USER'S MANUAL

MODEL: LVMCTRL-

LABVIEW MAGNET CONTROL

LabVIEW Driver V2.0

For LabVIEW Ver 8.2 [or later version]

Date Sold:_____

Serial number: _____

File No: MLVMCTRL GMW Magnet Control Software manual v2.0.doc Revision Date: Jan 11, 2008

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Section 1
MAGNET CONTROL SYSTEM SPECIFICATIONS

Magnet Control System Overview

The Magnet Control System is a special application driver written for using with LabVIEW for Windows version 8.2 or later. This driver provides the user with a GUI [Graphical User Interface] between LabVIEW and the Magnet Control System hardware. It enables operator control of up to two magnet systems comprising Electromagnet, Teslameter and Power Supply in four control modes:

- Open Loop Current Control mode.
- Open Loop Field Control mode.
- Closed Loop Field Control Simple mode.
- Closed Loop Field Control Hybrid mode.

It also supports magnet system without Teslameter in Open Loop Current Control mode or Open Loop Field control mode.

Magnet Control System Basic Requirements

A magnetic field meter from one of the following supported model [Note 1].

- Group3 DTM model: DTM-132/133-DG or DTM-141/151-DG.
- Senis Magnetic Field Transducer YM/3M [Note 2]
- MetroLab NMR 2020/2025 with GPIB

A suitable Power Supply which can be either controlled using analog signal [Note 3] or one of the following supported power supplies.

- Danfysik 853/858 power supply with GPIB interface.
- Sorensen SGA with GPIB interface
- Kepco BOP with GPIB interface
- GMW 231HC with NI DAQPad digital control option

A suitable computer system. At the time of printing this manual, suggested computer configuration:

1GB RAM, 1GB available hard drive space, Pentium 4 or equivalent CPU, 2 GHz or above.
Operating system Windows XP, SP2
One available USB 2.0 port for GPIB-USB controller if required
One available USB 2.0 port for NI DAQPad if required
A CD drive for installing software
LabVIEW for Windows version 8.2 or later. [Note4]

NI DAQPad 6015/6251.

Required only if using either Senis transducer, GMW 231HC or analog controlled power supply.
USB 2.0 interface.
Two analog output channels.
Output Range: +/-10V.
Output Resolution: 16bit.
Output impedance: 0.1 Ohm.

Table Mode.

Note:

1. Field (Closed Loop) Control mode cannot be used without a Teslameter installed on the Magnet Control System.
2. Senis Transducer is read through NI DAQ. 3M model is supported but only one field axis is read.
3. Power supply can be bipolar or unipolar. The analog programming range is -10DCV to +10DCV, 16bit resolution.
4. Both source VI and version of stand alone executable program file provided with the CD. The stand alone executable version cannot be altered by the end user. The stand alone executable version does not require LabVIEW.

Section 2
WARNINGS

REFER TO WARNINGS BELOW BEFORE OPERATING ELECTROMAGNET SYSTEM

1 Personnel Safety

If during operation the magnet fringing field is in excess of 0.5mT (5G), it can cause malfunctioning of sensitive electronic and magnetic components. We recommend that warning signs are posted in areas where the fringing field may exceed 0.5mT indicating that a magnetic field may be present.

2 Ferromagnetic Objects

During operation the magnet exerts magnetic attraction towards ferromagnetic objects in the near vicinity of its pole faces. Keep ferromagnetic items clear!

3 Arcing

Magnet stores energy in its field during operation. Do not disconnect any current lead while under load or the magnetic field energy will be discharged across the interruption causing arcing and possible damage to electronic circuits.

4 Coil Hot Resistance

Do not exceed the maximum coil hot resistance for the Electromagnet(s) given in the specifications or coil overheating and possible damage may occur

5 Watches, Credit Cards, and Magnetic Disks

Do not move magnetically sensitive items into the close vicinity of the magnet pole gap. Even some anti-magnetic watches can be damaged when placed in close proximity to the pole gaps during operation. Credit cards, and magnetic disks are affected by magnetic fields as low as 0.5mT (5G). Depending on the previous operating field and the pole gap, the remanent field in the gap can be in excess of 0.5mT (5G) with the magnet power supply off or disconnected.

6 Power off Power Supply

Switch off power supply before performing any hardware setup task around magnet or power supply. The current leads of magnet are isolated from ground. There is an electrical potential difference between the current leads and ground, even when the output current is zero. It could be a safety hazard for personnel or instruments if accidentally contacted to the current leads.

Section 3
MAGNET CONTROL SYSTEM SETUP

3.1 Hardware.

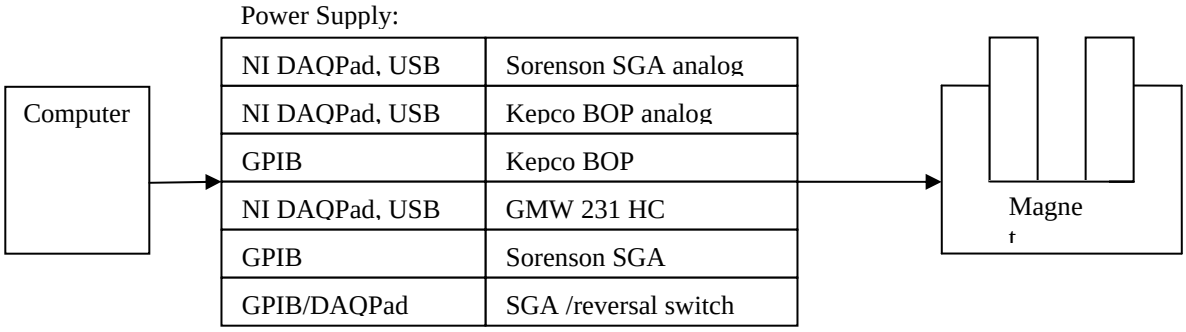
The Magnet Control System software can be used with different combination of supported field meter and power supply. Some typical combinations of field meter and power supply are listed as below.

-Supported field meter:
Group3 DTM 133/151 with GPIB interface.
Senis magnetic field transducer 0.2T/1T/2T/5T with analog output, must be used with NI DAQPad, USB 2.0 interface
MetroLab NMR teslameter 2025, GPIB interface.

-Supported power supply:
GMW 231HC, with NI DAQPad, USB 2.0 interface.
DANFYSIK 853/858, GPIB/RS232 interface.
Kepco BOP, GPIB interface.
Sorensen SGA GPIB interface
Sorensen SGA analog with NI DAQPad
Sorensen SGA analog with GMW Reversal switch, GPIB interface with ADI, USB 2.0 interface with new version of GMW Reversal Switch.
Custom power supply with analog programming +/-10V.

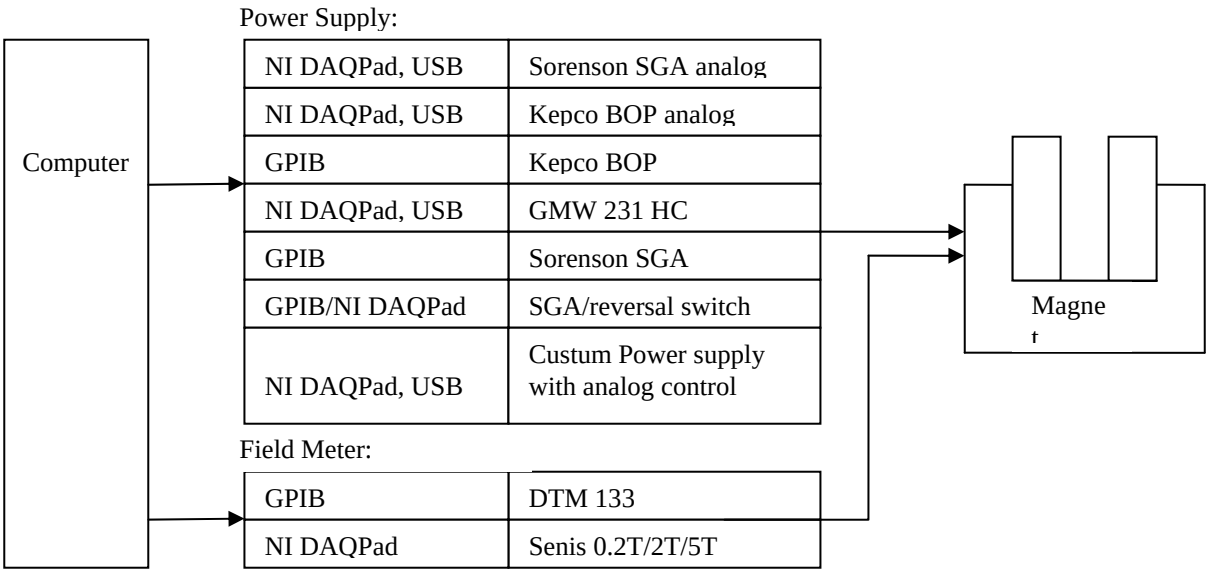
Computer interface:
USB 2.0 port.
GPIB: NI PCI GPIB board
NI USB to GPIB controller, using one USB 2.0 port.
RS232: USB to RS232 converter.

-Typical system configurations:



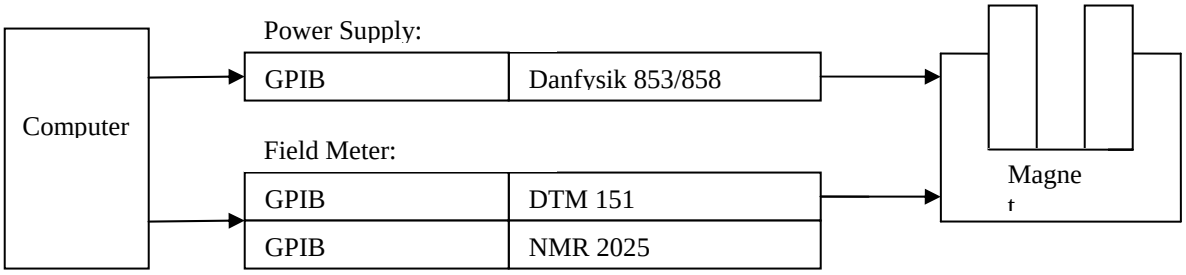
System setup 1

Without a field meter, this setup can be used for Open Loop Current and Open Loop Field control mode. Low cost and fast response.



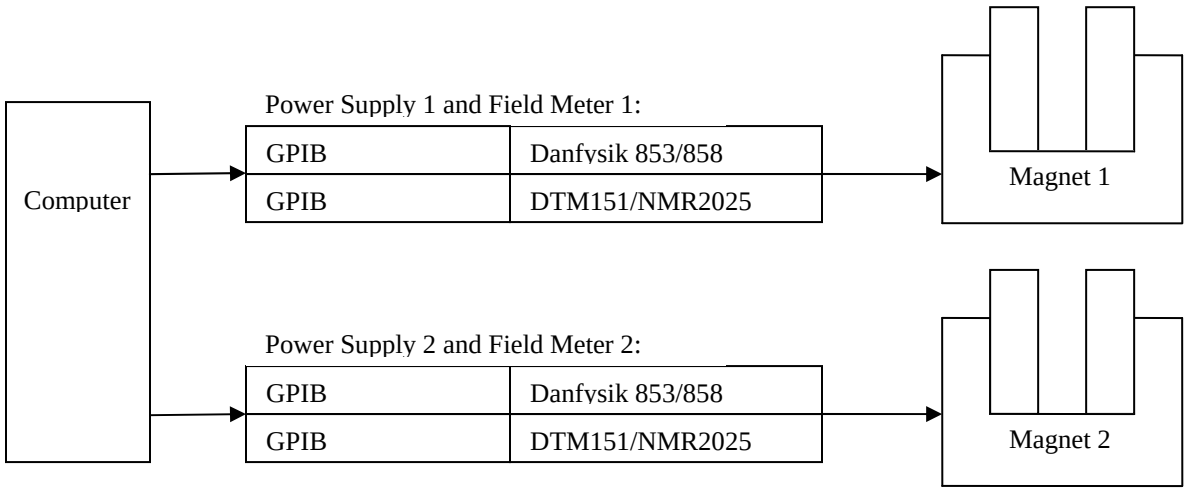
System setup 2

Basic setup used for Closed Loop Control. Low cost, low resolution and can be fast response.



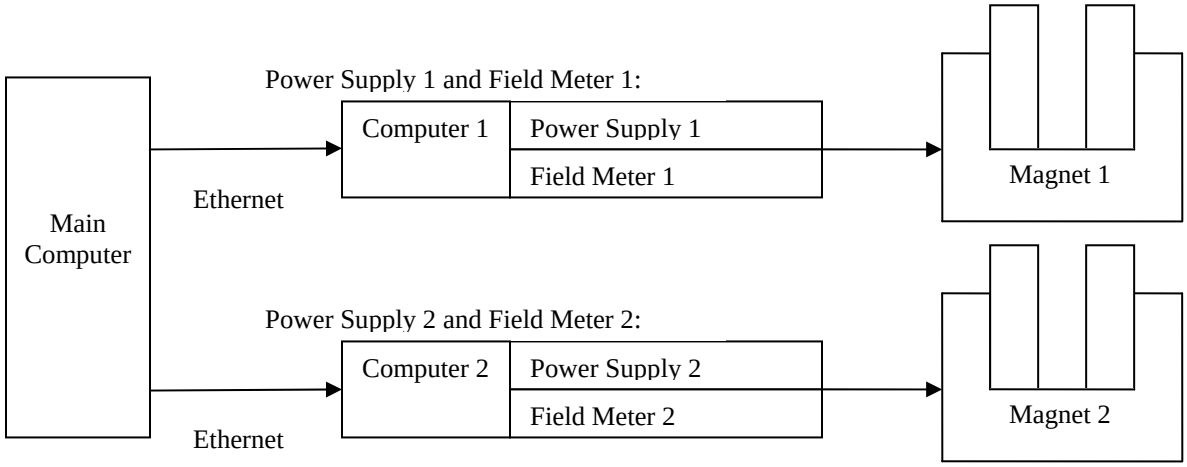
System setup 3

Closed Loop Control setup used for high field stability. Slow response and high resolution.



System setup 4

Two systems control are supported for low speed system setup. Analog control (using NI DAQ) is not supported for two channel control.



System setup 5

3.2 Field meter setup

3.2.1 Digital Teslameter [DTM -151/132/133-DG] setup

1. Power down the Digital Teslameter.
2. Remove the bottom cover by undoing the cover securing screw in the center of the cover.
3. The DIP switches located under the bottom cover must be set as detailed in the following table.
4. Replace the bottom cover.
5. Connect the GPIB cable to the GPIB connector located on the rear panel of the Digital Teslameter.
6. Connect the GPIB cable to the GPIB interface board installed in the computer.
7. Connect the Hall Probe.
8. Power up the Digital Teslameter.

Digital Teslameter

DIP Switch Settings

SW 1-1 OFF	GPIB address	(Note 1)
SW 1-2 ON	GPIB address	
SW 1-3 OFF	GPIB address	
SW 1-4 OFF	GPIB address	

Section 3

SW 1-5 OFF	GPIB address
SW 1-6 OFF	dual primary addressing disabled
SW 1-7 OFF	talker/listener
SW 1-8 OFF	not used
SW 2-1 ON	serviced requests enabled
SW 2-2 ON	EOI asserted
SW 2-3 ON	terminator carriage return
SW 2-4 OFF	double terminator disabled
SW 2-5 OFF	field units tesla
SW 2-6 OFF	no units symbol
SW 2-7 ON	digital filtering ON
SW 2-8 OFF	defaults no action

Note 1: Each DTM requires an unique GPIB address.

3.2.2 MetroLAB NMR 2025 setup

1. Power down the Digital Teslameter.
2. Set Micro-switch on the rear panel.
   1 to 5: GPIB address.
   6: Set to 0
   7: Set to 0. Listener/Talker mode
   8: Set to 1. Send <CR><LF> to terminate messages
   9: Set to 1. select GPIB (IEE 488) interface.
3. Connect all the cables.

3.3 Power Supply Setup

Below are brief descriptions for setting up powe supply for computer control. For details of how to setup either power supply, please refer to power supply documentation.

3.3.1 GMW 231HC

GMW 231HC has two versions of control. External Analog Control uses a customer provided programming source, such as a Waveform Function Genarator. Internal Analog Control uses a NI DAQ as programming source.

- Ensure the power switch is OFF
- Switch the Control Mode toggle Switch on the back of the GMW 231HC to Internal.
- Connect USB cable from NI DAQPad to computer USB port
- Install all software before power up the DAQPad.

3.3.2 Kepco

- Ensure the power switch is OFF
- Ensure the GPIB Interface board model setup matches power supply model. All new Kepco GPIB boards are set to 200V, 5A model. User needs to change the model on the GPIB board either using a DIP switch (model BIT4882F) or through computer (model BIT4886).
- Set the GPIB address. GMW Control Software uses 1 as default GPIB address. Power supply shipped from GMW will all set GPIB address to 1. If GPIB address needs to be changed, refer to the power supply user manual. Each instrument on the same GPIB bus must have a unique GPIB address.
- Ensure the AC line voltage is correct.
- Connect the currnt cable to magnet. Connect AC cord to power supply.
- Set Kepco power supply front control: Mode to Current, Voltage Control to OFF, Current Control to OFF.

3.3.3 Sorenson

- Ensure the power switch is OFF
- Set the rear panel switch S1-1 to ON to set the unit to remote mode.
- Set the rear panel switch S1-2 to OFF to set the power supply to no SRQ upon power-on.
- Set the rear panel switch S1-3 to ON to set the power supply to be the master device.
- Set the GPIB address. The rear panel switch S1-4 to S1-8 is GPIB address. Power supply shipped from GMW will all set GPIB address to 1. If GPIB address needs to be changed, refer to the power supply user manual. Each instrument on the same GPIB bus must have a unique GPIB address.
- Ensure the AC line voltage is correct.
- Connect the currnt cable to magnet. Connect AC cord to power supply.

3.3.4 Danfysik

- Ensure the power switch is OFF
- Set the GPIB address. If using NI GPIB-232CV-A, the following needs to be check/set.

1. Danfysik power supply main control board:
    - Remote Line needs to be set to RS232: Jumper on ST9. ST10 and ST11 must be left open without jumper.
    - Remote Line communication parameters are as Danfysik power supply defult: 9600 BAUD, No Parity, 8 Data bit, 1 Stop bit.
2. Cable between main control board and GPIB-232CV-A must be null modem cable, DB25 Male/DB9 Female.
3. NI GPIB-232CV-A.
    - Mode: D
    - Config:SRQ Disabled, small serial buffer
    - GPIB address: 1
    - Hand Shake:XON/OFF disabled
    - Data formate: 8 Data bit/No Parity/1 Stop bit
    - Baud: 9600

Power supply shipped from GMW will all set GPIB address to 1. If GPIB address needs to be changed, refer to the power supply user manual. Each instrument on the same GPIB bus must have a unique GPIB address.

- Ensure the AC line voltage is correct.
- Connect the currnt cable to magnet. Connect AC cord to power supply.
- Power on the Danfysik power supply. From front panel, change the Local/Remote control to REMote.

3.4 Analog Device Interface Setup for NI DAQPad [6015]

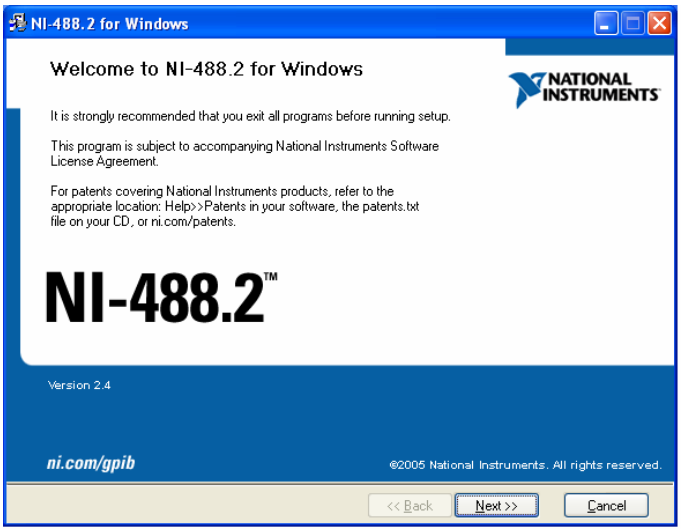
1. Ensure the power switch is OFF
2. Connect NI DAQPad analog output (BNC, male) to power supply analog control input.
3. Connect USB cable from NI DAQPad to computer USB port.
4. Install all software before power up the DAQPad.

3.5 Software Installation

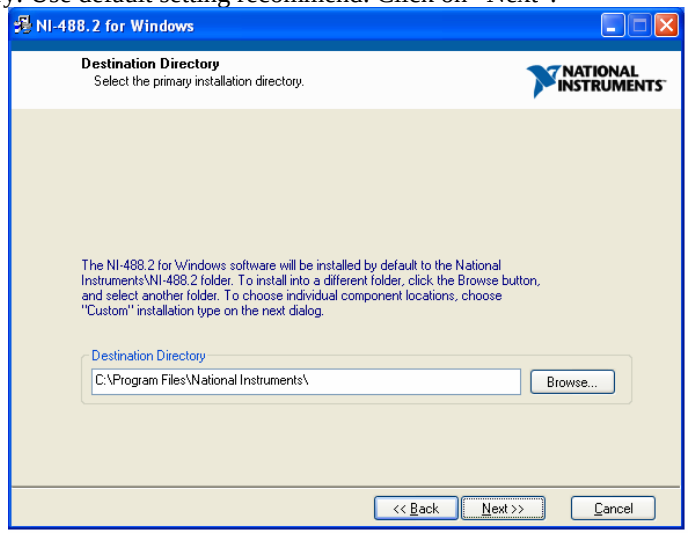
3.5.1 Install GPIB-USB driver

1. Insert NI-488.2 CD from National Instruments into CD-ROM drive.
2. Select “Install Software” from pop-up window.

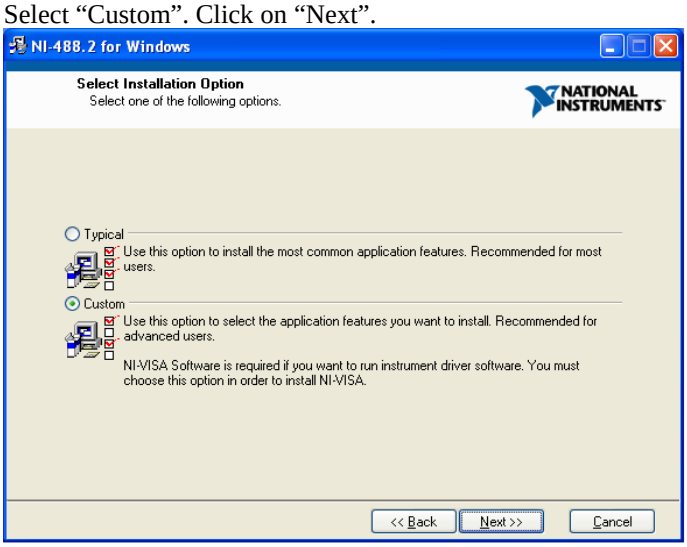
3. Click on “Next”.



