WAVE FACTORY

MULTIFUNCTION SYNTHESIZER

WF1965

INSTRUCTION MANUAL

NF Corporation

DA00008199-002

WF1965
50MHz
SYNTHESIZER
Instruction Manual

WAVE FACTORY

Foreword

Thank you very much for procuring the WF1965 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.

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 Ω.

● 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

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

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

⚠ WARNING

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

⚠ CAUTION

Appears in the text and on the product to advise risk of damage to the product.

Ground indication:

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

Indicates power switch on state.

Indicates power switch off state.

Contents

Section 1 Overview

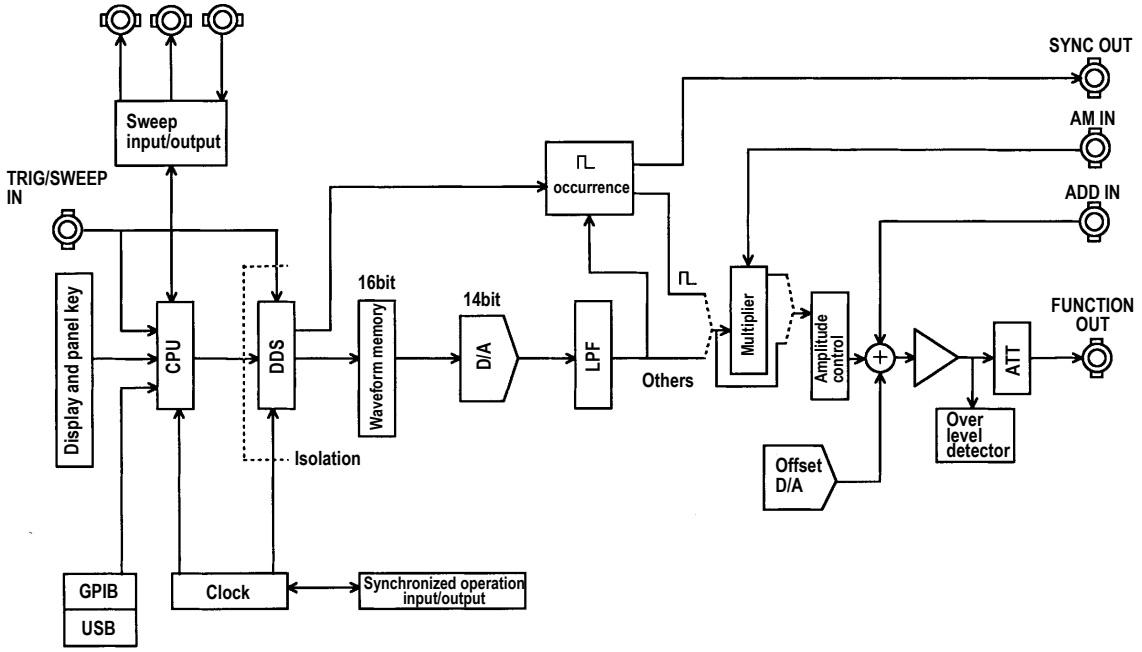
1.1 Features

The WF1965 Wave Factory is a multifunctional synthesizer based on the direct digital synthesizer (DDS) system.
Although the WF1965 is single-channel, the series also includes the 2-channel WF1966.

- Frequency setting range : 0.01 μHz to 50 MHz
- Maximum output voltage : 20 Vp-p/open, ±10 V/open
- Waveform resolution: 14 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 in 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.
- Variable rise time/fall time of square waves
- 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 synchronized operation option enables the synchronized operation of multiple units, increasing the number of channels for the oscillator.

1.2 Operating principles

■ Block diagram



- The CPU conducts analog control for display, panel keys, remote control (GPIB, USB), DDS, amplitude and DC offset.
  Sweep/internal modulation and sweep input/output control are also conducted.
- The clock generator produces DDS reference and CPU clock signals.
- An isolation circuit is inserted between the CPU and DDS, causing the analog circuit to float.
- 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

■ Main functions

• Oscillation mode selection

The oscillation type can be set for continuous (NORMAL), intermittent (BURST), sweep (SWEEP), modulation (MODU), noise (NOISE), or DC (DC).

• Waveform selection

The waveform type can be set for sinewave (∿), triangle waveform (△), squarewave (⊓ , 50 % fixed duty), squarewave (⊓ , variable duty), rising sawtooth (◿), descending sawtooth (◺), or arbitrary (ARB).

• Frequency setting

The frequency can be set by the keypad or modify dial.

The period, i.e., inverse of frequency, can also be set.

The duty and pulse width can also be set for the variable duty squarewave.

• Amplitude setting

The amplitude can be set by the keypad or modify dial.

• DC offset setting

The DC offset can be set by the keypad or modify dial.

• Phase setting

Oscillation starting phase during burst oscillation can be set.

• Output on/off

The waveform and sync signal output connectors are on/off switchable.

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**

  Coefficient multiplication and compensation addition can be applied to frequency, period, amplitude, DC offset, phase, and duty to allow values to be set and displayed in the desired units. The units can be expressed by up to 4 desired characters.

- **Setting store and recall**

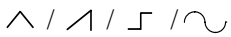
  The settings for frequency, amplitude, etc., can be stored and recalled.

  The WF1965 is capable of 10 combinations store/recall.

- **Computer control**

  GPIB or USB enables remote control from a personal computer.

■ Function tree

- Output
  - Output on/off
  - Oscillation mode
    - Normal
    - Burst
      - Burst/trigger/gate/triggered gate
    - Sweep
      - Sweep mode
        - SINGLE/CONT/GATED
      - Sweep type
        - Frequency/amplitude/DC offset/phase/duty
      - Sweep function
        - Linear/log
        - 
    - Modulation
      - Modulation type
        - Frequency/amplitude/DC offset/phase/duty
      - Modulation waveform
        - 
    - Noise
    - DC
  - Waveform
    -  (duty 50% fixed)/  (variable duty)/  /arbitrary waveform (ARB)
  - Voltage
    - Output range
    - Amplitude setting
    - DC offset setting
    - High-level setting
    - Low-level setting

(Continued on the following page)

Output (continued from the preceding page)

- Frequency
  - Frequency setting
  - Period setting
  - Pulse width setting (⎍ : for variable duty)
  - Duty setting (⎍ : for variable duty)
  - Rise time/fall time setting (⎍ , ⎍ : for variable duty)
- Phase
  - Oscillation start phase
- User unit

Setting content

- Store/recall/clear
- Initialization

Communication

- GPIB
- USB

Others

- Error display
- Output state setting at power-on
- SYNC OUT/sweep synchronized output
- Trigger/gate/sweep start input
- Sweep stop/restart input
- Sweep X-DRIVE output
- Sweep marker output
- External add input
- External AM input
- 1991 synchronized operation option

Section 2 Preparation

2.1 Check before using

■ Safety check

Before using the WF1965, 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.

Mainframe	1
Instruction Manual	1
Remote Control Instruction Manual	1
0105 Arbitrary Waveform Editor (CD-ROM)	1
Supplied accessories	
Power cable: (3-conductors)	1
Fuse : (100/115 V: 1 A or 230 V: 0.5 A)	1
(Time lag, 250 V, ϕ5.2 × 20 mm)	

For information on how to use 0105 Arbitrary Waveform Editor, refer to the CD-ROM of the 0105.

When repacking the equipment for transportation, use a packing carton having ample strength to protect the equipment and bear the weight of stacking.

⚠ WARNING

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

■ Options

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

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

2.2 Power source and grounding

■ Grounding

⚠ WARNING

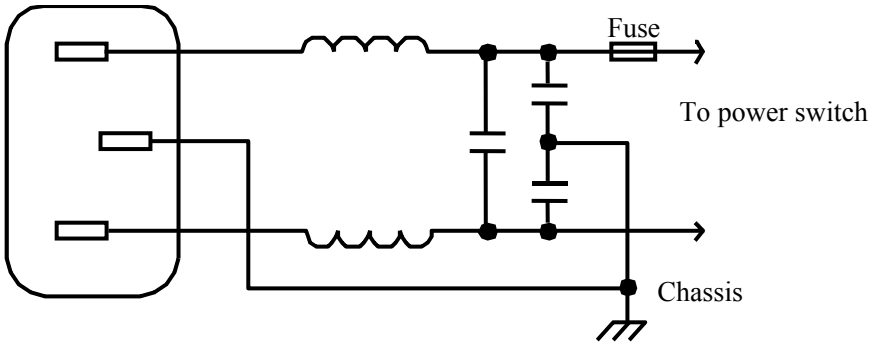
The WF1965 uses a line filter that incorporates the circuit below.

This equipment must be grounded in order to prevent electric shock accidents.

Confirm the protective ground terminal is connected to ground before connecting the equipment for measurements. The WF1965 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 WF1965 uses a line filter that incorporates the circuit below.
Because the maximum leakage current is 0.5 mArms at 250 V/62 Hz, touching a metallic part of the WF1965 could cause an electric shock.
For your safety, be sure to ground the device.



■ Power source

⚠ CAUTION

Be sure to observe the following in order to prevent damage to the equipment.
Confirm the power source voltage is within the range specified for the WF1965.

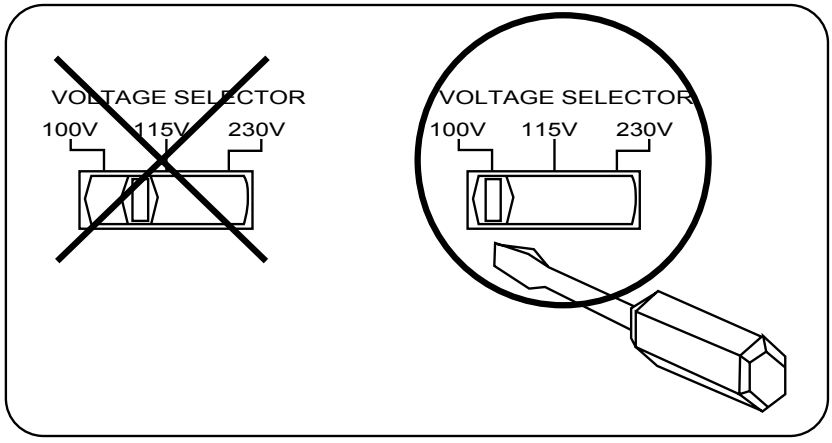
Check the power source voltage indication on the rear panel above the power source inlet. The WF1965 operates from the following commercial power source.

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 WF1965 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 WF1965 with a source voltage that differs from the factory setting, be sure to contact the sales representative of NF Corporation.

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

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

■ Power supply fuse

⚠ WARNING

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

Fuse: Time lag 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

⚠ CAUTION

Observe the following cautions to avoid damaging the WF1965.

- **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

Install the WF1965 in a place that satisfies the following temperature and humidity conditions:

Guaranteed performance: +5 to +35 °C, 5 to 85 %RH
(no condensation at an absolute humidity of 1 to 25 g/m^3)

Ambient storage conditions: -10 to +50 °C, 5 to 95 %RH
(no condensation at an absolute humidity of 1 to 29 g/m^3)

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 WF1965 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 WF1965 conforms to the following standards.

Safety: EN 61010-1: 2001

EMC: EN 61326: 1997/A1: 1998/A2: 2001

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

EN61000-4-2(1995), EN61000-4-4(1995), EN61000-4-5(1995), and EN61000-4-11(1994):B

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

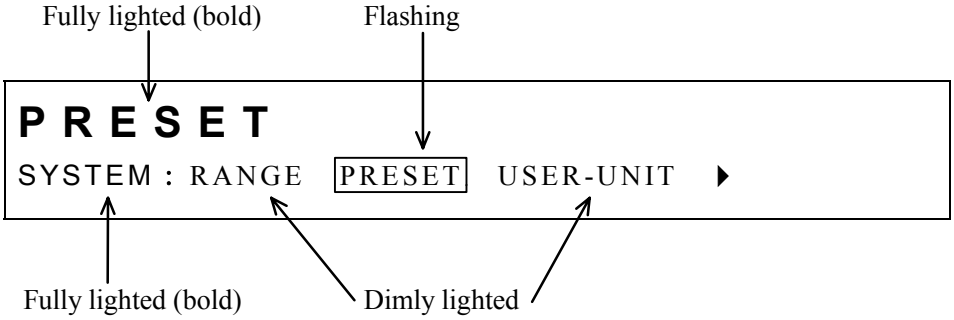
- Power cable : Accessory
- Signal cables : Coaxial cable with BNC connectors, 1 m (3D-2W or RG-143B/U or RG-223/U)
- GPIB cable : Shielded cable, 1 m (DDK: 408JE-101)

2.5 Calibration

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

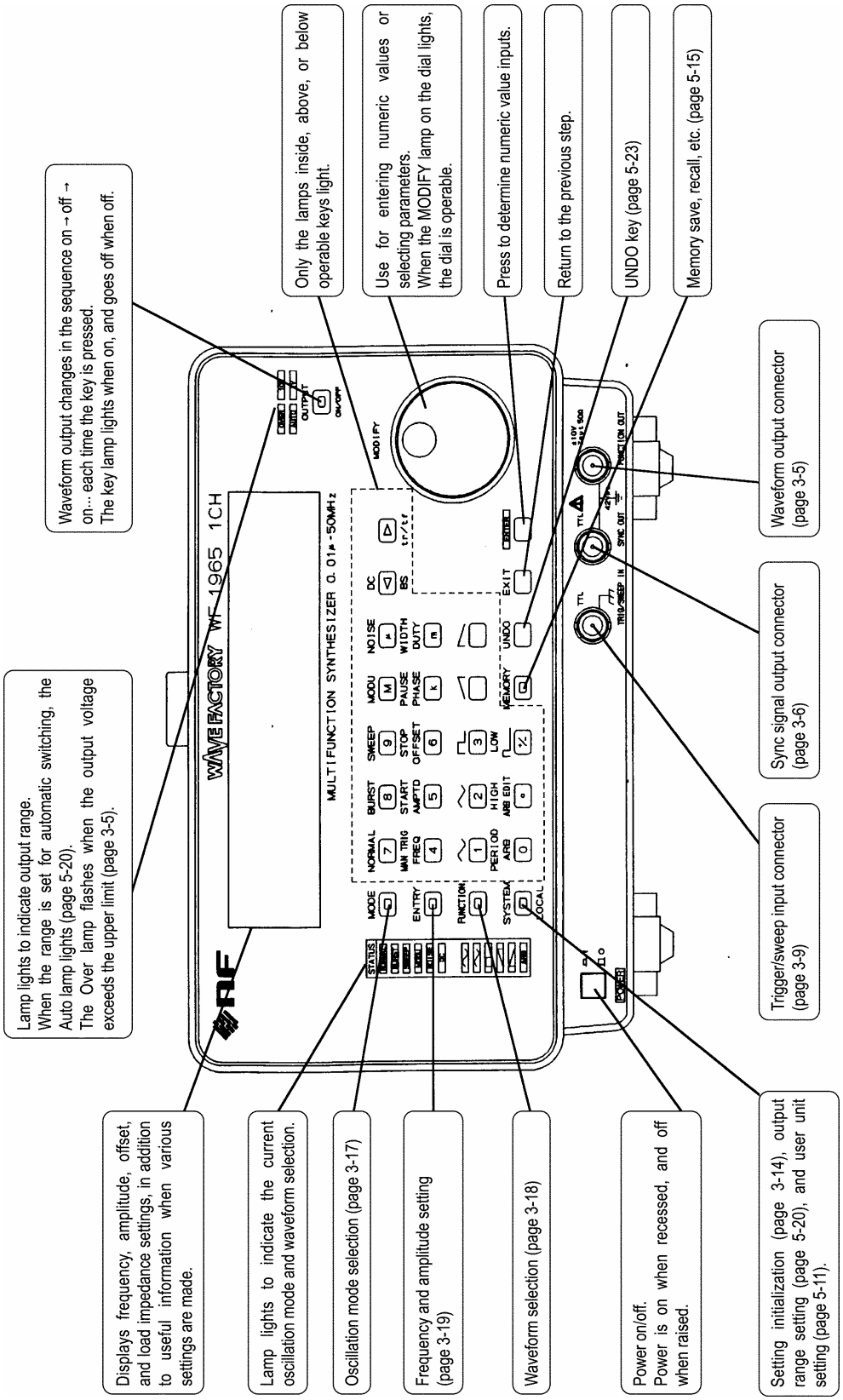
・Following is an example of the display when using this section.



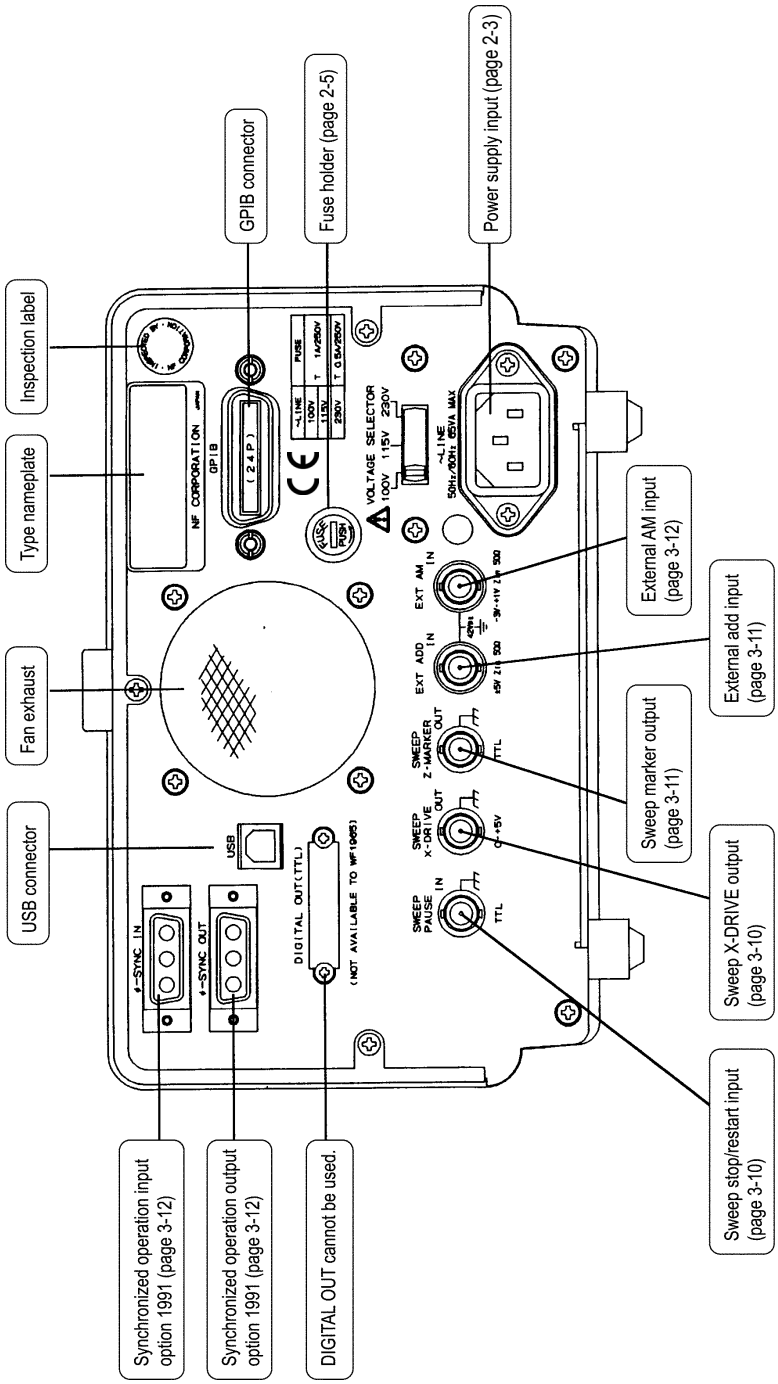
3.1 Panel description

This section describes the indications and functions of the front and rear panels of the WF1965.

■ Front panel

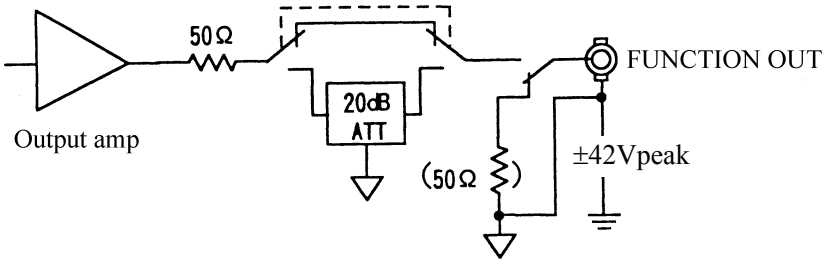

Waveform output changes in the sequence on → off → on... each time the key is pressed.
The key lamp lights when on, and goes off when off.
Only the lamps inside, above, or below operable keys light.
Use for entering numeric values or selecting parameters.
When the MODIFY lamp on the dial lights, the dial is operable.
Press to determine numeric value inputs.
Return to the previous step.
UNDO key (page 5-23)
Memory save, recall, etc. (page 5-15)
Waveform output connector (page 3-5)
Sync signal output connector (page 3-6)
Trigger/sweep input connector (page 3-9)
Lamp lights to indicate output range.
When the range is set for automatic switching, the Auto lamp lights (page 5-20).
The Over lamp flashes when the output voltage exceeds the upper limit (page 3-5).
Displays frequency, amplitude, offset, and load impedance settings, in addition to useful information when various settings are made.
Lamp lights to indicate the current oscillation mode and waveform selection.
Oscillation mode selection (page 3-17)
Frequency and amplitude setting (page 3-19)
Waveform selection (page 3-18)
Power on/off.
Power is on when recessed, and off when raised.
Setting initialization (page 3-14), output range setting (page 5-20), and user unit setting (page 5-11).

■ Rear panel


Inspection label
Type nameplate
Fan exhaust
USB connector
GPIB connector
Fuse holder (page 2-5)
Power supply input (page 2-3)
External AM input (page 3-12)
External add input (page 3-11)
Sweep marker output (page 3-11)
Sweep X-DRIVE output (page 3-10)
Sweep stop/restart input (page 3-10)
Synchronized operation input option 1991 (page 3-12)
Synchronized operation output option 1991 (page 3-12)
DIGITAL OUT cannot be used.
NF CORPORATION
GPIB
(24P)
VOLTAGE SELECTOR
100V 115V 230V
~LINE
50Hz/60Hz 65VA MAX
FUSE
EXT AM IN
EXT ADD IN
SWEEP Z-MARKER OUT
SWEEP X-DRIVE OUT
SWEEP PAUSE IN
TTL
USB
4-SYNC IN
4-SYNC OUT
DIGITAL OUT(TTL)
(NOT AVAILABLE TO WF1965)

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 (floated from the chassis)

⚠ CAUTION

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

・Output limiting

If the output voltage exceeds the following values, the output may be clipped depending on the high level/low level settings or the relationship between the amplitude and DC offset setting, and the external add and external AM settings.

