MicroNet TMR®
Digital Control

This manual replaces manual 85584 for the MicroNet TMR.

Installation and Operation Manual, Volume 1 of 2
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**
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.

**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*.

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IOLOCK. When a CPU or I/O module fails, watchdog logic drives it into an IOLOCK condition where all output circuits and signals are driven to a known de-energized state as described below. The System MUST be designed such that IOLOCK and power OFF states will result in a SAFE condition of the controlled device.

- CPU and I/O module failures will drive the module into an IOLOCK state.
- CPU failure will assert an IOLOCK signal to all modules and expansion racks to drive them into an IOLOCK state.
- Discrete outputs / relay drivers will be non-active and de-energized.
- Analog and actuator outputs will be non-active and de-energized with zero voltage or zero current.

The IOLOCK state is asserted under various conditions including:
- CPU and I/O module watchdog failures
- PowerUp and PowerDown conditions
- System reset and hardware/software initialization
- Entering configuration mode

NOTE: Additional watchdog details and any exceptions to these failure states are specified in the related CPU or I/O module section of the manual.

This manual is divided into two volumes:
- Volume 1 contains Chapters 1–8 (manual 26167V1).
- Volume 2 contains Chapters 9–16 and the appendixes (manual 26167V2).

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Regulatory Compliance

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


**Conditions for Use:**
This equipment is intended to be installed in a metal cabinet or enclosure. In TMR systems with 3 expansion racks (a 4-rack system), the installation must use an EMC enclosure to meet RF emission requirements. An EMC enclosure may be used any time to improve performance, however it is only required when more than one TMR chassis and two expansion racks are used.

**Low Voltage Directive:**  Declared to 2006/95/EC COUNCIL DIRECTIVE of 12 December 2006 on the harmonization of the laws of the Member States relating to electrical equipment designed for use within certain voltage limits.

**Other International Compliance:**
**GOST-R:**  Certified for use in ordinary locations within the Russian Federation per GOST-R certificates МЛ 03.В 00605 and POCC US. US.МЛ 03.В 00606.

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**IMPORTANT** USE IN THE RUSSIAN FEDERATION—This equipment is considered indicator equipment and is not to be used as metrology equipment. All measurements need to be verified using calibrated equipment.

**North American Compliance:**
These listings are limited only to those units bearing the UL identification.

**UL:**  UL Listed for Class I, Division 2, Groups A, B, C, & D, or non-hazardous locations only for use in Canada and the United States.
UL File E156028
The 16-channel relay interface modules are suitable for ordinary or non-hazardous locations only.

**Conditions for Safe Use:**
This equipment may be suitable for use in Class I, Division 2, Groups A, B, C, and D or non-hazardous locations only. The 16-channel relay interface modules are suitable for ordinary or non-hazardous locations only.

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

A fixed wiring installation is required. Grounding is required by the input PE terminal. Ground leakage current exceeds 3.5 mA.
EXPLOSION HAZARD—Do not connect or disconnect while circuit is live unless area is known to be non-hazardous.

Substitution of components may impair suitability for Class I, Division 2 applications.

Do not remove or install power supply while circuit is live unless area is known to be non-hazardous.

Do not remove or install modules while circuit is energized unless area is known to be non-hazardous.

RISQUE D’EXPLOSION—Ne pas raccorder ni débrancher tant que l’installation est sous tension, sauf en cas l’ambiance est décidément non dangereuse.

La substitution de composants peut rendre ce matériel inacceptable pour les emplacements de Classe I, applications Division 2.

Ne pas enlever ni installer l’alimentation électrique pendant que le circuit est sous tension avant de s’assurer que la zone est non dangereuse.

Ne pas enlever ni installer les cartes pendant que le circuit est sous tension sans s’assurer que la zone non dangereuse.
Electrostatic Discharge Awareness

All electronic equipment is static-sensitive, some components more than others. To protect these components from static damage, you must take special precautions to minimize or eliminate electrostatic discharges.

Follow these precautions when working with or near the control.

1. Before doing maintenance on the electronic control, discharge the static electricity on your body to ground by touching and holding a grounded metal object (pipes, cabinets, equipment, etc.).

2. 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.

3. Keep plastic, vinyl, and Styrofoam materials (such as plastic or Styrofoam cups, cup holders, cigarette packages, cellophane wrappers, vinyl books or folders, plastic bottles, and plastic ash trays) away from the control, the modules, and the work area as much as possible.

4. 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.

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.
Chapter 1.
General Information

1.1—Introduction

The MicroNet™ control is a 32-bit microprocessor-based digital controller that is programmable for many types of applications in the control of:
- Gas Turbines
- Steam Turbines
- Hydro Turbines
- Diesel Engines
- Gas Engines

The MicroNet platform provides a flexible system to control any prime mover and its associated processes such as high speed control functions, system sequencing, auxiliary system control, surge control, monitoring and alarming, and station control. The MicroNet platform is available in simplex, redundant, and triple modular redundant (TMR) configurations. This manual covers only TMR based control configurations. Please refer to MicroNet Plus manual 26166 for simplex and redundant based control configurations using the MicroNet Plus CPU. Please refer to manual 26336 for information on VxWorks Operating System tools used with the TMR5200 CPU module.

The MicroNet Operating System, together with Woodward’s GAP™ Graphical Application Program, produces a powerful control environment. Woodward’s unique rate group structure ensures that control functions will execute deterministically at rate groups defined by the application engineer. Critical control loops can be processed within 5 milliseconds. Less critical code is typically assigned to slower rate groups. The rate group structure prevents the possibility of changing system dynamics by adding additional code. Control is always deterministic and predictable.

Synchronized inputs and outputs (I/O) are available for key control signals while distributed I/O can be used for other less critical parameters.

The MicroNet platform provides several types of communications to program and service the control as well as to interface with other systems (Plant DCS, HMI, etc.). Woodward’s GAP and Ladder Logic programming tools are used to generate Application code. A service interface allows the user to view and tune system variables. Several tools are available to provide this interface (see Engineering and Service Access). Communication protocols such as TCP/IP, OPC, Modbus®, and other current designs are included so that the user can correctly interface the control to existing or new plant level systems.

---

*—Modbus is a trademark of Schneider Automation Inc.

The MicroNet TMR® platform is expandable into multiple chassis as required by the system size and will support any mix of I/O, including networked and distributed I/O. The MicroNet TMR main control chassis is only available in one size with 18 VME slots. All slots are dedicated to the control section. The power supply for the MicroNet TMR main control chassis is a separate chassis which connects to either the lower right or left of the MicroNet TMR main control chassis. The power supply chassis contains redundant power supplies.
The MicroNet TMR control may be expanded to a multi-chassis system using the Plus8 or Plus14 chassis options. For field upgrades, the expansion racks may also be the older Simplex6 or Simplex12 chassis. Each expansion chassis has dedicated power supply, control, and I/O sections located in a single chassis. The expansion power supply architecture supports simplex or redundant power supplies.

![MicroNet TMR System (Single Rack)](image1)

**Figure 1-1—MicroNet TMR System (Single Rack)**

**TMR Main Chassis:**
- (3) Kernels A, B, C

**Each Kernel:**
- (1) Kernel PS module
- (1) CPU module
- Up to 4 I/O modules

**TMR Main PS chassis**
- (2) Redundant PS's

![Expansion Chassis Options](image2)

**Figure 1-2—Expansion Chassis Options**

### 1.2—Specifications and Compatibility

For environmental specifications and MicroNet compatibility information, please refer to the appropriate appendix in Volume 2 of this manual.
Chapter 2.  
MicroNet™ TMR Systems

2.1—MicroNet TMR

The TMR Main chassis provides slots for kernel power supplies, CPU's, and twelve I/O Modules. This is the basis of the TMR systems whether using the TMR5200 processor or the TMR040 processor. NOTE: Kernel PS modules must be matched to the type of CPU being used. The system may be expanded to 3 I/O chassis using RTN networks with the TMR5200 processors. With the RTN each CPU has access to the I/O so I/O in the expansion chassis is considered Shared I/O.

With the TMR040 processors, Transceiver modules and copper or fiber cables are used to connect to multiple chassis to accommodate additional system I/O requirements. In this case, I/O is dedicated to a specific CPU.

2.1.1—MicroNet TMR Main Chassis

In the MicroNet TMR Main Chassis, whether the TMR040 or TMR5200 CPUs are used, the I/O modules are associated with a particular Kernel. If that Kernel fails, the associated I/O modules are failed.

<table>
<thead>
<tr>
<th>MicroNet TMR</th>
</tr>
</thead>
<tbody>
<tr>
<td>• MicroNet TMR Chassis</td>
</tr>
<tr>
<td>• 3 Kernel Power Supplies</td>
</tr>
<tr>
<td>• 3 TMR CPU Modules</td>
</tr>
<tr>
<td>• 4 I/O modules slots per Kernel</td>
</tr>
<tr>
<td>• Expandable to a 4-rack system.</td>
</tr>
</tbody>
</table>

2.1.2—MicroNet TMR Power Supply Chassis

The MicroNet TMR Power Supply Chassis, contains two redundant TMR power supply modules. Power supply modules come in low voltage DC, AC/DC, and high voltage AC/DC versions. Each module supplies power to the Kernel PS Modules.

<table>
<thead>
<tr>
<th>MicroNet TMR Power Supply Chassis</th>
</tr>
</thead>
<tbody>
<tr>
<td>• 1 or 2 TMR Power Supply Chassis can be configured.</td>
</tr>
<tr>
<td>• (2) Redundant PS Modules per Chassis</td>
</tr>
<tr>
<td>• PS Modules are load sharing</td>
</tr>
<tr>
<td>• 3 Module versions available</td>
</tr>
<tr>
<td>• Low voltage DC</td>
</tr>
<tr>
<td>• 120 VAC / VDC</td>
</tr>
<tr>
<td>• 220VAC/VDC</td>
</tr>
</tbody>
</table>
2.1.3 MicroNet TMR5200 Expansion Chassis
With the TMR5200 systems, connection to up to 3 Expansion chassis is accomplished through Real Time Networks (RTNs) associated with each Kernel. There are 3 RTN networks. The TMR5200 system supports the MicroNet Plus 8 or 14 chassis and MicroNet Simplex 6 or 12 chassis. The MicroNet Plus 8 or 14 chassis can have either 1 or 2 RTN modules. The MicroNet 6 or 12 chassis only have 1 RTN module. The I/O in the Expansion Chassis is not associated with a specific Kernel and is considered "shared" I/O. The failure of any Kernel does not affect the ability for the other CPUs to access the I/O.

MicroNet TMR5200 System

2.1.4—MicroNet TMR040 Expansion Chassis
With the TMR040 systems, each Kernel can be connected to up to 15 Expansion I/O Chassis via Transceiver (XCVR) modules. The TMR040 system supports the MicroNet 6 or 12 chassis. Refer to Chapters 6-2 through 6-4 for detailed information on the use of XCVR modules. Each expansion chassis is associated with a particular Kernel. If that Kernel fails, the associated I/O modules local and expansion are failed.
2.1.5—TMR CPU Theory

The basis of this control’s fault tolerance architecture is to detect control related faults, annunciate these faults, and allow on-line service/replacement of modules and/or transducers to correct these faults. A CPU fault tolerance logic of 3-2-0 allows the control to function normally with any CPU module failed or removed. A power supply fault tolerance logic of 2-1-0 allows the control to function normally with any one power supply failed or removed. I/O Fault tolerance can be customized to meet the application reliability requirements. This is discussed in more detail later.

In the TMR Main Chassis, three isolated kernel sections (A, B & C) each house a Kernel Power Supply module, CPU module, and have 4 VME slots for I/O modules. A single motherboard supplies nine electrically isolated data paths. Each CPU has a data path to its VME modules and two separate data paths, one to each of the other CPU modules. There is a total of six paths between CPUs allowing for redundancy and error checking.

Each CPU module runs the identical software application as the other two. All inputs from each kernel are distributed to the other two kernels. Each CPU then compares the value it read, with the value the other two CPUs read, before outputting a signal to the application software. Depending on the configuration, a total of nine values for the same input parameter could be used in the voting logic to provide the best signal to the application software. Even if a data value has been corrupted along any one of the data paths shown in Figure 2-1, all CPUs use the same correct data for their application calculations. All CPUs use the same voted input signals in the same application calculations to generate the same outputs.

All output values are exchanged between kernels, the results are voted and the appropriate value is output from each kernel. Since the system can handle significant single errors, even multiple errors may not shutdown a kernel section. In the event of consistent errors from one of the kernel section, an alarm will be announced and that particular kernel will be shut down.
2.1.6—TMR Inputs and Outputs

In a full TMR application, I/O modules are also triplicated. Each Kernel would have the same module and any expansion chassis would be triplicated. Specific TMR I/O Modules and Field Terminal Modules (FTMs) are designed for this sort of application. Inputs from a single field source are fanned out to 3 channels in 3 different I/O modules. After the control's kernels double exchange their input values, and vote out any erroneous values, the Application Software Redundancy Manager then compares each kernel's voted result to select a value to be used within the application logic. Analog Outputs are summed together so that up to two failures can be tolerated with no loss of output functionality. Relay outputs are managed by fault tolerant relays.

Depending on the application, Critical field devices may also be replicated or triplicated. In some cases more than 3 devices may be used. Application software must be defined to manage this different configurations but specific Redundancy Management software has been designed to address the most common cases.

Analog Input Example

Each analog input can withstand up to two failures with no loss of control functionality. If any two of an analog input's three “legs” are failed, the control uses the third healthy leg’s sensed input signal to control with.

All analog inputs are connected to the control via a TMR FTM. An input’s termination module is used to terminate customer control wiring and distribute each input signal to all three kernels. After the control’s kernels double exchange their input values and vote out any erroneous values, the Application Software Redundancy Manager then compares each kernel's voted result to select a value to be used within the application logic. Figure 2-2 is a graphical view of a control’s input architecture. Table 2-1 displays the redundancy manager’s input selection logic for each possible input condition.

An analog input signal is determined to be faulty when the I/O Module or I/O Channel fails or when it is below its “Fail Low Value” setting, or above its “Fail High Value” setting. For a 4–20 mA input, these high and low failure level settings typically correspond to 2 mA and 22 mA respectively. If an input is determined to be failed, that input is removed from the control’s voting logic.

Input deviation alarms are used to annunciate if any of the input channels or input legs are sensing a value that is different than the voted-good value used by the application. If an input channel’s sensed value deviates from the voted-good value, by a greater margin than its “Max Deviation” setting, an input channel alarm will be issued. This type of annunciation can be used to indicate when an input channel, or system transducer is going out of calibration. Max Deviation settings are typically defaulted to 1% (deviation range = 0.1 to 10%) of the configured input range. If a deviation alarm condition occurs, the alarmed input is not removed from the control’s voting logic, and still can be used to control with, in case all other channels fail.
Discrete Input Example

Each discrete input can withstand up to two failures with no loss of control functionality. If any two of a discrete input’s three “legs” fail, the control uses the third healthy leg’s sensed input signal to control with.

All discrete inputs are connected to the control via discrete termination modules (DTMs). A DTM is used to terminate customer control wiring and distribute each input signal to all three kernels. After the control’s kernels double exchange their input values and vote out any erroneous inputs, the Application Software Redundancy Manager then compares each kernel’s voted result to select a value to be used within the application logic. Figure 2-3 is a graphical view of the control’s discrete input architecture.
A discrete input signal is determined to be faulty when the I/O Module or I/O Channel fails or when it is determined to be different than the voted-good value used by the application. If an input is determined to be faulty, the input is removed from the control's voting logic and an input channel alarm is issued. Once the input fault is corrected the alarm condition can be reset by issuing a control “Reset” command.

<table>
<thead>
<tr>
<th>A-Fault</th>
<th>B-Fault</th>
<th>C_Fault</th>
<th>Output of Block (Application Input)</th>
</tr>
</thead>
<tbody>
<tr>
<td>FALSE</td>
<td>FALSE</td>
<td>FALSE</td>
<td>2 out of 3</td>
</tr>
<tr>
<td>FALSE</td>
<td>FALSE</td>
<td>TRUE</td>
<td>A OR B</td>
</tr>
<tr>
<td>FALSE</td>
<td>TRUE</td>
<td>FALSE</td>
<td>A OR C</td>
</tr>
<tr>
<td>FALSE</td>
<td>TRUE</td>
<td>TRUE</td>
<td>A</td>
</tr>
<tr>
<td>TRUE</td>
<td>FALSE</td>
<td>FALSE</td>
<td>B OR C</td>
</tr>
<tr>
<td>TRUE</td>
<td>TRUE</td>
<td>FALSE</td>
<td>C</td>
</tr>
<tr>
<td>TRUE</td>
<td>TRUE</td>
<td>TRUE</td>
<td>FALSE</td>
</tr>
</tbody>
</table>

Table 2-2. DI Redundancy Manager Truth Table

Readouts (Analog Outputs)

Each control readout can withstand up to two failures with no loss of output functionality. Any leg of an output channel can drive a readout’s full 4–20 mA current signal. Each CPU generates an analog output command using a Redundancy manager and known good output channels. The analog output commands are voted between the CPUs and the voted value is sent to the respective output channel.

Precision resistors are used in each channel’s readback circuitry to measure and verify the health of each output “leg”. If a fault condition is detected, the faulty output leg is disabled, and the Redundancy Manager redistributes the output signal to the remaining legs. In a case where two failures are experienced at the same time within different legs, the single good channel (leg) will drive the entire output. Figure 2-4 shows a Fault Tolerant Analog Output’s architecture. The TMR Field Termination Module (FTM) combines each analog output signal from all three kernels into one signal at the FTM’s terminal blocks.

Typically, an output is considered failed, and an alarm issued, when the I/O Module or I/O Channel fails or if a channel’s combined output or any leg of the output measures a difference of more than 10% from the output demand.

With this output architecture, any single output driver failure results in the output signal only stepping to 66.66% of its original value. The time between when a failure is sensed and when the control corrects for it by redistributing current through the other drivers depends on the application software scheduling and the I/O module response but can be as fast as 5 ms.

Upon the correction of an output failure, and a “Control Reset” command, each failed output performs a continuity check though the its external load before current is again redistributed evenly between all output drivers. This continuity check outputs a small amount of current through the failed driver’s output load and compares that value to the readback value.
Actuator Outputs
Each actuator output can withstand up to two failures with no loss of output functionality. Any leg of an output channel can drive an output's full current signal (4–20 mA or 20–160 mA). Each CPU generates an analog output command using a Redundancy manager and known good output channels. The analog output commands are voted between the CPUs and the voted value is sent to the respective output channel.

Precision resistors are used in each channel’s readback circuitry to measure and verify the health of each output “leg”. If a fault condition is detected, the faulty output leg is disabled, and the Redundancy Manager redistributes the output signal to the remaining legs. In a case where two failures are experienced at the same time within different legs, the lone good channel (leg) will drive the entire output. Figures 2-6 and 2-7 show a Fault Tolerant Actuator Output’s architecture. The TMR Field Termination Module (FTM) combines each actuator output signal from all three kernels into one signal at the FTM’s terminal blocks.

An output is considered failed, and an alarm issued, when the I/O Module or I/O Channel fails or if a channel’s combined output or any leg of the output measures a difference of more than 10% from the output demand.
Actuator outputs are treated the same way as the other analog outputs, with the exception of an added precision resistor in the actuator output’s return path. This resistor is used to measure and detect ground loops and coil shortages that are possible when interfacing to an actuator. If a single coil actuator is being driven, the dual coil terminal blocks are jumpered (wired) to the single coil terminal blocks and the redundancy manager shares the current equally between all three kernels. In the event of a fault, the Redundancy Manager will redistribute the load.

If the actuator connected to is a dual coil actuator, the Redundancy Manager shares half the current evenly between Kernels A & B outputs, and the other half comes from the Kernel C output. In the event of a fault, the Redundancy Manager redistributes load current.

With this output architecture, any single output driver failure results in the output signal only stepping to 66.66% of its original value (possibly 50% for dual coil applications). The time between when a failure is sensed and when the control corrects for it by redistributing current through the other drivers depends on the application software scheduling and the I/O module response but can be as fast as 5 ms.

Upon the correction of an output failure, and a “Control Reset” command, each failed output performs a continuity check through the actuator before current is again redistributed evenly between all output drivers. This continuity check outputs a small amount of current through the failed driver’s output load and compares that value to the readback value.

![Figure 2-5—Fault Tolerant Single Coil Actuator Output](image)
Figure 2-6—Fault Tolerant Dual Coil Actuator Output

Relay Outputs
A six relay configuration is used to form each fault tolerant relay output. When a relay output is closed, the contacts of all six relays are closed. Because of the series-parallel configuration that the relays are in, the failure of any individual relay will not cause the output to be open. This series-parallel configuration also allows any single relay of the six relay configuration to be removed and replaced “on-line” with no affect on the state of the fault tolerant relay output.

When a relay output is open, the contacts of all six relays are open. Because of the series-parallel configuration that the relays are in, the failure or removal of any one relay will not cause the output to be closed. The relay output would continue to be open.

Since this control’s fault tolerant architecture can tolerate a single fault, it is possible for this fault to go undetected. This is called a latent fault. If a second fault occurs while a latent fault exists, the state of the fault tolerant relay output may be affected, possibly resulting in a shutdown condition. This is why it is important to detect and annunciate latent faults in a fault tolerant system.
Latent fault detection is provided with this control to detect any relay related failure without effecting the state of the overall relay output. Each individual relay output can be configured to use or not use latent fault detection. A latent fault detection test is performed periodically or on command. The period of time between tests can be set from 1 to 3000 hours.

A relay output is tested by cycling the output’s individual relays closed then open (or vice-versa depending on the output state), to ensure that they are in the correct state, and that they can change state. Position readback circuitry allows the state of each relay contact to be detected. Any failures are annunciated, and further testing is disabled without affecting the state of the relay output contact or control operation.

Each fault tolerant relay configuration consists of 6 relays, driven by two discrete outputs from each kernel (as shown in Figure 2-7). The relays are configured in three legs of two relays each. Customer circuit power is connected to one side of the resulting configuration, and customer load to the other side. Field selectable jumpers, located on system FTMs, are provided to allow each output’s latent fault detection logic to be compatible with the circuit being interfaced to. Latent fault detection is used to monitor the actual contact positions of each of the six relays, and to momentarily change states of each relay one at a time. This verifies each relay’s “normally open” or “normally closed” contacts.

![Figure 2-7—Fault Tolerant Discrete Output](image)

Latent fault detection (LFD) is not usable with all applications or circuits. The control’s LFD logic can only work with circuits using voltages between 18–32 Vdc, 100–150 Vdc, or 88–132 Vac. For latent fault detection to work, a small leakage current is passed through the circuit’s load. Depending on the size of the load, the leakage current may be enough to cause a load to be on or active, when a relay contact is open. In this case, the individual relay’s latent fault detection logic may be disabled, eliminating the leakage current, or a shunt resister can be used across the load to reduce the leakage current.
2.1.7—Simplex Inputs and Outputs

The TMR system can also use Simplex I/O modules and FTMs. Typically these are used for non-critical signals although different levels of redundant and even TMR configurations can be supported with the correct application software and the correct selection and distribution of module and signals. Systems can consist of a hybrid of TMR I/O and Simplex I/O.

Each I/O module has connectors on the faceplate. For analog and discrete I/O, cables connect the module to a Field Terminal module (FTM). The FTM is used to connect to the field wiring. For communication modules, FTMs are not used. Cables are connected directly to the faceplate of the communications module. The following diagram shows the flow of analog and discrete inputs from the field to the application.

**Figure 2-8—Input Flow**

![Input Flow Diagram]

**Figure 2-9—Output Flow**

![Output Flow Diagram]

**Redundant Input Examples**

Two levels of redundancy are available. The first involves wiring two external input devices to two separate input channels. See Figure 2-10. In the event of a failed sensor or a failure in the connection from the sensor to the control, a valid input is still available.

**Figure 2-10—Redundant Sensors**

![Redundant Sensors Diagram]
The second level is wiring two external input devices to two separate I/O modules. See Figure 2-11. In the event of a failure in one of the sensors, connections, cables, FTMs, or I/O modules, a valid input is still available.

![Figure 2-11—Redundant Inputs]

Redundant Output Examples

Redundancy can be added to the outputs as well. Additional external relays can be used to prevent a faulted output from affecting the external device. For discrete outputs, this would require four relays for each output. For the actuator outputs, a dual coil actuator can be used. The dual coils will allow one coil to operate the actuator in the event of a failure.

The value of redundancy is dependent on the ability of the application to detect the failure. For analog and actuator outputs, current and/or voltage readback is provided. For discrete outputs, fault detection requires sensing the relay contact state.

2.2—MicroNet TMR Operation

2.2.1 Theory of Operation

MicroNet TMR systems are designed for 3-2-0 operation. Thus, to start a system, at least 2 CPUs must be started with the same application. If the CPUs are started individually, the first CPU will wait forever for a second CPU and 2 CPUs will wait up to 10 seconds for the 3rd CPU. If the 3rd CPU does not join the 2 CPUs within the 10 seconds the 2 CPUs will continue with only 2. NOTE: CPUs starting together must have both the same application and same EE values (stored tunables) to synchronize. If two CPUs are synchronized, a third CPU must have the same application but it will copy EE values from the running CPUs.
2.2.2 Loading Applications and Starting CPUs.

**TMR5200**
- Load and start the application on each CPU using AppManager.
- If the Control is given a CTRL_ID in the SYS_INFO block of the application software, AppManager can interface with the three CPUs as one system.
- AppManager can be used to start the three CPUs together.
- Once an application has started, Auto-start will be set. The CPU will automatically start on CPU initialization (whether from a power up or from a reset).

**TMR040**
- Load the application on each CPU using a PCMCIA card or Ethernet module.
- The application will start once it has been loaded.
- After an application has been loaded, the CPU will automatically start on CPU initialization when the Reset switch is toggled.

2.3—Module Replacement

TMR systems are designed to allow replacement of modules while running (hot-swap). This is a key to maintaining the high level of availability for critical applications. The hardware is fully capable of supporting hot-swap but care must be taken in the application software design to ensure that a module hot-swap does not adversely affect the application.

Chapter 14 contains installation procedures and Chapter 15 contains replacement procedures for VME Modules, power supplies, relay boxes, and other devices. Individual CPU and I/O module sections in Chapters 6 through 9 are an additional reference for installation and replacement information.

Chapter 4 contains additional details for power supply installation and replacement. Note that power must be removed from the power supply input before a module is removed or inserted.

---

**CAUTION**

Live insertion and removal of the TMR5200 and Remote RTN modules is allowed in a MicroNet TMR or Plus chassis. These modules should be reset immediately before removing them from the chassis. This notifies the module that it will be removed and provides a graceful CPU shutdown or failover to another healthy Remote RTN module if available.
2.4—Latent Fault Detection

Because a TMR system can tolerate single faults, it is possible for a fault to go undetected. Undetected faults are termed latent faults. If another fault occurs when a latent fault exists, the second fault could cause a shutdown. It is important to detect a latent fault in a TMR system so that it may be repaired before another fault occurs. For single, redundant, or TMR I/O points, fault detection is dependent on the application software to detect its I/O faults.

Example of MicroNet TMR5200 fault information available from the TCHAS_STAT status block.

<table>
<thead>
<tr>
<th>A1_A01</th>
<th>FLT_STAT</th>
</tr>
</thead>
<tbody>
<tr>
<td>RST</td>
<td></td>
</tr>
</tbody>
</table>

- **ALM**: This output displays the status of the Kernels alarms. A true indicates that the Kernel has an alarm.
- **ALM_NO**: This output displays the Kernels Alarm number. See the GAP help manual for a list of valid alarms.
- **CPU_A_FLT**: This output displays the status of Kernel "X". A true indicates that Kernel "X" has failed.
- **CPU_B_FLT**: 
- **CPU_C_FLT**: 
- **MFT_A_FLT**: 
- **MFT_B_FLT**: 
- **MFT_C_FLT**: This output displays the status of the Kernel "X" MFT (Minor Frame Timer). A true indicates that the Kernel "X" MFT has failed.
- **PS1_FAIL**: This output field goes true when a fault on the MAIN TMR #1 Power Supply is detected.
- **PS2_FAIL**: This output field goes true when a fault on the MAIN TMR #2 Power Supply is detected.
- **TEMP_ALARM**: This output field goes true when a high temperature is detected in the chassis.

Figure 2-12—TCHAS_STAT Block
Example of MicroNet TMR040 fault information available from the SYS_INFO block.

<table>
<thead>
<tr>
<th>MASTER</th>
<th>SYS_INFO</th>
</tr>
</thead>
<tbody>
<tr>
<td>MOE_DATE</td>
<td>SYS_ALM</td>
</tr>
<tr>
<td>ALM_RST</td>
<td>SYS_FLT</td>
</tr>
<tr>
<td>TS_CLOCK</td>
<td>PS_1_FLT</td>
</tr>
<tr>
<td>UPDATE_EE</td>
<td>PS_2_FLT</td>
</tr>
<tr>
<td>L_VAL</td>
<td>FAN_ALM</td>
</tr>
<tr>
<td>R160_RATE</td>
<td>TEMP_ALM_A</td>
</tr>
<tr>
<td>R80_RATE</td>
<td>TEMP_ALM_B</td>
</tr>
<tr>
<td>R40_RATE</td>
<td>TEMP_ALM_C</td>
</tr>
<tr>
<td>R20_RATE</td>
<td>S_PWD</td>
</tr>
<tr>
<td>R10_RATE</td>
<td>C_PWD</td>
</tr>
<tr>
<td>R5_RATE</td>
<td>A_FAULT</td>
</tr>
<tr>
<td>A_FAULT</td>
<td>B_FAULT</td>
</tr>
<tr>
<td>B_FAULT</td>
<td>C_FAULT</td>
</tr>
</tbody>
</table>

SYS_ALM: The System Alarm Boolean will be set true any time the operating system detects an alarm. This should be used in your application for alarm indications.

SYS_FLT: The System Fault Boolean will be set true any time the operating system detects a critical fault. It will cause an I/O lock to be asserted.

PS_1_FLT: The Power Supply 1 Boolean will be set true when any of the outputs from Power Supply 1 fail.

PS_2_FLT: The Power Supply 2 Boolean will be set true when any of the outputs from Power Supply 2 fail.

FAN_ALM: The Aux. Fans Are Running Boolean will be set true when the chassis exceeds a preset temperature and the second rack of fans are on.

TEMP_ALM_x: Temperature alarm for Kernel A, B, or C. This output is directly from a fan temperature switch which will trip at 60.0 °C. Only applicable to the MicroNet and MicroNet TMR chassis.

A_FAULT: The CPU A Fault Boolean will be set true when CPU A is not in sync. In a simplex system, A_FAULT, B_FAULT, and C_FAULT are false.

B_FAULT: The CPU B Fault Boolean will be set true when CPU B is not in sync. In a simplex system, A_FAULT, B_FAULT, and C_FAULT are false.

C_FAULT: The CPU C Fault Boolean will be set true when CPU C is not in sync. In a simplex system, A_FAULT, B_FAULT, and C_FAULT are false.

Figure 2-13—SYS_INFO Block
Chapter 3.
Chassis Configurations

3.1—TMR Main Chassis

This chassis contains eighteen slots for kernel power supplies, CPU's, and I/O modules. Normally, this allows three kernel power supplies, three CPUs, and twelve I/O modules. The power supply module will connect to either the lower right or left of the chassis.

If an I/O module slot is not occupied, it must be filled with a blanking plate (3799-301) to maintain proper cooling flow through the chassis.

![Figure 3-1—MicroNet TMR® Main Chassis](image)

3.1.1—Specification

The MicroNet™ control is designed around a modular six slot chassis (block). Each block consists of a premolded cage with a fan for cooling and a temperature switch for high temperature detection. The chassis are cooled by forced air, and either a module or a module blank must be installed in every slot to maintain correct air flow. The fans run whenever power is applied to the system.

The eighteen-slot MicroNet TMR control chassis is composed of three blocks with a motherboard inserted in the back of the assembly to make connections between the fans, switches, power supply chassis, and all three kernels. See Figure 3-2. The modules use the VERSAmodule Eurocard (VME) bus standard for connector specification and data transfer. Kernel-to-kernel and slot-to-slot logic and power connections are made through an etched-circuit motherboard. I/O connections are made through cables from the front of the boards to field termination modules (FTM's) in the cabinet.
From a module connector standpoint, any I/O module can be installed in any of the slots designated for I/O modules. However, when the application software is designed, each module will be assigned to a specific slot and thereafter, the software will expect that specific I/O module to always be in its designated slot.

**Chassis Outline Drawing**
The MicroNet TMR dimensions are shown below.
3.1.2—Installation

Figure 3-3 shows the mounting template and fasteners to bulkhead mount the chassis. Rack mounting is not recommended. For proper airflow, the installation should allow a 3” air gap above and below the chassis.

Figure 3-3—Mounting Template of MicroNet TMR Main Chassis
3.2—Expansion MicroNet Plus 8-Slot I/O

The MicroNet Plus 8-slot chassis offers redundant RTN capability and more I/O slots than the MicroNet 6, as well as improvements in airflow and overall system reliability.

Features:
- A total of 8 RTN and I/O slots are available for use
- A new 2-slot wide, redundant, load sharing power supply is used
- Redundant Smart fans are used for early notification of fan-failure
- Chassis temperature switches exist on the motherboard and trip at +65 °C
- Redundant, hot-swappable RTNs are supported

3.2.1—Specification

The MicroNet is designed around a modular 6-slot chassis (block). Each block consists of a premolded cage with a fan for cooling and a temperature switch for high temperature detection. The chassis are cooled by forced air, and either a module or a module blank must be installed in every slot to maintain correct airflow. The fans run whenever power is applied to the system.
The MicroNet Plus 8-slot chassis is composed of two blocks with a motherboard inserted in the back of the assembly to make connections between the fans, switches, power supplies, and control modules. See Figure 3-5. The modules use the VERSAmodule Eurocard (VME) bus standard for connector specification and data transfer. Slot-to-slot logic and power connections are made through an etched-circuit motherboard. I/O connections are made through cables from the front of the modules to field termination modules (FTM’s) the cabinet.

From a module connector standpoint, any I/O module can be installed in any of the slots designated for I/O modules. However, when the application software is designed, each module will be assigned to a specific slot and thereafter, the software will expect that specific I/O module to always be in its designated slot.

![Diagram of MicroNet Plus 8-Slot Chassis](image)

**RTN Slots (A1, A8)**

Chassis slots A1 and A8 are designated as RTN compatible slots. These slots provide extra functionality for monitoring fan status, chassis temperature status, and power supply status information. The RTN slots also support operation of Redundant RTNs and the associated RTN Failover functions. The RTN slots are identical except for slot address, thus a RTN can be installed in either one to control the MicroNet system.

- For simplex systems, RTN slot A8 can also be used as an I/O module slot.
- Live Insertion and removal is supported for field repairability.
- RTNs are located under different fan sets to improve reliability, airflow, and temperature performance.
- RTN slots use VME-64 connectors on the RTN module slots for improved RTN HotSwap capabilities.

**Power Supply Slots (PS1, PS2)**

A smaller 2-slot wide power supply has been designed for the MicroNet Plus chassis, thus allowing (2) more slots for I/O. Each power supply is located under different fan sets for improved reliability. The redundant smart fans are located above and below each power-supply for improved airflow. Each power supply provides input failure (AC_FAIL) and output failure (PWR_ALM) fault information to the RTN slots.
• Power supplies are located under different fan sets to improve reliability, airflow, and temperature performance.
• Three different 2-slot wide power supplies are available for use: a low voltage (24 Vdc input), a high voltage (120 Vac/dc input), and a high voltage 220 Vac input version. Refer to the power-supply section for additional information.

**Redundant Smart Fans**
Each smart-fan provides a tachometer output to the RTN slots. The RTN monitors the fans for slow operation or fan-failure. A GAP application fault is provided for each fan (See GAP help for CHAS_STAT block). Quick-connect FAN connectors are utilized for improved field replacement. The motherboard provides individual, short-circuit protected, +24 V Fan power to each fan.

**Motherboard Terminal Block (TB1)**
The MicroNet Plus chassis includes a terminal block that provides RTN1 and RTN2 Remote reset inputs. The same terminal block provides access to +24 Vdc motherboard power (3 terminals) through two separate 5 A fuses. If a direct short of this power output occurs, the fuses will blow to protect the motherboard, and the power supplies will shut down with a 24 Vdc power fault. Replacement fuses can be ordered as Woodward P/N 1641-1004. The system must be shut down to replace the fuses safely.

**24 Vdc Motherboard Power**
• **TMR & Redundant systems**—Not recommended for use.
• **Simplex systems**—This power may be used for local Ethernet switch power. Consider carefully the possibility of shorts and the type of connector wiring used.

---

**NOTICE**
The Motherboard +24 Vdc power outputs should be used locally in the same MicroNet cabinet only in rare instances, as the quality of this supply is critical to proper system operation.

**RTN Remote Reset Inputs (RST1, RST2)**
Each RTN may be reset by either using the front-panel reset button or a remote-reset input provided on the motherboard. The remote-reset inputs are available at the TB1 terminal block located at the bottom center of the chassis. The individual remote resets for each RTN are designated RST1+, RST1– for slot A1 and RST2+, RST2– for slot A8. These inputs are optically isolated on each respective RTN module and require both a 24 V(+) and a common(-) to be wired. A momentary high will cause a RTN-reset.

**Chassis Overtemp Alarm**
The MicroNet Plus 8-slot chassis provides (2) over-temperature switches on the motherboard. The over-temperature switches will trip at 65°C ± 3°C and communicate this warning to the RTN and GAP application.

**Chassis Outline Drawing**
The MicroNet Plus 8-slot chassis is physically the same dimensions as the MicroNet Simplex 6-slot chassis.
3.2.2—Installation

Figure 3-7 shows the mounting template and fasteners to bulkhead mount the chassis. Rack mounting is not recommended. For proper airflow, the installation should allow a 3” air gap above and below the chassis.

![Figure 3-7—Mounting Template of MicroNet Plus 8-Slot I/O Chassis](image)

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**Figure 3-6—Outline Drawing of MicroNet Plus 8-Slot Chassis**
3.3—Expansion MicroNet Plus 14-Slot I/O

The MicroNet Plus 14-slot chassis offers redundant RTN capability and more I/O slots, as well as improvements in airflow and overall system reliability.

Features:
- A total of (14) RTN and I/O slots are available for use
- A new 2-slot wide, redundant, load sharing power supply is used
- Redundant Smart fans are used for early notification of fan failure
- Chassis temperature switches exist on the motherboard and trip at +65 °C
- Redundant, hot-swappable RTNs are supported

3.3.1—Specification

The MicroNet is designed around a modular 6-slot chassis (block). Each block consists of a premolded cage with a fan for cooling and a temperature switch for high temperature detection. The chassis are cooled by forced air, and either a module or a module blank must be installed in every slot to maintain correct airflow. The fans run whenever power is applied to the system.
The MicroNet Plus chassis is composed of three blocks with a motherboard inserted in the back of the assembly to make connections between the fans, switches, power supplies, and control modules. See Figure 3-8. The modules use the VERSAmodule Eurocard (VME) bus standard for connector specification and data transfer. Slot-to-slot logic and power connections are made through an etched-circuit motherboard. I/O connections are made through cables from the front of the modules to field termination modules (FTM's) the cabinet.

From a module connector standpoint, any I/O module can be installed in any of the slots designated for I/O modules. However, when the application software is designed, each module will be assigned to a specific slot and thereafter, the software will expect that specific I/O module to always be in its designated slot.

**RTN Slots (A1, A14)**
Chassis slots A1 and A14 are designated as RTN compatible slots. These slots provide extra functionality for monitoring fan status, chassis temperature status, and power supply status information. The RTN slots also support operation of Redundant RTNs and the associated RTN Failover functions. The RTN slots are identical except for slot address, thus a RTN can be installed in either one to control the MicroNet system.

- For simplex systems, RTN slot A14 can also be used as an I/O module slot.
- Live Insertion and removal is supported for field repairability.
- RTNs are located under different fan sets to improve reliability, airflow, and temperature performance.
- RTN slots use VME-64 connectors on the RTN module slots for improved RTN HotSwap capabilities.

**Power Supply Slots (PS1, PS2)**
A smaller 2-slot wide power supply has been designed for the MicroNet Plus chassis, thus allowing (2) more slots for I/O. Each power supply is located under different fan sets for improved reliability. The redundant smart fans are located above and below each power-supply for improved airflow. Each power supply provides input failure (AC_FAIL) and output failure (PWR_ALM) fault information to the RTN slots.
Power supplies are located under different fan sets to improve reliability, airflow, and temperature performance.

Three different 2-slot wide power supplies are available for use: a low voltage (24 Vdc input), a high voltage (120 Vac/dc input), and a high voltage 220 Vac input version. Refer to the power-supply section for additional information.

**Redundant Smart Fans**
Each smart-fan provides a tachometer output to the RTN slots. The RTN monitors the fans for slow operation or fan-failure. A GAP application fault is provided for each fan. Quick-connect FAN connectors are utilized for improved field replacement. The motherboard provides individual, short-circuit protected, +24 V Fan power to each fan.

**Motherboard Terminal Block (TB1)**
The MicroNet Plus chassis includes a terminal block that provides RTN1 and RTN2 Remote reset inputs. The same terminal block provides access to +24 Vdc motherboard power (3 terminals) through two separate 5 A fuses. If a direct short of this power output occurs, the fuses will blow to protect the motherboard, and the power supplies will shut down with a 24 Vdc power fault. Replacement fuses can be ordered as Woodward P/N 1641-1004. The system must be shut down to replace the fuses safely.

**24 Vdc Motherboard Power**
- **TMR & Redundant systems**—Not recommended for use.
- **Simplex systems**—This power may be used for local Ethernet switch power. Consider carefully the possibility of shorts and the type of connector wiring used.

**NOTICE**
The Motherboard +24 Vdc power outputs should be used locally in the same MicroNet cabinet only in rare instances, as the quality of this supply is critical to proper system operation.

RTN Remote Reset Inputs (RST1, RST2)
Each RTN may be reset by either using the front-panel reset button or a remote-reset input provided on the motherboard. The remote-reset inputs are available at the TB1 terminal block located at the bottom center of the chassis. The individual remote resets for each RTN are designated RST1+, RST1– for slot A1 and RST2+, RST2– for slot A14. These inputs are optically isolated on each respective RTN module and require both a 24 V(+) and a common(-) to be wired. A momentary high will cause a RTN-reset.

**Chassis Overtemp Alarm**
The MicroNet Plus chassis provides (3) over-temperature switches on the motherboard. The over-temperature switches will trip at 65°C ± 3°C and communicate this warning to the RTN and GAP application.

**Chassis Outline Drawing**
The MicroNet Plus 14-slot chassis is physically the same dimensions as the MicroNet Simplex 12-slot chassis.
Figure 3-10—Outline Drawing of MicroNet Plus Chassis
3.3.2—Installation

Figure 3-11 shows the mounting template and fasteners to bulkhead mount the chassis. Rack mounting is not recommended. For proper airflow, the installation should allow a 3” air gap above and below the chassis.

Figure 3-11—Mounting Template of MicroNet Plus 14-Slot I/O Chassis

3.4—Expansion MicroNet Simplex 6-Slot I/O

This chassis contains six slots for remote transceiver and I/O modules. This allows one Remote XCVR or RTN module and five I/O modules, redundant RTNs are not allowed. In addition to the six I/O slots, two power supply positions are provided, which allows for redundant power input. Each power supply module occupies three slots of chassis space. The total width of the chassis is therefore twelve slots wide, when counting both power supply and I/O slots.

If a power supply or I/O module slot is not occupied, it must be filled with a blanking plate (3799-301) to maintain proper cooling flow through the chassis.

IMPORTANT

The 6 slot expansion chassis should not be used for new applications. The 6 slot expansion chassis should only be used in retrofit situations where the chassis is already installed.
3.4.1—Specification

The MicroNet control is designed around a modular six slot chassis (block). Each block consists of a premolded cage with a fan for cooling and a temperature switch for high temperature detection. The chassis are cooled by forced air, and either a module or a module blank must be installed in every slot to maintain correct air flow. The fans run whenever power is applied to the system.

