Subject: RE: The files
Date: Wed, 23 Jul 2003 14:33:42 -0400
From: "Earl" <support@tecmag.com>
To: "Gernot Laicher" <gernot@physics.utah.edu>

Dear Gernot,

It could be an issue with the reciever synthesizer. The synthesizer output should be around 1Vpp (0-4dbm) at all frequencies. What you should do is measure the output level of this board at 40 MHz, 11 MHz, and 5 MHz. The output of this board is CW and so all you will need to do is type in a frequency and hit return and you should see the frequency change to Obs. Freq + 12.5 MHz. The board should be in the slot labeled Synth7-RX. There are 4 smb connectors on this board. Three are inputs, one comes from the Clock, and the other two come from the DDDS-RX board next to it. The output of this board goes to the RF-RX.

Sincerely,

Earl

Earl Emery
Tecmag, Inc.
713-667-8747(ph)
support@tecmag.com

-----Original Message-----
From: Gernot Laicher [mailto:gernot@physics.utah.edu]
Sent: Wednesday, July 23, 2003 2:06 PM
To: Earl Emery; Brian Saam; Steven Morgan; Gernot
Subject: The files

Dear Earl,
I forgot to attach the files obtained with the Apollo. Here they are.
Regards,
Gernot

typed in → measured — Amplitude Vpp

2.0 MHz → 32.5 MHz — 432 mV pp (into 50Ω); 864 mV (into 1MΩ)

40 MHz → 52+/1 MHz — 378 mV (50Ω); 567 mV

11 MHz — 350 mV; 552 mV (1MΩ)

5 MHz — 596 mV (50Ω; ~~596 mV~~ (1MΩ; 904 mV (~1MΩ)

Apollo Installation

Introduction

Verify that the shipment is complete. See **Parts Lists**, below, and any shipping documents. Check for any notices or instructions attached to the units.

Parts List *

- Apollo console, including AC power cable and extra connectors
- PCI interface cables (two 50-pin, 6 ft ribbon cables)
- NTNMR software CD-ROM (required only for backup, re-installation, or installation on another computer)
- Computer system, including tower, power cord, keyboard, mouse, Tecmag PCI interface boards (factory-installed) and software (factory-installed). DISPLAY MONITOR NOT INCLUDED.

Optional Parts List *

- DAC-18 subsystem chassis, with serial data cables (RJ-45 connectors, 25 ft, similar to 10-base-T network cables) for imaging systems.

* Note: Consult packing list for exact list of items in your shipment

Installation Procedure

> *Note: NTNMR is pre-installed on the spectrometer computer at the factory - you do not need to run the NTNMR Installer from the CD! The NTNMR CD contains additional material as well as an installer for re-installing NTNMR if necessary.*

All connections are on the rear of the Apollo console cabinet.

1. Find a convenient location for the console box and the computer. The two units must be within about 4 feet of each other due to the length of the interconnecting cables. Be sure to leave the air vents on the console (top, bottom and rear) unobstructed.

2. Check that the power switch is off (rear panel, adjacent to the mains cord socket). Connect AC mains power of proper voltage. (See Environment.doc for details).

3. Set up the computer following instructions supplied with it. Set up your monitor and connect it to the computer. DO NOT MODIFY THE COMPUTER SYSTEM OR SOFTWARE by installing other boards or software until you have verified correct operation of the Apollo console (see below).

4. Connect the two ribbon cables from the PCI boards in the computer to the Apollo box, observing the polarity (key slots on the side of each connector). Note that the two connectors are identical, so observe the labelling on the cables to match the correct cable and connector. Care must be taken that *PCI-SI* goes to the System Interface and *PCI-SA* goes to the Signal Averager. The cables may be connected and disconnected while AC power is applied, although this is not recommended since excessive force may cause components in the computer to move causing electrical short circuits. Also, the state of the Apollo outputs cannot be guaranteed when the cables are disconnected.

5. Connect the following signals to the appropriate points in the NMR system using 50 ohm coaxial cable and BNC connectors (not supplied):

   - **F1** or **F1 TX out**. Approximately 1 V p-p modulated radiofrequency (RF) source for the F1 channel. Connect to the input of your RF amplifier. Use a fixed attenuator if required (not supplied).
   - **F2 TX out**. (If second channel was purchased). Approximately 1 V p-p modulated RF source for the F2 channel. Connect to the input of a second RF amplifier. Use a fixed attenuator if required (not supplied).
   - **RF in**. Low level RF signal from your RF preamplifier. A preamp with a gain of 20-30dB is recommended, depending on the application (not supplied). The internal amplifier has a gain of about 70dB, and the input may be damaged by excessive signal.
   - **10 MHz out**. 1 V p-p 10 MHz sine wave is available for synchronizing external devices (if required).
   - **Ext Trig in**. Apply a TTL (5v) pulse here to synchronize pulse sequences with external events (as required).

