WF1946B

MULTIFUNCTION SYNTHESIZER

INSTRUCTION MANUAL
WF1946B
MULTIFUNCTION
SYNTHESIZER
Instruction Manual
Thank you very much for procuring the WF1946B MULTIFUNCTION SYNTHESIZER. At the outset, please take a few minutes to read the Safety Precautions indicated in this manual in order to use this equipment safely and correctly.

● Warning and Caution notices
The following Warning and Caution notices appear in this manual. These must be observed in order to protect both the user from physical harm and the equipment from damage.

⚠️ WARNING
Risk of serious and possibly fatal physical injury from electric shock or other cause.

⚠️ CAUTION
Risk of damage to the equipment.

● Manual composition
Please read Section 1 before using the equipment for the first time. Refer to a separate volume for a description of remote control (GPIB or USB).

Section 1  Overview
Provides a general description of the equipment and a simple outline of the operating principles.

Section 2  Preparation
Required preparatory work before installing and operating the equipment. Be sure to read this section.

Section 3  Basic operation
Panel functions, operating principles and basic operations are described. Read while operating the equipment.

Section 4  Applications
Expanded operations are described.

Section 5  Other operations
Operations not covered in Sections 3 and 4 are described.

Section 6  Troubleshooting
Corrective measures when error messages or abnormalities occur.

Section 7  Maintenance
Inspection and performance tests are described.

Section 8  Specifications
Equipment specifications (functions and performance) are described.
Safety Precautions

Observe the following warnings and cautions in order to use this equipment safely. No responsibility or warranty is assumed for damages arising from use in a manner contrary to these warnings and cautions.

This product is an insulation standard class I device (with a protective conductor terminal) as defined by the IEC standards.

- **Observe text instructions**
  This manual has been compiled in order to enable safe operation and use of this equipment. Be sure to read this manual before using the equipment.
  Items designated by Warning advise of serious physical hazards. Be sure to observe these carefully.

- **Be sure to connect ground**
  Since the unit includes a built-in line filter, there is risk of shock if used without grounding.
  To prevent electric shock, be sure to properly connect the device to the electric ground which ground resistance is less than $100 \, \Omega$.

- **Confirm power source voltage**
  Before connecting this equipment, check that the proper voltage is being supplied to the power outlet.
  Refer to the Grounding and Power Supply section of this manual.

- **Use only the properly rated fuse**
  Improperly rated fuses present a fire hazard and other risks. Refer to the Grounding and Power Supply section of this manual and confirm the fuse rating.
  Be sure to disconnect the equipment from the power source before replacing the fuse.

- **Smoke, odor, noise**
  In event smoke, peculiar odor or noise is emitted, immediately disconnect the power source and avoid further operation. Contact service.

- **Flammable gas**
  Do not use this equipment in the presence of flammable gas. There is danger of fire and explosion.

- **Do not remove covers**
  This equipment contains dangerously high voltages. Do not remove external covers.
  Refer all internal inspection and service to a qualified service technician who fully understands the hazards.
**Do not modify**

Do not use parts other than specified by the manufacturer and by no means attempt to modify the equipment. There is risk of personnel hazard and damage to the equipment. The manufacturer reserves the option of refusing service in such cases.

**Safety related symbols and indications**

Following are general definitions of the symbols and indications used in the text and on the product.

- **⚠️** Advises of possible hazard to the user, as well as the need to consult this manual when using an operation or function.

- **⚠️ WARNING** Appears in the text and on the product to advise risk of fatal or otherwise serious physical injury.

- **⚠️ CAUTION** Appears in the text and on the product to advise risk of damage to the product.

- **Ground indication:** Indicates connector housing and signal ground is connected to a chassis ground.

- **Indicates power switch on state.**

- **Indicates power switch off state.**
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1.1 Features

The WF1946B Wave Factory is a multifunctional synthesizer based on the direct digital synthesizer (DDS) system.

Although the WF1946B is two-channel device, the series also includes a single-channel WF1945B, a single-channel WF1943B with basic functions, and a two-channel WF1944B with basic functions.

- Frequency setting range: 0.01 µHz to 15 MHz
- Maximum output voltage: 20 Vp-p/open, ±10 V/open
- Waveform resolution: 16 bits
- Key navigation lights the next keys to be operated, thus improving operational ease.
- User units function allows setting formula and character string to convert settings and display to the desired units.
- LOAD function aligns the setting and actual output voltages when an arbitrary load impedance is connected.
- Convenient use as a pulse generator with pulse period, width, high level and low level setting and display. A trigger delay function is also included.
- Five standard waveforms: sinewave, triangular wave, squarewave, rising sawtooth and descending sawtooth, plus arbitrary waveform.
- Frequency change and frequency sweep are coupled with phase, avoiding waveform cutoff.
- Unpredicted voltage is not produced during amplitude change. Since the output range is fixed, the amplitude can be changed from 0 to maximum without waveform cutoff.
- Versatile channel mode utilizing 2 channels
  - 2 channel independent mode
  - 2 phase mode oscillating at the same frequency
  - 2 tone mode oscillating at a fixed frequency difference
  - Ratio mode oscillating continuously at a fixed frequency ratio
  - Differential mode for simultaneous output of waveforms with top and bottom symmetrical
- Versatile oscillation modes
  - Continuous
  - Intermittent: Burst, trigger, gate, in addition to triggered gate for repeated oscillation start/stop
  - Sweep: Sweep for not only frequency, but also phase, amplitude, DC offset and duty.
  - Modulation: FM (FSK), phase (PSK), AM, DC offset and PWM
  - White noise generator
  - DC voltage generator
- Floating inputs and outputs to prevent ground loop effects. Isolation is also used between channels.
- The 1991 synchronous operation option enables synchronized operation of multiple units and operation as an oscillator with increased number of channels.
- The 1992 digital output option can provide a 15 bit digital signal corresponding to the output waveform and enable use as a digital pattern generator.
1.2 Operating principles

- The CPU conducts analog control for display, panel keys, remote control (GPIB, USB), DDS, amplitude and DC offset. Sweep input/output is also controlled for sweep internal/external modulation.
- The clock generator produces DDS reference and CPU clock signals.
- Two sets of circuits for DDS and analog compose two channels.
- An isolation circuit between the CPU and DDS provides floating functions.
- The DDS (Direct Digital Synthesizer) uses an original LSI device and generates digital data of the setting frequency.
- The waveform memory converts digital data from the DDS into standard or arbitrary waveform data. Waveform data are set from the CPU.
- The digital to analog (D/A) converter produces an analog signal from the resulting waveform data.
- The lowpass filter (LPF) smoothes the stepped D/A output signal.
- Amplitude control is set by the gain control. DC offset is produced by the offset D/A converter and the output amplifier adds and amplifies the output signal.
- The attenuator (ATT) selects the output range by 1/10 attenuation on/off.
1.3 Function outline

- **Description of main function**
  - **Channel mode selection**
    Channel 1 and Channel 2 operation can be set for 2 channel independent, 2 phase, fixed frequency difference, fixed frequency ratio or differential output.
  
  - **Oscillation mode selection**
    The oscillation type can be set for continuous, intermittent, sweep, modulated, noise or DC.
  
  - **Waveform selection**
    The waveform type can be set for sinewave ( ), triangle waveform ( ), squarewave ( 50 % fixed duty ), squarewave ( variable duty), rising sawtooth ( ), descending sawtooth ( ), or arbitrary (ARB).
  
  - **Frequency setting**
    The frequency can be set by the keypad or modify dial.
    The period, i.e., inverse of frequency, can also be set.
    The duty and pulse width can also be set for the variable duty squarewave ( ).
  
  - **Amplitude setting**
    The amplitude can be set by the keypad or modify dial.
  
  - **DC offset setting**
    The DC offset can be set by the keypad or modify dial.
  
  - **Phase setting**
    Phase between channels and oscillation starting phase during burst oscillation can be set.
  
  - **Output on/off**
    The waveform and sync signal output connectors are on/off switchable for each channel.
    The setting prior to power off is returned at power on. Be sure to set to either on or off as required.
  
  - **User units setting**
    Coefficients and compensation can be applied to frequency, period, amplitude, DC offset, phase and duty for setting and displaying these in desired units. The units can be expressed by up to 4 desired characters.
  
  - **Setting store and recall**
    The settings for frequency, amplitude, etc., can be stored and recalled.
    The WF1946B is capable of 10 combinations store/recall.
  
  - **Computer control**
    Remote control (GPIB or USB) enables remote control from a personal computer.
**Function outline**

- **Output**
  - Output on/off (each channel independently)
  - **Channel mode**
    - 2 channel independent, 2 phase, fixed frequency difference, fixed frequency ratio, differential output
  - **Channel selection**
    - CH 1/CH 2/both channels simultaneously
  - **Oscillation mode**
    - Normal
    - Burst
      - Burst, trigger, gate, triggered gate
  - **Sweep**
    - **Sweep mode**
      - Single, continuous, gated
    - **Sweep objective**
      - Frequency, amplitude, DC offset, phase, duty
    - **Sweep system**
      - Linear, logarithmic

- **Modulation**
  - **Modulation type**
    - Frequency, amplitude, DC offset, phase, duty
  - **Modulation waveform**
    - $\sim / \swarrow / \swarrow / \swarrow$ / $\sim$ / $\swarrow$ / $\swarrow$ / $\swarrow$ / $\swarrow$ / $\swarrow$

- **Noise**
  - DC

- **Waveform**
  - $\sim / \swarrow / \swarrow / \swarrow$ (50 % fixed duty)/ $\square$ (variable duty)/ $\swarrow$ / $\swarrow$ / $\swarrow$ / arbitrary waveform (ARB)

- **Voltage**
  - Output range
  - Amplitude setting
  - DC offset setting
  - High level setting
  - Low level setting

(continued)
1.3 Function outline

Output (continued)

- Frequency
  - Frequency setting
  - Period setting
  - Pulse width setting (\(\_\_\_\_\): variable duty)
  - Duty setting (\(\_\_\_\_\): variable duty)
- Phase
  - Phase between channels
  - Oscillation start phase
- User units

Setting contents

- Save/recall/clear
- Copy between channels
- Setting initialize

Communication

- GPIB
- USB

Others

- Error indication
- Output mode setting at power on
- Sync out, sweep period output
- Trigger, gate, sweep start input
- Sweep stop, restart input
- Sweep X-DRIVE output
- Sweep marker output
- External add input
- External AM input
- 1991 synchronous operation option
- 1992A digital output option
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2.1 Check before using

- **Safety check**
  Before using the WF1946B, refer to the Safety precautions of this manual and confirm safety. Also, before connecting the power, refer to Section 2.2 Power source and grounding and thoroughly check the safety.

- **Unpacking and repacking**
  First, inspect the equipment for possible damage in shipping. Check for the presence of the following items.

<table>
<thead>
<tr>
<th>Item</th>
<th>Quantity</th>
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<tbody>
<tr>
<td>Mainframe</td>
<td>1</td>
</tr>
<tr>
<td>Operation Manual</td>
<td>1</td>
</tr>
<tr>
<td>Remote Control Instruction Manual</td>
<td>1</td>
</tr>
<tr>
<td>0105 Arbitrary Waveform Editor (CD-ROM)</td>
<td>1</td>
</tr>
<tr>
<td>Supplied accessories</td>
<td></td>
</tr>
<tr>
<td>Power cable: (3-conductors)</td>
<td>1</td>
</tr>
<tr>
<td>Fuse: (100/115 V: 2 A or 230 V: 1 A)</td>
<td>1</td>
</tr>
<tr>
<td>(Time lag, 250 V, φ5.2 × 20 mm)</td>
<td></td>
</tr>
</tbody>
</table>

For information on how to use 0105 Arbitrary Waveform Editor, refer to the CD-ROM of the 0105. When repacking the equipment for transportation, use a packing carton having ample strength to protect the equipment and bear the weight of stacking.

---

**WARNING**

Do not remove covers.
This equipment contains dangerously high voltages. Do not remove external covers.
Refer all internal inspection and service to a qualified service technician who fully understands the hazards.
## Options

- **1991 synchronous operation option**
  If ordered, this option is installed at time of shipment.

- **1994 synchronous operation cable**
  Cable (1 meter) used with the 1991 synchronous operation option.
  The required number of cables is one less than the total number of connected units.

- **1992A digital output option**
  If ordered, this option is installed at time of shipment.
  The following accessory cable is also provided.

<table>
<thead>
<tr>
<th>Supplied accessory</th>
</tr>
</thead>
<tbody>
<tr>
<td>Digital output cable (1 meter)</td>
</tr>
</tbody>
</table>
2.2 Power source and grounding

- **Grounding**

  **WARNING**
  The WF1946B uses a line filter that incorporates the circuit below.
  
  This equipment must be grounded in order to prevent electric shock accidents.
  
  Confirm the protective ground terminal is connected to ground before connecting the equipment for measurements. The WF1946B protective ground is connected to ground by the 3-prong power supply plug. Use the supplied power supply cable to connect to a 3-terminal power outlet that has a protective ground contact.

- **Line filter**
  The WF1946B uses a line filter that incorporates the circuit below.
  
  Because the maximum leakage current is 0.5 mArms at 250 V/62 Hz, touching a metallic part of the WF1946B could cause an electric shock.
  
  For your safety, be sure to ground the device.

- **Power source**

  **CAUTION**
  Be sure to observe the following in order to prevent damage to the equipment.
  
  Confirm the power source voltage is within the range specified for the WF1946B.
Check the power source voltage indication on the rear panel above the power source inlet. The WF1946B operates from the following commercial power source.

- Power supply voltage range: AC100V/115V/230V±10%
- Power supply frequency range: 50/60 Hz ±2 Hz
- Power consumption: Max. 100 VA
- Overvoltage category: II

Connect to the power source according to the following procedure:
1. Set the WF1946B power switch to off.
2. Adjust the source voltage change-over switch at the back of the unit to the source voltage to be used.
3. Insert the power cable into the power inlet on the back of the unit.
4. Insert the power cable plug into a 3-terminal wall socket.

With a screwdriver, move the slide control of the source voltage change-over switch to the line indicating the source voltage to be used. Do not set the slide control between lines.

Before using the WF1946B with a source voltage that differs from the factory setting, be sure to contact the sales representative of NF Corporation.

Make sure that the power switch is off before connecting the power cable. Also, after switching power off, wait at least five seconds before switching the power on again.

Confirm the power switch is off before connecting the power cable. Also, after switching power off, wait at least 5 seconds before again switching power on.
### Power supply fuse

**WARNING**

Use only a fuse with the specified rating. There is risk of fire from an improperly rated fuse. Be sure to disconnect the power cable before replacing the fuse.

Fuse: Time lag 2 A (100/115 V) or time lag 1 A (230 V)

250 V, φ5.2 × 20 mm

The specified rating of a fuse changes depending on the power source voltage.
2.3 Installation

■ Cautions

Observe the following cautions to avoid damaging the WF1946B.

- The unit is cooled by a fan. In event the fan does not function, switch off the power and contact service. Continued use without the fan operating can lead to extensive damage and service complexity.
- Ventilation openings are located on the side and rear panels. Avoid obstructing the openings and provide at least 10 cm clear space at the sides and back of the unit when installing.
- Do not use the unit vertically (with the rear panel downward).

■ Installation conditions

Observe the following ambient when installing and storing the equipment. Moisture condensation must also be absent.

Temperature and humidity ranges

Guaranteed performance: +5 to +35 °C, 5 to 85 %RH
(no condensation at an absolute humidity of 1 to 25 g/m³)

Ambient storage conditions: -10 to +50 °C, 5 to 95 %RH
(no condensation at an absolute humidity of 1 to 29 g/m³)

Pollution degree  : 2

Avoid installing the equipment in the following types of locations.

- In direct sunlight or near heat sources
- Where subjected to dust, salt or metallic dust
- Corrosive gas, steam or oily smoke
- Flammable gas or vapors
- Strong vibration
- Strong magnetic or electromagnetic fields
- Near pulse type noise sources

Also, when using, provide separation between the power cords and signal cables of the WF1946B and those of other equipment. Operating error can occur if the power cords and signal cables are too close. Cable routing requires particular attention when installing in a rack or other facility.

■ Panel and case cleaning

Use a soft cloth to wipe dust from the panel and case. If soiling is severe, moisten the cloth slightly with a neutral detergent.

Do not use sprays, petroleum distillates or commercial cleaning cloths, which can deform or peel the finish.
The WF1946B conforms to the following standards.

**Safety:** EN 61010-1: 2001


However, the performance criteria for the following standards are as follows:

- EN61000-4-2(1995):C

The phase synchronization ($\phi$SYNC) operation may be required because the phase difference between channels is caused by the electrostatic discharge.

The following cables are used for the test of EN 61326: 1997/A1: 1998/A2: 2001

- **Power cable**: Accessory
- **Signal cables**: Coaxial cable with BNC connectors, 1 m (3D-2W or RG-143B/U or RG-223/U)
- **GPIB cable**: Shielded cable, 1 m (DDK: 408JE-101)
Section 7.3  the Performance tests are recommended at least once a year. These should also be conducted before important tests and measurements.
Section 3  Basic operation

3.1 Panel description
- Front panel
- Rear panel

3.2 Input and output connectors
- Waveform output (FUNCTION OUT)
- Sync signal output (SYNC OUT)
- Trigger/sweep input (TRIG/SWEEP IN)
- Sweep stop/restart input (SWEEP PAUSE IN)
- Sweep X-drive output (SWEEP X-DRIVE OUT)
- Sweep marker output (SWEEP Z-MARKER OUT)
- External add input (EXT ADD IN)
- External AM input (EXT AM IN)
- Synchronous operation input and output (SYNC IN, OUT)
- Digital output (DIGITAL OUT) (1992A option)

3.3 Basic operation
- Setting initialize (PRESET)
- Channel mode selection (CHANNEL MODE)
- Channel modes and settings
- Channel selection
- Oscillation mode selection
- Waveform selection
- Frequency setting
- Amplitude setting
- DC offset setting
- Phase setting
- Output on/off
- Operation tree

* Following is an example of the display when using this section.

Fully lighted (bold)  Flashing

Fully lighted (bold)  Dimly lighted
3.1 Panel description

This section describes the indications and functions of the front and rear panels of the WF1946B.
3.1 Panel description

- **Front panel**

  - **Output waveform on/off.** Key lamp lights when on, extinguishes when off.
  - **Display** of frequency, amplitude, offset and load impedance settings, in addition to information to assist when setting.
  - **Oscillation mode selection** (page 3-25).
  - **Frequency and amplitude setting** (pages 3-29 to 3-30).
  - **Select channel mode.** Lamp above key indicates present selection (page 3-20).
  - **Waveform select** (page 3-26).
  - **Select channel for display and setting.** Lamp above key indicates present selection.
  - **Power on/off.** Depress for power on, press and release to raised position for power off.
  - **Setting initialize** (page 3-16), output range setting (page 5-18), user unit setting (page 5-9).
  - **Trigger/sweep input connector** (page 3-9).
  - **Sync signal output connector** (page 3-6).
  - **Waveform output connector** (page 3-5).
  - **Key button, top or bottom lamps light only for operable keys.**
  - **When MODIFY lamp lights, turn dial to set values or parameters.**
  - **Press to enter, e.g., a numerical input.**
  - **Return to the previous step.**
  - **UNDO key** (page 5-21).
  - **Memory save, recall, etc.** (pages 5-13 to 5-15).
3.1 Panel description

- Rear panel
3.2 Input and output connectors

Waveform output (FUNCTION OUT)

Maximum output voltage: 20 Vp-p/open, 10 Vp-p/50 Ω load
Output impedance: 50 Ω, unbalanced
Load impedance: More than 45 Ω
Output off status: Open when output off (can be modified for 50 Ω at output off. Consult company.)
Ground: Connected to signal ground (floating from chassis)

Avoid shorting the output or applying an external signal. The unit can be damaged.

- Output limiting
  If the following voltages are exceeded by the amplitude, DC offset, external add or external AM settings, the OVER lamp lights and the output is clipped.

  10 V range: Approx. 11 Vp/open
  1 V range: Approx. 1.1 Vp/open

- Output connection note
  The FUNCTION OUT impedance is 50 Ω. By using coaxial cable with 50 Ω characteristic impedance for connection to other equipment, amplitude accuracy at high frequency can be improved and waveform disturbance reduced. In addition, performance deterioration up to maximum frequency can be prevented by connecting to a terminal having 50 Ω input impedance or terminating the input at 50 Ω.

- Setting and output voltages
  The setting voltage display and actual output voltage (load terminal voltage) differ according to the load resistance. “5.5 Other settings (LOAD function (equalize setting and output values))”, cf.
3.2 Input and output connections

*Sync signal output (SYNC OUT)*

![Output waveform diagram]

- Output waveform: $\square$
- Output voltage: $0\, V/+5\, V$ (open)
- Output impedance: $50\, \Omega$, unbalanced
- Load impedance: More than $45\, \Omega$
- Status at output off: High impedance
- Ground: Connected to signal ground (floating from chassis)

**CAUTION**

Avoid shorting the output or applying an external signal. The unit can be damaged.

- Output connection note
  The SYNC OUT impedance is $50\, \Omega$. By using coaxial cable with $50\, \Omega$ characteristic impedance for connection to other equipment, waveform disturbance can be reduced. Although $50\, \Omega$ termination is possible, the high level voltage is reduced by about half.

- Waveform and sync signal output relationship (Waveform phase definition)

  (1) Continuous oscillation mode (NORMAL)

  ① Sinewave

  ![Waveform diagram]
3.2 Input and output connections

② Triangular, rising sawtooth, descending sawtooth, arbitrary

FUNCTION OUT
triangular
FUNCTION OUT
rising sawtooth
FUNCTION OUT
descending sawtooth
FUNCTION OUT
arbitrary
SYNC OUT

Approximately 25 ns p-p jitter is also produced in the FUNCTION OUT waveform.

(Phase definition)

③ Squarewave (fixed 50% duty)

FUNCTION OUT
Approx. 15ns
SYNC OUT

Rising and falling edge hysteresis zones vary with phase history.

(Phase definition)

Approx. 2
0° 180° 360°

Jitter

25 ns p-p (Stop level on or 100 kHz and below)
2.5 ns rms and below (Stop level off and between above 100 kHz and below 1 MHz)
1.0 ns rms and below (Stop level off and 1 MHz and above)

④ Squarewave (variable duty)

FUNCTION OUT
Approx. 14ns
SYNC OUT

(Phase definition)

0° 360°

Jitter

25 ns p-p
3.2 Input and output connections

(2) Burst mode (BURST)

(3) Sweep mode (SWEEP)
Low level during sweep from start to stop points. High level at other times.

“4.2 Sweep (■Sweep value and Z-MARKER/SYNC/X-DRIVE outputs)”, cf.

(4) Modulation mode (MODU)
High level when modulation waveform phase is above 0 and less than 180 degrees. Low level above 180 and below 360 degrees.

(5) Noise mode (NOISE)
Digital (binary) noise source output.

(6) DC mode (DC)
Always high level.
### Trigger/sweep input (TRIG/SWEEP IN)

![Diagram of TRIG/SWEEP IN](image)

**Signal characteristics:** The following types are produced during the burst oscillation mode.
- **Trigger:** Select oscillation start for either \( f \) or \( \bar{f} \).
- **Gate:** Select oscillation at either high or low level.
- **Triggered gate:** Oscillation start/stop at \( f \) or \( \bar{f} \). Select either.

Minimum pulse width is 50 ns.

In sweep oscillation mode, the sweep starts at \( f \) or \( \bar{f} \). Select either.

Minimum pulse width is 200 ns.

**Input voltage:**
- High level \( \geq +3.9 \) V
- Low level \( \leq +1.6 \) V

**Input voltage range:**
- \(-0.5 \) to \(+5.5 \) V

**Input impedance:** Pull up to +5 V at approx. 10 kΩ

**Ground:** Connected to chassis ground

---

**CAUTION**

Do not apply a signal exceeding the above input voltage range. The unit can be damaged.

---

- **Drive circuit examples**

![Schematic](image)

(a) TTL logic output  
(b) Open collector output  
(c) High voltage logic output

Connect the trigger and sweep input drive signals to TTL or C-MOS logic IC outputs.

Since the input circuit is provided with a built-in pullup resistor, an open collector output drive can also be used. However, contact chatter from a mechanical switch or relay can prevent normal operation. Also, chattering will prevent normal operation when the oscillation mode is triggered gate.

Avoid using a logic IC circuit having a power supply voltage higher than +5 V such as example (c) for the WF1946B input.
3.2 Input and output connections

- **Sweep stop/restart input (SWEEP PAUSE IN)**

  ![Diagram](image)

  Signal characteristics:
  - Low level: sweep stop
  - High level: sweep restart

  Input voltage:
  - High level: $\geq +3.9 \text{ V}$
  - Low level: $\leq +1.6 \text{ V}$

  Input voltage range:
  - $-0.5$ to $+5.5 \text{ V}$

  Input impedance:
  - Pull up to $+5 \text{ V}$ at approx. $10 \text{ k}\Omega$

  Ground:
  - Connected to chassis ground

  **CAUTION**

  Do not apply a signal exceeding the above input voltage range. The unit can be damaged.

- Drive circuit examples
  Refer to “■ Trigger/sweep input.”

