Series 9

Modbus/TCP

Industrial Communication Option

Publication Reference : 120/16603-01

Issue A

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Proprietary Notice

Series 9 Modbus/TCP User's Manual

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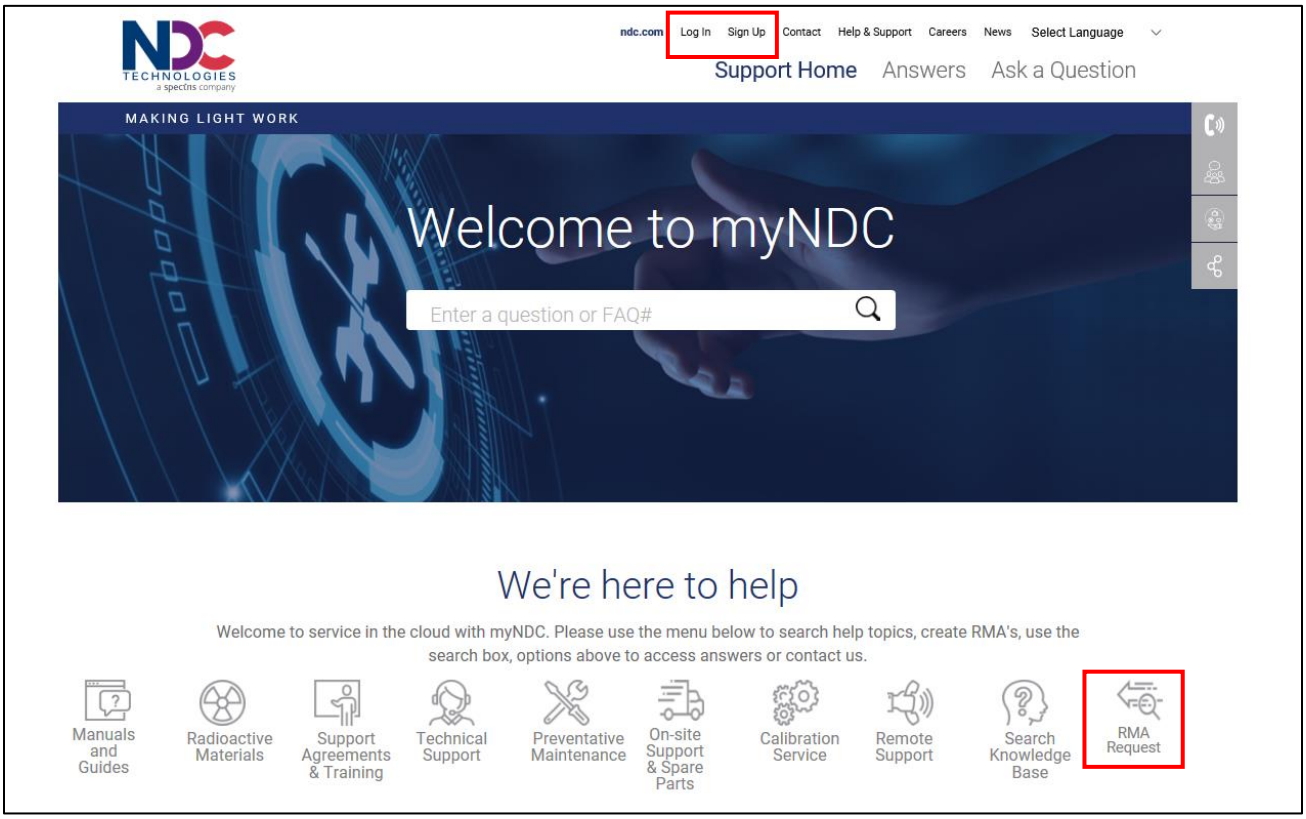

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Caution

- **The equipment described in this manual contains high potential voltages. Isolate the mains supply from the equipment during interconnection and maintenance.**
- **If the gauge is not installed and used in the manner prescribed in this manual, the safety protection afforded by the equipment may be impaired.**
- **For complete electrical safety in operation, the equipment has been supplied with double-pole neutral fusing incorporated. Do not modify in any way.**

Storage & Unpacking

Storage

Pending installation, store between 0°C and 70°C at less than 60% relative humidity. Allow the equipment to regain ambient temperature prior to installation.

Unpacking

Note: Before unpacking your on-line gauge, make sure you check off all the items against the packing list.

Retain the packaging used to ship all parts of your system, so that in the event that the equipment needs to be returned, it can be suitably re-packed for its safe return.

Open the packaging carefully and remove each item. Take the items to a clean room for inspection. Check that all the items on the Packing Note / Scope of Supply, have been supplied. Check that they are free from external damage, the connectors are free from dirt, and the cables are not chaffed or kinked.

Table of Contents

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CHAPTER 1

1 Introduction

The following supplement should be read in conjunction with the Series 9 User guide to ensure a reasonable level of familiarity with the gauge.

Series 9 Gauges have the option of communicating via the Modbus/TCP protocol. Modbus/TCP utilizes the regular Ethernet network.

This document uses terminology as defined in the Modbus/TCP specification, see Modbus-IDA – www.modbus.org for a complete reference.

The I/O data offered by the Gauge can be configured using the **GaugeToolsXL** Utility tool.
See Chapter 5 – Parameter Selection.

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CHAPTER 2

2 Modbus/TCP Implementation

The Series 9 Gauge implements a Modbus/TCP slave device with the following capabilities:

- Specification version 1.1b
- Multiple Modbus/TCP servers
- **Cycle Time** (interval between two parameter value updates):
  - Software limitation: 10 ms
  - New measurement data from hardware: 8 ms
  - Recommended: **500 ms or more**

The following standard functions are supported:

- Read Coils (Function Code = 0x01)
- Read Discrete Inputs (0x02)
- Read Holding Registers (0x03)
- Read Input Registers (0x04)
- Write Single Coil (0x05)
- Write Single Register (0x06)
- Write Multiple Coils (0x0F)
- Write Multiple Registers (0x10)

Note that the following functions are NOT supported:

- Diagnostics (0x08)
- Fetch Comm Event Ctr (0x0B)
- Fetch Comm Event Log (0x0C)
- Report Slave Id (0x11)
- Read General Reference (0x14)
- Write General Reference (0x15)
- Mask Write 4X Register (0x16)
- Read/Write 4X Registers (0x17)
- Read FIFO (0x18)

Should the Series 9 receive a Modbus message for an unsupported function, it will respond with an Exception response indicating Illegal Function (0x01).

2.1 Modbus/TCP I/O Data Layout

Parameters are grouped automatically in the following Modbus/TCP categories:

- **Discrete Inputs**: Read-only Boolean parameters
- **Coils**: Read-write Boolean parameters
- **Input Registers**: Read-only Integer or Float parameters
- **Holding Registers**: Read-write Integer or Float parameters

Note: String parameters are not supported and are therefore ignored in the configuration.

Boolean parameter values occupy 1 byte, corresponding to a single Discrete Input or Coil bit. Floating point parameters occupy 4 bytes, corresponding to two Input or Holding Registers. Integer parameters occupy 2 or 4 bytes depending on their type, corresponding to one or two Input or Holding Registers.

