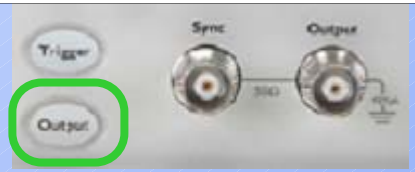
Agilent **33220A**
Function/ARBitrary waveform generator

20 MHz sine and square, ARBs, modulations
14-bit, **50** MSa/s, **64K**-point **DDS**; variable-edge **pulse**
GPIB (USB, LAN), **IntuiLink:** Waveform Editor

Factory default settings
power-on and reset state

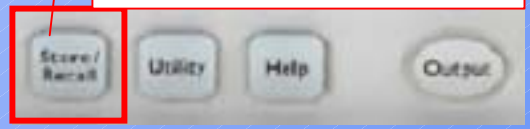
BE CAREFUL when applying the output to a circuit whose input resistance is **different** from **50 ohm**

Signal OUTPUT is **disabled** at power-on.
To **enable** press the 'OUTPUT' key.



GPIB address is displayed at power-on

'Store/Recall' key, then
'Set to **Default**' softkey - to reset
(press **Yes** to confirm the operation)



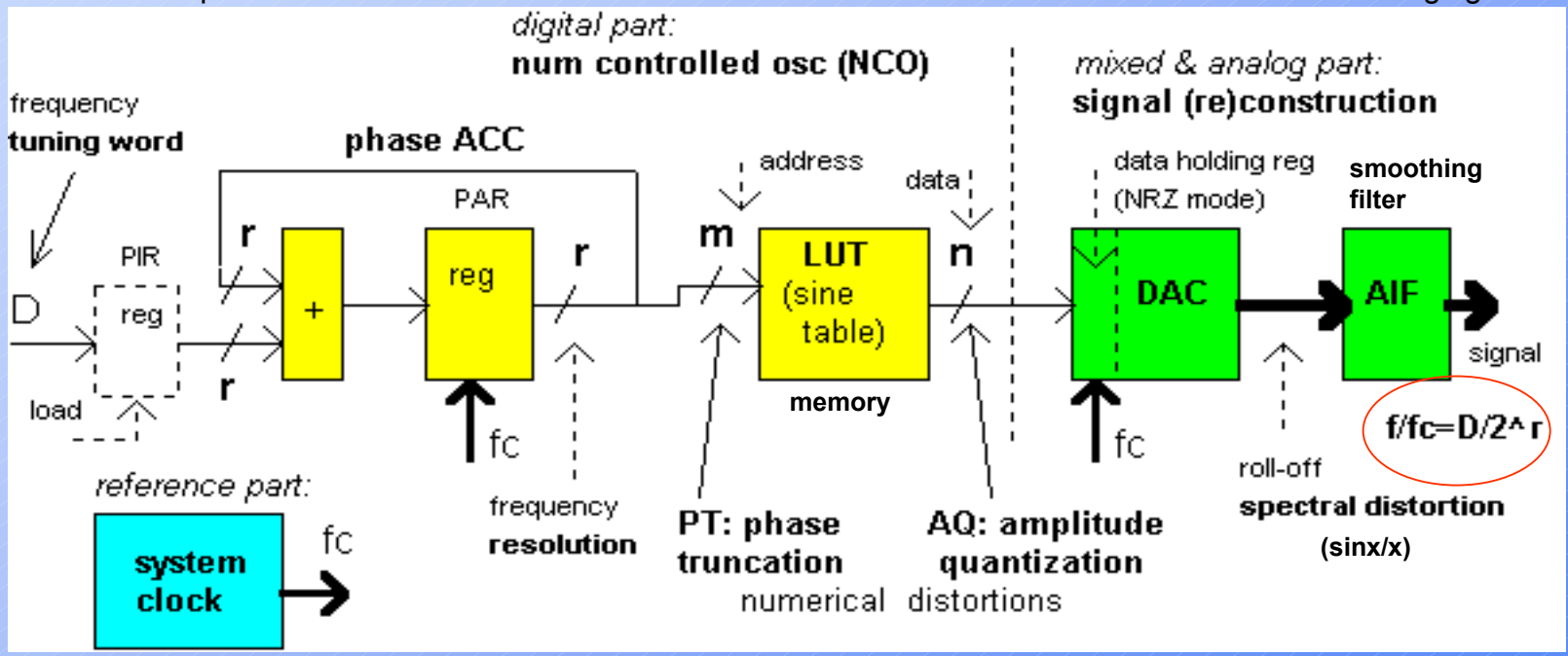
Output Configuration	**Factory Setting**
Function	Sine wave
Frequency	1 kHz
Amplitude / Offset	100 mVpp / 0.000 Vdc
Output Units	Vpp
Output Termination	50 Ω
Autorange	On
Modulation	**Factory Setting**
Carrier (AM, FM, PM, FSK)	1 kHz Sine wave
Carrier (PWM)	1 kHz Pulse
Mod. Waveform (AM)	100 Hz Sine wave
Mod. Waveform (FM, PM, PWM)	10 Hz Sine wave
AM Depth	100%
FM Deviation	100 Hz
PM Deviation	180 degrees
FSK Hop Frequency	100 Hz
FSK Rate	10 Hz
PWM Width Deviation	10 µs
Modulation State	Off
Sweep	**Factory Setting**
Start / Stop Frequency	100 Hz / 1 kHz
Sweep Time	1 Second
Sweep Mode	Linear
Sweep State	Off
Burst	**Factory Setting**
Burst Count	1 Cycle
Burst Period	10 ms
Burst Start Phase	0 degrees
Burst State	Off
System-Related Operations	**Factory Setting**
• Power-Down Recall	• Disabled
Display Mode	On
Error Queue	Errors are Cleared
Stored States, Stored Arbs	No Change
Output State	Off
Triggering Operations	**Factory Setting**
Trigger Source	Internal (Immediate)
Remote Interface Configuration	**Factory Setting**
• GPIB Address	• 10
• DHCP	• On
• IP Address	• 169.254.002.020
• Subnet Mask	• 255.255.000.000
• Default Gateway	• 000.000.000.000
• DNS Server	• 000.000.000.000
• Host Name	• *none*
• Domain Name	• *none*
Calibration	**Factory Setting**
Calibration State	Secured

Parameters marked with a bullet (•) are stored in *non-volatile* memory.

DDS: Direct Digital Synthesis
(@ constant clock-rate)

PIR : phase increment register
Phase **ACC :** accumulator
LUT : look-up table

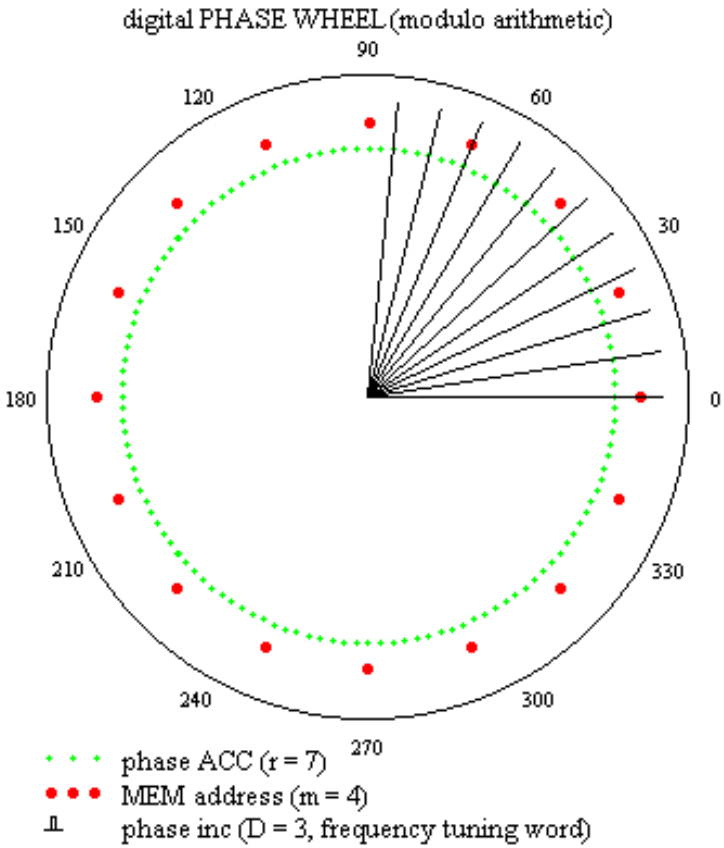
NRZ : non return to zero
DAC : digital to analog converter
AIF : anti imaging filter



33220A : r = **64** bit, m = **16** bit (64K memory), n = **14**bit, fc = **50** MHz
14 bit (16K memory)

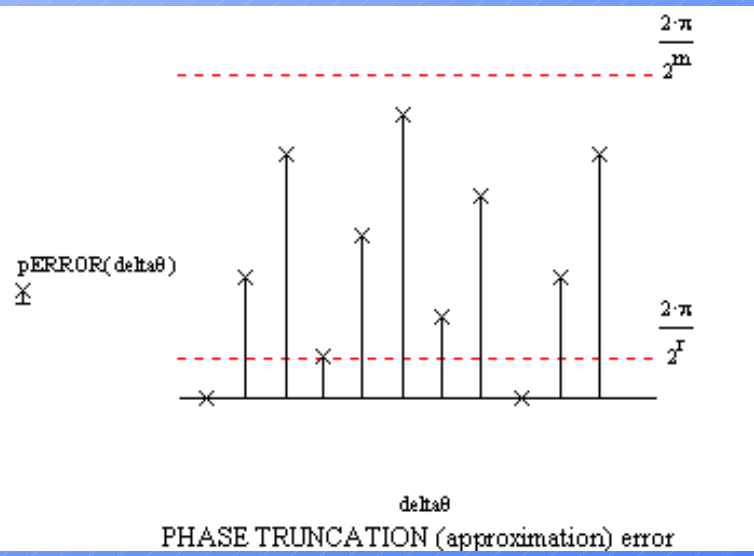
frequency resolution (internal): 2.7 pHz ($2^r = 2^{64} = 2^{4+10+10+10+10+10+10} = 2^4.10^{3+3+3+3+3+3}$)

