WF1945B
MULTIFUNCTION
SYNTHESIZER
Instruction Manual
Foreword

Thank you very much for procuring the WF1945B 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:

Ground indication:

Indicates connector housing and signal ground is connected to a chassis ground.

ON:

Indicates power switch on state.

OFF:

Indicates power switch off state.
Contents

- Foreword ....................................................................................................................... i
- Safety Precautions ....................................................................................................... ii

Section 1  Overview ........................................................................................................ 1-1
  1.1 Features .................................................................................................................... 1-2
  1.2 Operating principles .................................................................................................. 1-3
    - Block diagram ........................................................................................................... 1-3
  1.3 Function outline ....................................................................................................... 1-4
    - Function tree ............................................................................................................ 1-4

Section 2  Preparation ..................................................................................................... 2-1
  2.1 Check before using ................................................................................................... 2-2
    - Safety check ............................................................................................................. 2-2
    - Unpacking and repacking ....................................................................................... 2-2
  2.2 Power source and grounding .................................................................................... 2-4
    - Grounding ................................................................................................................ 2-4
    - Line filter ................................................................................................................. 2-4
    - Power source .......................................................................................................... 2-4
    - Power supply fuse ................................................................................................... 2-6
  2.3 Installation ................................................................................................................. 2-7
    - Cautions .................................................................................................................. 2-7
    - Installation conditions ............................................................................................ 2-7
    - Panel and case cleaning ......................................................................................... 2-7
  2.4 Conformable standards ............................................................................................ 2-8
  2.5 Calibration ................................................................................................................ 2-9

Section 3  Basic Operation ............................................................................................. 3-1
  3.1 Panel description ....................................................................................................... 3-2
    - Front panel ............................................................................................................... 3-3
    - Rear panel ................................................................................................................. 3-4
  3.2 Input and output connectors ...................................................................................... 3-5
    - Waveform output (FUNCTION OUT) ........................................................................ 3-5
    - Sync signal output (SYNC OUT) ............................................................................ 3-6
    - Trigger/sweep input (TRIG/SWEEP IN) ................................................................. 3-9
    - Sweep stop/restart input (SWEEP PAUSE IN) ......................................................... 3-10
    - Sweep X-drive output (SWEEP X-DRIVE OUT) ..................................................... 3-10
Contents

- Sweep marker output (SWEEP Z-MARKER OUT) ........................................ 3-11
- External add input (EXT ADD IN) ......................................................... 3-11
- External AM input (EXT AM IN) ........................................................ 3-12
- Synchronous operation input and output (φ-SYNC IN, OUT) .................. 3-12
- Digital output (DIGITAL OUT) ............................................................ 3-14

3.3 Basic operation .................................................................................. 3-16
- Setting initialize (PRESET) ................................................................. 3-16
- Oscillation mode selection ................................................................. 3-19
- Waveform selection ........................................................................... 3-20
- Frequency setting ................................................................................ 3-23
- Amplitude setting ............................................................................... 3-24
- DC offset setting .................................................................................. 3-25
- Phase setting ....................................................................................... 3-26
- Output on/off ....................................................................................... 3-27
- Operation tree ..................................................................................... 3-28

Section 4 Applications ........................................................................... 4-1

4.1 Burst oscillation .................................................................................. 4-2
- Burst oscillation (Type: Burst) ............................................................. 4-2
- Burst oscillation (Type: Trigger) ......................................................... 4-5
- Burst oscillation (Type: Gate) .............................................................. 4-9
- Burst oscillation (Type: Triggered Gate) ............................................ 4-13

4.2 Sweep ................................................................................................ 4-16
- Sweep (Mode: Single) ........................................................................... 4-16
- Sweep (Mode: Continuous) ................................................................. 4-22
- Sweep (Mode: Gated) ........................................................................... 4-27
- CENTER, SPAN, MARKER, MKR  →  CTR .............................................. 4-34
- Summary of the sweep setting items ................................................... 4-35
- Sweep (modulation) steps and step width ............................................ 4-36
- Sweep value and Z-MARKER/SYNC/X-DRIVE outputs ..................... 4-38

4.3 Modulation ......................................................................................... 4-40
- Frequency modulation (FM) ............................................................... 4-40
- Amplitude modulation (AM) ............................................................... 4-43
- DC offset modulation (OFSM) ............................................................. 4-46
- Phase modulation (PM) ....................................................................... 4-49
- Pulse width modulation (PWM) ......................................................... 4-52

4.4 Arbitrary Waveform ......................................................................... 4-55
- Arbitrary waveform (ARB) ................................................................. 4-55
4.5 Selecting waveforms of synchronous signals (SYNC OUT) ........................................ 4-60
- Procedure ............................................................................................................. 4-60
- When the oscillation mode is BURST ................................................................. 4-60
- When the oscillation mode is SWEEP ................................................................. 4-61
- When the oscillation mode is MODU ................................................................. 4-61
- Additional information: ....................................................................................... 4-62

4.6 Output waveforms for sweeping and modulation ............................................. 4-63

4.7 Equivalent noise bandwidth ............................................................................. 4-65

5.1 Convenient Settings ......................................................................................... 5-2
- Frequency [Hz] setting by period [s] .................................................................. 5-2
- Squarewave duty setting ...................................................................................... 5-3
- Squarewave pulse width setting ......................................................................... 5-4
- Amplitude and DC offset setting by high and low level ...................................... 5-5

5.2 Units ................................................................................................................ 5-7
- Engineering unit (µ, m, k, M) display ................................................................. 5-7
- Amplitude units change ....................................................................................... 5-8
- User-unit setting ................................................................................................ 5-9

5.3 Setting memory ................................................................................................ 5-13
- Setting store .......................................................................................................... 5-13
- Setting recall ........................................................................................................ 5-14
- Setting memory clear ........................................................................................ 5-15

5.4 External Input ................................................................................................ 5-16
- External add (EXT-ADD) ................................................................................... 5-16
- External AM (EXT-AM) ....................................................................................... 5-17

5.5 Other settings .................................................................................................. 5-18
- Output range change (use with fixed range) ..................................................... 5-18
- Output on/off at power on .................................................................................. 5-19
- LOAD function (equalize setting and output values) ...................................... 5-20
- UNDO function .................................................................................................. 5-21
- Pulse generator function ..................................................................................... 5-22
- Phase sync ............................................................................................................ 5-24

6.1 Error message .................................................................................................. 6-2
- Power on error ..................................................................................................... 6-2
- Operation error .................................................................................................... 6-3
6.2 Suspected failure ................................................................. 6-5
  ■ In case of abnormality ......................................................... 6-5

Section 7 Maintenance ............................................................... 7-1
7.1 Outline ............................................................................... 7-2
  ■ Work contents ................................................................. 7-2
  ■ Required test instruments ................................................... 7-2
7.2 Operation checks ............................................................... 7-3
  ■ Preparatory checks ............................................................ 7-3
  ■ Function checks .............................................................. 7-3
7.3 Performance tests .............................................................. 7-5
  ■ Performance tests ............................................................ 7-5
  ■ Preparatory checks ............................................................ 7-5
  ■ Test preparation ............................................................... 7-5
  ■ Frequency accuracy .......................................................... 7-5
  ■ Amplitude accuracy .......................................................... 7-6
  ■ DC offset accuracy ............................................................ 7-6
  ■ Amplitude vs. frequency characteristics ............................... 7-7
  ■ Sinewave distortion ........................................................... 7-7
  ■ Squarewave response ....................................................... 7-8
  ■ Duty factor ......................................................................... 7-8

Section 8 Specifications ............................................................. 8-1
8.1 Waveform and output characteristics .................................... 8-2
8.2 Output voltage ................................................................... 8-4
8.3 Other functions ................................................................... 8-5
8.4 Initialized settings ............................................................. 8-10
8.5 Remote control ................................................................. 8-11
8.6 Options ............................................................................. 8-12
8.7 General items ..................................................................... 8-13
  ■ External drawing ............................................................... 8-14

Index ......................................................................................... Index
Section 1  Overview

1.1 Features ........................................................................................................................................1-2
1.2 Operating principles .....................................................................................................................1-3
  ■ Block diagram ..............................................................................................................................1-3
1.3 Function outline ............................................................................................................................1-4
  ■ Function tree ................................................................................................................................1-4
1.1 Features

The WF1945B Wave Factory is a multifunctional synthesizer based on the direct digital synthesizer (DDS) system.
The WF1945B is single channel, but the series also includes the 2-channel WF1946B, the single-channel WF1943B with basic functions, and the 2-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 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.
- The 1991 synchronous operation option enables synchronized operation of multiple units and operation as an oscillator with increased number of channels.
- The 1992A 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.
- 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

- **Function tree**

  - **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 (\(\sim\)), triangle waveform (\(\sim\)), squarewave (\(\Delta\), 50% fixed duty), squarewave (\(\Delta\), variable duty), rising sawtooth (\(\nearrow\)), descending sawtooth (\(\searrow\)), 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 WF1945B is capable of 10 combinations store/recall.

• **Computer control**
  Remote control (GPIB or USB) enables external control from a personal computer.
1.3 Function outline

■ Function tree

Output
  - Output on/off
  - 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
      - arbitrary waveform (ARB)
  - Noise
    - DC
  - Waveform
    - (50 % fixed duty), (variable duty), arbitrary waveform (ARB)
  - Voltage
    - Output range
    - Gain 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
  - Oscillation start phase
- User units

Setting contents

- Save/recall/clear
- 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
Section 2  Preparation

2.1 Check before using ................................................................. 2-2
   ■ Safety check ...................................................................... 2-2
   ■ Unpacking and repacking ............................................... 2-2
2.2 Power source and grounding ..................................................... 2-4
   ■ Grounding ........................................................................ 2-4
   ■ Line filter .......................................................................... 2-4
   ■ Power source ...................................................................... 2-4
   ■ Power supply fuse ............................................................ 2-6
2.3 Installation .............................................................................. 2-7
   ■ Cautions ............................................................................ 2-7
   ■ Installation conditions ....................................................... 2-7
   ■ Panel and case cleaning .................................................... 2-7
2.4 Conformable standards ............................................................ 2-8
2.5 Calibration ........................................................................... 2-9
2.1 Check before using

■ Safety check
Before using the WF1945B, 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>
</tr>
</thead>
<tbody>
<tr>
<td>Mainframe</td>
<td>1</td>
</tr>
<tr>
<td>Instruction 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: 1 A or 230 V: 0.5 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.
2.1 Check before using

■ 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.

   | Supplied accessory                              |
   | Digital output cable (1 meter) | 1               |
2.2 Power source and grounding

GROUNDING

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 WF1945B 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 WF1945B uses a line filter that incorporates the circuit below.

