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Model 102C
0.01 Hz - 15 MHz
Analog Network Analyzer

MANUAL REVISION 1.0A
ANALYZER SOFTWARE VERSION 3
Copyright 2001

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Federal Communications Requirements

Warning- This equipment generates, uses,and can radiate radio frequency energy and if not installed and used in accordance with the instruction manual, may cause interference to radio communications. It has been tested and found to comply with the limits for a class A computing device pursuant to Subpart J of Part 15 of FCC rules, which are designed to provide reasonable protection against such interference when operated in a commercial environment. Operation of this equipment in residential areas is likely to cause interference in which case the user at his own expense will be required to take whatever measures may be required to correct the interference.

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Table Of Contents

1. System Installation 1
- The Model 102C Network Analyzer 1
- Hardware Installation 3
- Software Installation 7

2. Graphical User Interface 10
- NA Windows Connectivity Overview 10
- Graph Display Modes 12
- Menu Selections 14
- The Toolbar 20
  - Main Toolbar 20
  - Sweep Frequency Toolbar 23
  - Sweep Parameters Toolbar 24
  - Source Parameters Toolbar 25
  - Receiver Parameters Toolbar 26

3. System Calibration 27

4. Dynamic Data Exchange 33
- Understanding Dynamic Data Exchange (DDE) 33
- Using DDE in Microsoft Excel 36

5. Application Notes 41
- Introduction to Analog Network Measurements 41
- Basic Measurement Procedures 43
- High Frequency Measurements 45
- Circuits with Nonzero DC Voltage Levels at the Input / Output Node 46
- Measuring Circuits with High Common Mode Voltages 46
- Measuring Feedback Loop Frequency Response 47
- Measuring Complex Impedance 51
- IEC 555-2 Measurements 53
- Power Transmission/Reflection Measurements 54

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Appendix

A : Theory of Operation 57
B : Measurement Accuracy 60
C : Specifications 64
D : File Types; Use and Format 66
E : Default Setup Values 68
F : In Case of Difficulty 71
G : Repair and Warranty Information 72
H : Source Fuse Replacement 74

Index 75

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1 System Installation

The Model 102C Network Analyzer

The 102C Network Analyzer system is composed of an analog source/receiver unit, a digital signal processing (DSP) board with an on-board power supply for the source/receiver unit, probes, interface cables and software for a user provided IBM® compatible PC computer.

The 102C Network Analyzer offers the following high performance features

- 11.6 millihertz to 15 Megahertz coverage
- 110 dB's of dynamic range with 0.025 dB mag. and 0.2 degree phase accuracy
- Up to 2001 measurement points with linear or logarithmic frequency sweeps
- Automatic magnitude and phase correction compensates for test leads or fixtures

Graphical interface features

- Windows® based graphical user interface
- Virtual instrument front panel for complete access to all system parameters
- Dynamic Data Exchange (DDE) interface for data sharing between applications
- Automatic or manual scaling and shifting of screen plots for optimum viewing
- Two movable markers and master graphs give data and delta readouts.
- Advanced functions including complex impedance and IEC 555-2 display

Source features

- Direct digital synthesis for fast sweeps
- 11.6 millihertz to 15 MHz range, 11.6 millihertz resolution
- Output level adjustable in 1 dB steps from 1.25 millivolts to 1.77 volts rms
- 50 ohm output with current limiting
- Output can be DC offset up to +/- 10 V eliminating large coupling capacitors at low measurement frequencies

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Receiver features

- Two channels for B/A ratioed, transfer function measurements
- High selectivity two stage receiver architecture for high noise immunity
- Digital signal processing provides a user selectable IF bandwidth, optimizing noise immunity and measurement speed
- Selectable AC (>=10 Hz) or DC coupling with one megohm input impedance
- Inputs can be DC offset up to +/- 10 V facilitating DC coupled measurements.

Host PC requirements for using the Windows software

Operating System: Windows version 3.1 higher. NT version of software requires Windows NT 4.0 or higher. PC Hardware: 80386 processor or higher with math coprocessor. Mouse and VGA monitor.

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Hardware Installation

The DSP board needs one 2/3rd sized 16 bit ISA slot from the host IBM® PC compatible computer. The PC's CPU must be an 80386 or higher. A math coprocessor is also required. The host PC is also required to have a floppy drive, Windows® operating system, mouse and a VGA or better display adapter.

The unit requires 1.5 amps from the PC's +12v power supply or an external supply rated 30w or greater. The minimum recommended PC power supply is 150W which generally translates into a +12v supply of 6 amps or greater capacity. This allows the usual complement of one hard drive and one floppy drive.

CAUTION !

Before handling the DSP board make sure you are in a static free work environment, preferably wearing a grounded wrist strap, or at a minimum, taking care to discharge any static electricity by touching a grounded, conductive, object.

When operating the analyzer static discharge precautions must be taken to prevent damage to the source or receiver channels. This includes wearing a grounded wrist strap and using a grounded static control table mat.

WARNING !

DO NOT ATTEMPT TO MAKE MEASUREMENTS ON HOT OR UNGROUNDED SYSTEMS !!!. DO NOT ATTEMPT TO SHIFT THE SOURCE/RECEIVER GROUND BEYOND 42V PEAK FROM HOST PC (EARTH) GROUND OR OPERATOR SAFETY WILL BE COMPROMISED AND EQUIPMENT DAMAGE MAY OCCUR!!!. If it is necessary to make measurements on such systems then use an

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isolation transformer on the system and ground the system under test to an earth ground. See application notes for high common mode voltage measurement procedures. Working on or around line voltages has electrical shock hazards for both the operator and the instrument that must be understood before measurements are attempted!

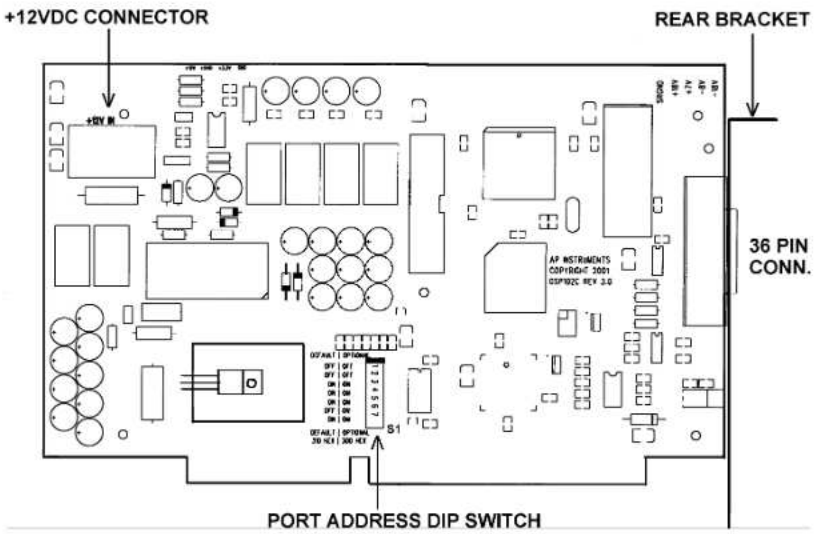
Installation Procedure

After ensuring the host PC has met the minimum requirements given above follow the directions below:

[1] Make sure the PC's power switch is turned OFF and gain access to the PC's card cage area by removing the necessary covers.

[2] Identify a free 16 bit ISA slot (two edge connectors). The selected slot should also have an empty slot next to it on the component side to maximize airflow to the DSP board's power supply. Remove the selected slot's existing rear card cage bracket, keeping the screw for the next step.

DSP Board Outline

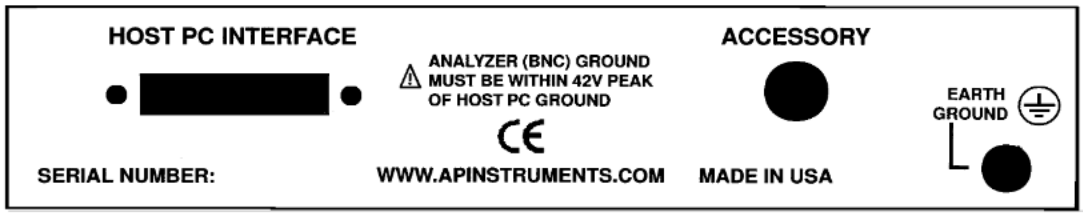


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[3] After taking the proper static safeguards as outlined above grasp the DSP board at the upper left and right edges, avoiding any components. Push the DSP board into its slot firmly at which point the mounting bracket clearance hole should be aligned with PC's card cage threaded hole. Use the screw saved from step 2 to secure the card in place.

[4] Using the included Y adapter cable if necessary, connect the PC's power supply harness to the DSP board's receptacle. The Y adapter can be used if there are no free power supply harness plugs by removing a plug from a disk drive and replacing it with the Y adapter plug, reinstalling the power supply harness plug into the Y adapter's receptacle. Use the end with the three wires, two black and a yellow, to plug into the DSP board.

Source / Receiver Rear Panel

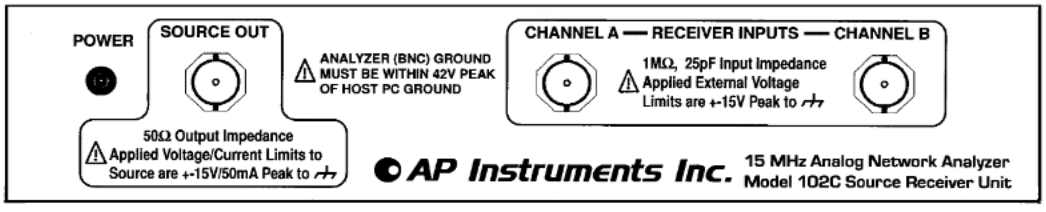


[5] Reinstall any covers, or sheet metal, previously removed.

[6] Push in the 9 foot cable's 36 pin plug into the DSP board's receptacle and secure using the cable's retaining clamps. Likewise, connect the other end to the source/receiver unit.

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Source / Receiver Front Panel



[7] Connect the source probe, a 1:1 cable with clips, to the source output BNC. Connect the two input probes, labeled "A" and "B" to their respective BNC's.

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Software Installation

Installing the Windows software

[1] Insert the software disk labeled "AP Instruments Windows Software for the Model 102C Network Analyzer, Version 3" into the host computers floppy drive.

[2] While in Windows, use the program manager's RUN command to execute the setup program "a:\setup" or "b:\setup" depending on the PC's floppy drive letter designation a: or b:. Choose the "First-time Software Installation (Full Install)" option. The setup program will create a directory (default location of C:\nawincon) and transfer the required program files to this directory. The setup program will also create a program group called "AP Instruments".

[3] The Windows analyzer software icon, named NA Windows Connectivity, is located within the AP Instruments program group. Before starting the software make sure the analyzer hardware is properly installed in the host PC and all cables are connected. Double clicking on the NA Windows Connectivity icon will start the software. Executing this program for the first time will bring up a dialog box prompting the user to enter the model number of the source/receiver unit and the DSP board's port address. The DSP Board's port address DIP switch has been preset at the factory to 310 Hex (784 Decimal). **The port address selected in the program must reflect the actual address switch settings on the DSP board.** If problems are encountered after installation that suggest conflicting port addresses then a new port address can be set on the DSP board's 7 position DIP switch. The factory setting is OFF OFF ON ON ON OFF ON with the switch positions read from left to right as 1234567 with switch 1 at the top side of the DSP board. Another generally available port is 768 decimal (300 Hex) given by the DIP switch set as OFF OFF ON ON ON ON ON. Taking the switch ON position to be a multiplier of 0 and the OFF position to be a multiplier of 1 the port address(dec) = s1*512 + s2*256 + s3*128 + s4*64 + s5*32 + s6*16 + s7*8.

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The program, NA Windows Connectivity, will allow power to the source/receiver unit (as will be evident by the green power indicator LED). At this point the virtual control panel will be available and the installation is complete. The power to the source/receiver unit will automatically switch off at program termination, or if a hard reset is performed or, of course, if the PC's power is cycled off-on.

IMPORTANT NOTICE !

It is recommended that the source/receiver unit be positioned, by at least several feet, away from the PC and the PC's monitor (CRT). These units generate strong magnetic fields that can cause erroneous measurement results. Also, do not set heavy objects on the source/receiver unit.

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2 Graphical User Interface

NA Windows Connectivity Overview

The Network Analyzer (NA) Windows Connectivity program provides the interface to the network analyzer. This interface allows complex problems to be solved quickly by integrating the following key components into an intuitive environment:

- A virtual front panel for Instrument control.
- A graphics display which plots the acquired data in a variety of formats, called display modes and provides real-time data analysis through markers and master traces.
- Control over system attributes such as graph colors and data format.
- Data exportation. Measured data is made available to other applications through the clipboard (as static data) and through Dynamic Data Exchange (DDE) so that real-time user defined post processing is possible.
- Environment persistence. Save and restore all the display attributes and analyzer parameters (including special calibrations) for a particular measurement configuration.

