DSS Direct Integration Manual

Direct Smart Sensors — Smart Digital MODBUS RTU RS-485 Sensors

Interfaced directly with customer-supplied PLC, SCADA or DCS equipment

Recommended integration path: Integration Module TT-ISO-DSS-DC

Version v1.5 — 23 July 2026

Released for customer distribution — Source Reconciliation Register closed

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Document Control

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Source documents	DSS Implementation Guide V3.0 · DSS Field Installation Guide (updated 26/08/2020) · Integration Module User Manual v1.6 (08/07/2026) · Direct Integration System Diagram v1.2
Supersedes	The three source documents below, for direct-integration customers
Changelog	v1.5 — 23 Jul 2026. Title-page hero image replaced: the previous hero was a screenshot of the old v1.1 title page (with stale version and DRAFT text baked into the image), which caused a spurious second title block to appear on page 1. Swapped for the clean DSS sensor-range product photo. No text/content change. v1.4 — 23 Jul 2026. Print formatting: data-table header rows now repeat at the top of every page a table continues onto, and a header row can no longer be left stranded at the foot of a page (it moves to the next page with its first data row). Applied programmatically in build_manual.py to all tables; no content change. v1.3 — 22 Jul 2026. Figure finalisation: the seven previously-placeholder line drawings sourced and inserted (Figures 4-1, 4-2, 4-3, 4-4 and A-3 from the Field Installation Guide detail/assembly drawings; Figure A-2 now shows the direct panel-mount interface, caption revised to match). Figure A-1 (direct-wire terminal-strip schematic) removed — no source drawing available that does not depict a discontinued powered junction box (contrary to §2A); Section A.4 prose and Table 4-1 carry the terminations. v1.2 — 22 Jul 2026. Source Reconciliation Register closed: conductivity high-range max-input corrected to 1,000,000/2,000,000/4,000,000 (R-17); register 40031 corrected to hours (R-19); serial-number worked example corrected to 22.08-t.35 (R-20); superseded DSS4F cable codes replaced with the current TT-ACC-DSS range and PC-Interface / Module-variant / programming-cable codes confirmed (R-23/R-24); Module supply-current figures updated (R-25); Modbus Poll screenshots and junction-box/Module photos inserted (R-26/R-28); Module field-wiring and commissioning cross-reference added (R-27/R-22). v1.1 — first consolidated edition; Module-first restructure; discontinued junction boxes and DSSmA/Analyser content removed.

Contents

How to Use This Manual

This manual is for a **competent system integrator or instrumentation technician** integrating Turtle Tough DSS sensors into their own MODBUS RTU equipment — PLC, SCADA, DCS, data logger, or any device that accepts a MODBUS RTU input. Direct integration requires a moderate to high level of onsite expertise in system integration and should ONLY be undertaken by someone with the requisite experience.

The Integration Module (TT-ISO-DSS-DC) is the recommended installation method and is required for full factory support (Part 3). Wiring a sensor directly to your PLC without the Module is technically possible but actively discouraged; it is documented only in Appendix A, with warnings.

Read the manual in order: commission the sensor first (Part 2), install via the Integration Module (Parts 3–4), then program your PLC (Part 5). Part 5 applies to **every** installation method — the Module is a transparent bridge, so your PLC reads the same registers either way.

Instructions for use of DSS sensors with other Turtle Tough solutions (Analysers, controllers) are outside the scope of this manual — refer to the manuals for those products.

Part 1 — Overview & Essential Safety

1.1 The DSS Ecosystem

Turtle Tough DSS sensors are smart digital RS-485 MODBUS RTU slave devices, available as:

Sensor type	Model family	Sensor Type code (reg. 40036)
pH	DSS-pH	1
ORP — Standard Range	DSS-ORP	2
ORP — Wide Range	DSS-ORP (wide)	3
Dissolved Oxygen	DSS-DO	4
Ion Selective (ISE)	DSS-ISE	5
Conductivity — Standard/High Range	DSS-CON-ISO	6
Conductivity — Ultralow Range	DSS-CON-ISO-L	7

Table 1-1 — DSS sensor types.

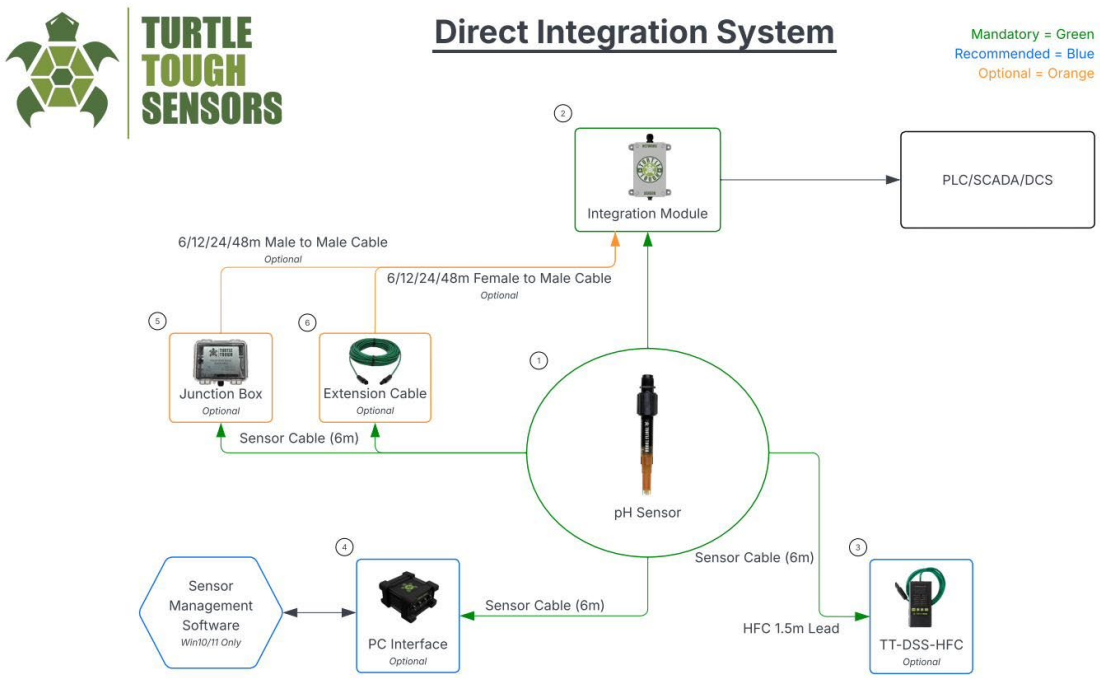
The supported **Direct Integration System** (Figure 1-1) comprises:

#	Component	Classification	Role
1	DSS Sensor + 6 m sensor cable	**Mandatory**	The measuring device
2	Integration Module TT-	**Mandatory**	Isolated MODBUS RTU bridge between sensor

#	Component	Classification	Role
	ISO-DSS-DC		and your PLC/SCADA/DCS
3	Handheld Field Communicator (TT-DSS-HFC), 1.5 m lead	Config tool	Calibration, configuration & diagnostics; self-powers the sensor
4	PC Interface + Turtle Tough Sensor Management Software (Windows 10/11 only)	Config tool	Calibration & configuration; sets sensor node address & baud rate; programs the Module
5	Junction box	Optional	Cable extension only — unpowered, 1 sensor : 1 box
6	Extension cable	Optional	Cable extension only

Table 1-2 — Direct Integration System components (per System Diagram v1.2).

Figure 1-1 — Direct Integration System topology (System Diagram v1.2). Core mandatory path: **DSS Sensor → Integration Module → your MODBUS RTU device (PLC/SCADA/DCS).** Colour code: green = mandatory, blue = recommended, orange = optional.



The HFC, PC Interface and Sensor Management Software are **essential components** of a properly implemented direct integration installation and are sold separately. At least one configuration tool — the HFC, or the PC Interface with software — is required, because the

sensor's node address and baud rate can only be set with these tools, never from the PLC (see §2.1).

1.2 Integration Options & the Recommended Path

There are two ways to physically connect a DSS sensor to your equipment:

1. **Via the Integration Module TT-ISO-DSS-DC — recommended, and required for full factory support.** The Module is the only supported powered solution. It provides clean, galvanically isolated power to the sensor and digital isolation on the RS-485 lines, and it manages the network-side communication settings (baud rate, parity, stop bits) and translation between your network and the sensor. See Part 3.
2. **Direct wiring to your PLC — discouraged.** Technically possible, but too much can go wrong: chiefly poor power quality and inadequate signal isolation, causing unreliable readings and frustration for customer and factory alike. Documented only in Appendix A.

Whichever physical method is used, the MODBUS data access and programming in Part 5 is identical — the Module is a transparent bridge.

Important information about integrating Direct Smart Sensors

TURTLE TOUGH DIRECT SMART SENSORS (DSS) are fully supported by a range of factory hardware solutions including Handheld Field Communicators, PC Communication tools, the Integration Module, and field implementation devices such as junction boxes and extension leads. This ecosystem provides a complete solution for reliable connectivity and sensor management.

TURTLE TOUGH sensors may also be directly interfaced with end-user hardware via the MODBUS RTU protocol. Integrating sensors directly into your industrial network requires a moderate to a high level of onsite expertise in system integration and should ONLY be undertaken by someone with the requisite experience. While direct integration provides some significant benefits, it also incurs a higher degree of risk as integrating with 3rd party hardware provides a lot of opportunities for unexpected issues to arise. 3rd party hardware includes any device or component not supplied by Turtle Tough and can include, but is not limited to, PLC's, SCADA systems, DCS's, data loggers, power supplies/isolators, or any other externally sourced interfacing device or component. We suggest you read this manual carefully to understand the full scope and requirement for installation, because:

3. Turtle Tough Pty Ltd and its representatives can provide only limited factory support when integrating sensors with 3rd party hardware. Unexpected behaviour or damage as the result of 3rd party hardware is not the responsibility of Turtle Tough.
4. Product support is limited to the information provided in our field implementation notes and guidelines. The product is fully supported for installation requirements, field implementation and programming protocols in direct relation to our product. It does not extend to the compatibility of our sensor with or the subsequent behaviour of 3rd party hardware. Due to the infinite amount of 3rd party hardware available we are unable to support issues related to 3rd party problems and it is the sole responsibility of the end-user to test and verify the compatibility of our product with their equipment.
5. Turtle Tough and its representatives are unable to provide support on 3rd party hardware or provide troubleshooting on equipment not supplied by us. If you intend to integrate the sensor directly with your hardware, we highly recommend the following:

- Read this manual in full. Make sure you understand the requirements and please contact us if you require clarification or further information.
- Seek advice from your 3rd party hardware provider and make sure this equipment meets the minimum specification requirement outlined in our support documentation.
- Purchase a handheld field communicator (HFC) from Turtle Tough. This stand-alone device self-powers the sensor and provides complete diagnostics and communication. The HFC allows us to independently test and verify sensor performance, independent of your system or hardware, and is the single fastest way to rule out any sensor performance issues and be able to identify field installation problems.
- Alternatively, you may purchase a Windows PC interface box. Once again, this factory-supplied and tested component will ensure reliable communication with the sensor, and it can be tested independently of your system.

WARRANTY: Our quick connect plugs must never be removed or modified in any way. This will immediately void the warranty. Only use Turtle Tough factory interface leads or panel mount connectors to interface with your hardware.

1.3 Safety Precautions

WARNING: Verify supply voltage and polarity before energising any component. Never apply voltage to RS-485 data terminals.

- Verify 9–36 V DC power and polarity before connecting the Integration Module.
- Never apply voltage to RS-485 terminals.
- Use ESD protection when handling electronics; sensors with internal boards are sensitive to electrostatic discharge.
- Disconnect power before wiring.
- Ensure proper grounding, and sealing of cable glands.
- Use shielded twisted-pair cable for RS-485 runs; ground the shield at one end only (typically the control-panel/PLC end) to minimise ground-loop currents.
- Ground loops, poor earthing and faulty electrical installations are a common cause of sensor damage. If you are experiencing unusual or erratic readings, refer to the Turtle Tough support document on ground loops.

1.4 Warranty-Critical Do's and Don'ts

Do	Don't
Use only Turtle Tough factory interface leads and panel mount connectors	Never cut, remove or modify quick connect plugs — **immediately voids the warranty**
Keep the unique identifier laminated to the cable end in place	Never remove the cable's laminated identifier — voids the warranty
Power the sensor via the Integration Module (or HFC/PC Interface during service)	Never power the sensor from an unverified/non-isolated supply — electronics damage is **not covered by warranty**

Do	Don't
Follow Turtle Tough installation instructions when opening the Module enclosure for wiring access	Never modify the Module, flash firmware, or alter components — voids the Module warranty

Table 1-3 — Warranty-critical practices. Full warranty terms: Part 8.

Part 2 — Commissioning (Before Installation)

2.1 Setting the Sensor's Node Address & Baud Rate

Two parameters **MUST** be set during commissioning, before the sensor joins your network: the **node address** and the **baud rate**.

NOTE: These can only be assigned with the **Handheld Field Communicator (HFC)** or the **PC Interface + Turtle Tough Sensor Management Software (Windows)** — **never from the PLC.** Sensors can be ordered with customised default baud rate and node address on request (contact the factory for ordering information).

Procedure:

6. Connect the sensor to the HFC, or to your PC via the PC Interface.
7. If the sensor's current baud rate or node address is not known, use the Sensor Management Software to scan for and determine them.
8. Assign a **unique node address** valid for your network.
9. Assign the baud rate — **9,600 or 19,200 baud** (see §2.2).
10. Note both values for PLC setup, and write the sensor type, node address and baud rate on the sensor label (§2.3).

For the detailed device-specific procedure, refer to the Handheld Field Communicator manual and the Turtle Tough Sensor Management Software manual.

2.2 MODBUS Network Fundamentals

For communication to be successful:

- **All MODBUS devices on the network must use the same baud rate.**
- **Every device must have a unique node address.**
- All DSS sensors use the standard RS-485 MODBUS RTU frame of **8-bit, even parity, 1 stop bit**. Any other MODBUS devices sharing the network with a DSS sensor must share these settings — unless the Integration Module is translating for you.