6. Signals are provided on the back panel of the Apollo system for amplifier blanking, scope trigger, etc. Consult the chart included for output assignments. For use of Spare LP lines, refer to NTNMR documentation or contact technical support. Note that Tecmag reserves the right to assign any one or more of these lines to specific purposes in future hardware/software releases.

Optional Gradient Subsystem Installation Procedure.

1. Find a convenient location near the gradient amplifiers for the DAC-18 subsystem box.

2. Connect the subsystem to the console using three RJ-45 serial cables. Note that the outputs of the gradient board in the console are X, Y, and Z in order from bottom to top. One serial cable goes to each channel. If you have ordered a B_0 compensation unit, you will need to install 3 additional cables for the X, Y, and Z components.

3. Connect the DAC-18 boards to their respective gradient amplifier inputs using short cables. BNC or Twin-ax connectors for these cables are supplied if ordered. If the B_0 compensation unit is included, a 3-to-1 adapter cable is provided to connect the 3 DAC outputs to the B_0 amplifier input.

4. Once the system has been tested, you may wish to mount the individual DAC-18 boards directly inside the respective gradient amplifiers, using the +/- 15V from the amplifier power supply to power them. This should significantly reduce any mains-frequency signal pickup by reducing ground loops.

Preliminary Test - Loopback

Disconnect **F1 TX out**, **F2 TX out**, and **RX in** from the console. Connect **F1 TX out** to **RX in** via a 50 ohm coaxial cable and a 20dB attenuator.

Turn on the power. The red LED on the front panel should light up. Turn on and boot up the computer. Log in to Windows NT as "administrator", no password required. If there is a "READ ME" icon on the desktop, double-click it to read last-minute instructions.

Double-click the NTNMR icon on the desktop. NTNMR will start, and after a minute or so, you will hear a "beep" signifying that the console has been initialized. (For troubleshooting purposes, you may open the hinged rear panel of the console (two knurled screws at the top of each panel) and watch the LEDs during this process. After NTNMR has been launched, or after the reset button ("hammer") has been clicked, all of the LEDs will flicker briefly. When the process is complete, all RED LEDs should be extinguished except the one on the Signal Averager.)

Open the file Data\TX_RX_Loopback.tnt (may be located in Data\test\). Click the "ZG" button on the toolbar. A waveform should appear on the screen, consisting of a "sinc function" followed by a "ramp".

If this test fails, contact Tecmag technical support immediately.

If this test passes, reconnect the cables to **F1 TX out**, **F2 TX out**, and **RX in**. You're ready to do NMR!

Additional Documentation

Other than the documentation in this folder (i.e. Installation Notes, last minute documentation changes, etc.), all documentation is online in either Adobe Acrobat format or in Microsoft HTML Help File format. The Adobe Acrobat Reader software package is pre-installed on the computer at Tecmag. HTML Help requires either Internet Explorer 4.01 or later, or the Microsoft HTML Help update (pre-installed on the computer at Tecmag).

The online documentation consists of:

- NTNMR Reference Manual
- NTNMR Online Help
- Hardware Reference Manual

Other items contained on the NTNMR CD include NTNMR File Format documentation, Visual Basic and Visual C++ automation examples.

Contacting Tecmag

Tecmag, Inc.
6006 Bellaire Blvd.
Houston, TX 77081

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Sales inquires: info@tecmag.com
Support inquires: support@tecmag.com

Rev.80111

Setting up the Optional Room Temperature Shim Control

This section describes the connections required for using the optional Tecmag 24DAC18 module for controlling a room temperature shim power supply. Information on using the shimming features of NTNMR can be found in the NTNMR Reference Manual (pre-installed on the computer and available on the supplied NTNMR CD).

> *This section does NOT apply to other types of shim control DACs such as the Acromag PCI card.*

General: The Tecmag 24DAC18 board provides 18-bit digital-to-analog (DAC) voltage outputs for up to 24 channels for control of a shim power supply or similar device. The board is configured at the factory for either +/- 1 V output, or +/- 3 V output on each channel. The output voltages are present on a 25-pin connector (DB25) labeled **Shim** or **Shim Cont** on the back of the Apollo-Console Chassis.

The 24DAC18 obtains its power and control signals from the Tecmag Bus (Apollo Bus).

> *Consult the system information document for the exact connector labeling on the Apollo-Console Chassis.*

Hardware Connections: The mapping of the coil term in the NTNMR shim panel to a particular output pin on the **Shim** connector is configurable in software. In most cases C1, C2, C3, … C24 in the [coils] section of the default.shm file (see the next section) are assigned to pin 1, pin 2, pin 3, … pin 24. Pin 25 of the **Shim** connector is always ground.

