



BusWorks® 900PB Series Profibus/RS485 Network I/O Modules

Model 972PB-2004 Four Channel Current Output
Model 972PB-2006 Six Channel Current Output

Model 973PB-2004 Four Channel Voltage Output
Model 973PB-2006 Six Channel Voltage Output

USER'S MANUAL



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Symbols on equipment:



Means Refer to User's Manual (this manual) for additional information".

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IMPORTANT SAFETY CONSIDERATIONS

You must consider the possible negative effects of power, wiring, component, sensor, or software failure in the design of any type of control or monitoring system. This is very important where property loss or human life is involved. It is important that you perform satisfactory overall system design and it is agreed between you and Acromag, that this is your responsibility.

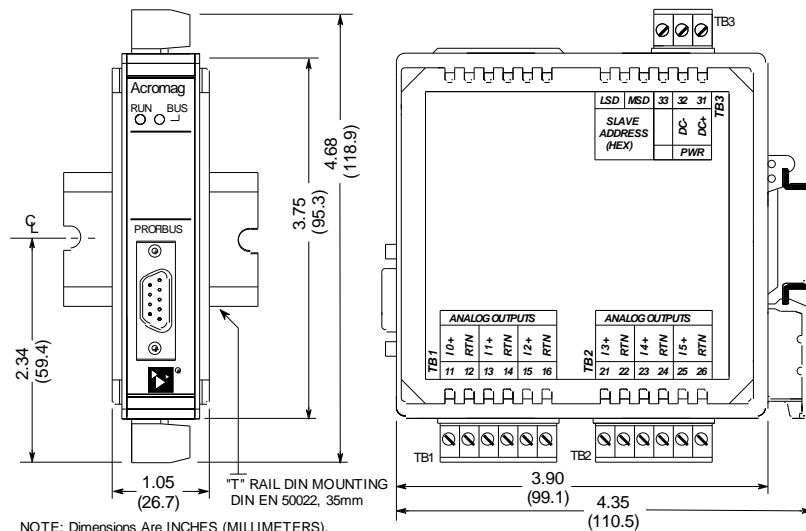
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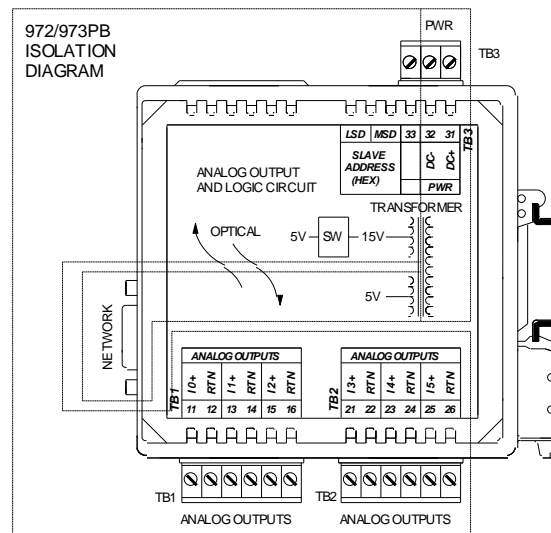
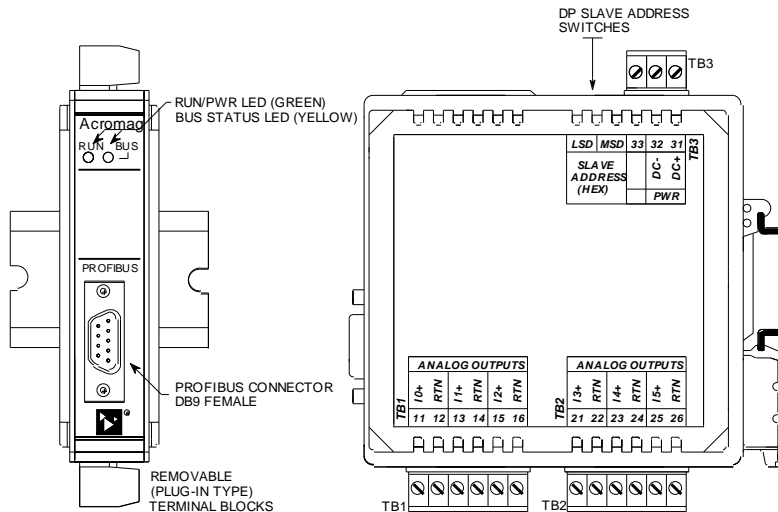
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MODEL 972/973PB-2006 ENCLOSURE DIMENSIONS



MOUNTING AND DIMENSIONS

Unit mounts to "T" type DIN rails (35mm, type EN50022).

Units may be mounted side-by-side on 1-inch centers.

WARNING: IEC Safety Standards may require that this device be mounted within an approved metal enclosure or sub-system, particularly for applications with exposure to voltages greater than or equal to 75VDC or 50VAC.

CONTROLS & INDICATORS

Green Run LED will stay ON if power is on and unit is OK, and will blink if unit fails.

Yellow BUS LED will turn ON if module is properly connected to the network and in data exchange mode.

ISOLATION BARRIERS

Dashed Lines denote isolation barriers.

The input circuit, network, and power circuit are isolated from each other for safety and noise immunity.

SETTING SLAVE ADDRESS

Address is set to 126 (7EH) from the factory. This address is reserved for commissioning purposes only.

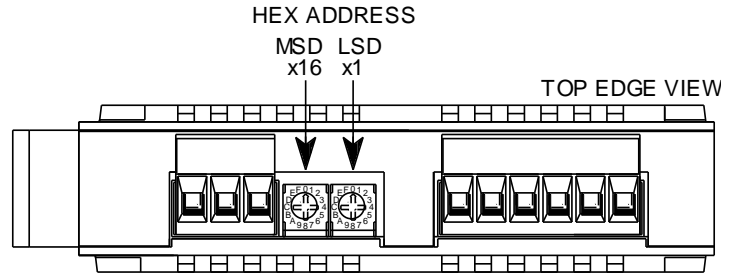
Locate hexadecimal address switches in recessed opening next to the power terminals.

Use a screwdriver to rotate these switches to set a unique valid address from 0 to 125.

If the switches are set to a valid address from 0-125, then the switch setting determines the slave address and the Set Slave Address software command will be rejected.

If these switches are instead set to 126 (7EH) upon power-up (or 126 to 254), the unit will retrieve its address from the internal EEPROM, which is modified via the Set Slave Address command.

If these switches are set to 255 (FFH) upon power-up, this will return the address in EEPROM to 126 (7EH).



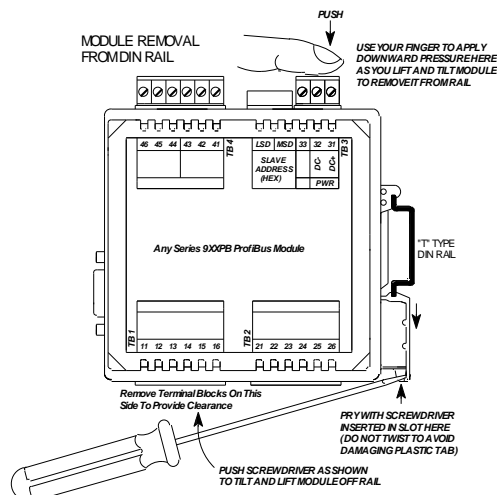
SET SWITCHES TO A VALID SLAVE ADDRESS FROM 0 TO 125 (00H TO 7DH)

1. Choose a slave address from 0-125 and locate highest MSD number less than this address. Set MSD switch to this number's corresponding HEX digit.
- | | | | | | | | | | | | | | | | | | |
|------------|-----|---|----|----|----|----|----|----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| MSD
x16 | | 0 | 16 | 32 | 48 | 64 | 80 | 96 | 112 | 128 | 144 | 160 | 176 | 192 | 208 | 224 | 240 |
| HEX | | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | A | B | C | D | E | F |
| LSD
x1 | DEC | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
| HEX | | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | A | B | C | D | E | F |
2. Determine the DECimal remainder and set the LSD switch to its corresponding HEX digit.

