

Agilent 33120A

Function/ARbitrary waveform generator

15 MHz sine and square, ARBs, modulations

12-bit, 40 MSa/s, 16K-point DDS

GPIB, **IntuiLink (Waveform Editor)**

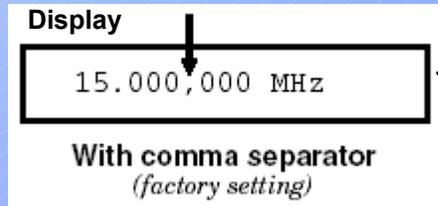


Getting started

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

Power-On and Reset State

The parameters marked with a bullet (•) are stored in **non-volatile** memory. The factory settings are shown.



GPIB address is displayed at power-on

Output Configuration	Power-On/Reset State
Function	Sine wave
Frequency	1 kHz
Amplitude (into 50 ohms)	100 mV peak-to-peak
Offset	0.00 Vdc
Output Units	Volts peak-to-peak
Output Termination	50 ohms
Modulation	Power-On/Reset State
AM Carrier Waveform	1 kHz Sine wave
AM Modulating Waveform	100 Hz Sine wave
AM Depth	100%
FM Carrier Waveform	1 kHz Sine wave
FM Modulating Waveform	10 Hz Sine wave
FM Peak Frequency Deviation	100 Hz
Burst Carrier Frequency	1 kHz Sine wave
Burst Count	1 cycle
Burst Rate	100 Hz
Burst Starting Phase	0 degrees
FSK Carrier Waveform	1 kHz Sine wave
FSK "Hop" Frequency	100 Hz Sine wave
FSK Rate	10 Hz
Modulation State	Off
Sweep Start / Stop Frequency	100 Hz / 1 kHz
Sweep Time	1 second
Sweep Mode	Linear
System-Related Operations	Power-On/Reset State
• Power-Down Recall	• Disabled
• Display Mode	• On
• Comma Separators	• On
Triggering Operations	Power-On/Reset State
Trigger Source	Internal
Input/Output Configuration	Power-On/Reset State
• GPIB Address	• 10
• Interface	• GPIB (IEEE-488)
• Baud Rate	• 9600 baud
• Parity	• None (8 data bits)
Calibration	Power-On/Reset State
Calibration State	Secured

Display Annunciators



Go to local



Adrs	Function generator is addressed to listen or talk over a remote interface. (GPIB)
Rmt	Function generator is in remote mode (remote interface).
Trig	Function generator is waiting for a single trigger or external trigger (Burst, Sweep).
AM	AM modulation is enabled.
FM	FM modulation is enabled.
Ext	Function generator is set for an external modulation source (AM, FSK, Burst).
FSK	FSK (frequency-shift keying) modulation is enabled.
Burst	Burst modulation is enabled.
Swp	Sweep mode is enabled.
ERROR	Hardware or remote interface command errors are detected.
Offset	The waveform is being output with an offset voltage.
Shift	"Shift" key has been pressed. <i>Press "Shift" again to turn off.</i>
Num	"Enter Number" mode is enabled. <i>Press "Shift-Cancel" to disable.</i>
Arb	Arbitrary waveform function is enabled.
~	Sine waveform function is enabled.
□	Square waveform function is enabled.
△	Triangle waveform function is enabled.
∩	Ramp waveform function is enabled.

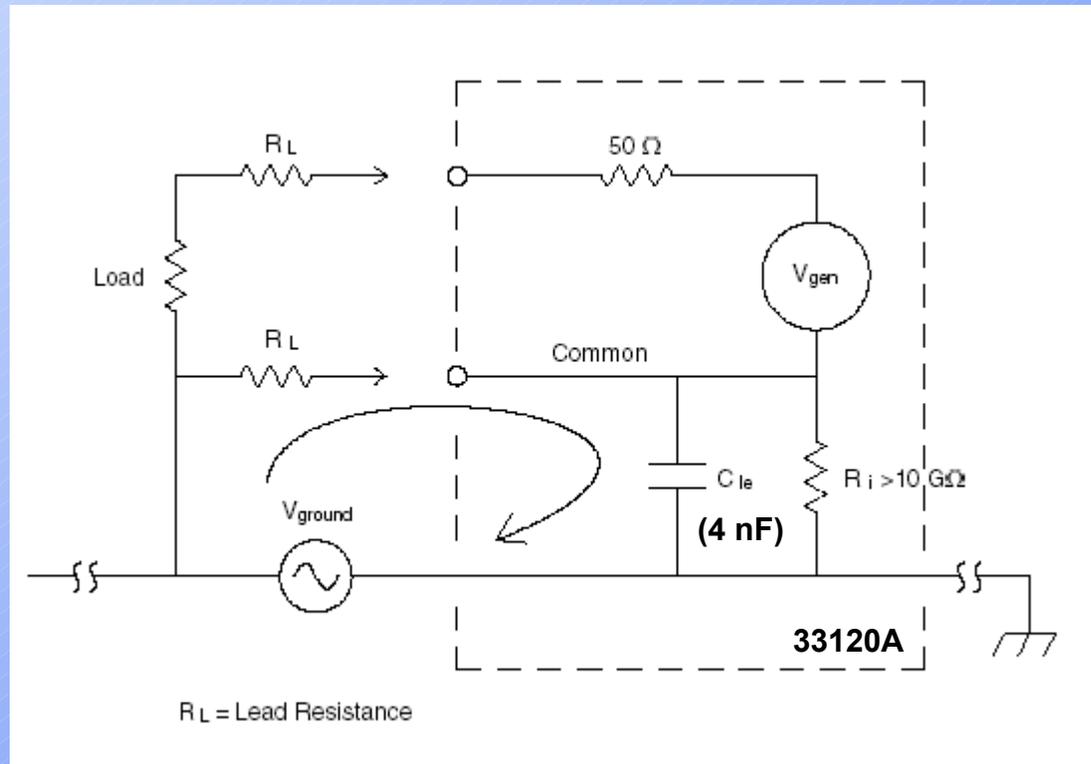
To review the display *annunciators*,
hold down the **Shift** key
as you turn on the function generator.

Some *message* appears on the display
for approximately 10 seconds.
Repeat the step as needed.



Floating signal generator

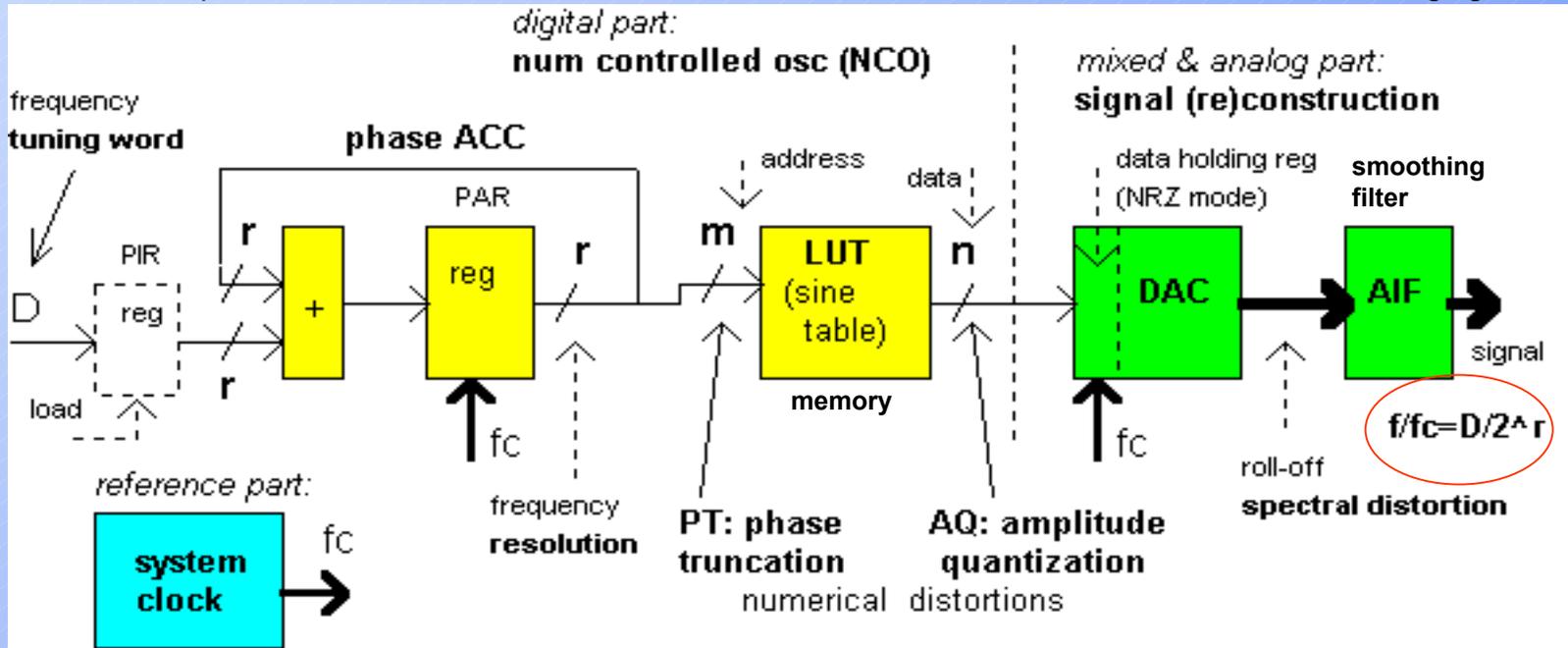
Many applications require a test signal which is isolated from earth ground for connection to powered circuits, to avoid ground loops, or to minimize other common mode noise. A floating signal generator such as the **33120A** has both sides of the output BNC connector isolated from chassis (earth) ground.



