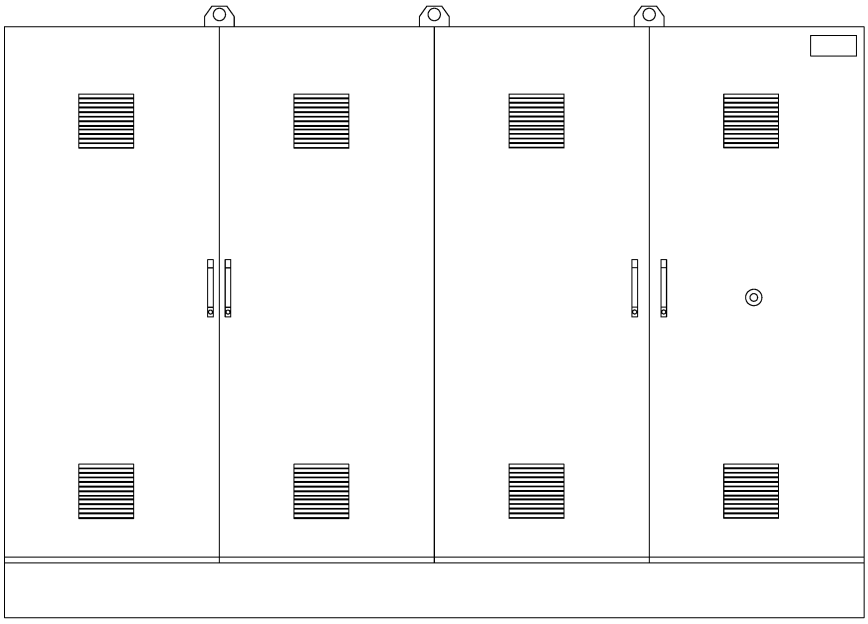
WOODWARD

Product Manual 26395
(Revision A)
Original Instructions



MicroNet™ Plus Turbine Control Panel for LM6000PD/PF Gas Turbine

GE AEP

Installation, Operation, and Maintenance 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 *26311* , *Revision Status & Distribution Restrictions of Woodward Technical Publications*, 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.

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 *26311* , *Revision Status & Distribution Restrictions of Woodward Technical Publications*, 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 Out-of-date translations are marked with ⚠.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.

Revisions—Changes in this publication since the last revision are indicated by a black line alongside the text.

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Important Definitions

This is the safety alert symbol. It is 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.

⚠WARNING

Automotive Applications

On- and off-highway Mobile Applications: Unless Woodward's control functions as the supervisory control, customer should install a system totally independent of the prime mover control system that monitors for supervisory control of engine (and takes appropriate action if supervisory control is lost) to protect against loss of engine control with possible personal injury, loss of life, or property damage.

NOTICE

Battery Charging Device

To prevent damage to a control system that uses an alternator or battery-charging device, make sure the charging device is turned off before disconnecting the battery from the system.

Electrostatic Discharge Awareness

NOTICE

Electrostatic Precautions

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*.

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

These listings are limited only to those units bearing the CE Marking.

European Compliance for CE Marking
These listings are limited only to those units bearing the CE Marking.

EMC Directive:	Declared to 89/336/EEC COUNCIL DIRECTIVE of 03 May 1989 on the approximation of the laws of the Member States relating to electromagnetic compatibility.
Low Voltage Directive:	Declared to 73/23/EEC COUNCIL DIRECTIVE of 10 February 1973 on the harmonization of the laws of the Member States relating to electrical equipment designed for use within certain voltage limits.

Special Conditions for Safe Use
The 24 Vdc input power must be supplied from a power supply/battery charger certified to IEC standard with a SELV (Safety Extra Low Voltage) classified output.

Field Wiring must have a flammability classification of FV-1 or better.

A switch or circuit breaker shall be included in the building installation that is in close proximity to the equipment and within easy reach of the operator and that is clearly marked as the disconnecting device for the equipment.

The power supply mains should be properly fused according to the National Electrical Code

The ground rail located at the bottom of the control panels must be connected to earth ground using braid of 10 AWG (5 mm²) or larger.

All wiring shall be rated at 300 V minimum and for the temperature that the wiring will be subjected to in the final installation.

Chapter 1.
General Information

Introduction

WARNING

Use of this equipment by untrained or unqualified personnel could result in damage to the control or the installation's equipment and possible loss of life or personal injury. Make sure personnel using or working on this equipment are properly trained.

This Manual details the installation procedure necessary to take this equipment from a delivered package to an installed unit ready for commissioning. Woodward has highlighted all the potential dangers that can be encountered during the installation of the unit, and the installation instructions must be closely followed and any safety instructions must be fully obeyed. All involved personnel must carefully read and understand the instructions before work is started, and also understand and obey all applicable local health and safety regulations. This Manual must always be kept near the unit for quick reference.

This Manual also describes the functional description for the Woodward MicroNet™ Plus TCP control system. It contains generic information for the TCP control system and its components. Application-specific information is supplied in a separate Woodward Application-specific data manual.

Together with the Application-specific Data Manual, this manual details the information necessary to take this equipment from a newly-installed condition to a fully-operational condition ready for start-up. It provides information for the electrical installation, set-up, calibration and operation of this Woodward control system.

This manual covers only equipment that is manufactured and software that has been programmed by Woodward and does not include operating instructions for the prime mover or the driven devices or processes, nor for control hardware and software that is not delivered by Woodward.

For specific operating instructions such as start-up, shutdown, and the prime mover's response to signals from the Woodward control, refer to the prime mover manufacturer's manual.

If you require more information on specific aspects of the unit or its installation, please contact Woodward at the address shown on the back cover.

Test Software

WARNING

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.

"Test ring software" can be included to create a simulation environment for the Woodward engineer. It can be used for software debugging and for HMI demonstration and training purposes without the necessity of using an external test stand. This ring may represent an attempt to simulate the behavior of all components in the field. It should be realized that it is only a model. This model, if activated by one specific software switch, generates inputs to the control software based upon control software outputs and standard settings. If the test environment is inactive, the input for the control software comes from field devices.

WARNING

Use of this Tester by untrained or unqualified personnel could result in unexpected or undesired control actions. The use of this tester is restricted to Woodward personnel only. Never activate the tester with any output card plugged into the chassis.

Identification Plate

An identification plate is installed in the cabinet. It contains the following information:

- Part number
- Serial number
- Manufacturing date
- Weight
- Customer name
- Customer
- Power supply information

Always quote the model number and the serial number in any correspondence with Woodward.

IMPORTANT

Do not lock TCP Bay 1 Cabinet door or the Driver Cabinet door. The Identification Plate is on the inside of the cabinet..

Cabinet Label Definitions

	**The Explanation Point located above the door handles indicate Electric Caution should be observed while inside the cabinet.**
	**The Lighting Bolt located above the door handles and in the cabinets indicate that High Voltage is contained inside the cabinet.** **High Voltage Label markers cover customer access to screws on field terminal blocks. Remove marker to access the screw and then re-install marker after wiring is complete.**
	**The PE label located on the field terminal blocks is a Protective Earth connection. This is also represented by a ground symbol with a circle around it in other locations in the cabinets.**
	**The IE label/Bar is Chassis Ground and no field wiring connection is required. This Chassis ground is tied to Protective Earth at one location (bottom of the TCP Bay 2 cabinet).**

HIGH VOLTAGE—The inside of the cabinet contains dangerously high voltages. Safely disconnect all voltage sources prior to entering the cabinet. Failure to do so could result in serious injury or death.

Chapter 2.
Specifications

Environment

Temperature	Operating: 0 to 50 °C (storage: –25 to +70 °C)
Humidity	95% non-condensing at 20 to 55 °C
Altitude	1000 m / 3280 ft above mean sea level
Air Quality	Pollution Degree 2
Installation Overvoltage Rating	Category II
Sound Level	Less than 70 dBA

Input Power Ratings

Power Supply	Frequency	Rated Voltage	Rated Current
1	50 Hz	230 Vac	1 A
2	50 Hz	230 Vac	6.25 A
3		125 Vdc	16 A
4		24 Vdc	125 A
5		24 Vdc	32 A

Physical Dimensions

Refer to Figures 2-1 and 2-2.

Weight TCP	Approximately 1430 kg (net), 1480 kg (gross—including packaging)
Width TCP	320 cm
Height TCP	220 cm
Depth TCP	80 cm
Weight Driver Panel	Approximately 312 kg (net), 337 kg (gross—including packaging)
Width Driver Panel	100 cm
Height Driver Panel	200 cm
Depth Driver Panel	40 cm

