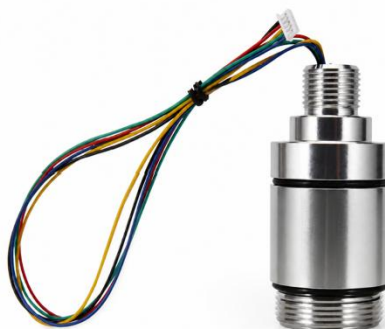


## SensorsX SX-GMSA Series

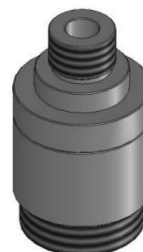
Industrial Smart Gas Sensor Module  
Standardized Plug-and-Play Gas Detection Module



|                                         |                                           |                                                 |
|-----------------------------------------|-------------------------------------------|-------------------------------------------------|
| <b>DC 5–24 V</b><br>Power Supply        | <b>UART / RS-485</b><br>Modbus RTU Output | <b>30–60 s</b><br>Warm-up Time                  |
| <b>Ø41 × 67 mm</b><br>(Ø1.61 × 2.64 in) | <b>35 g (1.23 oz)</b><br>Module Weight    | <b>–20 to +50°C</b><br>(–4 to +122°F) Operating |

### ■ PRODUCT OVERVIEW

The SX-GMSA Series is a smart gas sensor module that standardizes the interface for various gas sensors and converts sensor signals into standardized digital output. It supports digital output and optional analog voltage output for easier integration and commissioning. The module features a high-strength aluminum-alloy housing, a wide DC 5–24 V supply range, and factory calibration for plug-and-play operation. Typical applications include gas alarm instruments, industrial gas detection, mine gas detection, ambient gas monitoring, and research or academic applications.



### ■ KEY FEATURES

|                                                                                                     |                                                                                                         |
|-----------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------|
| ◆ Standardized Module Design Unified interface and packaging across many different gas sensor types | ◆ Hot-Swappable Plug-and-play terminal connection without soldering                                     |
| ◆ Factory-calibrated and ready to use; no recalibration or secondary development required           | ◆ Multiple Output Signals Simultaneous digital (UART) and analog output                                 |
| ◆ Optional RS-485 output with standard Modbus RTU protocol                                          | ◆ Broad sensor compatibility with electrochemical, catalytic-combustion, infrared, and PID technologies |
| ◆ Compact and lightweight design with high accuracy and fast, stable response                       | ◆ Fast warm-up and low power consumption with high resistance to interference                           |

## ■ TYPICAL APPLICATIONS

- Smart public-restroom gas detection
- Smart agriculture gas detection
- Utility tunnel and pipe-gallery gas detection
- Smart manhole-cover gas detection
- Tunnel and roadway gas detection
- Smart livestock-farming gas detection
- Smart grain-storage gas detection
- Underground parking-garage gas detection
- Research and environmental monitoring
- Industrial automation gas detection, including inspection robots
- Automotive electronics, smart fire safety, and test & measurement instruments

## ■ PERFORMANCE SPECIFICATIONS

|                            |                                                                                                    |
|----------------------------|----------------------------------------------------------------------------------------------------|
| <b>Detection Method</b>    | Natural diffusion (flow-through version available upon request)                                    |
| <b>Sensor Technologies</b> | Electrochemical / Catalytic combustion / Infrared / Photoionization (PID), depending on target gas |
| <b>Warm-Up Time</b>        | 30 – 60 s                                                                                          |
| <b>Operating Life</b>      | Electrochemical: 2 years   Infrared: 5 years   Catalytic combustion: 2 years                       |

### Detection Gas Parameters (Standard Range Options)

| Sensor Technology | Target Gas                          | Standard Range | Accuracy                              | Resolution | Power  |
|-------------------|-------------------------------------|----------------|---------------------------------------|------------|--------|
| Electrochemical   | Oxygen (O <sub>2</sub> )            | 0–30 %VOL      | ±3 %FS                                | 0.1 %VOL   | 15 mW  |
| Electrochemical   | Carbon Monoxide (CO)                | 0–1000 ppm     | ±5 ppm or ±10% (whichever is greater) | 1 ppm      | 15 mW  |
| Electrochemical   | Hydrogen Sulfide (H <sub>2</sub> S) | 0–100 ppm      | ±2 ppm or ±10% (whichever is greater) | 1 ppm      | 15 mW  |
| Electrochemical   | Nitric Oxide (NO)                   | 0–250 ppm      | ±5 %FS                                | 1 ppm      | 15 mW  |
| Electrochemical   | Nitrogen Dioxide (NO <sub>2</sub> ) | 0–20 ppm       | ±5 %FS                                | 0.1 ppm    | 15 mW  |
| Electrochemical   | Sulfur Dioxide (SO <sub>2</sub> )   | 0–20 ppm       | ±5 %FS                                | 0.1 ppm    | 15 mW  |
| Infrared          | Carbon Dioxide (CO <sub>2</sub> )   | 0–5 %VOL       | ±(0.05 + 5% of reading)               | 0.01 %VOL  | 100 mW |
| Infrared          | Carbon Dioxide (CO <sub>2</sub> )   | 0–5000 ppm     | ±(0.05 + 5% of reading)               | 1 ppm      | 100 mW |
| Electrochemical   | Ozone (O <sub>3</sub> )             | 0–20 ppm       | ±12 %FS                               | 0.1 ppm    | 15 mW  |
| Electrochemical   | Ammonia (NH <sub>3</sub> )          | 0–100 ppm      | ±10%                                  | 1 ppm      | 15 mW  |
| Electrochemical   | Hydrogen Fluoride (HF)              | 0–10 ppm       | ±10%                                  | 0.1 ppm    | 15 mW  |
| Electrochemical   | Hydrogen Chloride (HCl)             | 0–50 ppm       | ±10%                                  | 0.1 ppm    | 15 mW  |