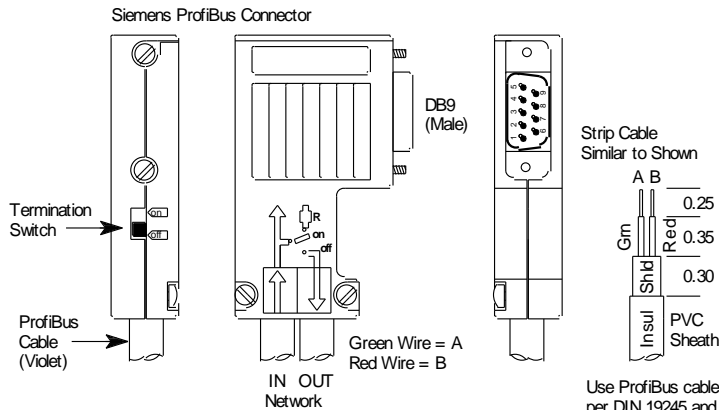
The address stored in the internal EEPROM is modified via the Set Slave Address command. If the address switches are set to 126 (or 126 to 254) upon power-up, the module will retrieve the last address stored within its EEPROM (126 from the factory). With both the internal EEPROM and external switch addresses set to 126, the unit will await the Set Slave Address command after power-up, before proceeding to the parameterization state (address 126 cannot be used in data exchange mode and is reserved for commissioning purpose only). You must use the Set Slave Address command to change the internal (EEPROM) address following power-up in order to proceed. However, if the switches are set to an address less than 126 upon power-up, then the switches determine the slave address and the EEPROM setting is ignored. You can later restore the internal EEPROM setting to 126 by powering the unit up with the address switches set to 255 (FF). You would then power the unit up again with these switches set to 126 in order to return the unit to commissioning mode.

CONNECTIONS

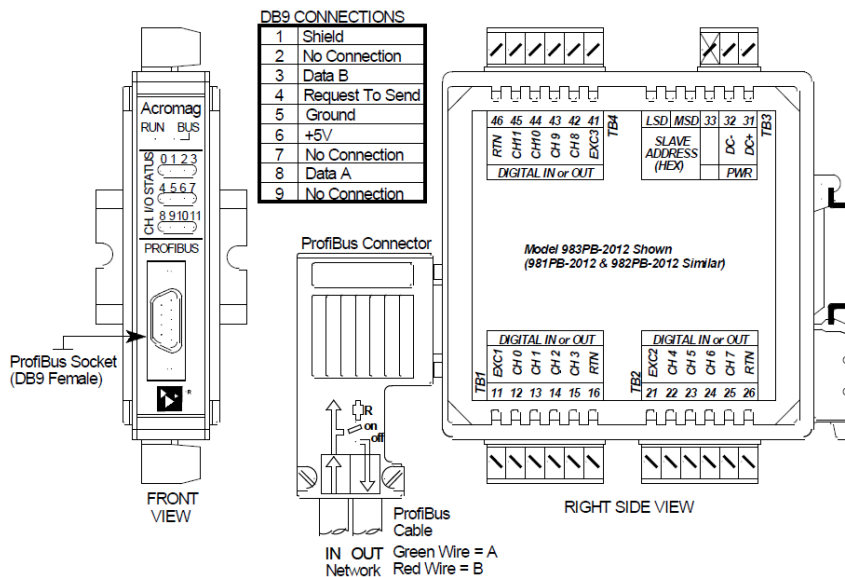
DIN-Rail Mounting & Removal



When attaching the module to the T-type DIN rail, angle the top of the unit towards the rail and locate the top groove of the adapter over the upper lip of the rail. Firmly push the unit towards the rail until it snaps into place. To remove, first separate the input terminal block(s) from the bottom side of the module to create a clearance to the DIN mounting area. Next, while holding the module in place from above, insert a screwdriver into the lower arm of the DIN rail connector and use it as a lever to force the connector down until the unit disengages from the rail (do not twist the screwdriver to avoid damaging plastic).



Do not mix RS485 A & B connections. Green wire is A, red wire is B. You MUST terminate the network at both ends only. Termination resistors are integrated in the ProfiBus connector. When you switch termination ON, the out-going connections are disconnected from the network.



Network Length

Use Type A ProfiBus cable per EN 50170. Keep line lengths less than the length indicated below for your transmission rate. For baud rates not shown, the lower length of the closest range end points apply (i.e. 100M at 3Mbps).

Bus Segment Length Limit Per Baud Rate For Type A Bus Cable

BAUD	9.6K	19.2K	93.75K	187.5K	500K	1.5M	12M
Type A	1200M	1200M	1200M	1000M	400M	200M	100M

Termination

The network must be terminated at both ends only. Most ProfiBus connectors include a switch for termination as shown above. Note that this switch will also disconnect the outgoing network signal.

CONNECTIONS

Network

Use ProfiBus connectors similar to the one shown at left (Siemens version shown).

Always use ProfiBus cable per DIN 19245 and EN 50170.

When building cables, do not mix A & B connections. Green wire is A, Red wire is B.

The connectors must have built-in inductors in order to operate at the higher baud rates.

GSD Files:

972PB-2004 ACRO0769.GSD
Ident_Number=0769H

972PB-2006 ACRO0768.GSD
Ident_Number=0768H

973PB-2004 ACRO06FF.GSD
Ident_Number=06FFH

973PB-2006 ACRO06FE.GSD
Ident_Number=06FEH

IMPORTANT: Do not connect earth ground to logic Ground (DB9 Pin 5). Earth Ground should connect to the cable Shield (common to DB9 Pin 1).

Note that Acromag modules also support the optional RTS direction control signal at Pin 4.

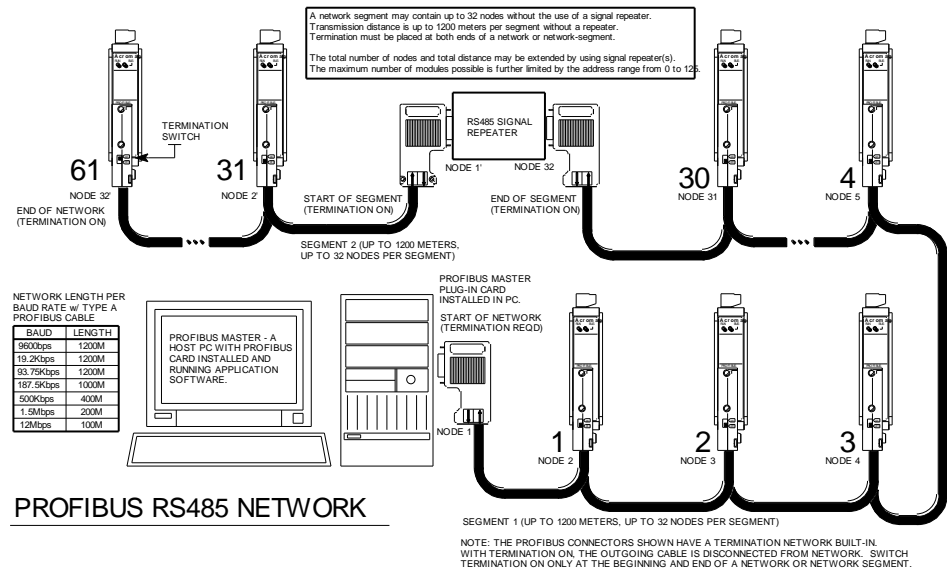
CONNECTIONS

Example Profibus System Connections

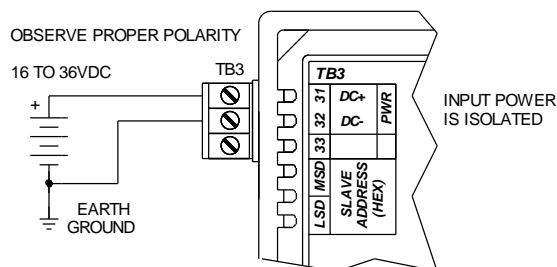
Up to 125 slave modules may network together with a class 1 master using four repeaters (one repeater every 31 nodes). Address 0 is typically reserved for the class 1 master.