Phase truncation (a “virtual memory” technique)

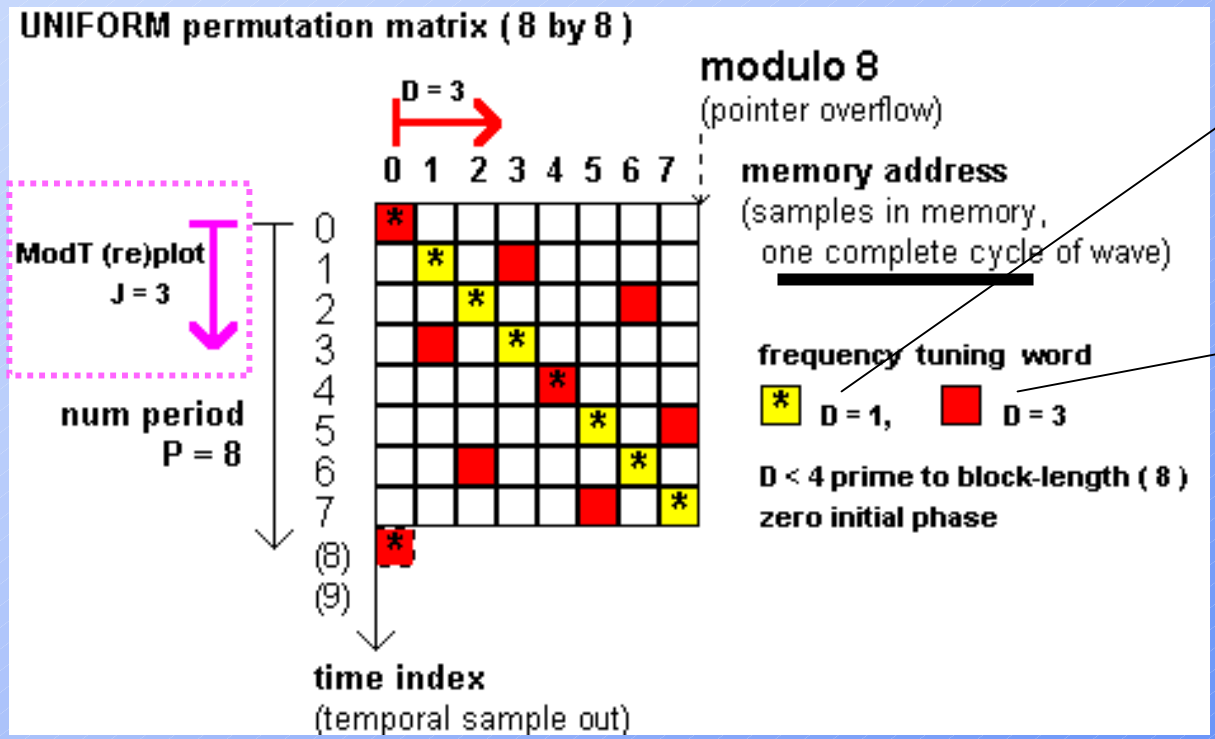


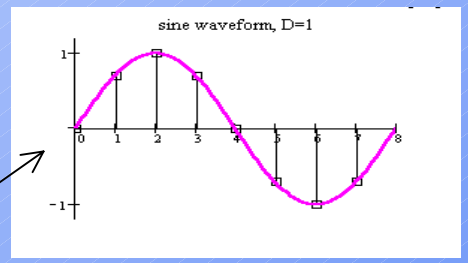
Each **red-point** (**MEM address**) on the phase wheel corresponds to the equivalent point on a cycle of (sine) waveform.

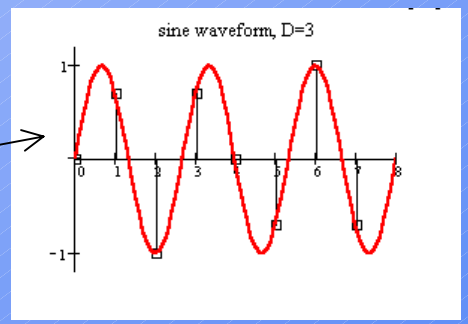
Phase error introduced by approximation (truncated ACC) results in periodic error in time (hence line spectra occurs in frequency) during the Phase to Amplitude Conversion process

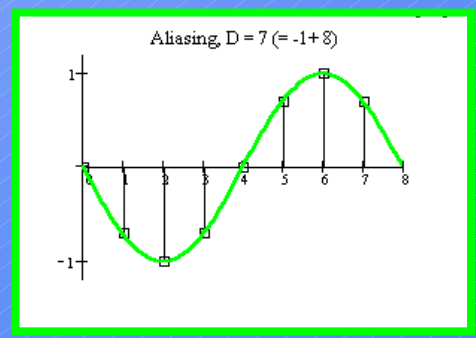


The **point(memory location)-skipping** nature of DDS: frequency control



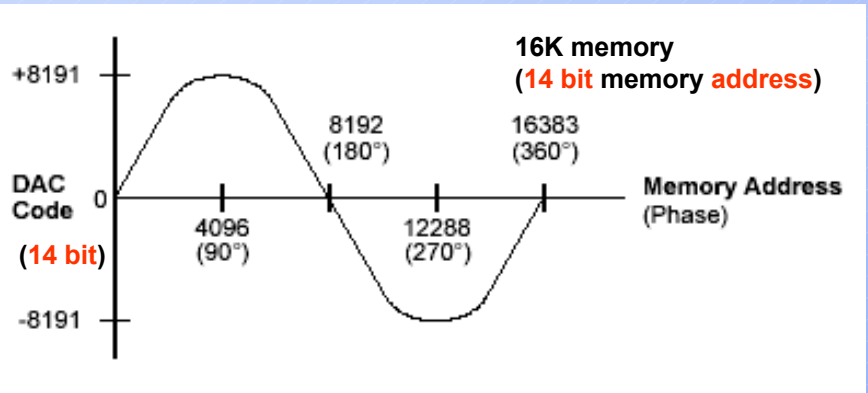


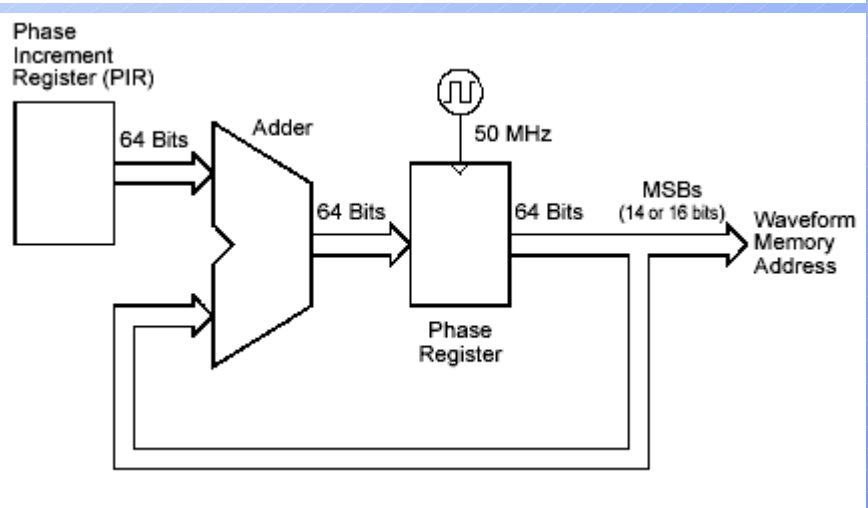




For the 33220A, you do not have to change the length of the waveform to change its output frequency.

Waveform representation



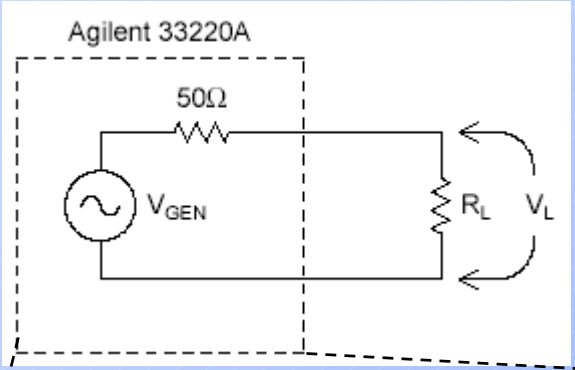


The 33220A represents **amplitude** values by 16,384 discrete voltage levels (or **14-bit** vertical resolution).

The specified waveform data is divided into **samples** such that one waveform cycle exactly fills waveform memory (see the illustration for a sine wave).

If you create an arbitrary waveform that does not contain exactly **16K** or **64K** points, the waveform is automatically “stretched” by repeating points or by interpolating between existing points as needed to **fill** waveform memory.

