REV	CHANGE DESCRIPTION	ECO #	INITIALS	DATE
A	Release	-	SLF	05/15/15
B	Updated CS and PI command responses for CP pumps	10815	DEL	12/09/15
C	Updated LM command	10832	DEL	12/22/15
D	Added AE, AM, IO, IS, VO, VS commands	10853	DEL	01/21/16
E	Added Ethernet	11316	DEL	03/23/17
F	Added Ethernet communication configuration example	11944	NANCY	04/29/20

1.0 Overview

This document describes how to properly control ***Next Generation SSI Pumps*** through the RS-232 serial port, the Micro USB port (hardware driver required), and the Ethernet port. A complete list of commands may be found in section **6.0** of this document, however it is highly recommended to read and understand the preceding sections to effectively utilize these commands.

Standalone Next Generation pumps have a two-character class identifier prefix (i.e. **M1-, MX-, LS-, LD-, LU-, PR-,** & **CP**-Class). They may also be identified by their serial number "**V**" prefix (e.g. **V0123456)**.

Next Generation pumps are available in a variety of configurations. Below are two examples of their appearance:

Figure 1 – Next Generation Standalone Pumps

The communication ports may be found on the rear of the pump, as shown below:

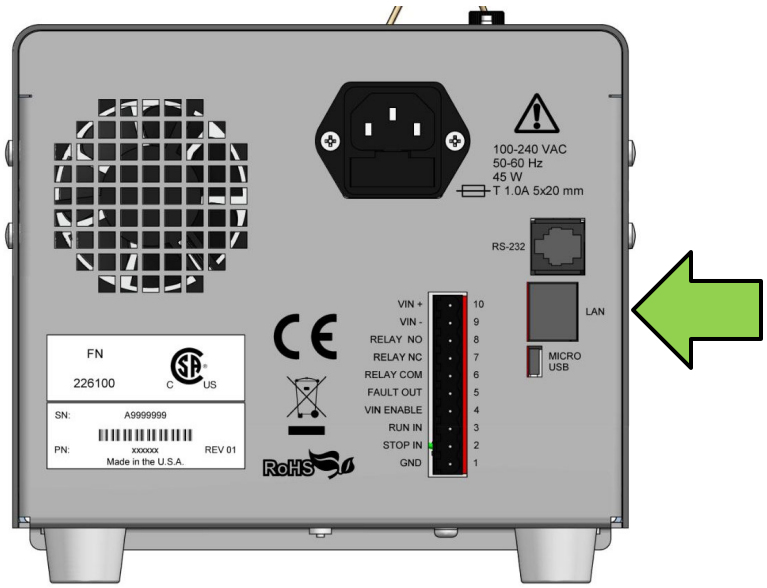


Figure 2 – Back Panel of Next Generation Standalone Pumps

Required Equipment

Computer:	Host Computer with ability to communicate to pump
RS-232 Cable:	RJ12 6P6C cable, connected to host computer
USB Cable:	Micro-B USB 2.0 cable, connected to host computer
Ethernet Cable:	RJ45 8P8C Cat-5 Ethernet cable, connected to host computer

2.0 Control Specifications

Input Buffer:	64 Byte
Output Buffer:	64 Byte
RS-232 Protocol:	9600 baud, 8 data bits, no parity, 1 stop bit
IP Configuration:	IPv4 10.10.0.20, Subnet 255.255.255.0, MAC BC-28-D6-FF-FF-FF

3.0 Communication Overview

3.1 Communications on the SSI pump are event driven. The pump will respond to commands, but will **never** initiate communication.

3.2 The minimum recommended interval between successive transmissions is **100 milliseconds**. All incoming commands are buffered to ensure that no commands are missed. Each command is responded to, as received, on a first in, first out basis; excessive streaming of commands may generate delays and ultimately lead to communication errors.

3.3 Hardware handshaking is implemented in the RS-232 interface, as follows: the DSR line is asserted while the pump is powered on; the DTR line is not monitored by the pump.