10 V range: Approx. 10Vp/open
10 V range: Approx. 5 Vp/50 Ω load
1 V range: Approx. 1.0Vp/open
1 V range: Approx. 0.5 Vp/50 Ω load

If the internal circuit is overloaded by the output voltage, the OVER lamp lights.
Although the operation is not a failure, the lamp indicates that the operation is not normal.

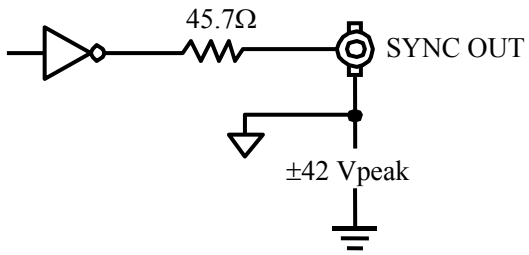
・Output connection note

Since FUNCTION OUT outputs high-speed signals, the WF1965 is designed for use with 50 Ω termination. To prevent performance deterioration, use a coaxial cable with a characteristic impedance of 50 Ω to connect to other equipment and terminate the input of the equipment to be connected at 50 Ω. Although possible, using the equipment without 50 Ω termination could lead to waveforms disturbed by signal reflection or performance deterioration.

・Setting and output voltages

The setting voltage display and actual output voltage (load terminal voltage) differ according to the load resistance. ☞ "5.5 Other settings (■LOAD function (equalize setting and output values))", cf.

■ Sync signal output (SYNC OUT)



Output waveform :	⎍
Output voltage :	0 V/+5 V (open)
Output impedance:	50 Ω, unbalanced
Load impedance:	More than 45 Ω
Status at output off :	High impedance
Ground :	Connected to signal ground (floated from the chassis)

⚠ CAUTION

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

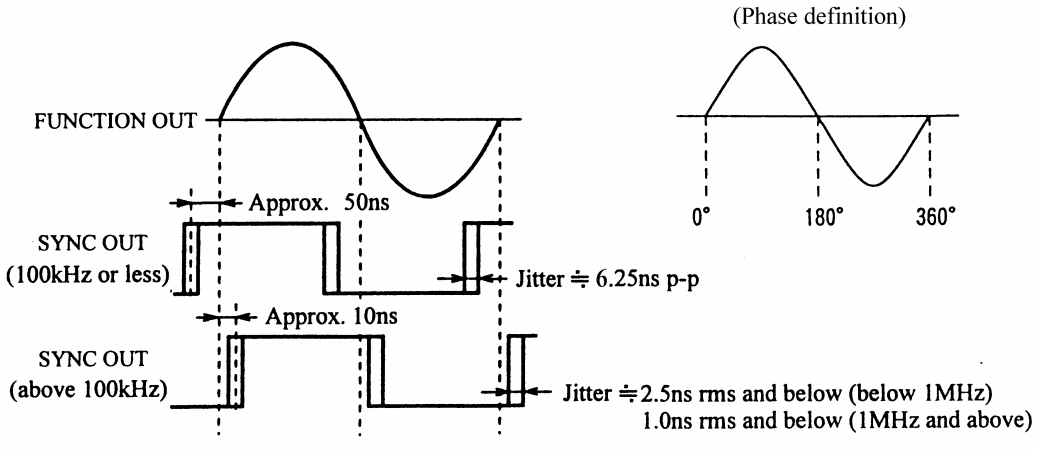
・Output connection note

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

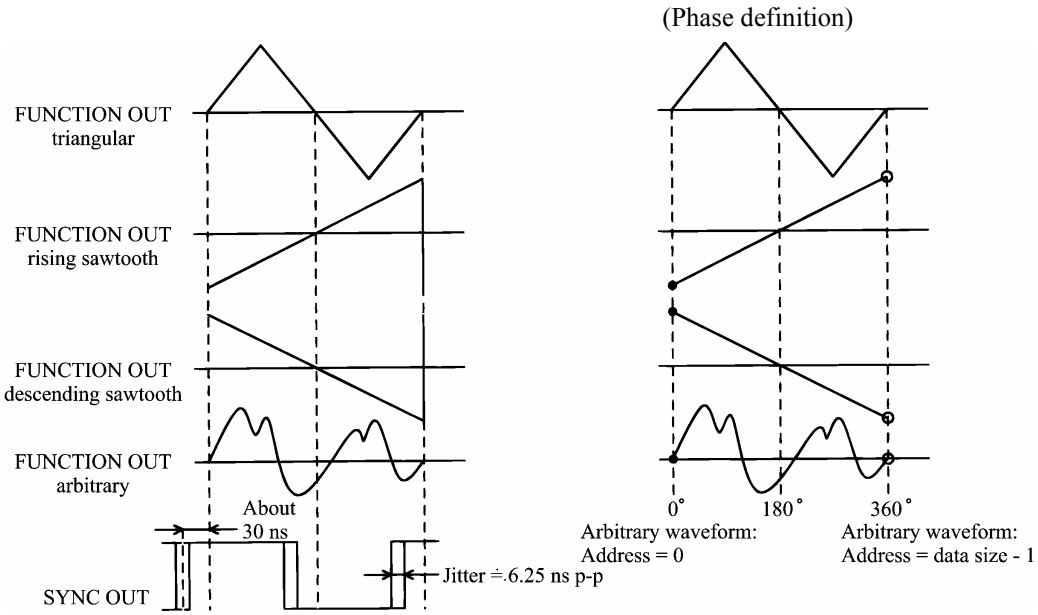
・Waveform and sync signal output relationship (Waveform phase definition)

(1) Continuous oscillation mode (NORMAL)

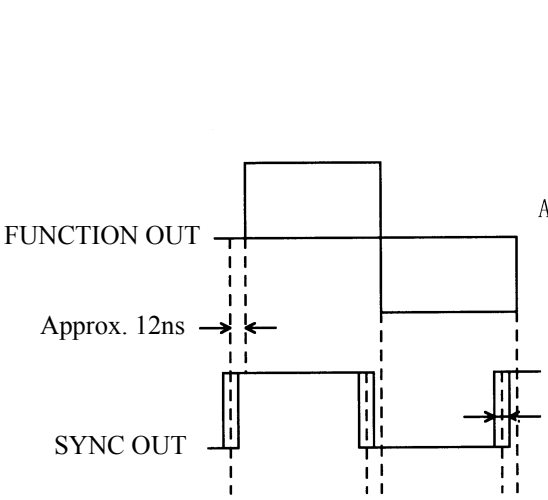
① Sinewave



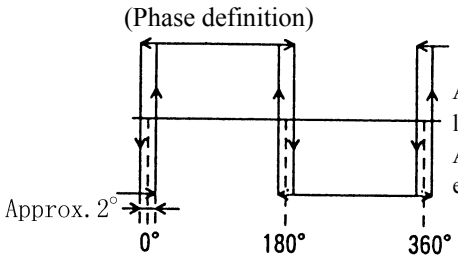
② Triangular, rising sawtooth, descending sawtooth, arbitrary



③ Squarewave (fixed 50 % duty)



Approximately 6.25 ns p-p jitter is also produced in The Function Out waveform when stop level is On or 100 kHz and below.

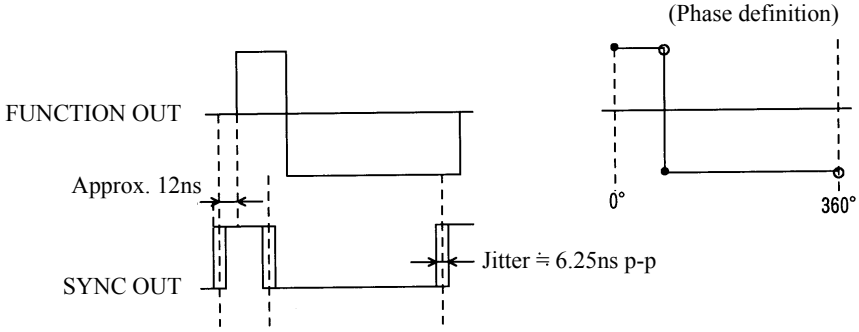


Above 100 kHz with stop level off.
At other times, see example ④ below.

Rising and falling edge hysteresis zones vary with phase history.

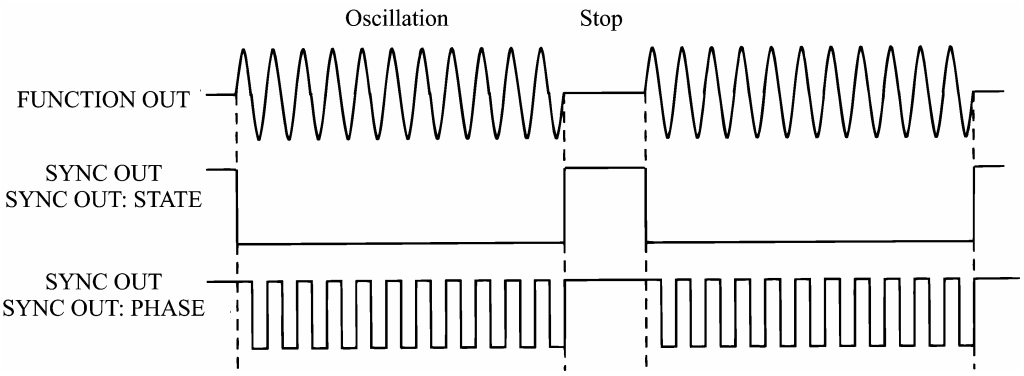
Jitter ≒
6.25 ns p-p (Stop level on or 100 kHz and below)
2.5 ns rms and below (Stop level off and between above 100 kHz and below 1 MHz)
1.0 ns rms and below (Stop level off and 1 MHz and above)

④ Squarewave (variable duty)



Approximately 6.25 ns p-p jitter is also produced in the Function Out waveform.

(2) Burst mode (BURST)



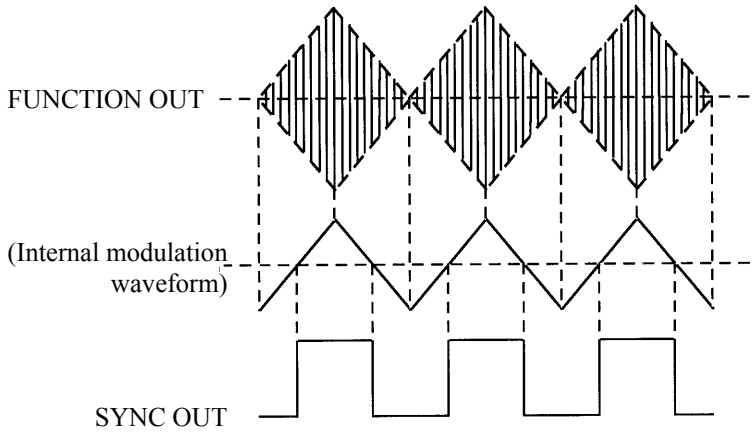
(3) Sweep mode (SWEEP)

Low level during sweep from start to stop points. High level at other times.

☞ "4.2 Sweep (■Sweep value and marker/sync/X-DRIVE output)", cf.

(4) Modulation mode (MODU)

High level when modulation waveform phase is above 0 and less than 180 degrees. Low level above 180 and below 360 degrees.



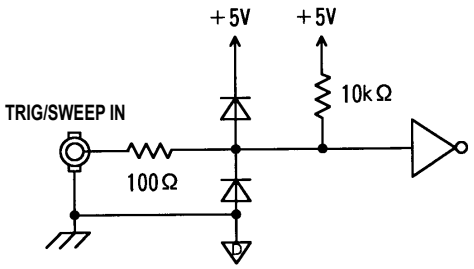
(5) Noise mode (NOISE)

Digital (binary) noise source output.

(6) DC mode (DC)

Always high level.

■ Trigger/sweep input (TRIG/SWEEP IN)



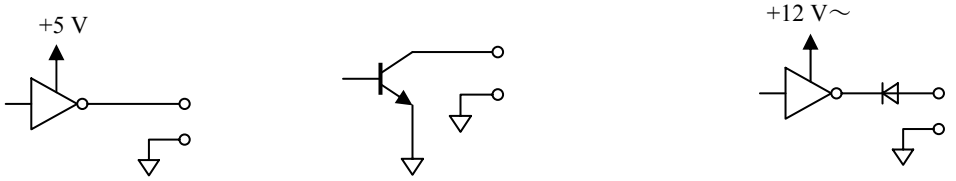
Signal characteristics: The following types are produced during the burst oscillation mode.
Trigger: Select oscillation start for either ↑ or ↓.
Gate: Select oscillation at either high or low level.
Triggered gate: Oscillation start/stop at ↑ or ↓. Select either.
Minimum pulse width is 50 ns.
In sweep oscillation mode, the sweep starts at ↑ or ↓. Select either.
Minimum pulse width is 200 ns.

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.

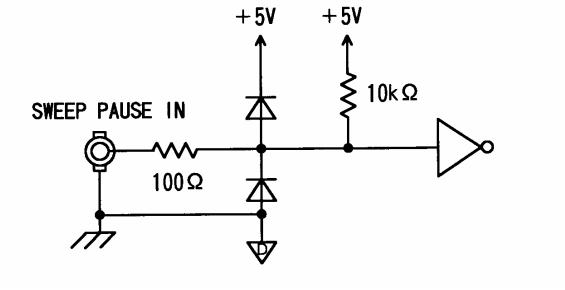
• Drive circuit examples



(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 WF1965 input

■ Sweep stop/restart input (SWEEP PAUSE IN)



Signal characteristics :	Sweep stop = Low level
	Sweep restart = High level
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 with about 10 kΩ
Ground :	Connected to chassis ground

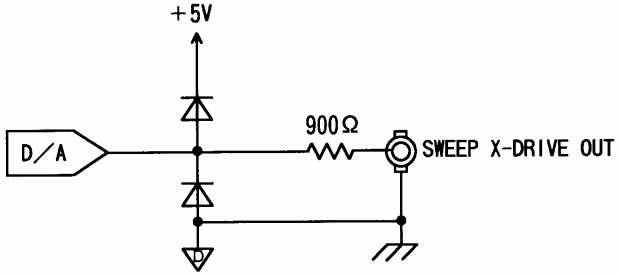
⚠ CAUTION

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

• Driver circuit example

☞ "3.2 Input and output connectors (■Trigger/sweep input)", cf.

■ Sweep X-DRIVE output (SWEEP X-DRIVE OUT)

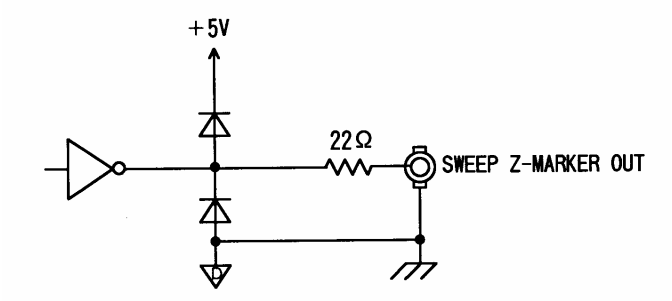


Signal characteristics :	0 V → +5 V = Sweep value is rising
	+5 V → 0 V = Sweep value is falling
Output voltage :	0 to +5 V (open)
Output impedance :	About 1 kΩ
Recommended load :	10 kΩ or more
Ground :	Connected to chassis ground

⚠ CAUTION

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

■ Sweep marker output (SWEEP Z-MARKER OUT)

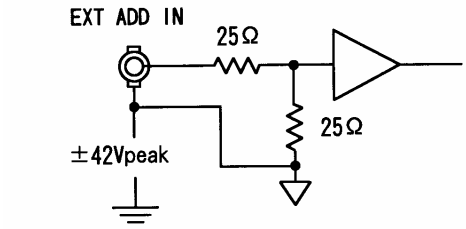


Signal characteristics :	Low level = Sweep value is larger than marker value
	High level = All other times
Output voltage :	0 V/+5 V
Recommended load :	1 kΩ or more
Ground :	Connected to chassis ground

⚠ CAUTION

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

■ External add input (EXT ADD IN)

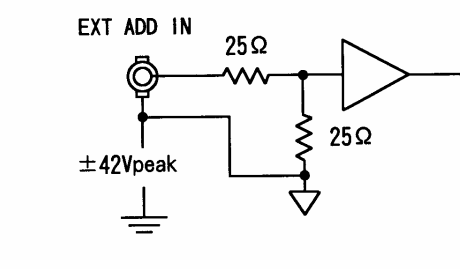


Input voltage :	Within ±5 V
Input impedance :	50 Ω
External add frequency :	10 MHz or less
Ground :	Connected to signal ground (floated from the chassis)

⚠ CAUTION

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

■ External AM input (EXT AM IN)



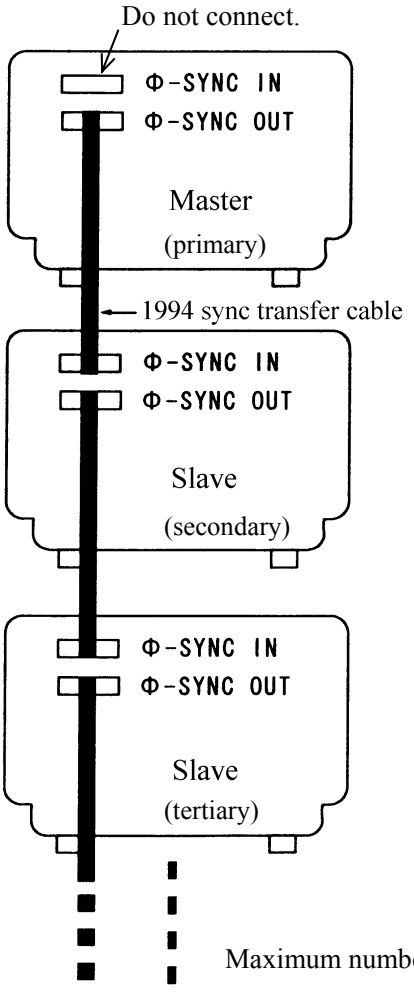
Input voltage : -3 V to +1 V
(output -100% at -3 V, output 0% at -1 V, and output 100% at +1 V)
Input impedance : 50 Ω
Modulated frequency : 10 MHz or less
Ground : Connected to signal ground (floated from the chassis)

⚠ CAUTION

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

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

(Options, 1991 and 1994)



Note: Effective during continuous (Normal) oscillation mode.

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

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

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

Maximum number of connected units: 6

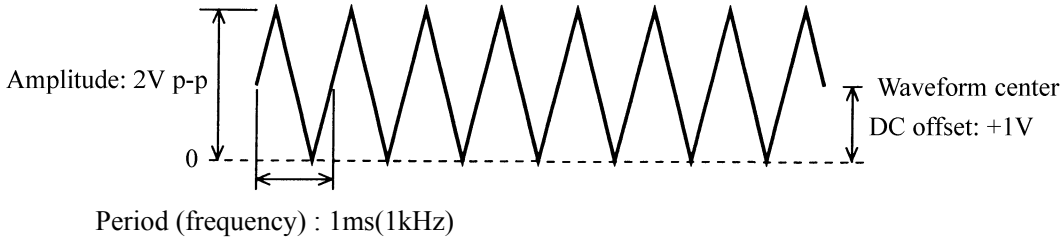
⚠ CAUTION

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.

3.3 Basic operation

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



■ Setting initialize(PRESET)

The operation of initializing all settings is described. This 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).

```
PRESET
SYSTEM : RANGE [PRESET] USER-UNIT ▸
```

② Press the ENTER key (upper PRESET flashes).

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

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.

Initialization table

Key operation	Menu	Initial settings	Remarks
MODE		NORMAL	
MODE→BURST	TYPE	BURST	
	SOURCE	EXT ↓ (1 ms, at INT)	When TYPE=TRIG, GATE,T-GATE
	DELAY	0.3 μs	When TYPE=TRIG
	MARK	1.0	When TYPE=BURST, TRIG
	SPACE	1.0	When TYPE=BURST
	STOP-LEVEL	OFF (0%, at ON).	
MODE→SWEEP	TYPE	FREQ	
	SOURCE	EXT ↓ (1 ms at INT)	When MODE=SINGLE, GATED
	MODE	SINGLE	
	FUNCTION	LIN ⟋	
	TIME	1 s	
	STOP-LEVEL	OFF (0%, at ON).	When MODE=GATED
MODE→SWEEP, TYPE=FREQ	START	1000 Hz	
	STOP	10000 Hz	
	CENTER	5500 Hz	
	SPAN	9000 Hz	
	MARKER	5000 Hz	
MODE→SWEEP, TYPE=AMPTD	START	0.1 Vp-p	
	STOP	1 Vp-p	
	CENTER	0.55 Vp-p	
	SPAN	0.9 Vp-p	
	MARKER	0.5 Vp-p	
MODE→SWEEP, TYPE=OFFSET	START	0.1 V	
	STOP	-0.1 V	
	CENTER	0 V	
	SPAN	0.2 V	
	MARKER	0 V	
MODE→SWEEP, TYPE=PHASE	START	-90 deg	
	STOP	90 deg	
	CENTER	0 deg	
	SPAN	180 deg	
	MARKER	0 deg	

Continued next page

Continued from previous page

Key operation	Menu	Initial settings	Remarks
MODE→SWEEP, TYPE=DUTY	START	40%	
	STOP	60%	
	CENTER	50%	
	SPAN	20%	
	MARKER	50%	
MODE→MODU	TYPE	FM	
	FREQUENCY	100Hz	
	FUNCTION	∿	
MODE→MODU, TYPE=FM	DEVIATION	1000Hz	
MODE→MODU, TYPE=AM	DEPTH	50%	
MODE→MODU, TYPE=OFSM	DEVIATION	0.2V	
MODE→MODU, TYPE=PM	DEVIATION	90 deg	
MODE→MODU, TYPE=PWM	DEVIATION	20%	
ENTRY→FREQ		1000 Hz	
ENTRY→AMPTD		0.1 Vp-p	
ENTRY→OFFSET		0 V	
ENTRY→PHASE		0 deg	
ENTRY→WIDTH		0.0005 s	In case of FUNCTION= ⎍
ENTRY→DUTY		50 %	In case of FUNCTION= ⎍
ENTRY→PERIOD		0.001 s	
ENTRY→HIGH		0.05 V	
ENTRY→LOW		–0.05 V	
ENTRY→tr / tf		7 ns	In case of FUNCTION= ⎍ , ⎍
FUNCTION		∿	
SYSTEM	RANGE	AUTO	
	LOAD	OPEN (50 Ω at SET)	
	EXT-AM	OFF	
	EXT-ADD	OFF	
	DUTY-VALID	IMMED	
	SYNC OUT	STATE	

■ Oscillation mode selection (MODE)

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

Terms:

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

Operation:

The selected oscillation mode is indicated in the STATUS area, which is located to the left of 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.

