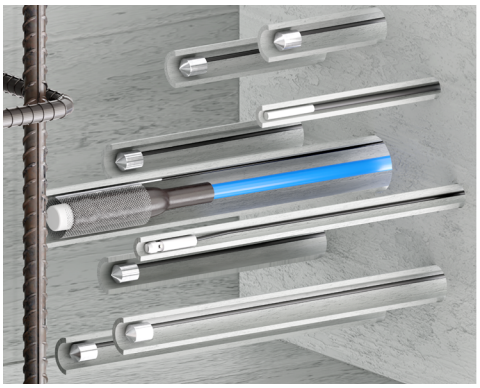
ENCARDIO RITE
METASENSING FOR MEGA STRUCTURES

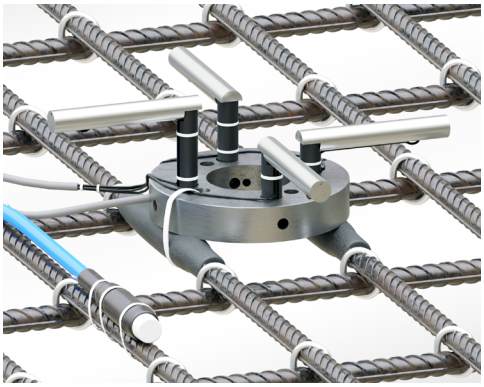
# CORRUSION MONITORING SYSTEM

## DATASHEET

**MODEL ECS-101**



Corrosion monitoring system in existing structure



Corrosion monitoring system in new structure

## OVERVIEW

Corrosion of reinforcement bars in concrete poses a significant challenge, leading to the premature deterioration of large-scale infrastructure worldwide. Such corrosion compromises the structural integrity and poses potential risks to people, surrounding communities and assets. Corrosion reduces the steel cross-section of the reinforcement bars, weakening the structure. Additionally, cracking and spalling decrease the steel-to-concrete bond strength, and the expansion of rust can lead to further concrete cracking.

Encardio-rite addresses this issue by offering a reliable and cost-effective early warning system for corrosion monitoring, tailored to detect and predict the initial corrosion stages in both existing and under construction concrete structures. The model ECS-101 corrosion monitoring system basically consists of electrodes/sensors embedded in concrete, data processing nodes, datalogger and data management software to monitor the current corrosion state and the rate of corrosion in the reinforcement bars.

With embedded sensors, the system provides accurate information about in-situ durability parameters of concrete structures, such as corrosion current density, concrete resistivity, ion concentration, and temperature. This diagnostic information enables early warnings about structural durability, allowing for timely maintenance strategies and the implementation of corrosion control measures. The system utilizes the following electro-chemical methods to evaluate and monitor corrosion activity over the long term:

- Potential measurement using reference electrode.
- Corrosion rate monitoring by means of linear polarization measurement.

The corrosion monitoring system is suitable for a wide range of environments, including inaccessible areas such as tunnels and bridges in corrosive marine settings, bridge decks, and underground parking garages exposed to de-icing salts. It is also ideal for structures like public swimming pools, amusement parks, and facilities exposed to acid rain, such as chimneys and smokestacks.