The six slot MicroNet expansion chassis is composed of two blocks with a motherboard inserted in the back of the assembly to make connections between the fans, switches, power supplies, and control modules. See Figure 3-13. The modules use the VERSAmodule Eurocard (VME) bus standard for connector specification and data transfer. Slot-to-slot logic and power connections are made through an etched-circuit motherboard. I/O connections are made through cables from the front of the modules to field termination modules (FTM’s) in the cabinet.

From a module connector standpoint, any I/O module can be installed in any of the slots designated for I/O modules. However, when the application software is designed, each module will be assigned to a specific slot and thereafter, the software will expect that specific I/O module to always be in its designated slot.
Figure 3-13—Outline Drawing of MicroNet Six Slot I/O
3.4.2—Installation

Figure 3-14 shows the mounting template and fasteners to bulkhead mount the chassis. Rack mounting is not recommended. For proper airflow, the installation should allow a 3” air gap above and below the chassis.

![Mounting Template of MicroNet 6 Slot I/O Chassis](image)

3.5—Expansion MicroNet Simplex 12-Slot I/O

3.5.1—Description

This chassis contains twelve slots for remote transceiver and I/O (input/output) modules. This allows one Remove XCVR or RTN module and eleven I/O modules, redundant RTN modules are not allowed. In addition to the 12 XCVR/RTN – I/O slots, two power supply positions are provided, which allows for redundant power input. Each power supply module occupies three slots of chassis space. When counting power supply and I/O slots, the total width of the chassis is 18 slots wide.

If a power supply or I/O module slot is not occupied, it must be filled with a blanking plate (3799-301) to maintain proper cooling flow through the chassis.

**IMPORTANT**

The 12 slot expansion chassis should not be used for new applications. The 12 slot expansion chassis should only be used in retrofit situations where the chassis is already installed.
3.5.2—Specification

The MicroNet is designed around a modular six slot chassis (block). Each block consists of a premolded cage with a fan for cooling and a temperature switch for high temperature detection. The chassis are cooled by forced air, and either a module or a module blank must be installed in every slot to maintain correct air flow. The fans run whenever power is applied to the system.

The twelve slot MicroNet expansion chassis is composed of three blocks with a motherboard inserted in the back of the assembly to make connections between the fans, switches, power supplies, and control modules. See Figure 3-16. The modules use the VERSAmodule Eurocard (VME) bus standard for connector specification and data transfer. Slot-to-slot logic and power connections are made through an etched-circuit motherboard. I/O connections are made through cables from the front of the modules to field termination modules (FTM’s) in the cabinet.

From a module connector standpoint, any I/O module can be installed in any of the slots designated for I/O modules. However, when the application software is designed, each module will be assigned to a specific slot and thereafter, the software will expect that specific I/O module to always be in its designated slot.
Figure 3-16—Outline Drawing of MicroNet 12 Slot I/O
3.5.3—Installation

Figure 3-17 shows the mounting template and fasteners to bulkhead mount the chassis. Rack mounting is not recommended. For proper airflow, the installation should allow a 3" air gap above and below the chassis.

Figure 3-17—Mounting Template of MicroNet 12 Slot I/O Chassis
Chapter 4.
Power Supplies

4.1—TMR Main Power Supplies

4.1.1—Module Description

The MicroNet TMR® main control power supply chassis uses redundant power supplies. A motherboard located on the back of the power supply chassis allows the two power supplies to form a redundant power system providing six separately regulated 24 Vdc, 6 A outputs to the control. See Figure 4-1. Power output regulation, including line, load, and temperature effects, is less than +5%.

When redundant power supplies are running, current sharing circuitry balances the load to reduce heat and improve the reliability of the power supplies. In the event that one supply needs replacement, this feature also ensures hot replacement of the power supplies without disrupting the operation of the control.

Each main power supply has four LEDs to indicate power supply health (OK, Input Fault, Overtemperature, and Power Supply Fault). See MicroNet TMR Power Supply Troubleshooting (Section 4.8) for a description of the LED indications.

Figure 4-1—TMR Power Supply Diagram
Input power connections are made to the main power supply through terminals on the front of the power supplies. A 50-pin ribbon cable is used for connecting the power supply chassis to the control chassis.

The ribbon cable connects to a connector at the back underside of the TMR Main Chassis. There are connectors beneath the A and C Kernels – either can be used. See Figure 4-2. NOTE: It is also possible to use two TMR Power Supply Chassis and connect one to each connector.

![Figure 4-2—TMR Main Chassis PS Ribbon Cable Connections](image)

On the Power Supply Chassis, the cable connects toward the back of the upper side of the Chassis. See Figure 4-3. The Power Supply Ribbon cable is only 1 foot in length so the TMR PS Chassis must be located immediately beneath the A or C Kernels of the TMR Main Chassis.

![Figure 4-3—TMR PS Chassis PS Ribbon Cable Connections](image)
A second Chassis-to-Chassis Power Cable can be used to provide redundant connections. See Figure 4-4.

Figure 4-4—Chassis to Chassis Power Cable

The MicroNet TMR Main power supplies must have the input power removed before installing or removing.

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

Wiring must be in accordance with Class I, Division 2 wiring methods and in accordance with the authority having jurisdiction.
4.2—TMR Main Power Supply Specifications

4.2.1—Main PS TMR (24 Vdc Input)

- Operating range: 18 to 36 Vdc
- Nominal voltage rating: 20 to 32 Vdc, as on power supply label
- Maximum current: 32 A
- Maximum power: 576 W
- Input power fuse/breaker rating: 50 A time delay
- Holdup time: 5 ms @ 24 Vdc

4.2.2—Main PS TMR (120 Vac/dc Input)

**AC**
- Operating range: 88 to 132 Vac (47 Hz to 63 Hz)
- Nominal voltage rating: 98 to 120 Vac, as on power supply label
- Maximum current: 13 A
- Maximum power: 1150 VA
- Input power fuse/breaker rating: 20 A time delay
- Holdup time: 1 cycle @ 120 Vac

**DC**
- Operating range: 100 to 150 Vdc
- Nominal voltage rating: 111 to 136 Vdc, as on power supply label
- Maximum current: 5.8 A
- Maximum power: 576 W
- Input power fuse/breaker rating: 10 A time delay
- Holdup time: 7 ms @ 120 Vdc
4.2.3—Main PS TMR (220 Vac Input)

**AC**
- Operating range: 180 to 264 Vac (47 Hz to 63 Hz)
- Nominal voltage rating: 200 to 240 Vac, as on power supply label
- Maximum current: 6.5 A
- Maximum power: 1150 VA
- Input power fuse/breaker rating: 10 A time delay
- Holdup time: 1 cycle @ 220 Vac

**DC**
- Operating range: 200 to 300 Vdc
- Nominal voltage rating: 223 to 272 Vac, as on power supply label
- Maximum current: 2.9 A
- Maximum power: 600 VA
- Input power fuse/breaker rating: 10 A time delay
- Holdup time: 7 ms @ 200 Vdc

4.3—TMR Main Power Supply Installation

![Figure 4-6—TMR Main Power Supply](image-url)
4.3.1—Input Power Wiring

MicroNet TMR controls require a fixed wiring installation for AC applications. Ground leakage exceeds 3.5 mA AC. Maximum ground leakage for AC installations is 7.2 mA at 60 Hz. A ground conductor connected to the chassis is required for safety. The power supply grounding terminal(s) should also be connected to earth to ensure grounding of the power supply printed circuit boards. The grounding conductor must be the same size as the main supply conductors.

Note that the control's power supplies are not equipped with input power switches. For this reason, some means of disconnecting input power to each main power supply must be provided for installation and servicing. A circuit breaker meeting the above requirements or a separate switch with appropriate ratings may be used for this purpose. To avoid nuisance trips, use only time-delay fuses or circuit breakers.

Branch circuit fuses, circuit breakers, and wiring must meet appropriate codes and authorities having jurisdiction for the specific country (CE, UL, etc). See Table 4-1 for maximum recommended fuse or breaker ratings. Do not connect more than one main power supply to any one fuse or circuit breaker. Use only the wire sizes specified in Table 4-1 which meet local code requirements. Time delay fuses or circuit breakers must be used to prevent nuisance trips.

Power requirements depend on the number and type of modules supplied for each system. For a system with a single I/O chassis, size the input power source according to the rating of the MicroNet TMR main power supply to which the source is connected. Do not size the supply mains for the sum of the MicroNet TMR main power supply ratings when redundant supplies are used. MicroNet™ supplies are redundant when installed in the same chassis. Redundant supplies share the load between them equally, but each must provide for full load in the event that one of the units is disabled. Table 4-1 gives the maximum overload protection for supply mains connected to any single or redundant pair of MicroNet main power supplies. It is not recommended that both MicroNet main power supplies of a redundant pair be connected to a single source, since failure of that source would disable the system.

Multiple chassis systems using MicroNet TMR main power supplies may have power supplies of the same model, but in different chassis, connected to the same source. In this case, each branch to a chassis must have its own overcurrent protection sized according to Table 4-1, and the power source must be sized for the sum of the branches.

Not all systems will require the full load capability of the MicroNet TMR main power supply. If not otherwise indicated on a cabinet system nameplate, either use the MicroNet TMR main power supply input ratings for sizing the system's source or consult Woodward for determining the minimum source requirements.

Table 4-1 provides fuse and wire size specifications for each power supply.
### Table 4-1—MicroNet TMR Power Supply Requirements

<table>
<thead>
<tr>
<th>Maximum Input Voltage Range</th>
<th>Maximum Fuse/C.B. Rating (Time Delay)</th>
<th>Wire Size ** (AWG/mm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>18–36 Vdc</td>
<td>50 A</td>
<td>8 / 10 *</td>
</tr>
<tr>
<td>100–150 Vdc</td>
<td>10 A</td>
<td>14 / 2.5</td>
</tr>
<tr>
<td>88–132 Vac 47–63 Hz</td>
<td>20 A</td>
<td>12 / 4</td>
</tr>
<tr>
<td>200–300 Vdc</td>
<td>5 A</td>
<td>16 / 1.5</td>
</tr>
<tr>
<td>180–264 Vac 47–63 Hz</td>
<td>10 A</td>
<td>14 / 2.5</td>
</tr>
</tbody>
</table>

* must use wire rated for at least 75 °C for use at 30 °C ambient
** except as noted, wire sizes are rated 60 °C for 30 °C ambient

When a cabinet is not supplied with the system, input power connections are made through terminals on the front of each main power supply. These terminals accept wires from 0.5 to 10 mm² (20–8 AWG). For a good connection, the inserted wires should have the insulation stripped back 8–9 mm (0.33 in). Torque to 0.5 to 0.6 N-m (0.37 to 0.44 lb-ft).

The 24 Vdc power supply model uses larger copper input terminals to accommodate the required 10 mm² (8 AWG) wire.

A green/yellow wire connection of at least the same size as the supply wire must be used for the PE ground.

### 4.4—TMR Kernel PS Module

#### 4.4.1—Module Description

The MicroNet TMR control contains three kernel power supply modules. Each kernel section (A, B, and C) will contain one kernel power supply module. The kernel power supply will be located in the first slot of each kernel section. This module receives 24 Vdc from the MicroNet main power supplies and regulates it to 5 Vdc, 10 A for the rest of the kernel section and also creates a 5 Vdc precharge voltage.

**IMPORTANT**

Kernel Power Supply 5466-318 MUST be used with the TMR040 CPU.
Kernel Power Supply 5466-1049 MUST be used with the TMR5200 CPU.

Each kernel power supply has one LED to indicate kernel power supply health. See MicroNet TMR Kernel Power Supply Troubleshooting (Section 4.8.2) for a description of the LED indication.

**WARNING**

The MicroNet TMR Kernel Power Supply module must have all modules in that kernel removed before installing or removing a Kernel Power Supply module.

This equipment is suitable for use in Class I, Division 2, Groups A, B, C, and D or non-hazardous locations only.
Figure 4-7—Kernel Power Supply Module

4.5—TMR Kernel PS Module Specifications

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input Voltage</td>
<td>24 Vdc ±10%</td>
</tr>
<tr>
<td>Output Voltage</td>
<td>5 Vdc ±5%</td>
</tr>
<tr>
<td>Output Current</td>
<td>10 A maximum</td>
</tr>
</tbody>
</table>
4.6—TMR Kernel PS Installation

The Kernel Power Supply must be installed in the first module slot from the left for each sub-chassis (kernel). The Kernel CPU module is installed in the next module slot directly to the right of each Kernel Power Supply.
4.7—TMR System Power-up

If at any time during this procedure the defined or expected result is not achieved, begin system troubleshooting.

1. Verify that the entire MicroNet TMR control system has been installed.

2. Turn on the power for one power supply, and verify that the power supply’s green LED is the only power supply LED that is on.

3. Turn on the power for the second power supply, and verify that the power supply’s green LED is the only power supply LED that is on.

4. Verify that all of Kernel Power Supply’s red fault LEDs are off. If any of the LEDs are on see the Kernel Power Supply Troubleshooting in section 4.8.2.

If the system is configured with the CPU_040 perform step #5 and skip step #6. If the TMR system uses the CPU_5200 skip step #5 and perform step #6.

5. **CPU_040**: Momentarily toggle two of the CPU’s RESET switches up, then back to their normal down position. Toggle remaining CPU RESET switch up, then back to its normal down position. At this point the system will perform off-line diagnostic testing, which could take several minutes. When all CPUs have synchronized and completed their diagnostic tests, no red LEDs on the CPU modules or I/O modules should be on, and the control will begin running the application program.

6. **CPU_5200**: Wait until the CPUs finish their off-line diagnostics and the CPUs are visible in AppManager. If the CPUs were running when the CPUs were powered off, the CPUs will automatically start the Application that was running when it was power off. If there was no Application running, select an Application on each CPU in AppManager and select “Start”. The CPUs will run the selected Application, synchronize and completed their diagnostic tests. There should be no red LEDs on the CPU modules or I/O modules and the control will be running the application program. The Green SYSCON and RUN LED’s should be on and the Yellow STBY LED should be off.

4.8—TMR Power Supply Troubleshooting

4.8.1—TMR Main Power Supply

System diagnostic routines continuously monitor each main power supply for proper operation. If a fault condition is detected, the fault is annunciated and the supply’s output disabled. If necessary, use the power supply’s front panel LEDs to assist in diagnosing any related problems. If all supply LEDs are off (not illuminated), its probable that input power is not present, and verification should be made.

4.8.1.1—TMR Main Power Supply LED Descriptions

**OK LED**—This green LED turns on to indicate that the power supply is operating and that no faults are present.
INPUT FAULT LED—This red LED turns on to indicate that the input voltage is either above or below the specified input range. If this LED is on, check the input voltage, and correct the problem. Long-term operation with incorrect input voltages may permanently damage the power supply. Once the input voltage is within the supply’s input specifications, this LED will turn off. Refer to the power supply input specifications.

OVERTEMPERATURE LED—This red LED gives an early warning of a thermal shutdown. The LED turns on to indicate that the internal power supply temperature has exceeded approximately 80 °C. If the internal supply temperature rises to approximately 90 °C, the supply will shut down. Because of the many variables involved (ambient temperature, load, thermal conductivity variations), there is no accurate way of predicting the time between the indication of overtemperature (LED illuminated) and power supply shutdown.

If this LED is turned on, verify that the fan in the power supply chassis is turning and is free of dust and other obstructions, and that the temperature around the power supply is less that 55 °C. If the power supply is cooled down without delay, it can recover from this situation without shutting down. This LED will turn off once the internal power supply heat sink temperature falls below approximately 75 °C.

POWER SUPPLY FAULT LED—This red LED turns on when one of the supply’s four power converters has shut down. If this LED is on, check for a short circuit on external devices connected to the control’s power supply. When the short circuit has been removed, the supply will resume normal operation. If no short circuit is found, reset the supply by removing input power for one minute. If the power supply is still not functioning after input power has been restored, verify that the supply is properly seated to the motherboard connector. If the supply is properly seated but is not working, then replace the supply.

4.8.1.2—TMR Main Power Supply Checks

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

- Is the input power within the range of the control’s power supply input?
- Is the input power free of switching noise or transient spikes?
- Is the power circuit dedicated to the governor only?
- Are the control’s supplies indicating that they are OK?
- Are the control’s supplies outputting the correct voltage?

4.8.2—Kernel Power Supply Module

The status of this module’s power supplies and communication memories is monitored by the CPU module that is installed in the adjacent slot.

4.8.2.1—Kernel Power Supply LED Description

KERNEL FAULT LED—This LED indicates that either the 5 V is not functioning or that the 5 V precharge is not functioning.

4.8.2.2—Kernel Power Supply Checks

The following is a table to assist in troubleshooting the Kernel Power Supply and the need for replacement.
Possible Cause | Result | Corrective Action
--- | --- | ---
5 V is not functioning | The kernel will not function. | Remove all modules from that kernel and remove the Kernel Power Supply. Reinstall the Kernel Power Supply. If the LED does not turn off, replace the module.

5 V precharge is not functioning | The kernel is still functioning. | Remove all modules from that kernel and remove the Kernel Power Supply. Reinstall the Kernel Power Supply. If the LED does not turn off, replace the module.

Table 4-2—Kernel Power Supply Troubleshooting

### 4.9—MicroNet Plus 8/14 Chassis Power Supplies

#### 4.9.1—Module Description

The MicroNet Plus Expansion Chassis may use either single or redundant power supplies. Each power supply module produces three regulated outputs: 24 V @ 12 A (max), 5 V @ 32 A (max, derated above 55 degree C external ambient temperature), and 5 V Precharge @ 3 A (max). A motherboard located on the back of the chassis provides the interconnection of the three outputs from each power supply module into three corresponding power busses: 24 V bus, 5 V bus, and 5 V precharge bus. The 24 V and 5 V busses are load shared between the two power supply modules. The 5 V precharge bus is not load shared. Power output regulation at the motherboard, including line, load, and temperature effects, is less than ±10% for the 24 V bus, +/-5% for the 5 V bus, and +/-10% for the 5 V Precharge bus. The 5 V and 5 V Precharge busses are not for external use. The 24 V bus is accessible from the motherboard for external use (protected by 5 A fuses on the source and return lines).

When redundant power supplies are running, current sharing circuitry balances the load to reduce heat and improve the reliability of the power supplies. In the event that one supply needs to be replaced, the recommended method for changing Power Modules is with the power off (to the module being removed and the module being inserted). The system will tolerate this “cold swap” method without failure.

Each main power supply has four LEDs to indicate power supply health (OK, Input Fault, Overtemperature, and Power Supply Fault). See MicroNet Plus Power Supply Troubleshooting (Section 5.5) for a description of the LED indications.

Input power connections are made to the power supply through a plug/header assembly on the front of the power supply.

For redundant operation, the control can use any combination of power supplies.

The power supplies can only be installed into slots PS1 (power supply #1) and PS2 (power supply #2). If redundant power supplies are not needed, blanking plates must be installed in the slots not being used.

For MicroNet Plus installation instructions, see Chapter 14.
The MicroNet Plus main power supplies must have the input power removed before installing or removing.

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

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

Figure 4-9—Power Supply Module
### 4.9.2—Power Supply Module Specifications

**IMPORTANT**
- All Temperature ratings specify the System Ambient Temperature as measured at the front of the MicroNet chassis.
- The Power Supply operating temperature range is –10 to +65 °C with de-rated 5 Vdc output current above 55 °C. See Power Supply specifications.
- For a particular system configuration, use the MicroNet Power Program to calculate the output current requirements (24 V, 5 V) as a function of the Chassis, CPUs, and I/O modules used in the system.

---

**Main PS (24 Vdc Input)**
- Operating range: 18 to 36 Vdc
- Nominal input voltage rating: 24 Vdc
- Maximum input current: 33 A
- Maximum input power: 600 W
- Input power fuse/breaker rating: 50 A time delay

| Maximum output current (24 Vdc): | 12.0 A @ 65 °C System Ambient Temp. |
| Maximum output current (5 Vdc):  | 22.0 A @ 65 °C, 28 A @ 60 °C, 32 A @ 55 °C |
| Holdup time:                     | 5 ms @ 24 Vdc                        |

**Main PS (110 Vac/dc Input)**
- **AC input**
  - Operating range: 88 to 132 Vac (47 to 63 Hz)
  - Nominal input voltage rating: 98 to 120 Vac, as on power supply label
  - Maximum input current: 13.6 A
  - Maximum input power: 1250 VA
  - Input power fuse/breaker rating: 20 A time delay

| Maximum output current (24 Vdc): | 12.0 A @ 65 °C System Ambient Temp. |
| Maximum output current (5 Vdc):  | 28.0 A @ 65 °C, 32 A @ 60 °C         |
| Holdup time:                     | 1 cycle @ 120 Vac                    |

- **DC input**
  - Operating range: 100 to 150 Vdc
  - Nominal input voltage rating: 111 to 136 Vdc, as on power supply label
  - Maximum input current: 6 A
  - Maximum input power: 600 W
  - Input power fuse/breaker rating: 10 A time delay

| Maximum output current (24 Vdc): | 12.0 A @ 65 °C System Ambient Temp. |
| Maximum output current (5 Vdc):  | 28.0 A @ 65 °C, 32 A @ 60 °C         |
| Holdup time:                     | 7 ms @ 120 Vdc                      |

**Main PS (220 Vac Input)**
- **High Voltage AC**
  - Operating range: 180 to 264 Vac (47 to 63 Hz)
  - Nominal input voltage rating: 200 to 240 Vac, as on power supply label
  - Maximum input current: 6.7 A
  - Maximum input power: 1250 VA
  - Input power fuse/breaker rating: 10 A time delay

| Maximum output current (24 Vdc): | 12.0 A @ 65 °C System Ambient Temp. |
| Maximum output current (5 Vdc):  | 22.0 A @ 65 °C, 28 A @ 60 °C, 32 A @ 55 °C |
| Holdup time:                     | 1 cycle @ 220 Vac                    |
Input Power Wiring
A ground conductor connected to the chassis is required for safety. The power supply grounding terminal(s) should also be connected to earth to ensure grounding of the power supply printed circuit boards. The grounding conductor must be the same size as the main supply conductors.

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

A circuit breaker meeting the above requirements 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. To avoid nuisance trips, use only time-delay fuses or circuit breakers.

Branch circuit fuses, circuit breakers, and wiring must meet appropriate codes and authorities having jurisdiction for the specific country (CE, UL, etc). See Table 4-3 for maximum recommended fuse or breaker ratings. Do not connect more than one main power supply to any one fuse or circuit breaker. Use only the wire sizes specified in Table 4-3 which meet local code requirements. Time delay fuses or circuit breakers must be used to prevent nuisance trips.

Power requirements depend on the number and type of modules supplied for each system. For a system with a single I/O chassis, size the input power source according to the rating of the MicroNet Plus power supply to which the source is connected. Do not size the supply mains for the sum of the MicroNet Plus power supply ratings when redundant supplies are used. MicroNet Plus supplies are redundant when installed in the same chassis. Redundant supplies share the load between them equally, but each must provide for full load in the event that one of the units is disabled. Table 4-3 gives the maximum overload protection for supply mains connected to any single or redundant pair of MicroNet Plus main power supplies. It is not recommended that both MicroNet Plus main power supplies of a redundant pair be connected to a single source, since failure of that source would disable the system.

Multiple chassis systems using MicroNet Plus power supplies may have power supplies of the same model, but in different chassis, connected to the same source. In this case, each branch to a chassis must have its own overcurrent protection sized according to Table 4-3, and the power source must be sized for the sum of the branches.

Not all systems will require the full load capability of the MicroNet Plus power supply. If not otherwise indicated on a cabinet system nameplate, either use the MicroNet power supply input ratings for sizing the system’s source or consult Woodward for determining the minimum source requirements.

Table 4-3 provides fuse and wire size specifications for each power supply.
Table 4-3—MicroNet Plus Power Supply Requirements

<table>
<thead>
<tr>
<th>MAXIMUM INPUT VOLTAGE RANGE</th>
<th>MAXIMUM FUSE/C.B. RATING (Time Delay)</th>
<th>WIRE SIZE ** (AWG/mm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>18–36 Vdc</td>
<td>50 A</td>
<td>8 / 10 *</td>
</tr>
<tr>
<td>100–150 Vdc</td>
<td>10 A</td>
<td>14 / 2.5</td>
</tr>
<tr>
<td>88–132 Vac 47–63 Hz</td>
<td>20 A</td>
<td>12 / 4</td>
</tr>
<tr>
<td>180–264 Vac 47–63 Hz</td>
<td>10 A</td>
<td>14 / 2.5</td>
</tr>
</tbody>
</table>

* must use wire rated for at least 75 °C for use at 30 °C ambient
** except as noted, wire sizes are rated 60 °C for 30 °C ambient

When a cabinet is not supplied with the system, input power connections are made through a plug/header assembly on the front of each main power supply. The plug accept wires from 0.5 to 16 mm² (20–6 AWG). For a good connection, the inserted wires should have the insulation stripped back 11-12 mm (0.45 in). Torque to 0.5 to 0.6 N·m (0.37 to 0.44 lb-ft).

A green/yellow wire connection of at least the same size as the supply wire must be used for the PE ground.

**System Power-Up**

If at any time during this procedure the defined or expected result is not achieved, begin system troubleshooting.

1. Verify that the entire MicroNet Plus control system has been installed.

2. Turn on the power to one power supply and verify that the power supply’s green LED is the only power supply LED on.

3. Turn off the power to the first power supply and turn on the power to the second power supply (if a second power supply is present) and verify that the power supply’s green LED is the only power supply LED on.

4. The RTN_CPUs in the chassis will not start automatically, the CPUs in the TMR chassis must command them to start. See GAP application program for details.
4.9.3—Power Supply Troubleshooting

System diagnostic routines continuously monitor each main power supply for proper operation. If a fault condition is detected, the fault is annunciated. If necessary, use the power supply’s front panel LEDs to assist in diagnosing any related problems. If all supply LEDs are off (not illuminated), it is probable that input power is not present, and verification should be made.

Power Supply LED Descriptions

OK LED—This green LED turns on to indicate that the power supply is operating and that no faults are present.

INPUT FAULT LED—This red LED turns on to indicate that the input voltage is either above or below the specified input range. If this LED is on, check the input voltage, and correct the problem. Long-term operation with incorrect input voltages may permanently damage the power supply. Once the input voltage is within the supply’s input specifications, this LED will turn off. Refer to the power supply input specifications.

OVERTEMPERATURE LED—This red LED gives an early warning of a thermal shutdown. The LED turns on to indicate that the internal power supply temperature has exceeded approximately 95 °C. If the internal supply temperature rises to approximately 100 °C, the supply may shut down. Because of the many variables involved (ambient temperature, load, thermal conductivity variations), there is no accurate way of predicting the time between the indication of overtemperature (LED illuminated) and power supply shutdown.

If this LED is turned on, verify that the fans in the power supply chassis are turning and free of dust and other obstructions, and that the temperature around the power supply is less than 55 °C. If the power supply is cooled down without delay, it can recover from this situation without shutting down. This LED will turn off once the internal power supply heat sink temperature falls below approximately 90 °C.

POWER SUPPLY FAULT LED—This red LED turns on when one of the supply’s three power converters has shut down or one or more of the supply levels is below internally specified levels. If this LED is on, check for a short circuit on external devices connected to the control’s power supply. When the short circuit has been removed, the supply will resume normal operation (Note that if the 24 V or 5 V outputs are shorted, these power converters will be latched OFF and can only be cleared by removing the shorted condition and removing the input power for 1 minute (or until the front panel LEDs extinguish). If no short circuit is found, reset the supply by removing input power for one minute. If the power supply is still not functioning after input power has been restored, verify that the supply is properly seated to the motherboard connector. If the supply is properly seated but is not working, then replace the supply.

Simplex Power Supply Checks

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

- Is the input power within the range of the control’s power supply input?
- Is the input power free of switching noise or transient spikes?
- Is the power circuit dedicated to the governor only?
- Are the control’s supplies indicating that they are OK?
- Are the control’s supplies outputting the correct voltage?
- Is the RTN / CPU Low Vcc LED ON?
4.10—MicroNet Simplex 6/12 Chassis Power Supplies

4.10.1—Module Description

The MicroNet expansion chassis may use either single or redundant power supplies. A motherboard located on the back of the chassis allows the two power supplies to form a redundant power system providing two separately regulated, 24 Vdc, 12 A outputs; two separately regulated, 5 Vdc, 20 A outputs; and two separately regulated, 5 Vdc precharge outputs to the control. Power output regulation, including line, load, and temperature effects, is less than ±5%.

When redundant power supplies are running, current sharing circuitry balances the load to reduce heat and improve the reliability of the power supplies. In the event that one supply needs replacement, this feature also ensures hot replacement of the power supplies without disrupting the operation of the control.

Each main power supply has four LEDs to indicate power supply health (OK, Input Fault, Overtemperature, and Power Supply Fault). See MicroNet Expansion Power Supply Troubleshooting (Section 4.13.1) for a description of the LED indications.

Input power connections are made to the power supply through terminals on the front of the power supply.

For redundant operation, the control can use any combination of power supplies.

The power supplies can only be installed into slots PA1 (power supply #1) and PA2 (power supply #2). If redundant power supplies are not needed, blanking plates (3799-301) must be installed in the slots not being used.

For MicroNet TMR installation instructions, see Chapter 14 and Section 3.3 of this chapter.

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**IMPORTANT**

The 6/12 slot expansion chassis should not be used for new applications. The 6/12 slot expansion chassis should only be used in retrofit situations where the chassis is already installed.

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**WARNING**

The MicroNet TMR main power supplies must have the input power removed before installing or removing.

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

Wiring must be in accordance with Class I, Division 2 wiring methods and in accordance with the authority having jurisdiction.
Expansion Chassis PS (24 Vdc Input)  
Expansion Chassis PS (120 Vac/dc Input)

Figure 4-10—Power Supply Modules
4.11—MicroNet Simplex Power Supply Specifications

Main PS Expansion (24 Vdc Input)

- Operating range: 18 to 36 Vdc
- Nominal voltage rating: 20 to 32 Vdc, as on power supply label
- Maximum current: 29.5 A
- Maximum power: 531 W
- Input power fuse/breaker rating: 50 A time delay
- Holdup time: 5 ms @ 24 Vdc

Main PS Expansion (120 Vac/dc Input)

**AC**

- Operating range: 88 to 132 Vac (47 to 63 Hz)
- Nominal voltage rating: 98 to 120 Vac, as on power supply label
- Maximum current: 12.1 A
- Maximum power: 1062 VA
- Input power fuse/breaker rating: 20 A time delay
- Holdup time: 1 cycle @ 120 Vac

**DC**

- Operating range: 100 to 150 Vdc
- Nominal voltage rating: 111 to 136 Vdc, as on power supply label
- Maximum current: 5.3 A
- Maximum power: 531 W
- Input power fuse/breaker rating: 10 A time delay
- Holdup time: 7 ms @ 120 Vdc

Main PS Expansion (220 Vac Input)

**High Voltage AC**

- Operating range: 180 to 264 Vac (47 to 63 Hz)
- Nominal voltage rating: 200 to 240 Vac, as on power supply label
- Maximum current: 5.9 A
- Maximum power: 1062 VA
- Input power fuse/breaker rating: 10 A time delay
- Holdup time: 1 cycle @ 220 Vac

**High Voltage DC**

- Operating range: 200 to 300 Vdc
- Nominal voltage rating: 223 to 272 Vdc, as on power supply label
- Maximum current: 2.7 A
- Maximum power: 531 W
- Input power fuse/breaker rating: 5 A time delay
- Holdup time: 7 ms @ 225 Vdc
4.12—MicroNet Simplex Power Supply Installation

Figure 4-11—MicroNet Simplex Power Supply

4.12.1—Input Power Wiring

MicroNet controls require a fixed wiring installation for ac applications. Ground leakage exceeds 3.5 mA AC. Maximum ground leakage for ac installations is 7.2 mA at 60 Hz. A ground conductor connected to the chassis is required for safety. The power supply grounding terminal(s) should also be connected to earth to ensure grounding of the power supply printed circuit boards. The grounding conductor must be the same size as the main supply conductors.

**IMPORTANT**

Note that the control’s power supplies are not equipped with input power switches. For this reason, some means of disconnecting input power to each main power supply must be provided for installation and servicing. A circuit breaker meeting the above requirements or a separate switch with appropriate ratings may be used for this purpose. To avoid nuisance trips, use only time-delay fuses or circuit breakers.
Branch circuit fuses, circuit breakers, and wiring must meet appropriate codes and authorities having jurisdiction for the specific country (CE, UL, etc). See Table 4-4 for maximum recommended fuse or breaker ratings. Do not connect more than one main power supply to any one fuse or circuit breaker. Use only the wire sizes specified in Table 4-4 which meet local code requirements. Time delay fuses or circuit breakers must be used to prevent nuisance trips.

Power requirements depend on the number and type of modules supplied for each system. For a system with a single I/O chassis, size the input power source according to the rating of the MicroNet power supply to which the source is connected. Do not size the supply mains for the sum of the MicroNet power supply ratings when redundant supplies are used. MicroNet supplies are redundant when installed in the same chassis. Redundant supplies share the load between them equally, but each must provide for full load in the event that one of the units is disabled. Table 4-4 gives the maximum overload protection for supply mains connected to any single or redundant pair of MicroNet main power supplies. It is not recommended that both MicroNet main power supplies of a redundant pair be connected to a single source, since failure of that source would disable the system.

Multiple chassis systems using MicroNet power supplies may have power supplies of the same model, but in different chassis, connected to the same source. In this case, each branch to a chassis must have its own overcurrent protection sized according to Table 4-4, and the power source must be sized for the sum of the branches.

Not all systems will require the full load capability of the MicroNet power supply. If not otherwise indicated on a cabinet system nameplate, either use the MicroNet power supply input ratings for sizing the system’s source or consult Woodward for determining the minimum source requirements.

Table 4-4 provides fuse and wire size specifications for each power supply.

<table>
<thead>
<tr>
<th>MAXIMUM INPUT VOLTAGE RANGE</th>
<th>MAXIMUM FUSE/C.B. RATING (Time Delay)</th>
<th>WIRE SIZE ** (AWG/mm²)</th>
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</table>

* must use wire rated for at least 75 °C for use at 30 °C ambient
** except as noted, wire sizes are rated 60 °C for 30 °C ambient

Table 4-4—MicroNet Simplex Power Supply Requirements
When a cabinet is not supplied with the system, input power connections are made through terminals on the front of each main power supply. These terminals accept wires from 0.5 to 10 mm² (20–8 AWG). For a good connection, the inserted wires should have the insulation stripped back 8–9 mm (0.33 in). Torque to 0.5 to 0.6 N·m (0.37 to 0.44 lb-ft).

The 24 Vdc power supply model uses larger copper input terminals to accommodate the required 10 mm² (8 AWG) wire.

A green/yellow wire connection of at least the same size as the supply wire must be used for the PE ground.

4.12.2—System Power-Up

If at any time during this procedure the defined or expected result is not achieved, begin system troubleshooting.

1. Verify that the entire MicroNet control system has been installed.

2. Turn on the power to one power supply and verify that the power supply’s green LED is the only power supply LED on.

3. Turn off the power to the first power supply and turn on the power to the second power supply (if a second power supply is present) and verify that the power supply’s green LED is the only power supply LED on.

4. If the RTN_CPUs are being used, they will not start automatically, the CPUs in the TMR chassis must command them to start. See GAP application program for details.

4.13—MicroNet Simplex Power Supply Troubleshooting

System diagnostic routines continuously monitor each main power supply for proper operation. If a fault condition is detected, the fault is annunciated and the supply’s output disabled. If necessary, use the power supply’s front panel LEDs to assist in diagnosing any related problems. If all supply LEDs are off (not illuminated), it is probable that input power is not present, and verification should be made.

4.13.1—Power Supply LED Descriptions

**OK LED**—This green LED turns on to indicate that the power supply is operating and that no faults are present.

**INPUT FAULT LED**—This red LED turns on to indicate that the input voltage is either above or below the specified input range. If this LED is on, check the input voltage, and correct the problem. Long-term operation with incorrect input voltages may permanently damage the power supply. Once the input voltage is within the supply’s input specifications, this LED will turn off. Refer to the power supply input specifications.
OVERTEMPERATURE LED—This red LED gives an early warning of a thermal shutdown. The LED turns on to indicate that the internal power supply temperature has exceeded approximately 80 °C. If the internal supply temperature rises to approximately 90 °C, the supply will shut down. Because of the many variables involved (ambient temperature, load, thermal conductivity variations), there is no accurate way of predicting the time between the indication of overtemperature (LED illuminated) and power supply shutdown.

If this LED is turned on, verify that the fan in the power supply chassis is turning and is free of dust and other obstructions, and that the temperature around the power supply is less than 55 °C. If the power supply is cooled down without delay, it can recover from this situation without shutting down. This LED will turn off once the internal power supply heat sink temperature falls below approximately 75 °C.

POWER SUPPLY FAULT LED—This red LED turns on when one of the supply’s four power converters has shut down. If this LED is on, check for a short circuit on external devices connected to the control’s power supply. When the short circuit has been removed, the supply will resume normal operation. If no short circuit is found, reset the supply by removing input power for one minute. If the power supply is still not functioning after input power has been restored, verify that the supply is properly seated to the motherboard connector. If the supply is properly seated but is not working, then replace the supply.

4.13.2—Expansion Power Supply Checks

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

- Is the input power within the range of the control’s power supply input?
- Is the input power free of switching noise or transient spikes?
- Is the power circuit dedicated to the governor only?
- Are the control’s supplies indicating that they are OK?
- Are the control’s supplies outputting the correct voltage?
Chapter 5.
CPUs

5.1—TMR5200 CPU Module

5.1.1—Module Description

The MicroNet TMR5200 CPU module contains a MPC5200 processor, 128 Mbyte DDR RAM, 64 MB of flash memory, a Real Time clock, and various communication peripherals. These peripherals include (2) general use Ethernet ports, (1) Real Time Network port, (1) serial port, (1) one service port, and (2) CAN ports. This module includes an FPGA to provide VMEbus master/slave capability as well as other functions necessary for redundant systems.

The TMR5200 Module is designed for 3-2-0 operation. A TMR system cannot operate with a single CPU.

This module was designed and rated for –40 to +85 °C operation in the industrial marketplace.
For CPU module installation and replacement instructions, see the instructions for installing the VME module in Chapter 14, and the instructions for replacement in Chapter 15.

Live insertion and removal of this module is allowed in a MicroNet TMR or Plus chassis. This module should be reset immediately before removing it from the chassis. This notifies the module that it will be removed and provides a graceful failover to another healthy CPU module if available.

The CPU module runs the GAP application program. Figure 5-2 is a block diagram of a CPU module. When the power is applied, the CPU module will perform diagnostic tests, before running the application program.

The CPU module contains a battery to power the real time clock when power to the control is off. This battery is not user-replaceable. During normal operation, on-board circuitry keeps the battery charged. Once the battery is fully charged (taking a maximum of three days), the battery will continue to run the clock for a minimum of three months without power to the control. If power is removed from the CPU module for longer than three months, the real time clock may need to be reset. The resolution of the real time clock is 10 milliseconds.

Figure 5-2—CPU Module Block Diagram
5.1.2—Module Configuration

**Hardware Configuration.** The Module Configuration Switch (S2) must be configured properly for CPU mode (main rack, address 0x000) operation. This module will be factory configured appropriately.

**Network Type.** The Network Type setting is factory set OFF to automatically configure the RTN communication port IP addresses to the 172.20.x.x series.

**Network Configuration.** Ethernet ports (ENET1, ENET2) can be configured for the customer network as desired. The RTN ports (RTN1, RTN2) are reserved for communicating with Woodward Real Time Network devices such as expansion racks. See the on-site Network Administrator to define an appropriate I/P address configuration for ENET1 and ENET2.

**IMPORTANT**

It is recommended to verify proper switch settings before installing the module in the system and when troubleshooting CPU-related issues.

**IMPORTANT**

If the CPU module is incorrectly configured for RTN mode, Ethernet ports #1 and #2 are NOT active and AppManager will not be available.

- **Network Type.** The Network Type setting is factory set OFF to automatically configure the RTN communication port IP addresses to the 172.20.x.x series.

**IMPORTANT**

It is recommended to verify proper switch settings before installing the module in the system and when troubleshooting CPU or RTN related issues.

The Network Type setting on all CPU and Remote RTN modules in the system must match for proper system operation.

The customer network attached to Ethernet #1 or #2 may already use the RTN port addresses of 172.20.x.x. In this case, the Network Type switch should be configured ON to use the 10.250.x.x RTN port addresses.

This module has been factory configured with fixed Ethernet IP addresses of

- Ethernet #1 (ENET1) = 172.16.100.1, Subnet Mask = 255.255.0.0
- Ethernet #2 (ENET2) = 192.168.128.20, Subnet Mask = 255.255.255.0
Network Configuration Utility (AppManager)
Woodward's AppManager software can be used to load Control software (GAP), monitor diagnostic faults, and configure Network settings. The AppManager utility can be downloaded from www.woodward.com/software. A PC connection must be made to Ethernet #1 (ENET1) using a RJ45 Ethernet cable.

**IMPORTANT** AppManager can always be used to “discover/view” the current CPU IP Address. However, to modify settings or load applications, the PC running AppManager must be reconfigured to be on the same “network” as the CPU.

- Locate the ControlName on the module faceplate and highlight it in AppManager.
- To VIEW the IP address configuration, select menu option CONTROL - CONTROL INFORMATION. Look for the Ethernet adapter addresses under the Footprint Description.
- To CHANGE the IP address configuration, select menu option CONTROL - CHANGE NETWORK SETTINGS.

### 5.1.3—Front Panel Indicators (LEDs)

The MicroNet PowerPC TMR5200 module has the following front-panel LEDs.

<table>
<thead>
<tr>
<th>LED</th>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>RUN</td>
<td>RUN / RESET</td>
<td>RUN / RESET (GREEN/RED)—Active RED when the user pushes the reset switch. Active GREEN upon release and after the CPU Operating system is loaded and running.</td>
</tr>
<tr>
<td>ETH</td>
<td>LINK</td>
<td>LINK ACTIVE (GREEN)—A valid Ethernet connection to another device exists.</td>
</tr>
<tr>
<td>TX/RX</td>
<td>TX/RX (YELLOW)</td>
<td>Active YELLOW when data is transmitted or received.</td>
</tr>
<tr>
<td>SYSTEM</td>
<td>SYSCON</td>
<td>System Controller (GREEN)—Active when this CPU module is the VMEbus System Controller.</td>
</tr>
<tr>
<td>STANDBY</td>
<td>Standby Ready</td>
<td>Standby Ready (YELLOW), NOT used for TMR systems. Active when this CPU module is ready to release or take over the System Controller functions in a failover event.</td>
</tr>
<tr>
<td>LVCC</td>
<td>Low VCC Power Fault</td>
<td>Low VCC Power Fault (RED)—A CPU or VME power supply high or low tolerance fault has been detected. - Local CPU power faults could be 1.2 V, 1.5 V, 1.8 V, 2.5 V, or 3.3 V. - VME power faults could be VME_5V, VME_5VPC, or VME_24V.</td>
</tr>
<tr>
<td>IOLOCK</td>
<td>IOLOCK (RED)</td>
<td>IOLOCK (RED)—This LED indicates that an I/O LOCK condition exists either locally on the CPU itself and/or on the VMEbus. Note: IOLOCK is a condition driven by the SYSCON where all I/O modules are placed into a failsafe condition and outputs are driven to a known state. For a main CPU rack, IOLOCK is activated within 18ms of a detected fault condition. For an RTN expansion rack, IOLOCK may take up to 55ms to be asserted.</td>
</tr>
<tr>
<td>FAULT</td>
<td>FAULT (RED)</td>
<td>CPU FAULT (RED)—Actively flashes CPU fault codes as necessary.</td>
</tr>
<tr>
<td>WATCHDOG</td>
<td>CPU Watchdog / Health Faults</td>
<td>CPU Watchdog / Health Faults (RED)—The processor watchdog or Health monitor has tripped and the CPU or Remote RTN module is prevented from running. The CPU Watchdog includes a 1 ms failover event and an 18 ms timeout event. Health faults include GAP fault, Watchdog events, and local SYSCLK and MFT hardware faults.</td>
</tr>
<tr>
<td>CAN LED’s</td>
<td>CAN #1, #2</td>
<td>CAN #1, #2 (GREEN/RED)—Active GREEN or RED when data is transmitted or received through CAN port #1 or #2.</td>
</tr>
</tbody>
</table>
5.1.4—Module Reset

Front Panel Reset Switch. The CPU module has a pushbutton reset switch on the front panel to reset the module. If a GAP application was successfully running at the time of reset, the same application will be auto-started and re-initialized.

