

Series 2040 Test Systems

**VACUUM
CONTROL
SYSTEM**

Part Number #4200-0130

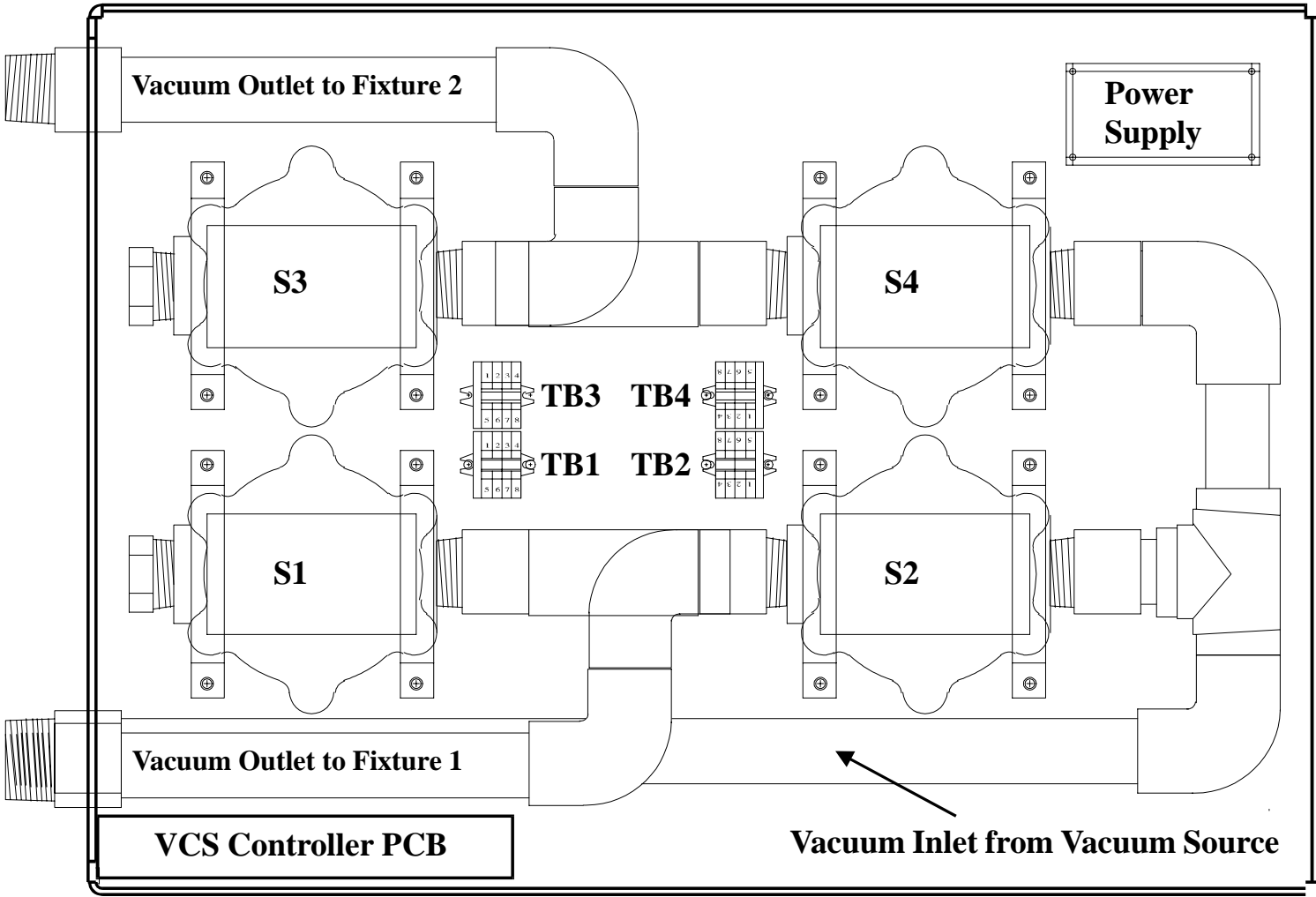
Version 1.1

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VACUUM CONTROL SYSTEMS
Model 170 & Model 180

Revision 1.1



SYSTEM OVERVIEW

The Model 170 & Model 180 Vacuum Control Systems (VCS) are designed and built to answer the need for vacuum fixture control on automatic test equipment.