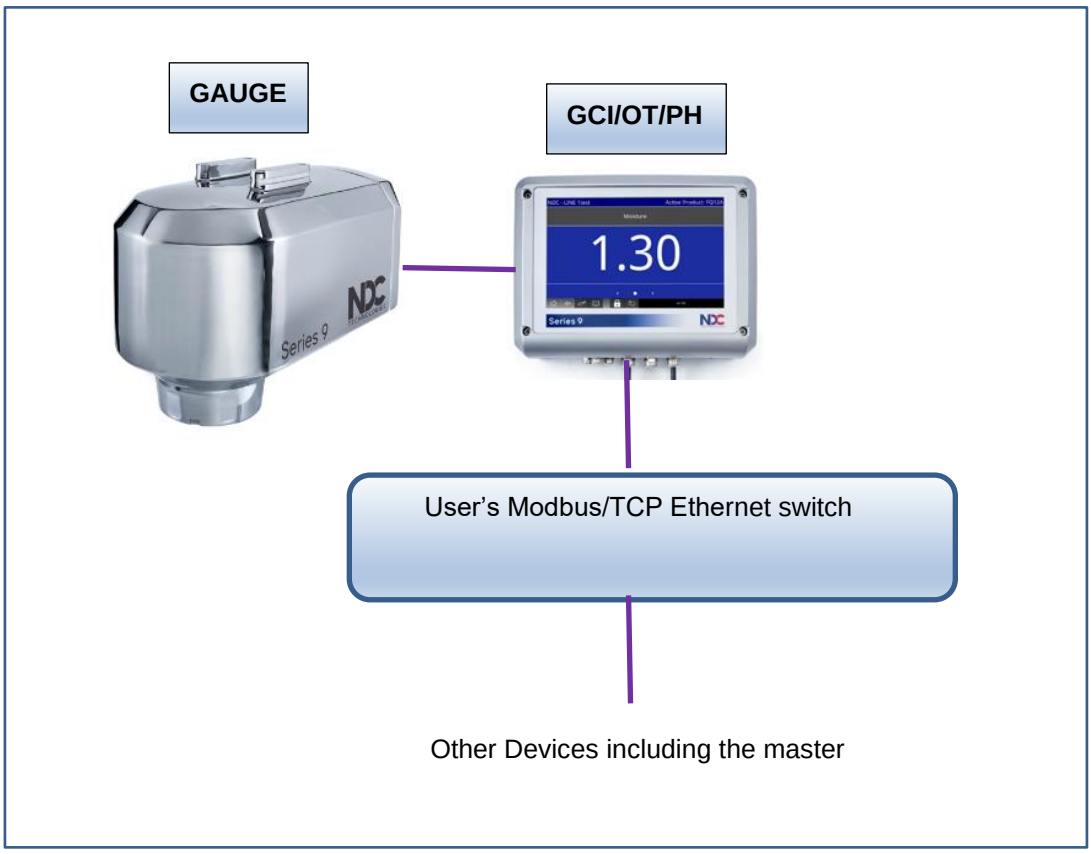
Data byte ordering is big endian by default, in accordance with the protocol specification, but can be configured to be big or little endian. See Section 5.8.1 - Endian Swap.

CHAPTER 3

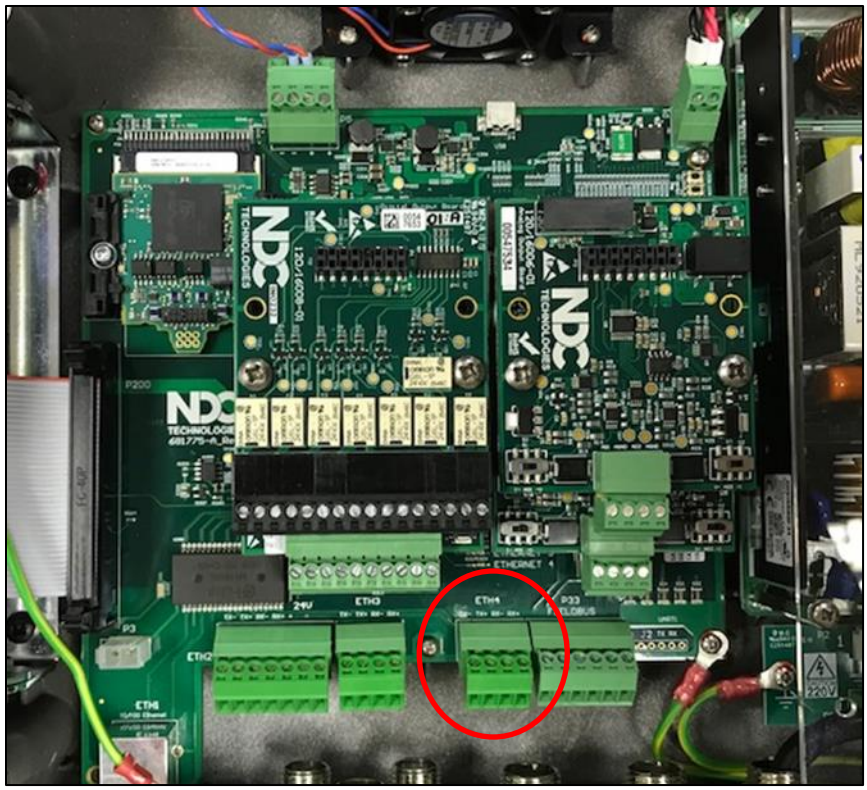
3 Physical Connection

The Modbus/TCP connection is made through one of the following three peripherals that is connected to the gauge:

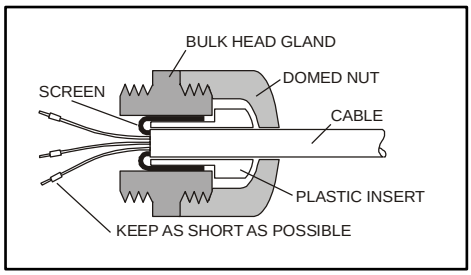
- Gauge Control Interface (GCI)
- Operator Terminal (OT)
- Power Hub (PH)



The Modbus/TCP connection point is the same in all the units - through a screw termination block marked ETH4, as circled in red in the photo below.



