# PRIMO POWER **Wa** Battery Charger
# PRIMO PULSE **Wo/Wp** Battery Charger


**MANUAL FOR USE BY AUTHORISED TECHNICIANS AND SERVICE PERSONNEL**

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## SUMMARY

## Chapter 1: INTRODUCTION

The new PRIMO POWER and PRIMO PULSE battery chargers implement a reliable and innovative charging method thanks to programmable electronics.
The PRIMO POWER series is built and programmed to charge the battery according to the Wa and WoWa charging characteristic.
The PRIMO PULSE series is built and programmed to charge the battery according to the WoWp charging characteristic.

The last generation microprocessor electronic control (PBM250) provides parameters with a wide range of programming possibilities to optimise charging in all types of situations.

All PRIMO POWER and PRIMO PULSE battery chargers have the following features:

- Charging data memory capable of reading the data of the last 1000 charging operations, thus allowing technical service to correctly and easily recognize system faults.
- Alphanumerical display - viewing of all the fundamental parameters at the same time: Voltage, current, integrated Ah, charging time and charging status or fault.
- View of charging status with 8 mm diameter LED, easily visible from a distance.
- Auxiliary relays to manage Top-up, Air Pump, power presence signal. (Optional Control Board)
- USB interface to upload charge data and to program configuration parameters such as:
- overcharging percentage,
- autostart time,
- times for activation and standby of pulses,
- safety timer,
- minimum and maximum cell voltage,
- gassing voltage,
- top-up function timing
- Automatic recognition of sulphated or low-charged batteries
- Automatic equalizing after each charge and floating charge every **7 days.**
- Special charging of new batteries during the first 3 charges (higher charge factor, to compensate possible formation deficits which could have occurred during manufacturing of the batteries).

The PRIMO PULSE battery charger, thanks to the special final pulse charging characteristic, provides:

- Greater savings of product, battery management and battery charger due to:
- Energy saving due to reduced charge factor;
- faster charging speed compared to a battery charger with Wa characteristic;
- lower water consumption due to reduced charging factor and therefore lower maintenance on batteries
- lower increase of battery temperature due to reduced charging factor and therefore extended battery life
- Batteries last longer because of charging with Ah control, with reduced charging factor.

**The recorded charging data includes:**

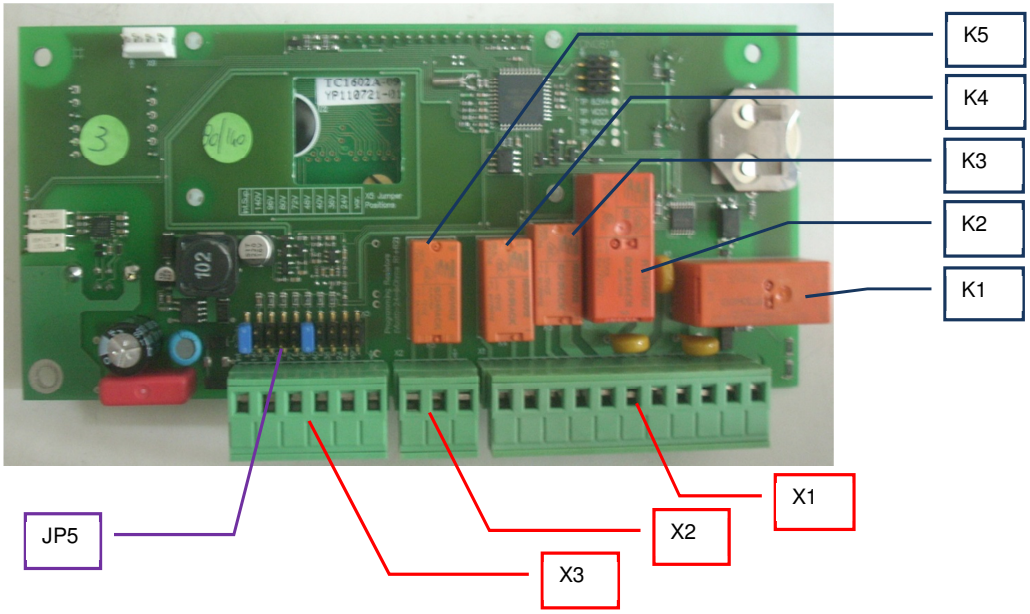
- Progressive identifier of charging cycle
- Time and date charging started
- Ah charged during main charging time (Ah)
- Ah charged during final charge (Ah)
- Total Ah charged (Ah)
- Final charge voltage (V/cell)
- Initial charge time (h)
- Final charge time (h)

## Chapter 2: DESCRIPTION OF PBM250 CIRCUIT BOARD

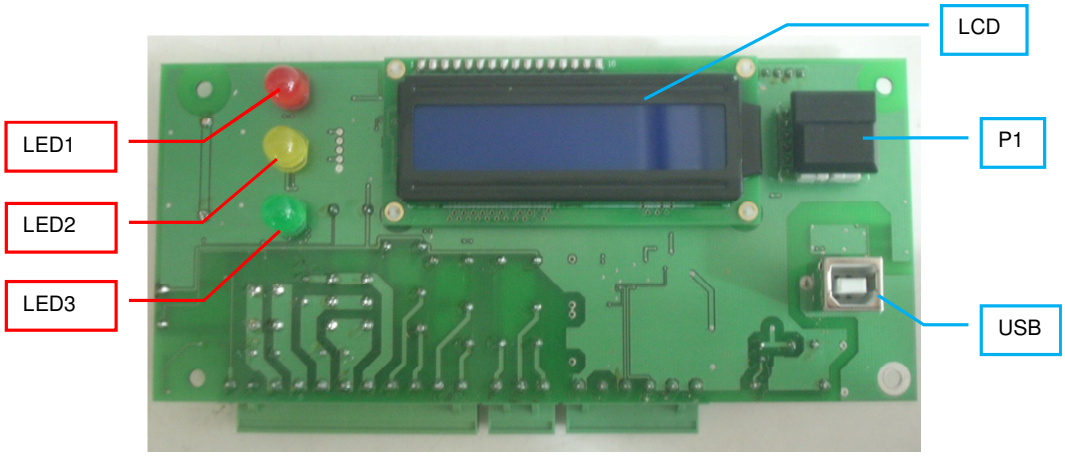
The main features of this control board are:

1. Battery-powered with 24V - 140V range of rated voltage
2. The boards are pre-set for the following standard battery voltages: 24, 36, 40, 48, 72, 80, 96, 140
3. Different voltages, other than the standard ones, can also be managed by mounting a special value precision resistance.
4. Special Input voltages are available within the 18Vdc - 350Vdc range
5. The maximum functioning voltage is 350Vdc
6. Reduced absorption thanks to the use of a switching power supply (max 50 mA while operating with battery connected)
7. Accurate reading of charging parameters
   - voltage measuring: ± 0.1 %
   - current measuring: ± 0.5 %
   - Ah count: ± 0.5 %
8. Extremely simple and complete user interface:
   - Three 8mm diameter LEDs indicating status, easily visible from a distance
   - LCD carrying main information
9. Serial communication interface (USB Connection) for:
   - programming charging parameters
   - reading memorised data of last 1000 charging cycles

The following image shows the main components on the components side



The following image shows the main components on the display side




Description of components:

**X1**: 11-position screw connector with 5.08mm pitch

X1.1: Vac-1
X1.2: Vac-2
X1:3: K1_COM
X1:4: K1_NO (Wa)
X1:5: K2_COM
X1:6: K2_NO (Wo)
X1:7: K2_NC (Wa/Wp)
X1:8: K3_COM (Top-up)
X1.9: K3_NO (Top-up)
X1.10: K4_COM (Air Pump)
X1.11: K4_NO (Air Pump)

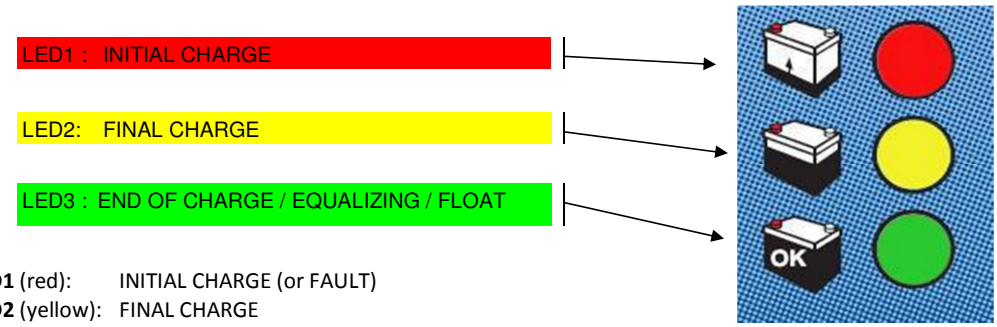
**X2**: 3-position screw connector with 5.08mm pitch

X2.1: K5_NC
X2.2: K5_COM
X2:3: K5_NO

**X3**: 6-position screw connector with 5.08mm pitch
X3.1: -Battery
X3.2: + Battery
X3.3: - Shunt 60mV
X3.4: + Shunt 60mV
X3.5: +24V: DC external power supply +24V
X3.6: GND: DC external power supply GND