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

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

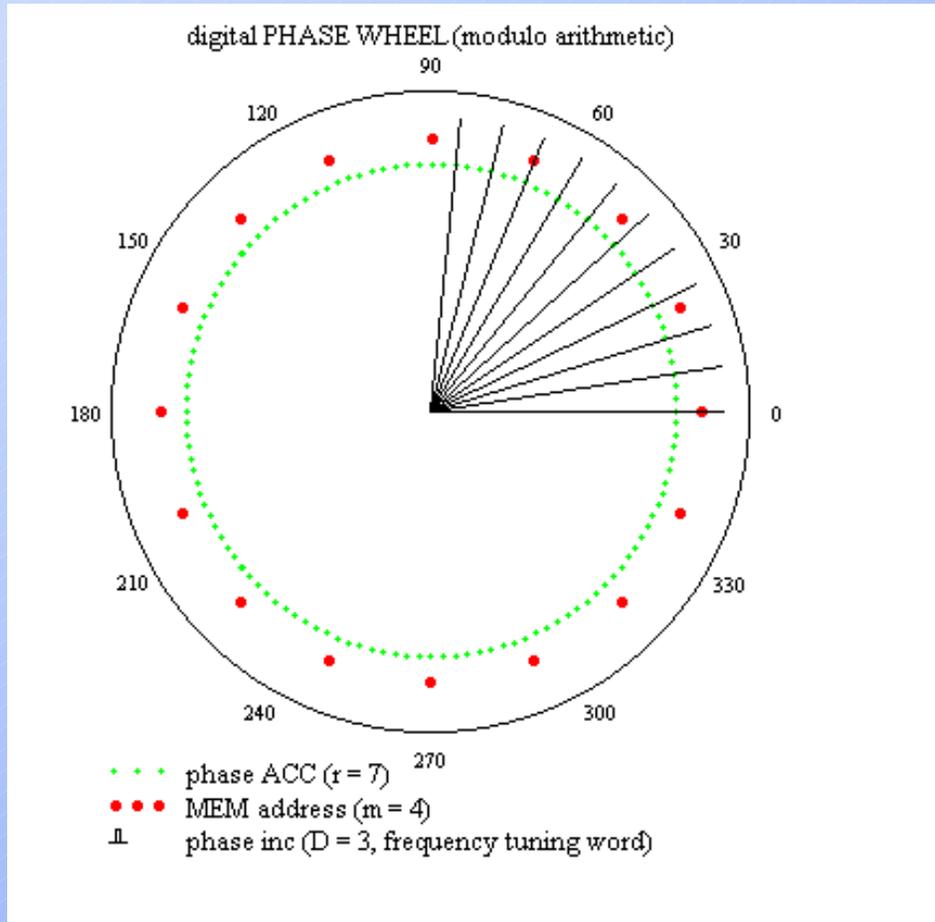
NRZ : non return to zero
DAC : digital to analog converter
AIF : anti imaging filter



33120A : $r = 48$ bit, $m = 14$ bit (16K memory), $n = 12$ bit, $f_c = 40$ MHz

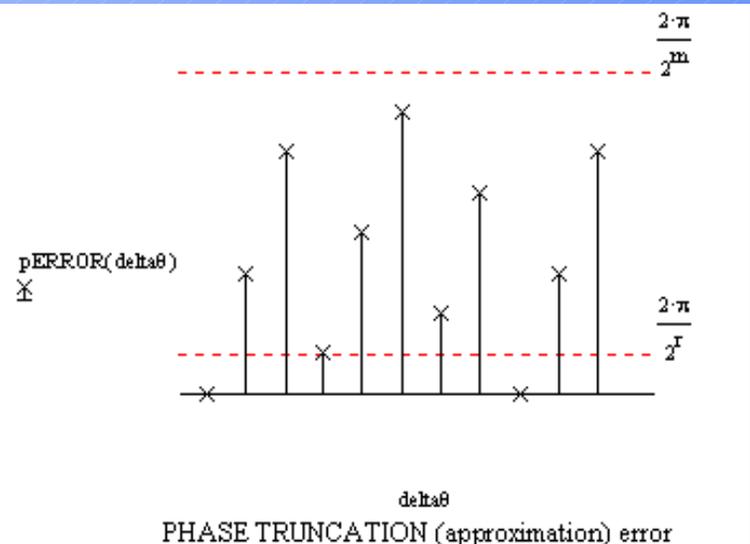
frequency resolution (internal): $2^r = 2^{48} = 2^{8+10+10+10+10} = 2^8 \cdot 10^{3+3+3+3}$

Phase truncation (a “virtual memory” technique)