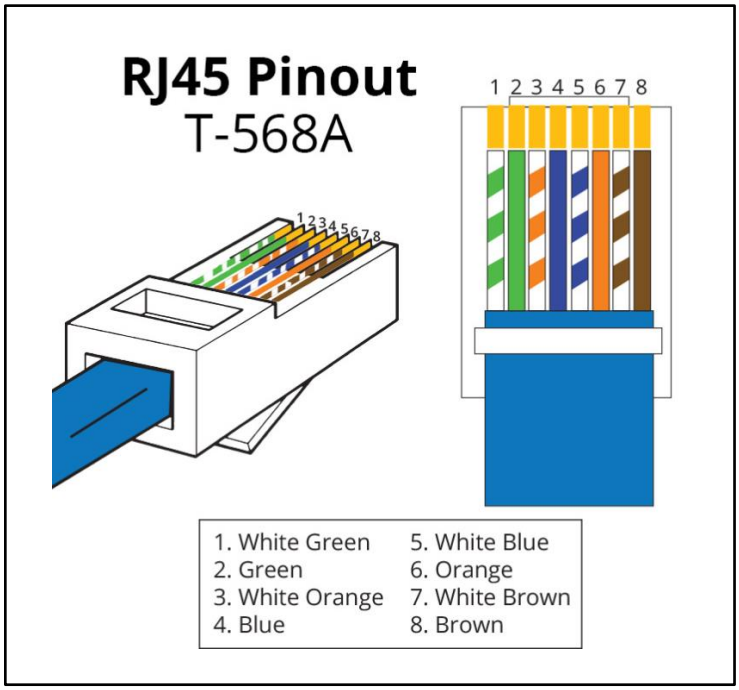
Only Cat5e or Cat6 twisted pair cable should be used, with the screen terminated to the metal gland as depicted below.



The signal terminations are as follows:

4 way	Name	Wire Colour
1	Tx-	White Green
2	Tx+	Green
3	Rx-	White Orange
4	Rx+	Orange

For reference, the RJ45 connector wire colours are shown below.



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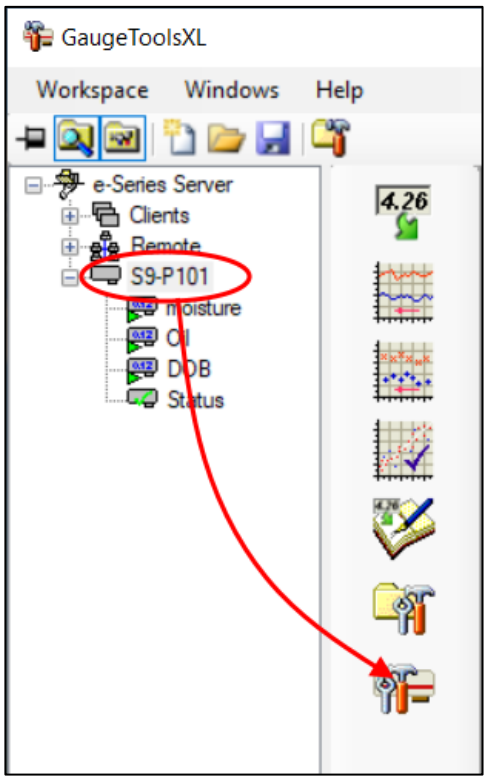
CHAPTER
4

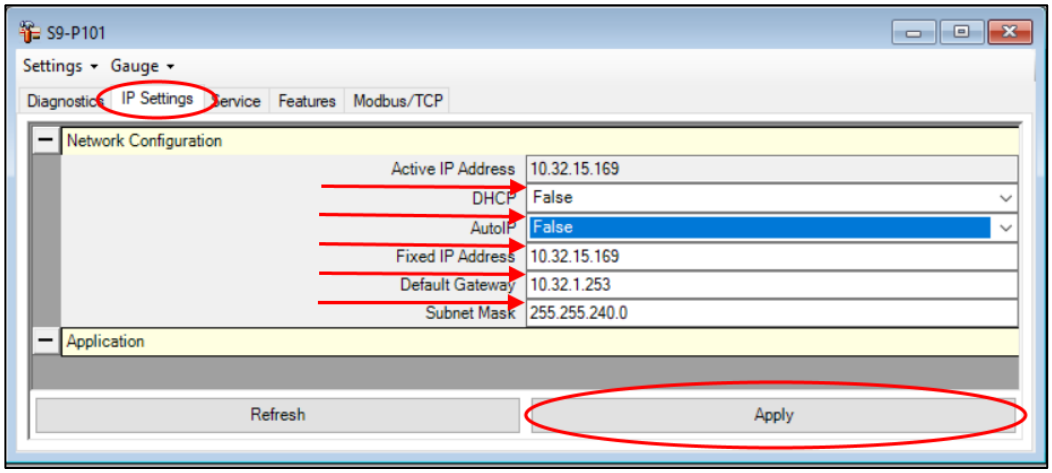
4 IP Address Settings

Modbus/TCP IP address is the same as set in the Series 9 gauge, which can be confirmed or changed through **GaugeToolsXL** as follows:

1. Start **GaugeToolsXL** and drag the Gauge node to the “Gauge Utility” icon.



2. Select the **IP Settings** tab and enter the required values.



3. Click **Apply** to use the new settings.

The host computer's original settings may now be re-applied.

Note: Each IP address on the network should be unique - if an IP conflict is found, it will be impossible to connect to the Gauge via GaugeToolsXL.

CHAPTER 5

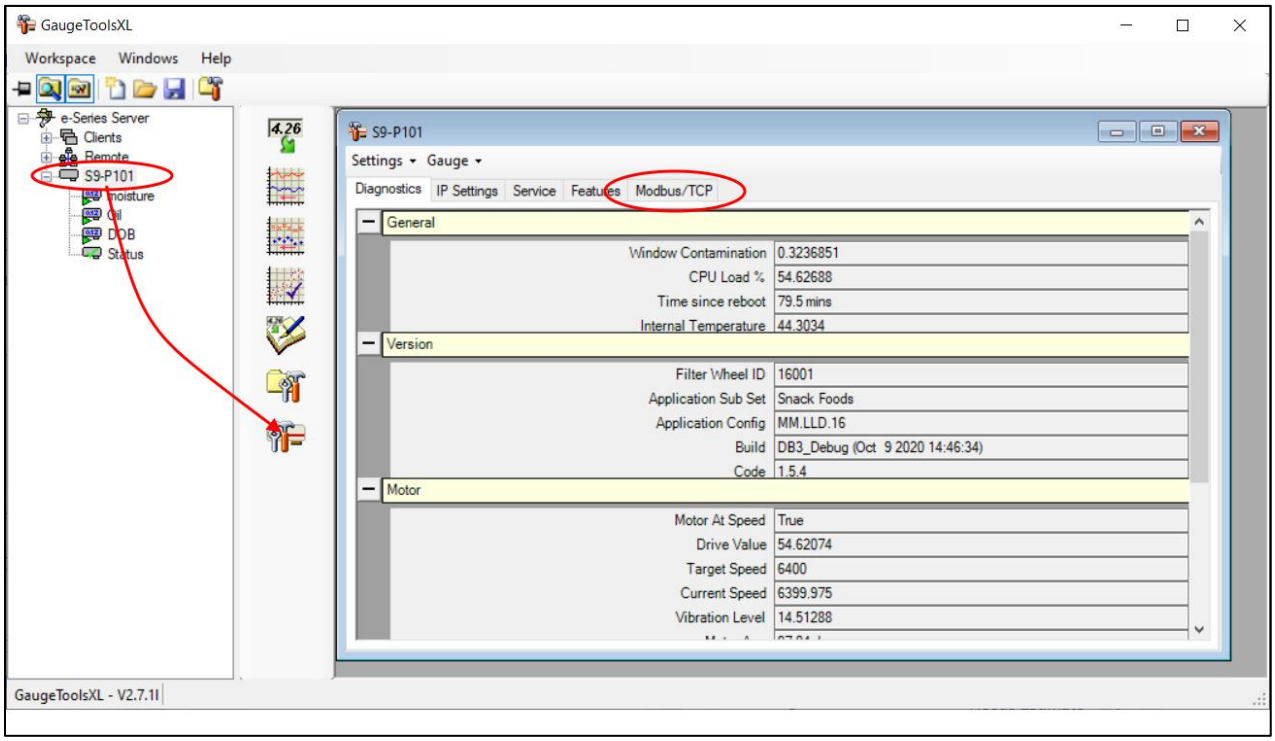
5 Parameter Selection

This chapter describes parameter selection using the **Utility** tool implemented in **GaugeToolsXL (GTXL)** for Series 9 Gauges. GaugeToolsXL is an *Offline* tool.