Software Configuration: Generally, the shim configuration in NTNMR will have been setup as per the users request. However, in some special situations you may wish to modify the software configuration for shim control.

The 24DAC18 is controlled via the NTNMR Console Window. Both the current shim settings, and the display format, are specified in the file C:\NTNMR\shims\Default.shm. There are three sections in this file: [Shims], [ShimTerms], and [Coils].

The first section, [Shims], has one entry for each defined shim term, and shows the current DAC values for each term. For a new installation, the DAC values can be entered as zeroes.

The second section, [ShimTerms], defines the layout in the Console Window. There are three subgroups of shims, A, B and C. Groups A and B are on the left in the window (one row each, of 5 terms each), and Group C is on the right (3 rows of 4, for

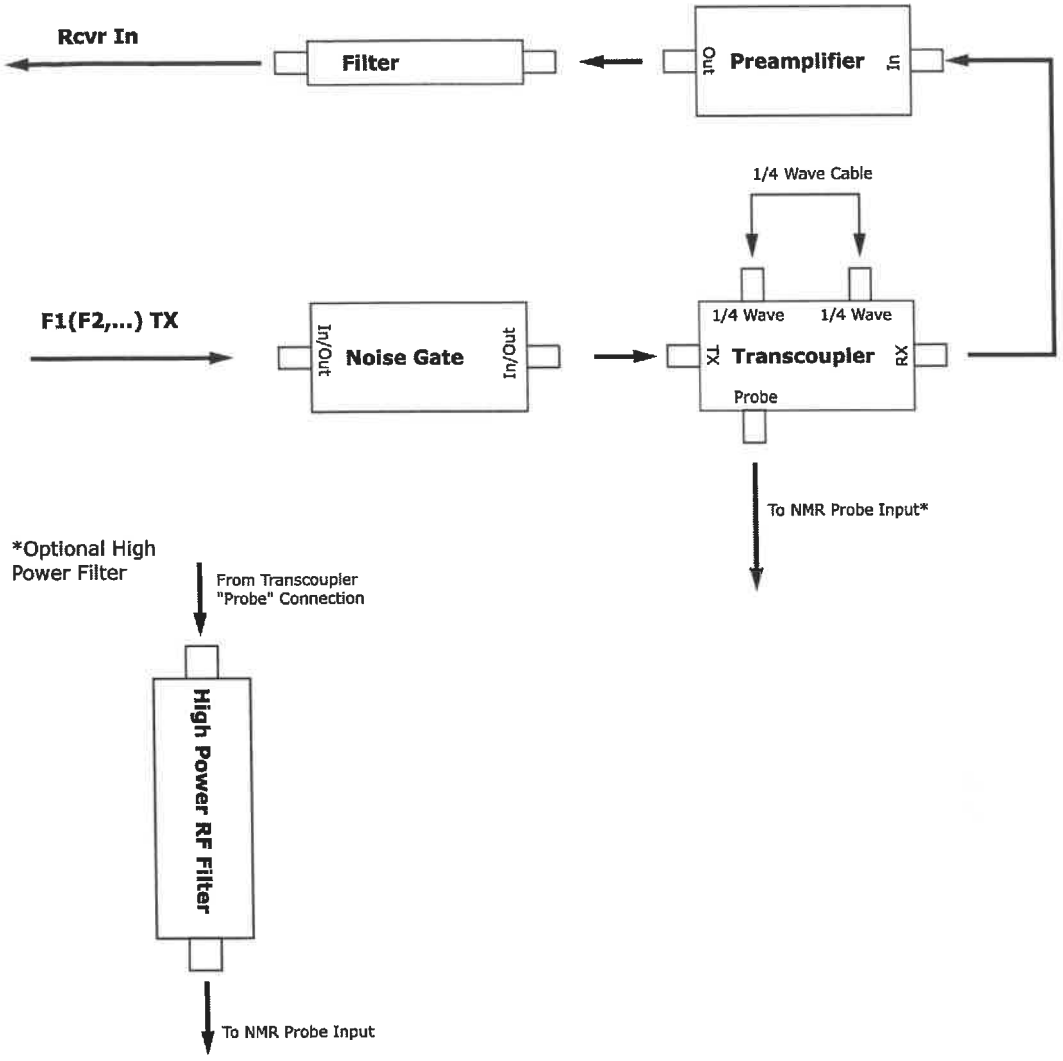
total 12 terms). Each group has an associated title text (Atext, Btext, and Ctext) which can be changed to suit the user. The shim terms are listed underneath. For example, in the sample, the first window in the second row on the left (Group B) is defined as "Z0". The shim terms are arbitrary text strings, so users can use either the Cartesian or Legendre notations, or anything else that suits. However, the terms must be named consistently between the three sections of the file!