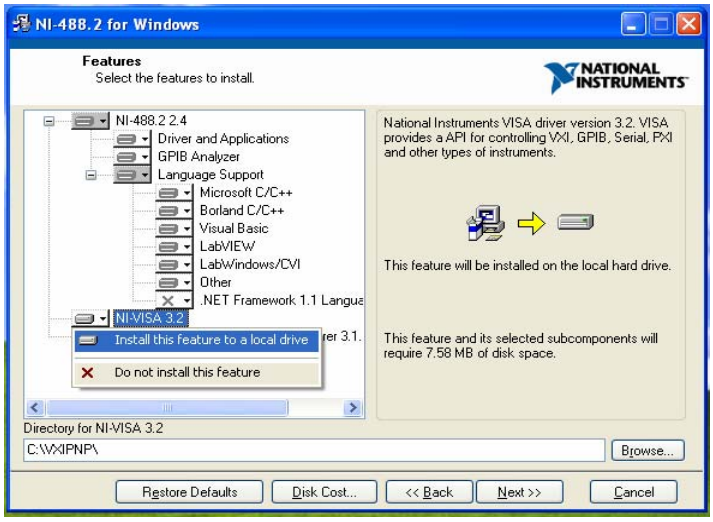
4. Select destination directory. Use default setting recommend. Click on “Next”.



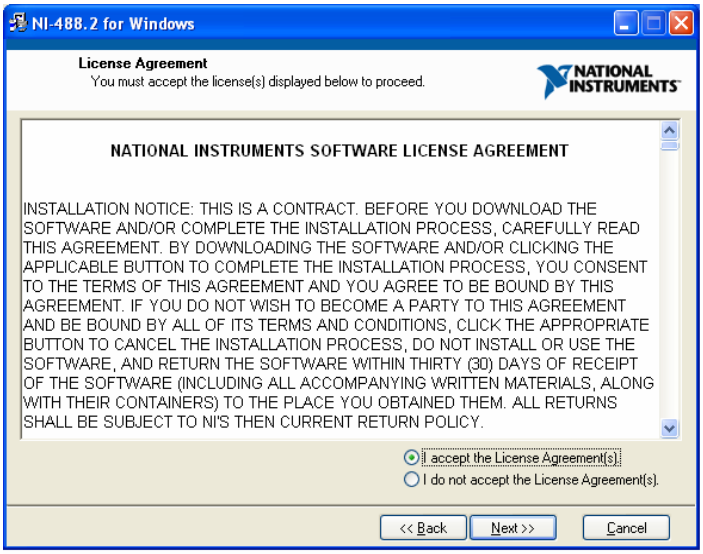
5. Select Installation option. Select “Custom”. Click on “Next”.



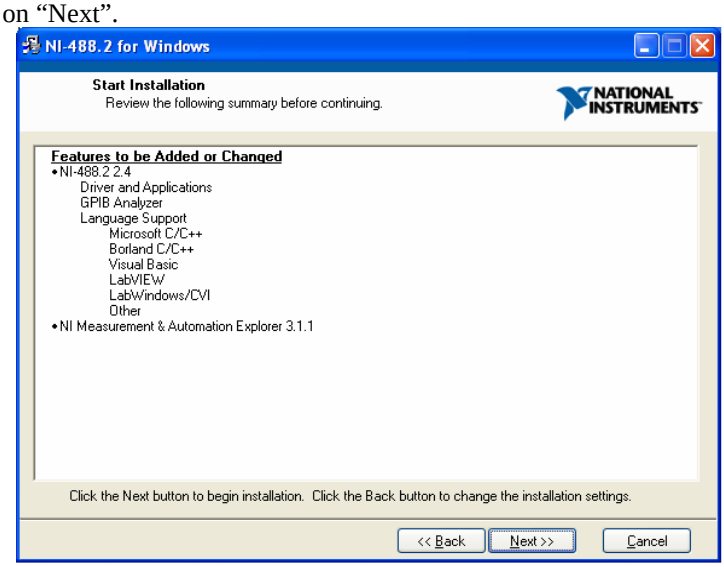
6. Select Features to install. Click on “NI-VISA 3.2”. Select “Install this feature to a local drive” from the drop-down menu. Click on “Next”.



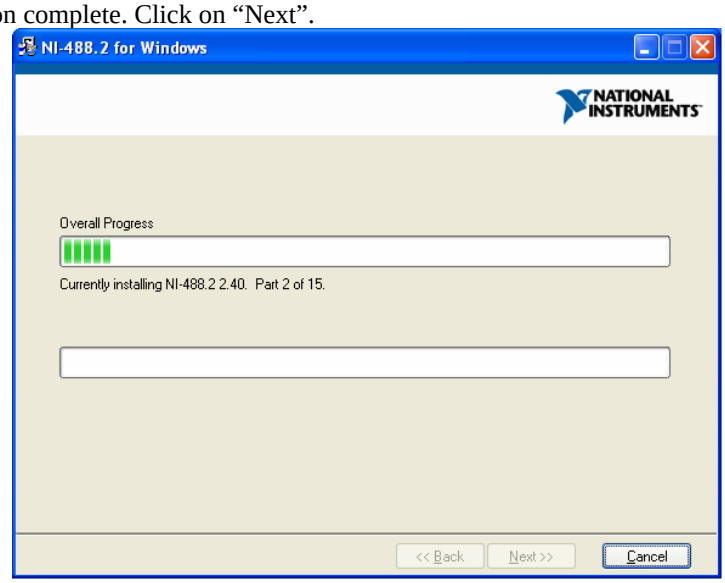
7. Accept the License Agreements. Click on “Next”.

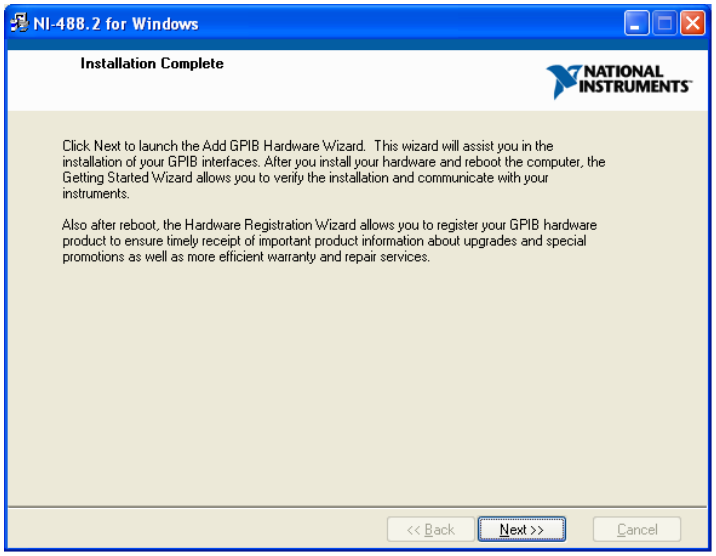


8. Start Installation. Click on “Next”.

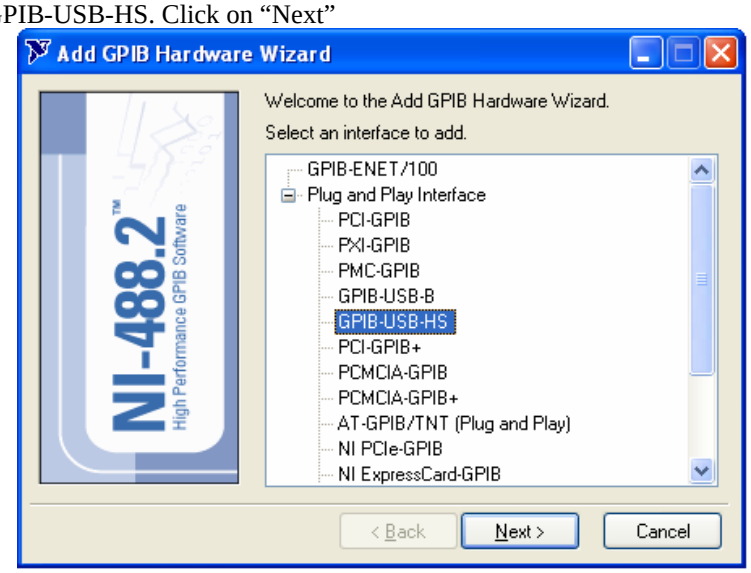


9. Wait until the installation complete. Click on “Next”.





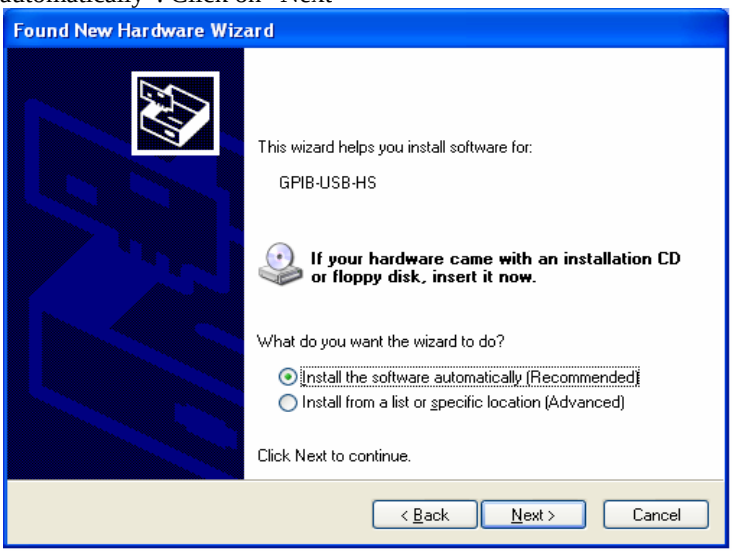
10. Select GPIB device: GPIB-USB-HS. Click on “Next”



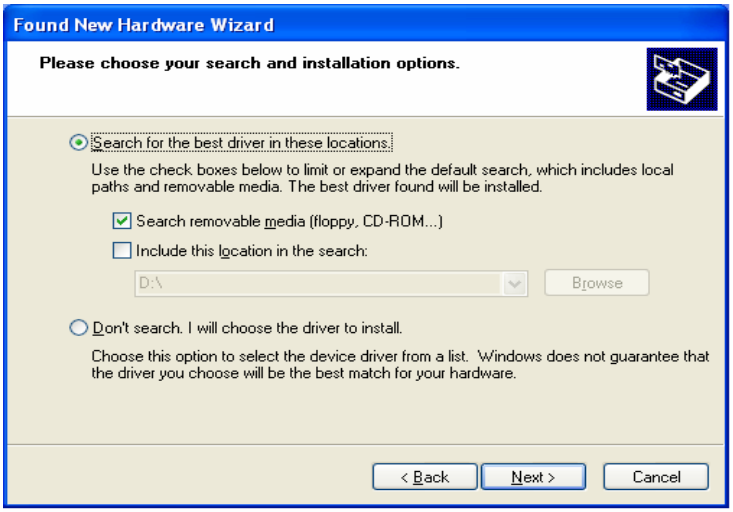
11. Select “Restart. Click on “Finish”.

12. After restart computer, connect GPIB-USB controller to computer USB port. Found New Hardware Wizard window appears. Select “No, not this time.” Click on “Next”

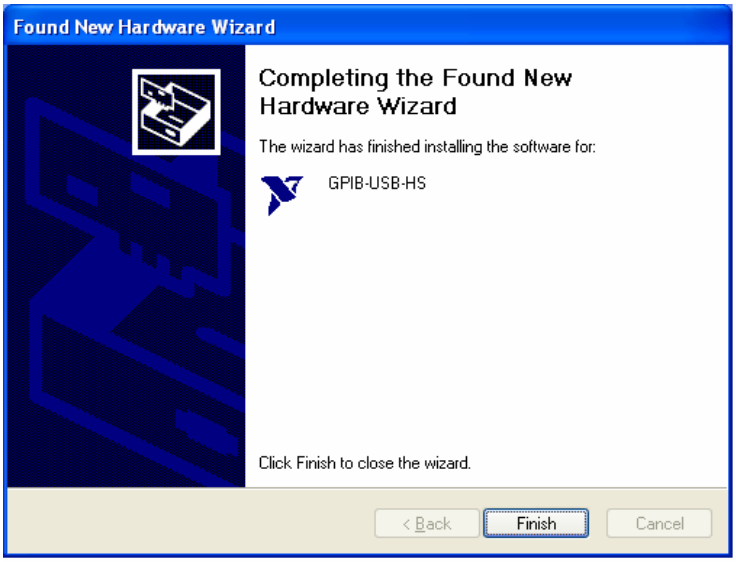
13. Select “Install software automatically”. Click on “Next”



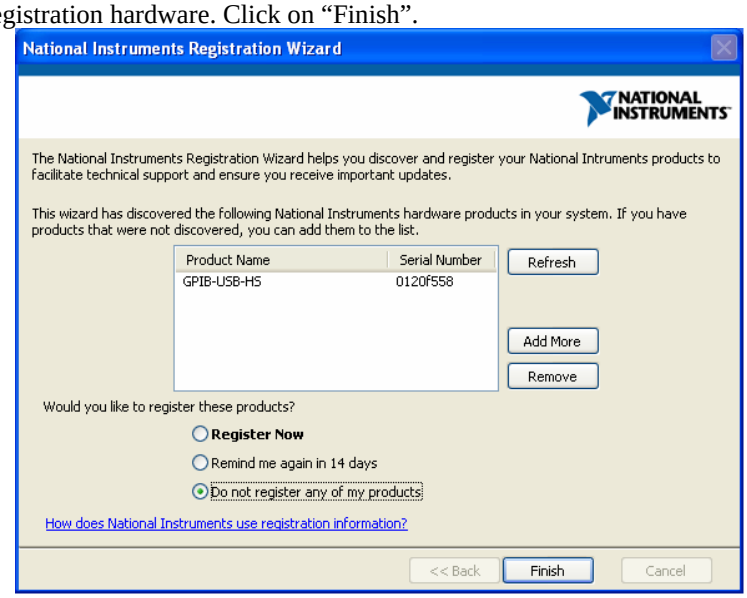
14. Select “Search for the best driver in these locations”. Click on “Next”.



15. Wait until finished. Click on “Finish”.



16. Select the option for registration hardware. Click on “Finish”.

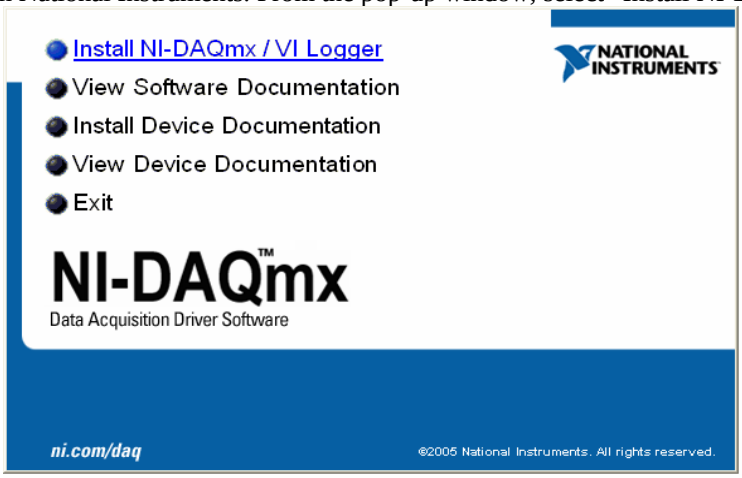


17. “NI 488.2 Getting Started Wizard” window appears. After verifying hardware and software installation, click on “Exit”.

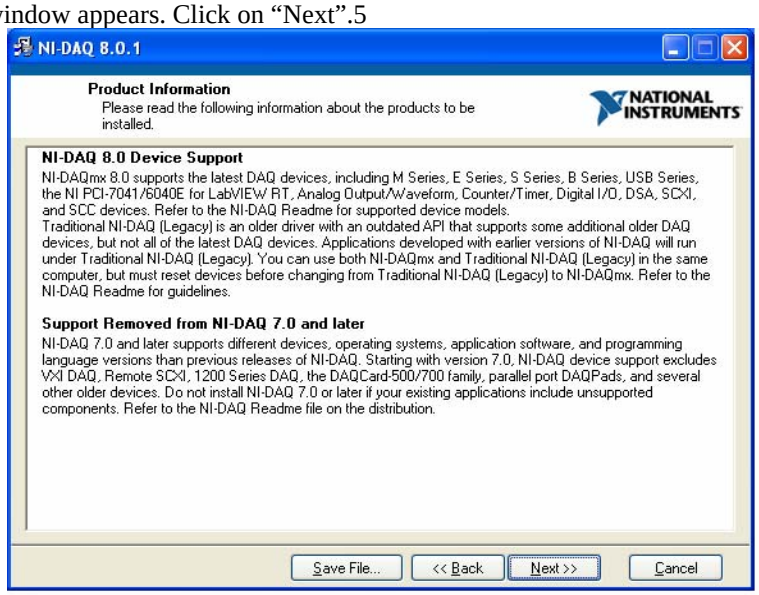
3.5.2 Install NI-DAQmx software for DAQPad.

Following steps are for NI-DAQmx 8.0.1. Actual step and screen may vary depend on version of DAQmx

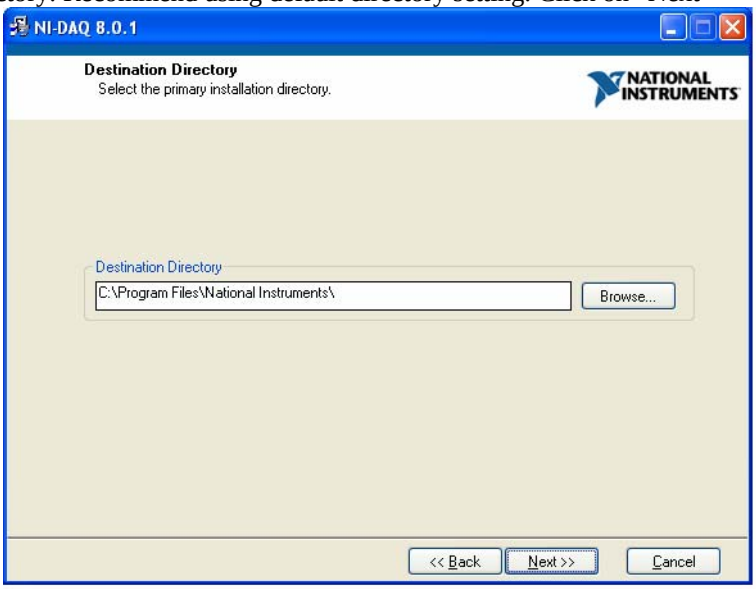
1. Insert DAQmx CD from National Instruments. From the pop-up window, select “Install NI-DAQmx/VI Logger”.



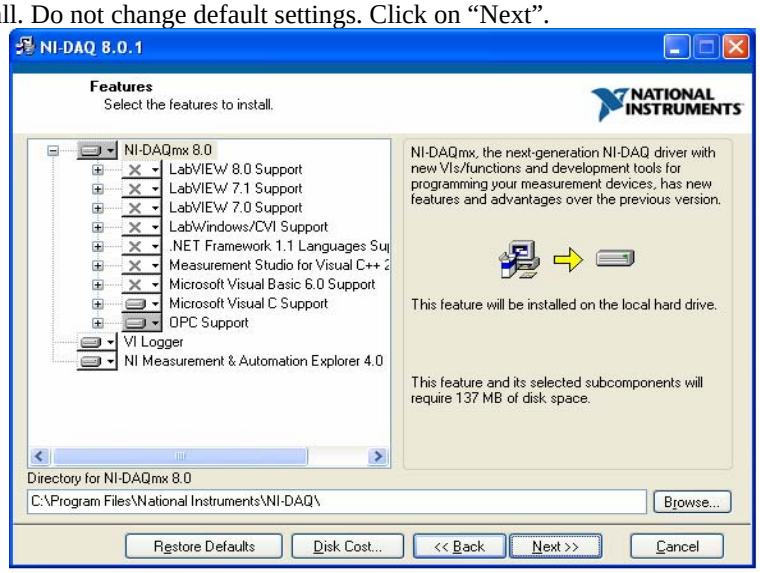
2. Product Information window appears. Click on “Next”.5



3. Select destination directory. Recommend using default directory setting. Click on “Next”

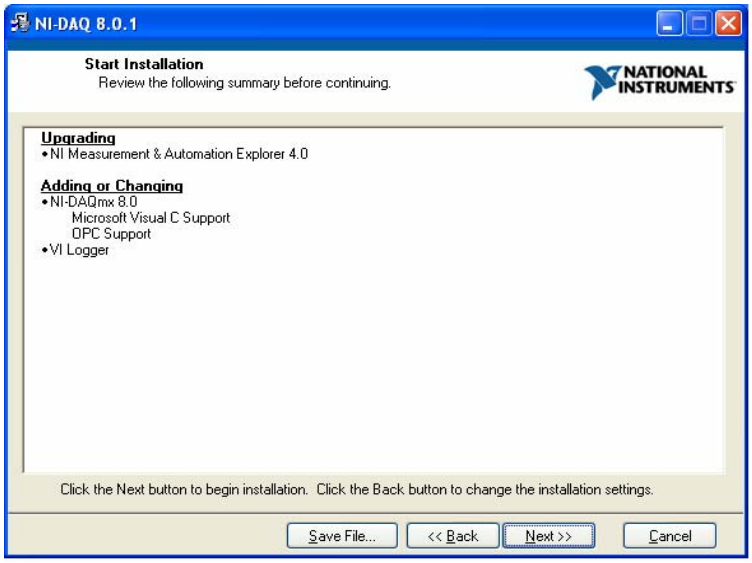


4. Select features to install. Do not change default settings. Click on “Next”.

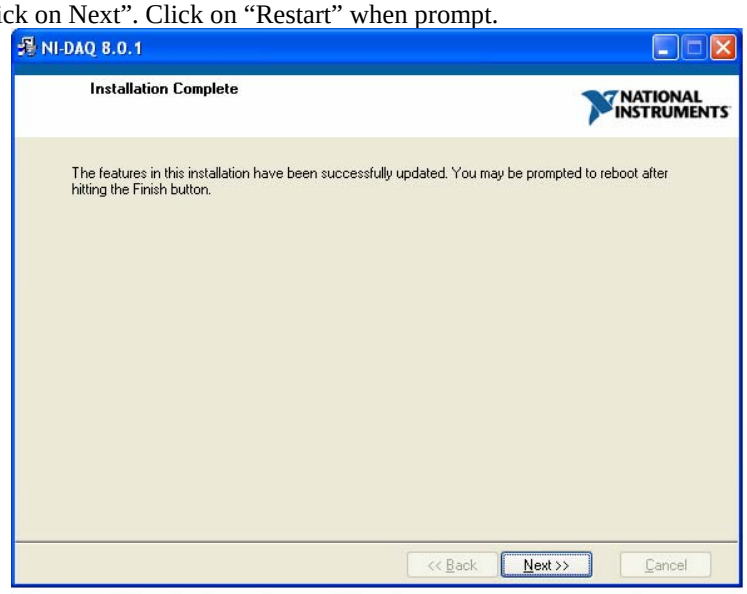


5. Accept the License Agreements. Click on “Next”.

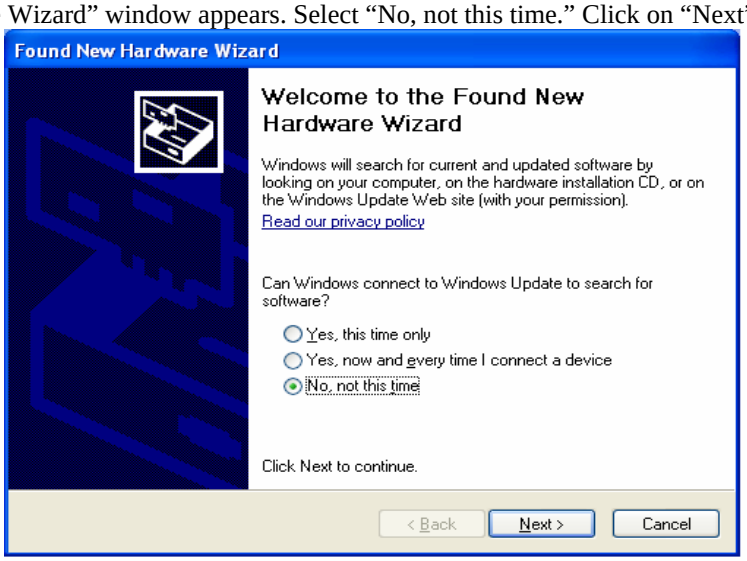
6. Start Installation.



