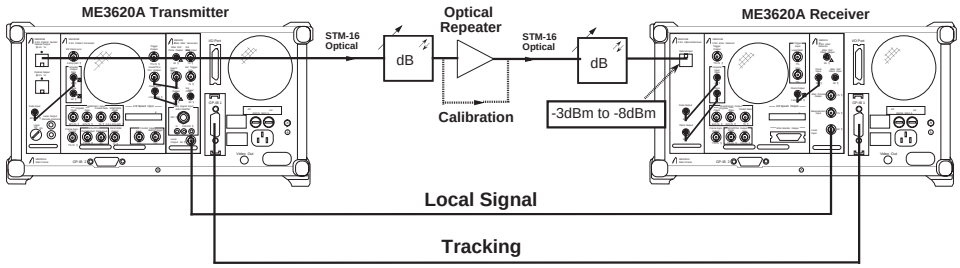


Fig. 6-5-1 Cable Connection

Note:
1. Make sure that the optical input/output power of the equipment matches that of the transmitter/receiver.
2. Set the jitter amplitude for the measurement below the jitter tolerance value for the measured equipment. If the setting value is over the jitter tolerance value, the measurement cannot be performed correctly.
3. The selective method of jitter transfer measurement is possible only with type C or D.

● Setting ◇ The setting of the transmitter is as follows:

• Sets the tracking control of the system condition to "ON".

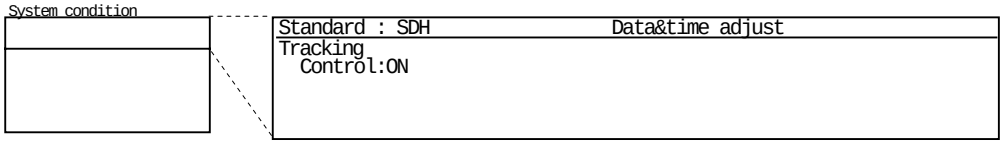


Fig. 6-5-2 Transmitter Setting

• Sets the jitter to "ON".

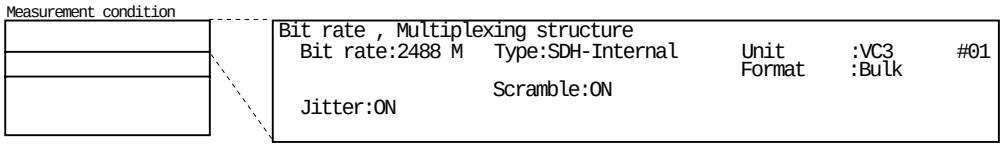


Fig. 6-5-3 Transmitter Setting

◇ The setting of the receiver is as follows:

• Sets the transmitter address.

• Sets the tracking control of the system condition to "ON".

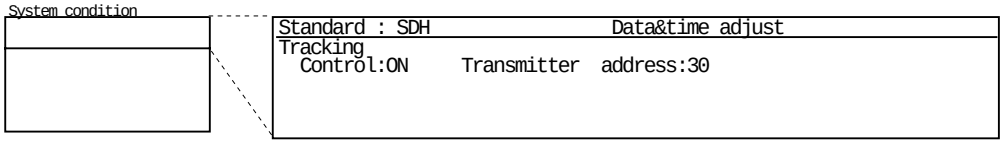


Fig. 6-5-4 Receiver Setting

Jitter transfer measurement by using the selective method.

Note:
1. This setting cannot use the same address as GP-IB 1.
2. This setting cannot be used when the option 01 (RS-232C interface) is installed in the ME0301A main frame.
3. When the Tracking Control cannot be set to "ON" because the error message is displayed, verify the following conditions :
   ◇ Option 01 : not installed
   - Transmitter address setting of receiver must be same as transmitter GP-IB address.
   - GP-IB cable is connected correctly.

   ◇ Option 01 : installed
   - The interface condition between transmitter and receiver must match.
   - RS-232C cable is connected correctly.

- Sets the optical band width to "Wide".
- Sets the mode of jitter condition to "Jitter transfer".
- Sets the transfer meas. method of jitter condition to "Selective".
- Sets the transfer meas. type of jitter condition to "Calibration".

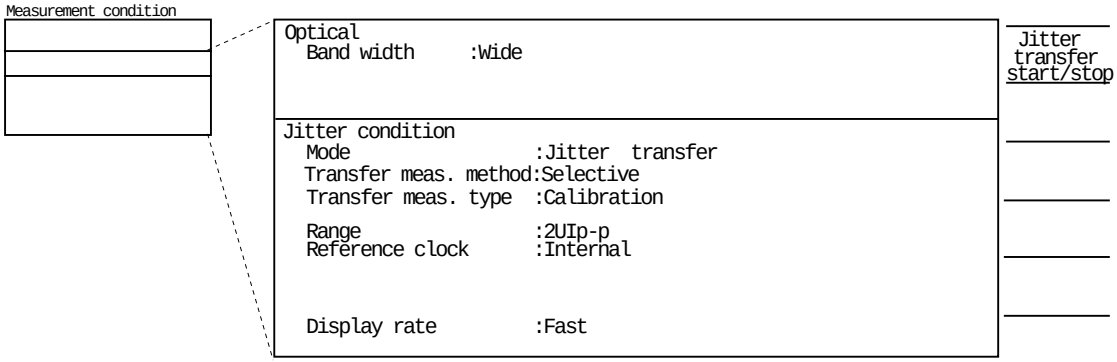
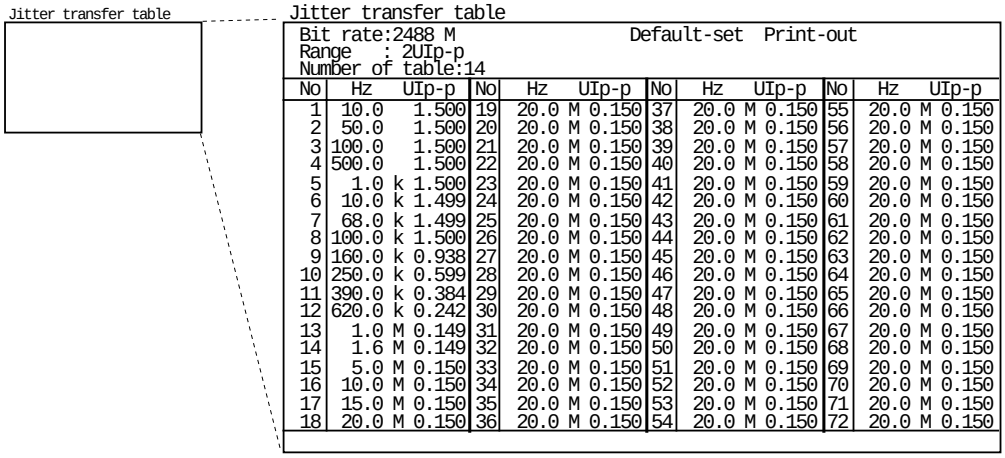


Fig. 6-5-5 Receiver Setting

- Sets the jitter transfer table.



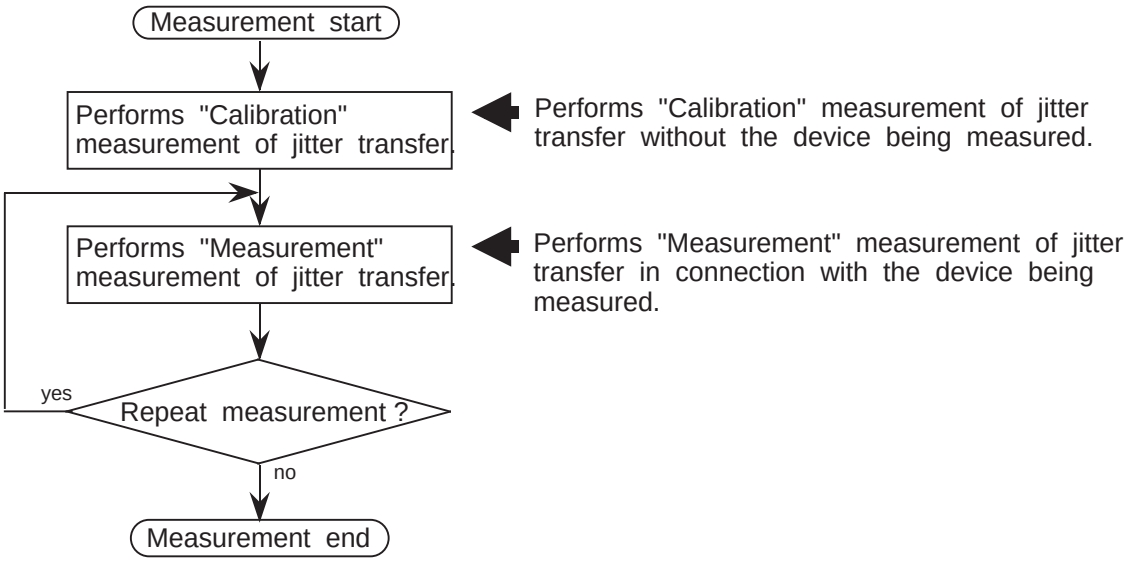
No	Hz	UIp-p	No	Hz	UIp-p	No	Hz	UIp-p	No	Hz	UIp-p
1	10.0	1.500	19	20.0 M	0.150	37	20.0 M	0.150	55	20.0 M	0.150
2	50.0	1.500	20	20.0 M	0.150	38	20.0 M	0.150	56	20.0 M	0.150
3	100.0	1.500	21	20.0 M	0.150	39	20.0 M	0.150	57	20.0 M	0.150
4	500.0	1.500	22	20.0 M	0.150	40	20.0 M	0.150	58	20.0 M	0.150
5	1.0 k	1.500	23	20.0 M	0.150	41	20.0 M	0.150	59	20.0 M	0.150
6	10.0 k	1.499	24	20.0 M	0.150	42	20.0 M	0.150	60	20.0 M	0.150
7	68.0 k	1.499	25	20.0 M	0.150	43	20.0 M	0.150	61	20.0 M	0.150
8	100.0 k	1.500	26	20.0 M	0.150	44	20.0 M	0.150	62	20.0 M	0.150
9	160.0 k	0.938	27	20.0 M	0.150	45	20.0 M	0.150	63	20.0 M	0.150
10	250.0 k	0.599	28	20.0 M	0.150	46	20.0 M	0.150	64	20.0 M	0.150
11	390.0 k	0.384	29	20.0 M	0.150	47	20.0 M	0.150	65	20.0 M	0.150
12	620.0 k	0.242	30	20.0 M	0.150	48	20.0 M	0.150	66	20.0 M	0.150
13	1.0 M	0.149	31	20.0 M	0.150	49	20.0 M	0.150	67	20.0 M	0.150
14	1.6 M	0.149	32	20.0 M	0.150	50	20.0 M	0.150	68	20.0 M	0.150
15	5.0 M	0.150	33	20.0 M	0.150	51	20.0 M	0.150	69	20.0 M	0.150
16	10.0 M	0.150	34	20.0 M	0.150	52	20.0 M	0.150	70	20.0 M	0.150
17	15.0 M	0.150	35	20.0 M	0.150	53	20.0 M	0.150	71	20.0 M	0.150
18	20.0 M	0.150	36	20.0 M	0.150	54	20.0 M	0.150	72	20.0 M	0.150

Fig. 6-5-6 Jitter Transfer Table Setting

6.5 Jitter Transfer (ITU-T G.958) Measurement Example (3/4)

Jitter transfer measurement by using the selective method.

● Measurement Performs the jitter transfer measurement according to the following procedure by pressing the function key of jitter transfer start/stop.



Note: The minimum jitter frequency is restricted as follows:

Bit Rate	Minimum Jitter Frequency	
	20UI Range	2UI Range
52Mb/s	5Hz	20Hz
156Mb/s	5Hz	20Hz
622Mb/s	5Hz	20Hz
2488Mb/s	10Hz	100Hz

Such transmitted and received jitter can be monitored by the following screen.

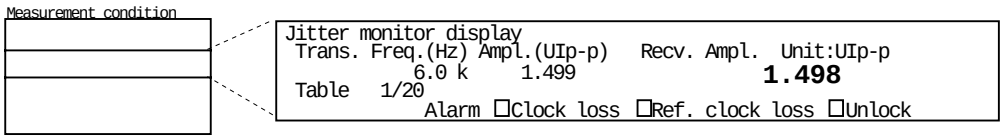
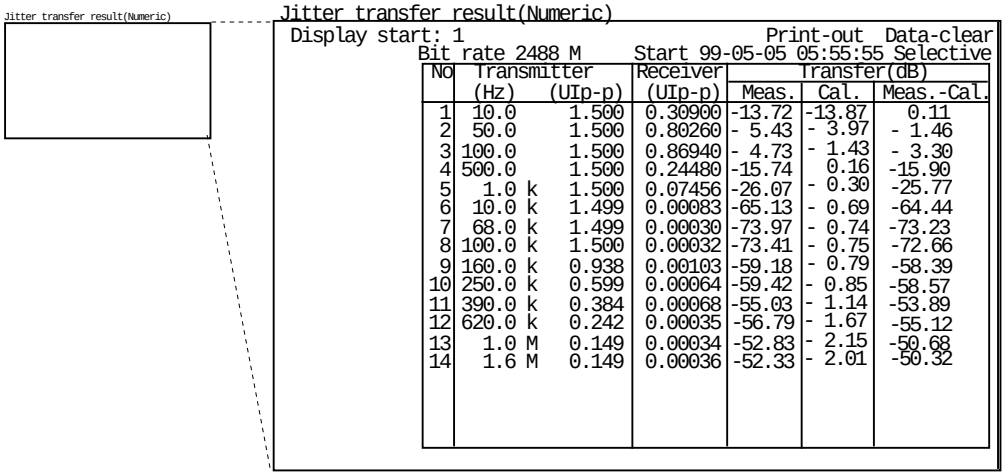


Fig. 6-5-7 Monitor Screen

Note: When the dynamic measuring range is required at the modulation frequency (fm)< 1kHz, perform the measurement procedure described in Section 6.6.

