SPECTRADYNAMICS, INC.

Noise Detector ND-1
Operating Manual

SPECTRADYNAMICS, INC • 1849 Cherry St. Unit 2 • Louisville, CO 80027
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ND-1 Description

The ND-1 is a noise detector that may be used to measure amplitude noise (AM) or phase noise (PM) on a carrier signal in the range of 1 MHz to 1 GHz. The instrument has two independent measurement channels labeled Detector 1 and Detector 2. Each channel may be used to make high-resolution single-channel measurements or combined to allow dual-channel noise analysis with a reduction in the measurement system noise floor. Each detector has three subsystems, the RF conditioning system, the IF amplifier and the programmable PLL. The RF conditioning system has the capability of measuring the RF input levels prior to the mixer and allows the adjustment of these levels with built in attenuators. A wideband calibration input is provided for automatic gain calibration of each detector. The IF amplifiers have variable gain and bandwidth settings. The programmable PLL is a second order phase-locked loop circuit that is programmed by selecting the desired lock frequency, the tuning sensitivity of the oscillator and the sensitivity of the mixer.

Safety and Preparation for Use

CAUTION!
Voltages capable of causing injury or death are present in this instrument. Use extreme caution whenever the instrument cover is removed.

Line Voltage
This instrument can be setup to operate on 100-120 or 220-240 VAC and a line frequency of 50 to 60 Hz. For conversion to a different line voltage please contact SDI.

Fuse
A 1.0 Ampere 250V slow blow fuse is used in this instrument for 100-120 VAC line voltage. A 0.5 Ampere 250V slow blow fuse is used for 220-240 VAC line voltage. Do not replace with a larger fuse.

Line Cord
The instrument has a detachable three-wire power cord for connection to a grounded power source. The enclosure of the unit is directly connected to the outlet ground to protect against electrical shock. Always use an outlet with a protective ground and do not disable this safety mechanism.

Service
Do not attempt to service or adjust the instrument unless another person, capable of providing first aid or resuscitation, is present.

Operation
To operate the unit, locate the AC power entry connector on the rear panel and connect the power cable. When power is applied to the unit, a red led located on the front panel, labeled “on”, should light up.

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Se habla español

The Front Panel

The ND-1 has two identical measurement channels, labeled Detector 1 and Detector 2. Each Detector has an LO input that directly drives the LO port of the internal mixer. The RF input has an adjustable attenuator that can provide 7 dB of attenuation in 1 dB steps. The two measurement channels are controlled via the front panel control section that consists of the LCD screen, soft-keys and RS-232 port.

ON BUTTON
The led is on when power is applied to unit and the unit is operating properly. **Press this button to toggle the unit from standby to on. The main power switch is located on the rear panel of the unit.**

RS-232
DB-9 connector for serial communications. This is a dumb terminal RS-232 port. A null modem adapter is not required. Default settings are 9600 baud, 8 bits, no parity, 1 stop bit.

REMOTE
This button is used to enter remote control mode via RS-232. When the instrument is in remote mode the button will be illuminated. To return to front panel control, press this button again.

STATUS
Under remote control mode, pressing this key will display the status of the instrument and clear the status register.

LCD SCREEN
The LCD screen displays the settings of the first detector on the left side of the screen and the settings of the second detector on the right side of the screen. The soft-key labels are displayed on the bottom section of the screen.

SOFT-KEYS
There are 2 sets of soft-keys, the first set consists of 5 keys directly under the LCD screen. The labels for the varying functionality of these buttons are displayed directly above each of the buttons. The second set consists of 4 keys to the right of the screen. This second set of keys are activated when they are illuminated and have the function of being the navigation keys UP, DOWN, LEFT and RIGHT.

The Front Panel

DETECTOR SMA INPUTS
Each detector has 3 SMA inputs labeled LO, RF and CAL. The LO input is connected to the LO port of the detection mixer. The RF input connects to the RF port of the detection mixer through a variable attenuator with a range of 7 dB and 1 dB steps. The CAL input is combined with the LO port signal to allow calibration of the detector. The CAL input connects to the LO port with a coupling factor of about –30dB.

IMPORTANT! Exceeding the maximum power of +17 dBm on any mixer port will damage the mixer. Make sure that the signals to the mixer are in the off-state before connecting any signal cable to the instrument. Once you have verified that the signal levels are appropriate you may set the instrument to the signal on-state.

For optimum performance the signal levels should be in the following range:
LO level (+10 dBm to +15 dBm)
RF level (+10 dBm to +15 dBm)
ATTEN 0 dB

For every dB of attenuation you may increase the RF input level by 1 dB.
The CAL input should be set to a level that is at least 40 dB below the LO level.