Because the maximum leakage current is 0.5 mAm at 250 V/62 Hz, touching a metallic part of the WF1945B could cause an electric shock.

For your safety, be sure to ground the device.

POWER SOURCE

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 WF1945B.
Check the power source voltage indication on the rear panel above the power source inlet. The WF1945B 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. 65 VA
- Overvoltage category: II

Connect to the power source according to the following procedure:
1. Set the WF1945B 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 WF1945B 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.
2.2 Power source and grounding

- 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 1 A (100/115 V) or time lag 0.5 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 WF1945B.

- 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 WF1945B 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.
2.4 Conformable standards

The WF1945B conforms to the following standards.

Safety:  EN 61010-1: 2001

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

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 (S WEEP 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 (φ-SYNC IN, OUT)
- Digital output (DIGITAL OUT)

3.3 Basic operation

- Setting initialize(PRESET)
- 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

P R E S E T

S Y S T E M : R A N G E  P R E S E T  U S E R - U N I T

Fully lighted (bold)  Dimly lighted
3.1 Panel description

This section describes the indications and functions of the front and rear panels of the WF1945B.
3.1 Panel description

- **Front panel**

- Lamp lights to indicate output range. When the range is set for automatic switching, the Auto lamp lights.
- The OVER lamp lights when the output voltage exceeds the upper limit (page 3-5).
- Lamp lights to indicate present oscillation mode and waveform selection.
- Lamp lights to indicate output range. When the range is set for automatic switching, the Auto lamp lights (page 5-18). The OVER lamp flashes when the output voltage exceeds the upper limit (page 3-5).
- Waveform output connector (page 3-5)
- Trigger/swEEP input connector (page 3-9)
- Sync signal output connector (page 3-6)
- Memory save, recall, etc. (page 5-13)
- Power on/off. Depress for power on, press and release to raised position for power off.
- Frequency and amplitude setting (pages 3-21 to 3-23)
- Oscillation mode selection (page 3-19)
- Displays frequency, amplitude, offset and load impedance settings, in addition to information to assist when setting.
- Lamps light to indicate present oscillation mode and waveform selection.
- Lamp lights to indicate output range. When the range is set for automatic switching, the Auto lamp lights (page 5-18). The OVER lamp flashes when the output voltage exceeds the upper limit (page 3-5).
- Output waveform on/off. Key lamp lights when on, extinguishes when off.
- Key button, top or bottom lamps light only for operable keys.
- When Modify lamp lights, turn dial to set values or parameters.
- Return to the previous step.
- Undo key (page 5-21)
- Setting initialize (page 3-16), output range setting (page 5-18), user unit setting (page 5-9)
- Waveform select (page 3-20)
- Press to enter, e.g., a numerical input.
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 flashes 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. "5.4 Other settings (■LOAD function (equalize setting and output values))", cf.
3.2 Input and output connections

**Sync signal output (SYNC OUT)**

- **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
3.2 Input and output connections

2. Triangular, rising sawtooth, descending sawtooth, arbitrary

- Triangular
- Rising sawtooth
- Descending sawtooth
- Arbitrary

FUNCTION OUT
- Triangular
- Rising sawtooth
- Descending sawtooth
- Arbitrary

SYNC OUT

Jitter = 25 ns p-p

3. Squarewave (fixed 50 % duty)

FUNCTION OUT
- Approx. 15ns

SYNC OUT

Approximately 25 ns p-p jitter is also produced in the FUNCTION OUT waveform when stop level is On or 100 kHz and below.

4. Squarewave (variable duty)

FUNCTION OUT
- Appendix. 14ns

SYNC OUT

Jitter = 25 ns p-p

Approximately 25 ns p-p jitter is also produced in the FUNCTION OUT waveform.
3.2 Input and output connections

(2) Burst mode (BURST)

![Burst mode diagram](image)

(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.
3.2 Input and output connections

**Trigger/sweep input (TRIG/SWEEP IN)**

- **Signal characteristics:**
  - Trigger: Select oscillation start for either $f$ or $g$.
  - Gate: Select oscillation at either high or low level.
  - Triggered gate: Oscillation start/stop at $f$ or $g$. Select either.
  - Minimum pulse width is 50 ns.
  - In sweep oscillation mode, the sweep starts at $f$ or $g$. 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**

  - (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 WF1945B input.
3.2 Input and output connections

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

  ![Diagram of SWEEP PAUSE IN](image)

  Signal characteristics:
  - Low level: sweep pause
  - High level: sweep restart
  
  Input voltage:
  - High level ≥ +3.9 V
  - Low level ≤ +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.

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

  ![Diagram of SWEEP X-DRIVE OUT](image)

  Signal characteristics:
  - 0 to +5 V: sweep increase
  - +5 to 0 V: sweep decrease
  
  Output voltage: 0 to +5 V (open)
  
  Output impedance: Approx. 1 kΩ
  
  Recommended load: Above 10 kΩ
  
  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)**

- **Signal characteristics:**
  - Low level: sweep greater than marker
  - High level: other times
- **Output voltage:** TTL level, 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)**

- **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)**

  Input voltage: -3 V 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)

  Do not connect.

  **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 to Slave. 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. The WF1945B, WF1946B, WF1945A, WF1946A, WF1965, WF1966, WF1945 (1945), WF1946 (1946), and WF1956 (1956) equipped with the 1991 can be connected.

  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]

  Drain line of the DIGITAL OUT connector’s housing and 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. Lease unused signal lines open.
  When the drain line is connected to the target signal ground, the WF1945B 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>Conne ct ion</th>
<th>Mark color</th>
<th>Mark quantity</th>
<th>Insulation color</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output control</td>
<td>Signal Red</td>
<td></td>
<td>3</td>
<td>White</td>
</tr>
<tr>
<td></td>
<td>GND Black</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D15 (MSB)</td>
<td>Signal Red</td>
<td></td>
<td>2</td>
<td>Orange</td>
</tr>
<tr>
<td></td>
<td>GND Black</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D14</td>
<td>Signal Red</td>
<td></td>
<td>3</td>
<td>Yellow</td>
</tr>
<tr>
<td></td>
<td>GND Black</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D13</td>
<td>Signal Red</td>
<td></td>
<td>1</td>
<td>Pink</td>
</tr>
<tr>
<td></td>
<td>GND Black</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D12</td>
<td>Signal Red</td>
<td></td>
<td>2</td>
<td>Pink</td>
</tr>
<tr>
<td></td>
<td>GND Black</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D11</td>
<td>Signal Red</td>
<td></td>
<td>2</td>
<td>Yellow</td>
</tr>
<tr>
<td></td>
<td>GND Black</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D10</td>
<td>Signal Red</td>
<td></td>
<td>3</td>
<td>Pink</td>
</tr>
<tr>
<td></td>
<td>GND Black</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D09</td>
<td>Signal Red</td>
<td></td>
<td>1</td>
<td>Yellow</td>
</tr>
<tr>
<td></td>
<td>GND Black</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D08</td>
<td>Signal Red</td>
<td></td>
<td>3</td>
<td>Orange</td>
</tr>
<tr>
<td></td>
<td>GND Black</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Signal</th>
<th>Conne ct ion</th>
<th>Mark color</th>
<th>Mark quantity</th>
<th>Insulation color</th>
</tr>
</thead>
<tbody>
<tr>
<td>D07</td>
<td>Signal Red</td>
<td></td>
<td>2</td>
<td>White</td>
</tr>
<tr>
<td></td>
<td>GND Black</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D06</td>
<td>Signal Red</td>
<td></td>
<td>4</td>
<td>Orange</td>
</tr>
<tr>
<td></td>
<td>GND Black</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D05</td>
<td>Signal Red</td>
<td></td>
<td>1</td>
<td>White</td>
</tr>
<tr>
<td></td>
<td>GND Black</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D04</td>
<td>Signal Red</td>
<td></td>
<td>3</td>
<td>gray</td>
</tr>
<tr>
<td></td>
<td>GND Black</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D03</td>
<td>Signal Red</td>
<td></td>
<td>2</td>
<td>gray</td>
</tr>
<tr>
<td></td>
<td>GND Black</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D02</td>
<td>Signal Red</td>
<td></td>
<td>4</td>
<td>gray</td>
</tr>
<tr>
<td></td>
<td>GND Black</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D01 (LSB)</td>
<td>Signal Red</td>
<td></td>
<td>1</td>
<td>gray</td>
</tr>
<tr>
<td></td>
<td>GND Black</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clock</td>
<td>Signal Red</td>
<td></td>
<td>4</td>
<td>White</td>
</tr>
<tr>
<td></td>
<td>GND Black</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Not used</td>
<td>Signal Red</td>
<td></td>
<td>1</td>
<td>Orange</td>
</tr>
<tr>
<td></td>
<td>GND Black</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chassis ground</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Drain line</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

  - 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**

  ![Diagram](image1)
  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**

  ![Diagram](image2)
  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:**
  - \([\text{duty 50% fixed}]\): Data corresponding to \(\text{~} \) is output.
  - \([\text{variable duty}]\): Data to be output is undefined.
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 instruction 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).

