NOVATECH INSTRUMENTS, INC.
Model DDS6m 40 MHz Serial Synthesizer Module

INSTRUCTION MANUAL

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1.0 DESCRIPTION

1.1 The DDS6m is a Direct Digital Synthesizer module with RS232 serial control. It can source up to 40MHz sine and ACMOS/TTL square waves simultaneously in 0.025 Hz exact steps (using internal clock). Multiple units can be synchronized using an external clock and frequency update pulse. The last saved settings are stored in non-volatile memory.

1.2 The DDS6m module is contained on a 2.5 inch by 3.5 inch (6.4 cm by 9.9 cm) circuit board. SMB connectors are provided for Sine out and ACMOS out. Power of +5 and -5 VDC is provided through a 3-pin connector header (mates with AMP # 640441-3 or equivalent). Two pin headers are provided for External Clock input, External Update input and Unfiltered out. The RS232 connection is via a female DE-9 connector. This allows direct connection to a PC serial port using readily available 9-pin monitor extension cables.

2.0 SPECIFICATIONS

2.1 OUTPUT

Types: Simultaneous Sine, ACMOS (TTL compatible) and unfiltered Sine
Impedance: 50 Ω
Range: 100 Hz to 40.000 MHz in exact 0.025 Hz steps (Using internal clock)

2.2 OUTPUT AMPLITUDE

Sine: Approx. 1 Vrms into open circuit, 0.5 Vrms into 50 Ω
ACMOS: (TTL Compatible) Vol: 0.5 V max, Voh: 3.5 V min into 30 pF, <5 ns rise and fall times

2.3 FREQUENCY CONTROL

RS232 interface allows setting of frequency to 0.025 Hz. Fixed at 9600 baud. Internal (default) or external frequency update input can be used to synchronize frequency change.

2.4 PHASE CONTROL

Serial interface allows setting phase in 11.25 degree increments. An unlimited number of DDS6m can be phase synchronized together using an externally supplied CMOS level sync pulse. (When used with external clock input.)

2.6 ACCURACY AND STABILITY

(Using Internal Clock)
Accurate to < ± 5 ppm @ 18 C ± 5 C, 24 hrs
Stable to ± 10 ppm per year at 18 C ± 5 C

2.5 SPECTRAL PURITY (Typical)

Phase Noise: <-125 dBc @ 1 kHz offset @5 MHz out

Spurious:	<-55 dBc below 10 MHz
	<-45 dBc below 40 MHz
Harmonic:	<-50 dBc below 10 MHz
	<-40 dBc below 40 MHz

2.7 EXTERNAL CLOCK INPUT

Jumper selectable external input accepts frequencies from 5 MHz to 100 MHz (typically 120 MHz), 1 Vpp to 5 Vpp Sine or Square Wave. Output frequency is derived from this clock. 50 Ω input impedance. Accuracy and stability depend on external clock.

2.8 CONNECTIONS

SMB for ACMOS out and Sine out. Three pin Amp for power. DE9F for RS232 (Tx: pin 2, Rx: pin 3, Gnd: pin 5). Two pin headers for external clock input, external sync input and unfiltered out.

