

NOVATECH INSTRUMENTS

INSTRUCTION MANUAL Model 408A 100MHz Quadrature Signal Generator



408A

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1.0 DESCRIPTION

1.1 The Model 408A is a 100MHz Quadrature Direct Digital Synthesizer (DDS) in a small table top case with RS232 serial control. The 408A provides both Cosine(I), Sine(Q) and 3.3V AC MOS output signals, which can be set from 100Hz to 100MHz in 1 μ Hz steps when using the internal VCTCXO (voltage controlled temperature compensated crystal oscillator) clock.

1.2 The 408A can also be used with an External Clock input. An on-board programmable frequency multiplier generates the master clock allowing user configured frequency ranges. The multiplier can be disabled for direct inputs up to 300MHz for optimum phase noise performance. When used with an external clock, multiple 408A are phase synchronous.

2.0 SPECIFICATIONS

2.1 OUTPUTS

TYPES: Sine, Cosine and AC MOS/TTL Simultaneously.

IMPEDANCE: 50 Ω .

FREQUENCY: 100Hz to 100MHz in 1 μ Hz steps, using Internal Clock. (1×10^{-13} resolution @10MHz)

2.2 SINE/COSINE AMPLITUDE

AMPLITUDE: Approximately 0.5Vrms (+7dBm) into 50 Ω . Programmable from 0/4096 to 4095/4096 of Full Scale (12 Bits).

FLATNESS: ± 3 dB from 100kHz to 100MHz referenced to amplitude at 30MHz, stable to ± 1 dB from 18-28 $^{\circ}$ C.

2.3 AC MOS/TTL AMPLITUDE

$V_{OL} < 0.5V$, $V_{OH} > 2.5V$ into a 15pF load, series terminated. Rise and Fall Times < 5 ns. Duty Factor: 45-55%. 50 Ω output impedance. Use series or capacitively-coupled parallel termination.

2.4 ACCURACY AND STABILITY

Accurate to $< \pm 1.5$ ppm at 10-40 $^{\circ}$ C. Stable to an additional ± 2 ppm per year, 18-28 $^{\circ}$ C.

2.5 EXTERNAL CLOCK INPUT

LEVEL: 0.35-2.5Vrms Sine or Square Wave can be applied to the EXT CLK Input BNC. 50 Ω .

FREQUENCY: Input range of 5MHz to 75MHz. Programmable frequency multiplier (4x to 20x) on board. Multiplier can be bypassed for direct input to 300MHz. An external filter may be required for optimum performance.

2.6 SPECTRAL PURITY (Typ. 50 Ω load, int clk)

Phase Noise: < -140 dBc, 10kHz offset, 5MHz out.

Spurious: < -70 dBc below 10MHz (200MHz span)

< -65 dBc below 40MHz

< -60 dBc below 60MHz

< -50 dBc below 100MHz

Harmonic: < -70 dBc below 1MHz

< -60 dBc below 10MHz

< -50 dBc below 20MHz

< -40 dBc below 50MHz

< -35 dBc below 100MHz

2.7 CONTROL

Output Frequency and phase (14-bits) are controlled by an RS232 serial port at 19.2kBaud. RS232 control allows non-volatile storage of settings.

2.8 SWITCHING TIME

RS232 control depends upon host speed and commands sent, typically < 10 ms for a new frequency.

2.9 POWER REQUIREMENTS

+4.5 to +5.5VDC @ < 1.25 A. Line voltage adapter provided. (Units with serial numbers before N06001 used +12V nominal).

2.10 SIZE

Table top case: 40mm H, 106mm W, 172mm L, excluding connectors.

2.11 CONNECTORS

Front panel BNCs for SINE(Q), COSINE(I) and AC MOS/TTL. Rear panel BNC for EXT CLK IN. Power: 2.5mm center positive. DE9F for serial.

3.0 HARDWARE INSTALLATION

3.1 Power Connection. Insert 2.5mm plug from AC-adaptor into the receptacle on the rear panel. The 408A requires a nominal +5VDC. Then plug the AC-adaptor into your AC-line source.