The VCS is a complete, self-contained system for providing controlled vacuum to test fixtures. The opto-isolated, solid state relay controlled, full capacity diaphragm-type valves are programmable through the IEEE-488 and RS-232 interface eliminating the need for discrete wiring of relays and valves. A “discrete logic” controller is also available.

The Model 170 is a single well vacuum controller and the Model 180 controls a dual-well fixture. These systems are packaged for a 19-inch rack and use only 8.75 inches of panel space. All electrical and vacuum connections are panel mounted for installation convenience. An optional cabinet allows stand alone installation.

These systems utilize 1-inch pipe and large orifice valves to give quick vacuum fixture pulldown even in the presence of small leaks. Each model has a selftest mode to check functionality of the system.

SYSTEM OPERATION

Power-Up Condition

On power-up, the Vacuum Controller System goes through a checksum test. The test involves calculating the checksum of the entire firmware and comparing the result to the expected value. If the test passes, the exhaust valves are opened, and the vacuum valves are closed. The two LEDs are also turned on under a normal power-up condition; however, if the checksum test fails, the two LEDs flash on and off, and the controller will not accept any command. For a further discussion of the meaning of the LEDs, see the LED status section. If the LEDs flash on and off on a power-up condition, then the VCS should be turned off and Digalog should be contacted.

LED Status

The two LEDs mounted on the rear panel are used to indicate the status of the VCS. On a normal power-up, the firmware goes through a PROM checksum test. If the test passes, both of the LEDs are turned on, but if the calculated checksum is incorrect, then both LEDs will flash on and off. Under this condition, the VCS will not accept any commands and should be powered off.

During normal operation, the right LED reflects the status of vacuum pipe 1 (for models 170 and 180) and the left LED reflects the status of vacuum pipe 2 (model 180 only). If a LED corresponding to a vacuum pipe is on, this indicates that the exhaust valve is on and the vacuum valve is off (fixture raised). If a LED corresponding to a vacuum pipe is off, this indicates that the exhaust valve is off and the vacuum valve is on (fixture lowered).

Commands

The VCS accepts commands from either the IEEE-488 or RS-232 bus in ASCII form. There are only five commands that can be issued to the VCS. Four of the commands are to operate the valves. The last command requests a status byte back from the controller.

The VCS uses the following commands:

<u>Name</u>	<u>Abbrev.</u>	<u>Description</u>
open1	o1	Opens fixture 1 to the vacuum source.
open2	o2	Opens fixture 2 to the vacuum source.
close1	c1	Closes fixture 1 to the vacuum source.
close2	c2	Closes fixture 2 to the vacuum source.
status	ss	Returns the status of the valves.

Upper and lower case of the same letter are equivalent. White space is skipped. Commands may be abbreviated to their first and last characters because all other characters in between are considered white space and therefore are skipped.

The command is sent in a message format. The syntax for the command message is dependent on which protocol the message is being transmitted, i.e. IEEE-488 or RS-232. The syntax for the above commands is described in detail for each protocol in their respective sections.

RS-232 Communication

The RS-232 communication is done through connector J2 on the VCS assembly shown in Appendix A. This is a standard male DB-9 connector. The pinout for this connector is described in the Maintenance section of this manual.

Echo

The controller can communicate via RS-232 with echo on or off. This is selected by switch 2 on the switch bank. With echo on, any message received by the controller will be echoed back on the line. This is required in a setup of multi-Vacuum Control Systems connected in a daisy-chain or when using a terminal with local echo off to control the VCS. The VCS controller is factory set for echo off.

Baud rate

The RS-232 interface of the VCS can be configured to run at one of four baud rates. The baud rates are selected by switches 4 and 5 on the switch bank. The available baud rates are 9600, 4800, 2400 and 1200. The VCS controller is factory set for 9600 baud. To change the baud rate for a different setup, please refer to the Switch Settings Table in the Maintenance section of this manual.

Addresses

The VCS can be set up with one of eight possible addresses and will respond to commands only designated for its address. The address is set using switches 6-8 on the VCS Controller and ranges from \$80 to \$87. Switch settings for the different addresses are shown in the Switch Settings Table in the Maintenance section. The VCS controller is factory set for address \$81 for RS-232 communication. This address must be specified in the command message which is discussed in the next section.

