# Contents

## Chapter 1  Introduction ................................................................. 1-1
- Principle of Operation ................................................................. 1-2
- Specifications .......................................................................... 1-3

## Chapter 2  Installation ................................................................ 2-1
- Lifting ..................................................................................... 2-1
- Unpacking and Inspection ...................................................... 2-1
- Setup Procedure ...................................................................... 2-3
- Startup .................................................................................... 2-5

## Chapter 3  Operation ................................................................. 3-1
- Display .................................................................................... 3-2
- Pushbuttons ............................................................................ 3-3
  - Soft Keys .............................................................................. 3-4
- Software Overview ................................................................ 3-4
- Power-Up Screen .................................................................. 3-6
- Run Screen ............................................................................. 3-6
- Main Menu ............................................................................. 3-7
- Range Menu ........................................................................... 3-8
  - Single Range Mode ............................................................ 3-9
  - Dual Range Mode .............................................................. 3-10
  - Autorange Mode ................................................................ 3-11
- Gas Units ............................................................................. 3-14
- \( \text{CO}_2 \) Range .................................................................. 3-15
- Set Custom Ranges ............................................................... 3-16
- Averaging Time ..................................................................... 3-17
- Calibration Factors Menu ..................................................... 3-18
  - \( \text{CO}_2 \) Background Correction ..................................... 3-19
  - \( \text{CO}_2 \) Span Coefficients ............................................. 3-21
- Calibration Menu ................................................................... 3-22
  - Calibrate \( \text{CO}_2 \) Background ........................................... 3-23
  - Calibrate \( \text{CO}_2 \) Coefficient ........................................... 3-24
- Zero/Span Check Menu .......................................................... 3-24
Contents

Instrument Controls Menu ................................................... 3-29
Datalogging Settings ......................................................... 3-30
Communication Settings ..................................................... 3-40
I/O Configuration .............................................................. 3-52
Temperature Compensation .............................................. 3-70
Pressure Compensation ..................................................... 3-71
Screen Contrast ............................................................... 3-72
Service Mode ................................................................. 3-73
Date/Time .................................................................... 3-73

Diagnostics Menu ............................................................... 3-74
Program Version ............................................................... 3-75
Voltages ........................................................................ 3-76
Temperatures ................................................................. 3-78
Pressure ....................................................................... 3-79
Flow ............................................................................ 3-79
Sample/Reference Ratio .................................................. 3-80
AGC Intensity ................................................................. 3-80
Motor Speed ................................................................. 3-81
Analog Input Readings ..................................................... 3-81
Analog Input Voltages ....................................................... 3-82
Digital Inputs ................................................................. 3-83
Relay States .................................................................. 3-83
Test Analog Outputs ....................................................... 3-84
Instrument Configuration ................................................ 3-86
Contact Information ....................................................... 3-87

Alarms Menu ................................................................... 3-87
Internal Temperature ....................................................... 3-88
Bench Temperature ........................................................ 3-90
Pressure ....................................................................... 3-91
Sample Flow ................................................................... 3-92
Bias Voltage ................................................................. 3-94
AGC Intensity ................................................................. 3-95
Motor Speed ................................................................. 3-96
Zero and Span Check ..................................................... 3-97
Zero and Span Auto Calibration ..................................... 3-98
Concentration ............................................................... 3-99

Service Menu ................................................................. 3-101
Single/Dual/Auto Select .................................................. 3-102
Pressure Calibration ....................................................... 3-103
Flow Calibration ............................................................. 3-106
Initial S/R Ratio ............................................................. 3-108
Multi-point Calibration .................................................... 3-109
Preamp Board Calibration .............................................. 3-112
Temperature Calibration ................................................ 3-113
Analog Output Calibration .............................................. 3-113
Chapter 4  Calibration ......................................................... 4-1
Equipment Required .......................................................... 4-1
  CO₂ Concentration Standard ........................................ 4-1
  Zero Air .............................................................................. 4-1
  Flow Meter(s) and Controller(s) ........................................ 4-2
  Pressure Regulator for CO₂ Standard Cylinder ................. 4-2
  Mixing Chamber .............................................................. 4-2
  Output Manifold ............................................................... 4-3
Pre-Calibration .................................................................. 4-3
Calibration ........................................................................... 4-4
  Connect the Instrument .................................................. 4-4
  Zero Adjust ........................................................................ 4-4
  Span Adjust ....................................................................... 4-5
  Additional Concentration Standards ................................. 4-6
  Calibration Curve ............................................................ 4-6
  Calibration Frequency ...................................................... 4-6
Periodic Zero and Span Checks ........................................... 4-6
References .......................................................................... 4-8
HI and LO Multi-Point Calibration ....................................... 4-8
  Default Coefficients ........................................................ 4-9
  Cal Point 1, 2, and 3 Adjust ............................................. 4-9

Chapter 5  Preventive Maintenance ........................................... 5-1
Replacement Parts .............................................................. 5-1
Cleaning the Outside Case .................................................. 5-2
IR Source Replacement ....................................................... 5-2
Fan Filter Inspection and Cleaning ...................................... 5-2
Leak Test and Pump Check Out .......................................... 5-3
  External Leaks ................................................................. 5-3
  Leaks Across the Optional Zero/Span and Sample Solenoid
    Valves ........................................................................... 5-4
Pump Rebuilding ................................................................ 5-4
Chapter 6  Troubleshooting.................................................................6-1
  Safety Precautions .....................................................................6-1
  Troubleshooting Guides .........................................................6-1
  Board-Level Connection Diagrams .......................................6-5
  Connector Pin Descriptions ................................................6-7
  Service Locations ...................................................................6-20

Chapter 7  Servicing .................................................................7-1
  Safety Precautions ...................................................................7-3
  Firmware Updates ....................................................................7-3
  Replacement Parts List ..........................................................7-4
  Cable List .................................................................................7-5
  Lowering the Partition Panel ...............................................7-6
  Fuse Replacement ......................................................................7-8
  Fan Replacement ........................................................................7-9
  IR Source Replacement .......................................................7-10
  Filter Wheel Replacement .....................................................7-11
  Chopper Motor Replacement ...............................................7-13
  Optical Bench Replacement ................................................7-14
  Optical Switch Replacement ................................................7-15
  Bench Heater Assembly Replacement ................................7-16
  Detector/Preamplifier Assembly Replacement ....................7-17
  Pump Replacement ....................................................................7-18
  Pressure Transducer Replacement .......................................7-19
  Pressure Transducer Calibration ........................................7-21
  Flow Transducer Replacement ..............................................7-23
  Flow Transducer Calibration ................................................7-24
  Capillary Cleaning or Replacement ......................................7-26
  Optional Zero/Span and Sample Solenoid Valve Replacement ........................................7-26
  Analog Output Testing .........................................................7-27
  Analog Output Adjustment .....................................................7-29
  Ambient Temperature Calibration .......................................7-31
  I/O Expansion Board (Optional) Replacement ......................7-32
  Digital Output Board Replacement .......................................7-34
  Motherboard Replacement ..................................................7-35
  Measurement Interface Board Replacement .......................7-36
  Front Panel Board Replacement .........................................7-37
  LCD Module Replacement ....................................................7-38
  Service Locations ...................................................................7-39
Chapter 8  System Description ................................................................. 8-1
Hardware .................................................................................................. 8-1
Optical Bench ..................................................................................... 8-2
Band-pass Filter ................................................................................ 8-2
Bench Heater Board ........................................................................ 8-2
Chopper Motor .................................................................................. 8-2
Optical Pickup .................................................................................. 8-3
Infrared Source .................................................................................. 8-3
Pre-amplifier Assembly with IR Detector ........................................ 8-3
Sample Flow Sensor .......................................................................... 8-3
Pressure Transducer ......................................................................... 8-3
Capillary .............................................................................................. 8-3
Pump ..................................................................................................... 8-3
Software ............................................................................................... 8-4
Instrument Control ........................................................................... 8-4
Monitoring Signals ........................................................................... 8-4
Output Communication ..................................................................... 8-4
Electronics ............................................................................................ 8-5
Motherboard ....................................................................................... 8-5
Measurement Interface Board .......................................................... 8-6
Flow Sensor Assembly ...................................................................... 8-6
Pressure Sensor Assembly ............................................................... 8-7
Bench Heater Board .......................................................................... 8-7
Pre-amp Board Assembly .................................................................. 8-7
Digital Output Board .......................................................................... 8-7
I/O Expansion Board (Optional) ........................................................ 8-7
Front Panel Connector Board ............................................................ 8-7
I/O Components .................................................................................. 8-8
Analog Voltage Outputs .................................................................... 8-8
Analog Current Outputs (Optional) .................................................. 8-8
Analog Voltage Inputs (Optional) ....................................................... 8-9
Digital Relay Outputs ......................................................................... 8-9
Digital Inputs ..................................................................................... 8-9
Serial Ports .......................................................................................... 8-10
RS-232 Connection ........................................................................... 8-10
RS-485 Connection ........................................................................... 8-11
Ethernet Connection .......................................................................... 8-11
External Accessory Connector .......................................................... 8-11

Chapter 9  Optional Equipment ............................................................... 9-1
Internal Zero/Span and Sample Valves .............................................. 9-1
Teflon Particulate Filter ....................................................................... 9-1
I/O Expansion Board Assembly ........................................................ 9-1
Terminal Block and Cable Kits ........................................................... 9-1
Mounting Options ............................................................................... 9-2
Appendix A Warranty ........................................................................................................... A-1

Appendix B C-Link Protocol Commands ........................................................................... B-1
Instrument Identification Number ................................................................. B-2
Commands ....................................................................................................................... B-2
Measurements ............................................................................................................... B-8
Alarms ............................................................................................................................. B-11
Diagnostics .................................................................................................................... B-15
Datalogging ..................................................................................................................... B-16
Calibration ...................................................................................................................... B-22
Keys/Display .................................................................................................................. B-25
Measurement Configuration ........................................................................................ B-27
Hardware Configuration ............................................................................................... B-30
Communications Configuration .................................................................................... B-32
I/O Configuration .......................................................................................................... B-36
Record Layout Definition ............................................................................................. B-40
  Format Specifier for ASCII Responses ................................................................. B-41
  Format Specifier for Binary Responses ................................................................. B-41
  Format Specifier for Front-Panel Layout ............................................................. B-41

Appendix C MODBUS Protocol ...................................................................................... C-1
Serial Communication Parameters ............................................................................. C-2
TCP Communication Parameters .............................................................................. C-2
Application Data Unit Definition ............................................................................... C-2
Function Codes .......................................................................................................... C-3
MODBUS Commands Supported .............................................................................. C-8
About This Manual

This manual provides information about operating, maintaining, and servicing the analyzer. It also contains important alerts to ensure safe operation and prevent equipment damage. The manual is organized into the following chapters and appendices to provide direct access to specific operation and service information:

- Chapter 1 “Introduction” provides an overview of product features, describes the principles of operation, and lists the specifications.
- Chapter 2 “Installation” describes how to unpack, setup, and startup the analyzer.
- Chapter 3 “Operation” describes the front panel display, the front panel pushbuttons, and the menu-driven software.
- Chapter 4 “Calibration” provides the procedures for calibrating the analyzer and describes the required equipment.
- Chapter 5 “Preventive Maintenance” provides maintenance procedures to ensure reliable and consistent instrument operation.
- Chapter 6 “Troubleshooting” presents guidelines for diagnosing analyzer failures, isolating faults, and includes recommended actions for restoring proper operation.
- Chapter 7 “Servicing” presents safety alerts for technicians working on the analyzer, step-by-step instructions for repairing and replacing components, and a replacement parts list. It also includes contact information for product support and technical information.
- Chapter 8 “System Description” describes the function and location of the system components, provides an overview of the software structure, and includes a description of the system electronics and input/output connections.
- Chapter 9 “Optional Equipment” describes the optional equipment that can be used with this analyzer.
- Appendix A “Warranty” is a copy of the warranty statement.
• Appendix B “C-Link Protocol Commands” provides a description of the C-Link protocol commands that can be used to remotely control an analyzer using a host device such as a PC or a datalogger.

• Appendix C “MODBUS Protocol” provides a description of the MODBUS Protocol Interface and is supported both over RS-232/485 (RTU protocol) as well as TCP/IP over Ethernet.

Safety

Review the following safety information carefully before using the analyzer. This manual provides specific information on how to operate the analyzer, however if the analyzer is used in a manner not specified by the manufacturer, the protection provided by the equipment may be impaired.

Safety and Equipment Damage Alerts

This manual contains important information to alert you to potential safety hazards and risks of equipment damage. Refer to the following types of alerts you may see in this manual.

Safety and Equipment Damage Alert Descriptions

<table>
<thead>
<tr>
<th>Alert</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DANGER</td>
<td>A hazard is present that will result in death or serious personal injury if the warning is ignored.</td>
</tr>
<tr>
<td>WARNING</td>
<td>A hazard is present or an unsafe practice can result in serious personal injury if the warning is ignored.</td>
</tr>
<tr>
<td>CAUTION</td>
<td>The hazard or unsafe practice could result in minor to moderate personal injury if the warning is ignored.</td>
</tr>
<tr>
<td>Equipment Damage</td>
<td>The hazard or unsafe practice could result in property damage if the warning is ignored.</td>
</tr>
</tbody>
</table>
Safety and Equipment Damage Alerts in this Manual

<table>
<thead>
<tr>
<th>Alert</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>WARNING</td>
<td>If the equipment is operated in a manner not specified by the manufacturer, the protection provided by the equipment may be impaired. The service procedures in this manual are restricted to qualified service personnel only. The Model 410i is supplied with a three-wire grounding cord. Under no circumstances should this grounding system be defeated.</td>
</tr>
<tr>
<td>CAUTION</td>
<td>If the LCD panel breaks, do not let the liquid crystal contact your skin or clothes. If the liquid crystal contacts your skin or clothes, wash it off immediately using soap and water.</td>
</tr>
<tr>
<td>Equipment Damage</td>
<td>Do not attempt to lift the analyzer by the cover or other external fittings. Some internal components can be damaged by small amounts of static electricity. A properly grounded antistatic wrist strap must be worn while handling any internal component. Do not remove the panel or frame from the LCD module. Handle all printed circuit boards by the edges only. The LCD module polarizing plate is very fragile, handle it carefully. Do not wipe the LCD module polarizing plate with a dry cloth, it may easily scratch the plate. Do not use Ketonics solvent or aromatic solvent to clean the LCD module, use a soft cloth moistened with a naphtha cleaning solvent. Do not place the LCD module near organic solvents or corrosive gases. Do not shake or jolt the LCD module.</td>
</tr>
</tbody>
</table>

Where to Get Help

Service is available from exclusive distributors worldwide. Contact one of the phone numbers below for product support and technical information.

866-282-0430

508-520-0430
Chapter 1 Introduction

The Model 410i Analyzer measures CO₂ concentration using advanced NDIR technology. The Model 410i combines proven detection technology, easy to use menu-driven software, and advanced diagnostics to offer unsurpassed flexibility and reliability. The Model 410i has the following features:

- 320 x 240 graphics display
- Menu-driven software
- Field programmable ranges
- User-selectable single/dual/auto range modes
- Multiple user-defined analog outputs
- Analog input options
- High sensitivity
- Fast response time
- Linearity through all ranges
- Highly specific to CO₂
- Self-aligning optics
- Automatic temperature and pressure compensation
- User-selectable digital input/output capabilities
- Standard communications features include RS232/485 and Ethernet
- C-Link, MODBUS, and streaming data protocols

For details of the analyzer’s principle of operation and product specifications, see the following topics:
• “Principle of Operation” on page 1-2 describes the principles by which your analyzer operates.

• “Specifications” on page 1-3 is a list of the analyzer’s performance specifications.

Thermo Electron is pleased to supply this CO₂ analyzer. We are committed to the manufacture of instruments exhibiting high standards of quality, performance, and workmanship. Service personnel are available for assistance with any questions or problems that may arise in the use of this analyzer. For more information on servicing, see Chapter 7 “Servicing”.

Principle of Operation

The Model 410i operates on the principle that carbon dioxide (CO₂) absorbs infrared radiation at a wavelength of 4.26 microns.

The sample is drawn into the Model 410i through the sample bulkhead, as shown in Figure 1-1. The sample flows through the optical bench. Radiation from an infrared source is chopped and then passed through a rotating optical wheel alternating between sample and reference filters. The radiation then enters the optical bench where absorption by the sample gas occurs. The infrared radiation then exits the optical bench and falls on an infrared detector. The chopped detector signal is modulated by the alternation between the filters with an amplitude related to the concentration of CO₂ in the sample cell. Because infrared absorption is a non-linear measurement, it is necessary to transform the basic analyzer signal into a linear output. The Model 410i uses an internally stored calibration curve to accurately linearize the instrument output over any range up to a concentration of 10,000 ppm.

The Model 410i outputs the CO₂ concentration to the front panel display, the analog outputs, and also makes the data available over the serial or ethernet connection.
Figure 1-1. Model 410i Flow Schematic

Specifications

Table 1-1. Model 410i Specifications

<table>
<thead>
<tr>
<th>Specification</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preset ranges</td>
<td>0-200, 500, 1000, 2000, 5000, and 10000 ppm</td>
</tr>
<tr>
<td></td>
<td>0-500, 1000, 2000, 5000, 10000, 20000 mg/m³</td>
</tr>
<tr>
<td>Custom ranges</td>
<td>0-200 to 10000 ppm ppm</td>
</tr>
<tr>
<td></td>
<td>0-500 to 20000 mg/m³</td>
</tr>
<tr>
<td>Zero noise</td>
<td>0.5 ppm RMS (60 second averaging time)</td>
</tr>
<tr>
<td>Minimum detectable</td>
<td>1 ppm</td>
</tr>
<tr>
<td>limit</td>
<td></td>
</tr>
<tr>
<td>Zero drift (24 hour)</td>
<td>± 1.0 ppm</td>
</tr>
<tr>
<td>Span drift (24 hour)</td>
<td>± 2% span concentration</td>
</tr>
<tr>
<td>Response time</td>
<td>90 seconds (30 second averaging time)</td>
</tr>
<tr>
<td>Linearity</td>
<td>± 1.5% of span (at concentrations of 10 to 100% of span)</td>
</tr>
<tr>
<td>Sample flow rate</td>
<td>1.0 LPM</td>
</tr>
<tr>
<td>Operating temperature</td>
<td>5–45 °C</td>
</tr>
</tbody>
</table>
### Specifications

<table>
<thead>
<tr>
<th>Power requirements</th>
<th>100 VAC @ 50/60 Hz</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>115 VAC @ 50/60 Hz</td>
</tr>
<tr>
<td></td>
<td>220–240 VAC @ 50/60 Hz</td>
</tr>
<tr>
<td></td>
<td>275 watts</td>
</tr>
<tr>
<td>Physical dimensions</td>
<td>16.75” (W) X 8.62” (H) X 23” (D)</td>
</tr>
<tr>
<td>Weight</td>
<td>Approximately 39 lbs.</td>
</tr>
<tr>
<td>Analog outputs</td>
<td>6 voltage outputs; 0–100 mV, 1, 5, 10 V (User selectable), 5% of full-scale over/under range, 12 bit resolution, user selectable for measurement input</td>
</tr>
<tr>
<td>Digital outputs</td>
<td>1 power fail relay Form C, 10 digital relays Form A, user selectable alarm output, relay logic, 100 mA @ 200 VDC</td>
</tr>
<tr>
<td>Digital inputs</td>
<td>16 digital inputs, user select programmable, TTL level, pulled high</td>
</tr>
<tr>
<td>Serial Ports</td>
<td>1 RS-232 or RS-485 with two connectors, baud rate 1200–115200, data bits, parity, and stop bits, protocols: C-Link, MODBUS, and streaming data (all user selectable)</td>
</tr>
<tr>
<td>Ethernet connection</td>
<td>RJ45 connector for 10Mbs Ethernet connection, static or dynamic TCP/IP addressing</td>
</tr>
</tbody>
</table>
Chapter 2 Installation

Installing the Model 410i includes the following recommendations and procedures:

- “Lifting” on page 2-1
- “Unpacking and Inspection” on page 2-1
- “Setup Procedure” on page 2-3
- “Startup” on page 2-5

Lifting

When lifting the instrument, use procedure appropriate to lifting a heavy object, such as, bending at the knees while keeping your back straight and upright. Grasp the instrument at the bottom in the front and at the rear of the unit. Although one person can lift the unit, it is desirable to have two persons lifting, one by grasping the bottom in the front and the other by grasping the bottom in the rear.

Equipment Damage Do not attempt to lift the instrument by the cover or other external fittings.

Unpacking and Inspection

The Model 410i is shipped complete in one container. If there is obvious damage to the shipping container when you receive the instrument, notify the carrier immediately and hold for inspection. The carrier is responsible for any damage incurred during shipment.

Use the following procedure to unpack and inspect the instrument.

1. Remove the instrument from the shipping container and set it on a table or bench that allows easy access to both the front and rear.

2. Remove the cover to expose the internal components.
3. Remove the packing material (Figure 2-1).

![Figure 2-1. Remove the Packing Material](image)

4. Remove the three shipping screws (Figure 2-2).

![Figure 2-2. Remove the Shipping Screws](image)

5. Check for possible damage during shipment.
6. Check that all connectors and circuit boards are firmly attached.

7. Re-install the cover.

**Setup Procedure**

Use the following procedure to setup the instrument.

1. Connect the sample line to the SAMPLE bulkhead on the rear panel (Figure 2-3). Ensure that the sample line is not contaminated by dirty, wet, or incompatible materials. All tubing should be constructed of FEP Teflon®, 316 stainless steel, borosilicate glass, or similar tubing with an OD of 1/4-inch and a minimum ID of 1/8-inch. The length of the tubing should be less than 10 feet.

   **Note** Gas must be delivered to the instrument at atmospheric pressure. If sample is supplied under pressure, it may be necessary to use an atmospheric bypass plumbing arrangement as shown in Figure 2-4.

2. Connect the EXHAUST bulkhead to a suitable vent. The exhaust line should be 1/4-inch OD with a minimum ID of 1/8-inch. The length of the exhaust line should be less than 10 feet. Verify that there is no restriction in this line.

3. If the optional zero/span solenoid valves are installed, connect a source of CO₂-free air to the ZERO bulkhead, and connect a source of CO₂ span gas to the SPAN bulkhead.

4. Connect a suitable recording device to the rear panel connector. See the “Operation” chapter for more information about the rear panel pin-outs.

5. Plug the instrument into an outlet of the appropriate voltage and frequency.

6. Connect a source of CO₂-free air or nitrogen to the PURGE port.

**WARNING** The Model 410i is supplied with a three-wire grounding cord. Under no circumstances should this grounding system be defeated.
**Installation**

Setup Procedure

---

**Figure 2-3.** Model 410i Rear Panel

**Figure 2-4.** Atmospheric Dump Bypass Plumbing
Startup

Use the following procedure when starting the instrument.

1. Turn the power ON.

2. Set the PURGE port input pressure to 20 psig.

3. Allow 90 minutes for the instrument to stabilize.

4. Set instrument parameters such as operating ranges and averaging times to appropriate settings. For more information about instrument parameters, see the “Operation” chapter.

5. Before beginning the actual monitoring, perform a multipoint calibration as described in the “Calibration” chapter.
Chapter 3 Operation

This chapter describes the front panel display, front panel pushbuttons, and menu-driven software.

- “Display” on page 3-2 describes the LCD graphics display.
- “Pushbuttons” on page 3-3 describes the various front panel pushbuttons and the expected key actions for each.
- “Software Overview” on page 3-4 describes the menu-driven software and submenus.
- “Range Menu” on page 3-8 describes the gas units, CO₂ range, and custom ranges.
- “Averaging Time” on page 3-17 describes the averaging period applied to CO₂ measurements.
- “Calibration Factors Menu” on page 3-18 describes the calibration factors used to correct CO₂ measurement readings.
- “Calibration Menu” on page 3-22 describes calibration of zero and span.
- “Instrument Controls Menu” on page 3-29 describes the instrument hardware control and configuration.
- “Diagnostics Menu” on page 3-74 describes the diagnostic information and functions.
- “Alarms Menu” on page 3-87 describes a list of items that are monitored by the analyzer.
- “Service Menu” on page 3-101 describes service related menu items.
- “Password” on page 3-120 describes how to enter/change a password, lock and unlock the analyzer.
Display  The 320 x 240 graphics liquid-crystal display (LCD) shows the sample sample concentrations, instrument parameters, instrument controls, help, and error messages. Some menus contain more items than can be displayed at one time. For these menus, use ↑ and ↓ to move the cursor up and down to each item.

Figure 3-1. 410i Front Panel Display

CAUTION If the LCD panel breaks, do not let the liquid crystal contact your skin or clothes. If the liquid crystal contacts your skin or clothes, wash it off immediately using soap and water.
Pushbuttons

The Pushbuttons allow the user to traverse the various screens/menus.

![Pushbutton Diagram]

**Figure 3-2. Front Panel Pushbuttons**

**Table 3-1. Front Panel Pushbuttons**

<table>
<thead>
<tr>
<th>Button</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>▼ ▼</td>
<td>Soft Keys: The soft keys are used to provide shortcuts that allow the user to jump to user-selectable menu screens. For more information on processing soft keys, see “Soft Keys” below.</td>
</tr>
<tr>
<td>▼</td>
<td>Run: The ▼ is used to display the Run screen. The Run screen normally displays the CO₂ concentration.</td>
</tr>
<tr>
<td>▼</td>
<td>Menu: The ▼ is used to display the Main Menu when in the Run screen, or back up one level in the menu system. For more information about the Main Menu, see “Main Menu” later in this chapter.</td>
</tr>
<tr>
<td>▼</td>
<td>Help: The ▼ is context-sensitive, that is, it provides additional information about the screen that is being displayed. Press ▼ for a brief explanation about the current screen or menu. Help messages are displayed using lower case letters to easily distinguish them from the operating screens. To exit a help screen, press ▼ or ▼ to return to the previous screen, or ▼ to return to the Run screen.</td>
</tr>
<tr>
<td>▼ ▼</td>
<td>Up, Down: The four arrow pushbuttons ▼ ▼ ▼ ▼ move the cursor up, down, left, and right or change values and states in specific screens.</td>
</tr>
<tr>
<td>▼ ▼</td>
<td>Left, Right: ▼ ▼ move the cursor up, down, left, and right or change values and states in specific screens.</td>
</tr>
<tr>
<td>▼</td>
<td>Enter: The ▼ is used to select a menu item, accept/set/save a change, and/or toggle on/off functions.</td>
</tr>
</tbody>
</table>
Soft Keys

The Soft Keys are multi-functional keys that use part of the display to identify their function at any moment. The function of the soft keys allow immediate access to the menu structure and most often used menus and screens. They are located directly underneath the display and as the keys’ functions change this is indicated by user-defined labels in the lower part of the display, so that the user knows what the keys are to be used for.

To process a soft key, place the menu cursor “>” on the item of the selected menu or screen you wish to set. Press followed by the selected soft key within 1 second of pressing the right-arrow key. The edit soft key prompt will be displayed for configuration for the new label.

Note Not all menu items may be assigned to soft keys. If a particular menu or screen item cannot be assigned, the key assignment screen will not come up upon entering right-arrow-soft key combinations. All items under the Service menu (including the menu itself) cannot be assigned soft keys.

Software Overview

The Model 410i is based on menu-driven software as illustrated by the flowchart in Figure 3-3. The Power-Up screen, shown at the top of the flowchart, is displayed each time the instrument is turned on. This screen is displayed while the instrument is warming up and performing self-checks. After the warm-up period, the Run screen is automatically displayed. The Run screen is the normal operating screen. It displays the CO₂ concentration, depending on operating mode. From the Run screen, the Main Menu can be displayed by pressing . The Main Menu contains a list of submenus. Each submenu contains related instrument parameters and/or functions. This chapter describes each submenu and screen in detail. Refer to the appropriate sections for more information.
Figure 3-3. Flowchart of Menu-Driven Software
Power-Up Screen

The Power-Up screen is displayed on power up of the Model 410i. The Self-Test is displayed while internal components are warming up and diagnostic checks are performed.

Run Screen

The Run screen displays the CO₂ concentrations. The status bar displays time and the status of the remote control interface, and optional zero/span solenoid valves, if installed. The word “SAMPLE” on the bottom left of the display indicates the analyzer has the span/zero valve option and is in “SAMPLE” mode. Other modes appear in the same area of the display as “ZERO” or “SPAN”. For more information about the optional solenoid valves, see Chapter 9, “Optional Equipment”.

When operating in dual or autorange mode two sets of coefficients are used to calculate the CO₂ “LOW” and “HIGH” concentrations. Also, two averaging times are used—one for each range. The title bar indicates which range concentrations are displayed. The words “LOW RANGE CONCENTRATION” on the top of the display indicates that the low concentration is displayed. The display shows as default the low concentrations. Use the ↑ and ↓ arrows to toggle between high and low concentrations. The example below shows the Run screen in single range mode.
Main Menu

The Main Menu contains a number of submenus. Instrument parameters and features are divided into these submenus according to their function. Use ↑ and ↓ to move the cursor to each submenu. Use ← to select a submenu.

```
CONCENTRATION

CO₂  15.8  PPM

SAMPLE  12:34  ALARM

RANGE  AVG  DIAGS  ALARM
```

```
CONCENTRATION

CO  15.80  PPM

SAMPLE  12:34  ALARM

MAIN MENU:
> RANKGE
  AVERAGING TIME
  CALIBRATION FACTORS
  CALIBRATION
  INSTRUMENT CONTROLS
  DIAGNOSTICS
  ALARMS

RANGE  AVG  DIAGS  ALARM

SERVICE
PASS WORD
```
Range Menu

The Range menu allows the operator to select the gas units, CO₂ ranges, and to set the custom ranges. The screens below show the range menu in single mode and dual/autorange modes. For more information about the single, dual or autorange modes, see “Single Range Mode”, Dual Range Mode”, and “Autorange Mode” below.

- In the Main Menu, choose Range.
- Use and to move the cursor up and down.
- Press to select a choice.
- Press to return to the Main Menu or to return to the Run screen.

![Range Menu Screen](image-url)
Single Range Mode

In the single range mode, there is one range, one averaging time, and one span coefficient.

By default, the two CO₂ analog outputs are arranged on the rear panel connector as shown in Figure 3-4. See Table 3-2 for channels and pin connections. Single range mode may be selected from the “Single/Dual/Auto Select” in the “Service Menu”, later in this chapter.

Figure 3-4. Pin-Out of Rear Panel Connector in Single Range Mode

Table 3-2. Default Analog Outputs in Single Range Mode

<table>
<thead>
<tr>
<th>Channel</th>
<th>Pin</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>14</td>
<td>CO₂ Analog Output</td>
</tr>
<tr>
<td>2</td>
<td>33</td>
<td>CO₂ Analog Output</td>
</tr>
<tr>
<td>3</td>
<td>15</td>
<td>None</td>
</tr>
<tr>
<td>4</td>
<td>34</td>
<td>None</td>
</tr>
<tr>
<td>5</td>
<td>17</td>
<td>None</td>
</tr>
<tr>
<td>6</td>
<td>26</td>
<td>None</td>
</tr>
<tr>
<td>Ground</td>
<td>16, 18, 19, 35, 37</td>
<td>Signal Ground</td>
</tr>
</tbody>
</table>

**Note** All channels are user definable. If any customization has been made to the analog output configuration, the default selections may not apply.
**Dual Range Mode**

In the dual range mode, there are two independent analog outputs. These are labeled simply as the “High Range” and the “Low Range”. Each channel has its own analog output range, averaging time, and span coefficient.

This enables the sample concentration reading to be sent to the analog outputs at two different ranges. For example, the low CO₂ analog output can be set to output concentrations from 0 to 500 ppm and the high CO₂ analog output set to output concentrations from 0 to 1,000 ppm.

In addition, each CO₂ analog output has a span coefficient. There are two span coefficients so that each range can be calibrated separately. This is necessary if the two ranges are not close to one another. For example, the low CO₂ range is set to 0–200 ppm and the high CO₂ range is set to 0–10,000 ppm.

By default, in the dual range mode, the analog outputs are arranged on the rear panel connector as shown in Figure 3-5. See Table 3-3 for channels and pin connections. Dual range mode may be selected from the “Single/Dual/Auto Select” in the “Service Menu,” later in this chapter.

![Figure 3-5. Pin-Out of Rear Panel Connector in Dual Range Mode](image)
Table 3-3. Default Analog Outputs in Dual Range Mode

<table>
<thead>
<tr>
<th>Channel</th>
<th>Pin</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>14</td>
<td>CO₂ High Range</td>
</tr>
<tr>
<td>2</td>
<td>33</td>
<td>CO₂ Low Range</td>
</tr>
<tr>
<td>3</td>
<td>15</td>
<td>None</td>
</tr>
<tr>
<td>4</td>
<td>34</td>
<td>None</td>
</tr>
<tr>
<td>5</td>
<td>17</td>
<td>None</td>
</tr>
<tr>
<td>6</td>
<td>26</td>
<td>None</td>
</tr>
<tr>
<td>Ground</td>
<td>16, 18, 19, 35, 37</td>
<td>Signal Ground</td>
</tr>
</tbody>
</table>

Note All channels are user definable. If any customization has been made to the analog output configuration, the default selections may not apply.

Autorange Mode

The autorange mode switches the CO₂ analog outputs between a high and low ranges, depending on the concentration level. The high and low ranges are defined in the Range menu.

For example, suppose the low range is set to 500 ppm and the high range is set to 1,000 ppm (Figure 3-6). Sample concentrations below 500 ppm are presented to the low ranges analog outputs and sample concentrations above 500 ppm are presented to the high ranges analog outputs. When the low range is active, the status output is at 0 volts. When the high range is active, the status output is at half of full-scale.

When the high range is active, the concentration must drop to 95% of the low CO₂ range for the low range to become active.

In addition, each CO₂ analog output has a span coefficient. There are two span coefficients so that each range can be calibrated separately. This is necessary if the two ranges are not close to one another. For example, the low CO₂ range is set to 0–200 ppm and the high CO₂ range is set to 0–1,000 ppm.
Figure 3-6. Analog Output in Autorange Mode

By default, in the autorange mode, the analog outputs are arranged on the rear panel connector as shown in Figure 3-7. Refer to Table 3-4 for channels and pin connections. Autorange mode may be selected from the “Single/Dual/Auto Select” in the “Service Menu”, later in this chapter.
Figure 3-7. Pin-Out of Rear Panel Connector in Autorange Mode

Table 3-4. Default Analog Outputs in Autorange Mode

<table>
<thead>
<tr>
<th>Channel</th>
<th>Pin</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>14</td>
<td>CO₂ Analog Output</td>
</tr>
<tr>
<td>2</td>
<td>33</td>
<td>CO₂ Status Output:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>half-scale = high range</td>
</tr>
<tr>
<td></td>
<td></td>
<td>zero scale = low range</td>
</tr>
<tr>
<td>3</td>
<td>15</td>
<td>None</td>
</tr>
<tr>
<td>4</td>
<td>34</td>
<td>None</td>
</tr>
<tr>
<td>5</td>
<td>17</td>
<td>None</td>
</tr>
<tr>
<td>6</td>
<td>26</td>
<td>None</td>
</tr>
<tr>
<td>Ground</td>
<td>16, 18, 19, 35, 37</td>
<td>Signal Ground</td>
</tr>
</tbody>
</table>

Note All channels are user definable. If any customization has been made to the analog output configuration, the default selections may not apply.
Gas Units

The Gas Units screen defines how the CO₂ concentration readings is expressed. Gas units of parts per million (ppm) and milligrams per cubic meter (mg/m³) are available. The mg/m³ gas concentration mode is calculated using a standard pressure of 760 mmHg and a standard temperature of 20 °C.

When switching from ppm to mg/m³, the analog ranges all default to the highest range in that mode. For example, when switching from mg/m³ to ppm, all the ranges default to 10,000 ppm. Therefore, whenever you change units, you should also check the range settings.

- In the Main Menu, choose Range > Gas Units.
- Use ↑ and ↓ for a list of choices.
- Press ← to save the new units.
- Press ▶ to return to the Range menu or ◀ to return to the Run screen.

Note If the units change from ppm to mg/m³ or vice versa, a display warning will appear that ranges will be defaulted and calibration parameters reset.

![Gas Units Screen](image)
**CO₂ Range**  
The CO₂ Range screen defines the concentration range of the analog outputs. For example, a CO₂ range of 0–500 ppm restricts the analog output to concentrations between 0 and 500 ppm.

The display shows the current CO₂ range. The next line of the display is used to change the range. The range screen is similar for the single, dual, and autorange modes. The only difference between the screens are the words “High” or “Low” displayed to indicate which range is displayed. The example below shows the CO₂ range screen in single mode. For more information about the dual and autorange modes, see “Single Range Mode”, “Dual Range Mode”, and “Autorange Mode” earlier in this chapter.

Table 3-5 lists the standard ranges.

- In the Main Menu, choose Range > **Range**.
- Use ↑ and ↓ for a list of choices.
- Press ← to save the new range.
- Press ◀ to return to the Range menu or ▶ to return to the Run screen.
Table 3-5. Standard Ranges

<table>
<thead>
<tr>
<th>ppm</th>
<th>mg/m^3</th>
</tr>
</thead>
<tbody>
<tr>
<td>200</td>
<td>500</td>
</tr>
<tr>
<td>500</td>
<td>1,000</td>
</tr>
<tr>
<td>1,000</td>
<td>2,000</td>
</tr>
<tr>
<td>2,000</td>
<td>5,000</td>
</tr>
<tr>
<td>5,000</td>
<td>10,000</td>
</tr>
<tr>
<td>10,000</td>
<td>20,000</td>
</tr>
<tr>
<td>C1</td>
<td>C1</td>
</tr>
<tr>
<td>C2</td>
<td>C2</td>
</tr>
<tr>
<td>C3</td>
<td>C3</td>
</tr>
</tbody>
</table>

For more information about custom ranges, see “Set Custom Ranges” below.