| Sensor Technology     | Target Gas                                         | Standard Range | Accuracy | Resolution | Power  |
|-----------------------|----------------------------------------------------|----------------|----------|------------|--------|
| Electrochemical       | Hydrogen Cyanide (HCN)                             | 0–50 ppm       | ±10%     | 0.1 ppm    | 15 mW  |
| Electrochemical       | Phosphine (PH <sub>3</sub> )                       | 0–20 ppm       | ±10%     | 0.1 ppm    | 15 mW  |
| Electrochemical       | Methyl Mercaptan (CH <sub>4</sub> S)               | 0–100 ppm      | ±10%     | 1 ppm      | 15 mW  |
| Electrochemical       | Formaldehyde (CH <sub>2</sub> O)                   | 0–10 ppm       | ±10%     | 0.1 ppm    | 15 mW  |
| Electrochemical       | Chlorine (Cl <sub>2</sub> )                        | 0–50 ppm       | ±10%     | 0.1 ppm    | 15 mW  |
| Electrochemical       | Hydrogen (H <sub>2</sub> )                         | 0–1000 ppm     | ±10%     | 1 ppm      | 15 mW  |
| Electrochemical       | Ethylene Oxide (C <sub>2</sub> H <sub>4</sub> O)   | 0–100 ppm      | ±10%     | 1 ppm      | 15 mW  |
| Infrared              | Methane (CH <sub>4</sub> )                         | 0–5 %VOL       | ±5 %FS   | 0.01 %VOL  | —      |
| Infrared              | Methane (CH <sub>4</sub> )                         | 0–100 %VOL     | ±5 %FS   | 1 %VOL     | —      |
| Catalytic Combustion  | Combustible Gas                                    | 0–100 %LEL     | ±5 %FS   | 1 %VOL     | 300 mW |
| Electrochemical       | Chlorine Dioxide (ClO <sub>2</sub> )               | 0–50 ppm       | ±10%     | 1 ppm      | 15 mW  |
| Electrochemical       | VOC                                                | 0–100 ppm      | ±10%     | 1 ppm      | 15 mW  |
| PID (Photoionization) | VOC / PID                                          | 0–10 ppm       | 0.1 ppm  | 1 ppb      | 110 mW |
| PID (Photoionization) | VOC / PID                                          | 0–40 ppm       | 1 ppb    | 10 ppb     | 110 mW |
| PID (Photoionization) | VOC / PID                                          | 0–100 ppm      | 25 ppb   | 25 ppb     | 110 mW |
| Electrochemical       | Hydrogen Peroxide (H <sub>2</sub> O <sub>2</sub> ) | 0–100 ppm      | ±10%     | 1 ppm      | 15 mW  |

※ Table lists standard range options for commonly supplied gases; other gases and ranges are available on request.

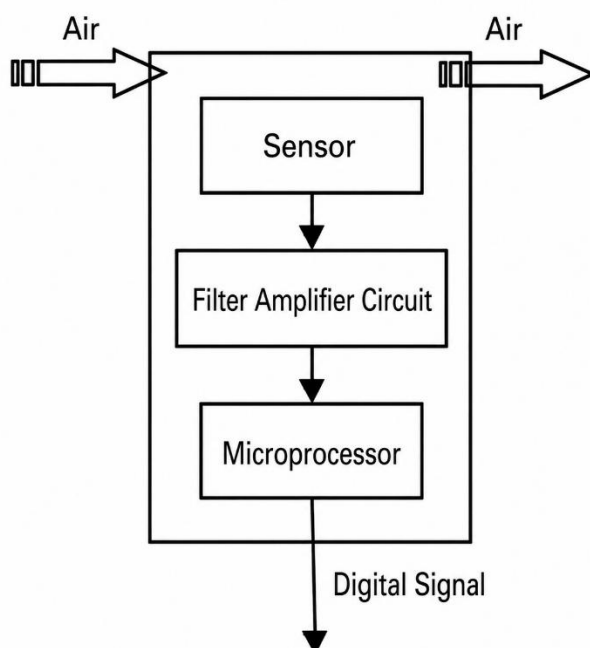
## ELECTRICAL SPECIFICATIONS

|                   |                                                                                               |
|-------------------|-----------------------------------------------------------------------------------------------|
| Supply Voltage    | DC 5 – 24 V                                                                                   |
| Power Consumption | See Performance Specifications (Detection Gas Parameters) table — varies by sensor technology |
| Digital Output    | UART or RS-485 (selectable), Modbus RTU protocol                                              |
| Analog Output     | 0 – 2 V (optional)                                                                            |
| Serial Parameters | Baud rate 9600 bps; Data bits 8; Stop bits 1; Parity None                                     |

