SENSORS
PETERCEM

MAFELEC TEAM
CREATING SMART AND SUSTAINABLE INTERFACES

Current Sensor – RFCS 1000&1500 A (Industry)

APPLICATION NOTE

A modern and efficient current sensor to measure AC, DC and pulsating currents with a galvanic insulation between primary and secondary circuits, able to measure currents from 10A to 3000A.

KEY FEATURES

- Rectangular design, to facilitate integration with busbars
- Compact dimensions to save up to 30% of space and reduce overall dimensions of the equipment
- A wide measurement range, up to 3 times nominal current value
- High level of accuracy
- Good behavior on presence of magnetic disturbances

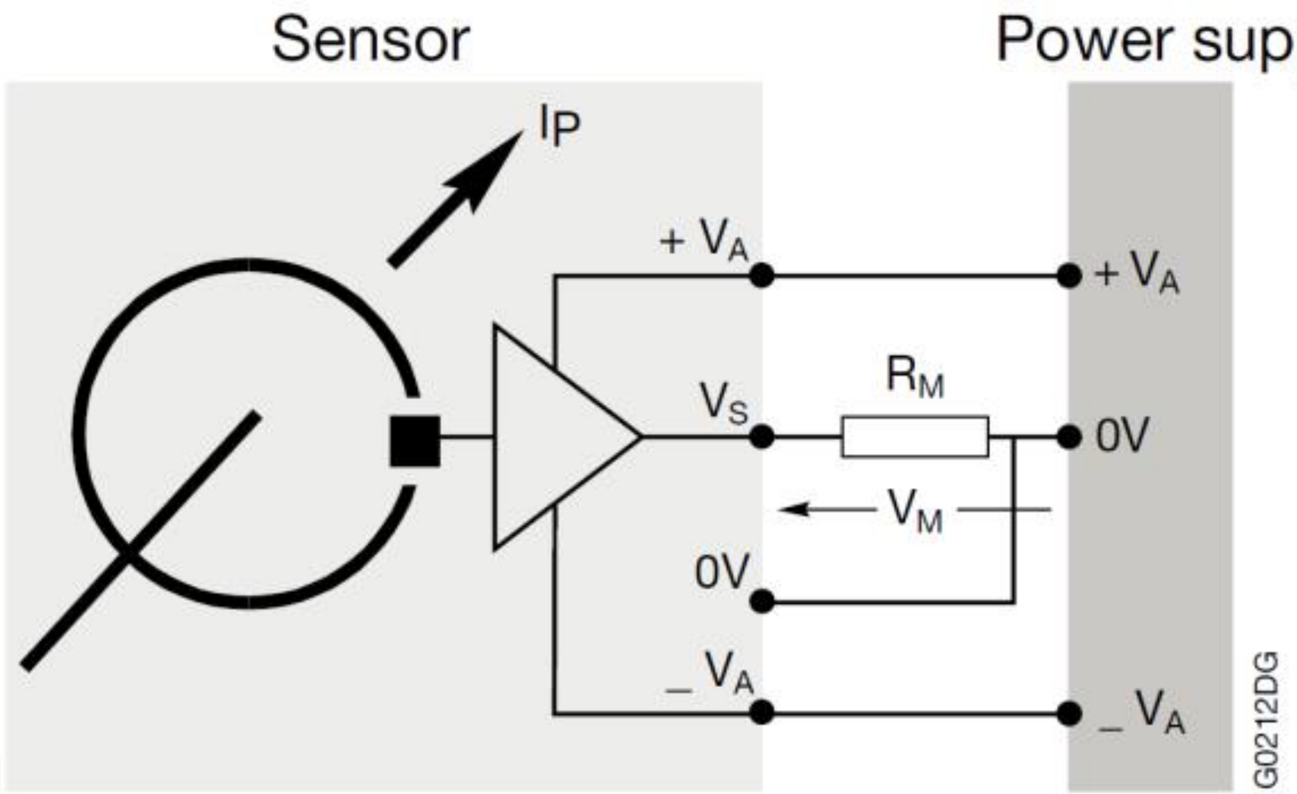
APPLICATIONS

INDUSTRIAL

- Uninterruptible Power Supplies (UPS)
- Switched Mode Power Supplies (SMPS)
- Power supplies for welding applications
- Static Converter for DC drives
- AC variable speed drives
- Servo motor drives
- Solar farm inverters
- Battery chargers
- Energy Storage System (ESS)
- Battery supplied application

At the beginning, we have developed a new range of sensors with a new technology (electronic measurement of DC/AC/pulsed currents) which is an electronic design and galvanic separation to ensure the protection between the primary circuit and the secondary circuit.

Concerning the features, this sensor based on Hall Effect use a new kind of technology, as known as the open loop technology.



Schematic diagram: RFCS sensor (open loop technology)

The principle:
The primary current Ip creates a field in the sensor's magnetic circuit. The magnetic field is sensed by the hall probe, which supplies a voltage to the amplifier block. The amplifier output generates a calibrated voltage VM proportional to the magnetic field and therefore to the primary current.

The field strength is assumed proportional to Ip:
→ Vs = k x Ip (k is a calibration constant)

The strengths of this technology are that this is a low cost solution (it will be more profitable for the end users), the voltage output (lower value), the low power consumption (more environmental friendly), adaptable to all forms of signal (AC/DC, pulse, etc…) and built with a galvanic isolation (ensure the reliability of the sensor).