Jitter transfer measurement by using the selective method.

The transfer result can be checked using the following screen.



NO	Transmitter (Hz)	Transmitter (UIp-p)	Receiver (UIp-p)	Transfer(dB) Meas.	Transfer(dB) Cal.	Transfer(dB) Meas.-Cal.
1	10.0	1.500	0.30900	-13.72	-13.87	0.11
2	50.0	1.500	0.80260	- 5.43	- 3.97	- 1.46
3	100.0	1.500	0.86940	- 4.73	- 1.43	- 3.30
4	500.0	1.500	0.24480	-15.74	0.16	-15.90
5	1.0 k	1.500	0.07456	-26.07	- 0.30	-25.77
6	10.0 k	1.499	0.00083	-65.13	- 0.69	-64.44
7	68.0 k	1.499	0.00030	-73.97	- 0.74	-73.23
8	100.0 k	1.500	0.00032	-73.41	- 0.75	-72.66
9	160.0 k	0.938	0.00103	-59.18	- 0.79	-58.39
10	250.0 k	0.599	0.00064	-59.42	- 0.85	-58.57
11	390.0 k	0.384	0.00068	-55.03	- 1.14	-53.89
12	620.0 k	0.242	0.00035	-56.79	- 1.67	-55.12
13	1.0 M	0.149	0.00034	-52.83	- 2.15	-50.68
14	1.6 M	0.149	0.00036	-52.33	- 2.01	-50.32

Fig. 6-5-8 Result (Numeric) Screen

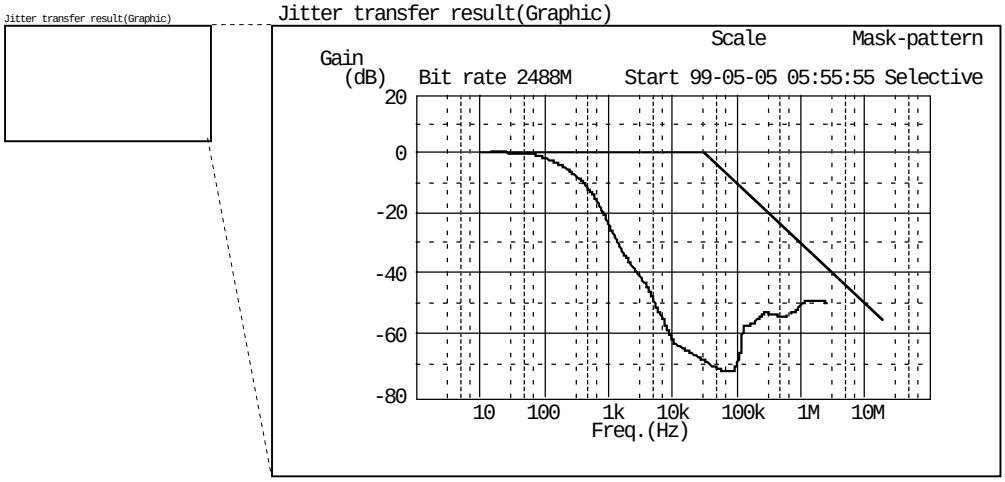


Fig. 6-5-9 Result (Graphic) Screen

Reference Standard ITU-T G.958

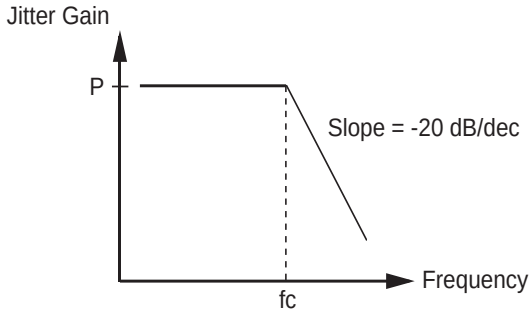


Figure 6.2/G.958 Jitter Transfer

Table-1/G.958 Jitter Transfer Parameters

STM level (Type)	fc (kHz)	P (dB)
STM-1 (A)	130	0.1
STM-1 (B)	30	0.1
STM-4 (A)	500	0.1
STM-4 (B)	30	0.1
STM-16 (A)	2000	0.1
STM-16 (B)	30	0.1

6.6 Jitter Transfer (ITU-T G.958) Measurement Example (1/4)

Jitter transfer measurement using a network analyzer.

● Connection The connection is as follows:

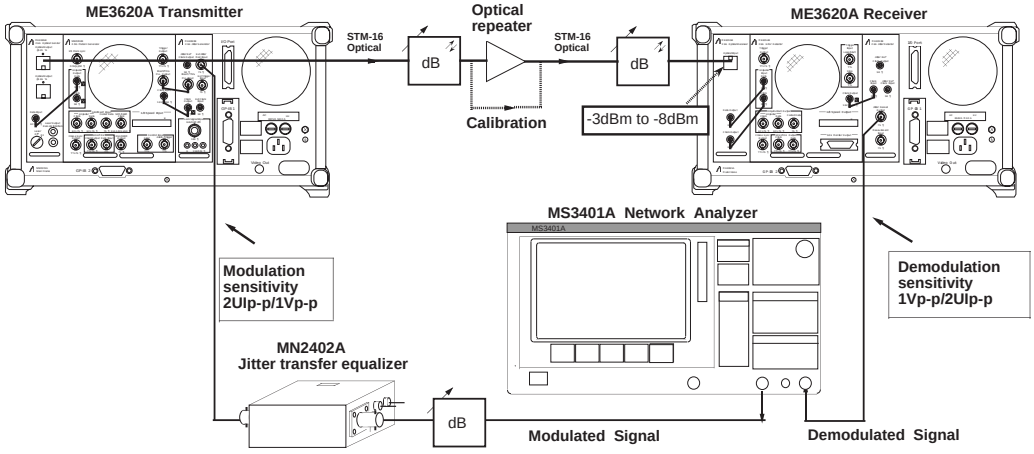


Fig. 6-6-1 Cable Connection

Note: 1. Make sure that the optical input/output power of the equipment matches that of the transmitter/receiver.

2. The MN2402A has an adapter that applies a jitter modulation amount that matches the jitter tolerance mask for the network analyzer's output signal level (Sweeping at a constant level)

● Setting ◇ The setting of the transmitter is as follows:

- Sets the jitter to "ON".
- Sets the mode of jitter condition to "External".

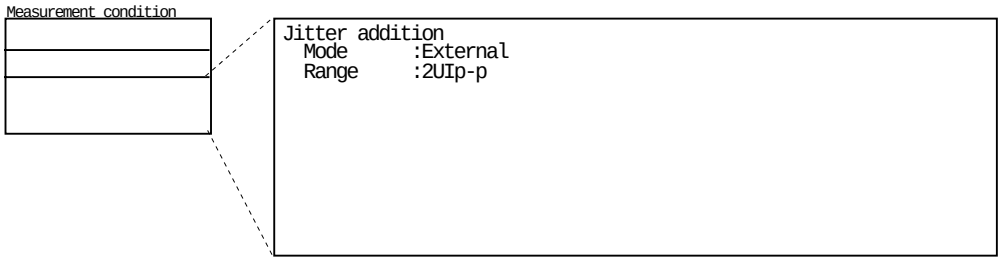


Fig. 6-6-2 Transmitter Setting

Jitter transfer measurement using a network analyzer.

◇ The setting of the receiver is as follows:

- Sets the optical band width to "Wide".
- Sets the mode of jitter condition to "Amplitude".

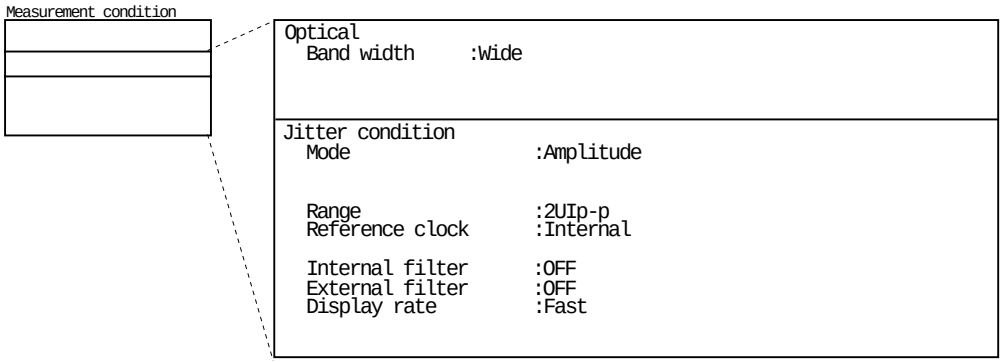
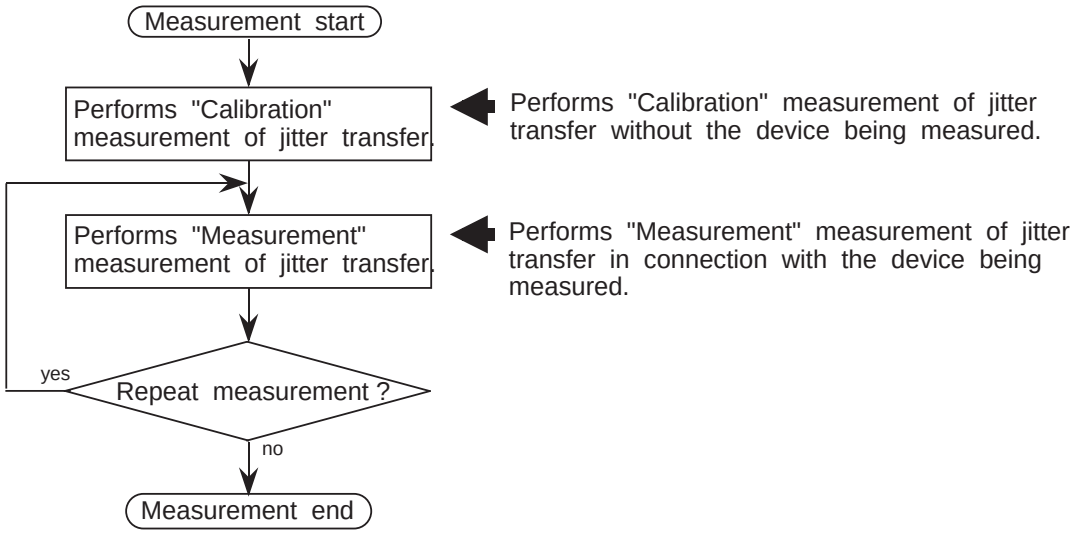


Fig. 6-6-3 Receiver Setting

● Measurement Performs the jitter transfer measurement according to the following procedure.



Note: The minimum jitter frequency is restricted as follows:

Bit Rate	Minimum Jitter Frequency	
	20UI Range	2UI Range
52Mb/s	5Hz	20Hz
156Mb/s	5Hz	20Hz
622Mb/s	5Hz	20Hz
2488Mb/s	10Hz	100Hz

Jitter transfer measurement using a network analyzer.

The transmitted jitter can be monitored by the following screen.

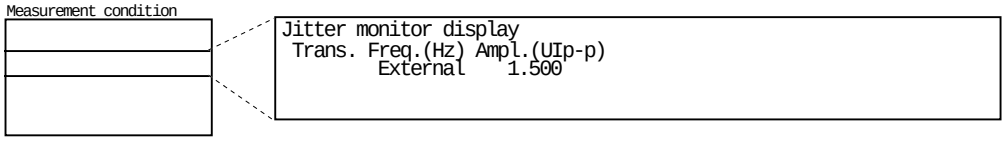


Fig. 6-6-4 Transmitter Monitor

The received jitter can be monitored by the following screen.

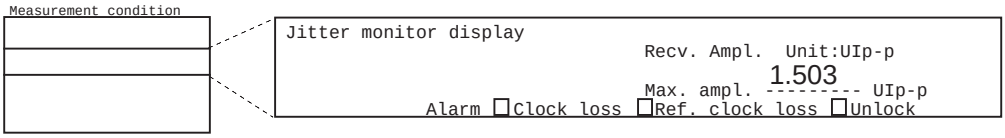


Fig. 6-6-5 Receiver Monitor

The measured result will be obtained as shown below.

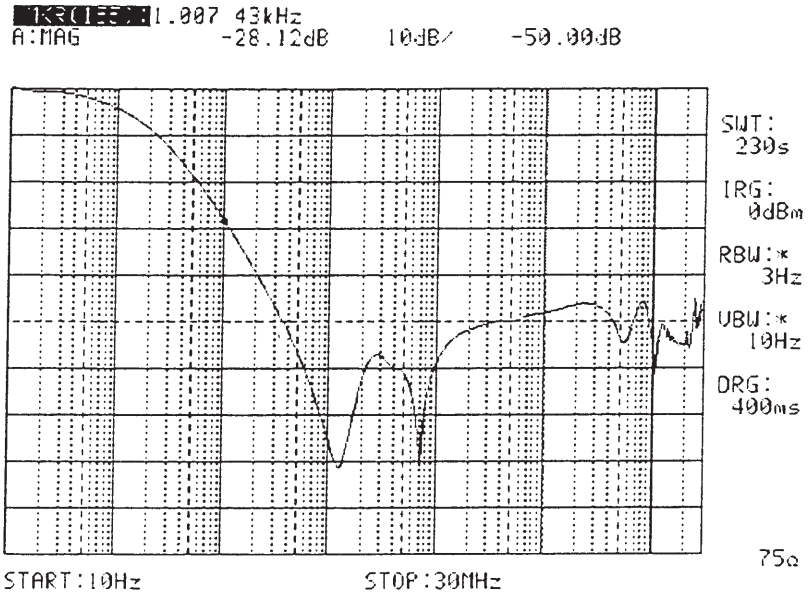


Fig. 6-6-6 Measured Result

Jitter transfer measurement using a network analyzer.