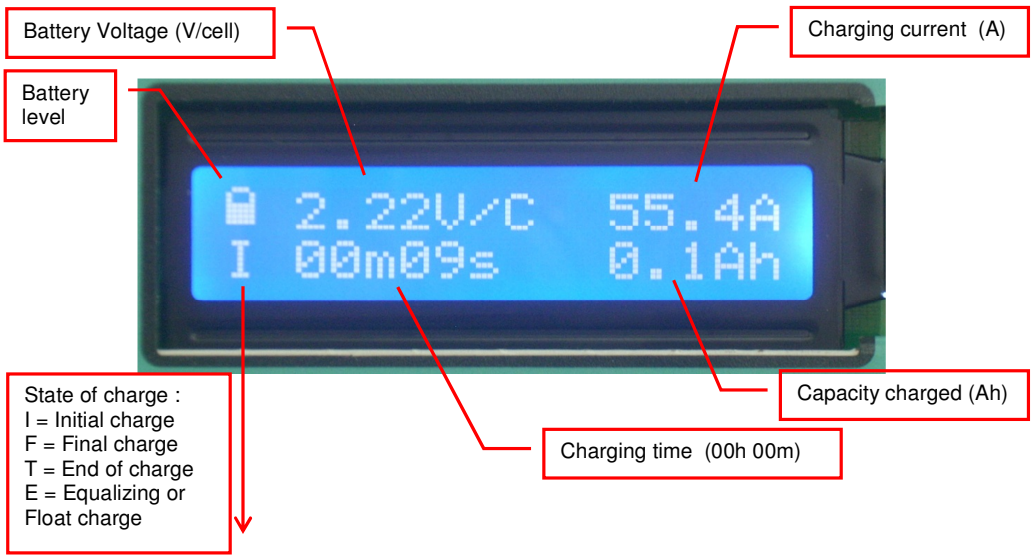
**JP5**: Jumpers for voltages battery selection (24, 36, 40, 48, 72, 80, 96V)

**P1**: START/STOP button allows to interrupt or restart charge cycle in progress.




**LED1** (red): INITIAL CHARGE (or FAULT)
**LED2** (yellow): FINAL CHARGE
**LED3** (green): CHARGING COMPLETED (or EQUALIZING / FLOAT)

**LCD**: Display signalling charging variables and Fault messages




If there is a delay to start charging the Display reads

- Charging start standby in: [min]

The error messages appear on the display in full text and are cancelled automatically at the subsequent charge.

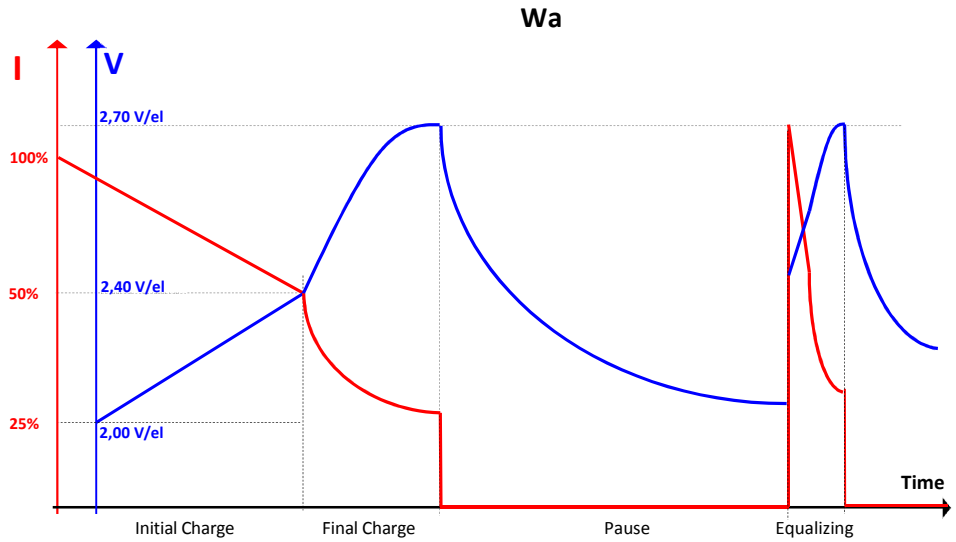
**USB**: USB communication ports
This communication port is used to program the charging parameters of the Battery charger and to download data referring to charges carried out and statistics.
These functions are made available by specific SW for PC called **PBM Service** (See the "SW PBM Service technical manual" for details).

| | | |
|---|---|---|
| **K1**: Main relay = ON/OFF | 1 contact: NO | 250Vac 16 A |
| **K2**: PULSE / WoWa relay | 2 contacts: NO+NC | 250Vac 16 A |
| **K3**: Pump Relay for Water Top-up | 1 contact: NO | 250Vac 6 A |
| **K4**: Air pump relay | 1 contact: NO | 250Vac 6 A |
| **K5**: Power presence signal relay (INHIBIT) | 2 contacts: NO+NC | 250Vac 5 A |

## Chapter 3 : DESCRIPTION OF Wa CHARGING CHARACTERISTIC

The charging curve to the charger PRIMO POWER Wa corresponds to a Wa curve defined by DIN 41774 and is characterized by the following trends:

• As the battery voltage increases the charge current decreases as described by Statement;
• The charge current is dimensioned as a C5 : 6;
• After reaching the gassing voltage of 2,40V/cell., the electronic control calculates the capacity of the battery and defines how many Ah have to be loaded into the final charge to get the desired charging factor.




• Charging stops when it reaches a **charging factor of about 118%** (adjustable);
• Control with safety timer **to 11 hours on the first charge**.
• Charging time provided 9.0 - 12.0 hours max depending on battery capacity (equalization charge excluded).

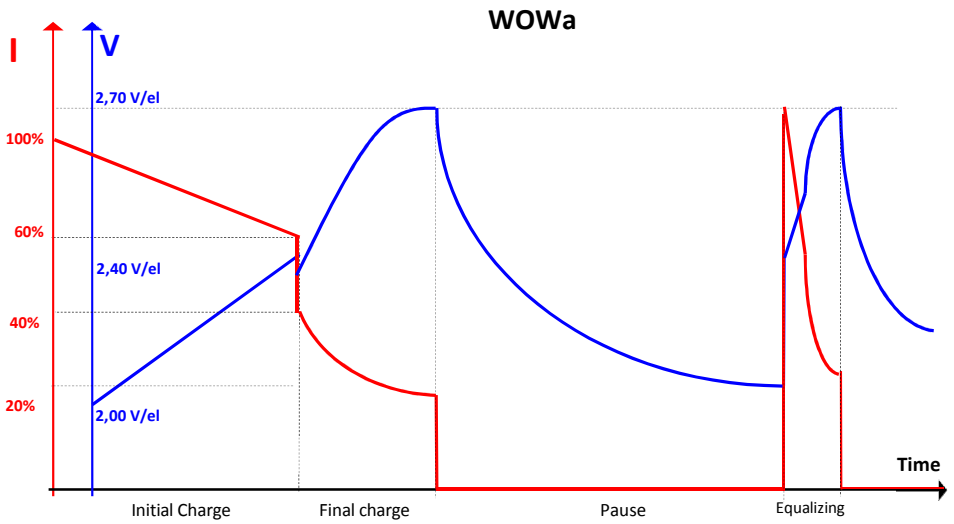
### EQUALIZING CHARGE

• If, after the charging, the charger is connected to the battery, after a pause of 16 hours (adjustable)it starts an automated process of equalization.
• During this phase charge is delivered, about 5 Ah battery per 100 Ah of battery capacity.
The charger calculates this value using the average capacity calculated in the last 7 charge cycles completed successfully. During the equalization charge the LED GREEN "END OF CHARGE" flashes.
• If the battery remains connected for a long period, the battery charger performs a cycle of maintaining every 7 days under the same conditions described for the equalization cycle.

## Chapter 4: DESCRIPTION OF WoWa CHARGING CHARACTERISTIC

The charging characteristic of a PRIMO POWER WOWa battery charger corresponds to the WoWa characteristic defined by the standard DIN 41772 and featured by the following trend:

- As the battery voltage increases, the charging current decreases as described by the Standard;
- During this phase the charging current is higher (C/5) to charge more quickly;
- Once the gassing voltage of 2.40V/cell has been reached, the electronic control switches the two contactors and the battery is automatically charged with a lower decreasing current to prevent the battery from overheating;




- Charging stops when an adjustable **recharging factor of approximately 118%** is reached;
- Forecasted recharging time 7.0 - 8.0 hours max, depending on capacity of battery (equalizing charge excluded).

**EQUALIZING CHARGE**

• If, after the charging, the charger is connected to the battery, after a pause of 16 hours (adjustable) starts an automated process of equalization.

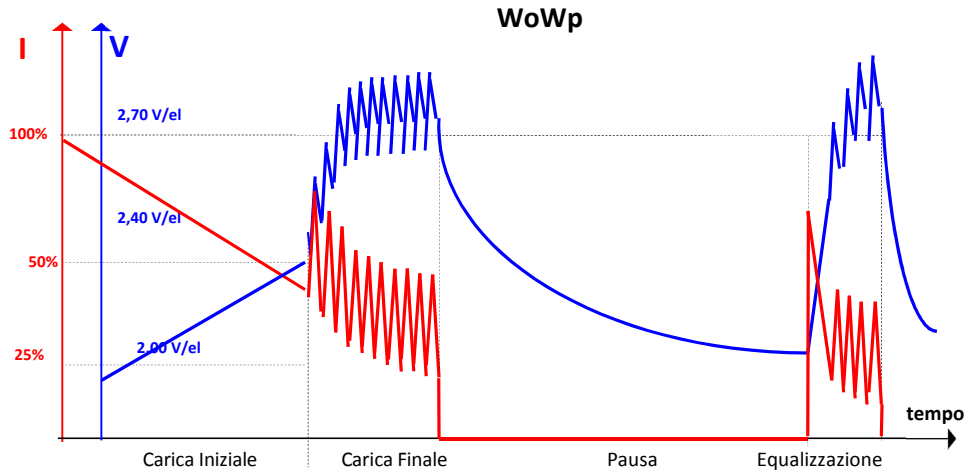
• During this phase charge is delivered, about 5 Ah battery per 100 Ah of battery capacity.. The charger calculates this value using the average capacity calculated in the last 7 charge cycles completed successfully. During the equalization charge the LED GREEN "END OF CHARGE" flashes.

