# ZT-100-C Water Cut Meter — User Manual

User Manual - Zelentech

**Manufacturer:** Zelentech
**Product:** ZT-100-C Digital Water Cut Meter
**Audience:** installers and operators
**Firmware covered:** CAP card `0.16.37-cap-b38` · SIGNAL card `0.17.35-sig-c59`
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# Contents

# About This Manual

This manual covers installation, wiring, commissioning, day-to-day operation and field calibration of the Zelentech ZT-100-C water cut meter, as built with CAP firmware `0.16.37-cap-b38` and SIGNAL firmware `0.17.35-sig-c59`.

## How to read this manual

This manual is ordered by what you are most likely to be doing:

| Part | Use it when |
|---|---|
| **Using the meter** | The meter is installed and you are reading, calibrating or diagnosing it |
| **Installing a new meter** | You are wiring and commissioning a unit |
| **Reference** | You want the HART surface or the full specifications |

- **Installing your first unit?** Start with the separate **Quick Start**, which takes a new meter from unpacking to a live reading in nine steps. Come here for the detail behind any of them.
- **The single most common commissioning failure on this product is RS485 A/B polarity.** If a console is silent or garbled, swap A and B before looking at anything else — see RS485 Connections.
- Every figure in this issue is a **placeholder**. Placeholders name the drawing or photograph that is wanted and, where one exists, point at a usable image in the previous-generation document set.
- Values marked **[TBC]** are *not yet established for this firmware and hardware build*. **Nothing in this manual is estimated or carried over from an earlier product without verification** — where a figure is missing it is marked missing.

## What this manual does not cover

- **The DISPLAY card.** See DISPLAY Card — Not Released.
- Approvals, certification and area classification. These are handled outside this document set.

## Earlier firmware

If you are familiar with the previous ZT-100-C generation, four behaviours have changed and the old habits will mislead you:

| Topic | Previous generation | This firmware |
|---|---|---|
| Loss of measurement data | Output **froze** at the last value | Output drives the **3.6 mA alarm** within about 2.5 s, and recovers by itself |
| Data quality | A number was a number | Every value carries a quality — `good` / `stale` / `overrange` / `underrange` / `fault` — and absence is shown, not hidden |
| RS485 default baud | 9600 | **115200** |
| Capacitance calibration | Fixed-point sequence | Interactive table editor ( `capcal show/add/del/save/load` ) on the CAP card |

# Product Overview

The ZT-100-C measures the water content of crude oil continuously and online. A capacitance probe immersed in the process forms one arm of a measuring bridge; the meter converts the measured probe capacitance, corrected for process and board temperature, into a water cut percentage, and publishes it on a 4-20 mA loop with HART.

## What is inside the enclosure

The ZT-100-C is built around **two cards** that share one enclosure and one internal RS485 bus:

| Card | Firmware | Responsibility |
|---|---|---|
| **CAP** (measurement) | `0.16.37-cap-b38` | Capacitance probe front end, PT100 process temperature, board temperature, the water-cut calculation, and all calibration data. Broadcasts its results once per second on the internal bus. |
| **SIGNAL** (output) | `0.17.35-sig-c59` | 4-20 mA loop output, HART slave, external RS485 operator console. Consumes CAP's broadcasts. Measures nothing itself. |

This split matters in the field:

- **CAP owns the measurement and the calibration.** Anything to do with water cut, capacitance, probe geometry, oil medium or field calibration lives on CAP.
- **SIGNAL owns the outputs.** The 4-20 mA span, the loop trim, HART identity and the operator console live on SIGNAL.
- The two are joined by the **internal RS485 link** inside the enclosure. CAP broadcasts a measurement packet at **1 Hz**.

## The pair contract — read this before commissioning

SIGNAL's 4-20 mA output is driven by measurements that **arrive from CAP over the internal link**. SIGNAL does not measure anything.

If CAP stops reporting — power loss on CAP, a broken internal link, a CAP fault — then:

1. SIGNAL ages every mirrored value to **STALE** after **2500 ms** without a fresh packet.
2. Stale data drives the loop to the **3.6 mA alarm current**, so the loop reaches alarm within about **2.5 seconds** of CAP going quiet.
3. HART raises the "primary variable out of limits" status.
4. **Recovery is automatic.** The next good packet from CAP clears the stale condition and the loop returns to tracking. No operator action, no reboot, no acknowledgement.

The previous firmware held the last current on a dead source. This firmware signals instead of pretending. A control system that was tuned to "the reading never moves, so the meter is fine" will need its alarm handling reviewed: **3.6 mA now means something and must not be ignored**.

## Honest data

Every value the meter publishes carries a **quality** alongside it:

| Quality | Meaning |
|---|---|
| `good` | Fresh and valid |
| `stale` | The source is alive but this data is old |

| Quality | Meaning |
|---|---|
| `overrange` | Above the measurable or configured range |
| `underrange` | Below the measurable range |
| `fault` | The source has faulted |
| `init` | Never written since power-up |

Qualities are visible on the console (`meas read`, `cap`), in the HART status bytes, and in the behaviour of the 4-20 mA output. A faulted or missing sensor is *surfaced*; a stale number is never presented as a live one.

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# Safety

**Read before opening the enclosure or handling the probe.**

## Electrical

- The ZT-100-C is supplied from a **24 VDC** source on terminals 9 (+) and 8 (−). Isolate the supply before working in the connection compartment.
- The 4-20 mA loop may remain energised from the control system after the meter's own supply is removed. Isolate the loop as well.
- Do not apply mains voltage to any terminal.
- Feed the meter from a regulated, fused **24 VDC** supply rated for at least **125 mA**, and follow your site's standard practice for low-voltage DC instrumentation.

## Process

- The probe is in direct contact with the process fluid. **Depressurise and isolate the process line before removing the probe.**
- Process piping and the probe may be hot. Allow to cool or use appropriate protection.
- Drain and vent according to your site procedure before breaking any process connection.

## Mechanical and handling

- The IME 9080 enclosure has a **separate connection compartment**. Field wiring lands there; the conductors are potted through into the electronics compartment. **Do not attempt to pull the field harness through the potting** — it is not a serviceable joint.
- Close and secure the enclosure covers after work. Do not leave the electronics compartment open in a wet or dusty environment.

## Data safety

- After a calibration commit, **wait for the record to be written to flash before removing power** (see Field Calibration). A calibration commit queues the write; power loss before it drains leaves the *previous* calibration in place. Nothing is corrupted, but your new calibration is lost.

# Consoles and Access

## Where the consoles are

| Console | Card | How to reach it | Notes |
|---|---|---|---|
| **External RS485** | SIGNAL | Terminals 7 (A) / 6 (B), 115200 8N1 | **This is the field console** |
| USB | SIGNAL | USB connector on the SIGNAL card | Factory setup |
| USB | CAP | USB connector on the CAP card | CAP's **only** local console — CAP has no RS485 console |

**In the field, use the external RS485 console** on terminals 7 (A) and 7 (B) in the connection compartment. The USB connectors are on the cards themselves, inside the electronics compartment, and are intended for factory and service access rather than routine field use.

## Reaching CAP from the field

CAP has no console of its own on the field terminals. Everything on CAP is reached **through SIGNAL**, by prefixing the command with `cap`:

```
cap meas read          # CAP's measurements
cap fcal show          # CAP's field calibration
cap probe show         # CAP's probe geometry
cap                    # (no arguments) link health + the values SIGNAL holds
```

Typed on the SIGNAL console, `cap <command>` forwards the command line to CAP over the internal link and prints CAP's answer. Up to five words may be passed. Replies are size-limited, and streaming commands do not stream through the proxy.

`cap` with **no arguments** is the fastest health check on the whole instrument — it shows the peer count, whether CAP's data is fresh or stale, how many broadcasts have been received, and every mirrored value with its quality.