NOTE:

Use only the AC line power adapter provided with your 408A.

3.2 RS232 Installation. To use the 408A connect your host computer to the 9-pin female RS232 connector on the 408A. If you are using a PC, a 9-pin monitor extension cable used as an RS232 cable will allow direct connection to the 408A without the use of a null modem cable or gender changer. If you are using a different computer, terminal or other control source, please note that the data **TO** the 408A is on pin 3; the data **FROM** the 408A is on pin 2 and the **COMMON** return is on pin 5. Set your host to 19.2 kbaud, 8 bits, 1 stop bit, no parity and no hardware flow control. See Table 2 for RS232 Serial Commands.

3.3 Commands are not case sensitive. There must be a space after each command except R, CLR, S and QUE. End with any combination of CR, LF or CRLF. Illegal commands will result in an error code being returned per Table 1.

Table 1: RS232 Error Codes

Error Code	Meaning
OK	Good command received (not sent for R, CLR and QUE)
?0	Unrecognized Command
?1	Bad Frequency
?2	Bad AM Command
?3	Input line too long
?4	Bad Phase
?5	Bad Time
?6	Bad Mode
?7	Bad Amp
?8	Bad Constant
?f	Bad Byte

3.4 The "QUE" command returns a string of 80 Hexadecimal (Hex) characters. The characters rep-

resent the present state of all the registers internal to the 408A. See Table 7 for the addresses that make up this string. Note that the frequency will be scaled as discussed below if an external clock has been used.

3.5 The command in "**Bold Italic**" ("**B**") can cause erroneous operation and must be used with care. Contact Novatech Instruments for application assistance if you feel you need to use this command, which is intended for "debugging" purposes.

NOTE:

The windows program SOF8 is available from Novatech Instruments This program provides a graphical interface for all the commands, allowing simple serial control of the 408A. A USB-to-Serial adapter is also available.

WARNING:

Instructions which require the case to be opened should be performed by a person qualified to do so.

3.6 Internal Clock. If you plan to use the 408A internal clock, verify that the clock select jumper wire (W1, see Figure 1) is in the INT position and that the External Clock Input is left unconnected (the jumper is a short piece of #28 AWG bare wire).

3.7 External Clock. If you are providing your own clock source, move the clock select jumper to the EXT position. Apply your clock to the External Clock Input BNC. Note that phase noise and stability are now dependent upon your supplied clock. See specifications for signal levels required and acceptable frequency range.

3.8 The external clock can also be used with Kp=1 for direct connection to the DDS generator. With Kp=1, the PLL multiplier is disabled. Use this direct input, up to 300MHz, for optimum phase noise performance.

NOTE:

When using an external clock, frequency scaling of the "F" command may be required. Please see Operation, Section 4, for details.