Output amplitude control

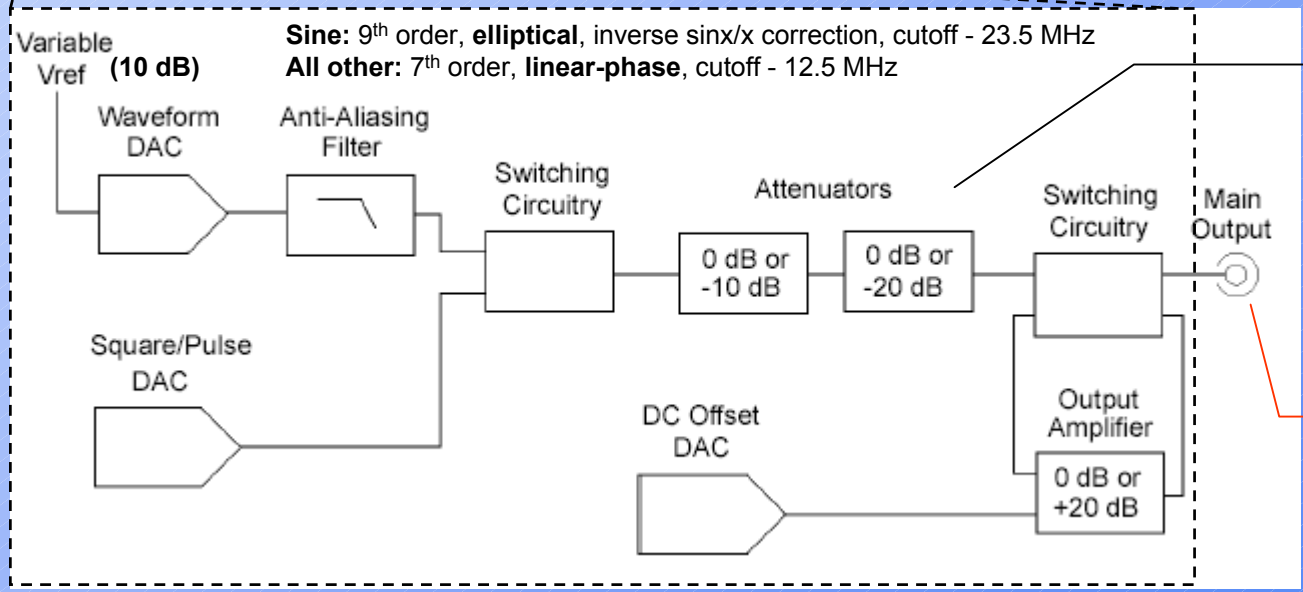


Setting of the **termination (R_L)** is simply provided *as a convenience* to ensure that the **displayed** voltage *matches* the **expected** load :

1 ohm – 10 Kohm or High impedance,

the default is **50 ohm**.

If you specify 50 ohm termination but are actually terminating into an **open** circuit, the output will be **twice** the value specified !!

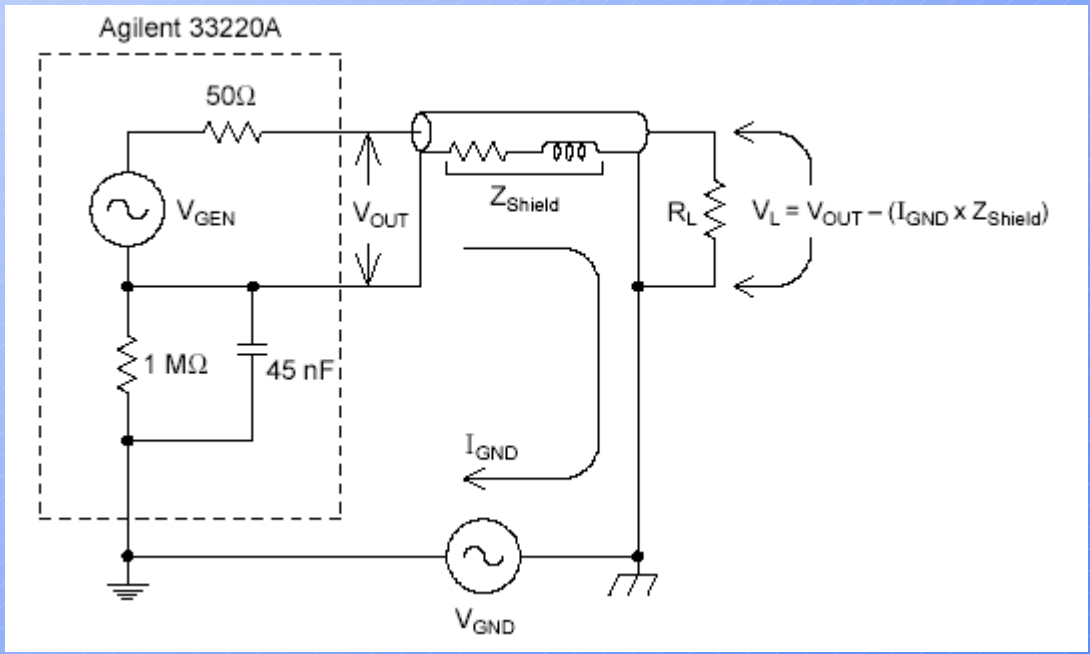


You can *disable* amplitude 'AutoRanging' to "freeze" the switches in their current states (glitch-free output), but … [*'Utility' key*]

Short-circuit protected.
Overload automatically disables main output

Floating signal generator

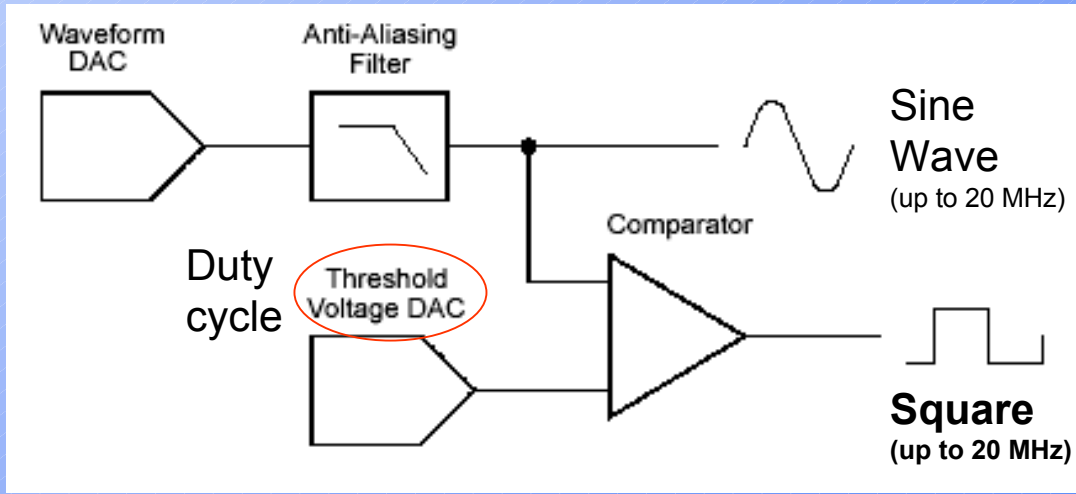
Except for its remote interface connectors and trigger connector, the **33220A** is isolated from chassis (earth) ground.
This isolation helps to eliminate ground loops in your system and also allows you to reference the output signal to voltages other than ground.



Square waveform generation (special hardware):

To eliminate distortion due to aliasing at higher frequencies, the 33220A uses a different waveform generation technique to create square waves.

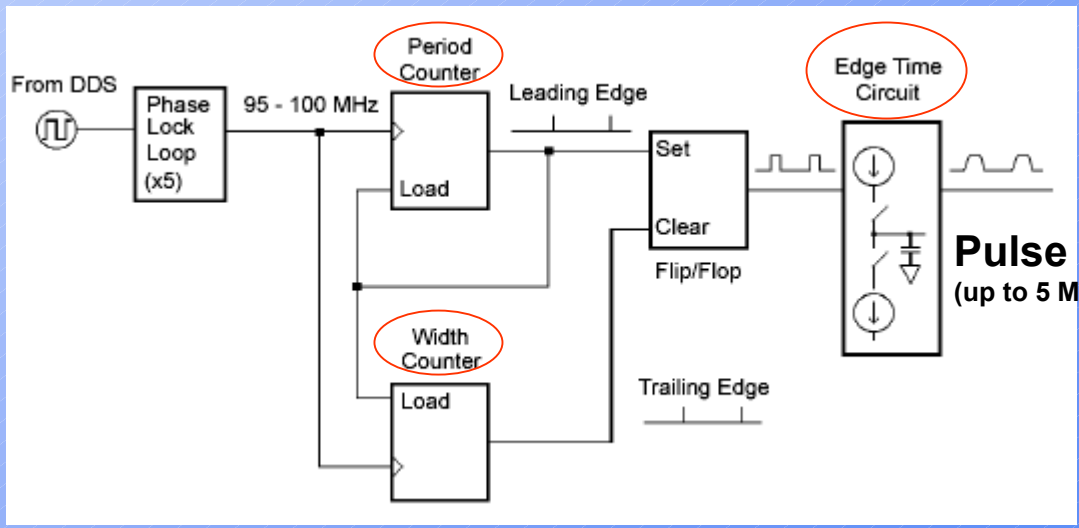
The *duty cycle* of the waveform can be varied by changing the comparator's threshold.



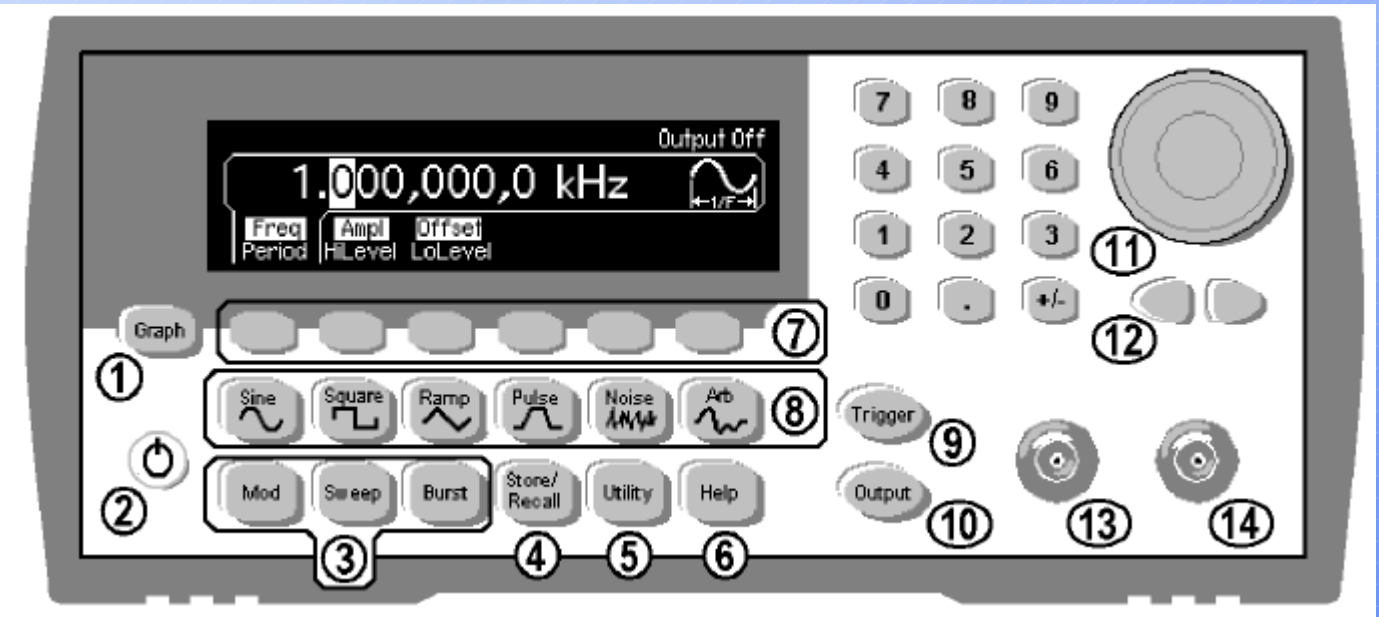
Pulse waveform generation (dedicated hardware):

To eliminate distortion due to aliasing at higher frequencies, the 33220A also uses a different waveform generation technique to create pulse waveforms.

