CONDUCTIVITY SENSOR W04

USER GUIDE

CENTRE FOR MICROCOMPUTER APPLICATIONS

https://cma-science.nl

Short description

The CMA Conductivity sensor W04 can be used to measure the conductivity of a solution within the range of 0 to 20 mS/cm. It is suitable for measuring salinity and changes in the conductivity of a water sample. Although it will not identify the specific ions that are present, it can be used to determine the total concentration of ions in a sample.

The power button located on the top of the sensor allows you to turn it on and off. The sensor is equipped with an OLED color display which shows sensor information and the measured values. This makes the sensor suitable to use as an independent measuring instrument.

The sensor can be used wirelessly via Bluetooth or wired via USB with the Coach 7 or Coach 7 lite programs/apps on computers (Windows and Mac), Chromebooks and mobile devices (Android and iOS).

How the sensor works

The Conductivity sensor consists of a conductivity electrode and an amplifier. The conductivity electrode is a simple ABS-bodied, 2-cell graphite type. The sensor measures the ability to conduct electricity in water solutions. When salts and other inorganic chemicals dissolve in water, they break apart into electrically charged ions, which increase the water's ability to conduct electrical current. Common ions in water that conduct electrical current include sodium, chloride, calcium, and magnesium. Organic compounds, such as sugars, oils, and alcohols, do not form ions.

The principle by which the sensor measures conductivity is simple: two graphite plates (cells) are placed in the sample, a potential is applied across the plates, and the current is measured. The Conductivity sensor measures the conductance G of the solution (the inverse of the resistivity R), which is determined from the voltage and current values according to Ohm's law ($G = 1/R = I/V$).

The specific cell constant (K) of the conductivity electrode is used to determine the conductivity (C). The conductivity is the cell conductance multiplied by the cell constant, $C=G*K$. The electrode separation distance divided by the electrode area determines the cell constant. The supplied electrode has a nominal cell constant K of 1.0 cm^{-1}.

The SI unit of conductance is Siemens (S). Since S is a very large unit, the conductance of aqueous samples is commonly measured in mS or μS, and conductivity in mS/cm or μS/cm.

Some typical conductivity ranges of hydrous solutions are:

Sample	Conductivity (µS/cm)
Pure water	0.055
Distilled water	0.5
Deionized water	0.1 – 10
Rain water	20 - 100
Drinking water	50 - 200
Tap water	100 - 1500
River water	250 - 800
Brackish water	1000 - 8000
KCl 0.01 M	1410
KCl 0.1 M	12900
Ocean water	53000
KCl 1.0 M	112000

In order to prevent complete ion migration to the two electrodes, the sensor uses alternating current. With each cycle of alternating current, the polarity of the electrodes is reversed, which in turn reverses the direction of ion flow. This prevents electrolysis and polarization.

Calibration

The sensor is supplied calibrated with a factory calibration in millisiemens per centimeter (mS/cm). For more accurate measurements, a user 2-point calibration can be performed and stored in the sensor's memory.

- Before starting the sensor calibration, ensure that the conductivity electrode is clean. Soak the tip of the electrode in distilled water for approximately 10 minutes. If this is not possible, rinse the tip thoroughly with distilled water before use and wipe the outer part of the electrode body with a clean paper towel. Shake vigorously to remove any droplets from the cell chamber. The electrode surface should be dry.
- Turn on the sensor. Double-press the power button to enter the user calibration mode. The display shows that you are now in user calibration mode.
- For the **first calibration point**, use the standard calibration solution of 1.41 mS. This expected conductivity value is shown as 1P on the sensor’s display. Place the electrode into the solution ensuring the entire elongated hole with electrode surfaces is submerged. The measured conductivity value is displayed as Val:. When the measured value is within the range of 0.4 to 2.4 mS, the message ‘Ready Press Btn’ appears (otherwise the display shows 'Out of Range'). Wait until the measured value stabilizes and press the power button once.

