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Notices used in this manual

This manual contains notices to highlight specific information as follows:

**Notes:**
These notices provide important tips, guidance, or advice.

**Important:**
These notices provide information that might help you avoid inconvenient or problem situations.

**Attention:**
These notices indicate possible damage to programs, devices, or data and is placed just before the instruction or situation in which damage could occur.

**Caution:**
These notices indicate situations that can be potentially hazardous to you. A Caution notice is placed just before a description of a potentially hazardous procedure, step, or situation.

Related publications

The following publications are listed below by part number followed by description and are available in Adobe Acrobat Portable Document Format (PDF) at http://www.mtssensors.com/. Note: The following documents are available only in English.

- 550784 - Product Specification, Level Plus M-Series Digital
- 551103 - Level Plus Accessories Catalog
- 551104 - Component Replacement Guide
- 550907 - Application Datasheet Rigid
- 550908 - Application Datasheet Sanitary
- 550909 - Application Datasheet 7/8” Flex
- 551410 - Brief Operation Manual for Safe Use

How this manual is organized

- “Introduction”, provides an overview of the manual.
- “Terms and Definitions”, provides definitions of terms used in this manual.
- “Product Overview”, gives an overall product description for the Level Plus liquid-level transmitter, its specifications, use, output, and electronics.
- “Installation and Mounting”, provides detailed installation and mounting information.
- “Electrical Connections and Wiring Procedures”, provides engineering specifications and wiring diagrams to assist in the installation process.
- “Maintenance and Field Service”, provides guidelines for general maintenance and procedures for replacing the Model MG electronic module or level transmitter.
- “Troubleshooting”, provides a list of symptoms, their possible cause and the action to be taken when troubleshooting the transmitter.
- “Quick Start-Up Guide, (Modbus and DDA)”, provides a list of steps to quickly set up your Modbus or DDA output.
- “Modbus Interface”, provides information to communicate via the Modbus RTU protocol.
- “FOUNDATION™ fieldbus Interface”, provides information to communicate via the FOUNDATION™ fieldbus protocol.
- “DDA Protocol”, provides the DDA hardware and software environment overviews.
- “Agency Information” provides comprehensive listings of agency approvals and standards, installation drawings, labels and applicable protocols.

Getting information, help, and service

You can get the latest ordering information and software updates by visiting www.mtssensors.com website
General contact information, shipping and office hours are available on page i.
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MTS Sensors
Level Plus® Liquid-Level Transmitters M-Series Model MG Digital Transmitter
Operation and Installation Manual, Document Number: 550791 Revision L (KOR) 03/2014
Model MG Operation and Installation Manual

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Introduction

MTS is recognized as the pioneer, innovator and leader in magnetostrictive sensing. The new Level Plus® M-Series transmitter design represents a continuation of our on-going effort to provide effective, innovative and reliable products to the Liquid Level marketplace.

This manual will provide the following information about the Level Plus Model MG digital transmitter:

- Terms and definitions
- Product overview
- Installation and mounting
- Electrical connections and wiring procedures
- Maintenance and field service
- Troubleshooting
- Quick start-up guide (Modbus and DDA)
- Modbus interface
- FOUNDATION™ fieldbus interface
- DDA interface
- Product certification

Public website support portal

Visit our support portal at http://www.mtssensors.com for:

- Building Level Plus M-Series model numbers
- Latest documentation releases
- Detailed ordering information
- Latest software updates
Terms and Definitions


6C Chemical – ‘Volume Correction Factors (VCF)’ for individual and special applications, volume correction to 60 °F against thermal expansion coefficients.

6C Mod – An adjustable temperature reference for defining VCF.

API Gravity – The measure of how heavy or light a petroleum liquid is compared to water. Allowable values are 0 to 100 degrees API for (6A) and 0 to 85 degrees API for (6B).


Density – Mass divided by the volume of an object at a specific temperature. The density value should be entered as lb / cu. ft.


Density – Mass divided by the volume of an object at a specific temperature. The density value should be entered as lb / cu. ft.

Noun

I

Interface – Noun; The measurement of the level of one liquid when that liquid is below another liquid.

Interface – Adj.; The Software Graphical User Interface (GUI) that allows the user to access software protocols (DDA, MODBUS).

Intrinsic safety – ‘Intrinsically safe’ - Type of protection based on the restriction of electrical energy within apparatus of interconnected wiring exposed to potentially explosive atmosphere to a level below that which can cause ignition by either sparking or heating effects.

M

Mass – The property of a body that causes it to have weight in a gravitational field, calculated by density at the reference temperature multiplied by the volume correction factor (Density * VCF).

MODBUS – A serial communications protocol published by Modicon in 1979 for use with its programmable logic controllers (PLCs). It has become a de facto standard communications protocol in industry, and is now the most commonly available means of connecting industrial electronic devices.

N

NEMA Type 4X – A product Enclosure intended for indoor or outdoor use primarily to provide a degree of protection against corrosion, windblown dust and rain, splashing water, and hose-directed water; and to be undamaged by the formation of ice on the enclosure. They are not intended to provide protection against conditions such as internal condensation or internal icing.

NPT – U.S. standard defining tapered pipe threads used to join pipes and fittings.

NSVP – ‘Net Standard Volume of the Product’ – The temperature corrected volume for the product liquid in the tank, requires the transmitter to be ordered with temperature measurement capabilities. The NSVP is calculated by multiplying the volume of the product liquid by a volume correction factor based on temperature (GOVP * VCF).

R

Reference Temperature – The temperature at which the density measurement is given, the allowable values are 32 °F to 150 °F.

S

Specific Gravity – The density ratio of a liquid to the density of water at the same conditions.

Sphere Radius – The internal radius of the sphere that contains the liquid, the value is used to calculate the volume along with the Sphere Offset.

Sphere Offset – An offset value that accounts for additional volume in a sphere from non-uniform sphere geometry, the value is used to calculate the volume along with the Sphere Radius.

Strap Table – A table of measurement correlating the height of a ves-
sel to the volume that is contained at that height. The transmitter can contain up to 100 points.

T

TEC – ‘Thermal Expansion Coefficient’ - a value correlating the change in temperature for an object with the change in its volume. Allowable values are 270.0 to 930.0. TEC units are in 10 E-6/Deg F.

Temperature Correction Method – One of five product correction methods used to correct the product volume in the tank due to changes in temperature from 60 °F including (6A, 6B, 6C, 6C Mod, and Custom Table).

V

Volume Calculation Mode – One of two methods use to calculate volume measurements from level measurements, including Sphere and Strap Table.

VCF – ‘Volume Correction Factor’ – A table of measurements correlating temperature points with correction factors for the liquids expansion/contraction. The transmitter can contain up to 50 points.

W

Working Capacity – The maximum volume of liquid that the user desires for their vessel to hold, typically 80% of the vessels maximum volume before overfill.
The Level Plus Model MG Liquid-Level transmitter is a continuous multi-functional magnetostrictive transmitter that provides product level, interface level, and temperature to the user via Modbus, DDA, or FOUNDATION™ fieldbus output. Magnetostrictive technology is one of the most accurate and repeatable level technologies available to date. MTS is the inventor and purveyor of magnetostrictive technology and has been serving the level industry for over 30 years.

Product Overview

INDUSTRIES
- Petroleum
- Liquid petroleum gas
- Pharmaceutical
- Food & beverage
- Chemical
- Wastewater

APPLICATIONS
- Tank farms
- Terminals
- Bullet tanks
- Spheres
- Separator tanks
- Battery tanks
- Storage tanks

FEATURES
- 3-in-1 measurement
  - Product level
  - Interface level
  - Temperature level
- 100 Point strap table
- No scheduled maintenance or recalibration
- API temperature corrected volumes
- Non-linearity 0.008% F.S.
- Field repairable

Components

The Level Plus Model MG liquid level transmitter consists of four main components; a housing, outer pipe, float, and electronics. Varying the components of the transmitter allows the transmitter to be customized to almost any application.

Housings

Level Plus Model MG transmitters are available in three housing configurations; NEMA Type 4X 316L stainless steel, flameproof single and dual-cavity housings as shown below:

- NEMA Type 4X 316L stainless-steel housing
- Single cavity flameproof housing
- Dual cavity flameproof housing
OUTER PIPE CONFIGURATIONS

The outer pipe is constructed of a variety of configurations, shown below. Contact factory for other materials (such as Hastelloy C or Teflon).

![Diagram of Outer Pipe Configurations]

**Figure 1** 5/8 in. diameter rigid outer pipe of 316L stainless steel

**Figure 2** 5/8 in. diameter rigid outer pipe of polished 316L stainless steel with sanitary process connection and end plug

**Figure 3** 7/8 in. diameter flexible pipe of 316L stainless steel
FLOATS

Model MG transmitters offer numerous floats for different applications such as stainless steel, 3-A sanitary, hastelloy, Teflon, and Nitrophyl for both product level and interface level. To be able to accurately detect the interface level there needs to be a difference of at least 0.05 in specific gravities between the product and interface liquids. For detailed information about floats, refer to the ‘Accessories Catalog’, MTS part number 551103.

For assistance with selecting a specific float for your application, please contact Technical Support with the following information:

- Specific gravity of liquid(s) being measured
- Process temperature
- Process Opening Size
- Vessel pressure

For KC approved, Model MG transmitters should be used with a float having an offset weight and made of stainless steel or Hastelloy C. This allows the float to stay in contact with the pipe to prevent the buildup of an electrostatic charge. For detailed information about floats, refer to the ‘Accessories Catalog’, MTS part number 551103.

Non-metalic floats with a projected surface area of less than 5,000 mm² should only be used in Zone 0, Gas group IIA such as float part numbers 201643-2, 201649-2, 201650-2, 201109, 251115 and 251116. All other non-metallic floats offered by MTS such as, 251939, 251119, 251120 and 252999, should not be used in a hazardous area application.

### NITROPHYLL FLOATS

<table>
<thead>
<tr>
<th>Float and dimension reference</th>
<th>Projected surface area</th>
<th>Part number</th>
</tr>
</thead>
<tbody>
<tr>
<td>18 mm (.07 in.) dia. Magnet</td>
<td>2356 mm²</td>
<td>201643-2</td>
</tr>
<tr>
<td>31 mm (1.2 in.) dia. Added weight for interface floats</td>
<td></td>
<td>201649-2</td>
</tr>
<tr>
<td>31 mm (1.2 in.) dia. Added weight for interface floats</td>
<td></td>
<td>201650-2</td>
</tr>
</tbody>
</table>

### TEFLON FLOATS

<table>
<thead>
<tr>
<th>Float and dimension reference</th>
<th>Projected surface area</th>
<th>Part number</th>
</tr>
</thead>
<tbody>
<tr>
<td>9 mm (0.35 in.) Magnet</td>
<td>4635 mm²</td>
<td>201109</td>
</tr>
<tr>
<td>76 mm (3 in.)</td>
<td></td>
<td>251115</td>
</tr>
<tr>
<td>61 mm (2.38 in.)</td>
<td></td>
<td>251116</td>
</tr>
</tbody>
</table>

### INTERNAL ELECTRONICS

All transmitters come with two electronic components of a sensing element and a board set. All sensing elements up to 300 inches (7620 mm) are rigid and greater lengths have flexible sensing elements. Flexible sensing elements are only available under 300 inches (7620 mm) as special orders. The board set consists of a top board and bottom board that differ depending on the output. A temperature sensing function is optional with the Model MG transmitter. The temperature sensing device is a digital thermometer (DT) mounted inside the transmitter’s pipe assembly. The DT is capable of an inherent accuracy of ± 0.5 °F (0.28 °C).

### ACCESSORIES

MTS also offers a series of displays, housings, converters, and other accessories, please refer to the ‘Accessories Catalog’, MTS part number 551103.
Theory of operation

Magnetostrictive M-Series transmitters precisely sense the position of an external float by applying an interrogation pulse to a waveguide medium. This current pulse causes a magnetic field to instantly surround the waveguide. The magnet installed within the float also creates a magnetic field. Where the magnetic fields from the waveguide and float intersect, a rotational force is created (waveguide twist). This, in turn, creates a torsional-sonic pulse that travels along the waveguide as shown in Figure 4.

The head of the transmitter houses the sensing circuit, which detects the torsional-sonic pulse and converts it to an electrical pulse. The distance from a reference point to the float is determined by measuring the time interval between the initiating current pulse and the return pulse and precisely knowing the speed of these pulses. The time interval is converted into a level measurement.

Accuracy

For magnetostrictive transmitters inherent accuracy is measured in terms of non-linearity. Non-linearity is a measurement of any imperfections in the waveguide that are reflected in the linearity of the transmitter’s output. MTS tolerances reflect a maximum non-linearity of ±1 mm (0.039 in.). MTS is able to achieve such strict tolerances by manufacturing all of its own waveguide from a proprietary alloy and testing 100% of all transmitters before shipping.

Warranty

Important:

Contact Technical Support or Customer Service for assistance if you suspect that the transmitter is not working correctly. Technical support can assist you with troubleshooting, part replacement, and Returned Material Authorization (RMA) information if required.

All M-Series transmitters come with a two year limited warranty from the factory shipment date. A Return Materials Authorization (RMA) number is required and must accompany any transmitter returns. Any unit that was used in a process must be properly cleaned in accordance with OSHA standards, before it is returned to the factory. A Material Safety Data Sheet (MSDS) must also accompany the transmitter that was used in any process.
## Model number identification for KC approval

<table>
<thead>
<tr>
<th><strong>TRANSMITTER MODEL</strong></th>
<th><strong>=</strong></th>
<th><strong>M</strong> 1</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>TYPE</strong></td>
<td><strong>=</strong></td>
<td><strong>G</strong> 2</td>
</tr>
<tr>
<td><strong>APPROVAL AGENCY</strong></td>
<td><strong>=</strong></td>
<td><strong>K</strong> 3</td>
</tr>
<tr>
<td><strong>OUTPUT</strong></td>
<td><strong>=</strong></td>
<td><strong>F</strong> 4</td>
</tr>
<tr>
<td><strong>HOUSING TYPE</strong></td>
<td><strong>=</strong></td>
<td><strong>D</strong> 5</td>
</tr>
<tr>
<td><strong>ELECTRONICS MOUNTING</strong></td>
<td><strong>=</strong></td>
<td><strong>1</strong> 6</td>
</tr>
<tr>
<td><strong>TRANSMITTER PIPE/HOSE</strong></td>
<td><strong>=</strong></td>
<td><strong>B</strong> 7</td>
</tr>
<tr>
<td><strong>MATERIALS OF CONSTRUCTION (WETTED PARTS)</strong> (Note: contact factory for other materials)</td>
<td><strong>=</strong></td>
<td><strong>A</strong> 8</td>
</tr>
<tr>
<td><strong>PROCESS CONNECTION TYPE</strong></td>
<td><strong>=</strong></td>
<td><strong>1</strong> 9</td>
</tr>
<tr>
<td><strong>PROCESS CONNECTION SIZE</strong></td>
<td><strong>=</strong></td>
<td><strong>7</strong> 10</td>
</tr>
<tr>
<td><strong>TEMPERATURE (DIGITAL THERMOMETERS)</strong></td>
<td><strong>=</strong></td>
<td><strong>0</strong> 11</td>
</tr>
</tbody>
</table>

- **TRANSMITTER MODEL**
  - M = Magnetostrictive transmitter
- **TYPE**
  - G = Digital output level transmitter
- **APPROVAL AGENCY**
  - K = KC Approval
- **OUTPUT**
  - M = Modbus RTU data format
  - F = FOUNDATION™ fieldbus (Flameproof Only)
- **HOUSING TYPE**
  - B = Single Cavity (Flameproof IIB)
  - C = Dual Cavity (Flameproof IIB)
  - P = NEMA 4X, 316L SS with cable (No Approval)
- **ELECTRONICS MOUNTING**
  - 1 = Integral electronics
- **TRANSMITTER PIPE/HOSE**
  - B = Industrial end-plug with stop collar
  - M = Flexible w/bottom fixing hook (stainless steel only)
  - N = Flexible w/bottom fixing weight (stainless steel only)
  - P = Flexible w/bottom fixing magnet (stainless steel only)
- **MATERIALS OF CONSTRUCTION (WETTED PARTS)**
  - 1 = Stainless steel, 1.4404
  - 2 = Stainless steel, 1.4404 electropolished (3A approved, Ra 15 finish)
  - 3 = Hastelloy C
  - A = Teflon / FEP
- **PROCESS CONNECTION TYPE**
  - 1 = NPT, adjustable fitting
  - 4 = Sanitary, welded
  - 5 = Sanitary, adjustable fitting
  - 6 = 150 lb. welded RF flange
- **PROCESS CONNECTION SIZE**
  - 7 = 300 lb. welded RF flange
  - 8 = 600 lb. welded RF flange
  - 9 = DIN flange welded according to specification
- **TEMPERATURE (DIGITAL THERMOMETERS)**
  - 0 = None
  - 1 = One DT, fixed position
  - 5 = Five DTs, evenly spaced as API
  - 2 = One DT, customer defined position
  - 6 = Five DTs, customer defined position
  - 18 E must also be selected
  - 3 = One DT at 203 mm (8 in.) from end of transmitter if the order length is less than 9144 mm (360 in.). If the length greater, One DT at 914 mm (36 in.) from the end of the transmitter.