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>MODE → BURST</td>
<td>TYPE</td>
<td>NORMAL</td>
<td></td>
</tr>
<tr>
<td>SOURCE</td>
<td>EXT</td>
<td>BURST (1 ms, at INT)</td>
<td></td>
</tr>
<tr>
<td>DELAY</td>
<td>0.3 μs</td>
<td>When TYPE=TRIG, GATE,T-GATE</td>
<td></td>
</tr>
<tr>
<td>MARK</td>
<td>1.0</td>
<td>When TYPE=BURST, TRIG</td>
<td></td>
</tr>
<tr>
<td>SPACE</td>
<td>1.0</td>
<td>When TYPE=BURST</td>
<td></td>
</tr>
<tr>
<td>STOP-LEVEL</td>
<td>OFF  (0 %, at ON).</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MODE → SWEEP</td>
<td>TYPE</td>
<td>FREQ</td>
<td></td>
</tr>
<tr>
<td>SOURCE</td>
<td>EXT</td>
<td>When MODE=SINGLE, GATED</td>
<td></td>
</tr>
<tr>
<td>MODE</td>
<td>SINGLE</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FUNCTION</td>
<td>LIN</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TIME</td>
<td>1 s</td>
<td></td>
<td></td>
</tr>
<tr>
<td>STOP-LEVEL</td>
<td>OFF  (0%, at ON).</td>
<td>When MODE=GATED</td>
<td></td>
</tr>
<tr>
<td>MODE → SWEEP, TYPE=FREQ</td>
<td>START</td>
<td>1000 Hz</td>
<td></td>
</tr>
<tr>
<td>STOP</td>
<td>10000 Hz</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CENTER</td>
<td>5500 Hz</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SPAN</td>
<td>9000 Hz</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MARKER</td>
<td>5000 Hz</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MODE → SWEEP, TYPE=AMPTD</td>
<td>START</td>
<td>0.1 Vp-p</td>
<td></td>
</tr>
<tr>
<td>STOP</td>
<td>1 Vp-p</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CENTER</td>
<td>0.55 Vp-p</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SPAN</td>
<td>0.9 Vp-p</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MARKER</td>
<td>0.5 Vp-p</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MODE → SWEEP, TYPE=OFFSET</td>
<td>START</td>
<td>0.1 V</td>
<td></td>
</tr>
<tr>
<td>STOP</td>
<td>−0.1 V</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CENTER</td>
<td>0 V</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SPAN</td>
<td>0.2 V</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MARKER</td>
<td>0 V</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MODE → SWEEP, TYPE=PHASE</td>
<td>START</td>
<td>−90 deg</td>
<td></td>
</tr>
<tr>
<td>STOP</td>
<td>90 deg</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CENTER</td>
<td>0 deg</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SPAN</td>
<td>180 deg</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MARKER</td>
<td>0 deg</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MODE → SWEEP, TYPE=DUTY</td>
<td>START</td>
<td>40 %</td>
<td></td>
</tr>
<tr>
<td>STOP</td>
<td>60 %</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CENTER</td>
<td>50 %</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SPAN</td>
<td>20 %</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MARKER</td>
<td>50 %</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Continued next page
### 3.3 Basic operation

Continued from previous page

<table>
<thead>
<tr>
<th>Key operation</th>
<th>Menu</th>
<th>Initial settings</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>MODE → MODU</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>MODE → MODU, TYPE=FM</td>
<td>DEVIATION</td>
<td>1000 Hz</td>
<td></td>
</tr>
<tr>
<td>MODE → MODU, TYPE=AM</td>
<td>DEPTH</td>
<td>50 %</td>
<td></td>
</tr>
<tr>
<td>MODE → MODU, TYPE=OFSM</td>
<td>DEVIATION</td>
<td>0.2 V</td>
<td></td>
</tr>
<tr>
<td>MODE → MODU, TYPE=PM</td>
<td>DEVIATION</td>
<td>90 deg</td>
<td></td>
</tr>
<tr>
<td>MODE → MODU, TYPE=PWM</td>
<td>DEVIATION</td>
<td>20 %</td>
<td></td>
</tr>
<tr>
<td>ENTRY → FREQ</td>
<td></td>
<td>1000 Hz</td>
<td></td>
</tr>
<tr>
<td>ENTRY → AMPTD</td>
<td></td>
<td>0.1 Vp-p</td>
<td></td>
</tr>
<tr>
<td>ENTRY → OFFSET</td>
<td></td>
<td>0 V</td>
<td></td>
</tr>
<tr>
<td>ENTRY → PHASE</td>
<td></td>
<td>0 deg</td>
<td></td>
</tr>
<tr>
<td>ENTRY → WIDTH</td>
<td></td>
<td>0.0005 s</td>
<td>In case of FUNCTION= π</td>
</tr>
<tr>
<td>ENTRY → DUTY</td>
<td></td>
<td>50 %</td>
<td>In case of FUNCTION= π</td>
</tr>
<tr>
<td>ENTRY → PERIOD</td>
<td></td>
<td>0.001 s</td>
<td></td>
</tr>
<tr>
<td>ENTRY → HIGH</td>
<td></td>
<td>0.05 V</td>
<td></td>
</tr>
<tr>
<td>ENTRY → LOW</td>
<td></td>
<td>−0.05 V</td>
<td></td>
</tr>
<tr>
<td>FUNCTION</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SYSTEM</td>
<td>RANGE</td>
<td>AUTO</td>
<td></td>
</tr>
<tr>
<td></td>
<td>LOAD</td>
<td>OPEN (50 ohms at SET)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>EXT-AM</td>
<td>OFF</td>
<td></td>
</tr>
<tr>
<td></td>
<td>EXT-ADD</td>
<td>OFF</td>
<td></td>
</tr>
<tr>
<td></td>
<td>DUTY-VALID</td>
<td>IMMED</td>
<td></td>
</tr>
<tr>
<td></td>
<td>SYNC-OUT</td>
<td>STATE</td>
<td></td>
</tr>
</tbody>
</table>
3.3 Basic operation

- 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

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
- \( \approx \) : Triangular wave
- \( \sqcap \) : Squarewave (50 % fixed duty)
- \( \sqcup \) : 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 the 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 \( \approx \) key.
   The \( \approx \) STATUS lamp lights

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

Other:
In 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.
3.3 Basic operation

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
3.3 Basic operation

- 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.

```
IMMED  CYCLE  EXPAND
SYSTEM:  øSYNC  DUTY-VALID
```

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.

   **Frequency**
   
   ![Frequency Display]

   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.
### Amplitude setting

Amplitude setting (AMPTD) 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.
   2. Press the `2` key, then the `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.  
  - “5.2 Units”, cf.
- 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.
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
   OFS     +0.0000 V
   1.000000000kHz  A2.0000Vp-p/OPEN

   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.

**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.

   ![](image)

   Frequency | Amplitude
   --- | ---
   1. 0000000000kHz | A2. 0000Vp-p/OPEN

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

The lamp lights when on, extinguishes when off.
### Operation tree

- **OUTPUT**
  - Output on/off

- **MODE**
  - 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)
  - * 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, ∨/∧/├/├/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

SWEEP Operation
- START / STOP / PAUSE

MODU

Menu (Internal modulation)
- TYPE (Modulation type) [FM/AM/OFSM/PM/PWM]
- DEVIATION  * DEPTH for TYPE: AM
- FREQ (Modulation frequency)
- FUNCTION (Modulated waveform) [SIN/∧/┌/┐/┐]

MODU Operation
- START / STOP

ENTRY

--- Main operation
- FREQ / AMPTD / OFFSET / PHASE / DUTY / WIDTH / PERIOD / HIGH / LOW

* DUTY/WIDTH for FUNCTION: ┌
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 (Selection of data size of arbitrary waveform)

**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
    - SCALE (Multiplier)
    - OFFSET
  - LOAD (LOAD function)
  - EXT-AM (Selection of external AM)
  - EXT-ADD (Selection of external addition)
  - φ SYNC (Phase synchronization)
  - DUTY-VALID (Duty)
  - POWER-ON (Output state selection at power-on)
  - REMOTE (Remote control menu)
    - 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 / BS

**Numeric modification (Modify)**

- + / - / / MODIY
Section 4  Applications

4.1 Burst oscillation

- Burst oscillation (Type: Burst) .................................................. 4-2
- Burst oscillation (Type: Trigger) ................................................ 4-5
- Burst oscillation (Type: Gate) .................................................... 4-9
- Burst oscillation (Type: Triggered Gate) .................................. 4-13

4.2 Sweep

- Sweep (Mode: Single) ............................................................ 4-16
- Sweep (Mode: Continuous) .................................................... 4-22
- Sweep (Mode: Gated) ............................................................. 4-27
- CENTER, SPAN, MARKER, MKR → CTR ................................ 4-34
- Summary of the sweep setting items ...................................... 4-35
- Sweep (modulation) steps and step width ............................... 4-36
- Sweep value and Z-MARKER/SYNC/X-DRIVE outputs .......... 4-38

4.3 Modulation

- Frequency modulation (FM) .................................................... 4-40
- Amplitude modulation (AM) .................................................... 4-43
- DC offset modulation (OFSM) ................................................ 4-46
- Phase modulation (PM) .......................................................... 4-49
- Pulse width modulation (PWM) .............................................. 4-52

4.4 Arbitrary Waveform

- Arbitrary waveform (ARB) ...................................................... 4-55

4.5 Selecting waveforms of synchronous signals (SYNC OUT)

- Procedure ................................................................. 4-60
- When the oscillation mode is BURST .................................... 4-60
- When the oscillation mode is SWEEP .................................... 4-61
- When the oscillation mode is MODU ..................................... 4-61
- Additional information ....................................................... 4-62

4.6 Output waveforms for sweeping and modulation

4.7 Equivalent noise bandwidth .............................................. 4-63

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

Burst oscillation (Type: Burst) (MODE → BURST → 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]

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).

![Type Selection Display]

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

![Display with Burst Setting]

④ 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).

\[
\begin{array}{c}
\text{BURST : TYPE} \\
\text{MARK} \quad \text{SPACE} \quad \text{STOP—LEVEL} \\
\text{1. 0 cycle}
\end{array}
\]

② Press the \(\text{ENTER}\) key.

③ Set the mark cycles with the keypad or \(\text{MODIFY}\) dial (0.5 cycles).

In this example, the setting is 2.0 cycles.

④ After setting, press the \(\text{EXIT}\) key once to exit mark cycle setting.

(3) Set SPACE cycle

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

\[
\begin{array}{c}
\text{BURST : TYPE} \\
\text{MARK} \quad \text{SPACE} \quad \text{STOP—LEVEL} \\
\text{1. 0 cycle}
\end{array}
\]

② Press the \(\text{ENTER}\) key.

③ Set the space cycles with the keypad or \(\text{MODIFY}\) dial (0.5 cycles). In this example, the setting is 1.5 cycles.

④ After setting, press \(\text{EXIT}\) once to exit space cycle setting.

(4) Set STOP-LEVEL

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

\[
\begin{array}{c}
\text{OFF} \\
\text{BURST : TYPE} \\
\text{MARK} \quad \text{SPACE} \quad \text{STOP—LEVEL}
\end{array}
\]
4.1 Burst oscillation

② Press the ENTER key.

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

```
ON
BURST : TYPE  MARK  SPACE  STOP—LEVEL
```

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)

• 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) (\(\text{MODE} \rightarrow \text{BURST} \rightarrow \text{TYPE : TRIG}\))

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 (\(\text{\textbeamerarrow} \)).

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

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).

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

   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).

   ![Display - Source Selection]

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 EXIT once to release trigger source setting.

(3) Set DELAY time

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

   ![Display - Delay Time]

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 EXIT once to release delay time setting.
(4) Set MARK cycle

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

\[
\begin{array}{cccc}
\text{TRIG: TYPE SOURCE DELAY} & \text{MARK} \\
\text{1.0 cycle} \\
\end{array}
\]

② Press the \(\text{ENTER}\) key.