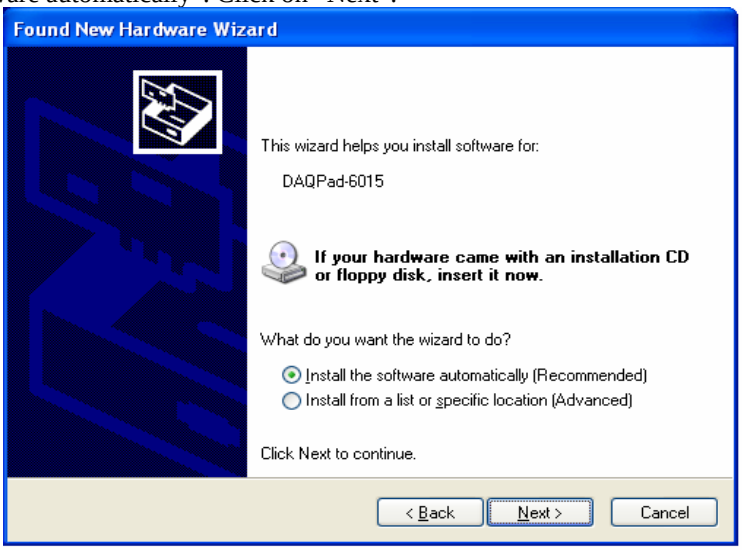
7. Wait until finished. Click on Next". Click on "Restart" when prompt.



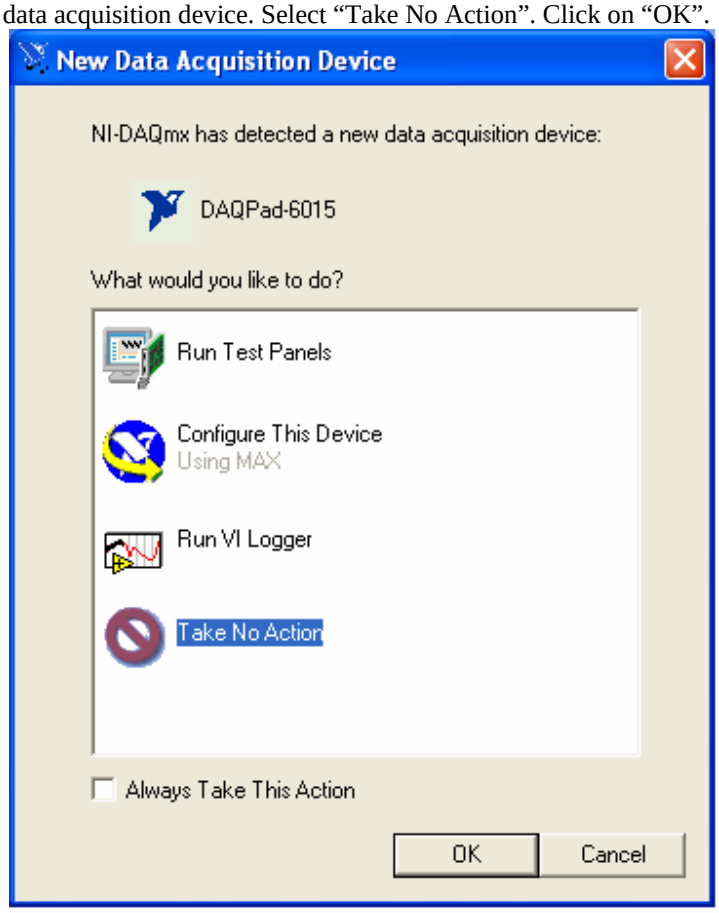
8. After restart computer, connect DAQPad to computer USB port.
9. "Found New Hardware Wizard" window appears. Select "No, not this time." Click on "Next".



10. Select "Install the software automatically". Click on "Next".

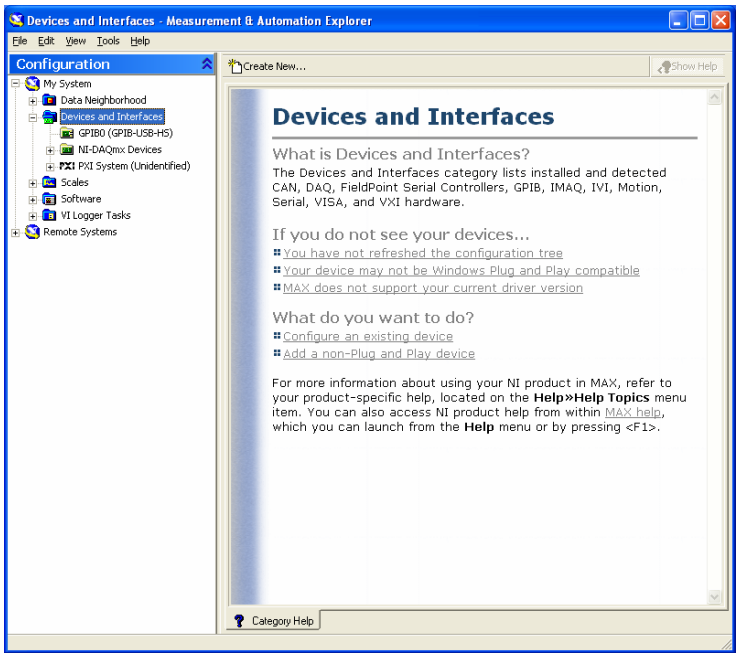


11. Wait until finished. Click on “Finish”.
12. NI-Max will detect new data acquisition device. Select “Take No Action”. Click on “OK”.

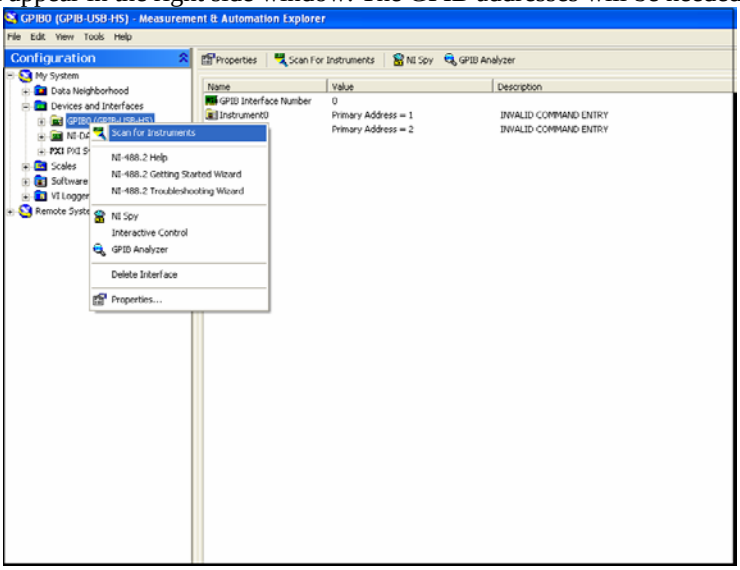


3.5.3 Verify hardware software installation

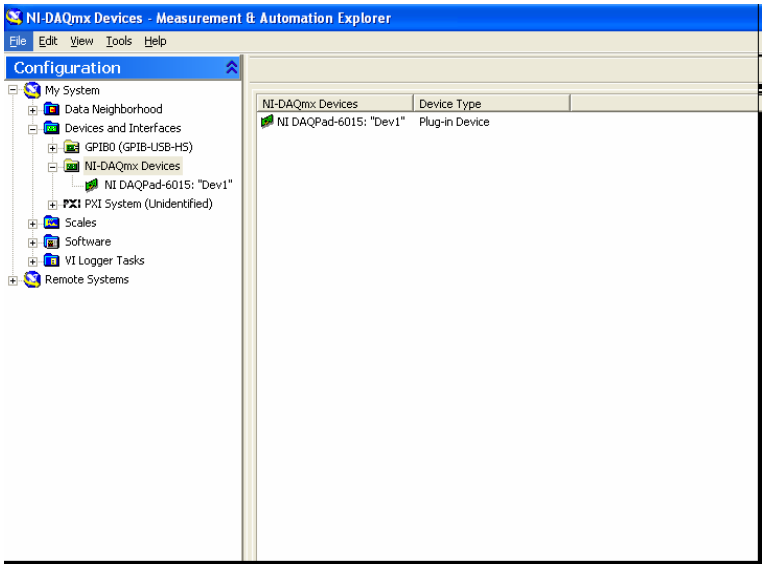
1. Open “Measurement and Automation Explorer” from National Instruments.
2. Go to “My System/Device and Interfaces”. There should be two entries, one as “GPIB0(GPIB-USB-HS)”, one as “NI-DAQmx Devices”



3. Right click on “GPIB0 (GPIB-USB-HS)”. Select “Scan for Instruments” from the drop down menu. All GPIB devices on the GPIB bus should appear in the right side window. The GPIB addresses will be needed later for software setup.

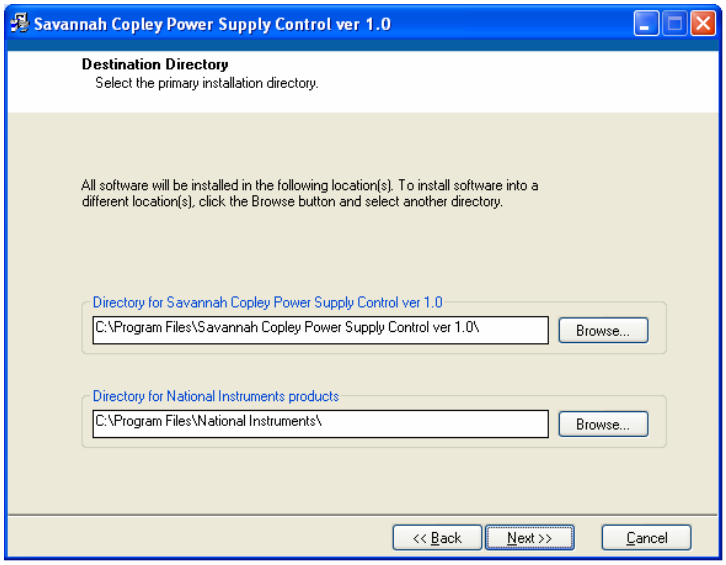


4. Click on “NI-DAQmx Devices”. The DAQPad should show on the right side window, without red cross. Note the device reference is “Dev1”. If more than one DAQPad have been connected to this computer, there will be more devices showing. This reference for device will be needed later for software setup.

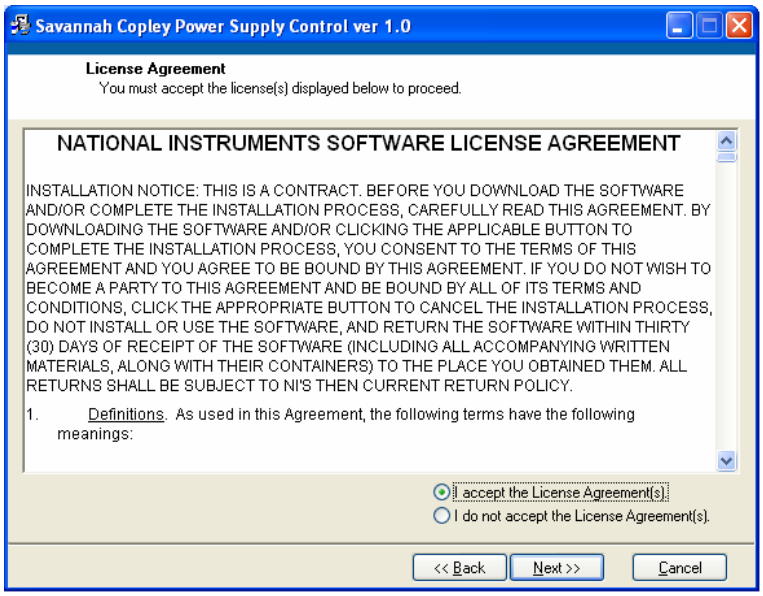


3.5.4 Install magnet control software from GMW.

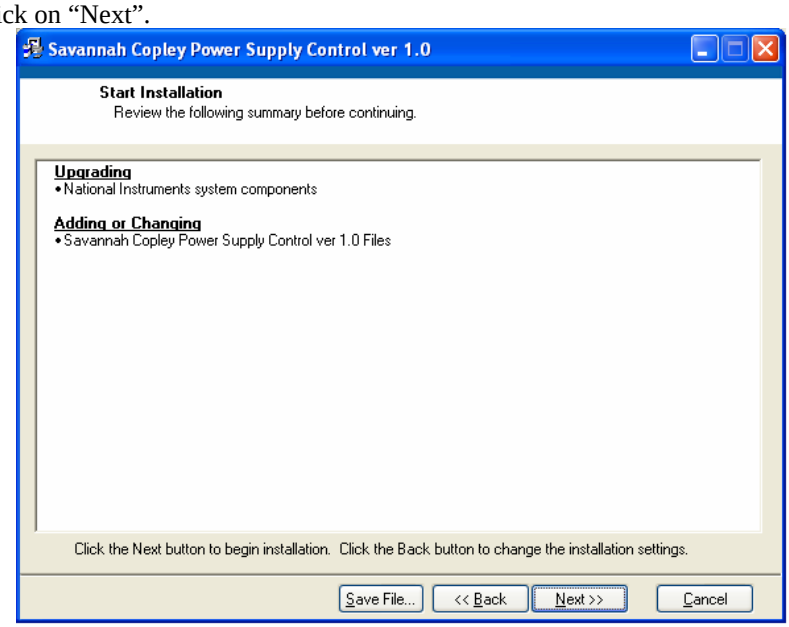
1. Insert software CD from GMW. Select D:\Installer\Setup.exe to start the installation.
2. Select destination directory. Make changes if wanted. It is recommended leave the “Directory for National Instruments products” unchanged. Click on ”Next”



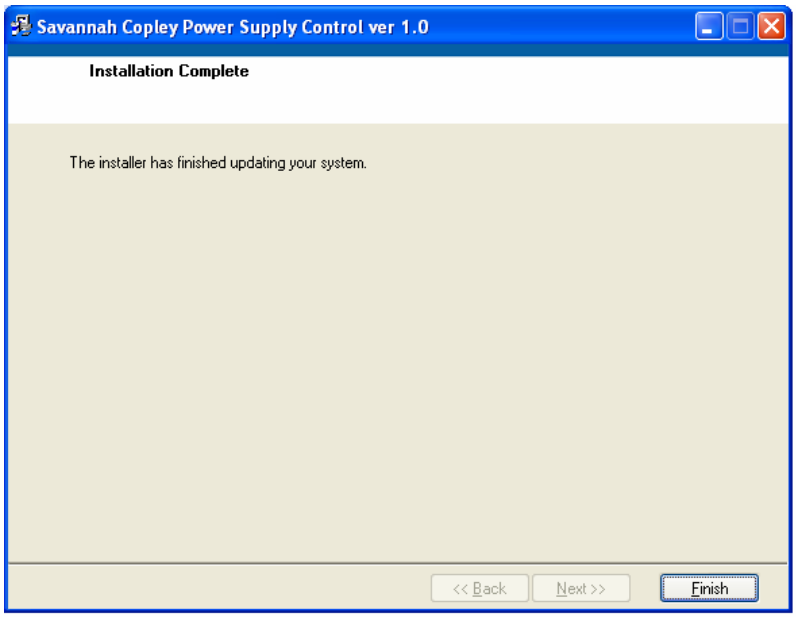
3. Accept the License Agreements. Click on “Next”



4. Start Installation. Click on “Next”.



5. Wait until finished. Click on “Finish”.

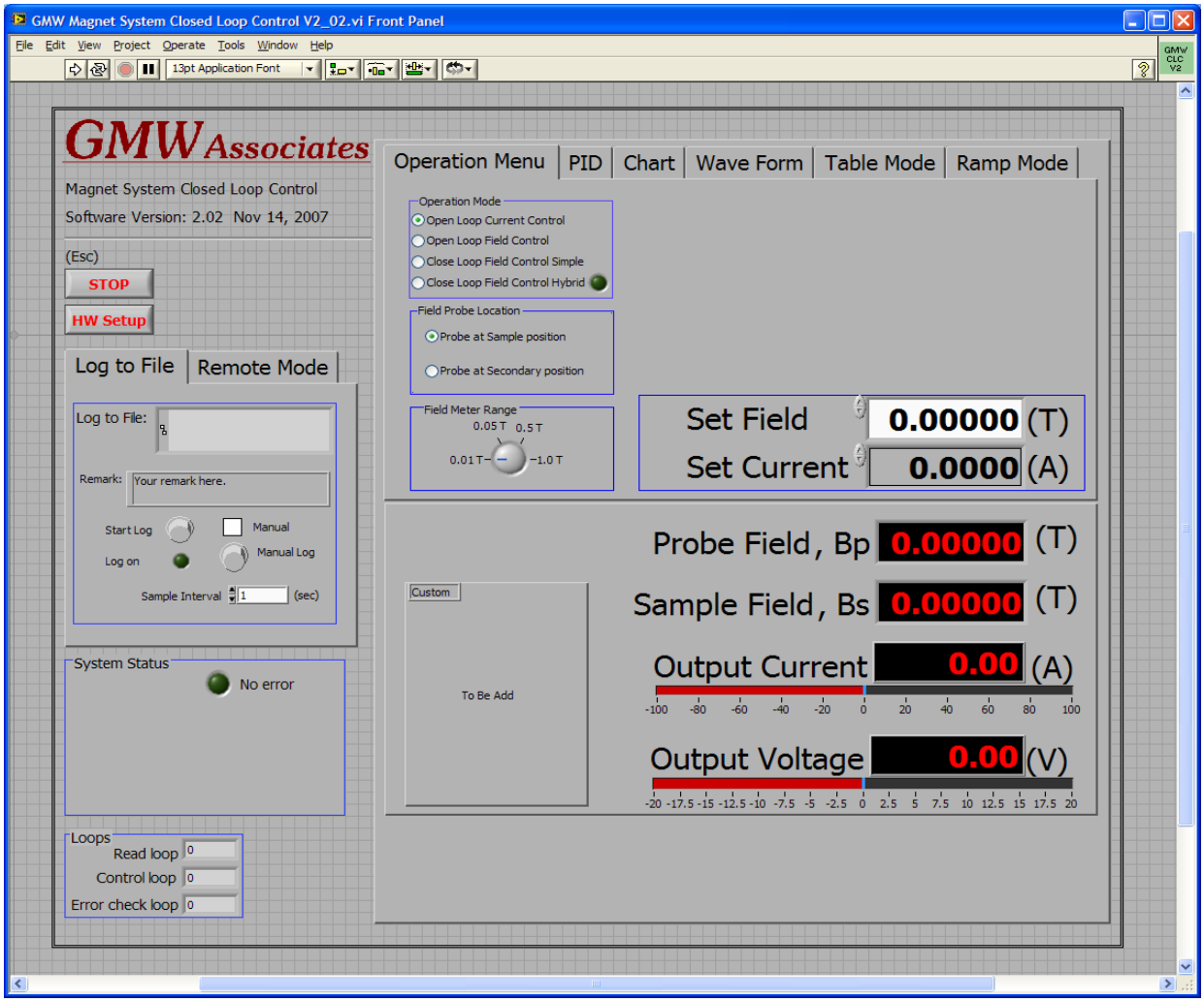


6. Restart computer when prompted.

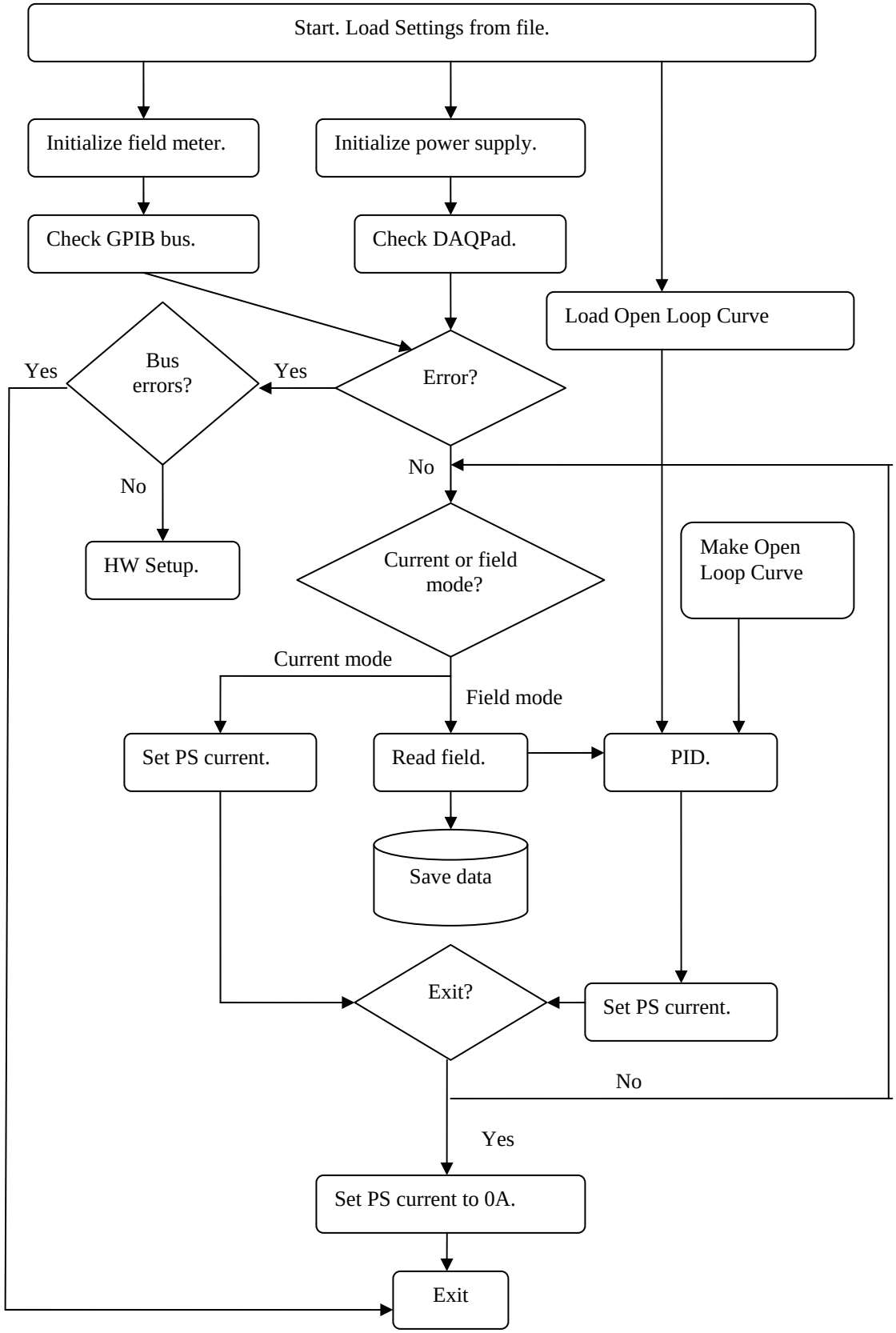
Section 4
OPERATION

4.1 The main operation screen

- Shows Field readings from the field meter if connected and configured correctly.
- Window control for selecting Window Sub Panels, Operation, PID, Chart, Wave Form, Table Mode and Ramp Mode
- Shows the system status.
- Access to Hardware setup menu. (HW Setup button)
- Controller Mode selects from one out of four control modes: Open Loop Current, Open Loop Field, Closed Loop Field Simple or Closed Loop Field Hybrid.
- STOP button programs the power supply to zero current and stops the program exection.
- System Parameters Strip chart shows system parameters on a strip chart under Chart tab. More details later.



