FLUKE®

271

Programmable 10 MHz DDS Function Generator

Getting Started Manual

PN 2423297
January 2005

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Safety

This function generator is a Safety Class I instrument according to IEC classification and has been designed to meet the requirements of EN61010-1 (Safety Requirements for Electrical Equipment for Measurement, Control and Laboratory Use). It is an Installation Category II instrument intended for operation from a normal single phase supply.

This instrument has been tested in accordance with EN61010-1 and has been supplied in a safe condition. This Getting Started Manual contains some information and warnings which must be followed by the user to ensure safe operation and to retain the instrument in a safe condition.

This instrument has been designed for indoor use in a Pollution Degree 2 environment in the temperature range 5 °C to 40 °C, 20 % - 80 % RH (non-condensing). It may occasionally be subjected to temperatures between +5 °C and -10 °C without degradation of its safety. Do not operate the instrument while condensation is present.

Use of this instrument in a manner not specified by these instructions may impair the safety protection provided. Do not operate the instrument outside its rated supply voltages or environmental range.

⚠⚠ Warning

To avoid the possibility of electric shock:

- **This instrument must be earthed.**
- **Any interruption of the mains earth conductor inside or outside the instrument will make the instrument dangerous. Intentional interruption is prohibited. The protective action must not be negated by the use of an extension cord without a protective conductor.**
- **When the instrument is connected to its supply, terminals may be live and opening the covers or removal of parts (except those to which access can be gained by hand) is likely to expose live parts.**

- **The apparatus shall be disconnected from all voltage sources before it is opened for any adjustment, replacement, maintenance or repair.**
- **Any adjustment, maintenance and repair of the opened instrument under voltage shall be avoided as far as possible and, if inevitable, shall be carried out only by a skilled person who is aware of the hazard involved.**
- **Make sure that only fuses with the required rated current and of the specified type are used for replacement. The use of makeshift fuses and the short-circuiting of fuse holders is prohibited.**

⚠ Caution

If the instrument is clearly defective, has been subject to mechanical damage, excessive moisture or chemical corrosion the safety protection may be impaired and the apparatus should be withdrawn from use and returned for checking and repair.

Note ♻

This instrument uses a Lithium button cell for non-volatile memory battery back-up. Typical battery life is 5 years. In the event of replacement becoming necessary, replace only with a cell of the correct type, a 3 V Li/Mn02 20 mm button cell type 2032. Do not mix with solid waste stream. Do not cut open, incinerate, expose to temperatures above 60 °C or attempt to recharge. Used batteries should be disposed of by a qualified recycler or hazardous materials handler. Contact your authorized Fluke Service Center for recycling information.

⚠ Caution

Do not wet the instrument when cleaning it and in particular use only a soft dry cloth to clean the LCD window.

The following symbols are used on the instrument and in this manual:


Caution - refer to the accompanying documentation, incorrect operation may damage the instrument.


Terminal connected to chassis ground.


Mains supply OFF.

Mains supply ON.


Alternating current.


Warning - hazardous voltages may be present.

EMC Compliance

This instrument meets the requirements of the EMC Directive 89/336/EEC.

Compliance was demonstrated by meeting the test limits of the following standards:

Emissions

EN61326 (1998) EMC product standard for Electrical Equipment for Measurement, Control and Laboratory Use. Test limits used were:

a)	Radiated:	Class B
b)	Conducted:	Class B
c)	Harmonics:EN61000-3-2 (2000) Class A	The instrument is Class A by product category.

Immunity

EN61326 (1998) EMC product standard for Electrical Equipment for Measurement, Control and Laboratory Use. Test methods, limits and performance achieved were:

a)	EN61000-4-2 (1995) Electrostatic Discharge: 4 kV air, 4 kV contact	Performance A.
b)	EN61000-4-3 (1997) Electromagnetic Field: 3 V/m, 80 % AM at 1 kHz	Performance A.
c)	EN61000-4-11 (1994) Voltage Interrupt: 1 cycle, 100 %	Performance A.
d)	EN61000-4-4 (1995) Fast Transient: 1 kV peak (ac line), 0.5 kV peak (signal lines and RS232/GPIB ports)	Performance A.

e) EN61000-4-5 (1995) Surge: 0.5 kV (line to line), 1 kV (line to ground) Performance A.

f) EN61000-4-6 (1996) Conducted RF: 3 V, 80 % AM at 1kHz
(ac line only; signal connections <3 m not tested) Performance A.

According to EN61326 the definitions of performance criteria are:

Performance criterion A: 'During test normal performance within the specification limits.'

Performance criterion B: 'During test, temporary degradation, or loss of function or performance which is self-recovering'.