Supplied Accessories

Lifting Eyebolt Brackets	6 off, 30 mm ID

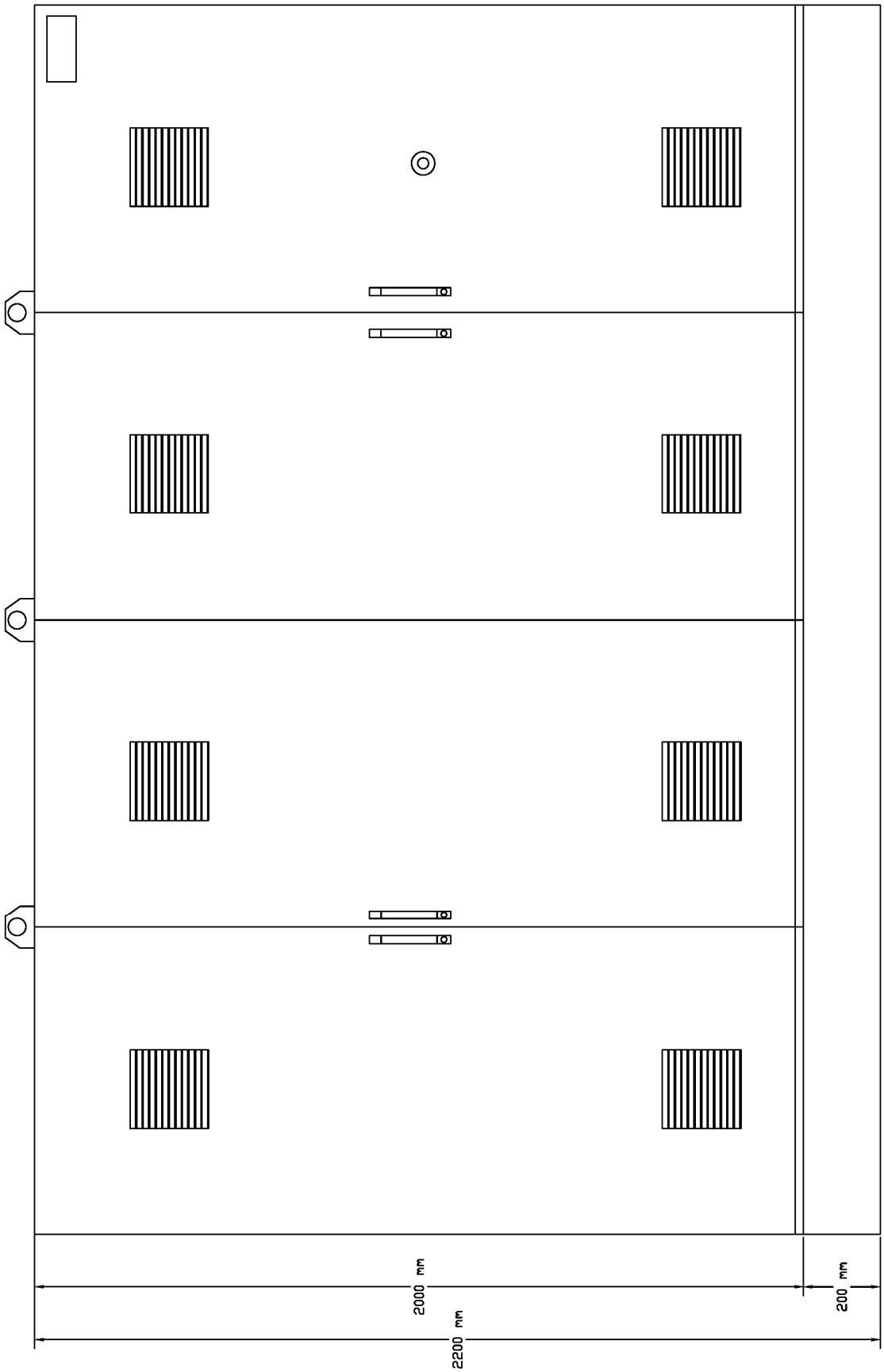

Figure 2-1. Front Dimensions

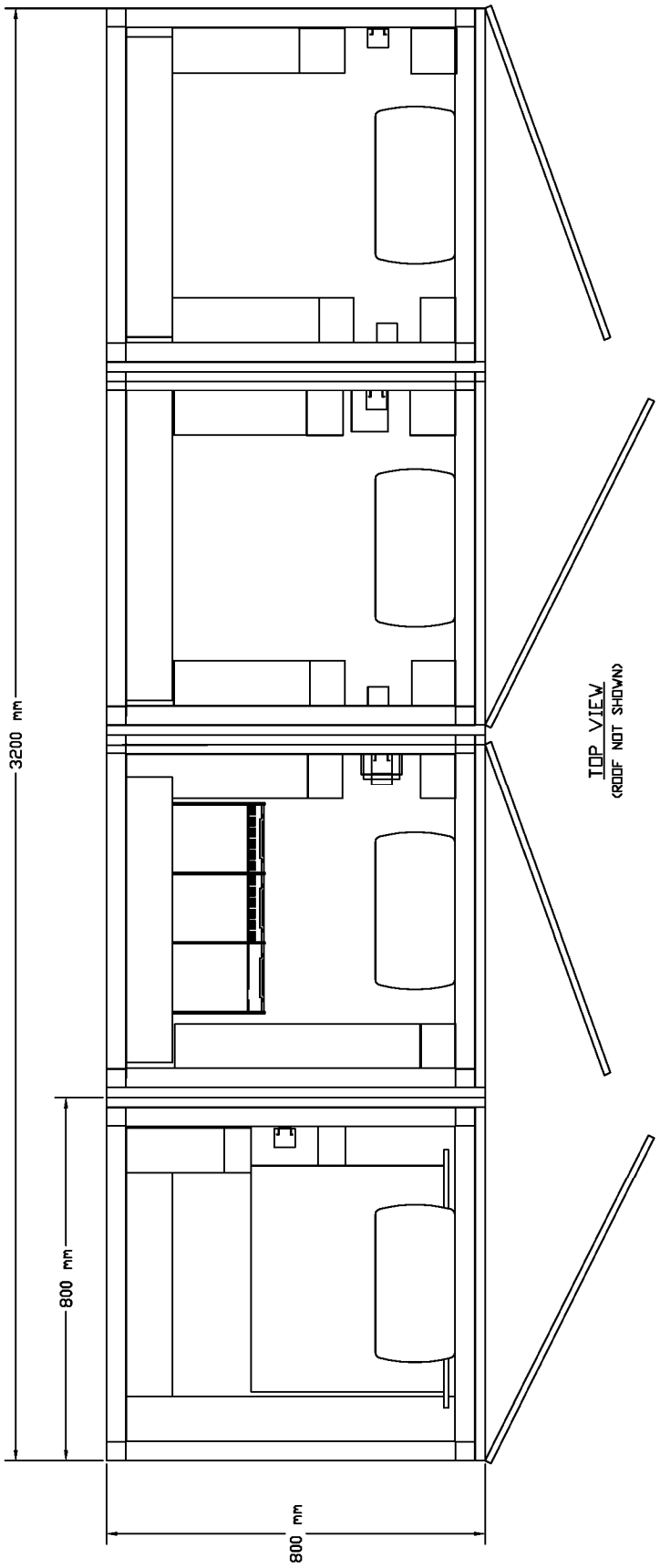

Figure 2-2. Plan Dimensions

Chapter 3.
Transportation and Unpacking

Safety

WARNING **The safety precautions given in this chapter are the minimum safety precautions necessary. Always refer to local health and safety instructions before you move the unit.**

WARNING **The unit is heavy (see Chapter 2, Specifications). Only use suitable lifting equipment with sufficient lifting capacity to move the unit.**

WARNING **The unit has a high center of gravity. Do not use a forklift truck to lift the unit. Only lift it from above using the supplied lifting eyes.**

Obey the following safety precautions when you transport the unit:

- Make sure the area where the unit is to move to is clear of personnel and equipment.
- Make sure all personnel fully understand the lifting procedure and applicable safety precautions before the unit is moved.
- Use lifting equipment with sufficient load capacity to move the unit.
- If you transport the unit on a vehicle make sure the unit is secure.

Inspection of Package after Delivery

Inspection before Unpacking

Before you move the unit to another position or unpack the unit you must carefully examine the crate and packaging for damage caused during transportation to the installation site. Damage that has occurred to the crate or packaging can be an indication that damage has occurred to the unit itself.

If external damage has occurred, assess the damage that may have also occurred to the unit. If you think that the unit is damaged contact the transportation carrier and Woodward. Make sure the carrier completes a transportation damage report immediately.

IMPORTANT **Do not remove the packaging because that can invalidate any claims that may be made.**

Inspection after Unpacking

Do this unpacking and inspection procedure:
1. Remove the crate and packaging from the unit.
2. Inspect the unit for damage and missing parts.
3. Check the parts supplied against the enclosed checklist and note any missing parts or incorrect part numbers.
4. Make sure the specified number and type of eyebolts are supplied with the unit (refer to Chapter 2, Specifications).

If you think that the unit is damaged or parts are missing, contact Woodward.

Handling the Unit

This is the only approved procedure for moving the unit into its installation position or a storage position:
1. Prepare the area to which the unit will be moved. For details about the lifting eyebolt brackets refer to Chapter 2, Specifications. For details about storage refer to the Storage section below. For the installation procedure refer to Chapter 4, Mechanical Installation.
2. Make sure the unit doors are closed and locked. Store the key in a safe place.
3. Connect to a minimum of 4 eyebolts in the top of the unit in positions that will give an even load distribution. Make sure the connection to the eyebolts is secure.
4. Remove all loose components and tools from the unit.

⚠WARNING **Make sure that the lifting cables always have an angle from vertical of less than 45° during lifting.**

5. Connect lifting cables between the eyebolts and the lifting equipment.
6. Attach guide ropes to each end of the unit's base.
7. Carefully lift the unit and move it slowly to the installation position. Control the movement of the unit using the guide ropes.
8. Lower the unit, carefully guiding it onto the floor attachments.
9. Electrically ground the unit immediately (see Chapter 5, Grounding Procedures section).

Storage

The unit can be stored for long periods if the ambient conditions stay within limits:
1. Move the unit to a position where the it can safely stand without being damaged.
2. If possible, electrically ground the unit.
3. Cover the unit with a protective cover.
4. Periodically monitor the ambient conditions around the unit and check the condition of the unit.

Chapter 4.
Mechanical Installation

Safety

WARNING **The safety precautions given in this paragraph are the minimum safety precautions necessary. Always refer to local health and safety instructions before you move the unit.**

WARNING **Only qualified and trained personnel must prepare and install the unit.**

Preparation

Before the unit is moved into position you must ensure that the installation area has been correctly prepared. The structure supporting and surrounding the unit must be in accordance with the mechanical requirements, the electrical installation (supplies and signal inputs and outputs, etc.) must be in accordance with the electrical requirements, and the area in which the unit will operate must be in accordance with the environmental requirements (temperature, humidity, water protection, etc.).

Mechanical Requirements

- Make sure the area where the unit is to be installed has been prepared for the installation of the unit. Make sure there is sufficient access for installation, calibration and maintenance procedures to be done. There must be sufficient physical space to open the unit doors fully, and to have access to the rear, sides and underside.
- The surface on which the unit is to be installed must be level, rigid and give a continuous support surface under the unit.
- Make sure the area is clean and free from all dirt and debris.
- Ventilation holes, ducts, filters, etc., must not be obstructed.
- If the unit is installed in a closed area, the air temperature and quality in the area must stay within limits (see Chapter 2, Specifications) when the unit is operational.

Environmental Requirements

- Make sure that water and condensation do not come into contact with the unit.
- Sufficient ventilation for cooling the equipment must be supplied. If necessary, air conditioning must be installed to keep the temperature and humidity within required limits.
- Vibration must be kept to a minimum.
- Dust, smoke, or any other small air-borne particles should be prevented from entering the area where the unit is installed.

Installation Procedures

The following procedures detail the mechanical installation of the unit. The installation area must be fully prepared in accordance with the information given in the Preparation section above, and the unit must be unpacked and inspected in accordance with the information given in Chapter 3, Transportation and Unpacking.

WARNING

Move the unit only in accordance with the instructions given in Chapter 3, Transportation and Unpacking.

WARNING

After installation, make sure the unit is securely installed and that it cannot move in any direction.

IMPORTANT

Close the unit doors when access is not required.

1. Lift the unit and install it on the studs. Make sure that the unit is level.
2. Open the doors of the unit.
3. Connect the unit ground bars to an electrical ground (see Chapter 5, Grounding Procedures section).
4. Install washers and nuts on the studs to secure the unit at the base.
5. If applicable, connect ventilation ducting to the unit.
6. Close the doors of the unit.

Chapter 5.
Electrical Installation

Introduction

The installation manual serves as a guide to connect external wiring to the Turbine Control Panel. In this section, guidelines are given for the cabling and wiring of this control system. Take care to follow the instructions listed in this document in order to prevent damage or degradation of performance of the Turbine Control Panel. This chapter is divided in the following sections:

- Strain Relief
- Grounding
- Shielding
- Cable Routing and Segregation
- Wiring
- Field Devices
- Input/Output Cable Connections
- Power Connection

The routing of all field cabling inside the cabinet should enter at the bottom and through the cable ducts to the field terminal blocks. Refer to the accompanying wiring drawings for details about connections. The layout of the cabinet and the cable ducting should be designed to keep high voltage cables separated from signal cables so interference is reduced. The floor panels should have holes cut in them to allow wires to pass through. Do not discard floor panels.

NOTICE **Do not locate cabling holes in the floor directly underneath other equipment or cabling in the cabinet.**

Cables shall be protected against abrasion and sharp bends at the point where the cable enters the equipment by an inlet or bushing with a smoothly rounded opening or by a reliably fixed cable guard.

NOTICE **Floor panels must be reinstalled after field cabling installation.**

After the mechanical installation of the control unit has been completed, this chapter can be used as a reference during the connection work of all electrical inputs and outputs of this control system.

NOTICE **To prevent damage to the control system or the external devices, do a loop-check of all wires connected to the control system before power is applied to the system.**

Strain Relief

Strain relief clamps are a means to relieve cables of mechanical strain for which they are not designed. Cables must be mechanically secured adjacent to their point of entry (if necessary this can be outside the cabinet) using the strain relief connectors supplied with each cabinet (see Figures 5-1 and 5-2).

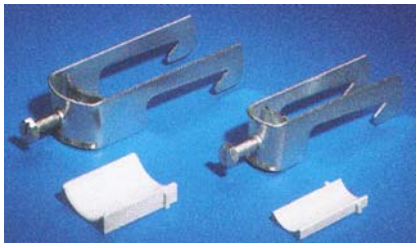

Figure 5-1. Strain Relief Clamps

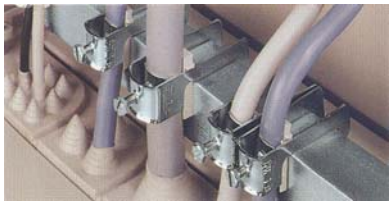

Figure 5-2. Strain Relief Clamps in the Cabinet

The cable clamp mounting rail is mounted in the base. One box of each size is supplied. Each box contains 25 pieces. In Table 5-1, the cable clamp can be selected against cable diameter.

Table 5-1. Cable Clamp Sizes

For cable diameter	Packs of	Model No. SZ
14 - 18 mm	25	2352.000
18 - 22 mm	25	2353.000
22 - 26 mm	25	2354.000
26 -30 mm	25	2355.000
30 - 34 mm	25	2356.000
34 - 38 mm	25	2357.000
38 - 42 mm	25	2358.000
42 - 46 mm	25	2359.000
46 - 50 mm	25	2360.000

Additional Cable clamps can be ordered from Rittal with the corresponding part numbers in the third column of the above table.

Grounding

Purpose of a Grounding System

Considerable design work has been done to ensure that this cabinet or panel has been designed to operate in a variety of industrial environments. The cabinet has been designed to meet industrial-level environments, with regard to noise, EMI and RFI conditions. The primary purpose of equipment grounding is personnel safety and to improve equipment operation and continuity of service. The four main reasons for having grounded systems are: lightning protection, reduction of noise emissions, safety, and signal integrity.

Grounding the Cabinet

The cabinet should have a solid connection to an earth ground. Both an earth ground connection and an EMC ground connection have been provided with this cabinet. The EMC and the earth ground are only connected together at one point, in the power distribution bay 2. For the grounding scheme please refer to the control wring diagram. Connections to earth ground can be made using a metal rod, buried water pipes, buried plates, or buried wire/cable. A ground connection should be durable, have low DC resistance and low AC impedance, and have adequate current carrying capability.

Grounding Procedures

The following requirements must be followed to ensure correct grounding of the unit:

- Connect the ground rail located at the bottom of the control panels firmly to electrical ground. Use braid of 10 AWG or larger.
- Do a bonding test between the ground rail and electrical ground. The resistance must be less than 0.10 ohms.
- All doors and plates must be connected to the ground rail by braid of 12 AWG or larger.
- Equipment units must be grounded either by a unique ground wire to the ground rail or to a unique ground area on the plate or door it is installed on.