Reference Standard ITU-T G.958

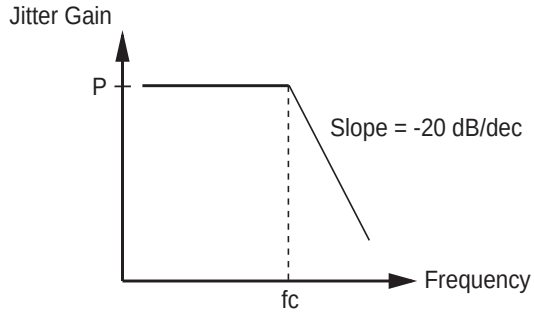


Figure 6.2/G.958 Jitter Transfer

Table-1/G.958 Jitter Transfer Parameters

STM level (Type)	fc (kHz)	P (dB)
STM-1 (A)	130	0.1
STM-1 (B)	30	0.1
STM-4 (A)	500	0.1
STM-4 (B)	30	0.1
STM-16 (A)	2000	0.1
STM-16 (B)	30	0.1

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7. Jitter Measurement Guide for MP1550A/B

● Connection The connection is as follows:

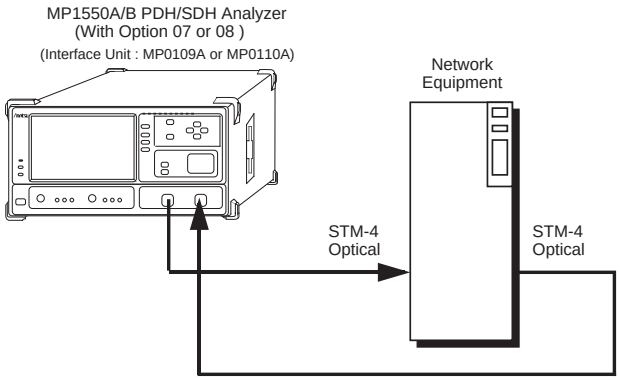

Fig. 7-1-1 Cable Connection

Note: Make sure that the optical input/output power of the equipment matches that of the transmitter/receiver.

● Settings ◇ The setting of Setup:Mapping is as follows:

- Sets the Bit rate to "622M".
- Sets the Ref. input to "Internal".

```
Setup        Mapping              [Tx&Rx]    Time 10:10:38 04/Oct/99

 Measuring mode  [ Out-of-service ]

 Bit rate        [      622M      ]
 Mapping         [STM4-AUG-AU4-VC4-139M(Async.)                      ]
 MUX/DEMUX       [      OFF       ]
 Frame           [      OFF       ]
 2M setting                              Jitter setting
    2Mch         [      30ch      ]        Mod. source  [    Internal    ]
    CRC-4        [      OFF       ]        Ref. input   [    Internal    ]
    Signalling   [      OFF       ]     Wander setting
    Interface    [   Unbalanced   ]        Ref. input   [     Clock      ]
 Clock           [    Internal    ]


 Performance     [      OFF       ]
 Graph resolution[     15min      ]
```

Fig. 7-1-2 The Setting of Setup:Mapping

7.1 Jitter Generation (ITU-T G.958) Measurement Example (2/2)

◇ The setting of Test Menu:Manual/Jitter is as follows:

- Sets the Tx Jitter to "OFF".
- Sets the Rx Range to "2UI".
- Sets the Filter to "HP".
- Sets the Meas. coupled to "OFF".

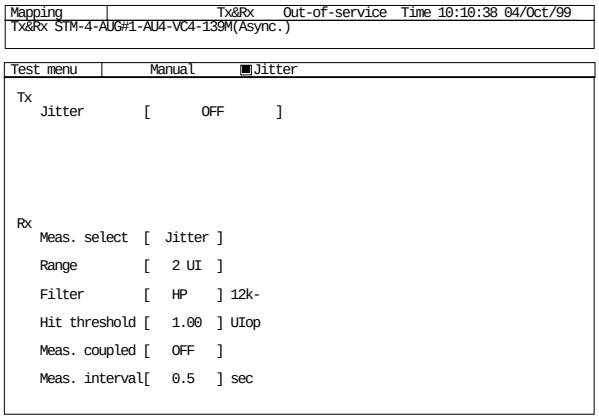

Fig. 7-1-3 The Setting of Test Menu:Manual/Jitter

◇ The setting of Result:Jitter/Wander is as follows:

- Sets the Unit to "RMS".

● Measurement ◇ The measured result is displayed in the following screen:

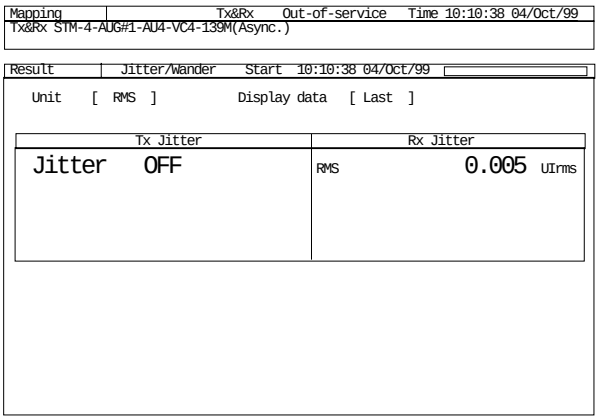

Fig.7-1-4 Result:Jitter/Wander Screen

Reference Standard ITU-T G.958

Jitter Generation: ≤ 0.01 UIrms

7.2 Output Jitter (ITU-T G.825) Measurement Example (1/3) (for SDH interface)

● Connection The connection is as follows:

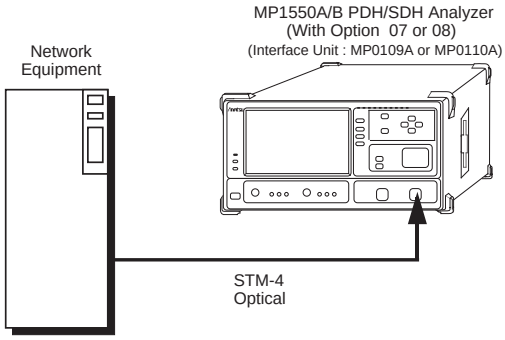

Fig. 7-2-1 Cable Connection

Note: Make sure that the optical output power of the equipment matches that of the input power range of the receiver.

● Settings ◇ The setting of Setup:Mapping is as follows:

- Sets the Bit rate to "622M".
- Sets the Ref. input to "Internal".

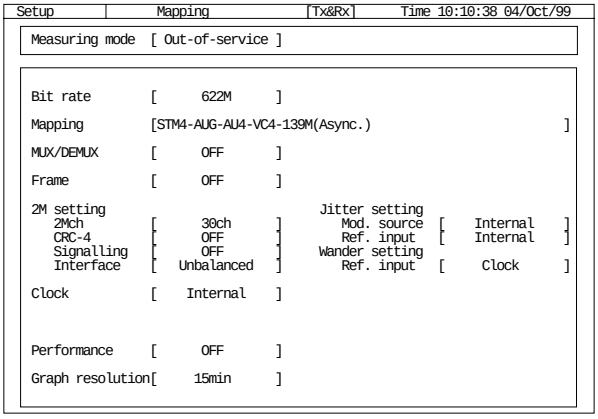

Fig. 7-2-2 The Setting of Setup:Mapping

7.2 Output Jitter (ITU-T G.825) Measurement Example (2/3)
(for SDH interface)

◇ The setting of Test menu:Manual/Jitter is as follows:

- Sets the Rx Range to "2UI".
- Sets the Filter to "HP1+LP" or "HP2+LP".
- Sets the Meas. coupled to "ON".

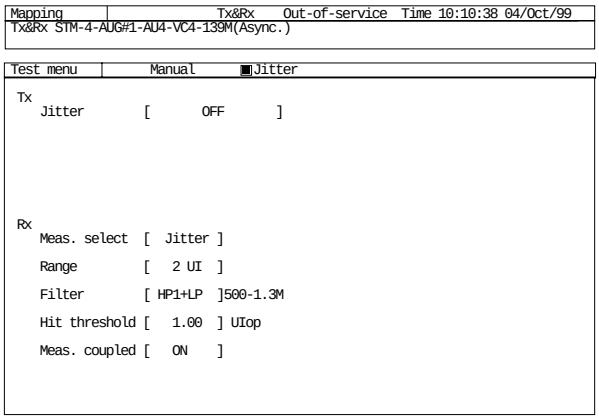

Fig. 7-2-3 The Setting of Test Menu:Manual/Jitter

◇ The setting of test menu:Manual is as follows:

- Sets the Mode to "Repeat 60 sec".

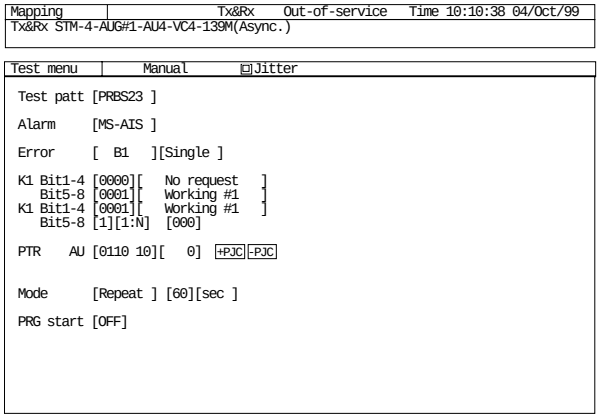

Fig. 7-2-4 The Setting of Test Menu:Manual

◇ The setting of Result:Jitter/Wander is as follows:

- Sets the Unit to "Peak".
- Sets the Display data to "Last".

7.2 Output Jitter (ITU-T G.825) Measurement Example (3/3)
(for SDH interface)

● Measurement ◇ The measurement is started by the pressing start/stop key.

• The measured result is displayed by the following screen:

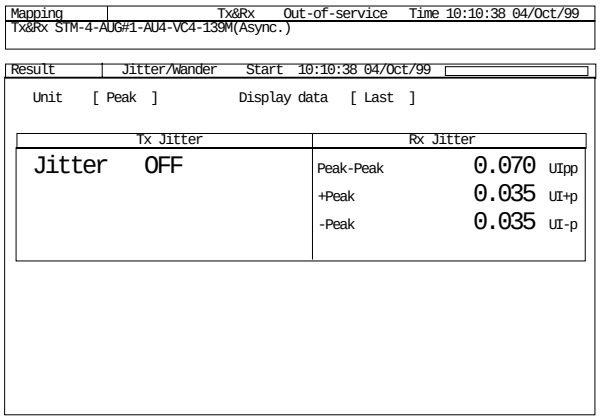

Fig. 7-2-5 Result:Jitter/Wander Screen

Reference Standard ITU-T G.825

Table-1/G.825 SDH Network Interface Output Jitter Specification Parameters

STM Level	Bandpass filter cut-off f1-f4	Bandpass filter cut-off f3-f4
STM-1	500Hz < pass < 1.3MHz	65kHz < pass < 1.3MHz
STM-4	1kHz < pass < 5MHz	250kHz < pass < 5MHz
Output Jitter	≤1.5UIpp	≤0.15UIpp

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7.3 Output Jitter (ITU-T G.823) Measurement Example (1/2)
(for PDH interface)

● Connection The connection is as follows:

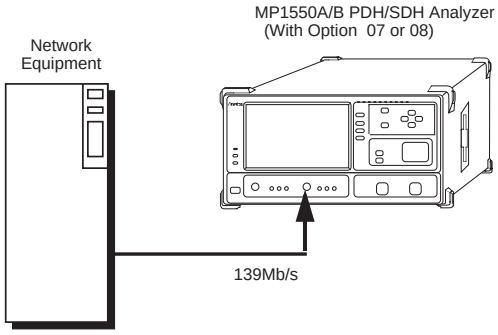


Fig. 7-3-1 Cable Connection

● Settings ◇ The setting of Setup:Mapping is as follows:

- Sets the Bit rate to "139M".
- Sets the Ref. input to "Internal".

```
Setup          Mapping          [Tx&Rx]     Time 10:10:38 04/Oct/99

 Measuring mode  [ Out-of-service ]

 Bit rate        [      139M      ]

 MUX/DEMUX       [      OFF       ]

 Frame           [      OFF       ]

 2M setting                                Jitter setting
    2Mch         [      30ch      ]          Mod. source  [    Internal    ]
    CRC-4        [      OFF       ]          Ref. input   [    Internal    ]
    Signalling   [      OFF       ]       Wander setting
    Interface    [   Unbalanced   ]          Ref. input   [     Clock      ]

 Clock           [    Internal    ]

 Monitor mode    [      OFF       ]

 Performance     [      OFF       ]

 Graph resolution[     15min      ]
```

Fig. 7-3-2 The Setting of Setup:Mapping

◇ The setting of Test menu:Manual/Jitter is as follows:

- Sets the Rx Range to "2UI".
- Sets the Filter to "HP1+LP" or "HP2+LP".
- Sets the Meas. coupled to "ON".

```
Mapping          Tx&Rx    Out-of-service  Time 10:10:38 04/Oct/99
Tx&Rx 139M

Test menu        Manual      ■Jitter

Tx
   Jitter        [      OFF       ]



Rx
   Meas. select  [  Jitter ]
   Range         [   2 UI  ]
   Filter        [ HP1+LP  ]200-3.5M
   Hit threshold [   1.00  ] UIop
   Meas. coupled [   ON    ]
```

Fig. 7-3-3 The Setting of Test Menu:Manual/Jitter

7.3 Output Jitter (ITU-T G.823) Measurement Example (2/2)
(for PDH interface)

◇ The setting of Test menu:Manual is as follows:

- Sets the Mode to " Repeat 60 sec ".

