WOODWARD

AtlasSC™ Digital Control

Control Part Numbers
8273-040, -041, -042, -043

Installation and Operation Manual

| ⚠ **General Precautions** | Read this entire manual and all other publications pertaining to the work to be performed before installing, operating, or servicing this equipment.

Practice all plant and safety instructions and precautions.

Failure to follow instructions can cause personal injury and/or property damage. |
|---|---|

| ⚠ **Revisions** | This publication may have been revised or updated since this copy was produced. To verify that you have the latest revision, check manual *26455, Customer Publication Cross Reference and Revision Status & Distribution Restrictions*, on the *publications page* of the Woodward website:

www.woodward.com/publications

The latest version of most publications is available on the *publications page*. If your publication is not there, please contact your customer service representative to get the latest copy. |
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⚠ **Proper Use**	Any unauthorized modifications to or use of this equipment outside its specified mechanical, electrical, or other operating limits may cause personal injury and/or property damage, including damage to the equipment. Any such unauthorized modifications: (i) constitute "misuse" and/or "negligence" within the meaning of the product warranty thereby excluding warranty coverage for any resulting damage, and (ii) invalidate product certifications or listings.

| ⚠ **Translated Publications** | If the cover of this publication states "Translation of the Original Instructions" please note:

The original source of this publication may have been updated since this translation was made. Be sure to check manual *26455, Customer Publication Cross Reference and Revision Status & Distribution Restrictions*, to verify whether this translation is up to date. Out-of-date translations are marked with ⚠. Always compare with the original for technical specifications and for proper and safe installation and operation procedures. |
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Revisions— A bold, black line alongside the text identifies changes in this publication since the last revision.

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Important Definitions

⚠ This is the safety alert symbol used to alert you to potential personal injury hazards. Obey all safety messages that follow this symbol to avoid possible injury or death.

- **DANGER** - Indicates a hazardous situation, which if not avoided, will result in death or serious injury.
- **WARNING** - Indicates a hazardous situation, which if not avoided, could result in death or serious injury.
- **CAUTION** - Indicates a hazardous situation, which if not avoided, could result in minor or moderate injury.
- **NOTICE** - Indicates a hazard that could result in property damage only (including damage to the control).
- **IMPORTANT** - Designates an operating tip or maintenance suggestion.

⚠ **WARNING** **Overspeed / Overtemperature / Overpressure**	**The engine, turbine, or other type of prime mover should be equipped with an overspeed shutdown device to protect against runaway or damage to the prime mover with possible personal injury, loss of life, or property damage.** **The overspeed shutdown device must be totally independent of the prime mover control system. An overtemperature or overpressure shutdown device may also be needed for safety, as appropriate.**

⚠ **WARNING** **Personal Protective Equipment**	**The products described in this publication may present risks that could lead to personal injury, loss of life, or property damage. Always wear the appropriate personal protective equipment (PPE) for the job at hand. Equipment that should be considered includes but is not limited to:** • **Eye Protection** • **Hearing Protection** • **Hard Hat** • **Gloves** • **Safety Boots** • **Respirator** **Always read the proper Material Safety Data Sheet (MSDS) for any working fluid(s) and comply with recommended safety equipment.**

⚠ **WARNING** **Start-up**	**Be prepared to make an emergency shutdown when starting the engine, turbine, or other type of prime mover, to protect against runaway or overspeed with possible personal injury, loss of life, or property damage.**

Electrostatic Discharge Awareness

<table>
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NOTICE

Electrostatic Precautions

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Electronic controls contain static-sensitive parts. Observe the following precautions to prevent damage to these parts:

- **Discharge body static before handling the control (with power to the control turned off, contact a grounded surface and maintain contact while handling the control).**
- **Avoid all plastic, vinyl, and Styrofoam (except antistatic versions) around printed circuit boards.**
- **Do not touch the components or conductors on a printed circuit board with your hands or with conductive devices.**

To prevent damage to electronic components caused by improper handling, read and observe the precautions in Woodward manual 82715, *Guide for Handling and Protection of Electronic Controls, Printed Circuit Boards, and Modules*.

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Follow these precautions when working with or near the control.
1. Avoid the build-up of static electricity on your body by not wearing clothing made of synthetic materials. Wear cotton or cotton-blend materials as much as possible because these do not store static electric charges as much as synthetics.
2. Do not remove the printed circuit board (PCB) from the control cabinet unless absolutely necessary. If you must remove the PCB from the control cabinet, follow these precautions:
   - Do not touch any part of the PCB except the edges.
   - Do not touch the electrical conductors, the connectors, or the components with conductive devices or with your hands.
   - When replacing a PCB, keep the new PCB in the plastic antistatic protective bag it comes in until you are ready to install it. Immediately after removing the old PCB from the control cabinet, place it in the antistatic protective bag.

Regulatory Compliance

North American Compliance:

    UL: UL Listed for Class I, Division 2, Groups A, B, C, & D, T4A at 70 °C ambient. For use in Canada and the United States.

These listings are limited to those units bearing the UL agency identification.

Marine Compliance

American Bureau of Shipping: ABS Rules 2003 SVR 4-2-1/7.3, 7.5.1, 7.9.3/17, 4-9-4/23, 4-9-7/Table 9

Det Norske Veritas: Standard for Certification No. 2.4, 2001: Temperature Class B, Humidity Class B, Vibration Class C, and EMC Class A

Lloyd's Register of Shipping: LR Type Approval Test Specification No. 1, 2002 for Environmental Categories ENV1, ENV2, and ENV3

Special Conditions for Safe Use
The AtlasSC control is suitable for use in Class I, Division 2, Groups A, B, C, D, per UL for Canada and US or non-hazardous locations only.

Wiring must be in accordance with North American Class I, Division 2 wiring methods as applicable, and in accordance with the authority having jurisdiction.

Field wiring must be suitable for at least 75 °C for operating ambient temperatures expected to exceed 50 °C.

A fixed wiring installation is required.

Do not connect more than one main power supply to any one fuse or circuit breaker.

Connect ground screw to earth ground (see Figure 3-1).

⚠ **WARNING**	**EXPLOSION HAZARD—Do not connect or disconnect while circuit is live unless area is known to be non-hazardous.** **Substitution of components may impair suitability for Class I, Division 2 applications.**

⚠ **AVERTISSEMENT**	**RISQUE D'EXPLOSION—Ne pas raccorder ni débrancher tant que l'installation est sous tension, sauf en cas l'ambiance est décidément non dangereuse.** **La substitution de composants peut rendre ce matériel inacceptable pour les emplacements de Classe I, Division 2.**

IMPORTANT	Some degraded performance can occur on RTD and thermocouple inputs in the presence of radiated energy from transmitters such as cell phones. This degraded performance is in the form of a slight change in the accuracy of the measured temperature. It is recommended that operation of such devices be kept more than 3 m from the AtlasSC control. This will prevent any degradation. Installation of the unit in a metal enclosure will also prevent degradation.

Chapter 1.
General Information

Introduction

This manual describes the Woodward AtlasSC™ Digital Control. It provides a variety of useful information for the user ranging from simple basic descriptions to detailed information on wiring, specifications, programming, and functionality. Included are:

- General information on the AtlasSC platform and available versions
- A physical description of the control hardware
- A description of all AtlasSC modules
- A listing of accessories that may be used with the platform
- Information on AtlasSC programming, distributed I/O (input/output), and control communications
- Installation and maintenance
- Troubleshooting information

AtlasSC Control Description

The AtlasSC digital control platform fits a wide range of prime mover applications. These include small mechanical-drive units with a minimum of complexity on up to small two-shaft gas turbine generator sets that require unit sequencing and load control. The AtlasSC control is programmed to the specific needs of the prime mover and its driven load.

At the heart of the AtlasSC control is a 32-bit microprocessor that runs a powerful Real Time Operating System. This operating system is specifically designed to control the proper timing of all application code so that dynamic performance of the final control system is absolutely guaranteed. Each piece of the application code is "scheduled" under a Rate Group structure that ensures execution of the code at a predetermined time.

Application programming is accomplished via Woodward's GAP™ Graphical Application Program. GAP is a pictures-to-code system that provides a high-level programming environment for users who have control expertise but do not have specific programming skills. Once the application program has been generated and loaded into the AtlasSC control, the user can view variables and tune the control with the Woodward Watch Window Standard service tool. Connection to other devices, such as an HMI, is accomplished by means of serial Modbus®* ports on the control, and the desired information flow is programmed into the control via GAP. Another serial Modbus port can be used to connect distributed I/O if required.

*—Modbus is a trademark of Schneider Automation Inc.

The hardware platform is based on the industry-standard PC/104 bus structure. In the AtlasSC control, the backplane is the SmartCore board. The PC/104 modules are "stacked" onto the SmartCore board in order to add I/O or other functionality. Each of the stacked modules has an on-board DIP switch that is positioned to the unique address of that particular module. The AtlasSC control uses a second stack called the Power Bus Stack. This stack is used primarily for power-related I/O. Three serial Modbus communications ports are available for a variety of uses. The control runs on low-voltage dc power (18–32 Vdc). AtlasSC field wiring is accomplished via terminal blocks that plug into the control modules.

Control Versions

The AtlasSC control versions are differentiated by anticipated application categories. As such, the I/O content will vary, and one or more of the optional I/O modules may be required. Table 1-1 shows the configuration of the modules for the AtlasSC part numbers that are available.

Table 1-1. AtlasSC Versions

Part Number	Application Category	Smart Core	Power Supply	Analog Combo	Power Sense
8273-040	Small gen set or mechanical drive	Yes	Yes	No	No
8273-041	Large gen set or mechanical drive	Yes	Yes	Yes	No
8273-042	Small gen set with real power sensing	Yes	Yes	No	Yes
8273-043	Large gen set with real power sensing	Yes	Yes	Yes	Yes

Figure 1-1 shows diagrammatically the physical arrangement of the modules in the AtlasSC hardware. The hardware uses two stacked-bus arrangements to provide the required structure. The Power Bus Stack is used for the power-related I/O as well as the discrete output drivers. The PC/104 Stack is used primarily for the signal I/O. Depending on the part number specified, the AtlasSC control may or may not have an Analog Combo board or a PowerSense board (refer to Table 1-1 above). The stack arrangement shown in Figure 1-1 is for the maximum configuration (8273-043).
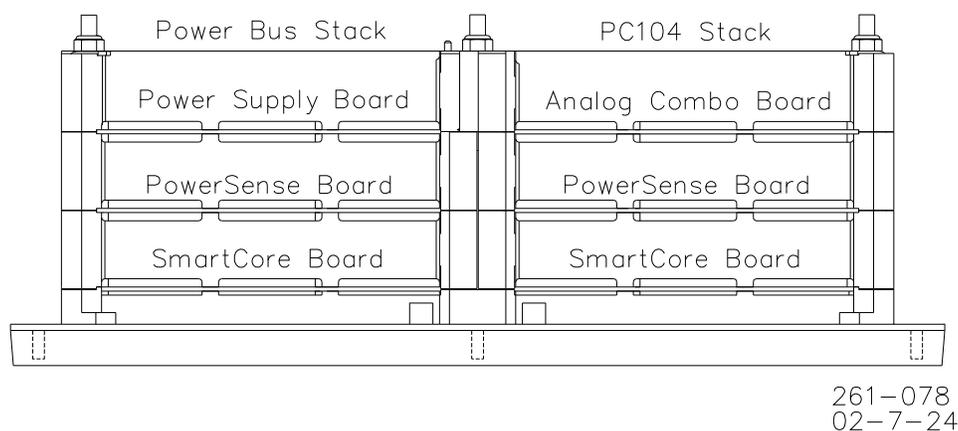
Figure 1-1. AtlasSC Module Layout

Control Accessories

The AtlasSC digital control is designed to interface with the Woodward Watch Window Standard and Watch Window Professional service tools. Watch Window is a configuration and troubleshooting tool that provides a window into the control system. It runs on a PC and is connected to a serial communication port on the AtlasSC control. Watch Window is available from the Woodward website (**www.woodward.com/ic**) or from a CD-ROM that can be purchased.

Watch Window Standard performs three primary functions:
- Initial Control Configuration
  Configures the AtlasSC control to specific application or site requirements.
- Monitoring and Tuning
  Allows the user to view system variables and tune the application software for desired performance.
- Management of Configuration and Setpoints
  Allows the user to upload or download all tuning and configuration variables to or from the AtlasSC control.

Watch Window Professional provides all of the functions of Watch Window Standard, plus it provides the tools to download application code into the AtlasSC hardware.
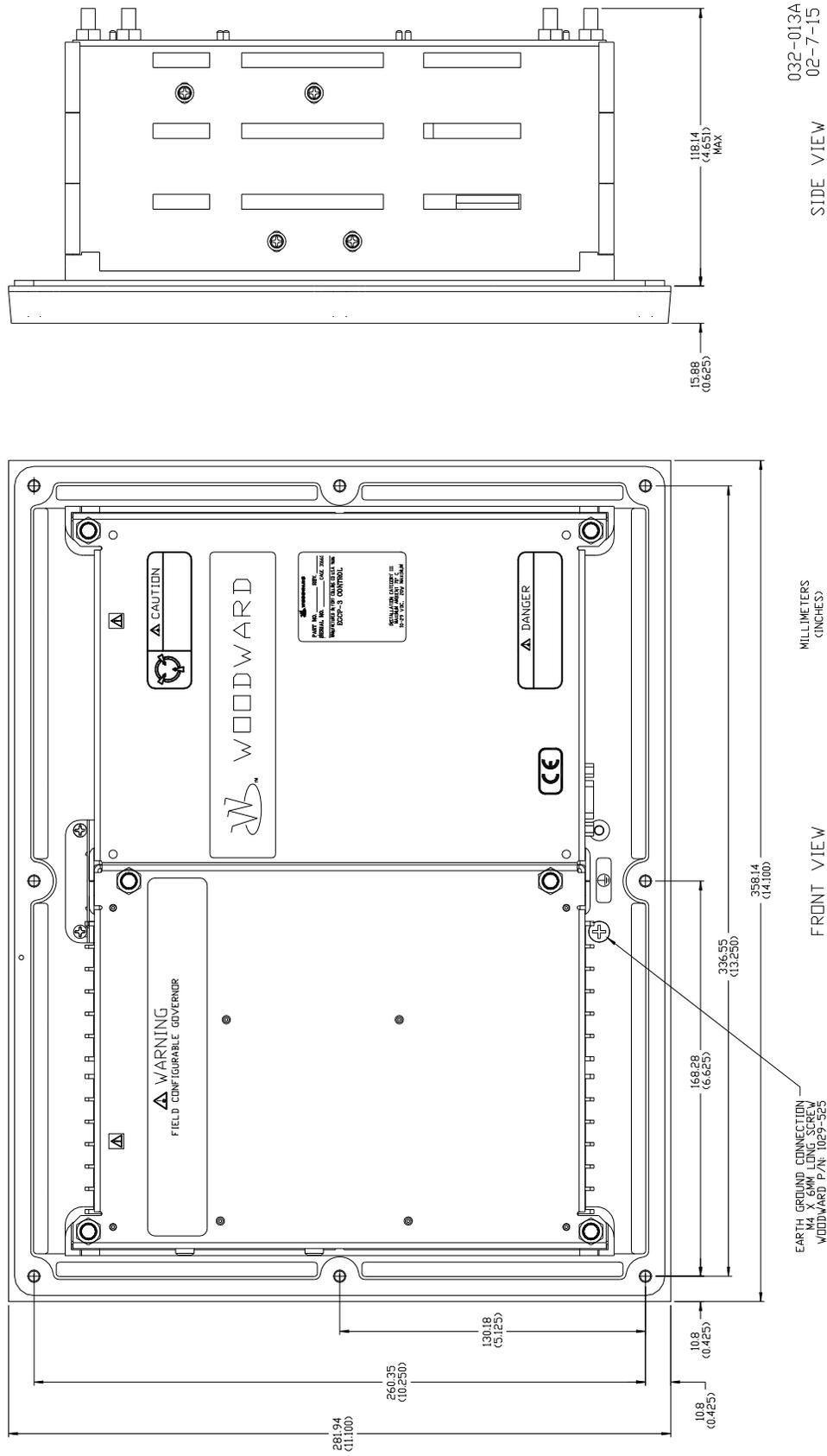
Figure 1-2. AtlasSC Control Layout
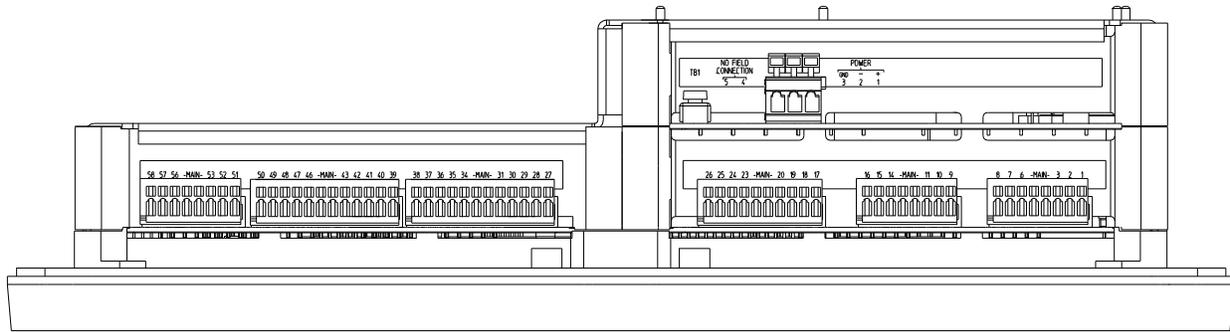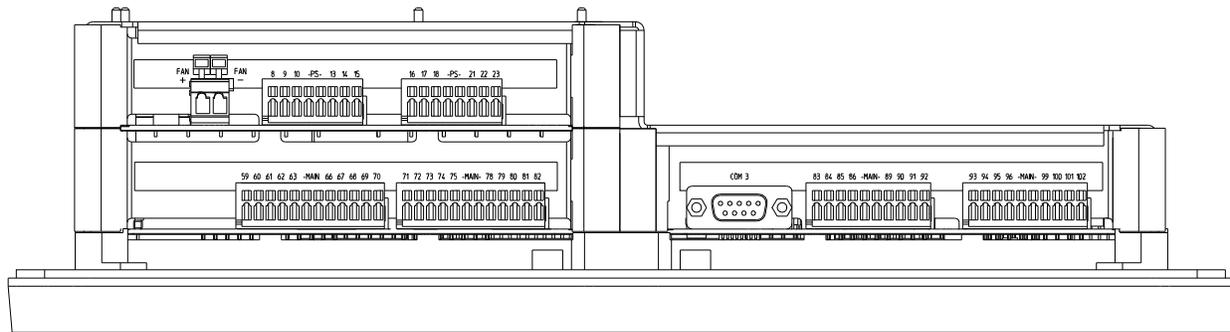
Figure 1-3. AtlasSC Control (8273-040)
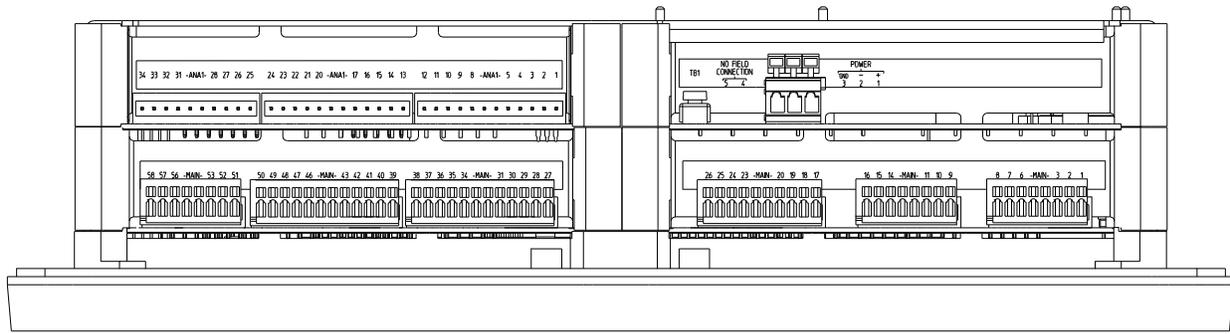
TOP VIEW
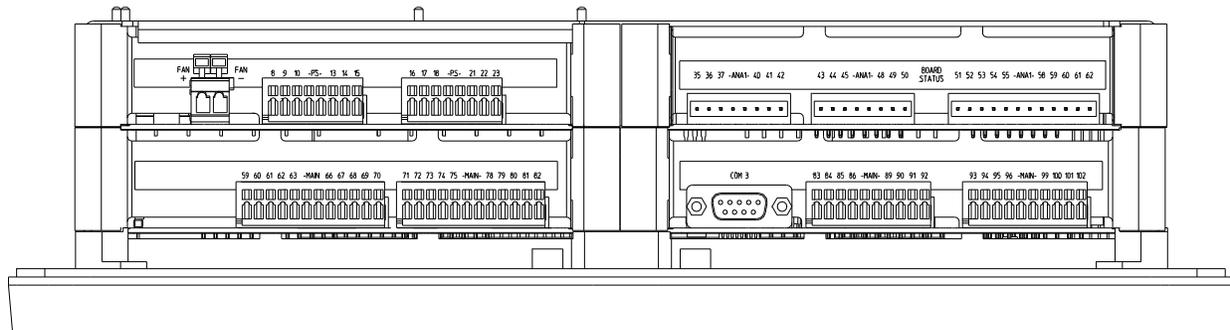
BOTTOM VIEW

261-075
02-7-8

Figure 1-4. AtlasSC Control (8273-041)
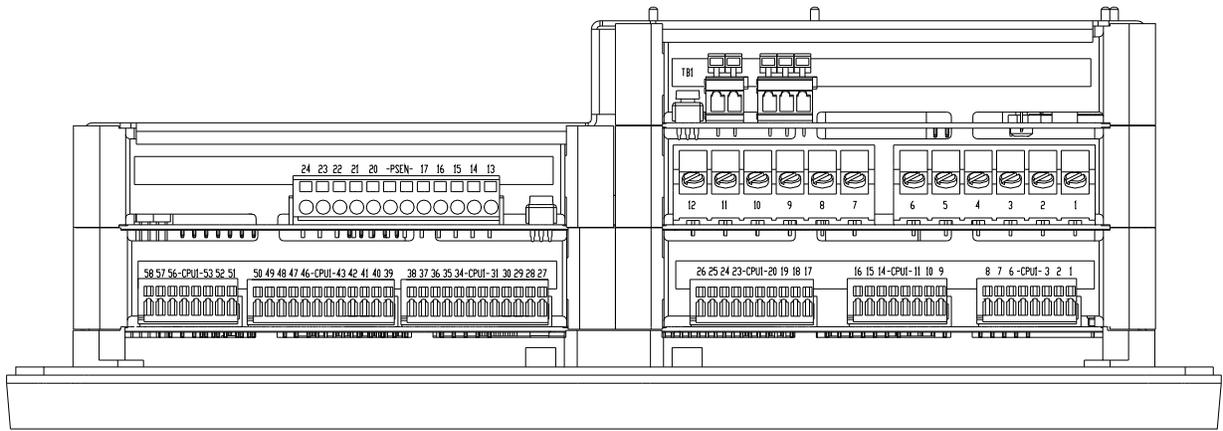
TOP VIEW
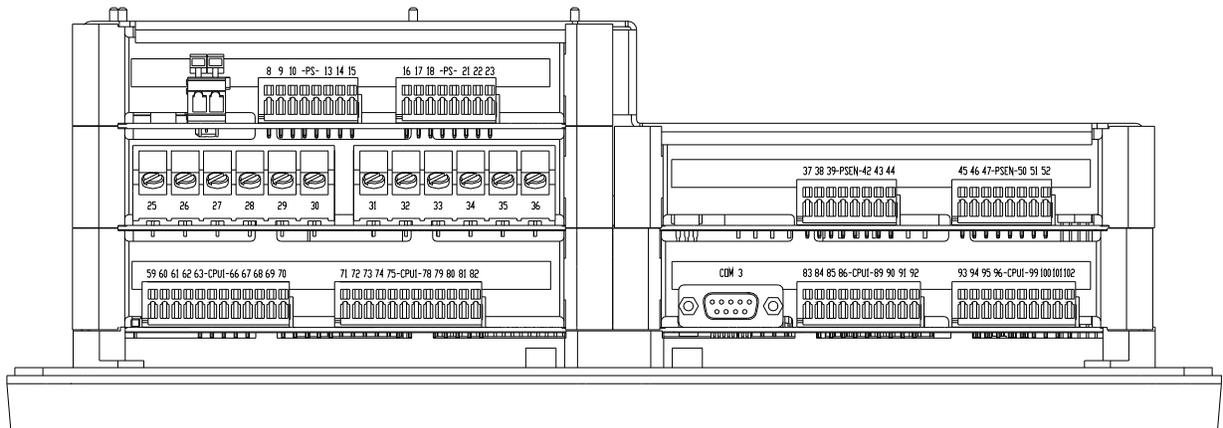
BOTTOM VIEW

261-077
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Figure 1-5. AtlasSC Control (8273-042)
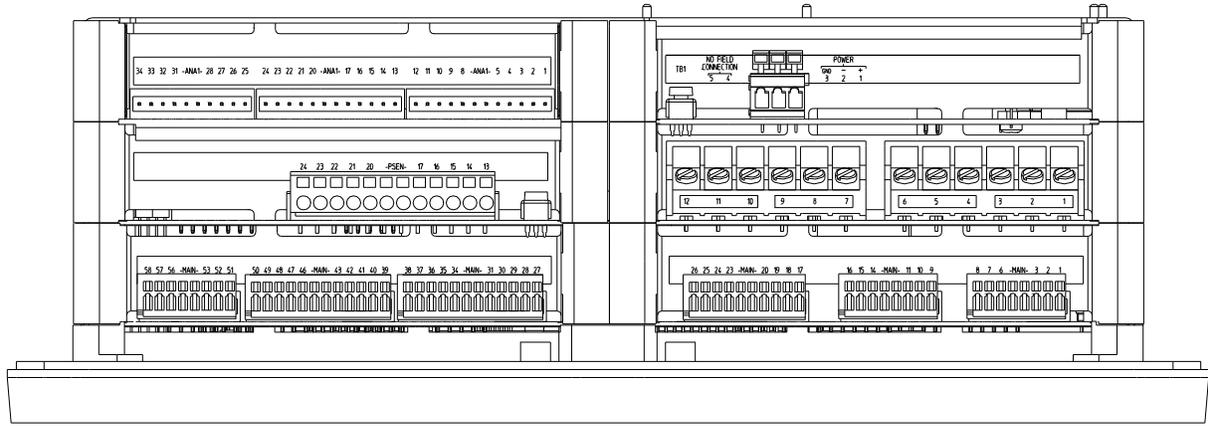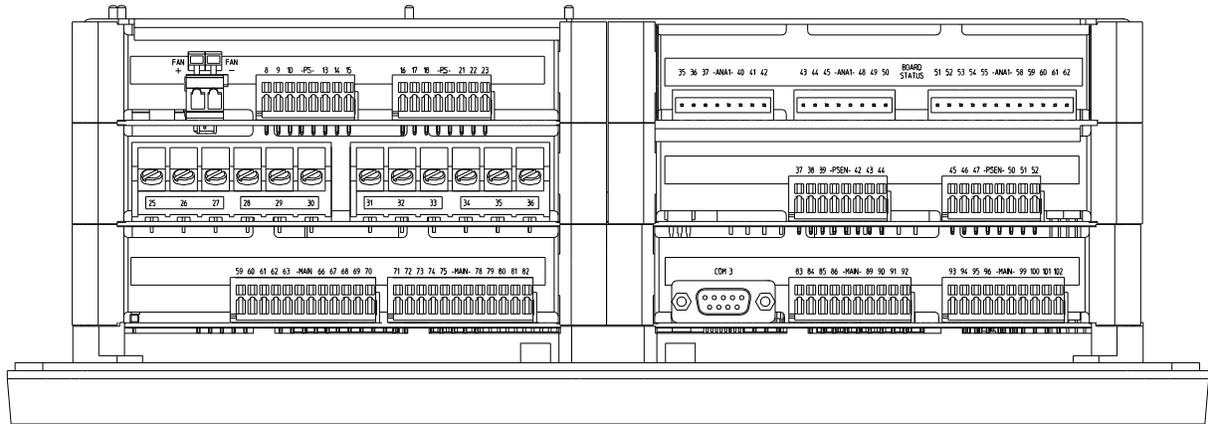
Figure 1-6. AtlasSC Control (8273-043)

Chapter 2
Installation

Introduction

This chapter provides the general information for mounting location selection, installation, and wiring of the AtlasSC™ control. Hardware dimensions, ratings, and requirements are given for mounting and wiring the control in a specific application.

General Installation

When selecting a location for mounting the AtlasSC control, consider the following:
- Protect the unit from direct exposure to water or to a condensation-prone environment.
- The operating range of the AtlasSC control is –20 to +70 °C
  (–4 to +158 °F).
- Provide adequate ventilation for cooling. Shield the unit from radiant heat sources.
- Do not install near high-voltage or high-current devices.
- Allow adequate space around the unit for servicing and wiring.
- Do not install where objects can be dropped on the terminals.
- Ground the chassis for proper safety and shielding.
- When installing on a generator set package, provide vibration isolation.

Shipping Carton

Before unpacking the control, refer to the inside front cover and page vi of this manual for WARNINGS and NOTICES. Be careful when unpacking the control. Check for signs of damage such as bent or dented panels, scratches, loose or broken parts. If any damage is found, immediately notify the shipper.

The AtlasSC control was shipped from the factory in an anti-static foam lined carton. This carton should always be used for transport of the control when it is not installed.

Mounting

Figure 1-2 shows the AtlasSC control layout and mounting pattern. The AtlasSC digital control is to be mounted in an appropriate enclosure for the installed environment. This equipment is designed for installation within a control room panel or cabinet.

The standard AtlasSC package must be mounted to allow sufficient room for wiring access. Eight front panel mounting holes permit secure mounting. Depending on its configuration, the AtlasSC weighs between 3.4 and 4.5 kg (7.5 and 10 pounds), and has an operating range of –20 to +70 °C ambient air temperature. A minimum of 25 mm (1 inch) of clear space around the outer surfaces of the AtlasSC is adequate for ventilation, however approximately 75 mm (3 inches) of space may be required for wiring, depending on wire size.

Environmental Specifications

Operating Temperature
The AtlasSC Control Platform operates in a specified ambient temperature of
–20 to +70 °C (–4 to +158 °F).

NOTICE	**Continuous operation with insufficient airflow or higher operating temperatures will lead to reduced reliability and possible damage to the control.**

Storage Temperature
The AtlasSC Control Platform is designed to be stored without applied power at the temperature range of –40 to +105 °C (–40 to +221 °F).

Shock
The AtlasSC Control Platform was designed to meet the shock requirements specified by MIL-STD-810C procedure 516.2, procedure 1 (30 Gs, 11 millisecond half sine pulse). During Shock, relay bounce shall be limited to less than 100 ms.

Vibration (Random)
SAE J1455 (10–2000 Hz @ 0.04 G²/Hz, 8.2 G$_{rms}$ PSD)

Vibration (Sine)
Lloyds Register Test Specification No. 1 Vibration Test 1 (5–13.2 Hz, ±1 mm; 13.2–100 Hz, 0.7 g)

Audible Noise Emission
The AtlasSC Control Platform does not emit an audible noise above 70 dBA as measured 1 meter away, with or without a fan.

Electrical Connections

Most inputs and outputs to the AtlasSC control are made through "CageClamp" terminal blocks. For noise suppression, it is recommend that all low-current wires be separated from all high-current wire.

The pluggable terminal blocks on the I/O modules are screwless CageClamp style blocks. The spring clamp can be actuated by using a standard 2.5 mm (3/32 inch) flat bladed screwdriver (see Figure 2-1). The AtlasSC pluggable terminal blocks accept wires from 0.08–1.1 mm² (28–18 AWG). Two 0.5 mm² (20 AWG) wires or three 0.3 mm² (22 AWG) wires can be easily installed in each terminal. Wires for the pluggable I/O terminals should be stripped 8 mm (0.3 inch).

Most of the AtlasSC control's terminal blocks are designed to be removed by hand. After AtlasSC input power is disconnected, the terminal blocks can be removed one at a time by pulling them straight out. Be careful not to pull the plug out at an angle, as this will fracture the end terminal.
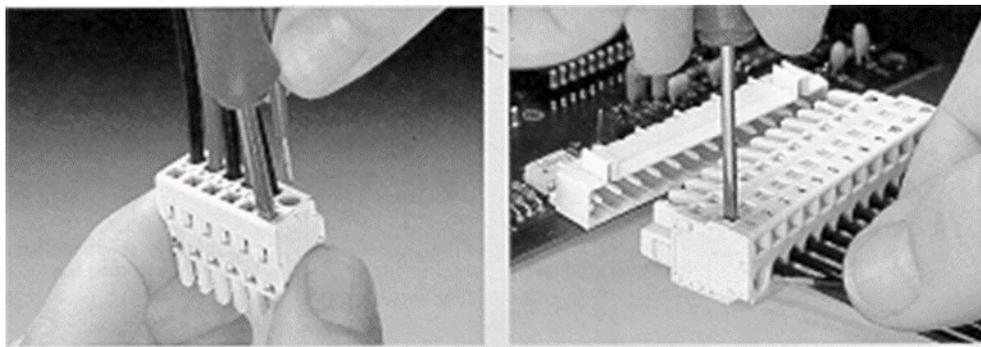
Method #1
Free Hand (holds spring open)

Method #2
Bench (momentarily opens spring while force is applied)

Figure 2-1. Spring Clamp

The AtlasSC fixed terminal blocks used for the power supply input accept wires from 0.08–1.1 mm² (28–18 AWG). Two 0.5 mm² (20 AWG) wires or three 0.3 mm² (22 AWG) wires can be easily installed in each terminal. Wires for the fixed mounted power terminals should be stripped 5 mm (0.2 inch).
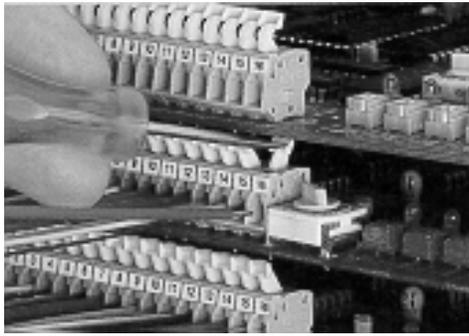
Figure 2-2. Wiring Fixed Terminal

IMPORTANT	**Do not tin (solder) the wires that terminate at the AtlasSC terminal blocks. The spring-loaded CageClamp terminal blocks are designed to flatten stranded wire, and if those strands are tinned together, the connection loses surface area and is degraded.**

All ac wiring for voltages and currents is done with fixed screw barrier blocks rather than pluggable terminal blocks. The fixed screw barrier blocks accept wires terminated into terminal lugs for #6 screws.

Figure 2-3. Fixed Terminals

Grounding

Protective Earth (PE) must be connected to the termination point on the backside of the unit next to the label with the symbol ⏚ to reduce the risk of electric shock. This connection will be made using a thread-forming screw (M4 x 6 mm). The conductor providing the connection shall have a properly sized ring lug and wire larger than or equal to 3.3 mm² (12 AWG).

Recommended Grounding Practices

Providing the proper ground for the AtlasSC control is important. Improper connection of the control chassis to the ground plane may lead to stray currents between the reference point for the ac signal sources (current and voltage transformers), and the reference point for the sensing inputs on the AtlasSC control. Differences in potential between these two points results in equalizing current flow which then produces unacceptably high common mode voltages. Common mode voltages may result in improper readings for the sensed ac inputs, or even damage to the AtlasSC control in extreme cases. To minimize this problem, it is necessary to provide a low resistance path between the ac signal reference point, and the chassis of the AtlasSC control. Typically this point is the designated ground for the generator set and related instrument transformers.

Shields and Grounding

An individual shield termination is provided at the terminal block for each of the signals requiring shielding. These include all sensor wiring and ac signal inputs. Relay outputs, contact inputs, and power supply wiring do not normally require shielding, but can be shielded if desired. All shielded cable must be twisted conductor pairs. Do not attempt to tin (solder) the braided shield. All signal lines should be shielded to prevent picking up stray signals from adjacent equipment. Wire exposed beyond the shield should be as short as possible, not exceeding 50 mm (2 inches). The other end of the shields must be left open and insulated from any other conductor.

The AtlasSC control is designed for shield termination to earth ground at the control. If intervening terminal blocks are used in routing a signal, the shield should be continued through the terminal block. If shield grounding is desired at the terminal block, it should be ac coupled to earth. All other shield terminations except at the AtlasSC control should be ac coupled to earth through a capacitor. A 1000 pF, 500 V capacitor is sufficient. The intent is to provide a low impedance path to earth for the shield at frequencies of 150 kHz and up. Multiple direct connections of a shield to earth risk high levels of current to flow within the shield. See Woodward application note 50532, *Interference Control in Electronic Governing Systems*, for more information.

Where shielded cable is required, cut the cable to the desired length and prepare the cable as instructed below.
1. Strip outer insulation from both ends, exposing the braided or spiral wrapped shield. Do not cut the shield.
2. Using a sharp, pointed tool, carefully spread the strands of the shield.
3. Pull inner conductor(s) out of the shield. If the shield is the braided type, twist it to prevent fraying.
4. Remove 6 mm (1/4 inch) of insulation from the inner conductors.
5. Connect wiring and shield as shown in plant wiring diagram.

For noise suppression reasons, it is recommend that all low-current wires be separated from all high-current wires. Input power ground terminal should also be wired to earth ground. Installations with severe electromagnetic interference (EMI) may require additional shielding precautions, such as wire run in conduit or double shielding. Contact Woodward for more information.

Shields can be grounded at both ends (AtlasSC control and load) if the cable length is sufficiently short (within a cabinet) to prevent ground loop current in the shield.

Cabinet Installations: If the AtlasSC control is installed in a cabinet, shielded I/O can be terminated directly to the cabinet (earth ground) at the entry to the cabinet, as well as at the control.

Input Power

The AtlasSC control requires a nominal voltage source of 18 to 32 Vdc. Input power requirements vary depending on the control version. Table 2-1 contains information for the maximum configuration.

NOTICE	**Power must be applied to the AtlasSC control at least 60 seconds prior to expected use. The control must have time to do its power up diagnostics to become operational. Failure of the diagnostics will disable control function.**

⚠ WARNING	**The AtlasSC power supply board must have the input power removed before installing or removing.**
	This equipment is suitable for use in Class 1, Division 2, Groups A, B, C, and D, or non-hazardous locations only.
	Wiring must be in accordance with Class I, Division 2 wiring methods and in accordance with the authority having jurisdiction.
	Do not connect more than one main power supply to any one fuse or circuit breaker.

Power supply output must be of a low impedance type for proper operation of the control. DO NOT power a control from a high voltage source containing dropping resistors and Zener diodes. If batteries are used for operating power, an alternator or other battery-charging device is necessary to maintain a stable supply voltage.

Significant inrush currents are possible when current is applied to the AtlasSC control. The magnitude of the inrush current depends on the power source impedance, so Woodward cannot specify the maximum inrush current. Time-delay fuses or circuit breakers must be used to avoid nuisance trips.

Input
Protect   ust be connected to the chassis at the termination point on the back side

labeled [⏚] . The power supply grounding terminals should also be connected to earth to ensure grounding of the power supply printed circuit boards. The grounding conductor must be the same size as the main supply conductors or the PT wires, whichever is larger.

Note that the control's power supplies are not equipped with input power switches. For this reason, some means of disconnecting input power to each main power supply must be provided for installation and servicing.

It is expected that the installation of this equipment will include over current protection between the power source and the AtlasSC control. This over current protection may be accomplished by series connection of properly rated fuses or circuit breakers. Branch circuit protection of no more than 250% of the maximum AtlasSC power supply input current rating must be provided. See Table 2-1 for maximum recommended fuse ratings. This value meets the 250% UL listing requirements. The use of properly sized UL class CC, J, T, G, RK1, or RK5 fuses meet the requirements for branch circuit protection. Do not connect more than one AtlasSC control to any one fuse. Use only the wire size specified in Table 2-1 or equivalent metric size which meets local code requirements. Time delay fuses should be used to prevent nuisance trips.

Table 2-1 provides the power supply holdup time specification; which is the time the supply will continue to operate within specification after its input power is interrupted. This information may be useful in specifying uninterruptible power supply (UPS) systems.

Table 2-1. Power Supply Requirements

Input Voltage Range	Fuse (Current Rating)	Fuse (I²t Rating)	Wire Size* **	Holdup Time
18–32 Vdc**	9 A	>800	2/4 mm² 12/14 AWG	8 ms

IMPORTANT	*** 4 mm² (12 AWG) is the largest wire gauge size that may be connected to the control power input terminal blocks.** **** The minimum input voltage allowed is 18 V at the power input of the control. The length, size of wire, and load current will determine the minimum supply output voltage. The minimum supply voltage measured at the source should always be greater than 18 V. Example: two (source and return) 20 foot (6 m) lengths of 14 AWG (2 mm²) wire carrying 1.2 A (maximum rated current) will result in a voltage drop from source output to control power input of approx. 0.16 volts. The resulting supply voltage from the example must be greater than 18.16 volts.**

Input Power Wiring Diagram

The power supply and ground connections are located on the power supply board.
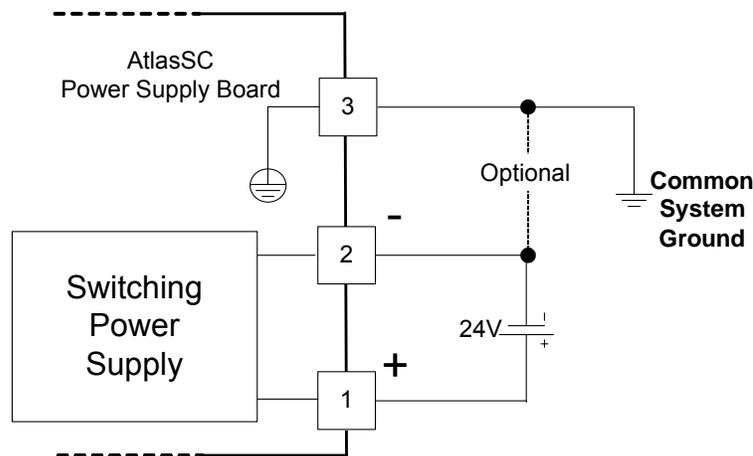
Figure 2-4. Input Power Wiring Diagram

Chapter 3.
Power Supply Board

General Description

The AtlasSC™ power supply contains the power supply and twelve discrete output driver channels. The discrete outputs are low-side drivers having short circuit and thermal shutdown protection. The discrete output drivers are not isolated from each other, and are powered by an external +12 Vdc or +24 Vdc. They are isolated from the internal power supplies of the AtlasSC Control platform.

Input power connections are made to the power supply through terminals on the upper edge of the power supply board.

