16-bit Standard Modbus Technical Use Sheet
For Version 1.2+ SEC 3120 Digital Transmitters
P/N 1580282, Rev 1, 20121228

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Table Of Contents

List Of Tables

List Of Figures

General Description

About The SEC 3120 Digital Gas Transmitter

      The SEC 3120 Digital Gas Transmitter is the latest generation Gas Transmitter from Sensor Electronics Corporation, and is fully compatible with its predecessor, the SEC 3100. The SEC 3120 Digital Gas Transmitter allows multiple single and multi-channel SEC sensors to be connected to it and acts as a central communication, control, status and data logging hub for them. While the SEC 3100 did not provide full 16-bit standard Modbus (PI-MBUS-300 Rev. J. compliance) support, the special SEC 3100MB16 does and is compatible with the SEC 3120 which provides full (relevant) compliance and major feature and sensor consolidation capabilities, as well as optional sensor redundancy.

SEC 3120 Modbus Standard Supported

      The SEC 3120 Digital Gas Transmitter supports master mode communication as a Modbus RTU slave. While it supports other Modbus interfaces, this document addresses the specific 16-bit standard Modbus protocol as described in the Modicon Modbus Specification PI-MBUS-300 Rev. J. The reader should familiarize themselves with this document to fully understand and utilized this Modbus interface.

16-bit Modbus Supported Features and Functions Overview

Functions Codes -

03 - Read Multiple Holding Registers (supported fully)
06 - Preset Single Holding Register (supported fully)
16 - Preset/Write Multiple Holding Registers (supported fully)
01 - Read Coils **(not supported)**
05 - Force Single Coil **(not supported)**
15 - Force/Write Multiple Coils **(not supported)**
07 - Read Exception Register **(not supported)**

      Broadcast (Network ID 0) for all other function codes is ***not supported,*** *except for Preset (code 06) Holding Register 42920 (Listen Only Modbus Mode) and 42921 (Resume from Listen Only Modbus Mode).*

      All other function codes are not supported for broadcast mode in this interface.

Overall SEC 3120 Modbus Register Map

Internal Register	Modbus Holding Register	Region Description
00000 - 01999	40001 - 42000	Reserved for coil registers- future
02000 - 02099	42001 - 42100	16-bit Sensor ALL apply region (region 0)
02100 - 02199	42101 - 42200	16-bit Sensor 1 region
02200 - 02299	42201 - 42300	16-bit Sensor 2 region
02300 - 02399	42301 - 42400	16-bit Sensor 3 region
02400 - 02499	42401 - 42500	16-bit Sensor 4 region
02500 - 02599	42501 - 42600	16-bit Sensor 5 region
02600 - 02699	42601 - 42700	16-bit Sensor 6 region
02700 - 02799	42701 - 42800	16-bit Sensor 7 region
02800 - 02899	42801 - 42900	16-bit Sensor 8 region
02900 - 02999	42901 - 43000	16-bit 3120 unit region (region 9)
03000 - 03999	43001 - 44000	Reserved for SEC HMI Legacy
04000 - 04999	44001 - 45000	Reserved for SEC HMI Legacy
05000 - 05499	45001 - 45500	Reserved for SEC 32-bit future
05500 - 05999	45501 - 46000	Reserved for SEC 32-bit future
06000 - 06999	46001 - 47000	Reserved for future use
07000 - 07499	47001 - 47500	Reserved for SEC 32-bit future
07500 - 07999	47501 - 48000	Reserved for SEC 32-bit future
08000 - 08999	48001 - 49000	Reserved for SEC HMI Advanced SID
09000 - 09998	49001 - 49999	Reserved for SEC HMI Legacy

Memory Map – 16-bit Interface Holding Registers Overview

The SEC 3120 implements the 16-bit Modbus interface by breaking the address region into ten classes (unit and sensors) and eight plus one sensor sub-regions (each sensor region repeats the same command set with the same relative offsets) as shown previously.

Region 0 applies a sub-set of written values to ALL logical sensors, while regions 1 – 8 apply to each individual logical sensor, and region 9 contains 3120 unit specific (non-sensor) information. The entire 16-bit region is shown previously in green.

Within the sensor regions, the same information/register address offsets are repeated, containing gas concentration, alarm set points, sensor status, etc. (relative offsets 42x01 – 42x99, where x = sensor number 1 – 8).

Within the unit specific region (9), the holding register addresses are absolute (42901 = operating status, 42902 = fault relay reason code, etc.).

Communication Parameters
- Protocol: Modbus RTU slave.
- Baud rates: 1200, 2400, 4800, 9600, 19200 bps field selectable, Word length 8.
- Parity: Odd, Even, None, field selectable.
- Stop Bits: 1 or 2, field selectable.
- Electrical Interface:
  - RS 485, multi-drop 2-wire positive/negative (using A/B nomenclature).
  - Transmit and Receive: Half Duplex.
  - Useable speed will depend on cable length.
- Modbus addressable: 1-247 (up to 254 if ONLY SEC 3120 units on a single bus).

Modbus Sensor Read Only Registers
- Gas concentration (expressed as an integer scaled up by factor) representing the units of measurement for that specific sensor's current gas type (PPM, % LEL, %V/V, etc.)
- Operating Status (normal, calibrating, self test, start up, in an alarm (low, mid high) or fault
- Gas category Type (toxic, hydrocarbons, oxygen, etc.)
- Sensor firmware version
- Sensor serial number
- Alarm relay mode (trip above or below threshold, audible or normal action)
- Modbus address (Network ID)
- Sensor Range and Gas Factor
- Sensor Status and Error code, as well as Cell Test Warn code
- ASCII Gas name and Gas Units Name

Modbus Sensor Read/Write Registers
- Alarm thresholds (low, mid and high set points)
- Zone ID (Network Zone ID)
- Execute Self Test

Modbus 3120 Unit Read Only Registers
- Unit Operation Status
- Unit Fault Relay Reason Code
- Unit Serial Number
- Maximum Number of Sensors That Can Be Attached
- Unit Clock- Read Current Time
- Unit Type
- Unit Firmware Version Info

Modbus 3120 Unit Read/Write Registers
- Unit Clock- Write New Time Registers
- Unit Clock- Set New Time Now
- Unit Diagnostics Control (force relays on/off, toggle LEDs to flash)
- Unit- Place into Modbus listen only mode
- Unit- Restore out of Modbus listen only mode

SEC 3120 Setup and Configuration

Connector Block P5

Pin7

Pin5

Pin4

Pin1
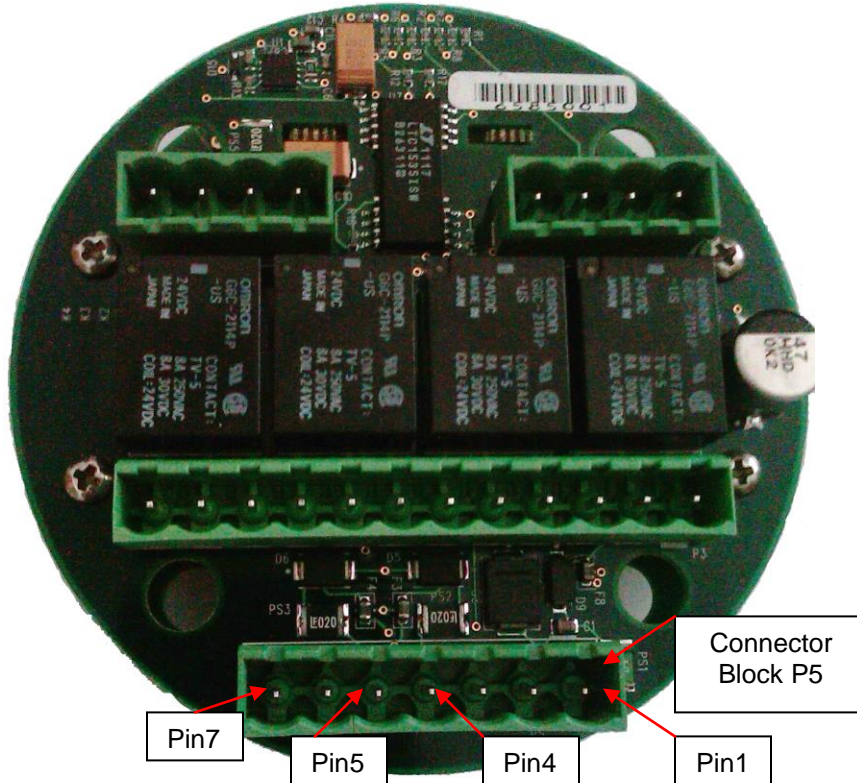
(Bottom View of SEC 3120- Relay Board Connectors)

SEC 3120 Modbus RS-485 Network Connections
- Pin 5 (RS485 B) of the SEC 3120 power and communication connection block P5 is typically connected to a Modbus Master device (RX-) terminal in two-wire connections. For the EGX-100 Gateway, this would be Pin 4 of the RS485 connection block.
- Pin 4 (RS485 A) of the SEC 3120 power and communication connection block P5 is typically connected to a Modbus Master device (RX+) terminal in two-wire connections. For the EGX-100 Gateway, this would be Pin 3 of the RS485 connection block.
- The EGX-100 Gateway is connected to the Ethernet using its Ethernet port and 10/100 base T/TX cable to an Ethernet switch.

