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INSTRUMENTS

171 MHz Four Channel Signal Generator
Model 409C

The 409C is a 171 MHz, Four Channel, Direct Digtal Synthesized Signal Generator in a small table top case. The 409C 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 (0.02º) of programmable phase. The sine wave amplitudes are 10-bit programmable.

The 409C is programmed by sending it simple text commands using a USB 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 409C.

The 409C uses a single master clock that synchronizes all four output channels. When Option /R is installed a 10Hz external clock is used to discipline the internal 28MHz TCXO. If a 10MHz signal is not connected, the 409C will detect that it is not present and will still use the internal clock but it will not be disciplined.

Model 409C Table Mode

The 409C has flash memory, configured as a Table, to enable high speed agile frequency, phase and amplitude modulation and hopping.

The 409C Table can store up to 14,250 rows. A row consists of a row number, a dwell time and at least one but as many as four sets of frequency, phase and amplitude values. The 409C can move through the table as fast as one row every 13 microseconds for rows with only one channel of data. It can also be controlled manually using single step serial commands. Stepping through the Table can also be controlled using external customer supplied hardware triggers.

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409C Rear View

409B Table Timing Control

External hardware logic signals can be used to trigger updates to the 409C Table. This can be done in two ways. One configuration, the default, enables an external trigger connected to the TS input to cause the 409C to advance through the table one step at a time. One step means all outputs in a row advance to the next row. There is a minimum dwell time that each row must be active before moving to the next row. This dwell time is dependent on the number of channels in the previous row and ranges from 13 microseconds for one channel to 31 microseconds for four channels.

Changing the default configuration by sending an "**I e**" command will change the behavior of the 409C when a trigger is applied to the TS connector. After an "I e" command, applying a trigger signal to the TS input will move the next row into DDS memory. After this load operation is completed, a subsequent hardware trigger on the IOUD connector causes the 409C to advance to the next row within about 100 nanoseconds. This enables tighter synchronization with external events.
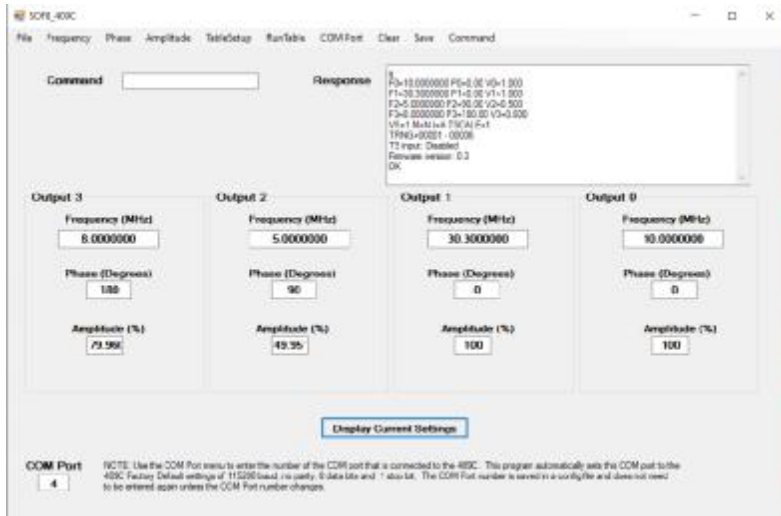
The J8 connector is standard and includes TS and IOUD pins. Alternately, the –AC option adds SMA connectors for the TS and IOUD input signals.

409B Option /R, Lock to Reference

Option /R adds a rear mounted BNC connector and a circuit board inside the 409C. The circuit board detects when a 10 MHz signal has been applied to the BNC connector and then phase locks the internal 409C oscillator to the external 10MHz signal. This improves the accuracy and stability of the 409C 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.

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SOF8_409C Windows Software

The Model 409C comes with a free copy of the SOF8_409C Software on a USB Memory Stick. The SOF8_409C 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 409C and to load data from external text files to run scripts and load the 409C Table. It also provides a command menu for sending text strings to the 409C. Display fields show the 409C settings including the frequency, phase and amplitude of each output channel. You can open multiple copies of the SOF8_409C Software at the same time using different COM port numbers for each copy in order to program multiple 409C from a single computer.

SPECIFICATIONS

OUTPUTS
TYPES: Four Sine simultaneously (four independent, phase synchronous outputs.)
IMPEDANCE: 50W
RANGE: 0.0Hz to 171MHz in 0.1 Hz steps (Sine out, int. clock).
SINE AMPLITUDE: Programmable from 0.000 tp 1.000 Vpp into 50W
PHASE: Programmable from 0 to 359.99 degrees
FLATNESS: ±3dB from 1kHz to 150MHz referenced to amplitude at 35 MHz, full scale.

TABLE
Stores up to 14,250 rows each containing row number, dwell time and from 1 to 4 channels of frequency, phase, and amplitude. .

CONTROL
All output frequencies (32-bits), amplitudes (10-bits) and phases (14-bits) are independently controlled by sending commands from the USB serial ort or by executing rows saved in the 409C table. All outputs and other settings can be saved in non-volatile memory.