## Access levels

| Level | How to enter | What it allows |
|---|---|---|
| **Operator** | Default at every session | Reading everything, and the **output trims** |
| **Commission** | `auth commission 1234` | **Field calibration, the identity fields and both serial numbers, the device tag and damping**, plus what disturbs the live signal or the comms: forced outputs, probe geometry and probe zero, the capacitance table, the PT100 reference resistor, RS485 baud, reboot |
| **Factory** | `auth factory 9999` | Diagnostics injection. Console only |

A session starts at operator level and can only be raised, never lowered. Closing the session drops it back to operator.

> The codes above are the fixed values in this firmware revision. Per-device codes arrive with a later provisioning release.

**Read the table as what each CARD enforces.** On the measuring card almost everything that changes the meter is commission-tier — field calibration, damping, the medium, the capacitance table and the PT100 reference resistor.

**But a command sent through `cap` inherits that tier automatically.** The forwarded session arrives at CAP already at commission, on the argument that reaching the internal bus is itself the authorisation. So `cap fcal save`, `cap cfg set meas.damping` and the rest need **no `auth` line at all**. What does need `auth commission 1234` is commission-tier work on the SIGNAL card you are typing at: the identity fields, both serial numbers and the device tag.

## Output modes

```
mode human      # human-readable text (default)
mode json       # newline-delimited JSON, one object per reply
```

JSON mode is intended for tooling. Each value gets a companion `_q` key carrying its quality.

## Stopping a stream

Streaming output (`meas stream start`, calibration progress) is stopped with **Ctrl-C** or **ESC**.

Stopping a *calibration progress* display does **not** abort the calibration — the capture keeps running and can be checked with `cal status`.

# Reading the Water Cut

## From the 4-20 mA loop

```
water cut % = (mA − 4) × pv.range / 16
```

See 4-20 mA Loop Output for the meaning of 3.6 and 20.4 mA.

## From the console

On the SIGNAL console, either ask the whole instrument:

```
cap
```

which shows link health plus every value SIGNAL holds with its quality, or go straight to the source:

```
cap meas read
```

which shows CAP's own measurement set — water cut, capacitance in pF, dielectric constant, process temperature, board temperature and the raw bridge readings — **each with its quality**.

## Reading the qualities

This is the part that repays attention:

| What you see | What it means | What to do |
|---|---|---|
| `wcut ... good` | Normal | Nothing |
| `wcut ... stale` | SIGNAL has not heard from CAP for over 2.5 s | Check the internal link and CAP's power. The loop is at 3.6 mA |
| `wcut ... overrange` | Water cut above the measurable range | Check the process; check the configured `pv.range` |
| `wcut ... underrange` | Water cut below zero, or the bridge is reading below its zero point | Check the probe and the probe zero calibration |
| `wcut ... fault` | The calculation failed | Check the probe wiring and the calibration table |
| `temp_proc ... fault` | The PT100 is missing or faulty; 25 °C is being substituted | Check the PT100. The reading is not temperature compensated |
| `temp_pcb ... fault` | The board temperature sensor failed; the last value is still being used | Service required |

## Live streaming

```
cap meas read
```

repeated, or on a directly connected CAP USB console:

```
meas stream start 1
```

streams the measurement set. Stop with Ctrl-C or ESC. Note that streaming does **not** work through the `cap` proxy — connect to CAP's USB console for it.

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# LED Indication

Each card carries two indicators: a **red heartbeat LED** and an **RGB status LED**.

> **These indicators are generally not visible on an assembled ZT-100-C** — the display assembly covers them. Treat them as a service aid for a unit with the electronics compartment open, and use the console ( `link status` , `cap` ) for the same information in normal operation.

## Red heartbeat LED — how many cards are talking

On both CAP and SIGNAL the red LED flashes a **burst**, then pauses. The number of flashes in the burst is **1 + the number of link peers this card can hear**:

| Pattern | Meaning |
|---|---|
| **2 flashes**, pause | **Normal.** This card plus one peer — CAP and SIGNAL are talking |
| **1 flash**, pause | **This card is alone.** It cannot hear the other card — check the internal link and the other card's power |
| **Fast, continuous toggle** (about 100 ms) | **The card is about to reset.** A unit has stalled and the watchdog is no longer being fed |

Each flash is 150 ms on, 150 ms off, followed by a 500 ms pause before the next burst.

**A ZT-100-C in normal operation shows 2 flashes on both cards.** One flash on either card means the pair is broken and the loop will be at 3.6 mA.

## RGB status LED

| Appearance | Meaning |
|---|---|
| **Green, breathing** (slow brighten/dim) | Healthy, idle |
| **Red, fast flashing** | A unit has stalled; the card is about to be reset by its watchdog |
| **Purple, steady for about 1.5 s** (CAP only) | A calibration flow was abandoned and auto-aborted after 60 s of inactivity |

No other colours are used on the ZT-100-C. If you have seen colour codes in an earlier document set describing mode colours or button feedback, those belong to a different product.

# Field Calibration

Field calibration corrects the meter's reading to agree with a laboratory water content analysis of a sample taken at the probe. It works by back-solving the **oil dielectric constant** used in the calculation — this is physics-correct and accounts for the composition of your particular crude, rather than smearing a fudge factor over the reading.

**All field calibration lives on the CAP card**, reached through the `cap` proxy from the field console.

## When to calibrate

- At commissioning, once the process is running normally
- When readings diverge from laboratory samples
- After a change of crude source or process conditions
- As part of scheduled verification (see Maintenance)

## Before you start

- The process must be **flowing and representative**. Do not calibrate on a settled or slugging line.
- The reading must be **`good`**. Check with `cap meas read`. A calibration cannot be captured on stale or faulted data.
- The **PT100 must be working**. If process temperature shows `fault`, the meter is running on a substituted 25 °C and the calibration will be anchored to a wrong temperature.
- **No password is needed.** Field calibration is commission-level on the measuring card, but a command forwarded with `cap` arrives there already at commission tier, so no `auth` line is required.

## Procedure

> **This is a two-visit procedure.** You pin the meter's reading at the moment the sample is drawn, and apply the laboratory result days later. The lab value is fitted to the **pinned** reading, not to whatever the meter happens to show when the result arrives — so the process does not have to be back in the same condition on the second visit.

### Step 1 — at the sample: pin the reading.

Take an oil sample at the probe location, and at the same moment pin what the meter is reading:

```
cap fcal save
```

The meter answers with the reading it has stored, for example:

```
sample pinned: 148.312 pF @ 47.8 C (raw WC 12.44 %)
  apply the lab result later with `fcal set <wc>`
```

Record those figures alongside the sample bottle. Also worth capturing for your own records:

```
cap meas read
cap fcal show
```

> **`fcal save` can refuse.** If the capacitance reads 0 pF it answers "*no usable reading to pin (capacitance is 0 pF - check the probe is connected and reading)*". Nothing is pinned, so **do not send the sample to the lab until you have a successful pin** — without one the result cannot be applied. A zero reading means the probe is disconnected, dry or below range; fix that first.

**Step 2 — laboratory analysis.**

Send the sample for laboratory water content analysis.

**Step 3 — apply the laboratory result.**

When the result comes back:

```
cap fcal set 5.20
```

where `5.20` is the laboratory water cut in percent. Permitted range is 0 to 98 %. The meter back-solves the oil dielectric constant that makes the **pinned** capacitance reading produce the laboratory figure, rebuilds its temperature-compensated oil table around it, and applies it.

Because the fit uses the pinned reading, you do **not** need to wait for the process to return to the sampling condition. That is the point of pinning.