Virtual Front Panel

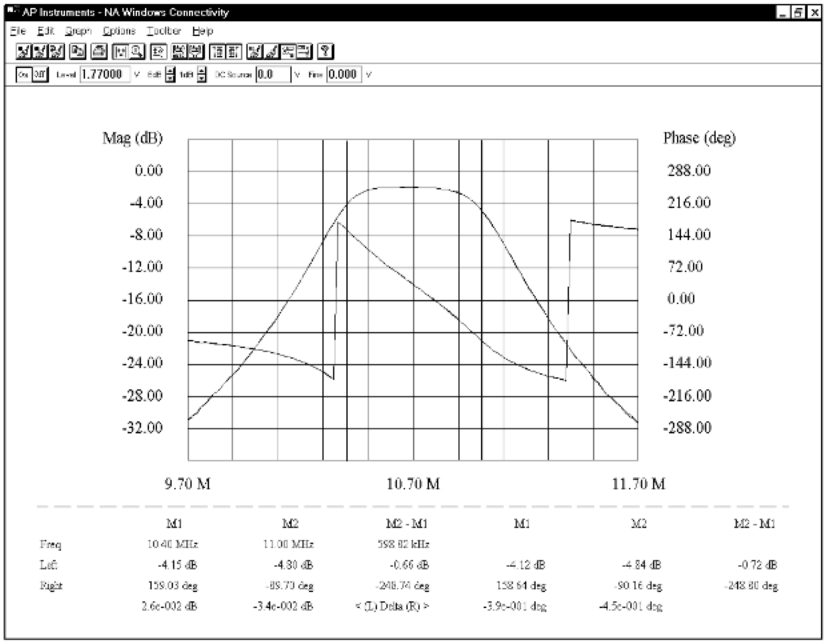
Nearly all functions relating to the operation of the Network Analyzer are available on the toolbar. The toolbar is divided into a upper and lower toolbar. The upper (main) toolbar contains controls for the general operation and display of the network analyzer. The main toolbar is always visible. The lower toolbar is used for instrument parameter entry and is one of four toolbars, as selected by the operator from the main toolbar.

All parameters take effect immediately as they are selected. The exception to this are the edit boxes which include start & stop frequency, sweep points, averaging factor, user dwell value, source output level & DC offset. These edit boxes have their values updated by hitting the Carriage Return (Enter) or Tab key.

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Graphics Display

The graph display has four basic modes of display. A particular mode is selected using the graph menu. The four modes are as follows: Magnitude and Phase, Absolute Magnitude, Complex Impedance, and IEC 555-2. Each graph mode maintains its own separate system wide parameters. This allows the operator to change parameters such as start and stop frequency in one mode without it affecting the start and stop frequency in another mode.



Graph Trace

The graph trace is plotted in real time for the first sweep and then after the end of each sweep for the remaining sweeps. The graph can display two separate data traces simultaneously, distinguishable by their color. These datum can be displayed together or singularly by using the left and right trace display selectors available through the [Options Trace Display...] dialog box or the toolbar. The trace colors can be selected by using the [Options Color...] dialog box the

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minimum and maximum range of the graphed data can be chosen manually or automatically using the [Graph Manual Scale...] or [Graph Auto Scale] menu selection or toolbar buttons. The axis scaling for each trace is indicated separately on the left and right ordinates. The format of all numeric data displayed for either the axis scaling or the marker readout can be changed using the [Options Format Data...] dialog box.

Markers

The graph display markers consist of a vertical line for each marker. The markers are first enabled by using the [Graph Markers] menu selection or toolbar button. The first marker, M1, is moved by depressing the left mouse button and moving the mouse left or right as desired. The second marker, M2, is moved similarly by depressing the right mouse button. The difference between the markers, M2 - M1, is also displayed along with the data at M1 and M2.

Master Trace

Also available within the graph display are master traces which allow comparisons between a stored trace and the active trace. To add master traces to the display use the [Graph Master Curves] menu selection (or the master trace toolbar button). When master traces are selected the current active trace data is copied as the master trace. The master trace marker data readout is displayed to the right of the active trace marker data readout. The delta data readout, displayed at the bottom of the graph window, gives the difference between the master and the active data trace separately for both left and right traces.

Graph Display Modes

Magnitude and Phase

The first display mode, magnitude and phase, graphs the ratioed measurement of channel B divided by channel A. The magnitude represented is expressed in dB while the phase is expressed in degrees. A positive value of magnitude indicates gain through the network under test (i.e. B>A) while a negative value of magnitude indicates attenuation. The phase display range can be chosen through the

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[Options Format Phase...] dialog box to be either a range of +/- 180 or 0 to 360 degrees. The phase shift indicates the relative phase shift from channels A to B. Note that the source level does not enter the equation. The source level does, however, become important for optimizing the signal to noise ratio and preserving the linearity of the network under test.

Absolute Magnitude

The second display mode, measures the absolute magnitude of channels A and B displaying it in RMS volts. This mode is useful for diagnosing a noisy B/A measurement by showing the actual (absolute) signal strength of each channel.

Complex Impedance

The third display mode graphs the complex impedance of a network under test when using an external reference resistor connected to the network in a specific manner (see application note on measuring complex impedance). The reference resistor value is entered as a parameter. The complex impedance, Z, can be displayed as one of the following :

Real Z and Imaginary Z
Magnitude and Phase of Z
Equivalent Capacitance and Resistance
Equivalent Inductance and Resistance.

A choice of series or parallel circuit models are available.

IEC 555-2

The fourth display mode graphs a plot of the first forty harmonics of the power line current. This mode is intended for IEC 555-2 pre-compliance testing. The line current frequency is user selectable as 50 Hz or 60 Hz. The current is measured using an external current transducer whose sensitivity in Volts per Amp is entered as an input parameter. The current transducer frequency response bandwidth is required to be flat from 50 Hz to 2.5 KHz.

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Menu Selections

File Menu

Open Data...

Opens a dialog box which allows previously saved sweep data to be loaded into memory and displayed in the graph window. Once in memory, sweep data is available for Clipboard Copy and, if a DDE Client is linked, the data will be sent to the client.

Save Data As...

Opens a dialog box which allows the current displayed sweep data to be saved as a text file. The data is written in the following format :

> One line per data point, On each line are five (5) tab separated values ordered as Frequency, Magnitude (B/A), Phase (B/A), Absolute Magnitude (A), and Absolute Magnitude (B).

Data is saved with the extension .dat.

Open Setup...

Opens a dialog box which allows a previously saved configuration to be loaded. All parameters will be set to the new values.

Save Setup As...

Opens a dialog box which allows the current configuration to be saved as a text file. This setup can then be recalled using the Open Setup... command. Only the configuration of the selected display mode is saved. On exit, the current configuration is saved automatically in the file nawincon.ini, and loaded when the application is started again. Setup files are also maintained for each display mode automatically. Whenever the display mode changes a setup file is written for the current mode and a setup file is loaded (if exists) for the newly selected display mode. See File Types, Use and Format for more information.

Default Setup

Resets the setup configuration of the currently selected display mode to the default state.

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Calibration...

Opens the Calibration File Maintenance dialog box which allows setting the pathnames of the network analyzer calibration files and the creation of new calibration files. To load an existing calibration file, click the Browse button and then choose the file to load. Clicking the Create button performs the calibration procedure and saves the new calibration data to a file. This newly created calibration file is automatically selected and used by the current graph display mode. See System Calibration for more information.

System Settings...

Opens the System Settings dialog box which displays the network analyzer model number and the software configured port address. The port address must reflect the port address dip switch setting on the DSP card. The system settings can not be changed while the application is running. To change the system settings:

[1] Exit NA Windows Connectivity
[2] Execute the Setup program from the software installation disk and choose the Hardware Configuration Change option.

Print...

Opens the standard print dialog box. The graph display window is printed using the selected print options. This command behaves differently than the toolbar print button which does not invoke the dialog box.

Exit

Exits the application. Sweep data in memory will be lost and any DDE links will be terminated. The current configuration is saved automatically.

Edit Menu

Copy

Copies sweep data to the clipboard. After executing this command the clipboard will contain the last full sweep, except during the first sweep which will copy only the current collected data. The sweep data will be copied with the same format

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as in [File Save Data As...] and using the selected phase format. This function is unavailable (grayed) when sweep data memory is empty. This function is also available on the Toolbar.

Graph Menu

Magnitude & Phase

Selects the Magnitude and Phase display mode. When this mode is selected the left trace will display magnitude B/A data in decibels and the right trace displays phase B/A data in degrees.

Absolute Magnitude

Selects the Absolute Magnitude display mode. When this mode is selected the left trace will display the absolute magnitude of channel A in volts and the right trace displays the absolute magnitude of channel B in volts.

Complex Impedance...

Selects the Complex Impedance display mode. When this mode is selected the Complex Impedance Setup dialog box appears which accepts complex impedance parameters, these parameters include :

Reference Resistor
: The series resistor to the network under test.

Equivalent Circuit
: Model the equivalent circuit as Series or Parallel.

From the dialog box a display view selection is made from the following :

Complex Impedance (Rect)
: Display complex impedance in rectangular coordinates, $Z(f)=X(f)+iY(f)$, the real part (X) on the left and the imaginary part (Y) on the right.

Complex Impedance (Polar)
: Display complex impedance in polar coordinates, $Z(f)=R(f)A(f)$, the magnitude ($R = |Z|$) on the left and the angle (A) on the right.

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Equivalent Circuit (R & C)
: Display the resistive (left trace) and capacitive (right trace) components of an equivalent (series / parallel) circuit.

Equivalent Circuit (R & L)
: Display the resistive (left trace) and inductive (right trace) components of an equivalent (series / parallel) circuit.

Before the complex impedance setup dialog box is displayed a warning is issued. This warning is a reminder that to produce meaningful data, specific measurement configurations are required as described by Measuring Complex Impedance (Application Notes). An option to disable this warning is available in the dialog box.

IEC 555-2...

Selects IEC 555-2 display mode. Prior to displaying data the IEC 555-2 Setup dialog box provides for the following selections :

Line Frequency
: The line frequency of the power supply.

Sensitivity
: The sensitivity of the current to voltage converter (in volts per amp).

Before the IEC 555-2 setup dialog box is displayed a warning is issued. This warning is a reminder that to produce meaningful data, specific measurement configurations are required as described by IEC 555-2 Measurements (Application Notes). An option to disable this warning is available in the dialog box.

Markers

Toggles graph markers. When enabled, the makers are visible and may be positioned by dragging the mouse with either the left (left marker) or right (right marker) button. The marker data is displayed below the graph.

Expand Markers

Sets the sweep start and stop frequencies to the current marker frequencies.

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Master Trace

Toggles master traces. At the moment this is enabled, the realtime traces are copied and displayed as master traces. When makers are enabled, master trace marker data is displayed, this includes the difference (Delta) between the master and realtime trace.

AutoScale

Executes an automatic scaling procedure on both the left and right trace, then re-displays the graph. Only the realtime trace data is used for autoscaling, Thus it is possible that master trace data may lie outside the graph after autoscale.

Manual Scale...

Opens the Manual Scale dialog box in which graph scaling for the left and right trace is accomplished. When this dialog box opens, the current minimum and maximum values are displayed

Options Menu

Title...

Opens the Graph Title dialog box to provide a title for the graph. The title is displayed centered in the window above the graph. The title is defined for the selected graph display mode, and is only displayed within the graph mode. A different title may be defined for each graph display mode.

Colors...

Opens the Graph Color Selection dialog box where color selections are made for the graph display window elements. Each of the six graph elements, Grid, Markers, Left & right traces, and Left & right master traces may be one of sixteen colors. While graph markers are enabled the marker data is displayed. By default, marker data is displayed in the associated trace color, but may be displayed in black.

Format Data...

Opens the Format Data dialog box which provides formatting of the data displayed along side and below the graph. Data formatting is independently avail-

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able for Frequency data, Left trace data, Right trace data, and Delta (Master trace minus the realtime trace) data. The three formatting options are as follows :

Standard
: Numbers are formatted with the standard notation of comma's separating every three digits (i.e. 12,456,100.96).

Exponential
: Numbers are formatted in exponential notation (i.e. 1.24 e07)

Engineering
: Numbers are formatted in a scientific notation with the value always between 1 and 1000, a unit modifier is added to represent the decimal position (i.e. 12.45 M).

The number of displayed significant digits is entered in the sigfig edit box. The values above were formatted with sigfig = 2.

Trace Display...

Opens the Trace Display dialog box to select viewing left trace only, right trace only, or both left and right traces.

Format Phase...

Opens the Format Phase dialog box which allows the phase data to be presented in either the +/- 180° or 0-360° format.

Toolbar Menu

Sweep Frequency

Display the sweep frequency toolbar (pg. 23).

Sweep Parameters

Display the sweep parameters toolbar (pg. 24).

Source Parameters

Display the source parameters toolbar (pg. 25).

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Receiver Parameters

Display the receiver parameters toolbar (pg. 26).

Help Menu

Contents

Executes the online help. This function is also available on the Toolbar.

About NA Windows Conn.

Opens a dialog box that displays program information such as the minimize Icon and version number.

The Toolbar

The toolbar is divided into a upper and lower toolbar. The upper (main) toolbar contains controls for the general operation and display of the network analyzer. The main toolbar is always visible. The lower toolbar is used for instrument parameter entry and is one of four toolbars, as selected by the operator from the main toolbar.

Main Toolbar



Start Sweep

Begins a sweep using the set parameters. Note: It is not necessary to click the OK button in the parameter window prior to starting a sweep, this will be done automatically. This function is also available from the sweep menu.

Stop Sweep

Terminates the sweep in progress. Sweep data is not accessible until a complete sweep is finished. This function is also available from the sweep menu.

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 Reset Sweep

Terminates the sweep in progress and begins a new sweep. This is the same as clicking Stop followed by Start. This function is also available from the sweep menu.

 Copy

Copies sweep data to the clipboard. After executing this command the clipboard will contain the last full sweep, except during the first sweep which will copy only the current collected data. This function is unavailable (grayed) when sweep data memory is empty. This function is also available from the edit menu.

 Print

Prints the graph display window on the default printer in landscape orientation. In order to print using alternate options use the print command from the file menu.