FREQUENCY ACCURACY AND STABILITY
Accuracy: $<\pm1.5$ppm at 10 to 40°C. Stable to an additional ±1ppm per year, 18 to 28°C. (Internal Clock)

/R OPTION 10MHz INPUT (BNC)
Accepts only 10.00 MHz, ±5ppm. Automatically detected. Internal clock is locked to and tracks this value. Level muist be 0.2 to 0.5 Vrms, sine or square wave into 50W.

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)

POWER REQUIREMENTS
+4.75 to +5.25V@<750mA. AC-adapter provided.

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

CONNECTORS
BNC for Sine Outputs and 10MHz IN. Type B Female for USB Serial control. 2.5mm center positive power receptacle for +5VDC power. 14 pin header for logic I/O (J8), SMA for –AC logic I/O. (J8 and –AC have redundant functionality)

LOGIC I/O
Voh $>=$2.4V and Vol $<=$ 0.4V when series terminated. Output rise and fall times approximately 100 ns.

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Command	Function
Fn xxx.xxxxxxx	Set **Frequency** of output "n" in MHz to nearest 0.1Hz. n=0, 1, 2 or 3. Decimal point not required. 0.00 sets a channel to DC. Maximum setting: 171.1276031 MHz. Single tone mode.
Pn xxx.xx	Set **Relative Phase** of output "n" in degrees. n=0,1,2 or 3. N= 0.00 to 359.99. Single tone mode.
Vn x.xxx	Set the **Amplitude** of output channel "n". n=0,1,2 or 3. The amplitude indicates the signal level in Vpp when driving a 50 ohm load. Maximum amplitude setting is 1.000 . The default amplitude is set to the maximum. If the amplitude scale factor is not 1, the Vn command specifies the output amplitude before the amplitude scale factor is applied.
Vs n	Set the output **Amplitude Scale Factor**. n=1 for full scale, n=2 for one half scale, n=4 for one quarter scale and n=8 for one eighth scale. All channels are scaled equally
E x	Serial **Echo** control. x=D for Echo Disable, x=E for Echo Enable
R	**Reset.** This command resets the 409C to the same state as after power-up or cycling power, except the baud rate remains unchanged (cycling power will reset the baud rate to 115.2KBaud).
CLR	**Clear.** This command resets all factory default values except for the values stored in table memory. Use the **TCLEAR** command to reset the table to an empty state.
S	**Save.** Saves Frequency, Amplitude, Amplitude Scale Factor, Relative Phase, Phase Reset Mode, Update Mode, Active Table Range, Table Dwell Scaling and Echo settings to flash memory. Does not save the Table Rows. Use TSAVE to save Table Rows. Saved values will be the default settings upon next power up or reset. Use the "CLR" command to return to factory default values.
Q	Returns the current values of the non-volatile settings and the firmware version.
M x	**Phase Mode**. x=N means the phase will not be reset with every update. This is the default mode. x=A means the phase will be reset on every update. x=S will force a manual update on all phases.
I x	**I/O Update (IOUD).** If x=a, then an IOUD update pulse is automatically sent at the end of each serial command. This is the default. If x=m, then an IOUD update pulse must be sent manually. If x=p a manual IOUD update pulse is sent. If x= e, then the IOUD is changed from an output to an input. If x=s, then external TS inputs are enabled. If x=d the external TS inputs are disabled.

Command	Table Function ([…] indicates optional parameters)
T r d c f p a [c f p a] [c f p a] [c f p a]	**T Command.** Enters a row into the table. Where r=row, d=dwell, c=channel, f=frequency, p=phase and a=amplitude. One channel set consisting of 'c f p a' values is required. Up to three additional channel sets as indicated by [...] is optional. The entire T command must be on one line.
TSCALE x	**Dwell Scaling Command.** 'x' can be 1 or 4. x=1 is the default and sets the maximum dwell time to 8191.875 microseconds. If x=4 then all the dwell times are multiplied by 4 and the maximum dwell time becomes (4 x 8191.875 = 32.7675) milliseconds. Parameter 'x' is saved using the 'S' command.
TSAVE	**Save to Flash Command**. The T Command creates table data in RAM memory. The TSAVE command saves this RAM table data to flash memory. The table only operates on data that is in flash memory.
D x y	**Display Table**. Reads and displays the table values from row x to row y.
TRNG x y	**Table Range Command**. Makes a range of rows in the table **Active**. The TRUN and TONCE commands only operate on the Active rows. The active rows start at row x and include all rows up to and including row y. Default is the entire table from row 0 to 14249. The parameters x and y are saved using the 'S' command.
TRUN [x y]	**Run Table Command.** Saves all table rows to flash memory if they have been entered but not saved and starts the table continuously looping through the active table rows. If the optional x and y parameters are entered then the table will loop from row x to row y. Also sets the IOUD signal to an output and disables the TS hardware inputs.
TONCE [x y]	**Run Table Once Command.** Saves all table rows that have been entered but not saved and causes the table to run once through the active table rows. If the optional x and y parameters are entered then the table will run once from row x to row y. Also sets the IOUD signal to an output and disables TS hardware inputs.
TSTOP	**Stops** the table from running. The state of the channels will be the sames as they were when the table was stopped.
TS [x]	**Table Step Command.** Causes the table to move to the next active row. Does not save table data in RAM to flash memory. You must use the TSAVE command to save to RAM. If the optional 'x' parameter is included it causes the table to go to row x.
TCLEAR	**Clear Table Command.** Resets all table rows in the table flash memory to the empty state.

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