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Technical Memory

Monitoring System for Membrane Cell Stack Electrolysers

DOC VERSION CONTROL

Date	Name	Changes
26-4-2021	Rubén Martín	Initial version.

Index

1 INSTALLATION STUDY

1.0 DESCRIPTION

This document contains Tecnosuti S.L's proposal for the design, manufacture and commissioning of a voltage and temperature monitoring system in the stack cells of a 5 cell tesbench and a 340-cell electrolyzer.

It is a design from scratch, tailor-made with the intention that it fits perfectly into the customer's requirements.

The proposed installation here includes the following features:

- High precision and repeatability system.
- Highly stable system with redundancy in critical elements.
- Modular and easy-to-install system. Removes hot-inserting modules without losing communication.
- Scalable system, can be adapted to any stack size.
- Configurable system, you can choose some system features and configure them in different ways according to speed and stability requirements.
- Robust mechanical system, design based and sized on finite element simulations of magnetoelectric and thermodynamic field sensitive parts.
- Modules with autotest and self-calibration of each cell.
- Alarm and Installation Error Management.

In the following points we describe a little more in depth the parts of the proposed installation.

1.1 INSTALLATION CONSIDERATIONS

As discussed in this budget, it envisages a design from scratch of an electrolyzer cell monitoring system in the considerations of a functional prototype test for 5 cells and 340 cells according to customer indications. See the quotes offered in paragraph 3.

As a system in development, many of the materials and stages of the project will be determined during the development of the project so this budget is still an approximate orientation in both R&D workload and materials.

For the realization of the first functional prototype, the one proposed for the installation of 5-cell tests in Switzerland, the Agile Methodology will be used to develop a prototype that meets the minimum requirements indicated by the customer and established as a target.

To do this we will develop an adaptive plan of evolutionary development and rapid manufacturing until we achieve the objectives of the first prototype. Subsequent prototypes and ecosystem will be continuously improved.

Thus, the objectives set for the first prototype agreed with the customer are:

- Cell voltage accuracy: 1mV
- Cell voltage range: from 1V to 4V
- Error in successive readings: +/- 1mV
- Cell temperature accuracy: 0,5°C
- Cell temperature range: -20°C to 200°C
- Operating ambient temperature 100°C

In addition, the following features have been assumed for prototypes:

- 8-channel modules for voltage measurement and 1-channel for temperature measurement every 8 cells of the electrolyzer.
- Copper interface to study in depth how electromagnetic interference affects the system.
- External communication interface: EtherNet IP.