DETECTOR SMA OUTPUTS
Each detector has an IF output, a 10 Volt rail PLL output and a 5 Volt rail PLL output. The IF output contains the filtered and amplified noise detected by the mixer. This is a DC or AC coupled signal with a voltage swing of up to +/- 10 Volts. This output may be directly connected to the FFT or spectrum analyzer. The PLL outputs can be used to lock an oscillator under test to a reference oscillator. The PLL can be setup to operate with +/- voltage rails or 0/+ voltage rails. The PLL parameters are calculated automatically from the following three parameters KVCO, KD, and FREQ. KVCO is the tuning port sensitivity of the oscillator under test. KD is the detector sensitivity nominally 6.5, and FREQ is the lock frequency of the PLL.

CAUTION! Please choose the appropriate output so that the tuning port voltage from the instrument does not damage the oscillator tuning port. Some tuning ports can also be damaged with a bipolar signal so make sure that the instrument is setup appropriately.

The Back Panel

AC POWER ENTRY MODULE

The ND-1 is configured to operate on 100 – 120 VAC. It uses a 1.0 Amp 250V slow blow fuse. The unit requires a 0.5 Amp, 250 V slow blow fuse for 220 – 240 VAC operation.

The LCD Display

The following section describes how information is displayed on the LCD screen. The display has four different areas. The top area displays the menu information such as the menu name. The middle part of the screen is divided into the left area displaying information about detector one and the right area displaying information about detector two. The last section of the screen is the bottom area, which displays the labels for the active soft keys.

The information displayed on the screen has the following color-coded scheme to help highlight important information.

RED Items that are displayed in the color red indicate that a parameter is out of range for a valid measurement, or a signal is not present.

GREEN Items displayed in green indicate that a parameter is within an acceptable range to make a valid measurement.

BLUE Items that are displayed in the color blue indicate that the user can edit them. When a detector has the focus on the screen the information for that detector is displayed in blue. The focus can be shifted form one detector to the other by pressing the DET soft key.

BLACK Items displayed in the color black are menu items and parameters. When a detector is not selected those parameters will be displayed in black.

Measurement Menu

The measurement menu is displayed on power up and displays the information that is necessary when making measurements. The screen displays the information about the settings of each detector as well as measured parameters including power levels and voltages.

The title displays **Measurement Menu**. The following information is displayed on the screen.

LO LEVEL The power level in dBm of the LO signal as applied to the mixer. Levels less than +7dBm will yield decreased detector sensitivity and higher system noise levels. DO NOT APPLY SIGNALS WITH LEVELS EXCEEDING +17dBm AS THIS WILL CAUSE IRREPARABLE DAMAGE TO THE INSTRUMENT.

RF LEVEL The power level in dBm of the RF signal as applied to the mixer. Note that this level is measured after the adjustable attenuator. RF levels as applied to the mixer, less than +7dBm, will yield decreased sensitivity and higher system noise levels. DO NOT APPLY SIGNALS WITH LEVELS EXCEEDING +17dBm AS THIS WILL CAUSE IRREPARABLE DAMAGE TO THE INSTRUMENT. Note that it is safe to apply RF signal to the instrument up to +22 dBm if the attenuator is first set to 7 dB.

MIXER The voltage in Volts at the output of the mixer. For phase noise measurements this value should be zero Volts. If the value is displayed in red the signals to the mixer may be too far from quadrature to make valid phase noise measurements. For amplitude noise measurements maximize the mixer output voltage, this will give maximum sensitivity to amplitude and minimize the sensitivity to phase.

PLL The voltage in Volts at the output of the phase-locked loop port with 10 V rails. This is the voltage that would be applied to the tuning port of the oscillator under test when the PLL circuit is activated.

DC TUNE The voltage in Volts at the output of the phase-locked loop port with 10 V rails. This is the voltage that would be applied to the tuning port of the oscillator under test when DC tuning is enabled.

Measurement Menu

SIGNAL — The status of the signal inputs to the mixer. If the SIGNAL is ON the signal inputs are connected to the mixer. If the label is OFF the signal inputs are terminated into 50 ohms to ground and the mixer is disconnected.

ATTEN — The attenuator setting in the RF input path to the detection mixer. This attenuator has a range of 7 dB and can be set in 1 dB steps.

IF BW — The bandwidth of the IF amplifier section that follows the detection mixer. The IF bandwidth can be set to 400 kHz or 1MHz.