Setting	Sensor side	Integration Module network side
Baud rate	9,600 or 19,200 (reg. 40009)	9600, 14400, 19200, 38400, 56000, 57600
Default baud	19,200	19200
Frame	8-bit, even parity, 1 stop bit	Parity Even/Odd/None; 1 or 2 stop bits

Setting	Sensor side	Integration Module network side
Node address	Default = sensor type code (Table 2-1)	1–255

Table 2-1 — Communication settings, sensor vs Module network side. The Module translates between the two (§3.1), so your network may run settings the sensor itself does not support.

2.3 Sensor Defaults & Labelling

By default the baud rate is **19,200** and the node address equals the **sensor type code**:

Sensor	Default node address	Default baud
DSS-pH	1	19,200
DSS-ORP Standard Range	2	19,200
DSS-ORP Wide Range	3	19,200
DSS-DO	4	19,200
DSS-ISE	5	19,200
DSS-CON-ISO (Std/High)	6	19,200
DSS-CON-ISO-L (Ultralow)	7	19,200

Table 2-2 — Factory defaults (sensor type per register 40036 / FC 03 index 35).

Best practice: write the sensor type, node address and baud rate on the sensor label for ease of ongoing maintenance.

2.4 Sampling Rates

The internal sampling rate of DSS sensors is **4 Hz (250 ms)** with a 1 second dampener applied to the raw values. Engineered values also have a dampener applied, with the number of seconds a user-adjustable parameter stored in the sensor EEPROM (register 40007).

The maximum recommended sampling rate for Read Input Register polls (process values) is **4 Hz (250 ms)**. For quite long cable lengths and/or very many nodes it may be necessary to reduce the sampling rate to 2 Hz (500 ms), 1 Hz (1,000 ms) or even 0.5 Hz (2,000 ms) if timeouts are occurring on the network.

Part 3 — Recommended Installation: the Integration Module (TT-ISO-DSS-DC)

3.1 What It Is & Why It Is the Recommended Path

The Turtle Tough Integration Module provides a **transparent and electrically isolated MODBUS RTU communication bridge** between the sensor and your network device. It eliminates ground loop interference, improves signal stability, and allows seamless integration between Turtle Tough DSS sensors and other MODBUS-compatible systems.

The Module functions as a bidirectional MODBUS RTU isolation and translation bridge. It:

- provides **galvanic isolation for power** and **digital isolation for the RS-485 lines**, preventing electrical interference, noise, and ground loop issues — the two things a customer-arranged installation most often fails to guarantee;
- **translates baud rate, parity and stop bits** between your network's configuration and the sensor's configuration;
- passes all MODBUS messages transparently, recalculating parity as required, while preserving data integrity and the timing of every transaction.

Although optimised for Turtle Tough DSS sensors, it is also compatible with any MODBUS RTU sensor operating within the supported communication parameters.

NOTE: Because the Module is transparent, your PLC addresses and reads the sensor exactly as described in Part 5 — no additional programming is required for the Module itself.

Features at a glance: transparent Modbus RTU bridge · galvanic isolation for power circuits · digital isolation for RS-485 · configurable node address, baud rate, parity & stop bits · compact form factor with wall-mount (IP67) or DIN-rail options.

3.2 Specifications, Enclosures & Network-Side Cable

*Figure 3-1 — The Integration Module (TT-ISO-DSS-DC). Orderable in two enclosures: **TT-ISO-DSS-DC-IP67** (IP67, cable glands, panel-mount female sensor connector) and **TT-ISO-DSS-DC-DIN** (DIN-rail, IP44, sensor input loom). Both are blind (no local display), accept 9–36 V DC input and output isolated MODBUS RTU.*

Electrical	Value
Input voltage (operating)	9–36 V DC
Output voltage	9 V

Electrical	Value
Max output current	170 mA
Operating current (no sensor)	64 mA
Operating current (conductivity sensor)	120 mA
Max current draw	200 mA
RS-485 isolation	±15 kV
Power isolation	1 kV
RS-485 bias	50 mV failsafe

Table 3-1 — Electrical specifications. Note: when configured via the Turtle Tough PC Interface, the Module is temporarily powered through the USB interface during setup. Size the DC supply feeding each Module for its operating draw — 64 mA (no sensor) to 120 mA (conductivity sensor connected) — and multiply by the number of Modules.

Environmental	Value
Operating temperature	−40 °C to +85 °C
Storage temperature	−40 °C to +125 °C

Table 3-2 — Environmental specifications.

Communication	Value
Default Modbus	19200, 8-bit, even parity, 1 stop bit
Supported baud rates	9600, 14400, 19200, 38400, 56000 & 57600
Parity	Even, Odd, None
Stop bits	1 or 2
Node range	1–255

Table 3-3 — Communication specifications (network side).

Enclosure options:

Option	Material	Rating / requirement
Wall-mount	Polycarbonate, light grey	IP67 — suitable for outdoor or washdown use
DIN-rail *(optional)*	ABS, light grey	Must be mounted in a protective

Option	Material	Rating / requirement
		cabinet

Table 3-4 — Enclosure options.

Network-side RS-485 cable recommendation. For reliable MODBUS RTU communication on the network side of the Module, Turtle Tough strongly recommends **Belden 8723** instrument cable:

- 22 AWG stranded copper conductors
- Twisted pair construction (D+ and D− run as a pair)
- Individually foil-shielded pairs (100% coverage)
- Drain wire for proper shield termination
- Industrial-rated outer jacket

For full Belden 8723 specifications, refer to the manufacturer datasheet.

CAUTION: Use of alternative cable types may result in degraded communication performance in electrically noisy environments. Ground the cable shield at **one end only** (typically the control panel or PLC end) to minimise ground loop currents.

3.3 Configuration

Prerequisites:

- Turtle Tough Sensor Management Software (Windows 10/11 only)
- Turtle Tough PC Interface — single-port TT-DSS-PC-1CH-USB or 4-port TT-DSS-PC-4CH-ISO-DLUX; USB-powered, provides power and communication for configuration (Windows 10/11 only)
- Integration Module programming cable (tinned-lead to male quick-connect) — included with each Module; requires the PC Interface (sold separately)

Hardware setup for configuration:

11. Connect the PC Interface to your PC via USB.
12. Attach the panel-mount female quick-connect to the male 4-pin connector on the Module.
13. Wire as per Table 3-5.
14. Feed the cable through the gland to maintain the seal.
15. Power up the system via the connection to the PC Interface.

Terminal	Lead colour
V+	Red
D−	Green
D+	White

Terminal	Lead colour
GND	Black

Table 3-5 — Module configuration wiring (4-pin quick-connect).

Permanent field wiring. On the sensor side the connection is plug-and-play: the sensor's male quick-connect mates directly with the Module's female panel-mount connector (IP67 variant) or sensor input loom (DIN variant), so no field wiring is required. The network and power side uses the same four connections as Table 3-5 — V+ and GND to your 9–36 V DC supply, and D+ / D− to your RS-485 MODBUS network.

Terminal	Connect to
V+ (Red)	Positive of the 9–36 V DC supply
GND (Black)	0 V / ground of the supply
D+ (White)	RS-485 D+ (network / PLC)
D− (Green)	RS-485 D− (network / PLC)

Table 3-5b — Module permanent field wiring (network + power side).

Device detection:

16. When the Sensor Management Software opens, it defaults to the **Sensors** tab.
17. Check the Interface connection in the **Interfaces** tab — it appears as *Windows Interface Device* with a COM port. Ensure the status reads **Connected**.
18. Switch to the **Integrators** tab; the Module appears automatically.

Editing network communication settings:

19. Click **Edit Sensor Details** to unlock the configuration parameters.
20. Set as required: Node Address 1–255 · Baud Rate 9600 / 14400 / 19200 / 38400 / 56000 / 57600 · Parity None/Odd/Even · Stop Bits 1/2.
21. Click **Save Changes** to apply the new settings (allow 2–3 seconds), or **Cancel** to exit without saving. Settings take effect immediately.

3.4 Operation, Indicators & Module Troubleshooting

Installed inline between your MODBUS network and the sensor, the Module acts as a transparent communication bridge, maintaining isolation and recalculating parity automatically.

The Module includes two communication indicators on the PCB:

LED	Colour	Meaning
TX (Transmit)	Green	Flashes when a message is sent from the PLC / network master to the sensor

LED	Colour	Meaning
RX (Receive)	Red	Flashes when a message is sent from the sensor to the PLC / network master

Table 3-6 — Communication indicators.

Under normal operating conditions the TX and RX LEDs flash **together**, indicating successful bidirectional communication. If the TX LED flashes without a corresponding RX flash, check the sensor-side wiring and verify the connected sensor's node address in the Sensor Management Software.

Symptom	Check
Module not detected	Interface COM port
Module listed but no comms	Node address / baud rate
RX/TX LEDs off	Power and wiring
Only TX flashing (no RX)	Sensor node address; sensor-side wiring
Changes not applied	Ensure **Save Changes** was pressed
Erratic comms	Ground loops or electrical noise

Table 3-7 — Module troubleshooting.

Firmware and factory configuration. Integration Modules are factory-programmed and tested. Firmware and serial data are not user-modifiable. Users may change Node Address, Baud Rate, Parity, and Stop Bits only. For service, contact Turtle Tough Technical Support.

Part 4 — Cabling & the Unpowered Junction Box

4.1 Lead & Terminal Colour Assignments

All DSS sensors and factory cables use the following four-conductor assignment (4-position, 22 AWG quick connect):

Pin	Lead colour	Function
1	Black	GND (DC ground)
2	Red	V+ (DC power)
3	White	D+ (MODBUS RS-485)
4	Green	D− (MODBUS RS-485)

Table 4-1 — DSS quick-connect pinout and lead / colour assignments.

All DSS sensors come standard with a **male quick connect**. Keyed quick-connect termination makes improper wiring impossible in the field after proper initial commissioning. All connections are NEMA 6P rated waterproof and corrosion-resistant when interfaced, and sealing caps are provided for all connectors — install them whenever a connector is not in use or a cable is being pulled through conduit.

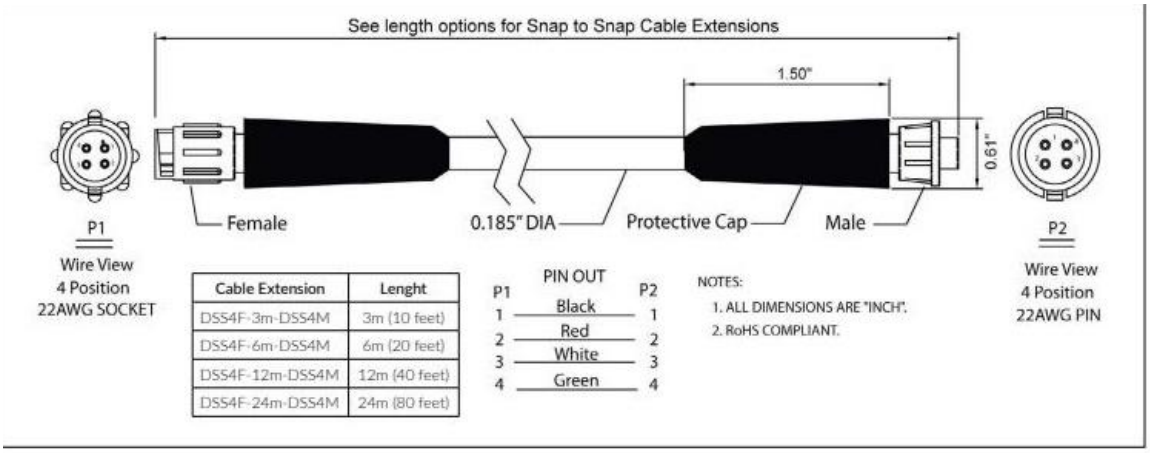


Figure 4-1 — Female-to-male quick-connect extension cable with wire views (P1 4-position 22 AWG socket, P2 4-position 22 AWG pin) and pinout: 1 Black, 2 Red, 3 White, 4 Green.

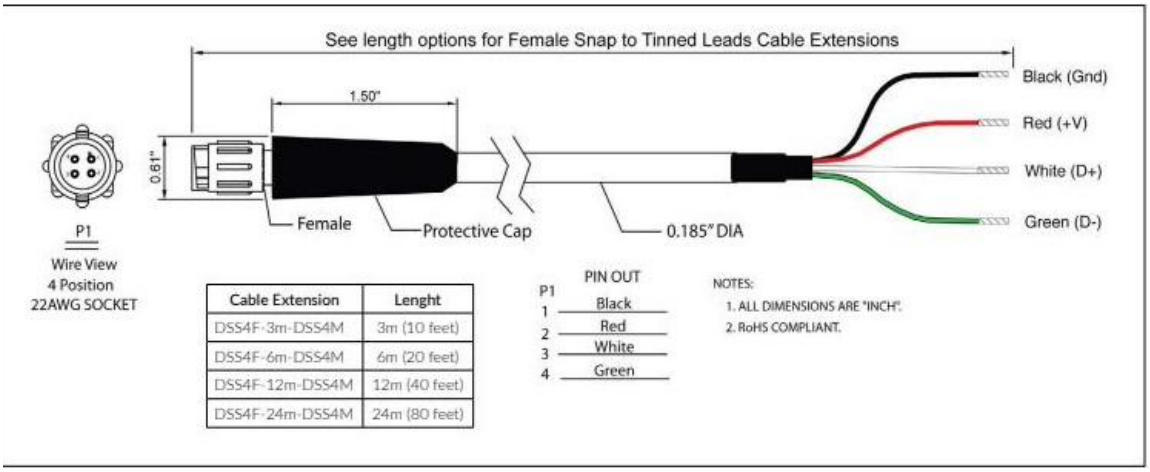


Figure 4-2 — Female quick-connect to tinned-leads extension cable with wire view and colour-coded leads: Black (GND), Red (+V), White (D+), Green (D−).