# FEATURES

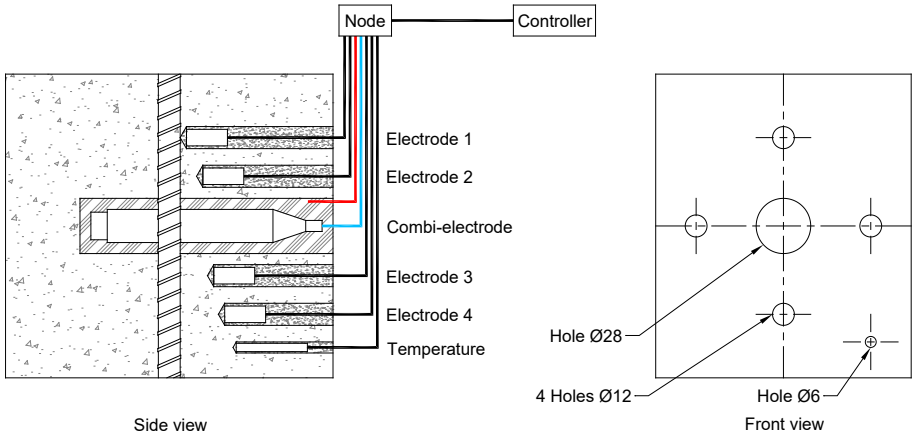
- **Real-time monitoring & alerts**: The system provides instant notifications via SMS or email when data surpasses set thresholds, ensuring prompt action during crucial events.
- **Adaptable sensor options**: For structures under construction as well as for existing structures.
- **Precision monitoring**: The system consistently monitors parameters like Corrosion Rate, Humidity, Temperature, Resistance, and Current in reinforced concrete. It utilizes potential measurements via a reference electrode and linear polarization for corrosion rate monitoring.
- **Environmental resilience**: It is engineered to withstand exposure to chlorides and carbonatization, critical elements in corrosion measurement.
- **Easy to install**: The system is designed for easy installaton in new or old structures.
- **Range:** 1 controller can be connected to a 100 nodes and has a range of 1 km.
- **Power flexibility**: Users can opt for battery, mains, or the eco-friendly solar power option (model ESP-12V-1A). For isolated locations, mains or solar power is recommended.
- **Data transfer options:** Model ECS-101C Controller Console can transmit data to a central cloud based remote server using cellular communication modem or internet over WiFi network.
- **Cloud data management:** All sensor data is securely uploaded to the Proqio cloud platform, offering round-the-clock access, advanced analytics, and visualization capabilities.
- **Online & manual measurements**: When paired with the ECS-101C Controller Console, the system delivers corrosion insights online.

  With model ECS-101R Zero-Ohm Ammeter, even the minute corrosion currents (micro-Amperes) can be measured manually. In case humidity is also to be manually measured, our model EDI-55 readout unit is available.

# PRODUCT OFFERING

The ECS-101 corrosion monitoring system incorporates 4-6 anodes (sensors) placed at varying depths, which can be adjusted based on concrete cover thickness, paired with a reference combi-electrode. The combi-electrode consists of a reference electrode and a mesh cathode. These monitor the progression of chloride or carbonation corrosion through the concrete cover of structures. To enhance the accuracy of the data, the system also includes humidity and temperature sensors.

The anodes are available in two models - ECS-101/01E designed for retrofitting onto existing structures, and ECS-101/01N suitable for deployment in structures that are under construction. These sensors are connected to measurement nodes, which transmit data via a single digital bus cable to the controller. The system is scalable, offering various solutions suitable for both small and large structures.




Typical installation scheme of a corrosion monitoring system installed in an existing concrete structure (single location)

# ECS-101 CORROSION SYSTEM COMPONENTS

## Sensors and nodes

| Component name | Description | |
|---|---|---|
| Reference electrode ECS-101/02R | The long-life electrode, used to measure the actual state of corrosion in reinforcement, provides stable voltage for over 30 years. Can be embedded in both new and existing structures.<br>It is a half-cell using manganese dioxide in a very alkaline electrolyte, placed in a stainless steel case and with an ionic membrane of cement mortar ensuring good affinity to the concrete. |  |
| Mesh cathode ECS-101/02M | Embedded over the reference electrode in concrete. Together, they are referred to as combi-electrode.<br>In retrofitted systems, combi-electrode is installed at the centre of the anodes. It provides corrosion rate through linear polarization measurement. |  <br>  |
| Metallic anode (retrofitting) ECS-101/01E | The anodes, made of the same material as reinforcement, are suitable to be installed in the **existing concrete structures**.<br>A group of 4 to 6 anodes are embedded at well-defined depths of the concrete cover, between the surface and the outermost layer of reinforcement, in a circular arrangement in 12 mm Ø drilled holes. |  |
| Metallic anode (embeddable) ECS-101/01N | A multi-sensory arrangement, designed for installation **during construction**. It consists of 4 steel anodes mounted over a circular noble metal cathode. Option of 6 anodes available on request.<br>It is cast into the concrete cover during construction, with the anodes positioned at well-defined distances between the concrete surface and the reinforcement. The reference electrode is installed nearby. |  |
| Temperature probe ECS-101/03T | Deployed to record temperature affecting the corrosion. It is embedded near anodes and is connected to the same measurement node. |  |
| Humidity probe ECS-101/04H (optional) | Deployed to record humidity affecting the corrosion. It is also installed near anodes but is connected to a separate humidity node. |  |
| Measurement node ECS-101MN | Placed near each monitoring location. Contains a Camur III node with an A/D converter, a microprocessor and has galvanic separation between analogue and digital side. It automatically monitors Linear Polarization Resistance (LPR), AC-resistance, potential, current and temperature.<br>It can connect up to 6 anodes, 1 reference electrode, 1 mesh electrode and 1 temperature probe. Data is transferred to the Controller console through a bus cable. |  |
| Humidity node ECS-101HN (optional) | Connects 2 humidity probes or 1 humidity and 1 temperature sensor. It consists of Camur III hum node and has a built-in power supply. It is placed near each monitoring location, data is transferred to the Controller console through a bus cable.<br>It can monitor sensor output in the range of 0-5 V. The input channels are galvanically separated from the bus side. |  |
| Bus cable | The bus cable connects all installed nodes in series; is terminated to the controller console. | |