> **`fcal set` refuses if nothing was pinned**, with "*no saved sample point - run `fcal save` at the sample, then apply the lab result*". If you see this, the pin at Step 1 did not happen or did not succeed, and the laboratory result cannot be applied to this sample — pin a fresh reading and take a fresh sample.

**Step 4 — confirm and let it persist.**

```
cap fcal show
sys nvm
```

`fcal show` should now report the calibration as enabled, with the laboratory value and the saved reading. **Wait for `sys nvm` to show the write drained before removing power.**

## Small adjustments

To nudge the calibration without a full lab cycle:

```
cap fcal adj 0.25         # move the calibrated water cut up by 0.25 %
cap fcal adj -0.25        # and down
```

Steps of −5 to +5 % are accepted. **This also needs a pinned sample** — it adjusts the lab value that was fitted to the pin, and refuses with the same "*no saved sample point*" message if there is none.

## Zeroing on dry oil

If you have a process condition you know to be water-free:

```
cap fcal zero
```

This makes the current reading read 0 % water cut. **It is the one-visit exception**: it pins and applies in the same breath, so it needs no prior `fcal save`. There is no laboratory result to wait for — the known-dry condition *is* the result.

## Removing field calibration

```
cap fcal clear
```

This disables field calibration and restores the original oil table. The meter returns to its factory calibration.

## Calibration over HART

The same operations are available to a HART master:

| HART command | Equivalent |
|---|---|
| **144** (no payload) | `fcal save` — **pin the sample, Step 1** |
| **143** (with the lab % as a float) | `fcal set` — apply the result, Step 3 |
| **147** | `fcal show` (summary read-back) |
| **148** | `fcal zero` |

**Both halves are on HART deliberately.** Command 143 refuses without a prior pin exactly as the console does, so a master that sends 143 alone cannot field-calibrate. Send 144 at the sample and 143 when the result arrives.

These are **accepted asynchronously** — the meter answers "accepted" and performs the work a moment later. "Accepted" is not "done". **Always verify with command 147 or `cap fcal show`.** A second request while the first is in flight answers "busy".

If the calibration is refused once it reaches the CAP card, command 147 raises the **"more status available"** bit and `hart status` names the reason on its `devcmd:` line.

## Safety net

Every calibration change is **all-or-nothing**. If the derivation fails, or the flash store is busy, the command reports the failure and changes nothing. Power loss before the write completes leaves the **previous** calibration intact. You cannot end up with a half-applied calibration.

## Probe zero

If the meter reads a persistent offset with the probe empty and dry, the probe capacitance zero can be reset.

**This belongs at a build or a card swap, not in service.** Zeroing measures the stray capacitance of cable, connector and pass-through with nothing in the probe. Run on a probe that has been in service and merely wiped out, it bakes whatever film is left into the offset, where it biases every later reading. If the probe cannot be properly emptied and dried, do not zero it — see *Field calibration* instead.

At a card replacement it is the right thing to do, and the procedure is in the Technical Manual. It is a **CAP** command, so from SIGNAL:

```
cap auth commission 1234
cap probe show
cap cal start capzero
cap cal enter
# capture runs about 6 seconds
cap cal commit
cap sys nvm
```

To simply discard a probe offset:

```
cap auth commission 1234
cap probe clear
```

## What is not a field operation

The **capacitance calibration table** (`capcal`) maps raw bridge readings to capacitance in pF. It is established at the factory with known reference capacitors and should not be touched in the field. It is documented in the Technical Manual.

---

# Output Trim Calibration

Trimming corrects the **4-20 mA output** against a reference meter. It does not touch the water cut measurement itself, only the signal that carries it. If the control system reads a different current from your meter, this is the adjustment that closes the gap.

There are two trims: **zero** at 4 mA and **span** at 20 mA. They are done as one sequence, zero first then span.

Unlike the potentiometer instruments this replaces, **the two ends do not interact.** Setting zero does not move span, so there is no working back and forth between them with a screwdriver. Set each once.

> ### The loop must be closed
>
> Trimming drives a fixed current and asks what your meter reads. With the loop open no current flows, the meter reads nothing, and anything entered is meaningless. Wire the milliammeter into the loop and confirm with `out status` that the loop reads closed **before** starting.

## The sequence

1. Connect a milliammeter in series with the 4-20 mA loop.
2. `auth commission 1234`
3. `out status` — confirm the loop reads closed.
4. `cal start trim4` — the output goes to a fixed **4.000 mA**.
5. Read the meter and enter what it shows, e.g. `cal enter 4.031`. The output moves so the meter lands on 4.000 mA.
6. `cal commit` — saves and returns to normal operation.
7. `cal start trim20`, then the same at **20.000 mA**.
8. `sys nvm` — wait for the write to drain before removing power.
9. `out trim` — confirm both offsets.

Over HART, **command 45 trims zero and command 46 trims span**.

## Things worth knowing

- **A trim is only stored when you commit it.** What you enter is a live preview; abandoning the flow, or losing power during it, leaves the previously saved trim untouched.
- **If nothing happens for 60 seconds the trim is abandoned automatically** and the previous value is restored.
- **There is a limit on how far a trim can correct: ±0.25 mA.** A correction beyond that is refused, not applied. That is not a nuisance limit — a meter needing more than that has a fault worth investigating rather than trimming out. Stop and report it.
- Trimming is **operator-level** work and needs no password. A meter in the loop verifies what the card drives; it does not redefine what the card believes, and the ±0.25 mA limit above is what keeps it that way. (It was commission until firmware 0.17.35-sig-c59.)

# Troubleshooting

## First three checks

Whatever the symptom, start here on the SIGNAL console:

```
cap             # is CAP alive and is its data fresh?
out status      # is the loop closed, and what state is the output in?
sys version     # which firmware is this?
```

Between them these answer most questions.

## Output sits at 3.6 mA

| Check | How | If |
|---|---|---|
| Is it "below span" or "source dead"? | `out status` → `state` | `sat-lo` = the water cut really is below zero → check the probe and the probe zero. `alarm` = the data is stale or faulted → continue below |
| Is CAP alive? | `cap` | `stale`, or peer count 0 → CAP is not being heard |
| Is CAP powered? | Red LED on CAP | No flashing = no power |
| Is the internal link intact? | Red LED flash count on **both** cards | **1 flash** = the cards cannot hear each other. Check terminals 2/3 and the internal harness |
| Is the measurement itself faulted? | `cap meas read` | `wcut ... fault` → probe or calibration problem |

Remember: the loop reaches 3.6 mA **about 2.5 seconds** after CAP stops broadcasting, and returns to normal automatically when CAP comes back. A loop that alarms and recovers repeatedly is telling you the internal link is intermittent.

## Output sits at 20.4 mA

The water cut is above the configured range. Either the process really is wetter than `pv.range`, or the range is set too narrow.

```
cap meas read         # what is the actual water cut?
cfg get pv.range      # what is 20 mA set to?
```

## No output at all / dead loop

| Check | Action |
|---|---|
| Supply | Measure 24 VDC at terminals 9 (+) / 8 (−) |
| Loop wiring | Check continuity of the loop through terminals 5 (+) / 4 (−) |
| Loop closed? | `out status` — the loop state must read closed |
| Loop resistance | Design to **500 Ω or less** (calculated ceiling ≈1000 Ω at 24 V). Too much burden shows as a loop fault, indistinguishable from a broken wire |
| Card alive? | Red heartbeat LED on SIGNAL |

## RS485 console does not answer

**This is nearly always A/B polarity.**

1. **Swap the two data wires** at terminals 7 and 6. Try again. This is safe and it is the most likely fix.
2. Check the baud rate: **115200**, not 9600. 8N1, no flow control.
3. Turn on **local echo** in your terminal — the meter does not echo your typing, so a silent terminal is not proof of a dead link.
4. Check that you are on terminals **7 and 6** (external) and not 2 and 3 (internal).
5. Check that nothing else is driving the bus.