4.2 Cable Lengths & Extension Options

Integral sensor cable. The standard integral cable length is **6 metres (20 feet)**. Shorter 3 metres (10 feet) or 1.5 metres (5 feet) integral lengths are available at the same price — specify **-DSS-1.5m** or **-DSS-3.0m**. A 12 metres (40 feet) integral cable is available as a special order (**-DSS-12m**).

Integral cable length	Order option	Availability
1.5 m (5 ft)	-DSS-1.5m	Standard
3 m (10 ft)	-DSS-3.0m	Standard

Integral cable length	Order option	Availability
6 m (20 ft)	-DSS (default)	Standard
12 m (40 ft)	-DSS-12m	Special order

Table 4-2 — Integral sensor cable options.

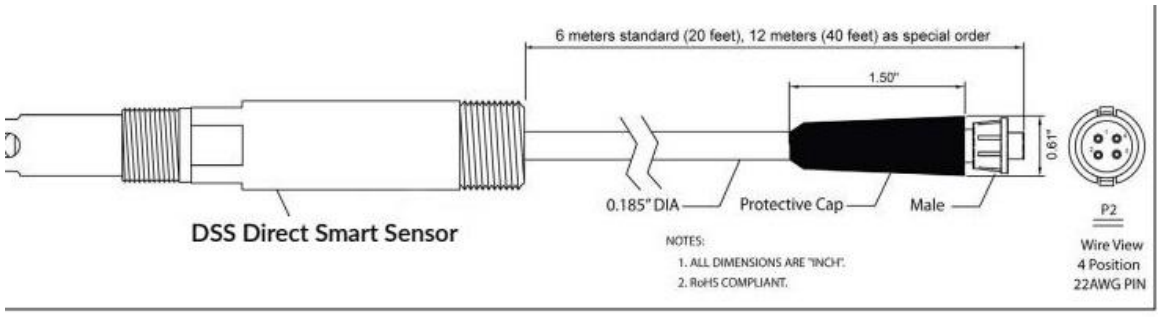


Figure 4-3 — Standard DSS sensor integral cable terminated with male quick connect (6 m standard / 12 m special order; protective cap shown).

Extension cables to the Integration Module. Optional cable runs between the sensor (or junction box) and the Module use male-to-male and female-to-male cables in **6 / 12 / 24 / 48 m** lengths (per System Diagram v1.2).

The current codes are **TT-ACC-DSS-QM-QM-XXm** (male-to-male) and **TT-ACC-DSS-QF-QM-XXm** (female-to-male), where XX = 3 / 6 / 12 / 24 / 48 m.

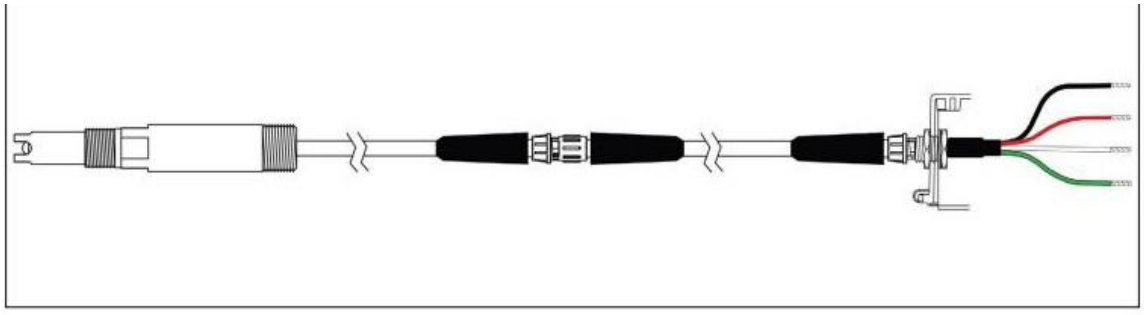


Figure 4-4 — Sensor bridged with a female-to-male quick-connect extension cable to a panel-mount connector. Multiple bridging extensions can be employed as required.

Best practice is to always use the well-stocked standard cable lengths and extension options to ensure the lowest cost and best availability. Longer non-standard lengths can be achieved with special-order options, though this may lead to longer lead times. Any combination of extension cables may be used so long as the total maximum cable length permissible for the sensor type and supply is not exceeded (contact the factory for assistance with long runs).

4.3 The Unpowered Junction Box (Optional, 1 Sensor : 1 Box)

A junction box is an **optional, unpowered** accessory used in a strict **1 sensor : 1 junction box** relationship. Its sole purpose is to **extend the cable run** toward your equipment.

NOTE: Junction boxes provide **no power and no isolation**. If you need power or isolation — you do — use the Integration Module (Part 3).

The junction box is designed for **plug-and-play** connectivity via quick-connects: you should not need to wire anything. This is the default and recommended way to use it.

Figure 4-5 — Current junction box. The junction boxes use the same enclosure as the Integration Module (Part 3, Figure 3-1). Connection is plug-and-play: the sensor's male quick connect mates with the box's panel-mount female quick connect.

Variant	Part code	Terminations	Notes
Standard — plug-and-play	TT-ACC-DSS-JB-2FQP-1CH	1× Sensor Input female plug, 1× Output female plug (quick connect only — no tinned leads)	Single channel junction box with Quick Connect Plugs (only). Requires a **QM-to-QM extension lead** (**TT-ACC-DSS-QM-QM-XXm**, XX = 3 / 6 / 12 / 24 / 48 m) for plug-and-play connectivity to the next component (e.g. the Integration Module).
Optional — wire your own terminal	TT-ACC-DSS-JB-FQP-TL	1× 4-pin quick connect sensor input; output tinned leads	Single Port DSS/PD Junction Box Assembly for all DSS/PD Smart Sensors. Sensor input only. Choose only if you want to wire your own terminal. **The output lead is not included and is**

Variant	Part code	Terminations	Notes
			customer-supplied.

Table 4-3 — Current junction box variants.

NOTE: In older catalogue text the junction box output is described as an "Analyser Output". For direct integration, that output goes to **your own MODBUS RTU device** via the Integration Module.

4.4 General Installation Notes

- **Separation:** all Turtle Tough sensors must be installed a minimum of **30 cm apart** to avoid interference. Some sensors have active components that can create interference to surrounding devices.
- **Shield grounding:** ground cable shields at **one end only** (§3.2).
- **Hot-swap:** sensors can be connected and disconnected at will without powering down the network. Note that a timeout error may occur on the PLC while a sensor is removed for servicing — implement a hold function to allow for cleaning and recalibration (see §6.3).
- **Remote operation:** long cable runs plus the MODBUS command set allow all calibration and configuration functions, and extensive diagnostics, to be performed remotely (Part 5, Part 6).

Part 5 — PLC / MODBUS Data Access

NOTE: This Part applies to **ALL installations**, including those using the Integration Module — the Module is a transparent bridge, so your PLC reads the same registers either way.

5.1 Integration Levels 1–3

There are three data-access levels for interfacing DSS MODBUS RTU sensor slaves with your PLC. Each level requires progressively more implementation work and accordingly directly accesses more capabilities.

Level	Scope	PLC function codes	Tasks remaining on HFC / Windows software
Integration Level 1	Core process values only	FC 04	Analytics, diagnostics and all calibrations
Integration Level 2	All read-only values — process values plus analytics, diagnostics and calibration data (read for information, not modified)	FC 04 + FC 03	Writing parameters and performing calibrations
Integration Level 3	Full read/write — all tasks from the PLC	FC 04 + FC 03 + FC 16	Only setting node address & baud rate (always via HFC / Windows software,

Level	Scope	PLC function codes	Tasks remaining on HFC / Windows software
			§2.1)

Table 5-1 — Integration Levels.

Call syntax throughout: <node> <function code> <starting index> <#values>. Values can be called starting at any index and any number of values can be requested so long as it does not exceed the total available from the starting index. Values are sent in succession from the starting index; if only one value is requested, just the starting index is sent.

5.2 Level 1 — Process Values: Read Input Registers (FC 04)

Access to READ core process values is gained through MODBUS function code **(04) READ INPUT REGISTERS**. Four values are available for most sensor types (six for DO and Conductivity).

#	Name	Range	Engineered values	Register	Index
1	Measurement pH	0..18,000	−2.000 to +16.000	30001	0
1	Measurement Standard Range ORP (mV)	0..20,000	−1,000.0 to +1,000.0	30001	0
1	Measurement Wide Range ORP (mV)	0..20,000	−2,000.0 to +2,000.0	30001	0
1	Measurement Dissolved Oxygen (DO) — ppm	0..15,000	0.00 to 150.00	30001	0
1	Measurement Ion Selective in pION units	0..18,000	−2.000 to +16.000	30001	0
1	Measurement Temp-Compensated Conductivity (EC)	0..50,000	See Table 5-3/5-4 for range & scaling	30001	0
2	Measurement °C	0..2,500	−40.0 to +210.0 °C	30002	1
3	Measurement raw mV for pH & Std ORP & ISE	5,000..45,000 *	−1,000.0 to +1,000.0	30003	2

#	Name	Range	Engineered values	Register	Index
3	Measurement raw mV for Wide Range ORP	5,000..45,000 *	−2,000.0 to +2,000.0	30003	2
3	Measurement raw mV for Dissolved Oxygen	0..25,000	+0.00 to +250.00	30003	2
3	Measurement raw Conductivity	0..50,000	See Table 5-3/5-4	30003	2
4	Measurement raw °C	0..2,500 **	−40.0 to +210.0 °C	30004	3
5	Measurement DO — % saturation with salinity	0..15,000	0.0 to 1,500.0 %	30005	4
5	Measurement computed salinity (Conductivity Sensor Type 6, Std/High)	0..50,000	0.000 to 50.000 PSU	30005	4
5	Measurement computed resistivity, linear temp comp (Conductivity Sensor Type 7, Ultralow)	0..50,000	0.000 to 50.000 MΩ	30005	4
6	Measurement DO — % saturation w/o salinity	0..15,000	0.0 to 1,500.0 %	30006	5
6	Measurement computed TDS NaCl, 442 or KCl (Conductivity Sensor Type 6, Std/High)	0..50,000	0 to 100,000 ppm	30006	5
6	Measurement computed resistivity, non-linear ultrapure water (UPW) temp comp	0..50,000	0.000 to 50.000 MΩ	30006	5

#	Name	Range	Engineered values	Register	Index
	(Conductivity Sensor Type 7, Ultralow)				

Table 5-2 — Process values, MODBUS Read Input Registers FC (04).

* When raw mV is below the engineered value limit, the integer **4,999** is sent for this index; above the limit, **45,001** is sent.

** When raw °C is above the engineered value limit, the integer **2,501** is sent for this index.

Scaling per sensor type:

- **DSS-pH (default node 1).** Value 1: calibrated, temperature-compensated pH, −2.000 to +16.000 sent as 0 to 18,000 (unsigned integer), resolution 0.001 pH. Value 3: absolute raw mV, −1,000.0 to +1,000.0 mV sent as 25,000 ± 20,000, resolution 0.05 mV. *pH values should be rounded from three decimal places (0.001 pH) down to two (0.01 pH) so that only significant figures are shown/recorded.*
- **DSS-ORP Standard Range (default node 2).** Value 1: calibrated standard ORP, −1,000.0 to +1,000.0 mV sent as 0 to 20,000, resolution 0.1 mV. Value 3: raw mV, −1,000.0 to +1,000.0 sent as 25,000 ± 20,000, resolution 0.05 mV.
- **DSS-ORP Wide Range (default node 3).** Value 1: calibrated wide-range ORP, −2,000.0 to +2,000.0 mV sent as 0 to 20,000, resolution 0.2 mV. Value 3: raw mV, −2,000.0 to +2,000.0 sent as 25,000 ± 20,000, resolution 0.1 mV. *ORP values should be rounded from 0.1/0.2 mV resolution down to whole mV so only significant figures are shown/recorded.*
- **DSS-DO (default node 4).** Value 1: calibrated, temperature-compensated DO, 0.00 to 150.00 ppm sent as 0 to 15,000, resolution 0.01 ppm. Value 3: raw mV, 0.00 to 250.00 sent as 0 to 25,000, resolution 0.01 mV. Value 5: % saturation DO with temperature, mmHg and salinity corrections (computed). Value 6: % saturation DO with temperature and mmHg corrections only (computed). Both 0.0 to 1,500.0 % sent as 0 to 15,000, resolution 0.1%.
- **DSS-ISE (default node 5).** Value 1: calibrated, temperature-compensated pION, −2.000 to +16.000 sent as 0 to 18,000, resolution 0.001 pION. Value 3: raw mV, −1,000.0 to +1,000.0 sent as 25,000 ± 20,000, resolution 0.05 mV. *See Appendix B to convert scientific pION units to common ppm units. Resolution is always 0.001 pION; converted ppm resolution varies with concentration and ion.*
- **DSS-CON(-L) (default node 6).** Value 1: calibrated, temperature-compensated conductivity; Value 3: absolute raw conductivity — range and resolution vary with cell constant and range mode (Tables 5-3/5-4). Values 5 & 6 (Type 6 Std/High): computed salinity 0.000–50.000 PSU sent as 0–50,000, and computed TDS 0–100,000 ppm sent as 0–50,000. Values 5 & 6 (Type 7 Ultralow): computed resistivity with linear ATC and with UPW ATC, 0.000–50.000 MΩ sent as 0–50,000. *The type of TDS ppm unit computed is defined by user register 40020; its default is defined by system register 40051.*
- **All types.** Value 2: calibrated temperature; Value 4: absolute raw temperature — −40.0 to +210.0 °C sent as 0 to 2,500, resolution 0.1 °C.

NOTE (sensor types 1, 2, 3 & 5): if index 4 or 5 (registers 30005 & 30006) is called, a dummy

value of 0 is returned. See Appendix C for Modbus Poll worked screens.

Conductivity cell & range tables

DSS-CON-ISO — Standard/High hardware. Range mode is defined by register 40018: **200 = standard mode, 2,000 = high mode**; the range mode can be modified in use by changing register 40018. The nominal cell constant is the integer from register 40019 divided by 100. Resolution is always 50,000 steps regardless of cell constant or range mode.

