



## 171 MHz Four Channel Signal Generator

### Model 409B



The 409B is a 171 MHz, Four Channel, Direct Digital Synthesized Signal Generator in a small table top case. The 409B generates four output signals simultaneously up to 171 MHz in 0.1Hz steps under serial control. The frequencies of the four outputs can be independently set and can be offset from each other by 14-bits ( $0.02^\circ$ ) of programmable phase. The sine wave amplitudes are 10-bit programmable.

The 409B is programmed by sending it simple text commands using an RS232 serial interface. All settings can be stored in non-volatile memory. A windows program is included and provides a graphical interface for generating the serial commands, allowing simple control of the 409B.

The 409B uses a single master clock that synchronizes all four output channels. This clock can be the internal 28MHz TCXO or an external clock input of up to 500MHz.

When Option /R is installed the REF IN external clock must be 10MHz and this external clock is used to discipline the internal 28MHz TCXO when it is present. If 10MHz is not connected to the REF IN connector then the undisciplined internal clock is used.

When both Option /R and /E are installed an additional SMA connector labeled EXT CLK is provided on the rear panel and the user has the

choice of using the internal clock (disciplined), the internal clock (undisciplined) or an external clock of up to 500 MHz. When using an external clock that is not disciplining the internal clock, the user must apply a scale factor when sending frequency commands and may also need to use an external analog filter.

The 409B has on board RAM, configured as a Table, to enable high speed agile frequency, phase and amplitude modulation and hopping.

#### Model 409B Table Mode

The Model 409B can store up to 32,768 profile points in a random access memory (RAM) Table. A profile point consists of a set of frequency, phase, amplitude and dwell time values for channels 0 and 1. The dwell time is an 8 bit value between 100 microseconds and 25 milliseconds. The 409B can step through the Table continuously and stay on each profile point for the duration of the dwell time. It can also bypass the dwell and execute single step serial commands. The table values are stored in static RAM and are backed up by a capacitor for about 10 minutes after power is removed. Stepping through the Table can also be controlled using external triggers when the -AC Option is installed as explained in the description of the -AC Option on the next page.



409B-AC /W Rear View (/W Dongle not shown)

### 409B Option -AC, Table Timing Control

Option -AC provides two SMA connectors, labeled TS and IOUD, to enable external control of the RAM Table. They can be configured in two ways. One configuration, the default, enables an external trigger connected to the TS connector to

cause the 409B to advance through the table one step at a time. There is a delay of about 100 microseconds after receipt of a trigger on the TS connector. One step means that both outputs 0 and 1 advance to the next profile point.

Changing the default configuration by sending an “I e” command will change the behavior of the 409B when a trigger is applied to the TS connector or when a TS serial command is received. Instead of advancing one step, the TS trigger initiates a load operation that takes about 100 microseconds. After the load operation is completed, a subsequent trigger on the IOUD connector causes the 409B to advance one step 100 nanoseconds ( $\pm 8$  nanoseconds) after the IOUD trigger. This enables tighter synchronization with external events.

### 409B Option /R, Lock to Reference

Option /R adds a circuit board inside the 409B that detects when a 10 MHz signal has been applied to the EXT REF BNC and then phase locks the internal 409B oscillator to the external 10 MHz signal. This improves the accuracy and stability of the

409B so that it is equal to the accuracy of the supplied 10 MHz signal. Improvements in frequency accuracy by factors of better than 10,000 are achievable using option /R. Adding the /R option disables the external clock feature of the 409B.