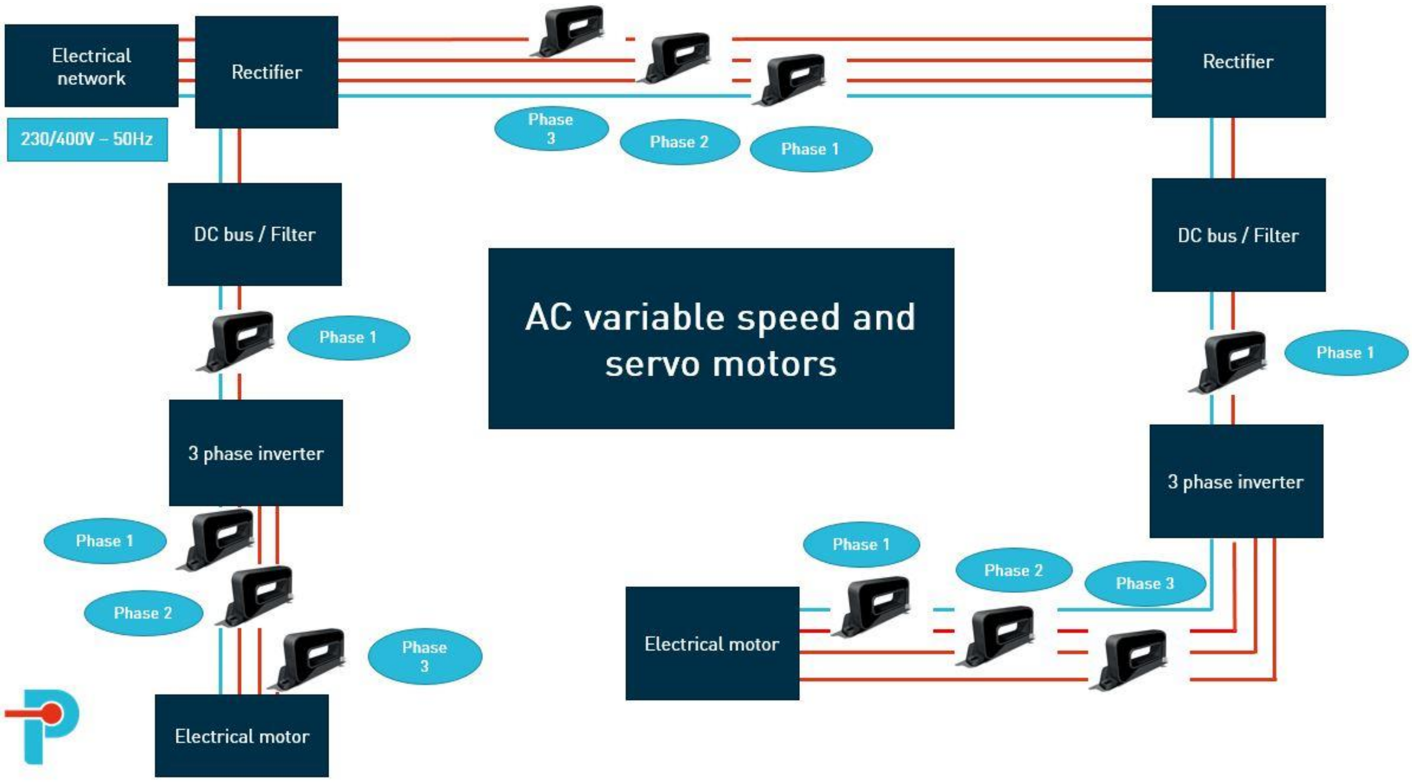
The advantages of this new sensor are various:

- High level of accuracy (<1%)
- Rectangular design (easy to fit with the bus bars)
- A wide measurement range (up to 3 times nominal current)
- Low insertion losses (we have developed our sensor in order to reduce hysteresis and eddy current losses)
- Easy installation (the sensor is only installed by fitting 2 M5 screws on the 2 sides of the sensor)
- Low power consumption (<0,3W which is minimal)
- Small size and space saving (this is a complete new design that it is smaller (reduced high size) and with a reduced width as well)
- High immunity to magnetic disturbances

FYI: You can consider that your RFCS sensor is able to measure a current with a good accuracy from 1/10 In to 2 In (nominal current).

Applications

- AC variable speed drives and servo motor drives

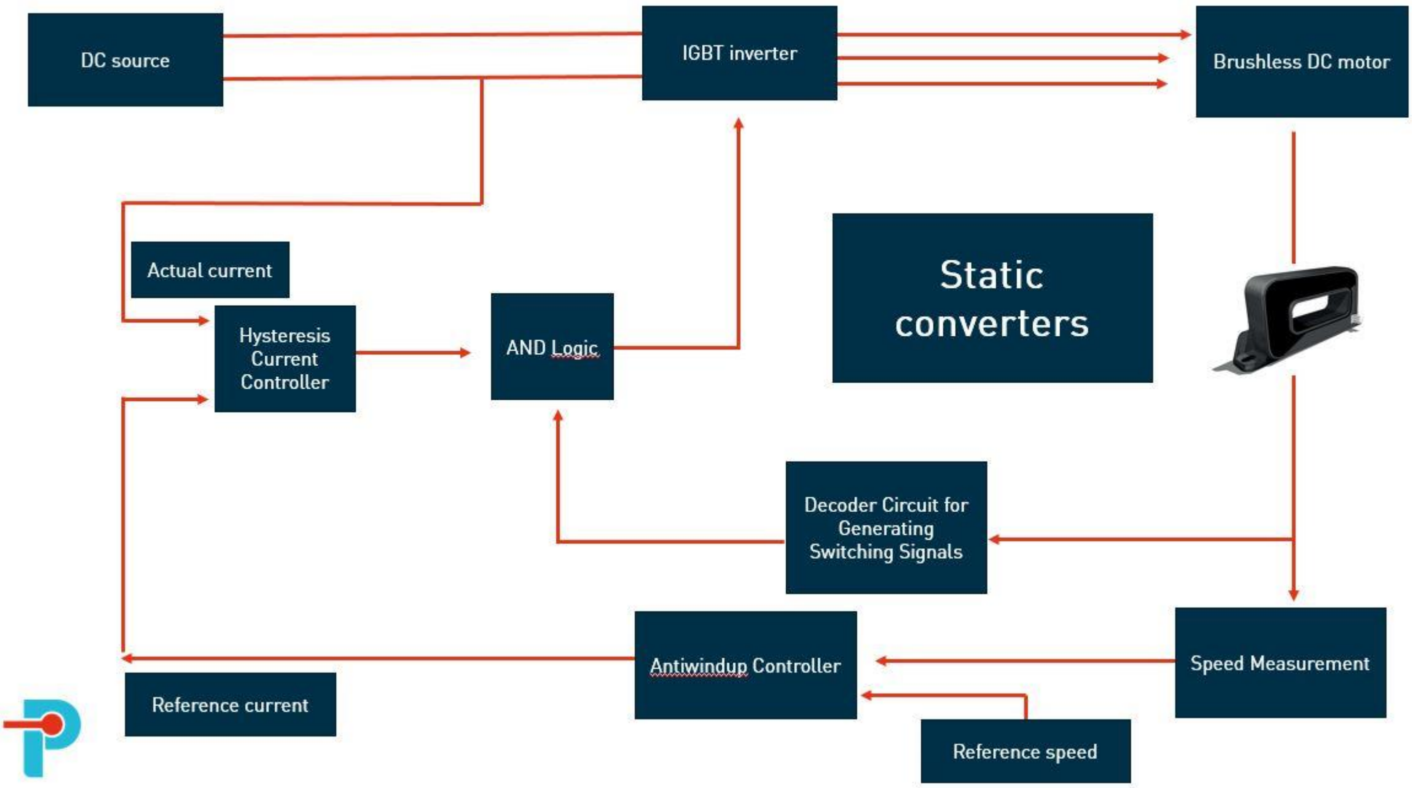


Each electrical motors are needed for running fans or compressors for example and are directly connected to 3-phase inverter. A three-phase inverter is an electronic device that converts direct current (DC) power into three-phase alternating current (AC) power. It is a crucial component in many electrical systems where a three-phase power supply is required.