4.2. Software block diagram.



Software block diagram

4.3. Starting and Stopping the Software

To open the program, go from Start>>Program>GMW Magnet System Closed Loop Control>GMW Magnet System Closed Loop Control V2.

To start the software, click on the arrow button on the top of the screen.
To stop the software, click on Stop button or use <Esc> key.

The software will load default settings from a configuration file (Config.txt) every time the software starts. To change the default settings click on HW Setup.

For first time setup, click HW Setup before starting the software. It will open the hardware setup window.

If more than one power supply/field meter are enabled in hardware setup, another tab will appear to show the second system. The second system display and control is identical with the first system. The description below is for the first system unless specified.

4.4. Operation Menu.

4.4.1 If controlling more than one power supply, power supply under control is selected by click on the proper tab. If no second magnet tab shown, the software is controlling one power supply.

4.4.2 Operation Mode:

Open Loop Current Control. Controls power supply current output by setting the Set Current to desired current value. User can not change Set Field under Current mode.

To change the current output of power supply under current mode, select Open Loop Current Mode, input desired current at Set Current. Output current will change after hit <Enter> or click anywhere outside the Set Current box.

Open Loop Field Control. Set power supply current output to reach a given field. Software will determine the output current from the given field through a predefined Field vs. Current excitation curve, (OLC, Open Loop Characterization file). The OLC file can be made either using a field meter support or a simulation file. OLC file in use is displayed under PID tab. The accuracy of Open Loop Field Control depends on the accuracy of the OLC file.
To change the current output of power supply under open loop field mode, select Open Loop Field Control, input desired field at Set Field. Output current will change after hit <Enter> or click on any where outside the Set Field box.

Close Loop Field Control Simple. Adjust power supply current output to maintain a given field by setting the Set Field to desired field value. Software will compare the desire field and the reading of field meter, adjust the output current accordingly. User can not change Set Current under Field mode.

To change the current output of power supply under close loop control field simple mode, select Close Loop Field Control Simple, input desired field at Set Field. Output current will change after hit <Enter> or click any where outside the Set Field box.

Close Loop Field Control Hybrid. In this mode the controller uses data from the Open Loop Characterization File and operates in PID mode only when the controller is within a 5% window of the desired Field Setpoint. The Open Loop Characterization File provides the controller with the field versus current excitation curve. The controller will not operate correctly if an Open Loop Characterization file is not loaded or the file has incorrect data for the magnet. When the user gives the system a new Field Setpoint the controller calculates an initial current setting for the desired Field Setpoint and transmits it to the Power Supply. During the ramp up or down to the desired Field Setpoint the PID Controller is disabled. When the actual field reaches a value within the Hybrid control window (defined in the HW setup and loaded when software started) the PID controller is activated. During the change over to PID control the Derivative control is disabled to allow the controller to settle before taking control of the system.
Generally the Hybrid PID mode is preferred since it provides the fastest transition time to a new Field Setpoint. User can not change Set Current under Field mode.

To change the current output of power supply under close loop field control mode, select Close Loop Field Control Hybrid, input desired field at Set Field. Output current will change after hit <Enter> or click on any where outside the Set Field box.

4.4.3 Field Probe Location:

Probe at Sample Position. Field reading from probe is used directly to control the field without change. The software is controlling the field at the point the probe is located.

Probe at Secondary Position. Field reading from probe is modified before used for controlling the field. The modification is made either by a constant multiplier or looking into two OLC files at Sample position and Secondary position. This allows controlling field indirectly if the probe cannot be placed at the intend controlling location. The constant multiplier and the two OLC files are defined in HW Setup window.

4.4.4 Closed Loop Field Control Operation Warning

Before attempted to run the Magnet Control System in the Closed Loop Field control mode check the items listed below.

1 The Teslameter is powered up.
2 The Teslameter probe is inserted in the magnet gap securely.
3 The Teslameter is set to the correct field range.
4 The Teslameter is connected to the GPIB bus and is returning correct field readings.
5. The Teslameter is reading the field correctly.

Running close loop field control without the field meter properly installed will cause the power supply to ramp up to max current. It is dangerous for both the operator and equipment setup.

4.4.5. Field Meter Range. Select the field meter full-scale range to be higher than the maximum possible field.

4.4.6. Field Reading.

- Probe Field. Shows the field meter reading.
- Sample Field. Shows the field at sample position. If the probe is located at sample position, the Probe and Field and Sample Field are the same. If the probe is located at secondary location, the Sample Field is calculated field.

4.5. Chart Control.

- Auto Scale ON/OFF: Turn on/off auto scaling for Y-axis.
- Time Axis: Set the time span for X-axis.
- Channel Select: Select/deselect which trace to be shown on the chart. This setting also determines if the trace will be saved to a file.

4.6. Log to File. Save data to a text file. The traces to be saved are selected from the Chart display, Channel Select. If a trace is unselected, that trace will not be saved to file. After Log to File is started, Select/unselect trace will cause software misplace data. User should avoid changing Change Select during logging.

- Log To File: Shows the data file name/path.
- Start Log: Click on Start Log. A window will prompt user for file name/directory to be saved.
- Auto/Manual: If Auto is selected, data will be saved every time interval defined by Sample Interval.
  If Manual is selected, data will be saved every time the user clicks on Manual Log.

4.7. PID Setup.

This menu is used for tuning the PID Controller

Before using the PID controller for the first time the controller will need to be tuned to obtain optimum performance. Follow the instructions listed below.

1. Select the PID Setup tab. The PID control panel will appear.
2. Set the Controller Mode required, either Hybrid PID or Simple PID control.
3. Enable the display of the field on the stripchart by selecting it on the Channel Select on the side of the stripchart.
4. Set the PID and Lead Lag controls to the initial values. Set the Lead Lag gain to 1, lag time to 0.2, lead time to 0.
5. Check that the correct Open Loop Characterization file is loaded. If no Open Loop Characterization file is found, a Default.olc will be loaded. [See Section 4.10 for Loading an Open Loop Characterization Plot.]
6. Set the Integral and Derivative controls to 0.00.

7. Enter a Field Setpoint value of 0.100000 Tesla. Retry with a Field Setpoint of 0.200000Tesla.
8. Increase lag time until the field can reach the target field quickly and does not have overshot.
9. Observe the trace of the field for the controller response on the System Parameter chart. It should not oscillate.
10. Increase the PID Gain a small increment.
11. Repeat steps 9 and step 10.
12. Continue repeating steps 10 and 11 until the controller oscillates in a steady state. Steady state oscillations mean the oscillations neither decrease or increase over a period of time.
13. Reduce the PID Gain a small increment, repeat steps 8 and step 9. If the controller does not oscillate then the system is set at maximum gain.
14. Reset the PID Integral and Derivative controls to the initial values given in Section 9 of this manual.
15. Repeat step 8 and step 9. If the system oscillates then decrease both the Integral and Derivative controls. If the systems overshoot the Field Setpoint then increase both the Integral and Derivative controls.

Note: 1. Integral and Derivative controls should have an approximate ratio of 4 to 1 between their settings.
[e.g. If the Integral control is set to 6.00 then the Derivative should be set to 1.50].
2. All the PID tuning control settings are saved only at HW Setup.

4.8 Open Loop File.

4.8.1 Load Open Loop File

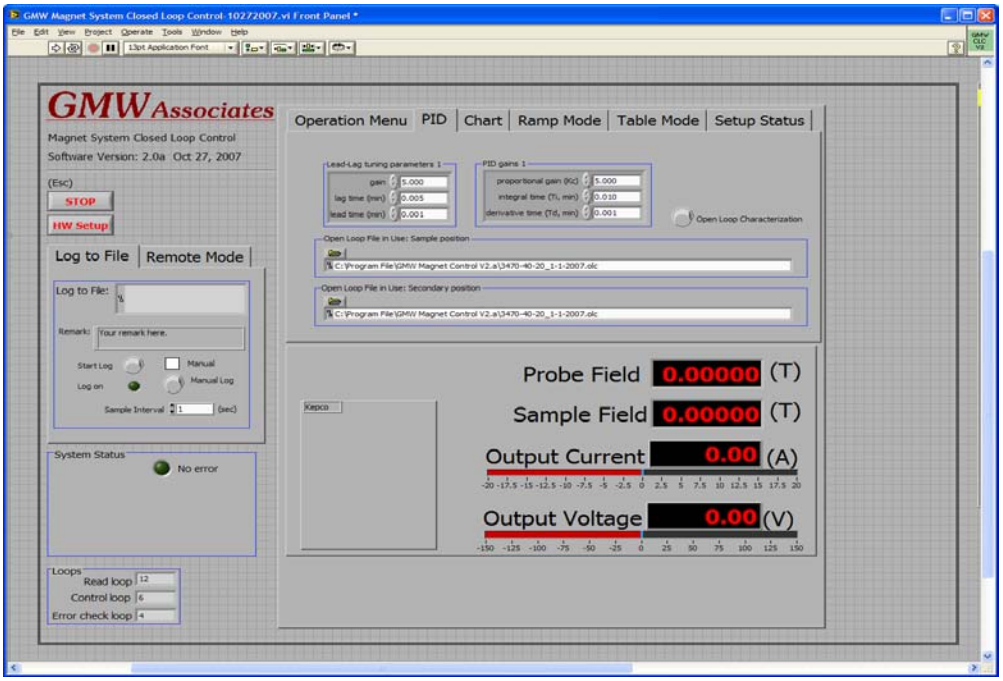
Before the PID controller is run, a B v I Open Loop Characterization File must first be loaded that matches the magnet and gap being used. This B v I Open Loop Characterization file (OLC file) can be generated either using a field meter or using a simulated field vs. current curves. An example OLC file below shows the file format. Current and Field columns is TAB delimited.

Current (Amps)	Field (Tesla)
0.0000E+0	-3.0350E-4
8.3333E-1	6.4058E-2
1.6667E+0	1.2882E-1
2.5000E+0	1.9346E-1
3.3333E+0	2.5757E-1
4.1667E+0	3.2085E-1
5.0000E+0	3.8263E-1

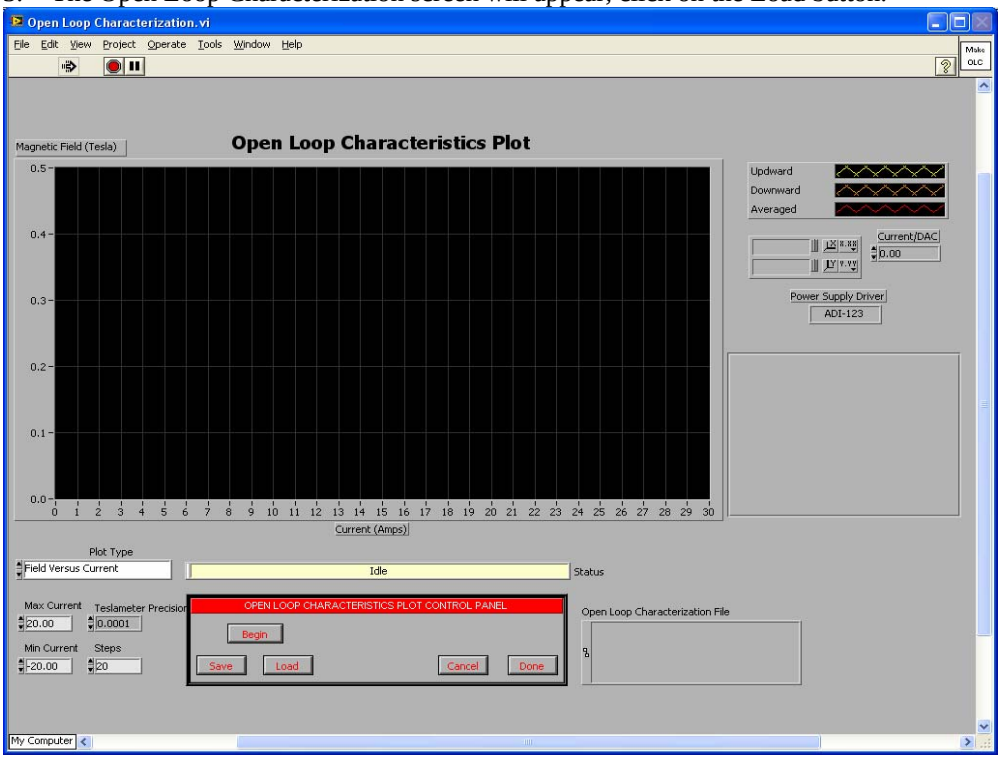
If the appropriate OLC file exists in the system, the OLC file can be loaded as detailed below. If the appropriate file does not exist the user will need to make the Open Loop Characterization File, [see Section 4.8.2 “Making an Open Loop Characterization Plot”]. To make the OLC to be loaded every time the software starts, making the OLC file in use as default file in the HW Setup window. [see Section 4.10 “HW Setup”]

1. Click on the LabVIEW Run arrow to start the Magnet Control software [if not already running].

2. Click on the PID tab and then click on Open Loop Characterization.



3. The Open Loop Characterization screen will appear, click on the Load button.



4. Select an Open Loop Characterization file by clicking on the desired file name. [A valid Open Loop Characterization file will have .olc extension on the end of the filename].
5. Click on OK or press the Enter key. The selected file will be loaded.
6. Check the selected file name is shown in the Loaded Open Loop Characterization File indicator. If correct then click on the Done button. The Open Loop Characterization Plot panel will close.
7. To use the selected OLC file each time the software starts, input the OLC file name and path in HW Setup>Power Supply>Open Loop File Path. Save the configuration.

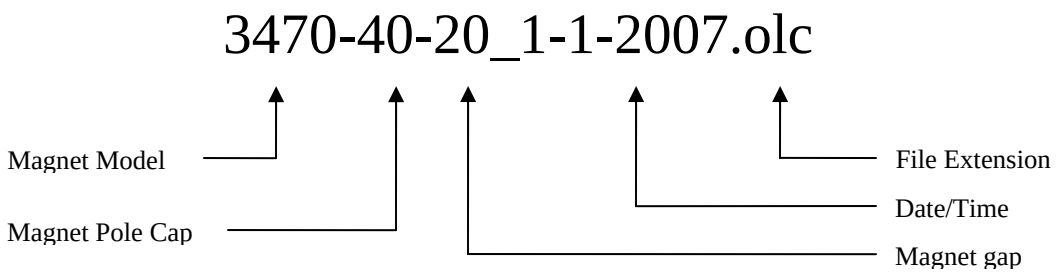
4.8.2 Making an Open Loop Characterization Plot.

Follow the previous steps to open the Open Loop Characterization screen.

1. Set the Max and Min current for the intend power supply operating range. It is not necessary the Max and Min current match the output range of the power supply.
2. Set the Steps. More steps will generate more accurate Open Loop Characterization Plot.
3. Click on Begin button.
4. The system will start taking data and report status in the status indicator. When the system reports it is Idle then click on the Save Button. Name the plot file using the correct format in the Filename box and click on OK or press the Enter key. [See next Section 4.8.3 for description of Open Loop Characterization filename format].

4.8.3 Open Loop Characterization filename format

It is recommended the Open Loop Characterization File name has the following format.

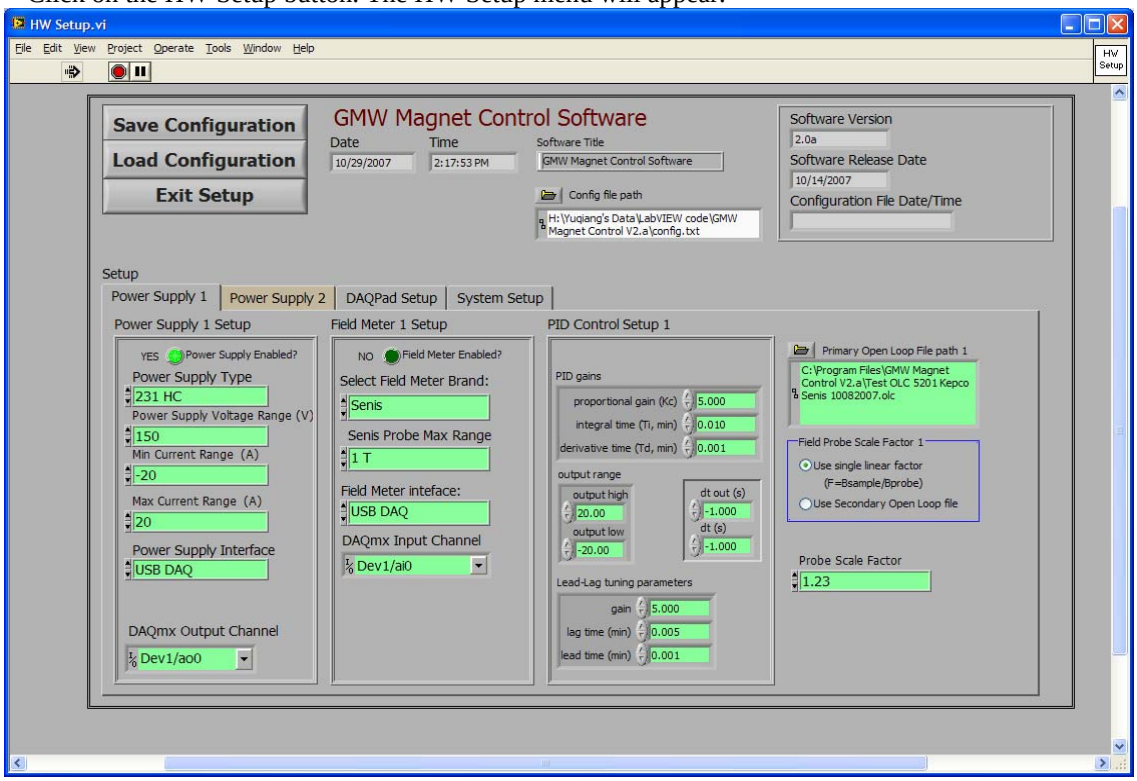


4.9. Setup Status.

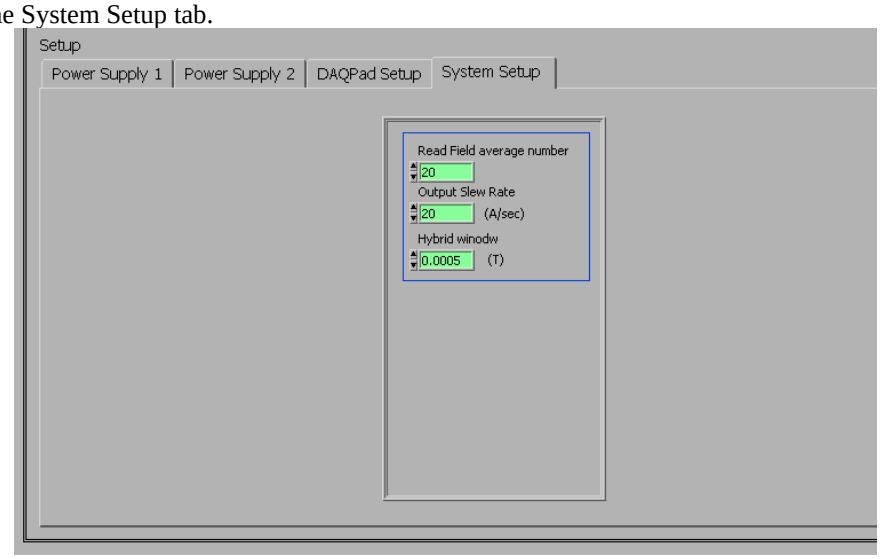
4.10. HW Setup.

HW Setup is used for configurating system hardware. All setup parameters are saved to a configuration file [Config.txt]. Software will load the settings from Config.txt every time the software is started. The user must stop and restart the software after the change of settings to enable the new settings to be applied.

4.10.1. Click on the HW Setup button. The HW Setup menu will appear.



4.10.2. Power supply 1 and power supply 2 have identical setup panels.
4.10.3. Select Power supply Type.
4.10.4. Input the minimum and maximum current range according to the power supply.
4.10.5. Select Power Supply Interface.
4.10.6. Select DAQmx Output Channel from the pull-down menu if using 231 HC or customer power supply with analog control. This is the analog output channel from National Instruments DAQPad. The Dev is the device address automatically assigned by software. DAQPad has two analog output channels, AO 0 and AO 1. Set the channel according to the physical connection between DAQPad and power supply. If only one power supply is under control, the default output channel is AO 0. If no pull-down menu is available, check the NI software installation and verify the hardware according to the Software/Hardware Installation section.
4.10.7. Select Field Meter Brand.
4.10.8. Select Field Meter Model or Range.
4.10.9. Select Field Meter interface.
4.10.10. Select the Field Meter GPIB addresses or DAQPad Channel from the pull-down menu. All devices on the same GPIB bus must have an unique GPIB address. The pull-down menu will show all the devices on the same GPIB interface. If no device shows on the pull-down menu, check the GPIB cable connection and power connection to the devices.
4.10.11. Input the PID settings. If first time setup, leave the PID settings unchanged.
4.10.12. Click on the button beside the Open Loop File path. Select the correct Open Loop File from the pop-up window.
4.10.13. On DAQPad setup, ensure the output sample rate is below 30.
4.10.14. Click on the System Setup tab.



- Read Field average number: Samples used for calculating moving average of the field meter reading.
- Max Output Slew Rate: Sets the limit for maximum current ramp rate.
- Hybrid Window: Window used for Hybrid PID control.