> ⚠ **WARNING**
>
> **The AtlasSC power supply board must have the input power removed before installing or removing.**
>
> **This equipment is suitable for use in Class 1, Division 2, Groups A, B, C, and D, or non-hazardous locations only.**
>
> **Wiring must be in accordance with Class I, Division 2 wiring methods and in accordance with the authority having jurisdiction.**

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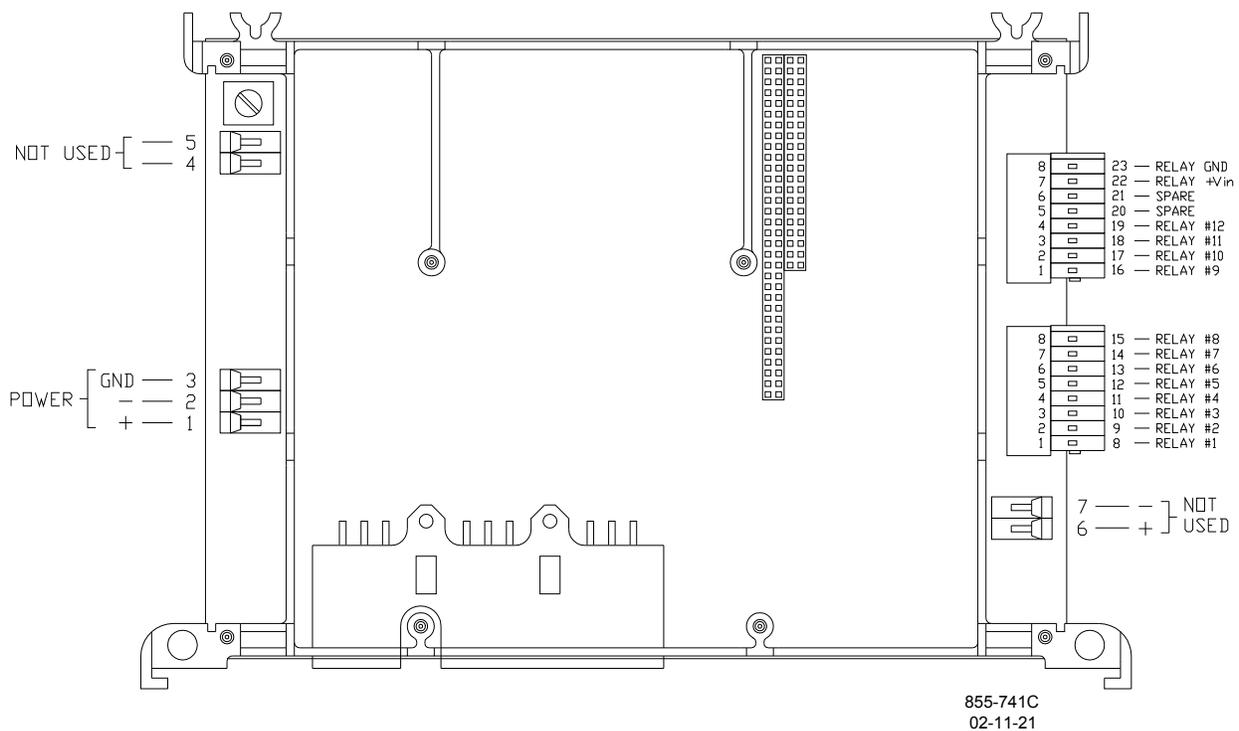
Figure 3-1. Power Supply Board (601-1008)

Specifications

Power Supply Input (Power Supply Board)

Range	18–32 Vdc
Input Current	1.5 A @ 24 Vdc
	1.9 A @ 18 Vdc
Input Power	less than 35 W at 70 °C
Interrupt Time Holdup	8 ms @ >/= 24 V
Efficiency	70% minimum over operating input voltage range
Reverse Polarity Protection	56 V
Input Wiring Constraints	The AtlasSC control platform shall be wired such that no other device receives power from the wiring between the AtlasSC Control Platform and the power supply source.

Discrete Output Drivers (Power Supply Board)

Number of channels	12
Type	Low-side driver with short circuit and overvoltage protection
Current drive rating	200 mA
Discrete Output Supply Voltage	9–32 V

Power Supply Monitoring Circuit (Power Supply Board)

LVdc Maximum voltage measured	35 Vdc
Resolution in volts	0.15 Vdc
Maximum Error due to temperature change	1.0 Vdc
Maximum Error due to load change	1.0 Vdc
Total maximum error at 25 °C (over 15 to 35 V range)	1.2 Vdc

Electric Shock

The AtlasSC control platform will not present an electrical shock hazard to the operator or maintenance personnel when used in a normal manner per the National Electrical Code Handbook, ANSI/NFPA 70 HANDBOOK-1990. Safety is ensured by certification through the safety agencies specified in the "Regulatory Compliance" section of this document.

Troubleshooting Guide

Power Supply Checks

The following is a troubleshooting guide for checking areas, which may present difficulties. If these checks are made prior to contacting Woodward for technical assistance, system problems can be more quickly and accurately assessed.

- Is the input voltage within the control's specified input voltage range (measured at control power supply input)?
- Is the input power free of switching noise or transient spikes?
- Is the power circuit dedicated to the AtlasSC control only?

Discrete Output Checks

The AtlasSC power supply contains twelve discrete output driver channels. The discrete outputs are low-side drivers having short circuit and thermal shutdown protection. The discrete output drivers are not isolated from each other, and are powered by an external +12 Vdc or +24 Vdc. They are isolated from the internal power supplies of the AtlasSC Control platform.

- Is the input power within the range of 9–32 V?
- Is the input free of switching noise or transient spikes?
- Is the power circuit dedicated to the control only?
- Are the individual discrete output lines current limited by external series connected components (example: relay coils) to <200 mA?
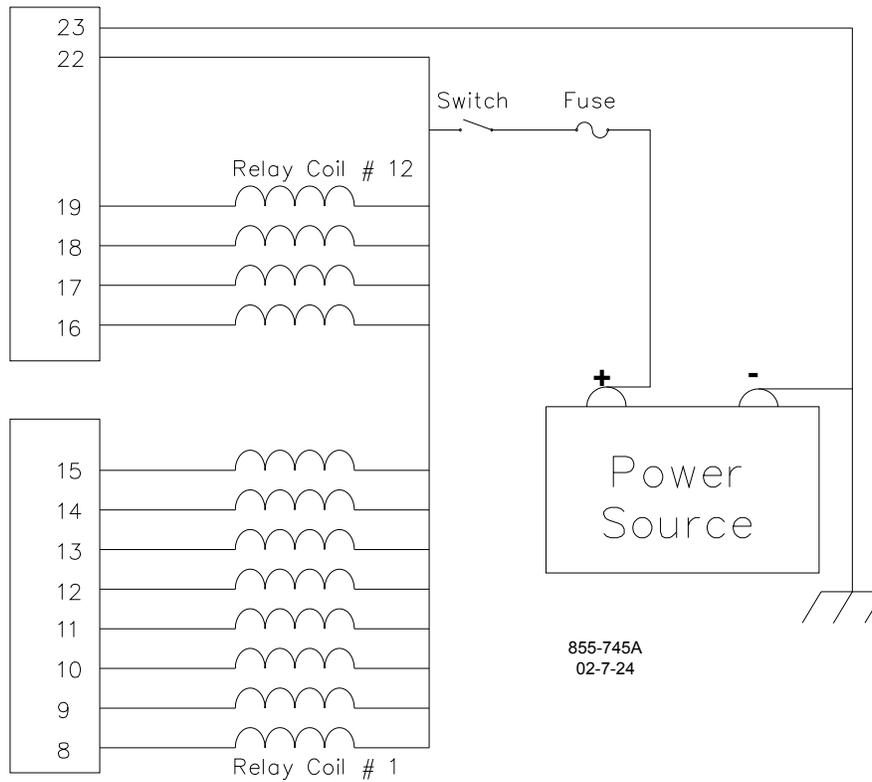
Figure 3-2. Discrete Output Wiring Example
(Discrete Output Interface Wiring to the Power Supply Board)

Configuration Notes
- Refer to Figure 3-2 for discrete output wiring.
- The discrete output commons are tied together, so each power supply board accepts only one voltage source.
- Power for the discrete outputs must be externally supplied, the external supply must be capable of supplying a voltage between 9–32 V while supplying up to 2.5 A. As specified in the Input Power Wiring Section, branch circuit protection of no more than 250% of the maximum rated current of the load (Discrete Output power input current plus 12 times the maximum Discrete Output channel current) shall be provided. Fuse current rating should not exceed 6.25 A (time delay fuses are recommended).
- Chapter 7 describes a relay module that can be used with these discrete outputs.

Chapter 4.
SmartCore Board with Actuators

General Description

This chapter covers SmartCore board part number 5503-293.

Each SmartCore board contains circuitry for two speed sensor inputs, six analog inputs, six analog outputs, 2 proportional actuator drivers, 3 serial ports, and 24 discrete inputs. Each speed sensor input may be from a magnetic pick-up or from a proximity probe, each Analog input may be 4–20 mA or 0–5 V, and two of the serial ports, may be RS-232, RS-422, or RS-485. The other serial port is a dedicated RS-232 port.

Features
- 5 ms update rate
- On-board processor for automatic calibration of the I/O channels
- Analog inputs have 14 bit resolution
- Analog outputs have 12 bit resolution

Physical
The AtlasSC boards connect to each other through either the PC/104 bus connectors, or the power bus connectors. All of the boards are held together and to the chassis, by screws. The Smart Core board is the size of two analog boards.

Specifications

Table 4-1. Digital Speed Sensor Inputs

Number of channels	2
	selectable as MPU or proximity probe, by terminal block wiring
Input frequency	100—24 950 Hz
Resolution	dependent on frequency, 13 bit minimum at maximum speed
Accuracy	less than ±0.08% full scale from –40 to +85 °C internal temperature

Table 4-2. MPU Inputs

Minimum input amplitude	See Figure 4-2
Input amplitude	70 V peak-to-peak
Input impedance	>1.5 kΩ
Isolation voltage	500 Vac minimum, each channel is isolated from all other channels and from the AtlasSC platform
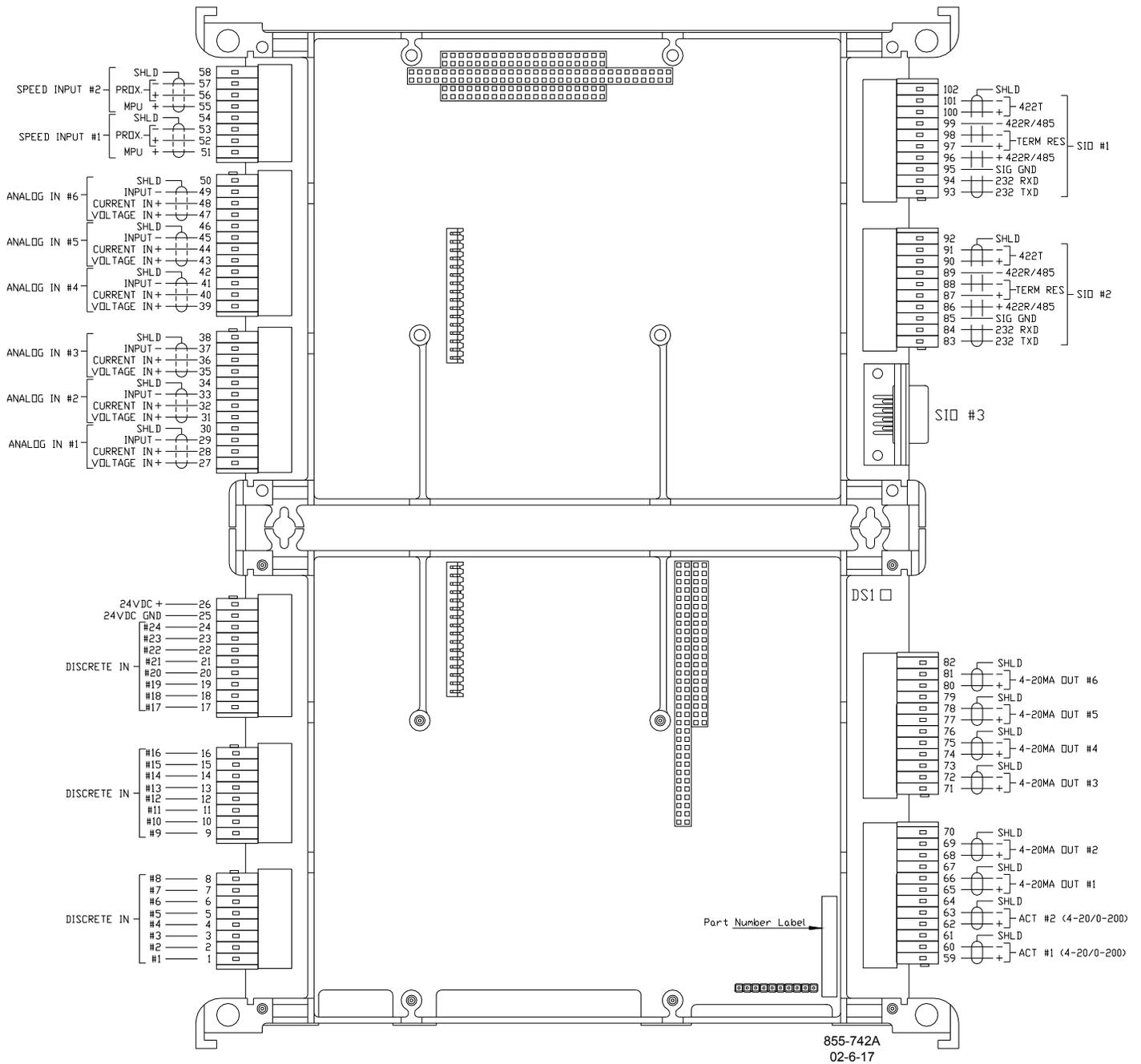
Figure 4-1. SmartCore Board with Actuators Connections

Table 4-3. Proximity Probe Inputs

Voltage threshold /duty cycle at 1 kHz	at 16 Vin, duty cycle = 10–80% at 24 Vin, duty cycle = 10–80% at 28 Vin, duty cycle = 10–80%
Voltage threshold /duty cycle at 3 kHz	at 16 Vin, duty cycle = 15–65% at 24 Vin, duty cycle = 10–60% at 28 Vin, duty cycle = 10–55%
Input voltage range	16–28 Vdc
Available power	none
Isolation	500 Vac minimum, each channel is isolated from all other channels and from the AtlasSC platform
Input frequency	0.5–3 kHz

- A derivative output is provided to the application software. The inherent noise on this output, due to resolution, increases with frequency. At 1000 Hz, it can be as much as 2.5 Hz/s. At 5000 Hz, it can be as much as 12.5 Hz/s. At 10 kHz, it can be as much as 25 Hz/s. At 20 kHz, it can be as much as 80 Hz/s. Typically, at 3600 Hz, noise on the MPU signal due to wiring runs will make the noise contribution due to resolution insignificant.
- No proximity probe power provided.
- If the proximity probe inputs are used, the corresponding MPU inputs must be jumpered.
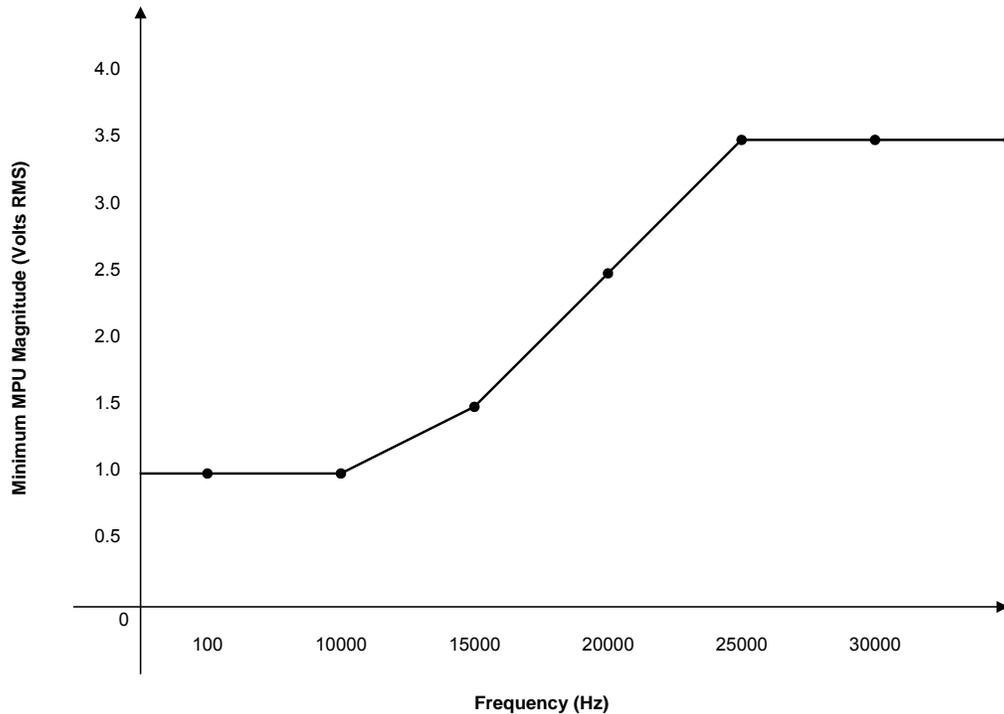
Figure 4-2. Minimum MPU Voltage Graph

Table 4-4. Analog Inputs

Number of channels	6
Input type	4–20 mA or 0–5 V
Max. input current	25 mA ±5% if configured for 4–20 mA
Max. input voltage	5.0 V ±5% if configured for 0–5 V
Common mode rejection	80 dB minimum
Input common mode range	±11 V minimum
Safe input common mode volt	±40 V minimum
Input impedance	200 Ω (±1%)
Anti-aliasing filter	2 poles at 10 ms
Resolution	14 bits
Accuracy @ 25 °C	less than ±0.1% of full scale, 0.025 mA
Temp Drift	171 ppm/°C, maximum (1.1% of full scale, 0.275 mA) 30 ppm/°C, typical (0.20% of full scale, 0.05 mA)
I/O Latency	2 channels at 1 ms, 2 channels at 3 ms, and 2 channels at 5 ms

- Loop power for the analog inputs is NOT available.
- 4–20 mA or 0–5 V is selected in the GAP block software, for each input, and selected by terminal block wiring. Both the GAP field, and the wiring must be changed.

IMPORTANT   **External loop powered transducers must be individually protected with a 100 mA fuse on each channel.**

Table 4-5. Analog Outputs

Number of channels	6
Output type	4–20 mA outputs, non-isolated
Common Mode Voltage	15 Vdc ±10%
Max current output	25 mA ±5%
Min. load resistance	0 Ω
Max load resistance	300 Ω at 22 mA
Resolution	12 bits
Accuracy @ 25 °C	less than ±0.1% of full scale, 0.025 mA
Temperature Drift	140 PPM/°C, 0.23 mA maximum 70 ppm/°C, typical (0.45% of full scale, 0.11375 mA)

Table 4-6. Actuator Outputs

Number of channels	2	
Actuator Type	Proportional, non-isolated	
Output Type	4-20 or 20-160 mA, software selectable	
Isolation	none	
Max current output	25mA ±5%	(4-20 mA output scale)
	200 mA ±5%	(20-160 mA output scale)
Min. load resistance	0 Ω	
Max load resistance	300 Ω at 22 mA	(4-20 mA output scale)
	45 Ω at 200 mA	(20-160 mA output scale)
Resolution	12 bits	
Accuracy @ 25 °C	less than ±0.1% of full scale,	
	0.026 mA	(4-20 mA output scale)
	0.2 mA	(20-160 mA output scale)
Readback Accuracy @ 25 °C	0.5%	
Temperature Drift	140 PPM/°C maximum,	
	0.24 mA maximum	(4-20 mA output scale)
	1.82 mA maximum	(20-160 mA output scale)
	70 ppm/°C typical	0.45% of full scale,
	0.12 mA	(4-20 mA output scale)
	0.91 mA	(20-160 mA output scale)
Readbacks	Actuator source and return currents	
Dither Current	25 Hz, fixed duty cycle, software variable amplitude	

Table 4-7. Discrete Inputs

Number of channels	24
Input type	Optically isolated discrete input
Input thresholds	< 8 Vdc = "OFF"
	> 16 Vdc = "ON"
Input current	3 mA @ 24 Vdc
Contact voltage	24 Vdc isolated
Max input voltage	28 Vdc
Isolation voltage	500 Vac, all channels are isolated from the AtlasSC platform

- For EMC compliance, the on-board, isolated, +24 Vdc supply is recommended for use as power to contacts, 100 mA maximum.
- All channels are common to each other. Isolation is with respect to the AtlasSC platform and other I/O types.

Table. 4-8. Serial I/O

Number of channels	3
Channel configuration	1 - RS-232, 9 pin sub D connector
	2 - RS-232/RS-485/RS-422 software configurable, terminal block connections
Termination Resistor	Located on the board and are accessible via field wiring. Termination resistors are provided for RS-485 and RS-422 Receive.
Isolation Voltage	500 Vdc

SmartCore Board Operation

This board includes no potentiometers and requires no field calibration. A SmartCore board may be replaced with another board of the same part number without any adjustment.

Speed Sensor Inputs

The MPU and proximity probe inputs are read and the speed is provided to the application program. A derivative output is also provided. The speed sensor inputs are filtered by the SmartCore board, and the filter time constant is selectable at 8 milliseconds or 16 milliseconds. Eight milliseconds should be acceptable for most turbine applications, while 16 milliseconds may be necessary for very slow speed applications. The speed range is selected in the application software and determines the maximum speed that the board will detect. The control output of the software will detect a minimum speed of one fiftieth of the speed range. This allows detection of failed speed sensors to help prevent overspeed due to slow update times at very low speeds. The monitor output of the GAP block will read down to 0.5 Hz, regardless of the speed range. An application may use any combination of accepted MPU and proximity probes, and any combination of speed ranges.

The SmartCore board uses speed sensing probes mounted on a gear connected or coupled to the turbine's rotor to sense turbine rotor speed. Any of the board's speed channels accept passive magnetic pickup units (MPUs) or proximity probes. It is not recommended that gears mounted on an auxiliary shaft coupled to the rotor be used to sense speed. Auxiliary shafts tend to turn more slowly than the rotor (reducing speed sensing resolution) and have coupling gear backlash, resulting in less than optimum speed control. For safety purposes, it is also not recommended that the speed sensing device sense speed from a gear coupled to a generator or mechanical drive side of a system's rotor coupling.
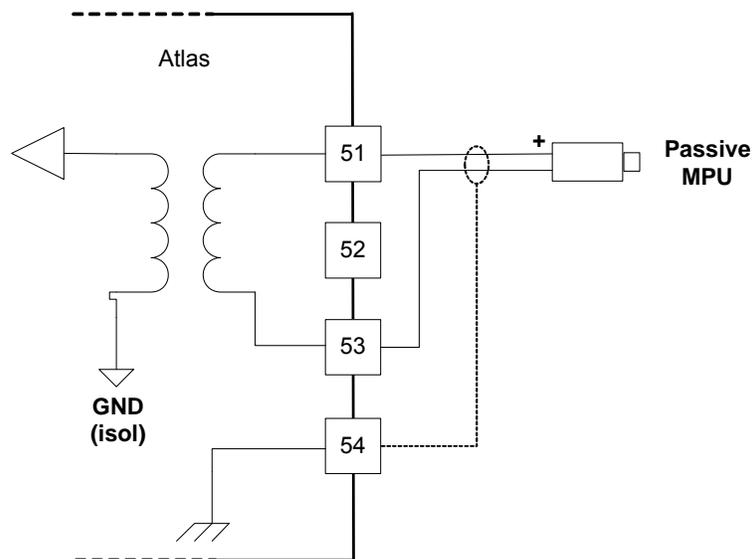
Figure 4-3. MPU Interface to the SmartCore Board
(wiring example)

A proximity probe may be used to sense very low speeds. With a proximity probe, speed can be sensed down to 0.5 Hz. When interfacing to open collector type proximity probes, a pull-up resistor is required between the supplied proximity probe voltage and the proximity probe input to the SmartCore board.
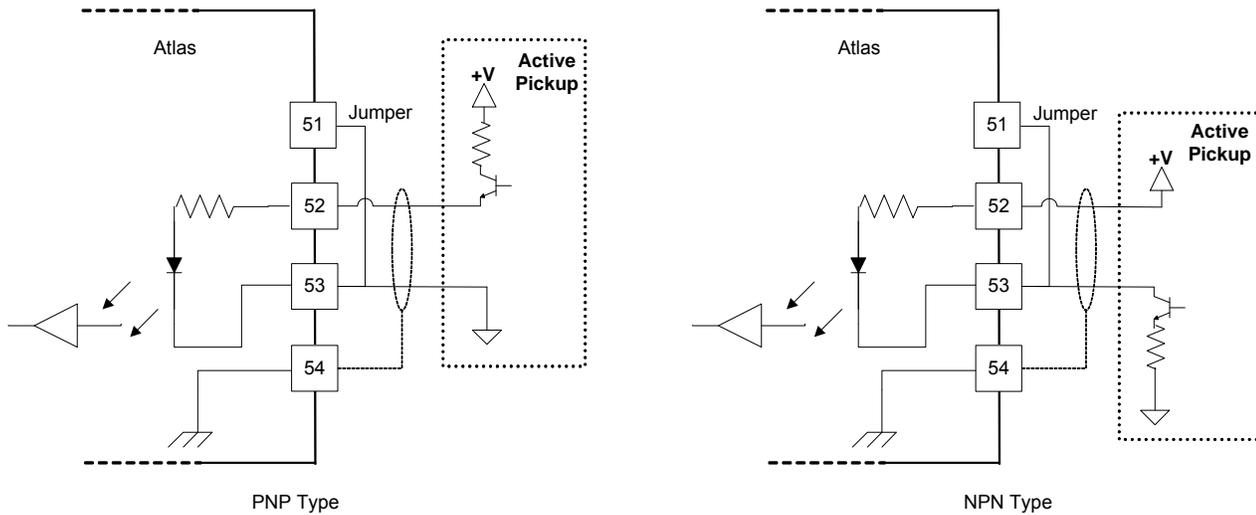
Figure 4-4. Proximity Probe to the SmartCore Board
(wiring example)

Configuration Notes
- Refer to Figures 4-3 and 4-4 for speed sensor wiring.
- Each speed input channel can only accept one MPU or one proximity probe.
- Proximity probe power is not provided.
- Proximity probes only—External pull-up resistors are required when interfacing to open collector type proximity probes.
- If the proximity probe inputs are used, the corresponding MPU inputs must be jumpered as shown.

Speed Sensor Input Software Configuration Limitations
- (TxMxR)/60 must be < 25 000 Hz
   T = gear teeth
   M = (overspeed test limit setting x 1.2)
   R = gear ratio

Analog Inputs
The analog inputs may be current or voltage type. If a current input is used, a jumper is installed on the terminal block, and the software must be selected for current. This allows the SmartCore card to use the applicable hardware calibration values. If a voltage input is needed, the jumper must be removed, and the software must be selected for voltage.

All Analog inputs may be used with two-wire ungrounded (*loop powered) transducers or isolated (self-powered) transducers. All Analog inputs have 10 Vdc of common mode rejection. If interfacing to a non-isolated device, which may have the potential of reaching over 10 Vdc with respect to the control's common, the use of a loop isolator is recommended to break any return current paths, which could produce erroneous readings.

For a 4–20 mA input signal, the SmartCore board uses a 200 Ω resistor across the input.
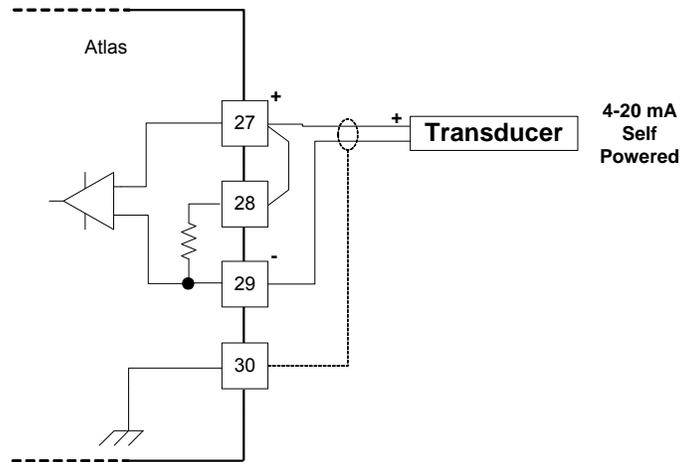
Figure 4-5a. 4–20 mA Input Interface to the SmartCore Board
(wiring example)
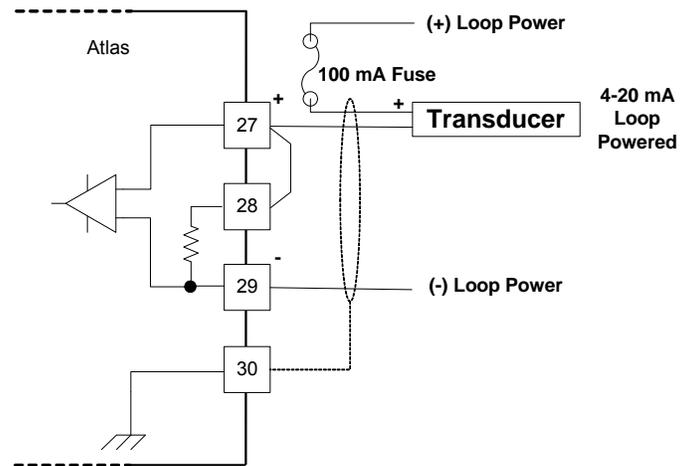
Figure 4-5b. 4–20 mA Input Interface using External Loop Power
(wiring example)
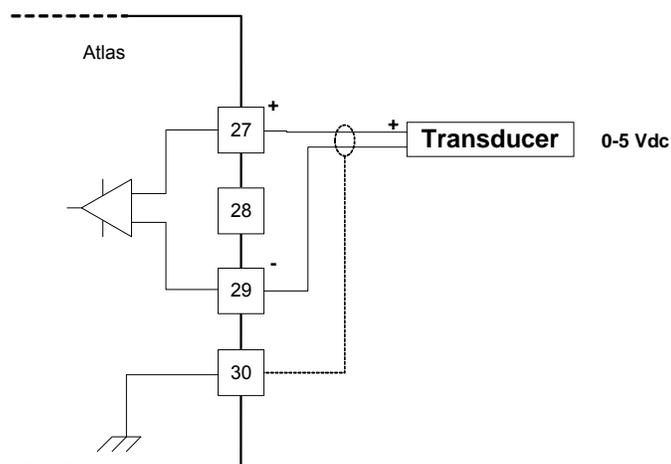
Figure 4-6. 0–5 V Input Interface to the SmartCore Board
(wiring example)

Configuration Notes
- Refer to Figures 4-5 and 4-6 for analog input wiring.
- All 4-20 mA inputs have an input impedance of 200 Ω.
- When a 4-20 mA input is used, a terminal block jumper must be installed, per Figure 4-5.
- The application software must be configured for a 4–20 mA type input, or a 0–5 V type input.
- Loop power is NOT provided by the Atlas control, it must be sourced externally.

IMPORTANT	**External loop powered transducers must be individually protected with a 100 mA fuse on each channel.**

Analog Outputs

The analog outputs are 4–20 mA with a full scale range of 0–24 mA. The SmartCore board has four analog outputs.
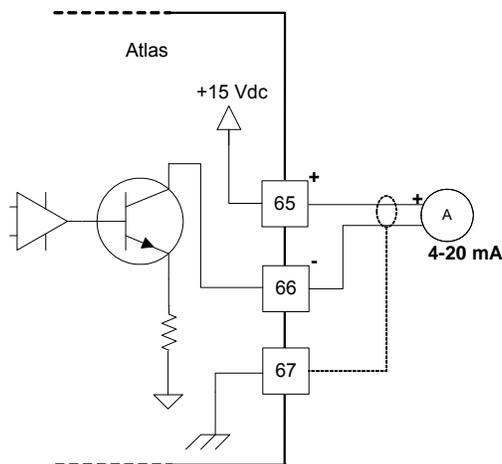
Figure 4-7. Analog Output Interface to the SmartCore Board
(wiring example)

Configuration Notes
- Refer to Figure 4-7 for analog output wiring.
- Only 4–20 mA signals are output.
- See the specifications section for the maximum analog output load.
- Care should be taken to prevent ground loops and other faults when interfacing to non-isolated devices.
- The output does not contain fault detection. If it is necessary to detect failures, then the device that is driven by the Analog output, for example an actuator driver, must contain reference failure detection.
- The analog outputs have a 15 V common mode voltage, with respect to AtlasSC control common.

NOTICE	Avoid misconnection of the Analog Output (+) to the Actuator Output (–). This will damage internal components, making the control inoperable.

Actuator Outputs

The proportional actuator driver outputs are 4–20 mA or 20-160 mA with a full scale range of 0–24 mA or 0-200 mA. The SmartCore board has two proportional actuator driver outputs, each output with source and return current readbacks.
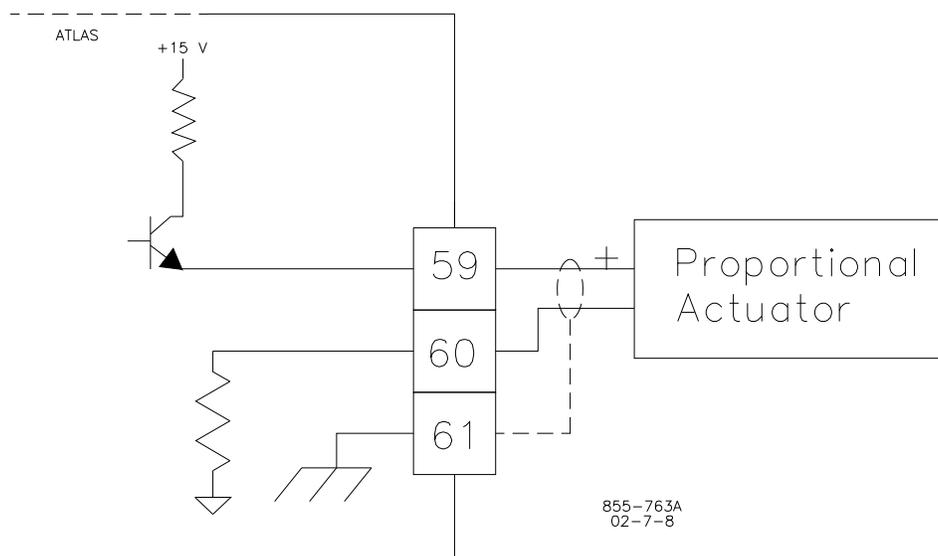
Figure 4-8. Actuator Output Interface to the SmartCore Board
(wiring example)

Configuration Notes
- Refer to Figure 4-8 for actuator output wiring.
- 4–20 mA or 20-160 mA signals are output.
- See the specifications section for the maximum actuator output load.
- Care should be taken to prevent ground loops and other faults when interfacing to non-isolated devices.
- Application software selects the actuator type, the output range, and the dither amount.
- The readbacks can be used in the application software for fault detection.

NOTICE	Avoid misconnection of the Analog Output (+) to the Actuator Output (–). This will damage internal components, making the control inoperable.

Discrete Inputs

The SmartCore board accepts 24 discrete inputs. Contact wetting voltage may be supplied by the SmartCore card. Optionally, an external 18–28 Vdc power source can be used to source the circuit wetting voltage.
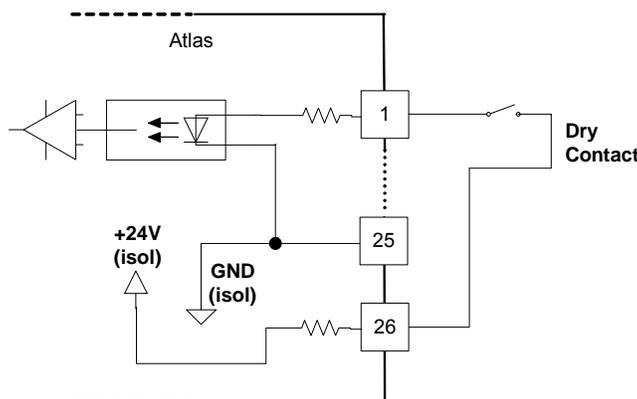
Figure 4-9. Discrete Input Interface to the SmartCore Board
(wiring example)

Configuration Notes
- Refer to Figure 4-9 for discrete input wiring.
- The discrete input commons are tied together, so each SmartCore board accepts only one voltage source, which can be internally or externally supplied.
- All contact inputs accept dry contacts.
- If an external power supply is used, it must be rated to 28 Vdc max from Class 2 type source for North America (SELV type source for applications outside North America). Power supply outputs must be fused with appropriately sized fuses (a maximum, current rating of 100 ÷ V, where V is the supply's rated voltage, or 5 A, whichever is less).
- The 24 V isolated contact power is protected by a 0.2 A poly switch. This may not prevent interruption in control operation due to a short in the field wiring, but should protect the control from damage. The poly switch will reset itself when the short condition is resolved.

Serial (Modbus) Port Protocols

There are three serial communication ports on the AtlasSC platform that may be used for the Modbus interface. Modbus can use RS-232, RS-422, and RS-485 configurations. Shielded cables and Serial Port Isolator/Converter(s) are required when using these ports. The first two ports on the SmartCore board may be configured for RS-232, RS-422, or RS-485, and the last port is configurable for RS-232 only.

RS-232—An ANSI (American National Standards Institute) standard definition of electrical, functional and mechanical connections for communications between DTE (Data Terminal Equipment) and DCE (Data Communications Equipment) such as connection of a computer to a modem. It has gained wide usage in short-distance applications (15 m/50 ft). In practice, the standard is largely ignored beyond the most rudimentary implementation of electrical signals (±3 to ±15 volts). Woodward's implementation will support speeds up to 115K baud in Atlas systems. The actual specification allows 19.2K baud at up to 15 m (50 ft).

RS-422—Also an ANSI standard definition of electrical connections for communications between devices. Because it uses balanced drivers, it can communicate over long distances (1200 m/4000 ft) at high baud rates (115K). Woodward's implementation of RS-422 is actually a 4-wire RS-485 communications network. Since Woodward convention has been to call this
RS-422, this manual will follow that convention. However, it may be important to understand that the actual port is RS-485. The port supports up to 32 devices as a full duplex, multi-drop communications network. This allows more than one device to be connected to the common bus with a single master requesting data. It requires two twisted pairs and ground to operate.

RS-485—Also an ANSI standard definition of electrical connections for communications between devices. Because it uses balanced drivers it can communicate over long distances (1200 m/4000 ft) at high baud rates (115K). This protocol is implemented identically to "RS-422" with the exception that only one twisted pair is required. Both transmitted and received data use the same pair of wires. A ground wire is still required since the output is isolated. The port supports up to 32 devices as a half duplex, multi-drop communications network. This allows more than one device to be connected to the common bus with a single master requesting data. It requires one twisted pair and ground to operate.

Interface Cables and Connectors

When choosing a cable for RS-485, it is necessary to examine the required distance of the cable and the data rate of the system. Beyond the obvious traits such as number of conductors and wire gauge, cable specifications include a handful of less intuitive terms.

Characteristic Impedance (ohms)—A value based on the inherent conductance, resistance, capacitance, and inductance of a cable that represents the impedance of an infinitely long cable. When the cable is cut to any length and terminated with this Characteristic Impedance, measurements of the cable will be identical to values obtained from the infinite length cable. Therefore, termination of the cable with this impedance gives the cable the appearance of being infinite length, allowing no reflections of the transmitted signal. When termination is required in a system, the termination impedance value should match the Characteristic Impedance of the cable.

Shunt Capacitance (pF/ft)—The amount of equivalent capacitive load of the cable, typically listed in a per foot basis (1 pF/ft = 3.28 pF/m). One of the factors limiting total cable length is the capacitive load. Systems with long lengths benefit from using low capacitance cable.

Propagation velocity (% of c)—The speed at which an electrical signal travels in the cable. The value given typically must be multiplied by the speed of light (c, $3x10^8$ m/s) to obtain units of meters per second. For example, a cable that lists a propagation velocity of 67% gives a velocity of 0.67 x $3x10^8$ = $2.01x10^8$ m/s. The higher the percentage, the smaller the signal delay.

General recommendations for serial cable are listed in the following table.

Table 4-9. Serial Cable Requirements

Impedance:	100 Ω ±20%
Cable capacitance:	52.5 pF/m (15.0 pF/ft) at 1 kHz
Propagation Velocity:	67.0%
Data Pairs;	0.2 mm² (24 AWG) solid bare copper
Signal attenuation:	6.0 dB maximum

Recommended Bulk Cable

For simplicity, Woodward will recommend cables consistent with long cable lengths and high baud rates. Longer cable lengths may be possible at lower baud rates with the best cables but are not supported by the ANSI standards for
RS-485. The same cables may be used for RS-232 applications, but length will be limited to 15 m (50 ft).

Ethernet Category 5 cable is a very good cable selection for RS-485 networks. It will support cables lengths to 1200 m (4000 ft) at baud rates up to 115,200. Since Ethernet cable is easy to find and is inexpensive, it will often be the cable of choice. Always use shielded cable.

Installations with high electrical interference (noise) and/or long cable lengths together with high baud rates may benefit from larger gauge cable.

Network Construction

While there are a number of different ways to physically connect devices on a network, Woodward recommends that multi-drop networks be constructed using a "daisy chain" configuration or a "backbone with stubs" for best performance. In a daisy chain, wires are run from device one to device two to device three, etc. In a backbone with stubs, a main trunk line is run between the two devices that are physically farthest apart, and then stub lines are run from the intermediate devices to the trunk line. Stubs should be kept as short as possible. See Figure
4-13 for a graphical representation.

Termination

To achieve best performance with RS-485 serial communication networks, it is necessary to terminate the network to prevent interference caused by signal reflections. RS-232 networks are short enough that termination is not required. For ease of setup, Woodward has provided built-in network termination resistors on the SmartCore board for the RS-485 serial ports. To activate the termination resistors, an external jumper must be placed at the connector. See Figures 4-15 and 4-18 for jumper location. The resistor network used is a special design intended to provide maximum noise immunity. The same design should be used at the opposite end of the network. See the circuit diagram (Figure 4-12). This termination network is necessary due to limitations of the Modbus protocol.

Termination resistors must be installed only on the two units that are at the physical ends of the network. Terminating other midpoint units can overload the network and put it into a cyclic thermal shutdown mode. As a rule, no matter how many units are on a network, there should never be more than two terminations installed. For 2-wire networks, a termination network should be used at the two physical ends of the network. For 4-wire networks, Woodward has elected to use a termination network only across the receiver lines at either end of the network. This is feasible due to the baud rate limit of 115K. In either case (2- or 4-wire configurations), a total of two termination networks are used.

Shielding

Shielded cable is required between the AtlasSC control and any other devices. Unshielded cables and improperly shielded cables are likely to cause communication problems and unreliable control operation. The shield must always be ac-coupled (connected through a capacitor) at one end and connected directly to earth on the opposite end for proper operation. The SmartCore board has been constructed so that the serial port Shield connections are directly connected to the Atlas chassis ground (which must be tied directly to earth). Devices connected to the opposite end of the cable must provide for the ac-coupled shield connection.

Woodward has found that a 0.01 µF capacitance is typically adequate for this purpose. A minimum rating of 1000 Vdc on the capacitor is required.

Serial I/O Ports

There are three serial ports on the AtlasSC control. They may all be used simultaneously and may all be configured independently. Performance of any one port will depend on how many ports are in use and the port traffic. Ports 1 and 2 may be configured as RS-232, RS-422, or RS-485 to match the intended application. All ports are optically isolated from each other.

Any port configured as RS-232 will meet the RS-232C standard for communications. The wiring shall meet the requirements of EIA RS-232. This standard states a maximum cable length of 15 meters (50 feet) with a total capacitance less than 2500 pF and a data rate not exceeding 56 kbps. All AtlasSC serial ports may be configured for data rates up to 115 200 bps but may not function properly at this high data rate when a full 15 meters of cable length is used. Do not leave an RS-232 null modem cable attached to the AtlasSC control if it is removed from the PC, to avoid the possibility of EMC noise being introduced to the control.