 Markers

Toggles graph markers. When enabled, the makers are visible and may be positioned by dragging the mouse with either the left (left marker) or right (right marker) button. The marker data is displayed below the graph. This function is also available from the graph menu.

 Master Trace

Toggles master traces. At the moment this is enabled, the realtime traces are copied and displayed as master traces. When makers are enabled, master trace marker data is displayed, this includes the difference (Delta) between the master and realtime trace. This function is also available from the graph menu.

 Expand Markers

Sets the sweep start and stop frequencies to the current marker frequencies.

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AutoScale

Executes an automatic scaling procedure on both the left and right trace, then redisplays the graph. Only the realtime trace data is used for autoscaling, Thus it is possible that master trace data may lie outside the graph after autoscale. This function is also available from the graph menu.



Manual Scale

Opens a dialog box in which graph scaling for the left and right trace is accomplished. When this dialog box opens, the current minimum and maximum values are displayed. This function is also available from the graph menu.



Display Left Trace

This button controls the visibility of the left trace. By default the trace is visible (button pressed). This function is also available from the Trace Display... command of the options menu



Display Right Trace

This button controls the visibility of the right trace. By default the trace is visible (button pressed). This function is also available from the Trace Display... command of the options menu



Display Parameter Entry Toolbar

Select the lower toolbar to be one of the four parameter entry toolbars : Sweep Frequency Toolbar, Sweep Parameters Toolbar, Source Parameters Toolbar, or Receiver Parameters Toolbar.

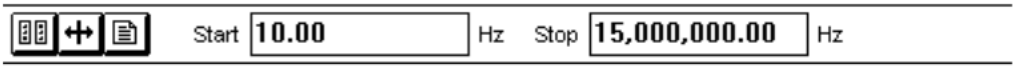


Help

Executes the online help. This function is also available from the help menu.

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Sweep Frequency Toolbar



Sweep frequency limits may be entered as Start/Stop, Center/Span, or File list values.

Start/Stop

Two edit boxes allow for sweep start and stop frequencies to be entered. Frequency values may be entered as standard values, with or without separating commas (ie. 100.2 or 1,200), exponential values (ie. 1.2e5), or with one of three standard SI prefixes : m-milli, k-kilo, M-mega (ie. 1k, 2.6M). After typing a new frequency value you must enter it by hitting the Carriage Return (Enter) or Tab key. Regardless of how the value was entered it will be converted to the comma separated format.

In the event the frequency value entered causes an error (value out of range or start frequency greater than stop frequency) a message box will be displayed and either value may be edited to remove the error. This is handy when entering a new sweep range which conflicts with the current sweep range.

Center/Span

Two edit boxes allow for the sweep range to be entered as a center frequency and the total frequency span. Frequency values are entered exactly as described in Start/Stop above.

File List

When File list is selected, a frequency points list (.fpl) file is used as the sweep frequency points. The filename is entered into the corresponding edit box either manually or selected through the Browse ([...]) dialog box.

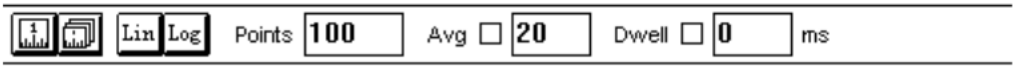
A frequency points list file (file extension .fpl) has the following format:

A series of frequency values separated by a carriage return <CR> (i.e. one value per line). The frequency values may be in decimal or exponential format. The

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sweep is accomplished by processing each point starting at the top of the file, therefore the value at any line in the file must be greater than that of the preceding line.

Sweep Parameters Toolbar



 Mode

If Single sweeps are enabled then the sweep activity is suspended upon collection of the last data point. A new single sweep is started by clicking the start sweep toolbar button or sweep menu option. If Continuous is selected then the sweeps are repeated continuously.

 Type

If Lin is enabled then the frequency increment between data points remains constant. The Log sweep mode gives a frequency increment between points that is logarithmically increasing with frequency thus compressing the frequency axis. Use the Log selection for Bode type plots. This parameter is not used when sweeping with a frequency points list file. The increment between each point is solely determined by each frequency point value.

Points

Enter the number of data points to collect. The maximum number of points is 2001. Available RAM may limit the number of points you can use. Approximately 25K Bytes of RAM are needed per 100 data points. This parameter is not used when sweeping with a frequency points list file. The number of data points will be equal to the number of frequency values in the file.

Avg

Sweep averaging is toggled on and off by clicking the Avg checkbox. The Averaging Factor specifies the weighting of each sweep into the displayed trace, is a value from 1 to 999, entered into the Avg edit box. The weighting of a sweep (weighting factor) is 1 / Averaging factor. When enabled, the averaging function

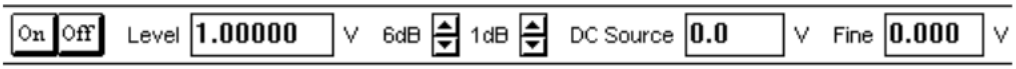
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averages each sweep into the trace with a weighting factor equal to the sweep count, until the Averaging Factor is reached. When the specified averaging factor is reached, the trace is updated with each sweep weighted by the Averaging Factor.

Dwell

User specified dwell is selected by clicking the Dwell checkbox. When the user specified edit box is selected, the value, in milliseconds, allows the sweep to be slowed down by specifying a dwell (delay) value that is used by each point before data collection commences. A value from 0 to 999 may be entered.

Source Parameters Toolbar



Output

If On then the AC output is set by the level established in the Level edit box. If Off then the AC output from the source is set to zero regardless of source Level setting. The DC source offset is not affected. The output must be off when measuring signals generated from an external source.

Level

The source output level entry ranges from 1.25 mV to 1.77 V RMS. There are 64 discrete levels available in 1 dB increments. The level may be typed in directly or increased / decreased in 6 dB and 1 dB steps. Note : When the level is typed in directly use the Carriage Return (Enter) or Tab key to enter the new value. When using the inc / dec buttons the source level will be updated automatically.

DC Offset

The Source entry has a range of +/- 10 Volts DC with a resolution of 0.1 Volts DC. The Fine entry has a range of +/- 0.128 Volts DC with a resolution of 0.002 Volts (two millivolts) DC. It is advised to first set the source followed by the fine adjust. The new DC offset will be entered after hitting the Carriage Return (Enter) or Tab key.

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Receiver Parameters Toolbar



AC DC Coupling

If AC is selected the analyzer uses its internal coupling capacitors. AC coupling can only be used for sweep frequencies >= 10 Hz. If DC coupling is selected than automatic DC offset tracking is employed for inputs up to +/- 10 VDC.

x1 x10 Atten

In order for the analyzer to use the proper frequency correction array the selection must reflect the actual input channel probe settings. Note that both channel A and channel B probes must have the same setting or else the measurement will have an erroneous result of 20 dB.

Preamp

This selection allows the automatic preamp gain selection to be overridden. Normally Auto is selected.

BandWidth

The higher, or wider, the IF bandwidth the faster the sweep will take place. The lower, or narrower the IF bandwidth the better the noise immunity. The noise floor will change approximately 10 dB with each setting. Choose the highest bandwidth that gives a trace with acceptable noise levels.

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3 System Calibration

Overview

To obtain accurate measurements the system must be calibrated. System calibration should be performed periodically and whenever the input probes configuration has changed or the ambient operating temperature has changed since the last calibration. Perform system calibration after the unit has warmed up for at least 30 minutes.

To obtain a NIST traceable calibration the analyzer must be sent to AP Instruments. AP Instruments uses custom hardware fixtures and data logging software to verify the results of the calibration with NIST traceable quantities. The following calibration procedure, as performed by the user, does not include the post calibration verification.

Use the Calibration File Maintenance dialog (select calibration in the Files menu) to change the current calibration setup. To load an existing calibration file, click the Browse button and then choose the file to load. Clicking the Create button performs the calibration procedure and saves the new calibration data to a file. The newly created calibration file is automatically selected and used by the current graph display mode.

System calibration is accomplished by performing the four calibration Create procedures in the following order :

[1] Source DC Null Calibration
[2] Receiver DC Null Calibration
[3] Frequency Response Calibration
[4] Absolute Magnitude Calibration

The calibration files are displayed within the dialog box in the top down order required for successful system calibration.

After every calibration procedure the cal data is saved to a file. Calibration files are saved with user defined names, this allows calibration files to be maintained for various test setup configurations. Be aware that the calibration files selected within a graph display mode are local to that mode, whenever a graph display mode is selected the calibration files last used in that mode are loaded. Default calibration files are provided by AP Instruments, named default.xxx. It is recommended that these cal files are not deleted or overwritten.

In the event that a calibration file cannot be found the system will provide notifi-

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cation as to which file type[s] could not be loaded. When this occurs, the system will first try to load the default file (default.xxx). If the default file could not be found it will be necessary to select (Browse) an existing file or create a new one.

Source DC Null Calibration

The network analyzer utilizes correction arrays to correct for source DC offsets. The calibration should be performed periodically especially if the ambient operating temperature changed since the last calibration.

Source DC Null Calibration Procedure

[1] If the system is running, stop sweep activity.
[2] Select Calibration from the File menu.
[3] Click the Create button to the right of the Source DC Null Cal Filename.
[4] When prompted, connect Channel A to ground, This can be accomplished by switching the Channel A probe to the REF position.
Click OK when ready. [Probe REF calibration will take approx 1 sec.]
[5] When prompted, connect Channel A to the Source Out of the unit.
Verify the Channel A probe is in the x1 position.
Click OK when ready. [x1 probe calibration will take approx 20 sec.]
[6] When calibration is complete save as a new file or overwrite an existing calibration file.

Receiver DC Null Calibration

When measuring signals that are derived from an external source (not the source built into the analyzer) the automatic receiver input offset calibration process cannot be used. For external sources another method, receiver input offset correction arrays, are then used to correct for the analyzer's receiver DC offsets. These arrays are created by the receiver DC null calibration procedure. The calibration procedure should be performed periodically, especially if the ambient operating temperature changed since the last calibration.

Receiver DC Null Calibration Procedure

[1] If the system is running, stop sweep activity.
[2] Select Calibration from the File menu.
[3] Click the Create button to the right of the Receiver DC Null Cal Filename.
[4] When prompted, remove any signal from the Channel A and Channel B

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inputs. Removing the probe BNC connectors from the unit will guarantee receiver isolation.
Click OK when ready. [Receiver calibration will take approx 10 sec.]

[5] When calibration is complete save as a new file or overwrite an existing calibration file.

Frequency Response Calibration

The network analyzer utilizes frequency correction arrays to automatically compensate for all combinations of probe (x1 or x10), band, coupling mode (AC or DC) and preamp selections. A frequency response calibration should be performed periodically and whenever the input probes configuration is changed. Note : the x10 position of the Receiver Atten will not provide correct measurements unless the x10 calibration is performed.

To check the validity of the frequency response correction arrays simply connect the source and receiver probes together. The analyzer should give a reading of 0 dB magnitude and 0 degrees phase, within the specified accuracy, across the frequency range. Make sure that the probes switch settings reflect the receiver menu probe selection. Optionally, to test all of the arrays all combinations of probe, band, coupling mode and preamp selections must be exercised. The band switch occurs at 11 kHz while the receiver preamp switching threshold takes place at approximately 0.396 V rms. Test probes will show a greater variation at high frequencies than coax with BNC interconnects due to long ground leads etc. The frequency calibration is performed at one power level only so any non-linearities in the receiver path will introduce small errors.

Frequency Response Calibration Procedure

[1] If the system is running, stop sweep activity.
[2] Select Calibration from the File menu.
[3] Click the Create button to the right of the Frequency Response Cal Filename.
[4] When prompted, connect the Source Out to both the Channel A and Channel B inputs. Verify the probes are in the x1 position.
Click OK when ready. [x1 probe calibration will take approx 1□ min.]
[5] If measurements will be made with the probes in the x10 position then select Yes to continue with x10 probe calibration. Otherwise, when using probes in the x1 position only, or in custom fixture applications the x10 calibration may be bypassed by selecting No. If the supplied probes are

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being used it is recommended that the x10 calibration be performed. Skip step [6] when selecting No.

[6] When prompted, Verify the probes are in the x10 position. Click OK when ready. [x10 probe calibration will take approx 1□ min.]

[7] When calibration is complete save as a new file or overwrite an existing calibration file.

Absolute Magnitude Calibration

There are three levels of calibration available, (1) default single point, (2) measured single point, and (3) full spectrum calibrations. Each level yields greater accuracy in absolute magnitude measurements. Choose the highest level in which the resources are available to perform the calibration. The first level of calibration is performed by selecting the single point calibration and using the default value. This first procedure requires no external measuring equipment and depends on the nominal value of the source for its accuracy. Since this nominal value has both a DC gain error and high frequency roll-off error the calibration array contains gain and roll-off error terms. The roll-off error term is approximately compensated for by fixed correction coefficients leaving a DC gain error term.

Measured Single Point Calibration (Correcting for the DC Gain Error Term)

To correct for the DC gain error use the second level calibration. The voltmeter required for this procedure needs to have an AC RMS voltage range capable of measuring 100 Hz, 1.0 VAC RMS with millivolt resolution. The voltmeter should have a bandwidth of 1 KHz or more to ensure an accurate response at the measurement frequency of 100 Hz. The AC voltmeter is connected up to the model 102 analyzer's source when the program prompts the operator for the measured value. Enter the value directly in volts AC RMS. The voltmeter is then removed and the model 102 analyzer's source is connected to the analyzer's channels A and B. To generate the correct calibration coefficients for the approximated roll-off error term it is required to make this connection using a specific cabling configuration. For the x1 cable use a BNC tee at the source with 12 inch BNC cables connecting channels A and B. This setup for the x1 position will give the absolute voltage referenced at the analyzer's BNC inputs. For the x10 cable (probe) configuration use a five foot BNC to minigrabber at the source with 10-to-1 probes connecting channels A and B. This setup for the x10 position will give the absolute voltage referenced at the x10 probe inputs.

