IEC 60747-16-2

Edition 1.1 2008-01

INTERNATIONAL STANDARD

Semiconductor devices – Part 16-2: Microwave integrated circuits – Frequency prescalers

IEC 60747-16-2:2001+A1:2007(E)

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INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

PRICE CODE **CG**

ICS 31.080.01

ISBN 2-8318-9451-4

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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FOREWORD

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International Standard IEC 60747-16-2 has been prepared by subcommittee 47E: Discrete semiconductor devices, of IEC technical committee 47: Semiconductor devices.

This consolidated version of IEC 60747-16-2 consists of the first edition (2001) [documents 47E/160/FDIS and 47E/172/RVD] and its amendment 1 (2007) [documents 47E/338/FDIS and 47E/343/RVD].

The technical content is therefore identical to the base edition and its amendment and has been prepared for user convenience.

It bears the edition number 1.1.

A vertical line in the margin shows where the base publication has been modified by amendment 1.

The committee has decided that the contents of the base publication and its amendments will remain unchanged until the maintenance result date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

SEMICONDUCTOR DEVICES –

Part 16-2: Microwave integrated circuits – Frequency prescalers

1 Scope

This part of IEC 60747 provides new measuring methods, terminology and letter symbols, as well as essential ratings and characteristics for integrated circuit microwave frequency prescalers.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60617:2001, *Graphical symbols for diagrams*

IEC 60747-1:2006, *Semiconductor devices – Part 1: General*

IEC 60748-2, *Semiconductor devices – Integrated circuits – Part 2: Digital integrated circuits*

IEC 60748-3, *Semiconductor devices. Integrated circuits – Part 3: Analogue integrated circuits*

IEC 60748-4, *Semiconductor devices – Integrated circuits – Part 4: Interface integrated circuits*

IEC 61340-5-1:2007, *Electrostatics – Part 5-1: Protection of electronic devices from electrostatic phenomena - General requirements*

IEC/TR 61340-5-2:2007, *Electrostatics – Part 5-2: Protection of electronic devices from electrostatic phenomena – User guide*

3 Terms and definitions

For the purpose of this part of IEC 60747, the following terms and definitions apply:

3.1
power supply voltage V_{xxi}
(terminal voltage)
d.c. voltage required to be applied to an 'i'-th terminal noted by 'xx'

3.2
power supply current I_{xxi}
d.c. current flowing through an 'i'-th terminal noted by 'xx'

3.3
output power P_o
a.c. power measured at the output terminal

3.4
output voltage V_o
amplitude of voltage swing measured at the output terminal

3.5
input power P_i
a.c. power delivered to the input terminal

3.6
input voltage V_i
amplitude of input voltage swing

3.7
high-level modulus control input voltage V_{CH}
control voltage value to transfer the division ratio from low-level modulus to high-level modulus

3.8
low-level modulus control input voltage V_{CL}
control voltage value to transfer the division ratio from high-level modulus to low-level modulus

3.9
high-level modulus control input current I_{CH}
control current value to transfer the division ratio from low-level modulus to high-level modulus

3.10
low-level modulus control input current I_{CL}
control current value to transfer the division ratio from high-level modulus to low-level modulus

3.11
input frequency f_i
input frequency for which the device functions

3.12
division ratio N
ratio of the output frequency and input frequency

3.13
set-up time t_{set}
(under consideration)

4 Essential ratings and characteristics

4.1 General

This clause gives ratings and characteristics required for specifying integrated circuit microwave frequency prescalers used at the microwave or millimetre-wave frequency band.

The integrated circuits contain fixed and two modulus prescalers.

4.1.1 Circuit identification and types

4.1.1.1 Designation and types

Indication of type (device name), category of circuit and technology applied should be given.

Microwave frequency prescalers are divided into two categories:

- type A: fixed modulus type;
- type B: two modulus type.

4.1.1.2 General function description

A general description should be made of the function performed by the integrated circuit microwave frequency prescalers, and the features for the application.

4.1.1.3 Manufacturing technology

The manufacturing technology, e.g. semiconductor monolithic integrated circuit, thin film integrated circuit, micro-assembly, should be stated. This statement should include details of the semiconductor technologies such as MESFET, MISFET, MOSFET, Si bipolar transistor, HBT, etc.

4.1.1.4 Package identification

The following should be stated:

a) chip or packaged form;
b) IEC and/or national reference number of the outline drawing or of the drawing of a non-standard package including terminal numbering;
c) principal package material, for example, metal, ceramic, plastic;
d) for chip form, outlines, dimensions, pad sizes, contact material, and recommended contact technologies.

4.1.1.5 Main application

The main application should be stated if necessary. If the device has restrictive applications, these should be stated here.

4.2 Application-related description

Information on the application of the integrated circuit and its relation to the associated devices should be given.

4.2.1 Conformance to system and/or interface information

It should be stated whether the integrated circuit conforms to an application system and/or an interface standard or recommendation.

Detailed information about application systems, equipment and circuits such as VSAT systems, DBS receivers, and microwave landing systems should also be given.

4.2.2 Overall block diagram

A block diagram of the applied systems should be given if necessary.

4.2.3 Reference data

The most important properties required to permit comparison between derivative types should be given.

4.2.4 Electrical compatibility

It should be stated whether the integrated circuit is electrically compatible with other particular integrated circuits or families of integrated circuits, or whether special interfaces are required.

Details should be given concerning the type of input and output circuits, for example, input/output impedances, d.c. block, open-drain.

Interchangeability with other devices, if any, should be given.

4.2.5 Associated devices

If applicable, the following should be stated here:

– devices necessary for correct operation (list with type number, name, and function);
– peripheral devices with direct interfacing (list with type number, name, and function).

4.3 Specification of the function

4.3.1 Detailed block diagram-functional blocks

A detail block diagram or equivalent circuit information concerning the integrated circuit microwave frequency prescalers should be given. The block diagram should be composed of the following:

a) functional blocks;
b) mutual interconnections among the functional blocks;
c) individual functional units within the functional blocks;
d) mutual interconnections among the individual functional blocks;
e) function of each external connection;
f) inter-dependence between the separate functional blocks.

The block diagram should identify the function of each external connection, and where no ambiguity can arise, can also show the terminal symbols and/or numbers. If the encapsulation has metallic parts, any connection to them from external terminals should be indicated. The connections with any associated external electrical elements should be stated, where necessary.