**Set Custom Ranges**

The Custom Ranges Menu lists three custom ranges: C1, C2, and C3. Custom ranges are user-defined ranges. In the ppm mode, any value between 1 and 10,000 ppm can be specified as a range. In the mg/m^3 mode, any value between 1 and 20,000 mg/m^3 can be specified as a range.

- In the Main Menu, choose Range > Set Custom Ranges.
- Use ↑ and ↓ to move the cursor up and down.
- Press ← to select a choice.
- Press → to return to the Range menu or → to return to the Run screen.
Custom Ranges

The Custom Ranges screen is used to define the custom ranges.

The display shows the current custom range. The next line of the display is used to set the range. To use the custom full-scale range, be sure to select it (Custom range 1, 2, or 3) in the CO₂ Ranges screen. For more information about selecting ranges, see “CO₂ Range” above.

- In the Main Menu, choose Range > Custom Ranges > Custom Range 1, 2, or 3.
- Use ▲ and ▼ to increment or decrement the numeric value.
- Press ← to save the new range.
- Press ◀ to return to the Set Custom Ranges menu or ▶ to return to the Run screen.

Averaging Time

The Averaging Time defines a time period (1 to 300 seconds) during which CO₂ measurements are taken. The average concentration of the readings are calculated for that time period. The front panel display and analog outputs are updated every 10 seconds for averaging times between 10 and 300 seconds. For averaging times of 1, 2, and 5 seconds, the front panel display and analog outputs are updated every second. An averaging time of 10 seconds, for example, means that the average concentration of the last 10 seconds will be output at each update. An averaging time of 300 seconds means that the moving average concentration of the last 300 seconds will be output at each update. Therefore, the lower the averaging time the faster the front panel display and analog outputs respond to concentration changes. Longer averaging times are typically used to smooth output data.
The Averaging Time screens for the single and dual or auto range modes are shown below. In the dual and auto range modes, an Averaging Time Menu is displayed before the averaging time screens. This menu is needed because the dual and autorange modes have two averaging times (high and low). The Averaging Time screens function the same way in the single, dual, and autorange modes. The following averaging times are available: 1, 2, 5, 10, 20, 30, 60, 90, 120, 180, 240, and 300 seconds.

- In the Main Menu, choose **Averaging Time**.
- Use ‹ and › for a list of choices.
- Press ′ to save the averaging time.
- Press ′ to return to the Main Menu or ′ to return to the Run screen.

![Averaging Time Menu](image)

**Calibration Factors Menu**

Calibration factors are used to correct the CO₂ concentration readings that the instrument generates using its own internal calibration data. The Calibration Factors menu displays the calibration factors. The screens below show the calibration factors menu in single mode and dual/autorange modes.

Normally, the instrument is calibrated automatically using the Calibration menu described in “Calibration Menu” later in this chapter. However, the instrument can also be calibrated manually using the Calibration Factors menu.

To manually calibrate the instrument, see “CO₂ Backgrounds” and “CO₂ Span Coefficients” below for more information.
• In the Main Menu, choose **Calibration Factors**.

• Use ↑ and ↓ to move the cursor up and down.

• Press ← to accept the choice.

• Press → to return to the Main Menu or ↑ to return to the Run screen.

---

**CO₂ Background Correction**

The CO₂ Background Correction is determined during zero calibration. The CO₂ background is the amount of signal read by the analyzer while sampling zero air. The background signal is the combination of electrical noise and scattered light. Before the analyzer sets the CO₂ reading to zero, it stores these values as the CO₂ background correction.
The CO₂ Background screen is used to perform a manual zero calibration of the instrument. As such, the instrument should sample zero air until stable readings are obtained. The first line of the display shows the current CO₂ reading. This reading is the CO₂ background signal. The second line of the display shows the CO₂ background correction that is stored in memory and is being used to correct the CO₂ reading. That is, the CO₂ background correction is subtracted from the CO₂ reading.

In the example below, the analyzer is reading 15.8 ppm of CO₂ while sampling zero air. The CO₂ background correction is 0.0 ppm. That is, the analyzer is not applying a zero background correction. The question mark is used as a prompt to change the background correction. In this case the background correction must be increased to 15.8 ppm in order for the CO₂ reading to be at 0 ppm.

To set the CO₂ reading in the example below to zero, use \( \uparrow \) to increment the CO₂ background correction to 15.8 ppm. As the CO₂ background correction is increased, the CO₂ concentration is decreased. At this point, however, no real changes have been made. To escape this screen without making any changes, press \( \rightarrow \) to return to the Calibration Factors menu or \( \uparrow \) to return to the Run screen. Press \( \leftarrow \) to actually set the CO₂ reading to 0 ppm and store the background correction of 15.8 ppm.

- In the Main Menu, choose Calibration Factors > CO₂ Bkg.
- Use \( \uparrow \) and \( \downarrow \) to increment or decrement the proposed background value.
- Press \( \leftarrow \) to save the new background.
- Press \( \rightarrow \) to return to the Calibration Factors menu or \( \uparrow \) to return to the Run screen.
**CO₂ Span Coefficients**

The CO₂ span coefficient is usually calculated by the instrument processor during calibration. The span coefficients are used to correct the CO₂ readings and normally has a value near 1.000.

The CO₂ Span Coefficient screen enables the CO₂ span coefficient to be manually changed while sampling span gas of known concentration.

**Note** The concentration value will show ERROR if the measured concentration is not a valid span value (either higher than the selected range, or 0 or lower).

The display shows the current CO₂ concentration reading. The next line of the display shows the CO₂ span coefficient that is stored in memory and is being used to correct the CO₂ concentration. Notice that as the span coefficient value is changed, the current CO₂ concentration reading above also changes. However, no real changes are made until \( \rightarrow \) is pressed.

In dual or autorange modes, “High” or “Low” is displayed to indicate the calibration of the high or low coefficient. The example below shows the coefficient screen in dual/autorange mode.

- In the Main Menu, choose Calibration Factors > Hi Coef.
- Use \( \uparrow \) and \( \downarrow \) to increment or decrement the coefficient value.
- Press \( \rightarrow \) to save the new coefficient.
- Press \( \rightarrow \) to return to the Calibration Factors menu or \( \rightarrow \) to return to the Run screen.
Calibration Menu

The Calibration menu is used to calibrate zero and span. The calibration menu is similar for the single, dual, and autorange mode as shown below. The dual and autorange modes have two CO₂ span factors (high and low). This allows each range to be calibrated separately. This is necessary if the two ranges used are not close to one another. For example, a low CO₂ range of 200 ppm and a high CO₂ range of 1,000 ppm. For more information about calibration, see Chapter 4, “Calibration”.

- In the Main Menu, choose Calibration.
- Use ▲ and ▼ to move the cursor up and down.
- Press ← to accept the choice.
- Press ▼ to return to the Main Menu or ▶ to return to the Run screen.
Calibrate CO₂ Background

The Calibrate CO₂ Background screen is used to adjust the CO₂ background, or perform a “zero calibration”. Before performing a zero calibration, ensure the analyzer samples zero air for at least 5 minutes.

It is important to note the averaging time when calibrating. The longer the averaging time, the more accurate the calibration will be. To be most accurate, use the 300-second averaging time. For more information about calibration, see Chapter 4, “Calibration”.

- In the Main Menu, choose Calibration > Cal CO₂ Background.
- Press ← to set the new reading to zero.
- Press → to return to the Calibration menu or to return to the Run screen.
**Calibrate CO₂ Coefficient**

The Calibrate CO₂ Coefficient screen is used to adjust the CO₂ coefficient and enter the span concentration. The display shows the current CO₂ concentration reading and the current CO₂ range. The next line of the display is where the CO₂ calibration gas concentration is entered.

The CO₂ span coefficient is calculated, stored, and used to correct the current CO₂ reading. For more information about calibration, see Chapter 4, “Calibration”. In dual or auto range modes, “High” or “Low” is displayed to indicate the calibration of the high or low coefficient.

- In the Main Menu, choose Calibration > Cal CO₂ Coefficient.
- Use ↑ and ↓ to move the cursor left or right.
- Use ← and → to increment or decrement the numeric value.
- Press ← to calculate and save the new coefficient based on the entered span concentration.
- Press ↑ to return to the Calibration menu or → to return to the Run screen.

---

**Zero/Span Check Menu**

The Zero/Span Check menu is available with the zero/span valve option. It is used to program the instrument to perform fully automated zero and span check or adjustments.

**Note** Zero and Span Calibration Reset are toggle items that change between yes or no when selected, and present only if auto calibration is installed.

- In the Main Menu, choose Calibration > Zero/Span Check.
• Use \( \uparrow \) and \( \downarrow \) to move the cursor up and down.

• Press \( \leftarrow \) to accept the choice.

• Press \( \llbracket \) to return to the Calibration menu or \( \rightarrow \) to return to the Run screen.

Next Date/Time

The Next Date/Time screen is used to set the initial date and time of the zero/span check. Once the initial zero/span check is performed, the date and of the next zero/span check is calculated and displayed.

- In the Main Menu, choose Calibration > Zero/Span Check > Next Date/Time.

- Use \( \leftarrow \), \( \rightarrow \), \( \uparrow \) and \( \downarrow \) to move and change the value of the date and time.

- Press \( \leftarrow \) to accept a change.

- Press \( \llbracket \) to return to the Zero/Span Check menu or \( \rightarrow \) to return to the Run screen.

<table>
<thead>
<tr>
<th>CONCENTRATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO2</td>
</tr>
<tr>
<td>15.8 PPM</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SAMPLE</th>
<th>12:34</th>
<th>ALARM</th>
</tr>
</thead>
<tbody>
<tr>
<td>ZERO/SPAN CHECK</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NEXT DATE/TIME</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PERIOD HOURS</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>ZERO DURATION MIN</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td>SPAN DURATION MIN</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td>PURGE DURATION MIN</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>ZERO/SPAN AVG SEC</td>
<td>60</td>
<td></td>
</tr>
<tr>
<td>ZERO CAL RESET</td>
<td>OFF</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>RANGE</th>
<th>AVG</th>
<th>DIAGS</th>
<th>ALARM</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPAN CAL RESET</td>
<td>OFF</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ZERO/SPAN RATIO</td>
<td>1</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Period Hours

The Zero/Span Period Hours screen defines the period or interval between zero/span checks. Periods between 0 and 999 hours are acceptable. To turn the zero/span check off, set the period to 0.

- In the Main Menu, choose Calibration > Zero/Span Check > Period Hours.
- Use \( \uparrow \) and \( \downarrow \) to increment and decrement the numeric value.
- Press \( \leftarrow \) to save the period.
- Press \( \rightarrow \) to return to the Zero/Span Check menu or \( \uparrow \) to return to the Run screen.
Zero/Span/Purge Duration Minutes

The Zero Duration Minutes screen defines how long zero air is sampled by the instrument. The span and purge duration screens look and function the same way as the zero duration screen, and are used to set how long the span gas and sample gas are sampled by the instrument. Durations between 0 and 30 minutes are acceptable. Each time a zero/span check occurs the zero check is done first, followed by the span check. To perform just a zero check, set the span duration screen to 0 (off). To perform just a span check, set the zero duration screen to 0 (off).

- In the Main Menu, choose Calibration > Zero/Span Check > Zero, Span or Purge Duration Min.
- Use \( \uparrow \) and \( \downarrow \) to increment and decrement the numeric value.
- Press \( \leftarrow \) to save the duration value.
- Press \( \downarrow \) to return to the Zero/Span Check menu or \( \rightarrow \) to return to the Run screen.

---

Zero/Span Averaging Time

The Zero/Span Averaging Time screen allows the user to adjust the zero/span averaging time. The following averaging times are available: 1, 2, 5, 10, 20, 30, 60, 90, 120, 180, 240, and 300 seconds.

- In the Main Menu, choose Calibration > Zero/Span Check > Zero/Span Avg Sec.
- Use \( \uparrow \) and \( \downarrow \) for a list of choices.
- Press \( \leftarrow \) to save the averaging time.
• Press \( \text{\textbullet} \) to return to the Zero/Span Check menu or \( \text{\textbullet} \) to return to the Run screen.

---

**Zero/Span Ratio**

The Zero/Span Ratio screen is used to adjust the ratio of zeros to spans. For example, if this value is set to 1, a span check will follow every zero check. If this value is set to 3, there will be two zero checks between each zero/span check. This value may be set from 1 to 10, with 1 as default.

- In the Main Menu, choose Calibration > Zero/Span Check > **Zero/Span Ratio**.

- Use \( \text{\textbullet} \) and \( \text{\textbullet} \) to increment and decrement the numeric value.

- Press \( \text{\textbullet} \) to save the ratio value.

- Press \( \text{\textbullet} \) to return to the Zero/Span Check menu or \( \text{\textbullet} \) to return to the Run screen.
The Instrument Controls menu contains a number of items. The software controls listed in this menu enable control of the listed instrument functions.

- In the Main Menu, choose Instrument Controls.
- Use ↑ and ↓ to move the cursor up and down.
- Press ← to accept the choice.
- Press → to return to the Main Menu or ← to return to the Run screen.
Datalogging Settings

The Datalogging Settings menu deals with datalogging.

- In the Main Menu, choose Instrument Controls > Datalogging Settings.

- Use \( \uparrow \) and \( \downarrow \) to move the cursor up and down.

- Press \( \leftarrow \) to select a choice.

- Press \( \rightarrow \) to return to the Instrument Controls menu or \( \rightarrow \) to return to the Run screen.

Select SREC/LREC

The Select SREC/LREC is used to select short record or long record format for other operations.

- In the Main Menu, choose Instrument Controls > Datalogging Settings > Select SREC/LREC.

- Use \( \uparrow \) and \( \downarrow \) for a list of choices.

- Press \( \leftarrow \) to set record format.

- Press \( \rightarrow \) to return to the Datalogging Settings menu or \( \rightarrow \) to return to the Run screen.
View Logged Data

The View Logged Data screen is used to select records relative to current or date/time filter type.

- In the Main Menu, choose Instrument Controls > Datalogging Settings > Select SREC or LREC > View Logged Data.
- Use ↑ and ↓ for a list of choices.
- Press ← to set the filter type and continue to record selection menu.

Relative Record Filter

The Relative Record Filter screen is used to select the starting record to display the number of records back to view.

- Use ↑ and ↓ to increment or decrement the numeric value.
• Press \( \rightarrow \) to set filter type in finding the starting record and continue to record display menu.

Date/Time Filter

The Date/Time Filter screen is used to view and change the system date and time.

• Use \( \uparrow \) and \( \downarrow \) to increment or decrement the selected date field.

• Use \( \leftarrow \) to advance to next date field.

• Press \( \leftarrow \) to set the date and time of the first record to be displayed and continue to record display screen.

Record Display

The Record Display screen (read only) displays the selected records.
• Use $\leftarrow$, $\rightarrow$, $\uparrow$ and $\downarrow$ to scroll left and right, up and down.

• Press $\leftarrow$ to return to the Datalogging Settings menu.

---

**Erase Log**

The Erase Log is used to enter the Erasure Warning screen (read only).

• In the Main Menu, choose Instrument Controls > Datalogging Settings > Erase Log.

• Press $\leftarrow$ to commit change and return to the Datalogging Settings menu.

• Press $\leftarrow$ to return to the Datalogging Settings menu or $\rightarrow$ to return to the Run screen.

---

<table>
<thead>
<tr>
<th>CONCENTRATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO₂</td>
</tr>
<tr>
<td>SAMPLE</td>
</tr>
</tbody>
</table>

<p>| RECORDS BACK FROM CURRENT: |</p>
<table>
<thead>
<tr>
<th>time</th>
<th>date</th>
<th>flags</th>
</tr>
</thead>
<tbody>
<tr>
<td>17:43 03/18/05 dc0088900</td>
<td></td>
<td></td>
</tr>
<tr>
<td>17:43 03/18/05 dc0088900</td>
<td></td>
<td></td>
</tr>
<tr>
<td>17:43 03/18/05 dc0088900</td>
<td></td>
<td></td>
</tr>
<tr>
<td>17:43 03/18/05 dc0088900</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**SREC CHANGE:**

**WARNING**

THIS SELECTION WILL ERASE ALL SAVED DATA FOR THIS RECORD TYPE

$\leftarrow$ TO CONTINUE
### Select Content

The Select Content submenu displays a list of record fields to use and a submenu list of the analog output signal group choices to choose from.

- In the Main Menu, choose Instrument Controls > Datalogging Settings > Select Content.

- Use ↑ and ↓ to move the cursor up and down.

- Press → to select a choice.

- Press ← to return to the Datalogging Settings menu or → to return to the Run screen.

```
<table>
<thead>
<tr>
<th>RECORD FIELDS TO USE:</th>
</tr>
</thead>
<tbody>
<tr>
<td>FIELD 1               NO</td>
</tr>
<tr>
<td>FIELD 2               CO2</td>
</tr>
<tr>
<td>FIELD 3               PRES</td>
</tr>
<tr>
<td>FIELD 4               PMTT</td>
</tr>
<tr>
<td>FIELD 5               INTT</td>
</tr>
<tr>
<td>FIELD 6               RCTT</td>
</tr>
<tr>
<td>FIELD 7               NONE</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>RANGE AVG DIAGS ALARM</th>
</tr>
</thead>
<tbody>
<tr>
<td>FIELD 8               NONE</td>
</tr>
<tr>
<td>FIELD 9               NONE</td>
</tr>
<tr>
<td>FIELD 10              NONE</td>
</tr>
<tr>
<td>FIELD 11              NONE</td>
</tr>
<tr>
<td>FIELD 12              NONE</td>
</tr>
<tr>
<td>FIELD 13              NONE</td>
</tr>
<tr>
<td>FIELD 14              NONE</td>
</tr>
<tr>
<td>FIELD 15              NONE</td>
</tr>
<tr>
<td>FIELD 16              NONE</td>
</tr>
<tr>
<td>FIELD 17              NONE</td>
</tr>
<tr>
<td>FIELD 18              NONE</td>
</tr>
<tr>
<td>FIELD 19              NONE</td>
</tr>
<tr>
<td>FIELD 20              NONE</td>
</tr>
<tr>
<td>FIELD 21              NONE</td>
</tr>
<tr>
<td>FIELD 22              NONE</td>
</tr>
<tr>
<td>FIELD 23              NONE</td>
</tr>
<tr>
<td>FIELD 24              NONE</td>
</tr>
<tr>
<td>FIELD 25              NONE</td>
</tr>
<tr>
<td>FIELD 26              NONE</td>
</tr>
<tr>
<td>FIELD 27              NONE</td>
</tr>
<tr>
<td>FIELD 28              NONE</td>
</tr>
<tr>
<td>FIELD 29              NONE</td>
</tr>
<tr>
<td>FIELD 30              NONE</td>
</tr>
<tr>
<td>FIELD 31              NONE</td>
</tr>
<tr>
<td>FIELD 32              NONE</td>
</tr>
</tbody>
</table>
```
Choose Item Type

The Choose Item Type submenu is a list of the type of data that can be logged for the current field. Choices are Concentrations, Other Measurements, and Analog Inputs (if the I/O expansion board is installed).

- In the Main Menu, choose Instrument Controls > Datalogging Settings > Select Content > Field 1-32.
- Use ↑ and ↓ to move the cursor up and down.
- Press ← to select a choice.
- Press → to return to the Datalogging Settings menu or ↑ to return to the Run screen.

Concentrations

The Concentrations screen allows the user to select the output signal that is tied to the selected field item. The selected item is shown by “<--” after it.

- In the Main Menu, choose Instrument Controls > Datalogging Settings > Select Content > Select Field > Concentrations.
- Use ↑ and ↓ to move the cursor up and down.
- Press ← to select a new choice.
- Press → to return to the Choose Item Type submenu or ↑ to return to the Run screen.
Other Measurements

The Other Measurements screen allows the user to select the output signal that is tied to the selected field item. The selected item is shown by “<--” after it.

- In the Main Menu, choose Instrument Controls > Datalogging Settings > Select Content > Select Field > Other Measurements.
- Use [↑] and [↓] to move the cursor up and down.
- Press [←] to select a new choice.
- Press [→] to return to the Choose Item Type submenu or [→] to return to the Run screen.
Analog Inputs

The Analog Inputs screen allows the user to select the output signal that is tied to the selected streaming data item. The selected item is shown by “<--” after it.

- In the Main Menu, choose Instrument Controls > Datalogging Settings > Select Content > Select Field > Analog Inputs.
- Use ↑ and ↓ to move the cursor up and down.
- Press ← to select a new choice.
- Press → to return to the Choose Item Type submenu or ◀ to return to the Run screen.

Configure Datalogging

The Configure Datalogging menu deals with datalogging configuration.

- In the Main Menu, choose Instrument Controls > Datalogging Settings > Configure Datalogging.
- Use ↑ and ↓ for a list of choices.
- Press ← to select a choice.
- Press → to return to the Datalogging Settings menu or ◀ to return to the Run screen.
Logging Period Min

The Logging Period Min screen is used to select the logging period in minutes for the record format (srec or lrec). List of choices include: off, 1 (default), 5, 15, 30, and 60.

- In the Main Menu, choose Instrument Controls > Datalogging Settings > Configure Datalogging > Logging Period Min.

- Use ↑ and ↓ for a list of choices.

- Press ← to set the logging period.

- Press → to return to the Configure Datalogging menu or ◀ to return to the Run screen.
**Memory Allocation Percent**

The Memory Allocation Percent screen is used to select the percentage of each record type for both srecs and lrecs. Percentages between 0 and 100% are available in increments of 10. This screen results in log erasure for both srecs and lrecs.

- In the Main Menu, choose Instrument Controls > Datalogging Settings > Configure Datalogging > Memory Allocation %.
- Use ↑ and ↓ for a list of choices.
- Press ← to set the percentage for both record types and proceed to the erasure warning screen.
- Press → to return to the Configure Datalogging menu or ↑ to return to the Run screen.

```
CONCENTRATION
CO2  15.8 PPM
SAMPLE 12:34 ALARM

SET PERCENT SRECS:
CURRENTLY:  50 %
SET TO:  100 %?

↑↑ CHANGE VALUE  ↓↓ SAVE
RANGE  AVG  DIAGS  ALARM
```

**Data Treatment**

The Data Treatment screen is used to select the data treatment for the selected record type: whether the data should be averaged over the interval, the minimum or maximum used, or the current value logged.

- In the Main Menu, choose Instrument Controls > Datalogging Settings > Configure Datalogging > Data Treatment.
- Use ↑ and ↓ for a list of choices.
- Press ← to set the data treatment.
- Press → to return to the Configure Datalogging menu or ↑ to return to the Run screen.
**Communication Settings**

The communication Settings menu is used with communications control and configuration.

- In the Main Menu, choose Instrument Controls > **Communication Settings**.

- Use and to move the cursor up and down.

- Press to accept a choice.

- Press to return to the Instrument Controls menu or to return to the Run screen.
**Baud Rate**  The Baud Rate screen is used to set the RS-232/RS-485 interface baud rate. Baud rates of 1200, 2400, 4800, and 9600, 19200, 38400, 57600, and 115200 are available.

- In the Main Menu, choose Instrument Controls > Communication Settings > Baud Rate.
- Use ↑ and ↓ for a list of choices.
- Press ← to save the new baud rate.
- Press → to return to the Communication Settings menu or to return to the Run screen.

**Instrument ID**  The Instrument ID screen allows the operator to edit the instrument ID. The ID is used to identify the instrument when using the C-Link or MODBUS protocols to control the instrument or collect data. It may be necessary to edit the ID number if two or more of the same instrument are connected to one computer. Valid Instrument ID numbers are from 0 to 127. The Model 410i has a default Instrument ID of 68. For more information about the Instrument ID, see Appendix B “C-Link Protocol Commands” or Appendix C “MODBUS Protocol”.

- In the Main Menu, choose Instrument Controls > Communication Settings > Instrument ID.
- Use ↑ and ↓ to increment or decrement the ID value.
- Press → to save the new instrument ID.
• Press \( \text{ } \) to return to the Communication Settings menu or \( \text{ } \) to return to the Run screen.

Communication Protocol

The Communication Protocol screen is used to change the instrument communication protocol for serial communications.

• In the Main Menu, choose Instrument Controls > Communication Settings > Communication Protocol.

• Use \( \text{ } \) and \( \text{ } \) for a list of choices.

• Press \( \text{ } \) to save the new protocol.

• Press \( \text{ } \) to return to the Communication Settings menu or \( \text{ } \) to return to the Run screen.
Streaming Data Configuration

The Streaming Data Configuration is used to allow for configuration of the streaming data output.

**Note** Add Labels and Prepend Timestamp are toggle items that change between yes or no when selected.

- In the Main Menu, choose Instrument Controls > Communication Settings > **Streaming Data Config**.
- Use \( \uparrow \) and \( \downarrow \) to move the cursor up and down.
- Press \( \leftarrow \) to select a choice.
- Press \( \text{ } \) to return to the Communication Settings menu or \( \rightarrow \) to return to the Run screen.

---

### Streaming Data Interval

The Streaming Data Interval screen is used to adjust the streaming data interval. The following interval times are available: 1, 2, 5, 10, 20, 30, 60, 90, 120, 180, 240, and 300 seconds.
In the Main Menu, choose Instrument Controls > Communication Settings > Streaming Data Config > **Streaming Data Interval**.

Use \( \uparrow \) and \( \downarrow \) for a list of choices.

Press \( \leftarrow \) to save the new streaming data period.

Press \( \text{•••} \) to return to the Streaming Data Config menu or \( \rightarrow \) to return to the Run screen.

---

**Choose Item Signal**

The Choose Signal screen displays a submenu list of the analog output signal group choices. Group choices are Concentrations, Other Measurements, and Analog Inputs (if the I/O expansion board is installed).

In the Main Menu, choose Instrument Controls > Communication Settings > Streaming Data Config > **Item 1-18**.

Use \( \uparrow \) and \( \downarrow \) to move the cursor up and down.

Press \( \leftarrow \) to select a choice.

Press \( \text{•••} \) to return to the Streaming Data Config submenu or \( \rightarrow \) to return to the Run screen.
Concentrations

The Concentrations screen allows the user to select the output signal that is tied to the selected streaming data item. The selected item is shown by “<--” after it.

- In the Main Menu, choose Instrument Controls > Communication Settings > Streaming Data Config > Select Item > Concentrations.

- Use ↑ and ↓ to move the cursor up and down.

- Press ← to select a new choice.

- Press → to return to the Choose Item Signal submenu or → to return to the Run screen.
Other Measurements

The Other Measurements screen allows the user to select the output signal that is tied to the selected streaming data item. The selected item is shown by “<--” after it.

- In the Main Menu, choose Instrument Controls > Communication Settings > Streaming Data Config > Select Item > Other Measurements.
- Use ↑ and ↓ to move the cursor up and down.
- Press ← to select a new choice.
- Press → to return to the Choose Item Signal submenu or ↑ to return to the Run screen.

Analog Inputs

The Analog Inputs screen allows the user to select the output signal that is tied to the selected streaming data item. The selected item is shown by “<--” after it.

- In the Main Menu, choose Instrument Controls > Communication Settings > Streaming Data Config > Select Item > Analog Inputs.
- Use ↑ and ↓ to move the cursor up and down.
- Press ← to select a new choice.
- Press → to return to the Choose Item Signal submenu or ↑ to return to the Run screen.
RS-232/RS-485 Selection

The RS-232/RS-485 Selection screen allows the user to choose between the RS-232 or RS-485 protocols for serial communication.

**WARNING** Disconnect the serial cable before changing RS-232 and RS-485 selection to prevent damage to the connected equipment.

- In the Main Menu, choose Instrument Controls > Communication Settings > RS-232/RS-485 Selection.
- Press \(
\) to leave the warning screen and toggle RS-232 or RS-485.
- Use \(\) to confirm and save the new selection change.
- Press \(\) to return to the Communication Settings menu or \(\) to return to the Run screen.
TCP/IP Settings

The TCP/IP Settings menu is used for defining TCP/IP settings.

**WARNING** The instrument power must be cycled after this parameter has been changed for the change to take effect.

- In the Main Menu, choose Instrument Controls > Communication Settings > TCP/IP Settings.
- Use \( \uparrow \) and \( \downarrow \) to move the cursor up and down.
- Press \( \leftarrow \) to select a choice.
- Press \( \left[ \) to return to the Communication Settings menu or \( \rightarrow \) to return to the Run screen.
Use DHCP

The Use DHCP screen is used to specify whether to use DHCP or not.

- In the Main Menu, choose Instrument Controls > Communication Settings > TCP/IP Settings > Use DHCP.

- Press $\leftarrow$ to toggle and set DHCP on or off.

- Press $\rightarrow$ to return to the TCP/IP Settings menu or $\rightarrow$ to return to the Run screen.

IP Address

The IP Address is used to edit the IP address.

- In the Main Menu, choose Instrument Controls > Communication Settings > TCP/IP Settings > IP Address.
Operation
Instrument Controls Menu

- Use \( \leftarrow, \rightarrow, \uparrow \) and \( \downarrow \) to move and change the value of the IP address.

- Press \( \Rightarrow \) to save the new address.

- Press \( \Rightarrow \) to return to the TCP/IP Settings menu or \( \Rightarrow \) to return to the Run screen.

### Netmask

The Netmask screen is used to edit the netmask.

- In the Main Menu, choose Instrument Controls > Communication Settings > TCP/IP Settings > Netmask.

- Use \( \leftarrow, \rightarrow, \uparrow \) and \( \downarrow \) to move and change the value of the netmask.

- Press \( \Rightarrow \) to save the new netmask.

- Press \( \Rightarrow \) to return to the TCP/IP Settings menu or \( \Rightarrow \) to return to the Run screen.
**Gateway**  
The Gateway screen is used to edit the gateway address.

- In the Main Menu, choose Instrument Controls > Communication Settings > TCP/IP Settings > Gateway.
- Use ←, →, ↑ and ↓ to move and change the value of the gateway address.
- Press ← to save the new address.
- Press → to return to the TCP/IP Settings menu or → to return to the Run screen.

**Host Name**  
The host name screen is used to edit the host name. When DHCP is enabled, this name is reported to the DHCP server.
• In the Main Menu, choose Instrument Controls > Communication Settings > TCP/IP Settings > Host Name.

• Use \( \leftarrow, \rightarrow, \uparrow \) and \( \downarrow \) to move the cursor or change between the edit field and the alpha page.

• Press \( \leftarrow \) to save the new letter in the alpha table or save the new alpha page.

• Press \( \leftarrow \) to return to the TCP/IP Settings menu or \( \rightarrow \) to return to the Run screen.

### I/O Configuration

The I/O Configuration menu deals with configuration of the analyzer’s I/O system.

**Note** This screen is present only when the I/O expansion board option is installed.

• In the Main Menu, choose Instrument Controls > I/O Configuration.

• Use \( \uparrow \) and \( \downarrow \) to move the cursor up and down.

• Press \( \leftarrow \) to select a choice.

• Press \( \leftarrow \) to return to the Instrument Controls menu or \( \rightarrow \) to return to the Run screen.
Output Relay Settings

The Output Relay Settings menu displays a list of the analog output relays available, and allows the user to select the instrument parameter or logic state to change for the relay selected.

**Note** The digital outputs may take up to one second after the assigned state occurs to show up on the outputs.

- In the Main Menu, choose Instrument Controls > I/O Configuration > Output Relay Settings > 1-10.
- Use ▲ and ▼ to move the cursor up and down.
- Press ← to select a choice.
- Press ▶ to return to the I/O Configuration menu or ▼ to return to the Run screen.
Logic State

The Logic State screen is used to change the I/O relay to either normally open or normally closed.

- Press \( \rightarrow \) to toggle and set the logic state between open and closed.
- Press \( \leftarrow \) to return to the Output Relay Settings menu or \( \rightarrow \) to return to the Run screen.

Instrument State

The Instrument State submenu allows the user to select the instrument state that is tied to the selected relay output. A submenu lists signal types of either alarm and non-alarm to choose from.
• In the Main Menu, choose Instrument Controls > I/O Configuration > Output Relay Settings > Select Relay > **Instrument State**.

• Use ‹ and › to move the cursor up and down.

• Press ← to select a choice.

• Press ↑ to return to the Output Relay Setup menu or → to return to the Run screen.

---

**Alarms**

The Alarms status screen allows the user to select the alarm status for the selected relay output. The selected item is shown by “<->” after it.

• In the Main Menu, choose Instrument Controls > I/O Configuration > Output Relay Settings > Select Relay > Instrument State > **Alarms**.

• Use ‹ and › for a list of choices.

• Press ← to save the new selection for the relay.

• Press ↑ to return to the Instrument State submenu or → to return to the Run screen.
Non-Alarm

The Non-Alarm status screen allows the user to select the non-alarm status for the selected relay output. The selected item is shown by “<--” after it.

- In the Main Menu, choose Instrument Controls > I/O Configuration > Output Relay Settings > Relay 1-10 > Instrument State > Non-Alarm.

- Use ↑ and ↓ for a list of choices.

- Press ← to save the new selection for the relay.

- Press → to return to the Instrument State submenu or ← to return to the Run screen.
Digital Input Settings

The Digital Input Settings menu displays a list of the digital inputs available, and allows the user to select the instrument parameter or logic state to change for the relay selected.

**Note** The digital inputs must be asserted for at least one second for the action to be activated.

- In the Main Menu, choose Instrument Controls > I/O Configuration > Digital Input Settings > 1-16.
- Use  and  to move the cursor up and down.
- Press  to select a choice.
- Press  to return to the I/O Configuration menu or  to return to the Run screen.
Logic State

The Logic State screen is used to change the I/O relay to either normally open or normally closed. The default state is open, which indicates that a relay connected between the digital input pin and ground is normally open and closes to trigger the digital input action. If nothing is connected to the digital input pin, the state should be left at open to prevent the action from being triggered.

- Press \( \leftarrow \) to toggle and set the logic state open or closed.
- Press \( \rightarrow \) to return to the Digital Input Settings menu or \( \rightarrow \) to return to the Run screen.
**Instrument State**  
The Instrument State screen allows the user to select the instrument state that is tied to the selected digital input.

- In the Main Menu, choose Instrument Controls > I/O Configuration > Digital Input Settings > Select Relay > **Instrument State**.

- Use ‼️ and ‼️ for a list of choices.

- Press ‼️ to save the new selection for the relay.

- Press ‼️ to return to the Digital Input Settings menu or ‼️ to return to the Run screen.
Analog Output Configuration

The Analog Output Configuration menu displays a list of the analog output channels available for configuration. Configuration choices include selecting range, setting minimum/maximum values, and choosing signal to output.

**Note** The current outputs are displayed only if the I/O expansion board option is installed.

- In the Main Menu, choose Instrument Controls > I/O Configuration > Analog Output Config.
- Use ← and → to move the cursor up and down.
- Press ← to select a choice.
- Press → to return to the I/O Configuration menu or → to return to the Run screen.
The Select Output Range screen is used to select the hardware range for the selected analog output channel. Possible ranges for the voltage outputs are: 0-100 mV, 0-1, 0-5, 0-10 V.

- In the Main Menu, choose Instrument Controls > I/O Configuration > Analog Output Config > Select Channel > Select Range.
- Use and to move the cursor up and down.
- Press to save the new range.
- Press to return to the Analog Output Configuration menu or to return to the Run screen.
**Minimum and Maximum Value**

The Minimum Value screen is used to edit the zero (0) to full-scale (100) value in percentages for the selected analog output channel. See Table 3-6 for a list of choices. The minimum and maximum output value screens function the same way. The example below shows the set minimum value screen.

- In the Main Menu, choose Instrument Controls > IO Configuration > Analog Output Config > Select Channel > Set Minimum or Maximum Value.
- Use ↑ and ↓ to increment or decrement the numeric value.
- Press ← to validate and save the new minimum value.
- Press → to return to the Analog Output Configuration menu or to return to the Run screen.

**Table 3-6. Analog Output Zero to Full-Scale Table**

<table>
<thead>
<tr>
<th>Output</th>
<th>Zero % Value</th>
<th>Full-Scale 100% Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO2</td>
<td>Zero (0)</td>
<td>Range Setting</td>
</tr>
<tr>
<td>LO CO2</td>
<td>Zero (0)</td>
<td>Range Setting</td>
</tr>
<tr>
<td>HI CO2</td>
<td>Zero (0)</td>
<td>Range Setting</td>
</tr>
<tr>
<td>Range Status (NOx)</td>
<td>Recommend not to change the setting for this output</td>
<td></td>
</tr>
<tr>
<td>S/R Ratio</td>
<td>0.0</td>
<td>1.2</td>
</tr>
<tr>
<td>LO S/R Ratio</td>
<td>0.0</td>
<td>1.2</td>
</tr>
<tr>
<td>HI S/R Ratio</td>
<td>0.0</td>
<td>1.2</td>
</tr>
<tr>
<td>Internal Temp</td>
<td>User-set alarm min value</td>
<td>User-set alarm max value</td>
</tr>
</tbody>
</table>
Choose Signal Type To Output

The Choose Signal Type To Output screen displays a submenu list of the analog output signal group choices. Group choices are Concentrations, Other Measurements, and Analog Inputs (if the I/O expansion board is installed). This allows the user to select the output signal to the selected output channel. The Concentrations screen is shown below. See Table 3-7 below for a list of items for each signal group choice.

- In the Main Menu, choose Instrument Controls > I/O Configuration > Analog Output Config > Select Channel > Choose Signal To Output.

- Use ↑ and ↓ to move the cursor up and down.

- Press ← to select a choice.

- Press → to return to the Analog Output Config menu or to return to the Run screen.