### Note:
- **If this DT option is selected, option ‘18 E’ must also be selected**
- **§ One DT at 203 mm (8 in.) from end of transmitter if the order length is less than 9144 mm (360 in.). If the length greater, One DT at 914 mm (36 in.) from the end of the transmitter.**
### Model number identification continued

<table>
<thead>
<tr>
<th>UNIT OF MEASUREMENT</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>M</td>
<td>Metric (millimeters) Encode length in millimeters if using metric (XXXXX mm)</td>
</tr>
<tr>
<td>U</td>
<td>US Customary (inches) Encode length in inches if ordering in US Customary (XXX.XX in.)</td>
</tr>
<tr>
<td>LENGTH</td>
<td>Order length based on unit of measurement</td>
</tr>
<tr>
<td>S</td>
<td>Standard product</td>
</tr>
<tr>
<td>E</td>
<td>Engineering special (not affecting agency controlled parts or features)</td>
</tr>
<tr>
<td>G</td>
<td>SPECIAL</td>
</tr>
</tbody>
</table>

- **LENGTH**
  - Rigid or Sanitary transmitter: 508 mm (20 in.) to 7620 mm (300 in.)
  - Flexible transmitter: 3048 mm (120 in.) to 22,000 mm (866 in.)
  - Teflon transmitter: 508 mm (20 in.) to 6096 mm (240 in.)
## Product specifications

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>LEVEL OUTPUT</strong></td>
<td></td>
</tr>
<tr>
<td>Measured variable:</td>
<td>Product level and interface level</td>
</tr>
<tr>
<td>Output signal / Protocol:</td>
<td>Modbus RTU, DDA or FOUNDATION™ fieldbus</td>
</tr>
<tr>
<td>Order length:</td>
<td></td>
</tr>
<tr>
<td>Flexible hose:</td>
<td>3048 mm (120 in.) to 22000 mm (866 in.) $\Delta$ §</td>
</tr>
<tr>
<td>Rigid pipe:</td>
<td>508 mm (20 in.) to 7620 mm (300 in.) $\Delta$ §</td>
</tr>
<tr>
<td>Sanitary pipe:</td>
<td>508 mm (20 in.) to 7620 mm (300 in.) $\Delta$ §</td>
</tr>
<tr>
<td>$\Delta$ Contact factory for longer lengths.</td>
<td></td>
</tr>
<tr>
<td>$\S$ Order length equals the measurement range plus the inactive zone.</td>
<td></td>
</tr>
<tr>
<td>Inherent accuracy:</td>
<td>$\pm 1$ mm (0.039 in.)</td>
</tr>
<tr>
<td>Hysteresis:</td>
<td>0.002% F.S. or 0.397 mm (1/64 in.) * (any direction)</td>
</tr>
<tr>
<td>* Whichever is greater</td>
<td></td>
</tr>
<tr>
<td>Resolution:</td>
<td>0.025 mm (0.001 in.)</td>
</tr>
<tr>
<td>Calculated variables:</td>
<td>GOVP</td>
</tr>
<tr>
<td></td>
<td>GOVI</td>
</tr>
<tr>
<td></td>
<td>GOVT</td>
</tr>
<tr>
<td></td>
<td>GOVU</td>
</tr>
<tr>
<td></td>
<td>NSVP</td>
</tr>
<tr>
<td><strong>TEMPERATURE OUTPUT</strong></td>
<td></td>
</tr>
<tr>
<td>Measured variable:</td>
<td>Average and multi-point temperatures Up to 12 Modbus $\Rightarrow$ Up to 5, DDA and FOUNDATION™ fieldbus $\Rightarrow$ Minimum length of 2032 mm (80 in.) for 12 temperature positions.</td>
</tr>
<tr>
<td>Temperature accuracy:</td>
<td>$\pm 0.28$ ºC ($\pm 0.5$ ºF)</td>
</tr>
<tr>
<td><strong>ELECTRONICS</strong></td>
<td></td>
</tr>
<tr>
<td>Input voltage:</td>
<td>Modbus and DDA: 10.5 to 30.1 Vdc</td>
</tr>
<tr>
<td><strong>FOUNDATION™ fieldbus:</strong></td>
<td>9 to 32 Vdc bus powered</td>
</tr>
<tr>
<td>Fail safe:</td>
<td>High, full scale</td>
</tr>
<tr>
<td>Reverse polarity protection:</td>
<td>Series diode</td>
</tr>
</tbody>
</table>

### Parameters Specifications

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Lightning/ Transient protection:</strong></td>
<td>Line-to-ground surge suppression; IEC 61000-4-5</td>
</tr>
<tr>
<td><strong>CALIBRATION</strong></td>
<td>Anywhere within the active length</td>
</tr>
<tr>
<td><strong>ENVIRONMENTAL</strong></td>
<td></td>
</tr>
<tr>
<td>Enclosure rating:</td>
<td>NEMA Type 4X</td>
</tr>
<tr>
<td>Humidity:</td>
<td>0 to 100% relative humidity, non-condensing</td>
</tr>
<tr>
<td><strong>Operating temperatures:</strong></td>
<td>Electronics: -40 ºC (~-40 °F) to 71 ºC (160 °F)</td>
</tr>
<tr>
<td>Sensing element:</td>
<td>-40 ºC (~-40 °F) to 125 ºC (257 °F) $\diamond$</td>
</tr>
<tr>
<td>Temperature element:</td>
<td>-40 ºC (~-40 °F) to 105 ºC (221 °F) $\diamond$</td>
</tr>
<tr>
<td>$\diamond$ Contact factory for specific temperature ranges.</td>
<td></td>
</tr>
<tr>
<td><strong>Vessel pressure:</strong></td>
<td>Industrial Rigid Pipe: 1000 psi (70 bar)</td>
</tr>
<tr>
<td>Sanitary Pipe:</td>
<td>435 psi (30 bar)</td>
</tr>
<tr>
<td>Teflon Pipe:</td>
<td>100 psi (7 bar)</td>
</tr>
<tr>
<td>Flexible Hose:</td>
<td>260 psi (18 bar)</td>
</tr>
<tr>
<td><strong>Materials:</strong></td>
<td>Wetted parts: 316L stainless steel †</td>
</tr>
<tr>
<td>Non-wetted parts:</td>
<td>316L stainless steel, Epoxy coated aluminum †</td>
</tr>
<tr>
<td>* Contact factory for alternative materials.</td>
<td></td>
</tr>
<tr>
<td><strong>FIELD INSTALLATION</strong></td>
<td></td>
</tr>
<tr>
<td>Housing dimensions:</td>
<td>Single cavity: 127 mm (5 in.) by 123 mm (4.85 in.)</td>
</tr>
<tr>
<td></td>
<td>121 mm (4.75 in.) O.D.</td>
</tr>
<tr>
<td>Dual cavity:</td>
<td>127 mm (5 in.) by 177 mm (6.95 in.)</td>
</tr>
<tr>
<td></td>
<td>121 mm (4.75 in.) O.D.</td>
</tr>
<tr>
<td>NEMA Type 4X:</td>
<td>81 mm (3.2 in.) by 123 mm (4.85 in.) O.D.</td>
</tr>
<tr>
<td>Mounting:</td>
<td>Rigid pipe: ¼ in. Adjustable MNPT fitting, Flange and Tri-Clamp® Mounts</td>
</tr>
<tr>
<td>Flexible hose:</td>
<td>1 in. Adjustable MNPT fitting, Flange mount</td>
</tr>
<tr>
<td>Wiring:</td>
<td>Modbus and DDA: 4-wire connections plus earth ground. Integral cable with pigtails.</td>
</tr>
<tr>
<td><strong>FOUNDATION™ fieldbus:</strong></td>
<td>Type A fieldbus cable</td>
</tr>
<tr>
<td><strong>ELECTRICAL CONNECTIONS</strong></td>
<td></td>
</tr>
<tr>
<td>Single and Dual Cavity:</td>
<td>M20 FNPT conduit opening</td>
</tr>
<tr>
<td>NEMA Type 4X:</td>
<td>½ in. FNPT conduit opening</td>
</tr>
</tbody>
</table>
Installation and mounting

If the installation is going to occur in a hazardous area, completely read the Agency Information section before starting any work. The Agency Information outlines additional regulations that need to be followed in order for the installation to comply with hazardous area regulations.

This section contains information about storing your transmitter (prior to installation) and detailed procedures for installing and mounting your transmitter.

Storage

If storage is required prior to installation, store indoors in a dry environment at ambient temperature range not exceeding -40 °C (-40 °F) to 71 °C (160 °F).

Stilling wells and guide poles

Level Plus transmitters can be mounted in slotted or un-slotted stilling wells but a slotted stilling well is always preferred. Using a un-slotted stilling well will negatively affect performance of any level device as the level in the stilling well will differ from the level in the tank. The Level Plus transmitter can also be installed to one side of the stilling well to also allow for sampling and manual gauging from the same opening as the automatic tank gauging. Contact Technical Support for details.

Level Plus transmitters do not require a stilling well for installation. Our transmitters are installed in numerous tanks without stilling wells with no loss in performance due to our patented flexible waveguide and hose. A stilling well is highly recommended for agitated, turbulent, and/or fast filling tanks.

Installation

The installation procedures below are illustrated using the adjustable NPT fitting for a threaded flange mount. The procedures will have to be slightly adjusted if using a welded flange or sanitary tri-clamp mount.

RIGID PROBE

Tools Required:
- Channel lock pliers
- Common screwdriver
- 5/32 in. Hex key (allen wrench)

Caution:
It is recommended that assembly and mounting of this transmitter should not be performed alone. To ensure proper and safe assembly of the M-Series transmitter, a minimum of two (2) individuals are recommended. Gloves are also recommended. In addition, PPE is required for work areas such as safety shoes, safety glasses, hard hat, and fire resistant clothing.

Perform the following steps to Install the Model MG Digital transmitter:

1. Remove the stop collar and E-ring. With assistance, feed the rigid pipe through the hole of the removed tank flange until the flange is positioned near the top of the transmitter. Insert the threaded portion of the adjustable fitting into the customer supplied flange and tighten (apply pipe thread sealant if required). Be careful not to drop the flange as it can damage the transmitter.
2. Slide the product float onto the rigid pipe. Slide the interface float (optional) onto the rigid pipe. Install stop collar 2 inches from the bottom (see ‘Note’ below). Do not drop the float(s) or allow them to free fall along the rigid pipe as damage may result. Install E-ring.

Note:
The stop collar can be removed or adjusted based on the float selected for the application. Please consult the factory for more information.

3. Slide float(s) back down to the stop collar to prevent them from free falling during installation into the tank. Insert the rigid pipe (with floats) through the tank opening and lower the transmitter/float assembly into the tank until it rests on the bottom. DO NOT DROP OR DAMAGE THE PIPE.
4. Secure the flange onto the tank mount.
5. Pull the transmitter upward so the end plug is just resting on the floor of the tank. Tighten the adjustable fitting to hold the transmitter in place.
6. Terminate the field wire cables noting proper wire orientation.
FLEXIBLE PROBE

Caution:
When assembling and installing the Model MG transmitter, be careful not to allow the flexible hose to kink or be coiled in less than 16 in. (406.5 mm) diameter. It is recommended that assembly and mounting of this transmitter should not be done alone. To ensure proper and safe assembly of the Model MG transmitter, a minimum of two (2) individuals are recommended. Gloves are also recommended. PPE is required for work areas such as safety shoes, safety glasses, hard hat, and fire resistant clothing.

Tools Required:
- 9/16 in. Socket and ratchet
- Channel lock pliers
- 3/16 in. Hex key (allen wrench)

1. Remove the stop collar. With assistance, feed the flexible hose through the hole of the removed tank flange until the flange is positioned at the rigid section of pipe near the top of the transmitter. Insert the threaded portion of the adjustable fitting into the customer supplied flange and tighten (apply pipe thread sealant if required). Be careful not to drop flange on the flexible hose as damage may result.

2. Slide the product float onto the flexible pipe. Slide the interface float (optional) onto the flexible pipe. Install stop collar 3 inches from the bottom of rigid section (see ‘Note’ below). Do not drop float(s) or allow them to free fall along the flexible pipe as damage may result.

Note:
The stop collar can be removed or adjusted based on the float selected for the application. Please consult the factory for more information.

3. Mount the hook, weight, or the magnet to the welded end-plug section of the pipe (this is the bottom rigid section of the pipe) using the supplied nut, spacer and washer, tighten securely as shown in Figure 5. For the magnet, remove washer before installing in tank.

![Image of bottom fixing hardware]

Figure 5. Bottom fixing hardware

DO NOT DROP OR DAMAGE THE PIPE

Important: Avoid kinking or bending the flexible pipe in less than 16 inch (406 mm) diameter or damage may result.

4. Slide float(s) back down to the stop collar to prevent them from free falling during installation into the tank. Insert the flex pipe and floats through the tank riser pipe and lower the transmitter/float assembly into the tank until it rests on the bottom. If you are using a bottom-fixing hook, fasten the hook to the appropriate customer-supplied mating hardware at the tank bottom.

5. Secure the flange onto the tank riser pipe.

6. Pull the transmitter upward to straighten the flexible pipe until the resistance of the weight, magnet, or hook is felt without raising the weight or magnet off the floor of the tank. Tighten the adjustable fitting to hold the transmitter in place.

7. Terminate the field wire cables noting proper wire orientation.
Mounting

The method of mounting the Level Plus M-Series transmitter is dependent on the vessel or tank in which it is being used, and what type of transmitter is being mounted. There are three typical methods for mounting; threaded flange mounting, welded flange mounting, and sanitary tri-clamp mounting.

**THREADED FLANGE MOUNTING**

In most applications, the Model MG transmitter can be mounted directly to the tank or flange via a NPT threaded fitting, assuming there is a proper threaded connection available. If the float will not fit through the flange opening when the flange is removed, there must be some alternative means to mount the float on the transmitter from inside the vessel; this may require an access port nearby the entry point of the transmitter as shown in [Figure 6].

**WELDED FLANGE MOUNTING**

The Model MG transmitter can also be mounted to a tank flange as shown in [Figure 7]. First, install float(s) onto the transmitter. Second, install the float retaining hardware on the tip of the transmitter. To complete the installation, mount the transmitter, flange and float(s) as a unit in to the tank.

![Figure 6. Threaded flange mounting for rigid (shown) and flexible pipe](image1)

![Figure 7. Welded flange mounting for rigid and flexible (shown) pipe](image2)
SANITARY TRI-CLAMP MOUNTING

In sanitary applications, the M-Series transmitter is mounted to the tank using a standard sanitary connection and clamp as shown in Figure 8. In most cases it is not necessary to remove the float as the sanitary end-plug fitting is sized to allow installation with the float in place. Please note that some sanitary end-plug styles have float(s) permanently mounted as shown in Figure 8. To install the clamp, the transmitter and float(s) into the mating process connection and attach the sanitary tri-clamp.

Figure 8. M-Series Model MG transmitter. Tank mounted with sanitary connection

<table>
<thead>
<tr>
<th>Inactive zone: 81 mm (3.2 in.) from tip (typical)</th>
<th>Inactive zone: 74 mm (2.9 in.) from tip (typical)</th>
<th>Inactive zone: 81 mm (3.2 in.) from tip (typical)</th>
<th>Inactive zone: 74 mm (2.9 in.) from tip (typical)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>TB</strong> Sanitary *</td>
<td><strong>DP</strong> Drain-in-place with end plug *</td>
<td><strong>CP</strong> Clean-in-place</td>
<td><strong>DN</strong> Drain-in-place no through hole</td>
</tr>
</tbody>
</table>

* This end plug style has permanently mounted floats. Floats cannot be removed from pipe.

Figure 9. End-plug options for transmitters in a sanitary pipe application
Electrical connections and wiring procedures

A typical intrinsically safe connection for the Level Plus M-Series transmitter includes protective safety barriers, a power supply and a reading or monitoring device. Refer to Agency information and Brief Operation Manual for Safe Use for detailed information.

A typical explosion proof connection for the M-Series transmitter includes a power supply and a reading or monitoring device connected using explosion proof conduit. Refer to Agency information and Brief Operation Manual for Safe Use for detailed information.

Notes:
For explosion proof installation, safety barriers are not required and wiring shall be installed in accordance with the National Electric Code ANSI/NFPA 70, Article 501-30 or the regional equivalent.

Safety recommendations for installation

Always follow applicable local and national electrical codes and observe polarity when making electrical connections. Never make electrical connections to the M-Series transmitter with power turned on. Make sure that no wire strands are loose or sticking out of the terminal block connection which could short and cause a problem. Make sure that no wire strands, including shield, are in contact with the electronic module enclosure. The electronics module enclosure is grounded through internal circuitry and electrically isolated from the flameproof enclosure.

Industrial topologies

There are four topologies described and illustrated below. However, the daisy chain topology is not recommended by MTS.

POINT-TO-POINT

The point-to-point topology consists of having only one device on the loop as shown in Figure 10. This topology is not usually used with a bus network since it does not take advantage of placing multiple devices on a loop.

BUS WITH SPURS

The bus with spurs topology has a main trunk cable that has each device connected via its own spur at a junction box as shown in Figure 11. The bus with spurs and tree topologies can also be used together to form a hybrid topology.

TREE ALIGNMENT

The tree topology is very similar to the bus with spurs topology with the main difference of having a common junction box for all of the transmitters as shown in Figure 12. Bus with spurs and tree topologies can also be used together to form a hybrid topology.

DAISY CHAIN

The daisy-chain topology utilizes a single cable that is connected to all of the transmitters with the cable being interconnected at each field device. When using this topology make sure that the wiring practice allows for one transmitter to be disconnected without disconnecting the entire loop as shown in Figure 13. MTS does not suggest using the daisy-chain topology.

Figure 10. Point-to-point topology
Figure 11. Bus with spurs topology
Figure 12. Tree topology
Figure 13. Daisy-chain topology
Recommended cable types

Listed below are general requirements of cable types for the Level Plus Model MG digital transmitter.

**CABLE RECOMMENDATION FOR MODBUS AND DDA**

Cable recommendation:

- Shielded, twisted pair, 24 AWG or heavier
- Minimum 85 °C temperature rating.
- Minimum 0.010 in. (0.25 mm) insulation thickness
- 30 picofarads/foot or less. (see Notes)

**Notes:**

1. The return conductor for the power supply circuit is connected to the shield at the safety barrier ground terminal. When determining the capacitance of cable for the power supply circuit, use the manufacturer’s capacitance specifications shown for one conductor and the other conductor connected to the shield.
2. Most cable manufacturers do not list inductance properties for cables. Where the inductance properties are unavailable, ISA RP12.6 (Installation of Intrinsically Safe Instrument Systems in Class I Hazardous Locations) recommends the use of 0.2 μH (micro henries) per foot as a value for cable inductance.
3. Termination and biasing of RS-485 data lines are as follows:
   - **Biasing** - Each M-Series transmitter has internal high impedance biasing resistors (30K Ω) on both RS-485 data lines. No additional biasing resistors should be present on the connecting devices (PLC, DCS, PC, converter).
   - **Termination** - Each M-Series transmitter has an internal termination resistor (100K Ω) installed across the RS-485 signal lines. No additional termination resistors are necessary in the connecting devices (PLC, DCS, PC, converter).

**CABLE RECOMMENDATION FOR FOUNDATION™ FIELDBUS**

General requirements of cable types for the M-Series FOUNDATION™ fieldbus transmitter:

Type A, FOUNDATION™ fieldbus cable (see Table 1 to the right)

**Electrical conduit installation**

**Important:**

Seal all conduits within 18 in. (457 mm).

**Notes:**

1. Use a flameproof type conduit sealing fitting.
2. Tighten housing cover (both front and back covers if dual cavity) to full stop against the O-ring. Make sure O-ring(s) are present and clean.
3. Do not over-tighten compression fittings.
4. Use side conduit entry only.
5. In high humidity areas, use a breather drain type conduit sealing fitting to minimize moisture intrusion.

**Table 1. Type A cable**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resistance</td>
<td>15Ω/km to 150 Ω/km</td>
</tr>
<tr>
<td>Inductance</td>
<td>0.4mH/km to 1mH/km</td>
</tr>
<tr>
<td>Capacitance</td>
<td>80nF/km to 200nF/km</td>
</tr>
</tbody>
</table>

Notes:

1. Use a flameproof type conduit sealing fitting.
2. Tighten housing cover (both front and back covers if dual cavity) to full stop against the O-ring. Make sure O-ring(s) are present and clean.
3. Do not over-tighten compression fittings.
4. Use side conduit entry only.
5. In high humidity areas, use a breather drain type conduit sealing fitting to minimize moisture intrusion.
Grounding

Note:

Grounding the transmitter through a threaded conduit connection does not provide sufficient ground.

There are two methods to provide an earth ground to the earth ground of the electronics.

- Run an earth ground through the conduit and connect directly to the earth ground of the electronics
- Run an earth ground directly to the ground lug on the outside of the housing and connect the ground lug inside of the housing to the earth ground of the electronics. Refer to *Table 2* and *Table 3* below for a limited listing of possible barrier selections.
Maintenance and field service

This section contains information about post installation maintenance and provides an overview of MTS Sensors’ repair and replacement procedures.