Standard range mode — µS/cm, range scaling factor 200:

Nominal cell	Max raw input limit	Resolution	Lowest recommended measurement at 25 °C	Max TC cond. @25 °C	@75 °C	@125 °C
1	200	0.004	2	200	100	66.67
2	400	0.008	4	400	200	133.33
5	1,000	0.02	10	1,000	500	333.33
10	2,000	0.04	20	2,000	1,000	666.67
20	4,000	0.08	40	4,000	2,000	1,333.33
50	10,000	0.2	100	10,000	5,000	3,333.33
100	20,000	0.4	200	20,000	10,000	6,666.67
200	40,000	0.8	400	40,000	20,000	13,333.33
300	60,000	1.2	600	60,000	30,000	20,000.00
500	100,000	2	1,000	100,000	50,000	33,333.33
1000	200,000	4	2,000	200,000	100,000	66,666.67
2000	400,000	8	4,000	400,000	200,000	133,333.33

High range mode — µS/cm, range scaling factor 2,000 (max temp-compensated conductivity using 2%/°C coefficient, columns at 25–75 °C, 125 °C, 175 °C):

Nominal cell	Max raw input limit	Resolution	Lowest recommended measurement at 25 °C	Max TC cond. @25–75 °C	@125 °C	@175 °C
1	2,000	0.04	20	1,000	666.67	500

Nominal cell	Max raw input limit	Resolution	Lowest recommended measurement at 25 °C	Max TC cond. @25–75 °C	@125 °C	@175 °C
2	4,000	0.08	40	2,000	1,333.33	1,000
5	10,000	0.2	100	5,000	3,333.33	2,500
10	20,000	0.4	200	10,000	6,666.67	5,000
20	40,000	0.8	400	20,000	13,333.33	10,000
50	100,000	2	1,000	50,000	33,333.33	25,000
100	200,000	4	2,000	100,000	66,666.67	50,000
200	400,000	8	4,000	200,000	133,333.33	100,000
300	600,000	12	6,000	300,000	200,000.00	150,000
500	1,000,000	20	10,000	500,000	333,333.33	250,000
1000	2,000,000	40	20,000	1,000,000	666,666.67	500,000
2000	4,000,000	80	40,000	2,000,000	1,333,333.33	1,000,000

Table 5-3 — DSS-CON-ISO sensor cell & range table, Standard/High hardware.

DSS-CON-ISO-L — Ultralow hardware. Range mode defined by register 40018: **2 = ultralow** (read-only for this sensor type).

Ultralow range mode — µS/cm, range scaling factor 2:

Nominal cell	Max raw input limit	Resolution	Lowest recommended measurement at 25 °C	Max TC cond. @25 °C	@75 °C	@125 °C
1	2	0.00004	0.02	2	1	0.667
2	4	0.00008	0.04	4	2	1.333
5	10	0.0002	0.1	10	5	3.333
10	20	0.0004	0.2	20	10	6.667
20	40	0.0008	0.4	40	20	13.333
50	100	0.002	1.0	100	50	33.333
100	200	0.004	2.0	200	100	66.667

Nominal cell	Max raw input limit	Resolution	Lowest recommended measurement at 25 °C	Max TC cond. @25 °C	@75 °C	@125 °C
200	400	0.008	4.0	400	200	133.33
300	600	0.012	6.0	600	300	200
500	1,000	0.02	10.0	1,000	500	333.33
1000	2,000	0.04	20.0	2,000	1,000	666.667
2000	4,000	0.08	40.0	4,000	2,000	1,333.33

Table 5-4 — DSS-CON-ISO-L sensor cell & range table, Ultralow hardware.

Conductivity unit conversion. If the sensor will only ever use one cell constant and range mode, simple scaling of 0–50,000 steps to the conductivity range is possible. The procedure below supports any cell constant in any range mode without changing the programming of the MODBUS RTU master:

- Converting registers 30001 & 30003 into µS/cm:

µS/cm = ((REG30001 × REG40019) × REG40018) / 50,000

(use register 30003 in place of 30001 for calibrated raw conductivity)

- Converting µS/cm into native 0–50,000 step resolution units (needed for autocalibration calls; sent to register 40011 — standard/ultralow slope — or register 40012 — high/low slope):

native units = (µS/cm × 50,000) / (REG40019 × REG40018)

5.3 Level 2 — Read-Only Holding Registers (FC 03)

Access to user parameters, statistics and system parameters is gained through **MODBUS READ HOLDING REGISTERS, function code (03)**.

User parameters — up to twenty (20) values:

#	Name	Range	Engineered units and values	Register	Index
1	Offset for pH measurement (A.P.)	0..5,000	0 = −250.0 mV and 5,000 = +250.0 mV	40001	0 **
1	Offset for Standard ORP measurement	0..5,000	0 = +250.0 mV and 5,000 = −250.0 mV	40001	0 **
1	Offset for Wide ORP	0..10,000	0 = +500.0 mV and 10,000 =	40001	0 **

#	Name	Range	Engineered units and values	Register	Index
	measurement		−500.0 mV		
1	Offset for ISE (mV @ ISO-Concentration)	0..20,000	0 = −1,000.00 & 20,000 = +1,000.00 mV	40001	0 **
1	Offset for Conductivity (Zero Dry in Air)	0..1,000	0.00 to 2.00% native resolution units	40001	0 **
2	Slope low pH measurement	600..1,800	600 = 30.0 mV and 1,800 = 90.0 mV	40002	1 *
2	Slope for Dissolved Oxygen measurement	70..600	70 = 0.70 mV and 600 = 6.00 mV	40002	1 *
2	Slope for Ion Selective measurement	200..2,000	200 = 10.00 mV & 2,000 = 100.00 mV	40002	1 *
2	Slope Conductivity Standard Range Mode	300..1,700	300 = 0.300 & 1,700 = 1.700	40002	1 *
3	Slope high pH measurement	600..1,800	600 = 30.0 mV and 1,800 = 90.0 mV	40003	2 ***
3	Slope Conductivity High Range Mode	300..1,700	300 = 0.300 & 1,700 = 1.700	40003	2 ***
4	Offset °C measurement	0..500	0 = −25.0 °C and 500 = +25.0 °C	40004	3
5	Step change for pH, ORP, Wide ORP, ISE (mV) & Conductivity (% change)	0..5	0=0.05, 1=0.10, 2=0.20, 3=0.50, 4=1.0, 5=2.0 (mV / % change)	40005	4
5	Salinity for Dissolved Oxygen	0..500	0 = 0.00 and 500 = 50.0 PSU	40005	4

#	Name	Range	Engineered units and values	Register	Index
6	Temp Comp Coefficient pH/ISE/Cond (EC)	0..999	µV for pH/ISE | (%/°C)×100 for EC	40006	5 *
6	Air Pressure for Dissolved Oxygen	600..900	600 = 600 and 900 = 900 mmHg	40006	5
7	Dampener	0..9	0=1, 1=2, 2=3, 3=4, 4=5, 5=8, 6=10, 7=15, 8=20, 9=30 seconds	40007	6
8	Output delay	0..9	0=1, 1=2, 2=3, 3=4, 4=5, 5=8, 6=10, 7=15, 8=20, 9=30 seconds	40008	7
9	Modbus baud rate	0..1	0 = 9,600 and 1 = 19,200 baud	40009	8
10	Reference auto calibration pH offset	0..1,800	0 = −2.00 pH and 1,800 = +16.00 pH	40010	9 **
10	Reference auto cal Standard ORP offset	0..2,000	0 = −1,000 and 2,000 = +1,000 mV	40010	9 **
10	Reference auto cal Wide ORP offset	0..4,000	0 = −2,000 and 4,000 = +2,000 mV	40010	9 **
10	Reference auto calibration ISE offset (pION)	0..18,000	0 = −2.000 & 18,000 = +16.000 pION	40010	9 **
11	Reference auto calibration slope low	0..900	0 = −2.00 pH and 900 = +7.00 pH	40011	10 *
11	Reference autocal dissolved oxygen	400..1,800	400 = 4.00 and 1,800 = 18.00 ppm	40011	10 *
11	Reference auto calibration ISE	0..18,000	0 = −2.000 & 18,000 =	40011	10 *

#	Name	Range	Engineered units and values	Register	Index
	slope (pION)		+16.000 pION		
11	Reference autocal Conductivity Slope Std	0..50,000	See Tables 5-3/5-4	40011	10 *
12	Reference auto calibration slope high	900..1,800	900 = +7.00 pH & 1,800 = +16.00 pH	40012	11 ***
12	Reference autocal Conductivity Slope High	0..50,000	See Tables 5-3/5-4	40012	11 ***
13	Reference auto calibration °C offset	0..2,500	0 = −40.0 °C and 2,500 = +210.0 °C	40013	12
14	Hours since mV offset adjustment	0..65,535	Units are Hours (Max 2,730 days)	40014	13
15	Hours since slope low pH/DO adjustment	0..65,535	Units are Hours (Max 2,730 days)	40015	14 *
16	Hours since slope high adjustment	0..65,535	Units are Hours (Max 2,730 days)	40016	15 ***
17	Hours since °C offset adjustment	0..65,535	Units are Hours (Max 2,730 days)	40017	16
18	Isopotential Concentration (pION)	0..18,000	0 = −2.000 & 18,000 = +16.000	40018	17 *
18	Conductivity Range Mode Selector (ultralow & standard/high hardware)	2 or 200/2,000	2 = Ultralow (read-only) or else 200 = Standard and 2,000 = High	40018	17 *
19	Nominal mV @ Isopotential Concentration	0..20,000	0 = −1,000.00 & 20,000 = +1,000.00 mV	40019	18 *

#	Name	Range	Engineered units and values	Register	Index
19	Nominal Cell Constant for Conductivity	1..2,000	1 = K=0.01/cm & 2,000 = K=20.0/cm	40019	18 *
20	Formula Weight of Ion (grams per mol)	0..65,535	0 = 0.00 & 65,535 = 655.35 g/mol	40020	19 *
20	Selector for TDS ppm unit type	0..2	0 = NaCl, 1 = 442, 2 = KCl	40020	19 *

Table 5-5 — User parameters, FC (03). Footnotes as per Table 5-8.

User statistics — eleven (11) values:

#	Name	Range	Engineered units and values	Register	Index
1	TURTLE TOUGH: manufacture date (Year)	00..99	00 = 2000 and 99 = 2099	40021	20
2	TURTLE TOUGH: manufacture date (Month)	01..12	1 = January … 12 = December	40022	21
3	TURTLE TOUGH: manufacture date (Day)	01..31	Day of month	40023	22
4	Serial Number (year)	00..99	00 = 2000 and 99 = 2099	40024	23
5	Serial Number (month)	01..12	1 = January … 12 = December	40025	24
6	Serial Number (letter)	0..18	0=A, 1=b, 2=C, 3=d, 4=E, 5=F, 6=g, 7=H, 8=i, 9=J, 10=L, 11=n, 12=o, 13=P, 14=r, 15=S, 16=t, 17=U, 18=Y	40026	25

#	Name	Range	Engineered units and values	Register	Index
7	Serial Number (#)	00..99	Unique identifier in alpha block	40027	26
8	Item Number	0..65,535	Unique identifier for sensor configuration and options	40028	27
9	Sensor: Min. temperature in use	0..2,500	0 = −40.0 °C and 2,500 = +210.0 °C	40029	28
10	Sensor: Max temperature in use	0..2,500	0 = −40.0 °C and 2,500 = +210.0 °C	40030	29
11	Sensor: Total hours in use	0..65,535	Units are Hours (raw 0..65,535 = up to 2,730 days max)	40031	30

Table 5-6 — User statistics, FC (03).

NOTE — serial number format: the complete serial number is typically shown as the string of indexes <23>.<24>-<25>.<26> and is heat-shrink sealed near the end of the sensor cable. The serial number reads year.month-letter.number; for example the registers 22 · 08 · 16 (= t) · 35 render as **22.08-t.35**.

System parameters — up to seventeen (17) values:

#	Name	Range	Engineered units and values	Register	Index
1	Type	0..255	1 = pH, 2 = Standard ORP, 3 = Wide ORP, 4 = Dissolved Oxygen, 5 = Ion Selective, 6 = Standard/High Range Conductivity, 7 = Ultralow Range Conductivity	40036	35
2	SW revision	0..255	Check factory for most current rev	40037	36

#	Name	Range	Engineered units and values	Register	Index
			#		
3	Production date (Year)	0..99	00 = 2000 and 99 = 2099	40038	37
4	Production date (Month)	1..12	1 = January … 12 = December	40039	38
5	Production date (Day)	1..31	Day of month	40040	39
6	Factory cal. (mV gain)	1..255	N/A (factory designation only)	40041	40
7	Factory cal. (°C offset)	1..255	N/A (factory designation only)	40042	41
8	Factory cal. (°C gain)	0..255	N/A (factory designation only)	40043	42
9	Factory cal. (mV offset)	1..65,535	N/A (factory designation only)	40044	43
10	TURTLE TOUGH cal for pH and Standard ORP (mV offset)	0..5,000	0 = −250.0 mV and 5,000 = +250.0 mV	40045	44 **
10	TURTLE TOUGH cal for Wide ORP (mV offset)	0..10,000	0 = −500.0 mV and 10,000 = +500.0 mV	40045	44 **
10	TURTLE TOUGH default for Isopotential Voltage	0..20,000	0 = −1,000.00 & 20,000 = +1,000.00 mV	40045	44
11	TURTLE TOUGH cal. (slope low)	600..1,800	600 = 30.0 mV and 1,800 = 90.0 mV	40046	45 *
11	TURTLE TOUGH default slope for ISE	200..2,000	200 = 10.00 mV & 2,000 = 100.00 mV	40046	45
12	TURTLE TOUGH cal. (slope high)	600..1,800	600 = 30.0 mV and 1,800 = 90.0 mV	40047	46 ***

#	Name	Range	Engineered units and values	Register	Index
13	TURTLE TOUGH cal. (°C offset)	0..500	0 = −25.0 °C and 500 = +25.0 °C	40048	47
14	Isopotential Concentration (pION)	0..18,000	0 = −2.000 & 18,000 = +16.000	40049	48
14	Conductivity Range Mode Selector (ultralow & standard/high styles)	2 or 200/2,000	2 = Ultralow or else 200 = Standard and 2,000 = High	40049	48 *
15	Nominal Isopotential Concentration	0..20,000	0 = −1,000.00 & 20,000 = +1,000.00 mV	40050	49
15	Nominal Cell Constant Conductivity	1..2,000	1 = K=0.01/cm & 2,000 = K=20.00/cm	40050	49 *
16	Formula Weight Ion (grams per mol)	0..65,535	0 = 0.00 & 65,535 = 655.35 g/mol	40051	50
16	Selector for TDS ppm unit type	0..2	0 = NaCl, 1 = 442, 2 = KCl	40051	50 *
17	Sign of slope: Cation (+), Anion (−)	0..1	Cation = 0, Anion = 1	40052	51

Table 5-7 — System parameters, FC (03). Footnotes as per Table 5-8.