## Datalogger and readout units

| | |
|---|---|
| Controller console ECS-101C | The controller console or datalogger houses Camur III control module, power supply, 4G router in a weatherproof enclosure.<br>Supports up to 100 nodes and has an internal memory of 1.5 million values. It controls the status of connected nodes, handles schedules and recordings and stores recorded data until they are transferred to the cloud. It powers the nodes through the bus cable. Data processing is split between the Controller and the Cloud-based software.<br>A repeater is available in case the distance is more than 1 km. |
| Zero-Ohm Ammeter ECS-101R | The handheld indicator measures minute corrosion currents in the range of micro-Amperes. It has up to 6 measuring channels for corrosion current and potential, along with temperature. It counters the effect of inserted resistance by keeping the voltage drop across the input terminals below a few microvolt, ensuring accurate, current readings without circuit interference. |
| Portable readout EDI-55 | In case humidity is also to be manually measured, our model EDI-55 readout unit is available. |


## ONLINE MEASUREMENTS

When connected to the ECS-101C Controller Console datalogging system, the system provides corrosion information through scheduled potential decay measurements, ensuring accurate potential measurement. The initial corrosion is discovered when threshold values of the potentials or current have been exceeded. The equilibrium potential is measured between the combi-electrode and individual electrodes within the concrete cover.

Key online measurements provided by the system include:

1. **Open circuit potential (OCP)** or Ecorr between standard cell and each of the 4 (or 6) anodes. OCP is highest between the standard cell and anode at greater depth from the surface.
2. **Resistivity** in Ohm cm between each of the 4 (or 6) anodes. This will be highest between electrodes 1 & 2 (figure on page 2).
3. **Linear polarization resistance (LPR)** to give corrosion rate and predict onset of corrosion in reinforcement concrete.

The system perturbs the anode slightly from its equilibrium potential by adjusting its potential by fixed amount (ΔE) with respect to the potential of reference electrode and monitoring the resulting current (ΔI)through the mesh or special cathode after a fixed time.

## OVERVIEW OF CORROSION

While reinforced steel bars, when ensconced in high-caliber concrete, are typically resistant to corrosion due to the concrete's inherent alkalinity (around pH 12/13), the porous nature of concrete introduces vulnerabilities. Concrete degradation generally occurs due to:

**Carbonation:** When carbon dioxide ($CO_2$) from the air penetrates the porous concrete, it reacts with calcium hydroxide ($Ca(OH)_2$) and calcium oxide (CaO) in the cement to form calcium carbonate ($CaCO_3$). This process, known as **carbonation,** lowers the concrete's alkalinity. A pH below 9 jeopardizes the protective oxide layer, making the reinforcement susceptible to corrosion, especially in moist and oxygen-rich environments.

**De-passivation:** Steel reinforcement bars are at risk from ingress of active ions like chlorides, especially in coastal areas or regions where de-icing salts are used. This reduces the concrete's electrical resistance, facilitating corrosion.

Corrosion initiates when carbonation depth exceeds the concrete cover or when chloride ions penetrate the concrete beyond a threshold level. Once started, corrosion of the steel reinforcement becomes self-sustaining, potentially increasing the dissolution rate to 10 µm/year. The resulting corrosion products expand, causing cracking, delamination, and spalling of the concrete. This damage further exposes the structure to $CO_2$, water, oxygen, and chlorides, potentially culminating in structural collapse.