## ENVIRONMENTAL SPECIFICATIONS

|                       |                                     |
|-----------------------|-------------------------------------|
| Operating Temperature | –20 to +50°C (–4 to +122°F)         |
| Operating Humidity    | 10% – 95% RH, non-condensing        |
| Housing Material      | High-strength aluminum alloy        |
| Overall Dimensions    | Ø41 mm × 67 mm (Ø1.61 in × 2.64 in) |

|               |                |
|---------------|----------------|
| <b>Weight</b> | 35 g (1.23 oz) |
|---------------|----------------|



**Working Principle:** The signal from the gas sensor is amplified and filtered (the filter/amplifier circuit differs by sensor type), after which the microprocessor performs the calculation and outputs a digital signal.

## ■ COMMUNICATION PROTOCOLS

### Modbus RTU — Serial Interface

|                        |          |
|------------------------|----------|
| <b>Baud Rate</b>       | 9600 bps |
| <b>Data Bits</b>       | 8        |
| <b>Stop Bits</b>       | 1        |
| <b>Parity</b>          | None     |
| <b>Default Address</b> | 0xFF     |

### Read Request Frame (Function Code 0x03)

| Address        | Function | Reg. Addr. Hi | Reg. Addr. Lo | Reg. Count Hi | Reg. Count Lo | CRC Lo | CRC Hi |
|----------------|----------|---------------|---------------|---------------|---------------|--------|--------|
| 0xFF (default) | 0x03     | —             | —             | —             | —             | —      | —      |

### Successful Read Response Frame

| Address        | Function | Byte Count | Data 1 ... Data n | CRC Lo | CRC Hi |
|----------------|----------|------------|-------------------|--------|--------|
| 0xFF (default) | 0x03     | —          | —                 | —      | —      |

### Error Response Frame

| Address        | Error Function Code | Error Code | CRC Lo | CRC Hi |
|----------------|---------------------|------------|--------|--------|
| 0xFF (default) | 0x83                | —          | —      | —      |

### Write Request / Response Frame (Function Code 0x10)

| Address        | Function | Reg. Addr. Hi/Lo | Reg. Count Hi/Lo | Byte Count | Data | CRC Lo/Hi |
|----------------|----------|------------------|------------------|------------|------|-----------|
| 0xFF (default) | 0x10     | —                | —                | —          | —    | —         |

## Register Map

| Logical Address | Register Description           | Count | Reference                             | Access       |
|-----------------|--------------------------------|-------|---------------------------------------|--------------|
| 0x2011          | Module Communication ID        | 1     | Modbus address 0–254                  | Read / Write |
| 0x2021          | Sensor Type                    | 1     | See Sensor Type table                 | Read Only    |
| 0x2027          | Gas Name Code                  | 1     | See Gas Name Code table               | Read Only    |
| 0x202B          | Measurement Range              | 1     | —                                     | Read Only    |
| 0x2030          | Unit Code                      | 1     | See Unit Code table                   | Read / Write |
| 0x2031          | Decimal Point Count            | 1     | —                                     | Read / Write |
| 0x6000          | Alarm Status                   | 1     | See Alarm Status table                | Read Only    |
| 0x6001          | Concentration Value            | 1     | —                                     | Read Only    |
| 0x6002          | AD Value                       | 1     | —                                     | Read Only    |
| 0x6006          | Run Status / Command Parameter | 1 / 1 | See Status / Command Parameter tables | Write & Read |

## Worked Examples

Read concentration value (register 0x6001):

| Send                    | Response             | Interpretation                                                                                                                                                    |
|-------------------------|----------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| FF 03 60 01 00 01 DE 14 | FF 03 02 00 05 51 93 | Returned value = 5. Concentration = value ÷ 10 <sup>^(decimal point count)</sup> . If decimal point count = 1, concentration = 0.5; if = 2, concentration = 0.05. |

Read decimal point count (register 0x2031):

| Send                    | Response             | Interpretation           |
|-------------------------|----------------------|--------------------------|
| FF 03 20 31 00 01 CB DB | FF 03 02 00 01 50 50 | Decimal point count = 1. |

Set sensor (slave) address — requires write-protect release first:

| Step                                                 | Send                             | Response                |
|------------------------------------------------------|----------------------------------|-------------------------|
| 1. Release write protection (0x4FFF)                 | FF 10 4F FF 00 01 02 55 AA FB D0 | FF 10 4F FF 00 01 32 F3 |
| 2. Write new address to 0x2011 (example: set ID = 1) | FF 10 20 11 00 01 02 00 01 0D 77 | FF 10 20 11 00 01 4F D2 |

Calibration sequence — requires write-protect release first (example: zero-point calibration):

| Step                                  | Send                                   | Response                            |
|---------------------------------------|----------------------------------------|-------------------------------------|
| 1. Release write protection (0x4FFF)  | FF 10 4F FF 00 01 02 55 AA FB D0       | FF 10 4F FF 00 01 32 F3             |
| 2. Write calibration command (0x6006) | FF 10 60 06 00 02 04 10 00 00 00 E8 AC | —                                   |
| 3. Read calibration result (0x6006)   | FF 03 60 06 00 01 6F D5                | FF 03 02 00 01 50 50 (01 = success) |

※ Up to 6 calibration points are supported. CRC16 uses the standard Modbus CRC-16 algorithm.