3.4 A carriage return (‘\r’, 0x0D) may be used to indicate the end of a transmitted string. Use of a carriage return is optional. Omitting a carriage return will cause the pump to delay its response to **partial** commands. For example, the flow rate input command ‘FI’ expects a total field length of 7 alphanumeric characters (length varies by command). The command ‘FI123’ will cause the pump to delay slightly while awaiting additional characters. To avoid this delay, use either the full-length command ‘FI00123’ or a carriage return ‘FI123\r’. It is not necessary to pad input values with leading zeroes; the following commands are treated identically: ‘FI25\r’, ‘FI025\r’, ‘FI0025\r’ and ‘FI00025\r’.

3.5 Commands are not case sensitive; the following commands are treated identically: ‘ru’, ‘Ru’, ‘rU’ and ‘RU’.

3.6 The response to a valid general-purpose command begins with the string ‘OK’. A software acknowledgment character of ‘/’ is used as the end of transmission indicator for all transmitted responses. Unrecognized commands are responded to with the string ‘Er/’.

3.7 Modern PCs are equipped with auto-MDIX Ethernet ports, in which case either a straight-through (patch) cable or a crossover cable may be used.

4.0 General Communication Tips

This section includes tips useful for general communications with an SSI pump, or for development of a communications driver or control application.

4.1 All common, general-use command responses begin with the string 'OK' and end with the '/' character. Received strings should be monitored for these characters to signal the beginning and end of the pump transmitted string.

4.2 As stated above, the recommended maximum transmission rate for communications should be no quicker than 100 milliseconds. It is strongly advised that commands NOT be sent on a fixed-time basis (e.g. every 100 ms). A proper command response should be received for each individual issued command before issue of another command. Additionally, if an error response is received, the preceding command should be re-issued (up to 3 times is general practice) before either issuing a system error or moving to the next command.

4.3 SSI offers an extremely wide array of pumps. Typically, control software will handle many different pump varieties, and it is helpful to know the capabilities of the connected instrument. Of course, if specific firmware numbers are known, the 'ID' command may be used for this purpose. Often however this is not the case. Furthermore, this approach can be quite limiting, as an update will be required to incorporate any new instruments which were not originally included. Alternatively, an initialization phase which issues the following commands may be useful for gathering specific pump information, which will allow the proper commands to be utilized.

4.3.1 The 'MF' command will return the maximum allowable flow rate for the pump, in ml/min. This command also includes the flow rate resolution, which is very useful for scaling flow rate commands.

- A response of 'OK,MF:5.00/' indicates that the pump has a flow range of 0.00 to 5.00 ml/min, and that the command 'FI123' will result in a flow rate of 1.23 ml/min.
- A response of 'OK,MF:5.000/' indicates that the pump has a flow range of 0.000 to 5.000 ml/min, and that the same command 'FI123' will result in a flow rate of 0.123 ml/min.

4.3.2 The 'PU' command will return the pressure units of the pump. Units are typically psi, although bar and MPa are also available.

4.3.3 If a pressure sensor is installed, the 'MP' command will return the maximum pressure capability of the pump, in the units specified by the 'PU' command (typically psi). This is useful both for setting pump limits and for knowing the pump capabilities for setting overall system fault limits.

4.4 Not all SSI pumps include a pressure sensor. If no pressure sensor is installed, the commands listed in the PRESSURE COMMANDS table below will return 'Er/'.

4.5 Not all SSI pumps include a leak sensor. If no leak sensor is installed, the commands listed in the LEAK SENSOR COMMANDS table below will return 'Er/'.

4.6 Not all SSI pumps include the solvent select feature. If solvent select is not installed, the commands listed in the SOLVENT SELECT COMMANDS table below will return 'Er/'.

4.7 Not all SSI pumps are configured for constant pressure operation. All non-CP-Class SSI pumps respond to the commands listed in the CONSTANT PRESSURE COMMANDS table below with 'Er/'.

4.8 The flow rate input command 'FI99999' may be used to set the pump flow rate to the maximum allowable, regardless of pump type. Similarly, 'UP99999' may be used to set the pump upper pressure limit to the maximum allowable, regardless of pump type. This can be useful for setting the maximum capabilities of the pump without explicit knowledge of the limits.

