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FLUKE®

271

Programmable 10 MHz DDS Function Generator

Users Manual

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 instruction manual contains some information and warnings which have to 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/$Mn0_2$ 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.'

⚠Cautions

To ensure continued compliance with the EMC directive the following precautions should be observed:

a) connect the generator to other equipment using only high quality, double-screened cables.

b) after opening the case for any reason ensure that all signal and ground connections are remade correctly before replacing the cover. Always ensure all case screws are correctly refitted and tightened.

c) In the event of part replacement becoming necessary, only use components of an identical type. Refer to the Service Manual.

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Chapter 1
Introduction and Specifications

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Introduction

This Programmable Function Generator uses direct digital synthesis to provide high performance and extensive facilities at a breakthrough price. It can generate a variety of waveforms between 0.1 mHz and 10 MHz with a resolution of 7 digits and an accuracy better than 10 ppm.

Principal features

Direct digital synthesis for accuracy & stability

Direct digital synthesis (DDS) is a technique for generating waveforms digitally using a phase accumulator, a look-up table and a DAC. The accuracy and stability of the resulting waveforms are related to that of the crystal master clock.

In addition the DDS generator offers high spectral purity, low phase noise and excellent frequency agility.

A wide range of waveforms

High quality sine, square and pulse waveforms can be generated over the full frequency range of 0.1 mHz to 10 MHz.

Triangle ramp and multi-level square waveforms also be generated over limited frequency ranges.

Variable symmetry or duty-cycle is available for all standard waveforms.

Arbitrary waveform capability

Arbitrary waveforms can be loaded via the digital interfaces and then used in a similar way to the standard waveforms.

Up to five arbitrary waveforms of 1024 10-bit words can be stored in non-volatile memory. The maximum waveform clock frequency is 27.48 MHz.

This facility considerably expands the versatility of the instrument, making it suitable for the generation of highly complex waveform patterns.

In addition, numerous complex waveforms are pre-defined in ROM, including commonly used wave shapes such as sin(x)/x, exponentially decaying sine wave, etc. Further wave shapes will be added to the library in response to customer requests.

Sweep

All waveforms can be swept over their full frequency range at a rate variable between 10 milliseconds and 15 minutes. Sweeps are fully phase continuous.

Sweeps can be linear or logarithmic, single or continuous. Single sweeps can be triggered from the front panel, the trigger input or the digital interfaces. Two sweep markers are provided.

Amplitude modulation

AM is available for all waveforms and is variable in 1 % steps up to 100 %. An internal AM source is incorporated. Modulation may also be controlled by an external generator.

Frequency shift keying

FSK provides phase coherent switching between two selected frequencies at a rate defined by the switching signal source.

The rate can be set from dc to 50 kHz internally, or dc to 1 MHz externally.

Triggered burst and gated modes

All waveforms are available as a triggered burst whereby each positive edge of the trigger signal will produce one burst of the carrier, starting and stopping at the phase angle specified by the start-stop phase setting.

The number of cycles in the burst can be set between 0.5 and 1023. The gated mode turns the output signal on when the gating signal is high and off when it is low.

Both triggered and gated modes can be operated from the internal trigger generator (0.005 Hz to 50 kHz) or from an external source (dc to 1 MHz).

Waveform hop and noise

The generator can be set up to hop between a number of different waveform settings, either at a predetermined rate or in response to a manual trigger.

Up to 16 different hop waveforms can be defined in terms of frequency, amplitude, function, offset and duration. Duration is variable in 1 ms steps up to 60 s. The generator can also be set to simulate random noise within the bandwidth 0.03 Hz to 700 kHz with adjustable amplitude and offset.

Multiple phase-locked generators

The signals from the reap panel **CLOCK IN/OUT** socket and **SYNC OUT** sockets can be used to phase lock two or more generators.

Phase locked generators can be used to generate multi-phase waveforms or locked waveforms of different frequencies.