■ Waveform selection (FUNCTION)

Waveform selection is described.

Symbols:

: Sinewave
: Triangular wave
: Squarewave (50 % fixed duty)
: Squarewave (variable duty)
: Rising sawtooth
: Descending sawtooth
ARB: Arbitrary waveform
☞ "4.4 Arbitrary Waveform (FUNCTION, ARB)", cf.

Operation:

The selected waveform is indicated in the STATUS area, which is located to the left of FUNCTION key. When the FUNCTION key is pressed, the FUNCTION key lamp lights, and at the same time, the lamp of every key located to the right of the FUNCTION key lights. The lamp of the selected waveform blinks.

To select another waveform (one whose key lamp is already lit), press the key of the waveform.

Operation example:

In this example, a triangular waveform is selected.

① Press the FUNCTION key, then the key.
The STATUS lamp lights

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

Other:

Waveforms cannot be selected in the following cases:

- The oscillation mode is NOISE or DC.
- The oscillation mode is SWEEP and the type is DUTY.
- The oscillation mode is MODU and the type is PWM.

■ Frequency setting (ENTRY → FREQ)

Frequency (FREQ) setting is described.

Operation:

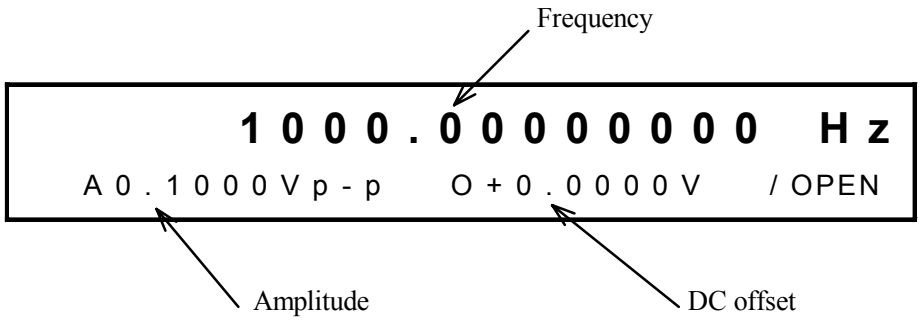
Two methods can be used for setting the frequency.

(1) Keypad

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

For example, set 1 kHz as follows.

① Press the ENTRY key, then the FREQ key.



② Press the 1 key, then the k key.

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

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

(2) Modify dial

This is convenient for continuously setting the frequency.

① Press the ENTRY key, then the FREQ key.

② Select the digit to be changed with the ◁ and ▷ keys. The selected digit flashes.

③ Turn the MODIFY dial to set the digit.

④ After setting, press the EXIT key.

Other:

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

■ Amplitude setting (ENTRY → AMPTD)

Amplitude (AMPTD) setting is described.

Operation:

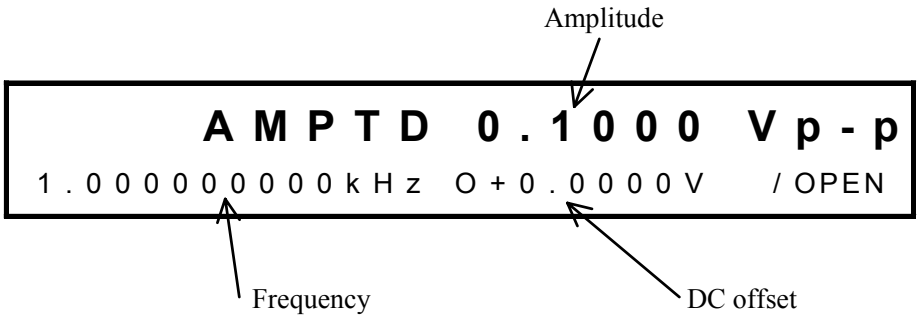
The amplitude can be set by two methods.

(1) Keypad

Convenient when the amplitude has been determined beforehand.
For example, set 2 Vp-p as follows.

① Press the ENTRY key, then the AMPTD key.

The following display is produced.



② Press the 2 key, then the ENTER key.

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

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

(2) Modify dial

The amplitude can be changed continuously.

① Press the ENTRY key, then the AMPTD key.

② Select the digit to be changed with the ◁ and ▷ keys.

③ Turn the MODIFY dial to set the flashing digit.

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

Other:

- When the oscillation mode is DC, the amplitude cannot be set.
- Units other than Vp-p can also be set. ☞ "5.2 Units (■Amplitude units change)", cf.
- When the oscillation mode is NOISE, the output amplitude becomes half the set amplitude as a result of the Vp-p setting only. Effective values in NOISE mode are the same as effective values of the 15-MHz models, such as the WF1946, with the same amplitude setting.
- 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.

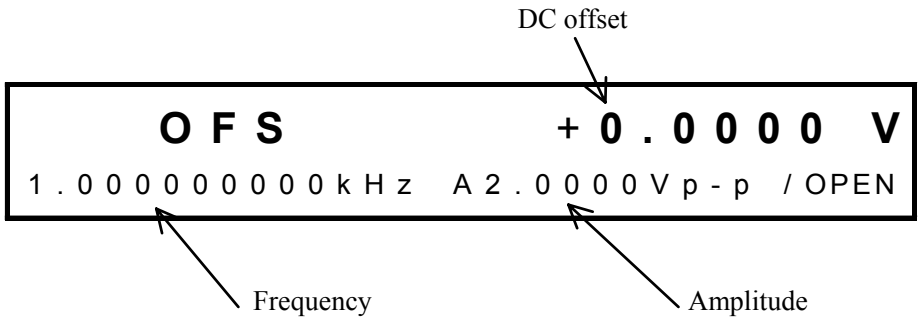
(1) Keypad

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.



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.

■ Phase setting (ENTRY → PHASE)

The oscillation starting phase setting for burst and (gated) sweep is described.

☞ 5.5 Other settings (■Phase sync)

Operation:

Two methods can be used for setting the phase.

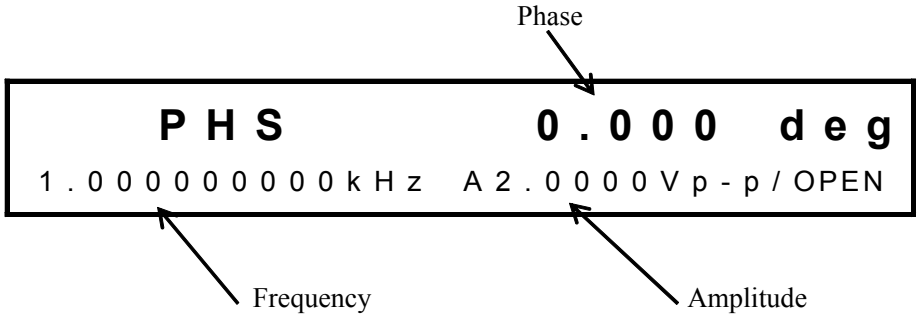
(1) Keypad

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.



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.

■ Square wave rise time/fall time setting (tr/tf) (ENTRY → tr/tf)

Operation to set the rise time/fall time of square waves is described.
The rise time/fall time setting controls the time during which the voltage changes from 10% to 90% on the assumption that the range of output voltage excluding overshoots from the low level to the high level is set to 100%. The example assumes that a square wave (including variable duty) is selected as the waveform.

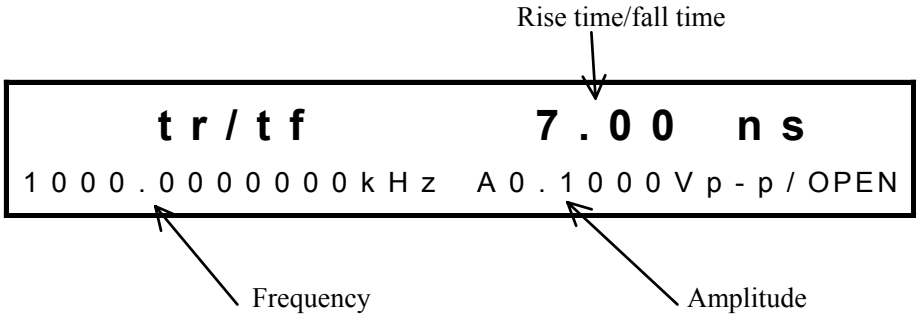
Operation:

Two methods can be used to set the values:

(1) Keypad

This method is convenient when the values have been determined beforehand.
For example, set 100 ns as follows.

① Press the ENTRY key, then the tr/tf key.
The following display is produced.



② Press the 0 , . , and 1 keys, and then the μ key (The input of 0.1 μs is converted into 100 ns).
To correct an entry, press the BS key before pressing μ .
③ This completes setting, afterwards, press the EXIT key.

(2) Modify dial

This method is convenient when the values to be set change continuously.

① Press the ENTRY key, then the tr/tf key.
② Press the ◁ and ▷ keys. The digit to be changed flashes.
③ Turn the MODIFY dial to increase/decrease the value of the flashing digit.
④ After setting, press the EXIT key to release the setting mode.

Other:

- Switching the stop level to ON disables the rise time/fall time setting.
- The range of the rise time/fall time setting may be limited because of the frequency, period, pulse width, and duty settings. If any of these settings is changed, the rise time/fall time may change accordingly.

■ Output on/off

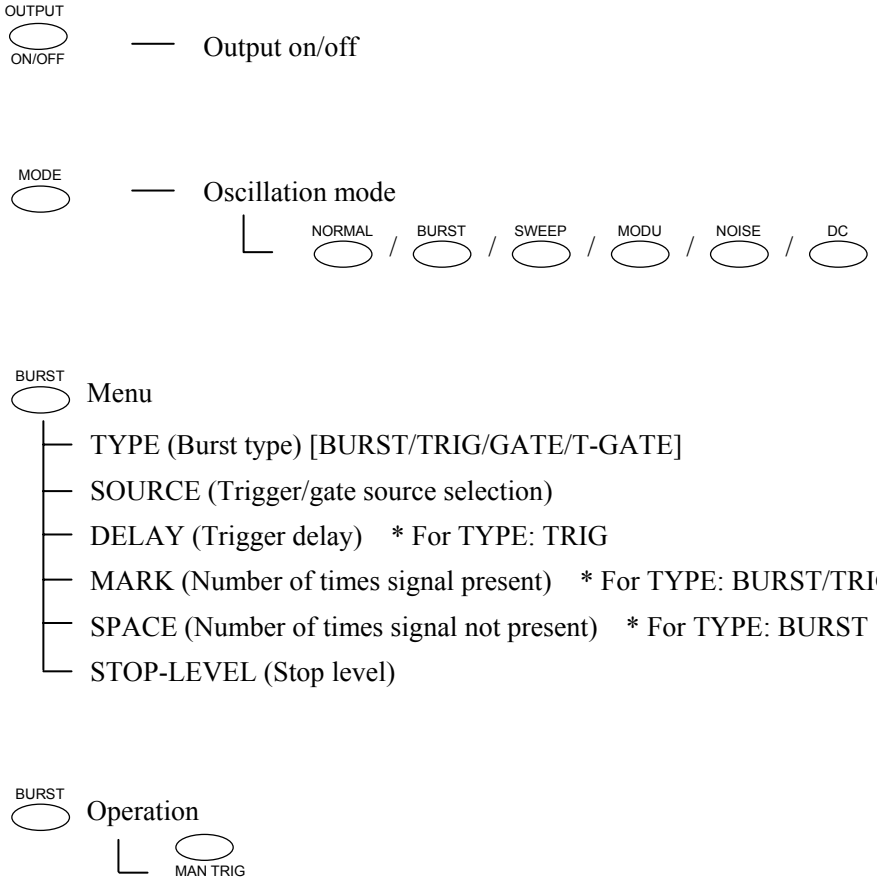
Output on/off setting is described.

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



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 (Stop level) * For MODE: GATED
- CENTER (Sweep center value)
- SPAN (Sweep width)
- MARKER (Marker value)
- MKR→CTR (Copy the marker value to the center value)
- START-STATE (Start state)
- STOP-STATE (Stop state)

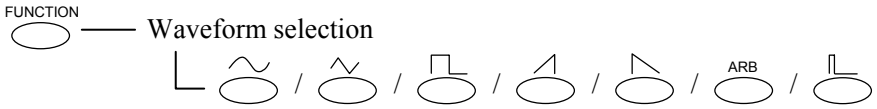
SWEEP
Operation
START / STOP / PAUSE

MODU
Menu (Internal modulation)
- TYPE (Modulation type) [FM/AM/OFSM/PM/PWM]
- DEVIATION (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 / tr/tf

* DUTY/WIDTH for FUNCTION: ⊓
tr/tf for FUNCTION: ⊓ or ⊓



ARB EDIT — Arbitrary waveform menu * For FUNCTION: ARB

- SELECT (Select arbitrary waveform)
- NAME (Arbitrary waveform name)
- EDIT (Edit arbitrary waveform)
- COPY (Copy arbitrary waveform)
- MARK-CLEAR (Clear mark)
- CLEAR (Clear arbitrary waveform)
- SIZE (Select size of arbitrary waveform data)

SYSTEM — Other operation menus

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

MEMORY Setup memory menu

- STORE (Save setup memory)
- RECALL (Call setup memory)
- CLEAR (Clear setup memory)

LOCAL (Return to local of GPIB)

UNDO (Cancel setting)

EXIT (Move to menu immediately above)

ENTER (Accept input value)

Numeric input (keypad)

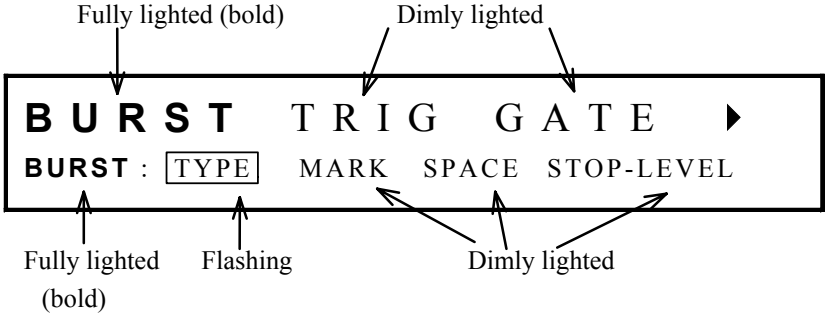
+/- / . / 0 / 1 / 2 / 3 / 4 / 5 / 6 / 7 /
8 / 9 / M / μ / k / m / BS

Numeric modification (Modify)

◁ / ▷ / MODIFY

Section 4 Applications

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



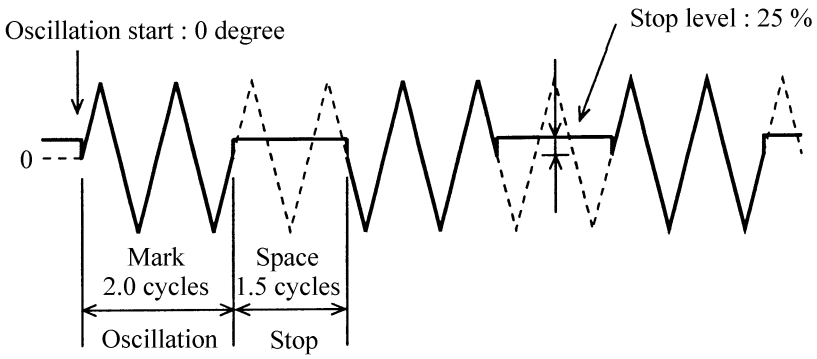
4.1 Burst oscillation

■ 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.



Operation:

(1) Set the burst oscillation TYPE to BURST.

① Press the MODE key, then the BURST key.

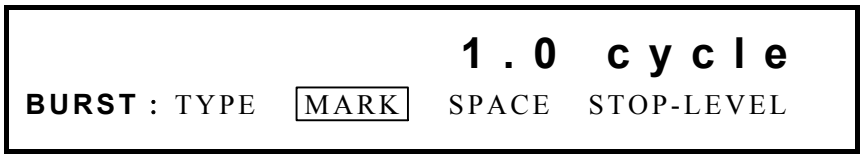
② Use the ◁ and ▷ keys to select the type (TYPE flashes).

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

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).



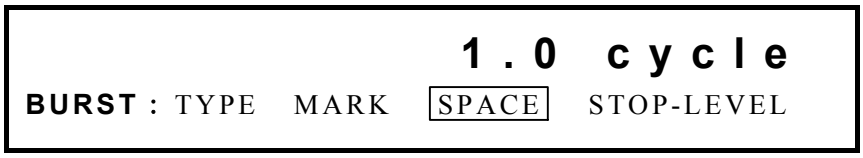
② Press the ENTER key.

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

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

(3) Set SPACE cycle

① Use the ◁ and ▷ keys to produce the following display (SPACE flashes)



② Press the ENTER key.

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

④ After setting, press EXIT once to exit space cycle setting.

(4) Set STOP-LEVEL

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

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

O N	**0 . 0 0 %**
BURST : TYPE MARK SPACE **STOP-LEVEL**	

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

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

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

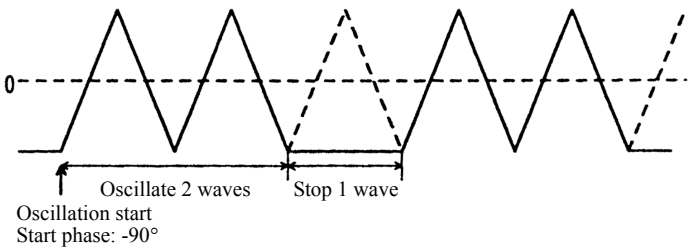
This completes burst oscillation (type: burst) setting.

Other:

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

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

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



*Also, by setting an amplitude (Vp-p) 1/2 DC offset or the low level to 0 V, a unipolar waveform can be obtained.
☞ "5.1 Convenient Settings (■Amplitude and DC offset setting by high and low level)",cf.

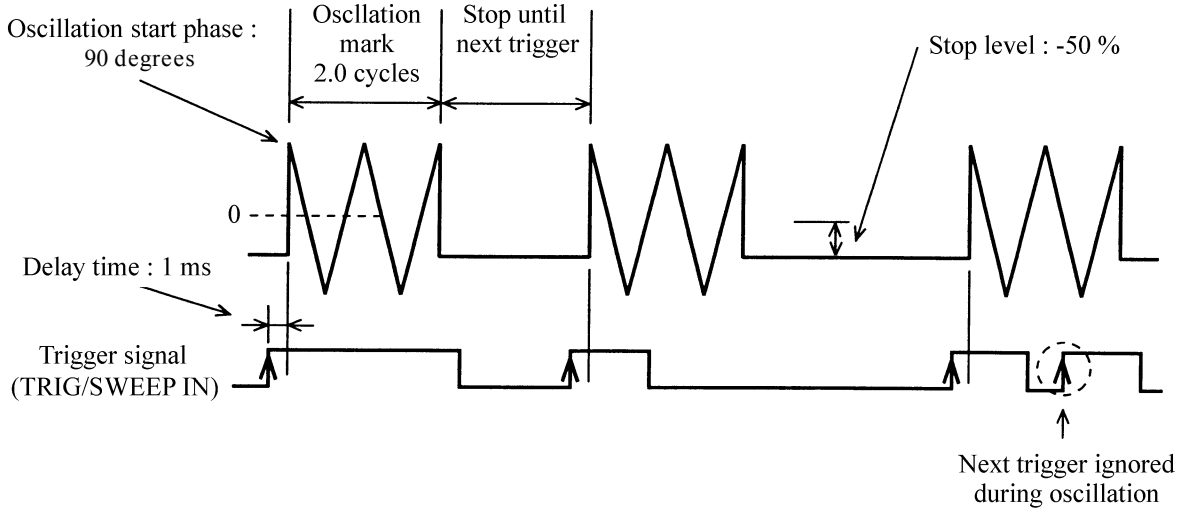
• Burst oscillation setting items (BURST menu)
TYPE: BURST
MARK (oscillation cycle) [cycle]
SPACE (cycle when oscillation stops) [cycle]
STOP-LEVEL [OFF, ON[%]]
PHASE (phase when oscillation starts) [deg] * ENTRY menu

■ Burst oscillation (Type: Trigger) (MODE → BURST → TYPE : TRIG)

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

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

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



Operation:

(1) Set the burst oscillation TYPE to TRIG.

① Press the MODE key, then the BURST key.

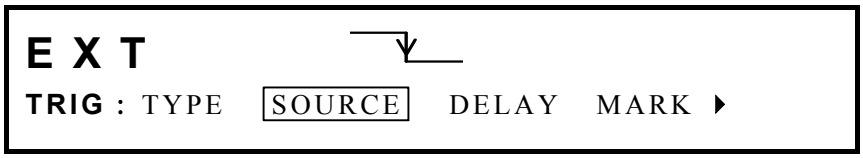
② Use the ◁ and ▷ keys to select the type (TYPE flashes).

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.

(2) Select trigger SOURCE

① Use the ◁ and ▷ keys to produce the following display (SOURCE flashes).



② Press the ENTER key.

③ Press the ▷ key, then turn the MODIFY dial to select rising trigger (⌐¯). (¯_ indicates falling trigger).

④ After setting, press the EXIT key once to release trigger source setting.

(3) Set DELAY time

① Use the ◁ and ▷ keys to produce the following display (DELAY flashes).

② Press the ENTER key.

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

For example, set to 1 ms.

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

(4) Set MARK cycle

① Use the ◁ and ▷ keys to produce the following display (MARK flashes).

② Press the ENTER key.
Set the mark cycles with the keypad or MODIFY dial (0.5 cycles).
In this example, the setting is 2.0 cycles.