For pulse waveform generation, clock cycles are counted to derive both the *period* and the pulse *width*.
The *rising and falling edge* times are controlled by a circuit that varies the charging currents in a capacitor.



Front panel at a glance



1 Graph Mode/Local Key
2 On/Off Switch
3 Modulation/Sweep/Burst Keys
4 State Storage Menu Key
5 Utility Menu Key
6 Help Menu Key
7 Menu Operation Softkeys
8 Waveform Selection Keys
9 Manual Trigger Key (*used for Sweep and Burst only*)
10 Output Enable/Disable Key
11 Knob
12 Cursor Keys
13 Sync Connector
14 Output Connector

Display: number format

Number Format

The function generator can show numbers on the front-panel display with periods or commas for the decimal point and digits separator. *This feature is available from the front panel only.* [*'Utility' key*]

Decimal Point: Period
Digits Separator: Comma

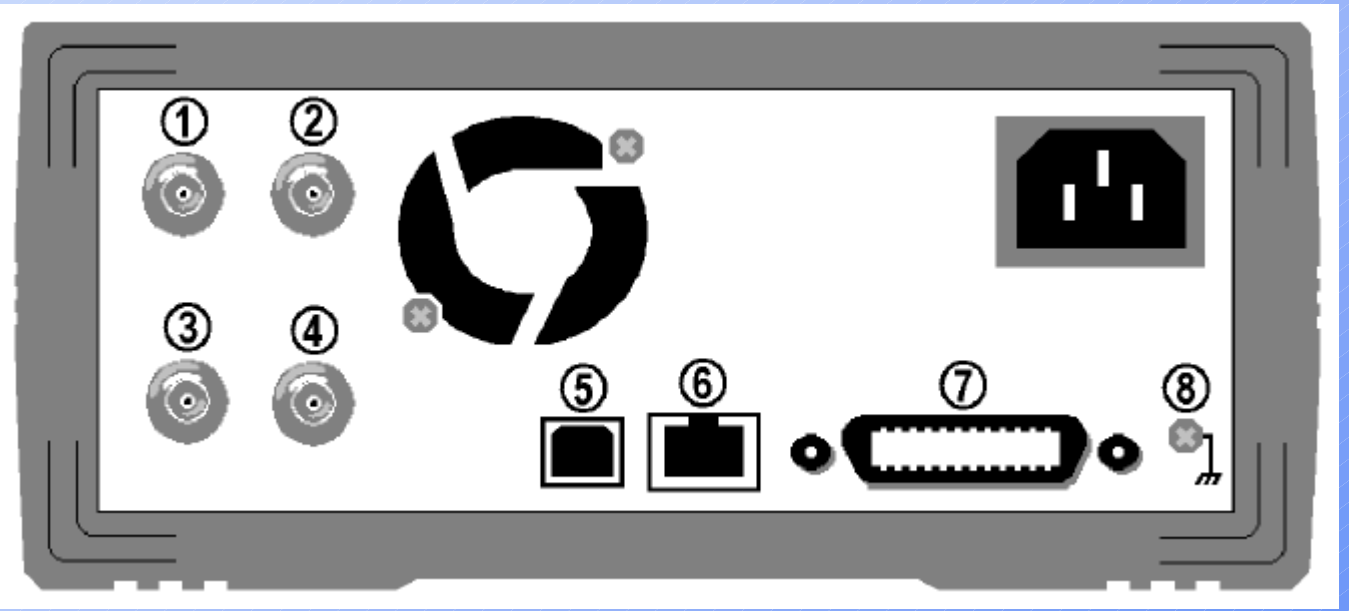
Decimal Point: Comma
Digits Separator: None

Display Contrast

To optimize the readability of the front-panel display, you can adjust the contrast setting. *This feature is available from the front panel only.*

- Display contrast: 15 to 50. *The default is 30.*

Rear panel at a glance



1 External 10 MHz Reference Input Terminal (Option 001 only).
2 Internal 10 MHz Reference Output Terminal (Option 001 only).
3 External Modulation Input Terminal
4 Input: External Trig/FSK/Burst Gate
Output: Trigger Output
5 USB Interface Connector
6 LAN Interface Connector
7 GPIB Interface Connector
8 Chassis Ground

Remote interface

The Agilent 33220A supports remote interface communication using a choice of three interfaces: **GPIB**, USB, and LAN.
All three interfaces are "live" at power up.

GPIB Configuration

You need only select a GPIB *address*.
Note: use the default value

USB Configuration

The USB interface requires *no* front panel configuration parameters.

LAN Configuration

There are *several* parameters that you may need to set to establish network communication using the LAN interface.

(A) **Output** configuration: waveform and parameters

Graph or Menu mode

Softkeys to configure the parameters

Mod
Type: AM
FM
PM
FSK
PWM
Source: INT
EXT

Sweep
LIN or LOG

Burst
N cycle or
EXT-gated

Sine
Square
Ramp
Pulse
Noise
Arb (currently selected)

DC ('Utility' key | DC on)

Knob and cursor keys
to modify the displayed number
Keypad
to enter numbers, and
Softkeys
to select units

	Sine	Square	Ramp	Pulse	Noise	DC	Arb
AM, FM, PM, FSK Carrier	•	•	•				•
PWM Carrier				•			
Sweep Mode	•	•	•				•
Burst Mode	•	•	•	•	•[1]		•

[1] *Allowed in the External Gated burst mode only.*

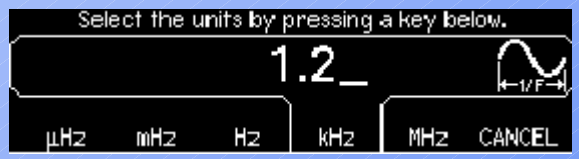
Basic limitations - 1

Output Frequency

Function	Minimum Frequency	Maximum Frequency
Sine	1 µHz	20 MHz
Square	1 µHz	20 MHz
Ramp	1 µHz	200 kHz
Pulse	500 µHz	5 MHz
Noise, DC	Not Applicable	Not Applicable
Arbs	1 µHz	6 MHz

To Set the Output Frequency

Press the 'Freq'(or 'Period') softkey,



enter the magnitude
using the numeric keypad
(or the knob and cursor),

select the desired units.

Basic limitations - 2

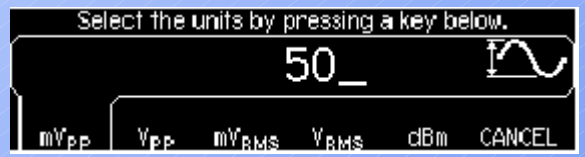
Output Amplitude

$$Vpp \leq 2 \times (Vmax - |Voffset|)$$

Note: V*max* is the maximum *peak voltage* for the selected output termination,
5 Volts for a 50 ohm load or **10** Volts for a high-impedance load.

To Set the Output Amplitude

Press the 'Ampl' softkey,



enter the magnitude
using the numeric keypad
(or the knob and cursor),

select the desired units.

Notes: **1)** Another way to set the *limits* of a signal is to specify its **HiLevel** (max) and **LoLevel** (min) values.
2) To *convert* the displayed **Ampl** from one unit to another: press **"+/-" key** and select the desired units.

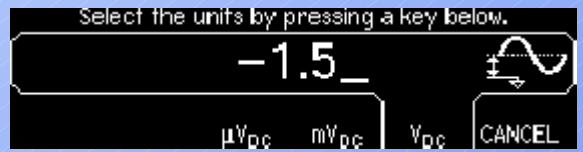
Basic limitations - 3

DC Offset Voltage

$$|Voffset| \leq Vmax - \frac{Vpp}{2}$$

To Set a DC Offset Voltage

Press the 'Offset' softkey,



enter the magnitude
using the numeric keypad
(or the knob and cursor),

select the desired units.

Basic limitations - 4

Duty Cycle of a **Square Wave**

Duty Cycle:	20% to 80%	(*frequency* ≤ 10 MHz)
	40% to 60%	(*frequency* > 10 MHz)

Notes:

1) The duty cycle represents the amount of time per cycle that the square wave is at a *high* level (note the icon on the right side of the display).

2) A 50% duty cycle is always used for a *modulating* square waveform.

To Set a Duty Cycle

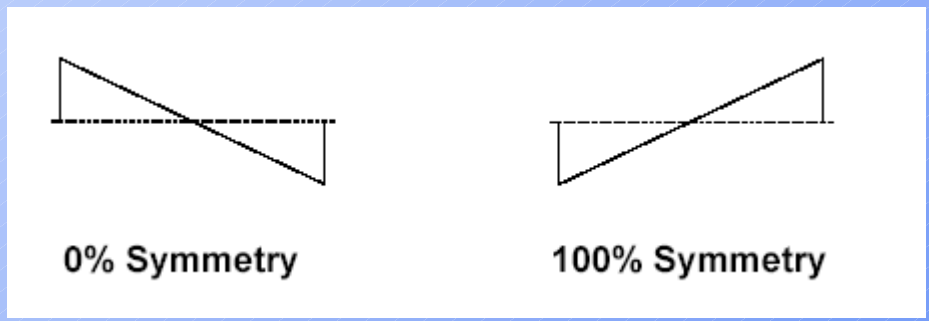
Press the 'Duty Cycle' softkey.