The GaugeToolsXL User's Manual details the installation and operation of the GaugeToolsXL software package.

5.1 Starting the Utility Tool

The Utility tool is activated by dragging a device from the device tree to the Utility tool icon in GTXL. GTXL opens the Utility tool window in the right-hand pane.



If the chosen device has Modbus/TCP enabled, then the Utility tool window contains a Modbus/TCP tab as shown above. Modbus/TCP is an optional service, so if the tab is not present, either the device does not support Modbus/TCP, or the service has not been enabled.

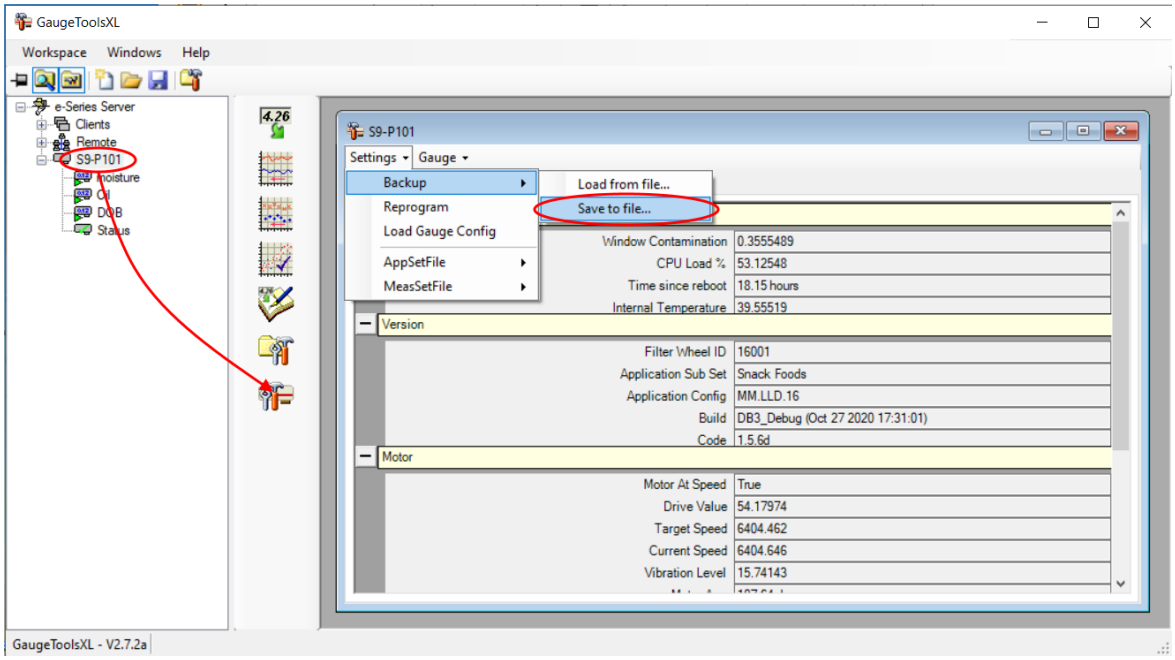
5.2 Backing up the Configuration

Before changing any settings, always back up the current configuration.

1. Connect the device to the same network as the PC on which GaugeToolsXL has been installed.

2. Start GaugeToolsXL.

3. Locate the device in the device tree, and drag it to the Utility tool icon.
   The Utility tool window opens in the right-hand panel, as described previously.



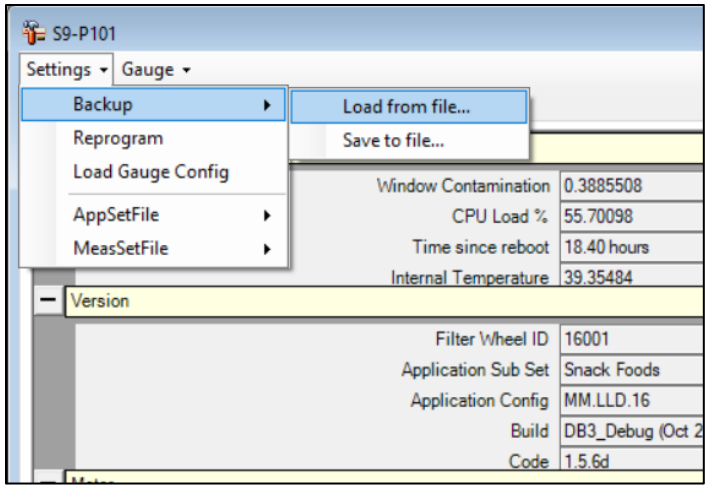
4. From the **Settings** menu, select the "**Save to file…**" menu item.
   Choose an appropriate filename when prompted.

GaugeToolsXL will then connect to the device, upload all configuration settings, and write them to the given backup file.

5.3 Downloading a Saved Configuration

1. Drag the device to the Utility icon to open the Utility tool window.

2. From the **Settings** menu, select "**Load from file…**".



3. When prompted, navigate to and select the backup file.

GaugeToolsXL connects to the device and downloads the backup file.