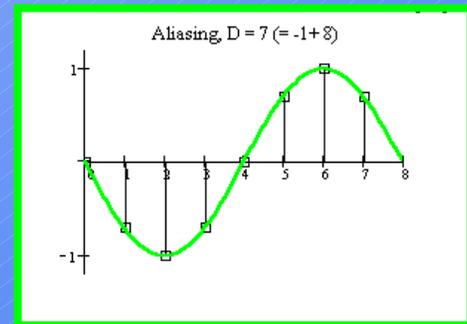
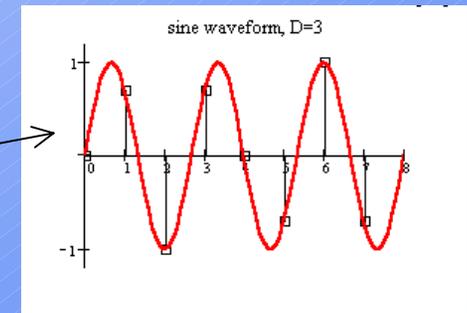
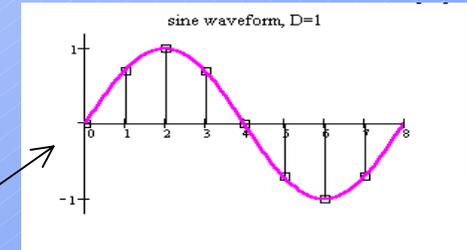
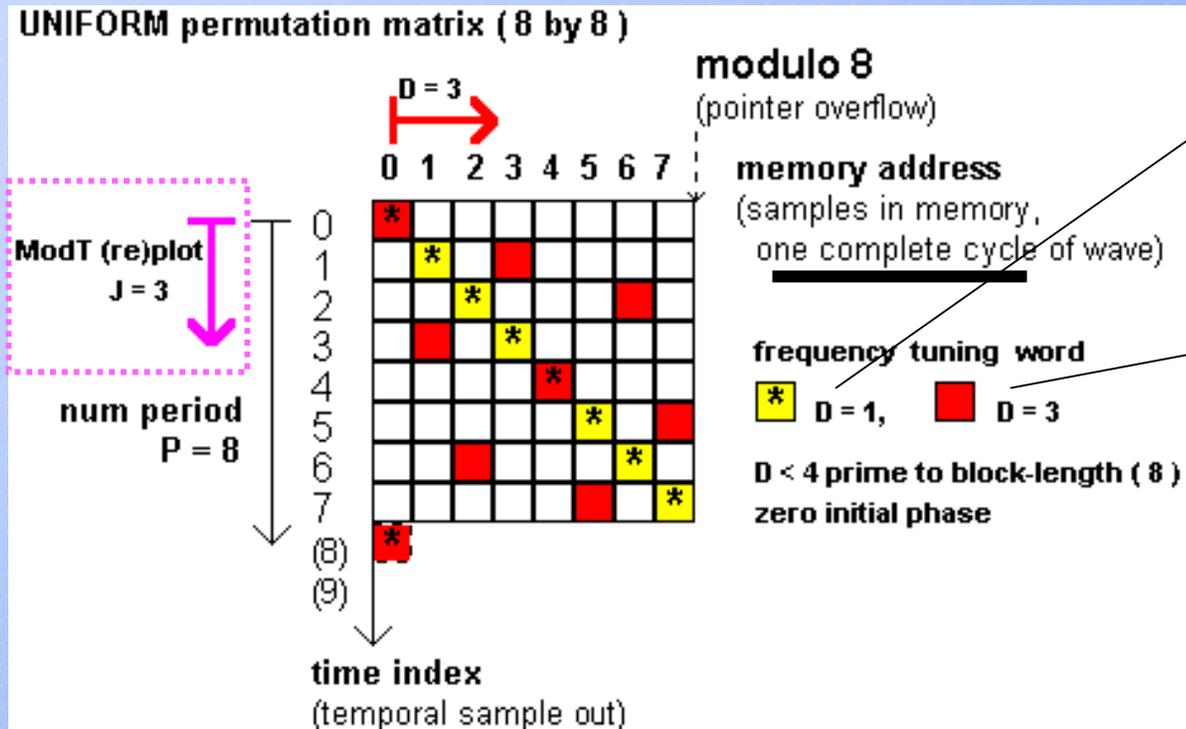


Each **red-point (MEM address)** on the phase wheel corresponds to the equivalent point on a cycle of (sine) waveform.

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

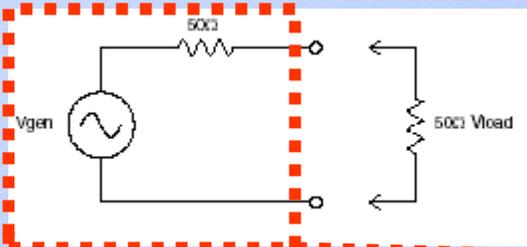


The point(memory location)-skipping nature of DDS: frequency control



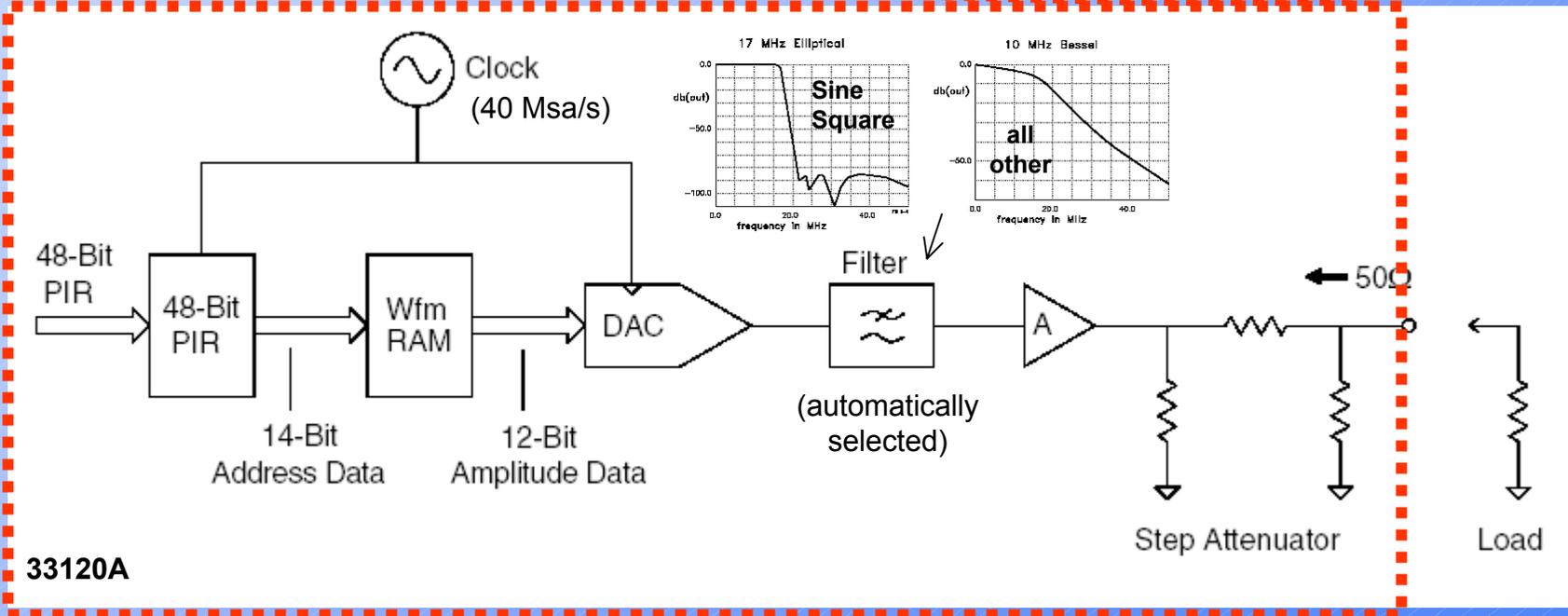
For the 33120A, you do not have to change the length of the waveform to change its output frequency.