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Full Spectrum Calibration (Correcting for the Roll-Off Error Term)

To accurately correct for the roll-off error term (and DC gain error term) another procedure, called full spectrum calibration, is available. One of the following pieces of equipment capable of covering the 100 Hz to 15MHz range is required: A spectrum analyzer, or a digital oscilloscope with FFT measurement capability. Connect the model 102 analyzer's source and the measuring instrument's input along with the analyzer's input channels A and B using x1 cable or x10 probes. The connection should be arranged so that the tap to the measuring instrument's input is close to the analyzer's inputs (or x10 probe inputs). If the measuring instrument's input is a high impedance input, then the input must be terminated with a 50 Ohm through-line adapter. The program will prompt the operator for the measured values at the sixteen frequency points (100Hz, 1-15MHz). Enter the value directly in volts RMS. Keep the measuring instrument connected until the correction array has been completed and stored to a file.

Absolute Magnitude Calibration Procedure

[1] If the system is running, stop sweep activity.
[2] Select Calibration from the File menu.
[3] Click the Create button to the right of the Absolute Magnitude Cal Filename.
[4] Select the single point or full spectrum calibration.
For the single point calibration, continue with the Single Point Calibration Procedure.
For the spectrum calibration, continue with the Full Spectrum Calibration Procedure.

Single Point Calibration Procedure

[a] When prompted, measure the Source Out voltage (Vrms) and enter the value. The default value may be used to perform the calibration when a voltmeter is not available. Click OK when ready.
[b] When prompted, connect the Source Out to both the Channel A and Channel B inputs. Review recommendations for cable connections (measured single point calibration). When using probes, verify that they are in the x1 position for the x1 cal. Click OK when ready. [Calibration will take approximately one minute to complete]
[c] If measurements will be made with the probes in the x10 position then select Yes to continue with x10 probe calibration. Otherwise, when using

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probes in the x1 position only, or in custom fixture applications the x10 calibration may be bypassed by selecting No. Steps [d] and [e] will be skipped when selecting No.

[d] When prompted, measure the Source Out voltage (Vrms) and enter the value. The default value may be used to perform the calibration when a voltmeter is not available. Click OK when ready.

[e] When prompted, verify the probes are in the x10 position and the Source Out to is connected both the Channel A and Channel B probes. Click OK when ready. [Calibration will take approximately one minute to complete]

[f] When calibration is complete save as a new file or overwrite an existing calibration file.

Full Spectrum Calibration Procedure.

[a] When prompted, connect the Source Out to both the Channel A and Channel B inputs and to the spectrum analyzer. Review recommendations for cable connections (full spectrum calibration). When using probes, verify that they are in the x1 position for the x1 cal. Click OK when ready.

[b] Measure the Source Out voltage (Vrms) using the spectrum analyzer and enter the value. Sixteen measurements will be required, at 100Hz and each at megahertz from 1MHz to 15MHz. Click OK to register each value and continue to the next measurement.
Calibration will proceed when the last measurement has been entered.

[c] If measurements will be made with the probes in the x10 position then select Yes tocontinue with x10 probe calibration. Otherwise, when using probes in the x1 position only, or in custom fixture applications the x10 calibration may be bypassed by selecting No. Steps [d] and [e] will be skipped when selecting No.

[d] When prompted, Verify the probes are in the x10 position. Click OK when ready.

[e] Measure the Source Out voltage (Vrms) using the spectrum analyzer and enter the value. Sixteen measurements will be required, at 100Hz and each at megahertz from 1MHz to 15MHz. Click OK to register each value and continue to the next measurement. Calibration will proceed when the last measurement has been entered.

[f] When calibration is complete save as a new file or overwrite an existing calibration file.

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4 Dynamic Data Exchange

Understanding Dynamic Data Exchange (DDE)

What is DDE?

Dynamic Data Exchange (DDE) is a protocol which allows windows applications to communicate with one another. A DDE server is an application which can provide data to other applications through the windows dynamic data exchange protocol. A DDE client is an application receiving data from a DDE server through a DDE link. A DDE link is a communications channel between a client and server. A DDE link is established by the client.

A DDE server can provide data to one or more DDE clients through DDE links. Clients establish a communication (link) with a server in the form of a request for information, Once this link is made the server will update the client with the requested information. There are two types of DDE links, Hot and Cold, The hot link is most common (and most useful). A DDE Hot link is a DDE link where, once established, the server will notify the client as data changes. The client is not required to initiate any other DDE communications. The server notifications will continue until the link is terminated by the client, or the server application exits. A DDE cold link is a DDE link in which data is sent by the server in response to a client request, then the link is terminated. The client must initiate a request (link) each time data is needed.

How is a DDE link established?

A client will begin requesting data by sending the server three pieces of information which describe the needed data. This information is the Service name, Topic name and Item name. In general, a server can have many services with each service having several topics and each topic handling several items. A client needs to know what services, topics and items the server provides. Each client has its own technique (syntax) for requesting this information, refer to the DDE client application software owners manual for specific information.

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A Client executes commands!

For the most part DDE is used as a means for one application (client) to receive real-time data from another application (server). In some cases the server allows the client to execute a command. This is accomplished as with a link, The client will send a service, topic and item for the command the server is to execute. After receiving the request the server will execute the command. Also, as with links, the client needs to be aware of what services, topics and items are available.

What about NA Windows Connectivity?

NA Windows Connectivity is a DDE server with the following capabilities:

Links:

Service - NAWINCON
Topic - NA_DATA
Items - POINTS, FLAGS, FREQ, MAG, PHASE, ABSMAGA, ABSMAGB

Executes:

Service - NAWINCON
Topic - NA_SWEEP
Items - [START], [STOP], [RESET]

Service - NAWINCON
Topic - NA_LOAD
Items - [DEFAULT], [SetupFilename.set]

Note : The brackets [ ] are required for execute items.

Item Definitions

POINTS

Returns: The number of points entered in the points edit box in the sweep parameters window. Or, when using a frequency points list file, the number of frequency points in the file.

Format: A single number. (Integer as text).

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FLAGS

Returns: The settings in the Format Phase dialog box.

Format: A single number. (Integer as text). The least significant bit holds the phase group information:

0 - +/- 180°

1 - 0 to 360°

FREQ

Returns: The frequency value for all points of a sweep.

Format: A series of numbers (doubles as text) separated by a <CR/LF> (0x0D 0x0A). There are as many numbers as the value of POINTS.

MAG

Returns: The magnitude (B/A) value for all points of a sweep.

Format: A series of numbers (doubles as text) separated by a <CR/LF> (0x0D 0x0A). There are as many numbers as the value of POINTS.

PHASE

Returns: The phase (B/A) value for all points of a sweep.

Format: A series of numbers (doubles as text) separated by a <CR/LF> (0x0D 0x0A). There are as many numbers as the value of POINTS. The values will be formatted 0->360 or +/- 180 as selected in the Format Data dialog box.

ABSMAGA

Returns: The absolute magnitude of input channel A for all points of a sweep.

Format: A series of numbers (doubles as text) separated by a <CR/LF> (0x0D 0x0A). There are as many numbers as the value of POINTS.

ABSMAGB

Returns: The absolute magnitude of input channel B for all points of a sweep.

Format: A series of numbers (doubles as text) separated by a <CR/LF> (0x0D 0x0A). There are as many numbers as the value of POINTS.

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[START]

Executes the Start Sweep function of NA Windows Connectivity.

[STOP]

Executes the Stop Sweep function of NA Windows Connectivity.

[RESET]

Executes the Reset Sweep function of NA Windows Connectivity.

[DEFAULT]

Executes the File| Default Setup menu option of NA Windows Connectivity.

[SetupFilename.set]

Allows loading a setup file through DDE. Executes the File| Open Setup menu option with SetupFilename.set as the setup file to load. SetupFilename.set is any valid setup file which has been previously saved.

Using DDE in Microsoft Excel

It is recommended the user be familiar with Excel and Excel Visual Basic programming. Also knowledge of NA Windows Connectivity's Services, Topics & Items is essential.

For use with NA Windows Connectivity there are three types of DDE links which are useful. These are :

(1) Hot data links for single values. Used to receive the Network Analyzer frequency points and data format flags.

(2) Hot data links for arrays of numbers. Used to receive the sweep arrays for Frequency, Magnitude and Phase measurements.

(3) Execute links to send commands to NA Windows Connectivity (i.e. Start sweep, stop sweep, load default settings, etc...).

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Hot links to data items of single values

Excel provides a simple method of establishing a data hot link. To start a hot link, enter into the cell :

=Service Topic!Item

Select the cell to contain the data then enter an equal sign (=) followed by the name of the Service (the service is always NAWINCON for NA Windows Connectivity), a vertical bar (may be found above the backslash), the Topic name (the topic is always NA_DATA for NA Windows Connectivity), an exclamation point (!), then finally the Item name (either POINTS or FLAGS). Since NA Windows Connectivity supports only two single value data links, the links may be established as:

=NAWINCON NA_DATA!POINTS

and

=NAWINCON NA_DATA!FLAGS

Once the cell formula has been entered the DDE link is established and the 'conversation' will begin. Note: The DDE server must be running or in the PATH to start the link.

Hot links to data items of arrays

This is similar to single value hot links but there are two important differences. First, multiple cells must be selected to hold the data (select as many cells as the number of sweep points). Multiple cells are selected by first selecting a single cell then dragging the bottom-right corner of the cell down the spreadsheet. While the cells are selected type in the formula as above. The five data arrays available for hot link transfer are :

=NAWINCON NA_DATA!FREQ
=NAWINCON NA_DATA!MAG
=NAWINCON NA_DATA!PHASE
=NAWINCON NA_DATA!ABSMAGA
=NAWINCON NA_DATA!ABSMAGB

Second, after typing in one of the above formulas, enter the array formula by pressing CTRL+SHIFT+ENTER (hold the CTRL & SHIFT keys then press ENTER).

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Execute links

Several NA Windows Connectivity commands are available through DDE to help automate data collection and analysis. Excel performs cold link connections by opening a DDE channel. Commands are sent using this open channel and the channel is closed when no longer needed. The procedures to open, send commands through, and close channels are executed in Visual Basic routines. To open a DDE channel use the DDEInitiate command as follows :

```
ChannelID = DDEInitiate("Service", "Topic")
```

DDEInitiate returns a channel ID, this ID is used to execute commands of the Service-Topic used as arguments of the DDEInitiate. To send a command use the DDEExecute command :

```
DDEExecute ChannelID, "Item"
```

And when finished with the channel close it using the DDETerminate command:

```
DDETerminate(ChannelID)
```

There are various ways to manage ChannelID's as defined by the Excel application. Below are two recommendations with examples.

First, If the channel is to be used infrequently (possibly only once) then place all DDE transactions in a single function. As an example, assume the parameter configuration setup file BANDPASS.SET is required whenever the spreadsheet is used.

Also it is assumed that NA Windows Connectivity has been installed using the default path location. The function Auto_Open() is defined as automatically executing whenever the spreadsheet begins. The subroutine below uses this function to load the setup file.

```
Sub Auto_Open()
    NA_LoadChannel = DDEInitiate("NAWINCON", "NA_LOAD")
    DDEExecute NA_LoadChannel, "[C:\NAWINCON\BANDPASS.SET]"
    DDETerminate(NA_LoadChannel)
End Sub
```

Next, If the channel is to be used frequently while the spreadsheet is active then it is easier to break up the DDE commands. In this case be sure to define the DDE Channel outside any function so it will have global variable scope. As an

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example, assume a macro is required that will start a sweep when called. This macro, ExecSweepStart(), may be called many times therefore the following programming methodology is used.

```
Dim NA_SweepChannel

Sub Auto_Open()
        :
        : other initialization
        :
        NA_SweepChannel = DDEInitiate("NAWINCON","NA_SWEEP")
End Sub

Sub Auto_Close()
        DDETerminate(NA_SweepChannel)
        :
        : other exit procedures
        :
End Sub

Sub ExecSweepStart()
        DDEExecute NA_SweepChannel, "[START]"
End Sub
```

As with Auto_Open(), Auto_Close() is defined in Excel to execute whenever the spreadsheet terminates. The spreadsheet provided with NA Windows Connectivity NALINK.XLS provides many examples of DDE communication and processing.

Example Excel Spreadsheets

Included are three example Excel spreadsheets. Feel free to use them as is, or modify for your own use.

NALINK.XLS

Nalink.xls is an excel spreadsheet for use with NA Windows Connectivity. Nalink becomes a DDE client of NA Windows Connectivity to view magnitude and phase data (graphically & numerically. Nalink will be most useful when in a video

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mode of 800x600 with Excel maximized, the graphs are designed to fit without scrolling.

Important : Ensure NA Windows Connectivity is running prior to starting this spreadsheet. Nalink.xls will not be able to establish the DDE links otherwise.

Nalink is configured as four pages (Data, Mag & Phase, Mag, and Phase) with buttons on each page to move to any other. Each page also has a button called "NA Controls", this brings NA Windows Connectivity forward for parameter entry. Click the Excel spreadsheet to place NA Windows Connectivity in back again. The Data page has buttons to set (and clear) the current data as a master waveform. The graphs display the master waveform along with the current data. The graph pages contain buttons to start and stop a sweep, and set NA Windows Connectivity to the default setup configuration.

