



JAPANESE
INDUSTRIAL
STANDARD

Translated and Published by
Japanese Standards Association

JIS C 6113 : 1997

**Measuring methods of transmitting
and/or receiving modules for middle
and high speed fiber optic trans-
mission**

ICS 33.180.01

Descriptors : optical fibres, digital signals, optical communication systems, transmitters, receivers, electrical measurement

Reference number : JIS C 6113 : 1997 (E)

C 6113:1997

Foreword

This translation has been made based on the original Japanese Industrial Standard established by the Minister of International Trade and Industry through deliberations at Japanese Industrial Standards Committee in accordance with the Industrial Standardization Law.

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Date of Establishment: 1997-11-20

Date of Public Notice in Official Gazette: 1997-11-20

Investigated by: Japanese Industrial Standards Committee

Divisional Council on Electronics

JIS C 6113:1997, First English edition published in 1998-11

Translated and published by: Japanese Standards Association
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Printed in Japan

Measuring methods of transmitting and/or receiving modules for middle and high speed fiber optic transmission

Introduction This Standard specifies measuring methods of transmitting and/or receiving modules for middle and high speed fiber optic transmission with 2R (waveform reproducing and reshaping) or 3R (waveform reproducing and reshaping, and synchronous signal reproducing) functions which are used for transmission of NR2 digital signal at a bit rate exceeding 10 Mb/s through optical fibers, in response to the requirement of early establishment of national Standard in such backgrounds that the market of fiber optic transmission link inside and outside of this country is spreading and the international standardization activity is promoted.

1 Scope This Japanese Industrial Standard specifies measuring method of transmitting and/or receiving modules for middle and high speed fiber optic transmission with at least waveform reproducing and reshaping functions which are used for transmission of digital signal at a bit rate exceeding 10 Mb/s through optical fibers.

Remarks: The transmitting and/or receiving module for middle and high speed fiber optic transmission dealt with here means a module composed of a transmitter consisting of a light emitting diode as the light emitting element, an electronic circuit and a joint with optical fiber and a receiver consisting of a light receiving element, an electronic circuit and a joint with optical fiber. It is the generic name of modules of the following three kinds in construction.

- (1) Transmitting module in which the above transmitter is employed as an individual module.
- (2) Receiving module in which the above receiver is employed as an individual module.
- (3) Transmitting and receiving module in which the above transmitter and receiver are employed to form a module.

2 Normative references The following standards contain provisions which, through reference in this Standard, constitute provisions of this Standard. The most recent editions of the standards indicated below shall be applied.

JIS C 1102-1 *Direct acting indicating analogue electrical measuring instruments and their accessories Part 1: Definitions and general requirements common to all parts*

JIS C 6112 *General rules of transmitting and/or receiving modules for middle and high speed fiber optic transmission*

3 Definitions For the purpose of this Standard, in addition to the definitions given in **JIS C 6110**, the following principal definitions apply:

- a) **measurement optical fiber** Such an optical fiber that its structural parameters and the structural parameters of the plug attached to it have respective values which satisfy the requirements of measurements.

- b) **reference transmitter and reference receiver** Such transmitter and receiver that their electrical and optical characteristics have respective values which satisfy the requirements of each item in the relevant standard.

4 Atmospheric conditions for measurement

4.1 Standard conditions Unless otherwise specified, the measurements shall be carried out at a temperature 15 °C to 35 °C, a relative humidity 25 % to 85 % and an air pressure 860 hPa to 1 060 hPa. If any doubt arises on the decision of measured values under these standard conditions, or if especially required, conditions of **4.3** shall be employed. If conversion to the reference conditions is necessary, conditions of **4.2** shall be employed.

If it is difficult to carry out a test under the standard conditions, the test may be carried out under the conditions other than the standard conditions unless any doubt arises on the decision.

4.2 Reference conditions The reference conditions shall be a temperature 25 °C, a relative humidity 45 % and an air pressure 860 hPa to 1 060 hPa. However, only the temperature may be employed as the reference conditions.

