

NOISE XT



Maintenance Manual

General Presentation

Methods

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1

INTRODUCTION

I.1 – Periodic Calibration / Verification process

The PN9000 is a phase noise instrument based on modular architecture.

This configuration presents a great advantage for maintaining the system updated over a very long period of operation, it also provides a great advantage for the maintenance: the customer having the capability to detect the faulty module in case of failure of the system. This module can be removed and sent for repair separately from the whole system.

The whole process of maintenance includes:

- 1/ The periodic full Calibration/Verification process.
- 2/ The simplified Verification process.
- 3/ The failure detection process
- 4/ The repair process

1/ Periodic Calibration / Verification process

This maintenance process can be done at the Noise XT factory level, or at the certified Noise XT local representative or, at customer's site if the specific calibration software has been provided.

This procedure is recommended every year.

2/ Simplified Verification process

This simplified verification is based on the measurement of calibrated sources having a certified phase noise spectrum. Noise XT provides a tools kit including these calibrated sources. After receiving the measurement results Noise XT outputs a verification certificate.

This simplified process can be fully setup at the customer site. The customer needs to characterized RF or mW sources, maintain operating these sources and run periodically phase noise measurements. The comparison of the plots performs a simple verification of the system. This process should be carefully control to insure a valuable test (be sure the sources are keeping a stable phase noise spectrum) .

This procedure is recommended every year.

3/ The failure detection process

On top of Noise XT full Calibration/Verification or simplified Verification process, the customer has the capability to test the faulty modules according the "Maintenance manual / Customer Level".

4/ The repair process

All the repair has to be done at Noise XT site or at a certified Noise XT local representative.

2

MAIN CAUTION INSTALLATION REQUIREMENTS

II 1 – Caution Installation Requirements

Ventilation:

This instrument is forced air cooled by a fan mounted on the rear panel. Air must be allowed to circulate freely through the ventilator grills located on the underside of the instrument. Before switching on the instrument, ensure that the air outlet on the rear panel is not restricted (i.e. clearance of at least 75 mm at the rear, 25 mm at each side, 15 mm on the underside). Failure to provide adequate clearances will increase internal temperatures and reduce the instrument reliability, so its performance may not meet specifications.

Power cords

General:

When the equipment has to be plugged into a Class II (ungrounded) 2-terminal socket outlet, the cable should either be fitted with a 3-pin Class 1 plug and used in conjunction with an adapter incorporating a ground wire, or be fitted with a Class II plug with an integral ground wire. The ground wire must be securely fastened to ground. Grounding one terminal on a 2-terminal socket will not provide adequate protection.

II 2 – Connecting To Supply

The power supply is automatically switched to work in two voltage ranges:

110V $\pm$ 20%

230V $\pm$ 10%, -20%

Frequency: 47-63 Hz

Power: 500 VA max

Fuses

One fuse of 5A TD is used for the two voltage ranges. Fuse is cartridge type measuring 5 mm X 20 mm.

The following electrical tests and inspection information is provided for guidance purposes and involves the use of voltages and currents that can cause injury. It is important that these tests are only performed by competent personnel.

Prior to carrying out any inspection and tests, the instruments must be disconnected from the main supplies and all external signal connections removed. All tests should include the instrument's own supply lead, all covers must be fitted and the equipment supply switch must be in the 'ON' position.

The recommended inspection and tests fall into three categories and should be carried out in the

Following sequence:

1. Visual inspection.
2. Earth bonding tests.
3. Insulation resistance test.

II 3-Operational conditions

This product must be used in a II environment class at 2000 m altitude. The operational temperature must be between 0°C and 50°C.

II 4-Visual inspection

A visual inspection should be carried out on a periodic basis. This interval depends on the operating environment, maintenance and use, and should be assessed in accordance with guidelines issued by the

Health and Safety Executive (HSE). As a guide, this instrument when used indoors in a relatively clean environment would be classified as 'low risk' equipment and so should be subject to safety inspections on an annual basis. If the use of the equipment is contrary to the conditions specified, you should review the safety re-test interval.

As a guide, the visual inspection should include the following where appropriate:

Check that the equipment has been installed in accordance with the instructions provided (e.g. that ventilation is adequate, supply isolators are accessible, supply wiring is adequate and properly routed).

The condition of the mains supply leads and supply connector(s).

Check that the mains supply switch isolates the instrument from the supply.

The correct rating and type of supply fuses. Security and condition of covers and handles.

Check the supply indicator functions (if fitted).

Check the presence and condition of all warning labels and markings and supplied safety information.

Check the wiring in re-wireable plugs and appliance connectors.

If any defect is noted this should be rectified before proceeding with the following electrical tests.

II 5-Earth bonding tests

Earth bonding tests should be carried out using a 25 A (12 V maximum open circuit voltage) DC source.

Tests should be limited to a maximum duration of 5 seconds and have a pass limit of 0.1W after allowing for the resistance of the supply lead. Exceeding the test duration can cause damage to the equipment.

The tests should be carried out between the supply earth and exposed case metalwork; no attempt should be made to perform the tests on functional earths (e.g. signal carrying connector shells or screen connections) as this will result in damage to the equipment.

II 6-Insulation resistance test

A 500 V DC test should be applied between the protective earth connections and combined live and neutral supply connections with the equipment supply switch in the 'ON' position. It is advisable to make the live/neutral link on the appliance tester or its connector to avoid the possibility of returning the instrument to the user with the live and neutral poles linked with an ad-hoc strap. The test voltage should be applied for 5 seconds before taking the measurement. Marconi Instruments products employ reinforced insulation in their construction and hence a minimum pass limit of 7 MW should be achieved during this test.

Where a DC power adapter is provided with the instrument, the adapter must pass the 7 MW test limit.

We do not recommend dielectric flash testing during routine safety tests. Most portable appliance testers use AC for the dielectric strength test which can cause damage to the supply input filter capacitors.

II 7-Rectification

It is recommended that the results of the above tests are recorded and checked during each repeat test. Significant differences between the previous readings and the measured values should be investigated. If any failure is detected during the above visual inspection or tests, the instrument should be disabled and the fault should be rectified by an experienced Service Engineer who is familiar with the hazards involved in carrying out such repairs.

Safety critical components should only be replaced with equivalent parts, using techniques and procedures recommended by NOISE XT SAS.

The above information is provided for guidance only. NOISE XT products are designed and constructed in accordance with International Safety Standards such that in normal use they represent no hazard to the operator. NOISE XT SAS reserve the right to amend the above information in the course of continuing its commitment to product safety.

II 8 - Cleaning

Before cleaning the device, switch off the instrument and disconnect it from the supply. The exterior surface of the case may be cleaned using a soft cloth moistened in water. Do not use aerosol or liquid solvent cleaners.

II 9 – Putting Into Storage

If the instrument is to be put into storage, ensure that the following conditions are maintained:

Temperature range: -40 to 70°C

Humidity: Less than 93% at 40°C

II 10 - Precautions

WARNINGS, CAUTIONS and NOTES.

These terms have specific meanings in this manual:

WARNINGS contain information to prevent personal injury.

CAUTIONS contain information to prevent damage to the equipment.

Notes contain important general information.

HAZARD SYMBOLS

The meaning of hazard symbols appearing on the equipment is as follows:

Symbol Nature of hazard

General hazard

Dangerous voltage

II 11 - Safety

This product has been designed and tested in accordance with BS4743 'Specification for safety requirements for electronic measuring apparatus' and IEC Publication 348 'Safety requirements for electronic measuring apparatus'.

II 12 – Warning Electrical Hazard

AC supply voltage. This equipment conforms to IEC Safety Class 1, meaning that it is provided with a protective grounding lead. To maintain this protection the supply lead must always be connected to the source of supply via a socket with a grounded contact.

Be aware that the supply filter contains capacitors that may remain charged after the equipment is disconnected from the supply. Although the stored energy is within the approved safety requirements, a slight shock may be felt if the plug pins are touched immediately after removal.