- **Sweep X-drive output (SWEEP X-DRIVE OUT)**

  ![Diagram](image)

  Signal characteristics:
  - 0 to $+5 \text{ V}$: sweep increase
  - $+5$ to 0 V: sweep decrease

  Output voltage:
  - 0 to $+5 \text{ V}$ (open)

  Output impedance:
  - Approx. 1 k$\Omega$

  Recommended load:
  - Above 10 k$\Omega$

  Ground:
  - Connected to chassis ground

  **CAUTION**

  Avoid shorting the output or applying an external signal. The unit can be damaged.
3.2 Input and output connections

- **Sweep marker output (SWEEP Z-MARKER OUT)**

  ![Diagram of sweep marker output](image)

  - **Signal characteristics:**
    - Low level: sweep greater than marker
    - High level: other times
  - **Output voltage:** 0 V/+5 V
  - **Recommended load:** Above 1 kΩ
  - **Ground:** Connected to chassis ground

  **CAUTION**
  Avoid shorting the output or applying an external signal. The unit can be damaged.

- **External add input (EXT ADD IN)**

  ![Diagram of external add input](image)

  - **Input voltage:** ±5 V
  - **Input impedance:** 50 Ω
  - **External add frequency:** Up to 10 MHz
  - **Ground:** Connected to signal ground (floating from chassis)

  **CAUTION**
  Do not apply a signal exceeding the above voltage. The unit can be damaged.
3.2 Input and output connections

- **External AM input (EXT AM IN)**

  **EXT AM IN**

  ![External AM input circuit diagram]

  - Input voltage: \(-3\) to \(±1\) V (\(-100\%\) output at \(-3\) V, \(0\%\) output at \(-1\) V, \(100\%\) output at \(+1\) V)
  - Input impedance: 50 Ω
  - Modulation frequency: Up to 10 MHz
  - Ground: Connected to signal ground (floating from chassis)

  **CAUTION**

  Do not apply a signal exceeding the above voltage. The unit can be damaged.

- **Synchronous operation input and output (φ-SYNC IN, OUT)**

  (Options, 1991 and 1994)

  ![Synchronous operation input and output diagram]

  **Note:** Effective during continuous (Normal) oscillation mode.

  Timing error: Maximum 35 ns per unit. Thus, phase error of 0.1 degree at approx. 8 kHz and 1 degree at approx. 80 kHz.

  Description: The clock is sent from Master to Slave (secondary) to Slave (tertiary). The delay per unit is approximately 17 nanoseconds. The clock period is approximately 25 ns. The phase synchronizing pulse can be generated by any of the master or slave units and sent toward the terminal. Delay per unit is approximately 8 ns. Due to the phase difference from this delay time, the error between adjacent units is approximately 25 ns (clock period) + 8 ns (phase sync pulse delay) = 33 ns.


  Maximum number of connected units: 6
Note the following for synchronous operation of multiple products:

- Switch off all products before connecting or disconnecting sync transfer cables.

- Switch on all products that are connected by the sync transfer cables and that will be used. Disconnect the sync transfer cable from any product that will not be used.

- If possible, simultaneously switch on all products that are connected by the sync transfer cables.
  If simultaneous switch-on is not possible, switch on products in succession from the master (primary) side to the slave (secondary, tertiary) side.

- If possible, simultaneously switch off all products that are connected by the sync transfer cables.
  If simultaneous switch-off is not possible, switch off products in succession from the slave (secondary, tertiary) side to the master (primary) side.
3.2 Input and output connections

### Digital output (DIGITAL OUT) (1992A option)

![Diagram of DIGITAL OUT connector's housing and drain line of the cable.]

Output impedance: Approx. 115 Ω  
Output voltage: 0 V/+5 V (open)  
Connections: See table  
Ground: Signal GND lines connected to signal ground (floating from chassis)  
Drain line connected to chassis ground

Connect GND to all target signal grounds. Leave unused signal lines open.
When the drain line is connected to the target signal ground, the WF1946B signal grounds (FUNCTION OUT, SYNC OUT, EXT ADD IN, EXT AM IN) are grounded to chassis.

The accessory cable signals are indicated by marking quantity and color, and insulation color.

<table>
<thead>
<tr>
<th>Signal</th>
<th>Connection Mark color</th>
<th>Mark quantity</th>
<th>Insulation color</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output control</td>
<td>Signal Red GND Black</td>
<td>3  White</td>
<td></td>
</tr>
<tr>
<td>D15 (MSB)</td>
<td>Signal Red GND Black</td>
<td>2  Orange</td>
<td></td>
</tr>
<tr>
<td>D14</td>
<td>Signal Red GND Black</td>
<td>3  Yellow</td>
<td></td>
</tr>
<tr>
<td>D13</td>
<td>Signal Red GND Black</td>
<td>1  Pink</td>
<td></td>
</tr>
<tr>
<td>D12</td>
<td>Signal Red GND Black</td>
<td>2  Pink</td>
<td></td>
</tr>
<tr>
<td>D11</td>
<td>Signal Red GND Black</td>
<td>2  Yellow</td>
<td></td>
</tr>
<tr>
<td>D10</td>
<td>Signal Red GND Black</td>
<td>3  Pink</td>
<td></td>
</tr>
<tr>
<td>D09</td>
<td>Signal Red GND Black</td>
<td>1  Yellow</td>
<td></td>
</tr>
<tr>
<td>D08</td>
<td>Signal Red GND Black</td>
<td>3  Orange</td>
<td></td>
</tr>
</tbody>
</table>

Note: GND: Signal ground

- The output control line is pulled up to +5 V at approx. 10 kΩ. When this line is low level, the clock and D01 to D15 output signals are on. When open, the output signals are high impedance.
3.2 Input and output connections

CAUTION

Avoid shorting the output or applying an external signal. The unit can be damaged.

- Accessory cable connection example 1

Since the sending impedance and transmission line characteristic impedance is nearly matching, a comparatively good waveform can be obtained even with an open load.

- Accessory cable connection example 2

Even better waveform quality can be obtained by terminating at 110 to 120 Ω. In this case, the amplitude at the load end is about 1/2 that at the output end. This response can be utilized to apply a suitable voltage to even a low operating voltage CMOS. But in this case, do not set to high impedance with the output control line. Circuit damage can occur with a CMOS device.

- Digital output is undefined when the oscillation mode is NOISE or DC.
- Except for the following cases, data corresponding to the waveform (FUNCTION) is output as digital output:
  - [ ] (duty 50% fixed): Data corresponding to  is output.
  - [ ] (variable duty): Data to be output is undefined.
3.3 Basic operation

Basic operation is described using an example of a triangular waveform with frequency 1 kHz, amplitude 2 Vp-p and DC offset +1 V from the waveform output connector.

Setting initialize (PRESET)

The operation of initializing all settings is described. This operation manual presumes operation directly after initializing.

Operation:

① Press the SYSTEM key, then use the [<] and [>] keys to produce the following display. (lower PRESET flashes).

```
PRESET
SYSTEM: RANGE  PRESET  USER-UNIT 
```

② Press the ENTER key (upper PRESET flashes).

③ Again press the ENTER key to initialize. To return without initializing, before pressing ENTER, press the EXIT key twice.
### 3.3 Basic operation

**Initialized settings:**

Initialized settings are indicated in the table.

Settings related to output on/off, output on/off at power on, arbitrary waveform, setting memory, user units, remote control, GPIB address, GPIB delimiter, and USB ID are not initialized.

<table>
<thead>
<tr>
<th>Key operation</th>
<th>Menu</th>
<th>Initial settings</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>CH 1/CH 2</td>
<td>CH 1 (BOTH is off)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CHANNEL MODE</td>
<td>INDEP</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MODE</td>
<td>NORMAL</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MODE → BURST</td>
<td>TYPE</td>
<td>BURST</td>
<td></td>
</tr>
<tr>
<td></td>
<td>SOURCE</td>
<td>EXT ( \text{ms} ) at INT</td>
<td>When TYPE=TRIG, GATE,T-GATE</td>
</tr>
<tr>
<td></td>
<td>SOURCE(CH2)</td>
<td>EXT CH2 ( \text{ms} ) at INT</td>
<td>When TYPE=TRIG, GATE,T-GATE</td>
</tr>
<tr>
<td></td>
<td>DELAY</td>
<td>0.3 ( \mu \text{s} )</td>
<td>When TYPE=TRIG</td>
</tr>
<tr>
<td></td>
<td>MARK</td>
<td>1.0</td>
<td>When TYPE=BURST, TRIG</td>
</tr>
<tr>
<td></td>
<td>SPACE</td>
<td>1.0</td>
<td>When TYPE=BURST</td>
</tr>
<tr>
<td></td>
<td>STOP-LEVEL</td>
<td>OFF (0%, at ON)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>OPER-COMMON</td>
<td>OFF</td>
<td>Both channels MODE=BURST, TYPE=TRIG, GATE or T-GATE, same TYPE.</td>
</tr>
<tr>
<td>MODE → SWEEP</td>
<td>TYPE</td>
<td>FREQ</td>
<td></td>
</tr>
<tr>
<td></td>
<td>SOURCE</td>
<td>EXT ( \text{ms} ) at INT</td>
<td>When MODE=SINGLE, GATED</td>
</tr>
<tr>
<td></td>
<td>SOURCE(CH2)</td>
<td>EXT CH2 ( \text{ms} ) at INT</td>
<td>When MODE=SINGLE, GATED</td>
</tr>
<tr>
<td></td>
<td>MODE</td>
<td>SINGLE</td>
<td></td>
</tr>
<tr>
<td></td>
<td>FUNCTION</td>
<td>LIN</td>
<td></td>
</tr>
<tr>
<td></td>
<td>TIME</td>
<td>1 s</td>
<td></td>
</tr>
<tr>
<td></td>
<td>STOP-LEVEL</td>
<td>OFF (0%, at ON)</td>
<td>When MODE=GATED</td>
</tr>
<tr>
<td></td>
<td>OPER-COMMON</td>
<td>OFF</td>
<td>When both channels SWEEP MODE</td>
</tr>
<tr>
<td>MODE → SWEEP, TYPE=FREQ</td>
<td>START</td>
<td>1000 Hz</td>
<td></td>
</tr>
<tr>
<td></td>
<td>STOP</td>
<td>10000 Hz</td>
<td></td>
</tr>
<tr>
<td></td>
<td>CENTER</td>
<td>5500 Hz</td>
<td></td>
</tr>
<tr>
<td></td>
<td>SPAN</td>
<td>9000 Hz</td>
<td></td>
</tr>
<tr>
<td></td>
<td>MARKER</td>
<td>5000 Hz</td>
<td></td>
</tr>
<tr>
<td>MODE → SWEEP, TYPE=AMPTD</td>
<td>START</td>
<td>0.1Vp-p</td>
<td></td>
</tr>
<tr>
<td></td>
<td>STOP</td>
<td>1Vp-p</td>
<td></td>
</tr>
<tr>
<td></td>
<td>CENTER</td>
<td>0.55Vp-p</td>
<td></td>
</tr>
<tr>
<td></td>
<td>SPAN</td>
<td>0.9Vp-p</td>
<td></td>
</tr>
<tr>
<td></td>
<td>MARKER</td>
<td>0.5Vp-p</td>
<td></td>
</tr>
</tbody>
</table>

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### 3.3 Basic operation

<table>
<thead>
<tr>
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<th>Menu</th>
<th>Initial settings</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>MODE → SWEEP, TYPE=OFFSET</strong></td>
<td>START</td>
<td>0.1V</td>
<td></td>
</tr>
<tr>
<td></td>
<td>STOP</td>
<td>-0.1V</td>
<td></td>
</tr>
<tr>
<td></td>
<td>CENTER</td>
<td>0V</td>
<td></td>
</tr>
<tr>
<td></td>
<td>SPAN</td>
<td>0.2V</td>
<td></td>
</tr>
<tr>
<td></td>
<td>MARKER</td>
<td>0V</td>
<td></td>
</tr>
<tr>
<td><strong>MODE → SWEEP, TYPE=PHASE</strong></td>
<td>START</td>
<td>−90 deg</td>
<td></td>
</tr>
<tr>
<td></td>
<td>STOP</td>
<td>90 deg</td>
<td></td>
</tr>
<tr>
<td></td>
<td>CENTER</td>
<td>0 deg</td>
<td></td>
</tr>
<tr>
<td></td>
<td>SPAN</td>
<td>180 deg</td>
<td></td>
</tr>
<tr>
<td></td>
<td>MARKER</td>
<td>0 deg</td>
<td></td>
</tr>
<tr>
<td><strong>MODE → SWEEP, TYPE=DUTY</strong></td>
<td>START</td>
<td>40%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>STOP</td>
<td>60%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>CENTER</td>
<td>50%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>SPAN</td>
<td>20%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>MARKER</td>
<td>50%</td>
<td></td>
</tr>
<tr>
<td><strong>MODE → MODU</strong></td>
<td>TYPE</td>
<td>FM</td>
<td></td>
</tr>
<tr>
<td></td>
<td>FREQUENCY</td>
<td>100 Hz</td>
<td></td>
</tr>
<tr>
<td></td>
<td>FUNCTION</td>
<td>▲</td>
<td></td>
</tr>
<tr>
<td></td>
<td>OPER-COMMON</td>
<td>OFF</td>
<td>When both channels MODU MODE</td>
</tr>
<tr>
<td><strong>MODE → MODU, TYPE=FM</strong></td>
<td>DEVIATION</td>
<td>1000 Hz</td>
<td></td>
</tr>
<tr>
<td><strong>MODE → MODU, TYPE=AM</strong></td>
<td>DEPTH</td>
<td>50%</td>
<td></td>
</tr>
<tr>
<td><strong>MODE → MODU, TYPE=OFSM</strong></td>
<td>DEVIATION</td>
<td>0.2V</td>
<td></td>
</tr>
<tr>
<td><strong>MODE → MODU, TYPE=PM</strong></td>
<td>DEVIATION</td>
<td>90 deg</td>
<td></td>
</tr>
<tr>
<td><strong>ENTRY → FREQ</strong></td>
<td></td>
<td>1000 Hz</td>
<td></td>
</tr>
<tr>
<td><strong>ENTRY → AMPTD</strong></td>
<td></td>
<td>0.1 Vp-p</td>
<td></td>
</tr>
<tr>
<td><strong>ENTRY → OFFSET</strong></td>
<td></td>
<td>0 V</td>
<td></td>
</tr>
<tr>
<td><strong>ENTRY → PHASE</strong></td>
<td></td>
<td>0 deg</td>
<td></td>
</tr>
<tr>
<td><strong>ENTRY → WIDTH</strong></td>
<td></td>
<td>0.0005 s</td>
<td>In case of FUNCTION= ▲__</td>
</tr>
<tr>
<td><strong>ENTRY → DUTY</strong></td>
<td></td>
<td>50 %</td>
<td>In case of FUNCTION= ▲__</td>
</tr>
<tr>
<td><strong>ENTRY → PERIOD</strong></td>
<td></td>
<td>0.001 s</td>
<td></td>
</tr>
<tr>
<td><strong>ENTRY → HIGH</strong></td>
<td></td>
<td>0.05 V</td>
<td></td>
</tr>
<tr>
<td><strong>ENTRY → LOW</strong></td>
<td></td>
<td>−0.05 V</td>
<td></td>
</tr>
</tbody>
</table>

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## 3.3 Basic operation

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<table>
<thead>
<tr>
<th>Key operation</th>
<th>Menu</th>
<th>Initial settings</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENTRY→ Δ FREQ</td>
<td></td>
<td>0 Hz</td>
<td>When CHANNEL MODE=2 TONE</td>
</tr>
<tr>
<td>ENTRY→ RATIO</td>
<td></td>
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</table>
3.3 Basic operation

- Channel mode selection (CHANNEL MODE)

Selecting the operating modes for channels 1 and 2 are described.

**Definitions:**

- **INDEP (independent 2 channel)**: CH1 and CH2 operate independently.
- **2 PHASE**: CH1 and CH2 operate at the same frequency.

<table>
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<tr>
<th></th>
<th>CH1</th>
<th>CH2</th>
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<td>Frequency sweep and frequency modulation settings and operation</td>
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<td>operation are also the same for CH1 and CH2.</td>
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- **2 TONE (fixed frequency difference)**: CH1 and CH2 operate continuously at a fixed frequency difference.

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<td>fixed frequency difference.</td>
<td>10 kHz</td>
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- **RATIO (fixed frequency ratio)**: CH1 and CH2 operate continuously at a fixed frequency ratio.

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<tr>
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<th>CH1</th>
<th>CH2</th>
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<td>fixed frequency ratio.</td>
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</table>

- **DIFF (differential output)**: CH1 and CH2 operate at the same frequency, amplitude and DC offset, but at opposite waveforms (reverse phase). In this mode, amplitude, DC offset, output range, output on/off, phase, frequency sweep and frequency modulation settings are copied from CH1 to CH2.
**Operation:**
As an example, 2 phase operation is described.

① Press the \[ CHANNEL MODE \] key, then select the mode with the \[ \leftarrow \] and \[ \rightarrow \] keys (2 PHASE flashes in this example).

② Press the \[ ENTER \] key to change the mode.
   The \[ 2PHASE \] lamp above the \[ CHANNEL MODE \] key lights.

This completes channel mode change.

**Other:**

- When the channel mode is changed, the CH2 setting is determined on the basis of the CH1 setting.

- The channel mode and setting relationships
  [3.3 Basic operation (Channel modes and settings)], cf.
3.3 Basic operation

### Channel modes and settings

The channel modes and setting limits are indicated in the following table.

- ○: Independent setting
- △: Both channel settings are the same.
- ▲: Frequency difference (Δ FREQ) and frequency ratio (RATIO) relationships are maintained.
- ×: Not settable

*2: Gated sweep mode not selectable
*3: LOG sweep function not selectable
*4: Only CH1 usable for TRIG/SWEEP IN and SWEEP PAUSE IN
*5: When the oscillation mode is sweep or modulation, FREQ indicated the type is frequency and OTHER indicates other than this.
*6: Control operation is common between channels.

<table>
<thead>
<tr>
<th>Key operation</th>
<th>Channel mode</th>
<th>[INDEP]</th>
<th>[2PHASE]</th>
<th>[2TONE]</th>
<th>[RATIO]</th>
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<td>△</td>
<td>△</td>
</tr>
<tr>
<td>CH 1/CH 2</td>
<td></td>
<td>△</td>
<td>△</td>
<td>△</td>
<td>△</td>
<td>△</td>
<td>△</td>
</tr>
<tr>
<td>CH 1, CH 2 OUT</td>
<td></td>
<td>△</td>
<td>△</td>
<td>△</td>
<td>△</td>
<td>△</td>
<td>△</td>
</tr>
</tbody>
</table>
3.3 Basic operation

Channel selection (CH1/CH2)

Channel selection for setting and display is described.

**Procedure:**

Each time that the CH1/CH2 key is pressed, the lamp that lights or flashes changes as shown below:

- CH1 (Set to CH1 only)
- CH2 (Set to CH2 only)
- BOTH and CH1 (Set to both CH1 and CH2 simultaneously. The displayed unit and auxiliary unit are the same as those of the preceding CH1)
- BOTH and CH2 (Set to both CH1 and CH2 simultaneously. The displayed unit and auxiliary unit are the same as those of the preceding CH2)

While CH1 is flashing, however, the value of CH2 is different from the displayed value. Also, while CH2 is flashing, the value of CH1 is different from the displayed value. If set again, CH1 and CH2 will operate with the same setting.

**Operation:**

In this example, CH1 is selected.

1. Press the CH1/CH2 key to where the CH1 lamp above the key lights.

   This selects the setting and display for CH1.
   Each time the key is pressed, the setting and display change as follows: CH1 → CH2 → CH1 BOTH → CH2 BOTH → CH1...

**Other:**

The channel cannot be selected when the channel mode is DIFF.
Oscillation mode selection (MODE)

Oscillation mode (continuous, burst, sweep, etc.) selection is described.

Terms:
- NORMAL (continuous): Continuous oscillation; normally use this mode.
- BURST: Intermittent oscillation (BURST, TRIG, GATE, T-GATE)
  - “4.1 Burst oscillation”, cf.
- SWEEP: Item such as frequency is automatically varied.
  - “4.2 Sweep”, cf.
- MODU (modulation): Modulated waveform output (FM, AM, OFSM, PM, PWM)
  - “4.3 Modulation”, cf.
- NOISE: White noise output
- DC: DC output
  - “3.3 Basic operation (DC offset setting)”, cf.

Operation:
The selected oscillation mode is indicated in the STATUS area, which is located to the left of the MODE key. When the MODE key is pressed, the MODE key lamp lights, and at the same time, the lamp of every key located to the right of the MODE key lights.

To use another oscillation mode (one whose key lamp is already lit), press the key of the mode.

Operation example:
In this example, first set to DC, then to continuous (NORMAL).

1. Press the MODE key, then the DC key to set the DC mode.
   The DC STATUS lamp lights.

2. Press the MODE key, then the NORMAL key to set the NORMAL mode.
   The NORMAL STATUS lamp lights.
3.3 Basic operation

■ Waveform selection (FUNCTION)

Waveform selection is described.

Symbols:

\[ \sim \] : Sinewave
\[ \wedge \] : Triangular wave
\[ \square \] : Squarewave (50 % fixed duty)
\[ \square \] : Squarewave (variable duty)
\[ \uparrow \] : Rising sawtooth
\[ \downarrow \] : Descending sawtooth
ARB: Arbitrary waveform

“4.4 Arbitrary Waveform (ARB)”, cf.

Operation:

The selected waveform is indicated in the STATUS area, which is located to the left of FUNCTION key. When the FUNCTION key is pressed, the FUNCTION key lamp lights, and at the same time, the lamp of every key located to the right of the FUNCTION key lights. The lamp of the selected waveform blinks. To select another waveform (one whose key lamp is already lit), press the key of the waveform.

Operation example:

In this example, a triangular waveform is selected.

① Press the FUNCTION key, then the \[ \wedge \] key. The STATUS lamp lights

② After selecting, press the EXIT key once to exit the setting mode.

Other:

In \[ \square \] squarewaves (variable duty), pulses may disappear depending on the relations between the cycle and duty when the pulse width falls below 25 ns. For such settings, an error message is displayed.

When the pulse width is 100 ns or less, jitter becomes relatively larger compared with the pulse width, and a warning message is displayed.

If the pulse width falls below 25 ns, pulses may disappear.

If the pulse width falls below 100 ns, jitter becomes relatively larger compared with the pulse width.
If the phase of the squarewaves (fixed duty) or squarewaves (variable duty) is changed, multiple pulses may be output in one cycle, as shown below.

If the duty of the squarewaves (variable duty) is changed, multiple pulses may be output in one cycle, as shown below.

If the pulse width is larger than 75 ns after the duty is changed, it is possible to suppress the output of multiple pulses in one cycle. Therefore, set DUTY-VALID to CYCLE. Note, however, that this setting cannot be made if the oscillation mode is SWEEP or MODU.

If DUTY-VALID is set to CYCLE, the set duty will be reflected in the subsequent cycles. Even though DUTY-VALID is set to CYCLE, extra pulses may be output if the frequency or phase is changed.

Operation when DUTY-VALID: IMMED

The setting will be reflected at the same time that the duty changes

Operation when DUTY-VALID: CYCLE

Duty change  The setting will be reflected in the subsequent cycles
In squarewaves (variable duty), the duty range can be switched to 0.0000% to 100.0000% or 0.0100% to 99.9900%. To set a duty in the range from 0.0000% to 100.0000%, set DUTY-VALID to EXPAND.

It is not possible to set CYCLE and EXPAND simultaneously. If DUTY-VALID is set to IMMED or CYCLE, the range in which the duty can be set is 0.0100% to 99.9900%. When the frequency is about 4 kHz or less, pulse losses can be prevented by restricting the duty range to 0.0100% to 99.9900%.

The waveform cannot be selected in the following cases.
- Oscillation mode is NOISE or DC.
- TYPE is DUTY in SWEEP oscillation mode.
- TYPE is PWM in MODU oscillation mode.
3.3 Basic operation

Frequency setting (ENTRY → FREQ)

Frequency (FREQ) setting is described.

**Operation:**

Two methods can be used for setting the frequency.

(1) Keypad

This method is convenient when the frequency has been determined beforehand.

For example, set 1 kHz as follows.

1. Press the ENTRY key, then the FREQ key.

2. Press the 1 key, then the k key.

   If the number was entered incorrectly, press the BS key before pressing the k key.

3. After setting, press the EXIT key to exit the setting mode.

(2) Modify dial

This is convenient for continuously setting the frequency.

1. Press the ENTRY key, then the FREQ key.

2. Select the digit to be changed with the < and > keys. The selected digit flashes.

3. Turn the MODIFY dial to set the digit.

4. After setting, press the EXIT key.

**Other:**

- The frequency cannot be set in the NOISE or DC oscillation modes.
- When keys such as k are not being used for industrial units (e.g., 50 Hz), press the ENTER key directly after entering the frequency. “5.2 Units”, cf.
- The frequency generating period can also be set. “5.1 Convenient Settings (Frequency [Hz] setting by period [s])”, cf.
3.3 Basic operation

- **Amplitude setting** (ENTRY → AMPTD)

  Amplitude (AMPTD) setting is described.

  **Operation:**
  The amplitude can be set by two methods.

  (1) **Keypad**
  Convenient when the amplitude has been determined beforehand.
  For example, set 2 Vp-p as follows.