Any port configured as RS-422 or RS-485 meets the ANSI standards for this type of communications. The wiring shall be one continuous cable between nodes and shall meet the requirements of EIA RS-422

or EIA RS-485 for 500 kbps. However, one half of the cable length limits is recommended due to harsh environments typical of prime mover installations as follows:

Table 4-10. Cable Length Limits

Cable	Length	Example
Standard shielded twisted pair cable	30 m (100 ft)	
24 AWG, low-capacitance cable	75 m (250 ft)	Belden 9841
22 AWG, low-capacitance cable	120 m (400 ft)	Belden 3105A
20 AWG, low-capacitance cable	150 m (500 ft)	Belden 89207
Fiber optic cable with optical repeaters	> 150 m (500 ft)	
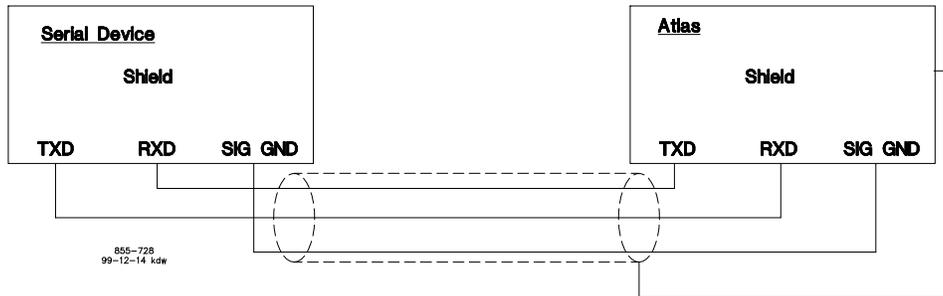
Figure 4-10. RS-232 Interface to the SmartCore Board
(wiring example)
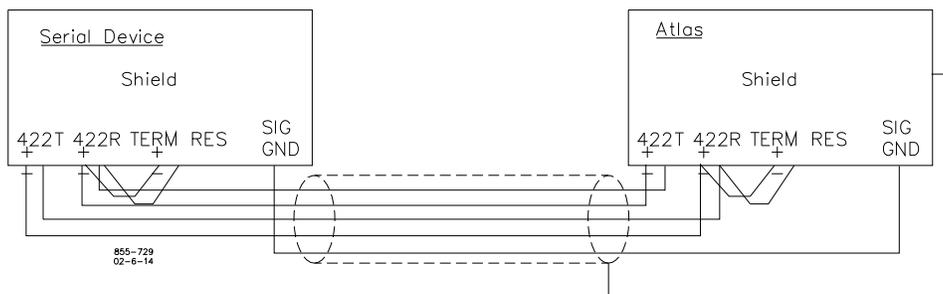
Figure 4-11. RS-422 Interface to the SmartCore Board
(wiring example)
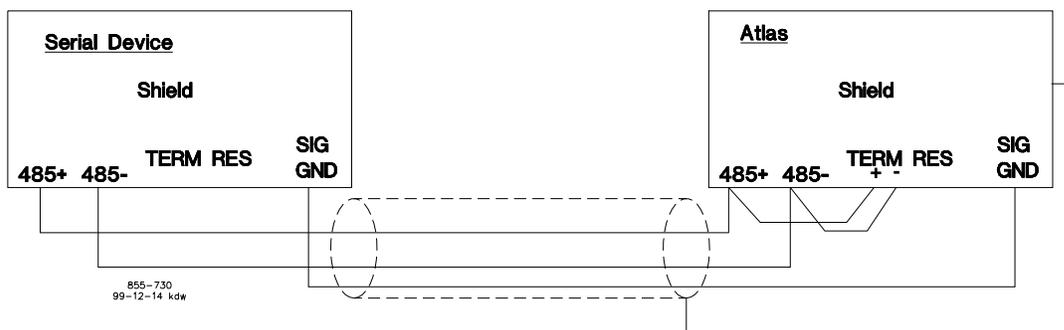
Figure 4-12. RS-485 Interface to the SmartCore Board
(wiring example)
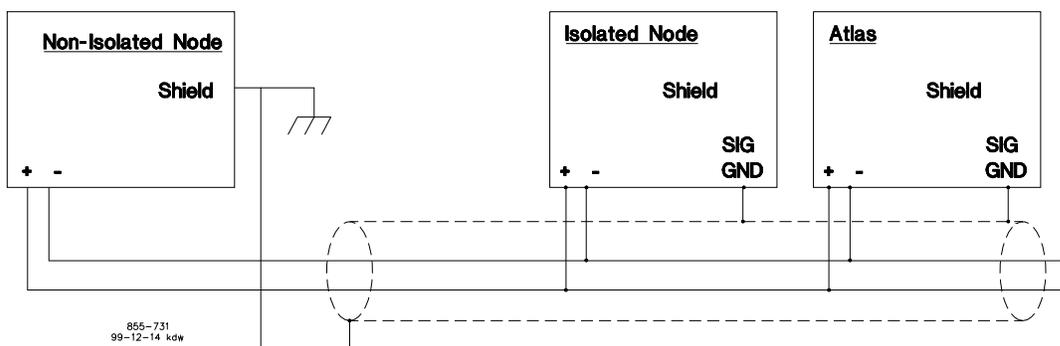
Figure 4-13. Alternate Multipoint Wiring
(wiring example without a separate signal ground wire for the SmartCore board)

Configuration Notes

- Refer to Figure 4-10 for RS-232 wiring. The transmit data (TXD), receive data (RXD), and signal ground (SIG GND) must be properly connected as shown. In addition the shield (SHLD) should be connected in at least one location.
- Refer to Figure 4-11 for RS-422 wiring. The transmit data pairs (422T+ and 422T-), receive data pairs (422R+ and 422R-), and signal ground (SIG GND) must be properly connected as shown. In addition, the shield (SHLD) should be connected in at least one location. The last unit in the network chain, and only the last unit, should have it's receiver terminated with a resistor. The AtlasSC has resistors built in (TERM RES) for this purpose. The unit at each end of the network should be terminated.
- Refer to Figure 4-12 for RS-485 wiring. The data lines (485+ and 485–) and signal ground (SIG GND) must be properly connected as shown. In addition, the shield (SHLD) should be connected in at least one location. The last unit in the chain, and only the last unit, should be terminated with a resistor. The AtlasSC has resistors built in (TERM RES) for this purpose. The unit at each end of the network should be terminated.
- The serial ports must be properly configured in the application software for the appropriate communication parameters.
- Termination resistors are available on the SmartCore board and should be wired across the network at the ends of the line.
- The serial ports are individually isolated from each other, and from the rest of the AtlasSC control. The RS-422 and RS-485 specifications state that a ground wire is needed if there is no other ground path between units. The preferred method for isolated ports is to include a separate wire in the ground cable that connects the circuit grounds together.
- Non-isolated nodes may not have a signal ground available. If signal ground is not available, use the alternate wiring scheme of connecting all circuit grounds of isolated nodes to the shield, and connecting the shield to earth ground at a non-isolated node.

Configurable Port (Com 1)

This port may be configured to use the MODBUS RTU protocol or Woodward's ServLink protocol.

The port configuration is defined in the GAP program and sets configuration for kbps, parity, data, and stop bits.

Wiring Diagram—RS-422 (Com 1)

Serial #1 - RS-422
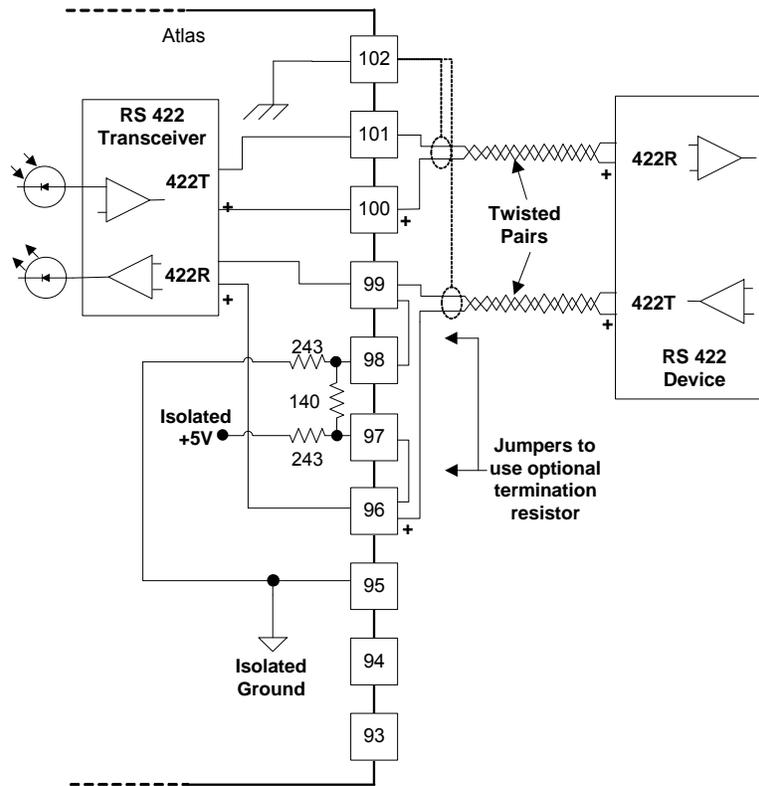
Figure 4-14. RS-422 Wiring Diagram (Com 1)

Wiring Diagram—RS-485 (Com 1)

Serial #1 - RS-485
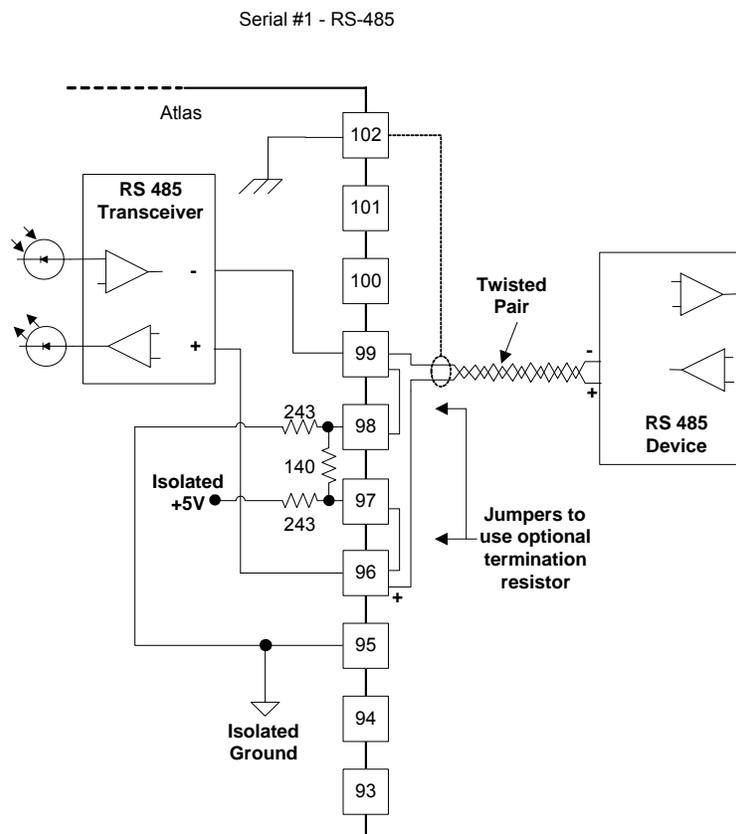
Figure 4-15. RS-485 Wiring Diagram (Com 1)

Wiring Diagram—RS-232 (Com 1)
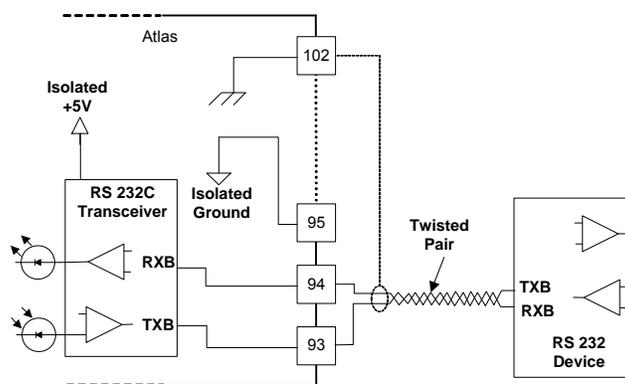
Figure 4-16. RS-232 Wiring Diagram (Com 1)

Modbus Port (Com 2)

This port may only be used as a MODBUS RTU port.

The port may be configured for RS-232, RS-422, or RS-485 by using the correct wiring connections and selecting the correct configuration mode. The port configuration is defined in the GAP program and sets configuration for kbps, parity, data, and stop bits.

Wiring Diagram—RS-422 (Com 2)
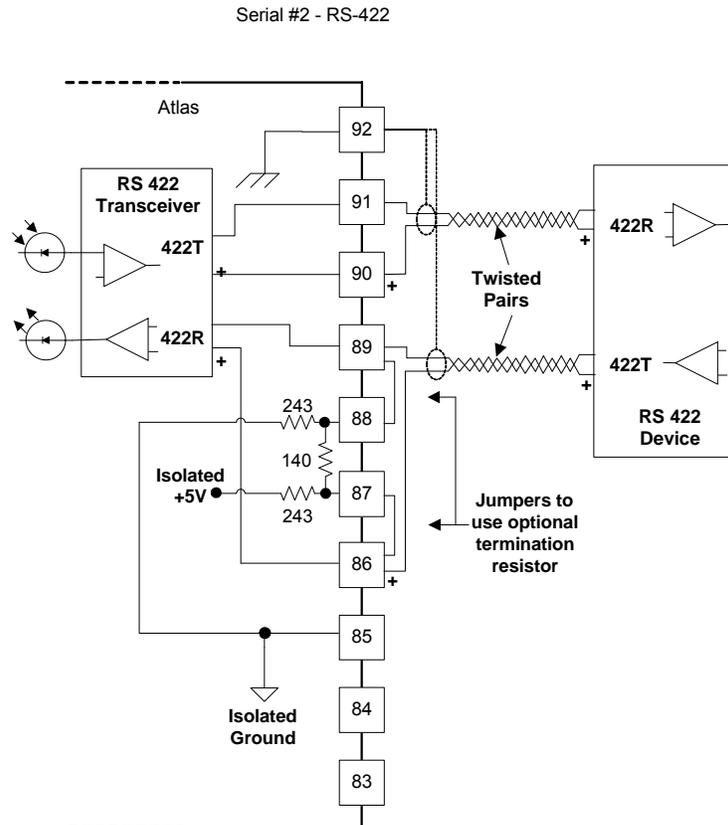
Figure 4-17. RS-422 Wiring Diagram (Com 2)

Wiring Diagram—RS-485 (Com 2)

Serial #2 - RS-485
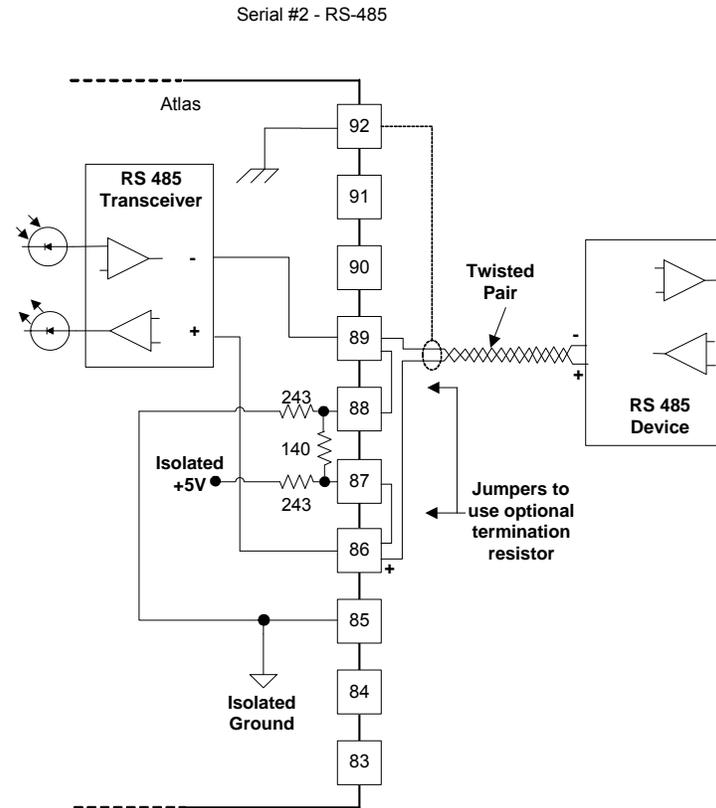
Figure 4-18. RS-485 Wiring Diagram (Com 2)

Wiring Diagram—RS-232 (Com 2)
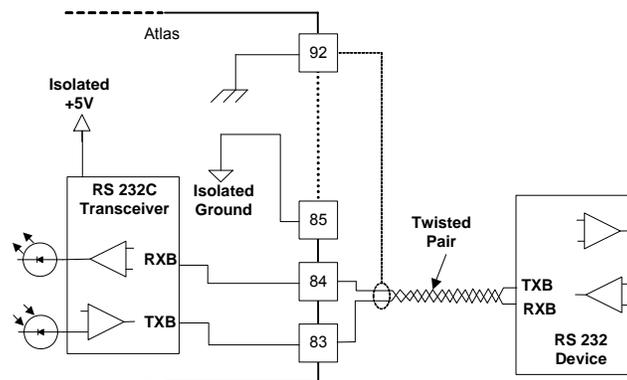
Figure 4-19. RS-232 Wiring Diagram (Com 2)

RS-232 Configuration Port (Com 3)

Since this port is the only one that can be used to download application code, we recommend that this port be used only as a Woodward ServLink port. Its primary purpose is for configuration using a PC with Woodward's Watch Window. However, it may also be connected to a PC based HMI for local configuration and monitoring.

The port is fixed as an RS-232 port only. The RS-232 port configuration is set in the GAP program. A Null Modem cable must be used to connect to this port. The AtlasSC has a standard DB-9 Female receptacle. It is best to use a metal shell connector at both ends with the shell connected to the cable shield but isolated from the ground signal wire. The shell of the 9-pin D-sub on the AtlasSC is chassis grounded.

Wiring Diagram—RS-232 (Com 3)
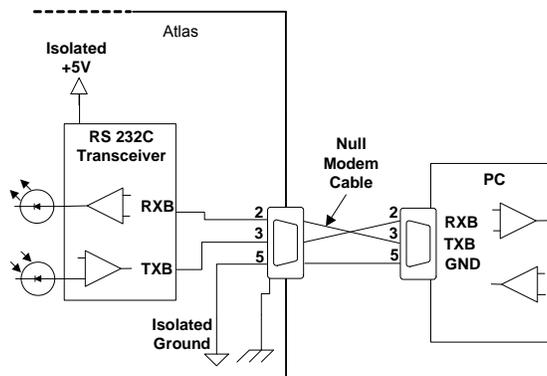
Figure 4-20. RS-232 Wiring Diagram (Com 3)

Fault Detection (Board Hardware)

Each SmartCore board has a red fault LED that is turned on when the system is reset. During initialization of a board, which occurs after every CPU reset, the CPU turns the Fault LED on. The CPU then tests the board using diagnostic routines built into the software. If the diagnostic test is not passed, the LED remains on or blinks. If the test is successful, the LED goes off. If the fault LED on a board is illuminated after the diagnostics and initialization have been completed, the SmartCore board may be faulty or may have the address DIP switches configured incorrectly. The DIP switch setting must match the module address set in the GAP application program. The DIP switch is factory set and should not be changed.

Table 4-11. SmartCore Failure Codes

Number of LED Flashes	Failure
1	CPU Failure (Clock Fail, Invalid Reset, Halt, etc.)
2	Unexpected CPU Exception (Bus Error, Address Error, Trap, etc.)
3	RAM Error
4	Watchdog Timeout
5	EEPROM Error
6	FLASH Memory Error
7	Operating System Error
8	Stack Memory Overflow
9	Application Checksum Error
10	Communication Error (68302 Fail)
11	Real Time Clock Error
12	Rate Group Slip Error
13-15	Unused
16	Data Log Error
17	NV Log Error
18	Math Exception

Fault Detection (I/O)

In addition to detecting board hardware faults, the application program may detect I/O faults.

- Analog Input Faults—The application software may set a high and low latch set point to detect input faults.
- Speed Sensor Input Faults—The application software may set a high and low latch set point to detect input faults.
- Serial Port Faults—The system monitors the serial communications on the three serial ports, for various communication errors.
- Microcontroller Faults—The system monitors a software watchdog, a hardware watchdog, and a software watchdog on the PC/104 bus communications. All outputs are shutdown in the event of a microcontroller fault.

Troubleshooting Guide

Speed Sensor Inputs

MPUs—If a magnetic pickup input is not functioning properly, verify the following:

- Check that the cable is shielded and the shield is properly grounded per the shields and grounding section in Chapter 2.
- Measure the input voltage on the terminal block. It should be greater than 1 Vrms.
- Verify that the signal waveform is clean and void of double zero crossings.
- Verify that no ground connection exists and that the resulting 60 Hz signal is absent.
- Measure the frequency. Frequency should be in the range of 100 Hz to 25 kHz.
- Check the wiring. Look for a loose connection at the terminal blocks and disconnected or misconnected cables.
- Check the software configuration to ensure that the input is configured properly.

After verifying all of the above, the AtlasSC should be returned for service.

Proximity Probes—If a proximity probe input is not functioning properly, verify the following:

- Check that the cable is shielded and the shield is properly grounded per the shields and grounding section in Chapter 2.
- Measure the input voltage on the terminal block. It should be in the range of 16–28 V peak, and the duty cycle should be within the specified range for the input voltage.
- Verify that the signal waveform is clean and void of double zero crossings.
- Verify that no ground connection exists and that the resulting 60 Hz signal is absent.
- Measure the frequency. Frequency should be in the range of 0.5 Hz to 3 kHz.
- Check the wiring. Look for a loose connection at the terminal blocks and disconnected or misconnected cables. If an open collector probe is used, check to ensure that the pull-up resistor is installed properly.
- Check the software configuration to ensure that the input is configured properly.
- Verify that the corresponding MPU input is jumpered.

After verifying all of the above, the AtlasSC should be returned for service.

Analog Inputs

If an Analog input is not functioning properly, verify the following:

- Check that the cable is shielded and the shield is properly grounded per the shields and grounding section in Chapter 2.
- Measure the input voltage on the terminal block. It should be in the range of 0–5 V.
- Verify that there are no or minimal ac components to the analog input signal. AC components can be caused by improper shielding.
- Check the wiring. If the inputs are reading 0 or the engineering units that correspond to 0 mA, look for a loose connection at the terminal blocks and disconnected or misconnected cables. If the unit is a 4–20 mA input, check for proper jumper installation on the terminal block.
- If all of the inputs are reading high, check that the power is not connected across the input directly.
- Check the software configuration to ensure that the input is configured properly.

- If the input is loop powered, ensure that power is provided externally, the Atlas control does not provide this power.

After verifying all of the above, the AtlasSC should be returned for service.

Analog Outputs
If an Analog output is not functioning properly, verify the following:
- Check that the cable is shielded and the shield is properly grounded per the shields and grounding section in Chapter 2.
- Check the load resistance, ensure that it is less than the specification limit for the output current.
- Check to ensure that the load wiring is isolated.
- Check the wiring, look for a loose connection at the terminal blocks and disconnected or misconnected cables.
- Disconnect the field wiring and connect a resistor across the output. If the output is correct across the resistor, there is a problem with the field wiring.
- Check the software configuration to ensure that the output is configured properly.

After verifying all of the above, the AtlasSC should be returned for service.

Proportional Actuator Outputs
If an Actuator output is not functioning properly, verify the following:
- Check that the cable is shielded and the shield is properly grounded per the shields and grounding section in Chapter 2.
- Check the load resistance, ensure that it is less than the specification limit for the output current.
- Check to ensure that the load wiring is isolated.
- Check the wiring, look for a loose connection at the terminal blocks and disconnected or misconnected cables.
- Disconnect the field wiring and connect a resistor across the output. If the output is correct across the resistor, there is a problem with the field wiring.
- Check the software configuration to ensure that the output is configured properly.

After verifying all of the above, the AtlasSC should be returned for service.

Discrete Inputs
If a discrete input is not functioning properly, verify the following:
- Measure the input voltage on the terminal block. It should be in the range of 18–28 Vdc.
- Check the wiring, look for a loose connection at the terminal blocks and disconnected or misconnected cables.
- Check the software configuration to ensure that the input is configured properly.

After verifying all of the above, the AtlasSC should be returned for service.

Serial I/O
If a serial port is not functioning properly, verify the following:
- Check the wiring, look for a loose connection at the terminal blocks and disconnected or misconnected cables.
- Check to be sure that termination resistors are properly installed where needed on the network.
- Check the software configuration to ensure that the input is configured properly.
- Check that the cable is shielded and the shield is properly grounded per the shields and grounding section in Chapter 2.

After verifying all of the above, the AtlasSC should be returned for service.

Chapter 5.
Analog Combo Board

General Description

Each Analog Combo board contains circuitry for two speed sensor inputs, fifteen analog inputs, one cold junction, and two Analog outputs. The first eleven analog inputs may be 4–20 mA inputs or thermocouple inputs, and the remaining four analog inputs may be 4–20 mA inputs or RTD inputs.

Features
- 5 ms update rate
- On-board processor for automatic calibration of the I/O channels
- Analog inputs have 15 bit resolution
- Analog outputs have 12 bit resolution
- First 11 analog inputs are software configurable 4–20 mA or thermocouple (in pairs)
- Last 4 analog inputs are software configurable 4–20 mA or RTD (individually)
- First 11 analog inputs are isolated as a group, from the other inputs, and from control common
- Last 4 analog inputs are isolated as a group, from the other inputs, and from control common
- A cold junction measurement is provided on the board
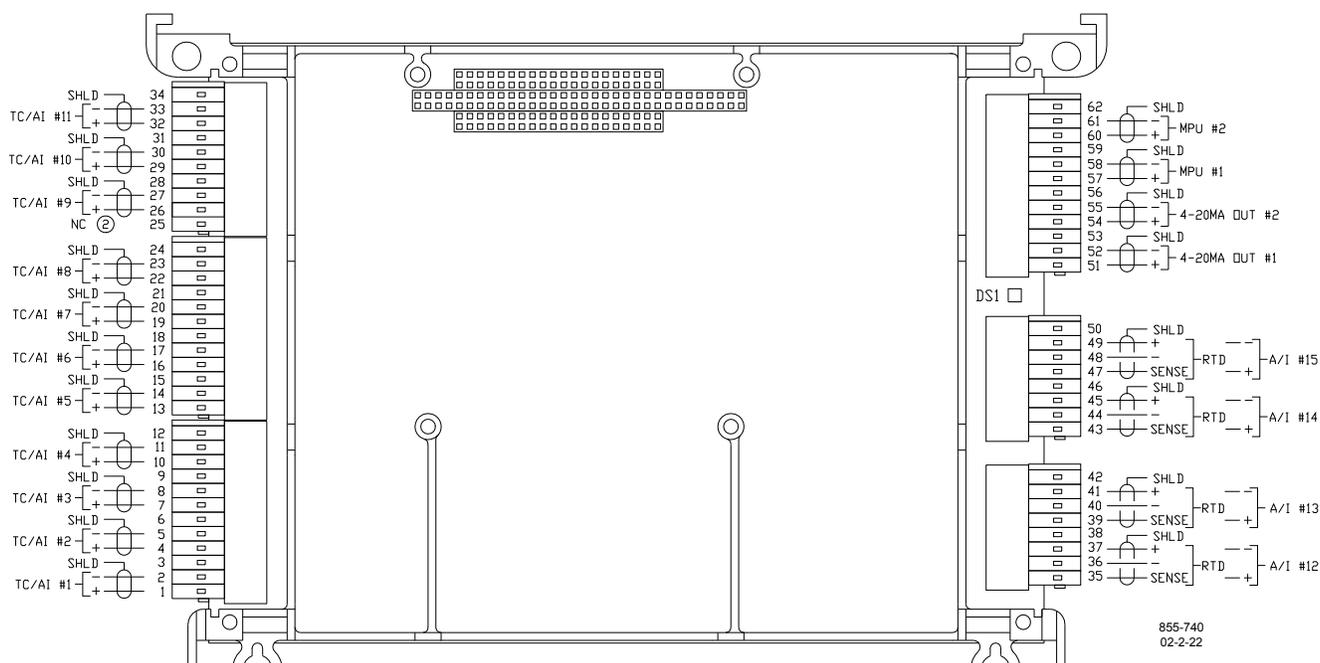
Figure 5-1. Analog Combo Board Connections

Physical
The AtlasSC Analog Combo board connects to the CPU board through the PC/104 bus. It does not connect to the AtlasSC power bus directly, it requires a SmartCore board for this purpose.

Specifications

Table 5-1. Thermocouple/4–20 mA Analog Inputs

Number of channels	11
Input type	4–20 mA, type J or type K, thermocouple (required)
Max. input current	24 mA if configured for 4–20 mA
Max. input voltage	±72.8 mV for thermocouples inputs
Thermocouple Range	Type E:–9.83 mV (–267.68 °C/–449.82 °F) to 72.8 mV (952.60 °C/1746.68 °F) Type J:–8.09 mV (–209.72 °C/–345.50 °F) to 69.55 mV (1199.94 °C/2191.89 °F) Type K:–6.45 mV (–263.95 °C/–443.11 °F) to 54.88 mV (1371.81 °C/2501.26 °F) Type N:–4.34 mV (–263.14 °C/–441.65 °F) to 47.51 mV (1299.92 °C/2371.86 °F) Type R:–0.22 mV (–48.27 °C/–54.89 °F) to 21.10 mV (1767.88 °C/3214.18 °F) Type S:–0.23 mV (–48.60 °C/–55.48 °F) to 18.69 mV (1767.76 °C/3213.97 °F) Type T:–6.25 mV (–265.71 °C/–446.28 °F) to 20.87 mV (399.97 °C/751.95 °F)
Common mode rejection	–80 dB minimum for analog inputs –96 dB typical for analog inputs –110 dB minimum for thermocouple inputs –120 dB typical for thermocouple inputs
Input common mode range	±11 V minimum
Safe input common mode volt	±40 V minimum
Input impedance	103 Ω (±1%) for 4–20 mA inputs
Anti-aliasing filter	2 poles at 10 ms (channel 11 has 2 poles at 5 ms)
Resolution	15 bits

Thermocouple Input Accuracy @ 25°C (%)	T/C type	Range							
		< 25 °C		> 25 °C		< 300 °C		> 300 °C	
		Typ	Max	Typ	Max	Typ	Max	Typ	Max
	E or K	0.21	0.80	0.14	0.60				
	J	0.16	0.65	0.11	0.55				
	N	0.23	0.95	0.18	0.65				
	R or S					0.35	0.85	0.30	0.65
	T	0.70	1.85	0.35	0.95				

Note—The Atlas may experience degraded performance of the thermocouple (TC) inputs of the Analog Combo cards from ~900 MHz to 1.1 GHz at field strengths greater than 10 V/m. Fields of 10–20 V/m degrade the steady-state performance from a 0.25% tolerance to a 1.2% tolerance. Installation of the Atlas in a metal cabinet will minimize this degradation.

4–20 mA Input Accuracy @ 25°C (%)	Input type	Typ	Max
	4–20 mA	0.20	0.34

Note—The Atlas may experience degraded performance of these 4–20 mA inputs of the Analog Combo cards from 410 MHz to 450 MHz at field strengths greater than 10 V/m. Fields of 10–20 V/m degrade the steady-state performance from a 0.1% tolerance to a 0.36% tolerance. Installation of the Atlas in a metal cabinet will minimize this degradation.

Temperature Drift	Input Type	Typ (ppm/°C)	Typ error (%)	Max (ppm/°C)	Max error (%)
	E or J	40	0.25	235	1.53
	K or N	55	0.35	235	1.53
	R, S, or T	135	0.90	235	1.53
	4–20 mA	105	0.68	160	1.04

> **IMPORTANT** **For thermocouple inputs, percent error is for positive full scale for 65 degree delta (25 to –40 °C). For 4–20mA inputs, percent error is for 25 mA full scale input for 65 degree delta (25 to –40 °C).**

CJ update time	5 ms
Latency	1 ms for odd channels and 3 ms for even numbered channels
Failure detection	Open wire detection provided for thermocouples
Isolation	All input channels are isolated from the rest of the AtlasSC platform to 500 Vac, however they are not isolated from each other. The inputs are differential, with a high impedance between channels.
CJ accuracy	±3 °C worst case at 25 °C, (±1 °C typical at 25 °C) uncalibrated ±1 °C worst case at 25 °C, (±0.5 °C typical at 25 °C) calibrated ±4 °C over the full temperature range (–40 to +85 °C) uncalibrated ±2 °C over the full temperature range (–40 to +85 °C) calibrated

Loop power for the analog inputs must be supplied by an external supply, if needed.

4–20 mA, or type J or K T/C is selected in the GAP block software, for each input. GAP configuration sets input gain via software.

Maximum wire size, one 16 AWG (1.5 mm²), or two 20 AWG (0.5 mm²) wires.

Channels 1–10 must be configured in pairs, that is, channels 1 and 2, 3 and 4, etc., must both be configured as 4–20 mA inputs or must both be configured as thermocouple inputs.

Any "unused" channel of a pair, Channels 1–10, must have its input shorted to prevent measurement errors on the "in-use" channel of the pair.

> **IMPORTANT** **External loop powered transducers must be individually protected with a 100 mA fuse on each channel.**

Table 5-2. RTD/4–20 mA Analog Inputs

Number of channels	4
Input type	100 or 200 Ω 3-wire
Max. input current	24 mA, if configured for 4–20 mA
Max. input resistance	781 Ω, if configured for RTD
RTD range European Curve (Type 385):	100 Ω RTD: 18.49 Ω (–200 °C/–328 °F) to 390.48 Ω (850 °C/1562 °F) 200 Ω RTD: 37.04 Ω (–200 °C/–328 °F) to 533.10 Ω (457 °C/854.6 °F)
RTD range American Curve (Type 392):	100 Ω RTD: 59.57 Ω (–100 °C/–148 °F) to 269.35 Ω (457 °C/854.6 °F) 200 Ω RTD: 119.14 Ω (–100 °C/–148 °F) to 538.70 Ω (457 °C/854.6 °F)
Common mode rejection	–80 dB minimum for analog inputs –96 dB typical for analog inputs –96 dB minimum for RTD inputs –115 dB typical for RTD inputs
Input common mode range	±11 V minimum
Safe input common mode volt	±40 V minimum

Input impedance	103 Ω (±1%) for 4–20 mA inputs		
Anti-aliasing filter	2 poles at 10 ms		
Resolution	15 bits		

	RTD and 4–20 mA Input Accuracy @ 25 °C (%)		
	Input type	Typ	Max
Accuracy	100 Ω American and European, 200 Ω American	0.13	0.54
	200 Ω European	0.13	0.64
	4–20 mA	0.20	0.34

Temperature Drift				
Input Type	Typ (ppm/°C)	Typ error (%)	Max (ppm/°C)	Max error (%)
100 Ω European Curve	30	0.20	290	1.89
100 Ω American Curve	50	0.33	290	1.89
200 Ω European Curve	20	0.13	290	1.89
200 Ω American Curve	20	0.13	290	1.89
4–20 mA	105	0.68	160	1.04

IMPORTANT | **For RTD inputs, percent error is for full scale for 65 degree delta (25 to –40 °C). For 4–20 mA inputs, percent error is for 25 mA full scale input for 65 degree delta (25 to –40 °C).**

Update time	5 ms
I/O Latency	1 ms
Isolation	All input channels are isolated from the rest of the AtlasSC platform to 500 Vdc, however inputs are not isolated from each other.

- Loop power for the Analog inputs must be supplied by an external supply if needed.
- 4–20 mA, or RTD is selected in the GAP block software, for each input. GAP configuration sets input gain via software.
- Maximum wire size, one 16 AWG (1.5 mm²), or two 20 AWG (0.5 mm²) wires.

IMPORTANT | **External loop powered transducers must be individually protected with a 100 mA fuse on each channel.**

Table 5-3. Digital Speed Sensor Inputs

Number of channels	2, MPU only
MPU Inputs:	
Input frequency	100—24 950 Hz
Minimum input amplitude	See Figure 5-2
Maximum input amplitude	70 V peak-to-peak
Input impedance	>550 Ω
Isolation voltage	500 Vac, each channel is isolated from all other channels, and from the AtlasSC platform
Resolution	dependent on frequency, 13 bit minimum at maximum speed
Accuracy	less than ±0.08% of full scale from –40 to +85 °C internal temperature
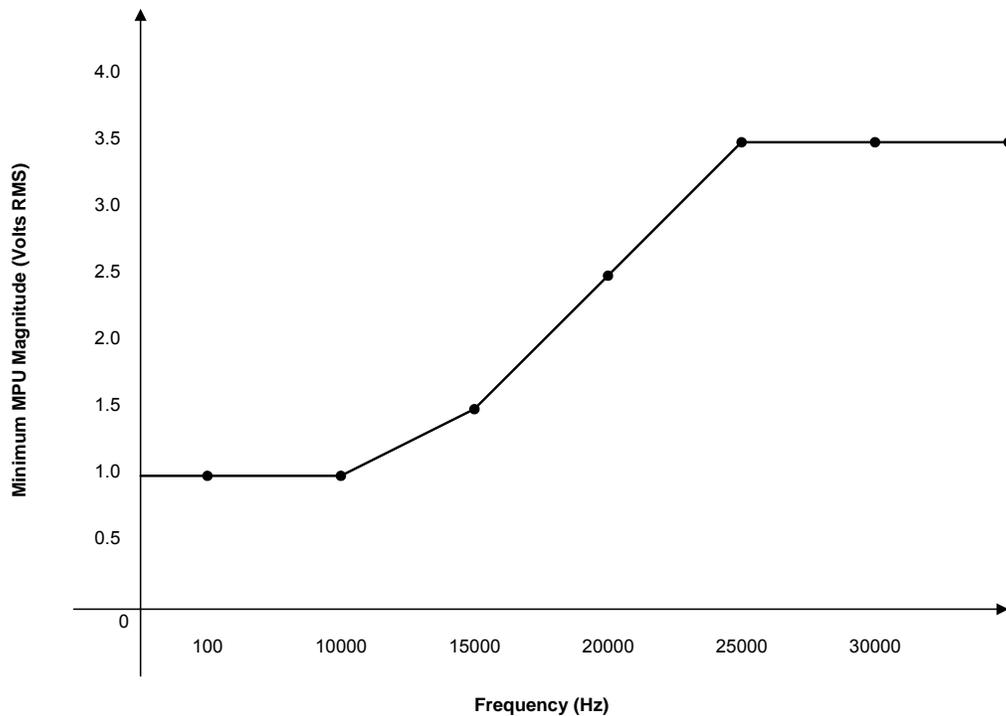
Figure 5-2. Minimum MPU Voltage

- A derivative output is provided. The inherent noise on this output, due to resolution, increases with frequency. At 1000 Hz, it can be as much as 2.5 Hz/sec. At 5000 Hz, it can be as much as 12.5 Hz/sec. At 10 kHz, it can be as much as 25 Hz/sec. At 20 kHz, it can be as much as 80 Hz/sec. Typically, at 3600 Hz, noise on the MPU signal due to wiring runs, will make the noise contribution due to resolution, insignificant.
- Maximum wire size, one 16 AWG (1.5 mm²), or two 20 AWG (0.5 mm²) wires.

Table 5-4. Analog Outputs

Number of channels	2
Output type	4–20 mA outputs, non-isolated
Current output	4–20 mA
Max current output	25mA ±5%
Isolation	0 Vdc
Min. load resistance	0 Ω
Max load resistance	300 Ω at 22 mA
Resolution	12 bits
Accuracy	less than ±0.1% of full scale at 25 °C (after software calibration)
Temperature drift	140 ppm/°C, maximum, =0.23 mA 70 ppm/°C, typical (0.45% of full scale), =0.11375 mA

- 0–1 mA OUTPUTS ARE NOT SUPPORTED, WITHOUT A GREATER THAN 4 BIT LOSS OF RESOLUTION. RESULTING RESOLUTION WOULD BE 7 BITS.
- Common mode voltage is 15 Vdc.
- Maximum wire size, one 16 AWG (1.5 mm²), or two 20 AWG (0.5 mm²) wires.

AtlasSC Analog Combo Board Operation

This board includes no potentiometers and requires no field calibration. An Analog Combo board may be replaced with another board of the same part number without any adjustment.

Speed Sensor Inputs

The MPU inputs are read and the speed is provided to the application program. A derivative output is also provided. The speed sensor inputs are filtered by the Analog Combo board, and the filter time constant is selectable at 8 milliseconds or 16 milliseconds. Eight milliseconds should be acceptable for most turbine applications, sixteen milliseconds may be necessary for very slow speed applications. The speed range is selected in the application software and determines the maximum speed that the board will detect. The control output of the software will detect a minimum speed of one fiftieth of the speed range. This allows detection of failed speed sensors to help prevent overspeed due to slow update times at very low speeds. The monitor output of the GAP block will read down to .5 Hz, irrespective of the speed range. An application may use any combination of accepted MPUs, and any combination of speed ranges.

The Analog Combo board uses speed sensing probes mounted on a gear connected or coupled to the turbine's rotor to sense turbine rotor speed. Any of the board's speed channels accept passive magnetic pickup units (MPUs) or proximity probes. It is not recommended that gears mounted on an auxiliary shaft coupled to the rotor be used to sense speed. Auxiliary shafts tend to turn more slowly than the rotor (reducing speed sensing resolution) and have coupling gear backlash, resulting in less than optimum speed control. For safety purposes, it is also not recommended that the speed sensing device sense speed from a gear coupled to a generator or mechanical drive side of a system's rotor coupling.
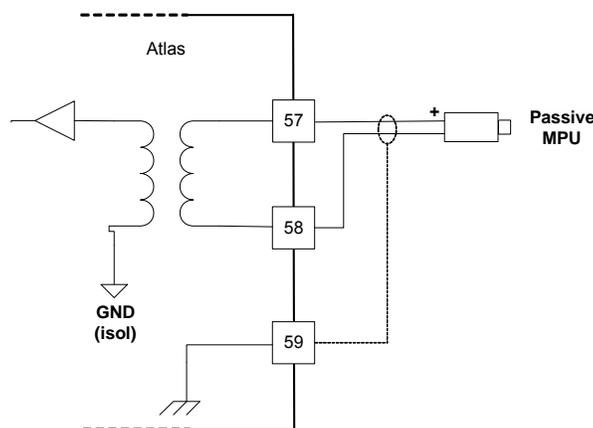
Figure 5-3. MPU Interface to the Analog Combo Board
(wiring example)

Configuration Notes
- Refer to Figure 5-3 for speed sensor wiring.

Speed Sensor Input Software Configuration Limitations
(TxMxR)/60 must be < 25000 Hz
T = gear teeth
M = (overspeed test limit setting x 1.2)
R = gear ratio

Analog Inputs

The Analog inputs may be current or temperature inputs. The first 11 inputs can be thermocouple inputs, and the other 4 inputs can be RTD inputs. The software must be configured for the correct input type. This allows the Analog Combo card to use the applicable hardware calibration values, and to configure the appropriate hardware gains. The first 10 inputs must be configured in pairs, that is, channels 1 and 2 must both be thermocouples or must both be 4–20 mA inputs. Channels 11–15 may be configured individually.