For the purpose of providing additional information, the complete electrical circuit diagram can be reproduced, though this will not necessarily involve giving indications of the function. Rules governing such diagrams may be obtained from IEC 60617.

4.3.2 Identification and function of terminals

All terminals should be identified on the block diagram (supply terminals, input or output terminals, input/output terminals).

The terminal functions 1) to 4) should be indicated in a table as follows:

Terminal number	Terminal symbol	1) Terminal designation	2) Function	Function of terminal	
				3) Input/output identification	4) Type of input/output circuits

1) Terminal designation

   A terminal name indicating the function of the terminal should be given. Supply terminals, ground terminals, blank terminals (with abbreviation NC) and non-usable terminals (with abbreviation NU) should be distinguished.

2) Function

   A brief indication of terminal function should be given:

   – each function of multi-role terminals, i.e. terminals having multiple functions;

   – each function of integrated circuits selected by mutual pin connections or function selection data applied to the function selection pin such as mode selection pin.

3) Input/output identification

   Input, output, input/output, and multiple input/output terminals should be distinguished.

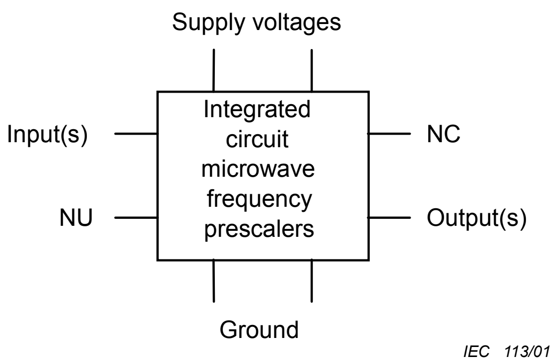
4) Type of input/output circuits

   The type of input and output circuits, for example, input/output impedances, with or without d.c. block, etc., should be distinguished.

5) Type of ground

   If the baseplate of the package is used as ground, this should be stated.

   Example:



4.3.3 Functional description

The function performed by the circuit should be specified and include the following information:

– basic function;
– relation to external terminals;
– operation mode (for example, set-up method, preference, etc.);
– interrupt handling.

4.3.4 Family-related characteristics

In this part, all family specific functional descriptions shall be provided (with reference to IEC 60748-2, IEC 60748-3 and IEC 60748-4).

If ratings and characteristics and function characteristics exist for the family, the relevant part of IEC 60748 should be used (for example, for microprocessors, see IEC 60748-2, Chapter III, section 3).

NOTE For each new device family, specific items shall be added to the relevant part of IEC 60748.

4.4 Limiting values (absolute maximum rating system)

The table of these values should contain the following.

– Any interdependence of limiting conditions shall be specified.
– If externally connected and/or attached elements, for example heatsinks, have an influence on the values of the ratings, the ratings shall be prescribed for the integrated circuit with the elements connected and/or attached.
– If limiting values are exceeded for transient overload, the permissible excess and their durations shall be specified.
– Where minimum and maximum values differ during programming of the device, this should be stated.
– All voltages are referenced to a specified reference terminal (V_{SS}, GND, etc.).
– In satisfying the following clauses, if maximum and/or minimum values are quoted, the manufacturer must indicate whether he refers to the absolute magnitude or to the algebraic value of the quantity.
– The ratings given must cover the operation of the multi-function integrated circuit over the specified range of operating temperatures. Where such ratings are temperature-dependent, such dependence should be indicated.

4.4.1 Electrical limiting values

Limiting values should be specified as follows:

Subclause	Parameters	Min.	Max.
4.4.1.1	Power supply voltage(s)	+	+
4.4.1.2	Power supply current(s) (where appropriate)		+
4.4.1.3	Terminal voltage(s) (where appropriate)	+	+
4.4.1.4	Terminal current(s) (where appropriate)		+
4.4.1.5	Input power		+
4.4.1.6	Power dissipation (where appropriate)		+

The detail specification may indicate those values within the table including notes 1 and 2.

Parameters (Note 1, Note 2)	**Symbols**	**Min.**	**Max.**	**Unit**

NOTE 1 Where appropriate, in accordance with the type of circuit considered.

NOTE 2 For power supply voltage range:

- limiting value(s) of the continuous voltage(s) at the supply terminal(s) with respect to a special electrical reference point;
- where appropriate, limiting value between specified supply terminals;
- when more than one voltage supply is required, a statement should be made as to whether the sequence in which these supplies are applied is significant; if so, the sequence should be stated;
- when more than one supply is needed, it may be necessary to state the combinations of ratings for these supply voltages and currents.

4.4.2 Temperatures

a) Operating temperature (ambient or reference-point temperature)

b) Storage temperature

c) Channel temperature

d) Lead temperature (for soldering)

The detail specification may indicate those values within the table including the note.

Parameters (Note)	**Symbols**	**Min.**	**Max.**	**Unit**

NOTE Where appropriate, in accordance with the type of circuit considered.

4.5 Operating conditions (within the specified operating temperature range)

They are not to be inspected but may be used for quality assessment purposes.

4.5.1 Power supplies – positive and/or negative values

4.5.2 Initialization sequences (where appropriate)

If special initialization sequences are necessary, the power supply sequencing and initialization procedure should be specified.

4.5.3 Input voltage(s) or input signal (where appropriate)

For RF input signal, waveform and characteristic impedance should be specified.

4.5.4 Output current(s) (where appropriate)

RF or d.c. current with relevant impedance should be specified.

4.5.5 Voltage and/or current of other terminal(s)

4.5.6 External elements (where appropriate)

4.5.7 Operating temperature range

4.6 Electrical characteristics

The characteristics shall apply over the full operating temperature range, unless otherwise specified.

Each characteristic should be stated: either

a) over the specified range of operating temperatures, or

b) at a temperature of 25 °C, and at maximum and minimum operating temperatures.

The parameters should be specified according to the type as follows:

Subclause	Parameters	Min.	Typ*	Max.	Types	
					A	B
4.6.1	Power supply current(s)		+	+	+	+
4.6.2	Output power	+	+		+	+
4.6.3	Output voltage	+	+		+	+
4.6.4	Minimum operating input power		+	+	+	+
4.6.5	Maximum operating input power	+	+		+	+
4.6.6	Minimum operating input voltage		+	+	+	+
4.6.7	Maximum operating input voltage	+	+		+	+
4.6.8	High-level modulus control input voltage	+	+	+		+
4.6.9	Low-level modulus control input voltage	+	+	+		+
4.6.10	High-level modulus control input current		+	+		+
4.6.11	Low-level modulus control input current	+	+			+
4.6.12	Minimum operating input frequency		+	+	+	+
4.6.13	Maximum operating input frequency	+	+		+	+
4.6.14	Set-up time		+	+	+	+

* Optional.