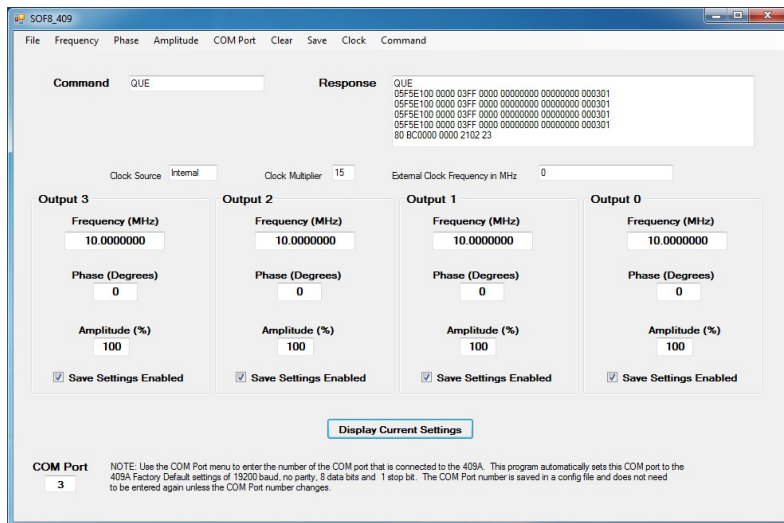


### 409B Option /W, Wireless Serial Interface

Option /W provides plug and play wireless communication between the Model 409B and a computer or tablet. There is no user setup or software required. It includes a dongle with a DB9 connector that plugs into the rear of the Model 409B and communicates wirelessly with a second dongle that has a USB connector. The DB9 dongle is powered by the 409B. The USB (or micro USB with the adapter) dongle is powered by a computer or tablet. The wireless communication range is



approximately 30 feet. A solid green light on the DB9 dongle shown above indicates a successful wireless connection. The USB Dongle uses the FTDI chipset. Most computers will automatically set up a virtual COM port when the USB dongle is plugged in. The USB dongle has been used successfully with Android devices running the “Serial USB Terminal” Android application, available from Google Play.



## SOF8\_409 Windows Software

The Model 409B comes with a free copy of the SOF8\_409 Software on a CD. The SOF8\_409 Software is a Microsoft Visual Basic application that runs in all versions of Microsoft Windows. It provides drop down menus to make it easy for users to control most functions of the 409B and to load data from external text files to run scripts and load the 409B RAM Table. It also provides a command menu for sending text strings to the 409B. Display fields show all of the 409B settings including the frequency, phase and amplitude of

each output channel. You can open multiple copies of the SOF8\_409 Software at the same time using different COM port numbers for each copy in order to program multiple 409B from a single computer.

## SPECIFICATIONS

### OUTPUTS

TYPES: Four Sine simultaneously (four independent, phase synchronous outputs.)

IMPEDANCE: Sine: 50Ω; LVCMOS: 50Ω.

RANGE: 0.0Hz to 171MHz in 0.1 Hz steps (Sine out, int. clock).

SINE AMPLITUDE: approximately 1V<sub>pp</sub> (+4dBm) into 50 Ω. Pro-programmable from 0/1024 to 1023/1024 of Full Scale (10-bits), or by scale factors of 1/2, 1/4, or 1/8.

PHASE: Each channel 14-bits programmable.

FLATNESS: ±3dB from 1kHz to 150MHz referenced to amplitude at 35 MHz, full scale.

**LVCMOS AMPLITUDE** (consult factory for availability)

V<sub>oh</sub> >=2.4V and V<sub>ol</sub> <=0.4V when series terminated. Rise and fall times <1.5ns with <15pF load. (>1 MHz, <125 MHz)

### CONTROL

All output frequencies (32-bits), amplitudes (10-bits) and phases (14-bits) are independently controlled by an RS232 serial port at 19.2kbaud. All settings can be saved in non-volatile memory.

### ACCURACY AND STABILITY

Accuracy: <±1.5ppm at 10 to 40°C. Stable to an additional ±1ppm per year, 18 to 28°C. (Internal Clock)

### EXTERNAL CLOCK IN (BNC)

LEVEL: 0.2 to 0.5Vrms Sine or Square Wave. 50Ω.

FREQUENCY: 10 MHz to 125 MHz with PLL clock multiplier of 4 to 20 enabled. Direct input of 1 MHz to 500 MHz.

### /E OPTION EXT CLK (SMA)

Same as External Clock above

### /R OPTION REF INPUT (BNC)

Changes functionality of REF IN BNC. Accepts only 10.00 MHz, ±5ppm. Automatically detected. Internal clock is locked to this value.