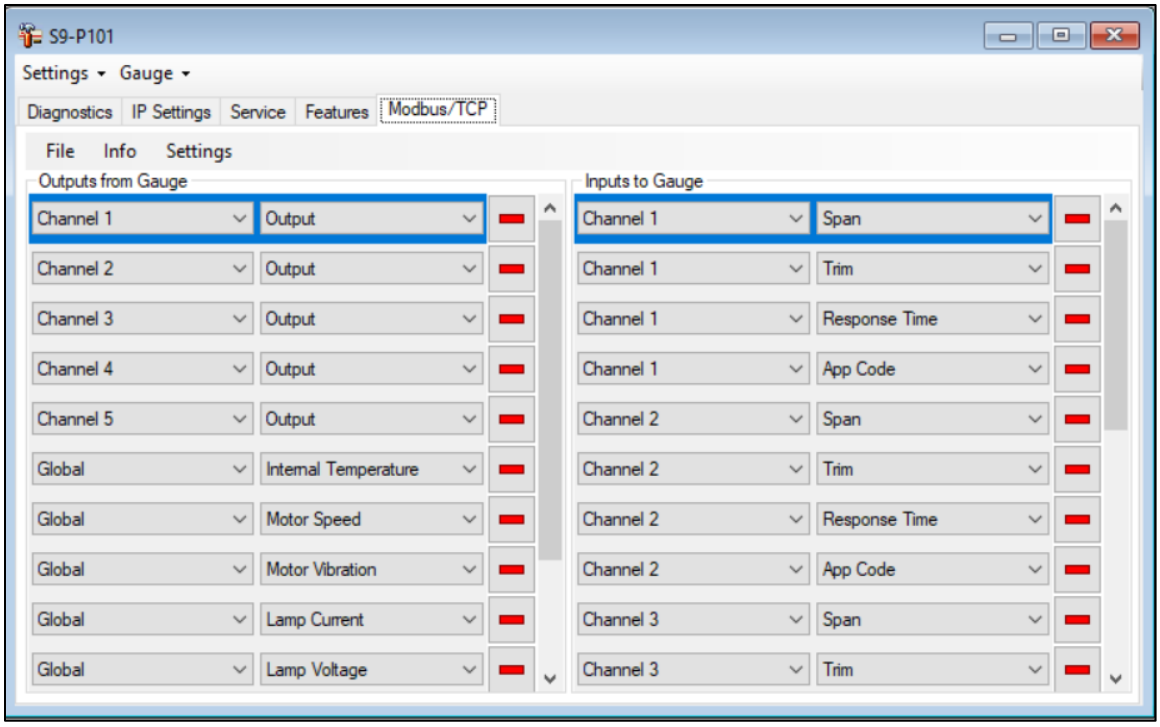
5.4 Changing the Modbus/TCP Configuration

The Modbus/TCP configuration can be modified using the GaugeToolsXL Utility tool.

1. Locate the device in the device tree, and drag it to the Utility tool icon.
   The Utility tool window opens in the right-hand panel.

2. If the selected device has Modbus/TCP enabled, then a Modbus/TCP tab appears in the Utility tool window.

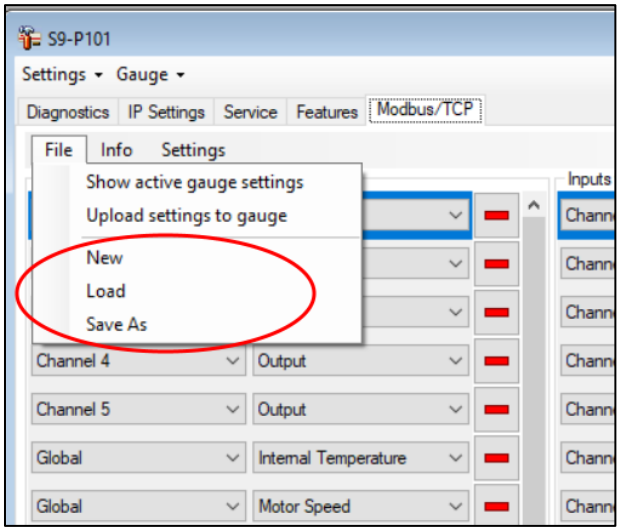
3. When the Modbus/TCP tab is selected, GaugeToolsXL connects to the device, uploads and displays the current configuration.



4. At this point, it is possible to:

   - Save the uploaded configuration to a PC file.
   - Modify the uploaded configuration.
   - Create a new configuration.
   - Load a previously saved configuration from a PC file.

   The **File** menu can be used to create a New empty configuration, Load a saved configuration from a PC file, or Save the current configuration to a file.



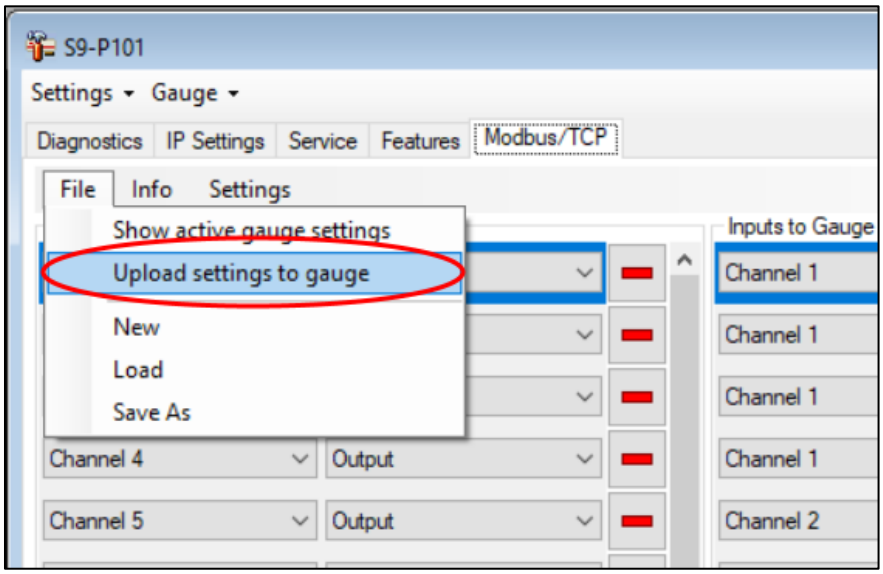
Once modifications to the configuration have been completed, it can be downloaded to the device.

5.5 Downloading a Configuration

The GaugeToolsXL Utility tool is used to load a Modbus configuration into the device.

1. First, use the Utility tool to create a new configuration, load a saved configuration, or upload the current configuration from the device.

2. Modify the configuration as required, then select **Upload settings to gauge** from the **File** menu to load the configuration into the device.

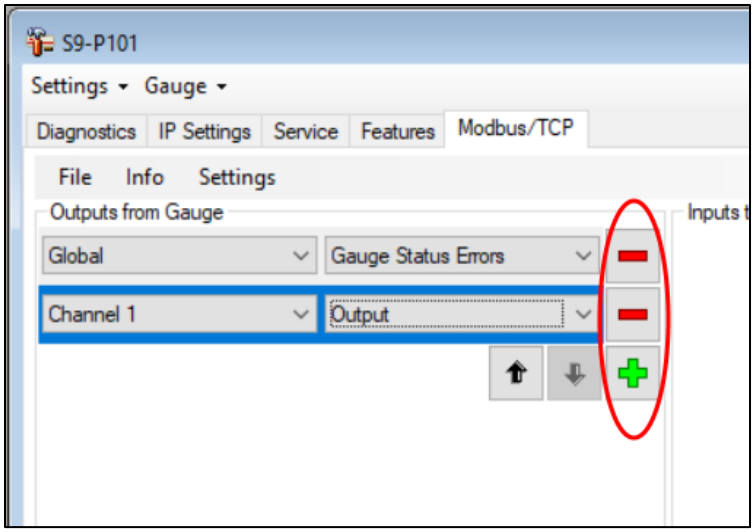


Note: The device must be restarted once the new or updated configuration has been downloaded.