Each 3 phase inverter are linked to DC bus/filter that DC bus carries direct current between different components in a system, and a DC filter is a component that helps smooth or filter the DC voltage on the bus, ensuring a more stable and controlled power supply. At least, Rectifier upstream is an electrical device that converts alternating current (AC) into direct current (DC).

The primary purpose of a rectifier is to change the direction of the current flow, allowing only the positive half cycles of the AC waveform to pass through while blocking the negative half cycles. Consequently, our RFCS current sensors are able to measure with accuracy each phase on your network after the electrical motor or the DC/bus filter or the rectifiers in order to monitor perfectly your electrical grid.

- Static converters for DC motor drivers

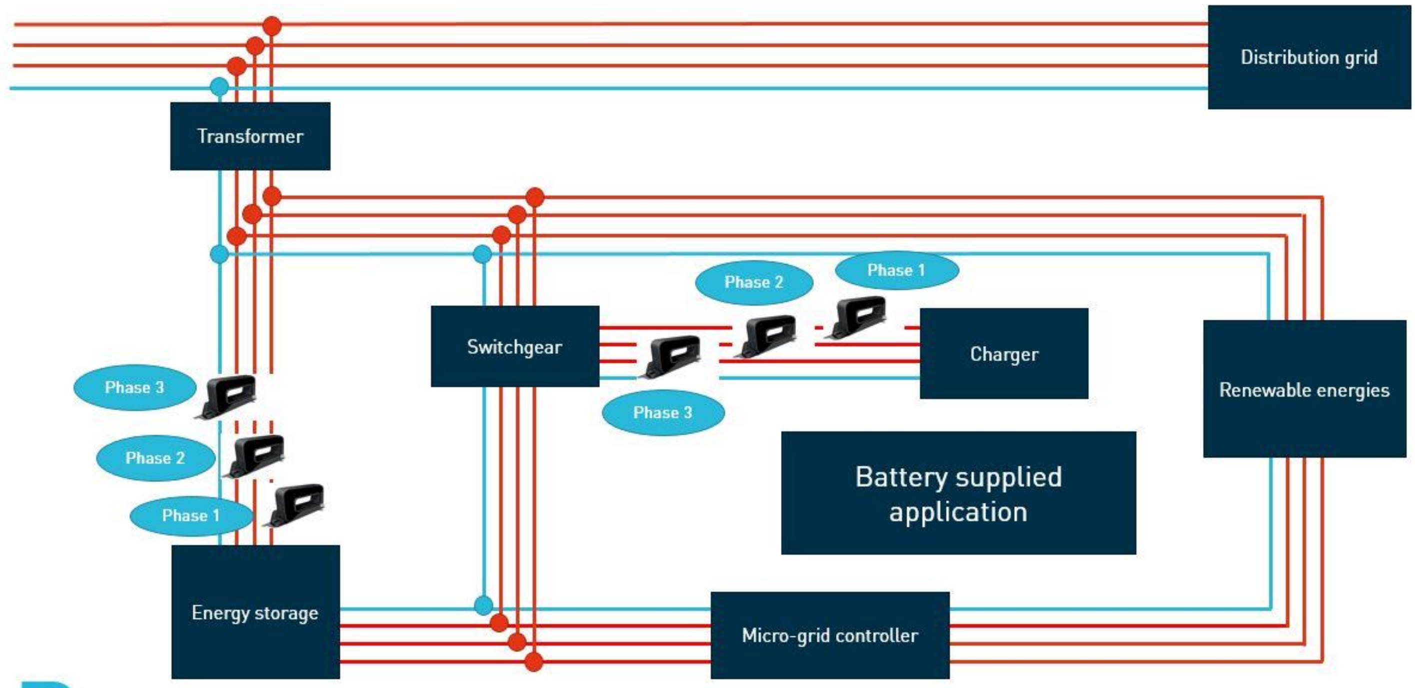


Each brushless DC motor are linked to RFCS current sensors (Hall sensor) on each phase of the motor. The RFCS will measure instantaneously on each phase the current. On the one hand, this value will serve for controlling the speed measurement as well give the value to the decoder circuit for generating switching signals.

The speed measurement as well as the reference speed will determine the antiwindup controller with an algorithm. This value will be used with an actual current to create a new algorithm and determine the hysteresis current controller.

The value of decoder circuit as well as the hysteresis current will use a logic device in order to give this value to the IGBT inverter. Then, the IGBT, which is insulated-gate bipolar transistor, will let or cut the current to the brushless DC motor. Globally, the RFCS is mandatory to ensure the reliability and performance to the DC motor drives.

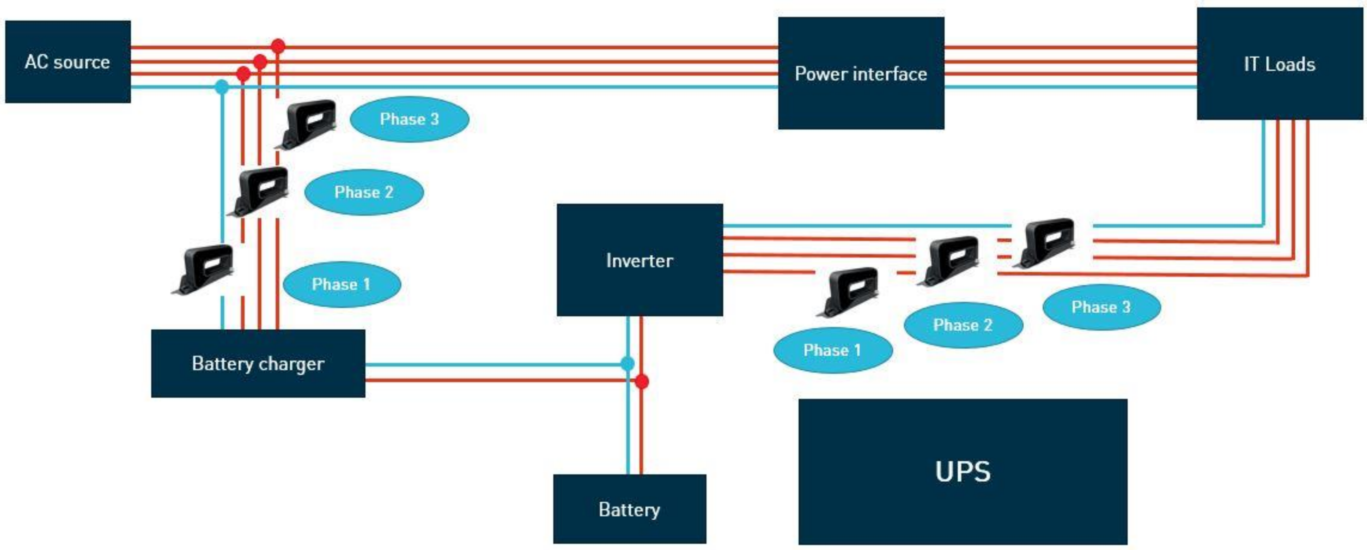
- Battery supplied application



Each renewable energies (windmill, solar…) is either connected to the micro grid controller or the transformer. The energy storage is an assembly of a battery (in series and/or parallel), consequently, it can be mandatory for your application to install on each phase one RFCS sensor due to the fact you can have a variation of a significant current on the network.