Set the mark cycles with the keypad or \(\text{MODIFY}\) dial (0.5 cycles).
In this example, the setting is 2.0 cycles.
③ After setting, press \(\text{EXIT}\) once to release mark cycle setting.

(5) Set STOP-LEVEL

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

\[
\begin{array}{cccc}
\text{TRIG: STOP—LEVEL} \\
\text{OFF} \\
\end{array}
\]

② Press the \(\text{ENTER}\) key.

Turn the \(\text{MODIFY}\) dial to produce the following display (ON flashes).

\[
\begin{array}{cccc}
\text{TRIG: STOP—LEVEL} \\
\text{ON} & \text{0.00 %} \\
\end{array}
\]

③ Press the \(\text{MODIFY}\) key, then set the stop level with the keypad or \(\text{MODIFY}\) 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 \(\text{EXIT}\) 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 (\(\downarrow\)) 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.

```
+----------------------------------+
<table>
<thead>
<tr>
<th>INT</th>
<th>TYPE</th>
<th>SOUR</th>
<th>DELAY</th>
<th>MARK</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.000ms</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
```

• **Stop level off**: Oscillation stops at the phase (set by ENTRY \(\rightarrow\) PHASE) setting (mark cycle is integer).

• **Manual trigger**: Press the MAN TRIG key, then set the trigger source to EXT \(\downarrow\). 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 \(\downarrow\).

For details of the remote control command, "Remote Control Instruction Manual", cf.
4.1 Burst oscillation

- Burst oscillation (Type: Trigger) setting items (BURST menu)
  
  TYPE: TRIG
  
  SOURCE (trigger source) [EXT - , EXT --, INT [s]]
  
  DELAY (trigger delay) [s]
  
  MARK (oscillation cycle) [cycle]
  
  STOP-LEVEL [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.

![Waveform Example](image)

Gate signal (TRIG/SWEEP IN) | Oscillation starts at gate signal high level.
---|---
High | Oscillation stops at end of a half cycle, when gate signal is low level.
Low |
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).

\[
\begin{array}{c}
\text{BURST} \\
\text{TRIG GATE} \\
\text{BURST: TYPE MARK SPACE STOP-LEVEL}
\end{array}
\]

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

\[
\begin{array}{c}
\text{BURST TRIG} \\
\text{GATE TYPE SOURCE STOP-LEVEL}
\end{array}
\]

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).

\[
\begin{array}{c}
\text{EXT} \\
\text{GATE: TYPE SOURCE STOP-LEVEL}
\end{array}
\]

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.
4.1 Burst oscillation

(3) Set STOP-LEVEL.

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

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

② Press the ENTER key.

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

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

③ Press the ► key, then set the stop level with the keypad or MODIFY 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 EXIT 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.

```
(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.

```
INT H-ON 1.000ms
GATE: TYPE SOURCE STOP-LEVEL
```
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 → 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 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 L-ON. For details of the remote control command, “Remote Control Instruction Manual”, cf.

- Burst oscillation (type: gate) setting items (BURST menu)
  
  TYPE: GATE
  
  SOURCE (trigger source) [EXT L-ON, EXT H-ON, INT [s] STOP-LEVEL [OFF, ON [%]]
  
  PHASE (phase when oscillation starts) [deg] * ENTRY menu
4.1 Burst oscillation

**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 (TRIG).

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

**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)

   ![BURST TRIG GATE](image)

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

   ![T-GATE](image)

   ① 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 0.00 %
T-GATE: TYPE SOURCE STOP-LEVEL
```

4. 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.
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 ENTRY → PHASE) or plus 180 degrees from that phase.

• **Manual trigger**: When a manual trigger signal is desired, press the 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 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.

For details of the remote control command, “Remote Control Instruction Manual”, cf.

• Burst oscillation (type: triggered gate) setting items (BURST menu)
  
  TYPE: T-GATE
  SOURCE (trigger source) [EXT, EXT]
  STOP-LEVEL [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.

![Sweep Waveform](image)

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).

   ![Single Display](image)

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

   ![Single Display](image)

   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).

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

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

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

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).

```
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 START frequency

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

![Frequency Display](image)

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 ◀ and ▶ keys to produce the following display (STOP flashes).

![Frequency Display](image)

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).

<table>
<thead>
<tr>
<th>F−SWP:</th>
<th>TIME</th>
<th>CENTER</th>
<th>SPAN</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.000 s</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

② Press 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) Sweep operation

① Sweep starts when the 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 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 START key is again pressed, sweep begins at the stop frequency and ends at the start frequency.
4.2 Sweep

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 sweep pause**: Supply a low level signal to the rear panel SWEEP PAUSE IN connector. Note that sweep restarts at high level or open input.
• **FUNCTION** determines the sweep type.
  
  : For example, \(\text{LIN} \rightarrow \text{LOG}\) 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.

  - \(\text{LIN} \rightarrow \text{LOG}\)
  - \(\text{LIN} \rightarrow \text{LOG}\)
  - \(\text{LIN} \rightarrow \text{LOG}\)

• **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.

• **START-STATE and STOP-STATE** : Respectively set the output to start and stop values. Since the sweep auxiliary output becomes the respective start and stop states, the full scale of the recorder can be adjusted and the state of external equipment can be checked. The Start-State is the same as pressing the \(\text{STOP}\) key (during single sweep).

  - Relation ship between sweep values and sweep auxiliary output \(\text{INT} \rightarrow 100.0\) ms \(\text{F-SWP : TYPE SOURCE MODE}\)

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

  During sweep, multiple pulses may be produced within 1 period output as indicated in the figure.

• **To generate the trigger signal via remote control (GPIB or USB)**, set the TRG command from the remote control interface.

  For details of the remote control command, \(\text{Remote Control Instruction Manual}\), cf.
4.2 Sweep

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

In a Sweep (Mode: Continuous), oscillation occurs by varying parameters such as the frequency and amplitude continuously between the start and stop settings.

Operation is described for producing a waveform output with linear and continuously frequency. The waveform is a sinewave with arbitrary Amplitude and DC offset.

Start amplitude: 1Vp-p

![Waveform](image)

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).

   ![Display](image)

   ③ Press the **ENTER** key, then use the **[ ]** and **[ ]** keys to produce the following display (CONT flashes).

   ![Display](image)

   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).

```
FREQ AMPTD OFFSET ▶
F−SWP:TYPE MODE FUNCTION START ▶
```

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

```
FREQ AMPTD OFFSET ▶
A−SWP:TYPE MODE FUNCTION START ▶
```

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).

```
LIN ▶
A−SWP:TYPE MODE FUNCTION START ▶
```

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.
4.2 Sweep

(4) Set the START amplitude (START)

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

```
AMPTD 0. 1000  V p-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 1 Vp-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  V p-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).

![TIME display]

② Press the ENTER key.

③ Set the sweep time with the key pad or MODIFY dial.

For example, set to 2 seconds.

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

(7) Sweep operation

① Press the 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 STOP key.

Other operations:

- **Sweep stop**: Press the STOP key. This becomes the sweep start value.
- **Sweep pause**: Press the PAUSE key. To resume sweep, again press the PAUSE key.
- **External pause**: Supply a low level signal to the rear panel SWEEP PAUSE IN connector.
  
  Note that sweep restarts at high level or open input

- **FUNCTION**: The function determines the sweep type. For example, SIN 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.
• **START-STATE and STOP-STATE**: Respectively set the output start and stop values. Since the sweep auxiliary output becomes the respective start and stop states, the full scale of the recorder can be adjusted and the state of external equipment can be checked.

The Start-State is the same as pressing the **STOP** key (during single sweep).

Relation ship between sweep values and sweep auxiliary output 

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

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

During sweep, multiple pulses may be produced within 1 period output as indicated in the figure.
### 4.2 Sweep

#### Sweep (Mode: Gated) (\[\text{MODE} \rightarrow \text{Sweep} \rightarrow \text{MODE : GATED}\])

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.

![Waveform diagram](image)

**Operation:**

1. **Set sweep MODE to GATED**
   
   ① Press the \[\text{MODE}\] key, then the \[\text{Sweep}\] key.
   
   ② Use the \[<\] and \[>\] keys to produce the following display (MODE flashes).

   ![Display](image)

   ③ Press the \[\text{ENTER}\] key, then use the \[<\] and \[>\] keys to produce the following display (GATED flashes).

   ![Display](image)

   ④ This completes setting the sweep mode to gated. Press the \[\text{EXIT}\] key once to release the setting mode.
4.2 Sweep

(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) Set the START frequency

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

![Frequency Display](image)

② Press the ENTER key.

③ Set the 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 the STOP frequency

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

![Frequency Display](image)

② Press the ENTER key.

③ Set the frequency with the keypad or MODIFY dial.

For example, set to 200 Hz.

④ After setting, press the EXIT 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.
(8) Start sweep

① Press the \text{\textit{START}} key.

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

- **Sweep stop**: Press the \( \text{STOP} \) key. Oscillation stops. When sweep is stopped at gated sweep end or during sweep, press the \( \text{STOP} \) key to set the start value. (Oscillation stops)

- **Sweep pause**: Press the \( \text{PAUSE} \) key. To resume sweep, again press the \( \text{PAUSE} \) key.

- **Gated sweep operation examples**

  ![Gated sweep diagram]

  - **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.

    - **EXT F-SWP**: TYPE SOURCE MODE

  - **External sweep pause**: Supply a low level signal to the rear panel SWEEP PAUSE IN connector. Note that sweep restarts at high level or open input

  - **FUNCTION**: The function determines the sweep type. For example, \( \text{LIN/LOG} \) provides linear or logarithmic variation of the output with respect to the time axis.

    - LIN
    - LOG
    - SIN \( (\sim) \) LIN
    - LOG
4.2 Sweep

- **Internal trigger source**
  - The internal trigger signal is produced at the rate indicated below. Even is set to less than 100 ms, the trigger is applied only at 100 ms intervals.

```
<table>
<thead>
<tr>
<th>INT</th>
<th>100.0 ms</th>
</tr>
</thead>
</table>
```

- **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 adjustments of the recorder and the status of external equipment can be checked.

- **Sweep type set to duty**: Output waveform fixed to squarewave (variable duty) and waveform (Function) cannot be selected.
  - During sweep, multiple pulses may be produced within 1 period output as indicated in the figure.