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

(5) Set STOP-LEVEL

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

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

③ Press the ▷ key, then set the stop level with the keypad or MODIFY dial.
In this example, the setting is -50 %.

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

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

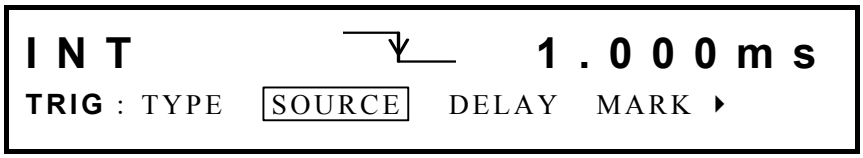
(6) Phase setting

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

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

Additional information:

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



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

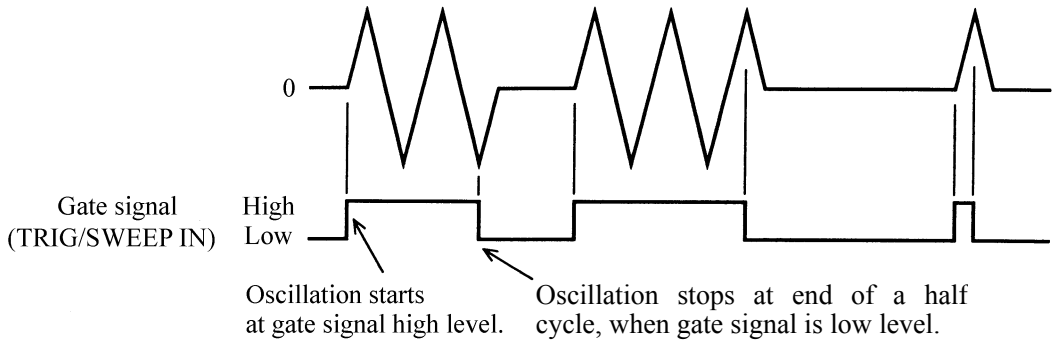
• **Manual trigger** : Press the MAN TRIG key, then set the trigger source to EXT . Operation is based on the logical OR of the external signal, key, and type of remote control (GPIB or USB).

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

• 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.



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).

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

④ 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).

② Press the ENTER key.

③ Press the ▷ key, then select positive logic (H-ON) with the MODIFY dial.

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

(3) Set STOP-LEVEL

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

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

③ Press the ▷ key, then set the stop level with the keypad or MODIFY dial.
In this example, the setting is 0 %.

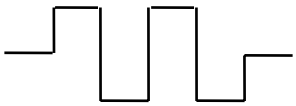
The stop level is the percentage with respect to the maximum positive (+100 %) and negative (-100 %) amplitude.

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. The gate rate is common for CH1 and CH2.

• **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.

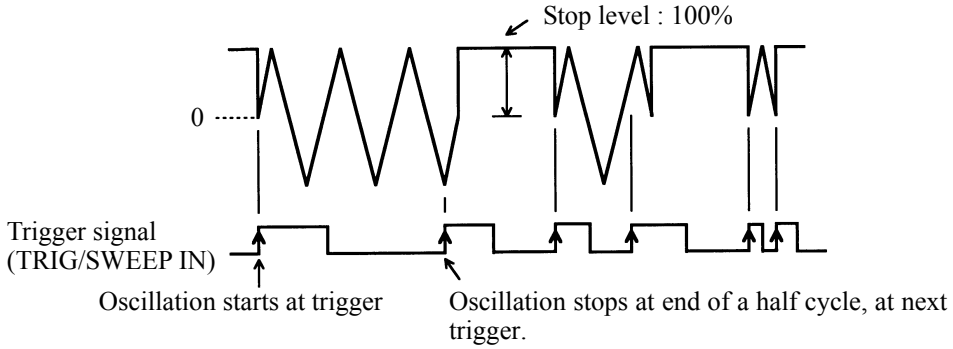
• **To generate the trigger signal via remote control (GPIB or USB),** set the GET command or TRG command from the remote control interface.
Also, set the trigger source to EXT L-ON.
For details of the remote control command, ☞ "Remote Control Instruction Manual", cf.

• 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

■ 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 ( ).

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)

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

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

(2) Select trigger source (SOURCE)

① Use the ◁ and ▷ keys to produce the following display (SOURCE flashes).

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).

② Press the ENTER key.

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

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.

  The trigger input and MAN TRIG operations operate in parallel. If oscillation is started by either of them, the output becomes oscillation. This oscillation cannot be stopped by the other operation.
  Oscillation stops during power-on.

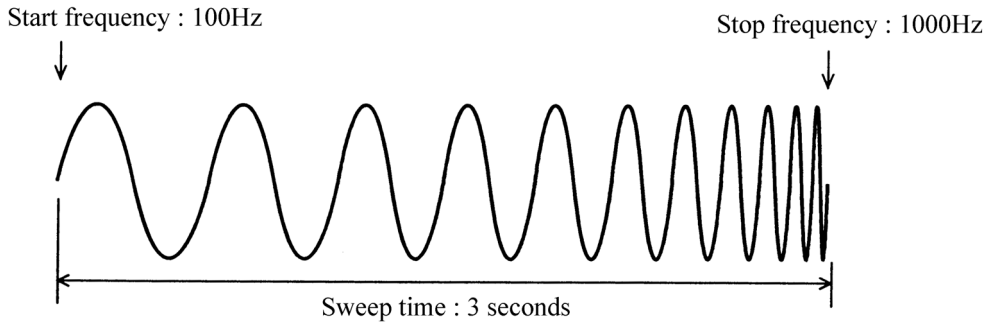
- **To generate the trigger signal via remote control (GPIB or USB),** set the GET command or TRG command from the remote control interface.
  Also, set the trigger source to EXT ⎍.
  For details of the remote control command, ☞ "Remote Control Instruction Manual", cf.

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



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).

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

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).

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

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).

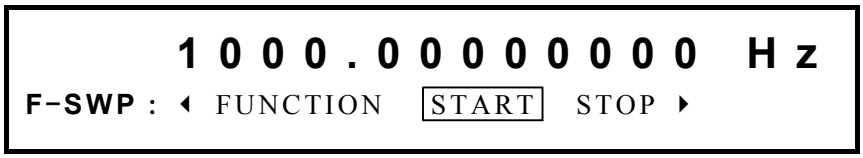
② Press the ENTER key.

③ Press the ▷ key, then select ／＼ with the MODIFY dial.

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

(4) Set START frequency

① Use the ◁ and ▷ keys to produce the following display (START flashes).



② Press ENTER key.

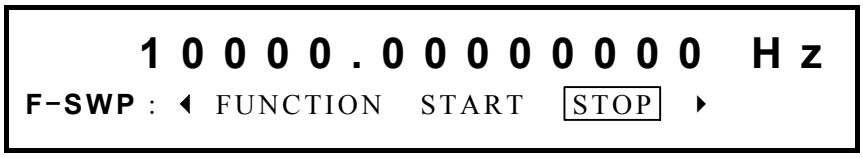
③ Set the start frequency with the keypad or MODIFY dial.

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).



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).

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.

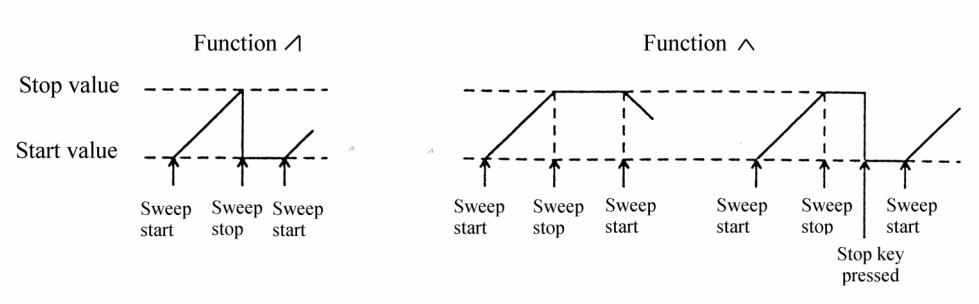
When sweep is started, an existing output frequency is quickly changed to the start frequency. If desiring to set the start frequency output beforehand, press the STOP key.

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.

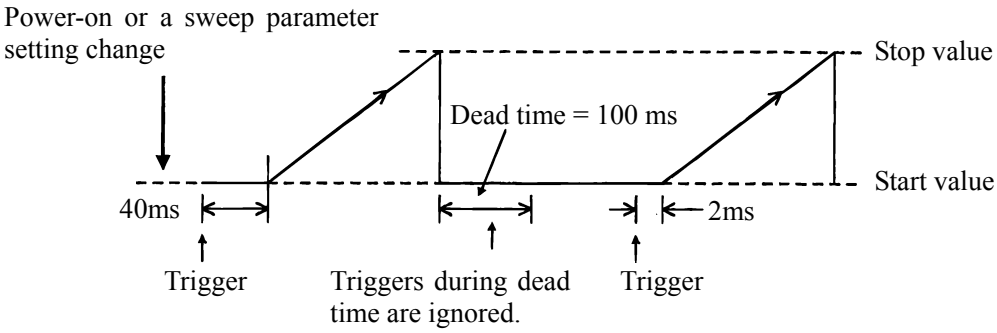
Other operations:

- **Sweep stop** : Press the STOP key. When sweep is stopped at the stop value at single sweep end or during sweep, press the STOP key to set the start value.
- **Sweep pause** : Press the PAUSE key. Again press the PAUSE key to resume sweep.
- **Single sweep operation examples**



- **Dead time and trigger delay**

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



- **External sweep start**

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

- **External pause**

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

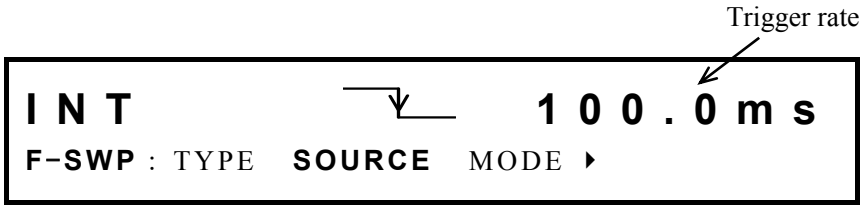
• **FUNCTION** determines the sweep type.

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

- ◿ — LIN / LOG
- ◠ — LIN / LOG
- ⌐¬
- SIN (∿) — LIN / LOG

• **Internal 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**: Set output to start and stop values, respectively.

Since sweep synchronization output becomes the respective start and stop states, full-scale adjustments of the recorder and the status of external equipment can be checked. START-STATE is the same as pressing the STOP key (during a single sweep).

Relationship between sweep values and sweep synchronization output, ☞ "4.2 Sweep (■Sweep value and marker/ sync/X-DRIVE output)", cf.

• **If the sweep type (TYPE) is set to DUTY,** the output waveform is forced to become a square wave (variable duty), making it impossible to select the waveform (FUNCTION).

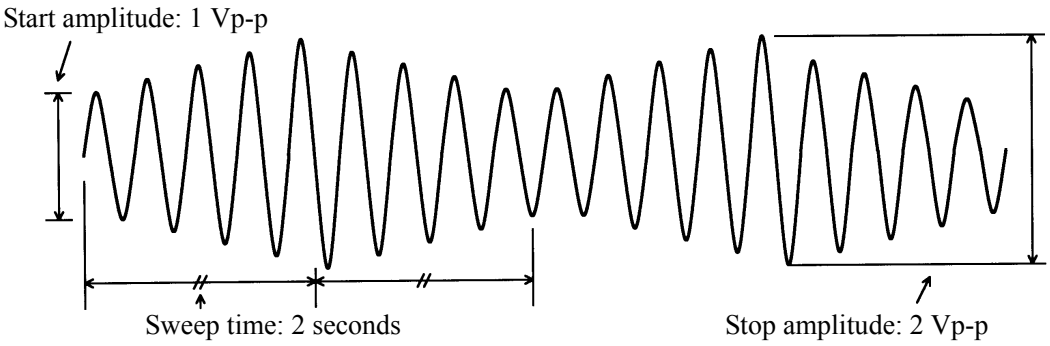
Multiple pulses may be output in one period during sweep, as shown below.

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

For details of the remote control command, ☞ "Remote Control Instruction Manual", cf.

■ 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.



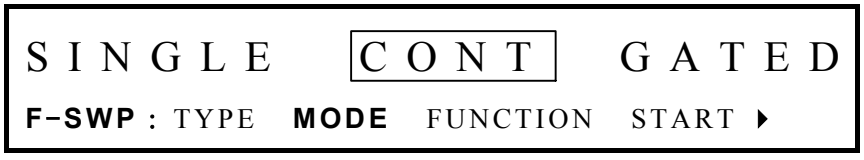
Operation:

(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).

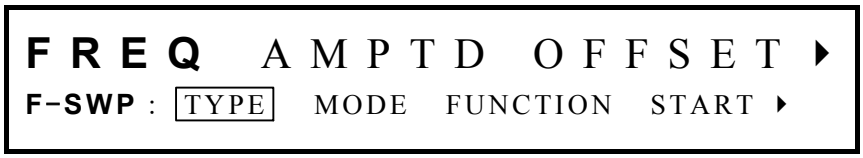
③ Press the ENTER key, then use the ◁ and ▷ keys to produce the following display (CONT flashes).



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).

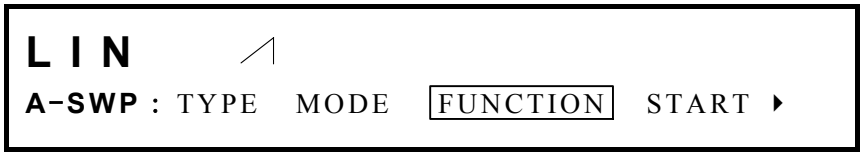


② Press the ENTER key, then use the ◁ and ▷ keys to produce the following display (AMPTD flashes).

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).



② Press the ENTER key.

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

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

(4) Set the start amplitude (START)

① Use the ◁ and ▷ keys to produce the following display (START flashes).

② Press the ENTER key.

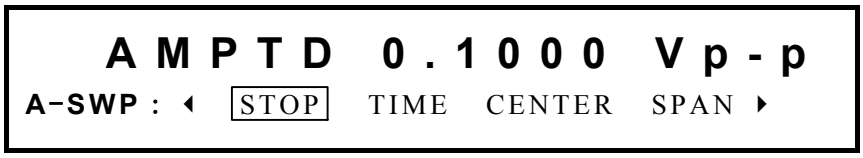
③ Set the start amplitude with the key pad or MODIFY dial.

For example, set to 1 Vp-p.

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

(5) Set the stop amplitude (STOP)

① Use the ◁ and ▷ keys to produce the following display (STOP flashes).



② Press the ENTER key.

③ Set the stop amplitude with the key pad or MODIFY dial.

For example, set to 2 Vp-p.

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

(6) Set the sweep TIME

① Use the ◁ and ▷ keys to produce the following display (TIME flashes).

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.

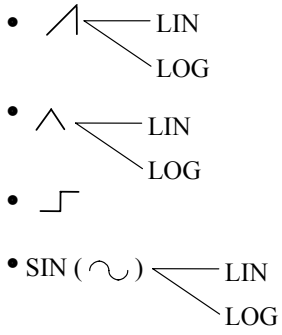
(7) Sweep operation

① Press the START key, then sweep starts.

If sweep is started, the amplitude output until then changes quickly to the start amplitude. To output the start amplitude 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** : Apply Low level to the rear panel SWEEP PAUSE IN connector. To resume sweep, apply a High level or open input.
- **FUNCTION** : The function determines the sweep type. For example, ⌐¬ provides step-type change of output (e.g., frequency) at the sweep time halfway point. LIN/LOG provides linear or logarithmic variation of the output with respect to the time axis.



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

Relationship between sweep values and sweep synchronization output, ☞ "4.2 Sweep (■Sweep value and marker/sync /X-DRIVE output)", cf.

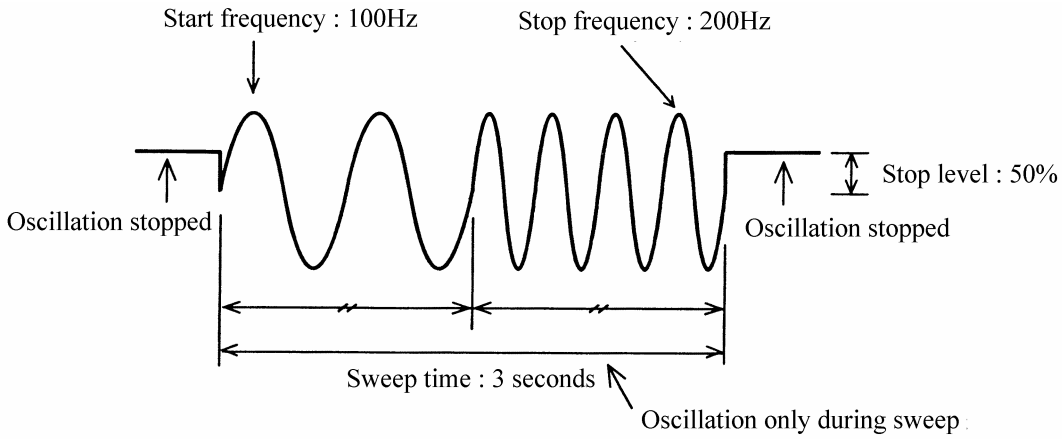
• **If the sweep type (TYPE) is set to DUTY,** the output waveform automatically becomes a square wave (variable duty). This makes it impossible to select the waveform (FUNCTION).
Multiple pulses may be output in one period during sweep, as shown below.

■ Sweep (Mode: Gated) (MODE → SWEEP → MODE : GATED)

In a Sweep (Mode: Gated), oscillation occurs only during sweep and stops when the sweep ends. Otherwise, behavior is the same as SINGLE-mode sweep behavior.

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.



Operation:

(1) Set sweep MODE to GATED

① Press the MODE key, then the SWEEP key.

② Use the ◁ and ▷ keys to produce the following display (MODE flashes).

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

④ This completes setting the sweep mode to gated. Press the EXIT key once to release the setting mode.

(2) Set sweep TYPE to FREQ

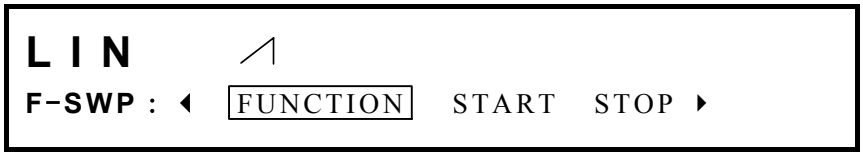
① Use the ◁ and ▷ keys to produce the following display (TYPE flashes).

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

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).



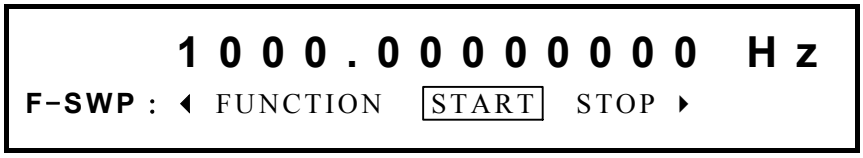
② Press the ENTER key.

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).



② Press the ENTER key.

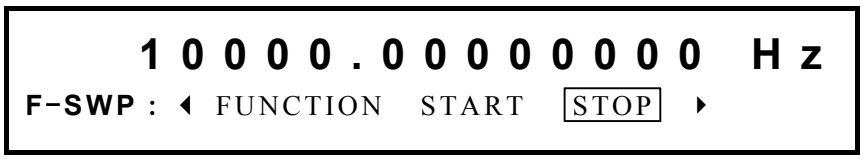
③ Set the frequency with the keypad or MODIFY dial.

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).



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).

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).

② Press the ENTER key.

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

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.

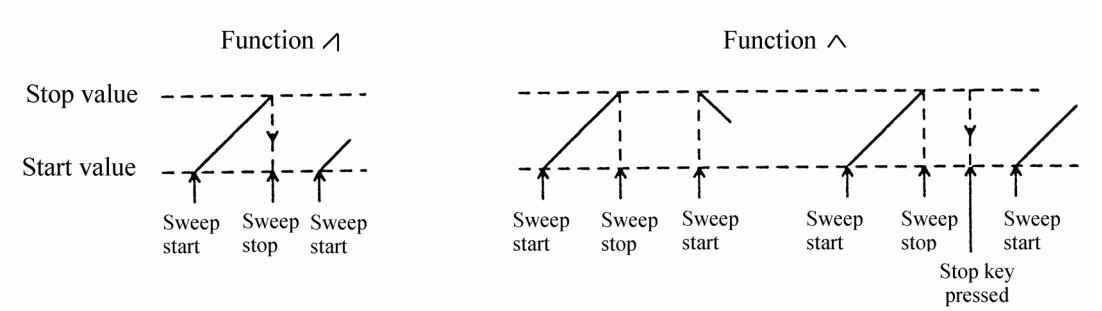
(8) Start sweep

① Press the START key.

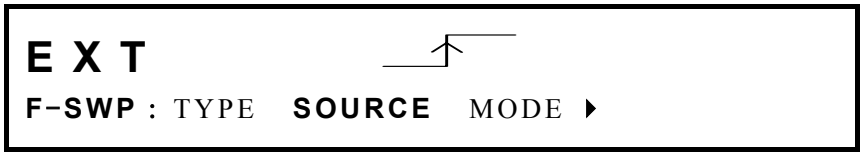
In this example, sweep ends after 3 seconds and oscillation stops. Again press the START key to sweep from the stop to the start frequency.

Other operations:

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

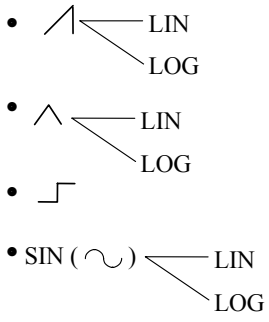


- **External start** :Change the sweep trigger source to EXT and select rising or falling. Supply an external signal to the front panel TRIG/SWEEP IN connector. Observe that retrigger is not accepted for 100 ms after sweep start.