4.9 The pump reset command 'RE' should NOT be used as a general response to an error condition; instead either the 'ST' or 'CF' commands should be used to clear a pump fault. Although using the 'RE' command will in fact clear any existing fault, it will also reset several user-controlled settings, which may be undesirable.

4.10 The commands most often used for general pump monitoring are 'CC', 'PR', and 'RF'. Often, a control program will setup a loop to continuously monitor these values. In this case, the timing information detailed above should be followed. If a specific sequence of data is required, custom commands may be available – please contact SSI Sales or SSI Engineering to discuss a solution.

4.11 The commands most often used for general pump control are 'CF', 'FI', 'RU', and 'ST'. These commands are generally used after some trigger in the control application, e.g. a pump fault is detected by the 'RF' command, which triggers a 'CF' command to clear the fault. These commands are generally not used in a main monitor-control loop.

4.12 Seal life may be monitored using the 'GS' command, which returns the value of a counter that is incremented with every full cam rotation. This counter is set to zero during programming at SSI. As received, a pump will likely contain a non-zero counter value, which is the result of testing at SSI. A general pump reset does NOT zero this counter; the 'ZS' command may be used for this purpose. A control program may check this counter value periodically (on startup, for example) and trigger a warning message to the user when the value exceeds a set limit.

4.13 The 'CS' and 'PI' commands contain extra 0's and 1's which no longer have meaning. This are included solely to maintain backwards compatibility with existing drivers, and may be ignored.

5.0 Typical Communication Issues

Below are several common communication issues with suggested solutions.

5.1 No communication.

- Verify that the transmit pin of the pump is connected to the receive pin of the PC, and vice versa (RS-232 only).
- Verify that the cable is known to be functional.
- Verify that the host configuration matches section **2.0**.
- If RS-232 hardware handshaking is used, ensure these connections are implemented.

5.2 Communication strings are not correctly received.

- The pump checks each received character against its list of acceptable commands. Any character which is out of sequence or incorrect will generate an 'Er/' response from the pump. If the control PC does not recognize this, future commands may also be "out of sequence", or not received as intended. The '#' command will force clear the pump's receive buffer. This may be used prior to any string to ensure the sequence of commands is seen correctly.

NOTE: The '#' command may appear to solve communication errors, but may be masking a more serious issue. Unsolved communication problems may resurface later if not properly resolved. Effort should be taken to identify and resolve the root cause of the issue.

5.3 Pump response is delayed.

- The pump will generally respond to valid commands within 15 milliseconds. Verify that transmitted strings are completed commands which appear in the subsequent command list. If a partial command is received, the pump will briefly wait for the remainder of the string to be received, before timing out and clearing the receive buffer.
- The pump will immediately respond to data in the receive buffer when the carriage return terminating character is received. Verify that a proper terminating character is in use.

5.4 Unrecognizable string received from pump.

- Verify baud rate of 9600 (RS-232 only).
- Verify proper grounding between devices.
- Ensure the competed string has been transmitted from the pump by receipt of the '/' character, which denotes end of transmission.

6.0 General User Command List

GENERAL COMMANDS			
Command	**Response**	**Description**	**Example**
CC	OK,<pressure>,<flow>/	**Current Conditions:** returns the following values: <pressure>: current operating pressure <flow>: current flow rate in ml/min	OK,0522,12.00/
CF	OK/	**Clear Faults:** clears any active faults.	OK/
CS	OK,<flow>,<UPL>, <LPL>,<p_units>,0, <R/S>,0/	**Current Status:** returns the following values: <flow>: current flow rate* in ml/min <UPL>: Upper Pressure Limit <LPL>: Lower Pressure Limit <p_units>: pressure units <R/S>: Run/Stop state, where 0 = stop, 1 = run *CP pumps return flow rate set point	OK,12.00, 10000,0000, psi,0,0,0/
FIxxxxx	OK,FI:<flow>/	**Flow Input:** sets the flow rate using up to 5 digits. If the entered value exceeds the maximum allowable flow rate of the pump, the flow rate will be automatically set to the maximum allowable flow rate.	OK,FI:01200/
GS	OK,GS:<seal>/	**Get Seal:** returns the seal-life stroke counter value.	OK,GS:7/
ID	OK, <ID> Version <ver>/	**ID:** returns the firmware version and part number. <ID>: firmware part number <ver>: firmware revision	OK, 196000 Version 1.0.0/
KD	OK/	**Keypad Disable:** disables front panel buttons.	OK/
KE	OK/	**Keypad Enable:** enables front panel buttons.	OK/