CPU Remote Reset. Each CPU module will respond to a +24 V remote reset signal. The chassis provides a terminal-block with inputs RST1+, RST1–, RST2+, RST2–, RST3+, and RST3– for wiring the remote reset signals to each CPU. Each reset signal is routed to an opto-isolated input on the appropriate CPU that requires a +24 V signal to cause a reset.

Reset Notes:
- Resetting a CPU or Remote RTN module creates a HealthFault that immediately sets the WDOG light RED.
- The front-panel RUN/RESET led will be RED while reset is held and will turn GREEN for a few seconds after releasing reset. After turning OFF, it will again turn GREEN when the operating system starts to boot.

NOTE: When a TMR System is running with only 2 healthy CPUs, Pressing the reset on either of the running CPUs will drive IOLOCK and IORESET on the entire TMR system. This will place the Control System and all expansion racks to a safe condition where all output signals are driven to a known failsafe condition.

BEFORE REMOVAL!

This module should be reset immediately before removing it from the chassis. This notifies the module and system software that it will be removed.

5.1.5—10/100 BaseT Ethernet Ports

There are two 10/100 BaseT Ethernet Ports (RJ45) available to the application software. These ports are full duplex, auto switching, and do not require the use of an Ethernet shield box.

ETHERNET CABLES—Max cable length is 30 meters. Double shielded, Cat 5 Ethernet cables (SSTP) are required for customer installations.

5.1.6—RTN Port

In a TMR5200 based system, each Kernel CPU provides Real Time Network (RTN) capability for expanding to other racks using Ethernet port 4 (RJ45). This RTN port communicates between the main chassis CPU's and any Remote RTN modules located in an expansion chassis. The GAP software application defines the expansion racks, their I/O modules, and the use of the RTN port (GAP block is RTN).
Up to two Remote RTN modules may be installed into each MicroNet Plus 8/14 expansion chassis (only one RTN for 6/12 slot expansion chassis). When initialized by the main chassis CPU, the Remote RTN modules will acquire either a SYSCON or STANDBY status. The Remote RTN module that becomes SYSCON will control the expansion chassis it is located in. It will synchronize with the STANDBY Remote RTN module and perform any redundancy functions as necessary. Input and output data from all I/O modules will be managed appropriately and made available to the GAP Application running in the main-chassis CPUs.

**Refer to the Communications section and the RTN Remote Transceiver module for additional information to configure expansion racks using either copper or fiber Ethernet cables.**

**REMOTE RTN CABLES (COPPER)**
- Double shielded, Cat 5 Ethernet cables (SSTP) are required for customer installations.
- Cable length between the Main rack and RTN switch is 3 m (10 ft) max.
- Cable length between the RTN switch and Expansion rack is 30 m (100 ft) max.

**5.1.7—RS-232/422/485 Serial Port**

An isolated, configurable RS-232 / 422 / 485 serial port is located on the front of the CPU module and is configured by the GAP software application. The baud rate is selectable from 300 baud to 115.2 Kbaud. Shielded cable is required when connecting to the CPU module’s serial port. Using shielded cable will help ensure the robustness of the serial communications.

```
Pin 1 – RS-422 Transmit (+)
Pin 2 – RS-232 Receive
Pin 3 – RS-232 Transmit
Pin 4 – RS-422 Transmit (-)
Pin 5 – Signal Ground
Pin 6 – Termination Resistor (+)
Pin 7 – RS-485/422 Receive (+)
Pin 8 – RS-485/422 Receive (-)
Pin 9 – Termination Resistor (-)
```

Figure 5-3—CPU Communications Port (DB9F)

**5.1.8—RS-232 Service Port**

An isolated RS-232 service port is located on the front of the CPU module. This port is for VxWorks* operating system use only and cannot be configured for application software use. The communication settings are fixed at 38.4 Kbaud, 8 data bits, no parity, 1 stop-bit, and no flow control.

*—VxWorks is a trademark of Wind River Systems, Inc.

For debug use, a null-modem cable and 5450–1065 Serial Adapter cable (PS2M to DB9F) is required to attach this port to a PC. **This port is to be used by trained Field Service personnel only!**

Shielded cable is required when connecting to the Service Port. Using shielded cable will help ensure the robustness of the serial communications.
5.1.9—CAN Communication Ports

CAN is not supported on the TMR5200 CPU at this time.

5.1.10—Troubleshooting and Tuning

The MicroNet CPU module runs off-line and on-line diagnostics that display troubleshooting messages through the debug Service Port and AppManager. Off-line diagnostics run automatically on power-up and when the Reset switch is asserted. On-line diagnostics run during normal Control System operation when the GAP application is active. More information on diagnostics tests, subsequent LED flash codes, and serial port messages is contained in the VxWorks manual.

A table of the CPU fault LED flash codes is shown below:

<table>
<thead>
<tr>
<th>Failure</th>
<th>Flash Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>RAM Test Failure</td>
<td>1, 4</td>
</tr>
<tr>
<td>Real Time Clock Test Failure</td>
<td>2, 2</td>
</tr>
<tr>
<td>Floating Point Unit Test Failure</td>
<td>2, 3</td>
</tr>
<tr>
<td>Flash Test Failure</td>
<td>2, 4</td>
</tr>
<tr>
<td>HD1 Flash Test Failure</td>
<td>2, 5</td>
</tr>
<tr>
<td>I2C Bus Test Failure</td>
<td>2, 6</td>
</tr>
<tr>
<td>Module Installed in wrong slot</td>
<td>2, 7</td>
</tr>
<tr>
<td>Main Chassis CPU switch must be set to 0</td>
<td>3, 5</td>
</tr>
<tr>
<td>Remote RTN Rate Group 5 Slip</td>
<td>3, 7</td>
</tr>
<tr>
<td>Remote RTN Rate Group 10 Slip</td>
<td>3, 8</td>
</tr>
<tr>
<td>Remote RTN Rate Group 20 Slip</td>
<td>3, 9</td>
</tr>
<tr>
<td>Remote RTN Rate Group 40 Slip</td>
<td>3, 10</td>
</tr>
<tr>
<td>Remote RTN Rate Group 80 Slip</td>
<td>3, 11</td>
</tr>
<tr>
<td>Remote RTN Rate Group 160 Slip</td>
<td>3, 12</td>
</tr>
<tr>
<td>Remote RTN Chassis Switch Invalid</td>
<td>4, 5</td>
</tr>
<tr>
<td>Backup Remote RTN Chassis Switch different from Primary Remote RTN</td>
<td>4, 6</td>
</tr>
<tr>
<td>This module does not support the CAN port(s)</td>
<td>4, 7</td>
</tr>
<tr>
<td>This module needs a &quot;footprint&quot; update</td>
<td>4, 9</td>
</tr>
</tbody>
</table>
*A table of Message ID values as displayed in AppManger:

<table>
<thead>
<tr>
<th>Description of ID</th>
<th>ID Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Created by the Coder (Evaluate specific Application)</td>
<td>1-99</td>
</tr>
<tr>
<td>&quot;sysinit&quot; – Problem in system initialization</td>
<td>184,185,186</td>
</tr>
<tr>
<td>VerifyCpuMem -- Problem in verify CPU memory</td>
<td>103</td>
</tr>
<tr>
<td>VerifyNVLog -- Problem in verify NV_LOG functions</td>
<td>104,143,145</td>
</tr>
<tr>
<td>ExecuteTMRMessageTask -- Freerun task error</td>
<td>101,102</td>
</tr>
<tr>
<td>TMRDportDiagnostics -- Problem running DualPort test</td>
<td>105,106,112,113,114</td>
</tr>
<tr>
<td>WaitRTNBuffer -- Problem waiting for the RTN messages</td>
<td>146,147</td>
</tr>
<tr>
<td>ioRead -- Problem in the ioRead function</td>
<td>142,183</td>
</tr>
<tr>
<td>Run_ll_int -- Problem in the Ladder Logic executive</td>
<td>180</td>
</tr>
<tr>
<td>SynCmdBuffer – Problem sending messages to RTN chassis</td>
<td>181</td>
</tr>
<tr>
<td>CheckSyncCmdBuffer - Problem sending message to RTN</td>
<td>182</td>
</tr>
<tr>
<td>Clk_xvstat -- TMR CPU missing in interrupt service routine</td>
<td>604,605</td>
</tr>
<tr>
<td>PresInt -- TMR CPU unable to reach previous target</td>
<td>660</td>
</tr>
<tr>
<td>CopyToPickup – Problem syncing lost CPU</td>
<td>130,131,132</td>
</tr>
<tr>
<td>Re-sync -- Problem syncing lost CPU</td>
<td>133,134,135,136,137,138</td>
</tr>
<tr>
<td>Re-sync -- Lost CPU failed to sync properly</td>
<td>139</td>
</tr>
</tbody>
</table>

5.2—CPU_040 Module

5.2.1—Module Description

Figure 5-5—040 CPU Module
Every MicroNet TMR® control contains three CPU modules, one located in the second slot of each kernel, just to the right of the kernel power supply.

For CPU module installation and replacement instructions, see the instructions for installing the VME module in Chapter 14, and for replacement in Chapter 15.

The CPU modules run the application program. Figure 5-7 is a block diagram of a CPU module. When the reset switch is toggled to the Run position, the CPU modules will perform diagnostic tests, sync together, and then run the application program.

The CPU has a PCMCIA (Personal Computer Memory Card International Association) slot on its front panel. The PCMCIA slot is used to download application files to the CPU module.

The CPU module contains a battery to power the real time clock when power to the control is off. This battery is not user-replaceable. During normal operation, on-board circuitry keeps the battery charged. Once the battery is fully charged (taking a maximum of three days), the battery will continue to run the clock for a minimum of three months without power to the control. If power is removed from the CPU module for longer than three months, the real time clock may need to be reset. The resolution of the real time clock is 10 milliseconds.
5.2.2—RS-232 Serial Port COM1

An RS-232 serial port is located on the front of the CPU module. This port should only be connected to a device with an isolated serial port. Baud rate is selectable from 300 baud to 38.4 Kbaud. Before this port can be used, Woodward kit P/N 8298-096 must be installed. To install this kit, the CPU must have screw posts. Some of Woodward’s earlier CPU modules have slide lock posts. These must be sent to Woodward for upgrade before the port may be used. See Chapter 12 for details on how to install this port filter kit. Shielded cable is required when connecting to the CPU module’s serial port. Using shielded cable will help ensure the robustness of the serial communications.

This communication port is non-isolated. Shielded cable and a Serial Port Isolator/Converter is required when using this port to avoid susceptibility to EMI noise and ground loops related to PC connections and typical industrial environments. The following standard options are available:

- RS-232–RS-232 Isolator and Filter
- RS-232–RS-485 Isolator/Converter and Filter
- RS-232–RS-422 Isolator/Converter and Filter

**IMPORTANT**

A Serial Port Isolator/Converter must be properly installed, grounded, and powered prior to connection with the CPU. Once properly installed, it may be connected to a field device at any time. Alternatively, the isolator may be connected to the field device. However, it must be properly installed, grounded, and powered prior to connection to the CPU.
5.2.3—FTM Reference

No FTM is used with this CPU. However, additional installation and application information can be found in Chapter 12.

5.2.4—Troubleshooting and Tuning

The MicroNet™ Operating System runs both off-line and on-line diagnostics. Diagnostics are run at power-up or when the Reset switch is toggled (off-line), and automatically when operating under application-program control (on-line).
## 68040 CPU Off-Line Diagnostics

The following table shows the tests run by off-line diagnostics, and the order in which they are run. Off-line diagnostics are started immediately after the Reset has toggled.

<table>
<thead>
<tr>
<th>TEST</th>
<th>EXPLANATION OF TEST</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. CSR (Control Status Register) Test</td>
<td>The CSR register of the CPU is tested by writing to it, reading from it, and then testing the value read back.</td>
</tr>
<tr>
<td>2. Simple DUART (dual universal asynchronous transmitter)</td>
<td>This test checks the DUART counter/timer, and on Channel A of the CPU module, it does an receiver/internal wrap-around test. If the Channel passes the test, the display is initialized, and communication with the VFD (vacuum-fluorescent display) is set up. If the VFD does not respond, the system sets up for a dumb terminal.</td>
</tr>
</tbody>
</table>
| 3. Local RAM Test | This test checks all of the local RAM installed by performing the following tests:  
A. Marching One test (writes to a bit location in memory, then reads that location back to verify it has is repeated for every bit-location in memory.  
B. Write Byte, read word; write word, read byte, etc.  
C. If memory is less than 512 KB, perform wraparound test (writes past word boundaries).  
D. Misalign test (accesses memory on a misaligned word boundary). |
| 4. Application RAM Test | This test determines whether the memory for the application is RAM or PROM. If application memory is PROM, no tests are done. If application memory is RAM, the following tests are performed.  
A. Marching One test.  
B. Write Byte, read word; write word, read byte, etc.  
C. If memory is less than 512 KB, perform wraparound test (writes past word boundaries).  
D. Misalign test. |
| 5. Extensive DUART Test | This test checks both channels of the DUART with:  
A. Internal wrap-around test  
B. Different BAUD rates, data bits, etc. |
| 6. Clock interrupt Test | This test enables the interrupt timer and checks that the interrupts are being generated. |
| 7. Local Bus Timeout Test | This test writes to a location on the Woodward I/O bus with no memory (module) installed, and checks that a bus error occurs. |
| 8. VME Bus Timeout Test | This test writes to a location on the VME bus with no module installed, and verifies that a bus error occurs. |
| 9. PROM Write Test | This test makes the CPU think that PROM is installed. It then writes to a location and verifies that the CPU generates a bus error. |
| 10. EEPROM Test | This test uses the last few locations in the EEPROM. It writes to a location, reads the data back, and checks to see if the write was successful. It then repeats the procedure for different locations. |
| 11. FPU (Floating Point) Test | This test checks the register locations on the Unit Test co-processor, does some math calculations with known answers, and checks to be sure the answers returned are correct. |
| 12. BOOT | If the self test has been successful so far, the system checks to see if PROM is installed. If PROM is installed, and if it has a valid application program in it, that program will be executed.  
If RAM is installed, the system checks the VME bus to see if there is a memory module with a valid application program. If it finds one, it will download it to the CPU RAM and execute it.  
If there is no application program, the system sets up for a download and requests the operator to download an application program.  
If PCMCIA module is installed, the CPU will download the application from the PCMCIA module and execute it. |

Table 5-1—Off-line Tests
If during diagnostics, a particular test fails, testing stops and a message identifying the cause of the failure will be displayed. Also, the FAILED LED on the CPU module will periodically repeat bursts of flashes; the number of flashes in each burst indicates the test that failed as shown in Table 5-2.

<table>
<thead>
<tr>
<th>FLAShES IN BURST</th>
<th>ERROR DETECTED</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Start Up test failed</td>
</tr>
<tr>
<td>2</td>
<td>Control Status Register test failed</td>
</tr>
<tr>
<td>3</td>
<td>DUART test Failed</td>
</tr>
<tr>
<td>4</td>
<td>Local RAM test failed</td>
</tr>
<tr>
<td>5</td>
<td>Local RAM Misaligned test failed</td>
</tr>
<tr>
<td>6</td>
<td>Application RAM test Failed</td>
</tr>
<tr>
<td>7</td>
<td>Application RAM Misaligned test failed</td>
</tr>
<tr>
<td>8</td>
<td>Clock Interrupt test failed</td>
</tr>
<tr>
<td>9</td>
<td>Local Bus Timeout test failed</td>
</tr>
<tr>
<td>10</td>
<td>VME Bus Timeout test failed</td>
</tr>
<tr>
<td>11</td>
<td>PROM Write test failed</td>
</tr>
<tr>
<td>12</td>
<td>EEPROM test failed</td>
</tr>
<tr>
<td>13</td>
<td>Floating Point Math Co-processor test failed</td>
</tr>
</tbody>
</table>

Table 5-2—Flash Codes

68040 CPU On-Line Diagnostics
As soon as the application program starts running, the system will use a small portion of run time to continuously run the following on-line diagnostic tests.

<table>
<thead>
<tr>
<th>TEST</th>
<th>EXPLANATION OF TEST</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Local Memory Test</td>
<td>This test gets a location from memory, saves the data from that location, then writes several different values to that location. It reads each value back, and checks it to be sure it is correct. It then restores the saved original data back to the RAM and repeats the process at another location.</td>
</tr>
<tr>
<td>2. Application Memory Test</td>
<td>RAM only: If the memory is RAM, this test gets a location from memory, saves the data from that location, then writes several different values to that location. It reads each value back, and checks it to be sure it is correct. It then restores the saved original data back to the RAM and repeats the process at another location. UVPRoM, RAM and Flash: The test then calculates the sumcheck value and compares it to the sumcheck value previously calculated offline and stored in memory.</td>
</tr>
<tr>
<td>3. FPU (Floating Point Unit) Test</td>
<td>This test checks the register locations on the co-processor, does some math calculations with known answers, and checks to be sure the answers are returned correct.</td>
</tr>
<tr>
<td>4. Task Overview</td>
<td>This test checks the last eight locations in the task that has just completed to make sure that the values that were set up when the task was created have not changed. If they have, it indicates that the task has overflowed its memory, and destroyed memory in another task.</td>
</tr>
</tbody>
</table>

Table 5-3—On-Line Tests
A failure of any one of the on-line tests results in the I/O lock being asserted and display of a message as shown in Table 5-4. The message will be displayed on the Service Panel at the time the error occurs, and it also will go into the Fault Mode Buffer so that it can be displayed in the Fault Mode.

<table>
<thead>
<tr>
<th>TEST</th>
<th>MESSAGE ON FAILURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Local RAM</td>
<td>Local RAM Failed</td>
</tr>
<tr>
<td>Application RAM</td>
<td>Application RAM Failed</td>
</tr>
<tr>
<td>FPU (Co-processor)</td>
<td>FPU Co-processor Failed</td>
</tr>
<tr>
<td>During execution, an operating system task ran out of memory, or its memory was corrupted by a different task</td>
<td>Task overrun</td>
</tr>
</tbody>
</table>

Table 5-4—Test Failure Messages

**68040 CPU Operation Errors**

Certain other errors can occur during system operation. These errors and their associated messages are listed in Tables 5-5 and 5-6.

<table>
<thead>
<tr>
<th>MESSAGE</th>
<th>MEANING</th>
</tr>
</thead>
<tbody>
<tr>
<td>Checksum Error</td>
<td>Local RAM Failed</td>
</tr>
<tr>
<td>System Error (#)</td>
<td>Application RAM Failed (ref. Table 5-6)</td>
</tr>
<tr>
<td>EEPROM Fault</td>
<td>FPU Co-processor Failed</td>
</tr>
<tr>
<td>Math Exception</td>
<td>The FPU (Co-processor) has received an illegal instruction</td>
</tr>
<tr>
<td>Rate Group Slip (#)</td>
<td>Rate group # (number) is scheduled to run and it did not complete its previous scheduled run.</td>
</tr>
<tr>
<td>EEPROM Initialization Fault</td>
<td>The CPU attempted to program the EEPROMs during system initialization and failed, or the EEPROM was detected bad (EEPROM FAULT). The system is not permitted to run because the EEPROM data is not current.</td>
</tr>
<tr>
<td>Exception Error Vector #</td>
<td>An error was detected by the processor. The vector number indicates which exception the 68040 processor took. For an explanation of exceptions, refer to page 8-5 of Motorola Manual M 68040 UM/AD, MC68040 Enhanced 32-bit Microprocessor Users Manual.</td>
</tr>
</tbody>
</table>

Table 5-5—Operation Errors
<table>
<thead>
<tr>
<th>NUMBER OPER.</th>
<th>SYS. FILE</th>
<th>MEANING</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>CREATE</td>
<td>Cannot create task with priority less than one.</td>
</tr>
<tr>
<td>2</td>
<td>CREATE</td>
<td>Stack size requested is smaller than the minimum size.</td>
</tr>
<tr>
<td>3</td>
<td>NEWPID</td>
<td>The priority is greater than the maximum allowed.</td>
</tr>
<tr>
<td>4</td>
<td>NEWPID</td>
<td>The rate group Proctab entry is not free.</td>
</tr>
<tr>
<td>5</td>
<td>NEWPID</td>
<td>All the Proctab entries are full.</td>
</tr>
<tr>
<td>6</td>
<td>GETMEM</td>
<td>Tried to get a (zero-byte) block of memory.</td>
</tr>
<tr>
<td>7</td>
<td>GETMEM</td>
<td>No memory available.</td>
</tr>
<tr>
<td>8</td>
<td>GETMEM</td>
<td>Not enough memory available for block size requested.</td>
</tr>
<tr>
<td>9</td>
<td>FREEMEM</td>
<td>Returned a (zero-byte) block of memory.</td>
</tr>
<tr>
<td>10</td>
<td>FREEMEM</td>
<td>Returned a block of memory outside of heap boundaries.</td>
</tr>
<tr>
<td>11</td>
<td>FREEMEM</td>
<td>Unable to return the block of memory.</td>
</tr>
<tr>
<td>12</td>
<td>NEWSEM</td>
<td>No semaphores available.</td>
</tr>
<tr>
<td>13</td>
<td>SUSPEND</td>
<td>Cannot suspend a task that is not current or ready.</td>
</tr>
<tr>
<td>14</td>
<td>SCOUNT</td>
<td>The semaphore number is invalid.</td>
</tr>
<tr>
<td>15</td>
<td>SCOUNT</td>
<td>The semaphore number passed in is undefined.</td>
</tr>
<tr>
<td>16</td>
<td>SCREATE</td>
<td>The initial count is smaller than zero.</td>
</tr>
<tr>
<td>17</td>
<td>SIGNAL</td>
<td>The semaphore number is invalid.</td>
</tr>
<tr>
<td>18</td>
<td>SIGNAL</td>
<td>The semaphore number passed in is undefined.</td>
</tr>
<tr>
<td>19</td>
<td>SIGNALN</td>
<td>The semaphore number is invalid.</td>
</tr>
<tr>
<td>20</td>
<td>SIGNALN</td>
<td>The semaphore number passed in is undefined.</td>
</tr>
<tr>
<td>21</td>
<td>SIGNALN</td>
<td>Must signal semaphore one or more times.</td>
</tr>
<tr>
<td>22</td>
<td>SRESET</td>
<td>The semaphore number is invalid.</td>
</tr>
<tr>
<td>23</td>
<td>SRESET</td>
<td>The semaphore number passed in is undefined.</td>
</tr>
<tr>
<td>24</td>
<td>RESET</td>
<td>Must set semaphore to zero or larger.</td>
</tr>
<tr>
<td>25</td>
<td>WAIT</td>
<td>The semaphore number is invalid.</td>
</tr>
<tr>
<td>26</td>
<td>WAIT</td>
<td>The semaphore number passed in is undefined.</td>
</tr>
</tbody>
</table>

Table 5-6—Numbered System Errors

When the system detects an error when starting or running an application, the CPU will flash the FAILED LED on the CPU module with two bursts of flashes separated by a medium longer pause. The CPU will re-start flashing the fault codes after a long pause. The number of flashes will match the display message or it can be determined by counting the two groups of short flashes between the medium pause. The number of flashes in each burst indicates the detected failure as shown in Table 5-7.
<table>
<thead>
<tr>
<th>FLASHERS IN BURST</th>
<th>ERROR DETECTED</th>
</tr>
</thead>
<tbody>
<tr>
<td>5,4</td>
<td>The Applications do not match, CPU_C different.</td>
</tr>
<tr>
<td>5,1</td>
<td>The Applications do not match, CPU_B different.</td>
</tr>
<tr>
<td>5,2</td>
<td>The Applications do not match, CPU_A different.</td>
</tr>
<tr>
<td>5,3</td>
<td>The Applications do not match, ALL different.</td>
</tr>
<tr>
<td>5,7</td>
<td>The Ladder Logic Applications do not match.</td>
</tr>
<tr>
<td>5,8</td>
<td>The EE (tunable) values do not match, CPU_A different.</td>
</tr>
<tr>
<td>5,9</td>
<td>The EE (tunable) values do not match, CPU_B different.</td>
</tr>
<tr>
<td>5,10</td>
<td>The EE (tunable) values do not match, CPU_C different.</td>
</tr>
<tr>
<td>5,11</td>
<td>The EE (tunable) values do not match, all CPUs different.</td>
</tr>
<tr>
<td>5,14</td>
<td>Pickup CPU failed, re-sync process</td>
</tr>
<tr>
<td>5,15</td>
<td>Pickup CPU failed, Application does not match running CPUs</td>
</tr>
<tr>
<td>5,16</td>
<td>Pickup CPU failed, EE (tunable) values do not match</td>
</tr>
<tr>
<td>5,17</td>
<td>Pickup CPU failed, EE (tunable) values do not match</td>
</tr>
<tr>
<td>5,19</td>
<td>Pickup CPU failed, Ladder Logic Applications do not match</td>
</tr>
<tr>
<td>5,20</td>
<td>Pickup CPU failed attempt to re-sync with running CPUs</td>
</tr>
<tr>
<td>5,21</td>
<td>Pickup CPU failed attempt to re-sync with running CPUs</td>
</tr>
<tr>
<td>5,22</td>
<td>Pickup CPU failed attempt to re-sync with running CPUs</td>
</tr>
<tr>
<td>5,23</td>
<td>Pickup CPU failed attempt to re-sync with running CPUs</td>
</tr>
<tr>
<td>5,24</td>
<td>Pickup CPU failed attempt to re-sync with running CPUs</td>
</tr>
<tr>
<td>5,25</td>
<td>Pickup CPU failed attempt to re-sync with running CPUs</td>
</tr>
<tr>
<td>6,4</td>
<td>Dual-port RAM error detected (Local Right)</td>
</tr>
<tr>
<td>6,5</td>
<td>Dual-port RAM error detected (Local Left)</td>
</tr>
<tr>
<td>6,7</td>
<td>Dual-port RAM error detected (Remote Right)</td>
</tr>
<tr>
<td>6,8</td>
<td>Dual-port RAM error detected (Remote Left)</td>
</tr>
<tr>
<td>6,9</td>
<td>Dual-port RAM error detected (Unknown)</td>
</tr>
<tr>
<td>6,14</td>
<td>Vote busted</td>
</tr>
<tr>
<td>6,10</td>
<td>Kill CPU called on CPU_A</td>
</tr>
<tr>
<td>6,11</td>
<td>Kill CPU called on CPU_B</td>
</tr>
<tr>
<td>6,12</td>
<td>Kill CPU called on CPU_C</td>
</tr>
<tr>
<td>6,13</td>
<td>Kill CPU called on all CPUs</td>
</tr>
<tr>
<td>7,1</td>
<td>Ladder Logic error, flash program failed</td>
</tr>
<tr>
<td>7,2</td>
<td>Ladder Logic error, flash program failed</td>
</tr>
<tr>
<td>7,4</td>
<td>Ladder Logic error, flash program failed</td>
</tr>
<tr>
<td>7,5</td>
<td>Ladder Logic error, flash initialization failed</td>
</tr>
<tr>
<td>7,6</td>
<td>Ladder Logic error, flash erase failed</td>
</tr>
<tr>
<td>7,8</td>
<td>Ladder Logic error, flash erase failed</td>
</tr>
<tr>
<td>7,9</td>
<td>Ladder Logic error, bad flash</td>
</tr>
<tr>
<td>7,10</td>
<td>Ladder Logic error, bad flash</td>
</tr>
<tr>
<td>7,11</td>
<td>Ladder Logic error, bad flash</td>
</tr>
<tr>
<td>7,12</td>
<td>Ladder Logic error,</td>
</tr>
<tr>
<td>9,1</td>
<td>Bus error</td>
</tr>
<tr>
<td>9,2</td>
<td>Fault detected – Checksum,RG Slip, TaskOver, SystemError, Exception, MathException,</td>
</tr>
<tr>
<td>9,3</td>
<td>bus error from Dualport broadcast address</td>
</tr>
<tr>
<td>9,4</td>
<td>LL CPU required (needs to have the 2nd bank of FLASH installed</td>
</tr>
<tr>
<td>9,6</td>
<td>memory fault stack overflow</td>
</tr>
<tr>
<td>10,1</td>
<td>insert failed, requested key is greater than NPROC</td>
</tr>
<tr>
<td>10,2</td>
<td>insert failed, task is already on a queue</td>
</tr>
<tr>
<td>10,3</td>
<td>insertdf failed, task is already on a queue</td>
</tr>
<tr>
<td>10,4</td>
<td>ready failed, task is already READY or CURRENT</td>
</tr>
<tr>
<td>10,5</td>
<td>reinsert failed, requested key is greater than NPROC</td>
</tr>
<tr>
<td>10,6</td>
<td>reinsert failed, task is already on a queue</td>
</tr>
<tr>
<td>88,12</td>
<td>PCMCIA transfer failed</td>
</tr>
</tbody>
</table>

Table 5-7—System Alarms
CPU_040 Alarms

The possible system alarms are listed in Table 5-8. The numbered system alarms are listed in Table 5-9.

The ALARMS in Tables 5-8 and 5-9 do not automatically display; they are stored by the system and to see them, you must use the OPSYS_FAULTS Mode of the Service Panel.

<table>
<thead>
<tr>
<th>MESSAGE</th>
<th>MEANING</th>
</tr>
</thead>
<tbody>
<tr>
<td>SIO n Configuration Fails port x</td>
<td>A configuration error occurred on Port n of SIO x module. n (1-...) = SIO number x (1-4) = port number</td>
</tr>
<tr>
<td>SIO n Missing</td>
<td>SIO n module is not installed. n (1-...) = SIO number</td>
</tr>
<tr>
<td>SIO n Self Test Failed</td>
<td>SIO n module failed its self test. n (1-...) = SIO number</td>
</tr>
<tr>
<td>SIO n Initialization Failed</td>
<td>SIO n module failed to initialize. n (1-...) = SIO number</td>
</tr>
<tr>
<td>System Alarm # n</td>
<td>A numbered system alarm has occurred. The number of the alarm is n (see Table 20-8, Numbered System Alarms).</td>
</tr>
<tr>
<td>Divide by Zero</td>
<td>A divide by zero operation was performed.</td>
</tr>
<tr>
<td>Real to Int Conversion Overflow</td>
<td>An Overflow has occurred during a Real-to-integer conversion operation.</td>
</tr>
</tbody>
</table>

Table 5-8—System Alarms

<table>
<thead>
<tr>
<th>NUMBER</th>
<th>OPER SYS. FILE</th>
<th>MEANING</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>CLOSE</td>
<td>The device number is invalid.</td>
</tr>
<tr>
<td>2</td>
<td>CONTROL</td>
<td>The device number is invalid.</td>
</tr>
<tr>
<td>3</td>
<td>GETC</td>
<td>The device number is invalid.</td>
</tr>
<tr>
<td>4</td>
<td>INIT</td>
<td>The device number is invalid.</td>
</tr>
<tr>
<td>5</td>
<td>OPEN</td>
<td>The device number is invalid.</td>
</tr>
<tr>
<td>6</td>
<td>PUTC</td>
<td>The device number is invalid.</td>
</tr>
<tr>
<td>7</td>
<td>READ</td>
<td>The device number is invalid.</td>
</tr>
<tr>
<td>8</td>
<td>RECVTIM</td>
<td>The time passed inn was less than zero.</td>
</tr>
<tr>
<td>9</td>
<td>SEND</td>
<td>The PID number is invalid.</td>
</tr>
<tr>
<td>10</td>
<td>SEND</td>
<td>Cannot send message to undefined task.</td>
</tr>
<tr>
<td>11</td>
<td>SEND</td>
<td>Process has message pending.</td>
</tr>
<tr>
<td>12</td>
<td>SENDF</td>
<td>The PID number is invalid.</td>
</tr>
<tr>
<td>13</td>
<td>SENDF</td>
<td>Cannot send message to undefined task.</td>
</tr>
<tr>
<td>14</td>
<td>WRITE</td>
<td>The device number is invalid.</td>
</tr>
<tr>
<td>15</td>
<td>IOERR</td>
<td>The function is not implemented for this device.</td>
</tr>
<tr>
<td>16</td>
<td>TTYCNTL</td>
<td>Baud rate invalid.</td>
</tr>
<tr>
<td>17</td>
<td>TTYCNTL</td>
<td>Mode (line/char) invalid.</td>
</tr>
<tr>
<td>18</td>
<td>TTYCNTL</td>
<td>Function invalid.</td>
</tr>
<tr>
<td>19</td>
<td>TTYREAD</td>
<td>Attempt to read fewer than zero characters.</td>
</tr>
<tr>
<td>20</td>
<td>TTYWRITE</td>
<td>Attempt to write fewer than zero characters.</td>
</tr>
<tr>
<td>21</td>
<td>ICCCNTL</td>
<td>Function invalid.</td>
</tr>
<tr>
<td>22</td>
<td>ICCINIT</td>
<td>Too many SIO modules are defined.</td>
</tr>
</tbody>
</table>

Table 5-9—Numbered System Alarms
Chapter 6. Communication

6.1—Remote RTN Module

6.1.1—Module Description

The MicroNet Remote Real Time Network (RTN) module is designed to be located in an expansion rack. The module’s primary function is to gather data from local I/O modules and communicate this data to the main rack CPUs while providing redundant failover control of the rack in which it is located.

The Remote RTN module contains a MPC5200 processor, 128 Mbyte DDR RAM, 64 MB of flash memory, a Real Time clock, and various communication peripherals. These peripherals include (3) Real Time Network ports and (1) service port. This module includes an FPGA to provide VMEbus master/slave capability, health monitoring, and failover functions necessary for redundant systems.

This module was designed and rated for –40 to +85 °C operation in the industrial marketplace. Figure 6-2 is a block diagram of a Remote RTN module.
Remote RTN modules can support simplex, redundant, and TMR systems. Every RTN expansion chassis contains one Remote RTN module located in the first slot (CPU1) of the chassis. A redundant configuration using a Plus chassis may also have a Remote RTN module located in the CPU2 location (slot 8 or slot 14 depending on the chassis used).

For Remote RTN module installation and replacement instructions, see the instructions for installing the VME module in Chapter 14, and for replacement in Chapter 15. This module will NOT automatically re-initialize to a running state after reset. This module is can only be initialized by the main-chassis CPU when the application starts and upon any application request.

**NOTICE**

Live insertion and removal of this module is allowed in a MicroNet Plus chassis. This module should be reset immediately before removing it from the chassis. This notifies the module that it will be removed and provides a graceful failover to another healthy Remote RTN module if available.
Operation
For redundant systems, up to two Remote RTN modules may be installed into each MicroNet Plus 8/14 slot expansion chassis (only one RTN can be installed in the MicroNet 6/12 slot chassis). When initialized by the main chassis CPU, the Remote RTN modules will acquire either a SYSCON or STANDBY status. The Remote RTN module that becomes SYSCON will control the expansion chassis it is located in. It will synchronize with the STANDBY Remote RTN module and perform any redundancy functions as necessary. Input and output data from all I/O modules will be managed appropriately and made available to the GAP Application running in the main-chassis CPUs.

The Remote RTN module communicates with the I/O modules in the expansion chassis and also the CPU modules in the main chassis. When the power is applied, the Remote RTN module will perform diagnostic tests before beginning communications.

6.1.2—RTN Expansion Chassis Configurations

The MicroNet TMR5200 can expand from a single main rack to a maximum 4-rack system by using Remote RTN modules and copper or fiber optic Ethernet switches. A maximum of 3 MicroNet Plus expansion racks (14 slot or 8 slot versions) or MicroNet Simplex racks (6 or 12 slot versions) are supported. If desired, fiber optic Ethernet switches can be used to locate each chassis in a different location. It is required to use Woodward approved Ethernet hardware for robust operation.

Example 4-rack systems using copper and fiber Ethernet cables.
6.1.3—Module Configuration

**Network Configuration.** No network configuration is required. Only the RTN ports are active on this module. Ethernet port (ENET1) is disabled on the Remote RTN module by the Module Config switch (S2) and no IP address configuration is necessary.

**Hardware Configuration.** The Module Configuration Dip-Switch (S2) must be configured properly for RTN mode with the expansion chassis address set appropriately as X1-X7 for Plus systems or X1-X3 for TMR systems.

- **RTN Mode.** The Module Config Switch (S2) is factory configured for RTN mode, expansion rack X1 operation (address 0x001). It may need to be re-configured for expansion rack X1-X3 in TMR systems. **Note:** RTN mode will disable Ethernet port #1.

- **Network Type.** The Network Type setting is factory set OFF to automatically configure the RTN communication port IP addresses to the 172.20.x.x series.
It is recommended to verify proper switch settings before installing the module in the system and when troubleshooting RTN related issues.

The Network Type setting on all CPU and Remote RTN modules in the system must match for proper system operation.

The customer network attached to Ethernet #1 or #2 at the main chassis CPUs may already use the RTN port addresses of 172.20.x.x. In this case, the Network Type switch should be configured ON to use the alternate 10.250.x.x RTN port addresses.

If the Remote RTN module is incorrectly configured for CPU mode, Ethernet ports #1 and #2 are active and have been factory-set to fixed Ethernet IP addresses of:

- Ethernet #1 (ENET1) = 172.16.100.1, Subnet Mask = 255.255.0.0
- Ethernet #2 (ENET2) = 192.168.128.20, Subnet Mask = 255.255.255.0

### 6.1.4—Front Panel Indicators (LEDs)

The Real Time Network (RTN) module has the following front-panel LED's.

<table>
<thead>
<tr>
<th>LED</th>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>RUN</td>
<td>RUN</td>
<td>RUN / RESET (GREEN/RED)—Active RED when the user pushes the reset switch. Active GREEN upon release and after the CPU Operating system is loaded and running.</td>
</tr>
<tr>
<td>LINK</td>
<td>LINK</td>
<td>LINK ACTIVE (GREEN)—A valid Ethernet connection to another device exists.</td>
</tr>
<tr>
<td>TX/RX</td>
<td>TX/RX</td>
<td>TX/RX (YELLOW)—Active YELLOW when data is transmitted or received.</td>
</tr>
<tr>
<td>SYSCON</td>
<td>SYSCON</td>
<td>System Controller (GREEN)—Active when the Remote RTN module is the VMEbus System Controller.</td>
</tr>
<tr>
<td>STANDBY</td>
<td>STANDBY</td>
<td>Standby Ready (YELLOW)—Active when the STANDBY mode of this CPU or Remote RTN module is ready to release or take over the System Controller functions in a failover event.</td>
</tr>
<tr>
<td>LVCC</td>
<td>LVCC</td>
<td>Low VCC Power Fault (RED)—An RTN or VME power supply high or low tolerance fault has been detected. - Local CPU power faults could be 1.2 V, 1.5 V, 1.8 V, 2.5 V, or 3.3 V. - VME power faults could be VME_5V, VME_5VPC, or VME_24V.</td>
</tr>
<tr>
<td>IOLOCK</td>
<td>IOLOCK</td>
<td>IOLOCK (RED)—This LED indicates that an I/O LOCK condition exists either locally on the CPU itself and/or on the VMEbus. Note: IOLOCK is a condition driven by the SYSCON where all I/O modules are placed into a failsafe condition and outputs are driven to a known state. For an RTN expansion rack, IOLOCK is activated within 55ms of a detected fault condition.</td>
</tr>
<tr>
<td>FAULT</td>
<td>FAULT</td>
<td>CPU FAULT (RED)—Actively flashes CPU fault codes as necessary.</td>
</tr>
<tr>
<td>WATCHDOG</td>
<td>WATCHDOG</td>
<td>CPU Watchdog / Health Faults (RED)—The processor watchdog or Health monitor has tripped and the CPU or Remote RTN module is prevented from running. The CPU Watchdog includes a 1 ms failover event and an 18 ms timeout event. Health faults include GAP fault, Watchdog events, and local SYSCLK and MFT hardware faults.</td>
</tr>
</tbody>
</table>
6.1.5—Module Reset

Front Panel Reset Switch. The Remote RTN module incorporates a pushbutton reset switch on the front panel to reset the module. This module will NOT automatically re-initialize to a running state after reset. The main-chassis CPU application can re-init this module upon request.

RTN1 and RTN2 Remote Reset. Each Remote RTN module will respond to a +24 V remote reset signal. The chassis provides a terminal-block with inputs RST1+, RST1-, RST2+, and RST2- for wiring the remote reset signals to each RTN. Each reset signal is routed to an opto-isolated input on the appropriate RTN that requires a +24 V signal to cause a reset.

Reset Notes:
- Resetting a Remote RTN module creates a HealthFault that immediately sets the WDOG light RED.
- Any Expansion chassis running with one healthy RTN. Reset detection will also drive IOLOCK and IORESET to place the expansion rack and all output signals into a known failsafe condition.
- Any Expansion chassis running with two healthy RTNs. Reset detection on the SYSCON (System Controller) causes an immediate "Failover" to the other STANDBY RTN who then becomes the new System Controller for this chassis. Reset detection on the STANDBY unit causes a HealthFault that removes it from STANDBY mode.
- The front-panel RUN/RESET led will be RED while reset is held and will turn GREEN for a few seconds after releasing reset. After turning OFF, it will again turn GREEN when the operating system starts to boot.

6.1.6—RTN Ports

Three Real Time Network ports (RJ45) provide communications between the expansion chassis Remote RTN module and the main-chassis CPU A, B, and C modules. Through these ports, expansion chassis I/O data is made available to the GAP Application running in the main-chassis CPUs.

REMOTE RTN CABLES (COPPER)
- Double shielded, Cat 5 Ethernet cables (SSTP) are required for customer installations.
- Cable length between the Main rack and RTN switch is 3 m (10 ft) max.
- Cable length between the RTN switch and Expansion rack is 30 m (100 ft) max.
6.1.7—Ethernet Switch Hardware

For systems with more than a single RTN module, copper or fiber optic Ethernet switches are required to achieve communication and hardware redundancy. Specific Ethernet switches have been tested and approved to obtain expansion chassis real time performance and redundancy.

Due to the critical nature of communications with an RTN expansion rack, it is required to use Woodward approved copper and fiber Ethernet switches for robust system operation. At the time of this writing, the following hardware part numbers are approved.

- 1752-423, Hirschmann copper Ethernet switch (RS2-TX, 8 port)
- 1711-1069, Hirschmann Fiber Optic Switch (RS2-4TX/1FX)
- 1751-6077, Hirschmann Fiber Optic Switch (RS2-3TX/2FX)

6.1.8—Expansion Racks using Copper or Fiber cables

MicroNet TMR5200 multiple-rack systems are supported by locating expansion racks locally with the main chassis or in different remote locations using fiber optic cables and Ethernet switches. A maximum of 3 MicroNet Plus expansion racks (14 slot or 8 slot versions) or MicroNet Simplex expansion racks (6 or 12 slot versions) are supported in up to 3 different remote locations using fiber optic Ethernet switches. It is required to use Woodward approved hardware for robust operation.

Configuration Notes:
- A combination of approved copper and fiber optic Ethernet switches are allowed.
- A maximum of 4 switches and 2 km of fiber cable shall be allowed in any communication path.
- RTN cables from the main CPU rack to the local RTN switch hardware shall be 3 m (10') max.

- **Copper Expansion**: Using copper Ethernet cables and switches, each expansion rack may be located up to 30 meters away from the main CPU chassis.

- **Fiber Optic Expansion**: Using fiber optic cables and switches, each expansion rack may be located up to 2 km away from the main CPU chassis.

**Fiber Optic Cable Specification**
- 62.5 / 125 μm multi-mode, duplex fiber
- Standard SC Type connectors
- Wavelength : 850 nm, 1300 nm
- Attenuation @ 1300 nm : < 1.5 db/km
- Bandwidth @ 1300 nm : > 500 MHz – km
- Flammability type OFNR (riser, UL-1666)
- Minimum bend radius of 7 cm
- Refer to Woodward reference dwg 9097-2077
6.1.9—RS-232 Service Port

An isolated RS-232 service port is located on the front of the Remote RTN module. This port is for VxWorks operating system use only and cannot be configured for application software use. The communication settings are fixed at 38.4 Kbaud, 8 data bits, no parity, 1 stop-bit, and no flow control.