NOTE 1 It is necessary to select either the parameter set of 4.6.2, 4.6.4 and 4.6.5 or that of 4.6.3, 4.6.6 and 4.6.7.

NOTE 2 The values of 4.6.2 and 4.6.3 depend on output impedance.

NOTE 3 The values of 4.6.4, 4.6.5, 4.6.6 and 4.6.7 depend on input impedance.

The detail specification may indicate those values within the table.

Characteristics	Symbols	Conditions	Min.	Typ.*	Max.	Units

* Optional

4.7 Mechanical and environmental ratings, characteristics and data

Any specific mechanical and environmental ratings applicable should be stated. (See also Clauses 5.10 and 5.11 of IEC 60747-1.)

4.8 Additional information

Where appropriate, the information detailed in the following subclauses should be given.

4.8.1 Equivalent input and output circuit

Detail information should be given regarding the type of input and output circuits, for example, input/output impedances, d.c. block, open-drain.

4.8.2 Internal protection

A statement shall be given to indicate whether the integrated circuit contains internal protection against high static voltages or electrical fields.

4.8.3 Capacitors at terminals

If capacitors for input/output d.c. block are needed, these capacitances should be stated.

4.8.4 Thermal resistance

4.8.5 Interconnections to other types of circuit

Where appropriate, details of the interconnections to other circuits, for example, detector circuit for AGC, sense amplifiers, buffer, should be given.

4.8.6 Effects of externally connected component(s)

Curves or data indicating the effect of externally connected component(s) that influence the characteristics may be given.

4.8.7 Recommendations for any associated device(s)

For example, decoupling of the power supply to a high-frequency device should be stated.

4.8.8 Handling precautions

Where appropriate, handling precautions specific to the circuit should be stated. (See also IEC 61340-5-1 and IEC/TR 61340-5-2 concerning electrostatic-sensitive devices.)

4.8.9 Application data

4.8.10 Other application information

4.8.11 Date of issue of the data sheet

5 Measuring methods

5.1 General

This clause prescribes measuring methods for electrical characteristics of integrated circuit microwave frequency prescalers used at microwave frequency bands.

5.1.1 General precautions

The general precautions listed in Clauses 6.3, 6.4 and 6.6 of IEC 60747-1, will be applied. In addition, special care should be taken to use low-ripple d.c. supplies and to decouple adequately all bias supply voltages at the frequency of measurement. Although the level of the input and/or output signal can be specified in either power or voltage, in this document it is expressed in power unless otherwise specified.

5.1.2 Characteristic impedance

Input/output impedances of the device should be fixed. Generally, the input impedance of the device should be 50 Ω; if it is much higher than 50 Ω, then a shunt resistor of 50 Ω should be connected to the port.

5.1.3 Handling precautions

When handling electrostatic-sensitive devices, reference should be made to the handling precautions given in IEC 61340-5-1 and IEC/TR 61340-5-2.

5.1.4 Types

The devices in this clause are both packaged and chip types.

5.2 Output power (P_o)

5.2.1 Purpose

To measure the output power under specified conditions.

5.2.2 Circuit diagram

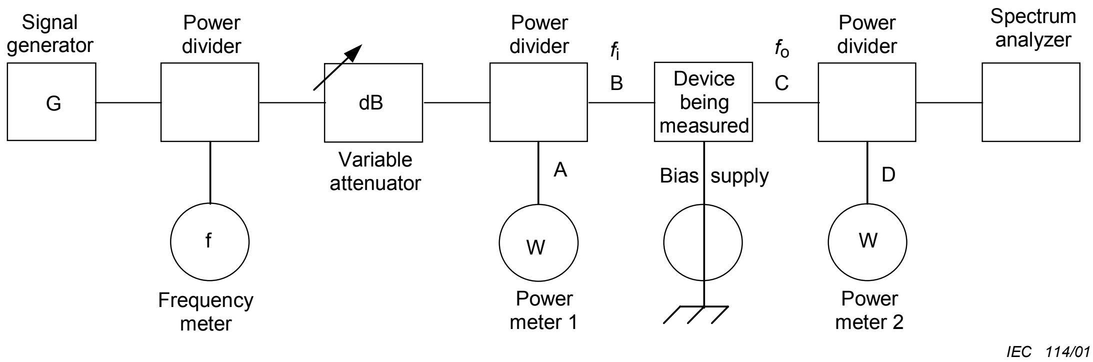


Figure 1 – Circuit for the measurement of output power

5.2.3 Principle of measurements

In the circuit diagram shown in figure 1, the input power P_i and output power P_o of the device being measured are derived from the following equation:

$$P_i = P_1 - L_1 \quad (1)$$

$$P_o = P_2 - L_2 \quad (2)$$

where P_1 and P_2 are the values indicated by power meters 1 and 2, respectively; L_1 is the power difference between points A and B; L_1 is defined by a subtraction from the power at point A to the power at point B; L_2 is defined by a subtraction from the power at point D to the power at the point C; P_i, P_o, P_1 and P_2 are expressed in dBm; and L_1 and L_2 are expressed in dB.

5.2.4 Circuit description and requirements

The circuit losses L_1 and L_2 should be measured beforehand. f_o is the frequency of the output signal, which equals the divided input frequency f_i by the division ratio *N*.

5.2.5 Precautions to be observed

The output signal and oscillation should be checked by a spectrum analyzer. Oscillation should be eliminated during these measurements. Harmonics or spurious responses of the signal generator should be reduced to negligible. An adequate attenuator should be inserted at the input of the spectrum analyzer when the output power is high.

5.2.6 Measurement procedure

The frequency of the signal generator should be adjusted to the specified value.

The bias under specified conditions is applied.

The specified input power is applied to the device being measured.

The indicated values on the power meters are read, then P_o is derived from the equation (2).

5.2.7 Specified conditions

- Ambient or reference-point temperature
- Bias conditions
- Input frequency
- Input power
- Division ratio *N*

5.3 Output voltage (V_o)

5.3.1 Purpose

To measure the output voltage under specified conditions.