Most of the DDE Data & Execute links of NA Windows Connectivity are used in this spreadsheet. All functions and macros (subroutines) are defined on the 'functions' tab.

ABSLINK.XLS

Abslink.xls is the functional equivalent of Nalink.xls but displays the absolute magnitudes of channel A & B instead of Mag & Phase.

Important : Ensure NA Windows Connectivity is running prior to starting this spreadsheet. Nalink.xls will not be able to establish the DDE links otherwise.

CPLXIMP.XLS

Cplximp.xls provides complex impedance and equivalent network component calculations.

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5 Application Notes

Introduction to Analog Network Measurements

Network analysis and network measurements determine the most fundamental properties of a given network. These properties include the frequency response transfer function, input/output impedance and group delay all over a given frequency range. In many electronic applications, including filters, amplifiers and systems with feedback the most important characteristic is the frequency response of that network, circuit or system. The frequency response gives the magnitude (gain or attenuation) and phase, as a function of frequency, between two desired points in the system under test. The frequency response is measured directly by a network analyzer for voltage-voltage transfer functions. High frequency power transfer functions are measured by the addition of a power splitter and through-line terminations. Impedance can be calculated using a known reference resistor in series with the unknown network. Group delay can be derived from the phase data since it is the negative derivative of phase with respect to frequency.

In the case of filters the two quantities of interest are typically the stopband attenuation and the passband insertion loss along with possibly the group delay characteristic in the passband. With amplifiers the main quantity of interest is gain "flatness" over frequency in which case the 3 dB gain rolloff point defines the amplifiers bandwidth. With feedback systems, either electrical or electromechanical, the open and closed loop frequency response characterize the system. Feedback systems can exhibit unwanted oscillations, i.e. instabilities, unless the open loop response is evaluated, and appropriately compensated for, to ensure stability.

The frequency response function of an electrical network is defined as the sinusoidal output response divided by the sinusoidal input stimulus. The input and output can be voltage or current depending of the desired transfer function. Note that the frequency response is a ratioed quantity of output to input, and that the input and output are described by complex numbers or phasors. The frequency response, at each frequency point of interest, is then given by a complex number, or phasor. The phasor can be fully described by its magnitude and

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phase components. It is these quantities, the magnitude and phase of the input and output that are measured and ratioed by the network analyzer to obtain the frequency response.

The B/A ratioed measurement described above is equivalent to subtracting the input signal from the output signal when each quantity is in logarithmic form. In the model 102C network analyzer the network's input signal is, by convention, measured by channel A and the output signal is measured by channel B. The expression B/A then describes the resulting frequency response transfer function.

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Basic Measurement Procedures

The optimum network analyzer measurement setup is, as expected, highly dependent on the circuit under test. The frequency range of interest, circuit gain, circuit impedance at the probe points and DC voltage levels are among the factors affecting the measurement setup. Passive circuits are generally easier to measure than active circuits because they have low noise levels, don't usually have special bias voltage requirements and are typically insensitive to source drive levels. Active circuits, on the other hand, may have the properties mentioned above that make measuring them in a linear mode of operation more challenging. It is important to have a good idea of what the measurement results should be before they are taken. The real value of network measurements is in finding the incalculable and the miscalculated frequency response.

Users that are new to network measurements should become familiar with the analyzer's operation by first measuring a simple passive network before advancing to measuring, for example, the loop gain of a high gain feedback circuit.

General Measurement Procedure

Using the control panel set the network analyzer parameters to the following:

[1] In the FILE menu select Default Setup or load a specific configuration previously defined and saved using the Open Setup menu selection. This will establish a set of system parameters for general use. Specific requirements are met by using the appropriate control panel button or menu selection.

[2] Set the desired frequency coverage by using the START and STOP or CENTER and SPAN control panel buttons located in the SWEEP subpanel. If the start frequency is less than 10 Hz then DC coupling will have to be selected in the RECEIVER subpanel.

[3] If desired set the graph title using the OPTIONS Title menu selection.

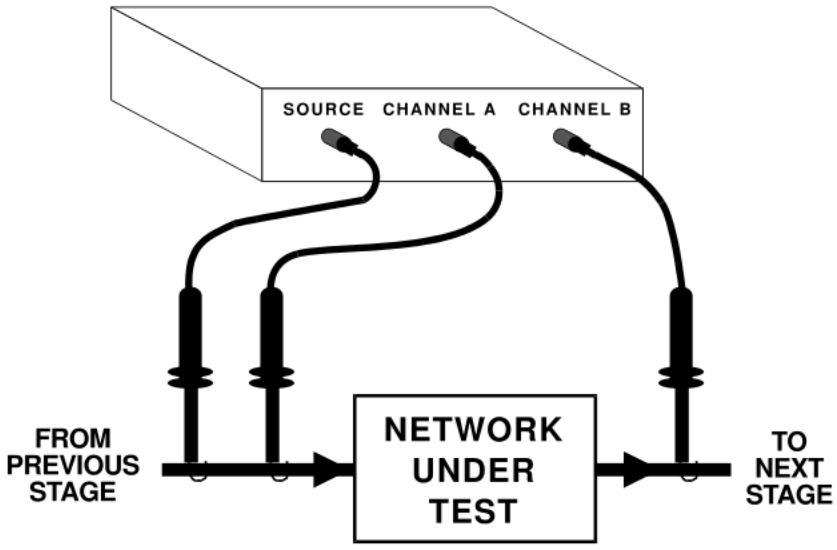
[4] Decide on what stage(s) in the circuit the transfer function is to be measured. Locate the input node and output node of this network.

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[5] As depicted below, connect up the source probe and the channel A probe to the network's input node. Connect up the channel B probe to the network's output node. If the output impedance of the stage preceding the network under test is less than approximately 50 ohms then an isolation resistor may be needed to provide a high enough source drive level. Make sure that the x1, x10 switch on both channel A and B probes are in the same position, typically x1, and this setting corresponds to the attenuation entered in the RECEIVER subpanel. See the application note on high frequency measurements.

[6] If not in a continuous sweep mode then select this mode in the SWEEP subpanel. Increase the source drive level from its minimum level until the graphics display shows a noise free plot. If the plot is not visible or only partly visible actuate the Autoscale function from the toolbar. Bandwidth can also be adjusted so as to optimize trace noise or sweep time. Take care not to increase the source drive level to a point such that the network under test is no longer operating in a linear mode of operation as this can give erroneous results.

Basic Measurement Setup



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High Frequency Measurements

At frequencies higher than a few hundred kilohertz two important issues arise in network measurements. The first is that of isolation between a network's input and output nodes. The analyzer has a minimum dynamic range of 100 dB which can be compromised by coupling paths within the network under test or in the probe connections themselves. The source of this isolation problem can be either 1) conducted through "common mode impedances" and/or 2) radiated, with radiated coupling typically increasing with frequency. Basic RF layout and design practices reduce or eliminate this problem. It is recommended that coaxial cables with BNC interconnects be used above one megahertz.

The second issue is that of probe loading effects. For higher frequency measurements on high impedance circuits determine (very approximately) if the 80 pf capacitance of the probe tip in the x1 position on the output node will influence the measurement. The output node should have an impedance commensurate with the desired measurement accuracy. For example at 1MHz a capacitance of 80 pf has an impedance of 2K ohms and the node under test should then have an impedance of 200 ohms or less, at 1 MHz. This will give errors of less than 0.05 dB magnitude and 6 degrees phase. Although inconvenient, the effect of the probe shunt capacitance can be factored out knowing the actual output impedance of the circuit. The x10 position will reduce the probe capacitance to under 15 pf although the dynamic range of the instrument will typically be lowered by 20 dB in this setting. Note that BOTH channel A AND channel B probes must have the SAME setting or else the measurement will have an erroneous result of 20 dB. It is also important that the probe attenuation be entered into the RECEIVER window Atten selection for the automatic frequency correction to be valid.

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Circuits with Nonzero DC Voltage Levels at the Input / Output Node

If the circuit's selected input node, also the network analyzer's source connection and channel A connection, has a nonzero DC voltage it will be necessary use one of the following techniques: 1) DC offset the source (+/- 10 VDC max) to match the circuit's offset using the DC OFFSET entry in the SOURCE window or 2) AC couple the source to the circuit using a capacitor or transformer. If method 2 is used consideration will have to be given to the difficulty in obtaining a sufficiently low driving impedance at low frequencies with a reasonably sized coupling capacitor. In the case of a transformer low and high frequency response needs to be considered. The coupling method does not need to have a flat response since ratioed measurements cancel source flatness deviations. In both techniques the input channels must also be either: 1) AC coupled using the network analyzer's internal coupling capacitor (>=10Hz only), or 2) DC coupled which will enable the automatic DC offset tracking up to a maximum of +/- 10 VDC. To allow sufficient voltage "headroom" for large amplitude signals the maximum DC offset should be +/- 7.5 VDC.

Measuring Circuits with High Common Mode Voltages

For frequency response measurements on circuits that have large voltage offsets (>10 VDC) from ground it is necessary to couple the source to the circuit under test using a signal injection transformer covering the frequency range of interest. Using 10-to-1 probes for the receiver's input channels will increase the maximum input voltage to 200 Volts. For high voltages the receiver channels can also be either transformer coupled, connected using active differential probes, or connected using an isolation amplifier. Running a frequency calibration with any of the aforementioned connection schemes, with the probes in place, will remove (i.e. normalize) the frequency response of the probes.

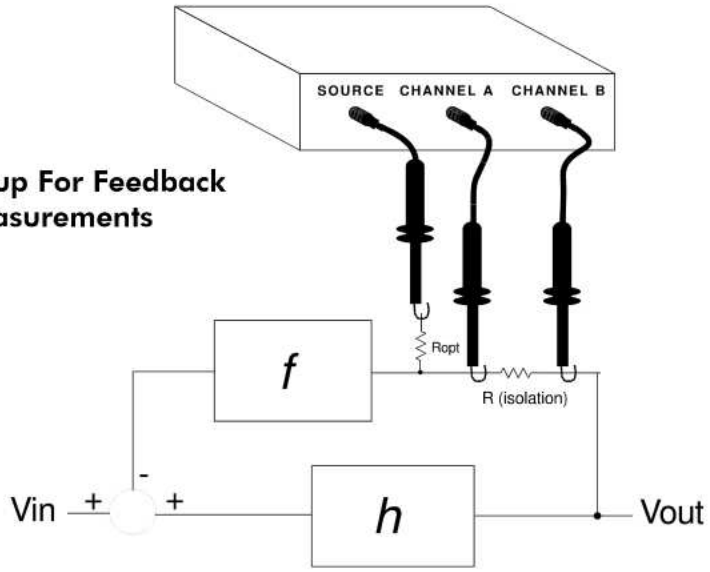
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Measuring Feedback Loop Frequency Response

In feedback circuits it is necessary to measure the gain and phase for the complete path around some chosen loop, i.e. the open loop gain and phase. If the network analyzer is connected such that the source and channel A are connected to the desired "beginning" point in the loop and channel B is connected to the desired "end" point in the loop the gain measured is the desired loop gain and the phase measured is the phase change around the loop. In the case of negative feedback, the phase change includes a 180 degree phase shift when the feedback signal is inverted in the loop.

The network analyzer display shows a +-180 degree phase range so the inversion in the feedback loop will cause any additional phase shifts beyond -180 degrees to "wrap around" and appear as a phase of +180 - (additional phase shifts). In a typical negative feedback circuit with one pole (i.e. 20 dB/decade rolloff) the phase would start off at +180 degrees and, at the pole frequency, show +135 degrees. The phase reading can then be directly interpreted as "phase margin" at the frequency where the loop gain magnitude is equal to one (0 dB).

Basic Setup For Feedback Loop Measurements



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In most cases to make a loop gain measurement the feedback loop must be left closed due to high DC gain or bias conditions. These conditions would force the circuit into a nonlinear area of operation if the loop was opened making a valid measurement impossible. If the node at the source connection has a nonzero voltage then the source will have to be DC offset to match the node voltage or AC coupled using a capacitor or transformer. The resistor Ropt can be used to prevent circuit loading due to small differences in source and circuit voltages. For high frequency loop gain measurements the source probe capacitance as well as the input channel probe capacitance can have a destabilizing effect on the circuit - see the high frequency measurement note above. The source probe capacitance effect can be reduced by using a series resistor between the source and the circuit's selected node. Use a resistor as large as needed to maintain stability. The source drive level can be increased to the level required to obtain a noise free trace.

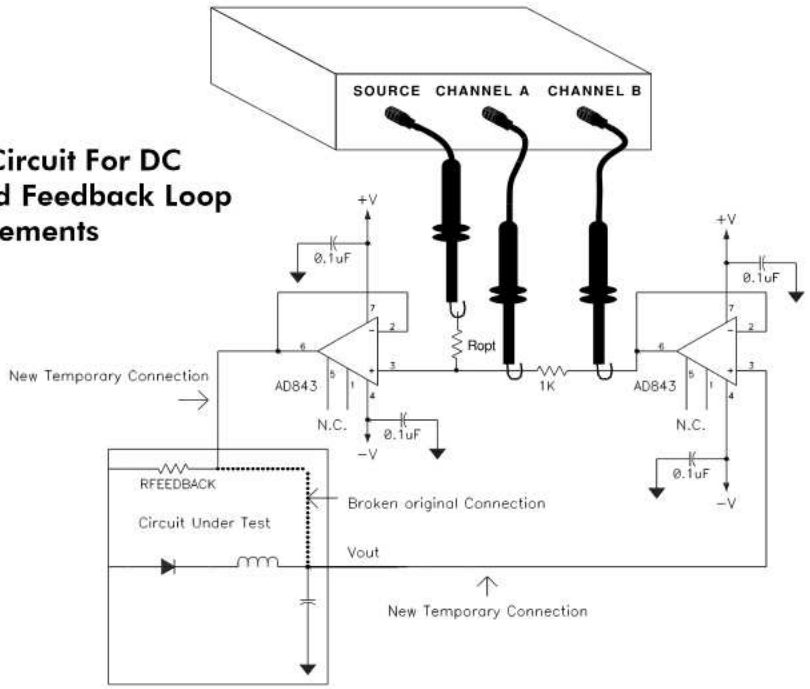
Two measurement methods are detailed below. The first is a DC coupled technique which has the advantages of a DC to 15 MHz frequency coverage. The disadvantage of this technique is that its implementation may require the use of a buffer amplifier. The second, AC coupled, technique is simpler in that it only requires a resistor and a transformer to implement. The disadvantage of this technique is that it is frequency limited by the bandwidth of the transformer used.

