EXCELLENCE IN MAGNETICS AND CRYOGENICS

MODEL 186 LIQUID LEVEL CONTROLLER

INSTALLATION, OPERATION, AND MAINTENANCE INSTRUCTIONS

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Introduction

The American Magnetics, Inc. (AMI) Model 186 Liquid Level Controller system is an advanced, microprocessor-based solution designed to provide accurate and reliable level monitoring and control of virtually any cryogenic liquid.

Capacitance-based level sensing

The system consists of a Model 186 Liquid Level Controller, sensor, connecting cables, and an optional solenoid-operated fill valve. The instrument sensing element is a 3/8 inch (9.5 mm) OD cylindrical capacitor constructed of stainless steel which allows a cryogenic fluid to become the dielectric between the concentric plates. The instrument measures the sensor capacitance which is directly related to the percentage of the sensor immersed in the cryogenic liquid. The sensors are normally constructed in overall lengths of up to 20 feet (6.1 m). The normal sensor maximum active length is typically 7 inches less than the overall length.

Convenient display

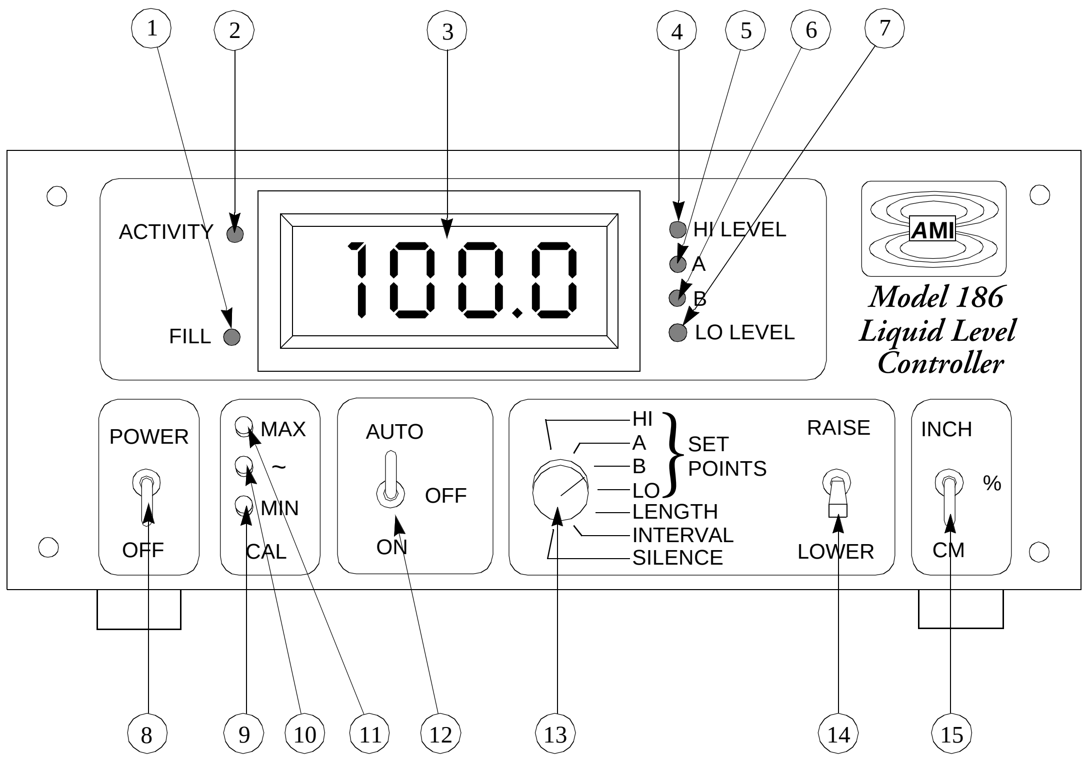
The instrument is equipped with a 4-digit LED display which provides liquid level indication in inches, centimeters, or percent as selected by a front panel switch. A front panel switch allows the user to adjust the instrument length quickly and easily for a specific active sensor length. The sensor active length can be entered in either inches or centimeters. This length adjustment only effects the display and does not change the calibration of the instrument.

Level control

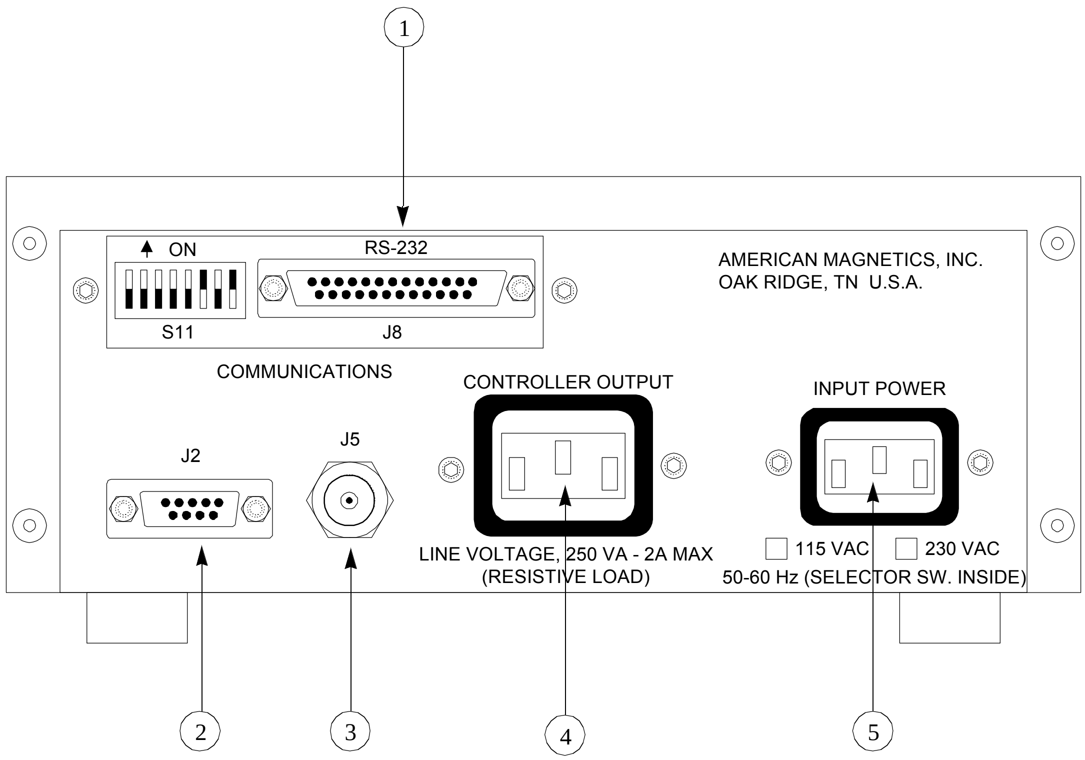
The instrument has four level setpoints, two of which are control setpoints used to control liquid level by the solenoid-operated fill valve. The other two set points are alarm setpoints and can be set for other control or alarm functions. Output from this second set of setpoints operates relay contacts in addition to the front panel LED indications. All four setpoints are continuously adjustable from the front panel. The automatic controller (fill) function can be manually overridden or disabled from the front panel.

Remote computer monitoring or controlled operation

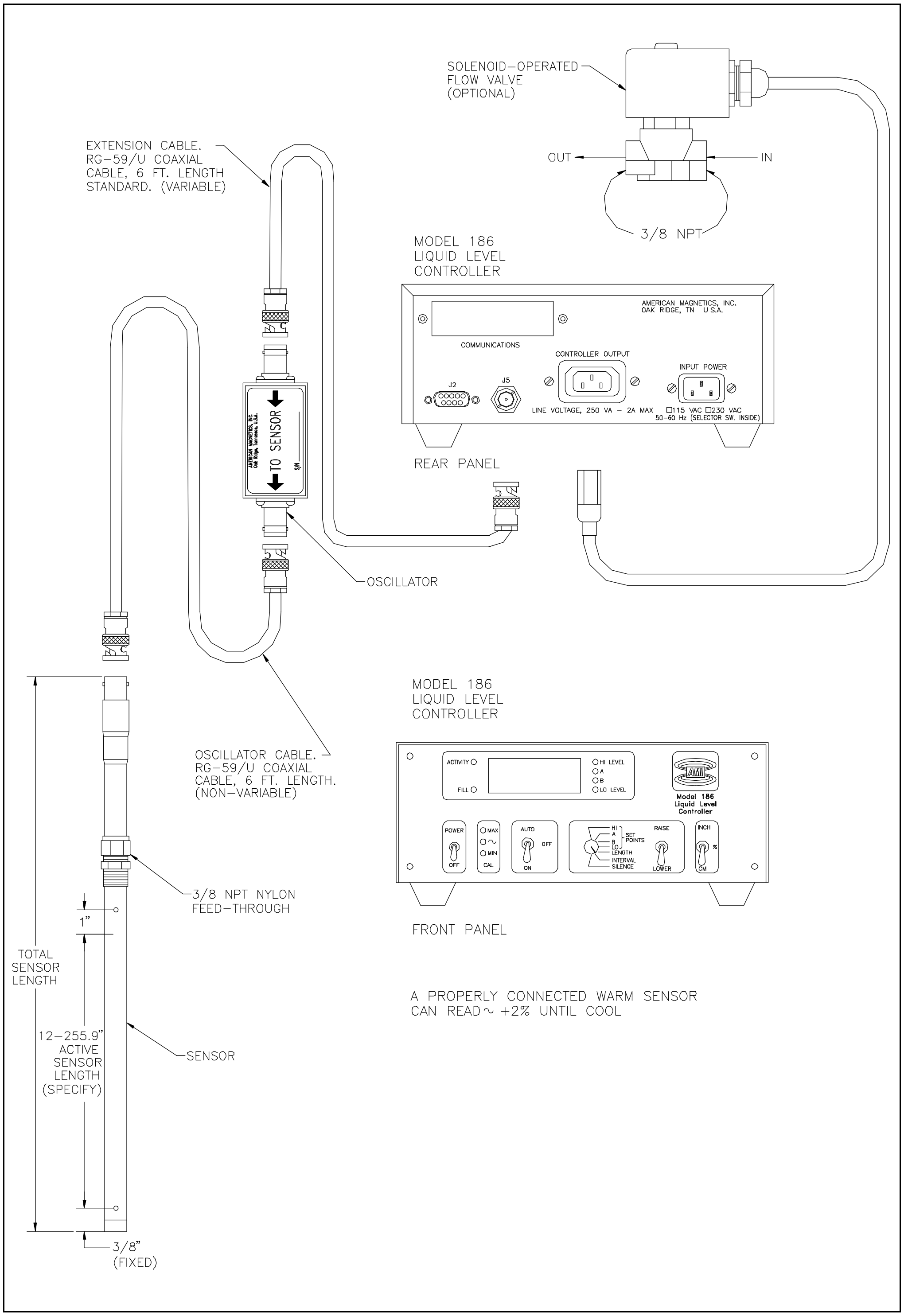
The Model 186 can be provided with an optional 0-10 volt DC signal on the rear panel of the instrument for use with a recorder. A 4-20 mA current loop option is available in lieu of the voltage signal. Computer interface options, including RS-232/422 Serial Port/Data Logger or IEEE-488, are also available.



1	Fill indication LED	**9**	MIN calibration push-button
2	Activity LED	**10**	Approximate calibration push-button
3	LED display	**11**	MAX calibration push-button
4	HI level LED	**12**	Fill toggle switch
5	A level LED (control band upper limit)	**13**	Control mode rotary switch
6	B level LED (control band lower limit)	**14**	Raise/lower toggle switch
7	LO level LED	**15**	Units mode toggle switch
8	Power toggle switch		



1	Optional RS-232/422 or IEEE-488 communications port (RS-232 shown)	**4**	Controller output receptacle
2	Auxiliary DB-9 connector (see *Appendix* for pinout)	**5**	Power cord connector
3	RG-59/U coaxial connector to oscillator unit via the extension cable		



Model 186 instrument, control valve, and sensor system diagram.