#### Alarm Status Bit Definitions (Register 0x6000)

| Bit        | Definition                                                                                 |
|------------|--------------------------------------------------------------------------------------------|
| Bit15 = 0  | Warming up — bits 14–0 give warm-up countdown time as a 15-bit word (time = value × 0.1 s) |
| Bit15 = 1  | Warm-up complete — bits 14–0 are individual status flags                                   |
| Bit6       | High-concentration protection                                                              |
| Bit5       | Sensor lost or damaged                                                                     |
| Bit4       | Over-range                                                                                 |
| Bit3       | TWA alarm                                                                                  |
| Bit2       | STEL alarm                                                                                 |
| Bit1       | High alarm                                                                                 |
| Bit0 (LSB) | Low alarm                                                                                  |

#### Run Status Definitions

| Value           | Description                                     |
|-----------------|-------------------------------------------------|
| 0x0000          | Module busy — warming up or executing a command |
| 0x0001          | Module idle / command executed successfully     |
| 0x0002          | Execution failed                                |
| 0x0003          | Unsupported command                             |
| 0x0004          | Invalid parameter                               |
| 0x0005          | Execution timed out                             |
| 0x0100 – 0x0103 | Executing command step 0 – 3                    |

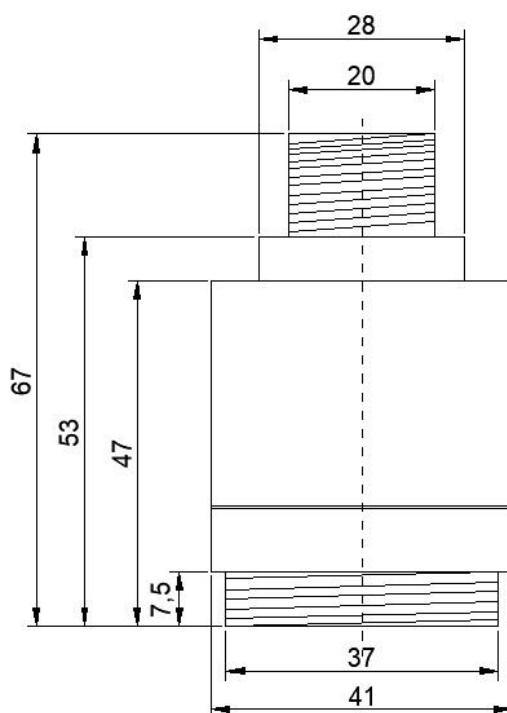
#### Command Parameters (Calibration)

| Value           | Description                                                                 |
|-----------------|-----------------------------------------------------------------------------|
| 0x1000          | Multi-point calibration, point 0 (parameter value not used)                 |
| 0x1001 – 0x1005 | Multi-point calibration, points 1–5 (parameter = calibration concentration) |

#### Sensor Type Codes (Register 0x2021)

| Code | Sensor Type                         |
|------|-------------------------------------|
| 1    | Catalytic combustion                |
| 2    | Electrochemical — positive reaction |
| 3    | Electrochemical — negative reaction |
| 4    | Oxygen-type                         |
| 5    | Infrared                            |
| 6    | PID (photoionization)               |
| 7    | Semiconductor                       |
| 8    | Thermal conductivity                |

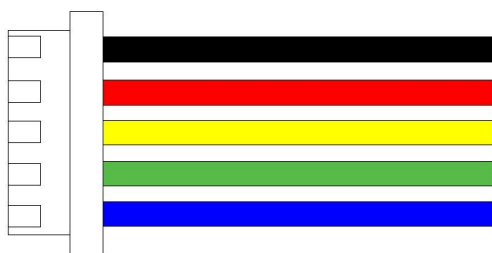
## ■ MECHANICAL DIMENSIONS



Module outline dimensions (mm). Overall: Ø41 mm (Ø1.61 in) × 67 mm (2.64 in).

Key dimensions: 67 mm (2.64 in) overall height; 53 mm (2.09 in); 47 mm (1.85 in); 7.5 mm (0.30 in); thread OD 41 mm (1.61 in) / 37 mm (1.46 in); upper boss 28 mm (1.10 in) OD / 20 mm (0.79 in) thread.

## ■ WIRING DIAGRAM



5-pin terminal wire-color sequence (1.25 mm pitch connector)

| Pin | Signal    | Wire Color | Function                    | Min (V) | Typ. (V) | Max (V) |
|-----|-----------|------------|-----------------------------|---------|----------|---------|
| 1   | GND       | Black      | Ground                      | 0       | 0.0      | —       |
| 2   | VCC       | Red        | Power Input                 | 5       | 12       | 24      |
| 3   | RX / 485B | Yellow     | Serial receive or RS-485 B  | 0       | 3.0      | —       |
| 4   | TX / 485A | Green      | Serial transmit or RS-485 A | 0       | 3.0      | —       |
| 5   | Vo        | Blue       | Analog output*              | 0       | 2.0      | 3.0     |

\* Vo is unused on UART/RS-485 output modules; on DAC-output modules this pin carries the analog output.