4.3 Referee conditions The referee conditions shall be a temperature $25\text{ °C} \pm 2\text{ °C}$, a relative humidity 45 % to 55 % and an air pressure 860 hPa to 1 060 hPa.

5 Measuring apparatus and equipment

5.1 Measuring power supply In the d.c. power supply the voltage fluctuation shall not exceed $\pm 0.5\%$ or 10 mV whichever is the larger, and in the a.c. power supply, the higher harmonic content shall not exceed 5 %. If commercial supply is used the higher harmonic content shall not exceed 10 %.

In the test to measure a.c. output especially, the ripple content of d.c. power supply, higher harmonic content of a.c. power supply and a.c. impedance of d.c. supply circuit through which a.c. current flows, shall have respective small values so that they will not affect the measurements. The power supply shall be enough protected against ingress of surges.

5.2 Instruments and measuring apparatus Unless otherwise specified, the instruments shall be those of class index 0.5 or better specified in **JIS C 1102-1**, and the measuring apparatus shall have an accuracy at least equivalent thereto. Their impedances shall have such values that the influence on the measuring system can be ignored.

Remarks: If there is no instrument of class index 0.5 or better, or measuring apparatus of equivalent accuracy as standard products, the provision of **5.2** does not apply.

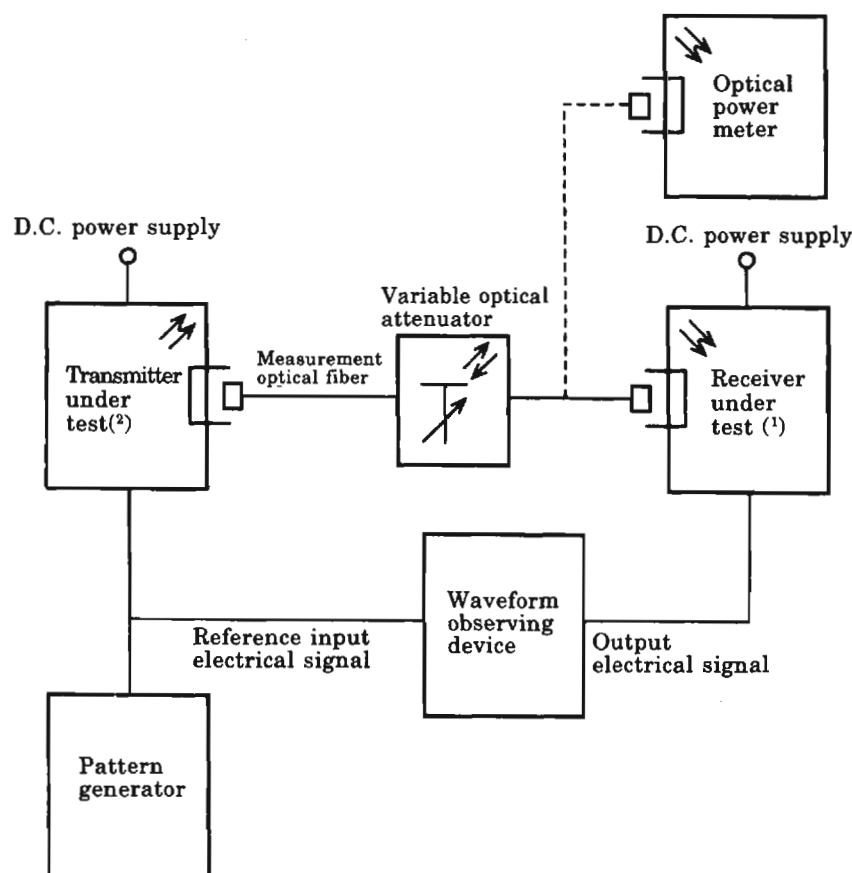
5.3 Optical power meter The optical power meter to be used for measurements shall be calibrated at the appropriate wavelength and the sensitivity distribution on light receiving plane shall be sufficiently flat.