NOTICE

Do not connect any cable grounds to "instrument ground", "control ground", or any non-earth ground system. Make all required electrical connections based on the wiring diagrams.

Shielding

Shielding is accomplished by 'over braiding' and inner shielding of cables. An outside conduit, braid, or shield of a cable is referred to as the over braid, and any internal signal shielding to the cable is referred to as the 'twisted wire shield'. When signals are grouped together in a cable, hard ground or capacitively couple the over braid of the cable close to the penetration point of the cabinet. Be sure to always have at least one end tied to hard ground. Ground bars or some other means of grounding are provided for this purpose. After the field wiring has been connected to the cabinet, be sure to go back and install any floor panels and wire duct covers, to 'close' up the cabinet in order to ensure that inside the cabinet the accumulation of dust is kept to a minimum.

Wire Connections to the Cabinet

For shielded cable to be effective, it should be shielded over the entire length of the cable. It is important that the shield be maintained over the cable as close as possible to the final termination on either end. If the cable is left unshielded, for example 10 % of its length, the effective shielding of the cable is 20 log(100%/10%) or 20 dB. All wires shown in the Control Wiring Diagram as shielded ***must*** be shielded.

Connecting Overbraids

Overbraids must be sealed using the correct size glands (not supplied), which should be installed in the floor plates in the base of the cabinet.

General rules for connecting wiring:

- Keep sensitive I/O cables separate from noisy power wires supplying the control and other devices.
- Keep shield terminations as short as possible (1/2" or less is preferable). 1" of shield termination acts like 10 ohms at 60 MHz.
- Solder sleeves cause reflections. For the best shielding terminate the shield itself, not an added wire.

- For best immunity from electro-magnetic interference it is necessary that the signal wires are double shielded. The inner shield must be connected at one point only. The outer shield or over braid must be connected to ground at as many points as possible. It should also have 360 degree contact with the enclosure gland plate.
- In some panels a zinc-plated rail can also serve not only as strain relief but also as grounding for the overall braded shield if done properly. This can be done by stripping the outer insulation from around the cable until the metal braiding is fully exposed around the cable so proper contact can be made. See Figure 6.3.

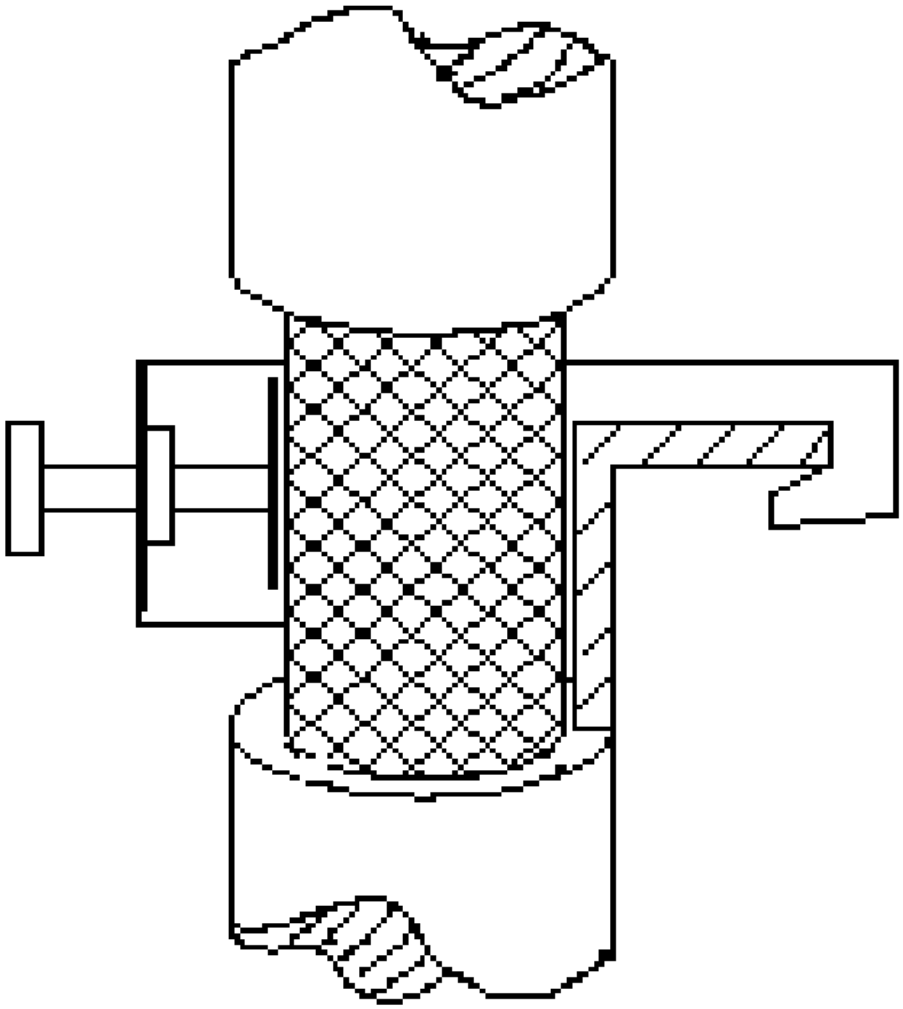

Figure 5-3. Strain Relief and Grounding

- In order to ensure full contact around the overall braiding EMC gasket may need to be applied around the braiding replacing the plastic inserts supplied.
- Do not tie the shields of different input channels together at any point (except through ground). The shield of any one cable must connect only to its designated terminal at the cabinet end of the cable.
- Ensure that a good electrical connection is obtained between any conductive armoring and the rack ground.
- Field wiring shields should be grounded as shown in the control wiring diagram.

Cable Routing and Segregation

To reduce interference the layout of the cabinet and the cable ducting is designed to keep cables with voltages >50 V separated from signal cables.

Field signals are grouped into signals <50 V and >50 V as well as analog and discrete signals. A voltage <50 V is considered safe. Whenever possible, these signals should be isolated in the cabinet as well as outside the cabinet. Analog signals are classified as signals that vary from one value to another, such as a thermocouple input or a current (4-20 mA) input. These types of signals should always be a twisted pair insulated and shielded cable. Discrete signals are signals that have an 'ON' and an 'OFF' value, but do not have a functional variation between the two readings. These types of signals usually are not shielded cables but in some cases are, due to electrical interference to other types of signals.

General rules for routing the wiring:

- Incoming power wires from the 24 Vdc supplying the control must be separated from signal wiring.
- For each connection check that the wires are not under tension.
- Do not place shielded wires in the same cable conduit as cables with voltages >50 V or large-current-carrying cables when possible.
- To reduce interference make sure that >50 V cables and high-current cables are kept separate from signal cables.
- The routing of all field cabling inside a cabinet should be done through cable ducts and guide them to the field terminal blocks.
- All field cables must enter the cabinet from the bottom side unless the cabinet is designed otherwise.

Wiring

Cable Lengths and Specifications General

In general, the wiring diameters are determined by the regulations to which the control cabinet has been built. Should information about cables not be available use the following guidelines:

- Use 0.75 mm^2 or larger stranded wire for the signal-carrying wires.
- Use 0.5 mm^2 or larger for twisted/shielded wire.
- Unused cores must be connected to ground at one point only within the control cabinet, preferably where they enter the cabinet.
- All customer connections must be made with safety listed wire having a flammability classification of FV-1 or better.
- Use wire with an appropriate insulation rating to prevent parts from becoming hazardous.

Application Specific Wiring

For more detailed information, refer to MicroNet™ manual 26166 for MicroNet modules, and Driver manual 26159 for the EM35 Digital Drivers.

Serial I/O module

The SIO module has four serial ports. Ports J1 and J2 are RS-232; ports J3 and J4 can be used as RS-232, RS-422, or RS-485.

Maximum cable length
To ensure correct communication, the length of the communication cable should not be longer than the maximum values listed in Table 5-2.

Table 5-2. Cable Length

Type	Maximum Cable Length (m)
RS-232	15
RS-422	1200
RS-485	1200

Termination
For RS-422, termination should be located at the receiver when one or more transmitters are connected to a single receiver. When a single transmitter is connected to one or more receivers, termination should be at the receiver farthest from the transmitter.

For RS-485, termination should be at each end of the cable. If termination cannot be located at the end of a cable, put it as close as possible to the ends.

If it is not known if a master can put its transmitter into a high-impedance state, terminate the line as described for the RS-422 termination. It is always better to terminate the line even when it is not used.

Termination is accomplished using a three-resistor voltage divider between a positive voltage and ground. The impedance of the resistor network should be equal to the characteristic impedance of the cable. This is usually between 100 and 120 ohms. The purpose is to maintain a voltage level between the two differential lines so that the receiver remains in a stable condition. The differential voltage can range between 0.2 and 6 V; the absolute maximum voltage between either receiver input and circuit common must be less than 10 V. The SIO board has the appropriate resistances mounted on the PCB.

CPU Module
The MicroNet PowerPC CPU contains a Motorola MPC5200 processor, 128 Mbyte DDR RAM, 64MB of flash memory, a Real Time clock and various communication peripherals. These peripherals include (2) general use Ethernet ports, (2) real Time Network ports, (1) serial port, (1) service port and (2) CAN ports.

Ethernet Communication Cables

The Woodward control can form a Local Area Network (LAN) together with one or more other devices. The CPUs communicate via an Ethernet™ card that is located in the control's chassis, using 10Base-2 or 10Base-5. The CPU communicates through an on-board Ethernet connection, using 10Base-T.

EM35 Digital Driver Cabling

Refer to Manual 26159, Chapter 3 and other applicable chapters according to the driver used.

Thermocouple Cables

Use the correct compensation cable for the type of thermocouple,. Use twisted pair shielded cables to eliminate noise.

Field Devices

- Use suppressors on all inductive devices (relays, pumps, motors, etc.).
- Install shielding according to control wiring diagram if applicable or according to the proposed schemes shown in Figure 6.4.
- Refer to Woodward Application Note 51204 for additional Grounding and Shield Terminations.

Input/Output Cable Connections

Configurable Dataforth FTM

Introduction
The configurable Dataforth Field terminal Module (FTM) is designed to interface to a 4-20 mA (0–5 V) 24 input, 8 output, standard NetCon®/MicroNet analog high density module. It replaces the existing FTM and is capable of Triple Modular Redundancy (TMR) operation. It is designed to interface with the existing 62-pin cable connector. It is designed to convert sensor input signals to a 0 to 5 V input compatible with the high density I/O module. Each channel is individually configurable via a plug-in standard isolated Dataforth SCM7B converter that has been modified to meet Woodward's bandwidth and input temperature range requirements. The converter modules are powered directly through the cable connector; meaning external power connections are not required on the FTM. These converters currently include 100 Ω RTDs, 200 Ω RTDs, and K-Type Thermocouples (T/Cs). Included are sections from the Dataforth catalog describing the RTD and T/C functionality. This includes a block diagram and specifications for the standard converters that the Woodward design was based upon. More information can be found at the Dataforth Internet site www.dataforth.com. Isolation is provided on each channel. This added isolation could eliminate the need for external intrinsically-safe isolation barriers, where they are required in certain applications. This FTM also accommodates the standard 4–20 mA transmitter input (including loop power with built-in fuse) via a pass through converter. This converter output is passed directly through the connector cable to the terminal blocks maintaining an identical design to the standard FTM. Channels are labeled to correspond to their software locations (for example, analog input 1 on the FTM will be analog input 1 in the application software).