Using the numeric keypad or the knob, select a duty cycle. The function generator adjusts the duty cycle *immediately*.

Basic limitations - 5

Symmetry of a **Ramp Waves**

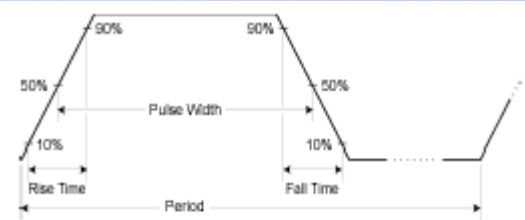
Symmetry represents the amount of time per cycle that the ramp wave is *rising* (assuming that the waveform is not inverted).



Note: If you select a ramp waveform as the *modulating* waveform, the symmetry setting *does not* apply.

Basic limitations - 6

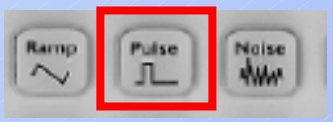
Parameters of a **Pulse** waveform



Pulse period: 200 ns to 2000 s.

Period ≥ Pulse Width + (1.6 X Edge Time)

Edge time: 5 ns to 100 ns



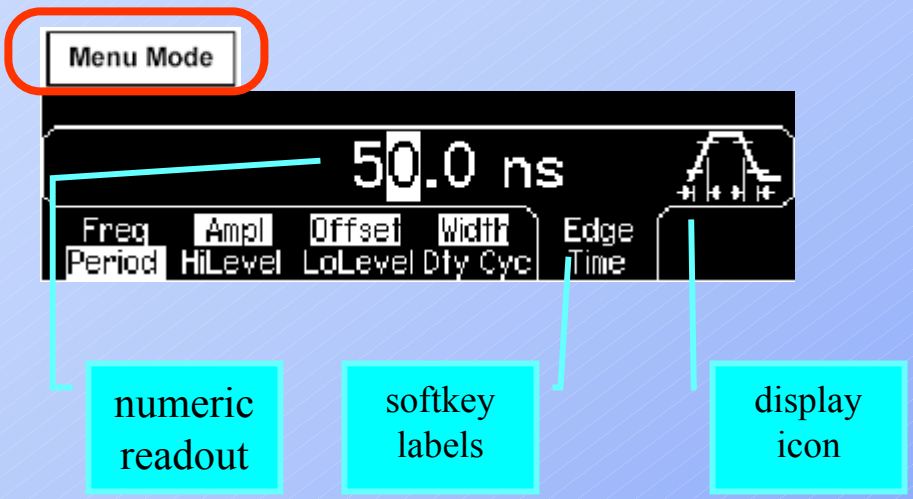
Set the pulse 'Width' (or 'Dty Cyc')

Note: The pulse **width** represents the time from the 50% threshold of the rising edge to the 50% threshold of the next falling edge (see: icon).

Set the 'Edge Time' for **both** edges.

Note: The **edge time** represents the time from the 10% threshold to the 90% threshold of each edge (note the display icon).

Display: **numeric** vs. **graphical** views



Note:
To get context-sensitive **help** on any front-panel key or menu softkey, press and hold down that key.

Press the Graph key to enable the Graph Mode. The name of the currently selected parameter, shown in the upper-left corner of the display, and the parameter's numeric value field are both highlighted.

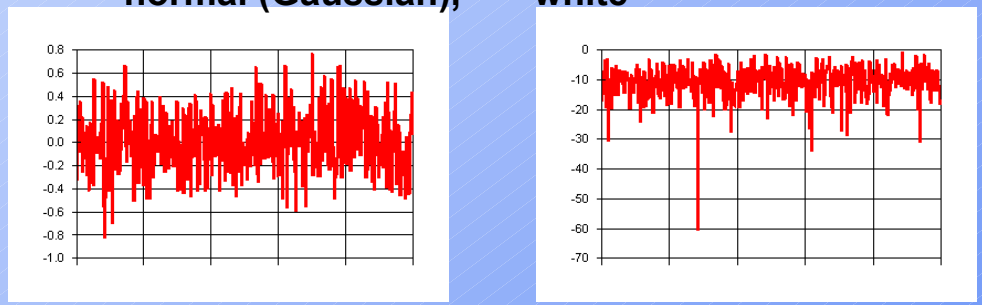
To exit the Graph Mode, press Graph again.

Note: The '**Graph**' key also serves as a **LOCAL key** to restore front-panel control after remote interface operations.

Noise

Outputs **Gaussian** noise with the specified *amplitude* and *dc offset* (the noise function has a 9 MHz bandwidth [-3 dB], typical).

normal (Gaussian), **white**



Noise *plotted* and *Fourier transformed* with **IntuiLink** *Waveform Editor* Tools | Equation Calculator (4K points)

Note: a 7th order *linear phase* anti-aliasing filter is used for ramp, **noise**, and arbitrary waveforms (with a cutoff frequency of 12.5 MHz).

Basic limitation - 7

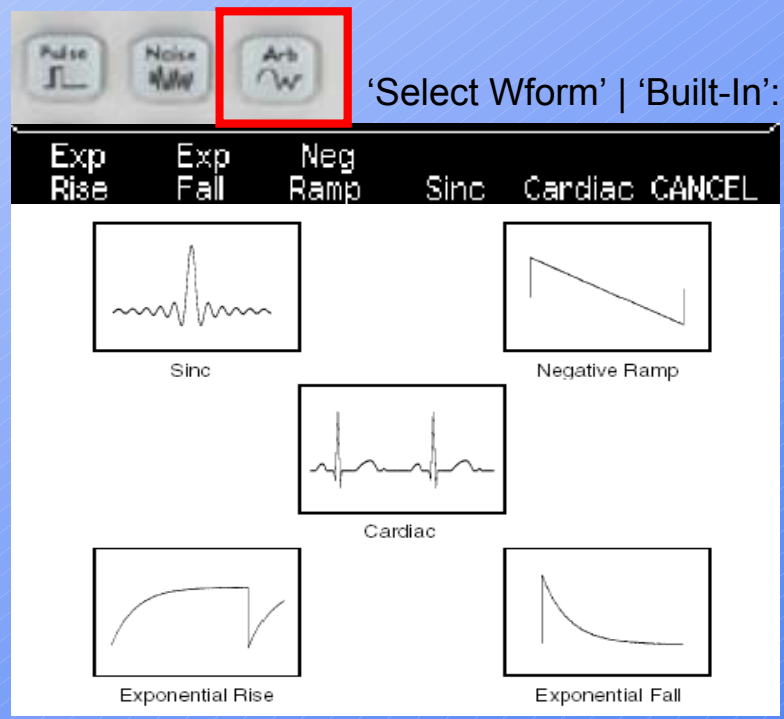
Output of a stored **ARB** waveform

The selected waveform is *assigned* to the ARB key.

• There are **five** *built-in* arbitrary waveforms stored in **non-volatile** memory.

• You can also download up to **four** *user-defined* waveforms into **non-volatile** memory in addition to **one** in **volatile** memory.

Note: **IntuiLink *Waveform Editor*** makes it easy to create and output arbitrary waveforms!

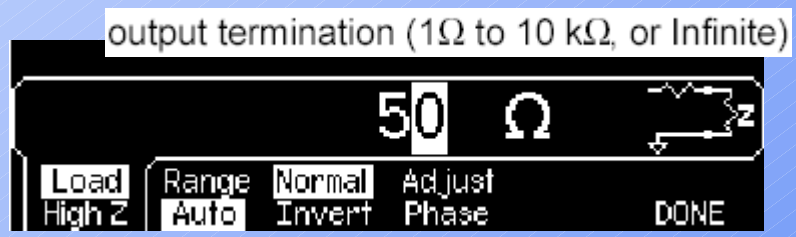


Output setup (1)

Output Control
You can disable or enable the front-panel *Output* connector. By default, the output is disabled at power on to protect other equipment.
When *enabled*, the 'Output' key is illuminated.

Select the Output Termination

The generator has a fixed series output impedance of 50 ohms.
If the actual load is different than the value specified, the *displayed* amplitude and offset levels will be incorrect.
The load impedance (termination) setting is simply provided as a convenience to ensure that the displayed voltage *matches* the expected load.



Press 'Utility' key,
press the 'Output setup' softkey, then
select the 'Load' softkey (or High Z)

Voltage Autoranging
Autoranging is enabled by default (the generator automatically selects the optimal settings for the output amplifier and attenuators).
With autoranging *disabled*, the function generator uses the *current* amplifier and attenuator settings.

Output setup (2)

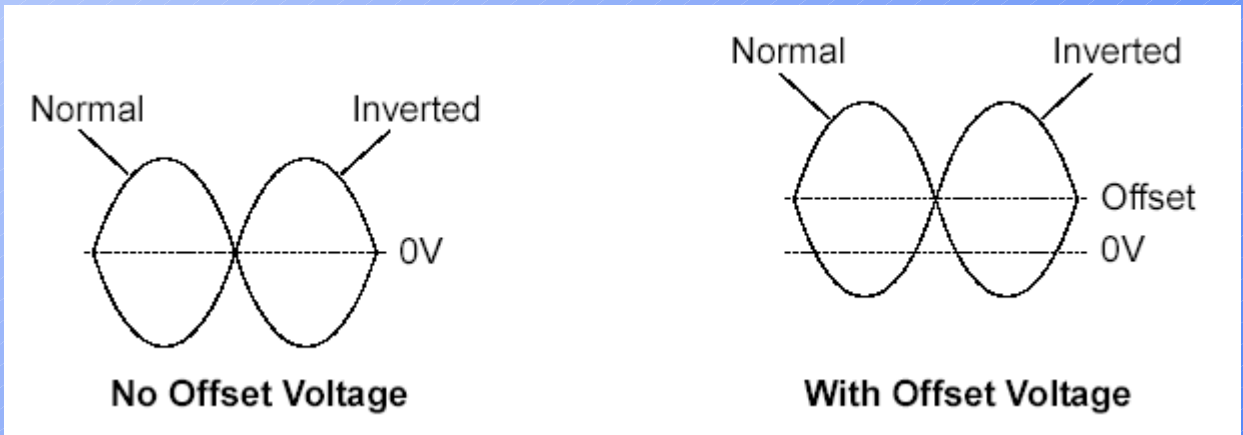
Waveform polarity

In the “Normal” mode (default), the waveform goes positive during the first part of the cycle. In the “Inverted” mode, the waveform goes negative during the first part of the cycle.