2.9 POWER

+5 Vdc ± 0.1 Vdc @ <175 mA
-5 Vdc ± 0.1 Vdc @ <35 mA
< 50 mV noise and ripple

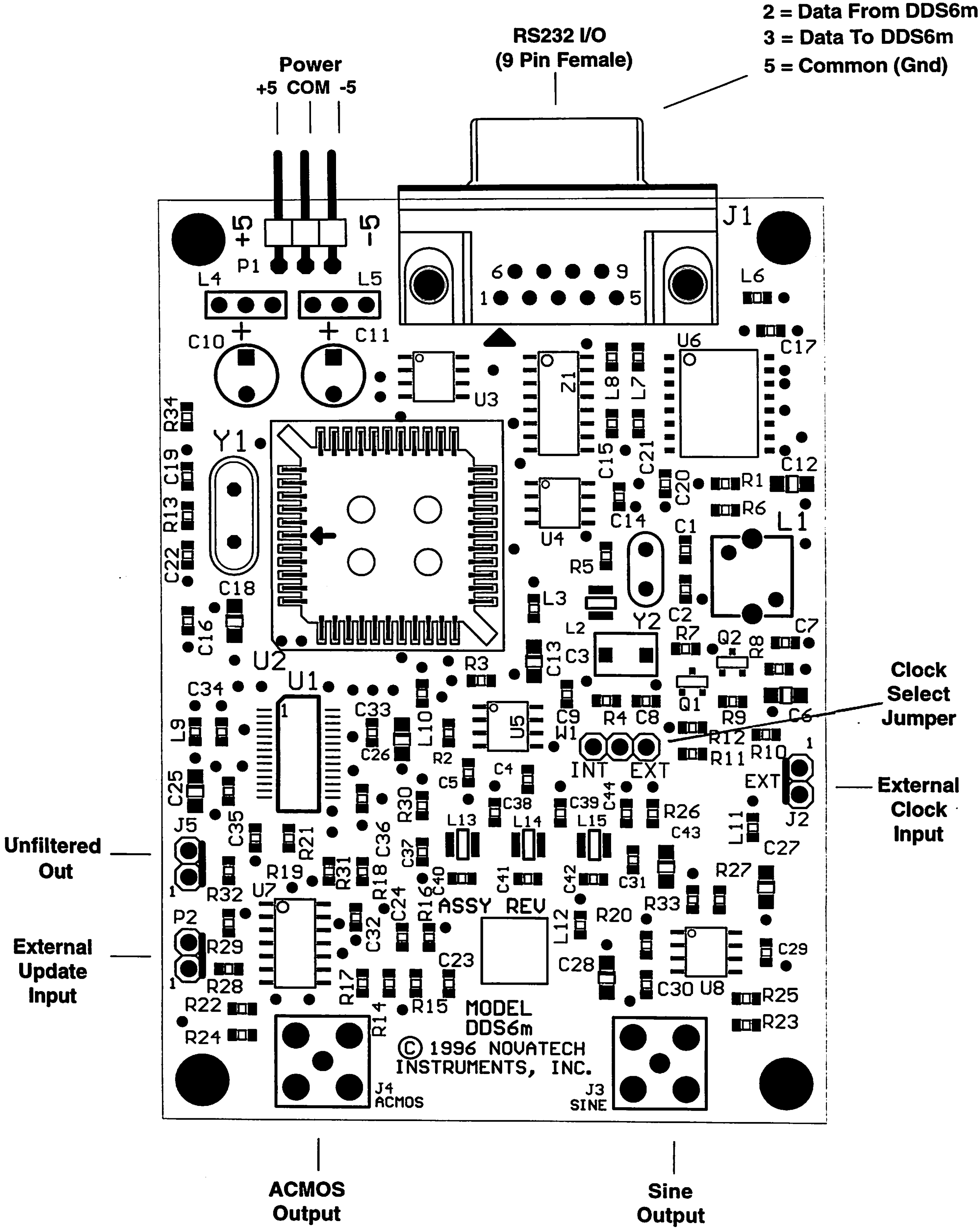
2.10 ENVIRONMENTAL

Operating Temperature: 5 C to 40 C
Humidity: 80% to 31 C, decreasing linearly to 50% at 40 C

2.11 SIZE

2.5 in by 3.5 in (6.4 cm by 8.9 cm)

Figure 1
DDS6m Drawing
Scale is 2:1



3.0 INSTALLATION

NOTE

The DDS6m contains static sensitive components. Please observe static and ESD precautions when handling and installing the DDS6m. Failure to do so may damage the DDS6m.

3.1 Figure 1 shows a top view of the DDS6m module. Power of +5 Vdc and -5 Vdc is applied through a 3-pin connector (pig-tail provided). If you are using the NOVATECH provided pigtail, splice your +5 Vdc supply to the RED wire; your -5 Vdc supply to the BLUE wire and their common-connected returns to the BLACK wire.

3.2 The quality of the +5V and -5V affects the performance of the DDS6m. The supply should be free of noise and ripple (<50 mV). Even though extensive filtering is used on the DDS6m board, a quiet and well regulated power supply will improve performance. If switching power supplies are used, please verify that your system noise requirements are being met.

3.3 RS232. Connect your host computer to the 9-pin female RS232 connector on the DDS6m. If you are using a PC, a 9-pin monitor extension cable will allow direct connection without the use of a null modem cable or gender changer. If you are using a different computer, please note that data **TO** the DDS6m is on pin 3; data **FROM** the DDS6m is on pin 2 and the **COMMON** return is on pin 5.