• If the battery remains connected for a long period, the battery charger performs a cycle of maintaining every 7 days under the same conditions described for the equalization cycle.

## Chapter 5: DESCRIPTION OF WoWp CHARGING CHARACTERISTIC

The charging characteristic of a PRIMO PULSE battery charger corresponds to a characteristic modified with respect to the Wa characteristic defined by the standard DIN 41774 and featured by the following trend:

a) As the battery voltage increases, the charging current decreases as described by the Standard DIN 41774 (Wa characteristic);
b) Once the gassing voltage of 2.40V/cell has been reached, the battery is charged alternately switching between a Wa characteristic (lower) and a Wp characteristic (higher).
c) Pulses last **3 minutes in the Wp characteristic followed** from **5 minute** intervals of the Wa characteristic.
d) This process goes on until a recharging factor of approximately **110%** is reached, at which point the battery charger switches off automatically.




- Initial charge with **decreasing current** for an undetermined amount of time until the final charge threshold of 2.40V/cell intervenes.
- Control with safety Timer at 11 hours on first charging phase.
- Final charge with pulse current of which: **3 minutes with high current (Wp)** alternated with **5 minutes of low current (Wa)** until **a recharging factor 110%** the rated capacity of the battery (Ah) is reached.
- Overall safety timer at 16 hours for complete charging cycle.
- Forecast recharging time 7.0 - 12 hours max, depending on battery capacity (equalizing charge excluded).

**EQUALIZING CHARGE**

• If, after the charging, the charger is connected to the battery, after a pause of 16 hours (adjustable) an automated process of equalization starts.
• During this phase charge is delivered, about 5 Ah per 100 Ah of battery capacity. The charger calculates this value using the average capacity calculated in the last 7 charge cycles completed successfully. During the equalization charge the LED GREEN "END OF CHARGE" flashes.
• If the battery remains connected for a long period, the battery charger performs a cycle of maintaining every 7 days under the same conditions described for the equalization cycle.

## Chapter 6: COMMISSIONING AND START-UP

Connect the battery charger to the battery.
If there is no mains power supply, the battery charger signals the mains power fault.
Then power the battery; as soon as the mains power is present, the battery charger performs an **AUTOTEST** for a few seconds.
Afterwards, since the **immediate AUTOSTART** function is set by default (without delay) charging will begin automatically.
An Autostart delay in minutes can be programmed (with the SW PBM Service via the USB communication) in order to take advantage of economical energy time bands or else to set a charging starting time.
The charging process ends automatically and the battery charger interrupts the charge when the battery is fully charged.
The LEDs indicate the charging phases and the display shows the charging data.
If charging needs to be suspended in advance, before disconnecting the battery from the battery charger, you must switch the battery charger off by pressing the ON/OFF button in order to avoid dangerous electric arcs.

### EQUALIZING CHARGE

If the battery charger remains connected to the battery and charging has terminated, after a pause of 16 hours an automatic equalizing process begins.
During this phase, approximately **5 Ah every 100 Ah** the capacity of the battery are charged. The battery charger calculates this value by using the average capacity calculated in the last 7 successful charging cycles. During the equalizing charge, the GREEN "CHARGING TERMINATED" LED flashes.
If the battery remains connected longer, the battery charger performs a **floating cycle** every **7 days** according to the same method described for the equalizing cycle.

## Chapter 7: FUNCTIONAL DESCRIPTION OF THE CHARGING CYCLE

- The battery is charged according to a balancing principle of the Ah missing in the battery. This means that mains voltage oscillations or variations are fully compensated.
- The battery begins to charge only when the battery voltage is within the range admitted by the battery charger (**1.60 - 2.40V/cell)**.
- Charging starts automatically after the battery charger has been connected to the battery.
- Should the charging time for reaching gassing voltage exceed a certain value (generally **7 hours** for WoWa chargers and **11 hours** for Wa and WoWp chargers), the charging is interrupted automatically by a first phase safety timer (programmable).
- An overall safety timer (programmable) is triggered when the total charging time exceeds a preset value (generally **16 Hours**).
- In the event of a power failure during charging, all the data relative to the charging cycle in progress is saved in a buffer memory. As soon as the mains voltage returns, charging restarts exactly from where it was interrupted.
- If the battery is improperly disconnected while being charged, the battery charger automatically interrupts charging and switches off.
- All data concerning charging is viewed on the backlit display: Cell voltage, Charging current, Ah, Charging time, and any fault message should an anomalous situation occur.
- Moreover, to distinguish the Initial charge from the Final charge, a capital letter appears at the start of the second line:

- **'I': Initial Charge**
- **'F': Final Charge**
- **'T': End of Charge**
- **'E': Equalizing or float Charge**

**NOTE: The battery charger (mode PULSE - WoWp) are programmed to do the first 3 charges on a "new battery", which means that 3 charges are automatically performed with the highest charge factor to complete the "training" the battery. Following charges will be "normal."**

- Also 3 large LEDs (8mm diameter) indicate the charging status

Red LED:  "INITIAL CHARGE"

Yellow LED:  "FINAL CHARGE"

Green LED:  "END of CHARGE"

Undercharged batteries are recognized during the charging process and this is documented among the data saved in the buffer memory.
"Cold" battery charging: all the main parameters for charging cold batteries are preset using specific configuration parameters, among which charging factor and gassing voltage.

## Chapter 8: CARD PROGRAMMING

One of the most innovative elements of the PBM250 card is the possibility of programming the charging parameters by means of a USB serial port, without needing to open the Battery Charger, by using the SW **PBMService**.

Hereafter we will describe the main parameters which may be programmed relating to the current configuration of PRIMO POWER / PRIMO PULSE.
See the SW PBM250 technical manual for a detailed description of the operation of SW PBM250 and of the parameters managed.

- **Battery Voltage:**

Default: 24, 36, 40, 48, 72, 80, 96, 140 [V] and special voltage.

- **Charge characteristic:**

Default: WoWp for PULSE battery chargers
WoWa for WoWa battery chargers
Wa for battery Wa chargers

- **Shunt Value:**

Default: depending on the shunt used, the rated value of the shunt (in A) is entered.

| Rated current Charger | Shunt value | Value entered |
|---|---|---|
| I ≤ 30 A | 30 A / 60 mV | 30 |
| 30 A < I ≤ 50 A | 50 A / 60 mV | 50 |
| 50 A < I ≤ 75 A | 75 A / 60 mV | 75 |
| 75 A < I ≤ 100 A | 100 A / 60 mV | 100 |
| 100 A < I ≤ 150 A | 150 A / 60 mV | 150 |
| 150 A < I ≤ 200 A | 200 A / 60 mV | 200 |
| 200 A < I ≤ 250 A | 250 A / 60 mV | 250 |

Meaning:
The shunt value, for example 100, means that with a voltage drop of 60 mV it is acknowledged as a charging current of 100A. The value entered for the shunt parameter must therefore be suited for the shunt used. **In this case 100mV shunts cannot be used, but only 60mV.**

- **Theoretical Charging Factor:**

Default: charging factor wanted as overcharging value in [%]

Meaning: With the PULSE characteristic, the electrolytic mixture is obtained by means of considerable gassing in the pulse phase. Therefore minimum charging factors within the 1.07 - 1.12 range are sufficient (here again referring to a discharge of 80% and battery temperature of at least 10 [°C]).

- **Equalizing/Floating charging factor:**

Default: 5 = 5 [%]

Meaning: This value indicates the percentage [%] of the battery capacity which must be recharged in the equalizing charge. Provided that the card does not know the rated capacity of the battery, the average Ah value charged is calculated by means of the charging data of cycles completed correctly, from which the SW estimates battery capacity.

- **Wp pulse duration: (Only for WoWp charging characteristic)**

Default: 180 [sec] = Duration of pulses with current according to Wp characteristic(3 min).

- **Wa pulse duration: (Only for WoWp charging characteristic)**

Default: 300 [sec] = Duration of pulses with Wa current (5 min.)

- **Autostart delay:**

Default: 0 [min]

Meaning: Charging may start in the following ways:
- After a delay of "x" minutes
- At a certain time hh:mm
- Manually by pressing the ON/OFF button

- **110Vac mode:**

Default: NO

Meaning: Small single-phase battery chargers do not integrate the contactors which supply the power transformer, but shut power directly with the control relay.
In the case of a 110Vac battery charger, since the relay is dimensioned for 16A non-inductive or 8A inductive, the capacity of the relay must generally be increased by using two relays in parallel.
The 110Vac mode obliges SW to implement the Wa charge characteristic alone and uses the K1 (ON/OFF) and K2 (1st/2nd stage) relays with the same ON/OFF function, making it possible to connect them in parallel.