5.3.2 Circuit diagram

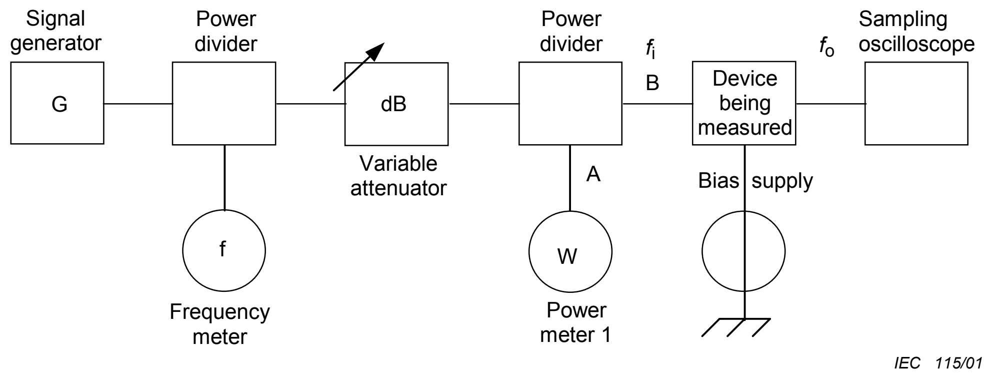


Figure 2 – Circuit for the measurement of output voltage

5.3.3 Principle of measurements

In the circuit diagram shown in figure 2, the input power P_i of the device being measured is derived from the following equation:

$$P_i = P_1 - L_1 \quad (3)$$

where P_1 is the value indicated by the power meter; L_1 is the power difference between points A and B; L_1 is defined by a subtraction from the power at point A to the power at point B; P_i and P_1 are expressed in dBm; and L_1 is expressed in dB.

5.3.4 Circuit description and requirements

See the circuit description and requirements of 5.2.4.

5.3.5 Precautions to be observed

See the precautions to be observed of 5.2.5.

5.3.6 Measurement procedure

The frequency of the signal generator should be adjusted to the specified value.

The bias under specified conditions is applied.

The specified input power is applied to the device being measured.

V_o is the value indicated by the sampling oscilloscope.

5.3.7 Specified conditions

– Ambient or reference-point temperature
– Bias conditions
– Input frequency
– Input power
– Division ratio N

5.4 Minimum operating input power ($P_{i,\ min}$)

5.4.1 Purpose

To measure the minimum operating input power under specified conditions.

5.4.2 Circuit diagram

See the circuit diagram shown in figure 1.

5.4.3 Principle of measurements

In the circuit diagram shown in figure 1, the input powers P_{iL} and P_{iH} of the device being measured are derived from the following equation:

$$P_{iL} = P_{1L} - L_1 \quad (4)$$

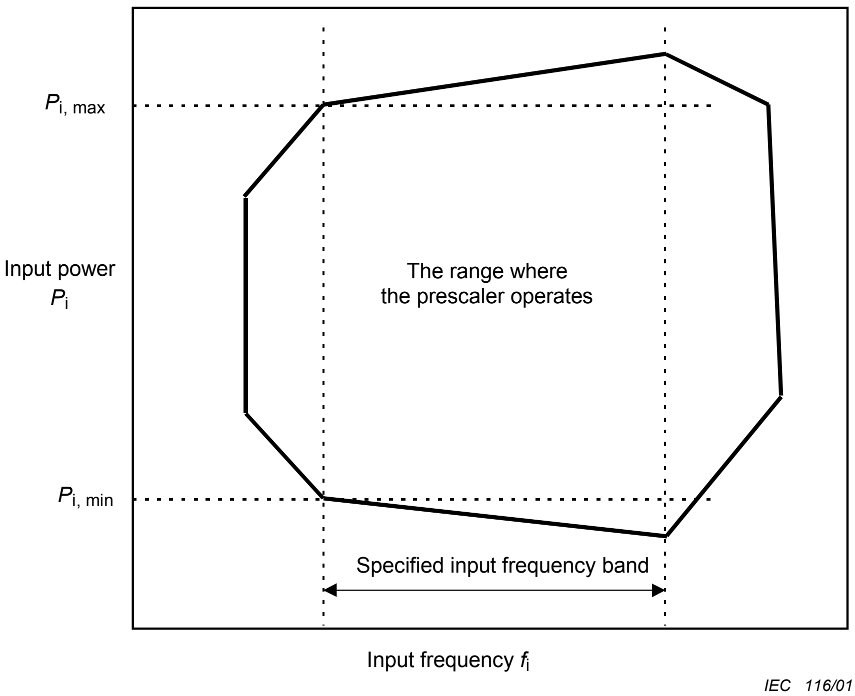
$$P_{iH} = P_{1H} - L_1 \quad (5)$$

where P_{1L} is the value indicated by the power meter 1 at the lowest value in the specified frequency band and P_{1H} is the value indicated by the power meter 1 at the highest value in the specified frequency band; L_1 is the power difference between points A and B; L_1 is defined by a subtraction from the power at point A to the power at point B; P_{iL}, P_{iH}, P_{1L} and P_{1H} are expressed in dBm; and L_1 is expressed in dB.

$P_{iL,\ min}$ and $P_{iH,\ min}$ are minimum operating input powers at lowest and highest frequency values in specified frequency range, respectively. The minimum operating input power $P_{i,\ min}$ is the larger one of $P_{iL,\ min}$ and $P_{iH,\ min}$.

The range where the prescaler operates is shown in figure 3.

NOTE When the prescaler operates properly, the output frequency f_o equals f_i/N.



Key

$P_{i,\ min}$ minimum operating input power;

$P_{i,\ max}$ maximum operating input power.

Figure 3 – Range of operation of a prescaler

5.4.4 Circuit description and requirements

See the circuit description and requirements of 5.2.4.

5.4.5 Precautions to be observed

See the precautions to be observed of 5.2.5.

5.4.6 Measurement procedure

The frequency of the signal generator should be adjusted to the minimum value in the specified input frequency band.

The bias under specified conditions is applied.

An adequate input power is applied to the device being measured. The input power should be adjusted to the value under the range where the prescaler operates, while the output frequency is monitored by the spectrum analyzer.

The input power should be increased while the output frequency is monitored by the spectrum analyzer.

The input power $P_{\mathrm{iL,\ min}}$ is measured as the prescaler starts to operate.