Instrument Specifications

Input line voltage	115/230 or 100/200 VAC ±10%
Input line frequency	50-60 Hertz, 1 phase
Controller output	250 VA maximum @ 2A max current (resistive load)
Readout accuracy	0.1%
Dimensions	3.8" H x 8.4" W x 11.1" D, Standard 3.475" H x 19" W x 11.1" D, Rack Mount
Weight	3.6 lbs. Standard; 4.3 lbs. Rack Mount
Operating environment	15 - 50°C non-condensing

Analog Output Specifications @ 25°C

Integral non-linearity	± 0.012%
Resolution	16 bits
Total error	± 0.25% for 4-20 mA output ± 0.5% for 0-10 V output
Current drift (4-20 mA)	75 ppm/°C
Voltage drift (0-10 V)	100 ppm/°C

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1 Installation

Warning

Before energizing the instrument, the earth ground of the power receptacle must be verified to be at earth potential and able to carry the rated current of the power circuit. Using extension cords should be avoided, however, if one must be used, ensure the ground conductor is intact and capable of carrying the rated current.

In the event that the ground path of the instrument becomes less than sufficient to carry the rated current of the power circuit, the instrument should be disconnected from power, labeled as unsafe, and removed from place of operation.

Do not operate this instrument in the presence of flammable gases. Doing so could result in a life-threatening explosion.

Do not modify this instrument in any way. If component replacement is required, return the instrument to AMI facilities as described in the Troubleshooting section of this manual.

1. Unpack the instrument

Carefully remove the instrument, sensor, oscillator and interconnecting coaxial cables from the shipping carton and remove all packaging material. A rack mounting kit is supplied if the instrument was purchased with the rack mount option.

Note

If there is any shipping damage, save all packing material and contact the shipping representative to file a damage claim. Do not return the instrument to AMI unless prior authorization has been received.

If the chassis is a table top model, place the instrument on a flat, secure surface.

Warning

Do not remove the cabinet feet and then reinsert the original screws. Doing so could present a severe life-threatening electrical hazard. If removal of the cabinet feet is desired, replace the original screws with screws not to exceed 1/4" in length.

2. Rack mount the instrument if desired

If the instrument has a rack mount chassis, follow the following procedure:

a. Attach the rack mount adapter pieces to the instrument by first removing the four screws on the side of the instrument that attach the cover to the chassis. Attach the rack mount adapter pieces to the sides of the instrument by reinstalling the screws.

b. Install the monitor in a 19" rack by securing the front panel to the rail in each of the four corners with mounting hardware supplied by the cabinet manufacturer.

3. Install the sensor in the cryo-vessel

Exercise care when installing the sensor since dents, crimps, bends or other physical distortions in the thin wall capacitor will change electrical characteristics possibly causing calibration errors and/or disruption of proper instrument operation. Before installing the sensor, the user may want to review the *Calibration* and *Operation* sections to determine what, if any, calibration procedures may be necessary.

Note

The coaxial interconnecting cables and the oscillator are temperature sensitive and should be mounted in such a manner as to avoid large temperature changes such as those encountered in the path of dewar vents.

4. Connect the oscillator cable to the AMI sensor

Connect the oscillator to the sensor using a supplied 6 foot RG-59/U coaxial cable. Ensure the oscillator is connected in the correct orientation (see page 5 for a system diagram). The cable length between the oscillator and the sensor should not exceed 6 feet.

Caution

Moisture or contaminants in any of the BNC coaxial connectors can short out the sensor and cause a false 'full' level indication or other erroneous readings. A pack of non-conductive electrical connection lubricant (ECL) has been included with the liquid level sensor packaging to reduce the possibility of this occurring. If desired, apply a small amount of ECL to any of the BNC connectors that may be exposed to moisture. Mate the doped connectors then remove any excess ECL from the outside of the connector. Added protection can be achieved by covering the doped connections with a short section of heat-shrink tubing.

Note: MSDS sheets for the ECL are available upon request.

5. Connect the instrument to the oscillator

Caution

Operation of the AMI Model 186 Liquid Level Instrument with a device other than an AMI Liquid Level Sensor may void the instrument warranty.

Using the J5 coaxial connector, connect the instrument to the oscillator using a RG-59/U coaxial cable. The length of the extension cable can be varied to suit the specific application, however, varying the extension cable length has minor effects on the calibration (varying this cable from 6' to 100' caused a 0.3% error when a 24" test sensor was used). Calibration errors can be reduced or eliminated by calibrating the instrument with the desired custom extension cable in place.

6. Install the optional solenoid-operated fill valve

Install the solenoid-operated fill valve by connecting the valve power cable to the AC controller output receptacle on the rear panel of the instrument. The standard AMI supplied valve has a 9/32 inch orifice and the input and output are tapped for 3/8 NPT.

Caution

When using a solenoid-operated control valve with the Model 186, ensure the valve is configured for the operating voltage of the Model 186. Failure to do so will result in faulty operation and may also result in valve damage.

7. Connect the instrument to the appropriate power receptacle

Warning

The Model 186 operates on 50-60 Hz power and may be configured for 115 or 230 VAC (100 or 200 VAC for Asian markets). The power requirements for each instrument is marked on the calibration sticker on the bottom of the instrument. Be sure your instrument is configured for your power source prior to plugging in the line cord. Do not fail to connect the input ground terminal securely to an external earth ground.

Ensure the front panel switch is in the OFF position. Verify that the instrument is configured for the proper operating voltage by referring to the calibration sticker affixed to the bottom of the instrument. If the operating voltage is correct, plug the line cord into the appropriate power receptacle.

If the instrument operating voltage needs to be changed, ensure the instrument is de-energized by disconnecting the power cord from the power source. Remove the instrument cover and slide the voltage selector switch on the main printed circuit board to the proper voltage. Replace the instrument cover.

2 Calibration

Model 186 instruments are calibrated at the factory for a specific length sensor for use in a specific liquid. The calibration length and calibration liquid are listed on the calibration sticker on the bottom of the instrument. If the factory calibration method utilized was approximate, the calibration length will be noted as an approximate value.

Relationship between calibration and sensor length

The capacitance-based method of measuring the liquid level operates by measuring the frequency of an oscillator, which is contained in the oscillator/transmitter unit. As the liquid level varies, the value of the capacitance varies proportionally. Since the dielectric properties of liquids vary and the component tolerances for the sensor and oscillator introduce variations, a calibration is required to assure maximum accuracy for a specific sensor immersed in the target liquid. The calibration MIN and MAX settings correspond to the maximum and minimum oscillation frequencies, respectively, for a given sensor and target liquid configuration.

The LENGTH setting of the instrument is only provided as a means of scaling the 0% (MIN) to 100% (MAX) range of the measurement to meaningful units of length. During the calibration it is important to accurately measure the distance between the physical locations on the sensor corresponding to the MAX and MIN calibration points. The measured value for the length will be used in configuring the instrument for operation.

Calibration methods

The most straightforward calibration method is the *Open Dewar Calibration* which requires the customer to have access to a filled dewar where the full active length of the sensor can be dipped. The *Closed Dewar Calibration* method can be performed in situations where it is not feasible for the customer to dip the sensor into an open dewar, such as situations where the target liquid is under pressure. The closed dewar calibration is more complex and may require initial preparations to insure success.

Occasionally customers ask AMI to calibrate an instrument and sensor for a liquid which is not available at AMI for calibration purposes and/or for a sensor which is too long to be calibrated at our facilities.

For the case of the target liquid being unavailable, AMI uses liquid nitrogen as the reference liquid and an *Approximate Calibration* is performed using mathematical manipulation of the ratio of the dielectric constants between liquid nitrogen and the desired liquid. This procedure is outlined in the *Approximate Calibration* section beginning on page 19. The technique is intended to provide the instrument with an approximate calibration so that it can be used immediately by the customer. However, the customer is still expected to perform a more accurate calibration where feasible, such as the open dewar or closed dewar calibration, with the target liquid.

For the case where a sensor is too long to be calibrated in AMI facilities, AMI will perform a partial length open dewar calibration in liquid nitrogen, and then calculate the MAX calibration point. A dielectric ratio may also be subsequently utilized to adjust for a target liquid other than liquid nitrogen. The customer is expected to perform a more accurate open dewar or closed dewar calibration if feasible.

As a quick guide for selection of the best calibration method available, a calibration selection diagram is presented below. If the instrument and sensor are purchased as a

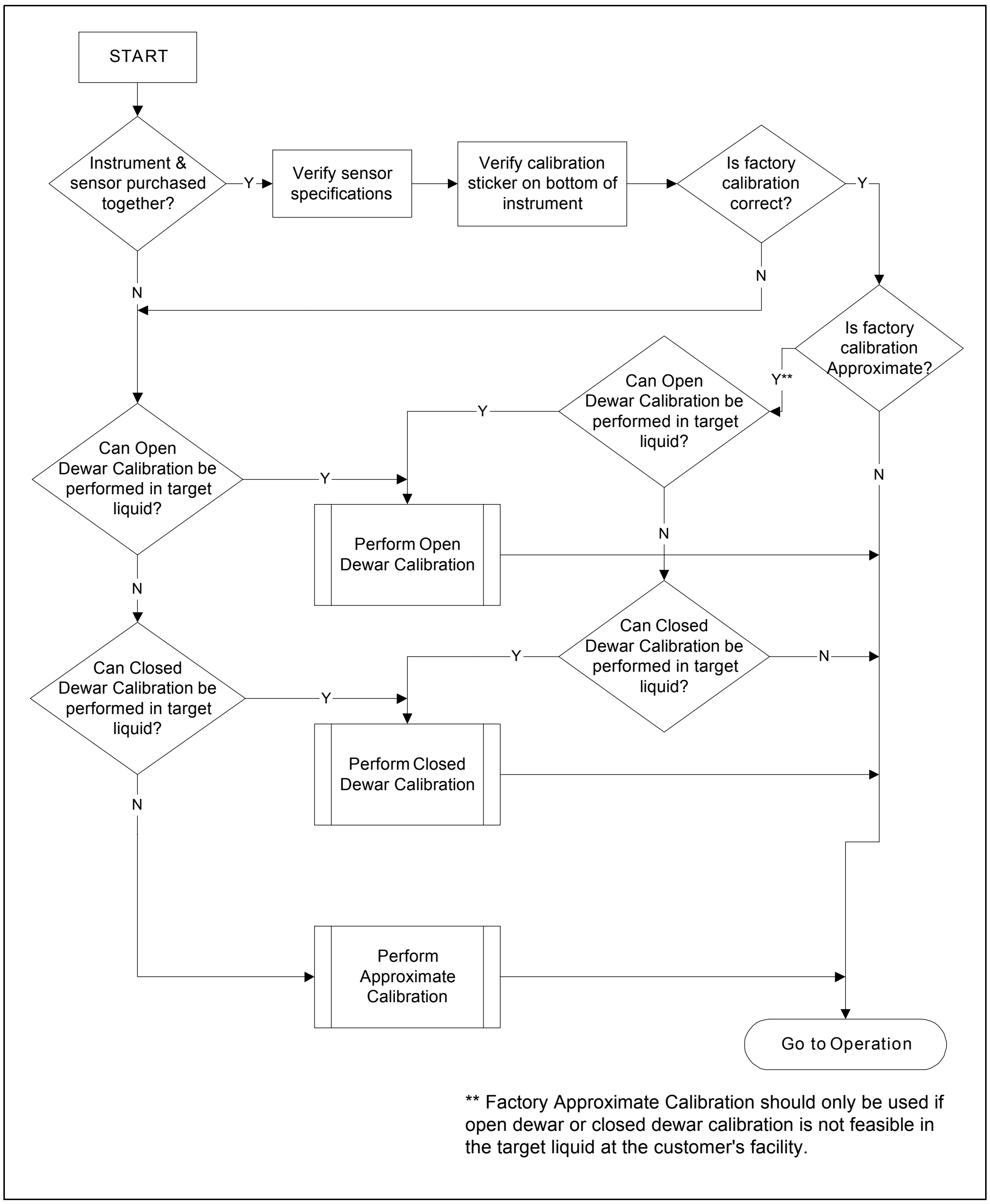


Figure 2-1. Calibration method selection diagram.

unit from AMI, then the factory calibration will be adequate in most cases. However, for the exceptions noted in the previous paragraphs (which are *approximate* calibrations), the customer should perform a more accurate open dewar or closed dewar calibration. A customer performed calibration is also required for sensors that are purchased as a separate item from the instrument, since the instrument and sensor were not both available for calibration at AMI facilities.