Figure 1: Modbus RS485 Connections
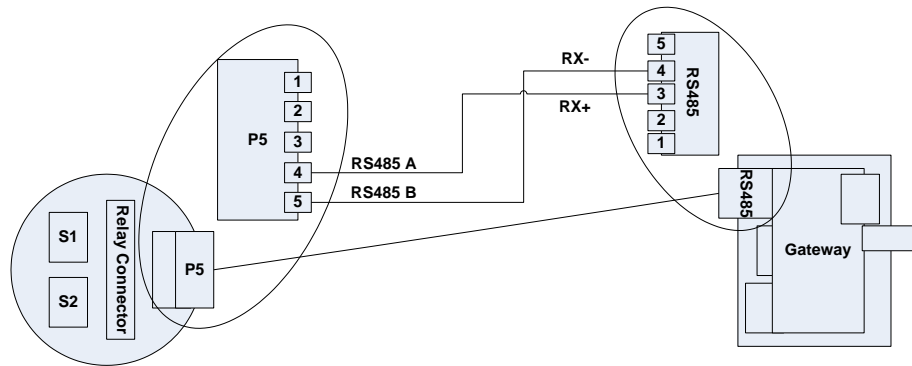
First Time Configuration

When SEC 3120 units are first removed from the shipping container, unless otherwise instructed upon ordering, units may arrive configured in the following modes:

1. **Sensor Role:** *Unique-* Multiple sensors can be connected having different gas types, units of measure and ranges. This can be changed to **"Identical"** mode if all attached sensors have identical gas types, ranges and units of measure, thus allowing redundancy of measurement. It can also be changed to **"Single"** mode, where only one sensor is attached to the unit in the sensor 1 connector. In "Single" mode, the unit will ignore anything connected to the sensor 2 connector.

2. **Relay Mode:** *OR-* Sensors control the alarm relay coils in a logical "OR" fashion. Fault relay is always controlled in a logical "OR" fashion (Any sensor fault drives fault relay coil). The alarm relay logic mode can be changed to **"AND"**- forcing both sensor's alarm status to be in agreement before the alarm relay coils are driven (except for fault relay coil). This mode is typically used with the **"Identical"** Sensor Role to provide measurement redundancy.

3. **Modbus Network ID Mode:** *Unique-* One Network ID is assigned to each sensor, typically sensor 2 ID is greater than sensor 1 ID. These ID's can be independently adjusted and are available on the bus and the unit will respond to either ID for all sensors attached (Ex: Sensor 2 ID: 12, Sensor 1 ID 11). This can be changed to "Single" mode, where all sensors are accessed through a single ID and the IDs are identical to all sensors (Sensors 1 and 2 IDs are 5).

4. **RS485 Bus Settings:** *SEC Default-* Baud rate is 9600, stop bits are 2, parity is set to none. This can be changed to **"Alternate:"**- Baud rate 9600, stop bits 1, parity none. The bus settings may also be set to custom values, where the baud rate, stop bits and parity are independently changed (i.e. Baud rate 19200, stop bits 1, parity odd).

To change these settings, you must adjust them using the user interface controls on the SEC 3120 unit. When making changes out of the box, the following order of changes should be made (remove the unit from the communication bus until everything is set the way you desire):

1. **Sensor Role-** Change the sensor role in the Network Modbus Settings menu. Save the changes first and exit the menus before returning to make further changes.
2. **Sensor Relay Mode**- Change the sensor relay mode in the Relay Settings menu. Save the changes first and exit the menus before returning to make further changes.
3. **Modbus Network Mode**- Change the Modbus Network mode in the Network Modbus Settings menu. Save the changes first and exit the menus before returning to make further changes. Do NOT try to change the network IDs or RS485 bus settings without exiting the menus first!
4. **Modbus Network IDs**- Set the Modbus Network ID(s) (Addresses based on the network mode chosen above, using the Network Modbus ID menu. Save the changes first and exit the menus before returning to make further changes.
5. **RS485 Bus Settings**- Set the RS485 Communication Settings to your desired line settings in the Network RS485 Bus Settings Menu. Changes are applied immediately after you choose to save them, therefore make sure these settings are correct before connecting the unit to the bus. Make sure you have no conflicting network IDs with any other Modbus devices on the bus.

Relevant Screens you may see in order of operation, to change the unit to the following settings (example):

- **Sensor Role - Unique**
- **Relay Logic Mode- OR**
- **Modbus Network Mode- Single**
- **Modbus Network IDs**
- **RS485 Bus Settings- SEC Alternate** (9600 baud, 1 stop bits, no parity)

First, we must examine how the user interface works on the 3120, is described on the following pages:

Figure 2: SEC 3120 User Interface
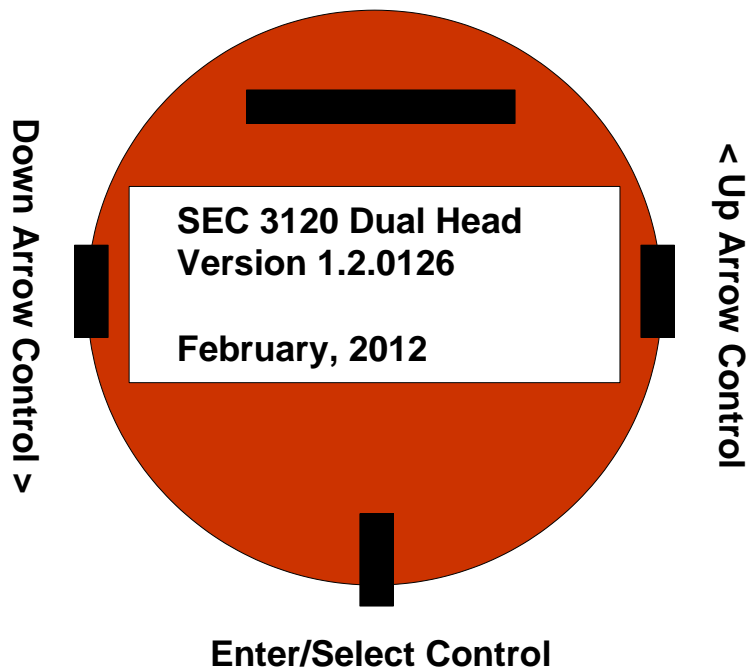
The SEC 3120 User Interface, as depicted above, contains the following key elements:

- The 4-Line LCD Display in the center. This will contain the main status screen (showing gas concentration, gas type, gas units, range, ID, etc.) for one or more sensors by automatically rotating and displaying the values for each sensor, one at a time for a few seconds dwell. The next sensor can be advance by activating either the down (left) or up (right) wand magnet/switches.
- The Down Arrow Control is positioned to the left. When activated (using a magnet on explosion-proof versions, or through a push button on DIN-rail mount units), the next menu item down the list is moved to, a lower value is chosen, etc.
- The Up Arrow Control is positioned to the right. When activated (using a magnet on explosion-proof versions, or through a push button on DIN-rail mount units), the previous menu item up the list is moved to, a higher value is chosen, etc.
- The Enter/Select Control is position below the center of the LCD display. When activated (using a magnet on explosion-proof versions, or through a push button on DIN-rail mount units) from the main status screen, the menu system is entered and displayed. If on a menu item, that item will be chosen. If a value is selected to be changed, it will either enter/exit changing a value.

The first menu displayed after it is brought up by activating the enter key from the main status display, is referred to as the "Top Menu". The top menu requires two full screens to present all of the possible items. The up/down controls allow navigation through the list, where selecting down below the bottom of the first page brings up the second page of the Top Menu. When selecting down below the bottom of the second page (end of the list), the top item of the list and the first page of the Top Menu is displayed. Likewise, if selecting above the top item in the first page of the Top Menu, the last item in the list on the second page will be highlighted and displayed, or if selecting

above the top item of the second page then the bottom item of the first page of the Top Menu is displayed.

This is indicated by ↑up and ↓down arrows next to the top and bottom menu items respectively, if this kind of multi-page menu scrolling is available. Not all menus are longer than one page, and therefore do not contain these arrow indicators.

The Top Menu is the first menu that is encountered and the last menu before returning to the status display. Every menu item selected from the Top Menu drives another nested menu or item that must be exited to bring the Top Menu back. Let's examine the Top Menu:

Figure 3: SEC 3120 Top Menu

Top Menu Page 1
```
*↑EJECT MEMORY CARD
  ABORT WARMUP
  INFO MENU
↓MAIN MENU
```

Top Menu Page 2
```
 ↑SEC DIAGNOSTICS
  RESET RELAYS
  FORMAT FLASH CARD
↓EXIT
```

The asterisk to the left of the menu item row indicates where the cursor is. As you advance the cursor down the list by activating the down (left) arrow control, the asterisk moves to indicate the newly highlighted menu item row, just as the asterisk moves up as you activate the up (right) arrow control. When you activate the Enter/Select control, that menu item is selected and the menu listed on that menu item row is display. This Top Menu will be returned to the display once the newly selected menu is exited.

The purpose of the Top Menu is to place the most important, quick access items up front to the user first. For example, if you want to eject the flash card immediately without incurring data loss or corruption, you would select this. If you want to display information about the SEC 3120 unit or attached sensors, you would select the Information Menu.

To leave the Top Menu and return to the main status screen, simply scroll down to the Exit Menu Item and select it. Menu timer time's key activations, and once it expires (typically 30 seconds), the menus are automatically exited and the main status screen is re-displayed.