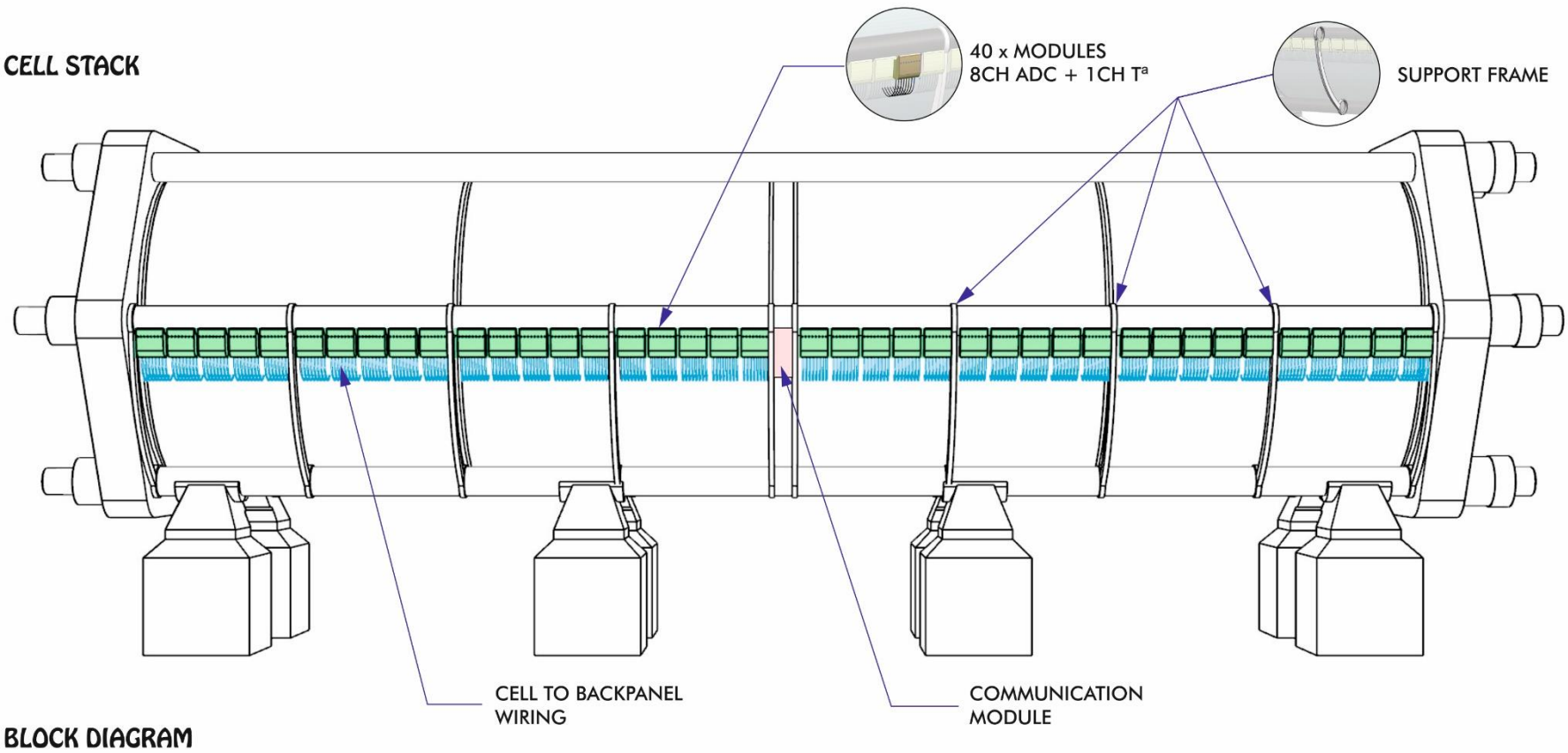
1.2 INSTALLATION DIAGRAM

1.3 BLOCK DIAGRAM - MINIMUM INSTALLATION

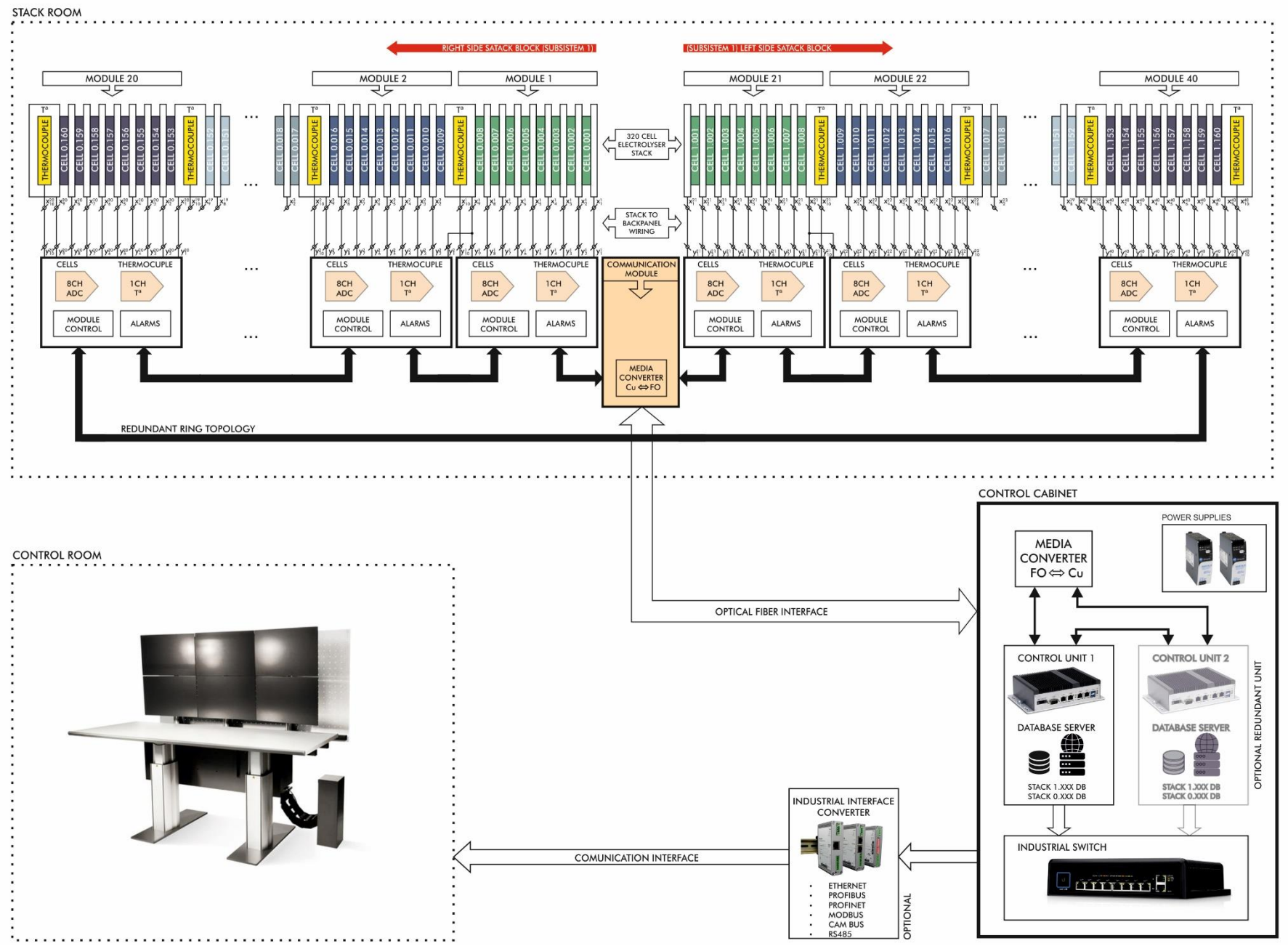
On the next page, we can see the Block Diagram of a minimal installation considering an installation of a Stack of 320 cells.