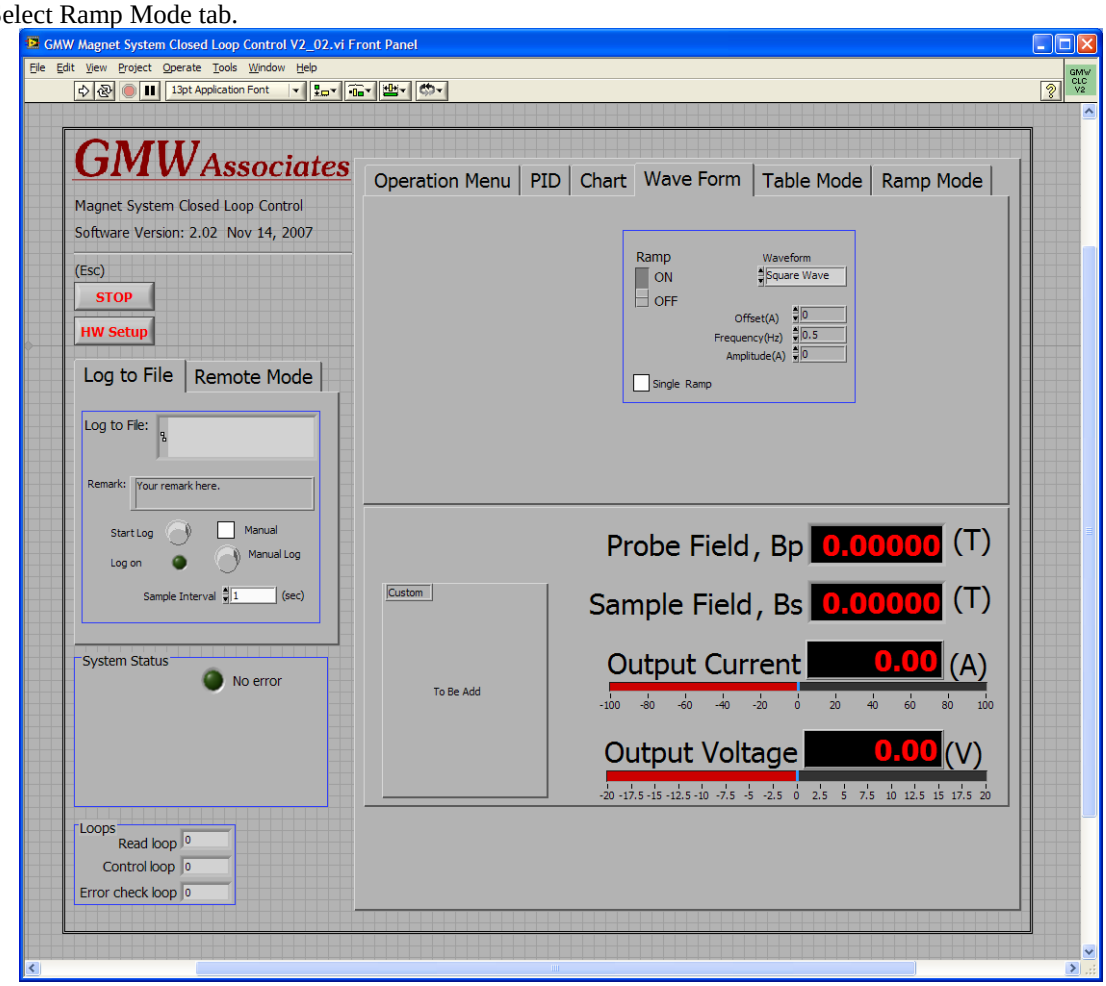
4.10.15. Save Configuration. Click on Save Configuration button. All the settings will be saved to file Config.txt. Each time Save Configuration is clicked, old settings are overwritten by the new settings. To preserve the old settings for latter use, copy the Config.txt file and rename the file using Window Explorer. The software has to be restarted to apply the new settings.

4.10.16. Load Configuration. Click on Load Configuration will let user load from a previous saved configuration file other than default Config.txt.

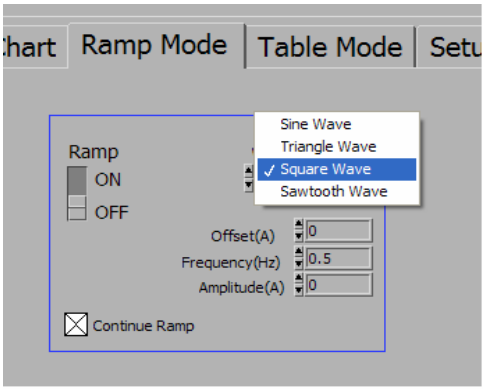
4.11. Wave Form Mode.

Wave Form mode will generate a wave form according to user settings and use the wave form to set the output current. Operate on current mode only.

4.11.1. Select Ramp Mode tab.



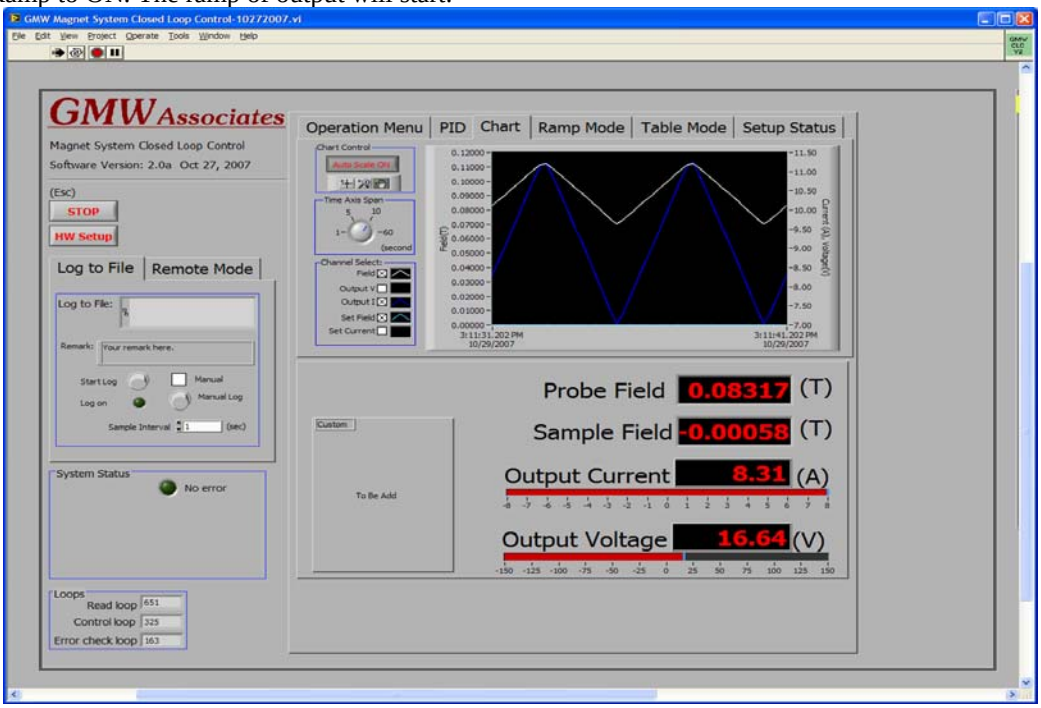
4.11.2. Select desired waveform.



4.11.3. Select Offset, Frequency, and Amplitude.

4.11.4. Select if Continue Ramp or Single Ramp.

4.11.5. Set Ramp to ON. The ramp of output will start.



4.12. Table Mode.

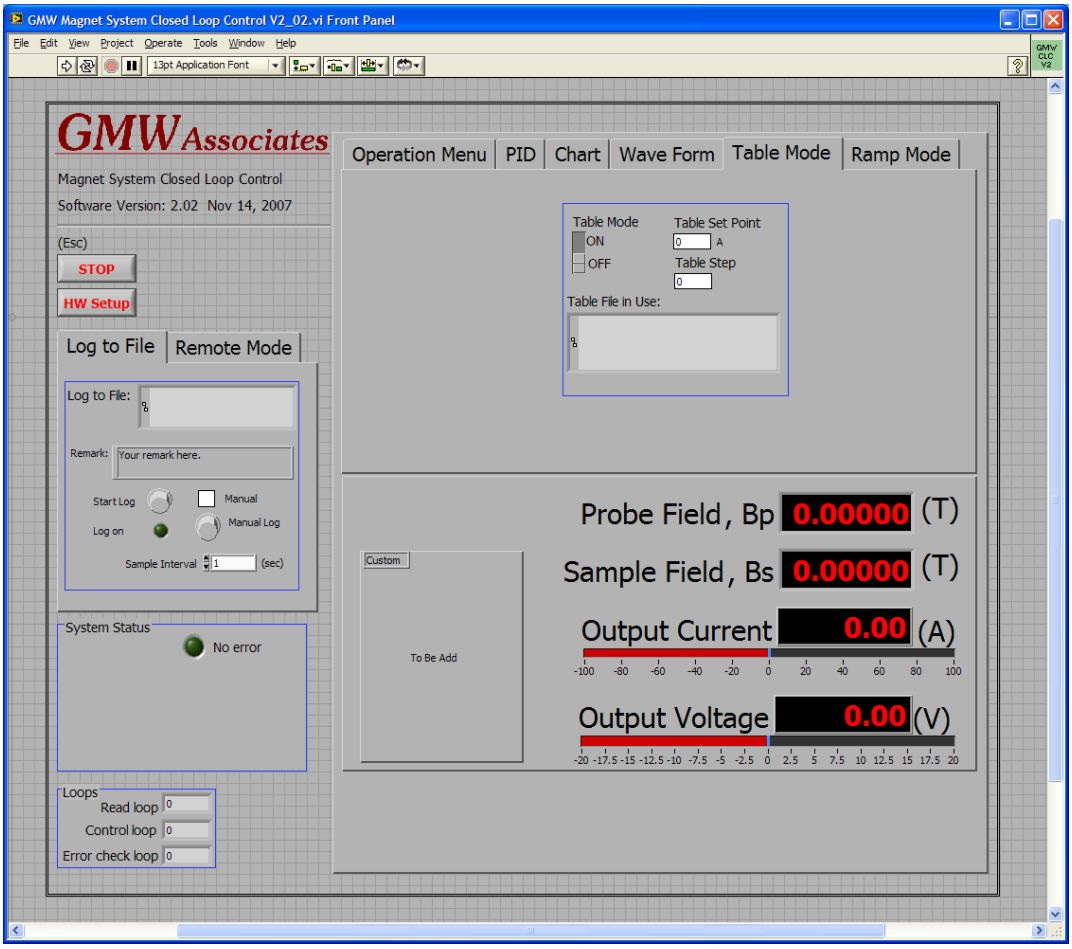
At Table mode, software will set the output current step through different set points at time interval defined by user. User can manually input a table or load table from a pre-saved file. The total number of Runs and Time between steps are not part of the table and need to be inputted by user each time the Table Mode was started.

Table Mode can run either on current or field control mode. The letter before the setpoint determines mode, “I” for current control mode and “F” for field control mode.

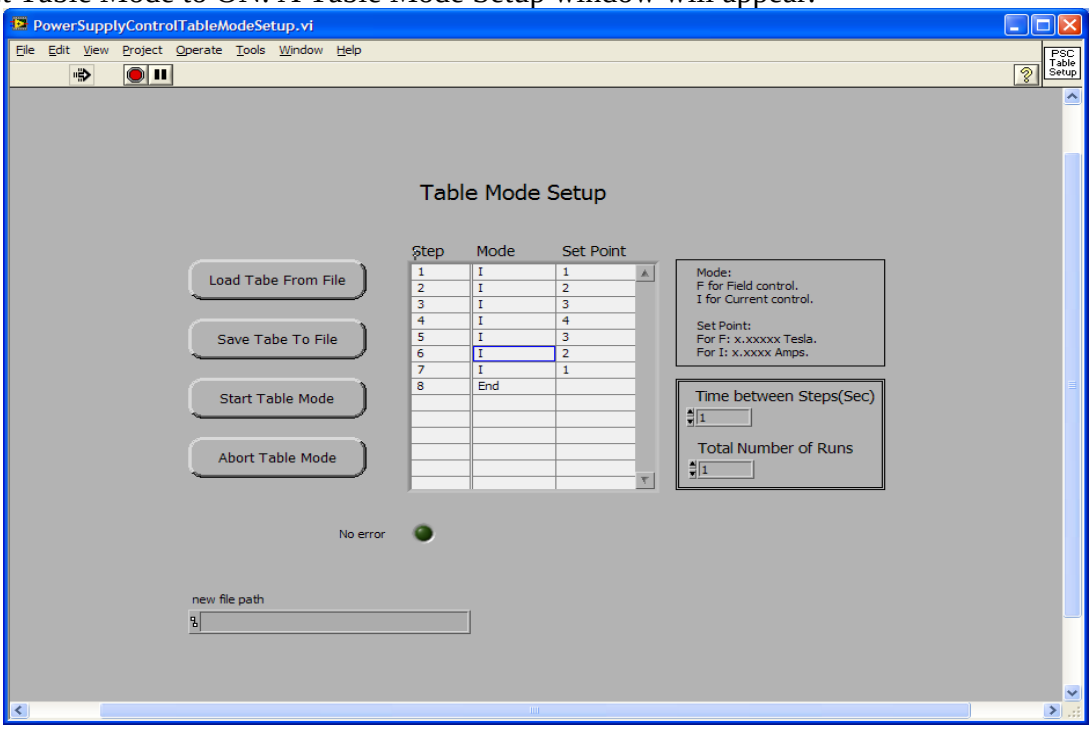
The table file is a plain txt file. It can be viewed, edited, or generated using an ASCII text editor, such as Notepad. The mode letter (I or F) and setpoint are separated with Tab. The table needs ended by “END”, case insensitive. The example table used below has the format as below:

I 1
I 2
I 3
I 4
I 3
I 2
I 1
End

4.12.1. Select from Table Mode tab.



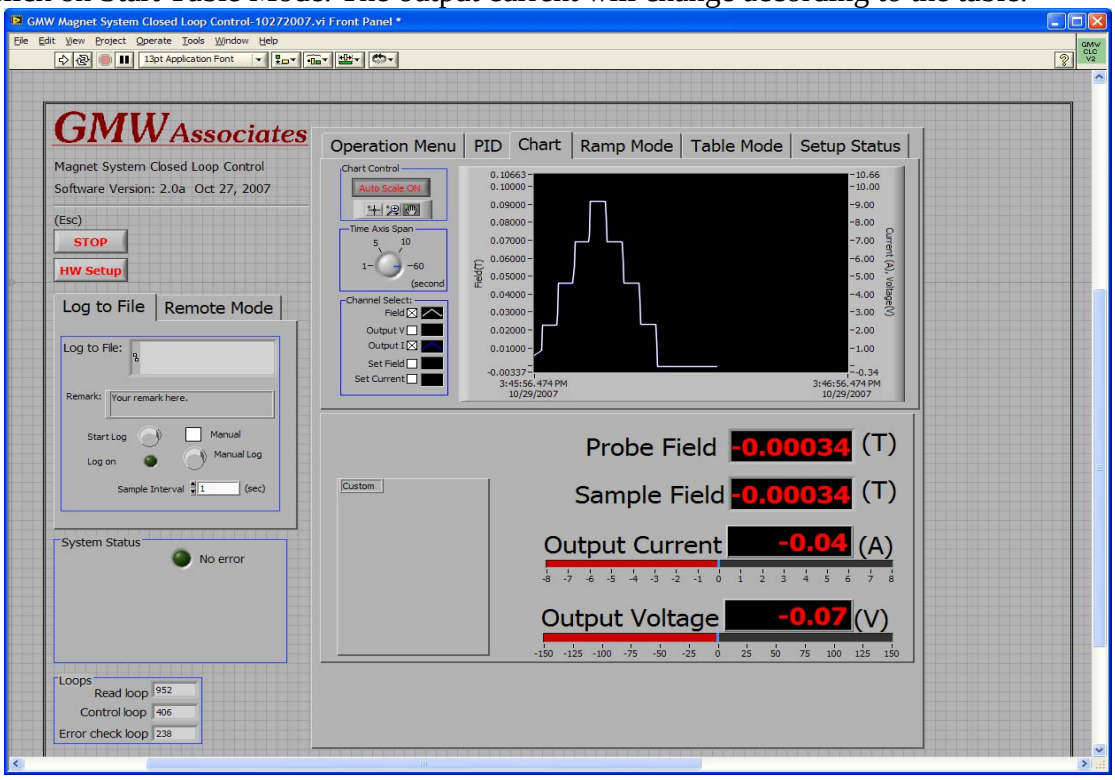
4.12.2. Set Table Mode to ON. A Table Mode Setup window will appear.



- Load Table From File. Load the table from a pre-saved file.

- **Save Table To File.** Save the current table to a user defined file name/directory.
- **Start Table Mode.** Close the Table Setup window and start table mode.
- **Abort Table Mode.** Close the Table Setup window and does not start Table mode.
- **Time between steps.** Time span for each step. For field control, this time needs be long enough to allow the field reach the setpoint.
- **Total Runs.** Total number of runs. Default value is 1, meaning only run through the table value once.

4.12.3. Click on Start Table Mode. The output current will change according to the table.



4.12.4. The table mode will automatically stop after reach the end of table, in the last run. The power supply output will return to the value defined in Operation Menu.

Section 5
MAINTENANCE

Section 6

EXCITATION CURVES

Section 7
TEST DATA

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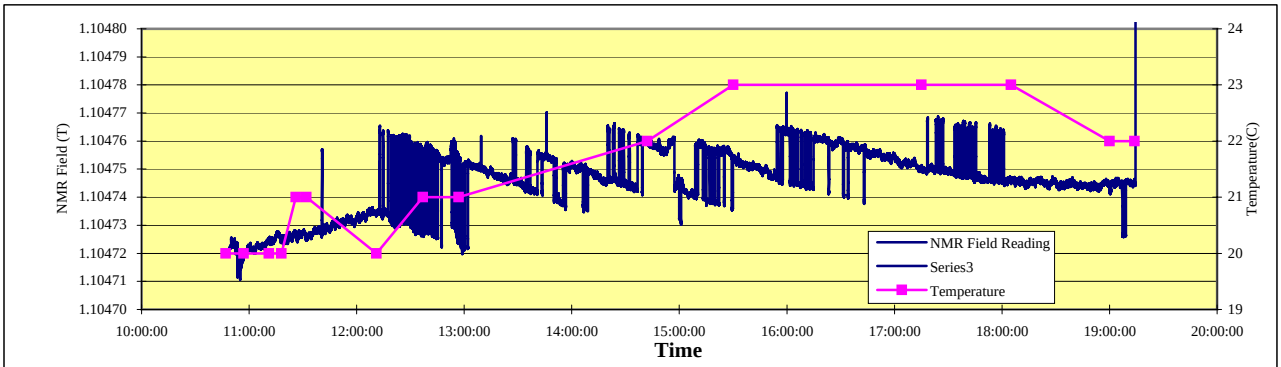
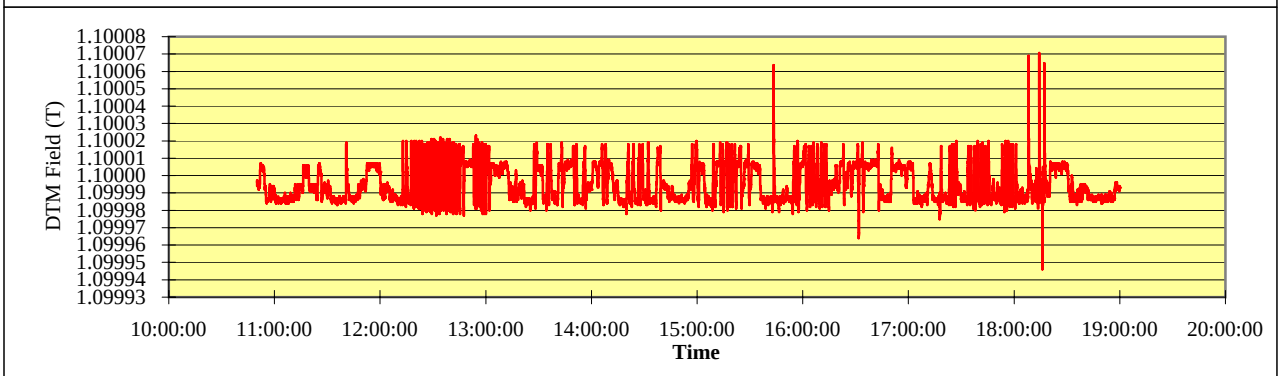
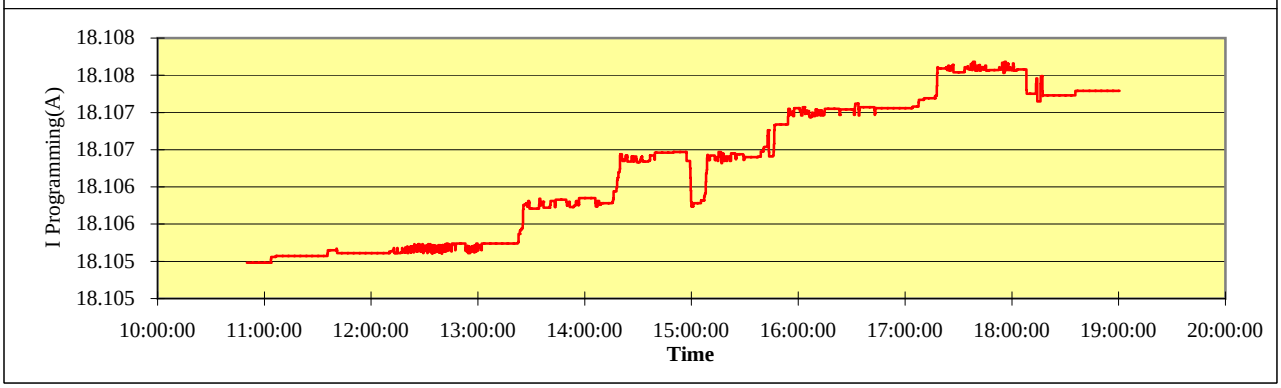
1. Sorensen power supply stability test.
2. Kepco power supply stability test.