Variations in the dielectric with changing density

For cryogenic liquids the dielectric of the liquid will change with a change in density. The amount of change is dependent on the properties of the specific liquid. Figure 2-2 illustrates the variations in dielectric for nitrogen vs. pressure under *saturated* conditions.[1] Since the instrument uses a capacitance-based method for determining liquid level, such a change in the dielectric of the liquid will result in a shift in the level reading of the instrument. The calibration procedures described herein are most accurate when applied in situations where the operating conditions of the cryo-vessel are relatively constant, i.e. the operating pressure and temperature of the cryo-vessel are relatively constant.

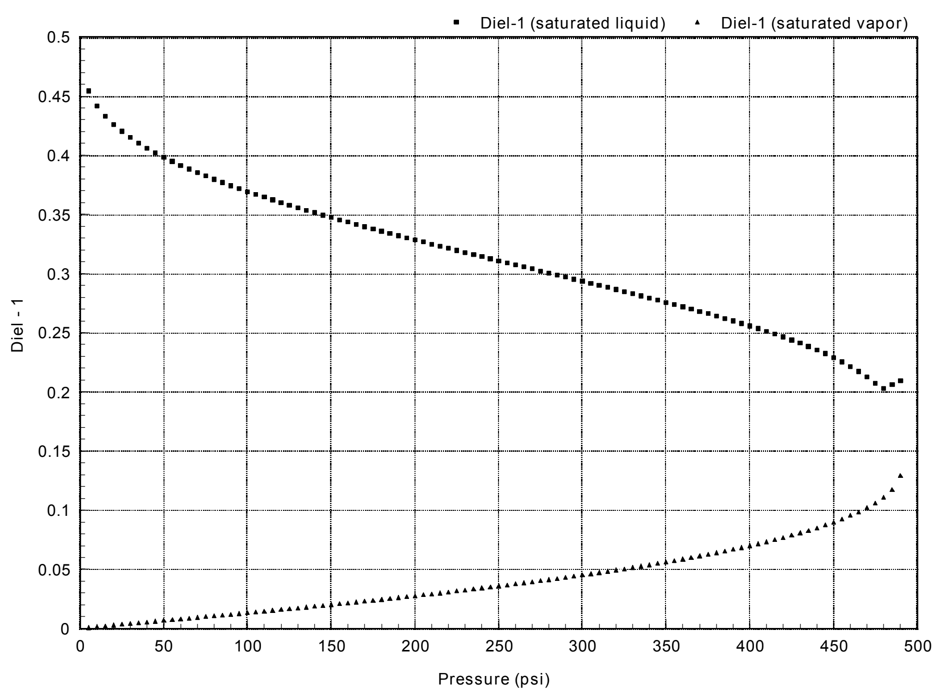


Figure 2-2. Dielectric vs. pressure for nitrogen under saturated conditions.

To minimize the effects of shifts in the dielectric of the target liquid, perform a closed dewar calibration at the expected operating condition of the cryo-vessel. If this is not feasible, then perform an open dewar calibration at atmospheric pressure and then use the approximate calibration method to compensate for the shift of the dielectric when

1. Data obtained from NIST Standard Reference Database 12.

the cryogenic liquid is under pressure. For this type of approximate calibration, the substitute *reference liquid* will be the *target liquid* at atmospheric pressure — see page 19 for a detailed discussion of the approximate calibration method. If any questions exist in regard to calibration issues, contact AMI for assistance in determining the optimal calibration strategy.

Open Dewar Calibration

The instrument should be energized with the sensor connected to the instrument via the oscillator (see the system diagram on page 5).

1. Slowly insert the sensor into the liquid until the level rests approximately one inch below the top sensor hole and then press the MAX push-button through the small hole provided on the instrument front panel. When the calibration point has been accepted, the display will show "bbb.b" and the push-button can then be released. The location of the liquid level on the sensor when the MAX button is pressed becomes the 100% level. The 100% level should always be lower than the upper hole to ensure the instrument will always reach 100% in the event the overall sensor capacitance changes slightly due to component drift, pressure variations, fluid impurities, etc.

2. Slowly withdraw the sensor out of the liquid to be measured until the level is approximately even with the bottom hole in the sensor and then press the MIN push-button through the small hole provided in the instrument front panel. When the calibration point has been accepted, the display will show "bbb.b" and the push-button can then be released. The location of the liquid level on the sensor when the MIN button is pressed becomes the 0% level. This completes the calibration procedure.

   Note

   Having a small amount of liquid on the sensor at the MIN calibration level helps stabilize the sensor capacitance for 0% level indication.

3. Permanently install the sensor in the vessel and proceed to the *Operation* section for directions for configuring the instrument.

Closed Dewar Calibration

A calibration can be performed in a closed dewar system by monitoring the liquid level while transferring the target liquid to an initially empty (or near empty) dewar at a constant rate. In order to insure success with the closed dewar technique, it is necessary to prepare the instrument by presetting the calibration MIN and MAX points outside the estimated level range. If the instrument is not prepared in this manner before the calibration procedure, it is possible to reach the MAX calibration point of the instrument before the target vessel is at the desired maximum level point.

If minimum and maximum liquid level indication is available via some other means (e.g. flow calculation, visual determination, point sensors, etc.), then the presetting of the instrument is not necessary.

Presetting the MAX/MIN calibration points

The following procedure should be performed before installation of the sensor in the target cryo-vessel.

1. Connect the extension and oscillator cables to the J5 coaxial connector on the rear panel of the instrument (see page 5 for a system diagram). *Do not connect the sensor.* Energize the instrument. Press the MIN push-button through the small hole provided on the instrument front panel. When the calibration point has been accepted, the display will show "bbb.b" and the push-button can then be released.

2. Connect the sensor to the oscillator cable (which is still connected to the instrument via the extension cable). Press the MAX push-button through the small hole provided on the instrument front panel. When the calibration point has been accepted, the display will show "bbb.b" and the push-button can then be released.

3. Calculate the factor C_{adj} using the following equation:

$$C_{adj} = 120\left[1 + \frac{2.1L_{active}}{5.2L_{total}}\right]\left[\frac{e-1}{0.454}\right]$$

   where L_{total} is the total sensor length in inches, L_{active} is the active sensor length in inches, and e is the dielectric constant of the target liquid.

4. Enter C_{adj} into the instrument by placing the front panel control mode rotary switch in the SILENCE position. By using the RAISE/LOWER toggle switch and holding it in the up or down position, adjust the displayed value up or down. The display will move slowly at first and then faster. Once near the desired value, simply release the switch momentarily and then resume changing the factor at the slower speed. Once the desired number has been reached, release the toggle switch.

5. Once the value for C_{adj} has been entered, momentarily press the CAL push-button labeled as "~" (the tilde character) through the small hole provided in the instrument front panel. When the value has been accepted, the display will show "ddd.d" and the button can then be released.

6. With the sensor connected, again press the MIN push-button through the small hole provided on the instrument front panel. When the calibration point has been accepted, the display will show "bbb.b" and the push-button can then be released. The presetting procedure is complete. Proceed to the closed dewar calibration procedure.

Closed dewar calibration procedure

1. Install the sensor in the dewar and energize the instrument with the sensor connected to the instrument via the oscillator and extension cables (see the system diagram on page 5).

2. Set the LENGTH to the active length of the sensor. After setting the LENGTH, set the units mode toggle switch to the % setting. For details on setting the LENGTH and units mode, refer to the *Operation* section of this manual.

3. Connect a strip chart recorder to the recorder output terminals on the rear panel of the instrument. If the recorder output is not available, the 4-20 mA current loop output may be used if installed, or an installed communications option can be used to query the instrument for the liquid level at regular time intervals during the calibration procedure. If no remote monitoring or communication option is installed, the level display must be manually plotted vs. time during the procedure.

4. Commence filling the dewar. While the sensor is cooling down, there may be a slow drift in the displayed liquid level. However, when the liquid actually touches the bottom of the sensor, contact with the liquid surface may become apparent by virtue of more random and frequent fluctuations in the displayed liquid level. The liquid level trace will also start to show an increasing profile with positive slope.

   Once the indications of the contact between the sensor and liquid become readily apparent, press the MIN push-button through the small hole provided in the instrument front panel. When the calibration point has been accepted, the display will show "bbb.b" and the push-button can then be released. This point is the 0% level of the sensor.

   Note

   If the sensor is installed in the dewar with some small amount of liquid already in contact with the sensor, then the final MIN calibration point can be set before filling begins but after any thermally induced fluctuations in the observed output have diminished. However, note that the active length of the sensor is reduced by the initial level of liquid in contact with the sensor.

5. Continue the transfer while observing the liquid level trace on the strip chart recorder or computer display, whose slope is proportional to the transfer rate. The slope of the liquid level trace should decrease significantly when the liquid reaches the hole in the top of the sensor.

   When the break in the slope of the level trace occurs (i.e. the slope of the level trace becomes 0 or horizontal), push the MAX push-button through the small hole provided in the instrument front panel. When the calibration data has been accepted, the display will show "bbb.b" and the push-button can then be released. The level on the sensor when the MAX button is pressed becomes the 100% level.

Note

If the instrument displayed a 100% reading before a break is observed in the slope of the level trace, then the MAX calibration point set prior to the current procedure has interfered. If this occurs, the customer has two options: 1) stop the procedure, repeatedly enter a value of 120 *for* C_{adj} *(see steps 4 and 5 of the presetting procedure) until the current liquid level display falls below 100%, and then continue the procedure; or 2) continue the liquid transfer until the liquid level is determined to be 100% by means other than feedback from the instrument and then pressing the MAX calibration push-button.*

6. To achieve a standard calibration of the sensor with the active region located from the lower hole to one inch below the upper hole, use the level data from the instrument to recalibrate the MAX point when the percent level corresponds to one inch below the upper hole. Use the following equation to determine the percent level at which to reset the MAX calibration point:

$$MAX_{percent} = 100 - 100\frac{1}{L_{active}}$$

where L_{active} is the active length of the sensor in inches. This technique can be used assuming the sensor was built as a standard sensor. If the sensor was made in a custom configuration, refer to the sensor documentation and/or drawing or contact AMI.

Example: 20" active length sensor:

When the sensor is calibrated by the closed dewar procedure, the actual length of calibration will be 21" (distance between the bottom and top holes in the sensor). When the liquid is 1" below the upper hole, the display will show 95.2% [e.g. 100% – (1"/21" x 100%)]. When the liquid level reaches this point during usage, push the MAX calibrate button. The instrument and sensor are now calibrated with a standard active region of 20". The LENGTH setting of the instrument should also be configured for 20".

7. Proceed to the *Operation* section for directions for configuring the instrument.

Approximate Calibration

This procedure is the least accurate form of calibration and should be used only when the aforementioned calibration procedures are not viable. The approximate calibration method can be used in cases where the sensor cannot be dipped into the target liquid, the full active length of the sensor cannot be dipped into an open dewar, or both. Approximate calibration may also be useful for situations where the sensor cannot be dipped into the target liquid under the expected operating pressure.

If the target liquid is not available for dipping, a substitute *non-conducting* reference liquid can be used. If the full length of the sensor cannot be dipped, then a partial length dip can be performed. If both situations are encountered, then a partial length dip can be performed in a substitute reference liquid.

1. First, cool the sensor as much as possible by dipping the sensor as far as possible in the available reference liquid.

2. Slowly withdraw the sensor out of the reference liquid until the level is approximately even with the bottom hole in the sensor and then press the MIN push-button through the small hole provided in the instrument front panel. When the calibration point has been accepted, the display will show "bbb.b" and the push-button can then be released. The location of the liquid level on the sensor when the MIN button is pressed becomes the 0% level.