MINIMAL INSTALLATION

320 CELL ELECTROLYSER MONITORING SYSTEM



BLOCK DIAGRAM



1.4 HOW IT WORKS

GENERAL

Electrically, operation is very simple. Each module carries a digital analog converter (to be determined) for each channel (8 or 16 channels are the proposals) and 1 or 4 temperature sensors to make a single measurement or per quadrant respectively. We will consider for this budget the option of 8 channels and 1 temperature sensor.

These conversions are sent over an internal ring-redundant channel to the communication module that sends (via FO or Cupper) the information to the control cabinet. For these early prototypes we will use Cupper interface, until we see how the system behaves in the face of electromagnetic interferences.

The Control Unit located in the control cabinet that is located in a safe area, analyzes, stores and controls the data and alarms to serve them through the communication bus to be determined (EtherNet, CAMBUS, PROFIBUS, RS485, MODBUS...). From now on we will consider the communication protocol to be Ethernet IP.

MODULES´ MECHANICS

At the mechanical level, each module is physically designed to make the wiring between the cells and the module as simple as possible.

All modules are inserted into a mechanical that protects electronics. This mechanic is specially designed to withstand the harsh physical conditions of the environment and must be attached to the structural frame of the Cell Stack.

The width of a module will occupy the same as the number of cells to be measured in the Stack so that the total width of the modules will be the same of the Stack with, in this way straight wiring is simpler.

CONTROL CABINET

Both the Control Unit, media converters and data servers will be designed for a standard cabinet as they will be positioned in a safe zone.

1.5 BLOCK DIAGRAM - DUAL INSTALLATION

The system is widely morphological and can be adapted to different speed-stability needs required in the installation. This allows two or more subsystems to run in parallel within the same Stack to improve speed requirements if necessary.