3.4 Internal Clock . If you plan to use the DDS6m internal clock, verify that the clock select jumper is in the INT position and that the External Clock input is left unconnected.

3.5 External Clock. If you are providing your own clock, move the clock select jumper to the EXT position. Apply your clock (1 Vpp - 5 Vpp sine or square) to the External clock input. Pin 2 is signal common. Note that phase noise and stability performance now depend upon the quality of the external clock.

Please see programming section for details on setting frequency output when using an external clock.

3.6 Outputs. There are three outputs available on the DDS6m. These are Sine, ACMOS and Unfiltered Sine. The Sine and ACMOS outputs are provided on SMB connectors at the board edge. Simply connect your 50 ohm application cable to the appropriate output. If you are not using the ACMOS output, it is suggested that it be disabled to lower system noise.

3.7 The Sine output on the DDS6m uses a steep roll-off 7th order Elliptic filter to produce a low distortion signal. If you are using an external clock, or require special filtering, use the unfiltered output provided on the board. Consult NOVATECH INSTRUMENTS, INC. if you need applications assistance for this output.

NOTE

The unfiltered output is unprotected. ESD or applied voltages will damage the DDS6m or degrade its specifications.

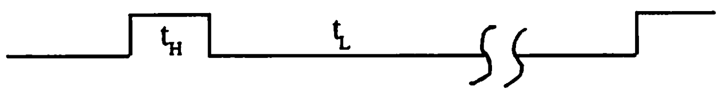
3.8 External Update. If the external update connection is left unused, the DDS6m will automatically update its output at the completion of a frequency or phase command. Multiple units can be synchronized by using the External Update. If an External clock is used all of the synchronized units will stay phase synchronous.

NOTE

The External Update is unprotected.

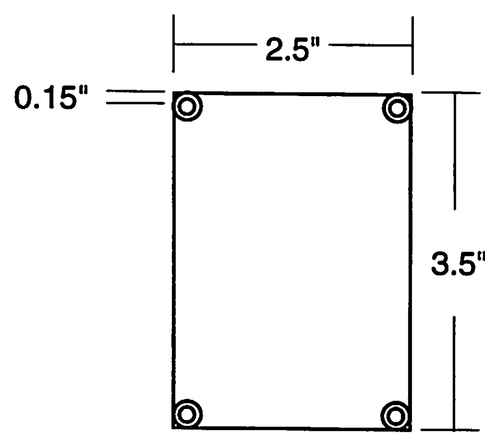
3.9 To use the External Update, connect a CMOS compatible input ($V_{OL} \leq 1.5V$, $V_{OH} \geq 3.5$ V) to the

Figure 2
External Update Pulse



Note that t_H and t_L must be greater than 25 nanoseconds. The frequency (or phase) will update to the previously loaded value 17 clock cycles following the rising edge. Internal frequency updates are inhibited while the applied update pulse is low (t_L). This signal is pulled up so a switch closure may be used.

Figure 3
DDS6m Mounting Dimensions



Dimensions are in inches.

External Update header. Pin 2 is signal common. Apply a pulse per Figure 2. Do not send an update pulse during a command from the RS232 host.

3.10 Mounting. Mounting holes are provided on the board. These holes provide clearance for #4 screws and are electrically connected to circuit common. See Figure 3 for dimensions.

4.0 OPERATION

4.1 After the DDS6m has been installed, all that is required is to send the appropriate RS232 serial commands to the unit. See Table 1 for a listing of the DDS6m commands.

4.2 The user host computer software must properly format the commands. Incorrect format will result in an error code being returned. See Table 1 for a listing of the DDS6m error codes.

4.3 To assist the user with a quick check of the DDS6m, the Quick Basic Programs shown in Table 2 are provided as examples. You may also use any terminal emulation program, set to 9600 baud, 8 bits, 1 stop bit, no parity, with no hardware flow control.

4.4 External Clock Scaling. The DDS6m internal frequency control software assumes that the internal clock is in use. If you have applied an external clock, your host software must scale the `F` command data.

4.5 The output frequency of the DDS6m when used with an external clock is given by:

$$F_{out} = (F_{setting})(F_{ext.\ clk.} / F_{int.\ clk.})$$

The value of the internal clock frequency, $F_{int.\ clk.}$, is a nominal 107, 374, 182.4 Hz.

4.6 To set a frequency using an external clock, the host software must first calculate the proper $F_{setting}$ and then send it to the DDS6m.