GMW Associates
Electromagnet Stability Plot

Model:	**3473-70**	**Model:**	**5403EG-50**	**Engr:**	**Y.Qin**
SN:	**127**	**Serial Number:**	**2**	**Date:**	**4/13/2007**
Pole Gap:	**25mm**	**Pole Gap:**	**5mm**		
Pole Face:	**150mm**	**Pole Face:**	**76mm**		
Field Meter:	**DTM-151(MPT-141-7S), NMR 2025**				
Power supply:	**Two Kepco BOP 20-20**				
Note 1:	**DAQ controlling two power suppl mag 1 set at 1.2T, mag 2 set at 0.3T(~18A)**				
Note 2:	**Field mode (closed loop control), ~8 hour test, 1.1T, DTM digital filter ON**				
Note 3:	**Kepco PS Temp Coefficient: 200ppm/ deg C, 8-hour drift: 200ppm**				
Note 4:	**DTM Temp Coeffcient: +/-10ppm/deg C; Zero +/-3ppm/deg C; Cable -3ppm*7m/deg C**				

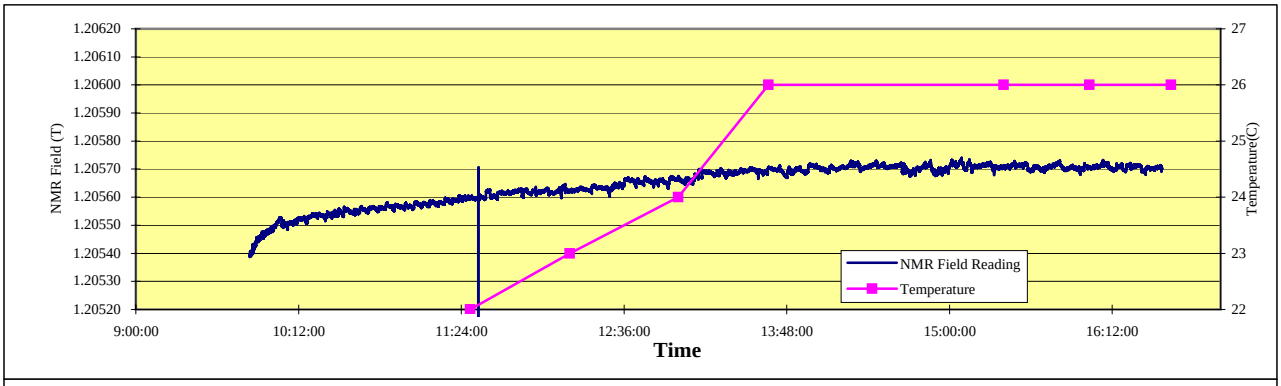


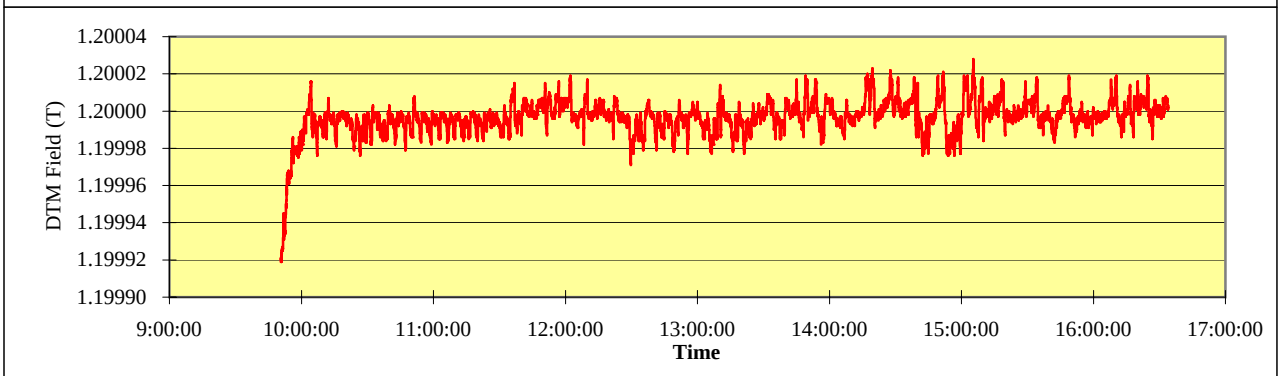


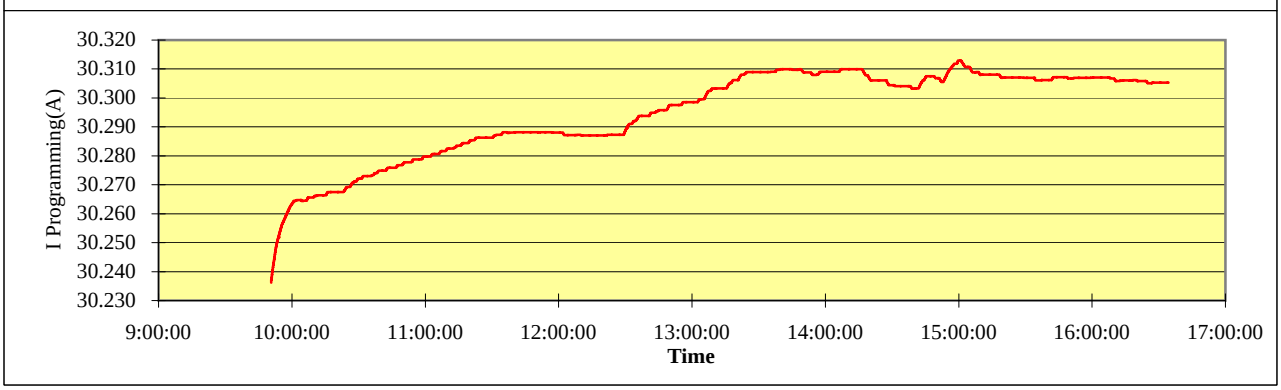


GMW Associates
Electromagnet Stability Plot

Model:	**3473-70**	**Model:**	**5403EG-50**	**Engr:**	**Y.Qin**
SN:	**127**	**Serial Number:**	**2**	**Date:**	**4/13/2007**
Pole Gap:	**25mm**	**Pole Gap:**	**5mm**		
Pole Face:	**150mm**	**Pole Face:**	**76mm**		
Field Meter:	**DTM-151(MPT-141-7S), NMR 2025**				
Power supply:	**Two sorensen, 160V/31A**				
Note 1:	**DAQ controlling two power suppl mag 1 set at 1.2T, mag 2 set at 0.25T(~15A)**				
Note 2:	**Field mode (closed loop control), ~8 hour test, 1.2T, DTM digital filter ON**				
Note 3:	**Sorensen PS Temp Coefficient: 300ppm/ deg C (0.03%/deg C)**				
Note 4:	**DTM Temp Coeffcient: +/-10ppm/deg C; Zero +/-3ppm/deg C; Cable -3ppm*7m/deg C**				







Section 8
APPENDIX

APPENDIX 1. NATIONAL INSTRUMENTS DAQPad 6015/6016 DATA SHEET
APPENDIX 2. NATIONAL INSTRUMENTS USB-DAQ 6251 DATA SHEET
APPENDIX 3. SORENSEN SG SERIES POWER SUPPLY DATA SHEET
APPENDIX 4. KEPCO BOP SERIES POWER SUPPLY DATA SHEET

Portable High-Performance Multifunction DAQ for USB

NI DAQPad-6015, NI DAQPad-6016

- 16 analog inputs at up to 200 kS/s, 16-bit resolution
- Built-in screw terminal connectors for easier and more cost-effective connectivity
- 2 analog outputs for accurate output signals
- 8 or 32 digital I/O lines (5 V TTL/CMOS)

Operating Systems
- Windows 2000/XP

Recommended Software
- LabVIEW
- LabWindows/CVI
- Measurement Studio
- VI Logger

Measurement Services Software (included)
- NI-DAQmx

Product	Bus	Analog Inputs[1]	Input Resolution	Sampling Rate	Input Range	Analog Outputs	Output Resolution	Output Rate[2]	Output Range	Digital I/O	Counter/Timers	Triggers
NI 6015	USB	16 SE/8 DI	16 bits	200 kS/s	±0.05 to ±10 V	2	16 bits	300 S/s	±10 V	8	2	Digital
NI 6016	USB	16 SE/8 DI	16 bits	200 kS/s	±0.05 to ±10 V	2	16 bits	300 S/s	±10 V	32	2	Digital

[1]SE – single ended, DI – differential [2]System dependent

Hardware Description

The National Instruments DAQPad-6015 and DAQPad-6016 multifunction data acquisition devices provide plug-and-play connectivity via USB for acquiring, generating, and logging data in a variety of portable and desktop applications. They include built-in screw terminal connectivity so you can easily connect sensors and signals without extra cost. Both devices feature 16-bit accuracy at up to 200 kS/s. The DAQPad-6016 also provides 32 digital I/O lines for applications requiring an extended interface to digital sensors and actuators.

Software Description

NI DAQPad-6015 and DAQPad-6016 devices include NI-DAQmx Measurement Services software with which you can quickly configure and begin taking measurements with your DAQ device. NI-DAQmx provides a seamless interface to LabVIEW, LabWindows/CVI, and Measurement Studio development environments with features such as DAQ Assistant.

Recommended Accessories

The DAQPad-6015 and DAQPad-6016 both have built-in connectivity, so no additional accessories are required.

Common Applications

The DAQPad-6015 and DAQPad-6016 devices are ideal for a number of applications where portability and accurate measurements are essential, such as:

- Portable data logging – log environmental or voltage data quickly and easily
- Field monitoring applications
- Embedded OEM applications
- In-vehicle data acquisition
- Academic lab use – academic discounts available for quantities of five or more. Visit ***ni.com/academic*** for details.

Information for OEM Customers

For information on special configurations and pricing, please visit ***ni.com/oem***.

Ordering Information

NI DAQPad-6015 779047-01
NI DAQPad-6016 779025-01
Includes NI-DAQmx software

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Portable High-Performance Multifunction DAQ for USB

Specifications

These specifications are typical at 25 °C unless otherwise stated.

Analog Input

Accuracy Specifications

	Absolute Accuracy							Relative Accuracy	
	Percent of Reading			Noise + Quantization (mV)		Absolute Accuracy	Temperature	Resolution (mV)	
Nominal Range (V)	24 hours	1 year	Offset (mV)	Single Point	Averaged	at Full Scale (mV)	Drift (%/°C)	Single Point	Averaged
± 10	0.0658	0.0700	1.8798	0.9330	0.0824	8.984	0.0010	1.0849	0.1085
± 5	0.0158	0.0200	0.9598	0.4665	0.0412	2.003	0.0005	0.5425	0.0542
± 0.5	0.0658	0.0700	0.1158	0.0562	0.0050	0.471	0.0010	0.0663	0.0066
± 0.05	0.0658	0.0700	0.0314	0.0314	0.0031	0.069	0.0010	0.04038	0.0040

Input Characteristics

Number of channels ..... 16 single-ended or 8 differential (software-selectable per channel)
Type of ADC ..... Successive approximation
Resolution ..... 16 bits, 1 in 65,536
Maximum sampling rate ..... 200 kS/s
Input signal ranges (bipolar only)

Device Gain (Software-Selectable)	Range
0.5	±10 V
1	±5 V
10	±500 mV
100	±50 mV

Input coupling ..... DC
Maximum working voltage (signal + common mode) ..... Each input should remain within ± 11 V of ground

Overvoltage protection

Signal Name	Powered Off (V)	Powered On (V)
AI<0..15>	±15	±25
AI SENSE	±15	±25

FIFO buffer size ..... 4,096 samples
Data transfers ..... Interrupts, programmed I/O
Configuration memory size ..... 512 words

Transfer Characteristics

Relative accuracy ..... ±1.5 LSB typical, ±3.0 LSB maximum
DNL ..... ±0.5 LSB typical, ±1.0 LSB maximum
No missing codes ..... 16 bits, guaranteed

Amplifier Characteristics

Input impedance
- Normal powered ..... 100 GΩ in parallel with 100 pF
- Powered off ..... 820 Ω
- Overload ..... 820 Ω

Input bias current ..... ±200 pA
Input offset current ..... ±100 pA
CMRR (DC to 60 Hz)
- Range ± 10 V, ± 5 V ..... 85 dB
- Range ± 500 mV, ± 50 mV ..... 96 dB

Dynamic Characteristics

Small signal (-3 dB) bandwidth ..... 425 kHz
Large signal (17. THD) bandwidth ..... 450 kHz
System noise (LSB_{rms}, including quantization)

Range	LSB_{rms}
± 10 V, ± 5 V	0.9
± 500 mV	1.1
± 50 mV	6.7

Settling time to full scale step

Range	Accuracy
± 10 V	±4 LSB, 5µs typical
± 5 V	±2 LSB, 5µs maximum
± 50 mV, ± 500 mV	±2 LSB, 5µs typical

Crosstalk (DC to 100 kHz)
- Adjacent channels ..... -75 dB
- All other channels ..... -90 dB

Analog Output

Accuracy Specifications

	Absolute Accuracy				
	Percent of Reading			Absolute Accuracy	Temperature
Nominal Range (V)	24 hours	1 year	Offset (mV)	at Full Scale (mV)	Drift (%/°C)
± 10	0.0154	0.0196	1.5680	3.530	0.0005

Output Characteristics

Number of channels ..... 2 voltage outputs
Resolution ..... 16 bits, 1 in 65,536
Maximum update rate ..... 300 S/s, system dependent
Type of DAC ..... Double-buffered, multiplying
FIFO buffer size ..... None
Data transfers ..... Interrupts, programmed I/O

Transfer Characteristics

Relative accuracy (INL) ..... ±3 LSB, typical
DNL ..... ±2 LSB, typical
Monotonicity ..... 15 bits

Voltage Output

Range ..... ±10 V
Output coupling ..... DC
Output impedance ..... 0.1 Ω , maximum
Current drive ..... ±5 mA, maximum
Protection ..... Short-circuit to ground
Power-on state ..... ±250 mV

Dynamic Characteristics

Settling time to full-scale step ..... 8 µs to ±1 LSB accuracy
Slew rate ..... 4 V/µs
Noise ..... 360 μV_{rms}, DC to 400 kHz
Glitch energy at mid-scale transition
- Magnitude ..... ±100 mV
- Duration ..... 4.0 µs

Digital I/O

Number of channels ..... 8 input/output
Compatibility ..... 5 V TTL/CMOS

P0.<0..7>

Digital logic levels

Level	Minimum (V)	Maximum (V)
Input low voltage	0	0.8
Input high voltage	2.0	5.0
Output low voltage (I_{out} = 2.5 µA)	–	0.4
Output high voltage (I_{out} = -2.5 µA)	4.35	–

Power-on state ..... Input (high impedance), 1.5 kΩ pull down to D GND
Data transfers ..... Programmed I/O
Max transfer rate ..... 250 S/s, system dependent

P1.<0..7>, P2.<0..7>, P3.<0..7> (NI 6016 only)

Digital logic levels

Level	Minimum (V)	Maximum (V)
Input low voltage	0	0.8
Input high voltage	2.2	5.0
Output low voltage (I_{out} = 24 mA)	–	0.4
Output high voltage (I_{out} = -13 mA)	3.7	–

Handshaking 2-wire
Power-on state ..... Input (high impedance), 100 kΩ pull up to +5 VDC
Data transfers ..... Interrupts, programmed I/O
Max transfer rate ..... 250 S/s, system dependent

Timing I/O

Number of channels
Up/down counter/timers 2
Frequency scaler 1
Resolution
Up/down counter/timers ..... 24 bits
Frequency scaler ..... 4 bits
Compatibility ..... 5 V TTL/CMOS
Digital logic levels

Level	Minimum (V)	Maximum (V)
Input low voltage	0	0.8
Input high voltage	2.0	5.0
Output low voltage (I_{out} = 5 mA)	–	0.4
Output high voltage (I_{out} = -3.5 mA)	4.35	–

Base clocks available
Up/down counter/timers ..... 20 MHz, 100 kHz
Frequency scaler ..... 10 MHz, 100 kHz
Base clock accuracy ..... ±0.01%
Maximum external source frequency
Up/down counter/timers ..... 20 MHz
External source selections ..... PFI <0..9>
External gate selections ..... PFI <0..9>
Minimum source pulse duration ..... 10 ns, edge-detect mode
Minimum gate pulse duration ..... 10 ns, edge-detect mode
Data transfers
Up/down counter/timer ..... Interrupts, programmed I/O
Frequency scaler ..... Programmed I/O

Digital Triggers

Purpose
Analog input ..... Start, reference, and pause trigger, sample clock
Analog output ..... Start and pause trigger, sample clock
Counter/timers ..... Source, gate
Source ..... PFI <0..9>
Response ..... Rising or falling edge, software-selectable
Compatibility ..... 5 V TTL
Pulse width ..... 10 ns minimum

Calibration

Recommended warm-up time ..... 15 minutes
Calibration interval ..... 1 year
Onboard calibration reference
Level ..... 5.000 V (± 3.5 mV) over full operating temperature, actual value stored in EEPROM
Temperature coefficient ..... ± 5.0 ppm/°C maximum
Long-term stability ..... ± 15.0 ppm/sqrt (1000 hours)

Physical

Enclosure dimensions ..... 17.60 x 14.85 x 3.08 cm (8.00 x 6.75 x 1.40 in.)
Weight ..... 2 lb
I/O Connectors ..... Screw terminals

Bus Interface

Type ..... USB 2.0, full speed

Power Requirement

9 to 25 V ..... 12 W
Power available at I/O connector ..... +4.65 to + 5.25 VDC at 1 A

Environment

Operating temperature ..... 0 to 55 °C
Storage temperature ..... -20 to 70 °C
Relative humidity ..... 10 to 90%, noncondensing

Certifications and Compliances

CE Mark Compliance CE

View additional specifications at ***ni.com/manuals***.

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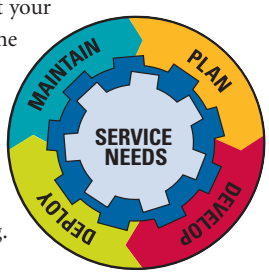

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High-Performance M Series Multifunction DAQ for USB – 16-Bit, up to 1.25 MS/s, up to 80 Analog Inputs

NI USB-6221, NI USB-6225, NI USB-6229, NI USB-6251, NI USB-6255, NI USB-6259

- Up to 80 analog inputs at 16 bits, 1.25 MS/s (1 MS/s or 750 KS/s scanning)
- Up to 4 analog outputs at 16 bits, 2.8 MS/s (2 µs full-scale settling)
- Up to 48 TTL/CMOS digital I/O lines (up to 32 hardware-timed at up to 1 MHz)
- Two 32-bit, 80 MHz counter/timers
- Analog and digital triggering
- NI-PGIA 2 and NI-MCal calibration technology for improved measurement accuracy
- NI signal streaming for 4 high-speed data streams on USB
- Power supply included
- 1-year warranty
- Additional warranty and calibration services available

Operating Systems

- Windows Vista (32- and 64-bit)/XP/2000

Recommended Software

- LabVIEW
- LabVIEW SignalExpress
- LabWindows™/CVI
- Measurement Studio

Other Compatible Software

- Visual Studio .NET
- C/C++/C#

Measurement Services Software (included)

- NI-DAQmx driver software
- Measurement & Automation Explorer configuration utility
- LabVIEW SignalExpress LE

Family	Bus	Analog Inputs	Resolution (bits)	Max Rate (S/s)	Analog Outputs	Analog Output Resolution (bits)	Max Rate (S/s)	Range (V)	Digital I/O	Clocked DIO[1]	Counter	Resolution (bits)
NI 6251	USB	16	16	1.25 M	2	16	2.86 M	±10	24	8, up to 1 MHz[1]	2	32
NI 6255	USB	80	16	1.25 M	2	16	2.86 M	±10	24	8, up to 1 MHz[1]	2	32
NI 6259	USB	32	16	1.25 M	4	16	2.86 M	±10	48	32, up to 1 MHz[1]	2	32
NI 6221	USB	16	16	250 k	2	16	833 k	±10	24	8, up to 1 MHz[1]	2	32
NI 6225	USB	80	16	250 k	2	16	833 k	±10	24	8, up to 1 MHz[1]	2	32
NI 6229	USB	32	16	250 k	4	16	833 k	±10	48	32, up to 1 MHz[1]	2	32

[1]Correlated DIO can be clocked at up to 1 MHz across the USB bus and up to 10 MHz using onboard regeneration.

Table 1. Selection Guide for High-Performance M Series Multifunction DAQ for USB

Overview and Applications

With recent bandwidth improvements and new innovations from National Instruments, USB has evolved into a core bus of choice for measurement and automation applications. National Instruments M Series devices for USB deliver high-performance data acquisition in an easy-to-use and portable form factor through USB ports on laptop computers and other portable computing platforms. NI designed a new and innovative patent-pending NI signal streaming technology that enables sustained bidirectional high-speed data streams on USB. The new technology, combined with advanced external synchronization and isolation, helps engineers and scientists achieve high-performance applications on USB.

NI M Series high-performance multifunction data acquisition (DAQ) modules for USB are optimized for superior accuracy at fast sampling rates. They provide an onboard NI-PGIA 2 amplifier designed for fast settling times at high scanning rates, ensuring 16-bit accuracy even when measuring all available channels at maximum speed. All high-performance devices have a minimum of 16 analog inputs, 24 digital I/O lines, seven programmable input ranges, analog and digital triggering, and two counter/timers. High-speed NI USB-625x and NI USB-622x M Series devices have two-year and one-year calibration intervals, respectively. USB M Series devices are ideal for test, control, and design applications including:

- Portable data logging – log environmental or voltage data quickly and easily
- Field-monitoring applications
- Embedded OEM applications
- In-vehicle data acquisition
- Academic lab use – academic discounts available

NI Signal Streaming

To optimize the use of the Universal Serial Bus (USB) and deliver high-performance data acquisition, National Instruments created several key technologies to push the limits of USB throughput and latency. NI signal streaming combines three innovative hardware- and software-level design elements to enable sustained high-speed and bidirectional data streams over USB. For more information, visit **ni.com/usb**.

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USB M Series for Test

For test, you can use the M Series high-speed analog inputs and 10 MHz digital lines with NI signal conditioning for applications including test, component characterization, and sensor measurement. High-speed USB-625x M Series devices are compatible with the NI SCC signal conditioning platform, providing amplification filtering and power for virtually every type of sensor. This platform is also compliant with IEEE 1451.4 smart transducer electronic data sheet (TEDS) sensors, which offer digital storage for sensor data sheet information.

USB M Series multifunction DAQ devices also complement existing test systems that need additional measurement channels. For higher-channel-count signal conditioning on USB, consider the NI CompactDAQ or SCXI platforms.

USB M Series for Control

USB M Series digital lines can drive 24 mA for relay and actuator control. By clocking the digital lines as fast as 10 MHz (with onboard regeneration), you can use these lines for pulse-width modulation (PWM) to control valves, motors, fans, lamps, and pumps. With four waveform analog outputs, two 80 MHz counter/timers, and four high-speed data streams on USB, M Series devices can execute multiple control loops simultaneously. High-speed USB-625x M Series devices also offer direct support for encoder measurements, protected digital lines, and digital debounce filters. With up to 80 analog inputs, 32 clocked digital lines, and four analog outputs, you can execute multiple control loops with a single device.

You can also create a complete custom motion controller by combining USB M Series devices with the NI SoftMotion Development Module.

USB M Series for Design

For design applications, you can use a wide range of I/O – from 80 analog inputs to 48 digital lines – to measure and verify prototype designs. USB M Series devices and National Instruments LabVIEW SignalExpress interactive measurement software bring benchtop measurements to the PC. With NI LabVIEW SignalExpress, you can quickly create design verification tests. The fast acquisition and generation rates of high-performance USB M Series high-speed devices along with LabVIEW SignalExpress provide fast design analysis. You can convert your tested and verified LabVIEW SignalExpress projects to LabVIEW applications for immediate M Series DAQ use, and bridge the gap between test, control, and design applications.

USB M Series for OEMs

Shorten your time to market by integrating National Instruments OEM products in your design. Board-only versions of USB M Series DAQ devices are available for OEM applications, with competitive quantity pricing and software customization. The NI OEM Elite Program offers free 30-day trial kits for qualified customers. Visit **ni.com/oem** for more information.

Recommended Training and Services

All M Series devices are available with additional warranty and calibration services. For new data acquisition programmers, NI recommends the "Data Acquisition: 7 Steps to Success" tutorial kit. This tutorial kit helps shorten development time for data acquisition applications by describing the various stages of getting started with DAQ including system definition, setup, test, and application programming.

Recommended Software

National Instruments measurement services software, built around NI-DAQmx driver software, includes intuitive application programming interfaces, configuration tools, I/O assistants, and other tools designed to reduce system setup, configuration, and development time. National Instruments recommends using the latest version of NI-DAQmx driver software for application development in National Instruments LabVIEW, LabVIEW SignalExpress, LabWindows/CVI, and Measurement Studio. To obtain the latest version of NI-DAQmx, visit **ni.com/support/daq/versions**. NI measurement services software speeds up your development with features including:

- A guide to create fast and accurate measurements with no programming using DAQ Assistant
- Automatic code generation to create your application in LabVIEW; LabWindows/CVI; LabVIEW SignalExpress; and Visual Studio .NET, C/C++/C#, or Visual Basic using Measurement Studio
- Multithreaded streaming technology for 1,000 times performance improvements
- Automatic timing, triggering, and synchronization routing to make advanced applications easy
- More than 3,000 free software downloads to jump-start your project available at **ni.com/zone**
- Software configuration of all digital I/O features without hardware switches/jumpers
- Single programming interface for analog input, analog output, digital I/O, and counters on hundreds of multifunction DAQ hardware devices

M Series devices are compatible with the following versions (or later) of NI application software – LabVIEW, LabWindows/CVI, or Measurement Studio versions 7.x or LabVIEW SignalExpress 2.x.