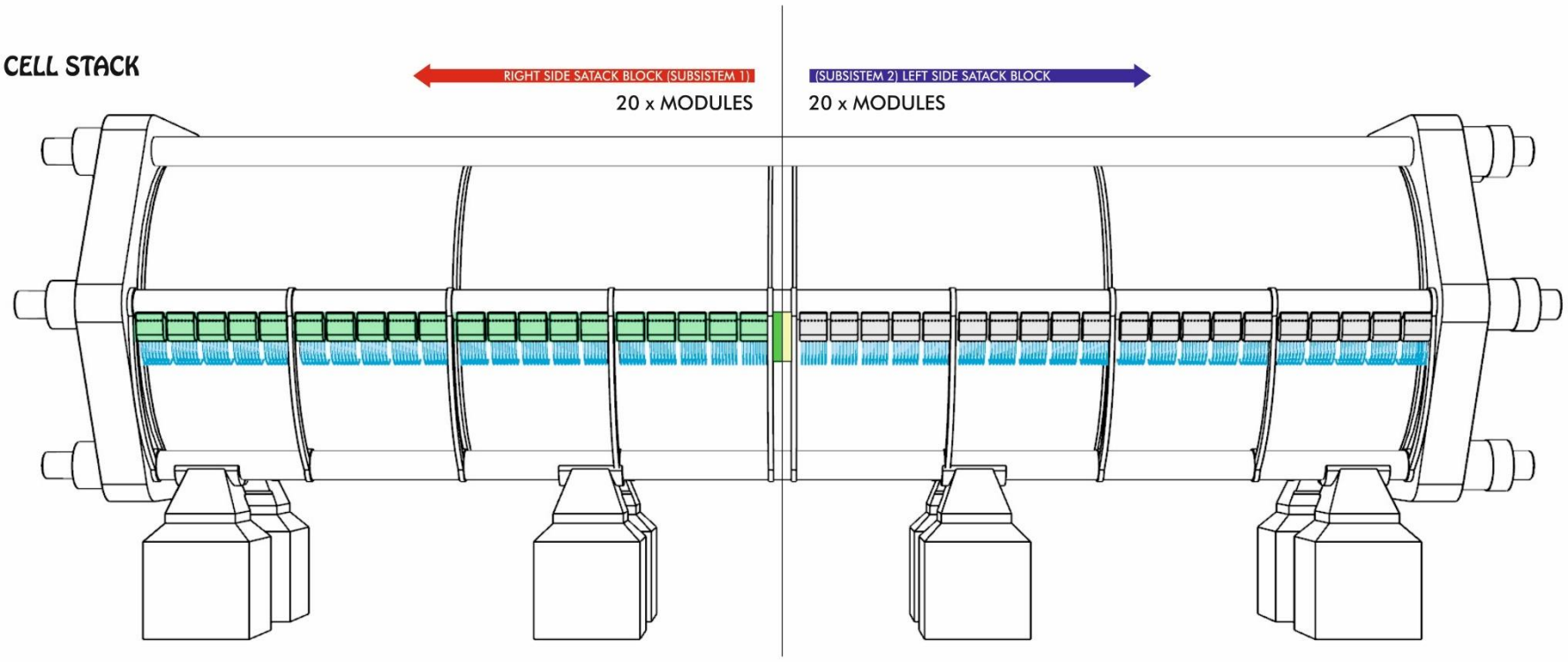
On the next page, we can see a block diagram of a dual installation on the same Stack used previously.

The direct consequences are:

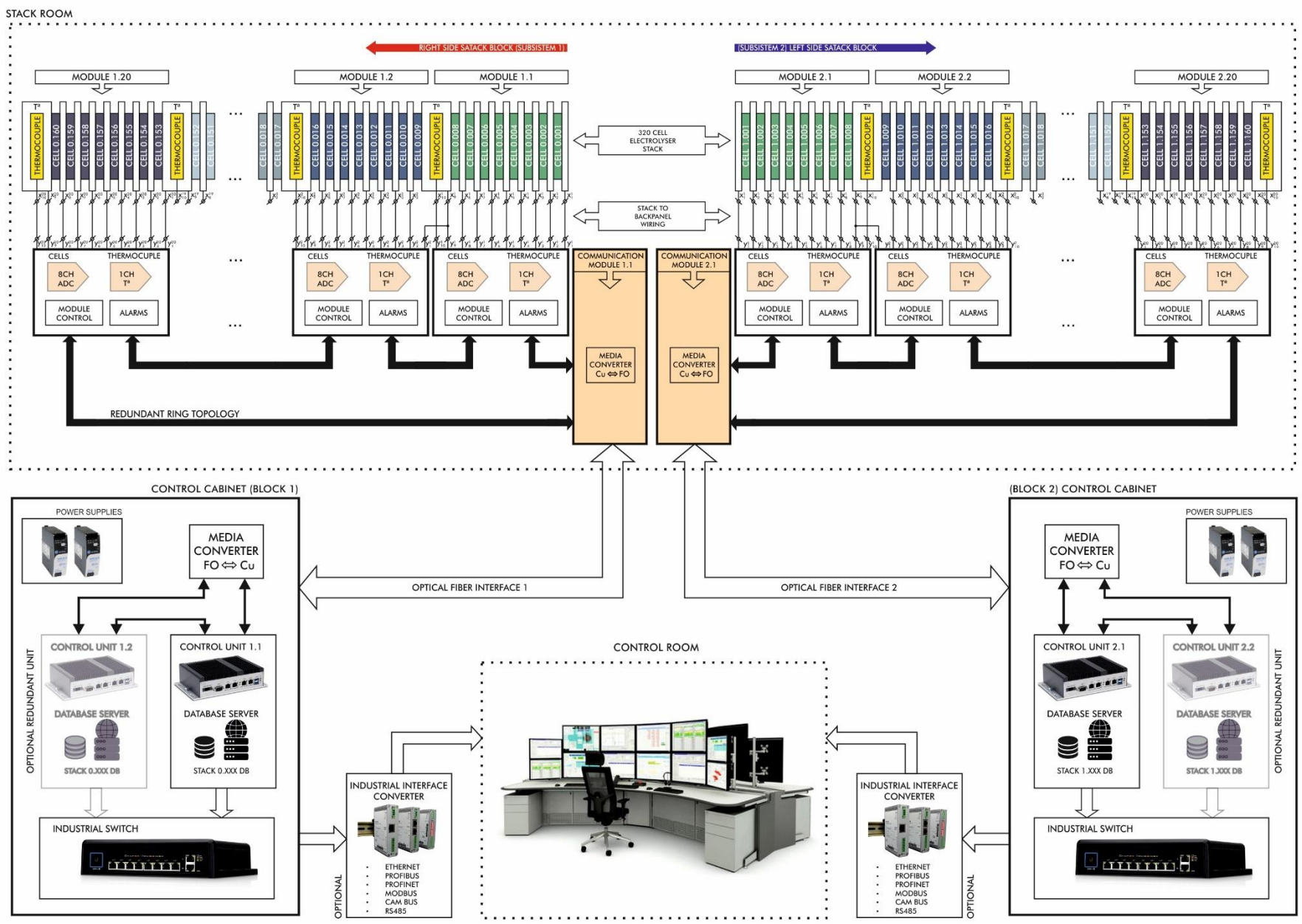
- an increase in the reading speed of the entire system.
- improved stability due to redundancy of control units.
- cost increase compared to the previous system.