Moreover, on the other part of the graph, you have a needed switchgear (like circuit breakers) between the transformer and the connection between energy storage and micro grid controller. This switchgear is linked to the chargers. As a result, it should be important to install our RFCS sensor one each of this phase to protect the long life of the chargers and save money for maintenance and retrofit chargers.

- Uninterruptible Power Supplies (UPS)

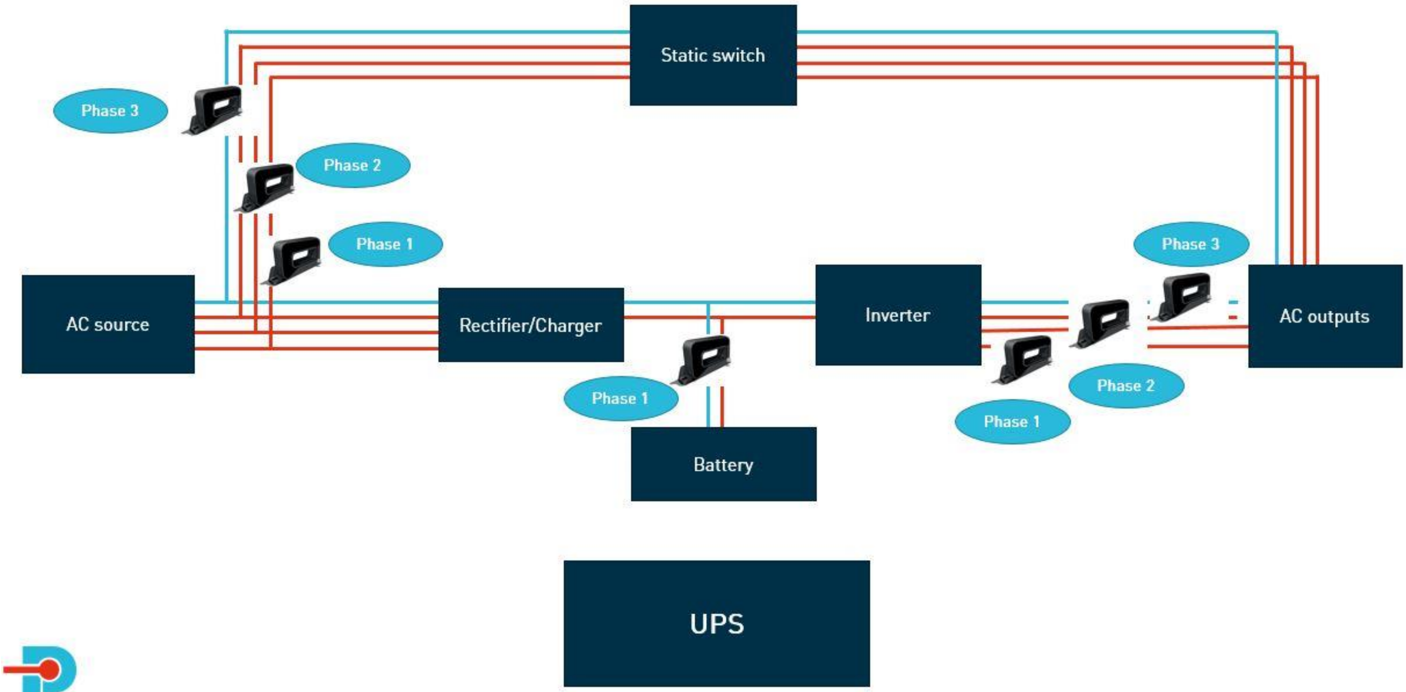


Internal design of a line-interactive UPS

An uninterruptible power supply, or UPS, is a power electronics device that provides a stable alternating current without interruptions, whatever happens on the electrical network. On this application, you have the AC source from the power grid directly linked to the power interface.

The battery charger is linked to the AC source and converts AC currents to DC currents in order to supply a battery which is connected to an inverter. This inverter will change DC to AC currents and is connected to the loads. The power interface is the interface between the AC source and IT loads.

The objective here is to guarantee a normal power flow from the AC source as well as stored energy power flow from the battery. At last, the battery will be recharge by AC source upstream. Now, we can have 3 strategic points to survey with our RFCS sensors, the AC currents upstream to the battery charger, the AC currents upstream to the inverter and the DC currents between the battery and the inverter.



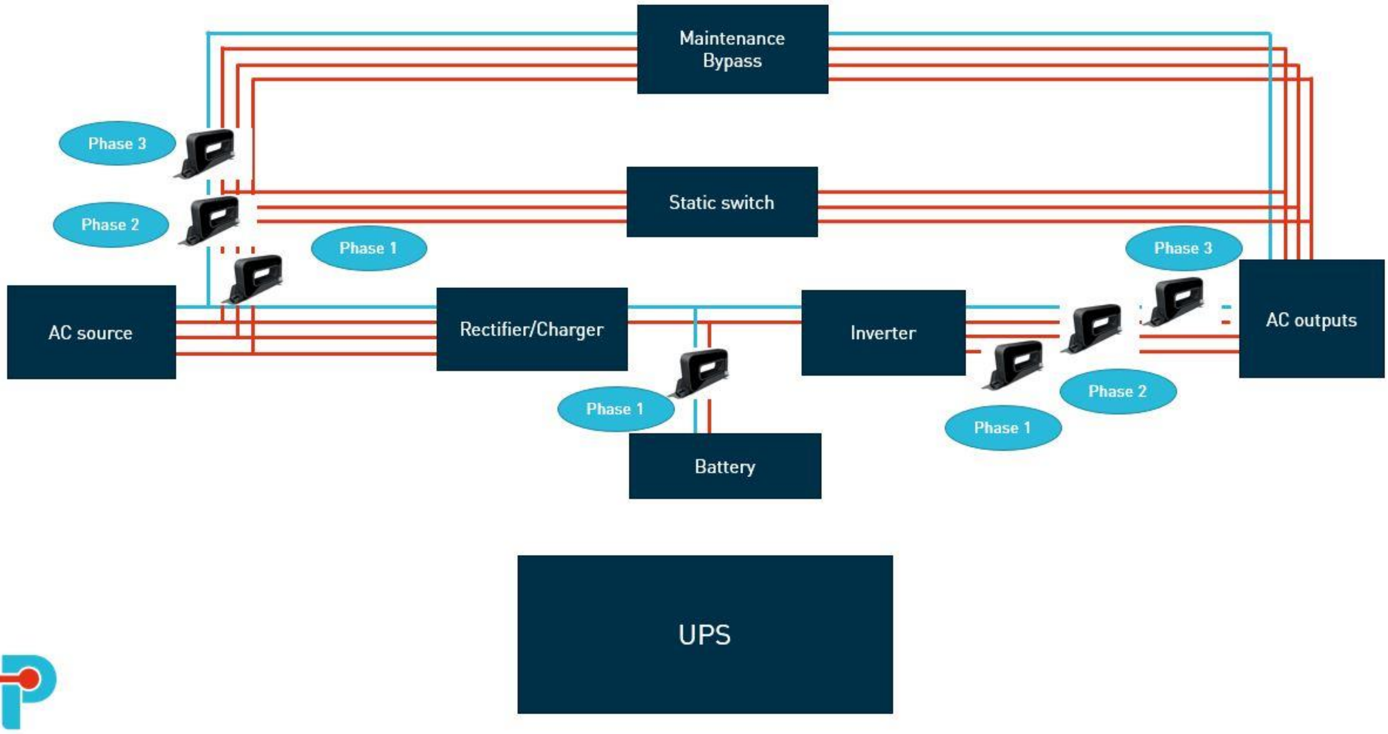
Internal design of a double-conversion UPS.