Output amplitude control

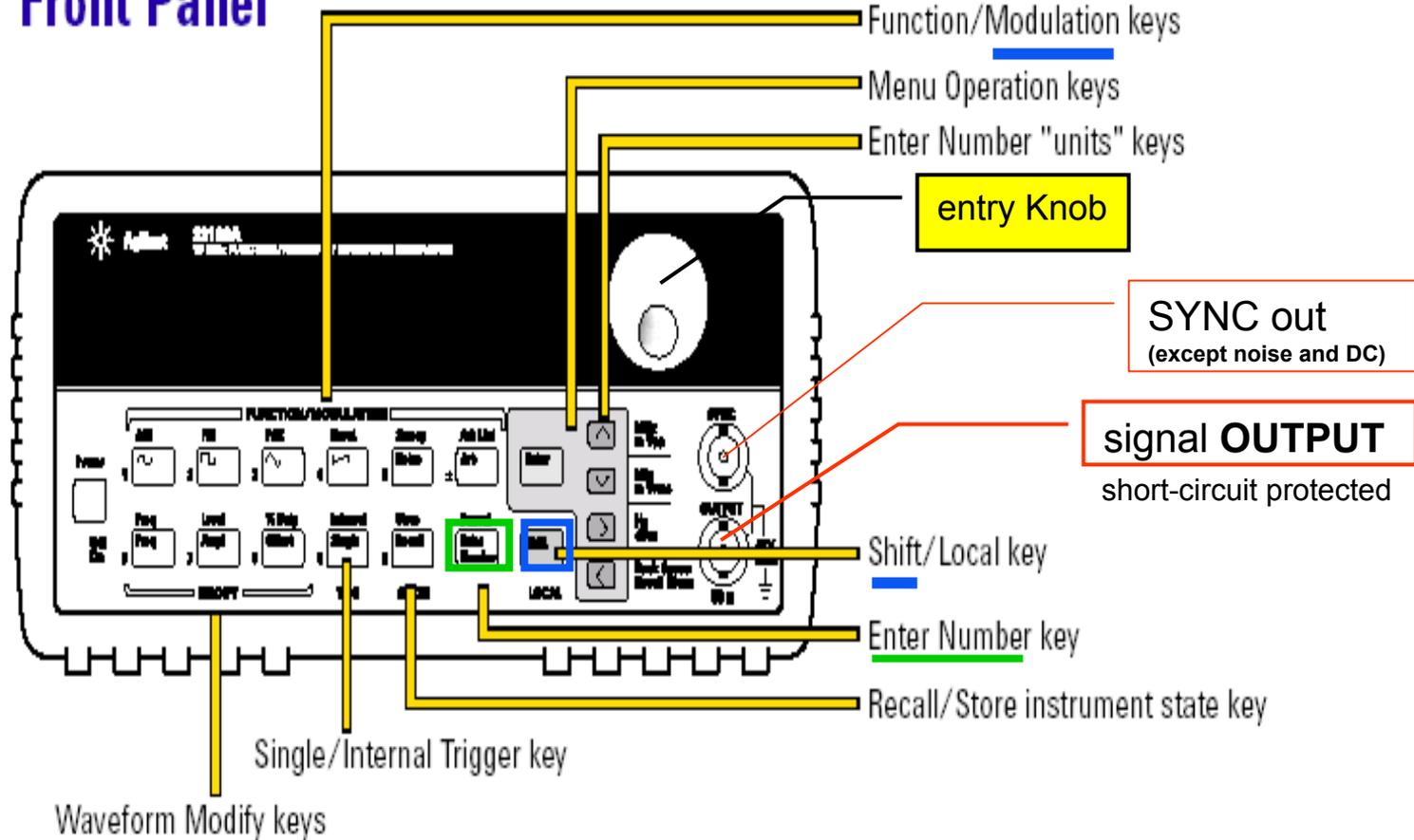


Output **termination**: **50 ohm** (or High impedance)
The default is 50 ohm.

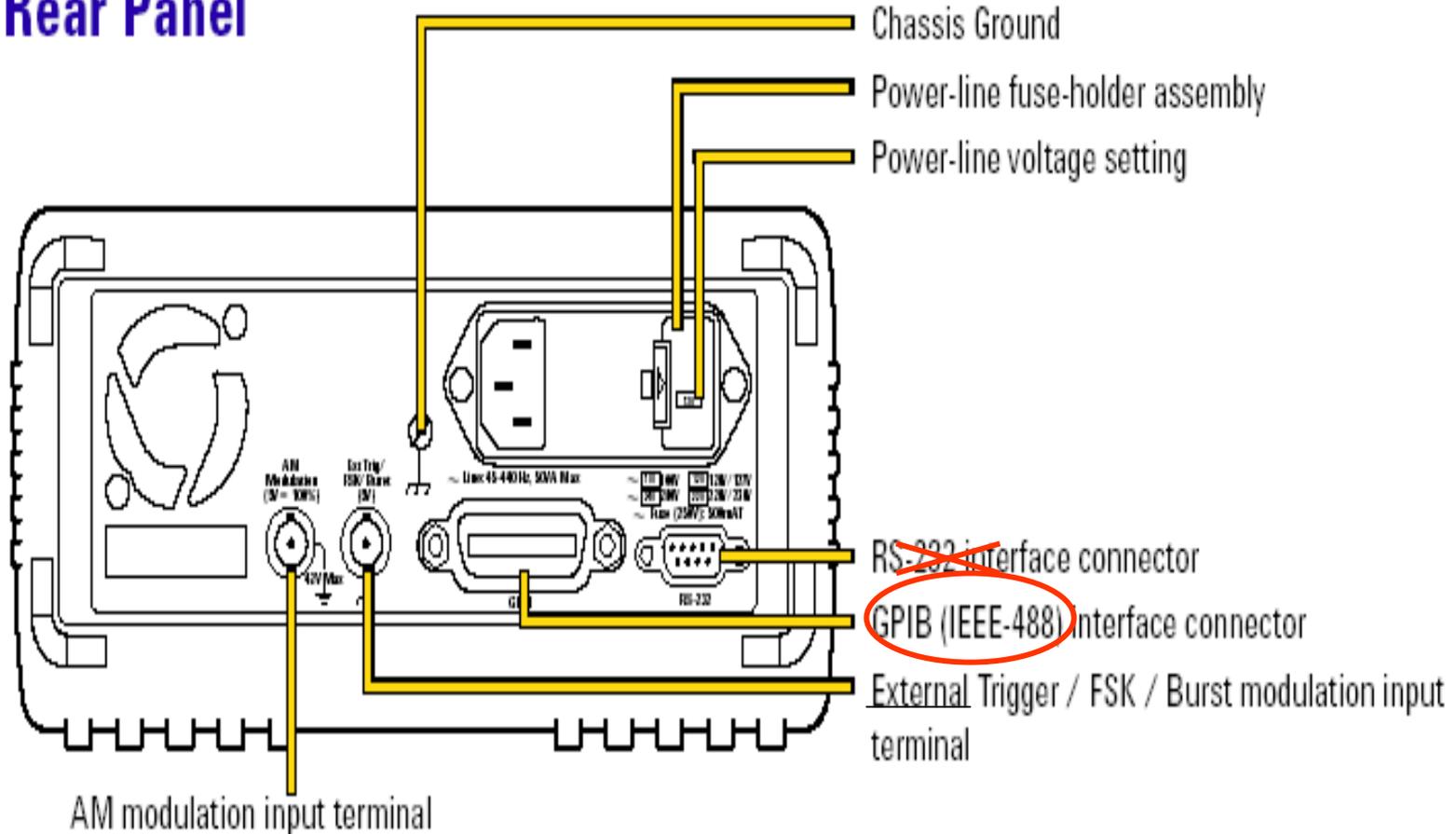
If you specify 50 ohm termination but are actually terminating into an **open** circuit, the output will be **twice** the value specified !!



Front Panel



Rear Panel



(1) Output **FUNCTION**, **MODIFY** Freq, Ampl or DC Offset (square: % Duty)

To select *one* of the Std waveforms, push the key



FUNCTION : **sine, square, triangle, ramp, noise, ARB**
DC (hold down a Function or the Offset key
more than 2 sec)

MODIFY: DC **Offset** (only square : **% Duty**)