Table 2: RS232 Serial Commands

RS232 Command	Function
F0 XX.XXXXXXXXXXXXXX	Set Frequency in MHz to nearest 1μHz. Decimal point required.
F1 XX.XXXXXXXXXXXXXX	Start Frequency in MHz to nearest 1μHz. Decimal point required. Same as F0 if Mode 0 is selected.
F2 XX.XXXXXXXXXXXXXX	Stop Frequency in MHz to nearest 1μHz. Decimal point required. Modes 1 and 2.
Fd XX.XXXXXXXXXXXXXX	Delta Frequency in MHz. Software sets to nearest 1μHz. Decimal point required.
E x	x=D for Echo D isable, x=E for Echo E nable
Q x	x=D for Q-channel D isable, x=E for Q-channel E nable
R	Reset. This command resets the 408A. 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.
Px N	Set Phase. N is an integer from 0 to 16383. Phase is set to $N*360^{\circ}/16384$ or $N*\pi/8192$ radians. Sets either the phase P1 or P2 depending upon the value of x (1 or 2). The I and Q outputs are always nominally 90°. In Mode 0, this sets the static phase. In Mode 4, the phase is either P1 or P2 depending upon the state of Pin 8 of the parallel connector.
A x	x=E for AC MOS/TTL E nable, x=D for AC MOS/TTL D isable
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 an 80-character string of all internal settings: hexadecimal format. See Table 7.
M N	Mode command. N is 0, 1, 2, 3 or 4. 0 is Single Tone, 1 is FSK (pin 8 of parallel port is active), 2 is Triangular Ramped Frequency, 3 is Chirp Frequency and 4 is BPSK (pin 8 is active). Defaults to Mode 0 upon turn-on, unless another mode is saved. See Appendix A.
Td N	Time at each Fd (see Appendix A). N is an integer from 0 to a maximum value of $2^{20}-1$ or 1048575. Applies to modes 2 and 3 only. Approximately 3.5ns increments using internal clock. In mode 2, frequency ramps from F1 to F2 and returns to F1 continuously in steps of Fd at time intervals of Td.
Tr N	Repeat time in mode 2 and 3. In mode 3, the frequency will ramp starting at F1 in steps of Fd, at time intervals Td, until Tr times out, repeating continuously from F1. N is an integer between 5 and $2^{32}-1$ (4294967295). Approximately 7.0ns increments with the internal clock. A 3.3V CMOS level pulse at the start of each ramp is provided on Pin 10 of the parallel I/O connector. Approximately 40ns (8 system clocks) wide for the internal clock. In Mode 2, Tr sets the timing of an external trigger pulse on Pin 10 of the parallel interface.
Vx N	Set voltage level of output. In default, the amplitude is set to the maximum: approximately +7dBm into 50Ω. N can range from 0 (off) to 4095 (no decimal point allowed). Voltage level is scaled to $N/4096$. x is I or Q to set the amplitude on the I or Q channel. If $N > 4095$, the scaling is turned off and both outputs are set to maximum. Overrides the "Z" command.
Kp aa	Set PLL reference multiplier constant. Must be one Hex byte as two characters. Legal values are 1 (bypass PLL) and 4 to 20 (01_h , 04_h to 14_h).
Z N	Turns on 30% Amplitude Modulation of Cosine (I) channel output. N is the frequency of modulation in 100Hz steps, 900Hz maximum (9). $N = 0$ turns off modulation. Use of this command overrides the V command on the I channel. Entering any "M" command turns off modulation.
B aadd	Set a data byte "dd" at address "aa" in Hex. Allows setting of all internal registers. "aa" is in the range of 00_h to 27_h while "dd" is from 00_h to ff_h . No error checking, other than correct format, is performed. It is possible to set the 408A into a nonfunctional state requiring a power cycle to recover with this command. Some internal modes may require excessive power and may permanently damage the 408A (for debugging).

3.9 Signal Outputs. There are three signal outputs on the 408A: Sine (Q), Cosine (I) and ACMOS/TTL. The Sine, Cosine and ACMOS/TTL are provided on BNC connectors on the front panel. Simply connect your 50Ω application cable to appropriate output. If you are not using the ACMOS/TTL output, it is suggested that it be disabled by sending the "A D" command for best system noise performance.

NOTE:

Modes 1, 3 and 4 shown in the command table require internal parallel connections. For maximum shielding effectiveness, these connections are not accessible on the 408A. See either the Model 2908A or the Model DDS8m if you require these modes.

4.0 Operation

4.1 Power on reset. After power is applied, the 408A takes one second to initialize. Commands sent during this time will be ignored or may cause erroneous operation.

4.2 Serial Operation. After the 408A has been installed in the customer application system, all that is required for operation is to send the appropriate RS232 commands per Table 2.

4.3 The user host computer software must properly format the serial commands. Incorrect formatting will result in an error code being returned. See Table 1 for a list of RS232 error codes.

4.4 For maximum interface speed, it is suggested that Echoing be disabled by the "E D" command. This will allow the host to send characters at a faster rate. Note that no flow control is provided. Depending upon your host, the 408A may not be able to process all the serial characters. The 408A will respond with an "OK" for a correctly received data command. You must verify correct operation at your host rate.