All 4–20 mA inputs may be used with two-wire ungrounded (*loop powered) transducers or isolated (self-powered) transducers. All Analog inputs have 11 Vdc of common mode rejection. If interfacing to a non-isolated device, which may have the potential of reaching over 11 Vdc with respect to the control's common, the use of a loop isolator is recommended to break any return current paths, which could produce erroneous readings.

RTD inputs must be configured to use either the European or American curve. 200 Ω RTDs are limited to the maximum temperature on the American curve, even when the European curve is used. The RTD source current is 2 ma, and the RTD sense input should be tied to the negative side of the RTD, at the RTD.

See the specifications section for supported thermocouple types. The cold junction sensor is provided on the AtlasSC Analog Combo board. If the actual cold junction in the field wiring occurs elsewhere, the temperature of that junction must be brought into the control as a thermocouple, RTD, or 4–20 mA input, and the application software must be configured to use the appropriate cold junction temperature.

The first 11 analog inputs are isolated as a group from control common, earth ground, and the other 4 analog inputs. The last 4 analog inputs are also isolated as a group from control common, earth ground, and the first 11 analog inputs.
For a 4–20 mA input signal, the Analog Combo board uses a 100 Ω resistor across the input.
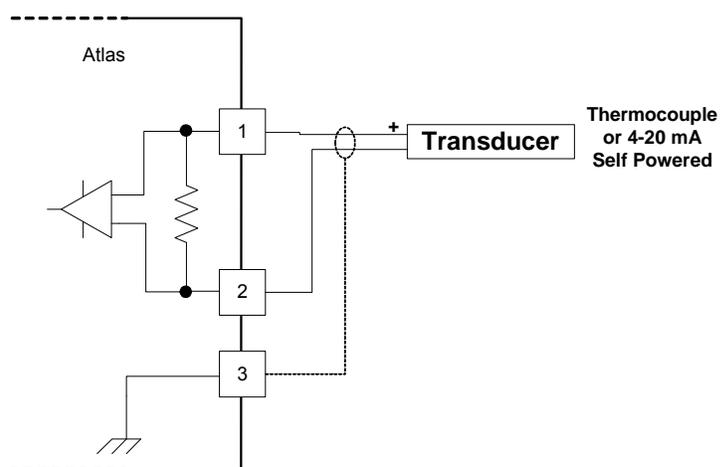
Figure 5-4a. 4–20 mA or Thermocouple Input Interface to the Analog Combo Board
(wiring example, inputs 1–11)
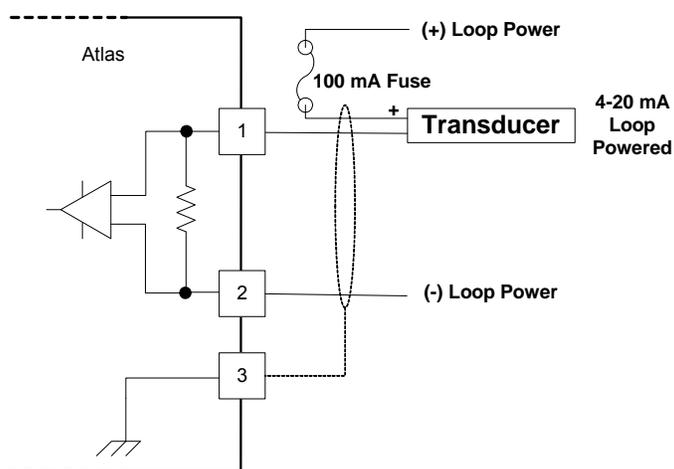
Figure 5-4b. 4–20 mA Input Interface using External Loop Power
(wiring example, inputs 1–11)
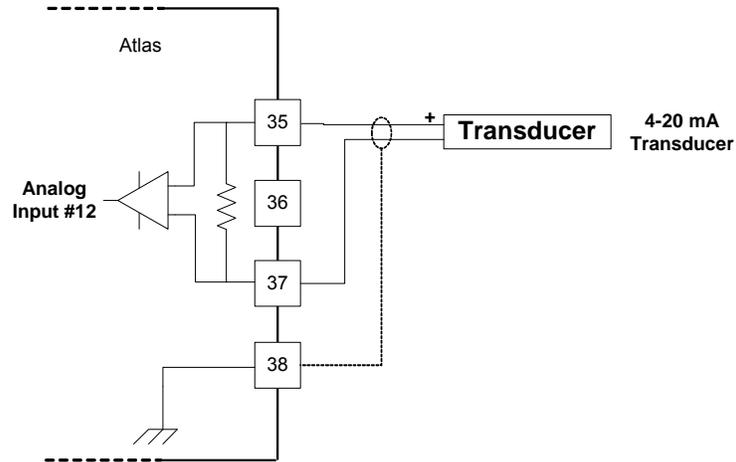
Figure 5-5. 4–20 mA Input Interface to the Analog Combo Board
(wiring example, inputs 12–15)
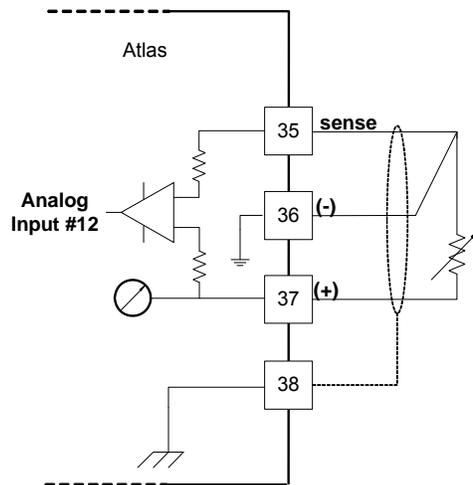
Figure 5-6. RTD Input Interface to the Analog Combo Board
(wiring example, inputs 12–15)

Configuration Notes
- Refer to Figures 5-4, 5-5, and 5-6 for analog input wiring.
- 4–20 mA inputs are supported, 0–5 V inputs are not.
- The application software must be configured to match the input type used, that is, 4–20 mA, 100 Ω RTD, k-type thermocouple, etc.

IMPORTANT	**External loop powered transducers must be individually protected with a 100 mA fuse on each channel.**

RTDs
- Only 100 and 200 Ω RTDs are supported.

- RTD inputs can use the European or American curve. 200 Ω RTDs are limited to the maximum temperature on the American curve, even when the European curve is used.
- The RTD source current is 2 mA.
- The RTD sense input should be tied to the negative side of the RTD, at the RTD.

Thermocouples
- See the specifications section for supported thermocouple types.
- The cold junction sensor is provided on the AtlasSC Analog Combo board. If the actual cold junction in the field wiring occurs elsewhere, the temperature of that junction must be brought into the control as a thermocouple, RTD, or 4–20 mA input, and the application software must be configured to use the appropriate cold junction temperature.
- The thermocouple and cold junction input units (°C or °F) should be consistent in the application software.

4–20 mA Inputs
- All 4–20 mA inputs have an impedance of 100 Ω.
- No loop power is provided.

IMPORTANT	External loop powered transducers must be individually protected with a 100 mA fuse on each channel.

Analog Outputs
The analog outputs are 4–20 mA with a full scale range of 0–24 mA. The SmartCore board has four analog outputs.
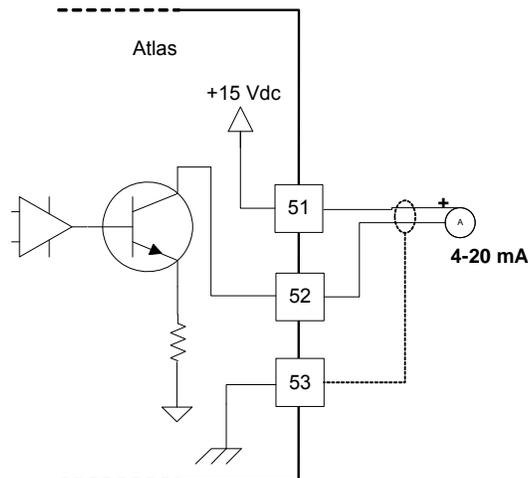
Figure 5-7. Analog Output Interface to the Analog Combo Board
(wiring example)

Configuration Notes
- Refer to Figure 5-7 for analog output wiring.
- Only 4–20 mA signals are output.
- See the specifications section for the maximum analog output load.
- Care should be taken to prevent ground loops and other faults when interfacing to non-isolated devices.
- The output does not contain fault detection. If it is necessary to detect failures, then the device that is driven by the Analog output, for example an actuator driver, must contain reference failure detection.
- The Analog outputs have a 15 V common mode voltage, with respect to AtlasSC control common.
- +V is 15 V

NOTICE	Avoid misconnection of the Analog Output (+) to the Actuator Output (–). This will damage internal components, making the control inoperable. This applies only when a SmartCore Board with actuators is installed in the control.

Fault Detection (Board Hardware)

Each Analog Combo board has a red fault LED that is turned on when the system is reset. During initialization of a board, which occurs after every CPU reset, the CPU turns the Fault LED on. The CPU then tests the board using diagnostic routines built into the software. If the diagnostic test is not passed, the LED remains on or blinks. If the test is successful, the LED goes off. If the fault LED on a board is illuminated after the diagnostics and initialization have been completed, the Analog Combo board may be faulty or may have the address DIP switches configured incorrectly. The DIP switch setting must match the module address set in the GAP application program.

Table 5-5. Analog Combo Fault Codes

Number of LED Flashes	Failure
1	Microprocessor failure
2	Bus, address, any unexpected exception error
5	Failure during EE test or erasing
7	Kernel software Watchdog count error
12	Failure during CPU Internal RAM test
13	Dual port RAM error

Fault Detection (I/O)

In addition to detecting board hardware faults, the application program may detect I/O faults.

- Analog Input Faults—The application software may set a high and low latch set point to detect input faults. For thermocouple inputs, open wire detection is provided.
- Speed Sensor Input Faults—The application software may set a high and low latch set point to detect input faults.
- Microcontroller Faults—The system monitors a software watchdog, a hardware watchdog, and a software watchdog on the PC/104 bus communications. All outputs are shutdown in the event of a microcontroller fault.

Troubleshooting Guide

Speed Sensor Inputs

If a magnetic pickup input is not functioning properly, verify the following:

- Check that the cable is shielded and the shield is properly grounded per the shields and grounding section in Chapter 2.
- Measure the input voltage on the terminal block. It should be greater than that shown in Figure 5-2.
- Verify that the signal waveform is clean and void of double zero crossings.
- Verify that no ground connection exists and that the resulting 60 Hz signal is absent.
- Measure the frequency. Frequency should be in the range of 100 Hz - 25 kHz.
- Check the wiring. Look for a loose connection at the terminal blocks and disconnected or misconnected cables.
- Check the software configuration to ensure that the input is configured properly; check the hertz to rpm ratio, and the maximum speed.

After verifying all of the above, the AtlasSC should be returned for service.

Analog Inputs

If an Analog input is not functioning properly, verify the following:

- Check that the cable is shielded and the shield is properly grounded per the shields and grounding section in Chapter 2.
- Measure the input voltage on the terminal block. It should be in the range of 0–5 V for 4–20 mA inputs. RTD inputs have a 2 mA current source. Thermocouple inputs should have the appropriate millivolt signal.
- Verify that there are no or minimal AC components to the Analog Input signal. AC components can be caused by improper shielding. Thermocouple inputs are extremely sensitive to signal fluctuations.
- Check the wiring. For a 4–20 mA input if the input is reading 0 or the engineering units that correspond to 0 mA, look for a loose connection at the terminal blocks and disconnected or misconnected cables.
- For RTD inputs, check for proper connection of the sense line.
- For thermocouple inputs, check for proper cold junction location.
- If the input is reading high, check that the power is not connected across the input directly.
- Check the software configuration to ensure that the input is configured properly. Ensure that the proper RTD or thermocouple type is selected, if applicable.

After verifying all of the above, the AtlasSC should be returned for service.

Analog Outputs

If an Analog output is not functioning properly, verify the following:

- Check that the cable is shielded and the shield is properly grounded per the shields and grounding section in Chapter 2.
- Check the load resistance, ensure that it is less than the specification limit for the output current.
- Check to ensure that the load wiring is isolated.
- Check the wiring, look for a loose connection at the terminal blocks and disconnected or misconnected cables.
- Disconnect the field wiring and connect a resistor across the output. If the output is correct across the resistor, there is a problem with the field wiring.
- Check the software configuration to ensure that the input is configured properly.

After verifying all of the above, the AtlasSC should be returned for service.

Chapter 6.
PowerSense Board

General Description

Each PowerSense board contains the circuitry for two sets of three-phase ac voltage (PT) and ac current (CT) inputs, as well as a speed bias output, a voltage bias output, and a LON communications port.

Features

- On-board processor for automatic calibration of the I/O channels
- PT and CT inputs provide fundamental as well as harmonic information
- PT and CT inputs are updated after 3 cycles, which is 50 ms at 60 Hz
- PT and CT inputs and bias outputs have 12 bit resolution
- PT inputs are software configurable for 70 V, 120 V, or 240 V ranges
- Each set of PT and CT inputs is isolated from the rest of the board and chassis
- 5 ms update rate for speed and voltage bias outputs
- Speed bias output is software configurable for 4–20 mA, 0–5 V, PWM, or ±3 V output
- Speed Bias output is isolated from the rest of the board
- Voltage Bias output is software configurable for 4–20 mA, ±1 V, ±3 V, and ±9 V
- Voltage bias output is isolated from the rest of the board
- The LON port is isolated from the rest of the board

Physical

The AtlasSC™ PowerSense board connects to the CPU board through the PC/104 bus. It connects to the power supply, through the AtlasSC power bus. It requires a SmartCore board or a Pentium CPU board as a master controller. The master controller is responsible for all application level tasks such as protective relaying, load share, and controlling the voltage and speed bias outputs.

Hazardous Live

The following circuits are classified as Hazardous Live because they carry potential shock hazardous voltages during normal operation or under single fault conditions:
- potential transformer (PT) inputs
- current transformer (CT) inputs
- voltage bias outputs

⚠ WARNING	**HIGH VOLTAGE—Do not contact the above inputs and outputs during system operation when such circuits are live. Possible serious personal injury or death could result.**

⚠ WARNING	**Before disconnecting the secondary terminals of the current transformer or the connections of the current transformer at the control, ensure that the transformer is short-circuited.**

⚠ WARNING	**HIGH VOLTAGE—To prevent risk of electric shock, make sure that the terminal block covers are installed on the above inputs before operation (see Figure 6-1).**
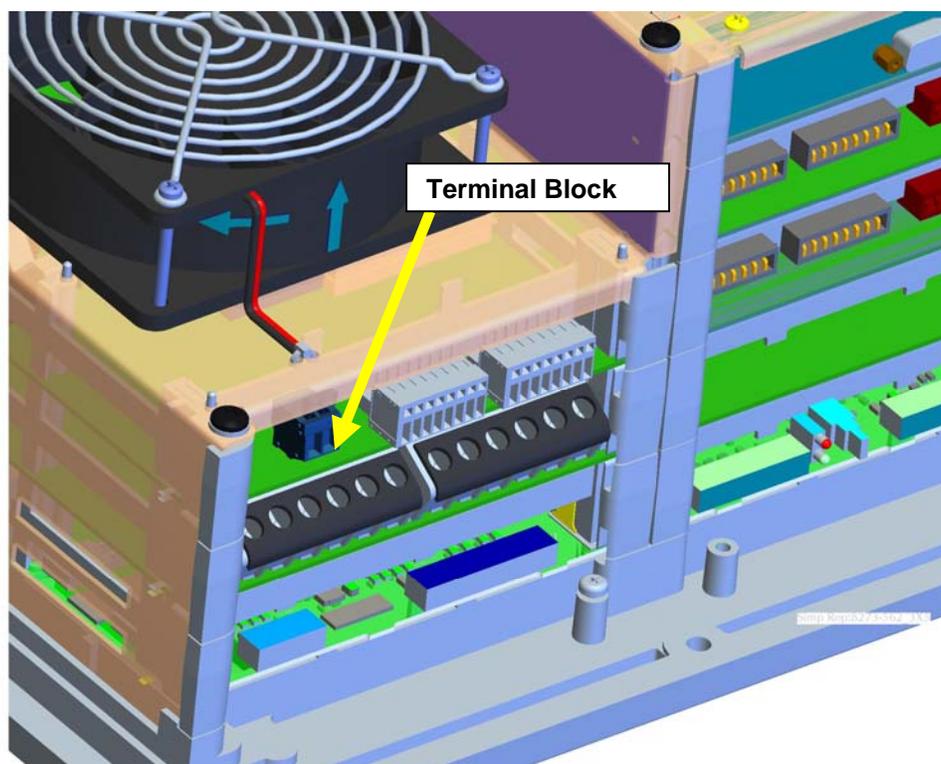
Figure 6-1. Terminal Block Covers

These inputs and outputs are provided with 500 V of dielectric isolation from chassis ground. In addition, these inputs/outputs are isolated from safety extra-low voltage (SELV) circuits (such as serial communication, PC/104 circuits) by optoisolators or transformers provided with double insulation and 3 kVac of dielectric isolation.
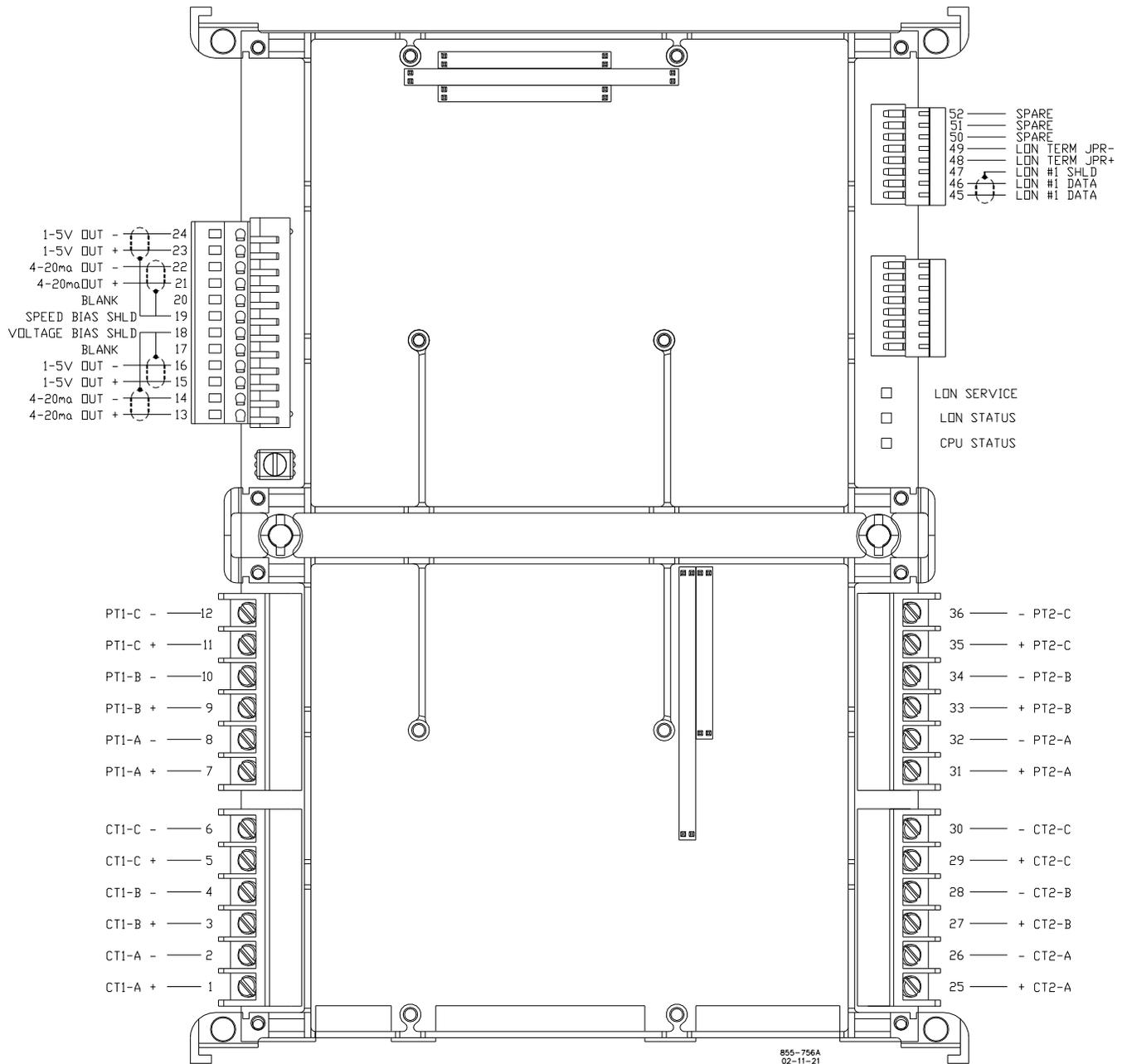
Figure 6-2. PowerSense Board Connections

Specifications

Table 6-1. Utility and Generator PT Voltage Inputs

Input Voltage (Typical)	77, 120, 240/277 Vac, transducers externally powered.
Max. Input Voltage	300 Vac
Input Current	3 mA maximum
Input Frequency	45—70 Hz
Common Mode Voltage	±450 Vdc minimum
Common Mode Rejection Ratio	–63 dB minimum

No harmonics	**Accuracy ***
Voltage	0.25% or 0.175V, 70V scale
	0.25% or 0.3V, 120V scale
	0.25% or 0.6V, 240V scale

Accuracy at 25 °C (applies to Voltage rows above)

*—with GAP-set Default Filters set at 0.67

PT Temp Drift

(Vrange = 70/120/240 Vrms)	**–40 to +85 °C**	**Any 40 °C change**
Typical (1σ):	< 0.4 % of Vrange	< 0.3% of Vrange
	0.28V, 70V scale	0.21V, 70V scale
	0.48V, 120V scale	0.36V, 120V scale
	0.96V, 240V scale	0.72V, 240V scale
Max (3σ):	< 1.2 % of Vrange	< 0.8% of Vrange
	0.84V, 70V scale	0.56V, 70V scale
	1.44V, 120V scale	0.96V, 120V scale
	2.88V, 240V scale	1.92V, 240V scale

Input Impedance	400 kΩ or greater
Isolation	see HAZARDOUS LIVE section above

Table 6-2. Utility and Generator CT Current Inputs

Input Current	5 A rms full scale
Max Transient Input Current	7.07 A rms
Input Frequency	45—70 Hz
Common Mode Voltage	±250 Vdc minimum
Common Mode Rejection Ratio	–63 dB minimum
Accuracy	see PT inputs section above

CT Temp Drift

(Full Scale = 5 Arms)	**–40 to +85 °C**	**Any 40 °C change**
Typical (1σ):	< 0.4% or 20.0 mA	< 0.3% or 15.0 mA
Max (3σ):	< 1.2% or 60.0 mA	< 0.8% or 40.0 mA

Input Impedance	0.030 Ω
Isolation	see HAZARDOUS LIVE section above

Table 6-3. Speed Bias Output

Number of channels	1
Current output option	4–20 mA selected by software switch and wiring
Max current output	25mA ±5%
Voltage output options	0–5 V (5 V max ±5%), ±3 V (±3V limit ±5%), 500 Hz PWM, selected by software switch and wiring
Isolation	500 Vac
Max load resistance	300 Ω at 24 mA for 4–20 mA output, infinite for V outputs
Min load resistance	0 Ω for current output, 450 Ω for ±3 V output, 1kΩ for 0–5 V output, PWM output.
Resolution	11 bits, except for PWM output
Accuracy	less than ±0.1% of full scale @ 25 °C or ±0.006V for ±3V output ±0.005V for 0–5 V output ±0.025 mA for 4–20 mA output

		–40 to +85 °C	**Any 40 °C change**
Temp Drift	Typical (1σ):	< 0.5% or 0.125 mA	< 0.3% or 0.075 mA
(4–20 mA, FS = 25 mA)	Max (3σ):	< 1.2% or 0.30 mA	< 0.8% or 0.20 mA
Temp Drift	Typical (1σ):	< 0.3% or 18.0 mV	< 0.2% or 12.0 mV
(±3V range)	Max (3σ):	< 0.7% or 42.0 mV	< 0.5% or 30.0 mV
Temp Drift	Typical (1σ):	< 0.1% or 5.0 mV	< 0.1% or 5.0 mV
(0–5 V range and PWM)	Max (3σ):	< 0.2% or 10.0 mV	< 0.2% or 10.0 mV

Options: 4–20 mA, 0–5 V, ±3V, PWM- 5V- 500 Hz. Both the GAP block field and the wiring must be changed to switch between current and voltage outputs. Only the GAP block field must be changed to switch between the voltage outputs.

Table 6-4. Voltage Bias Output

Number of channels	1
Current output option	4–20 mA selected by software switch and wiring
Max current	25mA ±5%
Voltage output options	±1, ±3, ±9 V selected by software switch and wiring
Max Voltage	±9V ±5%
Isolation	see HAZARDOUS LIVE section above
Max load resistance	300 Ω at 24 mA for 4–20 mA output, infinite for V output
Min load resistance	7kΩ for ±9V output, 0 Ω for 4–20 mA output
Resolution	11 bits for ±9V, >9 bits for ±3V, >7 bits for ±1V
Accuracy	less than ±0.1% of full scale @ 25 °C or ±0.018V for ±1V, ±3V, ±9V output ±0.025 mA for 4–20 mA output

		–40 to +85 °C	**Any 40 °C change**
Temp Drift	Typical (1σ):	< 0.5% or 0.125 mA	< 0.3% or 0.075 mA
(4–20 mA, FS = 25 mA)	Max (3σ):	< 1.2% or 0.30 mA	< 0.8% or 0.20 mA
Temp Drift	Typical (1σ):	< 0.3% or 54.0 mV	< 0.3% or 54.0 mV
(±9V range)	Max (3σ):	< 0.6% or 108.0 mV	< 0.5% or 90.0 mV
Temp Drift	Typical (1σ):	< 0.9% or 54.0 mV	< 0.9% or 54.0 mV
(±3V range)	Max (3σ):	< 1.8% or 108.0 mV	< 1.5% or 90.0 mV
Temp Drift	Typical (1σ):	< 2.7% or 54.0 mV	< 2.7 % or 54.0 mV
(±1V range)	Max (3σ):	< 5.4% or 108.0 mV	< 4.5% or 90.0 mV

Options: 4–20 mA, ±1V, ±3V, ±9V; software and wiring selectable. Both the GAP block field and the wiring must be changed to switch between current and voltage outputs. Only the GAP block field must be changed to switch between the voltage outputs.

Table 6-5. PT/CT Accuracy Table

Metering Item	Accuracy with Default Filter Values of 0.67
Voltage	0.25% or 0.175 V, 70 Vac scale
	0.25% or 0.3 V, 120 Vac scale
	0.25% or 0.6 V 240 Vac scale
Current	0.25% or 12.5 mA
Power	0.5% or 1.75 VA, 70 V scale
	0.5% or 3.0 VA, 120 V scale
	0.5% or 6.0 VA, 240 V scale
Power Factor	$\pm$0.003 PF Across entire range of 0.5 lead to 0.5 lag
Frequency	0.08% of 60 Hz or $\pm$0.048 Hz
Synchronizing	0.25% or $\pm$0.00157 rad or $\pm$0.9°
Harmonics 2-7	1% or 50 mA for current
	1% or 0.7 V, 70 Vac scale
	1% or 1.2 V, 120 Vac scale
	1% or 2.4 V, 240 Vac scale
Harmonics 9, 11, 13	2% or 100 mA for current
	2% or 1.4 V, 70 Vac scale
	2% or 2.4 V, 120 Vac scale
	2% or 4.8 V, 240 Vac scale
Negative Phase Sequence Voltage or Current	0.5% or 25 mA for current
	0.5% or 0.35 V, 70 Vac scale
	0.5% or 0.6 V, 120 Vac scale
	0.5% or 1.2 V, 240 Vac scale
Typical Temperature Drift for voltage inputs	<0.4% of Vrange for any 40 °C change
Typical Temperature Drift for current inputs	<0.4% or 20.0 mA for any 40 °C change

* Accuracy values at 25 °C with no harmonics

AtlasSC PowerSense Board Operation

This board includes no potentiometers and requires no field calibration.

A PowerSense board may be replaced with another board of the same part number without any physical adjustment.

PT Voltage Inputs

The PT inputs are designed to sense three phase voltage. All features of the three phase voltage for the generator are exactly duplicated for the mains inputs. The 'A' phase voltage inputs of each set (generator and mains) are used for frequency measurement and synchronizing. The fundamental magnitude and phase information is calculated, in addition to the magnitude and phase of each harmonic. All harmonics are calculated, up to the 7th harmonic, as well as the 9th, 11th, and 13th harmonics. In addition the PT voltage inputs are used in conjunction with the CT current inputs for power calculation purposes. All voltage calculations are performed using algorithms in accordance with IEEE 1459-2000.

Individual fundamental and harmonic voltage inputs are provided. A negative phase sequence voltage input, and a THD voltage input are also provided.

Three hardware ranges are provided and are selected by the application software. The nominal inputs for these ranges are 70 V, 120 V, and 240 V. Using the 70 V range, the lowest voltage that will be sensed it 26.67 V, using the 120 V range the lowest voltage is 40 V, and using the 240 V range the lowest voltage is 80 V.

PT ratio and gain inputs are provided, to allow field configuration of the PT scaling. The PT ratio will scale all three PT inputs by the same ratio. There is a separate gain input provided for each PT input (3 for the generator and 3 for the mains) that is provided to allow for compensation of potential transformer turns ratio inaccuracies.

The PT inputs, have adjustable software filters. All PT inputs are updated every 3 cycles. With an input of 60 Hz, this equates to 50 ms.

The hardware does not require three phases for voltage calculations, the application can configure the module for single phase, and all functionality will be modified accordingly. The single phase input that must be provided is the A phase. The application can also configure the module for a "Y" or "delta" line configuration, and the calculations will compensate appropriately. If the physical connections are to a wye connected generator or load, the input to PowerSense should also be wye connected (line-to-neutral). If the physical connections are to a Delta connected generator or load (no neutral present), the input to PowerSense should also be Delta connected (line-to-line).). The "Y" or "delta" configuration applies to the entire set of PT and CTs, it is not possible to configure the PTs for "Y", and the CTs for "delta", or vice versa. However, the configuration may differ between PT/CT 1 and PT/CT 2 (or gen and mains in a typical configuration).
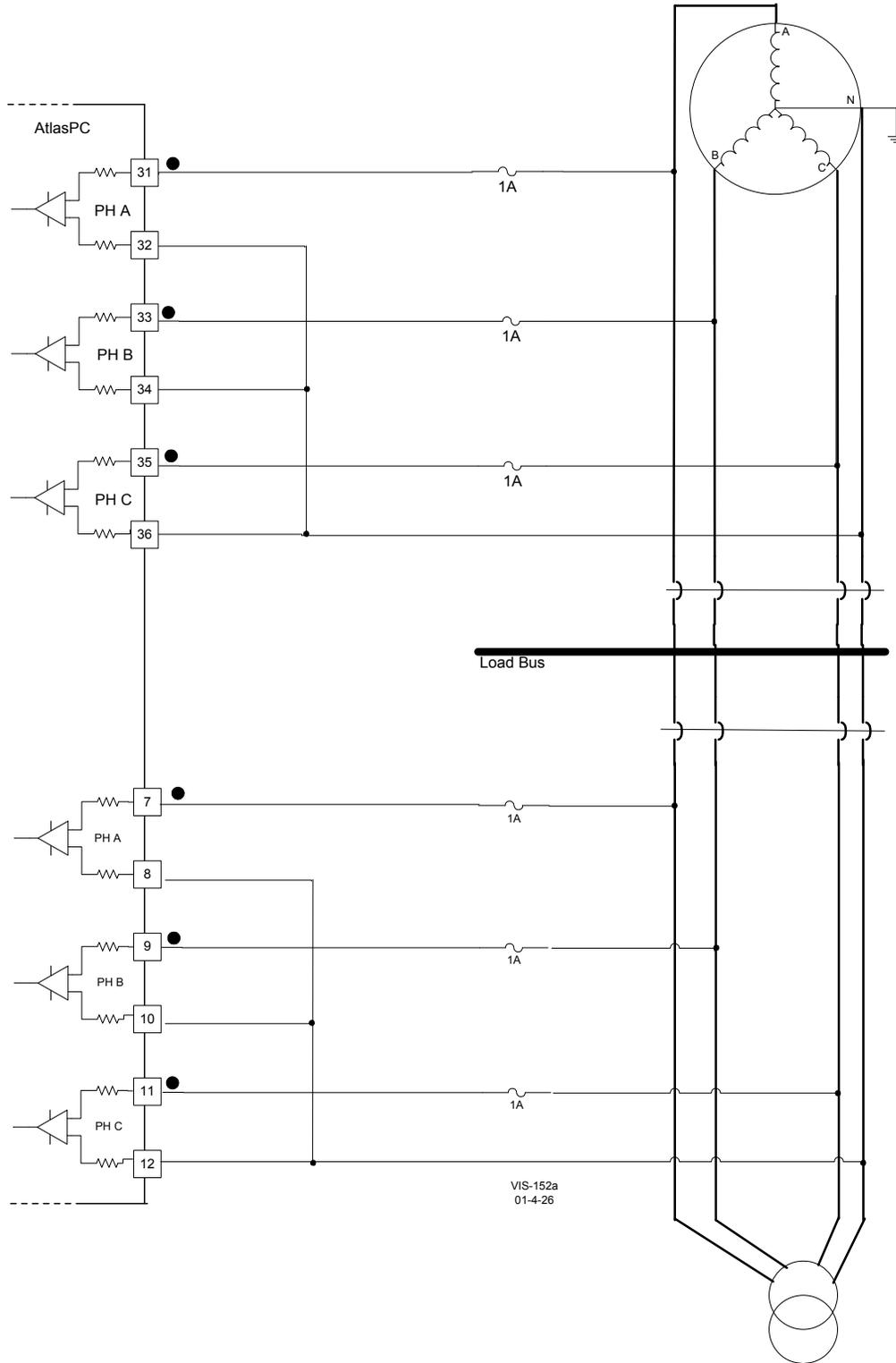
Figure 6-3. Wye Connected System
(wiring example, PT Interface wired L-N to the PowerSense Board)
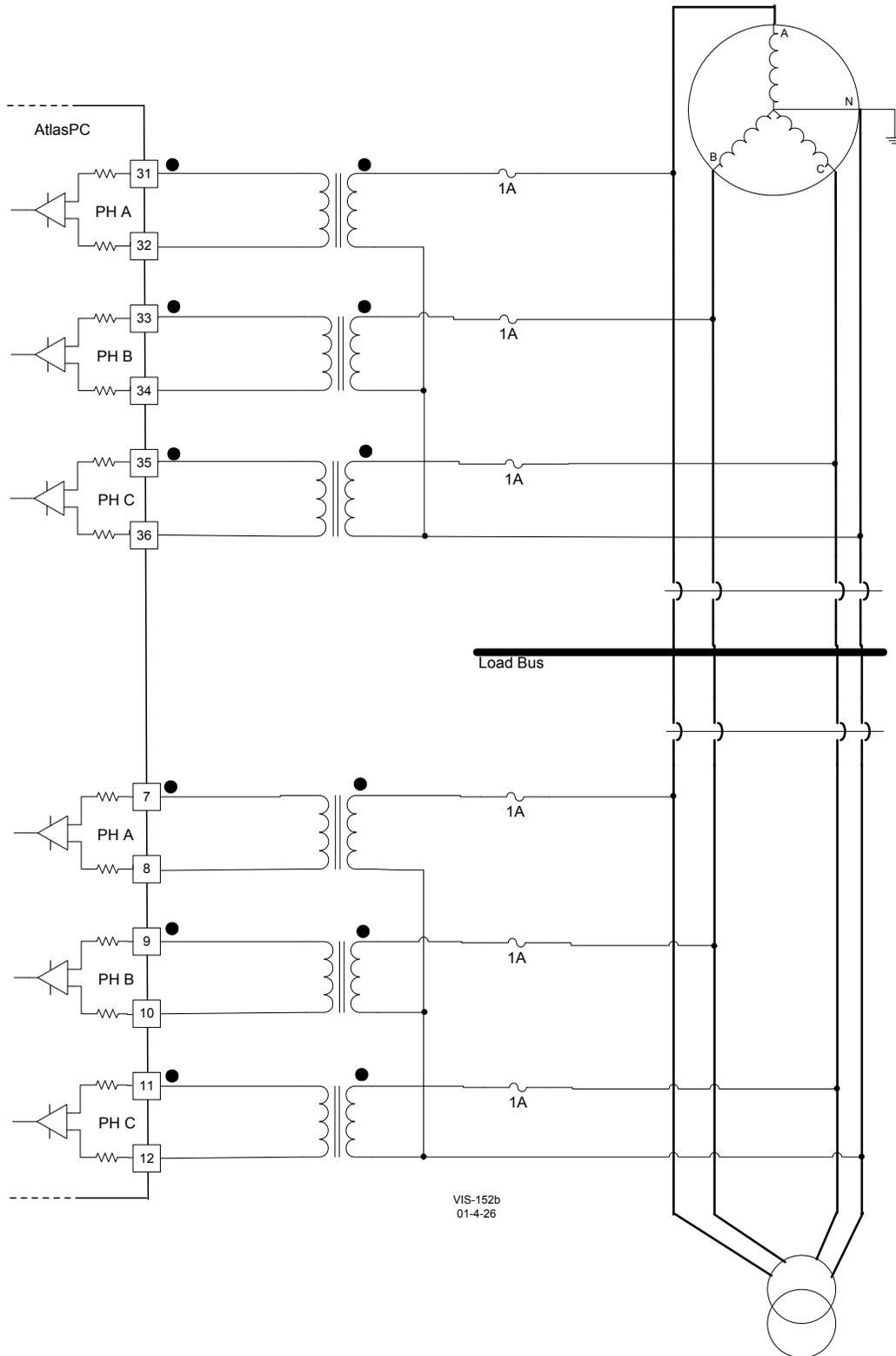
Figure 6-4. Wye Connected System
(wiring example, wired L-N to PowerSense with potential transformers used to step the voltage down to a
level within the capability of the PowerSense inputs)
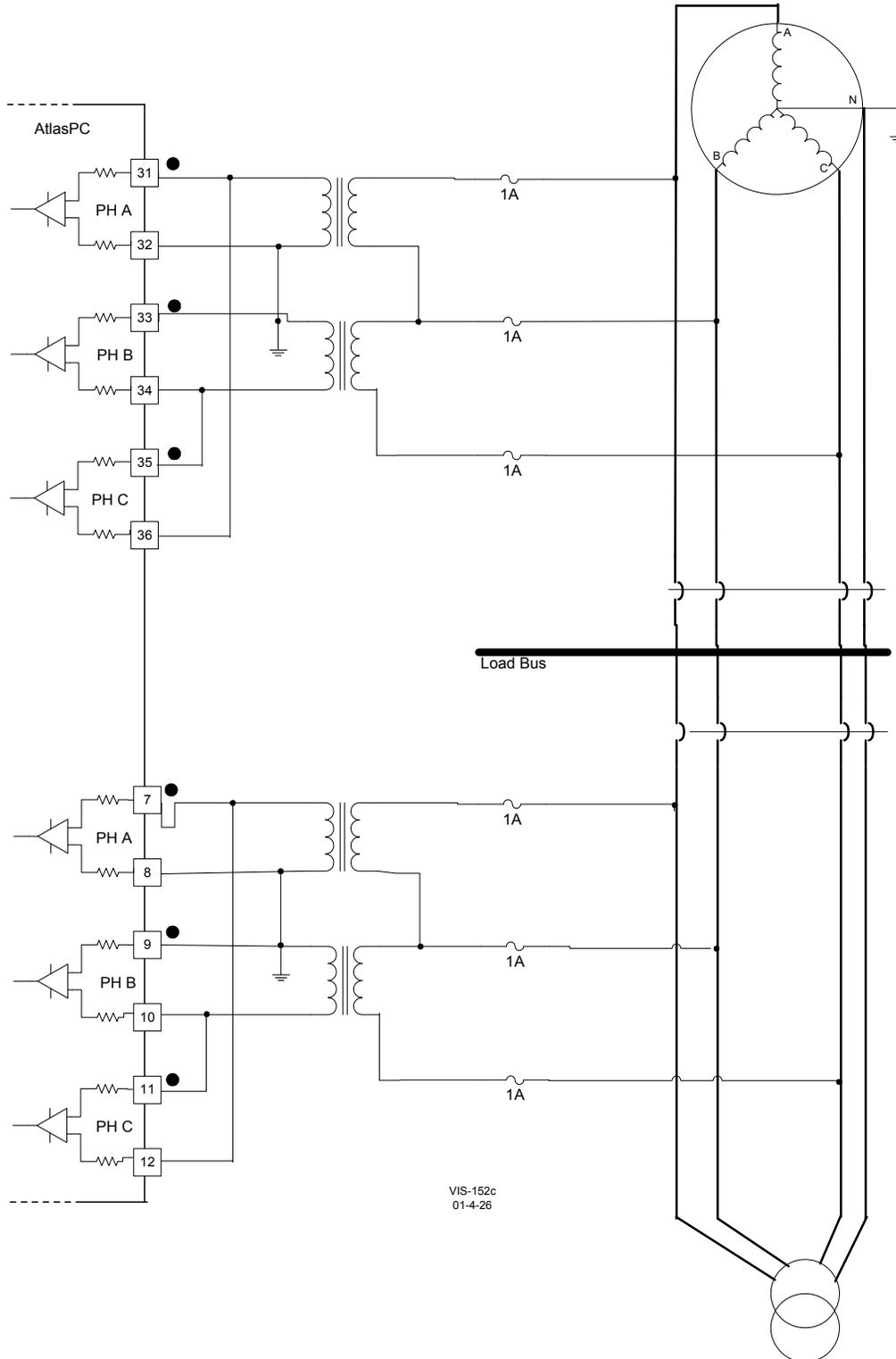
Figure 6-5. Wye Connected System
(wiring example, wired L-L to PowerSense with potential transformers used to step the voltage down to a
level within the capability of the PowerSense inputs; the ground on the b-phase input is optional.)
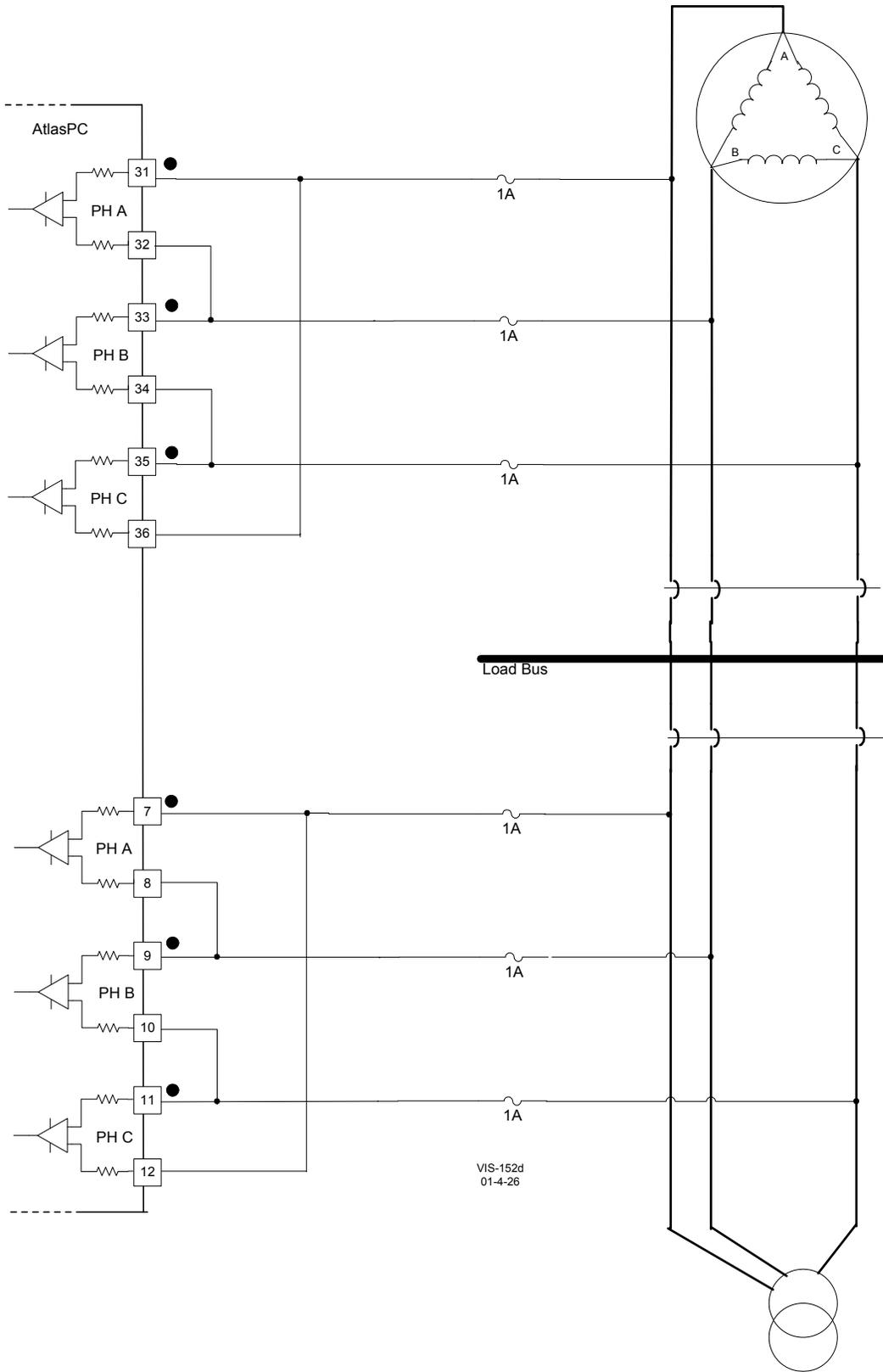
Figure 6-6. Delta Connected System
(wiring example, PT Interface wired L-L to the PowerSense Board)

Figure 6-7. Delta Connected System
(wiring example, wired L-L to PowerSense with potential transformers used to step the voltage down to a level within the capability of the PowerSense inputs; the ground on the B-phase input is optional.)