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

- 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

**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.
  CENTER = (START + STOP) / 2
  SPAN = |START - STOP|

- When stop is changed:
  Start does not change.
  CENTER = (START + STOP) / 2
  SPAN = |START - STOP|

- When center is changed:
  Span does not change.
  START = CENTER -/+ (SPAN / 2)
  STOP = CENTER +/- (SPAN / 2)

- When span is changed:
  Center does not change.
  START = CENTER -/+ (SPAN / 2)
  STOP = CENTER +/- (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.
Summary of the sweep setting items

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

TYPE (sweep target) [FREQ, AMPTD, OFFSET, PHASE, DUTY]
SOURCE (trigger source) [EXT, EXT, INT [s]
  * Set when the sweep mode is SINGLE or GATED
MODE (sweep mode) [SINGLE, CONT, GATED]
FUNCTION (sweep waveform) [LIN, LOG, LIN SIN, LOG SIN, LIN, LOG]
START (sweep start value)/STOP (sweep stop value)
  or
CENTER (sweep center value)/SPAN (sweep width)
TIME (sweep time) [s]
STOP-LEVEL
  Set when the sweep mode is GATED
PHASE (phase when oscillation starts) * main menu
MARKER (Marker value)
MKR→CTR (Copying of the marker value to the center value)

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)
4.2 Sweep

### 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, ∧∧, ▽▽, : Modulation period = \( \frac{1}{(\text{Modulation frequency} \times 2)} \)
- When the waveform is \( \checkmark \), \( \Delta \), \( \downarrow \): Modulation period = \( 1 + \text{Modulation frequency} \)

#### Step number derivation

1. **Sweep function is step (\( \sqrt{\quad} \)):**
   
   Step number = Sweep time \([\text{s}] \times 10000\) (raise up, even number *1)

2. **Sweep function is other than step and sweep type is frequency:**
   
   - **Sweep time is 25 ms and below:**
     
     Step number = Sweep time \([\text{s}] \times 10000\)
   
   - **Sweep time is more than 25 to 31.25 ms and below:**
     
     Step number = 250 (fixed)
   
   - **Sweep time is more than 31.25 ms:**
     
     Step number = Sweep time \([\text{s}] \times 8000\)

3. **Sweep function is other than step and sweep type is other than frequency:**
   
   - **Sweep time is 50 ms and below:**
     
     Step number = Sweep time \([\text{s}] \times 10000\)
   
   - **Sweep time is more than 50 to 62.5 ms and below:**
     
     Step number = 250 (fixed)
   
   - **Sweep time is more than 62.5 ms:**
     
     Step number = Sweep time \([\text{s}] \times 8000\)

*1: If raising up results in odd number, -1.
• Deriving step width

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

During logarithmic sweep, step width = \( \log_{10}^{-1} \left[ \log_{10} \left( \frac{\text{stop}}{\text{start}} \right) \div (\text{step no.} - 1) \right] \)

Step width during log sweep changes with step progression.

The marker output is synchronized with the sweep step output. The difference between marker setting and actual output 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></td>
<td>Start value &lt; stop value</td>
<td>Start value &gt; stop value</td>
</tr>
<tr>
<td>Sweep value</td>
<td><img src="image" alt="Diagram" /></td>
<td><img src="image" alt="Diagram" /></td>
</tr>
<tr>
<td>Marker output</td>
<td><img src="image" alt="Diagram" /></td>
<td><img src="image" alt="Diagram" /></td>
</tr>
<tr>
<td>Sync output</td>
<td><img src="image" alt="Diagram" /></td>
<td><img src="image" alt="Diagram" /></td>
</tr>
<tr>
<td>X-drive output</td>
<td><img src="image" alt="Diagram" /></td>
<td><img src="image" alt="Diagram" /></td>
</tr>
</tbody>
</table>

◆ is approx. 100 to 125 µs
### 4.2 Sweep

#### Single, gated sweep

(1 is sweep start timing, # is sweep in progress, * is sweep end state.)

<table>
<thead>
<tr>
<th>Sweep function</th>
<th>Start value &lt; stop value</th>
<th>Start value &gt; stop value</th>
<th>Continuous sweep</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sweep value</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High Marker</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High Marker</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sync output</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>X-drive output</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5V</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0V</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sweep time</td>
<td>Sweep time</td>
<td>Sweep time</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
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.

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

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).

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

④ This sets the modulation type for frequency. Press the 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 EXIT 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 EXIT 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).

```
S I N
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.

- Setting items at frequency modulation (MODU menu)
  
  TYPE: FM
  
  DEVIATION (frequency deviation) [Hz]
  
  FREQ (modulation frequency) [Hz]
  
  FUNCTION (modulation waveform) [SIN, , , , ]
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).

![Diagram showing AM modulation]

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

④ This sets the modulation type for amplitude. Press the EXIT key once to release the type setting mode.
(2) Set modulation DEPTH (width of amplitude variance)

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

<table>
<thead>
<tr>
<th>AM : TYPE DEPTH FREQ FUNCTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>50.0 %</td>
</tr>
</tbody>
</table>

② Press the ENTER key.
③ Use the keypad or MODIFY dial to set the modulation depth.
   For example, set to 33 %.
④ Press the EXIT key once to release the modulation depth setting mode

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

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

<table>
<thead>
<tr>
<th>AM : TYPE DEPTH FREQ FUNCTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>100.00 Hz</td>
</tr>
</tbody>
</table>

② Press the ENTER key.
③ Use the keypad or MODIFY dial to set the modulation frequency.
   For example, set to 200 Hz (5ms).
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).

![Display with SIN AM: TYPE DEPTH FREQ FUNCTION]

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

![Display with SIN 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 + (depth [%] ÷ 100))
  Min. amplitude = Amplitude setting ÷ 2 (1 − (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.

• Setting items at amplitude modulation (MODU menu)
  TYPE: AM
  DEPTH (modulation depth) [%]
  FREQ (modulation frequency) [Hz]
  FUNCTION (modulation waveform) [SIN, ⊲, ⊳, ⊼, ◐, ◽]
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 waveform with labels: Max.amplitude: 1.3Vp-p, Offset deviation: ±0.15V, 1Vp-p, 0V, 4ms (250Hz)]

**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 keys: 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 (OFSM flashes).

   ![Display with keys: FM, AM, OFSM, PM, PWM, OFSM: TYPE, DEVIATION, FREQ]

   ④ This sets the modulation type for DC offset. Press the EXIT key once to release the type setting mode.
(2) Set the DC offset DEVIATION

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

![Display shows +0.2000 V]

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 release the deviation setting mode.

(3) Set the modulation FREQ

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

![Display shows 100.00 Hz]

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) Select modulation waveform (FUNCTION)

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

![Display 1](image)

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

![Display 2](image)

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.

- Setting items at DC offset deviation (MODU menu)  
  TYPE: OFSM  
  DEVIATION (dc offset deviation) [V]  
  FREQ (modulation frequency) [Hz]  
  FUNCTION (modulation waveform) [SIN, ▼, ▲, △, ▽]
4.3 Modulation

Phase modulation (PM) (MODE \rightarrow MODU \rightarrow TYPE : PM)

Operation to produce a phase modulated waveform output is described below. The example is a sinewave, 1 kHz, DC offset 0 V, phase and amplitude arbitrary.

**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
```

① This sets the modulation type for phase. Press the EXIT key once to release the type setting mode.
(2) Set the phase DEVIAITION

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

```
PM: TYPE DEVIAITION 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

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

```
PM: TYPE DEVIAITION 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).

```
S I N   
PM: TYPE DEVIATION FREQ FUNCTION
```

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

- Setting items at phase modulation (MODU menu)
  
  TYPE: PM
  DEVIATION (phase deviation) [deg]
  FREQ (modulation frequency) [Hz]
  FUNCTION (modulation waveform) [SIN, ∨, ↓, ↓, ↓]
4.3 Modulation

**Pulse width modulation (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).

   ![Display](image)

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

   ![Display](image)

   ④ 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.
(2) Set the pulse width DEVIATION (amount of pulse-width variance)

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

```
             2 0. 0 0 0 0 %
PWM : TYPE DEVIATION FREQ FUNCTION
```

2. Press the ← key, then set the deviation with the keypad or MODIFY dial. For example, set to 80 %.
3. After setting, press the EXIT key once to release the pulse with deviation setting mode.

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

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

```
             1 0 0. 0 0 Hz
PWM : TYPE DEVIATION FREQ FUNCTION
```

2. Press the ← 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).

<table>
<thead>
<tr>
<th>SIN</th>
<th>PWM</th>
<th>TYPE</th>
<th>DEVIATION</th>
<th>FREQ</th>
<th>FUNCTION</th>
</tr>
</thead>
</table>

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

<table>
<thead>
<tr>
<th>SIN</th>
<th>PWM</th>
<th>TYPE</th>
<th>DEVIATION</th>
<th>FREQ</th>
<th>FUNCTION</th>
</tr>
</thead>
</table>

③ After selecting, press the 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 key. Resume modulation by pressing the 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 sweep, multiple pulses may be produced within 1 period output as indicated in the figure.

<p>| |</p>
<table>
<thead>
<tr>
<th></th>
</tr>
</thead>
</table>

• Setting items at pulse width modulation (MODU menu)
  TYPE: PWM
  DEVIATION (pulse width deviation) [%]
  FREQ (modulation frequency) [Hz]
  FUNCTION (modulation waveform) [SIN, , , , , ]
4.4 Arbitrary Waveform

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

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

  Waveform data: +23170  
  Waveform data: 0  
  Waveform address → 0 1024 3072 5120 7168 8191  
  Waveform data: -23170

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

  2. **Select an arbitrary waveform to be edited/output (SELECT).**
     1. Press the FUNCTION key, then use the and keys to produce the following display (SELECT flashes).

        0: ARB_00 1: ARB_01
        ARB: SELECT NAME EDIT COPY

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

        0: ARB_00 1: ARB_01
        ARB: SELECT NAME EDIT COPY

     3. This completes the selection of an arbitrary waveform (No. 1 is selected here). Press the key one time to release the arbitrary waveform selection mode.
4.4 Arbitrary Waveform

(3) Copy the waveform, for example, sinewave

① Press the key, then use the and keys to produce the following display (COPY flashes).

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

③ Press key to copy the sinewave.
(4) Edit the waveform, for example, peak clip

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

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

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

```
AD : 00000  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.
Press the **key for linear interpolation. In this example, the first half of the sinewave is clipped (⑥). 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
```

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:**
  
  ![WF1945B](image)

  - Flashes the waveform data (DT) digits. Use the keypad or 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:**
  
  ![WF1945B](image)

  - Then again press . The interpolation marks (*) are also cleared.