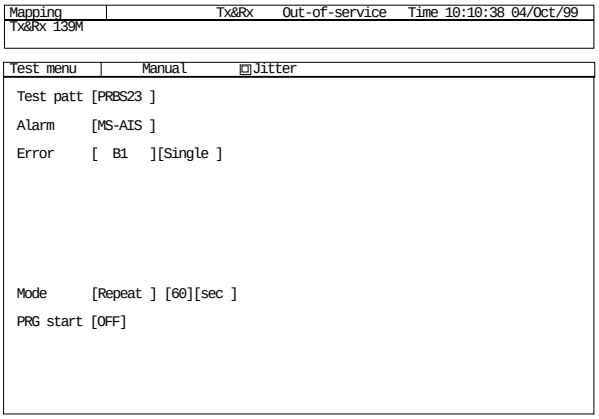


Fig. 7-3-4 The Setting of Test Menu :Manual

◇ The setting of Result:Jitter/Wander is as follows:

- Sets the Unit to "Peak".
- Sets the Display data to "Last".

● Measurement ◇ The measurement is started by pressing the start/stop key.

- The measured result is displayed in the following screen:

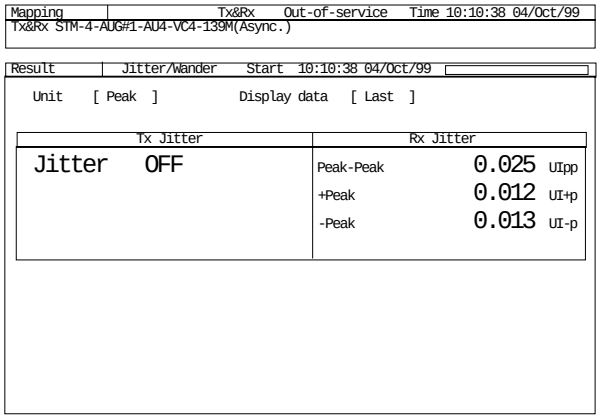


Fig. 7-3-5 Result:Jitter/Wander Screen

Reference Standard ITU-T G.823

Table-1/G.823 Maximum permissible jitter at a hierarchical interface

Digit rate(kbit/s) Output Jitter	Bandpass filter cut-off f1-f4	Bandpass filter cut-off f3-f4
2048	20Hz < pass < 100kHz ≤1.5UIpp	18kHz < pass < 100kHz (700Hz) ≤0.2UIpp
8448	20Hz < pass < 400kHz ≤1.5UIpp	3kHz < pass < 400kHz (80kHz) ≤0.2UIpp
34 368	100Hz < pass < 800kHz ≤1.5UIpp	10kHz < pass < 800kHz ≤0.15UIpp
139 264	200Hz < pass < 3.5MHz ≤1.5UIpp	10kHz < pass < 3.5MHz ≤0.075UIpp

* The frequency values shown in parenthesis only apply to certain national interfaces.

7.4 Jitter Tolerance (ITU-T G.958) Measurement Example (1/2) (for SDH interface)

● Connection The connection is as follows:

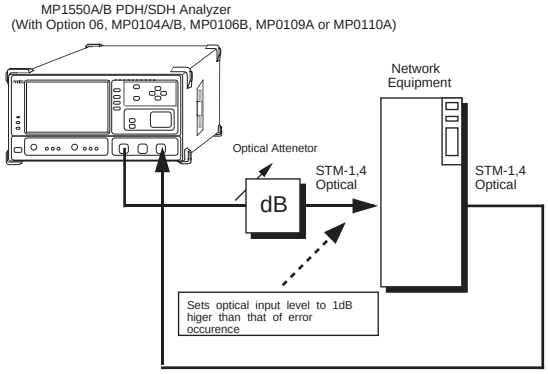


Fig. 7-4-1 Cable Connection

● Settings ◇ The setting of Setup:Mapping is as follows:

- Sets the Bit rate to "622M".
- Sets the Mod. source to "Internal".

```
Setup          Mapping          [Tx&Rx]     Time 10:10:38 04/Oct/99

Measuring mode  [ Out-of-service ]

Bit rate        [      622M      ]
Mapping         [STM4-AUG-AU4-VC4-139M(Async.)                    ]
MUX/DEMUX       [      OFF       ]
Frame           [      OFF       ]
2M setting                              Jitter setting
   2Mch         [      30ch      ]        Mod. source  [   Internal    ]
   CRC-4        [      OFF       ]        Ref. input   [   Internal    ]
   Signalling   [      OFF       ]     Wander setting
   Interface    [   Unbalanced    ]        Ref. input   [    Clock      ]
Clock           [    Internal    ]

Performance     [      OFF       ]
Graph resolution[     15min      ]
```

Fig. 7-4-2 The Setting of Setup:Mapping

◇ The setting of Setup:Jitter tolerance is as follows:

- Sets the Bit rate to "622M".
- Sets the Tolerance table.
- Sets the Mask table.

```
Setup          Jitter tolerance                  Time 10:10:38 04/Oct/99

Bit rate          [    622M    ]
Tolerance table   [G.958 Type A]
```

No	Freq.(Hz)	No	Freq.(Hz)
1	100	11	54,000
2	200	12	79,000
3	400	13	120,000
4	790	14	170,000
5	1,600	15	250,000
6	3,200	16	460,000
7	6,300	17	830,000
8	13,000	18	1,500,000
9	25,000	19	2,700,000
10	37,000	20	5,000,000

Mask table [G.958 Type A]

	Freq.(Hz)	UIpp
A	2	1.500
B	25,000	1.500
C	250,000	0.150
D	5,000,000	0.150

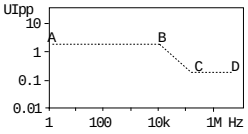


Fig. 7-4-3 The Setting of Setup:Jitter tolerance

7.4 Jitter Tolerance (ITU-T G.958) Measurement Example (2/2)
(for SDH interface)

◇ The setting of Test menu:Jitter tolerance is as follows:

- Sets the Tolerance table.
- Sets the Mask table.

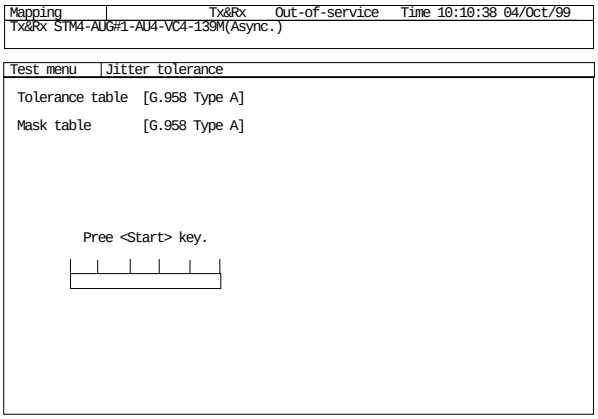
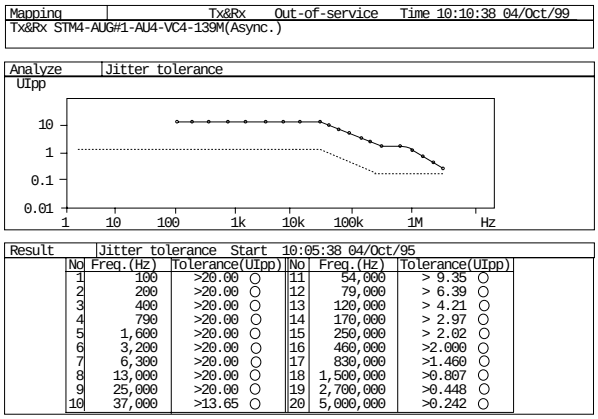


Fig. 7-4-4 The Setting of Test Menu:Jitter Tolerance

● Measurement ◇ The measurement is started by pressing the "start/stop" key.

- The tolerance result can be checked using the following screen.



Result — Jitter tolerance Start 10:05:38 04/Oct/95

No	Freq.(Hz)	Tolerance(UIpp)	No	Freq.(Hz)	Tolerance(UIpp)
1	100	>20.00 ○	11	54,000	> 9.35 ○
2	200	>20.00 ○	12	79,000	> 6.39 ○
3	400	>20.00 ○	13	120,000	> 4.21 ○
4	790	>20.00 ○	14	170,000	> 2.97 ○
5	1,600	>20.00 ○	15	250,000	> 2.02 ○
6	3,200	>20.00 ○	16	460,000	>2.000 ○
7	6,300	>20.00 ○	17	830,000	>1.460 ○
8	13,000	>20.00 ○	18	1,500,000	>0.807 ○
9	25,000	>20.00 ○	19	2,700,000	>0.448 ○
10	37,000	>13.65 ○	20	5,000,000	>0.242 ○

Fig. 7-4-5 Analyze & Result:Jitter Tolerance Screen

Reference Standard ITU-T G.958

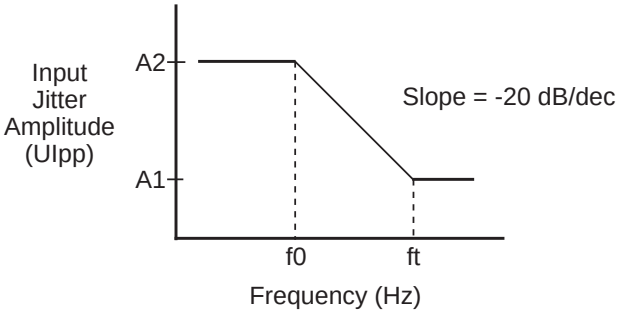


Fig 6.3/G.958 Jitter tolerance mask

Table 2/G.958 Jitter tolerance parameters

STM level (Type)	ft (kHz)	f0 (kHz)	A1 (UIp-p)	A2 (UIp-p)
STM-1 (A)	65	6.5	0.15	1.5
STM-1 (B)	12	1.2	0.15	1.5
STM-4 (A)	250	25	0.15	1.5
STM-4 (B)	12	1.2	0.15	1.5

7.5 Jitter Tolerance (ITU-T G.823) Measurement Example (1/2) (for PDH interface)

● Connection The connection is as follows:

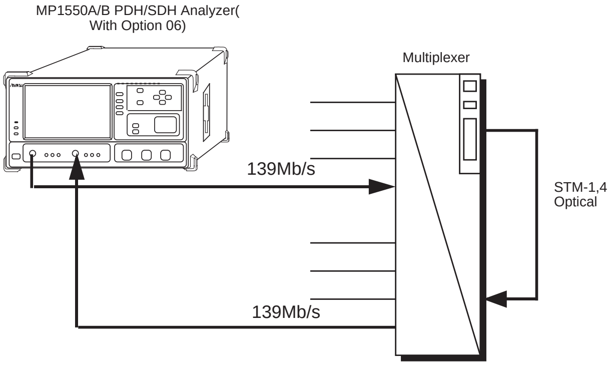


Fig. 7-5-1 Cable Connection

● Settings ◇ The setting of Setup:Mapping is as follows:

- Sets the Bit rate to "139M".
- Sets the Mod. source to "Internal".

```
Setup          Mapping            [Tx&Rx]     Time 10:10:38 04/Oct/99
 Measuring mode  [ Out-of-service ]

 Bit rate         [      139M      ]

 MUX/DEMUX        [      OFF       ]
 Frame            [      OFF       ]
 2M setting                              Jitter setting
    2Mch          [      30ch      ]        Mod. source  [   Internal   ]
    CRC-4         [      OFF       ]        Ref. input   [   Internal   ]
    Signalling    [      OFF       ]     Wander setting
    Interface     [   Unbalanced   ]        Ref. input   [    Clock     ]
 Clock            [    Internal    ]
 Monitor mode     [      OFF       ]
 Performance      [      OFF       ]
 Graph resolution[      15min      ]
```

Fig. 7-5-2 The Setting of Setup:Mapping

◇ The setting of Setup: Jitter tolerance is as follows:

- Sets the Bit rate to "139M".
- Sets the Tolerance table.
- Sets the Mask table.

Setup Jitter tolerance Time 10:10:38 04/Oct/99

Bit rate [139M]

Tolerance table [G.823]

No	Freq.(Hz)	No	Freq.(Hz)
1	200	11	10,000
2	320	12	19,000
3	500	13	37,000
4	730	14	70,000
5	1,100	15	140,000
6	1,500	16	260,000
7	2,200	17	500,000
8	3,300	18	950,000
9	4,700	19	1,800,000
10	6,900	20	3,500,000

Mask table [G.823]

	Freq.(Hz)	UIpp
A	2	1.500
B	500	1.500
C	10,000	0.075
D	3,500,000	0.075

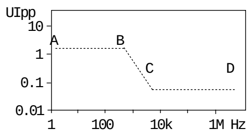


Fig. 7-5-3 The Setting of Setup:Jitter Tolerance

7.5 Jitter Tolerance (ITU-T G.823) Measurement Example (2/2)
(for PDH interface)

◇ The setting of Test menu:Jitter tolerance is as follows:

- Sets the Tolerance table.
- Sets the Mask table.