- **Time Control:**

Default: NO

Meaning: If only time control is activated, even for the duration of final charging a timer is used which depends on the time required for the initial charge and of the two programmable parameters which are **T1** (minimum final charging time) and **T2** (maximum final charging time).
The final charging time is the same as the initial charging time if the initial charging time is found in between **T1** and **T2**.
If the initial charging time is less than the **T1** value, final charging will last for a time equal to **T1**.
If the initial charging time is greater than the **T2** value, final charging will last for a time equal to **T2**.
However there is an exception linked to the fact that charging on a whole must still respect the minimum charging time constraint, for which reason if the initial charge lasts less than Tmin/2, the final charge will complete the minimum overall charging time Tmin.

- **New Battery**

Default: YES

Meaning: If the Flag "**New battery**" is activated, the first 3 charges will be carried out with higher charging factors to complete formation of the batteries if necessary.
The "increased" charging factor is approximately 15% higher than the standard charging factor.
After the first 3 charges with the increased charging factor, SW will go back to using the charging factors defined on the parameter table.

- **Cold Battery**

Default: NO

Meaning: This option means that if "Cold Battery" is selected, it is charged with a higher overcharging factor. In particular the gassing voltage is determined at a higher value and the presumed value is reduced as battery filling percentage at the gassing point.
In these conditions a "cold" battery can be considered one which is always within a temperature range of 0 and 10°C.

Table with Description of parameter setting for Cold Battery Selection

| | **Switching Voltage** | **Charging factor** | | **Presumed filling degree at gassing point** |
|---|---|---|---|---|
| | V/cell | Pulse and all characteristics with Electrolytic recirculation | Wa and WOWa characteristic (not implemented on PRIMO PULSE) | |
| **Standard Battery** | 2.42 | 1.12 | 1.18 | 93% |
| **Cold Battery** | 2.46 | 1.20 | 1.30 | 91% |

**N.B.** It must be said that these parameters do not correspond to the setting of the battery charger for so-called batteries for Refrigeration cells, which require particular characteristics and parameters.

- **AIR PUMP (relay 3):**

Default: NO

Meaning: If the "Airpump" function is activated, the relay used to drive the air pump is controlled as described hereafter.

- **Top-up (relay 4):**

Default: NO

Meaning: 3 settings can be selected:

A) **"no"**: no water top-up.
B) **"permanent"**: water top-up at the end of charging with a normally open electromagnetic valve, depending on the time set in the "duration of top-up at end of charging" parameter
C) **"intermittent"**: water is topped up at the end of charging depending on the time set in "duration of top-up at end of charging". During this time the valve repeatedly switches on and off with infinitesimal pauses. This variant keeps the electromagnetic valve from "gluing".

- **Remote signals (relay 5):**

Default: NO

Meaning: The user may associate the control of relay 5 to one or more events which could occur during charging. These events are selected by means of a “flag” ; can be:

- Battery Voltage Too Low
- Battery Voltage Too High
- Initial Charging Timeout
- Overall Charging Timeout
- Battery Detachment during charging
- Interruption by button
- Battery Undercharged
- Battery Sulphated
- Power interruption during charge
- Power failure
- Undercharge Voltage Recognition
- Equalizing completed
- Autostart in progress
- Charging Terminated

When activated, remote signalling can be implemented by a Luminous Monitor or an acoustic Indicator.

- **Message configuration on LCD:**

Default: NO

Meaning: This menu allows you to determine in which situations you would like an additional message to be displayed on the LCD (for example: Call Assistance, request maintenance!) ;
The displayed message corresponds to that inserted in strings 23 and 24 of the text file corresponding to the languages foreseen for messages on LCD.

- **Equalizing Delay:**

Default: 16 [hour/hours]. 0 [min]

Meaning: determines the delay with which the first equalizing charge is carried out

- **Float charge delay:**

Default: 168 [hours] 0 [min]

Meaning: determines the delay with which the first floating charge is carried out

- **T1: Minimum duration of final charge:**

Default: 2 [hours] 0 [min]

Meaning: This parameter has a different meaning depending on whether "only time control“ or "Ah control“ is preset:

- **With only time control:**

Default: 1 [hour] 0 [min]

Meaning: With this value the minimum charging time of the duration of final charging is entered as explained when describing the parameter “Only time control”.

- **Ah Control:**

Default: 2 [hours] 0 [min]

Meaning: By entering this value, the charging factor of charges with a minimum discharge level is increased according to the following rule:

- If ***the initial charging time is less than 1 hour***, the time **for final charging will be 1 hour**.
- If the ***initial charging time is less than T1***, the **final charging time will be equal to the initial charging time**, and therefore the overall charging time will be double the initial charging time.
- **If the initial charging time is greater than T1, the usual charge will be carried out calculating the charging factor.**
- **The value T1** (minimum final charge time) **must in any event be greater or the same as the value entered as minimum duration of overall charging time.**

- **T2 (maximum final charging time):**

Default: 4 [Hour/hours] 0 [min]

Meaning: This parameter is only valid for time control and determines the maximum duration of final charging.

- **Minimum duration of total charging:**

Default: 1 [Hour/hours] 0 [min]

Meaning: Charging generally lasts less than 1 hour. This helps avoiding problems which can arise when batteries are discharged too little and then once again connected to the battery charger.

- **Total charge safety timer:**

Default: 16 [hours] 0 [min]

Meaning: This is the value of the complete charge safety time. When this time is reached, charging is interrupted and a fault is signalled.

- **Initial Charge Safety Timer:**

Default: 11 [hours] 0 [min]

Meaning: This is the value of the initial charge safety time. When this timeout is reached during initial charging, charging is interrupted and a fault is signalled.

- **Minimum cell voltage:**

Default: 1.60 [V] (possible up to 1.2 [V])

Meaning: If the average voltage per cell is less than this parameter, the battery charger does not start charging and a minimum voltage fault is signalled.

- **Maximum cell voltage:**

Default: 2.40 [V]

Meaning: If the average voltage per cell is greater than this parameter, the battery charger does not start charging and a maximum voltage fault is signalled.

- **Gassing Voltage:**

Default: 2.40 [V]

Meaning: This is the so-called gassing voltage, which when reached shifts from initial charge to final charge. This voltage also represents the calibration point which the final charging time calculation refers to (with time control) or calculation of the amperes/hour to be charged during the final charge (with Ah balancing).

- **Final charge passage delay:**

Default: 10 [sec]

Meaning: This parameter indicates the minimum time at which the battery voltage must have exceeded the gassing voltage to acknowledge actual passage to final charging. This compensates any faults caused by power oscillations.

- **VGas filling level:**

Default: 93 [%]

Meaning: This value indicates the level of battery filling at the moment gassing is reached. It depends on many parameters and therefore is never a precise value.
It has values from 85% to beyond 100%.
The standard value (93%) refers to batteries in good conditions which are used at a temperature range from 15 to 50°C. Colder batteries never reach these values, and therefore in these cases special charging parameters must be used.

- **Top-Up Enabling Time:**

Default: 5 [min]

Meaning: This is a time at which the electromagnetic valve is opened for water inflow.

- **Top-Up Enabling Delay after end of charging**

Default: 20 [min]

Meaning: Defines the pause which intervenes at the end of charging before enabling the top-up relay

- **Duration of first Air Pump activation (Tap_on_1):**

Default: 30 [min]

Meaning: Electrolytic recirculation is activated at the start of charging for a time determined by this parameter (e.g. 30 minutes) without interruptions.

- **Duration of subsequent Air Pump activations (Tap_on_2):**

Default: 5 [min]

Meaning: After the time of the first activation of the Air Pump, air blow pause and activation times alternate, defined by the parameters Tap_on2 and Tap_off.
The value of this parameter indicates the activation time in this second phase.

- **Duration of Air Pump activation pause (Tap_off):**

Default: 25 [min]

Meaning: After the activation time Tap_on1, pause and blowing times alternate at preset intervals. The Tap_off value indicates how long the pump remains paused between one activation pulse and the next.

- **Undercharge recognition quotient**

Default: 108 [%]

Meaning: After a time called "1st detection instant" and again after a second time called "2nd detection instant" of the undercharge (for example after 1min and after 30 min of charging), the internal resistance is calculated from the charging current and voltage values, and the following value is determined:

$$100 \times \frac{\text{2nd internal resistance detection (30 min)}}{\text{1st internal resistance detection (1 min)}}$$

If this quotient (*100) is less than the value entered in "Undercharge recognition quotient" it means of that the battery was initially undercharged.

- **Undercharge Voltage**

Default: 1.95 [sec]

Meaning: Besides recognition of undercharging by means of the quotient calculation, another criterion is introduced for the presence of an undercharge.
Before charging begins (after the battery has been connected) the "rest voltage" is measured. If this is less than the present value, it means that an undercharge has occurred. However this condition is not sufficient.
Only if the evaluation of the internal resistance quotient also indicates recognition of an undercharge condition (both conditions must be met) then the battery is effectively considered undercharged, the user is given information on the LCD and the event is properly memorised in the historical data memory.

- **Minimum charging duration for saving data:**

Default: 0 [hours] 2 [min]

Meaning: To keep useless charging cycles from being memorised, only the records of charging data of cycles that lasted at least as long as the parameters set here are memorised.