6 Measuring methods of electrical and optical characteristics

6.1 Transmission delay time (composite test, transmitter individual test, receiver individual test)

6.1.1 Purpose To measure the transmission delay time of transmitter and/or receiver under specified conditions.

6.1.2 Measuring circuit The measuring circuit of transmission delay time shall be as illustrated in Fig. 1.



Notes (1) In the case of transmitter individual test, the reference receiver is used.

(2) In the case of receiver individual test, the reference transmitter is used.

Remarks 1 The dash line shows the connection state in procedure 6.1.3 c).

2 The optical delay in measurement optical fiber, variable optical attenuator, etc. and the delay in signal line of measurement circuit shall be previously calibrated.

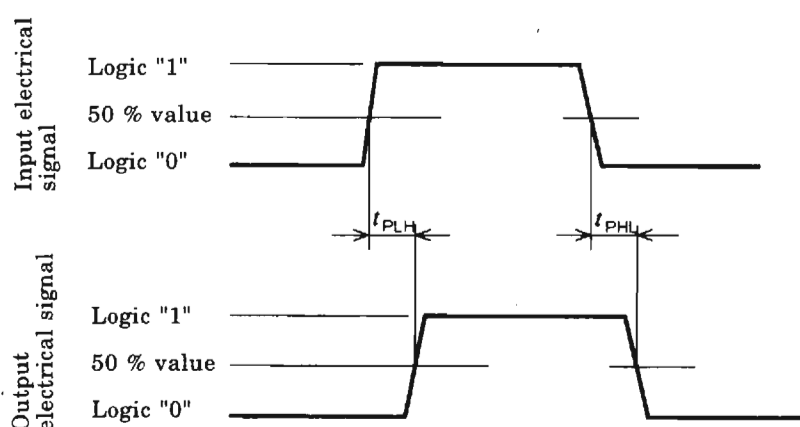
Fig. 1 Measuring circuit of transmission delay time

6.1.3 Measuring procedures

- Drive the transmitter and receiver under specified conditions.
- Apply the specified continuous input electrical signal of NRZ 1010... (mark density 50 %) to the transmitter as its input from the pattern generator.
- Input the optical output signal so prepared to the receiver through measurement optical fiber and optical attenuator.

Adjust the variable optical attenuator so that the specified optical power is inputted into the receiver.

- Observe the waveforms of the output from the pattern generator and the output from the receiver by means of a waveform observing device such as an oscilloscope, and measure the time differences t_{PLH} , t_{PHL} between the said two waveforms at their 50 % amplitude value shown in Fig. 2. The optical delay in the measurement optical fiber, variable optical attenuator and the delay in the signal line of the measuring system shall be previously calibrated. If there is a pulse width jitter in the output electrical signal, carry out the measurement at the maximum value of the jitter.



Remarks: This figure shows the case of positive logic, and in the case of negative logic, the logic "1" in the figure should be read as logic "0" and logic "0" as logic "1".

Fig. 2 Transmission delay time

- Calculate transmission delay time t_d from formula (1), formula (2) or formula (3).

For composite transmitter and receiver test

$$t_d = \max(t_{PLH}, t_{PHL}) \dots\dots\dots (1)$$

For transmitter individual test

$$t_d = \max(t_{PLH}, t_{PHL}) - t_{dr} \dots\dots\dots (2)$$

For receiver individual test

$$t_d = \max(t_{PLH}, t_{PHL}) - t_{ds} \dots\dots\dots (3)$$

where $\max(t_{PLH}, t_{PHL})$: the larger value among values of t_{PLH} and t_{PHL} . The value when they are equal

t_{dr} : transmission delay time of reference receiver

t_{ds} : transmission delay time of reference transmitter

- f) In the case of composite test and receiver individual test, adjust the variable optical attenuator so that the minimum received optical power and the maximum received optical power are attained at the receiver, repeat the measurement of t_d over the above range and take the maximum measured value as transmitting delay time. In the case of composite test where a transmitter and a receiver are combined, use the test specimens as the transmitter and receiver under test. In the case of transmitter individual test, use the reference receiver in lieu of the specimen receiver, and in the case of receiver individual test, use the reference transmitter in lieu of the specimen transmitter.