Removals of covers. Disconnect the supply before removing the covers so as to avoid the risk of exposing high voltage parts. If any internal adjustment or servicing has to be carried out with the supply on, it must only be performed by a skilled person who is aware of the hazard involved.

It is banned to use this product in the II, III, IV classification.

If this material is used in other conditions other than those specified by the manufacturer, the operator's protection is compromised.

II 13 – Warning Heavy Instrument

The weight of this instrument exceeds the 18 kg (40 lb) guideline for manual handling by a 'single person'. To avoid the risk of injury, an assessment should be carried out prior to handling which takes account of the load, workplace environment and individual capability, in accordance with European Directive 90/269/EEC and associated National Regulations.

II 14 – Warning Tilt Facility

When the instrument is in the tilt position, it is advisable, for stability reasons, not to stack other instruments on top of it.

II 15 – Caution Pulse Input

Before switching on the instrument, ensure that no signal voltage is present on the PULSE INPUT socket.

II 16 – Caution Static sensitive Components

This equipment contains static sensitive components which may be damaged by handling -refer to the Maintenance part of the Service Manual for handling precautions.

II 17 - Calibration

NOISE XT, manufacturer of PN9000 Phase Noise Measurement Systems, advises that calibration should be performed once a year (the PN9000 chassis & the central processing unit are needed).

Over this time the manufacturer will not approve the accuracy of measurements made by the user.

The calibration of the system is performed when the latter is in good working order. The equipment will be checked before calibration. Should defective parts be found out, NOISE XT will issue a quote shortly for the repair of the device.

3

BASIC TROUBLESHOOTING SEQUENCES

III / Base System:



The PN9000 phase noise system equipped with the main options is packaged into two "3 U" chassis

The PN9000 Base System consists of:

1 / Front Panel:

- Phase detector module (PN9431, PN9330 ...)
- LNA module
- Lock module
- Noise output module
- Status module

2/ Rear Panel:

- Power supply
- Interface module

Numerous options can be added to this basic system.

The main options are

PN9100: synthesized reference source (5MHz to 4.5GHz)

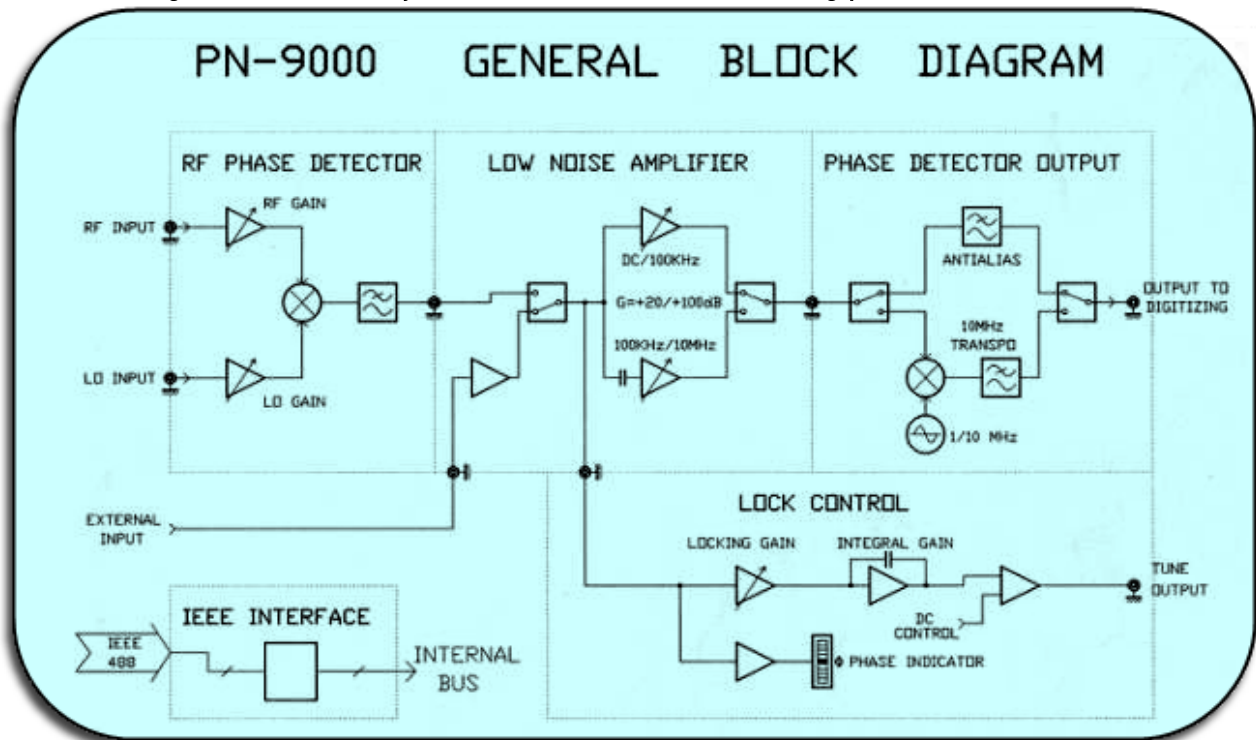
PN9151/PN9152: PN9100 frequency range extension (4.5GHz to 18GHz).

PN9273/74/76: microwave down-converter (2GHz to 50GHz)

To fit all these options two chassis are required.

The two chassis are remote controlled in parallel with either IEEE or RS232 interface module.

The block diagram of the Base System is described in the following picture:



The two inputs signals are fed into a front end phase detector (according the frequency range : RF or μW , the corresponding phase detector is selected) . The output of the phase detector drives a lock control module in order to lock the reference signal on the DUT (this is for the PLL method or Crystal mode) . The two input signals being locked, the carrier is removed at the output of the phase detector, this output is loaded into a low frequency amplifier chain (DC to 1MHz bandwidth) .

This amplified signal is the connected to the digitizing board plugged into the computer.

For the 1MHz to 40MHz analysis band, a digital control oscillator transposes the noise down to the 1MHz bandwidth, the analysis mode is then a sweep mode.

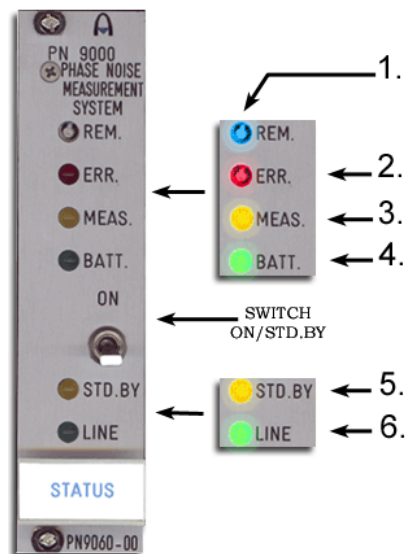
In the 1MHz band the analysis is done by a direct FFT.

All the other modules acts mainly as reference sources (PN9100 and PN9273/74) .

III 1 System Start Up:

1A/ On the Status Module the two LEDs (Line/6 and Standby/5) under the switch should light up when the power cord is connected.

Status (PN9060-00) :

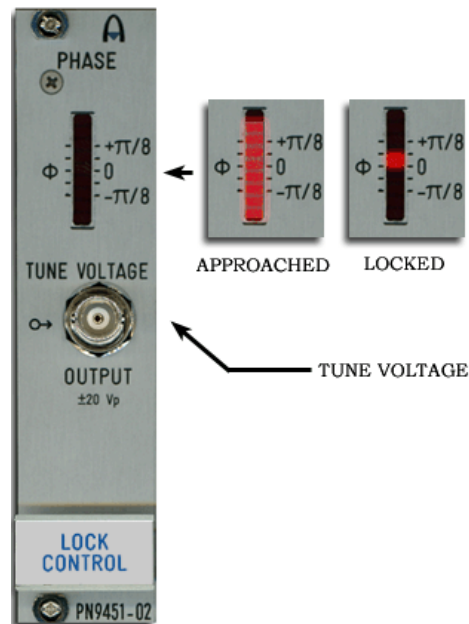


- 1. REMOTE CONTROL LED: Blue LED is lighted if the PN9000 is correctly connected on Serial interface or IEEE-488 interface.
- 2. ERROR LED: Red LED Blinked, if error during cycle measure.
- 3. MEASURE LED: Yellow LED Blinked during measurement.
- 4. BATTERY LED: not used.
- 5. STAND-BY LED: on during stand by
- 6. ON-LINE LED: on if PN9000 connected to the line

1 B/ When the unit is switched on:

- The "Standby" led switches off.
- The bar graph of the "LOCK" module should light up all the way up to the "0" guide mark.