Performance criterion C: 'During test, temporary degradation, or loss of function or performance which requires operator intervention or system reset occurs.'

Table of Contents

Getting Started

Introduction

This *Getting Started Manual* for the model 271 Programmable 10 MHz DDS Function Generator is designed to provide an initial understanding of the way the instrument is operated. The manual is set out in the form of a tutorial, guiding you through a series of basic front panel operations in order to familiarize you with the controls and the modes of operation.

The *Users Manual* contains detailed specifications and descriptions of all the functions and operations accessible both from the front panel and by means of the remote interfaces.

Before You Start

Mains Supply Voltage

Check that the instrument operating voltage marked on the rear panel is correct for the local supply. If it is necessary to change the operating voltage, follow the procedure described in Appendix A of the *Users Manual*.

Externally Applied Voltages

⚠ Caution - Front Panel Sockets

To avoid risk of damage to the instrument:

Do not apply external voltages to the MAIN OUT or AUX OUT sockets.

Do not apply external voltages exceeding ±10 V to the TRIG IN socket.

⚠ Caution - Rear Panel Sockets

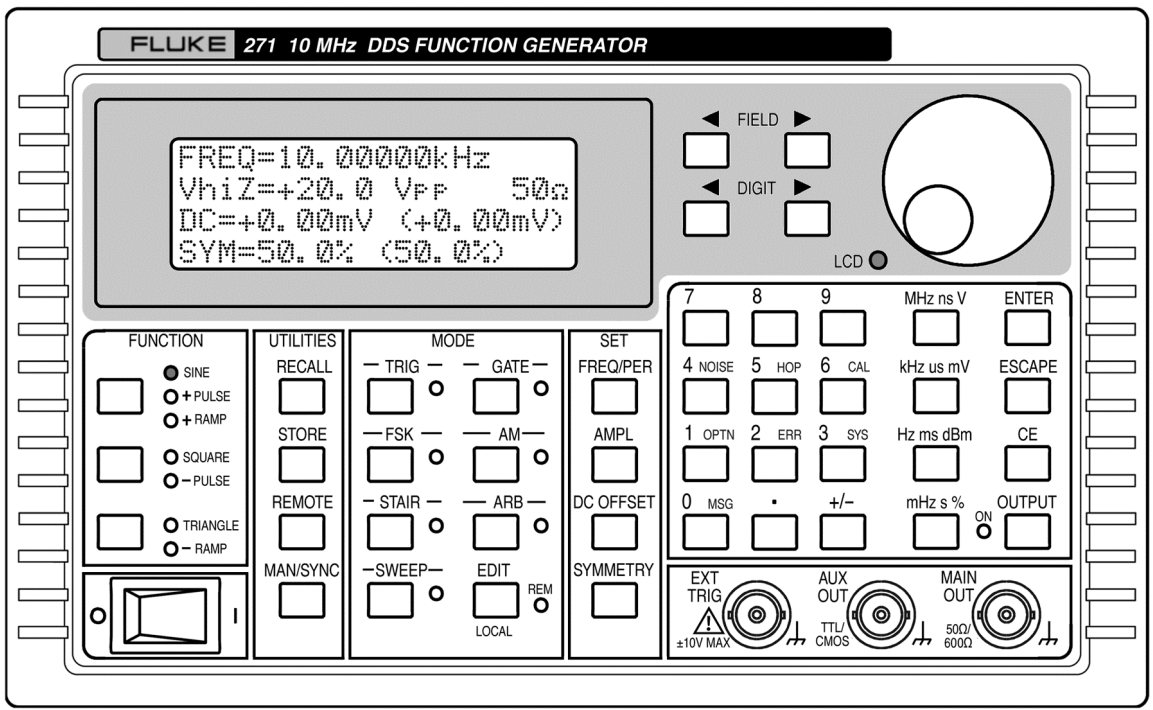
To avoid risk of damage to the instrument:

Do not apply external voltages to the SYNC OUT or TRIG/SWEEP OUT sockets.

Do not apply external voltages exceeding ±10 V to the VCA IN socket.

Do not apply external voltages exceeding +7.5 V or -2.5 V to the CLOCK IN/OUT socket.

Controls and Connections



shx0001f.gif

Figure 1. Model 271 Front Panel

The Liquid Crystal Display

The 4-line x 20-character LCD panel is used to display and edit all the parameter values. The paradigm used for selecting fields and editing values is described below.

If necessary (because of temperature variations etc.), you can adjust the display contrast using a small screwdriver or trimmer tool inserted in the hole marked **LCD**.

At power-up the instrument goes through a self-test cycle and the display shows the firmware revision number for a few seconds. If any tests fail, the display will show a message indicating the nature of the fault; if this happens, refer to the *Users Manual*.