Here is a second possible version of UPS. From AC source, you can either be connected to the static switch or to the rectifier/charger. The main function of the static switch is to hold the ability to get turned ON or OFF with a minimum time (in us). For the rectifier/charge, the functions are to convert the input power from AC to DC and to recharge the batteries while the DC power routes to the inverter too.

The battery between the rectifier/charger will store energy (DC current). Then, the inverter will play is role to convert DC/AC currents. Then, from inverter or static switch, it will be linked to AC outputs. What are the assets of this application? First of all, you will ensure the normal power flow from AC source to AC outputs.

The battery will serve to inject stored energy power flow to AC outputs. Furthermore, the AC source will supply battery with recharge energy flow. Moreover, in case of failure for the first branch of the grid, the emergency bypass power can flow from AC source, then to the static switch and finally to AC outputs.

In these applications, you can install our RFCS current sensors in 3 strategic areas: one between AC source and rectifier/charge (3 RFCS), then 1 RFCS sensor that can survey the DC current close the battery and one area between the inverter and AC outputs (3 RFCS). We can ensure the performance and reliability of the upstream diagram.



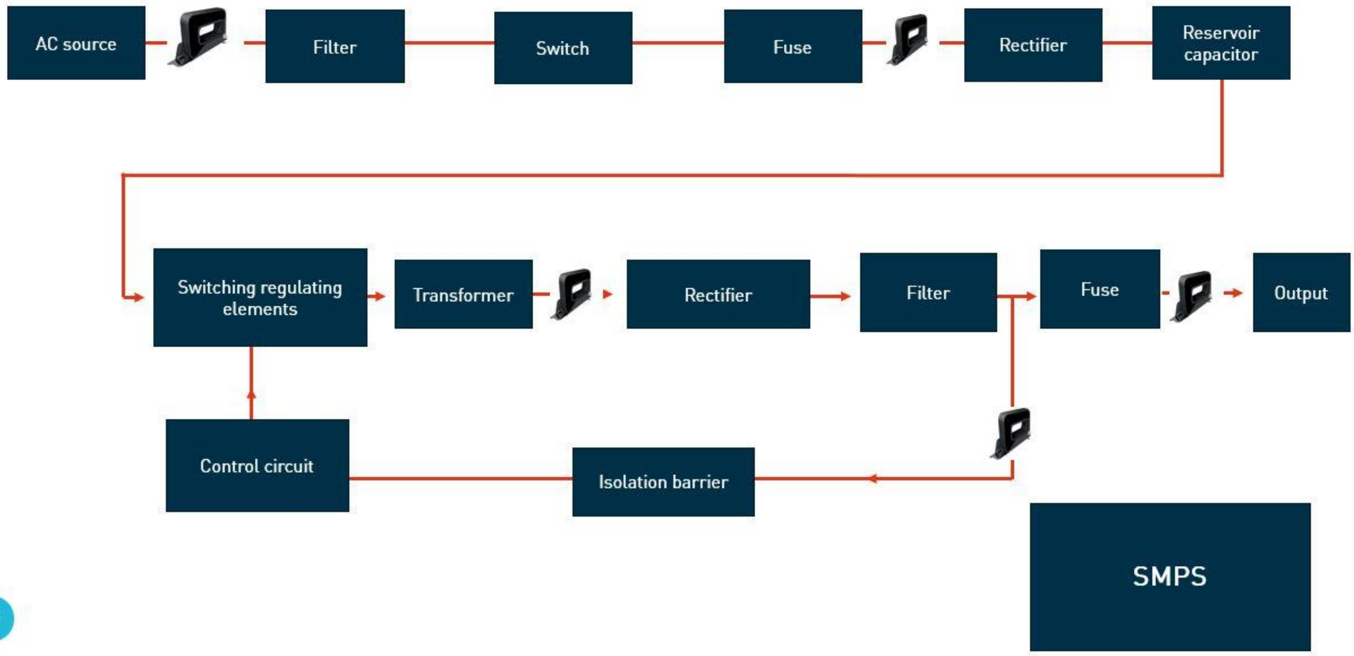
Internal design of a multi-mode UPS.

Please read upside to get more information about the main of these UPS mode. The maintenance bypass enable a UPS system to be electrically isolated, taken out of the critical power circuit for safe UPS maintenance. Consequently, you have a second electrical security that ensure the reliability of the grid.

What are the assets of this application? In that scenario, you have 3 branch that can be connected from AC source up to AC outputs. This UPS scenario has been developed for sensitive applications.

In these applications, you can install our RFCS current sensors in 3 strategic areas: one between AC source and rectifier/charge and between static switch and maintenance bypass (6 RFCS), then 1 RFCS sensor that can survey the DC current close the battery and one area between the inverter and AC outputs (3 RFCS). We can ensure the performance and reliability of the upstream diagram.

- Switched Mode Power Supplies (SMPS)



SMPS (Switched Mode Power Supplies) is a complex application with lots of components that it can be interesting to survey. The goal is to survey the main and strategic components in order to install the RFCS current sensors into your grid. First of all, we begin with AC source with 3 phases and 1 neutral and directly, we will filter this signal in order to eliminate the high frequency disturbance received or sent to AC source for example.

