NOVATECH

INSTRUMENTS

INSTRUCTION MANUAL

Model 426A, Dual Channel 400MHz Signal Generator

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1.0 DESCRIPTION

1.1 The Model 426A is a 48-Bit Direct Digital Synthesized (DDS) Signal Generator in a small shielded table top case with an asynchronous serial control port (RS232). The 426A provides two independently programmable sine wave output signals which can be set from 250 kHz to 400 MHz in steps of 10 μHz.

1.2 Relative phase is adjustable with 14-bits of resolution and amplitude can be trimmed over a 10-bit range.

1.3 Internal Clock. The 426A contains an internal Temperature Compensated Crystal Oscillator (TCXO) that is used in a phase lock loop to generate a 1GHz clock to drive the internal frequency synthesizer. This mode is set by the "C D" command. This is the factory default .

1.4 External Reference Input Clock. An external reference input signal is used in a phase lock loop to generate a 1GHz clock to drive the internal frequency synthesizer. The reference input frequency must be in the range of 1MHz to 25MHz in 8kHz steps. This mode is set by the "C E" command and requires that the "FR" command be used to store the value of the reference input frequency. When the reference input is used, the frequency accuracy of the 426A will be equal to the accuracy of the reference input clock.

1.5 Direct Input Clock. An external clock signal from 250MHz to 1GHZ can be used as the clock for the internal frequency synthesizer, bypassing the internal VCTCXO oscillator. This mode is set by the "C P" command and requires that the "FD" command be used to store the value of the direct input frequency. Multiple 426A units can have phase synchronous outputs if they all use the same direct clock Input. When the direct input clock is used, the accuracy of the 426A will be equal to the accuracy of the clock Input. The 426A will use the value stored by the "FD" command to automatically compute and apply a scale factor to the commanded frequency.

The 426A output filters are optimized for a 1 GHz clock. If the direct input frequency is significantly below 1GHz then the user may need to provide external filters to optimize output signal performance..

2.0 SPECIFICATIONS

2.1 OUTPUT
TYPE: Sine Waves on each of two output channels.
IMPEDANCE: 50Ω.
RANGE: 300kHz to 400MHz in 10 μHz steps.
AMPLITUDE: Approximately 2.7dBm into 50Ω at 100MHz output.
FLATNESS: Typically ± 3dBm from 10MHz to 200MHz referenced to amplitude at 100MHz

2.2 CONTROL
Output frequency (48-bits), amplitude attenuation (10-bits) and phase (14-bits) are controlled by sending simple text commands over a bit-serial interface port (RS232) at 19.2kBaud. Settings can be saved via the serial port.

2.3 INTERNAL CLOCK (FACTORY DEFAULT)
TYPE:TCXO clock in phase lock loop generates 1 GHz clock for the frequency synthesizers.
ACCURACY: <±1.5ppm at 10 to 40°C. Stable to an additional ±2ppm per year, 18 to 28°C.

2.4 EXTERNAL CLOCK (REFERENCE INPUT)
TYPE: User must supply a signal within range of 1MHz to 25MHz in 8kHz steps. Must be ±5ppm of value stored by "FR". Used in phase lock loop to generate 1GHz clock for the frequency synthesizers.
LEVEL: ± 5dBm (0.126Vrms to 0.4Vrms) Sine or Square Wave. 50Ω.
ACCURACY: When locked, equal to the accuracy of the user supplied signal.

2.5 EXTERNAL CLOCK (DIRECT INPUT)
TYPE: User must supply a signal within range of 250MHz to 1GHz. This signal is used directly as the clock for the frequency synthesizers.
LEVEL: ± 5dBm (0.126Vrms to 0.4Vrms) Sine or Square Wave. 50Ω.
ACCURACY: Equal to the accuracy of the user supplied signal.
SCALING: 426A firmware will use the frequency stored in "FD" and automatically apply a scale factor to the commanded frequency.

2.6 SPECTRAL PURITY (INTERNAL CLOCK)

(Typ. 50Ω load, 10MHz ref.)
Phase Noise: <-130dBc, 10kHz offset, 10MHz output.
Spurious: <-55dBc below 10MHz
<-50dBc below 80MHz
<-45dBc below 160MHz
<-35dBc below 400MHz

Harmonic: <-60dBc below 1MHz
<-55dBc below 20MHz
<-50dBc below 80MHz
<-40dBc below 160MHz
<-35dBc below 400MHz

2.7 POWER REQUIREMENTS

+5VDC (+4.75 to +5.25) @<1.5A. (90-240VAC with provided AC-adapter)

2.8 SIZE

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

2.9 ENVIRONMENTAL

Temperature: 0°C to +50°C operating.
Humidity: 80% to 31°C, decreasing linearly to 50% at 40°C.