### Table 3-6. Analog Output Zero to Full-Scale Table

<table>
<thead>
<tr>
<th>Output</th>
<th>Zero % Value</th>
<th>Full-Scale 100% Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bench Temp</td>
<td>User-set alarm min</td>
<td>User-set alarm max</td>
</tr>
<tr>
<td>Pressure</td>
<td>User-set alarm min</td>
<td>User-set alarm max</td>
</tr>
<tr>
<td>Sample Flow</td>
<td>User-set alarm min</td>
<td>User-set alarm max</td>
</tr>
<tr>
<td>Intensity</td>
<td>User-set alarm min</td>
<td>User-set alarm max</td>
</tr>
<tr>
<td>Motor Speed</td>
<td>User-set alarm min</td>
<td>User-set alarm max</td>
</tr>
<tr>
<td>Everything Else</td>
<td>0 units</td>
<td>10 units</td>
</tr>
</tbody>
</table>

The Choose Signal Type To Output screen displays a submenu list of the analog output signal group choices. Group choices are Concentrations, Other Measurements, and Analog Inputs (if the I/O expansion board is installed). This allows the user to select the output signal to the selected output channel. The Concentrations screen is shown below. See Table 3-7 below for a list of items for each signal group choice.

- In the Main Menu, choose Instrument Controls > I/O Configuration > Analog Output Config > Select Channel > Choose Signal To Output.

- Use ↑ and ↓ to move the cursor up and down.

- Press ← to select a choice.

- Press → to return to the Analog Output Config menu or to return to the Run screen.
Analog Input Configuration

The Analog Input Configuration menu displays a list of the analog input channels available for configuration. Configuration includes entering descriptor, units, decimal places, and choice of table points.

- In the Main Menu, choose Instrument Controls > I/O Configuration > Analog Input Config.
- Use \( \uparrow \) and \( \downarrow \) to move the cursor up and down.
- Press \( \leftarrow \) to select a choice.
- Press \( \rightarrow \) to return to the I/O Configuration menu or \( \rightarrow \) to return to the Run screen.

**Note** The current outputs are only displayed if the I/O expansion board option is installed.
Descriptor

The Descriptor screen allows the user to enter the descriptor for the selected analog input channel. The descriptor is used in datalogging and streaming data to report what data is being sent out. The descriptor may be from 1 to 3 characters in length, and defaults to IN1 to IN8 (user input channel number).

- In the Main Menu, choose Instrument Controls > I/O Configuration > Analog Input Config > Select Channel > Descriptor.
Operation
Instrument Controls Menu

• Press ⏯️ to save the new descriptor.

• Press ← to return to the Analog Input Config menu or ⏯️ to return to the Run screen.

### Units

The Units screen allows the user to enter the units for the selected analog input channel. The units are displayed on the diagnostic screen and in datalogging and streaming data. The units may be from 1 to 3 characters in length, and defaults to V (volts).

• In the Main Menu, choose Instrument Controls > I/O Configuration > Analog Input Config > Select Channel > Units.

• Press ⏯️ to save the new value.

• Press ← to return to the Analog Input Config menu or ⏯️ to return to the Run screen.
Decimal Places  The Decimal Places screen allows the user to select how many digits are displayed to the right of the decimal, from 0 to 6, with a default of 2.

- In the Main Menu, choose Instrument Controls > I/O Configuration > Analog Input Config > Select Channel > Decimal Places.
- Use and to increment or decrement the value.
- Press to save the new value.
- Press to return to the Analog Input Config menu or to return to the Run screen.

Number of Table Points  The Number of Table Points screen allows the user to select how many points are used in the conversion table. The points range from 2 to 10, with a default of 2.
In the Main Menu, choose Instrument Controls > I/O Configuration > Analog Input Config > Select Channel > **Table Points**.

Use ▲ and ▼ to move the cursor up and down.

Press ← to save the new value.

Press ▶ to return to the Analog Input Config menu or ▶ to return to the Run screen.

**Table Point**

The Table Point submenu allows the user to set up an individual table point.

In the Main Menu, choose Instrument Controls > I/O Configuration > Analog Input Config > **Table Point 1-10**.

Use ▲ and ▼ to move the cursor up and down.

Press ← to select a choice.

Press ▶ to return to the Analog Input Config menu or ▶ to return to the Run screen.
Volts  The Volts screen allows the user to set the input voltage for the selected table point in the conversion table, from 0.00 to 10.50. The default table is a two-point table with point 1: 0.00 V = 000.0 U and point 2: 10.00 V = 10.0 U.

- In the Main Menu, choose Instrument Controls > I/O Configuration > Analog Input Config > Select Table Point > Volts.
- Use ↑ and ↓ to move the cursor up and down.
- Press ← to save the new value.
- Press → to return to the Table Point submenu or ← to return to the Run screen.
**User Value**

The User Value screen allows the user to set the output value for the corresponding input voltage for the selected table point in the conversion table, from -999.9 to 999.9. The default table is a two-point table with point 1: 0.00 V = 000.0 U and point 2: 10.00 V = 10.0 U.

- In the Main Menu, choose Instrument Controls > I/O Configuration > Analog Input Config > Select Table Point > **User Value**.
- Use ← and → to move the cursor up and down.
- Press ← to save the new value.
- Press → to return to the Table Point submenu or ▶ to return to the Run screen.

**Temperature Compensation**

Temperature compensation provides compensation for any changes to the instrument’s output signal due to internal instrument temperature variations. The effects of internal instrument temperature changes on the analyzer’s subsystems and output have been empirically determined. This empirical data is used to compensate for any changes in temperature. This compensation can be used for special applications, or when operating the instrument outside the recommended temperature range, even though the Model 410i does not require temperature compensation for EPA equivalency.

When temperature compensation is on, the display shows the current internal instrument temperature (measured by a thermistor on the Interface board). When temperature compensation is off, the display shows the factory standard temperature of 25 °C.
• In the Main Menu, choose Instrument Controls > Temperature Compensation.

• Press ← to toggle the temperature compensation on or off.

• Press  to return to the Instrument Controls menu or  to return to the Run screen.

Pressure Compensation
Pressure compensation provides compensation for any changes to the instrument’s output signal due to reaction chamber pressure variations. The effects of reaction chamber pressure changes on the analyzer’s subsystems and output have been empirically determined. This empirical data is used to compensate for any change in reaction chamber pressure. This compensation can be used even though the Model 410i does not require pressure compensation for EPA equivalency.

When pressure compensation is on, the display represents the current pressure in the fluorescence chamber. When pressure compensation is off, the display shows the factory standard pressure of 750 mmHg.

• In the Main Menu, choose Instrument Controls > Pressure Compensation.

• Press ← to toggle the temperature compensation on or off.

• Press  to return to the Instrument Controls menu or  to return to the Run screen.
### Screen Contrast

The Screen Contrast screen is used to change the contrast of the display. Intensities between 0 and 100% in increments of 10 are available. Changing the screen contrast may be necessary if the instrument is operated at extreme temperatures.

- In the Main Menu, choose Instrument Controls > Screen Contrast.
- Use \( \uparrow \) and \( \downarrow \) to increment or decrement the screen contrast.
- Press \( \leftarrow \) to accept a change.
- Press \( \rightarrow \) to return to the Instrument Controls menu or \( \rightarrow \rightarrow \) to return to the Run screen.
Service Mode

The Service Mode screen is used to turn the service mode on or off. The service mode locks out any remote actions and includes parameters and functions that are useful when making adjustments or diagnosing the Model 410i. For more information about the service mode, see “Service Menu” later in this chapter.

**Note** The service mode should be turned off when finished, as it prevents remote operation.

- In the Main Menu, choose Instrument Controls > Service Mode.
- Press (left arrow) to toggle and set the service mode on or off.
- Press (right arrow) to return to the Instrument Controls menu or (up arrow) to return to the Run screen.

---

Date/Time

The Date/Time screen allows the user to view and change the system date and time (24-hour format). The internal clock is powered by its own battery when instrument power is off.

- In the Main Menu, choose Instrument Controls > Date/Time.
- Use (left arrow), (right arrow), (up arrow) and (down arrow) to move and change the value of the date and time.
- Press (left arrow) to save the new date and time.
- Press (right arrow) to return to the Instrument Controls menu or (up arrow) to return to the Run screen.
Diagnostics Menu

The Diagnostics menu provides access to diagnostic information and functions. This menu is useful when troubleshooting the instrument.

- In the Main Menu, choose Instrument Controls > Diagnostics.
- Use ✈️ and ⬇️ to move the cursor up and down.
- Press ⬅️ to select a choice.
- Press ⬅️ to return to the Instrument Controls menu or ⬅️ to return to the Run screen.
Program Version

The Program Version screen (read only) shows the version number of the program installed. Prior to contacting the factory with any questions regarding the instrument, please note the program version number.

- In the Main Menu, choose Diagnostics > Program Version.
- Press ( • ) to return to the Diagnostics menu or ( • ) to return to the Run screen.
**Voltages**

The Voltages menu displays the current diagnostic voltage readings. This screen enables the power supply to be quickly read for low or fluctuating voltages without having to use a voltage meter. The I/O board item is only displayed if the I/O expansion board is installed.

- In the Main Menu, choose Diagnostics > Voltages.
- Use ▲ and ▼ to move the cursor up and down.
- Press ◀ to select a choice.
- Press ◄ to return to the Diagnostics menu or ► to return to the Run screen.

**Motherboard Voltages**

The Motherboard screen (read only) is used to display the current voltage readings on the motherboard.

- In the Main Menu, choose Diagnostics > Voltages > Motherboard Voltages.
- Press ◄ to return to the Voltages menu or ► to return to the Run screen.
Interface Board Voltages

The Interface Board screen (read only) is used to display the current voltage readings on the interface board.

- In the Main Menu, choose Diagnostics > Voltages > Interface Board Voltages.
- Press \( \text{[up arrow]} \) to return to the Voltages menu or \( \text{[down arrow]} \) to return to the Run screen.

I/O Board Voltages

The I/O Board screen (read only) is used to display the current voltage readings on the I/O expansion board. This menu is only accessible if the I/O expansion board is installed.
In the Main Menu, choose Diagnostics > Voltages > I/O Board Voltages.

Press \( \text{TAB} \) to return to the Voltages menu or \( \text{R} \) to return to the Run screen.

**Temperatures**

The Temperatures screen (read only) displays the current internal instrument temperature and bench temperature. The internal temperature is the air temperature measured by a sensor located on the interface board.

- In the Main Menu, choose Diagnostics > Temperatures.
- Press \( \text{CH} \) to return to the Diagnostics menu or \( \text{R} \) to return to the Run screen.
**Pressure**  
The Pressure screen (read only) displays the current optical bench pressure. The pressure is measured by a pressure transducer.

- In the Main Menu, choose Diagnostics > Pressure.
- Press [•] to return to the Diagnostics menu or [→] to return to the Run screen.

![Pressure Screen](image)

**Flow**  
The Flow screen (read only) displays the flow rate. The flow is measured by internal flow sensors. For more information, see Chapter 1, “Operations”.

- In the Main Menu, choose Diagnostics > Flow.
- Press [•] to return to the Diagnostics menu or [→] to return to the Run screen.

![Flow Screen](image)
Sample/Reference Ratio

The Sample/Reference Ratio screen (read only) displays the ratio of the intensities of the light source through the sample wavelength and reference wavelength of the bandpass filter wheel. Normally, when zero air is being sampled, the sample/reference ratio is between 1.00 and 1.18. A ratio outside may indicate that the filter wheel is dirty or the infrared source is degraded.

- In the Main Menu, choose Diagnostics > Sample/Ref Ratio.
- Press \( \leftarrow \) to return to the Diagnostics menu or \( \rightarrow \) to return to the Run screen.

AGC Intensity

The AGC Intensity screen (read only) displays the intensity (in Hertz) of the reference channel Automatic Gain Control (AGC) circuit. The AGC circuit optimizes the noise and resolution levels of the Model 410i. The AGC intensity reading should be about 200,000 Hertz.

- In the Main Menu, choose Diagnostics > AGC Intensity.
- Press \( \leftarrow \) to return to the Diagnostics menu or \( \rightarrow \) to return to the Run screen.
Motor Speed

The Motor Speed screen (read only) displays the status of the chopper motor. A reading of 100.0% means that the motor speed is correct. A reading other than 100.0% indicates that there is a problem with the chopper motor or power supply.

- In the Main Menu, choose Diagnostics > Motor Speed.
- Press ▼ to return to the Diagnostics menu or ▶ to return to the Run screen.

Analog Input Readings

The Analog Input Readings screen (read only) displays the current user-scaled analog readings.

- In the Main Menu, choose Diagnostics > Analog Input Readings.
• Press \( \text{ } \) to return to the Diagnostics menu or \( \text{ } \) to return to the Run screen.

### Analog Input Voltages

The Analog Input Voltages screen (read only) displays the raw analog voltage readings.

• In the Main Menu, choose Diagnostics > Analog Input Voltages.

• Press \( \text{ } \) to return to the Diagnostics menu or \( \text{ } \) to return to the Run screen.
**Digital Inputs**  The Digital Inputs screen (read only) displays the state of the digital inputs.

- In the Main Menu, choose Diagnostics > Digital Inputs.
- Press \[→\] to return to the Diagnostics menu or \[←\] to return to the Run screen.

![Digital Inputs Screen](image)

**Relay States**  The Relay States screen displays the state of the digital outputs and allows toggling of the state to either on (1) or off (0). The relays are restored to their original states upon exiting this screen.

- In the Main Menu, choose Diagnostics > Relay States.
- Press \[→\] to return to the Diagnostics menu or \[←\] to return to the Run screen.
### Test Analog Outputs

The Test Analog Outputs menu contains a number of digital to analog converter (DAC) calibration items. The current channels are only displayed if the I/O expansion board option is installed.

- In the Main Menu, choose Diagnostics > Test Analog Outputs.
- Use ↻ and ↼ to move the cursor up and down.
- Press  to select output.
- Press  to return to the Diagnostics menu or  to return to the Run screen.

<table>
<thead>
<tr>
<th>RELAY STATE</th>
<th>OUTPUT 1</th>
<th>OUTPUT 2</th>
<th>OUTPUT 3</th>
<th>OUTPUT 4</th>
<th>OUTPUT 5</th>
<th>OUTPUT 6</th>
<th>OUTPUT 7</th>
<th>OUTPUT 8</th>
<th>OUTPUT 9</th>
<th>OUTPUT 10</th>
</tr>
</thead>
<tbody>
<tr>
<td>SAMPLE</td>
<td>SAMPLE</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>12:34</td>
<td></td>
<td></td>
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<td></td>
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<td></td>
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<tr>
<td>ALARM</td>
<td>ALARM</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RANGE AVG</td>
<td>OUTPUT</td>
<td>OUTPUT</td>
<td>OUTPUT</td>
<td>OUTPUT</td>
<td>OUTPUT</td>
<td>OUTPUT</td>
<td>OUTPUT</td>
<td>OUTPUT</td>
<td>OUTPUT</td>
<td>OUTPUT</td>
</tr>
<tr>
<td>AVG DIAGS ALARM</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

**Example Data:**

- **CO2 Concentration:** 15.8 PPM
- **Sample Time:** 12:34
- **Alarm Status:** High

<table>
<thead>
<tr>
<th>Output Channel</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>OUTPUT 1</td>
<td>1</td>
</tr>
<tr>
<td>OUTPUT 2</td>
<td>0</td>
</tr>
<tr>
<td>OUTPUT 3</td>
<td>0</td>
</tr>
<tr>
<td>OUTPUT 4</td>
<td>1</td>
</tr>
<tr>
<td>OUTPUT 5</td>
<td>0</td>
</tr>
<tr>
<td>OUTPUT 6</td>
<td>0</td>
</tr>
<tr>
<td>OUTPUT 7</td>
<td>0</td>
</tr>
<tr>
<td>OUTPUT 8</td>
<td>0</td>
</tr>
<tr>
<td>OUTPUT 9</td>
<td>0</td>
</tr>
<tr>
<td>OUTPUT 10</td>
<td>0</td>
</tr>
</tbody>
</table>
Set Analog Outputs

The Set Analog Outputs screen contains three choices: Set to full-scale, set to zero, or reset to normal. Full-scale sets the analog outputs to the full-scale voltage, zero sets the analog outputs to 0 volts, and normal operation. The example below shows the selected output state “ALL” is set to normal.

- In the Main Menu, choose Diagnostics > Test Analog Outputs > ALL, Voltage Channel 1-6, or Current Channel 1-6.
- Use ‣ up and ‣ down to move the cursor up and down.
- Press ‣ left to select a choice.
- Press ‣ right to return to the Diagnostics menu or ‣ right to return to the Run screen.
Instrument Configuration

The Instrument Configuration screen displays information on the hardware configuration of the instrument.

**Note** If the analyzer is in service mode, pressing on the item will toggle it yes or no (with the exception of purchased options such as dilution and auto calibration).

- In the Main Menu, choose Diagnostics > **Instrument Configuration**.
- Press to toggle instrument configuration (in service mode only).
- Press to return to the Diagnostics menu or to return to the Run screen.
Contact Information

The Contact Information screen displays the customer service information.

- In the Main Menu, choose Diagnostics > Contact Information.
- Press \( \leftarrow \) to return to the Diagnostics menu or \( \rightarrow \) to return to the Run screen.

Alarms Menu

The alarms menu displays a list of items that are monitored by the analyzer. If the item being monitored goes outside the lower or upper limit, the status of that item will go from “OK” to either “LOW” or “HIGH”, respectively. If the alarm is not a level alarm, the status will go from “OK” to “FAIL”.

The number of alarms detected is displayed to indicate how many alarms have occurred. If no alarms are detected, the number zero is displayed.

To see the actual reading of an item and its minimum and maximum limits, move the cursor to the item and press \( \leftarrow \).

The zero/span check and auto calibration screens are visible only if the zero/span check or auto calibration options are enabled. The motherboard status, interface board status, and I/O Expansion board status (if installed) indicate that the power supplies are working and connections are successful. There are no setting screens for these alarms.

- In the Main Menu, choose Alarms.
- Use \( \uparrow \) and \( \downarrow \) to move the cursor up and down.
- Press \( \leftarrow \) to select a choice.
- Press \( \leftarrow \) to return to the Main Menu or \( \rightarrow \) to return to the Run screen.
Internal Temperature

The Internal Temperature screen displays the current internal temperature and sets the minimum and maximum alarm limits. Acceptable alarm limits range from 8 to 53 °C. If the internal temperature reading goes beyond either the minimum or maximum alarm limit, an alarm is activated. The word “ALARM” appears in the Run screen and in the Main Menu.

- In the Main Menu, choose Alarms > Internal Temp.
- Use ↑ and ↓ to move the cursor up and down.
- Press ← to select a choice.
- Press ◄ to return to the Alarms menu or ► to return to the Run screen.
### Min and Max Internal Temperature Limits

The Minimum Internal Temperature alarm limit screen is used to change the minimum internal temperature alarm limit. The minimum and maximum internal temperature screens function the same way.

- In the Main Menu, choose Alarms > Internal Temp > **Min** or **Max**.
- Use ← and → to increment or decrement the numeric value.
- Press ↫ to save set to value as actual value.
- Press ↪ to return to the Internal Temperatures menu or ↦ to return to the Run screen.

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Actual Min</td>
<td>30.1 °C</td>
</tr>
<tr>
<td>Set Min To</td>
<td>10.0 °C</td>
</tr>
</tbody>
</table>

---

**Flight Data:**

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO2</td>
<td>15.8 ppm</td>
</tr>
<tr>
<td>Sample Time</td>
<td>12:34</td>
</tr>
<tr>
<td>Alarm</td>
<td>X</td>
</tr>
</tbody>
</table>

**Internal Temperature:**

- Actual: 30.1 °C
- Min: 8.0 °C
- Max: 53.0 °C

**Ranges:**

- AVG
- DIAGS
- Alarm
**Bench Temperature**

The Bench Temperature screen displays the current bench temperature and sets the minimum and maximum alarm limits. Acceptable alarm limits range from 50 to 59 °C. If the bench temperature reading goes beyond either the minimum or maximum limit, an alarm is activated. The word “ALARM” appears in the Run screen and in the Main Menu.

- In the Main Menu, choose Alarms > Bench Temp.
- Use ↑ and ↓ to move the cursor up and down.
- Press ← to select a choice.
- Press ▼ to return to the Alarms menu or ▶ to return to the Run screen.

<table>
<thead>
<tr>
<th>CONCENTRATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO₂</td>
</tr>
<tr>
<td>SAMPLE</td>
</tr>
<tr>
<td>ALARM</td>
</tr>
<tr>
<td>BENCH TEMPERATURE:</td>
</tr>
<tr>
<td>ACTUAL</td>
</tr>
<tr>
<td>&gt;MIN</td>
</tr>
<tr>
<td>MAX</td>
</tr>
</tbody>
</table>

**Min and Max Bench Temperature Limits**

The Minimum Bench Temperature alarm limit screen is used to change the minimum bench temperature alarm limit. The minimum and maximum Bench Temperature screens function the same way.

- In the Main Menu, choose Alarms > Bench Temp > Min or Max.
- Use ↑ and ↓ to increment or decrement the numeric value.
- Press ← to save set value as actual value.
- Press ▼ to return to the Bench Temperatures menu or ▶ to return to the Run screen.
Pressure

The Pressure screen displays the current reaction chamber pressure reading and set the minimum and maximum alarm limits. Acceptable alarm limits range from 250 to 1,000 mmHg. If the pressure reading goes beyond either the minimum or maximum limit, an alarm is activated. The word “ALARM” appears in the Run screen and in the Main Menu.

- In the Main Menu, choose Alarms > Pressure.
- Use the ↑ and ↓ to move the cursor up and down.
- Press ← to select a choice.
- Press → to return to the Alarms menu or ↓ to return to the Run screen.
Min and Max Pressure Limits

The Minimum Pressure alarm limit screen is used to change the minimum temperature alarm limit. The minimum and maximum pressure screens function the same way.

- In the Main Menu, choose Alarms > Pressure > Min or Max.
- Use ↑ and ↓ to increment or decrement the numeric value.
- Press ← to save set value as actual value.
- Press → to return to the Pressure menu or ↑ to return to the Run screen.

Sample Flow

The Sample Flow screen displays the current sample flow reading and set the minimum and maximum alarm limits. Acceptable alarm limits range from 0.350 to 1.500 LPM. If the sample flow reading goes beyond either the minimum or maximum limit, an alarm is activated. The word “ALARM” appears in the Run screen and in the Main Menu.

- In the Main Menu, choose Alarms > Sample Flow.
- Use ↑ and ↓ to move the cursor up and down.
- Press ← to select a choice.
- Press → to return to the Alarms menu or ↑ to return to the Run screen.
Min and Max Sample Flow Limits

The Minimum Sample Flow alarm limit screen is used to change the minimum sample flow alarm limit. The minimum and maximum sample flow screens function the same way.

- In the Main Menu, choose Alarms > Sample Flow > Min or Max.
- Use [INC] and [DEC] to increment or decrement the numeric value.
- Press [SAVE VALUE] to save set value as actual value.
- Press [RETURN] to return to the Sample Flow menu or [RETURN] to return to the Run screen.
Bias Voltage

The Bias Voltage screen displays the current bias voltage reading and sets the minimum and maximum alarm limits. Acceptable alarm limits range from -130 to -100 volts. If the bias voltage reading goes beyond either the minimum or maximum limit, an alarm is activated. The word “ALARM” appears in the Run screen and in the Main Menu.

- In the Main Menu, choose Alarms > Bias Voltage.
- Use ↑ and ↓ to move the cursor up and down.
- Press ← to select a choice.
- Press ▲ to return to the Alarms menu or ▶ to return to the Run screen.

Min and Max Bias Voltage Limits

The Minimum Bias Voltage alarm limit screen is used to change the minimum bias voltage alarm limit. The minimum and maximum bias voltage screens function the same way.

- In the Main Menu, choose Alarms > Bias Voltage > Min or Max.
- Use ↑ and ↓ to increment or decrement the numeric value.
- Press ← to save set value as actual vlaue.
- Press ▲ to return to the Bias Voltage menu or ▶ to return to the Run screen.
**AGC Intensity**

The AGC Intensity screen displays the current AGC Intensity reading and set the minimum and maximum alarm limits. Acceptable alarm limits range from 150,000 to 300,000 Hz. If the AGC intensity reading goes beyond either the minimum or maximum limit, an alarm is activated. The word “ALARM” appears in the Run screen and in the Main Menu.

- In the Main Menu, choose Alarms > AGC Intensity.
- Use ▲ and ▼ to move the cursor up and down.
- Press ← to select a choice.
- Press ▶ to return to the Alarms menu or ◄ to return to the Run screen.
Min and Max AGC Intensity Limits

The Minimum AGC Intensity alarm limit screen is used to change the minimum sample flow alarm limit. The minimum and maximum AGC Intensity screens function the same way.

- In the Main Menu, choose Alarms > AGC Intensity > Min or Max.
- Use ↑ and ↓ to increment or decrement the numeric value.
- Press ← to save set value as actual value.
- Press → to return to the AGC Intensity menu or ← to return to the Run screen.

Motor Speed

The Motor Speed screen (read only) displays the current motor speed. A reading other than 100.0% indicates a problem with either the motor or the power supply.

- In the Main Menu, choose Alarms > Motor Speed.
- Press ← to return to the Alarms menu or → to return to the Run screen.
Zero and Span Check

The Zero Span Check screen allows the user to view the status of the most recent zero check and set the maximum zero check offset. The zero and span check screens are visible only if the zero/span check option is enabled and function the same way.

- In the Main Menu, choose Diagnostics > Voltages > Zero or Span Check.
- Use the ↑ and ↓ to move the cursor up and down.
- Press → to select a choice.
- Press ← to return to the Alarms menu or → to return to the Run screen.
Max Zero and Span Offset

The Max Zero Check Offset screen is used to set the maximum zero check offset. The maximum zero and span offset screens function the same way.

- In the Main Menu, choose Alarms > Zero or Span Check > Max Offset.
- Use ↑ and ↓ to increment or decrement the numeric value.
- Press ← to save set to value as actual value.
- Press ▼ to return to the Zero or Span Check screen or ▶ to return to the Run screen.

Zero and Span Auto Calibration

The Zero Auto Calibration screen (read only) allow the user to view the status of the most recent auto background calibration. The zero and span auto calibration screens are visible only if the auto calibration option is enabled and function the same way.

- In the Main Menu, choose Alarms > Zero or Span Autocal.
- Press ▼ to return to the Alarms menu or ▶ to return to the Run screen.
Concentration

The Concentration screen displays the current CO₂ concentration and sets the minimum and maximum alarm limits. Acceptable alarm limits range from 0 to 10,000 ppm. The minimum alarm may be programmed as a floor trigger (alarm is triggered when the concentration falls below the minimum value) or a ceiling trigger (alarm is triggered when the concentration goes above the minimum value). If the CO₂ concentration goes beyond either the minimum or maximum limit, an alarm is activated. The word “ALARM” appears in the Run screen and in the Main Menu.

- In the Main Menu, choose Alarms > Concentration.
- Use ↑ and ↓ to move the cursor up and down.
- Press ← to select a choice.
- Press ◀ to return to the Alarms menu or ▶ to return to the Run screen.
Min and Max Concentration Limit

The Minimum Concentration alarm limit screens is used to change the minimum concentration alarm limits. The minimum and maximum concentration alarm limit screens function the same way.

- In the Main Menu, choose Alarms > Concentration > Min or Max.
- Use ▲ and ▼ to increment or decrement the numeric value.
- Press ◀ to save set to value as actual value.
- Press ◄ to return to the Concentration menu or ◄ to return to the Run screen.
**Min Trigger Concentration**

The Minimum Trigger screen allows the user to view and set the concentration alarm trigger type to either floor or ceiling. The minimum alarm may be programmed as a floor trigger (alarm is triggered when the concentration falls below the minimum value) or a ceiling trigger (alarm is triggered when the concentration goes above the minimum value).

- In the Main Menu, choose Alarms > Select Concentration > MinTrigger.

- Press \( \text{ } \) to toggle and set to floor or ceiling.

- Press \( \text{ } \) to return to the Concentration menu or \( \text{ } \) to return to the Run screen.

**Service Menu**

The Service menu appears only when the instrument is in the service mode. To put the instrument into the service mode:

- In the Main Menu, choose Instrument Controls > Service Mode.

Advanced diagnostic functions are included in the service mode. Meaningful data should not be collected when the instrument is in the service mode.

- In the Main Menu, choose Service.

- Use \( \text{ } \) and \( \text{ } \) to move the cursor up and down.

- Press \( \text{ } \) to select a choice.

- Press \( \text{ } \) to return to the Main Menu or \( \text{ } \) to return to the Run screen.
Single/Dual/Auto Select

The Range Mode Select screen is used to switch between the various range modes: single, dual, and autorange.

- In the Main Menu, choose Service > Range Mode Select.
- Use ↑ and ↓ for a list of choices.
- Press ← to save the new range mode.
- Press → to return to the Service menu or ← to return to the Run screen.
Pressure Calibration

The Pressure Calibration menu is used to calibrate the pressure sensor to zero, span, or restore factory default values. The pressure calibration is visible only when the instrument is in service mode. For more information on the service mode, see “Service Mode” earlier in this chapter.

The pressure sensor’s zero counts and span slope are displayed on the menu.

**WARNING** This adjustment should only be performed by an instrument service technician.

- In the Main Menu, choose Service > Pressure Calibration.
- Use the ↑ and ↓ to move the cursor up and down.
- Press ← to select a choice.
- Press ← to return to the Service menu or → to return to the Run screen.

---

### Calibrate Pressure Zero

The Calibrate Pressure Zero screen calibrates the pressure sensor at zero pressure.

**Note** A vacuum pump must be connected to the pressure sensor before performing the zero calibration.

- In the Main Menu, choose Service > Pressure Calibration > Zero.
- Press ← to save the current pressure reading as the zero reading.
• Press \( \text{[ ]} \) to return to the Pressure Calibration menu or \( \text{[ ]} \) to return to the Run screen.

---

**Calibrate Pressure Span**

The Calibrate Pressure Span screen allows the user to view and set the pressure sensor calibration span point.

**Note** The plumbing going to the pressure sensor should be disconnected so the sensor is reading ambient pressure before performing the span calibration. The operator should use an independent barometer to measure the ambient pressure and enter the value on this screen before calibrating.

• In the Main Menu, choose Service > Pressure Calibration > Span.

• Use \( \text{[ ]} \), \( \text{[ ]} \), \( \text{[ ]} \) and \( \text{[ ]} \) to move and change the value.

• Press \( \text{[ ]} \) to save set to value as actual value.

• Press \( \text{[ ]} \) to return to the Pressure Calibration menu or \( \text{[ ]} \) to return to the Run screen.
**Restore Default Pressure Calibration**

The Restore Default Pressure Calibration screen allows the user to reset the pressure calibration configuration values to factory defaults.

- In the Main Menu, choose Service > Pressure Calibration > **Set Defaults**.

- Press (←) to warn user and enable restore with (→).

- Use (→) to overwrite pressure sensor calibration parameters with factory default values when pressed after (←).

- Press (↓) to return to the Pressure Calibration menu or (→) to return to the Run screen.
Flow Calibration

The Flow Calibration menu is used to calibrate the flow sensor to zero, span, or restore factory default values. The flow calibration is visible only when the instrument is in service mode. For more information on the service mode, see “Service Mode” earlier in the chapter.

**WARNING** This adjustment should only be performed by an instrument service technician. ▲

- In the Main Menu, choose Service > Flow Calibration.
- Use the ↑ and ↓ to move the cursor up and down.
- Press ← to select a choice.
- Press ← to return to the Service menu or ← to return to the Run screen.

Calibrate Flow Zero

The Calibrate Flow Zero screen calibrates the flow sensor at zero flow.

**Note** The pump must be disconnected before performing the zero calibration. ▲

- In the Main Menu, choose Service > Flow Calibration > Zero.
- Press ← to save the current flow reading as the zero reading.
- Press ← to return to the Flow Calibration menu or ← to return to the Run screen.
Calibrate Flow Span

The Calibrate Flow Span screen allows the user to view and set the flow sensor calibrate span point.

**Note** An independent flow sensor is required to read the flow, then the operator enters the flow value on this screen to perform the calibration.

- In the Main Menu, choose Service > Flow Calibration > Span.
- Use \( \downarrow, \uparrow, \rightarrow, \leftarrow \) and \( \downarrow, \uparrow \) to move and change the value.
- Press \( \leftarrow \) to save set to value as actual value.
- Press \( \downarrow, \leftarrow \) to return to the Flow Calibration menu or \( \rightarrow \) to return to the Run screen.
**Operation**

**Service Menu**

**Restore Default Flow Calibration**

The Restore Default Flow Calibration screen allows the user to reset the flow calibration configuration values to factory defaults.

- In the Main Menu, choose Service > Flow Calibration > **Set Defaults**.
- Press ← to warn user and enable restore with →.
- Use → to overwrite pressure sensor calibration parameters with factory default values when pressed after ←.
- Press → to return to the Flow Calibration menu or ← to return to the Run screen.

<table>
<thead>
<tr>
<th>CONCENTRATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO2</td>
</tr>
<tr>
<td>SAMPLE</td>
</tr>
</tbody>
</table>

**Initial S/R Ratio**

The Initial S/R Ratio screen displays both the initial S/R ratio and the current S/R ratio. The initial S/R ratio is determined at the factory, and is used to correct for the slight variations found from one correlation wheel to another. The only time the initial S/R ratio should be changed is when the correlation wheel is replaced or sample/reference is between 1.14 and 1.18.

**WARNING** This adjustment should only be performed by an instrument service technician.

- In the Main Menu, choose Service > Initial S/R Ratio.
- Use the ↑ and ↓ to move and change the value.
- Press ← to save set to value as actual value.
Multi-point Calibration

Up to three gas concentrations (cal-points) for each range may be calibrated to using the following steps. Three cal-points will give the most accurate readings over the entire range. The Calibration process is sequential and will work properly if all steps are followed in order. The example below uses the multi-point calibration screens in single range mode. The Lo and Hi Multi-Point Calibration screens (when in dual and auto range mode) function the same way. For more information on “Lo and Hi Multi-Point Calibration”, see Chapter 4 “Calibration”.

WARNING This adjustment should only be performed by an instrument service technician.

- In the Main Menu, choose Service > Multipoint Calibration.
- Use the ↑ and ↓ to move the cursor up and down.
- Press ← to select a choice.
- Press → to return to the Service menu or ◄ to return to the Run screen.
Calibrate Point 1/2/3

The Calibrate Point 1 screen allows the user to view and set the selected calibration point. The calibrate 2 and calibrate 3 screens function the same way.

- In the Main Menu, choose Service > Multipoint Cal > Calibrate 1.
- Use ←, →, ↑, and ↓ to move and change the value.
- Press ← to save set to value as actual value.
- Press → to return to the Multipoint menu or ↓ to return to the Run screen.

Coefficients

The Coefficients screen allows the user to view and recalculate the calibration coefficients.
• In the Main Menu, choose Service > Multipoint Cal > Choose Cal Point > **Coefficients**.

• Press (←) to recalculate the coefficients.

• Press (↓) to return to the Multipoint menu or (↑) to return to the Run screen.

---

**Default Coefficients**  
The Default Coefficients screen allows the user to view and reset the calibration coefficients to default values.

• In the Main Menu, choose Service > Multipoint Cal > Choose Cal Point > **Coefficients**.

• Press (←) to recalculate the coefficients.

• Press (↓) to return to the Multipoint menu or (↑) to return to the Run screen.
Preamp Board Calibration

The Pre-amp Board Calibration screen is used to adjust the preamp board calibration parameters.

**WARNING** This adjustment should only be performed by an instrument service technician.

- In the Main Menu, choose Service > Preamp Calibration.
- Use ↑ and ↓ to increment or decrement the numeric value.
- Press ← to save the new counts to hardware.
- Press → to return to the Service menu or ◀ to return to the Run screen.
Temperature Calibration

The Temperature calibration screen allows the user to view and set the ambient temperature sensor calibration. The temperature calibration is visible only when the instrument is in service mode. For more information on the service mode, see “Service Mode” earlier in the chapter.

**WARNING** This adjustment should only be performed by an instrument service technician.

- In the Main Menu, choose Service > Temperature Calibration.
- Use and to move and change the value.
- Press to save set to value as actual value.
- Press to return to the Service menu or to return to the Run screen.

---

Analog Output Calibration

The Analog Output Calibration menu is a selection of analog output to calibrate, and allows the user to select the calibration action zero or span. The analog output calibration is visible only when the instrument is in service mode. For more information on the service mode, see “Service Mode” earlier in the chapter.
**Note** Current channels are only displayed if I/O expansion board option is installed.

**WARNING** This adjustment should only be performed by an instrument service technician.

- In the Main Menu, choose Service > Analog Out Calibration > Voltage Channel 1-6 or Current Channel 1-6.
- Use the ↑ and ↓ to move the cursor up and down.
- Press ← to select a choice.
- Press → to return to the Service menu or ◄ to return to the Run screen.
Analog Output Calibration Zero

The Analog Output Calibrate Zero screen allows the user to calibrate the zero state of the selected analog output. The operator must connect a meter to the output and adjust the output until it reads 0.0 V on the meter.

- In the Main Menu, choose Service > Analog Out Calibration > Select Channel > Calibrate Zero.

- Use the and to increment or decrement the numeric value.

- Press to save the value.

- Press to return to the Analog Out Calibration screen or to return to the Run screen.
The Analog Output Calibrate Full-Scale screen allows the user to calibrate the full-scale state of the selected analog output. The operator must connect a meter to the output and adjust output until it reads the value shown in the set output to: field.

- In the Main Menu, choose Service > Analog Out Calibration > Select Channel > Calibrate Full Scale.
- Use the ↑ and ↓ to increment or decrement the numeric value.
- Press ← to save the value.
- Press → to return to the Analog Out Calibration screen or → to return to the Run screen.