Easy and convenient to use

All of the main generator parameters are clearly displayed together on a backlit liquid crystal display (LCD) with 4 rows of 20 characters. Sub-menus are used for the modulation modes and other complex functions.

All parameters can be entered directly from the numeric keypad. Alternatively most parameters can be incremented or decremented using the rotary encoder.

This system combines quick and easy numeric data entry with quasi-analogue adjustment when required.

Fully programmable via addressable RS232 and GPIB interfaces

The generator has RS-232 and GPIB (IEEE-488) interfaces which can be used for remote control of all of the instrument functions and for downloading arbitrary waveforms.

As well as operating in conventional RS-232 mode the serial interface can be used in addressable mode whereby up to 32 instruments can be linked to a single PC serial port.

Specifications

Specifications apply at 18- 28 °C after one hour warm-up, at maximum output into 50 Ω.

Waveforms

Standard waveforms include sine, square, triangle, dc, positive ramp, negative ramp, positive pulse, negative pulse and multi-level square wave. In addition the instrument provides arbitrary waveforms (arb) and pseudo-random noise.

Sine

Range:	0·1 mHz to 10 MHz
Resolution:	0·1 mHz or 7 digits
Symmetry control:	1 to 99 % (0.1 % resolution) from 0.1 mHz to 10 MHz.
Accuracy:	10 ppm for 1 year
Temperature stability:	Typically <1 ppm/ºC outside 18 to 28 °C
Output Level:	2.5 mV to 10 V p–p into 50 Ω
Harmonic distortion:	<0.3 % THD to 100 kHz; <–50 dBc to 300 kHz <–35dBc to 10 MHz
Non–harmonic spurious:	<–65 dBc to 1 MHz, <–65 dBc +6 dB/octave 1 MHz to 10 MHz

Square

Range:	0.1 mHz to 10 MHz
Resolution:	0.1 mHz or 7 digits
Symmetry control:	1 to 99 % (0.1 % resolution) from 0.1 mHz to 30 kHz 20 % to 80 % (0.1 % resolution) from 30 kHz to 10 MHz
Accuracy:	10 ppm for 1 year
Output level:	2.5 mV to 10 V p–p into 50 Ω
Rise and fall times:	<22 ns
Aberrations:	<5 % +2 mV

Triangle

Range:	0.1 mHz to 100 kHz
Resolution:	0.1 mHz or 7 digits
Symmetry control:	1 to 99 % (0.1 % resolution) from 0.1 mHz to 100 kHz
Accuracy:	10 ppm for 1 year
Output level:	2.5 mV to 10 V p–p into 50 Ω
Linearity error:	<0.5 % to 30 kHz

Positive and Negative Ramps

Range:	0.1 mHz to 100 kHz
Resolution:	0.1 mHz (7 digits)
Symmetry Control:	1 to 99 % (0.1 % resolution) from 0.1 mHz to 100 kHz
Accuracy:	10 ppm for 1 year
Output Level:	2.5 mV to 10 V p–p into 50 Ω
Linearity Error:	<0.5 % to 30 kHz

Positive and Negative Pulses

Range:	0.1 mHz to 10 MHz
Resolution:	0.1 mHz or 7 digits
Symmetry control:	1 to 99 % (0.1 % resolution) from 0.1 mHz to 30 kHz 20 to 80 % (0.1 % resolution) from 30 kHz to 10 MHz
Accuracy:	10 ppm for 1 year
Output level:	2.5 mV to 10 V p-p into 50 Ω
Rise and fall times:	<22 ns
Aberrations:	<5 % +2 mV

Multi-level Square Wave

Maximum of 16 steps of discrete amplitude (10 bit resolution) and duration (1 to 1024 samples). Allows generation of three-level square wave, staircase, multiplexed LCD driver signals, etc.

Range:	All waveform points are continuously output up to approximately 27 kHz, above which sampling will introduce an uncertainty of 1 clock edge (1 clock = 36 ns).
Output level:	5 mV to 20 V p-p into an open circuit.
Rise and fall times:	<22 ns

Arbitrary

A number of frequently required waveforms are pre-programmed in the internal read-only memory (ROM). Waveforms may also be downloaded via the RS232 or GPIB interfaces and stored in the internal non-volatile random-access memory (RAM).