- **Apply a name to an arbitrary waveform:**
  
  ![WF1945B](image)

  - Then use the dial to select the characters. Shift position with and , and input.

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

  a b c d e f g h i j k l m n o p q r s t u v w x y z (space)  
  A B C D E F G H I J K L M N O P Q R S T U V W X Y Z 0 1 2 3 4 5 6 7 8 9

  ! “ # $ % & ’ ( ) + , - . / : ; < = > ? @ [ ] ¥ ^ _ \ | }

  - To select the data size:
    
    ![WF1945B](image)

    - Use and to select the data size

  Relation between the waveform data size and number of waveforms

<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</td>
<td>8 9 10 11 12</td>
</tr>
<tr>
<td>16K (16384)</td>
<td>0 1 2 3 4 5 6</td>
<td>12</td>
</tr>
<tr>
<td>32K (32768)</td>
<td>0 1 2 3</td>
<td>4 5 6</td>
</tr>
<tr>
<td>64K (65536)</td>
<td>0 1</td>
<td>2 3 4 5 6 7 8 9</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 , is assigned to waveform number 0 and to waveform number 1.
4.5 Selecting waveforms of synchronous signals (SYNC OUT)

This section describes the switching of SYNC OUT waveforms.

Procedure

① Press the SYSTEM key, then use the ▼ and ► keys to produce the following display (The lower SYNC OUT flashes).

![Display Diagram]

② Press the ENTER key, then use the ▼ and ► keys to set the SYNC OUT waveform.

③ After setting, press the EXIT key to release the SYNC OUT waveform setting mode.

When the oscillation mode is BURST

• STATE: Low level during oscillation. High level while stopped.
• PHASE: For 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.

![Waveform Diagram]
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  and  (fixed duty) at frequencies over 100 kHz, if SYNC OUT is set to PHASE, output becomes the waveform which applied the analog signal of a sinewave 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 shaded sections represent an undefined output level.](image-url)
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 $\square$, $\triangledown$, or $\triangle$, 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 $\triangle$ 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 $\triangledown$, $\triangledown$, and $\triangledown$.

Since the phase changes at intervals of 100 to 252 µs, discontinuities are generated when swept and when not swept.
4.6 Output waveforms for sweeping and modulation

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.

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

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

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 WF1945B is as shown in the following figure (a) "Frequency characteristics of noise generated by the WF1945B."

The effective values (rms) 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 ............................................................................................................. 5-2
- Frequency [Hz] setting by period [s] ....................................................................................... 5-2
- Squarewave duty setting ......................................................................................................... 5-3
- Squarewave pulse width setting ............................................................................................. 5-4
- Amplitude and DC offset setting by high and low level ......................................................... 5-5

5.2 Units .................................................................................................................................. 5-7
- Engineering unit (µ, m, k, M) display ....................................................................................... 5-7
- Amplitude units change ............................................................................................................ 5-8
- User-unit setting ..................................................................................................................... 5-9

5.3 Setting memory .................................................................................................................... 5-13
- Setting store ............................................................................................................................ 5-13
- Setting recall ............................................................................................................................ 5-14
- Setting memory clear .............................................................................................................. 5-15

5.4 External Input ...................................................................................................................... 5-16
- External add (EXT-ADD) ....................................................................................................... 5-16
- External AM (EXT-AM) .......................................................................................................... 5-17

5.5 Other settings ....................................................................................................................... 5-18
- Output range change (use with fixed range) ......................................................................... 5-18
- Output on/off at power on ....................................................................................................... 5-19
- LOAD function (equalize setting and output values) ............................................................. 5-20
- UNDO function ...................................................................................................................... 5-21
- Pulse generator function ........................................................................................................ 5-22
- Phase sync ............................................................................................................................... 5-24

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

<table>
<thead>
<tr>
<th>FREQ</th>
<th>PERIOD</th>
<th>AMP</th>
<th>TD</th>
</tr>
</thead>
</table>

Fully lighted (bold)

Dimly lighted

Fully lighted (bold)

Flashing

Fully lighted (bold)
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.

\[
\begin{array}{c}
P \quad 0.0010000000000000 \ s \\
A \quad 0.1000Vp-p \quad 0+0.0000V \quad \text{/OPEN}
\end{array}
\]

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.
5.1 Convenient Settings

■ 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.

   ![Display Example]

2. Set the duty with the keypad or 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.
- The actual waveform duty resolution is \(\text{oscillation frequency} \div \text{approx. 40 MHz}\) (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
A 1.000 V 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**

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.

Operation:

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

```
HIGH +0.0500 V
1000.0000000Hz L-0.0500V /OPEN
```

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 -0.0500 V
1000.0000000Hz H+5.0000V /OPEN
```

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></td>
<td>Unchanged</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, relationship between amplitude and DC offset settings, or the setting of the external addition and external AM, 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.

![1000.00000000 Hz]
A0. 1000Vp-p  O+0.0000V /OPEN

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

![1.00000000000kHz]
A0. 1000Vp-p  O+0.0000V /OPEN

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).

\[
\text{AMPTD 0. 1000 Vp-p}\]
\[
1000. 0000000Hz\quad 0+0. 0000V\quad /\text{OPEN}
\]

③ Turn the MODIFY dial to produce the following display.

\[
\text{AMPTD 0. 0354 Vrms}\]
\[
1000. 0000000Hz\quad 0+0. 0000V\quad /\text{OPEN}
\]

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](image)

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

   ![FREQ PERIOD AMP T D](image)

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

   ![FREQ PERIOD AMP T D](image)

   ④ This selects the setting type to frequency. Press the EXIT key once to release the type select mode.
5.2 Units

(2) Set the unit NAME (e.g., rpm)

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

![USER UNIT: TYPE NAME FORMULA](image)

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).

![USER UNIT: TYPE NAME FORMULA](image)

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

![USER UNIT: TYPE NAME FORMULA](image)

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. 0000000000000000E+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. 0000000000000000E+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. 00000000
A0. 1000Vp-p  O+0. 0000V /OPEN

③ Turn the MODIFY dial to produce the following display.

60000. 00000000
A0. 1000Vp-p  O+0. 0000V /OPEN
Other:

• User units can be used for frequency, period, amplitude, DC offset, phase and duty.
• 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 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 ENTER 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 ENTER key, then apply a desired name to the memory (may also be omitted). Select characters with the MODIFY dial and shift position with the < and > keys.

Up to 20 characters can be selected from the following list.

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

④ Press the ENTER key to store the name (in this example, save to memory 0).

The above completes memory storage. Press the EXIT 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
MEMORY : STORE RECALL CLEAR

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 1 2 3 4 5 6 7 8 9

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.

  • 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 WF1945B output. The external signal is connected to the rear panel EXT ADD IN connector. Refer to **External add input (EXT ADD IN)** on page 28.

**Operation:**

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

   \[
   \begin{array}{c}
   \text{OFF} \\
   \text{SYSTEM}: \leftarrow \text{LOAD} \text{ EXT-AM} \text{ EXT-ADD} \\
   \text{ON} \\
   \end{array}
   \]

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

   \[
   \begin{array}{c}
   \text{OFF} \\
   \text{SYSTEM}: \leftarrow \text{LOAD} \text{ EXT-AM} \text{ EXT-ADD} \\
   \text{ON} \\
   \end{array}
   \]
5.4 External Input

■ External AM (EXT-AM) (SYSTEM : EXT-AM)

Operation to modulate the WF1945B 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 add input (EXT ADD IN))”, cf.

Operation:

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

```
OFF ON
SYSTEM: ← LOAD EXT-AM EXT-ADD →
```

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

```
OFF ON
SYSTEM: ← LOAD EXT-AM EXT-ADD →
```

Note:

• AM appears at the head of the display when external AM is on.