The third section, [Coils], defines the relationship between the Console Window values and the DACs. Normally, there is a one-to-one correspondance between a shim term and a DAC (e.g. Z(X2-Y2) is assigned to coil C16 in the example). However, linear combinations of coils may also be defined for a single term (matrix shims). Contact the factory for details on this option. In this section, any term defined using special characters should be enclosed in square brackets ("[ ]"). (For example Z(X2-Y2).)

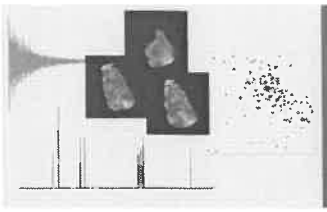
To modify the default.shm file follow these steps:

1. Open the file C:\NTNMR\shims\Default.shm using Windows **Notepad**.
2. Edit the file as necessary to match your shim power supply configuration.
3. Save the modified file with the same name.
4. Start NTNMR
5. Open the Console Window.
6. Click the **Shim** tab.
7. Verify the correct layout of the shim terms. Change one or more terms and observe the corresponding change in shim power supply output.

Apollo Installation – Transcoupler Diagram



Note: ¼ wave cables are frequency/nuclei specific (± 20%). If provided by Tecmag ¼ wave cables will be labeled by nuclei (i.e. 1H, 13C, etc.) and/or by frequency. Depending on system configuration, some items might not be provided.