4.5 If you are using an external clock, the value sent to the 408A during the "F" command must be scaled. The output frequency of the 408A when used with an external clock is given by:

$$F_{out} = (F_{command}) * (F_{ext\ clk} / F_{int\ clk})$$

NOTE:

An internal clock select jumper must be moved to use an external clock. See the appendix for jumper location.

4.6 The nominal Internal Clock has a nominal value of 28.1474976710656 MHz. Best performance is obtained when the External Clock input times the Reference PLL multiplier (Kp) is close to the default value (281.475MHz; max. 300MHz).

4.7 For an example, suppose an external clock of 10.000MHz is used and an output of 1.544MHz is desired:

$$F_{command} = (1.544) * (28.1474976710656) / 10.0$$

$$= 4.345973640413$$

4.8 The command then sent to the 408A for the 1.544MHz output, with a 10MHz external clock, will be (assuming Kp is unchanged):

$$f0\ 4.345973640413$$

NOTE:

You must account for your clock frequency error and calculation roundoff when using an external clock and the serial mode. Most hand calculators do not have enough digits to match the resolution of the 408A.

4.9 Since the resolution of the 408A is 48-bits, the typical fractional error for output frequencies in the MHz range will be less than 1×10^{-12} , even when exact values are not possible. The Novatech Instruments Model LPO30 can be used to lock to external references and create signals without fractional frequency error.

Typical Δf/f for External Clock of 10.0MHz

Kp	Desired Fout	Command	Δf/f
10	1.544MHz	f0 4.345973640413	1.09×10^{-13}
20	1.544MHz	f0 2.172986820206	3.93×10^{-13}
10	2.048MHz	f0 5.764607523034	1.33×10^{-13}
20	2.048MHz	f0 2.882303761517	3.06×10^{-13}

NOTE:

The "B" command can be used to access to all of the AD9854 internal registers. While not a real-time simulation of a high speed, each "B" command functions as a parallel input by putting a data byte "dd" at an address "aa", and then pulses the WRB- and IOUD lines on the AD9854.

All modes and set up conditions for the Analog Devices AD9854 can be accessed by using the "B" command. Please consult the AD9854 specifications for detailed operation.

Note that the 408A firmware modes are not identical to the AD9854 data sheet modes.

4.10 The use of an external clock scales the frequency output of the 408A. Using the 10MHz example of the serial mode description (where F_{setting} is the total binary value sent to the 408A):

$$F_{\text{out}} = F_{\text{setting}} * F_{\text{ext}} / F_{\text{int}} \mu\text{Hz}$$
$$F_{\text{out}} = 0.35527136788 * F_{\text{setting}} \mu\text{Hz}$$
$$F_{\text{setting}} = \text{Binary Value in DDS IC}$$

4.11 Note that values of F_{setting} greater than $2^{47}-1$ violate the Nyquist Theorem Limit for the 408A as it is a sampled data system.

4.12 The on-board Voltage Controlled Temperature Compensated Crystal Oscillator (VCTCXO) can be adjusted approximately ± 5 ppm from nominal by applying a 0 to 5Volt signal on P3. Your voltage control must be capable of sourcing and sinking 0.5mA. The nominal unloaded voltage at calibration is 2.37Volts. This feature is useful for applications which require Phase Locking to external sources, using customer supplied circuitry.

4.13 For systems requiring locking to an external reference, the Model LPO30A can be used to generate an external reference for the 408A. The LPO30 can generate the required 28,147,497.6710656 MHz external clock with a maximum error of 0.4 μ Hz, or a fractional frequency error of 1.4×10^{-14} , when locked to an external source.

4.14 For applications which require amplitude

matching between the I and Q channels, the recommended method is to use the "Vx N" command to adjust the I or Q channel to match the other.

5.0 Theory of Operation

5.1 Please refer to the simplified System Block Diagram in Figure 3 for the following discussion.

5.2 At every cycle of the 408A master clock, the 48-bit DDS integrated circuit increments the phase of an internal register by a value determined by the frequency setting loaded into the on-chip registers. This digital phase value is converted to both sine and cosine amplitude levels and delivered to on-chip 12-bit digital-to-analog converters. The analog signals from these converters are filtered by two 7th-order elliptical low pass filters, amplified and sent to the Cos(I) and Sine(Q) OUT BNC receptacles.