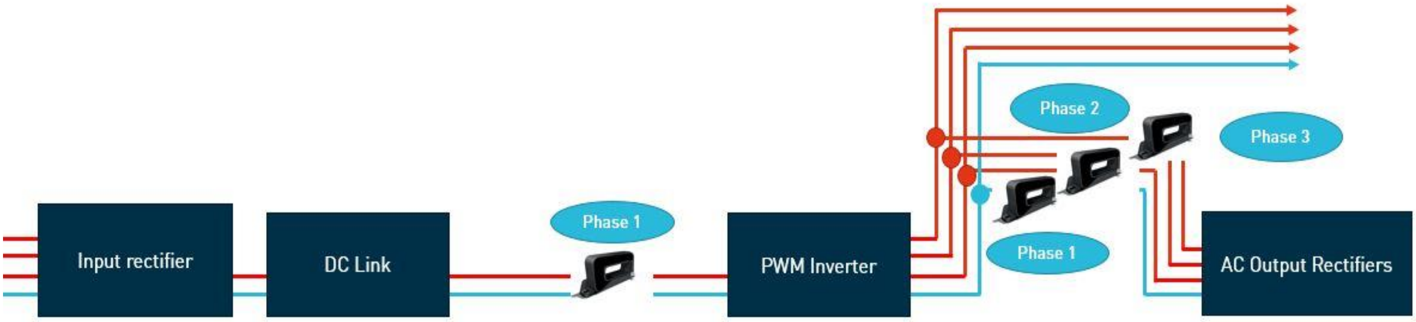
Then, the switch is to interrupt or not the AC current from In to 0 A in case of maintenance. The fuse will be necessary to survey the overcurrent of the AC currents. Then, the rectifier will convert AC currents to DC current. The reservoir capacitor will charge to the voltage peaks after leaving the rectifier. The switching regulating elements sent energy into the transformer and then into rectifier and filter. The transformer will raise or lower the AC currents.

Then, one rectifier again will converts AC/DC currents. Then, one filter will be needed to eliminate the parasitic currents. The fuse will be there to protect output components. Then, it will be connected to the output on one hand. On the other hand, we will check the values for DC current after the rectifier with an isolation barrier and a control. In this configuration, you can install the RFCS current sensors in 5 areas.

First, it will be great to survey your 3 phases current after AC source (3 RFCS). Secondly, it can be useful to check the current before or after the fuse owing to the fact that it is really important to install the sensors close to the protective equipment to prevent any failures (1 RFCS). Thirdly, it can be useful to install 3 RFCS sensors after the transformer because the current transformation could not be optimal.

Fourthly, it can be important to survey the DC current after the filter owing to the fact that is an important value that can serve for switching regulating elements application. Finally, it is extremely important to monitor the output value. This is why, we recommend to install 1 RFCS before the output (at the end).

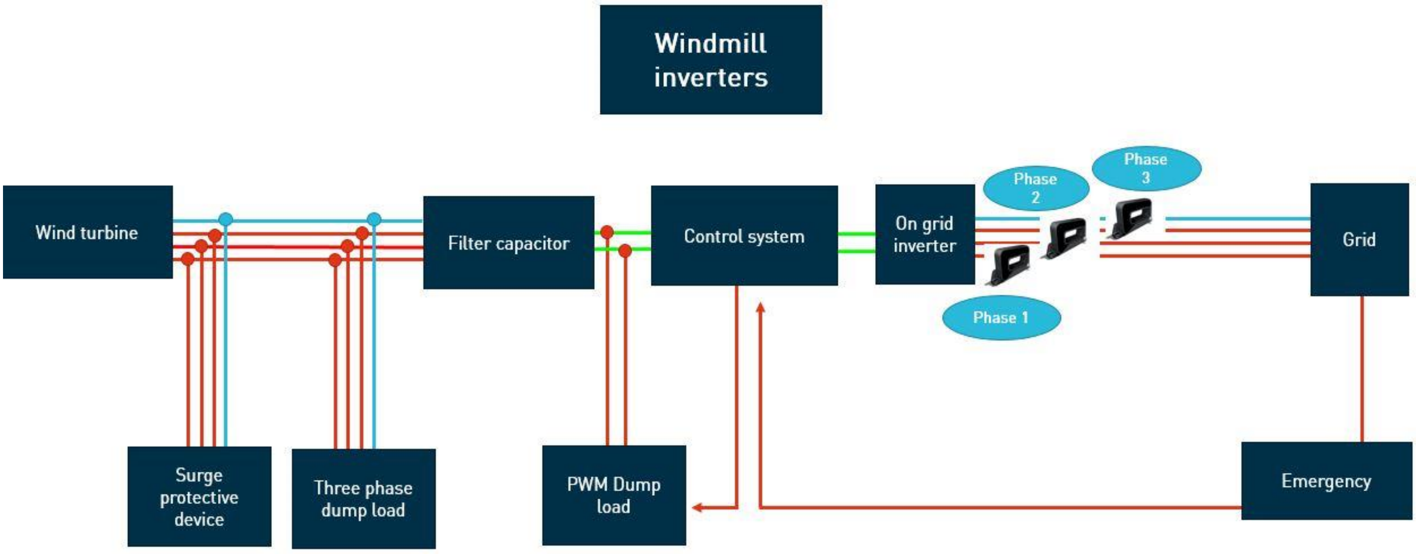
- Power suppliers for welding applications



Power suppliers for welding applications

For power suppliers for welding applications, the energy will arrived from basic electrical network. Then, the input rectifier will convert AC current to DC current with a special conversion. Then, you will get a DC link to stabilize the 1 DC phase for example. Before the inverter, we'll advise you to connect 1 RFCS sensors to ensure that the values after DC link is constant and you'll not get little peak currents. The inverter will properly convert DC currents to AC currents and you advise you to connect three RFCS sensors before AC output rectifier. To summarize, close to any electrical equipment that is sensitive and needs to be protected, you should install our RFCS current sensors.