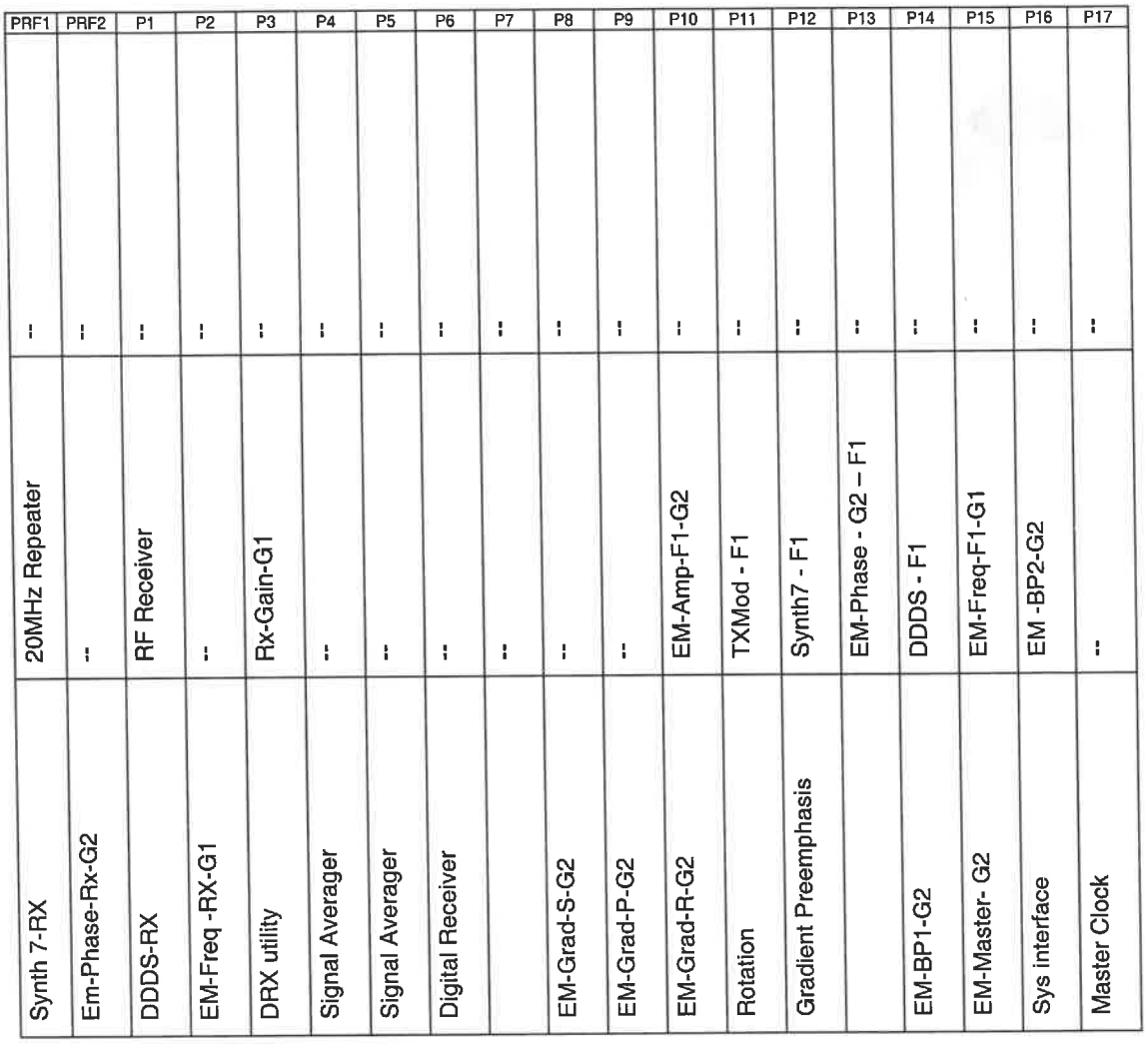


System Information

The table below lists configuration information about the system which may be system specific. This table should be used as a reference when reviewing system specifications and capabilities found in the "Hardware Reference Manual". *Consult the "Hardware Reference Manual" for all system specifications.*

General	
System	Apollo HF, 1 RF Channel, MRI
Ship Date	9/27/02
Hardware	
F1 Channel	
Freq Range	0.55 - 450 MHz
Phase Mod Type	G2
Amplitude Mod Type	G2
Freq Control Type	G1
F2 Channel	
Freq Range	N/A
Phase Mod Type	N/A
Amplitude Mod Type	N/A
Freq Control Type	N/A
Gradients	
Gradient Type	G2
Rotation Option	Yes

Chassis Layout Diagram



PRF1	PRF2	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12	P13	P14	P15	P16	P17
--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Synth 7-RX	20MHz Repeater																	
Em-Phase-Rx-G2	--																	
DDDS-RX	RF Receiver																	
EM-Freq -RX-G1	--																	
DRX utility	Rx-Gain-G1																	
Signal Averager	--																	
Signal Averager	--																	
Digital Receiver	--																	
	--																	
EM-Grad-S-G2	--																	
EM-Grad-P-G2	--																	
EM-Grad-R-G2	EM-Amp-F1-G2																	
Rotation	TXMod - F1																	
Gradient Preemphasis	Synth7 - F1																	
	EM-Phase - G2 – F1																	
EM-BP1-G2	DDDS - F1																	
EM-Master- G2	EM-Freq-F1-G1																	
Sys interface	EM -BP2-G2																	
Master Clock	--																	

Connector Label = BP1 *TTL output lines			
DB-25pin	**Signal**		**Assigned/Available to User***
1	LP00		N/A (RX_PhRst)
2	LP02		N/A (RX_DDDS_Ph_90)
3	LP04		
4	LP06		
5	LP08		
6	LP10		
7	LP12		
8	LP14		N/A (DRX_Trig_2)
9	LP16		N/A (DDDS_Trig)
10	LP18		
11	LP20		
12	LP22		
13	GND		Chassis ground
14	LP01		
15	LP03		N/A (RX_DDDS_Ph_180)
16	LP05		N/A (RX_LO)
17	LP07		
18	LP09		
19	LP11		
20	LP13		
21	LP15		N/A (DRX_Trig_1)
22	LP17		N/A (EM_Freq_RX)
23	LP19		Scope_Trig
24	LP21		
25	LP23		

*Leave blank if available
*Enter config.con name if assigned (i.e. F1_UnBlank, etc.)
*Enter N/A if unavailable

Connector Label = BP2 *TTL output lines			
DB-25pin	**Signal**		**Assigned/Available to User***
1	LP00		N/A (F1_PhRst)
2	LP02		
3	LP04		N/A (F1_Ph_90)
4	LP06		
5	LP08		
6	LP10		
7	LP12		N/A (F2_Ph_180)
8	LP14		
9	LP16		N/A (DDDS1_Trig)
10	LP18		
11	LP20		N/A (EM_Ph2_Trig)
12	LP22		N/A (EM_Ampl2_Trig)
13	GND		
14	LP01		N/A (Rcvr 1 Blank)
15	LP03		
16	LP05		N/A (F1_Ph_180)
17	LP07		N/A (F2_PhRst)
18	LP09		F2_UnBlank
19	LP11		N/A (F2_Ph_90)
20	LP13		F1_UnBlank
21	LP15		N/A (EM_Ph1_Trig)
22	LP17		N/A (EM_Ampl1_Trig)
23	LP19		
24	LP21		N/A (DDDS2_Trig)
25	LP23		

*Leave blank if available
*Enter config.con name if assigned (i.e. F1_UnBlank, etc.)
*Enter N/A if unavailable

Reference Manuals Errata

General Notes

Several new feature have recently been added to the Apollo system. In general the documentation is still correct, except that some new features are not yet fully documented. We are working hard on this and will send updated documentation as a soon as possible. Please note that there are additional read me files located in the 'man' directory that you should review.