```
1 0 0 0 . 0 0 0 0 0 0 0 0 0 Hz
AM A0. 1 0 0 0 V p - p 0 + 0 . 0 0 0 0 V / OPEN
```
5.5 Other settings

Output range change (use with fixed range) (SYSTEM: 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).

2. Press the ENTER key, then use the and keys to produce the following display (10 V flashes).

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).

LAST-STATE OFF ON
SYSTEM: ← SYNCOUT POWER-ON →

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

LAST-STATE OFF ON
SYSTEM: ← SYNCOUT POWER-ON →
## 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 Display]

   **OPEN**
   SYSTEM: [LOAD] EXT-AM EXT-ADD

2. Press the ENTER key, then turn the MODIFY dial to produce the following display (SET flashes).

   ![Set Display]

   **SET**
   SYSTEM: [LOAD] EXT-AM EXT-ADD

   ![Value Set]

   50 Ω

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 WF1945B 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 WF1945B output impedance and voltage errors are not converted.
5.5 Other settings

■ 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.
5.5 Other settings

### Pulse generator function

Operation of the WF1945B as a pulse generator is described.

**Operation:**

1. **Set for continuous pulse output**

   - **Period:** 2 ms
   - **Pulse width:** 0.2 ms
   - ① Set the waveform to squarewave (variable duty), (FUNCTION → ).
   - ② Set the voltage High level to +5 V and the Low level to 0 V.
     - (ENTRY → HIGH → 5 → ENTER, ENTRY → LOW → 0 → ENTER)
   - ③ Set the period to 2 ms (ENTRY → PERIOD → 2 → m).
   - ④ Set the pulse width to 0.2 ms (ENTRY → WIDTH → • → 2 → m).

2. **Use external trigger for pulse output**

   - **Pulse width:** 0.5 ms
   - **Delay time:** 0.1 ms
   - **Trigger signal** (TRIG/SWEEP IN)

   - ① Set the waveform to squarewave (variable duty), (FUNCTION → ).
   - ② Set the voltage High level to +5 V and the Low level to 0 V.
     - (ENTRY → HIGH → 5 → ENTER, ENTRY → LOW → 0 → ENTER)
③ Set the pulse width to 0.5 ms（ENTRY→WIDTH→・→5→m）.

④ Set oscillation mode.
（MODE→BURST→TYPE=TRIG, SOURCE=EXT, DELAY=0.1 ms, MARK=1.0 cycle, STOP-LEVEL=ON）

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 and press the MAN TRIG key.
(Do not connect anything to the TRIG/SWEEP IN connector.)
5.5 Other settings

■ Phase sync (\texttt{SYSTEM} : \( \phi \text{SYNC} \))

Operation is described for restarting the output waveform from a set phase so as to clarify the phase relationship. The function uses \( \phi \)-SYNC IN, OUT (1991 synchronous operation option) to synchronize the operation of multiple units.

Phase sync operation and waveform outputs of 1st and 2nd units (1st unit phase 0 degrees, 2nd unit phase 90 degrees)

**Operation:**

1. Press the \texttt{SYSTEM} key, then use the \(<\) and \(>\) keys to produce the following display (\( \phi \text{SYNC} \) flashes).

2. Press the \texttt{ENTER} key to engage phase synchronization.

**Other:**

- \( \phi \) 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).
Section 6 Troubleshooting

6.1 Error message ........................................................................................................... 6-2
  ■ Power on error ........................................................................................................... 6-2
  ■ Operation error ......................................................................................................... 6-3

6.2 Suspected failure ....................................................................................................... 6-5
  ■ In case of abnormality ............................................................................................... 6-5
6.1 Error message

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 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 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>
</tbody>
</table>
| SETTINGS CONFLICT 010          | Since the mode is SWEEP or MODU for \[
\text{variable duty,}
\]
DUTY VALID cannot be set.                                                                                                                                 |
<p>| STORE/RECALL MEMORY LOST      | Setting storage memory contents destroyed and settings cannot be recalled. Contact dealer.                                                                                                                            |</p>
<table>
<thead>
<tr>
<th>Error message</th>
<th>Cause or corrective measures</th>
</tr>
</thead>
<tbody>
<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 015</td>
<td>Because of DUTY VALID change, the duty was changed to 0.01% or 99.99%.</td>
</tr>
<tr>
<td>WARNING 016</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>Use the power source within the specified range.</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>External AM on</td>
<td>Set external AM off.</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 instruction manual</td>
<td>Settings have been initialized (PRESET).</td>
<td>The instruction manual presumes the settings have been initialized.</td>
</tr>
</tbody>
</table>
## Section 7 Maintenance

7.1 Outline

- Work contents
- Required test instruments

7.2 Operation checks

- Preparatory checks
- Function checks

7.3 Performance tests

- Performance tests
- Preparatory checks
- Test preparation
- Frequency accuracy
- Amplitude accuracy
- DC offset accuracy
- Amplitude vs. frequency characteristics
- Sinewave distortion
- Squarewave response
- Duty factor
## 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 instruction manual provides easily carried out procedures for inspection and performance checks. Consult the manufacturer or dealer regarding more thorough inspection, adjustment, calibration and repair.

### 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**

---

**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.
7.2 Operation checks

■ Preparatory checks

Check the following before inspection.

- Power source voltage is within specified range.
- Ambient temperature is within 5 to 35 °C.
- Ambient relative humidity is within 10 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 (OUTPUT 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.
To prevent any loss of setting information resulting from a depleted battery, 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 specified range.
  - 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 OUTPUT 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.
  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.

**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>1 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.

**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>0.000 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.

**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>@</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>▲</td>
<td>(Reference value)</td>
<td>±0.3 dB</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>▼</td>
<td>(Reference value)</td>
<td>±0.3 dB</td>
<td>±0.3 dB</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>△</td>
<td>(Reference value)</td>
<td>±0.5 dB</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>▼</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

**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>

■ 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>( \square ) (duty 50 % fixed)</td>
<td>1 MHz</td>
<td>490 to 510 ns</td>
</tr>
<tr>
<td>( \square ) (duty 50 % fixed)</td>
<td>10 MHz</td>
<td>47.0 to 53.0 ns</td>
</tr>
<tr>
<td>( \square ) (duty 50 % fixed)</td>
<td>15 MHz</td>
<td>30.0 to 36.7 ns</td>
</tr>
<tr>
<td>( \square ) (duty variable)</td>
<td>100 kHz</td>
<td>4.90 to 5.10 µs</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 .......................................................................................... 8-10
8.5 Remote control ............................................................................................... 8-11
8.6 Options ........................................................................................................... 8-12
8.7 General items .................................................................................................. 8-13
   ■ External drawing ............................................................................................ 8-14

Guaranteed values are shown with tolerance, values without tolerance are for reference.
8.1 Waveform and output characteristics

- **Waveforms (FUNCTION OUT)**
  - Output waveforms: \(\sin, \cos, \square, \triangle (Duty 50\% fixed), \triangledown, \downarrow, \uparrow, \rightarrow, \leftarrow, \rightarrow (Duty variable), \) arbitrary waveform (ARB), noise (NOISE), DC voltage (DC)
  - Waveform vertical resolution: 16 bit (\(\sin, \cos, \square, \triangle, \rightarrow, \rightarrow\) arbitrary waveform (ARB))
  - Output waveform and frequency:
    - For continuous oscillation: \(\sin, \cos, \square, \triangle (Duty 50\% fixed) : 0.01 \mu\text{Hz} \text{ to } 15 \text{ MHz}\)
    - arbitrary waveform \(0.01 \mu\text{Hz} \text{ to } 500 \text{ kHz}\)
    - Frequency: Arbitrary waveform : 0.01 \mu\text{Hz} \text{ to } 500 \text{ kHz}\)
    - However, the frequency in which all the data of arbitrary waveforms can be outputted is the maximum of the following value:
      \[
      (40\text{MHz}) \div [\text{waveform data size (words)}]
      \]
    - Analog band width: 10MHz
    - For burst, trigger, gate, triggered gate, or gated sweep: 0.01 \mu\text{Hz} \text{ to } 500 \text{ kHz}
  - Frequency:
    - Range: 0.01 \mu\text{Hz} \text{ to } 15 \text{ MHz}
    - Resolution: 0.01 \mu\text{Hz}
    - Accuracy when shipped: \(\pm 5 \text{ ppm}\)
    - Aging: \(\pm 3 \text{ ppm/year}\)
  - Setting by period: Frequency equivalent to inverse number of the setting period.
    - If the number is less than 0.01 \mu\text{Hz}, the number should be rounded off.
  - Duty:
    - Range: \(0.0100\% \text{ to } 99.9900\% / 0.0000\% \text{ to } 100.0000\%\)
    - 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 origination: 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 all 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.
\[
\text{rms value} = \frac{(V_{p-p \text{ set point}})}{2 \times \text{peak factor}}
\]
Binary output: Outputs from SYNC OUT during NOISE mode.

- **Output characteristics (FUNCTION OUT)**

<table>
<thead>
<tr>
<th>Amplitude frequency characteristics</th>
<th>Continuous oscillation, 50 Ω load, DC offset 0 V, amplitude setting 10 Vp-p/50 Ω, normalized frequency 1 kHz, effective rms value measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>∞ Up to 1 MHz: +0.2 dB, −0.3 dB</td>
</tr>
<tr>
<td></td>
<td>1 MHz to 3 MHz: +0.35 dB, −0.7 dB</td>
</tr>
<tr>
<td></td>
<td>3 MHz to 10 MHz: +0.5 dB, −1.5 dB</td>
</tr>
<tr>
<td></td>
<td>10 MHz to 15 MHz: +0.5 dB, −2.0 dB</td>
</tr>
<tr>
<td></td>
<td>( \sim ) Up to 1 MHz: ±0.3 dB</td>
</tr>
<tr>
<td></td>
<td>( \sim ) Up to 500 kHz: ±0.3 dB</td>
</tr>
<tr>
<td></td>
<td>( \sim, \triangleright ) Up to 500 kHz: ±0.5 dB</td>
</tr>
</tbody>
</table>

\( \sim \) spectrum purity

Continuous oscillation, external AM off, 50 Ω load, DC offset 0 V, amplitude setting 10 Vp-p/50 Ω

<table>
<thead>
<tr>
<th>Total harmonic distortion</th>
<th>10 Hz – 100 kHz: 0.2 % and below (bandwidth: 500 kHz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Harmonic spectrum</td>
<td>100 kHz to 1 MHz: −50 dBC and below</td>
</tr>
<tr>
<td></td>
<td>1 MHz to 15 MHz: −30 dBC and below</td>
</tr>
</tbody>
</table>

Spurious output

Continuous oscillation, external AM off, 50 Ω load, DC offset 0 V, amplitude setting 10 Vp-p/50 Ω

| Waveform characteristics   | Rise and fall time: 20 ns and below                                                                                         |
|                           | Overshoot: 5 % and below                                                                                                    |

| Duty                      | Continuous oscillation, external AM off, 50 Ω load, DC offset 0 V, amplitude setting 10 Vp-p/50 Ω                          |

| \( \sim \) (50 % fixed duty) | Up to 1 MHz: ±1 % of the period                                                                                          |
|                            | 1 MHz to 10 MHz: ±3 % of the period                                                                                      |
|                            | 10 MHz to 15 MHz: ±5 % of the period                                                                                     |

| \( \sim \) (duty variable) | Up to 100 kHz: ±1 % of the period                                                                                      |