## ■ NOTES / PRECAUTIONS

- Do not remove or replace the sensor installed in the module.
- Do not solder directly to the module's connector pins; soldering may be performed on the pin header housing only.
- Avoid exposing the module to organic solvents (including silicone and other adhesives), paints, chemical reagents, oils, or high-concentration gases.
- Do not subject the module to excessive shock or vibration.
- Allow at least 5 minutes' warm-up on initial power-up; if the module has been unused for an extended period, a warm-up of 24 hours or more is recommended.
- Do not store the module in high-concentration organic-gas environments for extended periods.
- Select the appropriate sensor range for the specific application and environment.

## ■ APPENDIX 1 — GAS NAME CODE TABLE (Modbus register 0x2027)

| Code | Gas Name (English)         | Formula / Symbol                 |
|------|----------------------------|----------------------------------|
| 0x01 | Carbon monoxide            | CO                               |
| 0x02 | Hydrogen sulfide           | H <sub>2</sub> S                 |
| 0x03 | Combustible gas (general)  | EX                               |
| 0x04 | Oxygen                     | O <sub>2</sub>                   |
| 0x05 | Sulfur dioxide             | SO <sub>2</sub>                  |
| 0x06 | Methane                    | CH <sub>4</sub>                  |
| 0x07 | Nitric oxide               | NO                               |
| 0x08 | Nitrogen dioxide           | NO <sub>2</sub>                  |
| 0x09 | Chlorine                   | Cl <sub>2</sub>                  |
| 0x0A | Ammonia                    | NH <sub>3</sub>                  |
| 0x0B | Hydrogen                   | H <sub>2</sub>                   |
| 0x0C | Hydrogen cyanide           | HCN                              |
| 0x0D | Hydrogen chloride          | HCl                              |
| 0x0E | Phosphine                  | PH <sub>3</sub>                  |
| 0x0F | Ozone                      | O <sub>3</sub>                   |
| 0x10 | Chlorine dioxide           | ClO <sub>2</sub>                 |
| 0x11 | Ethylene oxide             | C <sub>2</sub> H <sub>4</sub> O  |
| 0x12 | Carbon dioxide             | CO <sub>2</sub>                  |
| 0x13 | Benzene                    | C <sub>6</sub> H <sub>6</sub>    |
| 0x14 | Formaldehyde               | CH <sub>2</sub> O                |
| 0x15 | Volatile organic compounds | VOC                              |
| 0x16 | Toluene                    | C <sub>7</sub> H <sub>8</sub>    |
| 0x17 | Xylene                     | C <sub>8</sub> H <sub>10</sub>   |
| 0x18 | Nitrogen oxides            | NO <sub>x</sub>                  |
| 0x19 | n-Hexane                   | C <sub>6</sub> H <sub>14</sub>   |
| 0x1A | Hydrogen fluoride          | HF                               |
| 0x1B | Fluoride compounds         | xF                               |
| 0x1C | Methanol                   | CH <sub>3</sub> OH               |
| 0x1D | Propane                    | C <sub>3</sub> H <sub>8</sub>    |
| 0x1E | Cresol                     | C <sub>7</sub> H <sub>8</sub> O  |
| 0x1F | Ethane                     | C <sub>2</sub> H <sub>6</sub>    |
| 0x20 | Diethyl ether              | C <sub>4</sub> H <sub>10</sub> O |