Hardware Reference Manual – ch 2 – p 17-19. (6 places)

the Gp lines are assigned to the hardware 'Y' channel, the Gp lines are assigned to the hardware 'Y' channel

should read

the Gp lines are assigned to the hardware 'Y' channel, and the Gs lines are assigned to the hardware 'Z' channel

NTNMR Reference Manual – ch 8 – p 142.

This is the default mode for S.A. Dimension = 1.

should read

This is the default mode for S.A. Dimension = 0.

NTNMR Reference Manual – ch 9 – p 196 and following.

objectname.SetData *array*

should read

objectname.SetData *numPoints*, *array*

Example:
Data.SetData myArray

should read

Example:
Data.SetData 512, myArray

Also note that the parameter *numPoints* is the total number of points to be passed, not the number of complex points.

NTNMR Reference Manual – ch 9 – p 158 and following.

SetData	yes	array	variant (array)	-

should read

SetData	yes	numPoints, array	long, variant (array)	-

Also note that the parameter *numPoints* is the total number of points to be passed, not the number of complex points.

Remote Control Setup

Introduction

Using a third party software package called VNC (Virtual Network Computing) your system can be controlled remotely by other computers all over the world. Computer platforms supported for remote control clients are Windows, Linux, Macintosh, and various versions of UNIX. Tecmag is not the author of this software package and Tecmag does not assume any responsibility for the VNC software or any potential problems associated with its use. If you would like more information regarding the VNC software please see the VNC homepage at http://www.uk.research.att.com/vnc/.

You must perform the following steps to setup the computer for remote control.

- Assign a static IP address to the computer
- Connect the computer to the network with a permanent connection
- Install and activate the VNC software (see below)

> *Tecmag will never connect to the spectrometer computer without prior consent and arrangement by an authorized end-user of the system. The VNC software provides password protection and the end-user has full control and responsibility of the remote control software, including password assignment and allowing/disallowing connections.*

Basic Installation and Setup

Tecmag does not pre-install VNC; the end user must install the software on the spectrometer control computer. The latest release of the VNC software package for Windows and other platforms is included on the NTNMR CD in the "VNC" directory.

1. Insert the NTNMR CD and navigate to the VNC/Windows directory and double-click on "setup.exe" to run the VNC installer.

> *You must have a permanent TCP/IP network connection (not a dial-up connection) and a static IP address to use VNC.*

2. Point to the Start menu and locate the VNC program group (located under 'Programs). Select Run WinVNC (App Mode) to start the WinVNC server.

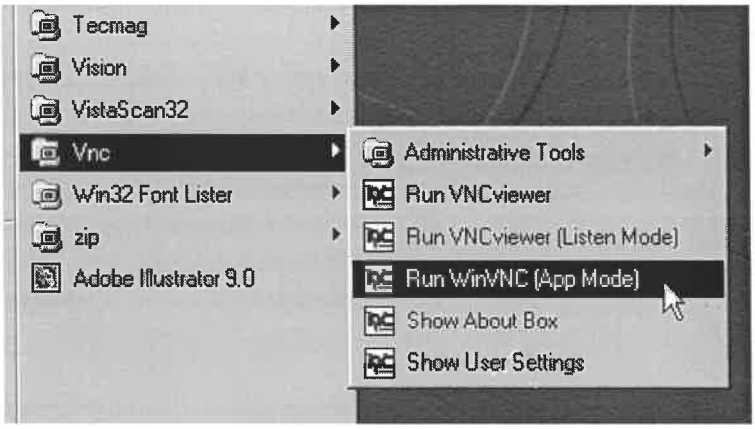


Figure 1 – VNC Program Group Menu

3. The first time the VNC server software is run the WinVNC properties panel should appear. (If the properties panel does not appear see "Opening the Properties Panel" below).

4. Setup the following items as shown below in Figure 2:

   - Check "Accept Socket Connections"
   - Check "Auto" next to Display number
   - Assign a password