Recommended Accessories (Mass-Termination Versions)

Signal conditioning is required for sensor measurements or voltage inputs greater than 10 V. NI SCC products, which are designed to increase the performance and reliability of your data acquisition system, are up to 10 times more accurate than using terminal blocks alone. Refer to Table 2 for more information or visit **ni.com/sigcon**.

Sensor/Signals (>10 V)		
System Description	**Cable**	**Carrier**
SCC Signal Conditioning	SH68-68-EP	SCC
Sensor/Signals (<10 V)		
System Description	**Cable**	**Terminal Block**
Screw Terminal (Shielded)[2]	SH68-68-EP	SCC-68[1]
BNC Connectivity	SH68-68-EP	BNC-2110
Screw Terminal (Nonshielded)[2]	R68-68	SCC-68[1]
Screw Terminal (Shielded)[2, 3]	SH68-68-S	SCB-68

[1]Includes SCC signal conditioning.
[2]Consider the integrated screw termination version of the USB DAQ device.
[3]For use with Connector 1 on USB-6225 and USB-6255 devices.

Table 2. Recommended Accessories

Ordering Information

NI USB-6221
- Screw terminal ..... 779808-0P[1]

NI USB-6225
- Screw terminal ..... 779973-0P[1]
- Mass terminal ..... 779974-0P[1]

NI USB-6229
- Screw terminal ..... 779810-0P[1]

NI USB-6251
- Screw terminal ..... 779627-0P[1]
- Mass terminal ..... 779694-0P[1]

NI USB-6255
- Screw terminal ..... 779958-0P[1]
- Mass terminal ..... 779959-0P[1]

NI USB-6259
- Screw terminal ..... 779628-0P[1]
- Mass terminal ..... 779695-0P[1]

Includes NI-DAQmx software.
[1] P is 1 (U.S. 120 VAC); 2 (Swiss 220 VAC); 3 (Australian 240 VAC); 4 (Universal Euro 240 VAC); 6 (United Kingdom 240 VAC); 7 (Japanese 100 VAC)
Includes data acquisition driver software, 1 m USB cable, and AC adapter.

Board-Only Devices for OEM

NI USB-6221 OEM (qty 1) 195959-02
NI USB-6225 OEM (qty 1) 197294-01
NI USB-6229 OEM (qty 1) 195959-01
NI USB-6251 OEM (qty 1) 194929-03
NI USB-6255 OEM (qty 1) 197201-01
NI USB-6259 OEM (qty 1) 194929-01

Accessories

Cables
- SH68-68-EP (shielded) 184749-01
- SH68-68-S (for USB-62x5) 185262-01
- R6868 (unshielded ribbon) 182482-01

Terminal Blocks and Signal Conditioning Carrier
- SCC-2345 carrier 777458-01
- SCC-68 screw-terminal block for mass termination 779475-01
- SCB-68 screw-terminal block for mass termination 776844-01
- BNC-2110 BNC terminal block for mass termination 777643-01

Data Acquisition Services

Data Acquisition: 7 Steps to Success 779489-01

BUY NOW!

For complete product specifications, pricing, and accessory information, call 800 813 3693 (U.S.) or go to **ni.com/usb**.

Specifications

>> For complete specifications, see the *NI 622x Specifications* and the *NI 625x Specifications* manuals at **ni.com/manuals**.

Specifications listed below are typical at 25 °C unless otherwise noted.

Analog Input

Number of channels	
USB-6221/6251	8 differential or 16 single ended
USB-6229/6259	16 differential or 32 single ended
USB-6225/6255	40 differential or 80 single ended
ADC resolution	16 bits
Maximum sampling rate	
USB-6221/6225/6229	250 kS/s single channel, 250 kS/s multichannel (aggregate)
USB-6251/6259	1.25 MS/s single channel, 1.00 MS/s multichannel (aggregate)
USB-6255	1.25 MS/s single channel, 750 kS/s multichannel (aggregate)
Input coupling	DC
Input range	
USB-6221/6225/6229	±10, ±5, ±1, ±0.2 V
USB-6251/6255/6259	±10, ±5, ±2, ±1, ±0.5, ±0.2, ±0.1 V
Maximum working voltage for analog inputs (signal + common mode)	±11 V of AI GND
Input impedance	
Device on	
AI+ to AI GND	>10 GΩ in parallel with 100 pF
AI– to AI GND	>10 GΩ in parallel with 100 pF
Device off	
AI+ to AI GND	820 Ω
AI– to AI GND	820 Ω
Input bias current	±100 pA
Crosstalk (at 100 kHz)	
Adjacent channels	-75 dB
Nonadjacent channels	
USB-6221/6225/6229	-90 dB
USB-6251/6255/6259	-95 dB
Input FIFO size	4,095 samples
Scan list memory	4,095 entries
Data transfers	NI signal streaming on USB, programmed I/O

Analog Triggers (USB-625x Devices Only)

Functions	Start Trigger Reference Trigger Pause Trigger Sample Clock Convert Clock Sample Clock Timebase
Modes	Analog edge triggering, analog edge triggering with hysteresis, and analog window triggering
Resolution	10 bits, 1 in 1,024

Analog Output

Number of channels	
USB-6221/6225/6251/6255	2
USB-6229/6259	4
DAC resolution	16 bits
Maximum update rate	
USB-6221/6225/6229	
1 channel	833 kS/s
2 channels	740 kS/s per channel
3 channels	666 kS/s per channel
4 channels	625 kS/s per channel
USB-6251/6255/6259	
1 channel	2.86 MS/s
2 channels	2.00 MS/s per channel
3 channels	1.54 MS/s per channel
4 channels	1.25 MS/s per channel
Timing accuracy	50 ppm of sample rate
Timing resolution	50 ns
Output range	
USB-6221/6225/6229	±10 V
USB-6251/6255/6259	±10 V, ±5 V, ±external reference on APFI <0..1>
Output coupling	DC
Output impedance	0.2 Ω
Output current drive	±5 mA
Output FIFO size	8,191 samples shared among channels used
Data transfers	NI signal streaming, programmed I/O

Calibration (AI and AO)

Recommended warm-up time	15 minutes
Calibration interval	
USB-6221/6225/6229	1 year
USB-6251/6255/6259	2 years

Digital I/O/PFI

Static Characteristics

Number of channels	
USB-6221/6225/6251/6255	24 total, 8 (P0.<0..7>), 16 (PFI <0..7>/P1, PFI <8..15>/P2)
USB-6229/6259	48 total, 32 (P0.<0..31>), 16 (PFI <0..7>/P1, PFI <8..15>/P2)
Ground reference	D GND
Direction control	Each terminal individually programmable as input or output
Pull-down resistor	50 kΩ typical, 20 kΩ minimum

Waveform Characteristics (Port 0 Only)

Terminals used	
USB-6221/6225/6251/6255	Port 0 (P0.<0..7>)
USB-6229/6259	Port 0 (P0.<0..31>)
Port/sample size	
USB-6221/6225/6251/6255	Up to 8 bits
USB-6229/6259	Up to 32 bits
Waveform generation (DO) FIFO	2,047 samples
Waveform acquisition (DI) FIFO	2,047 samples
DI sample clock frequency	0 to 1 MHz, system dependent
DO sample clock frequency	
Regenerate from FIFO	0 to 10 MHz
Streaming from memory	0 to 1 MHz, system dependent
Data transfers	NI signal streaming, programmed I/O

PFI/Port 1/Port 2 Functionality

Functionality	Static digital input, static digital output, timing input, timing output
Timing output sources	Many AI, AO, counter, DI, DO timing signals
Debounce filter settings	125 ns, 6.425 µs, 2.56 ms, disable; high and low transitions; selectable per input

General-Purpose Counter/Timers

Number of counter/timers	2
Counter measurements	Edge counting, pulse, semiperiod, period, two-edge separation
Position measurements	X1, X2, X4 quadrature encoding with Channel Z reloading; two-pulse encoding
Output applications	Pulse, pulse train with dynamic updates, frequency division, equivalent time sampling
Internal base clocks	80 MHz 20 MHz 0.1 MHz
Base clock accuracy	50 ppm
Inputs	Gate, Source, HW_Arm, Aux, A, B, Z, Up_Down
Data transfers	NI signal streaming, programmed I/O

Frequency Generator

Number of channels	1
Base clocks	10 MHz, 100 kHz
Divisors	1 to 16
Base clock accuracy	50 ppm

Output can be available on any PFI or RTSI terminal

Phase-Locked Loop (PLL)

Number of PLLs	1
Reference signal	PXI_STAR, PXI_CLK10, RTSI <0..7>
Output of PLL	80 MHz timebase; other signals derived from 80 MHz timebase including 20 MHz and 100 kHz timebases

External Digital Triggers

Source	Any PFI, RTSI, PXI_TRIG, PXI_STAR
Polarity	Software-selectable for most signals
Analog input function	Start Trigger Reference Trigger Pause Trigger Sample Clock Convert Clock Sample Clock Timebase
Analog output function	Start Trigger Pause Trigger Sample Clock Sample Clock Timebase
Counter/timer functions	Gate, Source, HW_Arm, Aux, A, B, Z, Up_Down
Digital waveform generation (DO) function	Sample Clock
Digital waveform acquisition (DI) function	Sample Clock

Bus Interface

USB	Hi-Speed USB or full-speed USB
NI signal streaming	4 high-speed data streams; can be used for analog input, analog output, digital input, digital output, counter/timer 0, counter/timer 1

Power Requirements

USB power supply requirements	11 to 30 VDC, 20 W

Power Limits

+5 V terminal	1 A max
P0/PFI/P1/P2 and +5 V terminals combined	2 A max
Power supply fuse	2 A, 250 V

Physical Requirements

Enclosure dimensions (includes connectors)	
Screw termination	26.67 by 17.09 by 4.45 cm (10.5 by 6.73 by 1.75 in.)
Mass termination	18.8 by 17.09 by 4.45 cm (7.4 by 6.73 by 1.75 in.)

Environmental

Operating temperature	0 to 45 ºC
Storage temperature	-20 to 70 ºC
Humidity	10 to 90% RH, noncondensing
Maximum altitude	2,000 m
Pollution degree (indoor use only)	2

Safety

This product is designed to meet the requirements of the following standards of safety for electrical equipment for measurement, control, and laboratory use:

- IEC 61010-1, EN 61010-1
- UL 61010-1, CSA 61010-1

Note: For UL and other safety certifications, refer to the product label or visit **ni.com/certification**, search by model number or product line, and click the appropriate link in the Certification column.

Electromagnetic Compatibility

This product is designed to meet the requirements of the following standards of EMC for electrical equipment for measurement, control, and laboratory use:

- EN 61326 EMC requirements; Minimum Immunity
- EN 55011 Emissions; Group 1, Class A
- CE, C-Tick, ICES, and FCC Part 15 Emissions; Class A

Note: For EMC compliance, operate this device according to product documentation.

CE Compliance

This product meets the essential requirements of applicable European Directives, as amended for CE marking, as follows:

- 2006/95/EC; Low-Voltage Directive (safety)
- 2004/108/EC; Electromagnetic Compatibility Directive (EMC)

Note: Refer to the Declaration of Conformity (DoC) for this product for any additional regulatory compliance information. To obtain the DoC for this product, visit **ni.com/certification**, search by model number or product line, and click the appropriate link in the Certification column.

Waste Electrical and Electronic Equipment (WEEE)

EU Customers: At the end of their life cycle, all products must be sent to a WEEE recycling center. For more information about WEEE recycling centers and National Instruments WEEE initiatives, visit **ni.com/environment/weee.htm**.

Environmental Management

NI is committed to designing and manufacturing products in an environmentally responsible manner. NI recognizes that eliminating certain hazardous substances from our products is beneficial not only to the environment but also to NI customers.

For additional environmental information, refer to the NI and the Environment Web page at **ni.com/environment**. This page contains the environmental regulations and directives with which NI complies, as well as any other environmental information not included in this document.

Management Methods for Controlling Pollution Caused by Electronic Information Products Regulation (China RoHS)

电子信息产品污染控制管理办法（中国 RoHS）

中国客户 National Instruments 符合中国电子信息产品中限制使用某些有害物质指令 (RoHS)。关于 National Instruments 中国 RoHS 合规性信息，请登录 ni.com/environment/rohs_china。(For information about China RoHS compliance, go to ni.com/environment/rohs_china.)

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NI training is the fastest, most certain route to productivity with our products. NI training can shorten your learning curve, save development time, and reduce maintenance costs over the application life cycle. We schedule instructor-led courses in cities worldwide, or we can hold a course at your facility. We also offer a professional certification program that identifies individuals who have high levels of skill and knowledge on using NI products. Visit **ni.com/training**.

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In offices worldwide, our staff is local to the country, giving you access to engineers who speak your language. NI delivers industry-leading technical support through online knowledge bases, our applications engineers, and access to 14,000 measurement and automation professionals within NI Developer Exchange forums. Find immediate answers to your questions at **ni.com/support**.

We also offer service programs that provide automatic upgrades to your application development environment and higher levels of technical support. Visit **ni.com/ssp**.

Hardware Services

NI Factory Installation Services

NI Factory Installation Services (FIS) is the fastest and easiest way to use your PXI or PXI/SCXI combination systems right out of the box. Trained NI technicians install the software and hardware and configure the system to your specifications. NI extends the standard warranty by one year on hardware components (controllers, chassis, modules) purchased with FIS. To use FIS, simply configure your system online with **ni.com/pxiadvisor**.

Calibration Services

NI recognizes the need to maintain properly calibrated devices for high-accuracy measurements. We provide manual calibration procedures, services to recalibrate your products, and automated calibration software specifically designed for use by metrology laboratories. Visit **ni.com/calibration**.

Repair and Extended Warranty

NI provides complete repair services for our products. Express repair and advance replacement services are also available. We offer extended warranties to help you meet project life-cycle requirements. Visit **ni.com/services**.

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351497B-01 2007-9287-301-101-D

Elgar Electronics Corp.

SG Series

Programmable Precision DC Power Supply

5 kW - 150 kW // 40 V - 600 V

Product Validation

Production ATE

Burn-In

DC Bus Power

LXI Ethernet

For Further Information or Sales Support
Contact Elgar Electronics Corporation
www.Elgar.com 858.450.0085

Overview

The SG series represents the next generation of high power programmable DC power supplies. Designed for exceptional load transient response, low noise and the highest power density in the industry. The industry leading power density is enhanced by a stylish front air intake allowing supplies to be stacked without any required clearance between units.

At the heart of the SG series is a 5 kW power module. Depending on the output voltage, one to six modules can be configured in a single chassis to deliver 5 kW to 30 kW of power. Combinations of these chassis can then be easily paralleled to achieve power levels up to 150 kW. Paralleled units operate like one single supply providing total system current. Available in two control versions, the SGA has basic analog controls, while the SGI provides intelligent control features

SGI: Advanced Intelligent Control

(Sorensen General purpose Intelligent) The SGI combines onboard intelligent controls with the outstanding power electronics common to all SG family supplies. These controls enable sophisticated sequencing, constant power mode and save/recall of instrument settings. Looping of sequences makes the SGI idea for repetitive testing. An impressive vacuum fluorescent graphical display in eight languages, context sensitive "soft" keys and front panel keyboard simplify programming of the SGI.

SGA: Outstanding Value - Analog Control

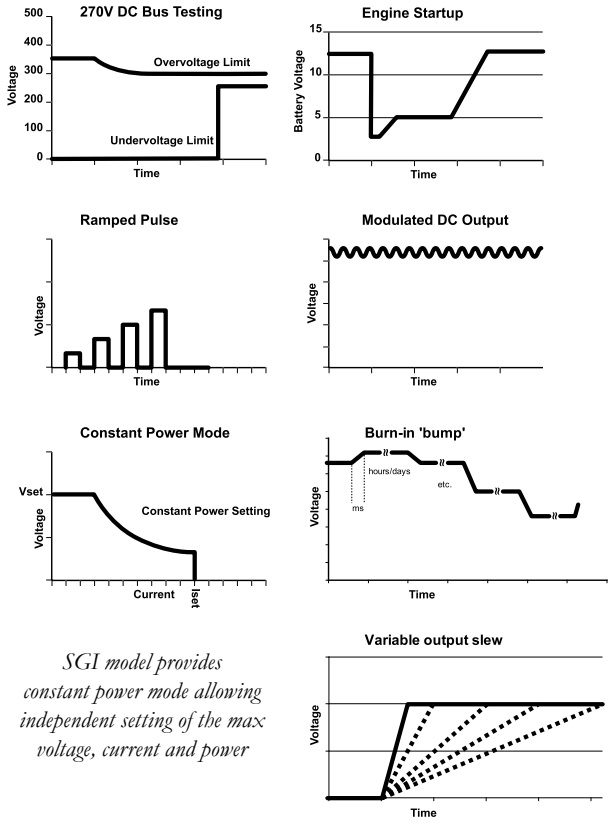
(Sorensen General purpose Analog) The SGA, with its industry leading price performance, is available for customers requiring simple front panel analog controls or external control. With the same high performance power electronics as the SGI, the SGA provides essential features like 10- turn potentiometers for setting voltage and current, 3 ½ digit LED readout plus front panel over-voltage protection (OVP) preview/adjustment and reset.

SGI / SGA Comparison Chart

Feature	SGA	SGI
Modular Design	•	•
Fast Load Transient	•	•
Parallelable	•	•
Analog & Digital Summing	Optional	•
Direct Front Panel V/I Control	•	•
3½ Digit LED Readout	•	
Graphics Display		•
Sequencing		•
Save/Recall Setups		•
System Power Readouts		•
Constant Power Mode		•
IEEE-488.2/RS-232C	Optional	RS-232C Std IEEE-488.2 Optional
LXI Compliant Ethernet	Optional	Optional

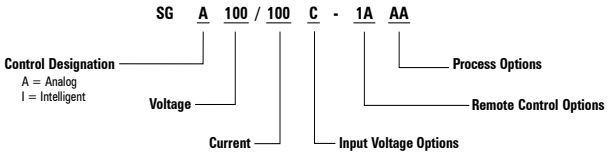
LXI Compliant Ethernet

Advanced Power Simulation



SGI model provides constant power mode allowing independent setting of the max voltage, current and power

SGI / SGA Model Number Description



Options and Accessories

Control Options:
- A: Analog
- I: Intelligent

Input Options:
- C: Input Voltage 187 / 242VAC, 3 Phase
- D: Input Voltage 342 / 440VAC, 3 Phase
- E: Input Voltage 396 / 528VAC, 3 Phase

Remote Control Options:
- 0A: No Option
- 1A: IEEE-488.2 + RS-232C
- 1C: Ethernet + RS-232C
- 1D: Isolated Analog Control
- 1E: Shaft Locks (SGA series only)

Contact factory for other combinations

Process Options:
- AA: No option
- AB: Certificate of Calibration (includes Test Data)

Accessories:
- 890-453-03: Paralleling Cable (for up to 5 units, requires one cable per unit placed in parallel)
- K550212-01: 3U Rack Slides (for 5kW, 10kW and 15kW models)
- K550213-01: 6U Rack Slides (for 20kW, 25kW and 30kW models)

Applications

Process Control

Whether you are controlling ion beams for the manufacture of semiconductors, or driving a current through electrolyte for precise control in a plating process, the SG series is an ideal choice with it's small size, reliable modular design and standard analog programmability. Direct control of V and I along with monitoring of the actual voltage and current, provides a simple interface for your PLC or other type of analog controller.

Product Development

Testing & Burn-in of DC-DC converters, laser diodes, automotive and semiconductor components and aircraft flight hardware are just a few of the items being tested using the SG product family. From simple front panel control to complex test sequences for compliance testing, the SG series will keep pace with your changing application needs.

Research

A research environment presents some of the most demanding requirements on your test instrumentation. Equipment that is sufficient today, may not meet the needs of the next project. With the SG series this is no longer a problem. The modular design allows you to easily upgrade to higher power levels in the future, or parallel units to achieve up to 150 kW. With the sophisticated sequencing capability of the SGI model, you can build an infinite variety of test or diagnostic programs and have them execute directly from the power supply.

Automotive Component Test

The 16-bit resolution and Ethernet enabled hardware triggering allows for detailed sequencing associated with battery fluctuation simulation. The tight load regulation capability of the SG series makes it a superior source for validation and acceptance testing and burn-in of automotive components. The 40V models, in particular, provide a full range of testing to simulate battery conditions. Margin testing of components, such as electronic control units (ECU) and electromechanical components, is easily achieved.

Rackmount ATE Systems

The high power density of the SG series makes it ideal for ATE System integration. The wide variety of voltage and current combinations in 3U and 6U heights allows multiple voltage outputs in a small amount of space. The wide variety of control methods possible, allows easy integration into legacy systems as well as high speed systems.

Battery Charging

The SG series provides high accuracy voltage output to optimize battery charging. Battery charging requires high accuracy voltage and stable current output. With the remote interface options, the charging process can easily be automated for volume production.

Applications

Burn-In	**Compliance Testing**
Materials Research	**Process Control**
Product Validation	**Automotive Electronics**
Rackmount ATE Systems	**Battery Charging**

*See the **SFA** product brochure for very high current slew rate and low stored energy applications.*

Key Features

- **High Power Density:** Up to 15 kW in a 3U / 30 kW in a 6U chassis
- **Wide Voltage Range:** 0-40V up to 0-600V, in increments of 5 kW from 5 to 30 kW
- **Fast Load Transient Response:** Protection from undesired voltage excursions
- **Low Ripple and Noise:** Suitable for the most sensitive applications
- **Parallelable up to 150 kW:** Expandable as your requirement grows
- **Modular Design:** Upgradeable for the ultimate in investment protection.
- **Sequencing:** Program custom waveforms
- **Easy-to-read Fluorescent Display:** SGI supports English, French, German, Italian, Spanish, Chinese, Japanese, and Korean languages
- **16-bit Resolution:** Optional IEEE-488.2 + RS-232C or Ethernet provides precise control
- **Ethernet Control:** LXI Class C compliant communication with integrated web server
- **Direct Relay Control:** Control output and sense isolation relays, along with polarity relays. (Ethernet Option Only)
- **Hardware Trigger:** Ethernet Option Only
- **5 Year Warranty**

Product Specifications

Common	
Remote Sense	Load-line loss compensation for models <= 100 V is 10% above full scale voltage total (5% per load-line), and models > 100 V is 4% above full scale voltage total (2% per load-line).
Parallel Operation	Up to 5 units may be paralleled for additional current within the power supply single-unit specifications, with exception of the DC output current set accuracy. Additional paralleled SG units will add 0.3% inaccuracy per unit. To parallel more than 5 units, contact factory.
Series Operation	Up to 2 units (see Output Float Voltage)
Input	
Nominal Voltage 3 phase, 3 wire + ground	208/220 VAC (operating range 187 - 242 VAC) 380/400 VAC (operating range 342 - 440 VAC) 440/480 VAC (operating range 396 - 528 VAC)* *Optional
Frequency	47 – 63Hz
Power Factor	>0.9 typical at 208/220 VAC input >0.78 typical at 380/400 VAC input >0.69 typical at 440/480 VAC input
Protection	½ cycle ride-though on all three phases, 3 cycle ride through on single phase; missing phase shutdown
Environmental	
Operating Temperature	0 to 50° C
Storage Temperature	-25° C to 65° C
Humidity Range	Relative humidity up to 95% non-condensing, 0° C – 50° C
Altitude	Operating full power available up to 5,000 ft. (~1,500 m), derate 10% of full power for every 1,000 feet higher; non-operating to 40,000 ft. (~12,000 m)
Cooling	Front and side air inlet, rear exhaust. Units may be stacked without spacing.
Regulatory	Certified to UL/CSA 61010 and IEC/EN 61010-1, CE Compliant, Semi-F47 Compliant
Physical	
Dimensions	Width: 19.00" (48.3 cm), Depth 25.0" (63.5 cm) Height: 5-15 kW units: 3U – 5.25" rack mount (13.34 cm) 20-30 kW units: 6U – 10.5" rack mount (26.67 cm)
Weight	3U < 80 lbs. (36 kg) 6U <160 lbs. (73 kg)
Shipping Weight	See web site for more product & shipping weights.