## SPECIFICATION

| | |
|---|---|
| Range | 1000 mm; can be calibrated to 500 mm |
| Sensor resolution | 0.01 mm |
| Sensor accuracy[1] | Better than ± 0.4 mm |
| Sensor output | Digital output - SDI-12 serial interface or Modbus RS-485 (6 core bus cable) |
| Operating Temperature range | -20 to 80°C |
| Protection | IP67 |

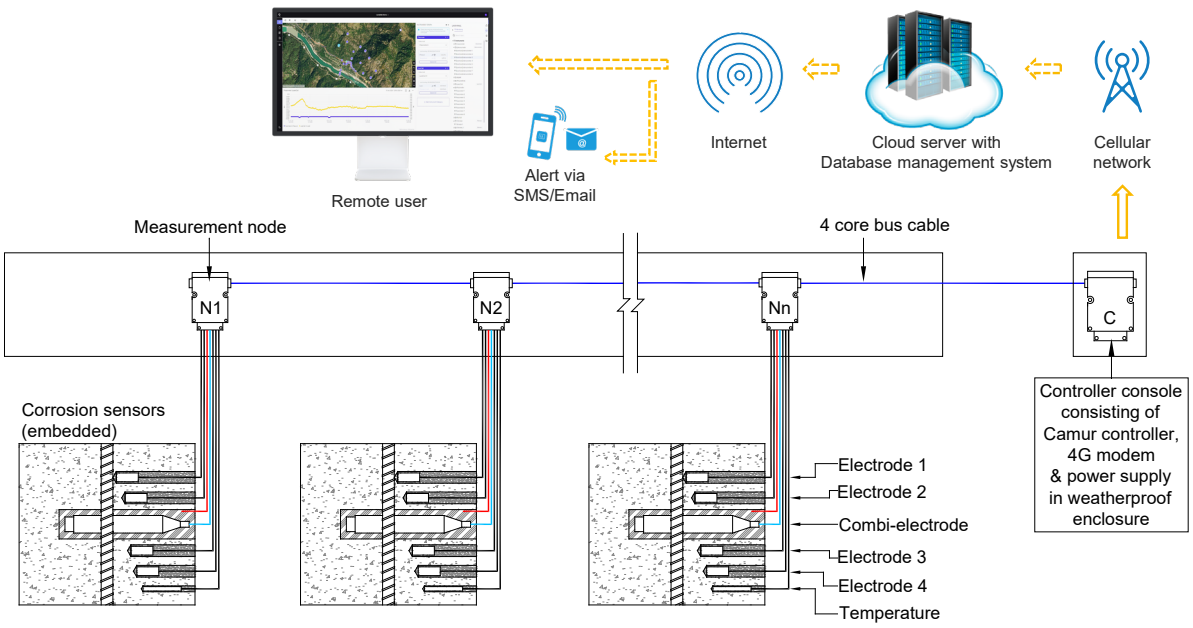
[1] As tested under lab conditions

## ORDERING INFORMATION

When placing an order, please provide the following details:

- **Anode probe type and number** - Whether it is for an existing structure or a new construction, and the number of anodes required. Options include:
  - **New structure**: ECS-101/01N-4 (4 anodes) or ECS-101/01N-6 (6 anodes)
  - **Existing structure:** ECS-101/01E-4 (4 anodes) or ECS-101/01E-6 (6 anodes)
- **Installation locations**: The total number of installation locations at a particular site.
- **Monitoring distance**: The distance between the monitoring locations and the controller console.
- **Data transmission**: The preferred medium for data transmission.
- **Power supply**: The desired power supply option.
- **Humidity monitoring**: Specify in case humidity sensor is required with humidity node.

The above details will enable us to offer a cost-effective corrosion monitoring solution tailored to your needs. Please note that clients are responsible for procuring any additional accessories and equipment required for installation.




Typical installation scheme for multiple corrosion monitoring systems installed at single site location in an existing concrete structure.

*All specifications are subject to change without prior notice





**Encardio-Rite Electronics Pvt. Ltd.** A-7, Industrial Estate, Talkatora Road, Lucknow, UP-226011, India | info@encardio.com | T: +91 522 2661039-320