**SPECTRAL PURITY** (Typ. 50W load, internal clock, full-scale output)

Phase Noise: <-120dBc, 10kHz offset, 5MHz out.

Spurious:

- <-60dBc below 10MHz (typ. 300MHz span)
- <-60dBc below 40MHz
- <-55dBc below 80MHz
- <-50dBc below 160MHz

Harmonic:

- <-65dBc below 1MHz
- <-55dBc below 20MHz
- <-45dBc below 80MHz
- <-35dBc below 160MHz

(channel-channel isolation: <-60dBc)

### TABLE MODE

On-board 4Mb static ram holds up to 32,768 profile points in table mode allowing a different output in 100ms increments.

### POWER REQUIREMENTS

+4.75 to +5.25V@<750mA. AC-adaptor provided.

### SIZE

39mm H, 107mm W, 172mm L, not including connectors.

### CONNECTORS

BNC for Outputs and REF IN. SMA for EXT CLK (option /E). Barrel with 2.5mm center positive for +5VDC power. DE9 for Serial Control.

## 409B RS232 Serial Commands

RS232 Command	Function
Fn xxx.xxxxxxx	Set Frequency of output channel "n" in MHz to nearest 0.1Hz. Decimal point required. Set to 0.00 to set a channel to DC. n = 0, 1, 2 or 3. Maximum setting: 171.1276031MHz. Single tone mode.
Pn x	Set Phase. x is an integer from 0 to 16383. Phase is set to $x \cdot 360^\circ / 16384$ or $x \cdot \pi / 8192$ radians. Sets the relative phase of the frequency output of channel n. n = 0, 1, 2 or 3. Single tone mode.
E x	Serial echo control. x = D for Echo Disable, x = E for Echo Enable
C x	Select clock source. x = E for External clock, x = I for Internal Clock. If External, may require adjustment of Kp and analog filtering of outputs. (Do not use this command if the /R option is installed.)
R	Reset. This command resets the 409B. EEPROM data is preserved and, if valid, is used upon restart. This is the same as cycling power.
CLR	Clear. This command clears the EEPROM valid flag and restores all factory default values.
A x	X = E for LVCMOS Enable, x = D for LVCMOS Disable. (consult factory for LVCMOS)
S	Saves current state into EEPROM and sets valid flag. State used as default upon next power up or reset. Use the "CLR" command to return to default values.
QUE	Return present frequency, phase and status. Returns a character string of all internal settings.
M x	Mode command. x = 0 puts the 409B into single tone on all channels (default). X = t puts the 409B into Table Mode for channels 0 and 1.
Vn x	Set voltage level of output. In default, the amplitude is set to the maximum: approximately 1Vpp (+4dBm) into 50 Ohms. x can range from 0 (off) to 1023 (no decimal point allowed). Voltage level is scaled by $x/1023$ . If $x \geq 1024$ , the scaling is turned off and the selected output is set to full scale. Use n = 0, 1, 2 or 3 to set the amplitude on output channel 0, 1, 2 or 3.
Vs x	Set the output scaling factor. x = 1 for full scale, x = 2 for one half scale, x = 4 for one quarter scale and x = 8 for one eighth scale. All channels are scaled equally.
Kp xx	Set Kp, the PLL reference multiplier constant. Parameter xx must be one Hexadecimal byte astwo characters. Legal values are 1 (bypass PLL) and 4 to 20 (01h, 04h to 14h). Values of xx times clock frequency must not be between 160MHz and 255MHz (for internal clock, this disallows $5 \leq xx \leq 9$ ).
TS	Table Step command. If the M command is set to t, sending TS causes the 409B to advance to the next table profile point. Requires all dwell settings to be ff. The TS command can also be executed by a negative edge (i.e. ground) on the rear mounted TS control input. (Option -AC adds the TS control Input)
I x	Set the I/O update pulse method. If x = a, then an I/O update is issued at the end of each serial command (default). If x = m, then a manual I/O update pulse is sent by a subsequent 'I p' command. If x = e then I/O update is issued when a positive 3.3V edge is applied to the rear mounted IOUD control input. (Option -AC adds the IOUD control input.)