2.10 CONNECTORS

Sine Outputs: Two front panel BNC; Reference and Direct Inputs: rear panel BNC.
RS232 control: DE9F on rear panel. +5V DC Power: 2.5mm power receptacle, center positive.

2.11 CONFIGURATIONS

Model 426A Two Output Channels
Model 426A/01 One Output Channel

3.0 HARDWARE INSTALLATION

3.1 Power Connection. The input power is applied through a 2.5mm center-positive power connector on the rear panel. A solid green light on the front panel LED indicates power is on.

3.2 Power Supply. The quality of your power supply affects the performance of the 426A. The supply should be free of ripple and noise (<50mV). Even though extensive filtering is used internal to the 426A, a quiet and well regulated power supply will ensure optimum performance. The supplied AC-adapter has been tested for proper operation.

3.3 Serial Port Interface Installation. The 426A is controlled by using an asynchronous serial port (RS232). Direct connections can be made from most PCs by using a USB to RS232 serial (DE9) adapter. The 426A rear panel connector is a 9-pin female.

3.4 If you are using a different computer, terminal or other control source, please note that the data TO the 426A is on pin 3; the data FROM the 426A is on pin 2 and the COMMON return is on pin 5. Set your host to 19200 baud, 8 bits, 1 stop bit, no parity and no hardware flow control.

3.5 Rack Mounting. An optional 1U rack adapter is available for mounting up to four 426A into a rack panel.

4.0 OPERATING INSTRUCTIONS

4.1 Apply Power

Plug the 5Vdc connector from the AC Power Adapter into the rear panel connector labeled 5V.

After power is applied, the 426A takes approximately 500ms to initialize. Commands sent during this time will be ignored or may cause erroneous operation.

4.2 Warmup. Specifications are met within approximately 15 minutes of power up.

4.3 Sending Commands. After the 426A has been installed in the customer application system, all that is required for operation is to use the serial port to send the appropriate commands. Commands are not case sensitive and must end with any combination of Carriage Return (CR) or CRLF. See the Table on page 5 for a list of the valid 426A commands.

4.4 Command Response Code. A response code of "OK" is returned after sending a valid command. A response code of "?0" is returned if the command is not recognized.

NOTE:

*The **NT Terminal** windows application is included with the 426A. This program enables you to conveniently send commands to the 426A and display the 426A responses. It has a "COM Port" menu where you can view the available COM ports and select the COM port number that is connected to your 426A. It also enables you to set the windows computer baud rate to the 426A baud rate of 19200 baud.*

4.5 Query Command. The **Q** command returns the present state of the 426A. See the Table of Commands on page 5 for an explanation of the values returned by the **Q** command. The default values are as follows:

q
F0 = 10.00000000000
P0 = 0.00
V0 = 1023
F1 = 10.00000000000
P1 = 0.00
V1 = 1023
FR: 10.000
FD: 1000.000
Clock mode: D
Update mode: A
PLL: Locked
Firmware version: x.x
OK

4.6 Echo. For maximum interface speed, it is suggested that Echoing be disabled by using the "E d" command. This will allow the host to send characters at a faster rate. Even when Echo is disabled, the 409B will respond with an "OK" for a correctly received data command.

4.7 Phase conversion to degrees. The PN command sets the relative phase of sinewave output N from 0 to 16383. N is either 0 (channel 0) or 1 (channel 1). To convert this to degrees use the formula Degrees = (P/16384)*360.

4.8 Phase Synchronization. Once P1 and P2 are set to the desired phase values, send the PS command to actually synchronize the phases.

4.9 Amplitude attenuation. The VN command sets the amplitude attenuation of sinewave output channel N from 0 to 1023. N is either 0 (channel 0) or 1 (channel 1). A VN of 1023 sets the output to the full scale amplitude. This is the default. A VN of 0 attenuates the output by about 14dBm.

4.10 Master Clock. The master clock determines the frequency accuracy of the 426A. There are three ways to configure the master clock. These are Internal, External Reference and External Direct.

4.11 Internal Master Clock. This is the default configuration and can also be selected by sending a "C D" command to the 426A. In this configuration, the 426A uses an internal 40MHz TCXO oscillator in free run mode as the Master clock for the synthesizers. A phase lock loop circuit multiplies the 40MHz to 1GHZ to drive the DDS ICs.