For debug use, a null-modem cable and 5450–1065 Serial Adapter cable (PS2M to DB9F) is required to attach this port to a PC. **This port is to be used by trained Field Service personnel only!**

Shielded cable is required when connecting to the Remote RTN module’s serial port. Using shielded cable will help ensure the robustness of the serial communications.

**Figure 6-5—RTN Service Port (mini-DIN6F)**

6.1.10—Troubleshooting / Flash Codes

The MicroNet Remote RTN module runs off-line and on-line diagnostics that display troubleshooting messages through the debug Service Port and AppManager. Off-line diagnostics run automatically on power-up and when the Reset switch is asserted. On-line diagnostics run during normal Control System operation when the GAP application is active. More information on diagnostics tests, subsequent LED flash codes, and serial port messages is contained in the VxWorks manual.

A table of the RTN fault LED flash codes is shown below:

<table>
<thead>
<tr>
<th>Failure</th>
<th>Flash Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>RAM Test Failure</td>
<td>1, 4</td>
</tr>
<tr>
<td>Real Time Clock Test Failure</td>
<td>2, 2</td>
</tr>
<tr>
<td>Floating Point Unit Test Failure</td>
<td>2, 3</td>
</tr>
<tr>
<td>Flash Test Failure</td>
<td>2, 4</td>
</tr>
<tr>
<td>HD1 Flash Test Failure</td>
<td>2, 5</td>
</tr>
<tr>
<td>I2C Bus Test Failure</td>
<td>2, 6</td>
</tr>
<tr>
<td>Module Installed in wrong slot</td>
<td>2, 7</td>
</tr>
<tr>
<td>Main Chassis CPU switch must be set to 0</td>
<td>3, 5, 6</td>
</tr>
<tr>
<td>Remote RTN Rate Group 5 Slip</td>
<td>3, 7</td>
</tr>
<tr>
<td>Remote RTN Rate Group 10 Slip</td>
<td>3, 8</td>
</tr>
<tr>
<td>Remote RTN Rate Group 20 Slip</td>
<td>3, 9</td>
</tr>
<tr>
<td>Remote RTN Rate Group 40 Slip</td>
<td>3, 10</td>
</tr>
<tr>
<td>Remote RTN Rate Group 80 Slip</td>
<td>3, 11</td>
</tr>
<tr>
<td>Remote RTN Rate Group 160 Slip</td>
<td>3, 12</td>
</tr>
<tr>
<td>Remote RTN Chassis Switch Invalid</td>
<td>4, 5</td>
</tr>
<tr>
<td>Backup Remote RTN Chassis Switch different from Primary Remote RTN</td>
<td>4, 6</td>
</tr>
<tr>
<td>This module does not support the CAN port(s)</td>
<td>4, 7</td>
</tr>
<tr>
<td>This module needs a “footprint” update</td>
<td>4, 9</td>
</tr>
</tbody>
</table>
6.2—Main Transceiver (XCVR) Module

6.2.1—Module Description

The Main XCVR module is only used with CPU 68040 systems. It allows extension of the VME back plane to the expansion I/O Chassis. The Main XCVR module sends and receives control, data, and address information to and from its associated Remote Transceiver module (see next section of this chapter) in an I/O chassis through a copper transceiver cable. The Main XCVR module is used in the Main Chassis. See Figure 6-6 for a block diagram of the module.

Figure 6-6—Main XCVR Module Block Diagram
6.2.2—Module Specification

Parallel Interface: High-speed, differential line drivers operating at VME transmission rate
Cable Interface: 100 pin metal shell Micro-D connector (2 per module)

Figure 6-7—Main XCVR Module

6.2.3—Installation

- The Main XCVR module can be installed in any slot in the Main Chassis.
- No jumpers are used to configure this module.
- This Transceiver module has no switches or LEDs.

6.2.4—Troubleshooting

1. If the Main XCVR module is not functioning or not functioning properly, verify cable connections.
2. If the module is still not functioning properly after verifying the cable connections, replace the cables connecting to module.
3. If the module is still not functioning properly after replacing cables, replace the module.
6.3—Remote Transceiver (XCVR) Module

6.3.1—Module Description

The Remote XCVR module is only used with CPU 68040 systems. The Remote XCVR module receives and sends control, data, and address information via cable to and from its associated Main XCVR module. This module must be used in each Remote I/O Chassis that is connected to the Main Chassis via copper cables.

The Remote XCVR module connects to the VME bus of the chassis. The bus receiver/driver of the Remote Transceiver module interfaces with the VME bus, exchanging control, data, and address information. The chassis decoder determines if this chassis is to be accessed, and if so, it activates the receiver/driver of this chassis' Remote Transceiver module to receive or send information. Figure 6-8 is a block diagram of the Remote Transceiver module.

![Figure 6-8—Remote XCVR Module Block Diagram](image-url)

The bus-arbitration logic determines priority of bus-access operations and controls the receiver/driver accordingly.
Table 6-1 shows the jumpers on the Remote XCVR module used to configure the chassis ID.

![Remote XCVR Module Jumpers Diagram](image)

<table>
<thead>
<tr>
<th>CHASSIS</th>
<th>JPR1</th>
<th>JPR2</th>
<th>JPR3</th>
<th>JPR4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>5</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>6</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>7</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>8</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>9</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>10</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>11</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>12</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>13</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>14</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>15</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

Table 6-1—Remote XCVR Module Jumpers (JPR1–4)
6.3.2—Module Specification

Parallel Interface: High-speed, differential line drivers operating at VME transmission rate
Cable Interface: 100 pin metal shell Micro-D connector (2 per module)

6.3.3—Installation

- The Remote XCVR module has no switches or LEDs.
- All expansion chassis except for the last one in the chain should use the Remote XCVR module without termination resistors. This module must be installed in Slot 1.
- The last expansion chassis in the chain should use the Remote XCVR module with termination resistors. This module must be installed in Slot 1.
6.3.4—Troubleshooting

1. If the Remote XCVR module is not functioning or not functioning properly, verify the cable connections.
2. If the module is still not functioning properly after verifying the cable connections, replace the cables connecting to module.
3. If the module is still not functioning properly after replacing cables, replace the module.

6.4—Transceiver Accessories

6.4.1—Description

These accessories are only used with CPU 68040 systems. Each expansion chassis except the last one should have the T-Module mounted next to it. The 3-foot (0.9 m) cables should connect these expansion chassis to the T-Modules. Connections from the Main Chassis, the last Expansion Chassis, and connections between the T-Modules should be made with 10-foot (3 m) cables.
6.4.2—Module Specification

Parallel Interface: High-speed, differential line drivers operating at VME transmission rate
Cable Interface: 100 pin metal shell Micro-D connector (2 per module)

6.4.3—Transceiver Accessories Installation (Outline)

The Main and Remote Transceiver modules must be connected exactly as shown in the following diagrams (Figures 6-16 and 6-17). The following notes apply on these figures.

Note 1: The Main Transceiver module can be installed in any slot in the Main Chassis.

Note 2: All expansion chassis except for the last one in the chain should use the module without termination resistors. This module must be installed in Slot 1.

Note 3: The last expansion chassis in the chain should use the module with termination resistors. This module must be installed in Slot 1.

Note 4: All expansion chassis except the last one should have the T-Module mounted next to it. The three-foot (0.9 m) cables should connect these expansion chassis to the T-Modules. Connections from the Main Chassis, the last Expansion Chassis, and connections between the T-Modules should be made with ten-foot (3 m) cables.
6.5—Ethernet Module

6.5.1—Module Description

This Ethernet module is only used with CPU 68040 systems. The MicroNet™ Ethernet module is a 32 bit VME bus module which has been integrated into the MicroNet product family. The module is designed to fully support auto-switching 10/100 Base-TX Ethernet connections, but has been configured to operate at only 10 Mbps for use with legacy products.

The Ethernet module has a VME adapter board attached to allow its use in a MicroNet chassis. However, this module is not “hot swappable” due to signal integrity issues on the VME backplane. When inserted into a powered chassis, the module will interrupt VME bus backplane communications and cause other Woodward modules and expansion racks to shut down.

On power-up, the Ethernet board runs a series of self-tests that check the board hardware. After successful completion of the tests, the red FAIL LED will turn OFF. The self-tests may last 10–20 seconds.
Due to addressing conflicts with the Pentium CPU and TMR5200, this module can be used only with the Motorola 68040 CPU family.

Figure 6-15—Ethernet Module

**LED Annunciations**
The following LEDs annunciate board failure as well as different functions related to Ethernet communications. When continuous communications are present, the RX and TX LEDs will be ON continuously.

<table>
<thead>
<tr>
<th>LEDs</th>
<th>Name</th>
<th>LED Color</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Link</td>
<td>LINK</td>
<td>GREEN</td>
<td>Indicates the Ethernet connection is good.</td>
</tr>
<tr>
<td>Col</td>
<td>COL</td>
<td>RED</td>
<td>Indicates a collision on the Ethernet.</td>
</tr>
<tr>
<td>100</td>
<td>100</td>
<td>GREEN</td>
<td>Indicates the Ethernet connection is functioning at 100 Mbps.</td>
</tr>
<tr>
<td>Rx</td>
<td>RX</td>
<td>GREEN</td>
<td>Indicates data is being received.</td>
</tr>
<tr>
<td>Tx</td>
<td>TX</td>
<td>GREEN</td>
<td>Indicates data is being received.</td>
</tr>
<tr>
<td>Fail</td>
<td>FAIL</td>
<td>RED</td>
<td>Indicates a module reset or self test failure.</td>
</tr>
</tbody>
</table>
10BaseT Ethernet

A 10BaseT RJ45 Ethernet connector is available for system use. This connection is used for control configuration, data gathering, and networking of multiple controls. In addition, this port may be relied upon for interfacing TCP/IP Distributed I/O devices into the control system.

To ensure signal integrity and robust operation of Ethernet devices, an Ethernet Interface FTM (Field Termination Module) is required when using this port. The FTM’s primary function is to implement EMI shielding and cable shield termination of the Ethernet cable. Along with the Ethernet Interface FTM, double-shielded Ethernet cables (SSTP) are required. See the Ethernet Interface FTM section below for more details.

6.5.2—Module Specifications

Ethernet Features
- Industry Standard 6U, VME-32 format
- Network interface conforming to the IEEE 802.3 standard
- Configured for 10BaseT communication support
- Module failure/reset, Link LED, Transmit, Receive, Collision, and 10/100 Mbps LEDs
- Supports Woodward communications such as Modbus, GAP Download, and Tunable Capture/Download.

Electrical Specifications
  Voltage: 5.0 Vdc, 5% tolerance
  Power: 15.0 W max (13.5 W typical)
  Processor: PowerPC 750, 400 MHz
  Memory: 64 MB DRAM, 2 MB boot flash, 32 MB user flash
  Bus Interface: 32 bit VME bus
  On board I/O: RJ45 10 Mbps Ethernet port
  Hardware Configuration: VME address #1 or #2 configuration for using 2 modules in a system

6.5.3—Installation

VME Address Configuration
The Ethernet module can be configured for an alternate VME address to support the use of two modules in a MicroNet system. For dual module operation, both the Woodward GAP and the module DIP switch must be configured properly.

**IMPORTANT**
The DIP switch (S2) is located directly behind the RJ45 Ethernet connector.
### RJ45 Ethernet Pinout

<table>
<thead>
<tr>
<th>Connector</th>
<th>Signal Mnemonic</th>
</tr>
</thead>
<tbody>
<tr>
<td>RJ45 female</td>
<td>Shielded RJ45</td>
</tr>
<tr>
<td></td>
<td>female receptacle</td>
</tr>
<tr>
<td>1</td>
<td>TX+</td>
</tr>
<tr>
<td>2</td>
<td>TX-</td>
</tr>
<tr>
<td>3</td>
<td>RX+</td>
</tr>
<tr>
<td>4</td>
<td>---</td>
</tr>
<tr>
<td>5</td>
<td>---</td>
</tr>
<tr>
<td>6</td>
<td>RX-</td>
</tr>
<tr>
<td>7</td>
<td>---</td>
</tr>
<tr>
<td>8</td>
<td>---</td>
</tr>
<tr>
<td>Shield</td>
<td>Chassis GND</td>
</tr>
</tbody>
</table>

### 6.5.4—FTM Reference

**Ethernet Interface FTM**

To ensure signal integrity and robust operation of Ethernet devices, an Ethernet Interface FTM (Field Termination Module) is required when interfacing Ethernet devices to the CPU. The FTM's primary function is to implement EMI shielding and cable shield termination of the Ethernet cable. Along with this FTM, double shielded Ethernet cables (SSTP) are required.

Please see Chapter 12 for the Ethernet Interface FTM specifications and wiring information.

**Ethernet System Requirements**

- This module is for use with Motorola x040/060 CPUs and cannot be used with the Pentium CPU.
- System wiring requires using the Ethernet Interface FTM.
- System wiring requires using shielded RJ45 Ethernet cables (for part numbers, see Appendix A):
  - double shielded Cat-5 Ethernet cable (SSTP), 1.5 ft (457 mm)
  - double shielded Cat-5 Ethernet cable (SSTP), 3 ft (914 mm)
  - double shielded Cat-5 Ethernet cable (SSTP), 7 ft (2.1 m)
  - double shielded Cat-5 Ethernet cable (SSTP), 10 ft (3.0 m)
  - double shielded Cat-5 Ethernet cable (SSTP), 14 ft (4.3 m)
  - double shielded Cat-5 Ethernet cable (SSTP), 25 ft (7.6 m)
  - double shielded Cat-5 Ethernet cable (SSTP), 50 ft (15 m)
  - double shielded Cat-5 Ethernet cable (SSTP), 100 ft (30 m)

### 6.5.5—Troubleshooting

1. If the Ethernet module is not functioning or not functioning properly, verify the cable connections.
2. If the module is still not functioning properly after verifying the cable connections, replace the cables connecting to module.
3. If the module is still not functioning properly after replacing cables, replace the module.
6.6—SIO Module

6.6.1—Module Description

The SIO (Serial In/Out) Module interfaces four serial communication ports to the VME bus.

Figure 6-17 is a block diagram of the SIO module. The module manages four serial ports. Port A(J1) and port B(J2) are RS-232 ports. Port C(J3) and Port D(J4) are for RS-232, RS-422, or RS-485 communication protocols. Ports C and D must be at the same baud rate when using 38.4 Kbaud or 57.6 Kbaud.

The processor on this module is a 68030. It controls the transfer of data between the ports and the VME bus.

This module can have as much as 4 KB of Dual-Port RAM and 64 KB of PROM. The local memory supports the 68030 processor on this module.

The SIO module has one LED (FAULT) and no switches.
6.6.2—Module Specification

Ports 1 and 2: RS-232 @ 110–38.4 Kbaud
Ports 3 and 4: RS-232, RS-422, and RS-485 (software selectable) @ 110–57.6 Kbaud
Software Support: Modbus RTU
                         Modbus ASCII
                         Woodward-specific service interface
6.6.3—Installation

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. Figure 6-18 is an example.

For RS-485, termination should be at each end of the cable. If termination can’t be located at the end of a cable, put it as close as possible to the ends. Figure 6-22 is an example.

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 about 100 to 120 Ω. The purpose is to maintain a voltage level between the two differential lines so that the receiver will be in a stable condition. The differential voltage can range between 0.2 and 6 V; the maximum voltage between either receiver input and circuit ground must be less than 10 V. There is one termination resistor network for each port located on the SIO board. Connection to this resistor network is made through the 9-pin connectors on pins 6 and 9. See Figure 6-20 for termination and cable connection examples.
Grounding and Shielding

The RS-422 and RS-485 specifications state that a ground wire is needed if there is no other ground path between units. The preferred method to do this is to include a separate wire in the cable that connects the circuit grounds together. Connect the shield to earth ground at one point only. The alternate way is to connect all circuit grounds to the shield, and then connect the shield to earth ground at one point only. If the latter method is used, and there are non-isolated nodes on the party line, connect the shield to ground at a non-isolated node, not an isolated node. Figures 6-24 and 6-25 illustrate these cabling approaches.

Non-isolated nodes may not have a signal ground available. If a signal ground is not available, use the alternate wiring scheme in Figure 6-21 with the signal ground connection removed on those nodes only.
6.6.4—Troubleshooting

1. If the SIO module is not functioning or not functioning properly, verify the cable connections.
2. If the module is still not functioning properly after verifying the cable connections, replace the cables connecting to module.
3. If the module is still not functioning properly after replacing cables, replace the module.
Chapter 7.
Discrete I/O Modules

7.1—Introduction

There are five types of discrete I/O modules currently available with the MicroNet™ system. These include the 24/12 TMR Discrete Combo module (24 discrete inputs, 12 discrete outputs), 48/24 Discrete Combo module (48 discrete inputs, 24 discrete outputs), 48 Ch DI module, 32 Ch DO module, and the 64 Ch DO module.

7.2—24/12 TMR Discrete I/O Module

Each 24/12 TMR Discrete I/O module (TMR High Density Discrete module) contains circuitry for twenty-four (24) discrete inputs and twelve (12) TMR discrete outputs, and provides latent fault detection for each relay output. Each discrete input may be 24 V, or 125 Vdc. Each relay output provides the option of using a normally open contact, or a normally closed contact.

7.2.1—Physical Description

The modules slide into card guides in the control's chassis and plug into the motherboard. The modules are held in place by two screws, one at the top and one at the bottom of the front panel. Also at the top and bottom of the module are two handles which, when toggled (pushed outward), move the modules out just far enough for the boards to disengage the motherboard connectors.

Figure 7-1—24/12 TMR Discrete I/O Module
7.2.2—Specifications

**Discrete Inputs**
- Number of channels: 24
- Update time: 5 ms
- Input type: Optically isolated discrete input
- 24 V Input thresholds: 
  - < 8 Vdc = "OFF", at .7 mA
  - > 16 Vdc = "ON", at 1.2 mA
- 125 V Input thresholds: 
  - < 24 Vdc = "OFF", at .7 mA
  - > 55 Vdc = "ON", at 4 mA
- Input current: 3.5 mA @ 24 Vdc; 8 mA @ 125 Vdc
- External input voltage: 
  - 18-32 Vdc (LVD and UL) or
  - 100–150 Vdc (UL)
- Isolation voltage: 
  - 500 Vdc to earth ground,
  - 1000 Vdc to control common
- Time stamping: 1 ms resolution
- Isolated 24 Vdc contact supply: 400 mA maximum

**Discrete Outputs**
- Number of channels: 12
- Update time: 5 ms
- Relay type: Dust-tight, magnetic blow-out
- Coil rating: 80 mA @ 24 Vdc, suppressor located on circuit board
- Minimum load: 50 mA @ 125 Vdc
- Relay response time: 15 ms (operate and release)
- Relay life expectancy: 50,000 operations @ rated load
- Replaceability: Relays are socket mounted and retained by a hold down spring
Contact ratings:
- 5.0 A @ 240 Vac, 50/60 Hz (resistive) (meets UL ratings only)
- 3.0 A @ 240 Vac, 50/60 Hz (inductive) (meets UL ratings only)
- 10.0 A @ 120 Vac, 50/60 Hz (resistive) (meets UL ratings only)
- 6.0 A @ 120 Vac, 50/60 Hz (inductive) (meets UL ratings only)
- 600 watt @ 120 Vac, 50/60 Hz (lamp) (meets UL ratings only)
- 3.0 A @ 150 Vdc (resistive) (meets UL ratings only)
- 1.2 A @ 150 Vdc (inductive) (meets UL ratings only)
- 10.0 A @ 28 Vdc (resistive) (meets LVD and UL ratings)
- 3.0 A @ 28 Vdc (inductive) (meets LVD and UL ratings)

7.2.3—24/12 TMR Discrete I/O Module and Associated Components

In a TMR system, each 24/12 TMR Discrete I/O module is connected through two high density 62 conductor discrete cables to four FT Relay/Discrete Input modules. All of the I/O on 24/12 TMR Discrete I/O module is accessible on the relay modules. See Figure 7-3 for an example.

7.2.4—24/12 TMR Discrete I/O Module Operation

This module includes no potentiometers and requires no calibration. A 24/12 TMR Discrete I/O module may be replaced with another module of the same part number without any adjustment.
7.2.4.1—Field Wiring

Figure 7-4—Wiring Diagram for a FT Relay/Discrete Input Module
7.2.4.2—Discrete Inputs
The 24/12 TMR Discrete I/O Discrete module accepts 24 discrete inputs. Each of the control’s four FT Relay/Discrete Input modules accepts six contact inputs. Contact wetting voltage can be supplied by the control or from an external source. 24 Vdc contact wetting voltage is available on each relay module. Optionally, an external 18-32 Vdc power source or an external 100–150 Vdc power source can be used to source the voltage. Because all discrete inputs are fully isolated, a common reference point must be established between the inputs and the contact power source. If the 24 Vdc internal power source is used for contact wetting, jumpers are required between relay module terminals 33, 34, and 35. If an external power source is used for contact wetting, the external source’s common must be connected to the relay module’s discrete input commons (terminals 34 and 35).

The inputs have components which establish a voltage threshold and a current threshold, to prevent a closed indication due to the leakage current of most solid state relays. The discrete inputs also have time stamping on a change of state, with 1 millisecond resolution.

Figures 7-5 and 7-6 illustrate the different discrete input wiring configurations based on the input voltage.

Figure 7-5—Optional Internal 24 Vdc Contact Wetting Configuration
7.2.4.3—Configuration Notes

**IMPORTANT** If there is 125 Vdc on the FT Relay/Discrete Input module terminal blocks, there will be 125 Vdc on the relay module sub D connectors and on the cable when it is connected to the relay module. For this reason, any power should be removed from the relay module terminal blocks, if possible, before installing the 24/12 TMR Discrete I/O module or the relay module.

Refer to Figures 7-5 and 7-6 for contact input wiring.
- All contact inputs accept dry contacts.
- The internal 24 Vdc power source, an external 18-36 Vdc (UL and LVD) power source, or an external 100–150 Vdc (UL only) power source can be used for circuit wetting.
- If the 24 Vdc internal power source is used, jumpers are required between FT Relay/Discrete Input module terminals 33 and 34, and terminals 33 and 35.
- If an external power source is used for contact wetting, the external source’s common must be connected to the relay module’s discrete input commons (terminals 34 and 35). Power for sensors and contacts must be supplied by the control’s power supplies, or the external power supply must be Class II at 30 Vdc or less and outputs must be fused with appropriately sized fuses (a maximum current rating of 100÷V, where V is the supply’s rated voltage or 5 A, whichever is less).
- Verify that the correct discrete input terminals are used, for low or high voltage inputs.
7.2.4.4—Latent Fault Detection

It is important to detect latent faults in a fault tolerant system, because although a single fault may go undetected, if another fault occurs it could cause a shutdown.

Discrete outputs can be configured to use latent fault detection to identify relay failures without affecting a relay output's state. Six individual relays make up one relay output. When a relay output is closed, the contacts of all six relays are closed. Because of the series-parallel configuration of the relays, the failure of any two individual relays will not cause the output to open. The individual relays are periodically opened and reclosed in pairs to ensure that they are in the correct state and that they change state.

When a relay output is open, the contacts of all six relays are open. Because of the series-parallel configuration of the relays, the failure of any one relay will not cause the output to close. The individual relays are periodically closed and reopened one by one to ensure that they change state.

Readback circuitry allows the state of each relay contact to be detected. Any failures are annunciated, and further testing is disabled without affecting the state of the relay output contact or control operation.

Latent fault detection is not appropriate for all applications or circuits. The control's latent fault detection logic can only work with circuits using voltages between 18-32 Vdc, 100–150 Vdc, or 88-132 Vac. For latent fault detection to work, a small leakage current is passed through the circuit’s load. Depending on the size of the load, the leakage current may be enough to cause a load to be on or active when a relay contact is open. In this case, the individual relay's latent fault detection logic may be disabled, eliminating the leakage current.
With latent fault detection, when a relay contact is closed no difference in operation is experienced; the relay output appears as a closed contact. However, when a relay contact is open, it appears to the interfaced circuit as a large resistor instead of an open contact. A small amount of current is leaked to the load, resulting in a developed voltage across the load. In most cases this has no bearing on the circuitry, because only a small amount of voltage is developed across its load. However, when a relay output is used with a very high resistance load (low current load), enough voltage may be developed across the load to prevent it from de-energizing.

**Verifying That Latent Fault Detection Can Be Used With a Relay Output**

1. Verify that the circuit the relay output is used with has a voltage level of 18-32 Vdc, 100–150 Vdc, or 88-132 Vac.
2. Use graph which corresponds to the circuit’s voltage level to determine if the voltage developed across the load (due to the leakage current) is lower than the load’s drop-out voltage level.
   - Acquire the resistance of the load (relay, motor, solenoid, etc.) to be driven by the relay.
   - Acquire the load’s minimum drop-out voltage.
   - From the bottom of the graph, follow the line corresponding to the load’s resistance up to the point at which it intersects the circuit power line. At this point the corresponding voltage level (on the left of the graph) is the level of voltage that will be developed across the load due to leakage current.

If circuit voltage is acceptable, and the developed load voltage (from the graph) is less than the load’s drop-out voltage, latent fault detection can be used with the circuit.

If the developed load voltage is greater than the load’s drop-out voltage, it is recommended that latent fault detection be disabled or that a resistor be connected in parallel (shunt) with the load. A correctly sized resistor connected in parallel with the circuit load will decrease the developed load voltage below the load’s drop-out voltage level. Using the corresponding latent fault detection graph and the load’s minimum drop-out voltage, perform the above procedure in reverse (see Step #2) to determine an acceptable shunt resistance. When selecting a shunt resistor, also verify that its voltage and wattage ratings meet that of the circuit.

**Latent Fault Detection Verification Example**

*Figure 7-9*

Circuit power = 110 Vac; load resistance = 200 ohms; load drop-out voltage = 25 Vac

Using the graph below, the intersection point between the 200 ohm load resistance line and the 110 Vac line was found. From this intersection point it was determined that the voltage developed across the load due to leakage current when the relay is open, is approximately 7.5 Vac. This voltage level is lower than the load’s 25 Vac drop-out voltage, so latent fault detection can be used.

If, however, the load resistance were 1200 ohms, the intersection would be approximately 29.5 Vac, too high for latent fault detection. By following the graph along the allowable drop-out voltage, 25 Vac, it can be determined that a total load resistance of 900 Ohms or less is needed. By placing a properly rated 3600 ohm resistor in shunt with the load, (1200 ohms//3600 ohms=>900 ohms) latent fault detection can be used.
Figure 7-8—Latent Fault Detection Verification Graph—18-32 Vdc Circuitry

Figure 7-9—Latent Fault Detection Verification Graph—18-132 Vac Circuitry
7.2.4.5—Relay Jumper Configurations
Relay coil power should be supplied by the control, because this supply is fault tolerant. Jumper banks (four jumpers in one package) are provided on each relay module to allow field selection of internal or external relay coil power. See Figure 14-11. If it is necessary to supply external relay coil power, the relay coil power jumper bank must be moved from its defaulted INT. position to the EXT. position.

To retain circuit integrity if an external power supply is used for relay coil power, the external power supply must be an isolated 24 Vdc source with +5% regulation. It is recommended that a start-up routine be utilized to remove the source during system power-up and power-down. This routine will guarantee that no relay is inadvertently energized due to system power-up surges. (By using the relay module’s internal relay coil power this start-up routine is automatically performed.)

Each relay output has two banks of jumpers. One jumper-bank (a set of nine jumpers) is used to match the latent fault detection circuit with the circuit voltage to which it is being interfaced. The second jumper bank (a set of four jumpers) is used to select which set of relay contacts (N.O. or N.C.) is tested by the latent fault detection logic. During operation, only one set of relay contacts (normally open or normally closed) can be tested. The set of relay contacts tested should be same set of relay contacts used by the load. Refer to [Figure 14-11 and 14-12]. Latent fault detection circuitry can be jumper configured to be compatible with the following circuit voltages:
- 18-32 Vdc circuit power
- 88-132 Vac circuit power
- 100–150 Vdc circuit power
After all jumper-banks have been correctly positioned, mark the placement of each jumper-bank on the FT Relay/Discrete Input module cover labels. See the figure below.

![Figure 7-12—FT Relay/Discrete Input Module Labels]

Configuration Notes

**WARNING**

HIGH VOLTAGE—If there is 125 Vdc on the FT Relay/Discrete Input module terminal blocks, there will be 125 Vdc on the relay module sub D connectors and on the cable when it is connected to the relay module. For this reason, any power should be removed from the relay module terminal blocks, if possible, before installing the 24/12 TMR Discrete I/O module or the relay module.
• Refer to Figure 7-13 for relay output wiring.
• Verify that each set of relay contacts meets the power requirements of the circuit with which it is being used. Interposing relays are required in cases where the interfaced circuit demands relay contacts with a higher power rating. If interposing relays or other inductive loads are required, it is recommended that interposing relays with surge (inductive kickback) protection be used. Improper connection could cause equipment damage.
• Verify that system power is off before removing or installing any relay module jumper. Use ESD precautions when removing and installing relay module jumper-banks.
• Select internal or external relay coil power. If the control’s internal power is used, verify that the relay module’s “Relay Coil Power Jumper” bank is in the INT. position. If external relay coil power is supplied, move the relay module’s “Relay Coil Power Jumper” bank to the EXT. position and verify that the external source is fully isolated. (Mark the module’s label to indicate jumper position.)
• Verify that latent fault detection can be used with each relay output.
• If latent fault detection cannot be used with the relay output, verify that the relay’s latent fault detection jumper-banks are in their disabled positions. (Mark the module’s label to indicate jumper position.) Alternatively, an external resistor can be wired in parallel with the load to allow latent fault detection to be used with the relay output. In this case it is the customer’s responsibility to calculate the required resistor ratings and install the resistor.
• If latent fault detection can be used with the relay output, move the relay’s latent fault detection jumper-bank to the correct position for the circuit power. Also select which set of relay contacts (N.O. or N.C.) are to be tested by the latent fault detection logic. (Mark the module’s labels to indicate jumper positions.)

![Figure 7-13—Example Relay Output Wiring Diagram](image-url)
7.2.4.6—Fault Detection (Module Hardware)
Each 24/12 TMR Discrete I/O module has a red Fault LED that is turned on when the system is reset. During initialization of a 24/12 TMR Discrete I/O module, which occurs after every CPU reset, the CPU turns the Fault LED on. The CPU then tests each 24/12 TMR Discrete I/O module using diagnostic routines built into the software. If the diagnostic test is not passed, the LED remains on or blinks. If the test is successful, the LED goes off. If the Fault LED on a 24/12 TMR Discrete I/O module is illuminated after the diagnostics and initialization have been run, the module may be faulty or may be located in the wrong slot.

<table>
<thead>
<tr>
<th>Number of LED Flashes</th>
<th>Failure</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Micro-controller internal RAM test failure</td>
</tr>
<tr>
<td>3</td>
<td>External RAM high and low byte test failure</td>
</tr>
<tr>
<td>4</td>
<td>External RAM low byte failure</td>
</tr>
<tr>
<td>5</td>
<td>External RAM high byte failure</td>
</tr>
<tr>
<td>6</td>
<td>EEPROM failure</td>
</tr>
<tr>
<td>7</td>
<td>Software not running</td>
</tr>
<tr>
<td>8</td>
<td>System monitor fault</td>
</tr>
<tr>
<td>9</td>
<td>MFT pulses missing</td>
</tr>
</tbody>
</table>

Table 7-1—LED Indications of Failure

Fault Detection (I/O)
In addition to detecting 24/12 TMR Discrete I/O module hardware faults, the application software may detect I/O faults.

Discrete Input Faults. The application software can detect faults by comparing the inputs from the three kernels.

Discrete Output Faults. The module monitors relay coil voltage and contact states. The contacts change state periodically to allow latent fault detection. The application determines the course of action in the event of a fault.

Microcontroller Faults. The system monitors a software watchdog, a hardware watchdog, and a software watchdog on the VME bus communications. All outputs are shut down in the event of a microcontroller fault.

7.2.4.7—24/12 TMR Discrete I/O Module Troubleshooting Guide
If during normal control operation all of a chassis’ 24/12 TMR Discrete I/O modules have Fault LEDs on, check the chassis’ CPU module for a failure. If during normal control operation only the 24/12 TMR Discrete I/O module’s Fault LED is on or flashing, insure that it is installed in the correct slot. If it is, then replace that 24/12 TMR Discrete I/O module. See instructions for module replacement in Chapter 21, Installation and Service. When a 24/12 TMR Discrete I/O module fault is detected, its outputs should be disabled or de-energized.

Discrete Inputs
If a discrete input is not functioning properly, verify the following:
- Measure the input voltage on the terminal block. It should be in the range of 18-32 Vdc for the low voltage input terminal blocks, or 100–150 Vdc for the high voltage terminal blocks.
- Check the wiring. If the inputs are reading open, look for a loose connection on the terminal blocks, disconnected or misconnected cables, or a missing jumper on the terminal block.
- Check the software configuration to ensure that the input is configured properly.
If the other channels on the 24/12 TMR Discrete I/O module are also not working, check the fuse on the 24/12 TMR Discrete I/O module. See instructions for module replacement in Chapter 21, Installation and Service. This fuse is visible and can be changed through the bottom of the module. If this fuse is blown, fix the wiring problem and replace the fuse with another fuse of the same type and rating.

After verifying all of the above, remove the 24/12 TMR Discrete I/O module and exchange the J1 and J2 cables. See instructions for replacing the module in Chapter 21, Installation and Service. If the problem moves to a different channel, replace the cable. If not, exchange the cables at the FT Relay/Discrete Input modules so J1 is driving J2 and vice versa. If the problem moves to a different input, replace the 24/12 TMR Discrete I/O module. If the fault remains with the same input, replace the FT Relay/Discrete Input module. See instructions for replacing the FT Relay/Discrete Input modules in Chapter 21, Installation and Service.

Discrete Outputs
If a discrete output is not functioning properly, verify the following:

- Check the wiring for a loose connection on the terminal blocks and disconnected or misconnected cables.
- Verify that the current through the relay contact does not exceed the contact rating.
- Make sure that if latent fault detection is being used, the trickle current through the relay is insufficient to energize the relay load. See Figures 15-8 through 15-10.
- If the other output channels on the 24/12 TMR Discrete I/O module are also not working, check the fuse on the 24/12 TMR Discrete I/O module. See instructions for module replacement in Chapter 21, Installation and Service. This fuse is visible and can be changed through the bottom of the module. If this fuse is blown, fix the wiring problem and replace the fuse with another fuse of the same type and rating.
- Check the software configuration to ensure that the output is configured properly.

After verifying all of the above, remove the 24/12 TMR Discrete I/O module and exchange the J1 and J2 cables. See instructions for replacing the module in Chapter 21, Installation and Service. If the problem moves to a different channel, replace the cable. If not, exchange the cables at the FT Relay/Discrete Input modules so J1 is driving J2 and vice versa. See instructions for replacing the module in Chapter 21, Installation and Service. If the problem moves to a different relay, replace the 24/12 TMR Discrete I/O module or the relay. See instructions for replacing the FT Relay/Discrete Input modules and relays in Chapter 21, Installation and Service. If the fault remains with the same relay, replace the relay or the FT Relay/Discrete Input module.

7.3—48/24 Discrete Combo Module

7.3.1—Module Description

A 48/24 Discrete Combo module contains circuitry for forty-eight discrete inputs and twenty-four discrete outputs. These modules have no potentiometers and require no calibration. A module may be replaced with another module of the same part number without any adjustment. There are two different FTM I/O configurations for the 48/24 Discrete Combo Module.
Configuration 1 consists of one 48/24 Discrete FTM connected to the 48/24 Discrete Combo module via two High Density Analog/Discrete cables. The 48/24 Discrete FTM is then connected to either two 16 Ch Relay Modules or one 32 Ch Relay Module via a Low Density Discrete Cable(s).

Configuration 2 consists of two 24/12 Discrete FTMs (DIN rail mounted) connected to the 48/24 Discrete Combo module via two High Density Analog/Discrete cables.

The discrete inputs are optically isolated and accessible through either the 48/12 Discrete FTM or the 24/12 Discrete FTM depending on the configuration. The discrete outputs are accessible through either the 24/12 Discrete FTM or the two 16 Ch Relay Modules or the one 32 Ch Relay Module when so configured. See Figures 7-15 and 7-20 for examples of configurations.

7.3.2—Module Specification

Discrete Inputs

| Number of channels: | 48 |
| Update time:        | 5 ms |
| Input type:         | Optically isolated discrete input (galvanically isolated) |
### 48/24 Discrete FTM

- **Input thresholds:**
  - **Low voltage:** 8 Vdc at 1.5 mA = “OFF”
  - > 16 Vdc at 3 mA = “ON”
  - **High voltage:** <29 Vdc at 1.8 mA = “OFF”
  - >67 Vdc at 4 mA = “ON”
- **Input current:** 4 mA @ 24 Vdc; 2.6–5 mA @ 125 Vdc
- **External input voltage:** 18–32 Vdc (UL and LVD), or 100–150 Vdc (UL) w/ high Voltage FTM
- **Isolation voltage:** 500 Vdc to earth ground, 1000 Vdc to control common
- **Time stamping:** 1 ms resolution
- **Isolated 24 Vdc contact supply:** 400 mA maximum

For the 24/12 Discrete FTM input specifications, see Chapter 12.

### Discrete Outputs

- **Number of channels:** 24
- **Update time:** 5 ms

For the 24/12 Discrete FTM, 16 Ch Relay Module, and the 32 Ch Relay Module output specifications, see Chapter 12.

### 7.3.3—Installation

The modules slide into card guides in the control's chassis and plug into the motherboard. The modules are held in place by two screws, one at the top and one at the bottom of the front panel. Also at the top and bottom of the module are two handles which, when toggled (pushed outward), move the modules out just far enough for the boards to disengage the motherboard connectors.

There are two different FTM I/O configurations for the 48/12 Discrete Combo Module.

#### Configuration 1

Configuration 1 consists of one 24 Vdc or 125 Vdc 48/24 Discrete FTM connected to the 48/24 Discrete Combo module via two High Density Analog/Discrete cables. The top connector on the 48/24 Discrete Combo module, which is labeled J1, connects to J1 on the 48/24 Discrete FTM, and J2 connects to J2. There are two versions of the FTM, one for 24 Vdc inputs, and one for 125 Vdc inputs. The LVD applies only to the 24 Vdc version. The 24 Vdc 48/24 Discrete FTM handles 24 Vdc input signals and the 125 Vdc 48/24 Discrete FTM handles 125 Vdc input signals. Either 48/24 Discrete FTM is then connected to either two 16 Ch Relay Modules or one 32 Ch Relay Module via a Low Density Discrete Cable(s) via the third connector. See Figure 7-15 for an example of configuration.
All of the discrete inputs on the module are accessible on the FTM, and the channels are labeled to correspond to their designation in the application software (discrete input 1 on the FTM will be discrete input 1 in the application software).

**Discrete Inputs**

Each 48/24 Discrete Combo module accepts 48 contact inputs. The 48/24 Discrete FTM may supply contact wetting voltage. Optionally, an external 18–32 Vdc power source or an external 100–150 Vdc power source can be used to source the circuit wetting voltage. If the 24 Vdc internal power source is used for contact wetting, a jumper is required between FTM terminals 98 and 99. If an external power source is used for contact wetting, the external source’s common must be connected to the FTM’s discrete input common, terminal 49. If 125 Vdc contact inputs are needed, the High Voltage (125 Vdc) FTM must be used. The FTM provides a common cage-clamp terminal connection for customer field wiring. Figures 7-16 and 7-17 illustrate different discrete input wiring configurations based on the input voltage.
Figure 7-16—Discrete Input Interface Wiring to a 24 Vdc 48/24 Discrete FTM

Figure 7-17—Discrete Input Interface Wiring to a 125 Vdc 48/24 Discrete FTM

**WARNING**

HIGH VOLTAGE—If the high voltage FTM is being used, and there is 125 Vdc on the FTM terminal blocks, there will be 125 Vdc on the FTM sub D connectors and on the cable when it is connected to the FTM. For this reason, any power should be removed from the FTM terminal blocks before installing the 48/24 Discrete Combo module or the FTM.

Configuration Notes:
- Refer to Chapter 12 for Discrete Input wiring.
- Each 48/24 Discrete I/O module can only accept one input voltage range, 24 Vdc (LVD and UL) or 125 Vdc (UL only).
- All contact inputs accept dry contacts.
- 24 Vdc FTM only—if the internal 24 Vdc is used, a jumper must be added to tie the internal 24 Vdc to the bussed power terminal blocks (see Figure 6-16).
- 24 Vdc FTM only—if an external 24 Vdc is used, the common for the external 24 Vdc must be tied to the discrete input common (see Figure 6-16). Power for contacts must be supplied by the control’s power supplies, or the external power supply outputs must be rated to Class II at 30 Vdc or less and outputs must be fused with appropriately sized fuses (a maximum current rating of $100 \div V$, where $V$ is the supply’s rated voltage or 5 A, whichever is less).
- High Voltage FTM only—the common for the 125 Vdc must be tied to the discrete input common (see Figure 7-17).
Discrete Outputs
For the 48/24 Discrete Combo FTM configuration, there are three types of relay output boxes that can be used. These consist of the 16 Ch Relay (Phoenix) Module, 16 Ch Relay Module, and the 32 Ch Relay Module (see Chapter 12 for a description of the available modules). The relay modules connect to the 48/24 Discrete FTM through individual cables and provide a common cage-clamp terminal connection for customer field wiring. The discrete outputs on the 48/24 Discrete I/O module are non-isolated; the isolation takes place in the relay boxes.

Discrete outputs 9, 10, 11, 12, 21, 22, 23, and 24, drive two relays per output (see Table 7-2). Internal wiring on the 48/24 Discrete I/O FTM provides this dual relay functionality. The application software may use these relays for outputs where extra relay contacts are needed, such as alarm or shutdown outputs.

<table>
<thead>
<tr>
<th>Discrete Outputs</th>
<th>16 Channel Relay Mod.(s)</th>
<th>32 Channel Relay Mod.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-8</td>
<td>Mod. 1 Ch. 1-8</td>
<td>Ch. 1-8</td>
</tr>
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<td>9</td>
<td>Mod. 1 Ch. 9, 10</td>
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<td>Mod. 1 Ch. 11, 12</td>
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<td>Mod. 1 Ch. 13, 14</td>
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<td>12</td>
<td>Mod. 1 Ch. 15, 16</td>
<td>Ch. 15, 16</td>
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<td>13-20</td>
<td>Mod. 2 Ch. 1-8</td>
<td>Ch. 17-24</td>
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<td>21</td>
<td>Mod. 2 Ch. 9, 10</td>
<td>Ch. 25, 26</td>
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<tr>
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<td>Mod. 2 Ch. 11, 12</td>
<td>Ch. 27, 28</td>
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<td>Mod. 2 Ch. 13, 14</td>
<td>Ch. 29, 30</td>
</tr>
<tr>
<td>24</td>
<td>Mod. 2 Ch. 15, 16</td>
<td>Ch. 31, 32</td>
</tr>
</tbody>
</table>

Table 7-2—Discrete Outputs/Relay Module Configuration

See Chapter 12 for field wiring of discrete output relays.

Figures 7-18 and 7-19 illustrate examples of different discrete output wiring configurations.
Configuration Notes

- Verify that each set of relay contacts meets the power requirements of the circuit with which it is being used. Interposing relays are required when the interfaced circuit demands relay contacts with a higher power rating. If interposing relays or other inductive loads are required, it is recommended that interposing relays with surge (inductive kickback) protection be used. Improper connection could cause serious equipment damage.

Configuration 2

Configuration 2 consist of two 24/12 Discrete FTMs (DIN rail mounted) connected to the 48/24 Discrete Combo module via two High Density Analog/Discrete cables. See Figure 7-20 for an example of configuration.