Note: 12Mbps installations require a minimum cable length of 1M between stations.

TIP: A recommended RS485 repeater for Profibus is the Siemens 6ES7 972-0AA01-0XA0.



- ✓ Connect 16-36V DC to power terminals labeled DC+ & DC-. Observe proper polarity. For supply connections, use No. 14 AWG wires rated for at least 75°C. **CAUTION:** Do not exceed 36VDC peak.



CAUTION: Risk of Electric Shock – More than one disconnect switch may be required to de-energize equipment before servicing.

IMPORTANT – External Fuse: If unit is powered from a supply capable of delivering more than 1A to the unit, it is recommended that this current be limited via a high surge tolerant fuse rated for a maximum current of 1A or less (for example, see Bel Fuse MJS1).

Analog Outputs

Output is DC Current (972PB) or DC Voltage (973PB).

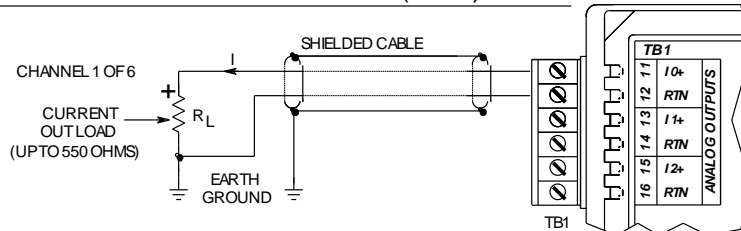
Outputs are not isolated channel-to-channel and share a common return (RTN).

Current outputs may drive up to 20.8mA into 500Ω.

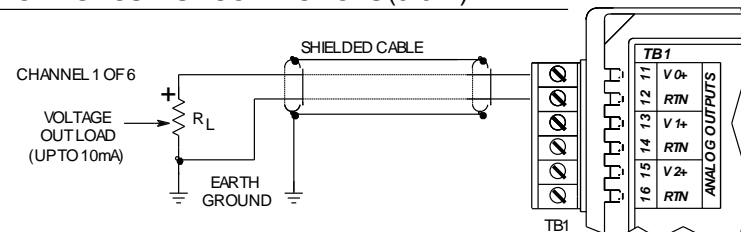
Voltage outputs may deliver up to 10V into 1KΩ (10mA).

- ✓ Connect analog outputs as shown below according to your model.

CURRENT OUTPUT CONNECTIONS (972PB)



VOLTAGE OUTPUT CONNECTIONS (973PB)



CONNECTIONS

Earth Ground

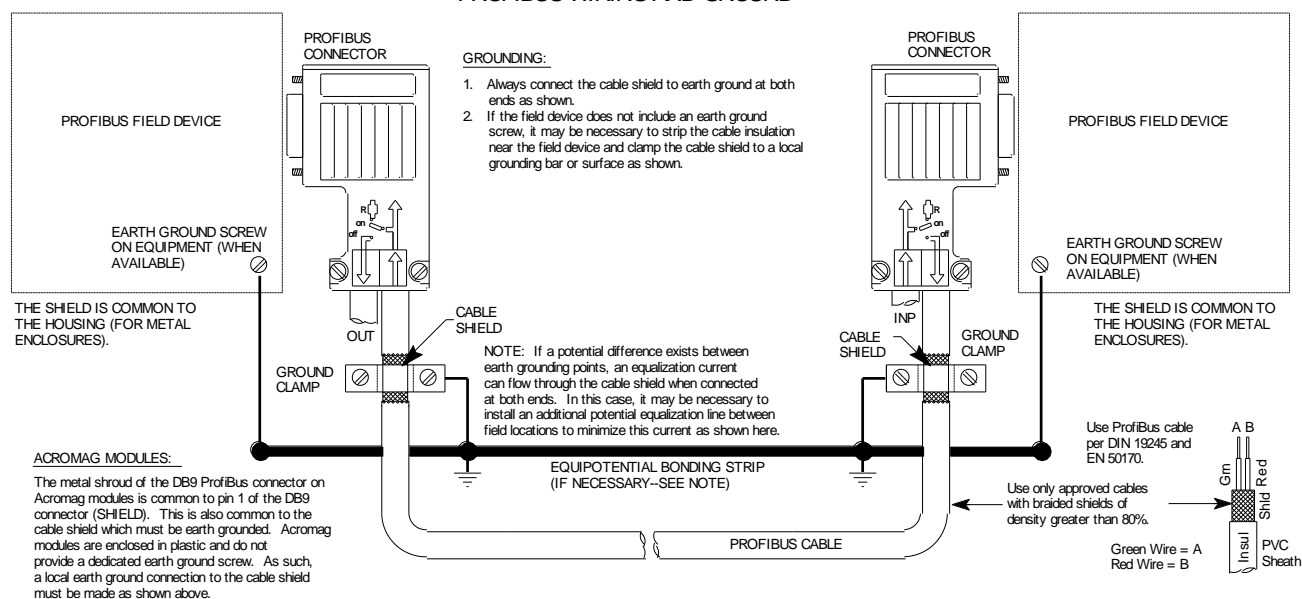
- ✓ Connect Earth Ground as shown in the connection drawings above. Additionally, ground the Profibus cable as shown in the drawing below.

The ground connections noted are recommended for best results. If sensors are already grounded, use caution and avoid making additional ground connections which could create ground loops.

The plastic module housing does not require earth ground.

Warning: To comply with safety and performance standards, use shielded cable and connect earth ground as noted. Failure to use good wiring and grounding practices may be unsafe and hurt performance.

PROFIBUS WIRING AND GROUND



The module routinely performs internal diagnostics following power-up or reset. During this period, the green "Run" LED will flash for a moment. If the diagnostics complete OK, the "Run" LED will stop flashing after a few seconds and remain ON. This indicates the unit is operating normally. Once the unit has passed through the initialization, parameterization, and configuration states, and is in data exchange mode, the yellow BUS LED will be ON. If the BUS LED is OFF and the unit is connected to the network, then this is indicative of an initialization problem.

TROUBLE-SHOOTING

- Follow the Profibus installation guidelines.
- Use the recommended cable and connectors of the standard.
- Verify that none of the wires are broken or shorted.
- Don't mix the A & B lines. Use green wire for A and red wire for B.
- Do not exceed the recommended segment length for the baud rate.
- Make sure that there are no more than 32 RS-485 devices per segment (including the master device and the repeater).