   Note

   Having a small amount of liquid on the sensor at the MIN calibration level helps stabilize the sensor capacitance for 0% level indication.

3. Reinsert the sensor in the reference liquid as far as possible, but not exceeding 1" below the top hole. Note the physical location of the liquid level on the sensor at the maximum insertion depth. While the sensor is submerged at the maximum depth, press the MAX push-button through the small hole provided in the instrument front panel. When the calibration point has been accepted, the display will show "bbb.b" and the push-button can then be released.

4. Measure the distance between the bottom hole of the sensor and the location of the liquid level noted during step 3. This measured length is L_{dipped}.

5. The dielectric constant for the reference liquid, e_1, and the target liquid, e_2, must be known to complete the approximate calibration. These values must be placed in the equation:

$$\text{Approximate Calibration Factor} = \left[\frac{e_2 - 1}{e_1 - 1} \times 100\right]\frac{L_{active}}{L_{dipped}}$$

   where L_{dipped} is the length of the sensor dipped in the reference liquid and L_{active} is the active sensor length.

   Note

   If the target liquid is available for dipping (i.e. the reference liquid and target liquid are the same), then the dielectric ratio, $(e_2-1)/(e_1-1)$, *becomes* 1. *If the full active length of the sensor can be dipped, then the length ratio,* L_{active} / L_{dipped}, *becomes* 1.

   Note that $e_1 = 1.454$ for liquid nitrogen at –203°C at atmospheric pressure. Dielectric constants for several liquids are provided in the *Appendix*. The dielectric constant varies with temperature and pressure, therefore for best accuracy use the dielectric constant for the target liquid at the temperature and pressure maintained in the containing vessel.

6. Once the approximate calibration factor is calculated, it can be entered into the instrument by placing the front panel control mode rotary switch in the SILENCE position. By using the RAISE/LOWER toggle switch and holding it in the up or down position, you can adjust the approximate calibration factor up or down. The display will move slowly at first and then faster. Once near the desired value, simply release the switch momentarily and then resume changing the factor at the slower speed. Once the desired number has been reached, release the toggle switch.

7. Once the approximate calibration factor has been entered, momentarily press the CAL push-button labeled as "~" (the tilde character) through the small hole provided in the instrument front panel. When the calibration factor has been accepted, the display will show "ddd.d" and the button can then be released. This completes the approximate calibration procedure.

   Note

   The approximate calibration factor should only be entered once without resetting the MAX and MIN calibration points.

   Example: Purchased a 100" active length sensor for operation in liquid argon at atmospheric pressure, however only liquid nitrogen is available for calibration at a maximum depth of 30":

   First, the sensor is dipped as far as possible into the liquid nitrogen and cooled. The MIN point is then set as outlined in step 2. The MAX point is set as outlined in step 3 while the sensor is submerged 30" in liquid nitrogen. The dielectric constant for liquid nitrogen is 1.454 and for liquid argon is 1.53. Substituting all values into the approximate calibration factor equation yields:

$$\text{Approximate Calibration Factor} = \left[\frac{1.53-1}{1.454-1}\times 100\right]\frac{100}{30} = 389.1$$

   A value of 389.1 should be entered and set as the approximate calibration factor as outlined in steps 6 and 7. The sensor is now *approximately* calibrated for 100" active length operation in liquid argon.

8. The sensor can now be installed in the dewar containing the target liquid. The approximate calibration can be used until an open dewar or closed dewar calibration can be performed with the target liquid.

9. Proceed to the *Operation* section for directions for configuring the instrument.

3 Operation

The Model 186 and sensor were functionally tested and calibrated at the factory. The calibration sticker located on the bottom of the instrument shows the calibration length, calibration liquid, and whether an approximate calibration method was utilized at the factory. In the event that the calibration is incorrect for the application, the instrument will need to be recalibrated by the user with a specific sensor and liquid. Refer to the *Calibration* section for the specific procedures.

1. Energize the instrument

After completion of the *Installation* procedures, energize the instrument by placing the power toggle switch in the POWER position. The LED display will indicate the liquid level and the yellow ACTIVITY LED will begin blinking.

> **Note**
>
> *The ACTIVITY LED provides visual indication that the microprocessor is making sensor readings. If a fault should develop which prohibits the microprocessor from operating correctly (such as a break in cabling) the LED will not blink or blink slowly, and the display will continuously show 100%.*

The instrument is normally calibrated at the factory for the specific sensor supplied with the unit for use in a target liquid. If the need arises for recalibration, see the *Calibration* section.

2. Configure the active length setting

After calibration, the instrument *must* be configured for the active length of the sensor in order to scale the measurement to meaningful units of length for display. For a standard calibration, the value of the active length is the sensor length between the bottom hole to 1 inch below the top hole of the sensor assembly. If the user performed a calibration, then the physical distance between the locations of the MIN and MAX calibration points on the sensor is the active length.

The instrument allows the user to display the liquid level in units of length (inches or centimeters) in addition to a percentage. The instrument was shipped with the length value set to the active sensor length if a sensor was purchased with the instrument.

To *view* the present length setting, place the units mode toggle switch in either the INCH or CM position. Place the control mode rotary switch on the front panel to the LENGTH position. Push and *release* the RAISE/LOWER toggle switch either up or down. The display will momentarily show the current length setting.

To *change* the length setting, use the RAISE/LOWER toggle switch to move the setting up or down by continuously holding it in the up or down position. The display will move slowly at first and then faster. Once near the desired value, simply release the switch momentarily and then resume changing the setpoint at the slower speed. The new active sensor length is permanently stored in memory. Check the value by momentarily placing the toggle switch in either position from the center position.

Note

The LENGTH adjustment can only be performed in the INCH or CM units modes. The LENGTH adjustment is inactive if the units are set for %.

3. Configure the HI SETPOINT and the LO SETPOINT

To adjust the HI and LO setpoints, place the control mode rotary switch in the HI SETPOINT position or the LO SETPOINT position, respectively. Use the RAISE/ LOWER toggle switch to adjust the respective setpoint in the same manner as described for the LENGTH adjustment in step 2. The setpoints may be located anywhere between 0% to 100% of the active sensor length. The HI and LO setpoint adjustments are compatible with all three units modes.

a. When the measured liquid level reaches or exceeds the HI setpoint, the HI LEVEL LED on the front panel is energized and a set of relay contacts are closed on the 9-pin D connector J2 on the rear panel (see the *Appendix* for the pinout). When the level falls below the HI setpoint, the LED is extinguished and the relay contacts open.

b. When the measured liquid level falls below the LO setpoint, the LO LEVEL LED on the front panel is energized and a set of relay contacts are closed on the 9-pin D connector J2 on the rear panel (see the *Appendix* for the pinout). When the level reaches or exceeds the LO setpoint, the LED is extinguished and the contacts open.

Note

The HI and LO contacts are both closed on power-off of the instrument which is a state unique to the power-off condition.

Note

If the LENGTH is adjusted subsequent to configuring the various setpoints, the percentage of active length will be maintained for all setpoints. For example, if the LENGTH is set to 100 cm and the HI SETPOINT is set to 80 cm, then adjusting the LENGTH to 150 cm will result in the HI SETPOINT being automatically scaled to 120 cm—i.e. the setting of 80% of active length is maintained.

4. Configure the A SETPOINT and the B SETPOINT

To adjust the A and B setpoints which specify the upper and lower limits for the liquid level control band, place the control mode rotary switch in the A SETPOINT position or the B SETPOINT position, respectively. Use the RAISE/LOWER toggle switch to adjust the respective setpoint in the same manner as described for the LENGTH adjustment in step 2. The A and B setpoint adjustments are compatible with all three units modes.

a. When the measured liquid level reaches or exceeds the A setpoint, the A LEVEL LED on the front panel is energized. When the level falls below the A setpoint, the LED is extinguished.

b. When the measured liquid level falls below the B setpoint, the B LEVEL LED on the front panel is energized. When the level reaches or exceeds the B setpoint, the LED is extinguished.

c. In addition to the LED functions, the controller output receptacle may be energized and de-energized as discussed in step 5 below.

Note

The A setpoint must always be above the B setpoint. The firmware does not allow these setpoints to be reversed. Both setpoints may be set from 0% to 100% of the LENGTH setting as long as A > B.

5. Select the operational mode of the controller output receptacle

The operation of the CONTROLLER OUTPUT receptacle of the instrument is controlled by the fill toggle switch. Operation of the fill toggle switch is as follows:

a. **OFF:** With the power on and the fill switch in the OFF position, the instrument serves only as a level monitor, giving a level reading on the digital display and providing data via any analog or communication options installed. All four setpoint LEDs (and associated J2 connector relay contacts) operate normally, however, the controller output receptacle on the rear panel will *always* be de-energized.

b. **ON:** With the fill switch in the ON position, the rear panel CONTROLLER OUTPUT receptacle will become energized, thereby initiating flow if the solenoid-operated fill valve is properly connected. The FILL LED on the front panel will light indicating the presence of power at the controller output receptacle. **The operator is solely responsible for terminating the fill flow.**

c. **AUTO:** With the fill switch in the AUTO position, the instrument is capable of automatically initiating and terminating liquid fill via the control valve, thereby maintaining the level between the selected A and B setpoints. If the liquid level falls below the B setpoint, the rear panel

CONTROLLER OUTPUT receptacle and front panel FILL LED are energized. When the liquid level subsequently reaches or exceeds the A setpoint, the controller output receptacle is de-energized and the FILL LED is extinguished.

6. Configure the INTERVAL setting (fill timer) if desired

An INTERVAL time-out of up to 600 minutes is provided to alleviate the possibility of liquid overflow. The time-out feature is enabled when the instrument is operated in the AUTO mode with an INTERVAL setting > 0. Once the liquid level falls below the B setpoint, an internal fill timer (whose period is the INTERVAL setting) begins to count down. If the liquid level does not reach the A setpoint before the timer expires, the display will flash rapidly and power to the rear panel CONTROLLER OUTPUT receptacle will be interrupted. To reset this function the fill toggle switch must be momentarily placed in the ON position (to complete the filling process manually) or power to the instrument must be momentarily turned off.

Note

The INTERVAL function is disabled when the INTERVAL setting is 0. Adjusting the INTERVAL setting to 0 will also terminate any in-progress functions of the INTERVAL timer.

The INTERVAL setting can be adjusted by placing the control mode rotary switch in the INTERVAL position and using the RAISE/LOWER toggle switch to adjust the setting up or down. The display will move slowly at first and then faster. Once near the desired value which is displayed in minutes, simply release the switch momentarily and then resume changing the setpoint at the slower speed. The instrument is shipped from the factory with a zero interval time.

7. Select the appropriate units display option

Place the units mode toggle switch in the position desired for the display output units during operation. The % position displays the percentage of active sensor length that is immersed in liquid.

Sensor contamination

To ensure proper instrument calibration and operation, care must be taken to ensure the sensor is kept free of contaminants and not subjected to any force which would physically distort the sensor. Water or other electrically conducting substances in the sensor will disturb the measured capacitance and therefore instrument response. Physically distorting the sensor in any way will also cause abnormal instrument operation by introducing variations in the sensor capacitance not due to liquid level. The absolute calibration of the instrument can be inaccurate if care is not taken to ensure the sensor is in a proper environment.

Cold sensors exposed to humidified air can show erroneous high level readings due to the fact that the air contains moisture which can condense between the cold sensing tubes. A small film of water can cause a shorted or partially shorted condition, which results in false level readings. As the sensor warms, the moisture may evaporate and the sensor will again read correctly. This is a physical phenomenon and does not indicate any problem with your AMI level equipment. Limit or eliminate exposure of cold sensors to humidified air to avoid this condition.

If a sensor should require cleaning, flushing with alcohol is recommended. The sensor cannot be used again until all the alcohol has been evaporated. Under no circumstances should the sensor be disassembled.

4 RS-232 Communication/Data Logger Option

The RS-232 communication/data logger option provides a 25-pin D-type connector on the rear panel of the instrument for serial communications and data logger function.