- Windmill inverters

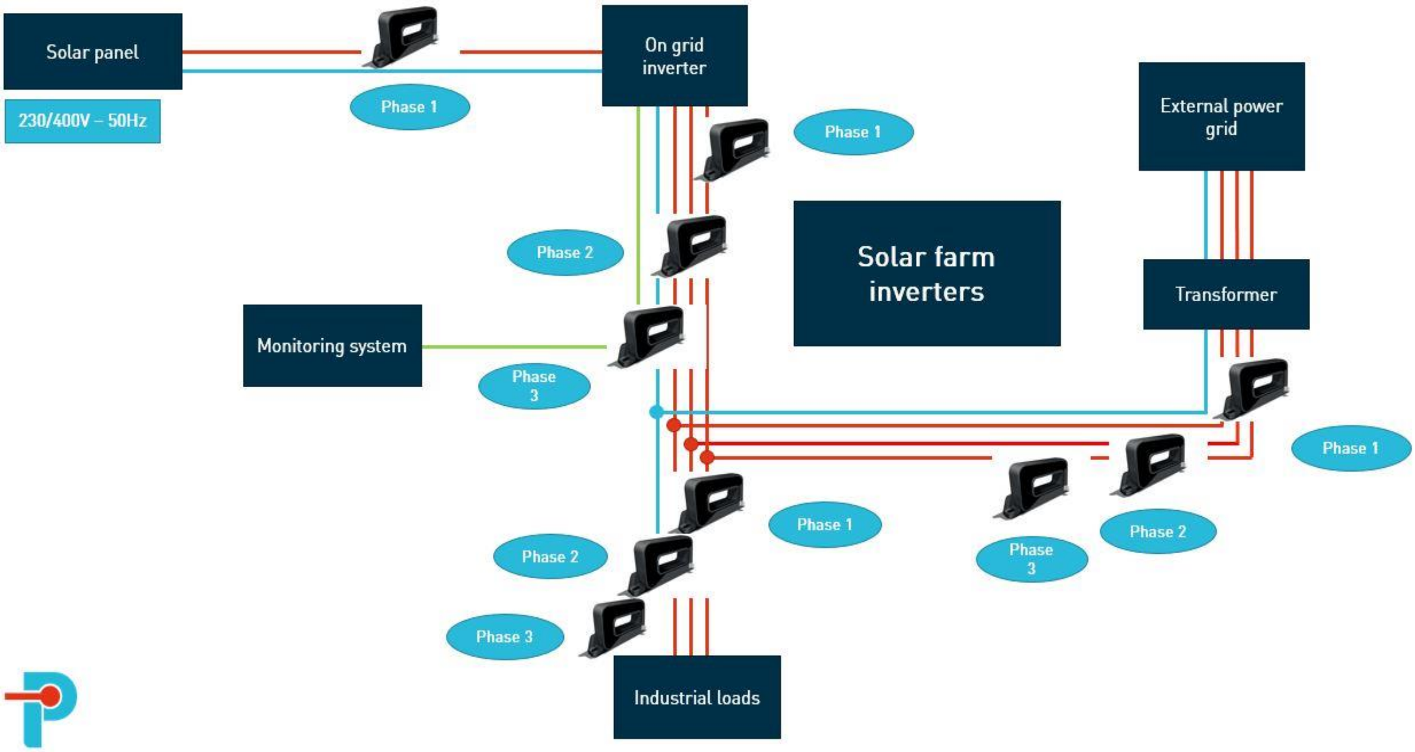


On each turbine, the electricity is produced by wind via an alternator that converts mechanical energy to electrical energy. At the end of the turbine, you will get surge protective device to protect against lightening strokes not detected by RFCS. RFCS used as a diversion charge controller. RFCS can also detect into the grid in order to monitor the overcurrent faults or over frequency for example. It should be a good idea to install our RFCS sensors in these areas. Then, the load dumps goal is to disconnect a power load in case of failure of supply to equipment.

The filter capacitor will use to filter out a range of frequencies from the upstream electrical network. The control system will check the value from emergency and control the dump load that can disconnect the electrical network before the control system in order to prevent any failures and long life of all the electrical equipment as maintenance technicians for example. It is used to charge the wind turbine in case of high winds or low loading from the grid. A RFCS can be used to control the charge of battery.

The control system is linked to the inverter which is it change DC currents to AC currents, this is why we will get 3 phases plus 1 neutral wires. It is mandatory to install our RFCS current on each phase after the inverter. All the precise values from our sensors can be used for the "emergency" system in order to monitor perfectly from scratch to the end your global electrical network.

- Solar farm inverters

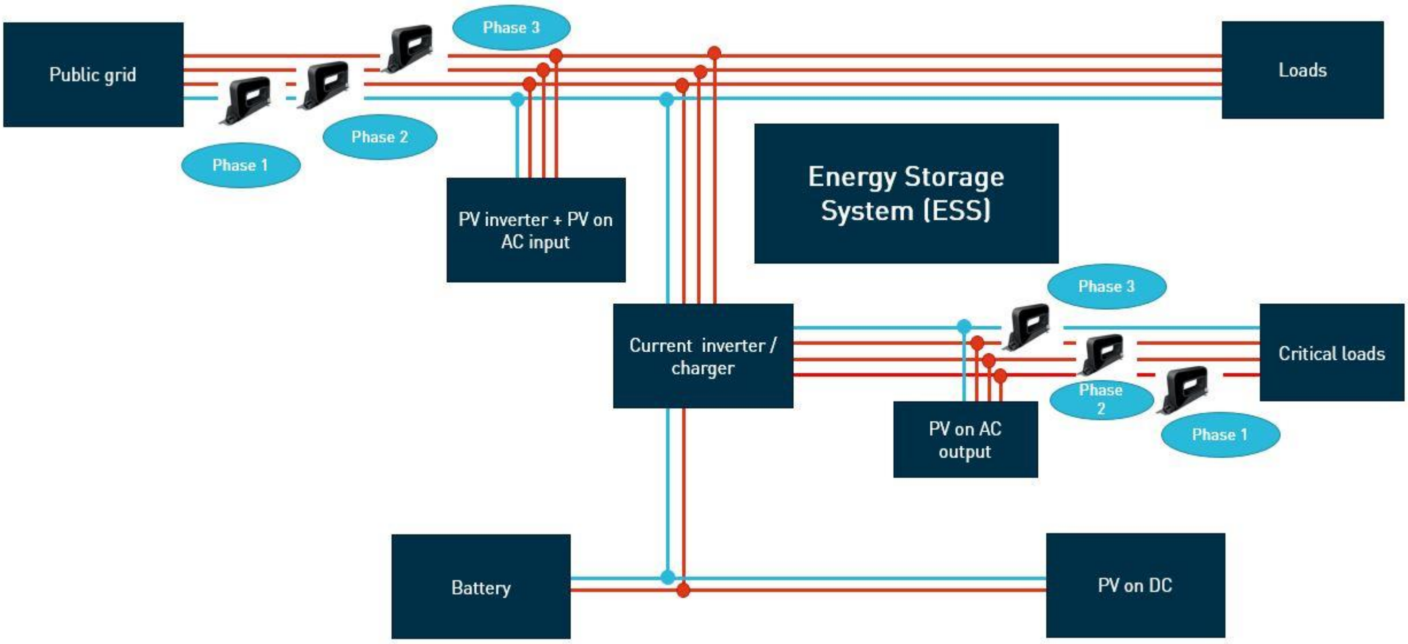


The electrical grid starts from the solar panel in DC current and pass over the inverter that converts DC current to AC currents. Then, everything is connected to the industrial load that refers to the power consumption of the device(s) that are being used in the system. Understanding your loads is critical to maintaining a well-functioning power system.