As shown in the examples below, the waveform is inverted *relative to* the *offset* voltage. Any offset voltage present will remain unchanged when the waveform is inverted.

Press ‘Utility’, select the ‘Output Setup’ softkey

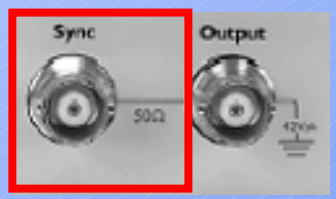
Press Normal softkey again to toggle between “Normal” and “Invert”



Sync output signal (1)

A sync output is provided on the front-panel *Sync* connector. All of the standard output functions (*except* **dc** and **noise**) have an associated Sync signal.

- For *sine*, *ramp*, and *pulse* waveforms, the Sync signal is a square waveform with a 50% duty cycle. The Sync signal is a TTL "high" when the waveform's output is positive, relative to zero volts (or the dc offset value). The Sync signal is a TTL "low" when the output is negative, relative to zero volts (or the dc offset value).
- For *square* waveforms, the Sync signal is a square waveform with the same duty cycle as the main output. The Sync signal is a TTL "high" when the waveform's output is positive, relative to zero volts (or the dc offset value). The Sync signal is a TTL "low" when the output is negative, relative to zero volts (or the dc offset value).
- For *arbitrary* waveforms, the Sync signal is a square waveform with a 50% duty cycle. The Sync signal is a TTL "high" when the first downloaded waveform point is output.



Note: You can disable the *Sync* connector. Press 'Utility' and select the '**Sync**' softkey again to toggle between "off" and "on".

Instrument **state** Store/Recall

You can **store** the instrument state in one of four **non-volatile** storage Locations (1 to 4).

The instrument stores the selected function, frequency, amplitude, dc offset, duty cycle, symmetry, as well as any modulation parameters in use. The instrument *does not* store *volatile* waveforms created in the arbitrary waveform function.

A *fifth* storage location (0) automatically holds the power-down configuration of the instrument. When power is restored, the instrument can automatically return to its state before power-down or factory default.

Press 'Store/Recall', select '**Store** State' softkey, select the desired storage location

Note: If desired, you can assign a custom name to each of the four locations.

(B) **Modulation** configuration: carrier and Mod

Graph or
Menu mode

Softkeys
to configure
the parameters

Mod
Type: AM
FM
PM
FSK
PWM
Source: **INT**
EXT

Sweep
LIN or LOG

Burst
N cycle or
EXT-gated

Carrier:
Sine
Square
Ramp
Pulse
Noise
Arb (currently selected)

Knob and cursor keys
to modify the displayed number
Keypad
to enter numbers, and
Softkeys
to select units

	Sine	Square	Ramp	Pulse	Noise	DC	Arb
AM, FM, PM, FSK Carrier	•	•	•				•
PWM Carrier				•			
Sweep Mode	•	•	•				•
Burst Mode	•	•	•	•	•[1]		•

[1] *Allowed in the External Gated burst mode only.*

Modulation – in a nutshell

Modulation is the process of modifying a high-frequency signal (called the **carrier** signal) with low-frequency information (called the **modulating** signal). The carrier and modulating signals can have any waveshape, but the carrier is usually a sine waveform.

The two most common types of modulation are *amplitude modulation* (**AM**) and *frequency modulation* (**FM**). These two forms of modulation modify the carrier's amplitude or frequency, respectively, according to the instantaneous value of the modulating signal. A third type of modulation is *phase modulation* (**PM**), which is similar to FM except that the phase of the carrier waveform is varied, rather than its frequency.

Another type of modulation is *frequency-shift keying* (**FSK**), where the output frequency "shifts" between two frequencies depending on the state of a digital modulating signal.
Finally, pulse width modulation (**PWM**), is provided for *pulse* waveforms *only*. In PWM, the pulse width (or duty cycle) of the pulse waveform is varied according to the modulating signal.

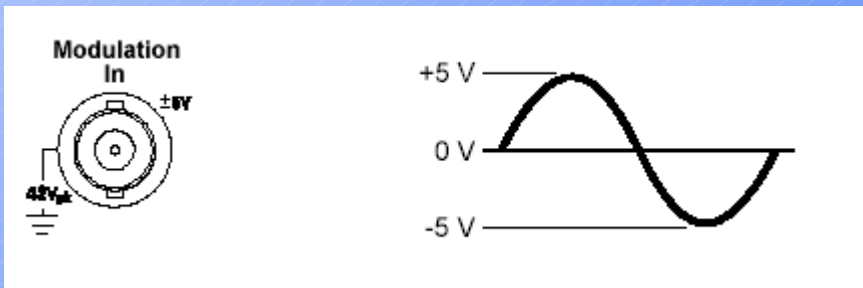
Int/Ext modulation **source**

The function generator will accept an *Internal* or *External* modulation source.

- If you select the *internal* source, the modulated waveform is generated by a **secondary DDS** synthesizer.

Modulating frequency (*internal source*): 2 mHz to 20 kHz.

- If you select the *external* source, the modulated waveform is controlled by the signal level present on the function generator's **rear-panel** *Modulation In* connector. The external signal is sampled and **digitized** by an analog-to-digital converter (ADC). Bandwidth: DC to 20 kHz.



With either modulation source, the result is a stream of digital samples representing the modulating waveform.

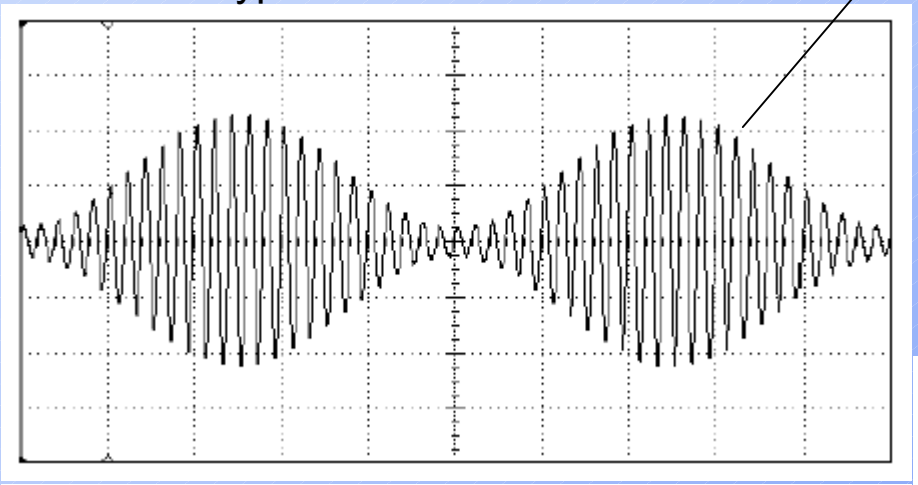
Internal modulation source: **shape**

- Modulating waveform shape (*internal source*): **Sine**, Square, Ramp, Negative Ramp, Triangle, Noise, or Arb waveform. *The default is Sine.*
  - Square has 50% duty cycle. 
  - Ramp has 100% symmetry. 
  - Triangle has 50% symmetry. 
  - Negative ramp has 0% symmetry. 
- You can use noise as the modulating waveshape, but you *cannot* use noise, pulse, or dc as the carrier waveform.
- If you select an arbitrary waveform as the *modulating* waveshape, the waveform is automatically limited to 4K points. Extra waveform points are removed using decimation.

Modulating frequency (*internal source*): 2 mHz to 20 kHz.

AM: amplitude modulation

33220A implements "double sideband transmitted carrier" amplitude modulation similar to a typical AM radio station.



Carrier:
sine, 5 kHz, 5 Vpp

MOD Type:
AM
Source: **Int**
AM Depth: 80%
AM Freq: 200 Hz,
Shape: **sine**

$$\frac{(1 + D \times Am(t)) \times \sin(2\pi \times Fc \times t)}{2}$$

"D" is the modulation depth ($0 \le D \le 1.2$).
"Am" is the modulating signal with peak amplitude ≤ 1.
"Fc" is the carrier frequency.

A constant is added to the modulating signal: the sum is always greater than zero (for <100% depth)

Note: when AM is selected, the generator automatically reduces its peak-to-peak amplitude by one-half so that a 100% modulation depth signal can be output.

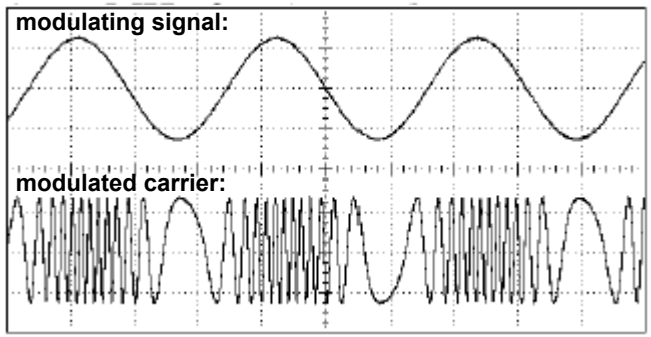
numeric view: Set 'AM Freq'

Graphical view

FM: frequency modulation

The variation in frequency of the modulated waveform from the carrier frequency is called the **frequency deviation**.
Waveforms with frequency deviations less than 1% of the modulating signal's bandwidth are referred to as *narrowband* FM.