Serial port connector and cabling

An IBM-compatible computer's serial port can be directly connected to the Model 186 via a standard PC modem cable. Refer to your computer's documentation to determine which serial ports are available on your computer and the required connector type. The cable to connect two DB25 connectors is wired directly, i.e. pin 1 to pin 1, pin 2 to pin 2, etc. If a DB9 connector is required at the computer interface, the connector translation is provided in the Appendix.

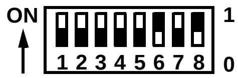
The Model 186 uses only three wires of the rear-panel DB25 connector: pin 2 (transmit), pin 3 (receive), and pin 7 (common). There is no software or hardware handshaking. The Model 186 is classified as a DCE (Data Communication Equipment) device since it transmits data on pin 3 and receives data on pin 2. The instrument to which the Model 186 is attached must do the opposite, i.e., transmit on pin 2 and receive on pin 3 (the requirements for a DTE, or Data Terminal Equipment device). If a serial-to-parallel converter is used, it must be capable of receiving data on pin 3 or the cable connected to the Model 186 must interchange the wires between pins 2 and 3.

Command/return termination characters

All commands are transmitted and received as ASCII values and are case insensitive. The Model 186 always transmits *<CR><LF>* (i.e. a *carriage return* followed by a *linefeed*) at the end of an RS-232 transmission. The Model 186 can accept *<CR>*, *<LF>*, *<CR><LF>*, or *<LF><CR>* as termination characters from an external computer.

The simplest method for communicating with the Model 186 via RS-232 is by using the interactive mode of a commercially available terminal emulation program. The Model 186 transmits and receives information at various baud rates and uses 8 data bits, no parity, and 1 stop bit. When the Model 186 receives a terminated ASCII string, it always sends back a reply as soon as the string is processed. *When sending commands to the Model 186, you must wait for the reply from the Model 186 before sending another command even if the reply consists of only termination characters.* Otherwise, the shared input/output command buffer of the Model 186 may become corrupted.

Communication DIP Switch Settings



The 8 DIP switches located on the rear panel of the Model 186 are used to control various parameters of the RS-232 interface. Switches 6 through 8 control the baud rate of the interface. Switches 3 through 5 control the time interval between data output if the data logger function is enabled. Switch 2 controls the echo feature and switch 1 enables the data logger function. Each of these features is fully discussed below.

Baud rate control

The Model 186 baud rate is controlled by switches 6 through 8 of the communication DIP switch on the rear panel. The unit is shipped with the baud rate set at 9600. The switch settings for various baud rates are (on = 1 or the up position):

DIP switch			
6	7	8	Baud rate
off	off	off	300
off	off	on	600
off	on	off	1200
off	on	on	2400
on	off	off	4800
on	off	on	9600

Data logger output interval

The interval between successive output from the data logger function is controlled by switches 3 through 5. The unit is shipped with the data logger function disabled (switch 1 = off). The available intervals and the corresponding switch settings are (on = 1 or the up position):

DIP switch			
3	4	5	Interval (minutes)
off	off	off	1
off	off	on	2
off	on	off	5
off	on	on	10

DIP switch			
3	4	5	Interval (minutes)
on	off	off	20
on	off	on	30
on	on	off	60

Echo function

The Model 186 has an *echo* feature which is enabled or disabled by communication DIP switch 2. When the echo function is enabled, the Model 186 will echo the incoming command characters back to the transmitting device. The echo feature is useful when using an interactive terminal program on a host computer for communicating with the Model 186. The settings are:

DIP switch 2	Function
on	Echo On
off	Echo Off

Data logger function

Switch 1 of the communications DIP switch controls the data logger function. This feature is normally used with a printer rather than a host computer, since a computer can be more usefully programmed utilizing the available command set. The data logger function generates a time relative to instrument power-up and a corresponding level. The units of the level output are set by the units mode toggle switch. The time and corresponding level are formatted and output to the host device at regular intervals as specified by the switches 3 through 5. The settings for the data logger function are:

DIP switch 1	Function
on	Data Logger On
off	Data Logger Off

The host device can be a standard dot matrix printer connected via a serial-to-parallel converter, or connected directly with a printer capable of receiving serial data. Presumably, any serial-to-parallel converter which can be properly configured is acceptable. AMI has tested the Model 186 with a standard, low cost converter configured as a DTE device, 8 data bits, no parity, and 1 stop bit. In order to communicate with the host device, it is necessary to set the Model 186 to the identical baud rate of the host device.

RS-232 Command Set Reference

All commands sent to the Model 186 are processed and the Model 186 responds with a return value (if applicable) and termination. If the command is invalid, the Model 186 will respond with an error code (see the *Error Codes* section). All return values including error codes are terminated with *<CR><LF>* (i.e. a *carriage return* followed by a *linefeed*). For those commands that do not return a value, the Model 186 will return the *<CR><LF>* termination only.

Commands for controlling the units of measurement

Command:	CM	Function:	Sets the units of measurement to centimeters	Returns:	*<CR><LF>*
Command:	INCH	Function:	Sets the units of measurement to inches	Returns:	*<CR><LF>*
Command:	PERCENT	Function:	Sets the measurement to % of sensor length	Returns:	*<CR><LF>*
Command:	UNIT	Function:	Returns the current units in use	Returns:	C, I, or % *<CR><LF>*

The CM command sets the units of measurement to centimeters and the INCH command selects inches. The PERCENT command sets the units of measurement to the percentage of active sensor length that is immersed in liquid. The units of measurement selected through the RS-232 interface are controlled independently from the units mode toggle switch used for controlling the front panel display. The default units are centimeters when the Model 186 is first powered on. The last unit command remains in effect until the unit is powered off. The setting is not saved in permanent memory. The UNIT command returns a one character value (and termination) indicating the current units—C for centimeters, I for inches, or % for percentage.

Commands for configuring permanent memory

Command:	HI=<value>	Function:	Configures the HI setpoint limit	Returns:	*<CR><LF>*
Command:	LO=<value>	Function:	Configures the LO setpoint limit	Returns:	*<CR><LF>*
Command:	A=<value>	Function:	Configures the A setpoint (control band upper limit)	Returns:	*<CR><LF>*
Command:	B=<value>	Function:	Configures the B setpoint (control band lower limit)	Returns:	*<CR><LF>*
Command:	INTERVAL= <value>	Function:	Configures the fill timer in minutes	Returns:	*<CR><LF>*
Command:	LENGTH=<value>	Function:	Configures the active sensor length	Returns:	*<CR><LF>*
Command:	SAVE	Function:	Saves the configuration to permanent memory	Returns:	*<CR><LF>*

The HI and LO command configure the high and low setpoint limit values respectively. For example, HI=90.0 would configure the high setpoint limit to 90.0 in whichever units of measurement last selected through the RS-232 interface. The A and B commands configure the upper limit and lower limit of the control band, respectively. The HI, LO, A, and B commands are compatible with the percent units selection.

The LENGTH command configures the active sensor length setting in the current units. LENGTH=35.0 would configure the active sensor length to 35.0 units of centimeters or inches.

Note

The LENGTH=<value> command will only function if CM or INCH are currently selected as the units of measurement. The LENGTH command does not configure the Model 186 if the units of measurement are PERCENT.

The INTERVAL command sets the fill timer in minutes as described in the *Operation* section on page 26. Setting the value of INTERVAL to 0 disables the fill timer function.

The SAVE command saves the HI, LO, A, B, INTERVAL and LENGTH settings to permanent memory. Saved settings are then recalled each time the power is turned off and then reapplied to the instrument. If the configuration is changed from the front panel, the settings are automatically saved to permanent memory.

Commands for querying the configuration

Command:	HI	Function:	Returns the HI setpoint limit in the current units	Returns:	<value> *<CR><LF>*
Command:	LO	Function:	Returns the LO setpoint limit in the current units	Returns:	<value> *<CR><LF>*
Command:	A	Function:	Returns the A setpoint limit in the current units	Returns:	<value> *<CR><LF>*
Command:	B	Function:	Returns the B setpoint limit in the current units	Returns:	<value> *<CR><LF>*
Command:	INTERVAL	Function:	Returns the fill timer setting in minutes	Returns:	<value> *<CR><LF>*
Command:	LENGTH	Function:	Returns the active sensor length in the current units	Returns:	<value> *<CR><LF>*

The HI, LO, A, B, INTERVAL, and LENGTH commands return the current configuration of the instrument. Each return value is terminated with *<CR><LF>*.

Command for returning a level measurement

Command:	LEVEL	Function:	Returns the liquid level in the current units	Returns:	<value> *<CR><LF>*

The LEVEL command returns the liquid level in the current units selected through the communication interface.

Error Codes

The Model 186 returns specific error codes for invalid commands and/or arguments. If an error condition is returned, the command is not processed and the configuration of the instrument is *not* modified. The table below provides a list of error codes, their meaning, and any associated limits.

Error Code	Meaning	Valid Range
−1	LO setpoint out of range	0 ≤ LO ≤ LENGTH
−2	B setpoint out of range	0 ≤ B < A
−3	A setpoint out of range	B < A ≤ LENGTH
−4	HI setpoint out of range	0 ≤ HI ≤ LENGTH
−5	Attempted to set or query for LENGTH in PERCENT units mode	
−6	Invalid argument, *value* out of maximum calibration range	1 cm ≤ *value* ≤ 650 cm
−7	INTERVAL setting out of range	0 ≤ INTERVAL≤ 600 min
−8	Unrecognized command	
−9	Invalid argument, value was negative or non-numeric	

5 IEEE-488 Communication Option

The IEEE-488 communication option provides a GPIB connector on the rear panel of the instrument for IEEE-488 (GPIB, HPIB) communications.

Command/return termination characters

All commands are transmitted and received as ASCII values and are case insensitive. The Model 186 always transmits <LF> and EOI as the termination for return data. The Model 186 can accept *<CR>*, *<LF>*, *<CR><LF>*, *<LF><CR>*, or *<LF>* with EIO as termination characters from an external IEEE-488 interface.

Only one command at a time should be sent to the Model 186 by the external IEEE-488 interface. Additional commands separated by a semicolon will not be processed. The instrument uses a single 16 character buffer for input and output. Consequently, all input strings including terminations should not be longer than 16 characters. Any excess characters will be discarded. All alphabetical characters are case insensitive and character encoding is in accordance with IEEE 488.2.