![Diagram of Configuration 2](image-url)
Both the 48 discrete inputs and 24 discrete outputs are wired to the 24/12 Discrete FTM. An external 24 Vdc source connection to the FTM is required for discrete input contact sensing and relay coil energizing. For wiring information on the 24/12 Discrete FTM, see Chapter 12.

**Discrete Inputs**

Each 24/12 Discrete FTM accepts 24 contact inputs. The 24/12 Discrete FTM may supply contact wetting voltage. Optionally, an external 18–32 Vdc power source can be used to source the circuit wetting voltage. If the 24 Vdc internal power source is used for contact wetting, a jumper is required between FTM terminals on TB9. If an external power source is used for contact wetting, the external source’s common must be connected to the FTM’s discrete input common, terminal 49 (see Figure 7-21).

**Configuration Notes:**

- Refer to Chapter 12 for Discrete Input wiring.
- All contact inputs accept dry contacts.
- If the internal 24 Vdc is used, a jumper must be added to tie the internal 24 Vdc to the bussed power terminal blocks (see Figure 7-21).
- If an external 24 Vdc is used, the common for the external 24 Vdc must be tied to the discrete input common (see Figure 7-21). Power for contacts must be supplied by the control’s power supplies, or the external power supply outputs must be rated to Class II at 30 Vdc or less and outputs must be fused with appropriately sized fuses (a maximum current rating of 100/V, where V is the supply’s rated voltage, or 5 A, whichever is less).
Discrete Outputs
The discrete outputs on the 48/24 Discrete I/O module are non-isolated; the isolation takes place in the 24/12 Discrete FTM. See Chapter 12 for field wiring of discrete output relays. Figure 7-22 illustrates an example of a discrete output wiring configuration.

![Discrete Outputs Diagram](image)

**Figure 7-22—Relay Output Interface Wiring to a 24/12 Discrete FTM**

**Configuration Notes**
- Verify that each set of relay contacts meets the power requirements of the circuit with which it is being used. Interposing relays are required when the interfaced circuit demands relay contacts with a higher power rating. If interposing relays or other inductive loads are required, it is recommended that interposing relays with surge (inductive kickback) protection be used. Improper connection could cause serious equipment damage.

**7.3.4—FTM Reference**
See Chapter 12 for detailed wiring of FTMs. See Appendix A for part number Cross Reference for modules, FTMs, and cables.

**7.3.5—Troubleshooting**

**Fault Detection (Module Hardware)**
Each 48/24 Discrete Combo module has a red Fault LED that is turned on when the system is reset. During initialization of a 48/24 Discrete Combo module, which occurs after every CPU reset, the CPU turns the Fault LED on. The CPU then tests each 48/24 Discrete Combo module using diagnostic routines built into the software. If the diagnostic test is not passed, the LED remains on or blinks. If the test is successful, the LED goes off. If the Fault LED on a 48/24 Discrete Combo module is illuminated after the diagnostics and initialization have been run, the module may be faulty or may be located in the wrong slot.
<table>
<thead>
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<td>Micro-controller internal RAM test failure</td>
</tr>
<tr>
<td>3</td>
<td>External RAM high and low byte test failure</td>
</tr>
<tr>
<td>4</td>
<td>External RAM low byte failure</td>
</tr>
<tr>
<td>5</td>
<td>External RAM high byte failure</td>
</tr>
<tr>
<td>6</td>
<td>EEPROM failure</td>
</tr>
<tr>
<td>7</td>
<td>Software not running</td>
</tr>
<tr>
<td>8</td>
<td>System monitor fault</td>
</tr>
<tr>
<td>9</td>
<td>MFT pulses missing</td>
</tr>
</tbody>
</table>

Table 7-3—LED Indications of Failure

Fault Detection (I/O)
In addition to detecting 48/24 Discrete I/O module hardware faults, the application software may detect I/O faults.

Discrete Output Faults: The module monitors the FTM control voltage and annunciates faults. The application software determines the course of action in the event of a fault.

Microcontroller Faults: The system monitors a software watchdog, a hardware watchdog, and a software watchdog on the VME bus communications. All outputs are shut down in the event of a microcontroller fault.

Figure 7-23—48/24 Discrete Combo Module Block Diagram

If during normal control operation all of a chassis’ 48/24 Discrete Combo modules have Fault LEDs on, check the chassis’ CPU module for a failure. If during normal control operation only the 48/24 Discrete Combo module’s Fault LED is on or flashing, insure that it is installed in the correct slot. If it is, then replace that 48/24 Discrete Combo module. When a module fault is detected, its outputs should be disabled or de-energized.
Discrete Inputs
If a discrete input is not functioning properly, verify the following:
1. Measure the input voltage on the terminal block. It should be in the range of 16–32 Vdc for the low voltage FTM or 100–150 Vdc for the high voltage FTM.
2. Check the wiring. If the inputs are reading open, look for a loose connection on the terminal blocks, disconnected or misconnected cables, or a missing jumper on the terminal block.
3. Check the application software configuration to ensure that the input is configured properly.
4. If the other channels on the 48/24 Discrete Combo module are not working either, check the fuse on the 48/24 Discrete Combo module. See the instructions in Chapter 15 for replacing the module. This fuse is visible and can be changed through the bottom of the module. If this fuse is blown, fix the wiring problem and replace the fuse with another fuse of the same type and rating.
5. After verifying all of the above, exchange the J1 and J2 cables. If the problem moves to a different channel, replace the cable. If not, replace the 48/24 Discrete Combo module.
6. If the readings are incorrect on several channels of the 48/24 Discrete Combo module, corresponding to both cables, replace the 48/24 Discrete Combo module.
7. If replacing the module does not fix the problem, replace the FTM. See the instructions in Chapter 15 for replacing the FTM.

Discrete Outputs
If a discrete output is not functioning properly, verify the following:
1. Check the wiring for a loose connection on the terminal blocks, or disconnected or misconnected cables.
2. Verify that the current through the relay contacts is not greater than the relay contact rating.
3. If the other output channels on the 48/24 Discrete Combo module are not working either, check the fuse on the 48/24 Discrete Combo module. See the instructions in Chapter 15 for replacing the module. This fuse is visible and can be changed through the bottom of the module. If this fuse is blown, fix the wiring problem and replace the fuse with another fuse of the same type and rating.
4. Check the software configuration to ensure that the output is configured properly.
5. After verifying all of the above, exchange the J1 and J2 cables. If the problem moves to a different channel, replace the cable. If not, exchange the cables at the FTM, so J1 is driving J2 and vice versa. If the problem moves to a different relay, replace the 48/24 Discrete Combo module. If the fault stays with the same relay, replace the relay or the relay module. See instructions for replacing the relay modules in Chapter 15. If replacing the relay module does not fix the problem, replace the cable between the relay module and the FTM, or replace the FTM itself. See the instructions in Chapter 15 for replacing the FTM.
7.4—48 Channel Discrete Input Module

7.4.1—Module Description

Each 48 Channel Discrete Input (48 Ch DI) Module is connected through two low density discrete cables to two separate FTMs. There are two types of FTMs available for use with the 48 Ch DI Module; the 24 Vdc Discrete Input/Output FTM and the Discrete Input (With LEDs) FTM (see Chapter 12 for additional information on this FTM module). The 24 Vdc Discrete Input/Output FTM doesn’t have LEDs and the Discrete Input (with LEDs) FTM has LEDs. All I/Os on the module are accessible on the FTMs, and the channels are labeled sequentially to correspond to their software locations (for example, discrete input 1 on the FTM will be discrete input 1 in the application software).

![Figure 7-24—Discrete Input Module](image)

This module receives discrete signals from 48 separate switches or relay contacts, and sends this data to the CPU. The inputs are optically isolated from the balance of the MicroNet control circuitry. The module system provides isolated +24 Vdc power for these external contacts on the 24 Vdc Discrete Input/Output FTM. The Discrete Input (With LEDs) FTM requires an external contact wetting power supply.

There are no potentiometers for tuning and requires no calibration. A module may be replaced with another 48 Ch DI Module of the same part number without any adjustment.
### 7.4.2—Module Specification

<table>
<thead>
<tr>
<th>Specification</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Channels:</td>
<td>48</td>
</tr>
<tr>
<td>Input Type:</td>
<td>Optically isolated discrete input</td>
</tr>
<tr>
<td>Input Thresholds:</td>
<td>$&lt; 8 \text{ Vdc} = \text{&quot;OFF&quot;}$</td>
</tr>
<tr>
<td></td>
<td>$&gt; 16 \text{ Vdc} = \text{&quot;ON&quot;}$</td>
</tr>
<tr>
<td>Input Current:</td>
<td>$3 \text{ mA} @ 24 \text{ Vdc}$</td>
</tr>
<tr>
<td>Contact Power:</td>
<td>Module provides isolated 24 Vdc, 0.3 A</td>
</tr>
</tbody>
</table>

### 7.4.3—Installation

The modules slide into card guides in the control's chassis and plug into the motherboard. The modules are held in place by two screws, one at the top and one at the bottom of the front panel. Also at the top and bottom of the module are two handles which, when toggled (pushed outward), move the modules out just far enough for the boards to disengage the motherboard connectors.

Each 48 Ch DI Module is connected through two low density discrete cables to two 24 Vdc Discrete Input/Output FTMs or Discrete Input (With LEDs) FTMs. All I/Os on the module are accessible on the FTMs, and the channels are labeled sequentially to correspond to their software locations (for example., discrete input 1 on the FTM will be discrete input 1 in the application software). The FTM plugged into J1 handles channels 1–24, and the FTM plugged into J2 handles channels 25–48. See Figure 7-25 for system installation configuration.

![Diagram of 48 Ch DI Module with two FTMs](image-url)

**Figure 7-25**—48 Ch DI Module with two FTMs
Each 48 Ch DI Module accepts 48 contact inputs. Contact wetting voltage may be supplied by the 48 Ch DI Module internal power supply. The supply can only supply 300 mA and therefore should not be used with the Discrete Input (with LEDs) FTM. If an external power source (18–32 Vdc) is supplied, the Discrete Input (with LEDs) FTM may be used. Figures 7-26 and 7-27 illustrate different discrete input wiring configurations based on internal or external power source.

**Configuration Notes:**
- Refer to Chapter 12 for Discrete Input wiring.
- All contact inputs accept dry contacts.
7.4.4—FTM Reference

See Chapter 12 for detailed wiring of FTMs. See Appendix A for part number Cross Reference for modules, FTMs, and cables.

7.4.5—Troubleshooting

Fault Detection (Module Hardware)
Each 48 Ch DI module has a red Fault LED that is turned on when the system is reset. During initialization of a 48 Ch DI module, which occurs after every CPU module reset, the CPU turns the Fault LED on. The CPU module via the VME bus turns off the Fault LED when the CPU has started execution of the application program and verified that the board is present.

Figure 7-28 is a block diagram of the Discrete Input module. The module receives information from as many as 48 field switches and relays. Field wiring is isolated from the MicroNet circuitry by optical isolators in each channel; the state of each discrete input is passed through an optoisolator to the buffers. The CPU then obtains the data for each channel through the VME interface.

If during normal control operation all of a chassis' 48 DI modules have Fault LEDs on, check the chassis' CPU module for a failure.
If a discrete input is not functioning properly, verify the following:

1. Measure the input voltage on the terminal block of the FTM. It should be in the range of 16–32 Vdc.
2. Check the wiring. If the inputs are reading open, look for a loose connection on the terminal blocks, disconnected or misconnected cables, or a missing jumper on the terminal block.
3. Check the application software configuration to ensure that the input is configured properly.
4. If the other channels on the 48 DI module are not working either, check the fuse on the 48 DI module. See the instructions in Chapter 15 for replacing the module. This fuse is visible and can be changed through the bottom of the module. If this fuse is blown, fix the wiring problem and replace the fuse with another fuse of the same type and rating.
5. After verifying all of the above, exchange the J1 and J2 cables. If the problem moves to a different channel, replace the cable. If not, replace the 48 DI module.
6. If replacing the module does not fix the problem, replace the FTM. See the instructions in Chapter 15 for replacing the FTM.

7.5—32 Channel Discrete Output Module

7.5.1—Module Description

The MicroNet control can provide discrete outputs to the prime mover from field wiring. Each Discrete Output (DO) module can individually control 32 outputs according to commands from the CPU module. These modules have no potentiometers and require no calibration. A module may be replaced with another module of the same part number without any adjustment. There are two different FTM I/O configurations for the 32 Ch DO Module. The module can be connected to one 32 Ch Relay Module or two 16 Ch Relay Modules (see Chapter 12 for additional information on the relay modules).

7.5.2—Module Specification

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of channels:</td>
<td>32</td>
</tr>
<tr>
<td>Update time:</td>
<td>5 ms</td>
</tr>
<tr>
<td>Output Type:</td>
<td>Open drain drivers, intended for use with Woodward relay interface modules.</td>
</tr>
<tr>
<td>Fault Detection Readback:</td>
<td>Output channel status, relay status is not available</td>
</tr>
<tr>
<td>System Faults:</td>
<td>Outputs are turned off if communications with the CPU is lost.</td>
</tr>
</tbody>
</table>

For the 16 Ch Relay Module and the 32 Ch Relay Module output specifications, see Chapter 12.
7.5.3—Installation

The modules slide into card guides in the control's chassis and plug into the motherboard. The modules are held in place by two screws, one at the top and one at the bottom of the front panel. Also at the top and bottom of the module are two handles which, when toggled (pushed outward), move the modules out just far enough for the boards to disengage the motherboard connectors.

This module receives digital data from the CPU and generates 32 non-isolated relay driver signals. All discrete output modules in the system interface to one or more Woodward Relay Modules, each with 16 or 32 relays. The contacts of these relays then connect to the field wiring.

A separate 24 Vdc power source must be provided for the relays; this module does not furnish this power. A section of a multi-output Main Power Supply can be used, or power from a single-output Main Power Supply can be used, as long as sufficient current is available.

Each 32 Ch DO Module is connected through one low density discrete cable to a 32 Ch Relay module or a 16 Ch Relay module daisy chained to a second 16 Ch Relay module with another low density cable. See Figure 7-30 for system installation configuration.
Figure 7-30—32 Ch DO Module with Relay Modules

See Chapter 12 for field wiring of discrete output relays.

Figures 7-31 and 7-32 illustrate examples different discrete output wiring configurations.
Configuration Notes

- Verify that each set of relay contacts meets the power requirements of the circuit with which it is being used. Interposing relays are required when the interfaced circuit demands relay contacts with a higher power rating. If interposing relays or other inductive loads are required, it is recommended that interposing relays with surge (inductive kickback) protection be used. Improper connection could cause serious equipment damage.

7.5.4—FTM Reference

See Chapter 12 for detailed wiring of relay modules. See Appendix A for part number Cross Reference for modules, FTMs, and cables.

7.5.5—Troubleshooting

Figure 7-33 is a block diagram of the 32-Channel Discrete Output module. The CPU sends the address of this module and the address and state of the channel to be output to this module. This information is received by the VME interface and passed to the latches. The latch associated with the channel to be output stores the information and passes it to the drivers. The driver for that channel then energizes or de-energizes the relay for that channel.

Each channel has a readback buffer that indicates the status of the output driver (not the relay). The CPU compares this status to the value written to the channel and generates a fault signal if these two values are different. The relay module power is turned off if communications with the CPU are lost or a fault is detected.
If a discrete output is not functioning properly, verify the following:
1. Check the wiring for a loose connection on the terminal blocks, or disconnected or misconnected cables.
2. Verify that the current through the relay contacts is not greater than the relay contact rating.
3. If the other output channels on the 32 Ch DO module are not working either, check the fuse on the 32 Ch DO module. See the instructions in Chapter 15 for replacing the module. This fuse is visible and can be changed through the bottom of the module. If this fuse is blown, fix the wiring problem and replace the fuse with another fuse of the same type and rating.
4. Check the software configuration to ensure that the output is configured properly.
5. If replacing the relay module does not fix the problem, replace the cable between the relay module and the FTM, or replace the FTM itself. See the instructions in Chapters 15 for replacing the FTM.
7.6—64 Channel Discrete Output Module

7.6.1—Module Description

The MicroNet control can provide discrete outputs to the prime mover from field wiring. Each of this type Discrete Output (DO) module can individually control 64 outputs according to commands from the CPU module. These modules have no potentiometers and require no calibration. A module may be replaced with another module of the same part number without any adjustment. There are several different FTM I/O configurations for the 64 Ch DO Module. The module can be connected to two 32 Ch Relay Module, four 16 Ch Relay Modules, or a combination of the two types (see Chapter 12 for additional information on the relay modules).
7.6.2—Module Specification

Number of channels: 64
Update time: 5 ms
Output Type: Open drain drivers, intended for use with Woodward relay interface modules.
Fault Detection Readback: Output channel status, relay status is not available
System Faults: Outputs are turned off if communications with the CPU is lost.

For the 16 Ch Relay Module, and the 32 Ch Relay Module output specifications, see Chapter 12.

7.6.3—Installation

The modules slide into card guides in the control's chassis and plug into the motherboard. The modules are held in place by two screws, one at the top and one at the bottom of the front panel. Also at the top and bottom of the module are two handles which, when toggled (pushed outward), move the modules out just far enough for the boards to disengage the motherboard connectors.

This module receives digital data from the CPU and generates 64 non-isolated relay driver signals. All discrete output modules in the system interface to one or more Woodward Relay Modules, each with 16 or 32 relays. The contacts of these relays then connect to the field wiring.

A separate 24 Vdc power source must be provided for the relays; this module does not furnish this power. A section of a multi-output Main Power Supply can be used, or power from a single-output Main Power Supply can be used, as long as sufficient current is available.

Each 64 Ch DO Module is connected through two low density discrete cables to two 32 Ch Relay modules or two 16 Ch Relay modules daisy chained to two additional 16 Ch Relay modules with two additional low density cables. See Figure 7-35 for system installation configuration.
### Power Supply #1

<table>
<thead>
<tr>
<th>CPU</th>
<th>64 DO</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1.png" alt="Diagram" /></td>
<td><img src="image2.png" alt="Diagram" /></td>
</tr>
</tbody>
</table>

### Power Supply #2

<table>
<thead>
<tr>
<th>CPU</th>
<th>64 DO</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image3.png" alt="Diagram" /></td>
<td><img src="image4.png" alt="Diagram" /></td>
</tr>
</tbody>
</table>

**Low Density Cable**

**Or**

**Low Density Cable**

**Or**

**Low Density Cable**

---

32Ch Relay Module (Channels 1-32)

16Ch Relay Module (Channels 1-16)

16Ch Relay Module (Channels 17-32)

32Ch Relay Module (Channels 33-64)

16Ch Relay Module (Channels 33-48)

16Ch Relay Module (Channels 49-64)

---

**Figure 7-35—64 Ch DO Module with Relay Modules**

See Chapter 12 for field wiring of discrete output relays.

Figures 7-36 and 7-37 illustrate examples different discrete output wiring configurations.

**Figure 7-36—Relay Output Interface Wiring to a 16 Ch Relay Module**
Figure 7-37—Relay Output Interface Wiring to a 32 Ch Relay Module

**Configuration Notes**
- Verify that each set of relay contacts meets the power requirements of the circuit with which it is being used. Interposing relays are required when the interfaced circuit demands relay contacts with a higher power rating. If interposing relays or other inductive loads are required, it is recommended that interposing relays with surge (inductive kickback) protection be used. Improper connection could cause serious equipment damage.

**7.6.4—FTM Reference**

The 64 Ch DO Module uses the same relay modules as the 32 Ch DO Module. See the previous section.

**7.6.5—Troubleshooting**

The 64 Ch DO Module uses the same relay modules as the 32 Ch DO Module and therefore has the same troubleshooting approach as the 32 Ch DO Module. See the previous section.
Chapter 8.
Analog I/O Modules

8.1—Introduction

This chapter contains information on those modules that are classified as analog I/O modules. There are two types analog I/O modules. There are the single function type modules and the combination modules. The combination modules consist of more than one type of input or output. The single type modules consist of a single type of I/O, such as all 4–20 mA inputs.

8.2—Combination I/O Modules

There are five Analog Combination I/O modules available from Woodward. These are described in sections 7.3 through 7.8.

8.3—TMR 24/8 Analog Module

8.3.1—Module Description

A 24/8 Analog module contains circuitry for twenty-four analog inputs and eight 4–20 mA outputs. These modules have no potentiometers and require no calibration. A module may be replaced with another module of the same part number without any adjustment.

The TMR 24/8 Analog module comes in the following configuration: 24 channels of 4–20 mA inputs with 8 channels of 4–20 mA outputs (2-pole 10 ms filter on all input channels, except channels 23 and 24, which have 2-pole 5 ms filter).

All 4–20 mA analog inputs may be used with two-wire ungrounded (loop powered) transducers or isolated (self-powered) transducers. All analog inputs have 200 Vdc of common mode rejection. If interfacing to a non-isolated device, which may have the potential of reaching over 200 Vdc with respect to the control’s common, the use of a loop isolator is recommended to break any return current paths producing erroneous readings.

Each board has an on-board processor for automatic calibration of the I/O channels. Each analog input incorporates a time-stamping feature with 5 ms resolution for two low setpoints and two high setpoints.
8.3.2—Module Specification

Analog Input Ratings

- Number of channels: 24
- Update time: 5 ms
- Input range: 0–25 mA; software and hardware selectable

<table>
<thead>
<tr>
<th>The maximum voltage input range may vary between 4.975 and 5.025 Volts from module to module.</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Isolation: 0 Vrms, 60 dB CMRR, 200 Vdc common mode rejection voltage; no galvanic isolation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input imp. (4–20 mA): 200 ohms</td>
</tr>
<tr>
<td>Anti-aliasing filter: 2 poles at 10 ms</td>
</tr>
<tr>
<td>Resolution: 16 bits</td>
</tr>
<tr>
<td>Accuracy: Software calibrated to 0.1%, over 0–25 mA full scale</td>
</tr>
<tr>
<td>Temp drift: 275 ppm/C, maximum</td>
</tr>
<tr>
<td>Fuse: 100 mA fuse per channel.</td>
</tr>
<tr>
<td>Time stamping: 5 ms resolution on low event and latch, and high event and latch</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>The 24 channel analog inputs are divided into two banks, with channel 1 through channel 12 data gathering at 1.8 ms after the MFT tick and channel 13 through channel 24 data gathering at 3.7 ms after the MFT tick.</th>
</tr>
</thead>
</table>
4–20 mA Output Ratings

- Number of channels: 8
- Update time: 5 ms
- Output Driver: Pulse Width Modulated (PWM)
- PWM frequency: 6.14 kHz
- Filter: 3 poles at 500 ms
- Current output: 4–20 mA
- Current output range: 0–25 mA
- Isolation: 0 Vrms
- Max load resistance: 600 ohms (load + wire resistance)
- Current readback: 8 bits
- Readback isolation: 60 dB CMRR, 200 Vdc common mode rejection voltage
- Resolution: 11 bits
- Accuracy: Software calibrated to 0.2% of 0–25 mA full scale
- Temperature drift: 125 ppm/C, maximum
- Readback accuracy: 0.5% of 0–25 mA full scale
- Readback temp drift: 400 ppm/C, maximum

8.3.3—Installation

The modules slide into card guides in the control’s chassis and plug into the motherboard. The modules are held in place by two screws, one at the top and one at the bottom of the front panel. Also at the top and bottom of the module are two handles which, when toggled (pushed outward), move the modules out just far enough for the boards to disengage the motherboard connectors.

Three 24/8 Analog I/O modules are connected through six high density 62 conductor analog cables (two from each module) to two 24/8 Analog I/O FTMs. Each 24/8 Analog I/O module has two sub D connectors on the front panel. The top sub D connector contains the first half of the channels (analog input channels 1-12 and analog output channels 1-4) and the bottom sub D connector contains the second half of the I/O channels. See Figure 8-2 for an example.
Analog Inputs
For a 4–20 mA input signal, the 24/8 Analog Module uses a 200 ohm resistor across the input located on the 24/8 Analog Module. Each analog input channel may power its own 4–20 mA transducer. See Figure 8-3 for analog input connection. This power is protected with a 100 mA fuse on each channel to prevent an inadvertent short from damaging the module. The 24 Vdc outputs are capable of providing 24 Vdc with ±10% regulation. The maximum current is 0.8 A. Power connections can be made through terminals located on the 24/8 Analog FTMs. See Chapter 12 for complete field wiring information for the 24/8 Analog FTM.

**IMPORTANT**

When configuring the AI Combo block in GAP, set Conf. input field to 1 for all inputs when used with the 24/8 Analog FTM. This will allow the block to use the module factory calibration values for the 4–20 mA inputs that were calibrated with 200 ohm internal resistors on the 24/8 Analog Module.

![Figure 8-3—Analog Input Wiring for a 24/8 Analog FTM](image_url)
Analog Outputs

There are 8 analog output channels of 4–20 mA with a full scale range of 0–25 mA. All Analog Outputs can drive a maximum load of 600 ohms (load + wire resistance). See Figure 8-4 for analog output connection. Each output monitors the output source current for fault detection. All of the analog outputs may be individually disabled. When a channel fault or a module fault is detected, the application program may annunciate the fault, disable the channel and stop using data in system calculations or control. Care should be taken to prevent ground loops and other faults when interfacing to non-isolated devices. See Chapter 12 for complete field wiring information for the Analog High Density FTM.

![Analog Output Wiring for a 24/8 Analog FTM](image)

8.3.4—FTM Reference

See Chapter 12 for complete field wiring information for the Analog High Density FTM. See Appendix A for part number Cross Reference for modules, FTMs, and cables.

8.3.5—Troubleshooting

Each 24/8 Analog module has a red Fault LED that is turned on when the system is reset. During initialization of a module, which occurs after every CPU reset, the CPU turns the Fault LED on. The CPU then tests each module using diagnostic routines built into the software. If the diagnostic test is not passed, the LED remains on or blinks. If the test is successful, the LED goes off. If the Fault LED on a module is illuminated after the diagnostics and initialization have been run, the module may be faulty or may be located in the wrong slot.

<table>
<thead>
<tr>
<th>Number of LED Flashes</th>
<th>Failure</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Hardware watchdog, CPU clock failure, reset fail</td>
</tr>
<tr>
<td>2</td>
<td>Micro-controller internal RAM test failure</td>
</tr>
<tr>
<td>3</td>
<td>External RAM test failure</td>
</tr>
<tr>
<td>4</td>
<td>Unexpected exception error</td>
</tr>
<tr>
<td>5</td>
<td>Dual Port RAM test failure</td>
</tr>
<tr>
<td>6</td>
<td>EEPROM failure</td>
</tr>
<tr>
<td>7</td>
<td>Communications watchdog time out</td>
</tr>
<tr>
<td>8</td>
<td>EEPROM error is corrected (reset the module to continue)</td>
</tr>
<tr>
<td>9</td>
<td>Missing an A/D Converter interrupt</td>
</tr>
</tbody>
</table>

Table 8-1—LED Indications of Failure
Fault Detection (I/O)
In addition to detecting the High Density Analog I/O module hardware faults, the application software may detect I/O faults.

Analog Input Faults: The application software may be set with a high and low latch setpoint to detect input faults.

Analog Output Driver Faults: The module monitors the source currents and annunciates faults. The application software determines the course of action in the event of a fault.

Microcontroller Faults: The system monitors a software watchdog, a hardware watchdog, and a software watchdog on the VME bus communications. All outputs are shut down in the event of a microcontroller fault.

Troubleshooting Guide
If during normal control operation all of a chassis’ 24/8 Analog I/O modules have Fault LEDs on, check the kernel’s CPU module for a failure. If during normal control operation only the 24/8 Analog I/O module’s Fault LED is on or flashing, ensure that it is installed in the correct slot. If it is, then replace that 24/8 Analog I/O module. See instructions for replacing the module in Chapter 21, Installation and Service. When a module fault is detected, its outputs should be disabled or de-energized.

Analog Inputs
If an analog input is not functioning properly, verify the following:
• Check that the cable is shielded and the shield is properly grounded per the section on Shields and Grounding in Chapter 21, Installation and Service.
• Measure the input voltage on the terminal block. It should be in the range of 0–5 V.
• Look at the individual inputs into each kernel. Each 24/8 Analog I/O module reads the same input from the FTM, so the application software should contain three separate numbers, one from each 24/8 Analog I/O module. The numbers should be within 0.1% of each other unless a high common mode voltage is present.

The following actions may shut down the prime mover.
• If all of the 24/8 Analog I/O modules are reading approximately the same number, but the reading is incorrect, go to step 1. If two of the 24/8 Analog I/O modules are reading correctly, but one is reading incorrectly, go to step 2.
1. Check the wiring. If the inputs are reading 0 or the engineering units that correspond to 0 mA, look for a loose connection on the terminal blocks, disconnected or misconnected cables, a missing jumper on the terminal block if the input is a loop powered current input, or a blown fuse on the 24 Vdc on the FTM. See instructions for replacing the fuse on the FTM below. If all of the inputs are reading high, check to ensure that the 24 Vdc is not connected across the input directly. Check the fuse on the 24/8 Analog I/O module. See instructions for replacing the module in Chapter 21, Installation and Service. This fuse is visible and can be changed through the bottom of the module. If this fuse is blown, fix the wiring problem and replace the fuse with a fuse of the same type and rating. Check the application software configuration to ensure that the input is configured properly. If the connections and application software are verified and the correct voltage is present on the terminal block, but all of the 24/8 Analog I/O modules are reading 0 V, exchange FTM #1 with FTM #2. See instructions for replacing the FTM in Chapter 15. If the problem follows the FTM, replace the FTM. The FTM contains only a wire wound 3 W resistor and traces, so failure is extremely unlikely.

2. If one or two of the 24/8 Analog I/O modules are reading the correct number, but the other 24/8 Analog I/O module(s) is (are) incorrect, check the application software configuration of the modules with the non-working channels, and check to ensure that the cables are connected properly. If the other channels on the same 24/8 Analog I/O module are not working either, check the fuse on the 24/8 Analog I/O module. See instructions for replacing the module in Chapter 21, Installation and Service. This fuse is visible and can be changed through the bottom of the module. If this fuse is blown, fix the wiring problem and replace the fuse with a fuse of the same type and rating. If the reading is still incorrect, but the other readings from the 24/8 Analog I/O module are correct, remove the 24/8 Analog I/O module and exchange the J1 and J2 cables. If the problem moves to a different channel, replace the cable. If not, replace the 24/8 Analog I/O module. If the readings are incorrect on several channels of the 24/8 Analog I/O module, corresponding to both cables, replace the 24/8 Analog I/O module.

**Analog Outputs**

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

- Check that the cable is shielded and the shield is properly grounded. Shields and Grounding section in Chapter 21, Installation and Service.
- Check the load resistance to ensure that it is below 600 ohms.
- Check to ensure that the load wiring is isolated.

**CAUTION**

The following actions may shut down the prime mover.

- Disconnect the field wiring and connect a resistor across the output. If the output current is 0 mA, go to step 1. If the output current is correct, but some of the outputs have a fault, go to step 2.
1. Check the wiring for a loose connection on the terminal blocks or disconnected or misconnected cables. If none of the outputs on a given 24/8 Analog I/O module are functioning, check the 24/8 Analog I/O module fuse. See instructions for replacing the module in Chapter 21, Installation and Service. This fuse is visible and can be changed through the bottom of the module. If the fuse is blown, fix the wiring problem and replace the fuse with a fuse of the same type and rating. Check the application software configuration to ensure that the output is configured properly. If the connections and application software are verified, exchange FTM #1 with FTM #2. See instructions for replacing the FTM in Chapter 15. If the problem follows the FTM, replace the FTM. The FTM contains only traces and a few discrete components, so failure is extremely unlikely.

2. If one or two of the 24/8 Analog I/O modules have an output fault, but the other module(s) does (do) not, check the application software, and check to ensure that the cables are connected properly. If the other output channels on the same 24/8 Analog I/O module are also not working, check the fuse on the 24/8 Analog I/O module. See instructions for replacing the module in Chapter 21, Installation and Service. This fuse is visible and can be changed through the bottom of the module. If the fuse is blown, fix the wiring problem and replace the fuse with a fuse of the same type and rating. If the output still has a fault, but the other output channels on the 24/8 Analog I/O module are functioning properly, remove the 24/8 Analog I/O module and exchange the J1 and J2 cables. If the problem moves to a different channel, replace the cable. If not, replace the 24/8 Analog I/O module. If the readings are incorrect on several channels of the 24/8 Analog I/O module, corresponding to both cables, replace the same 24/8 Analog I/O module.

Replacing a Fuse on the Field Terminal Module (FTM)
1. Verify that the condition that caused the fuse to blow has been corrected.

2. Remove FTM cover carefully, to prevent contact with any FTM circuitry under the cover. To remove the FTM cover, pinch the retaining barb and lift the cover.

3. Locate and replace the fuse with another fuse of the same size, type, and rating. See Figure 12-12 or Figure 12-13 for channel fuse location.

4. Replace the FTM Cover.

If power has not been removed from the control system, power will be active at the module and also at the FTM. Shorting of protected circuitry could cause a control system shutdown.
8.4—TMR Analog Combo Module

8.4.1—Module Description

Each High Density Analog Combo module contains circuitry for four speed sensor inputs, eight analog inputs, four analog outputs, and two proportional actuator driver outputs. Each speed sensor input may be from a magnetic pick-up or from a proximity probe, each analog input must be 4–20 mA, and each actuator driver may be configured as 4–20 mA or 20–160 mA.

There are two configurations of the Analog Combo Modules. One has the analog inputs configured for 4–20 mA and the other is configured for 0–5 V. See Appendix A for specific part numbers. In a simplex system, either Analog Combo module is connected through two analog cables to one Analog Combo FTM. All of the I/O are accessible on the FTM, and the channels are labeled to correspond to their software locations, e.g. analog input 1 on the FTM will be analog input 1 in the application software.

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

Figure 8-5—Analog Combo Module
8.4.2—Module Specifications

Digital Speed Sensor Inputs
Number of channels: 4
Update time: 5 ms

MPU Input Ratings
Input frequency: 100 - 25000 Hz
Input amplitude: 1-25 Vrms
Input impedance: 2000 Ohms
Isolation voltage: 500 Vrms
Resolution: 12 bits minimum over chosen frequency range
Accuracy: 0.03% full scale, minimum

Proximity Probe Input Ratings
Input frequency: 0.5 - 25000 Hz
Input amplitude: 3.5 - 32 Vdc input to the module
Available power: 12 Vdc or 24 Vdc, 50 mA maximum
Isolation voltage: 0 Vrms
Resolution: 12 bits minimum over chosen frequency range
Accuracy: Software calibrated to 0.03% full scale
Fuse: 24 Vdc 100 mA fuse/channel, 12 Vdc short circuit protected
Time Stamping: 5 millisecond resolution on low event and low latch

Analog Input Ratings
Number of channels: 8
Update time: 5 millisecond
Input range: 0–25 mA

The maximum input voltage range may vary between 4.975 and 5.025 Volts from module to module.

Isolation: 0 VRMS, -60 dB CMRR, 200 Vdc common mode rejection voltage; no galvanic isolation
Input impedance: 200 ohms
Anti-aliasing filter: 2 poles at 10 ms
Resolution: 16 bits
Accuracy: Software calibrated to 0.1%, over 25 mA full scale
Temp drift: 275 ppm/C, maximum
Fuse: 100 mA fuse per channel
Time stamping: 5 ms resolution on low event and latch, and high event and latch

4–20 mA Analog Output Ratings
Number of channels: 4
Update time: 5 ms
Driver: Pulse Width Modulated (PWM)
PWM frequency: 6.14 kHz
Filter: 3 poles at 500 ms
Current output: 4–20 mA current output range: 0 - 25 mA
Isolation: 0 Vrms
Max load resistance: 600 ohms (load + wire resistance)
Current readback: 11 bits
Readback isolation: -60 dB CMRR, 200 Vdc common mode
Resolution: 11 bits
Accuracy: Software calibrated to 0.2%, over 25 mA full scale
Temperature drift: 125 ppm/C, maximum
Readback accuracy: 0.2%, over 25 mA full scale
Readback temp drift: 400 ppm/C, maximum

Actuator Driver Output Ratings
Number of channels: 2
Update time: 5 millisecond
Driver: PWM (proportional only), single or dual coil
PWM frequency: 6.14 kHz
Filter: 3 poles at 500 microseconds
Current output: 4–20 mA or 20–160 mA, software selectable
Current output range: 0-24 mA or 0–196 mA, depending on the selected range
Isolation: 0 Vrms
Max. act resistance: 45 ohms on the 20–160 mA output, 360 ohms on the 4–20 mA output

Readback
Actuator source and return currents
Readback isolation: -60 dB CMRR, 200 Vdc common mode
Dither current: 25 Hz, fixed duty cycle, software variable amplitude
Resolution: 11 bits over 25 or 200 mA range
Accuracy: Software calibrated to 0.2% of 25 or 200 mA range
Temperature drift: 125 ppm/C, maximum
Readback accuracy: 0.1% of 25 or 200 mA range
Readback temp drift: 150 ppm/C, maximum

88.4.3—Installation

The modules slide into card guides in the control’s chassis and plug into the motherboard. The modules are held in place by two screws, one at the top and one at the bottom of the front panel. Also at the top and bottom of the module are two handles which, when toggled (pushed outward), move the modules out just far enough for the boards to disengage the motherboard connectors.

Three MPU and Analog I/O modules are connected through six analog cables (two from each module) to two FTMs. Each MPU and Analog I/O module has two sub D connectors on the front panel. The top sub D connector contains the first half of the channels (speed sensor channels 1 and 2, actuator channel 1, analog output channels 1 and 2, and analog input channels 1-4), and the bottom sub D connector contains the second half of the I/O channels. See Figure 8-6 for an example.

Figure 8-6—Example Fault Tolerant System Configuration
Field Wiring
See Chapter 12 for complete wiring connections for the TMR Analog Combo FTM. Wire each channel per the following examples for each type of signal.

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

Any of the module's four speed channels accepts passive magnetic pickup units (MPUs) or proximity probes. Each speed input channel can only accept one MPU or one proximity probe.

A proximity probe may be used to sense very low speeds. With a proximity probe, speed can be sensed down to 0.5 Hz. When interfacing to open collector type proximity probes, a pull-up resistor is required between the supplied proximity probe voltage and the proximity probe input to the FTM. Individually fused 12 Vdc and 24 Vdc sources are provided with each speed input to power system proximity probes (100 mA fuses, located on the FTMs, are used). External pull-up resistors are required when interfacing with an open collector type proximity probe. See Figure 8-7 for MPU/proximity probe wiring example. Channel 1 shows an MPU connection, channel 2 shows a 24 V proximity connection, and channel 3 is an example of a 12 V proximity connection. Always jumper the unused MPU connection to eliminate possible noise interference when connecting a proximity probe.

IMPORTANT
It is not recommended that gears mounted on an auxiliary shaft coupled to the rotor be used to sense speed. Auxiliary shafts tend to turn more slowly than the rotor (reducing speed sensing resolution) and have coupling gear backlash, resulting in less than optimum speed control. For safety purposes, it is also not recommended that the speed sensing device sense speed from a gear coupled to a mechanical drive side of a system's rotor coupling.
When a speed sensor input channel has been wired as *either* MPU or proximity probe input, the unused MPU/Prox must be jumpered at the FTM. When an input channel is not used, both the MPU and Prox inputs must be jumpered. See example in Figure 8-7.

Figure 8-7—MPU/Proximity Interface Wiring to the TMR Analog Combo FTM
Analog Inputs

The analog inputs must be current type. See Appendix A for specific part numbers. All modules use the same cable and FTMs.

All current inputs may be used with two-wire ungrounded (loop powered) transducers or isolated (self-powered) transducers. All analog inputs have 200 Vdc of common mode rejection. If interfacing to a non-isolated device, which may have the potential of reaching over 200 Vdc with respect to the control’s common, the use of a loop isolator is recommended to break any return current paths that may produce erroneous readings. All current inputs use 200 ohm resistors across their inputs.

Each current input channel may power its own 4–20 mA transducer. This power is protected with a 100 mA fuse on each channel to prevent an inadvertent short from damaging the module. The 24 Vdc outputs are capable of providing 24 Vdc with ±10% regulation. Power connections can be made through terminals located on the FTMs. Refer to Figure 8-8 for 4–20 mA Current Input wiring.

![Current Input Wiring for an Analog Combo Module FTM](image-url)
Only self-powered voltage transducers should be used on voltage input channels. The full scale range must not exceed 5 volts. Refer to Figure 8-9 for 0–5 Vdc voltage transducer input wiring.

Figure 8-9—Voltage Input Wiring for an Analog Combo Module FTM
Analog Outputs
The analog outputs are 4–20 mA with a full-scale range of 0–25 mA. Each output monitors the output source current for fault detection. All of the analog outputs may be individually disabled. When a channel fault or a module fault is detected, the application program may annunciate the fault, disable the channel or module, and stop using the data in system calculations or control.

The Analog Combo module has four 4–20 mA current output drivers. All analog outputs can drive a maximum load of 600 ohms (load + wire resistance). Care should be taken to prevent ground loops and other faults when interfacing to non-isolated devices. See Figure 8-10 for an example of 4–20 mA output wiring.

Actuator Outputs
The actuator outputs may be configured for 4–20 mA or 20–160 mA. Configuration is done through the application software; no hardware modifications in the forms of jumpers or switches are necessary. For fault detection, each output monitors the output source current and the output return current. All of the actuator outputs may be individually disabled. When a channel fault or a module fault is detected, the application program may annunciate the fault, disable the channel or module, and stop using the data in system calculations or control.

Dither may be provided in the application software for each output. Dither is a low frequency (25 Hz) signal consisting of a 5 millisecond pulse modulated onto the DC actuator-drive current to reduce sticking due to friction in linear type actuators. Woodward TM-type actuators typically require dither. Dither amplitude is variable through the application software. See Figure 8-10 for an example of actuator wiring.

**IMPORTANT**
For a dual coil actuator in a simplex system, two actuator driver outputs must be used.

Configuration Notes
- Maximum impedance for a 4 to 20 mA actuator output driver is 360 ohms (actuator impedance + wire resistance).
- Maximum impedance for a 20 to 160 mA actuator output is 45 ohms (actuator impedance + wire resistance).
- Each actuator driver senses its source and return current to allow overcurrent and undercurrent alarms and shutdowns.

8.4.4—FTM Reference
See Chapter 12 for complete Analog Combo FTM field wiring information. See Appendix A for proper Module, FTM, and cable part numbers.
Figure 8-10—Analog Output and Actuator Wiring for an Analog Combo FTM
8.4.5—Troubleshooting

Fault Detection (Module Hardware)
Each Analog Combo module has a red Fault LED that is turned on when the system is reset. During initialization of a module, which occurs after every CPU reset, the CPU turns the Fault LED on. The CPU then tests the module using diagnostic routines built into the software. If the diagnostic test is not passed, the LED remains on or blinks. If the test is successful, the LED goes off. If the Fault LED on a module is illuminated after the diagnostics and initialization have been completed, the Analog Combo module may be faulty or may be located in the wrong slot.

<table>
<thead>
<tr>
<th>Number of LED Flashes</th>
<th>Failure</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Hardware watchdog, CPU clock failure, reset fail</td>
</tr>
<tr>
<td>2</td>
<td>Micro-controller internal RAM test failure</td>
</tr>
<tr>
<td>3</td>
<td>External RAM test failure</td>
</tr>
<tr>
<td>4</td>
<td>Unexpected exception error</td>
</tr>
<tr>
<td>5</td>
<td>Dual Port RAM test failure</td>
</tr>
<tr>
<td>6</td>
<td>EEPROM failure</td>
</tr>
<tr>
<td>7</td>
<td>Communications watchdog time out</td>
</tr>
</tbody>
</table>

Table 8-2—LED Indications of Failure

Fault Detection (I/O)
In addition to detecting module hardware faults, the application program may detect I/O faults.

Analog Input Faults. The application software may set a high and low latch setpoint to detect input faults.

Speed Sensor Input Faults. The application software may set a high and low latch setpoint to detect input faults. The low latch setpoint must be greater than one fiftieth of the frequency range.

Analog Output Driver Faults. The module monitors the source currents and annunciates faults. The application determines the course of action in the event of a fault.

Actuator Driver Or Load Faults. The module monitors the source and return currents and annunciates faults. The application determines the course of action in the event of a fault.