Command Message

The RS-232 command messages use OPTO 22 compatible syntax for serial communication. The command message consists of three sections. The first section contains the start of command character, '>', followed by two ASCII-hex digits representing the address of the VCS. The address of the VCS is set with a switch on the controller board. The VCS will only respond to commands sent to the correct address

allowing for multiple devices on the serial bus. The VCS base address is \$80. There is a switch on the controller board which will allow the VCS to respond to one address between \$80 and \$87. The VCS is factory set for address \$81, so a command message could start with '>81.'

The second part of the message contains the command. Recall that the valid commands are open1, open2, close1, close2, and status. Also, recall that the commands can be abbreviated and use either lower or upper case letters.

The third and final part of the message contains a one-byte checksum followed by a command terminator character. The checksum is calculated by adding the ASCII value of each character in the command message except for the start of command character '>.' The sum is then divided by 256 and the integer remainder is the checksum. The checksum is always sent as a two digit hexadecimal number. An example message with the checksum calculation is shown below. Valid command terminators are a '.' or a carriage return. Two ASCII question mark characters, '?,' can be used as a wildcard checksum for debugging purposes, but should not be used for the final application.

The command to open fixture 1 to vacuum on a VCS addressed as \$81 is '>81o109.' The checksum is calculated as follows:

ASCII characters: 8 1 o 1
Decimal equivalent: 56 + 49 + 111 + 49 = 265
 $265/256 = 1$ with a remainder of 9
The checksum characters are 09.

ACK and NACK

When the host computer sends a command to the VCS via RS-232 the VCS sends back a message stating whether or not the command was executed successfully or not. If the command was executed successfully, the VCS will return an 'A' followed by a carriage return. If the command was not executed successfully, the VCS will return an 'N' followed by a two-digit error code and a carriage return, i.e. N05cr. Errors returned from VCS are listed on the next page.

VCS Error codes

<u>Value</u>	<u>Description</u>
01	Unknown Error
02	Buffer Overrun
03	Bad Checksum
04	Bad Terminator
05	Bad Command Sequence

If the status command was sent to the VCS, it will return an 'A' followed by the status, a two-digit checksum, and a carriage return. A typical message would be 'A0161cr'. The 'A' means the status command was executed correctly, the '01' means fixture one is open to vacuum and fixture two is closed to vacuum. The hex value '61' is the checksum of the '01'. Finally, the carriage return, 'cr,' is the message terminator.

IEEE-488 Communication

The IEEE-488 communication is passed through connector J1 on the VCS assembly shown in Appendix A. This is a standard 24-pin IEEE-488 connector.

VCS Configuration

The TMS9914A General Purpose Interface Bus Controller is the IEEE-488 chip used on the VCS. On power-up the IEEE-488 address is read from the switch bank and stored in the TMS9914A. It is then put in listen-only mode where the chip listens for its address to be put on the IEEE-488 bus. When the VCS is addressed, the TMS9914A does all the handshaking of the command message and stores the command in the VCS buffer where the command is read and executed. The VCS will remain in listen only mode until the IEEE-488 controller puts it in talk mode. This is normally done after a status command has been issued. The VCS will then write the status of the fixtures on the IEEE-488 bus. After the VCS is done talking, the IEEE-488 controller puts the VCS back into the listen only mode.

The VCS supports the IEEE-488 protocol of sending the EOI message with the last byte of a response. It also supports the Device Clear command by resetting the LEDs and vacuum valves into the power-up state. The VCS issues a release DAC holdoff after it has been reset by a Device Clear command.

Command Message

The IEEE-488 command message is slightly different than the RS-232 message. The IEEE-488 command message does not have a start of command character, '>.' The IEEE-488 device has a specific address which is determined by five bits in the switch setting on the VCS Controller (see page 16). The host computer software will issue commands to the VCS device specified with the correct address. The open, close, and status commands remain the same, and a '.' is the command message terminator. The IEEE-488 protocol does not use a checksum. A typical message to open fixture one to vacuum is 'o1.'

ACK and NACK

The VCS does not respond with an ACK or a NACK when using the IEEE-488 protocol.

Return Message

The VCS only returns a message when asked for the status. When the status command is sent to the VCS, it will return only the status. A typical message would be '01.' The '01' means fixture one is open to vacuum and fixture two is closed to vacuum. No ACK or NACK is returned, and neither is a checksum nor message terminator.