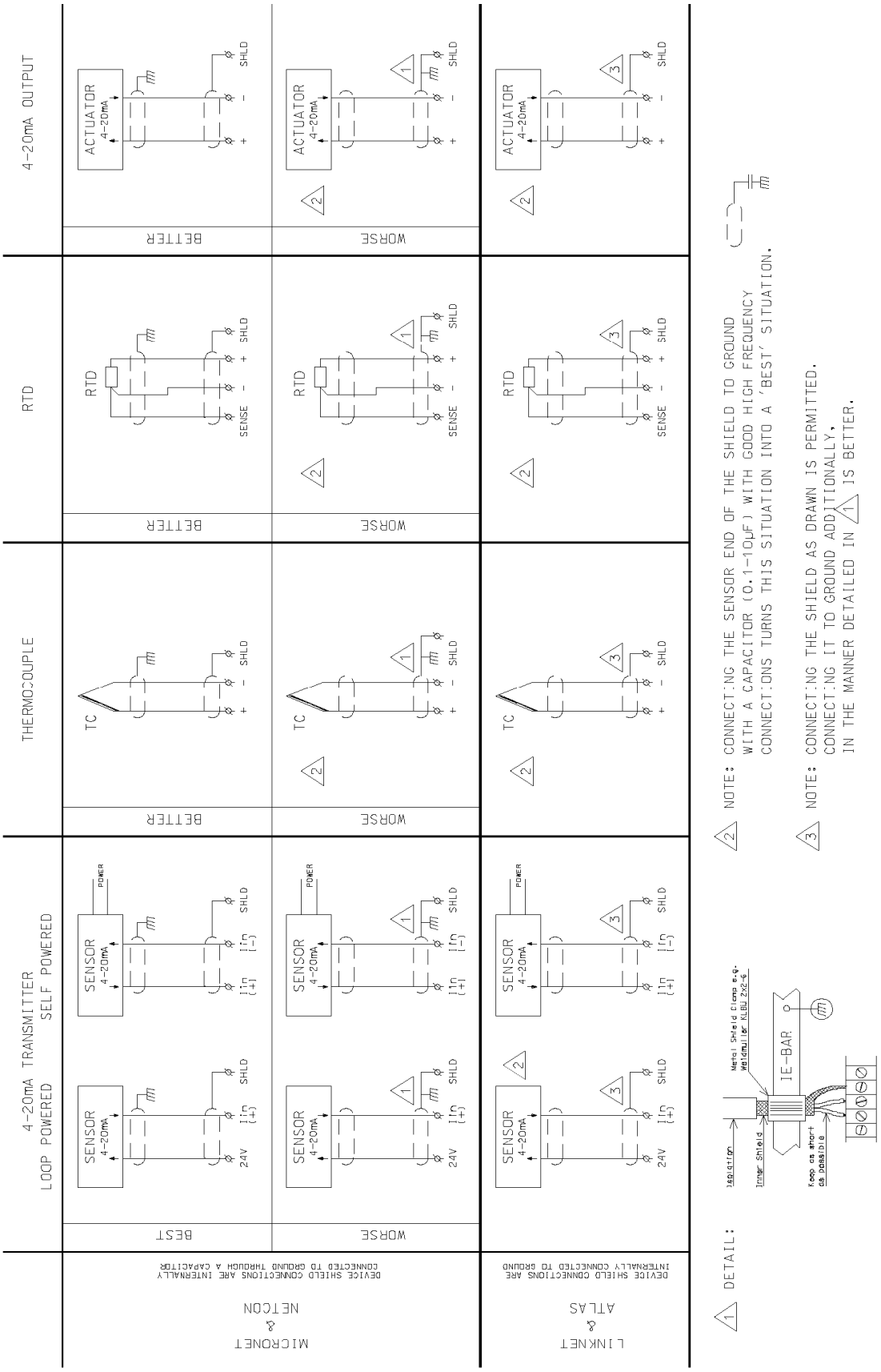

Figure 5-4. Shielding Practices

Field wiring

The Dataforth FTM must be wired according Table 5-3. Sheets 2 and 3 of Woodward drawing 9097-602 show the circuit for each input and output channel. Each input channel requires a Dataforth module per input. The Control Wiring Diagram shows detailed field wiring for each type of signal.

Table 5-3. Wiring Table for the Configurable Dataforth FTM

Input channel	TB	Function	4-20 mA (self-powered)	4-20 mA (loop-powered)	T/C	RTD	Output channel	TB	Function
#1, 13	13	X				Sense	#1, 5	1	-
	14	-	-		-	-		2	+
	15	+	+	-	+	+		3	SH
	16	SH	Shield	Shield	Shield	Shield			
	17	COM					#2, 6	4	-
	18	+24v		+				5	+
#2, 14	19	X				Sense			
	20	-	-		-	-	#3, 7	7	-
	21	+	+	-	+	+		8	+
	22	SH	Shield	Shield	Shield	Shield		9	SH
	23	COM							
	24	+24V		+			#4, 8	10	-
#3, 15	25	X				Sense		12	SH
	26	-	-		-	-			
	27	+	+	-	+	+			
	28	SH	Shield	Shield	Shield	Shield	X TO -ON RTDs		
	29	COM							
	30	+24V		+					
#4, 16	31	X				Sense			
	32	-	-		-	-			
	33	+	+	-	+	+			
	34	SH	Shield	Shield	Shield	Shield			
	35	COM							
	36	+24V		+					
#5, 17	37	X				Sense			
	38	-	-		-	-			
	39	+	+	-	+	+			
	40	SH	Shield	Shield	Shield	Shield			
	41	COM							
	42	+24V		+					
#6, 18	43	X				Sense			
	44	-	-		-	-			
	45	+	+	-	+	+			
	46	SH	Shield	Shield	Shield	Shield			
	47	COM							
	48	+24V		+					
#7, 19	49	X				Sense			
	50	-	-		-	-			
	51	+	+	-	+	+			
	52	SH	Shield	Shield	Shield	Shield			
	53	com							
	54	+24V		+					
#8, 20	55	X				Sense			
	56	-	-		-	-			
	57	+	+	-	+	+			
	58	SH	Shield	Shield	Shield	Shield			
	59	com							
	60	+24V		+					
#9, 21	61	X				Sense			
	62	-	-		-	-			
	63	+	+	-	+	+			
	64	SH	Shield	Shield	Shield	Shield			
	65	COM							
	66	+24V		+					
#10, 22	67	X				Sense			
	68	-	-		-	-			
	69	+	+	-	+	+			

Input channel	TB	Function	4-20 mA (self-powered)	4-20 mA (loop-powered)	T/C	RTD	Output channel	TB	Function
	70	SH	Shield	Shield	Shield	Shield			
	71	COM							
	72	+24V		+					
#11, 23	73	X				Sense			
	74	-	-		-	-			
	75	+	+	-	+	+			
	76	SH	Shield	Shield	Shield	Shield			
	77	COM							
	78	+24V		+					
*12, 24	79	X				Sense			
	80	-	-		-	-			
	81	+	+	-	+	+			
	82	SH	Shield	Shield	Shield	Shield			
	83	com							
	84	+24V		+					
	85	Not Used							
	86	Ground							

Specifications

At this time the FTM accepts five different types of Dataforth Modules for analog inputs:

- Thermocouple
- RTD (PT 100 & 200 ohm)
- 4-20mA pass-through
- 0 to 5 V pass through module

For analog outputs no modules are required. Each Dataforth SCM7B module provides a single channel isolated analog input. Drawing 9097-601 shows the pin-out configuration of the plug-in module. The signal conditioners are designed to maintain existing accuracy and bandwidth performance of the NetCon/ MicroNet T/C, RTD, and 4-20 mA inputs modules. Drawing 9097-601 summarizes the specifications from Dataforth including accuracy, bandwidth, operating and storage temperatures, CMRR (Common Mode Rejection), and range for each type of signal converter. To obtain overall signal input accuracy and bandwidth, the 4-20 mA (0-5 V) module input accuracy must be taken into account. The NetCon/MicroNet high density analog input module accuracy is as follows (refer to manual 26166 for full details):

Number of Channels	24
Update Time	5 ms
Input Range	0–25 mA or 0–5 Vdc, software and hardware selectable
Isolation	0 Vrms, 60 dB CMMR, 200 Vdc common mode rejection Voltage: no galvanic isolation
Input Impedance	200 Ω
Anti-aliasing Filter	2 poles at 10 ms
Channels 23 & 24 Reduced Filtering	2 poles at 5 ms & 2 ms
Resolution	16 bits
Accuracy	Software calibrated to 0.1% maximum, over 0-25 mA (0-5 V) full scale
Temp Drift	275 ppm/°C, maximum
Fuse	100 mA fuse per channel.

Thermocouple module

The Type K Thermocouple module accepts a single channel of input from type K. The signal is filtered, isolated, amplified, linearized, and converted to a 1 to +5 V analog voltage for output to MicroNet I/O Module.

Linearization is achieved by creating a non-linear transfer function through the module itself. This non-linear transfer function is configured at the factory, and is designed to be equal and opposite to the thermocouple non-linearity.

Cold Junction Compensation (CJC) is performed using an NTC thermistor externally mounted from the module on the FTM. Open thermocouple detection is upscale using a 30 mA current source in the input circuitry.

These modules incorporate a five-pole filtering approach to maximize both time and frequency response by taking advantage of both Thompson (Bessel) and Butterworth characteristics. One pole of the filter is on the field side of the isolation barrier; four are on the process control side.

After the initial field side filtering, the input signal is chopped by a proprietary chopper circuit and transferred across the transformer isolation barrier, suppressing transmission of common mode spikes and surges. The signal is then reconstructed and filtered for process control input.

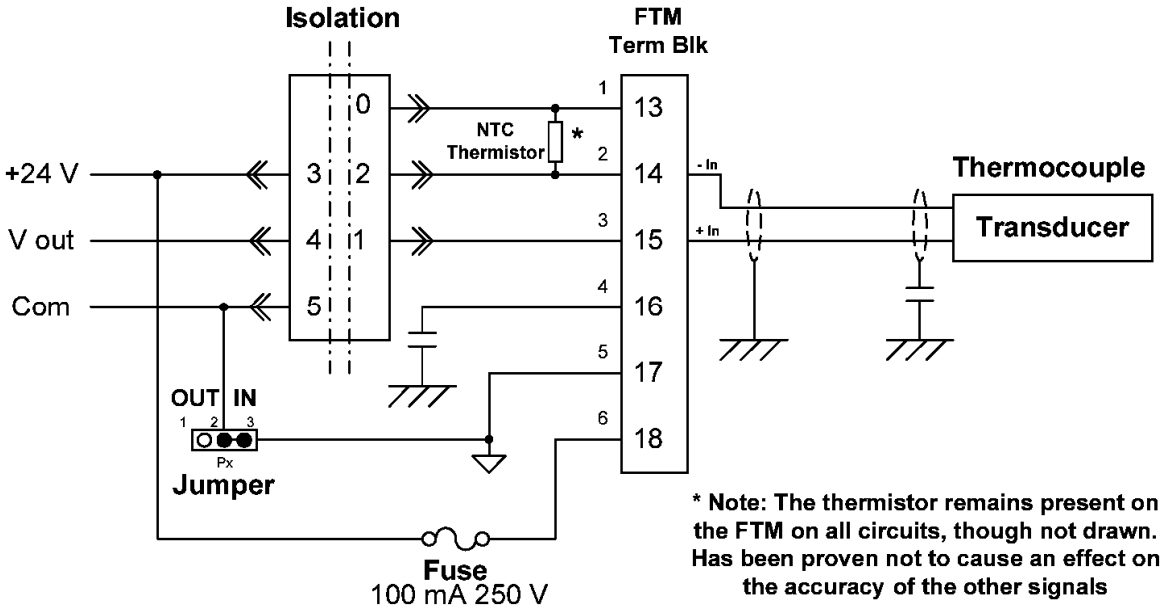

Figure 5-5. Example Wiring Diagram—Thermocouple to Dataforth FTM

RTD module

The RTD module accepts a single channel of 100 or 200 Ω platinum RTD, depending on the selected RTD module, and produces an input voltage in response to a low level current excitation. The input signal input is filtered, isolated, amplified, linearized, and converted to a 1 to +5 V analog voltage for output to the MicroNet I/O module.

These modules incorporate a five-pole filtering approach to maximize both time and frequency response by taking advantage of both Thompson (Bessel) and Butterworth characteristics. One pole of the filter is on the field side of the isolation barrier; and four are on the process control side.

In response to the low-level current excitation signal, the RTD input signal is chopped by a proprietary chopper circuit and transferred across the transformer isolation barrier, suppressing transmission of common mode spikes and surges. The signal is then reconstructed and filtered for process control input.

Linearization is achieved by creating a non-linear transfer function through the module itself. This non-linear transfer function is configured at the factory, and is designed to be equal and opposite to the specific RTD non-linearity. Lead compensation is achieved by matching two current paths thus canceling the effects of lead resistance.