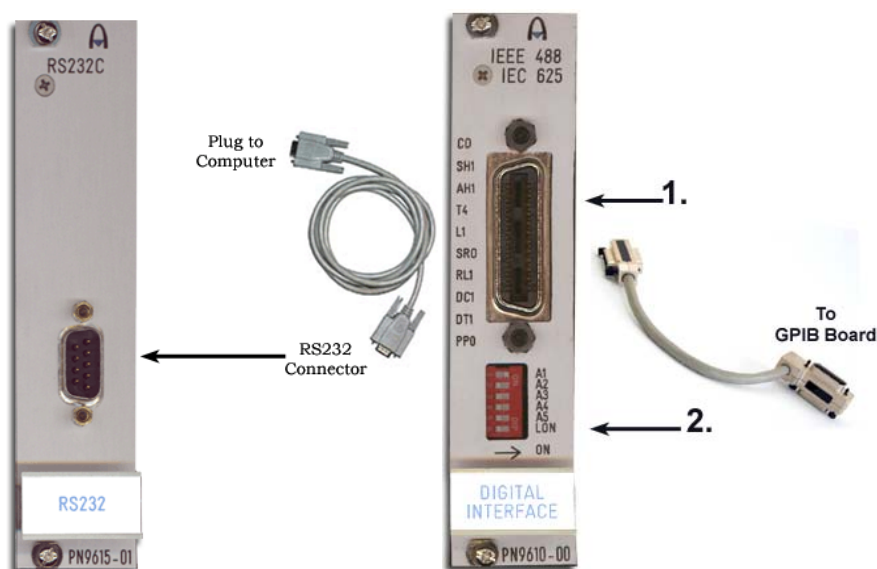
Lock Control (PN9451-02):



- If the system does not combine all these previous conditions, it is necessary to check the power supply. The "Power Supply" module can be tested on the rear panel (see chapter V).

1 C/ Check the IEEE or RS232 connector and the coaxial cables between the computer and the PN9000 unit.

Serial Interface (PN9615-01):



- RS232 CONNECTOR: The RS232 cable is single ended for one chassis; it is double ended cable for two chassis. The two ended plug are cabled in parallel.

1.D) Launch the WPN9000 program.

Run WPN9000 application.

The "remote" led (blue colour / 1) of the "Status" module should light up. If this led does not light up, this means that the PN9000 system is not controlled by the computer. The user will have to check:

1/ The RS232 cord.

Or

2/ The IEEE cord and the address (=1) of the "Interface-IEEE" module.

If there is still a problem after the previous elements have been checked, either the "Interface-RS232/IEEE" module or the IEEE board (in the computer) is faulty (check if this board is well plugged in into the computer, and test it by controlling it with an other RS232/IEEE equipment).

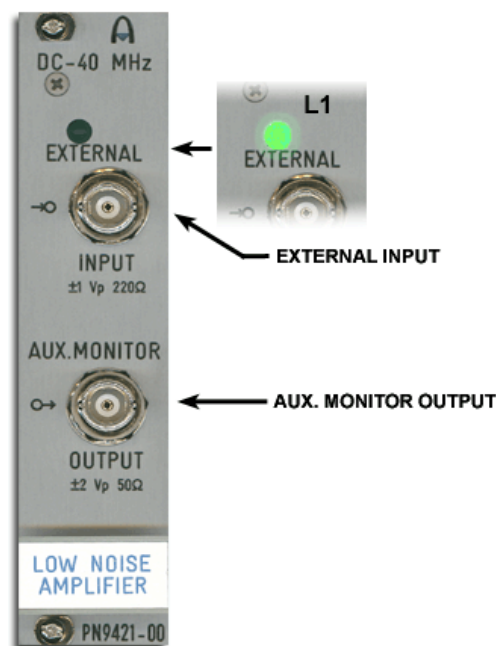
III 2 Checking the Programming Information:

2.A) LED Control Test:

Select the Method "PLL Xtal ", then the "Config / Manual" mode.

Validate the "External" source and check that the led of the "LNA" module lights up.

Low Noise Amplifier (PN9421-00):



2.B) Control the "LOCK" module bar-graph display modes.

- Launch the "LOCK ON" command. The bar graph should show a line close the "0" guide mark.
- Launch the "LOCK OFF" command. The bar graph should light up all the way up to the "0" guide mark.

See picture above.

2.C) Frequency counter

Select the Top Bar menu "F Counter".

- connect an input signal to RF and LO channels (two tops connectors) , measure the frequency and check the response (2MHz to 2GHz) .
- During the frequency measurement the phase detector switch to RF HL position, then it should come back to its current position.

Phase Detector (PN9341-01, PN9330-02):



2.D) Tune Voltage:

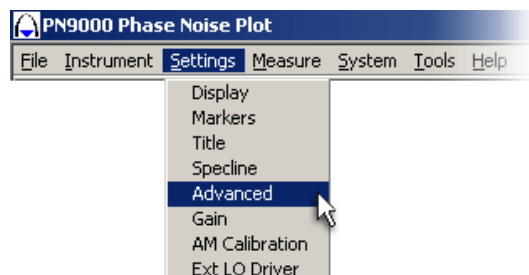
Connect a voltmeter to the "Tune-Voltage" output (see above picture for the Lock module front panel) . Select the Top Bar menu "V Tune", change the value and check the result with the voltmeter.

3) Checking the measurement parameters, RESET:

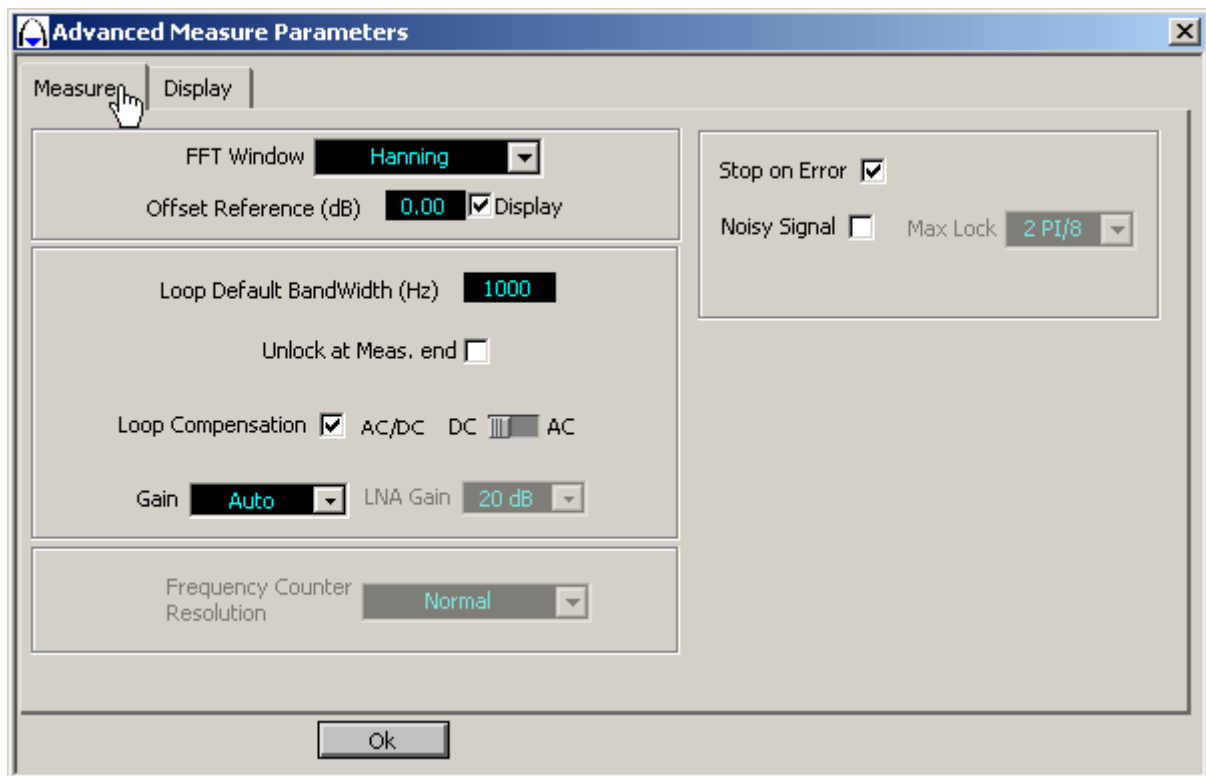
In the menu "Advanced" a list of parameters are defining the configuration of the measurement. These parameters have to be checked in order to insure a correct measurement process; some of these parameters affect directly the phase noise numbers. The operator has two possibilities : change manually the wrong parameter or select the **RESET** command in the menu FILE , this command resets to the default values all parameters , it also resets the plot memories A/B/C.....