Figure 4: SEC 3120 Nested Menu Navigation

Shown below, is the menu navigation list. Each new menu is shown indented, indicating that you must back out (or exit) that current menu level to return to the next menu up:

```
TOP MENU PAGE 1:
        EJECT FLASH CARD
        ABORT SENSOR WARMUP
        INFO MENU:
                ABOUT 3120 UNIT
                ABOUT SENSORS
                EXIT MENU ABOUT MENU
        MAIN MENU:
          MAIN MENU PAGE 1:
                CONFIGURATION MENU (CALIBRATION):
                        CONFIGURATION TOP MENU PAGE 1:
                                SELECT SENSOR NUMBER-
                                ZERO CALIBRATION SENSOR
                                SPAN CALIBRATE SENSOR
                                CHANGE CALIBRATION VALUE-
                        CONFIGURATION TOP MENU PAGE 2:
                                EXIT CONFIGURATION MENU
                ALARM CONFIGURATION TOP MENU:
                        ALARM PAGE 1:
                          SELECT SENSOR NUMBER-
                                LOW ALARM SETTINGS MENU:
                                        CHANGE LOW SET POINT VALUE-
                                        CHANGE LOW ACTIVE MODE-
                                        EXIT LOW ALARM SETTINGS MENU
                                MID ALARM SETTINGS MENU:
                                        CHANGE MID SET POINT VALUE-
                                        CHANGE MID ACTIVE MODE-
                                        EXIT MID ALARM SETTINGS MENU
                                HIGH ALARM SETTINGS MENU:
                                        CHANGE HIGH SET POINT VALUE-
                                        CHANGE HIGH ACTIVE MODE-
                                        EXIT HIGH ALARM SETTINGS MENU
                        ALARM PAGE 2:
                          EXIT TOP ALARM CONFIGURATION MENU
                RELAY CONFIGURATION TOP MENU:
                        RELAY PAGE 1:
                                LOW RELAY SETTINGS MENU:
                                        LOW RELAY SETTINGS MENU PAGE 1:
                                                CHANGE LOW LATCHING MODE-
                                                CHANGE LOW ON DELAY TIME-
                                                CHANGE LOW OFF DELAY TIME-
                                                CHANGE LOW COIL ENERGIZE MODE-
                                        LOW RELAY SETTINGS MENU PAGE 2:
                                                EXIT LOW RELAY SETTINGS MENU
                                MID RELAY SETTINGS MENU:
                                        MID RELAY SETTINGS MENU PAGE 1:
                                                CHANGE MID LATCHING MODE-
                                                CHANGE MID ON DELAY TIME-
                                                CHANGE MID OFF DELAY TIME-
                                                CHANGE MID COIL ENERGIZE MODE-
                                        MID RELAY SETTINGS MENU PAGE 2:
                                                EXIT MID RELAY SETTINGS MENU
                                HIGH RELAY SETTINGS MENU:
                                        HIGH RELAY SETTINGS MENU PAGE 1:
                                                CHANGE HIGH LATCHING MODE-
                                                CHANGE HIGH ON DELAY TIME-
                                                CHANGE HIGH OFF DELAY TIME-
                                                CHANGE HIGH COIL ENERGIZE MODE-
                                        HIGH RELAY SETTINGS MENU PAGE 2:
                                                EXIT HIGH RELAY SETTINGS MENU
                                FAULT RELAY SETTINGS MENU:
```

```
                              FAULT RELAY SETTINGS MENU PAGE 1:
                                  CHANGE FAULT LATCHING MODE-
                                  CHANGE FAULT ON DELAY TIME-
                                  CHANGE FAULT OFF DELAY TIME-
                                  CHANGE FAULT COIL ENERGIZE MODE-
                              FAULT RELAY SETTINGS MENU PAGE 2:
                                  EXIT FAULT RELAY SETTINGS MENU
                    RELAY PAGE 2:
                         RELAY LOGIC MODE MENU:
                                  CHANGE RELAY LOGIC MODE-,
                                  EXIT RELAY LOGIC MODE MENU
                         EXIT TOP RELAY CONFIGURATION MENU
              NETWORK TOP MENU:
                    NETWORK ID MENU:
                         SELECT SENSOR-
                         CHANGE SENSOR NETWORK ID-
                         CHANGE SENSOR NETWORK ZONE ID-
                         EXIT NETWORK ID MENU
                    MODBUS NETWORK MENU:
                       MODBUS NETWORK MENU PAGE 1:
                              CHANGE DEVICE ONLINE-
                              CHANGE SENSOR ROLE-
                              CHANGE NETWORK ID MODE-
                              485 BUS SETTINGS MENU:
                                  SELECT SEC DEFAULT SETTINGS
                                  SELECT ALTERNATE SETTINGS
                                  CUSTOM 485 LINE SETTINGS MENU:
                                     CUSTOM 485 LINE SETTINGS PAGE 1:
                                          CHANGE DATA BITS-
                                          CHANGE STOP_BITS-
                                          CHANGE PARITY MODE-
                                          CHANGE BAUD RATE-
                                     CUSTOM 485 LINE SETTINGS PAGE 2:
                                          EXIT CUSTOM 485 SETTINGS MENU
                                  EXIT 485 BUS SETTINGS MENU
                       MODBUS NETWORK MENU PAGE 2:
                              EXIT MODBUS NETWORK MENU
                    EXIT NETWORK TOP MENU
         MAIN MENU PAGE 2:
              HIDE LOW GAS MENU:
                       TOGGLE HIDE MODE ON/OFF-
                       EXIT GAS HIDE MENU
              SELF TEST MENU:
                       SELECT SENSOR-
                       CANCEL SELF TEST MENU
                       ABORT OPERATING SENSOR SELF TEST
                       START SENSOR SELFT TEST
              DATE AND TIME MENU:
                       CHANGE DATE:
                              CHANGE MONTH-
                              CHANGE DAY-
                              CHANGE YEAR-
                              EXIT CHANGE DATE
                       CHANGE TIME:
                              CHANGE HOURS-
                              CHANGE MINUTES-
                              CHANGE SECONDS-
                              EXIT CHANGE TIME
                       EXIT DATE AND TIME MENU
              EXIT MAIN MENU
    TOP MENU PAGE 2:
         SEC DIAGNOSTICS MENU
                   REBOOT SYSTEM
                   TOGGLE AND FLASH LEDS
                   TOGGLE RELAYS ON/OFF MENU:
                     MENU_DIAGNOSTICS_RLY_TOGGLE_t,
                              MENU_TOGGLE_LOW,
                              MENU_TOGGLE_MID,
                              MENU_TOGGLE_HI,
                              MENU_TOGGLE_FAULT,
```

MENU_DIAGNOSTICS_RLY_TOGGLE_2,
MENU_TOGGLE_EXIT,
EXIT SEC DIAGNOSTICS MENU
RESET LATCHED RELAYS
FORMAT FLASH CARD
EXIT TOP MENU

Note: When changes are made to values, a **"Save or Abort Changes"** message is displayed forcing you to choose to save the changes or discard them before the previous menu is displayed. If you want to make the changes permanent, choose "Save", if you are not sure, then choose "Abort":

Save or Abort Changes Popup
* SAVE CHANGES
  ABORT CHANGES

Figure 5: Changing the 3120 Sensor Role
After entering the menu system, choose the Main Menu:
Top Menu 1
 ↑EJECT MEMORY CARD
  ABORT WARMUP
  INFO MENU
*↓MAIN MENU

Top Menu 2
 ↑SEC DIAGNOSTICS
  RESET RELAYS
  FORMAT FLASH CARD
↓EXIT

Then choose the Network Menu:
Main Menu 1
 ↑CALIBRATION
  ALARM
  RELAY
*↓NETWORK

Main Menu 2
 ↑HIDE LOW GAS
  SELF TEST
  SET DATE TIME
↓PREVIOUS MENU

Then choose the Modbus Settings Menu:

Network Top Menu
 NETWORK ID MENU
* MODBUS SETTINGS
 PREVIOUS MENU

Then highlight the Sensors Item and activate enter:

Modbus Settings Menu 1
 ↑ONLINE   YES
* SENSORS   UNIQUE *
 NET ID   SINGLE
 ↓485 BUS MENU

Modbus Settings Menu 2
 ↓PREVIOUS MENU

      Activate the left/right up/down controls until "Unique" (for our example) is shown. Notice the asterisk to the right of the mode- this indicates the value that is changing and that the up/down controls now effect choosing a value up/down. When the correct choice shows, active enter again and the asterisk to the right will disappear. Scroll down the menu and choose "Previous Menu" to back out of the Modus Settings menu, then choose "Previous Menu" to exit the Network Menu (which will bring up the Save or Abort confirmation), then scroll down to and choose the "Previous Menu" item and exit the Main Menu, then scroll down to "Exit" and press enter to return to the Main Status Display.

Figure 6: Changing the 3120 Relay Logic Mode
After entering the menu system, choose the Main Menu:

Top Menu 1
 ↑EJECT MEMORY CARD
  ABORT WARMUP
  INFO MENU
*↓MAIN MENU

Top Menu 2
 ↑SEC DIAGNOSTICS
  RESET RELAYS
  FORMAT FLASH CARD
 ↓EXIT

Then choose the Relay Settings Menu:

Main Menu 1
 ↑CALIBRATION
   ALARM
*   RELAY
 ↓NETWORK

Main Menu 2
 ↑HIDE LOW GAS
   SELF TEST
   SET DATE TIME
 ↓PREVIOUS MENU

Then scroll down to and choose the Relay Logic Mode Menu:

Relay Top Menu 1
 ↑LOW
   MID
   HIGH
 ↓FAULT

Relay Top Menu 2
*↑LOGIC MODE
 ↓PREVIOUS MENU

Then use the up/down keys to select the desired mode:

Relay Logic Mode Menu
* MODE   AND *
   PREVIOUS MENU

       Change the item to "OR" (for our example). Notice the asterisk to the right disappears. Now scroll down and choose the "Previous Menu" item to return to the Relay Settings menu (which will bring up the Save or Abort confirmation). Scroll down to and choose the "Previous Menu" item to return to the Main Menu. Then scroll down to and choose the "Previous Menu" item to return to the Top Menu. Then scroll down to and choose the "Exit" item to return back to the Main Status screen.

Figure 7: Changing the 3120 Network ID Mode

After entering the menu system, choose the Main Menu:

Top Menu 1
↑EJECT MEMORY CARD
　ABORT WARMUP
　INFO MENU
*↓MAIN MENU

Top Menu 2
↑SEC DIAGNOSTICS
　RESET RELAYS
　FORMAT FLASH CARD
↓EXIT

Then choose the Network Menu:

Main Menu 1
↑CALIBRATION
　ALARM
　RELAY
*↓NETWORK

Main Menu 2
↑HIDE LOW GAS
　SELF TEST
　SET DATE TIME
↓PREVIOUS MENU

Then choose the Modbus Settings Menu:

Network Top Menu
　NETWORK ID MENU
* MODBUS SETTINGS
　PREVIOUS MENU

Then highlight the Net ID item and activate enter:

Modbus Settings Menu 1
↑ONLINE　　　　　　YES
　SENSORS　　　　　UNIQUE
* NET ID　　　　　　SINGLE　*
↓485 BUS MENU

Modbus Settings Menu 2
↓PREVIOUS MENU

　　　Using the up/down arrows, change the value to "Single" (for our example). Press enter, and note that the asterisk to the right of the value now disappears. Scroll down to and choose the "Previous Menu" item to exit to the Network Top Menu (which will bring

up the Save or Abort confirmation). Scroll down to and choose the "Previous Menu" item to exit to the Main Menu. Scroll down to and choose the "Previous Menu" item to exit to the Top Menu. Scroll down to and choose the "Exit" menu item to exit the menu system and return back to the Main Status Screen.