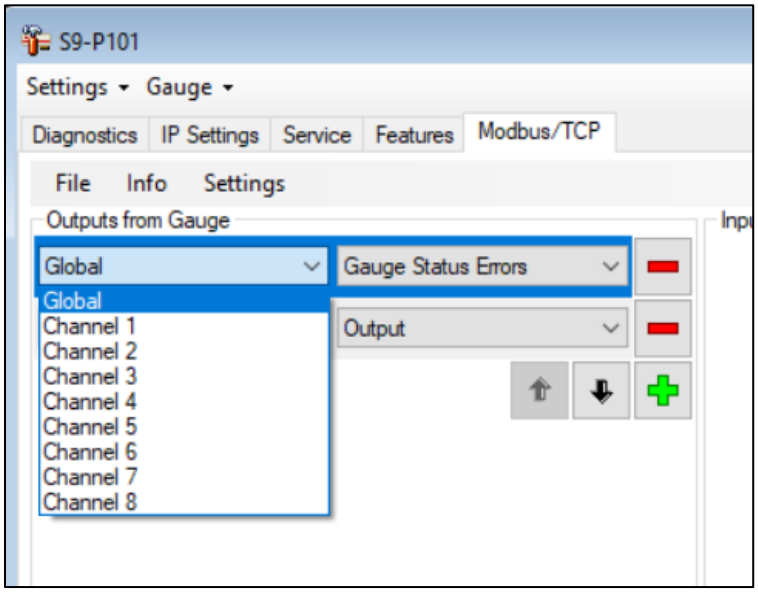
5.6 Changing the Parameters

1. Select the Modbus/TCP tab in the Utility tool window.

2. Parameters can be added or removed from the configuration by clicking on the buttons indicated.

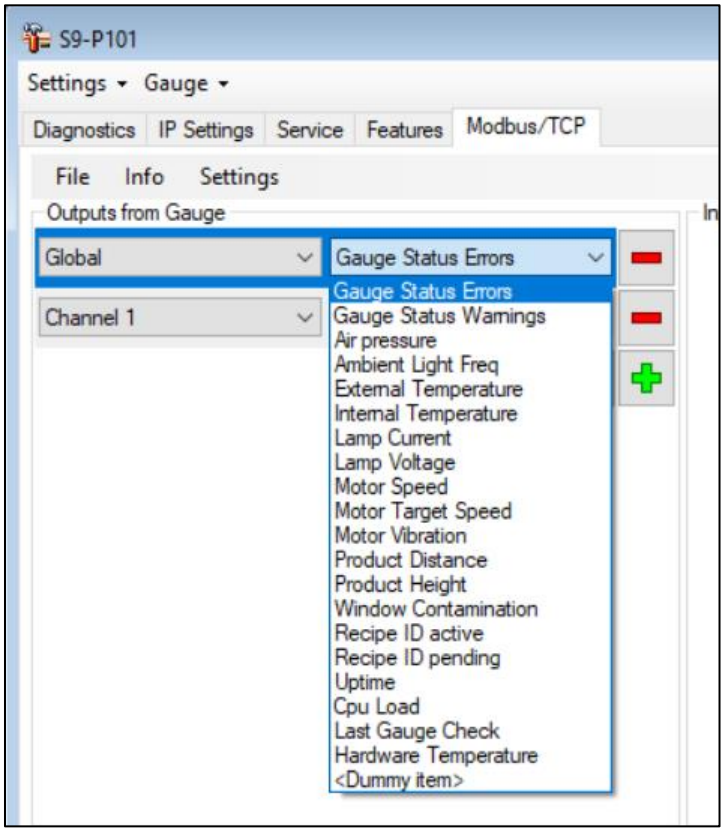


3. Using the **parameter type** drop down, select whether the parameter is a measurement parameter, or a global parameter value. For measurement parameters, select the required channel number.

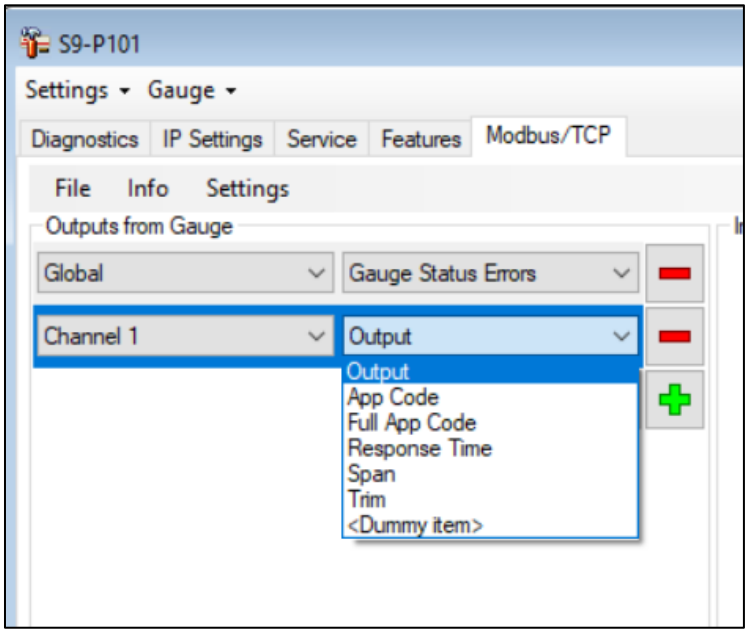


4. Use the **parameter** drop down to select the required parameter. The parameters available for selection depend on the type of parameter selected by the **parameter type** drop down.

   Global parameters:



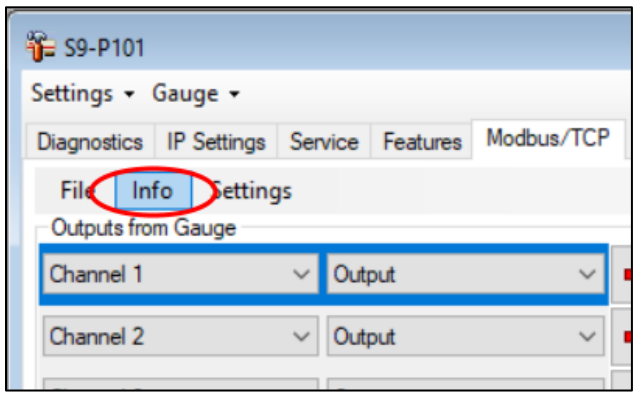
Measurement parameters:

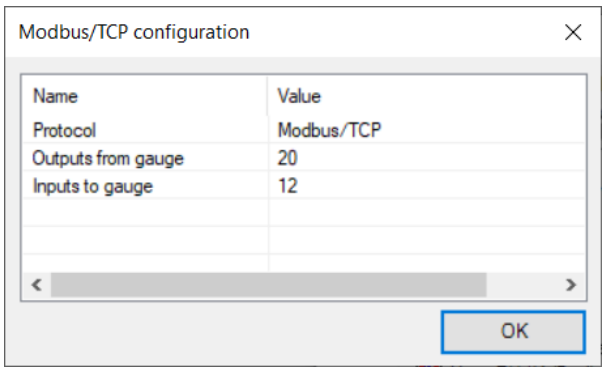


A detailed description of each parameter can be found in Chapter 6 - Data Parameters.