General maintenance and field service requirements

<table>
<thead>
<tr>
<th>Notes:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Please contact Technical Support or Customer Service for help when damage occurs in order to obtain a return materials authorization (RMA) number. Packages without a RMA number may be rejected. Any unit that was used in a process must be properly cleaned in accordance with OSHA standards, before it is returned to the factory. A Material Safety Data Sheet (MSDS) must accompany material that was used in any media.</td>
</tr>
</tbody>
</table>

FLOAT MAINTENANCE

Level Plus M-Series transmitters use magnetostrictive technology and only have one moving part—the float. This technology ensures no scheduled maintenance or recalibration is required. However, MTS recommends that you check the transmitter pipe annually for build up of process material. Floats should move freely along the pipe. If they do not, routine cleaning should be performed.

FIELD SERVICE

If damage does occur to a M-Series transmitter, the transmitter can be serviced in the field with replacement parts. All electronic parts can be changed in the field without having to open the process vessel. Please contact Technical Support and refer to the Transmitter Electronics Replacement Guide (MTS part no. 551104) for detailed steps of field replacement.

SERVICE / RMA POLICY

If the customer suspects their transmitter is damaged or not functioning correctly, call MTS Technical Support for further instruction. If it is necessary to return the transmitter to the factory, an RMA number is required and can only be issued by Technical Support. Product returns that do not include an RMA will be returned to the customer. MTS evaluates the transmitter and advises the customer whether a repair or replacement is necessary and any cost that might be incurred. If the customer declines repair/replacement or the transmitter has no fault found, the unit is sent back as is and the customer is charged with a standard evaluation fee.

If the transmitter is under warranty and a manufacturer’s defect is detected, there will be no cost to the customer for repair or replacement. If the transmitter is out of warranty or if the customer has damaged the transmitter, a repair or replacement quote will be provided. In specific cases where the transmitter can not be removed and returned to the factory for evaluation, field evaluations can be performed on-site by an MTS technician. If field evaluation must be performed, the customer is responsible for all expenses incurred for travel, evaluation, parts and repair time. However, if the transmitter is under warranty and the problem is due to a manufacturer’s defect, there is no cost to the customer for replacement parts. To discuss all service options, contact Technical Support.
## Troubleshooting

Table 4 below contains troubleshooting information for the Model MG digital transmitter.

### Troubleshooting procedures

<table>
<thead>
<tr>
<th>Symptom</th>
<th>Possible Cause</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>No communication with transmitter</td>
<td>No power</td>
<td>Check voltage at transmitter</td>
</tr>
<tr>
<td></td>
<td>Wiring incorrect</td>
<td>Reference installation drawing (see Electrical connections and wiring)</td>
</tr>
<tr>
<td></td>
<td>Wrong address</td>
<td>DDA factory default is ‘192’ Modbus factory default is ‘247’</td>
</tr>
<tr>
<td></td>
<td>Wrong software</td>
<td>Confirm correct software</td>
</tr>
<tr>
<td></td>
<td>Wrong protocol</td>
<td>Confirm software and transmitter are same protocol</td>
</tr>
<tr>
<td>Missing magnet error</td>
<td>Float not recognized</td>
<td>Confirm that the float is attached</td>
</tr>
<tr>
<td></td>
<td>Float is in the dead zone</td>
<td>Raise float to see if the error stops</td>
</tr>
<tr>
<td></td>
<td>Wrong number of floats selected</td>
<td>Confirm that the number of floats on the transmitter and the number of floats the transmitter is attempting to verify are the same.</td>
</tr>
<tr>
<td>Trigger level error</td>
<td>Gain needs to be adjusted</td>
<td>Consult Factory</td>
</tr>
<tr>
<td></td>
<td>SE is damaged</td>
<td>Consult Factory</td>
</tr>
<tr>
<td></td>
<td>Min. trigger level too high</td>
<td>Consult Factory</td>
</tr>
<tr>
<td>Volume calculation error</td>
<td>No strap table entered</td>
<td>Enter strap table</td>
</tr>
<tr>
<td></td>
<td>Level outside range of strap table</td>
<td>Enter additional points in strap table</td>
</tr>
<tr>
<td></td>
<td>Strap table incorrect</td>
<td>Check value entries</td>
</tr>
<tr>
<td>VCF error</td>
<td>No VCF table entered</td>
<td>Enter VCF table</td>
</tr>
<tr>
<td></td>
<td>VCF table incorrect</td>
<td>Check VCF value entries</td>
</tr>
</tbody>
</table>

Table 4. Troubleshooting reference
Quick start-up guide (Modbus and DDA)

BEFORE YOU BEGIN

**Note:**

You must use a RS-485 converter with “Send Data Control” and the M-Series Set-up Software to ensure proper operation.

*Example:*


**Default communication parameters**

<table>
<thead>
<tr>
<th>Modbus: 4800 BAUD</th>
<th>8, N, 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>DDA: 4800 BAUD</td>
<td>8, E, 1</td>
</tr>
</tbody>
</table>

**QUICK START-UP PROCEDURE**

1. Connect +24 Vdc to terminals.
2. Connect data lines to terminals.
3. Connect the PC (or other device) to data lines.  
   (If you are using a PC, use a RS-232 to RS-485 converter. See *Note* above for more information.)
4. Turn on power to the transmitter.
5. Start the M-Series Setup Software. Click the ‘Data From Device’ tab. Click the ‘Device’ pull down menu (located in the upper right corner of the window) to verify communications using factory default address ‘247’ for Modbus or factory default ‘192’ for DDA.
6. Change the address to one that is suitable for the installation network.
7. Verify proper operation of product and or interface floats and temperature.
8. Turn off power to the transmitter.
9. Remove data lines.
10. Install the transmitter into the vessel (*see Installation and mounting on page 11*).
11. Reconnect power and data lines.
12. Verify communications with the host system (*repeat step 5*).
13. Calibrate current tank level (optional). Setup is complete.
Model MG Operation and Installation Manual
Modbus User Interface

Modbus Interface

Notes:
Termination and biasing of RS-485 data lines are as follows:

- **Biasing**
  Each M-Series transmitter has internal high impedance biasing resistors (30K Ω) on both RS-485 data lines. No additional biasing resistors should be present on the connecting devices (PLC, DCS, PC, Converter).

- **Termination**
  Each M-Series transmitter has an internal termination resistor (100K Ω) installed across the RS-485 signal lines. No additional termination resistors are necessary in the connecting devices (PLC, DCS, PC, Converter).

MODBUS IMPLEMENTATION

The Modbus implementation for the M-Series digital transmitter conforms to the ‘Modicon Modbus Protocol Reference Guide, PIMBUS-300 Rev. G’ available from Modicon, Inc. The information provided below assumes familiarity with the Modbus protocol as outlined in this reference guide. All information provided applies to Modbus RTU protocol only.

MODBUS FUNCTION CODES

<table>
<thead>
<tr>
<th>Communication parameters:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Modbus: 4800 BAUD or 9600</td>
<td>8, N, 1</td>
</tr>
<tr>
<td>(Reference) Monitor: Modbus RTU Variable BAUD Rate</td>
<td>8, E, 1</td>
</tr>
</tbody>
</table>

The following Modbus function codes are supported:

- **Function 03** - Read Holding Registers
- **Function 04** - Read Input Registers
- **Function 06** - Preset Single Register
- **Function 08** - Diagnostics (Subfunction 00, Return Query Data)
- **Function 08** - Diagnostics (Subfunction 01, Restart Communications Option)
- **Function 08** - Diagnostics (Subfunction 04, Force Listen Only Mode)
- **Function 16** - Preset Multiple Registers
- **Function 17** - Report Slave ID

**Function 03 - Read Holding Registers**

The device responds to this message by returning the contents of the requested data register(s).

The following implementation-specific considerations apply:

- If an unsupported or reserved register is requested, a maximum negative value (8000H or 80000000H for paired registers) is returned (See ‘Device Modbus Register Maps’ on page 22 for unsupported/reserved registers).
- If a register contains an device error a maximum negative value is returned.
- If a register is blank, indicating that the desired function is not enabled (e.g., volume calculations) a value of 0000H is returned.
- Unsupported or reserved bits will always be set to 0. See ‘Device Modbus Register Maps’ on page 22 for alarm bit definitions.

**Function 04 - Read Input Registers**

This function is handled exactly the same as **Function 03**. (Be advised that all registers are read-only in this implementation).

**Function 06 – Preset Single Registers**

Confirmation of successful transmission is confirmed when the device responds by echoing back what was sent.

**Function 08 - Diagnostics (Subfunction 00, Return Query Data)**

The device responds to this request with the following data:

- Slave address: echoed
- Function: 08H
- Subfunction high: 00H
- Subfunction low: 00H
- Query data (16-bit): echoed
- Error check: 16-bit CRC/8-bit LRC

**Function 08 - Diagnostics (Subfunction 01, Restart Communications Option)**

Note:
The communications event log is not supported. The “Query data” field is irrelevant (normally, FF00H would clear the log).

If the device is in listen-only mode, the device responds to this message by switching out of listen-only mode - (resulting in no response being sent to the request).

If the device is not in listen only mode, it responds as follows:

- Slave address: echoed
- Function: 08H
- Subfunction high: 00H
- Subfunction low: 01H
- Query data (16-bit): echoed (0000H or FF00H)
- Error check: 16-bit CRC/8-bit LRC

**Function 08 - Diagnostics (Subfunction 04, Force Listen-Only Mode)**

The device responds to this request by switching to listen-only mode. Messages are still received and parsed, but no responses are transmitted. To switch out of listen-only mode, issue a ‘Restart Communications Option’ request (function 08, subfunction 01) or cycle power.

**Function 16 - Preset Multiple Registers**

The device response returns the slave address, function code, starting address, and quantity of registers preset.
**MODBUS FUNCTION CODES (CONTINUED)**

**Function 17 - Report Slave ID**
The device responds to this request with the following data:
- Slave address: echoed
- Function: 11H
- Byte count: 05H
- Slave ID: FFH
- Run indicator status: FFH (ON)
- Additional data: ‘DMS’
- Error check: 16-bit CRC/8-bit LRC

**Modbus Exceptions**
The following standard Modbus exceptions are implemented:
- **Error code 01 (Illegal Function)**
  - Reported when:
    - A function other than 03, 04, 06, 08, 16 or 17 is requested
    - Function 08 is requested, and a subfunction other than 00, 01, or 04 is requested
  
- **Error code 02 (Illegal Data Address)**
  - Reported when:
    - Function 03 or 04 is requested and the starting register number is greater than 5198 (register greater than 35198 or 45198)

- **Error code 03 (Illegal Data Value)**
  - Reported when:
    - Function 03 or 04 is requested and the number of data points is greater than 800.

**DEVICE MODBUS REGISTER MAPS**

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<thead>
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<th>Data Description</th>
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<td>30264</td>
<td>263</td>
<td>Alarm/Status High Word ‡</td>
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<td>30265</td>
<td>264</td>
<td>Alarm/Status Low Word ‡</td>
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<td>30266</td>
<td>265</td>
<td>VCF Calculation Error Status ‡</td>
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<tr>
<td>30267</td>
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<td>30300</td>
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<td>Temperature Units High ‡</td>
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<td>30301</td>
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<td>Density Units High ‡</td>
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<td>Volume Units High ‡</td>
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<td>Volume Units Low ‡</td>
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<td>305</td>
<td>Length Units High ‡</td>
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<td>30307</td>
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<td>30309</td>
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<td>Mass Units Low ‡</td>
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<td>30310</td>
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<td>Set New Device Address ‡</td>
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<tr>
<td>31101</td>
<td>1100</td>
<td>Tank offset High (x 10)</td>
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<tr>
<td>31102</td>
<td>1101</td>
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<tr>
<td>31103</td>
<td>1102</td>
<td>Calibrate Using Current Product Level High (x 1000)</td>
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<td>31104</td>
<td>1103</td>
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<td>31105</td>
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<tr>
<td>31107</td>
<td>1106</td>
<td>Calibrate Using Current Roof Level High (x 1000)</td>
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<tr>
<td>31108</td>
<td>1107</td>
<td>Calibrate Using Current Roof Level Low (x 1000)</td>
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<td>31109</td>
<td>1108</td>
<td>Alarm Units High</td>
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<td>33, Page 29</td>
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<tr>
<td>31110</td>
<td>1109</td>
<td>Alarm Units Low</td>
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<td>31111</td>
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<td>31112</td>
<td>1111</td>
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<td>Interface Low Alarm High (x 100)</td>
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<td>1117</td>
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<td>1118</td>
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<td>31120</td>
<td>1119</td>
<td>Roof High Alarm Low (x 100)</td>
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<tr>
<td>31121</td>
<td>1120</td>
<td>Roof Low Alarm High (x 100)</td>
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<td>39, Page 29</td>
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<td>31122</td>
<td>1121</td>
<td>Roof Low Alarm Low (x 100)</td>
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<td>31123</td>
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<td>40, Page 29</td>
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<tr>
<td>31124</td>
<td>1123</td>
<td>Temperature Average High Alarm Low (x 100)</td>
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<td>31126</td>
<td>1125</td>
<td>Temperature Average Low Alarm Low (x 100)</td>
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<td>1126–1997</td>
<td>Reserved</td>
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<tr>
<td>31199</td>
<td>1998</td>
<td>Number Of Strap Table Entries High</td>
<td></td>
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</tr>
<tr>
<td>32000</td>
<td>1999</td>
<td>Number Of Strap Table Entries Low</td>
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<td>32001</td>
<td>2000</td>
<td>Strap Table Level 1 High (x 10000)</td>
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<td>43, Page 29</td>
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## Modbus User Interface

### DEVICE MODBUS REGISTER MAPS (CONTINUED)

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<th>Modbus Register</th>
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<tr>
<td>32002</td>
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<td>Strap Table Level 1 Low (x 10000)</td>
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<td>32003</td>
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<td>Strap Table Level 2 High (x 10000)</td>
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<td>32004</td>
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<td>32005</td>
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<td>32006</td>
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### DEVICE MODBUS REGISTER MAPS (CONTINUED)

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<tr>
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<td>VCF Table Temperature 2 Low (x 10000)</td>
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<td>VCF Table Temperature 3 High (x 10000)</td>
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<td>VCF Table Temperature 3 Low (x 10000)</td>
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<td>35099</td>
<td>5098</td>
<td>VCF Table Temperature 50 High (x 10000)</td>
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<tr>
<td>35100</td>
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<td>VCF Table Temperature 50 Low (x 10000)</td>
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<tr>
<td>35101</td>
<td>5100</td>
<td>VCF Table Correction 1 High (x 10000)</td>
<td>50, page 30</td>
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### SPECIAL/ADVANCED DIAGNOSTIC REGISTER MAPS

<table>
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<tbody>
<tr>
<td>35201</td>
<td>5200</td>
<td>Num Linearization Entries Hi</td>
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<tr>
<td></td>
<td></td>
<td>Num Linearization Entries Lo</td>
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<tr>
<td>35203</td>
<td>5202 - 5999</td>
<td>Lintable Level1 Hi</td>
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<td></td>
<td></td>
<td>Lintable Level1 Lo</td>
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<td>5600</td>
<td>Lintable Level200 Hi</td>
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<td></td>
<td>Lintable Level200 Lo</td>
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<tr>
<td>35603</td>
<td>5602 - 5999</td>
<td>Lintable Error1 Hi</td>
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</tr>
<tr>
<td></td>
<td></td>
<td>Lintable Error1 Lo</td>
<td></td>
</tr>
</tbody>
</table>

### HOW UNITS ARE USED

Registers that are read or preset are done so using the current unit type’s programmed unit.

*For example:*  
If the current unit type is ‘Length’ and you currently have selected ‘Feet’ as your unit, then the value returned will be in that unit. Make sure the value programmed is also done so using that unit.

### MODBUS REGISTER MAP NOTE REFERENCES

1. All registers can be accessed using either Modbus Function 03 (Read Holding Registers) or Modbus Function 04 (Read Input Registers). However, all registers are read-only in this implementation.  
   *For example:*  
   Registers 30001 and 30002 (using Function 03) can also be read as registers 40001 and 40002 (using Function 04).

2. Pairs of registers identified as ‘High Word’ and ‘Low Word’ must be read together reading the ‘High Word’ first. Both values need to be concatenated by the master to form a 32-bit ‘long word’ quantity.

   *For example:*  
   Register 30001 (16-bit high word) = 0002H (Must be read first)  
   Register 30002 (16-bit low word) = 3F8CH  
   Long word (32-bit) = 00023F8CH (decimal 147340)  
   Or:  
   Register 30001 (high word) = 2  
   Register 30002 (low word) = 16268  
   Multiply register 30001 x 65536 : 2 x 65536 = 131072  
   Add result to register 30002 : 131072 + 16268 = 147340
DEVICE MODBUS REGISTER MAPS (CONTINUED)

3. All registers identified as ‘(x 10),’ ‘(x 100),’ ‘(x 1000),’ ‘(x 10000)’ or ‘(x 10000000)’ have been scaled (multiplied) by a factor of 10, 100, 1000, 10000 or 10000000 before transmission to preserve the fractional portion of the data value. The master must divide these values by the scale factor as necessary.

For example:
Register 30001 (16-bit high word) = 0002H
Long word (32-bit) = 00023F8CH (decimal 147340)
Divide by 1000, actual value = 147.340

4. Individual digital temperature

5. Average submerged temperature

6. \( \text{GOVP} \) = Gross Observed Volume Product

7. \( \text{GOVI} \) = Gross Observed Volume Interface

8. \( \text{GOVT} \) = Gross Observed Volume Total

9. \( \text{GOVU} \) = Gross Observed Volume Ullage

10. \( \text{NSVP} \) = Net Standard Volume of Product

11. Temperature Correction Method
    There are five methods to choose from:
    1 = (6A) Heavy Oils
    2 = (6B) Light Oils
    3 = (6C) Chemicals
    4 = Chemicals with wider coefficients than 6C and a movable reference temperature (6C Mod).
    5 = Custom Table.

12. Thermal Expansion Coefficient (TEC)
    Temperature correction method ‘6C’ uses the thermal expansion coefficient of the product being measured to determine the volume correction factor. Allowable values are 270.0 to 930.0. TEC Units are in 10E-6/Deg F.

13. Density
    Temperature correction method ‘6C’ and ‘Custom Table’ requires you to enter the density (at the given reference temperature) of the product being measured for the net mass calculation.

14. Reference Temperature
    This is the desired base temperature for the VCF calculation when Temperature Correction Method ‘6C Mod’ is used.

15. Volume Calculation Mode
    This is the mode you wish the volume calculations to be performed by:
    1 = Use Strap Table
    0 = Use Sphere Calculation

16. Sphere Radius
    The radius of the sphere when volume calculations are performed (using the sphere calculation mode).

17. Sphere Offset
    The offset of the sphere when volume calculations are performed (using the sphere calculation mode).