  ① Press the ENTRY key, then the AMPTD key.

  The following display is produced.

  ![Display](image)

  ② Press the 2 key, then the ENTER key.
  To correct an entry, press the BS key before pressing ENTER key.

  ③ This completes setting, afterwards, press the EXIT key.

  (2) **Modify dial**
  The amplitude can be changed continuously.

  ① Press the ENTRY key, then the AMPTD key.

  ② Select the digit to be changed with the ⬅️ and ➤️ keys.

  ③ Turn the MODIFY dial to set the flashing digit.

  ④ After setting, press the EXIT key to release the setting mode.

  **Other:**
  - When the oscillation mode is DC, the amplitude cannot be set.
  - Units other than Vp-p can also be set. See “5.2 Units (Amplitude units change)”, cf.
  - Can also be set by waveform high level and low level.
    See “5.1 Convenient Settings (Amplitude and DC offset setting by high and low level)”, cf.
3.3 Basic operation

DC offset setting (ENTRY → OFFSET)

DC offset determines the offset component added to the waveform or the output voltage when the oscillation mode is DC.

Setting the DC offset (OFFSET) is described.

Operation:
Two methods can be used for setting the DC offset.

(1) Keypad
Convenient when the DC offset has been determined beforehand.
For example, set +1 V as follows.

① Press the ENTRY key, then the OFFSET key.

The following display is produced.

```
DC offset
O F S  + 0 . 0 0 0 0 V
1 . 0 0 0 0 0 0 0 0 0 kHz A 2 . 0 0 0 0 V p p / O P E N
```

② Press the 1 key, then the ENTER key.
To correct an entry, press the BS key before pressing ENTER.
③ This completes setting, afterwards, press the EXIT key.

(2) Modify dial
The offset can be changed continuously.

① Press the ENTRY key, then the OFFSET key.
② Select the digit to be changed with the < and > keys.
③ Turn the MODIFY dial to set the flashing digit.
④ After setting, press the EXIT key to release the setting mode.

Other:
- Can also be set by waveform high level and low level.

“5.1 Convenient Settings (Amplitude and DC offset setting by high and low level)”, cf.
3.3 Basic operation

**Phase setting (ENTRY → PHASE)**

The oscillation starting phase setting for burst and (gated) sweep is described. Set CH1 and CH2 independently to also allow setting the phase difference between these channels.

“5.5 Other settings (Phase sync)”, cf.

**Operation:**

Two methods can be used for setting the phase.

1. **Keypad**

   Convenient when the phase has been determined beforehand.

   For example, set 90 degrees as follows.

   ① Press the ENTRY key, then the PHASE key.

   The following display is produced.

   ![Phase display]

   ② Press keys 9 and 0, then the ENTER key.

   To correct an entry, press the BS key before pressing ENTER.

   ③ This completes setting, afterwards, press the EXIT key.

2. **Modify dial**

   The phase can be changed continuously.

   ① Press the ENTRY key, then the PHASE key.

   ② Select the digit to be changed with the << and >> keys.

   ③ Turn the MODIFY dial to set the flashing digit.

   ④ After setting, press the EXIT key to release the setting mode.
Output on/off

Output on/off setting is described.

Operation:

1. Press the ON/OFF key. The setting alternates between on and off each time the key is pressed.

The lamp lights when on, extinguishes when off.

Other:

Except when the channel mode is DIFF, each channel operates independently. In the DIFF mode, the channel outputs are coupled (i.e., by operating either CH1 OUT or CH2 OUT, both channel outputs are set on/off).
### 3.3 Basic operation

#### Operation tree

- **Output on/off**

- **Channel mode** [INDEP/2PHASE/2TONE/RATIO/DIFF]

- **Channel selection** [CH 1/CH 2/BOTH CH1/BOTH CH2]

- **Oscillation mode**
  - NORMAL
  - BURST
  - SWEEP
  - MODU
  - NOISE
  - DC

---

**BURST Menu**

- **TYPE** (Burst type) [BURST/TRIG/GATE/T-GATE]
- **SOURCE** (Trigger/gate source selection)
- **DELAY** (Trigger delay)  * For TYPE: TRIG
- **MARK** (Number of cycles signal present)  * For TYPE: BURST/TRIG
- **SPACE** (Number of cycles signal not present)  * For TYPE: BURST
- **STOP-LEVEL** (Stop level)
- **OPER-COMMON** (Simultaneous operation of both channels)
  - * When the same TYPE is set for both channels

---

**BURST Operation**

- **MAN TRIG**
3.3 Basic operation

**Sweep Menu**
- **TYPE** (Sweep target) [FREQ/AMPTD/OFFSET/PHASE/DUTY]
- **SOURCE** (Trigger source selection) * For MODE: SINGLE/GATED
- **MODE** (Sweep mode) [SINGLE/CONT/GATED]
- **FUNCTION** (Sweep waveform) [LIN/LOG, \(\triangle\)/\(\triangle\)/\(\triangle\)/SIN]
- **START** (Sweep start value)
- **STOP** (Sweep end value)
- **TIME** (Sweep time)
- **STOP-LEVEL** * For MODE: GATED
- **CENTER** (Sweep center value)
- **SPAN** (Sweep width)
- **MARKER** (Marker value)
  - **MKR → CTR** (Copying of the marker value to the center value)
- **START-STATE**
- **STOP-STATE**
- **OPER-COMMON** (Simultaneous operation of both channels)
  - * When sweeping both channels

**Sweep Operation**
- **START** / **STOP** / **PAUSE**

**Modulation Menu**
- **TYPE** (Modulation type) [FM/AM/OFSM/PM/PWM]
- **DEVIAION** * DEPTH for TYPE: AM
- **FREQ** (Modulation frequency)
- **FUNCTION** (Modulated waveform) [SIN/\(\triangle\)/\(\triangle\)/\(\triangle\)/\(\triangle\)]
- **OPER-COMMON** (Simultaneous operation of both channels)
  - * When modulating both channels

**Modulation Operation**
- **START** / **STOP**

**Entry Menu**
- **FREQ / AMPTD / OFFSET / PHASE / DUTY / WIDTH / PERIOD / HIGH / LOW /
  - \(\triangle\):FREQ / RATIO

* **DUTY/WIDTH** for FUNCTION: \(\triangle\)
  - \(\triangle\) FREQ is for CHANNEL MODE: 2TONE
  - RATIO is for CHANNEL MODE: RATIO
3.3 Basic operation

**FUNCTION**
- Waveform selection

**ARB EDIT**
- Arbitrary waveform menu  * For FUNCTION: ARB
  - SELECT (Select arbitrary waveform)
  - NAME (Arbitrary waveform name)
  - EDIT (Edit arbitrary waveform)
  - COPY (Copy arbitrary waveform)
  - MARK-CLEAR (Clear mark)
  - CLEAR (Clear arbitrary waveform)
  - SIZE (Select arbitrary waveform data size)

**SYSTEM**
- Other operation menus
  - RANGE (Select output range) [AUTO/10V/1V]
  - PRESET (Initialization)
  - USER-UNIT (User-unit menu)
    - TYPE (Setting target) [FREQ/PERIOD/AMPTD/OFFSET/PHASE/DUTY]
    - NAME (Unit name)
    - FORMULA (Formula)
    - SCALE (Multiplier)
    - OFFSET (Offset)
  - LOAD (LOAD function)
  - COPY 1 → 2 (Copy a setting)
  - COPY 2 → 1 (Copy a setting)
  - EXT-AM (External AM selection)
  - EXT-ADD (External addition selection)
  - φ SYNC (Phase synchronization)
  - DUTY-VALID (Duty)
  - POWER-ON (Output state selection at power-on)
  - REMOTE (Remote control menu)
    - INTERFACE (Interface)
    - ADDRESS/ID (GPIB address/USB ID)
    - DELIMITER (GPIB delimiter)
  - OPTION (Option menu)
3.3 Basic operation

**MEMORY**
- Setup memory menu
  - STORE (Save setup memory)
  - RECALL (Call setup memory)
  - CLEAR (Clear setup memory)

- LOCAL (Release remote state)

- UNDO (Cancel setting)

- EXIT (Move to menu immediately above)

- ENTER (Accept input value)

**Numeric input (keypad)**
- + / - / . / 0 / 1 / 2 / 3 / 4 / 5 / 6 / 7 / 8 / 9 / M / µ / k / m

**Numeric modification (Modify)**
- ▼ / ▲ / □
Section 4  Applications

4.1 Burst oscillation

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- Following is an example of the display when using this section.

Fully lighted (bold)  Dimly lighted
BURST TRIG GATE
BURST : TYPE
MARK SPACE STOP–LEVEL

Fully lighted (bold)  Flashing  Dimly lighted
4.1 Burst oscillation

**Burst oscillation (Type: Burst)**

Burst oscillation (Type: Burst) produces an intermittent oscillation at the designated oscillation cycle and stop cycle.

Operation is described with reference to an example of producing a waveform output such as indicated in the figure.

In this example, the waveform is triangular, the DC offset is set to 0 V, the oscillation start phase is set to 0 degrees, and the frequency and amplitude are set to arbitrarily defined values.

![Waveform Diagram](image)

**Operation:**

1. Set the burst oscillation TYPE to BURST.

   ① Press the **MODE** key, then the **BURST** key.

   ② Use the **<** and **>** keys to select the type (TYPE flashes).

   [Diagram]

   **BURST** TRIG GATE

   **BURST : TYPE** MARK SPACE STOP—LEVEL

   ③ Press the **ENTER** key, then produce the following display with the **<** and **>** keys (BURST flashes).

   [Diagram]

   **BURST** TRIG GATE

   **BURST : TYPE** MARK SPACE STOP—LEVEL

   ① This sets the burst oscillation type to burst. Press the **EXIT** key once to exit type setting.
(2) Set MARK cycle

① Use the ◄ and ► keys to produce the following display (MARK flashes).

```
1.0 cycle
BURST: TYPE MARK SPACE STOP—LEVEL
```

② Press the ENTER key.

③ Set the mark cycles with the keypad or MODIFY dial (0.5 cycles).
   In this example, the setting is 2.0 cycles.

④ After setting, press the EXIT key once to exit mark cycle setting.

(3) Set SPACE cycle

① Use the ◄ and ► keys to produce the following display (SPACE flashes)

```
1.0 cycle
BURST: TYPE MARK SPACE STOP—LEVEL
```

② Press the ENTER key.

③ Set the space cycles with the keypad or MODIFY dial (0.5 cycle units). In this example, the setting is 1.5 cycles.

④ After setting, press the EXIT key once to release space cycle setting.

(4) Set STOP-LEVEL

① Use the ◄ and ► keys to produce the following display (STOP-LEVEL flashes).

```
OFF
BURST: TYPE MARK SPACE STOP—LEVEL
```
4.1 Burst oscillation

② Press the ENTER key.
   Turn the MODIFY dial to produce the following display (ON flashes).

- BURST: TYPE MARK SPACE STOP—LEVEL
  0.00 %

③ Press the MODIFY key, then set the stop level with the keypad or MODIFY dial.
   In this example, the setting is 25%.

The stop level is the percentage with respect to the maximum positive (+100%) and negative (-100%) amplitude.

④ After setting, press the EXIT key to release the setting mode.

This completes burst oscillation (type: burst) setting.

Other:
- If the frequency exceeds 5 MHz, mark cycles and space cycles may be unpredictable.
  If the cycles are undefined, the start phase may be shifted by half a cycle even though the frequency is set to less than 5 MHz. If such a shift occurs, set the continuous oscillation and then the burst oscillation.

- Stop level off: Oscillation stops at the phase (set by ENTRY → PHASE ) setting (mark cycles more than 1.0 and mark + space cycles are integers).

Waveform example of oscillation start phase: -90°, mark waves: 2, space waves: 1

Also, by setting an amplitude (Vp-p) 1/2 DC offset or the low level to 0 V, a unipolar waveform can be obtained.

5.1 Convenient Settings (Amplitude and DC offset setting by high and low level), cf.

- Burst oscillation setting items (BURST menu)
  TYPE: BURST
  MARK (oscillation cycle) [cycle]
  SPACE (cycle when oscillation stops) [cycle]
  STOP-LEVEL [OFF, ON[%]]
  PHASE (phase when oscillation starts) [deg] * ENTRY menu
### Burst oscillation (Type: Trigger) (MODE → BURST → TYPE : TRIG)

Burst oscillation (Type: Trigger) produces an intermittent oscillation output at a designated cycle at each trigger signal.

Operation is described with reference to an example of producing a waveform output such as indicated in the figure in response to an external trigger (△).

The example is a triangular waveform, DC offset 0 V, frequency and amplitude arbitrary.

![Waveform diagram](image)

**Operation:**

1. Set the burst oscillation TYPE to TRIG.

   ① Press the MODE key, then the BURST key.
   ② Use the ‹ and › keys to select the type (TYPE flashes).

   ![Type selection display](image)

   ③ Press the ENTER key, then produce the following display with the ‹ and › keys (TRIG flashes).

   ![Display with TRIG setting](image)

   ④ This sets the burst oscillation type to trigger. Press the EXIT key to exit type setting.
4.1 Burst oscillation

(2) Select trigger SOURCE

① Use the < and > keys to produce the following display (SOURCE flashes).

```
EXT
TRIG: TYPE SOURCE DELAY MARK
```

② Press the ENTER key.
③ Press the > key, then turn the MODIFY dial to select rising trigger (▲). (▼ indicates falling trigger).
④ After setting, press the EXIT key once to release trigger source setting.

(3) Set DELAY time

① Use the < and > keys to produce the following display (DELAY flashes).

```
TRIG: TYPE SOURCE DELAY MARK
```

0.3μs

② Press the ENTER key.
③ Set the delay time with the keypad or MODIFY dial.
For example, set to 1 ms.
④ After setting, press the EXIT key once to release delay time setting.
(4) Set MARK cycle

① Use the < and > keys to produce the following display (MARK flashes).

![Image of 1.0 cycle display]

② Press the ENTER key.

Set the mark cycles with the keypad or MODIFY dial (0.5 cycle units).
In this example, the setting is 2.0 cycles.

③ After setting, press the EXIT key once to release mark cycle setting.

(5) Set STOP-LEVEL

① Use the < and > keys to produce the following display (STOP-LEVEL flashes).

![Image of OFF display]

② Press the ENTER key.

Turn the MODIFY dial to produce the following display (ON flashes).

![Image of ON display]

③ Press the > key, then set the stop level with the keypad or MODIFY dial.

In this example, the setting is -50 %.

The stop level is the percentage with respect to the maximum positive (+100 %) and negative (-100 %) amplitude.

④ After setting, press the EXIT key to release the setting mode.
(6) Phase setting

1. Press the ENTRY key, then the PHASE key.
2. Set the phase with the keypad or MODIFY dial.
   For example, set the phase to 90 degrees.
3. After setting, press the EXIT key to release the setting mode.

The above sets burst oscillation (type: trigger). Oscillation is produced when a signal is applied to the TRIG/SWEEP IN connector.

Additional information

- **Internal trigger**: The trigger signal is produced at the rate indicated below for oscillation start/stop. The trigger rate is common for CH1 and CH2.

![Trigger Details]

- **Stop level off**: Oscillation stops at the phase (set by ENTRY → PHASE) setting (mark cycle is integer).
- **Manual trigger**: Press the MAN TRIG key, then set the trigger source to EXT. Operation is based on the logical OR of the external signal, key, and type of remote control (GPIB or USB).
- **To generate the trigger signal via remote control (GPIB or USB)**, set the GET command or TRG command from the remote control interface. Also, set the trigger source to EXT.

For details of the remote control command, "Remote Control Operation Manual", cf.
• To simultaneously generate a trigger signal for both channels manually or via remote control (GPIB or USB), set Type for both channels to Trigger and set OPER-COMMON to on. If the BOTH lamp is on, behavior is the same even though OPER-COMMON is off.

• Burst oscillation (type: trigger) setting items (BURST menu)
  TYPE: TRIG
  SOURCE (trigger source) CH1: [EXT, EXT, INT [s], INT [s]]
  CH2: [EXT CH2, EXT CH2, EXT CH1, EXT CH1, INT [s], INT [s]]
  DELAY (trigger delay) [s]
  MARK (oscillation cycle) [cycle]
  STOP-LEVEL [OFF, ON[%]]
  OPER-COMMON (trigger in both channels) [OFF, ON]
  PHASE (phase when oscillation starts) [deg] * ENTRY menu

■ Burst oscillation (Type: Gate) (MODE → BURST → TYPE : GATE)

Burst oscillation (Type: Gate) is intermittent with start and stop according to the trigger signal level. Operation is described with reference to an example of producing a waveform output such as indicated in the figure in response to an external gate signal.

The example is a triangular waveform, DC offset 0 V, oscillation start phase 0 degrees, frequency and amplitude arbitrary.
4.1 Burst oscillation

Operation:
(1) Set burst oscillation TYPE to GATE.

① Press the MODE key, then the BURST key.
② Use the ◀ and ▶ keys to produce the following display (TYPE flashes).

```
BURST TRIG GATE ▶
BURST : TYPE MARK SPACE STOP-LEVEL
```

③ Press the ENTER key, then produce the following display with the ◀ and ▶ keys (GATE flashes).

```
BURST TRIG GATE ▶
GATE : TYPE SOURCE STOP-LEVEL
```

① This sets the burst oscillation type for gate.
Press the EXIT key once to release the type setting mode.

(2) Select gate SOURCE

① Use the ◀ and ▶ keys to produce the following display (SOURCE flashes).

```
EXT L-ON
GATE : TYPE SOURCE STOP-LEVEL
```

② Press the ENTER key.
③ Press the ▶ key, then select positive logic (H-ON) with the MODIFY dial.
④ After setting, press the EXIT key to release the setting mode.
(3) Set STOP-LEVEL

① Use the and keys to produce the following display (STOP-LEVEL flashes).

![Display](image)

② Press the key.

Turn the dial to produce the following display (ON flashes).

![Display](image)

③ Press the key, then set the stop level with the keypad or dial.

In this example, the setting is 0 %.

The stop level is the percentage with respect to the maximum positive (+100 %) and negative (-100 %) amplitude.

④ After setting, press the key to release the setting mode.

The above selects sets burst oscillation (type: gate). Oscillation occurs when a high level signal is applied to the TRIG/SWEEP IN connector. If the connection is open, oscillation continues due to internal pullup.

Other settings:

• At the above settings, when the waveform is squarewave, a three squarewave is obtained such as shown in the following figure.

![Waveform](image)

(When stop level is off, the oscillation stops at either high or low level.)

• Internal gate source: A 50 % duty gate signal is generated at the following period for oscillation start/stop. The gate rate is common for CH1 and CH2.
4.1 Burst oscillation

- **Stop level off**: Oscillation stops at the half-cycle after gate signal off (i.e., at the phase set by $ENTRY \rightarrow PHASE$).

- **Manual gate signal**: Press the $MAN\_TRIG$ key. The gate signal is on (i.e., oscillation) while the key is pressed. In this case, set the trigger source for EXT L-ON.

- **To generate the gate signal via remote control (GPIB or USB)**, set the TRG command from the remote control interface.
  Also, set the gate source to EXT L-ON.
  For details of the remote control command, see "Remote Control Operation Manual", cf.

- **To simultaneously generate a gate signal for both channels manually or via remote control (GPIB or USB)**, set Type for both channels to Gate and set OPER-COMMON to on.
  If the BOTH lamp is on, behavior is the same even though OPER-COMMON is off.

  ![OFF ON](image)

- **Burst oscillation (type: gate) setting items (BURST menu)**
  TYPE: GATE
  SOURCE (gate source)
  CH1: [EXT L-ON, EXT H-ON, INT L-ON [s], INT H-ON [s]]
  CH2: [EXT CH2 L-ON, EXT CH2 H-ON, EXT CH1 L-ON, EXT CH1 H-ON, INT L-ON [s], INT H-ON [s]]
  STOP-LEVEL [OFF, ON [%]]
  OPER-COMMON (simultaneous gate generation for both channels) [OFF, ON]
  PHASE (phase when oscillation starts) [deg] * ENTRY menu
Burst oscillation (Type: Triggered gate) (MODE → BURST → TYPE : T-GATE)

Burst oscillation (type: triggered gate) is intermittent with repeated start and stop at each trigger signal. Operation is described with reference to an example of producing a waveform output such as indicated in the figure in response to an external trigger (触发信号)．

The example is a triangular waveform, DC offset 0 V, oscillation start phase 0 degrees, frequency and amplitude arbitrary.

![Waveform Diagram]

Stop level : 100%

Trigger signal (TRIG/SWEEP IN)
Oscillation starts at trigger
Oscillation stops at end of a half cycle, at next trigger

Operation:

1. Set burst oscillation TYPE to trig’d gate (T-GATE)

   ① Press the MODE key, then the BURST key.
   ② Use the << and >> keys to produce the following display (TYPE flashes)

   ![Display 1]

   ③ Press ENTER key, then use the << and >> keys to produce the following display (T-GATE flashes).

   ![Display 2]

   ④ This sets the burst oscillation type for triggered gate. Press the EXIT key once to release the type setting mode.
4.1 Burst oscillation

(2) Select trigger source (SOURCE)

① Use the ◀ and ▶ keys to produce the following display (SOURCE flashes).

```
EXT
TRIG: TYPE SOURCE STOP—LEVEL
```

② Press the ENTER key.

③ Select rising (▼) using the MODIFY dial. (▼ indicates falling of the trigger signal)

④ After making a selection, press the EXIT key once to exit the trigger source selection.

(3) Set STOP-LEVEL

① Use the ◀ and ▶ keys to produce the following display (STOP-LEVEL flashes).

```
OFF
T-GATE: TYPE SOURCE STOP—LEVEL
```

② Press the ENTER key.

③ Turn the MODIFY dial to produce the following display (ON flashes).

```
ON
T-GATE: TYPE SOURCE STOP—LEVEL 0.00 %
```

① Press the ▶ key, then set the stop level with the keypad or MODIFY dial. For example, set to 100 %.

The stop level is the percentage with respect to the maximum positive (+100 %) and negative (−100 %) amplitude.

⑤ After setting, press the EXIT key to release the setting mode.

The above sets the burst oscillation (type: triggered gate). Oscillation alternates between start and stop each time a signal (▼) is applied to the TRIG/SWEEP IN connector.
4.1 Burst oscillation

Other settings:

- **Stop level off**: Oscillation stops after the trigger signal is applied, at the end of a half cycle (i.e., at the phase set by \( \text{ENTRY} \rightarrow \text{PHASE} \)) or plus 180 degrees from that phase.

- **Manual trigger**: When a manual trigger signal is desired, press the \( \text{MAN TRIG} \) key. Oscillation starts and stops each time the key is pressed. However, produce the manual trigger signal after the oscillation has stopped. If oscillation is from an external signal, oscillation will not stop even if the \( \text{MAN TRIG} \) key is pressed.

Oscillation stops during power-on.

- **To generate the trigger signal via remote control (GPIB or USB)**, set the GET command or TRG command from the remote control interface. Also, set the trigger source to EXT \( \rightarrow \). For details of the remote control command, \( \text{cf.} \) "Remote Control Instruction Manual", cf.

- **To simultaneously generate a signal for both channels manually or via remote control**, set Type for both channels to Trigger and set OPER-COMMON to on. If the BOTH lamp is on, behavior is the same even though OPER-COMMON is off.

![OFF ON T-GATE: OPER-COMMON](image)

- Burst oscillation (type: triggered gate) setting items (BURST menu)

  TYPE: T-GATE
  SOURCE (trigger source) CH1: [EXT \( \rightarrow \), EXT \( \rightarrow \)]  
  CH2: [EXT CH2 \( \rightarrow \), EXT CH2 \( \rightarrow \), EXT CH1 \( \rightarrow \),  
  EXT CH1 \( \rightarrow \)]
  STOP-LEVEL [OFF, ON[%]]
  OPER-COMMON (trigger in both channels) [OFF, ON]
  PHASE (phase when oscillation starts) * ENTRY menu
4.2 Sweep

Sweep (Mode: Single) (MODE -> SWEEP -> MODE : SINGLE)

In a Sweep (Mode: Single), oscillation occurs by varying parameters such as the frequency and amplitude one time between the start and stop settings. Oscillation continues after the sweep is completed. Operation to produce a waveform output with frequency that varies linearly and continuously is described. The setting example is a sinewave with arbitrary amplitude and DC offset.

Start frequency : 100Hz
Stop frequency : 1000Hz
Sweep time : 3 seconds

Operation:
(1) Set sweep MODE to SINGLE

① Press the MODE key, then the SWEEP key.
② Use the < and > keys to produce the following display (MODE flashes).

\[
\text{SINGLE CONT GATED} \quad F-\text{SWP} : \text{TYPE SOURCE MODE} \quad \rightarrow
\]

③ Press ENTER, then use the < and > keys to produce the following display (SINGLE flashes).

\[
\text{SINGLE CONT GATED} \quad F-\text{SWP} : \text{TYPE SOURCE MODE} \quad \rightarrow
\]

④ This sets the sweep mode for single. Press the EXIT key once to release mode select.
(2) Set the sweep TYPE to FREQ

① Use the < and > keys to produce the following display (TYPE flashes).