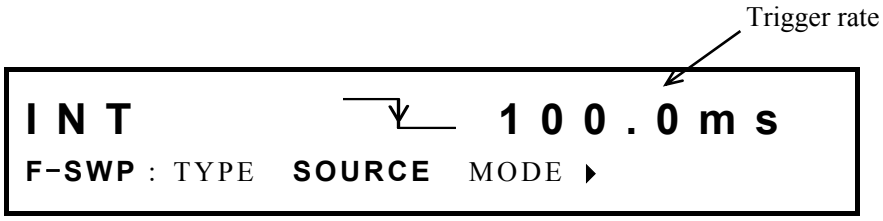
- **External pause :** : Apply Low level to the rear panel SWEEP PAUSE IN connector. To resume sweep, apply a High level or open input.

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



• Internal trigger source

: The internal trigger signal is produced at the trigger rate. Even is set to less than 100 ms, the trigger is applied only at 100 ms intervals.



• 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.
☞ "4.2 Sweep (■ Sweep value and marker/ sync/X-DRIVE output)", cf.

• If the sweep type (TYPE) is set to DUTY, the output waveform automatically becomes a square wave (variable duty). This makes it impossible to select the waveform (FUNCTION).
Multiple pulses may be output in one period during sweep, as shown below.

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

• MARKER sets a value that changes the sweep marker output (SWEEP Z-MARKER OUT).

• MKR → CTR copies the marker value (MARKER) to the center value (CENTER).

■ 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], 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)
Sweep range setting
TIME (sweep time) [s]
STOP-LEVEL (stop level)
PHASE (phase when oscillation starts) * ENTRY menu
Set when the sweep mode is GATED

• Sweep operations

• Main operation
START (sweep start)
STOP (sweep end/sweep start state)
*For subsequent operation when the sweep has been completed, the state is reset to the sweep start state.
PAUSE (sweep pause/restart)

• In the SWEEP menu
START-STATE (sweep start state)
STOP-STATE (sweep stop state)

■ Sweep (Modulation) steps and step width

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

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

The modulation period is determined as follows.

When the waveform is SIN, ⌒ , ⊓ , : Modulation period = 1 ÷ (Modulation frequency × 2)

When the waveform is ◿ , ⌒ : Modulation period = 1 ÷ Modulation frequency

• Step number derivation

(1) Sweep function is step (⌐):

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

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

① Sweep time is 25 ms and below:

Step number = Sweep time [s] × 10000

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

Step number = 250 (fixed)

③ Sweep time is more than 31.25 ms:

Step number = Sweep time [s] × 8000

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

① Sweep time is 50 ms and below:

Step number = Sweep time [s] × 10000

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

Step number = 250 (fixed)

③ Sweep time is more than 62.5 ms:

Step number = Sweep time [s] × 8000

*1: If raising up results in odd number, -1.

• Deriving step width

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

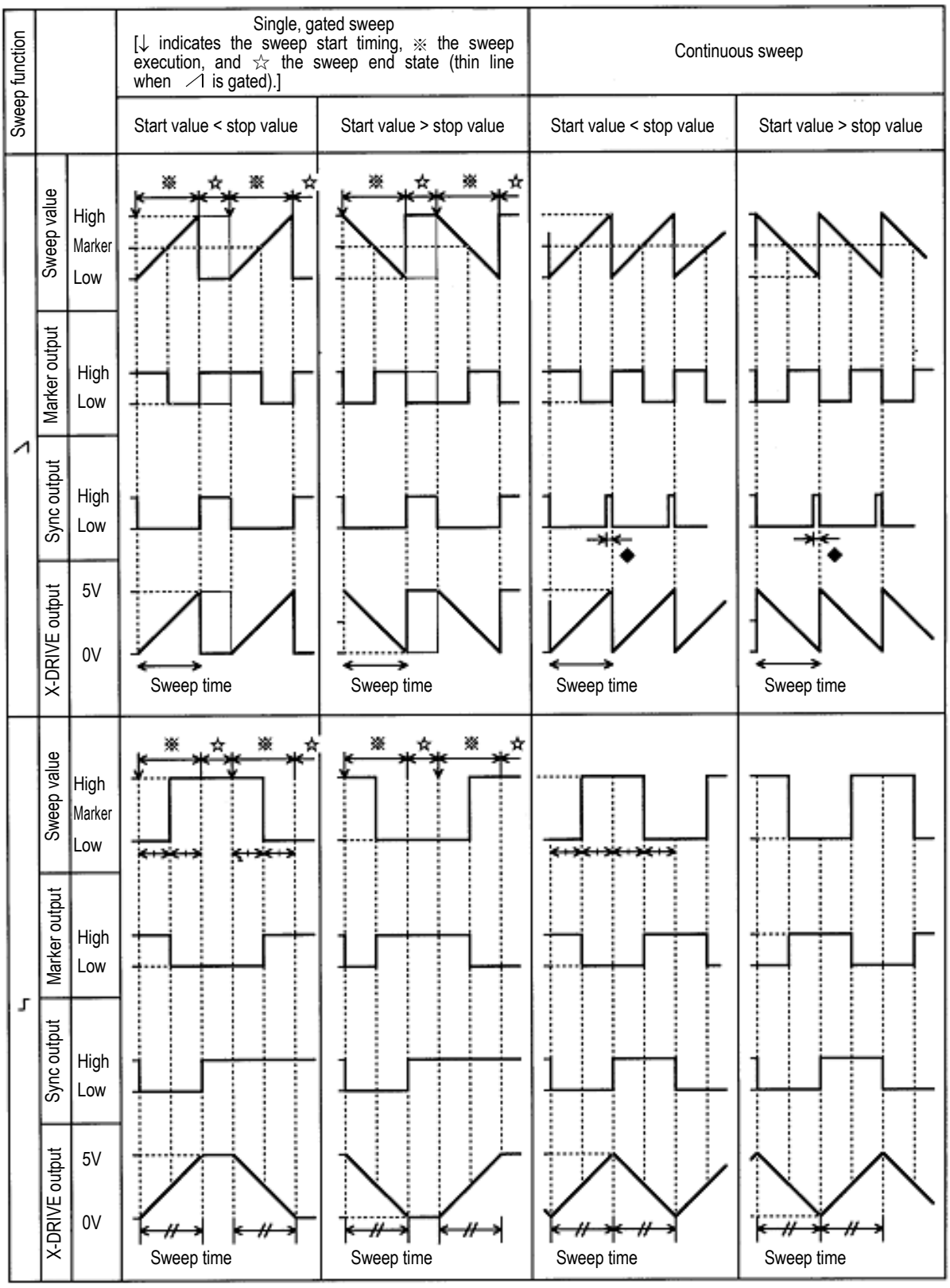
During logarithmic sweep, step width = $\log_{10}{}^{-1}\left[\log_{10}\frac{\text{stop}}{\text{start}} \div (\text{step number -1})\right]$

Step width during log sweep changes with step progression.

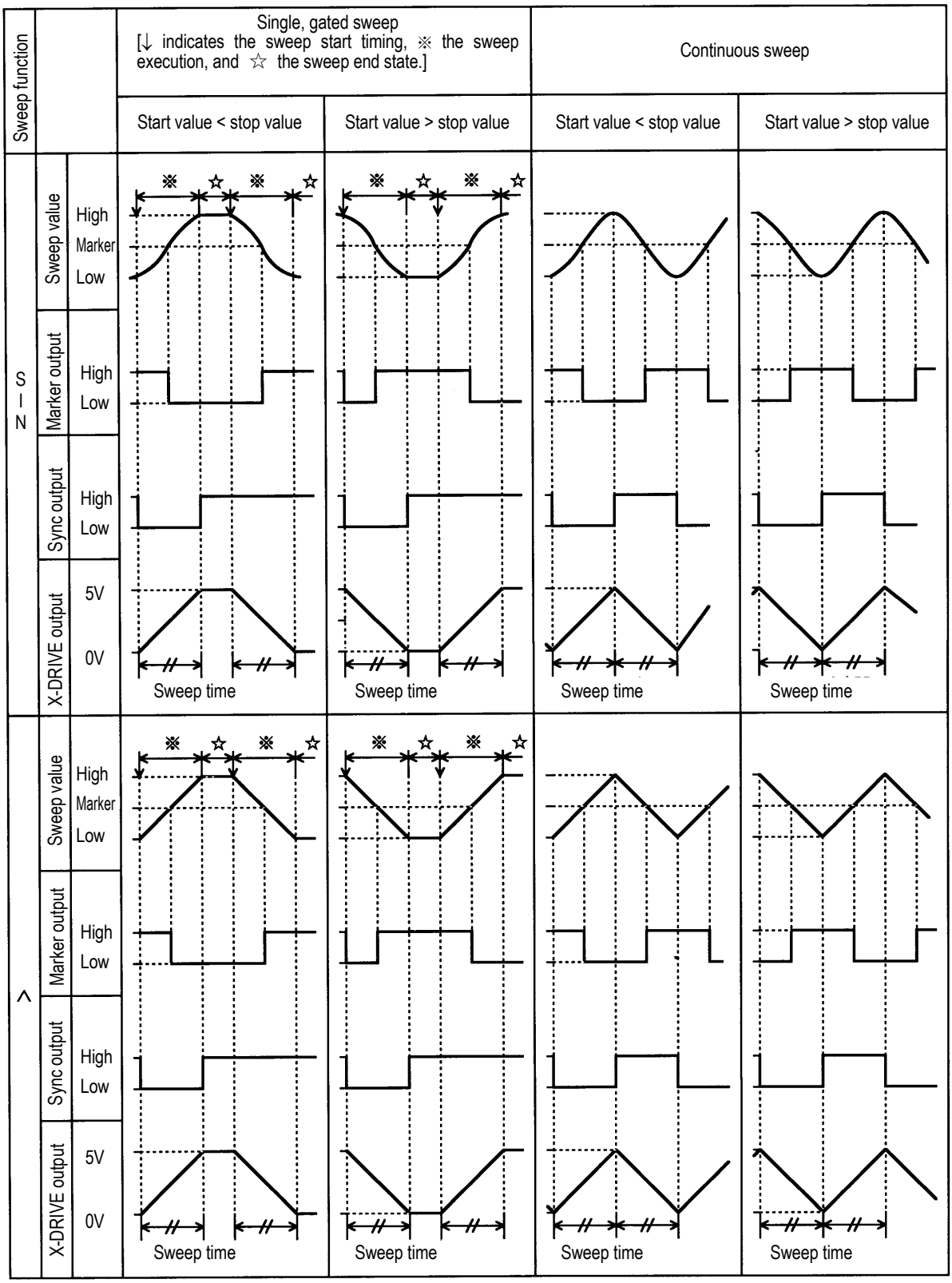
Marker output is synchronized with the sweep step. The shift between the marker value setting and the actual value that changes marker output becomes the ±step width.

■ Sweep value and marker/sync/X-DRIVE outputs

(SWEEP Z-MARKER OUT／SYNC OUT／SWEEP X-DRIVE OUT)



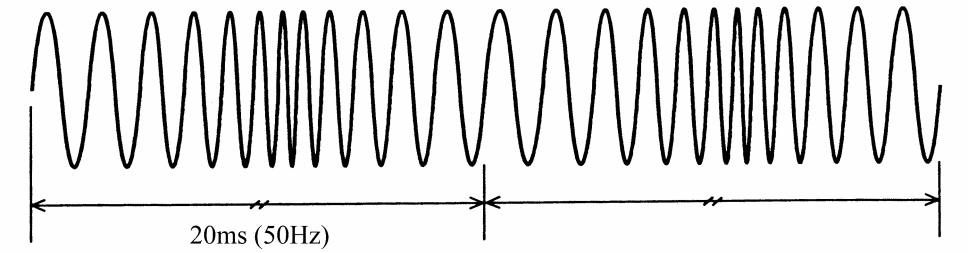
◆ is about 100 - 125 μs.


Sweep function
Single, gated sweep
[↓ indicates the sweep start timing, ※ the sweep execution, and ☆ the sweep end state.]
Continuous sweep
Start value < stop value
Start value > stop value
Start value < stop value
Start value > stop value
S – N
^
Sweep value
Marker output
Sync output
X-DRIVE output
High
Marker
Low
5V
0V
Sweep time

4.3 Modulation

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

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



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).

F M A M O F S M P M P W M
FM : [TYPE] DEVIATION FREQ FUNCTION

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

[F M] A M O F S M P M P W M
FM : TYPE DEVIATION FREQ FUNCTION

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

(2) Set the frequency DEVIATION

① Use the ◁ and ▷ keys to produce the following display (DEVIATION flashes).

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).

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).

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

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

The above completes frequency modulation setting.

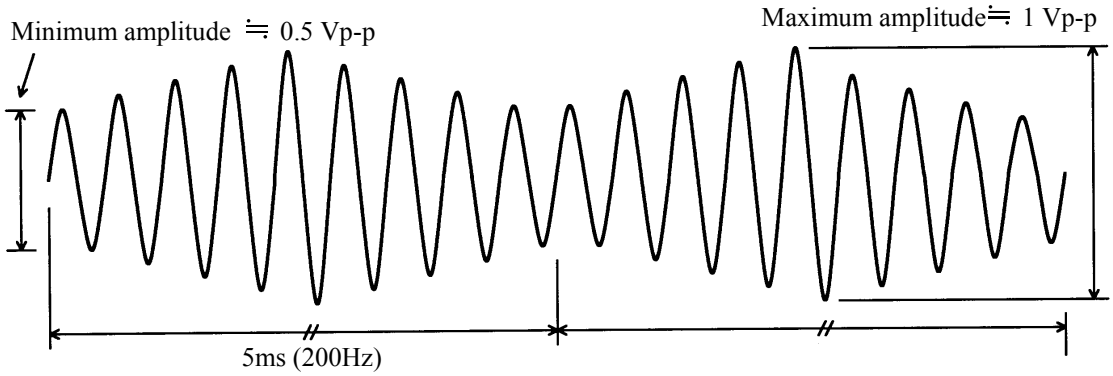
Other operations:

• 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, ∿, ⊓, ◿, ◺]

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

Operation to produce an amplitude modulated waveform output is described below.
In the example, the waveform is a sine wave, the frequency is 1800 Hz, the amplitude is 1.5 Vp-p, and the DC offset is set to 0 V.



Operation:

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

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 (AM flashes).

```
FM  [AM]  OFSM  PM  PWM
AM : TYPE  DEPTH  FREQ  FUNCTION
```

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

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

① Use the ◁ and ▷ keys to produce the following display (DEPTH flashes).

② Press the ENTER key.

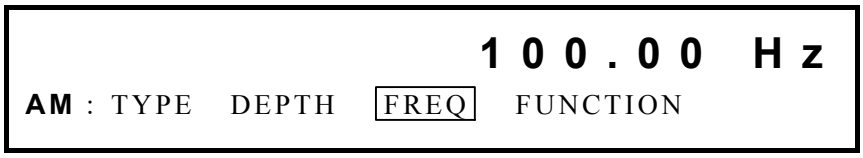
③ Use the keypad or turn the MODIFY dial to set the modulation factor.

For example, set to 33%.

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

(3) Set the modulated frequency (frequency at which the amplitude changes, FREQ)

① Use the ◁ and ▷ keys to produce the following display (FREQ flashes).



② Press the ENTER key.

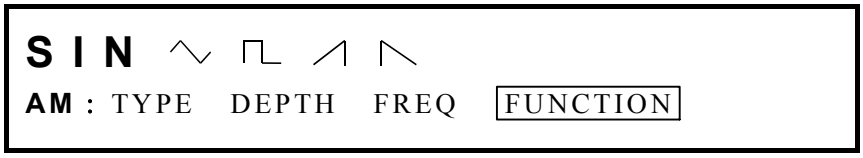
③ Use the keypad or turn the MODIFY dial to set the modulated frequency.

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

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

(4) Select the modulated waveform (FUNCTION)

① Use the ◁ and ▷ keys to produce the following display (FUNCTION flashes).



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

③ When selection is complete, press the EXIT key to release the setting mode.

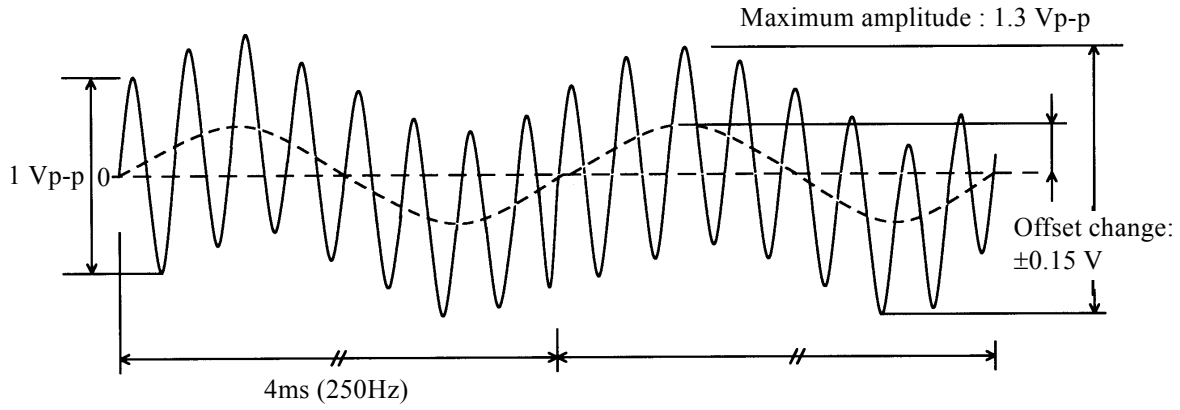
The above completes setting of the amplitude modulation.

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, ∿, ⊓, ◿, ◺]
  OPER-COMMON (operation in both channels) [OFF, ON]

■ 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.



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).