- For the second calibration point use the standard calibration solution of 12.88 mS. This expected conductivity value is shown as 2P on the sensor's display. Rinse the end of the probe with distilled water. Place the electrode into the solution ensuring the entire elongated hole with electrode surfaces is submerged. The measured conductivity value is displayed as Val:. When the measured value is within the range of 11.3 to 14.3, the message 'Ready Press Btn' (otherwise the display shows 'Out of Range'). Wait until the measured value stabilizes and press the power button once.
- After entering both calibration points, the display shows the symbol U0, indicating that the user calibration is in use. The user calibration is stored and will be used each time you connect the sensor. To restore the factory calibration, double-press the power button again while the symbol U0 is displayed on the screen.

There is no exact relationship between Conductivity in µS/cm and total solids TDS in ppm (parts per million). It has been discovered experimentally that for particular types of water there is an approximate relationship. In water with a higher proportion of sodium chloride, to get to ppm just multiply the µS/cm reading by 0.5. For most other water solutions use a factor of 0.67 instead.

Automatic temperature compensation

Temperature has a large effect on conductivity. The Conductivity electrode has a built-in temperature sensor that is used to compensate for changes in the conductivity of solutions with a temperature between 5 and 35°C. Readings are automatically referenced to a conductivity value at 25°C – therefore the sensor will give the same conductivity in a solution that is at 15°C as it would if the same solution were warmed to 25°C. This means that one calibration can be used for measurements in water samples of different temperatures. Without temperature compensation the conductivity readings change with temperature, even though the actual ion concentration did not.

Software

You can use the Conductivity sensor W04 with Coach 7 or Coach 7 Lite (free) program on computers (Windows and Mac) or Coach 7 and Coach 7 Lite (free) app on mobile devices (Android and iOS). For Chromebooks, we offer a special Android app. The support for wireless sensors is added starting from Coach version 7.10.

Check the CMA website for the latest installations. https://cma-science.nl/downloads_en

Conducting measurements with the sensor

Follow these steps when collecting data with the Conductivity sensor:

- Before starting data collection, clean the conductivity electrode. Soak the tip of the electrode in distilled water for about 10 minutes. If this is not possible, rinse the tip thoroughly with distilled water. Wipe the outer part of the electrode body with a clean paper towel. Shake vigorously to remove any droplets from the cell chamber.
- The liquid sample to be tested must be at least 3 cm deep to ensure the cell chamber of the electrode is fully submerged.
- Stir the solution gently to get rid of any air bubbles that could be trapped in the cell chamber. Wait for 10 seconds to allow the readings to stabilize.
- If you are taking readings in a solution that has a temperature below 10°C or above 35°C, allow more time for the readings to stabilize.
- Rinse the end of the probe with distilled water before taking another measurement.
- Clean thoroughly when the measurement is completed to avoid any contamination for the electrode's next use.

Warning: Do not place the electrode in viscous, organic liquids, such as heavy oils, glycerin (glycerol) or ethylene glycol, and in acetone or non-polar solvents, such as pentane or hexane.

Collecting data without Software connection

- Turn the Conductivity sensor on by pressing its power button.
- The sensor briefly displays its Bluetooth identification code. This ID code is also printed on the sticker located on the bottom side of the sensor box.
- Then the display shows:
  - the Bluetooth mode, Mobile or PC.
    Mobile indicates Bluetooth Low Energy mode which should be used when working with mobile devices (Android, iOS), Chromebook and Apple computers.
    PC indicates Bluetooth Classic which should be used for Windows computers.
  - the battery level, and
  - the current measured value.
- Now you can use the sensor as an independent measuring instrument.

Collecting data via the Bluetooth connection

Mobile devices, Chromebooks, and Apple computers

For mobile devices (Android, iOS), Chromebooks and Apple computers Bluetooth Low Energy technology is used for wireless communication. For these devices **do not pair** the sensor just use it directly in the Coach software.