GENERAL COMMANDS (continued)			
Command	**Response**	**Description**	**Example**
MF	OK,MF:<max_flow>/	**Maximum Flow:** returns the maximum allowable flow rate for the pump, in ml/min.	OK,MF:12.00/
PI	OK,<flow>,<R/S>, <p_comp>,<head>,0,1, 0,0,<UPF>,<LPF>, <prime>,<keypad>, 0,0,0,0,<stall>/	**Pump Information:** returns the current pump information. <flow>: current flow rate* in ml/min <R/S>: run/stop state, where 0 = stop, 1 = run <p_comp>: manual pressure compensation value <head>: head identification <UPF>: upper pressure fault status <LPF>: lower pressure fault status <prime>: 0 = not in prime, 1 = in prime <keypad>: 0 = keypad buttons enabled, 1 = disabled <stall>: 0 = no motor stall fault, 1 = faulted *CP pumps return flow rate set point	OK,12.00,0,0, S10D,0,1,0, 0,0,0,0,0,0, 0,0,0,0/
RE	OK/	**Reset:** reset all user adjustable values to factory defaults. This includes the flow rate, upper pressure limit, lower pressure limit, selected solvent, flow rate compensation, and CP values.	OK/
RF	OK,<stall>,<UPF>,<LPF>/	**Read Faults:** returns status of all fault indicators, where 0 = no fault, 1 = fault. <stall>: motor stall fault <UPF>: upper pressure fault status <LPF>: lower pressure fault status	OK,0,0,0/
RU	OK/	**Run:** run the pump.	OK/
ST	OK/	**Stop:** stop the pump.	OK/

GENERAL COMMANDS (continued)

Command	Response	Description	Example
UC	OK,UC:<user_comp>/	**User Compensation:** returns the user flow rate compensation, where xxx.x = xxx.x % e.g. UC:102.5/ = 102.5% compensation, or +2.5%	OK,UC:100.0/
UCxxxx	OK,UC:<user_comp>/	**User Compensation:** stores the user flow rate compensation, where xxx.x = xxx.x % e.g. UC102.5 = 102.5% compensation, or +2.5% input range: 0850 to 1150 (i.e. ± 15.0%)	OK,UC:100.0/
ZS	ZS:OK/	**Zero Seal:** reset the seal-life stroke counter to zero.	ZS:OK/
#	(no response)	Clears all characters from the command buffer.	

PRESSURE COMMANDS
The following commands are active ONLY for instruments with a PRESSURE SENSOR.
All other instruments will respond with error message Er/.

Command	Response	Description	Example
PR	OK,<pressure>/	**Pressure:** returns the current operating pressure.	OK,0897/
MP	OK,MP:<max_pressure>/	**Maximum Pressure:** returns the maximum allowable pressure for the pump.	OK,MP:10000/
LP	OK,LP:<LPL>/	**Lower Pressure:** returns the lower pressure limit.	OK,LP:0000/
UP	OK,UP:<UPL>/	**Upper Pressure:** returns the upper pressure limit.	OK,UP:10000/
LPxxxxx	OK/	**Lower Pressure:** stores the lower pressure limit. psi input format: LP200 = 200 psi bar input format: LP200 = 20.0 bar MPa input format: LP200 = 2.00 MPa	OK/
UPxxxxx	OK/	**Upper Pressure:** stores the upper pressure limit. psi input format: LP200 = 200 psi bar input format: LP200 = 20.0 bar MPa input format: LP200 = 2.00 MPa	OK/
PU	OK,<p_units>/	**Pressure Units:** returns the pressure units.	OK,psi/

LEAK SENSOR COMMANDS
The following commands are active ONLY for instruments with a LEAK SENSOR.
All other instruments will respond with error message Er/.