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

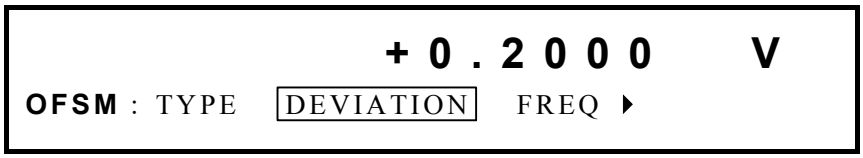
③ Press the ENTER key, then use the ◁ and ▷ keys to produce the following display (OFSM flashes).

```
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 selection mode.

(2) Set the DC offset DEVIATION

① Use the ◁ and ▷ keys to produce the following display (DEVIATION flashes).



② Press the ENTER key.

③ Set the deviation with the keypad or MODIFY dial.

For example, set to 0.3 V.

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

(3) Set the modulated FREQ

① Use the ◁ and ▷ keys to produce the following display (FREQ flashes).

② Press the ENTER key.

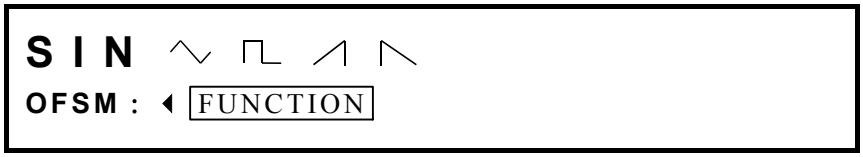
③ Set the frequency with the keypad or MODIFY dial.

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

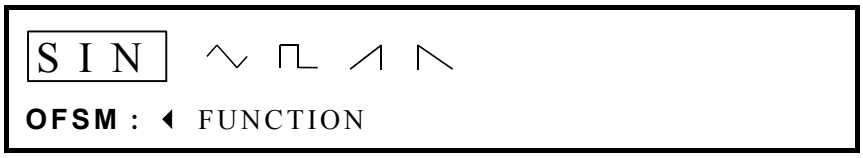
④ After setting, press the EXIT key once to release the modulated frequency setting mode.

(4) Select the modulated waveform (FUNCTION)

① Use the ◁ and ▷ keys to produce the following display (FUNCTION flashes).



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



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 [Vpeak] + DC offset deviation

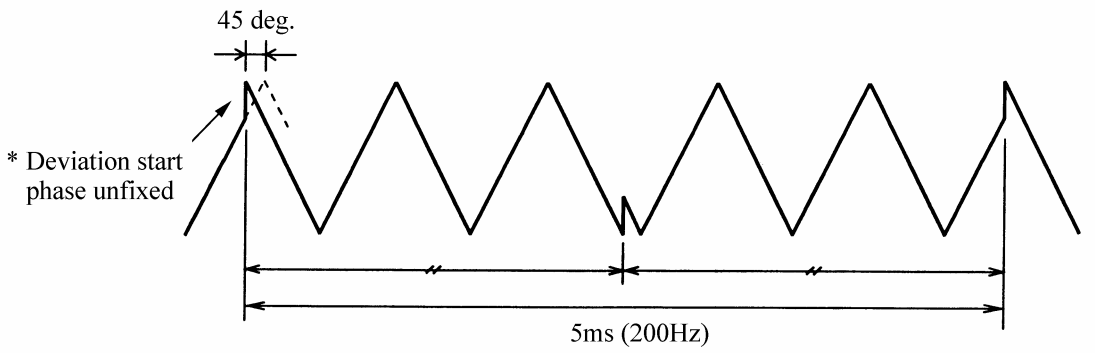
- When the oscillation mode is changed to modulation (MODU), modulation occurs at the setting at that time point.

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

- Setting items in DC offset modulation (MODU menu)
  TYPE: OFSM
  DEVIATION (DC offset deviation) [V]
  RREQ (frequency modulation) [Hz]
  FUNCTION (modulation waveform) [SIN, ∿, ⊓, ◿, ◺]

■ Phase modulation (PM) (MODE → MODU → TYPE : PM)

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



Operation:

(1) Set modulation TYPE to phase (PM)

① Press the MODE key, then the MODU key.

② Use the ◁ and ▷ keys to produce the following display (TYPE flashes).

F M A M O F S M P M P W M
FM : [TYPE] DEVIATION FREQ FUNCTION

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

F M A M O F S M [P M] P W M
PM : TYPE DEVIATION FREQ FUNCTION

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

(2) Set the phase DEVIATION

① Use the ◁ and ▷ keys to produce the following display (DEVIATION flashes).

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 release the deviation setting mode.

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

① Use the ◁ and ▷ keys to produce the following display (FREQ flashes).

② Press the ENTER key.

③ Set the frequency with the keypad or MODIFY dial.

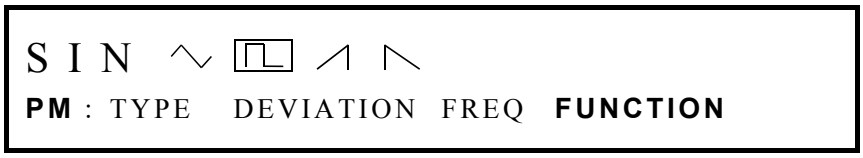
For example, set to 200 Hz (5 ms).

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).

② Press the ENTER key, then use the ◁ and ▷ keys to produce the following display (⊓ flashes).



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

The above completes phase modulation setting.

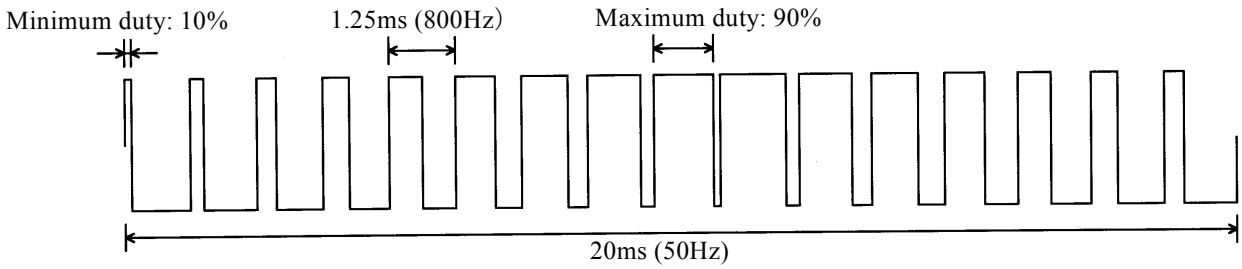
Other operations:

- 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) [Hz]
  FREQ (modulation frequency) [Hz]
  FUNCTION (modulation waveform) [SIN, ∿, ⊓, ◿, ◺]

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

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



Operation:

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

① Press the MODE key, then the MODU key.

② Use the ◁ and ▷ keys to produce the following display (TYPE flashes).

FM AM OFSM PM PWM
FM : [TYPE] DEVIATION FREQ FUNCTION

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

FM AM OFSM PM [PWM]
PWM : TYPE DEVIATION FREQ FUNCTION

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

① Use the ◁ and ▷ keys to produce the following display (DEVIATION flashes).

② Press the ENTER key.

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

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

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

① Use the ◁ and ▷ keys to produce the following display (FREQ flashes).

② Press the ENTER key.

Set the frequency with the keypad or MODIFY dial.

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

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

(4) Select the modulated waveform (FUNCTION)

① Use the ◁ and ▷ keys to produce the following display (FUNCTION flashes).

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

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

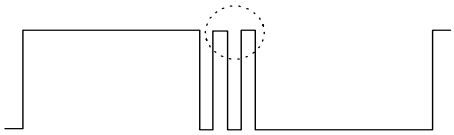
The above completes pulse width modulation setting.

Other operations:

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

  : Max. duty = Duty setting + (pulse width deviation% ÷ 2)

  Min. duty = Duty setting – (pulse width deviation% ÷2)
- During modulation, multiple pulses may be output in one cycle, as shown below.



- Setting items at pulse width modulation (MODU menu)

  TYPE: PWM

  DEVIATION (pulse width deviation) [%]

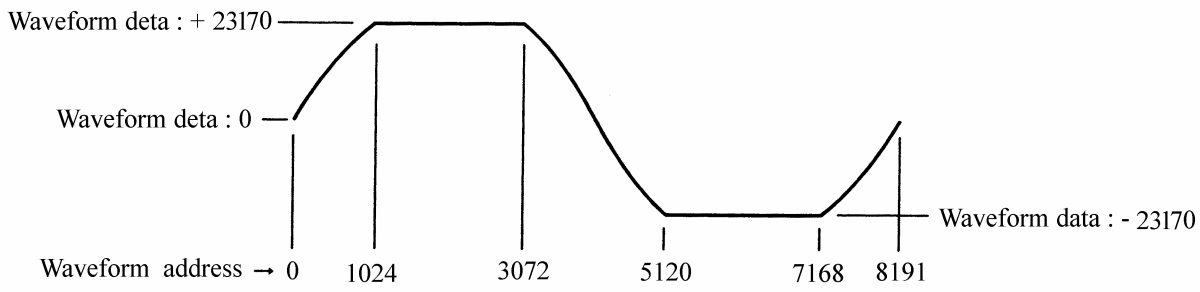
  FREQ (modulation frequency) [Hz]

  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.



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 ARB EDIT key, then use the ◁ and ▷ keys to produce the following display (SELECT flashes).

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

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

(3) Copy the waveform, for example, sinewave

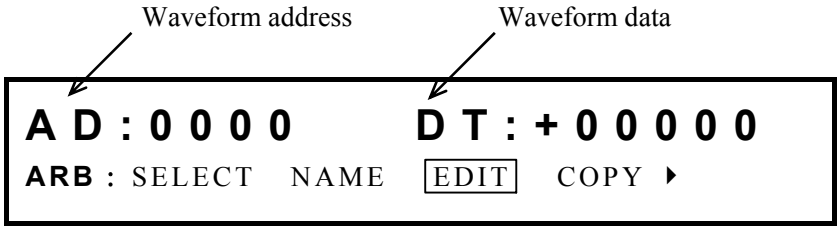
① Press the ARB EDIT key, then use the ◁ and ▷ keys to produce the following display (COPY flashes).

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

③ Press ENTER 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).



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

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).

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

⑤ Next, use above steps ③ and ④ to set the interpolation mark (*) to waveform address 3072.

⑥ Press the (k) key for linear interpolation. In this example, the first half of the sinewave is clipped (⎍). 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).

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:** ARB EDIT → EDIT select → ENTER → ▷ flashes the waveform data (DT) digits. Use the keypad or MODIFY dial to set the data.

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

- **Clear (to 0) waveform data:** ARB EDIT → CLEAR select → ENTER, then again press ENTER. The interpolation marks (*) are also cleared.

- **Apply a name to an arbitrary waveform:** ARB EDIT → NAME select → ENTER, then use the MODIFY 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 ▾ (s p a c e)
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
! ” # $ % & ’ ( ) * + , – . / : ; < = > ? @ [\ ] ^ _ ` { | } → ←

- Change the waveform data size: ARB EDIT → SIZE select → ENTER → Use ◁ and ▷ to select the data size

Relation between the waveform data size and number of waveforms

Data size	Waveform number												Number of waveforms
8k(8192)	0	1	2	3	4	5	6	7	8	9	10	11	12
16k(16384)	0		1		2		3		4		5		6
32k(32768)	0				1				2				3

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 ∿ for waveform number 0, ∩ 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).

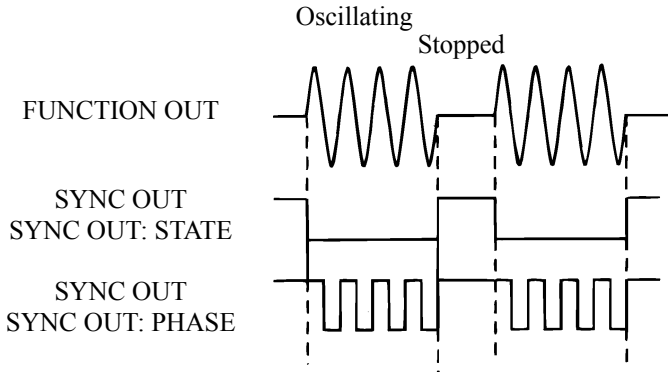
```
STATE  :PHASE
SYSTEM : ◂ DUTY-VALID [SYNCOUT] ▸
```

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

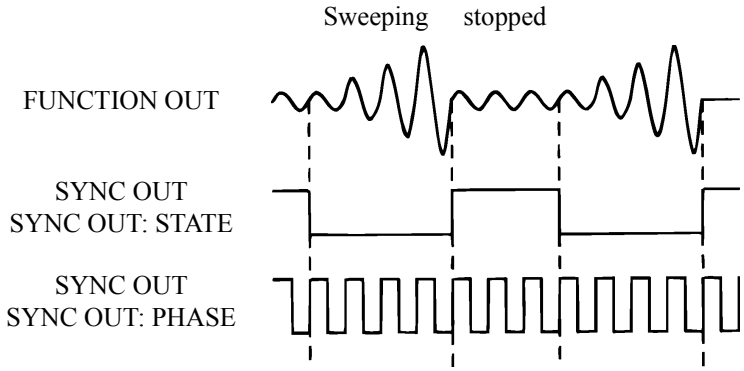
- STATE: Low level during oscillation. High level while stopped.
- PHASE: For ⎍ squarewaves (variable duty), the same waveform as that for FUNCTION OUT. For other cases, high level while between 0 and 180 degrees of the waveform in the oscillation period, and low level while between 180 and 360 degrees.



■ When the oscillation mode is SWEEP

• STATE: Low level while sweeping from the start value to the stop value. Otherwise, high level.

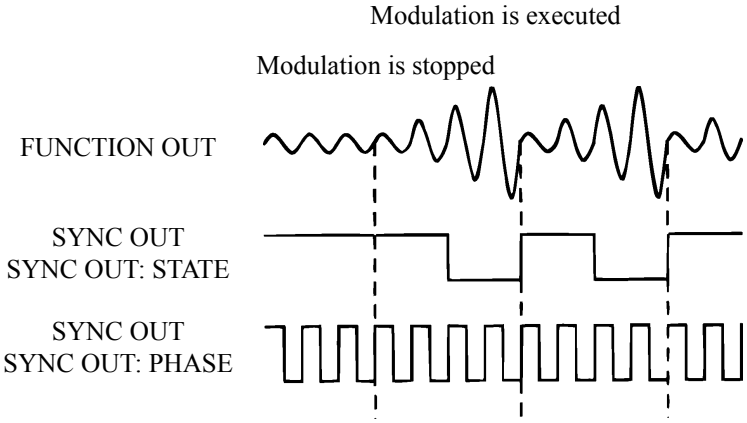
• PHASE: For ⎍ squarewaves (variable duty), the same waveform as that for FUNCTION OUT. Otherwise, high level while between 0 and 180 degrees of the waveform, and low level while between 180 and 360 degrees.



■ When the oscillation mode is MODU

• STATE: High level while modulation is stopped, or the modulated wave is between 0 and 180 degrees. Low level while the modulated wave is between 180 and 360 degrees.

• PHASE: 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.

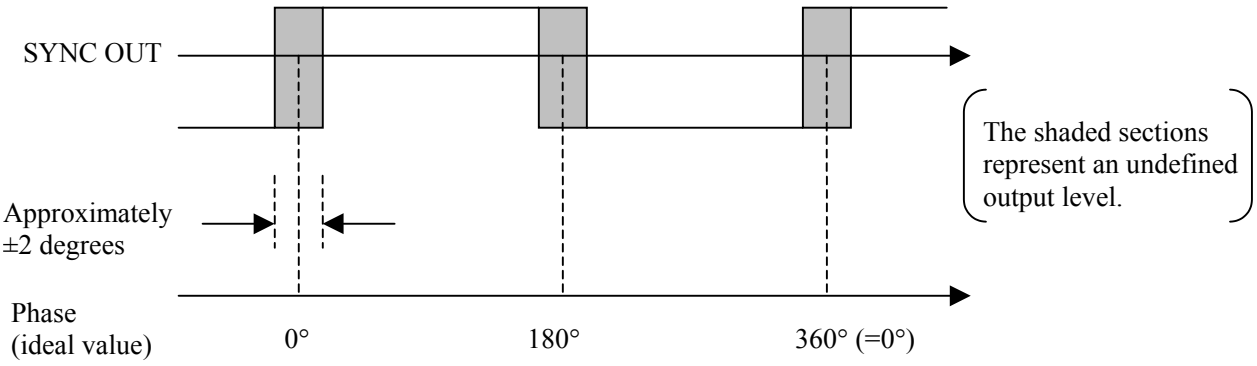


■ Additional information:

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

In particular, note that when the oscillation mode is switched during a burst or gated sweep while oscillation is stopped, the output level may vary or the waveform may become glitch-shaped.

If a precise output level is required while oscillation is stopped, shift the phase setting. For example, setting the phase at + 90 degrees shifts the output level to the high level while oscillation is stopped.

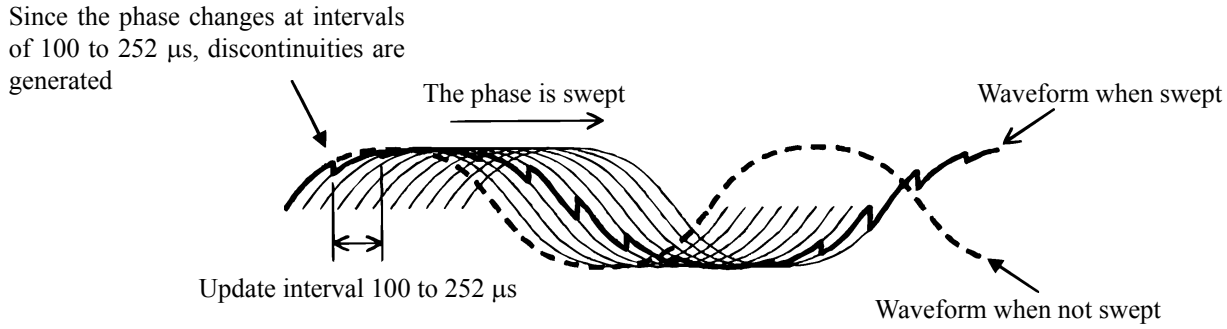


4.6 Output waveforms for sweeping and modulation

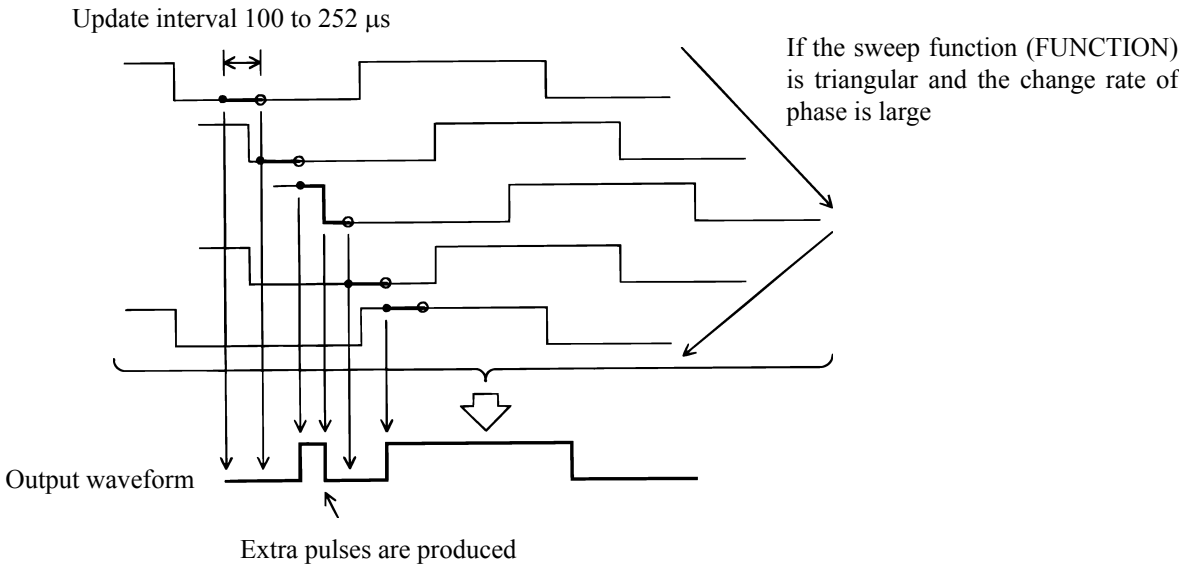
The setup values for sweeping and modulation are updated every 100 to 252 μs. Thus, if the sweep time is short or the modulation frequency is high, the amount of change for updating increases, leading to marked discontinuities.
If the sweep function (modulated waves) is ⊓, ◿, or ◺, discontinuities become 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 ◿ in the phase sweep, the phase shifts about 26 degrees every 100 μs, producing the following output waveforms. Discontinuities are generated not only by ∿, but also by ◠◡, ◿, and ◺.



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.



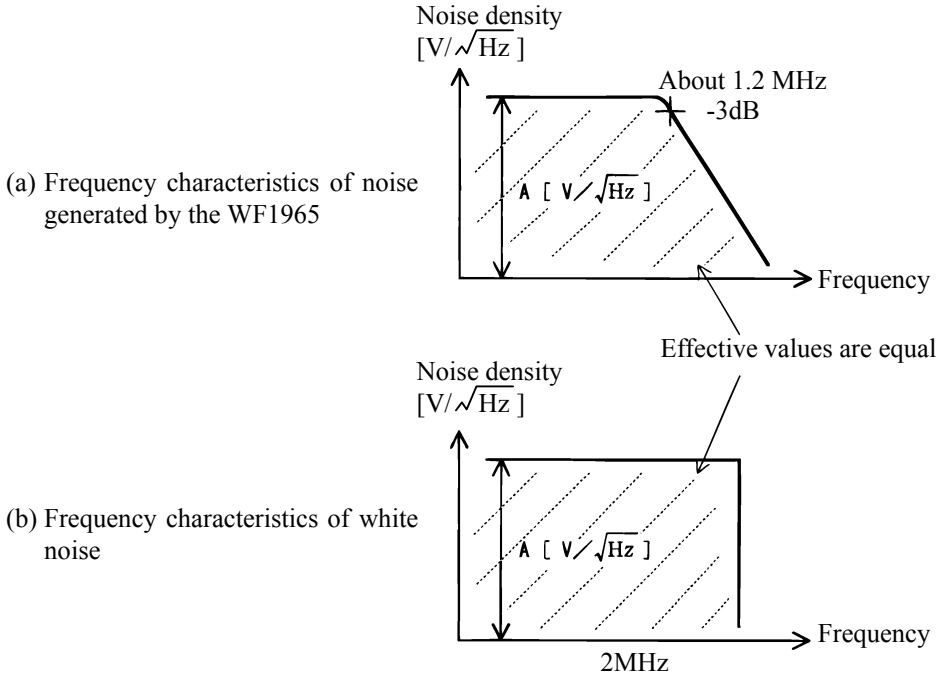
The occurrence frequency when the sweep function is ∿, ∿, or ◺ is roughly given by the following formula:

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

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 WF1965 is as shown in the following figure (a) "Frequency characteristics of noise generated by the WF1965."
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 (2 MHz) is called the equivalent noise bandwidth.



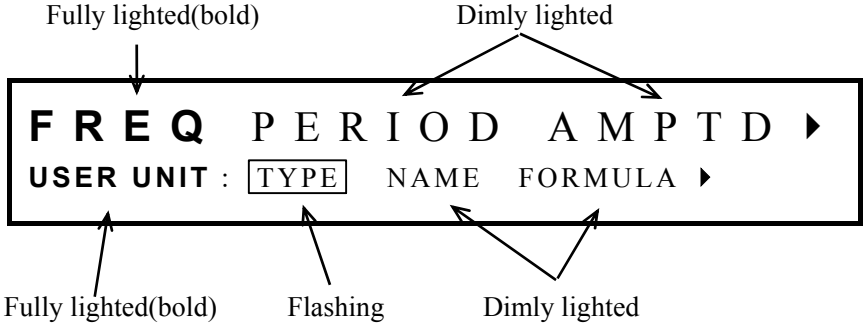
(a) Frequency characteristics of noise generated by the WF1965

(b) Frequency characteristics of white noise

The noise density shows flat frequency characteristics up to about 1.2 MHz. If the band of noise is too wide or extra signal elements outside the band cause a problem, connect, for example, a low-pass filter for output. Note, however, that the amplitude becomes smaller as band restrictions increase.

Section 5 Other Operations

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



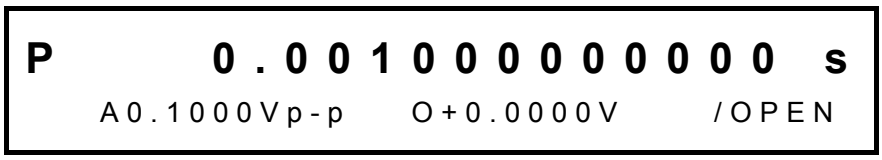
5.1 Convenient Settings

■ 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.



② Set the period with the keypad or MODIFY dial.

Other:

The period setting is frequency with the reciprocal less than 0.01 μHz discarded. Thus, the setting tolerance is large when the frequency setting digits are fewer (period longer).
In this situation, even if setting is changed by the keypad or MODIFY dial, the actual oscillation period does not change in some cases.

■ Squarewave duty setting (ENTRY → DUTY)

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

Operation:

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

D U T Y	**5 0 . 0 0 0 0 %**
1 0 0 0 . 0 0 0 0 0 0 0 Hz	A 0 . 1 0 0 0 Vp-p/OPEN

② Set the duty with the keypad or MODIFY dial.

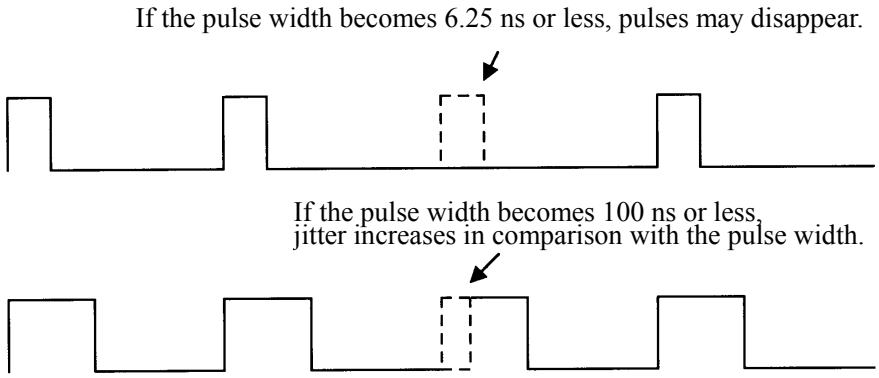
Other:

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

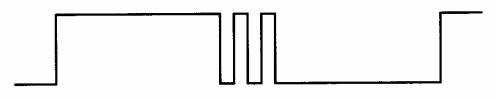
Change ↓	Frequency (FREQ)	Period (PERIOD)	Pulse width (WIDTH)	Duty (DUTY)
Frequency (FREQ)		Changed	Changed	Unchanged
Period (PERIOD)	Changed		Unchanged	Changed
Pulse width (WIDTH)	Unchanged	Unchanged		Changed
Duty (DUTY)	Unchanged	Unchanged	Changed	

- Due to the oscillation period and duty relationship, the pulse can be lost when the actual pulse width is less than 6.25 ns. An error message is displayed at this type of setting.
  Also, jitter increases when the pulse width is less than 100 ns. A warning message is displayed at this type of setting.
- The actual waveform duty resolution is [oscillation frequency] ÷ [approx. 160 MHz] (0.00001 % at minimum). When the stop level is on, the minimum actual waveform duty resolution is approximately 0.003 %.

• If the pulse width of the ⌊‾ square wave (variable duty) is 6.25 ns or less, pulses may disappear depending on the relationship between the period and duty. Such a setting causes an error message to be displayed.
If the pulse width is 100 ns or less, jitter increases in comparison with the pulse width, and a warning message is displayed.



• If the phase of the ⌐⌊ square wave (fixed duty) or ⌊‾ square wave (variable duty) is changed, multiple pulses may be output in one period, as shown below:



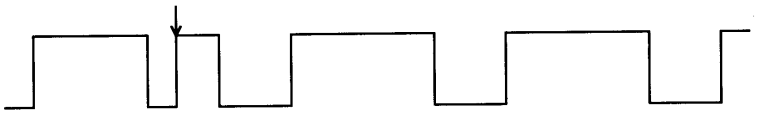
• If the duty of the ⌊‾ square wave (variable duty) is changed, multiple pulses may be output in one period, as shown below:

If the pulse width is larger than 75 ns after the duty is changed, it is possible to suppress the output of multiple pulses. For this purpose, set DUTY-VALID to CYCLE.
If the oscillation mode is sweep or modulation, however, this setting has no meaning.

When DUTY-VALID is set to CYCLE, the duty will be reflected starting at the next period.
If the frequency or phase is changed, extra pulses may be output even if DUTY-VALID is set to CYCLE.

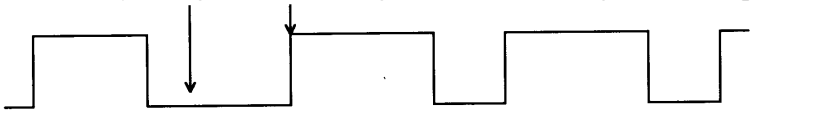
Operation when DUTY-VALID: IMMED

The setting is reflected at the same time that the duty is changed



Operation when DUTY-VALID: CYCLE

Duty change The setting is reflected starting at the next period



- The duty setting range for the ⎍ square wave (variable duty) can be switched to 0.0000% to 100.0000% or 0.0100% to 99.9900%. To set the duty in the range of 0.0000% to 100.0000%, set DUTY-VALID to EXPAND.

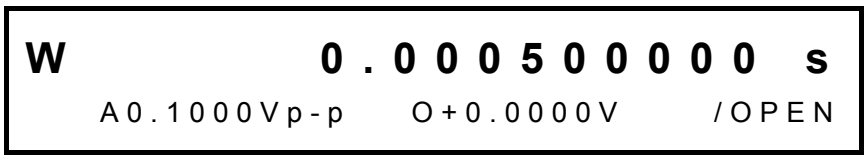
However, it is not possible to set CYCLE and EXPAND simultaneously.
When DUTY-VALID is set to IMMED or CYCLE, the duty setting range becomes 0.0100% to 99.9900%. When the frequency is approximately 16 kHz or less, pulse losses can be prevented by restricting the duty range to 0.0100% to 99.9900%.

■ 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.



② Set the width with the keypad or MODIFY dial.

Other:

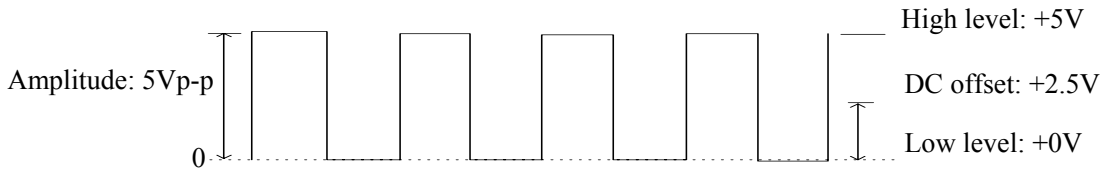
• The table indicates the effects on other parameters when the frequency, period, width or duty is changed.

Change ↓	Frequency (FREQ)	Period (PERIOD)	Pulse width (WIDTH)	Duty (DUTY)
Frequency (FREQ)		Changed	Changed	Unchanged
Period (PERIOD)	Changed		Unchanged	Changed
Pulse width (WIDTH)	Unchanged	Unchanged		Changed
Duty (DUTY)	Unchanged	Unchanged	Changed	

• Due to the oscillation period and duty relationship, the pulse can be lost when the actual pulse width is less than 6.25 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.

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

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



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

Change ↓	Amplitude (AMPTD)	DC offset (OFFSET)	High level (HIGH)	Low level (LOW)
Amplitude (AMPTD)		Unchanged	Changed	Changed
DC offset (OFFSET)	Unchanged		Changed	Changed
High level (HIGH)	Changed	Changed		Unchanged
Low level (LOW)	Changed	Changed	Unchanged	

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

  10 V range: Approx. 11 V peak/open time

  1 V range: Approx. 1.1 V peak/open time

5.2 Units

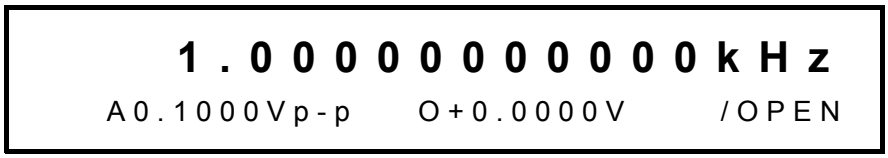
■ Engineering unit (μ, m, k, M) display

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

Operation:

① Press the ENTRY key, then the FREQ key.

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



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 step②, press the ENTER key.

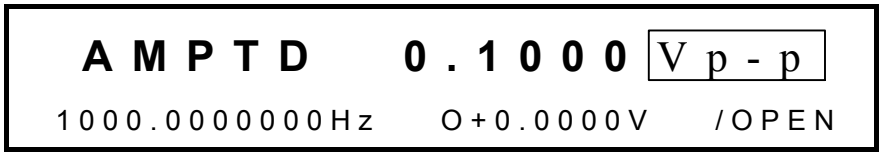
■ Amplitude units change

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

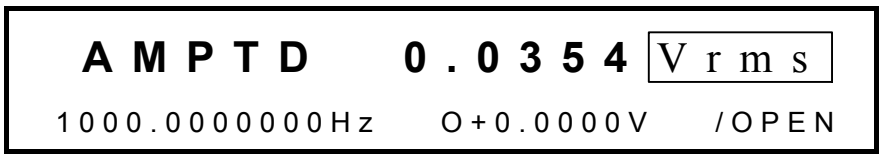
Operation:

① Press the ENTRY key, then the AMPTD key.

② Press the ▷ key to produce the following display (Vp-p lights).



③ Turn the MODIFY dial to produce the following display.



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).

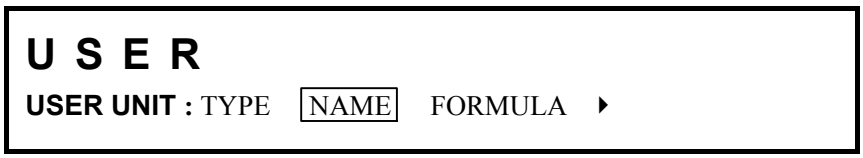
② Press the ENTER key, then use the ◁ and ▷ keys to produce the following display (TYPE flashes).

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

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

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

① Use the ◁ and ▷ keys to produce the following display (NAME flashes).



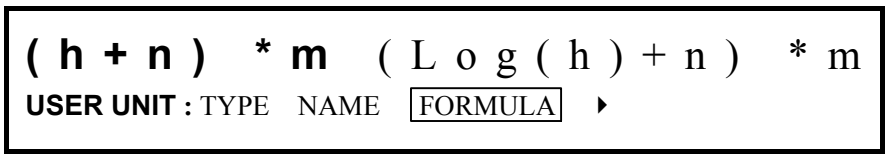
② Press the ENTER key, then use the MODIFY dial and ◁ and ▷ keys to input the unit name (e.g., rpm). Up to 4 of the following characters can be used for the unit name.

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 ▾ (s p a c e)
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
! ” # $ % & ’ ( ) * + , – . / : ; < = > ? @ [¥] ^ _ ` { | } → ←

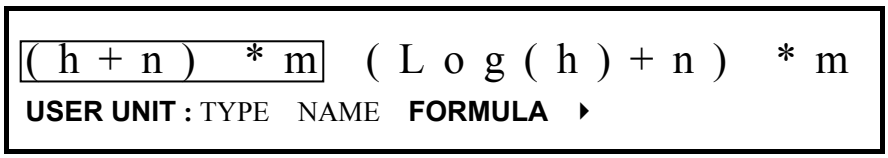
③ After inputting, press the EXIT key once to release unit name setting.

(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).



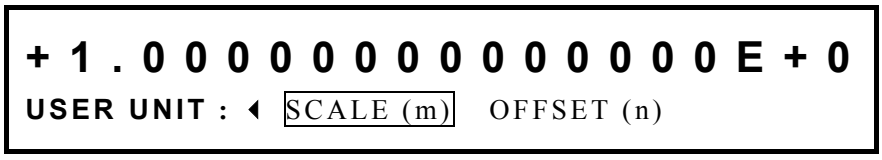
② Press the ENTER key, then use the ◁ and ▷ keys to produce the following display [(h+n)*m flash].



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).

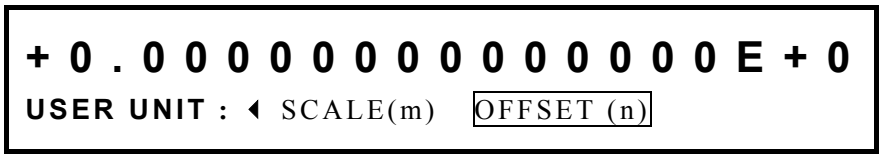


② Press the ENTER key, then set the scale with the keypad or MODIFY dial.

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].



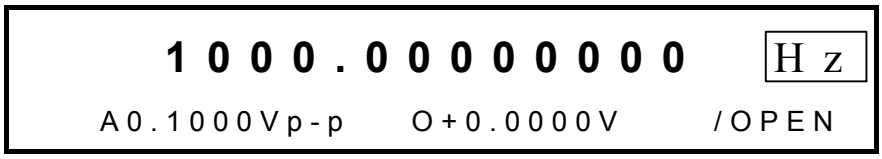
② Press the ENTER key, then set the offset with the keypad or MODIFY dial.

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

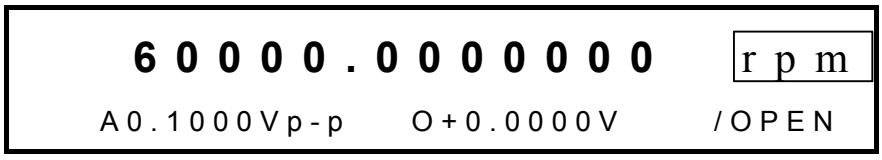
(6) Display the above settings

① Press the ENTRY key, then the FREQ key.

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



③ Turn the MODIFY dial to produce the following display.



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 conversion to the user unit is made, an attempt is made to calculate the logarithm of a negative value to display the user setup value.

  Since the logarithm of a negative value cannot be a real number, "OVER" is displayed.

  Thereafter, user setup values can be changed arbitrarily. 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).