- Turn the sensor on by pressing its power button.
- Ensure your sensor is set to Mobile mode.
  If the display shows in the top-left corner 'PC' first you must set the sensor to the Mobile mode. Turn off the sensor. Then press and hold the power button until the text 'Bluetooth mode Change Mobile' is shown, then release the button. The mode is set to 'Mobile' which means that Bluetooth Low Energy is used.
- Start the Coach 7 or Coach 7 Lite program/app.
- Select the Dashboard Activity 'Measurement with Wireless sensors'.
- On opening of the Activity Coach starts searching for sensors which are turned on and in the Mobile discovery mode. The found Bluetooth sensors appear in the list.
- Select the Conductivity sensor you want to connect to. If needed check the sensor's Bluetooth ID which is located on the sensor's bottom label.
- When the connection is established the Bluetooth symbol appears in the top-left corner of the sensor's display and the icon of the sensor appears showing the measured temperature values.
- Now you are ready to use the Conductivity sensor for your measurement.

Windows computers

For Windows computers, Bluetooth Classic technology is used for wireless communication. Before you start to use the sensor for measurement in Coach **you have to pair it**.

- Turn the Conductivity sensor on.
- Ensure your sensor is set to PC mode.
  If the display shows in the top-left corner 'Mobile' first you must set the sensor to the PC mode. Turn off the sensor. Then press and hold the power button until the text 'Bluetooth mode Change PC' is shown, then release the button. The mode is set to 'PC' which means that Bluetooth Classic is used.
- Pair your sensor.
  - Go to the Windows Settings **Bluetooth and other devices** and select **Add Bluetooth or other devices**. Select **Bluetooth device**.
  - Windows looks for Bluetooth devices and after a while lists discovered devices. The wireless sensors are listed with their Bluetooth IDs.
  - Select the sensor you want to connect to. If needed check the sensor's Bluetooth

ID which is located on the bottom label of your sensors.
  - When the connection is successfully established Windows indicates that the sensor is paired and ready to go.
  - Click **Done** to accept it. The sensor appears in the list of paired Bluetooth devices.
- Start the Coach 7 or Coach 7 Lite program.
- Select the Dashboard Activity 'Measurement with Wireless sensors'.
- Coach starts searching and displays the list with detected sensors, even if they are not paired.
- Select the Conductivity sensor you want to connect to. If needed check the sensor's Bluetooth ID which is located on the sensor's bottom label. If the sensor was not paired yet Coach will force you to pair the sensor first via Windows Settings.
- When the connection is established the Bluetooth symbol appears in the top-left corner of the sensor's display and the icon of the sensor appears showing the measured current values.
- Now you are ready to use the Conductivity sensor for your measurement.

Collecting data via the USB connection

For computers (Windows and Mac) the Conductivity sensor can also be used as USB sensor.

- Turn the Conductivity sensor on.
- Use the provided USB cable to connect the sensor to a USB port.
- Start the Coach 7 or Coach 7 Lite program.
- Select a Measurement Activity. If it is made for another interface choose **Use with Wireless sensors** during opening of the activity or right click the interface panel and choose **Change interface** in the activity.
- The connected USB sensor should be detected automatically, and its icon appears on the first empty sensor position in the Wireless sensors panel, or if the sensor was already predefined it changes its status from grey to green.
- When the connection is established the USB symbol appears in the top-left corner of the sensor's display and the icon shows measured data.
- Now you are ready to use the Conductivity sensor for your measurement.

Using the Conductivity Sensor with other sensors

It is very important to know that the Conductivity Sensor will interact with some other sensors, if they are placed in the same solution and they are connected via the USB to the same computer. This situation arises because the conductivity sensor outputs a signal in the solution, and this signal can affect the reading of another sensor. The following sensors cannot be connected to the same interface and placed in the same solutions:

- dissolved oxygen sensor,
- pH sensor,
- salinity sensor.

In such situation more sensors can be connected at the same time to the interface but only one at a time can be placed inside the solution to take readings.

This restriction is not valid when the sensors are used wirelessly.

Cleaning, storage and maintenance of the Conductivity electrode

The Conductivity electrode needs to be kept clean. Depending on the sample application, the electrode may require cleaning periodically to ensure accurate measurements.