Figure 8: Changing the 3120 Network ID
After entering the menu system, choose the Main Menu:
Top Menu 1
 ↑EJECT MEMORY CARD
  ABORT WARMUP
  INFO MENU
*↓MAIN MENU

Top Menu 2
 ↑SEC DIAGNOSTICS
  RESET RELAYS
  FORMAT FLASH CARD
 ↓EXIT

Then choose the Network Menu:
Main Menu 1
 ↑CALIBRATION
  ALARM
  RELAY
*↓NETWORK

Main Menu 2
 ↑HIDE LOW GAS
  SELF TEST
  SET DATE TIME
 ↓PREVIOUS MENU

Then choose the Network ID Menu:
Network Top Menu
* NETWORK ID MENU
  MODBUS SETTINGS
  PREVIOUS MENU

        Then highlight the Network ID item and activate enter (in single sensor role, you cannot change the sensor number so this item cannot be highlighted and the ID should be selected automatically first):
Network ID Menu
  FOR SENSOR: ONE
* ID   12 *
  ZONE   4
  PREVIOUS MENU

Using the up/down controls, change the ID value to the desired value. Activate enter. You may also change the Zone value as well. If you are not in Single Sensor Role, you may also scroll up and change the sensor number to TWO and repeat the process if you are choosing to set different network IDs.

Once you are done, scroll down and choose the "Previous Menu" item to exit to the Network Top Menu. Scroll down and choose the "Previous Menu" item to exit to the Main Menu (which will bring up the Save or Abort confirmation). Scroll down to and choose the "Previous Menu" item to exit to the Top Menu. Scroll down to and choose the "Exit" menu item to exit and return back to the Main Status Screen.

Figure 9: Changing 3120 485 Bus Settings
After entering the menu system, choose the Main Menu:
Top Menu 1
 ↑EJECT MEMORY CARD
   ABORT WARMUP
   INFO MENU
*↓MAIN MENU

Top Menu 2
 ↑SEC DIAGNOSTICS
   RESET RELAYS
   FORMAT FLASH CARD
 ↓EXIT

Then choose the Network Menu:
Main Menu 1
 ↑CALIBRATION
   ALARM
   RELAY
*↓NETWORK

Main Menu 2
 ↑HIDE LOW GAS
   SELF TEST
   SET DATE TIME
 ↓PREVIOUS MENU

Then choose the Modbus Settings Menu:
Network Top Menu
   NETWORK ID MENU
* MODBUS SETTINGS
   PREVIOUS MENU

Then highlight the 485 Bus menu and activate enter:

Modbus Settings Menu 1
↑ONLINE   YES
  SENSORS   UNIQUE
  NET ID   SINGLE
*↓485 BUS MENU

Modbus Settings Menu 2
↓PREVIOUS MENU

        Scroll down to and choose "Comm-Alternate" to change from stop bits of 2 to 1 while preserving all other SEC default settings. Press enter, and all of the bus values will be displayed.

485 Bus Settings Menu
  COMM-DEFAULT
* COMM-ALTERNATE
  COMM-CUSTOM
  PREVIOUS MENU

        The values will be displayed for all parameters, and when you are done viewing them, press enter to return to the 485 Bus Settings menu. Scroll down to and choose the "Previous Menu" item (which will bring up the Save or Abort confirmation) to exit and return to the Modbus Settings menu. Scroll down to and choose the "Previous Menu" item to exit and return to the Network Top Menu. Scroll down to and choose the "Previous Menu" item (which will bring up the Save or Abort confirmation) to exit and return to the Main Menu. Scroll down to and choose the "Previous Menu" item to exit and return to the Top Menu. Scroll down to and choose the "Exit" menu item to exit and return to the Main Status Screen.

        Place the unit on your bus when you are properly configured and ready to test. Navigate through the menus to the Network Menu, Modbus Settings Menu and make sure that the device is set to be "Online".

        You may use a Modbus Master device on the bus (such as the WEB interface of a Schneider EGX gateway) or a PC running ModSCan32 to read the network ID by choosing the network ID of the 3120 device, choosing holding register 42110, 1 item. The value read back should be the same value as the network ID.

Modbus 16-bit Holding Register Map

Table 1: Overall 16-bit Holding Register Region Map

Region	Address Range	Description
0	42001 – 42100	Apply parameter subset to all Sensors
1	42101 – 42200	Sensor 1 Parameters
2	42201 – 42300	Sensor 2 Parameters
3	42301 – 42400	Sensor 3 Parameters
4	42401 – 42500	Sensor 4 Parameters
5	42501 – 42600	Sensor 5 Parameters
6	42601 – 42700	Sensor 6 Parameters
7	42701 – 42800	Sensor 7 Parameters
8	42801 – 42900	Sensor 8 Parameters
9	42901 – 43000	3120 Unit Parameters

Table 2: Region 0: All Sensors- Write only

Holding Register Address Range	ALL Sensor Register Description (Write Only) (See Parameter Tables for specifics)
42004 - 07	Alarm Set Points (Scaled)
42011	Network Zone ID (with password)
42019 - 27	Alarm Set Points (IEE 754 32-bit floating point)
42028 - 39	Calibration Value (IEE 754 32-bit floating point)
42040	Start Self Test

Table 3: Regions 1 - 8: Sensors (x = region/sensor #)

Holding Register Address	Read or Write	Sensor Register Description (See Parameter Table for specifics)
42x01	Read	Gas Concentration (Scaled)
42x02	Read	Operating Status (bit map)
42x03	Read	Sensor Firmware Version
42x04 - x06	Read/Write	Alarm Set Points (Scaled)
42x07	Read/Write	Calibration Value (Scaled)
42x08	Read	Range Value (Scaled)
42x09	Read	Gas Factor (Scale value)
42x10	Read	Network Address ID
42x11	Read/Write	Network Zone ID
42x12	Read	Sensor Device Type Code
42x13	Read	Sensor Status Code
42x14	Read	Sensor Error Code
42x15	Read	Sensor Cell Test Warning Code
42x16	Read	Sensor Serial Number
42x17 - x18	Read	Current Gas (IEEE 754 32-bit float)
42x19 - x27	Read/Write	Alarm Set Points (IEEE 754 32-bit float)

Holding Register Address	Read or Write	Sensor Register Description (See Parameter Table for specifics)
42x28 -x 30	Read/Write	Calibration Value (IEEE 754 32-bit float)
42x31 -x32	Read	Sensor Range (IEEE 754 32-bit float)
42x33	Read	Alarm Configuration (bit map)
42x34 - x37	Read	Gas Name (ASCII characters eight, 1st left to right)
42x38 - x39	Read	Gas Units Name (ASCII characters four, 1st left to right)
42x40	Write Only	Start Self Test (with password)

Table 4: Region 9: 3120 Unit Registers

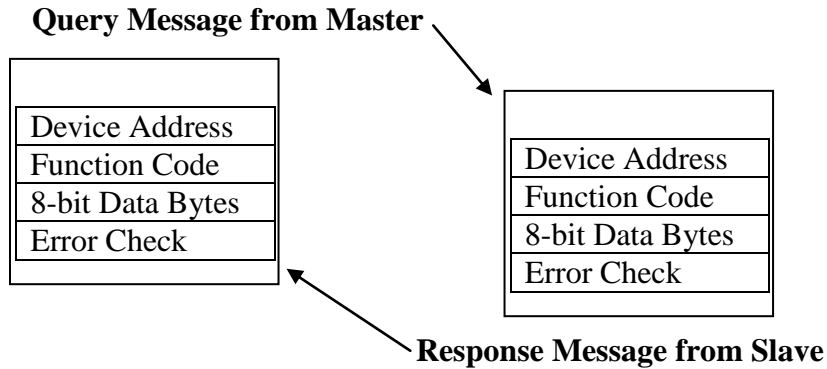| Holding Register Address	Read or Write	3120 Unit Register Description (See Parameter Table for specifics)
42901	Read	Unit Operating Status (bit map)
42902 - 03	Read	Fault Relay Reason Code (32-bit bit map)
42904 - 05	Read	Unit Serial Number (32-bit integer)
42906 - 11	Read	Clock Read Registers (real-time)
42912 - 17	Write Only	Clock Write Registers (New write hold registers)
42918	Write Only	Set Clock from New Clock write hold registers
42919	Write Only	Diagnostics (force alarm/fault relays, force LED blinking)
42920	Write Only	Set Unit into Listen Only Modbus Mode
42921	Write Only	Restore Unit back from Listen Only Modbus Mode
42922	Read	Maximum number of sensors that can be attached
42923	Read	Unit Type Code
42924 - 25	Read	Unit Firmware Version (2- words for major.minor.build)

Modbus Protocol

Introducing Modbus Protocol

Modbus communication is based on a master–slave technique, in which only one device (the master) can initiate transactions (queries). The other devices (the slaves) respond by supplying the requested data to the master, or by taking the action requested in the query. The master can address individual slaves or can initiate a broadcast message to all slaves. Slaves return a message (a response) to queries that are addressed to them individually. Responses are not returned to broadcast queries from the master.

The Modbus protocol establishes the format for the master's query by placing the device (or broadcast) address, a function code defining the requested action, any data to be sent and an error-checking field into the message. The slave's response message is also constructed using Modbus protocol. The response contains fields confirming the action taken, any data to be returned and an error-checking field. If an error occurred in receipt of the message, or if the slave is unable to perform the requested action, the slave will construct an error message and send it as the response.