Sample Visual BASIC Program

Instead of using the GPIB functions and the low level vacuum controller command messages, there is a Visual BASIC function called 'fixture()' that can be used to raise and lower the fixture wells. This function is distributed with the vacuum controller. It is contained in two Visual BASIC files. They are called 'gpib.bas' and 'fixture.bas' and are located in the '..\Digalog\Include' directory. If they are added to a Visual BASIC project the functional call 'fixture()' can be used.

This functional call controls the raising or lowering of the left and right fixture well connected to the vacuum controller. It has the following syntax:

Call Fixture(ByVal Side As Integer, ByVal Position As Integer)

WHERE:**Side**

- = 1 Left fixture well (connected to vacuum controller fixture pipe #1).
- = 2 Right fixture well (connected to vacuum controller fixture pipe #2).

Position

- = 1 Raise the fixture well.
- = 2 Lower the fixture well.

EXAMPLES:

' Raise the fixture well connected to vacuum controller pipe #1
Call Fixture(1, 1)

'Lower the fixture well connected to vacuum controller pipe #2
Call Fixture(2, 2)

Discrete Controller

The Discrete Control Assembly (DCA) allows the user to switch vacuum using discrete binary signals. The signals can be TTL levels or edges, relays placed in parallel with the inputs or open collector devices placed in parallel with the inputs.

All odd numbered input pins to the DCA (J1) are "pulled up" to a logic high (5 volts) via an internal 4.7k ohm resistor. All even numbered input pins are tied to the 5 volt return of the DCA. This allows the user to create a logic high or low using relays or opto coupler output transistors.

The LED indicators used on the VCS discrete control board are used to indicate when the exhaust (rather than the vacuum) valves are open. This allows the user to see when the control board is in a reset state (such as power on).

Jumper Selections

On board jumpers allow the user to select edge or level sensitivity as well as polarity of the signal. The general functions of the jumpers are shown below:

Jumper Functions

JP1	Vacuum switch 1, input1, polarity select
JP2	Vacuum switch 1, input 2, polarity select
JP3	Vacuum switch 2, input 1, polarity select
JP4	Vacuum switch 2, input 2, polarity select
JP5	Vacuum switch 1, level/edge select
JP6	Vacuum switch 2, level/edge select

In the following paragraphs, information for vacuum switch 1 is listed first followed by the information for vacuum switch 2 in brackets e.g., JPx [JPy]). The Model 170 VCS uses only the information for the first vacuum switch.

Level Mode

When JP5 [JP6] is jumpered from 1 to 2, the level mode of the vacuum switch is selected. The level mode allows the vacuum switch to be controlled from the voltage level at IN1 (J1-1) [IN3 (J1-5)]. IN2 (J1-3) [IN4 (J1-7)] is not used in this mode. Devices driving the input pins must be able to sink at least 1 mA and source 1 mA of current. The vacuum switch will change state when the input level changes state. Polarity is determined by JP1 [JP3]. When the polarity jumper is in a logic low at the input pin will allow vacuum to pass through the vacuum switch and a logic high will prevent vacuum from passing through the switch. When the jumper is out, the action is reversed.

See the listing of the “Jumper positions for level mode” on the next page.

Jumper Positions for Level Mode

Jumper	Position	Action
JP1	Shorted	Low input (J1-1) opens switch 1 to vacuum High input (J1-1) closes switch 1 to vacuum
JP1	Open	High input (J1-1) opens switch 1 to vacuum Low input (J1-1) closes switch 1 to vacuum
JP2	Not Used	
JP3	Shorted	Low input (J1-5) opens switch 2 to vacuum High input (J1-5) closes switch 2 to vacuum
JP3	Open	High input (J1-5) opens switch 2 to vacuum Low input (J1-5) closes switch 2 to vacuum
JP4	Not Used	
JP5	1-2 Shorted	Vacuum switch 1 level mode selected
JP6	1-2 Shorted	Vacuum switch 2 level mode selected

Edge Mode

When JP5 [JP6] is jumpered from 2 to 3 the edge mode of the control board is selected. Two [Four] inputs are used in this mode. The first input, IN1 (J1-1) [IN3 (J1-5)], is used for switching to vacuum, the second input is used to turn that switch off. The switching action occurs on the edge of the signal applied to the input(s). Once the edge occurs, the state is latched until an edge occurs on IN2 (J1-3) [IN4 (J1-7)]. This allows the user to use separate signals to control the on or off states of the valves or to debounce relays used to control the system. If a user wants to control the system using one signal, the first and second inputs can be wired together. Polarity for any input can be either rising or falling edge. A complete list of jumper functions is shown on the next page. An assembly view of the DCA is shown in Appendix A.