Command	Response	Description	Example
LS	OK,LS:<leak>/	**Leak Status:** returns the leak sensor status. 0 = no leak detected 1 = leak detected	OK,LS:0/
LMx	OK,LM:<mode>/	**Leak Mode:** sets the leak sensor mode. 0 = leak sensor disabled 1 = detected leak does not cause fault 2 = detected lead does cause fault	OK,LM:0/

SOLVENT SELECT COMMANDS
The following commands are active ONLY for instruments featuring Solvent Select.
All other instruments will respond with error message Er/.

Command	Response	Description	Example
RS	OK,<solvent>/	**Read Solvent:** returns the solvent value.	OK,121/
SSxxx	OK/	**Set Solvent:** stores the solvent value.	OK/

ANALOG INPUT COMMANDS
The following commands are used to configure the analog input located on the external control board.

Command	Response	Description	Example
AM	OK,AM:<mode>/	**Analog Mode:** returns the input mode. 0 = voltage input (0 – 10 Vdc) 1 = current input (4 – 20 mA)	OK,AM:0/
AMx	OK,AM:<mode>/	**Analog Mode:** sets the input mode. 0 = voltage input (0 – 10 Vdc) 1 = current input (4 – 20 mA)	OK,AM:0/
AE	OK,AE:<mode>/	**Analog Enable:** returns the analog input enable (override), which activates analog flow control regardless of the physical enable line state. 0 = override disabled: must connect enable line on external control board to activate analog input. 1 = override enabled: activates analog input regardless of external enable line state.	OK,AE:0/
AEx	OK,AE:<mode>/	**Analog Enable:** sets the analog input enable (override), which activates analog flow control regardless of the physical enable line state. 0 = override disabled: must connect enable line on external control board to activate analog input. 1 = override enabled: activates analog input regardless of external enable line state.	OK,AE:0/

4-20mA CURRENT INPUT CALIBRATION COMMANDS The following commands are active ONLY when 4-20mA CURRENT INPUT MODE is selected. When 0-10V VOLTAGE INPUT is selected, instruments will respond with error message Er/.			
IO	OK,IO:<i_offset>/	**Current Offset:** returns offset value used in 4-20mA calibration, in A/D counts.	OK,IO:184/
IOxxxx	OK,IO:<i_offset>/	**Current Offset:** sets offset value used in 4-20mA calibration, in A/D counts. input range: 0 to 1000	OK,IO:184/
IS	OK,IS:<i_span>/	**Current Span:** returns span (gain) value used in 4-20mA calibration, in A/D counts.	OK,IS:816/
ISxxxx	OK,IS:<i_span>/	**Current Span:** sets span (gain) value used in 4-20mA calibration, in A/D counts. input range: 0 to 1000	OK,IS:816/

0-10V VOLTAGE INPUT CALIBRATION COMMANDS The following commands are active ONLY when 0-10V VOLTAGE INPUT MODE is selected. When 4-20mA CURRENT INPUT is selected, instruments will respond with error message Er/.			
VO	OK,VO:<v_offset>/	**Voltage Offset:** returns offset value used in 0-10V calibration, in A/D counts.	OK,VO:5/
VOxxxx	OK,VO:<v_offset>/	**Voltage Offset:** sets offset value used in 0-10V calibration, in A/D counts. input range: 0 to 1000	OK,VO:5/
VS	OK,VS:<v_span>/	**Voltage Span:** returns span (gain) value used in 0-10V calibration, in A/D counts.	OK,VS:1000/
VSxxxx	OK,VS:<v_span>/	**Voltage Span:** sets span (gain) value used in 0-10V calibration, in A/D counts. input range: 0 to 1000	OK,VS:1000/

CONSTANT PRESSURE COMMANDS
The following commands are active ONLY for CP Class instruments.
All other instruments will respond with error message Er/.