Micro-controller Faults. The system monitors a software watchdog, a hardware watchdog, and a software watchdog on the VME bus communications. All outputs are shutdown in the event of a microcontroller fault.

Troubleshooting Guide
If during normal control operation all of a chassis’ I/O modules have Fault LEDs on, check the kernel’s CPU module for a failure. If during normal control operation only the MPU and Analog I/O module’s Fault LED is on or flashing, insure that it is installed in the correct slot. If it is, then replace that MPU and Analog I/O module. See instructions for replacing the module in Chapter 21, Installation and Service. When a module fault is detected, its outputs should be disabled or de-energized.
Speed Sensor Inputs

MPUs. If a speed sensor input is not functioning properly, verify the following:

- Check that the cable is shielded and the shield is properly grounded per the Shields and Grounding section in Chapter 21, Installation and Service.
- Measure the input voltage on the terminal block. It should be in the range of 1-25 VRMS.
- Verify that the signal waveform is clean and void of double zero crossings.
- Verify that no ground connection exists and that the resulting 60 Hz signal is absent.
- Measure the frequency. It should be in the range of 100 Hz - 25 kHz.
- Look at the individual inputs into each kernel. A and B should read an input, and C should also read this input if the terminal block jumpers are installed. The application software should contain three separate numbers, one from each module. The numbers should be within 0.1% of each other, except kernel C if the jumpers are not installed.
- Verify that any unused MPU/Proxi inputs are jumpered per Figure 8-7.

The following actions may shut down the prime mover. If all of the MPU and Analog I/O modules are reading approximately the same number, but it is not the right reading, go to step 1. If two of the MPU and Analog I/O modules are reading correctly, but one is reading incorrectly, go to step 2.

1. Check the wiring. If the inputs are reading 0, look for a loose connection on the terminal blocks or disconnected or misconnected cables. Check the application software configuration to ensure that the input is configured properly. If the connections and application software are verified and the correct voltage is present on the terminal block, but all of the MPU and Analog I/O modules are reading 0 V, exchange FTM #1 with FTM #2. See instructions for replacing the FTM in Chapter 15. If the problem follows the FTM, replace the FTM. The FTM contains only traces and a few discrete components, so failure is extremely unlikely.

2. If one or two of the MPU and Analog I/O modules are reading the correct number, but the other module(s) is (are) incorrect, check the application software configuration of the modules with the non-working channels, and check to ensure that the cables are connected properly. If C kernel is not working, but A and B are, check to ensure that the terminal block jumpers are installed if the MPU can drive three inputs. If the reading is still incorrect, but the other readings from the MPU and Analog I/O module are correct, remove the MPU and Analog I/O module and exchange the J1 and J2 cables. See instructions for replacing the module in Chapter 21, Installation and Service. If the problem moves to a different channel, replace the cable. If not, replace the MPU and Analog I/O module. If the readings are incorrect on several channels of the same MPU and Analog I/O module, corresponding to both cables, replace the MPU and Analog I/O module.
Proximity Probes. If a speed sensor input is not functioning properly, verify the following:
- Check that the cable is shielded and the shield is properly grounded per the Shields and Grounding section in Chapter 21, Installation and Service.
- Measure the input voltage on the terminal block. It should be in the range of 3.5 - 32 Vpeak.
- Verify that the signal waveform is clean and void of double zero crossings.
- Verify that no ground connection exists and that the resulting 60 Hz signal is absent.
- Measure the frequency. It should be in the range of 0.5 Hz, to 25 kHz.
- Check the wiring. Look for a loose connection at the terminal blocks, disconnected or misconnected cables, a missing jumper on the terminal block, or a blown fuse on the 24 Vdc on the FTM. See Figure 11-21 for FTM fuse locations.
- Check the software configuration to ensure that the input is configured properly.
- Check the fuse on the FTM. See the instructions and fuse locations below.
- If the other channels on the MPU and Analog I/O module are also not working, check the fuse on the MPU and Analog I/O module. This fuse is visible and can be changed through the bottom of the module. If the fuse is blown, fix the wiring problem and replace the fuse with another fuse of the same type and rating.
- Look at the individual inputs into each kernel. Each module reads the same input from the FTM, so the software should contain three separate numbers, one from each MPU and Analog I/O module. The numbers should be within 0.1% of each other unless a high common mode voltage is present.
- Verify that any unused MPU/Prox inputs are jumpered per Figure 8-7.

The following actions may shut down the prime mover. If all of the MPU and Analog I/O modules are reading approximately the same number, but it is not the right reading, go to step 1. If two of the modules are reading correctly, but one is reading incorrectly, go to step 2.

1. Check the wiring. If the inputs are reading 0, look for a loose connection on the terminal blocks, disconnected or misconnected cables, a missing jumper on the terminal block, or a blown fuse on the 24 Vdc on the FTM. See instructions for replacing the fuse, below. Check the MPU and Analog I/O module fuse. See instructions for replacing the module in Chapter 21, Installation and Service. This fuse is visible and can be changed through the bottom of the module. If the fuse is blown, fix the wiring problem, then replace the fuse with another fuse of the same type and rating. Check the application software configuration to ensure that the input is configured properly. If the connections and application software are verified and the correct voltage is present on the terminal block, but all of the MPU and Analog I/O modules are reading 0 V, exchange FTM #1 with FTM #2. See instructions for replacing the FTM in Chapter 15. If the problem follows the FTM, replace the FTM. The FTM contains only a wire wound 3 W resistor and traces, so failure is extremely unlikely.
2. If one or two of the MPU and Analog I/O modules are reading the correct number, but the other module(s) is (are) incorrect, check the application software configuration of the modules with the non-working channels, and check to ensure that the cables are connected properly. If the other channels on the same MPU and Analog I/O module are also not working, check the fuse on the MPU and Analog I/O module. See the instructions for replacing the module in Chapter 21, Installation and Service. This fuse is visible and can be changed through the bottom of the module. If this fuse is blown, fix the wiring problem and replace the fuse with a fuse of the same type and rating. If the reading is still incorrect, but the other readings from the MPU and Analog I/O module are correct, remove the MPU and Analog I/O module and exchange the J1 and J2 cables. If the problem moves to a different channel, replace the cable. If not, replace the MPU and Analog I/O module. If the readings are incorrect on several channels of the MPU and Analog I/O module, corresponding to both cables, replace the MPU and Analog I/O module.

**Analog Inputs**

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

- Check that the cable is shielded and the shield is properly grounded per the Shields and Grounding section in Chapter 21, Installation and Service.
- Measure the input voltage on the terminal block. It should be in the range of 0–5 V.
- Look at the individual inputs into each kernel. Each module reads the same input from the FTM, so the application software should contain three separate numbers, one from each MPU and Analog I/O module. The numbers should be within 0.1% of each other unless a high common mode voltage is present.
- Check the wiring. If the inputs are reading 0 or the engineering units that correspond to 0 mA, look for a loose connection on the terminal blocks, disconnected or misconnected cables, a missing jumper on the terminal block if the input is a current input, or a blown fuse on the 24 Vdc on the FTM. See Figure 11-21 for FTM fuse locations.
- If all of the inputs are reading high, check that the 24 Vdc is not connected across the input directly.
- Check the software configuration to ensure that the input is configured properly.
- Check the fuse on the FTM. See the instructions and fuse locations below.

![CAUTION](image)

The following actions may shut down the prime mover. If all of the MPU and Analog I/O modules are reading approximately the same number, but the reading is incorrect, go to step 1. If two of the MPU and Analog I/O modules are reading correctly, but one is reading incorrectly, go to step 2.

1. Check the wiring. If the inputs are reading 0 or the engineering units that correspond to 0 mA, look for a loose connection on the terminal blocks, disconnected or misconnected cables, a missing jumper on the terminal block if the input is a loop powered current input, or a blown fuse on the 24 Vdc on the FTM. See instructions for replacing the fuses on the FTM, below. If all of the inputs are reading high, check to ensure that the 24 Vdc is not connected across the input directly. Check the MPU and Analog I/O module fuse. See instructions for replacing the module in Chapter 21, Installation and Service. This fuse is visible and can be changed through the bottom of the module. If the fuse is blown, fix the wiring problem, then replace the fuse with another fuse of the same type and rating. Check the application software configuration to ensure that the input is configured properly. If the connections and application software are verified and the correct voltage is
present on the terminal block, but all of the MPU and Analog I/O modules
are reading 0 V, exchange FTM #1 with FTM #2. See instructions for
replacing the FTM in Chapter 15. If the problem follows the FTM, replace
the FTM. The FTM contains only a wire wound 3 W resistor and traces, so
failure is extremely unlikely.

2. If one or two of the MPU and Analog I/O modules are reading the correct
number, but the other module(s) is (are) incorrect, check the application
software configuration of the modules with the non-working channels, and
check to ensure that the cables are connected properly. If the other
channels on the same MPU and Analog I/O module are not working either,
check the fuse on the MPU and Analog I/O module. See instructions for
replacing the module in Chapter 21, Installation and Service. This fuse is
visible and can be changed through the bottom of the module. If this fuse is
blown, fix the wiring problem and replace the fuse with a fuse of the same
type and rating. If the reading is still incorrect, but the other readings from
the MPU and Analog I/O module are correct, remove the MPU and Analog
I/O module and exchange the J1 and J2 cables. If the problem moves to a
different channel, replace the cable. If not, replace the MPU and Analog I/O
module. If the readings are incorrect on several channels of the MPU and
Analog I/O module, corresponding to both cables, replace the MPU and
Analog I/O module.

Analog Outputs

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

- Check that the cable is shielded and the shield is properly grounded per the
  Shields and Grounding section in Chapter 21, Installation and Service.
- Check the load resistance to ensure that it is below 600 ohms.
- Check to ensure that the load wiring is isolated.
- Check the wiring for a loose connection on the terminal blocks and
disconnected or misconnected cables.
- Disconnect the field wiring and connect a resistor across the output. If the
  output is correct across the resistor, there is a problem with the field wiring.
- If the other output channels on the MPU and Analog I/O module are also not
  working, check the fuse on the MPU and Analog I/O module. See
  instructions for module replacement in Chapter 21, Installation and Service.
  This fuse is visible and can be changed through the bottom of the module. If
  the fuse is blown, fix the wiring problem and replace the fuse with a fuse of
  the same type and rating.
Check the software configuration to ensure that the output is configured properly.

The following actions may shut down the prime mover. Disconnect the field wiring and connect a resistor across the output. If the output current is 0 mA, go to step 1. If the output current is correct, but some of the outputs have a fault, go to step 2.

1. Check the wiring for a loose connection on the terminal blocks or disconnected or misconnected cables. If none of the outputs on a given MPU and Analog I/O module are functioning, check the MPU and Analog I/O module fuse. See instructions for replacing the module in Chapter 21, Installation and Service. This fuse is visible and can be changed through the bottom of the module. If the fuse is blown, fix the wiring problem, then replace the fuse with another fuse of the same type and rating. Check the application software configuration to ensure that the output is configured properly. If the connections and application software are verified, exchange FTM #1 with FTM #2. See instructions for replacing the FTM in Chapter 15. If the problem follows the FTM, replace the FTM. The FTM contains only traces and a few discrete components, so failure is extremely unlikely.

2. If one or two of the MPU and Analog I/O modules have an output fault, but the other module(s) does (do) not, check the application software, and check to ensure that the cables are connected properly. If the other output channels on the same MPU and Analog I/O module are also not working, check the fuse on the MPU and Analog I/O module. See instructions for replacing the module in Chapter 21, Installation and Service. This fuse is visible and can be changed through the bottom of the module. If the fuse is blown, fix the wiring problem and replace the fuse with a fuse of the same type and rating. If the output still has a fault, but the other output channels on the MPU and Analog I/O module are functioning properly, remove the MPU and Analog I/O module and exchange the J1 and J2 cables. If the problem moves to a different channel, replace the cable. If not, replace the MPU and Analog I/O module. If the readings are incorrect on several channels of the MPU and Analog I/O module, corresponding to both cables, replace the same MPU and Analog I/O module.

Actuator Outputs
If an actuator output is not functioning properly, verify the following:

- Check that the cable is shielded and the shield is properly grounded per the Shields and Grounding section in Chapter 21, Installation and Service.
- Check the load resistance to ensure that it is below the specified limit.
- Check to ensure that the load wiring is isolated.
- Check the wiring for a loose connection on the terminal blocks or disconnected or misconnected cables.
- Disconnect the field wiring and connect a resistor across the output.
- If the other output channels on the MPU and Analog I/O module are also not working, check the fuse on the MPU and Analog I/O module. See instructions for module replacement in Chapter 21, Installation and Service. This fuse is visible and can be changed through the bottom of the module. If the fuse is blown, fix the wiring problem, and replace the fuse with a fuse of the same type and rating.
- Check the software configuration to ensure that the output is configured properly.
The following actions may shut down the prime mover. Disconnect the field wiring and connect a resistor across the output; if the output current is 0 mA, go to step 1. If the output current is correct, but some of the outputs have a fault, go to step 2.

1. Check the wiring for a loose connection on the terminal blocks, or disconnected or misconnected cables. If none of the outputs on a given MPU and Analog I/O module are functioning, check the MPU and Analog I/O module fuse. See instructions for replacing the module in Chapter 21, Installation and Service. This fuse is visible and can be changed through the bottom of the module. If the fuse is blown, fix the wiring problem, then replace the fuse with another fuse of the same type and rating. Check the application software configuration to ensure that the output is configured properly. If the connections and application software are verified, exchange FTM #1 with FTM #2. See instructions for replacing the FTM in Chapter 15. If the problem follows the FTM, replace the FTM. The FTM contains only traces and a few discrete components, so failure is extremely unlikely.

2. If one or two of the MPU and Analog I/O modules have an output fault, but the other module(s) does (do) not, check the application software configuration, and check to ensure that the cables are connected properly. Check the wiring for dual coil and single coil actuators, and ensure that the wiring configuration matches the application software configuration. If the other output channels on the same MPU and Analog I/O module are also not working, check the fuse on the MPU and Analog I/O module. See instructions for replacing the module in Chapter 21, Installation and Service. This fuse is visible and can be changed through the bottom of the module. If this fuse is blown, fix the wiring problem and replace the fuse with a fuse of the same type and rating. If the output still has a fault, but the other output channels on the MPU and Analog I/O module are functioning properly, remove the MPU and Analog I/O module and exchange the J1 and J2 cables. If the problem moves to the other channel, replace the cable. If not, replace the MPU and Analog I/O module. If the readings are incorrect on several channels of the same MPU and Analog I/O module, corresponding to both cables, replace the MPU and Analog I/O module.

Replacing a Fuse on the Field Terminal Module (FTM)
1. Verify that the condition that caused the fuse to blow has been corrected.

2. Remove FTM cover carefully, to prevent contact with any FTM circuitry under the cover. To remove the FTM cover, pinch the retaining barb and lift the cover.

3. Locate and replace the fuse with another fuse of the same size and rating. See Figure 11-20 or Figure 11-21 for channel fuse locations.

4. Replace the FTM cover.
8.5—24/8 Analog Module

8.5.1—Module Description

A 24/8 Analog module contains circuitry for twenty-four analog inputs and eight 4–20 mA outputs. These modules have no potentiometers and require no calibration. A module may be replaced with another module of the same part number without any adjustment.

The 24/8 Analog Modules come in four different configurations.

1. 24 channels of 4–20 mA inputs with 8 channels of 4–20 mA outputs (2-pole 10 ms filter on all input channels).
2. 24 channels of 4–20 mA inputs with 8 channels of 4–20 mA outputs (2-pole 10 ms filter on all input channels, except channels 23 and 24, which have 2-pole 5 ms filter).
3. 12 channels of 4–20 mA inputs, 12 channels 0–5 Vdc inputs with 8 channels of 4–20 mA outputs (2-pole 10 ms filter on all input channels).

All 4–20 mA analog inputs may be used with two-wire ungrounded (loop powered) transducers or isolated (self-powered) transducers. All analog inputs have 200 Vdc of common mode rejection. If interfacing to a non-isolated device, which may have the potential of reaching over 200 Vdc with respect to the control’s common, the use of a loop isolator is recommended to break any return current paths producing erroneous readings.

Each board has an on-board processor for automatic calibration of the I/O channels. Each analog input incorporates a time-stamping feature with 5 ms resolution for two low setpoints and two high setpoints.
8.5.2—Module Specification

Analog Input Ratings

- Number of channels: 24
- Update time: 5 ms
- Input range: 0–25 mA or 0–5 V; software and hardware selectable

The maximum voltage input range may vary between 4.975 and 5.025 Volts from module to module.

<table>
<thead>
<tr>
<th>Property</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Isolation</td>
<td>0 Vrms, 60 dB CMRR, 200 Vdc common mode rejection voltage; no galvanic isolation</td>
</tr>
<tr>
<td>Input imp. (4–20 mA)</td>
<td>200 ohms</td>
</tr>
<tr>
<td>Anti-aliasing filter</td>
<td>2 poles at 10 ms</td>
</tr>
<tr>
<td>Resolution</td>
<td>16 bits</td>
</tr>
<tr>
<td>Accuracy</td>
<td>Software calibrated to 0.1%, over 0–25 mA full scale</td>
</tr>
<tr>
<td>Temp drift</td>
<td>275 ppm/C, maximum</td>
</tr>
<tr>
<td>Fuse</td>
<td>100 mA fuse per channel</td>
</tr>
</tbody>
</table>

Time stamping: 5 ms resolution on low event and latch, and high event and latch
The 24 channel analog inputs are divided into two banks, with channel 1 through channel 12 data gathering at 1.8 ms after the MFT tick and channel 13 through channel 24 data gathering at 3.7 ms after the MFT tick.

### 4–20 mA Output Ratings

- **Number of channels:** 8
- **Update time:** 5 ms
- **Output Driver:** Pulse Width Modulated (PWM)
- **PWM frequency:** 6.14 kHz
- **Filter:** 3 poles at 500 ms
- **Current output:** 4–20 mA
- **Current output range:** 0–25 mA
- **Isolation:** 0 Vrms
- **Max load resistance:** 600 ohms (load + wire resistance)
- **Current readback:** 8 bits
- **Readback isolation:** 60 dB CMRR, 200 Vdc common mode rejection voltage
- **Resolution:** 11 bits
- **Accuracy:** Software calibrated to 0.2% of 0–25 mA full scale
- **Temperature drift:** 125 ppm/C, maximum
- **Readback accuracy:** 0.5% of 0–25 mA full scale
- **Readback temp drift:** 400 ppm/C, maximum

### 8.5.3—Installation

The modules slide into card guides in the control’s chassis and plug into the motherboard. The modules are held in place by two screws, one at the top and one at the bottom of the front panel. Also at the top and bottom of the module are two handles which, when toggled (pushed outward), move the modules out just far enough for the boards to disengage the motherboard connectors.

Each 24/8 Analog Module is connected through two High Density Analog/Discrete cables to two 24/8 Analog FTMs. All I/Os on the module are accessible on the FTM, and the channels are labeled to correspond to their software locations (e.g., analog input 1 on the FTM will be analog input 1 in the application software). See Figure 8-13 for an example.
Analog Inputs
For a 4–20 mA input signal, the 24/8 Analog Module uses a 200 ohm resistor across the input located on the 24/8 Analog Module. Each analog input channel may power its own 4–20 mA transducer. See Figure 8-14 for analog input connection. This power is protected with a 100 mA fuse on each channel to prevent an inadvertent short from damaging the module. The 24 Vdc outputs are capable of providing 24 Vdc with ±10% regulation. The maximum current is 0.8 A. Power connections can be made through terminals located on the 24/8 Analog FTM. See Chapter 12 for complete field wiring information for the 24/8 Analog FTM.

**IMPORTANT**
When configuring the AI Combo block in GAP, set Conf. input field to 1 for all inputs when used with the 24/8 Analog FTM. This will allow the block to use the module factory calibration values for the 4–20 mA inputs that were calibrated with 200 ohm internal resistors on the 24/8 Analog Module.
Figure 8-14—Analog Input Wiring for a 24/8 Analog FTM

**Analog Outputs**

There are 8 analog output channels of 4–20 mA with a full scale range of 0–25 mA. All Analog Outputs can drive a maximum load of 600 ohms (load + wire resistance). See Figure 8-15 for analog output connection. Each output monitors the output source current for fault detection. All of the analog outputs may be individually disabled. When a channel fault or a module fault is detected, the application program may annunciate the fault, disable the channel and stop using data in system calculations or control. Care should be taken to prevent ground loops and other faults when interfacing to non-isolated devices. See Chapter 12 for complete field wiring information for the Analog High Density FTM.
8.5.4—FTM Reference

See Chapter 12 for complete field wiring information for the Analog High Density FTM. See Appendix A for part number Cross Reference for modules, FTMs, and cables.

8.5.5—Troubleshooting

Each 24/8 Analog module has a red Fault LED that is turned on when the system is reset. During initialization of a module, which occurs after every CPU reset, the CPU turns the Fault LED on. The CPU then tests each module using diagnostic routines built into the software. If the diagnostic test is not passed, the LED remains on or blinks. If the test is successful, the LED goes off. If the Fault LED on a module is illuminated after the diagnostics and initialization have been run, the module may be faulty or may be located in the wrong slot.

Number of LED Flashes | Failure                                           
-----------------------|--------------------------------------------------
          1            | Hardware watchdog, CPU clock failure, reset fail 
          2            | Micro-controller internal RAM test failure      
          3            | External RAM test failure                       
          4            | Unexpected exception error                      
          5            | Dual Port RAM test failure                      
          6            | EEPROM failure                                  
          7            | Communications watchdog time out                
          8            | EEPROM error is corrected (reset the module to continue) 
          9            | Missing an A/D Converter interrupt              

Table 8-3—LED Indications of Failure

Fault Detection (I/O)

In addition to detecting the High Density Analog I/O module hardware faults, the application software may detect I/O faults.

Analog Input Faults: The application software may be set with a high and low latch setpoint to detect input faults.

Analog Output Driver Faults: The module monitors the source currents and annunciates faults. The application software determines the course of action in the event of a fault.
Microcontroller Faults: The system monitors a software watchdog, a hardware watchdog, and a software watchdog on the VME bus communications. All outputs are shut down in the event of a microcontroller fault.

Troubleshooting Guide
If during normal control operation, all of the 24/8 Analog modules have Fault LEDs on, check the chassis' CPU module for a failure. If during normal control operation only the 24/8 Analog module’s Fault LED is on or flashing, insure that it is installed in the correct slot. If it is, then replace that module. See instructions for replacement in Chapter 15. When a module fault is detected, its outputs will be disabled or de-energized.

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

1. Check that the cable is shielded and the shield is properly grounded per the Shields and Grounding section in Chapter 14.
2. Measure the input voltage on the FTM terminal block. It should be in the range of 0–5 V.
3. Verify that there are no or minimal AC components to the Analog Input signal. Improper shielding may introduce AC noise on the input terminals.
4. Check the wiring. If the inputs are reading 0 or the engineering units that correspond to 0 mA, look for a loose connection on the terminal blocks, disconnected or misconnected cables, a missing jumper on the terminal block if the input is a current input, or a blown fuse on the 24 Vdc on the FTM.
5. If all of the inputs are reading high, check that the 24 Vdc is not connected across the input directly.
6. Check the software configuration to ensure that the input is configured properly.
7. If all of the channels on the 24/8 Analog module are not working, check the fuse on the 24/8 Analog module. See instructions for module replacement in Chapter 15. This fuse is visible and can be changed through the bottom of the module. If the fuse is blown, fix the wiring problem, then replace the fuse with another fuse of the same type and rating.
8. After verifying all of the above, exchange the J1 and J2 cables. If the problem moves to a different channel, replace the cable. If not, replace the module.
9. If the readings are incorrect on several channels of the 24/8 Analog module, corresponding to both cables, replace the module.
10. If replacing the module does not fix the problem, replace the FTM. The FTM contains only traces and a few discrete components, so failure is extremely unlikely. See instructions for replacing the FTM in Chapter 15.
Analog Outputs

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

1. Check that the cable is shielded and the shield is properly grounded per the Shields and Grounding section in Chapter 14.
2. Check the load resistance to ensure that it is not greater than 600 ohms.
3. Check to ensure that the load wiring is isolated.
4. Check the wiring for a loose connection on the FTM terminal blocks and disconnected or misconnected cables.
5. Disconnect the field wiring and connect a resistor across the output. If the output is correct across the resistor, there is a problem with the field wiring.
6. If all of the channels on the 24/8 Analog module are not working, check the fuse on the 24/8 Analog module. See instructions for module replacement in Chapter 15. This fuse is visible and can be changed through the bottom of the module. If the fuse is blown, fix the wiring problem, then replace the fuse with another fuse of the same type and rating.
7. Check the software configuration to ensure that the output is configured properly.
8. After verifying all of the above, exchange the J1 and J2 cables. If the problem moves to a different channel, replace the cable. If not, replace the module.
9. If the readings are incorrect on several channels of the module, corresponding to both cables, replace the module.
10. If replacing the module does not fix the problem, replace the FTM. The FTM contains only traces and a few discrete components, so failure is extremely unlikely. See instructions for replacing the FTM in Chapter 15.
8.6—Dataforth® 24/8 Analog Module

8.6.1—Module Description

The Dataforth® Analog Module uses the same board as utilized in the 24/8 Analog Module in section 7.3. The module is configured for 24 channels of 0–5 Vdc inputs and 8 channels of 4–20 mA outputs. In place of the two standard 24/8 Analog FTMs, two special Simplex Dataforth FTMs are connected through two high density analog/digital cables. The Simplex Dataforth FTM is designed to convert sensor input signals to a 0 to 5 V input compatible with the 24/8 Analog 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. Each module can plug into any of the 12 channels on the FTM. Each plug-in module converts the incoming signal to a 1 to 4 volt signal. No Calibration is required on the FTM or its plug-in modules. The plug-in modules are powered directly through the cable connector; resulting in no need for external power connections to the FTM. These plug-in modules currently include 4–20 mA input (internal shunt resistor), 0–5 Vdc input (pass through), 100 Ω RTDs, 200 Ω RTDs, and Type K Thermocouples. For Analog Outputs no plug-in modules are required. Isolation is provided on each channel. Channels are labeled to correspond to their software locations (e.g., analog input 1 on the FTM corresponds to analog input 1 in the application software.)
8.6.2—Specifications

To obtain overall signal input accuracy and bandwidth, the Dataforth FTM (0–5 V) module input accuracy and the Dataforth 24/8 Analog Module must be taken into account.

<table>
<thead>
<tr>
<th>Module</th>
<th>K Type Thermocouple</th>
<th>RTD 100 Ω Pt European Curve</th>
<th>Pass Through with 200 Ω Resistor (0.1%, 3 Watt)</th>
<th>Pass Through</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dataforth P/N</td>
<td>SCM7B47K-1458</td>
<td>SCM7B34-1459</td>
<td>SC7B8PT-1460</td>
<td>SC7BPT</td>
</tr>
<tr>
<td>Woodward P/N</td>
<td>1784-653</td>
<td>1784-655</td>
<td>1784-659</td>
<td>1784-657</td>
</tr>
<tr>
<td>Input Range</td>
<td>-70°F (-56.67°C)</td>
<td>-70°F (-56.67°C)</td>
<td>0 to 25 mA (Limited by MicroNet card input range.)</td>
<td>0 to 5 V (limited by MicroNet card input range.)</td>
</tr>
<tr>
<td>Input Protection</td>
<td>Continuous</td>
<td>120 Vrms max</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Input Protection</td>
<td>Transient</td>
<td>ANSI/IEEE C37.90.1-1989</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Output Range</td>
<td>1 to +5 V Linearized</td>
<td>1 to +5 V Linearized</td>
<td>0 to 5 V**</td>
<td>0 to 5 V</td>
</tr>
<tr>
<td>Isolation (Input to Output)</td>
<td>1500 Vrms</td>
<td>1500 Vrms</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>CMRR (50 or 60 Hz)</td>
<td>100 dB</td>
<td>100 dB</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Accuracy Maximum</td>
<td>±0.32% of Span*</td>
<td>±0.075% of Span*</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Gain Stability</td>
<td>±40 ppm/°C</td>
<td>±60 ppm/°C</td>
<td>±20 ppm/°C</td>
<td>N/A</td>
</tr>
<tr>
<td>Input Offset Stability</td>
<td>±0.5 μV/°C</td>
<td>±1.0 μV/°C</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Output Offset Stability</td>
<td>±0.002%Span/°C</td>
<td>±0.002%Span/°C</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Open Input Response</td>
<td>Upscale</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Open Input Detection Time</td>
<td>10 s. max</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Bandwidth (-3 dB)</td>
<td>150 Hz</td>
<td>150 Hz</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Step Response (0 to 90%)</td>
<td>3 ms</td>
<td>3 ms</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Supply Voltage</td>
<td>14-35 Vdc</td>
<td>14-35 Vdc</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Supply Current</td>
<td>30 mA max</td>
<td>30 mA max</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Supply Sensitivity</td>
<td>±0.0001%/% Vs</td>
<td>±0.0001%/% Vs</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Operating Temp. Range</td>
<td>+5 to +45°C</td>
<td>-40 to +85°C</td>
<td>-40 to +85°C</td>
<td>-40 to +85°C</td>
</tr>
<tr>
<td>Storage Temp. Range</td>
<td>-40 to +85°C</td>
<td>-40 to +85°C</td>
<td>-40 to +85°C</td>
<td>-40 to +85°C</td>
</tr>
<tr>
<td>Relative Humidity</td>
<td>0 to 90% Non-condensing</td>
<td>0 to 90% Non-condensing</td>
<td>0 to 90% Non-condensing</td>
<td>0 to 90% Non-condensing</td>
</tr>
<tr>
<td>Sensor Excitation Current</td>
<td>N/A</td>
<td>250 μA</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Lead Resistance Effect</td>
<td>N/A</td>
<td>±0.02°C/Ω max</td>
<td>N/A</td>
<td>N/A</td>
</tr>
</tbody>
</table>

Table 8-4—Module Accuracy

* Accuracy includes the effects of repeatability, hysteresis, and conformity. CJC sensor, thermocouple, or RTD sensor accuracy should be added to the module accuracy to compute the overall measurement accuracy.

** The maximum input voltage range may vary between 4.975 and 5.025 Volts from Dataforth module to Dataforth module.

Outputs can drive a maximum load of 600 ohms (load + wire resistance).
8.6.3—Installation

The modules slide into card guides in the control's chassis and plug into the motherboard. The modules are held in place by two screws, one at the top and one at the bottom of the front panel. Also at the top and bottom of the module are two handles which, when toggled (pushed outward), move the modules out just far enough for the boards to disengage the motherboard connectors.

Each Dataforth module is connected through two high density analog/discrete cables to two Simplex Dataforth FTMs. All I/Os on the module are accessible on the FTM. See Figure 8-17 for an example.

Field Wiring
See Chapter 12 for complete wiring connections for the Simplex Dataforth FTM. Each input channel requires a Dataforth plug-in module per input. Install one of the five different Dataforth modules into each of the 12 plug-in slots on the FTM. It is not necessary to have a plug-in module in a slot if not used. With the Simplex Dataforth FTM connected to J1 of the Dataforth Module, channels 1-12 will be active. With the Simplex Dataforth FTM connected to J2 of the Dataforth Module, channels 13-24 will be active. Wire each channel per the following examples for each type of plug-in module. Install jumpers on FTM module as shown for specific type of input.

Thermocouple Plug-in Module
The Thermocouple Plug-in module accepts a single input from a type K thermocouple. The signal is filtered, isolated, amplified, linearized, and converted to a 1 to +5 V analog voltage for output to the Dataforth 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.
The cold junction compensation (CJC) is performed by using an NTC thermistor, externally mounted on the FTM module, as shown in Figure 8-18. The thermocouple signal will fail high if an open wire is detected.

These modules incorporate both Thompson (Bessel) and Butterworth five-pole filter to maximize both time and frequency response. After the initial field side filtering, the input signal is chopped by a proprietary chopper circuit and transferred across the transformer isolation barrier. The signal is then reconstructed and filtered and scaled for 1 to 5 V for the Dataforth Module.

![Thermocouple Wiring to Simplex Dataforth FTM](image)

**Figure 8-18—Thermocouple Wiring to Simplex Dataforth FTM**

**RTD Plug-in Module**

The RTD Plug-in module accepts a single connection from a 100 or 200 Ohm Platinum RTD, depending on the selected RTD Plug-in module as shown in Figure 8-19. The input signal is filtered, isolated, amplified, linearized, and converted to a 1 to +5 V analog voltage for output to High Density Analog I/O Module.

These modules incorporate both Thompson (Bessel) and Butterworth five-pole filter to maximize both time and frequency response. After the initial field side filtering, the input signal is chopped by a proprietary chopper circuit and transferred across the transformer isolation barrier. The signal is then reconstructed and filtered and scaled for 1 to 5 V for the Dataforth 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 specific RTD non-linearity. Lead compensation is achieved by matching two current paths thus canceling the effects of lead resistance.
Current Input Plug-in Module
The Current Input Plug-in Module is a pass-through module with a 200 ohm precision shunt resistor to convert the 4–20 mA input to 0.8 to 4 Vdc signal. No filtering is done on this module. See Figure 8-20 for an example of wiring a loop powered transducer and Figure 8-21 for a self powered transducer.

**IMPORTANT** When configuring the AI Combo block in GAP, set Conf. input field to 2 for all 4–20 mA inputs when used with the current input plug-in module. This will allow the block to use the module factory voltage calibration values with a gain factor for a 200 ohm external resistor on the Dataforth FTM.
Voltage Input Plug-in Module

The Voltage Input Module is a pass-through module and is capable of reading voltage signals between 0.8 and 4.8 Vdc. No filtering is provided by the Dataforth module. See section 24/8 Analog Module for filtering provided by the Dataforth Module. See Figure 8-22 for an example of wiring a voltage transducer.

**IMPORTANT**

When configuring the AI Combo block in GAP, set Conf. input field to 0 for all voltage inputs when used with the voltage input plug-in module. This will allow the block to use the module factory voltage calibration values with the Dataforth FTM.
Analog Output Connection

The Analog Output circuit doesn’t use a plug-in module. No jumper connections are required. See Figure 8-23 for an example of wiring a 4–20 mA output device.

![MicroNet™ Module Diagram](image)

Figure 8-23—Analog Output Signal Wiring to Simplex Dataforth FTM

8.6.4—FTM Reference

See Chapter 12 for complete field wiring of the Simplex Dataforth FTM. See Appendix A for part number Cross Reference for modules, FTMs, and cables.

![Figure 8-24—Dataforth Plug-in Modules](image)
8.6.5—Troubleshooting

Each Dataforth 24/8 Analog Module has a red Fault LED that is turned on when the system is reset. During initialization of a module, which occurs after every CPU reset, the CPU turns the Fault LED on. The CPU then tests each module using diagnostic routines built into the software. If the diagnostic test is not passed, the LED remains on or blinks. If the test is successful, the LED goes off. If the Fault LED on a module is illuminated after the diagnostics and initialization have been run, the module may be faulty or may be located in the wrong slot.

<table>
<thead>
<tr>
<th>Number of LED Flashes</th>
<th>Failure</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Hardware watchdog, CPU clock failure, reset fail</td>
</tr>
<tr>
<td>2</td>
<td>Micro-controller internal RAM test failure</td>
</tr>
<tr>
<td>3</td>
<td>External RAM test failure</td>
</tr>
<tr>
<td>4</td>
<td>Unexpected exception error</td>
</tr>
<tr>
<td>5</td>
<td>Dual Port RAM test failure</td>
</tr>
<tr>
<td>6</td>
<td>EEPROM failure</td>
</tr>
<tr>
<td>7</td>
<td>Communications watchdog time out</td>
</tr>
<tr>
<td>8</td>
<td>EEPROM error is corrected (reset the module to continue)</td>
</tr>
<tr>
<td>9</td>
<td>Missing an A/D Converter interrupt</td>
</tr>
</tbody>
</table>

Table 8-5—LED Indications of Failure

Fault Detection (I/O)

In addition to detecting the High Density Analog I/O module hardware faults, the application software may detect I/O faults.

Analog Input Faults: The application software may be set with a high and low latch setpoint to detect input faults.

Analog Output Driver Faults: The module monitors the source currents and annunciates faults. The application software determines the course of action in the event of a fault.

Microcontroller Faults: The system monitors a software watchdog, a hardware watchdog, and a software watchdog on the VME bus communications. All outputs are shut down in the event of a microcontroller fault.

Troubleshooting Guide

If during normal control operation all of a chassis’ Dataforth 24/8 Analog Module have Fault LEDs on, check the chassis’ CPU module for a failure. If during normal control operation only the Dataforth Module’s Fault LED is on or flashing, insure that it is installed in the correct slot. If it is, then replace that module. See instructions for replacement in Chapter 15. When a module fault is detected, its outputs should be disabled or de-energized.

Thermocouple Inputs

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

1. Verify that the correct Dataforth plug-in module is installed. Swap plug-in modules on FTM. Replace module if problem follows module.
2. Check that the cable is shielded and the shield is properly grounded per section Shields and Grounding section in Chapter 14.
3. Verify that there are no or minimal AC components to the Analog Input signal. AC components can be caused by improper shielding.
4. Check the wiring. If the inputs are reading full scale, look for a loose connection on the terminal blocks, disconnected or misconnected cables, a missing jumper on the terminal block, or a blown fuse on the 24 Vdc on the FTM.
5. Check the software configuration to ensure that the input is configured properly.
6. Verify that FTM module is within operating limits of +5 to 45 degrees C.
7. If all of the thermocouple channels on the Dataforth Module are not working, check the fuse on the Dataforth Module. See instructions for module replacement in Chapter 15. This fuse is visible and can be changed through the bottom of the module. If the fuse is blown, fix the wiring problem, then replace the fuse with another fuse of the same type and rating.
8. If the readings are incorrect on several channels of the Dataforth Module, after replacing both cables, replace the module. If replacing the module does not fix the problem, replace the FTM. See instructions for replacing the FTM in Chapter 15.

RTD Inputs
If an RTD input is not functioning properly, verify the following:
1. Verify that the correct Dataforth plug-in module is installed. Swap plug-in modules on FTM. Replace module if problem follows module.
2. Check that the cable is shielded and the shield is properly grounded per section Shields and Grounding section in Chapter 14.
3. Verify that there are no or minimal AC components to the Analog Input signal. AC components can be caused by improper shielding.
4. Check the wiring. If the inputs are minimum scale or full scale, look for a loose connection on the terminal blocks, disconnected or misconnected cables, a missing jumper on the terminal block, or a blown fuse on the 24 Vdc on the FTM.
5. Check the software configuration to ensure that the input is configured properly.
6. If all of the RTD channels on the Dataforth Module are not working, check the fuse on the Dataforth Module. See instructions for module replacement in Chapter 15. This fuse is visible and can be changed through the bottom of the module. If the fuse is blown, fix the wiring problem, then replace the fuse with another fuse of the same type and rating.
7. If the readings are incorrect on several channels of the Dataforth Module, after replacing both cables, replace the module. If replacing the module does not fix the problem, replace the FTM. See instructions for replacing the FTM in Chapter 15.
### 4–20 mA Analog Inputs

If a 4–20 mA analog input is not functioning properly, verify the following:

1. Verify that the correct Dataforth plug-in module is installed.
2. Check that the cable is shielded and the shield is properly grounded.
3. Measure the input voltage on the FTM terminal block. It should be in the range of 0.8-4.0 V.
4. Verify that there are no or minimal AC components to the Analog Input signal. AC components can be caused by improper shielding.
5. Check the wiring. If the inputs are reading 0 or the engineering units that correspond to 0 mA, look for a loose connection on the terminal blocks, disconnected or misconnected cables, a missing jumper on the terminal block if the input is a current input, or a blown fuse on the 24 Vdc on the FTM.
6. Check the software configuration to ensure that the input is configured properly.
7. If all of the 4–20 mA channels on the Dataforth Module are not working, check the fuse on the Dataforth Module. See instructions for module replacement in Chapter 15. This fuse is visible and can be changed through the bottom of the module. If the fuse is blown, fix the wiring problem, then replace the fuse with another fuse of the same type and rating.
8. If the readings are incorrect on several channels of the Dataforth Module, after replacing both cables, replace the module. If replacing the module does not fix the problem, replace the FTM. The 4–20 mA configured FTM contains only traces and a few discrete components, so failure is extremely unlikely. See instructions for replacing the FTM in Chapter 15.

### 0–5 Vdc Analog Inputs

If an 0–5 Vdc analog input is not functioning properly, verify the following:

1. Verify that the correct Dataforth plug-in module is installed.
2. Check that the cable is shielded and the shield is properly grounded.
3. Verify that there are no or minimal AC components to the Analog Input signal. AC components can be caused by improper shielding.
4. Check the wiring. If the inputs are minimum scale or full scale, measure the input voltage on the FTM terminal block. It should be in the range of 0.8-4.8 V. Look for a loose connection on the terminal blocks, disconnected or misconnected cables on the terminal block.
5. Check the software configuration to ensure that the input is configured properly.
6. If all of the voltage channels on the Dataforth Module are not working, check the fuse on the Dataforth Module. See instructions for module replacement in Chapter 15. This fuse is visible and can be changed through the bottom of the module. If the fuse is blown, fix the wiring problem, then replace the fuse with another fuse of the same type and rating.
7. If the readings are incorrect on several channels of the Dataforth Module, after replacing both cables, replace the module. If replacing the module does not fix the problem, replace the FTM.
Analog Outputs

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

1. Check that the cable is shielded and the shield is properly grounded.
2. Check the load resistance to ensure that it is not greater than 600 ohms.
3. Check to ensure that the load wiring is isolated.
4. Check the wiring for a loose connection on the FTM terminal blocks and disconnected or misconnected cables.
5. Disconnect the field wiring and connect a resistor across the output. If the output is correct across the resistor, there is a problem with the field wiring.
6. If all of the channels on the Dataforth Module are not working, check the fuse on the Dataforth Module. See instructions for module replacement in Chapter 15. This fuse is visible and can be changed through the bottom of the module. If the fuse is blown, fix the wiring problem, then replace the fuse with another fuse of the same type and rating.
7. Check the software configuration to ensure that the output is configured properly.
8. After verifying all of the above, exchange the J1 and J2 cables. If the problem moves to a different channel, replace the cable. If not, replace the module.
9. If the readings are incorrect on several channels of the module, corresponding to both cables, replace the module.
10. If replacing the module does not fix the problem, replace the FTM. The FTM contains only traces and a few discrete components, so failure is extremely unlikely. See instructions for replacing the FTM in Chapter 15.
8.7—Analog Combo Module

8.7.1—Module Description

Each High Density Analog Combo module contains circuitry for four speed sensor inputs, eight analog inputs, four analog outputs, and two proportional actuator driver outputs. Each speed sensor input may be from a magnetic pick-up or from a proximity probe, each analog input may be 4–20 mA or 0–5 V, and each actuator driver may be configured as 4–20 mA or 20–160 mA.

There are two configurations of the Analog Combo Modules. One has the analog inputs configured for 4–20 mA and the other is configured for 0–5 V. See Appendix A for specific part numbers. In a simplex system, either Analog Combo module is connected through two analog cables to one Analog Combo FTM. All of the I/O are accessible on the FTM, and the channels are labeled to correspond to their software locations, e.g. analog input 1 on the FTM will be analog input 1 in the application software.