**Analog Input Calibration**

The Analog Input Calibration menu is a selection of analog input to calibrate, and allows the user to select the calibration action zero or span. The analog input calibration is visible only when the instrument is in service mode. For more information on the service mode, see “Service Mode” earlier in the chapter.

**Note** This screen is present only when the I/O expansion board option is installed.

**WARNING** This adjustment should only be performed by an instrument service technician.
• In the Main Menu, choose Service > Analog Input Calibration > Input Channel 1-8.

• Use the (↑) and (↓) to move the cursor up and down.

• Press (←) to select a choice.

• Press (←) to return to the Service menu or (→) to return to the Run screen.

**Analog Input Calibration Zero**

The Analog Input Calibrate Zero screen allows the user to calibrate the zero state of the selected analog input.
In the Main Menu, choose Service > Analog Input Calibration > Select Channel > Calibrate Zero. (Hook up a voltage source of 0 V to the analog input channel.)

- Press  to save the value.
- Press  to return to the Analog Input Calibration screen or  to return to the Run screen.

**Analog Input Calibrate Full-Scale**

The Analog Input Calibration Full-Scale screen allows the user to calibrate the full-scale state of the selected analog input.

- In the Main Menu, choose Service > Analog Input Calibration > Select Channel > Calibrate Full Scale. (Hook up a voltage source of 10 V to the analog input channel.)
- Use the  and  to increment or decrement the numeric value.
- Press  to save the value.
- Press  to return to the Analog Input Calibration screen or  to return to the Run screen.
Display Pixel Test

The Display Pixel Test is used to test the LCD display. The display pixel test is visible only when the instrument is in service mode. For more information on the service mode, see “Service Mode” earlier in the chapter.

- In the Main Menu, choose Service > Display Pixel Test.

- Press ( ) to begin test by turning all pixels ON, then toggle between on and off.

- Press ( ) to return to the Service menu or ( ) to return to the Run screen.
**Restore User Defaults**

The Restore User Defaults screen is used to reset the user calibration and configuration values to factory defaults. The restore default user is visible only when the instrument is in service mode. For more information on the service mode, see “Service Mode” earlier in the chapter.

- In the Main Menu, choose Service > **Restore User Defaults**.
- Press (←) to warn and enable restore with (→).
- Press (→) to overwrite all user settings with factory default values.
- Press (↓) to return to the Service menu or (↑) to return to the Run screen.

---

**Password**

The Password menu allows the user to configure password protection. This menu is only shown if the password has been entered or the password has not been set. For information on entering a new password, see “Enter Password” below.

- In the Main Menu, choose **Password**.
- Use (↑) and (↓) to move the cursor up and down.
- Press (←) to select a choice.
- Press (↓) to return to the Main Menu or (↑) to return to the Run screen.
Lock Instrument

The Lock Instrument screen is used to lock the instrument’s front panel so users cannot change any settings from the front panel.

- In the Main Menu, choose Password > Enter Password.
- Press [←] to enable instrument lock.
- Press [↓] to return to the Password Menu or [→] to return to the Run screen.

Change Password

The Change Password is used to set or change the password used to unlock the instrument’s front panel.

- In the Main Menu, choose Password > Change Password.
• Press \( \text{\textless} \) to change password.

• Press \( \text{\textless} \) to return to the Password Menu or \( \rightarrow \) to return to the Run screen.

Remove Password

The Remove Password screen is used to erase the current password and disable password protection.

• In the Main Menu, choose Password > Remove Password.

• Press \( \text{\textless} \) to remove password.

• Press \( \text{\textless} \) to return to the Password Menu or \( \rightarrow \) to return to the Run screen.
Enter Password

The Enter Password screen is used to enter the password to unlock the front panel.

- In the Main Menu, choose Password > Enter Password.
- Press \( \leftarrow \) to enter password and disable instrument lock.
- Press \( \rightarrow \) to return to the Password Menu or \( \downarrow \) to return to the Run screen.
Chapter 4 Calibration

This chapter describes the procedures for performing a standard zero/span calibration and Multi-Point calibrations of the Model 410i. The information described here is adequate to perform the calibration. However, if greater detail is needed, please refer to the Quality Assurance Handbook for Air Pollution Measurement Systems.\(^1\)

The following sections discuss the required apparatus and procedure for calibrating the instrument.

### Equipment Required

The following equipment is required to calibrate the instrument:

- **CO₂ Concentration Standard**
  
  A cylinder of CO₂ in air containing an appropriate concentration of CO₂ suitable for the selected operating range of the analyzer under calibration is necessary. The assay of the cylinder must be traceable either to a National Institute of Standards and Technology (NIST) CO₂ in Air Standard Reference Material (SRM) or an NIST/EPA approved gas manufacturer’s Certified Reference Material (CRM).

  A recommended protocol for certifying CO₂ gas cylinders against a CO₂, SRM or CRM is given in the Quality Assurance Handbook.\(^1\) The CO₂ gas cylinder should be recertified on a regular basis determined by the local quality control program.

- **Zero Air**
  
  Calibration requires zero air that is free of contaminants which will cause a detectable response on the CO₂ analyzer. The zero air should contain <0.5 ppm CO₂.

  Depending on the grade, zero air as supplied in cylinders from commercial suppliers typically contains CO₂ concentrations in the 0.1 to 400 ppm range. So cylinder zero air should be scrubbed of the residual CO₂ prior to its use in the Model 410i as a dilution gas or a zero standard.

  It is also possible to use a zero air generator in place of zero air cylinders. Zero air generation is a three-step process involving:

  - Compression
Calibration

Equipment Required

- Drying
- Scrubbing of CO₂

Compression

The zero air source should be at an elevated pressure to allow accurate and reproducible flow control and to aid in subsequent operations such as drying, and scrubbing. An air compressor that gives an output of 30 psig is usually sufficient for most applications.

Drying

Several drying methods are available. Passing the compressed air through a bed of silica gel, using a heatless air dryer, or removing water vapor with a permeation dryer are three possible approaches.

Scrubbing

The last step in the generation of the zero air is the removal of the remaining contaminants by either further reaction or absorption. Regenerative CO₂ adsorption systems are available and can produce zero air containing less than 1 ppm CO₂. A regenerative system can be followed by a soda-lime scrubber to remove residual CO₂.

Flow Meter(s) and Controller(s)

In order to obtain an accurate dilution ratio in the dilution method used for calibration, the flow rates must be regulated to 1%, and be measured to an accuracy of at least 2%. The meter and controller can be two separate devices, or combined in one device. The user’s manual for the meter should be consulted for calibration information.

Additional information on the calibration of flow devices can be found in the Quality Assurance Handbook¹. It should be noted that all flows should be corrected to 25 °C and 760 mm Hg, and that care should be exercised in correcting for water vapor content.

Pressure Regulator for CO₂ Standard Cylinder

The regulator used must have a nonreactive diaphragm and internal parts, as well as a suitable delivery pressure.

Mixing Chamber

A chamber constructed of glass, Teflon®, or other nonreactive material, and designed to provide thorough mixing of CO₂ and diluent air for the dilution method is required.
Output Manifold
The output manifold should be constructed of glass, Teflon®, or other nonreactive material, and should be of sufficient diameter to ensure an insignificant pressure drop at the analyzer connection. The system must have a vent designed to ensure atmospheric pressure at the manifold and to prevent ambient air from entering the manifold.

Pre-Calibration
Prior to calibration, be sure the instrument is operating properly. Turn on the instrument and allow it to stabilize for one 90 minutes. Perform the service checks of the “Preventive Maintenance” chapter. Select the operating range and the averaging time of the Model 410i.

**Note** The averaging time should be less than the zero duration and less than the span duration. ♦

**Note** The calibration and calibration check duration times should be long enough to account for the transition (purge) process when switching from sample to zero and from zero to span. This transition time is the time required to purge the existing air. ♦

Depending on the plumbing configuration and the instrument, data from approximately the first minute of a zero calibration or check should be disregarded because of residual sample air. Also, data from approximately the first minute of a span calibration or check should be disregarded because the span is mixing with the residual zero air. ♦
Calibration

Use the following procedure to calibrate the instrument.

Connect the Instrument

Connect the instrument and the calibration equipment as shown in Figure 4-1. If an optional sample line filter is used, the calibration must be performed through this filter. Ensure that the flow rate into the output manifold is greater than the total flow required by the analyzer and any other flow demand connected to the manifold.

![Calibration Flow Schematic](image)

Figure 4-1. Calibration Flow Schematic

Zero Adjust

Use the following procedure to set the CO₂ reading to zero.

1. Allow sufficient time for the Model 410i to warm up and stabilize.

2. Adjust the dilution system of Figure 4-1 so that zero air alone is present in the manifold.

   Since not all flow controllers have a positive shut off, it might be necessary to disconnect the CO₂ input line and cap it.

3. Allow the instrument to sample zero air until a stable reading is obtained.

4. Press \( \text{Calibrate Zero} \) and choose Calibration > Calibrate Zero.
5. In the Calibrate Zero screen, press \( \text{←} \) to set the CO\(_2\) reading to zero.

If a strip chart recorder is used to obtain a record of the analog output, it is recommended that the system be adjusted to obtain a zero trace at 5% of scale. This is to allow observation of zero drift and/or zero noise. Record the stable zero air response as \( Z \).

**Span Adjust**

Use the following procedure to adjust the span.

1. Adjust the zero air flow and the CO\(_2\) flow from the standard CO\(_2\) cylinder to provide a diluted CO\(_2\) concentration of approximately 80% of the upper range limit (URL) of the analyzer.

The total air flow must exceed the total demand of the analyzer connected to the output manifold to ensure that no ambient air is pulled into the manifold vent. The exact CO\(_2\) concentration is calculated from:

\[
[\text{CO}_2]_{\text{OUT}} = \frac{[\text{CO}_2]_{\text{STD}} \times F_{\text{CO2}}}{F_{\text{D}} + F_{\text{CO2}}} \quad (1)
\]

Where:

- \([\text{CO}_2]_{\text{OUT}}\) = diluted CO\(_2\) concentration at the output manifold, ppm
- \([\text{CO}_2]_{\text{STD}}\) = concentration of the undiluted CO\(_2\) standard, ppm
- \(F_{\text{CO2}}\) = flow rate of CO\(_2\) standard corrected to 25 °C and 760 mm Hg in LPM
- \(F_{\text{D}}\) = flow rate of dilution air corrected to 25 °C and 750 mm Hg in LPM

2. Allow the instrument to sample this CO\(_2\) concentration standard until a stable response is obtained.

3. From the Main Menu, choose Calibration > **Calibrate Span**.

The first line of the display shows the current CO\(_2\) concentration reading. The second line of the display shows the CO\(_2\) range and the third line is where the CO\(_2\) concentration is entered.
4. Enter the CO₂ calibration gas concentration using the pushbuttons, then press \( \rightarrow \) to calibrate the CO₂ reading to the CO₂ calibration gas.

\[
\text{recorder response (percent scale)} = \left( \frac{[\text{CO}_2]_{\text{OUT}} \times 100}{\text{URL}} \right) + Z_{\text{CO}_2}
\]

Where:

- \( \text{URL} \) = nominal upper range limit of the instrument operating range
- \( Z_{\text{CO}_2} \) = instrument response to zero air, %scale

5. Record the CO₂ concentration and the instrument’s response.

**Additional Concentration Standards**

Generate several additional concentrations (at least five others are suggested) by decreasing \( F_{\text{CO}} \) or increasing \( F_{\text{D}} \). Be sure the total flow exceeds the instrument’s total flow demand. For each concentration generated, calculate the exact CO₂ concentration using Equation (1). Record the concentration and the instrument’s response for each concentration.

**Calibration Curve**

Plot the instrument’s response versus the corresponding CO₂ concentrations. Connect the experimental points using a straight line, preferably determined by linear regression techniques. The calibration curve is used to reduce subsequent ambient data.

**Calibration Frequency**

In order to generate data of the highest confidence, it is recommended that a multipoint calibration be performed:

- every three months
- any time any major disassembly of components is performed
- any time the zero or span checks give results outside the limits described in the “Periodic Zero and Span Checks” that follows

**Periodic Zero and Span Checks**

In order to achieve data of the highest confidence, it is suggest that periodic zero and air span checks be performed. These checks can be performed by:

1. Periodically challenging the instrument with zero air. The output of the zero air supply should be greater than the flow demand of the instrument. In addition, an atmospheric dump bypass should be utilized
to ensure that the zero air gas flow is being delivered at atmospheric pressure.

Record the Model 410i’s response in percent of scale as $A_O$. Compute the zero drift from the following equation:

$$\text{Zero Drift } \% = A_O - Z$$

Where:

$Z$ is the recorder response obtained at the last calibration for zero air, % scale.

2. Periodically challenging the instrument with a CO$_2$ level of approximately 80% of the URL. The 80% URL level may be obtained by dilution of a higher level of CO$_2$ using a system similar to that of Figure 4-1, or by using a low level cylinder of CO$_2$ containing CO$_2$ in air at a concentration of approximately 80% of the URL. In either case the cylinder of CO$_2$ should be checked against an SRM or CRM. It should also be true for a cylinder of low level CO$_2$.

The *Quality Assurance Handbook* should be referred to for the cylinder checking procedure.

Record the instrument’s response in % of scale as $A_{80}$. Compute the span error from the following equation:

$$\text{Span Error, } \% = ([A_{80} - Z]URL/100) - [CO_2]) X 100/[CO_2]$$

Where:

$Z = $ Recorder response obtained at the last calibration for zero air, % scale.

$[CO_2] = $ Span concentration

3. Latest copy of the *Quality Assurance Handbook for Air Pollution Measurement Systems* should be consulted to determine the level of acceptance of zero and span errors.

For detailed guidance in setting up a quality assurance program, refer to the *Code of Federal Regulations* and the *EPA Handbook on Quality Assurance*. 
HI and LO Multi-Point Calibration

The instrument can also be calibrated using dual ranges and three span points per range. The ranges are designated as the “low” range and the “high” range “A.”

“A” and the span gases are designated as:

- Cal Point 1
- Cal Point 2
- Cal Point 3

The customer defines the ranges and Thermo Electron recommends the following calibration points for each range:

- Cal Point 1: 80% of range
- Cal Point 2: 50% of range
- Cal Point 3: 20% of range

For example, an operator measuring CO₂ emissions from a stack might designate the low range to be 0-100 ppm and the high range to be 0-5000 ppm. In this case, the suggested span gases would be the following:

Low range Cal Point 1: 80 ppm
Low range Cal Point 2: 50 ppm
Low range Cal Point 3: 20 ppm
High range Cal Point 1: 4000 ppm
High range Cal Point 2: 2500 ppm
High range Cal Point 3: 1000 ppm

References

1. QUALITY ASSURANCE HANDBOOK FOR AIR POLLUTION MEASUREMENT SYSTEMS, Volume II - Ambient Air Specific Methods EPA 600/4-77-027a, May 1977 and 40 CFR 50, Appendix C.
**Default Coefficients**

*Note* If performing a multi-point calibration after a “bad” calibration or changing ranges it is recommended to start off with default values for the Cal point coefficients.

To set default values, from the Main Menu select Service Mode > **Hi Multi-Point Cal** or **Lo Multi-Point Cal**. From Hi or Lo Multi-Point Cal, select **Default Coef** and press \( \leftarrow \). The instrument will automatically reset the default values.

**Cal Point 1, 2, and 3 Adjust**

Use the following procedure to adjust cal points 1, 2, and 3.

1. Adjust the zero air flow and the CO\(_2\) flow from the standard CO\(_2\) cylinder to provide a diluted CO\(_2\) concentration of approximately 80% of the upper range limit (URL) of the instrument. The total air flow must exceed the total demand of the instrument connected to the output manifold to ensure that no ambient air is pulled into the manifold vent.

2. Allow the Model 410i to sample this CO\(_2\) concentration standard until a stable response is obtained.

3. From the Main Menu select Service Mode > Lo Multi-Point Cal > **Cal Point 1**.

4. Use \( \leftarrow \), \( \rightarrow \) to move the cursor and \( \uparrow \), \( \downarrow \) to increment or decrement the digit values until they match the concentration being introduced to the instrument. Press \( \leftarrow \).

   The instrument will perform a series of calculations and save the new parameters.

5. Press \( \Uparrow \) to back up a step in the Service Mode menu.

6. Repeat Step 1 for a 50% concentration of the upper range.

7. Select Cal Point 2.
8. Use ← → to move the cursor and ↑ ↓ to increment or decrement the digit values until they match the concentration being introduced to the instrument. Press ←.

The instrument will perform a series of calculations and save the new parameters.

9. Press ← to back up a step in the Service Mode menu.

10. Repeat Step 1 for a 20% concentration of the upper range.

11. Select Cal Point 3.

12. Use ← → to move the cursor and ↑

13. ↓ to increment or decrement the digit values until they match the concentration being introduced to the instrument. Press ←.

The instrument will perform a series of calculations and save the new parameters.

14. Press ← to back up a step in the Service Mode menu.

15. Select Coefficients and press ←.

The instrument will automatically calculate the new coefficients and save the new parameters.

16. Repeat Steps 1 through 13 for Hi Multi-Point Cal.
Chapter 5 Preventive Maintenance

This chapter describes the periodic maintenance procedures that should be performed on the instrument to ensure proper operation.

Since usage and environmental conditions vary greatly, you should inspect the components frequently until an appropriate maintenance schedule is determined. This includes the sample pump, solenoid valves, and IR source which have a limited life.

Other operations such as cleaning the optics and checking the calibration of the pressure and temperature transducers should be performed on a regular basis.

This chapter includes the following maintenance information and replacement procedures:

- “Replacement Parts” on page 5-1
- “Cleaning the Outside Case” on page 5-2
- “IR Source Replacement” on page 5-2
- “Fan Filter Inspection and Cleaning” on page 5-2
- “Leak Test and Pump Check Out” on page 5-3
- “Pump Rebuilding” on page 5-4

Replacement Parts

See the “Servicing” chapter for a list of replacement parts and the associated replacement procedures.

WARNING If the equipment is operated in a manner not specified by the manufacturer, the protection provided by the equipment may be impaired.
Cleaning the Outside Case

Clean the outside case using a damp cloth being careful not to damage the labels on the case.

Equipment Damage Do Not use solvents or other cleaning products to clean the outside case.

IR Source Replacement

The IR source control system has been designed to operate the wire wound resistor IR source conservatively in order to increase its life. Nevertheless, the IR source does have a finite life. Since the IR source is relatively inexpensive and easily replaced, it is recommended that the IR source be replaced after one year of continuous use. This will prevent loss of data due to IR source failure. If an IR source is to be replaced on an as needed basis, it should be replaced when:

- There is no light output
- After cleaning the optics, the IR light intensities remain below 100,000 Hz

It is not necessary to recalibrate the Model 410i after replacing the IR source since the Model 410i is a ratio instrument, and replacing the IR source does not affect the calibration.

Fan Filter Inspection and Cleaning

Use the following procedure to inspect and clean the fan filter.

1. Remove the fan guard from the fan and remove the filter (Figure 5-1).

2. Flush the filter with warm water and let dry (a clean, oil-free purge will help the drying process) or blow the filter clean with compressed air.

3. Re-install the filter and fan guard.
Leak Test and Pump Check Out

There are two major types of leaks: external leaks and leaks across the optional zero/span solenoid valve seals.

External Leaks

Use the following procedure to test for external leaks.

1. Disconnect the sample input line and plug the SAMPLE fitting.

2. Press \[ \text{ } \] to display the Main Menu.

3. Press \[ \text{ } \] to move the cursor to Diagnostics and press \[ \text{ } \] to display the Diagnostics menu.

4. Press \[ \text{ } \] to move the cursor to Flow and press \[ \text{ } \] to display the Sample Flow screen. The flow reading should indicate zero flow and the pressure reading should be less than 250 mm Hg. If not, check to see that all fittings are tight and that none of the input lines are cracked or broken. For detailed information about this screen, refer to the “Operation” chapter.

If the pump diaphragm is in good condition and the capillary not blocked, it should take less than one minute from the time the inlet is plugged to the time the reading below 250 mm Hg is obtained.
Leaks Across the Optional Zero/Span and Sample Solenoid Valves

In order to check for leaks across the optional valves, plug the SPAN inlet line, press \[\text{\textup{\textbullet}}\] and follow the “External Leaks” procedure.

If the pressure drops below 250 mm Hg the valve associated with the span line is functioning normally. Repeat for the valve associated with the zero line by plugging the zero inlet, press \[\text{\textup{\textbullet}}\] and follow the “External Leaks” procedure.

If the pressure drops below 250 mm Hg, the valve associated with the zero line is functioning normally.

Pump Rebuilding

Use the following procedure to rebuild the pump (Figure 5-2). To replace the pump, see “Pump Replacement” in the “Servicing” chapter.

Equipment Required:

- Flatblade screwdriver
- Pump rebuild kit (flapper valve and diaphragm)

Equipment Damage Some internal components can be damaged by small amounts of static electricity. A properly grounded antistatic wrist strap must be worn while handling any internal component. ▲

1. Turn instrument OFF, unplug the power cord, and remove the cover.

2. Loosen the fittings and remove both lines going to the pump.

3. Remove the four screws from the top plate, remove top plate, flapper valve, and the bottom plate (Figure 5-2).
Figure 5-2. Rebuilding the Pump

4. Remove the screw securing the diaphragm to piston and remove diaphragm.

5. Assemble the pump by following the previous steps in reverse, make sure the Teflon® (white) side of the diaphragm is facing up and that the flapper valves cover the holes of the top and bottom plate.

6. Perform the “Leak Test and Pump Checkout” procedure described in this chapter.
This instrument has been designed to achieve a high level of reliability. In the event of problems or failure, the troubleshooting guidelines, board-level connection diagrams, connector pin descriptions, and testing procedures presented in this chapter should be helpful in isolating and identifying problems.

The Technical Support Department at Thermo Electron can also be consulted in the event of problems. See “Service Locations” at the end of this chapter for contact information. In any correspondence with the factory, please note both the serial number and program number of the instrument.

This chapter provides the following troubleshooting and service support information:

- “Safety Precautions” on page 6-1
- “Troubleshooting Guides” on page 6-1
- “Board-Level Connection Diagrams” on page 6-5
- “Connector Pin Descriptions” on page 6-7
- “Service Locations” on page 6-20

Safety Precautions

Read the safety precautions in the Preface and “Servicing” chapter before performing any actions listed in this chapter.

Troubleshooting Guides

The troubleshooting guides presented in this chapter are designed to help isolate and identify instrument problems.

Table 6-1 provides general troubleshooting information and indicates the checks that you should perform if you experience an instrument problem.
Table 6-2 lists all the alarm messages you may see on the graphics display and provides recommendations about how to resolve the alarm condition.

Table 6-1. Troubleshooting - General Guide

<table>
<thead>
<tr>
<th>Malfunction</th>
<th>Possible Cause</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Does not start</td>
<td>No power or wrong power configuration</td>
<td>Check the line to confirm that power is available and that it matches the voltage and frequency configuration of the instrument.</td>
</tr>
<tr>
<td></td>
<td>Main fuse is blown or missing</td>
<td>Unplug the power cord, open the fuse drawer on the back panel, and check the fuses visually or with a multimeter.</td>
</tr>
<tr>
<td></td>
<td>Bad switch or wiring connection</td>
<td>Unplug the power cord, disconnect the switch and check operation with a multimeter.</td>
</tr>
<tr>
<td></td>
<td>Pressure transducer defective</td>
<td>Replace pressure transducer.</td>
</tr>
<tr>
<td></td>
<td>Recorder noise</td>
<td>Replace or repair recorder.</td>
</tr>
<tr>
<td></td>
<td>Sample CO₂ concentration varying</td>
<td>Run instrument on a span CO₂ source - if quiet, there is no malfunction.</td>
</tr>
<tr>
<td></td>
<td>Foreign material in optical bench</td>
<td>Clean optical bench.</td>
</tr>
<tr>
<td></td>
<td>System leak</td>
<td>Find and repair leak</td>
</tr>
<tr>
<td></td>
<td>Pressure or temperature transducer out of calibration</td>
<td>Recalibrate pressure and temperature transducer.</td>
</tr>
<tr>
<td></td>
<td>Dirty system</td>
<td>Clean cells and flow components.</td>
</tr>
<tr>
<td></td>
<td>Faulty recorder</td>
<td>Replace recorder.</td>
</tr>
<tr>
<td></td>
<td>D/A calibration off</td>
<td>Recalibrate the D/A with a DVM known to be in calibration.</td>
</tr>
</tbody>
</table>

Table 6-2. Troubleshooting - Alarm Messages

<table>
<thead>
<tr>
<th>Alarm Message</th>
<th>Possible Cause</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alarm - Internal Temp</td>
<td>Check fan operation</td>
<td>Replace fan if not operating properly.</td>
</tr>
<tr>
<td>Alarm Message</td>
<td>Possible Cause</td>
<td>Action</td>
</tr>
<tr>
<td>------------------------</td>
<td>---------------------------------------------</td>
<td>------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Check fan filter</td>
<td>Clean or replace foam filter, refer to “Preventive Maintenance” chapter in this manual.</td>
<td></td>
</tr>
<tr>
<td>Alarm - Chamber Temp</td>
<td>Chamber temperature below set point of 50 °C</td>
<td>Check 10K thermistor, replace if bad.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Check temperature control board to insure the LEDs are coming on. If not, temperature control board could be defective.</td>
</tr>
<tr>
<td>Alarm - Pressure</td>
<td>High pressure indication</td>
<td>Check the pump for a tear in the diaphragm, replace with pump repair kit if necessary. Refer to “Preventive Maintenance” chapter in this manual. Check that capillaries are properly installed and O-rings are in good shape. Replace if necessary. Check flow system for leaks.</td>
</tr>
<tr>
<td>Alarm - Flow</td>
<td>Flow low</td>
<td>Check sample capillary (15 mil) for blockage. Replace as necessary. If using sample particulate filter make sure it is not blocked. Disconnect sample particulate filter from the sample bulkhead, if flow increases, replace the filter.</td>
</tr>
<tr>
<td>Alarm - Bias voltage</td>
<td>Defective measurement interface board</td>
<td>Replace measurement interface board.</td>
</tr>
<tr>
<td></td>
<td>Defective pre-amp board</td>
<td>Replace pre-amp board.</td>
</tr>
<tr>
<td>Alarm - AGC intensity</td>
<td>Pre-amp Gain not set properly</td>
<td>Check Gain adjustment.</td>
</tr>
<tr>
<td></td>
<td>Defective measurement interface board</td>
<td>Replace measurement interface board.</td>
</tr>
<tr>
<td>Alarm - Motor Speed</td>
<td>Defective measurement interface board</td>
<td>Replace measurement interface board.</td>
</tr>
<tr>
<td></td>
<td>Defective chopper motor or cable</td>
<td>Check chopper motor cable. Replace chopper motor.</td>
</tr>
</tbody>
</table>
### Table 6-2. Troubleshooting - Alarm Messages, continued

<table>
<thead>
<tr>
<th>Alarm Message</th>
<th>Possible Cause</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alarm - CO₂ Conc.</td>
<td>Concentration has exceeded range</td>
<td>Check to insure range corresponds with expected</td>
</tr>
<tr>
<td></td>
<td>limit</td>
<td>value. If not select proper range.</td>
</tr>
<tr>
<td></td>
<td>Concentration low</td>
<td>Check user-defined low set point, set to zero.</td>
</tr>
<tr>
<td>Alarm - Zero Check</td>
<td>Instrument out of calibration</td>
<td>Recalibrate instrument.</td>
</tr>
<tr>
<td>Alarm - Span Check</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alarm - Zero Autocal</td>
<td>Internal cables not connected</td>
<td>Check that all internal cables are connected properly.</td>
</tr>
<tr>
<td>Alarm - Span Autocal</td>
<td>properly</td>
<td>Recycle AC power to instrument. If still alarming,</td>
</tr>
<tr>
<td>Alarm - Motherboard Status</td>
<td>Board is defective</td>
<td>change board.</td>
</tr>
<tr>
<td>Alarm - Interface Status</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alarm - I/O Exp Status</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Figure 6-1 and Figure 6-2 are board-level connection diagrams for the common electronics and measurement system. These illustrations can be used along with the connector pin descriptions in Table 6-3 through Table 6-8 to troubleshoot board-level faults.

**Figure 6-1.** Board-Level Connection Diagram - Common Electronics
Figure 6-2. Board-Level Connection Diagram - Measurement System
The connector pin descriptions in Table 6-3 through Table 6-8 can be used along with the board-level connection diagrams to troubleshoot board-level faults.

### Table 6-3. Motherboard Connector Pin Descriptions

<table>
<thead>
<tr>
<th>Connector Label</th>
<th>Reference Designator</th>
<th>Pin</th>
<th>Signal Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>INTF DATA J1</td>
<td></td>
<td>1</td>
<td>Ground</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
<td>+RS485 to Interface Board</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3</td>
<td>-RS485 to Interface Board</td>
</tr>
<tr>
<td>10-BASE-T J2</td>
<td></td>
<td>1</td>
<td>Ethernet Output (+)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
<td>Ethernet Output (-)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3</td>
<td>Ethernet Input (+)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4</td>
<td>NC</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5</td>
<td>NC</td>
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<tr>
<td></td>
<td></td>
<td>6</td>
<td>Ethernet Input (-)</td>
</tr>
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<td></td>
<td></td>
<td>7</td>
<td>NC</td>
</tr>
<tr>
<td></td>
<td></td>
<td>8</td>
<td>NC</td>
</tr>
<tr>
<td>INTF DATA J1</td>
<td></td>
<td>1</td>
<td>Ground</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
<td>+RS485 to Interface Board</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3</td>
<td>-RS485 to Interface Board</td>
</tr>
<tr>
<td>10-BASE-T J2</td>
<td></td>
<td>1</td>
<td>Ethernet Output (+)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
<td>Ethernet Output (-)</td>
</tr>
<tr>
<td></td>
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<td>3</td>
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<td>NC</td>
</tr>
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<td></td>
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<td>8</td>
<td>NC</td>
</tr>
<tr>
<td>EXPANSION BD J3</td>
<td></td>
<td>1</td>
<td>+5V</td>
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<tr>
<td></td>
<td></td>
<td>2</td>
<td>+24V</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3</td>
<td>+24V</td>
</tr>
<tr>
<td></td>
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<td>4</td>
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<td></td>
<td></td>
<td>7</td>
<td>+RS485 to Expansion Board</td>
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<tr>
<td></td>
<td></td>
<td>8</td>
<td>-RS485 to Expansion Board</td>
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### Table 6-3. Motherboard Connector Pin Descriptions, continued

<table>
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<th>Connector Label</th>
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<th>Pin</th>
<th>Signal Description</th>
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<tr>
<td>SPARE DATA J4</td>
<td></td>
<td>1</td>
<td>+5V</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
<td>+24V</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3</td>
<td>+24V</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4</td>
<td>Ground</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5</td>
<td>Ground</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6</td>
<td>Ground</td>
</tr>
<tr>
<td></td>
<td></td>
<td>7</td>
<td>+RS485 to Spare Board</td>
</tr>
<tr>
<td></td>
<td></td>
<td>8</td>
<td>-RS485 to Spare Board</td>
</tr>
<tr>
<td>I/O J5</td>
<td>1</td>
<td>Power Fail Relay N.C. Contact</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Ground</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>TTL Input 1</td>
<td></td>
</tr>
<tr>
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<td>4</td>
<td>TTL Input 2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>Ground</td>
<td></td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>TTL Input 5</td>
<td></td>
</tr>
<tr>
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<td>TTL Input 7</td>
<td></td>
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<td>8</td>
<td>TTL Input 8</td>
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<td>9</td>
<td>TTL Input 10</td>
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</tr>
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<td></td>
<td>10</td>
<td>Ground</td>
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<td>TTL Input 13</td>
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<td>Ground</td>
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<tr>
<td></td>
<td>14</td>
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<td>16</td>
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<td>17</td>
<td>Analog Voltage Output 5</td>
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<td></td>
<td>18</td>
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<td>19</td>
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<td></td>
<td>20</td>
<td>Power Fail Relay COM</td>
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<td>Power Fail Relay N.O. Contact</td>
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<td>25</td>
<td>TTL Input 6</td>
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Table 6-3. Motherboard Connector Pin Descriptions, continued

<table>
<thead>
<tr>
<th>Connector Label</th>
<th>Reference Designator</th>
<th>Pin</th>
<th>Signal Description</th>
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<td>TTL Input 16</td>
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<td>33</td>
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<td></td>
<td>Analog Voltage Output 2</td>
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<td>34</td>
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<td>Analog Voltage Output 4</td>
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<td>Ground</td>
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<td>36</td>
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<td></td>
<td>Analog Voltage Output 6</td>
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<td>37</td>
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<td>Ground</td>
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<tr>
<td>SER EN</td>
<td>J7</td>
<td>1</td>
<td>Serial Enable Jumper</td>
</tr>
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<td></td>
<td></td>
<td>2</td>
<td>+3.3V</td>
</tr>
<tr>
<td>24V IN</td>
<td>J10</td>
<td>1</td>
<td>+24V</td>
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<td></td>
<td>2</td>
<td>Ground</td>
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<tr>
<td>DIGITAL I/O</td>
<td>J14</td>
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<td>+5V</td>
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<td></td>
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<td>2</td>
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<td>SPI Output</td>
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<td>10</td>
<td>SPI Board Select</td>
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<td></td>
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<td>11</td>
<td>SPI Clock</td>
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<td>J15</td>
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<td>-RS485 to Rear Panel</td>
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<td>+RS485 to Rear Panel</td>
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<td></td>
<td>3</td>
<td>+5V</td>
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<td>5</td>
<td>+5V</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6</td>
<td>Ground</td>
</tr>
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### Table 6-3. Motherboard Connector Pin Descriptions, continued

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<th>Connector Label</th>
<th>Reference Designator</th>
<th>Pin</th>
<th>Signal Description</th>
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<td>7</td>
<td>Ground</td>
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<td>8</td>
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<td>+24V</td>
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### Table 6-4. Measurement Interface Board Connector Pin Descriptions

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### Table 6-4. Measurement Interface Board Connector Pin Descriptions, continued

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### Table 6-5. Front Panel Board Connector Pin Diagram

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<td>27</td>
<td>Keypad Col 4 Select</td>
<td>27</td>
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<td>Keypad Col 3 Select</td>
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<td>Ground</td>
</tr>
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<td>29</td>
<td>Ground</td>
<td>29</td>
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<td>30</td>
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<td>30</td>
<td>+24V</td>
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<td>31</td>
<td>Ground</td>
<td>31</td>
<td>+24V</td>
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<td>32</td>
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<td>32</td>
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Table 6-5. Front Panel Board Connector Pin Diagram, continued

<table>
<thead>
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<th>Reference Designator</th>
<th>Pin</th>
<th>Signal Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>EXPANSION I/O</td>
<td>J1</td>
<td>1</td>
<td>Analog Voltage Input 1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
<td>Analog Voltage Input 2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3</td>
<td>Analog Voltage Input 3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4</td>
<td>Ground</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5</td>
<td>Analog Voltage Input 4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6</td>
<td>Analog Voltage Input 5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>7</td>
<td>Analog Voltage Input 6</td>
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<tr>
<td></td>
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<td>8</td>
<td>Ground</td>
</tr>
<tr>
<td></td>
<td></td>
<td>9</td>
<td>Analog Voltage Input 7</td>
</tr>
</tbody>
</table>

Table 6-6. I/O Expansion Board (Optional) Connector Pin Descriptions

<table>
<thead>
<tr>
<th>Connector Label</th>
<th>Reference Designator</th>
<th>Pin</th>
<th>Signal Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>EXPANSION I/O</td>
<td>J1</td>
<td>1</td>
<td>Analog Voltage Input 1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
<td>Analog Voltage Input 2</td>
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<td></td>
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<td>3</td>
<td>Analog Voltage Input 3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4</td>
<td>Ground</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5</td>
<td>Analog Voltage Input 4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6</td>
<td>Analog Voltage Input 5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>7</td>
<td>Analog Voltage Input 6</td>
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<td>8</td>
<td>Ground</td>
</tr>
<tr>
<td></td>
<td></td>
<td>9</td>
<td>Analog Voltage Input 7</td>
</tr>
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### Table 6-6. I/O Expansion Board (Optional) Connector Pin Descriptions, continued

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<th>Pin</th>
<th>Signal Description</th>
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<tbody>
<tr>
<td>MOTHER BD J1</td>
<td></td>
<td>1</td>
<td>+5V</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
<td>+24V</td>
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<td>3</td>
<td></td>
<td></td>
<td>+24V</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
<td>Ground</td>
</tr>
<tr>
<td>5</td>
<td></td>
<td></td>
<td>Ground</td>
</tr>
<tr>
<td>6</td>
<td></td>
<td></td>
<td>Ground</td>
</tr>
<tr>
<td>7</td>
<td></td>
<td></td>
<td>+RS485 to Motherboard</td>
</tr>
<tr>
<td>8</td>
<td></td>
<td></td>
<td>-RS485 to Motherboard</td>
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### Table 6-7. Digital Output Board Connector Pin Descriptions

<table>
<thead>
<tr>
<th>Connector Label</th>
<th>Reference Designator</th>
<th>Pin</th>
<th>Signal Description</th>
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<tbody>
<tr>
<td>MOTHER BD J1</td>
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<td>1</td>
<td>+5V</td>
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<tr>
<td>2</td>
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<td>+24V</td>
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<tr>
<td>4</td>
<td></td>
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<td>Ground</td>
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## Table 6-7. Digital Output Board Connector Pin Descriptions, continued

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<th>Pin</th>
<th>Signal Description</th>
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<tr>
<td>5</td>
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<td>6</td>
<td></td>
<td>Ground</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td></td>
<td>SPI Reset</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td></td>
<td>SPI Input</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td></td>
<td>SPI Output</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td></td>
<td>SPI Board Select</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td></td>
<td>SPI Clock</td>
<td></td>
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<tr>
<td>DIGITAL OUTPUTS</td>
<td>J2</td>
<td>1</td>
<td>Relay 1 Contact a</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
<td>Relay 2 Contact a</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3</td>
<td>Relay 3 Contact a</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4</td>
<td>Relay 4 Contact a</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5</td>
<td>Relay 5 Contact a</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6</td>
<td>Relay 6 Contact a</td>
</tr>
<tr>
<td></td>
<td></td>
<td>7</td>
<td>Relay 7 Contact a</td>
</tr>
<tr>
<td></td>
<td></td>
<td>8</td>
<td>Relay 8 Contact a</td>
</tr>
<tr>
<td></td>
<td></td>
<td>9</td>
<td>Relay 9 Contact a</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10</td>
<td>Relay 10 Contact a</td>
</tr>
<tr>
<td></td>
<td></td>
<td>11</td>
<td>NC</td>
</tr>
<tr>
<td></td>
<td></td>
<td>12</td>
<td>Solenoid Drive Output 1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>13</td>
<td>Solenoid Drive Output 2</td>
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<td>14</td>
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<td></td>
<td>15</td>
<td>Solenoid Drive Output 4</td>
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<td></td>
<td></td>
<td>16</td>
<td>Solenoid Drive Output 5</td>
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<td></td>
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<td>17</td>
<td>Solenoid Drive Output 6</td>
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<td></td>
<td>18</td>
<td>Solenoid Drive Output 7</td>
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<td></td>
<td></td>
<td>19</td>
<td>Solenoid Drive Output 8</td>
</tr>
<tr>
<td></td>
<td></td>
<td>20</td>
<td>Relay 1 Contact b</td>
</tr>
<tr>
<td></td>
<td></td>
<td>21</td>
<td>Relay 2 Contact b</td>
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<td></td>
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<td>22</td>
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<td>24</td>
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<td></td>
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<td>25</td>
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Table 6-7. Digital Output Board Connector Pin Descriptions, continued

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<th>Signal Description</th>
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<tr>
<td>26</td>
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<td>Relay 7 Contact b</td>
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<tr>
<td>27</td>
<td></td>
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<td></td>
<td>Relay 9 Contact b</td>
<td></td>
</tr>
<tr>
<td>29</td>
<td></td>
<td>Relay 10 Contact b</td>
<td></td>
</tr>
<tr>
<td>30</td>
<td></td>
<td>+24V</td>
<td></td>
</tr>
<tr>
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<td>32</td>
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<tr>
<td>37</td>
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Table 6-8. Pre-amp Board Connector Pin Descriptions

<table>
<thead>
<tr>
<th>Connector Label</th>
<th>Signal Description</th>
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<tbody>
<tr>
<td>OUT</td>
<td>Preamp Signal Output</td>
</tr>
<tr>
<td>SH</td>
<td>Ground for Shield</td>
</tr>
<tr>
<td>BLK</td>
<td>Ground</td>
</tr>
<tr>
<td>GRN</td>
<td>SPI – Data Out</td>
</tr>
<tr>
<td>ORG</td>
<td>SPI - CLK</td>
</tr>
<tr>
<td>VIO</td>
<td>SPI - CS</td>
</tr>
<tr>
<td>BLU</td>
<td>+15V</td>
</tr>
<tr>
<td>BRN</td>
<td>+5V</td>
</tr>
<tr>
<td>RED</td>
<td>+18V for IR Source</td>
</tr>
<tr>
<td>WHT</td>
<td>-100V</td>
</tr>
<tr>
<td>BLK</td>
<td>-100V Return</td>
</tr>
<tr>
<td>YEL</td>
<td>+18V for IR Source</td>
</tr>
<tr>
<td>YEL</td>
<td>IR Source Return</td>
</tr>
<tr>
<td>RED</td>
<td>IR Detector Cooler +</td>
</tr>
<tr>
<td>BLK</td>
<td>IR Detector Cooler -</td>
</tr>
<tr>
<td>WHT</td>
<td>IR Detector</td>
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</table>
Table 6-8. Pre-amp Board Connector Pin Descriptions, continued

<table>
<thead>
<tr>
<th>Connector Label</th>
<th>Signal Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>WHT</td>
<td>IR Detector</td>
</tr>
</tbody>
</table>

Service Locations

For additional assistance, Environmental Instruments Division has service available from exclusive distributors worldwide. Contact one of the phone numbers below for product support and technical information.