|      |                                   |                                               |
|------|-----------------------------------|-----------------------------------------------|
| 0x21 | Coal gas                          | CH <sub>4</sub>                               |
| 0x22 | Carbon disulfide                  | CS <sub>2</sub>                               |
| 0x23 | Silane                            | SiH <sub>4</sub>                              |
| 0x24 | Acetylene                         | C <sub>2</sub> H <sub>2</sub>                 |
| 0x25 | Methyl chloride                   | CH <sub>3</sub> Cl                            |
| 0x26 | Nitrogen                          | N <sub>2</sub>                                |
| 0x27 | Styrene                           | C <sub>8</sub> H <sub>8</sub>                 |
| 0x28 | Arsine                            | AsH <sub>3</sub>                              |
| 0x29 | Ethanol                           | C <sub>2</sub> H <sub>6</sub> O               |
| 0x2A | Vinyl chloride                    | C <sub>2</sub> H <sub>3</sub> Cl              |
| 0x2B | 1,2-Dichloroethane                | C <sub>2</sub> H <sub>4</sub> Cl <sub>2</sub> |
| 0x2C | Ethyl acetate                     | C <sub>4</sub> H <sub>8</sub> O <sub>2</sub>  |
| 0x2D | Dichloromethane                   | CH <sub>2</sub> Cl <sub>2</sub>               |
| 0x2E | Acrylonitrile                     | C <sub>3</sub> H <sub>3</sub> N               |
| 0x2F | Aniline                           | C <sub>6</sub> H <sub>7</sub> N               |
| 0x30 | Natural gas                       | EX                                            |
| 0x31 | Bromine                           | Br <sub>2</sub>                               |
| 0x32 | Phosgene                          | COCl <sub>2</sub>                             |
| 0x33 | Hydrazine                         | N <sub>2</sub> H <sub>4</sub>                 |
| 0x34 | Formic acid                       | CHOOH                                         |
| 0x35 | Hydrogen bromide                  | HBr                                           |
| 0x36 | Methanethiol                      | CH <sub>4</sub> S                             |
| 0x37 | Butene                            | C <sub>4</sub> H <sub>8</sub>                 |
| 0x38 | Ethylene                          | C <sub>2</sub> H <sub>4</sub>                 |
| 0x39 | Propylene                         | C <sub>3</sub> H <sub>6</sub>                 |
| 0x3A | Vinyl acetate                     | C <sub>4</sub> H <sub>6</sub> O <sub>2</sub>  |
| 0x3B | Isopropanol                       | C <sub>3</sub> H <sub>8</sub> O               |
| 0x3C | Acetaldehyde                      | C <sub>2</sub> H <sub>4</sub> O               |
| 0x3D | Butadiene                         | C <sub>4</sub> H <sub>6</sub>                 |
| 0x3E | Carbon oxysulfide                 | COS                                           |
| 0x3F | Dimethyl sulfide                  | C <sub>2</sub> H <sub>6</sub> S               |
| 0x40 | Tetrahydrothiophene               | C <sub>4</sub> H <sub>8</sub> S               |
| 0x41 | Propylene chlorohydrin            | C <sub>2</sub> H <sub>5</sub> OCl             |
| 0x42 | Chloroform                        | CHCl <sub>3</sub>                             |
| 0x43 | Carbon tetrachloride              | CCl <sub>4</sub>                              |
| 0x44 | Tungsten hexafluoride             | WF <sub>6</sub>                               |
| 0x45 | Tin tetrachloride                 | SnCl <sub>4</sub>                             |
| 0x46 | Hydrogen peroxide                 | H <sub>2</sub> O <sub>2</sub>                 |
| 0x47 | Methyl ethyl ketone               | C <sub>4</sub> H <sub>8</sub> O               |
| 0x48 | Hydrocarbons                      | C <sub>n</sub> H <sub>2n</sub>                |
| 0x49 | Sulfuryl fluoride                 | SO <sub>2</sub> F <sub>2</sub>                |
| 0x4A | Total VOC                         | TVOC                                          |
| 0x4B | Volatile organic compounds (VOCs) | VOCs                                          |
| 0x4C | Methyl isobutyl ketone            | C <sub>6</sub> H <sub>12</sub> O              |
| 0x4D | Fluorine                          | F <sub>2</sub>                                |

|      |                         |                                                  |
|------|-------------------------|--------------------------------------------------|
| 0x4E | Hydrocyanic acid        | HCN                                              |
| 0x4F | Dimethyl sulfate        | (CH <sub>3</sub> O) <sub>2</sub> SO <sub>2</sub> |
| 0x50 | Dimethylformamide       | C <sub>3</sub> H <sub>7</sub> NO                 |
| 0x51 | Phosphorus trichloride  | PCl <sub>3</sub>                                 |
| 0x52 | Phosphorus oxychloride  | POCl <sub>3</sub>                                |
| 0x53 | Acetate ester           | CH <sub>3</sub> COOR                             |
| 0x54 | Particulate matter      | PM <sub>2.5</sub>                                |
| 0x55 | Particulate matter      | PM <sub>10</sub>                                 |
| 0x56 | Particulate matter      | PM <sub>1.0</sub>                                |
| 0x57 | Hydrocarbons            | HC                                               |
| 0x58 | Hydrazine hydrate       | N <sub>2</sub> H <sub>4</sub> .H <sub>2</sub> O  |
| 0x59 | Aldehydes               | C <sub>3</sub> H <sub>4</sub> O                  |
| 0x5A | Fuel vapor              | C <sub>3</sub> H <sub>8</sub>                    |
| 0x5B | LPG fuel vapor          | LPG                                              |
| 0x5C | Methacrylonitrile       | C <sub>4</sub> H <sub>5</sub> N                  |
| 0x5D | Vinylidene chloride     | C <sub>2</sub> H <sub>2</sub> Cl <sub>2</sub>    |
| 0x5E | n-Butane                | C <sub>4</sub> H <sub>10</sub>                   |
| 0x5F | n-Pentane               | C <sub>5</sub> H <sub>12</sub>                   |
| 0x60 | Isobutane               | C <sub>4</sub> H <sub>10</sub>                   |
| 0x61 | Dimethylformamide (DMF) | C <sub>3</sub> H <sub>7</sub> NO                 |
| 0x62 | m-Diethylbenzene        | C <sub>10</sub> H <sub>14</sub>                  |
| 0x63 | Chlorobenzene           | C <sub>6</sub> H <sub>5</sub> Cl                 |
| 0x64 | Methylamine             | CH <sub>3</sub> NH <sub>2</sub>                  |
| 0x65 | Nitrous oxide           | N <sub>2</sub> O                                 |
| 0x66 | Toluene diisocyanate    | TDI                                              |
| 0x67 | Freon / refrigerant     | freon                                            |
| 0x68 | Sulfur trioxide         | SO <sub>3</sub>                                  |
| 0x69 | Nitrogen trifluoride    | NF <sub>3</sub>                                  |
| 0x6A | Methyl bromide          | CH <sub>3</sub> Br                               |
| 0x6B | Sodium cyanide          | NaCN                                             |
| 0x6C | Epichlorohydrin         | C <sub>3</sub> H <sub>5</sub> ClO                |
| 0x6D | Propylene oxide         | C <sub>3</sub> H <sub>6</sub> O                  |
| 0x6E | Trichloroethylene       | C <sub>2</sub> HCl <sub>3</sub>                  |
| 0x6F | Acetone                 | CH <sub>3</sub> COCH <sub>3</sub>                |
| 0x70 | Tetrachloroethylene     | C <sub>2</sub> Cl <sub>4</sub>                   |
| 0x71 | Lower explosive limit   | LEL                                              |
| 0x72 | Pressure                | PRESSURE                                         |
| 0x73 | Acid gas (generic)      | ACID                                             |
| 0x74 | Cyclohexane             | C <sub>6</sub> H <sub>12</sub>                   |
| 0x75 | Diborane                | B <sub>2</sub> H <sub>6</sub>                    |
| 0x76 | Argon                   | Ar                                               |
| 0x77 | Acetic acid             | CH <sub>3</sub> COOH                             |
| 0x78 | Phenol                  | C <sub>6</sub> H <sub>5</sub> OH                 |
| 0x79 | Sulfur hexafluoride     | SF <sub>6</sub>                                  |
| 0x7A | Ethanethiol             | C <sub>2</sub> H <sub>5</sub> SH                 |