4.12 External Reference Master Clock. The frequency accuracy can be improved by using a precise external reference frequency. This is accomplished by entering the external reference frequency using the "FR xx.xxx" command and then sending a "C e" command. The 426A will use a phase lock loop to step up the reference frequency to about 1GHz and use this as the master oscillator. The external reference must be a signal from 1MHz to 25MHz in steps of 8kHZ.

4.13 Direct Input Master Clock. An external signal from 250MHz to 1GHz can be used directly as the 426A master clock. This is accomplished by sending the "C P" command to the 426A and storing the value of the external signal in the 426A by using FD command. When the master clock is set to direct input the frequency accuracy is equal to the accuracy of the external signal and the 426A output is phase synchronous with the direct input signal. This master clock configuration enables the user to use multiple 426A and make their outputs phase synchronous.

426A Table of Commands

Command	Function
FN xxx.xxxxxxxxxx	Sets frequency of output "N" in MHz to nearest 10 μMHz. N=0 or 1. Maximum setting is 403 MHz. Factory default is 10MHz.
PN xxxxx	Set phase of output N. N = 0 or 1. x must be an integer from 0 to 16383. Phase is set to N*360/16384 degrees (N*π/8192 radians). This command sets the relative phase of the output sine wave.
PS	Synchronizes the phase alignment of both channels
I x	Update mode. x = A sets the update to happen immediately after each command is executed. X = M sets updates to be deferred until an I P command is sent. X = P updates all channels with pending updates.
VN xxxx	Sets the amplitude attenuation of frequency output channel N. N is 0 or 1. x is an integer from 0 to 1023. 1023 is full scale and is the factory default. 0 sets the attenuation to about 14dBm.
FR xx.xxx	Stores the reference frequency Input in MHz in 1kHz steps. Range: 1MHz to 25MHz. This value is used in a phase lock circuit to generate a 1GHz clock for the internal synthesizer(s). Factory default is 10MHz.
FD xxx.xxx	Stores the direct frequency input in MHz. Range is 250.000 to 1000.000. The 426A uses this value as the clock for the internal synthesizer(s). There will be no fractional frequency error if the ratio FD/FN = 2^y where y is an integer.
C x	Sets the clock source for controlling the internal synthesizer(s). x=D for internal TCXO oscillator (Default). x=E for an external reference input. X=P for external direct input.
E x	Serial Echo Control. X = D for Echo Disable, x = E for Echo Enable. Factory default is Enabled.
S	Saves settings to non-volatile memory.
R	This command resets the 426A. Non-volatile data is preserved and, if valid, it is used upon restart. This is the same as cycling power.
CLR	This command restores all factory default values and restarts the 426A.
Q	Returns a formatted text string with the status of all programmable settings. Where: **Q** is the echo of the command, **F0** & **F1** are the output frequencies, **P0 & P1** are the phase, **V0** & **V1** are the amplitude attenuation, **FR** is the reference frequency input value, **FD** is the Direct Frequency Input value, **Clock Mode** is D(Internal), E(External Reference) or P(Direct Input). **Update Mode** is A(automatic) or M(Manual) as set by the I x command. When set to M an I P command must be sent to perform an Update. PLL locked means the 426A 1 GHz clock is locked to the external reference (if clock mode is E) or to the internal 40MHz TCXO clock (if the clock mode is D).

5.0 THEORY OF OPERATION

5.1 The Model 426A generates sine wave outputs using one or two internal 48-Bit Direct Digital Sythesizer (DDS) integrated circuits. At every cycle of the 426A master clock, the DDS IC increments the phase of an internal accumulator by a value determined by the frequency setting loaded into the on-chip registers. This digital phase value is converted on-chip to a sinusoidal amplitude level and delivered to an on-chip 14-bit digital to analog converter. The analog signal from this converter is filtered, amplified and sent to the sine output connector.

5.2 Master Clock. The 426A master clock determines the frequency accuracy of the 426A. The 426A uses one of three sources for the master clock. These are:

1. The internal 1.5ppm TCXO oscillator is used in a phase lock loop to generate a 1 GHz master clock.

2. A 1 to 25MHz external reference input signal is used in a phase lock loop to generate a 1 GHz master clock.

3. A user provided external direct input signal from 250MHz to 1GHZ that is used directly as the master clock . There will be no fractional frequency error if the ratio FD/FN = 2^y where FD is the direct input frequency and FN is the commanded frequency for channel N and y is an integer.