Tips For Building Profibus Networks

Tips For Building Profibus Networks

- Check for proper termination of all copper-wire network segments (an RS-485 segment must have a termination resistor at both ends of the segment only).
- All activated terminations must be powered all the time. If this is not possible, then consider using an active-termination box.
- Check whether the station address is set to the correct value.
- If your network connects between buildings or runs through hazardous environments, consider the use of fiber-optics.
- Avoid drop lines and keep their length within the specified maximum. For T-drops, consider using repeaters and active-bus terminations.

Top Four Common Profibus Problems

1. Incorrect slave address set at the slave.
2. Profibus connector between the master and slave has its termination switch turned ON.
3. Incorrect module configuration sent to slave.
4. Configuration is based on outdated GSD file information.

Troubleshooting Tools

There are several models of handheld devices on the market that simplify the installation and troubleshooting of Profibus networks. The more sophisticated units include LCD displays that read out errors directly. Two of these of these devices are referenced below:

Hand-Held Profibus Network Maintenance Tools

Manufacturer	Part Number	Special Features
Siemens	BT 200	Primarily a Cable Tester
Comsoft	NetTest II Set 4000-7-06C-J	Includes DP Mono-Master Functionality

In general, these devices can be used to check the network wiring before devices are connected to the bus and are often used to indicate:

- Whether the A and B lines have been switched.
- Whether a short exists between the A & B lines and shield.
- The occurrence of a wire-break in the A or B line, or shield line.
- Improper termination.

These devices can also be used to check the RS-485 interface of Profibus devices after they have been connected. They may include the following functions:

- The ability to create a list of all stations connected to a network (useful for identifying missing or "offline" devices).
- Test individual stations and help identify duplicate addresses.
- Measure the distance along a network segment to verify whether it complies with the Profibus requirements for distance and data rate.
- Detect signal reflections along the network, useful for locating bus line interruptions and discontinuities.

Acromag strongly suggests the use of these tools for building and maintaining Profibus networks.

Note that Profichip also offers a Profibus connector (PA003100) that includes 4 network diagnostic LED's that may be helpful in trouble-shooting your network (see table below).

The standard 9-pin Profibus connectors with integrated termination resistors are also helpful in troubleshooting segments of the network. In most of these connectors, when the termination resistors are switched ON, the outgoing portion of the connector is disconnected. As such, you can selectively disable segments of the network until you find the branch that is causing the problem. For example, if your handheld unit is connected to the beginning of a network and indicates a wire break, you can selectively switch off portions of the network and recheck your handheld unit to help pin point the portion of the network that is causing the problem. Below are some Profibus connectors that we recommend:

Preferred Bus Connectors

Mfg	Part Number	Special Features
Siemens	6ES7972-0BA12-0XA0	Switchable termination.
Siemens	6ES7972-0BB12-0XA0	Adds PB interface (piggy-back DB9 for diagnostic connection).
Profichip	PA003100	Adds PB interface & 4 diagnostic LED's for trouble-shooting.

Profibus includes a rich diagnostic function that can be used to troubleshoot Profibus devices. This function contains 6 bytes of standard diagnostic information, plus up to an additional 238 bytes of device specific diagnostic information. Most configuration tools support this command and can read the diagnostic information from the Profibus device.

SYMPTOM	POSSIBLE CAUSE	POSSIBLE FIX
<i>Yellow BUS LED does not light.</i>	Initialization Problem. LED ON if module in data exchange state.	Check Station Address. Is GSD file correct? Check for wiring error.
	Both internal EEPROM and external address switches are set to an address of 126.	Module is awaiting Set Slave Address command in order to complete initialization. Alternately, set switches from 0-125 and re-power.
<i>Cannot communicate.</i>	Power ON at module and/or converter?	Check power. Is green RUN LED ON?
	Is address correct?	Check address settings.
	Is the termination switch of the Profibus connector at the prior node turned on?	Switch Termination on only at the ends of the network. With termination switch on, the outgoing connections are disconnected from the network chain.
<i>Yellow BUS LED turned OFF.</i>	Communication Halted.	Cycle power to reset unit. Investigate grounding.
<i>Continuous flashing green RUN LED.</i>	Internal firmware problem.	Return the module for service.
<i>Many Communication Errors.</i>	Missing Termination Resistors?	Termination resistors must be placed only at both ends of a network or segment.
	Is baud rate too high for distance?	Maximum distance is limited below 1200 meters as baud rate is increased above 93.75Kbps (see Table).

Using Connectors To Troubleshoot

Diagnostics Function

Diagnostics Table

If your problem still exists after checking your wiring and reviewing this information, or if other evidence points to another problem with the unit, an effective and convenient fault diagnosis method is to exchange the module with a known good unit. Acromag's Application Engineers can provide further technical assistance if required. Complete repair services are also available from Acromag.

CALIBRATION

The Series 972/973PB output modules are calibrated using a single base output range with fixed calibration endpoints. The calibration of the module's sub-ranges are interpolated based on these results. Prior to calibration, the 972PB models must have the 4-20mA output range selected, and the 973PB must have the 0-10V output range selected. Calibration is then performed by adjusting the output signal level until its measured value precisely matches the low or high calibration range endpoint indicated. With the output level precisely adjusted to the Calibration LOW or HIGH range endpoint signal, the module is triggered to store the output channel's raw DAC count by toggling the corresponding channel's Cal HIGH (upper byte) or Cal LOW (lower byte) calibration register. The following table gives the calibration values for the base output range of these models. Your success in recalibrating the output will strongly depend upon the accuracy and precision of your measurement system with respect to calibrating the base range endpoints.

IMPORTANT: *This module has already been calibrated at the factory and recalibration is not normally required, except as necessary to correct for long term component aging, or to satisfy your company's maintenance requirements. Do not attempt to recalibrate this module unless absolutely required, as miscalibration will negatively affect the module's performance.*

		Cal LOW (Zero)		Cal HIGH (Full-Scale)	
Model	Range	Signal	~Write %	Signal	~Write %
972PB	4-20mA	4.000mA	4000	20.000mA	20000
973PB	0-10V	0.000V	0	10.000V	20000

Notes:

1. Output values are written via 16-bit signed integer values with resolution of 0.005%/lsb. ± 20000 is used to represent $\pm 100\%$. For example, -100%, 0% and +100% are represented by decimal values -20000, 0, and 20000, respectively. The full range is -163.84% (-32768 decimal) to +163.835% (+32767 decimal).
2. The "Write %" values noted above are the ideal values written to the output word of the channel and may only approximate the value required to produce the Cal LOW and Cal HIGH endpoint signals. During calibration, you need to adjust these values as required to precisely reproduce the endpoint signals.
3. Calibration of the 0-20mA & 0-1mA, and 0-5V & 0-1V subranges are internally interpolated from the resultant calibration of the base range noted in the table above for each model. Additionally, since resolution is degraded for the sub-ranges, it is very important that high accuracy be ensured for the primary base calibration when making output adjustments and measurements.

These models have two output configuration definitions in their GSD files: one for normal output operation (4 or 6 output words according to the number of output channels), and another for accomplishing output calibration (with 8 or 12 output words according to the number of output channels). The normal data exchange definition supports 4 or 6 output words (8 or 12 output bytes representing your programmed values). A second calibration definition supports 4 or 6 output words, plus an additional 4 or 6 output words that represent the channel calibration words. Your Master software allows you to choose which mode the slave will assume—normal Output Mode or Output Calibration Mode. The method used to transfer information between the master and slave will vary widely between systems. The steps below represent the minimum steps necessary to accomplish software calibration. If you choose to perform output calibration and select the Calibration Mode, the master will download the 4/4 or 6/6 word configuration during the startup sequence, and the module may then be calibrated as follows:

IMPORTANT: For best results, you must measure the output signal via an external current or volt meter that is at least as accurate as the module itself (better than $\pm 0.1\%$ of span). Always calibrate the low value before the high value and allow the module to warm up a few minutes prior to calibration.