Shift % Duty

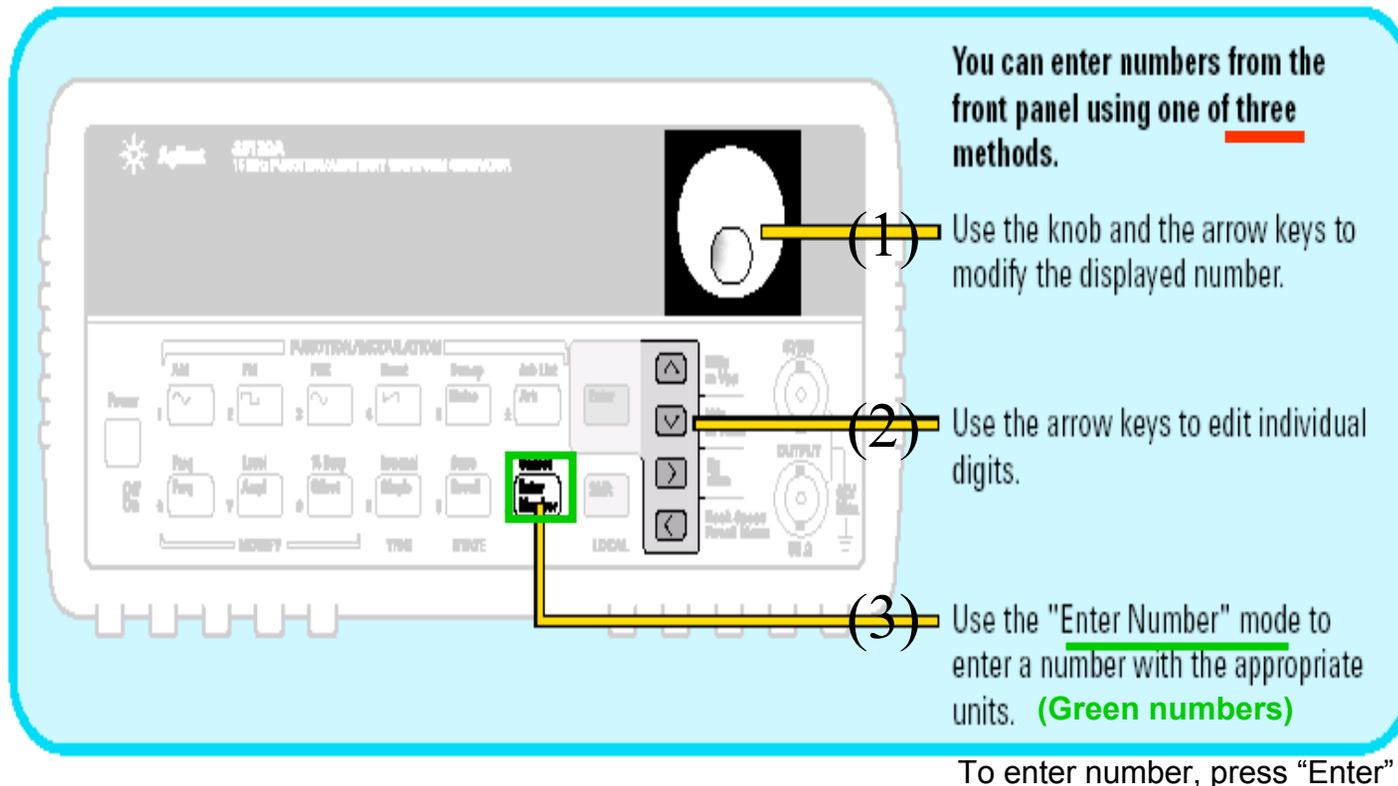


MODIFY: **Amplitude** - Vpp, Vrms, dBm(50 ohm)

MODIFY: **Frequency** – Hz, kHz, MHz

MODIFY the displayed number

Front Panel Number Entry



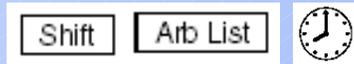
The diagram shows the front panel of the 33120A Function/ARB generator. The display at the top shows the model number and a sun icon. Below the display is a control panel with various buttons and a knob. Three methods for number entry are highlighted:

- (1) Use the knob and the arrow keys to modify the displayed number.
- (2) Use the arrow keys to edit individual digits.
- (3) Use the "Enter Number" mode to enter a number with the appropriate units. (Green numbers)

To enter number, press "Enter"

Output of a stored **ARB** waveform

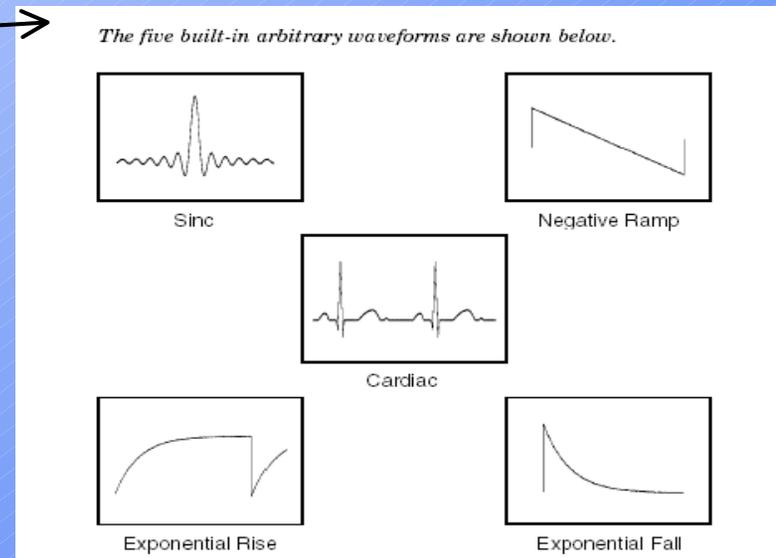
Press the **Arb** key to output the arbitrary waveform *currently* selected
(to scroll through the waveform choices and make a selection: **shift | Arb List**, scroll, then **Enter**).



- 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.

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



Offset annunciator is **on** if average value of an ARB waveform is not equal to zero.

Parameters

Output
FREQuency

Function	Minimum Frequency	Maximum Frequency
Sine	100 μ Hz	15 MHz
Square	100 μ Hz	15 MHz
Triangle	100 μ Hz	100 kHz
Ramp	100 μ Hz	100 kHz
Built-In Arbs ¹	100 μ Hz	5 MHz

Square is generated from Sine with comparator

¹ There are five built-in arbitrary waveforms stored in non-volatile memory: sinc, negative ramp, exponential rise, exponential fall, and cardiac.

For downloaded ARB waveforms

Number of Arb Points	Minimum Frequency	Maximum Frequency
8 to 8,192 (8k)	100 μ Hz	5 MHz
8,193 to 12,287 (12k)	100 μ Hz	2.5 MHz
12,288 to 16,000	100 μ Hz	200 kHz

Output
AMPLitude

$$|V_{offset}| + \frac{V_{pp}}{2} \leq V_{max} \quad \text{and} \quad |V_{offset}| \leq 2 \times V_{pp}$$

V_{max} is either 10V for a high impedance termination or 5V for a 50 ohm termination

(2) Instrument **STATE** Store/Recall

You can store up to **three** different instrument states in **non-volatile** memory (numbered **1, 2, and 3**). This enables you to recall the *entire* instrument configuration.

The state storage feature “remembers” the function, frequency, amplitude, dc offset, duty cycle, as well as any modulation parameters. (**ARB** waveforms from **non-volatile** memory is remembered.)

Shift | **Store**; scroll; then **Enter**:



Recall; scroll; then **Enter**:



Notes:

- When power is turned off, the function generator automatically stores its state in memory location “**0**”. You can recall the *power-down state*, but you **cannot** store the state to location “**0**” from the front panel.
- The 33120A does not have a simple ON/OFF switch for the output. **One possible method of producing zero output is to output 0 Volts DC.** The desired instrument state may be stored and then recalled when desired.

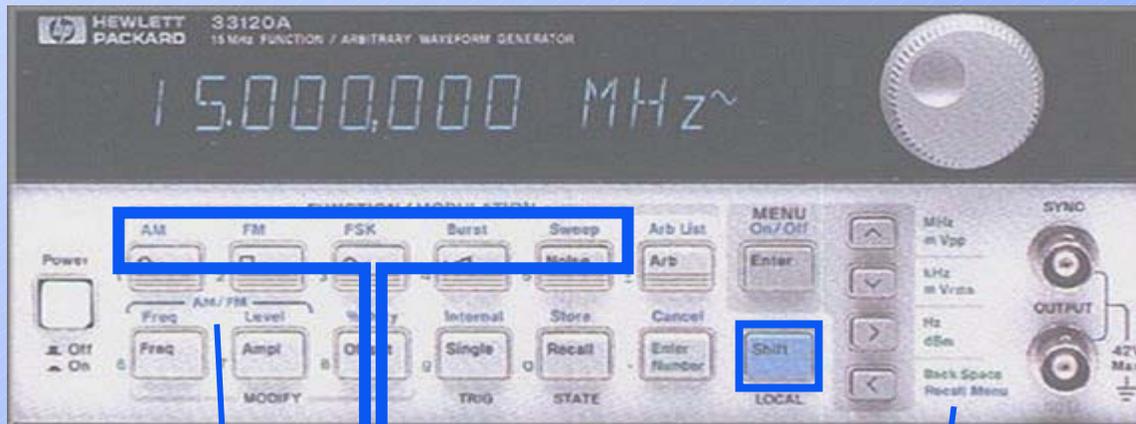
SYNC out

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

- For *sine*, *square*, *triangle*, and *ramp* waveforms, the sync signal is a TTL “high” when the waveform’s output is positive, relative to zero volts (or the dc offset value). The signal is a TTL “low” when the output is negative, relative to zero volts (or the dc offset value).
- For *arbitrary* waveforms, a momentary TTL “high” pulse (> 200 ns) is output which corresponds to the first downloaded point in the waveform.
- For *AM* and *FM*, the sync signal is referenced to the modulating signal (not the carrier). A momentary TTL “high” pulse (> 200 ns) is output at each zero-crossing point of the modulating signal.
- For the *triggered burst mode*, a TTL “low” signal is output while the specified number of cycles is output (for the duration of the burst). After the specified number of cycles has been output, the sync signal goes “high” until the next burst.
- For the *external gated burst mode*, the sync signal is a TTL “high” when the output is positive, relative to zero volts (or the dc offset value). The signal is a TTL “low” when the output is negative, relative to zero volts (or the dc offset value).
- For *FSK*, a momentary TTL “high” pulse (> 200 ns) is output on the transition to the “hop” frequency.
- For *frequency sweeps*, the sync signal is a TTL “low” at the start of the sweep (when the start frequency is output) and is a TTL “high” at the end of the sweep (when the stop frequency is output).