|                           | Jitter: 30 nsp-p and below                                                                                             |
8.2 Output voltage

**Output voltage (FUNCTION OUT)**

- **Output range**: 10 V range / 1 V 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 addition 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, nominal
  - **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**: ∆
- **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 wave unit
  (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 wave unit
  (Space wave number is the stop wave number at the time of burst).

  Phase
    - 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).

  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 k$\Omega$, pull up to $+5$ V.
    - Input connector: Front panel BNC receptacle (TRIG/SWEEP IN)

  Internal trigger oscillator
    - 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**

<table>
<thead>
<tr>
<th>Sweep items</th>
<th>Frequency, phase, amplitude, DC offset, and duty (duty variable)</th>
</tr>
</thead>
</table>
| Setting items | Sweep start/stop or sweep center/span  
Sweep marker, substitute sweep center for sweep marker  
Sweep start and stop state |
| Sweep functions | Continuous / single / gated sweep  
LIN/LOG (LOG is available frequency only) |
| Sweeping time | Range: 1 ms to 10000.00 s  
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)  
External trigger: 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
- **High level**: Other times
  (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
- **High level**: stop release
- **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.
- **High level**: other times
- **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, +5 V → +0 V: sweep value is decreasing.
- **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
  - Resolution: 5 digits at 1 Hz and more, 0.1 mHz at less than 1 Hz.

- **External modulation functions**

  Modulation item: AM, on/off selectable
  
  External modulation frequency: DC to 10 MHz
  
  External AM depth
  - -3 V input: -100%
  - -1 V input: 0%
  - 0 V input: 50% of the set amplitude
  - +1 V input: the set amplitude.
  
  Input voltage range: -3 V to +1 V
  
  Input impedance: 50 Ω

- **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 V range: × 2
  - 1 V range: × 0.2

  Input voltage range: ±5 V

  Input impedance: 50 Ω

- **Setting initialization**

  Functions: Initializes nearly all setting contents.

  Initialization settings,  "3.3 Basic operation (Initialization table)", cf.
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**: \((\text{Output voltage at load}}) = (\text{Output voltage at no-load}) \times \frac{\text{Impedance} \times 50}{\text{Impedance} \times 50 + \text{Load impedance}}\)
  - **Load impedance**
    - **Range**: 45 \(\Omega\) to 999 \(\Omega\)
    - **Resolution**: 1 \(\Omega\)

- **Output on/off**
  - **Function**: Output switched on/off
    - **Output off state**: FUNCTION OUT: open.
    - **SYNC OUT**: TTL three states high impedance.
  - **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**
  
  Initialization, "3.3 Basic operation (Initialization table)", cf.

- **Error from backup battery depletion**

  In addition to setting initialization, following are set:

<table>
<thead>
<tr>
<th>Setting</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output on/off</td>
<td>Off</td>
</tr>
<tr>
<td>Output on/off in turning on</td>
<td>LAST-STATE (condition just before power off)</td>
</tr>
<tr>
<td>Setting memory</td>
<td>ALL NOT STORED</td>
</tr>
<tr>
<td>Setting memory comment</td>
<td>&quot; &quot; (blank)</td>
</tr>
<tr>
<td>User unit name</td>
<td>USER</td>
</tr>
<tr>
<td>User unit computation formula</td>
<td>(h+n)*m</td>
</tr>
<tr>
<td>User unit coefficient</td>
<td>1</td>
</tr>
<tr>
<td>User unit offset</td>
<td>0</td>
</tr>
<tr>
<td>Arbitrary waveform selection</td>
<td>ARB_00</td>
</tr>
<tr>
<td>Arbitrary waveform name</td>
<td>ARB_00 ~ ARB_11</td>
</tr>
<tr>
<td>Arbitrary waveform data size</td>
<td>8K</td>
</tr>
<tr>
<td>Arbitrary waveform data</td>
<td>All 0</td>
</tr>
<tr>
<td>Remote control interface</td>
<td>GPIB</td>
</tr>
<tr>
<td>GPIB address</td>
<td>2</td>
</tr>
<tr>
<td>GPIB delimiter</td>
<td>CR+LF</td>
</tr>
<tr>
<td>USB ID</td>
<td>2</td>
</tr>
</tbody>
</table>
8.5 Remote control

- **GPIB interface**

<table>
<thead>
<tr>
<th>GPIB function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SH1</td>
<td>All source handshake functions</td>
</tr>
<tr>
<td>AH1</td>
<td>All acceptor handshake functions</td>
</tr>
<tr>
<td>T6</td>
<td>Basic talker, serial poll, talker release by MLA</td>
</tr>
<tr>
<td>L4</td>
<td>Basic listener, listener release by MTA</td>
</tr>
<tr>
<td>SR1</td>
<td>All service request functions</td>
</tr>
<tr>
<td>RL1</td>
<td>All remote/local functions</td>
</tr>
<tr>
<td>PP0</td>
<td>No parallel poll functions</td>
</tr>
<tr>
<td>DC1</td>
<td>All device clear functions</td>
</tr>
<tr>
<td>DT1</td>
<td>All device trigger functions</td>
</tr>
<tr>
<td>C0</td>
<td>No controller functions</td>
</tr>
</tbody>
</table>

  **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)
  **Remote release**: Remote condition 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: Synchronous operation of multiple units of the WF 19 series*
  1991 is required all synchronous operation.
  Time difference: 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.
  The cable connecting multiple units of the WF 19 series* is optional.

- **1994 synchronous operation cable**
  1991 synchronous operation option, for connecting multiple units of the WF 19 series*. To connect n units of the WF 19 series* (n−1) of 1994 synchronous operation cables are necessary.

- **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>ARB and: Data: DAC commands</th>
<th>ARW and: Data: DAC WORD commands</th>
<th>Output data</th>
</tr>
</thead>
<tbody>
<tr>
<td>+16383</td>
<td>+32766, +32767</td>
<td>7FFFH</td>
<td></td>
</tr>
<tr>
<td>+16382</td>
<td>+32764, +32765</td>
<td>7FEFH</td>
<td></td>
</tr>
<tr>
<td>+16381</td>
<td>+32762, +32765</td>
<td>7FFDH</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>+2</td>
<td>+4, +5</td>
<td>4002H</td>
<td></td>
</tr>
<tr>
<td>+1</td>
<td>+2, +3</td>
<td>4001H</td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>0, +1</td>
<td>4000H</td>
<td></td>
</tr>
<tr>
<td>-1</td>
<td>-2, -1</td>
<td>3FFFH</td>
<td></td>
</tr>
<tr>
<td>-2</td>
<td>-4, -3</td>
<td>3FFEH</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-16382</td>
<td>-32764, -32763</td>
<td>0002H</td>
<td></td>
</tr>
<tr>
<td>-16383</td>
<td>-32766, -32765</td>
<td>0001H</td>
<td></td>
</tr>
<tr>
<td>-16384</td>
<td>-32768, -32767</td>
<td>0000H</td>
<td></td>
</tr>
</tbody>
</table>

Accessory: Digital output cable: One

8.7 General items

- **Input/output ground**
  The signal ground of FUNCTION OUT, SYNC OUT, EXT AM IN, EXT ADD IN, and DIGITAL OUT is floated from the chassis and the input/output ground of these signals is common.
  Signal ground dielectric strength: 42 Vpeak, 30 Vrms (DC to 20 kHz continuous)
  The input/output ground of all other signals is 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 1 A (100 V/115 V) or time lag 0.5 A (230 V) 250 V, Φ5.2 × 20 mm
  - Consumption electric power: 65 VA and less
  - Overvoltage category: 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 time: −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).

- **Dimensions**
  216(W) × 132.5(H) × 290(D) mm (Excluding protrusions).

- **Mass**
  Mainframe excluding attachments, options, etc.
  Approx. 4.3 kg

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

- **EMC**
  However, the performance criteria for the following standards are as follows:
8.7 General items

- External drawing

Surface preparation
Front panel: Plastic sheet  Black 4C Frame: Painting  Metallic gray Cover: Polyvinyl chloride metal laminated plate  Metallic gray

Side view
Front panel
Rear panel
Option
Front and rear panel indications (alphabetical order).

AMPTD .................................. 3-24, 5-6, 5-8, 5-20
ARB ........................................ 4-55, 5-8
ARB EDIT .................................. 4-56
BS ........................................... 3-23, 3-24, 3-25, 3-26
BURST ..................................... 3-8, 3-19, 4-2
DC ........................................... 3-8, 3-19, 3-22, 3-23, 3-24, 3-25
DIGITAL OUT .............................. 3-14
DUTY ....................................... 5-3, 5-4
ENTER ...................................... 3-3, 3-16, 5-7
ENTRY ..................................... 3-23, 3-24, 3-25, 3-26, 5-2, 5-3, 5-4, 5-5
EXIT ....................................... 3-3, 3-16
EXT ADD IN ................................. 3-11, 5-16
EXT AM IN .................................. 3-12, 5-17
FREQ ....................................... 3-23, 5-3, 5-4
FUNCTION .................................. 3-20, 4-55
FUNCTION OUT ............................ 3-5
HIGH ....................................... 5-5
k ............................................. 4-58, 5-7
LOCAL—REMOTE CONTROL separate volume
LOW ......................................... 5-5
m ............................................. 4-57, 5-7
M ............................................. 5-7
MAN TRIG .................................. 4-8, 4-12, 4-15, 5-23
MEMORY .................................... 5-13
MODE ....................................... 3-19, 4-2, 4-16, 4-40
MODU ....................................... 3-8, 3-19, 4-40
NOISE ..................................... 3-8, 3-19, 3-22, 3-23, 5-8
NORMAL .................................... 3-19, 5-24
OFFSET .................................... 3-25, 5-6, 5-20
OUTPUT .................................... 3-3, 3-27
OVER ....................................... 3-5
PAUSE ...................................... 4-20, 4-25, 4-32
PERIOD ..................................... 5-2, 5-3, 5-4
PHASE ...................................... 3-26, 5-24
START ...................................... 4-19, 4-25, 4-31, 4-42, 4-45, 4-48, 4-51, 4-54
STOP ....................................... 4-19, 4-20, 4-21, 4-25, 4-26, 4-32, 4-42, 4-45, 4-48, 4-51, 4-54
SWEEP ...................................... 3-8, 3-19, 4-16
SWEEP PAUSE IN .......................... 3-10, 4-20, 4-25, 4-32
SWEEP X-DRIVE OUT ...................... 3-10, 4-38
SWEEP Z-MARKER OUT .................... 3-11, 4-34, 4-38
SYNC OUT .................................. 3-6, 4-38
SYSTEM .................................... 3-16, 5-9, 5-16, 5-17, 5-18, 5-19, 5-20, 5-24
TRIG/SWEEP IN ............................ 3-9, 4-8, 4-11, 4-14, 4-20, 4-32, 5-23
UNDO ....................................... 5-21
WIDTH ...................................... 5-3, 5-4
φ-SYNC IN,OUT ............................. 3-12, 5-24
µ ............................................. 5-7
**WARRANTY**

**NF Corporation** certifies that this instrument was thoroughly tested and inspected and found to meet its published specifications when it was shipped from our factory.

All **NF** products are warranted against defects in materials and workmanship for a period of one year from the date of shipment. During the warranty period of, **NF** will, at its option, either will repair the defective product without any charge for the parts and labor, or either repair or replace products which prove to be defective. For repair service under warranty, the product must be returned to a service center designated by **NF**. Purchaser shall prepay all shipping cost, duties, and taxes for the product to **NF** from another country, and **NF** shall pay shipping charge to returned the product to purchaser.

This warranty shall not apply to any defect, failure or damage caused by improper use, improper or inadequate maintenance and care or modified by purchaser or personnel other than **NF** representatives.

**NF Corporation**
If there are any misplaced or missing pages, we will replace the manual. Contact the sales representative.

NOTES

• Reproduction of the contents of this manual is forbidden by applicable laws.
• The contents of this manual may be revised without notice.
• Information provided in this manual is intended to be accurate and reliable. However, we assume no responsibility for any damage regarding the contents of this manual.
• We assume no responsibility for influences resulting from the operations in this manual.

Copyright 2005, NF Corporation

WF1945B MULTIFUNCTION SYNTHESIZER Instruction Manual

NF Corporation
3-20 Tsunashima Higashi 6-chome, Kohoku-ku. Yokohama-shi
223-8508, JAPAN
Phone +81-45-545-8111  Fax +81-45-545-8191