CALIBRATION

General Calibration Procedure:

1. With your master software, select the "Calibration Mode" from the GSD file when setting up the master to communicate with the module.
2. With user parameterization bytes 1-6 (or 1-4), set the base range for each channel to be calibrated. Select 4-20mA for 972PB models, or 0-10V for 973PB models.
3. Write the zero calibration % value to the output to be calibrated and adjust this value as necessary to precisely reproduce the Cal LOW (zero) signal (see table of prior page). Allow the output to settle a few seconds.
4. Write FFH into the low-order byte of the channel's calibration word several times to ensure transmission. In Output Calibration Mode, the module will automatically calibrate the channel's zero value when FFH is detected in the low-order byte. Then write 00H into the low-order byte to complete zero calibration.
5. Write the full-scale calibration % value to the output to be calibrated and adjust this value as necessary to precisely reproduce the Cal HIGH (full-scale) signal (see table of prior page). Allow the output to settle a few seconds.
6. Write FFH into the high-order byte of the channel's calibration word several times to ensure transmission. In Output Calibration Mode, the module will automatically calibrate the channel's full-scale value when FFH is detected in the high-order byte. Then write 00H into the high-order byte to complete full-scale calibration.
7. Repeat steps 3-6 for each output channel to be calibrated.
8. When finished calibrating, use the master software to return the module to the normal "Output Mode" to prevent miscalibration. With user parameter bytes 1-6 (or 1-4), select the range required for your application. You may then check the calibration of the alternate range(s). Note that the alternate ranges are calibrated by interpolating their calibration endpoints from those of the base range.

After completing calibration, the module should be reconfigured as required and placed in the normal Output Mode configuration (output configuration is 4 or 6 output words only). In general, your software allows you to select the normal "Output Mode" configuration, and the slave will then be taken off-line by the master and reconfigured. If reconfiguration is successful, the slave module will pass to the data exchange state with a normal Output Mode configuration.

TECHNICAL REFERENCE

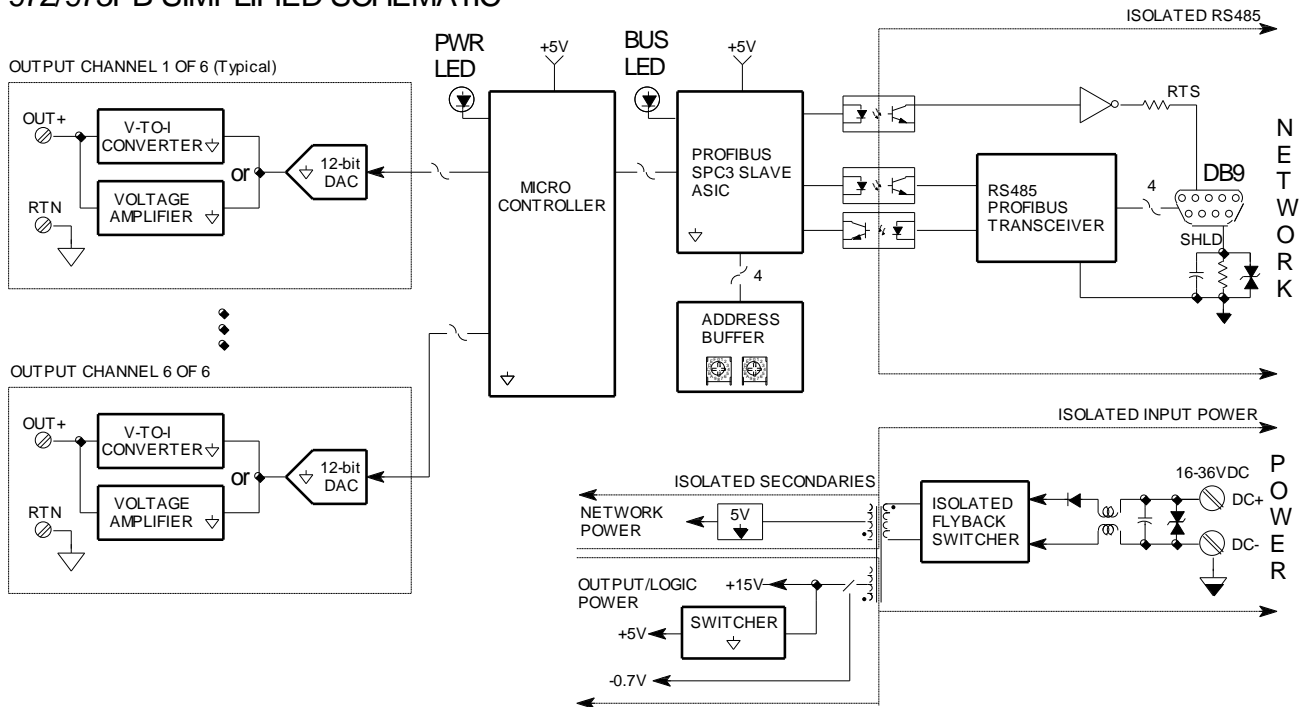
KEY FEATURES

- **PTO Certified** - Unit certified by the Profibus Trade Organization.
- **Safety Agency Approvals** – CE, UL, & cUL listed, plus Class 1; Division 2; Groups A, B, C, D approvals.
- **Fully Independent Slave w/ Direct I/O Connection** – This self-contained unit does not require special bus couplers, power supplies, or a rack mount to operate.
- **Plug-In Terminal Blocks & DIN-Rail Mount** - Make mounting, removal, and replacement easy.
- **Industry Standard ASIC** – Uses Siemens SPC3 intelligent ASIC to talk Profibus.
- **Isolated RS485/Profibus Network Interface** – Highly immune to noise and can operate over long distances. Allows many modules to network together.
- **Flexible Process Current Output (972PB)** – Generates up to 6 process current signals in 3 ranges.
- **Flexible DC Voltage Output (973PB)** – Generates up to 6 DC voltage signals in 3 ranges.
- **Selected Ranges May Vary Channel-to-Channel** – Multiple channels may have different ranges configured.
- **Auto-Baud Rate Detection** – The baud rate is set automatically.
- **High-Speed Data Rates** – Half-duplex RS485 up to 12M baud.
- **Includes RTS Support** – Profibus interface includes the optional RTS (Request-To-Send) direction control.
- **Precise High-Resolution D/A Conversion** – Modules use high resolution (12-bit), low noise, digital-to-analog conversion for high accuracy and reliability.
- **Nonvolatile Reprogrammable Memory** – Allows the functionality of this device to be reliably reprogrammed thousands of times.
- **Fully Isolated** – Output channels (as a group), network, and power are all isolated from each other for safety and increased noise immunity.
- **LED Indicators** – A green LED indicates power. A yellow bus status LED indicates proper network connection and unit in data exchange mode.
- **Watchdog Timer Built-In** – Standard for the ASIC and operates in the data exchange mode if communication with the master is lost.
- **Self-Diagnostics & Diagnostic Watchdog** - For easy maintenance and troubleshooting. Includes a hardware watchdog timer built into the microcontroller that causes it to initiate a self reset if the controller ever “locks up” or fails to return from an operation in a timely manner.
- **Wide-Range DC-Power** - Diode-coupled for use with redundant supplies, and/or battery back-up.
- **Hardened For Harsh Environments** - For protection from RFI, EMI, ESD, EFT, & surges. Has low radiated emissions per CE requirements.
- **Wide Ambient Operation** – Reliable over a wide temperature range.