866-282-0430

508-520-0430
Chapter 7 Servicing

This chapter explains how to replace the Model 410i subassemblies. It assumes that a subassembly has been identified as defective and needs to be replaced.

For fault location information refer to the “Preventive Maintenance” chapter and the “Troubleshooting” chapter in this manual.

The service mode described in the “Operation” chapter also includes parameters and functions that are useful when making adjustments or diagnosing problems.

For additional service assistance, see “Service Locations” at the end of this chapter.

This chapter includes the following parts information and component replacement procedures.

“Safety Precautions” on page 7-3
“Firmware Updates” on page 7-3
“Replacement Parts List” on page 7-4
“Cable List” on page 7-5
“Fuse Replacement” on page 7-8
“Fan Replacement” on page 7-9
“IR Source Replacement” on page 7-10
“Filter Wheel Replacement” on page 7-11
“Chopper Motor Replacement” on page 7-13
“Optical Bench Replacement” on page 7-14
“Optical Switch Replacement” on page 7-15
“Bench Heater Assembly Replacement” on page 7-16

“Detector/Preamplifier Assembly Replacement” on page 7-17

“Pump Replacement” on page 7-18

“Pressure Transducer Replacement” on page 7-19

“Flow Transducer Replacement” on page 7-23

“Capillary Cleaning or Replacement” on page 7-26

“Optional Zero/Span and Sample Solenoid Valve Replacement” on page 7-26

“Analog Output Testing” on page 7-27

“Analog Output Adjustment” on page 7-29

“Ambient Temperature Calibration” on page 7-31

“I/O Expansion Board (Optional) Replacement” on page 7-32

“Digital Output Board Replacement” on page 7-34

“Motherboard Replacement” on page 7-35

“Measurement Interface Board Replacement” on page 7-36

“Front Panel Board Replacement” on page 7-37

“LCD Module Replacement” on page 7-38

“Service Locations” on page 7-39
Safety Precautions

Read the safety precautions before beginning any procedures in this chapter.

**WARNING** The service procedures in this manual are restricted to qualified service representatives.  

If the equipment is operated in a manner not specified by the manufacturer, the protection provided by the equipment may be impaired.

**CAUTION** Carefully observe the instructions in each procedure.

**Equipment Damage** Some internal components can be damaged by small amounts of static electricity. A properly grounded antistatic wrist strap must be worn while handling any internal component (Figure 7-1). If an antistatic wrist strap is not available, be sure to touch a grounded metal object before touching any internal components. When the instrument is unplugged, the chassis is not at earth ground.

Handle all printed circuit boards by the edges.

![Figure 7-1. Properly Grounded Antistatic Wrist Strap](image)

Firmware Updates

The firmware can be updated by the user in the field via the serial port or over the Ethernet. This includes both the main processor firmware and the firmware in all low-level processors. Refer to the i-Port manual for the firmware update procedure.
Table 7-1 lists the replacement parts for the Model 410i major subassemblies. Refer to Figure 7-2 to identify the component location.

**Table 7-1. Model 410i Replacement Parts**

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Description</th>
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<tbody>
<tr>
<td>100480-00</td>
<td>Front Panel Pushbutton Board</td>
</tr>
<tr>
<td>101491-00</td>
<td>Processor Board</td>
</tr>
<tr>
<td>100533-00</td>
<td>Motherboard</td>
</tr>
<tr>
<td>100539-00</td>
<td>Digital Output Board</td>
</tr>
<tr>
<td>100542-00</td>
<td>I/O Expansion Board (Optional)</td>
</tr>
<tr>
<td>102340-00</td>
<td>Front Panel Connector Board</td>
</tr>
<tr>
<td>102496-00</td>
<td>Front Panel Display</td>
</tr>
<tr>
<td>101399-00</td>
<td>Transformer, 220-240VAC (Optional)</td>
</tr>
<tr>
<td>101863-00</td>
<td>Transformer, 100VAC (Optional)</td>
</tr>
<tr>
<td>100868-00</td>
<td>Measurement Interface Board</td>
</tr>
<tr>
<td>101780-00</td>
<td>Detector Assy</td>
</tr>
<tr>
<td>101023-00</td>
<td>Pressure Transducer</td>
</tr>
<tr>
<td>102055-00</td>
<td>Flow Transducer (Sample)</td>
</tr>
<tr>
<td>101866-02</td>
<td>Solenoid Valve Assembly</td>
</tr>
<tr>
<td>101426-00</td>
<td>Pump 110VAC w/Plate and Fittings</td>
</tr>
<tr>
<td>8606</td>
<td>Pump Repair Kit (for 101426-00)</td>
</tr>
<tr>
<td>101055-00</td>
<td>AC Receptacle Assembly</td>
</tr>
<tr>
<td>101681-00</td>
<td>Power Supply Assembly, 24VDC, w/Base Plate and Screws</td>
</tr>
<tr>
<td>100907-00</td>
<td>Fan, 24VDC</td>
</tr>
<tr>
<td>4510</td>
<td>Fuse, 250VAC, 3.0 Amp, SlowBlow (for 100VAC and 110VAC models)</td>
</tr>
<tr>
<td>14009</td>
<td>Fuse, 250VAC, 1.25 Amp, SlowBlow (for 220-240VAC models)</td>
</tr>
<tr>
<td>4109</td>
<td>Capillary, Flow Transducer</td>
</tr>
<tr>
<td>7336</td>
<td>Capillary, 0.018-inch ID</td>
</tr>
<tr>
<td>8630</td>
<td>Filter Guard Assembly (w/foam)</td>
</tr>
<tr>
<td>101892-00</td>
<td>Filter, Wheel Assy</td>
</tr>
<tr>
<td>7361</td>
<td>I/R Source</td>
</tr>
<tr>
<td>102015-00</td>
<td>Heater Board Assembly</td>
</tr>
<tr>
<td>101423-00</td>
<td>Optical Switch</td>
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<tr>
<td>102595-00</td>
<td>Preventive Maintenance Kit</td>
</tr>
<tr>
<td>101427-00</td>
<td>Chopper Motor</td>
</tr>
<tr>
<td>101562-00</td>
<td>Terminal Block and Cable Kit (DB25)</td>
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**Table 7-1. Model 410i Replacement Parts, continued**

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<th>Description</th>
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</thead>
<tbody>
<tr>
<td>101556-00</td>
<td>Terminal Block and Cable Kit (DB37)</td>
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</table>

**Cable List**

Table 7-2 describes the Model 410i cables. See the “Troubleshooting” chapter for associated connection diagrams and board connector pin descriptions.

**Table 7-2. Model 410i Cables**

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Description</th>
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<tbody>
<tr>
<td>101267-00</td>
<td>Fan Cable</td>
</tr>
<tr>
<td>101036-00</td>
<td>DC Power Supply, 24V Output</td>
</tr>
<tr>
<td>101037-00</td>
<td>115VAC Supply to Measurement Interface Board</td>
</tr>
<tr>
<td>101038-00</td>
<td>Power Switch to Motherboard</td>
</tr>
<tr>
<td>101048-00</td>
<td>RS-485/Data</td>
</tr>
<tr>
<td>101055-00</td>
<td>Main AC Receptacle Assembly</td>
</tr>
<tr>
<td>101054-00</td>
<td>Motherboard to Front Panel Board</td>
</tr>
<tr>
<td>101364-00</td>
<td>DC Power Supply Status Monitor</td>
</tr>
<tr>
<td>101035-00</td>
<td>DC Power Supply AC Input</td>
</tr>
<tr>
<td>101033-00</td>
<td>AC from Receptacle</td>
</tr>
<tr>
<td>101377-00</td>
<td>AC to Power Switch</td>
</tr>
<tr>
<td>102057-00</td>
<td>AC to External Pump</td>
</tr>
<tr>
<td>101267-00</td>
<td>Fan Power Cable</td>
</tr>
</tbody>
</table>
Lowering the Partition Panel

The partition panel of the measurement bench can be lowered to improve access to connectors and components. Refer to the following steps when a procedure requires lowering the partition panel (see Figure 7-3).

Figure 7-2. Component Layout
Figure 7-3. Removing the Measurement Bench and Lowering the Partition Panel

Equipment Required:

Philips screwdriver

Equipment Damage Some internal components can be damaged by small amounts of static electricity. A properly grounded antistatic wrist strap must be worn while handling any internal component.

1. Turn instrument OFF and unplug the power cord.

2. If the instrument is mounted in a rack, remove it from the rack.

3. Remove the cover.
4. Disconnect the plumbing connections at the rear of the measurement bench.

5. Disconnect the connectors that pass through the center of the partition panel.

6. Remove two screws from the left side of the case.

7. Remove one screw from the bottom front of the case.

8. Remove one screw from the top front of the partition panel.

9. While holding the case securely, loosen the captive screw at the rear of the measurement bench, and pull the measurement bench from the rear of the case.

10. Remove the screw at the top rear of the partition panel securing the top of the partition panel to the measurement bench, and lower the panel being careful not to put excessive tension on the cables.

11. Replace the measurement bench by following the previous steps in reverse.

**Fuse Replacement**

Use the following procedure to replace the fuse.

**Equipment Required:**

Replacement fuses:

- 250VAC, 3 Amp, SlowBlow (for 100VAC and 110VAC models)
- 250VAC, 1.25 Amp, SlowBlow (for 220-240VAC models)

1. Turn instrument OFF and unplug the power cord.

2. Remove fuse drawer, located on the AC power connector.
3. If either fuse is blown, replace both fuses.

4. Insert fuse drawer and reconnect power cord.

---

**Fan Replacement**

Use the following procedure to replace the fan (Figure 7-4).

**Equipment Required:**
- Fan
- Philips screwdriver
- Adjustable wrench

**Equipment Damage** Some internal components can be damaged by small amounts of static electricity. A properly grounded antistatic wrist strap must be worn while handling any internal component.

1. Turn instrument OFF, unplug the power cord, and remove the cover.

2. Remove the fan guard from the fan and remove the filter.

3. Pull the power connectors off the fan.

4. Remove the four fan mounting screws and remove the fan.

5. Install a new fan following the previous steps in reverse.
**IR Source Replacement**

Use the following procedure to replace the IR source (Figure 7-5).

**Equipment Required:**
- IR Source
- Flatblade screwdriver

**Equipment Damage** Some internal components can be damaged by small amounts of static electricity. A properly grounded antistatic wrist strap must be worn while handling any internal component.

1. Turn instrument OFF, unplug the power cord, and remove the cover.

2. Remove the two cover screws holding the IR source cover to the motor plate and remove the IR source cover.

3. Loosen both clamp screws from the IR source mounting posts and remove IR source.

4. Install a new IR source by following the previous steps in reverse. Ensure that the IR source element is evenly spaced between the mounting posts.

**Figure 7-4. Replacing the Fan**

![Figure 7-4. Replacing the Fan](image-url)
Filter Wheel Replacement

Use the following procedure to replace the filter wheel.

Equipment Required:

- Filter wheel
- Allen wrench, 5/32-inch and 5/64-inch
- Philips screwdriver
1. Turn instrument OFF, unplug the power cord, and remove the cover.

2. Remove the chopper motor and wheel assembly by removing the three motor plate Allen screws holding the motor plate to the optical bench (Figure 7-6).

3. Remove the cross recessed screw on the bottom or the motor plate.

4. Insert a 5/64-inch Allen wrench through the access hole in the bottom of the motor plate (Figure 7-5), loosen the set screw holding the filter wheel to the motor shaft, and carefully pry the filter wheel off the motor shaft.

5. Install new filter wheel by following the previous steps in reverse. Make sure that the set screw seats on the flat of the motor shaft.

6. After the filter wheel is installed, spin the wheel and observe that it runs true on the motor shaft.

Equipment Damage Some internal components can be damaged by small amounts of static electricity. A properly grounded antistatic wrist strap must be worn while handling any internal component.
7. Let the instrument sample zero air for about 90 minutes.

8. From the Main Menu, press \( \downarrow \) to scroll to Service > press \( \leftarrow \) > \( \downarrow \) to scroll to Initial S/R Ratio and press \( \leftarrow \).

The Initial S/R Ratio screen appears.

If the Service Mode is not displayed on the Main Menu, use the following procedure to display it.

a. At the Main Menu, press \( \downarrow \) to scroll to Instrument Controls > press \( \leftarrow \) > \( \downarrow \) to scroll to Service Mode > and press \( \leftarrow \).

The Service Mode screen appears.

b. Press \( \leftarrow \) to toggle the Service Mode to ON.

c. Press \( \leftarrow \) > \( \leftarrow \) to return to the Main Menu.

d. Continue the procedure at Step 6 to access the Initial S/R Ratio screen.

9. At the Initial S/R Ratio screen, press \( \leftarrow \) to select set the initial S/R ratio to the value of the current ratio and press to store the value. The initial S/R ratio should be between 1.14 and 1.18.

10. Calibrate the instrument.

---

**Chopper Motor Replacement**

Use the following procedure to replace the chopper motor (Figure 7-6).

**Equipment Required:**

- Chopper motor
- Allen wrenches, 5/32-inch and 5/64-inch
- Flatblade screwdriver

**Equipment Damage** Some internal components can be damaged by small amounts of static electricity. A properly grounded antistatic wrist strap must be worn while handling any internal component.
1. Disconnect the chopper motor power cable from the MOT DRV connector on the measurement interface board.

2. Follow the directions for “Filter Wheel Replacement” procedure, up to and including Step 3.

3. Remove the chopper motor from the motor plate by removing the two screws that hold it to the motor plate.

4. Install the new chopper motor by following the previous steps in reverse.

5. Install the filter wheel on the motor shaft, make sure that the set screw seats on the flat of the motor shaft, and tighten the set screw.

6. Calibrate the instrument. Refer to the “Calibration” chapter in this manual.

**Optical Bench Replacement**

Use the following procedure to replace the optical bench (Figure 7-7).

**Equipment Required:**

- Optical bench
- Philips screwdriver

**Equipment Damage** Some internal components can be damaged by small amounts of static electricity. A properly grounded antistatic wrist strap must be worn while handling any internal component.

1. Turn instrument OFF, unplug the power cord, and remove the cover.

2. Disconnect the chopper motor cable from the MOT DRV connector on the measurement interface board, and disconnect the detector cable from the PREAMP cable connector on the measurement interface board.

3. Disconnect the plumbing connections from the optical bench.
4. Remove the six screws holding the optical bench assembly to the shock mounts and carefully remove the optical bench.

5. Replace the optical bench by following the previous steps in reverse.

**Figure 7-7.** Replacing the Optical Bench

---

**Optical Switch Replacement**

Use the following procedure to replace the optical switch (**Figure 7-8**).

**Equipment Required:**

- Optical switch
- Philips screwdriver
- Flatblade screwdriver

**Equipment Damage** Some internal components can be damaged by small amounts of static electricity. A properly grounded antistatic wrist strap must be worn while handling any internal component.

1. Turn instrument OFF, unplug the power cord, and remove the cover.

2. Remove the optical bench following the “Optical Bench Replacement” procedure in this chapter.
3. Turn the optical bench over, remove the two screws securing the optical switch assembly to the case, and remove the optical switch.

4. Install the new optical switch by following the previous steps in reverse.

**Figure 7-8.** Replacing the Optical Switch (Inverted View)

**Bench Heater Assembly Replacement**

Use the following procedure to replace the bench heater assembly (Figure 7-8).

Equipment Required:

- Bench heater
- Heat conductive compound
- Flatblade screwdriver
1. Turn instrument OFF, unplug the power cord, and remove the cover.

2. Remove the optical bench following the “Optical Bench Replacement” procedure in this chapter.

3. Remove the two screws holding each heater to the bottom of the optical bench, and remove both heaters and the heater board assembly.

4. Apply heat conductive compound to the bottom of the heaters and install the new heaters and heater board assembly.

**Equipment Damage** Some internal components can be damaged by small amounts of static electricity. A properly grounded antistatic wrist strap must be worn while handling any internal component.

---

**Detector/Preamplifier Assembly Replacement**

Use the following procedure to replace the detector/preamplifier assembly (Figure 7-9).

**Equipment Required:**

- Detector/preamplifier assembly
- Allen wrenches, 3/32-inch, 7/64-inch

**Equipment Damage** Some internal components can be damaged by small amounts of static electricity. A properly grounded antistatic wrist strap must be worn while handling any internal component.
4. Insert an Allen wrench through the access holes in the preamplifier printed circuit board, and remove the screws holding the detector assembly to the optical bench. Carefully remove the detector/preamplifier assembly from the optical bench.

5. Install the new detector/preamplifier assembly by following the previous steps in reverse.

**Figure 7-9. Replacing the Detector/Preamplifier Assembly**

**Pump Replacement**

Use the following procedure to replace the pump (Figure 7-10). To rebuild the pump, refer to the “Pump Rebuilding” procedure in the “Preventive Maintenance” chapter.

Equipment Required:

- Pump
- Nut driver
- Philips screwdriver

**Equipment Damage** Some internal components can be damaged by small amounts of static electricity. A properly grounded antistatic wrist strap must be worn while handling any internal component.
1. Turn instrument OFF, unplug the power cord, and remove the cover.

2. Disconnect the pump power cable from the AC PUMP connector on the measurement interface board.

3. Remove both lines from the pump.

4. Loosen the four captive screws holding the pump bracket to the shock mounts and remove the pump assembly and the shock mounts.

5. Invert the pump assembly, remove the two pump mounting screws located on the bottom side of the pump bracket, and remove the bracket from the pump.

6. Install the new pump by following the previous steps in reverse.

7. Perform a leak test as described in the “Preventive Maintenance” chapter.

![Diagram of pump and components]

**Figure 7-10.** Replacing the Pump

**Pressure Transducer Replacement**

Use the following procedure to replace the pressure transducer (Figure 7-11).
Servicing
Pressure Transducer Replacement

Equipment Required:

Pressure transducer

Philips screwdriver

Equipment Damage Some internal components can be damaged by small amounts of static electricity. A properly grounded antistatic wrist strap must be worn while handling any internal component.

1. Turn instrument OFF, unplug the power cord, and remove the cover.

2. Disconnect plumbing from the pressure transducer assembly (Figure 7-2). Note the plumbing connections to facilitate reconnection.

3. Disconnect the pressure transducer from the PRES connector on the measurement interface board.

4. Remove the two pressure transducer assembly retaining screws and remove the pressure transducer assembly (Figure 7-11).

![Figure 7-11. Replacing the Pressure Transducer](image)

5. To install the pressure transducer assembly, follow the previous steps in reverse.

6. Calibrate the pressure transducer. Refer to the “Pressure Transducer Calibration” procedure that follows.
Pressure Transducer Calibration

Use the following procedure to calibrate the pressure transducer.

**Note** An error in the zero setting of the pressure transducer does not introduce a measurable error in the output concentration reading. Therefore, if only a barometer is available and not a vacuum pump, only adjust the span setting.

A rough check of the pressure accuracy can be made by obtaining the current barometric pressure from the local weather station or airport and comparing it to the pressure reading. However, since these pressures are usually corrected to sea level, it may be necessary to correct the reading to local pressure by subtracting 0.027 mm Hg per foot of altitude.

Do not attempt to calibrate the pressure transducer unless the pressure is known accurately.

**Equipment Required:**
- Vacuum pump

**Equipment Damage** Some internal components can be damaged by small amounts of static electricity. A properly grounded antistatic wrist strap must be worn while handling any internal component.

1. Turn instrument OFF, unplug the power cord, and remove the cover.

2. Disconnect the tubing from the pressure transducer and connect a vacuum pump known to produce a vacuum less than 1 mm Hg.

3. From the Main Menu, press \( \downarrow \) to scroll to Service > press \( \leftarrow \) > \( \downarrow \) to scroll to **Pressure Calibration** > and press \( \leftarrow \).

   The Pressure Sensor Cal screen appears

   If the Service Mode is not displayed on the Main Menu, use the following procedure to display it.

   a. At the Main Menu, press \( \downarrow \) to scroll to Instrument Controls > press \( \leftarrow \) > \( \downarrow \) to scroll to Service Mode > and press \( \leftarrow \).

      The Service Mode screen appears.

   b. Press \( \leftarrow \) to toggle the Service Mode to ON.
c. Press \( \uparrow \) > \( \downarrow \) to return to the Main Menu.

d. Continue the procedure at Step 3 to access the Pressure Sensor Cal screen.

4. At the Pressure Sensor Cal screen, press \( \rightarrow \) to select **Zero**.

   The Calibrate Pressure Zero screen appears.

5. Wait at least 10 seconds for the zero reading to stabilize, then press \( \leftarrow \) to save the zero pressure value.

6. Disconnect the pump from the pressure transducer.

7. Press \( \rightarrow \) to return to the Pressure Sensor Cal screen.

8. At the Pressure Sensor Cal screen, press \( \downarrow \) \( \rightarrow \) to select **Span**.

   The Calibrate Pressure Span screen appears.

9. Wait at least 10 seconds for the ambient reading to stabilize, use \( \leftarrow \) \( \rightarrow \) and \( \uparrow \) \( \downarrow \) to enter the known barometric pressure, and press \( \leftarrow \) to save the pressure value.

10. Reconnect the instrument tubing to the pressure transducer.

11. Install the cover.
Flow Transducer Replacement

Use the following procedure to replace the flow transducer (Figure 7-12).

Equipment Required:

- Flow transducer
- Philips screwdriver

**Equipment Damage** Some internal components can be damaged by small amounts of static electricity. A properly grounded antistatic wrist strap must be worn while handling any internal component.

1. Turn instrument OFF, unplug the power cord, and remove the cover.

2. Disconnect flow transducer cable from the FLOW connector on the measurement interface board (Figure 7-2).

3. Disconnect the plumbing connections from the flow transducer. Note the plumbing connections to facilitate reconnection.

4. Remove the two retaining screws holding the flow transducer to the floor plate and remove the flow transducer (Figure 7-12).

5. Install the new flow transducer following the previous steps in reverse.

6. Calibrate the flow transducer. Refer to the “Flow Transducer Calibration” procedure that follows.

![Figure 7-12. Replacing the Flow Transducer](image)
Flow Transducer Calibration

Use the following procedure to calibrate the flow transducer.

Equipment Required:

Calibrated flow sensor

**WARNING** The service procedures in this manual are restricted to qualified service representatives.

If the equipment is operated in a manner not specified by the manufacturer, the protection provided by the equipment may be impaired.

**Equipment Damage** Some internal components can be damaged by small amounts of static electricity. A properly grounded antistatic wrist strap must be worn while handling any internal component.

1. Remove the cover.

2. Disconnect the pump cable from AC PUMP connector on the measurement interface board.

3. From the Main Menu, press \( \downarrow \) to scroll to Service > press \( \leftarrow \) > \( \downarrow \) to scroll to Flow Calibration > and press \( \leftarrow \).

The Flow Sensor Cal screen appears.

If the Service Mode is not displayed on the Main Menu, use the following procedure to display it.

a. At the Main Menu, press \( \downarrow \) to scroll to Instrument Controls > press \( \leftarrow \) > \( \downarrow \) to scroll to Service Mode > and press \( \leftarrow \).

The Service Mode screen appears.

b. Press \( \leftarrow \) to toggle the Service Mode to ON.

c. Press \( \text{Home} \) > \( \text{Menu} \) to return to the Main Menu.

d. Continue the procedure at Step 2 to access the Flow Sensor Cal screen.
4. At the Flow Sensor Cal screen, press \( \leftarrow \) to select **Zero**. 
   The Calibrate Flow Zero screen appears.

5. Wait at least 10 seconds for the zero reading to stabilize, then press \( \leftarrow \) to save the zero flow value.

6. Reconnect the pump cable to the AC PUMP connector on the measurement interface board.

7. Connect a calibrated flow sensor at the SAMPLE bulkhead on the rear panel.

8. Press \( \leftarrow \) to return to the Flow Sensor Cal screen.

9. At the Flow Sensor Cal screen, press \( \downarrow \) \( \leftarrow \) to select **Span**. 
   The Calibrate Flow Span screen appears.

10. Wait at least 10 seconds for the reading to stabilize, use \( \leftarrow \) \( \rightarrow \) and \( \uparrow \) \( \downarrow \) to enter the flow sensor reading, and press \( \leftarrow \) to save the value.

11. Install the cover.
Capillary Cleaning or Replacement

Use the following procedure to clean or replace the capillary (Figure 7-13).

Equipment Required:

- Capillary
- Capillary cleaning wire (smaller than 0.015-inch)

**Equipment Damage** Some internal components can be damaged by small amounts of static electricity. A properly grounded antistatic wrist strap must be worn while handling any internal component.

1. Turn instrument OFF, unplug the power cord, and remove the cover.

2. Remove the capillary from the inlet elbow fitting on the pump head.

3. Clean with less than 0.015-inch diameter wire or replace.

4. Install the capillary by following the previous steps in reverse.

**Figure 7-13.** Cleaning or Replacing the Capillary

Optional Zero/Span and Sample Solenoid Valve Replacement

Use the following procedure to replace the solenoid.

Equipment Required:

- Solenoid
Philips screwdriver

Wrench, 9/16-inch

**Equipment Damage** Some internal components can be damaged by small amounts of static electricity. A properly grounded antistatic wrist strap must be worn while handling any internal component.

1. Turn instrument OFF, unplug the power cord, and remove the cover.

2. Unplug the solenoid electrical connector from the measurement interface board.

3. Remove the Teflon® lines from the solenoid.

4. Remove both screws holding the solenoid to the rear panel, and remove the solenoid.

5. Install the solenoid by following the previous steps in reverse.

6. Perform a leak test as described in the “Preventive Maintenance” chapter.

**Analog Output Testing**

The analog outputs should be tested if the concentration value on the front panel display disagrees with the analog outputs. To check the analog outputs, you connect a meter to an analog voltage output channel and compare the meter reading with the output value set on the Test Analog Outputs screen.

Use the following procedure to test the analog outputs.

1. Connect a meter to the channel to be tested. **Figure 7-14** shows the analog output pins and **Table 7-3** identifies the associated channels.
2. From the Main Menu, press \( \downarrow \) to scroll to Diagnostics > press \( \leftarrow \) > \( \downarrow \) to scroll to Test Analog Outputs, and press \( \leftarrow \).

The Test Analog Outputs screen displays.

3. Press \( \downarrow \) to scroll to the channel (Voltage Channel 1-6) corresponding to the rear panel terminal pin where the meter is connected, and press \( \leftarrow \).

---

**Figure 7-14.** Rear Panel Analog Voltage Output Pins

**Table 7-3.** Analog Output Channels and Rear Panel Pin Connections

<table>
<thead>
<tr>
<th>Channel</th>
<th>Pin</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>14</td>
</tr>
<tr>
<td>2</td>
<td>33</td>
</tr>
<tr>
<td>3</td>
<td>15</td>
</tr>
<tr>
<td>4</td>
<td>34</td>
</tr>
<tr>
<td>5</td>
<td>17</td>
</tr>
<tr>
<td>6</td>
<td>36</td>
</tr>
<tr>
<td>Ground</td>
<td>16, 18, 19, 35, 37</td>
</tr>
</tbody>
</table>
The Set Analog Outputs screen displays.

4. Press \[\uparrow\] to set the output to full scale.

   The Output Set To: field displays Full Scale.

5. Check that the meter is displaying the full scale value. If the meter reading differs by more than one percent, the analog outputs should be adjusted. Refer to the “Analog Output Adjustment” procedure that follows.

6. Press \[\downarrow\] to set the output to zero.

   The Output Set To: field displays Zero.

7. Check that the meter is displaying a zero value. If the meter reading differs by more than one percent, the analog outputs should be adjusted. Refer to the “Analog Output Adjustment” procedure that follows.

---

**Analog Output Adjustment**

Use the following procedure to adjust the analog voltage outputs if a meter reading in the “Analog Output Testing” procedure differed by more than one percent.

1. Connect a meter to the channel to be adjusted. Figure 7-14 shows the analog output pins and Table 7-3 identifies the associated channels.

2. From the Main Menu, press \[\downarrow\] to scroll to Service > press \[\leftarrow\] > \[\downarrow\] to scroll to Analog Output Calibration > and press \[\leftarrow\].

   The Analog Output Cal screen displays.

   If the Service Mode is not displayed on the Main Menu, use the following procedure to display it.

   a. At the Main Menu, press \[\downarrow\] to scroll to Instrument Controls > press \[\leftarrow\] > \[\downarrow\] to scroll to Service Mode > and press \[\leftarrow\].

   The Service Mode screen displays.
b. Press \( \text{[Enter]} \) to toggle the Service Mode to ON.
c. Press \( \text{[Enter]} \) > \( \text{[Enter]} \) to return to the Main Menu.
d. Continue the procedure at Step 2.

3. At the Analog Output Cal screen, press \( \text{[Down]} \) to scroll to the channel (Voltage Channel 1-6) corresponding to the rear panel terminal pin where the meter is connected, then press \( \text{[Enter]} \).

The Analog Output Cal: screen displays.

4. With the cursor at Calibrate Zero, press \( \text{[Enter]} \).

The Analog Output Cal: line displays Zero.

5. Use \( \text{[Up]} \), \( \text{[Down]} \) until the meter reads 0V, then press \( \text{[Enter]} \) to save the value.

6. Press \( \text{[Enter]} \) to return to the Analog Output Cal: screen.

The Analog Output Cal: screen displays.

7. Press \( \text{[Down]} \), \( \text{[Enter]} \) to select Calibrate Full Scale.

The Analog Output Cal: Span screen displays.

8. Use \( \text{[Up]} \), \( \text{[Down]} \) until the meter reads the value shown in the Set Output To: line, then press \( \text{[Enter]} \) to save the value.
Ambient Temperature Calibration

Use the following procedure to calibrate the ambient internal temperature for the instrument.

Equipment Required:

Calibrated thermometer or 10K ±1% resistor

**WARNING** The service procedures in this manual are restricted to qualified service representatives.

If the equipment is operated in a manner not specified by the manufacturer, the protection provided by the equipment may be impaired.

**Equipment Damage** Some internal components can be damaged by small amounts of static electricity. A properly grounded antistatic wrist strap must be worn while handling any internal component.

1. Remove the instrument cover.

2. Tape the thermistor (Figure 7-2) to a calibrated thermometer.

**Note** Since the thermistors are interchangeable to an accuracy of ±0.2 °C, and have a value of 10K ohms at 25 °C, an alternate procedure is to connect an accurately known 10K resistor to the thermistor input on the measurement interface board, and enter the temperature reading.

A 1 °C change corresponds to a ±5% change in resistance, thus this alternative procedure can be quite accurate as a check; however, it clearly is not NIST traceable.

3. From the Main Menu, press \[\downarrow\] to scroll to Service > press \[\leftarrow\] > \[\downarrow\] to scroll to **Temperature Calibration** > and press \[\leftarrow\].

The Calibrate Ambient Temperature screen appears.

If the Service Mode is not displayed on the Main Menu, use the following procedure to display it.

a. At the Main Menu, press \[\downarrow\] to scroll to Instrument Controls > press \[\leftarrow\] > \[\downarrow\] to scroll to Service Mode > and press \[\leftarrow\].
The Service Mode screen appears.

b. Press → to toggle the Service Mode to ON.

c. Press > to return to the Main Menu.

d. Continue the procedure at the beginning of Step 3 to access the Calibrate Ambient Temperature screen.

4. Wait at least 10 seconds for the ambient reading to stabilize, use ← → and ↑ ↓ to enter the known temperature, and press ← to save the temperature value.

5. Install the cover.

---

I/O Expansion Board (Optional) Replacement

Use the following procedure to replace the optional I/O expansion board (Figure 7-15).

Equipment Required:

- I/O expansion board
- Nut driver, 1/4-inch

Equipment Damage  Some internal components can be damaged by small amounts of static electricity. A properly grounded antistatic wrist strap must be worn while handling any internal component.

1. Turn instrument OFF, unplug the power cord, and remove the cover.

2. Unplug the I/O expansion board cable from the EXPANSION BD connector on the motherboard.

3. Remove the two standoffs holding the I/O expansion board connector to the rear panel (Figure 7-16).

4. Pop off the board from the mounting studs and remove the board.

5. To install the I/O expansion board, follow previous steps in reverse.
Figure 7-15. Replacing the I/O Expansion Board (Optional)

Figure 7-16. Rear Panel Board Connectors
Digital Output Board Replacement

Use the following procedure to replace the digital output board (Figure 7-15).

Equipment Required:

- Digital output board
- Nut driver, 1/4-inch

Equipment Damage Some internal components can be damaged by small amounts of static electricity. A properly grounded antistatic wrist strap must be worn while handling any internal component.

1. Turn instrument OFF, unplug the power cord, and remove the cover.

2. Remove the I/O expansion board (optional), if used. See the “I/O Expansion Board Replacement” procedure in this chapter.

3. Disconnect the digital output board ribbon cable from the motherboard.

4. Using the nut driver, remove the two standoffs securing the board to the rear panel (Figure 7-16).

5. Pop off the digital output board from the mounting studs and remove the board.

6. To install the digital output board, follow previous steps in reverse.
Motherboard Replacement

Use the following procedure to replace the motherboard (Figure 7-15).

Equipment Required:

- Motherboard
- Philips screwdriver
- Nut driver, 1/4-inch

**Equipment Damage** Some internal components can be damaged by small amounts of static electricity. A properly grounded antistatic wrist strap must be worn while handling any internal component.

1. Turn instrument OFF, unplug the power cord, and remove the cover.

2. Remove the I/O expansion board (optional), if used. See the “I/O Expansion Board Replacement” procedure in this chapter.