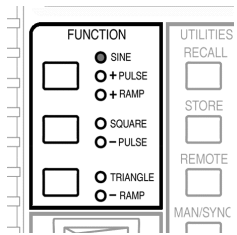
The display shown above is called the "main menu" and shows the frequency (or period), amplitude, dc offset and symmetry of the waveform. Other menus, called "edit menus", are called when you press the **EDIT** key followed by a **MODE** key.

If the main menu display is not as shown in figure 1 above then you should reset all settings to their factory defaults. Do this by pressing **RECALL**, then the numeric **0** key, then **ENTER**.

Controls

Function Keys

These three keys are used to choose between the basic waveforms: sine, square and triangular waves, and pulses and ramps of either polarity.



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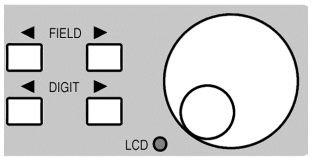
Repeated presses of a key will cycle the selection through the two or three choices offered. The associated LED will light.

FIELD and DIGIT Keys and the Rotary Control

The **FIELD** keys move the display cursor between fields.



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The fields in the display shown in figure 1 above are "FREQ=", "10.00000", "kHz", "VhiZ=" and so on.

Each field is one of three types: a parameter name, a parameter value or a unit name.

The **DIGIT** keys work in different ways depending on selected field type.

When the field contains a numeric parameter value the **DIGIT** keys move the cursor right (less significant) or left (more significant). The rotary control will then increment or decrement the digit indicated.

When the field contains a unit name, the **DIGIT** keys have the effect of multiplying or dividing the value by 10; they simultaneously set the display of the value and its unit in the most convenient engineering format. The rotary control has the same effect.

Thus, for example, if you select kHz with the **FIELD** key, successive presses of the right **DIGIT** key (or rotating the knob clockwise) change the value and the units as follows:

```
10.00000kHz
100.0000kHz
1.000000MHz
10.00000MHz
```

When the field contains a parameter name, successive presses of the **DIGIT** keys allow you to make a selection from all the possible choices for that parameter. Again, the rotary control has the same effect.

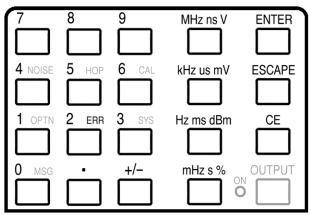
For example, with VhiZ selected in the start-up screen above, successive presses of the right **DIGIT** key (or rotating the knob clockwise) change the amplitude displayed as follows:

```
VhiZ=+20.0 Vpp
VhiZ=+7.07 Vrms
V    =+10.0 Vpp
V    =+3.54 Vrms
OUT =+24.0dBm
```

All of these are equivalent representations of the output amplitude, for a sine wave. If the waveform is not sinusoidal then you can still display the rms values but the dBm representation is excluded from the list.

Numeric, Units and SET Keys

You can use these keys to enter parameter values directly. For example, to set the period to 125 µs, select the first field (FREQ), change it to period (PER) by pressing a **DIGIT** key, then enter **1, 2, 5, us** on the keypad.



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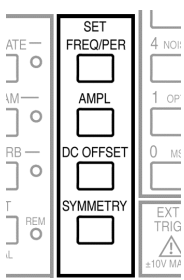
If the numeric value is dimensionless, for example a BURST COUNT, the **ENTER** key terminates the entry; otherwise it is terminated by the units key.

If you are editing one of the parameters in the main menu (frequency/period, amplitude, dc offset or symmetry) you can use one of the **SET** keys to navigate to the appropriate field directly.



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The **CE** key clears the entry, one key press at a time.

The **ESCAPE** key abandons the current editing action.

In addition, if the display is of any menu other than the main menu, the **ESCAPE** key will return you to the main menu.

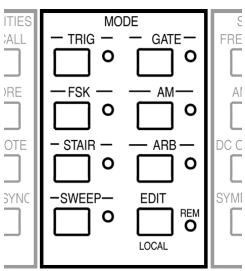
MODE Keys

Alternate presses of a **MODE** key will turn the mode (**TRIG**, **GATE**, **AM**, etc.) on or off, and when the function is on the associated lamp is lit.

If you press the **EDIT** key then press a **MODE** key you will see the edit menu for that mode. The associated lamp flashes when the edit menu is displayed.

Some of the modes share keys with the numeric keypad. For example, to see the edit screens for **HOP** mode, press **EDIT** then the numeric **5** key.

To return to the main menu from any edit menu, press the **ESCAPE** key.