DC/AC — The label indicates whether the IF amplifier is DC coupled or AC coupled. The value displayed is the gain setting either 56 dB or 66 dB.

There are 4 active soft-keys, RF, IF, PLL and INST.

RF — The RF soft key will bring up the RF Menu. The RF Menu is used to adjust the RF attenuator and turn on or off the calibration signal and mixer inputs.

IF — The IF soft key will bring up the IF Menu. The IF Menu is used to adjust the IF amplifier settings.

PLL — The PLL soft key will bring up the PLL Menu. The PLL Menu is used to set the PLL parameters.

INST — The INST soft key will bring up the INST Menu. The Inst Menu is used to calibrate the built in RF power level sensors.

RF Menu

The RF Menu displays the information that is necessary to setup the signal at the front end of the mixer. The screen displays the information about the settings of each detector as well as measured parameters including power levels and mixer voltage.

The title displays **RF Menu**. The following information is displayed on the screen.

LO LEVEL The power level in dBm of the LO signal as applied to the mixer. Levels less than +7dBm will yield decreased detector sensitivity and higher system noise levels. DO NOT APPLY SIGNALS WITH LEVELS EXCEEDING +17dBm AS THIS WILL CAUSE IRREPARABLE DAMAGE TO THE INSTRUMENT.

RF LEVEL The power level in dBm of the RF signal as applied to the mixer. Note that this level is measured after the adjustable attenuator. RF levels as applied to the mixer, less than +7dBm, will yield decreased sensitivity and higher system noise levels. DO NOT APPLY SIGNALS WITH LEVELS EXCEEDING +17dBm AS THIS WILL CAUSE IRREPARABLE DAMAGE TO THE INSTRUMENT. Note that it is safe to apply RF signal to the instrument up to +22 dBm if the attenuator is first set to 7 dB.

MIXER The voltage in Volts at the output of the mixer. For phase noise measurements this value should be zero Volts. If the value is displayed in red the signals to the mixer may be too far from quadrature to make valid phase noise measurements. For amplitude noise measurements maximize the mixer output voltage, this will give maximum sensitivity to amplitude and minimize the sensitivity to phase.

SIGNAL The status of the signal inputs to the mixer. If the SIGNAL is ON the signal inputs are connected to the mixer. If the label is OFF the signal inputs are terminated into 50 ohms to ground and the mixer is disconnected.

CAL SIG The status of the calibration signal input. If the calibration signal is ON, then it is coupled into the LO port of the mixer with a coupling factor of -30dB. If the calibration signal is OFF, the calibration signal is terminated into 50 ohms.

ATTEN The attenuator setting in the RF input path to the detection mixer. This attenuator has a range of 7 dB and can be set in 1 dB steps.

RF Menu

There are 5 active soft-keys, SIG, CAL, ATTEN, DET and EXIT.

SIG	This soft key will turn on or turn off the input signals to the mixer. When the signals are off they are terminated into 50 ohms.
CAL	This soft key will turn on or turn off the calibration signal input. When the s calibration signal is turned off it is terminated into 50 ohms.
ATTEN	This soft key will activate the UP and DOWN buttons at the left of the screen to allow stepping up or stepping down the RF attenuator. While the up and down buttons are active they will be illuminated. To return to the RF Menu and inactivate the UP/DOWN buttons press the ATTEN key again. The range for the RF attenuator is 0 to 7 dB.
DET	This soft key is used to toggle between the Detector 1 and Detector 2 settings. The Detector that has the edit focus has the labels displayed in blue.
EXIT	This soft key is used to exit the RF Menu and return to the Main Menu.

IF Menu

The IF Menu displays the information that is necessary to setup the signal at the output of the mixer. The screen displays the information about the settings of each detector.

The title displays **IF Menu**. The following information is displayed on the screen.

IF BW — Displays the IF amplifier bandwidth. The IF bandwidth can be set to 400 kHz or 1 MHz.

COUPLING — The IF amplifier may be DC coupled or AC coupled.

GAIN — Displays the gain setting of the IF amplifier. The gain may be set to 56 dB or 66 dB.

There are 5 active soft-keys, BW, CPL, GAIN, DET and EXIT.

BW — This soft key is used to set the IF amplifier bandwidth. The bandwidth can set to 400 kHz or 1 MHz.

CPL — This soft key is used to select AC or DC coupling for the IF amplifier.

GAIN — This soft key is used to select between an IF gain of 56 dB or 66 dB.

DET — This soft key is used to toggle between the Detector 1 and Detector 2 settings. The Detector that has the edit focus has the labels displayed in blue.