3. Remove the digital output board. See the “Digital Output Board Replacement” procedure in this chapter.

4. Unplug all connectors from the motherboard. Note connector locations to facilitate reconnection.

5. Using the nut driver, remove the six standoffs securing the board to the rear panel.

6. Pop off the motherboard from motherboard support bracket, and remove the motherboard.

7. To install the motherboard, follow previous steps in reverse.
Use the following procedure to replace the measurement interface board (Figure 7-17).

Equipment Required:

- Measurement interface board
- Philips screwdriver

**Equipment Damage** Some internal components can be damaged by small amounts of static electricity. A properly grounded antistatic wrist strap must be worn while handling any internal component.

1. Unplug all connectors. Note the locations of the connectors to facilitate reconnection.

2. Pop off the measurement interface board from the four mounting studs and remove the board.

3. To install the measurement interface board, follow the previous steps in reverse.

4. Re-install the measurement bench. Refer to “Removing the Measurement Bench” in this chapter.

---

**Figure 7-17.** Replacing the Measurement Interface Board
Front Panel Board Replacement

Use the following procedure to replace the front panel board (Figure 7-18).

Equipment Required:

- Front panel board

**Equipment Damage** Some internal components can be damaged by small amounts of static electricity. A properly grounded antistatic wrist strap must be worn while handling any internal component.

1. Turn instrument OFF, unplug the power cord, and remove the cover.

2. Remove the three ribbon cables and the two-wire connector from the front panel board.

3. Pop off the board from the two top mounting studs and remove the board by lifting it up and off the slotted bottom support.

4. Replace the front panel board by following previous steps in reverse.

---

**Figure 7-18.** Replacing the Front Panel Board and the LCD Module
LCD Module Replacement

Use the following procedure to replace the LCD module (Figure 7-18).

Equipment Required:

- LCD module
- Philips screwdriver

**CAUTION** If the LCD panel breaks, do not let the liquid crystal contact your skin or clothes. If the liquid crystal contacts your skin or clothes, wash it off immediately using soap and water.

**Equipment Damage** Some internal components can be damaged by small amounts of static electricity. A properly grounded antistatic wrist strap must be worn while handling any internal component.

- Do not remove the panel or frame from the module.
- The polarizing plate is very fragile, handle it carefully.
- Do not wipe the polarizing plate with a dry cloth, it may easily scratch the plate.
- Do not use alcohol, acetone, MEK or other Ketone based or aromatic solvents to clean the module, use a soft cloth moistened with a naphtha cleaning solvent.
- Do not place the module near organic solvents or corrosive gases.
- Do not shake or jolt the module.

1. Turn instrument OFF, unplug the power cord, and remove the cover.

2. Remove the two screws from right side of LCD module (viewed front front). Refer to Figure 7-18.

3. Disconnect the ribbon cable and the two-wire connector from the front panel board.
4. Loosen left-side retaining screw (viewed from front) and slide the LCD module out towards the right and rear of the instrument.

5. Replace the LCD module by following previous steps in reverse.

Service Locations

For additional assistance, Thermo Electron has service available from exclusive distributors worldwide. Contact one of the phone numbers below for product support and technical information.

866-282-0430 Toll Free

508-520-0430 International
Chapter 8 System Description

This chapter describes the function and location of the system components, provides an overview of the software structure, and includes a description of the system electronics and input/output connections and functions.

- “Hardware” on page 8-1 describes the analyzer components.
- “Software” on page 8-4 provides an overview of the software organization and detailed information on the software tasks.
- “Electronics” on page 8-5 describes the system boards, assemblies, and connectors.
- “I/O Components” on page 8-8 describes the input and output communication functions and components.

Hardware  
Model 410i hardware components (Figure 8-1) include:

- Optical bench
- Band-pass filter
- Bench heater board
- Chopper motor
- Optical pickup
- Infrared source
- Pre-amplifier assembly with IR detector
- Sample flow sensor
- Pressure transducer
- Capillary
- Pump
Optical Bench

The optical bench is an airtight chamber that contains the sample gas. The bench directs the infrared light from the infrared source to pass through the sample gas before reaching the infrared detector.

Band-pass Filter

The band-pass filter limits the light entering the optical bench to a narrow band of the infrared portion of the spectrum.

Bench Heater Board

The bench heater board applies power to the bench heater resistors and transmits the bench temperature monitored by a thermistor. This assembly is used for maintaining the optical bench at a constant temperature.

Chopper Motor

The chopper motor spins the filter wheel and chopper disk at a uniform speed.

Figure 8-1. Hardware Components
**Optical Pickup**

The optical pickup detects the position of the filter wheel, provides synchronizing signals for the signal demodulation, and provides a method for checking the chopper motor speed.

**Infrared Source**

The infrared source is a special wire-wound resistor operated at high temperature to create infrared radiation.

**Pre-amplifier Assembly with IR Detector**

The pre-amplifier assembly is mounted on the optical bench along with an infrared detector that detects the energy of the infrared light passing through the optical bench. The preamplifier amplifies the pulsating signal from the infrared detector.

**Sample Flow Sensor**

The sample flow sensor, located at the optical bench outlet, measures the flow of sample through the optical bench.

**Pressure Transducer**

The pressure transducer measures the pressure of the sample gas.

**Capillary**

The capillary and the pump control the sample gas flow.

**Pump**

The pump draws the sample gas through the optical filter bench.
Software
The processor software tasks are organized into four areas:

- Instrument control
- Monitoring signals
- Measurement calculations
- Output communication

Instrument Control
Low-level embedded processors are used to control the various functions on the boards, such as analog and digital I/O. These processors are controlled over a serial interface with a single high-level processor that also controls the front-panel user interface. The low-level processors all run a common piece of firmware that is bundled with the high-level firmware and loaded on power-up if a different version is detected.

Each board has a specific address that is used to identify to the firmware what functions are supported on that board. This address is also used for the communications between the low-level processors and the high-level processor.

Every tenth of a second the frequency counters, analog I/O, and digital I/O are read and written to by the low-level processor. The counters are accumulated over the past second and the analog inputs are averaged over that second. The high-level processor polls the low-level processors once per second to exchange the measurement and control data.

Monitoring Signals
Signals are gathered from the low-level processors once per second, and then processed by the high-level processor to produce the final measurement values. The one-second accumulated counts are accumulated and reported for the user-specified averaging time. If this averaging time is greater than ten seconds, the measurement is reported every 10 seconds. The one-second average of the other analog inputs are reported directly (no additional signal conditioning is performed by the high-level processor).

Output Communication
The front panel display, serial and Ethernet data ports, and analog outputs are the means of communicating the results of the above calculations. The front panel display presents the concentrations simultaneously. The display is updated every 1-10 seconds, depending on the averaging time.
The analog output ranges are user selectable via software. The analog outputs are defaulted based on the measurement range. The defaults are calculated by dividing the data values by the full-scale range for each of the three parameters and then multiplying each result by the user-selected output range. Negative concentrations can be represented as long as they are within -5% of full-scale. The zero and span values may be set by the user to any desired value.

**Electronics**

All electronics operate from a universal switching supply, which is capable of auto-sensing the input voltage and working over the entire operating range. Internal pumps and heaters all operate on 110VAC. An optional transformer is required if operating on the 210-250VAC or 90-110VAC ranges.

An on/off switch controls all power to the instrument, and is accessible on the front panel.

**Motherboard**

The motherboard contains the main processor, power supplies, a sub-processor and serves as the communication hub for the instrument. The motherboard receives operator inputs from the front panel mounted function key panel and/or over I/O connections on the rear panel and sends commands to the other boards to control the functions of the instrument and to collect measurement and diagnostic information. The motherboard outputs instrument status and measurement data to the front-panel mounted graphics display and to the rear-panel I/O. The motherboard also contains I/O circuitry and the associated connector to monitor external digital status lines and to output analog voltages that represent the measurement data. Connectors located on the motherboard include:

**External Connectors**

External connectors include:

- External Accessory
- RS-232/485 Communications (two connectors)
- Ethernet Communications
- I/O connector with Power Fail Relay, 16 Digital Inputs, and 6 Analog Voltage Outputs.

**Internal Connectors**

Internal connectors include:
System Description
Electronics

- Function key panel and Display
- Measurement Interface Board Data
- I/O Expansion Board Data
- Digital Output Board
- AC distribution

Measurement Interface Board
The measurement interface board serves as a central connection area for all measurement electronics in the instrument. It contains power supplies and interface circuitry for sensors and control devices in the measurement system. It sends status data to the motherboard and receives control signals from the motherboard.

Measurement Interface Board Connectors
Connectors located on the measurement interface board include:
- Data communication with the motherboard
- 24V and 120VAC power supply inputs
- Fan and solenoid outputs
- 120VAC output and thermistor input from the bench heater board
- Flow and pressure sensor inputs
- Chopper motor output
- Optical pickup input
- Pre-amp board
- Ambient temperature thermistor

Flow Sensor Assembly
The flow sensor assembly consists of a board containing an instrumentation amplifier and a flow transducer with input and output gas fittings. The flow transducer output is produced by measuring the pressure difference across a precision orifice. This unit is used for measuring the flow of sample gas in the measurement system.
**Pressure Sensor Assembly**
The pressure sensor assembly consists of a board containing an instrumentation amplifier and a pressure transducer with a gas input fitting. The pressure transducer output is produced by measuring the pressure difference between the sample gas pressure and ambient air pressure.

**Bench Heater Board**
The bench heater board provides connections for the optical bench heater resistors and optical bench temperature thermistor.

The optical bench temperature is measured with a thermistor. The voltage across the thermistor is applied to the main processor and used to display and control the temperature of the optical bench. The main processor compares the voltage to a set point and controls the 120VAC power to the bench heater resistors to maintain a constant bench temperature.

**Pre-amp Board Assembly**
The pre-amp board assembly amplifies the signal from an infrared sensor that receives light passing through the sample gas. The preamplifier gain is adjusted by the main processor to bring the signal amplitude within a normal operating range. The output of the pre-amp board is fed to the measurement interface board. Wires from the pre-amp board apply power to the infrared source resistor. The pre-amp board assembly is mounted on top of the optical bench.

**Digital Output Board**
The digital output board connects to the motherboard and provides solenoid driver outputs and relay contact outputs to a connector located on the rear panel of the instrument. Ten relay contacts normally open (with power off) are provided which are electrically isolated from each other. Eight solenoid driver outputs (open collector) are provided along with a corresponding +24VDC supply pin on the connector.

**I/O Expansion Board**
The I/O expansion board connects to the motherboard and adds the capability to input external analog voltage inputs and to output analog currents via a connector located on the rear panel of the instrument. It contains local power supplies, a DC/DC isolator supply, a sub-processor and analog circuits. Eight analog voltage inputs are provided with an input voltage range of 0V to 10VDC. Six current outputs are provided with a normal operating range of 0 to 20 mA.

**Front Panel Connector Board**
The front panel connector board interfaces between the motherboard and the front panel mounted function key panel and Graphics display. It serves as central location to tie the three connectors required for the function key panel, the graphics display control lines, and the graphics display backlight.
to a single ribbon cable extending back to the motherboard. This board also includes signal buffers for the graphics display control signals and a high voltage power supply for the graphics display backlight.

**I/O Components**

External I/O is driven from a generic bus that is capable of controlling the following devices:

- Analog output (voltage and current)
- Analog input (voltage)
- Digital output (TTL levels)
- Digital input (TTL levels)

**Note** The instrument has spare solenoid valve drivers and I/O support for future expansion.

**Analog Voltage Outputs**

The instrument provides six analog voltage outputs. Each may be software configured for any one of the following ranges, while maintaining a minimum resolution of 12 bits:

- 0-100mV
- 0-1V
- 0-5V
- 0-10V

The user can calibrate each analog output zero and span point through firmware. At least 5% of full-scale over and under range are also supported.

The analog outputs may be assigned to any measurement or diagnostic channel with a user-defined range in the units of the selected parameter. The voltage outputs are independent of the current outputs.

**Analog Current Outputs (Optional)**

The optional I/O Expansion board includes six isolated current outputs. These are software configured for any one of the following ranges, while maintaining a minimum resolution of 11 bits:

- 0-20 mA
• 4-20 mA

The user can calibrate each analog output zero and span point through firmware. At least 5% of full-scale over and under range are also supported.

The analog outputs may be assigned to any measurement or diagnostic channel with a user-defined range in the units of the selected parameter. The current outputs are independent of the voltage outputs. The current outputs are isolated from the instrument power and ground, but they share a common return line (Isolated GND).

**Analog Voltage Inputs (Optional)**

The optional I/O expansion board includes eight analog voltage inputs. These inputs are used to gather measurement data from third-party devices such as meteorological equipment. The user may assign a label, unit, and a voltage to user-defined unit conversion table (up to 16 points). All voltage inputs have a resolution of 12 bits over the range of 0 to 10 volts.

**Digital Relay Outputs**

The instrument includes one power fail relay on motherboard and ten digital output relays on the digital output board. These are reed relays rated for at least 500 mA @ 200VDC.

The power fail relay is Form C (both normally opened and normally closed contacts). All other relays are Form A (normally opened contacts) and are used to provide alarm status and mode information from the analyzer, as well as remote control to other devices, such as for controlling valves during calibration. The user may select what information is sent out each relay and whether the active state is opened or closed.

**Digital Inputs**

Sixteen digital inputs are available which may be programmed to signal instrument modes and special conditions including:

• NO Measure Mode
• NOx Measure Mode
• Zero Gas Mode
• Span Gas Mode

The actual use of these inputs will vary based on analyzer configuration.

The digital inputs are TTL level compatible and are pulled up within the analyzer. The active state can be user defined in firmware.
Serial Ports

Two serial ports allow daisy chaining so that multiple analyzers may be linked using one PC serial port.

The standard bi-directional serial interface can be configured for either RS-232 or RS-485. The serial baud rate is user selectable in firmware for standard speeds from 1200 to 19,200 baud. The user can also set the data bits, parity, and stop bits. The following protocols are supported:

- C-Link
- Streaming Data
- Modbus Slave

The Streaming Data protocol transmits user-selected measurement data via the serial port in real-time for capture by a serial printer, data logger, or PC.

RS-232 Connection

A null modem (crossed) cable is required when connecting the analyzer to an IBM Compatible PC. However, a straight cable (one to one) may be required when connecting the analyzer to other remote devices. As a general rule, when the connector of the host remote device is female, a straight cable is required and when the connector is male, a null modem cable is required.

Data Format:

1200, 2400, 4800, 9600, 19200, 38400, 57600, or 115200 BAUD

8 data bits

1 stop bit

no parity

All responses are terminated with a carriage return (hex 0D)

Refer to Table 8-1 for the DB9 connector pin configuration.

Table 8-1. RS-232 DB Connector Pin Configurations

<table>
<thead>
<tr>
<th>DB9 Pin</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>RX</td>
</tr>
<tr>
<td>3</td>
<td>TX</td>
</tr>
<tr>
<td>7</td>
<td>RTS</td>
</tr>
<tr>
<td>8</td>
<td>CTS</td>
</tr>
</tbody>
</table>
**RS-485 Connection**

The instrument uses a four wire RS-485 configuration with automatic flow control (SD). Refer to Table 8-2 for the DB9 connector pin configuration.

<table>
<thead>
<tr>
<th>DB9 Pin</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>+ receive</td>
</tr>
<tr>
<td>8</td>
<td>- receive</td>
</tr>
<tr>
<td>7</td>
<td>+ transmit</td>
</tr>
<tr>
<td>3</td>
<td>- transmit</td>
</tr>
<tr>
<td>5</td>
<td>ground</td>
</tr>
</tbody>
</table>

**Ethernet Connection**

An RJ45 connector is used for the 10Mbs Ethernet connection supporting TCP/IP communications via standard IPV4 addressing. The IP address may be configured for static addressing or dynamic addressing (set using a DHCP server).

Any serial port protocols may be accessed over Ethernet in addition to the serial port.

**External Accessory Connector**

The external accessory connector is not used in the Model 410i analyzer.

This port is used in other models to communicate with smart external devices that may be mounted hundreds of feet from the analyzer using an RS-485 electrical interface.
Chapter 9 Optional Equipment

The Model 410i is available with the following options:

- “Internal Zero/Span and Sample Valves” on page 9-1
- “Teflon Particulate Filter” on page 9-1
- “I/O Expansion Board Assembly” on page 9-1
- “Terminal Block and Cable Kits” on page 9-1
- “Mounting Options” on page 9-2

Internal Zero/Span and Sample Valves

With the zero/span assembly option, a source of span gas is connected to the SPAN port and a source of zero air is connected to the ZERO port. Zero and span gas should be supplied at atmospheric pressure. It may be necessary to use an atmospheric dump bypass plumbing arrangement to accomplish this.

For more information, refer to the “Installation” chapter. If this option is installed, refer to the “Operation” chapter for more information.

Teflon Particulate Filter

A 5-10 micron pore size, 2-inch diameter Teflon® element is available for the Model 410i. This filter should be installed just prior to the SAMPLE bulkhead. When using a filter, all calibrations and span checks must be performed through the filter.

I/O Expansion Board Assembly

For a detailed description, refer to the “System Description” chapter.

Terminal Block and Cable Kits

The terminal block and cable kit provides a convenient way to connect devices to the analyzer. The kit breaks out the signals on the rear panel connector to individual numbered terminals.
Two types of terminal block and cable kits are available. One kit is for the DB37 connectors and can be used for either the analog output connector or the relay output connector. The other kit is for the DB25 connector and can be used for the optional I/O expansion board. The parts available in these kits can also be purchased separately.

Each kit consists of:

- one six-foot cable
- one terminal block
- one snap track

**Note** Supporting all of the connections on units with the optional I/O expansion board requires:

- two DB37 kits
- one DB25 kit

### Mounting Options

The analyzer can be installed in the configurations described in Table 9-1 and shown in Figure 9-1 through Figure 9-4.

#### Table 9-1. Mounting Options

<table>
<thead>
<tr>
<th>Mounting Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bench</td>
<td>Positioned on bench, includes mounting feet, and front panel side-trim handles.</td>
</tr>
<tr>
<td>EIA rack</td>
<td>Mounted in an EIA-style rack, includes mounting slides, and front panel EIA-rack mounting handles.</td>
</tr>
<tr>
<td>Retrofit rack</td>
<td>Mounted in a Thermo non-EIA rack, includes mounting slides, and retrofit front panel rack-mounting handles.</td>
</tr>
</tbody>
</table>
Figure 9-1. Rack Mount Option Assembly
Figure 9.2. Bench Mounting
Figure 9-3. EIA Rack Mounting
Figure 9-4. Retrofit Rack Mounting
Appendix A  Warranty

Seller warrants that the Products will operate substantially in conformance with Seller’s published specifications, when subjected to normal, proper and intended usage by properly trained personnel, for 12 months from date of shipment (the "Warranty Period"). Seller agrees during the Warranty Period, provided it is promptly notified in writing upon the discovery of any defect and further provided that all costs of returning the defective Products to Seller are pre-paid by Buyer, to repair or replace, at Seller’s option, defective Products so as to cause the same to operate in substantial conformance with said specifications. Replacement parts may be new or refurbished, at the election of Seller. All replaced parts shall become the property of Seller. Shipment to Buyer of repaired or replacement Products shall be made in accordance with the provisions of Section 5 above. Lamps, fuses, bulbs and other expendable items are expressly excluded from the warranty under this Section 8. Seller’s sole liability with respect to equipment, materials, parts or software furnished to Seller by third party suppliers shall be limited to the assignment by Seller to Buyer of any such third party supplier’s warranty, to the extent the same is assignable. In no event shall Seller have any obligation to make repairs, replacements or corrections required, in whole or in part, as the result of (i) normal wear and tear, (ii) accident, disaster or event of force majeure, (iii) misuse, fault or negligence of or by Buyer, (iv) use of the Products in a manner for which they were not designed, (v) causes external to the Products such as, but not limited to, power failure or electrical power surges, (vi) improper storage of the Products or (vii) use of the Products in combination with equipment or software not supplied by Seller. If Seller determines that Products for which Buyer has requested warranty services are not covered by the warranty hereunder, Buyer shall pay or reimburse Seller for all costs of investigating and responding to such request at Seller’s then prevailing time and materials rates. If Seller provides repair services or replacement parts that are not covered by the warranty provided in this Section 8, Buyer shall pay Seller therefore at Seller’s then prevailing time and materials rates. ANY INSTALLATION, MAINTENANCE, REPAIR, SERVICE, RELOCATION OR ALTERATION TO OR OF, OR OTHER TAMPERING WITH, THE PRODUCTS PERFORMED BY ANY PERSON OR ENTITY OTHER THAN SELLER WITHOUT SELLER’S PRIOR WRITTEN APPROVAL, OR ANY USE OF REPLACEMENT PARTS NOT SUPPLIED BY SELLER, SHALL IMMEDIATELY VOID AND CANCEL ALL WARRANTIES WITH RESPECT TO THE AFFECTED PRODUCTS.
THE OBLIGATIONS CREATED BY THIS SECTION TO REPAIR OR REPLACE A DEFECTIVE PRODUCT SHALL BE THE SOLE REMEDY OF BUYER IN THE EVENT OF A DEFECTIVE PRODUCT. EXCEPT AS EXPRESSLY PROVIDED IN THIS SECTION 8, SELLER DISCLAIMS ALL WARRANTIES, WHETHER EXPRESS OR IMPLIED, ORAL OR WRITTEN, WITH RESPECT TO THE PRODUCTS, INCLUDING WITHOUT LIMITATION ALL IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR ANY PARTICULAR PURPOSE. SELLER DOES NOT WARRANT THAT THE PRODUCTS ARE ERROR-FREE OR WILL ACCOMPLISH ANY PARTICULAR RESULT.
Appendix B  C-Link Protocol Commands

This appendix provides a description of the C-Link protocol commands that can be used to remotely control a Model 410i analyzer using a host device such as a PC or a datalogger. C-Link protocol may be used over RS-232, RS-485, or Ethernet. C-Link functions can be accessed over Ethernet using TCP/IP port 9880.

• “Instrument Identification Number” on page B-2 describes the C-Link command format.

• “Commands” on page B-2 lists all the 410i C-Link commands in Table B-1.

• “Measurements” on page B-8 describes and gives examples of the measurement commands.

• “Alarms” on page B-11 describes and gives examples of the alarm commands.

• “Diagnostics” on page B-15 describes and gives examples of the diagnostic commands.

• “Datalogging” on page B-16 describes and gives examples of the datalogging commands.

• “Calibration” on page B-22 describes and gives examples of the calibration commands.

• “Keys/Display” on page B-25 describes and gives examples of the keys and display commands.

• “Measurement Configuration” on page B-27 describes and gives examples of the measurement configuration commands.

• “Hardware Configuration” on page B-30 describes and gives examples of the hardware commands.

• “Communications Configuration” on page B-32 describes and gives examples of the communication commands.
C-Link Protocol Commands
Instrument Identification Number

- “I/O Configuration” on page B-36 describes and gives examples of the I/O commands.
- “Record Layout Definition” on page B-40 describes and gives examples of the record layouts.

Instrument Identification Number

Each command sent to the analyzer must begin with the American Standard Code for Information Interchange (ASCII) symbol or byte value equivalent of the instrument’s identification number plus 128. For example, if the instrument ID is set to 25, then each command must begin with the ASCII character code 153 decimal. The analyzer ignores any command that does not begin with its instrument identification number. If the instrument ID is set to 0, then this byte is not required. For more information on changing Instrument ID, see Chapter 3, “Operation.”

Commands

The analyzer must be in the remote mode in order to change instrument parameters via remote. However, the command “set mode remote” can be sent to the analyzer to put it in the remote mode. Report commands (commands that don’t begin with “set”) can be issued either in the remote or local mode. For information on changing modes, see Chapter 3, “Operation.”

The commands can be sent in either uppercase or lowercase characters. Each command must begin with the proper instrument identification number (ASCII) character. The command in the example below begins with the ASCII character code 171 decimal, which directs the command to the Model 410i, and is terminated by a carriage return “CR” (ASCII character code 13 decimal).

Send: set unit ppm
Receive: set unit ppm bad cmd

The “save” and “set save params” commands stores parameters in FLASH. It is important that each time instrument parameters are changed, that this command be sent. If changes are not saved, they will be lost in the event of a power failure.
Table B-1 lists the 410i C-Link protocol commands. The interface will respond to the command strings outlined below.

**Table B-1. C-Link Protocol Commands**

<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>addr dns</td>
<td>Reports/sets dns address</td>
<td>B-32</td>
</tr>
<tr>
<td>addr gw</td>
<td>Reports/sets default gateway address</td>
<td>B-32</td>
</tr>
<tr>
<td>addr ip</td>
<td>Reports/sets IP address</td>
<td>B-32</td>
</tr>
<tr>
<td>addr nm</td>
<td>Reports/sets netmask address</td>
<td>B-33</td>
</tr>
<tr>
<td>agc int</td>
<td>Reports current AGC intensity</td>
<td>B-15</td>
</tr>
<tr>
<td>alarm agc intensity max</td>
<td>Reports/sets AGC intensity alarm maximum value</td>
<td>B-11</td>
</tr>
<tr>
<td>alarm agc intensity min</td>
<td>Reports/sets AGC intensity alarm minimum value</td>
<td>B-11</td>
</tr>
<tr>
<td>alarm bias voltage max</td>
<td>Reports/sets bias voltage alarm maximum value</td>
<td>B-11</td>
</tr>
<tr>
<td>alarm bias voltage min</td>
<td>Reports/sets bias voltage alarm minimum value</td>
<td>B-11</td>
</tr>
<tr>
<td>alarm chamber temp max</td>
<td>Reports/sets chamber temperature alarm maximum value</td>
<td>B-12</td>
</tr>
<tr>
<td>alarm chamber temp min</td>
<td>Reports/sets chamber temperature alarm minimum value</td>
<td>B-12</td>
</tr>
<tr>
<td>alarm conc max</td>
<td>Reports/sets current CO$_2$ concentration alarm maximum value</td>
<td>B-12</td>
</tr>
<tr>
<td>alarm conc min</td>
<td>Reports/sets current CO$_2$ concentration alarm minimum value</td>
<td>B-12</td>
</tr>
<tr>
<td>alarm internal temp max</td>
<td>Reports/sets internal temperature alarm maximum value</td>
<td>B-13</td>
</tr>
<tr>
<td>alarm internal temp min</td>
<td>Reports/sets internal temperature alarm minimum value</td>
<td>B-13</td>
</tr>
<tr>
<td>alarm motor speed max</td>
<td>Reports/sets motor speed alarm maximum value</td>
<td>B-13</td>
</tr>
<tr>
<td>alarm motor speed min</td>
<td>Reports/sets motor speed alarm minimum value</td>
<td>B-13</td>
</tr>
<tr>
<td>alarm pressure max</td>
<td>Reports/sets pressure alarm maximum value</td>
<td>B-13</td>
</tr>
<tr>
<td>alarm pressure min</td>
<td>Reports/sets pressure alarm minimum value</td>
<td>B-14</td>
</tr>
<tr>
<td>alarm sample flow max</td>
<td>Reports/sets sample flow alarm maximum value</td>
<td>B-14</td>
</tr>
<tr>
<td>alarm sample flow min</td>
<td>Reports/sets sample flow alarm minimum value</td>
<td>B-14</td>
</tr>
<tr>
<td>alarm trig conc co2</td>
<td>Reports/sets current CO$_2$ concentration alarm warning value</td>
<td>B-14</td>
</tr>
<tr>
<td>analog iout range</td>
<td>Reports analog current output range per channel</td>
<td>B-36</td>
</tr>
</tbody>
</table>
## C-Link Protocol Commands

### Commands

<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>analog vin</td>
<td>Retrieves analog voltage input data per channel</td>
<td>B-36</td>
</tr>
<tr>
<td>analog vout range</td>
<td>Reports analog voltage output range per channel</td>
<td>B-37</td>
</tr>
<tr>
<td>avg time</td>
<td>Reports/sets averaging time</td>
<td>B-8</td>
</tr>
<tr>
<td>baud</td>
<td>Reports/sets current baud rate</td>
<td>B-33</td>
</tr>
<tr>
<td>bias voltage</td>
<td>Reports current IR bias supply voltage</td>
<td>B-15</td>
</tr>
<tr>
<td>cal co2 bkg</td>
<td>Sets/auto-calibrates CO₂ background</td>
<td>B-22</td>
</tr>
<tr>
<td>cal co2 coef</td>
<td>Sets/auto-calibrates CO₂ coefficient</td>
<td>B-22</td>
</tr>
<tr>
<td>cal high co2 coef</td>
<td>Sets/auto-calibrates high range CO₂ coefficient</td>
<td>B-23</td>
</tr>
<tr>
<td>cal low co2 coef</td>
<td>Sets/auto-calibrates low range CO₂ coefficient</td>
<td>B-23</td>
</tr>
<tr>
<td>chamber temp</td>
<td>Reports optical chamber temperature</td>
<td>B-9</td>
</tr>
<tr>
<td>clr lrecs</td>
<td>Clears away only long records that have been saved</td>
<td>B-16</td>
</tr>
<tr>
<td>clr records</td>
<td>Clears away all logging records that have been saved</td>
<td>B-16</td>
</tr>
<tr>
<td>clr srecs</td>
<td>Clears away only short records that have been saved</td>
<td>B-16</td>
</tr>
<tr>
<td>co2</td>
<td>Reports current CO₂ concentration</td>
<td>B-9</td>
</tr>
<tr>
<td>co2 bkg</td>
<td>Reports/sets current CO₂ background</td>
<td>B-24</td>
</tr>
<tr>
<td>co2 coef</td>
<td>Reports/sets current CO₂ coefficient</td>
<td>B-23</td>
</tr>
<tr>
<td>coef 0</td>
<td>Reports coefficients of the curve developed from hi multi-point calibration</td>
<td>B-23</td>
</tr>
<tr>
<td>coef 1</td>
<td>Reports coefficients of the curve developed from hi multi-point calibration</td>
<td>B-23</td>
</tr>
<tr>
<td>coef 2</td>
<td>Reports coefficients of the curve developed from hi multi-point calibration</td>
<td>B-23</td>
</tr>
<tr>
<td>contrast</td>
<td>Reports/sets current screen contrast</td>
<td>B-30</td>
</tr>
<tr>
<td>copy lrec to sp</td>
<td>Sets/copies current lrec selection into the scratch pad</td>
<td>B-21</td>
</tr>
<tr>
<td>copy sp to lrec</td>
<td>Sets/copies current selections in scratch pad into lrec list</td>
<td>B-21</td>
</tr>
<tr>
<td>copy sp to srec</td>
<td>Sets/copies current selections in scratch pad into srec list</td>
<td>B-21</td>
</tr>
<tr>
<td>copy sp to stream</td>
<td>Sets/copies current selections in scratch pad into stream list</td>
<td>B-21</td>
</tr>
<tr>
<td>copy srec to sp</td>
<td>Sets/copies current srec selection into the scratch pad</td>
<td>B-21</td>
</tr>
<tr>
<td>copy stream to sp</td>
<td>Sets/copies current streaming data selection into the scratch pad</td>
<td>B-21</td>
</tr>
<tr>
<td>custom</td>
<td>Reports/sets defined custom range concentration</td>
<td>B-27</td>
</tr>
<tr>
<td>date</td>
<td>Reports/sets current date</td>
<td>B-30</td>
</tr>
<tr>
<td>default params</td>
<td>Sets parameters to default values</td>
<td>B-31</td>
</tr>
<tr>
<td>dhcp</td>
<td>Reports/sets state of use of DHCP</td>
<td>B-33</td>
</tr>
<tr>
<td>diag volt iob</td>
<td>Reports diagnostic voltage level for I/O expansion board</td>
<td>B-16</td>
</tr>
</tbody>
</table>
## Table B-1. C-Link Protocol Commands

<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>diag volt mb</td>
<td>Reports diagnostic voltage level for motherboard</td>
<td>B-15</td>
</tr>
<tr>
<td>diag volt mib</td>
<td>Reports diagnostic voltage level for measurement interface board</td>
<td>B-15</td>
</tr>
<tr>
<td>dig in</td>
<td>Reports status of the digital inputs</td>
<td>B-37</td>
</tr>
<tr>
<td>din</td>
<td>Reports/sets digital input channel and active state</td>
<td>B-37</td>
</tr>
<tr>
<td>do (down)</td>
<td>Simulates pressing down pushbutton</td>
<td>B-25</td>
</tr>
<tr>
<td>dout</td>
<td>Reports/sets digital output channel and active state</td>
<td>B-38</td>
</tr>
<tr>
<td>dtoa</td>
<td>Reports outputs of the digital to analog converters per channel</td>
<td>B-38</td>
</tr>
<tr>
<td>en (enter)</td>
<td>Simulates pressing enter pushbutton</td>
<td>B-25</td>
</tr>
<tr>
<td>er</td>
<td>Returns a brief description of the main operating conditions in the format specified in the commands</td>
<td>B-17</td>
</tr>
<tr>
<td>erec</td>
<td>Returns a brief description of the main operating conditions in the command</td>
<td>B-17</td>
</tr>
<tr>
<td>erec format</td>
<td>Reports/sets erec format (ASCII or binary)</td>
<td>B-18</td>
</tr>
<tr>
<td>erec layout</td>
<td>Reports current layout of erec data</td>
<td>B-19</td>
</tr>
<tr>
<td>flags</td>
<td>Reports 8 hexadecimal digits (or flags) that represent the status of the AGC circuit, pressure and temperature compensation status, gas units, gas mode, and alarms</td>
<td>B-10</td>
</tr>
<tr>
<td>flow</td>
<td>Reports current measured sample flow in LPM</td>
<td>B-9</td>
</tr>
<tr>
<td>format</td>
<td>Reports/sets current reply termination format</td>
<td>B-34</td>
</tr>
<tr>
<td>gas mode</td>
<td>Reports current mode of sample, zero, or span</td>
<td>B-28</td>
</tr>
<tr>
<td>gas unit</td>
<td>Reports/sets current gas units</td>
<td>B-29</td>
</tr>
<tr>
<td>he (help)</td>
<td>Simulates pressing help pushbutton</td>
<td>B-25</td>
</tr>
<tr>
<td>high avg time</td>
<td>Reports/sets high range averaging time</td>
<td>B-8</td>
</tr>
<tr>
<td>high co2</td>
<td>Reports CO₂ concentration calculated with high range coefficients</td>
<td>B-9</td>
</tr>
<tr>
<td>high co2 coef</td>
<td>Reports/sets high range CO₂ coefficients</td>
<td>B-23</td>
</tr>
<tr>
<td>high coef 0</td>
<td>Reports coefficients of the curve developed from hi multi-point calibration</td>
<td>B-23</td>
</tr>
<tr>
<td>high coef 1</td>
<td>Reports coefficients of the curve developed from hi multi-point calibration</td>
<td>B-23</td>
</tr>
<tr>
<td>high coef 2</td>
<td>Reports coefficients of the curve developed from hi multi-point calibration</td>
<td>B-23</td>
</tr>
<tr>
<td>high range</td>
<td>Reports/sets current CO₂ high range</td>
<td>B-27</td>
</tr>
<tr>
<td>high ratio</td>
<td>Reports sample/reference ratio calculated using the high averaging time</td>
<td>B-10</td>
</tr>
<tr>
<td>high sp conc</td>
<td>Reports/sets high span concentration</td>
<td>B-24</td>
</tr>
</tbody>
</table>
### Table B-1. C-Link Protocol Commands

<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>host name</td>
<td>Reports/sets host name string</td>
<td>B-34</td>
</tr>
<tr>
<td>init ratio</td>
<td>Reports initial sample/reference ratio</td>
<td>B-24</td>
</tr>
<tr>
<td>instr name</td>
<td>Reports instrument name</td>
<td>B-35</td>
</tr>
<tr>
<td>instrument id</td>
<td>Reports/sets instrument id</td>
<td>B-35</td>
</tr>
<tr>
<td>internal temp</td>
<td>Reports current internal instrument temperature</td>
<td>B-9</td>
</tr>
<tr>
<td>isc (iscreen)</td>
<td>Retrieves framebuffer data used for the display</td>
<td>B-25</td>
</tr>
<tr>
<td>layout ack</td>
<td>Disables stale layout/layout changed indicator (‘*’)</td>
<td>B-36</td>
</tr>
<tr>
<td>le (left)</td>
<td>Simulates pressing left pushbutton</td>
<td>B-25</td>
</tr>
<tr>
<td>list din</td>
<td>Lists current selection for digital input</td>
<td>B-16</td>
</tr>
<tr>
<td>list dout</td>
<td>Lists current selection for digital output</td>
<td>B-16</td>
</tr>
<tr>
<td>list lrec</td>
<td>Lists current selection lrec logging data</td>
<td>B-16</td>
</tr>
<tr>
<td>list sp</td>
<td>Lists current selection in the scratchpad list</td>
<td>B-16</td>
</tr>
<tr>
<td>list srec</td>
<td>Lists current selection srec logging data</td>
<td>B-16</td>
</tr>
<tr>
<td>list stream</td>
<td>Lists current selection streaming data output</td>
<td>B-16</td>
</tr>
<tr>
<td>list var aout</td>
<td>Reports list of analog output, index numbers, and variables</td>
<td>B-39</td>
</tr>
<tr>
<td>list var din</td>
<td>Reports list of digital input, index numbers, and variables</td>
<td>B-39</td>
</tr>
<tr>
<td>list var dout</td>
<td>Reports list of digital output, index numbers, and variables</td>
<td>B-39</td>
</tr>
<tr>
<td>low avg time</td>
<td>Reports/sets low averaging time</td>
<td>B-8</td>
</tr>
<tr>
<td>low co2</td>
<td>Reports CO₂ concentration calculated with low range coefficients</td>
<td>B-9</td>
</tr>
<tr>
<td>low co2 coef</td>
<td>Reports/sets low range CO₂ coefficient</td>
<td>B-23</td>
</tr>
<tr>
<td>low coef 0</td>
<td>Reports coefficients of the curve developed from lo multi-point calibration</td>
<td>B-23</td>
</tr>
<tr>
<td>low coef 1</td>
<td>Reports coefficients of the curve developed from lo multi-point calibration</td>
<td>B-23</td>
</tr>
<tr>
<td>low coef 2</td>
<td>Reports coefficients of the curve developed from lo multi-point calibration</td>
<td>B-23</td>
</tr>
<tr>
<td>low range</td>
<td>Reports/sets current CO₂ low range</td>
<td>B-27</td>
</tr>
<tr>
<td>low ratio</td>
<td>Reports sample/reference ratio calculated using the low averaging time</td>
<td>B-10</td>
</tr>
<tr>
<td>low sp conc</td>
<td>Reports/sets low span concentration</td>
<td>B-24</td>
</tr>
<tr>
<td>Ir</td>
<td>Outputs long records in the format specified in the command</td>
<td>B-17</td>
</tr>
<tr>
<td>lrec</td>
<td>Outputs long records</td>
<td>B-17</td>
</tr>
<tr>
<td>lrec format</td>
<td>Reports/sets output format for long records (ASCII or binary)</td>
<td>B-18</td>
</tr>
<tr>
<td>lrec layout</td>
<td>Reports current layout of lrec data</td>
<td>B-19</td>
</tr>
</tbody>
</table>
### Table B-1. C-Link Protocol Commands