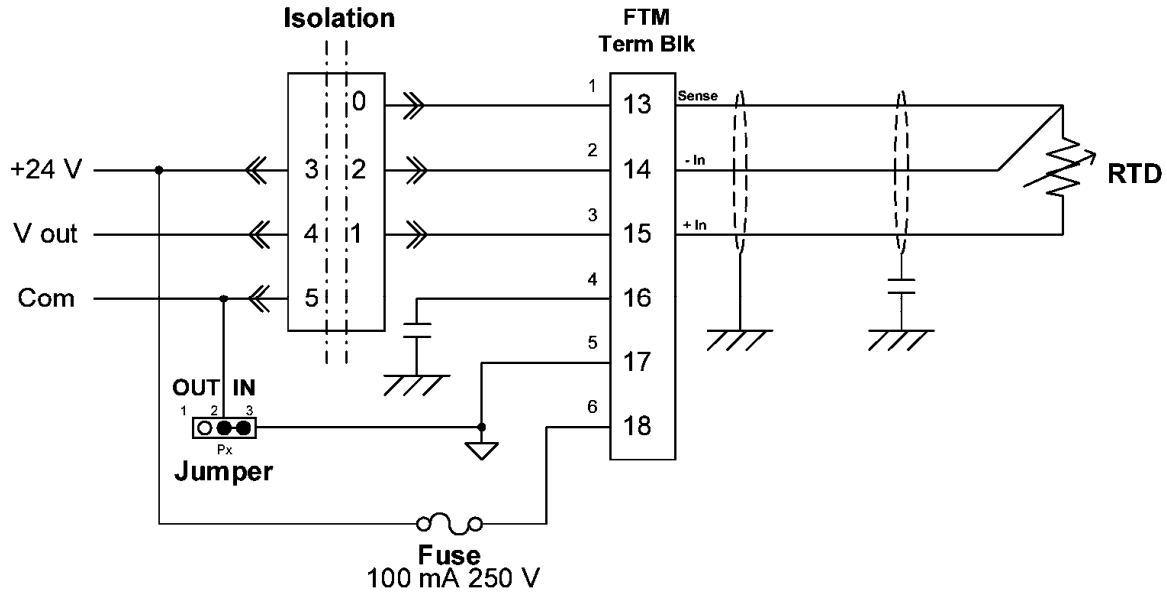

Figure 5-6. Example Wiring Diagram—RTD to Dataforth FTM

Non-isolated current and voltage input module

The non-isolated Current and Voltage input module is a non-isolated pass-thru module which shorts the signal inputs-to-outputs. Since the simplex high density analog I/O Module (24 4–20 mA inputs, 8 4–20 mA outputs) is configured for voltage input, a conversion has to take place from current to voltage for the current input module. This is accomplished by adding a 200 Ω resistor in parallel to the input signal. No filtering is done on either of the modules.

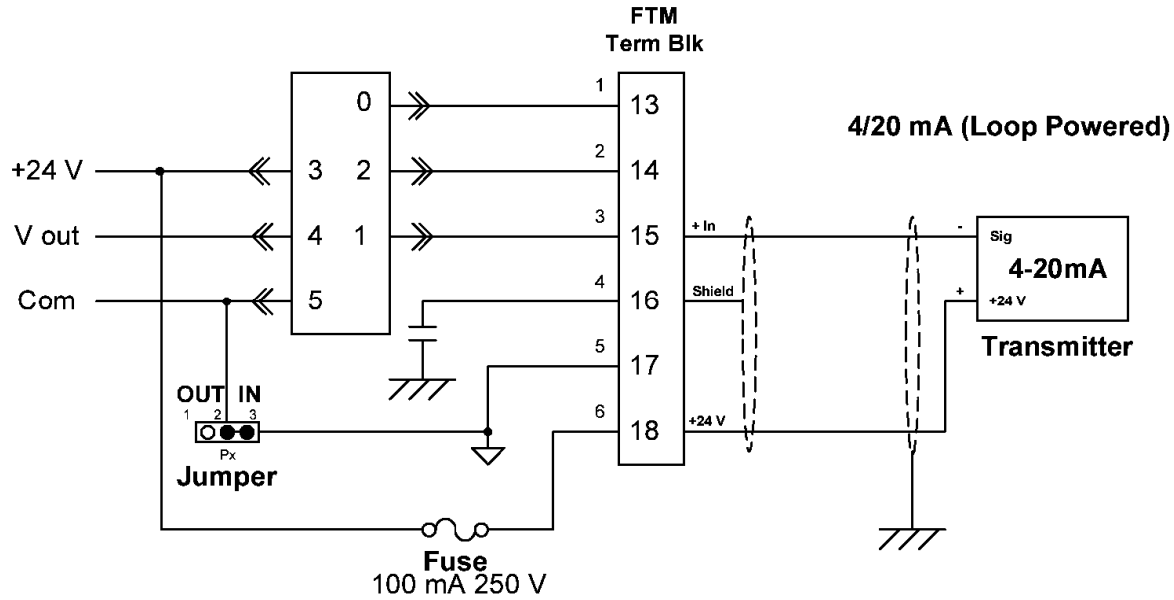

Figure 5-7. Example Wiring Diagram - Loop Powered 4–20 mA Signal to Dataforth FTM

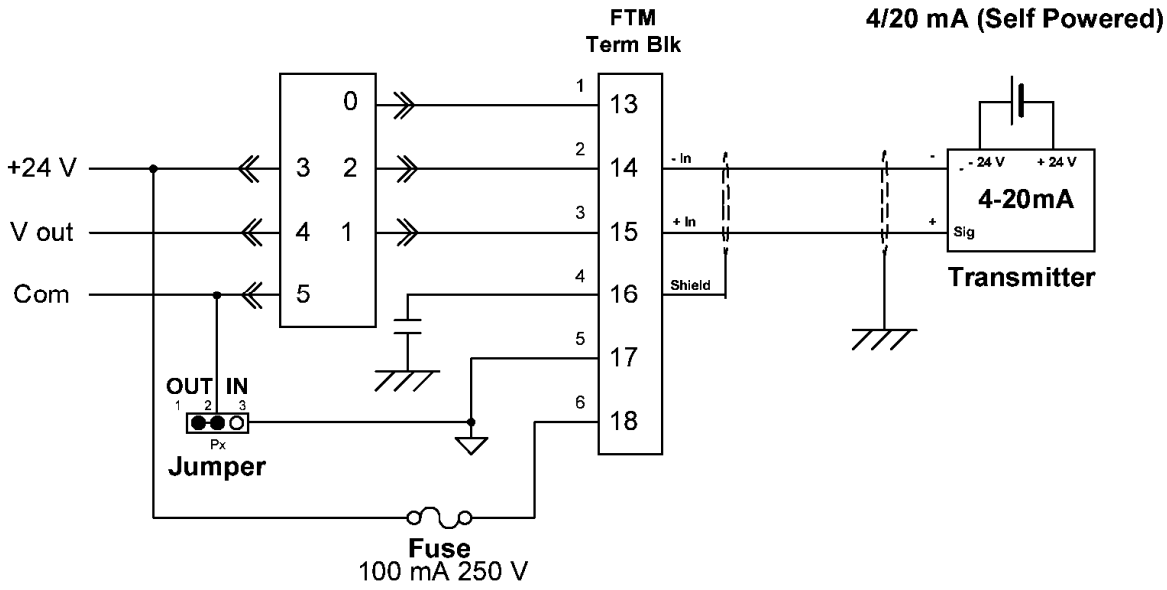

Figure 5-8. Example Wiring Diagram - Self-powered 4–20 mA Signal to Dataforth FTM

Filtering and other performance are limited to those of the input card. For more details see the MicroNet Hardware Manual.

Configuring the FTM
No calibration is required on the FTM or its modules, but there is a jumper that must be set. Drawing 9097-602 sheet 1 illustrates the Jumper location and IN or OUT position. Both loop and external powered circuits can be used with the Dataforth FTM. When a loop-powered circuit is desired, the jumper for the appropriate circuit (located next to the fuse and below the channels module), ensures that the jumper is in the “IN” position. For externally (or self-powered) circuits the jumper needs to be moved in the “OUT” position.

GE Fanuc Input and Output Modules

The GE Fanuc modules used in the system are listed in Table 1-1 in a separate Woodward application-specific data manual.

Please follow the applicable procedures and instructions as described in the appropriate GE Fanuc Manuals: GFK0262F, GFk0826G, MAN0076-06 and MAN0063-03.

MPU Signal Inputs

The inputs for speed signals can accept voltages in the range from 1.5 Veff to 70 Veff. The input circuitry contains a Schmitt-trigger to eliminate noise interference. The frequency determination is based on time integration of one signal cycle. For zero speed detection, the maximum time window is limited. Both shafts have two speed-sensors for redundancy.

Zero-speed detection, speed control, and overspeed detection is based on the highest of the two measured speeds.

Chip Detector Processing using RTD Inputs

For the detection of metal particles in oil circuits, chip detectors can be used in combination with RTD cards or RTD GE Fanuc modules. This early warning system against complete bearing failures can be considered as a resistor, R_{chip}, of which the value is determined by the amount of metal particles in the oil.

Equation 5-1
For the RTD module, the measured resistance, R_m, can be calculated as:

$$R_m = 1 / [[1 / (R_1 + R_{chip})] + [1 / R_2]]$$

To illustrate how alarm settings can be determined, an example is given with $R_1 = R_2 = 100\ \Omega$. With the field wiring intact, the value of R_m can vary between the following values:

- With new chip detectors installed and with zero particles in the oil, the resistance of the chip detector R_{chip} is theoretically infinitely high. This means that the measured resistance in this case is $R_m = 1 / [[1 / R_2]] = R_2 = 100\ \Omega$.
- If the chip detectors are completely covered with small metal pieces, the resistance of the chip detector R_{chip} is theoretically zero. This means that the measured resistance in this case is $R_m = 1 / [[1 / R_1] + [1 / R_2]] = 50\ \Omega$.

So in practice, the measured resistance should always be between 50 Ω and 100 Ω. If a short circuit in the field wiring occurs or a wire is disconnected, the measured value is either much lower than 50 Ω or much higher than 100 Ω. Thus two fault-detection levels can be set, based on the read-out and the configuration of R_1 and R_2.

During normal operation, the build-up of metal particles as a function of time will be gradual. Starting from an almost infinitely high value, the value of R_{chip} will decrease as wear and ageing of the equipment produces more and more particles. Therefore, two low-alarm values can be set for R_{chip}, of which the highest can be considered as a pre-warning.

As an example, consider the following values:

Table 5-4. Example Settings for Chip Detection
(DO NOT USE THE VALUES BELOW)

Additional resistor R_1	90 Ω
Additional resistor R_2	270 Ω
Additional resistors lay-out	See MicroNet Manual
R_m value for open wire detection	> 300 Ω, approx. 450 °C
R_m value for short circuit detection	< 80 Ω, approx. –50 °C *
1st alarm level R_{chip}/corresponding R_m value	1000 Ω / 91.7 Ω approx. –30 °C
2nd alarm level R_{chip}/corresponding R_m value	100 Ω / 66.7 Ω, approx. –100 °C *

* RTD cards can detect as low as –40 °C. This corresponds to approximately 84.6 Ω. Thus in this example, the layout and value of the additional resistors is not satisfactory and the short-circuit value of 50 Ω and chip alarm levels lower than 1 kΩ cannot be detected. It is recommended that careful research is done to find the best circuit lay out and resistor values.

If other values of R_1 and R_2 are used, or the layout of the additional resistors is completely different, the settings in the table should be re-determined for that set-up.

IMPORTANT

All figures are in ohms, while the readout of an RTD module is in °C. Verify that the correct translation of temperature into resistance is made in the control software, or alternatively, apply the described alarm and failure values expressed in °C.

Power Connection

When all I/O signal wires are connected, the power input cables can be connected in accordance with the wiring diagram. As shown in the wiring diagram make sure to connect the power supply grounding terminal(s) using a grounding conductor the same size as the main supply conductors. Note that the 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. A circuit breaker or a separate switch with appropriate ratings may be used for this purpose. Label the circuit breaker and locate it in close proximity to the equipment and within easy reach of the operator. The switch or circuit breaker shall interrupt all current carrying conductors but shall not interrupt the protective earth conductor.

IMPORTANT

The 24 Vdc input power must be supplied from a power supply/battery charger certified to IEC standard with a SELV (Safety Extra Low Voltage) classified output.

NOTICE

Do not apply power to the system at this time. First do a loop check on the wiring. Incorrectly installed wiring can damage the control and any equipment connected to the control when power is applied.

⚠WARNING

When power has to be supplied to the system, make sure it is safe to do so.

The incoming power cables must be connected to the points identified in the Control Wiring Diagram.

Power Connection Layout

The power distribution layout is shown on the Control Wiring diagram. It contains the breakers and fuses and their ratings.

The following fuses are contained in TCP Cabinet Bay 4 with their appropriate replacement. These fuses are used for the 125VDC Gas Staging Valves.

- **F101 to F112/F113**—ANTI-SURGE FUSE WOUND CONSTRUCTION 5X20 MM 1A 250V SLOW BLOW FUSE (Woodward Item number 1641-575)

Power Connections

The power inputs are required to power the power supplies of the control system.
All power connections are in TCP Cabinet Bay 2.

IMPORTANT

High Voltage Label markers cover customer access to screws on field terminal blocks for 125 Vdc and 230 Vac. Remove marker to access the screws and then re-install markers after the wiring is complete. Make sure no power is supplied to the cabinet when accessing these connections.

Before closing the circuit breakers and applying power to the cabinet, do the following procedure to check the correct connection of the power wires, and correct operation of the power supply (or supplies).

1. Make sure the incoming power to the circuit breakers is turned off.
2. Open all circuit breakers.
3. Turn on incoming power supply with all the circuit breakers still open.
4. Check that power is distributed to all expected points, as shown on the wiring diagram.
5. Check the polarity if the voltages at all the expected points.

Power supply for the staging valves

1. Check that the incoming voltage to the circuit breaker is between the 105 and 125 Vdc, as required for the staging valves
2. Check that the polarity of the wiring to the power supplies is not reversed.
3. Switch on the circuit breaker for one power supply.
4. Check that that the voltage monitoring relay activates correctly.
5. Open the circuit breaker to switch off the power to staging valves.