Do **not** try to diagnose this by matching wire colours. The colours in this manual describe this enclosure's harness only.

## Console answers but the data is garbled

Baud mismatch, or A/B swapped on a bus with more than two devices. Confirm 115200 8N1 at both ends, then swap A/B.

## HART does not respond

| Check | Action |
|---|---|
| **Is the loop closed?** | `out status`. **While the loop is open the HART modem is held in reset and will not answer anything.** This is the most common cause |
| Poll address | Default 0. `cfg get hart.polladdr` |
| Master settings | 1200 baud, 8 data bits, **odd** parity, 1 stop bit |
| Loop resistance | HART needs **250 Ω** nominal, and it is **not fitted in the meter**. Confirm the loop actually contains one |
| Try the simplest command | HART command 0 (read identity) |

## Water cut reading looks wrong

| Symptom | Likely cause | Action |
|---|---|---|
| Reading fluctuates rapidly | Gas or slugging in the line | Increase damping (`cap cfg set meas.damping 10`); review the installation point |
| Reading drifts over hours | Process temperature not compensated | `cap meas read` — is `temp_proc` `good`? A `fault` means 25 °C is being substituted |
| Reading drifts over weeks | Probe fouling | Inspect and clean the probe |
| Reading is offset by a constant | Field calibration needed | See Field Calibration |
| Reading is offset and calibration will not fix it | Wrong probe geometry | `cap probe show` — compare with the fitted probe |
| Reading stuck near a mid value, never goes low | Incomplete factory calibration table | Check for the "incomplete calibration" warning — see the Technical Manual |

## Card keeps resetting

A red **fast-flashing** RGB LED and a fast red heartbeat mean a unit has stalled and the watchdog is about to reset the card. After the reset:

```
sys boot
```

reports the cause of the last reset and, where evidence was captured, a crash summary. Record this before doing anything else and contact support.

## `nvm busy` when saving

The flash store serialises writes through one buffer. If another write is in flight your command **fails honestly and changes nothing**. Wait a few seconds and repeat. Check progress with `sys nvm`.

---

# Maintenance

## Routine checks

Maintenance intervals depend far more on your process and site practice than on the instrument. The following is offered as a starting point:

| Interval | Check |
|---|---|
| Each shift or daily | Loop reading against expectation; confirm the loop is not sitting at 3.6 or 20.4 mA |
| Weekly | Compare the meter against a laboratory sample |
| Monthly | Verify the 4-20 mA output against a reference meter; confirm both cards show a **2-flash** heartbeat |
| Quarterly | Inspect the probe for build-up; inspect the connection compartment for moisture and corrosion |
| Annually | Full calibration verification; verify PT100 reading against a reference |

## Health check without tools

Look at the red heartbeat LED on both cards (if visible):

- **2 flashes on both cards** — the pair is healthy
- **1 flash on either card** — the cards are not hearing each other; the loop is in alarm
- **Fast continuous flashing** — a card is about to reset

## Health check from the console

```
cap              # link health + all values with qualities
out status       # loop state, output state, control-write counter
sys nvm          # flash store health
sys uptime       # how long since the last reset
sys boot         # why the last reset happened
link status      # link peer detail
```

## Cleaning the probe

1. Isolate and depressurise the process line. Allow to cool.
2. Remove the probe according to the process connection's procedure.
3. Clean with a solvent appropriate to the deposit and to the probe materials. **Check the probe's own documentation for material compatibility** — probes vary by model and this manual does not specify cleaning agents.
4. Inspect the insulators for cracks, scoring or swelling. Replace the probe if the insulation is damaged.
5. Rinse with clean oil before reinstalling.
6. After reinstallation, verify the reading against a laboratory sample and re-run field calibration if needed.

## Verifying the 4-20 mA output

At commission access, with a reference meter in the loop:

```
auth commission 1234
out test 4
out test 12
out test 20
out auto
```

Each `out test` holds for **30 seconds** and then reverts by itself. If the reference meter disagrees, the loop can be trimmed — see the Technical Manual.

## Firmware upgrade

Firmware is upgraded per card. Note that at the cutover from the previous generation the **flash record store is reformatted**: data written by the earlier firmware is **not read in place**. Calibration is carried across by exporting it as JSON from the old firmware and importing it into the new one. Plan an upgrade accordingly — **do not assume calibration survives the cutover by itself**.

Firmware upgrade is a service operation and is covered in the Technical Manual, not here.

## Spares and support

When contacting Zelentech support, have ready:

- The device tag and serial number
- The output of `sys version` from **both** cards (`sys version` and `cap sys version`)
- The output of `cap`, `out status` and `sys boot`
- A description of the symptom and what the loop is doing

---

# Installation and Wiring

## The enclosure

The ZT-100-C is housed in an **IME 9080 enclosure with a separate connection compartment**. Field wiring lands on a 10-position terminal block in the connection compartment. From there the conductors are **potted through into the electronics compartment**, where they reach the CAP and SIGNAL cards.

Practical consequences:

- Routine wiring work is done entirely in the connection compartment. The electronics compartment does not need to be opened to land field wiring.
- The pass-through is potted. It is not a connector and cannot be unplugged.
- Terminal positions, not wire colours, define the connections. See the warning below.

## What you wire and what you do not

**You wire the connection compartment. That is all.**

| | Who |
|---|---|
| The 10-position terminal block in the connection compartment | **You** |
| Everything inside the electronics compartment | **Factory** |

Inside the electronics compartment the field conductors reach a **backplane card**, and the CAP and SIGNAL cards **piggyback onto it through plug-in connectors**. None of that is field wiring:

- **There are no user-facing terminals on the CAP or SIGNAL cards.** They have no screw terminals of their own for you to land anything on.
- **Do not disturb the backplane wiring.** It is factory made and is not a field adjustment point.
- **Card replacement, if it is ever needed, involves no wiring at all.** The cards unplug and plug back in. If a procedure appears to call for stripping, landing or re-terminating a conductor inside the electronics compartment, it is the wrong procedure — stop and contact support.

## Field terminal block

The field terminal block has **10 positions**. This is the authoritative map for the ZT-100-C:

| Terminal | Function | Wire colour |
|---|---|---|
| **0** | 4-20 mA IN (+) — feeds the display | Red |
| **1** | 4-20 mA IN (−) — feeds the display | Black |
| **2** | Internal RS485 **A** | Grey |
| **3** | Internal RS485 **B** | Purple |
| **4** | 4-20 mA (−) | Blue |
| **5** | 4-20 mA (+) | Green |
| **6** | External RS485 **B** | Orange |
| **7** | External RS485 **A** | Yellow |
| **8** | 24 VDC (−) | White |
| **9** | 24 VDC (+) | Brown |


The 10-position field terminal block, looking into the connection compartment. The wiring-diagram label in the centre carries the 0–9 position numbering used throughout this manual.

## Which terminals you actually connect

| Terminals | Connect in the field? | Notes |
|---|---|---|
| **9 / 8** — 24 VDC (+) / (−) | **Yes, always** | Meter supply |
| **5 / 4** — 4-20 mA (+) / (−) | **Yes** | Process output to the control system; HART rides on this loop |
| **7 / 6** — External RS485 A / B | **Yes, when a console or configuration PC is used** | Zelentech text console. See RS485 Connections |
| **2 / 3** — Internal RS485 A / B | **No** | The CAP ↔ SIGNAL bus inside the enclosure, wired at the factory. **Nothing is attached here in the field** |

| Terminals | Connect in the field? | Notes |
|---|---|---|
| **0 / 1** — 4-20 mA IN (+) / (−) | **No, not in this revision** | This input is provisioned to feed the DISPLAY card, which is **not released** (see DISPLAY Card). Leave unconnected |

## ⚠ The wiring failure that costs the most time

**RS485 A/B polarity is the most common wiring failure on this product.**

The letters "A" and "B" are **not applied consistently between manufacturers**. Your PLC, your USB-RS485 adapter and this meter may each label the same physical line differently. There is no way to be certain from the labels alone.