(3) Output MODULATION, MODIFY parameters

Only *one* modulation mode can be enabled at a time



Menu: MODIFY
modulating shape, etc.

select : **Shift | AM, FM, FSK, Burst, Sweep**
(using the *present settings* for the carrier **Function**,
Frequency, output **Amplitude** and **Offset** voltage)

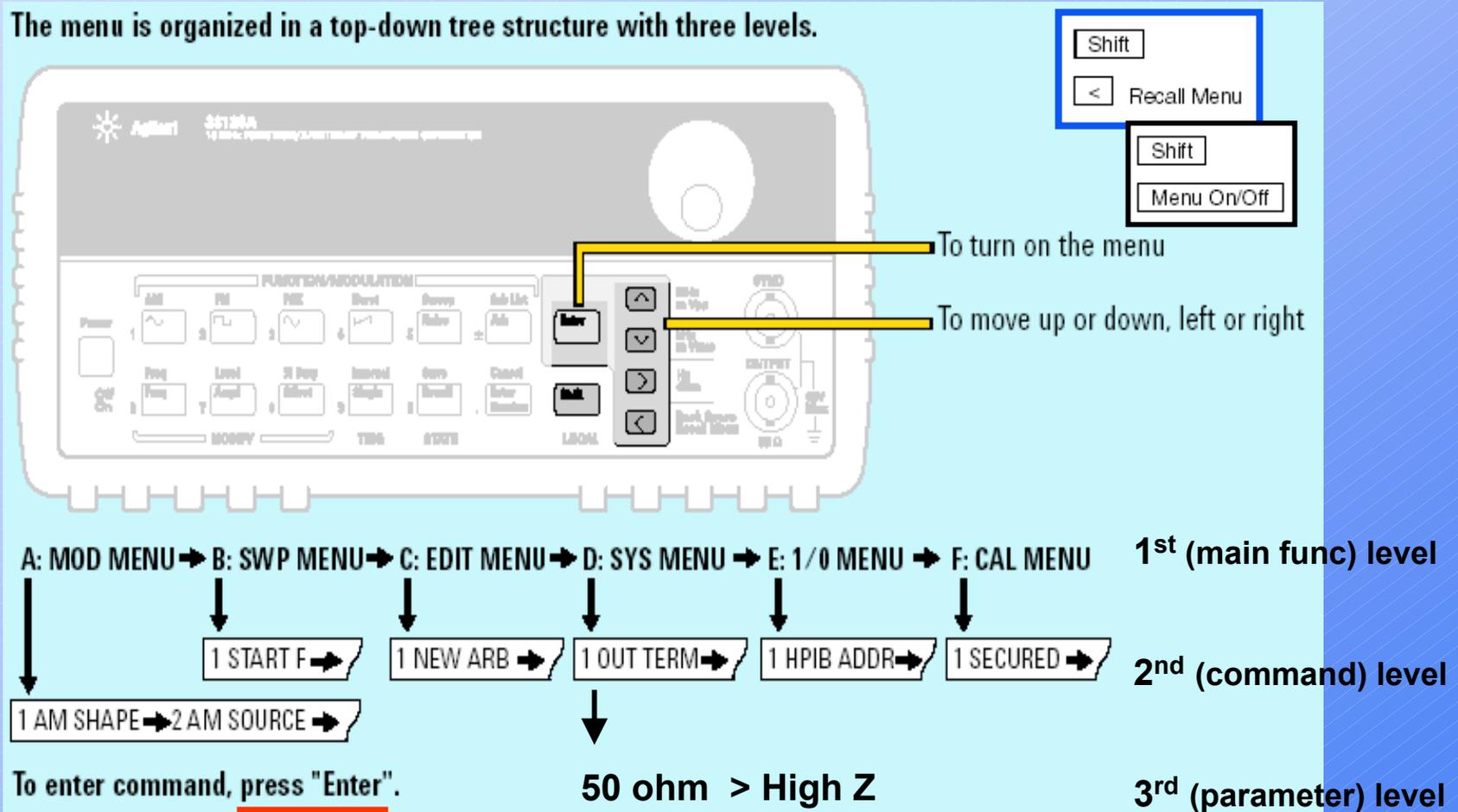
MODIFY **AM/FM** *modulating*
Freq, Level (mod Depth)

Shift Freq

Shift Level

Menu

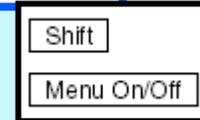
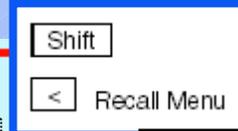
The menu is organized in a top-down tree structure with three levels.



MOD and SWP Menu; modulation matrix

A: MODulation Menu

- 1: AM SHAPE Selects the shape of the AM modulating waveform.
- 2: AM SOURCE Enables or disables the internal AM modulating source.
- 3: FM SHAPE Selects the shape of the FM modulating waveform.
- 4: BURST CNT Sets the number of cycles per burst (1 to 50,000 cycles).
- 5: BURST RATE Sets the burst rate in Hz for an internal burst source.
- 6: BURST PHAS Sets the starting phase angle of a burst (-360 to +360 degrees).
- 7: BURST SRC Selects an internal or external gate source for burst modulation.
- 8: FSK FREQ Sets the FSK "hop" frequency.
- 9: FSK RATE Selects the internal FSK rate between the carrier and FSK frequency.
- 10: FSK SRC Selects an internal or external source for the FSK rate.



B: SWP (Sweep) MENU

- 1: START F Sets the start frequency in Hz for sweeping.
- 2: STOP F Sets the stop frequency in Hz for sweeping.
- 3: SWP TIME Sets the repetition rate in seconds for sweeping.
- 4: SWP MODE Selects linear or logarithmic sweeping.

MODULATION
MATRIX

Each "X" indicates a valid combination.	Sine	Square	Triangle	Ramp	Noise	Arb
AM Carrier	X	X	X	X		X
AM Modulating Wave	X	X	X	X	X	X
FM Carrier	X	X	X	X		X
FM Modulating Wave	X	X	X	X	X	X
FSK Modulation	X	X	X	X		X
Burst Modulation	X	X	X	X		X
Frequency Sweep	X	X	X	X		X

Internal modulation source

Internally, the function generator incorporates a **second**, lower speed and lower resolution DDS arbitrary waveform generator to produce the modulating signal **independent** of the carrier signal.

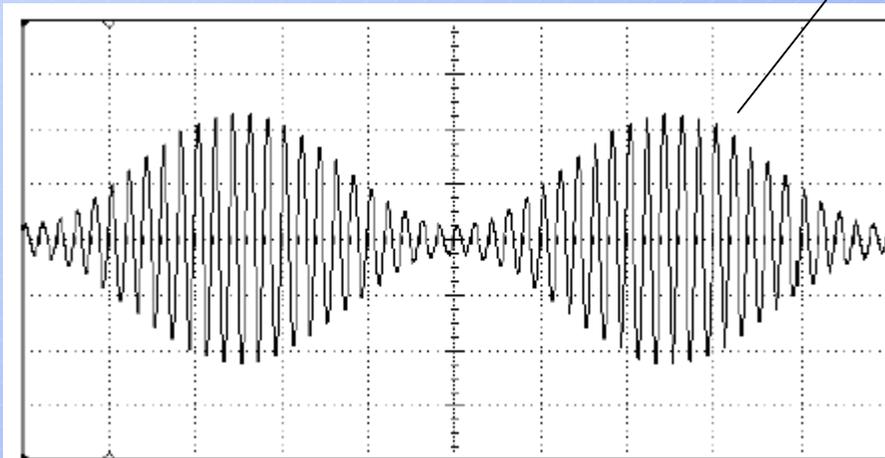
- Internal modulation waveshapes range in length: *from 2K to 4K*.
- User-defined arbitrary waveforms are *automatically* expanded or compressed in length.
- Unlike the main signal output, modulation waveshapes are sampled using a **variable** “*point clock*”.