The Query–Response Cycle

Query Message from Master

Device Address
Function Code
8-bit Data Bytes
Error Check

Device Address
Function Code
8-bit Data Bytes
Error Check

Response Message from Slave

The Query: The function code in the query tells the addressed slave device which kind of action to perform. The data bytes contain any additional information that the slave will need to perform the function. For example, function code 03 will query the slave to read holding registers and respond with their contents. The data field must contain the information telling the slave which register to start at and how many registers to read. The error check field provides a method for the slave to validate the integrity of the message contents.

The Response: If the slave makes a normal response, the function code in the response is an echo of the function code in the query. The data bytes contain the data collected by the slave, such as register values or status. If an error occurs, the function code is modified to indicate that the response is an error response, and the data bytes contain a code that describes the error. The error check field allows the master to confirm that the message contents are valid.

RTU Modbus Message Framing

In RTU serial transmission mode, a Modbus message is placed by the transmitting device into a frame that has a known beginning and ending point. This allows receiving devices to begin at the start of the message, read the address portion, determine which device is addressed (or all devices, if the message is broadcast) and know when the message is completed. Partial messages can be detected and errors can be set as a result.

In RTU mode, messages start with a silent interval of at least 3.5 character times. This is most easily implemented as a multiple of character times at the baud rate that is being used on a network (shown as T1-T2-T3-T4 in Table 5). The first field then transmitted is the device address.

The allowable characters transmitted for all fields are hexadecimal 0-9, A-F. Networked devices monitor the network bus continuously, including during the "silent" intervals. When the first field (the address field) is received, each device decodes it to determine if it is the addressed device.

Following the last transmitted character, a silent interval of at least 3.5 character times marks the end of the message. A new message can begin after this interval.

The entire message frame must be transmitted as a continuous stream. If a silent interval of more than 1.5 character times occurs before completion of the frame, the receiving device flushes the incomplete message and assumes that the next byte will be the address field of a new message.

Similarly, if a new message begins earlier than 3.5 character times following a previous message, the receiving device will consider it a continuation of the previous message. This will set an error, as the value in the final CRC field will not be valid for the combined messages. A typical message is shown below:

Table 5: RTU Message Frame

Start	Address	Function	Data	CRC Check	End
T1-T2-T3-T4	8 Bits	8 Bits	n x Bits (high byte to low byte)	16 Bits (low byte then high byte)	T1-T2-T3-T4

The address field of a message frame contains eight bits (RTU). Valid slave devices are assigned addresses in the range of 1–247 (if only SEC 3120 devices are on this bus slave addressed may go up to 254). A master addresses a slave by placing the slave address in the address field of the message. When the slave sends its response, it places its own address in the address field of the response to let the master know which slave is responding.

Address 0 is used for the broadcast address, which all slave devices recognize.

The function code field of a message frame contains eight bits (RTU). For the SEC 3120, valid codes are 1, 3, 5, 6, 15 and 16 (although holding register ranges are currently only established for codes 3, 6, and 16).

When a message is sent from a master to a slave device, the function code field tells the slave what kind of action to perform. When the slave responds to the master, it uses the function code field to indicate either a normal (error-free) response or that some kind of error occurred (called an exception response). For a normal response, the slave simply echoes the original function code. For an exception response, the slave returns a code that is equivalent to the original function code with its most significant bit set to logic 1.

In addition to its modification of the function code for an exception response, the slave places a unique code into the data field of the response message. This tells the master what kind of error occurred or the reason for the exception.

The master device's application program has the responsibility of handling exception responses. Typical responses are to post subsequent retries of the message, to try diagnostic messages to the slave and to notify operators.

The data field of messages sent from a master to slave devices contains additional information that the slave must use to take the action defined by the function code. This can include items such as discrete and register addresses, the quantity of items to be handled and the count of actual data bytes in the field.

For example, if the master requests a slave to read a group of holding registers (function code 03), the data field specifies the starting register and how many registers are to be read.

If no error occurs, the data field of a response from a slave to a master contains the data requested. If an error occurs, the field contains an exception code that the master application can use to determine the next action to be taken.

The data field can be nonexistent (of zero length) in certain kinds of messages.

CRC Error Checking

In RTU mode, messages include an error-checking field that is based on a Cyclical Redundancy Check (CRC) method. The CRC field checks the contents of the entire message. It is applied regardless of any parity check method used for the individual characters of the message.

The CRC field is 2 bytes, containing a 16-bit binary value. The CRC value is calculated by the transmitting device, which appends the CRC to the message. The receiving device recalculates a CRC during receipt of the message and compares the calculated value to the actual value it received in the CRC field. If the two values are not equal, an error results. The CRC algorithm uses a polynomial of Hexadecimal A001:

1. Load a 16–bit register with FFFF hex (all 1's). Call this the CRC register.
2. Exclusive OR the first 8–bit byte of the message with the low–order byte of the 16–bit CRC register, putting the result in the CRC register.
3. Shift the CRC register one bit to the right (toward the LSB), zero–filling the MSB. Extract and examine the LSB.
4. (If the LSB was 0): Repeat Step 3 (another shift).
   (If the LSB was 1): Exclusive OR the CRC register with the polynomial value A001 hex (1010 0000 0000 0001).
5. Repeat Steps 3 and 4 until 8 shifts have been performed. When this is done, a complete 8–bit byte will have been processed.
6. The CRC register now contains the check value to be appended to (or compared to the received message check value) the end of the message, low 8-bit CRC byte followed by the high 8-bit CRC byte.

Implemented Functions and Registers Defined

The function code identifies the command being issued to the device. It is one byte in length and has a value of 1, 3, 5, 6, 15 or 16.

Table 6: Function Codes Supported By SEC 3120

Function Code	Description
1	Read Coil Status Registers (not supported)
3	Read Holding Registers
5	Force Single Coil Register (not supported)
6	Preset Single Holding Register
15	Force Multiple Coil Registers (not supported)
16	Preset Multiple Holding Registers

For the current 16-bit version, registers are only mapped for function codes 3, 6, and 16. Otherwise an exception response will be generated.

In most cases, there is no response for a query that contains an invalid slave address, invalid CRC data or a non-supported broadcast mode, etc. In some cases, the unit might issue an Exception 2 as an error response if an invalid register address is requested for a valid function code. However, if invalid function code is issued, such as function 07 were transmitted, then an Exception 1 message would be generated to indicate that the function code is not supported.

Query Coil Status Message	
Field Name	**Example (Hex)**
Slave Address	01
Function Code	03
Address High	01
Address Low	5B
Num Points High	00
Num Points Low	03
CRC Low Byte	75
CRC High Byte	E4

Response Exception 2	
Field Name	**Example (Hex)**
Slave Address	01
Function Code	83
Exception Code	02
CRC Low Byte	C0
CRC High Byte	F1

Query Exception Status Message	
Field Name	**Example (Hex)**
Slave Address	11
Function Code	07
CRC Low Byte	4C
CRC High Byte	22

Response Exception 1	
Field Name	**Example (Hex)**
Slave Address	11
Function Code	87
Exception Code	01
CRC Low Byte	83
CRC High Byte	F5

Function Code 03 - Read Holding Registers

The following holding registers (4X references) are supported by the SEC 3120 for one or multiple sequential function code 03 read 16-bit binary operations (multiple read operations must be sequential starting at the specified valid holding register address in the read list). Broadcast mode is not supported for this function.

Table 7: Function Code 03 Read Holding Registers

Internal Register Address x = sensor number (1 - 8)	Holding Register Address	Function Code 03- Read Sensor Register Description (Data bits and Parameter Specifics)
2x00	42x01	*Scaled Sensor Gas Concentration
2x01	42x02	Bit-mapped Sensor Operating Status: Bit 0,1: alarm status (0,0 = no alarm, 0,1 = low alarm, 1,0 = mid alarm, 1,1 = high alarm. Bit 2: fault alarm status (1 = fault, 0 = no) Bit 3: self test (1 = testing, 0 = not) Bit 4: cell test warning (1 = have warning, 0 = no) Bit 5: init/warm (1 = init/startup, 0 = idle/run) Bit 6: sensor missing (1 = missing, 0 = ok) Bit 7: calibration (1 = calibrating, 0 = not) Bit 8 - 15: **Sensor Status Code (8 bit integer)
2x02	42x03	Sensor Firmware Version (1 – 255)
2x03	42x04	*Scaled Low Sensor Alarm Set Point
2x04	42x05	*Scaled Mid Sensor Alarm Set Point
2x05	42x06	*Scaled High Sensor Alarm Set Point
2x06	42x07	*Scaled Sensor Calibration Value
2x07	42x08	*Scaled Sensor Range Value
2x08	42x09	Sensor Gas Factor
*These registers are scaled by Sensor Gas Factor (2x08). To obtain the real floating point		

Internal Register Address x = sensor number (1 - 8)	Holding Register Address	Function Code 03- Read Sensor Register Description (Data bits and Parameter Specifics)
		value in its specific gas units (2x37,38), divide these *register values by the gas factor.
2x09	42x10	Network Address ID (1 – 254)
2x10	42x11	Network Zone ID (1 – 254)
2x11	42x12	Sensor Device Type Code (1/11= toxic, 2/12 = oxygen, 32/33 = infrared combustible, others t.b.d.)
2x12	42x13	**Sensor Status Code
2x13	42x14	***Sensor Error Code
2x14	42x15	Sensor Cell Test Warning Code (128 - to 255 t.b.d)
2x15	42x16	Sensor Serial Number
2x16	42x17	**** Sensor Current Gas Concentration high word
2x17	42x18	**** Sensor Current Gas Concentration low word
2x18	42x19	Sensor Low Alarm Set Point Password Register
2x19	42x20	****Sensor Low Alarm Set Point high word
2x20	42x21	****Sensor Low Alarm Set Point low word
2x21	42x22	Sensor Mid Alarm Set Point Password Register
2x22	42x23	****Sensor Mid Alarm Set Point high word
2x23	42x24	****Sensor Mid Alarm Set Point low word
2x24	42x25	Sensor High Alarm Set Point Password Register
2x25	42x26	****Sensor High Alarm Set Point high word
2x26	42x27	****Sensor High Alarm Set Point low word
2x27	42x28	Sensor Calibration Value Password Register
2x28	42x29	****Sensor Calibration Value high word
2x29	42x30	****Sensor Calibration Value low word
2x30	42x31	****Sensor Range Value high word
2x31	42x32	****Sensor Range Value low word
2x32	42x33	*****Sensor Alarm Configuration
2x33	42x34	Sensor Gas Name (ASCII first and second characters)
2x34	42x35	Sensor Gas Name (ASCII third and fourth characters)
2x35	42x36	Sensor Gas Name (ASCII fifth and sixth characters)
2x36	42x37	Sensor Gas Name (ASCII seventh and eighth characters)
2x37	42x38	Sensor Gas Units (ASCII first and second characters)
2x38	42x39	Sensor Gas Units (ASCII third and fourth characters)

**See Sensor Status Parameter Table 8
***See Sensor Error Code Parameter Table 9
****Value is an IEEE 754 32-bit Floating Point number represented in its associated gas units (2X37, 38). Values are split into two 16-bit register words, high word followed by low word.
*****See Alarm Configuration Parameter Table 10
Sensor Gas Name Example: ASCII text such as "Chlorine", "Oxygen ", etc..
Sensor Gas Units Example: ASCII text such as "PPM ", "%LEL", "%V/V", etc.