5.3 The filtered cosine signal is also sent to an on-chip comparator converting the cosine level to a 3.3V AC/MOS/TTL level signal which is then sent to the AC/MOS/TTL OUT BNC receptacle. See specifications for output level details.

5.4 The frequency generated by the DDS IC is determined by the 48-bit frequency word loaded into the frequency register on the 408A. The output frequency is given by:

$$F_{\text{out}} = F_{\text{setting}} * K_p * F_{\text{clock}} / 2^{48} \text{ Hz}$$

Where: $F_{\text{clock}} = 28,147,497.6710656 \text{ Hz (int.)}$
 $F_{\text{setting}} = \text{Binary value in DDS IC.}$
(F_{setting} ranges from 0 to $2^{47}-1$)
 $K_p = \text{PLL Multiplier (4 to 20, or 1)}$

This reduces to:

$$F_{\text{out}} = F_{\text{setting}} \mu\text{Hz}$$

for the internal (default) clock and the default PLL Multiplier ($K_p=10$) settings.

5.5 Since the DDS IC is a sampled data system, the output frequency is limited to a maximum of 1/2 the master clock frequency ($F_{\text{setting}} \leq 2^{47}-1$). While it is possible to generate an output near 50% of the

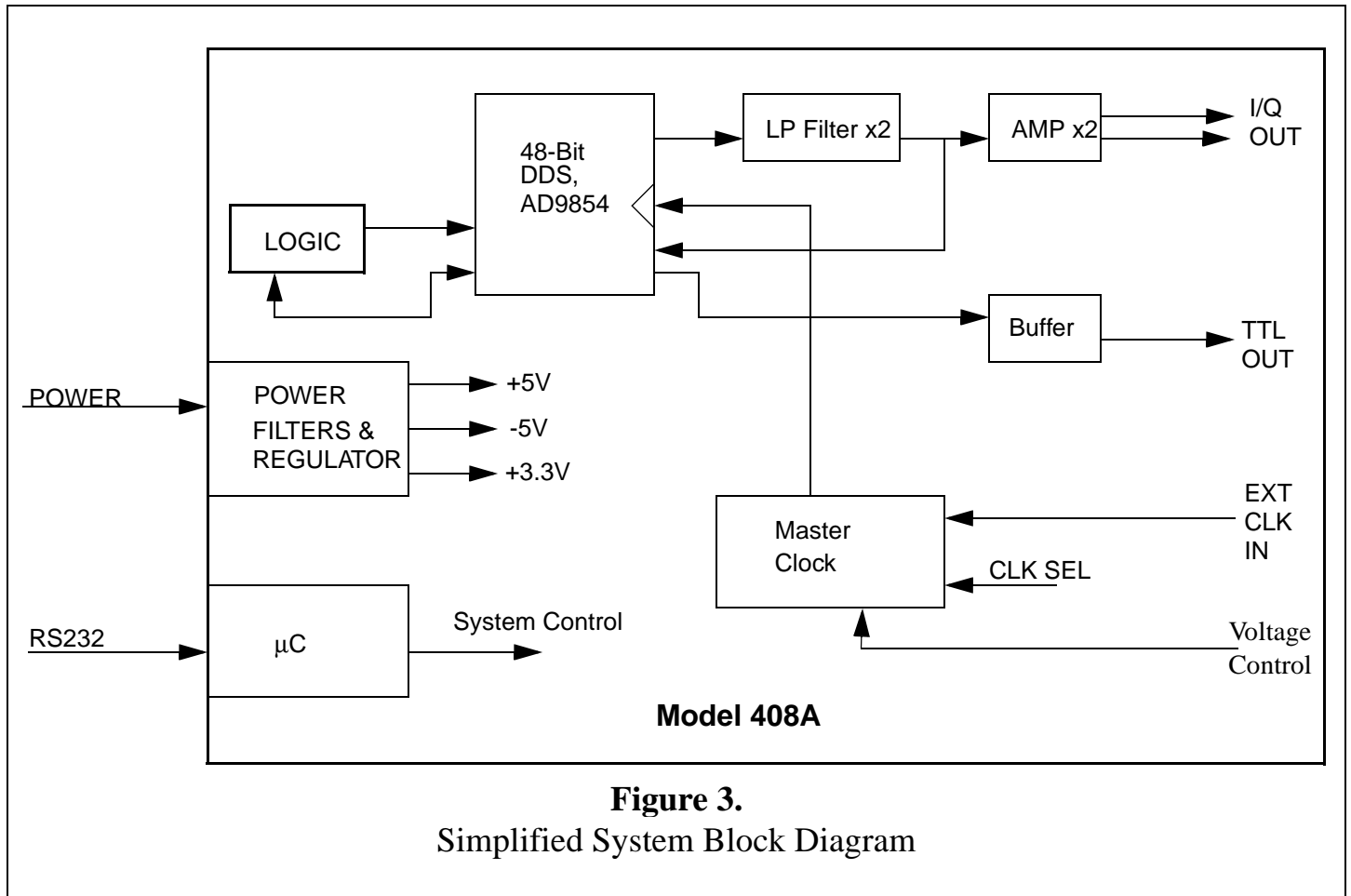


Figure 3.
Simplified System Block Diagram

Table 7: DDS-chip Internal Registers (MSB lowest address)

Address (Hex)	Function	Default Value (Hex)
00 to 01	Phase Adjust Register #1, 14-bits, bits 15, 14 don't care	00 00
02 to 03	Phase Adjust Register #2, 14-bits	00 00
04 to 09	Frequency Tuning Word Number 1, 48-bits	09 18 4e 72 a0 00
0a to 0f	Frequency Tuning Word Number 2, 48-bits	00 00 00 00 00 00
10 to 15	Delta Frequency Word, 48-bits	00 00 00 00 00 00
16 to 19	Update Clock, 32-bits	00 00 00 05
1a to 1c	Ramp Rate Clock, 20-bits, bits 23, 22, 21, 20 don't care	00 00 00
1d	4=CMP PD, 3=low, 2=QDAC PD, 1=DAC PD, 0=DIG PD	00