**If RS485 is silent or the characters that come back are garbled, swap A and B.** That is the fix, and it is the *only* polarity choice available on a two-wire differential pair. RS485 is not damaged by reversed data lines — swapping is safe and takes seconds.

**Do not rely on cable colour matching alone.** The wire colours in the table above describe *this* enclosure's harness. They have no relationship to the colours on your adapter cable, your field cable, or any third-party equipment. Land by terminal number, then verify by communicating, then swap if it does not work.

## General wiring practice

- Use the connection compartment's cable entries. Gland sizes are set by the installation — **see the instrument data sheet**.
- Use shielded twisted pair for RS485 and for the 4-20 mA loop where the run is long or the environment is electrically noisy.
- Terminate the shield at **one end only** to avoid a ground loop. **There is no shield landing point inside this enclosure** — earth the shield at the control-system end.
- Conductor cross-section: **up to 0.82 mm² (AWG 18)**, set by the enclosure's terminal specification. **0.75 mm²** is the nearest standard metric size below that limit.
- The meter's RS485 ports are **permanently terminated at 120 Ω** and are therefore always bus end points. Do not add a terminator at the meter and do not install it as a middle node. Maximum bus length depends on baud rate, cable type and cross-section, and on the installation — apply the usual RS485 practice for the cable you are using.

Wiring outside the instrument is not specified here. It is frequently a certified area with its own rules, and nothing in this manual should be read as overriding them.

# Power

## Connection

| Terminal | Function | Wire colour |
|---|---|---|
| **8** | 24 VDC (−) | White |
| **9** | 24 VDC (+) | Brown |

Both cards inside the enclosure are supplied from this pair.

Both cards are fed from a **single internal rail**. The supply enters at terminals 8 and 9, passes to the SIGNAL card, and continues up the internal stack to CAP. Each card regulates its own internal voltages from it — there is no separate supply to either card, and no way to power one without the other.

> ### ⚠ Check polarity before switching on
>
> The regulator supply is protected against reversed polarity, but **the 4-20 mA loop driver's rail is not** — it is connected upstream of that protection. Reversing the supply will prevent the meter from starting, and risks damaging the loop output stage.
>
> There is no fuse or protective component between the field terminals and that rail. Confirm terminal 9 is positive and terminal 8 is negative before applying power.

## Isolation

The **capacitance probe front end is galvanically isolated** from the rest of the meter, including its own power and data crossings.

The barrier is rated **2500 V test voltage, 400 $V_{RMS}$ working**, and is **functional insulation only**. It is formed by two devices — a Würth 760390014 push-pull transformer for power and an ISO1541 isolator for data — and the transformer is the limiting element: it carries functional insulation for a 400 $V_{RMS}$ working voltage, where the ISO1541 alone would be basic. **Do not rely on this barrier for safety separation from mains.** It exists to keep the measurement clean, not to protect an operator.

Everything else shares a common reference: the **PT100 input**, the **4-20 mA loop return**, the internal link and the supply negative are all on the same ground. In particular, do not assume the PT100 is isolated from the loop or from the supply — it is not.

The external RS485 console is isolated on the SIGNAL card, but its isolated common is **not brought out to any terminal**. See External RS485.

## Power supply

The terminal block is labelled **24 VDC**.

- Rate the supply at a maximum of **125 mA** per meter. The meter does not exceed that figure in service.
- Use a regulated supply. Both cards regulate internally from the incoming supply, but the practical minimum is set by the 4-20 mA loop headroom rather than by the regulators — a low supply reduces the loop resistance the meter can drive before the regulators care.

## Power-up behaviour

On power-up each card:

1. Loads its defaults, then overlays whatever is stored in its flash record store.
2. Prints a banner on its USB console giving the product, the firmware version and the cause of the last reset.
3. Starts measuring / driving the loop.
4. Arms its watchdog last.

CAP begins broadcasting at 1 Hz as soon as it has data. SIGNAL will show its mirrored values as `stale` until the first packet arrives, and will therefore sit at the **3.6 mA alarm** for the first moments after power-up. This is correct behaviour, not a fault.

# 4-20 mA Loop Output

## Connection

| Terminal | Function | Wire colour |
| --- | --- | --- |
| **5** | 4-20 mA (+) | Green |
| **4** | 4-20 mA (−) | Blue |

The 4-20 mA output is driven by the **SIGNAL** card. HART is superimposed on this same loop.

> ### ⚠ DO NOT APPLY A LOOP SUPPLY
>
> **The meter powers its own loop.** It sources the 4-20 mA current itself. The receiving system must present a passive load — a sense resistor or an analog input — and **must not** apply its own loop supply to terminals 5 and 4.
>
> Connecting an external supply drives current back into the meter's output stage. There is no protective component between the field terminals and the loop driver, so the driver is at risk.

## Loop resistance

**Design the loop for 500 Ω or less.** That covers the standard HART 250 Ω sense resistor plus normal cable and input burden with wide margin.

The calculated ceiling is higher — approximately **1000 Ω at a 24 V supply**, falling to about **825 Ω at 20 V**. The relationship is close to linear: every volt lost in the supply or the field wiring costs roughly **49 Ω** of allowable loop burden.

| Supply at the meter | Calculated maximum loop burden |
| --- | --- |
| 20 V | ≈ 825 Ω |
| 22 V | ≈ 925 Ω |
| 24 V | ≈ 1020 Ω |

> These ceilings are **calculated** from the output driver's compliance specification and the fitted series resistor, not measured on a built unit. The output stage uses an external boost transistor whose own voltage drop is not included, so the true limit may be slightly lower. This is why the working recommendation is 500 Ω rather than the calculated figure.

If the loop resistance is too high the output cannot reach the current it was asked for. The meter **detects this and reports a fault** rather than quietly saturating — see Loop-open detection. Note that the meter cannot distinguish "too much loop resistance" from "broken wire": both appear as a loop fault.

## HART and the 250 Ω resistor

A HART master needs a defined loop impedance to work — nominally **250 Ω**. That resistor is **not fitted inside the meter**; it is part of the loop and must be provided by the receiving system or added by the installer. Many control-system analog inputs already include a 250 Ω sense resistor, in which case nothing further is needed.

The alarm current of 3.6 mA remains drivable across the entire permitted loop resistance range, so a fault is always signalled regardless of loop burden.

## What the current means

The current represents water cut over the configured range:

```
mA = 4 + 16 × (water cut %) / (pv.range %)
```

and, inverted, for reading a meter:

```
water cut % = (mA − 4) × (pv.range %) / 16
```

With the factory default `pv.range` of **25 %**: 4 mA = 0 % water cut, 12 mA = 12.5 %, 20 mA = 25 %.

## Special currents — what they tell you

| Current | Meaning |
|---|---|
| 4.000 – 20.000 mA | Normal. Water cut within the configured range |
| **20.4 mA** | **Above span.** Water cut is higher than `pv.range` |
| **3.6 mA** | **Either** below span **or** the measurement is dead (stale or faulted) |

**3.6 mA is ambiguous by design** — it is a low alarm in the NAMUR sense, and it is also where a below-zero reading saturates. To distinguish the two, ask the meter:

```
out status
```

The `state` field reads `sat-lo` for "below span" and `alarm` for "source dead". See Troubleshooting.

## Loop-open detection

The output driver reports whether current is actually flowing. The meter requires **3 consecutive identical samples** before it changes its opinion, so a momentary disturbance does not flap the indication. The loop state is visible with `out status` and it also **gates HART**: while the loop is open the HART modem is held in reset and will not transmit (see HART Connection).