Internal Register Address	Holding Register Address	Function Code 03- Read Unit Register Description (Data bits and Parameter Specifics)
2900	42901	Bit-mapped Unit Operating Status: Bit 0: In calibration mode. Bit 1: In start-up init mode. Bit 2: Relays and lights under master control. Bit 3: User operating 3120 display menus. Bit 4: Reading sensors. Bit 5: Accessing media. Bit 6: Saving parameters to NVROM. Bit 7: B.I.T. operation in progress. Bit 8: Formatting media. Bit 9: Setting real time clock. Bit 10: Low relay engaged. Bit 11: Mid relay engaged. Bit 12: High relay engaged. Bit 13: Fault relay engaged. Bit 14: One or more relays latched on. Bit 15: 3120 busy/write protected from changes.
2901	42902	Bit-mapped Fault Relay On Reason Code, Word 1: Bit 0: Have a fault from sensor 1. Bit 1: Have a fault from sensor 2. Bit 2: Have a fault from sensor 3. Bit 3: Have a fault from sensor 4. Bit 4: Have a fault from sensor 5. Bit 5: Have a fault from sensor 6. Bit 6: Have a fault from sensor 7. Bit 7: Have a fault from sensor 8. Bits 8 - 15: Reserved for future sensor channels.
2902	42903	Bit-mapped Fault Relay On Reason Code, Word 2: Bits 7 - 0: Sensor error code of highest faulting sensor. Bits 15 -0: Have a 3120 unit fault (0xFFFF). Bit 15: Alone, sensor is missing. Bits 12,8: Under master control- on (1,0). Bits 12,8: Under master control- off (1,1). Bits 13,14,11,10,9: 0 not defined, t.b.d.
2903	42904	Unit Serial Number (32-bit) high 16-bit word
2904	42905	Unit Serial Number (32-bit) low 16-bit word
2905	42906	Unit Clock Month- Read register (1 - 12)
2906	42907	Unit Clock Day- Read register (1 - 31)
2907	42908	Unit Clock Year- Read register (2000 - 2150)
2908	42909	Unit Clock Hours- Read register (0 - 23)
2909	42910	Unit Clock Minutes- Read register (0 - 59)
2910	42911	Unit Clock Seconds- Read register (0 - 59)
2917	42918	Unit Clock Set Status- Set pending (1), not (0)

Internal Register Address	Holding Register Address	Function Code 03- Read Unit Register Description (Data bits and Parameter Specifics)
2921	**42922**	Maximum number of sensors that can be attached (Allows master to determine if device is a SEC 3100MB16, which only supports one sensor, or an advanced transmitter such as the SEC 3120 which supports at least two sensors)
2922	**42923**	Unit Type Code (0x0100 or 256 decimal)- SEC 3100MB16, (0x0101 or 257 decimal)- SEC 3120 Dual Sensor, (0x0111 or 273 decimal)- SEC 3120 supporting multiple logical sub-channels, other values TBD...
2923	**42924**	Unit Firmware Version Word 1 (Major version- MSB {0 - 255}, Minor version- LSB {0 - 255})
2924	**42925**	Unit Firmware Version Word 2 (Revision/Build number- 16-bit build number increment, 0 - 65535)

Table 8: Sensor Status Code Parameter Table

Value (Hex)	Description
0000	**Sensor is running, normal mode. All is well, OK.**
0001	Not used.
0002	**Sensor Zero Calibrating.**
0003	**Sensor Span Calibrating.**
0004	Sensor 4-20ma Calibrating.
0005	**Sensor in Warm-up.**
0006	Sensor in Power Up Fault.
0007	Sensor in Calibration Fault.
0008	Sensor in Span Fault.
0009	Sensor in Unit Fault.
000A	Sensor in Optics Fault.
000B	**Sensor in Zero Drift Fault.**
000C	Sensor in Configuration Fault.
000D	Sensor in Hot Zero Calibration.
000E	Sensor in Cool Zero Calibration.
000F	Sensor in Self Test Operation.
0010	Sensor in Reference Channel Fault.
0011	Sensor in Active Channel Fault.
0012	Sensor in Power Fault.
0013 - 00FF	Other values t.b.d.

Table 9: Sensor Error Code Parameter Table

Error Code (Hex)	Description
0000	No error, all is well and OK.
0001	EEPROM Header Error.
0002	EEPROM Checksum Error.
0003	Sensor Never Zero Calibrated.
0004	Sensor Never Span Calibrated.
0005	Zero values out of spec.
0006	4-20ma Calibration 1 error.
0007	4-20ma Calibration 2 error.
0008	Signal High Error.
0009	4VDC Reference Low.
000A	4VDC Reference High.
000B	Balance Pot Max.
000C	Balance Pot Min.
000D	AGC Pot Max.
000E	AGC Pot Min.
000F	Span Pot Max.
0010	Span Pot Min.
0011	Sensor Never Hot Zero Calibrated.
0012	Sensor Never Cool Zero Calibrated.
0013	Unit Temperature > +85 degrees Celsius.
0014	Unit Temperature < -35 degrees Celsius.
0015	Insufficient Analytical Range.
0016	No table downloaded.
0017	Span calibration invalidated by new range or calibration value.
0018	Span Pot overflow (not enough span pot range for temperature adjustment or insufficient analog signal).
0019	24VDC Supply Low.
001A	24VDC Supply High.
001B - 00FF	t.b.d.

Table 10: Alarm Configuration Parameter Table

Bit Field	Description
Bit 0	Low alarm relay normally energized (1) or not (0).
Bit 1	Low alarm relay latching mode enabled (1) or not (0).
Bit 2	Low alarm relay audible alarm mode enabled (2) or not (0).
Bit 3	Low alarm on when gas is above low set point (1) or below (0).
Bit 4	Mid alarm relay normally energized (1) or not (0).
Bit 5	Mid alarm relay latching mode enabled (1) or not (0).
Bit 6	Mid alarm relay audible alarm mode enabled (2) or not (0).
Bit 7	Mid alarm on when gas is above mid set point (1) or below (0).
Bit 8	High alarm relay normally energized (1) or not (0).
Bit 9	High alarm relay latching mode enabled (1) or not (0).
Bit 10	High alarm relay audible alarm mode enabled (2) or not (0).
Bit 11	High alarm on w/gas above high set point (1) or below (0).
Bit 12	Fault alarm relay normally energized (1) or not (0).
Bit 13	Fault alarm relay latching mode enabled (1) or not (0).
Bit 14	Fault alarm relay audible alarm mode enabled (2) or not (0).
Bit 15	Fault alarm on when fault code for sensor non-zero (always 0).

Read Holding Registers Query

The query message specifies the starting register and quantity of registers to be read. SEC 3120 internal registers are addressed starting at zero: Modbus holding registers 1–16 are addressed as 0–15.

Multiple sensors are allowed to be attached to a single 3120 unit; therefore the register map is split into regions as shown previously in Table 1. Each sensor has its own region (a repetition of the same parameter registers that address each specific sensor's parameters), and each region is a multiple of 100, as expressed by its sensor number (i.e. sensor 1 - region 1, or internal register 21xx, sensor 2 - region 2, or internal register 22xx).

Region 0 is reserved for write-only for applying changes to all sensors, therefore *Region 0 (internal registers 20xx) cannot be read.*

Region 9 is reserved for SEC 3120 unit level information rather than sensor specific information. Region 9 (internal registers 29xx) can be read. The maximum number of sensors that may be attached to the transmitter can be queried from internal registers 2921. This will allow the master to determine if the other regions apply (region 0, 2-8) if it returns a one indicating that it is an SEC 3100MB16 device, or an advanced transmitter such as the SEC 3120 (returning two or more).

Note: An SEC 3120 configure as "Single Sensor" mode, will return a one indicating that only regions 1 and 9 are accessible- requests to read regions outside of this range (2 - 8 or 0) will generate exception 2 messages.

Here is an example of a request to read Modbus holding registers 42104–42106 from slave device 17, sensor 1 (region 1 = 21xx):

Read Holding Register Query

Field Name	Example (Hex)
Slave Address	11
Function Code	03
Starting Address High	08
Starting Address Low	37
Num Points High	00
Num Points Low	03
CRC Low Byte	B4
CRC High Byte	F5

Response

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 byte contains the low order bits.

Here is an example of a response to the query:

Read Holding Register Response

Field Name	Example (Hex)
Slave Address	11
Function Code	03
Byte Count	06
Data High Byte (Register 42104)	01
Data Low Byte (Register 42104)	2A
Data High Byte (Register 42105)	01
Data Low Byte (Register 42105)	8F
Data High Byte (Register 42106)	03
Data High Byte (Register 42106)	21
CRC Low Byte	04
CRC High Byte	5D

The contents of register 42104 are shown as the two byte values of 01 2A hex or 298 decimal. The contents of registers 42105 and 42106 are 01 8F and 03 21 hex, or 399 and 801 decimal, respectively.