<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>lrec mem size</td>
<td>Reports maximum number of long records that can be stored</td>
<td>B-19</td>
</tr>
<tr>
<td>lrec per</td>
<td>Reports/sets long record logging period</td>
<td>B-19</td>
</tr>
<tr>
<td>malloc lrec</td>
<td>Reports/sets memory allocation for long records</td>
<td>B-20</td>
</tr>
<tr>
<td>malloc srec</td>
<td>Reports/sets memory allocation for short records</td>
<td>B-20</td>
</tr>
<tr>
<td>me (menu)</td>
<td>Simulates pressing menu pushbutton</td>
<td>B-25</td>
</tr>
<tr>
<td>mode</td>
<td>Reports operating mode in local, service, or remote</td>
<td>B-35</td>
</tr>
<tr>
<td>motor</td>
<td>Reports motor speed</td>
<td>B-9</td>
</tr>
<tr>
<td>no of lrec</td>
<td>Reports/sets number of long records stored in memory</td>
<td>B-20</td>
</tr>
<tr>
<td>no of srec</td>
<td>Reports/sets number of short records stored in memory</td>
<td>B-20</td>
</tr>
<tr>
<td>pres</td>
<td>Reports current reaction chamber pressure</td>
<td>B-10</td>
</tr>
<tr>
<td>pres comp</td>
<td>Reports/sets pressure compensation on or off</td>
<td>B-29</td>
</tr>
<tr>
<td>program no</td>
<td>Reports analyzer program number</td>
<td>B-35</td>
</tr>
<tr>
<td>push</td>
<td>Simulates pressing a key on the front panel</td>
<td>B-25</td>
</tr>
<tr>
<td>range</td>
<td>Reports/sets current CO₂ range</td>
<td>B-27</td>
</tr>
<tr>
<td>range mode</td>
<td>Reports/sets current range mode</td>
<td>B-28</td>
</tr>
<tr>
<td>ratio</td>
<td>Reports sample/reference ratio</td>
<td>B-10</td>
</tr>
<tr>
<td>relay stat</td>
<td>Reports/sets relay logic status to for the designated relay(s)</td>
<td>B-39</td>
</tr>
<tr>
<td>ri (right)</td>
<td>Simulates pressing right pushbutton</td>
<td>B-25</td>
</tr>
<tr>
<td>ru (run)</td>
<td>Simulates pressing run pushbutton</td>
<td>B-25</td>
</tr>
<tr>
<td>sample</td>
<td>Sets zero/span valves to sample mode</td>
<td>B-28</td>
</tr>
<tr>
<td>save</td>
<td>Stores parameters in FLASH</td>
<td>B-31</td>
</tr>
<tr>
<td>save params</td>
<td>Stores parameters in FLASH</td>
<td>B-31</td>
</tr>
<tr>
<td>sc (screen)</td>
<td>C-series legacy command that reports a generic response (Use scree instead)</td>
<td>B-26</td>
</tr>
<tr>
<td>sp conc</td>
<td>Reports/sets span concentration</td>
<td>B-24</td>
</tr>
<tr>
<td>sp field</td>
<td>Reports/sets item number and name in scratch pad list</td>
<td>B-21</td>
</tr>
<tr>
<td>span</td>
<td>Sets zero/span valves to span mode</td>
<td>B-29</td>
</tr>
<tr>
<td>sr</td>
<td>Reports last short record stored</td>
<td>B-17</td>
</tr>
<tr>
<td>srec</td>
<td>Reports maximum number of short records</td>
<td>B-17</td>
</tr>
<tr>
<td>srec format</td>
<td>Reports/sets output format for short records (ASCII or binary)</td>
<td>B-18</td>
</tr>
<tr>
<td>srec layout</td>
<td>Reports current layout of short record data</td>
<td>B-19</td>
</tr>
<tr>
<td>srec mem size</td>
<td>Reports maximum number of short records</td>
<td>B-19</td>
</tr>
<tr>
<td>srec per</td>
<td>Reports/sets short record logging period</td>
<td>B-19</td>
</tr>
<tr>
<td>stream per</td>
<td>Reports/sets current set time interval for streaming data</td>
<td>B-21</td>
</tr>
</tbody>
</table>
C-Link Protocol Commands

Measurements

Table B-1. C-Link Protocol Commands

<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>stream time</td>
<td>Reports/sets a time stamp to streaming data or not</td>
<td>B-22</td>
</tr>
<tr>
<td>temp comp</td>
<td>Reports/sets temperature compensation on or off</td>
<td>B-29</td>
</tr>
<tr>
<td>time</td>
<td>Reports/sets current time (24-hour time)</td>
<td>B-31</td>
</tr>
<tr>
<td>up</td>
<td>Simulates pressing up pushbutton</td>
<td>B-25</td>
</tr>
<tr>
<td>zero</td>
<td>Sets zero/span valves to zero mode</td>
<td>B-29</td>
</tr>
</tbody>
</table>

Measurements

avg time
high avg time
low avg time

These commands report the averaging time in seconds when operating in single range, or averaging time used with the high and low ranges when operating in dual or auto range mode. The example below shows that the averaging time is 300 seconds, according to Table B-2.

Send:    avg time
Receive: avg time 11:300 sec

set avg time selection
set high avg time selection
set low avg time selection

These commands set the averaging time, high and low averaging times, according to Table B-2. The example below sets the low range averaging time to 120 seconds.

Send:    set low avg time 8
Receive: set low avg time 8 ok

Table B-2. Averaging Times

<table>
<thead>
<tr>
<th>Selection</th>
<th>Averaging Time (seconds)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1 seconds</td>
</tr>
<tr>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>3</td>
<td>10</td>
</tr>
<tr>
<td>4</td>
<td>20</td>
</tr>
<tr>
<td>5</td>
<td>30</td>
</tr>
<tr>
<td>6</td>
<td>60</td>
</tr>
<tr>
<td>7</td>
<td>90</td>
</tr>
<tr>
<td>8</td>
<td>120</td>
</tr>
</tbody>
</table>
**C-Link Protocol Commands**

**Measurements**

**Thermo Electron Corporation Model 410**

**Instruction Manual**

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**Table B-2. Averaging Times**

<table>
<thead>
<tr>
<th>Selection</th>
<th>Averaging Time (seconds)</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>180</td>
</tr>
<tr>
<td>10</td>
<td>240</td>
</tr>
<tr>
<td>11</td>
<td>300</td>
</tr>
</tbody>
</table>

---

**co2**

**high co2**

**low co2**

These commands report the measured CO2 concentration when operating in single range, or high and low CO2 when operating in dual or auto range mode. The example below shows that the CO2 concentration is 40 ppm.

Send: co2  
Receive: co2 0040E+0 ppm

---

**flow**

This command reports the current sample flow. The example below reports that the current sample flow is 1.108 liters/minute.

Send: flow  
Receive: flow 1.108 1/m

---

**chamber temp**

This command reports the current optical chamber temperature. The example below reports that the current optical chamber temperature is 45.2 °C.

Send: chamber temp  
Receive: chamber temp 45.2 deg C

---

**internal temp**

This command reports the current internal instrument temperature. The first reading is the temperature being used in instrument calculations. The second temperature is the actual temperature being measured. If temperature compensation is on, then both temperature readings are the same. If temperature compensation is off, a temperature of 30 °C is used as the default temperature even though the actual internal temperature is 27.2 °C. The example below shows that temperature compensation is on and that the internal temperature is 27.2 °C.

Send: internal temp  
Receive: internal temp 27.2 deg C

---

**motor**
This command reports the current motor speed. The example below reports that the current motor speed is 100%.

Send: motor
Receive: motor 100%

`pres`
This command reports the current reaction chamber pressure. The first pressure reading is the pressure reading being used in instrument calculations. The second pressure is the actual pressure reading being measured. If pressure compensation is on, then both pressure readings are the same. If pressure compensation is off, a pressure of 760 mmHg is used as default pressure even though the actual pressure is 753.4 mmHg. The example below shows that the actual reaction chamber pressure is 753.4 mmHg.

Send: pres
Receive: pres 753.4 mmHg

`ratio`
`high ratio`
`low ratio`
The “ratio” command reports the sample/reference ratio in single mode. The “high ratio” command reports the sample/reference ratio using high averaging time and the “low ratio” command using low averaging time, when operating in dual or auto mode. The example below shows that the current ratio is 1.16110.

Send: ratio
Receive: ratio 1.16110

`flags`
This reports 8 hexadecimal digits (or flags) that represent the status of the AGC circuit, pressure and temperature compensation status, gas units, gas mode, and alarms. To decode the flags, each hexadecimal digit is converted to binary as shown in the Figure B-1. It is the binary digits that define the status of each parameter. In the example below, the instrument is reporting that the AGC circuit is on, that the instrument is in the span gas mode, and that the CO₂ high concentration alarm is activated.

Send: flags
Receive: flags 80038000
Alarms

**alarm agc intensity min**
**alarm agc intensity max**

These commands report the agc intensity alarm minimum and maximum value current settings. The example below reports that the agc intensity alarm minimum value is 20.

Send:    alarm agc intensity min
Receive: alarm agc intensity min 20

**set alarm agc intensity min** value
**set alarm agc intensity max** value

These commands set the agc intensity alarm minimum and maximum values to value, where value is a floating-point number representing agc intensity alarm limits. The example below sets the agc intensity alarm maximum value to 20.

Send:    set alarm agc intensity max 20
Receive: set alarm agc intensity max 20 ok

**alarm bias voltage min**
**alarm bias voltage max**
These commands report the bias voltage alarm minimum and maximum value current settings. The example below reports that the bias voltage alarm minimum value is 20.

Send:   alarm bias voltage min
Receive: alarm bias voltage min 20

**set alarm bias voltage min** *value*
**set alarm bias voltage max** *value*
These commands set the bias voltage alarm minimum and maximum values to *value*, where *value* is a floating-point number representing bias voltage alarm limits. The example below sets the bias voltage alarm maximum value to 20.

Send:   set alarm bias voltage max 20
Receive: set alarm bias voltage max 20 ok

**alarm chamber temp min**
**alarm chamber temp max**
These commands report the chamber temperature alarm minimum and maximum value current settings. The example below reports that the chamber temperature alarm minimum value is 35.0 °C.

Send:   alarm chamber temp min
Receive: alarm chamber temp min 35.0 deg C

**set alarm chamber temp min** *value*
**set alarm chamber temp max** *value*
These commands set the chamber temperature alarm minimum and maximum values to *value*, where *value* is a floating-point number representing chamber temperature alarm limits in degrees C. The example below sets the chamber temperature alarm maximum value to 55.0 °C.

Send:   set alarm chamber temp max 55.0
Receive: set alarm chamber temp max 55.0 ok

**alarm conc min**
**alarm conc max**
These commands report the CO₂ concentration alarm minimum and maximum values current setting. The example below reports that the CO₂ concentration minimum is 5.2 ppm.

Send:   alarm conc min
Receive: alarm conc min 5.2 ppm

**set alarm conc min** *value*
**set alarm conc max** *value*
These commands set the CO₂ concentration alarm minimum and maximum values to `value`, where `value` is a floating-point representation of the concentration alarm limits. Values must be in the units that are currently set for use. The example below sets the CO₂ concentration alarm maximum value to 215.

Send: set alarm conc max 215
Receive: set alarm conc max 215 ok

**alarm internal temp min**  
**alarm internal temp max**  
These commands report the internal temperature alarm minimum and maximum value current settings. The example below reports that the internal temperature alarm minimum value is 15.0 °C.

Send: internal temp alarm min  
Receive: internal temp alarm min 15.0 deg C

**set internal temp alarm min** `value`  
**set internal temp alarm max** `value`  
These commands set the internal temperature alarm minimum and maximum values to `value`, where `value` is a floating-point number representing internal temperature alarm limits in degrees C. The example below sets the internal temperature alarm maximum value to 45.0 °C.

Send: set internal temp alarm max 45  
Receive: set internal temp alarm max 45 ok

**alarm motor speed min**  
**alarm motor speed max**  
These commands report the motor speed alarm minimum and maximum value current settings. The example below reports that the motor speed alarm minimum value is 20 minutes.

Send: alarm motor speed min  
Receive: alarm motor speed min 20

**set alarm motor speed min** `value`  
**set alarm motor speed max** `value`  
These commands set the motor speed alarm minimum and maximum values to `value`, where `value` is a floating-point number representing motor speed alarm limits in minutes. The example below sets the motor speed alarm maximum value to 20 minutes.

Send: set alarm motor speed max 20  
Receive: set alarm motor speed max 20 ok

**alarm pressure min**
alarm pressure max
These commands report the pressure alarm minimum and maximum value current settings. The example below reports that the pressure alarm minimum value is 205 mmHg.

Send: pressure alarm min
Receive: pressure alarm min 205 mmHg

set alarm pressure min value
set alarm pressure max value
These commands set the pressure alarm minimum and maximum values to value, where value is a floating-point number representing pressure alarm limits in millimeters of mercury. The example below sets the pressure alarm maximum value to 215 mmHg.

Send: set alarm pressure max 215
Receive: set alarm pressure max 215 ok

alarm sample flow min
alarm sample flow max
These commands report the sample flow alarm minimum and maximum value current settings. The example below reports that the sample flow alarm minimum value is 2 LPM.

Send: alarm sample flow min
Receive: alarm sample flow min 2 l/min

set alarm sample flow min value
set alarm sample flow max value
These commands set the sample flow alarm minimum and maximum values to value, where value is a floating-point number representing sample flow alarm limits in liters per minute. The example below sets the sample flow alarm maximum value to 1 LPM.

Send: set alarm sample flow max 1
Receive: set alarm sample flow max 1 ok

alarm trig conc
This command reports the CO₂ concentration alarm trigger action for minimum alarm, current setting, to either floor or ceiling. The example below shows the CO₂ concentration minimum alarm trigger to ceiling, according to Table B-3.

Send: alarm trig conc
Receive: alarm trig conc 1

set alarm trig conc value
These commands set the CO₂ concentration alarm minimum *value*, where *value* is set to either floor or ceiling, according to Table B-3. The example below sets the CO₂ concentration minimum alarm trigger to ceiling.

Send:  set alarm trig conc 1  
Receive: set alarm trig conc 1 ok

<table>
<thead>
<tr>
<th>Value</th>
<th>Alarm Trigger</th>
</tr>
</thead>
<tbody>
<tr>
<td>00</td>
<td>Floor</td>
</tr>
<tr>
<td>01</td>
<td>Ceiling</td>
</tr>
</tbody>
</table>

**Diagnostics**

**agc int**
This command reports the current intensity of the reference channel AGC circuit. The example below reports that the current AGC intensity is 200,000 Hz.

Send:  agc int  
Receive: agc int 250000 Hz

**bias voltage**
This command reports the current IR bias supply voltage. The example below reports that the bias voltage is -102.3 volts.

Send:  bias voltage  
Receive: bias voltage -102.3 V

**diag volt mb**
This command reports the diagnostic voltage measurements on the motherboard. The sequence of voltages is: Positive 24, positive 15, positive 5, positive 3.3, and negative 3.3. Each voltage value is separated by a space.

Send:  diag volt mb  
Receive: diag volt mb 24.1 14.9 4.9 3.2 -3.2

**diag volt mib**
This command reports the diagnostic voltage measurements on the measurement interface board. The sequence of voltages is: Positive 24, positive 15, negative 15, positive 5, positive 3.3, positive 18 IR, positive 18 MOT, and VBIAS. Each voltage value is separated by a space.

Send:  diag volt mib  
Receive: diag volt mib 24.1 14.9 -14.9 4.9 3.2 17.9 17.9
**C-Link Protocol Commands**

**Datalogging**

---

**diag volt iob**
This command reports the diagnostic voltage measurements on the I/O expansion board. The sequence of voltages is: Positive 24, positive 5, positive 3.3, and negative 3.3. Each voltage value is separated by a space.

Send: diag volt iob
Receive: diag volt iob 24.1 4.9 3.2 -3.2

---

**Datalogging**

---

**clr records**
This command will clear all long and short records that have been saved.

Send: clear records
Receive: clear records ok

---

**set clr lrecs**
**set clr srecs**
These commands will clear only the long records or only the short records that have been saved. The example below clears short records.

Send: set clr srecs
Receive: set clr srecs ok

---

**list din**
**list dout**
These commands report the current selection for the digital outputs in the format. Output no Index number variable name active state. The active state for digital outputs is open or closed. The active state for digital inputs is high or low.

Send: list dout
Receive: output index variable state
1 22 I/O BD COMM closed
2 2 LOCAL/REMOTE open
3 4 UNITS open
4 19 BIAS VOLTAGE closed
7 7 SAMPLE MODE open
8 8 GEN MODE open

---

**list lrec**
**list srec**
**list stream**
**list sp**
These commands report the list of current selections for long record logging data, short record logging data, streaming data output, or the scratch pad (sp) list. The example below shows the list for streaming data output.
C-Link Protocol Commands

Datalogging

Send: list stream
Receive: list stream
field index variable
  x 0 time
  1 10 auxt
  2 13 pres
  3 14 smplfl
  4 15 intensity

er xy
lr xy
sr xy
  x = | 0 | 1 | : Reply termination format (see “set format format” command)
  y = | 0 | 1 | 2 | : Output format (see “set erec/lrec/srec format format” command)

These commands report the last long and short records stored or the dynamic data record. In the example below, the command requests a long record with no checksum, in ASCII format with text. For details on how to decode the flag fields within these records, see the “flags” command.

Send: lr01
Receive: lr01
  10:15 05-12-03 flags 9c040000 co2 7349E+0 loco2 5994E+0
  intt 33.2 cht 44.7 pres 758.9 smplfl 1.085 speed 100.0 biasv -115.5 intensity 1999940

erec
This command returns a brief description of the main operating conditions at the time the command is issued (i.e. dynamic data). The example below shows a typical response. The format is defined by the current settings of “format” and “erec format” commands. For details on how to decode the flag fields within these records, see the “flags” command.

Send: erec
Receive: erec
  09:48 04-06-05 flags 9C040510 co2 0.000 4 loco2 -0.002 4
  s/r 0.000 los/r 0.902 biasv -112.668 agci 96.500 intt 34.023
  cht 47.995 smplfl 0.000 pres 0.000 avg1 10 avg2 10 co2bkg -0.000 co2coef 1.000 loco2coef 1.000 co2range 10000000.000
  loco2range 10000000.000 motor 100.000

lrec
srec
lrec xxxx yy
srec xxxx yy
lrec aa:bb oo-pp-qq yy
srec aa:bb oo-pp-qq yy
C-Link Protocol Commands

Datalogging

$xxxx$ = the number of past records
$yy$ = the number of records to return (1 to 10)
$aa$ = hours (01 to 24)
$bb$ = minutes (01 to 59)
$oo$ = month (01 to 12)
$pp$ = day (01 to 31)
$qq$ = year

These commands output long or short records. The output format is determined by the “set lrec format” and “set srec format” commands. The logging time is determined by the “set lrec per” and “set srec per” commands.

In the following example, there are 740 long records currently stored in memory. When the command lrec 100 5 is sent, the instrument counts back 100 records from the last record collected (record 740), and then returns 5 records: 640, 641, 642, 643, and 644. For details on how to decode the flag fields within these records, see the “flags” command.

Send: lrec 5
Receive:

10:15 05-12-03 flags 9c040000 co2 7349E+0 loco2 5994E+0 intt 33.2 cht 44.7 pres 758.9 smplfl 1.085 speed 100.0 biasv -115.5 intensity 1999940
10:15 05-12-03 flags 9c040000 co2 7349E+0 loco2 5994E+0 intt 33.2 cht 44.7 pres 758.9 smplfl 1.085 speed 100.0 biasv -115.5 intensity 1999940
10:15 05-12-03 flags 9c040000 co2 7349E+0 loco2 5994E+0 intt 33.2 cht 44.7 pres 758.9 smplfl 1.085 speed 100.0 biasv -115.5 intensity 1999940
10:15 05-12-03 flags 9c040000 co2 7349E+0 loco2 5994E+0 intt 33.2 cht 44.7 pres 758.9 smplfl 1.085 speed 100.0 biasv -115.5 intensity 1999940
10:15 05-12-03 flags 9c040000 co2 7349E+0 loco2 5994E+0 intt 33.2 cht 44.7 pres 758.9 smplfl 1.085 speed 100.0 biasv -115.5 intensity 1999940

erec format
lrec format
srec format

These commands report the output format for long and short records, and dynamic data in various formats such as ASCII without text, ASCII with text, or binary. The example below shows the output format for long records is ASCII with text, according to Table B-4.

Send: lrec format
Receive: lrec format 01

set erec format format
set lrec format \textit{format}
set src format \textit{format}

These commands set the output format for long and short records, and dynamic data, according to Table B-4. The example below sets the long record output format to ASCII with text.

Send: \texttt{set lrec format 1}
Receive: set lrec format 1 ok

<table>
<thead>
<tr>
<th>Format</th>
<th>Output Format</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>ASCII no text</td>
</tr>
<tr>
<td>1</td>
<td>ASCII with text</td>
</tr>
<tr>
<td>2</td>
<td>binary data</td>
</tr>
</tbody>
</table>

erec layout
lrec layout
src layout

These commands report the layout (string indicating the data formats) for data that is sent out in response to the erec, lrec, srec, and related commands. For details on how to interpret the strings, see “Record Layout Definition” later in this appendix.

Send: lrec layout
Receive: lrec layout %s %s %lx %f %f %f %f
t D L ffff
s/r pres intensity motor

lrec mem size
src mem size

These commands report the long and short records that can be stored with the current settings and the number of blocks reserved for long and short records. To calculate the number of short records per block, add 2 to the number of records, and then divide by the number of blocks. The example below shows that 10 blocks were reserved for long records, and the maximum number of long records that can be stored in memory is 2038.

Send: lrec mem size
Receive: lrec mem size 2038 recs, 10 blocks

lrec per
src per

These commands report the long and short records logging period. The example below shows that the short record logging period is 5 minutes.
Send:    srec per
Receive: srec per 5 min

**set srec per** value
**set srec per** value
value = 1 | 5 | 15 | 30 | 60 |

These commands set the long and short records logging period to *value* in minutes. The example below sets the long record logging period to 15 minutes.

Send:    set lrec per 15
Receive: set lrec per 15 ok

---

**no of lrec**
**no of srec**

These commands report the number of long and short records stored in the long and short records memory. The example below shows that 50 long records have been stored in the memory.

Send:    no of lrec
Receive: no of lrec 50 recs

---

**malloc lrec**
**malloc srec**

These commands report the currently set memory allocation for long and short records in percent of total memory.

Send:    malloc lrec
Receive: malloc lrec 10%

---

**set malloc lrec** value
**set malloc srec** value
value = 0 to 100

These commands set the percent of memory space allocated for long and short records to *value*, where *value* is a floating-point number representing percent. The example below sets the memory allocation for long records to 10.

**Note** Issuing these commands will clear all the logging data memory. All the existing records should be retrieved using appropriate commands, if required.

Send:    set malloc lrec 10
Receive: set malloc lrec 10 ok
**set copy sp to lrec**  
**set copy sp to srec**  
**set copy sp to stream**  
These commands copy the current selections in scratch pad (sp) into the long record, short record, or streaming data list. The example below copies the current list in scratch pad into the long records list.

Send:  
Receive: 

**set copy lrec to sp**  
**set copy srec to sp**  
**set copy stream to sp**  
These commands copy the current contents of the long record, short record, or streaming data list into the scratch pad (sp). These commands are useful in easy modification of current long record, short record, or streaming data lists. The example below copies the current list of long records into the scratch pad.

Send:  
Receive: 

**sp field number**  
This command reports the variable number and name stored at index in the scratch pad list. The example below shows that the field 5 in the scratch pad is set to index number 13, which is for the variable pressure.

Send:  
Receive: 

**sp field number value**  
number = 1-32 is the maximum number of fields in long and short record lists.  
number = 1-18 is for streaming data lists.

This command sets the scratch pad field number (item number in scratch pad list) to value, where value is the index number of a variable in the analog out variable list. Available variables and their corresponding index numbers may be obtained using the command “list var aout”. The “set sp field” command is used to create a list of variables which can then be transferred into the long record, short record, or streaming data lists, using the “set copy sp to lrec”, “set copy sp to srec”, or “set copy sp to stream” commands.

Send:  
Receive: 

**stream per**
This command reports the currently set time interval in seconds for streaming data.

Send: stream per
Receive: stream per 10

**set stream per number value**

*number value* = | 1 | 2 | 5 | 10 | 20 | 30 | 60 | 90 | 120 | 180 | 240 | 300 |

This command sets the time interval between two consecutive streaming data strings to *number value* in seconds. The example below sets the number value to 10 seconds.

Send: set stream per 10
Receive: set stream per 10 ok

**stream time**

This command reports if the streaming data string will have a time stamp attached to it or not, according to Table B-5.

Send: stream time
Receive: stream time 0

**set stream time value**

This command enables *value*, where *value* is to attach or disable time stamp to streaming data string, according to Table B-5. The example below attaches a time stamp to streaming data.

Send: set stream time 0
Receive: set stream time 0 ok

<table>
<thead>
<tr>
<th>Value</th>
<th>Stream Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>00</td>
<td>Attaches time stamp to streaming data string</td>
</tr>
<tr>
<td>01</td>
<td>Disables time stamp to streaming data string</td>
</tr>
</tbody>
</table>

**Calibration**

**set cal co2 bkg**

This command will auto-calibrate the CO2 background. The example below shows a successful auto-calibration of the CO2 background.

Send: set cal co2 bkg
Receive: set cal co2 bkg ok

**set cal co2 coef**
set cal high co2 coef
set cal low co2 coef
These commands will auto-calibrate CO2 coefficients based on CO2 span gas concentrations. The high and low commands are only available in dual and auto range mode. If the mode is incorrect, the instrument responds with “can't, wrong settings”. The example below shows a successful auto-calibration of the low CO2 coefficient.

Send: set cal low co2 coef
Receive: set cal low co2 coef ok

co2 coef
high co2 coef
low co2 coef
These commands report CO2 coefficients in single range mode, or the high and low range coefficients in dual or auto range mode. If the mode is incorrect, the instrument responds with “can't, wrong settings”. The example below reports that the CO2 coefficient is 1.200.

Send: co2 coef
Receive: co2 coef 1.200

set co2 coef value
set high co2 coef value
set low co2 coef value
These commands set the CO2 coefficients to user-defined values to value, where value is a floating-point representation of the coefficient. The example below sets the CO2 coefficient to 1.200.

Send: set co2 coef 1.200
Receive: set co2 coef 1.200 ok

coef 0
deco 1
deco 2
high coef 0
high coef 1
high coef 2
low coef 0
low coef 1
low coef 2
The “coef 0”, coef 1”, and coef 2” commands report the coefficients of the curve developed from the Hi Multi-Point Calibration in single range mode. The “high coef 0”, high coef 1”, and high coef 2” commands report the coefficients of the curve developed from the Hi Multi-Point Calibration in dual or auto range mode. The “low coef 0”, low coef 1”, and low coef 2”
commands report the coefficients of the curve developed from the Lo Multi-Point Calibration in dual and auto range mode. The example below reports the coefficient 0 having a value of 1.005.

Send: coef 0
Receive: coef 0 1.005 ok

**co bkg**
This command reports the current CO₂ backgrounds. The example below reports that the CO₂ background is 1.400 ppm.

Send: co2 bkg
Receive: co2 bkg 1.400 ppm

**set co2 bkg value**
This command is used to set CO₂ backgrounds to user-defined values to value, where value is a floating-point representation of the background in current selected units. The example below sets the CO₂ background to 1.4 ppm.

Send: set co2 bkg 1.400
Receive: set co2 bkg 1.400 ok

**init ratio**
This command reports the initial sample/reference ratio. The example below reports that the initial ratio was 1.16210.

Send: initial ratio
Receive: initial ratio 1.16210

**sp conc**
**high sp conc**
**low sp conc**
These commands report span concentration in single range mode, or the high and low span concentrations in dual or auto range mode. If the mode is incorrect, the instrument responds with “can't, wrong settings”. The example below reports that the span gas concentration in single range mode.

Send: sp conc
Receive: sp conc 1000

**set sp conc value**
**set high sp conc value**
**set low sp conc value**
These commands set the span concentrations to user-defined values to
\textit{value}, where \textit{value} is a floating-point representation of the span
concentration in current selected units. The example below sets the span
concentration to 1000 ppm in the single range mode.

Send: \texttt{set sp conc 1000}  
Receive: \texttt{set sp conc 1000 ok}

\textbf{Keys/Display}

\texttt{push button}

\texttt{button} = | do | down | en | enter | he | help | le | left | me | menu | ri | right |
\texttt{ru | run | up | 1 | 2 | 3 | 4 |}

These commands simulate pressing the front panel pushbuttons. The
numbers represent the front-panel soft keys, from left to right.

Send: \texttt{push enter}  
Receive: \texttt{push enter ok}

\texttt{isc}

\texttt{iscreen}

This command retrieves the framebuffer data used for the display on the
iSeries instrument. It is 19200 bytes in size, 2-bits per pixel, 4 pixels per
byte arranged as 320 by 240 characters. The data is sent in RLE encoded
form to save time in transmission. It is sent as a type '5' binary c_link
response with no checksum.

The RLE encoding consists of a 0 followed by an 8-bit count of consecutive
0xFF bytes. The following 'c' code will expand the incoming data.
To convert this data into a BMP for use with windows, it needs to be turned into a 4BPP as that is the smallest windows can display. Also note that BMP files are upside down relative to this data, i.e. the top display line is the last line in the BMP.

```c
Void unpackDisplay ( void far* tdib, unsigned char far* rlescreen )
{
    int i,j,k;
    unsigned char far *sc4bpp, *sc2bpp, *screen, *ptr;

    ptr = screen = (unsigned char far *)malloc(19200);
    //RLE decode the screen
    for (i=0; i<19200 && (ptr - screen) < 19200; i++)
    {
        *(ptr++) = *(rlescreen + i);
        if (*(rlescreen + i) == 0)
        {
            unsigned char rlecount = *(unsigned char *)(rlescreen + ++i);
            while (rlecount)
            {
                *(ptr++) = 0;
                rlecount--;
            }
        }
        else if (*(rlescreen + i) == 0xff)
        {
            unsigned char rlecount = *(unsigned char *)(rlescreen + ++i);
            while (rlecount)
            {
                *(ptr++) = 0xff;
                rlecount--;
            }
        }
    }
}
```

This command is meant for backward compatibility on the C series. Screen information is reported using the “iScreen” command above.

```
sc
screen
```

This command is meant for backward compatibility on the C series. Screen information is reported using the “iScreen” command above.

Send: screen
Receive: screen
This is an I series Instrument. Screen Information not available
**C-Link Protocol Commands**

**Measurement Configuration**

**range**

**high range**

**low range**

These commands report CO₂ range in single range mode, or the high and low ranges in dual or auto range mode. If the mode is incorrect, the instrument responds with “can’t, wrong settings”. The example below reports that the CO₂ full-scale range to 50 ppm, according to Table B-6.

Send: range
Receive: range 6: 5000E-2 ppm

**set range Selection**

**set high range Selection**

**set low range Selection**

These commands select the CO₂ full-scale ranges, according to Table B-6. The example below sets the CO₂ full-scale range to 50 ppm.

Send: set range 5
Receive: set range 5 ok

**Table B-6. Standard Ranges**

<table>
<thead>
<tr>
<th>Selection</th>
<th>ppm</th>
<th>mg/m³</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>3</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>4</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>5</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>6</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>7</td>
<td>200</td>
<td>200</td>
</tr>
<tr>
<td>8</td>
<td>500</td>
<td>500</td>
</tr>
<tr>
<td>9</td>
<td>1,000</td>
<td>1,000</td>
</tr>
<tr>
<td>10</td>
<td>2,000</td>
<td>2,000</td>
</tr>
<tr>
<td>11</td>
<td>5,000</td>
<td>5,000</td>
</tr>
<tr>
<td>12</td>
<td>10,000</td>
<td>10,000</td>
</tr>
<tr>
<td>13</td>
<td>C1</td>
<td>C1</td>
</tr>
<tr>
<td>14</td>
<td>C2</td>
<td>C2</td>
</tr>
<tr>
<td>15</td>
<td>C3</td>
<td>C3</td>
</tr>
</tbody>
</table>

**custom range**
range = [1 | 2 | 3 ]

This command reports the user-defined value of custom range 1, 2, or 3. The example below reports that custom range 1 is defined to 225.0 ppm.

Send: custom 1
Receive: custom 1 2250E-2 ppm

**set custom range range value**
**set custom 1 range value**
**set custom 2 range value**
**set custom 3 range value**

These commands are used to set the maximum concentration for any of the three custom ranges 1, 2, or 3 to range value, where value is a floating-point number representing concentration in ppm or mg/m³. The example below sets the custom 1 range to 225.0 ppm.

Send: set custom 1 range 225.5
Receive: set custom 1 range 225.5 ok

**range mode**
This command reports the current range mode.

Send: range mode
Receive: range mode single

**set range mode mode**
This command sets the current range mode to single, dual, or auto. The example below sets the range mode to single.

Send: set range mode single
Receive: set range mode single ok

**gas mode**
This command reports the current mode of sample, zero, or span. The example below reports that the gas mode is sample.

Send: gas mode
Receive: gas mode sample

**set sample**
This command sets the zero/span valves to the sample mode. The example below sets the instrument to sample mode, that is, the instrument is reading the sample gas.

Send: set sample
Receive: set sample ok
**set zero**
This command sets the zero/span valves to the zero mode. The example below sets the instrument to zero mode that is, the instrument is reading the sample gas.

Send: `set zero`
Receive: `set zero ok`

**set span**
This command sets the zero/span valves to the span mode. The example below sets the instrument to span mode that is, the instrument is sampling span gas.

Send: `set span`
Receive: `set span ok`

**gas unit**
This command reports the current gas units (ppm or mg/m³). The example reports that the gas unit is set to ppm.

Send: `gas unit`
Receive: `gas unit ppm`

**set gas unit**
\[ unit = \{ ppm, mg/m^3 \} \]
This command sets the gas units to ppm or mg/m³. The example below sets the gas units to mg/m³.

Send: `set gas unit mg/m3`
Receive: `set gas unit mg/m3 ok`

**pres comp**
This command reports whether pressure compensation is on or off. The example below shows that pressure compensation is on.

Send: `pres comp`
Receive: `pres comp on`

**set pres comp on/off**
These commands turn the pressure compensation on or off. The example below turns pressure compensation off.

Send: `set pres comp off`
Receive: `set pres comp off ok`

**temp comp**
This command reports whether temperature compensation is on or off. The example below shows the temperature compensation is off.

Send: temp comp
Receive: temp comp off

set temp comp on off
These commands turn the temperature compensation on or off. The example below turns temperature compensation off.

Send: set temp comp off
Receive: set temp comp off ok

---

Hardware Configuration

contrast
This command reports the screen's level of contrast. The example below shows the screen contrast is 50%, according to Table B-7.

Send: contrast
Receive: contrast 5:50%

set contrast level
This command sets the screen's level of contrast, according to Table B-7. The example below sets the contrast level to 50%.

Send: set contrast 5
Receive: set contrast 5 ok

<table>
<thead>
<tr>
<th>Level</th>
<th>Contrast Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>1</td>
<td>10%</td>
</tr>
<tr>
<td>2</td>
<td>20%</td>
</tr>
<tr>
<td>3</td>
<td>30%</td>
</tr>
<tr>
<td>4</td>
<td>40%</td>
</tr>
<tr>
<td>5</td>
<td>50%</td>
</tr>
<tr>
<td>6</td>
<td>60%</td>
</tr>
<tr>
<td>7</td>
<td>70%</td>
</tr>
<tr>
<td>8</td>
<td>80%</td>
</tr>
<tr>
<td>9</td>
<td>90%</td>
</tr>
<tr>
<td>10</td>
<td>100%</td>
</tr>
</tbody>
</table>

date
This command reports the current date. The example below reports the date as December 1, 2004.

Send: date
Receive: date 12-01-04

set date \textit{mm-dd-yy}
\textit{mm} = month
\textit{dd} = day
\textit{yy} = year

This command sets the date of the analyzer’s internal clock. The example below sets the date to December 1, 2004.

Send: set date 12-01-04
Receive: set date 12-01-04 ok

set default params
This command sets all the parameters to their default values. This does not affect the factory-calibrated parameters.