<table>
<thead>
<tr>
<th>FREQ</th>
<th>AMPTD</th>
<th>OFFSET</th>
<th>F-SWP : TYPE SOURCE MODE</th>
</tr>
</thead>
</table>

② Press ENTER key, then use the < and > keys to produce the following display (FREQ flashes).

<table>
<thead>
<tr>
<th>FREQ</th>
<th>AMPTD</th>
<th>OFFSET</th>
<th>F-SWP : TYPE SOURCE MODE</th>
</tr>
</thead>
</table>

③ This sets the sweep type for frequency. Press the EXIT key once to release the type setting mode.

(3) Select sweep FUNCTION

① Use the < and > keys to produce the following display (FUNCTION flashes).

<table>
<thead>
<tr>
<th>LIN</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>F-SWP : FUNCTION START STOP</td>
<td></td>
</tr>
</tbody>
</table>

② Press the ENTER key.

③ Press the > key, then select with the MODIFY dial.

④ After selecting, press the EXIT key once to release the function select mode.
(4) Set START frequency

① Use the [left] and [right] keys to produce the following display (START flashes).

```
1 0 0 0 . 0 0 0 0 0 0 0 0 0 0 0 0 0 Hz
F−SWP : ↓ FUNCTION START STOP →
```

② Press [ENTER] key.

③ Set the start frequency with the keypad or [modify] dial.

For example, set to 100 Hz.

④ After setting, press the [exit] key once to release the start frequency setting mode.

(5) Set STOP frequency

① Use the [left] and [right] keys to produce the following display (STOP flashes).

```
1 0 0 0 0 . 0 0 0 0 0 0 0 0 0 0 0 0 Hz
F−SWP : ↓ FUNCTION START STOP →
```

② Press [ENTER] key.

③ Set the stop frequency with the keypad or [modify] dial.

For example, set to 1000 Hz.

④ After setting, press the [exit] key once to release the stop frequency setting mode.
(6) Set sweep TIME

① Use the \(<\) and \(>\) keys to produce the following display (TIME flashes).

```
F-SWP : TIME CENTER SPAN
```

② Press \(\text{ENTER}\) key.

③ Set the sweep time with the keypad or \(\text{MODIFY}\) dial.
   For example, set to 3 seconds.

④ After setting, press the \(\text{EXIT}\) key once to release the sweep time setting mode.

(7) Sweep operation

① Sweep starts when the \(\text{START}\) key is pressed.
   When sweep is started, an existing output frequency is quickly changed to the start frequency. If desiring to set the start frequency output beforehand, press the \(\text{STOP}\) key.
   The output quickly changes to the start frequency, then sweeps to the stop frequency in 3 seconds (in this example). Oscillation then continues at the stop frequency.
   When the \(\text{START}\) key is again pressed, sweep begins at the stop frequency and ends at the start frequency.
Other operations:

- **Sweep stop**: Press the STOP key. When sweep is stopped at the stop value at single sweep end or during sweep, press the STOP key to set the start value.

- **Sweep pause**: Press the PAUSE key. Again press the PAUSE key to resume sweep.

- **Single sweep operation examples**

- **Dead time and trigger delay**: Triggers input within 100 ms of completion of the last sweep are ignored. The trigger delay for the first sweep after power-on or a parameter change is 40 ms. Otherwise, it is 2 ms.

- **External sweep start**: Set the sweep trigger source to EXT and select rising or falling. Supply an external signal to the front panel TRIG/SWEEP IN connector. However, note that retrigger cannot be applied for 100 ms after sweep start. During a sweep, the sweep restarts if a trigger is input.

- **External pause**: Apply Low level to the rear panel SWEEP PAUSE IN connector. To resume sweep, apply a High level or open input.
4.2 Sweep

• **FUNCTION** determines the sweep type.
  - For example, provides step-type change of output (e.g., frequency) at the sweep time halfway point. LIN/LOG provides linear or logarithmic variation of the output with respect to the time axis.
  - ![LIN](image1)
  - ![LOG](image2)
  - ![LIN](image3)
  - ![LOG](image4)
  - ![SIN](image5)

• **Internal sweep trigger source**
  - The trigger signal is generated at the following rate, then sweep is conducted. However, the trigger interval is 100 ms even if set to less. The trigger rate is common for CH1 and CH2.

  ![INT](image6)

• **START-STATE and STOP-STATE**
  - Set output to start and stop values, respectively.
  - Since sweep synchronization output becomes the respective start and stop states, full-scale adjustments of the recorder and the status of external equipment can be checked.
  - START-STATE is the same as pressing the key (during a single sweep).
  - Relationship between sweep values and sweep synchronization output, “4.2 Sweep (■Sweep value and Z-MARKER/SYNC/X-DRIVE output)”, cf.

• **Sweep type set to duty**
  - Output waveform fixed to squarewave (variable duty) and waveform (Function) cannot be selected.
  - During a sweep, multiple pulses may be output in one cycle, as shown below.
4.2 Sweep

• During sweep, if the oscillation mode of the other channel is changed, sweep stops.

• **To generate the trigger signal via remote control (GPIB or USB)**, set the GET command or TRG command from the remote control interface.
  For details of the remote control command, “Remote Control Instruction Manual”, cf.

• **To simultaneously operate sweep (start, stop, pause, restart) for both channels manually or via remote control (GPIB or USB)**, set both channels to sweep mode and set OPER-COMMON to on.
  If the BOTH lamp is on, behavior is the same even though OPER-COMMON is off.

<table>
<thead>
<tr>
<th>OFF</th>
<th>ON</th>
</tr>
</thead>
<tbody>
<tr>
<td>F－SWP</td>
<td>OPER－COMMON</td>
</tr>
</tbody>
</table>
4.2 Sweep

Sweep (Mode: Continuous) (MODE → SWEEP → MODE : CONT)

In a Sweep (Mode: Continuous), oscillation occurs by varying parameters such as the amplitude and amplitude continuously between the start and stop settings. Operation to produce waveform output with frequency varying linearly and continuously is described. The waveform shown below is a sinewave with an arbitrarily defined amplitude and DC offset.

Start amplitude: 1Vp-p

Stop amplitude: 2Vp-p

Operation:

1) Set sweep MODE to continuous (CONT)

① Press the MODE key, then the SWEEP key.
② Use the < and > keys to produce the following display (MODE flashes).

SINGLE CONT GATED
F-SWP : TYPE SOURCE MODE

③ Press the ENTER key, then use the < and > keys to produce the following display (CONT flashes).

SINGLE CONT GATED
F-SWP : TYPE MODE FUNCTION START

④ This completes setting the sweep mode to continuous. Press the EXIT key once to release the setting mode.
(2) Set sweep TYPE to amplitude (AMPTD)

① Use the ⬅️ and ➔ keys to produce the following display (TYPE flashes).

![Display with TYPE flashing]

② Press the ENTER key, then use the ⬅️ and ➔ keys to produce the following display (AMPTD flashes).

![Display with AMPTD flashing]

③ This completes setting the sweep type to amplitude. Press the EXIT key once to release the setting mode.

(3) Select the sweep FUNCTION

① Use the ⬅️ and ➔ keys to produce the following display (FUNCTION flashes).

![Display with FUNCTION flashing]

② Press the ENTER key.

③ Press the ➔ key, then turn the MODIFY dial to select .

④ After selecting, press the EXIT key once to release the function select mode.
(4) Set the START amplitude (START)

① Use the < and > keys to produce the following display (START flashes).

```
AMPTD 0.1000 Vp-p
A-SWP: TYPE MODE FUNCTION START
```

② Press the ENTER key.

③ Set the start amplitude with the key pad or MODIFY dial.
   For example, set to 1Vp-p.

④ After setting, press the EXIT key once to release the start setting mode.

(5) Set the STOP amplitude (STOP)

① Use the < and > keys to produce the following display (STOP flashes).

```
AMPTD 0.1000 Vp-p
A-SWP: STOP TIME CENTER SPAN
```

② Press the ENTER key.

③ Set the stop amplitude with the key pad or MODIFY dial.
   For example, set to 2Vp-p.

④ After setting, press the EXIT key once to release the stop setting mode.
4.2 Sweep

(6) Set the sweep TIME

1. Use the \(<\) and \(>\) keys to produce the following display (TIME flashes).

```
1.000 s
A−SWP : ◀ STOP TIME CENTER SPAN ▶
```

2. Press the \(\text{MODIFY}\) key.

3. Set the sweep time with the key pad or \(\odot\) dial.
For example, set to 2 seconds.

4. After setting, press the \(\text{EXIT}\) key once to release the sweep time setting mode.

(7) Sweep operation

1. Press the \(\text{START}\) key, then sweep starts.

   The output quickly changes to the sweep start amplitude.
   If desiring to set the start amplitude output beforehand, press the \(\text{STOP}\) key.

Other operations:

- **Sweep stop**: Press the \(\text{STOP}\) key. This becomes the sweep start value.
- **Sweep pause**: Press the \(\text{PAUSE}\) key. To resume sweep, again press the \(\text{PAUSE}\) key.
- **External pause**: Apply Low level to the rear panel SWEEP PAUSE IN connector. To resume
  sweep, apply a High level or open input.
- **FUNCTION**: The function determines the sweep type. For example, \(\text{LIN}\) provides step-type
  change of output (e.g., frequency) at the sweep time halfway point. LIN/LOG provides
  linear or logarithmic variation of the output with respect to the time axis.

```
• \(\text{LIN}\)
• \(\text{LOG}\)
• \(\text{LIN}\)
• \(\text{LOG}\)
• \(\text{SIN (}\odot\text{) LIN}\)
• \(\text{SIN (}\odot\text{) LOG}\)
```
• **START-STATE and STOP-STATE:** Set output to start and stop values, respectively. Since sweep synchronization output becomes the respective start and stop states, full-scale adjustments of the recorder and the status of external equipment can be checked. START-STATE is the same as pressing the **STOP** key (during a continuous sweep).

Relationship between sweep values and sweep synchronization output, "4.2 Sweep (Sweep value and Z-MARKER/SYNC/X-DRIVE output)", cf.

• **Sweep type set to duty**

  : Output waveform fixed to squarewave (variable duty) and waveform (Function) cannot be selected.

  During a sweep, multiple pulses may be output in one cycle, as shown below.

  ![Waveform diagram](image)

  • During sweep, if the oscillation mode of the other channel is changed, sweep stops.

  • **To start, stop, pause, or restart a sweep operation on both channels simultaneously by manual operation or via remote control (GPIB or USB),** set both channels to sweep mode and set OPER-COMMON to on.

    If the BOTH lamp is on, behavior is the same even though OPER-COMMON is off.
4.2 Sweep

**Sweep (Mode: Gated) (MODE : GATED)**

In a Sweep (Mode: Gated), oscillation occurs by varying parameters such as the frequency and amplitude one time between the start and stop settings. Oscillation stops before the sweep starts and when the sweep is completed.

Operation to produce a waveform output with frequency that varies in step form and oscillation stops is described.

The setting example is a sinewave with arbitrary amplitude and DC offset 0.

![Image of Sweep (Mode: Gated) parameters]

**Operation:**

1. Set sweep **MODE** to **GATED**

   ① Press the **MODE** key, then the **SWEEP** key.

   ② Use the **<** and **>** keys to produce the following display (MODE flashes).

   ![Display](image1)

   ③ Press the **ENTER** key, then use the **<** and **>** keys to produce the following display (GATED flashes).

   ![Display](image2)

   ④ This completes setting the sweep mode to gated. Press the **EXIT** key once to release the setting mode.
(2) Set sweep TYPE to FREQ

① Use the << and >> keys to produce the following display (TYPE flashes).

```
FREQ AMPTD OFFSET
F-SWP : TYPE SOURCE MODE
```

② Press the ENTER key, then use the << and >> keys to produce the following display (FREQ flashes).

```
FREQ AMPTD OFFSET
F-SWP : TYPE SOURCE MODE
```

③ This completes setting the sweep type to frequency. Press the EXIT key once to release the setting mode.

(3) Select the sweep FUNCTION

① Use the << and >> keys to produce the following display (FUNCTION flashes).

```
LIN
F-SWP : FUNCTION START STOP
```

② Press the ENTER key.

③ Press the >> key, then select with the MODIFY dial

④ After selecting, press the EXIT key once to release the function select mode.
4.2 Sweep

(4) Set the START frequency

① Use the 和 keys to produce the following display (START flashes).

![Display](image)

② Press the key.

③ Set the frequency with the keypad or dial.
   For example, set to 100 Hz.

④ After setting, press the key once to release the start frequency setting mode.

(5) Set the STOP frequency

① Use the 和 keys to produce the following display (STOP flashes).

![Display](image)

② Press the key.

③ Set the frequency with the keypad or dial.
   For example, set to 200 Hz.

④ After setting, press the key once to release the stop frequency setting mode.
(6) Set the sweep TIME

① Use the < and > keys to produce the following display (TIME flashes).

```
F−SWP : ⬅️ TIME STOP−LEVEL CENTER ➡️
```

② Press the ENTER key.

③ Set the sweep time with the keypad or MODIFY dial.

For example, set to 3 seconds.

④ After setting, press the EXIT key once to release the sweep time setting mode.

(7) Set the STOP-LEVEL

① Use the < and > keys to produce the following display (STOP-LEVEL flashes).

```
OFF
F−SWP : ⬅️ TIME STOP−LEVEL CENTER ➡️
```

② Press the ENTER key.

③ Turn the MODIFY dial to produce the following display (ON flashes).

```
ON             0.00 %
F−SWP : ⬅️ TIME STOP−LEVEL CENTER ➡️
```

④ Press the ➡️ key, then set the stop level with the keypad or MODIFY dial. For example, set to 50 %.

The stop level is a percentage with respect to the maximum positive and negative amplitudes taken respectively as +100 % and -100 %.

⑤ After setting, press the EXIT key to exit stop level setting.
4.2 Sweep

(8) Start sweep

① Press the START key.

In this example, sweep ends after 3 seconds and oscillation stops. Again press the START key to sweep from the stop to the start frequency.
Other operations:

- **Sweep stop**: Press the STOP key. Oscillation stops. When sweep is stopped at gated sweep end or during sweep, press the STOP key to set the start value. (Oscillation stops)
- **Sweep pause**: Press the PAUSE key. To resume sweep, again press the PAUSE key.
- **Gated sweep operation examples**

- **External start**: Change the sweep trigger source to EXT and select rising or falling. Supply an external signal to the front panel TRIG/SWEEP IN connector. Observe that retrigger is not accepted for 100 ms after sweep start.

- **External pause**: Apply Low level to the rear panel SWEEP PAUSE IN connector. To resume sweep, apply a High level or open input.

- **FUNCTION**: The function determines the sweep type. For example, provides step-type change of output (e.g., frequency) at the sweep time halfway point. LIN/LOG provides linear or logarithmic variation of the output with respect to the time axis.

  - LIN
  - LOG
  - LIN
  - LOG
  - SIN (LIN)
  - LOG
• **Internal trigger source**

  The internal trigger signal is produced at the rate indicated below. Even if set to less than 100 ms, the trigger is applied only at 100 ms intervals. The trigger rate is common for CH1 and CH2.

  ![Trigger rate](image)

  ![INT 100.0ms F-SWP: TYPE SOURCE MODE](image)

• **START-STATE and STOP-STATE** : Set output to start and stop values, respectively.

  Both START-STATE and STOP-STATE oscillation can be conducted together with a gated sweep. Since sweep synchronization output becomes the respective start and stop states, full-scale adjustment of the recorder and the status of external equipment can be checked.

  !["4.2 Sweep (Sweep value and Z-MARKER/SYNC/X-DRIVE output)", cf.](image)

• **Sweep type set to duty** : Output waveform fixed to squarewave (variable duty) and waveform (Function) cannot be selected.

  During a sweep, multiple pulses may be output in one cycle, as shown below.

  ![Waveform](image)

• If the frequency is low and the sweep rest period short, in some cases, oscillation may not stop immediately at the end of sweep.

• During sweep, if the oscillation mode of the other channel is changed, sweep stops.

• **TO start, stop, pause, or restart a sweep operation on both channels simultaneously by manual operation or via remote control (GPIB or USB)**, set both channels to sweep mode and set OPER-COMMON to on.

  ![OFF ON OPER-COMMON](image)
4.2 Sweep

**CENTER, SPAN, MARKER, MKR → CTR**

- **Center** is the sweep center value, while **span** is the range setting. The relationship among center, span, start and stop is as follows.

Values cannot be entered for CENTER and SPAN, however, if the sweep type is set from a user unit that has the log function.

- When start is changed:
  Stop does not change.
  \[\text{CENTER} = (\text{START} + \text{STOP}) ÷ 2\]
  \[\text{SPAN} = |\text{START} - \text{STOP}|\]

- When stop is changed:
  Start does not change.
  \[\text{CENTER} = (\text{START} + \text{STOP}) ÷ 2\]
  \[\text{SPAN} = |\text{START} - \text{STOP}|\]

- When center is changed:
  Span does not change.
  \[\text{START} = \text{CENTER} −/+ (\text{SPAN} ÷ 2)\]
  \[\text{STOP} = \text{CENTER} +/− (\text{SPAN} ÷ 2)\]

- When span is changed:
  Center does not change.
  \[\text{START} = \text{CENTER} −/+ (\text{SPAN} ÷ 2)\]
  \[\text{STOP} = \text{CENTER} +/− (\text{SPAN} ÷ 2)\]

- A value that changes the SWEEP Z-MARKER OUT signal is set for MARKER.

- **MKR→CTR** copies the marker value to the center value.

- When an amplitude sweep is set with 0 as the start or stop values and the sweep function is set with LOG / LOG / LOG, "SETTING CONFLICT 001" is displayed continuously during a short trigger cycle and the menu may not be displayed. In such cases, switch the trigger source, or stop input to the SWEEP PAUSE IN connector.
4.2 Sweep

## Summary of the sweep setting items

- The following summarizes the items that need to be set during a sweep operation (in the SWEEP menu).

<table>
<thead>
<tr>
<th>Type (sweep target)</th>
<th>[FREQ, AMPTD, OFFSET, PHASE, DUTY]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Source (trigger source)</td>
<td>CH1: [EXT, EXT, INT [s], INT [s]]</td>
</tr>
<tr>
<td></td>
<td>CH2: [EXT CH2, EXT CH2, EXT CH1, INT [s], INT [s]]</td>
</tr>
<tr>
<td>* Set when the sweep mode is SINGLE or GATED</td>
<td></td>
</tr>
<tr>
<td>Mode (sweep mode)</td>
<td>[SINGLE, CONT, GATED]</td>
</tr>
<tr>
<td>Function (sweep waveform)</td>
<td>[LIN /, LOG /, LIN SIN, LOG SIN, LIN /, LOG \]</td>
</tr>
<tr>
<td>Start (sweep start value)/Stop (sweep stop value)</td>
<td>or Sweep range setting</td>
</tr>
<tr>
<td>Center (sweep center value)/Span (sweep width)</td>
<td></td>
</tr>
<tr>
<td>Time (sweep time) [s]</td>
<td></td>
</tr>
<tr>
<td>Stop-Level</td>
<td>Set when the sweep mode is GATED</td>
</tr>
<tr>
<td>Phase (phase when oscillation starts) * ENTRY menu</td>
<td></td>
</tr>
<tr>
<td>Marker (Marker value)</td>
<td></td>
</tr>
<tr>
<td>MKR→CTR (Copying of the marker value to the center value)</td>
<td></td>
</tr>
<tr>
<td>Oper-Common (simultaneous sweep operation of both channels) [OFF, ON]</td>
<td></td>
</tr>
</tbody>
</table>

- Sweep operations

- Main operation
  - Start (sweep start)
  - Stop (sweep end/sweep start state)
    * For subsequent operation when the sweep has been completed, the state is reset to the sweep start state.
  - Pause (sweep pause/restart)

- In the SWEEP menu
  - Start-State (sweep start state)
  - Stop-State (sweep stop state)
Sweep (Modulation) steps and step width

Sweep and modulation outputs are changed by software. Methods for estimating sweep, modulation step number (number of output changes between start and stop values) and step width (variation width per change) are indicated below.

Sweep is described here. For modulation, replace sweep function with modulation waveform, sweep type with modulation type, and sweep time with modulation period, respectively.

The modulation period is determined as follows.

When the waveform is SIN, 逆, \[ \text{Modulation period} = 1 \div (\text{Modulation frequency} \times 2) \]
When the waveform is 逆, 逆: Modulation period = 1 \div \text{Modulation frequency}

**Step number derivation** (when oscillation mode of only one channel is sweep or modulation. Other times, see next page.)

(1) Sweep function is step ( 逆):

Step number = Sweep time [s] \times 10000 (raise up, even number *1)

(2) Sweep function is other than step and sweep type is frequency:

① Sweep time is 25 ms and below:

Step number = Sweep time [s] \times 10000

② Sweep time is more than 25 to 31.25 ms and below:

Step number = 250 (fixed)

③ Sweep time is more than 31.25 ms:

Step number = Sweep time [s] \times 8000

(3) Sweep function is other than step and sweep type is other than frequency:

① Sweep time is 50 ms and below:

Step number = Sweep time [s] \times 10000

② Sweep time is more than 50 to 62.5 ms and below:

Step number = 250 (fixed)

③ Sweep time is more than 62.5 ms:

Step number = Sweep time [s] \times 8000

*1: If raising up results in odd number, -1.
• Step number derivation (when oscillation mode of both channels is sweep or modulation. Other times, see previous page.)

First, determine the reference and secondary channels. The reference channel is that with the shorter sweep time or modulation period and is defined by the following method. The reverse is used for the secondary channel. The modulation period is determined by the following formulae.

When the modulation waveform is $\sin$, $\wedge$ or $\sqrt{2}$,
the modulation period = $1 \div (\text{modulation frequency} \times 2)$

When the modulation waveform is $\wedge$ or $\sqrt{2}$,
the modulation period = $1 \div \text{modulation frequency}$

a. Reference channel step number

(1) Sweep type is frequency

① Sweep time: 25 ms and less
   Step no. = sweep time (s) × 5000 (round down, even number if more than 1.6 ms *2)

② Sweep time: more than 25 ms, but 31.25 ms and less
   Step no. = 124 (fixed)

③ Sweep time: more than 31.25 ms
   Step no. = sweep time (s) × 4000

(2) Sweep type other than frequency

① Sweep time: 50 ms and less
   Step no. = sweep time (s) × 5000 (round down, even number if more than 1.6 ms *2)

② Sweep time: more than 50 ms, but 62.5 ms and less
   Step no. = 250 (fixed)

③ Sweep time: more than 62.5 ms
   Step no. = sweep time (s) × 4000

(3) Sweep type modulation

① Modulation period: 25 ms and less
   Step no. = sweep time (s) × 5000
   (rounded off, if modulation waveform is $\wedge$ or $\sqrt{2}$, even number *2, also integer multiple of 4.
   If other modulation waveform, even number if more than 1.6 ms *2.)

② Modulation period: more than 25 ms, but 31.25 ms and less
   Step no. = 124 (fixed)

③ Modulation period: more than 31.25 ms
   Step no. = sweep time (s) × 4000
   (rounded off, if modulation waveform is step, even number)

*2: If rounded up/off results are odd, -1.
(4) Modulation type other than frequency

① Modulation period: 50 ms and less
   Step no. = sweep time (s) \times 5000
   (rounded off, if modulation waveform is \( \uparrow \) or \( \downarrow \), even number *2, also integer multiple of 4 if more than 3.2 ms. If other modulation waveform, even number if more than 1.6 ms *2)

② Modulation period: more than 50 ms, but 62.5 ms and less
   Step no. = 250 (fixed)
   (248 if the modulated waveform is \( \uparrow \) or \( \downarrow \))

③ Modulation period: more than 62.5 ms
   Step no. = modulation period (s) \times 4000
   (rounded off, if modulation waveform is step, even number)

(5) Exceptions

① If the sweep type is changed after setting the sweep time, the step number remains the same.
   For example, if the sweep type is changed from frequency to amplitude, the step number remains as in item (1).

② If the modulation type is changed after the modulation frequency is set, the step number remains the same. For example, if the modulation type is changed from frequency to amplitude, the step number remains the same as in (3).

b. Secondary channel step number

Step no. = reference channel step no. \times secondary channel sweep time (modulation period) \div reference channel sweep time (modulation period)
(If function is step, round up to even number *2, if other function, round off.)

*2: If rounded up/off results are odd, -1.