Chapter 6.
System Description and Operation

Introduction

This chapter gives an overview of the hardware layout and function of the system. It helps with the initial steps to gain familiarity with the GAP code. For precise and definitive data, consult the GAP code and tunable list.

System Definition

This control system has been designed to control and monitor a GE AEP/GE LM6000PD/PF Gas Fuel generator drive turbine system.

Control System Setup

The control system consists of a 2-rack MicroNet™ Plus system, a GE Fanuc and some auxiliary devices. The system has a hardwired Master Protection System. Every shaft sensor has its own electrical overspeed detection module.

I/O processing is done by MicroNet cards with FTMs.

The two MicroNet racks form the Fuel Control Unit (FCU). It contains fuel control software according to and certified by GE against GE's LM6000PD/PF Control Specification. This software is called "the Core". In addition all the software that is needed to embed this software in the system's environment is present in the FCU.

The FCU is equipped with a CPU of sufficient power, Ethernet connections, and all the cards that are needed to accommodate the Core related hardware I/O.

The GE Fanuc contains software that controls all sequencing and auxiliary systems not directly related to fuel control and energy conversion process.

The GE Fanuc contains the software that handles all sequencing, and controls all auxiliary systems that are not directly related to fuel control and the Gas Turbine process. The GE Fanuc's software is not manufactured by Woodward, and is therefore not described in this manual. The GE Fanuc and the FCU communicate with each other through 2 separate Ethernet links. See the Wiring diagram for details.

Prime Mover

The prime mover that drives the generator load is a General Electric LM6000PD/PF The system runs on gas fuel.

Communication

Ethernet Global Data (EGD) protocol is used to communicate between the GE Fanuc PLC and the MicroNet. A Software Development Kit (SDK) has been developed. The EGD SDK allows a Woodward Governor MicroNet controller and a GE Fanuc Automation Series 90™ PLC to exchange data samples using the EGD Protocol across an Ethernet network contained within a customer solution (e.g., a gas turbine power generation system). The SDK supports combinations of two or more MicroNet and/or PLC controllers connected to the same network for this and other applications.

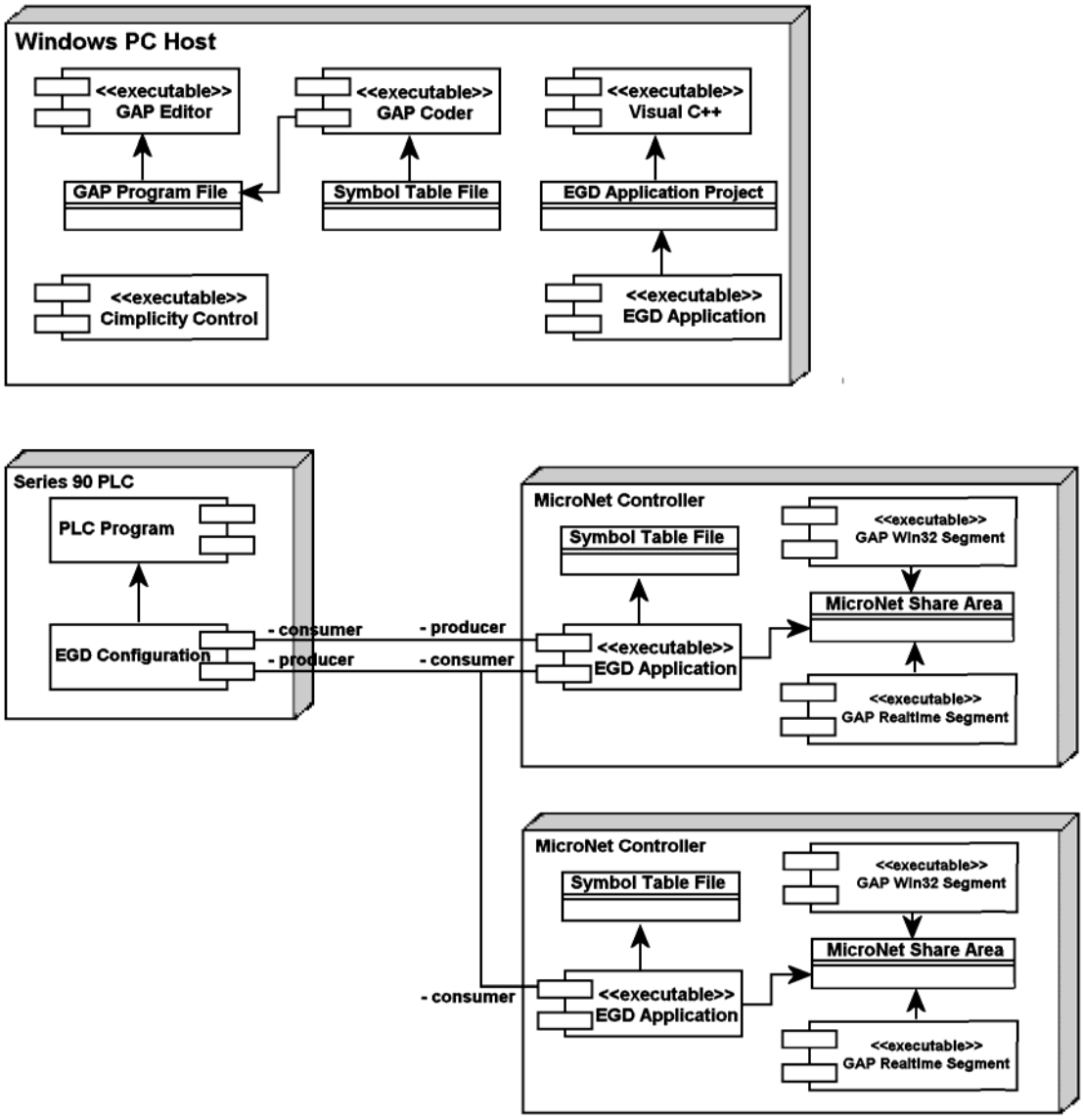

Figure 6-1. Communication Schematic

MicroNet programs are typically defined and generated once using Woodward's GAP toolset on a Windows PC Host, then distributed to one or more MicroNet controllers. Of particular interest is the GAP Coder which generates three key files from the GAP program (.gap) file. These files are:

- The Win32 executable (.exe) component of the GAP program
- The Real-Time executable (.rtss) component of the GAP program
- The Symbol Table Information (.SYM) file.

These (minimum) three files are distributed to each MicroNet controller that runs the same GAP program. When the Win32 component is executed, it creates a shared memory object and starts the real-time component of the GAP program. The shared memory object (also called MicroNet Share Area) contains memory allocated for each symbol defined in the GAP program, and is used for inter-process communication between the Win32 and real-time components. The Symbol Table Information file describes how the memory is mapped to the GAP symbols.

An EGD application is a Win32 console application (.exe) typically developed on the same Windows PC Host as the GAP program. The application uses the SDK to define EGD exchanges, and subsequently produce and consume data samples defined by those exchanges. The application is distributed to the same MicroNet controllers as the GAP program.

When defining the EGD exchanges, the SDK uses the Symbol Table Information file on the MicroNet controller to link exchange variables in the data samples to GAP symbols in the MicroNet Share Area. Two types of exchanges can be defined: a *consumed exchange* and a *produced exchange*.

A *consumed exchange* consumes data samples produced by another EGD node. When the exchange is enabled, the SDK accepts data samples from the network and decodes the field data in each data sample into the linked GAP symbols in the MicroNet Share Area. For every consumed exchange defined in the application, there should be one EGD node on the network that produces the corresponding data sample.

A *produced exchange* produces data samples for other EGD nodes. When the exchange is enabled, the SDK encodes data from linked GAP symbols in the MicroNet Share Area into data samples and sends those samples across the network. For a given exchange, the samples may be sent to the Unicast IP address of a specific EGD node, the Multicast IP address of a group of EGD nodes, or broadcasted to any EGD node on the network. For every produced exchange defined in the application, there should be at least one EGD node on the network that consumes the corresponding data sample.

Communication between Control Parts

The communication between the two controllers is through three channels:

The hardware link
A solid-state relay is used for the watchdog between the MicroNet and the GE Fanuc. This signal toggles every scan to the MicroNet at a specific pace. This signal must not be allowed to leave the cabinet, for reliability reasons.

The Ethernet link
The EGD link on Ethernet transports a large quantity of signals that the GE Fanuc or external equipment (such as a plant control system) can use for monitoring and control. The EGD link between the GE Fanuc and FCU is vital for running the turbine. These signals are used for both monitoring and control.

The Ethernet cable is also used to connect to equipment outside the cabinet, such as DCS and HMI. That makes one channel inherently unreliable (anyone or anything outside the cabinet can render this channel inoperative, e.g. by removing the 50 Ohm termination resistor). Therefore a dedicated Ethernet connection is made between the GE Fanuc and the MicroNet.

Communication to the External Equipment

The following channels exist to external equipment.

- **A tunable up/download link**
  Any PC with a Control Assistant can be used to exercise this feature.
- **A Datalog printing link**
  Any PC with a Control Assistant can be used to exercise this feature.
- **The Watch Window port**
  A PC with the Watch Window program installed can be connected to the CPU's serial port. The Watch Window is a high-end alternative to the 2-line Service Panel, once the control program is running.
- **The Watch Window II port**
  A PC with the Watch Window II program installed can be connected to the CPU's via Ethernet. The Watch Window II uses OPC protocol to communicate between the control and the PC. The Watch Window is a high-end alternative to the 2-line Service Panel, once the control program is running.

Core Fuel Control

The Core Fuel Control software module monitors and controls the basic parameters of the LM6000PD/PF Fuel gas turbine.

The LM6000PD/PF gas turbine, manufactured by GE, is an aero-derivative gas turbine that utilizes a high-speed compressor/expander axis and a low speed compressor/expander. The load is connected to either side of the low speed axis.

The LM6000PD/PF gas turbine utilizes a three-ring annular combustor design (Pilot, Inner, and Outer rings). The control system design employs staged combustion (specific to the Inner and Outer combustor rings) to achieve the required air/fuel flow ratio necessary to maintain the correct combustor flame temperature and emissions control. The fuel flow is individually metered for each combustor ring, therefore there are DLE metering valve legs for the Pilot, Inner, and Outer combustor manifolds.

The steady state and transient control of the LM6000PD/PF gas turbine requires that the correct fuel flow and airflow be provided. Highly accurate fuel-flow metering is required for various reasons, but primarily to ensure the accurate calculation of the combustor flame temperature. The airflow is actively controlled through the 2 variable geometry vane systems and the various air bleed valves, all directly controlled by the software.

The overall control strategies include typical gas turbine control schemes, but the driving force of the DLE control system is maintaining the correct combustor flame temperature. The combustor flame temperature is the primary control variable utilized to determine the operating window required to meet the target emission levels for the gas turbine.

Current technology requires that the combustor flame temperature be derived from model-based algorithms that reside in the Core Fuel Control. The required bulk combustor flame temperature needed to maintain the correct operating point is used to develop individual ring combustor flame temperature calculations. The ring combustor flame temperatures are correlated to the respective ring fuel flow demands, which in conjunction with the standard control loops and airflow control maintain gas turbine operation in the required operating window.

This software is a separate piece of software in a separate file, developed separately and certified by GE. The interfacing to the rest of the software is in two places:

1. Inputs to the Core are through blocks with category names starting with IFACE_.

Block name	Used for
IFACE_HDWR	Interfacing of hardware readings and validity qualifiers
IFACE_CORE	Software control signals. Often changing signals
IFACE_CNFG	Configuration parameters. Rarely or non changing signals
IFACE_MON	Interface to accumulating logic (hour counters, event counters)
IFACE_COMM	Connection to the GE Datalon Modbus® *

*—Modbus is a trademark of Modicon, Inc.

2. Several link blocks provide outputs from the core to the other software.

The Core Fuel Control application software was developed in such a way that whenever possible, the GE LM6000PD/PF gas turbine Control Specification M50TF3807, was implemented directly as defined by GE. Similar terminology was used where applicable to ease the translation from the GE control specification to Woodward-supplied application software. In all cases where direct input of GE specification could not be done, GE was informed and functionality of logic verified as a part of the control system qualification.

The GE Installation and Design Manual (IDM), although more specific to the installation and packaging of the gas turbine, provides insights into certain control system functions that are not included in the Core Fuel Control (i.e. start-stop sequencing, instrumentation installation requirements, etc.).

For detailed information about the contents of the core control software, about core interfacing, or about core input-output handling, please refer to Core Fuel Control description that is available at Woodward.

Analog Inputs

The analog inputs take in a number of signals that are related to the general turbine process. All values are imported from the hardware, scaled and ranged, and then fed to the core. The core's results are then further processed for reporting and for alarm effect implementation.