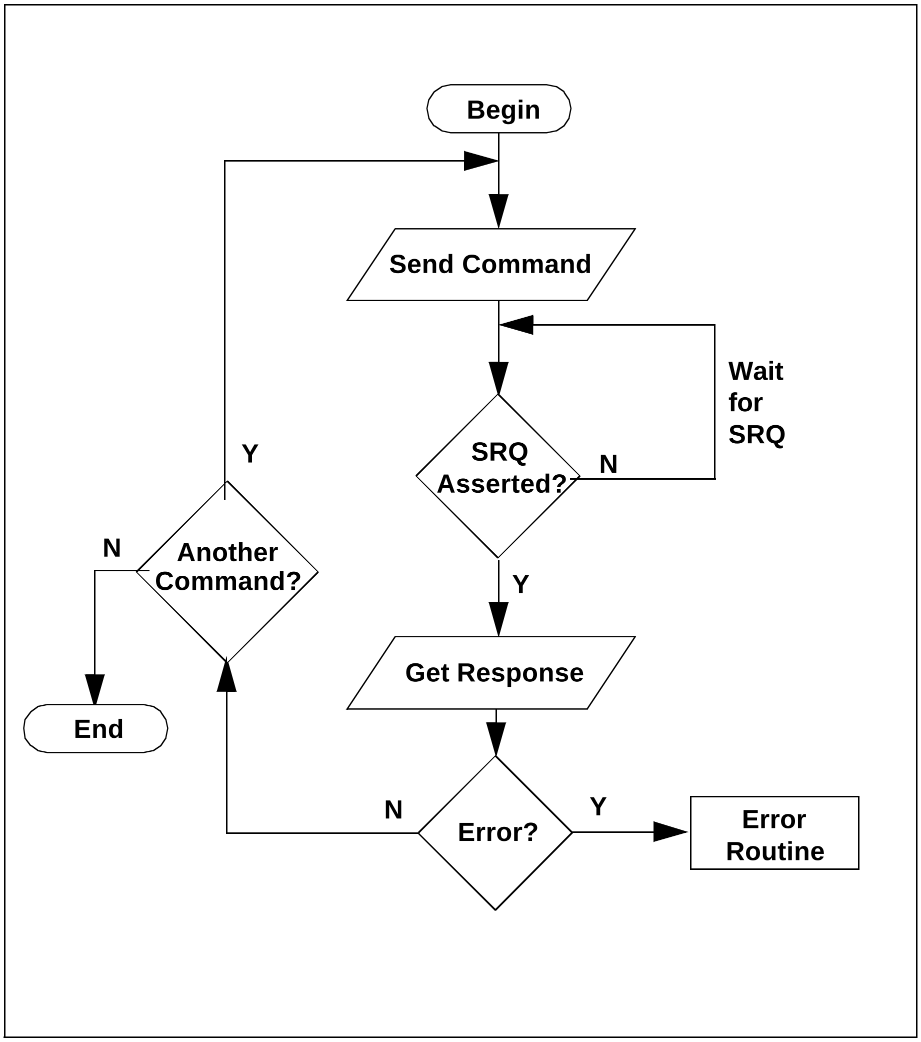
Communicating with the Model 186

The use of a single buffer for both input and output is a result of memory limitations in the Model 186. In order to keep the external IEEE-488 interface from sending successive commands faster than the Model 186 can respond, the Model 186 uses the Serial Poll Service Request (SRQ) to let the external computer know it has finished processing the last command received and is ready to send a response. This is true of all commands. Thus sending commands to the Model 186 using IEEE-488 protocol is a three step process: 1) send the ASCII command, 2) wait for SRQ, and 3) get the instrument response.

Note

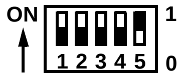
API's for some manufacturer's cards require you to use different functions to check for SRQ and read the serial poll status (spoll) byte. Invoking the command to read the spoll byte may be required to actually clear the SRQ status.

A basic flow diagram for sending an ASCII command to the Model 186 and receiving a response is shown on the following page.



Basic communication flow diagram for IEEE-488 commands.

Communication DIP Switch Settings



The 5 DIP switches located on the rear panel of the Model 186 are used to set the primary IEEE-488 bus address of the unit.

IEEE-488 primary bus address

The Model 186 primary bus address is controlled by switches 1 through 5 of the communication DIP switch on the rear panel. Valid primary addresses are between 0 and 30. The Model 186 does not use secondary addressing. Note that many IEEE-488 controller cards in external computers will use address 0. The bus address for each Model 186 *should be unique* with respect to other Model 186 units or any other devices on the bus. The switch settings for the various addresses are (on = 1 or the up position):

DIP switch					Primary bus address
1	2	3	4	5	
off	off	off	off	off	0
off	off	off	off	on	1
off	off	off	on	off	2
off	off	off	on	on	3
off	off	on	off	off	4
off	off	on	off	on	5
off	off	on	on	off	6
off	off	on	on	on	7
off	on	off	off	off	8
off	on	off	off	on	9
off	on	off	on	off	10
off	on	off	on	on	11
off	on	on	off	off	12
off	on	on	off	on	13
off	on	on	on	off	14
off	on	on	on	on	15
on	off	off	off	off	16
on	off	off	off	on	17
on	off	off	on	off	18

DIP switch					Primary bus address
1	2	3	4	5	
on	off	off	on	on	19
on	off	on	off	off	20
on	off	on	off	on	21
on	off	on	on	off	22
on	off	on	on	on	23
on	on	off	off	off	24
on	on	off	off	on	25
on	on	off	on	off	26
on	on	off	on	on	27
on	on	on	off	off	28
on	on	on	off	on	29
on	on	on	on	off	30

IEEE-488 Command Set Reference

All commands sent to the Model 186 are processed and the Model 186 responds with a return value and termination. If the command is invalid, the Model 186 will respond with an error code (see the *Error Codes* section). All return values including error codes are terminated with *<LF>* (*linefeed*) and EOI asserted. For those commands that do not return a value, the Model 186 will echo the command string in the return message. The Model 186 does not implement a full complement of IEEE 488.2 commands, nor does it conform to the Standard Commands for Programmable Instruments (SCPI) protocol. These limitations are due to memory constraints in the microprocessor board design.

Device clear (DCL) command

The Model 186 responds to the device clear (DCL) command from a host IEEE controller. The device clear resets the instrument. The default units are centimeters and the permanently saved configuration settings are restored.

Commands for controlling the units of measurement

Command:	CM	Function:	Sets the units of measurement to centimeters	Returns:	CM
Command:	INCH	Function:	Sets the units of measurement to inches	Returns:	INCH
Command:	PERCENT	Function:	Sets the measurement to % of active sensor length	Returns:	%
Command:	UNIT	Function:	Returns the current units in use	Returns:	C, I, or %

The CM command sets the units of measurement to centimeters and the INCH command selects inches. The PERCENT command sets the units of measurement to the percentage of the active sensor length that is immersed in liquid. The units of measurement selected through the IEEE-488 interface are controlled independently from the units mode toggle switch used for controlling the front panel display. The default units are centimeters when the Model 186 is first powered on. The last unit command remains in effect until the unit is powered off. The setting is not saved in permanent memory. The UNIT command returns a one character value (and termination) indicating the current units—C for centimeters, I for inches, or % for percentage.

Commands for configuring permanent memory

Command:	HI=<value>	Function:	Configures the HI setpoint limit	Returns:	HI=<value>
Command:	LO=<value>	Function:	Configures the LO setpoint limit	Returns:	LO=<value>
Command:	A=<value>	Function:	Configures the A setpoint (upper limit of control band)	Returns:	A=<value>
Command:	B=<value>	Function:	Configures the B setpoint (lower limit of control band)	Returns:	B=<value>
Command:	INTERVAL= <value>	Function:	Configures the fill timer in minutes	Returns:	INTERVAL= <value>
Command:	LENGTH=<value>	Function:	Configures the active sensor length	Returns:	LENGTH= <value>
Command:	SAVE	Function:	Saves the configuration to permanent memory	Returns:	SAVE

The HI and LO command configure the high and low setpoint limit values respectively. For example, HI=90.0 would configure the high setpoint limit to 90.0 in whichever units of measurement last selected through the IEEE-488 interface. The A and B commands configure the upper limit and lower limit of the control band, respectively. The HI, LO, A, and B commands are compatible with the percent units selection.

The LENGTH command configures the active sensor length setting in the current units. LENGTH=35.0 would configure the active sensor length to 35.0 units of centimeters or inches.

<u>Note</u>

The LENGTH=<value> command will only function if CM or INCH are currently selected as the units of measurement. The LENGTH command does not configure the Model 186 if the units of measurement are PERCENT.

The INTERVAL command sets the fill timer in minutes as described in the *Operation* section on page 26. Setting the value of INTERVAL to 0 disables the fill timer function.

The SAVE command saves the HI, LO, A, B, INTERVAL, and LENGTH settings to permanent memory. Saved settings are then recalled each time the power is turned off and then reapplied to the instrument. If the configuration is changed from the front panel, the settings are automatically saved to permanent memory.

Commands for querying the configuration

Command:	HI	Function:	Returns the HI setpoint limit in the current units	Returns:	<value>
Command:	LO	Function:	Returns the LO setpoint limit in the current units	Returns:	<value>
Command:	A	Function:	Returns the A setpoint limit in the current units	Returns:	<value>
Command:	B	Function:	Returns theB setpoint limit in the current units	Returns:	<value>
Command:	INTERVAL	Function:	Returns the fill timer setting in minutes	Returns:	<value>
Command:	LENGTH	Function:	Returns the sensor length in the current units	Returns:	<value>

The HI, LO, A, B, INTERVAL, and LENGTH commands return the current configuration of the instrument. Each return value is terminated with *<LF>* and EOI.

Command for returning a level measurement

Command:	LEVEL	Function:	Returns the liquid level in the current units	Returns:	<value>

The LEVEL command returns the liquid level in the current units selected through the communication interface.

Error Codes

The Model 186 returns specific error codes for invalid commands and/or arguments. If an error condition is returned, the command is not processed and the configuration of the instrument is *not* modified. The table below provides a list of error codes, their meaning, and any associated limits.

Error Code	Meaning	Valid Range
−1	LO setpoint out of range	0 ≤ LO ≤ LENGTH
−2	B setpoint out of range	0 ≤ B < A
−3	A setpoint out of range	B < A ≤ LENGTH
−4	HI setpoint out of range	0 ≤ HI ≤ LENGTH
−5	Attempted to set or query for LENGTH in PERCENT units mode	
−6	Invalid argument, *value* out of maximum calibration range	1 cm ≤ *value* ≤ 650 cm
−7	INTERVAL setting out of range	0 ≤ INTERVAL≤ 600 min
−8	Unrecognized command	
−9	Invalid argument, *value* was negative or non-numeric	

Serial Poll Status Byte

The serial poll status byte (spoll byte) can be used to obtain information about the state of the instrument. Bit 7 of the status byte is reserved for SRQ. The remaining bits are used to provide custom information as shown in the table below.

Bit	ON	OFF
1	HI relay on	HI relay off
2	A relay on	A relay off
3	B relay on	B relay off
4	LO relay on	LO relay off
5	Fill mode off (controller output de-entergized)	Fill mode on (controller output energized)
6	Data ready	No data available
7	Service Request (SRQ)	No SRQ
8	Not used	Not used

Note

The fill mode indication is only accurate if the fill mode toggle switch on the front panel is in the AUTO position. There is no remote indication available for the OFF or ON manual override selections.

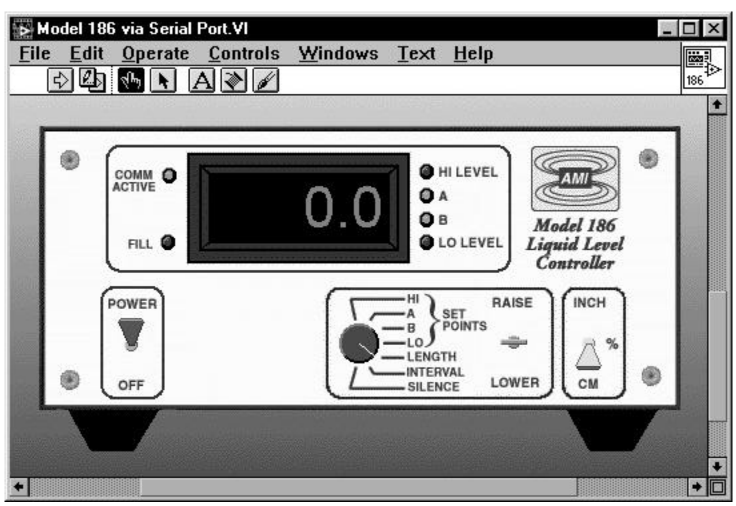
6 Virtual Instrument Operation

In order to make the communications options easier to use for the customer, AMI provides a LabVIEW-based interface for remote monitoring and control of the Model 186. LabVIEW® is a virtual instrument (VI) development and deployment software tool produced and marketed by National Instruments. LabVIEW is available on several platforms including Microsoft Windows™, Microsoft Windows NT™, Apple Macintosh™, Sun Solaris™, and HP-UX™. The AMI provided VI's are developed and tested under Microsoft Windows 3.1 and 3.11, however, they should be portable with only minor modifications across all LabVIEW-supported platforms. Please contact National Instruments for detailed information on the available products and specifications.

The AMI provided VI's are supplied on one 3.5" 1.44 MB diskette. ***The VI's require version 3.1 (or above) of LabVIEW and a minimum of a 256 color display.*** The VI's are stored in one LabView VI Library (LLB) file which contains the multiple VI's needed for operation of the instrument as a whole. AMI's provided VI's are designed for continuous operation under the control of LabVIEW, and do not conform to the instrument driver specifications to which National Instruments' own instrument drivers adhere. Any additional functionality gained by conforming to such specifications was deemed of minimal value by AMI due to the relative simplicity of communicating with the Model 186 instrument.