Jumper Positions for Edge Mode

<u>Jumper</u>	<u>Position</u>	<u>Action</u>
JP1	Shorted	Falling edge opens switch 1 to vacuum
JP1	Open	Rising edge opens switch 1 to vacuum
JP2	Shorted	Falling edge closes switch 2 to vacuum
JP2	Open	Rising edge closes switch 2 to vacuum
JP3	Shorted	Falling edge opens switch 2 to vacuum
JP3	Open	Rising edge opens switch 2 to vacuum
JP4	Shorted	Falling edge closes switch 2 to vacuum
JP4	Open	Rising edge closes switch 2 to vacuum
JP5	2-3 Shorted	Vacuum switch 1 edge mode selected
JP6	2-3 Shorted	Vacuum switch 2 edge mode selected

MAINTENANCE**INSTALLATION****Tools Required**

The only tools required to install the Vacuum Controller into a 19-inch rack are a standard #2 Phillips-Head Screwdriver and a #2 Slotted-Head Screwdriver.

Parts Included

The following parts should be included in the package for the Vacuum Controller:

<u>Quantity</u>	<u>Description</u>	<u>Digalog Part #</u>
1	A.C. Line Cord	6000-1027
4	Spring Nuts, U Type	1400-1042
4	Panel Screws	1400-1044
2*	Pipe to Hose Adaptor	2825-1532
3**	Pipe to Hose Adaptor	2825-1532
2*	1-inch Vacuum Hose (Optional)	0004-0235
3**	1-inch Vacuum Hose (Optional)	0004-0235

* Model 170

** Model 180

Parts Required

Communication cables from the Vacuum Controller to Host Computer are not supplied by Digalog Systems unless specially ordered. One of the following cables is required (except for the Discrete Controller Assembly):

2-Meter IEEE-488/GPIB Cable L-COM Part Number CMB-24-2M
(Digalog # 6000-1039)

OR

Female DB9 Serial Cable to Computer DB9/DB25 Null Modem F/F
(Digalog # 6000-1616)

or

DB9/DB9 Null Modem F/F
(Digalog # 6000-1617)

Installing The Vacuum Controller

1. **SWITCH SETTINGS:** The internal switches on the VCS Controller should be set prior to installing the Vacuum Controller. See “Internal Switch Settings” on page 16 for further details.
2. **INSTALL SPRING NUTS ON 19-INCH RACK.** See Figure 1 for the spacing of the spring nuts. Make sure that you have a minimum of an 8.75 inch opening in the rack so that the unit will fit.

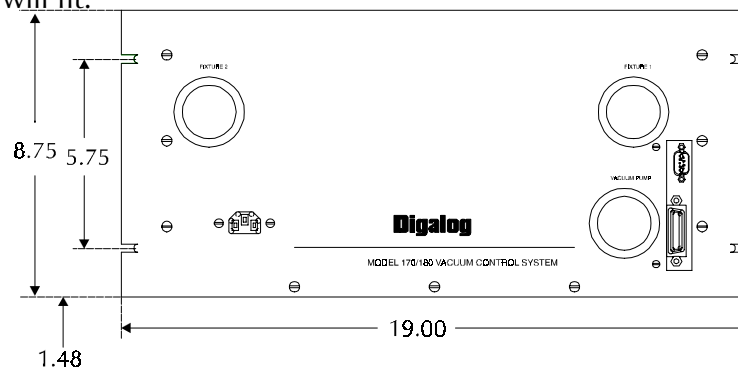


Figure 1

3. **INSTALL ANY INTERNAL COMMUNICATION OR A.C. POWER CABLES.** Any cables that need to be routed to the inside of the cabinet should be installed at this time.
4. **MOUNT THE VACUUM CONTROLLER.** Slide the vacuum controller into the rack and fasten the system in place by screwing the panel screws into the spring nuts.
5. **INSTALL THE PIPE TO HOSE ADAPTERS.** Screw the adapters onto both the vacuum pump and fixture pipes out of the front panel.
6. **CONNECT VACUUM PUMP HOSE.** Connect the pipe labeled “Vacuum Pump” out of the front panel to a vacuum source with a 1-inch hose.