- **Minimum duration of mains power to start charging:**

Default: 2 [sec]

Meaning: The presence of mains voltage is recognized only if the voltage lasts for at least a time determined by this parameter.

- **1st Sulphation check instant:**

Default: 60 [sec]

Meaning: The connected battery is sulphated if when charging begins the charging current increases or decreases the charging voltage, or if both situations occur simultaneously. This is caused by decrease of the relatively high resistance of the battery with formation of sulphuric acid with good conductivity at the beginning of charging.
The 1st sulphation check instant corresponds to the moment that the first current value is memorised.

- **2nd Sulphation check instant:**

Default: 30 [min]

Meaning: Reaching the charging time called 2nd sulphation check instant, the charging current is again measured and this value is compared to the value of the charging current detected at the 1st current measurement instant.

- **Current increase for sulphation recognition:**

Default: 20 [%]

Meaning: If the current measured at the 2nd sampling is greater than the current measured at the 1st sampling of the percentage value determined by this parameter, then the battery is acknowledged to be sulphated.
This event is memorised among the diagnostic data as "sulphated battery" condition.

- **Battery disconnection recognition:**

Disconnection of the battery can be recognised through two events:
1) Sudden rising of cell voltage (provided by rectified no-load voltage reading of power transformer (this parameter can be enabled or disabled)
2) Current close to trivial value.

- **Cell voltage greater than:**

Default: 2.75 [V] Active: YES

Meaning: In the event of control of battery disconnection due to voltage increase (flag on active), the board recognises that the battery has been disconnected from the battery charger if the voltage of the battery is greater than the value defined here (e.g. 2.75 V/cell).
If the active Flag is set at NO, the trend of the voltage is not taken into consideration to recognise battery disconnection.

- **Current less than:**

Default: 1.5 A

Meaning: Battery disconnection can also be recognised by the sole reading of battery current lower than a preset value.
If recognition by voltage is not active, this reading of the current below a minimum threshold will be the only condition to recognise battery disconnection. Otherwise recognition occurs by the combination of the two events.

- **Charging cable resistance:**

Default: 0.0 [mOhm]

Meaning: This indicates the resistance of the line associated to the charging cable to compensate voltage drop which occurs along this cable through the board. These mOhm values depend on the cross-section and length of the charging cable and are defined in the following tables depending on the length and cross-sections of the cable used in the different single-phase and three-phase models.
Table defining battery cable cross-section, shunt value and overall resistance of battery cables:

**PRIMO POWER Wa / WoWa / Pulse SINGLE-PHASE, length of loading cables: 3,5 m = 7 m total**

| Rated current (A) | Cable cross-section Battery ($mm^2$) | Shunt (A) | Battery Cable Resistance (mOhm) |
|---|---|---|---|
| 10 | 10 | 30 | 12,5 |
| 20 | 10 | 30 | 12,5 |
| 25 | 10 | 30 | 12,5 |
| 30 | 10 | 30 | 12,5 |
| 40 | 10 | 50 | 12,5 |
| 50 | 16 | 50 | 7,8 |
| 60 | 16 | 75 | 7,8 |
| 70 | 25 | 75 | 7,8 |
| 80 | 25 | 100 | 5,0 |
| 90 | 25 | 100 | 5,0 |
| 100 | 25 | 100 | 3,6 |

**PRIMO POWER WoWa / PRIMO PULSE THREE-PHASE, length of loading cables: 3.5 m = 7 m total**

| Rated current (A) | Cable cross-section Battery ($mm^2$) | Shunt (A) | Battery Cable Resistance (mOhm) |
|---|---|---|---|
| 30 | 10 | 30 | 12.5 |
| 40 | 10 | 50 | 12.5 |
| 45 | 16 | 50 | 7.8 |
| 50 | 16 | 50 | 7.8 |
| 65 | 16 | 75 | 7.8 |
| 70 | 25 | 75 | 5.0 |
| 85 | 25 | 100 | 5.0 |
| 90 | 25 | 100 | 5.0 |
| 100 | 25 | 100 | 5.0 |
| 120 | 35 | 150 | 3.6 |
| 130 | 35 | 150 | 3.6 |
| 140 | 35 welding | 150 | 3.6 |
| 150 | 50 welding | 150 | 2.5 |
| 160 | 50 welding | 200 | 2.5 |
| 180 | 50 welding | 200 | 2.5 |
| 200 | 70 welding | 200 | 1.8 |
| 220 | 70 welding | 250 | 1.8 |
| 240 | 70 welding | 250 | 1.8 |
| 260 | 70 welding | 300 | 1.8 |

## Chapter 9: MEMORISED DATA AND STATISTICS

For each charging cycle, the PBM250 card records all the main parameters and implements some useful statistics on these to highlight malfunctioning of the battery charger, anomalous battery states or incorrect behaviour by the user.
This data can be downloaded through the USB serial port connected to a COM Port of the PC using SW PBMService.
For further details on how to read this data and on the shape of the log files, refer to the **"SW PBMService Technical Manual".**

**DATA MEMORISED:**
The following is a list and description of all the data memorised for each charging cycle:

- **Progressive event Identifier:** The data blocks of the single charging cycles, as well as equalizing charges, are numbered progressively starting from the first charge carried out by the battery charger.
- **Time and date at start of charge:** When charging starts, the date and time are recorded and entered into the data block of this charge.
- **End charge voltage:** Charging voltage at the end of charging, of bit before charging interrupts, regardless of the type of interruption. In the event of pulse charging, voltage at the end of charging is that of the last WO phase, not that of the pulse phase Wp.
- **Initial charge time:** The initial charge time is the time it takes for charging to reach the gassing voltage. This gassing voltage is determined in the charging program as constant and for the WoWa and pulse characteristic, it represents the voltage of passage from the Wo phase to the Wa phase, namely from the WO phase to the pulse phase Wp.
- **Final charge time:** The final charge time is the charging time from when gassing voltage is reached, namely switching voltage, until the end of charging, regardless of how the charge is interrupted.

**Overall charge time:** This is the sum of the initial charge time + final charge time.

- **Ampere/hour recharged during initial charge:** Ampere/hour recharged from the start of charging until gassing voltage (initial charge time).
- **Ampere/hour charged during final charge:** Ampere/hour charge from when gassing voltage is reached until the end of charging (final charge time).
- **Total ampere/hour charged:** The Ampere/hour from the start of charging until it is interrupted regardless of the type of interruption. These Amperes/hour correspond to the sum of the Ah provided in initial charging and in final charging.
- **Equalizing charge execution:** If the battery charger remains connected to the battery after standard charging has ended, for example, at least for 16 hours, an equalizing charge is carried out and recorded.

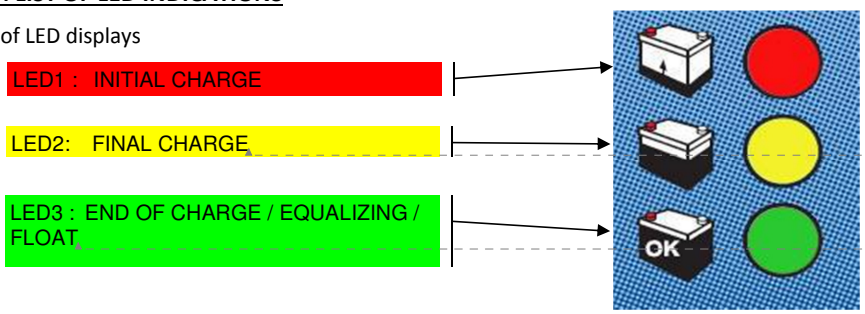
**STATISTICS PERFORMED ON CHARGING DATA:**

The following is a list and description of the statistics taken starting from the charging cycle data.

- **Total amount of charges started:** The total amount of charges started indicates how many times the CB began charging after being connected to a battery.
- **Total amount of charges interrupted in advance:** The total amount of charges interrupted in advance indicates the frequency with which charges were interrupted due to improper use or particular faults (for example power failures).
- **Total amount of stops due to exceeding maximum time:** This indicates that a wrong battery was connected or faulty batteries were charged.
- **Total amount of sulphated battery charges :** If a so-called “negative voltage trend“ occurs at the start of charging, namely charging voltage decreases while charging current remains constant or increases, this means that the battery being charged is sulphated and its internal resistance is decreasing. This effect must be entered into the “sulphated battery” count.
- **Total amount of under-discharges:** Under-discharges reduce battery life and can also cause safety time to be overcome. In order to recognise under-discharges, if the voltage/current values measured at the beginning of charging change, we need to understand what type of internal resistance is present, and if the battery was previously undercharged, the undercharge totaliser must increase its count by one unit.
- **Total power failures:** A power failure, or failure of one phase in the case of three-phase appliances, must be detected and must produce the relative fault signalling.
- **Total amount of equalizing charges performed:** The total amount of equalizing charges, compared to the total amount of charges started, indicates whether the required equalizing charges were performed.