Mark	Meaning
*	N/A for ORP. Value is sent but is invalid.
**	N/A for Dissolved Oxygen. Value is sent but is invalid. Galvanic DO cell requires no offset calibration.
***	N/A for ORP, Dissolved Oxygen or ISE. Value is sent if requested but has no meaning.
	ONLY valid for Ion Selective type sensors. The isopotential concentration for ISE (register 40018) & formula weight of measured ion (register 40020) are set at the factory & cannot be changed. Calibrated mV at

Mark	Meaning
	isopotential concentration is defined by the sum of the nominal mV default value (register 40019) and the offset mV from calibration (register 40001).
*	ONLY valid for Conductivity type sensors. The effective calibrated cell constant used to compute raw and temperature-compensated conductivity is the product of the scaled nominal cell (register 40019) & the slope gain calibration (register 40002).

Table 5-8 — Footnote key for Tables 5-5, 5-7 and 5-9.

5.4 Level 3 — Writing Parameters (FC 16) & Calibration Commands

Access for all WRITE-type parameters is gained through MODBUS function code **(16) PRESET MULTIPLE REGISTERS**. Values can be written starting at any index and any number of values can be written so long as it does not exceed the total number of parameters available from the starting index of the call. Values are written in succession from the starting index; if only one value is to be written, just the value of the starting index is written.

#	Name	Range	Engineered units and values	Register	Index
1	Offset for pH measurement (A.P.)	0..5,000	0 = −250.0 mV and 5,000 = +250.0 mV	40001	0 **
1	Offset for Standard ORP measurement	0..5,000	0 = +250.0 mV and 5,000 = −250.0 mV	40001	0 **
1	Offset for Wide ORP measurement	0..10,000	0 = +500.0 mV and 10,000 = −500.0 mV	40001	0 **
1	Offset for ISE (mV @ ISO-Concentration)	0..20,000	0 = −1,000.00 & 20,000 = +1,000.00 mV	40001	0 **
1	Offset for Conductivity (Zero Dry in Air)	0..1,000	0.00 to 2.00% native resolution units	40001	0 **
2	Slope low pH measurement	600..1,800	600 = 30.0 mV and 1,800 = 90.0 mV	40002	1 *
2	Slope for Dissolved Oxygen	70..600	70 = 0.70 mV and 600 = 6.00 mV	40002	1 *

#	Name	Range	Engineered units and values	Register	Index
	measurement				
2	Slope for Ion Selective measurement	200..2,000	200 = 10.00 mV & 2,000 = 100.00 mV	40002	1 *
2	Slope Conductivity Standard Range Mode	300..1,700	300 = 0.300 & 1,700 = 1.700	40002	1 *
3	Slope high pH measurement	600..1,800	600 = 30.0 mV and 1,800 = 90.0 mV	40003	2 ***
3	Slope Conductivity High Range Mode	300..1,700	300 = 0.300 & 1,700 = 1.700	40003	2 ***
4	Offset °C measurement	0..500	0 = −25.0 °C and 500 = +25.0 °C	40004	3
5	Step change for pH, ORP, Wide ORP, ISE (mV) and Conductivity (% change)	0..5	0=0.05, 1=0.10, 2=0.20, 3=0.50, 4=1.0, 5=2.0 (mV / % change)	40005	4
5	Salinity for Dissolved Oxygen	0..500	0 = 0.00 and 500 = 50.0 PSU	40005	4
6	Temp Comp Coefficient pH/ISE/Cond (EC)	0..999	µV for pH/ISE | (%/°C)×100 for EC	40006	5 *
6	Air Pressure for Dissolved Oxygen	600..900	600 = 600 and 900 = 900 mmHg	40006	5
7	Dampener	0..9	0=1, 1=2, 2=3, 3=4, 4=5, 5=8, 6=10, 7=15, 8=20, 9=30 seconds	40007	6
8	Output delay	0..9	0=1, 1=2, 2=3, 3=4, 4=5, 5=8, 6=10, 7=15,	40008	7

#	Name	Range	Engineered units and values	Register	Index
			8=20, 9=30 seconds		
10	Reference auto calibration pH offset	0..1,800	0 = −2.00 pH and 1,800 = +16.00 pH	40010	9 **
10	Reference auto cal Standard ORP offset	0..2,000	0 = −1,000 and 2,000 = +1,000 mV	40010	9 **
10	Reference auto cal Wide ORP offset	0..4,000	0 = −2,000 and 4,000 = +2,000 mV	40010	9 **
10	Reference auto calibration ISE offset (pION)	0..18,000	0 = −2.000 & 18,000 = +16.000 pION	40010	9 **
11	Reference auto calibration slope low	0..900	0 = −2.00 pH and 900 = +7.00 pH	40011	10 *
11	Reference autocal Dissolved Oxygen	400..1,800	400 = 4.00 and 1,800 = 18.00 ppm	40011	10 *
11	Reference auto calibration ISE slope (pION)	0..18,000	0 = −2.000 and 18,000 = +16.000 pION	40011	10 *
11	Reference autocal conductivity slope Std	0..50,000	See Tables 5-3/5-4	40011	10 *
12	Reference auto calibration slope high	900..1,800	900 = +7.00 pH & 1,800 = +16.00 pH	40012	11 ***
12	Reference autocal conductivity slope high	0..50,000	See Tables 5-3/5-4	40012	11 ***
13	Reference auto calibration °C offset	0..2,500	0 = −40.0 °C and 2,500 = +210.0 °C	40013	12

#	Name	Range	Engineered units and values	Register	Index
18	Conductivity Range Modes available (standard/high & ultralow hardware)	2 or 200/2,000	2 = Ultralow (read-only) or else 200 = Standard & 2,000 = High (adjustable)	40018	17 *
20	Selector for TDS ppm unit type	0..2	0 = NaCl, 1 = 442, 2 = KCl	40020	19 *

Table 5-9 — Writable parameters, FC (16). Footnotes per Table 5-8.

Calibration commands

Name	Register	Index	Value
Reset calibrations to TURTLE TOUGH settings	40148	147	118
Reset address to type	40148	147	199
Autocalibration Offset for pH, ORP, Ion Selective (ISE) & Conductivity	40198	197	N/A †
Autocalibration Offset °C	40199	198	N/A †
Autocalibration Slope for pH, Dissolved Oxygen, Ion Selective (ISE) & Conductivity	40200	199 *	N/A †

*Table 5-10 — Calibration commands. † Autocalibration is invoked by either writing a value to this register or else just calling the index without sending any value. * N/A for ORP — value is sent but is invalid. Offset autocalibration N/A for Dissolved Oxygen (galvanic DO cell requires no offset calibration).*

IMPORTANT — slope calibration for pH and ISE sensors: before using the "Autocalibration Slope" command for a pH sensor you MUST previously perform an offset calibration.

NOTE — general autocalibration: the index defining the value to which the autocalibration will be performed should always be written BEFORE invoking the command (except for DO sensors, which write their own reference value). The value of the measured parameter will be adjusted to the reference value defined for the autocalibration after the delay to which the dampener is currently set.

Offset autocalibration for ISE sensors. The auto-calibration value must be sent in pION units to register 40010 before invoking the offset calibration command. Calibrated mV at isopotential

concentration is defined by the sum of the nominal mV (register 40019) and the offset mV from calibration (register 40001) default value. If the calibration call exceeds offset limits an error will be returned.

Slope autocalibration for ISE sensors. The mV per pION slope (register 40002) can be from 10.00 to 100.00 mV. The autocalibration value must be sent in pION units to register 40011 before invoking the slope calibration command. If the magnitude of the slope computed from the autocalibration call is outside boundary conditions, or if the sign of the slope is incorrect for the type of ion measured (cation vs anion), an error will be returned.

Creating pION values for DSS-ISE sensors. Appendix B has instructions for converting from common ppm units to the scientific pION units used by the sensor. All reference values for autocalibration on DSS-ISE sensors must be sent in scientific pION units.

5.5 Sensor-Type Calibration Reference

Adjustment limits per sensor type when calibrating from the PLC (FC 16):

Sensor	Adjustment	Limit	Sent as (FC16 index)
DSS-pH	Offset adjust temperature	±25.0 °C from raw value	0 to 2,500 = −40.0 to +210.0 °C (index 12)
DSS-pH	Offset adjust pH (asymmetric potential)	±250 mV from default	0 to 1,800 = −2.00 to +16.00 pH (index 9)
DSS-pH	Adjust acidic slope (used when pH < 7)	30 to 90 mV per pH unit	0 to 1,800 = −2.00 to +16.00 pH (index 10)
DSS-pH	Adjust alkaline slope (used when pH > 7)	30 to 90 mV per pH unit	0 to 1,800 = −2.00 to +16.00 pH (index 11)
DSS-ORP (Std)	Offset adjust temperature	±25.0 °C from raw value	0 to 2,500 = −40.0 to +210.0 °C (index 12)
DSS-ORP (Std)	Offset adjust mV	±250 mV from default	0 to 2,000 = −1,000 to +1,000 mV (index 9)
DSS-ORP (Wide)	Offset adjust temperature	±25.0 °C from raw value	0 to 2,500 = −40.0 to +210.0 °C (index 12)
DSS-ORP (Wide)	Offset adjust mV	±250 mV from default	0 to 4,000 = −2,000 to +2,000 mV (index 9)
DSS-DO	Offset adjust temperature	±25.0 °C from raw value	0 to 2,500 = −40.0 to +210.0 °C (index 12)
DSS-DO	Adjust slope (at 100% saturation)	0.70 to 6.00 mV per DO ppm unit	400 to 1,800 = 4.00 to 18.00 DO ppm (index 10)
DSS-ISE	Offset adjust temperature	±25.0 °C from raw value	0 to 2,500 = −40.0 to +210.0 °C (index 12)

Sensor	Adjustment	Limit	Sent as (FC16 index)
DSS-ISE	Offset adjust pION (isopotential)	±1,000 mV from default	0 to 18,000 = −2.000 to +16.000 pION (index 9)
DSS-ISE	Adjust slope	10.00 to 100.00 mV per pION unit	0 to 18,000 = −2.000 to +16.000 pION (index 10)
DSS-CON	Offset adjust temperature	±25.0 °C from raw value	0 to 2,500 = −40.0 to +210.0 °C (index 12, reg. 40013)
DSS-CON	Offset adjust conductivity (zero dry in air; reference always 0)	0.00 to 2.00% of native resolution units	0–1,000 = 0.00–2.00% (index 9, reg. 40010)
DSS-CON	Adjust slope (gain) for span	0.300 to 1.700 × nominal cell constant	Native 0–50,000 units per §5.2 conversion (index 10 & 11, reg. 40011 & 40012)

Table 5-11 — Calibration adjustment limits per sensor type.

NOTE: the DSS-pH sensor automatically assigns a slope calibration call as acidic or alkaline based on whether the pH value to be adjusted is less than or greater than 7.

5.6 Worked Example — Modbus Poll

Example use of a 3rd-party software: **Modbus Poll v10.5.0** (we recommend using the latest version). Example assumes a pH sensor.

Connecting:

22. Ensure the sensor is connected to your PC via a PC communication tool.
23. Select **Connection > Connect**; the set-up window will pop up.
24. Select the appropriate USB Serial Port from the Serial Settings dropdown menu.
25. After hitting OK your settings are saved and you return to the main window. By default Modbus Poll will try to communicate with Node 1 — you may or may not get an error depending on whether your sensor is node 1.

Reading Input Registers:

26. Right-click the white space and select **Read/write Definition**.
27. Input your sensor node address in the **Slave ID** field.
28. Change Function code to **4**.
29. Change Quantity to **6**. The sensor only has 6 parameters on function code 4 — attempting to poll more results in an error.
30. Hit **OK**; you should now receive live raw measurements.

NOTE: the left column remains blank until edited — double-click a blank cell to label parameters. By default the format is **Signed Integer** and may need changing per parameter (right-click the

parameter cell > Format).

The measurements shown are raw integer values and need converting to engineered values:

#	Name	Integer value	Engineered value	Register	Index
1	Measurement pH	6057	4.057	30001	0
2	Measurement °C	615	21.5	30002	1
3	Measurement raw mV (pH)	28201	160.05	30003	2
4	Measurement raw °C	616	21.6	30004	3

Table 5-12 — Example raw-to-engineered conversion (pH sensor).

NOTE: you must determine the sensor type before assigning engineered values — sensor type is register 40036 (FC 03, index 35). The index values correspond to the numbers in the left-hand column in Modbus Poll.

To scale in Modbus Poll: right-click the parameter cell, select **Scaling**, enter values per the engineered-value tables, and check **Enable**.

See Appendix C for the worked screenshots, including reading holding registers (FC 03) for user parameters, statistics and system parameters.