## Bench-testing the output

At commission access level:

```
out test 12          # drive a fixed 12.000 mA for 30 s, then auto-revert
out auto             # return to tracking the measurement now
```

`out test` accepts **3.5 to 21 mA** and **reverts automatically after 30 seconds** — you cannot accidentally leave the loop parked on a test value.

# RS485 Connections

The ZT-100-C has **two** RS485 buses. They are not interchangeable.

| Bus | Terminals | Purpose | Baud |
|---|---|---|---|
| **External** | **7** = A (Yellow), **6** = B (Orange) | Operator / configuration console | Default **115200**, settable |
| **Internal** | **2** = A (Grey), **3** = B (Purple) | CAP ↔ SIGNAL link, factory wired | Fixed 115200 |

## External RS485 — the operator console

This is the port you connect a laptop or a serial master to. It reaches the **SIGNAL** card's text console.

| Setting | Value |
|---|---|
| Terminals | 7 = A, 6 = B |
| Baud | **115200** by default |
| Framing | 8 data bits, no parity, 1 stop bit |
| Flow control | None |
| Protocol | Zelentech text console (CLI), line based |
| Modbus | RTU slave, address 1, same port and baud — see Modbus |

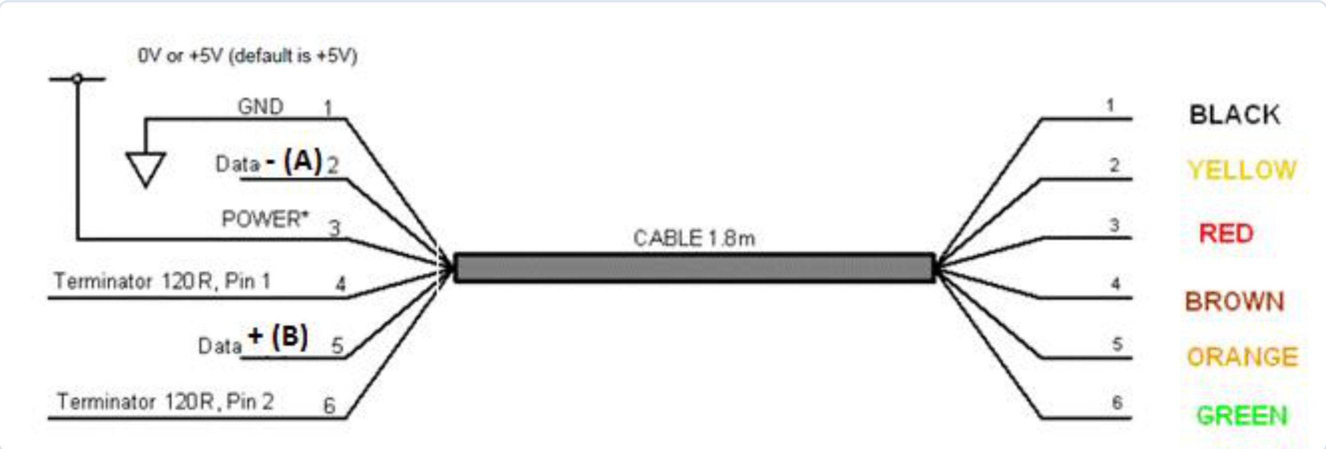
> **The default baud rate is 115200, not 9600.** If you have configured a terminal from an earlier ZT-100-C document set, change it.

To change it:

```
auth commission 1234
cfg set rs485.baud 19200
sys reboot
```

The new baud rate applies **at the next power-up**, not immediately — so you will finish the session at the old rate. Permitted values are 9600 to 460800.

A USB-RS485 adapter cable with flying leads.




Wire map for the adapter cable shown above, as published by its maker: pin 2 yellow = Data− (A), pin 5 orange = Data+ (B). These colours belong to the adapter, not to the meter — the meter's terminals are defined by the terminal map above.

## Connecting a USB-RS485 adapter

1. Land the adapter's two data wires on **terminal 7 (A)** and **terminal 6 (B)**.
2. Open a terminal program at **115200 8N1**, no flow control.
3. Press Enter and type `sys version`.
4. If nothing comes back, or the reply is garbled: **swap the two data wires** and try again.

**There is no signal-common terminal, by design of the current build.** The 10-position block has no ground position available for RS485, and the SIGNAL card's isolated RS485 common is not routed to any connector. The console is therefore a **two-wire connection: A and B only.**

This works, and it is how the meter is used on the bench. The limitation is that the two ends have no shared reference, so they rely on the transceivers' common-mode range to stay in step. In practice that means:

- **Keep the run short** and use a twisted pair.
- Use a **shielded** cable, with the shield grounded at the control-system end only — there is no shield landing point inside this enclosure.
- If the two ends are on widely separated grounds, expect trouble before you expect a fault in the meter.

> Landing the adapter's common on **terminal 8 (24 VDC −)** is electrically possible and gives a shared reference, but it ties the console's ground to the supply return, so any current in the supply negative appears as common-mode offset on the bus. **It is not a recommendation** — treat it as a last resort on a bench, not a field practice.

## Termination

Both RS485 ports carry a **fitted 120 Ω termination resistor**. It is soldered, not jumper-selectable, so **the meter is permanently a bus end point**. Do not install it as a middle node on a multi-drop RS485 segment, and do not add another terminator at the meter.

There is **no fail-safe biasing** on either port. An idle bus with no driver asserting is undefined rather than held at a known state; this is normal for the point-to-point console use this port is intended for.

## Two things that surprise people

- **The meter does not echo what you type.** Neither console echoes keystrokes. If you cannot see your typing, turn on **local echo** in your terminal program. This is normal.
- **A/B lettering is not standardised.** See the warning in Installation and Wiring. If in doubt, swap.

## Internal RS485 — do not disturb

Terminals **3 (A, Grey)** and **4 (B, Purple)** carry the internal bus that joins CAP and SIGNAL. It is wired at the factory, runs at a fixed 115200 baud, and carries the 1 Hz measurement broadcast that drives the 4-20 mA output.

**Disconnecting or shorting this pair puts the loop into the 3.6 mA alarm within about 2.5 seconds.** This bus is factory wiring: do not attach anything to it, and do not use it as a diagnostic access point. The external RS485 console on terminals 7 and 6 gives you everything, including CAP's values through the `cap` proxy.

## Modbus

The SIGNAL card runs a **Modbus RTU slave** on the external RS485 port.

| Setting | Value |
|---|---|
| Slave address | **1** |
| Baud | As the console — **115200** by default |
| Framing | 8 data bits, no parity, 1 stop bit |
| Function codes | FC02, FC03, FC04, FC06, FC16 |

You do not switch the port into a mode. A traffic classifier inspects each burst and routes console text to the console and Modbus frames to the slave, so a terminal and a Modbus master can share the wiring. A stray Modbus master on a shared bus therefore cannot corrupt a console session, which is what the classifier was built for in the first place.

**Read the register map from the card**, not from a document:

```
mb map
```

It prints every register this card implements and marks the ones it does not, so it is always right about the firmware in front of you. `mb stats` shows frame counters. The Technical Manual describes the map's shape and the parts of it that are absent on SIGNAL; the card is the authority on its contents.

## Two things to know before you integrate

**Every measurement carries its quality in the same read as its value.** Each one occupies four registers — the value as a 32-bit float, then a quality code, then a reserved register. Read the pair together and act on the quality: `1` means good, and anything else means the number should not be trusted as a live reading. This is deliberate, so that a master cannot pair a fresh value with a stale quality by reading them separately.