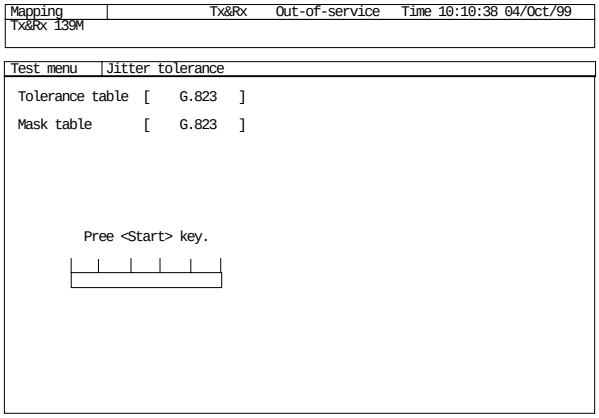
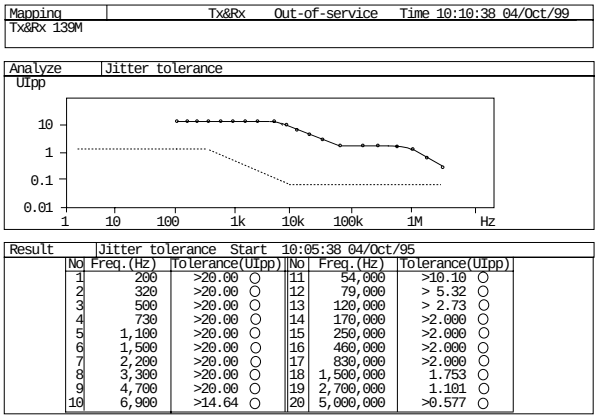


Fig. 7-5-4 The Setting of Test Menu:Jitter Tolerance

● Measurement ◇ The measurement is started by pressing the "start/stop" key.

- The tolerance result can be checked using the following screen.



No	Freq.(Hz)	Tolerance(UIpp)	No	Freq.(Hz)	Tolerance(UIpp)
1	200	>20.00 ○	11	54,000	>10.10 ○
2	320	>20.00 ○	12	79,000	> 5.32 ○
3	500	>20.00 ○	13	120,000	> 2.73 ○
4	730	>20.00 ○	14	170,000	>2.000 ○
5	1,100	>20.00 ○	15	250,000	>2.000 ○
6	1,500	>20.00 ○	16	460,000	>2.000 ○
7	2,200	>20.00 ○	17	830,000	>2.000 ○
8	3,300	>20.00 ○	18	1,500,000	1.753 ○
9	4,700	>20.00 ○	19	2,700,000	1.101 ○
10	6,900	>14.64 ○	20	5,000,000	>0.577 ○

Fig. 7-5-5 Analyze & Result:Jitter Tolerance Screen

Reference Standard ITU-T G.823

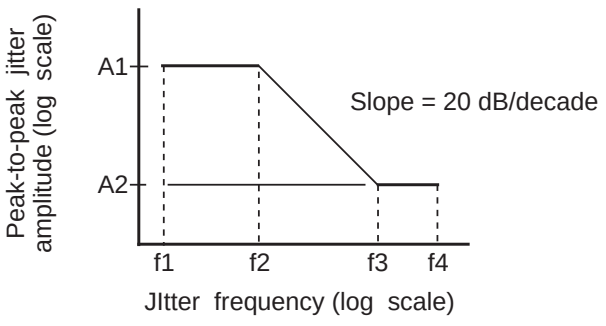


Fig 3/G.823 Lower limit of maximum tolerable input jitter

Table 2/G.823 Parameter values for input jitter tolerance

Digit rate(kbit/s)	A1 (UIp-p)	A2 (UIp-p)	f1 (Hz)	f2 (Hz)	f3 (Hz)	f4 (Hz)
2048	1.5	0.2	20	2.4K (93)	18k (700)	100k
8448	1.5	0.2	20	400 (10.7k)	3k (80k)	400k
34 368	1.5	0.15	100	1k	10k	800k
139 264	1.5	0.075	200	500	10k	3.5M

7.6 Jitter Transfer (ITU-T G.958) Measurement Example (1/3) (for SDH interface)

● Connection The connection is as follows:

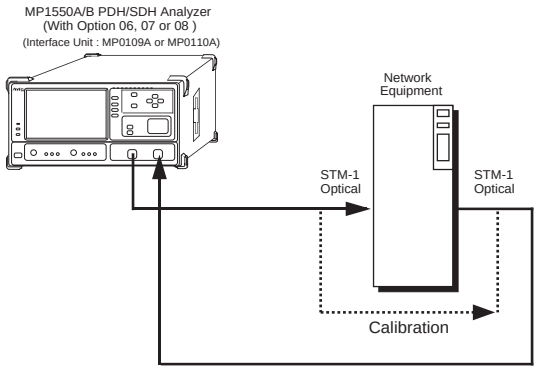


Fig. 7-6-1 Cable Connection

Note: 1. Make sure that the optical input/output power of the equipment matches that of the transmitter/receiver.
2. Set the jitter amplitude for the measurement below the jitter tolerance value for the measured equipment. If the setting value is over the jitter tolerance value, the measurement cannot be performed correctly.

● Settings ◇ The setting of Setup:Mapping is as follows:

- Sets the Bit rate to "156M".
- Sets the Mod. source to "Internal".
- Sets the Ref. input to "Internal".

```
Setup        Mapping              [Tx&Rx]    Time 10:10:38 04/Oct/99
 Measuring mode  [ Out-of-service ]

 Bit rate        [     156M     ]
 Mapping         [STM4-AUG-AU4-VC4-139M(Async.)                      ]
 MUX/DEMUX       [     OFF      ]
 Frame           [     OFF      ]
 2M setting                              Jitter setting
    2Mch         [     30ch     ]          Mod. source  [   Internal   ]
    CRC-4        [     OFF      ]          Ref. input   [   Internal   ]
    Signalling   [     OFF      ]       Wander setting
    Interface    [  Unbalanced  ]          Ref. input   [    Clock     ]
 Clock           [   Internal   ]


 Performance     [     OFF      ]
 Graph resolution[    15min     ]
```

Fig. 7-6-2 The Setting of Setup:Mapping

7.6 Jitter Transfer (ITU-T G.958) Measurement Example (2/3)
(for SDH interface)

◇ The setting of Setup:Jitter transfer is as follows:

- Sets the Bit rate to "156M".
- Sets the Transfer table.
- Sets the Mask table.

Setup | Jitter transfer | Time 10:10:38 04/Oct/99

Bit rate [156M]

Transfer table [G.958 Type A]

No	Freq.(Hz)	UIpp	No	Freq.(Hz)	UIpp
1	100	1.500	11	30,000	0.325
2	200	1.500	12	44,000	0.222
3	400	1.500	13	65,000	0.150
4	810	1.500	14	100,000	0.150
5	1,600	1.500	15	150,000	0.150
6	3,200	1.500	16	230,000	0.150
7	6,500	1.500	17	360,000	0.150
8	9,500	1.026	18	550,000	0.150
9	14,000	0.696	19	850,000	0.150
10	21,000	0.464	20	1,300,000	0.150

Mask table [User]

Default

	Freq.(Hz)	dB
A	[2]	[0.10]
B	[500]	[0.10]
C	[1,300,000]	[-19.90]
D	[1,300,000]	[-19.90]

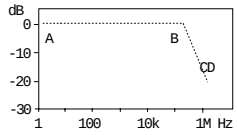


Fig. 7-6-3 The Setting of Setup:Jitter Transfer

◇ The setting of Test menu:Jitter transfer is as follows:

- Sets the Measurement type.
- Sets the Transfer table.
- Sets the Mask table.

Mapping | Tx&Rx Out-of-service Time 10:10:38 04/Oct/99

Tx&Rx STM1-AUG#1-AU4-VC4-139M(Async.)

Test menu | Jitter transfer

Measurement type [Calibration]

Transfer table [G.958 Type A]

Mask table [G.958 Type A]

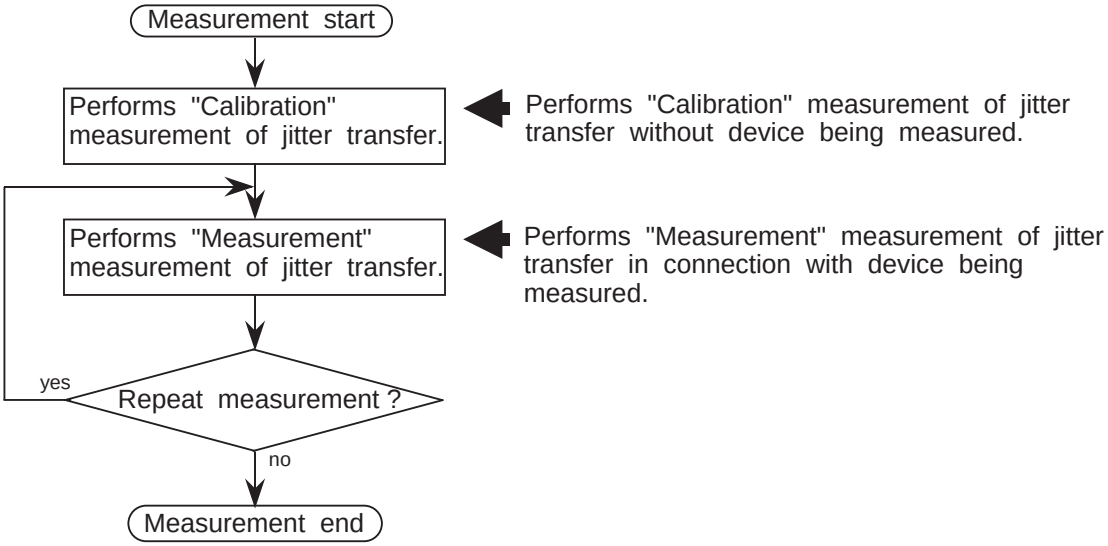
Ensure the following loopback.
Output port to input port on the interface unit

Pree <Start> key.

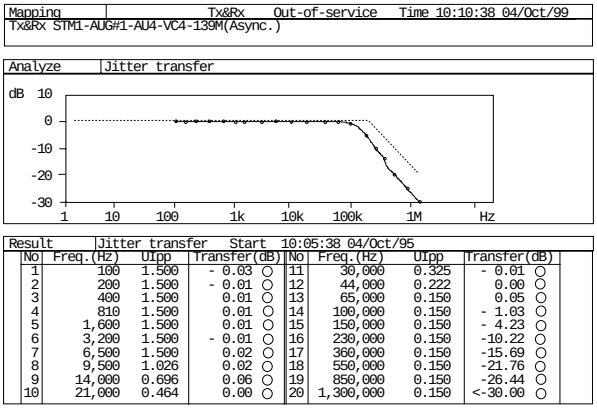
Fig. 7-6-4 The Setting of Test Menu:Jitter Transfer

7.6 Jitter Transfer (ITU-T G.958) Measurement Example (3/3)
(for SDH interface)

● Measurement ◇ Performs the jitter transfer measurement according to the following procedure by pressing the "start/stop" key.



• The transfer result can be checked using the following screen.



No	Freq.(Hz)	UIpp	Transfer(dB)	No	Freq.(Hz)	UIpp	Transfer(dB)
1	100	1.500	- 0.03 ○	11	30,000	0.325	- 0.01 ○
2	200	1.500	- 0.01 ○	12	44,000	0.222	0.00 ○
3	400	1.500	0.01 ○	13	65,000	0.150	0.05 ○
4	810	1.500	0.01 ○	14	100,000	0.150	- 1.03 ○
5	1,600	1.500	0.01 ○	15	150,000	0.150	- 4.23 ○
6	3,200	1.500	- 0.01 ○	16	230,000	0.150	-10.22 ○
7	6,500	1.500	0.02 ○	17	360,000	0.150	-15.69 ○
8	9,500	1.026	0.02 ○	18	550,000	0.150	-21.76 ○
9	14,000	0.696	0.06 ○	19	850,000	0.150	-26.44 ○
10	21,000	0.464	0.00 ○	20	1,300,000	0.150	<-30.00 ○

Fig. 7-6-5 Analyze & Result:Jitter Transfer Screen

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7.7 Jitter Transfer (ITU-T G.823) Measurement Example (1/3) (for PDH interface)

● Connection The connection is as follows:

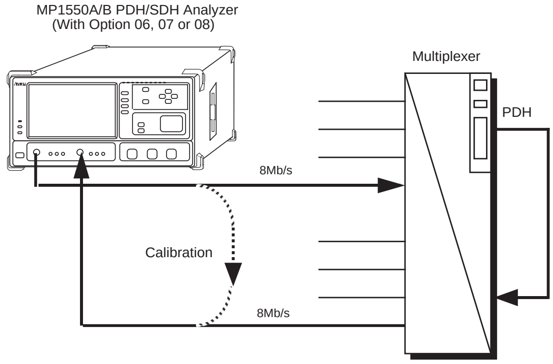


Fig. 7-7-1 Cable Connection

● Settings ◇ The setting of Setup:Mapping is as follows:

- Sets the Bit rate to "8M".
- Sets the Mod. source to "Internal".
- Sets the Ref. input to "Internal".

```
Setup        Mapping              [Tx&Rx]     Time 10:10:38 04/Oct/99
 Measuring mode  [ Out-of-service ]

 Bit rate        [      8M      ]

 MUX/DEMUX       [     OFF      ]
 Frame           [     OFF      ]
 2M setting                          Jitter setting
   2Mch          [     30ch     ]      Mod. source  [  Internal  ]
   CRC-4         [     OFF      ]      Ref. input   [  Internal  ]
   Signalling    [     OFF      ]    Wander setting
   Interface     [  Unbalanced  ]      Ref. input   [   Clock    ]
 Clock           [   Internal   ]

 Performance     [     OFF      ]
 Graph resolution[    15min     ]
```

Fig. 7-7-2 The Setting of Setup:Mapping

◇ The setting of Setup:Jitter transfer is as follows:

- Sets the Bit rate to "8M".
- Sets the Transfer table.
- Sets the Mask table.

```
Setup        Jitter transfer                  Time 10:10:38 04/Oct/99
  Bit rate         [    8M    ]
  Transfer table   [G.823 Hight-Q]
```

No	Freq.(Hz)	UIpp	No	Freq.(Hz)	UIpp
1	20	1.500	11	15,000	1.070
2	40	1.500	12	21,000	0.764
3	81	1.500	13	30,000	0.535
4	160	1.500	14	41,000	0.391
5	330	1.500	15	57,000	0.282
6	670	1.500	16	80,000	0.200
7	1,300	1.500	17	120,000	0.200
8	2,700	1.500	18	180,000	0.200
9	5,500	1.500	19	270,000	0.200
10	11,000	1.459	20	400,000	0.200

Mask table [G.751]
Default

	Freq.(Hz)	dB
A	[2]	[0.50]
B	[100]	[0.50]
C	[10,000]	[-19.90]
D	[400,000]	[-19.90]

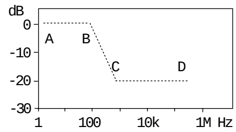


Fig. 7-7-3 The Setting of Setup:Jitter Transfer

7.7 Jitter Transfer (ITU-T G.823) Measurement Example (2/3)
(for PDH interface)

◇ The setting of Test menu:Jitter transfer is as follows:

- Sets the Measurement type.
- Sets the Transfer table.
- Sets the Mask table.