• Deriving step width

During linear sweep, step width = \frac{\text{Span}}{\text{Step number} - 1}

During logarithmic sweep, step width = \log_{10}^{-1} \left[ \log_{10} \frac{\text{Stop}}{\text{Start}} + (\text{Step number} - 1) \right]

Step width during log sweep changes with step progression.
The step width during a log sweep changes according to the sweep progression.
Output of MARKER OUT is synchronized with sweep steps. Therefore, the range of difference in value between marker value settings and the actual value of MARKER OUT is ± step width.
### Sweep value and Z-MARKER/SYNC/X-DRIVE outputs

<table>
<thead>
<tr>
<th>Sweep function</th>
<th>Single, gated sweep</th>
<th>Continuous sweep</th>
</tr>
</thead>
<tbody>
<tr>
<td>Start value</td>
<td>Start value</td>
<td>Start value</td>
</tr>
<tr>
<td>&lt; stop value</td>
<td>&gt; stop value</td>
<td>&lt; stop value</td>
</tr>
</tbody>
</table>

#### High Marker

- **Sweep value**:
  - High
  - Low
- **Marker output**:
  - High
  - Low
- **Sync output**:
  - High
  - Low
- **X-drive output**: 0V, 5V

- **Sweep time**:
  - Single, gated sweep: Approximately 200 to 250 µs
  - Continuous sweep: Approximately 100 to 125 µs

- **Approximately 200 to 250 µs when the oscillation mode of both CH1 and CH2 is sweep or modulation, approx. 100 to 125 µs at other times.**
<table>
<thead>
<tr>
<th>Sweep function</th>
<th>Single, gated sweep</th>
<th>Continuous sweep</th>
</tr>
</thead>
<tbody>
<tr>
<td>Start value</td>
<td>Start value</td>
<td>Start value</td>
</tr>
<tr>
<td>&lt; stop value</td>
<td>&gt; stop value</td>
<td>&lt; stop value</td>
</tr>
<tr>
<td>* is sweep start timing, # is sweep end state.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sweep value</th>
</tr>
</thead>
<tbody>
<tr>
<td>High Marker</td>
</tr>
<tr>
<td>Low</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>5V</th>
</tr>
</thead>
<tbody>
<tr>
<td>0V</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sync output</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
</tr>
<tr>
<td>Low</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>X-drive output</th>
</tr>
</thead>
<tbody>
<tr>
<td>5V</td>
</tr>
<tr>
<td>0V</td>
</tr>
</tbody>
</table>

Sweep time
### 4.3 Modulation

**Frequency modulation (FM)** (MODE → MODU → TYPE : FM)

Operation to produce a frequency modulated waveform output is described. The example is a sinewave, 1 kHz, amplitude and DC offset arbitrary.

- **Operation:**
  - **(1) Set modulation TYPE to frequency (FM)**
    1. Press the [MODE] key, then the [MODU] key.
    2. Use the [<] and [>] keys to produce the following display (TYPE flashes).
      
      ![Diagram](image)

      Frequency is 1 kHz varying ± 250 Hz
      Deviation period is 20 ms (50 Hz)

      **FM AM OFSM PM PWM**
      **FM : TYPE** DEVIATION FREQ FUNCTION

    3. Press the [ENTER] key, then use the [<] and [>] keys to produce the following display (FM flashes).
      
      ![Diagram](image)

      **FM AM OFSM PM PWM**
      **FM : TYPE** DEVIATION FREQ FUNCTION

    1. This sets the modulation type for frequency. Press the [EXIT] key once to release the type setting mode.
(2) Set the frequency DEVIATION

① Use the < and > keys to produce the following display (DEVIATION flashes).

![1000.00000000 Hz](image)

② Press the ENTER key.

③ Set the deviation with the keypad or MODIFY dial.

For example, set to 500 Hz.

④ After setting, press the key once to exit frequency deviation setting.

(3) Set the modulation FREQ

① Use the < and > keys to produce the following display (FREQ flashes).

![100.00 Hz](image)

② Press the ENTER key.

③ Set the frequency with the keypad or MODIFY dial.

For example, set to 50 Hz (20 ms).

④ After setting, press the key once to release the modulation setting mode.

(4) Select the modulation waveform (FUNCTION)

① Use the < and > keys to produce the following display (FUNCTION flashes).

![SIN](image)
4.3 Modulation

② Press the ENTER key, then use the < and > keys to produce the following display (SIN flashes).

![SIN FM: TYPE DEVIATION FREQ FUNCTION]

③ After making a selection, press the EXIT key to exit function setting.

The above completes frequency modulation setting.

Other operations:

- When the oscillation mode is changed to modulation (MODU), modulation occurs at the setting at that time point.
  
  To stop modulation: Press the STOP key. Resume modulation by pressing the START key.

- During modulation, if the oscillation mode of the other channel is changed, modulation stops.

- To start or stop modulation of both channels simultaneously on a manual operation or via remote control (GPIOB or USB), set both channels to modulation mode and set OPER-COMMON to on.
  
  If the BOTH lamp is on, behavior is the same even though OPER-COMMON is off.

![OFF ON FM: FUNCTION OPER-COMMON]

- Setting items at frequency modulation (MODU menu)
  
  TYPE: FM
  
  DEVIATION (frequency deviation) [Hz]
  
  FREQ (modulation frequency) [Hz]
  
  FUNCTION (modulation waveform) [SIN, , , , ]
  
  OPER-COMMON (operation in both channels) [OFF, ON]
4.3 Modulation

Amplitude modulation (AM) (MODE → MODU → TYPE : AM)

Operation to produce an AM waveform output is described below.
The example is a sinewave, 1800 Hz, amplitude 1.5 Vp-p and DC offset 0 V.

Operation:
(1) Set modulation TYPE to amplitude (AM)

① Press the MODE key, then the MODU key.
② Use the and keys to produce the following display (TYPE flashes).

<table>
<thead>
<tr>
<th>FM</th>
<th>AM</th>
<th>OFSM</th>
<th>PM</th>
<th>PWM</th>
</tr>
</thead>
<tbody>
<tr>
<td>FM : TYPE</td>
<td>DEVIATION</td>
<td>FREQ</td>
<td>FUNCTION</td>
<td></td>
</tr>
</tbody>
</table>

③ Press the ENTER key, then use the and keys to produce the following display (AM flashes).

<table>
<thead>
<tr>
<th>FM</th>
<th>AM</th>
<th>OFSM</th>
<th>PM</th>
<th>PWM</th>
</tr>
</thead>
<tbody>
<tr>
<td>AM : TYPE</td>
<td>DEPTH</td>
<td>FREQ</td>
<td>FUNCTION</td>
<td></td>
</tr>
</tbody>
</table>

④ This sets the modulation type for amplitude. Press the EXIT key once to release the type setting mode.
4.3 Modulation

(2) Set the modulation DEPTH (width of amplitude variance)

① Use the < and > keys to produce the following display (DEPTH flashes).

\[
\text{AM: TYPE DEPTH FREQ FUNCTION}
\]

| 50.0 % |

② Press the \( \text{ENTER} \) key.

③ Use the keypad or \( \text{MODIFY} \) dial to set the modulation depth.

For example, set to 33 %.

④ Press the \( \text{EXIT} \) key once to release the modulation depth setting mode.

(3) Set the modulation FREQ (frequency with varying amplitude)

① Use the < and > keys to produce the following display (FREQ flashes).

\[
\text{AM: TYPE DEPTH FREQ FUNCTION}
\]

| 100.00 Hz |

② Press the \( \text{ENTER} \) key.

③ Use the keypad or \( \text{MODIFY} \) dial to set the modulation frequency.

For example, set to 200 Hz (5ms).

④ After setting, press the \( \text{EXIT} \) key once to release the modulation setting mode.
4.3 Modulation

(4) Select modulation waveform (FUNCTION)

① Use the ◀ and ▶ keys to produce the following display (FUNCTION flashes).

```
S I N
AM: TYPE DEPTH FREQ FUNCTION
```

② Press the ENTER key, then use the ◀ and ▶ keys to produce the following display (SIN flashes).

```
S I N
AM: TYPE DEPTH FREQ FUNCTION
```

③ After selecting, press the EXIT key to release the setting mode.

The above completes amplitude modulation setting.

Other operations:

• When the oscillation mode is changed to modulation (MODU), modulation occurs at the setting at that time point.

• To stop modulation: Press the STOP key. Resume modulation by pressing the START key.

• Amplitude setting vs. maximum or minimum amplitudes

  : Max. amplitude = Amplitude setting ÷ 2 \( (1 + \text{(depth [%]} ÷ 100)) \)
  
  Min. amplitude = Amplitude setting ÷ 2 \( (1 - \text{(depth [%]} ÷ 100)) \)

• At 0 % depth, the output amplitude is 1/2 the setting. At 100 % depth, the output amplitude is the same as the setting.

• During modulation, if the oscillation mode of the other channel is changed, modulation stops.

• To start or stop a modulation operation on both channels simultaneously by manual operation or via remote control (GPIB or USB), set both channels to modulation mode and set OPER-COMMON to on.
4.3 Modulation

- Setting items at frequency modulation (MODU menu)
  - **TYPE:** AM
  - **DEPTH** (modulation depth) [%]
  - **FREQ** (modulation frequency) [Hz]
  - **FUNCTION** (modulation waveform) [SIN, ▼, ▲, ◁, ▶]
  - **OPER-COMMON** (operation in both channels) [OFF, ON]
4.3 Modulation

**DC offset modulation (OFSM) (MODE → MODU → TYPE : OFSM)**

Operation to produce a DC offset modulated waveform output is described below. The example refers to a sinewave, 2 kHz, amplitude 1 Vp-p and DC offset 0 V.

![Diagram of DC offset modulation](image)

**Operation:**

1. Set modulation TYPE to DC offset (OFSM)

   ① Press the MODE key, then the MODU key.

   ② Use the ← and → keys to produce the following display (TYPE flashes).

   ![Display with OFSM highlighted](image)

   ③ Press the ENTER key, then use the ← and → keys to produce the following display (OFSM flashes).

   ![Display with OFSM highlighted](image)

   ① This sets the modulation type for DC offset. Press the EXIT key once to release the type setting mode.
4.3 Modulation

(2) Set the DC offset DEVIATION

① Use the < and > keys to produce the following display (DEVIATION flashes).

![Display: +0.2000 V]

OFSM: TYPE DEVIATION FREQ

② Press the ENTER key.

③ Set the deviation with the keypad or MODIFY dial.

For example, set to 0.3 V.

④ After setting, press the EXIT key once to exit DC offset deviation setting.

(3) Set the modulation FREQ

① Use the < and > keys to produce the following display (FREQ flashes).

![Display: 100.00 Hz]

OFSM: TYPE DEVIATION FREQ

② Press the ENTER key.

③ Set the frequency with the keypad or MODIFY dial.

For example, set to 250 Hz (4 ms).

④ After setting, press the EXIT key once to release the modulation frequency setting mode.
4.3 Modulation

(4) Select modulation waveform (FUNCTION)

① Use the ← and → keys to produce the following display (FUNCTION flashes).

```
S I N
O F S M : ← FUNCTION
```

② Press the ENTER key, then use the ← and → keys to produce the following display (SIN flashes).

```
S I N
O F S M : ← FUNCTION
```

③ After selecting, press the EXIT key to release the setting mode.

The above completes DC offset modulation setting.

Other operations:

• **Amplitude setting vs. maximum amplitudes**
  
  : Max. amplitude = Amplitude setting + DC offset deviation

• When the oscillation mode is changed to modulation (MODU), modulation occurs at the setting at that time point.

• **To stop modulation**
  
  : Press the STOP key. Resume modulation by pressing the START key.

• During modulation, if the oscillation mode of the other channel is changed, modulation stops.

• **To start or stop a modulation operation on both channels simultaneously by manual operation or via remote control (GPIB or USB),** set both channels to modulation mode and set OPER-COMMON to on.

```
O F F   O N
O F S M : ← FUNCTION OPER-COMMON
```
4.3 Modulation

- Setting items in DC offset modulation (MODU menu)
  
  TYPE: OFSM
  
  DEVIATION (DC offset deviation) [%]
  
  FREQ (modulation frequency) [Hz]
  
  FUNCTION (modulation waveform) [SIN, \(\sim\), \(\prod\), \(\Uparrow\), \(\Downarrow\)]
  
  OPER-COMMON (operation in both channels) [OFF, ON]
Phase modulation (PM) (MODE ➔ MODU ➔ TYPE : PM)

Operation to produce a phase modulated waveform output is described below. In this example, the waveform is triangular, the 1 kHz, DC offset is set to 0 V, the oscillation start phase is set to 0 degrees, and the frequency and amplitude are set to arbitrarily defined values.

Operation:
(1) Set modulation TYPE to phase (PM)

① Press the MODE key, then the MODU key.
② Use the ← and → keys to produce the following display (TYPE flashes).

FM AM OFSM PM PWM
FM : TYPE DEVIATION FREQ FUNCTION

③ Press the ENTER key, then use the ← and → keys to produce the following display (PM flashes).

FM AM OFSM PM PWM
PM : TYPE DEVIATION FREQ FUNCTION

④ This sets the modulation type for phase. Press the EXIT key once to release the type setting mode.
4.3 Modulation

(2) Set the phase DEVIATION

① Use the `[←]` and `[→]` keys to produce the following display (DEVIATION flashes).

```
PM: TYPE DEVIATION FREQ FUNCTION
```

90.000 deg

② Press the `[ENTER]` key.

③ Set the deviation with the keypad or MODIFY dial.

For example, set to 45 degrees.

④ After setting, press the `[EXIT]` key once to exit phase deviation setting.

(3) Set the modulation FREQ (frequency with varying phase)

① Use the `[←]` and `[→]` keys to produce the following display (FREQ flashes).

```
PM: TYPE DEVIATION FREQ FUNCTION
```

100.00 Hz

② Press the `[ENTER]` key.

③ Set the frequency with the keypad or MODIFY dial.

For example, set to 200 Hz (5 ms).

④ After setting, press the `[EXIT]` key once to release the modulation frequency setting mode.

(4) Select the modulation waveform (FUNCTION)

① Use the `[←]` and `[→]` keys to produce the following display (FUNCTION flashes).

```
PM: TYPE DEVIATION FREQ FUNCTION
```

SIN
4.3 Modulation

② Press the ENTER key, then use the ◄ and ► keys to produce the following display (_ART flashes).

S I N
PM : TYPE DEVIATION FREQ FUNCTION

③ After selecting, press the EXIT key to release the function setting mode.

The above completes phase modulation setting.

Other operations:

• When the oscillation mode is changed to modulation (MODU), modulation occurs at the setting at that time point.

  **To stop modulation:** Press the STOP key. Resume modulation by pressing the START key.

• During modulation, if the oscillation mode of the other channel is changed, modulation stops.

• To start or stop modulation of both channels simultaneously on a manual operation or via remote control (GPIB or USB), set both channels to sweep mode and set OPER-COMMON to on.

OFF ON
PM : FUNCTION OPER-COMMON

• Setting items at phase modulation (MODU menu)
  TYPE: PM
  DEVIATION (phase deviation) [deg]
  FREQ (modulation frequency) [Hz]
  FUNCTION (modulation waveform) [SIN, ART, R, F, ]
  OPER-COMMON (operation in both channels) [OFF, ON]
4.3 Modulation

Pulse width modulation (PWM) (MODE → MODU → TYPE : PWM)

Operation to produce a pulse width modulated waveform output is described below. The example is a squarewave (duty variable), duty 50 %, frequency 800 Hz, amplitude and DC offset arbitrary.

Operation:
(1) Set modulation TYPE to pulse width (PWM)

① Press the MODE key, then the MODU key.
② Use the < and > keys to produce the following display (TYPE flashes).

```
FM  AM  OFSM  PM  PWM
FM : TYPE  DEVIATION  FREQ  FUNCTION
```

③ Press the ENTER key, then use the < and > keys to produce the following display (PWM flashes).

```
FM  AM  OFSM  PM  PWM
PWM : TYPE  DEVIATION  FREQ  FUNCTION
```

① This sets the modulation type for pulse width. Press the EXIT key once to release the type setting mode.

The waveform is automatically set to squarewave (variable duty) during PWM. The waveform (FUNCTION) cannot be selected.
4.3 Modulation

(2) Set the pulse width DEVIATION (amount of pulse-width variance)

① Use the < and > keys to produce the following display (DEVIATION flashes).

```
PWM : TYPE DEVIATION FREQ FUNCTION
```

```
20.0000 %
```

② Press the ENTER key.
Set the deviation with the keypad or MODIFY dial. For example, set to 80%.

③ After setting, press the EXIT key once to exit pulse width deviation setting.

(3) Set the modulation FREQ (frequency with varying pulse-width)

① Use the < and > keys to produce the following display (FREQ flashes).

```
PWM : TYPE DEVIATION FREQ FUNCTION
```

```
100.00 Hz
```

② Press the ENTER key.
Set the frequency with the keypad or MODIFY dial.
For example, set to 50 Hz (20 ms).

③ After setting, press the EXIT key once to release the modulation frequency setting mode.
4.3 Modulation

(4) Select modulation waveform (FUNCTION)

① Use the < and > keys to produce the following display (FUNCTION flashes).

\[
\begin{array}{c}
\text{SIN} \\
\text{PWM: TYPE DEVIATION FREQ FUNCTION}
\end{array}
\]

② Press the ENTER key, then use the < and > keys to produce the following display (SIN flashes).

\[
\begin{array}{c}
\text{SIN} \\
\text{PWM: TYPE DEVIATION FREQ FUNCTION}
\end{array}
\]

③ After selecting, press the EXIT key to release the setting mode.

The above completes pulse width modulation setting.

Other operations:

• When the oscillation mode is changed to modulation (MODU), modulation occurs at the setting at that time point.

• To stop modulation: Press the STOP key. Resume modulation by pressing the START key.

• Duty setting vs. maximum or minimum duties
  Max. duty = Duty setting + (pulse width deviation[\%] ÷ 2)
  Min. duty = Duty setting − (pulse width deviation[\%] ÷ 2)

• During modulation, multiple pulses may be output in one cycle, as shown below.

\[
\begin{array}{c}
\text{PWM: FUNCTION OPER-COMMON}
\end{array}
\]

• During modulation, if the oscillation mode of the other channel is changed, modulation stops.

• To start or stop modulation of both channels simultaneously on a manual operation or via remote control (GPIB or USB), set both channels to modulation mode and set OPER-COMMON to on.
• Setting items at pulse width modulation (MODU menu)
  TYPE: PWM
  DEVIATION (pulse width deviation) [%]
  FREQ (modulation frequency) [Hz]
  FUNCTION (modulation waveform) [SIN, ∨, \(\forall\), \(\Lambda\), \(\triangleleft\)]
  OPER-COMMON (operation in both channels) [OFF, ON]
4.4 Arbitrary Waveform

- **Arbitrary waveform (ARB) (FUNCTION → ARB)**

Operation using arbitrary waveform (ARB) to produce a sinewave with clipped peak output is described.

**Operation:**

1. **Set waveform to arbitrary (ARB)**
   - Press the **FUNCTION** key, then the **ARB** key.

2. **Select an arbitrary waveform to be edited/output (SELECT).**
   - Press the **ARB EDIT** key, then use the **<** and **>** keys to produce the following display (SELECT flashes).

   ![Waveform data: +23170](image1)

   ![Waveform data: 0](image2)

   ![Waveform data: -23170](image3)

   - Press the **ENTRY** key, then use the **<** and **>** keys to produce the following display (1:ARB_01 flashes).

   ![Waveform address: 0](image4)

   ![Waveform address: 1024](image5)

   ![Waveform address: 3072](image6)

   ![Waveform address: 5120](image7)

   ![Waveform address: 7168](image8)

   ![Waveform address: 8191](image9)

   - Press the **EXIT** key one time to release the arbitrary waveform selection mode.

   ![Waveform address: 0](image10)

   ![Waveform address: 1024](image11)

   ![Waveform address: 3072](image12)

   ![Waveform address: 5120](image13)

   ![Waveform address: 7168](image14)

   ![Waveform address: 8191](image15)
(3) Copy the waveform, for example, sinewave

① Press the \text{ARB EDIT} key, then use the \text{<} and \text{>} keys to produce the following display (COPY flashes).

\[
\begin{array}{c}
\text{S I N} \\
\text{ARB : SELECT NAME EDIT COPY}
\end{array}
\]

② Press \text{ENTER} key, then use the \text{<} and \text{>} keys to produce the following display (SIN flashes).

\[
\begin{array}{c}
\text{S I N} \\
\text{ARB : SELECT NAME EDIT COPY}
\end{array}
\]

③ Press \text{ENTER} key to copy the sinewave.
(4) Edit the waveform, for example, peak clip

① Use the [4] and [6] keys to produce the following display (EDIT flashes).

```
AD: 0000 DT: +00000
ARB: SELECT NAME EDIT COPY
```

② Press [ENTER] key, then the [AD] key (AD digit flashes).

```
AD: 0000 DT: +00000
ARB: SELECT NAME EDIT COPY
```

③ Set the waveform address (AD) with the keypad or [MODIFY] dial. For example, set to 1024.

④ Press the [m] key to produce the following display (the asterisk (*) is displayed).

```
AD: 1024 DT: +23170 *
ARB: SELECT NAME EDIT COPY
```

* is interpolation type mark and indicates the linear interpolation type address. The mark appears and extinguishes each time the [m] key is pressed.

⑤ Next, use above steps ③ and ④ to set the interpolation mark (*) to waveform address 3072.
⑥ Press the k key for linear interpolation. In this example, the first half of the sinewave is clipped ( \( \cap \) ). The waveform data (DT) change as a result of linear interpolation between the starred addresses.

⑦ Press the EXIT key, then use the < and > keys to produce the following display (MARK-CLEAR flashes).

```
1: ARB_01
ARB: MARK-CLEAR CLEAR SIZE
```

Press the ENTER key twice to clear the interpolation marks from addresses 1024 and 3072.

⑧ In the same manner as above steps ① to ⑥, clip the first half of a sinewave (set interpolation marks at 5120 and 7168).

The above completes arbitrary waveform setting.
Other operations:

- **Arbitrary waveform data input:**  
  \[ \text{ARB EDIT} \rightarrow \text{EDIT select} \rightarrow \text{MODIFY} \rightarrow \text{ENTER} \]  
  Flashes the waveform data (DT) digits. Use the keypad or \[ \text{MODIFY} \] dial to set the data.

Data upper and lower limits are \(+32767\) and \(-32768\), which correspond to the amplitude peak-to-peak settings. For this reason, when the waveform vertical limits are changed by the above type of method, the amplitude setting (Vp-p) and the actual output waveform Vp-p do not coincide. The data set addresses are automatically the linear interpolation addresses (the * mark is displayed).

- **Clear (to 0) waveform data:**  
  \[ \text{ARB EDIT} \rightarrow \text{CLEAR select} \rightarrow \text{ENTER}, \text{press again} \rightarrow \text{ENTER} \]  
  The interpolation marks (*) are also cleared.

- **Apply a name to an arbitrary waveform:**  
  \[ \text{ARB EDIT} \rightarrow \text{NAME select} \rightarrow \text{ENTER}, \text{select characters using} \]  
  \[ \text{MODIFY \dial} \]  
  Shift position with \( \leftarrow \) and \( \rightarrow \), and input.

Up to 8 characters can be input. Following are the usable characters:

\[
\text{abcdefghijklmnopqrstuvwxyz (space)}
\text{ABCDEFGHIJKLMNOPQRSTUVWXYZ0123456789}
\text{!"#$%&\'()\*+.\;-./:;<=>?@[¥]^_`{|}→←}
\]

- **Change the waveform data size:**  
  \[ \text{ARB EDIT} \rightarrow \text{SIZE select} \rightarrow \text{ENTER} \]  
  Use \( \leftarrow \) and \( \rightarrow \) to select the data size

<table>
<thead>
<tr>
<th>Data size</th>
<th>Waveform number</th>
<th>Number of waveforms</th>
</tr>
</thead>
<tbody>
<tr>
<td>8K(8192)</td>
<td>0   1   2   3   4   5   6   7   8   9   10   11   12</td>
<td></td>
</tr>
<tr>
<td>16K(16384)</td>
<td>0   1   2   3   4   5   6</td>
<td></td>
</tr>
<tr>
<td>32K(32768)</td>
<td>0   1   2   3                                3</td>
<td></td>
</tr>
<tr>
<td>64K(65536)</td>
<td>0                                1</td>
<td></td>
</tr>
</tbody>
</table>

The output waveform changes as described below when the waveform data size is changed. If, for example, the waveform data size is changed from 16 KB to 8 KB when there is a waveform like \( \sim \) for waveform number 0, \( \sim \) is assigned to waveform number 0 and \( \sim \) to waveform number 1.

- **Arbitrary waveform data are common for CH1 and CH2.**
4.5 Selecting waveforms of synchronous signals (SYNC OUT)

This section describes the switching of SYNC OUT waveforms.

■ Procedure

① Press the \textbf{SYSTEM} key, then use the \textbf{<} and \textbf{>} keys to produce the following display (The lower SYNC OUT flashes).

\begin{center}
\textbf{STATE} : \textbf{PHASE}
\textbf{SYSTEM} : \textbf{DUTY-VALID SYNCOUT}
\end{center}

② Press the \textbf{ENTER} key, then use the \textbf{<} and \textbf{>} keys to set the SYNC OUT waveform.

③ After setting, press the \textbf{EXIT} key to release the SYNC OUT waveform setting mode.

■ When the oscillation mode is BURST

- \textbf{STATE}: Low level during oscillation. High level while stopped.
- \textbf{PHASE}: For \textbf{\textbackslash n} squarewaves (variable duty), the same waveform as that for FUNCTION OUT. For other cases, high level while between 0 and 180 degrees of the waveform in the oscillation period, and low level while between 180 and 360 degrees.
4.5 Output waveforms for sweeping and modulation

When the oscillation mode is SWEEP

- **STATE**: Low level while sweeping from the start value to the stop value or stopped. Otherwise, high level.
- **PHASE**: For squarewaves (variable duty), the same waveform as that for FUNCTION OUT. Otherwise, high level while between 0 and 180 degrees of the waveform, and low level while between 180 and 360 degrees.