## Chapter 10: LIST OF LED INDICATIONS

Description of LED displays

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| Signals | Red LED 1 | Yellow LED 2 | Green LED 3 |
|---|---|---|---|
| Power supply from mains only | OFF | OFF | OFF |
| Power supply from battery only | ON | OFF | OFF |
| Board switch-on | 3 FLASH | 3 FLASH | 3 FLASH |
| Mains Autotest OK | OFF | BLK | BLK |
| Autostart execution | ROT.FLASH | ROT.FLASH | ROT.FLASH |
| Initial charge | BLK | OFF | OFF |
| Final charge | OFF | BLK | OFF |
| Charging ended | OFF | OFF | ON |
| Equalizing or floating pause | OFF | OFF | ON |
| Equalizing or floating charge | OFF | OFF | BLK |
| Power failure | BLK | BLK | BLK |
| Low battery voltage | BLK | BLK | BLK |
| High battery voltage | BLK | BLK | BLK |
| Initial Charge Safety Timer | ON | ON | ON |
| Final Charge Safety Timer | BLK | BLK | BLK |
| Battery Detachment during charging | OFF | OFF | OFF |
| Charging interruption from ON/OFF button | NO CHANGE | NO CHANGE | NO CHANGE |

Where: OFF = the LED is off,
ON = the LED is on,
BLK = the LED blinks slowly (T=2sec)
FLASH =1 quick flash followed by long pause (Ton = 0.5 sec, Toff = 1.5 sec)
ROT. FLASH = sequence of rotation flashes
NO CHANGE = the LED remains as is

## Chapter 11: LIST OF FAULTS VIEWED ON ALPHANUMERICAL DISPLAY

The following is a list of the faults viewed on the display during charging or on the database

| MESSAGE ON DISPLAY | DESCRIPTION |
|---|---|
| Low batt. volt. | Battery voltage too low for CB – Battery connection error |
| High batt. volt. | Battery voltage too high for CB – Battery connection error |
| Timeout In. C. | Error due to intervention of Safety Timer on Initial Charge |
| Timeout tot. C. | Error due to intervention of Safety Timer on Overall Charge |
| Interr. by Button | Charging suspension due to stop through ON/OFF button |
| Battery under discharged | Battery recognized to be under-discharged |
| Battery sulphated | Battery recognized sulphated |
| Power interruption | Power interruption during charge |
| Power failure | Power failure: start of charging delayed |

## Chapter 12: INSTALLATION, SAFETY, TROUBLESHOOTING AND MAINTENANCE

This chapter provides the main information required for **Assistance Service** to properly install the battery charger, for quick search of the most common faults and correct maintenance of the device in time.

### 12.1: INSTALLATION

General information for installation of the battery charger is already widely described in the user manual attached to each battery charger.
The main elements are summarised as follows:

- Always make sure that the power available by the final user and the mains voltage are adequate and correspond to those required for the battery charger to work properly.
- The battery charger is equipped with sockets for mains regulation (± 5%) capable of compensating differences between the voltage available by the user and the rated voltage.
- Three-phase battery chargers are regulated by a rated voltage of 400VAC.
- **It is fundamental to check the mains voltage**: more or less voltage than the rated value cause significant differences in the current supplied by the battery charger with ensuing malfunctioning or loss of battery performance.
- **Remember that PRIMO POWER WoWa and PRIMO PULSE battery chargers perform their charge through Ah balancing and therefore the recharging factor does not depend on the trend of the mains voltage. Nonetheless charging time is greatly affected by the mains voltage value.**

### 12.2: SAFETY INFORMATION

1) Make sure the battery charger is placed on the stable surface and protected against impacts by forklift trucks or other vehicles.
2) The battery charger must be positioned in a zone free from materials obstructing proper natural ventilation required to exhaust the heat produced.
3) Make sure there are no explosive, flammable and/or dangerous materials nearby.
4) Make sure the battery charger is positioned in a zone sheltered from rain, water, steam and fog; we recommend not installing the unit outdoors* below roofs and/or temporary shelters.
   * except for special versions with an IP43 protection rating or greater.
5) Also check the electrical conditions of the sockets, fuses and/or switches of the user and of the connection cables; do not add extension cords to the power cable of the battery charger!!
6) Make sure the battery charger is supplied with an electric plug compatible for its power and current and is connected to an adequate mains socket!! (check the absorption and power indicated on the identification plate).
7) Check the integrity of the connections between the battery and the battery charger which could cause dangerous overheating if damaged and/or worn.

**It is absolutely necessary to warn the operators that THEY MUST NEVER DISCONNECT THE BATTERY CONNECTOR DURING CHARGING !!**

**8) All control and/or calibration operations must be carried out by qualified personnel and in any event trained and authorised.**

## Chapter 13: TROUBLESHOOTING

The following are general indications since the types of faults and/or malfunctioning can vary and therefore the Assistance Service must resolve the problems due to their experience. The following can be said of the battery chargers:

**The decreasing current battery chargers are also subject to *apparent malfunctioning* due to external causes, such as electrical systems and/or batteries in poor conditions. For this reason during all control operations, keep this eventuality in mind.**

**Please remember that the Service must be equipped with a laptop, a USB cable to connect to the card and the SFW PBMService.**

### 13.1: FIRST CHECKS TO BE PERFORMED

- Preliminary check of the general conditions of the battery charger and of the battery (see previous paragraph).
- Make sure the power cable of the battery charger is properly connected to the mains socket and that the mains switch is OFF.
- Make sure the battery charger is powered.
- Make sure the battery charger is connected properly to the battery and check the conditions of the connectors.

### 13.2 : FUNCTIONAL CHECKS

- **Check whether the card indicates a fault message and related messages** (see Chapter 10/11) ;
- Connect PC on the card to display any messages of previous anomalies ;

**If the anomaly appears in the list below, check the following :**

| MESSAGE ON LCD | DESCRIPTION |
|---|---|
| Low batt. volt. | Battery voltage too low for battery charger – Battery connection error |
| High batt. volt. | Battery voltage too high for battery charger – Battery connection error |
| Checks : | • Check the setting of jumper X5 on the card;<br>• Verify with the SW that the charger has been programmed for the proper Battery Voltage<br>• If the setting is corresponding to the rated voltage of the battery, check battery status. |

| MESSAGE ON LCD | DESCRIPTION |
|---|---|
| Timeout In. C. | Error due to intervention of Safety Timer on Initial Charge |
| Checks : | Are elapsed 7 hours (WoWa) or 11 hours (Wa / Pulse) without the battery has reached the threshold of 2,40 V/cell. for which :<br>• Check the mains voltage (transformer) ;<br>• Check the condition of the bridge diodes (RD) *;<br>• Check that the charger supplies the right current according to the model;<br>• Check the battery status. |

| MESSAGE ON LCD | DESCRIPTION |
|---|---|
| Timeout In. C. | Error due to intervention of Safety Timer on Overall Charge |
| Checks : | Are elapsed 16 hours without the battery has completed charging, for which :<br>• Check the "historical data" if there are other similar anomalies;<br>• Check the mains voltage (transformer),<br>• Check the condition of the bridge diodes (RD) *;<br>• Check that the charger supplies the right current according to the model;<br>• Check the battery status. |

| MESSAGE ON LCD | DESCRIPTION |
|---|---|
| Interr. by Button | Charging suspension due to stop through ON/OFF button |
| Checks : | It is not really an anomaly since the operator may have stopped charging for the need to use the lift truck ;<br>However, this may give rise to a partial recharge or not complete that has repercussions on the next charge, for which :<br>• Check the “historical” data charges before and this. |

| MESSAGE ON LCD | DESCRIPTION |
|---|---|
| Battery under charges | Battery recognized to be over discharged |
| Checks : | This anomaly affects the batteries that are "normally" discharged below the threshold of 80%; This use can cause battery to be not fully rechargers because of a rapid increase of the voltage at the start of charging.<br>• Check the "historical" data of the previous cycles to see if this behavior happens often. In this case inform the user to use the battery properly not subjecting the battery to excessive discharge. |

| MESSAGE ON LCD | DESCRIPTION |
|---|---|
| Battery sulphated | Battery recognized to be sulphated |
| Checks : | The second anomaly is caused from the fact the user leave battery without using them for a long period, so that sulphate crystals covers the plates.<br>• Check the "historical" data of the previous cycles to see if this behavior happen often. In this case inform the user to use the battery properly not subjecting the battery to excessive discharge. |

**Checking rectifier bridge RD:**
The rectifier bridge is made up of button diodes on aluminium plates acting as dissipaters.
To achieve different current capacities, the bridge is made up of a variable number of diodes positioned in parallel on the same plate.
The Bridge must be disconnected from the rest of the battery charger to perform a functional check.

Place the Tester in "Diode Check" mode and do as follows:

A) check **diode voltage** (0.4V - 1V) by placing the **positive tip at the input of the alternates** coming from the transformer and the **negative tip on the positive output pole**.
B) Check an infinite diode voltage with the positive tip on the positive output pole of the bridge and the negative tip on each input of the alternates.
C) check **diode voltage** (0.4V - 1V) by placing the **positive tip on the negative output pole** of the bridge and the **negative tip on the input of the alternates** coming from the transformer.
D) Check an infinite diode voltage with the positive tip on the alternates and the negative tip on the negative output of the bridge.