The frequency of the signal generator should be adjusted to the maximum value in the specified input frequency band.

An adequate input power is applied to the device being measured.

The input power should be adjusted to the value under the range where the prescaler operates while the output frequency is monitored by the spectrum analyzer.

The input power should be increased while the output frequency is monitored by the spectrum analyzer.

The input power $P_{\mathrm{iH,\ min}}$ is measured as the prescaler starts to operate.

The minimum operating input power $P_{\mathrm{i,\ min}}$ is the larger one of $P_{\mathrm{iL,\ min}}$ and $P_{\mathrm{iH,\ min}}$ (see figure 3).

5.4.7 Specified conditions

– Ambient or reference-point temperature
– Bias conditions
– Input frequency band
– Input signal waveform
– Division ratio *N*

5.5 Maximum operating input power ($P_{\mathrm{i,\ max}}$)

5.5.1 Purpose

To measure the maximum operating input power under specified conditions.

5.5.2 Circuit diagram

See the circuit diagram shown in figure 1.

5.5.3 Principle of measurements

In the circuit diagram shown in figure 1, the input powers P_{iL} and P_{iH} of the device being measured are derived from the following equation:

$$P_{iL} = P_{1L} - L_1 \qquad (6)$$

$$P_{iH} = P_{1H} - L_1 \qquad (7)$$

where P_{1L} is the value indicated by the power meter 1 at the lowest value in the specified frequency band and P_{1H} is the value indicated by the power meter 1 at the highest value in the specified frequency band; L_1 is the power difference between points A and B; L_1 is defined by a subtraction from the power at point A to the power at point B; P_{iL}, P_{iH}, P_{1L} and P_{1H} are expressed in dBm; and L_1 is expressed in dB.

$P_{iL,\ max}$ and $P_{iH,\ max}$ are maximum operating input powers at lowest and highest frequency values in specified frequency range, respectively. The maximum operating input power $P_{i,\ max}$ is the smaller one of $P_{iL,\ max}$ and $P_{iH,\ max}$.

The range where the prescaler operates is shown in figure 3.

NOTE When the prescaler operates properly, the output frequency f_o equals f_i/N.

5.5.4 Circuit description and requirements

See the circuit description and requirements of 5.2.4.

5.5.5 Precautions to be observed

See the precautions to be observed in 5.2.5.

5.5.6 Measurement procedure

The frequency of the signal generator should be adjusted to the minimum value of the specified input frequency band.

The bias under specified conditions is applied.

An adequate input power is applied to the device being measured. The input power should be adjusted to the value over the range where the prescaler operates while the output frequency is monitored by the spectrum analyzer.

The input power should be decreased while the output frequency is monitored by the spectrum analyzer.

The input power $P_{iL,\ max}$ is measured as the prescaler starts to operate.

The frequency of the signal generator should be adjusted to the maximum value in the specified input frequency band.

An adequate input power is applied to the device being measured.

The input power should be adjusted to the value over the range where the prescaler operates while the output frequency is monitored by the spectrum analyzer.

The input power should be decreased while the output frequency is monitored by the spectrum analyzer.

The input power $P_{iH,\ max}$ is measured as the prescaler starts to operate.

The maximum operating input power $P_{i,\ max}$ is the smaller one of $P_{iL,\ max}$ and $P_{iH,\ max}$ (see figure 3).

NOTE When the input power should be adjusted to the value over the range where the prescaler operates, the input power should first be adjusted to the value in the range where the prescaler operates, and then should be increased as the prescaler stops operating.

5.5.7 Specified conditions

- Ambient or reference-point temperature
- Bias conditions
- Input frequency band
- Input signal waveform
- Division ratio N

5.6 Minimum operating input voltage ($V_{i,\ min}$)

5.6.1 Purpose

To measure the minimum operating input voltage under specified conditions.

5.6.2 Circuit diagram

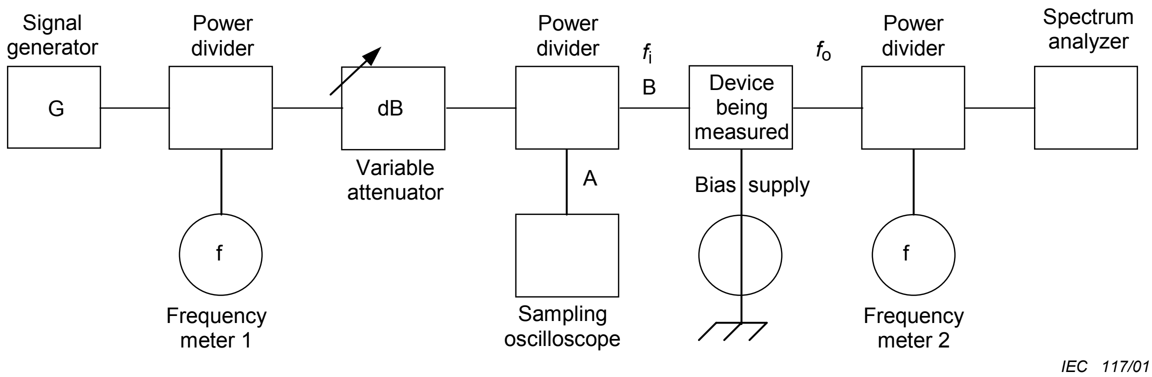


Figure 4 – Basic circuit for the minimum and maximum operating input voltage

5.6.3 Principle of measurement

$V_{i,\ min}$ of the device being measured is defined as the minimum voltage that causes the frequency divide operation under the specified input frequency band. V_{iL} and V_{iH} are derived from the following equation:

$$V_{iL} = V_{AL} \times 10^{(L1/20)} \tag{8}$$

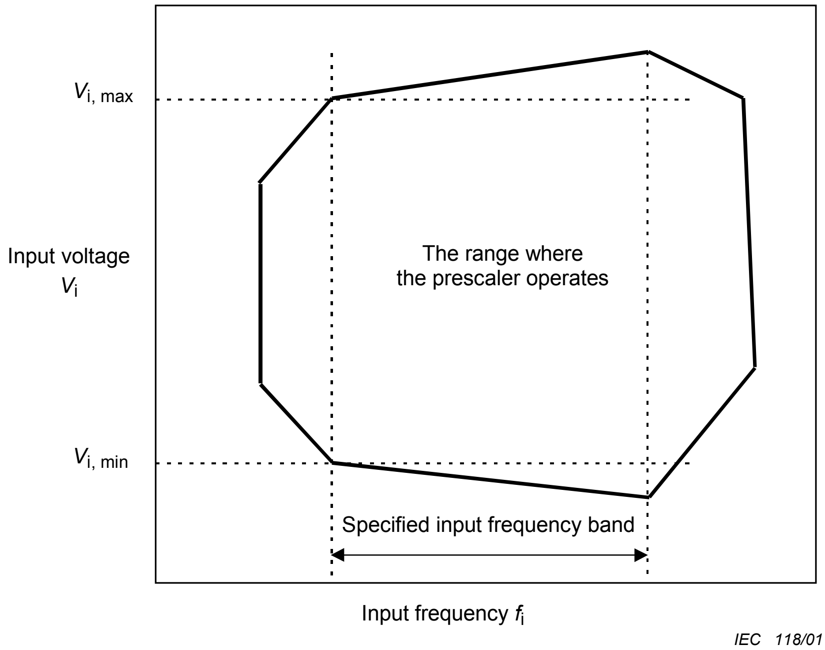
$$V_{iH} = V_{AH} \times 10^{(L1/20)} \tag{9}$$

where V_{AL} is the value indicated by the sampling oscilloscope at the lowest value in the specified frequency band, and V_{AH} is the value indicated by the sampling oscilloscope at the highest value in the specified frequency band; L_1 is defined by a subtraction from the power at point A to the power at point B; V_{iL}, V_{iH}, V_{AL} and V_{AH} are expressed in volts; and L_1 is expressed in dB.

$V_{iL,\ min}$ and $V_{iH,\ min}$ are minimum operating input voltages at lowest and highest frequency values in specified frequency range, respectively. The minimum operating input voltage $V_{i,min}$ is the larger one of $V_{iL,\ min}$ and $V_{iH,\ min}$.

The range where the prescaler operates is shown in figure 5.

NOTE When the prescaler operates properly, the output frequency f_o equals to f_i/N.



Key

$V_{i,\ min}$ minimum operating input voltage;

$V_{i,\ max}$ maximum operating input voltage.

Figure 5 – Range of operation of a prescaler

5.6.4 Circuit description and requirements

See the circuit description and requirements of 5.2.4.

5.6.5 Precautions to be observed

See the precautions to be observed of 5.2.5.

5.6.6 Measurement procedure

The frequency of the signal generator should be adjusted to the minimum value in the specified input frequency band.

The bias under specified conditions is applied.

An adequate input voltage is applied to the device being measured.

The input voltage should be adjusted to the value under the range where the prescaler operates while the output frequency is monitored by frequency meter 2.

The input voltage should be increased while the output frequency is monitored by the frequency meter 2.

The input voltage $V_{iL,\ min}$ is measured as the prescaler starts to operate.

The frequency of the signal generator should be adjusted to the maximum value in the specified input frequency band.

An adequate input voltage is applied to the device being measured.

The input voltage should be adjusted to the value under the range where the prescaler operates while the output frequency is monitored by frequency meter 2.

The input voltage should be increased while the output frequency is monitored by frequency meter 2.

The input voltage $V_{iH,\ min}$ is measured as the prescaler starts to operate.

The minimum operating input voltage $V_{i,\ min}$ is the larger of $V_{iL,\ min}$ and $V_{iH,min}$.

5.6.7 Specified conditions

- Ambient or reference-point temperature
- Bias conditions
- Input frequency band
- Input signal waveform
- Division ratio N

5.7 Maximum operating input voltage ($V_{i,\ max}$)

5.7.1 Purpose

To measure the maximum operating input voltage under specified conditions.

5.7.2 Circuit diagram

See the circuit diagram shown in figure 4.

5.7.3 Principle of measurements

$V_{i,\ max}$ of the device being measured is defined as the maximum voltage that causes the frequency divide operation under the specified input frequency band. V_{iL} and V_{iH} are derived from the following equation:

$$V_{iL} = V_{AL} \times 10^{(L1/20)} \tag{10}$$

$$V_{iH} = V_{AH} \times 10^{(L1/20)} \tag{11}$$

where V_{AL} is the value indicated by the sampling oscilloscope at the lowest value in the specified frequency band, and V_{AH} is the value indicated by the sampling oscilloscope at the highest value in the specified frequency band; L_1 is defined by a subtraction from the power at point A to the power at point B; V_{iL}, V_{iH}, V_{AL} and V_{AH} are expressed in volts; and L_1 is expressed in dB.

$V_{iL,\ max}$ and $V_{iH,\ max}$ are maximum operating input voltages at lowest and highest frequency values in specified frequency range, respectively. The maximum operating input voltage $V_{i,\ max}$ is the smaller one of $V_{iL,\ max}$ and $V_{iH,\ max}$.

The range where the prescaler operates is shown in figure 5.

NOTE When the prescaler operates properly, the output frequency f_o equals f_i/N.

5.7.4 Circuit description and requirements

See the circuit description and requirements of 5.2.4.

5.7.5 Precautions to be observed

See the precautions to be observed of 5.2.5.

5.7.6 Measurement procedure

The frequency of the signal generator should be adjusted to the minimum value in the specified input frequency band.

The bias under specified conditions is applied.

An adequate input voltage is applied to the device being measured.

The input voltage should be adjusted to the value over the range where the prescaler operates while the output frequency is monitored by frequency meter 2.

The input voltage should be decreased while the output frequency is monitored by frequency meter 2.

The input voltage $V_{\mathrm{iL,\,max}}$ is measured as the prescaler starts to operate.

The frequency of the signal generator should be adjusted to the maximum value in the specified input frequency band.

An adequate input voltage is applied to the device being measured.

The input voltage should be adjusted to the value over the range where the prescaler operates while the output frequency is monitored by frequency meter 2.

The input voltage should be decreased while the output frequency is monitored by frequency meter 2.

The input voltage $V_{\mathrm{iH,\,max}}$ is measured as the prescaler starts to operate.

The maximum operating input voltage $V_{\mathrm{i,\,max}}$ is the smaller of $V_{\mathrm{iL,max}}$ and $V_{\mathrm{iH,\,max}}$.

NOTE When the input voltage should be adjusted to the value over the range where the prescaler operates, the input voltage should first be adjusted to the value in the range where the prescaler operates, and then should be increased as the prescaler stops operating.