18. Average Interval
    All level, temperature and volume calculation can be averaged using timed method. Allowable values are as follows:
    0 = 1 second (default)
    5 = 5 seconds
    10 = 10 seconds
    15 = 15 seconds
    20 = 20 seconds
    25 = 25 seconds
    30 = 30 seconds
    35 = 35 seconds
    40 = 40 seconds
    45 = 45 seconds
    50 = 50 seconds
    55 = 55 seconds
    60 = 60 seconds

19. Alarm/Status bit definitions:
    D1 Interface Alarm High
    D2 Interface Alarm Low
    D3 Product Alarm High
    D4 Product Alarm Low
    D5 Roof Alarm High
    D6 Roof Alarm Low
    D7 Average Temperature Alarm High
    D8 Average Temperature Alarm Low
    D9 Magnet Is Missing
    D10 Digital Temperature 0 Error
    D11 Digital Temperature 1 Error
    D12 Digital Temperature 2 Error
    D13 Digital Temperature 3 Error
    D14 Digital Temperature 4 Error
    D15 Digital Temperature Average Error
    D16 – D32 Reserved

For each corresponding alarm bit:
0 = ALARM OFF
1 = ALARM ON
Reserved bits will always be set to 0 (OFF).
20. **Volume Correction Factor Calculation Error Status.**
   This value can only be read. If there is no error performing the volume correction factor then the value is zero otherwise, the value is a non-zero code and one of the following:
   1 = Invalid API value or invalid temperature input value for 6A or 6B VCF calculation.
   2 = Invalid API value or invalid temperature input range for 6A VCF calculation.
   3 = Invalid API value or invalid temperature input range for 6B VCF calculation.
   4 = Invalid API value or invalid temperature input value for 6C VCF calculation.
   5 = Invalid API value or invalid temperature range for 6C VCF calculation.
   6 = Invalid API value or invalid temperature range for 6C Wide VCF calculation.
   7 = Invalid delta temperature for 6C VCF calculation.
   8 = Interpolation error, temperature value not found in the table.
   9 = Invalid or No VCF method selected.

21. **Volume Calculation Error Status**
   This value can only be read. If there is no error performing the volume calculations then the value is zero otherwise the value is a non-zero code and one of the following:
   1 = Negative table entries are not allowed.
   2 = Interpolation error, level value not found in the table.
   3 = Sphere Calculation error, level exceeds sphere radius x 2.
   4 = Calculated a negative volume value.

22. **Undefined or reserved registers within the register map** will return a maximum negative value (8000H, or 80000000H for register pairs). Attempting to read registers outside the register map (35198 or higher) will cause a Modbus Exception Error Code 02 (Illegal Data Value) to be returned.

23. **Temperature Units**
   The value for temperature units can be one of the following codes:
   0 = Celsius
   1 = Fahrenheit

24. **Density Units High**
   The value for density units can be one of the following codes:
   0 = Grams/Milliliters
   1 = Grams/Liter
   2 = Kilograms/Cubic Meters
   3 = Kilograms/Liter
   4 = Pounds/Cubic Inch
   5 = Pounds/Cubic Foot
   6 = Pounds/Gallon
   7 = Tonnes/Cubic Meter
   8 = Tons/Cubic Yard

25. **Volume Units**
   The value for volume units can be one of the following codes:
   0 = Liters
   1 = Cubic Millimeters
   2 = Cubic Meters
   3 = Cubic Inches
   4 = Cubic Feet
   5 = Gallons
   6 = Barrels

26. **Length Units**
   The value for length units can be one of the following codes:
   0 = Millimeters
   1 = Centimeters
   2 = Meters
   3 = Kilometers
   4 = Inches
   5 = Feet
   6 = Yards

27. **Mass Units**
   The value for mass units can be one of the following codes:
   0 = Kilograms
   1 = Grams
   2 = Ounces
   3 = Pounds
   4 = Tons
   5 = Tonnes

28. **Set New Device Address**
   This register will program the new device address. Valid values for Modbus are between: 1 – 247.

29. **Tank Offset**
   This is the value that will be added or subtracted from the level measurements. This allows the tank level reading to be calibrated to the users hand gauged tank reading (or other level reference guide).
   (See notes 30, 31 and 32) for more information.

30. **Calibrate Using Current Product Level**
   This is used to calibrate the level measurements. This allows the user to enter the hand gauged tank reading (or other level reference guide) of the Product and the device will calculate the necessary calibration offset.
   The calculated value will then be stored as the ‘Tank Offset’.
   (See note 29)

31. **Calibrate Using Current Interface Level**
   This is used to calibrate the level measurements. This allows the user to enter the hand gauged tank reading (or other level reference guide) of the Interface and the device will calculate the necessary calibration offset.
   The calculated value will then be stored as the ‘Tank Offset’.
   (See note 29)
DEVICE MODBUS REGISTER MAPS (CONTINUED)

32. Calibrate Using Current Roof Level
   This is used to calibrate the level measurements. This allows
   the user to enter the hand gauged tank reading (or other level
   reference guide) of the Roof and the device will calculate the
   necessary calibration offset.
   The calculated value will then be stored as the ‘Tank Offset’.
   (See note 29)

33. Alarm Units
   This register programs the unit type for which you can
   configure alarms. Product and Interface can be ‘Volume or
   ‘Length’ unit type, however Roof can only be ‘Length’ unit
   type.
   Valid Values are as follows:
   2 = Volume Units Type.
   3 = Length Units Type.

34. Interface High Alarm
   The value for which the Interface cannot be >=. Make sure the
   value is programmed in the current Alarm Units type.
   (See Note 33)

35. Interface Low Alarm
   The value for which the Interface cannot be <=.
   Make sure the value is programmed in the current Alarm Units
   type. (See Note 33)

36. Product High Alarm
   The value for which the Product cannot be >=.
   Make sure the value is programmed in the current Alarm Units
   type. (See Note 33)

37. Product Low Alarm
   The value for which the Product cannot be <=.
   Make sure the value is programmed in the current Alarm Units
   type. (See Note 33)

38. Roof High Alarm
   The value for which the Roof cannot be >=.
   This value can only be in unit type of Length. (See Note 33)

39. Roof Low Alarm
   The value for which the Roof cannot be <=.
   This value can only be in unit type of Length. (See Note 33)

40. Temperature Average High Alarm
    The value for which the Average Temperature cannot be >=.

41. Temperature Average Low Alarm
    The value for which the Average Temperature cannot be <=.

42. Number Of Strap Table Entries
    This value specifies the number of strap table entries to be
    used in the tank-strapping table.
    Table sizes can range from 2 to 100 entries.

43. Strap Table Level 1
    This is the register for the first strap table level value entry,
    Each register can be accessed individually (but programmed in
    pairs) using the following formula:
    
    \[ \text{Strap Table Level 1 High} + \left( (\text{Desired Entry #}) \times 2 \right) - 2 \]

    For example,
    if you wanted to program the 50th table entry:
    \[ 32000 + \left( (50 \times 2) - 2 \right) = 32098. \]
    You can program the entire table by setting the strap table
    Level 1 High register (32000) as your first register and a
    length of 100 using Modbus Function 16. You could also use
    Modbus Function 6 to program a single register pair.

44. Strap Table Level 100
    This is the register for the last strap table Level value entry.
    (See note 43) for details.

45. Strap Table Volume 1
    This is the register for the first strap table volume value entry.
    Each register can be accessed individually (but programmed in
    pairs) using the following formula:
    
    \[ \text{Strap Table Volume 1 High} + \left( (\text{Desired Entry #}) \times 2 \right) - 2 \]

    For example,
    If you wanted to program the 50th table entry:
    \[ 32000 + \left( (50 \times 2) - 2 \right) = 32098. \]
    You can program the entire table by providing the strap Table
    Volume 1 High register (32000) as your first register and a
    length of 100 using Modbus Function 16. You could also use
    Modbus Function 6 to program a single register pair.

46. Strap Table Volume 100
    This is the register for the last strap table Volume value entry.
    (See note 45) for details.

47. Number of VCF Table Entries
    This value specifies the number of VCF table entries to be used
    in the volume correction factor table.
    Table sizes can range from 2 to 50 entries.

48. VCF Table Temperature 1
    This is the register for the first VCF table Temperature value
    entry.
    Each register can be accessed individually (but programmed in
    pairs) using the following formula:
    
    \[ \text{VCF Table Temperature 1 High} + \left( (\text{Desired Entry #}) \times 2 \right) - 2 \]

    For example,
    if you wanted to program the 25th table entry:
    \[ 35000 + \left( (25 \times 2) - 2 \right) = 35048. \]
    You can program the entire table by providing the VCF table
Temperature 1 High register (35000) as your first register and a length of 50 using Modbus Function 16. You could also use Modbus Function 6 to program a single register pair.

49. VCF Table Temperature 50
This is the register for the last VCF table Temperature value entry. *(See note 48)* for more information.

50. VCF Table Correction 1
This is the register for the first VCF table Correction value entry. Each register can be accessed individually (but programmed in pairs) using the following formula:

\[
VCF = \exp \left( -A(T) \times (t-T) \times \left[ 1 + (0.8 \times A(T) \times (t-T)) \right] \right)
\]

Where:
- \( t \): any temperature*
- \( T \): BASE TEMPERATURE (60 DEGREES F)
- \( A(T) \): coefficient of thermal expansion at the base temperature \( T \)

\*API 2540 states that temperature data is rounded to the nearest tenth (0.1) degree.

This section includes all the constants used by the software to calculate the volume correction factors and valid ranges for the API (density) and temperature data.

### Constants:
- \( K0 = 341.0957 \)
- \( K1 = 0.0 \)

### Valid temperature range
<table>
<thead>
<tr>
<th>Temperature</th>
<th>Valid gravity ranges (API)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 to +300.0 °F</td>
<td>0 to 40.0 °API</td>
</tr>
<tr>
<td>0 to +250.0 °F</td>
<td>40.1 to 50.0 °API</td>
</tr>
<tr>
<td>0 to +200.0 °F</td>
<td>50.1 to 100.0 °API</td>
</tr>
</tbody>
</table>

**Table 5.** 6A heavy oils
FORMULAS USED IN VOLUME CALCULATIONS (CONTINUED)

<table>
<thead>
<tr>
<th>Product type</th>
<th>Constants</th>
<th>Valid gravity range (API)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuel oil</td>
<td>K0 = 103.8720 K1 = 0.2701</td>
<td>0.0 to 37.0 °API</td>
</tr>
<tr>
<td>Jet group</td>
<td>K0 = 330.3010 K1 = 0.0</td>
<td>37.1 to 47.9 °API</td>
</tr>
<tr>
<td>Transition group</td>
<td>K0 = 1489.0670 K1 = -0.0018684</td>
<td>48.0 to 52.0 °API</td>
</tr>
<tr>
<td>Gasoline</td>
<td>K0 = 192.4571 K1 = 0.2438</td>
<td>52.1 to 85.0 °API</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Valid temperature ranges</th>
<th>Valid TEC ranges</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 to +300.0 °F</td>
<td>0 to 40.0 °API</td>
</tr>
<tr>
<td>0 to +250.0 °F</td>
<td>40.1 to 50.0 °API</td>
</tr>
<tr>
<td>0 to +200.0 °F</td>
<td>50.1 to 85.0 °API</td>
</tr>
</tbody>
</table>

*For the transition group, A(T) = [K1 + K0 (DEN (T) x DEN (T))]

**TEC is the thermal expansion coefficient of the product being measured

Table 6. 6B light oils

Installing the M-Series Digital Setup Software

Adjustments to the calibration and setup parameters of the transmitter can be performed using the M-Series Digital Setup Software package. The software can be run from any PC using a RS-485 to RS-232 converter (See Table 9 MTS part number references). In the 'MTS Digital Gauge Configuration - Modbus -COM' window, you will see two tabs labeled 'Data From Device' (see Figure 14) on page 32 and 'Volume Calculations' (see Figure 15 on page 32). You will use these tabs to calibrate the transmitter and change setup parameters.

<table>
<thead>
<tr>
<th>M-Series PC Digital Setup Software (Modbus) CD and RS-485 to RS-232 converter</th>
<th>M-Series PC Digital Setup Software (Modbus) CD</th>
<th>RS-485 to RS-232 converter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Order number: 625051</td>
<td>Order number: 625052</td>
<td>Order number: 380075</td>
</tr>
</tbody>
</table>

Table 9. MTS part number references

Perform the following steps to install the transmitter setup software to establish communications with the transmitter:

1. Install Setup Software from the CD that came with your transmitter or go to www.mtssensors.com to download the latest version.
2. Connect transmitter to the RS-485 to RS-232 converter and attach the converter to your PC. Some PC’s will require an additional Serial to USB converter.
3. Open the Software program.
4. Select COM Port. If you do not know which COM port to select, right click My Computer and select Properties -> Hardware Tab -> Device Manager -> Ports (COM & LPT) to view the list.
5. Click the Device: pull-down window and select the ‘transmitter address’, the factory default for Modbus is 247.
INSTALLING THE SETUP SOFTWARE (CONTINUED)

Setting up and calibrating the Model MG digital transmitter

Pages 32 to 36 contain the following software parameter information for both 'Data From Device' and 'Volume Calculations' tabs:

DATA FROM DEVICE PARAMETERS:

- Units
- Alarms
- Offset
- Address
- Backup/Restore File
- Adjust
- COM Port
- Continuous Update
- Data Logging

DATA FROM DEVICE TAB

Units

To change Unit parameters, click the 'Units' button in the 'Data From Device' tab window. In the 'Select Units' window (See Figure 16) you can update units of measurement for length, temperature, volume, mass and density can be changed by selecting the appropriate parameter in the drop down menu, then click 'Send'. A confirmation popup window confirms the send is successful.

Figure 16. Select Units window

Alarms

To set the Alarms, select the 'Alarms' button in the 'Data From Device' tab window. A high and low alarm is offered for the product, interface, and average temperature and can be set to either length units or volume units from the pull down menu (See Figure 17). Each alarm needs to be checked and entered before you click the 'Send' button. A confirmation popup window confirms the send is successful.

Figure 17. Alarm Configuration window
DATA FROM DEVICE TAB (CONTINUED)

Calibration
When you click the ‘Offset’ button in the ‘Data From Device’ tab window, the ‘Offsets’ window opens. There are two calibration ‘Offset Methods’ to choose from, ‘Enter Current Tank Level’ and ‘Enter Level Offset’. Click to open the ‘Offset Method’ drop down menu and select a calibration method. Choose either method ‘Enter Current Tank Level’ or ‘Enter Current Interface Level’ and type a value in the active field, then click the ‘Send’ button. A confirmation popup window confirms the send is successful.

![Offsets window - Enter Current Tank Level](image1)

Figure 18. Offsets window - Enter Current Tank Level

When you choose ‘Enter Level Offset’ from the ‘Offset Method’ drop down menu, you can adjust the offset where the transmitters zero point is located. This adjustment will significantly shorten the span of the transmitter or counter inactive zones. Adjust the value accordingly and click ‘Send’. A confirmation popup window confirms the send is successful.

![Offsets window - Enter Level Offset method](image2)

Figure 19. Offsets window - Enter Level Offset method

Address
To change the transmitter address, click the ‘Address’ button in the ‘Data From Device’ tab window. In the ‘Change Address’ window, type the ‘New Address’ in the active field and click ‘Send’. A confirmation popup window confirms the send is successful.

![Change Address window - New Address entry](image3)

Figure 20. Change Address window - New Address entry

Backup / Restore File
If your electronics requires a replacement or if your current settings need to be refreshed, it is recommended that you create a backup or restoration file. To create a backup, click the ‘Backup/Restore’ button in the ‘Data From Device’ tab window. In the ‘Backup and Restore Device Settings’ window, click the ‘Get Data From Sensor’ button and ‘Save Settings to File’ button. When prompted, save the file to a designated place where you can find it. To upload a file, click the ‘Read Settings from File’ button and select your backup file. Click ‘Write Data to Sensor’. A confirmation popup window confirms the upload is successful.

![Backup and Restore Device Settings window](image4)

Figure 21. Backup and Restore Device Settings window

Adjust
To adjust the Gain, click the ‘Adjust’ button located in the ‘Data From Device’ tab window. The ‘Modbus Adjust Gain’ window displays different parameter settings depending on the firmware of the transmitter. All transmitters will have the ability to adjust the ‘Gain’ from this menu. Other transmitters will have the ability to adjust the gain, and display the following; magnet blanking, delta, and blanking reference. None of these parameters should be changed without MTS Technical Support and are password protected. ~mtsdda~

![Modbus Adjust Gain window](image5)

Figure 22. Modbus Adjust Gain window
DATA FROM DEVICE TAB (CONTINUED)

COM Port
To select the Setup Software communication port, click the ‘COM Port’ button in the ‘Data From Device’ tab window. Select the appropriate communication port and click ‘OK’.

![Select A COM Port window](image)

Figure 23. Select a COM Port window

Volume Calculations tab

Note:
As a first step always press the ‘Read’ button to determine the transmitter’s current configuration. After editing any parameters always press the ‘Write’ button to program the transmitter.

Correction Method
The correction method is selected by clicking the pull down menu and selecting the appropriate correction method. Available selections include 6A (Heavy Oils), 6B (Light Oils), 6C (Chemical), 6C Mod, Custom Table, and Disabled. If ‘Custom Table’ is chosen, you must click ‘Volume Correction Factor Table’ and enter the table.

API Gravity
Enter the ‘API gravity’ (normalized density) value for the product being measured in the applicable field. Allowable values are:
- 6A - 0.0 deg to 100.0 deg API
- 6B - 0.0 deg to 85.0 deg API

TEC (Thermal Expansion Coefficient)
Temperature Correction Method ‘6C’ uses the thermal expansion coefficient of the product being measured to determine the volume correction factor. Allowable values are 270.0 to 930.0. TEC units are in 10 E-6/deg F. In the ‘TEC (6C)’ field, enter the appropriate value.

Reference Temperature
When selecting correction method 6C Mod you will need to enter the desired base temperature for the volume calculations in the ‘Reference Temperature’ field. The allowable values are 32 deg F to 150 deg F.

Density
Entering a density is required when using Temperature Correction Method ‘6C’ or ‘Custom Table’ for net mass calculations. The density measurement should be entered as ‘LB/cu.ft’. at the given reference temperature.

Volume Correction Factor Table
When Custom Table is chosen as the temperature correction method the user has to enter the volume correction factor table. The table will hold up to 50 entries of temperature points and correction factors. Once the file is created it can be saved to a file and kept on a computer for safe keeping or transferred to multiple transmitters. Before closing the user must click ‘Send’ to send the VCF table to the transmitter.

![Volume Correction Factor Table window](image)

Figure 24. Volume Correction Factor Table window

Continuous Update
To view realtime data using the Setup Software interface, select the ‘Continuous Update’ box. The Interval may be changed to slow down updates but is not necessary.

Data Logging
To download a transmitter data log, Click ‘Select File’ in the ‘Data From Device’ tab window. Select an Excel file and check the ‘Log Data to File’ box to save your data.
Model MG Operation and Installation Manual

Modbus User Interface

VOLUME CALCULATIONS TAB (CONTINUED)

Working Capacity
In the working capacity field, enter the volume of safe fill level using the same units defined in the strap table to calculate Gross Observed Volume Ullage (GOVU).

Average Readings
In the ‘Average Ratings’ pull-down menu, select from preset averaging for the data being calculated. Selections are available from 5 to 60 seconds.