Part 6 — Calibration & Maintenance

6.1 Calibration Options

Calibration of DSS sensors can be performed three ways:

Method	Tool	Notes
Handheld	Battery-powered HFC	The HFC provides the power to energise the sensor during calibration
PC	PC Interface + Sensor Management Software	Factory-supplied, tested communication path
From the PLC	FC 03/16 per §5.4	Full inline calibration without removing the sensor from service

Table 6-1 — Calibration methods.

If all calibrations are performed with the HFC or the Windows software, then just the simple Read Input Registers call (FC 04) is required at the PLC to receive calibrated and temperature-compensated process values — Integration Level 1.

Inline offset adjustments for the process reading and/or temperature — without removing the sensor from field service — can be performed from the connected PLC with a local or remote HMI (Integration Level 3). If the PLC has remote access via an ethernet or wireless gateway, offset calibration can be made offsite; this is desirable if grab samples are analysed in an offsite lab.

6.2 On-Board Diagnostics

Diagnostic information stored inside the sensor and readable at Integration Level 2 (FC 03):

- Hours since each calibration adjustment (registers 40014–40017)
- Total time in field use, energised (register 40031)
- Minimum and maximum temperature experienced in use (registers 40029–40030)
- Factory-assigned identity: serial number, item number, software revision (registers 40021–40028, 40036–40040)

Adjustable parameters such as the dampener (time-averaging of the process reading, register 40007) and the output delay from boot (register 40008) can be optimised for the installation and application.

6.3 Hot-Swap & Portability

DSS sensors store all calibration information in **non-volatile EEPROM**, allowing full portability and hot-swap capability between installation points so long as the baud rate and node addresses are matched. Sensors can be connected and disconnected at will without powering down.

NOTE: a timeout error may occur on the PLC while a sensor is removed from the network — implement hold functionality to allow servicing, cleaning and recalibration.

Part 7 — Troubleshooting & FAQ

WARNING: The communicator used for calibration and configuration is ONLY for use with genuine Turtle Tough supplied SMART DSS MODBUS sensors. Connecting any other sensor may permanently damage the communicator or sensor. If there is any doubt as to whether you are connecting a genuine Turtle Tough DSS digital sensor and/or mating communicator, please inquire with the Turtle Tough factory for verification.

The SMART DSS MODBUS sensors are designed for seamless, simple plug-and-play operation with the universal handheld communicator for calibration, configuration and diagnostics. The HFC automatically recognises the connected sensor type and loads the appropriate options once the node address is entered. If the node address is not known, use the Sensor Management Software to scan for it. In the unlikely event that an exception occurs, diagnostic error codes are shown on the communicator display — contact the Turtle Tough factory for instructions if they appear.

If no genuine DSS sensor is connected (or the pairing is improper), expect one or more error codes, or no discernible response at all.

General troubleshooting tips:

Step	Action
1	Ensure all quick-connect connections with extension cables are secure and no pins are damaged
2	Check the integrity of PVC insulation on leads and cable jacket for sensor and extension cables
3	Disconnect and reconnect the sensor at the quick-connect; allow ~5–10 seconds before reconnecting
4	Cycle power to the sensor, and swap the extension cable for a known-good unit
5	Connect a known-good genuine DSS sensor to verify the receiving device
6	Isolate the sensor with an HFC or PC Interface — the fastest way to rule sensor performance in or out (§1.2)

Table 7-1 — General troubleshooting sequence. For Integration Module troubleshooting see Table 3-7.

Communication FAQ:

- **No response from sensor:** verify matching baud rate across the network, unique node address, and the 8-bit / even parity / 1 stop bit frame (§2.2).
- **Timeouts on long runs / many nodes:** reduce the polling rate per §2.4.
- **Erratic readings:** check for ground loops and poor earthing (§1.3); confirm shield grounded at one end only; confirm the sensor is powered via the Integration Module.

For further information visit turtletoughsensors.com or contact your distributor.

Part 8 — Warranty, Returns & Support

8.1 Warranty

Product Warranty

Every Turtle Tough product is thoroughly inspected and tested before leaving the factory and prior to shipping. In addition to any statutory rights and remedies you may have, Turtle Tough warrants all its products against defective workmanship and faulty materials for **12 months from the date of purchase** and undertakes, at its option, to repair or replace, free of charge, each product or part thereof on condition that:

- The complete product is returned to Turtle Tough or one of its authorised service agents, in person or freight pre-paid by you, and found, on examination, to be suffering from a manufacturing defect.

- The product or relevant part has not been subject to misuse, neglect, or been involved in an accident.
- The repairs are not required because of normal wear and tear.
- Damage caused by wear and tear, inadequate maintenance, improper installation, corrosion, or by the effects of chemical processes is excluded from this warranty coverage.

Sensor Warranty

Turtle Tough sensors are electrochemical devices and as such have a limited operating life. Life expectancy depends on the field of application such as the medium, pressure and temperature. It can vary between a few weeks to several years. There are special cases in extreme environments where operating life will only be a few days. Characteristic and response time will also change with aging. As such electrochemical sensors are articles of consumption and are not subject to a common guarantee. Replacements or exchanges are generally excluded unless a manufacturing defect is determined to be the cause. It is not possible to predict the rate of deterioration for a particular process, nor can we provide a guarantee on sensor life because it is impossible to predict the rate of exposure, contamination and deterioration. Damage caused by wear and tear, inadequate maintenance, faulty installations, corrosion, or the effects of chemical processes is excluded from this warranty coverage. Our agents or representatives may provide you with a life expectancy guide based on similar applications we have experienced; however, this in no way constitutes a warranty of performance and is a general indicator.

Shelf-Life Warranty

The standard shelf life for a Turtle Tough sensor is **one year from the date of shipment**. Sensors stored longer than this period may still be functional but are no longer under warranty. Sensors should be stored in a cool, dry location with the sensor tip (where the pH/ORP element is located) oriented toward the ground. All pH/ORP/ISE sensors come standard with a conditioning solution in the cap — 50% pH 4 buffer and 50% saturated potassium chloride (mixed by volume). The sensor cap should be kept tightly affixed to the sensor body and sealed with common piping Teflon tape when the sensor is not in use. Sensors returned for a shelf-life warranty claim must have the original sensor cap and conditioning solution intact to be eligible for warranty replacement.

Integration Module Warranty

The Turtle Tough Integration Module is supplied fully tested and covered under the standard Turtle Tough warranty against defects in materials and workmanship. The warranty is void if:

- The module is modified or altered beyond normal installation or wiring access.
- Incorrect wiring, reversed polarity, or over-voltage conditions are applied.
- The module is operated outside of its rated electrical or environmental specifications.
- Unauthorized firmware flashing or electronic component modification is attempted.
- Physical damage occurs due to mishandling, contamination, or improper sealing of the enclosure.

Opening the enclosure to access terminal connections for wiring is permitted and does not void the warranty when performed according to Turtle Tough installation instructions. Turtle Tough accepts no liability for damage to connected equipment caused by incorrect wiring, grounding, or configuration. Installation and operation must follow Turtle Tough documentation and general electrical safety practices.

8.2 Damage to Electronics, Cables & Connectors

Damage to Internal Electronics

Damage to the sensor's internal electronic components is not covered under warranty. Analogue sensors with internal preamplifiers are sensitive to electrostatic discharge. Sensors with preamps are clearly marked and extra care must be taken when handling these sensors as human contact with the electrical connections can discharge static to the preamplifier causing it to blow. This will render the product inoperable. Additionally, sensors containing digital RS-485 boards are susceptible to damage when powered incorrectly or improperly installed. Sensors containing internal electronic boards undergo additional quality checks prior to shipment to ensure that components are 100% operational upon delivery. Ground loop and 3rd party hardware problems (including but not limited to power supplies) may also cause blown electronics or damage to the sensor components and as such faulty installations are not covered by warranty.

IMPORTANT: Ground loops, poor earthing and faulty electrical installations are a common cause of sensor damage. If you are experiencing unusual or erratic readings, please refer to our support document on ground loops.

Damage to Cables and Connectors

Please note that integral sensor cables, connectors and plugs must NOT be cut, removed or modified in any way. Sensors contain sensitive internal electronics, and our cables and connectors are designed to protect the integrity of these components. Any modification or alteration to cables and connectors can compromise their integrity and will void the warranty. Always use factory-approved/manufactured cables and connectors. Additionally, the cable contains a unique identifier laminated to the cable end and this must not be removed, or it will also void the warranty.

8.3 Return Goods

For all return goods the following information must be included in the letter accompanying the returned goods:

- Model Code and Serial Number
- Original Purchase Order and Date
- Length of time in service and description of the process
- Description of the fault and circumstances of the failure
- Process/environmental conditions that may be related to the failure of the sensor
- Statement as to whether warranty or non-warranty service is requested
- Complete shipping and billing instructions for return of material, plus the name and phone number of a contact person that can be reached for further information
- **Clean Statement:** returned goods that have been in contact with process fluids must be decontaminated and disinfected prior to shipment. Goods should carry a certificate to this effect, for the health and safety of our employees. Material Safety Datasheets must be included for all components of the process to which the sensor(s) have been exposed.

All sensor returns are to be accompanied by a completed **Return Material Authorisation Document** clearly stating the reason for the return and with the Clean Statement filled in. See the warranty and returns section under support on our website turtletoughsensors.com for details.

8.4 Contact & Support

Turtle Tough Pty Ltd

Phone: +61 (0)3 9872 5055

Email: info@turtletoughsensors.com

Web: turtletoughsensors.com

For technical support please contact head office or visit our website for information on sensor care, calibration, wiring and installation-related issues.

Appendix A — Direct Sensor-to-PLC Wiring (ADVANCED — NOT RECOMMENDED)

WARNING: Wiring a DSS sensor directly to your PLC without the Integration Module is **actively discouraged**. Too much can go wrong — chiefly poor power quality and inadequate signal isolation — causing unreliable readings and frustration for customer and factory alike. **The Integration Module (Part 3) is the recommended path and is required for full factory support.** Electronics damaged by faulty installations, ground loops or 3rd-party power problems is **not covered by warranty** (§8.2).

If you nonetheless proceed, the requirements below must all be met. MODBUS programming is identical to the Module path — see Part 5; nothing in this appendix changes the register map.

A.1 Requirements

31. A data acquisition or control device with an **isolated RS-485 input dedicated** for use with only the DSS sensors.
32. An **isolated and regulated 9 VDC or 12 VDC power supply dedicated** to energising the DSS sensors.

The DSS sensors can operate normally from **7 VDC to 13 VDC at the sensor board**. The 9 VDC or 12 VDC supply should either be altogether dedicated to this purpose, or a DC/DC converter & isolator employed to completely separate the DC ground connected to the DSS sensors from all other equipment at the site. DC/DC converters typically operate over a wide input range such as 9–36 VDC, allowing flexibility at sites with various non-isolated, non-regulated DC sources.

A.2 Powering Multiple Sensors

An isolated supply may energise more than one DSS sensor: the black ground leads and red +V leads can be bridged into the same terminal on the isolated supply. Two caveats apply:

33. The isolated power supply is dedicated to powering DSS sensors and not connected to any other equipment at site.
34. The total max load of the supply is not exceeded. Contact the factory for the maximum current consumption of each DSS sensor type before sizing a shared supply. Typically as many as up to 50 DSS sensors can be powered from a typical power supply module.

Remote installations can be powered from a single isolated supply using a four-conductor cable carrying D+ & D− MODBUS communications (white, green) plus DC ground and +V (black, red). Voltage drop due to cable resistance should be considered — contact the factory for assistance.

A.3 Cable Runs

- DSS sensors operate to **610 metres (2,000 feet)** with a 9 VDC supply or **1,000 metres (3,280 feet)** with a 12 VDC supply.
- Total distance can be achieved with Turtle Tough NEMA 6P rated quick-connect extension cables and/or a junction box (Part 4). Since all DSS sensors terminate in a male quick connect, at some point in the scheme a **female quick connect to tinned lead** extension cable must be employed to reach your PLC terminals.
- Any combination of female-to-male and female-to-tinned-lead extension cables may be used so long as the total maximum permissible cable length for the supply voltage and sensor type is not exceeded.

Female quick-connect to tinned-lead interface cables (current):

Length	Part code
1.5 m (5 ft)	TT-ACC-DSS-QF-TL-1.5m
3 m (10 ft)	TT-ACC-DSS-QF-TL-3m
6 m (20 ft)	TT-ACC-DSS-QF-TL-6m
12 m (40 ft)	TT-ACC-DSS-QF-TL-12m
24 m (80 ft)	TT-ACC-DSS-QF-TL-24m

Table A-1 — Female quick-connect to tinned-lead interface cables (current TT-ACC-DSS range).

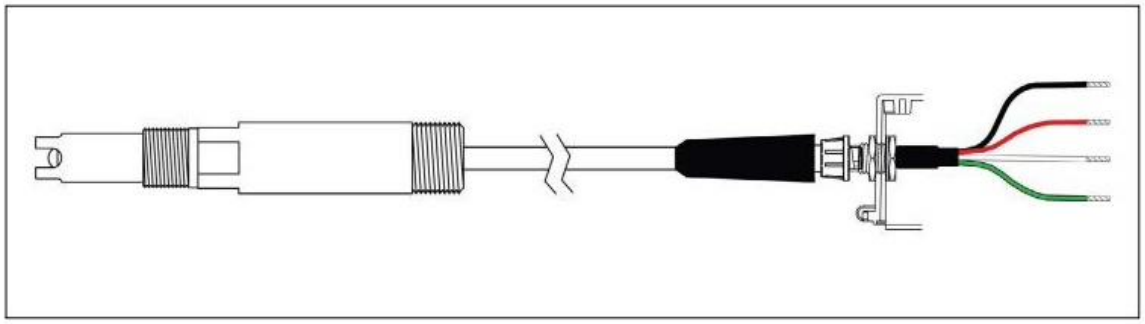


Figure A-2 — Direct-wire scheme: the sensor's integral-cable male quick-connect plugs directly into a panel-mount (bulkhead) connector on the enclosure; the connector's tinned leads (Black GND, Red +V, White D+, Green D−) terminate at the PLC terminals. Shortest run — no extension cable.