DC Coupled, Buffer Amplifier Method

Unless the feedback loop under test has a buffer stage with high input impedance and low output impedance it may be necessary to temporarily add such a stage to maintain the existing feedback loop characteristics and make a valid measurement. The diagram below shows the placement of such a temporary buffer and the network analyzer connections for a feedback loop frequency response measurement. The buffer circuit below, with the 35 MHz bandwidth op-amps, adds approximately 3 degrees of phase shift at 1 MHz to the measurement. Lower speed op-amps can be used for lower frequencies, if desired. The circuit shown assumes **Z**out @ **V**out is much lower than **R**FEEDBACK over the frequencies of interest. If this is not the case then to obtain the actual loop gain response it may be necessary to terminate the **V**out node with an impedance equivalent to **R**FEEDBACK and to add a series impedance to **R**FEEDBACK equal to **Z**out.

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Buffer Circuit For DC Coupled Feedback Loop Measurements

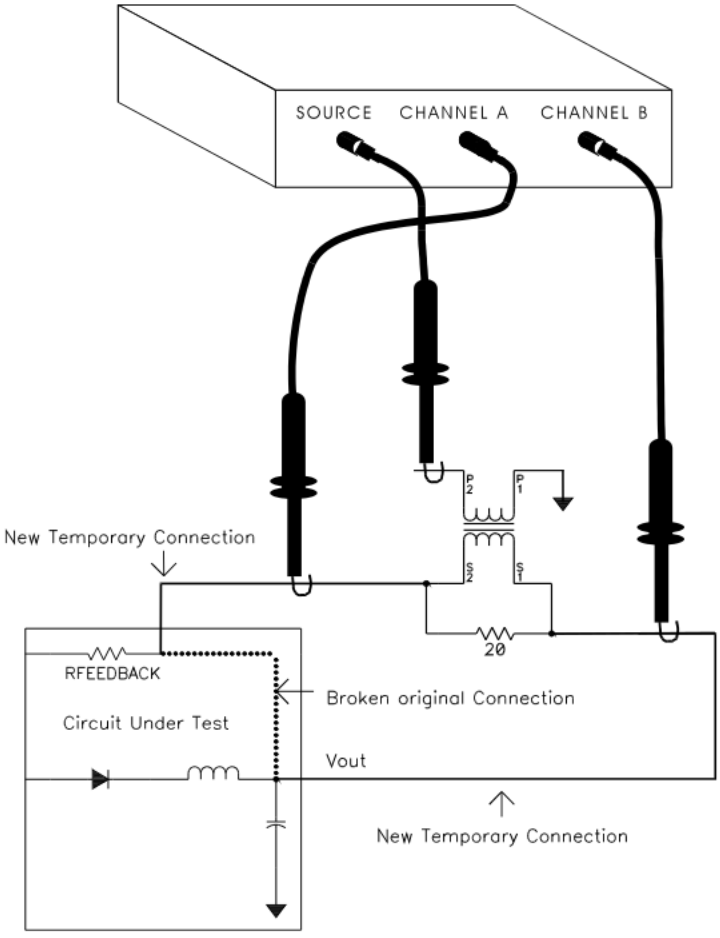


AC Coupled, Transformer Method

The secondary of a transformer is used in this technique to develop a drive voltage across a small resistor, typically 10 to 50 Ohms. This resistor is typically placed in series with the loop's feedback resistor as shown in the diagram below. The transformer's frequency response does not have to be flat over the measurement range but does need to provide an adequate drive level over the measurement range to ensure a good signal to noise ratio.

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Configuration For Transformer Coupled Feedback Loop Measurements:

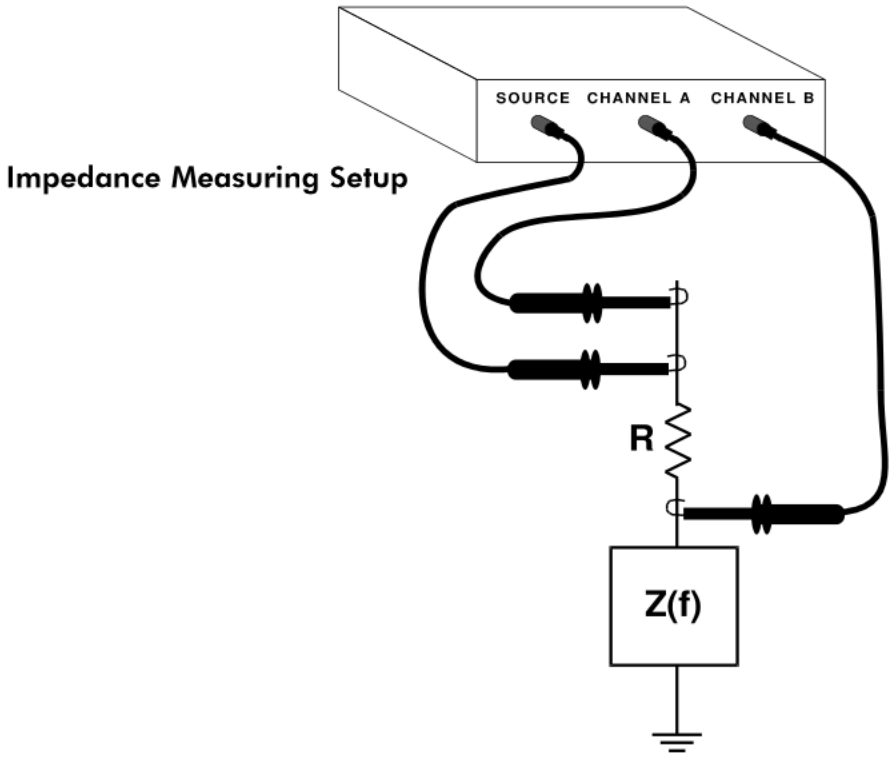


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Measuring Complex Impedance

To measure the input or output impedance of a network the analyzer is connected to a known reference resistor, **R**, that is in series with the network. The source output and channel A are connected to one side of **R** and the other side of **R** is connected to channel B and the network under test as depicted below. For best accuracy the resistor **R** is chosen such that its impedance is within a factor of 5 or so of the expected impedance of the network under test, at the frequency of interest. The impedance calculations derived below are done automatically by the software when the Complex Impedance option is chosen within the Graph menu.

Let the transfer function measured by the analyzer be **H**(f), the unknown complex impedance, **Z**(f)= x + j·y, is then given by: **Z**(f) = **R**·**H**(f)/(1-**H**(f)). This result is derived using the generalized voltage divider formula with the substitution of **VB** = **H**·**VA**. First the magnitude of **H**(f) is converted from dB's to linear form by dividing by 20 and taking the antilog (base 10). The phase is used directly as read



Impedance Measuring Setup

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from the analyzer taking care to include the sign. The converted magnitude along with the phase now represents **H**(f) in polar form, and is then converted to rectangular form and substituted into the formula above. The resulting complex number is the impedance in ohms and will typically have a real part, x, representing the equivalent series resistance, and a imaginary part, y, representing the equivalent reactance of the network under test. A capacitive reactance will have a negative imaginary part, while an inductive reactance will have a positive imaginary part. The equivalent capacitance is given by **C** = -1/(2·pi·f·y) and the equivalent inductance given by **L** = y/(2·pi·f) where f is the measurement frequency in Hz.

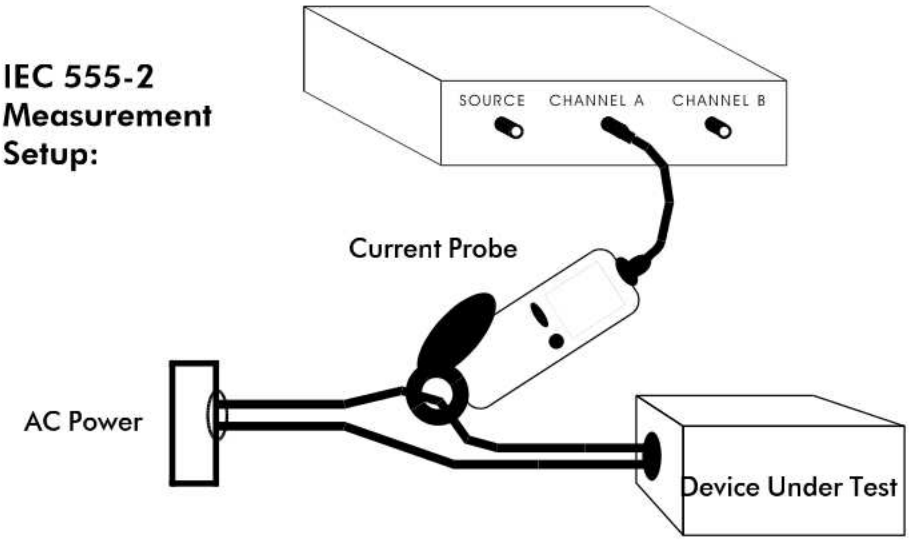
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IEC 555-2 Measurements

A display and measurement mode for IEC 555-2 precompliance testing is available when the IEC 555-2 option is chosen within the Graph menu. This mode graphs a plot of the first forty harmonics of the power line current as measured using an external current transducer connected to channel A. The limits as set forth by the IEC 555-2 document, section 4.1 table 1, are plotted with an x. It is highly recommended that the IEC 555-2 standard be obtained and understood by the user before this test is undertaken. A copy of this standard is available through ANSI, Phone (212) 642-4900. The measured data, the first forty current harmonics, is plotted as a bar chart. The line current frequency is user selectable as 50 Hz or 60 Hz.

The current is measured using an external current transducer, connected to channel A, whose sensitivity in Volts per Amp is entered as an input parameter. The current transducer frequency response bandwidth is required to be flat from 50 Hz to 2.5 KHz. Note that the current transducer must have an output that is safety isolated and meets the SELV (Safety Exposed Low Voltage) requirements when connected to measure line current. One such current transducer that meets the above requirements is the PR-30 available from LEM USA.

IEC 555-2 Measurement Setup:



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Power Transmission/Reflection Measurements

In applications such as passive filters and circuits for communications the parameters of interest involve not voltage transfer functions but rather power transfer functions. Because power can be reflected as well as transmitted through a network due to impedance mismatches the voltage and power transfer functions are not necessarily the same. The model 102B network analyzer, in its most basic configuration, measures voltage/voltage transfer functions since it has high impedance inputs. To measure power transfer functions the network analyzer inputs need to be terminated, using feedthrough terminations, to the desired impedance (typically 50 or 75 ohms). This will convert the power into a voltage which is measured by the analyzer. Also the measurement configuration must be able to determine the actual power transmitted through or reflected from the network under test. This is accomplished by using a power splitter and, in the case of reflection measurements, a directional coupler. The model 102B network analyzer has the capability to measure transmission (S21 or S12) as well as the return loss of a reflection measurement directly. The derived quantities including the reflection coefficient, VSWR and impedance can be calculated from the return loss measurement's magnitude and phase information using the relationships given below.

Reflection coefficient magnitude = 10^ (-return loss/20) where the return loss is expressed as a positive quantity in dB. The reflection coefficient magnitude is between 0 and 1.

Reflection coefficient phase = the phase measured at the return loss measurement.

VSWR = (1+ reflection coefficient magnitude)/(1 - reflection coefficient magnitude).

Impedance = Characteristic impedance (i.e. 50 Ohms) *(1 + reflection coefficient)/(1 - reflection coefficient)

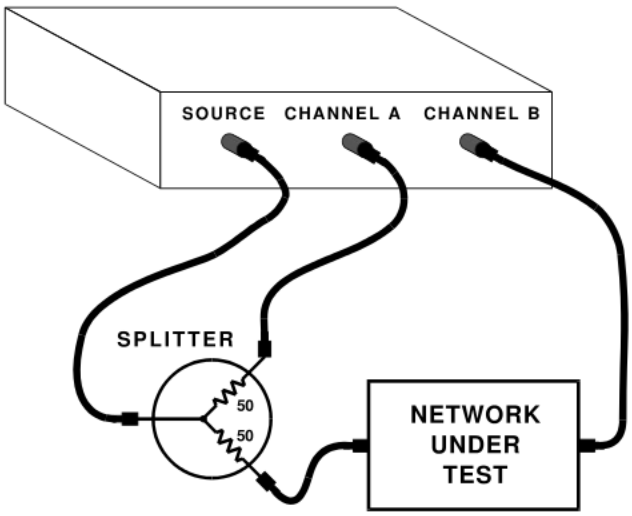
Transmission Measurements

In the case of transmission measurements the power incident to the network under test can be determined by sampling the incident source power using a power splitter and making a ratioed measurement of the output power to input power. As shown in the drawing (below) the sampled incident power is mea-

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sured by channel A while the transmitted power is measured by channel B. Note that the input channels A and B must be terminated to the characteristic impedance of the network under test using feedthrough terminations. A frequency calibration can be performed with the power splitter in place and a through line substituted for the network under test for enhanced accuracy. The power splitter can be a simple resistive splitter shown below which will result in a 6 dB power loss from the source to the network under test. A low loss transformer coupled splitter such as a Mini-Circuits model ZSC-2-2 can also be used.