Advanced Measure Parameters Menu:

Select on WPN9000 Top Bar menu "Advanced"



3.A) Measure Menu:



FFT Window: Different standard signal processing windows are available, but in the general case use the Hanning: **there is no significant effect on measurement.**

Offset Reference (dB): Value applied to the measurement. **This parameter affects directly the measurement.**

Loop Default Bandwidth (Hz): In the phase lock loop menu, for the PLL method, the user can select this default value for the Loop bandwidth. The user can change this default value. **Care if an unrealistic value is entered.**

Loop Compensation: For a calibrated measurement, tick off the "Loop compensation" box. With the PLL method, the demodulated phase noise inside the Loop Bandwidth of the reference is modified because the Loop effect. The signal processing software compensates this effect to normalize the plot.

For example:

Care: this parameter should be on "Compensation ON" for all Phase noise source measurements.

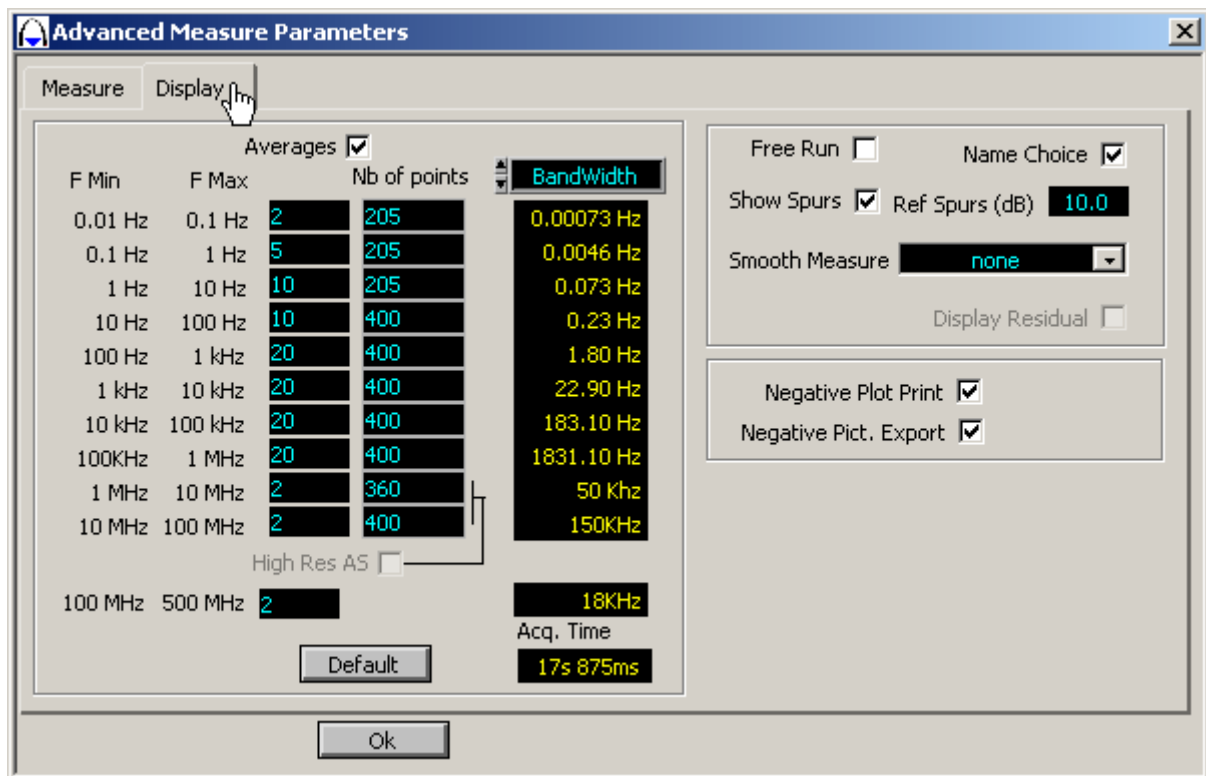
Gain: Auto, Replay, Manual.

-Auto: the system will define decade per decade the maximum video gain (LNA module) amplifying the noise before the ADC conversion , in order to obtain the maximum dynamic.

Care: generally this parameter should be on "Auto" position.

Noisy Signal (On/Off): In case of very noisy signal, this selection allows the system to increase the "Lock" detection range; this range can be selected by "Max Lock". **There is no significant effect on measurement.**

3.B) Display Menu :



The user can select specific values to set up his own measurement.

Averages: Number of averages per decade. The dispersion of the video noise of the plot depends on the number of averages. A standard value is 20. Instead of using a too large value, use better the smooth process. It is much more efficient in time. Select the top box to validate the average.

Nb of points: The number of points in one decade defines the frequency resolution. An approximation: resolution = (2 x max decade frequency) / Nb of points.

_____ Decade 1K 10K, N=400 resolution = 2x10K/400=50Hz.

Bandwidth = The FFT corresponding Bandwidth is displayed according to the decade end the number of points.

Free Run: The system launches a new measurement until the user presses the "space bar" or "esc" key.

Care: this is a specific configuration, not to use for a standard measurement.

Name Choice: Before each measurement the system may require a name for the current curve.

Show Spur: If selected the spurs will be displayed in dBc/Hz, if not selected the spurs will be suppressed from the plot.

Care: if the spur are "off", the measurement will not display the spurs .

Ref Spur: The signal processing detecting the spurs from the noise uses a reference level between the noise and the spur to decide if the data is a spur or is a noise. The amplitude of the noise is variable, it depends of the average number, the user has the capability to set a specific value. The standard is 10dB, which means that a data is detected as a spur if there are 10dB between the top of the spur and the closing noise. Use a minimum value of 3dB when the measurement is done with a large number of averages.

Care: if the "Ref spur" is not correctly defined, the spurs will not be detected correctly.

Smooth Measure: A special signal processing can smooth the results in order to reject the video noise due to a limited number of averages.

Negative Plot Print: Opposite colors of the curves, for an impression on white Background.

Negative Pict. Export: Opposite colors of the curves, to see pictures on white Background.

5) Launching a measurement with no DUT on RF:

- Select the "Spectrum log +Time domain" mode, with a span analysis from 1Hz to 1MHz.