7. CONNECT FIXTURE HOSE. Connect the pipe labeled "Fixture" out of the front panel to the vacuum fixture. For Model 180 systems, you may only need to connect the "Fixture 2" hose if the Test-Fixture is a dual-well type.
8. CONNECT APPROPRIATE COMMUNICATIONS CABLE TO THE COMPUTER. Attach either the IEEE-488 cable OR the RS-232 cable to the front panel of the Vacuum Controller and to the computer.
9. CONNECT THE A.C. LINE CORD. One end of the cord plugs into the connector located on the front panel. The other end should be plugged into a 115 VAC source.
10. CHECK THE FRONT PANEL LEDs. At this time, the unit should be on and both of the LEDs on the front panel should be on. The valves to the vacuum source should also be closed.

The system should now be complete and ready to operate.

Internal Switch Settings:

<u>ON</u>	SW1	<u>OFF</u>
NORMAL OPERATION	SW2	RUN FULL SELFTEST
ECHO OFF (SERIAL)	SW3	ECHO ON (SERIAL)
IEEE-488 MODE		RS-232 SERIAL MODE

RS-232 Serial Settings:

	<u>SW4</u>	<u>SW5</u>	<u>SW6</u>	<u>SW7</u>	<u>SW8</u>
9600 Baud	ON	ON			
4800 Baud	OFF	ON			
2400 Baud	ON	OFF			
1200 Baud	OFF	OFF			
RS-232 Address \$80			ON	ON	ON
RS-232 Address \$81			OFF	ON	ON
RS-232 Address \$82			ON	OFF	ON
RS-232 Address \$83			OFF	OFF	ON
RS-232 Address \$84			ON	ON	OFF
RS-232 Address \$85			OFF	ON	OFF
RS-232 Address \$86			ON	OFF	OFF
RS-232 Address \$87			OFF	OFF	OFF

IEEE-488 Settings:

	<u>SW4</u>	<u>SW5</u>	<u>SW6</u>	<u>SW7</u>	<u>SW8</u>
IEEE-488 Address 0	ON	ON	ON	ON	ON
IEEE-488 Address 1	OFF	ON	ON	ON	ON
IEEE-488 Address 2	ON	OFF	ON	ON	ON
IEEE-488 Address 3	OFF	OFF	ON	ON	ON
IEEE-488 Address 4	ON	ON	OFF	ON	ON
...
IEEE-488 Address 31	OFF	OFF	OFF	OFF	OFF

CONNECTOR PINOUT

The VCS controller assembly has connectors for IEEE-488, RS-232 and valve control/power. These are labeled as J1, J2, and J3 respectively on the VCS assembly diagram shown in Appendix A. The IEEE-488 and the RS-232 connectors are front panel mounted and are user accessible. The 24-pin IEEE-488 connector offers a full implementation of the IEEE standard. The 9-pin (male DB-9) RS-232 connector is configured as a DTE with the following pinout:

<u>Pin</u>	<u>Function</u>
1	Pulled up to +10v
2	Rx - Receive
3	Tx - Transmit
4	Not connected
5	GND - System ground
6	Pulled up to +10v
7	RTS - Request to send
8	CTS - Clear to send
9	Not connected

The valve control/power connector is a 10-pin header, which is not user accessible. It has the following pinout:

<u>Pin</u>	<u>Connected to</u>	
1	Vcc	
2	Gnd	
3	Not connected	
4	Not connected	
5	AC line in	
6	Valve 1 control	
7	Valve 2 control	
8	Valve 3 control	(Model 180 only)
9	Valve 4 control	(Model 180 only)
10	Earth ground	

24-pin IEEE-488 Connector

<u>Pin</u>	<u>Function</u>
1	DI0 - Data Bit #0
2	DI1 - Data Bit #1
3	DI2 - Data Bit #2
4	DI3 - Data Bit #3
5	EOI
6	DAV
7	NRFD
8	NDAC
9	IFC
10	SRQ
11	ATN
12	GND - System Ground
13	DI4 - Data Bit #4
14	DI5 - Data Bit #5
15	DI6 - Data Bit #6
16	DI7 - Data Bit #7
17	REN
18	GND - System Ground
19	GND - System Ground
20	GND - System Ground
21	GND - System Ground
22	GND - System Ground
23	GND - System Ground
24	GND - System Ground

SPECIFICATIONS

Model 180 specifications in parentheses where different.