Transmission Measuring Setup



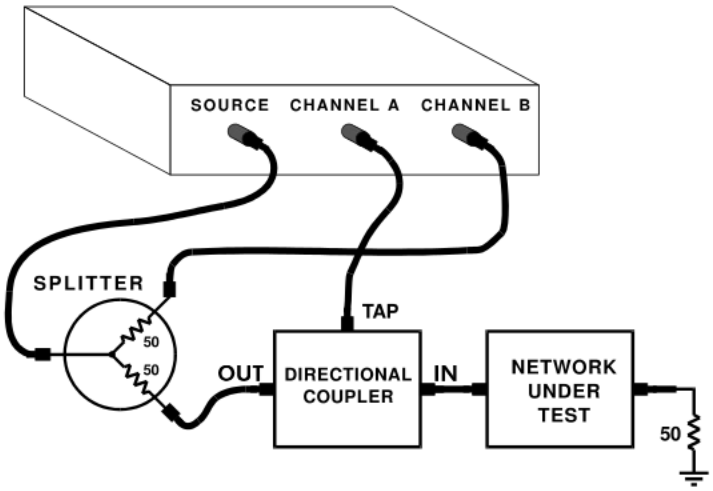
Reflection or Return Loss Measurements

With reflection measurements the power reflected from the network under test back toward the source is the quantity of interest. The reflected power is measured by a directional coupler such as a Mini-Circuits model ZDC-15-6. The directional coupler has a tap which represents a portion (i.e. -15 dB) of the reflected power. A return loss measurement can be made by taking a ratioed measurement of the incident power to the reflected power. The incident source power is sampled using a power splitter. As shown in the drawing (below) the sampled incident power is measured by channel B while the reflected power, as sampled from the coupler tap, is measured by channel A. This ratio is taken to

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keep return loss a positive quantity. Note that the directional coupler's output port is connected to the power splitter while the coupler's input port is connected to the network under test. This is because it is the reflected power from the test network that enters the coupler's input port. Note that the input channels A and B must be terminated to the characteristic impedance of the network under test using feedthrough terminations. A frequency response calibration **must** be performed with the power splitter and directional coupler in place using a short substituted for the network under test. The short will give a theoretical return loss of 0 dB with a phase shift of 180 degrees and gives the reference point by which the return loss is measured. The -15 dB reflected power coupling tap of the directional coupler is calibrated out by the frequency response calibration procedure.

Reflection Measuring Setup



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APPENDIX A

Theory of Operation

The Model 102C Network Analyzer System is comprised of a host PC, a DSP board and a Source/Receiver unit. The host PC provides the operator I/O, file storage and data post-processing. The DSP Board provides the real time data preprocessing and power supply for the Source/Receiver unit. The Source/Receiver unit contains the frequency source output and the two input, or receiver channels.

The host PC interfaces with the DSP microprocessor (uP) using the PC's 16 bit data bus. The DSP uP in turn interfaces with the Source/Receiver unit, via a cable, using a high speed bidirectional serial interface isolated from the host PC using differential driver/receivers. The DSP board's isolated DC-DC converter uses the PC's +12v supply as its power source. The converter up and down converts the +12v input to supply the Source/Receiver unit with the needed voltages.

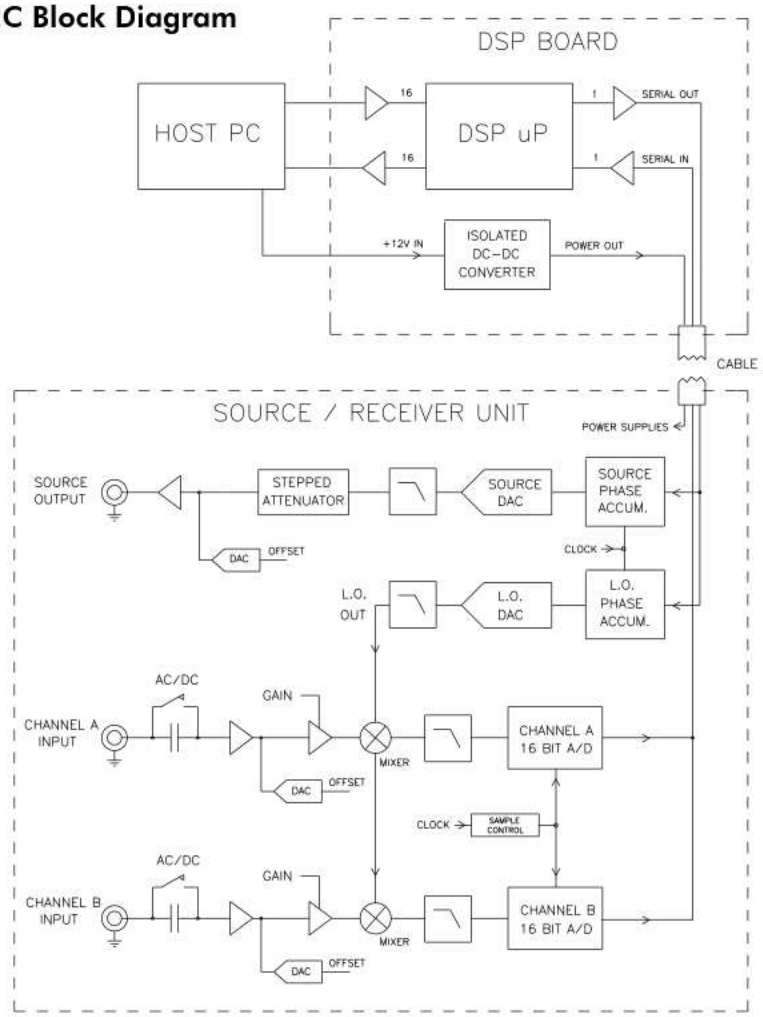
The network analyzer uses a "swept sine" approach to measure the transfer function of the network under test. This approach requires a sinusoidal, variable frequency, source output and two input channels capable of sampling the sinusoidal input over a broad frequency range. The source is of the DDS or direct digital synthesis type which meets the requirements of fast frequency changes, logarithmic or linear sweeps, wide frequency range and low parts count. The receiver is of the heterodyning type which enables a broad frequency range with a fixed low frequency I.F. for high accuracy and low noise analog to digital conversion. The block diagram (below) shows the various stages of the network analyzer in a simplified form.

Both the source and L.O. use a DDS source which functions by accumulating a selectable phase increment at the system clock rate. This accumulated phase value is then directly mapped to the sine value using a ROM lookup table. The sine value is then converted to a voltage using a high speed DAC, the output of which is low pass filtered to remove aliases. The L.O. output is used directly to drive the L.O. side of the receiver mixers. The source output, however, is passed through a stepped attenuator giving 0 to 63 dB's of attenuation. The attenuator's output is then DC offset by a user selected amount and buffered enabling the source output to drive 50 ohm loads.

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The receiver channels A and B are identical thus the following description applies to both. The input signal drives a high impedance input buffer which in turn drives a stage capable of being DC offset for automatic DC offset tracking. The offset stage then drives an amplifier stage switched by the DSP uP for maximum signal to noise ratio. The amplifiers output drives the signal side of the mixer resulting in a mixer output that is a fixed I.F.. The I.F. signal is then low pass filtered to remove aliases and sampled by the analog to digital converter.

Model 102C Block Diagram



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The receiver's analog to digital converter output is sent to the DSP uP over the serial interface. The DSP uP converts the data from both input channels, in real time, to complex numbers representing the phase and magnitude of the sinusoids at the channel A and B inputs. The DSP uP then passes these complex numbers to the PC for error correction and scaling for presentation on the PC's graphics display.

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APPENDIX B

Measurement Accuracy

The basic accuracy of the analyzer is specified to be 0.025 dB magnitude and 0.2 degrees phase. These specifications assume that a system calibration has been performed after a 30 minute warm-up period at the operating ambient temperature. The analyzer's accuracy can be undermined by changing or swapping the input probes after calibration has been performed.

There are a number of factors that determine the accuracy, or lack thereof (uncertainty or error) of a given frequency response measurement made by the 102C network analyzer. They are listed below in an order which does not necessarily reflect their significance.

Possible error contributing factors **external** to the analyzer include:

Probe Loading
Probe Compensation
Transmission Line Effects

Possible error contributing factors **internal** to the analyzer include:

Signal to Noise Ratio
Source Frequency Accuracy
Temperature Drift
Receiver Linearity

To obtain the worst case measurement error the errors from all of these factors need to be summed together as they relate to a given measurement situation. The term 'res', as used in the charts below, indicates the values are below 0.01 dB magnitude or 0.1 degrees phase.

Probe Loading Error

Probe impedance, chiefly capacitance, can cause loading of the circuit under test and can be a significant error source as described in the discussion on high frequency measurements.

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Probe Compensation Error

Ten-to-one (x10) probes, needed for reducing the probe loading effect introduce a frequency response error. The frequency response error can be canceled by performing a frequency response calibration. The adjustment procedure is performed once at the factory on the included probes and should be performed periodically as follows: Select the x1 probe attenuation setting in the RECEIVER window. Set the analyzer for a 0.994 V rms signal level output and sweep from 100 Hz to 100 kHz (log sweep). Connect the source and input channels together. Place one probe in the x1 position, if available, or use a 1:1 cable. Place the other probe in the x10 position. Using a small screwdriver or adjustment tool set the x10 probe compensation adjustment for maximum flatness. Likewise, adjust the second x10 probe in a similar manner keeping the probe on its assigned channel (do not swap probes back and forth between channels). Before making measurements perform a frequency calibration, followed by selecting the appropriate probe attenuation choice in the RECEIVER window.

Transmission Line Effects

When using coaxial cables at higher frequencies and long cable lengths the transmission line effects give rise to "standing wave patterns" on cables unless the cables are properly terminated at their endpoints with the cable's characteristic impedance. The analyzer's inputs have a one megohm impedance which may need to be terminated to the cables impedance. To avoid this type of error use through-line terminators at the analyzer's input channel BNC's.

Signal to Noise Ratio Error

This error term is labeled "signal to noise ratio" or SNR and is the difference, in dB's, between the analyzer's receiver noise floor and the smallest of the two input channel's signal magnitude. The analyzer's noise floor is specified to be at least 100 dB's below the largest allowable signal which is 1.7 volts rms. An input signal at the worst case noise floor level would then have a magnitude of approximately 18 microvolts rms and the SNR would be 0 dB. The analyzer's typical noise floor is approximately 5uV rms using a IF bandwidth of 10 Hz. This type of error is a random quantity that manifests itself as trace noise. The chart below lists the measurement error as a function of SNR.

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Signal to Noise Ratio Error Chart

Signal Strength	SNR in dB's	Mag. Error (dB)	Phase Error (deg.)
18 uV	0	3	45
56 uV	10	0.414	13.6
180 uV	20	0.043	5.7
560 uV	30	0.0043 (< res)	1.81
1.8 mV	40	< res	0.573
5.6 mV	50	< res	0.181
18 mV	60	< res	0.0573 (< res)
56 mV or more	70 or more	< res	< res

Source Frequency Error

The source frequency is accurate to 100 ppm (0.01%) or 20 ppm (special) which makes its consideration important only on circuits with extremely high Q such as crystal filters.

Temperature Drift Error

The temperature drift error is due to magnitude and phase changes with the analyzer's internal temperature changing. This results from the operating temperature being different from the temperature at the time the frequency calibration was performed. This error source can be minimized by performing a frequency calibration at the ambient operating temperature after a 30 minute warm-up period. The expected worst case temperature coefficients are 0.0025 dB magnitude and 0.01 degree phase, per degree Celsius.

Receiver Linearity Error

Since the frequency calibration is performed at a single, high, input level any variations in the analyzer's linearity will cause a magnitude error at other, significantly different, input levels. The chart below gives this error as a function of input level.

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Receiver Linearity Error Chart

Input Signal Level	Magnitude Error in dB's
0.1 mV	0.30
1 mV	0.15
10 mV	0.01
>10 mV	< res

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APPENDIX C

Specifications

SYSTEM

PARAMETER	TYPICAL SPEC.	MIN. / MAX. SPEC.
Sweep Speed, Per Point [1]	3 msec. (600 Mhz PC)	PC Dependent
Source/ Receiver Isolation	120 dB	100 dB min.
Temperature, Operating		5 °C / 35 °C
Temperature, Storage		-40 °C / 70 °C
Source/Receiver:		
Weight	4.2 lbs.	
Dimensions	2"H x 9"W x 15.5"L	
DSP Card (PC XT size) :		
Weight	0.66 lbs	
Dimensions	5"H x 0.75"W x 8"L	
Analyzer (BNC) ground to PC ground common mode voltage		42V Peak

SOURCE

PARAMETER	TYPICAL SPEC.	MIN. / MAX. SPEC.
Frequency Accuracy	50 ppm	100 ppm
Flatness, DC to 1 Mhz [2]	+/- 0.2 dB	
1 to 15 Mhz	+/- 1.5 dB	
Harmonics	- 40dBc	
Spurious, Exc. Harmonics	- 55dBc	
AC Output Level Range		1.25mV / 1.77V rms
AC Output Level Error [2]	5%	
DC Offset Range		-10.128/+10.128 V Peak
DC Offset Error	5%	
Residual DC Offset	10mV	
Current Limit	80mA	
Output Impedance	50 Ohms	
Absolute Maximum Safe Voltage at Source Output		-/+ 15 Volts Peak

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RECEIVER

PARAMETER	TYPICAL SPEC.	MIN. / MAX. SPEC.
Dynamic Range[3] <5MHz	110 dB	100 dB min.
>=5MHz	95 dB	90 dB min.
B/A Magnitude Accuracy [3]	+/- 0.025 dB	See appendix B
Abs. Magnitude Accuracy [4]	+/- 2%	
Phase Accuracy [3]	+/- 0.2 degree	See appendix B
Resolution (IF) Bandwidth	Depends on frequency and Bandwidth selection	0.01Hz / 1KHz
Input Signal Range(AC) [3]	5 uV to 1.77 V rms	17.7uV / 1.77 V rms
Input Signal Range(AC+DC)	-12/+12 V Peak	-10/+10 V Peak
A to B Isolation <5MHz	110 dB	100 dB min.
>=5MHz	95 dB	90 dB min.
Input Imped., x1 probe	1 Megohm	
Input Imped., x10 probe	10 Megohm	
Input Cap., at BNC conn.	22 pF	
Absolute Maximum Safe Voltage at Receiver Input		-/+ 20 V Peak

1 For measurement frequencies > 11KHz. A minimum of 1.2 cycles at the source frequency are used giving a minimum time per point of (1.2/frequency) + 2 ms.