5.7.7 Specified conditions

– Ambient or reference-point temperature
– Bias conditions
– Input frequency band
– Input signal waveform
– Division ratio N

5.8 Maximum input frequency ($f_{i,\,max}$)

5.8.1 Purpose

To measure the maximum input frequency $f_{i,\,max}$ under specified conditions.

5.8.2 Circuit diagram

See the circuit diagram shown in figure 1.

5.8.3 Principle of measurements

$f_{i,\,max}$ is defined as the highest limit frequency of the device operation for the specified input power P_i.

NOTE 1 The device operation is confirmed when the output frequency f_o is equal to f_i/N. P_i is obtained by the following equation for figure 1:

$$P_i = P_1 - L_1 \qquad (12)$$

where P_1 is the value indicated by the power meter 1; L_1 is the power difference between points A and B; L_1 is defined by a subtraction from the power at point A to the power at point B; P_i and P_1 are expressed in dBm; and L_1 is expressed in dB.

NOTE 2 L_1 should be measured before measurement.

5.8.4 Circuit description and requirements

See the circuit description and requirements of 5.2.4.

5.8.5 Precautions to be observed

See the precautions to be observed of 5.2.5.

5.8.6 Measurement procedure

Bias under specified conditions is applied.

Input power under specified conditions is applied.

Input frequency should be adjusted to an adequate upper frequency which the prescaler does not operate by monitoring the spectrum analyzer.

The input frequency value is decreased under the specified input power.

The operation should be monitored using the spectrum analyzer.

When the prescaler begins its normal operation, its frequency is the maximum input frequency.

NOTE For researching the maximum input frequency, the following procedure can be used.

Input frequency is adjusted to an adequate device operation frequency division by the monitoring spectrum analyzer.

The input frequency value is increased under the specified input power.

The operation should be monitored using the spectrum analyzer.

When the prescaler stops its normal operation, the input frequency decreases under the specified input power.

When the prescaler begins its normal operation, its frequency is the maximum input frequency.

5.8.7 Specified conditions

– Ambient or reference point temperature
– Bias conditions
– Input power
– Division ratio *N*

5.9 Minimum input frequency ($f_{i,\ min}$)

5.9.1 Purpose

To measure the minimum input frequency $f_{i,\ min}$ under specified conditions.

5.9.2 Circuit diagram

See the circuit diagram shown in figure 1.

5.9.3 Principle of measurements

$f_{i,\ min}$ is defined as the lowest limit frequency of the device operation for the specified input power P_i.

NOTE 1 The device operation is confirmed when the output frequency f_o is equal to the divided frequency of the input frequency f_i by the division ratio *N*. P_i is obtained by the following equation for figure 1.

$$P_i = P_1 - L_1 \tag{13}$$

where P_1 is the value indicated by the power meter 1; L_1 is the power difference between points A and B; L_1 is defined by a subtraction from the power at point A to the power at point B; P_i and P_1 are expressed in dBm; and L_1 is expressed in dB.

NOTE 2 L_1 should be measured beforehand.

5.9.4 Circuit description and requirements

See the circuit description and requirements of 5.2.4.

5.9.5 Precautions to be observed

See the precautions to be observed of 5.2.5.

5.9.6 Measurement procedure

Bias under specified conditions is applied.

Input power under specified conditions is applied.

Input frequency should be adjusted to an adequate lower frequency at which the prescaler does not operate, by the monitoring spectrum analyzer.

The input frequency value is increased under the specified input power.

The operation should be monitored using the spectrum analyzer.

When the prescaler begins its normal operation, its frequency is the minimum input frequency.

NOTE For researching the minimum input frequency, the following procedure can be used.

Input frequency is adjusted to an adequate device operation frequency division by the monitoring spectrum analyzer.

The input frequency value is decreased under the specified input power.

The operation should be monitored using the spectrum analyzer.

When the prescaler stops its normal operation, the input frequency increases under the specified input power.

When the prescaler begins its normal operation, the frequency is then the minimum input frequency.

5.9.7 Specified conditions

– Ambient or reference point temperature
– Bias conditions
– Input power
– Division ratio N

5.10 High-level modulus control input voltage (V_{CH})

5.10.1 Purpose

To measure the high-level modulus control input voltage under specified conditions.