```
S T O R E  M E N U
MEMORY : [STORE]  RECALL  CLEAR
```

② Press the ENTER key, then use the ◁ and ▷ keys to produce the following display (0 flashes).

```
( N O T  S T O R E D )
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.

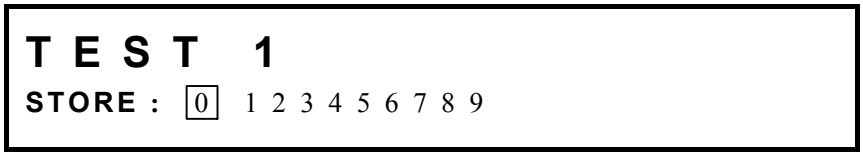
■ Setting recall (MEMORY : RECALL)

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).

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.



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

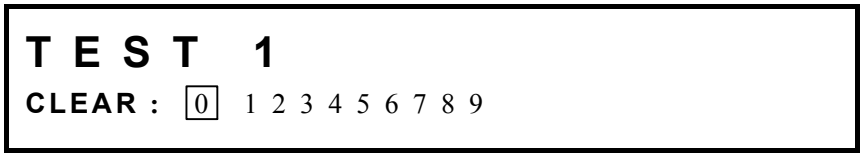
■ Setting memory clear (MEMORY : CLEAR)

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).

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.



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 WF1965 output. The external signal is connected to the rear panel EXT ADD IN connector.

☞ For details on connectors, “3.2 Input and output connectors (■External add input (EXT ADD IN))”, cf.

Operation:

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

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

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

Operation to modulate the WF1965 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.

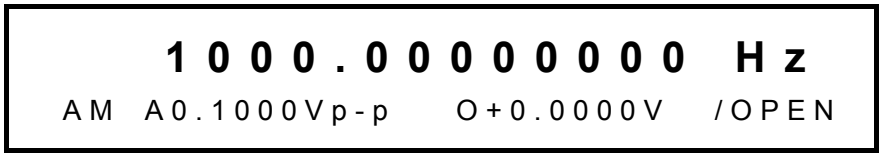
Operation:

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

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

Other:

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



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:

• When the amplitude setting is larger than 2 Vp-p (open) in the 1 V range, the amplitude is automatically changed to 1/10, since voltage exceeding 2 Vp-p (open) cannot be output in the 1 V range.

■ Output on/off at power on (SYSTEM : POWER - ON)

Selectable return to the state when the power supply was switched off or output on/off state. The example is setting the output for off at power on.

Operation:

① Press the SYSTEM key, then use the ◁ and ▷ keys to produce the following display (POWER-ON flashes).

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

■ 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 100Ωload impedance.

Operation:

① Press the SYSTEM key, then use the ◁ and ▷ keys to produce the following display (LOAD flashes).

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

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 WF1965 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 WF1965 output impedance and voltage errors are not converted.

■ UNDO function

The UNDO function is described for returning a numerical or other setting to the previous state.

Operation:

① Press the UNDO to return a setting to the previous state (ineffective when UNDO is extinguished).

Other:

• Undo enabled:

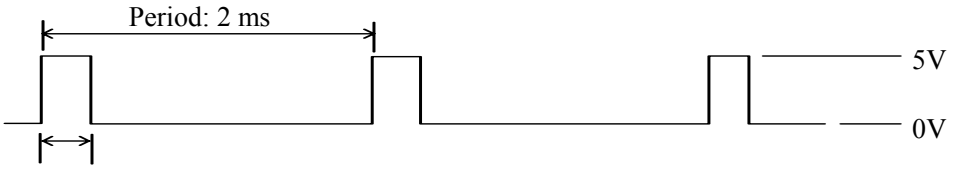
1. Directly after changing frequency, amplitude, etc., with the keypad or MODIFY dial.
2. Directly after setting recall (MEMORY → RECALL). Press the UNDO key to return the state prior to recall.

■ Pulse generator function

Operation of the WF1965 as a pulse generator is described.

Operation:

(1) Set for continuous pulse output



Pulse width: 0.2 ms

① Set the waveform to squarewave (variable duty), (FUNCTION →).

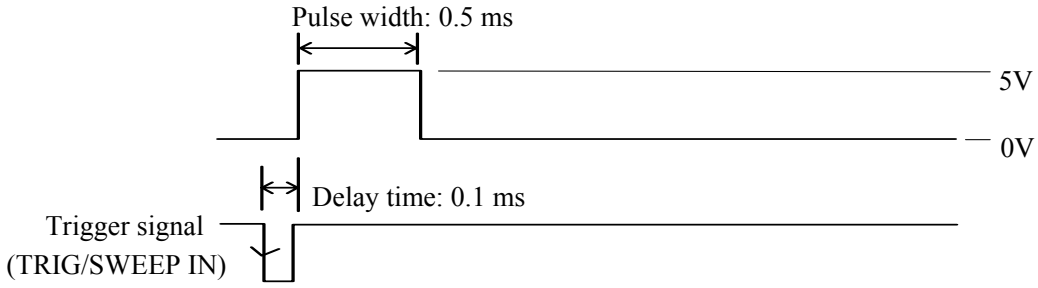
② Set the voltage High level to +5 V and the Low level to 0 V.

(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



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 –100%)

⑤ Apply the trigger signal to the TRIG/SWEEP IN connector.

Other:

- **Double pulse output:** At above step ④, set MARK = 2.0 cycles.

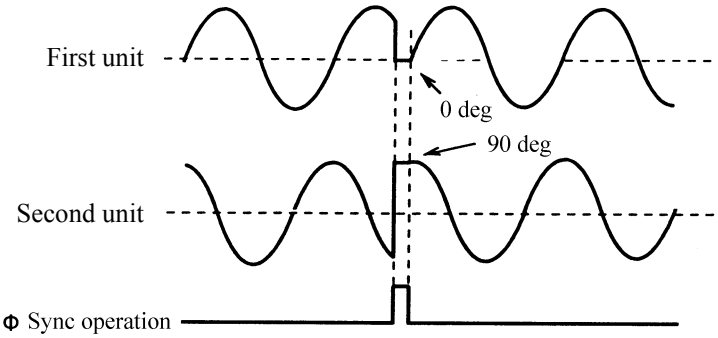
- **Manual trigger:** At above step ④, set SOURCE = EXT and press the MAN TRIG key.

  (Do not connect anything to the TRIG/SWEEP IN connector.)

■ Phase sync (SYSTEM : ϕ SYNC)

Operation is described for restarting the output waveforms from a set phase so as to clarify the phase relationship.

Phase sync is used when operation of multiple units is synchronized using ϕ SYNC IN/OUT (1991 synchronized operation option).



The phase sync operation and waveform outputs of the first and second units (when the phase of the first unit is 0 deg and the phase of the second unit is 90 deg)

Operation:

① Press the SYSTEM key, then use the ◁ and ▷ keys to produce the following display (ϕ SYNC flashes).

② Press the ENTER key to engage phase synchronization.

Other:

- Phase sync is effective during the Normal oscillation mode. In other modes, the phase may shift 180 deg. from the setting value.

- The phase among outputs of units during synchronized operation is the difference of the phase setting (PHASE) set for each unit.

Section 6 Troubleshooting

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

Error message	Cause	Corrective measures
BACKUP MEMORY LOST	Battery backup memory contents destroyed.	Backup battery probably depleted. Contact dealer. Press the ENTER key to start the system at the factory settings.
CALIBRATION MEMORY LOST	Calibration data destroyed.	Contact dealer. Although possible to start by pressing the ENTER key, accuracy cannot be guaranteed.
SYSTEM TEST FAILED 001	Internal ROM sum check error.	Contact dealer.
SYSTEM TEST FAILED 002	Internal RAM read/write error.	Contact dealer.

■ Operation error

Error message	Cause or corrective measures
DATA OUT OF RANGE	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.
INVALID NUMERIC DATA	Keypad input data invalid (e.g., decimal point only).
SETTINGS CONFLICT 001	Start or stop value set to 0 during LOG sweep and sweep cannot be executed.
SETTINGS CONFLICT 002	Combined center and span exceed the permissible sweep type (e.g., frequency) setting range.
SETTINGS CONFLICT 003	Combined modulation type (e.g., frequency) and Deviation or Depth exceed the permissible modulation type setting range and modulation cannot be executed.
SETTINGS CONFLICT 004	Combined modulation type (e.g., frequency) and Deviation or Depth exceed the permissible modulation type setting range.
SETTINGS CONFLICT 007	Combined period and pulse width exceed the permissible duty setting range.
SETTINGS CONFLICT 009	Combined frequency and duty exceed the permissible tr/tf setting range.
SETTINGS CONFLICT 010	Since the mode is SWEEP or MODU for ⎍ (variable duty), DUTY-VALID cannot be set.

continued next page

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Error message	Cause or corrective measures
STORE/RECALL MEMORY LOST	Setting storage memory contents destroyed and settings cannot be recalled. Contact dealer.
WARNING 001	Combined frequency and duty set the pulse width to not more than 6.25 ns and the pulse may be lost.
WARNING 002	Because the pulse width is set to 6.25 ns to 100 ns due to the combination of frequency and duty, the pulse width may be unstable (large jitter component).
WARNING 003	Since high frequency, burst oscillation mark and space may be unstable.
WARNING 004	Low level setting changed due to high level setting change, or conversely, high level setting changed due to low level setting change.
WARNING 005	Changed to simple standard units (Hz, s, Vp-p, V).
WARNING 006	Since combined period and pulse width exceed the permissible duty setting range, pulse width was changed in order to enter the permissible duty range. Since combined frequency and duty exceeded the permissible tr/tf setting range, tr/tf was changed to be within the setting range.
WARNING 010	The sweep function was changed from LOG to LIN.

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Error message	Cause and treatment
WARNING 011	The sweep mode was changed from gated to single.
WARNING 013	Sweep time or modulation frequency exceeded the settable range and was automatically changed to within the permissible setting range.
WARNING 015	Because of DUTY-VALID change, the duty was changed to 0.01% or 99.99%.
WARNING 016	Because of a mode change, DUTY-VALID was changed to IMMED.

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.

Symptom	Possible causes	Correction
No power on	Power source not within specified range	Use the power source within the specified range.
	Power supply fuse open	Replace the power supply fuse. (Be sure to use the correctly rated fuse.)
	External noise	Install the equipment in a site with favorable conditions.
Panel inoperative	Remote mode enabled	Press the LOCAL key to set the local mode.
	Keys or Modify dial defective	Contact service.
Output abnormal	Ambient temperature and humidity outside specified range	Use the equipment under the specified environmental conditions.
	Inadequate warm up	Allow the equipment to warm up for at least 30 minutes after power on.
	DC offset applied	Set DC offset to 0 V.
	External AM is on	Switch off the external AM.
	Set for user units	Select standard units
	LOAD function being used	Set for OPEN.
Cannot be set via remote control	Address or USB ID different from that in the program	Set the address and USB ID to match those in the program.
	Address or USB ID identical to that of another device	Set the address and USB ID so that they do not match those of other devices.
Does not operate according to instruction manual	Settings have been initialized (PRESET)	The instruction manual presumes the settings have been initialized.

Section 7 Maintenance

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.