Frequency range:	0.1 mHz to 10 MHz Waveform points are continuously output up to approximately 27 kHz, above which they are sampled.
Output level:	5 mV to 20 V p-p into an open circuit.
Sampling frequency:	27.48 MHz
Number of samples:	1024
Sample levels:	1024 (10 bits)

Hop

Up to 16 different waveforms can be output in sequence at a rate determined by either the internal timer, an external trigger a remote command, or from the keyboard. Each waveform can be set to any wave shape (except noise), frequency, amplitude and offset. Frequency-only changes are phase-continuous.

Noise

White noise output with a typical -3 dB bandwidth of 0.03 Hz to 700 kHz. Amplitude and offset are adjustable. Noise can only be used with gated and AM modes.

Modulation Modes

Continuous

Continuous cycles of the selected waveform are output at the programmed frequency.

Trigger and burst

Phase-coherent signal keying: each positive edge of the trigger signal will produce one burst of the carrier, starting and stopping at the phase angle specified by the start/stop phase setting.

Carrier frequency:	0.1 mHz to >1 MHz
Carrier waveforms:	All
Number of cycles:	1 to 1023 (resolution 1 cycle) or 0.5 to 511.5 (resolution 0.5 cycle).
Trigger repetition rate:	dc to 50 kHz internal, dc to 1 MHz external.
Source:	Manual (front panel key), internal trigger generator, external signal or remote interface.

Gated

Non-phase coherent signal keying: the output carrier wave is on while the gate signal is high and off while it is low.

Carrier frequency:	From 0.1 mHz to 10 MHz.
Carrier waveforms:	All
Trigger repetition rate:	dc to 50 kHz internal, dc to 1 MHz external.
Gate signal source:	Manual (front panel key), internal trigger generator, external signal or remote interface.

Sweep

Carrier waveforms:	All
Sweep modes:	Linear or logarithmic, single or continuous.
Sweep width:	From 0.1 mHz to 10 MHz in one range. Phase continuous. Start and stop frequency may be set independently.
Sweep time:	10 ms to 999 s with 3 digit resolution.
Markers:	Two, variable during sweep, available at the rear panel socket.
Sweep trigger source:	The sweep may be free run or triggered manually (front panel key), by an external signal or through a remote interface.

Amplitude Modulation

Carrier frequency:	From 0.1 mHz to 10 MHz.
Carrier waveforms:	All.
Depth:	Variable 0 to 100% typical, resolution 1 %.
Internal source:	1 kHz fixed sine wave or 0.005 Hz to 50 kHz square wave.
External:	See *VCA In* below.

Frequency Shift Keying (FSK)

Phase coherent switching between two selected frequencies at a rate defined by the switching signal source.

Carrier frequency:	From 0.1 mHz to 10 MHz.
Carrier waveforms:	All.
Switch repetition rate:	dc to 50 kHz internal, dc to 1 MHz external.
Switching signal source:	Manual (front panel key), internal trigger generator, external signal or remote interface.

Start/Stop Phase

The phase relationship between the **MAIN OUT** and **AUX OUT** sockets is determined by the start/stop phase setting.

Carrier frequency:	0.1 mHz to >1 MHz.
Carrier waveforms:	All.
Range:	-360 to +360 degrees.
Resolution:	1 degree.
Accuracy:	Typically 1 degree to 30 kHz.

Trigger Generator

Internal source 0.005 Hz to 50 kHz square wave, adjustable in 20 µs steps with 3 digit resolution. Available for external use from a rear panel socket.