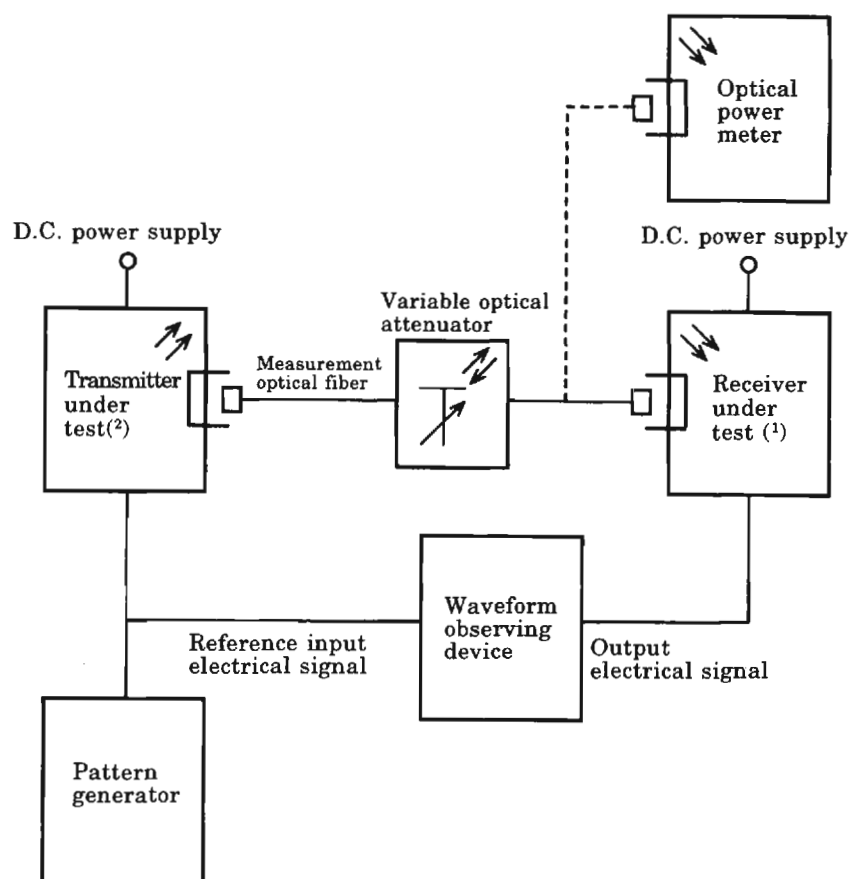
6.1.4 Items to be specified in detail specification

- a) Operating temperature
- b) Transmission delay time, rise time, fall time, distortion of pulse width, random jitter, maximum received optical power and minimum received optical power of reference receiver (the random jitter shall be sufficiently smaller than that of the transmitter under test).
- c) Transmission delay time, rise time, fall time, distortion of pulse width, random jitter, peak emission wavelength and output optical power of reference transmitter (the random jitter shall be sufficiently smaller than that of the receiver under test).
- d) Conditions for driving transmitter and receiver (supply voltage)
- e) Input signal for transmitter (transmission bit rate, waveform)
- f) Measurement optical fiber
- g) Maximum received optical power and minimum received optical power of receiver

6.2 Distortion of pulse width (composite test, transmitter individual test, receiver individual test)

6.2.1 Purpose To measure the distortion of pulse width of transmitter and/or receiver under specified conditions.

6.2.2 Measuring circuit The measuring circuit of distortion of pulse width shall be as illustrated in Fig. 3.



- Remarks 1 The dash line shows the connection state in procedure 6.2.3 c).
- 2 The optical delay in measurement optical fiber, variable optical attenuator, etc. and the delay in signal line of measurement circuit shall be previously calibrated.