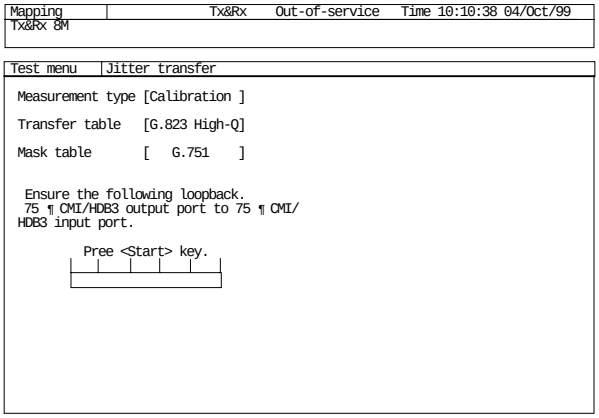
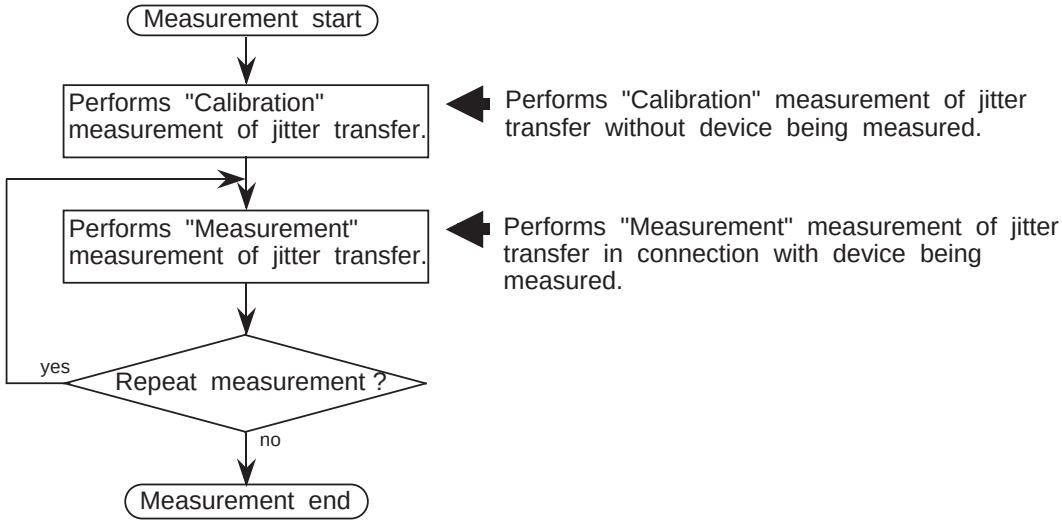
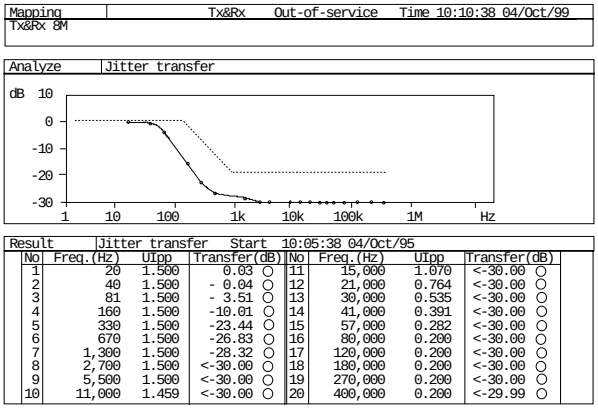


Fig. 7-7-4 The Setting of Test Menu:Jitter Transfer

● Measurement ◇ Performs the jitter transfer measurement according to the following Procedure by pressing the "start/stop" key.



- The transfer result can be checked using the following screen.



No	Freq.(Hz)	UIpp	Transfer(dB)	No	Freq.(Hz)	UIpp	Transfer(dB)
1	20	1.500	0.03 ○	11	15,000	1.070	<-30.00 ○
2	40	1.500	- 0.04 ○	12	21,000	0.764	<-30.00 ○
3	81	1.500	- 3.51 ○	13	30,000	0.535	<-30.00 ○
4	160	1.500	-10.01 ○	14	41,000	0.391	<-30.00 ○
5	330	1.500	-23.44 ○	15	57,000	0.282	<-30.00 ○
6	670	1.500	-26.83 ○	16	80,000	0.200	<-30.00 ○
7	1,300	1.500	-28.32 ○	17	120,000	0.200	<-30.00 ○
8	2,700	1.500	<-30.00 ○	18	180,000	0.200	<-30.00 ○
9	5,500	1.500	<-30.00 ○	19	270,000	0.200	<-30.00 ○
10	11,000	1.459	<-30.00 ○	20	400,000	0.200	<-29.99 ○

Fig. 7-7-5 Analyze & Result:Jitter Transfer Screen

Reference Standard ITU-T G.823

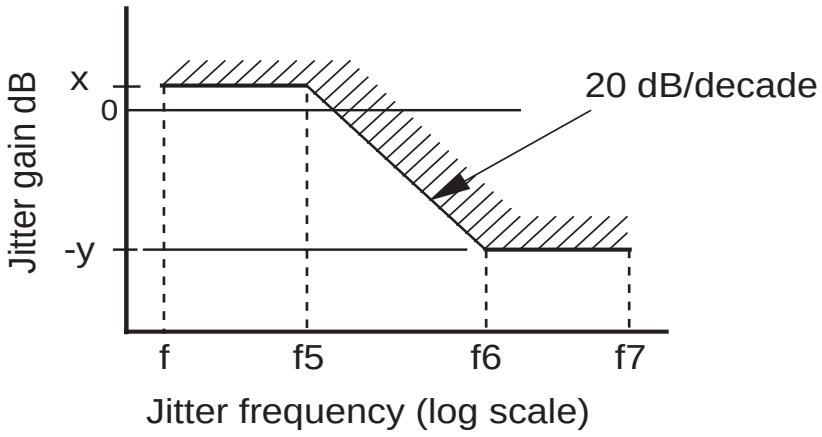


Fig 4/G.823 Typical jitter transfer characteristics.

* Figure 4/ G.823 indicates the general shape of typical jitter transfer characteristics. The appropriate values for the levels x and -ydB and the frequencies f, f5, f6 and f7 can be obtained from the relevant Recommendation.

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● Connection The connection is as follows:

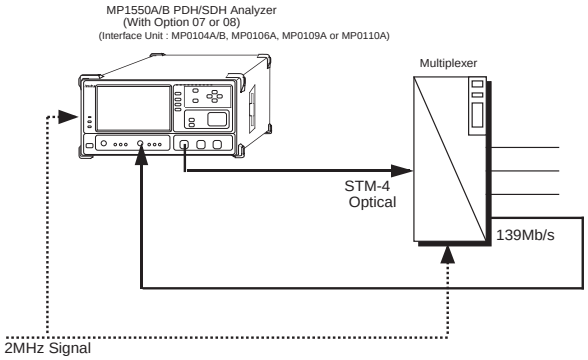

Fig. 7-8-1 Cable Connection

Note: Make sure that the optical output power of the transmitter matches that of the input power range of the equipment.

● Settings ◇ The setting of Setup:Mapping is as follows:

- Sets the Tx Bit rate to "622M".
- Sets the clock to "Lock (Balanced)" or "Lock (Unbalanced)".
- Sets the Rx Bit rate to "139M".
- Sets the Ref. input to "Internal".

```
Setup          Mapping              [Tx&Rx]    Time 10:10:38 04/Oct/99

 Measuring mode  [ Out-of-service ]

 Tx Bit rate     [      622M      ]
    Mapping      [STM4-AUG-AU4-VC4-139M(Async.)                        ]
    MUX          [      OFF       ]
    Frame        [      OFF       ]
 2M setting                                Jitter setting
    2Mch         [      30ch      ]          Mod. source  [   Internal   ]
    CRC-4        [      OFF       ]
 Clock           [ Lock(Balanced) ]

 Rx Bit rate     [      139M      ]
    DEMUX        [      OFF       ]
    Frame        [      OFF       ]
 2M setting                                Jitter setting
    2Mch         [      30ch      ]          Ref. input   [   Internal   ]
    CRC-4        [      OFF       ]       Wander setting
    Signalling   [      OFF       ]          Ref. input   [    Clock     ]
    Interface    [   Unbalanced   ]
 Monitor mode    [      OFF       ]
 Performance     [      OFF       ]
 Graph resolution[     15min      ]
```

Fig. 7-8-2 The Setting of Setup:Mapping

◇ The setting of Test menu:Manual/Jitter is as follows:

- Sets the Tx Jitter to "OFF".
- Sets the Rx range to "2UI".
- Sets the Filter to "HP1+LP" or "HP2+LP".
- Sets the Mes. coupled to "ON"

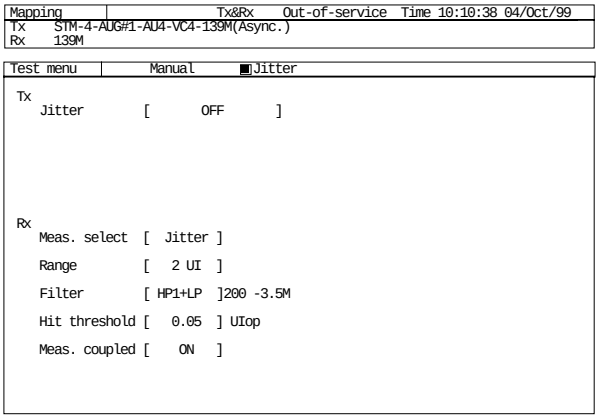

Fig. 7-8-3 The Setting of Test Menu:Manual

◇ The setting of test menu:Pointer sequence is as follows:

- Sets the Type to "Double of opposite polarity".
- Sets the PTR to "AU".
- Sets the T1 to 10000 ms.
- Sets the Mode to "Repeat 10 sec".

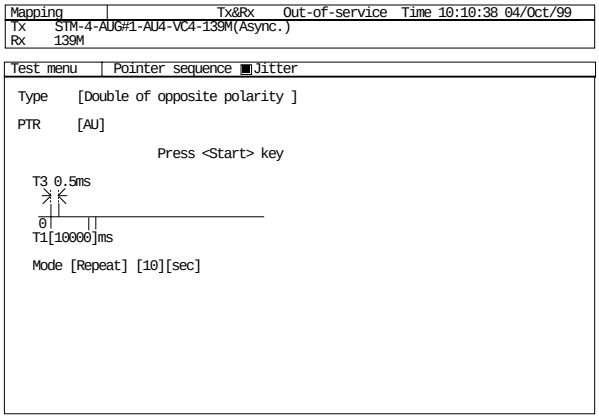

Fig. 7-8-4 The Setting of Test Menu:Pointer Sequence.

◇ The setting of Result:Jitter/Wander is as follows:

- Sets the Unit to "Peak".
- Sets the Display data to "Last".

● Measurement ◇ The measurement is started by pressing the "start/stop" key.

• The combined jitter result can be checked using the following screen.