Notes:

- The function generator incorporates an internal 8-bit (+-7 bits peak) digital-to-analog converter (DAC) to create an *analog copy* of the modulation signal for amplitude modulation (**AM**). This signal is internally applied to a conventional four-quadrant analog multiplier circuit to achieve amplitude modulation.
- The generator uses *digital signal processing* to combine the carrier and modulation signals for frequency modulation (**FM**). The FM modulation signal maintains 12-bit resolution for frequency values.

AM (amplitude modulation)

33120A implements "double sideband transmitted carrier" amplitude modulation similar to a typical AM radio station



Carrier:

sine, 5 kHz, 5 Vpp

Modulating waveform:

AM shape: sine

AM source:

INT (default)

Freq: 200 Hz,

Level: 80% mod Depth

$$\frac{(1 + D \times A_m(t)) \times \sin(2\pi \times F_c \times t)}{2}$$

"D" is the modulation depth
($0 \leq D \leq 1.2$).

"Am" is the modulating signal
with peak amplitude ≤ 1 .

"Fc" is the carrier frequency.

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

Note: When amplitude modulation is selected, the 33120A automatically reduces its peak-to-peak amplitude by one-half so that a 100% modulation depth signal can be output.

Interactive Amplitude Modulation Model and Application Notes :

<http://contact.tm.agilent.com/Agilent/tmo/an-150-1/classes/liveAM.html>

AM settings

(1) Carrier

- (1) **Function** (see modulation MATRIX)
- (2) **Freq**
- (3) **Ampl**
- (4) **(Offset)**

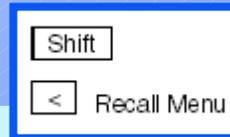
(2) select: **shift | AM**

(3) Modulating signal

(1) **A: MODulation Menu**

- 1: AM SHAPE
- 2: AM SOURCE

Selects the shape of the AM modulating waveform.
Enables or disables the internal AM modulating source.



(2) **shift | Freq** – 10 mHz to 20 KHz

(3) **shift | Level** – mod Depth in % (0 to 120)

Note: modulating signal SOURCE – **EXT/INT** (both) or **EXT** only

*The **EXT** modulating source is **always** enabled.*

The function generator **adds** the INT and EXT mod signals.



FM (frequency modulation)

The function generator will accept *only* an **internal** FM modulating signal (*no external* source is available).

- The extent of carrier frequency change is called *deviation*.

The frequency deviations are caused by the amplitude changes of the modulating information signal. You can set the amount of the **peak** frequency in FM with the *deviation* parameter.

- 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.

- For FM signals, the BW of the modulated signal can be approximated by:

$$BW \approx 2 \times (\text{Deviation} + \text{Information Signal Bandwidth}) \quad \textit{For wideband FM}$$

$$BW \approx 2 \times (\text{Information Signal Bandwidth}) \quad \textit{For narrowband FM}$$

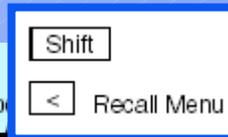
Narrowband FM occurs when the ratio of the deviation frequency to the information signal bandwidth is approximately 0.01 or less.

FM settings

- (1) Carrier
 - (1) **Function** (see modulation MATRIX)
 - (2) **Freq**
 - (3) **Ampl**
 - (4) **(Offset)**
- (2) select: **shift | FM**
- (3) Modulating signal

(1) **A: MODulation Menu**

1: AM SHAPE	Selects the shape of the AM modulating waveform.
2: AM SOURCE	Enables or disables the internal modulator.
3: FM SHAPE	Selects the shape of the FM modulating waveform.



- (2) **shift | Freq** – 10 mHz to 10 KHz
- (3) **shift | Level** – Peak freq Deviation: 10 mHz to 7.5 MHz

Note: The sum of the carrier frequency and *peak frequency deviation* must be less than or equal to the maximum frequency for the selected function **plus 100 kHz**

Interactive Frequency Modulation Model and Application Notes :
<http://contact.tm.agilent.com/Agilent/tmo/an-150-1/classes/liveFM.html>

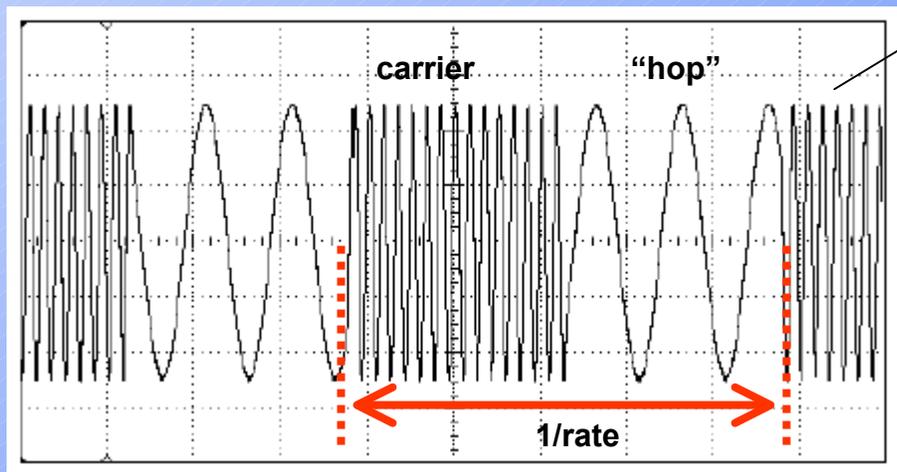
FSK (frequency-shift keying)

FSK is essentially a *special case* of frequency modulation (**FM**)

- The modulating signal shape is always a **square wave** with an amplitude of zero to +1.
- The *deviation* is either positive or negative depending on whether the “hop” frequency is larger or smaller than the present “carrier” frequency (as shown below).

$$\text{Deviation} = \text{Hop Frequency} - \text{Carrier Frequency}$$

- The **internal** FSK rate generator specifies the period (= 1/ rate) of the modulating square wave signal.
- When selected, the **external** FSK input *replaces* the internal FSK rate generator to directly control the hop rate (TTL “0”: carrier, “1”: hop; max rate 1 MHz).



Carrier:

sine, 3 kHz, 5Vpp

FSK FREQ (“hop” frequency):

500 Hz

FSK RATE:

100 Hz

FSK SCR (source):

INT (default)

FSK settings

(1) Carrier

- (1) **Function** (see modulation MATRIX)
- (2) **Freq**
- (3) **Ampl**
- (4) **(Offset)**

(2) select: **shift | FSK**

(3) Modulating signal parameters

(1) **A: MODulation Menu**

1: AM SHAPE	Selects the shape of the AM modulating waveform.
2: AM SOURCE	Enables or disables the internal AM modulating source.
3: FM SHAPE	Selects the shape of the FM modulating waveform.
4: BURST CNT	Sets the number of cycles per burst (1 to 50,000).
5: BURST RATE	Sets the burst rate in Hz for an internal burst source.
6: BURST PHAS	Sets the starting phase angle of a burst (-360 to 360 degrees).
7: BURST SRC	Selects an internal or external source for the burst.
8: FSK FREQ	Sets the FSK "hop" frequency.
9: FSK RATE	Selects the internal FSK rate between the carrier and FSK frequency.
10: FSK SRC	Selects an internal or external source for the FSK rate.