Gas Properties—Gas Analysis System

These points process the inputs that characterize the properties of the gas in relation to the combustion process.

The LHV and SGP can be obtained from either the Gas Chromatograph or the calorimeter. If both are operational, the calorimeter value takes precedence.

Valves Actuator System

The valves actuator system controls 6 actuators. It accepts the hardware status and feedback signals, presents them to the core. The position demand signal from the core is presented to the hardware. Calibration and stroking is also handled here. The actuators are:

- The CDP, VBV and ST8 valves are primarily used for airflow regulation in the combustor.
- IGV and VSV control variable geometries.
- TBV controls the thrust compensation system that alleviates the thrust bearings.

Because the extraction of the bleed flows has a direct effect on the fuel-air ratio in the GG combustor, it is not permitted to add additional extraction points (for example, anti-icing, etc) unless approved by the engine manufacturer.

IMPORTANT

Before starting the machine for the first time, check for additional bleed air extractions. If present, check that the engine manufacturer permits them. Parasitic bleed flows can affect the DLE model inside the control and can result in unpredictable emissions.

The core fuel control parameters for the 6 valves are interfaced to the hardware actuator driver channels.

The transducer feedback voltage ratio for each actuator is calculated according to the following formula:

$$V\_ratio = (V\_a - V\_b) / (V\_a + V\_b)$$

Where:

V_a = the feedback voltage from transducer A.
V_b = the feedback voltage from transducer B.

For the valve actuator calibration procedures, refer to the Actuator Manual.

Stroking the valves is done using the MicroPanel. The ability to stroke and to calibrate can be inhibited by a signal on the external calibration inhibit input.

All the actuators have a null current associated with them that, when applied, causes the valve not to move. For some actuators this current is positive, for others negative, according to the table below.

In addition, actuator controllers can be reverse acting or forward acting: when the demanded position exceeds the actual position, a forward-acting controller drives the output more positive, and a reverse- acting controller drives the output more negative. This is configured in the software according to the following table:

Setting	VBV	VSV	IGV	TBV	CDP	ST8	Remark
hw channel	A108-1	A109-2	A109-1	A108-2	A103-1	A103-2	
sw channel	A108-1	A109-2	A109-1	A108-2	A202-1	A202-2	
CTRL_TYPE	3	3	3	3	3	3	"P" controller. Note: this is not "PROP".
FWD_REV	2	1	1	1	1	1	1: forward, 2: reverse acting actuator
I_RANGE	5	5	5	5	5	5	for 250 mA card type
MAX_I	120	120	120	60	60	60	mA
MIN_I	-80	-80	-80	-100	-100	-100	mA
NULL_I	20	20	20	-20	-20	-20	mA
EXC_VOLTS	7.07	7.07	7.07	7.07	7.07	7.07	Vrms
FB_1_TYPE	4	4	4	4	4	4	(A-B)/(A+B)
FB_CHK_OPN	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	
FB_2_TYPE	4	4	4	4	4	4	(A-B)/(A+B)
FB_FAILSEL	2	1	1	1	2	2	1: Fail high, 2: fail low

Gas Fuel Metering System

The gas fuel metering system handles all signals that are tied to the hardware around the three gas fuel metering legs.

Hardware handled by this module is:

Module Tag	Point Tag
TGS	Temperature of incoming gas fuel
GP1	Pressure transducer upstream of metering valves
GP2I	Gas pressure transducer downstream of Inner Ring metering valve
GP2P	Gas pressure transducer downstream of Pilot Ring metering valve
GP2O	Pressure transducer downstream of Outer Ring metering valve
GMVI	Inner ring Gas Metering Valve
GMVP	Pilot ring Gas Metering Valve
GMVO	Outer ring Gas Metering Valve

The Core expects a pressure measurement upstream and downstream of each of the three metering valves, in order to be able to calculate the flow through the valves. The actual hardware has only one common upstream pressure transducer. The module contains software that calculates the three upstream pressures from the single measurement, using the expected flows to account for the pressure drops in the tubing.

In order not to compromise the C&E structure of the Core, the original alarms related to the three virtual upstream transducers have been retained. The alarms from the actual transducers are connected to the alarm inputs for the virtual transducers. In addition, these alarms are connected to the ALM alarm bus. Thus a transducer failure causes several alarms: the separate ones from the 3 virtual transducers, and a warning alarm from the actual transducer, indicating that the source is physical.

The valves can be put into a manual-stroking mode (calibration check). This mode is enabled together with the Calibration Mode for the actuator valves, although the calibration function is not identical.

Staging Valves Module

The gas fuel staging valves module provides the core fuel control shell for the 11 staging valves on the machine. They are divided over the three rings in which the burner cups are arranged. When a staging valve is opened, fuel is allowed to flow from the metering valve with which the ring is associated to the burner cups. Valves 02, 04, 07, 09 and 11 are connected to the Outer Ring (Ring A), valves 01, 03, 05, 08 and 10 are connected to the Inner Ring (Ring C) while valve 06 connects the Pilot Ring (Ring B) to the “ELBO” Ring.

The number of staging valves commanded open by the Core depends on the “burner demand”. This mode changes as the machine’s loading changes. The ELBO valve (staging valve 06) closes only after the burner demand has exceeded a configurable minimum, in this case a burner demand greater than 9 (AB).

The opening of the other valves is dictated by the following LM6000 burner modes:

- B-mode (Burner demand 0), i.e. pilot ring only. Only valve 06 is open.
- BC/2-mode (Burner demand 3), i.e. pilot ring and half of inner ring. This means that in a steady state, staging valves 01, 03, 06 and 08 are open.
- BC-mode (Burner demand 5), i.e. pilot ring and inner ring. This means that in a steady state, staging valves 01, 03, 05, 06, 08, and 10 are open.
- BC2A-mode (burner demand 7), i.e. pilot and inner ring and half of outer ring. This means that in a steady state, staging valves 01, 03, 04, 05, 06, 08, 09, and 10 are open.
- AB-mode (burner demand 10), i.e. pilot and outer ring. This means that in a steady state, staging valves 02, 04, 07, 09, and 11 are open. Note that the ELBO valve is now closed.
- ABC-mode (burner demand 15), i.e. pilot ring, inner ring, and outer ring. This means that in a steady state, all staging valves except valve 06 are open.

One exception on the above is the behavior during start-up. As long as the ignition demand is active, the core fuel control opens an additional staging valve in the vicinity of the igniter to ensure light off:

- If igniter 1 is selected, valve 04 is always open.
- If igniter 2 is selected, valves 09 and 011 are always open.

The staging valves can be put in manual mode. Both the Core and the BOP must grant permission. Manual mode is initiated from the HMI or a secondary interface. If the Core or the secondary source inhibits manual mode while it is active, manual mode is abandoned. If in manual mode, each valve can be controlled individually.

Enhanced Lean Blow-out Valves

This module provides control over the B-ELBO purge circuit staging valve and the ELBO shut off and vent valves. There is no manual control over these valves. Whenever the machine is running on gas and is not too hot, these valves are opened (and the vent valve closed).

Condition Monitoring

The Condition Monitoring module encapsulates some logic that is used to gather and accumulate some data that is relevant for determining and monitoring the overall health of the turbine. GE specifies all captured data items.

There are 3 different types of values:

Timers	Monitors the accumulated duration of a certain condition.
Counter	Counts the number of occurrences of a certain event.
Peak values	Remembers the highest encountered value of a signal.

The data is stored in non-volatile memory. This ensures that the data is not reset to a starting value on every power-up or system reset.

As the non-volatile memory can handle only a limited (but large) number of write cycles before requiring replacement, the data is not updated continuously. Instead it is updated:

- Every 24 hours
- At every shutdown
- Whenever the value at CONDMON.CUSTWR toggles from FALSE to TRUE.

A power down or system reset will result in the loss of any change of the data after the last non-volatile update.

If the CPU needs replacement, the non-volatile data needs to be transferred from the old CPU (where the memory resides) to the new one. There are two ways to do this.

- The first method works well as long as the list of items in the non-volatile memory is not changed
- The second method is also applicable if the non-volatile memory needs to be changed.

IMPORTANT

Changing the list of non-volatile memory items (e.g. in a new GAP program) will result in the loss of stored data. Hardcopy the current data before doing this. Use the HMI for an overview of the current values.

IMPORTANT

Pre-setting counters or timers will result in the loss of stored data. Before pre-setting counter and timer values, which have been included to meet the engine manufacturer's specifications, make sure that the engine manufacturer's instructions have been followed.

First Method:

Step 1	Stop the program.
Step 2	Copy all files with the same name as the program files, and the program files themselves to a service PC. The .nlg file holds the non-volatile memory data.
Step 3	Insert the new CPU.
Step 4	Copy all files from the service PC to the NT CPU.
Step 5	Check the validity of the data.

Second method:

Step 1	Write down all current values. These can be found on the HMI screen. These values are inclusive of the not yet saved data. The numbers in the tables below can be used to translate the descriptions into item numbers.
Step 2	Exchange the CPUs.
Step 3	Fill in all data in the appropriate places: Timer values in COND_MON.PRIORTMxx Counter values in COND_MON.PRIORCNTxx Peak values in COND_MON.PRIORPKxx Where xx is the number of the value (see tables below)
Step 4	Toggle COND_MON.REWRITE from FALSE to TRUE. This initializes all condition monitoring logic to the values in the PRIORXXxx blocks above.

Chapter 7.
Master Protection Circuit Operation

Introduction

The Master Protection System (MPS) is the hardwired critical path circuit that de-activates the fuel shut-off valves in case of a Emergency Shut Down no Motoring. This circuit contains the following items that are individually able to remove electrical power from the fuel shut-off valve solenoids:

- Shut-off valve command from the control software in the GE Fanuc
- Shut off valve command from the control software in the FCU
- Current continuity check by thyristors
- Hardware overspeed switches N25 and NSD
- External master protection inputs
- Voltage monitoring relay for Staging Valves.

IMPORTANT **See the Control Wiring Diagram for further details.**

MPS Trip Train

The two overspeed devices, the external emergency contacts, the voltage monitoring relay and output-contacts from both the fuel control unit and the sequencer are connected in series to the coil of the positive master shutdown relay K1. This relay is initially energized by the alarm reset button (AR) and a contact from K115 and remains energized by its own holding contact. K1 de-energizes whenever a specific device in series opens its contact or when power to the relay is lost. The one-shot relays K115 and K5 are controlled by N360-CH12. K5 resets the vibration system and may be used to override the overspeed switches SSW1 and SSW2.

K115 should be set for a single shot for a period of three seconds. The settings for the one-shot K115 relay is as indicated in the control-wiring diagram.

The GE Fanuc arms the MPS by pulsing N360-CH12 which energizes relay K1. K1 in turn energizes K2 and K3. K2 allows the fuel shut-off valves to be energized. K3 is reserved for the LM6000 PC engine only.

When all these relays are energized closed and the proper outputs are activated, the GE Fanuc can trigger the thyristors by pulsing KA15. This connects the -24 Volt power to the shut-off valves.

The thyristors carry current until, for whatever reason, the current momentarily drops below a (very low) threshold. When the current drops, the thyristors stop carrying current until KA15 is pulsed again. This prevents events where power may drop so momentarily that the control does not notice, while the flame may be lost. This could lead to dangerous situations. The other reason for the current to stop would be any of the overspeed devices opening their contacts (in an overspeed situation) or the external emergency contact opening, or either FCU or GE Fanuc opening their contacts.

Emergency Shutdown Contacts

Emergency shutdown contacts can be tied into the MPS on terminal bar TB11. There are provisions for 3 contacts. If any one of these 3 is not used, a jumper should short it. For normal operation, the contacts must be closed. An open contact causes a shut down or prevents the resetting of a shut down state.

IMPORTANT **All external emergency stop switches must be in accordance with IEC 60947-5-1.**

Overspeed Protection Devices

There are 2 independent hardware overspeed protection devices (Jacquet FT1723 or the newer programmable T401):

- Unit SSW1 for N25
- Unit SSW2 for NSD.

When any device detects an overspeed, the respective protection train is opened, thus removing electrical power from the solenoid terminal blocks. The settings for the overspeed switches are:

- N25 overspeed setting is 10800 rpm
- N2/NSD overspeed setting is 4300 rpm.

The FT1723 devices have a number of jumpers that can be reached by removing the front plate. These jumpers should be set as follows:

P.O.R.	ON
RELAY	INV
RES	NAMUR
S	OPEN

The newer T401 Programmable Devices come pre-programmed from Woodward.

See the Jacquet speed switches Operating Instruction Manual for details on settings and operation.

Voltage Monitoring Device

The voltage monitoring relay K292A is installed and a contact from this relay is present in the MPS. The function of this relay is to close the fuel shutoff valves within 140 ms from when electrical power was lost to the staging valves (loss of electrical power is < 95 Vdc for > 100 ms).