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

Figure 8-25—Analog Combo Module
8.7.2—Module Specifications

Digital Speed Sensor Inputs
- Number of channels: 4
- Update time: 5 ms

MPU Input Ratings
- Input frequency: 100 - 25000 Hz
- Input amplitude: 1-25 Vrms
- Input impedance: 2000 Ohms
- Isolation voltage: 500 Vrms
- Resolution: 12 bits minimum over chosen frequency range
- Accuracy: 0.03% full scale, minimum

Proximity Probe Input Ratings
- Input frequency: 0.5 - 25000 Hz
- Input amplitude: 3.5 - 32 Vdc input to the module
- Available power: 12 Vdc or 24 Vdc, 50 mA maximum
- Isolation voltage: 0 Vrms
- Resolution: 12 bits minimum over chosen frequency range
- Accuracy: Software calibrated to 0.03% full scale
- Fuse: 24 Vdc 100 mA fuse/channel, 12 Vdc short circuit protected
- Time Stamping: 5 millisecond resolution on low event and low latch

Analog Input Ratings
- Number of channels: 8
- Update time: 5 millisecond
- Input range: 0–25 mA, or 0–5 V; Dependent on module part number.
- Isolation: 0 VRMS, -60 dB CMRR, 200 Vdc common mode rejection voltage; no galvanic isolation
- Input impedance: 200 ohms
- Anti-aliasing filter: 2 poles at 10 ms
- Resolution: 16 bits
- Accuracy: Software calibrated to 0.1%, over 25 mA full scale
- Temp drift: 275 ppm/C, maximum
- Fuse: 100 mA fuse per channel
- Time stamping: 5 ms resolution on low event and latch, and high event and latch

The maximum input voltage range may vary between 4.975 and 5.025 Volts from module to module.
4–20 mA Analog Output Ratings

- Number of channels: 4
- Update time: 5 ms
- Driver: Pulse Width Modulated (PWM)
- PWM frequency: 6.14 kHz
- Filter: 3 poles at 500 ms
- Current output: 4–20 mA current output range: 0 - 25 mA
- Isolation: 0 Vrms
- Max load resistance: 600 ohms (load + wire resistance)
- Current readback: 11 bits
- Readback isolation: -60 dB CMRR, 200 Vdc common mode
- Resolution: 11 bits
- Accuracy: Software calibrated to 0.2%, over 25 mA full scale
- Temperature drift: 125 ppm/C, maximum
- Readback accuracy: 0.2%, over 25 mA full scale
- Readback temp drift: 400 ppm/C, maximum

Actuator Driver Output Ratings

- Number of channels: 2
- Update time: 5 milliseconds
- Driver: PWM (proportional only), single or dual coil
- PWM frequency: 6.14 kHz
- Filter: 3 poles at 500 microseconds
- Current output: 4–20 mA or 20–160 mA, software selectable
- Current output range: 0-24 mA or 0–196 mA, depending on the selected range
- Isolation: 0 Vrms
- Max. act resistance 45 ohms on the 20–160 mA output, 360 ohms on the 4–20 mA output
- Readback: Actuator source and return currents
- Readback isolation: -60 dB CMRR, 200 Vdc common mode
- Dither current: 25 Hz, fixed duty cycle, software variable amplitude
- Resolution: 11 bits over 25 or 200 mA range
- Accuracy: Software calibrated to 0.2% of 25 or 200 mA range
- Temperature drift: 125 ppm/C, maximum
- Readback accuracy: 0.1% of 25 or 200 mA range
- Readback temp drift: 150 ppm/C, maximum

8.7.3—Installation

The modules slide into card guides in the control's chassis and plug into the motherboard. The modules are held in place by two screws, one at the top and one at the bottom of the front panel. Also at the top and bottom of the module are two handles which, when toggled (pushed outward), move the modules out just far enough for the boards to disengage the motherboard connectors.
There are two configurations of the Analog Combo Modules. One has the analog inputs configured for 4–20 mA and the other is configured for 0–5 V. See Appendix A for specific part numbers. In a simplex system, each Analog Combo module is connected through two Low Density analog cables to one Analog Combo FTM. All of the I/O are accessible on the FTM, and the channels are labeled to correspond to their software locations. See Figure 8-26 for configuration.

Field Wiring
See Chapter 12 for complete wiring connections for the Analog Combo FTM. Wire each channel per the following examples for each type of signal.

CE COMPLIANCE—MPU / proximity probe field wiring cables should be limited to less than 30 m (100 ft) for best EMC surge performance.

Degraded surge performance may occur under the following conditions:
- cable lengths greater than 30 m
- ground fault conditions created by poor cable shield termination
- DGND coupled/connected to protective earth

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

Any of the module’s four speed channels accepts passive magnetic pickup units (MPUs) or proximity probes. Each speed input channel can only accept one MPU or one proximity probe.
When a speed sensor input channel has been wired as either MPU or proximity probe input, the unused MPU/Prox must be jumpered at the FTM. When an input channel is not used, both the MPU and Prox inputs must be jumpered. See example in Figure 8-27.
A proximity probe may be used to sense very low speeds. With a proximity probe, speed can be sensed down to 0.5 Hz. When interfacing to open collector type proximity probes, a pull-up resistor is required between the supplied proximity probe voltage and the proximity probe input to the FTM. Individually fused 12 Vdc and 24 Vdc sources are provided with each speed input to power system proximity probes (100 mA fuses, located on the FTMs, are used). External pull-up resistors are required when interfacing with an open collector type proximity probe. See Figure 8-27 for MPU/proximity probe wiring example. Channel 1 shows an MPU connection, channel 2 shows a 24 V proximity connection, and channel 3 is an example of a 12 V proximity connection. Always jumper the unused MPU connection to eliminate possible noise interference when connecting a proximity probe.

It is not recommended that gears mounted on an auxiliary shaft coupled to the rotor be used to sense speed. Auxiliary shafts tend to turn more slowly than the rotor (reducing speed sensing resolution) and have coupling gear backlash, resulting in less than optimum speed control. For safety purposes, it is also not recommended that the speed sensing device sense speed from a gear coupled to a mechanical drive side of a system’s rotor coupling.

**Analog Inputs**
The analog inputs may be current or voltage type dependent on the part number. See Appendix A for specific part numbers. Both modules use the same cable and FTM.

All current inputs may be used with two-wire ungrounded (loop powered) transducers or isolated (self-powered) transducers. All analog inputs have 200 Vdc of common mode rejection. If interfacing to a non-isolated device, which may have the potential of reaching over 200 Vdc with respect to the control’s common, the use of a loop isolator is recommended to break any return current paths that may produce erroneous readings. All current inputs use 200 ohm resistors across their inputs.

Each current input channel may power its own 4–20 mA transducer. This power is protected with a 100 mA fuse on each channel to prevent an inadvertent short from damaging the module. The 24 Vdc outputs are capable of providing 24 Vdc with ±10% regulation. Power connections can be made through terminals located on the FTMs. Refer to Figure 8-28 for 4–20 mA Current Input wiring.
Figure 8-28—Current Input Wiring for an Analog Combo Module FTM
Only self-powered voltage transducers should be used on voltage input channels. The full scale range must not exceed 5 volts. Refer to Figure 8-29 for 0–5 Vdc voltage transducer input wiring.

Figure 8-29—Voltage Input Wiring for an Analog Combo Module FTM
Analog Outputs
The analog outputs are 4–20 mA with a full-scale range of 0–25 mA. Each output monitors the output source current for fault detection. All of the analog outputs may be individually disabled. When a channel fault or a module fault is detected, the application program may annunciate the fault, disable the channel or module, and stop using the data in system calculations or control.

The Analog Combo module has four 4–20 mA current output drivers. All analog outputs can drive a maximum load of 600 ohms (load + wire resistance). Care should be taken to prevent ground loops and other faults when interfacing to non-isolated devices. See Figure 8-30 for an example of 4–20 mA output wiring.

Actuator Outputs
The actuator outputs may be configured for 4–20 mA or 20–160 mA. Configuration is done through the application software; no hardware modifications in the forms of jumpers or switches are necessary. For fault detection, each output monitors the output source current and the output return current. All of the actuator outputs may be individually disabled. When a channel fault or a module fault is detected, the application program may annunciate the fault, disable the channel or module, and stop using the data in system calculations or control.

Dither may be provided in the application software for each output. Dither is a low frequency (25 Hz) signal consisting of a 5 millisecond pulse modulated onto the DC actuator-drive current to reduce sticking due to friction in linear type actuators. Woodward TM-type actuators typically require dither. Dither amplitude is variable through the application software. See Figure 8-30 for an example of actuator wiring.

**IMPORTANT** For a dual coil actuator in a simplex system, two actuator driver outputs must be used.

Configuration Notes
- Maximum impedance for a 4 to 20 mA actuator output driver is 360 ohms (actuator impedance + wire resistance).
- Maximum impedance for a 20 to 160 mA actuator output is 45 ohms (actuator impedance + wire resistance).
- Each actuator driver senses its source and return current to allow overcurrent and undercurrent alarms and shutdowns.

8.7.4—FTM Reference
See Chapter 12 for complete Analog Combo FTM field wiring information. See Appendix A for proper Module, FTM, and cable part numbers.
Figure 8-30—Analog Output and Actuator Wiring for an Analog Combo FTM

8.7.5—Troubleshooting

Fault Detection (Module Hardware)

Each Analog Combo module has a red Fault LED that is turned on when the system is reset. During initialization of a module, which occurs after every CPU reset, the CPU turns the Fault LED on. The CPU then tests the module using diagnostic routines built into the software. If the diagnostic test is not passed, the LED remains on or blinks. If the test is successful, the LED goes off. If the Fault LED on a module is illuminated after the diagnostics and initialization have been completed, the Analog Combo module may be faulty or may be located in the wrong slot.

<table>
<thead>
<tr>
<th>Number of LED Flashes</th>
<th>Failure</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Hardware watchdog, CPU clock failure, reset fail</td>
</tr>
<tr>
<td>2</td>
<td>Micro-controller internal RAM test failure</td>
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<tr>
<td>6</td>
<td>EEPROM failure</td>
</tr>
<tr>
<td>7</td>
<td>Communications watchdog time out</td>
</tr>
</tbody>
</table>

Table 8-6—LED Indications of Failure
Fault Detection (I/O)
In addition to detecting module hardware faults, the application program may detect I/O faults.

Analog Input Faults. The application software may set a high and low latch setpoint to detect input faults.

Speed Sensor Input Faults. The application software may set a high and low latch setpoint to detect input faults. The low latch setpoint must be greater than one fiftieth of the frequency range.

Analog Output Driver Faults. The module monitors the source currents and annunciates faults. The application determines the course of action in the event of a fault.

Actuator Driver Or Load Faults. The module monitors the source and return currents and annunciates faults. The application determines the course of action in the event of a fault.

Micro-controller Faults. The system monitors a software watchdog, a hardware watchdog, and a software watchdog on the VME bus communications. All outputs are shutdown in the event of a microcontroller fault.

Troubleshooting Guide
If during normal control operation all of a chassis’ Analog Combo modules have Fault LEDs on, check the chassis’ CPU module for a failure. If during normal control operation only the Analog Combo module’s Fault LED is on or flashing, insure that it is installed in the correct slot. If it is, then replace that Analog Combo module. See instructions for replacement in Chapter 15. When a module fault is detected, its outputs should be disabled or de-energized.

Speed Sensor Inputs
MPUs. If a magnetic pickup input is not functioning properly, verify the following:
1. Check that the cable is shielded and the shield is properly grounded per the Shields and Grounding section in Chapter 14.
2. Measure the input voltage on the terminal block. It should be in the range of 1–25 VRMS.
3. Verify that the signal waveform is clean and void of double zero crossings.
4. Verify that no ground connection exists and that the resulting 60 Hz signal is absent.
5. Measure the frequency. It should be in the range of 100 Hz - 25 kHz.
6. Verify that any unused MPU/Prox inputs are jumpered per Figure 8-27.
7. Check the wiring. Look for a loose connection at the terminal blocks and disconnected or misconnected cables.
8. Check the software configuration to ensure that the input is configured properly.
9. After verifying all of the above, exchange the J1 and J2 cables. If the problem moves to a different channel, replace the cable. If not, replace the Analog Combo module.
10. If the readings are incorrect on several channels of the module, corresponding to both cables, replace the Analog Combo module.
11. If replacing the module does not fix the problem, replace the FTM. See instructions for replacing the FTM in Chapter 15. The FTM does not contain any active components on the MPU inputs, so replacing it should be the last option.

**Proximity Probes**

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

1. Check that the cable is shielded and the shield is properly grounded per the Shields and Grounding section in Chapter 14.
2. Measure the input voltage on the terminal block. It should be in the range of 3.5 – 32 Vpeak.
3. Verify that the signal waveform is clean and void of double zero crossings.
4. Verify that no ground connection exists and that the resulting 60 Hz signal is absent.
5. Measure the frequency. It should be in the range of 0.5 Hz to 25 kHz.
6. Verify that any unused MPU/Prox inputs are jumpered per Figure 8-27.
7. Check the wiring. Look for a loose connection at the terminal blocks, disconnected or misconnected cables, a missing jumper on the terminal block, or a blown fuse on the 24 Vdc on the FTM.
8. Check the software configuration to ensure that the input is configured properly.
9. After verifying all of the above, exchange the J1 and J2 cables. If the problem moves to a different channel, replace the cable. If not, replace the Analog Combo module.
10. If the readings are incorrect on several channels of the Analog Combo module, corresponding to both cables, replace the Analog Combo module.
11. If replacing the module does not fix the problem, replace the FTM. See instructions for replacing the FTM in Chapter 15. The FTM contains only a wire-wound 3 W resistor and traces, so failure is extremely unlikely and replacing it should be the last option.

**Analog Inputs**

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

1. Check that the cable is shielded and the shield is properly grounded per the Shields and Grounding section in Chapter 14.
2. Measure the input voltage on the terminal block. It should be in the range of 0–5 V.
3. Verify that there are no or minimal AC components to the Analog Input signal. AC components can be caused by improper shielding.
4. Check the wiring. If the inputs are reading 0 or the engineering units that correspond to 0 mA or volts, look for a loose connection on the terminal blocks, disconnected or misconnected cables, a missing jumper on the terminal block if the input is a current input, or a blown fuse on the 24 Vdc on the FTM.
5. If all of the inputs are reading high, check that the 24 Vdc is not connected across the input directly.
6. Check the software configuration to ensure that the input is configured properly.
7. Check the fuse on the FTM. See the instructions and fuse locations below.
8. If the other channels on the Analog Combo module are not working either, check the fuse on the Analog Combo module. See instructions for module replacement in Chapter 15. This fuse is visible and can be changed through the bottom of the module. If the fuse is blown, fix the wiring problem, then replace the fuse with another fuse of the same type and rating.

9. After verifying all of the above, exchange the J1 and J2 cables. If the problem moves to a different channel, replace the cable. If not, replace the Analog Combo module.

10. If the readings are incorrect on several channels of the module, corresponding to both cables, replace the Analog Combo module.

11. If replacing the module does not fix the problem, replace the FTM. See instructions for replacing the FTM in Chapter 15. The FTM does not contain any active components on the MPU inputs, so replacing it should be the last option.

**Analog Outputs**

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

1. Check that the cable is shielded and the shield is properly grounded per the Shields and Grounding section in Chapter 14.
2. Check the load resistance to ensure that it is not greater than 600 ohms.
3. Check to ensure that the load wiring is isolated.
4. Check the wiring for a loose connection on the terminal blocks and disconnected or misconnected cables.
5. Disconnect the field wiring and connect a resistor across the output. If the output is correct across the resistor, there is a problem with the field wiring.
6. If the other output channels on the Analog Combo module are also not working, check the fuse on the Analog Combo module. See instructions for module replacement in Chapter 15. This fuse is visible and can be changed through the bottom of the module. If the fuse is blown, fix the wiring problem and replace the fuse with a fuse of the same type and rating.
7. Check the software configuration to ensure that the output is configured properly.
8. After verifying all of the above, exchange the J1 and J2 cables. If the problem moves to a different channel, replace the cable. If not, replace the Analog Combo module.
9. If the readings are incorrect on several channels of the module, corresponding to both cables, replace the Analog Combo module.
10. If replacing the module does not fix the problem, replace the FTM. See instructions for replacing the FTM in Chapter 15. The FTM does not contain any active components on the MPU inputs, so replacing it should be the last option.
Actuator Outputs

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

1. Check that the cable is shielded and the shield is properly grounded per the Shields and Grounding section in Chapter 14.
2. Check the load resistance to ensure that it is below the specified limit.
3. Check to ensure that the load wiring is isolated.
4. Check the wiring for a loose connection on the terminal blocks or disconnected or misconnected cables.
5. Disconnect the field wiring and connect a resistor across the output.
6. If the other output channels on the Analog Combo module are also not working, check the fuse on the Analog Combo module. See instructions for module replacement in Chapter 15. This fuse is visible and can be changed through the bottom of the module. If the fuse is blown, fix the wiring problem, and replace the fuse with a fuse of the same type and rating.
7. Check the software configuration to ensure that the output is configured properly.
8. After verifying all of the above, exchange the J1 and J2 cables. If the problem moves to a different channel, replace the cable. If not, replace the Analog Combo module.
9. If the readings are incorrect on several channels of the module, corresponding to both cables, replace the Analog Combo module.
10. If replacing the module does not fix the problem, replace the FTM. See instructions for replacing the FTM in Chapter 15. The FTM does not contain any active components on the MPU inputs, so replacing it should be the last option.

Replacing a Fuse on the Field Terminal Module (FTM)

1. Verify that the condition that caused the fuse to blow has been corrected.

2. Remove FTM cover carefully, to prevent contact with any FTM circuitry under the cover. To remove the FTM cover, pinch the retaining barb and lift the cover.
3. Locate and replace the fuse with another fuse of the same size and rating.
4. Replace the FTM cover.

If power has not been removed from the control system, power will be active at the module and also at the FTM. Shorting of protected circuitry could cause a control system shutdown.
8.8—34 Ch High Density Versatile Input Module (HDVIM)

8.8.1—Module Description

This board includes no potentiometers and requires no calibration. A Configurable 34 Ch HDVIM module may be replaced with another board of the same part number without any adjustment. Each Configurable 34 Ch HDVIM Module contains circuitry for 34 Analog inputs and two cold junction inputs. 24 of the Analog inputs may be 4–20 mA inputs or thermocouple inputs, and the remaining ten Analog inputs may be 4–20 mA inputs or RTD inputs. The Configurable 34 Ch HDVIM Module connects to the CPU board through the VME bus.

The first 12 Thermocouple/4–20 mA inputs are isolated as a group, from the other inputs, and from control common. The second 12 Thermocouple/4–20 mA inputs are isolated as a group, from the other inputs, and from control common. The first 4 RTD/4–20 mA inputs are isolated as a group, from the other inputs, and from control common. The second 6 RTD/4–20 mA inputs are isolated as a group, from the other inputs, and from control common.

Figure 8-31—34 Channel HDVIM Module
Chapter 8.8.2—Module Specifications

Thermocouple/4–20 mA Analog Inputs

<table>
<thead>
<tr>
<th>Specification</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of channels</td>
<td>24</td>
</tr>
<tr>
<td>Current range</td>
<td>0-24 mA (if configured for 4–20 mA)</td>
</tr>
<tr>
<td>Voltage range</td>
<td>±72.8 mV (if configured for thermocouple)</td>
</tr>
<tr>
<td>Input impedance</td>
<td>103 ohms (±1%) for 4–20 mA inputs</td>
</tr>
</tbody>
</table>

Thermocouple Type and Range

(Type E, J, K, N, R, S, and T thermocouples must conform to the common commercial specifications published in the Annual Book of ASTM Standards with voltage predictions in line with N.I.S.T. Monograph 175 or ITS-90.)

<table>
<thead>
<tr>
<th>Thermocouple Type</th>
<th>Voltage Range (°C/°F)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type E</td>
<td>-9.83 mV (–267.68 °C/–449.82 °F) to 72.8 mV (952.60 °C/1746.68 °F)</td>
</tr>
<tr>
<td>Type J</td>
<td>-8.09 mV (–209.72 °C/–345.50 °F) to 69.55 mV (1199.94 °C/2191.89 °F)</td>
</tr>
<tr>
<td>Type K</td>
<td>-6.45 mV (–263.95 °C/–443.11 °F) to 54.88 mV (1371.81 °C/2501.26 °F)</td>
</tr>
<tr>
<td>Type N</td>
<td>-4.34 mV (–263.14 °C/–441.65 °F) to 47.51 mV (1299.92 °C/2371.86 °F)</td>
</tr>
<tr>
<td>Type R</td>
<td>-0.22 mV (–48.27 °C/–54.89 °F) to 21.10 mV (1767.88 °C/3214.18 °F)</td>
</tr>
<tr>
<td>Type S</td>
<td>-0.23 mV (–48.60 °C/–55.48 °F) to 18.69 mV (1767.76 °C/3213.97 °F)</td>
</tr>
<tr>
<td>Type T</td>
<td>-6.25 mV (–265.71 °C/–446.28 °F) to 20.87 mV (399.97 °C/751.95 °F)</td>
</tr>
</tbody>
</table>

Common Mode Rejection

-80 dB minimum for Analog inputs
-96 dB typical for Analog inputs
-110 dB minimum for thermocouple inputs
-120 dB typical for thermocouple inputs

Operational Input common mode voltage range: ±11 V minimum
Maximum Non-operational common mode voltage range: ±40 V minimum
Anti-aliasing filter: 2 poles at 10 ms (channel 11 has 2 poles at 5 ms)
Resolution: 15 bits
4–20 mA Input Accuracy: 1.1% FS (4–20 mA)

**IMPORTANT** The overall accuracy of the 4–20 mA input measurement is dependent on the ambient temperature of the board. The accuracy is based on a board temperature between 0 and 55 °C. The accuracy is in percent of full scale range.
Thermocouple Accuracy
The overall accuracy of the thermocouple measurement is dependent on the ambient temperature of the board. The following accuracies are based on a board temperature between 0 and 55°C. All accuracies are in percent of full scale range for the type of thermocouple and the range specified.

- Type E(<25°C): 1.15%
- Type E(>25°C): 1.08%
- Type J(<25°C): 1.09%
- Type J(>25°C): 1.07%
- Type K(<25°C): 1.14%
- Type K(>25°C): 1.08%
- Type N(<25°C): 1.21%
- Type N(>25°C): 1.09%
- Type R(<300°C): 1.16%
- Type R(>300°C): 1.09%
- Type S(<300°C): 1.16%
- Type S(>300°C): 1.09%
- Type T(<25°C): 2.53%
- Type T(>25°C): 1.27%

Thermocouple accuracy may be reduced by RF interference in the 900 MHz to 1 GHz frequency range. RF interference may reduce the accuracy another 0.45% of full scale when present.

CJ Update time: 5 ms
CJ accuracy: ±3 °C
Latency
odd numbered channels: 1 ms
even numbered channels: 3 ms
Failure detection: Open wire detection provided for thermocouples
Isolation: All input channels are isolated from the rest of the MicroNet platform to 500 Vdc, however they are not isolated from each other. The inputs are differential, with a high impedance between channels.

RTD/4–20 mA Analog Inputs
Number of channels: 10
Input type: 100 or 200 ohm 3-wire
Max. input current: 24 mA, if configured for 4–20 mA
Max. input resistance: 781 Ω, if configured for RTD
RTD source current: 1 mA
RTD Range
(Must conform to DIN (Deutsche Institut for Normung) standard for 100 or 200 ohm European curve (Alpha = .00385) or American curve 100 or 200 ohm curve (Alpha = .00392))

100Ω RTD (European Curve): 18.49 Ω (–200 °C/–328 °F) to 390.48 Ω (850 °C/1562 °F)
200Ω RTD (European Curve): 37.04 Ω (–200 °C/–328 °F) to 533.10 Ω (457 °C/854.6 °F)
100Ω RTD (American Curve): 59.57 Ω (–100 °C/–148 °F) to 269.35 Ω (457 °C/854.6 °F)
200Ω RTD (American Curve): 119.14 Ω (–100 °C/–148 °F) to 538.70 Ω (457 °C/854.6 °F)

Common mode rejection: –80 dB minimum for analog inputs
–96 dB typical for analog inputs
–96 dB minimum for RTD inputs
–115 dB typical for RTD inputs

Input common mode range: ±11 V minimum
Safe input common mode volt: ±40 V minimum
Input impedance: 103 ohms (±1%) for 4–20 mA inputs
Anti-aliasing filter: 2 poles at 10 ms
Resolution: 15 bits

RTD Accuracy
The overall accuracy of the RTD measurement is dependent on the ambient temperature of the board. The following accuracies are based on a board temperature between 0 and 55°C. All accuracy are in percent of full scale range for the type of RTD specified.

100Ω RTD (European Curve): 1.28% FS
200Ω RTD (European Curve): 1.28% FS
100Ω RTD (American Curve): 1.28% FS
200Ω RTD (American Curve): 1.28% FS

Update time: 5 ms
I/O Latency: 1 ms

Isolation: All input channels are isolated from the rest of the MicroNet platform to 500 Vdc, however inputs are not isolated from each other.

8.8.3—Installation
The modules slide into card guides in the control's chassis and plug into the motherboard. The modules are held in place by two screws, one at the top and one at the bottom of the front panel. Also at the top and bottom of the module are two handles which, when toggled (pushed outward), move the modules out just far enough for the boards to disengage the motherboard connectors.
In a Simplex system, each 34 Ch HDVIM module is connected through two high density 62 conductor analog cables to two 34 Ch HDVIM FTMs. All inputs on the module are accessible on the FTM, and the channels are labeled to correspond to their software locations (e.g., analog input 1 on the FTM will be analog input 1 in the application software). See Figure 8-32, for an example.

Loop power for the Analog inputs must be supplied by an external supply, if needed. This supply should be wired to terminals 40 and 81 on each FTM. The FTM will fuse and distribute the power to 9 sets of terminals on the FTM. The 4–20 mA, thermocouple, or RTD configurable inputs are selected in the GAP block software, for each input. The GAP block configuration sets input gain via software. The maximum wire size that the FTM can accept is one 16 AWG or two 20 AWG wires.

**34 Ch HDVIM Module Operation**

All 34 inputs can be configured as 4–20 mA analog inputs. The first 24 channels can be configured as 4–20 mA inputs or thermocouples inputs and the last 10 can be configured as 4–20 mA inputs or RTD inputs. The application software must be configured to match the input type used, i.e. 4–20 mA, 100 ohm RTD, K type thermocouple, etc. This allows the 34 Ch HDVIM module to use the applicable hardware calibration values, and to configure the appropriate hardware gains. The first thermocouple inputs must be configured in pairs, i.e. channels 1 and 2 must both be thermocouples or must both be 4–20 mA inputs. The RTD channels may be configured individually. Any 'un-used' channel of a pair, Channels 1 - 24, must have its input shorted to prevent measurement errors on the 'in-use' channel of the pair.
Figure 8-33—Wiring Diagram for 34 Ch HDVIM FTM
4–20 mA Inputs
For a 4–20 mA input signal, the 34 Ch HDVIM module uses a 100 ohm resistor across the input. All 4–20 mA inputs may be used with two-wire ungrounded (loop powered) transducers or isolated (self-powered) transducers. All Analog inputs have 11 Vdc of common mode rejection. If interfacing to a non-isolated device, which may have the potential of reaching over 11 Vdc with respect to the control’s common, the use of a loop isolator is recommended to break any return current paths, which could produce erroneous readings. 0–5 V inputs are not supported by this module. No loop power is provided by the MicroNet module. An external supply must be connected to the FTM for powering loop powered inputs.

RTD Inputs
RTD inputs must be configured to use either the European or American curve in software. Only 100 and 200 ohm platinum RTDs are supported. 200 ohm RTDs are limited to the maximum temperature on the American curve, even when the European curve is used. The RTD source current is 2 mA, and the RTD sense input should be tied to the negative side of the RTD, at the RTD.

Thermocouple Inputs
See Module Specifications for supported thermocouple types. A cold junction sensor is provided on the 34 Ch HDVIM FTM. If the actual cold junction in the field wiring occurs elsewhere, the temperature of that junction must be brought into the control as a thermocouple, RTD, or 4–20 mA input, and the application software must be configured to use the appropriate cold junction temperature. The thermocouple and cold junction input units (°C or °F) should be consistent in the application software.

The first 12 Analog inputs on each FTM are isolated as a group from control common, earth ground, and the rest of the Analog inputs. The next 4 or 6 Analog inputs on the FTM are also isolated as a group from control common, earth ground, and the rest of the Analog inputs. This results in 4 isolated groups of inputs on each module.

**IMPORTANT**
If 4–20 mA inputs are configured for the first twelve channels on a FTM, and thermocouple inputs are also used on that FTM, then the 4–20 mA inputs should use an isolated power supply. Similarly, if 4–20 mA inputs are configured for the last 4-6 channels on a FTM, and RTD inputs are also used on that FTM, the 4–20 mA inputs should use an isolated power supply. This prevents 4–20 mA inputs from introducing noise on temperature inputs, when they share the same isolated input ground on the module.

8.8.4—FTM Reference
See Chapter 12 for complete 34 Ch HDVIM FTM field wiring information. See Appendix A for proper Module, FTM, and cable part numbers.
Figure 8-34—Analog Input Interface Wiring to the 34 Ch HDVIM Module for Thermocouple Inputs

Figure 8-35—Analog Input Interface Wiring to the 34 Ch HDVIM Module for 4–20 mA Inputs

Figure 8-36—4–20 mA Input Interface Wiring to the 34 Ch HDVIM Module for 4–20 mA on 4/20 mA/RTD Inputs

Figure 8-37—RTD Input Interface Wiring to the 34 Ch HDVIM Module for RTDs on 4–20 mA/RTD Inputs
8.8.5—Troubleshooting

Each 34 Ch HDVIM module has a red fault LED that is turned on when the system is reset. During initialization of a board, which occurs after every CPU reset, the CPU turns the Fault LED on. The CPU then tests the board using diagnostic routines built into the software. If the diagnostic test is not passed, the LED remains on or blinks. If the test is successful, the LED goes off. If the fault LED on a board is illuminated after the diagnostics and initialization have been completed, the 34 Ch HDVIM module may be faulty.

<table>
<thead>
<tr>
<th>Number of LED Flashes</th>
<th>Failure</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Micro-Processor failure</td>
</tr>
<tr>
<td>2</td>
<td>Bus, Address, any unexpected exception error</td>
</tr>
<tr>
<td>3</td>
<td>Internal RAM failure</td>
</tr>
<tr>
<td>4</td>
<td>Internal Watchdog failure</td>
</tr>
<tr>
<td>5</td>
<td>EEPROM failure</td>
</tr>
<tr>
<td>7</td>
<td>Kernel software Watchdog count error</td>
</tr>
<tr>
<td>13</td>
<td>Dual port RAM error</td>
</tr>
</tbody>
</table>

Table 8-7—LED Indications of Failure

Fault Detection (I/O)

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

Analog Input Faults. The application software may set a high and low latch setpoint to detect input faults. For thermocouple inputs, open wire detection is provided.

Micro-controller Faults. The system monitors a software watchdog, a hardware watchdog, and a software watchdog on the VME bus communications. All outputs are shutdown in the event of a microcontroller fault.
Troubleshooting Guide
If an Analog input is not functioning properly, verify the following:

1. Check that the cable is shielded and the shield is properly grounded per the Shields and Grounding section in Chapter 14.
2. Measure the input voltage on the terminal block. It should be in the range of 0–5 V for 4–20 mA inputs. RTD inputs have a 2 mA current source. Thermocouple inputs should have the appropriate millivolt signal.
3. Verify that there are no or minimal AC components to the Analog Input signal. AC components can be caused by improper shielding. Thermocouple inputs are extremely sensitive to signal fluctuations.
4. Check the wiring. For a 4–20 mA input if the input is reading 0 or the engineering units that correspond to 0 mA, look for a loose connection at the terminal blocks and disconnected or misconnected cables.
5. For RTD inputs, check for proper connection of the sense line.
6. For thermocouple inputs, check for proper cold junction location.
7. If the input is reading high, check that the power is not connected across the input directly.
8. Check the software configuration to ensure that the input is configured properly. Ensure that the proper RTD or thermocouple type is selected, if applicable.
9. After verifying all of the above, exchange the J1 and J2 cables. If the problem moves to a different channel, replace the cable. If not, replace the 34 Ch HDVIM module.
10. If the readings are incorrect on several channels of the 34 Ch HDVIM module, corresponding to both cables, replace the 34 Ch HDVIM module.
11. If replacing the module does not fix the problem, replace the FTM. See the instructions in Chapter 15 for replacing the FTM. The FTM contains only traces and a few discrete components, so failure is extremely unlikely.

8.9—Current Input Modules

There are three different 8 Ch Current Input modules available from Woodward. These consist of the 8 Ch Current Input (4–20 mA) module, Non-Standard 8 Ch Current Input (4–20 mA) module, and the 8 Ch Current/Voltage Input Module. The 8 Ch Current/Voltage Input module was created for a special program and is not a standard Woodward product.
8.10—8 Ch Current Input (4–20 mA) Module

8.10.1—Module Description

Each 8 Ch Current Input (4–20 mA) Module contains circuitry for eight fully isolated double-ended current inputs. The module is connected through one Low Density Analog cable to one Analog Input FTM for field wiring connections. All analog inputs may be used with two-wire ungrounded (loop powered) transducers or isolated (self-powered) transducers. The Input signal range is between 0 and 25 mA. The module has a built-in precision voltage source. The readings from the precision-voltage reference are used for on-line temperature compensation and automatic calibration for the module.

These modules have no potentiometers and require no calibration. A module may be replaced with another module of the same part number without any adjustment.

Figure 8-38—8 Channel Current Input (4–20 mA) Module
8.10.2—Specification

Number of Channels: 8
Input Range: 0–25 mA
Accuracy: 0.5% of full scale
Temperature Coefficient: 12 ppm/degrees C
Anti-aliasing filter: 2 poles at 12 ms (Channels 1-8)
Module interface: VMEbus
Resolution: 16 bit converter
Isolation: 1500 Vac continuous (channel input to control common)
CMRR: -90 db
Input Impedance: 249 ohms
Status Indication: RED LED - channel fault or board fault

8.10.3—Installation

The modules slide into card guides in the control’s chassis and plug into the motherboard. The modules are held in place by two screws, one at the top and one at the bottom of the front panel. Also at the top and bottom of the module are two handles which, when toggled (pushed outward), move the modules out just far enough for the boards to disengage the motherboard connectors.

In a simplex system, each 8 Ch Current Input (4–20 mA) module is connected through one Low Density Analog cable to one Analog Input FTM. All of the I/O are accessible on the FTM. See Figure 8-39 for configuration.

![Figure 8-39—8 Ch Current Input (4–20 mA) Module Configuration](image-url)
Field Wiring
See Chapter 12 for complete wiring connections for the Analog Input FTM. See Figure 8-40 for transducer wiring.

All analog inputs may be used with two-wire ungrounded (loop powered) transducers or isolated (self-powered) transducers. Loop powered or self powered 4–20 mA transducers may be connected to the current input modules via the Analog Input FTM shown in Figure 8-40.

8.10.4—FTM Reference
See Chapter 12 for complete Analog Input FTM field wiring. See Appendix A for proper Module, FTM, and cable part numbers.

8.10.5—Troubleshooting
The input MUX (multiplexer) permits the module to read either the value of the precision-voltage reference for this channel, or the sensed input for this channel. The MUX receives the current input and, under the control of the microcontroller, passes the value through the Gain amplifier to the Isolation Amplifier. The output of the Isolation Amplifier goes to one input of the channel-selecting MUX.
Figure 8-40—Analog Input Wiring for an 8 Ch Current Input (0–25 mA) Module
This MUX, under control of the microprocessor, selects the channel to be read. The analog output of this MUX is converted to a digital value by the A/D converter, and passed to the microcontroller. The microcontroller makes any necessary corrections to this value and stores the result in the Dual-Port RAM. The CPU can then access the values stored in Dual-Port RAM through the VME interface and bus. See Figure 8-41 for block diagram of module.

![Figure 8-41—8 Ch Current Input (0–25 mA) Module Block Diagram](image_url)

During initialization, which occurs after every reset, the CPU turns the FAULT LEDs on. The CPU then tests each I/O module using diagnostic routines built into software. If the diagnostic test is not passed, the LED remains on. If the test is successful, the LED goes off.

During initialization of the module, the module's micro-controller turns the LED off after power-on self tests have passed and the CPU has initialized the module.

The CPU also tells this module in which rate group each channel is to run, as well as special information. At run time, the CPU then periodically broadcasts a "key" to all I/O cards, telling them which rate groups are to be updated at that time. Through this initialization/key broadcast system, each I/O module handles its own rate-group scheduling with minimal CPU intervention.

This module also has on-card on-line fault detection and automatic calibration/compensation. Each input channel has its own precision voltage reference. Once per minute, while not reading inputs, the on-board microcontroller reads this reference. The microcontroller then uses this data read from the voltage reference for both fault detection and automatic temperature compensation/calibration.
Limits have been set for the expected readings when the on-board microcontroller reads each voltage reference. If the reading obtained is outside these limits, the system determines that the input channel, A/D converter, or the channel's precision-voltage reference is not functioning properly. If this happens, the micro-controller flags that channel as having a fault condition. The CPU will then take whatever action the application engineer has provided for in the application program.

The readings from the precision-voltage reference are also used for on-line temperature compensation and automatic calibration for the module. The readings of the precision-voltage reference, obtained from the A/D converter, are used by the microcontroller to determine software scaling- and offset-constants for each channel. These scaling-and offset-constants are respectively multiplied by and added to each channel reading to provide corrected channel readings. The module therefore includes no potentiometers and needs no calibration.

Each I/O module has a fuse on it; this fuse is visible and can be changed through a cutout in the plastic cover of the module. If this fuse is blown, replace it with a fuse of the same type and size.

Troubleshooting Guide
If a current input is not functioning properly, verify the following:

1. Check that the cable is shielded and the shield is properly grounded per the Shields and Grounding section in Chapter 14.
2. Measure the input voltage across the + and – inputs on the terminal block. It should be in the range of 0–5 V.
3. Verify that there are no or minimal AC components to the Analog Input signal. AC components can be caused by improper shielding.
4. Check the wiring. If the inputs are reading 0 or the engineering units that correspond to 0 mA, look for a loose connection on the terminal blocks, disconnected or misconnected cables.
5. Check the software configuration to ensure that the input is configured properly.
6. If the other channels on the module are not working either, check the fuse on the 8 Ch Current Input (0–25 mA) module. This fuse is visible and can be changed through the bottom of the module. If the fuse is blown, fix the wiring problem, then replace the fuse with another fuse of the same type and rating.
7. If the problem remains, swap out the 8 Ch Current Input (0–25 mA) module with another module of the same part number. If the problem remains, replace the cable.
8. If the problem remains, replace the FTM. The FTM contains only traces and a few discrete components, so failure is extremely unlikely. See instructions for replacing the FTM in Chapter 15.
8.11—Non-Standard 8 Ch Current Input (4–20 mA) Module

8.11.1—Module Description

Each Non-Standard 8 Ch Current Input (4–20 mA) Module utilizes the same circuitry that the 8 Ch Current Input (4–20 mA) module uses. Seven of the eight double-ended channels of this module are fully isolated. Through the use of a special FTM and cable, the derivative of the signal from channel 7 is generated on the FTM and then fed to channel 8 on the analog Input module. This derivative signal can be used for monitoring a rate of change in the channel 7 input transducer. The first seven channels may be connected to current transducers. Channels 1 through 6 are standard 0–25 mA inputs with standard frequency response. Channel 7 has been altered to allow for higher frequency response. The module has a built-in precision voltage source. The readings from the precision-voltage reference are used for on-line temperature compensation and automatic calibration for the module.

These modules have no potentiometers and require no calibration. A module may be replaced with another module of the same part number without any adjustment.
8.11.2—Specification

Number of Channels: 8
Input Range: 0–25 mA
Accuracy: 0.5% of full scale
Temperature Coefficient: 12 ppm/degrees C
Anti-aliasing filter: 2 poles at 12 ms (Channels 1-6)
Anti-aliasing filter: 2 poles at 5 ms (Channels 7-8)
(Channel 8 is the derivative of channel 7.)
Module interface: VMEbus
Resolution: 16 bit converter
Isolation: 1500 Vac continuous (channel input to control common)
CMRR: -90 dB
Input Impedance: 249 Ohms
Status Indication: RED LED - channel fault or board fault

8.11.3—Installation

The modules slide into card guides in the control's chassis and plug into the motherboard. The modules are held in place by two screws, one at the top and one at the bottom of the front panel. Also at the top and bottom of the module are two handles which, when toggled (pushed outward), move the modules out just far enough for the boards to disengage the motherboard connectors.

In a simplex system, each 8 Ch Current Input module is connected through one analog cable to one FTM. All of the I/O are accessible on the FTM.

![Figure 8-43—Non-Standard 8 Channel Current Input (4–20 mA) Module Configuration](image-url)
Field Wiring
See Chapter 12 for complete wiring connections for the Non-standard Analog Input FTM. See Figure 8-44 for transducer wiring.

The first six analog inputs may be used with two-wire ungrounded (loop powered) transducers or isolated (self-powered) transducers. The seventh channel can be used with a self powered transducer only. Channel eight should not be connected to any field wiring. Loop powered or self powered 4–20 mA transducers may be connected to the current input modules via the Non-Standard Analog Input FTM shown in Figure 8-44.

8.11.4—FTM Reference

The output from channel seven is split and fed to channel seven on the Non-Standard Current Input (4–20 mA) Module and also fed through a derivative circuit on the FTM to channel eight on the Non-Standard Current Input (4–20 mA) Module. See Chapter 12 for complete field wiring information for the Non-Standard Analog Input FTM. See Appendix A for proper Module, FTM, and cable part numbers.

8.11.5—Troubleshooting

The input MUX (multiplexer) permits the module to read either the value of the precision-voltage reference for this channel, or the sensed input for this channel. The MUX receives the current input and, under the control of the microcontroller, passes the value through the Gain amplifier to the Isolation Amplifier. The output of the Isolation Amplifier goes to one input of the channel-selecting MUX.
Figure 8-44—Analog Input Wiring for a Non-Standard 8 Ch Current Input (0–25 mA) Module
This MUX, under control of the microprocessor, selects the channel to be read. The analog output of this MUX is converted to a digital value by the A/D converter, and passed to the microcontroller. The microcontroller makes any necessary corrections to this value and stores the result in the Dual-Port RAM. The CPU can then access the values stored in Dual-Port RAM through the VME interface and bus. See Figure 8-41 for block diagram of module.

During initialization, which occurs after every reset, the CPU turns the FAULT LEDs on. The CPU then tests each I/O module using diagnostic routines built into software. If the diagnostic test is not passed, the LED remains on. If the test is successful, the LED goes off.

During initialization of the module, the module’s microcontroller turns the LED off after power-on self tests have passed and the CPU has initialized the module.

The CPU also tells this module in which rate group each channel is to run, as well as special information. At run time, the CPU then periodically broadcasts a "key" to all I/O cards, telling them which rate groups are to be updated at that time. Through this initialization/key broadcast system, each I/O module handles its own rate-group scheduling with minimal CPU intervention.

This module also has on-card on-line fault detection and automatic calibration/compensation. Each input channel has its own precision voltage reference. Once per minute, while not reading inputs, the on-board microcontroller reads this reference. The microcontroller then uses this data read from the voltage reference for both fault detection and automatic temperature compensation/calibration.

Limits have been set for the expected readings when the on-board microcontroller reads each voltage reference. If the reading obtained is outside these limits, the system determines that the input channel, A/D converter, or the channel's precision-voltage reference is not functioning properly. If this happens, the microcontroller flags that channel as having a fault condition. The CPU will then take whatever action the application engineer has provided for in the application program.

The readings from the precision-voltage reference are also used for on-line temperature compensation and automatic calibration for the module. The readings of the precision-voltage reference, obtained from the A/D converter, are used by the microcontroller to determine software scaling- and offset-constants for each channel. These scaling-and offset-constants are respectively multiplied by and added to each channel reading to provide corrected channel readings. The module therefore includes no potentiometers and needs no calibration.

Each I/O module has a fuse on it; this fuse is visible and can be changed through a cutout in the plastic cover of the module. If this fuse is blown, replace it with a fuse of the same type and size.
Troubleshooting Guide

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

1. Check that the cable is shielded and the shield is properly grounded per the Shields and Grounding section in Chapter 14.

2. Measure the input voltage across the + and – inputs on the terminal block. It should be in the range of 0–5 V.

3. Verify that there are no or minimal AC components to the Analog Input signal. AC components can be caused by improper shielding.

4. Check the wiring. If the inputs are reading 0 or the engineering units that correspond to 0 mA, look for a loose connection on the terminal blocks, disconnected or misconnected cables.

5. Check the software configuration to ensure that the input is configured properly.

6. If the other channels on the module are not working either, check the fuse on the Non-Standard 8 Ch Current Input (0–25 mA) module. This fuse is visible and can be changed through the bottom of the module. If the fuse is blown, fix the wiring problem, then replace the fuse with another fuse of the same type and rating.