SEC 3120 units support 40+ holding registers for each sensor attached, as well as an additional 12+ holding registers specific to the 3120 unit head itself as listed in Table 7.

If a starting address is not within the range shown in Table 7, the SEC 3120 unit will issue an Exception 2 as a response. If the number of points is too many, the SEC 3120 may issue an Exception 3 as a response.

Response Exception 2	
Field Name	**Example (Hex)**
Slave Address	01
Function Code	83
Exception Code	02
CRC Low Byte	C0
CRC High Byte	F1

Response Exception 3	
Field Name	**Example (Hex)**
Slave Address	01
Function Code	83
Exception Code	03
CRC Low Byte	01
CRC High Byte	31

Note: <u>SCAN MODE</u>: A crucial feature of the SEC 3120 16-bit Modbus implementation is that it **enables a Modbus Master to gain one or *more* holding register contents at a time.** This allows the master to start at any legal holding register address and retrieve in *one scan block,* an *entire set* of relevant parameters for a given sensor, such as Gas Concentration, Operating Status and Alarm Set Points or more in *one read query operation.*

Function Code 06 - Preset Single Holding Register

Description

Presets a value into a single holding register (4x references). Modbus allows a broadcast mode with function presets to the same register reference in all attached slaves, however the SEC 3120 supports multiple sensors attached to a single unit, hence broadcast mode is not allowed, except for one preset register pair 42920 (listen only mode) and 42921 (restore from listen only mode).

To accomplish the same functionality as a broadcast to the same preset reference in the SEC 3120, so long as the sensors attached are truly identical, region 0 of the holding register map (holding register address range 42001 - 42099) may be used. If written to the same relative offsets as the sensor regions (i.e. 42004 for 42x04, 42005 for 42x05, where x = specific sensor number) then the values written to region 0 registers will apply as if written to all sensor relative region offset registers.

The advantage of using a preset function is that it does not have the overhead of an item count or a byte count. It is a very small packet targeted at changing one very specific 16-bit register with a full read-back of the contents to ensure proper communication.

Table 11: Function Code 06 Preset Holding Register

Internal Register Address x = sensor number, or 0 to apply to all sensors.	Holding Register Address	Function Code 06- Preset Sensor Register Description (Data bits and Parameter Specifics)
2x03	42x04	*Scaled Integer Sensor Alarm Low Set Point. 4000 Hex must be added as a password to write value.
2x04	42x05	*Scaled Integer Sensor Alarm Mid Set Point. 4000 Hex must be added as a password to write value.
2x05	42x06	*Scaled Integer Sensor Alarm High Set Point. 4000 Hex must be added as a password to write value.
2x06	42x07	*Scaled Integer Sensor Calibration Value. 4000 Hex must be added as a password to write value.
2x10	42x11	**Sensor Zone ID. 4000 Hex must be added as a password to write value.
2x39	42x40	**Start Sensor Self Test Operation (00FF Hex Start, 0 stop) 4000 Hex must be added as a password to write value.

*The real value must be multiplied by the Gas Factor (2x08).
i.e. 2.12 ppm to set low set point register: scaled low set point = 2.12 X 10 (from 2x08) = 212 (00D4 Hex). When the password is added (4000 Hex) the complete value needed to write the register and change the low set point then is 40D4 Hex.

** Zone ID (2010/42012) and Self Test (2039/42040) may be written to in region zero (apply to all sensors) for a 3120 with two or more sensors attached, when the sensor role is either "Unique" or "Identical" modes, but NOT when in "Single" sensor role- an exception message will be generated and sent back to the master in place of a message echo. If sensor role is "Identical", values must also be identical!

Internal Register Address	Holding Register Address	Function Code 06- Preset Unit Register Description (Data bits and Parameter Specifics)
2911	42912	New 3120 Unit Clock Month Value. 4000 Hex must be added as a password to write value.
2912	42913	New 3120 Unit Clock Day Value. 4000 Hex must be added as a password to write value.
2913	42914	New 3120 Unit Clock Year Value. 4000 Hex must be added as a password to write value.
2914	42915	New 3120 Unit Clock Hours Value. 4000 Hex must be added as a password to write value.
2915	42916	New 3120 Unit Clock Minutes Value. 4000 Hex must be added as a password to write value.
2916	42917	New 3120 Unit Clock Seconds Value. 4000 Hex must be added as a password to write value.
2917	42918	Set New 3120 Unit Clock NOW (00FF Hex set, 0 clear). 4000 Hex must be added as a password to write value.

Internal Register Address	Holding Register Address	Function Code 06- Preset Unit Register Description (Data bits and Parameter Specifics)

2918	**42919**	Bit-mapped Diagnostics Force Coils And Toggle LEDs.
		    Bit 0: Force low relay coil (1 = on, 0 = off)
		    Bit 1: Force mid relay coil (1 = on, 0 = off)
		    Bit 2: Force high relay coil (1 = on, 0 = off)
		    Bit 3: Force fault relay coil (1 = on, 0 = off)
		    Bit 4: Toggle LEDs red/green (1 = on, 0 = off)
		Duration of force will be approximately 30 seconds unless re-written.
		4000 Hex must be added as a password to write value.

2919	**42920**	Modbus Listen Only (00FF engages). No response will be given and unit will not respond to any commands addresses to it or broadcast, other than command to restore from listen only (2920). 4000 Hex must be added as a password to write value.
2920	**42921**	Modbus Restore From Listen Only (00FF engages). Response will be given and unit will resume responding to commands addresses to it or broadcast. 4000 Hex must be added as a password to write value.

The SEC 3120 supports sensor preset holding registers as shown in table 11 previously. To avoid accidentally writing to any of these registers, 4000 hex (16384 decimal) must be added to the register value as a password. Parameter registers low, mid, and high alarm set points and calibration value must be less than the full scale (range) of measurement. For example, if the range of measurement is 2000 ppm for Chlorine, then to set 1200 ppm as the high alarm set point, the value of register 42x06 should be 44B0 hex (17584 decimal).

The normal response is an echo of the query, returned after the register contents have been preset.

Query

The query message specifies the register reference to be preset. Registers are addressed starting at zero: register 1 is addressed as 0.

Here is an example of a request to preset register 42106 to set high alarm set point as 1200 in slave device 17, for sensor 1:

Preset One Sensor High Set Point Holding Register Query	
Field Name	**Example (Hex)**
Slave Address	11
Function Code	06
Address High	08
Address Low	39
Data High	44
Data Low	B0
CRC Low Byte	6B
CRC High Byte	83

Preset ALL Sensor High Set Point Holding Registers Query	
Field Name	**Example (Hex)**
Slave Address	11
Function Code	06
Address High	07
Address Low	D5
Data High	44
Data Low	B0
CRC Low Byte	A9
CRC High Byte	62

The normal response is an echo of the query, returned after the register contents have been preset.

Response

Here is an example of a response to the query shown above:

Preset One Sensor High Set Point Holding Register Response	
Field Name	**Example (Hex)**
Slave Address	11
Function Code	06
Address High	08
Address Low	39
Data High	44
Data Low	B0
CRC Low Byte	6B
CRC High Byte	83

Preset ALL Sensor High Set Point Holding Registers Response	
Field Name	**Example (Hex)**
Slave Address	11
Function Code	06
Address High	07
Address Low	D5
Data High	44
Data Low	B0
CRC Low Byte	A9
CRC High Byte	62

If the register address in the query shown previously is not valid for a preset register function, the SEC 3120 unit will issue an Exception 2 as a response. If the preset data in the query does not include the password, the SEC 3120 unit will issue an Exception 8 as a response. If the SEC 3120 unit is not operating in identical sensor role mode (for setting threshold values), it will generate an Exception 3 response.

Response Exception 2	
Field Name	**Example (Hex)**
Slave Address	01
Function Code	86
Exception Code	02
CRC Low Byte	C3
CRC High Byte	A1

Response Exception 3	
Field Name	**Example (Hex)**
Slave Address	01
Function Code	86
Exception Code	03
CRC Low Byte	02
CRC High Byte	61

Response Exception 8	
Field Name	**Example (Hex)**
Slave Address	01
Function Code	86
Exception Code	08
CRC Low Byte	43
CRC High Byte	A6

Function Code 16 - Write Multiple Holding Registers

Description

Writes a set of values into one or more sequential holding registers (4x references). Modbus does NOT allow a broadcast mode with this function code.

Table 12: Function Code 16 Multiple Write Holding Registers

Internal Register Address x = sensor number, or 0 to apply to all sensors.	Holding Register Address	Function Code 16- Write Multiple Sensor Registers (Data bits and Parameter Specifics)
2x03	42x04	*Scaled Integer Sensor Alarm Low Set Point. 4000 Hex must be added as a password to write value.
2x04	42x05	*Scaled Integer Sensor Alarm Mid Set Point. 4000 Hex must be added as a password to write value.
2x05	42x06	*Scaled Integer Sensor Alarm High Set Point. 4000 Hex must be added as a password to write value.
2x06	42x07	*Scaled Integer Sensor Calibration Value. 4000 Hex must be added as a password to write value.
2x10	42x11	***Sensor Zone ID. 4000 Hex must be added as a password to write value.
2x18	42x19	Sensor Low Set Point Enable Register. This register must be written to first with 4259 Hex as a password.
2x19	42x20	**Sensor Low Alarm Set Point Float high word.
2x20	42x21	**Sensor Low Alarm Set Point Float low word.
2x21	42x22	Sensor Low Alarm Set Point Enable Register. This register must be written to first with 4259 Hex as a password.
2x22	42x23	**Sensor Alarm Mid Set Point Float high word.
2x23	42x24	**Sensor Alarm Mid Set Point Float low word.
2x24	42x25	Sensor Alarm High Set Point Enable Register. This register must be written to first with 4259 Hex as a password.
2x25	42x26	**Sensor Alarm High Set Point Float high word.
2x26	42x27	**Sensor Alarm High Set Point Float low word.
2x27	42x28	Sensor Calibration Value Enable Register. This register must be written to first with 4259 Hex as a password.
2x28	42x29	**Sensor Calibration Value Float high word.
2x29	42x30	**Sensor Calibration Value Float low word.
2x39	42x40	***Start Sensor Self Test Operation (00FF Hex Start, 0 stop) 4000 Hex must be added as a password to write value.