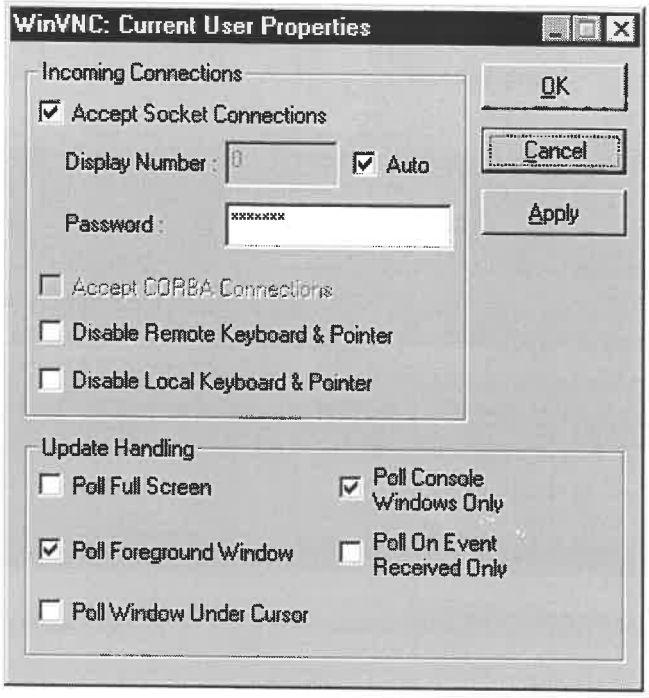


Figure 2 – The VNC Properties Window

5. Click OK to save the settings. VNC is now ready to accept connections from the Internet. Note that a user assigned password is required to connect the computer. This password is not the same as the Windows password.

Opening the Properties Panel

If the VNC properties panel does not open the first time the VNC server is started (as described above in Basic Installation and Setup) or if you need to change the properties later right click on the VNC icon in the Taskbar and select "Properties".

If the VNC icon is not visible in the Taskbar this indicates that the VNC server is not running. VNC will not allow connections to the computer unless the VNC server is running.

Figure 3 – VNC Icon in taskbar

Figure 4 – VNC right-click menu

Closing VNC

Normally the VNC server is run as an application (as described above). Connection are only allowed when the VNC server application is running as indicated by the presence of the VNC icon in the taskbar.

To close VNC right-click on the VNC icon in the taskbar and select Close VNC from the right click menu (Figure 4).

Frequently Asked Questions

Which TCP/IP port does the VNC server use?
A VNC server listens on two ports. The exact port numbers depend on the VNC display number, because a single machine may run multiple servers. The most important one is 59xx, where xx is the display number. The VNC protocol itself runs over this port. So for most PC servers, the port will be 5900, because they use display 0 by default.

My University/Institution/Company has a firewall, what can I do?
In many cases your IT department will be able to create a very restricted hole in the firewall that you can use to allow connections. Contact your IT department for more information.

We use a DHCP server to dynamically assign IP addresses. Will this cause VNC to fail?
VNC uses the IP address assigned to the machine running the server. As long as you have some method for determining the IP address currently in use by the computer running VNC, there should not be any problems. Your IT department should be able to help you determine the current IP address.

Where can I find more information about VNC?
The VNC documentation is installed on the NTNMR CD in the VNC directory along with the VNC programs for various computer platforms. You can also connect to http://www.uk.research.att.com/vnc/ for more information

dBm - Voltage Chart

dBm	mV (p-p)	mWatts	dBm	V (p-p)	mWatts	dBm	V (p-p)	Watts
-30	20.0	0.0010	0	0.632	1.00	30	20.0	1.00
-29	22.4	0.0013	1	0.710	1.26	31	22.4	1.26
-28	25.2	0.0016	2	0.796	1.58	32	25.2	1.58
-27	28.3	0.0020	3	0.893	2.00	33	28.3	2.00
-26	31.7	0.0025	4	1.00	2.51	34	31.7	2.51
-25	25.6	0.0032	5	1.12	3.16	35	35.6	3.16
-24	29.9	0.0040	6	1.26	3.98	36	39.9	3.98
-23	44.8	0.0050	7	1.42	5.01	37	44.8	5.01
-22	50.2	0.0063	8	1.59	6.31	38	50.2	6.31
-21	56.4	0.0079	9	1.78	7.94	39	56.4	7.94
-20	63.2	0.0100	10	2.00	10	40	63.2	10.00
-19	71.0	0.0126	11	2.24	12.6	41	71.0	12.59
-18	79.6	0.0158	12	2.52	15.8	42	79.6	15.85
-17	89.3	0.0200	13	2.83	20.0	43	89.3	19.95
-16	100	0.0251	14	3.17	25.1	44	100	25.12
-15	112	0.0316	15	3.56	31.6	45	112	31.62
-14	126	0.0398	16	3.99	39.8	46	126	39.81
-13	142	0.0501	17	4.48	50.1	47	142	50.12
-12	159	0.0631	18	5.02	63.1	48	159	63.10
-11	178	0.0794	19	5.64	79.4	49	178	79.43
-10	200	0.100	20	6.32	100	50	200	100.0
-9	224	0.126	21	7.10	126	51	224	125.9
-8	252	0.158	22	7.96	158	52	252	158.5
-7	283	0.200	23	8.93	200	53	283	199.5
-6	317	0.251	24	10.02	25.1	54	317	251.2
-5	356	0.316	25	11.25	316	55	356	316.2
-4	399	0.398	26	12.62	398	56	399	398.1
-3	448	0.501	27	14.16	501	57	448	501.2
-2	502	0.631	28	15.89	631	58	502	631.0
-1	564	0.794	29	17.83	794	59	564	794.3
0	632	1.00	30	20.00	1000	60	632	1000
1	710	1.26	31	22.44	1259	61	710	1259
2	796	1.58	32	25.18	1585	62	796	1585
3	893	2.00	33	28.25	1995	63	893	1995

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tecmag
TECHNOLOGY FOR MAGNETIC RESONANCE

Paul. → Earl.