When the oscillation mode is MODU

- **STATE**: Low level while executing modulation and between 180 and 360 degrees of the modulated waves. Otherwise, high level.
- **PHASE**: For squarewaves (variable duty), the same waveform as that for FUNCTION OUT. Otherwise, high level while between 0 and 180 degrees of the modulated waves, and low level while between 180 and 360 degrees.
**Additional information:**

- For \( \sim \) and \( \bar{n} \) (fixed duty) at frequencies over 100 kHz, if SYNC OUT is set to PHASE, the output signal becomes a waveform with the analog signals of a sinewave applied to the comparator. For this reason, the output level (high or low) may be undefined at 0, 180, and 360 degrees (±2 degrees, approximately).

In particular, note that when the oscillation mode is switched during a burst or gated sweep while oscillation is stopped, the output level may vary or the waveform may become glitch-shaped. If a precise output level is required while oscillation is stopped, shift the phase setting. For example, setting the phase at +90 degrees shifts the output level to the high level while oscillation is stopped.

![Diagram showing the undefined output level](image)

The shaded sections represent an undefined output level.
The setup values for sweeping and modulation are updated every 100 to 252 µs. Thus, if the sweep time is short or the modulation frequency is high, the amount of change for updating increases, leading to marked discontinuities.

If the sweep function (modulated waves) is \( \sqcap \), \( \triangleright \), or \( \triangledown \), discontinuities become conspicuous in some of the stepwise variations.

Since the setup values vary enormously in some of the stepwise variations, discontinuities are generated. If such discontinuities are removed, the remaining variations have the appearance shown below.

If, as an extreme example, the oscillation frequency is 1 kHz, the sweep time is 4 ms, the start phase is 180 degrees, the stop phase is -180 degrees, and the sweep function is \( \triangleright \) in the phase sweep, the phase shifts about 26 degrees every 100 µs, producing the following output waveforms. Discontinuities are generated not only by \( \triangledown \), but also by \( \sqcap \), \( \triangleright \), and \( \triangledown \).

Since the phase changes at intervals of 100 to 252 µs, discontinuities are generated.
Since the squarewaves (fixed duty) and squarewaves (variable duty) are generated differently from other waveforms, extra pulses are produced. Similarly, extra pulses are also produced by phase modulation, duty sweep, and PWM.

\[
\text{Extra pulses are produced}
\]

The occurrence frequency when the sweep function is \(\wedge\), \(\wedge\), or \(\wedge\) is roughly given by the following formula:

\[
\text{Occurrence frequency [\%]} = \frac{\text{phase span [deg]}}{360 \times \text{oscillation frequency [Hz] \times sweep time [s]}} \times 100
\]

If, for example, the frequency is 1 kHz, the phase span is 90 degrees, and the sweep time is 100 ms, an extra pulse is generated every 400 cycles on average.
4.7 Equivalent noise bandwidth

The density of noise generated by the WF1946B is as shown in the following figure "(a) Frequency characteristics of noise generated by the WF1946B." The rms values of (a) are equal to those of white noise in the figure "(b) Frequency characteristics of white noise," that follows. This equivalent bandwidth (500 kHz) is called the equivalent noise bandwidth.
Section 5 Other Operations

5.1 Convenient Settings
- Frequency [Hz] setting by period [s]
- Squarewave duty setting
- Squarewave pulse width setting
- Amplitude and DC offset setting by high and low level

5.2 Units
- Engineering unit (µ, m, k, M) display
- Amplitude units change
- User-unit setting

5.3 Setting memory
- Setting store
- Setting recall
- Setting memory clear

5.4 External Input
- External add (EXT-ADD)
- External AM (EXT-AM)

5.5 Other settings
- Output range change (use with fixed range)
- Output on/off at power on
- LOAD function (equalize setting and output values)
- UNDO function
- Pulse generator function
- Phase sync
- Copy settings between channels
- Fixed frequency difference (2TONE)
- Fixed frequency ratio (RATIO)

* Following is a typical example of the display panel indications used in this Section.

```
FREQ PERIOD AMPTD
USER UNIT: TYPE NAME FORMULA
```

- Fully lighted (bold)
- Dimly lighted
- Flashing
5.1 Convenient Settings

- Frequency [Hz] setting by period [s] (ENTRY → PERIOD)

Operation is described for setting the waveform repetition rate not in frequency (Hz) but as period (s).

Operation:

1. Press the ENTRY key, then the PERIOD key to produce the following display.

```
P  0.001000000000000000 s
A 0.1000Vp-p  O+0.0000V  /OPEN
```

2. Set the period with the keypad or MODIFY dial.

Other:

The period setting is frequency with the reciprocal less than 0.01 µHz, the number should be rounded off. Thus, the setting tolerance is large when the frequency setting digits are fewer (period longer). In this situation, even if setting is changed by the keypad or MODIFY dial, the actual oscillation period does not change in some cases.
Squarewave duty setting (ENTRY → DUTY)

Operation to set the squarewave duty is described. The setting changes the width (%) of the pulse with respect to the overall waveform (portion indicated by arrows).

Select squarewave (variable duty).

Operation:

① Press the ENTRY key, then the DUTY key to produce the following display.

```
D U T Y  5 0 . 0 0 0 0 %
1 0 0 0 . 0 0 0 0 0 0 H z  A 0 . 1 0 0 0 V p p / O P E N
```

② Set the duty with the keypad or MODIFY dial.

Other:

- The table indicates the effects on other parameters when the frequency, period, width or duty is changed.

<table>
<thead>
<tr>
<th>Change ↓</th>
<th>Frequency (FREQ)</th>
<th>Period (PERIOD)</th>
<th>Pulse width (WIDTH)</th>
<th>Duty (DUTY)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency (FREQ)</td>
<td>Changed</td>
<td>Changed</td>
<td>Changed</td>
<td>Unchanged</td>
</tr>
<tr>
<td>Period (PERIOD)</td>
<td>Changed</td>
<td>Unchanged</td>
<td>Changed</td>
<td>Changed</td>
</tr>
<tr>
<td>Pulse width (WIDTH)</td>
<td>Unchanged</td>
<td>Unchanged</td>
<td>Changed</td>
<td>Changed</td>
</tr>
<tr>
<td>Duty (DUTY)</td>
<td>Unchanged</td>
<td>Unchanged</td>
<td>Changed</td>
<td></td>
</tr>
</tbody>
</table>

- Due to the oscillation period and duty relationship, the pulse can be lost when the actual pulse width is less than 25 ns. An error message is displayed at this type of setting.
- Also, jitter increases when the pulse width is less than 100 ns. A warning message is displayed at this type of setting.
- The actual waveform duty resolution is [oscillation frequency] ÷ [approx. 40 MHz] (0.00001 % at minimum). When the stop level is on, the minimum actual waveform duty resolution is approximately 0.003 %.
- For other notes, see "Waveform selection" in Section 3.3, "Basic operation."
5.1 Convenient Settings

■ Squarewave pulse width setting (ENTRY → WIDTH)

Operation to set the squarewave pulse width is described. The setting changes the width of the pulse (portion indicated by arrows ↘). Select squarewave (variable duty).

Operation:

1. Press the ENTRY key, then the WIDTH key to produce the following display.

```
W       0. 000500000 s
A0. 1000V p-p 0+0. 0000V /OPEN
```

2. Set the width with the keypad or MODIFY dial.

Other:

- The table indicates the effects on other parameters when the frequency, period, width or duty is changed.

<table>
<thead>
<tr>
<th>Change ↓</th>
<th>Frequency (FREQ)</th>
<th>Period (PERIOD)</th>
<th>Pulse width (WIDTH)</th>
<th>Duty (DUTY)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency (FREQ)</td>
<td>Changed</td>
<td>Changed</td>
<td>Changed</td>
<td>Unchanged</td>
</tr>
<tr>
<td>Period (PERIOD)</td>
<td>Changed</td>
<td>Unchanged</td>
<td>Changed</td>
<td>Changed</td>
</tr>
<tr>
<td>Pulse width (WIDTH)</td>
<td>Unchanged</td>
<td>Unchanged</td>
<td>Changed</td>
<td></td>
</tr>
<tr>
<td>Duty (DUTY)</td>
<td>Unchanged</td>
<td>Unchanged</td>
<td>Changed</td>
<td></td>
</tr>
</tbody>
</table>

- Due to the oscillation period and duty relationship, the pulse can be lost when the actual pulse width is less than 25 ns. An error message is displayed at this type of setting. Also, jitter increases when the pulse width is less than 100 ns. A warning message is displayed at this type of setting.
### 5.1 Convenient Settings

**Amplitude and DC offset setting by high and low level (ENTRY → HIGH / LOW)**

Operation to set the waveform vertical size as high and low level, in place of amplitude and DC offset, is described.

Select the waveform type for squarewave.

Amplitude: 5Vp-p

<table>
<thead>
<tr>
<th></th>
<th>High level: +5V</th>
</tr>
</thead>
<tbody>
<tr>
<td>DC offset: +2.5V</td>
<td></td>
</tr>
<tr>
<td>Low level: +0V</td>
<td></td>
</tr>
</tbody>
</table>

**Operation:**

1. Press the Entry key, then the High key to produce the following display.

   ![High Display](image)

<table>
<thead>
<tr>
<th>HIGH</th>
<th>+0. 0500 V</th>
</tr>
</thead>
<tbody>
<tr>
<td>1000. 0000000Hz</td>
<td>L-0. 0500V</td>
</tr>
<tr>
<td>/OPEN</td>
<td></td>
</tr>
</tbody>
</table>

2. Set the High level with the keypad or Modify dial.
   For example, set to +5 V.

3. Press the Exit key, then the Low key to produce the following display.

   ![Low Display](image)

<table>
<thead>
<tr>
<th>LOW</th>
<th>−0. 0500 V</th>
</tr>
</thead>
<tbody>
<tr>
<td>1000. 0000000Hz</td>
<td>H+5. 0000V</td>
</tr>
<tr>
<td>/OPEN</td>
<td></td>
</tr>
</tbody>
</table>

4. Set the Low level with the keypad or Modify dial.
   For example, set to +0 V.
Other:
The table indicates the effects on other parameters when the amplitude, DC offset, high level or low level is changed

<table>
<thead>
<tr>
<th>Change ↓</th>
<th>Amplitude (AMPTD)</th>
<th>DC offset (OFFSET)</th>
<th>High level (HIGH)</th>
<th>Low level (LOW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amplitude (AMPTD)</td>
<td>Unchanged</td>
<td>Changed</td>
<td>Changed</td>
<td>Changed</td>
</tr>
<tr>
<td>DC offset (OFFSET)</td>
<td>Unchanged</td>
<td>Changed</td>
<td>Changed</td>
<td>Changed</td>
</tr>
<tr>
<td>High level (HIGH)</td>
<td>Changed</td>
<td>Changed</td>
<td>Unchanged</td>
<td></td>
</tr>
<tr>
<td>Low level (LOW)</td>
<td>Changed</td>
<td>Changed</td>
<td>Unchanged</td>
<td></td>
</tr>
</tbody>
</table>

- Due to the relationships between high and low level settings, and between amplitude and DC offset settings, when the output voltage exceeds the following values, the Over lamp flashes and the output is clipped in some cases.

  - 10 V range: Approx. 11 V peak/open time
  - 1 V range: Approx. 1.1 V peak/open time
5.2 Units

Engineering unit (µ, m, k, M) display

Operation is described for displaying engineering units (e.g., the k of 1 kHz). As an example, the frequency units are changed.

Operation:

① Press the ENTRY key, then the FREQ key.

![Display example](image)

② Press the k key to change the display as follows.

![Display example](image)

Other:

- **Unit change enable**: Only when the µ, m, k or M key is lighted.
- **Initializing units (e.g., from kHz to Hz)**: At above step ②, press the ENTER key.
5.2 Units

- **Amplitude units change**

Operation to change the amplitude units is described. For example, set to Vrms.

**Operation:**

1. Press the **ENTRY** key, then the **AMPTD** key.
2. Press the **key** to produce the following display (Vp-p lights).

```
AMPTD 0. 1000  Vp-p
1000. 00000000Hz 0+0. 0000V /OPEN
```

3. Turn the **MODIFY** dial to produce the following display.

```
AMPTD 0. 0354  Vrms
1000. 00000000Hz 0+0. 0000V /OPEN
```

**Other:**

- The following units can be used.
  - Vp-p, Vrms, dBV, dBm (*1), USER (*2)
  - *1: Selectable when LOAD function is SET.
  - *2: Set User units name is displayed.

Notes: Only Vp-p and USER can be selected when the oscillation mode is NOISE.
Only Vp-p and USER can be selected when the selected waveform is ARB.

- Even if the amplitude units are changed, the actual output voltage does not change.
User-unit setting (SYSTEM → USER-UNIT)

Operation for changing the units by using the user unit function is described. For example, set for expressing frequency as rpm (revolutions per minute, e.g., engine rotation).

Operation:

(1) Select setting type, for example, frequency

① Press the SYSTEM key, then use the << and >> keys to produce the following display (USER-UNIT flashes).

```
USER UNIT MENU
SYSTEM: RANGE PRESET USER-UNIT
```

② Press the ENTER key, then use the << and >> keys to produce the following display (TYPE flashes).

```
FREQ PERIOD AMPTD
USER UNIT: TYPE NAME FORMULA
```

③ Again press the ENTER key, then use the << and >> keys to produce the following display (FREQ flashes).

```
FREQ PERIOD AMPTD
USER UNIT: TYPE NAME FORMULA
```

④ This selects the setting type to frequency. Press the EXIT key once to release the type select mode.
(2) Set the unit NAME (e.g., rpm)

① Use the [<] and [>] keys to produce the following display (NAME flashes).

```
USER
USER UNIT: TYPE NAME FORMULA
```

② Press the [ENTER] key, then use the [MODIFY] dial and [<] and [>] keys to input the unit name (e.g., rpm). Up to 4 of the following characters can be used for the unit name.

```
abcdefghijklmnopqrstuvwxyz (space)
ABCDEFGHIJKLMNOPQRSTUVWXYZ0123456789
!"#$%&'()*+,-./:;<=>?@[¥]^_'{|}
```

③ After inputting, press the [EXIT] key once to release unit name setting.

(3) Select the FORMULA, for example, (h+n)*m. The setting type (e.g., frequency) is h, n is offset, and m is the coefficient.

① Use the [<] and [>] keys to produce the following display (FORMULA flashes).

```
(h+n) * m  (Log (h) + n) * m
USER UNIT: TYPE NAME FORMULA
```

② Press the [ENTER] key, then use the [<] and [>] keys to produce the following display [(h+n)*m flash].

```
(h+n) * m  (Log (h) + n) * m
USER UNIT: TYPE NAME FORMULA
```

③ This sets the formula to (h+n)*m. Press the [EXIT] key once to release the formula setting mode.
(4) Set the coefficient [SCALE (m)], e.g., to 60

① Use the << and >> keys to produce the following display (SCALE (m) flashes).

```
+1. 00000000000000000E+0
USER UNIT: SCALE (m) OFFSET (n)
```

② Press the ENTER key, then set the scale with the keypad or MODIFY dial.

③ Press the EXIT key to release the scale setting mode.

(5) Set the offset [OFFSET (n)], for example, to 0

① Use the << and >> keys to produce the following display [OFFSET (n) flashes].

```
+0. 00000000000000000E+0
USER UNIT: SCALE (m) OFFSET (n)
```

② Press the ENTER key, then set the offset with the keypad or MODIFY dial.

③ Press the EXIT key to release the offset setting mode.

(6) Display the above settings

① Press the ENTRY key, then the FREQ key.

② Press the key to produce the following display (Hz flashes).

```
1000. 000000000
Hz
AO. 1000Vp-p 0+0.0000V /OPEN
```

③ Turn the MODIFY dial to produce the following display.

```
60000. 0000000
rpm
AO. 1000Vp-p 0+0.0000V /OPEN
```
5.2 Units

Other:

- User units can be used for frequency, period, amplitude, DC offset, phase and duty. Also, CH1 and CH2 can be set independently.
  However, at the channel mode difference (DIFF) setting, all CH1 user unit settings (formula, name, coefficient and offset) are copied to CH2.

  “3.3 Basic operation (Channel modes and settings)”, cf.

- Even when user units are set, the actual output does not change.
- According to the coefficient and offset settings, setting resolution may be less precise when user units are used.
- When using user units for the DC offset and phase in LOG selection, note the following.
  If a negative value is set before the conversion to user units is made, an attempt is made to calculate the logarithm of a negative value. Since the logarithm of a negative value cannot be a real number, "OVER" is displayed.
  Thereafter, user setup values can be arbitrarily changed. However, the DC offset and phase output to FUNCTION OUT cannot be converted to a negative value while user units are being used.
5.3 Setting memory

■ Setting store (MEMORY : STORE)

Operation is described for saving frequency, amplitude and other settings in memory.

Operation:

① Press the MEMORY key, then use the and keys to produce the following display (STORE flashes).

STORE MENU
MEMORY: STORE RECALL CLEAR

② Press the key, then use the and keys to produce the following display (0 flashes).

(NOT STORED)
STORE: 0 1 2 3 4 5 6 7 8 9

③ Press the key, then apply a desired name to the memory (may also be omitted). Select characters with the dial and shift position with the and keys.

Up to 20 characters can be selected from the following list.

abcdefghijklmnopqrstuvwxyz (space)
ABCDEFGHIJKLMNOPQRSTUVWXYZ
!"#$%&'()*+,-./;:<=>?@[¥]^_`{|}→←

④ Press the key to store the name (in this example, save to memory 0).

The above completes memory storage. Press the key to release the storage mode.

Other:

• By pressing the keypad at above step ②, name input is omitted and storage is at the memory of the depressed number.
5.3 Setting memory

Setting recall (MEMORY : RECALL)

Operation to recall settings from memory is described.

Operation:

① Press the MEMORY key, then use the < and > keys to produce the following display (RECALL flashes).

![RECALL MENU]

② Press the ENTER key, then use the < and > keys to produce the following display (0 flashes). In this example, TEST 1 is recalled from memory.

![TEST 1 STORE:0]

③ Press ENTER key for recall.

Other:

• If the keypad is pressed at above step ②, the pressed memory number is recalled. Only the stored numbers of the keypad light.

• Items stored in the setting memory and user unit settings are noted in Section [3.3 Basic operation, Setting initialize]. The following items do not change before and after recall.

  • Channel selection
  • Output on/off
  • Output on/off state at power on
  • Arbitrary waveform parameter
  • Type of remote control
  • GPIB parameter
  • USB ID
### Setting memory clear (MEMORY : CLEAR)

Operation to clear the memory is described. The operation also clears names entered in the memory.

**Operation:**

1. Press the MEMORY key then use the ← and → keys to produce the following display (CLEAR flashes).

   ![CLEAR MENU](image)

2. Press the ENTER key, then use the ← and → keys to produce the following display (0 flashes). In this example, TEST 1 is cleared from memory.

   ![TEST 1](image)

3. Press ENTER key to clear the memory recall.

**Other:**

- At above step 2, pressing the keypad clears the corresponding memory number. Only the stored numbers of the keypad light.
5.4 External Input

External add (EXT-ADD) (SYSTEM : EXT-ADD)

Operation is described for adding an external signal to the 1946B output. The external signal is connected to the rear panel EXT ADD IN connector.

For details on connectors, “3.2 Input and output connectors (External add input (EXT ADD IN))”, cf.

Operation:

1. Press the SYSTEM key, then use the  and  keys to produce the following display (EXT-ADD flashes).

```
OFF  ON
SYSTEM: ← EXT-AMExt-ADD φSYNC →
```

2. Press the ENTER key, then use the  and  keys to produce the following display (ON flashes).

```
OFF  ON
SYSTEM: ← EXT-AMExt-ADD φSYNC →
```
Operation to modulate the 1946B output with an external AM signal is described. The external signal is applied to the rear panel EXT AM IN connector.

For details on connectors, “3.2 Input and output connectors (External AM input (EXT AM IN))”, cf.

**Operation:**

1. Press the SYSTEM key, then use the ◄ and ► keys to produce the following display (EXT-AM flashes).

```
OFF ON
SYSTEM: ◄ EXT-AM EXT-ADD ◄SYNC ►
```

2. Press the ENTER key, then use the ◄ and ► keys to produce the following display (ON flashes).

```
OFF ON
SYSTEM: ◄ EXT-AM EXT-ADD ◄SYNC ►
```

**Other:**

- AM appears at the head of the display when external AM is on.

```
1000.00000000Hz
AM A0 1000Vp-p 0+0.0000V OPEN
```
5.5 Other settings

**Output range change (use with fixed range)**

Operation is described for fixing the voltage output range to 10 V.
Although AUTO is normally used, by fixing the range, output interruption from automatic switching can be avoided.
A disadvantage is during output voltage below 2 Vp-p (open), setting resolution is 1 digit less than the 1 V range.

**Operation:**

1. Press the `SYSTEM` key, then use the `<` and `>` keys to produce the following display (RANGE flashes).

   ![Display 1]

2. Press the `ENTER` key, then use the `<` and `>` keys to produce the following display (10 V flashes).

   ![Display 2]

**Other:**

- If the output range is set as 1 V when the amplitude setting is larger than 2 Vp-p (open), the amplitude is automatically changed to 1/10 since voltage exceeding 2 Vp-p (open) cannot be output in the 1 V range.
Output on/off at power on (SYSTEM : POWER - ON)

Selectable return to the state when the power supply was switched off or output on/off state. The example is setting the output for off at power on.

Operation:

1. Press the SYSTEM key, then use the < and > keys to produce the following display (POWER-ON flashes).

2. Press the ENTER key, then use the < and > keys to produce the following display (OFF flashes).
5.5 Other settings

- **LOAD function (equalize setting and output values) (SYSTEM : LOAD)**

Operation is described for equalizing the amplitude (AMPTD) and DC offset (OFFSET) setting values with the actual output values (FUNCTION OUT connector voltage).

The example is setting at the 100Ω load impedance.

**Operation:**

① Press the SYSTEM key, then use the < and > keys to produce the following display (LOAD flashes).

```
OPEN
SYSTEM: < LOAD COPY1→2 COPY2→1
```

② Press the ENTER key, then turn the MODIFY dial to produce the following display (SET flashes).

```
SET
SYSTEM: < LOAD COPY1→2 COPY2→1
```

③ Press the > key, then turn the MODIFY dial to set the load impedance to 100 Ω.

The above setting calculates the actual voltage of FUNCTION OUT connector from the WF1946B output impedance (50 Ω) and the load impedance for automatically changing the indicated value.

**Other:**

- The load impedance setting range is 45 to 999 Ω, resolution is 1 Ω.
- The WF1946B output impedance and voltage errors are not converted.
**UNDO function**

The UNDO function is described for returning a numerical or other setting to the previous state.

**Operation:**

① Press the UNDO button to return a setting to the previous state (ineffective when UNDO is extinguished).

**Other:**

• Undo enabled:

1. Directly after changing frequency, amplitude, etc., with the keypad or MODIFY dial.
2. Directly after setting recall (MEMORY → RECALL). Press the UNDO key to return the state prior to recall.
## Pulse generator function

Operation of the WF1946B as a pulse generator is described.

**Operation:**

1. **Set for continuous pulse output**

   ![Diagram of pulse output](image)

   - Set the waveform to squarewave (variable duty), (FUNCTION →).
   - Set the voltage High level to +5 V and the Low level to 0 V.
     - (ENTRY → HIGH → 5 → ENTER, ENTRY → LOW → 0 → ENTER).
   - Set the period to 2 ms (ENTRY → PERIOD → 2 → m).
   - Set the pulse width to 0.2 ms (ENTRY → WIDTH → 0.2 → m).

2. **Use external trigger for pulse output**

   ![Diagram of external trigger](image)

   - Set the waveform to squarewave (variable duty), (FUNCTION →).
   - Set the voltage High level to +5 V and the Low level to 0 V.
     - (ENTRY → HIGH → 5 → ENTER, ENTRY → LOW → 0 → ENTER).
   - Set the trigger signal (TRIG/SWEEP IN) and delay time: 0.1 ms.
③ Set the pulse width to 0.5 ms (ENTRY → WIDTH → ・ → 5 → m).

④ Set oscillation mode.
(MODE → BURST → TYPE = TRIG, SOURCE = EXT ounter, DELAY = 0.1 ms,
MARK = 1.0 cycle, STOP-LEVEL = ON 100%)

⑤ Apply the trigger signal to the TRIG/SWEEP IN connector.

Other:

• **Double pulse output:** At above step ④, set MARK = 2.0 cycles.

• **Manual trigger:** At above step ④, set SOURCE = EXT ounter and press the MAN TRIG key.
(Do not connect anything to the TRIG/SWEEP IN connector.)
5.5 Other settings

■ Phase sync (SYSTEM : φ SYNC)

Operation is described for restarting the CH1 and CH2 output waveforms from a set phase so as to clarify the phase relationship.

This function is used when the channel mode is INDEP or when multiple units are synchronized by using the 1991 synchronizer option.

When the channel mode is changed, phase sync is processed automatically.

CH1 and CH2 waveform outputs in the INDEP channel mode when the phase is synchronized (CH1 is 0 deg. and CH2 is 90 deg.)