These transmitters will drive up to six analog current outputs (972PB), or six analog voltage outputs (973PB), and provide an isolated Profibus network interface for configuration and control of the outputs. The Profibus protocol is implemented via the industry-standard SPC3 ASIC from Siemens. The ASIC transfers network data to the microcontroller and automatically provides a response to the bus. The ASIC communicates with the network via an optically isolated RS485 transceiver. This ASIC acts like a RAM or UART chip to the internal microcontroller and completely handles the requirements of the Profibus protocol. The microcontroller completes the output transfer function according to the output type/range per its embedded program, and sends output values to two, 12-bit, quad-output DAC's (Digital-to-Analog Converters). The corresponding DAC output voltages are sent to individual voltage-to-current converter circuits (972PB), or to non-inverting output amplifiers (973PB). Output configuration and calibration parameters are stored in non-volatile memory integrated within the microcontroller. A factory program port allows the microcontroller to be reprogrammed in circuit. A wide input switching regulator (isolated flyback) provides isolated power to the output circuit and the RS485 port. A second switcher converts the 15V output supply to a 5V logic supply. Refer to the simplified schematic below to gain a better understanding of the circuit.

HOW IT WORKS

972/973PB SIMPLIFIED SCHEMATIC



SPECIFICATIONS

These DIN-rail mount, Profibus DP slave, output modules will drive up to six process current, or voltage signals, according to the model, and provide an isolated RS485/Profibus network interface for configuration and control of the outputs. Units are DC-powered and include reverse polarity protection. Outputs share a common return connection and are not isolated channel-to-channel. Outputs (as a group), network, and power are isolated from each other. Non-volatile reprogrammable memory in the module stores configuration and calibration information.

Model Numbers

972PB-2004 (4x Current)
972PB-2006 (6x Current)
973PB-2004 (4x Voltage)
973PB-2006 (6x Voltage)

The Profibus model prefix "900" denotes the Series 900. The "PB" suffix denotes Profibus. Select 972MB for current output, and 973PB for voltage output. The four digit suffix of this model number represents the following options, respectively: "2" = Profibus DP; "0" = Default; "04" or "06" = 4 or 6 channels, respectively.

Analog Outputs

Four or six analog output channels for current or voltage according to model number. The unit must be wired and configured for the intended output type and range (see Connections Section for details). The following paragraphs summarize this model's output types, ranges, and applicable specifications.

Current Output Specifications (972PB Only):

Output Ranges: Select 0-20mA DC, 4-20mA DC, or 0-1mA DC. The 0-20mA and 0-1mA ranges are sub-ranges of the 4-20mA range.

Note: The 0-20mA and 0-1mA output ranges may not precisely go to the 0mA endpoint. The 0-20mA range will typically approach 0mA within 0.1% of span. Do not use 0 as a calibration endpoint.

Output Maximum Current: ~20.8mA typical (DAC count ~3758).

Output Accuracy: See Resolution & Accuracy Table under General Specifications.

Output Compliance: 12V Minimum, 13V Typical.

Output Load Resistance Range: 0 to 625Ω, typical.

Response Time: 11ms typical into 500Ω, for measurement to reach 98% of the final value in response to a step command. Actual response time will vary with load.

Output Resolution: 12 bits, or 1 part in 4096 based on a theoretical 22.67mA over-range value. This is 5.535uA/bit (22.67mA/4096bits). Note the over-range DAC count is internally limited to approximately 3758, or 20.8mA. See below for effective resolution calculations.

DAC Count (Current): Internal DAC count can be approximated by multiplying the output current by 180680. The resultant value (rounded) can be used to calculate the effective resolution and to approximate the required output register program value (see below). The over-range DAC count is internally limited to approximately 3758, or 20.8mA.

Internal DAC Count Versus Current Output Range

Range	DAC 0%	DAC 100%	DAC Span
0-1mA	0	181	181
4-20mA	723	3614	2891
0-20mA	0	3614	3614

The effective resolution is 1 part in the DAC Span. The resolution and accuracy for the 0-1mA range is significantly less than the other ranges.

Register Program Value: Output values use integers with ± 20000 representing $\pm 100\%$. The required output register program value can be approximated using the DAC values shown above via the formula:
 Register Value = $20000 * (\text{DAC Count} - \text{DAC } 0\%) / \text{DAC Span}$.

Analog Outputs

Ideal Current Output Register Program Value

Range	Output Current				
	0mA	1mA	4mA	12mA	20mA
0-1mA	0	20000	---	---	---
4-20mA	---	---	0	10000	20000
0-20mA	0	1000	4000	12000	20000

Voltage Output Specifications (973PB Only):

Output Range: Select 0-10V DC, 0-5V DC, or 0-1V DC. Ranges are sub-ranges of nominal 0-11.3V design limit (which includes approximately 13% of over-range).

Output Maximum Voltage: 11.3V, typical.

Output Accuracy: See Resolution and Accuracy Table under General Specifications.

Output Current: 0-10mA DC maximum.

Output Impedance: 1Ω .

Output Short Circuit Protection: Included

Response Time: 110us rise time typical, 150us fall time typical, unloaded, for output to reach 98% of the final value in response to a step command. Actual response time will vary with load.

Output Resolution: 1 part in 4046 based on 11.368V full-scale, or 2.81mV/bit (11.368V/4046bits).

DAC Count (Voltage): The internal DAC count can be calculated by multiplying 355.96 by the sum of the output voltage and 0.1393. The resultant value (rounded) can be used to calculate the effective resolution and to approximate the required output register program value (see below). Note the effective resolution is 1 part in the DAC Span.

Internal DAC Count Versus Voltage Output Range

Range	DAC 0%	DAC 100%	DAC Span
0-1V	50	406	356
0-5V	50	1829	1779
0-10V	50	3609	3559

Register Program Value: Output values use integers with ± 20000 representing $\pm 100\%$. The required output register program value can be approximated using the DAC values shown above via the following formula: Register Value = $20000 * (\text{DAC Count} - \text{DAC } 0\%) / \text{DAC Span}$.

Ideal Voltage Output Register Program Value

Range	Output Voltage				
	0V	1V	2.5V	5V	10V
0-1V	0	20000	---	---	---
0-5V	0	4000	10000	20000	---
0-10V	0	2000	5000	10000	20000

Accuracy: Outputs are accurate to better than $\pm 0.1\%$ of output span, typical, for 4-20mA, 0-20mA, 0-10V, and 0-5V ranges (see table below). This includes the effects of repeatability, terminal point conformity, and linearization.

General Specifications

General Specifications

Ambient Temperature Effect: Better than $\pm 0.005\%$ of output span per $^{\circ}\text{C}$ ($\pm 50\text{ppm}/^{\circ}\text{C}$), or $\pm 1.0\text{uV}/^{\circ}\text{C}$, whichever is greater.

Digital-to-Analog Converter: Burr-Brown/Texas Instruments DAC7615, 12-bit. Monotonic to 12 bits.

Integral Non-Linearity: $\pm 0.1\%$ of span or $\pm 2\text{LSB}$ typical, whichever is larger, for spans equal to or greater than 16mA (972PB), or 5V (973PB).