In addition to the instrument checks, the following observation checks can be carried out:

- Visual checks to exclude that there are blown diodes or an unsoldered reophore.
- If **strong vibrations** are heard during the charging process and charging is not performed properly due to intervention of the master switch or fuses, **the bridge is short-circuited and must be replaced**.
- On the other hand it is easy to diagnose **the open bridge failure on a three-phase battery charger** by operating the charger without connecting the battery and forcing the power supply of the transformer. If an anomalous transformer voltage, instead of a no-load voltage, is detected under these conditions, it means that the **rectifier bridge is at least partially open and needs replacing**.
- For **PRIMO POWER WoWa and PRIMO PULSE three-phase battery chargers**, **the no-load output voltage** corresponds to the values contained in the following table (provided that the transformer is correctly powered).

| BATTERY RATED VOLTAGE | NO-LOAD OUTPUT VOLTAGE (D.C.) |
|---|---|
| 24V | 33-38V |
| 36V | 50-58V |
| 48V | 72-78V |
| 72V | 100-108V |
| 80V | 110-120V |
| 96V | 130-150V |

- For **PRIMO POWER WoWa and PRIMO PULSE single-phase battery chargers**, **the no-load output voltage** corresponds to the values contained in the following table (provided that the transformer is correctly powered).

| BATTERY RATED VOLTAGE | NO-LOAD OUTPUT VOLTAGE (D.C.) |
|---|---|
| 12V | 14-16V |
| 24V | 27-30V |
| 36V | 40-45V |
| 48V | 56-59V |
| 72V | 82-88V |
| 80V | 92-98V |
| 96V | 110-118V |

## Chapter 14: MAINTENANCE and CLEANING

**All maintenance and cleaning operations must be carried out by qualified personnel and in any event trained and authorised.**

- The battery charger is a static electrical device and having no moving mechanical parts it needs no special maintenance.
- It is however suggested to check, inspect and clean **at least once a year** making sure that the battery charger works in a fairly "clean" environment.
- For "heavy duty" environments with exposure to dust and/or humidity, **more frequent checks** are required.

The main operations to be carried out are:

- Bring the battery charger/s outside and remove the closing panels.
- Wear a face mask and personal protective equipment (PPE) and remove dust accumulated inside with compressed air.
- Use non-corrosive detergents to remove sludge deposits or other dirt.

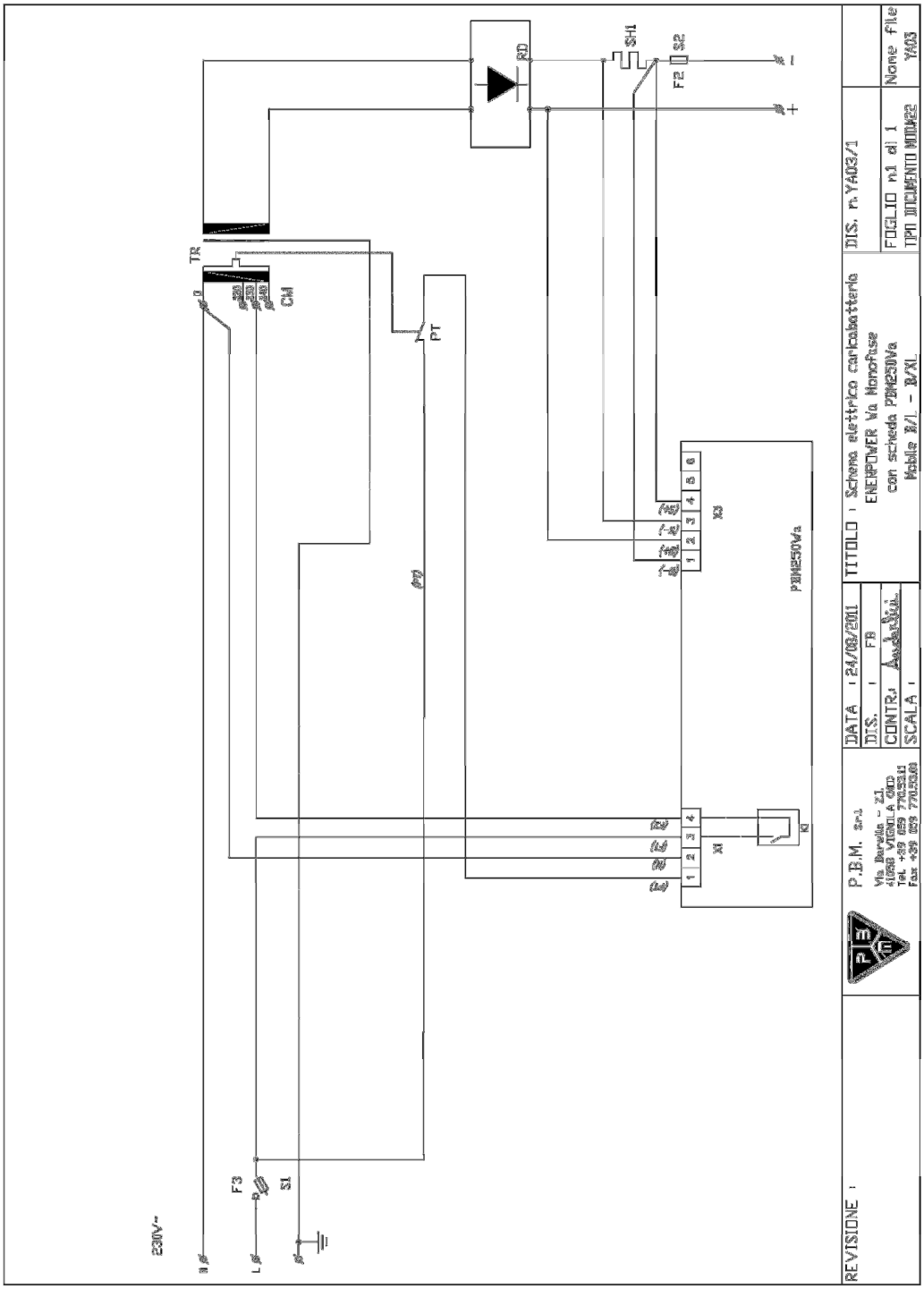
Once cleaning has been completed, check:

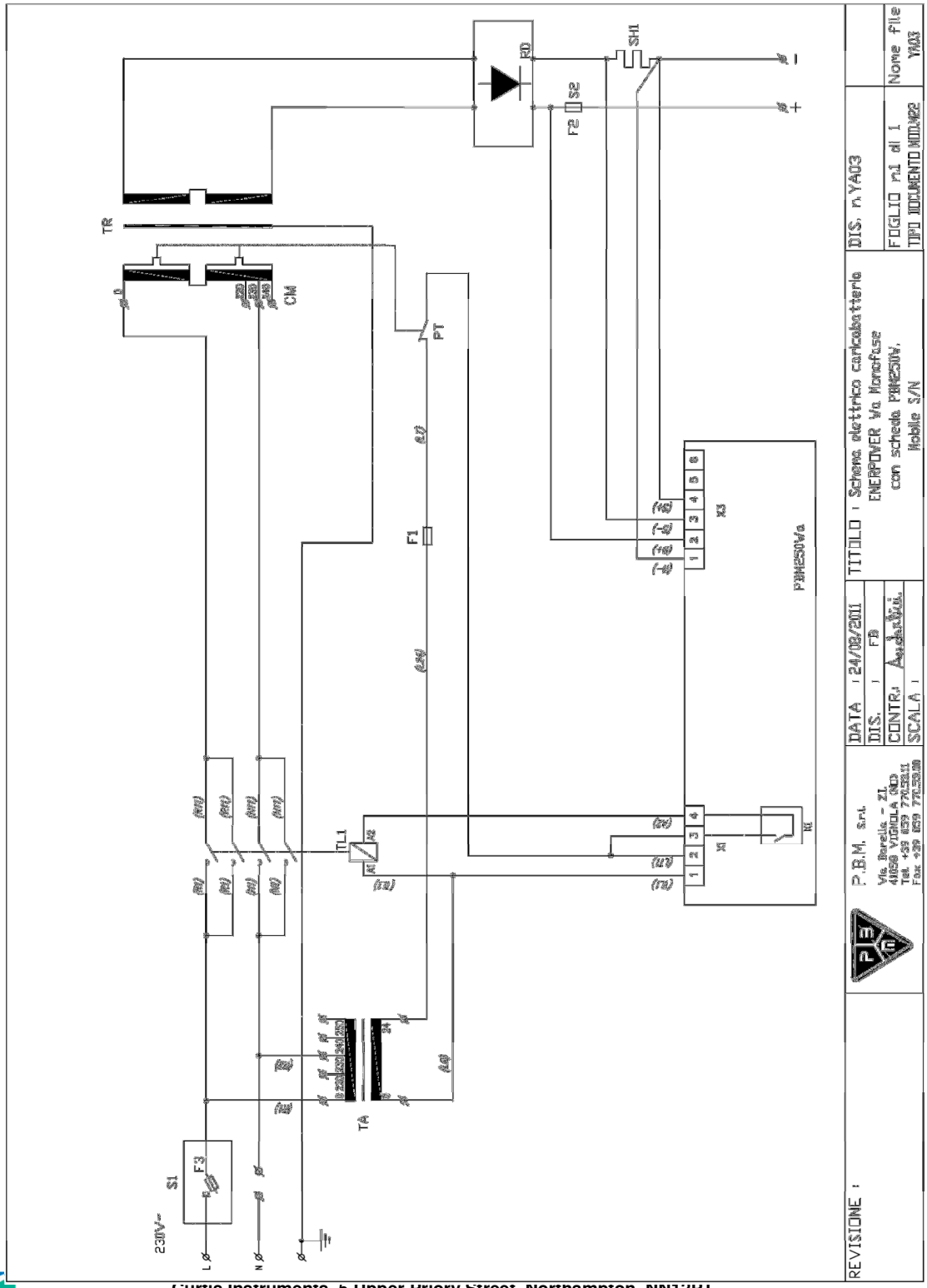
- The overall conditions of components and their integrity.
- Replace any oxidised cables and/or terminals.
- Clean electrical contacts on the contactors, switches and selector switches with proper sprays.
- Check the tightening of screws and bolts, replace any "rusted" parts.
- Perform a "dry" cleaning or use proper sprays to clean the circuit boards.
- Check the status of control and power connectors; check the "wear" of the power connectors on the battery and replace them if necessary.
- Check the conditions of the electrical plugs.
- When these operations are complete, close the panels, doors and covers and put the battery charger back in place.