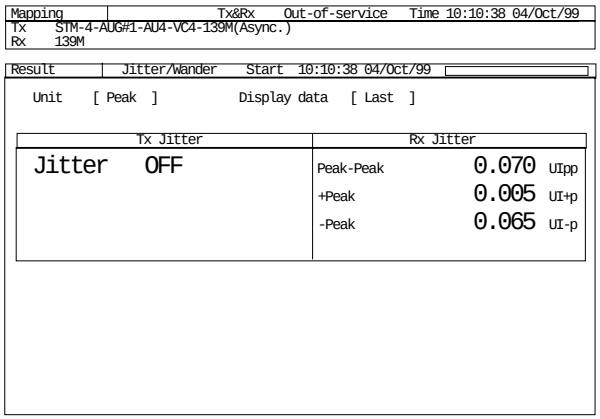

Fig. 7-8-5 Result:Jitter/Wander Screen

Reference Standard ITU-T G.783

Table 6-2/G.783 Combined jitter generation specification

G.703 interface	Sequence (Note 1)	Time Interval			Filter characteristics			Maximum pk-pk jitter	
					f1 high pass	f3 high pass	f4 low pass	combined	
		T1	T2	T3				f1-f4	f3-f4
2 048 kbit/s	B,D,E	10s	750ms	2ms	20Hz	18kHz	100kHz	0.4	0.075
34 368 kbit/s	B,D,E	10s	34ms	0.5ms	20Hz	10kHz	800kHz	0.4	0.075
	C	10s	34ms	0.5ms	100Hz	10kHz	800kHz	0.75	0.075
139 264 kbit/s	B,D,E	10s	34ms	0.5ms	200Hz	10kHz	3.5MHz	0.4	0.075
	C	10s	34ms	0.5ms	200Hz	10kHz	3.5MHz	0.75	0.075

Note 1- Sequence B: Single Pointers of Opposite Polarity
Sequence C: Double Pointers of Opposite Polarity
Sequence D: Regular Pointers with One Missing Pointer
Sequence E: Regular Pointers Plus One Double Pointer

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● Connection The connection is as follows:

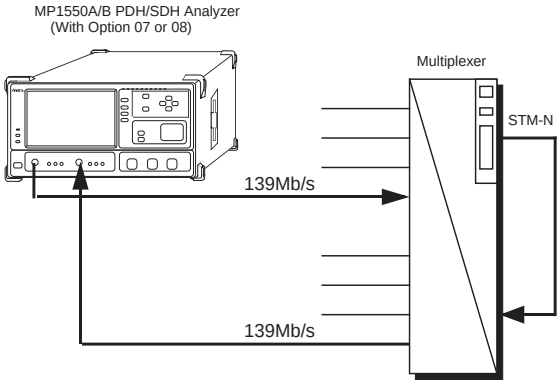

Fig. 7-9-1 Cable Connection

● Settings ◇ The setting of Setup:Mapping is as follows:

- Sets the Bit rate to "139M".
- Sets the Ref. input to "Internal".

```
Setup          Mapping          [Tx&Rx]    Time 10:10:38 04/Oct/99

Measuring mode  [ Out-of-service ]

Bit rate        [     139M     ]

MUX/DEMUX       [     OFF      ]
Frame           [     OFF      ]
2M setting                              Jitter setting
   2Mch         [     30ch     ]          Mod. source  [   Internal   ]
   CRC-4        [     OFF      ]          Ref. input   [   Internal   ]
   Signalling   [     OFF      ]        Wander setting
   Interface    [  Unbalanced  ]          Ref. input   [    Clock     ]
Clock           [   Internal   ]
Monitor mode    [     OFF      ]
Performance     [     OFF      ]
Graph resolution[    15min     ]
```

Fig. 7-9-2 The Setting of Setup:Mapping

◇ The setting of the Test menu:Manual is as follows:

- Sets the Tx Jitter to "OFF".
- Sets the Rx range to "2UI".
- Sets the Filter to "HP1+LP" or "HP2+LP".
- Sets the Mes. coupled to "OFF"

```
Mapping                    Tx&Rx    Out-of-service  Time 10:10:38 04/Oct/99
Tx&Rx 139M

Test menu        Manual      ■Jitter

Tx
   Jitter        [      OFF      ]

Rx
   Meas. select  [  Jitter ]
   Range         [   2 UI  ]
   Filter        [ HP1+LP  ]200 -3.5M
   Hit threshold [   0.05  ] UIop
   Meas. coupled [   OFF   ]
   Meas. interval[   0.5   ] sec
```

Fig. 7-9-3 The Setting of Test Menu:Manual

◇ The setting of Result:Jitter/Wander is as follows:

- Sets the Unit to "Peak".
- Sets the Display data to "Last".

● Measurement ◇ The mapping jitter result can be checked using the following screen.

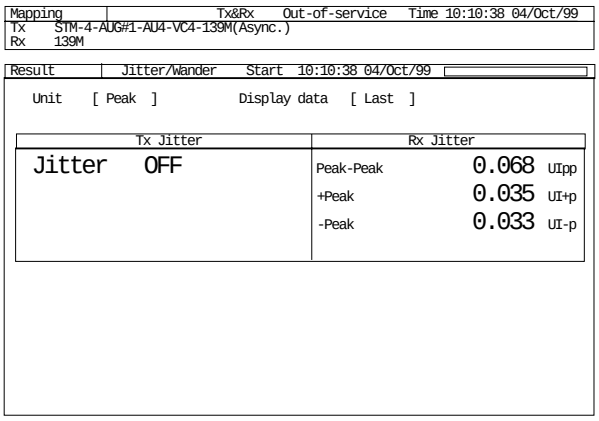

Fig. 7-9-4 Result:Jitter/Wander Screen

Reference Standard ITU-T G.783

Table 6-1/G.783 Mapping jitter generation specification

G.703 interface	Filter Characteristics			Maximum pk-pk Jitter	
	f1 high pass	f3 high pass	f4 low pass	mapping	
				f1-f4	f3-f4
2 048 kbit/s	20Hz	18kHz	100kHz	(Note 1)	0.075
34 368 kbit/s	100Hz	10kHz	800kHz	(Note 1)	0.075
139 264 kbit/s	200Hz	10kHz	3.5MHz	(Note 1)	0.075

Note 1- For further study.

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8. Jitter Measurement Guide for MP1520B

● Connection The connection is as follows:

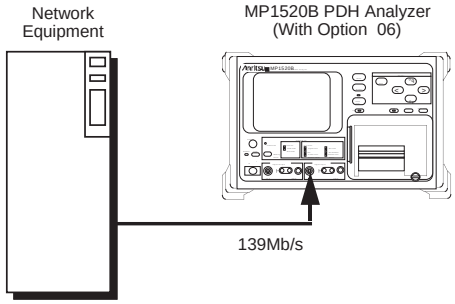


Fig. 8-1-1 Cable Connection

● Settings ◇ The setting of Menu:Condtn/Result is as follows:

- Sets the Bit rate to "139Mb/s".
- Sets the Mode to "Repeat [60 secs]".

```
Condtn:Tx&Rx    Bit rate:139Mb/s    0ppm
 MUX  :OFF
 Patt :PRBS23
 Frame:ON
 Alarm:OFF          Error:OFF
 Mode :Repeat[60 secs ]   Jitt:OFF
-------------------------------------------
Result:Error -Bit      Dspl:Current
 Time :Timed          [      00 00:00:40]
 EC             0
 ER      0.00E-08
 ES             0

 Freq        +0.2ppm
```

Fig. 8-1-2 The Setting of Menu:Condtn/Result

◇ The setting of Menu:Jitter is as follows:

- Sets the Meas mode to "Coupled".
- Sets the Rx Range to "2UI".
- Sets the Filter to "HP1+LP" or "HP2+LP".

```
Jitter:Manual
    Tx(139Mb/s)          Rx(139Mb/s)
 Mode :Internal       Meas mode:Coupled
 Range: 2UI           Range     : 2UI
 Freq :500.0Hz        Filter    :HP1+LP
 Amptd:Coarse U/D     Threshold:1.00UIo-p
-------------------------------------------
Result                  Dspl:Current Zoom
 Time :Timed          [      00 00:00:40]
 Jitter amplitude    Hit
  Tx     ------UIp-p  Count            0
  Rx      0.043UIp-p  Seconds          0
   +Peak  0.022UI+p   %FS       100.0000%
   -Peak  0.021UI-p
                      Status
```

Fig. 8-1-3 The Setting of Menu:Jitter

◇ The setting of Menu:Jitter is as follows:
- Sets the Dspl to "Last".

● Measurement ◇ The measurement is started by pressing the start/stop key.
- The measured result is displayed in the following screen:
- Push the zoom button.

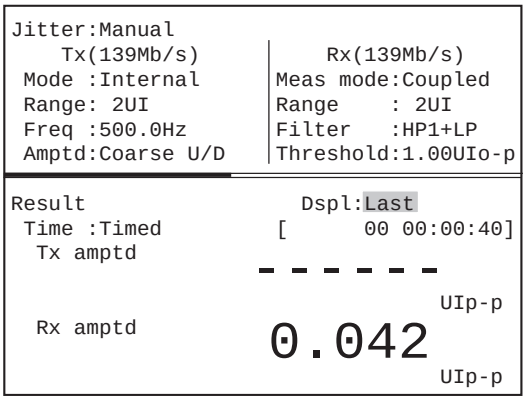


Fig. 8-1-4 Result of Jitter:Manual

Reference Standard ITU-T G.823

Table-1/G.823 Maximum permissible jitter at a hierarchical interface

Digit rate(kbit/s) Output Jitter	Bandpass filter cut-off f1-f4	Bandpass filter cut-off f3-f4
2048	20Hz < pass < 100kHz ≤1.5UIpp	18kHz < pass < 100kHz (700Hz) ≤0.2UIpp
8448	20Hz < pass < 400kHz ≤1.5UIpp	3kHz < pass < 400kHz (80kHz) ≤0.2UIpp
34 368	100Hz < pass < 800kHz ≤1.5UIpp	10kHz < pass < 800kHz ≤0.15UIpp
139 264	200Hz < pass < 3.5MHz ≤1.5UIpp	10kHz < pass < 3.5MHz ≤0.075UIpp

* The frequency values shown in parenthesis only apply to certain national interfaces.

● Connection The connection is as follows:

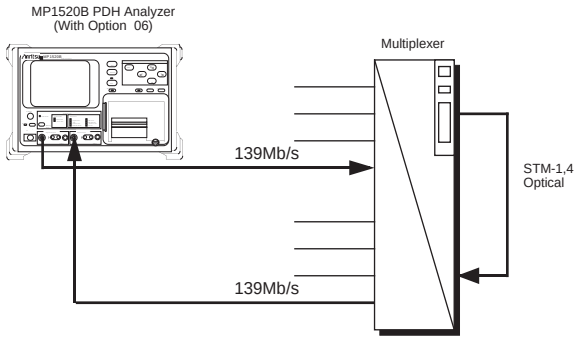


Fig. 8-2-1 Cable Connection

● Settings ◇ The setting of Menu:Condtn/Result is as follows:

- Sets the Bit rate to "139Mb/s".
- Sets the Jitt to "ON".

```
Condtn:Tx&Rx    Bit rate:139Mb/s    0ppm
 MUX  :OFF
 Patt :PRBS23
 Frame:ON
 Alarm:OFF          Error:OFF
 Mode :Repeat[ 1 secs ]   Jitt:ON
-------------------------------------------
Result:Error -Bit      Dspl:Current
 Time :Timed         [      00 00:00:40]
 EC             0
 ER      0.00E-08
 ES             0

 Freq       +0.2ppm
```

Fig. 8-2-2 The Setting of Menu:Condtn/Result

◇ The setting of Menu:Jitter is as follows:

- Sets the Jitter to "Sweep mask".
- Sets the Sweep mask table.
- Sets the Mask table.

```
Jitter:Sweep mask Table:139M-R
 1:200.0 Hz 1.500UI |  6: 10.0kHz 0.075UI
 2:500.0 Hz 1.500UI |  7: 40.0kHz 0.075UI
 3:  1.0kHz 0.750UI |  8:200.0kHz 0.075UI
 4:  2.0kHz 0.375UI |  9:  1.0MHz 0.075UI
 5:  4.5kHz 0.167UI | 10:  3.5MHz 0.075UI
-------------------------------------------
  20                                G.823
  10
                                    x:Err
   1                                o:No
                                      Err
 0.1                                UN-
0.01                                LOCK
(UIp-p)  10  100 1k  10k 100k 1M  (Hz)
```

Fig. 8-2-3 The Setting of Menu:Jitter

● Measurement ◇ The measurement is started by pressing the "start/stop" key.

• The tolerance result can be checked using the following screen.

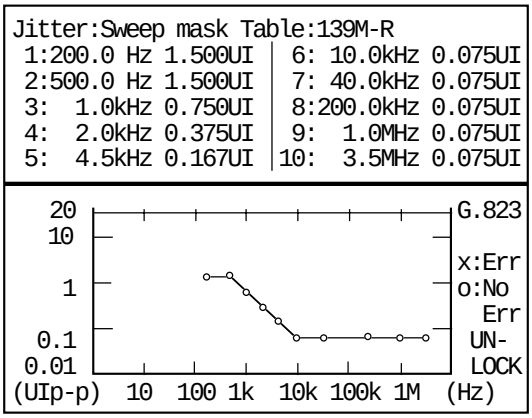


Fig. 8-2-4 Result of Jitter tolerance

Note: The sweep mask measurement does not measure the actual tolerance value.