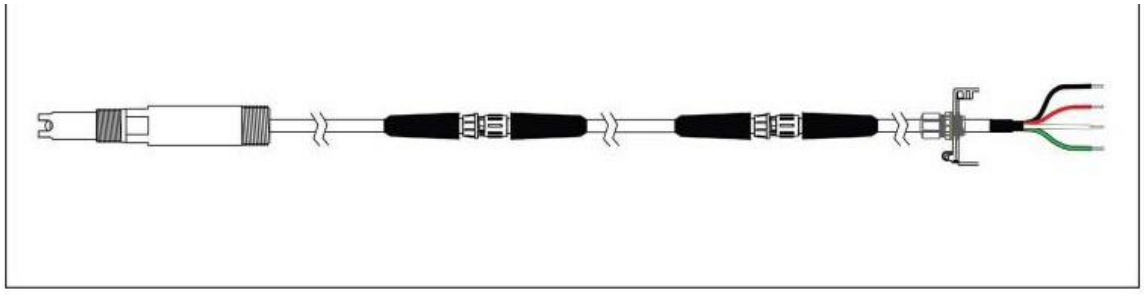


Figure A-3 — Direct-wire scheme with both a female-to-male bridging extension and a female-to-tinned-leads extension for longer runs.

Example total cable lengths — sensor + one female-to-tinned-lead extension:

Integral cable	+1.5 m	+3 m	+6 m	+12 m
1.5 m (5 ft)	3 m (10 ft)	4.5 m (15 ft)	7.5 m (25 ft)	13.5 m (45 ft)*
3 m (10 ft)	4.5 m (15 ft)	6 m (20 ft)	9 m (30 ft)	15 m (50 ft)*
6 m (20 ft)	7.5 m (25 ft)	9 m (30 ft)	12 m (40 ft)	18 m (60 ft)*
12 m (40 ft)*	9 m (30 ft)*	12 m (40 ft)*	18 m (60 ft)*	24 m (80 ft)*

Table A-2 — Totals with a single tinned-lead extension (= includes special-order items).*

Example total cable lengths — sensor + one female-to-male bridge + one female-to-tinned-lead extension:

Integral cable	+4.5 m	+9.0 m	+18 m	+36 m
1.5 m (5 ft)	6 m (20 ft)	10.5 m (35 ft)	19.5 m (65 ft)	37.5 m (125 ft)*
3 m (10 ft)	7.5 m (25 ft)	12 m (40 ft)	21 m (70 ft)	39 m (130 ft)*
6 m (20 ft)	10.5 m (35 ft)	15 m (50 ft)	24 m (80 ft)	42 m (140 ft)*
12 m (40 ft)*	16.5 m (55 ft)*	21 m (70 ft)*	30 m (100 ft)*	48 m (160 ft)*

Table A-3 — Totals with bridge + tinned-lead combination: +4.5 m = 3 m bridge + 1.5 m TL; +9.0 m = 6 m bridge + 3 m TL; +18 m = 12 m bridge + 6 m TL; +36 m = 24 m bridge + 12 m TL (= includes special-order items).*

A.4 Wiring to the PLC

Terminate the tinned leads at your PLC per Table 4-1: Red = V+, Black = GND, White = D+, Green = D−. Secure the cable with a sealing cable gland in the enclosure assembly. Care should be taken when making these connections — improper wiring can damage the DSS sensor.

IMPORTANT: Contact the Turtle Tough factory for proper wiring to your data acquisition, SCADA, PLC or other control device/system BEFORE commissioning an installation with the DSS sensor.

Appendix B — Converting Between pION and ppm Units

The ion selective sensors operate in the linear scientific pION units. If you wish to operate in the common non-linear ppm units, use the instructions below to program your MODBUS RTU master. If you operate in native pION units, no conversion is required.

B.1 Background

The units commonly used for ion measurements are ppm. The ion selective sensor does not have a linear response to ppm; it has a linear response to pION units — the ion-selective corollary of pH, since pH sensors are a special type of ion selective sensor measuring hydrogen ion activity:

- pH = − $\log_{10}$ [Hydrogen Ion Activity in Molarity Units]
- pION = − $\log_{10}$ [Analyte Ion Activity in Molarity Units], so [Analyte Ion Activity in Molarity] = 10^(−pION)

B.2 pION → ppm

To get the floating-point pION from the integer in register 30001: divide by 1,000 and subtract 2.000 (0–18,000 → −2.000 to +16.000). The formula weight of the measured ion is register 40020 divided by 100 (g/mol).

ppm = { 10^(−((REG30001/1,000) − 2.000)) × ((REG40020/100) × 1,000) }

It may be necessary to convert from unsigned integer to floating point when reading registers 30001 and 40020.

Example — Ammonium (NH_4^+), cation, slope always positive. Register 40036 = 5 (ISE, default node 5); register 40020 = 1804 → formula weight 18.04 g/mol:

pNH_4	ppm NH_4^+
6.000	0.018
5.000	0.18
4.000	1.80
3.000	18.04
2.000	180.40
1.000	1,804.00
0.000	18,040.00
−1.000	180,400.00

Table B-1 — pION → ppm, ammonium.

Example — Fluoride (F^-), anion, slope always negative. Register 40020 = 1900 → formula weight 19.00 g/mol:

pF	ppm F^-
6.000	0.019

pF	ppm F^-
5.000	0.19
4.000	1.90
3.000	19.00
2.000	190.00
1.000	1,900.00
0.000	19,000.00
−1.000	190,000.00

Table B-2 — pION → ppm, fluoride.

NOTE — slope sign: since the charge of the measured ion is intrinsic to the ISE sensor type, the permitted sign of the slope is programmed at the factory and cannot be changed in the field. Contact the factory with any questions about your ISE sensor type and its permitted slope sign.

NOTE — significant figures: the significant figures are always just 3, as obtained from the source pION value; the computed ppm may show more digits, but this does not increase the number of significant figures. The same pION value produces different ppm values for different ions (formula-weight dependence), and the sensor's mV response is NOT linear in ppm.

B.3 ppm → pION

Reference values for autocalibration (register 40010 offset, register 40011 slope) must be provided in pION units. To convert from ppm:

[Analyte Ion Activity in Molarity] = ppm / ((REG40020/100) × 1,000)

pION = $-\log_{10}$ [ppm / ((REG40020/100) × 1,000)]

Example — Ammonium (reg. 40020 = 1804 → 18.04 g/mol):

ppm NH_4^+	pNH_4
0.1	5.256
1	4.256
10	3.256
100	2.256
1,000	1.256

ppm NH_4^+	pNH_4
10,000	0.256
100,000	−0.744

Table B-3 — ppm → pION, ammonium.

Example — Fluoride (reg. 40020 = 1900 → 19.00 g/mol):

ppm F^-	pF
0.1	5.279
1	4.279
10	3.279
100	2.279
1,000	1.279
10,000	0.279
100,000	−0.721

Table B-4 — ppm → pION, fluoride.

NOTE: reference values for offset and slope calibration calls must be sent as unsigned integers: multiply the floating-point pION by 1,000 and add 2,000. A pION of 5.256 is sent as 7,256 (to register 40010 for offset or 40011 for slope).

Appendix C — Modbus Poll Worked Screens

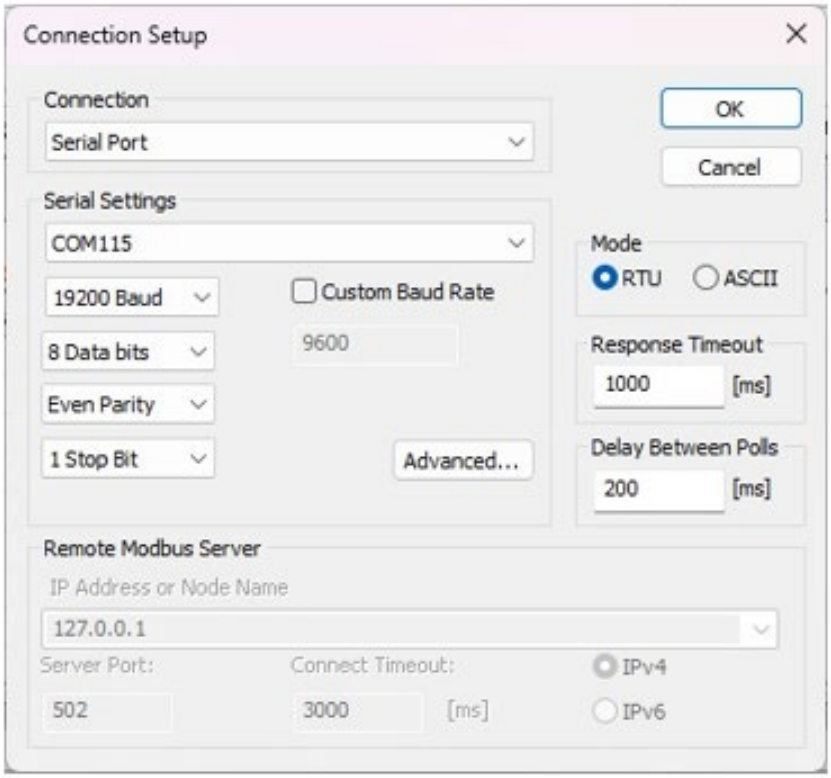


Figure C-1 — Connecting to a sensor: Connection > Connect, serial settings (COM port, 19200 baud, 8 data bits, even parity, 1 stop bit, RTU mode).

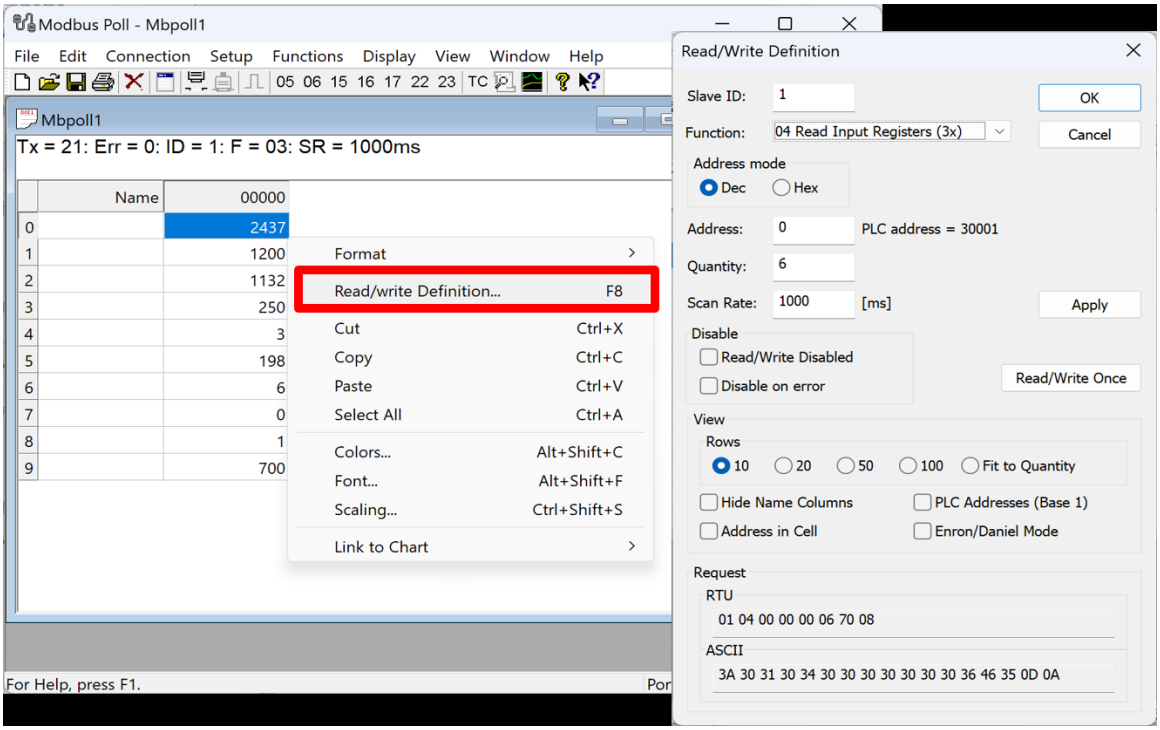


Figure C-2 — Read/Write Definition set to Function 04 (Read Input Registers), with the live polled values returned from the sensor.

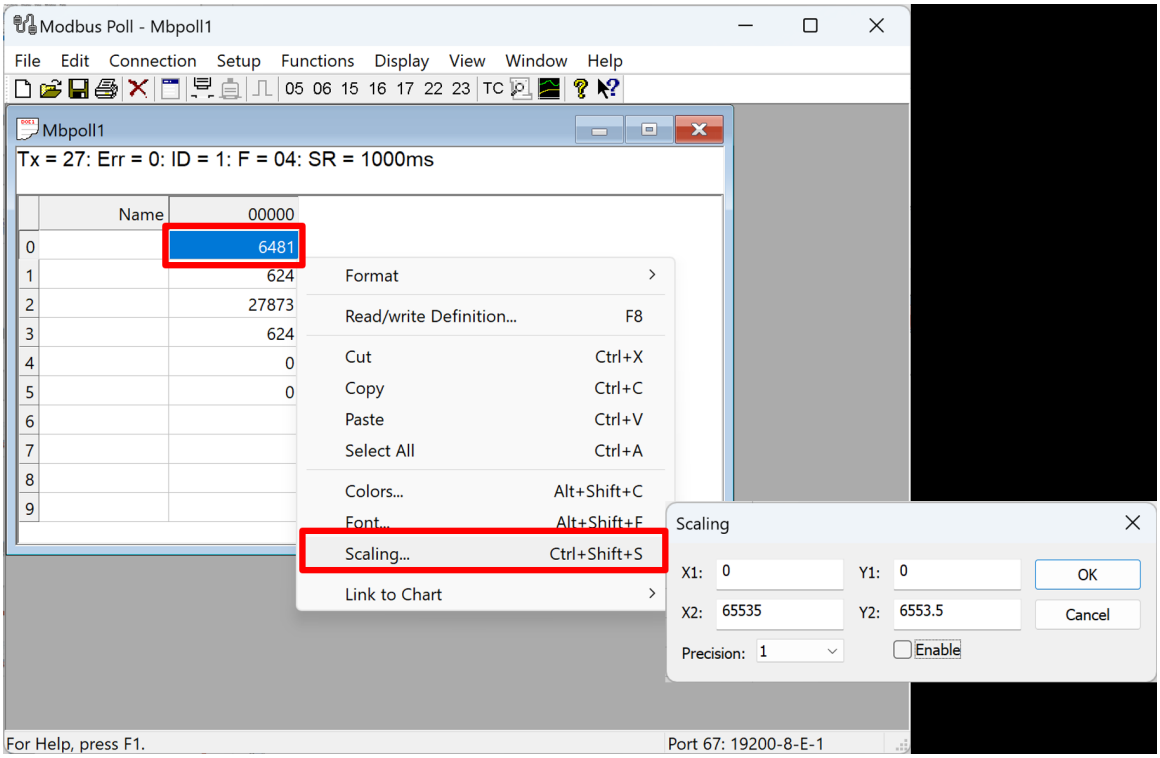


Figure C-3a — Opening the Scaling dialog (right-click a register, or Display > Scaling / Ctrl+Shift+S).