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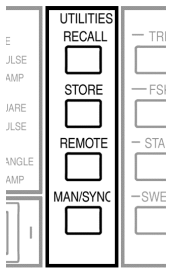
UTILITIES Keys

The **UTILITIES** keys give access to the **STORE**, **RECALL** and **REMOTE** edit menus. The instrument can store up to nine set-ups (numbered 1 to 9), and can recall any of those plus set-up 0 which is the factory default set-up and is not editable.



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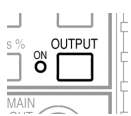
The **MAN/SYNC** key is used for manual triggering and synchronizing two or more generators when suitably connected together. Further information on synchronizing two generators is given in the _Users Manual_.

OUTPUT Key

The **OUTPUT** key turns the **MAIN OUT** on and off. When the output is on the LED next to the key is lit. The default state at power-up is with the output off.



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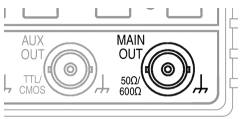
Front Panel Inputs and Outputs

MAIN OUT

MAIN OUT is the 50 Ω or 600 Ω output from the main generator. It will provide up to 20 V p-p into a high-impedance load or 10 V p-p into a matched 50 Ω or 600 Ω load. It can tolerate a short circuit for 60 seconds.



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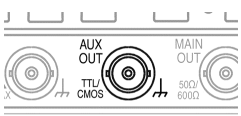
AUX OUT

The **AUX OUT** socket provides a two-level TTL and CMOS compatible signal, synchronous with the signal from the **MAIN OUT** socket.



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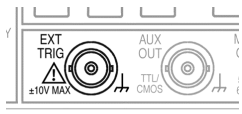
The symmetry of the **AUX OUT** signal is the same as that set for the main output but you can adjust the phase relationship between **MAIN OUT** and **AUX OUT** using the `PHASE` setting in the `TRIG` menu.

AUX OUT logic levels are nominally 0 V and 5 V from typically 50 Ω. **AUX OUT** will withstand a short-circuit.

EXT TRIG

EXT TRIG is the external trigger input for the non-continuous modes (trigger, gate, sweep, FSK and hop) and for synchronizing the generator as a slave to an external master generator.



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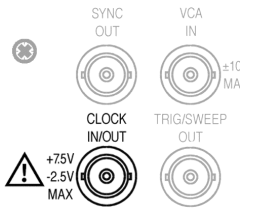
Rear Panel Connectors

CLOCK IN/OUT

This socket operates both as an input and as an output, depending on the mode in which the instrument is being used.



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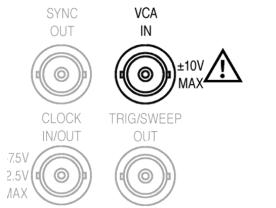
As an input it can be used either to run the instrument from an external master clock or as a synchronization input when slaved to another instrument as the master.

As an output it provides the internal master clock or the master synchronization output for another instrument as the slave.

In both modes the levels are TTL and CMOS compatible.

VCA IN

This is the modulation input for voltage controlled amplitude (VCA). +2.5 V will drive the amplitude to 100 % of its programmed value. The input impedance is approximately 6 kΩ.



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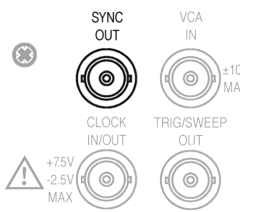
Modulation is beyond the scope of this *Getting Started Manual* but is covered in detail in chapter 8 of the *Users Manual*.

SYNC OUT

This socket is used when the instrument is the master in a master-slave set-up. It provides a signal to drive the **EXT TRIG** front panel input of the slaved instrument.



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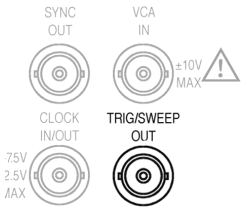
Master-slave operation is beyond the scope of this *Getting Started Manual* but is covered in chapters 12 and 13 of the *Users Manual*.

TRIG/SWEEP OUT

The **TRIG/SWEEP** output socket provides both trigger and marker signals, depending on the instrument's mode of operation.



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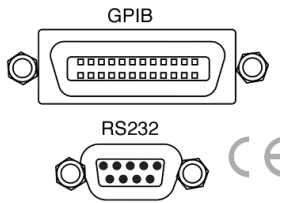
Its primary use is for triggering an oscilloscope or other recording device, but it can also provide z-axis bright-up markers during sweep and frequency-hopping modes.

RS232 and GPIB Interface Connectors

These sockets are for controlling the instrument remotely, using a PC or other controller device. Remote control is beyond the scope of this *Getting Started Manual*, but is covered in detail in chapter 16 of the *Users Manual*.