1e	6=PLL RNG, 5=BP PLL, 4=0=REF MULT	4a
1f	7=CLR ACC1, 6=CLR ACC2, 5=TRI, 4=QDAC, 3-1=MODE, 0=IOUD	00
20	6=BP INV SINC, 5=OSK EN, 4=OSK INT	40
21 to 22	Output Shape Key #1 Multiplier, 12-bits, bits 15, 14, 13, 12 don't care	0f ff
23 to 24	Output Shape Key #2 Multiplier, 12-bits, bits 15, 14, 13, 12 don't care	0f ff
25	Output Shape Key Ramp Rate, 8-bits	00
26 to 27	QDAC, 12-bits, 2's complement, bits 15, 14, 13, 12 don't care	0f ff

clock, the distortion may be unacceptable. Therefore, the output is limited to approximately 40% of the system clock and steep output filters are provided on board: in this case 7th-order elliptical low pass filters.

5.6 If you are using an external clock and a Kp which give a clock substantially lower than the 281.47MHz default internal clock, you may need to filter the Sine and Cosine Outputs to obtain acceptable distortion for your application. For best performance, set the corner frequency at 40% or less of your external clock frequency times Kp. The lower your filter as a percentage of your clock frequency, the lower the distortion.

NOTE:

Since filtering occurs before the signal is level shifted to AC MOS/TTL, the AC MOS/TTL output may be erratic or distorted when using low clock frequencies. If you require an AC MOS/TTL level signal when using low clock frequencies, it is recommended that you use an external comparator/level shifter connected to the output of your external filter. Contact Novatech Instruments if you require application assistance.

5.7 For example, if you are using a 10MHz external clock, with the default reference multiplier (Kp) of 10, then the internal clock is 100MHz. An optimal filter for this frequency would then be approximately 40MHz (40% of 100MHz).