Send: set default params
Receive: set default params ok

save
set save params
This command stores all current parameters in FLASH memory. It is important that each time instrument parameters are changed, that this command be sent. If changes are not saved, they will be lost in the event of a power failure. The example below saves the parameters to FLASH memory.

Send: set save params
Receive: set save params ok

time
This command reports the current time (24-hour time). The example below reports that the internal time is 2:15:30 pm.

Send: time
Receive: time 14:15:30

set time \textit{hh:mm:ss}
\textit{hh} = hours
\textit{mm} = minutes
\textit{ss} = seconds
This command sets the internal clock (24-hour time). The example below sets the internal time to 2:15 pm.

**Note** if seconds are omitted, the seconds default to 00.

Send: set time 14:15  
Receive: set time 14:15 ok

### Communications Configuration

**addr dns**  
This command reports the TCP/IP address for the domain name server.

Send: addr dns  
Receive: addr dns 192.168.1.1

**set addr dns address**  
This command sets the dns address, where address consists of four numbers ranging from 0-255 inclusive, separated by “.”.

Send: set addr dns 192.168.1.1  
Receive: set addr dns 192.168.1.1 ok

**addr gw**  
This command reports the default TCP/IP gateway address.

Send: addr gw  
Receive: addr gw 192.168.1.1

**set addr gw address**  
This command sets the default gateway address, where address consists of four numbers ranging from 0-255 inclusive, separated by “.”.

Send: set addr gw 192.168.1.1  
Receive: set addr gw 192.168.1.1 ok

**addr ip**  
This command reports the IP address of the analyzer.

Send: addr ip  
Receive: addr ip 192.168.1.200

**set addr ip address**  
This command sets the analyzer’s IP address, where address consists of four numbers ranging from 0-255 inclusive, separated by “.”.

Send: set addr ip 192.168.1.200  
Receive: set addr ip 192.168.1.200 ok
**addr nm**
This command reports the IP netmask.

Send: addr nm  
Receive: addr nm 255.255.255.0

**set addr nm address**
This command sets the nm address, where address consists of four numbers ranging from 0-255 inclusive, separated by ".".

Send: set addr nm 255.255.255.0  
Receive: set addr nm 255.255.255.0 ok

**baud**
This command reports the current baud rate for the serial port (RS232/RS485). The example below reports that the current baud rate is 9600 baud.

Send: baud  
Receive: baud 9600

**set baud rate**
rate = | 1200 | 2400 | 4800 | 9600 | 19200 | 38400 | 57600 | 115200 |

This command sets the instrument baud rate. The example below sets the instrument’s baud rate to 9600.

**WARNING** After the command is sent, the baud rate of the sending device must be changed to agree with the instrument.

Send: set baud 9600  
Receive: set baud 9600 ok

**dhcp**
This command reports the current state of use of DHCP on or off. DHCP is used to assign an IP address to the analyzer automatically. The example below shows that DHCP is on.

Send: dhcp  
Receive: dhcp on

**set dhcp onoff**
These commands enables and disables the DHCP service by either on or off. Changes to this parameter will only take effect when the analyzer is powered up. The example below sets the DHCP service on.

**WARNING** When DHCP is set to on, the user-supplied addr gw, addr dns, addr ip, and addr nm parameters are not used.

```
Send: set dhcp on
Receive: set dhcp on ok
```

**format**
This command reports the current reply termination format. The example below shows that the reply format is 00, which means reply with no checksum, according to Table B-8.

```
Send: format
Receive: format 00
```

**set format** *format*
This command sets the reply termination format, where format is set according to Table B-8. The example below sets the reply termination format to checksum.

```
Send: set format 01
Receive: set format 01 ok
```

**Table B-8. Reply Termination Formats**

<table>
<thead>
<tr>
<th>Format</th>
<th>Reply Termination</th>
</tr>
</thead>
<tbody>
<tr>
<td>00</td>
<td>&lt;CR&gt;</td>
</tr>
<tr>
<td>01</td>
<td>&lt;NL&gt; sum xxxx &lt;CR&gt;</td>
</tr>
</tbody>
</table>

where xxxx = 4 hexadecimal digits that represent the sum of all the characters (bytes) in the message

**host name**
This command reports the host name string.

```
Send: host name
Receive: host name analyzer01
```

**set host name** *string*
This command sets the host name string, where string is 1-13 alphanumeric characters.
Send: set host name analyzer01  
Receive: set host name analyzer01 ok

**instr name**
This command reports the instrument name.

Send: instr name  
Receive: instr name  
            CO2 Analyzer  
            CO2 Analyzer

**instrument id**
This command reports the instrument id.

Send: instrument id  
Receive: instrument id 12

**set instrument id** *value*
This command sets the instrument id to *value*, where *value* is a decimal number between 0 and 127 inclusive.

*Note* sending this command via RS-232 or RS-485 will require the host to use the new id for subsequent commands.

Send: set instrument id 12  
Receive: set instrument id 12 ok

**mode**
This command reports what operating mode the instrument is in: local, service, or remote. The example below shows that the instrument is in the remote mode.

Send: mode  
Receive: mode remote

**set mode local**  
**set mode remote**
These commands set the instrument to local or remote mode. The example below sets the instrument to the local mode.

Send: set mode local  
Receive: set mode local ok

**program no**
This command reports the analyzer’s model information and program version number, which will be dependant on the current version.
C-Link Protocol Commands

I/O Configuration

Send: program no
Receive: program no iSeries 410i 01.01.10.003

**set layout ack**
This command disables the stale layout/layout change indicator (***) that is attached to each response if the layout has changed.

Send: set layout ack
Receive: set layout ack ok

---

**I/O Configuration**

**analog iout range channel**
This command reports the analog current output range setting for *channels*, where *channel* must be between 1 and 6, inclusive. The example below reports current output channel 4 to the 4-20 mA range, according to Table B-9. This command responds with “feature not enabled” if the I/O expansion board is not detected.

Send: analog iout range 4
Receive: analog iout range 4 2

**set analog iout range channel range**
This command sets analog current output *channel* to the *channel range* where *channel* is between 1 and 6 inclusive, and *range* is set according to Table B-9. The example below sets current output channel 4 to the 0-20 mA range. This command responds with “feature not enabled” if the I/O expansion board is not detected.

Send: set analog iout range 4 1
Receive: set analog iout range 4 1 ok

**Table B-9. Analog Current Output Range Values**

<table>
<thead>
<tr>
<th>Range</th>
<th>Output Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0-20 mA</td>
</tr>
<tr>
<td>2</td>
<td>4-20 mA</td>
</tr>
<tr>
<td>0</td>
<td>Undefined</td>
</tr>
</tbody>
</table>

**analog vin channel**
This command retrieves the analog voltage input *channel* data, both the calculated value and the actual voltage. In the example below, the “calculated” value of channel 1 is 75.325 degrees F, volts are 2.796. This command responds with “feature not enabled” if the I/O expansion board is not detected.

Send: analog vin 1
Receive: analog vin 1 75.325 2.796
**analog vout range channel**
This command reports the analog voltage output channel range, where channel is between 1 and 6 inclusive, according to Table B-10.

Send: analog vout range 2
Receive: analog vout range 2 3

**set analog vout range channel range**
This command sets analog voltage output channel to the range, where channel is between 1 and 6 inclusive, and range is set according to Table B-10. The example below sets channel 2 to the 0-10 V range.

Send: set analog vout range 2 3
Receive: set analog vout range 2 3 ok

**Table B-10. Analog Voltage Output Range Values**

<table>
<thead>
<tr>
<th>Range</th>
<th>Output Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0-1 V</td>
</tr>
<tr>
<td>2</td>
<td>0-100 mV</td>
</tr>
<tr>
<td>3</td>
<td>0-10 V</td>
</tr>
<tr>
<td>4</td>
<td>0-5 V</td>
</tr>
<tr>
<td>0</td>
<td>[cannot be set to this, but may report] Undefined</td>
</tr>
</tbody>
</table>

**dig in**
This command reports the status of the digital inputs as a 4-digit hexadecimal string with the most significant bit (MSB) being input 16.

Send: dig in
Receive: dig in 0xff7f

**din channel**
This command reports the action assigned to input channel and the corresponding active state. The example below reports the input 1 to be assigned an index number 3 corresponding to action of “set background” mode with the active state being high.

Send: din 1
Receive: din 1 3 SET BACKGROUND high

**set din channel index state**
This command assigns digital input channel (1-16) to activate the action indicated by index (1-35), when the input transitions to the designated state (high or low). Use “list din var” command to obtain the list of supported index values and corresponding actions.
**C-Link Protocol Commands**

**I/O Configuration**

Send:    set din 5 9 high  
Receive: set din 1 9 high ok

---

**dout channel**

This command reports the index number and output variable and the active state assigned to output *channel*. The example below reports the input 2 to be assigned an index number 2 corresponding to “local/remote” with the active state being open.

Send:    dout 2  
Receive: dout 2 2 LOCAL/REMOTE open

---

**set dout channel index state**

This command assigns digital output *channel* to be assigned to the action associated with *index*, and assigns it an active state of *state* (open or closed).

Send:    set dout 2 2 open  
Receive: set dout 2 2 open ok

---

**dtoa channel**

This reports the outputs of the 6 or 12 Digital to Analog converters, according to Table B-11. The example below shows that the D/A #1 is 97.7% full-scale.

Send:    dtoa 1  
Receive: dtoa 1 97.7%

---

**Note** All channel ranges are user definable. If any customization has been made to the analog output configuration, the default selections may not apply.

---

**Table B-11. Default Output Assignment**

<table>
<thead>
<tr>
<th>D to A</th>
<th>Function</th>
<th>Single Range</th>
<th>Dual Range</th>
<th>Autorange</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Voltage Output</td>
<td>Low CO₂</td>
<td>Low CO₂</td>
<td>High/Low CO₂</td>
</tr>
<tr>
<td>2</td>
<td>Voltage Output</td>
<td>Low CO₂</td>
<td>High CO₂</td>
<td>Range Status</td>
</tr>
<tr>
<td>3</td>
<td>Voltage Output</td>
<td>Not Assigned</td>
<td>Not Assigned</td>
<td>Not Assigned</td>
</tr>
<tr>
<td>4</td>
<td>Voltage Output</td>
<td>Not Assigned</td>
<td>Not Assigned</td>
<td>Not Assigned</td>
</tr>
<tr>
<td>5</td>
<td>Voltage Output</td>
<td>Not Assigned</td>
<td>Not Assigned</td>
<td>Not Assigned</td>
</tr>
<tr>
<td>6</td>
<td>Voltage Output</td>
<td>Not Assigned</td>
<td>Not Assigned</td>
<td>Not Assigned</td>
</tr>
<tr>
<td>7</td>
<td>Current Output</td>
<td>Low CO₂</td>
<td>Low CO₂</td>
<td>High/Low CO₂</td>
</tr>
<tr>
<td>8</td>
<td>Current Output</td>
<td>Low CO₂</td>
<td>High CO₂</td>
<td>Range Status</td>
</tr>
<tr>
<td>9</td>
<td>Current Output</td>
<td>Not Assigned</td>
<td>Not Assigned</td>
<td>Not Assigned</td>
</tr>
</tbody>
</table>
list var aout
list var dout
list var din

These commands report the list of index numbers, and the variables (associated with that index number) available for selection in the current mode (determined by single/dual/auto, gas mode) for analog output, digital output and digital inputs. The index number is used to insert the variable in a field location in a list using “set sp field index”. The example below reports the list of analog output, index numbers, and variables.

Send: list var aout
Receive: list var aout
index variable
0 none
5 s/r
8 intt
9 cht
10 auxt
13 pres
14 smplfl
15 intensity
16 motor
17 ain1
18 ain2
19 ain3
20 ain4
21 ain5
22 ain6
23 ain7
24 ain8
25 co2

relay stat

This command reports the current relay logic normally “open” or normally “closed,” if all the relays are set to same state, that is all open or all closed. The example below shows that the status when all the relays logic is set to normally “open”.

Send: relay stat
Receive: relay stat open
Note if individual relays have been assigned different logic then the response would be a 4-digit hexadecimal string with the least significant byte (LSB) being relay no 1.

For example:

Receive: relay stat 0x0001 (indicates relay no 1 is set to normally open logic, all others are normally closed)
Receive: relay stat 0x0005 (indicates relay no 1 and 3 are set to be normally open logic, all others are normally closed)

set relay open
set relay open value
set relay closed
set relay closed value

These commands set the relay logic to normally open or closed for relay number value, where value is the relay between 1 and 16. The example below sets the relay no 1 logic to normally open.

Note if the command is sent without an appended relay number then all the relays are assigned the set logic of normally open/closed.

Send: set relay open 1
Receive: set relay open 1 ok

Record Layout Definition

The Erec, Lrec Srec layouts contain the following

- A format specifier for parsing ASCII responses
- A format specifier for parsing binary responses,

In addition to these the Erec Layout contains

- A format specifier for producing the front-panel displays.

In operation, values are read in using either the ASCII or binary format specifiers and converted to uniform internal representations (32-bit floats or 32-bit integers). These values are converted into text for display on the screen using the format specifier for the front-panel display. Normally, the specifier used to parse a particular datum from the input stream will be strongly related to the specifier used to display it (e.g., all of the floating point inputs will be displayed with an 'f' output specifier, and all of the integer inputs will be displayed with a 'd' specifier).
FormatSpecifier for ASCII Responses

The first line of the Layout response is the scanf-like parameter list for parsing the fields from an ASCII ERec response. Parameters are separated by spaces and the line is terminated by a \n (the normal line separator character). Valid fields are:

- \%s - parse a string
- \%d - parse a decimal number
- \%ld - parse a long (32-bit) decimal number
- \%f - parse a floating point number
- \%x - parse a hexadecimal number
- \%lx - parse a long (32-bit) hex number
- \* - ignore the field

Note signed versus unsigned for the integer values does not matter; it is handled automatically.

FormatSpecifier for Binary Responses

The second line of the Layout response is the binary parameter list for parsing the fields from a binary response. Parameters MUST be separated by spaces, and the line is terminated by a \n. Valid fields are:

- t - parse a time specifier (2 bytes)
- D - parse a date specifier (3 bytes)
- i - ignore one 8-bit character (1 byte)
- e - parse a 24-bit floating point number (3 bytes: n/x)
- E - parse a 24-bit floating point number (3 bytes: N/x)
- f - parse a 32-bit floating point number (4 bytes)
- c - parse an 8-bit signed number (1 byte)
- C - parse an 8-bit unsigned number (1 byte)
- n - parse a 16-bit signed number (2 bytes)
- N - parse a 16-bit unsigned number (2 bytes)
- m - parse a 24-bit signed number (3 bytes)
- M - parse a 24-bit unsigned number (3 bytes)
- l - parse a 32-bit signed number (4 bytes)
- L - parse a 32-bit unsigned number (4 bytes)

There is an optional single digit \d which may follow any of the numeric fields which indicates that after the field has been parsed out, the resulting value is to be divided by 10^d. Thus the 16-bit field 0xFFC6 would be interpreted with the format specifier 'n3' as the number -0.058.

FormatSpecifier for Front-Panel Layout

The subsequent lines in the ERec Layout response describe the appearance of the full panel. The full instrument panel as it appears on the screen has two columns of lines. Each line is composed of three major components: (1) a text field, (2) a value field, and (3) a button. None of these three components is required. The text field contains statically displayed text.
The value field displays values which are parsed out of the response to a DATA/ERec command. It also displays, though background changes, alarm status. The button, when pressed, triggers input from either a dialog box or a selection list. There are five kinds of buttons, B, I, L, T, and N.

Each line in the layout string corresponds to one line on the display. The layout string describes each of the three major fields as well as translation mechanisms and corresponding commands.

**Text**  
The first field in the layout string is the text. It is delimited by a ':'. The string up to the first ':' will be read and inserted in the text field of the line.

**Value String**  
This is followed by a possible string, enclosed in quotes. This is used to place a string into the value field.

**Value Source**  
The value source, which is the item (or word) number in the DATA/ERec response, appears next. This is followed by an optional bitfield designator. The datum identified by the value source can be printed as a string 's', hexadecimal 'x', decimal 'd', or floating point 'f', or binary 'b' number. Typically, bitfield extractions are only done for decimal or hexadecimal numbers.

Floating-point numbers can be followed with an optional precision specifier which will be used as an argument to printf’s %f format (e.g., a field of '4' would be translated into the printf command of ‘%f.3f’). Alternately, the special character '*' can precede the precision specifier; this causes an indirection on the precision specifier (which now becomes a field number).

This is useful when formatting, for example, numbers which have varying precision depending on the mode of the instrument.

Binary numbers can also have an optional precision specifier which is used to determine how many bits to print. For example, the specifier 'b4' will print the lowest four bits of the parsed number.

There are serious restrictions on where an ‘s’ field may appear: currently sources 1 and 2 must be ‘s’, and no others may be ‘s’.

**Alarm Information**  
The value source is followed by optional alarm information, indicated by a commercial at sign '@' with a source indicator and a starting bit indicator. All alarm information is presumed to be two bits long (low and high). The bitfield extraction is performed on the integer part of the source. Typical alarm information would appear as '@6.4'.
Translation Table
Then, there appears an optional translation table within braces ‘{}’. This is a string of words separated by spaces. An example translation table would be '{Code_0 Code_1 Code_2 Code_3}'. The value, once extracted is used as a zero-based index into the translation table to determine the string to display.

Selection Table
Then there appears an optional selection table within parentheses '(...))'. This is a string of numbers separated by spaces '(0 1)'. The selection table lists the translation table entries which the user may select from when setting the parameter. This is not necessarily the same as the entries which may be displayed.

Button Designator
Then there appears an optional button designator. This will be one of 'B', 'I', 'L', 'T', or 'N'.

- **B**—Indicates a button which pops up an input dialog prompting the user for a new value using the designated input format. The input format is specified from the 'B' through the subsequent semicolon.

- **I**—Indicates a button which pops up a selection list with input translation. That is, the values read are translated before they are compared to the selection list options.

- **L**—Indicates a button which pops up a selection list without any translation. The output value is number of the selected option.

- **T**—Indicates a button which pops up a selection list with output translation. The number of the option selected is used as an index into the translation table to generate an output string.

- **N**—Indicates a button which only sends the subsequent command to the instrument. No user-prompting happens.

The following string through an optional '|' or the end of the line is the command which is to be sent to the instrument upon the completion of the button selection. The command string should normally contain print-style formatting to include the user input. If a '|' is present, it indicates a command which is sent to the instrument upon successful completion of the button command to update the value field.

This is not currently used.

Examples
Some examples ('\n' is the C syntax for an end-of-line character):

`'Concentrations\n'`
This is a single text-only line.

'\n'

This is a single blank line.

' NO:3s\n'

This is a line which appears slightly indented. The text field is 'NO', the value is taken from the third element of the data response, and interpreted as a string.

' NO:18sBd.ddd;set no coef %s\n'

This is a line which also appears slightly indented. The next field is also 'NO', but the value is taken from the eighteenth element of the data response, again interpreted as a string. A button appears on this line which, when pressed, pops up an input dialog which will state "Please enter a new value for NO using a d.ddd format." The string entered by the user is used to construct the output command. If the user enters, for example, '1.234', the constructed command will be 'set no coef 1.234'.

' NO:21f{Code_0 Code_1 Code_2 Code_3 Code_4 Code_5 Code_6 Code_7 Code_8 Code_9 Code_10 Code_11}Lset range no %d\n'

This is a line which appears slightly indented, the title is again 'NO', and the value the twenty-first element of the data response, interpreted as a floating-point number. There is a no-translation button which creates a selection list of twelve "Code nn" options. The number of the user selection is used to create the output command.

' Mode:6.12-13x{local remote service service}(0 1)Tset mode %s\n'

This is a line which has a title of 'Mode', and value taken from the sixth field of the data response. There is a bitfield extraction of bits 12 through 13 from the source (the value type is not important here because the value is being translated to an output string). Once the bits have been extracted, they are shifted down to the bit-zero position. Thus, the possible values of this example will be 0 through 3. The translation list shows the words which correspond to each input value, the zeroth value appearing first (0 -> local, 1 -> remote, etc.). The selection list shows that only the first two values, in this case, are to be shown to the user when the button is pressed. The 'T' button indicates full translation, input code to string, and user selection number to output string.

'\xC'
This is a line that starts a new column (the \xC or ^L),

' Comp:6.11x{off on}Tset temp comp %s\n'

This shows that the bitfield end (the second part of a bitfield specification) is optional. The bitfield will be one bit long, starting in this case at the eleventh bit.

'Background:7f*8Bd.ddd;set o3 bkg %s\n'

This shows the use of indirect precision specifiers for floating point displays. The background value is taken from the 7th element, and the precision specifier is taken from the 8th. If the asterisk were not present, it would indicate instead that 8 digits after the decimal point should be displayed.
Appendix C MODBUS Protocol

This appendix provides a description of the MODBUS Protocol Interface and is supported both over RS-232/485 (RTU protocol) as well as TCP/IP over Ethernet.

The MODBUS Commands that are implemented are explained in detail in this document. The MODBUS protocol support for the iSeries enables the user to perform the functions of reading the various concentrations and other analog values or variables, read the status of the digital outputs of the analyzer, and to trigger or simulate the activation of a digital input to the instrument. This is achieved by using the supported MODBUS commands listed below.

For details of the Model 410i MODBUS Protocol specification, see the following topics:

- “Serial Communication Parameters” on page C-2 describes the parameters used to support MODBUS RTU protocol.
- “TCP Communication Parameters” on page C-2 describes the parameters used for TCP connection.
- “Application Data Unit Definition” on page C-2 describes the formats used over serial and TCP/IP.
- “Function Codes” on page C-3 describes the various function codes supported by the instrument.
- “MODBUS Commands Supported” on page C-8 lists the MODBUS commands supported.

Serial Communication Parameters

The following are the communication parameters that are used to configure the serial port of the iSeries to support MODBUS RTU protocol.

Number of Data bits : 8
Number of Stop bits : 1
Parity : None
Data rate : from 1200-115200 Baud (9600 is default)

TCP Communication Parameters

iSeries Instruments support the MODBUS/TCP protocol. The register definition is the same as for the serial interface.

TCP connection port for MODBUS : 502

Application Data Unit Definition

Here are the MODBUS ADU (Application Data Unit) formats over serial and TCP/IP:

<table>
<thead>
<tr>
<th>Serial:</th>
<th>Slave Address</th>
<th>Function Code</th>
<th>Data</th>
<th>Error Check</th>
</tr>
</thead>
<tbody>
<tr>
<td>TCP/IP:</td>
<td>MBAP Header</td>
<td>Function Code</td>
<td>Data</td>
<td></td>
</tr>
</tbody>
</table>

Slave Address

The MODBUS slave address is a single byte in length. This is the same as the instrument ID used for C-Link commands and can be between 1 and 127 decimal (i.e. 0x01 hex to 0x7F hex). This address is only used for MODBUS RTU over serial connections.

Note

Device ID '0' used for broadcast MODBUS commands, is not supported. Device IDs 128 through 247 (i.e. 0x80 hex to 0xF7 hex) are not supported because of limitations imposed by C-Link.

MBAP Header

In MODBUS over TCP/IP, a MODBUS Application Protocol Header (MBAP) is used to identify the message. This header consists of the following components:

- Transaction Identifier : 2 Bytes, 0x0000 to 0xFFFF (Passed back in response)
- Protocol Identifier : 2 Bytes, 0x00 (MODBUS protocol)
- Length : 2 Bytes, 0x0000 to 0xFFFF (Number of following bytes)
- Unit Identifier : 1 Byte, 0x00 to 0xFF (Passed back in response)
A Slave address is not required in MODBUS over TCP/IP because the higher-level protocols include device addressing. The unit identifier is not used by the instrument.

**Function Code**

The function code is a single byte in length. The following function codes are supported by the instrument:

- **Read Coils**: 0x01
- **Read Inputs**: 0x02
- **Read Holding Registers**: 0x03
- **Read Input Registers**: 0x04
- **Force (Write) Single Coil**: 0x05
- **Read Exception Status**: 0x07

If a function code is received that is not in this list, an invalid function exception is returned.

**Data**

The data field varies depending on the function. For more description of these data fields, see “Function Codes” below.

**Error Check**

In MODBUS over Serial an error check is included in the message. This is not necessary in MODBUS over TCP/IP because the higher-level protocols ensure error-free transmission. The error check is a two-byte (16-bit) CRC value.

**Function Codes**

This section describes the various function codes that are supported by the Model 410i.

**(0x01/0x02) Read Coils / Read Inputs**

Read Coils/Inputs reads the status of the digital outputs (relays) in the instrument. Issuing either of these function codes will generate the same response.

These requests specify the starting address, i.e. the address of the first output specified, and the number of outputs. The outputs are addressed starting at zero. Therefore, outputs numbered 1–16 are addressed as 0–15.
The outputs in the response message are packed as one per bit of the data field. Status is indicated as 1 = Active (on) and 0 = Inactive (off). The LSB of the first data byte contains the output addressed in the query. The other outputs follow toward the high order end of this byte, and from low order to high order in subsequent bytes. If the returned output quantity is not a multiple of eight, the remaining bits in the final data byte will be padded with zeros (toward the high order end of the byte). The Byte Count field specifies the quantity of complete bytes of data.

**Note** The values reported may not reflect the state of the actual relays in the instrument, as the user may program these outputs for either active closed or open.

**Request**

<table>
<thead>
<tr>
<th>Field Name</th>
<th>Hex</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Function code</td>
<td>1 Byte</td>
<td>0x01 or 0x02</td>
</tr>
<tr>
<td>Starting Address Hi</td>
<td>2 Bytes</td>
<td>0x0000 to maximum allowed by instrument</td>
</tr>
<tr>
<td>Starting Address Lo</td>
<td>2 Bytes</td>
<td>1 to maximum allowed by instrument</td>
</tr>
<tr>
<td>Quantity of Outputs Hi</td>
<td>2 Bytes</td>
<td>0x00 to 0xFF (Passed back in response)</td>
</tr>
<tr>
<td>Unit Identifier</td>
<td>1 Byte</td>
<td>0x00 to 0xFF (Passed back in response)</td>
</tr>
</tbody>
</table>

**Response**

<table>
<thead>
<tr>
<th>Field Name</th>
<th>Hex</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Function code</td>
<td>1 Byte</td>
<td>0x01 or 0x02</td>
</tr>
<tr>
<td>Byte count</td>
<td>1 Byte</td>
<td>N*</td>
</tr>
<tr>
<td>Output Status n</td>
<td>n Byte</td>
<td>n = N or N+1</td>
</tr>
</tbody>
</table>

* N = Quantity of Outputs / 8, if the remainder not equal to zero, then N=N+1

**Error Response**

<table>
<thead>
<tr>
<th>Field Name</th>
<th>Hex</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Function code</td>
<td>1 Byte</td>
<td>Function code + 0x80</td>
</tr>
<tr>
<td>Exception code</td>
<td>1 Byte</td>
<td>01=Illegal Function, 02=Illegal Address, 03=Illegal Data, 04=Slave Device Failure</td>
</tr>
</tbody>
</table>

Here is an example of a request and response to read outputs 2–15:

**Request**

- **Field Name**
  - **Function** 0x01
  - **Starting Address Hi** 0x00
  - **Starting Address Lo** 0x02
  - **Quantity of Outputs Hi** 0x00
  - **Quantity of Outputs Lo** 0x0D
The status of outputs 2–10 is shown as the byte value 0xCD, or binary 1100 1101. Output 10 is the MSB of this byte, and output 2 is the LSB. By convention, bits within a byte are shown with the MSB to the left, and the LSB to the right. Thus the outputs in the first byte are ‘10 through 2’, from left to right. In the last data byte, the status of outputs 15-11 is shown as the byte value 0x0A, or binary 0000 1010. Output 15 is in the fifth bit position from the left, and output 11 is the LSB of this byte. The four remaining high order bits are zero filled.

**(0x03/0x04) Read Holding Registers / Read Input Registers**

Read holding/input registers reads the measurement data from the instrument. Issuing either of these function codes will generate the same response. These functions read the contents of one or more contiguous registers.

These registers are 16 bits each and are organized as shown below. All of the values are reported as 32-bit IEEE standard 754 floating point format. This uses 2 sequential registers, least significant 16 bits first.

The request specifies the starting register address and the number of registers. Registers are addressed starting at zero. Therefore registers numbered 1–16 are addressed as 0–15. The register data in the response message are packed as two bytes per register, with the binary contents right justified within each byte. For each register, the first byte contains the high order bits and the second contains the low order bits.

<table>
<thead>
<tr>
<th>Field Name</th>
<th>(Hex)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Function</td>
<td>0x01</td>
</tr>
<tr>
<td>Byte Count</td>
<td>0x03</td>
</tr>
<tr>
<td>Outputs status 2-10</td>
<td>0xCD</td>
</tr>
<tr>
<td>Outputs status 11-15</td>
<td>0x0A</td>
</tr>
</tbody>
</table>

**Request**

<table>
<thead>
<tr>
<th>Function code</th>
<th>1 Byte</th>
<th>0x03 or 0x04</th>
</tr>
</thead>
<tbody>
<tr>
<td>Starting Address</td>
<td>2 Bytes</td>
<td>0x0000 to maximum allowed by instrument</td>
</tr>
<tr>
<td>Quantity of Registers</td>
<td>2 Bytes</td>
<td>1 to maximum allowed by instrument</td>
</tr>
</tbody>
</table>
Response
Function code 1 Byte 0x03 or 0x04
Byte count 1 Byte 2 x N*
Register value N* x 2 Bytes n = N or N+1
*N = Quantity of Registers

Error Response
Function code 1 Byte Function code + 0x80
Exception code 1 Byte 01=Illegal Function, 02=Illegal Address,
03=Illegal Data, 04=Slave Device Failure

Here is an example of a request to read registers 10–13:

Request
Field Name (Hex)
Function 0x03
Starting Address Hi 0x00
Starting Address Lo 0x09
No. of Registers Hi 0x00
No. of Registers Lo 0x04

Response
Field Name (Hex)
Function 0x03
Byte Count 0x06
Register value Hi (10) 0x02
Register value Lo (10) 0x2B
Register value Hi (11) 0x00
Register value Lo (11) 0x00
Register value Hi (12) 0x00
Register value Lo (12) 0x64
Register value Hi (13) 0x00
Register value Lo (13) 0x64

The contents of register 10 are shown as the two byte values of 0x02 0x2B. The contents of registers 11–13 are 0x00 0x00, 0x00 0x64 and 0x00 0x64, respectively.
**(0x05) Force (Write) Single Coil**

The force (write) single coil function simulates the activation of the digital inputs in the instrument, which triggers the respective action.

This function code is used to set a single action to either ON or OFF. The request specifies the address of the action to be forced. Actions are addressed starting at zero. Therefore, action number 1 is addressed as 0. The requested ON/OFF state is specified by a constant in the request data field. A value of 0xFF00 requests the action to be ON. A value of 0x0000 requests it to be OFF. All other values are illegal and will not affect the output. The normal response is an echo of the request, returned after the state has been written.

**Request**

- **Function code**: 1 Byte, 0x05
- **Output Address**: 2 Bytes, 0x0000 to maximum allowed by instrument
- **Output Value**: 2 Bytes, 0x0000 or 0xFF00

**Response**

- **Function code**: 1 Byte, 0x05
- **Output Address**: 2 Bytes, 0x0000 to maximum allowed by instrument
- **Output Value**: 2 Bytes, 0x0000 or 0xFF00

**Error Response**

- **Function code**: 1 Byte, Function code + 0x80
- **Exception code**: 1 Byte, 01=Illegal Function, 02=Illegal Address, 03=Illegal Data, 04=Slave Device Failure

Here is an example of a request to write Coil 5 ON:

**Request**

<table>
<thead>
<tr>
<th>Field Name</th>
<th>(Hex)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Function</td>
<td>05</td>
</tr>
<tr>
<td>Output Address Hi</td>
<td>00</td>
</tr>
<tr>
<td>Output Address Lo</td>
<td>05</td>
</tr>
<tr>
<td>Output Value Hi</td>
<td>FF</td>
</tr>
<tr>
<td>Output Value Lo</td>
<td>00</td>
</tr>
</tbody>
</table>
MODBUS Protocol
MODBUS Commands Supported

The following Tables 1–3 lists the MODBUS commands supported for the Model 410i.

Table C-1. Read Registers for 410i

<table>
<thead>
<tr>
<th>Register Number</th>
<th>Variable</th>
</tr>
</thead>
<tbody>
<tr>
<td>40001&amp;40002</td>
<td>NOT USED</td>
</tr>
<tr>
<td>40003&amp;40004</td>
<td>NOT USED</td>
</tr>
<tr>
<td>40005&amp;40006</td>
<td>NOT USED</td>
</tr>
<tr>
<td>40007&amp;40008</td>
<td>RANGE STATUS</td>
</tr>
<tr>
<td>40009&amp;40010</td>
<td>S/R</td>
</tr>
<tr>
<td>40011&amp;40012</td>
<td>LO S/R</td>
</tr>
<tr>
<td>40013&amp;40014</td>
<td>HI S/R</td>
</tr>
<tr>
<td>40015&amp;40016</td>
<td>INT TEMP</td>
</tr>
<tr>
<td>40017&amp;40018</td>
<td>BENCH TEMP</td>
</tr>
<tr>
<td>40019&amp;40020</td>
<td>AUX TEMP</td>
</tr>
<tr>
<td>40021&amp;40022</td>
<td>PERM OVN GAS</td>
</tr>
<tr>
<td>40023&amp;40024</td>
<td>PERM OVN HTR</td>
</tr>
<tr>
<td>40025&amp;40026</td>
<td>BENCH PRES</td>
</tr>
<tr>
<td>40027&amp;40028</td>
<td>SAMPLE FLOW</td>
</tr>
<tr>
<td>40029&amp;40030</td>
<td>INTENSITY</td>
</tr>
<tr>
<td>40031&amp;40032</td>
<td>MOTOR SPEED</td>
</tr>
<tr>
<td>40033&amp;40034</td>
<td>ANALOG IN 1</td>
</tr>
<tr>
<td>40035&amp;40036</td>
<td>ANALOG IN 2</td>
</tr>
<tr>
<td>40037&amp;40038</td>
<td>ANALOG IN 3</td>
</tr>
<tr>
<td>40039&amp;40040</td>
<td>ANALOG IN 4</td>
</tr>
<tr>
<td>40041&amp;40042</td>
<td>ANALOG IN 5</td>
</tr>
<tr>
<td>40043&amp;40044</td>
<td>ANALOG IN 6</td>
</tr>
</tbody>
</table>
### Table C-1. Read Registers for 410i

<table>
<thead>
<tr>
<th>Register Number</th>
<th>Variable</th>
</tr>
</thead>
<tbody>
<tr>
<td>40045&amp;40046</td>
<td>ANALOG IN 7</td>
</tr>
<tr>
<td>40047&amp;40048</td>
<td>ANALOG IN 8</td>
</tr>
<tr>
<td>40049&amp;40050</td>
<td>CO2</td>
</tr>
<tr>
<td>40051&amp;40052</td>
<td>LO CO2</td>
</tr>
<tr>
<td>40053&amp;40054</td>
<td>HI CO2</td>
</tr>
</tbody>
</table>

### Table C-2. Write Coils for 410i

<table>
<thead>
<tr>
<th>Coil Number</th>
<th>Action Triggered</th>
</tr>
</thead>
<tbody>
<tr>
<td>101</td>
<td>ZERO MODE</td>
</tr>
<tr>
<td>102</td>
<td>SPAN MODE</td>
</tr>
<tr>
<td>103</td>
<td>SET BACKGROUND</td>
</tr>
<tr>
<td>104</td>
<td>CAL TO SPAN</td>
</tr>
<tr>
<td>105</td>
<td>AOUTS TO ZERO</td>
</tr>
<tr>
<td>106</td>
<td>AOUTS TO FS</td>
</tr>
</tbody>
</table>

### Table C-3. Read Coils for 410i

<table>
<thead>
<tr>
<th>Coil Number</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>AUTORANGE</td>
</tr>
<tr>
<td>2</td>
<td>LOCAL/REMOTE</td>
</tr>
<tr>
<td>3</td>
<td>SERVICE</td>
</tr>
<tr>
<td>4</td>
<td>UNITS</td>
</tr>
<tr>
<td>5</td>
<td>ZERO MODE</td>
</tr>
<tr>
<td>6</td>
<td>SPAN MODE</td>
</tr>
<tr>
<td>7</td>
<td>SAMPLE MODE</td>
</tr>
<tr>
<td>8</td>
<td>GEN ALARM</td>
</tr>
<tr>
<td>9</td>
<td>CONC MAX ALARM</td>
</tr>
<tr>
<td>10</td>
<td>CONC MIN ALARM</td>
</tr>
<tr>
<td>11</td>
<td>INTERNAL TEMP ALARM</td>
</tr>
<tr>
<td>12</td>
<td>BENCH TEMP ALARM</td>
</tr>
<tr>
<td>13</td>
<td>PRESSURE ALARM</td>
</tr>
<tr>
<td>14</td>
<td>SAMPLE FLOW ALARM</td>
</tr>
</tbody>
</table>
### Table C-3. Read Coils for 410i

<table>
<thead>
<tr>
<th>Coil Number</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>INTENSITY ALARM</td>
</tr>
<tr>
<td>16</td>
<td>MOTOR SPEED ALARM</td>
</tr>
<tr>
<td>17</td>
<td>BIAS VOLTAGE ALARM</td>
</tr>
<tr>
<td>18</td>
<td>MB STATUS ALARM</td>
</tr>
<tr>
<td>19</td>
<td>INTERFACE BD STATUS ALARM</td>
</tr>
<tr>
<td>20</td>
<td>I/O EXP BD STATUS ALARM</td>
</tr>
<tr>
<td>21</td>
<td>CONC ALARM</td>
</tr>
</tbody>
</table>