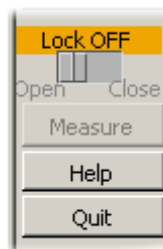
Top Bar Display:



Selection of display windows: Time domain, Spectrum with Log scale, Spectrum with Log scale + Time Domain.

Selection of the start and stop scale: Start, Stop. To modify Scale click in Start or Ending Value in X Scale.

- Launch the measurement command: "MEASURE".



Lock OFF (Open/Close): Open or Close the Loop.

Measurement: Run a measurement.

Help: Open WPN9000 help file.

A continuous curve should be obtained, with no significant steps between each decade and no stop during the measurement. The result should be close to the residual noise of the test set. Record the curve.

If a problem should occur, first make a general visual inspection of the digitizing board located in the computer (bad connection in the computer, damaged components, faulty 12V power supply....).

5) Testing the digitizing board with a low-frequency signal from an external generator:

PCI Acquisition Sampling Board (PN9656):



- 1: main cable, from “noise output” module.
- 2: option: 10MHz external reference (only for the “Frequency stability” measurement process) .

First of all check that the board is well plugged into the Controller connector. Some chocks due to the transportation can unplug this board.

5.A) Analog to digital conversion test:

- Disconnect the cable between the PN9000 and the computer.
- Connect a frequency generator to the digitizing board that is plugged at the back of the computer.
- Set 1 KHz, 0.1 Volt peak signal.
- Set in the menu “Advanced”, Gain = manual = 20dB.
- Select the “Time domain menu” with Time span = 10 ms and Scale=1 Volts.
- Launch the measurement.
- Check that the displayed data are in the range of $25\text{mVp} \pm 5\text{mV}$.

5.B) Checking the frequency counter implemented on the digitizing board:

- Set 1 KHz, 1 Volt peak signal.
- With the Top Bar menu, check the IF frequency.
- Test the frequency response with the frequency counter, in “F beat” mode ($F < 400\text{KHz}$) .

4

BASIC TROUBLESHOOTING: GENERAL TESTS

1) CHECKING THE CALIBRATION PROCESS

- Connect two frequency shifted sources (< 10 KHz) with an output level of 0dBm / +7dBm RF and $> +7$ dBm LO (PN9100 is used as LO if installed) .
- In the Method "PLL Xtal" Manual mode, select the Kphi box , enter a value of 0.2V/rad .
- Parameter: the bar-graph must light up totally. If it doesn't, check the possible failures:
 - The "RF PHASE DETECTOR" module is not mixing any more.
 - The display of the "LOCK" module does not work.
 - The "LNA" (amplifier) module is not transferring the beat to the "LOCK" module.

For any of these problems, please refer to the troubleshooting procedure for each module.

- Measure the frequency of the beat using "Measure IF freq" key.
 - If a problem should occur, check that the beat is yielded by the "NOISE OUTPUT" module (square wave > 1 Vpp) , and check the frequency counter separately (see digitizing board) .
- Launch a calibration process: if the two sources under test are stable, the calibration signal should be "clean"; i.e. it must show a periodical signal without noise.
- If this is not the case:
 - Check the Noise output, sinuswave > 800 Vpp.
 - Check the quality of the sources.
 - Check the Digitizing Board using a low-frequency generator.

For RF (< 1 GHz) levels between 0 dBm and +10 dBm, the calibration constant must be between 0.1 V/rad and 0.2 V/rad.

2) CHECKING THE LOCK PROCESS

- Bring the frequencies of the two sources under test close to one another in order to obtain a very low frequency beat.
- In the PLL Xtal / Manual Mode menu, select a loop bandwidth higher than the beat frequency.
- Check the Tune slope of the reference source.
- Launch the "LOCK ON" command :

The program controls DC at the output of the mixer. It must be close to "0"; otherwise the error message "Error-lock" will appear. This error message has two meanings: either the DC voltage is too high (and so it does not guarantee the good quadrature of the sources under test (perfect quadrature: $DC = 0$)), or the source is not locked. To differentiate these two errors, look at the bar-graph:

- If the voltage is too high, the bar-graph shows a line far from the "0" guide mark.
- If there is no locking source, a beat is shown.

If no problem is noticed, the bar-graph shows a line close to the "0" guide mark. When the bar-graph shows a DC far from "0", the guide marks $p/8$ allow to estimate the error. During the calibration process, the system shows the error in dB, for a quadrature faulty of $\pm p/8$. The user can keep on running measurements if he considers that this error is compatible with the degree of precision he requires. If the lock function does not operate well, check the "LOCK" module.

3) CHECKING THE MEASUREMENT PROCESS

3.A) Checking the measurement process

After calibrating the test set and locking the reference source, run a measurement in the whole range of the test set. - During the measurement, if the error message "ACQ default" appears, the digitizing board must be tested.

- During the measurement if the error message "Saturation" appears, it means that high instability has saturated the amplifier during the measurement. To determine the nature of this instability, the "Spectrum.log+ Time domain" window should be used. This instability can be:
 - Temporary and caused by an external factor: external disturbances, shocks during the measurement, power supply variations...
 - Generated by the sources under test (faulty operation).
 - Generated by a weak loop gain. In this case, increase the bandwidth using the phase lock loop menu in Manual mode.
 - Generated by the faulty operation of the test set itself. In this case, check the "RF Phase Detector", "LNA" and "Lock" modules.
- During the measurement, the appearance of the error message: "Error lock" means that the reference source is no longer locked. Check the locking process.

Notice: The Time Domain should be used to detect bad phase noise transients. Bad transients can be easily detected because the amplitude could be ten times as large as the normal noise, and it appears only during a short time. The consequence is a disturbed spectrum with no meaning.

3.B) Checking the coherence of the results

At the boundary of the decades (1, 10, 100 Hz ...), if a difference in level of more than 3 dB appears each time between the lower and higher decades, the time domain has to be checked (window Spectrum.log + Time domain).

Random "spike" can cause an unstable spectrum.

Check the PN9000 with stable oscillators.

4) CHECKING THE CALIBRATION PROCESS

4.A) Checking the calibration gain

- Select the method "PLL Xtal" / Manual mode .
- Select the "External" source mode .
- Connect a low-frequency generator to the "external" input of the "LNA" (amplifier) module.
- Select a 5 KHz frequency and 0.2 Volts peak.
- Run the calibration using the "Beat peak" mode.

Check the result value which should be $V = 0.2 \pm 5\%$.

4.B) Checking the Tune Voltage

- Select the range $\pm 10\text{Volts}$.
- Select Tune Voltage =0 and check the value using a multimeter ($V = 0 \pm 0.01$).

- Select different values for Tune Voltage (they should have a degree of precision of $\pm 5\%$, in the range $\pm 10\text{Volts}$).

4.C) Checking the loop gain

- Connect a low-frequency generator to the "external" input of the "LNA" (amplifier) module.
- Select a frequency of 5 KHz and 0.2 Volts peak.
- Select the "External" source mode in the manual mode menu.
- In the manual mode menu "measure Kphi", enter: "Kphi = 0.1 V/rd", "Bandwidth= 100 Hz", "Tuneslope = 100 Hz/Volt", "Drift compensated = off".
- Run the locking process, using the "LOCK ON" command.
- Check the output voltage of the "LOCK" module: in this configuration, the gain module is equal to 10 and the control voltage should be 2 Volts peak $\pm 5\%$.

4.D) Checking the measurement gains

GAIN DC - 100 KHz :

- In the method "PLL Xtal" / Manual mode, set Kphi = 0, 1.
- Set a beat of 50 KHz between two sources, RF / LO, with an RF level of RF = - 30 dBm.
- In the "Advanced" menu, select the values: Gain = +20 dB", Gain = "Manual"
- In the main display: select the mode "Spectrum.log" , 10K / 100 KHz.
- Run the measurement.
- In the Top Bar menu Fx, "Spur" menu, read the level of the 50 KHz spurious.
- In the "Advanced" menu, adjust "Offset ref" to calibrate this 50 KHz spurious at -30 dB (run a new measurement for verification purpose).
- Make the level of the RF channel move down by steps of 10 dB (with an attenuator calibrated at 0.1 dB). Compensate this attenuation by increasing the measurement gain by "steps" of 10 dB (20dB / 30dB / 40dB.....).
- Measure the 50KHz spur and check the level is moving accordingly (-30dB / -40dB / -50dB) These values should be precise by ± 0.5 dB.