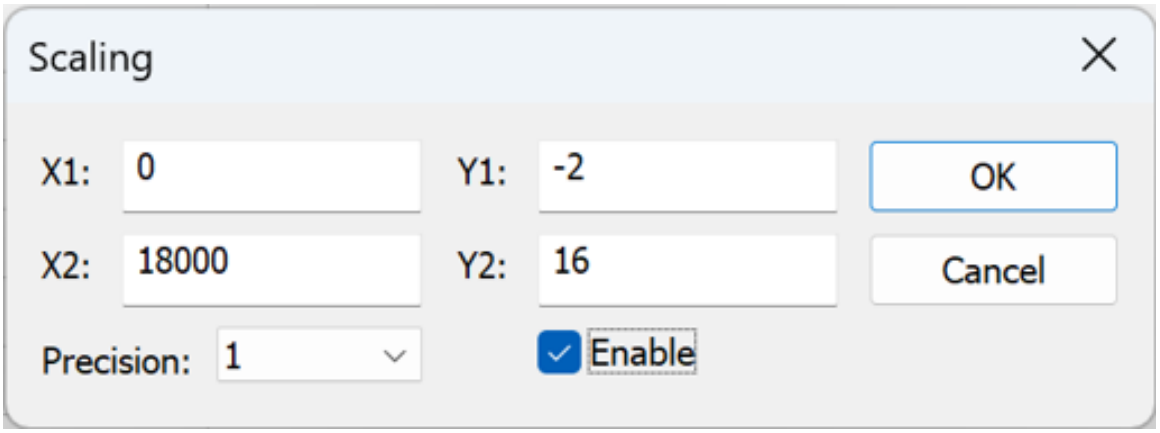


Figure C-3b — pH mapping example: raw 0..18000 scaled to −2..16 pH (precision 1).

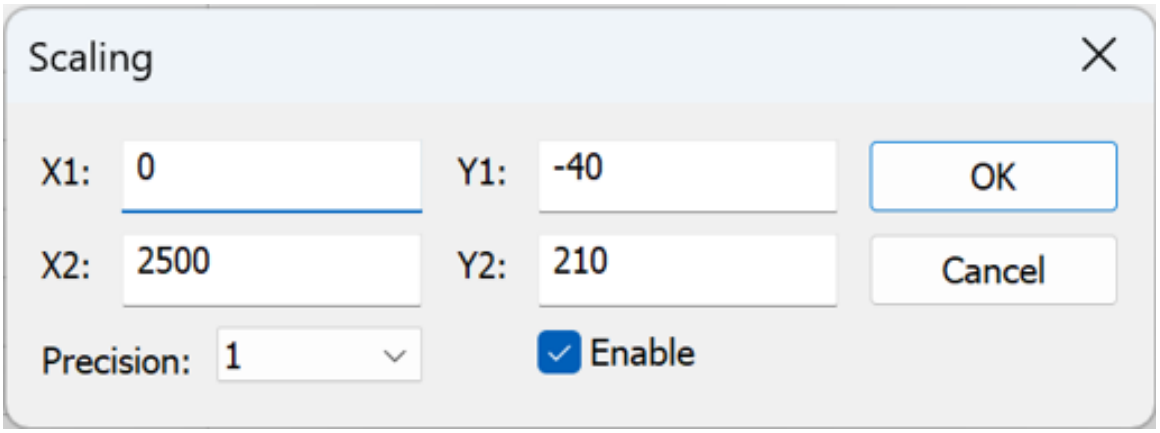


Figure C-3c — Temperature mapping example: raw 0..2500 scaled to −40..210 (°C ×10).

X2 (maximum raw value) and the Y-range differ by sensor type and range — see the Part 5 register tables (for example Table 5-2 / 5-3) for your sensor's scaling values.

Reference — Read Holding Registers (FC 03), pH sensor example, user parameters:

#	Name	Integer value	Engineered value	Register	Index
1	Offset pH/mV measurement	2358	−14.2 mV	40001	0
2	Slope low pH measurement	1196	59.80 mV per pH unit	40002	1
3	Slope high pH measurement	1105	55.25 mV per pH unit	40003	2
4	Offset °C measurement	251	0 = −25.0 °C and 500 = +25.0 °C	40004	3
5	Step change	5	2.0 mV	40005	4
6	Temp coefficient for pH compensation	198	198 µV (microvolts)	40006	5
7	Dampener	6	10 seconds	40007	6
8	Output delay	0	1 second	40008	7
9	Modbus baud rate	1	19,200 baud	40009	8
10	Reference auto calibration pH offset	900	+7.00 pH	40010	9
11	Reference auto calibration slope low	600	+4.00 pH	40011	10
12	Reference auto calibration slope high	1205	+10.05 pH	40012	11
13	Reference auto calibration °C offset	650	+25.0 °C	40013	12
14	Hours since mV offset adjustment	0	0 hours	40014	13
15	Hours since slope low pH	0	0 hours	40015	14

#	Name	Integer value	Engineered value	Register	Index
	adjustment				
16	Hours since slope high adjustment	0	0 hours	40016	15
17	Hours since °C offset adjustment	0	0 hours	40017	16

Table C-1 — FC 03 user parameters worked example (pH).

Reference — Read Holding Registers (FC 03), user statistics example:

#	Name	Integer value	Engineered value	Register	Index
1	TURTLE TOUGH: manufacture date (Year)	22	2022	40021	20
2	TURTLE TOUGH: manufacture date (Month)	9	September	40022	21
3	TURTLE TOUGH: manufacture date (Day)	2	2	40023	22
4	Serial Number (year)	22	2022	40024	23
5	Serial Number (month)	8	August	40025	24
6	Serial Number (letter)	16	T	40026	25
7	Serial Number (#)	35	35	40027	26
8	Item Number	1666	1666	40028	27
9	Sensor: Min. temperature in use	510	−11.1 °C	40029	28
10	Sensor: Max temperature in	838	+126.7 °C	40030	29

#	Name	Integer value	Engineered value	Register	Index
	use				
11	Sensor: Total hours in use	216	216 hours	40031	30

Table C-2 — FC 03 user statistics worked example.

Reference — Read Holding Registers (FC 03), system parameters example:

#	Name	Integer value	Engineered value	Register	Index
1	Type	1	pH	40036	35
2	SW revision	10	10	40037	36
3	Production date (Year)	22	2022	40038	37
4	Production date (Month)	4	April	40039	38
5	Production date (Day)	28	28	40040	39
6	Factory cal. (mV gain)	192	N/A (factory designation only)	40041	40
7	Factory cal. (°C offset)	50	N/A (factory designation only)	40042	41
8	Factory cal. (°C gain)	230	N/A (factory designation only)	40043	42
9	Factory cal. (mV offset)	16171	N/A (factory designation only)	40044	43
10	TURTLE TOUGH cal. (mV offset)	2500	0.0 mV	40045	44
11	TURTLE TOUGH cal. (slope low)	1183	59.15 mV per pH unit	40046	45
12	TURTLE TOUGH cal. (slope high)	1183	59.15 mV per pH unit	40047	46

#	Name	Integer value	Engineered value	Register	Index
13	TURTLE TOUGH cal. (°C offset)	250	0.0 °C	40048	47

Table C-3 — FC 03 system parameters worked example.

Appendix D — Register-Map Quick Reference

This appendix summarises the full MODBUS map by function code and Integration Level. All registers are accessed as described in Part 5; the Integration Module is transparent, so the map is identical whether the sensor is wired via the Module or (Appendix A) direct to the PLC.

Function code	Registers	Contents	Integration Level	Detail
FC 04 — Read Input Registers	30001–30006	Process values (measurement, °C, raw mV / raw conductivity, raw °C, computed values)	1	Table 5-2
FC 03 — Read Holding Registers	40001–40020	User parameters (offsets, slopes, step change, dampener, output delay, baud, autocal references, range mode, TDS unit)	2	Table 5-5
FC 03 — Read Holding Registers	40021–40031	User statistics (manufacture/serial dates, serial & item numbers, min/max temperature, time in use)	2	Table 5-6
FC 03 — Read Holding Registers	40036–40052	System parameters (sensor type, SW revision, production date, factory calibration, isopotential / nominal cell constant, TDS unit, slope sign)	2	Table 5-7
FC 16 — Preset Multiple Registers	40001–40020	Writable parameters — same map as the user parameters above (calibration offsets & slopes, step change, dampener, output delay, autocal references, range mode, TDS unit)	3	Table 5-9
FC 16 — Preset Multiple Registers	40148	Reset commands: reset calibrations to Turtle Tough settings (value 118); reset address to type (value 199)	3	Table 5-10

Function code	Registers	Contents	Integration Level	Detail
FC 16 — Preset Multiple Registers	40198–40200	Calibration commands: autocalibration offset (pH/ORP/ISE/Conductivity), autocalibration offset °C, autocalibration slope (pH/DO/ISE/Conductivity)	3	Table 5-10

Table D-1 — Register-map quick reference by function code and Integration Level.

NOTE: The sensor's node address and baud rate are **not** part of this PLC-writable map — they are set only with the HFC or the PC Interface + Sensor Management Software (§2.1), never over FC 16.

Appendix E — Part-Number & Cable-Code Index

Current Turtle Tough part codes referenced throughout this manual, gathered for ordering convenience.

Sensors (default node address = sensor type code, §2.3)

Sensor	Order code	Default node
pH	DSS-pH	1
ORP — standard range	DSS-ORP	2
ORP — wide range	DSS-ORP (wide range)	3
Dissolved oxygen	DSS-DO	4
Ion selective (ISE)	DSS-ISE	5
Conductivity — standard/high	DSS-CON-ISO	6
Conductivity — ultralow	DSS-CON-ISO-L	7

Table E-1 — Sensor order codes.

Integral sensor cable options (§4.2, Table 4-2)

Length	Order option	Availability
1.5 m (5 ft)	-DSS-1.5m	Standard
3 m (10 ft)	-DSS-3.0m	Standard
6 m (20 ft)	-DSS (default)	Standard

Length	Order option	Availability
12 m (40 ft)	-DSS-12m	Special order

Table E-2 — Integral cable options.

Integration & configuration hardware (Parts 1, 3)

Item	Part code	Notes
Integration Module (isolated MODBUS RTU bridge)	TT-ISO-DSS-DC	Mandatory (Part 3). Orderable as -IP67 (IP67, glands, panel-mount sensor connector) or -DIN (DIN-rail, IP44, sensor loom)
Handheld Field Communicator (HFC)	TT-DSS-HFC	Config tool; supplied with a 1.5 m lead; self-powers the sensor
PC Interface — single port	TT-DSS-PC-1CH-USB	USB-powered comms hub for all DSS sensors (pH/ORP/DO/CON/NTU); Windows 10/11 only
PC Interface — deluxe 4-port	TT-DSS-PC-4CH-ISO-DLUX	USB-powered 4-port hub, deluxe aluminium enclosure; Windows 10/11 only
Sensor Management Software (Windows 10/11)	(software — no part code)	Required with the PC Interface
Integration Module programming cable	Included with Module	Tinned-lead to male quick-connect; ships with each Module; PC Interface required (sold separately)

Table E-3 — Integration and configuration hardware.

Junction boxes — unpowered, 1 sensor : 1 box (§4.3)

Variant	Part code	Notes
Standard — plug-and-play (quick-connect only)	TT-ACC-DSS-JB-2FQP-1CH	1× sensor-input female plug, 1× output female plug; requires a QM-to-QM extension lead
Optional — wire-your-own-terminal	TT-ACC-DSS-JB-FQP-TL	Quick-connect in, tinned leads out; output lead customer-supplied

Table E-4 — Current junction-box variants.

Extension cables — current (System Diagram v1.2, §4.2)

Cable	Part code	Notes
QM-to-QM extension lead (J-box → Module)	TT-ACC-DSS-QM-QM-XXm	XX = 3 / 6 / 12 / 24 / 48 m
Male-to-male extension	TT-ACC-DSS-QM-QM-XXm	XX = 3 / 6 / 12 / 24 / 48 m; to the Integration Module
Female-to-male extension	TT-ACC-DSS-QF-QM-XXm	XX = 3 / 6 / 12 / 24 / 48 m; to the Integration Module
Female-to-tinned-lead interface cable	TT-ACC-DSS-QF-TL-XXm	XX = 1.5 / 3 / 6 / 12 / 24 m
MODBUS output cable (male QC → tinned leads)	TT-ACC-DSS-QM-TL-XXm	XX = 1.5 / 3 / 6 / 12 / 24 / 48 m
Panel-mount female interface plug (20 cm tinned loom)	TT-ACC-DSS-QPF-TL	Panel-mount interface to a terminal strip / MODBUS RTU device input

Table E-5 — Current interface and extension cables.