Shift

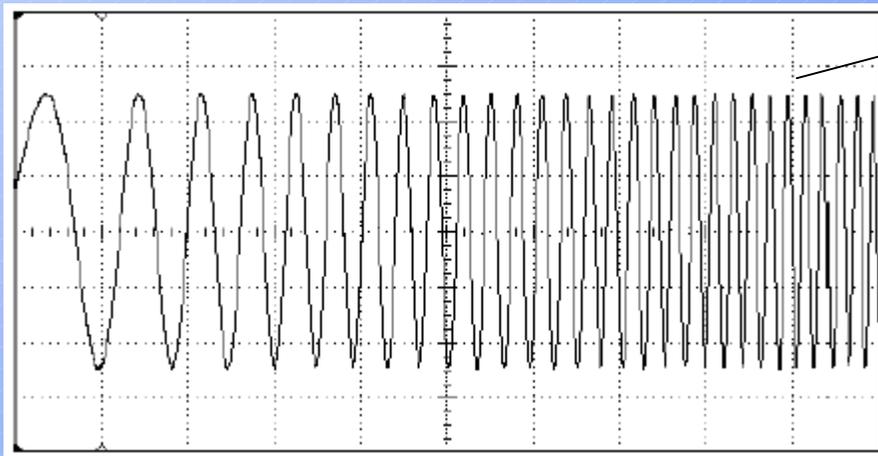
< Recall Menu

Note: FSK rate – 10 mHz to 50 kHz

Frequency Sweep

Like FSK modulation, the sweep function is also a *special case* of **FM**.

- The *modulation* waveshape for sweeps is a **ramp** wave or **exponential** wave for **LIN** or **LOG** sweeps, respectively, based on the sweep mode setting.
- The sweep time parameter adjusts the period of the modulating waveform.
- The direction of frequency sweeps can be varied by setting the stop frequency either above or below the start frequency.
- The 33120A performs **phase-continuous** frequency sweeping — stepping from the start frequency to the stop frequency with between 2,048 and 4,096 *discrete* frequency steps.



Carrier
sine, 5 Vpp

START F: 50 Hz
STOP F: 5 kHz
SWP TIME: 1 s
SWP MODE:
LIN (default)

Sweep settings

(1) Carrier

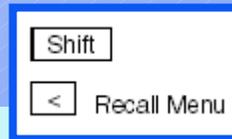
- (1) **Function** (see modulation MATRIX)
- (2) **Ampl**
- (3) **(Offset)**

(2) select: **shift | Sweep**

(3) SWEEP parameters

(1) **B: SWP (Sweep) MENU**

- | | |
|-------------|---|
| 1: START F | Sets the start frequency in Hz for sweeping. |
| 2: STOP F | Sets the stop frequency in Hz for sweeping. |
| 3: SWP TIME | Sets the repetition rate in seconds for sweeping. |
| 4: SWP MODE | Selects linear or logarithmic sweeping. |



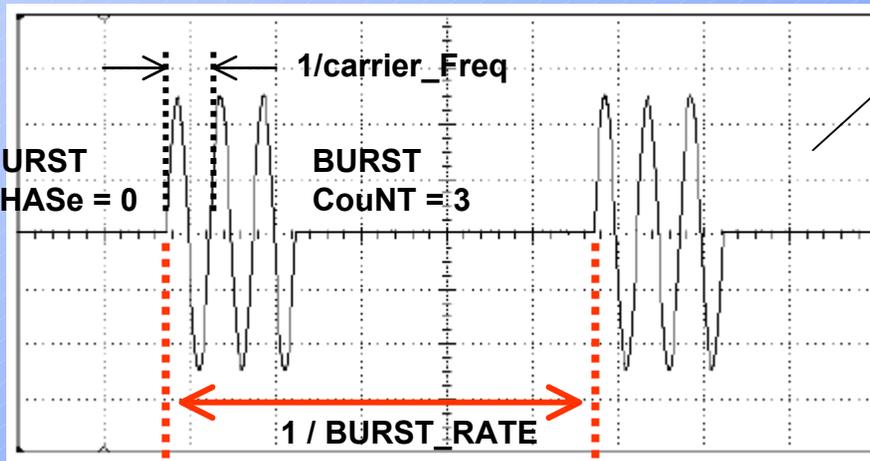
Notes:

- SWEEP TIME – 1 ms to 500 s
- To generate **one** frequency sweep: press *SINGLE* key (or apply a trigger pulse to rear-panel EXT Trig terminal)

Burst waveform

The function generator turns the carrier wave output “on” and “off” in a controlled (triggered or externally gated) manner.

- Triggered mode: outputs a carrier waveform with a user-specified number of **complete** cycles (burst count).
- Ext Gated mode (burst COUNT, RATE, PHASE has **no** effect): rear-panel *Burst* terminal is used to directly (and **asynchronously**) turn off/on the signal (TTL “0”: off, “1”: on)



Carrier
sine, 1 KHz, 5 Vpp

BURST CNT : 3
BURST RATE: 100 Hz
BURST PHAS: 0
BURST SCR:
INT (default)

Appl Note 1407: How to generate LOW Duty-Cycle pulses with a function generator

Burst settings

(1) Carrier

(1) **Function** (see modulation MATRIX)

(2) **Freq**

(3) **Ampl**

(4) **(Offset)**

For sine, square, and arbitrary waveforms only.

Carrier Frequency	Minimum Burst Count
10 mHz to 1 MHz	1
>1 MHz to 2 MHz	2
>2 MHz to 3 MHz	3
>3 MHz to 4 MHz	4
>4 MHz to 5 MHz	5

For Carrier ≤ 100 Hz

$$\frac{\text{Burst Count}}{\text{Carrier Frequency}} \leq 500 \text{ seconds}$$

(2) select: **shift | Burst**

(3) Burst parameters

(1)

A: MODulation Menu

- 1: AM SHAPE Selects the shape of the AM modulating waveform.
- 2: AM SOURCE Enables or disables the internal AM modulation.
- 3: FM SHAPE Selects the shape of the FM modulating waveform.
- 4: BURST CNT Sets the number of cycles per burst (1 to 50,000 cycles).
- 5: BURST RATE Sets the burst rate in Hz for an internal burst source.
- 6: BURST PHAS Sets the starting phase angle of a burst (-360 to +360 degrees).
- 7: BURST SRC Selects an internal or external gate source for burst modulation.

Shift

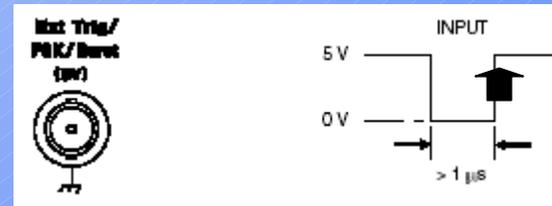
Recall Menu

Notes:

- Burts Rate – 10 mHz to 50 KHz
- To generate a **single** burst (with the specified count): Press *SINGLE* key (or apply a trigger pulse to rear-panel Ext Trig terminal)
- To output a **continuous** waveform upon receipt of a trigger, set CNT: *infinite*

To **TRIG**ger a sweep or burst

- *Internal* or “automatic” triggering is enabled when you turn on the generator. In this mode, the function generator outputs **continuously** when burst modulation or sweep is selected.
- *Single* triggering outputs **one** burst or initiates **one** frequency sweep each time you press *Single* key. Continue pressing this key to re-trigger the generator.
Pressing *Single* to enable the *single* trigger mode also enables the **external** trigger mode.



- **Shift | Internal** enables *internal* trigger.



(4) Menu – system related operations

Shift
Menu On/Off

C: EDIT MENU*

1: NEW ARB → [2: POINTS] → [3: LINE EDIT] → [4: POINT EDIT] → [5: INVERT]
→ [6: SAVE AS] → 7: DELETE

* The commands enclosed in square brackets ([]) are “hidden” until you make a selection from the NEW ARB command to initiate a new edit session.

IntuiLink – Waveform Editor

D: SYStem MENU

1: OUT TERM → 2: POWER ON → 3: ERROR → 4: TEST → 5: COMMA → 6: REVISION

output termination: 50 ohm | High Z

E: Input/Output MENU

1: GPIB ADDR → 2: INTERFACE → 3: BAUD RATE → 4: PARITY → 5: LANGUAGE

GRIB = GPIB

F: CALibration MENU*

1: SECURED → [1: UNSECURED] → [2: CALIBRATE] → 3: CAL COUNT → 4: MESSAGE

* The commands enclosed in square brackets ([]) are “hidden” unless the function generator is UNSECURED for calibration.