Strap Table
When selecting the ‘Use Strap Table’ volume calculation mode the user must enter a strap table. The model MG with Modbus is capable of handling a 100 point strap table. To enter a strap table click ‘Strap Table’ and click ‘Add’ to start entering each volume and distance point. Once the strap table is entered save a copy to your PC by clicking ‘Write to File.’ Before closing the user must click ‘Send’ to send the strap table to the transmitter. Straptable default password is ‘becareful’.
FOUNDATION™ fieldbus interface

FOUNDATION™ fieldbus is an open, integrated total architecture for information integration that is an all digital, two way communication system. A differentiator for FOUNDATION™ fieldbus is its built in capability to distribute the control application across the network. The model MG transmitter interfaces via H1 that interconnects field devices at 31.25 kbit/s.

The H1 FOUNDATION™ Fieldbus retains and optimizes the desirable features of the 4 to 20 mA analog system such as:

- Single loop integrity
- A standardized physical interface to the wire
- Bus-powered devices on a single wire pair
- Intrinsic safety options

Device description

The Device Description (DD) file provides information needed for a control system or host to understand the meaning of the data from the field device. DD files are platform and operating system independent so any control system or host can operate a device if it has the device’s DD files. The DD files are similar to the drivers that a PC uses to operate printers, USB’s, and other devices. Current DD files are available for download from http://www.fieldbus.org.

Transducer block

The model MG transmitter contains two transducers blocks: Setup and Factory. All of the information and functions needed to setup, calibrate, and troubleshoot the model MG are located in the transducer blocks. Please contact Technical Support for help before changing parameters in the transducer blocks. Some of the parameters are password protected for the end users’ benefit.

<table>
<thead>
<tr>
<th>SETUP TRANSDUCER BLOCK</th>
<th>SETUP TRANSDUCER BLOCK</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Index</strong></td>
<td><strong>Parameter mnemonic</strong></td>
</tr>
<tr>
<td>1</td>
<td>ST_REV</td>
</tr>
<tr>
<td>2</td>
<td>TAG_DESC</td>
</tr>
<tr>
<td>3</td>
<td>STRATEGY</td>
</tr>
<tr>
<td>4</td>
<td>ALERT_KEY</td>
</tr>
<tr>
<td>5</td>
<td>MODE_BLK</td>
</tr>
<tr>
<td>6</td>
<td>BLOCK_ERR</td>
</tr>
<tr>
<td>7</td>
<td>UPDATE_EVT</td>
</tr>
<tr>
<td>8</td>
<td>BLOCK_ALM</td>
</tr>
<tr>
<td>9</td>
<td>TRANSDUCER_DIRECTORY</td>
</tr>
<tr>
<td>10</td>
<td>TRANSDUCER_TYPE</td>
</tr>
<tr>
<td>11</td>
<td>XD_ERROR</td>
</tr>
<tr>
<td>12</td>
<td>COLLECTION_DIRECTORY</td>
</tr>
</tbody>
</table>

**Dynamic variables (Setup transducer block)**

<table>
<thead>
<tr>
<th>Index</th>
<th>Parameter mnemonic</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>13</td>
<td>PRODUCT_LEVEL_AI</td>
<td>Output Level 1 (Product)</td>
</tr>
<tr>
<td>14</td>
<td>INTERFACE_LEVEL_AI</td>
<td>Output Level 2 (Interface)</td>
</tr>
<tr>
<td>15</td>
<td>AVERAGE_TEMPERATURE</td>
<td>Output Average Temp of submersed DTs (Temperature sensors)</td>
</tr>
<tr>
<td>16</td>
<td>NSVP</td>
<td>NSVP = GOVP x VCF (Volume Correction Factor)</td>
</tr>
<tr>
<td>17</td>
<td>GOVP</td>
<td>GOVP = Total Volume - Interface Volume</td>
</tr>
<tr>
<td>18</td>
<td>GOVI</td>
<td>GOVI = Interface Volume</td>
</tr>
<tr>
<td>20</td>
<td>TEMPERATURE1</td>
<td>DT 1 (Temperature sensor 1)</td>
</tr>
<tr>
<td>21</td>
<td>TEMPERATURE2</td>
<td>DT 2 (Temperature sensor 2)</td>
</tr>
<tr>
<td>22</td>
<td>TEMPERATURE3</td>
<td>DT 3 (Temperature sensor 3)</td>
</tr>
<tr>
<td>23</td>
<td>TEMPERATURE4</td>
<td>DT 4 (Temperature sensor 4)</td>
</tr>
<tr>
<td>24</td>
<td>TEMPERATURE5</td>
<td>DT 5 (Temperature sensor 5)</td>
</tr>
<tr>
<td>25</td>
<td>GOVT</td>
<td>GOVT = GOVP - GOVI</td>
</tr>
<tr>
<td>26</td>
<td>GOVU</td>
<td>GOVU = Working capacity - GOVT</td>
</tr>
<tr>
<td>27</td>
<td>MASS</td>
<td>MASS = NSVP x Density</td>
</tr>
<tr>
<td>Index</td>
<td>Parameter mnemonic</td>
<td>Description</td>
</tr>
<tr>
<td>-------</td>
<td>--------------------</td>
<td>-------------</td>
</tr>
<tr>
<td>28</td>
<td>TEMP_CORR_METHOD</td>
<td>There are five methods to choose from: 1 = Heavy Oils 2 = Light Oils 3 = Chemicals 4 = Chemicals with wider coefficients than 6C and a movable reference temperature 5 = custom table</td>
</tr>
<tr>
<td>29</td>
<td>API GRAVITY</td>
<td>Normalized Density value</td>
</tr>
<tr>
<td>30</td>
<td>WORKING_CAPACITY</td>
<td>Working capacity of tank</td>
</tr>
<tr>
<td>31</td>
<td>TEC</td>
<td>Thermal correction method 6C uses the thermal expansion coefficient of the product being measured to determine the volume correction factor. Allowable values are 270.0 to 930.0 TEC Units. TEC Units are in 10E-6/DegF.</td>
</tr>
<tr>
<td>32</td>
<td>DENSITY</td>
<td>Temperature correction method 6C and “custom table” requires you to enter the density (at a given reference temperature) of the product being measured.</td>
</tr>
<tr>
<td>33</td>
<td>REF_TEMPERATURE</td>
<td>This is the desired base temperature for the VCF calculation when Temperature Correction Method 4 (6C Wide) is used.</td>
</tr>
<tr>
<td>34</td>
<td>VOL_CALC_MODE</td>
<td>This is the mode you wish the volume calculations to be performed by: 1 = Use Strap Table 0 = Use Sphere Calculations</td>
</tr>
<tr>
<td>35</td>
<td>SPHERE_RADIUS</td>
<td>The radius of the sphere when volume calculations are performed (using the sphere calculation mode).</td>
</tr>
<tr>
<td>36</td>
<td>SPHERE_OFFSET</td>
<td>The offset of the sphere when volume calculations are performed (using the sphere calculation mode).</td>
</tr>
<tr>
<td>37</td>
<td>AVERAGE_INTERVAL</td>
<td>All level, temperature, and volume calculations can be averaged using timed method.</td>
</tr>
<tr>
<td>38</td>
<td>ALARM_STATUS</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Index</th>
<th>Parameter mnemonic</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>39</td>
<td>VCF_COR_ERR_STATUS</td>
<td>If there is no error performing the volume correction factor then the value is zero otherwise the value is a non-zero code.</td>
</tr>
<tr>
<td>40</td>
<td>VOL_CAL_ERR_STATUS</td>
<td>If there is no error performing the volume calculations then the value is zero otherwise the value is a non-zero code.</td>
</tr>
<tr>
<td>41</td>
<td>TEMP_UNITS</td>
<td>Celsius, Fahrenheit</td>
</tr>
<tr>
<td>42</td>
<td>DENSITY_UNITS</td>
<td>Grams per Milliliter, Grams per Liter, Kilograms per Cubic Meter, Kilograms per Liter, Pounds per Cubic Inch, Pounds per Cubic Foot, Pounds per Gallon, Metric Tonnes per Cubic Meter, Tons per Cubic Yard</td>
</tr>
<tr>
<td>43</td>
<td>VOLUME_UNITS</td>
<td>Liters, Cubic Millimeters, Cubic Meters, Cubic Inches, Cubic Feet, Gallons, or Barrels</td>
</tr>
<tr>
<td>44</td>
<td>LENGTH_UNITS</td>
<td>Millimeters, Centimeters, Meters, Kilometers, Inches, Feet, or Yards</td>
</tr>
<tr>
<td>45</td>
<td>MASS_UNITS</td>
<td>Kilograms, Grams, Ounces, Pounds, Tons, or Metric Tonnes</td>
</tr>
<tr>
<td>46</td>
<td>TANK_OFFSET</td>
<td>This is the value that will be added or subtracted from the level measurement. This allows the tank level reading to be calibrated to the users gauged tank reading (or other reference guide.)</td>
</tr>
<tr>
<td>47</td>
<td>INTERFACE_TANK_OFFSET</td>
<td>This is the value that will be added or subtracted from the interface measurement. This allows the tank interface reading to be calibrated to the users gauged tank reading (or other reference guide.)</td>
</tr>
</tbody>
</table>

(Transducer block - Setup parameters continued on next page)
### SETUP TRANSDUCER BLOCK

<table>
<thead>
<tr>
<th>Index</th>
<th>Parameter mnemonic</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>48</td>
<td>CAL_CURRENT_PROD_LEV</td>
<td>This is used to calibrate the level measurement. This allows the user to enter the hand gauged tank reading (or other level reference guide) of the Product and the device will calculate the necessary calibration offset. The calculated value will then be stored as the “Tank Offset”.)</td>
</tr>
<tr>
<td>49</td>
<td>CAL_CURRENT_INTER_LEV</td>
<td>This is used to calibrate the level measurement. This allows the user to enter the hand gauged tank reading (or other level reference guide) of the Interface and the device will calculate the necessary calibration offset. The calculated value will then be stored as the “Tank Offset”.)</td>
</tr>
<tr>
<td>50</td>
<td>ALARM_UNITS</td>
<td>This parameter the unit type for which you can program the alarm. Product and Interface can be “volume” or “length” unit types, however Roof can only be “Length” unit type.</td>
</tr>
<tr>
<td>51</td>
<td>INTERFACE_HI_ALM</td>
<td>The value for which the Interface cannot be &gt;=. Make sure that the value is programmed in the current Alarm unit type.</td>
</tr>
<tr>
<td>52</td>
<td>INTERFACE_LO_ALM</td>
<td>The value for which the Interface cannot be &lt;=. Make sure that the value is programmed in the current Alarm unit type.</td>
</tr>
<tr>
<td>53</td>
<td>PRODUCT_HI_ALM</td>
<td>The value for which the Product cannot be &gt;=. Make sure that the value is programmed in the current Alarm unit type.</td>
</tr>
<tr>
<td>54</td>
<td>PRODUCT_LO_ALM</td>
<td>The value for which the Product cannot be &lt;=. Make sure that the value is programmed in the current Alarm unit type.</td>
</tr>
<tr>
<td>57</td>
<td>TEMP_AVR_HI_ALM</td>
<td>The value for which the Average Temperature cannot be &gt;=.</td>
</tr>
<tr>
<td>58</td>
<td>TEMP_AVR_LO_ALM</td>
<td>The value for which the Average Temperature cannot be &lt;=.</td>
</tr>
</tbody>
</table>

### FACTORY TRANSDUCER BLOCK

<table>
<thead>
<tr>
<th>Index</th>
<th>Parameter Mnemonic</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1ST_REV</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>TAG_DESC</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>STRATEGY</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>ALERT_KEY</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>MODE_BLK</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>BLOCK_ERR</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>UPDATE_EVT</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>BLOCK_ALM</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>TRANSDUCER_DIRECTORY</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>TRANSDUCER_TYPE</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>XD_ERROR</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>COLLECTION_DIRECTORY</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>PASSWORD</td>
<td>Password, 43991</td>
</tr>
<tr>
<td>14</td>
<td>REG_MEAS_LENGTH</td>
<td>Length of the Transmitter</td>
</tr>
<tr>
<td>15</td>
<td>REG_SER_NO</td>
<td>Serial Number</td>
</tr>
<tr>
<td>16</td>
<td>REG_SW_REV</td>
<td>Software Revision</td>
</tr>
<tr>
<td>17</td>
<td>REG_GRADIENT</td>
<td>Gradient</td>
</tr>
<tr>
<td>18</td>
<td>REG_NUM_TEMPS</td>
<td>Number of DT’s</td>
</tr>
<tr>
<td>19</td>
<td>REG_SIGNAL_GAIN</td>
<td>Signal Gain</td>
</tr>
<tr>
<td>20</td>
<td>REG_MIN_TRIG_LEVEL</td>
<td>Min Trigger Level</td>
</tr>
<tr>
<td>21</td>
<td>REG_TRANSMIT_DELAY</td>
<td>Transmission Delay, Always 0</td>
</tr>
<tr>
<td>22</td>
<td>REG_SARA_BLANKING</td>
<td>SARA Blanking</td>
</tr>
<tr>
<td>23</td>
<td>REG_MAGNET_BLANKING</td>
<td>Magnet Blanking</td>
</tr>
<tr>
<td>24</td>
<td>REG_DELTA</td>
<td>Delta</td>
</tr>
<tr>
<td>25</td>
<td>REG_MEAS_INTERFACE_FIRST</td>
<td>Measure Interface First</td>
</tr>
</tbody>
</table>
Analog input function blocks

The Model MG transmitter contains 6 Analog Inputs with the output options of product, interface, average temperature, NSVP, GOVP, and GOVI. The Interface and GOVI Analog Inputs require the transmitter to be configured for measuring product and interface levels. To perform a quick configuration of the function blocks configure the following:

<table>
<thead>
<tr>
<th>Channel</th>
<th>Analog Input</th>
<th>Channel #</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Product</td>
<td>1</td>
<td>Length units</td>
<td></td>
</tr>
<tr>
<td>Interface</td>
<td>2</td>
<td>Length units</td>
<td></td>
</tr>
<tr>
<td>Average Temperature</td>
<td>3</td>
<td>Temperature units</td>
<td></td>
</tr>
<tr>
<td>NSVP</td>
<td>4</td>
<td>Volume units</td>
<td></td>
</tr>
<tr>
<td>GOVP</td>
<td>5</td>
<td>Volume units</td>
<td></td>
</tr>
<tr>
<td>GOVI</td>
<td>6</td>
<td>Volume units</td>
<td></td>
</tr>
</tbody>
</table>

**Linearization Type**

- **Direct**: Choose direct when the output is the transmitter’s value.
- **Indirect**: Choose indirect when the output is calculated based off of the transmitter’s value and the relationships is linear, i.e. 0 to 100%
- **Indirect Square Root**: Choose indirect square root when the output is calculated based off of the transmitter’s and the output is the square root of the transmitter’s value.

**Transducer Scale and Output Scale**

- **Direct**: Transducer Scale and Output Scale do not need to be configured.
- **Indirect or Indirect Square Root**: The transducer scale should be set to the full operating range that the transmitter will see during use. The output scale should contain the values that would be outputted when the transducer scale is at its minimum and maximum. The relationship is linear.

The Transducer Scale and Output Scale can also be configured to display in set units and with a set number of significant digits.

**Transducer Scale** units will be the same as the units programmed into the transmitter; the default settings are Inches for length, Fahrenheit for temperature, and Gallons for volume. Units can be changed under MTS SETUP TB -> Setup Parameters -> Data from device -> Units. It is best to double check the units in the transmitter and the Transducer Scale incase someone has changed them accidently.

**Example 1: Output of product level**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Configured Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Channel</td>
<td>1 - Product</td>
</tr>
<tr>
<td>Linearization Type</td>
<td>Direct</td>
</tr>
<tr>
<td>Transducer Scale: EU at 100%</td>
<td>N/A</td>
</tr>
<tr>
<td>Transducer Scale: EU at 0%</td>
<td>N/A</td>
</tr>
<tr>
<td>Transducer Scale: Units Index</td>
<td>N/A</td>
</tr>
<tr>
<td>Transducer Scale: Decimal</td>
<td>N/A</td>
</tr>
<tr>
<td>Output Scale: EU at 100%</td>
<td>N/A</td>
</tr>
<tr>
<td>Output Scale: EU at 0%</td>
<td>N/A</td>
</tr>
<tr>
<td>Output Scale: Units Index</td>
<td>N/A</td>
</tr>
<tr>
<td>Output Scale: Decimal</td>
<td>N/A</td>
</tr>
</tbody>
</table>

**Example 2: Output of Product Level in Percent for 10 m (33 ft.) Transmitter**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Configured Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Channel</td>
<td>1 - Product</td>
</tr>
<tr>
<td>Linearization Type</td>
<td>Indirect</td>
</tr>
<tr>
<td>Transducer Scale: EU at 100%</td>
<td>396</td>
</tr>
<tr>
<td>Transducer Scale: EU at 0%</td>
<td>0</td>
</tr>
<tr>
<td>Transducer Scale: Units Index</td>
<td>In</td>
</tr>
<tr>
<td>Transducer Scale: Decimal</td>
<td>3</td>
</tr>
<tr>
<td>Output Scale: EU at 100%</td>
<td>100</td>
</tr>
<tr>
<td>Output Scale: EU at 0%</td>
<td>0</td>
</tr>
<tr>
<td>Output Scale: Units Index</td>
<td>%</td>
</tr>
<tr>
<td>Output Scale: Decimal</td>
<td>3</td>
</tr>
</tbody>
</table>
**Resource block**

The Resource Block describes characteristics of the Fieldbus device such as the device name, manufacturer, and serial number. A device has only one Resource Block.

**LAS/Back-up LAS**

The model MG transmitter is designed as a Link Master and can be used as a primary or secondary Link Active Scheduler (LAS). For the majority of networks the host system will be the primary LAS with a field device acting as secondary LAS in the event that the primary LAS fails. The typically use of the model MG transmitter will be as a secondary LAS for back-up.

**Setup and calibration**

Setup and Calibration can be conducted from any host with a different process. Below are common parameters that will need to be changed. Please consult the Transducer Block section to locate the parameters. Specific parameters are password protected to keep users from accidentally changing factory parameters that should not be changed unless advised by Technical Support.

<table>
<thead>
<tr>
<th>Note:</th>
</tr>
</thead>
<tbody>
<tr>
<td>The mode will have to be changed to Out of Service (OOS) when editing parameters. When making this change most host systems will warn you that this may upset the process and create a dangerous situation in your plant. Before making the change to OOS, verify that taking the transmitter out of service will not negatively affect control of the plant.</td>
</tr>
</tbody>
</table>

**UNITS**

The model MG transmitter allows the user to select the units for length, temperature, volume, mass, and density.

| TEMP_UNITS | Celsius, Fahrenheit |
| DENSITY_UNITS | Grams per Milliliter, Grams per Liter, Kilograms per Cubic Meter, Kilograms per Liter, Pounds per Cubic Inch, Pounds per Cubic Foot, Pounds per Gallon, Metric Tones per Cubic Meter, Tons per Cubic Yard |
| VOLUME_UNITS | Liters, Cubic Millimeters, Cubic Meters, Cubic Inches, Cubic Feet, Gallons, or Barrels |
| LENGTH_UNITS | Millimeters, Centimeters, Meters, Kilometers, Inches, Feet, or Yards |
| MASS_UNITS | Kilograms, Grams, Ounces, Pounds, Tons, or Metric Tonnes |

**CALIBRATION**

Calibration can be done either using the current tank level or entering an offset for both the product and interface level. The TANK_OFFSET and INTERFACE_TANK_OFFSET contain values that adjust the reference point for the zero point on the transmitter. By adjusting the offsets up or down the user can change the value the transmitter outputs. This process is harder then it sounds and Technical Support should be contacted before proceeding.