Frequency deviation: 1 µHz to 10.05 MHz (limited to 150 kHz for ramps and 3.05 MHz for arbitrary waveforms). *The default is 100 Hz.*
The sum of the *carrier frequency* and deviation must be less than or equal to the maximum frequency for the selected function ***plus 100 kHz***



In frequency modulation, "100% modulation" has a different meaning than in AM. Modulation of 100% in FM indicates a variation of the carrier by the amount of the **full** permissible deviation.

BW ≅ 2 x (Modulating Signal Bandwidth) *For narrowband FM*

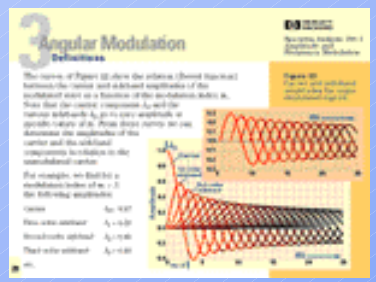
BW ≅ 2 x (Deviation + Modulating Signal Bandwidth) *For wideband FM*

Note: since the **rear-panel** *Modulation In* connector is DC coupled, you can use the 33220A to *emulate* a voltage-controlled oscillator (VCO).

Spectrum analysis: Amplitude & Frequency Modulation

Online Materials:
http://contact.tm.agilent.com/Agilent/tmo/an-150-1/index.html

The *basic theory* behind AM and FM modulation including time and frequency domain representation is presented.



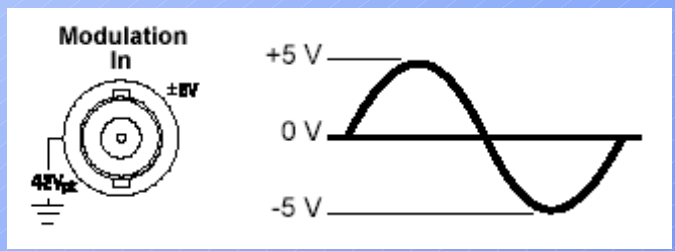
There are also two *interactive* Java™ signal models allowing the exploration and experience of basic concepts underlying AM and FM modulation.

PM: phase modulation

PM is very similar to FM, but for PM, the *phase* of the carrier waveform is varied, rather than the frequency.

The **phase deviation** setting represents the peak variation in phase of the modulated waveform from the carrier waveform. The phase deviation can be set from 0 to 360^0 (degrees, the default is 180^0).
Note: since a 360^0 phase deviation is equivalent to 0^0,
the *maximum* effective deviation setting is 180^0.

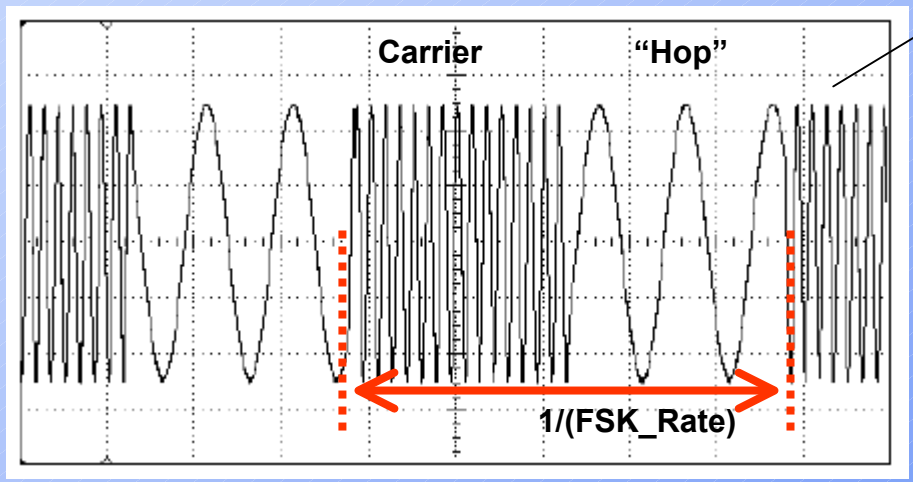
If you select the *External* source, the carrier waveform is modulated with an external waveform. The phase deviation is controlled by the ±5V signal level present on the rear-panel *Modulation In* connector.



For example, if you have set the deviation to 180^0, then a +5V signal level corresponds to a 180^0 phase shift. Lower external signal levels produce less deviation.

FSK: frequency-shift keying

The generator “shifts” its output frequency between two preset values.
The **rate** at which the output shifts between the two frequencies (called the “carrier frequency” and the “**hop** frequency”) is determined by the Internal rate generator or the signal level on the rear-panel *Trig In* connector (Ext – “0”: Carrier, “1”: Hop; max external FSK rate: 100 kHz).



Carrier:
sine, 3 kHz, 5Vpp

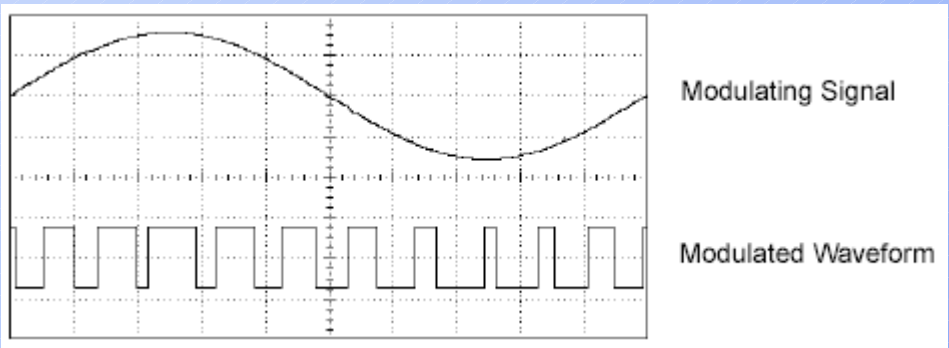
MOD Type:
FSK
Source : **Int**
Hop Freq : 500 Hz
FSK Rate : 100 Hz

numeric view: Set the ‘FSK rate’

Graphical view

PWM: pulse width modulation

PWM is used in digital audio applications, motor control circuitry, switching power supplies, and other control applications. The 33220A provides PWM for **pulse** waveforms (and PWM is the *only* type of modulation supported for *pulse* carrier).



The variation of pulse width is called the **Width Deviation**.
The deviation of width (in <u>time</u> units) is *symmetrical* around the pulse width of the *original* pulse waveform.
<u>Note</u>: The deviation can also be expressed in terms of duty cycle (as a <u>percentage</u> referenced to the period of the pulse waveform), which is called the **Duty Cycle Deviation**.

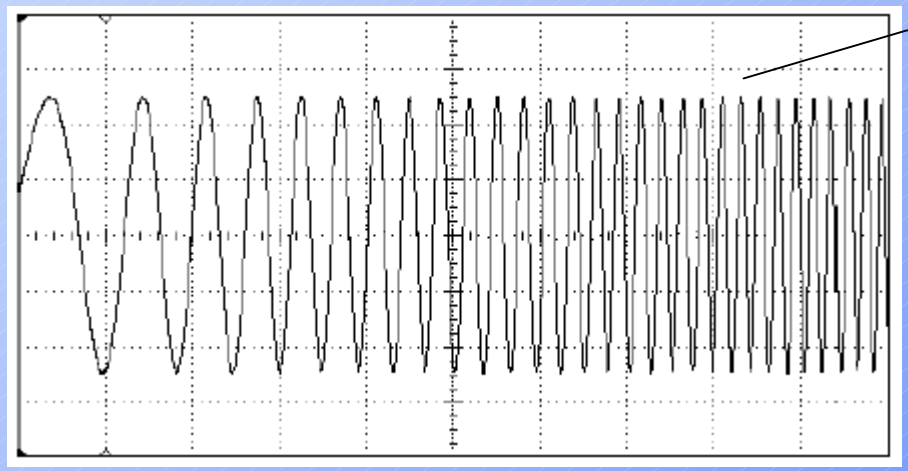
numeric view: Set 'PWM Freq'

Graphical view

Frequency **Sweep** (1)

The function generator “steps” from the **start** frequency to the **stop** frequency at a *sweep rate* which you specify by the **sweep time**. (A sweep consists of a *finite* number of small frequency steps.)

You can sweep up or down in frequency, and with either **Linear** or **Logarithmic** spacing.



Carrier:
sine, 5 Vpp

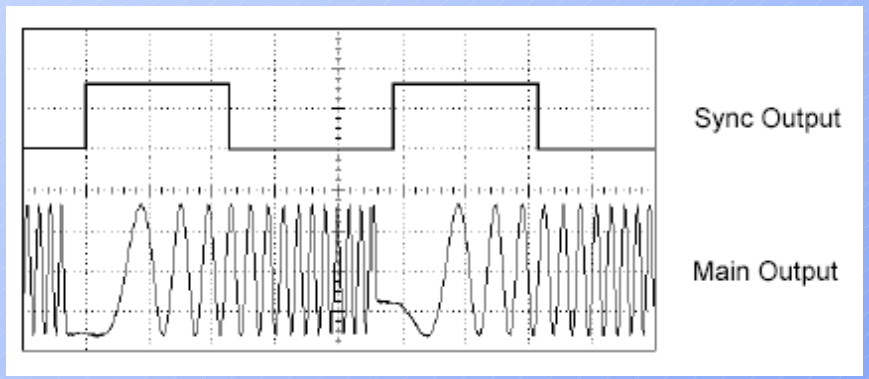
Sweep Mode :
Linear
Start freq: 50 Hz
Stop freq: 5 kHz
Sweep Time : 1 s

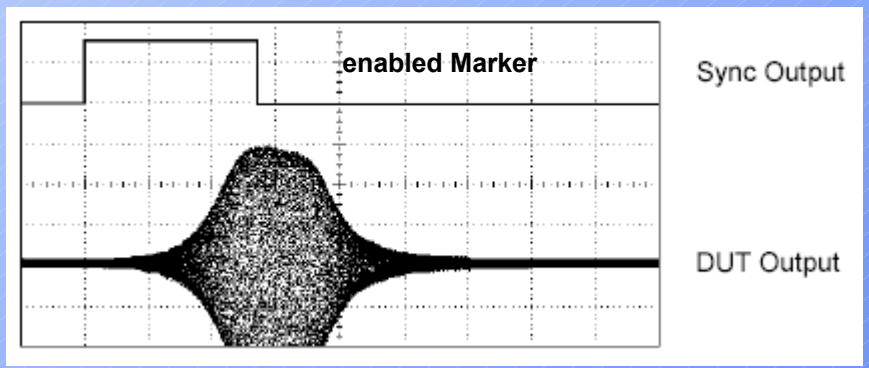
numeric view

Graphical view

Frequency **Sweep** (2)

Sync and Marker Signals. The output from the front-panel *Sync* connector goes "high" at the beginning of each sweep. If you have *disabled* the Marker function, the Sync signal goes "low" at the midpoint of the sweep.
However, if you have *enabled* the **Marker** function, the Sync signal goes "low" when the output frequency reaches the specified marker frequency.