Pressure range 760 to 25 Torr
 Flow rate Approx. 290 SCFM
 Ambient operating temperature 10 to 50 degrees Celsius

(For 115 VAC models)

Line voltage range 104 to 132 VAC 60 Hz.
 Operating current25 amps(.5 amps)
 Maximum inrush current 1.5 amps

Maximum outside dimensions:

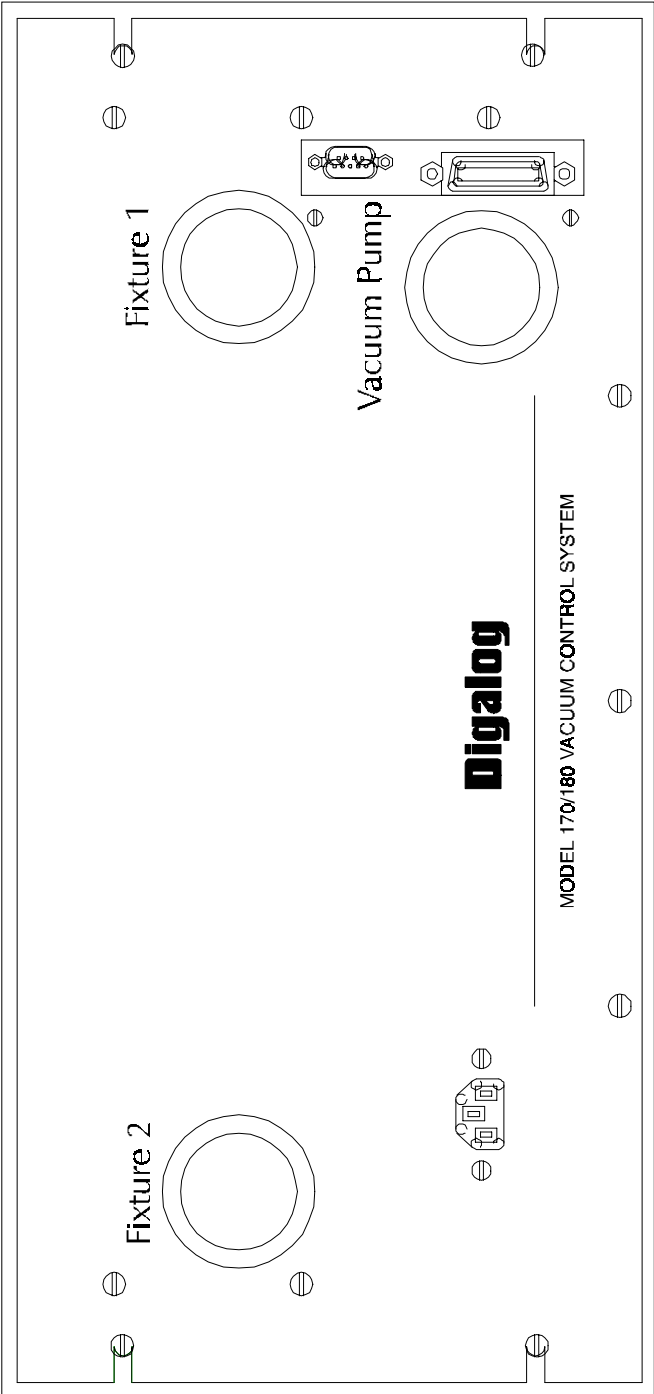
Height 8.75 inches
 Length 25 inches
 Width 19 inches

19 inch rack mount depth 23.5 inches
 19 inch rack mount height 8.75 inches
 Weight 21 lbs. (29 lbs.)

Inlet hose connection 1 inch male N.P.T.
 Outlet hose connection(s) 1 inch male N.P.T.

Communication protocols:

IEEE-488 SH1,AH1,T4,TE0,L2,LE0,SR0,RL0,PP0,DC1,DT0,C0
 RS-232 9600 Baud, 8 bits, no parity, 1 stop bit, x-on/x-off handshake



180 Rear Panel