An alternative method of calibration is to use CAL_CURRENT_PROD_LEV and CAL_CURRENT_INTER_LEV to calibrate the product and interface levels respectively. In order to do so the tank should be static and the user can hand gauge the tank. The user can then take the hand gauge measurement and input it into the transmitter. Make sure that the level does not move from the time the measurement is taken until the transmitter is calibrated. The transmitter will take the current level that is entered and calculate the offsets for the user.

**VOLUME CALCULATION**

The model MG will calculate the volume of the vessel using either a sphere or a strap table formula. The user can choose which method by selecting a 1 for Strap Table or a 0 for a Sphere under VOL_CALC_MODE. When selecting to use the Sphere method the user will have to enter the SPHERE_RADIUS and SPHERE_OFFSET. Despite which method is chosen, the user should enter the WORKING_CAPACITY and AVERAGE_INTERVAL.

When the user selects to calculate volume based off of a strap table the user will need to enter the strap table. The first step is to enter the NUM_STRAP_TAB_ENTRIES between 2 and 100. For each strap table point the user will have to enter the STRAP_TAB_LEVEL and STRAP_TAB_VOL for every entry.

**TEMPERATURE CORRECTION METHOD**

The TEMP_CORR_METHOD is selected by selecting the appropriate correction method. Available selections include:

1. 6A (Heavy Oils)
2. 6B (Light Oils)
3. 6C (Chemical)
4. 6C Mod
5. Custom Table

If Custom Table is chosen the user will need to enter the NUM_VCF_TAB_ENTRIES.

Enter the API_GRAVITY (normalized density) value for the product being measured in the applicable field. Allowable values are:

6A - 0.0 deg to 100.0 deg API
6B - 0.0 deg to 85.0 deg API

TEC (Temperature Correction Method) 6C uses the thermal expansion coefficient of the product being measured to determine the volume
correction factor. Allowable values are 270.0 to 930.0. TEC units are in 10 E-6/deg F. In the TEC (6C) field, enter the appropriate value.

When selecting correction method 6C Mod you will need to enter the desired base temperature for the volume calculations in the REF_TEMPERATURE. The allowable values are 32 deg F to 150 deg F.

Entering a DENSITY is required when using Temperature Correction Method 6C or Custom Table for net mass calculations. The density measurement should be entered as LB/cu.ft. at the given reference temperature.

**MTS_SETUP_TB**

- **Password**
- **Settings**
  - Gradient
  - Serial Number
  - Software Revision
  - Number of DT’s
  - Signal Gain
  - Min Trigger Levels
  - Transmission Delay
  - SARA Blanking
  - Magnet Blanking
  - Delta
  - Measure Interface First

**Digital Temperature Setup**

- Number of DT’s
- Enter Temperature Points

**Float Configuration**

- **Set Trigger Levels**

**Temperature Correction Methods**

- Temperature Correction Method
- API Gravity
- TEC (6C)
- Ref Temperature (6C Mod)
- Density
- Custom Table
  - Num of VCF table entries
  - Enter Custom Table
  - VCF Corr Table: Temperature
  - VCF Corr Table: Correction Factor

**Volume Calculations**

- Mode
- Working Capacity
- Average Interval

**MTS_FACTORY_TB**
DDA interface

<table>
<thead>
<tr>
<th>Data line termination and biasing:</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Termination and biasing of RS-485 data lines are as follows:</strong></td>
</tr>
</tbody>
</table>
| • **Biasing**  
  Each M-Series transmitter has internal high impedance biasing resistors (30K Ω) on both RS-485 data lines. No additional biasing resistors should be present on the connecting devices (PLC, DCS, PC, converter). |
| • **Termination**  
  Each M-Series transmitter has an internal termination resistor (100K Ω) installed across the RS-485 signal lines. No additional termination resistors are necessary in the connecting devices (PLC, DCS, PC, converter). |

<table>
<thead>
<tr>
<th>Communication parameters:</th>
</tr>
</thead>
<tbody>
<tr>
<td>The 2-wire differential communication interface and all data transmissions must be at half duplex. Only one device (either the master or a single transmitter) can transmit data at any given time. BAUD rate limitations are listed below.</td>
</tr>
<tr>
<td>Modbus: 4800 or 9600 BAUD 8, N, 1</td>
</tr>
<tr>
<td>DDA: 4800 BAUD 8, E, 1</td>
</tr>
<tr>
<td>(Reference) Monitor: Modbus RTU Variable BAUD Rate 8, E, 1</td>
</tr>
</tbody>
</table>

Hardware and software environments

The Level Plus Model MG digital transmitter operates in a networked, intrinsically safe RS-485 DDA software environment. This environment supports up to 8 multi-dropped transmitters on one communication line. The network requires a 4-wire bus to provide both power and communications to each of the transmitters located in the hazardous area. The transmitters are connected in multi-point configuration (see Figure 25).

The RS-485 network operates in a master/slave mode where the master (host computer or similar type network controller) interrogates each slave (DDA transmitter) for a specific type of data. Each slave has a unique switch programmable hardware address that is by the host computer to activate a particular transmitter. In addition, the DDA hardware supports a command decoder that supports up to 128 different commands. The host computer interrogates a transmitter for data by sending an address byte, followed immediately by a command byte. The addressed transmitter will ‘wake up’, identify itself by transmitting an echo of its own local address followed by the received command, and then perform the requested action. After the requested action has been completed, the data (if any) will be transmitted back to the host computer on the RS-485 network. Refer to Section ‘DDA Command decoder examples’ on page 43 for more information.

![Figure 25. Typical Electrical Connections - Intrinsically Safe System](image-url)
DDA command decoder examples

SERIAL DATA TRANSMISSION FORMAT

Example 1:

<table>
<thead>
<tr>
<th>0</th>
<th>X</th>
<th>X</th>
<th>X</th>
<th>X</th>
<th>X</th>
<th>X</th>
<th>X</th>
<th>P</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Start bit

D1 bit

D8 bit

Parity bit

Stop bit

After the DDA address decoder circuitry receives the 11-bit word, an even parity check is performed across the 8-bit data field. If a parity error is found, the word is ignored and the decoder circuitry resets for the next transmission. If the parity check is good, the decoder circuitry checks for a valid address byte. The address decoder circuitry uses the ‘D8’ bit to distinguish the difference between address bytes and command bytes. Address bytes are defined as having the most significant bit ‘D8’ set equal to one. Valid address byte values include ‘C0’ hex to ‘FD’ hex (192 to 253 decimal). Address byte values from 80 hex to ‘BF’ hex are reserved for future use, address byte values ‘FE’ and ‘FF’ hex are reserved for test functions. (see Example 2).

ADDRESS BYTE

Example 2:

<table>
<thead>
<tr>
<th>X</th>
<th>X</th>
<th>X</th>
<th>X</th>
<th>X</th>
<th>X</th>
<th>X</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

D8 bit = 1

(8-bit word - shown as D1 bit)

If the received address byte matches the local DDA address, the DDA power supply circuitry is activated. If a valid address byte has been command.

DDA/Host computer communication protocol

The DDA/Host computer communication protocol consists of two parts: the interrogation sequence generated by the host computer and the data response generated by the interrogated DDA transmitter. The host interrogation sequence always consists of an address byte followed immediately by a command byte (see Example 4).

DDA/HOST COMMUNICATION

Example 4:

```
<address byte><command byte>
```

00 Hex to 7F Hex (0 to 127 decimal)

C0 Hex to FD Hex (192 to 253 decimal)

The maximum delay between the address byte and the command byte is 5 milliseconds. The DDA transmitter will not receive the new command byte if this delay period is exceeded (and the old command byte will be left in the command buffer). See previous section for additional information on verification of the Address/Command bytes. An example of an interrogation sequence to access a transmitter programmed for address ‘F0’ hex (see Example 5).

The transmitter response consists of several components. After a transmitter has been interrogated, the transmitter first responds by transmitting its own local address and the command that was received from the host computer. This re-transmission of the transmitter address and received command serves two purposes. The first being a simple identification that the correct transmitter received the correct command and that it is currently active. The second purpose is to reset the DDA Address/Command decoder circuitry for the next interrogation sequence.

INTERROGATION DATA SEQUENCE

Example 5:

```
<F0><0A>
```

Command 0A Hex (10 decimal)

Address F0 Hex (240 decimal)

Note:

If the DDA transmitter does not respond to the first interrogation by the host, the Address/Command decoder will be left in an intermediate state. If this occurs, the host will have to interrogate the respective transmitter to reset the Address/Command decoder circuitry and then interrogate the respective transmitter again to perform a new transmitter measurement. This hardware feature must be considered when writing software communication drivers to access DDA transmitter data.
DDA/Host computer communication protocol (Continued)

After the DDA transmitter has retransmitted its local address and received command, it will perform the requested measurement as defined by the received command. After the requested measurement has been completed, the data for that measurement will be transmitted to the host in a predefined format including certain control characters. The DDA transmitted data format begins with a ‘start of text’ ‘STX’ character (STX = 02 hex). The ‘STX’ character set is immediately followed by the requested data and then terminated with an ‘end of text’ ‘ETX’ character set (ETX = 03 hex). Certain commands allow multiple data fields to be transmitted within one transmitted data sequence. For these data transmissions, each data field is separated by an ASCII colon ‘:’ character (=: 3A hex), (see Examples 6 and 7).

Single field data transmission
Example 6:

<STX><dddd.ddd><ETX>

Multiple field data transmission
Example 7:

<STX><dddd.ddd:dddd.ddd:dddd.ddd><ETX>

All transmitted data will consist of 7-bit ASCII characters limited to hex values between ‘00’ hex and ‘7F’ hex (i.e. data bit D8 = 0).

After a DDA transmitter has completed a data transmission, the host must wait 50 milliseconds before another interrogation can be performed. This delay is required to enable the previously interrogated transmitter to go into sleep mode and release the network communication lines.

All DDA control commands support a checksum calculation function, Data Error Detection (DED) that allows the host computer (master) to check the integrity of the transmitted data. The actual checksum value that is transmitted is the compliment (2’s compliment) of the calculated value. The checksum scheme is based on a 16-bit summation of the hex data within the transmitted block (including ‘STX’ and ‘ETX’ character sets) without regard to overflow. The two byte result of the adding process is then complimented and appended to the transmitted data block.

This compliment process makes the final checksum comparison more efficient in that the checksum result added to its compliment will always result in a zero sum for uncorrupted data transmissions. Checksum data (two hex bytes) can range from ‘0000’ hex to ‘FFFF’ hex. Since the communication network only allows transmitted data values between ‘00’ and ‘7F’ hex, special processing is required on the hex checksum value before it can be transmitted.

This two byte hex value must first be converted to numeric (decimal) ASCII characters before transmission. For example, a checksum value of ‘FFFF’ hex would be transmitted as ASCII 65535. The host computer would then have to convert ASCII 65535 back to FFFF hex and perform its own checksum calculation and comparison for the received data from the DDA transmitter. An example is shown (see Example 8) of a single field data transmission including checksum data and an sample checksum calculation.

Checksum calculation

Example 8:

<STX><dddd.ddd><ETX><cccccc>

Append checksum

Note:
The appended checksum value will always consist of five decimal (ASCII) characters ranging from 00000 to 65535. The checksum function can be enabled or disabled.

Message transmitted from DDA transmitter (command 12 Hex):

<STX>265.322.109.456<ETX>64760

Hex character equivalent of transmitted data record including ‘STX’ and ‘ETX’ characters:

02, 32, 36, 35, 2E, 33, 32, 32, 3A, 31, 30, 39, 2E, 34, 35, 36, 03

Two byte Hex summation of data: 0308 Hex
Two’s compliment: FCF8 Hex
Convert to decimal ASCII: 64760

To verify transmitted data from the DDA transmitter, perform the two byte Hex summation over the data record (including ‘<STX>’ and ‘<ETX>’) shown in (Example 8). The result in this example is 0308 Hex. Then convert the decimal ASCII checksum value back to Hex (for example, 64760 to FCF8 Hex). Add the Hex summation value to the Hex checksum value and the result will be zero (disregarding overflow) for uncorrupted data. 0308 Hex + FCF8 Hex = 0000 Hex.

Note:

Cyclic Redundancy Check (CRC) error checking will be offered at a later date. A command switch will be defined that will let the DDA data be transmitted with CRC error checking instead of checksum error checking. The checksum calculations will use the CRC-CCITT defined polynomial with a 16-bit CRC result. This 16-bit CRC value will be appended to each transmitted message. Since the communication network only allows transmitted data values between 00 and 7F hex, special processing is required on the 16-bit hex CRC value before it can be transmitted. This 16-bit (two byte) hex value must first be converted to numeric (decimal) ASCII characters before transmission. For example, a checksum value of ‘FFFF’ hex would be transmitted as ASCII 65535.
NETWORK PROTOCOL/TIMING CONSIDERATIONS

The DDA network has several timing constraints that must be considered when designing and coding communication drivers. The DDA network follows the RS-485 standard which defines a multi-drop communication interface that uses differential drivers and receivers operating in half-duplex mode. When using the RS-485 standard configuration, each device’s driver and receiver are wired together (see Figure 26).

Each device drive on the network must be disabled (high impedance) except when the device is ready to transmit data. In order to keep devices from transmitting data at the same time, one device is selected as the host (or master). In a DDA network, the host computer (or other communication interface) is the master, and controls the communication timing and protocol. The DDA transmitters act as slave devices, only transmitting data when requested by the host computer device. In this case, the host computer enables its driver and transmits the ‘Address/Command’ interrogation sequence.

After the Address/Command has been completely transmitted, the host disables its driver to allow reception of the data from the DDA transmitter. The transmitter with the matching address then becomes active, enables its driver and transmits the Address/Command echo followed by the requested data. The transmitter then disables its driver and goes back into sleep mode. Since all devices operate independently, certain timing constraints are imposed on the protocol to eliminate multiple devices from transmitting data simultaneously.

Network protocol timing sequences (interrogation sequences) are shown in (Figure 27). This time line representation of data transmission sequences also provides information about host computer control of the RS-485 communication card and also illustrates driver enabled control through the RTS control line.

The following steps provide an interrogation sequence example:

1. The start of the sequence begins when the host enables its RS-485 driver to transmit the Address/Command bytes (see time line ‘T0’ in Figure 27).
2. After the driver is enabled, the host performs a small time delay ‘T1’. In this example, the host enables the driver by raising the RTS control line of the computer to the active (enabled) state. This typically requires no more than 1 millisecond. If the communication lines are extremely long, additional time may be required due to the additional capacitance of the wires.
3. The host then transmits the address byte followed immediately by the command byte. For 4800 Baud transmission rates, the time to transmit one byte (11-bit word size) is fixed at 2.3 milliseconds. Then time delays ‘T2’ and ‘T4’ are fixed at 2.3 milliseconds. Time delay ‘T3’ is the interbyte transmission time. Normally this is at least one bit time.

Note:

Many available communication cards (line drivers) for use with the host computer device use a special control line input to control the enabling and disabling of the RS-485 driver. Typically this input is connected to the computers RTS or DTR communication port control line. The computer can then control the state of the driver by toggling the RTS or DTR signal lines via software control. An example of this control method is shown in (Figure 27). Other control methods are also used depending on the manufacturer of the equipment.

Figure 26. RS-485 Multi-drop example

Figure 27. Network protocol timing information

1. (0.21 milliseconds @ 4800 Baud) which is controlled by the computer communication hardware. Sometimes software overhead can extend this delay. The maximum permissible delay for period ‘T3’ is 5 milliseconds. Then the total maximum delay for periods ‘T2, T3, T4’ is 9.6 milliseconds.
2. After the host transmits the address and command bytes, the host disables its driver to allow the transmitter to transmit the Address/Command echo and the requested data. Before the driver is disabled, the software must insure that the command byte has been completely transmitted. This can be done by observing control flags from ‘UART’ of the communication port, such as Transmit Register Empty (TRE) and Transmit Holding Register Empty (if the UART is double buffered). Software delay methods based on maximum character transmission times for 4800 Baud rates can also be
1. **Interrogation sequence examples (Continued)**

   used but are less reliable. Once it has been verified that the command byte ‘0’ has been completely transmitted, an additional delay should be added before the driver is disabled.

   This delay ‘T5’ will insure that data has propagated the network wiring before the driver goes to the high impedance (disabled) state. A delay period of ‘T5’ = 1 millisecond is adequate for most long cable runs. The maximum delay allowed for ‘T5’ is based on the fact that time period ‘T6’ is fixed in the DDA hardware to be 22 (+/-2) milliseconds. The host driver should be disabled well before (at least 5 milliseconds) the DDA transmitter enables its driver and begins transmission of the Address/Command echo. Assuming the maximum delay of 5 milliseconds for period ‘T3’, and 2.3 milliseconds for ‘T4’, and that the host driver should be disabled for 5 milliseconds before the DDA transmitter begins transmitting data, the maximum delay for ‘T5’ then is 7.7 milliseconds.

   **Note:**
   
   If ‘T3’ is less than 5 milliseconds, then the maximum delay for ‘T5’ can be extended by the difference (5 milliseconds - T3 actual).

2. The transmitter will begin to transmit the Address/Command echo in 22 (+/-2) milliseconds after the address byte is received from the host computer. This is defined as period ‘T6’ and is fixed by the DDA hardware. Based on a Baud rate of 4800, the address echo is transmitted in 2.3 milliseconds (period ‘T7’). The interbyte delay period ‘T8’ for the DDA transmitter is fixed at 0.1 milliseconds and the command echo is transmitted 2.3 milliseconds (period ‘T9’).

3. Period ‘T10’ is the time required for the DDA electronics to perform the requested command. This is a variable delay based on the command requested. The typical transmitter response time for each command is listed in section ‘11.4 DDA command definitions’.

4. Period ‘T11’ is the time required for the DDA electronics to transmit the data for the requested command. This is a variable delay based on the command requested. The typical data transmission time for each command is listed in section ‘11.4 DDA command definitions’.

5. After the transmitter has completed the data transmission for the requested command, it will disable its driver and go back to inactive mode. The transmitter electronics require 50 milliseconds to transition from active mode to inactive mode. Another transmitter (or the same transmitter) cannot be interrogated until time period ‘T12’ = 50 milliseconds has elapsed.

6. Repeat the sequence for the next transmitter.

Other protocol considerations

1. The transmitted ASCII data from the DDA transmitter may contain data fields with ‘Exxx’ error codes. All DDA error codes are preceded by ASCII ‘E’ (45 hex, 69 decimal). Communication interface drivers must parse and handle DDA error codes properly or data processing errors could result. For additional information about DDA error codes, (see page 54 ).