Reference Standard ITU-T G.823

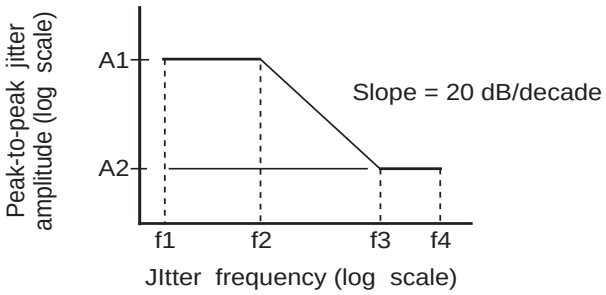


Fig 3/G.823 Lower limit of maximum tolerable input jitter

Table 2/G.823 Parameter values for input jitter tolerance

Digit rate(kbit/s)	A1 (UIp-p)	A2 (UIp-p)	f1 (Hz)	f2 (Hz)	f3 (Hz)	f4 (Hz)
2048	1.5	0.2	20	2.4K (93)	18k (700)	100k
8448	1.5	0.2	20	400 (10.7k)	3k (80k)	400k
34 368	1.5	0.15	100	1k	10k	800k
139 264	1.5	0.075	200	500	10k	3.5M

● Connection The connection is as follows:

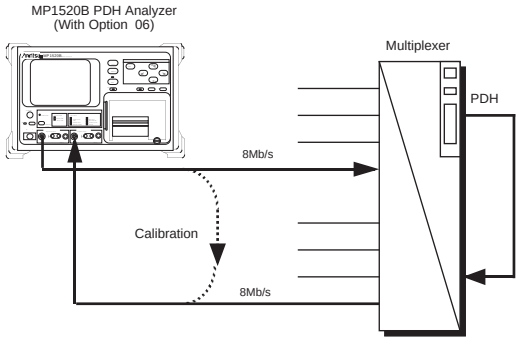


Fig. 8-3-1 Cable Connection

● Settings ◇ The setting of Menu:Condtn/Result is as follows:

- Sets the Bit rate to "8Mb/s".
- Sets the Jitt to "ON".

```
Condtn:Tx&Rx    Bit rate:  8Mb/s    0ppm
 MUX  :OFF
 Patt :PRBS15
 Frame:ON
 Alarm:OFF          Error:OFF
 Mode :Repeat[ 1 secs ]   Jitt:ON
-------------------------------------------
Result:Error -Bit      Dspl:Current [Zoom]
 Time :Timed          [      00 00:00:40]
 EC              0
 ER      0.00E-08
 ES              0

 Freq        +0.2ppm
```

Fig. 8-3-2 The Setting of Menu:Condtn/Result

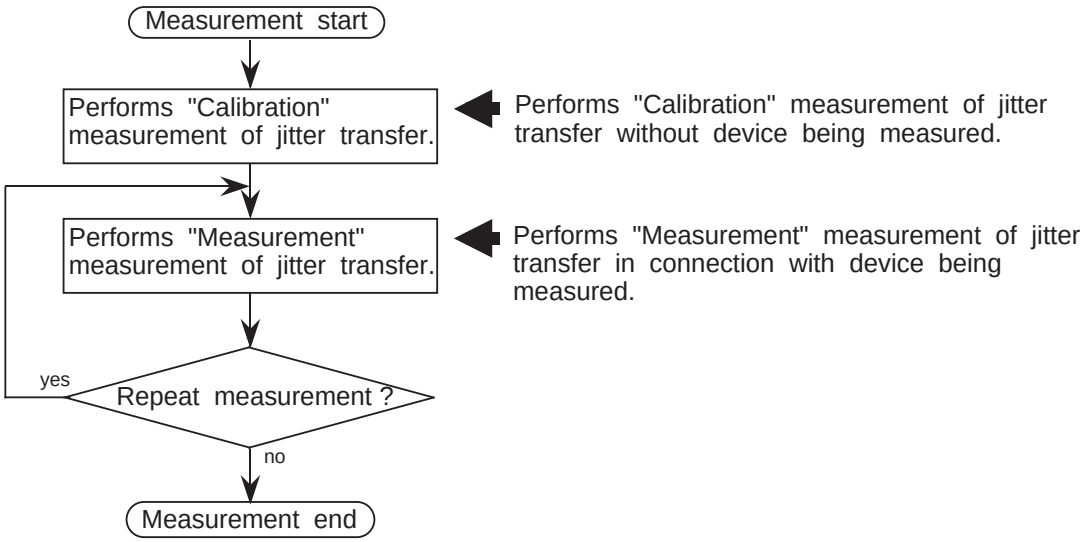
◇ The setting of Menu: Jitter is as follows:

- Sets the Jitter to "Transfer".
- Sets the Transfer table.
- Sets the Mask table.

```
Jitter:Transfer   Table:  8M-U  Point:10
 1: 15.0 Hz 1.500UI |  6:  2.0kHz 0.300UI
 2:100.0 Hz 1.500UI |  7:  3.0kHz 0.200UI
 3:200.0 Hz 1.500UI |  8: 20.0kHz 0.200UI
 4:500.0 Hz 1.500UI |  9:100.0kHz 0.200UI
 5:  1.0kHz 0.600UI | 10:400.0kHz 0.200UI
-------------------------------------------
Mode:Meas  Dspl:Meas(Graph)   Scale:10dB
   10
                                  G.751
    0
  -10
  -20                             UN-
  -30                             LOCK
   (dB)  10  100 1k  10k 100k 1M  (Hz)
```

Fig. 8-3-3 The Setting of Menu:Jitter

● Measurement ◇ Performs the jitter transfer measurement according to the following procedure by pressing the "start/stop" key.



- The transfer result can be checked using the following screen.
- Set the Dspl to "Meas(Graph)".

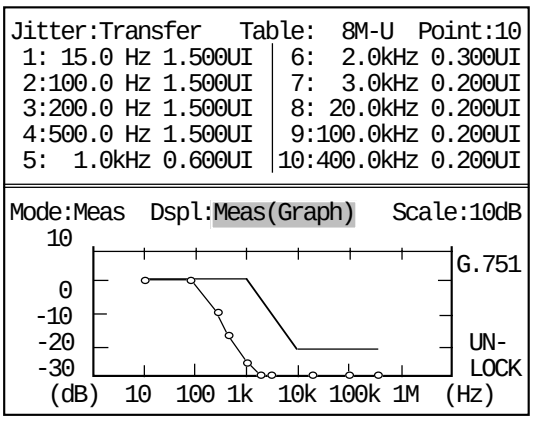


Fig. 8-3-4 Graphical Result of Jitter Transfer

- Set the Dspl to "Meas (Table)".

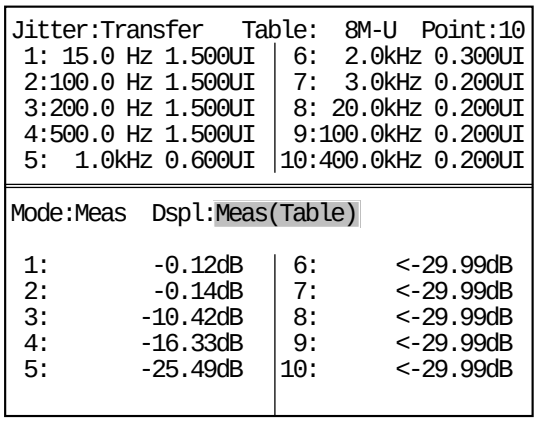


Fig. 8-3-5 Numerical Result of Jitter Transfer

Reference Standard ITU-T G.823

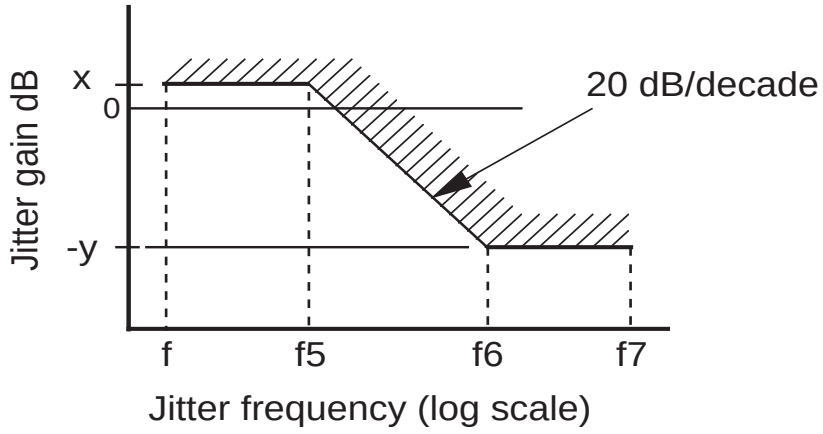


Fig 4/G.823 Typical jitter transfer characteristics.

* Figure 4/ G.823 indicates the general shape of a typical jitter transfer characteristic. The appropriate values for the levels x and -ydB and the frequencies f, f5, f6 and f7 can be obtained from the relevant Recommendation.

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8.4 Mapping Jitter (ITU-T G.783) Measurement Example (1/2)

● Connection The connection is as follows:

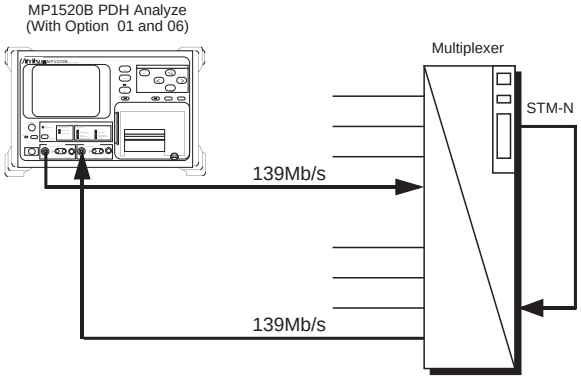

Fig. 8-4-1 Cable Connection

● Settings ◇ The setting of Menu:Condtn/Result is as follows:

- Sets the Bit rate to "139Mb/s".
- Sets the Jitt to "ON".

```
Condtn:Tx&Rx    Bit rate:139Mb/s    0ppm
 MUX  :OFF
 Patt :PRBS23
 Frame:ON
 Alarm:OFF          Error:OFF
 Mode :Repeat[ 1 secs ]   Jitt:ON
-------------------------------------
Result:Error -Bit      Dspl:Current
 Time :Timed          [      00 00:00:40]
 EC              0
 ER      0.00E-08
 ES              0

 Freq        +0.2ppm
```

Fig. 8-4-2 The Setting of Menu:Condtn/Result

◇ The setting of Menu:Jitter is as follows:

- Sets the Jitter to "Jitt/Freq".
- Sets the Min freq.
- Sets the Max freq.
- Sets the Filter to "HP1+LP" or "HP2+LP".

```
Jitter:Jitt/Freq
 Min freq:139M -50ppm
 Max freq:139M +50ppm
 Step    :       5ppm
 Interval: 1secs
 Filter  :HP2+LP
-------------------------------------
Max Jitter                 Scale:0.1UI
 0.5
 0.4
 0.3
 0.2                              UN-
 0.1                              LOCK
   0
(UIp-p)     -30       0       +30  (ppm)
```

Fig. 8-4-3 The Setting of Menu:Jitter

● Measurement ◇ The measurement is started by pressing the "start/stop" key.

• The mapping jitter result can be checked using the following screen.

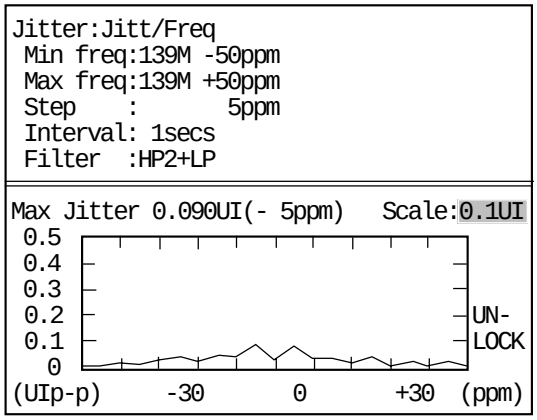

Fig. 8-4-4 Result of Mapping Jitter

Reference Standard ITU-T G.783

Table 6-1/G.783 Mapping jitter generation specification

G.703 interface	Filter Characteristics			Maximum pk-pk Jitter	
	f1 high pass	f3 high pass	f4 low pass	mapping	
				f1-f4	f3-f4
2 048 kbit/s	20Hz	18kHz	100kHz	(Note 1)	0.075
34 368 kbit/s	100Hz	10kHz	800kHz	(Note 1)	0.075
139 264 kbit/s	200Hz	10kHz	3.5MHz	(Note 1)	0.075

Note 1- For further study.

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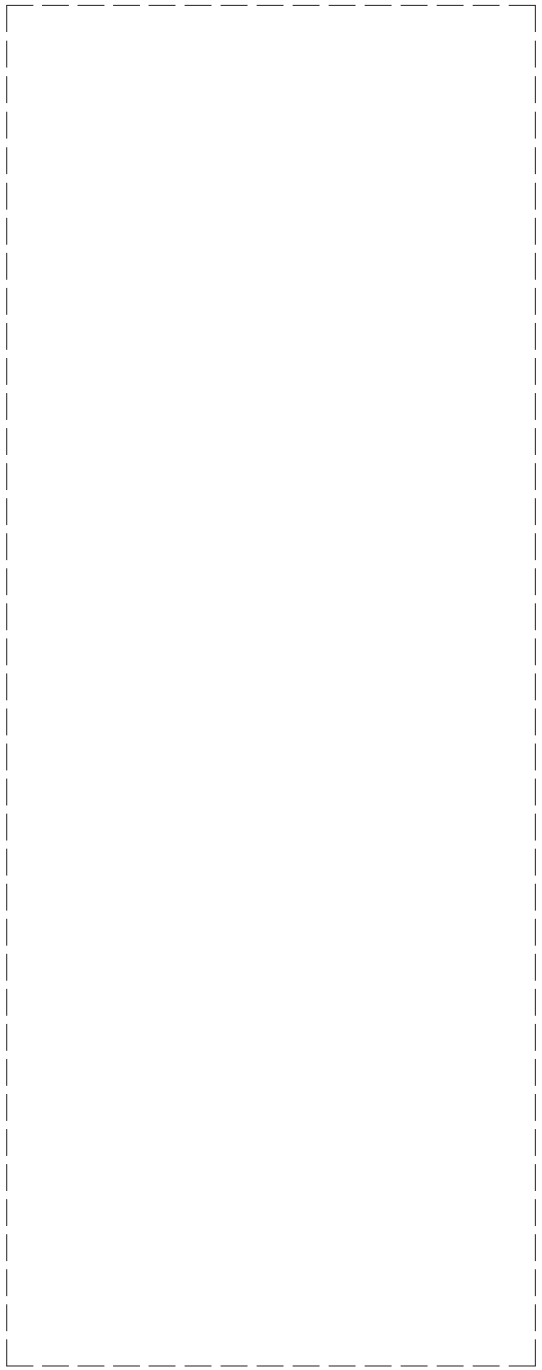

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