5.7 Parameter Summary

The Utility tool provides a summary of the Modbus parameter configuration when the “I**nfo**” menu is selected on the Modbus/TCP tab.





5.8 Other Settings

The following sections describe the available Modbus/TCP configuration settings.

Note: In all cases, any changes to the settings require a reboot of the gauge for the new setting(s) to take effect.

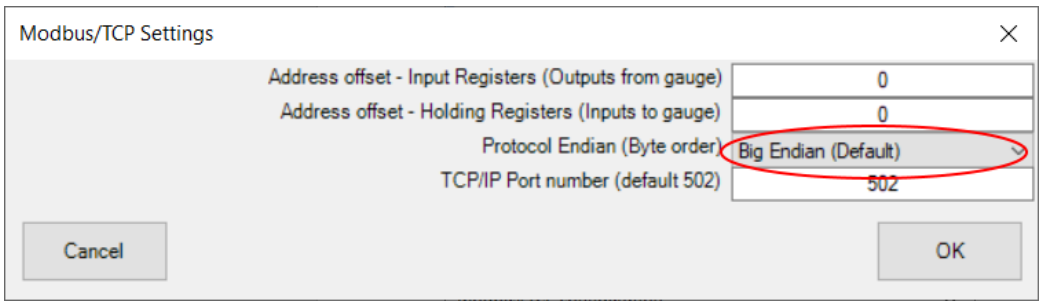
5.8.1 Endian Swap

It is possible to override the protocol's default endian specification, and choose little or big endian explicitly in the I/O data representation.

Endian swapping on floats and integers reverses the order of all bytes.

Note: Endian swapping only affects the parameter values in the I/O data buffer. The other values in the protocol (tags in packet headers, attributes of services, etc.) still obey the protocol's default endian requirement.

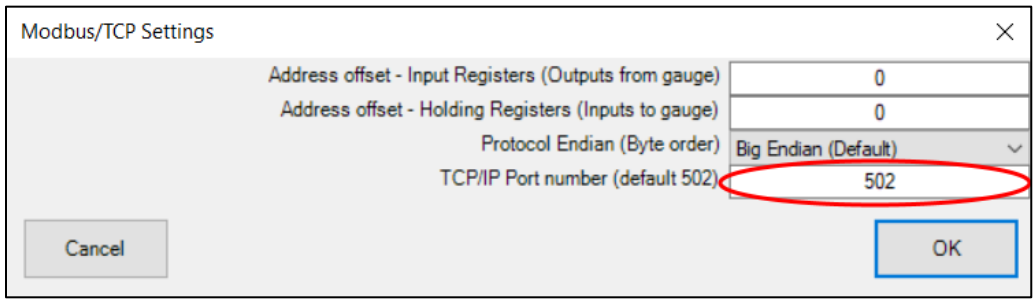
Click on the **Settings** menu, then use the **Protocol Endian** dropdown list to select the required endian setting. The default is big endian.



5.8.2 Modbus Port

The TCP port used by the Modbus/TCP slave to accept connections from Modbus/TCP masters can also be configured. The default is port 502.

Click on the **Settings** menu, then enter the desired port number into the **TCP/IP Port number** edit box.

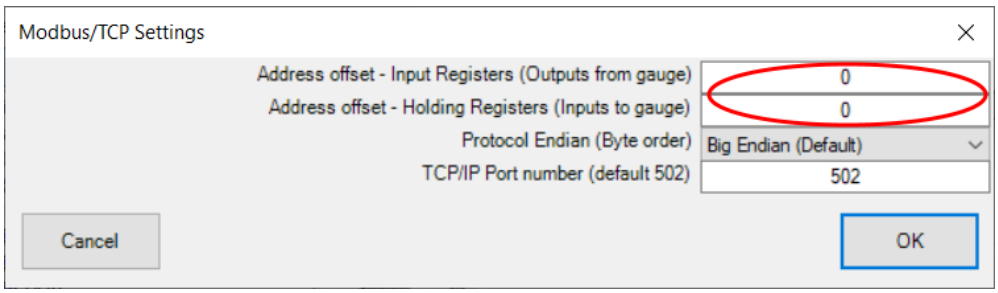


5.8.3 Address Offsets

The Series 9 allocates Modbus addresses starting from Modbus address 1 for each of the Modbus data types. See Chapter 6 - Data Parameters for the address allocation of the default register configuration.

In some customer setups, it may be necessary for the Modbus master to read the Modbus data starting from an address other than 1. In such instances, an address offset can be configured. For example, to read the holding registers starting from Modbus address 1001, rather than 1, an offset of 1000 is set.

To configure the address offset, click on the **Settings** menu, then enter the desired offset into the **Input** and/or **Holding Registers** edit box. The default is 0, to give Modbus addresses starting from 1.



CHAPTER 6

6 Data Parameters

The default register assignment for Modbus/TCP are given in the tables below.

All parameter data is 32-bit, occupies 2 addresses per value, and is transmitted in big endian format by default.

Read Only Parameters (Outputs from the gauge mapped to Input Registers)

Modbus Address	Value	Type
1	Channel 1 Output	32 bit Float
3	Channel 2 Output	32 bit Float
5	Channel 3 Output	32 bit Float
7	Channel 4 Output	32 bit Float
9	Channel 5 Output	32 bit Float
11	Internal Temperature	32 bit Float
13	Motor speed	32 bit Float
15	Motor vibration	32 bit Float
17	Lamp current	32 bit Float
19	Lamp voltage	32 bit Float
21	Window contamination	32 bit Float
23	CPU load	32 bit Float
25	Air Flow monitor (if fitted)	32 bit Float

Read/Write Parameters (Input/Output to the gauge mapped to Holding Registers)

Modbus Address	Value	Type
1	Channel 1 span	32 bit Float
3	Channel 1 trim	32 bit Float
5	Channel 1 response time	32 bit Float
7	Channel 1 Application code	Unsigned 32 bit integer
9	Channel 2 span	32 bit Float
11	Channel 2 trim	32 bit Float
13	Channel 2 response time	32 bit Float
15	Channel 2 Application code	Unsigned 32 bit integer
17	Channel 3 span	32 bit Float
19	Channel 3 trim	32 bit Float
21	Channel 3 response time	32 bit Float
23	Channel 3 Application code	Unsigned 32 bit integer
25	Channel 4 span	32 bit Float
27	Channel 4 trim	32 bit Float
29	Channel 4 response time	32 bit Float
31	Channel 4 Application code	Unsigned 32 bit integer
33	Channel 5 span	32 bit Float
35	Channel 5 trim	32 bit Float
37	Channel 5 response time	32 bit Float
39	Channel 5 Application code	Unsigned 32 bit integer

Alternative configurations of the Modbus parameter assignments may be programmed as the user requires, as described in Chapter 5 - Parameter Selection.

Note: When using GaugeToolsXL to alter the configuration, changes are applied after downloading the configuration to the gauge, and rebooting the gauge. If pre-configured files are provided by NDC, these will be detailed in a separate document.

The following section describes the currently available Gauge Parameters, along with a brief description.