RS-232 Virtual Instrument

The figure below illustrates the front panel of the Model 186 virtual instrument (VI). The front panel appears nearly identical to the front panel of the actual instrument. The functionality of the VI is very similar to that of the actual instrument as well.



When running the VI it is important to operate the instrument using the VI and not via the actual instrument front panel. Otherwise, the VI and the actual instrument may not be synchronized. The only exceptions to this rule are calibration procedures or operation of the fill toggle switch if manual override becomes necessary, both of which are functions that are not available from the VI. Any function available from the VI should be normally be set by using the VI and not the front panel of the instrument.

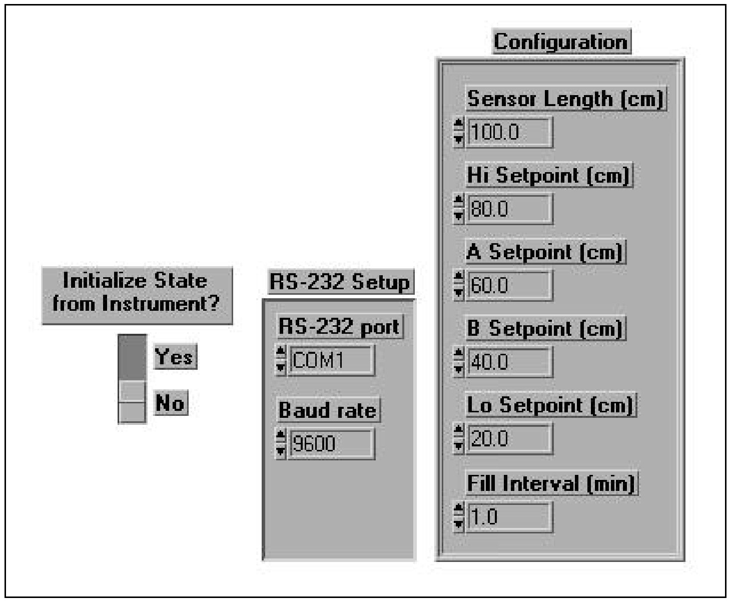
Launching and initializing the RS-232 VI

First, make sure the Model 186 is connected to a COM port on the host computer and that the instrument is powered on. The VI library, provided in the file MODEL186.LLB, for the RS-232 virtual instrument contains the following files:

VI	Function
186 Alarms.vi	Manages alarm functions for 186.
Config 186 via Serial Port.vi	Initializes actual instrument from VI configuration.
Convert from CM.vi	Displays inches or percentage given input in cm.
Counter.vi	Timer function for the virtual display.
Get 186 Level via Serial Port.vi	Updates virtual display with current level.
Init from 186 via Serial Port.vi	Initializes VI configuration from actual instrument.
Model 186 via Serial Port.vi	The main VI containing the configuration and front panel controls. This is the VI the user should open and execute.
Serial Port Send.vi	Manages sending and receiving of ASCII strings from the actual instrument.
Set 186 A via Serial Port.vi	Configures the A setpoint.
Set 186 B via Serial Port.vi	Configures the B setpoint.
Set 186 Fill via Serial Port.vi	Configures the fill interval setting.
Set 186 HI via Serial Port.vi	Configures the HI setpoint.
Set 186 Length via Serial Port.vi	Configures the active sensor length.
Set 186 LO via Serial Port.vi	Configures the LO setpoint.

Open the *Model 186 via Serial Port.vi*. Before running the VI, the user must select an initialization option and provide any necessary settings. In order to initialize the VI, scroll to the area above the virtual front panel. Several controls are visible for setup by the user. The figure below illustrates the available controls. The *Initialize State from Instrument?* switch allows the user to select whether the instrument is initialized from the current settings of the actual instrument or from the controls available from the VI.

If the *Yes* option is selected, the VI will initialize all settings from the actual instrument. If the *No* option is selected, the user should enter all data in the control fields (*Sensor Length*, *Hi Setpoint*, etc.) in the indicated units. The user should also



select the correct RS-232 port and baud rate, according to the port to which the Model 186 is connected and the baud rate to which the Model 186 is set (see page 30 for instructions on setting the Model 186 baud rate). The user may then start the VI. Please refer to your LabVIEW documentation for instructions on how to start and control the execution of VI's.

Interacting with the running VI

While the VI is running the user may manipulate the virtual toggle and rotary switches in the same manner as required for the front panel operation of the actual instrument. See the Operation section of this manual for instructions on operating the front panel controls, however, please note that there are some minor differences discussed below.

The RAISE/LOWER toggle switch functions slightly different in the VI. If the RAISE/LOWER toggle switch is moved from the center position to the RAISE or LOWER position, then the display changes to show the appropriate parameter. After approximately 4 seconds in the RAISE or LOWER position, the display will begin incrementing or decrementing by tenths. After approximately 12 additional seconds, the display will begin incrementing/decrementing by ones. Move the RAISE/LOWER toggle switch back to the center position to stop the incrementing or decrementing function.

The virtual instrument's FILL LED indicator is only accurate if the fill toggle switch is in the AUTO position. There is no remote monitoring or control of the manual override states of the fill toggle switch available through the communication command set.

As a more convenient option for controlling the settings, the user may scroll to the area above the VI and enter the values for the Sensor Length, Hi Setpoint, A Setpoint, B Setpoint, Lo Setpoint, and Fill Interval directly in the control fields (please observe the specified units). Any changes in the fields are recognized and sent to the actual instrument in the form of the appropriate command string. Any settings changed by the VI virtual panel toggle switches or control fields are saved in permanent memory in the actual instrument.

The VI may be gracefully stopped by using the STOP toggle switch in the lower left corner of the VI. After stopping the VI, this switch must be placed back in the up position in order to restart the VI.

IEEE-488 Virtual Instrument

The IEEE-488 (or GPIB) VI functions nearly identically to the RS-232 VI with a few exceptions. The VI library, provided in the file MODEL186.LLB, for the IEEE-488 virtual instrument contains the following files:

VI	Function
186 Alarms.vi	Manages alarm functions for 186.
Config 186 via GPIB.vi	Initializes actual instrument from VI configuration.
Convert from CM.vi	Displays inches or percentage given input in cm.
Counter.vi	Timer function for the virtual display.
Get 186 Level via GPIB.vi	Updates virtual display with current level.
Init from 186 via GPIB.vi	Initializes VI configuration from actual instrument.
Model 186 via GPIB.vi	The main VI containing the configuration and front panel controls. This is the VI the user should open and execute.
Non-exclusive loop control.vi	This VI, *which is only available in the COMP186.LLB library*, should be modified and executed for non-exclusive GPIB operation.
GPIB Send.vi	Manages sending and receiving of ASCII strings from the actual instrument.
Set 186 A via GPIB.vi	Configures the A setpoint.
Set 186 B via GPIB.vi	Configures the B setpoint.
Set 186 Fill via GPIB.vi	Configures the fill interval setting.
Set 186 HI via GPIB.vi	Configures the HI setpoint.
Set 186 Length via GPIB.vi	Configures the active sensor length.
Set 186 LO via GPIB.vi	Configures the LO setpoint.

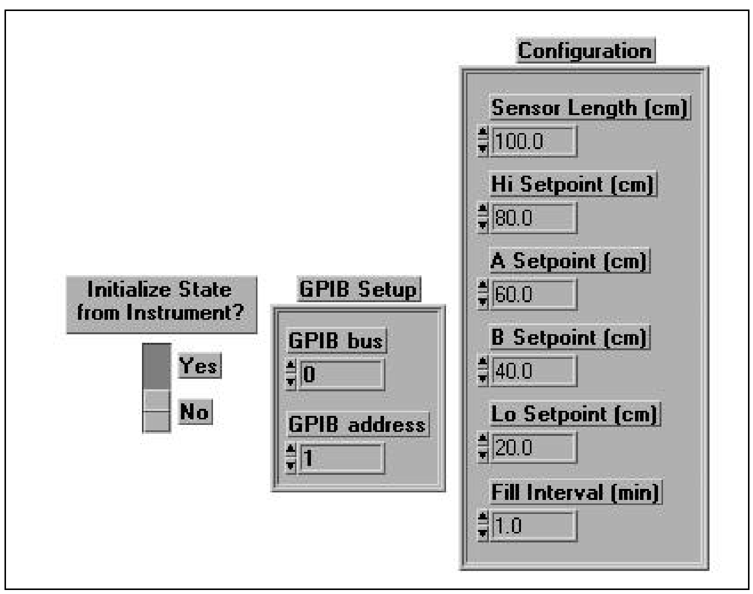
The *Model 186 via GPIB.vi* in the MODEL186.LLB library should be used if the Model 186 has exclusive control of the GPIB bus, i.e. is the only device present and operating on the bus.

An additional library provided on the LabVIEW floppy disk, COMP186.LLB, contains all the VI's included in the MODEL186.LLB library along with the additional *Non-exclusive loop control.vi* and reusable version of the *Model 186 via GPIB.vi*. The *Non-exclusive loop control.vi* provides a control example which can be customized to coexist with multiple devices on one GPIB bus. The exact design of the non-exclusive operation is dependent upon the specific devices you may have connected to the bus.

When running a VI it is important to operate the instrument using the VI and not via the actual instrument front panel. Otherwise, the VI and the actual instrument may not be synchronized. The only exceptions to this rule are calibration procedures or operation of the fill toggle switch if manual override becomes necessary, both of which are functions that are not available from the VI. Any function available from the VI should be normally be set by using the VI and not the front panel of the instrument.

Launching and initializing the GPIB VI

First, make sure the Model 186 is connected to the GPIB bus and that the unit is powered on. Independent of whether you use the exclusive or non-exclusive mode of execution, the initialization method of the Model 186 should be determined. To set the initialization method, scroll to the area above the virtual front panel and observe the virtual controls as illustrated below (the version of the *Model 186 via GPIB.vi* provided in COMP186.LLB provides inputs for the initialization method and input/output for the configuration). The *Initialize State from Instrument?* switch allows the



user to select whether the instrument is initialized from the current settings of the actual instrument or from the controls available from the VI. If the *Yes* option is selected, the VI will initialize all settings from the actual instrument. If the *No* option is selected, the user should enter all data in the control fields (*Sensor Length*, *Hi Setpoint*, etc.) in the indicated units. The user should also select the correct GPIB bus and primary address (see page 39 for instructions on setting the Model 186 primary address). If only one GPIB interface is present in the host computer, the GPIB bus is normally set to 0. Refer to your LabVIEW documentation for more information on how to determine the GPIB bus setting appropriate for your computer. After setting the initialization parameters, the user may then start the VI. Please refer to your LabVIEW documentation for instructions on how to start and control the execution of VI's.

Interacting with the running VI

While the VI is running the user may manipulate the virtual toggle and rotary switches in the same manner as required for the front panel operation of the actual instrument. See the Operation section of this manual for instructions on operating the front panel controls, however, please note that there are some minor differences discussed below.

The RAISE/LOWER toggle switch functions slightly different in the VI. If the RAISE/LOWER toggle switch is moved from the center position to the RAISE or LOWER position, then the display changes to show the appropriate parameter. After approximately 4 seconds in the RAISE or LOWER position, the display will begin incrementing or decrementing by tenths. After approximately 12 additional seconds, the display will begin incrementing/decrementing by ones. Move the RAISE/LOWER toggle switch back to the center position to stop the incrementing or decrementing function.

The virtual instrument's FILL LED indicator is only accurate if the fill toggle switch is in the AUTO position. There is no remote monitoring or control of the manual override states of the fill toggle switch available through the communication command set.

As a more convenient option for controlling the settings, the user may scroll to the area above the VI and enter the values for the Sensor Length, Hi Setpoint, A Setpoint, B Setpoint, Lo Setpoint, and Fill Interval directly in the control fields (please observe the specified units). Any changes in the fields are recognized and sent to the actual instrument in the form of the appropriate command string. Any settings changed by the VI virtual panel toggle switches or control fields are saved in permanent memory in the actual instrument. The control fields and toggle switches function whether the VI is run exclusively or non-exclusively on the GPIB bus.