5.8 In amplitude modulation (the "Z" command), the modulation frequency is derived from the micro-controller clock and is asynchronous to the carrier. The modulation signal is unfiltered and is a stepwise approximation to a sine wave.

6.0 PERFORMANCE TEST

6.1 Install the 408A as directed in the Serial Operation part of Section 3. Connect your host controller and operate the 408A per Section 4. The test limits assume a stable environment of 18-28°C.

6.2 The performance test detailed below verifies each functional block on the 408A.

NOTE:

Allow the 408A to warm up for at least 15 minutes before performing any measurements. For best results, the 408A should be verified in its installed environment.

6.3 See Table 8 for a list of recommended test equipment to perform the following measurements.

Table 8: Recommended Test Equipment

<u>Item</u>	<u>Minimum Specification</u>	<u>Recommended</u>
Oscilloscope	300MHz, 50Ω	Tektronix TDS3032
RF Probe	100kHz-100MHz	Tektronix P6420 or HP34301A
DMM	ACrms, dB	HP34401A
50Ω Termination	50Ω, ±1%	Tektronix 011-0049-01
Frequency Counter	120MHz	HP53132A
Counter Time Base	<±0.1ppm	Novatech Instruments Model 2960AR

6.4 **Verify Frequency Accuracy.** To verify the frequency of the 408A, set the output sequentially to each value in Table 9. Connect the recommended frequency counter set to 50Ω termination and 1Hz resolution. Verify the limits show in Table 9. Test Sine (Q) Out, Cosine (I) Out and AC MOS Out to verify functionality of all outputs. If you do not use an external reference for the frequency counter, be sure to add the error of your counter to the tolerance. (LSD = Least Significant Digit on counter).

Table 9: Frequency Test Points

Frequency	Tolerance
100 kHz	±0.1Hz ±1 LSD
1 MHz	±1Hz ±1 LSD
10 MHz	±10Hz ±1 LSD
30 MHz	±30Hz ±1 LSD
50 MHz	±50Hz ±1 LSD
99 MHz	±99Hz ±1 LSD

6.5 **Sine (Q) Out Amplitude Verification.** Set the frequency of the 408A to 100kHz. Connect the 408A to the DMM through a 50Ω feedthrough ter-

mination. Set the DMM to AC Volts. Verify a reading of $0.5V_{rms} \pm 0.05V_{rms}$. Remove the 50Ω termination. Verify an amplitude of $1.0V_{rms} \pm 0.1V_{rms}$. Repeat for the I output.

6.6 Level Command Test. Leave the output frequency set to 100kHz. Send the commands "Vi 2048" and "Vq 2048". Verify that the amplitude on the I and Q channels decrease by half. Send the "R" command to reset the levels before performing the next tests.

6.7 Output Flatness Verification. Verify that the Sine (Q) Out is flat with frequency by performing the following test: Connect an RF probe to the 408A terminated with a 50Ω feedthrough termination. Connect the output of the RF probe to the DMM, set to DC Volts. Set the output of the 408A to 30MHz. Select dB on the DMM.

6.8 Set the 408A to the values of Table 9. Verify that the DMM reading is $0dB \pm 3dB$.

6.9 Repeat the output flatness verification test for the Cosine (I) output.

6.10 AC/MOS/TTL Verification. Using a short 50Ω coaxial cable, connect the AC/MOS/TTL output to the recommended oscilloscope set for 50Ω termination. Using the values of Table 9, verify that the output duty factor ranges from a minimum of 45% high and 55% low to a maximum of 55% high and 45% low.

6.11 Set the frequency to 10kHz. Change the termination from 50Ω to $1M\Omega$ on the oscilloscope. Verify that the 50Ω amplitude is 1/2 that of the $1M\Omega$ amplitude, $\pm 10\%$.

6.12 This concludes the verification test of the 408A.

7.0 CALIBRATION

7.1 The 408A has only two adjustable components: Y2, frequency; and R52, output amplitude. Calibration should be performed only if the 408A fails the performance test or if the unit has been repaired. Routine adjustments are not recommended nor generally required. This procedure assumes that the

408A has failed the performance test or has been repaired.