DUAL INSTALLATION

2 x160 CELL ELECTROLYSER MONITORING SYSTEM



BLOCK DIAGRAM



2 ELEMENTS OF THE INSTALLATION TO BE QUOTED

2.1 SENSORS, FIXING AND POSITIONING

DESCRIPTION

In this section we quote how to perform the wiring of the cells from the stack to the module. We will indicate the position and how to perform the wiring of the cells and the fixing of the temperature sensor.

DESIGN

This section includes the design and best solution prior study of the best option.

It does not include the realization which must be carried out by the Stack manufacturer.

DOCUMENTATION

The necessary documents will be provided.

2.2 MECHANICAL AND ELECTRONIC SUPPORT

DESCRIPTION

In this phase we will develop a support structure to place the cell reading modules and associated electronics that join the modules together and with the Communication Module. This electronics in which modules are inserted is usually named as backpanel.

The modules structure with the backpanel will be fixed to the Stack's own structural frame. that will be the least invasive possible.

3D MECHANICAL AND ELECTRONIC DESIGN MCAD-ECAD

It will be 3D designed, modeling and simulating the structure to withstand loads in the worst conditions.

Support electronics for the modules or backpanel will also need to be designed. This electronics is where the modules are inserted and where data and control buses circulate. These buses are shared by all Acquisition Modules and controlled by the Communication Module. Power supplies for the modules are also wired in the backpanel.

MANUFACTURING

The support structure manufacturing process will depend on the conclusions we draw during the study of possible solutions.

Manufacturing costs will depend on stack size, number of modules and number of orders.

INSTALLATION

The installation will be at the behed of the stack manufacturer.

DOCUMENTATION

We will provide all necessary documentation for the installation of the support structure.

2.3 ACQUISITION MODULES

DESCRIPTION AND FEATURES

The reading modules will be responsible for reading the voltages in 8 cells and the temperature in cell number 8.

The electrical characteristics agreed with the customer and indicated in the considerations section, are as follows:

- Cell voltage accuracy: 1mV
- Cell voltage range: from 1V to 4V
- Error in successive readings: +/- 1mV
- Cell temperature accuracy: 0,5°C
- Cell temperature range: -20°C to 200°C
- Operating ambient temperature 100°C

MECHANICAL AND ELECTRONIC DESIGN MCAE - ECAD

The design of the Data Acquisition Modules includes:

- Design of a housing that isolates and protects electronics from harsh physical and electromagnetic conditions outside. See simulations section.
- The design and assembly of the electronics needed to perform the readings and manage the module.

SIMULATIONS

FEM CFD Magnetoelectric and Thermodynamic simulations for the calculation of the modules insulation and cooling system.

Particular care will be taken on the following issues that directly influence the stability of the system:

- Temperature. CFD thermodynamic simulations, to ensure a working temperature within the operating range of electronic components. The necessary decisions shall be taken to achieve an optimal working temperature by using and design heatsinks or forced flows as necessary.
- EMC isolation. The aim shall be to divert the intense magnetic field generated under nominal conditions from the sensitive parts of the electronics by varying the reluctance of the medium, for this purpose magnetic FEM simulations of the designed modules housing case will be carried out.
- EMC interference. During the start-off of the electrolyzer, currents induced by the variable magnetic field can damage nearby electronic components. Areas where higher stresses will appear must be pointed to accommodate the electronic design and avoid damage.

MANUFACTURING

Both electronics and mechanical manufacturing will use rapid prototyping services for early iterations.