Configuration Notes

- Refer to Figures 6-3 through 6-7 for PT wiring.
- When using the 3 different PT ranges, 70 V, 120 V, and 240 V, the physical input must be the correct voltage AND the application software must configure the PT/CT block for the correct voltage range.
- When using a single phase input, the PT input used must be phase A, and the application software must configure the PT/CT block for "single phase" operation.
- The application software must configure the PT/CT block for the correct system frequency 50Hz or 60 Hz, as well as for the correct rotation, clockwise or counterclockwise.
- See the GAP help, for information on application software configuration variables.
- The terminal block screws should be torqued to 8 – 10 in-lbs (0.9038782 - 1.129848 N-m).

Generator Current Inputs

The CT inputs are designed to sense three phase current inputs. The 'A' phase current inputs of each set are used for phase calculations. The fundamental magnitude and phase information is calculated, in addition to the magnitude and phase of each harmonic. All harmonics are calculated, up to the 7th harmonic, as well as the 9th, 11th, and 13th harmonics. In addition the CT current inputs are used in conjunction with the PT voltage inputs for load calculation purposes. All current calculations implement algorithms in accordance with IEEE 1459-2000.

Individual fundamental and harmonic CT inputs are provided. A negative phase sequence current input and a THD current input are also provided.

The CT inputs are rated at 5A and function down to 50 mA. For optimum accuracy in the usable range, it is recommended to use 5 A secondary CTs with PowerSense (not 1A secondary CTs). Take care to avoid secondary currents greater than 7 Arms, as this will cause damage.

CT ratio and gain inputs are provided, to allow field configuration of the CT scaling. The CT ratio will scale all three CT inputs by the same ratio. There is a separate gain input provided for each CT input (3 for the generator and 3 for the mains) that is provided to allow for compensation of current transformer turns ratio inaccuracies.

The CT inputs have adjustable software filters. All CT inputs are updated every 3 cycles. With an input of 60 Hz, this equates to 50 ms.

The hardware does not require three phases for current calculations, the application can configure the module for single phase, and all functionality will be modified accordingly. The single phase input that must be provided is the A phase. The application can also configure the module for a "Y" or "delta" line configuration, and the calculations will compensate appropriately. If the physical connections are to a wye connected generator or load, the input to PowerSense should also be wye connected (line-to-neutral). If the physical connections are to a Delta connected generator or load (no neutral present), the input to PowerSense should also be Delta connected (line-to-line).). The "Y" or "delta" configuration applies to the entire set of PT and CTs, it is not possible to configure the PTs for "Y", and the CTs for "delta", or vice versa. However, the configuration (line type and single or three-phase) may differ between PT/CT 1 and PT/CT 2 (gen and mains in most systems).

Configuration Notes

- Refer to Figures 6-8 and 6-9 for CT wiring.
- When using only one CT, rather than 3, the CT must be phase A, and the application software must configure the PT/CT block for "single phase" operation.
- The application software must configure the PT/CT block for the correct system frequency 50 Hz, or 60 Hz, as well as for the correct rotation, clockwise or counterclockwise.
- See the GAP help, for information on application software configuration variables.
- The terminal block screws should be torqued to 8–10 lb-in (0.9–1.1 N·m).

Power Calculations

Individual and total watts, VARs, VA, and power factor inputs. A negative phase sequence voltage input and a THD voltage input are also provided.

All power calculations implement algorithms in accordance with IEEE 1459-2000.

The power inputs have adjustable software filters. All power inputs are updated every 3 cycles. With an input of 60 Hz, this equates to 50 ms.

The hardware does not require three phases for load calculations, the application can configure the module for single phase, and all functionality will be modified accordingly. The single phase input that must be provided is the A phase. The application can also configure the module for a "Y" or "delta" line configuration, and the calculations will compensate appropriately. If the physical connections are to a wye connected generator or load, the input to PowerSense should also be wye connected (line-to-neutral). If the physical connections are to a Delta connected generator or load (no neutral present), the input to PowerSense should also be Delta connected (line-to-line). The "Y" or "delta" configuration applies to the entire set of PT and CTs, it is not possible to configure the PTs for "Y", and the CTs for "delta", or vice versa.

Figure 6-8. CT Interface to the PowerSense Board
(wiring example)
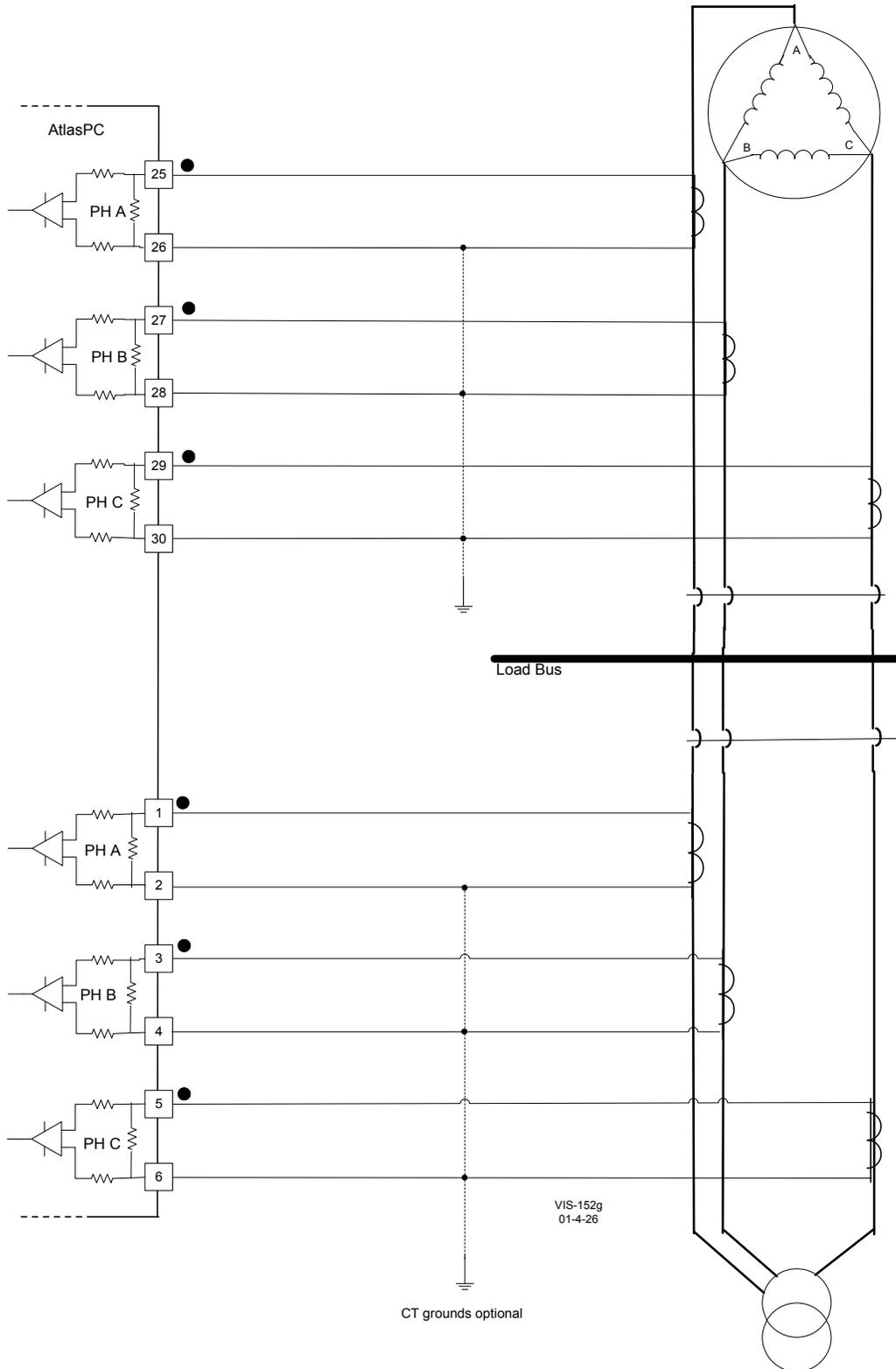
Figure 6-9. CT Interface to the PowerSense Board
(wiring example)

Speed Bias Output

The Speed Bias output is configurable for 4–20 mA with a full scale range of 0–24 mA, or as a ±3 V, 0–5 V, or PWM voltage output. When used as a PWM output, the PWM frequency is 500 Hz. Configuring the output requires wiring and application software configuration. This output is isolated from the rest of the control system, to prevent ground loops when connecting the PowerSense board to other controls.

Configuration Notes

- Refer to Figures 6-10 and 6-11 for Speed Bias Output wiring.
- The Speed Bias output must be configured for the correct type, 4–20 mA or the voltage type in the application software.
- See the specifications section for the maximum output load.
- The output does not contain fault detection. If it is necessary to detect failures, then the device that is driven by the analog output, for example an actuator driver, must contain reference failure detection.
- The output cannot be used as a voltage output and a current output at the same time.
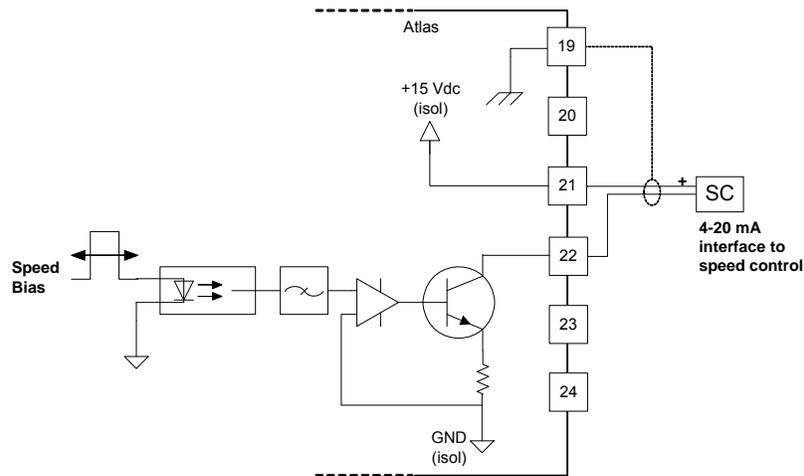
Figure 6-10. Speed Bias Output Interface to the PowerSense Board
(wiring example, configured for 4–20 mA)
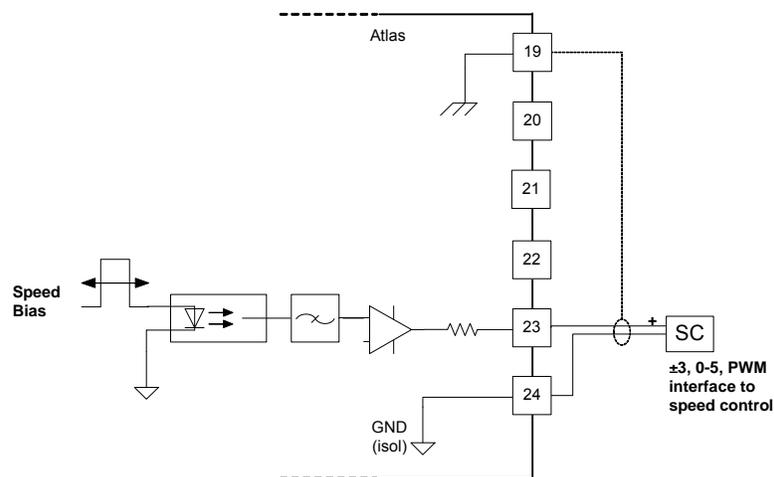
Figure 6-11. Speed Bias Output Interface to the PowerSense Board
(wiring example, configured for ±3 V, 0–5 V, or PWM)

Voltage Bias Output

The Voltage Bias output is configurable for 4 - 20 mA with a full scale range of 0 - 24 mA, or as a ±1, ±3V, or ±9V voltage output. Configuring the output requires wiring and application software configuration. This output is isolated from the rest of the control system to prevent ground loops when connecting the PowerSense board to other controls. The voltage outputs are configured in the software, therefore the ±9V output has about 3 times better accuracy and resolution than the ±3V output, which has about 3 times better accuracy and resolution than the ±1V output.

Configuration Notes
- Refer to Figures 6-12 and 6-13 for Voltage Bias Output wiring.
- The Voltage Bias output must be configured for the correct type, 4–20 mA or the voltage type, in the application software.
- See the specifications section for the maximum output load.
- The output does not contain fault detection. If it is necessary to detect failures, then the device that is driven by the analog output, for example an actuator driver, must contain reference failure detection.
- The output cannot be used as a voltage output and a current output, at the same time.
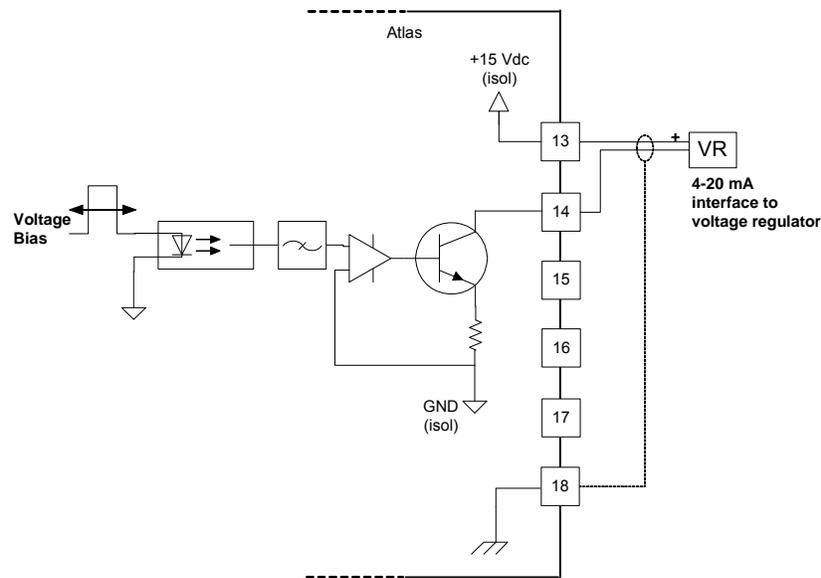
Figure 6-12. Voltage Bias Output Interface to the PowerSense Board
(wiring example, configured for 4–20 mA)
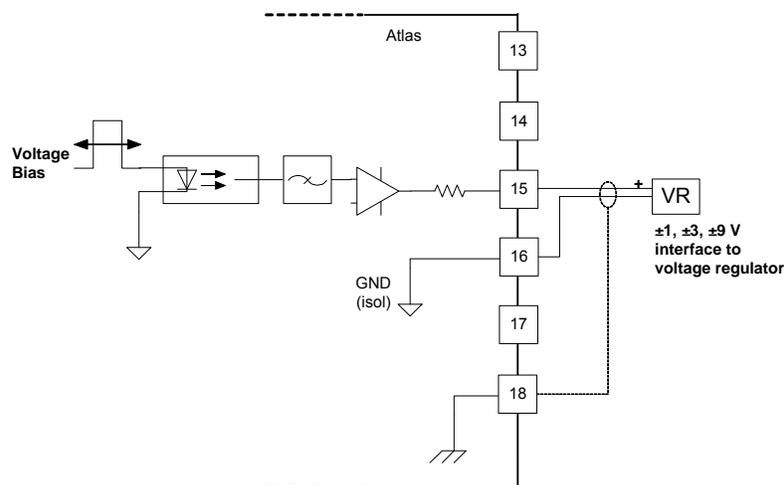
Figure 6-13. Voltage Bias Output Interface to the PowerSense Board
(wiring example, configured for ±1 V, ±3 V, or ±9 V)

LON Channel
The PowerSense board has one LON channel.
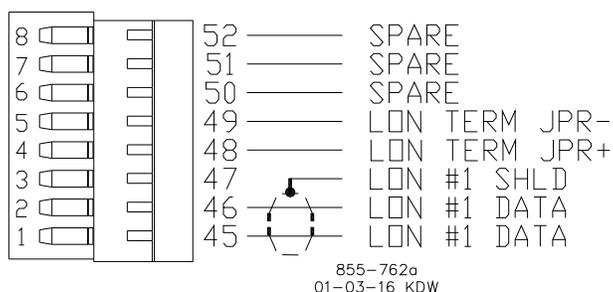
Figure 6-14. LON Interface to the PowerSense Board
(wiring example)

Configuration Notes
- Refer to Figure 6-14 for LON channel wiring.
- The LON network must be terminated with load terminating resistors.
- The LON channel is DSLC/MSLC and EGCP-3 compatible. It may only be used with specified Woodward equipment.

Fault Detection (Board Hardware)
Each PowerSense board has a red fault LED that is turned on when the system is reset. During initialization of a board, which occurs after every CPU reset, the CPU turns the Fault LED on. The CPU then tests the board using diagnostic routines built into the software. If the diagnostic test is not passed, the LED remains on or blinks. Table 6-1 below explains what a blinking LED indicates. The LED will blink the appropriate number of times, rest for one second, then blink again in repetition. If the test is successful, the LED goes off. If the fault LED on a board is illuminated after the diagnostics and initialization have been completed, the PowerSense board may be faulty or may have the address DIP switches configured incorrectly. The DIP switch setting must match the module address set in the GAP application program. It cannot be the same address used by any other card on the PC/104 bus. These are factory set at the time the system is built.

Table 6-6. PowerSense Failure Codes

Number of LED Flashes	Failure
Off	No failure, system OK
Solid	Module in initialization mode
1	Hardware watchdog, CPU clock failure, reset fail
2	Unexpected Exception Error
3	RAM test failure
5	EEPROM failure
7	Kernel Watchdog Timeout
10	System Error
11	Board Identification Error
12	TPU RAM failure
13	Dual Port RAM test failure
14	QSM or ADC Initialization failure
15	Self test status failure
20	Invalid A/D converter selected
21	QSPI timeout
24	ADC auto calibration time-out

Fault Detection (I/O)—In addition to detecting board hardware faults, the application program may detect I/O faults, by comparing values against each other at specific operating points. For example, if phases A and C are reading correctly, and phase B is significantly different, the application could annunciate a problem with phase B.

Microcontroller Faults—The system monitors a software watchdog, a hardware watchdog, and a software watchdog on the PC/104 bus communications. All outputs are shutdown in the event of a microcontroller fault or watchdog detection.

Troubleshooting Guide

PT Inputs
If a PT input is not functioning properly, verify the following:
- Measure the voltage and frequency on the terminal block, to ensure that they are correct.
- Check the wiring. Look for a loose connection at the terminal blocks and for disconnected or misconnected cables.
- Check the PT range configuration in the application software, to ensure that it corresponds to the rated voltage at the input.
- Check the system frequency configuration in the application software, to ensure that 50Hz or 60 Hz is selected, as appropriate.
- Check the "3 phase" configuration in the application software. In single phase mode, phases B and C will be set to 0.
- Check the A phase signal. B and C phase PTs will not read correctly without the A phase PT. If the A phase frequency is unstable, B and C readings will be unstable.
- Verify the settings to the PT/CT block in the application software.
- Verify the settings for wye or delta (L-N or L-L) match the actual wiring
- Verify proper grounding. Incorrect grounding practices may cause inaccurate voltage readings.

After verifying all of the above, the AtlasSC should be returned for service.

CT Inputs
If a CT input is not functioning properly, verify the following:
- Measure the current and frequency on the terminal block, to ensure that they are correct.
- Check the wiring. If the input is reading 0, look for a shorted connection at the terminal blocks and for misconnected cables.
- Check the system frequency configuration in the application software, to ensure that 50Hz or 60 Hz is selected, as appropriate.
- Check the "3 phase" configuration in the application software, in single phase mode phases B and C will be set to 0.
- Check the A phase PT signal, CT phases A, B, and C will not read correctly without the A phase PT. If the A phase PT frequency is unstable the CT readings will be unstable.
- Verify the settings to the PT/CT block, in the application software.
- Verify the settings for wye or delta (L-N or L-L) match the actual wiring
- If the CT common is not grounded, try grounding it to eliminate offsets in the readings. Be sure to ground it in the same location as the other system grounds following good, accepted grounding practices.

After verifying all of the above, the AtlasSC should be returned for service.

Speed and Voltage Bias Outputs

If a speed or voltage output is not functioning properly, verify the following:

- Check to make sure that the output is wired to the correct terminals, 4–20 mA connections are different from voltage output connections.
- Check that the cable is shielded and the shield is properly grounded per the shields and grounding section in Chapter 2.
- Check the load resistance, ensure that it is less than the specification limit for the output current.
- Check the wiring, look for a loose connection at the terminal blocks and disconnected or misconnected cables.
- Disconnect the field wiring and connect a resistor across the output. If the output is correct across the resistor, there is a problem with the field wiring.
- Check the software configuration to ensure that the output is configured properly.

After verifying all of the above, the AtlasSC should be returned for service.

LON Channel

If the LON channel is not functioning properly, verify the following:

- Check the network wiring, it should be low capacitance cable.
- The cable length should not exceed the maximum allowed cable length.
- Check to make sure that termination networks are installed on the ends of the network.
- Check the software configuration.

After verifying all of the above, the AtlasSC should be returned for service.

Chapter 7.
12-Channel Relay Module

General Information
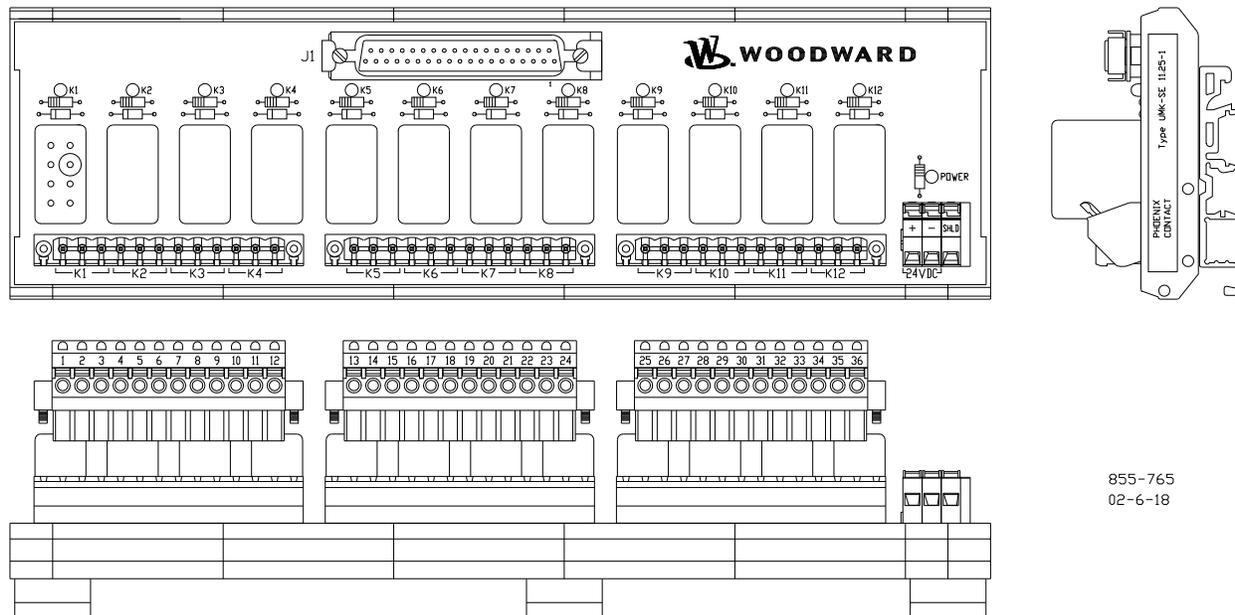
Figure 7-1. 12-Channel Relay Module

The Atlas system has 12 relay drivers on the power supply board. For customers that do not wish to wire their own discrete relays, Woodward can provide an integrated 12-channel relay module with cable harness that is certified for use in ordinary, hazardous, and marine locations.

The module is DIN rail mounted. Approximate dimensions are 254 mm long, 76 mm wide, and 64 mm tall (10 inches long, 3 inches wide, and 2.5 inches tall).

- Relay Module, Item Number 5441-699
- Cable, Item Number 5417-747

Relay Information

Each relay has one set of normally open contacts and one set of normally closed contacts.
The relay contact ratings are:

    3.0 A at 120 Vac (resistive)
    2.0 A at 120 Vac (inductive)
    0.5 A at 120 Vac (lamp or tungsten as UL prefers)
    5.0 A at 28 Vdc (resistive)
    0.1 A at 125 Vdc (resistive)
    0.112 hp—28 Vdc (motor)
    0.241 hp—120 Vac (motor)

Shielding

There is a terminal on the module labeled "SHLD". A wire should be connected between this terminal and a good local system ground. Alternatively, a ground wire can be crimped to the bare shield wire at the Atlas end of the cable and then tied to the chassis ground stud of the Atlas. If this shield wire is not used at the Atlas end of the cable, it should be trimmed back to the insulation jacket of the cable.

Board Status Lights

The module is equipped with twelve yellow LEDs to indicate when each relay has been energized, and one green LED to indicate that there is external power to the module. For proper operation, the green LED must be lit any time the Atlas system is being used.

Wiring

The relay module requires an external 18 to 32 Vdc power supply and a wiring harness. One end of this cable has been stripped back several inches, and individual wires are labeled with the terminal numbers of the appropriate terminals used on the Atlas power supply board. Refer to the following plant wiring diagram and the power supply chapter of this manual for more details.
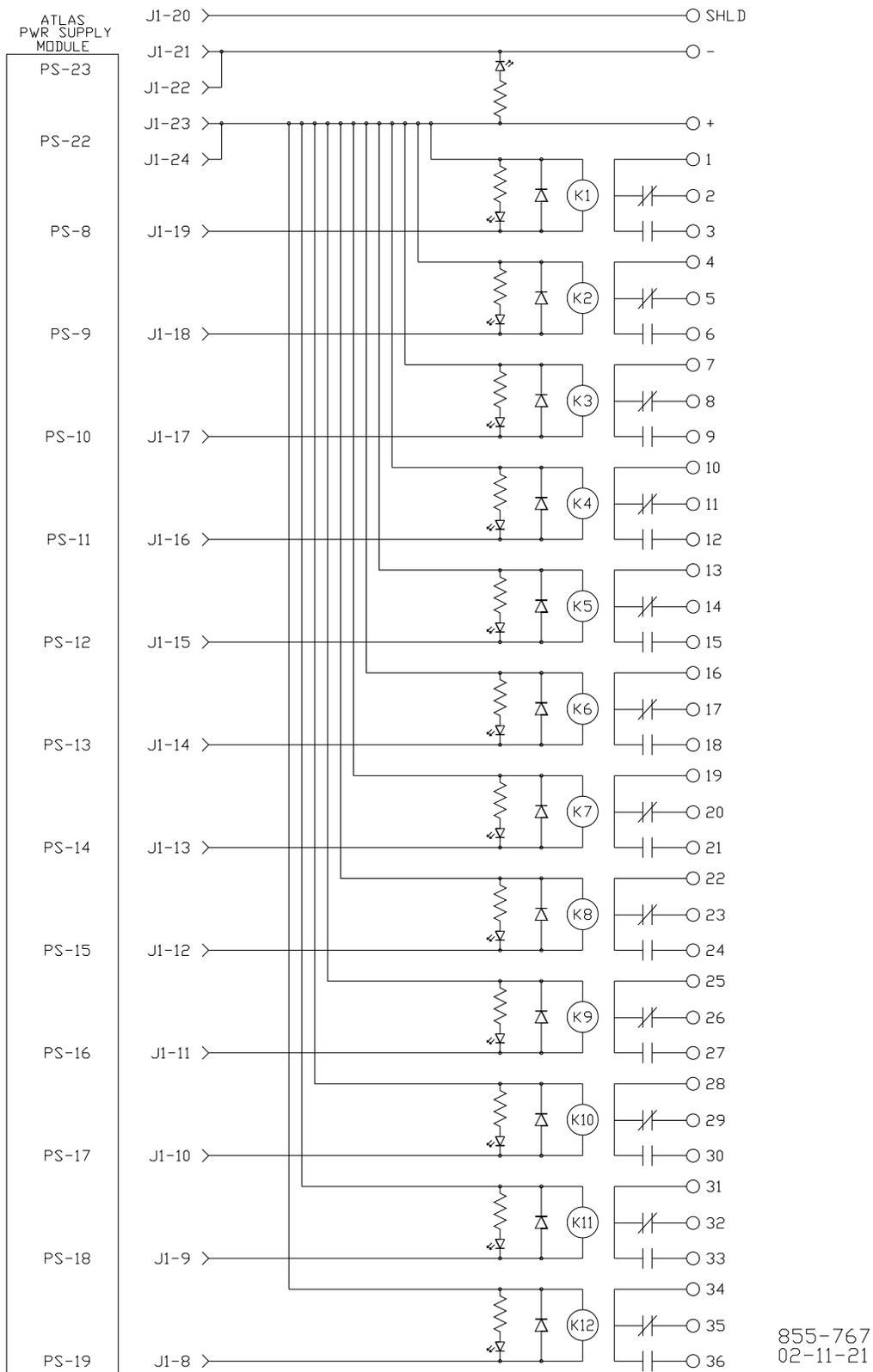
Figure 7-2. 12-Channel Relay Module Connections

Chapter 8.
Distributed I/O

General Description

The AtlasSC™ control has been designed for limited I/O applications. If additional I/O is required, the use of third party distributed I/O modules connected to a serial port on the SmartCore board can be used to augment the AtlasSC I/O. This chapter explains the use of these distributed I/O modules and gives specific examples of two commonly used brands. Distributed I/O modules are limited in their update rates and therefore are not recommended for core control applications. They are ideal for use with secondary limit monitoring, auxiliary controls, and instrumentation display requirements.

This chapter has been divided into two sections. The Serial Interface section contains general information on hardware for end users and software for application developers. The Distributed I/O Example section contains a detailed example of an Automation Direct setup. We hope that this specific example of I/O module configurations can be used as a foundation for building a majority of the AtlasSC control applications where Distributed I/O is needed.

Serial (Modbus) Interface

The AtlasSC control supports industry standard AEG-Modicon Inc.'s Modbus® protocol. The Modbus protocol determines how the master and slaves establish and break off contact, how the sender and receiver are identified, how messages are exchanged in an orderly manner, and how errors are detected. The protocol also controls the query and response cycle which takes place between the master and slave devices.

Modbus is an application layer messaging protocol, at level 7, as defined in the OSI (Open System Interconnection) model. It provides client/server communication between devices connected on different types of buses or networks. It is a request/reply protocol and offers services specified by function codes. Modbus function codes are elements of Modbus request/reply PDUs (Protocol Data Unit).

Modicon developed the Modbus addressing scheme around the data table and I/O structure in Modicon PLCs.

Serial Software and Hardware Requirements
- GAP™ Programming Tool (all versions)
- Serial Cables and Connectors
- Slave Interface and Modules
- Device Memory Maps and Scaling (Manuals)
- Woodward Interface Tools

Serial (Modbus) Port Protocols
There are up to three serial communication ports on the Atlas platform that may be used for the Modbus interface. Modbus can use RS-232, RS-422, and RS-485 configurations. The first two ports on the SmartCore board may be configured for RS-232, RS-422, or RS-485 and the last port is configurable for RS-232 only.

RS-232—An ANSI (American National Standards Institute) standard definition of electrical, functional, and mechanical connections for communications between DTE (Data Terminal Equipment) and DCE (Data Communications Equipment) such as connection of a computer to a modem. It has gained wide usage in very short-distance applications (15m/50 ft). In practice the standard is largely ignored beyond the most rudimentary implementation of electrical signals (±3 to ±15 volts). Woodward's implementation will support speeds up to 115K baud in AtlasSC systems. The actual specification allows 19.2K baud at up to 15 m (50 ft).

RS-422—Also an ANSI standard definition of electrical connections for communications between devices. Because it uses balanced drivers, it can communicate over long distances (1200 m/4000 ft) at high baud rates. Woodward's implementation of RS-422 supports data rates up to 115K baud. In addition to the standard RS-422 features, a multidrop function is implemented as well. This allows more than one device to be connected to a common bus (up to 32 devices) with a single master requesting data. It requires two twisted pairs and ground to operate.

RS-485—Also an ANSI standard definition of electrical connections for communications between devices. This protocol is implemented identically to RS422 at Woodward with the exception that only one twisted pair is required. Both transmitted and received data use the same pair of wires. A ground wire may or may not be required, depending on whether the grounds are connected through the chassis or other connections.

Connectors Pinouts

Table 8-1. SmartCore SIO # 1 Connector and Pinout
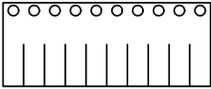
Connector	Terminal	Signal Mnemonic
PHOENIX	SmartCore with Actuator Pinout	
1	93	232 TXD
2	94	232 RXD
3	95	SIG GND
4	96	422/485 (+) RECEIVE
5	97	TERM RES. +
6	98	TERM RES. -
7	99	422/485 (–) RECEIVE
8	100	422 (+) TRANSMIT
9	101	422 (1) TRANSMIT
10	102	SHLD (CHASSIS)

Table 8-2. SmartCore SIO # 2 Connector and Pinout
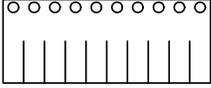
Connector	Terminal	Signal Mnemonic
PHOENIX	SmartCore with Actuator Pinout	
1	83	232 TXD
2	84	232 RXD
3	85	SIG GND
4	86	422/485 (+) RECEIVE
5	87	TERM RES. +
6	88	TERM RES. -
7	89	422/485 (–) RECEIVE
8	90	422 (+) TRANSMIT
9	91	422 (1) TRANSMIT
10	92	SHLD (CHASSIS)

Table 8-3. SmartCore SIO # 3 Connector and Pinout

Connector	Signal Mnemonic
DB9F	Shielded DB9 female receptacle
1	--
2	RXD
3	TXD
4	--
5	GND
6	--
7	--
8	--
9	--
Shield	--
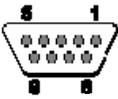
Network Wiring
See Chapter 4 for serial I/O wiring.

Network Length
When choosing a transmission line for RS-232, RS-422, or RS-485, it is necessary to examine the required distance of the cable and the data rate of the system. Losses in a transmission line are a combination of ac losses (skin effect), dc conductor loss, leakage, and ac losses in the dielectric.

	Maximum Distances
RS-232	15 m (50 ft)
RS-422, RS-485	1219 m (4000 ft)

Serial (Modbus) Slave Hardware
The AtlasSC control system may control Modbus slave modules from many different manufacturers. With the exception of Woodward-manufactured devices, Woodward makes no expressed or implied statement of suitability of these devices. It is the user's responsibility to ensure EMC compliance of their system, if necessary, by using distributed modules that are CE compliant. The following Serial Modbus slave hardware has been tested with the AtlasSC control to confirm functionality.

1) All Woodward devices designed for Modbus.

2) Automation Direct Terminator I/O

Part Number	Description
T1K-01AC	Power Supply
T1K-01DC	Power Supply
T1K-MODBUS	Modbus Interface
T1K-08ND3	Discrete Input (Sink)
T1K-16ND3	Discrete Input (Sink)
T1K-16TD1	Discrete Output
T1K-08TRS	Discrete Output (Relay)
T1F-16AD-1	Analog Input (Current)
T1F-16DA-1	Analog Output (Current)
T1F-14THM	Thermocouple Input
T1K-08B-1	Terminal Base
T1K-16B-1	Terminal Base

Serial (Modbus) Software

IMPORTANT | **Many end users will be purchasing pre-programmed AtlasSC units and will not need the information in this section. The information below is aimed at programmers using the GAP programming tool provided by Woodward. The information provided here covers the basics.**

Programmers will need the following:
- Device memory maps and scaling (Manuals)
- GAP Programming Tool (all versions) to create the application. (This can be downloaded from our website:
- **www.woodward.com/software**

The AtlasSC is configured to communicate with a serial network by performing the following steps:
1. Determine slave and I/O modules to be used.
2. Determine order of I/O modules.
3. Review the Serial Modbus slave manuals and understand the hardware addressing.
4. Create GAP application which reads and writes to the Serial I/O.
5. Transfer GAP application to AtlasSC control.
6. Start GAP application.

Serial (Modbus) Software Configuration (Protocol)
The AtlasSC supports both the ASCII and RTU versions of the Modbus protocol. RTU is more widely used since it is the more efficient of the two.
- ASCII: hex coding / 7 bits per character (4 transmitted) / any parity / 1 or 2 stop bits
- RTU: 8 bit binary coding / 8 bits per character (8 transmitted) / any parity / 1 or 2 stop bits

RTU sends data in 8-bit binary characters. ASCII firsts divides each RTU character into two 4-bit parts (high order and low order) and then represents them by their hexadecimal equivalent. The ASCII characters representing the hexadecimal characters are used to construct the message thus using twice as many characters as RTU mode. Additionally, RTU message characters are transmitted in a continuous stream, whereas ASCII can have breaks of up to one second between characters.

The following is a guideline for configuring a serial port interface from the control to a communication device.

Table 8-4. Serial Port Interface Guideline

	Modbus RTU
BAUD	10 (38400)
BITS	2 (RTU-8 bits)
STOP	1 (1 stop)
PARITY	1 (none)
MODE	1 (line)
FLOW	1 (off)
ECHO	1 (off)
ENDLINE	3 (crlf)
IGNCR	1 (off)

Serial (Modbus) Software Configuration (GAP)
See the next section for specific configuration examples for Automation Direct applications.

After the GAP application has been completed, it must be compiled and downloaded to the AtlasSC control using AppManager. Once the GAP application is started on the AtlasSC, the Serial Modbus module will automatically initialize and start the Modbus Network.

IMPORTANT	**The timing of the serial scan rate will depend on the number of groups (heads) and the number of nodes (I/O modules) in the network and will be independent of the rate group structure.**

Distributed I/O Example

This section documents the hardware setup and software configuration for one manufacturer of Distributed I/O modules. Since there are numerous options available from numerous manufacturers, Woodward chose Automation Direct Terminator I/O hardware as a system representative. There are other good high-end and low-cost manufacturers of Distributed I/O systems, and therefore this example should not be taken as a Woodward endorsement. The I/O configurations were limited to specific I/O modules and a limited application of the possible options available with these modules.

It is the responsibility of the end user to review the options available from each distributed I/O supplier and derive the necessary software configurations needed to support their specific applications. Woodward makes no expressed or implied statement of suitability for Automation Direct or any other supplier of Distributed I/O systems. We hope that this specific example of I/O module configurations can be used as a foundation for building a majority of the AtlasSC control applications where Distributed I/O is needed. Ease in applying the Woodward software interface may differ from vendor to vendor. Due to limited resources, Woodward can only supply limited technical support for those applications using other vendors or part numbers not shown in these examples. If extensive support is required, contact Woodward for setting up an application development contract.

At this writing, Automation Direct has Modbus Interface Modules that are compatible with the AtlasSC serial interface.

The following example will demonstrate a systematic process to use in generating a distributed I/O network.

Implementing a Distributed I/O Network
1. Determine the number and type of I/O channels needed.
2. Select the best manufacturer of I/O modules that meet the network and I/O requirements.
3. Lay out the hardware configuration (how the modules will be arranged and wired).
4. Create the Modbus addressing configuration.
5. Generate an address spreadsheet to track address numbers for Reads and Writes based on the specific module memory maps.
6. Review the published documentation on the I/O modules and select the options required.
7. Generate the GAP I/O files.
8. Wire control and Distributed I/O network.
9. Download the GAP into the control.
10. Run application and verify functionality.

Automation Direct Terminator I/O Modbus Configuration

The Terminator I/O is a modular system which combines the functions of terminal blocks and I/O modules for distributed I/O. Each Terminator I/O system has the following components: a Power Supply, a Base Controller, and one or more I/O Module(s). Terminator I/O systems can contain up to 16 I/O modules per slave (node). Each slave (node) system can be divided into one row of base I/O plus two rows of local expansion I/O using a base expansion cable.

In this example, one T1K-MODBUS adapter and two power supplies from Automation Direct are interfaced with seven terminal base units with installed Terminator I/O modules, forming a Terminator I/O system.

The T1K-MODBUS is a Network Interface Adapter that communicates between the Terminator I/O modules backplane and the AtlasSC/Master across a serial RS-232 connection. The T1K-MODBUS module is a slave device to the AtlasSC control, and is a master controller of the Terminator I/O modules. The I/O data exchange occurs as follows. Output data is sent from the AtlasSC across the RS-232 connection to the T1K-MODBUS adapter. The network interface adapter then automatically transfers the data across the Terminator I/O backplane to the output modules. Inputs from the input modules are collected by the network interface adapter via the backplane and sent across the RS-232 connection to the AtlasSC control.

In order to simplify the nomenclature used in creating the GAP application, certain naming conventions were changed with respect to the manufacturer's naming convention. In this example, Woodward refers to the node address as the Group address. The T1K-MODBUS Group address, (Node address), is set by two rotary switches located on the front of the T1K-MODBUS module. In this example the address is set to 01.

The Automation Direct Terminator I/O system requires DIN rail mounted power supplies to power the individual I/O module over the Terminator I/O back plane. In this example, a 120 Vac unit (T1K_01AC) was used to power the Discrete I/O modules and a 24Vdc unit (T1K-01DC was used to power the Analog I/O modules.