2. Use the DDA ‘Data Error Detection’ function to verify the integrity of the data transmitted from the transmitter.

3. Certain RS-485 communication cards and (RS-232 to RS-485 converter cards) allow user control of the receiver function. This feature must be considered when developing communication drivers. Due to the half-duplex RS-485 loopback wire connections, all data that is transmitted by the host computer device will be ‘echoed’ into the receiver inputs. If the receiver function is enabled, then the host transmitted data along with the DDA transmitter transmitted data will be received into the computer receive buffer.

---

**DDA Command definitions (includes protocol information)**

**SPECIAL CONTROL COMMANDS**

**Command 00 Hex (0 Dec) - Transmitter disable command**

This command can be used to disable an active transmitter (force transmitter back to sleep mode). This command does not need to be preceded by an address byte and can only be issued when DDA transmitters are not transmitting data. This ‘disabled’ command is typically used with other commands that could leave the transmitter in active mode, i.e. certain memory transfer commands, test mode commands, etc.

**Note:**

During normal mode operation, a DDA transmitter will force itself back into sleep mode if any data is transmitted on the network by any other device. This is a safety feature added to the firmware to avoid data collisions on the network.

**Command 01 Hex (1 Dec):**

Module identification command

**Data format:**

<STX><DDA><ETX><cccc>

- Fixed length record containing 3 ASCII characters ‘<DDA>’
- Five (5) character checksum appended after ‘<ETX>’ character set

**Command 02 Hex (2 Dec):**

Change address

**Data format:**

<SOH><ddd><EOT>

- Fixed length record with three (3) characters
- The data field is the new address
- The data range is the new address
- The data range is from 192 - 253
- ‘<SOH>’ is ASCII 01 Hex
- ‘<EOT>’ is ASCII 04 Hex
- Default Address is ‘192’

**Command 03 Hex - Command Hex 09 - Not Defined**
LEVEL COMMANDS

Command 0A Hex (10 Dec):  Output level 1 (product) at 0.1 inch resolution (with checksum)
Data format: <STX><dddd.d><ETX><cccc>  
- Variable length record with one (1) to four (4) characters to the left of decimal character
- Fixed at one (1) character to the right of decimal character
- Five (5) character checksum appended after the ‘<ETX>’ character set

Command 0B Hex (11 Dec):  Output level 1 (product) at 0.01 inch resolution (with checksum)
Data format: <STX><dddd dd><ETX><cccc>  
- Variable length record with one (1) to four (4) characters to the left of decimal character
- Fixed at two (2) characters to the right of decimal character
- Five (5) character checksum appended after the ‘<ETX>’ character set

Command 0C Hex (12 Dec):  Output level 1 (product) at 0.001 inch resolution (with checksum)
Data format: <STX><dddd ddd><ETX><cccc>  
- Variable length record with one (1) to four (4) characters to the left of decimal character
- Fixed at three (3) characters to the right of decimal character

Data characters can include the following:
- 0 through 9
- (–) minus sign
- (.) decimal point
- (E) ASCII 45 Hex precedes all error codes
- (:) ASCII 3A Hex is used as a data field separator for multiple data field transmissions
- (space) ASCII 20 Hex space character

Note:
<cccc> Checksum characters are only appended if the Data Error Detection (DED) function is enabled.

Command 0D Hex (13 Dec):  Output level 2 (interface) at 0.1 inch resolution (with checksum)
Data format: Same as Command 0A

Command 0E Hex (14 Dec):  Output level 2 (interface) at 0.01 inch resolution (with checksum)
Data format: Same as Command 0B

Command 0F Hex (15 Dec):  Output level 2 (interface) at 0.001 inch resolution (with checksum)
Data format: Same as Command 0C

Command 10 Hex (16 Dec):  Output level 1 (product) and level 2 interface at 0.1 inch resolution (with checksum)
Data format: <STX><dddd dd:dddd dd><ETX><cccc>  
- Variable length record with one (1) to four (4) characters to the left of each decimal character in each data field
- Fixed at one (1) character to the right of each decimal character

TEMPERATURE COMMANDS

Command 19 Hex (25 Dec):  Average Temperature at 1.0 °F resolution (with checksum)
Data format: <STX><dddd><ETX><cccc>  
- Variable length record with one (1) to four (4) characters
- Five (5) character checksum appended after the ‘<ETX>’ character set

Note:
Average temperature is the average temperature reading from all DTs submerged by approximately 1.5 inches of product.

Command 1A Hex (26 Dec):  Average temperature at 0.2 °F resolution (with checksum)
Data format: <STX><dddd d><ETX><cccc>  
- Variable length record with one (1) to four (4) characters to the left of decimal character
- Fixed at one (1) character to the right of decimal character
- Five (5) character checksum appended after the ‘<ETX>’ character set

Command 1B Hex (27 Dec):  Average temperature at 0.02 °F resolution (with checksum)
Data format: <STX><dddd dd:dddd dd><ETX><cccc>  
- Variable length record with one (1) to four (4) characters to the left of each decimal character
- Fixed at two (2) characters to the right of each decimal character
- Five (5) character checksum appended after the ‘<ETX>’ character set
TEMPERATURE COMMANDS (CONTINUED)

Command 1C Hex (28 Dec):
Individual DT temperature at 1.0 °F resolution (with checksum)

Data format:
<STX><dddd.dd:dddd.dd:dddd.dd:dddd.dd:dddd.dd><ETX><cccc>
- Variable length record with one (1) to four (4) characters in each data field
- Variable number of data fields (up to 5) separated by ASCII colon (:) characters. Number of data fields is based on the number of DTs programmed in DDA transmitter memory
- First data field is always DT #1, second data field is DT #2, etc
- Five (5) character checksum appended after the '<ETX>' character set

Command 1D Hex (29 Dec):
Individual DT temperature at 0.2 °F resolution (with checksum)

Data format:
- Variable length record with one (1) to four (4) characters to the left of decimal character in each data field
- Fixed at one (1) character to the right of each decimal character in each data field
- Variable number of data fields (up to 5) separated by ASCII colon (:) characters. Number of data fields is based on the number of DTs programmed in DDA transmitter memory
- First data field is always DT #1, second data field is DT #2,...etc
- Five (5) character checksum appended after the '<ETX>' character set

Command 1E Hex (30 Dec):
Individual DT temperature at 0.02 °F resolution (with checksum)

Data format:
- Variable length record with one (1) to four (4) characters to the left of decimal character in each data field
- Fixed at one (1) character to the right of each decimal character in each data field
- Variable number of data fields (up to 5) separated by ASCII colon (:) characters. Number of data fields is based on the number of DTs programmed in DDA transmitter memory
- First data field is always DT #1, second data field is DT #2,...etc
- Five (5) character checksum appended after the '<ETX>' character set

Command 20 Hex (32 Dec):
Average and individual DT temperature at 0.2 °F resolution (with checksum).

Data format:
- Variable length record with one (1) to four (4) characters to the left of decimal character in each data field
- Fixed at one (1) character to the right of each decimal character in each data field
- Variable number of data fields (up to 6) separated by ASCII colon (:) characters. The number of data fields is based on the number of DTs programmed in DDA transmitter memory (number of DTs + 1)
- The first data field is always the average of the individual DTs submerged by at least 1.5 inches of product
- The second data field is always DT #1, third data field is DT #2, ... etc
- Five (5) character checksum appended after the '<ETX>' character set

Command 21 Hex (33 Dec):
Average and individual DT temperature at 0.02 °F resolution (with checksum).

Data format:
- Variable length record with one (1) to four (4) characters to the left of decimal character in each data field
- Fixed at two (2) characters to the right of each decimal character in each data field
- Variable number of data fields (up to 6) separated by ASCII colon (:) characters. The number of data fields is based on the number of DTs programmed in DDA transmitter memory (number of DTs + 1)
- The first data field is always the average of the individual DTs submerged by at least 1.5 inches of product
- The second data field is always DT #1, third data field is DT #2, ... etc
- Five (5) character checksum appended after the '<ETX>' character set

Command 22 Hex - Command 24 Hex - Reserved

Command 25 Hex (37 Dec):
Fast average and individual DT temperature at 1.0 °F resolution (with checksum)

Data format:
Same as command 1F Hex

Command 26 Hex - Command 27 Hex - Not defined

MULTIPLE OUTPUT COMMANDS
(LEVEL AND TEMPERATURE)

Command 28 Hex (40 Dec):
Level 1 (product) at 0.1 inch resolution, and average temperature at 1.0 °F resolution (with checksum)

Data format:
<STX><dddd.d:dddd.d><ETX><cccc>
- Variable length record with one (1) to four (4) characters to the left of decimal character in first data field
- Fixed at one (1) character to the right of decimal character in first data field
- Variable length record with one (1) to four (4) characters in second data field
- Level 1 temperature data fields separated by ASCII colon (:) character
- Five (5) character checksum appended after the '<ETX>' character set
MULTIPLE OUTPUT COMMANDS (CONTINUED)

Command 29 Hex (41 Dec):  
Level 1 (product) at 0.01 inch resolution, and average temperature at 0.2 °F resolution (with checksum)  
Data format:  
<STX><dddd.dd:dddd.dd:dddd.dd><ETX><ccccc>  
- Variable length record with one (1) to four (4) characters to the left of decimal character in first data field  
- Fixed at two (2) characters to the right of decimal character in first data field  
- Variable length record with one (1) to four (4) characters to the left of decimal character in second data field  
- Fixed at one (1) character to the right of decimal character in second data field  
- Level 1, temperature data fields separated by ASCII colon (:) character.  
- Five (5) character checksum appended after the '<ETX>' character set.

Command 2A Hex (42 Dec):  
Level 1 (product) at 0.001 inch resolution, and average temperature at 0.02 °F resolution (with checksum)  
Data format:  
<STX><dddd.ddd:dddd.ddd:dddd.dd><ETX><ccccc>  
- Variable length record with one (1) to four (4) characters to the left of decimal character in first data field  
- Fixed at three (3) characters to the right of decimal character in first data field  
- Variable length record with one (1) to four (4) characters to the left of decimal character in second data field  
- Fixed at two (2) characters to the right of decimal character in second data field  
- Level 1, temperature data fields separated by ASCII colon (:) character.  
- Five (5) character checksum appended after the '<ETX>' character set.

Command 2B Hex (43 Dec):  
Level 1 (product), level 2 (interface) at 0.1 inch resolution, and average temperature at 1.0 °F resolution (with checksum)  
Data format:  
<STX><dddd.dd:dddd.dd:dddd.dd><ETX><ccccc>  
- Variable length record with one (1) to four (4) characters to the left of decimal character in first data field  
- Fixed at one (1) character to the right of decimal character in first data field  
- Variable length record with one (1) to four (4) characters to the left of decimal character in second data field  
- Fixed at one (1) character to the right of decimal character in second data field  
- Variable length record with one (1) to four (4) characters to the left of decimal character in third data field  
- Fixed at three (3) characters to the right of decimal character in third data field  
- Level 1, level 2, temperature data fields separated by ASCII colon (:) character.  
- Five (5) character checksum appended after the '<ETX>' character set.

Command 2C Hex (44 Dec):  
Level 1 (product), level 2 (interface) at 0.01 inch resolution, and average temperature at 0.2 °F resolution (with checksum)  
Data format:  
<STX><dddd.dd:dddd.dd:dddd.dd><ETX><ccccc>  
- Variable length record with one (1) to four (4) characters to the left of decimal character in first data field  
- Fixed at two (2) characters to the right of decimal character in first data field  
- Variable length record with one (1) to four (4) characters to the left of decimal character in second data field  
- Fixed at two (2) characters to the right of decimal character in second data field  
- Variable length record with one (1) to four (4) characters to the left of decimal character in third data field  
- Fixed at three (3) characters to the right of decimal character in third data field  
- Level 1, level 2, temperature data fields separated by ASCII colon (:) character.  
- Five (5) character checksum appended after the '<ETX>' character set.

Command 2D Hex (45 Dec):  
Level 1 (product), level 2 (interface) at 0.001 inch resolution, and average temperature at 0.02 °F resolution (with checksum)  
Data format:  
<STX><dddd.ddd:dddd.ddd:dddd.dd><ETX><ccccc>  
- Variable length record with one (1) to four (4) characters to the left of decimal character in first data field  
- Fixed at one (1) character to the right of decimal character in first data field  
- Variable length record with one (1) to four (4) characters to the left of decimal character in second data field  
- Fixed at two (2) characters to the right of decimal character in second data field  
- Variable length record with one (1) to four (4) characters to the left of decimal character in third data field  
- Fixed at two (2) characters to the right of decimal character in third data field  
- Level 1, level 2, temperature data fields separated by ASCII colon (:) character.  
- Five (5) character checksum appended after the '<ETX>' character set.

HIGH-LEVEL MEMORY READ COMMANDS

Command 4B Hex (75 Dec):  
Read 'number of floats and number of DTs' control variables  
Data format:  
<STX><d:d><ETX><ccccc>  
- Fixed length record with one (1) character in each field.  
- The first data field is the number of floats, second data field is the number of DTs  
- Five (5) character checksum appended after the '<ETX>' character set.

Command 4C Hex (76 Dec):  
Read 'gradient' control variable  
Data format:  
- Fixed length record with seven (7) characters (including decimal point).  
- Five (5) character checksum appended after the '<ETX>' character set.

Command 4D Hex (77 Dec):  
Read float zero position data  
Data format:  
<STX><d:d:d:d:d:<ETX><ccccc>  
(Continued on next page)
HIGH-LEVEL MEMORY READ COMMANDS (CONTINUED)

Command 4D Hex (77 Dec): continued

- Variable length record with one (1) to four (4) characters to the left of decimal character in first data field. The data may include an ASCII (‘-) negative sign character (2D Hex) in the first character position
- Fixed at three (3) characters to the right of decimal character in first data field
- Variable length record with one (1) to four (4) characters to the left of decimal character in second data field. The data may include an ASCII (‘-) negative sign character (2D Hex) in the first character position
- Fixed at three (3) characters to the right of decimal character in second data field
- Float #1, float #2 data fields separated by ASCII colon (:) character
- Five (5) character checksum appended after the ‘<ETX>’ character set

Note:
DT position data is referenced from the mounting flange of the transmitter housing. DT #1 is the DT closest to the tip of the transmitter.

Command 4E Hex (78 Dec):
Read DT position data (DTs 1 - 5)

Data format:


- Variable length record with one (1) to four (4) characters to the left of decimal character in each data field
- Fixed at one (1) character to the right of decimal character in each data field
- Variable number of data fields (up to 5) separated by ASCII colon (:) characters. The number of data fields is based on the ‘number of DTs’ control variable. (see command 4B Hex)
- The first data field is always DT #1, second field is always DT #2,...etc.
- Five (5) character checksum appended after the ‘<ETX>’ character set

Command 50 Hex (80 Dec):
Read firmware control code #1

Data format:

<STX><d:d>d:d:d<d:ETX><cccccc>

- Fixed length record with one (1) character in each data field
- First data field is the control variable for the data error detection (DED) mode
- The second data field is the control variable for the communication time-out timer (CTT)
- The third data field is the control variable for temperature data units
- The fourth data field is the control variable for linearization enable/disable
- The fifth data field is the control variable for innage/ullage level output
- The sixth data field is reserved for future use; the output value for this field is ASCII ‘0’

Note:

Command 51 Hex (81 Dec):
Read hardware control code #1

Data format:

<STX><dddddd:ETX><cccccc>

- Fixed length record with six (6) characters
- The hardware control code controls various functions in the DDA electronic hardware
- The hardware control code must match the hardware control code stamped on the transmitter label; the control code on the label is preceded by ‘CC’ (for example, CC001122)
- Five (5) character checksum appended after the ‘<ETX>’ character set
- For additional information about the hardware control code, (see section 8, Quick Start-up Guide Modbus and DDA)

Command 52 Hex (82 Dec):
Not defined

Command 53 Hex (83 Dec):
Reserved for factory use

Command 54 Hex (84 Dec):
Not defined

HIGH-LEVEL MEMORY WRITE COMMANDS

Command 55 Hex (85 Dec):
Write ‘number of floats and number of DTs’ control variables

Host Issued Command (Part 1)

Data format:

<addr><commands>

- ‘<addr>’ is the DDA transmitter address
- ‘<command>’ is DDA command 55
- After the address and command byte have been transmitted by the host, the respective DDA transmitter will ‘wake up’ and retransmit (echo) the local DDA address and received command. The DDA transmitter will remain active, waiting for the second part of the memory write command to be issued by the host. If the second part of the memory write command is not received within 1.0 seconds (see note below), or the command is not received in the proper format, the DDA transmitter will cancel the current command sequence and go back to sleep mode.

Note:
The time-out timer function can be enabled or disabled.

Host Issued Command (Part 2)

Data format:

<SOH><d:d><EOT>

- Fixed length record with two (2) data fields
- ‘<SOH>’ is ASCII 01 Hex
- The first data field contains the ‘number of floats’ value to be written to the ‘number of floats’ control variable. This variable is limited to a value of 1 or 2 (ASCII)
- The second data field contains the ‘number of DTs’ value to be written to the ‘number of DTs’ control variable. This variable is limited to a value between 0 and 5 (ASCII)
- ASCII colon (:) is the ‘number of floats/number of DTs’ field separator.
- ‘<EOT>’ is ASCII 04 Hex

DDA Transmitter Response (verification sequence)

Data format:

<STX><d:d><ETX><cccccc>
HIGH-LEVEL MEMORY WRITE COMMANDS (CONTINUED)

- Fixed length record with two (2) data fields
- `<STX>` is ASCII 02 Hex
- The first data field contains the ‘number of floats’ value to be written to the ‘number of floats’ control variable. This variable is limited to a value of 1 or 2 (ASCII)
- The second data field contains the ‘number of DTS’ value to be written to the ‘number of DTS’ control variable. This variable is limited to a value between 0 and 5 (ASCII)
- ASCII colon (:) is the ‘number of floats/number of DTS’ field separator
- `<ETX>` is ASCII 03 Hex
- ‘<cccccc>‘ is a five (5) character checksum appended after the ‘<ETX>‘ character set

Host Issued Command (Part 3)
Data format: `<ENQ>`

- `<ENQ>` is ASCII 05 Hex. This character set is sent by the host to initiate the EEPROM write cycle. After the EEPROM memory locations have been successfully written to, the DDA transmitter will respond back to the host with a ‘ACK‘ character set signifying the memory write cycle was successful, or with a ‘NAK‘ character set the memory write cycle was unsuccessful. See DDA transmitter response below.
- EEPROM write time is 10 milliseconds per byte. The ‘ACK/NAK‘ response will not be transmitted by the DDA transmitter until the memory bytes have been written and verified or a memory write error has caused the DDA transmitter to time-out.

DDA Transmitter Response:
Data format: `<ACK>`

- `<ACK>` is ASCII 06 Hex. This character set is sent by the DDA transmitter to confirm to the host that the EEPROM memory write cycle was completed successfully.

Data format: `<NAK>;<EXXX><ETX><cccccc>`

- `<NAK>` is ASCII 15 Hex. This character set is sent by the DDA transmitter to confirm to the host that the EEPROM memory write cycle was not completed successfully.
- `<EXXX>` is an error code defining the memory write error that occurred during the EEPROM write cycle. ‘E’ is ASCII 45 Hex and ‘xxx’ is the numeric ASCII error code ranging from 000 to 999. For additional information about DDA error codes, (see section X.X).
- `<ETX>` is ASCII 03 Hex
- `<cccccc>` is a five character checksum appended after the ‘<ETX>‘ character set
- Value can range from 00000 to 65535.