Then, it is linked to the transformer, which the mission is to convert a small voltage to a higher voltage in order to be connected to the power grid. In this graph, you have four ways to monitor and survey all electrical grid. First, it can be important to check the fluctuation of the DC current between the solar panel and the inverter because the delta current can be significant (installation of one RFCS sensor).

Then, you should install after the inverter on each phase as well as before the industrial loads, so 6 RFCS sensors totally. Finally, it could be interesting to measure the current before the transformer.

- Energy Storage System (ESS)

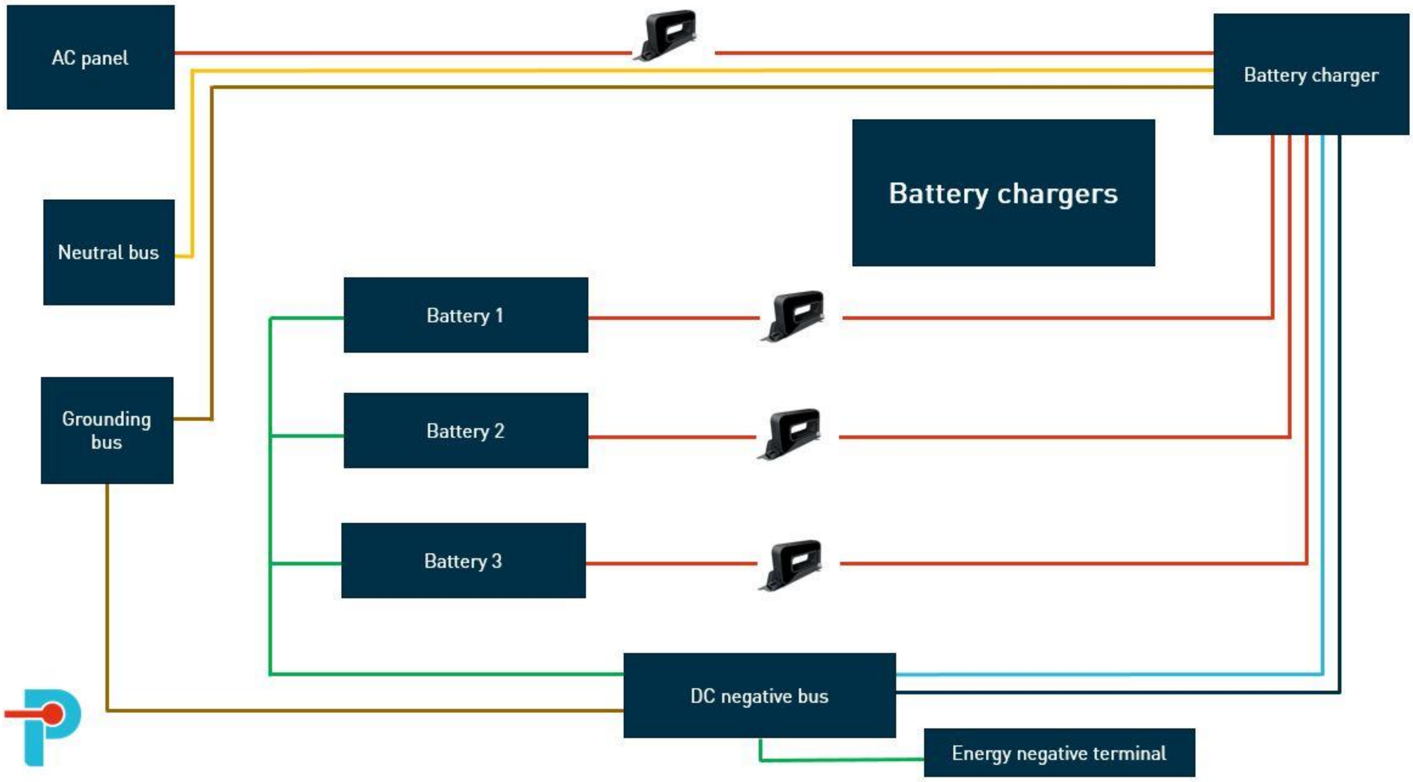


First, the public grid is the classic electrical network that retrieve the electricity from solar panels in this example. Connected to the public grid, you have loads that should be matched for optimal power balance. Downstream of this connection, we find an installation for PV (Photovoltaic) inverter that converts the DC currents output from PV solar panel into a utility frequency AC currents into the electrical grid (that's the same case for PV on AC output). Downstream, we could have a current inverter, which takes over the supply of the connected loads.

Directly linked to this current inverter, we can find a critical load. Linked to the current inverter, we have simultaneously the connection of a battery as well as a PV inverter on DC.

Into the grid, you have many possibilities in order to supervise your ESS. First option is to detect the currents on each phase between the loads and public grid (so 3 RFCS sensors needed). At the output from each PV on AC/DC output, we recommend to connect our RFCS sensor (1 in DC needed and 3 in AC).

- Battery chargers



Each battery charger can be an opportunity to use our RFCS current sensors on each battery (3 RFCS in total) and upstream the battery charger linked to the AC panel (3 more RFCS sensors).. Each battery (1 phase/DC) is linked to the battery charger. Each battery is connected to DC negative bus in order to close the electrical circuit.

The battery charger use a grounding wire to protect the equipment (prevent lightning strikes) as well as the people from the maintenance. The neutral wire is linked to the battery charger which allows the return of current to the distributor in an electrical installation and ensures that a 220V single-phase voltage is obtained from a 380V three-phase voltage.

Finally, the battery charger is connected to the AC panel (PV). The main goal of the battery charger is that it stores energy in 3 batteries on this scenario by running an electric current through it. The goal of the battery is to store the energy because we do not know how to stock it.

Then, you can connect the batteries to inject the currents directly to another grid. In this scenario, it is due to the green energy from the solar energy that transits to the battery charger and batteries that we can be able to use this application (the energy can come from wind energy, geothermic...).

Our RFCS range are well designed for industrial applications (only). The upstream examples are just some examples and our sensor can be able to fit to any kind of applications that require 1000A at nominal range (from 100 to 2000A).

FYI: Our RFCS sensors can be adapted to fit your needs depending on budget and/or expecting time. We will be pleased to examine your tailor and specific requirements. Please find below some examples (this list is not exhaustive):

- Special secondary connections
- Adapting the distance "between fixing points" size
- Define a new sensor fixations
- Adjust a new Ipeak value
- Define a new bandwith
- Improve the linearity
- Improve the delay time
- Answer to a high accuracy
- Answer to a specific and restrictive norm
- Answer to a harsh environment (salt mist)