Internal Register Address x = sensor number, or 0 to apply to all sensors.	Holding Register Address	Function Code 16- Write Multiple Sensor Registers (Data bits and Parameter Specifics)

*The real value must be multiplied by the Gas Factor (2x08).

i.e. 2.12 ppm to set low set point register: scaled low set point = 2.12 X 10 (from 2x08) = 212 (00D4 Hex). When the password is added (4000 Hex) the complete value needed to write the register and change the low set point then is 40D4 Hex.

**Sensor Float parameters (low, mid and high set points and calibration values) must be written in sequence in at least one multiple item write operation, starting in order with the enable password register, high word then low word. These values are IEEE 754 encoded 32-bit values split into two 16-bit words. Upon a complete write of the triad, the value is saved internally.

***Zone ID (2010/42011) and Self Test (2039/42040) may be written in region 0 (apply to all sensors) when a SEC 3120 is in either "Identical" or "Unique" sensor roles (unlike set point or threshold registers where the sensor role must be "Identical"), however if in the "Single" sensor role, an exception message will be transmitted to the master. If sensor role is "Identical", values must also be identical!

Internal Register Address	Holding Register Address	Function Code 16- Write Multiple Unit Registers (Data bits and Parameter Specifics)
2911	42912	New 3120 Unit Clock Month Value. 4000 Hex must be added as a password to write value.
2912	42913	New 3120 Unit Clock Day Value. 4000 Hex must be added as a password to write value.
2913	42914	New 3120 Unit Clock Year Value. 4000 Hex must be added as a password to write value.
2914	42915	New 3120 Unit Clock Hours Value. 4000 Hex must be added as a password to write value.
2915	42916	New 3120 Unit Clock Minutes Value. 4000 Hex must be added as a password to write value.
2916	42917	New 3120 Unit Clock Seconds Value. 4000 Hex must be added as a password to write value.
2917	42918	Set New 3120 Unit Clock NOW (00FF Hex set, 0 clear). 4000 Hex must be added as a password to write value.
2918	42919	Bit-mapped Diagnostics Force Coils And Toggle LEDs. Bit 0: Force low relay coil (1 = on, 0 = off) Bit 1: Force mid relay coil (1 = on, 0 = off) Bit 2: Force high relay coil (1 = on, 0 = off) Bit 3: Force fault relay coil (1 = on, 0 = off) Bit 4: Toggle LEDs red/green (1 = on, 0 = off) Duration of force will be approximately 30 seconds unless re-written. 4000 Hex must be added as a password to write value.

The SEC 3120 supports multiple write holding sensor and unit registers as shown in table 12 above. To avoid accidentally writing to any of these registers, a password is required. For most registers (as designated in the table above) 4000 hex (16384 decimal) must be added to the register value as a password.

For floating point register sets, the first register in the trio is the password enable register. This register must have the Hex value 4259 written to it first, followed by the high word and then the low word of the 32-bit IEEE floating point encoded value, using at leas one multiple write operation.

Parameter registers low, mid, and high alarm set points and calibration value must be less than the full scale (range) of measurement.

When setting the new clock time, registers 42912-17 are written first, followed by 42918 to actually set the time (copy new values to clock and run).

The normal response is an echo of the query header (which contains the unit number, function code, starting address and number of registers).

Query

The query message specifies the register reference to be preset. Registers are addressed starting at zero: register 1 is addressed as 0.

Here is an example of a request to write holding registers 42119 - 42121 to set the low alarm set point floats 400.12 (43C8 0F5C Hex) in slave device 17, for sensor 1:

Write Multiple Holding Registers Query	
Field Name	**Example (Hex)**
Slave Address	11
Function Code	10
Address High	08
Address Low	46
Item Count High	00
Item Count Low	03
Num Data Bytes	06
Data High (42119)	42
Data Low (42119)	59
Data High (42120)	43
Data Low (42120)	C8
Data High (42121)	0F
Data Low (42121)	5C
CRC Low Byte	92
CRC High Byte	27

The normal response is an echo of the query header, returned after the register contents have been written.

Response

Here is an example of a response to the query on the previous page:

Write Multiple Holding Registers Response

Field Name	Example (Hex)
Slave Address	11
Function Code	10
Address High	08
Address Low	46
Item Count High	00
Item Count Low	03
CRC Low Byte	61
CRC High Byte	2D

If the register address in the query is not valid for a multiple register write function, the SEC 3120 unit will issue an Exception 2 as a response. If the multiple register write enable password register in the query did not include the proper password, the SEC 3120 unit will issue an Exception 8 as a response. If the SEC 3120 unit is not operating in identical sensor role mode, and an attempt to write to ALL sensors (address range 42001 to 42100, except 42011- Zone ID & 42040- Self Test) it will generate an Exception 3 response.

Response Exception 2

Field Name	Example (Hex)
Slave Address	01
Function Code	86
Exception Code	02
CRC Low Byte	C3
CRC High Byte	A1

Response Exception 3

Field Name	Example (Hex)
Slave Address	01
Function Code	86
Exception Code	03
CRC Low Byte	02
CRC High Byte	61

Response Exception 8

Field Name	Example (Hex)
Slave Address	01
Function Code	86
Exception Code	08
CRC Low Byte	43
CRC High Byte	A6

Note: <u>SCAN MODE</u>: A crucial feature of the SEC 3120 16-bit Modbus implementation is that it **enables a Modbus Master to update one or *more* holding register contents at a time.** This allows the master to start at any legal holding register address and update in *one scan block,* an *entire set* of relevant parameters for a given sensor, such as all Alarm Set Points in *one write operation.*

This is especially useful for updating a sequence of 16-bit registers that need to be written together to be valid and protect against unwanted or accidental write operations. In the case of the IEEE 754 32-bit Floating Point Alarm Set Points, a triad of registers is required to fully change a given set point, all in one action otherwise the operation will be rejected as a password failure. Since a 32-bit floating point value requires two 16-bit registers to hold the entire contents, a set of three registers is designated;
  1. Password enable register- must contain the Hexadecimal value 4259.
  2. High 16-bit word of IEEE 754 encoded floating point set point value.
  3. Low 16-bit word of IEEE 754 encoded floating point set point value.

A state machine ensures that the sequence order is followed and that the password enable register occurs first in the multi-write operation and contains the correct value. If the sequence is not followed correctly or the password is incorrect, the set point will not be updated and an exception generated. This prevents un-intended write operations.

At the same time, it allows multiple-word values or blocks that make up a huge value to be written, without breaking the Modbus 16-bit specification or creating a burdensome long set of 16-bit operations.

In both multiple read and write operations, it allows a low-level Master driver to determine whether it uses a single or multiple register operation, thus enabling better efficiency in the Modbus Master.

Sensor Roles and Modbus

The SEC 3120 allows three major modes or roles of operation regarding attached sensors;

1. **Single Sensor Role-** In this role, the SEC 3120 works much more like the SEC 3100 and 3100MB16, monitoring and reporting on only one attached sensor to its sensor one connector while ignoring any other attached sensors. The effect is a single sensor, single network ID, and total exclusive control of the units relays, screen and LEDs.
   - **Modbus Effects-** since the 3120 (head) operates as if it only has a single sensor attached;
     o The address ALL sensor region (42001 - 42099) will be ignored and generate exception messages if addressed by a master. No reads or writes will be allowed.
     o Sensor region one will only be readable and writeable (42101 - 42199).
     o Sensor regions two through eight (42201 - 42899) will be ignored and if accessed will generate exception messages to the master.
     o Unit region nine (42901 - 42999) will function normally as described in this document, unaffected by sensor role.

2. **Identical Sensor Role-** In this role, ALL sensors attached (more than one) must have identical gas types, detection types and gas ranges. The purpose of this role is to provide redundancy and reliability to sensitive detection operations where relays should not be activated unless at least two sensors are in agreement as to the actual gas concentration levels independently measured. The relays are controlled in a logical "AND" operation for alarm levels, while faults continue to operate the fault relay in a logical "OR" configuration- meaning ANY sensor with a fault will cause the fault relay to energize.
   - **Modbus Effects-** since the 3120 (head) operates as if it has identical sensors attached;
     o The address ALL sensor region (42001 - 42099) will be allowed to apply thresholds/set points and calibration values to ALL sensors to streamline setup and configuration.
     o All sensor regions in accordance with the number of reported maximum attached sensors (see unit register 42922) are independently readable and writeable (42101 - 42899).
     o A change written in threshold/set point registers in any given sensor region will result in that value being copied to the other corresponding sensor parameter.
     o Writes to Zone ID (42x11) must be identical in all sensors regions, and in fact, the final region written (typically 42211) will set the final value for all sensors.
     o Unit region nine (42901 - 42999) will function normally as described in this document, unaffected by sensor role.

3. **Unique Sensor Role-** In this role, all sensors attached may have different gas types, ranges and detection types. The purpose of this role is consolidate space and act as a central hub to multiple sensors and logical sub-channels. Alarm relays may be programmed to operate in any fashion, but typically driven in a logical "OR" configuration, thus ANY sensor alarm level drives the respective relay. Sensor faults by any sensor operate the fault relay in a logical "OR" configuration as well.

- **Modbus Effects-** since the 3120 (head) operates allowing multiple sensors having different gas detection types and ranges and sub-channels;
  - o The address ALL sensor region (42001 - 42099) will be ignored and generate exception messages if addressed by a master. No reads or writes will be allowed.
  - o All sensor regions in accordance with the number of reported maximum attached sensors (see unit register 42922) are independently readable and writeable (42101 - 42899).
  - o Unit region nine (42901 - 42999) will function normally as described in this document, unaffected by sensor role.

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