|      |                              |        |
|------|------------------------------|--------|
| 0x7B | Allyl chloride               | C3H5Cl |
| 0x7C | Ethylamine                   | C2H7N  |
| 0x7D | Dimethylamine                | C2H7N  |
| 0x7E | Odor / odorous gas (generic) | —      |

## ■ APPENDIX 2 — UNIT CODE TABLE (Modbus register 0x2030)

| Code | Unit     | Description                                                                                    |
|------|----------|------------------------------------------------------------------------------------------------|
| 1    | %LEL     | Lower explosive limit                                                                          |
| 2    | ppm      | Parts per million (international unit)                                                         |
| 3    | ppb      | Parts per billion                                                                              |
| 4    | %VOL     | Volume percent (total)                                                                         |
| 5    | μmol/mol | Parts per million equivalent                                                                   |
| 6    | mg/m³    | Mass concentration, mass/volume [source text has apparent duplication; transcribed faithfully] |
| 7    | μg/m³    | Mass concentration, mass/volume                                                                |
| 8    | °C       | Temperature                                                                                    |
| 9    | %RH      | Humidity                                                                                       |
| 10   | m/s      | Velocity                                                                                       |
| 11   | kPa      | Pressure                                                                                       |
| 12   | lx       | Light intensity                                                                                |
| 13   | MPa      | Pressure                                                                                       |

## ■ APPENDIX 3 — DETECTED GAS PARAMETER LIST

| Detected Gas                        | Range (standard) | Accuracy                             | Resolution | Power  |
|-------------------------------------|------------------|--------------------------------------|------------|--------|
| (Electrochemical) Oxygen            | 0-30 %VOL        | ±3% FS                               | 0.1 %VOL   | 15 mW  |
| (Electrochemical) Carbon monoxide   | 0-1000 ppm       | ±5 ppm or ±10%, whichever is greater | 1 ppm      | 15 mW  |
| (Electrochemical) Hydrogen sulfide  | 0-100 ppm        | ±2 ppm or ±10%, whichever is greater | 1 ppm      | 15 mW  |
| (Electrochemical) Nitric oxide      | 0-250 ppm        | ±5% FS                               | 1 ppm      | 15 mW  |
| (Electrochemical) Nitrogen dioxide  | 0-20 ppm         | ±5% FS                               | 0.1 ppm    | 15 mW  |
| (Electrochemical) Sulfur dioxide    | 0-20 ppm         | ±5% FS                               | 0.1 ppm    | 15 mW  |
| (Infrared) Carbon dioxide           | 0-5 %VOL         | ±( 0.05 + 5% of reading)             | 0.01 %VOL  | 100 mW |
| (Infrared) Carbon dioxide           | 0-5000 ppm       | ±( 0.05 + 5% of reading)             | 1 ppm      | 100 mW |
| (Electrochemical) Ozone             | 0-20 ppm         | ±12% FS                              | 0.1 ppm    | 15 mW  |
| (Electrochemical) Ammonia           | 0-100 ppm        | ±10%                                 | 1 ppm      | 15 mW  |
| (Electrochemical) Hydrogen fluoride | 0-10 ppm         | ±10%                                 | 0.1 ppm    | 15 mW  |
| (Electrochemical) Hydrogen chloride | 0-50 ppm         | ±10%                                 | 0.1 ppm    | 15 mW  |
| (Electrochemical) Hydrogen cyanide  | 0-50 ppm         | ±10%                                 | 0.1 ppm    | 15 mW  |
| (Electrochemical) Phosphine         | 0-20 ppm         | ±10%                                 | 0.1 ppm    | 15 mW  |
| (Electrochemical) Methanethiol      | 0-100 ppm        | ±10%                                 | 1 ppm      | 15 mW  |