7.2 The adjustments shown are set to 1/2 the specification limit values.

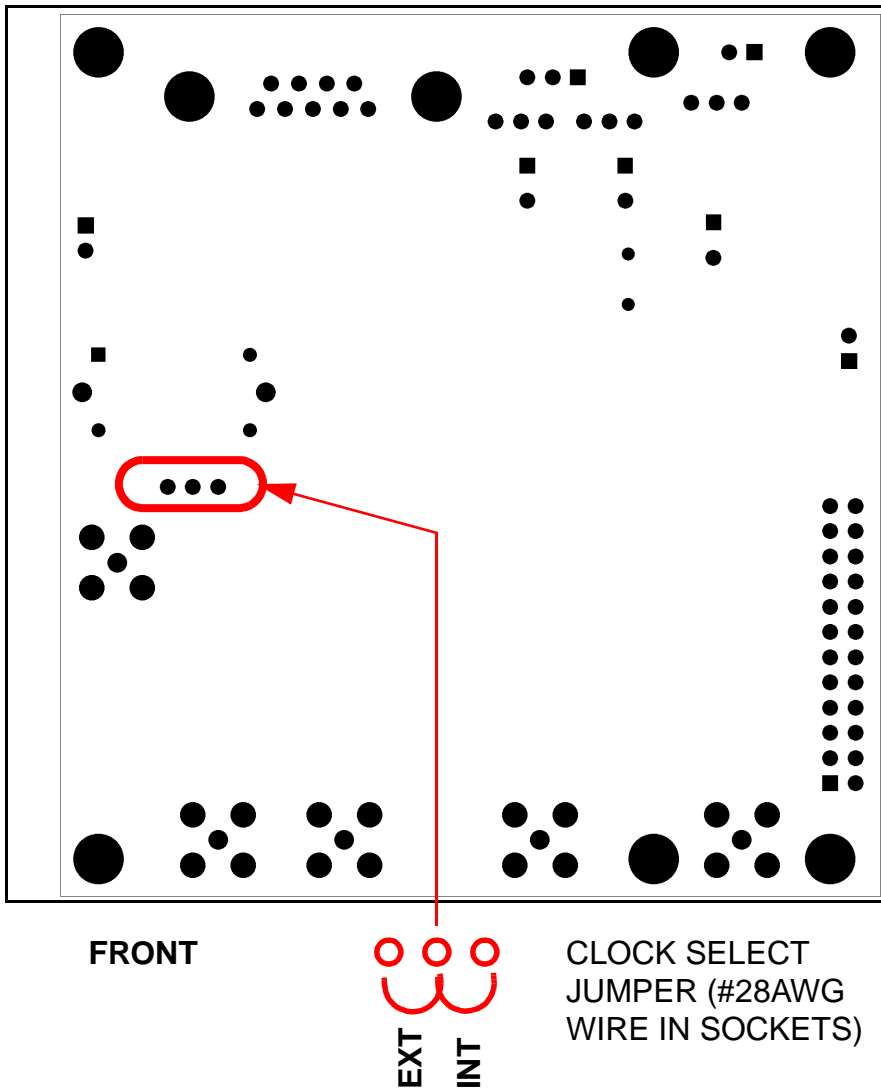
NOTE:

Allow the 408A to warm up for at least 15 minutes before performing any adjustments. For optimum performance the 408A should be calibrated in its installed environment.

7.3 Frequency Adjust, Y2. Set the output of the 408A to 10.000000MHz. Connect the Cosine (I) Output to your frequency counter set for 50Ω termination. Adjust Y2 using a non-metallic adjustment tool for 10.000000MHz, $\pm 5Hz$.

7.4 Amplitude Adjust, R52. Set the frequency to 100kHz. Connect the Cosine (I) Output to the DMM set for AC Volts. Do not use a 50Ω termination. Adjust R52 for $1.00V_{rms} \pm 0.05V_{rms}$. This completes the calibration of the Model 408A.

Appendix A: Clock select jumper location. (Serial numbers N06001 and up.)



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 misuse, 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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