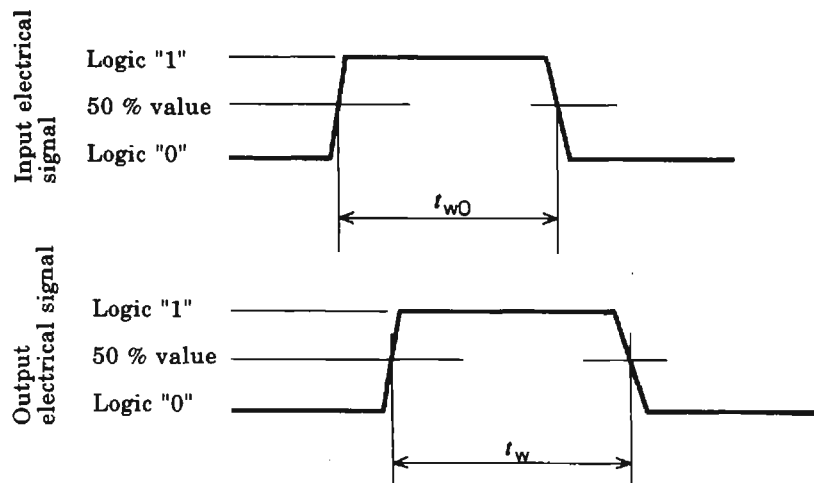
Fig. 3 Measuring circuit of distortion of pulse width

6.2.3 Measuring procedures

- Drive the transmitter and receiver under specified conditions.
- Apply the specified continuous input electrical signal of NRZ 1010... (mark density 50 %) to the transmitter as its input from the pattern generator.
- Input the optical output signal so prepared to the receiver through measurement optical fiber and variable optical attenuator.

Adjust the optical attenuator so that the specified optical power is inputted into the receiver.

- Observe the input electrical signal and output electrical signal by means of such a waveform observing device as an oscilloscope and measure the average values of pulse width t_{w0} and t_w , respectively (see Fig. 4). If there is a random jitter in the output electrical signal, carry out the measurement at the maximum value of the jitter.



Remarks: This figure shows the case of positive logic, and in the case of negative logic, the logic "1" in the figure should be read as logic "0" and logic "0" as logic "1".

Fig. 4 Pulse width distortion

- e) Calculate the distortion of pulse width from formula (4), formula (5) or formula (6).

For composite test

$$\Delta t_w = t_w - t_{w0} \dots\dots\dots (4)$$

For transmitter individual test

$$\Delta t_w = t_w - t_{w0} - \Delta t_{wr} \dots\dots\dots (5)$$

For receiver individual test

$$\Delta t_w = t_w - t_{w0} - \Delta t_{ws} \dots\dots\dots (6)$$

where, Δt_{wr} : distortion of pulse width of reference receiver

Δt_{ws} : distortion of pulse width of reference transmitter

- f) In the case of composite test and receiver individual test, adjust the variable optical attenuator so that the minimum received optical power and the maximum received optical power are attained at the receiver, repeat the measurement of Δt_w over the above range and take the maximum measured value as distortion of pulse width. In the case of composite test where a transmitter and a receiver are combined, use the test specimens as the transmitter and receiver under test. In the case of transmitter individual test, use the reference receiver in lieu of the specimen receiver, and in the case of receiver individual test, use the reference transmitter in lieu of the specimen transmitter.