→ Config Folder

→ default.txt under \setup\dashboard\

→ shims folder

AC power cable.

dBm - volts - watts conversion

(50-ohm system)

dBm	V	P_o	dBm	V	P_o	dBm	mV	P_o	dBm	µV	P_o
+53	100.0	200W	0	.225	1.0 mW	-49	0.80		-98	2.9	
+50	70.7	100W	-1	.200	.80 mW	-50	0.71	.01 µW	-99	2.51	
+49	64.0	80W	-2	.180	.64 mW	-51	0.64		-100	2.25	.1 pW
+48	58.0	64W	-3	.160	.50 mW	-52	0.57		-101	2.0	
+47	50.0	50W	-4	.141	.40 mW	-53	0.50		-102	1.8	
+46	44.5	40W	-5	.125	.32 mW	-54	0.45		-103	1.6	
+45	40.0	32W	-6	.115	.25 mW	-55	0.40		-104	1.41	
+44	32.5	25W	-7	.100	.20 mW	-56	0.351		-105	1.27	
+43	32.0	20W	-8	.090	.16 mW	-57	0.32		-106	1.18	
+42	28.0	16W	-9	.080	.125 mW	-58	0.286				
+41	26.2	12.5W	-10	.071	.10 mW	-59	0.251		dBm	nV	
+40	22.5	10W	-11	.064		-60	0.225	.001 µW	-107	1000	
+39	20.0	8W	-12	.058		-61	0.200		-108	900	
+38	18.0	6.4W	-13	.050		-62	0.180		-109	800	
+37	16.0	5W	-14	.045		-63	0.160		-110	710	.01 pW
+36	14.1	4W	-13	.050		-64	0.141		-109	640	
+35	12.5	3.2W	-16	.0355					-112	580	
+34	11.5	2.5W				dBm	µV		-113	500	
+33	10.0	2W	dBm	mV		-65	128		-114	450	
+32	9.0	1.6W	-17	31.5		-66	115		-115	400	
+31	8.0	1.25W	-18	28.5		-67	100		-116	355	
+30	7.10	1.0W	-19	25.1		-68	90		-117	825	
+29	6.40	800 mW	-20	22.5	.01 mW	-69	80		-118	285	
+28	5.80	640 mW	-21	20.0		-70	71	.1nW	-119	251	
+27	5.00	500 mW	-22	17.9		-71	65		-120	225	.001 pW
+26	4.45	400 mW	-23	15.9		-72	58		-121	200	
+25	4.00	320 mW	-24	14.1		-73	50		-122	180	
+24	3.55	250 mW	-25	12.8		-74	45		-123	160	
+23	3.20	200 mW	-26	11.5		-75	40		-124	141	
+22	2.80	160 mW	-27	10.0		-76	35		-125	128	
+21	2.52	125 mW	-28	8.9		-77	32		-126	117	
+20	2.25	100 mW	-29	8.0		-78	29		-127	100	
+19	2.00	80 mW	-30	7.1	.001mW	-79	25		-128	90	
+18	1.80	64 mW	-31	6.25		-80	22.5	.01 nW	-129	80	.1fW
+17	1.60	50 mW	-32	5.8		-81	20.0		-130	71	
+16	1.41	40 mW	-33	5.0		-82	18.0		-131	61	
+15	1.25	32 mW	-34	4.5		-83	16.0		-132	58	
+14	1.15	25 mW	-35	4.0		-84	11.1		-133	50	
+13	1.00	20 mW	-36	3.5		-85	12.9		-134	45	
+12	.90	16 mW	-37	3.2		-86	11.5		-135	40	
+11	.80	12.5 mW	-38	2.85		-87	10.0		-136	35	
+10	.71	10 mW	-39	2.5		-88	9.0		-137	33	
+9	.64	8 mW	-40	2.25	.1µW	-89	8.0		-138	29	
+8	.58	6.4 mW	-41	2.0		-90	7.1	.001 nW	-139	25	
+7	.500	5 mW	-42	1.8		-91	6.1		-140	23	.01fW
+6	.445	4 mW	-43	1.6		-92	5.75				
+5	.400	3.2 mW	-44	1.4		-93	5.0				
+4	.355	2.5 mW	-45	1.25		-94	4.5				
+3	.320	2.0 mW	-46	1.18		-95	4.0				
+2	.280	1.6 mW	-47	1.00		-96	3.51				
+1	.252	1.25 mW	-48	0.90		-97	3.2				

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