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Using the Instrument

While familiarizing yourself with the instrument you will find it useful to observe the outputs on an oscilloscope. For most purposes it is sufficient to connect the **MAIN OUT** front panel socket to the oscilloscope's Y input, and the **AUX OUT** front panel socket to the oscilloscope's trigger input.

If no oscilloscope is available you can still learn a great deal about the instrument settings, since the effect of front-panel operations is visible in the LCD display in the form of text messages, parameter information, menus and status information.

Starting up

The ac supply on/off switch is located at the bottom left side of the front panel.

⚠ Caution

Before connecting to the ac supply, check that the supply voltage setting is correct for the region. Please refer to the *Users Manual* if it needs to be changed.

Plug in and switch on the instrument

On power-up the LCD panel illuminates and the instrument performs a series of self tests. In the event that an error message is displayed please refer to the *Users Manual*.

Check the LCD Display

It should look similar to the main menu shown in figure 1. If not, press **RECALL, 0, ENTER** to bring up the factory default main menu.

Generating Continuous Signals

Select **SINE** on the function keys, if it is not already selected.

If there is no signal at the oscilloscope input it will almost certainly be because the generator's output is switched off. If the lamp next to the **MAIN OUT** socket is not lit, press the **OUTPUT** key. The **AUX OUT** socket is always on.

Press the right **FIELD** key to put the cursor in the numeric part of the top line and move the cursor a couple of digits to the right with the right **DIGIT** key. You can experiment with the rotary control to adjust the frequency setting.

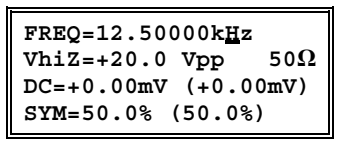
You can also experiment with entering frequencies using the numeric keypad, and with using the **DIGIT** key to adjust the frequency in decades; to do this, put the cursor under the rightmost (units) field.

Set a frequency, for example 12.5 kHz

You can do this by either of the methods above.

The easiest is probably to key
FREQ/PER, **1**, **2**, **.**, **5**, **kHz**, **ENTER**.

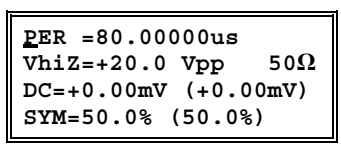
The display should look like this:



You can also view and edit in terms of period.

Move the cursor into the first field and press one of the **DIGIT** keys.

The display should change to:



Set the amplitude to +10 dBm

You can do this by keying **AMPL**, **1**, **0**, **dBm**.

The display will now look like this:

```
PER =80.00000us
OUT =+10.0dBm     50Ω
DC=+0.00mV (+0.00mV)
SYM=50.0% (50.0%)
```

If you switch the amplitude display back to `VhiZ` you should see:

```
PER =80.00000us
VhiZ=+4.00 Vpp    50Ω
DC=+0.00mV (+0.00mV)
SYM=50.0% (50.0%)
```

If you are using a 50 Ω termination on the oscilloscope input then the signal amplitude will be half the displayed value, 2 V p-p.

Have a look at some other waveforms

Using the function keys you can select any of the waveforms and observe them on the oscilloscope display.

Change the dc offset

If the output is still set to 4 V p-p then with the dc offset in the fractional millivolts range you will not be able to see changes on the oscilloscope, so the first thing to do is to force a range change.

Do this by pressing the **DC OFFSET** key and entering (say) **1.5 V**.

You can then use the rotary control to adjust the waveform offset in steps which depend on the cursor position. For smoother control press the right **DIGIT** key.

```
PER =80.00000us
VhiZ=+4.00 Vpp    50Ω
DC=+1.50 V (+1.50 V)
SYM=50.0% (50.0%)
```

Note that with the cursor placed as shown, pressing the **+/-** key will change the polarity of the offset voltage.

Effect of the output attenuator

The instrument has an output attenuator with fixed steps of 20 dB. The attenuator follows the output stages so any dc offset added to the waveform is subject to the attenuator.

With the waveform amplitude set to 4 V p-p the attenuator is switched out; however if you adjust the output to (say) 0.4 V p-p, 20 dB of attenuation is switched in. When this happens you will be warned that the dc offset has been changed.

Try it. Set the amplitude to 4 V p-p and the dc offset to +1.5 V.

Now change the amplitude by pressing **AMPL**, **0.4**, **V**. The instrument will beep and you should see something like this for a few seconds:

```
**** WARNING 07 ****
* DC OFFSET CHANGE *
* BY OUTPUT LEVEL  *
********************
```

Then this:

```
PER =80.00000us
VhiZ=+4.00 Vpp   50Ω
DC=+1.50 V (+151.mV)
SYM=50.0% (50.0%)
```

The figure in brackets to the right of the programmed dc offset is the value which results from the application of 20 dB of attenuation. It may differ slightly from the calculated value (150 mV) because of the attenuator's saved calibration factors.