⚠ WARNING

Do not remove external covers.
Internal inspection of this equipment must be performed only by a trained service technician who is fully aware of the hazards involved.

■ Required test instruments

The following equipment is required for inspection and performance tests.

- Oscilloscope — At least 100 MHz bandwidth
- Universal counter — Reference oscillator accuracy better than 5×10^{-7}
- DC voltmeter — Accuracy better than 0.1 %
- AC voltmeter 1 — True rms, accuracy better than 0.3 %, bandwidth at least 100kHz
- AC voltmeter 2 — True rms, accuracy better than 1 %, bandwidth at least 20MHz
- Distortion meter — Full scale 0.1 %, frequency up to 100 kHz
- 50 Ω feed through terminator
- 50 Ω 20 dB attenuator

7.2 Operation checks

■ Preparatory checks

Check the following before inspection.

- Power source voltage is within specified range.
- Ambient temperature is within 5 to 35 °C.
- Ambient relative humidity is within 5 to 85 %RH (absolute humidity: 1 to 25 g/m^3)
- Condensation is absent.

■ Function checks

- Power on

  Confirm absence of error message at power on.

  If an error message appears, ☞ 6. Troubleshooting.

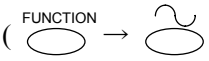
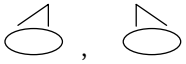
  If an abnormal indication appears at power on, switch power off and wait at least 5 seconds, then again switch power on.

- 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)

- 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 (CH1).
Judgment:	Normal if within ±5 ppm (999.995 to 1.000005 MHz) (when shipped) However, since aging may occur with up to ±3 ppm/year, deterioration up to ±8 ppm (999.992 to 1.000008 MHz) may have occurred if one year has passed since shipment.

■ 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.

Waveform	Output range	Setting	Normal range
∿	10 V	20 Vp-p/open (7.071 Vrms/open)	6.983 to 7.159 Vrms
∿, ⩘, ⩗	10 V	20 Vp-p/open (5.774 Vrms/open)	5.701 to 5.846 Vrms
⎍	10 V	20 Vp-p/open (10.00 Vrms/open)	9.875 to 10.125 Vrms
∿	10 V	10 Vp-p/open (3.536 Vrms/open)	3.483 to 3.589 Vrms
∿	10 V	5 Vp-p/open (1.768 Vrms/open)	1.732 to 1.803 Vrms
∿	10 V	2 Vp-p/open (0.707 Vrms/open)	0.682 to 0.732 Vrms
∿	1 V	2 Vp-p/open (0.7071 Vrms/open)	0.697 to 0.718 Vrms

■ 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.

Output range	DC offset setting	Normal range
10 V	±10.000 V/open	±9.850 to ±10.150 V
10 V	±5.000 V/open	±4.875 to ±5.125 V
10 V	±2.000 V/open	±1.890 to ±2.110 V
10 V	±1.000 V/open	±0.895 to ±1.105 V
10 V	0.000 V/open	–0.100 to +0.100 V
1 V	±1.0000 V/open	±0.985 to ±1.015 V
1 V	0.0000 V/open	–0.010 to +0.010 V

■ Amplitude vs. frequency characteristics

Connection: Use coaxial cable to connect FUNCTION OUT to AC voltmeter 2 (50 Ω termination).
Setting: Initialize, then set the amplitude to 20 Vp-p/open and select the frequency and waveform as indicated in the table.
Measurement: Measure the true rms output voltage for each frequency and waveform. (CH1,CH2)
Judgment: The normal ranges are indicated in the table.

Waveform	1 kHz Setting	100 kHz Setting	to 1 MHz	to 5 MHz	to 10 MHz	to 20 MHz	to 50 MHz
	————	(Reference value)	±0.2 dB	+0.2/-0.5 dB	+0.2/-1.0 dB	+0.3/-1.5 dB	+1.0/-3.0 dB
	(Reference value)	————	±0.3 dB	————	————	————	————
	(Reference value)	————	±0.3 dB	————	————	————	————
	(Reference value)	————	±0.5 dB	————	————	————	————
	(Reference value)	————	±0.5 dB	————	————	————	————

■ 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.

Frequency	Normal range
10 Hz to 100 kHz	0.3 % or less

(Bandwidth 500 kHz)

■ Squarewave response

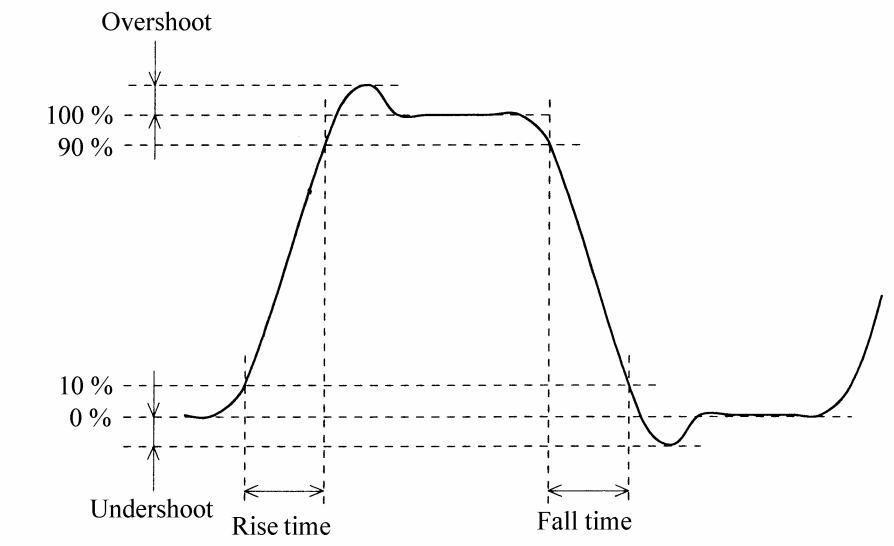
Connection: Use coaxial cable to connect FUNCTION OUT to an oscilloscope (50 Ω termination).

Setting: Initialize, then set ⎍, frequency to 1 MHz, amplitude to 20 Vp-p/open, and tr/tf/7ns.

Measurement: Observe the waveform and measure the rise and fall times, overshoot and undershoot.

Judgment: The normal range is indicated in the table.

Item	Normal range
Rise and fall times	10 ns or less
Overshoot and undershoot	5 % or less



■ 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.

Waveform	Frequency	Rated range
⎍ (duty 50 % fixed)	1 MHz	490 to 510 ns
⎍ (duty 50 % fixed)	10 MHz	45.0 to 55.0 ns
⎍ (duty 50 % fixed)	50 MHz	6 to 14 ns
⎍ (duty variable)	100 kHz	4.90 to 5.10 μs

Section 8 Specifications

Guaranteed values are shown with tolerance, values without tolerance are for reference.

8.1 Waveform and output characteristics

● Waveforms (FUNCTION OUT)

Output waveforms	∿, ⩘, ⊓ (Duty 50 % fixed), ⊓ (Duty variable), ◿, ◺, arbitrary waveform (ARB), and noise (NOISE), DC voltage (DC)
Waveform vertical resolution	14 bit (∿, ⩘, ◿, ◺, arbitrary waveform (ARB))
Output waveform and frequency	
For continuous oscillation	∿, ⊓ (duty 50% fixed) : 0.01 μHz to 50 MHz ⩘, ⊓ (duty variable), ◿, ◺ : 0.01 μHz to 2 MHz Arbitrary waveform : 0.01 μHz to 2 MHz However, the frequency in which all the data of arbitrary waveforms can be outputted is the maximum of the following value. (160MHz) ÷ [waveform data size (words)] Analog band width 35MHz
For burst, trigger, gate, triggered gate, or gated sweep	0.01 μHz to 500 kHz
Frequency	
Range:	0.01 μHz to 50 MHz
Resolution:	0.01 μHz
Accuracy when shipped:	±5 ppm
Aging:	±3 ppm/year
Setting by period	Frequency equivalent to inverse number of the setting period. If the number is less than the frequency setting resolution, the number should be rounded off.
Duty	
Range:	0.0000% to 100.0000% switching/0.0100% to 99.9900% switching
Resolution:	0.0001 %
Arbitrary waveform data size	Can be switched among 8 K, 16 K, and 32 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
Arbitrary waveform data edit	Data writing of designated points and linear interpolation by panel operation, or data writing using remote control
Arbitrary waveform data resolution	16 bits (-32768 to +32767) For output waveform, upper 14 bits are output.

Noise

Noise source: M-series dummy noise from the 45-stage shift register or the equivalent
Period 53.406 hours, Spectrum interval 5.2013 μHz

White noise bandwidth (equivalent noise bandwidth): about 2 MHz

Peak factor (crest factor): 3

Set the amplitude to Vp-p. The output amplitude becomes half the set amplitude.

Effective value = (Vp-p set point) ÷ 4 ÷ (peak factor)

Binary output: Outputs from SYNC OUT during NOISE mode.

● Output characteristics (FUNCTION OUT)

Amplitude frequency characteristics

Continuous oscillation, External AM off, 50-Ω load, DC offset 0 V, amplitude setting 10 Vp-p/50 Ω, frequency 100 kHz (∿)/1 kHz (otherwise) reference, effective value (RMS) measured

∿ Up to 1 MHz: ±0.2 dB
1 MHz to 5 MHz: +0.2dB, –0.5 dB
5 MHz to 10 MHz: +0.2dB, –1.0 dB
10 MHz to 20 MHz: +0.3dB, –1.5 dB
20 MHz to 50 MHz: +1.0dB, –3.0 dB

⊓ Up to 1 MHz: ±0.3 dB

◺ Up to 1 MHz: ±0.3 dB

◿, ◸ Up to 1 MHz: ±0.3 dB

Spectrum purity

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

10 Hz to 100 kHz:
Harmonic spectrum

10 Hz – 100 kHz: 0.3 % and below
100 kHz to 1 MHz: –47 dBc and below
1 MHz to 50 MHz: –35 dBc and below

Spurious output

Up to 50 MHz: –30 dBc and below

Square waveform characteristics

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

Overshoot

5% or less

Rise time/fall time

Range

7 ns to 1 ms

Resolution

3 digits

Duty

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

⊓ (50 % fixed duty)

Up to 1 MHz: ±1 % of the period
1 MHz to 10 MHz: ±5 % of the period
10 MHz to 50 MHz: ±20 % of the period

⊓ (duty variable)

Up to 100 kHz: ±1 % of the period
Jitter: 7 nsp-p

8.2 Output voltage

● Output voltage (FUNCTION OUT)

Output range	10 V range / 1V range fixed, or automatic switchable
Amplitude	
Range	10 V range : 0 mVp-p to 20.000 Vp-p/open
	1 V range : 0.0 mVp-p to 2.0000 Vp-p/open
Resolution	10 V range : 1 mVp-p/open
	1V range : 0.1 mVp-p/open
Accuracy	Continuous oscillation, external AM off, ∿, 1 kHz, rms value measured
	10 V range : ± (1 % of amplitude setting [Vp-p] + 0.05 Vp-p)/open
	1 V range : ± (1 % 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	10 V range : ± (0.5% of DC offset setting [V] + 0.1 V)/open
	1 V range : ± (0.5% of DC offset setting [V] + 0.01 V)/open
	When DC voltage is generated for both cases.
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	Phase from oscillation stop to oscillation start
Range	−1800.000° to +1800.000°
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.
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 ≥ +3.9 V, low level ≤ +1.6 V
Minimum pulse width	50 ns
Input impedance	At 10 kΩ, pull up to +5 V.
Input connector	Front panel BNC receptacle (TRIG/SWEEP IN)
Internal trigger oscillator	
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 %

● Sweep

Sweep items	Frequency, phase, amplitude, DC offset, duty (⎍ variable duty)
Setting items	Sweep start/stop or sweep center/span, sweep marker (replaces center), sweep start state, sweep stop state
Sweep functions	Continuous / single / gated sweep LIN/LOG (LOG for frequency/amplitude) ⩘ / ◿ / ∿ / ⎍
Sweeping time	
Range	1 ms to 10000.000 s
Resolution	1 ms
Sweep trigger	Indicates start of single / gated sweep.
Sweep trigger period	100 ms and more.
Trigger source	Selectable internal trigger oscillator or external trigger input. Also, applicable from panel keys and via remote control.
External trigger	
Polarity	Selectable rise/fall.
Input connector	Front panel, BNC receptacle (TRIG/SWEEP IN)
Minimum pulse width	200 ns
Trigger delay	2 ms
Internal trigger oscillator period	
Range	1 μs to 100.0 s
Resolution	4 digits at 1 ms and more, 1 μs at less than 1 ms.
Oscillation stop level	On/off setting effective during gated sweep. Off; stop at set phase. On; stop at set stop level.
Range	−100.0 %（maximum negative output) to +100.0 % (maximum positive output)
Resolution	0.01 %

● 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) Combined use with SYNC OUT
Sweep stop/restart input	
Input level	High level ≥ +3.9 V, low level ≤ +1.6 V
Signal characteristics	Low level: Stop sweep when sweep in progress High level: Release the stop
Input impedance	Pulled up to +5 V with 10 kΩ
Input connector	Rear panel BNC receptacle (SWEEP PAUSE IN)
Sweep marker output	
Output level	0/+5 V (open)
Signal characteristics	Low level: Sweep marker or higher during sweep High level: All other times
Output impedance	30 Ω, unbalanced
Load impedance	1 kΩ or 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 rising +5 V → 0 V: Sweep value is falling
Output impedance	1 kΩ, unbalanced
Load impedance	10 kΩ or more
Output connector	Rear panel BNC receptacle (SWEEP X-DRIVE OUT)

● Internal modulation functions

Modulation items	FM (FSK), PM (PSK), AM, DC offset modulation, PWM (⎍ variable duty)
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.
Internal modulation waveform	∿, ⩘, ⎍, ⩗, ◺

● External modulation function

Modulation item	AM, DSB-SC AM, on/off selection
External modulated frequency	DC to 10 MHz
External AM depth	-3 V input: -100% -1 V input: 0% 0 V input: 50% +1 V input: Setup amplitude
Input voltage range	-3 V to +1 V
Input impedance	50 Ω
Input connector	Rear panel BNC receptacle (EXT AM IN)

● External add function

External add	Function that adds an external signal to the FUNCTION OUT signal on/off selection
External add frequency	DC to 10 MHz
External add gain	Unloaded 10 V range: × 2 1 V range: × 0.2
Input voltage range	±5 V
Input impedance	50 Ω
Input connector	Rear panel BNC receptacle (EXT ADD IN)

● Setting initialization

Functions	Initializes nearly all setting contents. Initialization settings, ☞ 3.3 Basic operation.

● 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 [(internal set up) + n] × m, or [$\log_{10}$ (internal set up) + n] × m; then, set the value of n and m. Frequency and period: 15 digits mantissa and 1 digit expornent (both m and n) Amplitude, DC offset and duty.: 6 digits mantissa and 1 digit expornent (m and n) Phase: 7 digits mantissa and 1 digit expornent (m and n)
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: (Output voltage at load) = (Output voltage at no-load) × $\frac{(\text{Load impedance})}{(\text{Output impedance : } 50\,\Omega) + (\text{Load impedance})}$
Load impedance setting	
Range	45 Ω to 999 Ω
Resolution	1 Ω

● 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. Output voltage in inadequate. Battery needs replacement (fee charged)

8.4 Initialized settings

● Initialized settings

Initialization settings, ☞ "3.3 Basic operation(■Initialization table)", cf.

● Error from backup battery depletion

In addition to setting initialization, following are set:

Output on/off	Off
Output on/off in turning on	LAST-STATE (condition just before power off)
Setting memory	ALL NOT STORED
Setting memory comment	" " (blank)
User unit name	USER
User unit computation formula	(h+n)*m
User unit coefficient	1
User unit offset	0
Arbitrary waveform selection	0:ARB_00
Arbitrary waveform name	ARB_00 (00 to 11)
Arbitrary data size	8 K
Arbitrary waveform data	All 0
Remote control interface	GPIB
GPIB address	2
GPIB delimiter	CR+LF
USB ID	2

8.5 Remote control

GPIB interface

GPIB function	SH1	All source handshake functions
	AH1	All acceptor handshake functions
	T6	Basic talker serial poll, talker release by MLA
	L4	Basic listener, listener release by MTA
	SR1	All service request functions
	RL1	All remote/local functions
	PP0	No parallel poll functions
	DC1	All device clear functions
	DT1	All device trigger functions
	C0	No controller functions
Use code	ISO 7 bit codes (ASCII code)	
Address	0 to 30 (set from panel)	
Output driver	DIO1-8, NDAC, NRFD and SRQ : Open collector DAV and EOI : 3-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 synchronized operation option

Function	Synchronizes operation of multiple WAVE FACTORY series Note machines. The 1991 is needed on all machines that participate in synchronized operation.
Time difference	When the phase is synchronized after setting of the same waveform and frequency for continuous oscillation, external AM off, 50-Ω load, 0 V DC offset, and amplitude setting of 10 Vp-p/50 Ω Time difference between units: ±25 ns plus maximum of 10 ns for each unit
Cabling	The cable used to connect multiple WAVE FACTORY series Note machines is sold separately (1994 synchronized-operation cable).

● 1994 synchronized-operation cable

Cable for the 1991 synchronized operation option to connect multiple WAVE FACTORY series Note machines. For connection of n WAVE FACTORY series Note machines, (n-1) 1994 synchronized-operation cables are needed.

Note : 1945, 1946, 1956, WF1945, WF1946, WF1956, WF1965, and WF1966 from NF Corporation

8.7 General items

Input/output ground

The signal grounds of FUNCTION OUT, SYNC OUT, EXT AM IN, and EXT ADD IN are floated from the chassis. The input/output grounds of these signals on one channel are common.
Signal ground dielectric strength: ±42 Vpeak, 30 Vrms (DC to 20 kHz, continuous)
The input/output grounds of all other signals are connected to the chassis.

Power supply

Power supply voltage range	AC100 V/115 V/230 V
Power supply frequency range	50/60 Hz ± 2 Hz
Power supply fuse	Time lag 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/m^3)
Storage time	–10 to +50° C, 5 to 95 %RH (no condensation at an absolute humidity of 1 to 29 g/m^3)
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. 4.4 kg,

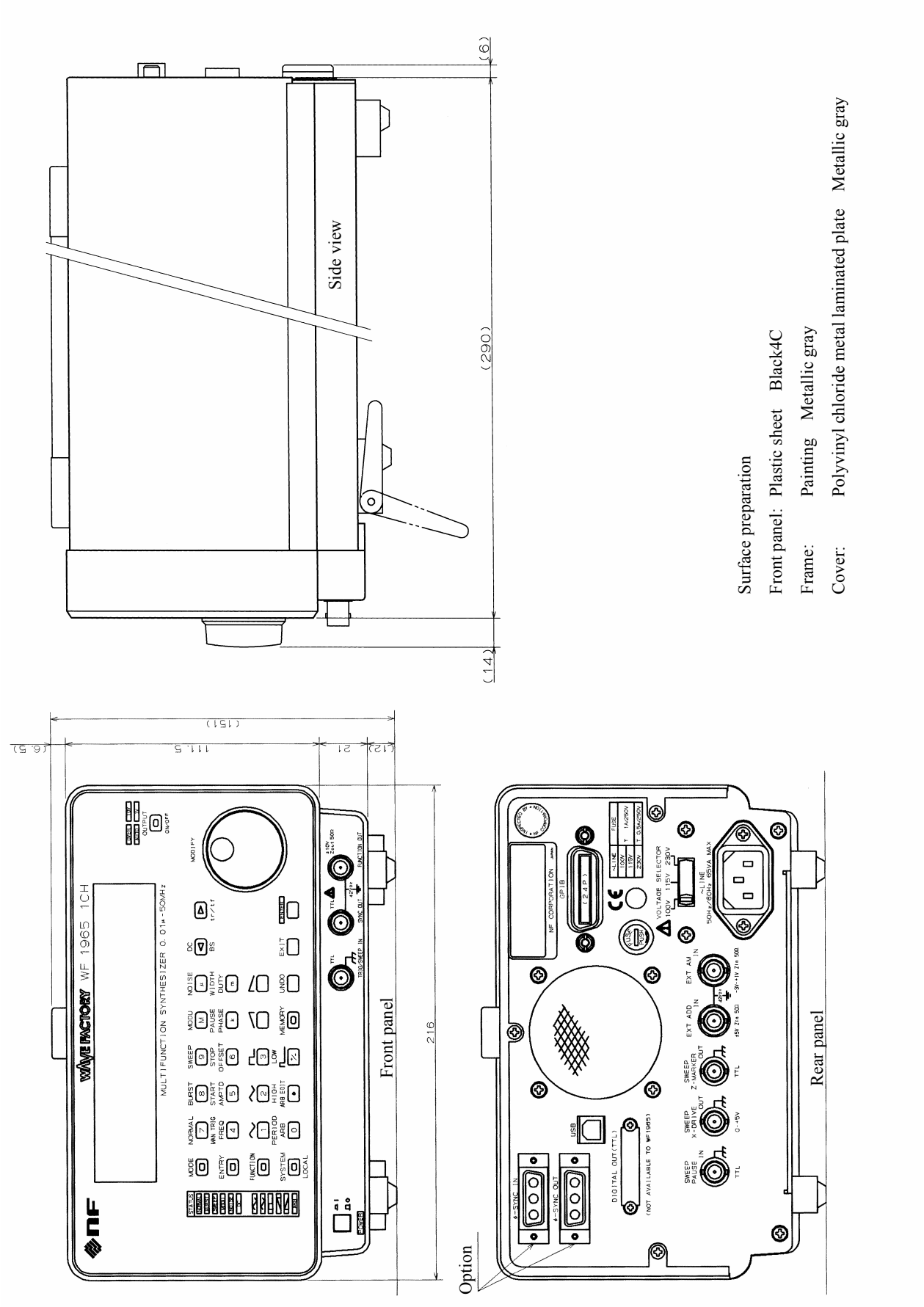
Safety

EN 61010-1: 2001

EMC

EN 61326: 1997/A1: 1998/A2: 2001
However, the performance criteria for the following standards are as follows:
EN61000-4-2(1995), EN61000-4-4(1995), EN61000-4-5(1995), and EN61000-4-11(1994):B

■ External drawing



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Front and rear panel indications (alphabetical order).

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

WABUN: (≈510061-8)

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

NOTES

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- 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.

WF1965 MULTIFUNCTION SYNTHESIZER Instruction Manual

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