**Some data lives on the CAP card and is not on SIGNAL's map.** Probe geometry, the capacitance calibration table, and the two calibration status flags are CAP's, and SIGNAL does not hold copies of them. Their registers read as absent rather than as zero or as a guess. Commands that would change them are refused with "*CAP-owned; no such command on SIGNAL*". Read and set those over the console with the `cap` proxy, or on CAP's own console. What you *can* do over Modbus is read the measurements, the field-calibration summary and the output trims, set the 4-20 mA span, and drive the output and its trim flows.

# Configuring Range and Damping

Two settings shape what the loop does with the measurement. They live on **different cards**.

## Output range — on SIGNAL

`pv.range` sets what water cut percentage corresponds to 20 mA. 4 mA is always 0 %.

```
auth commission 1234
cfg get pv.range
cfg set pv.range 10
```

| `pv.range` | 4 mA | 20 mA | Resolution |
|---|---|---|---|
| 100 % | 0 % | 100 % | 6.25 % per mA |
| 25 % (default) | 0 % | 25 % | 1.5625 % per mA |
| 10 % | 0 % | 10 % | 0.625 % per mA |
| 5 % | 0 % | 5 % | 0.3125 % per mA |
| 1 % | 0 % | 1 % | 0.0625 % per mA |
| 0.1 % (minimum) | 0 % | 0.1 % | 0.00625 % per mA |

- Permitted values: **0.1 to 100.0 %**.
- **Takes effect immediately** — no reboot.
- If the water cut exceeds the range the output saturates at **20.4 mA** and `out status` shows `sat-hi`.

Choose the smallest range that comfortably covers your process. A narrower range gives better resolution on the loop, at the cost of saturating sooner.

> **The narrow end of the scale is for genuinely dry duty.** At `0.1 %` the whole 16 mA covers a tenth of a percent of water, so the loop resolves 0.00625 % per mA — and measurement noise is magnified in the same proportion, about 250× against the 25 % default. Expect a livelier output, and expect it to pin at 20.4 mA on the smallest excursion above range. Set it this narrow because the process really is that dry, not to get a finer-looking number.

A HART master can read this with command **15** and set it with command **35** — sending the range as the *upper* value, with the lower value 0.

## Damping

`meas.damping` smooths the water cut reading. It lives on the **measuring card**, so it is reached through the `cap` prefix, and it affects the console reading, the loop and HART alike.

```
cap cfg set meas.damping 5
cap cfg get meas.damping
```

- Permitted values: **0.0 to 60.0 seconds**.
- **Takes effect immediately** — no reboot.
- **No password needed.** The key is commission-tier on the measuring card, but a command forwarded with `cap` arrives there already at commission, so no `auth` line is required.

Use more damping for a noisy or slugging process, less for a process you need to follow quickly. Damping slows the response to real changes as well as to noise.

> **`0` really does mean unfiltered here.** There is no second filter on the measuring card on this firmware: `meas.damping` is the only damping in the signal path, so `0` leaves the reading as the measurement produces it.

A HART master reads this with command **15** and sets it with command **34**. The write is dispatched across the link to the measuring card, so it is answered **"accepted"** rather than *done*.

> **Confirm a damping change by reading command 15 back.** "Accepted" means the request was queued, not that it succeeded. Command 15 reads a mirror that is only updated when the measuring card confirms the value, so a read-back still showing the old number means the write did not take.

## Making settings stick

Configuration changes are written to flash **in the background**. The command returns immediately; the record lands over the next few seconds. Check with:

```
sys nvm
```

Wait for the write to have drained before removing power.

## Device tag

```
auth commission 1234
cfg set device.tag "SEP-A INLET"
```

Free text, up to 24 characters, a label only.

There is a second, separate set of identity fields — `id.tag` (8 characters, default `ZTWCM`), `id.descriptor` (16), `id.message` (32), `id.longtag` (32) and `id.date` — plus two serial numbers, `unit.serial` for the **assembly** and `probe.serial` for the **sensor**. These are what a HART master reads and writes, and they are also readable and writable over Modbus. They are called `id.*` rather than `hart.*` because the same block exists on every Zelentech card, including ones with no HART at all.

**The two serial numbers are different things and part company at an RMA.** The unit serial follows the electronics; the probe serial follows the sensor. Set both at commissioning.

## Reading the identity back

```
id show
cap id show
```

`id show` prints everything identifying the card and the unit in one reply — both serial numbers, the identity date, the four text fields, the MCU unique id and the PCB label. It is the record to take at commissioning.

**Run it on both cards.** CAP and SIGNAL each carry their own copy of the identity block and their own PCB label, so a record with only SIGNAL's half cannot say which CAP board is in the enclosure. `cap id show` asks CAP through SIGNAL's console.

**An unset serial prints `NOT SET`, not `0`** — 0 is a legal serial number and cannot mean both things.

---

# HART Connection

HART is superimposed on the 4-20 mA loop at terminals **5 (+)** and **4 (−)**. Connect the HART master or handheld across the loop in the normal way.

| Parameter | Value |
|---|---|
| HART revision | **5** |
| Physical layer | Bell 202 FSK, 1200 baud |
| Framing | 8 data bits, **odd** parity, 1 stop bit |
| Default poll address | **0** |
| Default preamble count | **5** |
| Default tag | `ZTWCM` |
| Loop resistance required for HART | **250 Ω nominal — not fitted in the meter.** The loop or the receiving system must provide it |

## HART variables

| Variable | Value |
|---|---|
| **PV** (primary) | Water cut, % |
| **SV** (secondary) | Process temperature, °C |
| **TV** (tertiary) | Probe capacitance, pF |
| **QV** (quaternary) | Not specified in this issue. The card publishes a value here; it is not part of the published specification and must not be used for monitoring or control |
| Loop current | The actual output current |
| Loop state | Loop closed / open |

## The loop gate — the first thing to check

**While the 4-20 mA loop is open, the HART modem is held in reset.** It will not key a carrier, and received bytes are discarded at the door.

This is deliberate: an open loop has no defined signal path, and the previous generation's demodulator would scream into the void under exactly these conditions.

**If HART does not respond, check the loop first**, not the HART master:

```
out status
```

The loop must read closed, with good quality, before HART will answer anything.

## What HART can do on this product

The universal commands implemented are **0, 1, 2, 3, 6, 7, 8, 9, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 38 and 48**, and the common-practice commands are **34, 35, 40, 45, 46, 49 and 59**. Commands outside these lists are not implemented. Of them, the ones whose effect on the meter's own configuration is documented are **6** (polling address), **18** and **22** (tag and device identity) and **59** (preamble count) — see [Identity written over HART is kept](#) below.

(Earlier issues of this manual listed command **42**, device reset, which this meter does not implement, and omitted a dozen it does.)

These standard commands read and change the meter's output and range:

| Command | Purpose |
|---|---|
| **15** | Read the range, the damping and the alarm setting |
| **34** | Change the damping |
| **35** | Change the 4-20 mA range (the upper value; the lower is always 0) |
| **40** | Hold the loop at a fixed current, or release it with **0** |
| **45** / **46** | Trim the 4 mA and 20 mA ends against a meter reading |

And these device-specific commands are useful in the field:

| Command | Purpose |
|---|---|
| **143** | Apply a laboratory water cut result (see Field Calibration) |
| **144** | **Pin the sample** — step 1 of field calibration |
| **147** | Read back the field-calibration summary |
| **148** | Zero the field calibration |
| **151** | Read device diagnostics |

Commands **140, 145 and 146 are not implemented** and answer with "command not implemented". Probe geometry, the medium and the capacitance calibration table have no HART commands and are set from a console.

> **A HART master cannot restart the meter.** Command 42, device reset, is not implemented — the HART specification forbids it in new device types — and the meter answers "command not implemented". Restart from a console with `sys reboot`, or by removing power.