The final production order will be launched to local electronic companies specialized in electronic assembly and with large production capacity. Costs will be reduced.

The final mechanics will also be launched to trusted local companies to improve costs.

INSTALLATION

The modules will be installed during the commissioning phase by Tecnosuit or qualified personnel.

DOCUMENTATION

User and service manuals of the Data Acquisition Modules shall be drawn up.

2.4 COMMUNICATION MODULE

DESCRIPTION AND FEATURES

The Communication Module is responsible for transporting the data from the Acquisition Module readings to the Control Unit in the Control Cabinet located in a safe area.

As mentioned in the considerations, until we see how the interference from the environment affects this communication, we will use a copper link and if necessary, we would move on to make a link by Fiber Optics.

MECHANICAL AND ELECTRONIC DESIGN MCAE - ECAD

Like Data Acquisition Modules, the Communication Module is also mounted on the backpanel near the Stack so it shares the two design aspects listed previously:

- Design of a housing that isolates and protects electronics from harsh physical and electromagnetic conditions outside. See simulations section.
- The design and assembly of the electronics necessary to carry out the management and control of the readings of the Acquisition Modules and Communication Module with the Control Unit.

SIMMULATIONS

FEM CFD Magnetoelectric and Thermodynamic simulations for the module insulation and cooling calculation.

Particular care will be taken on the following issues that directly influence the stability of the system:

- Temperature. CFD thermodynamic simulations, to ensure a working temperature within the operating range of electronic components. The necessary decisions will be taken to achieve an optimal working temperature.
- EMC isolation. The aim shall be to divert the intense magnetic field generated under nominal conditions from the sensitive parts of the electronics by varying the reluctance of the medium, for this purpose magnetic FEM simulations of the designed modules housing case will be carried out.
- EMC interference. During the start-off of the electrolyzer, currents induced by the variable magnetic field can damage nearby electronic components. Areas where higher stresses will appear must be pointed to accommodate the electronic design and avoid damage.

MANUFACTURING

For prototypes, both the manufacture of electronics and the mechanics thereof will be carried out using rapid prototyping services.

Final production order will be launched to local electronic companies. Costs will be reduced.

The final mechanics will also be launched to trusted local companies to lower costs.

INSTALLATION

The modules will be installed during the commissioning phase by Tecnosuit or qualified personnel.

DOCUMENTATION

User and service manuals of the Communication Module shall be drawn up.

2.5 CONTROL UNIT

DESCRIPTION AND FEATURES

The Control Unit is located in the Control Cabinet in a safe area and is responsible for collecting the data that arrives by the bus and adapting it so that they can be read by the industrial PC that lifts the database and the server. The data can be accessed from the Control and Monitoring Room and Other Networks.

MECHANICAL AND ELECTRONIC DESIGN MCAE - ECAD

This electronics is in a safe area with lower incidence of electromagnetic interference and reduced thermal and mechanical stress so no specific FEM simulations will be required to carry out this electronic.

Like Acquisition and Communication Modules, a custom housing will be designed or a catalog housing will be used as decided during the design process.

PROGRAMMING

In this part we value the development of the programming in the Control Unit and the industrial PC, taking into account the following needs:

- Firmware programming, the control unit will have one or more drivers to be programmed.
- DSP programming, filters will be implemented to improve communication and Data Acquisition.
- Database and IP Server. The industrial PC will need to develop:
    - Driver to communicate with the Control Unit.
    - A specific software to collect data.
    - One or more Databases to store the data read.
    - A Data Server to access data from the Monitoring Room or Other Networks.

MANUFACTURING

As with the other modules, for prototypes, both the manufacture of electronics and the mechanics thereof will be carried out using rapid prototyping services.

The final production order will be launched to local electronic companies specialized in electronic assembly and with large production capacity. Costs will be reduced.

The final mechanics will also be launched to trusted local companies to improve costs.

INSTALLATION

This nodule shall be delivered mounted on the control cabinet, so the costs arising from the installation are valued in 2.7 section.

DOCUMENTATION

User and service manuals of the Control Unit shall be drawn up.

2.6 INDUSTRIAL OUTPUT INTERFACE MODULE:

DESCRIPTION

It is an optional module to communicate with the system through a specific industrial bus other than the system native (Ethernet).

DESIGN

In this case, we will opt for existing adaptation modules and incorporate it into the ecosystem of our product according to the needs of the customer. What we value here is the adaptation and integration into our system.

Options, among others, are:

- EtherNet IP (native protocol)
- Profibus
- Profinet
- ModBus
- Cam Bus
- RS 485

INSTALLATION

This nodule will be delivered assembled to the Control Cabinet, so the costs arising from the installation are rated at the next point.