EXIT — This soft key is used to exit the IF Menu and return to the Main Menu.

PLL Menu

The PLL Menu is used to view and modify the phase-locked loop settings.

The title displays **PLL Menu**. The following information is displayed on the screen.

OUTPUT Displays the output settings of the PLL. The output of the phase-locked loop can swing from zero to the positive voltage rail or from the negative voltage rail to the positive voltage rail.

DC TUNE Displays the IF amplifier setting. The options are DC coupled or AC coupled.

GAIN Displays the gain setting of the IF amplifier. The gain may be set to 56 dB or 66 dB.

There are 5 active soft-keys, SETUP, POL, TUNE, DET and EXIT.

SETUP This soft key activates the PLL SETUP Menu that is used to set PLL parameters such as the mixer sensitivity KD, the VCO tuning sensitivity KVCO and the PLL bandwidth FREQ.

POL This soft key is used to select the output behavior of the PLL. Select between positive voltage output and bipolar output.

TUNE This soft key enables the UP/DOWN buttons and the LEFT/RIGHT buttons on the right side of the screen. These buttons will be illuminated when active. The LEFT button turns off DC tuning and enables the phase-locked loop output. The RIGHT button turns on DC tuning and disables the PLL output. Use the UP and DOWN buttons to increase or decrease the DC voltage on the PLL output. This feature is useful in measuring the tuning sensitivity of the tuning port on an oscillator under test.

DET This soft key is used to toggle between the Detector 1 and Detector 2 settings. The Detector that has the edit focus has the labels displayed in blue.

EXIT This soft key is used to exit the PLL Menu and return to the Main Menu.

PLL Setup Menu

The PLL Setup Menu is used to modify the phase-locked loop parameters.

The title displays **PLL Setup Menu**. The following information is displayed on the screen.

FREQ — Displays the bandwidth of the phase-locked loop in Hertz. The valid range is dependent upon the parameters KD and KVCO. The approximate range for FREQ is 0.5 Hz to 500 Hz for reasonable values of the parameter KVCO. This is a user selectable parameter and may be changed with the FREQ soft key.

KD — Displays the mixer sensitivity KD, in units of Volts/Radian. The default factory setting is 6.5. The default value may be used for signal input levels that are within the suggested range of (+7 dBm to +15 dBm). If the value for KD is obtained by measurement, pressing the KD soft key may enter it.

KVCO — Displays the tuning port sensitivity of the oscillator under test in unit of Hz/Volt. This value is needed in the calculations performed by the instrument to obtain the appropriate PLL time constants. KVCO, for the oscillator under test, should be measured and entered into the ND-1 using the KVCO soft key.

There are 5 active soft-keys, FREQ, KD, KVCO, DET and EXIT.

FREQ — This soft key is used to change the bandwidth of the phase-locked loop. The soft key enables the UP/DOWN buttons and the LEFT/RIGHT buttons on the right side of the screen. These buttons will be illuminated when active. The LEFT button decreases the step size of the frequency change and the RIGHT button increases the step size. The step size is displayed in the color blue on the lower left side of the screen. The UP button increments the frequency by the step amount. The DOWN button decrements the frequency by the step amount.

KD — This soft key is used to change the mixer gain KD. The soft key enables the UP/DOWN buttons and the LEFT/RIGHT buttons on the right side of the screen. These buttons will be illuminated when active. The LEFT button decreases the step size and the RIGHT button increases the step size.

PLL Setup Menu

The step size is displayed in the color blue on the lower left side of the screen. The UP button increments the value for KD by the step amount. The DOWN button decrements the value for KD by the step amount.

KVCO — This soft key is used to change the value for KVCO, which represents the tuning sensitivity of the oscillator under test. The soft-key enables the UP/DOWN buttons and the LEFT/RIGHT buttons on the right side of the screen. These buttons will be illuminated when active. The LEFT button decreases the step size and the RIGHT button increases the step size. The step size is displayed in the color blue on the lower left side of the screen. The UP button increments the value for KVCO by the step amount. The DOWN button decrements the value for KVCO by the step amount.

DET — This soft key is used to toggle between the Detector 1 and Detector 2 settings. The Detector that has the edit focus has the labels displayed in blue.

EXIT — This soft key is used to exit the PLL Setup Menu and return to the PLL Menu.

Inst Menu

The Instrument Menu is used to calibrate the built in power level detectors for the RF and LO ports. To run the calibration routine you will need a calibrated 0 dBm reference at the frequency of interest (if running a general calibration use a 0 dBm, 50 MHz source), a calibrated 10 dB attenuator.