5.10.2 Circuit diagram

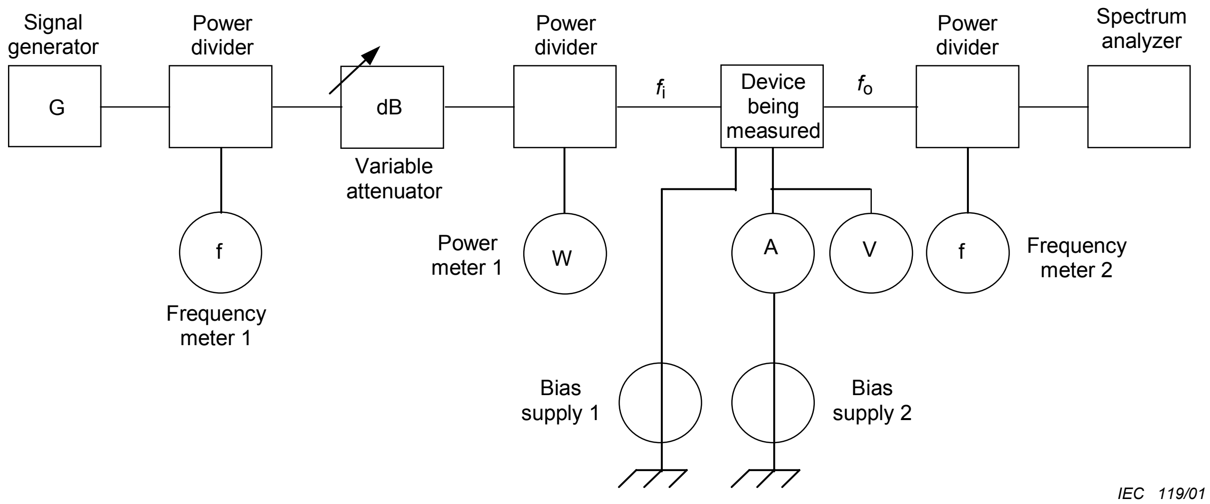


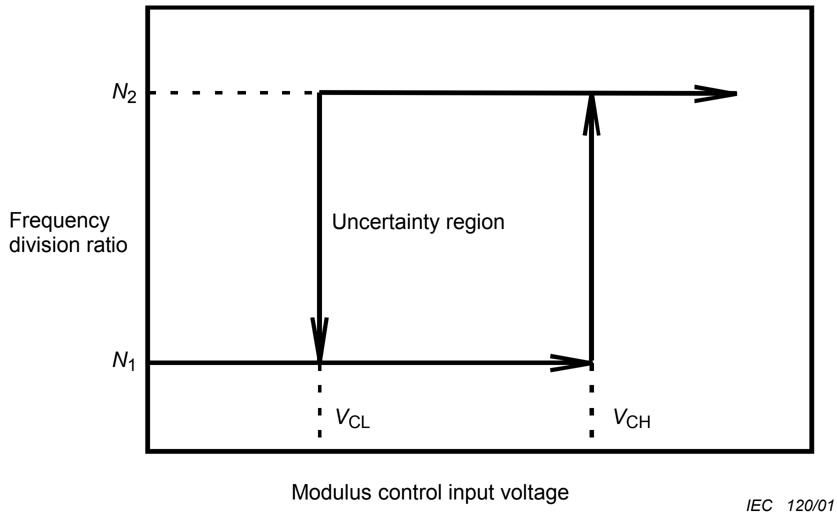
Figure 6 – Circuit for the measurement of modulus control input voltage and current

5.10.3 Principle of measurements

V_{CH} is defined as the modulus control input voltage at which the specified division ratio N_1 transits to N_2 for the specified input power and input frequency.

After the specified division ratio N_1 transits to another specified value N_2 by increasing the modulus control input voltage, the division ratio N_2 does not return to N_1 at V_{CH} by decreasing the modulus control input voltage.

Furthermore, by decreasing the modulus control voltage, N_2 returns to N_1 at a lower voltage than V_{CH} generally.



Key

N_1 specified division ratio;

N_2 second specified division ratio;

V_{CL} low-level modulus control input voltage;

V_{CH} high-level modulus control input voltage.

NOTE The uncertainty region is the region of the input modulus control voltage where the division ratio is not fixed to N_1 or N_2.

Figure 7 – Correlation of modulus control input voltage and frequency division ratio

5.10.4 Circuit description and requirements

See the circuit description and requirements of 5.2.4.

5.10.5 Precautions to be observed

See the precautions to be observed of 5.2.5.

5.10.6 Measurement procedure

The frequency of the signal generator should be adjusted to the specified value.

The bias under specified conditions is applied to the device being measured.

The input power under specified conditions is applied to the device being measured.

When monitoring f_o on frequency meter 2, increase the modulus control terminal input voltage by bias supply 2 from the low-voltage side.

Measure V_{CH} on the voltage meter at which division ratio N_1 transits to the specified N_2.

5.10.7 Specified conditions

- Ambient or reference-point temperature
- Bias conditions
- Input frequency
- Input power
- Input signal waveform
- Division ratio N_1
- Division ratio N_2

5.11 Low-level modulus control input voltage (V_{CL})

5.11.1 Purpose

To measure the low-level modulus control input voltage under specified conditions.

5.11.2 Circuit diagram

See the circuit diagram shown in figure 6.

5.11.3 Principle of measurements

V_{CL} is defined as the modulus control input voltage at which the specified division ratio N_2 transits to N_1 for the specified input power and input frequency.

After the specified division ratio N_2 transits to another specified value N_1 by the modulus control input voltage, the division ratio N_1 does not return to N_2 at V_{CL} by increasing the modulus control input voltage. Generally, by increasing modulus control voltage, N_1 returns to N_2 at a higher voltage than V_{CL}.

5.11.4 Circuit description and requirements

See the circuit description and requirements of 5.2.4.

5.11.5 Precautions to be observed

See the precautions to be observed of 5.2.5.

5.11.6 Measurement procedure

The frequency of the signal generator should be adjusted to the specified value.

The bias under specified conditions is applied to the device being measured.

The input power under specified conditions is applied to the device being measured.

When monitoring f_o on frequency meter 2, decrease the modulus control terminal input voltage by bias supply 2 from the high-voltage side.

Measure V_{CL} on the voltage meter at which division ratio N_2 transits to the specified N_1.

5.11.7 Specified conditions

- Ambient or reference-point temperature
- Bias conditions
- Input frequency
- Input power
- Input signal waveform
- Division ratio N_1
- Division ratio N_2

5.12 High-level modulus control input current (I_{CH})

5.12.1 Purpose

To measure the high-level modulus control input current under specified conditions.

5.12.2 Circuit diagram

See the circuit diagram shown in figure 6.

5.12.3 Principle of measurements

I_{CH} is defined as the modulus control input current for the specified input power and input frequency when the specified maximum value of high-level modulus input voltage is applied to the modulus control input.

5.12.4 Circuit description and requirements

See the circuit description and requirements of 5.2.4.

5.12.5 Precautions to be observed

See the precautions to be observed of 5.2.5.

5.12.6 Measurement procedure

The frequency of the signal generator should be adjusted to the specified value.

The bias under specified conditions is applied to the device being measured.

The input power under specified conditions is applied to the device being measured.

The specified maximum value of high-level modulus control voltage is applied to the modulus control input.

The modulus control input current I_{CH} is measured.

5.12.7 Specified conditions

- Ambient or reference-point temperature
- Bias conditions
- Input frequency
- Input power
- The maximum value of high-level modulus control voltage
- Input signal waveform

5.13 Low-level modulus control input current (I_{CL})

5.13.1 Purpose

To measure the low-level modulus control input current under specified conditions.

5.13.2 Circuit diagram

See the circuit diagram shown in figure 6.

5.13.3 Principle of measurements

I_{CL} is defined as the modulus control current for the specified input power and input frequency when the specified minimum value of low-level modulus input voltage is applied to the modulus control input.

5.13.4 Circuit description and requirements

See the circuit description and requirements of 5.2.4.

5.13.5 Precautions to be observed

See the precautions to be observed of 5.2.5.

5.13.6 Measurement procedure

The frequency of the signal generator should be adjusted to the specified value.

The bias under specified conditions is applied to the device being measured.

The input power under specified conditions is applied to the device being measured.

The specified minimum value of low-level modulus control voltage is applied to the modulus control input.

The modulus control input current I_{CL} is measured.

5.13.7 Specified conditions

- Ambient or reference-point temperature
- Bias conditions
- Input frequency
- Input power
- The minimum value of low-level modulus control voltage
- Input signal waveform

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