4.7 For example, suppose a clock of 10 MHz is used and an output of 1.544 MHz is desired. The calculation is as follows:

$$F_{setting} = (1.544)(107{,}374{,}182.4) / 10{,}000{,}000.0$$
$$= 16.57857376256$$

NOTE

Most hand calculators do not provide enough resolution to perform this calculation to maximum accuracy. The DDS6m rounds to the nearest setting internally. For best performance, send all nine digits to the right of the decimal point in the `F` command.

The command sent to the DDS6m will then be:

```
F 16.578573763
```

and the output of the DDS6m (excluding clock tolerance) will be 1,544,000.00116 Hz.

The example program, `swp6m.bas`, shown in Table 2 performs this scaling for clocks other than the internal clock.

4.8 Since the internal output filter is set for 40 MHz you will need to provide an external anti-aliasing filter if you use an external clock substantially lower than the internal clock. Contact NOVATECH INSTRUMENTS, INC., for applications assistance.

4.9 The `Que` command returns a string of the form "`02625A00 00 A:E E:E`". The first number is the binary frequency setting in hexadecimal (Hex); multiply by 0.025 Hz (internal clock) to obtain output frequency.

Table 1
RS232 Commands

F XX.XXXXXXXXX	Sets frequency in MHz. Software sets to nearest 0.025 Hz setting. 1 MHz default. Decimal point required.
E D	Disables echo.
E E	Enables echo.
R	Reset. Same as cycling power.
P N	N is integer 0 to 31. Phase is set to N*11.25. (N*Pi/16 radians)
A E	Enables ACMOS/TTL output.
A D	Disables ACMOS/TTL output. Output is set low. (Lowers system noise for critical applications)
SAVE	Save current output. Used as default on next power up.
QUE	Return last saved frequency and phase.

The commands are not case sensitive. There must be a space after each command except Reset, Save and Que. End with CR.

ERROR CODES RETURNED

?0	Unrecognized Command
?1	Bad Frequency
?2	(Not Used)
?3	Input line to long
?4	Bad Phase

Table 2
Sample Programs

```
'This QBASIC program named "dds6m_ex.bas" sends commands to
'the serial port for testing the DDS6m module.

CLS
LOCATE 1,1
OPEN "COM1:9600,n,8,1,cd0,cs0,ds0,op0,rs" FOR RANDOM as #1
PRINT #1, ""
LINE INPUT #1, a$
DO WHILE 1 = 1
PRINT
INPUT "Enter command to send to DDS6m: ", cmnd$
PRINT #1, cmnd$
LINE INPUT #1, resp$
PRINT resp$
LOOP
END
```

Table 2 (Continued)
Sample Programs

```
'This QBASIC program named "swp6m.bas" can be used to cause the DDS6m to sweep
'the output frequency and to set up the DDS6m for use with an external clock.
CLS
LOCATE 1, 1
OPEN "com1:9600,n,8,1,cd0,cs0,ds0,op0,rs" FOR RANDOM AS #1
INPUT "What is your clock frequency (0 for internal): ", clock#
INPUT "enter initial frequency (in MHz): ", freq1#
INPUT "enter final frequency (in MHz): ", freq2#
INPUT "enter number of steps: ", steps#
stepsize# = (freq2# - freq1#) / steps#
'
' scale all the values based upon the clock frequency
defclock# = 107.3741824#
IF clock# = 0# THEN goto 10
scale# = defclock# / clock#
freq1# = scale# * freq1#
freq2# = scale# * freq2#
stepsize# = scale# * stepsize#
'
10 PRINT #1, "e d"
LINE INPUT #1, resp$
PRINT "Response ", resp$
f# = freq1#
WHILE f# <= freq2#
    PRINT #1, "f ";
IF f# < 10 THEN PRINT #1, USING "#.#########"; f#
IF f# < 10 THEN PRINT , USING "#.#########"; f#
IF f# >= 10 THEN PRINT #1, USING "##.#########"; f#
IF f# >= 10 THEN PRINT , USING "##.#########"; f#
    LINE INPUT #1, resp$
    PRINT "Response "; resp$
    'wait for 250 ms on each step
       t0 = TIMER
       WHILE TIMER - t0 < .25
       WEND
     f# = f# + stepsize#
WEND
'reset to enabled echo
PRINT #1, "e e"
PRINT "Done"
STOP
```

The next number is the phase setting in Hex. The next two terms show status of the A and E commands.