In this example, the power supplies were also used to generate the needed current for the externa`l power requirements of the circuits. See Figure 8-1 for Automation Direct Terminator I/O configuration layout.
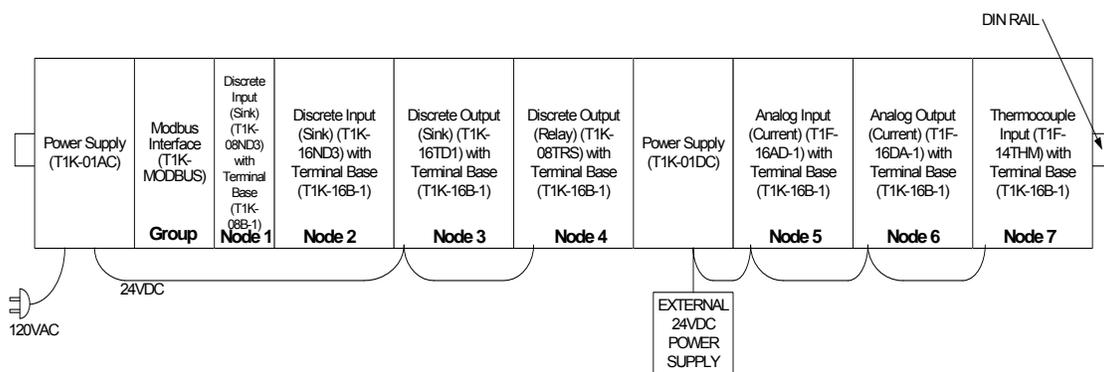
Figure 8-1. Automation Direct Terminator I/O Configuration

Address Spreadsheet

The I/O map for a module is divided into read words and write words. Read words consist of input and status words, and write words consist of output and configuration words. The number of read words or write words can be 0 or more.

To keep track of the addressing for all of the reads and writes, an address spreadsheet is very useful. This address spreadsheet can be derived from memory maps in the I/O modules User Manual and the network interface module (head) T1K-MODBUS User Manual. These memory maps define which addresses to allocate within the Address Spreadsheet. Not all of the addresses allocated to each module are written to or read from. Some addresses are either not used or reserved. See specific I/O module memory maps for detail functionality used to define the GAP reads and writes. The Automation Direct Terminator I/O system addresses its discrete I/O by bits and analog I/O by words. See Table 8-1 for the address spreadsheet for this example.

Nomenclature
When creating a new GAP application, it is important to establish a well organized block naming convention up front. Once done, it is easier to find specific functions and I/O within a large GAP application.

GAP Application
In order to communicate between the Atlas serial RS-232 port and the T1K-MODBUS, a MOD_PORT and MODBUS_M block must be defined in GAP. The MOD_PORT block defines the serial communications baud rate, stop, parity, and type of interface (RS-232, -422, -485). The MODBUS_M block defines the addressing for Modbus communications between the Atlas and the distributed I/O. Based on the Address Spreadsheet, this block can be customized to read and write to appropriate addresses. See Figure 8-2 for MODBUS_M/MOD_PORT setup example.
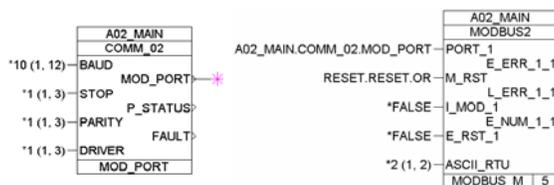
Figure 8-2. MODBUS_M Block Example

The E_ERR_1_x output field on the MODBUS_M block is used to display Exception Error on PORT_1 per RPTx. It latches TRUE when an exception error is detected. E_NUM_1_X (hidden) displays the error number. See Table 8-2 for exception errors.

Table 8-1. Modbus Word Address Spreadsheet

Module	Byte #	Read Address Bits	Write Address Bits
T1K-MODBUS	0	None	None
T1K-08ND3	0	10000-10008	None
T1K-16ND3	0	10009-10016	None
	1	10017-10024	None
T1K-16TD1	0	None	00000-00008
	1	None	00009-00016
T1K-08TRS	0	None	00017-00024
Module	Word #	Read Addr. Words	Write Addr. Words
T1F-16AD-1	0	30001	None
	1	30002	
	2	30003	
	3	30004	
	.	.	
	.	.	
	.	.	
	29	30030	
	30	30031	
	31	30032	
T1F-16DA-1	0	None	40001
	1		40002
	2		40003
	3		40004
	.		.
	.		.
	.		.
	29		40030
	30		40031
	31		40032
T1F-14THM	0	30033	None
	1	30034	
	2	30035	
	3	30036	
	.	.	
	.	.	
	.	.	
	29	30062	
	30	30063	
	31	30064	

Use the following documents from the manufacturer to obtain the Memory Maps and related information.

Module	Document P/N
I/O modules	T1K-INST-M
Modbus Interface	T1K-MODBUS-M

Table 8-2. MODBUS_M Exception Errors

CODE	NAME	MEANING
The following are generated by the slave.		
00	NO ERROR	Error free
01	ILLEGAL FUNCTION	Message function received is not an allowable action for addressed slave. (Unsupported or illegal function code).
02	ILLEGAL DATA ADDRESS	Address referenced in data field is not an allowable address for the addressed slave location. (Master requested data which is not configured from slave).
03	ILLEGAL DATA VALUEA	mount of data requested from slave was too large for slave to return in a single response.
The following are generated by the master.		
09	CHECKSUM ERROR	Error in checksum in message from slave. Can indicate link quality and/or noise problems.
10	GARBLED MESSAGE	Data received from the slave, but is too short to be a valid Modbus message/response.
20	UNSOLICITED RESPONSE	Unsolicited message received from slave.
21	BAD FC IN RESPONSE	Slave returned a message with a different function code from the command sent.
22	BAD ADD IN RESPONSE	Slave returned a message with a different address from the command sent.
23	NO SLAVE RESPONSE	No response from slave.
24	MOE/CODER ERROR	MOE/CODER error.
25	INTERNAL SYS ERROR	Internal system error.

The L_ERR_1_x is used to display Link Error on PORT_1 for RPTx. It goes TRUE when the slave fails to answer a data request. If a response isn't received in TIME_OUT_x seconds, the request is retried. If a response isn't received in TIME_OUT_x seconds after the request is retried, then this output is set true.

While waiting for a response from one slave, the master is not communicating with the other slaves. So, if multiple slaves fail at the same time (i.e. broken cable), the L_ERR_1_x for the first slave attempted will occur at 2 x TIME_OUT_x. But, the second L_ERR_1_x won't go true until 2 x TIME_OUT_x after the first failure because no communications are attempted with that slave until after the first has timed out.

In this example, the TIK-MODBUS adapter is configured for the 584 / 984 Addressing mode (Dip switch 7). See Figure 8-3, for the full T1K-MODBUS adapter addressing table.

Figure 8-3. T1K-MODBUS Adapter Addressing Table

Modbus Data Type		T1K–MODBUS		
		Range (Decimal)	Points	Memory Type
Coil		1 – 1024	1024	Discrete Output
		1025 – 9999	–	not supported
Input		10001 – 11024	1024	Discrete Input
		11025 – 19999	–	not supported
Modbus Data Type		V Memory Range		
		Range (Decimal)	Words (16– bit)	Channel (32– bit)	Memory Type
Input Register	Analog Input	30001 – 30128	128	64	Analog Input Register
	Input Register	30129 – 38999	–	–	not supported
	Bit Input Register	30201 – 30264	64	–	Discrete Input Bit Register
	Input Register	39129 – 39999	–	–	not supported
Hold Register	Analog output	40001 – 40128	128	64	Analog Output Register
	Hold Register	40129 – 40200	–	–	not supported
	Bit Output Register	40201 – 40264	64		Discrete Output Bit Register
	Hold Register	40265 – 49000	–	–	not supported
	Hold Register	49001 – 49128	128	–	Special Register
	Hold Register	49129 – 49999	–	–	not supported

In the RPT window for the MODBUS_M block, the BR_F_CODE and AR_F_CODE fields specify the Boolean and Analog read Function Codes for Modbus. The Boolean Read Function Code input defines the Boolean read and write addresses as follows:
1 = 00001–0FFFF Input Coils (Boolean READ/WRITE)
2 = 10001–1FFFF Input Status (Boolean READ ONLY)

The Analog Read Function Code input defines the Analog read and write addresses as follows:
3 = 40001–4FFFF Holding Registers (Analog READ/WRITE)
4 = 30001–3FFFF Input Registers (Analog READ ONLY)

By setting the BR_F_CODE to 2 and the AR_F_CODE field to 4 (defaults), the MODBUS_M block will access the following addresses as specified by the 584/984 Addressing mode of the T1K-MODBUS adapter:

1–1024   Discrete Outputs
10001–11024 Discrete Inputs
30001–30128 Analog Input Registers
30201–30264 Bit Input Registers
40001–40128 Analog Output Registers
40201–40264 Bit Output Registers

The S_ADD_1 field must agree with the Group or Node address for the T1K-MODBUS adapter. In this example, the address is set to 01 which matches the two rotary switch settings on the adapter. See Figure 8-4 for example of MODBUS_M repeat fields.

hide	< S_ADD_1	1
hide	< S_IP_1_1	[0]
hide	< S_IP_2_1	[0]
hide	< S_IP_3_1	[0]
hide	< S_IP_4_1	[0]
hide	< S_PORT_1	[0]
show	< I_MOD_1	*FALSE
show	< E_RST_1	*FALSE
hide	< TIMEOUT_1	[1.5]
show	> E_NUM_1_1	
show	> E_ERR_1_1	
show	> L_ERR_1_1	
hide	> E_NUM_2_1	
hide	> E_ERR_2_1	
hide	> L_ERR_2_1	
hide	< BW_ADD_1	0
>>	RPTbw1	
hide	< BR_F_CODE_1	[2]
hide	< BR_ADD_1	0
>>	RPTbr1	
hide	< AR_F_CODE_1	[4]
hide	< AR_ADD_1	
>>	RPTar1	
hide	< AW_ADD_1	0
>>	RPTaw1	

Figure 8-4. MODBUS_M Block RPT Example

Within the MODBUS_M RPT window, there are four repeats (RPTbw1, RPTbr1, RPTar1, and RPTaw1). Each one of these RPT fields opens another window which displays the addresses assigned for that particular RPT. See the specific module sections below for memory map function assignment. Example for the T1K-08ND3 module bits (BR_V_1_1): since the starting address is 10000, the BR_F_CODE = 2. The BR_ADD_1 offset is 0. Therefore the T1K-08ND3 module bit (BR_V_1_1) has an address of 10000 + 0 + 1 = 10001. All of the addresses specified in the address spreadsheet are mapped into the MODBUS_M block by applying this formula. See Figures 8-5, 8-6, 8-7, and 8-8 for all read/write address windows. Figure 8-5 shows the write addresses for the discrete output modules (T1K-16TD1 and T1K-08TRS), addresses 00001 to 00024.

hide	< BW_C_1_1	16TD1 CH1		hide	< BW_C_1_13	16TD1 CH13
hide	< BW_V_1_1	AD16TD1.BO_01.B_NAME		hide	< BW_V_1_13	AD16TD1.BO_13.B_NAME
hide	< BW_C_1_2	16TD1 CH2		hide	< BW_C_1_14	16TD1 CH14
hide	< BW_V_1_2	AD16TD1.BO_02.B_NAME		hide	< BW_V_1_14	AD16TD1.BO_14.B_NAME
hide	< BW_C_1_3	16TD1 CH3		hide	< BW_C_1_15	16TD1 CH15
hide	< BW_V_1_3	AD16TD1.BO_03.B_NAME		hide	< BW_V_1_15	AD16TD1.BO_15.B_NAME
hide	< BW_C_1_4	16TD1 CH4		hide	< BW_C_1_16	16TD1 CH16
hide	< BW_V_1_4	AD16TD1.BO_04.B_NAME		hide	< BW_V_1_16	AD16TD1.BO_16.B_NAME
hide	< BW_C_1_5	16TD1 CH5		hide	< BW_C_1_17	08TRS CH1
hide	< BW_V_1_5	AD16TD1.BO_05.B_NAME		hide	< BW_V_1_17	AD08TRS.BO_1.B_NAME
hide	< BW_C_1_6	16TD1 CH6		hide	< BW_C_1_18	08TRS CH2
hide	< BW_V_1_6	AD16TD1.BO_06.B_NAME		hide	< BW_V_1_18	AD08TRS.BO_2.B_NAME
hide	< BW_C_1_7	16TD1 CH7		hide	< BW_C_1_19	08TRS CH3
hide	< BW_V_1_7	AD16TD1.BO_07.B_NAME		hide	< BW_V_1_19	AD08TRS.BO_3.B_NAME
hide	< BW_C_1_8	16TD1 CH8		hide	< BW_C_1_20	08TRS CH4
hide	< BW_V_1_8	AD16TD1.BO_08.B_NAME		hide	< BW_V_1_20	AD08TRS.BO_4.B_NAME
hide	< BW_C_1_9	16TD1 CH9		hide	< BW_C_1_21	08TRS CH5
hide	< BW_V_1_9	AD16TD1.BO_09.B_NAME		hide	< BW_V_1_21	AD08TRS.BO_5.B_NAME
hide	< BW_C_1_10	16TD1 CH10		hide	< BW_C_1_22	08TRS CH6
hide	< BW_V_1_10	AD16TD1.BO_10.B_NAME		hide	< BW_V_1_22	AD08TRS.BO_6.B_NAME
hide	< BW_C_1_11	16TD1 CH11		hide	< BW_C_1_23	08TRS CH7
hide	< BW_V_1_11	AD16TD1.BO_11.B_NAME		hide	< BW_V_1_23	AD08TRS.BO_7.B_NAME
hide	< BW_C_1_12	16TD1 CH12		hide	< BW_C_1_24	08TRS CH8
hide	< BW_V_1_12	AD16TD1.BO_12.B_NAME		hide	< BW_V_1_24	AD08TRS.BO_8.B_NAME

Figure 8-5. MODBUS_M Block Boolean Write RPT Example

Figure 8-6 shows all of the used read input addresses for Discrete Input modules (T1K-08ND3 and T1K-16ND3), addresses 10001 to 10024.

Figure 8-6. MODBUS_M Block Boolean Read RPT Example

Figure 8-7 shows all of the used read input addresses for analog Input modules (T1F-16AD-1 and T1F-14THM), addresses 30001 to 30060.

IMPORTANT	The Automation Direct analog modules use two address words per channel. The first word is used, and the second is not used. The unused address must be accounted for when addressing the modules and therefore requires each channel to increment by two addresses. Example: 2X16 addresses for the T1F-AD-1 module + 2X14 addresses for the T1F-14THM module = 60 addresses total.

Figure 8-7. MODBUS_M Block Analog Read RPT Example

Figure 8-8 shows all of the used write output addresses for the analog output module (T1F-16DA-1), addresses 40001 to 40032.

IMPORTANT	The Automation Direct analog modules use two address words per channel. The first word is used, and the second is not used. The unused address must be accounted for when addressing the modules and therefore requires each channel to increment by two addresses.

hide < AW_C_1_1	16DA-1 CH1	
hide < AW_V_1_1	AD16DA-1.AO_01.CURVE_2D	
hide < AW_M_1_1	(1.0)	
hide < AW_C_1_2	16DA-1 MODULE CONTROL BYTE	
hide < AW_V_1_2	AD16DA-1.MODCTLBYTE.OUT_1	
hide < AW_M_1_2	(1.0)	
hide < AW_C_1_3	16DA-1 CH2	
hide < AW_V_1_3	AD16DA-1.AO_02.CURVE_2D	
hide < AW_M_1_3	(1.0)	

Figure 8-8. MODBUS_M Block Analog Write RPT Example

Automation Direct Modbus Interface (T1K-MODBUS) Module
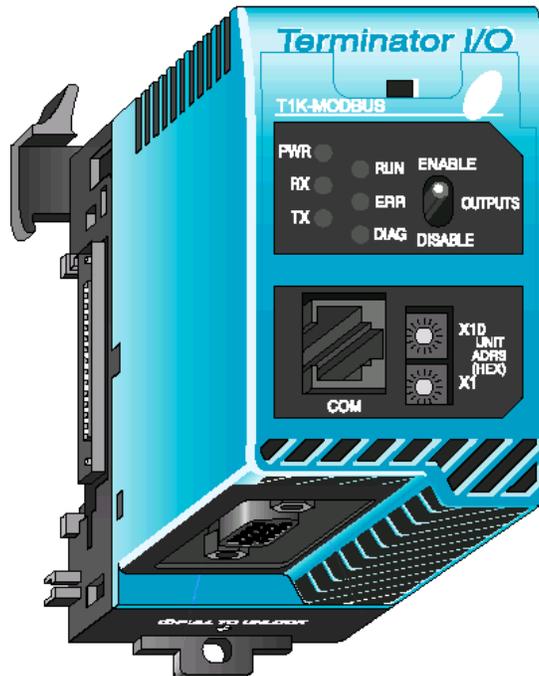
In this example, the T1K-MODBUS adapter was set up for RS-232 communications. The T1K-MODBUS RS-232 communications setup must be configured manually with DIP switches located on the Adapter. These DIP switches must agree with the settings specified in the MOD_PORT and MODBUS_M blocks. The MOD_PORT block uses 8 data bits per word. The settings for this example are shown in Figure 8-9, T1K-MODBUS Dip Switch Settings.

Set module DIP switches for Modbus 38400 Baud, Maint port 9600.

		Off On	
Modbus port	Sw 1		On
	Sw 2		On
	Sw 3		On
Comm Setting	Sw 4		Off
Hold Outputs	Sw 5		Off
Maintenance Port Baud Rate	Sw 6		Off
Address Mode	Sw 7		Off
RTS/CTS	Sw 8		Off
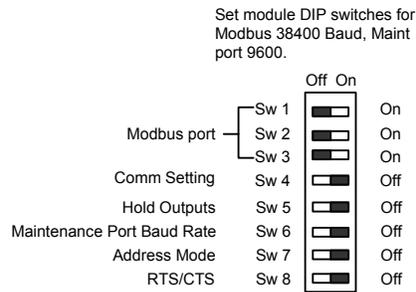
Figure 8-9. T1K-MODBUS Dip Switch Settings

This configures the module for 38400 Baud rate (Sw1-3), default communication setting mode (Sw4), hold outputs off (Sw5), 9600 bps for RJ12 connection (Sw6), 584/984 Modbus slave addressing mode (Sw7), and disable the CTS pin on the RJ12 connector (Sw8). Because the default communications mode is selected, the RJ12 connection is not used. The default communications mode is set for 8 bit communications data, 1 start bit, 1 stop bit, odd parity, 1second communication timeout, and 0 ms RTS Delay time. The MOD_PORT GAP block settings must match these communication settings when configured.

The T1K-MODBUS adapter will support RS-232, RS-422, and RS-485 connections. In this example, the connection between the AtlasSC communications port (Comm 02) and the T1K-MODBUS adapter was wired as a RS-232 connection. See Figure 8-10 for an example of the RS-232 connection.

ATLAS SMARTCORE BOARD
SERIAL PORT

DISTRIBUTED I/O MODBUS MODULE
T1K-MODBUS

A02_MAIN.COMM_02 (RS-232/485/422)	RS-232 TXD	TB10-93	DB15-1	5V
	RS-232 RXD	TB10-94	DB15-2	TXD (RS-232C)
	SIG. GROUND	TB10-95	DB15-3	RXD (RS-232C)
	RS-485/422 (+) RECEIVE	TB10-96	DB15-4	RTS (RS-232C)
	(+) TERM. RES.	TB10-97	DB15-5	CTS (RS-232C)
	(-) TERM. RES.	TB10-98	DB15-6	RXD (-) (RS-422)
	RS-485/422 (-) RECEIVE	TB10-99	DB15-7	LOGIC GROUND
	RS-422 (+) TRANSMIT	TB10-100	DB15-8	LOGIC GROUND
	RS-422 (-) TRANSMIT	TB10-101	DB15-9	TXD (+) (RS-422)
	SHLD (CHASSIS)	TB10-102	DB15-10	TXD (-) (RS-422)
			DB15-11	RTS (+) (RS-422)
			DB15-12	RTS (-) (RS-422)
			DB15-13	RXD (+) (RS-422)
			DB15-14	CTS (+) (RS-422)
			DB15-15	CTS (-) (RS-422)

Figure 8-10. Automation Direct Modbus RS-232 Serial Connection

The Automation Direct T1K-MODBUS adapter doesn't reserve any read or write addresses for status words.

Automation Direct Discrete Input (Sink) (T1K-08ND3) Module
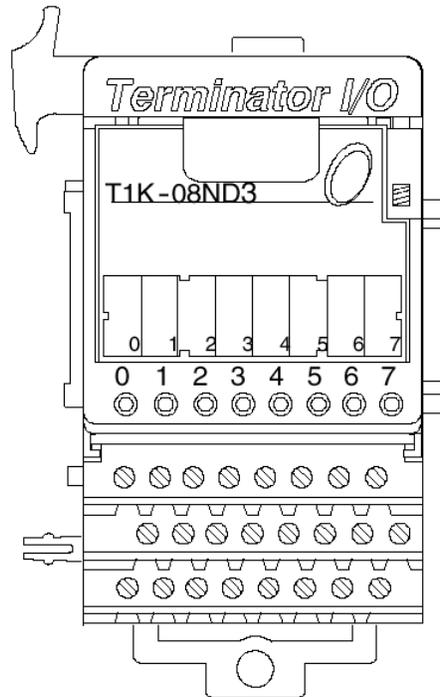
The T1K-08ND3 can be configured for sink or source detection with internal or external power. In this example, the unit is configured for sink mode with external power. This configuration is set up with jumpers located on the module. See Figure 8-11 for T1K-08ND3 Sink/External Power Configuration.
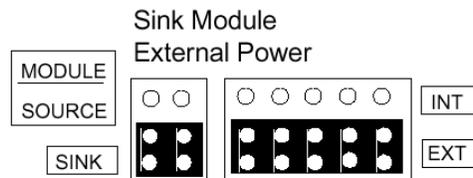
Figure 8-11. T1K-08ND3 Sink/External Power Configuration

See Figure 8-12 for example of T1K-08ND3 module wiring.

DISTRIBUTED I/O Automation Direct T1K-08ND3 DISCRETE INPUT		
MBI.A1.A02.G1.N1_BI_01	Input	Input 0
	Common	Com0-0
	Internal Supply Voltage	V0-0
MBI.A1.A02.G1.N1_BI_02	Input	Input 1
	Common	Com0-1
	Internal Supply Voltage	V0-1
MBI.A1.A02.G1.N1_BI_03	Input	Input 2
	Common	Com0-2
	Internal Supply Voltage	V0-2
MBI.A1.A02.G1.N1_BI_04	Input	Input 3
	Common	Com0-3
	Internal Supply Voltage	V0-3
MBI.A1.A02.G1.N1_BI_05	Input	Input 4
	Common	Com1-4
	Internal Supply Voltage	V1-4
MBI.A1.A02.G1.N1_BI_06	Input	Input 5
	Common	Com1-5
	Internal Supply Voltage	V1-5
MBI.A1.A02.G1.N1_BI_07	Input	Input 6
	Common	Com1-6
	Internal Supply Voltage	V1-6
MBI.A1.A02.G1.N1_BI_08	Input	Input 7
	Common	Com1-7
	Internal Supply Voltage	V1-7

Figure 8-12. T1K-08ND3 Module Wiring
(example)

The T1K-08ND3 memory map indicates that there is one read byte (8 bits) address and no write addresses. See Figure 8-13 for memory map of Automation Direct T1K-08ND3 Discrete input module.

Memory Map of 8-Point Discrete Input Modules (T1K–08NA–1 and T1K–08ND3)									
Decimal Bit	07	06	05	04	03	02	01	00	Size
Octal Bit	07	06	05	04	03	02	01	00	
	X7	X6	X5	X4	X3	X2	X1	X0	Read Byte 1
Not Used									Write Byte 1

Figure 8-13. T1K-08ND3 Memory Map

The Automation Direct T1K-08ND3 doesn't have any filter or other options to set, therefore there are no write addresses assigned. In this example, each bit is displayed using a B_NAME block. Each block is connected to the specific address in the MODBUS_M block RPT window shown above. See Figure 8-14 for example of T1K-08ND3 Read GAP blocks.
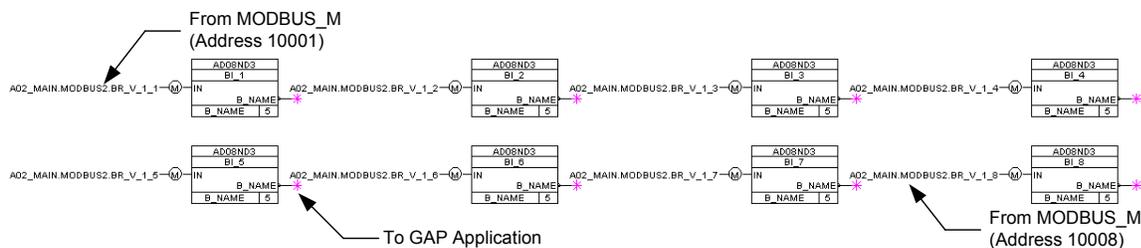
Figure 8-14. T1K-08ND3 Read GAP Blocks
(example)

Automation Direct Discrete Input (Sink) (T1K-16ND3) Module
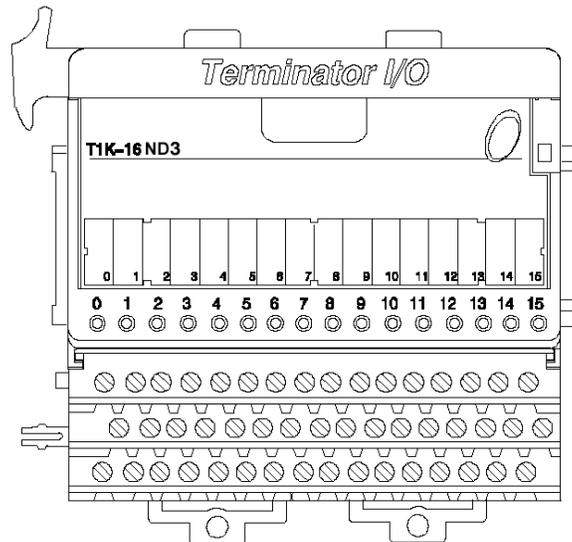
The T1K-16ND3 can be configured for sink or source detection with internal or external power. In this example, the unit is configured for sink mode with external power. This configuration is set up with jumpers located on the module. See Figure 8-15 for T1K-16ND3 Sink/External Power Configuration.
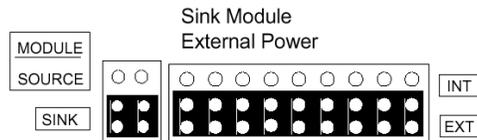
Figure 8-15. T1K-16ND3 Sink/External Power Configuration

See Figure 8-16 for example of T1K-16ND3 module wiring.

DISTRIBUTED I/O
Automation Direct T1K-16ND3

DISCRETE INPUT

MBI.A1.A02.G1.N2_BI_01	Input	Input 0
	Common	Com0-0
	Internal Supply Voltage	V0-0
MBI.A1.A02.G1.N2_BI_02	Input	Input 1
	Common	Com0-1
	Internal Supply Voltage	V0-1
MBI.A1.A02.G1.N2_BI_03	Input	Input 2
	Common	Com0-2
	Internal Supply Voltage	V0-2
MBI.A1.A02.G1.N2_BI_04	Input	Input 3
	Common	Com0-3
	Internal Supply Voltage	V0-3
MBI.A1.A02.G1.N2_BI_05	Input	Input 4
	Common	Com1-4
	Internal Supply Voltage	V1-4
MBI.A1.A02.G1.N2_BI_06	Input	Input 5
	Common	Com1-5
	Internal Supply Voltage	V1-5
MBI.A1.A02.G1.N2_BI_07	Input	Input 6
	Common	Com1-6
	Internal Supply Voltage	V1-6
MBI.A1.A02.G1.N2_BI_08	Input	Input 7
	Common	Com1-7
	Internal Supply Voltage	V1-7
MBI.A1.A02.G1.N2_BI_09	Input	Input 8
	Common	Com2-8
	Internal Supply Voltage	V2-8
MBI.A1.A02.G1.N2_BI_10	Input	Input 9
	Common	Com2-9
	Internal Supply Voltage	V2-9
MBI.A1.A02.G1.N2_BI_11	Input	Input 10
	Common	Com2-10
	Internal Supply Voltage	V2-10
MBI.A1.A02.G1.N2_BI_12	Input	Input 11
	Common	Com2-11
	Internal Supply Voltage	V2-11
MBI.A1.A02.G1.N2_BI_13	Input	Input 12
	Common	Com3-12
	Internal Supply Voltage	V3-12
MBI.A1.A02.G1.N2_BI_14	Input	Input 13
	Common	Com3-13
	Internal Supply Voltage	V3-13
MBI.A1.A02.G1.N2_BI_15	Input	Input 14
	Common	Com3-14
	Internal Supply Voltage	V3-14
MBI.A1.A02.G1.N2_BI_16	Input	Input 15
	Common	Com3-15
	Internal Supply Voltage	V3-15

Figure 8-16 T1K-16ND3 Module Wiring
(example)

The T1K-16ND3 memory map indicates that there are two read byte (16 bits) addresses and no write addresses. See Figure 8-17 for memory map of Automation Direct T1K-16ND3 Discrete input module.

Memory Map of 16-Point Discrete Input Modules								
(T1K–16NA–1 and T1K–16ND3)								
Decimal Bit	07	06	05	04	03	02	01	00	Size
Octal Bit	07	06	05	04	03	02	01	00	Size
	X7	X6	X5	X4	X3	X2	X1	X0	Read Byte 1
	X17	X16	X15	X14	X13	X12	X11	X10	Read Byte 2
Not Used								Write Byte 1

Figure 8-17. T1K-16ND3 Memory Map

The Automation Direct T1K-16ND3 doesn't have any filter or other options to set, therefore there are no write addresses assigned. In this example, each bit is displayed using a B_NAME block. Each block is connected to the specific address in the MODBUS_M block RPT window shown above. See Figure 8-18 for example of T1K-16ND3 Read GAP blocks.
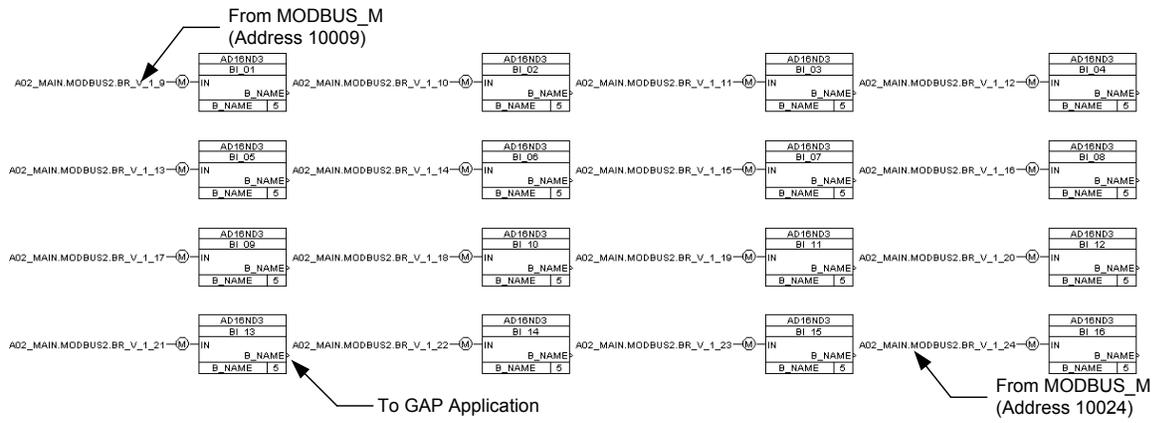
Figure 8-18. T1K-16ND3 Read GAP Blocks
(example)

Automation Direct Discrete Output (Sink) (T1K-16TD1) Module
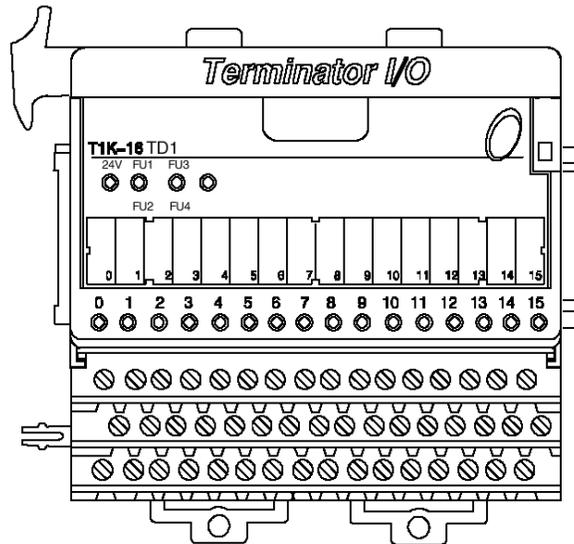
In this example the T1K-16ND3 was connected to a Woodward 16 channel relay module. See Figure 8-19 for example of T1K-16ND3 module wiring.
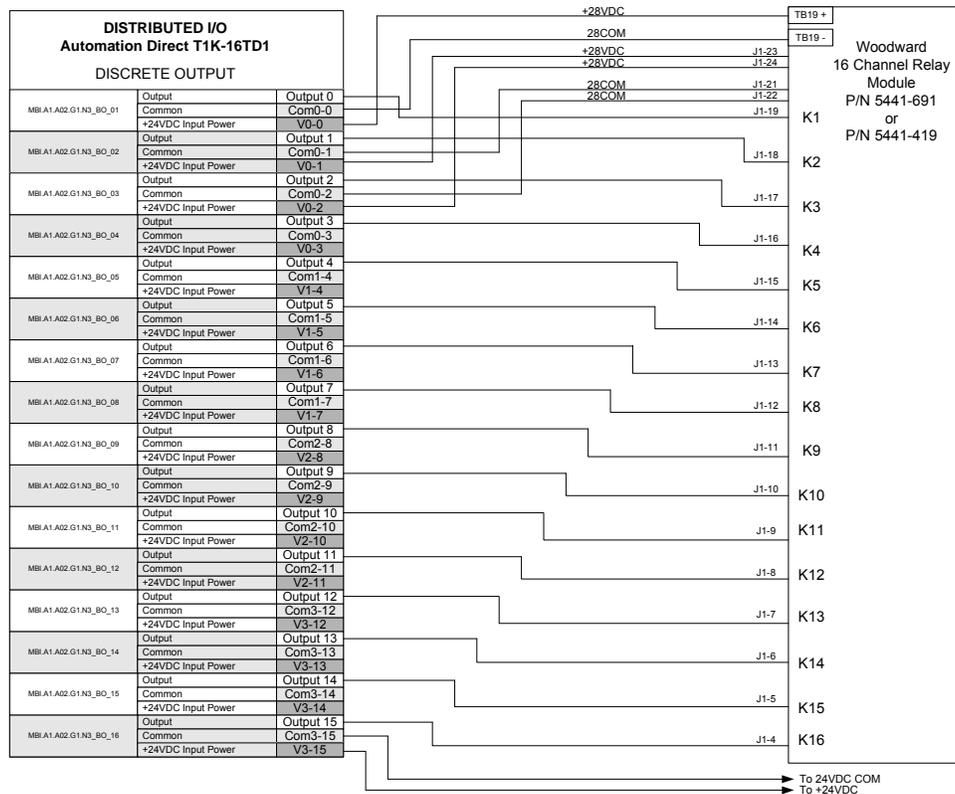
Figure 8-19. T1K-16ND3 Module to Relay Module Wiring
(example)

The T1K-16TD1 memory map indicates that there are no read byte (8 bits) addresses and two write byte (16 bits) addresses. See Figure 8-20 for memory map of Automation Direct T1K-16TD1 Discrete Output module.

Memory Map of 16-Point Discrete Input Modules (T1K–16TA, T1K–16TD1, T1K–16TD2 and T1K–16TR)								
Decimal Bit	07	06	05	04	03	02	01	00	Size
Octal Bit	07	06	05	04	03	02	01	00	
Not Used									Read Byte 1
	Y7	Y6	Y5	Y4	Y3	Y2	Y1	Y0	Write Byte 1
	Y17	Y16	Y15	Y14	Y13	Y12	Y11	Y10	Write Byte 2

Figure 8-20. T1K-16TD1 Module Memory Map

The Automation Direct T1K-16TD1 module doesn't have any status words to read, therefore there are no read addresses assigned. In this example, each bit is written using a B_NAME block. Each block is connected to the specific address in the MODBUS_M block RPT window shown above. See Figure 8-21 for example of T1K-16TD1 write GAP blocks.

To MODBUS_M
(Address 00001)

From GAP Application

To MODBUS_M
(Address 00016)
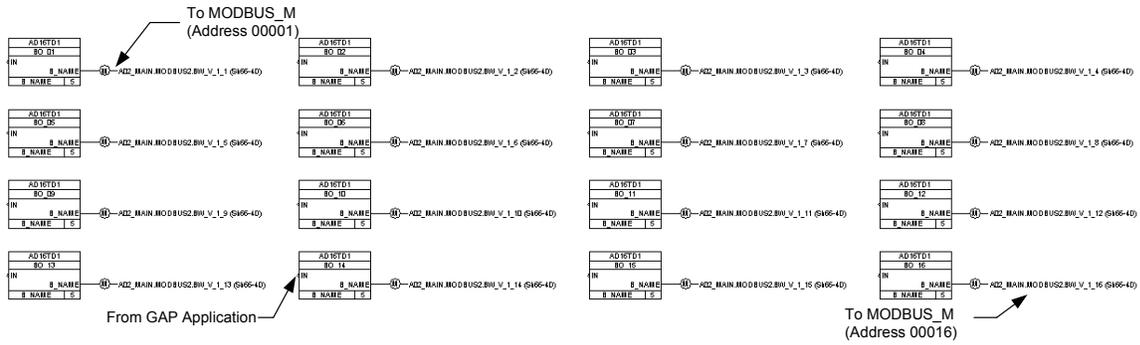
Figure 8-21. T1K-16TD1 GAP Write Blocks
(example)

Automation Direct Relay Output (T1K-08TRS) Module
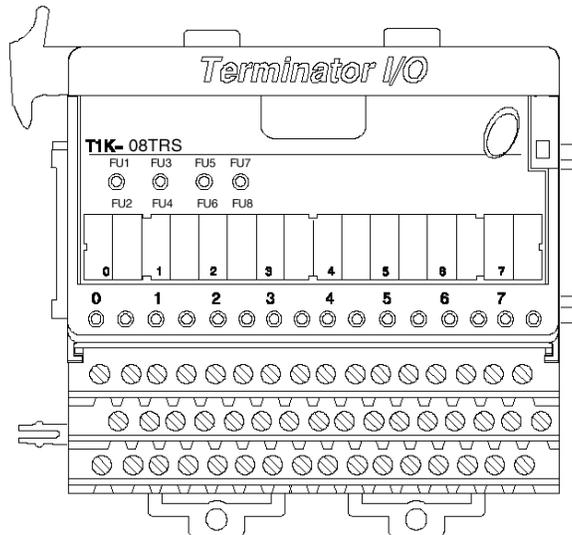
See Figure 8-22 for example of T1K-08TRS module wiring.
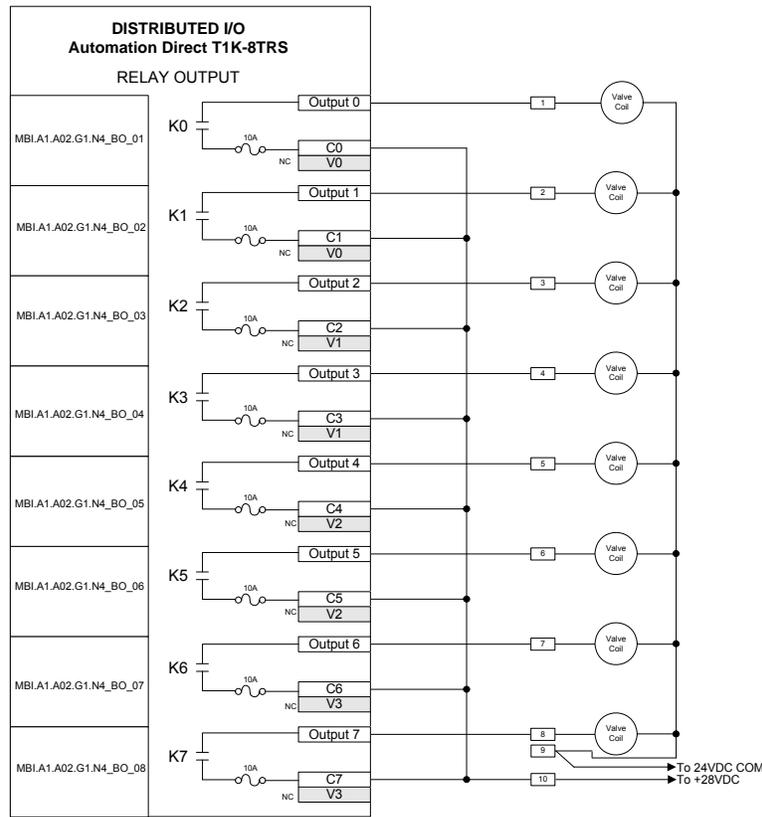
Figure 8-22. T1K-08TRS Module Wiring
(example)

The T1K-08TRS memory map indicates that there are no read byte addresses and one write byte (8 bits) address. See Figure 8-23 for memory map of Automation Direct T1K-08TRS Relay Output module.