All high level memory write commands adhere to the communication sequence as described above, and consist of the following six components:

1. Host issued command (Part 1): `<address><command>`
2. DDA transmitter response: `<address><command> echo`
3. Host issued command (Part 2):
   `data to be written (including necessary control characters)`
4. DDA transmitter response: verification sequence
5. Host issued command (Part 3): `<ENQ>`
6. DDA transmitter response: `<ACK> or <NAK>`

Descriptions for other high level memory write commands will include only the Data format for Part 2 of each host issued command.

Command 56 Hex (86 Dec): Write ‘gradient’ control variable
Data format: `<SOH><d.dddd><EOT>`

- Fixed length record with one data field
- `<SOH>` is ASCII 01 Hex
- The fixed length data field contains the ‘gradient’ value to be written to the ‘gradient’ control variable. This variable is limited to a value between 7.00000 and 9.99999 (ASCII)
- ‘<ETX>‘ is ASCII 04 Hex

Command 57 Hex (87 Dec): Write float zero position data
Data format: `<SOH><c:dddd.ddd><EOT>`

- Variable length record with two (2) data fields
- The first data field contains one character that controls which zero position memory location is written to (i.e., float #1 or float #2). This control character is limited to a value of 1 or 2 (ASCII)
- The second data field contains the ‘zero position’ data value to be written to the ‘zero position’ memory location. This is a variable length data field with one (1) to four (4) characters to the left of the decimal character and fixed at three (3) characters to the right of the decimal character. The data may include the ASCII (-) negative sign character (2D Hex) in the first position. The zero position data is limited to a value between -999.999 and 9999.999 (ASCII)
- ‘<ETX>‘ is ASCII 04 Hex

Note:
Zero position is referenced from the mounting flange of the transmitter housing.

Command 58 Hex (88 Dec): Write float zero position data
Data format: `<SOH><c:dddd.ddd><EOT>`

- Variable length record with two (2) data fields
- The first data field contains one character that controls which zero position memory location is written to (i.e., float #1 or float #2). This control character is limited to a value of 1 or 2 (ASCII)
- The second data field contains the ‘current float position’ data value to be used to calculate the ‘zero position’ value that is to be written to the ‘zero position’ memory location. This is a variable length data field with one (1) to four (4) characters to the left of the decimal character and fixed at three (3) characters to the right of the decimal character. The data may include the ASCII (-) negative sign character (2D Hex) in the first position. The ‘current float position’ data is limited to a value between -999.999 and 9999.999 (ASCII)
- ‘<ETX>‘ is ASCII 04 Hex
HIGH-LEVEL MEMORY WRITE COMMANDS (CONTINUED)

**Command 59 Hex (89 Dec):** Write DT position data (DT1-5).
**Data format:**
- Variable length record with two (2) data fields
- The first data field contains one (1) character that controls which 'DT position' memory location is written to (i.e. DT position #1, 2, 3, 4 or 5)
- This control character is limited to a value between 1 and 5 (ASCII)
- The second data field contains the 'DT position' data value to be written to the respective 'DT position' memory location. This is a variable length data field with one (1) to four (4) characters to the left of the decimal character and fixed at one (1) character to the right of the decimal character. The DT position data is limited to a value between 0.0 and 9999.9 (ASCII)
- `<EOT>` is ASCII 04 Hex

**Command 5A Hex (90 Dec):** Write firmware control code #1
**Data format:**
- Fixed length record with one character in each data field
- `<SOH>` is ASCII 01 Hex
- The first data field is the control variable for the data error detection (DED) function. This variable can have a value of 0, 1, or 2. A value of 0 enables the DED function, using a 16-bit checksum calculation. A value of 1 enables the DED function, using a 16-bit CRC calculation. A value of 2 disables the DED function
- The second field is the control variable for the communication time-out timer (CTT) function. This variable can have a value of 0 or 1. A value of 0 enables the CTT function, and a value of 1 disables the CTT function
- The third data field is the control variable for temperature data units. This variable can have a value of 0 or 1. A value of 0 enables Fahrenheit temperature units. A value of 1 enables Celsius temperature units
- The fourth data field is the control variable for linearization control. This variable can have a value of 0 or 1. A value of 0 disables linearization of the level data. A value of 1 enables linearization
- The fifth data field is the control variable for innage/ullage level output. This variable can have a value of 0, 1 or 2. A value of 0 enables normal innage level output. A value of 1 enables ullage level output with reversed DT submersion processing. Mode 2 is used for inverted transmitter applications where the transmitter is installed from the bottom of the tank
- The sixth data field is reserved for future use. The data value for this field must be ‘0’ 30 Hex
- `<EOT>` is ASCII 04 Hex

**Command 5B Hex (91 Dec):** Write hardware control code #1
**Data format:**
- Fixed length record with six (6) characters
- `<SOH>` is ASCII 01 Hex
- The hardware control code controls various functions in the DDA electronic hardware.
- The hardware control code must match the hardware control code stamped on the transmitter label. The control code on the label is preceded by ‘CC’ (i.e. CC0001122)
- `<EOT>` is ASCII 04 Hex

**Command 5C Hex (92 Dec):** Not Defined

**Command 5D Hex (93 Dec):** Reserved for factory use

**Command 5F Hex - 7F Hex - Reserved for future use**

**DIAGNOSTIC/SPECIAL COMMAND SET**

- `enum alarmStatusBits`
  - `INTERFACE_ALARM_HIGH`: `0x0001`
  - `INTERFACE_ALARM_LOW`: `0x0002`
  - `PRODUCT_ALARM_HIGH`: `0x0004`
  - `PRODUCT_ALARM_LOW`: `0x0008`
  - `ROOF_ALARM_HIGH`: `0x0010`
  - `ROOF_ALARM_LOW`: `0x0020`
  - `AVG_TEMP_ALARM_HIGH`: `0x0040`
  - `AVG_TEMP_ALARM_LOW`: `0x0080`
  - `MAGNET_IS_MISSING`: `0x0100`
  - `DIG_TEMP0_ERROR`: `0x0200`
  - `DIG_TEMP1_ERROR`: `0x0400`
  - `DIG_TEMP2_ERROR`: `0x0800`
  - `DIG_TEMP3_ERROR`: `0x1000`
  - `DIG_TEMP7_ERROR`: `0x2000`
  - `DIG_AVG_TEMP_ERROR`: `0x4000`
  - `DELIVERY_IN_PROGRESS`: `0x8000`
  - `TRIGGER_LEVEL_ERROR`: `0x10000`
  - `EEPROM_ERROR`: `0x20000`

**DDA ERROR CODES**

All error codes are preceded by a capital letter ‘E’ ASCII (45 hex) and are in the form of ‘Exxx’ where ‘xxx’ can be any number from ‘000’ to ‘999’. Error codes can be embedded in any data field within a transmitted record. Certain DDA commands can generate multiple error codes. Refer to the following examples:

**Command 0A Hex:**

```
<STX><Exxx><ETX><ccccc>
```

**Command 2D Hex:**

```
<STX><Exxx:Exxx:ddd.dd><ETX><ccccc>
```

**Command 1E Hex:**

```
<STX><E203:ddd.dd:ddd.dd:E207:ddd.dd><ETX><ccccc>
```

**E102:** Missing Float(s) (Level 1 or Level 2)
The number of floats measured by the hardware is less than the ‘number of floats’ control variable.

**E201:** No DTS Programmed
A request for temperature data has been made with the ‘number of DTs’ control variable set to equal zero (0) or all programmed DTs are set inactive (for example, DT position data is set equal to zero (0.000)).

**E212:** DT Communication Error
The indicated DT is not active (for example, DT position data is set equal to zero (0) or is not responding).
**Model MG Digital setup software installation, setup and calibration**

Adjustments to the calibration and setup parameters of the transmitter can be performed using the M-Series Digital Setup Software package. The software can be run from any PC using a RS-485 to RS-232 converter (see Table 10 MTS part number references). In the ‘MTS Digital Gauge Configuration - DDA-COM’ window, you will see one tab labeled ‘Data From Device’ (see Figure 28). You will use this tab and its button selections to calibrate the transmitter and change setup parameters.

**Note:**

You must use a RS-485 converter with ‘Send Data Control’ when using the M-Series Digital Setup software to ensure proper operation. *Example: B & B Electronics 485BAT3 (815-433-5100 www.bb-elec.com).*

<table>
<thead>
<tr>
<th>Level Plus M-Series PC Digital Setup Software (DDA) CD</th>
<th>RS-485 to RS-232 converter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Order number: 625053</td>
<td>Order number: 380075</td>
</tr>
</tbody>
</table>

**Table 10. MTS part number references**

**DATA FROM DEVICE TAB**

Perform the following steps to install the transmitter setup software to establish communications with the transmitter:

1. Install Setup Software from the CD that came with your transmitter or go to www.mtssensors.com to download the latest version.
2. Connect transmitter to the RS-485 to RS-232 converter and attach the converter to your PC. Some PC’s will require an additional Serial to USB converter.
3. Open the Software program.
4. Select COM Port. If you do not know which COM port to select, right click My Computer and select Properties -> Hardware Tab -> Device Manager -> Ports (COM & LPT) to view the list.
5. Click the ‘Data From Device’ tab, click the Device: pull-down and select the ‘transmitter address’, the factory default for DDA is 192 (see Figure 28).

Parameter settings and calibration is performed from within the Data From Device tab window (see Figure 28).

**CALIBRATION**

When you click the ‘Calibrate’ button in the ‘Data From Device’ tab window, the ‘Calibrate DDA Device’ window opens. There are two calibration ‘Float Methods’ to choose from, ‘Enter Float Positions (Calibrate)’ and ‘Enter Float Zero Positions’. Click the ‘Offset Method’ drop down menu to select a calibration method. Type a value in the active field, then click the ‘Send’ button. A confirmation window displays when the send is successful.

![Calibrate DDA Device window - Offset Method](Figure 29)

When you choose ‘Enter Float Zero Positions’ from the ‘Offset Method’ drop down menu, you can adjust the offset where the transmitters zero point is located. This adjustment will significantly shorten the span of the transmitter or counter inactive zones. Adjust the value accordingly and click ‘Send’. A confirmation window displays when the send is successful.

![Calibrate DDA Device - Offset Method](Figure 30)

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**Figure 28.** Data from device tab

**Figure 29.** Calibrate DDA Device window - Offset Method

**Figure 30.** Calibrate DDA Device - Offset Method
CHANGE ADDRESS

To change the transmitter address, click the ‘Change Address’ button in the ‘Data From Device’ tab window. In the ‘Change Address’ window, type the ‘New Address’ in the active field and click ‘Change’. A popup window confirms the change is successful.

BACKUP AND RESTORE DEVICE SETTINGS

If your electronics requires a replacement or if your current settings need to be refreshed, it is recommended that you create a backup or restoration file. To create a backup, click the ‘Backup/Restore’ button in the ‘Data From Device’ tab window. In the ‘Backup and Restore Device Settings’ window, click the ‘Get Data From Sensor’ button and ‘Save Settings to File’ button. When prompted, save the file to a designated place where you can find it.

To upload a file, click the ‘Read Settings from File’ button and select your backup file. Click ‘Write Data to Sensor’. A popup window confirms the upload is successful.

COM PORT

To select the Setup Software communication port, click the ‘COM Port’ button in the ‘Data From Device’ tab window. Select the appropriate communication port and click ‘OK’.

DATA LOGGING

To download a transmitter data log, Click ‘Select File’ in the ‘Data From Device’ tab window. Select an Excel file and check the ‘Log Data to File’ box to save your data.
MTS maintains IECEx, ATEX, FM, CSA, NEPSI, and other hazardous area approvals. For additional information please consult English manual or MTS Sensors.

**KC**

**KC SPECIFIC MODEL MG NUMBER REQUIRED AS SHOWN ON PAGE 9.**

<table>
<thead>
<tr>
<th>Model</th>
<th>Approval Type</th>
<th>Classification</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>MGK</td>
<td>Flameproof</td>
<td>Ex d IIB T4 Ga/Gb</td>
<td>IEC 60079-0:2012</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>IEC 60079-1:2007</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>IEC 60079-26:2007</td>
</tr>
</tbody>
</table>

**IP / NEMA RATING**

IEC 60529:2001 IP 66
Figure 43. KC for Modbus and DDA installation drawing
## INSTALLATION DRAWING NOTES

<table>
<thead>
<tr>
<th>Notes:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Power supply cable must be 0.22 mm² or heavier (e.g. 1.32 mm² AWG 16), shielded twisted pair cable. Cable capacitance must be less than 90 pF/m (30 pF/ft). Cable shield is connected to system ground at safety barrier end only.</td>
</tr>
<tr>
<td>2. Communications cable must be 0.22 mm² or heavier (e.g. 1.32 mm² AWG 16), shielded twisted pair cable. Cable capacitance must be less than 90 pF/m (30 pF/ft). Cable shield is connected to system ground at safety barrier end only.</td>
</tr>
<tr>
<td>3. The wire connection between earth ground and the safety barrier ground terminal must be less than 1 ohm.</td>
</tr>
<tr>
<td>4. Connection to earth ground for transient protection circuitry.</td>
</tr>
<tr>
<td>5. Ground screw earthing hardware provided to connect gauge housing to earth ground.</td>
</tr>
<tr>
<td>6. The transducer frame shall be grounded to earth ground directly or through the equipment on which it is mounted and shall be at the same potential as the safety barrier ground electrode.</td>
</tr>
<tr>
<td>7. Electronic equipment connected to associated apparatus must not use or generate more than 250 volts RMS.</td>
</tr>
<tr>
<td>8. Cable sets that are run together must have sufficient insulation to withstand 250 volts RMS between sets.</td>
</tr>
<tr>
<td>9. All wiring must meet the local regulations and/or other national/international standards.</td>
</tr>
<tr>
<td>10. Seal all conduits within 457 mm (18 in).</td>
</tr>
</tbody>
</table>

---

**Figure 43a.** KC for Modbus and DDA installation drawing (continued)
### INSTALLATION DRAWING NOTES (CONTINUED)

<table>
<thead>
<tr>
<th>Model Number</th>
<th>Approval Agency</th>
<th>Approval Type</th>
<th>Approval classifications</th>
<th>Ground Connection (Figure reference)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MGK _ B</td>
<td>X</td>
<td>X</td>
<td>Ex d IIB T4 Ga/Gb</td>
<td>Figure 45</td>
</tr>
<tr>
<td>MGK _ C</td>
<td>X</td>
<td>X</td>
<td>Ex d IIB T4 Ga/Gb</td>
<td>Figure 46</td>
</tr>
</tbody>
</table>

**Figure 43b**  KC for Modbus and DDA installation drawing (continued)
**WIRING AND CONNECTIONS**

**Figure 45.** Single cavity housing

**Note:**

Ground terminal provided in housing to connect gauge housing to earth ground.

**Figure 46.** Dual cavity housing
PRODUCT LABELS

Figure 49. Label for models MG _ _ B and C with industrial rigid pipe

Figure 50. Label for models MG _ _ B and C with flexible hose
SPECIAL CONDITIONS FOR USE

- The electronics housing is to be installed in zone 1 (category 2G, EPL Gb). The sensor pipe/hose may be installed in zone 0 (category 1, EPL Ga) if not restricted below.
- Equipotential bonding shall be installed inside and outside the hazardous area along the cable for supply and data.
- Float usage:
  - Metallic floats may only be used if they have a weight offset (asymmetric weight distribution).
  - Metallic floats on non-metallic pipes may not be used.
  - Aluminum floats may not be used.
- Plastic floats may only be installed in hazardous areas which require apparatus of category 1G (for zone 0) with explosion group IIA. Plastic floats may not be used on non-metallic pipes.
- Sensors with flexible measuring hoses:
  - The hose has to be mechanically protected from external impacts which may affect its function as separation wall.
  - Avoid kinking or bending the flexible hose in less than 16 inch (406 mm) diameter.
- Consult MTS if dimensional information on flameproof joints are necessary.
Figure 57. FOUNDATION™ fieldbus installation drawing
INSTALLATION DRAWING NOTES

Notes:

1. Cabling shall be FOUNDATION™ fieldbus H1 Type Cable.
2. A terminator is required at each end of a fieldbus between fieldbus network segments.
3. Shield is connected to earth ground at one point only, usually at the control room fieldbus power conditioner.
4. Ground lug provided to connect gauge housing to earth ground. The transducer frame shall be founded directly or through the equipment on which it is mounted.
5. Electronic equipment connected to associated apparatus must not use or generate more than 250 volts RMS
6. Cable sets that are run together must have sufficient insulation to withstand 250 volts RMS between sets.
7. Wiring shall be installed in accordance with the country in use (eg Canadian Electrical Code, Part 1, National Electric Code ANSI/RFPA 70 Article 504-30).
8. Conduit seals are required within 457 mm (18 in.) of housing.
9. Caution: In hazardous locations, keep cover tight while circuits are energized.

Figure 57a. installation drawing notes for FOUNDATION™ fieldbus

<table>
<thead>
<tr>
<th>Model number FOUNDATION™ fieldbus</th>
<th>Approval agencies</th>
<th>Approval types</th>
<th>Approval classifications</th>
<th>Ground connection (Figure references)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MGKFB</td>
<td>X</td>
<td>X</td>
<td>Ex ia IIB T4 Ga/Gb</td>
<td>Figure 58</td>
</tr>
<tr>
<td>MGKFC</td>
<td>X</td>
<td>X</td>
<td>Ex ia IIB T4 Ga/Gb</td>
<td>Figure 59</td>
</tr>
</tbody>
</table>

Figure 57b. FOUNDATION™ fieldbus installation drawing (continued)
**WIRING AND CONNECTIONS**

**Figure 45.** Single cavity housing

**Figure 46.** Dual cavity housing

**Note:**
Ground terminal provided in housing to connect gauge housing to earth ground.
PRODUCT LABELS

Figure 60. Label for models MGKFB and MGKFC with industrial rigid pipe

Figure 61. Label for models MGKFB and MGKFC with flexible hose
SPECIAL CONDITIONS FOR USE

- The electronics housing is to be installed in zone 1 (category 2G, EPL Gb). The sensor pipe/hose may be installed in zone 0 (category 1, EPL Ga) if not restricted below.
- Equipotential bonding shall be installed inside and outside the hazardous area along the cable for supply and data.
- Float usage:
  - Metallic floats may only be used if they have a weight offset (asymmetric weight distribution).
  - Metallic floats on non-metallic pipes may not be used.
  - Aluminum floats may not be used.
- Plastic floats may only be installed in hazardous areas which require apparatus of category 1G (for zone 0) with explosion group IIA. Plastic floats may not be used on non-metallic pipes.
- Sensors with flexible measuring hoses:
  - The hose has to be mechanically protected from external impacts which may affect its function as separation wall.
  - Avoid kinking or bending the flexible hose in less than 16 inch (406 mm) diameter.
- Consult MTS if dimensional information on flameproof joints are necessary.