4.10 All other commands require no special considerations. A correctly received and executed command will respond with an "OK". (Except Que and R)

5.0 PERFORMANCE TEST

5.1 Install the DDS6m per Section 3 and run the sample program. Allow at least 15 minutes for the DDS6m temperature to stabilize in an ambient of 18-28C.

5.2 Connect a frequency counter to the DDS6m SINE output. Set the output frequency to the values shown in Table 3 and verify the limits shown (internal clock mode).

5.3 Move the connection to the ACMOS output. Verify the values in Table 3.

5.4 Using the Frequencies shown in Table 3 verify that the ACMOS output has $V_{OL} \leq 0.8$ and $V_{OH} \geq 3.5$ into an open circuit (< 30pF, ≥ 500 ohms)

5.5 Connect the SINE output to an RF probe through a 50 ohm feed-through termination. Measure the amplitude of 10.000 MHz. Verify 0.5 Vrms ± 3dB (0.35 - 0.71 Vrms). Disconnect the 50 ohm termination. Verify 1.0 Vrms ± 3 dB (0.71 - 1.41 Vrms).

5.6 EEPROM Test. Set the output frequency to any value except 1.00 MHz (factory default). Execute the Save command. Cycle power. Verify that the frequency out is now the same as that set above. Run the Que command. Verify that the value returned is the same as that saved.

5.7 Change the Frequency setting but do not save it. Execute the Reset command (R). Verify that the output returns to the last saved value. Cycle power. Again note that the value returns to the last saved value.

6.0 CALIBRATION

6.1 The DDS6m contains only two adjustable components. Periodic adjustments are not recommended and should be performed only if the DDS6m fails the performance test or if it has been repaired.

6.2 Install the DDS6m per Section 3 and run the sample program provided.

NOTE

Allow the DDS6m under test to warm up for at least 15 minutes in a 18-28C environment.

NOTE

Best system performance is obtained if the DDS6m is calibrated using the same power supply levels and the same shielding environment as the final installed application.

6.3 Adjustment of L1. L1 should only be adjusted if it or oscillator (Y2 and associated components) parts have been replaced. Connected a 500 ohm 10x oscilloscope probe to the junction of R7 and base of Q1. Adjust L1 using a non-metallic tool for maximum amplitude. This is a broad peak and need not be centered exactly.

6.4 C3 Adjustment (Set Frequency). Set the output of the DDS6m under test to 1.0000 MHz using the command "F 1.0". Connect the output to a frequency counter. Using a non-metallic adjustment tool, adjust C3 for 1.000 000 MHz ± 2.5 Hz reading on the counter. Note that ± 1 ppm is ± 1 Hz.

6.5 If your are using the external clock input, there are no adjustments which affect the performance of the DDS6m.

Table 3
Performance Test Settings

Frequency (MHz)	As Shipped	One Year
1.000	0.999995 - 1.000005	0.999990 - 1.000010
5.000	4.999975 - 5.000025	4.999950 - 5.000050
10.000	9.999950 - 10.000050	9.999900 - 10.000100
20.000	19.999900 - 20.000100	19.999800 - 20.000200
40.000	39.999800 - 40.000200	39.999600 - 40.000400

Note: Tolerances exclude frequency counter error

Table 4
Recommended Test Equipment

Item	Specification	Recommended
Oscilloscope	500 MHz, 50 ohm Input	Tektronix TDS520 w/P6156A 10x Probe.
RF Probe	100kHz - 50 MHz	Tektronix P6420 HP 34301A
DMM	3 1/2 Digits, dB	HP34401A
50 ohm Termination	50 ohm, 2%	Tektronix 011-0049-01 Pomona 4119-50
Frequency Counter	50 MHz	HP53131A-001

WARRANTY

NOVATECH INSTRUMENTS, INC. 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 intruments that have been returned by purchaser, at the purchaser's expense, to NOVATECH INSTRUMENTS, INC. and that have not been subjected to misuse, neglect, improper installation, repair alteration or accident. NOVATECH INSTRUMENTS, INC. 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, INC. 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, INC. 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, INC. and the purchaser and no agreement extending or modifying it will be binding on NOVATECH INSTRUMENTS, INC. unless made in writing and signed by an authorized official of NOVATECH INSTRUMENTS, INC.

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