Outputs

Main Output

Output Impedance:	50 Ω or 600 Ω
Amplitude:	5 mV to 20 V p-p into an open circuit, 2.5 mV to 10V p-p into 50 Ω/600 Ω. Output can be specified as VhiZ (open circuit value) or V (voltage into characteristic impedance) in p-p, r.m.s. or dBm.
Amplitude accuracy:	±3 % ±1 mV at 1 kHz into 50 Ω/600 Ω.
Amplitude flatness:	±0.2 dB to 500 kHz; ±1 dB to 10 MHz.
DC offset range:	±10 V. The dc offset plus signal peak is limited to ±10 V from 50 Ω/600 Ω.
DC offset accuracy:	typically ±3 % ±10 mV, unattenuated.
Resolution:	3 digits for both amplitude and dc offset.
Pulse aberrations:	<5 % + 2 mV.

Aux Out

CMOS/TTL levels with symmetry and frequency of main output. The phase relationship between **MAIN OUT** and **AUX OUT** is determined by the start/stop phase setting.

Trig/Sweep Out

The function of this output is automatically determined by the generator operating mode. Except in sweep and hop modes the output is that of the internal trigger generator, a fixed amplitude square wave, the frequency of which is set in the `trig` or `gate` menu. The rising edge of the trigger generator initiates trigger, gate and burst modes.

In sweep mode the output is a 3-level waveform, changing from high (4 V) to low (0 V) at the start of the sweep, with narrow 1 V pulses at marker points.

In hop mode the output goes low on entry to each waveform step and high after the new frequency and wave shape of that step have been set.

Output impedance is 1 kΩ.

Inputs

Ext Trig

Frequency range:	dc to 1 MHz.
Signal range:	Threshold nominally TTL level; maximum input ±10 V.
Minimum pulse width:	50 ns for trigger, gate and FSK modes; 1 ms for sweep and hop modes.
Input impedance:	10 kΩ

VCA In

Frequency range:	DC - 100 kHz.
Signal range:	2.5 V for 100% level change at maximum output.
Input impedance:	typically 6 kΩ.

Phase locking

The signals from these sockets are used to phase lock two or more generators.

Clock In/Out

TTL/CMOS threshold level as an input.
Output logic levels nominally 1 V and 4 V from typically 50 Ω as an output.

Sync Out

TTL/CMOS logic levels from typically 50 Ω.

Interfaces

Full remote control facilities are available through the RS232 or GPIB interfaces.

RS232:	Variable Baud rate, 9600 Baud maximum. 9-pin D-connector. As well as operating in a conventional RS232 mode the interface can be operated in addressable mode whereby up to 32 instruments can be addressed from one RS232 port.
GPIB (IEEE-488):	Conforms with IEEE488.1 and IEEE488.2

General

Display:	20 character x 4 row alphanumeric LCD.
Data Entry:	Keyboard selection of mode, waveform etc. Value entry direct by numeric keys or by rotary control.
Stored Settings:	Up to 9 complete instrument set-ups may be stored and recalled from battery-backed memory.
Size:	3U (130mm) high; half-rack (212mm) wide; 330mm deep.
Weight:	4.1 kg (9 lb)
Power:	100 V ac, 110-120 V ac or 220-240 V ac ±10 %, 50/60 Hz, adjustable internally; 40 VA max. Installation category II.
Temperature range:	operating: +5 to 40 °C, 20-80 % RH. storage: -20 to +60 °C
Environmental:	Indoor use at altitudes up to 2000 m,

	Pollution degree 2.
Options:	19 inch rack mounting kit.
Safety:	Complies with EN61010-1.
EMC:	Complies with EN61326.

Chapter 2
Installation

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Mains Operating 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 the appendix.

Fuse

Ensure that the correct mains fuse is fitted for the set operating voltage. The correct mains fuse types are listed in Appendix A.

Mains Lead

⚠⚠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 a three core mains lead with bare ends is provided it should be connected as follows:-

Brown	Mains Live
Blue	Mains Neutral
Green / Yellow	Mains Earth

Mounting

This instrument is suitable both for bench use and rack mounting. It is delivered with feet for bench mounting. The front feet include a tilt mechanism for optimal panel angle.

A rack kit for mounting in a 19 inch rack is available from the manufacturers.

Chapter 3
Connections

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