6.1 Parameter Descriptions

6.1.1 Measurement Parameters

Parameter	Type	Description
Output	Real	Measurement value of the specified channel. The Units of the measured value depend on the target material and the application (e.g. moisture [%]).
App Code	Real	This value is the full 32-bit integer application code. This code is used to select the appropriate algorithm in the gauge for the intended measurement.
Full App Code	Real	
Response Time	Real	Output smoothing using an exponential factor [0…3600].
Span	Real	Multiplier factor for the Output: **Output = (Span * X) + Trim** (where **X** is the raw measurement value). This parameter is available for all measurements, including temperature.
Trim	Real	Offset for the output: **Output = (Span * X) + Trim** (where **X** is the raw measurement value). This parameter is available for all measurements, including temperature.

6.1.2 Global Parameters

Parameter	Type	Description
Air Pressure	Real	Airflow monitor (if fitted).
Ambient Light Freq	Real	
External Temperature	Real	Temperature external to gauge (if fitted).
Internal Temperature	Real	Internal temperature of the gauge.
Lamp Current	Real	Current through the lamp.
Lamp Voltage	Real	Voltage across the lamp.
Motor Speed	Real	The current speed of the Filter Wheel (motor) in the gauge.
Motor Target Speed	Real	The desired speed of the Filter Wheel.
Motor Vibration	Real	Vibration of the motor.
Product Distance	Real	
Product Height	Real	
Window Contamination	Real	The Window Contamination level in raw ADC units as seen by the sensor. (A clean window will usually generate a base reading of a few thousand.) This Parameter is in uncalibrated A/D units, and should be used for indication purposes only. It may be monitored while setting up the threshold levels which will trigger an error in the Gauge Status Errors bitfield.
Uptime	Unsigned Integer	Number of seconds that the gauge has been running.
Cpu Load	Real	CPU load.
Hardware Temperature	Real	Measured temperature of internal gauge hardware.

6.1.2.1 Gauge Status Errors

The **Gauge Status Errors** Parameter is a 32-bit value with each bit corresponding to various aspects of the Gauge hardware. Under normal operating conditions, all bits would be zero. Any non-zero value in this Parameter indicates an abnormal condition requiring attention.

The bit fields are described below:

Bit	Meaning (when set)
0	Motor Speed Error
1	Lamp Current/Voltage Error
2	Signal Low Error
3	Signal High Error
4	Window Contamination Error
5	Temperature Error
6	Internal Reference Error
7	Voltage Error
8	Slave Head Error
9	Airflow Error
10	Sync Pulse Error
11	Auto Sampler Error

If the **Gauge Status Errors** Parameter value becomes unavailable, all 32 bits of the Parameter will be set to a logic ‘1’ after a delay of approximately 5 seconds. The **Gauge Status Errors** Parameter may be continually monitored for this condition to indicate when a remote Gauge is powered down or disconnected from the network.

6.1.2.2 Gauge Status Warnings

The **Gauge Status Warnings** Parameter is a 32-bit value which has the same bit assignments as the **Gauge Status Errors** Parameter described above. Under normal operating conditions, all bits would be zero. Any non-zero value in this Parameter indicates a condition that does not require immediate attention.

6.1.2.3 Product Management Parameters

Parameter	Type	Description
Recipe ID active	Unsigned Integer	Identity of currently active product recipe.
Recipe ID pending	Unsigned Integer	Identity of product recipe which is about to be loaded.

Product Recipe ID's can be found on the Product Load and Product Configuration pages of the gauge's web interface.

The **Recipe ID active** parameter contains the ID of the currently active product recipe. To change this, set the **Recipe ID pending** to the ID of the required recipe. If the ID is valid, the gauge will automatically load the selected product. The **Recipe ID active** parameter will update to the selected product ID. This can be used to verify that the product has successfully loaded.

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   Purchaser assumes the risk for use of this product and agrees to indemnify and hold NDC Technologies harmless for any and all damage to person or to property resulting therefrom.

   NDC Technologies grants no license under any patent rights except the right, under only such patents as may be owned or acquired by NDC Technologies, to use the product sold hereby for the purpose for which it is sold. NDC Technologies does not warrant that the product or its use does not infringe any patent owned by persons other than NDC Technologies.

2. NDC Technologies guarantees all products to be free from defects in material and workmanship for the following periods[1]:

   - Product and peripherals – 2 years from shipment
   - Source lamp – 5 years from shipment
   - Filter wheel motor – 5 years from shipment
   - Spare parts – 1 year from shipment
   - Replacement lamps and motors supplied under warranty – 1 year or up to the original 5 year warranty from shipment of the sensor, whichever is longer

   [1] Refer to the contractual terms and conditions of the Order for usage of the warranty.

   During this period, NDC Technologies will repair or at its option replace, free of all charges for parts and labor, any NDC Technologies parts determined by it to have been broken or damaged due to causes other than improper application, abuse or negligence. NDC Technologies' obligation to repair or replace shall not extend to expendable parts which are subject to normal operating wear.

   Nothing in this paragraph 2 will require NDC Technologies to make repairs or replacements where:

A. The product has been repaired, other than by an authorized NDC Technologies dealer or an NDC Technologies employee, or altered in any way without the prior written consent of NDC Technologies; or

B. The product has not been properly maintained in accordance with any operating and maintenance manual supplied therewith; or

C. The product has been damaged as a result of fire, flood, war, insurrection, civil commotion, acts of God or any other cause beyond the control of NDC Technologies or Buyer.

3. NDC Technologies' liability shall be limited to the obligations set forth in Paragraph 2. These shall be the Buyer's sole and exclusive remedies, whether in contract, tort or otherwise, provided, however, that in lieu thereof, NDC Technologies at its option may replace the entire product on an exchange basis or refund the purchase price against the return of the defective product.

4. NDC Technologies will not be responsible for failure to provide service or parts due to shortage of materials, labor or transportation strikes or delays, or any causes beyond NDC Technologies' control.

5. Unless otherwise specified by NDC Technologies, all warranty repairs will be made at NDC Technologies' facility. The customer shall be responsible for all expenses of packing, freight and insurance in connection with the shipment of products to NDC Technologies for repair. NDC Technologies will pay the cost of returning the equipment to customer.

   If it is mutually determined by the buyer and NDC Technologies that the examination, replacement or repair takes place at the buyer's facility, then the buyer will be responsible for NDC Technologies' travel and living expenses incurred in traveling to and from the buyer's facility, and during the time of the visit, as well as the cost of field labor and replacement parts unless the parts being repaired or replaced are determined to have been defective, in which event the cost of said repaired or replacement parts shall be borne by NDC Technologies. These travel and living expenses will be billed to the buyer at actual cost to NDC Technologies.

6. No person, including any NDC Technologies distributor, agent or representative, is authorized to assume any liability on behalf or in the name of NDC Technologies, and NDC Technologies shall not be bound to any understandings, representations, or agreements with respect to warranties except as set forth in this policy.

7. NDC Technologies requests immediate notification of any claims arising from damage in transit in order to determine if carrier responsibility exists. If damaged equipment arrives, save the shipping container for inspection by the carrier and telephone NDC Technologies as soon as possible.