Asymmetric waveforms

Symmetry adjustments work in much the same way as dc offset adjustments. However, because of the lengthy calculations which the instrument makes following a change to the symmetry setting, you may find it easier to use direct numeric entry rather than the rotary control.

Again, the symmetry of the output is displayed in brackets at the right of the programmed value and in certain circumstances the programmed and actual values may differ. For example, at high output frequencies the specification limits for symmetry are 20 to 80 % for a square wave but 1 to 99 % for a sine wave. Full details are given in the *Specifications* section in chapter 1 of the *Users Manual.*

Adjusting the phase

The **AUX OUT** socket supplies a TTL and CMOS-compatible (0/+4 V) reference signal against which you can adjust the phase of the signal at the **MAIN OUT** socket.

Return to the factory default settings by pressing **RECALL**, **0**, **ENTER**, then press the **EDIT** key followed by **TRIG**.

The lamp next to the **TRIG** key will flash and you should see a screen like this:

```
SOURCE=EXT
TGEN=1.00ms 1.000kHz
BURST COUNT= 0001
PHASE=+000° (+000°)
```

The instrument is still operating in continuous, not triggered mode, so the settings for the trigger source, the internal trigger generator and the burst count are not relevant here. The only item on this menu which affects continuous modes as well as triggered and gated modes is the `PHASE` setting.

Move the cursor to the last digit of the phase numeric value field and use the rotary control to move the phase of the **AUX OUT** relative to that of the **MAIN OUT**.

```
SOURCE=EXT
TGEN=1.00ms 1.000kHz
BURST COUNT= 0001
PHASE=+116° (+116°)
```

You may want to trigger the oscilloscope from the

instrument's **AUX OUT** socket in order to see the phase effects more clearly.

There are some limitations on using the phase control at frequencies above 30 kHz - chapter 5 of the *Users Manual* explains these in detail.

Generating Swept Signals

The instrument has an independently-controlled internal trigger generator which produces a square wave with a period from 20 µs to 200 s (in 20 µs steps), corresponding to a repetition frequency from 0.005 Hz to 50 kHz. In most modes the signal is made available at the rear panel **TRIG/SWEEP OUT** socket.

In sweep mode, the sweep begins on the negative edge of the signal (the transition from +4 to 0 V; if you include markers in the sweep set-up then each marker produces an additional narrow +1 V pulse on the **TRIG/SWEEP OUT** signal.

For this tutorial we will generate a logarithmic sine wave sweep from 261.6 to 1108.7 Hz. This 2-octave range is well within the limits of audibility, so you can listen on headphones if you wish. Set the amplitude to about -10 dBm or you may be surprised by the intensity.

The description "logarithmic" means that the sweep spends an equal period at each note of the scale (and is a misnomer because the rate of frequency increase with time is in fact exponential).

The set up process is as follows:

Press **RECALL**, **0**, **ENTER** to reset to the factory defaults. Then press **EDIT** and **SWEEP**.

At this point the lamp next to the **SWEEP** key should be flashing and the display should look like this:

```
MODE=BEG-END LAW=LOG
RAMP TIME=0.05 s
TRIG SRC=CONTINUOUS
         MORE->>>
```

All these settings are fine except for the sweep time, which is too short if you are listening to the signal.

Change the sweep time to, say, 5 seconds. When you press the **ENTER** key the display will return to the main menu, so press **EDIT** and **SWEEP** again and use the **FIELD** key to move to the next screen.

```
MODE=BEG-END LAW=LOG
RAMP TIME=5.00 s
TRIG SRC=CONTINUOUS
         MORE->>>
```

Now set the beginning and end frequencies. The frequencies shown here correspond to a sweep of 2 octaves starting at middle C, with a marker in the middle of the sweep.

```
BEG  FRQ=261.6000 Hz
END  FRQ=1.108700kHz
MARK FRQ=523.3000 Hz
         MORE->>>
```

Now press the **SWEEP** key.

The sweep is generated continuously. You can reverse the direction on the first sweep edit menu by changing `MODE=BEG-END` to `MODE=END-BEG`.

You can also set up to initiate the sweep manually - do this by changing `TRIG SRC=CONTINUOUS` to `TRIG SRC=MAN/REMOTE`. Single sweeps are now initiated by pressing the **MAN/SYNC** key.

Note that the settings for the internal trigger generator have no bearing on the sweep in this instance.