GAIN 100 KHz - 40 MHz : Same process as above, using the "100 KHz - 40 MHz" amplifier, a beat signal of 500 KHz, and a spectral analysis range of 100KHz / 1 MHz.

4.E) Checking the Constant: level

- Use a white noise generator , a digital one would be more suitable, to obtain a perfect flat spectrum.
- Connect this generator to the "external" input of the "LNA" (amplifier) module.
- Launch a spectral analysis in the whole range (this range must be compatible with the noise generator). On the spectrum, check the Constant level ($< \pm 1.5$ dB).

5

CHECKING THE BASE SYSTEM MODULES

The modules of the base system perform the phase noise or AM noise demodulation and the spectral analysis.

This part includes:

- 1/ The chassis with its power supply (see specific chapter).
- 2/ The five left modules located in the mainframe.

This part of the Maintenance Manual is dedicated to the faulty detection of these five modules.

1) Checking the "RF Phase Detector" Module

Phase Detector (PN9341-01, PN9330-02):



1.A) Testing the mixer

- Select the method "PLL Xtal" or "PLL synth" , "Manual" mode.
- According to the selected mixer, check the front panel LED matches the selection.
- Select the standard RF mixer, use two "RF" generators to get a frequency beat between these two sources (RF>0dBm LO>+7dBm) .
- Check this signal on the "AUX" connector of the "LNA" (amplifier) module.
- Make the frequency of the sources move from 2 MHz to 1.8 GHz and check that a frequency beat is obtained in all cases.
- Run a calibration, from 2MHz to 1GHz $K_{phi} > 0,1V/rd$, at 1.8GHz $K_{phi} > 0,03 V/rd$.
- Check RF and HL mixers (HL needs $> +15dBm$ LO) .
- Select the microwave mixer and set two microwave signals (2GHz to 18GHz /26,5GHz) : check the beat frequency as for the RF range.

1.B) Testing the mixer configuration

- Check if during a measurement process the current position stays on the selected mixer. (only during frequency counter measurement the position switches to RF HL position and then come back to the current position) .
- Check in the transposition mode if the RF and the microwave mixers are selected (method "PLL synth " , mW range only) .
- Check in Pulse mode if the mixer is selected with the "External" position.

1.C) Testing the "RF" amplifiers

- Select the standard mixer .
- Select a RF frequency < 1 GHz.
- Attenuate the "RF" channel by 10 and 20 dB.
- Compensate the loss of the signal by an amplification of +10 and +20 dB.
- Run a calibration and check this amplification on the beat signal.

1.D) Testing the Frequency counter

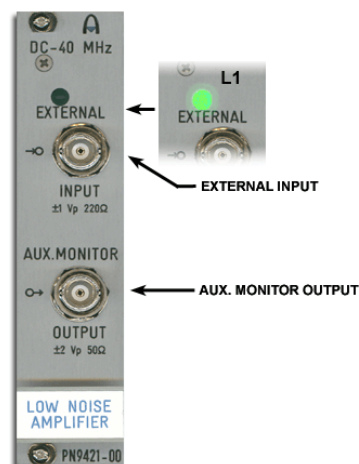
- Set two signals on RF > 0 dBm / LO $> +7$ dBm .
- Select the Top Bar menu "Fcounter" and check the corresponding value .

1.E) Testing the AM detector

- Check the corresponding LED is selected.
- Check the AM calibration mode is working in "DC" mode.

2) Checking the Amplifier Module

Low Noise Amplifier (PN9421-00):



When operating in Manual Mode, select the "External" source. The led of this module must light up.

2.A) Checking the measurement gains

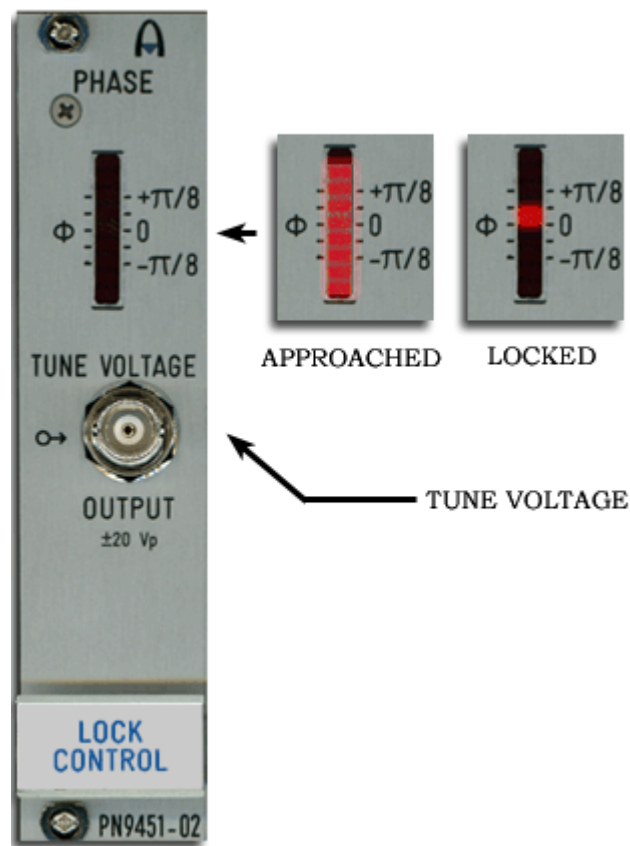
GAIN DC - 100 KHz:

- In the method "PLL Xtal" / Manual mode, set $K_{phi} = 0,1$.
- Set a beat of 50 KHz between two sources, RF / LO, with an RF level of $RF = -30$ dBm.
- In the "Advanced" menu, select the values: Gain = +20 dB", Gain = "Manual"
- In the main display: select the mode "Spectrum.log" , 10K / 100 KHz.
- Run the measurement.
- In the Top Bar menu Fx , "Spur" menu, read the level of the 50 KHz spurious.
- In the "Advanced" menu, adjust "Offset ref" to calibrate this 50 KHz spurious at -30 dB (re run a measurement to check) .
- Make the level of the RF channel move down by steps of 10 dB (with an attenuator calibrated at 0.1 dB). Compensate this attenuation by increasing the measurement gain by "steps" of 10 dB (20dB / 30dB / 40dB.....).
- Measure the 50KHz spur and check the level is moving accordingly (-30dB / -40dB / -50dB) These values should be precise by ± 0.5 dB.

GAIN 100 KHz - 40 MHz : Same process as above, using the "100 KHz - 40 MHz" amplifier, a beat signal of 500 KHz, and a spectral analysis range of 100KHz / 1 MHz.

3) Checking The "Lock" Module

Lock Control (PN9451-02):



3.A) Testing the Tune-Voltage output

- In "LOCK OFF" mode, change the Tune-Voltage value and check this value with a Voltmeter. This value must have a precision of $\pm 5\%$ in the ± 10 Volts range.

3.B) Testing the "Bar-graph"

- Set a beat frequency between two sources, or using an external low-frequency generator.
- Select the Manual Mode menu and for the "Kphi" parameter, enter values ranging from 0.1 and 1 V/rad.
- The "bar-graph" indicator must vary according to the value that has been selected: a large value should decrease the swing on the "bar-graph".

3.C) Testing the loop's proportional gain

- Set a standard PLL method RF measurement with two sources.
- Set the RF source at 0dBm maximum.
- Select Tune-Voltage = 0V.
- Select the PLL/manual mode.