Operation:

① Press the SYSTEM key, then use the ← and → keys to produce the following display (φ SYNC flashes).

| φ SYNC | SYSTEM: ← EXT-AM EXT-ADD φSYNC → |

② Press the ENTER key to engage phase synchronization.

Other:

• φ sync is effective in Normal oscillation mode. In other modes, the phase may shift 180 degrees and the values of the mark cycle and space cycle settings may change.

• The phase between outputs of units (channels) in synchronous operation is the difference between the phase settings (PHASE) set for each unit (channel).
5.5 Other settings

■ Copy settings between channels (SYSTEM : COPY1 → 2 / COPY2 → 1)

Operation to copy settings from CH1 to CH2 (or vice versa) is described.

Operation:

① Press the SYSTEM key, then the [ ] and [ ] keys to produce the following display (COPY 1 → 2 flashes).

COPY CH1 → CH2
SYSTEM:

LOAD COPY1→2 COPY2→1

② Press the ENTER key, COPY CH1 → CH2 flashes. Then again press the ENTER key to copy between the channels.

This completes setting copy.

To copy from CH2 to CH1, at above step ①, flash COPY 2→1.

Other:

• The following items do not change before and after copying.
  • Channel select
  • Output on/off
  • Arbitrary waveform parameter
  • User units parameter *: When the copy from settings are user units, the copy to settings are also user units. When user units are used for the respective channel settings (formula, name, coefficient, offset), the settings are determined so as to provide uniform final output values.
  • Type of remote control
  • GPIB parameter
  • USB ID
Fixed frequency difference (2TONE) (CHANNEL MODE: 2TONE)

Following is a description of the 2 tone channel mode whereby a fixed frequency difference is maintained between CH1 and CH2.
In this mode, if the frequency of either channel is changed, the frequency of the other channel is automatically changed to maintain the fixed difference.

Operation:
(1) Set the channel mode to 2 tone.

① Press the CHANNEL MODE key, then the  and  keys to produce the following display (2 TONE flashes).

![Display]

② Press the ENTER key to select this channel mode.

(2) Set the frequency difference (ΔFREQ) between CH2 and CH1.

① Press the ENTER key, then the ΔFREQ key.

② Set the frequency difference with the keypad or MODIFY dial.

③ Press the EXIT key once to release the setting mode.

Other:
• If the frequency difference (ΔFREQ) is changed, the frequency of CH2 changes.
• The frequency difference (ΔFREQ) cannot be a negative value.
• If the channel mode is set to the fixed frequency difference (2TONE), the frequency of CH2 changes according to the frequency difference (ΔFREQ).
5.5 Other settings

■ Fixed frequency ratio (RATIO) (CHANNEL MODE : RATIO)

Following is a description of the ratio channel mode whereby a fixed frequency ratio is maintained between the frequencies of CH1 and CH2 (or vice versa).

In this mode, if the frequency of either channel is changed, the frequency of the other channel is automatically changed to maintain the fixed ratio.

Operation:
(1) Set the channel mode to ratio

① Press the CHANNEL MODE key, then the < and > keys to produce the following display (RATIO flashes).

RATIO DIFF
SELECT CHANNEL MODE

② Press the ENTER key to select this channel mode.

(2) Set the frequency ratio between CH2 and CH1.

① Press the ENTRY key, then the RATIO key.

CH 1 CH 2
R 0000001:0000001
1000.0000000Hz 0.1000Vp-p /OPEN

② Select the affected channel with the < and > keys, then set the frequency ratio with the keypad or MODIFY dial.

③ Press the EXIT key once to release the setting mode.

Other:

• During ratio, the frequency resolution = 10 nHz × set ratio.

• If the channel mode is set to the fixed frequency ratio (RATIO), the frequency of CH2 changes according to the frequency ratio (RATIO).
Section 6  Troubleshooting

6.1 Error message
- Power on error
- Operation error

6.2 Suspected failure
- In case of abnormality
Self-check is conducted at power on and in case of an abnormality, an error message is displayed. An error message is also displayed if an erroneous operation is conducted.

Error message contents, causes and corrective measures are indicated in the following tables.

### Power on error

<table>
<thead>
<tr>
<th>Error message</th>
<th>Cause</th>
<th>Corrective measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>BACKUP MEMORY LOST</td>
<td>Battery backup memory contents destroyed.</td>
<td>Backup battery probably depleted. Contact dealer. Press the ENTER key to start the system at the factory settings.</td>
</tr>
<tr>
<td>CALIBRATION MEMORY LOST</td>
<td>Calibration data destroyed.</td>
<td>Contact dealer. Although possible to start by pressing the ENTER key, accuracy cannot be guaranteed.</td>
</tr>
<tr>
<td>SYSTEM TEST FAILED 001</td>
<td>Internal ROM sum check error.</td>
<td>Contact dealer.</td>
</tr>
<tr>
<td>SYSTEM TEST FAILED 002</td>
<td>Internal RAM read/write error.</td>
<td>Contact dealer.</td>
</tr>
</tbody>
</table>
### Operation error

<table>
<thead>
<tr>
<th>Error message</th>
<th>Cause or corrective measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>DATA OUT OF RANGE</td>
<td>Input values outside of permissible setting range. Confirm permissible setting range and again input. Upper and lower limits can be easily checked by using the MODIFY dial to change the values.</td>
</tr>
<tr>
<td>INVALID NUMERIC DATA</td>
<td>Keypad input data invalid (e.g., decimal point only).</td>
</tr>
<tr>
<td>SETTINGS CONFLICT 001</td>
<td>Start or stop value set to 0 during LOG sweep and sweep cannot be executed.</td>
</tr>
<tr>
<td>SETTINGS CONFLICT 002</td>
<td>Combined center and span exceed the permissible sweep type (e.g., frequency) setting range.</td>
</tr>
<tr>
<td>SETTINGS CONFLICT 003</td>
<td>Combined modulation type (e.g., frequency) and either Deviation or depth exceed the permissible modulation type setting range and modulation cannot be executed.</td>
</tr>
<tr>
<td>SETTINGS CONFLICT 004</td>
<td>Combined modulation type (e.g., frequency) and either Deviation or depth exceed the permissible modulation type setting range.</td>
</tr>
<tr>
<td>SETTINGS CONFLICT 007</td>
<td>Combined period and pulse width exceed the permissible duty setting range.</td>
</tr>
<tr>
<td>SETTINGS CONFLICT 008</td>
<td>Combined frequency (FREQ) and frequency difference (ΔFREQ) or frequency ratio (RATIO) settings exceed the permissible frequency setting range.</td>
</tr>
<tr>
<td>SETTINGS CONFLICT 010</td>
<td>Since the mode is SWEEP or MODU for [variable duty], DUTY-VALID cannot be set.</td>
</tr>
<tr>
<td>Error message</td>
<td>Cause or corrective measures</td>
</tr>
<tr>
<td>----------------------------------</td>
<td>----------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>STORE/RECALL MEMORY LOST</td>
<td>Setting storage memory contents destroyed and settings cannot be recalled. Contact dealer.</td>
</tr>
<tr>
<td>WARNING 001</td>
<td>Combined frequency and duty set the pulse width to not more than 25 ns and the pulse may be lost.</td>
</tr>
<tr>
<td>WARNING 002</td>
<td>Combined frequency and duty set the pulse width to 25 and 100 ns and pulse width may be unstable (large jitter component).</td>
</tr>
<tr>
<td>WARNING 003</td>
<td>Since high frequency, burst oscillation mark and space may be unstable.</td>
</tr>
<tr>
<td>WARNING 004</td>
<td>Low level setting changed due to high level setting change, or conversely, high level setting changed due to low level setting change.</td>
</tr>
<tr>
<td>WARNING 005</td>
<td>Changed to simple standard units (Hz, s, Vp-p, V).</td>
</tr>
<tr>
<td>WARNING 006</td>
<td>Since combined period and pulse width exceed the permissible duty setting range, pulse width was changed in order to enter the permissible duty range.</td>
</tr>
<tr>
<td>WARNING 007</td>
<td>Changing the frequency relationship exceeded the permissible frequency setting range for the other channel. Therefore, the frequency relationship of both channels was changed to within this range.</td>
</tr>
<tr>
<td>WARNING 008</td>
<td>Because of channel mode change, the oscillation mode was changed to normal.</td>
</tr>
<tr>
<td>Error message</td>
<td>Cause and treatment</td>
</tr>
<tr>
<td>---------------</td>
<td>---------------------</td>
</tr>
<tr>
<td>WARNING 009</td>
<td>Due to channel mode change, the oscillation mode was changed to normal. The sweep/modulation type was changed to frequency. Therefore the other channel sweep/modulation was changed to frequency. Sweep/modulation type was changed to a type other than frequency, or the oscillation mode was changed to other than sweep/modulation. Therefore, the oscillation mode of the other channel was changed to normal.</td>
</tr>
<tr>
<td>WARNING 010</td>
<td>The sweep function was changed from LOG to LIN.</td>
</tr>
<tr>
<td>WARNING 011</td>
<td>The sweep mode was changed from gated to single.</td>
</tr>
<tr>
<td>WARNING 012</td>
<td>Since the oscillation mode of the other channel was changed during sweep or modulation, sweep or modulation was stopped.</td>
</tr>
<tr>
<td>WARNING 013</td>
<td>Sweep time or modulation frequency exceeded the settable range and was automatically changed to within the permissible setting range.</td>
</tr>
<tr>
<td>WARNING 015</td>
<td>Because of DUTY-VALID change, the duty was changed to 0.01% or 99.99%.</td>
</tr>
<tr>
<td>WARNING 017</td>
<td>Because of a mode change, DUTY-VALID was changed to IMMED.</td>
</tr>
</tbody>
</table>
# 6.2 Suspected failure

**In case of abnormality**

If an abnormality is suspected, check as indicated in the following table. If normal operation cannot be returned, contact the dealer.

<table>
<thead>
<tr>
<th>Symptom</th>
<th>Possible causes</th>
<th>Correction</th>
</tr>
</thead>
<tbody>
<tr>
<td>No power on</td>
<td>Power source not within specified range</td>
<td>Check the rear panel power supply rating. Use the equipment at single phase AC, at the rated voltage ± 10 %, 50 to 60 Hz (48 to 62 Hz).</td>
</tr>
<tr>
<td></td>
<td>Power supply fuse open</td>
<td>Replace the power supply fuse. (Be sure to use the correctly rated fuse.)</td>
</tr>
<tr>
<td></td>
<td>External noise</td>
<td>Install the equipment in a site with favorable conditions.</td>
</tr>
<tr>
<td>Panel inoperative</td>
<td>Remote mode enabled</td>
<td>Press the LOCAL key to set the local mode.</td>
</tr>
<tr>
<td></td>
<td>Keys or Modify dial defective</td>
<td>Contact service.</td>
</tr>
<tr>
<td>Output abnormal</td>
<td>Ambient temperature and humidity outside specified range</td>
<td>Use the equipment under the specified environmental conditions.</td>
</tr>
<tr>
<td></td>
<td>Inadequate warm up</td>
<td>Allow the equipment to warm up for at least 30 minutes after power on.</td>
</tr>
<tr>
<td></td>
<td>DC offset applied</td>
<td>Set DC offset to 0 V.</td>
</tr>
<tr>
<td></td>
<td>Set for user units</td>
<td>Select standard units</td>
</tr>
<tr>
<td></td>
<td>LOAD function being used</td>
<td>Set for OPEN.</td>
</tr>
<tr>
<td>Cannot be set via remote control</td>
<td>Address or USB ID different from that in the program</td>
<td>Set the address and USB ID to match those in the program.</td>
</tr>
<tr>
<td></td>
<td>Address or USB ID identical to that of another device</td>
<td>Set the address and USB ID so that they do not match those of other devices.</td>
</tr>
<tr>
<td>Does not operate according to operation manual</td>
<td>Setting have not been initialized (PRESET)</td>
<td>The operation manual presumes the settings have been initialized.</td>
</tr>
<tr>
<td></td>
<td>Operated channel reversed</td>
<td>Check if CH1 or CH2.</td>
</tr>
</tbody>
</table>
Section 7  Maintenance

7.1 Outline .................................................................7-2
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   ■ Performance tests ..................................................7-5
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7.1 Outline

■ Work contents

The following types of maintenance are required in order to use the equipment in optimum condition.

- Inspection: Check that the equipment is operating correctly.
- Performance tests: Check that the equipment meets specifications.
- Adjustment and calibration: When the equipment does not meet specifications, it is adjusted and calibrated in order to restore performance at the manufacturer.
- Service: Cause and location of failure are investigated and repair is conducted at the company.

This operation manual provides easily carried out procedures for inspection and performance checks. Consult the manufacturer or dealer regarding more thorough inspection, adjustment, calibration and repair.

⚠️ WARNING

Do not remove external covers.
Internal inspection of this equipment must be performed only by a trained service technician who is fully aware of the hazards involved.

■ Required test instruments

The following equipment is required for inspection and performance tests.

- Oscilloscope: At least 100 MHz bandwidth
- Universal counter: Reference oscillator accuracy better than $5 \times 10^{-7}$
- DC voltmeter: Accuracy better than 0.1 %
- AC voltmeter 1: True rms, accuracy better than 0.3 %, bandwidth at least 100kHz, recommended: Keithley Model 2001
- AC voltmeter 2: True rms, accuracy better than 1 %, bandwidth at least 20MHz, recommended: Boonton Model 9200C+952016+952002
- Distortion meter: Full scale 0.1 %, frequency up to 100 kHz
- 50 Ω feed through terminator
- 50 Ω 20 dB attenuator
7.2 Operation checks

■ Preparatory checks

Check the following before inspection.

- Power source voltage is within ± 10 % of the rating
- Ambient temperature is within 5 to 35 °C.
- Ambient relative humidity is within 5 to 85 %RH (absolute humidity: 1 to 25 g/m³)
- Condensation is absent.

■ Function checks

- Power on
  Confirm absence of error message at power on.
  If an abnormal indication appears at power on, switch power off and wait at least 5 seconds, then again switch power on.

- Main function checks
  To avoid setting error, initialize the settings (SYSTEM → PRESET).
  Connect FUNCTION OUT to an oscilloscope with 50 Ω coaxial cable to monitor the output.
  Operate to change the following settings several times and confirm normal functions. Test both keypad and MODIFY dial for settings such as frequency.

  - Frequency (ENTRY → FREQ)
  - Amplitude (ENTRY → AMPTD)
  - DC offset (ENTRY → OFFSET)
  - Waveform (FUNCTION → , , Duty fixed 50 %, ,)
  - Duty (FUNCTION → Variable duty, ENTRY → DUTY)
  - Output on/off (CH 1 OUT ON/OFF, CH 2 OUT ON/OFF)
7.2 Operation checks

- **Backup function**
  Switch off the power, wait at least 5 seconds, then switch the power on.
  Confirm the settings for the following items prior to switching off the power have been correctly saved.
  - Frequency
  - Amplitude
  - DC offset
  - Waveform
  - Duty

If stored at room temperature, the backup period is typically 3 years, but may vary among individual units and usage conditions.

Accuracy cannot be guaranteed if calibration data cannot be backed up due to battery depletion.
Therefore, regular battery replacement is recommended.

- **GPIB/USB**
  Conduct some of the main function checks via GPIB/USB and confirm the same output variations.
  Also note that the remote (REM) indicator lights.
  Press the LOCAL key and confirm the remote indicator extinguishes and the local mode is returned (not local lock out).
7.3 Performance tests

- **Performance tests**

  Performance tests are an important part of preventive maintenance and serve to prevent serious deterioration of the equipment performance.
  Conduct these tests at incoming inspection, routine inspection, following repair and whenever performance needs to be confirmed.
  When specifications are not met in performance tests, service is required. Contact the dealer.

- **Preparatory checks**

  Check the following before testing performance.
  - Power source voltage is within ±10% of the rating.
  - Ambient temperature is 23 ± 5°C.
  - Ambient relative humidity is within 20 to 70% RH.
  - Condensation is absent.
  - Allow at least 30 minutes warm up.

- **Test preparation**

  - Signal cables are 50 Ω coaxial, RG-58A/U or thicker, less than 1 meter length and fitted at both ends with BNC connectors.
  - Where items call for 50 Ω termination, set the input impedance of the connected instrument to 50 Ω.
    Where this is impossible, use a 50 Ω feed through terminator at the test instrument input.
  - Initialize the settings for each test item (SYSTEM → [PRESET]), set the output on (key internal LED lights according to CH 1 OUT ON/OFF or CH 2 OUT ON/OFF) and the item to be changed is indicated.

- **Frequency accuracy**

  Connection: Use coaxial cable to connect FUNCTION OUT to a universal counter (50 Ω termination).
  Setting: Initialize, then set frequency to 1 MHz and amplitude to 20 Vp-p/open.
  Measurement: Measure frequency with the universal counter (CH1).
  Judgment: Normal if within ±5 ppm (999.995 to 1.000005 MHz) (when shipped)
  However, since aging may occur with up to ±3 ppm/year, deterioration up to ±8 ppm (999.992 to 1.000008 MHz) may have occurred if one year has passed since shipment.
7.3 Performance tests

### Amplitude accuracy

**Connection:** Use coaxial cable to connect FUNCTION OUT to AC voltmeter 1.

**Setting:** After setting initialize, set the amplitude, output range and waveform as indicated in the following table.

**Measurement:** Measure the true rms output voltage for each waveform. (CH1,CH2)

**Judgment:** The normal ranges are indicated in the table.

<table>
<thead>
<tr>
<th>Waveform</th>
<th>Output range</th>
<th>Setting</th>
<th>Normal range</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>10 V</td>
<td>20 Vp-p/open (7.071 Vrms/open)</td>
<td>7.004 to 7.138 Vrms</td>
</tr>
<tr>
<td></td>
<td>10 V</td>
<td>20 Vp-p/open (5.774 Vrms/open)</td>
<td>5.719 to 5.828 Vrms</td>
</tr>
<tr>
<td></td>
<td>10 V</td>
<td>20 Vp-p/open (10.00 Vrms/open)</td>
<td>9.905 to 10.095 Vrms</td>
</tr>
<tr>
<td></td>
<td>10 V</td>
<td>10 Vp-p/open (3.536 Vrms/open)</td>
<td>3.493 to 3.578 Vrms</td>
</tr>
<tr>
<td></td>
<td>10 V</td>
<td>5 Vp-p/open (1.768 Vrms/open)</td>
<td>1.738 to 1.798 Vrms</td>
</tr>
<tr>
<td></td>
<td>10 V</td>
<td>2 Vp-p/open (0.707 Vrms/open)</td>
<td>0.684 to 0.730 Vrms</td>
</tr>
<tr>
<td></td>
<td>10 V</td>
<td>2 Vp-p/open (0.7071 Vrms/open)</td>
<td>0.699 to 0.716 Vrms</td>
</tr>
</tbody>
</table>

### DC offset accuracy

**Connection:** Connect FUNCTION OUT to a DC voltmeter.

**Setting:** After setting initialize, set the DC mode, output range and DC offset as indicated in the following table.

**Measurement:** Measure the output voltage. (CH1,CH2)

**Judgment:** The normal ranges are indicated in the table.

<table>
<thead>
<tr>
<th>Output range</th>
<th>DC offset setting</th>
<th>Normal range</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 V</td>
<td>±10.000 V/open</td>
<td>±9.880 to ±10.12 V</td>
</tr>
<tr>
<td>10 V</td>
<td>±5.000 V/open</td>
<td>±4.905 to ±5.095 V</td>
</tr>
<tr>
<td>10 V</td>
<td>±2.000 V/open</td>
<td>±1.920 to ±2.080 V</td>
</tr>
<tr>
<td>10 V</td>
<td>±1.000 V/open</td>
<td>±0.925 to ±1.075 V</td>
</tr>
<tr>
<td>10 V</td>
<td>0.0000 V/open</td>
<td>−0.070 to +0.070 V</td>
</tr>
<tr>
<td>1 V</td>
<td>±1.0000 V/open</td>
<td>±0.985 to ±1.015 V</td>
</tr>
<tr>
<td>1 V</td>
<td>0.0000 V/open</td>
<td>−0.010 to +0.010 V</td>
</tr>
</tbody>
</table>
### Amplitude vs. frequency characteristics

Connection: Use coaxial cable to connect FUNCTION OUT to AC voltmeter 2 (50 Ω termination).

Setting: Initialize, then set the amplitude to 20 Vp-p/open and select the frequency and waveform as indicated in the table.

Measurement: Measure the true rms output voltage for each frequency and waveform. (CH1,CH2)

Judgment: The normal ranges are indicated in the table.

<table>
<thead>
<tr>
<th>Waveform</th>
<th>1 kHz (Setting)</th>
<th>to 500 kHz</th>
<th>to 1 MHz</th>
<th>to 3 MHz</th>
<th>to 10 MHz</th>
<th>to 15 MHz</th>
</tr>
</thead>
<tbody>
<tr>
<td>sin</td>
<td>(Reference value)</td>
<td>+0.2/-0.3 dB</td>
<td>+0.2/-0.3 dB</td>
<td>+0.35/-0.7 dB</td>
<td>+0.5/-1.5 dB</td>
<td>+0.5/-2.0 dB</td>
</tr>
<tr>
<td>triangle</td>
<td>(Reference value)</td>
<td>±0.3 dB</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>rectangle</td>
<td>(Reference value)</td>
<td>±0.3 dB</td>
<td>±0.3 dB</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>sawtooth</td>
<td>(Reference value)</td>
<td>±0.5 dB</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>square</td>
<td>(Reference value)</td>
<td>±0.5 dB</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
</tbody>
</table>

### Sinewave distortion

Connection: Use coaxial cable to connect FUNCTION OUT to a distortion meter (50 Ω termination).

Setting: Initialize, then set the amplitude to 20 Vp-p/open and the frequency as indicated in the table.

Measurement: Measure the distortion (CH1,CH2)

Judgment: The normal range is indicated in the table.

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Normal range</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 Hz to 100 kHz</td>
<td>0.2 % or less</td>
</tr>
</tbody>
</table>

(Bandwidth 500 kHz)
7.3 Performance tests

■ Squarewave response

Connection: Use coaxial cable to connect FUNCTION OUT to an oscilloscope (50 Ω termination).
Setting: Initialize, then set frequency to 1 MHz and amplitude to 20 Vp-p/open.
Measurement: Observe the waveform and measure the rise and fall times, overshoot and undershoot.
Judgment: The normal range is indicated in the table.

<table>
<thead>
<tr>
<th>Item</th>
<th>Normal range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rise and fall times</td>
<td>20 ns or less</td>
</tr>
<tr>
<td>Overshoot and undershoot</td>
<td>5 % or less</td>
</tr>
</tbody>
</table>

![Overshoot and Undershoot Diagram]

■ Duty factor

Connection: Use coaxial cable to connect Function Out to a universal counter (50 Ω terminated).
Settings: Initialize the settings, then set amplitude to 20 Vp-p, and waveform and frequency according to the following table.
Measurement: Set the counter rise and fall period to the interval timer mode and measure the duty (time). Use the average value, since jitter will cause dispersion in the measurement values.
Determination: The ranges indicated in the following table are normal.

<table>
<thead>
<tr>
<th>Waveform</th>
<th>Frequency</th>
<th>Rated range</th>
</tr>
</thead>
<tbody>
<tr>
<td>√ (duty 50 % fixed)</td>
<td>1 MHz</td>
<td>490 to 510 ns</td>
</tr>
<tr>
<td>√ (duty 50 % fixed)</td>
<td>10 MHz</td>
<td>47.0 to 53.0 ns</td>
</tr>
<tr>
<td>√ (duty 50 % fixed)</td>
<td>15 MHz</td>
<td>30.0 to 36.7 ns</td>
</tr>
<tr>
<td>√ (duty variable)</td>
<td>100 kHz</td>
<td>4.90 to 5.10 μs</td>
</tr>
</tbody>
</table>
### Time difference between channels

**Connections:**
- CH1 Function Out to universal counter input 1 (50 Ω terminated)
- CH2 Function Out to universal counter input 2 (50 Ω terminated)

Use the same length and same type coaxial cables.

**Settings:**
After setting initialize, set channel mode 2PHASE, amplitude 20 Vp-p/open (CH1 and CH2), CH2 phase 180 deg, and frequency and waveform according to the following table.

**Measurement:**
Set timer mode between counter inputs 1 and 2, and measure the time difference between CH1 and CH2. Set the counter trigger level to 0 V and the trigger polarity to rising for both inputs 1 and 2. Use the average value, since dispersion occurs in the measured values.