Analog Output Range Resolution & Accuracy

Calibrated Output Range	Effective Resolution	Inaccuracy as a Percent-of-Span
Model 972PB-2004 or 972PB-2006		
0 to 20mA DC	.028%, 1/3614	$\pm 0.1\%$ span ($\pm 0.02\text{mA}$)
4 to 20mA DC	.035%, 1/2891	$\pm 0.1\%$ span ($\pm 0.02\text{mA}$)
0 to 1mA DC	.552%, 1/181	$\pm 1.6\%$ span ($\pm 0.016\text{mA}$)
Model 973PB-2004 or 973PB-2006		
0-10V DC	.028%, 1/3559	$\pm 0.1\%$ span ($\pm 10\text{mV}$)
0-5V DC	.056%, 1/1779	$\pm 0.1\%$ span ($\pm 5\text{mV}$)
0-1V DC	.281%, 1/356	$\pm 0.8\%$ span ($\pm 8\text{mV}$)

Note (0-1mA & 0-1V ranges only): Due to the possible inability of the output to precisely adjust to the ideal range endpoints as a result of the low resolution for the 0-1mA & 0-1V ranges, effective inaccuracy may be as high as 2.2% & 1.1% respectively for these sub-ranges.

Enclosure and Physical

Dimensions: 1.05 inches wide, 4.68 inches tall, 4.35 inches deep. Refer to the dimensions drawing at the front of this manual.

DIN Rail Mount: Type EN50022; "T" rail (35mm).

I/O Connectors: Removable plug-in type terminal blocks rated for 15A/300V; AWG #12-24 stranded or solid copper wire.

Network Connector: 9-pin D-Sub connector (female) with metal housing and 4-40 jack screw support.

D-Sub Pin	Signal	Description
1	SHLD	Shield (Connect to Earth Ground)
2	NC	No Connection
3	A	Data A (TxD/RxD+)
4	RTS	Request To Send
5	GND	RS485 Logic Ground
6	+5V	+5V
7	NC	No Connection
8	B	Data B (TxD/RxD-)
9	NC	No Connection

Case Material: Self-extinguishing NYLON type 6.6 polyamide thermoplastic UL94 V-2, color beige; general purpose NEMA Type 1 enclosure.

Printed Circuit Boards: Military grade FR-4 epoxy glass.

Shipping Weight: 1 pound (0.45 Kg) packed.

Agency Approvals

Profibus Trade Organization (PTO): Certified.

Safety Approvals: CE marked (EMC Directive 89/336/EEC); UL Listed (UL508, UL1604); cUL Listed (Canada Standard C22.2, No. 142-M1987 & 213-M1987); Hazardous Locations: Class 1; Division 2; Groups A, B, C, and D.

Operating Temperature: 972PB: -25°C to +60°C (-13°F to +140°F);

973PB: -25°C to +70°C (-13°F to +158°F).

Storage Temperature: -40°C to +85°C (-40°F to +185°F).

Relative Humidity: 5 to 95%, non-condensing.

Power Requirements: 16-36V DC SELV (Safety Extra Low Voltage).

Observe proper polarity. Current draw will decrease up to 10% as the baud rate is increased to 12MB. Data below is at 9600 baud with current outputs (972PB) set to 20mA, and voltage outputs (973PB) set to 10V across 1KΩ (10mA).

Power Supply	972PB-2004 Current Typical/Maximum	972PB-2006 Current Typical/Maximum
16V	204mA/224mA	289mA/318mA
24V	132mA/145mA	173mA/190mA
36V	92mA/101mA	115mA/127mA

Power Supply	973PB-2004 Current Typical/Maximum	973PB-2006 Current Typical/Maximum
16V	154mA/169mA	188mA/207mA
24V	103mA/113mA	123mA/135mA
36V	73mA/80mA	85mA/94mA

CAUTION: Risk of Electric Shock – More than one disconnect switch may be required to de-energize equipment before servicing.

Power Supply Effect:

Volts: Less than ±0.001% of output span change per volt for rated power supply variations.

60/120 Hz Ripple: Less than 0.01% of output span per volt peak-to-peak of power supply ripple.

Isolation: Output channels (as a group), power, and network circuits are isolated from each other for common-mode voltages up to 250VAC, or 354V DC off DC power ground, on a continuous basis (will withstand 1500VAC dielectric strength test for one minute without breakdown). Complies with test requirements of ANSI/ISA-82.01-1988 for voltage rating specified.

Installation Category: Designed to operate in an Installation in a Pollution Degree 2 environment with an Installation Category (over-voltage category) II rating.

Electromagnetic Interference Immunity (EMI): Output shift has been demonstrated at less than ±0.25% of output span for interference from switching solenoids, commutator motors, and drill motors.

Electromagnetic Compatibility (EMC) -

Minimum Immunity Per European Norm EN50082-1:

Electrostatic Discharge (ESD) Immunity: 4KV direct contact and 8KV air-discharge to the enclosure port per EN61000-4-2.

Radiated Field Immunity (RFI): 10V/M, 80 to 1000MHz AM and 900MHz keyed carrier, per EN61000-4-3 and ENV50204.

Electrical Fast Transient Immunity (EFT): 2KV to power, and 1KV to signal I/O per EN61000-4-4.

Conducted RF Immunity (CRFI): 10Vrms, 150KHz to 80MHz, per EN61000-4-6.

Surge Immunity: 0.5KV per EN61000-4-5.

Emissions Per European Norm EN50081-1:

Radiated Frequency Emissions: 30 to 1000MHz per EN55022 Class A

Environmental

CAUTION: Do not exceed 36VDC peak, to avoid damage to the module.

External Fuse: Select a high surge tolerant fuse rated for 1A or less to protect unit.

Note that input channels are not isolated channel-to-channel, except for small common-mode variations less than ±4V peak.

These limits represent the minimum requirements of the standard, but product has typically been tested to comply with higher standards in some cases.

Environmental

WARNING: This is a Class A product. In a domestic environment, this product may cause radio interference in which the user may be required to take adequate measures.

IMPORTANT: Power, input, and output (I/O) wiring must be in accordance with Class I, Division 2 wiring methods Article 501-4(b) of the National Electrical Code, NFPA 70 for installations in the U.S., or as specified in section 18-1J2 of the Canadian Electrical Code for installations within Canada and in accordance with the authority having jurisdiction.

This equipment is suitable for use in Class I, Division 2, Groups A, B, C, and D, or non-hazardous locations only.

WARNING – EXPLOSION HAZARD – Substitution of components may impair suitability for Class I, Division 2.

WARNING – EXPLOSION HAZARD – Do not disconnect equipment unless power has been switched off or the area is known to be non-hazardous.

Communication Interface

Interface Standard: 3-wire RS-485 multi-drop, half-duplex (D, D-bar, and Common), asynchronous.

Command/Response Protocol: Standard Profibus DP (Master/Slave) protocol per European Norm EN50170.

Baud Rate: Supported baud rates are 9600, 19.2K, 45.45K, 93.75K, 187.5K, 500K, 1.5M, 3M, 6M, and 12M bits per second, auto-detected. Maximum transmission length is dependent on baud rate selection (range is up to 1200M at 9600bps, or up to 100M at 12Mbps). Refer to the following table for maximum transmission distances at supported baud rates using recommended type A (<30pF/M), or alternately type B (<60pF/M) bus wire (see EN50170):

Baud Rate	NETWORK LENGTH	
	Type A	Type B
9600 bps	1200M	1200M
19.2K bps	1200M	1200M
≤ 93.75K bps	1200M	1200M
187.5K bps	1000M	600M
500K bps	400M	200M
1.5M bps	200M	NA
≤ 12M bps	100M	NA

Address: Set via two rotary hexadecimal switches adjacent to the power terminals, or alternately via the Set Slave Address command. Valid setting is 0-125 (7 bits). Address 126 (7EH) is the default factory address and is reserved for commissioning purposes only. Address 127 (7FH) is reserved by the software as a global address for broadcast messages. If the address switches are set to 126 upon power-up (or 126-254), then the unit will retrieve its address from its internal EEPROM rather than the switches. The internal EEPROM setting is modified via the Set Slave Address command. Powering up with switches set to 255 (FFH) will cause the internal EEPROM setting to revert back to 126 (7EH), which may be used to recommission the module. If both the internal EEPROM address and the switches are set to 126 upon power-up (this is the initial state from the factory), the module will await the Set Slave Address command before completing initialization and assuming the data exchange mode.