Command	Response	Description	Example
PS	OK,PS:<target>/	**Pressure Setpoint:** returns the target pressure.	OK,PS:05000/
PG	OK,PG:<p_gain>/	**Proportional Gain:** returns the CP algorithm P term.	OK,PG:02000/
IG	OK,IG:<i_gain>/	**Integral Gain:** returns the CP algorithm I term.	OK,IG:00500/
DG	OK,DG:<d_gain>/	**Derivative Gain:** returns the CP algorithm D term.	OK,DG:0075/
PSxxxxx	OK,PS:<target>/	**Pressure Setpoint:** sets the target pressure.	OK,PS:05000/
PGxxxxx	OK,PG:<p_gain>/	**Proportional Gain:** sets the CP algorithm P term.	OK,PG:02000/
IGxxxxx	OK,IG:<i_gain>/	**Integral Gain:** sets the CP algorithm I term.	OK,IG:00500/
DGxxxxx	OK,DG:<d_gain>/	**Derivative Gain:** sets the CP algorithm D term.	OK,DG:0075/

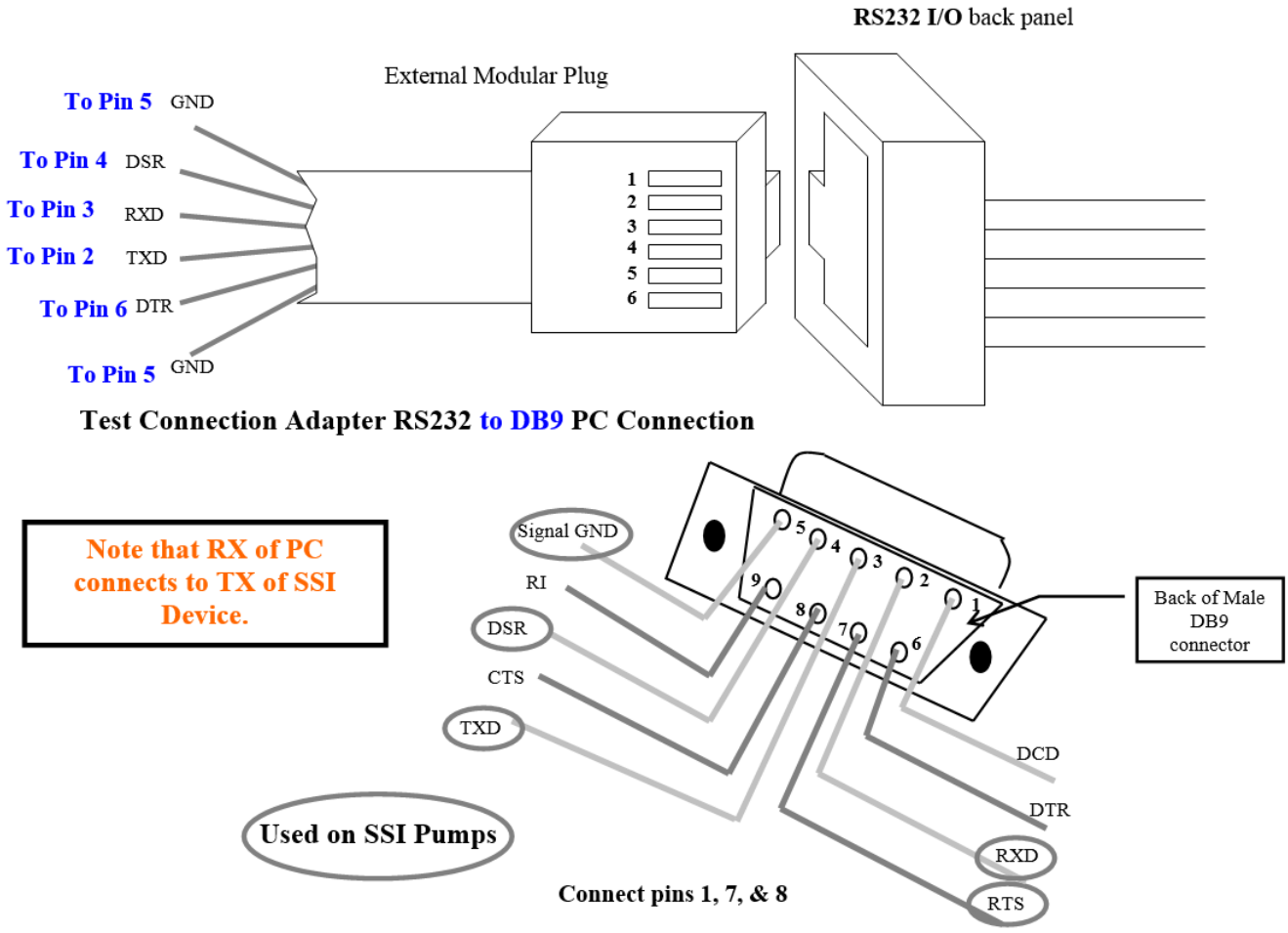
PRESSURE SENSOR CALIBRATION COMMANDS
The following commands are required for pressure sensor calibration.