If the VI is executed exclusively, then the VI may be gracefully stopped by using the STOP toggle switch in the lower left corner of the VI. After stopping the VI, this switch must be placed back in the up position in order to restart the VI. If you are executing the VI in a non-exclusive polling loop on the GPIB bus, then the STOP toggle switch has no function and the user should control the execution of the VI from the controlling parent VI(s).

Running multiple GPIB devices

The *Model 186 via GPIB.vi* in the MODEL186.LLB library is designed to have exclusive control of the GPIB bus. AMI recognizes this is generally not the case for a GPIB bus configuration. Therefore, the *Non-exclusive loop control.vi* example is provided in the COMP186.LLB library to demonstrate how the *Model 186 via GPIB.vi* can be cooperatively executed on a GPIB bus with multiple devices connected.

In order to use multiple devices from the same host computer and GPIB bus, the Model 186 should be set to a unique primary address. In addition to modifications required to use other devices present on the bus, the user should modify the *Non-exclusive loop control.vi* to both initialize and then execute the *Model 186 via GPIB.vi* at a regular interval. The longer the interval between execution, the less responsive the VI will appear. This is due to the fact that the VI assumes periodic execution in order to poll the virtual switches and control fields for user-initiated changes. The suggested period between execution is 1 second in order to exhibit a reasonable level of responsiveness from the VI. The requirement to constantly poll a virtual panel for changes is an unfortunate requirement for running these types of continuously executing interfaces using LabVIEW.

7 Troubleshooting

LED display not on

1. Ensure that the instrument is energized from a power source of proper voltage.

Warning

If the instrument has been found to have been connected to an incorrect power source, return the instrument to AMI for evaluation to determine the extent of the damage. Frequently, damage of this kind is not visible and must be determined using test equipment. Connecting the instrument to an incorrect power source could damage the internal insulation and/or the ground requirements, thereby, possibly presenting a severe life-threatening electrical hazard.

2. Verify continuity of the line fuse, F1, located on the instrument printed circuit board.

Warning

This procedure is to be performed only when the instrument is completely de-energized by removing the power-cord from the power receptacle. Failure to do so could result in personnel coming in contact with high voltages capable of producing life-threatening electrical shock.

   a. Ensure the instrument is de-energized by disconnecting the power cord from the power source. Disconnect the power cord from the connector located on the rear panel of the instrument.

   b. Remove the instrument top cover and check the fuse F1 for continuity.

   c. If the fuse is bad, replace with a fuse of identical rating.

Caution

Installing fuses of incorrect values and ratings could result in damage to the instrument in the event of component failure.

   d. Replace the fuse and securely fasten the instrument top cover. Reconnect the power-cord.

3. Verify the input voltage selector switch on the instrument's printed circuit board is in the proper position for the available power receptacle at the customer's facility. Checking the input voltage selector requires removal of the top cover of the instrument. Observe the same safety procedures as presented in step 2.

Erratic or erroneous level reading

1. Verify that the sensor is properly connected to the oscillator cable and the extension cable (see the system diagram on page 5).

2. Verify the cabling has no breaks or cuts.

3. If the Model 186 suddenly reads 100% without a corresponding level, there is a possibility of moisture in the connector at the top of the sensor. Disconnect the BNC connection and remove any moisture. Moisture or contaminants in any of the BNC coaxial connectors can short out the sensor and cause a false ‘full’ level indication or other erroneous readings. A pack of non-conductive electrical connection lubricant (ECL) has been included with the liquid level sensor packaging to reduce the possibility of this occurring. Apply a small amount of ECL to any of the BNC connectors that may be exposed to moisture. Mate the doped connectors then remove any excess ECL from the outside of the connector. Added protection can be achieved by covering the doped connections with a short section of heat-shrink tubing.

   Note: MSDS sheets for the ECL are available upon request.

4. Ensure the oscillator unit is not exposed to large temperature gradients such as those that occur near dewar vents. Extreme temperature changes of the oscillator unit can cause readout errors.

5. Rapidly varying or sloshing liquids will sometimes make one think the instrument is in error when it is actually operating properly.

6. Capacitance-based sensors used in cryogenic liquid systems are sometimes exposed to humidified air when the cryogenic vessel is emptied. This often happens when a cold trap runs out of liquid. As the sensor warms, the electronics can show large errors (readings greater than 20% are not uncommon). This is due to the fact that air contains moisture which will condense between the cold sensing tubes. This small film of moisture can cause a shorted or partially shorted condition. The electronics may recognize this as a higher level reading and display some positive level. As the sensor warms over some period of time, the moisture can evaporate and the sensor will again approach the correct reading of 0%. This condition can also be corrected immediately if liquid nitrogen is added to the cold trap freezing the residual moisture. This is a physical phenomenon and does not indicate any problem with your AMI level equipment.

7. Verify the sensor is free of contaminants and not subject to any physical distortion. Disconnect the BNC connector at the top of the sensor and measure the sensor resistance by placing an ohmmeter across the center pin and the outer barrel of the connector. The resistance of the sensor should typically be >10 MΩ.

Controller output does not energize

Warning

This procedure is to be performed only when the instrument is completely de-energized by removing the power-cord from the power receptacle. Failure to do so could result in personnel coming in contact with high voltages capable of producing life-threatening electrical shock.

1. Verify continuity of controller output fuse, F2, located on the instrument printed circuit board.

   a. Ensure the instrument is de-energized by disconnecting the power cord from the power source. Disconnect the power cord from the connector located on the rear panel of the instrument.

   b. Remove the instrument top cover and check the fuse F2 for continuity.

   c. If the fuse is bad, replace with a fuse of identical rating.

   d. Check your connected equipment for compliance with the output receptacle rating.

Caution

Installing fuses of incorrect values and ratings could result in damage to the instrument in the event of component failure.

2. Replace the fuse and securely fasten the instrument top cover. Reconnect the power-cord.

Unit not responding to communications

1. Verify your communications cable integrity and wiring. See the *Appendix* for DB-25 to DB-9 translation for RS-232 cables.

2. Check to make sure you are sending the correct termination to the instrument. If you are using the RS-232 option, make sure the echo feature is set correctly for your application and the baud rate matches the setting of the host device. If you are using the IEEE-488 option, check the primary address setting and make sure the controller software is set to query the instrument at the primary address selected.

3. Check your host communications software and make sure it is recognizing the return termination characters from the instrument. For RS-232 communication, the return termination characters are *<CR><LF>*. For IEEE-488, the return message termination characters are *<LF>* with EOI.

4. If the instrument is responding repeatedly with *-8* as the return message, try a device clear command (DCL) or powering the instrument off and then back on. Be sure you are sending valid commands.

5. If you experience continued trouble with the IEEE-488 option, you may have an incompatible IEEE-488 card in your host computer. In the past, AMI has found subtle differences between manufacturers of IEEE-488 cards that have introduced communication errors. AMI attempts to establish compatibility with as many products as possible, however it is difficult to test every card available. Contact AMI directly if you have thoroughly checked your setup and continue to experience problems with the IEEE-488 option.

6. Version 2.6 of the NI-488.2 drivers from National Instruments has known bugs that prevent the correct operation of the IEEE-488 interface when executed from LabVIEW. Contact National Instruments for workarounds appropriate for your configuration.

If the cause of the problem cannot be located, contact an AMI customer service representative at (423) 482-1056 for assistance. Do not send the unit back to AMI without prior return authorization.

WARRANTY

All products manufactured by AMI are warranted to be free of defects in materials and workmanship and to perform as specified for a period of one year from date of shipment. In the event of failure occurring during normal use, AMI, at its option, will repair or replace all products or components that fail under warranty, and such repair or replacement shall constitute a fulfillment of all AMI liabilities with respect to its products. Since, however, AMI does not have control over the installation conditions or the use to which its products are put, no warranty can be made of fitness for a particular purpose, and AMI cannot be liable for special or consequential damages. All warranty repairs are F.O.B. Oak Ridge, Tennessee, USA.

RETURN AUTHORIZATION

Items to be returned to AMI for repair (warranty or otherwise) require a return authorization number to ensure your order will receive proper attention. Please call an AMI representative at (423) 482-1056 for a return authorization number before shipping any item back to the factory.

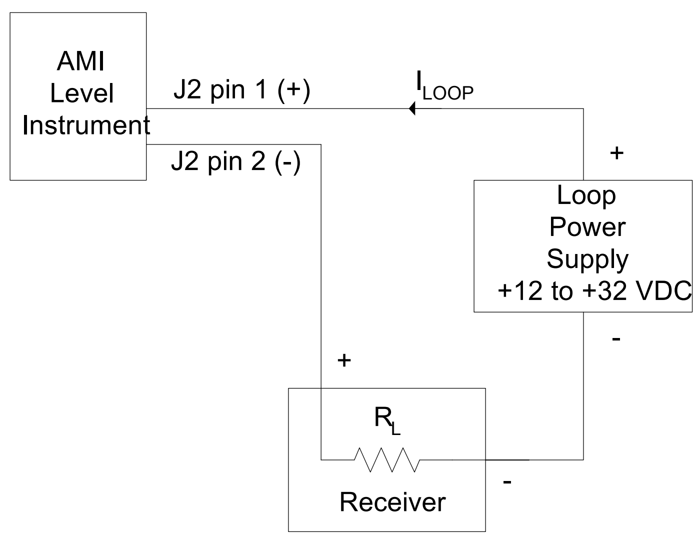
Appendix

4-20 mA current loop option

The 4-20 mA output utilizes pins 1 and 2 of connector J2. When the Model 186 is configured for the 4-20 mA current loop option, the 0-10 VDC analog output from connector J2 is not available. The figure below shows the wiring diagram and the voltage requirements for the power supply and receiver.

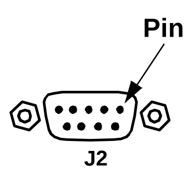
Caution

It is extremely important to observe all polarities and to not exceed +32 VDC for the loop power supply in order to prevent damage to the 4-20 mA driver circuit.



Auxiliary connector J2 pinout

Pin	Function
1	4-20 mA current loop input (optional feature)
2	4-20 mA current loop output (optional feature)
3	0-10 VDC output (optional feature)
4	0-10 VDC output common (optional feature)
5 & 6	Lo level relay contacts (dry)
7 & 8	Hi level relay contacts (dry)
9	Not used



The HI level and LO level contacts are provided for external use by the customer. When a HI or LO level condition exists, the respective contact pairs are closed. The HI level and LO level contacts also provide positive indication of a power-off condition. With a power-off condition, both the HI level and LO level contacts will be closed, which is a state unique to the power-off condition.

The following table provides the specifications for the relay contacts:

Max switching VA	10
Max switching voltage	200 VDC
Max switching current	0.5 A
Max continuous current	1.5 A
Dielectric between contacts	200 VDC minimum

RS-232 cable DB-25 to DB-9 translation

DB-25 Pin	DB-9 Pin
2	3
3	2
4	7
5	8
6	6
7	5
8	1
20	4
22	9

All other pins on the DB-25 connector are unused. This is standard PC modem cable wiring.

Dielectric constants for common liquids

The table below contains dielectric constants for several common liquids at atmospheric pressure (unless otherwise noted).

Liquid	Dielectric constant[a]
Argon (A)	1.53 @ −191°C
Carbon dioxide (CO_2)	1.60 @ 20°C, 50 atm
Hydrogen (H_2)	1.228 @ 20.4 K
Methane (CH_4)	1.70 @ −173°C
Nitrogen (N_2)	1.454 @ −203°C
Propane (C_3H_8)	1.61 @ 0°C
Oxygen (O_2)	1.507 @ −193°C

a. Reference: Weast, Robert C. Ph.D., Editor, *CRC Handbook of Chemistry and Physics 67th Edition*, CRC Press, Inc., Boca Raton, FL, 1986 (pgs. E-49 through E-53).

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