- Run a calibration to measure the Kphi parameter , check if the beat frequency is close to a sinusoidal signal (no distortion).
- Set Tuneslope=LoopBandwidth (example 100Hz for both) , enter these values manually whatever the carrier frequency is and whatever the values selected by the system are.
- Select "Drift compensated =off".
- Launch the "LOCK ON" command.
- Check that the "LOCK" module yields the beat signal with 0V DC.
- Check the beat amplitude voltage , it should be close to 1Vpeak .
- Check that the amplitude of this signal moves if the "Bandwidth" parameter is changed : if LoopBandwidth = Tuneslope/10 , the beat signal should be close to 0,1Vpeak.

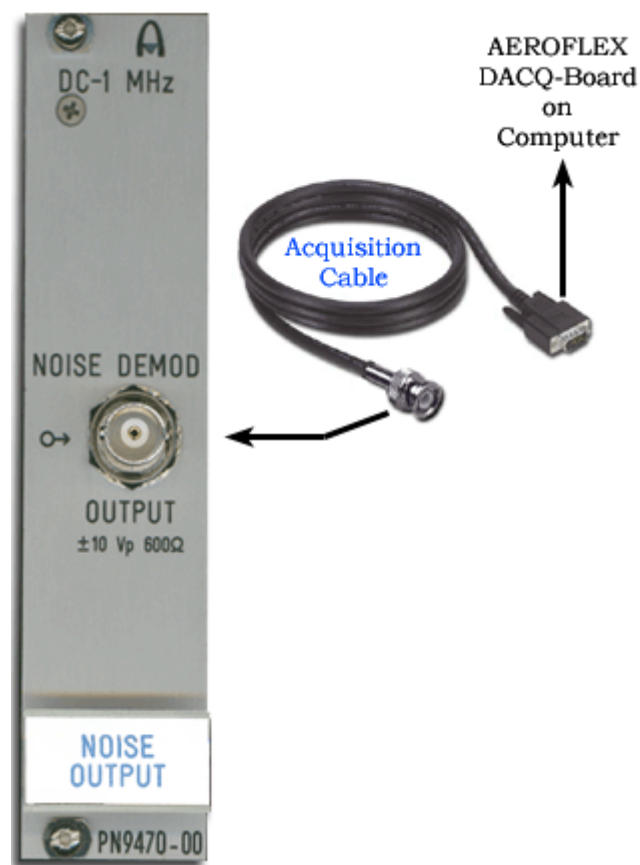
3.D) Testing the integral gain

In the Manual Mode menu, select "Drift compensated =on".

- Launch the "LOCK ON" command.
- Check that the signal yielded by the module slips to ± 10 Volts (integral gain is an infinite continuous gain) gradually.

4) Checking the "Noise output» Module

Noise Output (PN9470-00) :



The standard module is with 1MHz span , the option PN9490 is with 40MHz span

This modules includes two channels: 1MHz channel and 40MHz channel.

1/ In the 1MHz mode, the demodulated noise coming from the LNA module is buffered and output to the digitizer

2/ in the 40MHz mode the demodulated noise coming from the LNA module is first transposed below 1MHz by means of a local VCO transposing the 40MHz bandwidth down-to 625KHz , step by step. At each step a measurement point is displayed on the plot.

See the block diagram picture.

4.A) 1 MHz Channel

Select the method "PLL Xtal" , Manual mode , External.

Select in the menu "Advanced" , Gain = manual , 20dB .

Set a frequency signal $< 1\text{MHz} / 50\text{mVp}$ on the external LNA input (see LNA mode) .

Run a measurement with the corresponding FFT decade (example : beat 500KHz : span = 100KHz to 1MHz) .

Check with an oscilloscope having two channels

1/ the signal coming out the LNA "Aux" output, it should be in the range = 100 to 300mVp .

2/ the signal coming out the Noise Output module, it should be in the range = 100 to 300mVp.

4.B) 40MHz Channel

Set a frequency signal $> 1\text{MHz} < 10\text{MHz} / -60\text{dBm}$ on the external LNA input .

Select in the menu "Advanced" , Gain = manual , 50dB .

Run a measurement with the decade 1MHz / 10MHz .

Check with an oscilloscope having two channels

1/ the signal coming out the LNA "Aux" output , this signal should stay constant during the measurement (in the range of 50mVp to 100mVp) .

2/ Check with an oscilloscope the signal coming out the Noise Output module.

The system will sweep the internal transposition in order to provide a 625KHz signal representing the amplitude of the signal to be measured.

During the sweep at the moment where the input signal (9MHz) is to be measured a 625KHz should appeared . This 625KHz is viewed only during the time where the system is measuring the corresponding band. To increase this time increase the number of averages (output voltage about 1Vp) .

Set a frequency signal $> 10\text{MHz} < 40\text{MHz} / -60\text{dBm}$ on the external LNA input.

Select in the menu "Advanced", Gain = manual , 50dB .

Run a measurement with the decade 10MHz / 40MHz.

Do the same check as for the 1MHz to 10MHz range.

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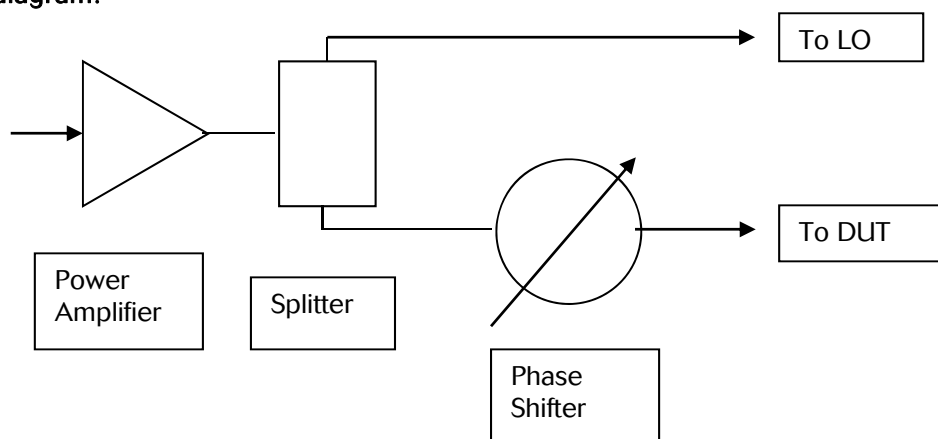
CHECKING THE OPTIONS

1) Added noise RF

RF ADDED noise module (PN9845-04) :



Block diagram:



The main functions are:

1/ Power amplifier and Splitter

2/ Phase shifter on one Channel.

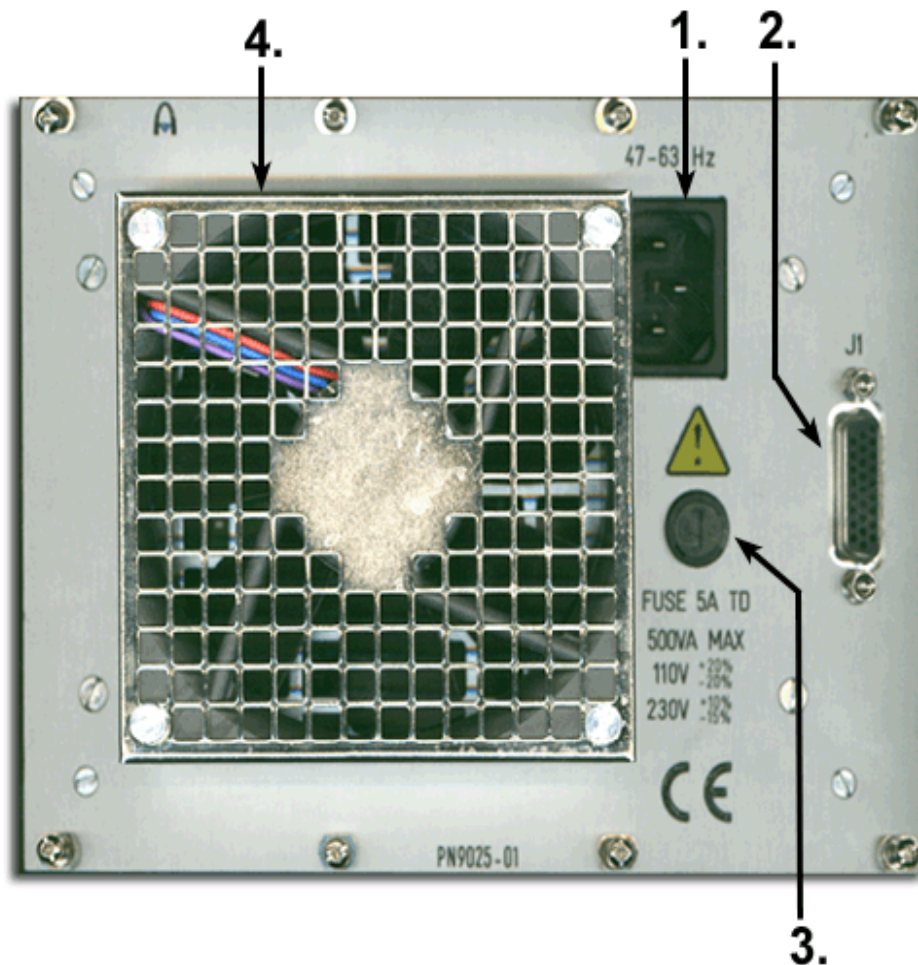
The tests are reported in the following report (use an external RF generator and a power meter) :