Command	Response	Description	Example
QQ	OK, Debug Commands Enabled/	Enable debug command mode.	OK, Debug Commands Enabled/
AZ	AZ:OK/	**Auto Zero:** stores current value of A/D converter into offset value used in pressure A/D conversion.	AZ:OK/
AC	AC:OK/	**Auto Calibrate:** stores current value of A/D converter into gain value used in pressure A/D conversion.	AC:OK/
GA	GA:<ADC>/	**Get ADC:** returns value of A/D converter.	GA:00584/
GZ	GZ:<zero>/	**Get Zero:** returns offset value used in pressure A/D conversion, in A/D counts.	GZ:170/
GC	GC:<cal>/	**Get Calibration:** returns gain value used in pressure A/D conversion, in A/D counts.	GC:41800/
GP	GP:<pressure>/	**Get Pressure:** returns pressure value used in pressure A/D conversion, in psi.	GP:10000/
SZxxxxx	SZ:<zero>/	**Store Zero:** sets offset value used in pressure A/D conversion, in A/D counts.	SZ:170/
SCxxxxx	SC:<cal>/	**Store Calibration:** sets gain value used in pressure A/D conversion, in A/D counts.	SC:41800/
SPxxxxx	SP:<pressure>/	**Store Pressure:** sets pressure value used in pressure A/D conversion, in psi.	SP:10000/

ETHERNET CONFIGURATION COMMANDS
The following commands are used to setup the Ethernet interface.
COMMANDS TAKE EFFECT AFTER NEXT POWER CYCLE.
CI AND NM COMMANDS ARE NOT AVAILABLE ON RS-232.

Command	Response	Description	Example
IA	OK,IA:<mode>/	**IP Assignment:** returns the IP address assignment mode. 0 = dynamic; assigned by DHCP. 1 = static; assigned manually.	OK,IA:1/
IP	OK,IP:<address>/	**IP Address:** returns the IP address.	OK,IP:10.10.0.20/
SB	OK,SB:<mask>/	**Subnet:** returns the network subnet mask.	OK,SB:255.255.255.0/
MC	OK,MC:<MAC>/	**MAC Address:** returns the MAC address.	OK,MC:bc-28-d6-ff-ff-ff/
IAx	OK,IA:<mode>/	**IP Assignment:** sets the IP address assignment mode. 0 = dynamic; assigned by DHCP. 1 = static; assigned manually.	OK,IA:1/
CIxxx.xxx.xxx.xxx	OK,CI:<address>/	**Configure IP:** sets the IP address, in dot-decimal notation.	OK,CI:10.10.0.20/
NMxxx.xxx.xxx.xxx	OK,NM:<mask>/	**Network Mask:** sets the subnetwork mask, in dot-decimal notation.	OK,NM:255.255.255.0/
CMxx	OK,CM:<MAC>/	**Configure MAC:** sets the least significant byte of the MAC address, in hexadecimal format. Other bytes cannot be changed.	OK,CM:ff/
RN	OK,RN/	**Reset Network:** resets network settings to default values; also resets user-adjustable values, similar to RE command.	OK,RN/