|                                     |            |         |           |        |
|-------------------------------------|------------|---------|-----------|--------|
| (Electrochemical) Formaldehyde      | 0-10 ppm   | ±10%    | 0.1 ppm   | 15 mW  |
| (Electrochemical) Chlorine          | 0-50 ppm   | ±10%    | 0.1 ppm   | 15 mW  |
| (Electrochemical) Hydrogen          | 0-1000 ppm | ±10%    | 1 ppm     | 15 mW  |
| (Electrochemical) Ethylene oxide    | 0-100 ppm  | ±10%    | 1 ppm     | 15 mW  |
| (Infrared) Methane                  | 0-5 %VOL   | ±5% FS  | 0.01 %VOL | -      |
| (Infrared) Methane                  | 0-100 %VOL | ±5% FS  | 1 %VOL    | -      |
| (Catalytic) Combustible gas         | 0-100 %LEL | ±5% FS  | 1 %VOL    | 300 mW |
| (Electrochemical) Chlorine dioxide  | 0-50 ppm   | ±10%    | 1 ppm     | 15 mW  |
| (Electrochemical) VOC               | 0-100 ppm  | ±10%    | 1 ppm     | 15 mW  |
| (Photoionization, PID)              | 0-10 ppm   | 0.1 ppm | 1 ppb     | 110 mW |
| (Photoionization, PID)              | 0-40 ppm   | 1 ppb   | 10 ppb    | 110 mW |
| (Photoionization, PID)              | 0-100 ppm  | 25 ppb  | 25 ppb    | 110 mW |
| (Electrochemical) Hydrogen peroxide | 0-100 ppm  | ±10%    | 1 ppm     | 15 mW  |

#### ■ APPENDIX 4 — ALARM STATUS DEFINITION (Modbus register 0x6000)

| Main State                   | Bit / Field | Description                                                                                   |
|------------------------------|-------------|-----------------------------------------------------------------------------------------------|
| Preheating (Bit15 = 0)       | Bit14-0     | Output is the preheat countdown timer, encoded as a full 16-bit integer. Time = value x 0.1 s |
| Preheat complete (Bit15 = 1) | Bit14       | Reserved / idle                                                                               |
| Preheat complete (Bit15 = 1) | Bit13       | Reserved / idle                                                                               |
| Preheat complete (Bit15 = 1) | Bit12       | Reserved / idle                                                                               |
| Preheat complete (Bit15 = 1) | Bit11       | Reserved / idle                                                                               |
| Preheat complete (Bit15 = 1) | Bit10       | Reserved / idle                                                                               |
| Preheat complete (Bit15 = 1) | Bit9        | Reserved / idle                                                                               |
| Preheat complete (Bit15 = 1) | Bit8        | Reserved / idle                                                                               |
| Preheat complete (Bit15 = 1) | Bit7        | Reserved / idle                                                                               |
| Preheat complete (Bit15 = 1) | Bit6        | High-concentration protection                                                                 |
| Preheat complete (Bit15 = 1) | Bit5        | Sensor lost or damaged                                                                        |
| Preheat complete (Bit15 = 1) | Bit4        | Over-range                                                                                    |
| Preheat complete (Bit15 = 1) | Bit3        | TWA alarm                                                                                     |
| Preheat complete (Bit15 = 1) | Bit2        | STEL alarm                                                                                    |
| Preheat complete (Bit15 = 1) | Bit1        | High alarm                                                                                    |
| Preheat complete (Bit15 = 1) | Bit0 (LSB)  | Low alarm                                                                                     |

#### ■ APPENDIX 5 — STATUS DEFINITION (Modbus register 0x6006)

| Value  | Description                                     |
|--------|-------------------------------------------------|
| 0x0000 | Module busy — preheating or executing a command |
| 0x0001 | Module idle, or execution successful            |
| 0x0002 | Execution failed                                |
| 0x0003 | Unsupported command                             |

|        |                          |
|--------|--------------------------|
| 0x0004 | Invalid parameter        |
| 0x0005 | Execution timed out      |
| 0x0100 | Executing command step 0 |
| 0x0101 | Executing command step 1 |
| 0x0102 | Executing command step 2 |
| 0x0103 | Executing command step 3 |

## ■ APPENDIX 6 — COMMAND PARAMETERS (written to register 0x6006)

| Value  | Description                                                                           |
|--------|---------------------------------------------------------------------------------------|
| 0x1000 | Multi-concentration calibration, point 0 — parameter value is not used                |
| 0x1001 | Multi-concentration calibration, point 1 — parameter is the calibration concentration |
| 0x1002 | Multi-concentration calibration, point 2 — parameter is the calibration concentration |
| 0x1003 | Multi-concentration calibration, point 3 — parameter is the calibration concentration |
| 0x1004 | Multi-concentration calibration, point 4 — parameter is the calibration concentration |
| 0x1005 | Multi-concentration calibration, point 5 — parameter is the calibration concentration |

## ■ APPENDIX 7 — SENSOR TYPE TABLE (Modbus register 0x2021)

| Code | Sensor Type                        | Remarks |
|------|------------------------------------|---------|
| 1    | Catalytic combustible type         | —       |
| 2    | Electrochemical, positive reaction | —       |
| 3    | Electrochemical, negative reaction | —       |
| 4    | Oxygen type                        | —       |
| 5    | Infrared type                      | —       |
| 6    | PID type                           | —       |
| 7    | Semiconductor type                 | —       |
| 8    | Thermal conductivity type          | —       |
| 9    | —                                  | —       |
| 10   | —                                  | —       |