> **A fixed current set over HART stays fixed.** Unlike the console's `out test`, which releases after 30 seconds, command 40 holds the loop until a master sends command 40 with **0**. **If you fix the loop for a test, release it when you are done** — otherwise the meter keeps reporting that current instead of the process. A HART master can always see the condition: every reply carries a "loop current fixed" flag while the loop is held.

**To trim the loop against a reference meter**, put the loop where the meter can read it first — commands 45 and 46 refuse unless it is already there, because the number you send only means something if the card was driving the nominal current when you took the reading:

1. Command **40** with `4.0`, then read the loop with your meter
2. Command **45** with the value your meter showed
3. Command **40** with `20.0`, read the meter again
4. Command **46** with that value
5. Command **40** with `0` to return the loop to the measurement

The loop stays fixed after a trim, so you can re-read the meter at step 2 or 4 to confirm the trim landed before moving on.

> **Some commands are asynchronous.** Commands 143, 144, 148 and the damping write 34 must be forwarded to the CAP card over the internal link, which cannot happen inside a HART reply window. The meter answers **"accepted"** immediately and does the work a moment later. **"Accepted" means the request was queued — not that it succeeded.** If a previous request is still in flight it answers **"busy"** — wait and retry. Confirm a calibration afterwards with command 147, or on the console with `cap fcal show`.
>
> **Confirm a damping change by reading command 15 back.** The meter reports only the damping CAP has confirmed, so if the write did not take, reading 15 shows the *previous* value — which is how you find out. A read-back that still shows the old damping means the change did not land, not that the display is lagging.

If the CAP card refuses the calibration after the meter has already answered "accepted", you are told two ways: command 147 raises the **"more status available"** bit, and the console command `hart status` prints the reason in CAP's own words on its `devcmd:` line, with a count of how many device commands have failed. The bit stays raised until a later calibration command succeeds. A calibration that quietly failed is never presented as one that worked.

Note that command 147's data comes from a cache that SIGNAL refreshes from CAP every 30 seconds. If the cache is missing or older than 95 seconds, the reply raises the same "more status available" bit. The `cache:` line of `hart status` tells the two cases apart.

**Command 15 reports damping the same way**, from its own mirror of CAP's setting. Just after a power-up, or while the internal link is down, the meter has not yet been told the damping and reports it as **not a number** rather than as zero — zero is a real setting meaning damping is off, so it cannot also mean "not known". This clears within about 30 seconds of a normal start. The `damping:` line of `hart status` shows the mirror's age and whether the last change was refused.

## Identity written over HART is kept

Tag, descriptor, device ID, polling address and preamble count written by a HART master are folded into the meter's own configuration and persisted. They survive a power cycle. Polling address and preamble count take effect immediately, with no reboot.

# Specifications

This table states only what has been verified for this firmware and hardware build.

## Measurement

| Parameter | Value |
|---|---|
| Measured quantity | Water content of crude oil (water cut), % |
| Measurement principle | Capacitance bridge, 16-bit ADC, with process- and board-temperature compensation |
| Water cut scale | 0 – 100 % |
| Readings above 100 % | Clamped and flagged `overrange` |
| Readings below 0 % | Flagged `underrange` |
| Process temperature sensor | 3-wire PT100, on the CAP card |
| Board temperature sensor | On-board digital sensor, CAP card |
| Damping | 0 – 60 s on SIGNAL, default 0 s, plus a fixed 1 s noise filter on the measuring card |
| Accuracy | **±0.01 %** water cut over 0 – 5 %, **±0.1 %** at 25 % (see note) |
| Repeatability | **±0.01 %** water cut over 0 – 5 %, **±0.1 %** at 25 % (see note) |
| Resolution | **0.007 %** water cut at 0 %, **0.010 %** at 25 % |
| Process temperature range | Varies by model — **see the instrument data sheet** |

**Accuracy and repeatability degrade as water content rises.** The figures above are the low-range and mid-range points; performance is best near zero and falls off across the span. They are the established product claim rather than a per-unit measured result.

**Resolution is not the same as accuracy.** The resolution figures are the smallest change the instrument can distinguish, derived from the 16-bit converter, its gain setting and the bridge network. The instrument resolves considerably finer than it is accurate — do not read the resolution figure as an accuracy claim.

## Analog output

| Parameter | Value |
|---|---|
| Output | 4-20 mA current loop, on the SIGNAL card |
| Mapping | 0 % → 4 mA, configured range → 20 mA |
| Range setting | `pv.range`, 0.1 – 100.0 %, default **25 %** |
| Above span | Saturates at **20.4 mA** |
| Below span | Saturates at **3.6 mA** |
| Data stale or faulted | Alarm at **3.6 mA** |
| Update cadence | 50 ms |
| Loop-open detection | Yes, from the output driver's fault pin, debounced over 3 consecutive samples |
| Maximum loop resistance | **Design to 500 Ω or less.** Calculated ceiling is ≈1000 Ω at a 24 V supply — see Loop resistance |
| Loop supply | **The meter powers its own loop.** Do not apply an external loop supply |
| Voltage output | **Not fitted.** The ZT-100-C has no voltage output. |

## Digital communication

| Parameter | Value |
|---|---|
| HART | Bell 202 on the 4-20 mA loop, 1200 baud, 8 data bits / **odd** parity / 1 stop bit. The meter declares **HART revision 6** as supplied; **revision 7** is set at the factory when an order calls for it |
| HART poll address | 0 by default, settable 0 – 63 |
| HART preambles | 5 by default, settable **5 – 20** |
| HART tag | `ZTWCM` by default, up to 8 characters |
| External RS485 | Half duplex, 8N1, **default 115200 baud**, settable 9600 – 460800 (takes effect at next power-up) |
| External RS485 protocol | Zelentech text console (CLI) and Modbus RTU, classified per burst |
| Modbus | RTU slave, address 1, same port and baud as the console |
| Internal RS485 | Card-to-card link, fixed 115200 baud, factory wired |
| USB | USB CDC console on each card (see Consoles) |

## Electrical and mechanical

| Parameter | Value |
|---|---|
| Supply | 24 VDC, on terminals 9 (+) and 8 (−) |
| Supply range | Regulated 24 V DC. The practical minimum is set by 4-20 mA loop headroom, not by the regulators |
| Current consumption | **Max 125 mA at 24 V (3.0 W)** |
| Isolation | **2500 V test, 400 $V_{RMS}$ working — functional insulation only, not a safety barrier.** The **capacitance probe front end is galvanically isolated**; the PT100 input, the 4-20 mA loop return and the supply share a common reference. See Isolation |
| Reverse-polarity protection | Present on the regulator supply, **absent on the loop-driver rail** — see the warning under Power |
| Enclosure | IME 9080, with a separate connection compartment |
| Field terminals | 10-position terminal block in the enclosure's connection compartment |
| Terminal conductor size | **Maximum 0.82 mm² (AWG 18)**, per the enclosure specification |
| Cable glands | By installation — **see the instrument data sheet** |
| Ingress protection | **IP66** |

| Dimensions and weight | Varies by model — **see the instrument data sheet** | | Ambient operating temperature | **−20 °C to +60 °C** |

**All field wiring is done in the connection compartment.** The electronics compartment contains no user-serviceable wiring: the cards are factory wired and plug together. See What you wire and what you do not.

# DISPLAY Card — Not Released

> **A DISPLAY card is planned for the ZT-100-C but is not released in this revision. No display firmware exists.**

Consequences for this build:

- The ZT-100-C consists of **two** cards, CAP and SIGNAL.
- Field terminals **0 and 1** (4-20 mA IN, Red and Black) are provisioned to feed a display card. **Leave them unconnected.**
- Nothing in this manual describes display behaviour, because there is none to describe.

Do not plan an installation around display functionality in this revision.

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*ZT-100-C Digital Water Cut Meter — Zelentech*