You can use the Marker function to identify a notable frequency in the response of a device under test (DUT) – for example, you may want to identify a **resonance**.

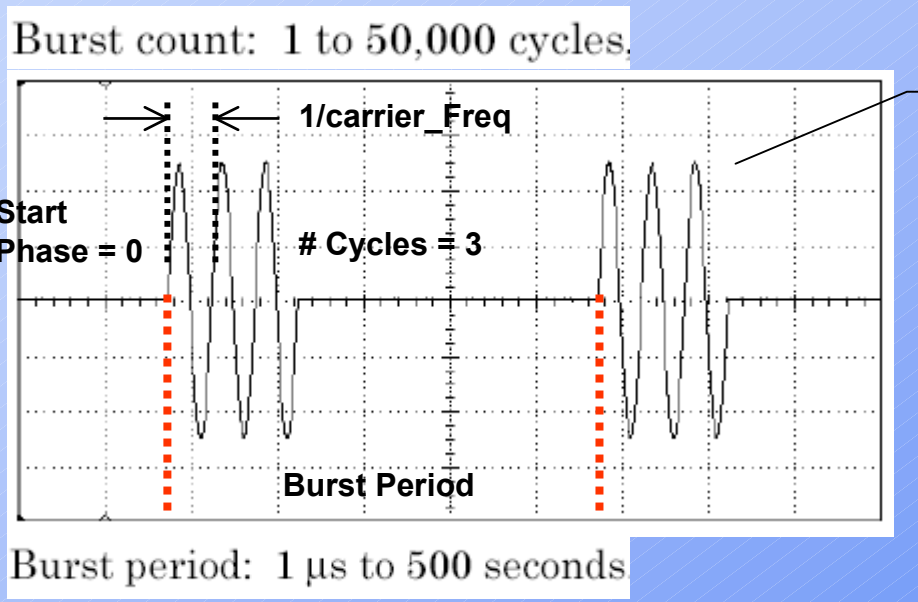
To do this, connect the *Sync* output to one channel of your oscilloscope and connect the DUT output to another channel. Then, trigger the oscilloscope with the rising edge of the Sync signal to position the start frequency on the left side of the screen.

Adjust the marker frequency until the falling edge of the Sync signal lines up with the interesting feature in the device's response. You can then *read* the frequency from the front-panel display of the 33220A ARB generator.

‘N Cycle’ **Burst** (triggered)

In this mode, the generator outputs a waveform with a specified ‘number of cycles’ (**burst count**) each time a trigger is received. After the specified number of cycles have been output, the function generator stops and waits for the next trigger.

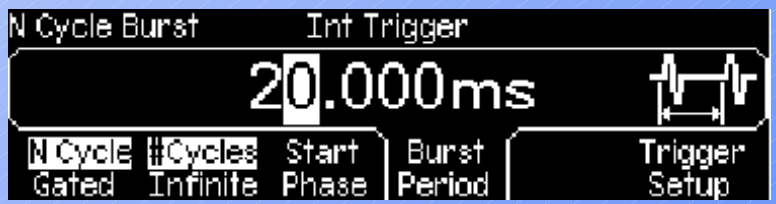
Trigger – Int (continuously), or Ext**:** ‘Trigger’ key (manual), *Trig In* connector (HW trig) or SW trig



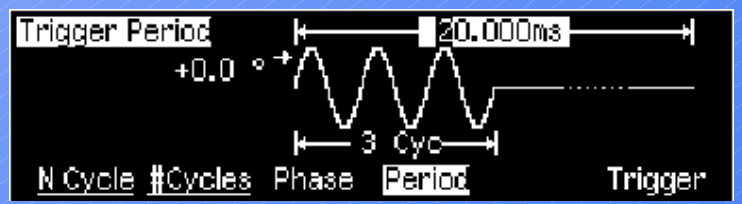
Carrier:
sine, 500 Hz, 5 Vpp

Burst Mode:
N Cycle
#Cycles : 3
Start Phase: 0
Burst Period: 20 ms

numeric view



Graphical view

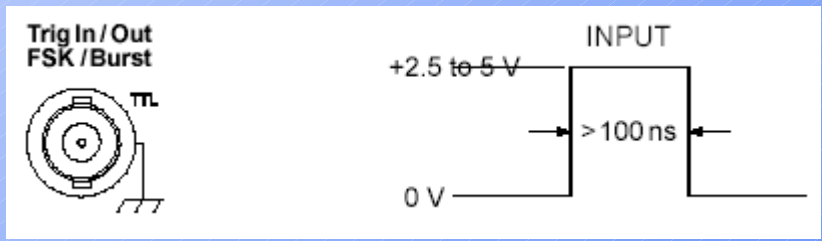


‘Gated’ **Burst**

In this mode, the output waveform is either “ON” or “OFF ” based on the level of the external signal applied to the **rear-panel** *Trig In* connector.

- When the gate signal is *true*, the function generator outputs a continuous waveform.
- When the gate signal goes *false*, the current waveform **cycle is completed** and then the function generator stops while remaining at the voltage level corresponding to the ‘Starting burst Phase’ of the selected waveform.
- For a *noise* waveform, the output stops **immediately** when the gate signal goes false.

Note: when the *gated* mode is selected, the burst count (‘# Cycles’), ‘Burst Period’, and trigger source are *ignored* (these parameters are used for the triggered burst mode only).



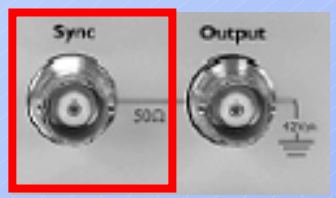
To **TRIGger** a sweep or burst

You can issue triggers for sweeps or bursts using *internal* triggering, *external* triggering, or *manual* triggering.

• Internal or “automatic” triggering is enabled when you turn on the function generator. In this mode, the function generator outputs continuously when the sweep or burst mode is selected.
• External triggering uses the rear-panel *Trig In* connector to control the sweep or burst. The function generator initiates one sweep or outputs one burst each time *Trig In* receives a TTL pulse. You can select whether the function generator triggers on the *rising* or *falling* edge of the external trigger signal.
• Manual triggering initiates one sweep or outputs one burst each time you press from the front-panel. Continue pressing this key to re-trigger the function generator.
The key is illuminated while the function generator is waiting for a manual trigger (the key is disabled when in remote and when a function other than burst or sweep is currently selected).

Sync output signal (2)

A sync output is provided on the front-panel *Sync* connector. All of the standard output functions (*except* **dc** and **noise**) have an associated Sync signal.



Note: You can disable the *Sync* connector. Press 'Utility' and select the **Sync** softkey again to toggle between "off" and "on".

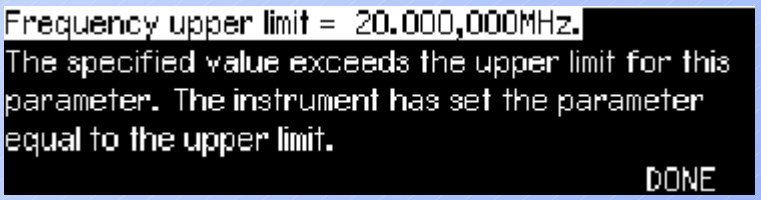
- For internally-modulated *AM*, *FM*, *PM*, and *PWM*, the Sync signal is referenced to the modulating waveform (not the carrier) and is a square waveform with a 50% duty cycle. The Sync signal is a TTL "high" during the first half of the modulating waveform.
- For externally-modulated *AM*, *FM*, *PM*, and *PWM*, the Sync signal is referenced to the carrier waveform (not the modulating waveform) and is a square waveform with a 50% duty cycle.
- For *FSK*, the Sync signal is referenced to the "hop" frequency. The Sync signal is a TTL "high" on the transition to the "hop" frequency.
- For *frequency sweeps* with *Marker Off*, the Sync signal is a square waveform with a 50% duty cycle. The Sync signal is a TTL "high" at the beginning of the sweep and goes "low" at the midpoint of the sweep. The frequency of the sync waveform equals the specified sweep time.
- For *frequency sweeps* with *Marker On*, the Sync signal is a TTL "high" at the beginning of the sweep and goes "low" at the marker frequency.
- For a *triggered burst*, the Sync signal is a TTL "high" when the burst begins. The Sync signal is a TTL "low" at the end of the specified number of cycles (may not be the zero-crossing point if the waveform has an associated start phase). For an *infinite count burst*, the Sync signal is the same as for a continuous waveform.
- For an *externally-gated burst*, the Sync signal follows the external gate signal. However, note that the signal will not go to a TTL "low" until the end of the last cycle (may not be the zero-crossing point if the waveform has an associated start phase).

(C) System-related operations

Built-In Help System

The built-in help system is designed to provide *context-sensitive* assistance on any front-panel key or menu softkey.

A list of Help topics is also available to assist you with several front-panel operations.



Whenever a limit is exceeded or any other invalid configuration is found, the function generator will display a message.

For *example*, if you enter a value that exceeds the frequency limit for the selected function, a message will be displayed.

Error Conditions

A record of up to 20 command syntax or hardware errors can be stored in the function generator's error queue.

Self test

A *power-on* self-test occurs automatically when you turn on the function generator.

A *complete* self-test runs a series of tests and takes approx 15 seconds to execute. If all tests pass, you can have high confidence that the function generator is fully operational.