7. If the problem remains, swap out the Non-Standard 8 Ch Current Input (0–25 mA) module with another module of the same part number. If the problem remains, replace the cable.

8. If the problem remains, replace the FTM. The FTM contains only traces and a few discrete components, so failure is extremely unlikely. See instructions for replacing the FTM in Chapter 15.

8.12—Voltage Input Modules

There is one voltage input module available from Woodward.

8.13—8 Channel Voltage Input (0–10 Vdc) Module

8.13.1—Module Description

Each 8 Ch Voltage Input (0–10 Vdc) Module has eight channels for 0–10 Vdc transducers. All eight channels are fully isolated double-ended voltage inputs. The module is connected through one Low Density Analog cable to one Analog Input FTM for field wiring connections. The module has a built-in precision voltage source. The readings from the precision-voltage reference are used for on-line temperature compensation and automatic calibration for the module.

These modules have no potentiometers and require no calibration. A module may be replaced with another module of the same part number without any adjustment.
8.13.2—Specification

- Number of Channels: 8
- Input Range: 0–10 Volts
- Accuracy: 0.5% of full scale
- Temperature Coefficient: 12 ppm/degrees C
- Anti-aliasing filter: 2 poles at 12 ms (Channels 1-8)
- Module interface: VMEbus
- Resolution: 16 bit converter
- Isolation: 1500 Vac continuous (channel input to control common)
- CMRR: -90 db
- Input Impedance: $\geq 2 \text{ M}\Omega$
- Status Indication: RED LED - channel fault or board fault

8.13.3—Installation

The modules slide into card guides in the control's chassis and plug into the motherboard. The modules are held in place by two screws, one at the top and one at the bottom of the front panel. Also at the top and bottom of the module are two handles which, when toggled (pushed outward), move the modules out just far enough for the boards to disengage the motherboard connectors.
In a simplex system, each 8 Ch Voltage Input module is connected through one analog cable to one FTM. All of the I/O are accessible on the FTM.

Field Wiring
See Chapter 12 for complete wiring connections for the Analog Input FTM. See Figure 8-47 for transducer wiring.

8.13.4—FTM Reference
See Chapter 12 for complete field wiring information for the Voltage Input (0–10 Vdc) FTM. See Appendix A for part number Cross Reference for modules, FTMs, and cables.

8.13.5—Troubleshooting
The input MUX (multiplexer) permits the module to read either the value of the precision-voltage reference for this channel, or the sensed input for this channel. The MUX receives the voltage input and, under the control of the microcontroller, passes the value through the Gain amplifier to the Isolation Amplifier. The output of the Isolation Amplifier goes to one input of the channel-selecting MUX.
Figure 8-47—Voltage Input Wiring for an 8 Channel Voltage Input (0–10 Vdc) Module
This MUX, under control of the microprocessor, selects the channel to be read. The analog output of this MUX is converted to a digital value by the A/D converter, and passed to the microcontroller. The microcontroller makes any necessary corrections to this value and stores the result in the Dual-Port RAM. The CPU can then access the values stored in Dual-Port RAM through the VME interface and bus. See Figure 8-48 for block diagram of module.

![Block Diagram of Module](image)

Figure 8-48—8 Ch Voltage Input (0–10 Vdc) Module Block Diagram

During initialization, which occurs after every reset, the CPU turns the FAULT LEDs on. The CPU then tests each I/O module using diagnostic routines built into software. If the diagnostic test is not passed, the LED remains on. If the test is successful, the LED goes off.

During initialization of the module, the module's micro-controller turns the LED off after power-on self tests have passed and the CPU has initialized the module.

The CPU also tells this module in which rate group each channel is to run, as well as special information. At run time, the CPU then periodically broadcasts a "key" to all I/O cards, telling them which rate groups are to be updated at that time. Through this initialization/key broadcast system, each I/O module handles its own rate-group scheduling with minimal CPU intervention.

This module also has on-card on-line fault detection and automatic calibration/compensation. Each input channel has its own precision voltage reference. Once per minute, while not reading inputs, the on-board microcontroller reads this reference. The microcontroller then uses this data read from the voltage reference for both fault detection and automatic temperature compensation/calibration.
Limits have been set for the expected readings when the on-board microcontroller reads each voltage reference. If the reading obtained is outside these limits, the system determines that the input channel, A/D converter, or the channel's precision-voltage reference is not functioning properly. If this happens, the micro-controller flags that channel as having a fault condition. The CPU will then take whatever action the application engineer has provided for in the application program.

The readings from the precision-voltage reference are also used for on-line temperature compensation and automatic calibration for the module. The readings of the precision-voltage reference, obtained from the A/D converter, are used by the microcontroller to determine software scaling- and offset-constants for each channel. These scaling-and offset-constants are respectively multiplied by and added to each channel reading to provide corrected channel readings. The module therefore includes no potentiometers and needs no calibration.

Each I/O module has a fuse on it; this fuse is visible and can be changed through a cutout in the plastic cover of the module. If this fuse is blown, replace it with a fuse of the same type and size.

**Troubleshooting Guide**

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

1. Check that the cable is shielded and the shield is properly grounded per the Shields and Grounding section in Chapter 14.
2. Measure the input voltage across the + and – inputs on the terminal block. It should be in the range of 0–5 V.
3. Verify that there are no or minimal AC components to the Analog Input signal. AC components can be caused by improper shielding.
4. Check the wiring. If the inputs are reading 0 or the engineering units that correspond to 0 V, look for a loose connection on the terminal blocks, disconnected or misconnected cables.
5. Check the software configuration to ensure that the input is configured properly.
6. If the other channels on the module are not working either, check the fuse on the 8 Ch Voltage Input (0–10 Vdc) module. This fuse is visible and can be changed through the bottom of the module. If the fuse is blown, fix the wiring problem, then replace the fuse with another fuse of the same type and rating.
7. If the problem remains, swap out the 8 Ch Voltage Input (0–10 Vdc) module with another module of the same part number. If the problem remains, replace the cable.
8. If the problem remains, replace the FTM. The FTM contains only traces and a few discrete components, so failure is extremely unlikely. See instructions for replacing the FTM in Chapter 15.

**8.14—Current Output Modules**

There are two Current Output modules.
8.15—8 Ch Current Output (4–20 mA) Module

8.15.1—Module Description

Each 8 Ch Current Output (4–20 mA) Module has eight channels for outputting 0–25 mA. The module is connected through one Low Density Analog cable to one Analog Input FTM for field wiring connections.

These modules have no potentiometers and require no calibration. A module may be replaced with another module of the same part number without any adjustment.

Figure 8-49—8 Channel Current Output (4–20 mA) Module
8.15.2—Specification

- Number of Channels: 8
- Current range: 0–25 mA
- Maximum load resistance: 600 ohms max.
- Analog Channel bandwidth: 500 Hz min.
- Module interface: VMEbus
- Output update time: 1 ms
- Resolution: 12 bit
- Accuracy: 0.1% of full scale @25 degrees C
- Maximum Drift: 50 ppm/degrees C
- Status Indication: RED LED - channel fault or board fault
- Channel faults: Output current monitored
- Microcontroller faults: System monitors a software watchdog
- System faults: All outputs are set to zero if MFT is lost.
- Operating Temp: 0 to 70 °C
- Isolation: None

8.15.3—Installation

The modules slide into card guides in the control's chassis and plug into the motherboard. The modules are held in place by two screws, one at the top and one at the bottom of the front panel. Also at the top and bottom of the module are two handles which, when toggled (pushed outward), move the modules out just far enough for the boards to disengage the motherboard connectors.

In a simplex system, each 8 Ch Current Output module is connected through one analog cable to one FTM. All of the I/O are accessible on the FTM.

![Diagram](image-url)
There are 8 analog output channels of 4–20 mA with a full scale range of 0–25 mA. All Analog Outputs can drive a maximum load of 600 ohms (load + wire resistance). See Figure 8-51 for analog output connection. Each output monitors the output source current for fault detection. All of the analog outputs may be individually disabled. When a channel fault or a module fault is detected, the application program may annunciate the fault, disable the channel and stop using data in system calculations or control. Care should be taken to prevent ground loops and other faults when interfacing to non-isolated devices.

8.15.4—FTM Reference

See Chapter 12 for complete field wiring information for the 8 Ch Current Output (4–20 mA) FTM. See Appendix A for part number Cross Reference for modules, FTM's, and cables.

8.15.5—Troubleshooting

The system writes output values to the Dual-Port RAM through the VME bus and interface. The microcontroller scales the data using calibration constants stored in EEPROM, and schedules outputs to occur at the proper time.
Figure 8-51—Analog Output Wiring for an 8 Channel Current Output (4–20 mA) Module
The microcontroller monitors the output current of each channel and alerts the system if a fault is detected. The current-output drivers can be disabled by the system. If a fault, which prevents the entire card from operating is detected by either the microcontroller or the system, the FAULT LED will illuminate. See Figure 8-52 for module block diagram.

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

1. Check that the cable is shielded and the shield is properly grounded per the Shields and Grounding section in Chapter 14.
2. Check the load resistance to ensure that it is not greater than 600 ohms.
3. Check to ensure that the load wiring is isolated.
4. Check the wiring for a loose connection on the terminal blocks and disconnected or misconnected cables.
5. Disconnect the field wiring and connect a resistor across the output. If the output is correct across the resistor, there is a problem with the field wiring.
6. If the other output channels on the 8 Ch Current Output (4–20 mA) Module are also not working, check the fuse on the 8 Ch Current Output (4–20 mA) Module. See instructions for module replacement in Chapter 15. This fuse is visible and can be changed through the bottom of the module. If the fuse is blown, fix the wiring problem and replace the fuse with a fuse of the same type and rating.
7. Check the software configuration to ensure that the output is configured properly.
8. After verifying all of the above, replace the 8 Ch Current Output (4–20 mA) Module.
9. If replacing the module does not fix the problem, replace the FTM. See instructions for replacing the FTM in Chapter 15. The FTM does not contain any active components on the MPU inputs, so replacing it should be the last option.
8.16—8 Ch Current Output (0–1 mA) Module

8.16.1—Module Description

Each 8 Ch Current Output (0–1 mA) Module has eight channels for outputting 0–1 mA. The module is connected through one Low Density Analog cable to one Analog Input FTM for field wiring connections. This module utilizes the same circuits that the 8 Ch Current Output (0-20 mA) Module uses.

These modules have no potentiometers and require no calibration. A module may be replaced with another module of the same part number without any adjustment.

Figure 8-53—8 Channel Current Output (0–1 mA) Module
### 8.16.2—Specification

<table>
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<tr>
<th>Specification</th>
<th>Details</th>
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<tbody>
<tr>
<td>Number of Channels:</td>
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<tr>
<td>Current range:</td>
<td>0 – 1.25 mA</td>
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<td>Maximum load resistance:</td>
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</tr>
<tr>
<td>Analog Channel bandwidth:</td>
<td>500 Hz min.</td>
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<tr>
<td>Module interface:</td>
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<tr>
<td>Output update time:</td>
<td>1 ms</td>
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<tr>
<td>Resolution:</td>
<td>12 bit</td>
</tr>
<tr>
<td>Accuracy:</td>
<td>0.1% of full scale @25 °C</td>
</tr>
<tr>
<td>Maximum Drift:</td>
<td>50 ppm/degrees C</td>
</tr>
<tr>
<td>Status Indication:</td>
<td>RED LED - channel fault or board fault</td>
</tr>
<tr>
<td>Channel faults:</td>
<td>Output current monitored</td>
</tr>
<tr>
<td>Microcontroller faults:</td>
<td>System monitors a software watchdog</td>
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<tr>
<td>System faults:</td>
<td>All outputs are set to zero if MFT is lost.</td>
</tr>
<tr>
<td>Operating Temp:</td>
<td>0 to 70 °C</td>
</tr>
<tr>
<td>Isolation:</td>
<td>None</td>
</tr>
</tbody>
</table>

### 8.16.3—Installation

See 8 Ch Current Output (4–20 mA) Module.

### 8.16.4—FTM Reference

See Chapter 12 for complete field wiring information for the 8 Ch Current Output (0–1 mA) FTM. See Appendix A for part number Cross Reference for modules, FTM, and cables.

### 8.16.5—Troubleshooting

See 8 Ch Current Output (4–20 mA) Module.

### 8.17—Voltage Output Modules

There are two Current Output modules.
8.18—8 Ch Voltage Output (0–5 Vdc ) Module

8.18.1—Module Description

Each 8 Ch Voltage Output (0–5 Vdc) Module has eight channels for outputting 0–5 Vdc. The module is connected through one Low Density Analog cable to one Analog Input FTM for field wiring connections.

These modules have no potentiometers and require no calibration. A module may be replaced with another module of the same part number without any adjustment.

Figure 8-54—8 Channel Voltage Output (0–5 Vdc) Module
8.18.2—Specification

Number of Channels: 8
Current range: 0–6.25 V
Minimum load resistance: 500 ohms
Analog Channel bandwidth: 500 Hz min.
Module interface: VMEbus
Output update time: 1 ms
Accuracy: 0.1% of full scale @25 °C
Maximum Drift: 50 ppm/degrees C
Status Indication: RED LED - channel fault or board fault
Channel faults: Output current monitored
System faults: All outputs are set to zero if MFT is lost.
Operating Temp: 0 to 70 °C
Isolation: None

8.18.3—Installation

The modules slide into card guides in the control's chassis and plug into the motherboard. The modules are held in place by two screws, one at the top and one at the bottom of the front panel. Also at the top and bottom of the module are two handles which, when toggled (pushed outward), move the modules out just far enough for the boards to disengage the motherboard connectors.

In a simplex system, each 8 Ch Voltage Output module is connected through one analog cable to one FTM. All of the I/O are accessible on the FTM.

[Diagram of module configuration]

Figure 8-55—8 Ch Voltage Output (0–5 Vdc) Module Configuration
There are 8 analog output channels of 0–5 Vdc with a full scale range of 0-6.25 Vdc. All Analog Outputs can drive a minimum load of 500 ohms (load + wire resistance). See Figure 8-56 for analog output connection. Each output monitors the output source voltage for fault detection. All of the analog outputs may be individually disabled. When a channel fault or a module fault is detected, the application program may annunciate the fault, disable the channel and stop using data in system calculations or control. Care should be taken to prevent ground loops and other faults when interfacing to non-isolated devices.

8.18.4—FTM Reference

See Chapter 12 for complete field wiring information for the 8 Ch Voltage Output (0–5 Vdc) FTM. See Appendix A for part number Cross Reference for modules, FTM, and cables.

8.18.5—Troubleshooting

Figure 8-57 is a block diagram of the Voltage Output Module with eight 0–5 Vdc outputs.

The system writes output values to the Dual-Port RAM through the VME bus and interface. The microcontroller scales the data using calibration constants stored in EEPROM, and schedules outputs to occur at the proper time.

The microcontroller monitors the output voltage of each channel and alerts the system if a fault is detected. If a fault, which prevents the entire card from operating is detected by either the microcontroller or the system, the FAULT LED will illuminate.
### Figure 8-56—Analog Output Wiring for an 8 Channel Voltage Output (0–5 Vdc) Module
If an analog output is not functioning properly, verify the following:

1. Check that the cable is shielded and the shield is properly grounded per the Shields and Grounding section in Chapter 14.
2. Check the load resistance to ensure that it is not less than 500 ohms.
3. Check to ensure that the load wiring is isolated.
4. Check the wiring for a loose connection on the terminal blocks and disconnected or misconnected cables.
5. Disconnect the field wiring and check that the output is correct across the FTM terminals. If the output is correct, there is a problem with the field wiring.
6. If the other output channels on the 8 Ch Voltage Output (0–5 Vdc) Module are also not working, check the fuse on the 8 Ch Voltage Output (0–5 Vdc) Module. See instructions for module replacement in Chapter 15. This fuse is visible and can be changed through the bottom of the module. If the fuse is blown, fix the wiring problem and replace the fuse with a fuse of the same type and rating.
7. Check the software configuration to ensure that the output is configured properly.
8. After verifying all of the above, replace the 8 Ch Voltage Output (0–5 Vdc) Module.
9. If replacing the module does not fix the problem, replace the FTM. See instructions for replacing the FTM in Chapter 15. The FTM does not contain any active components on the MPU inputs, so replacing it should be the last option.
8.19—8 Ch Voltage Output (0–10 Vdc) Module

8.19.1—Module Description

The 8 Ch Voltage Output (0–10 Vdc) Module is the same as a 8 Ch Voltage Output (0–5 Vdc) Module with different feedback gain to scale the output for 0–10 Vdc on each channel.

Figure 8-58—8 Channel Voltage Output (0–10 Vdc) Module
8.19.2—Specification

Number of Channels: 8
Current range: 0 – 12.5 V
Maximum load resistance: 500 ohms min.
Analog Channel bandwidth: 500 Hz min.
Module interface: VMEbus
Output update time: 1 ms
Resolution: 12 bit
Accuracy: 0.1% of full scale @ 25 °C
Maximum Drift: 50 ppm/degrees C
Status Indication: RED LED - channel fault or board fault
Channel faults: Output current monitored
Microcontroller faults: system monitors a software watchdog
System faults: All outputs are set to zero if MFT is lost.
Operating Temp: 0 to 70 °C
Isolation: None

8.19.3—Installation

See 8 Ch Voltage Output (0–5 Vdc) Module.

8.19.4—FTM Reference

See Chapter 12 for complete field wiring information for the 8 Ch Voltage Output (0–10 Vdc) FTM. See Appendix A for part number Cross Reference for modules, FTM, and cables.

8.19.5—Troubleshooting

See 8 Ch Voltage Output (0–5 Vdc) Module.

8.20—Thermocouple Input Modules

There are two Thermocouple Input modules.
8.21—8 Ch TC (Fail Low) Module

8.21.1—Module Description

There are eight fully isolated thermocouple channels on this module. Each channel receives a signal from a thermocouple. These signals can be from an E, J, K, R, S, or T type thermocouple. The same module can read all types of thermocouples. The GAP application configuration determines the type of thermocouple each channel reads. If an open thermocouple wire is detected by the module, the output of the channel will ramp down to its minimum value. There is a 9th Channel used to measure the reference junction temperature of the junction between the thermocouple and the copper traces on the FTM. This measurement is used to calculate the thermocouple measurement temperature through the GAP application. This cold junction measurement is located on the FTM and utilizes an AD590 temperature sensor. If the actual cold junction in the field wiring occurs elsewhere, the temperature of that junction must be brought into the control as a thermocouple, RTD, or 4–20 mA input, and the application software must be configured to use the appropriate cold junction temperature. The thermocouple and cold junction input units (°C or °F) should be consistent in the application software.

The board performs on-line temperature compensation and hardware diagnostics. These modules have no potentiometers and require no calibration. A module may be replaced with another module of the same part number without any adjustment.

Figure 8-59—8 Channel TC (Fail Low) Module
8.21.2—Specification

Number Channels: 8 double ended, fully isolated, thermocouple input channels
1 cold junction channel.

(Type E, J, K, R, S, and T thermocouples must conform to the common commercial specification published in the Annual Book of ASTM Standards with voltage predictions in line with N.I.S.T. Monograph 175 or ITS-90.)

Thermocouple Types and ranges:

<table>
<thead>
<tr>
<th>T/C TYPE</th>
<th>LOW END °C (°F)</th>
<th>HIGH END °C (°F)</th>
</tr>
</thead>
<tbody>
<tr>
<td>J</td>
<td>-40°C (-40°F)</td>
<td>1050°C (1922°F)</td>
</tr>
<tr>
<td>K</td>
<td>-40°C (-40°F)</td>
<td>1600°C (2912°F)</td>
</tr>
<tr>
<td>E</td>
<td>-40°C (-40°F)</td>
<td>800°C (1472°F)</td>
</tr>
<tr>
<td>R</td>
<td>-40°C (-40°F)</td>
<td>1750°C (3182°F)</td>
</tr>
<tr>
<td>S</td>
<td>-40°C (-40°F)</td>
<td>1750°C (3182°F)</td>
</tr>
<tr>
<td>T</td>
<td>-40°C (-40°F)</td>
<td>1050°C (1922°F)</td>
</tr>
<tr>
<td>CJ</td>
<td>-40°C (-40°F)</td>
<td>150°C (302°F)</td>
</tr>
</tbody>
</table>

Module interface: VMEbus
Open thermocouple detection: Fail Low
Output: Linearized temperatures in °C
Resolution: 16 bit converter
Accuracy: 0.5% of full scale over the entire temperature range
Temperature Coefficient: 12 ppm/degree C
Isolation: 1500 Vac continuous (channel input to control common)
Input Impedance: 2 MΩ
CMRR: -90 db
Status Indication: RED LED - channel fault or board fault
Cold Junction Comp: AD590L IC sensor 1% accuracy (Located on FTM)

8.21.3—Installation

The modules slide into card guides in the control's chassis and plug into the motherboard. The modules are held in place by two screws, one at the top and one at the bottom of the front panel. Also at the top and bottom of the module are two handles which, when toggled (pushed outward), move the modules out just far enough for the boards to disengage the motherboard connectors.

In a simplex system, each 8 Ch TC (Fail Low) module is connected through one low Density analog cable to one TC Input FTM. All of the I/O are accessible on the FTM.
See Figure 8-61 for Thermocouple field wiring connections.

### 8.21.4—FTM Reference

See Chapter 12 for TC Input FTM information. See Appendix A for proper Module, FTM, and cable part numbers.
Figure 8-61—8 Ch TC Input (Fail Low) Module Field Wiring
8.21.5—Troubleshooting

The board performs on-line temperature compensation and hardware diagnostics. To do this, once per minute, it reads two known voltages for each channel. These values are checked against certain limits to determine if a hardware fault has occurred. These values are also used to determine software scaling constants used for temperature compensation. The MUX receives the thermocouple input and, under the control of the microcontroller, passes the value through the gain amplifier to the isolation amplifier. The output of the isolation amplifier goes to one input of the channel-selecting MUX.

This MUX, under control of the microprocessor, selects the channel to be read. The analog output of this MUX is converted to a digital value by the A/D converter, and passed to the microcontroller. The microcontroller uses a lookup table to linearize the thermocouple readings and stores the result in the Dual-Port RAM. The CPU can then access the values stored in Dual-Port RAM through the VME interface and bus. Upon detection of an open wire on the input, the channel will indicate a minimum scale reading. See Figure 8-62 for module block diagram.

During initialization, which occurs after every reset, the CPU turns the FAULT LEDs on. The CPU then tests each I/O module using diagnostic routines built into software. If the diagnostic test is not passed, the LED remains on. If the test is successful, the LED goes off.

During initialization of the module, the module’s micro-controller turns the LED off after power-on self tests have passed and the CPU has initialized the module.
The CPU also tells this module in which rate group each channel is to run, as well as special information. At run time, the CPU then periodically broadcasts a "key" to all I/O cards, telling them which rate groups are to be updated at that time. Through this initialization/key broadcast system, each I/O module handles its own rate-group scheduling with minimal CPU intervention.

This module also has on-card on-line fault detection and automatic calibration/compensation. Each input channel has its own precision voltage reference. Once per minute, while not reading inputs, the on-board microcontroller reads this reference. The microcontroller then uses this data read from the voltage reference for both fault detection and automatic temperature compensation/calibration.

Limits have been set for the expected readings when the on-board microcontroller reads each voltage reference. If the reading obtained is outside these limits, the system determines that the input channel, A/D converter, or the channel's precision-voltage reference is not functioning properly. If this happens, the microcontroller flags that channel as having a fault condition. The CPU will then take whatever action the application engineer has provided for in the application program.

The readings from the precision-voltage reference are also used for on-line temperature compensation and automatic calibration for the module. The readings of the precision-voltage reference, obtained from the A/D converter, are used by the microcontroller to determine software scaling- and offset-constants for each channel. These scaling-and offset-constants are respectively multiplied by and added to each channel reading to provide corrected channel readings. The module therefore includes no potentiometers and needs no calibration.

Each I/O module has a fuse on it; this fuse is visible and can be changed through a cutout in the plastic cover of the module. If this fuse is blown, replace it with a fuse of the same type and size.

Troubleshooting Guide
If an Thermocouple input is not functioning properly, verify the following:

1. Check that the cable is shielded and the shield is properly grounded per the Shields and Grounding section in Chapter 14.
2. Measure the input voltage on the terminal block. It should be in the range of appropriate millivolt signal.
3. Verify that there are no or minimal AC components to the Analog Input signal. AC components can be caused by improper shielding. Thermocouple inputs are extremely sensitive to signal fluctuations.
4. If the input is reading minimum range, look for a loose connection at the terminal blocks and disconnected or misconnected cables.
5. If all the temperature measurements are offset by a fixed amount, check for proper cold junction location. Replace the FTM.
6. Check the software configuration to ensure that the input is configured properly. Ensure that the proper thermocouple type is selected.
7. After verifying all of the above, replace the 8 Ch TC module.
8.22—8 Ch TC (Fail High) Module

8.22.1—Module Description

There are two types of the Thermocouple (Fail High) modules. The standard module is the same as the 8 Ch TC (Fail Low) Module except when a failure is detected, the signal will indicate a full scale value. The Non-standard 8 Ch TC (Fail High) module has replaced the type “E” table with a type “N” table and also fails high when a failure is detected.

8.22.2—Specification

Number Channels: 8 double ended, fully isolated, thermocouple input channels
1 cold junction channel.

(Type E, J, K, N, R, S, and T thermocouples must conform to the common commercial specification published in the Annual Book of ASTM Standards with voltage predictions in line with N.I.S.T. Monograph 175 or ITS-90.)

Figure 8-63—8 Channel TC (Fail High) Module
Thermocouple Types and ranges:

<table>
<thead>
<tr>
<th>T/C TYPE</th>
<th>LOW END °C (°F)</th>
<th>HIGH END °C (°F)</th>
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<tr>
<td>J</td>
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<td>1050°C (1922°F)</td>
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<tr>
<td>K</td>
<td>-40°C (-40°F)</td>
<td>1600°C (2912°F)</td>
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<tr>
<td>E</td>
<td>-40°C (-40°F)</td>
<td>800°C (1472°F)</td>
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<tr>
<td>R</td>
<td>-40°C (-40°F)</td>
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<td>T</td>
<td>-40°C (-40°F)</td>
<td>1050°C (1922°F)</td>
</tr>
<tr>
<td>N</td>
<td>-40°C (-40°F)</td>
<td>1051°C (1925°F)</td>
</tr>
<tr>
<td>CJ</td>
<td>-40°C (-40°F)</td>
<td>150°C (302°F)</td>
</tr>
</tbody>
</table>

Module interface: VMEbus  
Open thermocouple detection: Fail Low  
Output: Linearized temperatures in °C  
Resolution: 16 bit converter  
Accuracy: 0.5% of full scale over the entire temperature range  
Temperature Coefficient: 12 ppm/degree C  
Isolation: 1500 Vac continuous (channel input to control common)  
Input Impedance: 2 MΩ  
CMRR: -90 db  
Status Indication: RED LED - channel fault or board fault  
Cold Junction Comp: AD590L IC sensor 1% accuracy

8.22.3—Installation

See 8 Ch TC (Fail Low) Module.

8.22.4—FTM Reference

See Chapter 12 for complete field wiring information for the 8 Ch TC (Fail High) FTM. See Appendix A for part number Cross Reference for modules, FTMs, and cables.

8.22.5—Troubleshooting

See 8 Ch TC (Fail Low) Module.

8.23—RTD Input Modules

There are four RTD (Resistance Temperature Device) Input modules.
8.24—8 Ch RTD Input (10 ohm)

8.24.1—Module Description

The eight channels of this module are semi-isolated. The channels are isolated from the control common but not from each other. Each channel receives a signal from an RTD. This signal must be from a 10Ω Copper RTD with the following temperature to Resistance relationship:

\[ T = (R \times 25.95) - 234.5 \]

Where

- \( R \) = resistance of copper RTD (Ohms)
- \( T \) = °C

The board performs on-line temperature compensation and hardware diagnostics. These modules have no potentiometers and require no calibration. A module may be replaced with another module of the same part number without any adjustment.

Figure 8-64—8 Channel RTD Input Module (10 ohm)
**8.24.2—Specification**

- **Number of Channels:** 8 semi-isolated, RTD channels
- **Input Type:** 3 wire
- **Temperature range:** 40 to +300 °C
- **Module interface:** VMEbus
- **Output:** Linearized temperatures in °C
- **Resolution:** 14 bit converter
- **Accuracy:** 0.5% of full scale over the entire temperature range
- **Temperature Coefficient:** 12 ppm/degrees C
- **Isolation:** 1500 Vac continuous (input channels to control common, not channel to channel)
- **Input Impedance:** 2.2 MΩ
- **CMRR:** -90 db
- **Status Indication:** RED LED - channel fault or board fault
- **Excitation:** 4 mA

**8.24.3—Installation**

The modules slide into card guides in the control's chassis and plug into the motherboard. The modules are held in place by two screws, one at the top and one at the bottom of the front panel. Also at the top and bottom of the module are two handles which, when toggled (pushed outward), move the modules out just far enough for the boards to disengage the motherboard connectors.

In a simplex system, each 8 Ch RTD Input Module is connected through one low Density analog cable to one Analog Input FTM. All of the I/O are accessible on the FTM.

See Figure 8-65—8 Ch RTD Module Configuration

See Figure 8-66 for RTD field wiring connections.
8.24.4—FTM Reference

See Chapter 12 for complete field wiring information for the 8 Ch RTD Input (10 ohm) FTM. See Appendix A for part number Cross Reference for modules, FTM's, and cables.

8.24.5—Troubleshooting

The board performs on-line temperature compensation and hardware diagnostics. To do this, once per minute, it reads two known voltages for each channel. These values are checked against certain limits to determine if a hardware fault has occurred. These values are also used to determine software scaling constants used for temperature compensation. The MUX receives the RTD input and, under the control of the microcontroller, passes the value through the gain amplifier to the isolation Amplifier. The gain amplifier introduces the proper gain for the type of RTD used. The output of the isolation amplifier goes to one input of the channel-selecting MUX.
Figure 8-66—8 Ch RTD Input Module Field Wiring
This MUX, under control of the microprocessor, selects the channel to be read. The analog output of this MUX is converted to a digital value by the A/D converter, and passed to the microcontroller. The microcontroller uses a lookup table to linearize the RTD reading and stores the result in the Dual-Port RAM. The CPU can then access the values stored in Dual-Port RAM through the VME interface and bus. See Figure 8-67 for module block diagram.

During initialization, which occurs after every reset, the CPU turns the FAULT LEDs on. The CPU then tests each I/O module using diagnostic routines built into software. If the diagnostic test is not passed, the LED remains on. If the test is successful, the LED goes off.

During initialization of the module, the module’s micro-controller turns the LED off after power-on self tests have passed and the CPU has initialized the module.

The CPU also tells this module in which rate group each channel is to run, as well as special information. At run time, the CPU then periodically broadcasts a "key" to all I/O cards, telling them which rate groups are to be updated at that time. Through this initialization/key broadcast system, each I/O module handles its own rate-group scheduling with minimal CPU intervention.

This module also has on-card on-line fault detection and automatic calibration/compensation. Each input channel has its own precision voltage reference. Once per minute, while not reading inputs, the on-board microcontroller reads this reference. The microcontroller then uses this data read from the voltage reference for both fault detection and automatic temperature compensation/calibration.

![Figure 8-67—RTD Input Block Diagram](image-url)
Limits have been set for the expected readings when the on-board microcontroller reads each voltage reference. If the reading obtained is outside these limits, the system determines that the input channel, A/D converter, or the channel's precision-voltage reference is not functioning properly. If this happens, the micro-controller flags that channel as having a fault condition. The CPU will then take whatever action the application engineer has provided for in the application program.

The readings from the precision-voltage reference are also used for on-line temperature compensation and automatic calibration for the module. The readings of the precision-voltage reference, obtained from the A/D converter, are used by the microcontroller to determine software scaling- and offset-constants for each channel. These scaling-and offset-constants are respectively multiplied by and added to each channel reading to provide corrected channel readings. The module therefore includes no potentiometers and needs no calibration.

Each I/O module has a fuse on it; this fuse is visible and can be changed through a cutout in the plastic cover of the module. If this fuse is blown, replace it with a fuse of the same type and size.

**Troubleshooting Guide**

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

1. Check that the cable is shielded and the shield is properly grounded per the Shields and Grounding section in Chapter 14.
2. Measure the input voltage on the terminal block (Sense to – input). It should be in the range generated by a 4 mA current source across the RTD.
3. Verify that there are no or minimal AC components to the Analog Input signal. AC components can be caused by improper shielding.
4. Check for proper connection of the sense line.
5. Check the software configuration to ensure that the input is configured properly. Ensure that the proper RTD is selected.
6. If replacing the module does not fix the problem, replace the FTM. See the instructions in Chapter 15 for replacing the FTM. The FTM contains only traces and a few discrete components, so failure is extremely unlikely.
8.25—8 Ch RTD Input (100 ohm)

8.25.1—Module Description

The eight channels of this module are semi-isolated. The channels are isolated from the control common but not from each other. Each channel receives a signal from an RTD. This signal must be from a 100 Ω Platinum RTD (European or American curve). There are two types of 100 ohm modules. The standard module has the same temperature ranges for the American and European curves (–40 to +450 °C). The high temperature module has a temperature range of –40 to +450 °C for the American curve and –40 to +645 °C for the European curve.

![Figure 8-68—8 Channel RTD Input Module (100 ohm)]

8.25.2—Specification

- Number of Channels: 8 semi-isolated, RTD channels
- Input Type: 3 wire

(Must conform to (Deutsche Institut for Normung) DIN standard for 100 ohm European curve (\(\text{Alpha} = .00385\)) or American curve 100 ohm curve (\(\text{Alpha} = .00392\)))
### Temperature ranges

<table>
<thead>
<tr>
<th>Description</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard module:</td>
<td>–40 to +450 °C</td>
</tr>
<tr>
<td>High Temp Module:</td>
<td>–40 to +645 °C</td>
</tr>
</tbody>
</table>

Excitation: 2 mA  
Module interface: VMEbus  
Output: Linearized temperatures in °C  
Resolution: 14 bit converter  
Accuracy: 0.5% of full scale over the entire temperature range  
Temperature Coefficient: 12 ppm/degree C  
Isolation: 1500 Vac continuous (input channels to control common, not channel to channel)  
Input Impedance: 2.2 MΩ  
CMRR: -90 db  
Status Indication: RED LED - channel fault or board fault

### 8.25.3—Installation

See 8 Ch RTD Input (10 ohm) Module.

### 8.25.4—FTM Reference

See Chapter 12 for complete field wiring information for the 8 Ch RTD Input (100 ohm) FTM. See Appendix A for part number Cross Reference for modules, FTM, and cables.

### 8.25.5—Troubleshooting

See 8 Ch RTD Input (10 ohm) Module.
8.26—8 Ch RTD Input (200 ohm)

8.26.1—Module Description

The eight channels of this module are semi-isolated. The channels are isolated from the control common but not from each other. Each channel receives a signal from an RTD. This signal must be from a 200Ω Platinum RTD (European or American curve).

![Figure 8-69—8 Channel RTD Input Module (200 ohm)](image)

8.26.2—Specification

- Number of Channels: 8 semi-isolated, RTD channels
- Input Type: 3 wire

(Must conform to (Deutsche Institut for Normung) DIN standard for 200 ohm European curve (Alpha = .00385) or American curve 200 ohm curve (Alpha = .00392))
Temperature ranges: –40 to +450 °C (200 ohm platinum, American, European)

Excitation: 1 mA
Module interface: VMEbus

Output: Linearized temperatures in °C
Resolution: 14 bit converter
Accuracy: 0.5% of full scale over the entire temperature range

Temperature Coefficient: 12 ppm/degree C
Isolation: 1500 Vac continuous (input channels to control common, not channel to channel)

Input Impedance: 2.2 MΩ
CMRR: -90 db
Status Indication: RED LED - channel fault or board fault

8.26.3—Installation

See 8 Ch RTD Input (10 ohm) Module.

8.26.4—FTM Reference

See Chapter 12 for complete field wiring information for the 8 Ch RTD Input (200 ohm) FTM. See Appendix A for part number Cross Reference for modules, FTM, and cables.

8.26.5—Troubleshooting

See 8 Ch RTD Input (10 ohm) Module.
8.27—8 Ch RTD Input (500 ohm)

8.27.1—Module Description

The eight channels of this module are semi-isolated. The channels are isolated from the control common but not from each other. Each channel receives a signal from an RTD. This signal must be from a 500Ω Platinum RTD (European or American curve).

![8 Channel RTD Input Module (500 ohm)](image)

Figure 8-70—8 Channel RTD Input Module (500 ohm)

8.27.2—Specification

- Number of Channels: 8 semi-isolated, RTD channels
- Input Type: 3 wire

(Must conform to (Deutsche Institut for Normung) DIN standard for 500 ohm European curve (Alpha = .00385) or American curve 500 ohm curve (Alpha = .00392))
Temperature ranges: -40 to +450 °C (500 ohm platinum, American, European)

Excitation: 400 μA
Module interface: VMEbus
Output: Linearized temperatures in °C
Resolution: 14 bit converter
Accuracy: 0.5% of full scale over the entire temperature range
Temperature Coefficient: 12 ppm/degree C
Isolation: 1500 Vac continuous (input channels to control common, not channel to channel)
Input Impedance: 2.2 MΩ
CMRR: -90 db
Status Indication: RED LED - channel fault or board fault

8.27.3—Installation

See 8 Ch RTD Input (10 ohm) Module.

8.27.4—FTM Reference

See Chapter 12 for complete field wiring information for the 8 Ch RTD Input (500 ohm) FTM. See Appendix A for part number Cross Reference for modules, FTMIs, and cables.

8.27.5—Troubleshooting

See 8 Ch RTD Input (10 ohm) Module.
8.28—4 Ch MPU/Proximity Module

There are many configurations of the MPU/Proximity Module. See Appendix A for the various part numbers.

8.28.1—Module Description

This module has four speed inputs that can be configured as either transformer isolated MPU inputs or non-isolated proximity inputs. The configuration of MPU and proximity inputs is dependent on the part number.

These modules have no potentiometers and require no calibration. A module may be replaced with another module of the same part number without any adjustment.

Figure 8-71—4 Channel MPU/Proximity Module
8.28.2—Specification

Number Channels: 4
Input Type: MPU/Proximity Detector (factory selected by part number)
Input Frequency Range: MPU: 50 Hz to 25 KHz
                      Prox: 0.04 Hz to 2 KHz
Input Amplitude: MPU: 1 Vrms min, 25 Vrms max, Freq > 20 Hz
                  Prox: 10 mA
Input Impedance: MPU: 2000 Ω
                 Prox: 2000 Ω
Isolation Voltage: MPU: 500 Vrms
                  Prox: None
Resolution: 16 bits
            0.0015% of range per LSB
Speed Accuracy (max): 0.01% over temperature range
Temperature drift: 1 ppm/°C
Derivative Accuracy (max): 0.10% of range (p-p)
Speed Filter: 5-10,000 ms (2 real poles)
Derivative Filter: 5-10,000 ms (1 pole + speed filter)
Acceleration Limit: 1-10,000 percent/second
Operating Temperature: –15 to +55 °C

8.28.3—Installation

The modules slide into card guides in the control's chassis and plug into the motherboard. The modules are held in place by two screws, one at the top and one at the bottom of the front panel. Also at the top and bottom of the module are two handles which, when toggled (pushed outward), move the modules out just far enough for the boards to disengage the motherboard connectors.

In a simplex system, each 4 Ch Speed Module is connected through one low Density analog cable to one Analog Input FTM. All of the I/O are accessible on the FTM.

![Diagram of 4 Ch MPU/Proximity Module](image)
Any of the module’s four speed channels accept passive magnetic pickup units (MPUs) or proximity probes. The number of MPU and proximity inputs per module is determined by the position of jumpers internal to the module. These jumpers are factor set. The part number of the module will determine the ratio of MPU to Proximity inputs. Each speed input channel can only accept one MPU or one proximity probe. See Appendix A for desired part number of modules.

A proximity probe may be used to sense very low speeds. With a proximity probe, speed can be sensed down to 0.5 Hz. When interfacing to open collector type proximity probes, a pull-up resistor is required between the supplied proximity probe voltage and the proximity probe input to the FTM. See Figure 7-62 for MPU and proximity probe wiring examples.

**IMPORTANT**

It is not recommended that gears mounted on an auxiliary shaft coupled to the rotor be used to sense speed. Auxiliary shafts tend to turn more slowly than the rotor (reducing speed sensing resolution) and have coupling gear backlash, resulting in less than optimum speed control. For safety purposes, it is also not recommended that the speed sensing device sense speed from a gear coupled to a mechanical drive side of a system’s rotor coupling.

### 8.28.4—FTM Reference

See Chapter 12 for complete field wiring information for the 4 Ch MPU/Proximity FTM. See Appendix A for part number Cross Reference for modules, FTMs, and cables.

### 8.28.5—Troubleshooting

Speed ranges are selected from the GAP and the signal is pre-scaled accordingly. The pre-scaled signal then goes to a counter where the period of the signal is measured. The Digital Signal Processor samples the counter's values every 100 microseconds and performs a divide to generate a digital speed signal.

Every 100 microseconds a digital-filter algorithm is executed to average the speed values in order to improve speed-sensor resolution at input frequencies greater than 200 Hz. This digital filter also provides a derivative output.

Once every rate time (5-200 ms typically), the latest speed and derivative information is moved to the Dual-Port RAM for access by the CPU module.

During initialization, which occurs after every reset, the CPU turns the FAULT LEDs on. The CPU then tests each I/O module using diagnostic routines built into software. If the diagnostic test is not passed, the LED remains on. If the test is successful, the LED goes off.

During initialization of the module, the module’s micro-controller turns the LED off after power-on self tests have passed and the CPU has initialized the module.
Figure 8-73—MPU and Proximity Probe Interface Wiring
The CPU also tells this module in which rate group each channel is to run, as well as special information. At run time, the CPU then periodically broadcasts a "key" to all I/O cards, telling them which rate groups are to be updated at that time. Through this initialization/key broadcast system, each I/O module handles its own rate-group scheduling with minimal CPU intervention.

Each I/O module has a fuse on it; this fuse is visible and can be changed through a cutout in the plastic cover of the module. If this fuse is blown, replace it with a fuse of the same type and size.

Troubleshooting Guide
MPUs. If a magnetic pickup input is not functioning properly, verify the following:

1. Check that the cable is shielded and the shield is properly grounded per the Shields and Grounding section in Chapter 14.
2. Measure the input voltage on the terminal block. It should be in the range of 1-25 VRMS.
3. Verify that the signal waveform is clean and void of double zero crossings.
4. Verify that no ground connection exists and that the resulting 60 Hz signal is absent.
5. Measure the frequency. It should be in the range of 50 Hz - 25 kHz.
6. Check the wiring. Look for a loose connection at the terminal blocks and disconnected or misconnected cables.
7. Check the software configuration to ensure that the input is configured properly.
8. If the readings are incorrect on several channels of the module, replace the Speed module.
9. If replacing the module does not fix the problem, replace the FTM. See instructions for replacing the FTM in Chapter 15. The FTM does not contain any active components on the MPU inputs, so replacing it should be the last option.
Proximity Probes
If a proximity probe input is not functioning properly, verify the following:

1. Check that the cable is shielded and the shield is properly grounded per the Shields and Grounding section in Chapter 14.
2. Measure the input voltage on the terminal block. It should be in the range of 3.5 - 24 Vpeak.
3. Verify that the signal waveform is clean and void of double zero crossings.
4. Verify that no ground connection exists and that the resulting 60 Hz signal is absent.
5. Measure the frequency. It should be in the range of 0.5 Hz to 25 kHz.
6. Check the wiring. Look for a loose connection at the terminal blocks, disconnected or misconnected cables.
7. Check the software configuration to ensure that the input is configured properly.
8. If the readings are incorrect on several channels of the Speed module, replace the Speed module.
9. If replacing the module does not fix the problem, replace the FTM. See instructions for replacing the FTM in Chapter 15.

Chapters 9–15 and the appendixes are contained in volume 2.