DOCUMENTACIÓN

The required documentation will be generated.

2.7 CONTROL CABINET

DESCRIPTION

The control cabinet contains the components necessary to operate the Electrolyte Cell Measurement and Monitoring System proposed herein and detailed in previous points.

PARTS

Inside the cabinet we can find the following materials that we quote in this budget:

- CABINET. The size will depend on the installation and the number of subsystems we want to monitor.
- PSU. The power supplies required for the Control Unit, the Acquisition and Communication Modules and the rest of the system components. A minimum of 4 PSUs (2 PSUs for Acquisition Modules, 1 PSU for Control Unit, 1 PSU for the rest of the system). The final number will depend on the system.
- INSOLATIONS AND PROTECTIONS. Signals and feeds to the Stack Room will have Intrinsic Safety Barriers.
- INDUSTRIAL PC. An industrial PC is required for the data server.
- INDUSTRIAL SWITCH. An industrial switch will be required as a hub.

WIRING AND INSTALLATION

Initial wiring and testing will take place at Tecnosuit's facilities.

The installation of the cabinet will be carried out by the customer.

DOCUMENTATION

The necessary documentation will be generated.

2.8 OTHERS

DESCRIPTION

Other aspects and general budget issues that have not been taken into account in previous blocks are then valued.

BUS

At this point we value issues related to the wiring of the communication bus between the Stack and the Control Cabinet assuming a distance of 20m between the two.

- Communication cable the main bus.
- Secondary bus communication cable.
- Power cables.
- Cable holding. Cable protectors and pipelines.

INSTALLATION DOCUMENTATION

General documentations.

USER MANUALS AND MAINTENANCE

Drafting of general manuals.

COMMISSIONING AND SERVICE DOCUMENTATION

Drafting documentation for commissioning.

START-UP AND VALIDATION COSTS

Here we value the costs for two people for 40 hours of work:

- Salaries
- Displacement, maintenance and derived costs.

TRAINING SERVICES

Services to be determined with the customer.

3 SUMMARY OF RESOURCES AND EXPENSES

3.1 MANUFACTURING AND VALIDATION - 5-CELL PROTOTYPE

DESCRIPTION

This budget includes the tasks necessary for the development, manufacture and validation of a membrane electrolyzer cell monitoring system in a 5-cell test scenario at Switzerland facilities.

Index	Name	R&D (h)	Cost (€)	Quantity	Total (€)	Notes
2.1	SENSORS, FIXING AND HOLDING					
	DESIGN	80			*0,00 €*	
	DOCUMENTATION	80			*0,00 €*	
2.2	MECHANIC AND ELECTRONIC SUPPORT					
	MECHANICAL DESIGN	160			*0,00 €*	
	ELECTRONIC DESIGN	160			*0,00 €*	
	MECHANICAL MANUFACTORING		500,00 €	2	*1.000,00 €*	5 Cell Stack
	ELECTRONIC MANUFACTORING		500,00 €	1	*500,00 €*	5 Cell Stack
	DOCUMENTATION	120			*0,00 €*	
2.3	DATA ADQUISITION MODULES					
	MECHANICAL DESIGN	320			*0,00 €*	
	ELECTRONIC DESIGN	320			*0,00 €*	
	SIMULATIONS	320			*0,00 €*	
	MECHANICAL MANUFACTORING		500,00 €	5	*2.500,00 €*	5 Cell Stack
	ELECTRONIC MANUFACTORING		300,00 €	5	*1.500,00 €*	5 Cell Stack
	DOCUMENTATION	320			*0,00 €*	
2.4	COMMUNICATION MODULE					
	MECHANICAL DESIGN	240			*0,00 €*	
	ELECTRONIC DESIGN	320			*0,00 €*	
	SIMULATIONS	240			*0,00 €*	
	MECHANICAL MANUFACTORING		500,00 €	1	*500,00 €*	
	ELECTRONIC MANUFACTORING		400,00 €	1	*400,00 €*	
	INSTALLATION				*0,00 €*	
	DOCUMENTATION	240			*0,00 €*	
2.5	CONTROL UNIT					
	MECHANICAL DESIGN	120			*0,00 €*	
	ELECTRONIC DESIGN	400			*0,00 €*	
	PROGRAMATION	560			*0,00 €*	
	MECHANICAL MANUFACTORING		100,00 €	1	*100,00 €*	
	ELECTRONIC MANUFACTORING		1.000,00 €	1	*1.000,00 €*	
	DOCUMENTATION	320			*0,00 €*	
2.6	INDUSTRIAL INTERFACE ADAPTOR					
	DESIGN	160			*0,00 €*	
	DOCUMENTATION	120			*0,00 €*	
2.7	CONTROL CABINET					
	CABINET		1.000,00 €	1	*1.000,00 €*	
	PSUs		200,00 €	4	*800,00 €*	
	INSOLATORS PROTECTIONS		500,00 €	1	*500,00 €*	
	INDUSTRIAL PC		1.500,00 €	1	*1.500,00 €*	
	INDUSTRIAL SWITCH		500,00 €	1	*500,00 €*	
	MANUFACTURING	240			*0,00 €*	
	DOCUMENTATION	240			*0,00 €*	
2.8	OTHER ISSUES					
	BUS		300,00 €	2	*600,00 €*	length 2m
	DOCUMENTATION GENERAL	320			*0,00 €*	
	STARTUP, SERVICE AND VALIDATION		6.000,00 €	1	*6.000,00 €*	7 days, 2 technicians
	TRAINING AND FORMATION				*0,00 €*	consult this service