7.0 Wiring Diagram for SSI RJ12 (6P6C) RS232 Connection

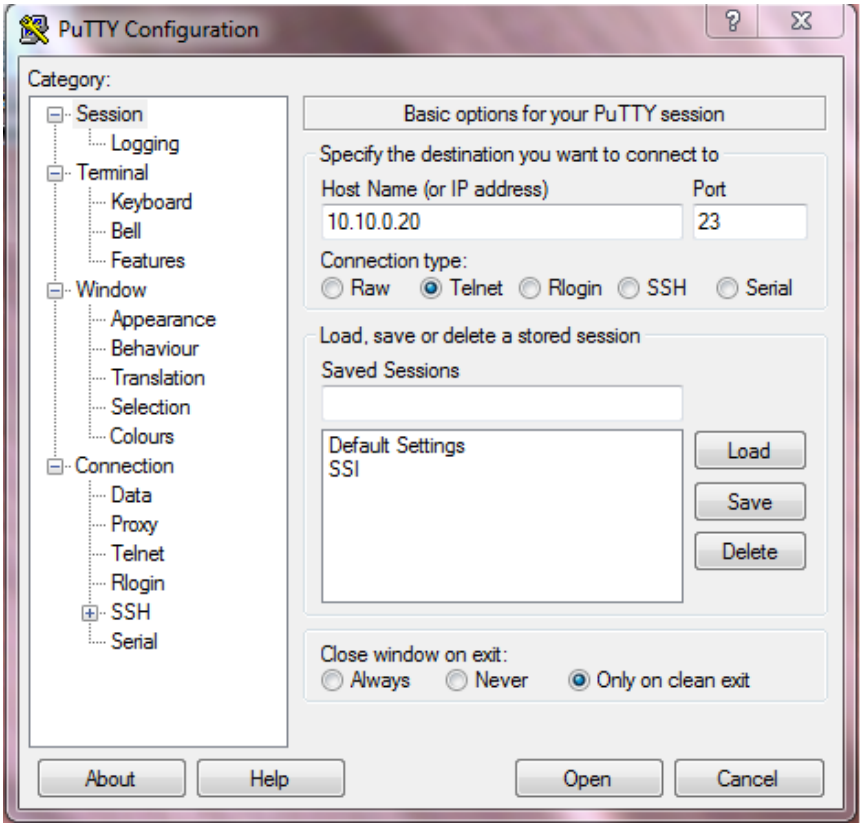


8.0 Ethernet Communication

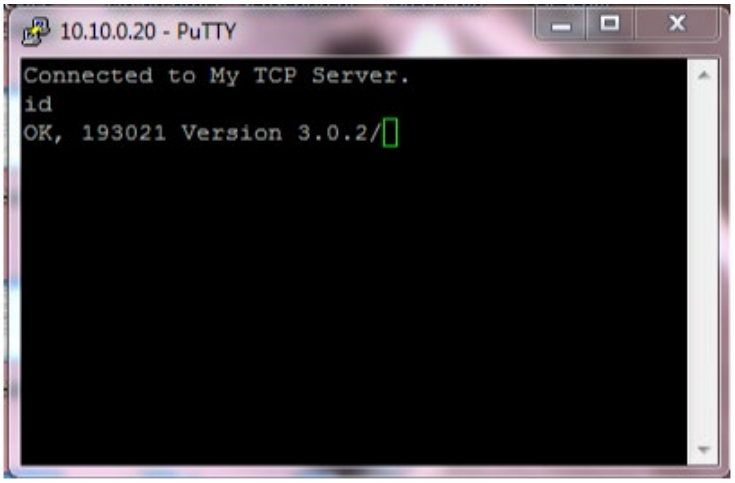
The Next Generation SSI pumps feature user communication with a host PC or other device via an RJ45 (8P8C) Cat-5 Ethernet cable. Modern PCs are equipped with auto-MIDX, in which case either a straight-through (patch) cable or a crossover cable may be used. The default values are listed below; most settings are configurable.

IP Assignment:	Static
IP Address:	10.10.0.20
Subnet Mask:	255.255.255.0
MAC Address:	BC.28.D6.FF.FF.FF

The LAN port can be accessed via third-party terminal emulator software (e.g. PuTTY) not supplied with the pump. Here's an example of general configuration using PuTTY:



Click "Open", the interface will look like below if the connection is established successfully. Then commands listed in section 6.0 can be used to communicate with the pump.



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