- In most situations, water with a mild liquid detergent is an effective cleanser. Soak the electrode in warm water and a mild detergent for 15 minutes.
- Ethanol may be used to clean the electrode as long as the wash time is limited to a maximum of 5 minutes.
- Lime or hydroxide coating can be removed by soaking in a dilute acid solution such as 0.1 M hydrochloric acid or 0.5 M acetic acid for 15 minutes.
- To prevent cell damage, abrasives or sharp objects should not be used to clean an electrode.
- After cleaning, rinse well with distilled water, shake vigorously and leave to air-dry.
- Store the electrode dry.

Practical information

- Avoid scratching the inside electrode surfaces of the probe.
- The most common reason for inaccurate measurements is cross contamination of samples. Take care not to transfer droplets of one sample to another. Clean the electrode with distilled water between different samples.
- Be sure that samples are capped to prevent evaporation. It is best to fill sample bottles to the brim to prevent a gas such as carbon dioxide dissolving in the water sample.
- Do not use the sensor in a situation that could result in damage to the graphite plates in the cell chamber. Do not attempt to blot or wipe the inside of the cell.

- The automatic temperature compensation for this electrode operates over the range 5°C to 35°C, but it can be placed in solutions within a temperature range of 0 to 80°C.
- The conductivity electrode not only measures conductivity between the graphite plates but also, to a lesser extent, in a field to the sides of the electrode. In a narrow vessel, the walls may interfere with this field. If the electrode is held too close to the top of the liquid level or other objects (e.g. the bottom of a beaker) an incorrect reading may result.

Charging the batteries

An internal rechargeable battery (Li-Poly 3.7 V, 700 mAh) powers the sensor. The battery symbol located in the top-right corner of the sensor's display shows the battery level. When the battery level becomes critical, the battery gauge shows an empty battery. Use the provided cable to connect the sensor to a USB port for charging. A fully discharged battery requires up to 2 hours of charge time to become fully charged again. To prolong battery life, automatic power down turns the sensor off after 5 minutes of inactivity.
To replace the battery, use **only** the approved rechargeable batteries provided by CMA.

Suggested experiments

The Conductivity sensor can be used to perform a wide variety of experiments:

- Confirmation of the direct relation between conductivity and ion concentration in aqueous solutions. Concentration of unknown samples can be determined.
- Measurement of changes in conductivity resulting from photosynthesis in aquatic plants, with the resulting decrease in bicarbonate-ion concentration due to the carbon dioxide consumption.
- Monitoring the rate of reaction in a chemical reaction in which dissolved ions and solution conductivity varies with time due to ionic species being consumed or produced.
- Performing a conductivity titration to determine when stoichiometric quantities of two substances have been combined.
- Finding the rate at which ionic species diffuse through a membrane such as dialysis tubing.
- Monitoring changes in conductivity or total dissolved solids in an aquarium containing aquatic plants and animals. These changes could be due to photosynthesis or respiration.

Technical Specifications

Sensor kind	Digital (on-sensor digital conversion) 14-bit resolution
Measuring range	0 to 20 mS/cm
Resolution	0.01 mS/cm
Accuracy	±1% of full-scale reading
Response time	98% of full-scale reading in 5 s, 100% in 15 s.
Temperature	Compensation: automatic between 5°C and 35°C. Range: between 0°C and 80°C
Cell constant	1.0 cm-1, dip type, ABS body, parallel carbon (graphite) electrodes
Maximal sampling rate	100 Hz
Battery life after full charge	Approximately 4 hours Battery life varies by use, configuration, temperature, and many other factors; actual results will vary.
Connection	Bluetooth 5, Low Energy (Mac, Android, iOS) Bluetooth 2.1, Classic (Windows) USB 2.0 (type C)
Bluetooth ID	W04COND-xxx

Warranty:

The Conductivity sensor W04 is warranted to be free from defects in materials and workmanship for a period of 24 months from the date of purchase provided that it has been used under normal laboratory conditions. This warranty does not apply if the sensor has been damaged by accident or misuse.

Note: *This product is to be used for educational purposes only. It is not appropriate for industrial, medical, research, or commercial applications.*

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