The title displays **Instrument Setup Menu**. The following information is displayed on the screen.

LO LEVEL The power level in dBm of the LO signal as applied to the mixer. Levels less than +7dBm will yield decreased detector sensitivity and higher system noise levels. DO NOT APPLY SIGNALS WITH LEVELS EXCEEDING +17dBm AS THIS WILL CAUSE IRREPARABLE DAMAGE TO THE INSTRUMENT.

RF LEVEL The power level in dBm of the RF signal as applied to the mixer. Note that this level is measured after the adjustable attenuator. RF levels as applied to the mixer, less than +7dBm, will yield decreased sensitivity and higher system noise levels. DO NOT APPLY SIGNALS WITH LEVELS EXCEEDING +17dBm AS THIS WILL CAUSE IRREPARABLE DAMAGE TO THE INSTRUMENT. Note that it is safe to apply RF signal to the instrument up to +22 dBm if the attenuator is first set to 7 dB.

There are 4 active soft-keys, LO CAL, RF CAL, DET and EXIT.

LO CAL This soft key will activate the calibration routine for the LO port power level sensor. Follow the directions on the screen. You will be prompted to connect a 0 dBm source to the LO port and then press the LO CAL soft key. The next step will be to insert a 10 dB attenuator in the signal path so that the signal applied to the LO port is now –10 dBm. At this point you will be prompted to press the LO CAL soft key again to complete the calibration. All calibration values are lost if the instrument main power at the rear of the unit is turned off.

RF CAL This soft key will activate the calibration routine for the RF port power level sensor. Follow the directions on the screen. You will be prompted to connect a 0 dBm source to the RF port and then press the RF CAL soft key. The next step will be to insert a 10 dB attenuator in the signal path so that the signal applied to the RF port is now –10 dBm. At this point you will be prompted to press the RF CAL soft key again to complete the calibration.

Inst Menu

All calibration values are lost if the instrument main power at the rear of the unit is turned off.

DET — This soft key is used to toggle between the Detector 1 and Detector 2 settings. The Detector that has the edit focus has the labels displayed in blue.

EXIT — This soft key is used to exit the Instrument Menu and return to the Main Menu.

RS-232 Port

RS-232 Communication Port

The ND-1 functions are accessed through the RS-232 port located on the front panel. A standard serial cable with a DB-9 connector can be used to interface to the ND-1. The user can input commands using a simple dumb terminal program on a remote computer or more sophisticated control can be used with software such as Labview.

Port Settings

On power-up the RS-232 port settings are:

Baud rate 9600 8 Bits 1 Stop Bit No Parity.

Hardware handshaking is not used. The DB-9 connector pinout is described below.

Pin	Function
1	NC
2	Data out
3	Data in
4	NC
5	GND
6	NC
7	NC
8	NC
9	NC

Specifications

PARAMETER	CONDITIONS	TYP	UNITS
RF Measurement Range	Carrier Level +7 to +17 dBm	1 - 1000	MHz
Signal Level Measurement		-25 to +25	dBm
IF Bandwidth	Low High	400 1000	kHz
IF Gain	Low High	56 66	dB
PLL Tuning Bandwidth	Carrier Level +7 to +17 dBm	0.5 - 500	Hz
System Residual PM Noise 5MHz Carrier, +15 dBm Level	Fourier Frequency 1 Hz 10 Hz 100 Hz 1 kHz 10 kHz 100 kHz	 -147 -157 -167 -172 -178 -179	dBc/Hz
RF Attenuator		7	dB

Rack Mount Enclosure
Size: 3.5” X 19” X 16”
Weight: 20 lbs

AC Power 110–120/ 220–240VAC

WARRANTY

Warranty

The ND-1 is warranted to be free of defects under normal operating conditions, as specified, for one year from date of original shipment from SpectraDynamics, Inc (SDI). SDI's obligation and liability under this warranty is expressly limited to repairing or replacing, at SDI's option, any product not meeting the said specifications. This warranty shall be in effect for one (1) year from the date a ND-1 is sold by SDI. SDI makes no other warranty, express or implied, and makes no warranty of the fitness for any particular purpose. SDI's obligation under this warranty shall not include any transportation charges or costs of installation or any liability for direct, indirect, or consequential damages or delay. Any improper use, operation beyond capacity, substitution of parts not approved by SDI, or any alteration or repair by others in such manner as in SDI's reasonable judgment affects the product materially and adversely shall void this warranty. No employee or representative of SDI is authorized to change this warranty in any way or grant any other warranty.