Memory Map of 8-Point Discrete Output Modules (T1K–08TA, T1K–08TD1 and T1K–08TR)									
Decimal Bit	07	06	05	04	03	02	01	00	Size
Octal Bit	07	06	05	04	03	02	01	00	
Not Used									Read Byte 1
	Y7	Y6	Y5	Y4	Y3	Y2	Y1	Y0	Write Byte 1

Figure 8-23. T1K-08TRS Module Memory Map

The Automation Direct T1K-08TRS module doesn't have any status words to read, therefore there are no read addresses assigned. In this example, each bit is written using a B_NAME block. Each block is connected to the specific address in the MODBUS_M block RPT window shown above. See Figure 8-24 for example of T1K-08TRS write GAP blocks.
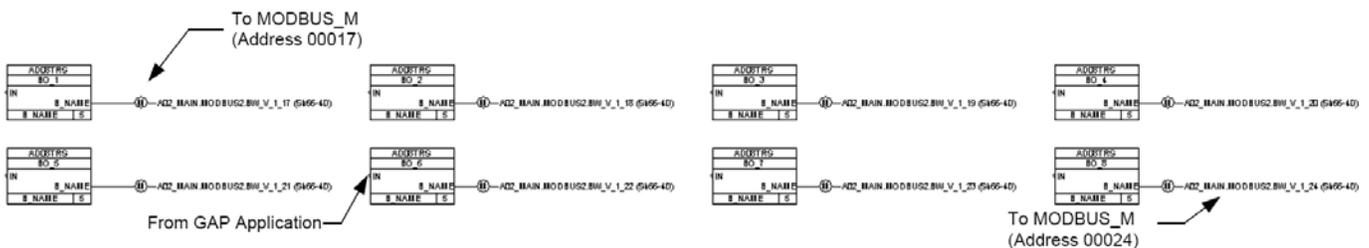
Figure 8-24. T1K-08TRS GAP Write Blocks

(example)

Automation Direct Analog Input (T1F-16AD-1) Module
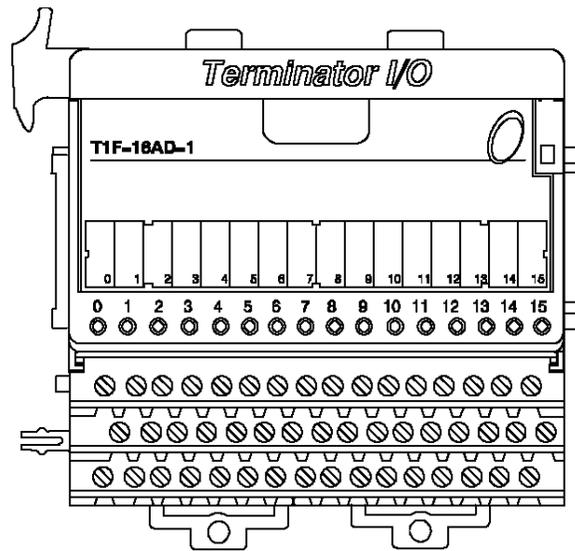
In this example, the T1F-16AD-1 is wired with loop powered transducers. See Figure 8-25 for example of T1F-16AD-1 module wiring.
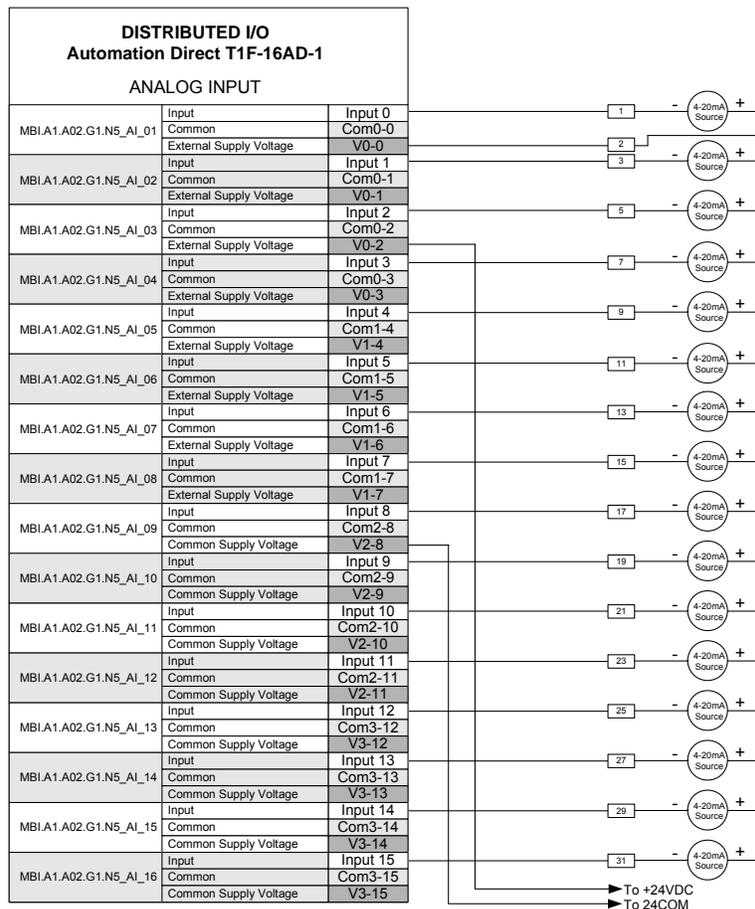
Figure 8-25. T1F-16AD-1 Module Wiring
(example)

The T1F-16AD-1 memory map indicates that there are 64 read byte (32 words) addresses and no write byte addresses. See Figure 8-26 for memory map of Automation Direct T1F-16AD-1 Analog Input module.

Memory Map of 16-Channel Analog Input Module (T1F–16AD)									
Decimal Bit	07	06	05	04	03	02	01	00	Size
Octal Bit	07	06	05	04	03	02	01	00	
Analog Value Channel 1									Read Byte 1
Analog Value Channel 1									Read Byte 2
not used									Byte3
reserved for future use									Byte4
Analog Value Channel 2									Read Byte 5
Analog Value Channel 2									Read Byte 6
not used									Byte7
reserved for future use									Byte8
Analog Value Channel 3									Read Byte 9
Analog Value Channel 3									Read Byte 10
not used									Byte11
reserved for future use									Byte12
Analog Value Channel 4									Read Byte 13
Analog Value Channel 4									Read Byte 14
not used									Byte15
reserved for future use									Byte16
Analog Value Channel 5									Read Byte 17
Analog Value Channel 5									Read Byte 18
not used									Byte19
reserved for future use									Byte20
Analog Value Channel 6									Read Byte 21
Analog Value Channel 6									Read Byte 22
not used									Byte23
reserved for future use									Byte24
Analog Value Channel 7									Read Byte 25
Analog Value Channel 7									Read Byte 26
not used									Byte27
reserved for future use									Byte28
Analog Value Channel 8									Read Byte 29
Analog Value Channel 8									Read Byte 30
not used									Byte31
reserved for future use									Byte32

Decimal Bit	07	06	05	04	03	02	01	00	Size
Octal Bit	07	06	05	04	03	02	01	00	
Analog Value Channel 9									Read Byte 33
Analog Value Channel 9									Read Byte 34
not used									Byte35
reserved for future use									Byte36
Analog Value Channel 10									Read Byte 37
Analog Value Channel 10									Read Byte 38
not used									Byte39
reserved for future use									Byte40
Analog Value Channel 11									Read Byte 41
Analog Value Channel 11									Read Byte 42
not used									Byte43
reserved for future use									Byte44
Analog Value Channel 12									Read Byte 45
Analog Value Channel 12									Read Byte 46
not used									Byte47
reserved for future use									Byte48
Analog Value Channel 13									Read Byte 49
Analog Value Channel 13									Read Byte 50
not used									Byte51
reserved for future use									Byte52
Analog Value Channel 14									Read Byte 53
Analog Value Channel 14									Read Byte 54
not used									Byte55
reserved for future use									Byte56
Analog Value Channel 15									Read Byte 57
Analog Value Channel 15									Read Byte 58
not used									Byte59
reserved for future use									Byte60
Analog Value Channel 16									Read Byte 61
Analog Value Channel 16									Read Byte 62
not used									Byte63
reserved for future use									Byte64
Not Used									Write Byte 1

Figure 8-26. T1F-16AD-1 Analog Input Module Memory Map

To scale the analog input for the T1F-16AD-1 module, CURVE_2D blocks were used. For the GAP block to convert the raw counts read from the T1F-16AD-1 module to engineering units, the relationship between raw counts and engineering units is specified in the CURVE_2D block. The raw count to milliamp relationship can be found in the Automation Direct manual T1K-INST-M. See Figure 8-27 for Current Input Module Resolution. The charts specify counts in decimal form. In this example, the 0-20mA scaling graph was used. The CURVE_2D block can be scaled to output any engineering units desired. In this example, the CURVE_2D block was scaled to output 0-20mA when 0–20 mA is seen by the module. The X_1 field specifies the module output counts when the module input is at 0 mA. The X_2 field specifies the module output counts when the input is at 20 mA. The Y_1 field specifies the block output in milliamps when the input counts are 0. The Y_2 field specifies the block output in milliamps when the input is at maximum counts (8191). The CURVE_2D X_1 and Y_1 fields have been set up as tunable so that the block can be set for a 4-20mA scale if desired. See Figure 8-28 for example of T1F-16AD-1 GAP CURVE_2D scaling blocks.
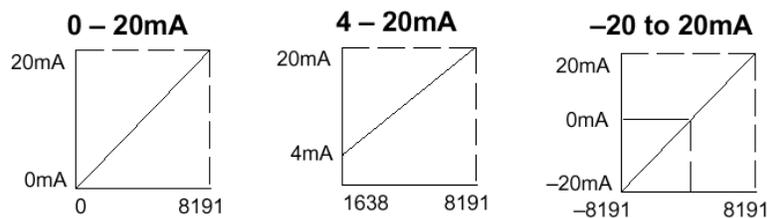
Figure 8-27. T1F-16AD-1 Current Input Module Resolution

Since each channel has two read words, each block address is incremented by two, starting at 30001 and going to 30031.
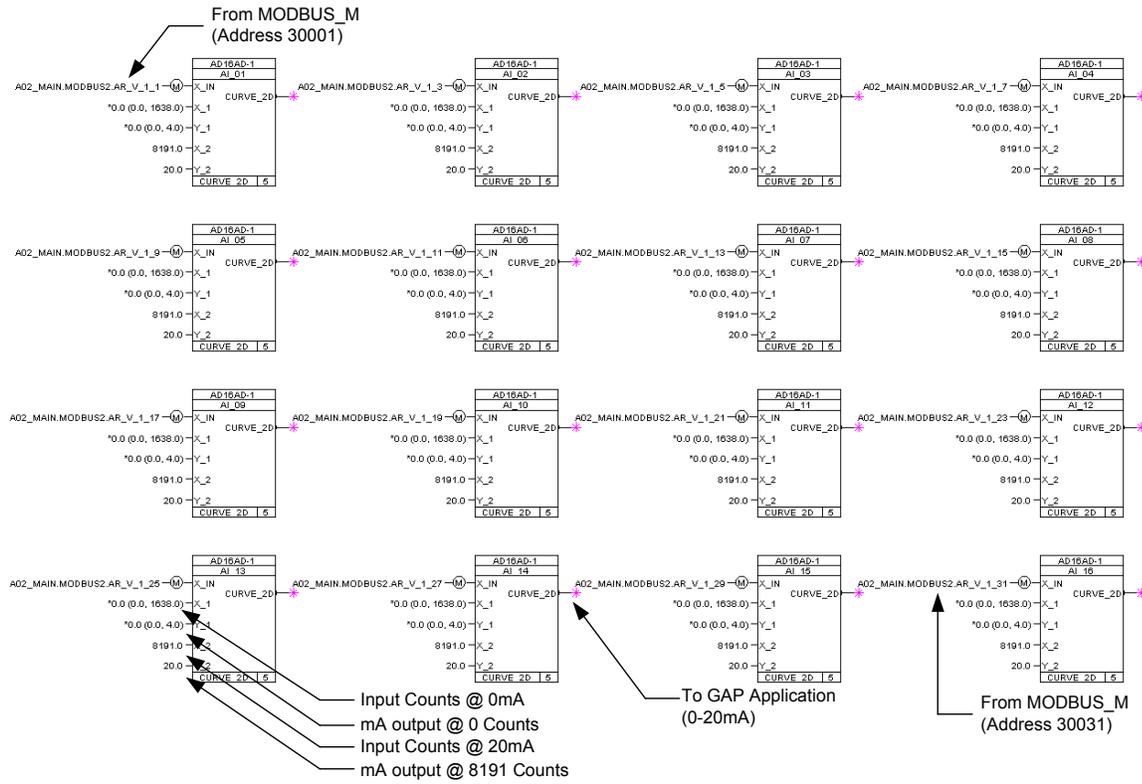
Figure 8-28. T1F-16AD-1 GAP CURVE_2D Scaling Blocks
(example)

Automation Direct Analog Output (T1F-16DA-1) Module
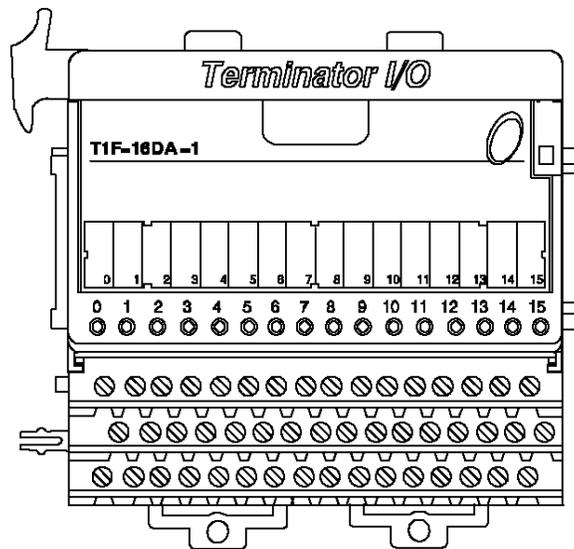
See Figure 8-29 for example of T1F-16DA-1 module wiring.

DISTRIBUTED I/O Automation Direct T1F-16DA-1 ANALOG OUTPUT		
MBI.A1.A02.G1.N6_AO_01	Output	Output 0
	Common	Com0-0
	External Supply Voltage	V0-0
MBI.A1.A02.G1.N6_AO_02	Output	Output 1
	Common	Com0-1
	External Supply Voltage	V0-1
MBI.A1.A02.G1.N6_AO_03	Output	Output 2
	Common	Com0-2
	External Supply Voltage	V0-2
MBI.A1.A02.G1.N6_AO_04	Output	Output 3
	Common	Com0-3
	External Supply Voltage	V0-3
MBI.A1.A02.G1.N6_AO_05	Output	Output 4
	Common	Com1-4
	External Supply Voltage	V1-4
MBI.A1.A02.G1.N6_AO_06	Output	Output 5
	Common	Com1-5
	External Supply Voltage	V1-5
MBI.A1.A02.G1.N6_AO_07	Output	Output 6
	Common	Com1-6
	External Supply Voltage	V1-6
MBI.A1.A02.G1.N6_AO_08	Output	Output 7
	Common	Com1-7
	External Supply Voltage	V1-7
MBI.A1.A02.G1.N6_AO_09	Output	Output 8
	Common	Com2-8
	Common Supply Voltage	V2-8
MBI.A1.A02.G1.N6_AO_10	Output	Output 9
	Common	Com2-9
	Common Supply Voltage	V2-9
MBI.A1.A02.G1.N6_AO_11	Output	Output 10
	Common	Com2-10
	Common Supply Voltage	V2-10
MBI.A1.A02.G1.N6_AO_12	Output	Output 11
	Common	Com2-11
	Common Supply Voltage	V2-11
MBI.A1.A02.G1.N6_AO_13	Output	Output 12
	Common	Com3-12
	Common Supply Voltage	V3-12
MBI.A1.A02.G1.N6_AO_14	Output	Output 13
	Common	Com3-13
	Common Supply Voltage	V3-13
MBI.A1.A02.G1.N6_AO_15	Output	Output 14
	Common	Com3-14
	Common Supply Voltage	V3-14
MBI.A1.A02.G1.N6_AO_16	Output	Output 15
	Common	Com3-15
	Common Supply Voltage	V3-15

To +24VDC
To 24COM

Figure 8-29. T1F-16DA-1 Module Wiring
(example)

The memory map indicates that there are no read addresses and 64 byte (32 words) write addresses. Each Analog channel uses 4 bytes. The first and second bytes of a channel contain the analog data. The third and fourth bytes are not used at this time. Channel 1 is an exception, where the 4th byte is the Module Control Byte. See Figure 8-30 for the memory map for the Automation Direct T1F-16DA-1 module.

Memory Map of 16-Channel Analog Output Module (T1F–016DA)										Size
Decimal Bit	07	06	05	04	03	02	01	00		Size
Octal Bit	07	06	05	04	03	02	01	00		
Not Used										Read Byte 1
Analog Value Channel 1										Write Byte 1
Analog Value Channel 1										Write Byte 2
not used										Byte3
Module Control Byte										Write Byte 4
Analog Value Channel 2										Write Byte 5
Analog Value Channel 2										Write Byte 6
not used										Byte7
reserved for future use										Byte8
Analog Value Channel 3										Write Byte 9
Analog Value Channel 3										Write Byte 10
not used										Byte11
reserved for future use										Byte12
Analog Value Channel 4										Write Byte 13
Analog Value Channel 4										Write Byte 14
not used										Byte15
reserved for future use										Byte16
Analog Value Channel 5										Write Byte 17
Analog Value Channel 5										Write Byte 18
not used										Byte19
reserved for future use										Byte20
Analog Value Channel 6										Write Byte 21
Analog Value Channel 6										Write Byte 22
not used										Byte23
reserved for future use										Byte24
Analog Value Channel 7										Write Byte 25
Analog Value Channel 7										Write Byte 26
not used										Byte27
reserved for future use										Byte28
Analog Value Channel 8										Write Byte 29
Analog Value Channel 8										Write Byte 30
not used										Byte31
reserved for future use										Byte32

Decimal Bit	07	06	05	04	03	02	01	00	Size
Octal Bit	07	06	05	04	03	02	01	00	
Analog Value Channel 9									Write Byte 33
Analog Value Channel 9									Write Byte 34
not used									Byte35
reserved for future use									Byte36
Analog Value Channel 10									Write Byte 37
Analog Value Channel 10									Write Byte 38
not used									Byte39
reserved for future use									Byte40
Analog Value Channel 11									Write Byte 41
Analog Value Channel 11									Write Byte 42
not used									Byte43
reserved for future use									Byte44
Analog Value Channel 12									Write Byte 45
Analog Value Channel 12									Write Byte 46
not used									Byte47
reserved for future use									Byte48
Analog Value Channel 13									Write Byte 49
Analog Value Channel 13									Write Byte 50
not used									Byte51
reserved for future use									Byte52
Analog Value Channel 14									Write Byte 53
Analog Value Channel 14									Write Byte 54
not used									Byte55
reserved for future use									Byte56
Analog Value Channel 15									Write Byte 57
Analog Value Channel 15									Write Byte 58
not used									Byte59
reserved for future use									Byte60
Analog Value Channel 16									Write Byte 61
Analog Value Channel 16									Write Byte 62
not used									Byte63
reserved for future use									Byte64

Figure 8-30. T1F-16DA-1 Module Memory Map

Since each channel has two read words, each block address is incremented by two, starting at 40001 and going to 40031. Based on the memory map and the Control Byte Table, there are 32 bits (4 bytes or 2 words) allocated for channel 1. The 4th byte (2nd word) is designated as the Module Control Byte. The control byte allows discrete bits to be set for certain functions. This byte is addressed using word address 40002. Individual bits are set using a B16_TO_A block to write to address 40002. See Figure 8-31 for example of the Control Byte GAP block. The first 8 bits (byte3) are not used. Bit 24 in the Control Byte Table is the IN_9_1 field on the block. This bit is the first bit in byte 4. In this example, Outputs Enable (bit 24) is on (True), the polarity is Unipolar (False), the Voltage Range (bit 26) is not needed and therefore set to (False), the Current Range (bit 27) is set for 0–20 mA (False), and bits 28–31 are reserved and therefore set to (False). See Figure 8-32 for T1F-16DA-1 Control Byte Table.

Module Control Byte of 8&16-Channel Analog Output Module (T1F–08DA, T1F–16DA)									
Decimal Bit	31	30	29	28	27	26	25	24	Read/Write
Octal Bit	37	36	35	34	33	32	31	30	
Bit 24	**Outputs Enable** 0 = All outputs OFF 1 = All outputs Enabled								Write
Bit 25	**Unipolar / Bipolar** 0 = Unipolar selected 1 = Bipolar selected								Write
Bit 26	**5V / 10V Range** 0 = 5V range 1 = 10V range								Write
Bit 27	**0 – 20mA / 4–20mA Range** 0 = 0 – 20mA range 1 = 4 – 20mA range								Write
Bit 28 – 31	Reserved for system use								–

Figure 8-31. T1F-16DA-1 Control Byte Table
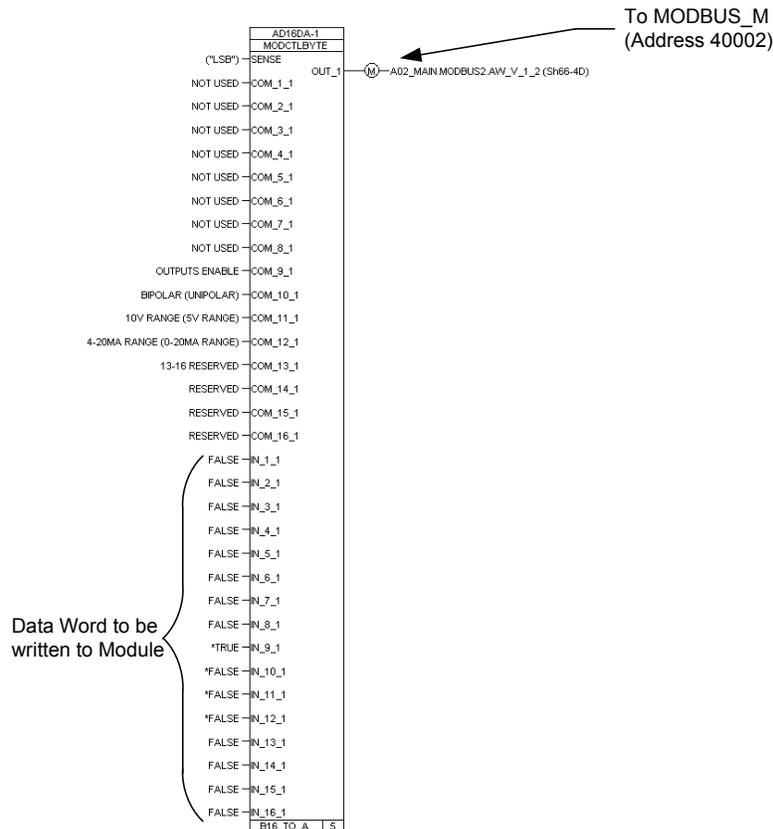
Figure 8-32. T1F-16DA-1 Control Byte GAP Block
(example)

To scale the analog output words for the T1F-16DA-1 module, CURVE_2D blocks were used. The GAP block converts the input, in milliamps, to raw counts used by the T1F-16AD-1 module. The milliamp to raw count relationship can be found in the Automation Direct manual T1K-INST-M. See Figure 8-33 for Current Output Module Resolution. The charts specify counts in decimal form. In this example, the 0–20 mA scaling graph was used. The CURVE_2D block can be scaled to output any engineering units desired. In this example, the CURVE_2D block was scaled to output 0–4095 counts when 0–20 mA is seen by the application. The X_1 field specifies the minimum milliamp value (0 mA) from the GAP application. The X_2 field specifies the maximum milliamp value (20mA) from the GAP application. The Y_1 field specifies the block output in counts (0 counts) when the minimum input is 0 mA. The Y_2 field specifies the block output in counts (4095 counts) when the maximum input is 20 mA. The CURVE_2D X_1 field has been set up as tunable so that the block can be set for a 4–20 mA scale if desired. See Figure 8-34 for example of T1F-16DA-1 GAP CURVE_2D scaling blocks.
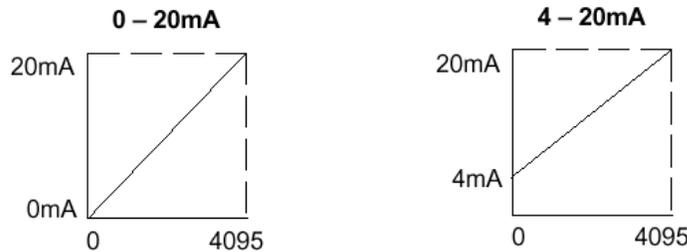
Figure 8-33. T1F-16DA-1 Current Output Module Resolution
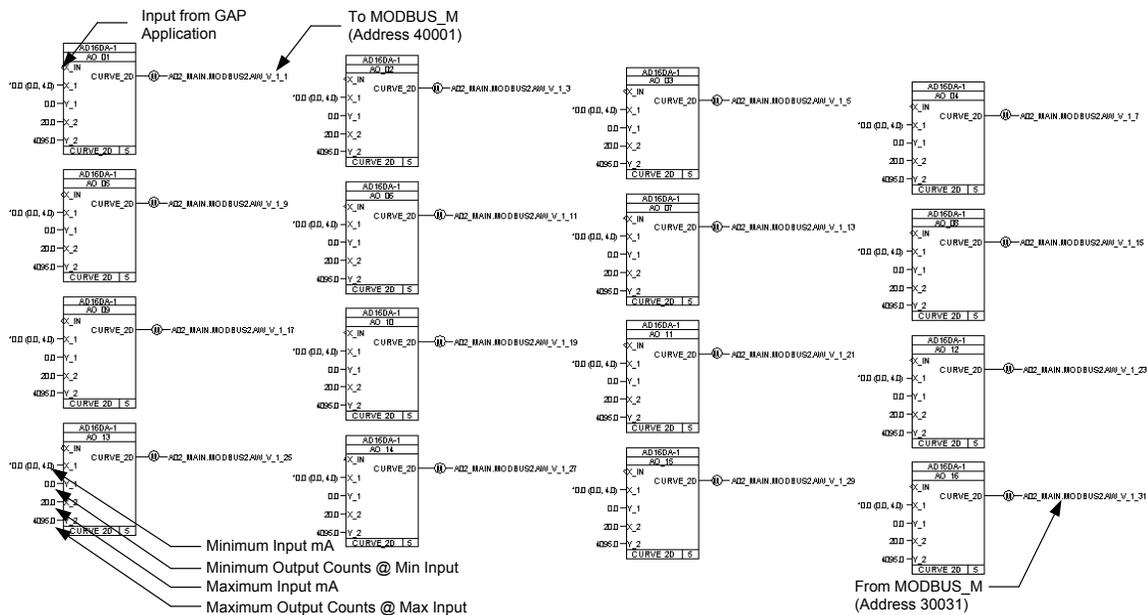
Figure 8-34. T1F-16DA-1 GAP Analog Write Blocks
(example)

Automation Direct Thermocouple Input (T1F-14THM) Module
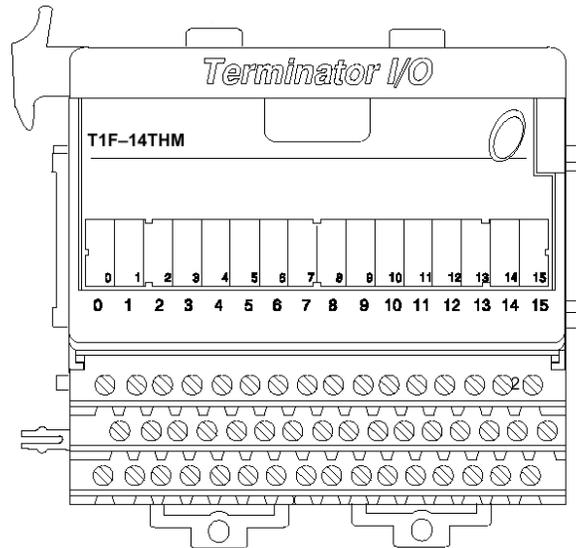
In this example, Type K thermocouples are used. See Figure 8-35 for example of T1F-14THM module wiring.

DISTRIBUTED I/O
Automation Direct T1F-14THM

THERMOCOUPLE INPUT

MBI.A1.A02.G1.N7_TC_01	TC (+)	1+	
	TC (-)	1-	
MBI.A1.A02.G1.N7_TC_02	TC (+)	2+	
	TC (-)	2-	
MBI.A1.A02.G1.N7_TC_03	TC (+)	3+	
	TC (-)	3-	
MBI.A1.A02.G1.N7_TC_04	TC (+)	4+	
	TC (-)	4-	
MBI.A1.A02.G1.N7_TC_05	TC (+)	5+	
	TC (-)	5-	
MBI.A1.A02.G1.N7_TC_06	TC (+)	6+	
	TC (-)	6-	
MBI.A1.A02.G1.N7_TC_07	TC (+)	7+	
	TC (-)	7-	
MBI.A1.A02.G1.N7_TC_08	TC (+)	8+	
	TC (-)	8-	
MBI.A1.A02.G1.N7_TC_09	TC (+)	9+	
	TC (-)	9-	
MBI.A1.A02.G1.N7_TC_10	TC (+)	10+	
	TC (-)	10-	
MBI.A1.A02.G1.N7_TC_11	TC (+)	11+	
	TC (-)	11-	
MBI.A1.A02.G1.N7_TC_12	TC (+)	12+	
	TC (-)	12-	
MBI.A1.A02.G1.N7_TC_13	TC (+)	13+	
	TC (-)	13-	
MBI.A1.A02.G1.N7_TC_14	TC (+)	14+	
	TC (-)	14-	

Chromel / Alumel — Chromel / Alumel

CJC

24V (+): +24V +24V +24V +24V +24V +24V +24V +24V → To +24VDC

24V (-): 0V 0V 0V 0V 0V 0V 0V 0V → To 24COM

Figure 8-35. T1F-14THM Module Wiring
(example)

According to Automation Direct, the T1F-14THM module uses the same memory map as the T1F-16AD-1 module. Based on this memory map, there are 64 byte (32 words) addresses and no write byte addresses. See Figure 8-36 for memory map of Automation Direct T1F-14THM Thermocouple module.

Memory Map of 16-Channel Analog Input Module (T1F–16AD)

Decimal Bit 07 06 05 04 03 02 01 00 / Octal Bit 07 06 05 04 03 02 01 00	Size
Analog Value Channel 1	Read Byte 1
Analog Value Channel 1	Read Byte 2
not used	Byte3
reserved for future use	Byte4
Analog Value Channel 2	Read Byte 5
Analog Value Channel 2	Read Byte 6
not used	Byte7
reserved for future use	Byte8
Analog Value Channel 3	Read Byte 9
Analog Value Channel 3	Read Byte 10
not used	Byte11
reserved for future use	Byte12
Analog Value Channel 4	Read Byte 13
Analog Value Channel 4	Read Byte 14
not used	Byte15
reserved for future use	Byte16
Analog Value Channel 5	Read Byte 17
Analog Value Channel 5	Read Byte 18
not used	Byte19
reserved for future use	Byte20
Analog Value Channel 6	Read Byte 21
Analog Value Channel 6	Read Byte 22
not used	Byte23
reserved for future use	Byte24
Analog Value Channel 7	Read Byte 25
Analog Value Channel 7	Read Byte 26
not used	Byte27
reserved for future use	Byte28
Analog Value Channel 8	Read Byte 29
Analog Value Channel 8	Read Byte 30
not used	Byte31
reserved for future use	Byte32

Decimal Bit 07 06 05 04 03 02 01 00 / Octal Bit 07 06 05 04 03 02 01 00	Size
Analog Value Channel 9	Read Byte 33
Analog Value Channel 9	Read Byte 34
not used	Byte35
reserved for future use	Byte36
Analog Value Channel 10	Read Byte 37
Analog Value Channel 10	Read Byte 38
not used	Byte39
reserved for future use	Byte40
Analog Value Channel 11	Read Byte 41
Analog Value Channel 11	Read Byte 42
not used	Byte43
reserved for future use	Byte44
Analog Value Channel 12	Read Byte 45
Analog Value Channel 12	Read Byte 46
not used	Byte47
reserved for future use	Byte48
Analog Value Channel 13	Read Byte 49
Analog Value Channel 13	Read Byte 50
not used	Byte51
reserved for future use	Byte52
Analog Value Channel 14	Read Byte 53
Analog Value Channel 14	Read Byte 54
not used	Byte55
reserved for future use	Byte56
Analog Value Channel 15	Read Byte 57
Analog Value Channel 15	Read Byte 58
not used	Byte59
reserved for future use	Byte60
Analog Value Channel 16	Read Byte 61
Analog Value Channel 16	Read Byte 62
not used	Byte63
reserved for future use	Byte64
Not Used	Write Byte 1

Figure 8-36. T1F-14THM Thermocouple Module Memory Map

The T1F-14THM Thermocouple module has a set of jumpers located under the top cover of the module for configuring certain parameters. See Figure 8-37 for T1F-14THM jumper configuration tables. In this example, the jumpers were configured for 14 channels of Type K thermocouples with output in degrees F and calibration disabled. See Figure 8-38 for T1F-14THM jumper locations.

Number of Channels

Number of Channels	CH+1	CH+2	CH+3	CH+4
1				
2	X			
3		X		
4	X	X		
5			X	
6	X		X	
7		X	X	
8	X	X	X	
9				X
10	X			X
11		X		X
12	X	X		X
13			X	X
14	X	X	X	X

X = Jumper Installed,
Blank Space = Jumper Removed

Input Type

Thermocouple / Voltage Inputs	T/C Type 0	T/C Type 1	T/C Type 2	T/C Type 3
J	X	X	X	X
K		X	X	X
E	X		X	X
R			X	X
S	X	X		X
T		X		X
B	X			X
N				X
C	X	X	X	
0–5V.		X	X	
±5V.	X		X	
0–156mV.			X	
±156mV.	X	X		

Thermocouple Conversion Units

Jumper	Magnitude Plus Sign °F	Magnitude Plus Sign °C	2's Complement °F	2's Complement °C
Units-0	X		X	
Units-1	X	X		

X = Jumper Installed,
Blank Space = Jumper Removed

Figure 8-37. for T1F-14THM Jumper configuration Tables

Figure 8-38. T1F-14THM Jumper Locations

It has been found that the thermocouple value must be scaled to one tenth the value output by the T1K-MODBUS interface module. A divide by 10 block is used to scale the thermocouple inputs. See Figure 8-39 for example of T1F-14THM GAP DIVIDE Blocks.

Figure 8-39. T1F-14THM GAP DIVIDE Blocks
(example)

Chapter 9.
Communications

Modbus Communication

The AtlasSC™ control can communicate with plant distributed control systems (DCS) and/or CRT-based operator control panels through three Modbus® communication ports. These ports support RS-232, RS-422, or RS-485 communications using ASCII or RTU MODBUS transmission protocols. Modbus uses a master/slave protocol. This protocol determines how a communication network's master and slave devices establish and break contact, how a sender is identified, how messages are exchanged, and how errors are detected.

The AtlasSC control supports two Modbus transmission modes. A mode defines the individual units of information within a message and the numbering system used to transmit the data. Only one mode per Modbus network is allowed. The supported modes are ASCII (American Standard Code for Information Interchange), and RTU (Remote Terminal Unit). These modes are defined in the following table.

Table 9-1. ASCII vs RTU Modbus

CHARACTERISTIC	ASCII	RTU
Coding System	hexadecimal (uses ASCII printable binary characters: 0-9, A-F)	8-bit binary
Start Bits	1	1
Data Bits per Char	7	8
Parity	even, odd, or none	even, odd, or none
Stop Bits	1, 1.5, or 2	1, 1.5, or 2
Baud Rate	110, 300, 600, 1200, 1800,2400, 4800, 9600, 19200, 38400, or 57600	110,300, 600, 1200, 1800, 2400, 4800, 9600, 19200, 38400, or 57600
Error Checking	LRC (Longitudinal Redundancy Check)	CRC (Cyclical Redundancy Check)

In the RTU mode, data is sent in 8-bit binary characters and transmitted in a continuous stream. In the ASCII mode, each binary character is divided into two 4-bit parts (high order and low order), changed to be represented by a hexadecimal equivalent, then transmitted, with breaks of up to 1 second possible. Because of these differences, data transmission with the ASCII mode is typically slower (see Figure 9-1).

Figure 9-1. ASCII/RTU Representation of 3

The Modbus protocol allows one master and up to 247 slaves on a common network. Each slave is assigned a fixed, unique device address in the range of 1 to 247. With the Modbus protocol, only the network master can initiate a transaction. A transaction consists of a request from the master to a slave unit and the slave's response.

The AtlasSC control can directly communicate with a DCS or other Modbus supporting device on a single communications link, or through a multi-dropped network. If multi-dropping is used, up to 246 devices (AtlasSC controls or other customer devices) can be connected to one Master device on a single network.

Each message to or from a master has a defined structure called the message "frame". A frame consists of the slave device address, a code defining the requested data, and error checking information (see Figure 9-2).

Table 9-2. Modbus Frame Definition

	BEGINNING OF FRAME	SLAVE ADDRESS	FUNCTION CODE	DATA	ERROR CHECK CODE	END OF FRAME
ASCII	:	2 CHARS 8 BITS	2 CHARS 8 BITS	4 BITS DATA PER CHAR	2 CHAR 8 BITS	CR LF
RTU	3-CHAR DEAD TIME	1 CHAR 8 BITS	1 CHAR 8 BITS	8 BITS DATA PER CHAR	2 CHAR 16 BITS	3 CHAR DEAD TIME

855-382
93-09-27 DAR

The Modbus function code tells the addressed slaves what function to perform. The following table lists the function codes supported by this control.

Modbus Function Codes

Table 9-2. Modbus Function Codes

CODE	DEFINITION	REFERENCE ADDRESS
01	Read Digital Outputs (Raise/Lower and Enable/Disable Commands)	0XXXX
02	Read Digital Inputs (Status Indications / Alarms and Trips)	1XXXX
03	Read Analog Outputs	4XXXX
04	Read Analog Inputs (Speed, Setpt, etc)	3XXXX
05	Write Single Discrete Output (Raise/Lower and Enable/Disable Commands)	0XXXX
06	Write Single Register (Enter Setpt Directly)	4XXXX
08	Loopback Diagnostic Test (supports subfunction 0 only)	N/A
15	Write Digital Outputs	0XXXX
16	Write Analog Outputs	4XXXX

When a Modbus message is received, it is checked for any errors or invalid data. If there is invalid data in the message, an error code is sent back to the master and the control issues an alarm message. The error codes are defined in the following table.

Table 9-3. Modbus Slave Exception Error Codes

CODE	ERROR MESSAGE	TO MASTER	DESCRIPTION
0	No Error	0	No Error
1	Bad Modbus function	1	The specified function is not supported for this control
2	Bad Modbus data address	2	The Modbus value address is not valid for this control
3	Bad Modbus data value	3	Too many values requested or the on/off indicator in function code 5 is invalid
9	Bad Modbus checksum	None	Message checksum did not match
10	Bad Modbus message	None	Message could not be decoded
n/a	Lost Modbus link	None	No messages received for the configured time-out period

Port Adjustments

Before the AtlasSC control will communicate with another device, the communication parameters must be verified. These values are set in the GAP program, and the GAP programmer may also make these values tunable if desired.

Table 9-4. Modbus Communication Port Adjustments

PARAMETER	ADJUSTMENT RANGE
Baud Rate	110 TO 57600
Parity	NONE, ODD, or EVEN
Stop Bits	1 TO 2
Driver	RS-232, RS-422, or RS-485

Chapter 10.
Programming and Service Tools

Introduction

The primary program download and service tool for the AtlasSC™ control is the Woodward Watch Window system. This software runs on a PC that is connected to the control with an RS-232 serial cable. Also running on the same PC is the Woodward ServLink I/O server software that allows Watch Window to access selected application variables that were generated in the GAP™ application program. The details of the specific GAP application programming are beyond the scope of this manual, but Woodward publication number 80018 is available to assist the application engineer in this process.

Two versions of Watch Window are available for use with the AtlasSC control:
1. Watch Window Professional is a licensed software tool that enables the GAP-generated application program to be downloaded into the AtlasSC hardware. From that point on, Watch Window Professional is used to
   - Configure the control software to the specific site or application needs
   - Monitor and tune system variables that were selected in the GAP application program
   - Upload and download all tunable and configuration variables from the AtlasSC control
2. Watch Window Standard is a software tool that does not have the capability to download application software. Otherwise, it provides the same functionality as Watch Window Professional

This chapter covers the following procedures:
- Connecting the AtlasSC control to a PC
- Loading the Watch Window Professional or Watch Window Standard software as well as the ServLink I/O software on the PC
- Applying power to the control
- Opening communications with the control
- Downloading the GAP-generated application software to the AtlasSC control
- Using Watch Window to view variables and to tune the control
- Uploading and downloading tunable and configuration variables from/to the AtlasSC control

Connecting the AtlasSC Control to a PC

Connection of a generic PC to the AtlasSC control is required in order to load application software and view/tune within that software application. Figure 10-1 shows the connection details.
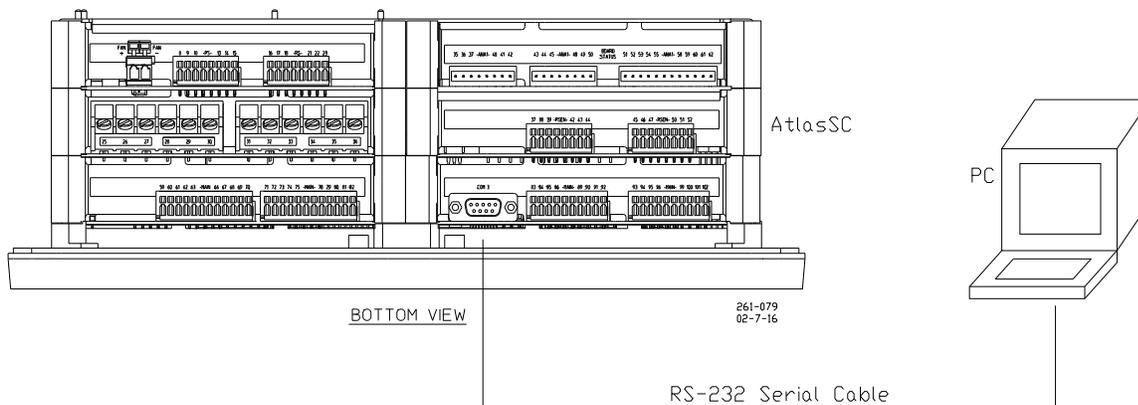
Figure 10-1. Connecting the AtlasSC Control to a PC

Loading Watch Window and ServLink on the PC

Woodward's Watch Window Standard and Watch Window Professional tools may be downloaded from the Woodward website (**www.woodward.com/ic**). Alternatively, a Watch Window CD Install Kit may be purchased from your Woodward distributor. Once downloaded, the kit's Setup.exe program will guide the user through the installation of Watch Window and ServLink software on the PC hard drive.

Applying Power to the AtlasSC Control

At power-up, the AtlasSC control runs through its boot-up routine and performs a set of initial diagnostics to verify CPU, memory, and bus health. This boot-up routine takes up to 90 seconds to execute. During this time, the control's red status LED (located at the bottom/center area of the control) should be illuminated. When boot-up is complete, the application program (if loaded) will begin running, the control's outputs will be enabled, and system control will begin. The red status LED will be turned off and should remain off as long as the control is running.

Opening Communications with the AtlasSC Control

Initial AtlasSC Communications
Before communications can begin between the Watch Window software and the AtlasSC control, a Network Definition file must be created. Once this file is created and saved, it never has to be recreated unless a new GAP application program is installed.

Create the Network Definition File
1. Make sure that all other programs that may access your computer's communication port are shut down.
2. Start the ServLink software by selecting Start> Programs> Woodward> Watch Window Professional (or Watch Window Standard)> ServLink Server on the PC. Then select File> New on the ServLink dialog window. In the dialog window (shown below) select the proper COM port for your computer, select POINT TO POINT communications mode, and set the baud rate to 57600. This is the factory default baud rate. If the control has been
re-programmed after leaving the factory, the user may need to contact the entity that supplied the new program to determine the correct baud rate.

