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**

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**Power-On and Reset State**

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

**Display**

15.000,000 MHz

With comma separator (factory setting)

**GPIB address is displayed at power-on**

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33120A  Function/ARB generator
### Display Annunciators

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

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

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

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33120A Function/ARB generator
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.

\[ R_L = \text{Lead Resistance} \]
**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): $2^r = 2^{48} = 2^{8+10+10+10+10} = 2^8 \cdot 10^{3+3+3+3}$

**33120A Function/ARB generator**
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!!

![Diagram of 33120A Function/ARB generator](image)
SYNC out (except noise and DC)
Signal OUTPUT
short-circuit protected

Front Panel

Function/Modulation keys
Menu Operation keys
Enter Number "units" keys
entry Knob
SYNC out (except noise and DC)
signal OUTPUT
short-circuit protected

Single/Internal Trigger key
Waveform Modify keys
Shift/Local key
Enter Number key
Recall/Store instrument state key

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33120A Function/ARB generator
(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)

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

MODIFY: Frequency – Hz, kHz, MHz
MODIFY the displayed number

Front Panel Number Entry

You can enter numbers from the front panel using one of three methods.

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

**Function/ARB generator**

### Output FREQuency

Square is generated from Sine with comparator

<table>
<thead>
<tr>
<th>Function</th>
<th>Minimum Frequency</th>
<th>Maximum Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sine</td>
<td>100 µHz</td>
<td>15 MHz</td>
</tr>
<tr>
<td>Square</td>
<td>100 µHz</td>
<td>15 MHz</td>
</tr>
<tr>
<td>Triangle</td>
<td>100 µHz</td>
<td>100 kHz</td>
</tr>
<tr>
<td>Ramp</td>
<td>100 µHz</td>
<td>100 kHz</td>
</tr>
<tr>
<td>Built-In Arbs ¹</td>
<td>100 µHz</td>
<td>5 MHz</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Number of Arb Points</th>
<th>Minimum Frequency</th>
<th>Maximum Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>8 to 8,192 (8k)</td>
<td>100 µHz</td>
<td>5 MHz</td>
</tr>
<tr>
<td>8,193 to 12,287 (12k)</td>
<td>100 µHz</td>
<td>2.5 MHz</td>
</tr>
<tr>
<td>12,288 to 16,000</td>
<td>100 µHz</td>
<td>200 kHz</td>
</tr>
</tbody>
</table>

\[
| V_{offset} | + \frac{V_{pp}}{2} \leq V_{max} \text{ and } | V_{offset} | \leq 2 \times V_{pp} \\
\]

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

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33120A Function/ARB generator
(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)
Menu

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

1st (main func) level

A: MOD MENU ➔ B: SWP MENU ➔ C: EDIT MENU ➔ D: SYS MENU ➔ E: 1/0 MENU ➔ F: CAL MENU

1st (command) level

1 START F ➔ 1 NEW ARB ➔ 1 OUT TERM ➔ 1 HPB ADDR ➔ 1 SECURED ➔

1st (parameter) level

1 AM SHAPE ➔ 2 AM SOURCE

To enter command, press "Enter".

50 ohm > High Z

To turn on the menu

To move up or down, left or right

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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.

<table>
<thead>
<tr>
<th></th>
<th>Sine</th>
<th>Square</th>
<th>Triangle</th>
<th>Ramp</th>
<th>Noise</th>
<th>Arb</th>
</tr>
</thead>
<tbody>
<tr>
<td>AM Carrier</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>AM Modulating Wave</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>FM Carrier</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>FM Modulating Wave</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>FSK Modulation</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Burst Modulation</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Frequency Sweep</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
</tbody>
</table>

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33120A Function/ARB generator
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.

![AM Waveform Diagram](image)

**Carrier:**
- sine, 5 kHz, 5 Vpp

**Modulating waveform:**
- AM shape: sine
- AM source:
  - INT (default)
  - Freq: 200 Hz,
  - Level: 80% mod Depth

"D" is the modulation depth 
(0 ≤ D ≤ 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

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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:

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

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

  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 Use for selecting the internal
          reference input signal.
      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 (0 to 360 degrees).
   7: FSK SRC Selects an internal or external source for the FSK rate.
   8: FSK FREQ Sets the FSK “hop” frequency.
   9: FSK RATE Selects the internal FSK rate between the carrier and FSK frequency.

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.

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**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)

**Apply Note 1407:** How to generate LOW Duty-Cycle **pulses** with a function generator
**Burst settings**

1. **carrier**
   - **function** (see modulation MATRIX)
   - **freq**
   - **ampl**
   - **offset**

2. select: **shift | burst**

3. **burst parameters**

A: MODulation Menu

1. AM SHAPE
2. AM SOURCE
3. FM SHAPE
4. BURST CNT
5. BURST RATE
6. BURST PHAS
7. BURST SRC

Notes:
- Bursts 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

For sine, square, and arbitrary waveforms only.

<table>
<thead>
<tr>
<th>Carrier Frequency</th>
<th>Minimum Burst Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 mHz to 1 MHz</td>
<td>1</td>
</tr>
<tr>
<td>&gt;1 MHz to 2 MHz</td>
<td>2</td>
</tr>
<tr>
<td>&gt;2 MHz to 3 MHz</td>
<td>3</td>
</tr>
<tr>
<td>&gt;3 MHz to 4 MHz</td>
<td>4</td>
</tr>
<tr>
<td>&gt;4 MHz to 5 MHz</td>
<td>5</td>
</tr>
</tbody>
</table>

For Carrier ≤ 100 Hz

Burst Count ≤ 500 seconds
To TRIGger 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

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.

D: SYStem MENU
output termination: 50 ohm | High Z

E: Input/Output MENU
1: HPIB ADDR → 2: INTERFACE → 3: BAUD RATE → 4: PARITY → 5: LANGUAGE

GRIB = HPIB

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

IntuiLink – Waveform Editor