The external reference and external direct signals can be more accurate that the internal 40MHz TCXO. An advantage of the external direct input signal is that it enables the 426A output to be phase synchronous with the direct input master clock signal.

5.2 Independent Outputs. The two sine wave outputs of the 426A each have their own DDS IC and thus are independently programmable in frequency, phase and amplitude.

6.0 PERFORMANCE/FUNCTIONAL TEST

6.1 Setup. Power up the 426A and connect your host troller. Maintain the 426A in a stable environment of 18-28°C.

NOTE:

Allow the 426A to warm up for at least 15 minutes and verify there is a steady green light on the front panel LED before performing any measurements. For best results, the 426A should be verified in its installed environment.

6.2 Verify Frequency Accuracy. Set the 426A to internal clock and set the output(s) sequentially to each value in the Frequency Test Point Table on page 7. Connect a frequency counter with a ±0.1ppm or better timebase, 50Ω termination and 1 Hz resolution to the 426A output (s). Verify that the 426A meets the accuracy specification shown in the Frequency Test Point Table. Test both output channels.

6.3 Verify Amplitude. Set the frequency of the 426A output(s) to 100MHz and amplitude(s) to full scale (Vn = 1023). Connect the 426A to a spectrum analyzer (or oscilloscope) set for 50Ω termination. Verify a reading of 2.7 dBm ±3 dBm (0.86 Vpp ±0.2.5Vpp) on both outputs.

6.4 Verify Output Flatness. Set the 426A outputs to 100MHz and observe the output amplitudes. Change the 426A frequency to 10 MHz and then 200MHz on each channel. Using a Spectrum Analyzer, verify that the amplitude reading remains within ±3dB of the value at 100MHz.

6.5 Verify the External Clock Reference Input Function. Connect a 10 MHz external clock to the REF IN BNC on the 426A rear panel. The 10MHz clock must meet the specs shown in paragraph 2.4. Next send a "C E" command and an "FR 10" command to the 426A. Finally send an "F0 100" command to the 426A and then verify that the frequency on the 426A output channel 0 is 100MHz ± the external clock frequency error.

Recommended Test Equipment

Item	Minimum Specification	Recommended
Oscilloscope	500 MHz 50Ω	Tektronix TDS3052C
50Ω Termination	50Ω ±1%	
Frequency Counter	350 MHz	HP53132A
Counter Time Base	10 MHz <±0.1 ppm	
External Clock	400 MHz	Novatech Instruments Model 426A

Frequency Test Points

Frequency	Tolerance
10 MHz	±15 Hz ±1 LSD
100 MHz	±150 Hz ±1 LSD
300 MHz	±450 Hz ±1 LSD

6.6 Verify the External Clock Direct Input Function. Connect a direct clock signal between 250MHz and 1GHz to the REF IN BNC on the 426A rear panel. The direct cock signal must meet the specs shown in paragraph 2.5. Next send a "C P" command and an "FD xxx.xxx" command to the 426A where xxx.xxx is equal to the frequency of the direct clock signal . Finally send an "F0 100" command to the 426A and then verify that the frequency on the 426A output channel 0 is 100MHz ± the direct clock frequency error.

7.0 Calibration. There are no user calibration adjustments on the 426A.

WARRANTY

NOVATECH INSTRUMENTS warrants that all instruments it manufactures are free from defects in material and workmanship and agrees to replace or repair any instrument found defective during a period of one year from date of shipment to original purchaser.

This warranty is limited to replacing or repairing defective instruments that have been returned by purchaser, at the purchaser's expense, to NOVATECH INSTRUMENTS and that have not been subjected to mis-use, neglect, improper installation, repair alteration or accident. NOVATECH INSTRUMENTS shall have the sole right to final determination regarding the existence and cause of a defect.

This warranty is in lieu of any other warranty, either expressed or implied, including but not limited to any warranty of merchantability or fitness for a particular purpose. In no event shall seller be liable for collateral or consequential damages. Some states do not allow limitations or exclusion of consequential damages so this limitation may not apply to you.

All instruments manufactured by NOVATECH INSTRUMENTS should be inspected as soon as they are received by the purchaser. If an instrument is damaged in shipment the purchaser should immediately file a claim with the transportation company. Any instrument returned to NOVATECH INSTRUMENTS should be shipped in its original shipping container or other rigid container and supported with adequate shock absorbing material.

This warranty constitutes the full understanding between NOVATECH INSTRUMENTS and the purchaser and no agreement extending or modifying it will be binding on NOVATECH INSTRUMENTS unless made in writing and signed by an authorized official of NOVATECH INSTRUMENTS.

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