IMPORTANT	**If a previous download activity was interrupted before completion of the download, the control will have no installed program. In this instance, after the control is reset and the boot-up period has elapsed, the control will continuously scan COM3 port at 57600 and 115200 baud looking for a connection to ServLink. The user may have to hit <Retry> a few times until the control and ServLink baud rates are matched and communications are established.**
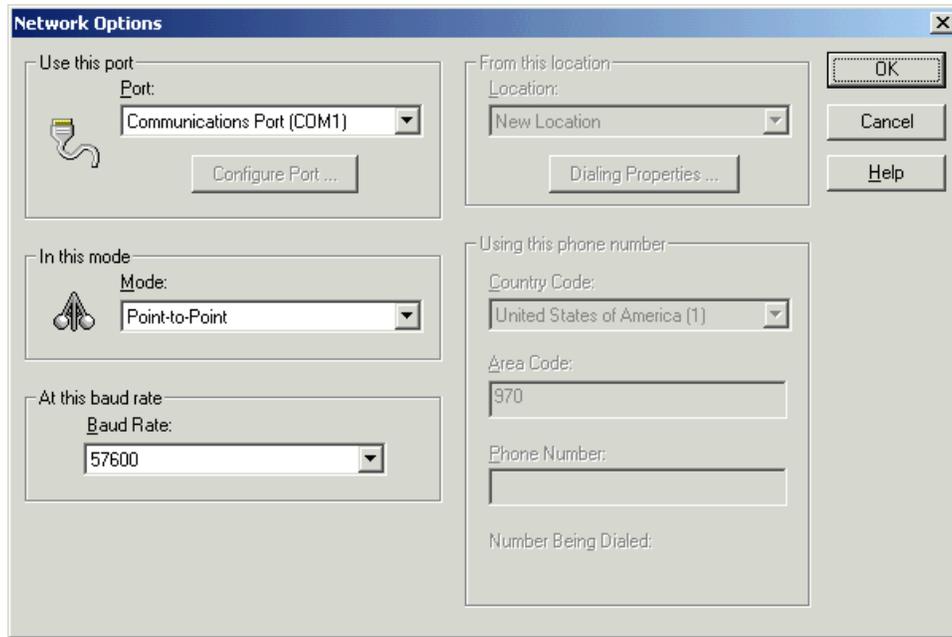
3. Select OK. If everything is working correctly there will be an animated graphic of a string of "1"s and "0's flying from the control to the PC on the screen. Once this transfer is completed, a Network Definition file whose default name is NET1.NET will have been generated. This file should be saved by using the 'File> Save As' feature on the PC. Link this name to the control part number as it will only work with that application. For example, if the control part number is 8273-040, one can save the Network Definition file as 8273040.NET. See example below. Do not disconnect the server.
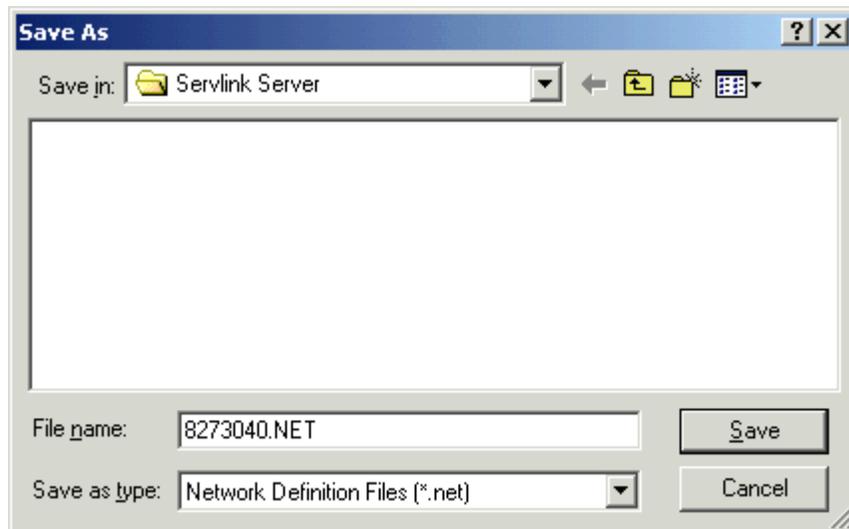
4. In the ServLink window there will be another dialog window entitled "your filename.NET". Unless the user has given the control a serial number (or name) with the SLSN.EXE program, this name will display as "<unidentified>". The user should note this name. See example below.
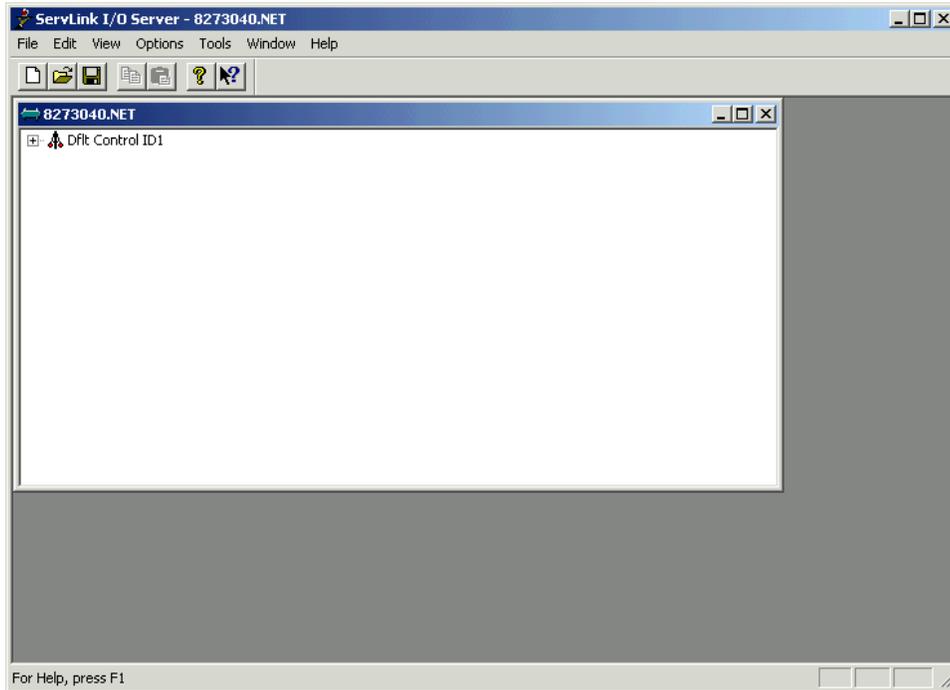
Downloading the GAP Application Code

The AtlasSC control is shipped from the factory with a default GAP program. In order to download a new GAP-generated application program it is necessary to use the Watch Window Professional service tool. The following steps are required for this program downloading process.

Download the Application File
1. Start the Watch Window program by selecting Start> Programs> Woodward> Watch Window Professional> Watch Window Professional on the PC. Under the title bar in the Explorer section of the screen, a tab with the Network Definition filename and the Control ID will be displayed. Right click on this tab to display a pop-up menu and select LOAD APPLICATION. See example screen below.
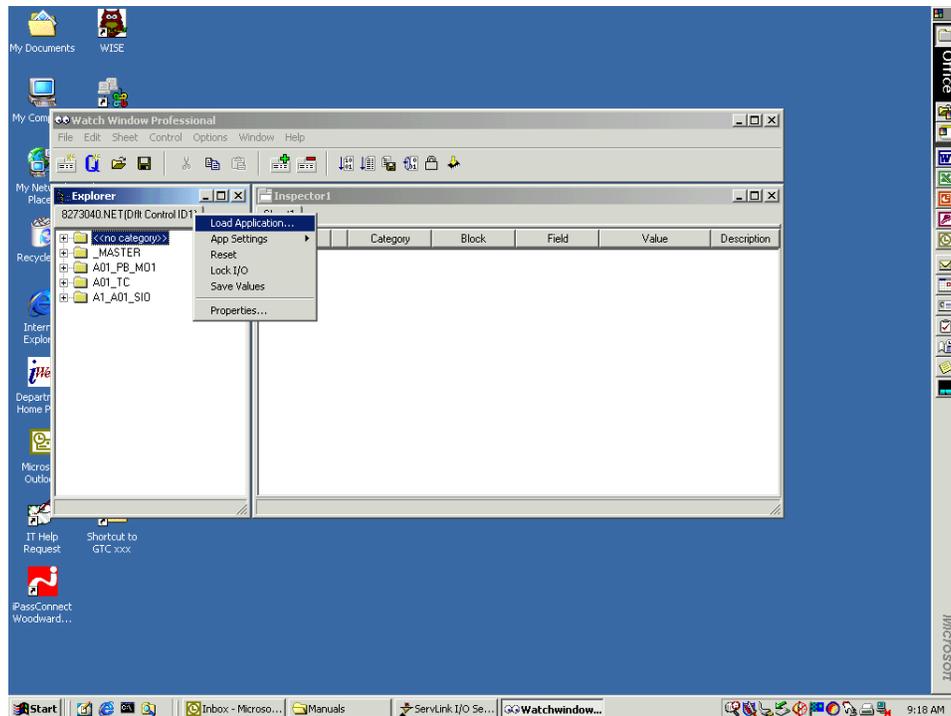
2. Once the Load Application selection has been made, the Inspector window will close and a new window will appear. In this new window the user enters the name of the file that is to be downloaded into the control. Once the filename is correct, click on the Open button. See example below
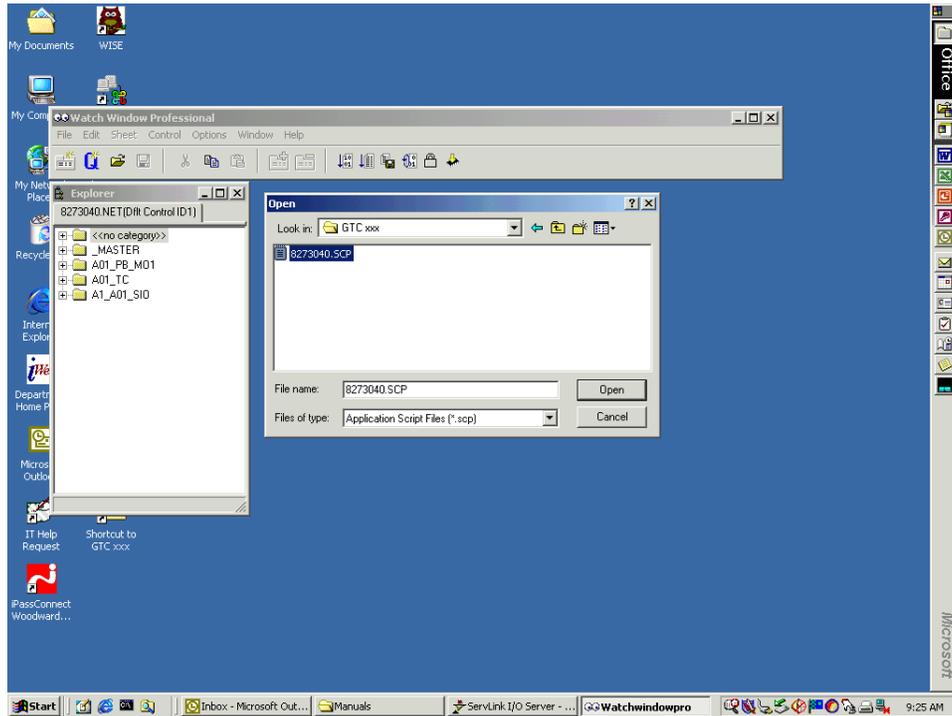
3. A warning screen will ask that the user make sure the prime mover is shut down before downloading. When the warning screens have been addressed, the downloading will commence automatically. This may take several minutes depending on the size of the application. When downloading is complete, the control will reboot automatically and the red status LED will come on. When reboot is completed, the red status LED will go out and the control will begin execution of the new application program.
4. At the end of the download process, an Information window will appear in Watch Window (see below) to alert the user to the fact that a new Network Definition file must be created that matches the new program that has been downloaded. The same procedure that was used initially to create a Network Definition file can be used again.

⚠ WARNING	Be sure the engine or turbine is shut down before downloading. Damage to the machine or other serious problems can result if the unit is running during the download procedure.

Using Watch Window

Here are brief instructions for using the Watch Window in conjunction with ServLink to view and tune the variables for your AtlasSC control. These instructions are meant to be introductory only. Full on-line help is available in each application. It is assumed that you already have ServLink and Watch Window installed. The default installation location can be found by clicking the START icon (Microsoft Windows 95 or later) on the main menu bar and then clicking the PROGRAMS menu item. Look for an icon called WOODWARD WATCH WINDOW.

1. Make sure that all other programs that may access your computer communications port are shut down.
2. Start the ServLink server and open a new file. Select the proper COM port for your PC, verify that POINT TO POINT communications mode is selected, and verify that the baud rate matches the baud rate of the AtlasSC control. See the on-line help file if you have been changing the port settings of your control.
3. Select OK. If everything is working right, you should see an animated picture of a string of "1"s and "0"s flying from the control to the PC on your screen. You now have a network definition file whose default name is NET1. You should save this file as "your filename.net" (use FILE/SAVE AS). Link this name to your control part number, as it will work only with that application. For instance, if the upper level control number is 8273-040, you could save the file as 8273040.NET. Do not disconnect the server.
4. In the ServLink window you will now have another dialog window titled "your filename.net". In this window you will see a ballhead icon and a control identifier name. Unless you have given the control a serial number (or name) with the SLSN.EXE program, this name will display as "<unidentified>".
5. Start the Watch Window application. When Watch executes, you will have a screen displaying three windows entitled Watch Window, Explorer, and Inspector.
6. The Explorer window will have two groups displayed, SERVICE and CONFIGURE. Double clicking on either of these will expand them to show groups of values. Explorer is used only to locate a tunable or monitor value. In order to change a value or monitor a value, you must drag and drop a value from the Explorer window into the Inspector window.
7. Once a value is displayed in the Inspector, you can see several blocks of information. The most important blocks for a tunable value are the FIELD and VALUE blocks. The FIELD block is used to identify a particular value, and the VALUE block displays the current value of a variable. There are two types of values available in Watch. One is a monitor value, which is marked in the INSPECTOR window with a pair of glasses. This means it may only be looked at. The other value is a read/write value, which is marked with a pencil. The read/write type may be modified using the up and down arrows in the value block.

Chapter 11.
Product Support and Service Options

Product Support Options

If you are experiencing problems with the installation, or unsatisfactory performance of a Woodward product, the following options are available:

- Consult the troubleshooting guide in the manual.
- Contact the manufacturer or packager of your system.
- Contact the Woodward Full Service Distributor serving your area.
- Contact Woodward technical assistance (see "How to Contact Woodward" later in this chapter) and discuss your problem. In many cases, your problem can be resolved over the phone. If not, you can select which course of action to pursue based on the available services listed in this chapter.

OEM or Packager Support: Many Woodward controls and control devices are installed into the equipment system and programmed by an Original Equipment Manufacturer (OEM) or Equipment Packager at their factory. In some cases, the programming is password-protected by the OEM or packager, and they are the best source for product service and support. Warranty service for Woodward products shipped with an equipment system should also be handled through the OEM or Packager. Please review your equipment system documentation for details.

Woodward Business Partner Support: Woodward works with and supports a global network of independent business partners whose mission is to serve the users of Woodward controls, as described here:

- A **Full Service Distributor** has the primary responsibility for sales, service, system integration solutions, technical desk support, and aftermarket marketing of standard Woodward products within a specific geographic area and market segment.

- An **Authorized Independent Service Facility (AISF)** provides authorized service that includes repairs, repair parts, and warranty service on Woodward's behalf. Service (not new unit sales) is an AISF's primary mission.

- A **Recognized Turbine Retrofitter (RTR)** is an independent company that does both steam and gas turbine control retrofits and upgrades globally, and can provide the full line of Woodward systems and components for the retrofits and overhauls, long term service contracts, emergency repairs, etc.

A current list of Woodward Business Partners is available at **www.woodward.com/directory**.

Product Service Options

The following factory options for servicing Woodward products are available through your local Full-Service Distributor or the OEM or Packager of the equipment system, based on the standard Woodward Product and Service Warranty (5-01-1205) that is in effect at the time the product is originally shipped from Woodward or a service is performed:

- Replacement/Exchange (24-hour service)
- Flat Rate Repair
- Flat Rate Remanufacture

Replacement/Exchange: Replacement/Exchange is a premium program designed for the user who is in need of immediate service. It allows you to request and receive a like-new replacement unit in minimum time (usually within 24 hours of the request), providing a suitable unit is available at the time of the request, thereby minimizing costly downtime. This is a flat-rate program and includes the full standard Woodward product warranty (Woodward Product and Service Warranty 5-01-1205).

This option allows you to call your Full-Service Distributor in the event of an unexpected outage, or in advance of a scheduled outage, to request a replacement control unit. If the unit is available at the time of the call, it can usually be shipped out within 24 hours. You replace your field control unit with the like-new replacement and return the field unit to the Full-Service Distributor.

Charges for the Replacement/Exchange service are based on a flat rate plus shipping expenses. You are invoiced the flat rate replacement/exchange charge plus a core charge at the time the replacement unit is shipped. If the core (field unit) is returned within 60 days, a credit for the core charge will be issued.

Flat Rate Repair: Flat Rate Repair is available for the majority of standard products in the field. This program offers you repair service for your products with the advantage of knowing in advance what the cost will be. All repair work carries the standard Woodward service warranty (Woodward Product and Service Warranty 5-01-1205) on replaced parts and labor.

Flat Rate Remanufacture: Flat Rate Remanufacture is very similar to the Flat Rate Repair option with the exception that the unit will be returned to you in "like-new" condition and carry with it the full standard Woodward product warranty (Woodward Product and Service Warranty 5-01-1205). This option is applicable to mechanical products only.

Returning Equipment for Repair

If a control (or any part of an electronic control) is to be returned for repair, please contact your Full-Service Distributor in advance to obtain Return Authorization and shipping instructions.

When shipping the item(s), attach a tag with the following information:
- Return authorization number
- Name and location where the control is installed
- Name and phone number of contact person
- Complete Woodward part number(s) and serial number(s)
- Description of the problem
- Instructions describing the desired type of repair

Packing a Control

Use the following materials when returning a complete control:
- Protective caps on any connectors
- Antistatic protective bags on all electronic modules
- Packing materials that will not damage the surface of the unit
- At least 100 mm (4 inches) of tightly packed, industry-approved packing material
- A packing carton with double walls
- A strong tape around the outside of the carton for increased strength

NOTICE	To prevent damage to electronic components caused by improper handling, read and observe the precautions in Woodward manual 82715, *Guide for Handling and Protection of Electronic Controls, Printed Circuit Boards, and Modules.*

Replacement Parts

When ordering replacement parts for controls, include the following information:
- The part number(s) (XXXX-XXXX) that is on the enclosure nameplate
- The unit serial number, which is also on the nameplate

Engineering Services

Woodward offers various Engineering Services for our products. For these services, you can contact us by telephone, by email, or through the Woodward website.
- Technical Support
- Product Training
- Field Service

Technical Support is available from your equipment system supplier, your local Full-Service Distributor, or from many of Woodward's worldwide locations, depending upon the product and application. This service can assist you with technical questions or problem solving during the normal business hours of the Woodward location you contact. Emergency assistance is also available during non-business hours by phoning Woodward and stating the urgency of your problem.

Product Training is available as standard classes at many of our worldwide locations. We also offer customized classes, which can be tailored to your needs and can be held at one of our locations or at your site. This training, conducted by experienced personnel, will assure that you will be able to maintain system reliability and availability.

Field Service engineering on-site support is available, depending on the product and location, from many of our worldwide locations or from one of our Full-Service Distributors. The field engineers are experienced both on Woodward products as well as on much of the non-Woodward equipment with which our products interface.

For information on these services, please contact us via telephone, email us, or use our website: **www.woodward.com**.

Contacting Woodward's Support Organization

For the name of your nearest Woodward Full-Service Distributor or service facility, please consult our worldwide directory at **www.woodward.com/directory**, which also contains the most current product support and contact information.

You can also contact the Woodward Customer Service Department at one of the following Woodward facilities to obtain the address and phone number of the nearest facility at which you can obtain information and service.

Products Used in Electrical Power Systems	Products Used in Engine Systems	Products Used in Industrial Turbomachinery Systems
Facility --------------- Phone Number	**Facility --------------- Phone Number**	**Facility --------------- Phone Number**
Brazil ------------- +55 (19) 3708 4800	Brazil ------------- +55 (19) 3708 4800	Brazil ------------- +55 (19) 3708 4800
China ----------- +86 (512) 6762 6727	China ----------- +86 (512) 6762 6727	China ----------- +86 (512) 6762 6727
Germany:	Germany ------ +49 (711) 78954-510	India --------------- +91 (124) 4399500
Kempen---- +49 (0) 21 52 14 51	India --------------- +91 (124) 4399500	Japan---------------+81 (43) 213-2191
Stuttgart - +49 (711) 78954-510	Japan---------------+81 (43) 213-2191	Korea---------------+82 (51) 636-7080
India --------------- +91 (124) 4399500	Korea---------------+82 (51) 636-7080	The Netherlands--+31 (23) 5661111
Japan---------------+81 (43) 213-2191	The Netherlands--+31 (23) 5661111	Poland -------------- +48 12 295 13 00
Korea---------------+82 (51) 636-7080	United States-----+1 (970) 482-5811	United States-----+1 (970) 482-5811
Poland -------------- +48 12 295 13 00		
United States-----+1 (970) 482-5811		

Technical Assistance

If you need to contact technical assistance, you will need to provide the following information. Please write it down here before contacting the Engine OEM, the Packager, a Woodward Business Partner, or the Woodward factory:

General	
Your Name	
Site Location	
Phone Number	
Fax Number	

Prime Mover Information	
Manufacturer	
Turbine Model Number	
Type of Fuel (gas, steam, etc.)	
Power Output Rating	
Application (power generation, marine, etc.)	

Control/Governor Information	
Control/Governor #1	
Woodward Part Number & Rev. Letter	
Control Description or Governor Type	
Serial Number	
Control/Governor #2	
Woodward Part Number & Rev. Letter	
Control Description or Governor Type	
Serial Number	
Control/Governor #3	
Woodward Part Number & Rev. Letter	
Control Description or Governor Type	
Serial Number	

Symptoms	
Description	

If you have an electronic or programmable control, please have the adjustment setting positions or the menu settings written down and with you at the time of the call.

Appendix A.
Acronyms and Glossary of Terms

Acronyms

ADC	Analog-to-Digital Converter
AWG	American Wire Gauge (metric equivalent is mm²)
CE	The CE marking is a European proof of conformity and is also described as "passport" that allows manufacturers and exporters to circulate products freely within the EU. The letters "CE" (French for "Conformité Européenne") indicate that the manufacturer has satisfied all assessment procedures specified by law for its product.
CPU	Central Processing Unit. Executes the GAP application program.
CT	Current Transformer. Used to measure the generator or bus current.
dc	Direct Current
EEPROM	Electrically Erasable and Programmable Read Only Memory
EMC	Electromagnetic Conformity
EMI	Electromagnetic Interference
GAP	Graphical Application Program
I/O	Input/Output
LED	Light Emitting Diode
LON	Local Operating Network
MFT	Minor Frame Timer. Used by the CPU for scheduling execution of the software.
MPU	Magnetic Pick-Up
MTBF	Mean Time Between Failures
PC	Personal Computer
PCB	Printed Circuit Board
PT	Potential Transformer. Used to measure the generator or bus voltage.
PWM	Pulse Width Modulated
RAM	Random Access Memory
RG	Rate Group. Defines how often software is executed.
RTD	Resistance Temperature Device
RXD	Receive Data Line
SRAM	Static Random Access Memory
SSTP	Shielded-Shielded Twisted Pair (or Double Shielded Ethernet Cables)
THD	Total Harmonic Distortion
TXD	Transmit Data Line
V/I	Voltage-to-Current converter

Glossary of Terms

AtlasSC™ Analog Combo board—An AtlasSC board with an analog format that connects to the AtlasSC SmartCore board through the PC/104 interface. It contains 15 analog inputs, 2 speed sensor inputs, and 2 Analog outputs.

AtlasSC Power Supply board—An AtlasSC board with primary power supply and 12 discrete outputs.

AtlasSC SmartCore board—An AtlasSC board with 6 analog inputs, 2 actuator outputs, 6 analog outputs, 2 speed sensor inputs, 24 discrete inputs, and 3 serial communication ports. This board includes both the PC/104 and the power bus connections, allowing it to function as a backplane.

AtlasSC Chassis—A combination of pieces required to hold the boards together.

AtlasSC Platform—The combination of boards, a power supply, and a chassis, that can be combined to compose a variety of controls for a variety of applications. The boards must have either a PC/104 connection, or a proprietary power bus connection, and meet certain packaging constraints.

Analog Input—A 4–20 mA or 0–5 V input on the SmartCore board, and a thermocouple, RTD or 4–20 mA input on the Analog Combo board.

Analog Output—A 4–20 mA output, usually the full range is 0–24 mA.

Backplane—A board that ties other boards together electrically. AtlasSC needs the SmartCore board to connect the power bus voltages to the PC/104 bus.

Discrete Input—An input used for switches or other contacts, that registers only two states, open or closed.

Discrete Output—Output drivers used for driving relays that register only two states, high or low.

Serial Port—A connection for RS-232, RS-422, or RS-485.

Speed Sensor Input—An MPU or proximity probe input on the SmartCore board, and a MPU only input on the Analog Combo board.

Appendix B.
Wiring Diagrams
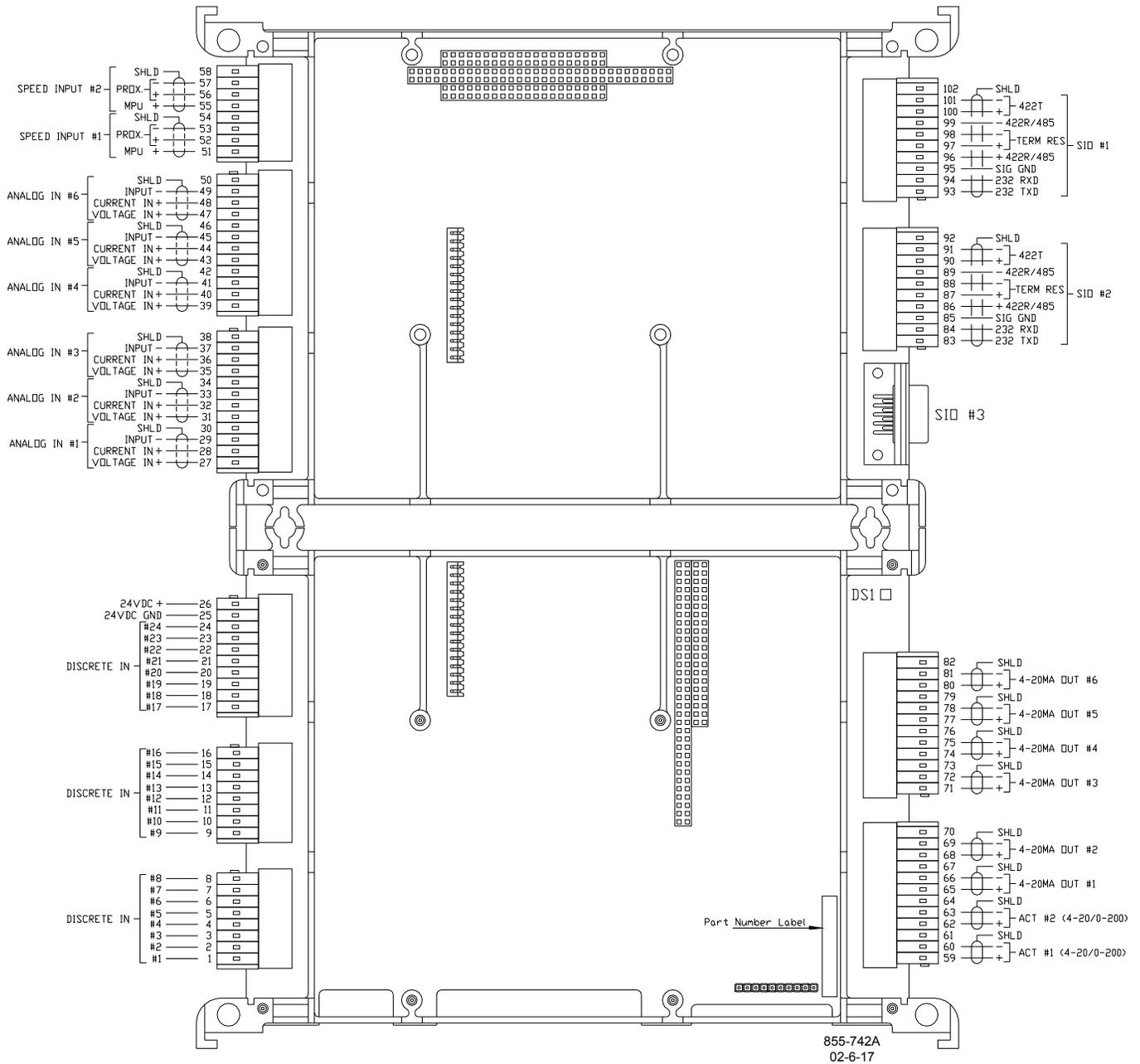
Figure B-1. SmartCore Board with Actuators Connections
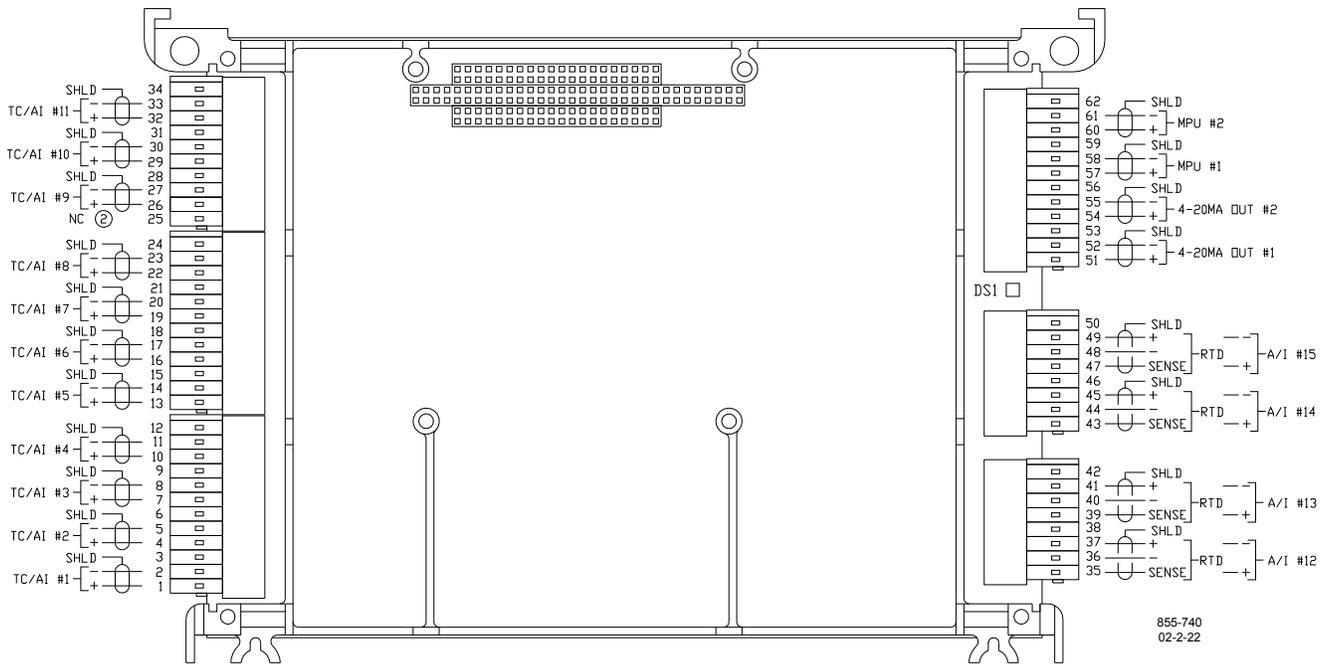
Figure B-2. Analog Combo Board Connections
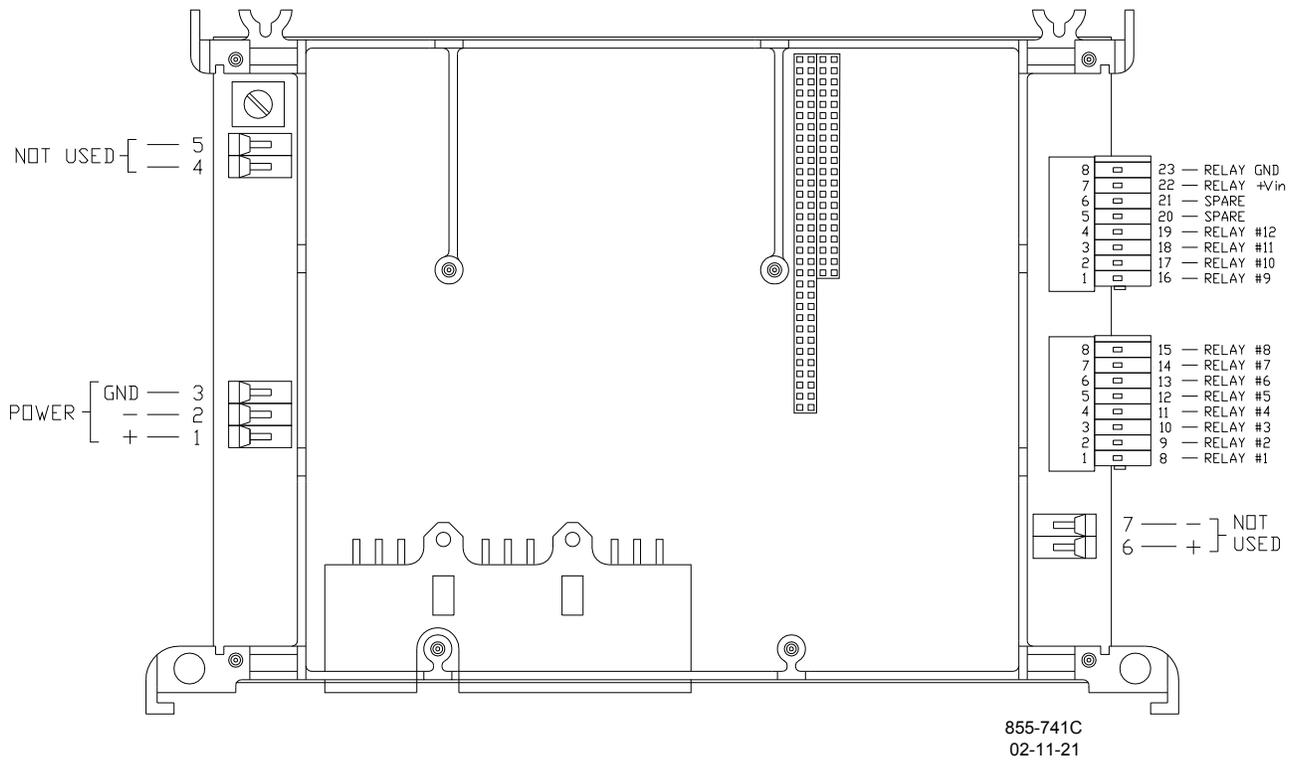
Figure B-3. Power Supply Board Connections
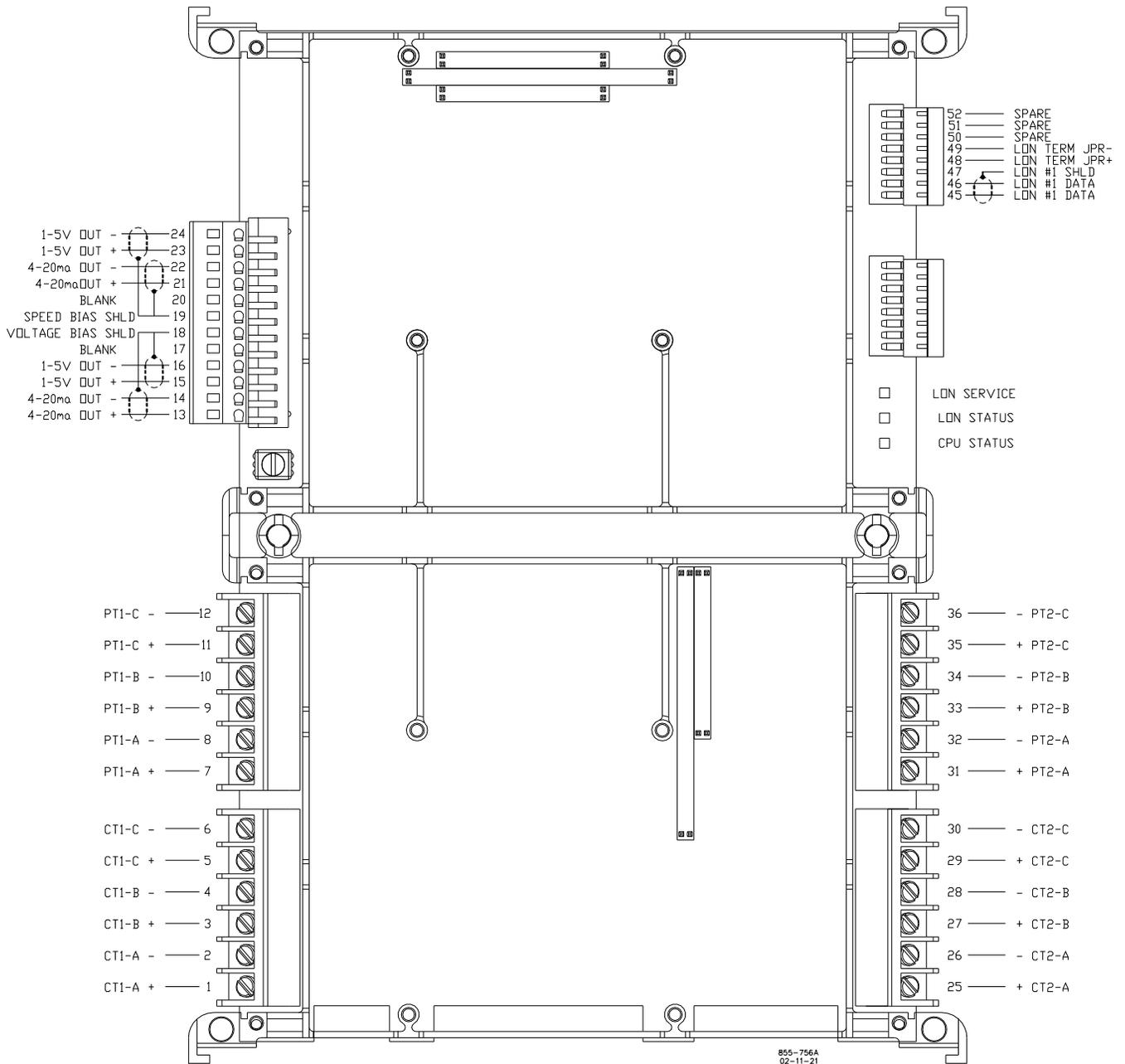
Figure B-4. PowerSense Board Connections
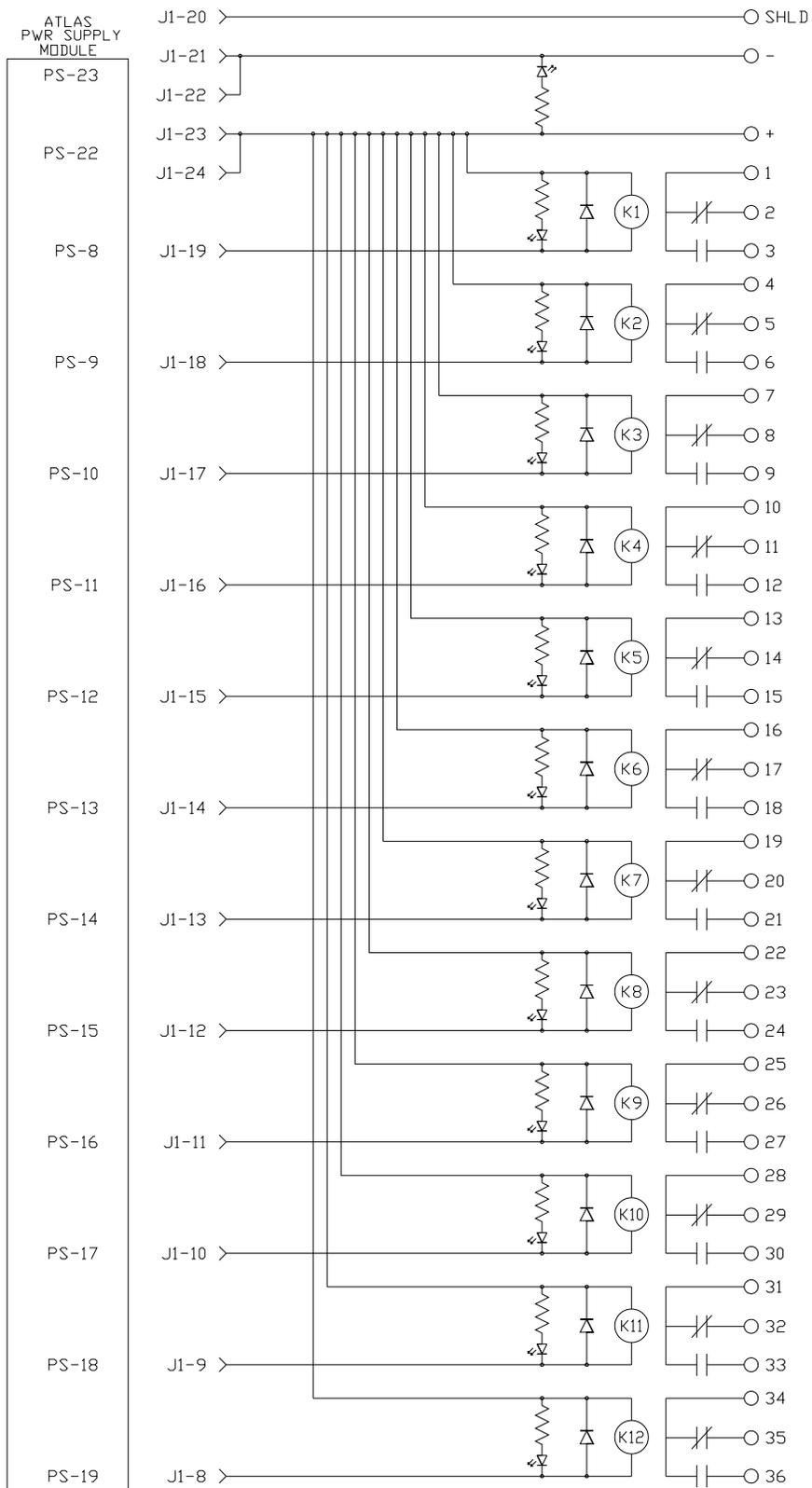
Figure B-5. 12-Channel Relay Module Connections

Appendix C.
Flash Codes

Number of LED Flashes	Failure
1	CPU Failure (Clock Fail, Invalid Reset, Halt, etc.)
2	Unexpected CPU Exception (Bus Error, Address Error, Trap, etc.)
3	RAM Error
4	Watchdog Timeout
5	EEPROM Error
6	FLASH Memory Error
7	Operating System Error
8	Stack Memory Overflow
9	Application Checksum Error
10	Communication Error (68302 Fail)
11	Real Time Clock Error
12	Rate Group Slip Error
13–15	Unused
16	Data Log Error
17	NV Log Error
18	Math Exception

Table C-1. SmartCore Failure Codes

Number of LED Flashes	Failure
1	Microprocessor failure
2	Bus, address, any unexpected exception error
5	Failure during EE test or erasing
7	Kernel software Watchdog count error
12	Failure during CPU Internal RAM test
13	Dual port RAM error

Table C-2. Analog Combo Failure Codes

Number of LED Flashes	Failure
Off	No failure, system OK
Solid	Module in initialization mode
1	Hardware watchdog, CPU clock failure, reset fail
2	Unexpected Exception Error
3	RAM test failure
5	EEPROM failure
7	Kernel Watchdog Timeout
10	System Error
11	Board Identification Error
12	TPU RAM failure
13	Dual Port RAM test failure
14	QSM or ADC Initialization failure
15	Self test status failure
20	Invalid A/D converter selected
21	QSPI timeout
24	ADC auto calibration time-out

Table C-3. PowerSense Failure Codes

Revision History

Changes in Revision J—
- Removed reference to Zone 2 and DEMKO certification
- Removed EMC, Low Voltage Directive, ATEX and DEMKO references
- Removed European Zone 2 information
- Removed Zone 2, Group IIC information
- Deleted DoC