**Determination:**
The ranges indicated in the following table are normal.

<table>
<thead>
<tr>
<th>Waveform</th>
<th>Frequency</th>
<th>Rating range</th>
</tr>
</thead>
<tbody>
<tr>
<td>~</td>
<td>10 MHz</td>
<td>40 to 60 ns</td>
</tr>
<tr>
<td>(duty 50 % fixed)</td>
<td>10 MHz</td>
<td>40 to 60 ns</td>
</tr>
<tr>
<td>_</td>
<td>500 kHz</td>
<td>990 to 1010 ns</td>
</tr>
</tbody>
</table>
Section 8 Specifications

8.1 Waveform and output characteristics ................................................................. 8-2
8.2 Output voltage ...................................................................................................... 8-4
8.3 Other functions .................................................................................................. 8-5
8.4 Initialized settings ............................................................................................. 8-11
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8.7 General items ..................................................................................................... 8-14
   ■ External drawing ................................................................................................ 8-16

Guaranteed values are shown with tolerance, values without tolerance are for reference.
8.1 Waveform and output characteristics

- **Waveforms (FUNCTION OUT)**

  Output waveforms:
  - 
  -  (Duty 50% fixed),  
  -  (Duty variable),  
  - arbitrary waveform (ARB),  
  - and noise (NOISE), DC voltage (DC)

  Waveform vertical resolution: 16 bit (, , , arbitrary waveform (ARB))

  Output waveform and frequency:
  
  For continuous oscillation:
  -  (Duty 50% fixed) : 0.01 µHz to 15 MHz
  -  (Duty variable),  : 0.01 µHz to 500 kHz
  - Arbitrary waveform : 0.01 µHz to 500 kHz

  However, the frequency in which all the data of arbitrary waveforms can be outputted is the maximum of the following value:
  
  
  Analog band width: 10 MHz

  For burst, trigger, gate, triggered gate, or gated sweep: 0.01 µHz to 500 kHz

  Frequency:
  
  Range: 0.01 µHz to 15 MHz

  Resolution: 0.01 µHz

  Accuracy when shipped: ±5 ppm

  Aging: ±3 ppm/year

  Setting by period:

  Frequency equivalent to inverse number of the setting period.

  If the number is less than 0.01 µHz, the number should be rounded off.

  Duty:
  
  Range: 0.0100% to 99.9900%/0.0000% to 100.0000%

  Resolution: 0.0001%

  Arbitrary waveform data size:

  Can be switched among 8 K, 16 K, 32 K, and 64 K words.

  1 K words equal 1024 words.

  Number of arbitrary waveforms:

  Number of arbitrary waveforms that can be select, and waveforms are backed up

  12 waveforms for 8 K words/6 waveforms for 16 K words/

  3 waveforms for 32 K words/ 1 waveform for 64 K words

  Arbitrary waveform data originiation:

  Point specification and linear interpolation by the panel operation
  or data writing by GPIB or USB

  Arbitrary waveform data resolution:

  16 bits (-32768 to 0 to +32767)

  The 1992A digital output option outputs upper 15 bits and clock.
### 8.1 Waveform and output response

**Noise**
- Noise source: pseudo-M-series by 42-step shift register
- Period 30.518 hours, Spectrum interval 9.1022 µHz
- White noise bandwidth (equivalent noise bandwidth): about 500 kHz
- Peak factor (crest factor): 6
  - Amplitude can be set in Vp-p.
  - \[ \text{rms value} = \left( \frac{\text{Vp-p set point}}{2} \right) \div \text{(peak factor)} \]
- Binary output: Outputs from SYNC OUT during NOISE mode.

#### Output characteristics (FUNCTION OUT)

<table>
<thead>
<tr>
<th>Amplitude frequency characteristics</th>
<th>Continuous oscillation, External AM off, 50 ( \Omega ) load, DC offset 0 V, amplitude setting 10 Vp-p/50 ( \Omega ), normalized frequency 1 kHz, rms rms value measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \sim ) Up to 1 MHz: +0.2 dB, −0.3 dB</td>
<td></td>
</tr>
<tr>
<td>( \sim ) 1 MHz to 3 MHz: +0.35 dB, −0.7 dB</td>
<td></td>
</tr>
<tr>
<td>( \sim ) 3 MHz to 10 MHz: +0.5 dB, −1.5 dB</td>
<td></td>
</tr>
<tr>
<td>( \sim ) 10 MHz to 15 MHz: +0.5 dB, −2.0 dB</td>
<td></td>
</tr>
<tr>
<td>( \perp ) Up to 1 MHz: ±0.3 dB</td>
<td></td>
</tr>
<tr>
<td>( \sim / ) Up to 500 kHz: ±0.3 dB</td>
<td></td>
</tr>
<tr>
<td>( \perp ) Up to 500 kHz: ±0.5 dB</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>spectrum purity</th>
<th>Continuous oscillation, External AM off, 50 ( \Omega ) load, DC offset 0 V, 10 Vp-p/50 ( \Omega ), 10 Hz to 100 kHz: 0.2 % and below (bandwidth: 500 kHz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total harmonic distortion</td>
<td>100 kHz to 1 MHz: −50 dBc and below</td>
</tr>
<tr>
<td>Harmonic spectrum</td>
<td>1 MHz to 15 MHz: −30 dBc and below</td>
</tr>
<tr>
<td>Spurious output</td>
<td>Up to 15 MHz: −35 dBc and below</td>
</tr>
<tr>
<td>waveform characteristics</td>
<td>Continuous oscillation, External AM off, 50 ( \Omega ) load, DC offset 0 V, amplitude setting 10 Vp-p/50 ( \Omega ), Rise and fall time: 20 ns and below</td>
</tr>
<tr>
<td>Duty</td>
<td>Overshoot: 5 % and below</td>
</tr>
<tr>
<td>( \perp ) Rise and fall time: 20 ns and below</td>
<td>Continuous oscillation, External AM off, 50 ( \Omega ) load, DC offset 0 V, amplitude setting 10 Vp-p/50 ( \Omega ),</td>
</tr>
<tr>
<td>( \perp ) (50 % fixed duty)</td>
<td>Rise and fall time: 20 ns and below</td>
</tr>
<tr>
<td>( \perp ) (duty variable)</td>
<td>Overshoot: 5 % and below</td>
</tr>
<tr>
<td>( \perp ) Up to 1 MHz: ±1 % of the period</td>
<td>Jitter: 30 nsp-p and below</td>
</tr>
<tr>
<td>( \perp ) 1 MHz to 10 MHz: ±3 % of the period</td>
<td></td>
</tr>
<tr>
<td>( \perp ) 10 MHz to 15 MHz: ±5 % of the period</td>
<td></td>
</tr>
</tbody>
</table>
8.2 Output voltage

- **Output voltage (FUNCTION OUT)**

  Output range: 10 V range / 1V range fixed, or automatic switchable

  **Amplitude**
  - **Range**
    - 10 V range : 0 mVp-p to 20.000 Vp-p/open
    - 1 V range : 0.0 mVp-p to 2.0000 Vp-p/open
  - **Resolution**
    - 10 V range : 1 mVp-p/open
    - 1 V range : 0.1 mVp-p/open
  - **Accuracy**
    - Continuous oscillation, external AM off, 1 kHz, rms value measured
    - 10 V range : ± [0.7% of amplitude setting (Vp-p) + 0.05 Vp-p]/open
    - 1 V range : ± [0.7% of amplitude setting (Vp-p) + 0.01 Vp-p]/open

  **DC offset**
  - **Range**
    - 10 V range : ±10.000 V/open
    - 1 V range : ±1.0000 V/open
  - **Resolution**
    - 10 V range : 1 mV/open
    - 1 V range : 0.1 mV/open
  - **Accuracy**
    - DC mode, External AM off, external add off
    - 10 V range : ± (0.5% of DC offset setting [V] + 0.07 V)/open
    - 1 V range : ± (0.5% of DC offset setting [V] + 0.01 V)/open
  - **Amplitude and DC offset limiting**
    - If output voltage exceeds the following value, the OVER light blinks and the output may be clipped.
    - 10 V range : 11 V/open
    - 1 V range : 1.1 V/open

  **Output impedance** 50 Ω, unbalanced

  **Load impedance** 45 Ω and more

  **Output connector** Front panel, BNC receptacle (FUNCTION OUT)

  **Others**
  - Output voltage can be set with high and low level buttons.

- **SYNC OUT Output voltage (SYNC OUT)**

  **Output voltage** 0/+5V (open)

  **Output waveform** .mods

  **Rise/fall time** 2.5 ns

  **Output impedance** 50 Ω, unbalanced

  **Load impedance** 45 Ω and more

  **Output connector** Front panel BNC receptacle (SYNC OUT)
8.3 Other functions

- **Burst**

  - **Oscillation modes**: Burst, gate, trigger and trig’d gate
    (Trig’d gate: gate on/off at each trigger)
  - **Mark wave number**: 0.5 to 500000.0, 0.5 cycles
    (The mark wave number is the oscillation wave number at the time of burst and trigger).
  - **Space wave number**: 0.5 to 500000.0, 0.5 cycles
    (Space wave number is the stop wave number at the time of burst).
  - **Phase**: Phase from oscillation stop to oscillation start
    - **Range**: $-1800.000^\circ$ to $+1800.000^\circ$
    - **Resolution**: 0.001°
  - **Trigger source**: Selectable internal trigger oscillator or external trigger input.
    Trigger can be applied from the panel keys or via remote control (GPIB or USB).
    The external trigger of CH1 can also be selected as the CH2 trigger source.
  - **External trigger**
    - **Polarity**: Trigger: Rising or falling edge selectable
      Gate: Positive or negative logic selectable.
      Trig’d gate: Rising or falling edge selectable
    - **Input level**: High level $\geq +3.9$ V, low level $\leq +1.6$ V
    - **Minimum pulse width**: 50 ns
    - **Input impedance**: At 10 kΩ, pull up to +5 V.
    - **Input connector**: Front panel BNC receptacle (TRIG/SWEEP IN)
  - **Internal trigger oscillator period**
    - **Range**: 1µs to 100.0 s
    - **Resolution**: 4 digits at 1 ms and more, 1 µs at less than 1 ms.
  - **Trigger delay**
    - **Range**: 0.3 µs to 100.00 s
    - **Resolution**: 5 digits at 1 ms and more, 0.1 µs at less than 1 ms.
    - Oscillation mode: Effective with trigger.
  - **Trigger jitter**: Less than 50 ns
  - **Oscillation stop level**
    - **On and off settable**
      - Off: stops at set phase.
      - On: stops at set stop level.
    - **Range**: $-100.0 \%$ (maximum negative output) to $+100.0 \%$ (maximum positive output)
    - **Resolution**: 0.01 %
8.3 Other functions

- **Sweep**

  **Sweep items**
  - Frequency, phase, amplitude, DC offset, and duty (duty variable)

  **Setting items**
  - Sweep start/stop or sweep center/span
  - Sweep marker, substitute sweep center for sweep marker
  - Sweep start and stop conditions

  **Sweep functions**
  - Continuous / single / gated sweep
  - LIN/LOG (LOG is available frequency only)

  **Sweeping time**
  - **Range**
    - 1 ms to 10000.000 s (during 2 channel independent, sweep or modulation of only one of the channels)
    - 2 ms to 10000.00 s (other times)
  - **Resolution**
    - 1 ms

  **Sweep trigger**
  - Indicates start of single / gated sweep.

  **Sweep trigger period**
  - 100 ms and more (If applying less than 100 ms, trigger is at 100 ms intervals).

  **Trigger source**
  - Selectable internal trigger oscillator or external trigger input.
  - Also, applicable from panel keys and via remote control (GPIB or USB)
  - The CH1 external trigger can also be selected for the CH2 trigger source.

  **External trigger**
  - **Polarity**
    - Selectable rise/fall.
  - **Input connector**
    - Front panel, BNC receptacle (TRIG/SWEEP IN)
  - **Minimum pulse width**
    - 200 ns
  - **Trigger delay**
    - 2 ms

  **Internal trigger oscillator period**
  - **Range**
    - 1 µs to 100.0 s
  - **Resolution**
    - 4 digits at 1 ms and more, 1 µs at less than 1 ms.

  **Oscillation stop level**
  - On/off setting effective during gated sweep.
  - (However, ineffective and fixed at off if the sweep item is duty)
  - Off: stop at set phase.
  - On: stop at set stop level.
  - **Range**
    - −100.00 % (maximum negative output) to +100.00 % (maximum positive output)
  - **Resolution**
    - 0.01 %
8.3 Other functions

- **Sweep input/output**

  **Sweep trigger input**
  - **Input level**: High level ≥ +3.9 V, low level ≤ +1.6 V
  - **Signal characteristic**: Single/gated sweep start at rising or falling edge (selectable)
  - **Minimum pulse width**: 200 ns.
  - **Input impedance**: At 10 kΩ, pulling up to +5 V
  - **Input connector**: Front panel, BNC receptacle (TRIG/SWEEP IN)

  **Synchronous sweep output**
  - **Output level**: 0/+5 V (open)
  - **Signal characteristics**: Low level: sweeping from start to stop
  - **(If sweep, high level for about 0.2 ms to 0.5 ms directly before quick change from stop to start.)**
  - **Output impedance**: 50 Ω, unbalanced
  - **Load impedance**: 45 Ω and more
  - **Output connector**: Front panel, BNC receptacle (SYNC OUT)

  **Sweep stop/restart input**
  - **Input level**: High level ≥ +3.9 V, low level ≤ +1.6 V
  - **Signal characteristic**: Low level: sweep interrupt
  - **Input impedance**: At 10 kΩ, pull up to +5 V.
  - **Input connector**: Rear panel, BNC receptacle (SWEEP PAUSE IN)

  **Sweep marker output**
  - **Output level**: 0/+5 V/open
  - **Signal characteristic**: Low level: exceeds marker during sweep.
  - **Output impedance**: 30 Ω, unbalanced
  - **Load impedance**: 1 kΩ and more
  - **Output connector**: Rear panel, BNC receptacle (SWEEP Z-MARKER OUT)

  **Sweep X-DRIVE output**
  - **Output level**: 0 V to +5 V/open
  - **Signal characteristics**: 0 V→+5 V: sweep value is increasing.
  - **Output impedance**: 1 kΩ, unbalanced
  - **Load impedance**: 10 kΩ and more
  - **Output connector**: Rear panel, BNC receptacle (SWEEP X-DRIVE OUT)
8.3 Other functions

- **Internal modulation functions**
  
  Modulation items: FM(FSK), PM(PSK), AM, DC offset modulation, PWM (-duty variable)
  
  Internal modulation frequency
  
  Range
  
  0.1 mHz to 500.00 Hz (during 2 channel independent, sweep or modulation of only one of the channels)
  
  0.1 mHz to 250.00 Hz (other times)
  
  Resolution
  
  5 digits at 1 Hz and more, 0.1 mHz at less than 1 Hz.
  
  Internal modulation waveform: \(\sim, \sim, \sim, \sim, \sim\)

- **External modulation functions**
  
  Modulation item: AM, DSB-SC AM, on/off selectable
  
  External modulation frequency: DC to 10 MHz
  
  External AM depth
  
  \(-3 \text{ V input: } -100\%.
  
  0 \text{ V input: } 50\% \text{ of the set amplitude}
  
  +1 \text{ V input: the set amplitude.}
  
  Input voltage range: \(-3\) to \(+1\) V
  
  Input impedance: 50 \(\Omega\)
  
  Input connector: Rear panel, BNC receptacle (EXT AM IN)

- **External add functions**
  
  External add: Add external signal to FUNCTION OUT signal
  
  On/off selectable
  
  External addition frequency: DC to 10 MHz
  
  External addition gain
  
  At no-load
  
  \(10 \text{ V range: } \times 2\)
  
  \(1 \text{ V range: } \times 0.2\)
  
  Input voltage range: \(\pm 5 \text{ V}\)
  
  Input impedance: 50 \(\Omega\)
  
  Input connector: Rear panel, BNC receptacle (EXT ADD IN)
### 8.3 Other functions

#### Channel operation

<table>
<thead>
<tr>
<th><strong>Channel modes</strong></th>
<th>2-channel independent/2 phase (same frequency)/fixed frequency ratio/fixed frequency difference/differential output (same frequency, amplitude, DC offset, reverse waveform)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Phase</strong></td>
<td>Common with start phase during burst, gate, trigger, triggered gate and gated sweep.</td>
</tr>
<tr>
<td><strong>Range</strong></td>
<td>(-1800.000^\circ) to (+1800.000^\circ) (not effective for the differential output).</td>
</tr>
<tr>
<td><strong>Resolution</strong></td>
<td>0.001°</td>
</tr>
<tr>
<td><strong>Time difference between channels</strong></td>
<td>Less than (\pm 10) ns during continuous oscillation, 50 Ω load, DC offset 0 V, amplitude setting 10 Vp-p/50 Ω, same waveform, 2-phase channel mode.</td>
</tr>
<tr>
<td><strong>Frequency difference</strong></td>
<td>Valid in fixed frequency difference mode. The frequency difference between CH2 and CH1 is set.</td>
</tr>
<tr>
<td><strong>Range</strong></td>
<td>0.00 (\mu)Hz to 14.99999999999999 MHz</td>
</tr>
<tr>
<td><strong>Resolution</strong></td>
<td>0.01 (\mu)Hz</td>
</tr>
<tr>
<td><strong>Frequency ratio</strong></td>
<td>Valid in fixed frequency ratio mode. The CH1 and CH2 frequency ratio is set in the form N:M.</td>
</tr>
<tr>
<td><strong>Range</strong></td>
<td>N and M are respectively 0000001 to 9999999.</td>
</tr>
<tr>
<td><strong>Resolution</strong></td>
<td>1 (Frequency resolutions are (N \times 0.01 , \mu\text{Hz}) and (M \times 0.01 , \mu\text{Hz}) respectively).</td>
</tr>
<tr>
<td><strong>Phase synchronization</strong></td>
<td>Manual or remote control (GPIB or USB) Automatic when changing channel mode.</td>
</tr>
<tr>
<td><strong>Simultaneous setting</strong></td>
<td>Function for making a setting for two channels simultaneously</td>
</tr>
<tr>
<td><strong>Others</strong></td>
<td>Copies the CH2 setting to CH1</td>
</tr>
<tr>
<td></td>
<td>Copies the CH1 setting to CH2</td>
</tr>
</tbody>
</table>

#### Setting initialization

<table>
<thead>
<tr>
<th><strong>Functions</strong></th>
<th>Initializes nearly all setting contents. Initialization settings, cf. “3.3 Basic operation (Initialization table)”, cf.</th>
</tr>
</thead>
</table>
8.3 Other functions

- **User-unit function**
  - Function: Converts to desired units for set up and display.
  - Setting items: Frequency, period, amplitude, DC offset, phase and duty.
  - Coefficient setting: Select either \([(\text{internal set up}) + n] \times m\), or \[\log_{10} (\text{internal set up}) + n] \times m\); then, set the value of n and m.
  - Frequency and period: 15 digits mantissa and 1 digit index (both m and n)
  - Amplitude, DC offset, and duty: 6 digits mantissa and 1 digit index (m and n)
  - Phase: 7 digits mantissa and 1 digit index
  - Unit character string: Alphanumeric and 34 symbols
    - Set up and display up to 4 characters.

- **Load function**
  - Function: Set up and display at actual voltage for an arbitrary load
  - Conversion formula:
    \[
    \frac{(\text{Output voltage at load})}{(\text{Output voltage at no-load})} \times (\text{Load impedance}) = \frac{(\text{Output impedance : 50} \Omega)}{(\text{Load impedance})} + (\text{Load impedance})
    \]
  - Load impedance:
    - Range: 45 Ω to 999 Ω
    - Resolution: 1 Ω

- **Output on/off**
  - Function: Output switched on/off
  - Power on state: Selectable return to the state when the power supply was switched off or output on/off state.

- **Setting memory, Backup**
  - Setting memory: Nearly all setting items can be stored and recalled.
    - 10 sets from 0 to 9
  - Backup: Battery back up for nearly all settings prior to power off.
  - Backup period: Three years and more under normal temperature.
  - Battery: Lithium cell
  - Operation when battery depleted:
    - Error at power on and settings are initialized.
    - Setting memory and arbitrary waveform memory are initialized.
    - Battery needs replacement (fee charged)
8.4 Initialized settings

- **Initialized settings**
  
  "3.3 Basic operation (Initialization table)", cf.

- **Error from backup battery depletion**

  In addition to setting initialization, following are set:

  - Output on/off: Off
  - Output on/off in turning on: LAST-STATE (condition just before power off)
  - Setting memory: All NOT STORED
  - Setting memory comment: " " (blank)
  - User unit name: USER
  - User unit computation formula: (h+n)*m
  - User unit coefficient: 1
  - User unit offset: 0
  - Arbitrary waveform selection: 0:ARB_00
  - Arbitrary waveform name: ARB_00 ~ ARB_11
  - Arbitrary waveform data size: 8 K
  - Arbitrary waveform data: All 0
  - Remote control interface: GPIB
  - GPIB address: 2
  - GPIB delimiter: CR+LF
  - USB ID: 2
8.5 Remote control

- **GPIB interface**

  GPIB function
  - SH1 All source handshake functions
  - AH1 All acceptor handshake functions
  - T6 Basic talker, serial poll, talker release by MLA
  - L4 Basic listener, listener release by MTA
  - SR1 All service request functions
  - RL1 All remote/local functions
  - PP0 No parallel poll functions
  - DC1 All device clear functions
  - DT1 All device trigger functions
  - C0 No controller functions

  Use code
  - ISO 7 bit codes (ASCII code)

  Address
  - 0 to 30 (set from panel)

  Output driver
  - DIO1-8, NDAC, NRFD and SRQ : Open collector
  - DAV and EOI : three state

  GPIB parameters
  - GPIB address (0 to 30), delimiter in transmission (CR/LF+EOI, CR+EOI, LF+EOI)

  Cancellation of remote state
  - Remote state can be canceled by LOCAL key.
    (Except for Local Lockout)

  Connector
  - Rear panel, IEEE 488 (24-pins) connector

- **USB interface**

  USB1.1 full speed
8.6 Options

- **1991 synchronous operation option**
  Function: Function for performing synchronous operation with WF19 series units *1
  Time difference: 1991 is required all synchronous operation.
  Under condition of continuous oscillations, external AM off, 50 Ω load, DC offset 0 V and amplitude setting 10 Vp-p/50 Ω, phase synchronization after setting same waveform and frequency.
  The time difference among the equipment: (±25 ns + 10 ns/unit) and below.
  Others: The cable for connecting multiple WF19 series units (*1) is optional. (1994 synchronous operation cable)

- **1994 synchronous operation cable**
  Optional cable for 1991 synchronous operation used to connect multiple WF19 series units *1
  Connection of n WF19 series units (*1) requires (n-1) 1994 synchronous operation cables.

- **1992A digital output option**
  Function: Output digital signal applied to waveform D/A.
  Upper 15 bits of the 16-bit waveform data and the clock are output.
  Data format: The relation between arbitrary waveform data setting and output data is as follows:

<table>
<thead>
<tr>
<th>Arbitrary waveform data</th>
<th>Output data</th>
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<tr>
<td>ARB and :Data:DAC commands</td>
<td>ARW and :Data:DAC:WORD commands</td>
</tr>
<tr>
<td>+16383</td>
<td>+32766, +32767</td>
</tr>
<tr>
<td>+16382</td>
<td>+32764, +32765</td>
</tr>
<tr>
<td>+16381</td>
<td>+32762, +32763</td>
</tr>
<tr>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>+2</td>
<td>+4, +5</td>
</tr>
<tr>
<td>+1</td>
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</tr>
<tr>
<td>0</td>
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<td>-1</td>
<td>-2, -1</td>
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<tr>
<td>-2</td>
<td>-4, -3</td>
</tr>
<tr>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>-16382</td>
<td>-32764, -32763</td>
</tr>
<tr>
<td>-16383</td>
<td>-32766, -32765</td>
</tr>
<tr>
<td>-16384</td>
<td>-32768, -32767</td>
</tr>
</tbody>
</table>

  Accessory: Digital output cable: One

8.7 General items

- **Input/output ground**
  The ground of FUNCTION OUT, SYNC OUT, EXT AM IN and EXT ADD IN are floating from the chassis, within 1 channel these four signal input/output grounds are common. Signal ground withstand voltage: ±42 Vpeak, 30 Vrms (DC to 20 kHz, continuous) Individually for CH1 and CH2.
  All other signal input/output grounds are connected to the chassis.

- **Power supply**
  - Power supply voltage range: AC100 V/115 V/230 V
  - Power supply frequency range: 50/60 Hz ± 2 Hz
  - Power supply fuse: Time lag 2 A (100 V/115 V) or time lag 1 A (230 V)
  - Power consumption: 100 VA and below
  - Over voltage cat.: II

- **Cooling**
  Forced-air cooling, rear exhaust

- **Setup condition**
  Horizontal (Within 10 °)

- **Environmental conditions**
  Ambient temperature and humidity range
  - Performance guarantee: +5 to +35 °C, 5 to 85%RH (no condensation at an absolute humidity of 1 to 25 g/m³)
  - Storage: -10 to +50 °C, 5 to 95%RH (no condensation at an absolute humidity of 1 to 29 g/m³)
  - Pollution degree: 2

- **Insulation resistance**
  20 MΩ and more (DC 500 V, power input lines versus chassis).

- **Withstand voltage**
  AC 1500 V (power input lines versus chassis).
8.7 General items

- **Dimensions**
  216(W) × 132.5(H) × 290(D) mm (Excluding protrusions).

- **Mass**
  Mainframe excluding attachments, options, etc.
  Approx. 4.6 kg

- **Safety standard**
  EN61010-1: 2001

- **EMC**
  However, the performance criteria for the following standards are as follows:
  EN61000-4-2(1995):C
8.7 General items

- **External drawing**

  [Diagram of the external drawing with dimensions and labels for surface preparation, front panel, frame, and cover details.]

  - Surface preparation: Plastic sheet, Black4C
  - Frame: Painting, Metallic gray
  - Cover: Polyvinyl chloride metal laminated plate, Metallic gray
Front and rear panel indications (alphabetical order).

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