2 Ratioed measurements cancel source flatness deviations and absolute source level errors.

3 Using (IF) bandwidth of 10 Hz or less and 50 sweep Averages.

4 With an Absolute Magnitude Full Spectrum calibration as described in Chapter 3.

Specifications subject to change without notice.

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APPENDIX D

File Types; Use and Format

Below is a description of the various files which are used by the Network Analyzer Windows software.

nawincon.ini

This file is used to save the setup on program termination. Each time the program is started, the setup configuration is initialized to the values in this file. Nawincon.ini is located in the windows directory. Although this is a text file, editing is not recommended, Changes can be made by exiting the program with the desired setup parameters (including calibration files). Refer to [File System Settings...] when changing the hardware port address on the DSP circuit card.

Filename.set

Files of extension .set are user defined setup files. These files are created using the menu command [File Save Setup As...]. User setup files have the same effect as nawincon.ini except that they are saved and loaded at any time (also, they are normally saved in the nawincon directory). User setup files are text files with the same format as nawincon.ini. The program maintains four setup files of it's own, these are known as the ampersand-dot-set (&.set) files (mp_&.set, abs_&.set, ci_&.set, iec_&.set). These files are used to save and recall system settings whenever the graph display mode changes.

Filename.dat

Data files. Created with the command [File Save Data As...] are text files of sweep data. The data is written in the following format: One line per data point, On each line are five (5) tab separated values ordered as Frequency, Magnitude (B/A), Phase (B/A), Absolute Magnitude (A), and Absolute Magnitude (B). Data in this format should be easily imported into most applications.

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Filename.fpl

A Frequency Points List (.fpl) file is used to define specific frequency values for a sweep. The format of this text file is described in detail below (Frequency Point List (FPL) Files).

Warning : iec_50hz.fpl and iec_60hz.fpl are used by the system when in IEC 555-2 display mode and should not be deleted or modified.

Filename.frq, Filename.src, Filename.rcv, Filename.abs

These files are required for system calibration. They are binary files and should not be edited. Creating and loading calibration files is accomplished through the Calibration File Maintenance dialog box. The command [File Calibration...] opens this dialog box.

Frequency Point List (FPL) Files

As an alternate method of sweeping, NA Windows Connectivity allows a series of frequency values (stored in a file) to be used as the data collection points. These files have the extension .fpl (Frequency Points List) and the format is as follows : An ASCII text file with one frequency value per line. The value may be either decimal or exponential format. It is important that there are no blank lines (even at the top of the file) or extra carriage returns, also, the frequencies must increase from the top of the file on down.

The following is a valid 5 point FPL file :

```
100.38
103.45
1E+4
5.23E+4
800000.9654
```

The [File Save Data As...] menu option can be helpful in creating FPL files. Suppose a 400 point logarithmic sweep from 1K to 100K is desired, but the sweep must include the exact value of 10500.00. This can be accomplished by performing a standard log sweep with the limits specified, then save the data to a file (creating a .dat file). By deleting all but the first column in the .dat file and changing the extension to .fpl a 400 point FPL file of the frequency values used in the logarithmic sweep is created. Now find the frequency value closest to 10500.00, +1.05826072562617E+004, and change it to 10500.00. This file can now be used to perform the required sweep.

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APPENDIX E

Default Setup Values

Calibration

Frequency Calibration File	default.frq
Source DC Null Calibration File	default.src
Receiver DC Null Calibration File	default.rcv
Absolute Magnitude Calibration File	default.abs

Sweep

Sweep Points	100
Sweep Frequency Input	Start / Stop
Sweep Start Frequency	10 Hz
Sweep Stop Frequency	15,000,000 Hz
Sweep Center Frequency	7,500,005 Hz
Sweep Span	14,999,990 Hz
Sweep Averaging	Off
Sweep Averaging Factor	20
Sweep Mode	Continuous
Sweep Type	Linear
Sweep Dwell	Auto
Sweep Dwell User Value	0 ms

Source

Source Output	On
Source DC Offset (Source)	0.0 V
Source DC Offset (Fine)	0.0 V
Source Level	1.25 mV

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Receiver

Receiver Coupling	AC
Receiver Attenuation	x1 (unaffected by default setup)
Receiver Preamp	Auto
Receiver BandWidth	1 Khz

Colors

Grid	Light Gray
Markers	Dark Green
Left Trace	Light Blue
Left Master Trace	Dark Blue
Right Trace	Light Red
Right Master Trace	Dark Red
Marker Data Black	Off

Data Format

Mag & Phase	Frequency	Eng / 2
	Left Trace	Std / 2
	Right Trace	Std / 2
	Delta	Exp / 1
Abs Mag	Frequency	Eng / 2
	Left Trace	Std / 3
	Right Trace	Std / 3
	Delta	Exp / 1
Cmplx Imp	Frequency	Eng / 2
	Left Trace	Exp / 3
	Right Trace	Exp / 3
	Delta	Exp / 1
IEC 555-2	Frequency	Eng / 2
	Left Trace	Std / 2
	Right Trace	N / A
	Delta	Exp / 1

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Trace Display	Left & Right Trace
Phase Format	+/- 180°
Title	Clear

Complex Impedance Setup

Reference Resistor	1000 ohms
Equivalent Circuit Mode	Series
Display Mode	Impedance (Rect)
Warning Message	Enabled

IEC 555-2 Setup

Line Frequency	50 Hz
Sensitivity	1 Volt / Amp
Warning Message	Enabled

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APPENDIX F

In Case of Difficulty

SYMPTOM	CHECK
After starting the analyzer's software the system freezes, not allowing parameters to be entered nor the sweep to be started. The source/receiver unit does not power up, i.e. the green power light is not on when the analyzer's software is running.	Make sure the DSP board is plugged into a 16 bit ISA slot (two edge connectors). Verify that the port address on the DSP board matches that entered in the program and does not conflict with other cards. Verify that the DSP board is plugged into the host PC's power supply harness to receive +12v. Verify that the 36 pin cable assembly has been connected to both the host PC and the Source/Receiver unit.
The host PC is malfunctioning after installing the DSP board.	The port address may conflict with another card in the host PC. Try a new port address and run the analyzer's program again after first deleting the nawincon.ini file.

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APPENDIX G

Repair and Warranty Information

Repair

If, after reviewing and implementing the diagnostic procedures in appendix F the unit is still non-operational then proceed as follows:

[1] Contact AP Instruments for further assistance and, if needed, a return authorization.

[2] Pack the instrument, including all accessories, in the original packing and shipping materials. If the original shipping materials are not available ensure that there is at least four inches of packing material surrounding the instrument and the individual components have been separately wrapped to prevent scratches during shipping.

[3] Ship the package, insured for full value, to the address obtained in the factory return authorization contact above.

Warranty

The Model 102C comes with a one year limited warranty. During the warranty period, AP Instruments will, at its option, either repair or replace the products that prove to be defective. Should AP Instruments be unable to repair or replace the product within a reasonable amount of time, a refund of the purchase price may be given upon return of the product.

Warranty Exclusions

The warranty on your Model 102C shall not apply to defects resulting from:

- Customer supplied software or interfacing.
- Damage by accident or abuse.
- Unauthorized modifications or misuse.
- Operation outside the environmental specifications of the product.

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APPENDIX H

Source Fuse Replacement

The Model 102C's source is fused to protect against an excessive external current flowing into the analyzer source output stage. The lack of output from the source can be the result of a blown source protection fuse. The protection fuse is a LITTLEFUSE PICO II 0.125 Amp Fast Blow part number 251.125.

The socketed fuse is located immediately behind the source output BNC connector and is accessible without removing the shields. Replacing the fuse first requires removing the source/receiver unit's top cover. This is accomplished by removing the top inner three screws on each side of the 102C's case. A socketed spare fuse, located to the side of the source BNC connector, is available.

Preventing Blown Fuses

The source protection fuse blows if the circuit under test had voltage potentials which resulted in excessive current into the source output. To prevent this from occurring it is recommended to ensure a source impedance of 20 ohms per volt of exposed voltage. For example a 300 Ohm resistor in series with the source should suffice to keep the source current below 50 mA in case of a misconnection to a +/-15v potential. Make sure the analyzer is powered up before connecting to powered circuits. Likewise, remove the analyzer connections before powering down the circuit under test.

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INDEX

A

Absolute Magnitude. See Graph: Absolute Magnitude
Application Notes
  Basic Measurement Procedures 43
  High Frequency Measurements 45
  IEC 555-2 Measurements 53
  Introduction to Analog Network Measurements 41
  Measuring Circuits with High Common Mode Voltages 46
  Measuring Circuits with Nonzero DC Voltage Levels 46
  Measuring Complex Impedance 51
  Measuring Feedback Loop Frequency Response 47
  Power Transmission/Reflection Measurements 54
Attenuation, Receiver 26
AutoScale 18, 22
Avgeraging, Sweep 24

B

BandWidth, Receiver 26
Basic Measurement Procedures 43

C

Calibration 15
  Absolute Magnitude 30
  Frequency Response 29
  Receiver DC Null 28
  Source DC Null 28
  System 27
Colors, Trace 18
Complex Impedance. See Graph: Complex Impedance
Complex Impedance, Measuring 51
Configuration, Minimum Computer 2
Copying Data 15, 21
Coupling, Receiver 26

D

DC Offset, Source 25
DDE. See Dynamic Data Exchange
Default Setup 14
Default Setup Values 68
Difficulty, In Case of Guide 71
DSP
  Board 4
  Port Address 8, 15
Dwell, Sweep 25
Dynamic Data Exchange 33

E

Edit
  Copy 15
Edit Menu 15
Excel Spreadsheets 39
Excel, Using DDE with 36
Expand Markers 17, 21

F

File
  Calibration 15
  Default Setup 14
  Exit 15
  Frequency Point List (fpl) 67
  Open Data 14
  Open Setup 14
  Print 15
  Save Data As 14
  Save Setup As 14
  System Settings 15
File Menu 14
File Types, Use, and Format 66
Formatting Data (Numerically) 18
Frequency Point List (fpl) Files 67
Frequency, Sweep 23
Fuse Replacement, Source 74

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G

Graph
- Absolute Magnitude 13, 16
- AutoScale 18, 22
- Complex Impedance 13, 16
- Display Modes 12
- IEC 555-2 13, 17
- Magnitude and Phase 12, 16
- Manual Scale 18, 22
- Markers 12, 17, 21
- Master Trace 12, 18, 21
- Trace 11

Graph Menu 16
Graphical User Interface 10

H

Help 22
Help Menu 20
High Frequency Measurements 45

I

IEC 555-2. See Graph: IEC 555-2
IEC 555-2 Measurements 53
Installation
- Hardware 3
- Software 7

Introduction to Analog Network Measurements 41

L

Level, Source 25

M

Magnitude and Phase. See Graph: Magnitude and Phase
Manual Scale 22
Markers 12
- Display 17, 21
- Expand 17, 21

Master Trace 12, 18, 21
Measurement Accuracy 60
Measuring Circuits with High Common Mode Voltages 46
Measuring Circuits with Nonzero DC Voltage Levels 46
Measuring Complex Impedance 51
Measuring Feedback Loop Frequency Response 47
Menu Selections 14
Mode, Sweep 24

O

Options
- Colors 18
- Format Data 18
- Format Phase 19
- Title 18
- Trace Display 19

Options Menu 18
Output, Source 25

P

Phase, Formatting 19
Points, Sweep 24
Port Address, DSP 8, 15
Power Transmission/Reflection Measurements 54
Preamp, Receiver 26
Print 15, 21

R

Receiver
- Attenuation 26
- BandWidth 26
- Coupling 26

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Preamp 26
Repair, Unit 72
Reset Sweep 21

S

Source
DC Offset 25
Fuse Replacement 74
Level 25
Output 25
Specifications, System 64
Spreadsheets, Excel 39
Start Sweep 20
Stop Sweep 20
Sweep
Averaging 24
Dwell 25
Frequency 23
Mode 24
Points 24
Reset 21
Start 20
Stop 20
Type 24

T

Theory of Operation 57
Title, Graph 18
Toolbar 20
Main 20
Receiver Parameters 26
Source Parameters 25
Sweep Frequency 23
Sweep Parameters 24
Type, Sweep 24

V

Virtual Front Panel 10

W

Warranty Information 72

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