Generating a Triggered Burst

In this exercise you will use the internal trigger generator to initiate a burst of 500 cycles of a 2 kHz tone twice every second. The period of the internal trigger generator is thus 500 ms.

Press **RECALL**, **0**, **ENTER** to reset to the factory defaults. Then press **EDIT** and **TRIG**. The lamp next to the TRIG key should flash and the display should show:

```
SOURCE=EXT
TGEN=1.00ms 1.000kHz
BURST COUNT=0001
PHASE=+000° (+000°)
```

Change the settings to:

```
SOURCE=TGEN [FREE]
TGEN=500.ms 2.000 Hz
BURST COUNT=0500
PHASE=+000° (+000°)
```

The word `FREE` against the `SOURCE` parameter indicates that the internal trigger generator has not already been assigned to some other function. If it had been, that function would be shown in place of the word `FREE`.

Press **ENTER**, turn the output on and set the frequency on the main menu to 2 kHz, which at that point will be a continuous tone.

```
FREQ=2.000000kHz
VhiZ=+20.0 Vpp   50Ω
DC=+0.00mV (+0.00mV)
SYM=50.0% (50.0%)
```

Press **TRIG** to initiate the triggered burst mode.

To synchronize an oscilloscope to the trigger generator (rather than to the burst waveform itself), connect the rear panel **TRIG/SWEEP OUT** socket to the oscilloscope's trigger input.

Again, by changing the trigger source to `TRIG SRC=MAN/REMOTE`, you can initiate tone bursts by pressing the **MAN/SYNC** key.

There are similar modes which use the internal trigger generator as the source of trigger signals, and there are gated (i.e. level-sensitive) modes which correspond to the edge-sensitive triggered modes. The *Users Manual* contains detailed information on these modes.

FSK Mode

The FSK (frequency shift keying) mode can also be driven from the internal trigger generator. Setting up is very straightforward; the following settings give a continuous waveform which switches between 800 Hz and 1.2 kHz twice every second.

The edit menu for the FSK mode includes the basic settings for the trigger generator, so there is no need to visit the trigger generator set-up screen itself. First, free the internal trigger generator. This is most easily done by returning to the factory default settings.

Press **EDIT** then **FSK** and enter the settings shown here:

```
FREQ A=800.0000 Hz
FREQ B=1.200000kHz
SOURCE=TGEN [FREE]
TGEN=250.ms 4.000 Hz
```

Then press **FSK** again to start the generator with the new settings and turn the output on.

Special Waveforms

Staircases

The instrument can generate a staircase waveform with up to 16 steps. To demonstrate the set-up process we will create a signal that approximates a 625-line PAL TV line signal. This is the signal applied to the Z-axis of the TV's CRT to modulate the brightness of the spot.

The refresh rate in PAL TV is 25 Hz (40 ms), and the screen is rasterized into 625 lines. Thus each line takes 64 µs and the line frequency is the inverse of this, 15.625 kHz.

By definition, the black level (called the "blanking level" because it cuts off the electron beam completely) is 30 % of peak amplitude and the white level is 100 %. These levels usually correspond to +0.3 V and 1.0 V respectively.

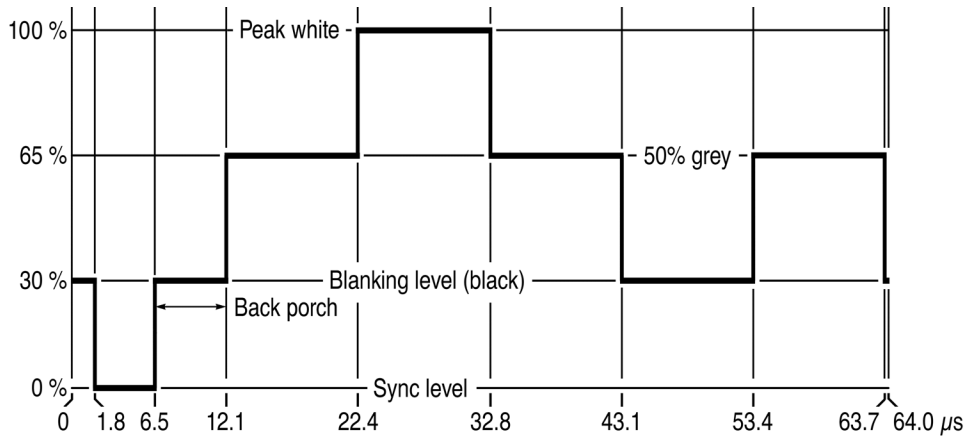
The line sync pulse is negative-going and takes the level down to 0 %. It is nominally 4.7 µs wide and it occurs in the first few microseconds of the cycle, just before a region called the "back porch" which precedes the scan.