Output: Voltage and Current Ranges

	3U			6U			Ripple & Noise	
Power	5 kW	10 kW	15 kW	20 kW	25 kW	30 kW	rms (20 Hz-300 kHz)	p-p (20 Hz-20 MHz)
Voltage	Current							
40	125	250	375	500*	625*	750*	20 mV	75 mV
60	83	167	250	333	417	500	20 mV	75 mV
80	63	125	188	250	313	375	20 mV	100 mV
100	50	100	150	200	250	300	20 mV	100 mV
160	31	63	94	125	156	188	25 mV	150 mV
200	25	50	75	100	125	150	25 mV	175 mV
250	20	40	60	80	100	120	30 mV	200 mV
330	15	30	45	61	76	91	30 mV	200 mV
400	12	25	38	50	63	75	30 mV	300 mV
600	8	17	25	33	42	50	60 mV	350 mV

** By way of paralleling 5 kW, 10 kW & 15 kW supplies*

Output	
Ripple & Noise (Voltage Mode)	Ripple and noise, typical, measured at full load, nominal AC input. Noise measured with 6 ft. cable, 1μf at load.
Ripple (Current Mode)	<+/- 0.04% of full scale rms current
DC Voltage Slew Rate	100 ms 5-95% of full scale typical (Contact factory for model specific slew rates)
DC Current Slew Rate	45A / ms typical
Line Regulation	(±10% of nominal AC input, constant load) Voltage Mode: +/- 0.01% of full scale Current Mode: +/- 0.05% of full scale
Load Regulation	(no load to full load, nominal AC input) Voltage Mode: +/- 0.02% of full scale Current Mode: +/- 0.1% of full scale
Load Transient Response	Recovers within 1ms to +/-0.75% of steadystate output for a 50% to 100% or 100% to 50% load change
Efficiency	87% typical at nominal line and max load
Stability	±0.05% of set point after 8 hrs. warm-up at fixed line, load and temperature
Temperature Coefficient	0.02%/ C of maximum output voltage rating for voltage set point 0.03%/ C of maximum output current rating for current set point
Output Float Voltage	Negative terminal within +/- 150 V of chassis potential.

Programming & Read-back Specifications

	Programming		Read-Back / Monitoring		
	Accuracy	Resolution	Accuracy	Resolution	
Front panel Display	SGA: +/- (0.5%fs + 1 digit) SGI, Voltage: +/- 0.1% of full scale SGI, Current: +/- 0.4% of full scale	SGA: 3.5 digits SGI: 4.0 digits	SGA: +/- (0.5%fs + 1 digit) SGI, Voltage: +/- 0.1% of full scale SGI, Current: +/- 0.4% of full scale	SGA: 3.5 digits SGI: 4.0 digits	Knob control & Display read-back
Remote Analog Interface	Voltage: +/-0.25% of full scale for 0-5 V range, +/-0.5% of full scale for 0-10 V range Current: 0.8% of full scale	NA	+/-1.0% of full scale (0 - 10V)	NA	25-pin D-sub connector (0~5 V or 0~10 V)
Remote Digital Interface	Voltage: +/- 0.1% of full scale, Current: +/- 0.4% of full scale	+/-0.002% of full scale	Voltage: +/- 0.15% of full scale, Current: +/- 0.4% of full scale	+/-0.002% of full scale	RS-232C (Standard on SGI), Optional IEEE-488.2 and Optional LXI Compliant 10/100 base-T Ethernet (see Options)
OVP	+/- 1% of full scale	+/-0.002% of full scale			Programming range: 5-110% Configured from front panel, remote analog or via optional digital inputs
User I/O	Disconnect & Polarity-reversal relay control (Only available with Ethernet Option)				Digital 10-pin Molex type connector See www.elgar.com/go/pinouts
Software	IVI & CVI drivers available under SUPPORT at: www.Elgar.com				

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SERIES **BOP**

Analog Meters
Model BOP 50-2M (top) and BOP 100-4M (bottom)
100, 200 and 400 Watt Linear High-Speed Amplifiers

Digital Meters
Model BOP 20-5D (top) and BOP 72-6D (bottom)
100, 200 and 400 Watt Linear High-Speed Amplifiers

BOP, while fully rated power supplies, are also high-powered operational amplifiers with full 4-quadrant, bipolar operation. Their output is capable of both sustained d-c and the replication of arbitrary a-c waveforms.

In Kepco's BOP, the voltage and current outputs can be controlled smoothly and linearly through the entire rated plus and minus ranges, passing smoothly through zero with no polarity switching.

BOP are high speed power operational amplifiers that can be used to provide dynamically agile voltage for test and simulation. They are *not* general purpose power supplies. By the nature of the bipolar high speed design, they do not have any energy-storage noise discriminating output capacitors. To realize the full high speed potential of BOP, the load characteristics should be mainly resistive. If the load is capacitive, (>0.1 microfarad), the BOP must be slowed to avoid oscillation. This is accomplished in voltage mode by increasing the value of the feedback capacitance. Special terminals on the user port are available to slow the BOP for optimum current-mode stability into inductive loading.

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Email: hq@kepcopower.com • www.kepcopower.com/bop.htm

BOP MODEL TABLE

MODEL(1) (5)	d-c OUTPUT RANGE E_o max.	I_o max.	CLOSED LOOP GAIN VOLTAGE CHANNEL G_V (V/V)	CURRENT CHANNEL G_I (A/V)	OUTPUT IMPEDANCE VOLTAGE MODE SERIES R	SERIES L(2)	CURRENT MODE SHUNT R	SHUNT C (3)
100 WATT								
BOP 20-5M	± 20V	± 5A	2.0	0.5	80μΩ	20μH	40kΩ	0.05μF
BOP 50-2M	± 50V	± 2A	5.0	0.2	0.5mΩ	100μH	50kΩ	0.05μF
BOP 100-1M	± 100V	± 1A	10.0	0.1	2.0mΩ	200μH	100kΩ	0.05μF
200 WATT								
BOP 20-10M	± 20V	± 10A	2.0	1.0	40μΩ	50μH	20kΩ	0.1μF
BOP 36-6M	± 36V	± 6A	3.6	0.6	120μΩ	50μH	36kΩ	0.1μF
BOP 50-4M	± 50V	± 4A	5.0	0.4	0.25mΩ	100μH	50kΩ	0.05μF
BOP 72-3M	± 72V	± 3A	7.2	0.3	0.48mΩ	200μH	72kΩ	0.05μF
BOP 100-2M	± 100V	± 2A	10.0	0.2	1.0mΩ	200μH	100kΩ	0.05μF
BOP 200-1M(4)	± 200V	± 1A	20.0	0.1	4.0mΩ	1.2mH	200kΩ	0.03μF
400 WATT								
BOP 20-20M	± 20V	± 20A	2.0	2.0	20μΩ	50μH	20kΩ	0.2μF
BOP 36-12M	± 36V	± 12A	3.6	1.2	60μΩ	50μH	36kΩ	0.2μF
BOP 50-8M	± 50V	± 8A	5.0	0.8	125μΩ	100μH	50kΩ	0.15μF
BOP 72-6M	± 72V	± 6A	7.2	0.6	240μΩ	200μH	72kΩ	0.1μF
BOP 100-4M	± 100V	± 4A	10.0	0.4	500μΩ	200μH	100kΩ	0.1μF

(1) For factory installed digital interfaces add appropriate suffix. See page 55.
(2) For determining dynamic impedance in voltage mode.
(3) For determining dynamic impedance in current mode.
(4) Same size as 400W models.
(5) To specify digital display, substitute the suffix letter "D" for the suffix letter "M."

FEATURES

- Source and sink 100% of their current rating. See Figure 1.
- Separate control circuits for voltage and current with automatic crossover to current and voltage limits.
- All controls and flag signals accessible through a 50-terminal user-port at the rear.
- Zeroable preamplifier available for scaling and summing external signals.
- Optional digital displays. Specify by substituting the suffix "D" in place of the "M."

This KEPCO product is backed by a firm **5-YEAR WARRANTY**

For high power bipolar power supplies, see Series BOP High Power, page 44.

For high voltage bipolar power supplies, see Series BOP-HV, page 56.

The tabulation of the effective series resistance and inductance in voltage mode, and the effective shunt resistance and shunt capacitance in current mode, is done to allow a calculation of the output impedance versus frequency.

BOP accept plug-in cards for remote digital control

- BIT 4882 provides 12-bit IEEE 488.2 talk-listen control with SCPI support.
- BIT 4886 provides 16-bit IEEE 488.2 talk-listen control with SCPI support.
- BIT TMA-27 connect BOP to Kepco's single-address multiple instrument serial bus for long range (>300m) control from IEEE 488.2, RS 232 or VXI-based hosts.
- BIT 488B or BIT 488D offer listen-only GPIB support in binary or Hex format.

Cards may be factory installed. See page 55 for appropriate suffix designations.

VXI plug&play member

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4-QUADRANT™

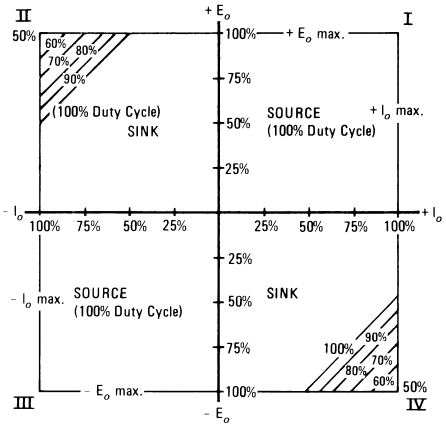

FIGURE 1
Output Source-Sink plot

TABLE 1
Source current measured worst case, 125V a-c.

MODEL	CURRENT (Amps)
BOP 20-5M	2.6
BOP 20-10M	5.5
BOP 20-20M	11.0
BOP 36-6M	5.1
BOP 36-12M	10.6
BOP 50-2M	2.6
BOP 50-4M	4.8
BOP 50-8M	9.5
BOP 72-3M	5.0
BOP 72-6M	10.8
BOP 100-1M	2.6
BOP 100-2M	4.8
BOP 100-4M	9.2
BOP 200-1M	5.5

CE BOP are CE marked per the Low Voltage Directive (LVD), EN61010-1.

BOP GENERAL SPECIFICATIONS

SPECIFICATION	RATING/DESCRIPTION	CONDITION
INPUT		
a-c Voltage	95-113, 105-125, 190-226, 210-250V a-c	User selectable
Current	See Table 1	Max load, 115V a-c
Frequency	47-65Hz	Range
OUTPUT		
d-c Output	Bi-direction, series pass	Transistor (1)
Type of stabilizer	Automatic crossover	Voltage/current
Voltage	0 to 100% of rating (bipolar)	Adjustment range for temp 0-55°C
Current	0 to 100% of rating (bipolar)	
Sink	See source/sink plot	Duty cycle
Error Sense	0.5V per load wire	Voltage allowance
Isolation Voltage	500V d-c or peak	Output to ground
Leakage Current	<5 microamperes	rms at 115V a-c 60Hz
Output to Ground	<50 microamperes	p-p at 115V a-c 60Hz
Series Connection	500V	Max voltage off ground
Parallel Connection	Current sharing	Use master-slave connection
OVP	Not available	
CONTROL		
Type — Voltage / Current	Variable input, fixed gain	
Voltage/ Current — Local	10-turn zero-center pot	
Remote Analog	-10V to +10V	
Local Digital	Serial bus or GPIB or VXI	Optional internal BIT card
Remote Digital	Use SN or SNR interface	
Bounding	±Volt/current local	Four screwdriver trimmers
	±Volt/current remote	0 to 10 volts
Dynamics	See dynamic spec table	Fast only
User Amplifiers	Uncommitted gain 20K	Two provided
References	±10 volts, 1mA	Two provided
Options (built-in) For user added card refer to "BIT" models page 55	GPIB hex card	Suffix -488B
	GPIB BCD card	Suffix -488D
	Long range serial card/VXI	Suffix -TMA
	Talk-listen 4882 card (SCPI)	Suffix -4882
	Talk-listen 4886 card (SCPI)	Suffix -4886
	Serial RS 232	Suffix -232
MECHANICAL		
Input Connection	Detachable IEC type 3-wire	All models
Output Connections	Front signal/output	Binding posts
	Rear user port	50-terminal connector
	Rear output	Barrier strip
Meters	Two 2½″ horiz., 2% zero center analog	Front panel
Indicators	Four LEDs	Voltage/Current/Bounding
Mounting (in std 19" racks)	Use RA 37 rack adapter	¾ rack size
	Mounting "ears" supplied	Full rack size
Cooling	Forced air	Exhaust to rear
Dimensions (HxWxD) add 2½″ to rear for connector — inches	5 7/32 x 12 17/32 x 17 9/64	¾ rack size
Dimensions (HxWxD) add 2½″ to rear for connector — mm	132.6 x 318.3 x 435.4	
Dimensions (HxWxD) add 2½″ to rear for connector — inches	5 7/32 x 19 x 20 5/64	Full rack size
Dimensions (HxWxD) add 2½″ to rear for connector — mm	132.6 x 482.6 x 510	
Finish; Fed Std 595	Light gray, color 26440	Front panel
Weight (packed for shipment)	47lb (21.4Kg)	¾ rack size (100W)
	53lb (24.1Kg)	¾ rack size (200W)
	76lb (34.5Kg)	Full rack size

(1) 200V model uses FET.

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BOP DYNAMIC SPECIFICATIONS

MODEL	BANDWIDTH (d-c to f_{-3dB}) KHz (minimum) Mode V	Mode I	RISE & FALL TIME 10%-90% µsec (maximum) Mode V	Mode I	LARGE SIGNAL FREQUENCY (min) RESPONSE, KHz Mode V	Mode I	SLEWING RATE (minimum) Mode V	Mode I	RECOVERY STEP LOAD µsec (maximum) Mode V	Mode I
100 WATT										
BOP 20-5M	18	12	20	30	17	13	5V/µsec	0.15A/µsec	25	10
BOP 50-2M	18	12	20	30	17	13	5V/µsec	0.15A/µsec	25	10
BOP 100-1M	18	11	17	22	18	11	11V/µsec	70mA/µsec	40	25
200 WATT										
BOP 20-10M	18	6	20	60	17	7	2V/µsec	0.4A/µsec	80	20
BOP 36-6M	16	13	20	27	15	14	3V/µsec	0.5A/µsec	50	35
BOP 50-4M	23	14	14	25	15	11	4.5V/µsec	0.25A/µsec	40	30
BOP 72-3M	20	15	18	26	17	12	10V/µsec	0.15A/µsec	30	30
BOP 100-2M	22	15	18	26	17	12	10V/µsec	0.15A/µsec	30	30
BOP 200-1M	4.0	2.5	110	150	4.0	2.5	5V/µsec	15mA/µsec	150	120
400 WATT										
BOP 20-20M	9.5	10	35	35	8	10	1V/µsec	1.25A/µsec	100	75
BOP 36-12M	20	10	16	30	19	10	4V/µsec	0.75A/µsec	50	30
BOP 50-8M	24	10	14	35	24	11	7.5V/µsec	0.5A/µsec	40	30
BOP 72-6M	19	9.5	18	40	20	11	9V/µsec	0.4A/µsec	50	20
BOP 100-4M	18	14	22	30	16	10	10V/µsec	0.25A/µsec	40	30

BOP STATIC SPECIFICATIONS

INFLUENCE QUANTITY		OUTPUT EFFECTS(1) VOLTAGE MODE TYPICAL	VOLTAGE MODE MAXIMUM	CURRENT MODE TYPICAL	CURRENT MODE MAXIMUM	PREAMPLIFIER(4) OFFSETS ΔE_{io}	ΔI_{io}	REFERENCE ± 10V
Source (min.-max.)		<0.0005%	0.001%	<0.002%	0.005%	<5µV	<1nA	<0.0005%
Load (NL-FL)		<0.001%	0.002%	<0.5mA	1mA	—	—	<0.0005%
Time (8-hour drift)		<0.005%	0.01%	<0.01%	0.02%	<20µV	<1nA	<0.005%
Temp., per °C		<0.005%	0.01%	<0.01%	0.02%	<20µV	<1nA	<0.005%
Ripple and Noise (2)	rms	<1mV	3mV(5)	<0.01%	0.03%	—	—	—
	p-p(3)	<10mV	30mV(5)	<0.1%	0.3%	—	—	—

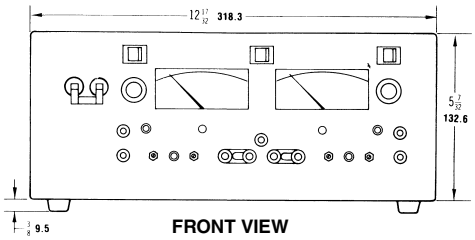
(1) Output effects, expressed as a percentage, are referred to the maximum rated output voltage or current.
(2) Measured with the common terminal grounded so that the common mode current does not flow through the load.
(3) Peak-to-peak ripple is measured over a 20Hz to 10MHz bandwidth.
(4) The output effect can be calculated by the relationship:
$\Delta E_o = \pm\Delta E_r\,(R_f/R_i) \pm \Delta E_{io}(1+R_f/R_i) \pm \Delta I_{io}(R_f)$ where R_f is the feedback resistor, and R_i is the input resistor from the reference, E_r.
(5) For BOP 200-1M the maximum ripple and noise is 5mV rms and 50mV p-p.

The tabulated offsets, more particularly their change as a function of source, time and temperature, allow a user to calculate performance of the uncommitted amplifier(s) with user specified input and feedback components. The formula for this is given in the static specifications table footnote.

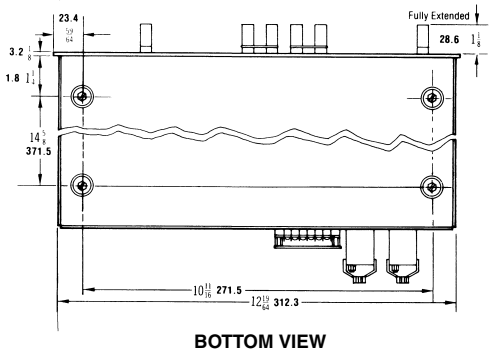
OUTLINE DIMENSIONAL DRAWINGS

Fractional dimensions in light face type are in inches,**dimensions in bold face type are in millimeters.**
Tolerance: ± 1/64" **(0.4)** between mounting holes
± 1/32" **(0.8)** other dimensions

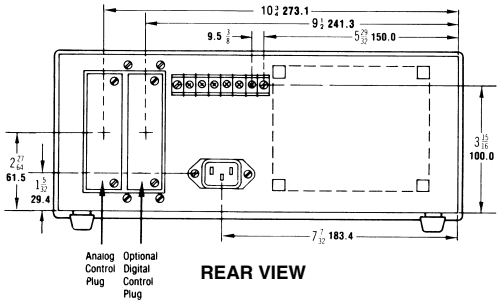
100 & 200 WATT MODELS (THREE-QUARTER RACK)



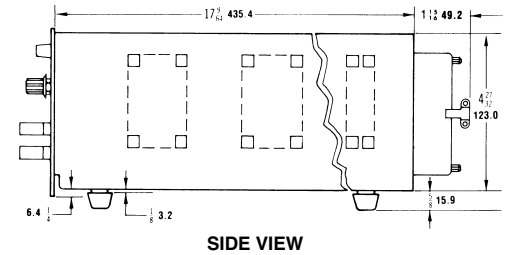
FRONT VIEW



BOTTOM VIEW

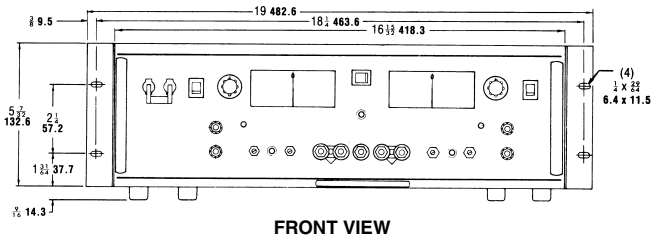


REAR VIEW

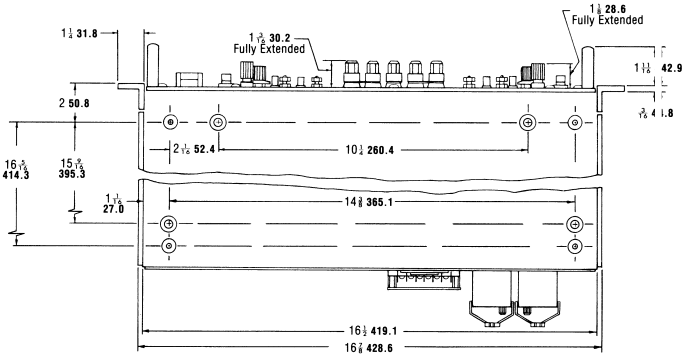


SIDE VIEW

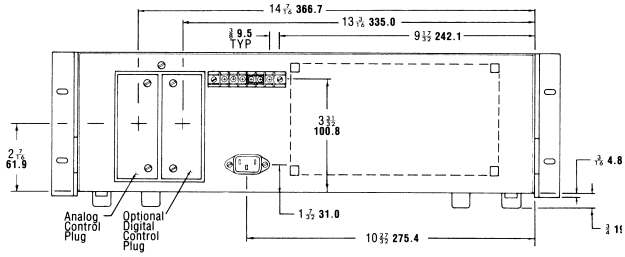
400 WATT MODELS (FULL RACK) AND BOP 200-1M



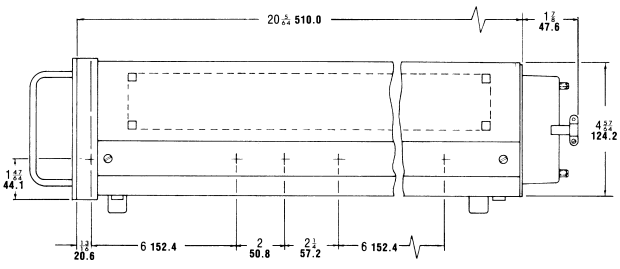
FRONT VIEW



BOTTOM VIEW



REAR VIEW



SIDE VIEW

BOP 3/4 rack width power supplies can be rack mounted using RA 37. See page 77.

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