6.2.4 Items to be specified in detail specification

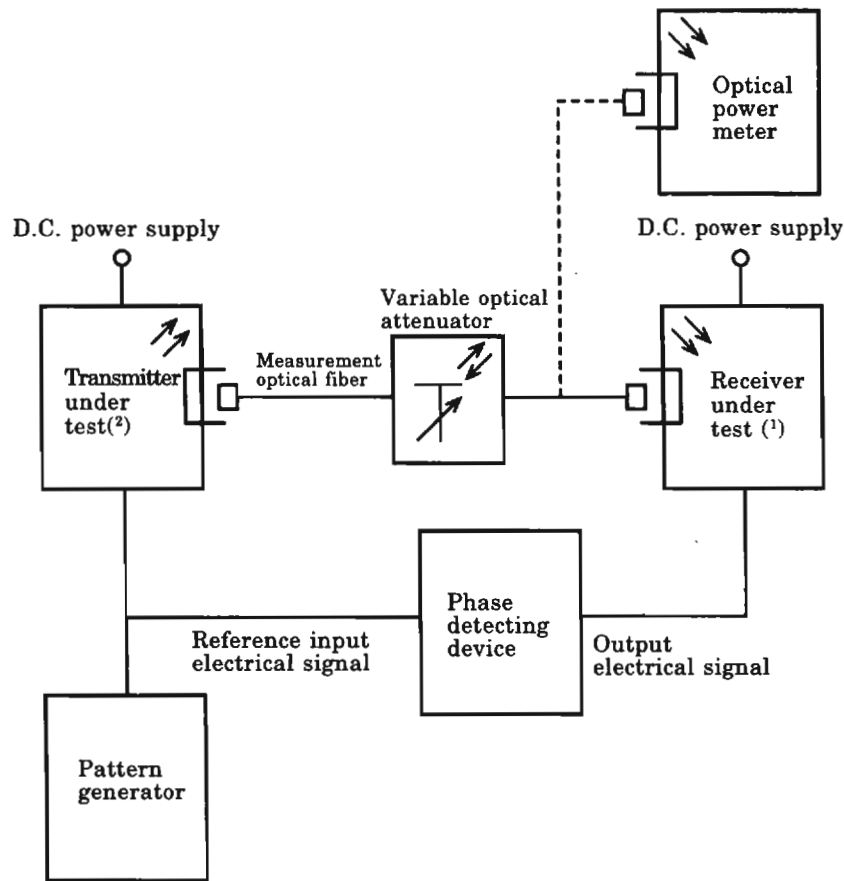
- a) Operating temperature

- b) Transmission delay time, rise time, fall time, distortion of pulse width, random jitter, maximum received optical power and minimum received optical power of reference receiver (the random jitter shall be sufficiently smaller than that of the transmitter under test.)
- c) Transmission delay time, rise time, fall time, distortion of pulse width, random jitter, peak emission wavelength and output optical power of reference transmitter (the random jitter shall be sufficiently smaller than that of the receiver under test.)
- d) Conditions for driving transmitter and receiver (supply voltage)
- e) Input signal for transmitter (transmission bit rate, waveform)
- f) Measurement optical fiber
- g) Maximum received optical power and minimum received optical power of receiver

6.3 Random jitter (composite test, transmitter individual test, receiver individual test)

6.3.1 Purpose To measure the random jitter of transmitter and/or receiver under specified conditions.

6.3.2 Measuring circuit The measuring circuit of random jitter shall be as illustrated in Fig. 5.



- Remarks 1 The dash line shows the connecting state in procedure 6.3.3 c).
- 2 The optical delay in measurement optical fiber, variable optical attenuator, etc. and the delay in signal line of measurement circuit shall be previously calibrated.

Fig. 5 Measuring circuit of random jitter

6.3.3 Measuring procedures

- Drive the transmitter and receiver under specified conditions.
- Apply the input electrical signal of specified quasi random signal (mark density 50 %) to the transmitter as its input from the pattern generator.
- Input the optical output signal so prepared to the receiver through measurement optical fiber and variable optical attenuator.

Adjust the variable optical attenuator so that the specified optical power is inputted into the receiver.

- Input the output electrical signal from receiver into the phase detecting device, and measure the phase variations Δt_{j1} and Δt_{j2} corresponding to the pulse width t_{w0} (see Fig. 6).