This device measures and monitors the voltage that controls the staging valves. Both contacts are used; one in the MPS and the other is wired to the GE Fanuc. The devices have a number of dials that can be set for the desired function. These dials should be set as shown in the Control Wiring Diagram.

Calibrations and Checks

Before the system can be fully operated, a number of checks and calibrations have to be completed. In addition, exchanging hardware, such as actuators, or doing regular checks on this system requires an overview of items that need calibration or verification. This chapter gives the overview for these tasks.

Actuator Valves Calibration and Stroking

There are a number of valves/actuators that require calibration and that can be stroked. The procedure is the same for all valves.

Calibration

The valve system can be calibrated in the Service Mode using the MicroPanel two-line display, while monitoring is done on the HMI. This procedure needs to be performed for each of the actuator channels.

To change or view a service mode item:
1. On the MicroPanel enter Service Mode.
2. Scroll left or right to the required category (Service Header).
3. Step down to the required item in that category.

IMPORTANT **Check the wiring before starting the calibration procedure. If you have questions regarding the wiring scheme or calibration routine, contact Woodward.**

The required category can be identified by the header prompt:

Required valve	Service category header prompt
TBV	** THRUST BAL CALIBR. **
IGV	** INLET GUIDE V CALIBR. **
VSV	** VAR. STATOR V CALIBR. **
VBV	** VAR. BLEED CALIBR. **
CDP	** CDP BLEED CALIBR. **
ST8	** ST8 BLEED CALIBR. **

The service category must be used for the calibration of the specific valve. To be able to move the actuator, sufficient oil pressure and flow is required (refer to the manufacturer's manual for the minimum required pressure and flow values for this type of actuator). Therefore, the first task is to start cranking the unit or to use an external oil pressure source, so that oil pressure is available to move the valve. The calibration procedure has been divided into 17 steps that will have to be followed:

1 **SET CAL_ENBL 'TRUE'**	This sets the driver to calibration mode. Set the tunable to “TRUE”. Proceed to the next step.
2 **VERIFY:CAL STATUS = 1 NOW?**	This is to check that the transducer calibration procedure is in the ‘waiting for AT_POS_0’ status. Proceed to the next step if the number ‘1’ appears on the screen.
3 **SET THE 'AT 0%' FLAG TRUE**	By setting this tunable to ‘True’, the 0% position is stored in the memory. This is only allowed if the feedback voltages are in a proper range. Proceed to the next step.
4 **VERIFY:CAL STATUS = 2 NOW ?**	This step checks that the transducer calibration procedure is in the ‘waiting for AT_POS_100‘ status. Proceed to the next step if the number ‘2’ appears on the screen.
5 **SET THE 'AT 100%' FLAG TRUE**	By setting this tunable to ‘True’, the 100% position is stored in the memory. This is only allowed if the feedback voltages are in a proper range. Proceed to the next step.
6 **VERIFY:CAL STATUS = 3 NOW?**	This checks that the transducer calibration procedure is in the ‘MANUAL_IN control mode (waiting for CAL_ENBL false)’ status. Proceed to the next step if the number ‘3’ appears on the screen.
7 **MOVE VALVE TO CHECK**	Open and close the valve by increasing or decreasing the tunable demand value. Repeat this three times to free air that was possibly trapped in the system. Check if the demand corresponds to the feedback percentage for different positions of the valve. Visually check that the valve can travel from fully closed to fully-open and back to fully closed when the demand is changed over the entire range. Proceed to the next step.
8 **SET CAL_ENBL 'FALSE'**	After the tunable value is changed to ‘false’, the valve is out of calibration mode. Proceed to the next step.
9 **VERIFY:CAL STATUS = 0 NOW ?**	This checks that the transducer calibration procedure is in the ‘Not in CAL MODE’ status. Proceed to the next step if the number ‘0’ appears on the screen.
10 **PRESS EXIT TWICE TO STORE**	The calibration is now complete. Scroll through the procedure and change all Boolean tunables for the 0% and 100% position items back to ‘FALSE’. Press ‘exit’ twice to store the calibration data in the non-volatile memory of the control.

IMPORTANT **Check Voltages during calibration and verify with the table below.**

The ‘core fuel control’ monitors the actual null current during normal operation of the engine. It compares the measured current with the configured null current. If a null-shift error is detected, corrective actions occur and an alarm annunciation is given.

The configurable value is not really the null current, but the offset of the null current from a value of 20 mA. The reason for this is that even an un-configured null current value is not too far off the required value. This should be kept in mind when configuring the null current value.

Table 7-1. Tunables Containing the Configurable Null-Current Offset Values

Required valve	Configurable value
TBV	ADJ.TBVNULJA.IN
IGV	ADJ.IGVNULJA.IN
VSV	ADJ.VSVNULJA.IN
VBV	ADJ.VBVNULJA. IN
CDP	ADJ.CDPNULJA. IN
ST8	ADJ.ST8NULJA. IN

Table 7-2. Acceptable Voltage Ranges During Calibration

Position	Voltage	VBV	VSV	IGV	TBV	CDP	ST8
0%	V1A	< 1.75	< 1.75	< 1.75	< 1.9	< 1.9	< 1.35
	V2A	< 1.75	< 1.75	< 1.75	< 1.9	< 1.9	< 1.35
	V1B	> 4.1	> 4.1	> 4.1	> 4.0	> 4.0	> 4.15
	V2B	> 4.1	> 4.1	> 4.1	> 4.0	> 4.0	> 4.15
100%	V1A	> 3.4	> 4.1	> 4.1	> 4.0	> 4.0	> 4.1
	V2A	> 3.4	> 4.1	> 4.1	> 4.0	> 4.0	> 4.1
	V1B	< 2.4	< 1.75	< 1.75	< 1.9	< 1.9	< 1.9
	V2B	< 2.4	< 1.75	< 1.75	< 1.9	< 1.9	< 1.9

Stroking

Once the actuator channel is calibrated, it is possible to manually stroke the valve from the HMI. To be able to move the actuator, sufficient oil pressure and flow is required (refer to the manufacturer's manual for the minimum required pressure and flow values for this type of actuator). Therefore, the first task is to start cranking the unit or to use an external oil pressure source, so that oil pressure is available to move the valve.

The procedure for manual stroking is:
1. Make sure that the actuator has been calibrated correctly.
2. Make sure that oil pressure is present and that there is permission to stroke the valve (as indicated on the HMI).
3. Click on the 'manual stroke' button to activate the stroking mode. The indication for manual stroking operation shows 'ON' if activation is successful. The manual stroking demand now controls the selected demand to the valve.
4. Click on the 'manual set' button and enter the required position set point. This is the manual stroking demand to the core fuel control module.
5. Once you have finished the check, click on the 'manual stroke' button to deactivate the stroking mode. The selected demand to the bleed valve is now controlled by the demand from the core fuel control module.

Fuel Metering Valve Calibration and Stroking

Fuel Metering Valve Calibration

The DLE fuel metering valves do not require manual calibration. Each valve/actuator assembly is calibrated in the flow test laboratory at Woodward. The calibration data of each valve is stored in a file that must be uploaded into the control system. All analog backup feedback signals will need to be verified and calibrated.

Fuel Metering Valve Stroking

It is possible to manually stroke the fuel valves from the HMI. The actuators are electric and do not need oil pressure to be able to move, therefore it is not necessary to crank the machine first.

The procedure for manual stroking is:
1. Decide which fuel valve is to be stroked.
2. Click on the corresponding Manual Stroke button to activate the stroking mode. The indication for manual stroking operation shows 'ON' if activation is successful. The selected demand to the fuel-metering valve is now dictated by the manual stroking demand.
3. Click on the Manual Set button and enter the required position setpoint. This is the manual stroking demand to the core fuel control module.
4. Once you have finished the check up, click on the Manual Stroke button and deactivate the stroking mode. The selected demand to the fuel-metering valve is now dictated by the demand from the core fuel control module again.

Clock Adjustments

Real-Time Clock (RTC) (NetCon® Simplex)
In the GAP application file, the RTC block is used to define a real-time clock in MicroNet™ simplex systems. This block is defined in the CPU module. The outputs are from a real-time clock chip with battery backup located on the CPU module. When this block is defined, a real-time clock is available and can be used in the system's software.

With a charged battery, the RTC continues to keep time and date information when the power is off. If a new application is loaded, the RTC is not affected unless specifically reset by the RST input.

The clock is the same clock that keeps time for the NT environment. Adjusting the NT system clock adjusts the RTC as well.

To pre-set the RTC from within the GAP:

1. Enter the DEBUG mode in the MicroNet system
2. Find category A101 and next find block CPU_CLOCK.
3. The following input fields can be tuned to the correct values:
   - YEAR_IN
   - MONTH_IN
   - DAY_IN
   - HOUR_IN
   - MIN_IN
   - SEC_IN
4. Next find block CPU_SET in category A101 and go to the IN_1 input field.
5. When IN_1 is toggled from FALSE to TRUE and back to FALSE, the RTC will update the date and time to the pre-set values in the CPU_CLOCK block.
6. Use EXIT (twice) to leave DEBUG mode and save the current tunable values.

Chapter 8.
Maintenance

No maintenance is required for the Turbine Control Panel. The fan and vent filter mats located at the top and bottom of each bay should be inspected monthly and the filter mats replaced as needed. These mats can be ordered directly from Rittal Corp. (p/n 3172.1000).

Chapter 9. Decommissioning

Decommissioning

Decommissioning occurs when the unit can no longer be used in its present installation. Decommissioning involves the complete removal of the unit and its return to Woodward or its disposal.

Safety (including dangerous materials)

⚠WARNING **The safety precautions given in this chapter are the minimum safety precautions necessary. Always refer to local health and safety instructions before you move the unit.**

There are no dangerous materials used in the construction or installation of this unit.

Removal

⚠WARNING **Switch-off all electrical power to the unit before you start this procedure.**

⚠WARNING **The unit is heavy (see Chapter 2, Specifications). Only use suitable lifting equipment with sufficient lifting capacity to move the unit.**

⚠WARNING **The unit has a high centre of gravity. Do not use a forklift truck to lift the unit. Only lift it from above using the supplied lifting eyes.**

Remove the unit as follows:

1. Disconnect all electrical connections and ground leads from the unit.
2. Remove the nuts and washers securing the unit to the floor.
3. Remove the unit (refer to Chapter 3, Handling the Unit section).
4. Dispose of the unit in a responsible and environmentally friendly manner (refer to local regulations)

Chapter 10.
Service Options

Product Service 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 and 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 Engine Retrofitter (RER)** is an independent company that does retrofits and upgrades on reciprocating gas engines and dual-fuel conversions, and can provide the full line of Woodward systems and components for the retrofits and overhauls, emission compliance upgrades, long term service contracts, emergency repairs, etc.
- 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.

You can locate your nearest Woodward distributor, AISF, RER, or RTR on our website at:

www.woodward.com/directory

Woodward Factory Servicing 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**.

How to Contact Woodward

For assistance, call one of the following Woodward facilities to obtain the address and phone number of the facility nearest your location where you will be able to get information and service.

Electrical Power Systems

Facility	Phone Number
Brazil	+55 (19) 3708 4800
China	+86 (512) 6762 6727
Germany	+49 (0) 21 52 14 51
India	+91 (129) 4097100
Japan	+81 (43) 213-2191
Korea	+82 (51) 636-7080
Poland	+48 12 295 13 00
United States	+1 (970) 482-5811

Engine Systems

Facility	Phone Number
Brazil	+55 (19) 3708 4800
China	+86 (512) 6762 6727
Germany	+49 (711) 78954-510
India	+91 (129) 4097100
Japan	+81 (43) 213-2191
Korea	+82 (51) 636-7080
The Netherlands	+31 (23) 5661111
United States	+1 (970) 482-5811

Turbine Systems

Facility	Phone Number
Brazil	+55 (19) 3708 4800
China	+86 (512) 6762 6727
India	+91 (129) 4097100
Japan	+81 (43) 213-2191
Korea	+82 (51) 636-7080
The Netherlands	+31 (23) 5661111
Poland	+48 12 295 13 00
United States	+1 (970) 482-5811

You can also locate your nearest Woodward distributor or service facility on our website at:

www.woodward.com/directory

Technical Assistance

If you need to telephone for technical assistance, you will need to provide the following information. Please write it down here before phoning:

Your Name	
Site Location	
Phone Number	
Fax Number	
Engine/Turbine Model Number	
Manufacturer	
Number of Cylinders (if applicable)	
Type of Fuel (gas, gaseous, steam, etc)	
Rating	
Application	
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	

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.

We appreciate your comments about the content of our publications.

Send comments to: icinfo@woodward.com

Please reference publication 26395A.

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Email and Website—www.woodward.com

**Woodward has company-owned plants, subsidiaries, and branches,
as well as authorized distributors and other authorized service and sales facilities throughout the world.**

Complete address / phone / fax / email information for all locations is available on our website.

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