R&D Workload (h): 5400	**Manufacturing: *18.400,00 €***

3.2 MANUFACTURING AND VALIDATION - 320-CELL PROTOTYPE

DESCRIPTION

This budget includes the tasks necessary for the development, manufacture and validation of a membrane electrolyzer cell monitoring system in a real 320-cell scenario at the Austrian facility.

Index	Name	R&D (h)	Cost (€)	Quantity	Total (€)	Notes
2.1	SENSORS, FIXING AND HOLDING					
	DESIGN	80			*0,00 €*	
	DOCUMENTATION	80			*0,00 €*	
2.2	MECHANIC AND ELECTRONIC SUPPORT					
	MECHANICAL DESIGN	160			*0,00 €*	
	ELECTRONIC DESIGN	160			*0,00 €*	
	MECHANICAL MANUFACTORING		500,00 €	10	*5.000,00 €*	320 Cell Stack
	ELECTRONIC MANUFACTORING		500,00 €	8	*4.000,00 €*	320 Cell Stack
	INSTALLATION				*0,00 €*	Customer
	DOCUMENTATION	120			*0,00 €*	
2.3	DATA ADQUISITION MODULES					
	MECHANICAL DESIGN	320			*0,00 €*	
	ELECTRONIC DESIGN	320			*0,00 €*	
	SIMULATIONS	320			*0,00 €*	
	MECHANICAL MANUFACTORING		500,00 €	40	*20.000,00 €*	320 Cell Stack
	ELECTRONIC MANUFACTORING		300,00 €	40	*12.000,00 €*	320 Cell Stack
	DOCUMENTATION	320			*0,00 €*	
2.4	COMMUNICATION MODULE					
	MECHANICAL DESIGN	240			*0,00 €*	
	ELECTRONIC DESIGN	320			*0,00 €*	
	SIMULATIONS	240			*0,00 €*	
	MECHANICAL MANUFACTORING		500,00 €	1	*500,00 €*	
	ELECTRONIC MANUFACTORING		400,00 €	1	*400,00 €*	
	INSTALLATION				*0,00 €*	
	DOCUMENTATION	240			*0,00 €*	
2.5	CONTROL UNIT					
	MECHANICAL DESIGN	120			*0,00 €*	
	ELECTRONIC DESIGN	400			*0,00 €*	
	PROGRAMATION	560			*0,00 €*	
	MECHANICAL MANUFACTORING		100,00 €	1	*100,00 €*	
	ELECTRONIC MANUFACTORING		1.000,00 €	1	*1.000,00 €*	
	DOCUMENTATION	320			*0,00 €*	
2.6	INDUSTRIAL INTERFACE ADAPTOR					
	DESIGN	160			*0,00 €*	
	DOCUMENTATION	120			*0,00 €*	
2.7	CONTROL CABINET					
	CABINET		1.000,00 €	1	*1.000,00 €*	
	PSUs		200,00 €	4	*800,00 €*	
	INSOLATORS PROTECTIONS		500,00 €	1	*500,00 €*	
	INDUSTRIAL PC		1.500,00 €	1	*1.500,00 €*	
	INDUSTRIAL SWITCH		500,00 €	1	*500,00 €*	
	MANUFACTURING	240			*0,00 €*	
	DOCUMENTATION	240			*0,00 €*	
2.8	OTHER ISSUES					
	BUS		300,00 €	20	*6.000,00 €*	length 20m
	DOCUMENTATION GENERAL	320			*0,00 €*	
	STARTUP, SERVICE AND VALIDATION		6.000,00 €	1	*6.000,00 €*	7 days, 2 technicians
	TRAINING AND FORMATION				*0,00 €*	consult this service

R&D Workload (h): 5400	Manufacturing: *59.300,00 €*