The horizontal scan runs from 12.05 to 63.70 µs; outside this period the CRT is blanked.

To produce an image on the TV screen we will divide the scan period into five approximately equal segments and

set the levels to produce five monochrome stripes from left to right: grey, white, grey, black and grey again.

Our line signal thus looks like the drawing below:



shx0019f.gif

Figure 2. 625-line PAL TV Signal

In the instrument the number of horizontal points which make up the complete waveform is 1024, so the horizontal steps must be scaled to the range 0-1023.

Similarly, the full-scale signal amplitude is defined by values up to +511, so the vertical amplitudes must be scaled to to the range 0-511.

We can produce a table of all nine steps of the waveform (numbered 0 to 8), as follows:

step	name	start (µs)	amplitude	start scaled to 0-1024	step length	amplitude scaled to 0-511
0		0	30%	0	29	153
1	sync pulse	1.8	0%	29	75	0
2	back porch	6.5	30%	104	90	153
3	50% grey	12.1	65%	194	165	332
4	white	22.4	100%	358	165	511
5	50% grey	32.8	65%	525	165	332
6	black	43.1	30%	690	165	153
7	50% grey	53.4	65%	854	165	332
8	front porch	63.7	30%	1019	5	153

These values can now be entered in the staircase set-up screens. Press **EDIT** then the **STAIR** key. You should see this screen:

```
VALS=ABS  AUTO=YES
STEP=00  ACTIVE
LENGTH=0256
LEVEL=+511
```

Change the length for the first step (00) to 29 and the level to +153. If you use the numeric and **ENTER** keys to make the change, the step number automatically increments after the level has been entered.

The second screen appears:

```
VALS=ABS  AUTO=YES
STEP=01  ACTIVE
LENGTH=0256
LEVEL=+000
```

Continue entering the pairs of length and level values in the table until the last step (08).

This is the final screen in which the length and level have been keyed in, immediately before the final press of the **ENTER** key:

```
VALS=ABS  AUTO=YES
STEP=08  ACTIVE
LENGTH=0005
LEVEL=+153_
```

The remaining steps (9 to 15 inclusive) are all inactive. Press **ESCAPE** to complete this part of the set-up. You should see a brief display indicating that the instrument is making some calculations on the new waveform.

When the calculations are complete the display will return to the main menu, on which you can complete the set-up by changing the amplitude to 1.0 V peak into 50 Ω and the frequency to 15.625 kHz (or the period to 64 µs).

To initiate the signal, turn the output on and press the **STAIR** key.

Saving and Recalling Settings

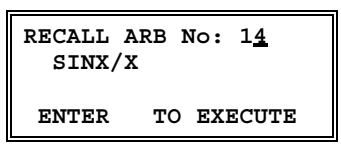
Having done all this work it would be wise to save the settings for future use. You can do this simply by pressing the **STORE** key, followed by a number in the range 1 to 9 and the **ENTER** key. Store 0 is reserved for the factory default settings. You can recall the set-up at any time using the **RECALL** key.

Arbitrary Waveforms

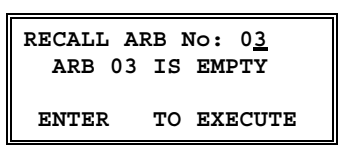
Arbitrary waveforms are best defined on a PC and downloaded to the instrument via the RS232 or GPIB interface. Each is identified by a name with up to 16 characters.

Several commonly-used waveforms are available from the internal read-only memory (ROM) and can be recalled by pressing the **EDIT** then the **ARB** keys.

The display will look something like this:



Or possibly like this:



The ROM is used for the factory-preset waveforms 06 to 21 inclusive, and the internal non-volatile RAM is used for

arbitrary waveforms 01 to 05. These first five store locations are available for waveforms downloaded from a PC.

When you press the **ENTER** key the output switches to the selected waveform but the display does not change; press **ESCAPE** to return to the main menu, then press **ARB** and switch the output on to initiate the signal.

Note that there are no facilities for storing waveforms edited using the instrument itself. However, certain waveforms, for example waveforms which emulate the effect of passing sharp edges through low-pass filters, can be generated without the aid of a computer. There are some examples described in chapter 15, *Application Examples*, of the *Users Manual*.

Other Functions and Waveforms

The instrument offers a number of additional capabilities and features which are beyond the scope of this *Getting Started Manual*. These include:

- Amplitude modulation
- Frequency hopping
- Phase locking
- Noise generation
- Synchronizing two or more generators in master-slave mode
- Remote operation through the RS232 and GPIB interfaces.

These are all covered in detail in the *Users Manual*.