3) Control of Levels			
<i>DUT Output Level</i>			
Freq.=100MHz	dBm	≥12	18,2
Freq.=500MHz	dBm	≥12	16,4
Freq.=1GHz	dBm	≥12	20
Freq.=2GHz	dBm	≥12	14
<i>"To LO" Output Level</i>			
Freq.=100MHz	dBm	≥18	19,6
Freq.=500MHz	dBm	≥18	20,7
Freq.=1GHz	dBm	≥18	20,8
Freq.=2GHz	dBm	≥18	19
4) Phase Noise			
measurement at 1GHz	ok	X	OK
<i>Specified Value</i>			
10Hz ---> -136 dBc/Hz	dBc/Hz		-140
100Hz ---> -146 dBc/Hz	dBc/Hz		-153
1kHz ---> -155 dBc/Hz	dBc/Hz		-162
10kHz ---> -161 dBc/Hz	dBc/Hz		-168
100kHz ---> -165 dBc/Hz	dBc/Hz		-170
1MHz ---> -165 dBc/Hz	dBc/Hz		-172
10MHz ---> -165dBc/Hz	dBc/Hz		-172

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POWER SUPPLY TROUBLE SHOOTING

Power Supply (PN9025-01) :



- AC INPUT CONNECTOR :
- Auxiliary OUTPUT : Pin 1 on bottom right as wrote on connector
- PIN 13 to 18 = Ground / PIN 2 = +5.3Volt+/-0.2Volt
- PIN 4 = -15.5Volt+/-0.5Volt / PIN3 = +15Vol+/-0.5Volt.
- 3. FUSE PLUG :
- 4. FAN :

Verify the Voltage on the auxiliary connector, if no voltage verify the fuse .

The power supply is automatically switched to work in two voltage ranges :

110V $\pm$ 20% / 230V + 10%,-20%

Frequency: 47-63 Hz / Power: 500 VA max

Fuses : One fuse of 5A TD is used for the two voltage ranges .Fuse is cartridge type measuring 5 mm X 20 mm.

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ANNEXE I

PN9000 BASE SYSTEM SPECIFICATIONS

Frequency Range	: 2 MHz to 26.5 GHz, depending on Phase Noise Detectors.
Offset Analysis	: 0.01 Hz to 1 MHz standard (option for 40 MHz).
Measurement Accuracy	: ± 2 dB up to 10 MHz offset, ± 3 dB above 10 MHz offset.
Reference Tuning Voltage	: ± 20 Volt with 5 mV resolution.
Phase Lock Loop Gain	: Proportional and Integral (DUT drift compensation).
Loop Compensation	: Automatic (can be disabled).
Phase and AM Noise Detectors	: Typical values for nominal RF & LO input levels.

Parameters	Standard RF	High Level RF	MW (option) Std level	MW (option) High level	AM (option)
Frequency range, GHz	0.002 to 1.8	0.002 to 1.0	1.6 to 26.5	1.6 to 26.5	0.01 to 26.5
RF Input min. dBm	-20	+10	-10	+10	-5
RF Input max. dBm	+10	+20	+15	+20	+15
LO Input min. dBm	0	+10	+7	+17	None
LO Input max. dBm	+10	+20	+15	+23	None
RF Input Gain, dB	-10, 0, 10, 20	None	None	None	None
LO Input Gain, dB	0, 10	None	None	None	None
Noise floor, in dBc/Hz at					
1 Hz offset	-130	-140	-120	-128	None
10 Hz	-140	-150	-130	-138	None
100 Hz	-150	-160	-140	-148	-142
1 kHz	-160	-170	-150	-158	-150
10 kHz	-168	-178	-160	-168	-160
100 kHz & beyond	-168	-178	-168	-174	-160
Nominal RF Input level, dBm	+6	+16	+6	+13	+10
Nominal LO Input level, dBm	+7	+17	+10	+20	None

For specified values add + 3 dB (+/- 2 dB accuracy). For RF levels < nominal value, the noise floor will increase by number of dB below the nominal value. For example, for 0 dBm RF input, increase of +6, the typical system residual noise is, at 10 kHz offset, -168 dBc /Hz - 6 dB= -162 dBc/Hz.

Spurious level	: -110 dBc.
Built-in Counter, DUT, Reference LO	: 2 MHz to 2 GHz.
IF/Beat	: 0.3 Hz to 400 kHz.
Temperature & Humidity, operating	: 0 to +50 °C.
Storage	: -40 to + 75°C. Up to 95% non condensing..

ANNEX II

PN9000 BASE SYSTEM COMPLIANCE TESTS

The final compliance test include the following tests (depending on the installed option)

I / Tests generating auto-correction coefficients

- 1 Power supply test
- 2 Reference gain 20db
- 3 Lock gain
- 4 V Control
- 5 LNA Gain DC-100KHz
- 6 LNA Gain 100KHz-40MHz
- 7 Frequency counter
- 8 Timer
- 9 Flatness tests
 - 1 Flatness at -45 dbv2 span 1KHz
 - 2 Flatness at -45 dbv2 span 10KHz
 - 3 Flatness at -45 dbv2 span 10KHz filter
 - 4 Flatness at -45 dbv2 span 100KHz
 - 5 Flatness at -45 dbv2 span 1MHz
 - 6 Flatness at -45 dbv2 span 10MHz INT
 - 7 Flatness at -45 dbv2 span 40MHz INT
 - 8 Flatness at -45 dbv2 span 1MHz EXT
 - 9 Flatness at -45 dbv2 span 10MHz EXT
 - 10 Flatness at -45 dbv2 span 40MHz EXT

II / Compliance Tests

- 1 Residual Standard
- 3 Flatness Standard 1Hz-40MHz
- 4 Smooth Flatness Standard 1 KHz-40MHz
- 5 Residual High Level
- 6 Residual High Level Spec line
- 7 Flatness High Level 1Hz-40MHz
- 8 Smooth Flatness High Level Spec line 1 KHz-40MHz
- 9 Residual AM
- 10 Residual Microwave 1Hz-40MHz
- 11 Residual Microwave Spec line 1Hz-40MHz
- 12 Linearity Loop 50
- 13 Linearity Loop 500

SYNTHESIZER PN9100 (if installed)

- 1 PN9100 10MHz
- 2 PN9100 100MHz
- 3 PN9100 1GHz
- 4 PN9100 2GHz
- 5 PN9100 4GHz
- 6 PN9100 8GHz Wide

OTHERS OPTIONS (if installed)