IMPORTANT (Address Setting): The internal EEPROM address setting and external switch setting is 126 from the factory. As such, the module will await the Set Slave Address command following power-up and will not proceed to exchange data, unless the external switches are instead set to an address from 0-125, or the internal setting is changed to an address from 0-125 via the Set Slave Address command.

Parity/Stop Bits: Even parity with one stop bit.

Communication Distance: Up to 1200 meters without a repeater.

Maximum Message Size: Up to 32 bytes recommended, extendable up to 244 bytes of data/node/message, plus 11 bytes of overhead (frame).

Profibus Character: 11 bits (1 start bit + 8 data bits + 1 even parity bit + 1 stop bit). Applies to all bytes, including frame bytes.

Ident Number: 0769H (972PB-2004), 0768H (072PB-2006), 06FFH (973PB-2004), 06FEH (973PB-2006).

GSD File: 972PB-2004: ACRO0769.GSD; 972PB-2006: ACRO0768.GSD; 973PB-2004: ACRO06FF.GSD; 973PB-2006: ACRO06FE.GSD.

Bus Idle State: "1" (a start bit causes line to go to "0"). An idle state of at least 33 Tbits (sync-time) must be provided between messages.
Note: 1Tbit at 12Mbaud = 1/12000000bit/sec = 83nsec.

Network Capacity: Multi-drop up to 31 modules, plus a host, without a repeater. Up to 125 modules plus a host if four repeaters are used (one for every 31 nodes).

Network Termination: Use 220Ω "A" to "B", plus 390Ω "A" to GND, and 390Ω "B" to +5V. Use ±2%, 0.25W resistors.

LED Indicators:

Run (Green) - Constant ON indicates power applied and unit OK. Flashing ON/OFF indicates unit is performing diagnostics (first few seconds following power-up), or has failed diagnostics (after a few seconds).

Bus (Yellow) – ON indicates unit has completed its initialization sequence and is in the data exchange mode on the network.

Switches:

Slave Address: Two hexadecimal rotary DIP switches located in the recessed opening adjacent to power terminals and represent the hex MSB & LSB of the 8 bit address. See Address above for operation.

These models include 27 user parameterization bytes (6 channel "-2006" models), or 19 user parameterization bytes (4 channel "-2004" models) of User_Prm_Data defined as follows (any changes to user parameterization bytes take effect immediately):

User Parameterization Bytes (User_Prm_Data)

"-2006" BYTE	"-2004" BYTE	DESCRIPTION	DEF
0	0	Do Not Use – Reserved for SPC3 ASIC.	NA
1	1	CH 0 Range Select (typical for all channels): 00H = 0-20mA (972PB), 0-10V (973PB) 01H = 4-20mA (972PB), 0-5V (973PB) 02H = 0-1mA (972PB), 0-1V (973PB)	00H
2	2	CH 1 Range Select (see CH 0 for definition).	00H
3	3	CH 2 Range Select (see CH 0 for definition).	00H
4	4	CH 3 Range Select (see CH 0 for definition).	00H
5	NA	CH 4 Range Select (see CH 0 for definition).	00H
6	NA	CH 5 Range Select (see CH 0 for definition).	00H

Communication Interface

Controls & Indicators

Module Specific Parameters (User_Prm_Data)

Module Specific Parameters (User_Prm_Data)

This model does not include any user defined diagnostic data (Ext_Diag_Data).

User Parameterization Bytes (User_Prm_Data)...continued

"-2006" BYTE	"-2004" BYTE	DESCRIPTION	DEF
7	5	CH 0 Output Action – action taken in Clear Mode or upon Watchdog Timeout (typical for all channels): 00H = Clear outputs (set all outputs to zero). 01H = Do not change (maintain last value). 02H = Set outputs according to user definition in bytes 13-24 (or 9-16) below. Outputs go to these pre-defined levels.	00H
8	6	CH 1 Output Action (see CH0 for definition).	00H
9	7	CH 2 Output Action (see CH0 for definition).	00H
10	8	CH 3 Output Action (see CH0 for definition).	00H
11	NA	CH 4 Output Action (see CH0 for definition).	00H
12	NA	CH 5 Output Action (see CH0 for definition).	00H
13	9	CH 0 Predefined Output High Order Byte	00H
14	10	CH 0 Predefined Output Low Order Byte	00H
14	11	CH 1 Predefined Output High Order Byte	00H
16	12	CH 1 Predefined Output Low Order Byte	00H
17	13	CH 2 Predefined Output High Order Byte	00H
18	14	CH 2 Predefined Output Low Order Byte	00H
19	15	CH 3 Predefined Output High Order Byte	00H
20	16	CH 3 Predefined Output Low Order Byte	00H
21	NA	CH 4 Predefined Output High Order Byte	00H
22	NA	CH 4 Predefined Output Low Order Byte	00H
23	NA	CH 5 Predefined Output High Order Byte	00H
24	NA	CH 5 Predefined Output Low Order Byte	00H
25	17	Writing 55H to this register will cause the module to restore its original factory calibration (55H is not stored, but acts as a trigger, and this byte always reads as 00H).	00H
26	18	Factory Use Only – Do Not Modify.	NA

Data Types

I/O values of Acromag 9xxPB modules are represented by the simple data types noted at right for temperature, percentage, and discrete on/off. Note that when transferring words, data bytes are transmitted using "Big Endian" format (MSB first, LSB second).

Data Types	Description
Percentage (This Model)	A 16-bit signed integer value with resolution of 0.005%/lsb. ± 20000 is used to represent $\pm 100\%$. For example, -100%, 0% and +100% are represented by decimal values -20000, 0, and 20000, respectively. The full range is -163.84% (-32768 decimal) to +163.835% (+32767 decimal).
Temperature	A 16-bit signed integer value with resolution of 0.1°C/lsb. For example, a value of 12059 is equivalent to 1205.9°C, a value of -187 equals -18.7°C. The maximum possible temperature range is -3276.8°C to +3276.7°C.
Discrete	A discrete value is generally indicated by a single bit of an 8-bit byte. The bit number/position typically corresponds to the discrete channel number. Unless otherwise defined for outputs, a 1 bit means the corresponding output is closed or ON, a 0 bit means the output is open or OFF. For active-high inputs, a value of 1 means the input is in its high state (usually >> 0V), while a value of 0 specifies the input is in its low state (near 0V). For active low inputs, a value of 1 means the input is ON (Active low near 0V), while a value of 0 specifies the input is OFF or in its high state (usually >> 0V).

Revision History

The following table shows the revision history for this document:

Release Date	Version	EGR/DOC	Description of Revision
27 JUN 03	A	BC/KLK	Initial release.
28 OCT 03	B	BC/KLK	UL updates per ECN 03J022.
02 NOV 04	C	CAP/KLK	Added latest UL information to manuals and labels per ECN 04J008.
11 AUG 06	D	BC/KLK	Max current update per ECN 06E022.
02 FEB 15	E	FJM/ARP	Correction to connectors on DB9 Connections table.