## Chapter 15: PRIMO POWER and PRIMO PULSE PARTS LIST

| | |
|---|---|
| **F1** | Control circuit fuse 24Vac 1.6 A-T (glass 5x20) |
| **F2** | Battery side outlet fuse NH00 (up to 160A), NH-1(200A-250A) or NH-2 (250A-315A) |
| **F3/F4/F5** | Mains fuses 10.3x38 ..... A-T, 14x51 ..... A-T or 22x58 ..... A-T |
| **S1** | Three-pole fuse-holder 10.3x38mm, 14x51mm or 22x58mm |
| **S2** | Monopolar fuse-holder base NH00 (up to 160A), NH-1(200A-250A) or NH-2 (250A-315A) |
| **TL1 / TL2** | Line contactor |
| **PT** | Thermal cut-out on transformer |
| **CM** | Terminal board with pins for mains adjustment |
| **TR** | Power transformer |
| **TA** | Auxiliary transformer |
| **RD** | Diode rectifier bridge |
| **SH1** | Amperometric Shunt 60mV |
| **PBM250** | Control and display board **PBM250** |

## WIRING DIAGRAM PRIMO POWER Wa

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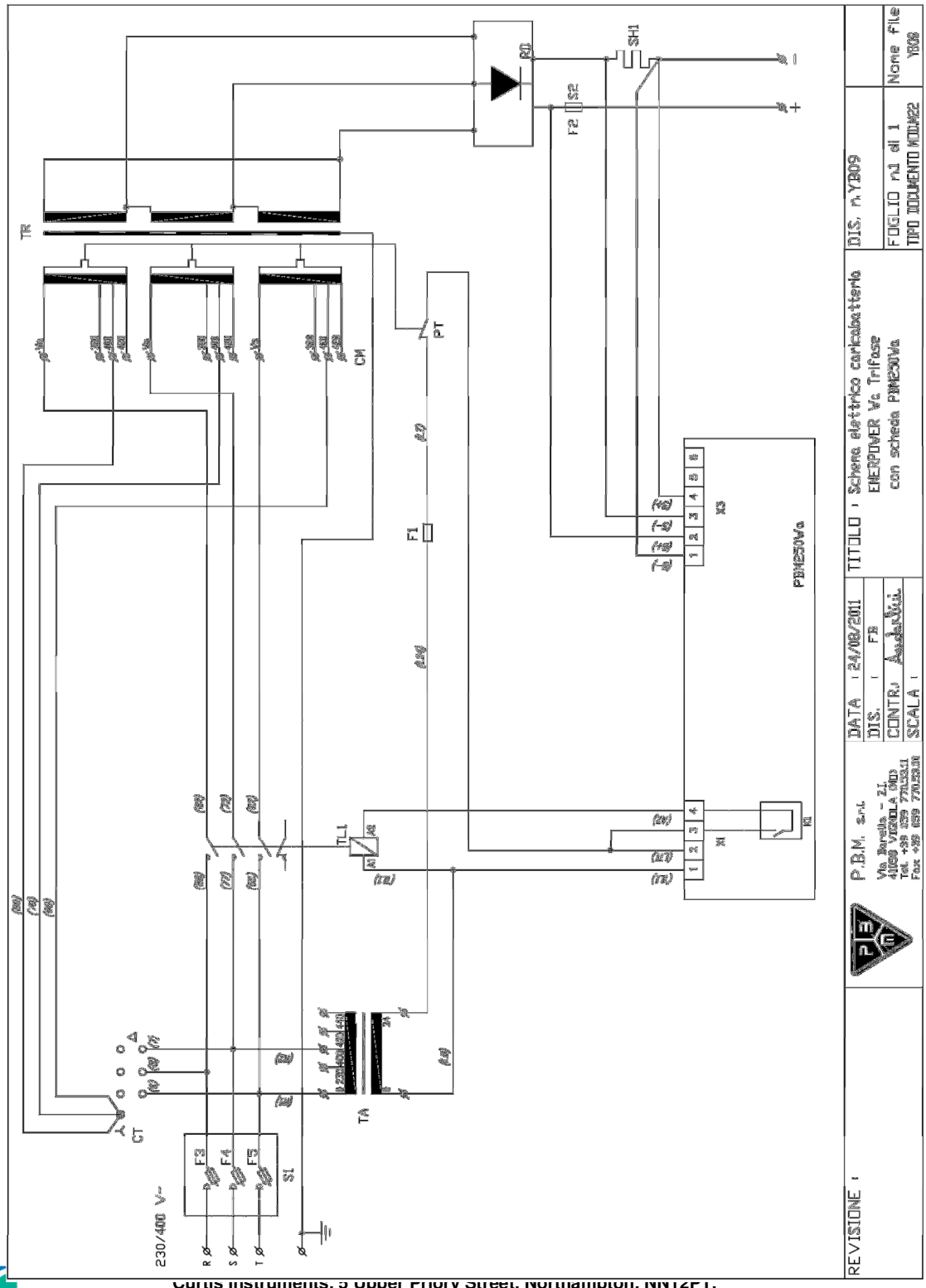
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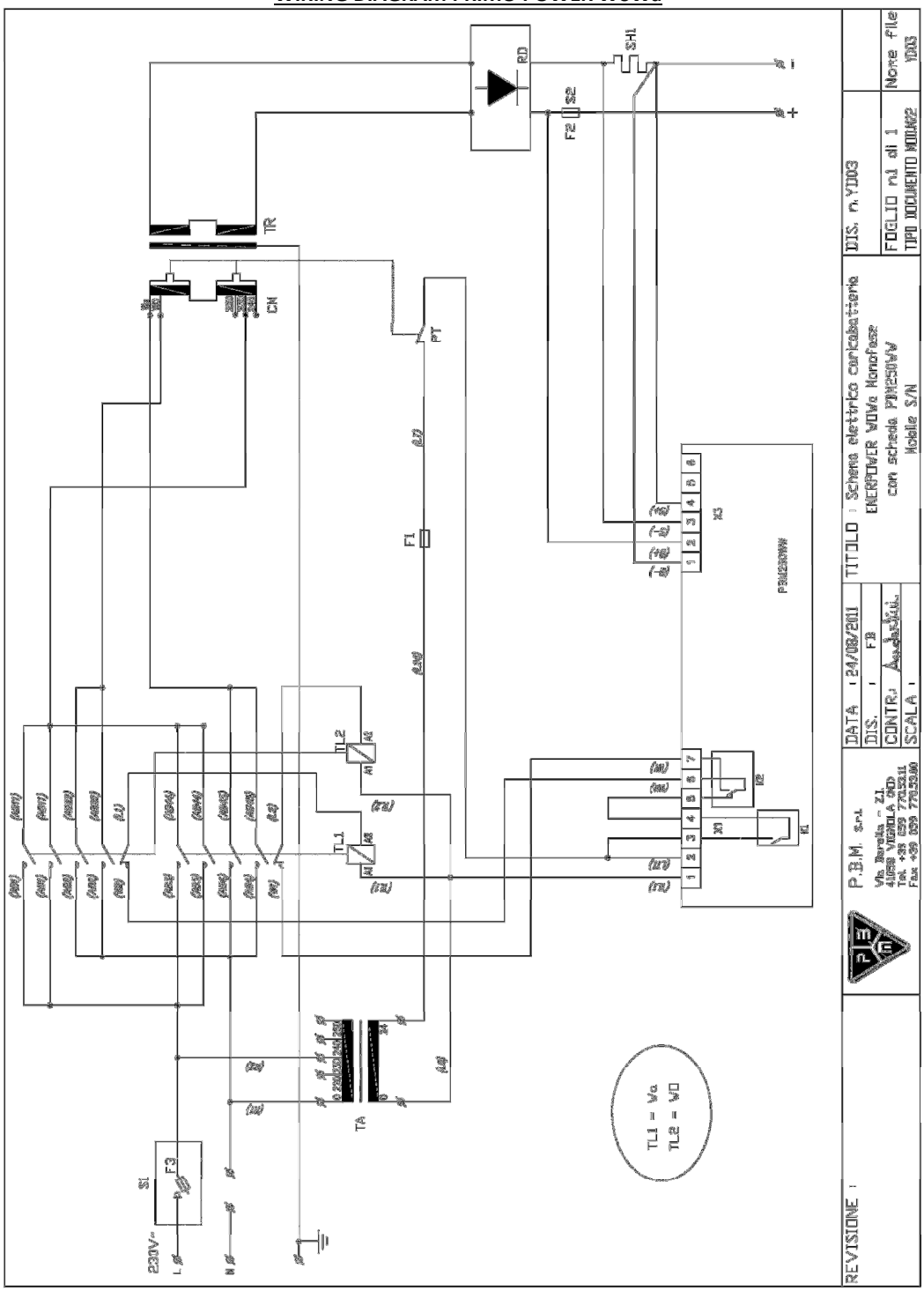

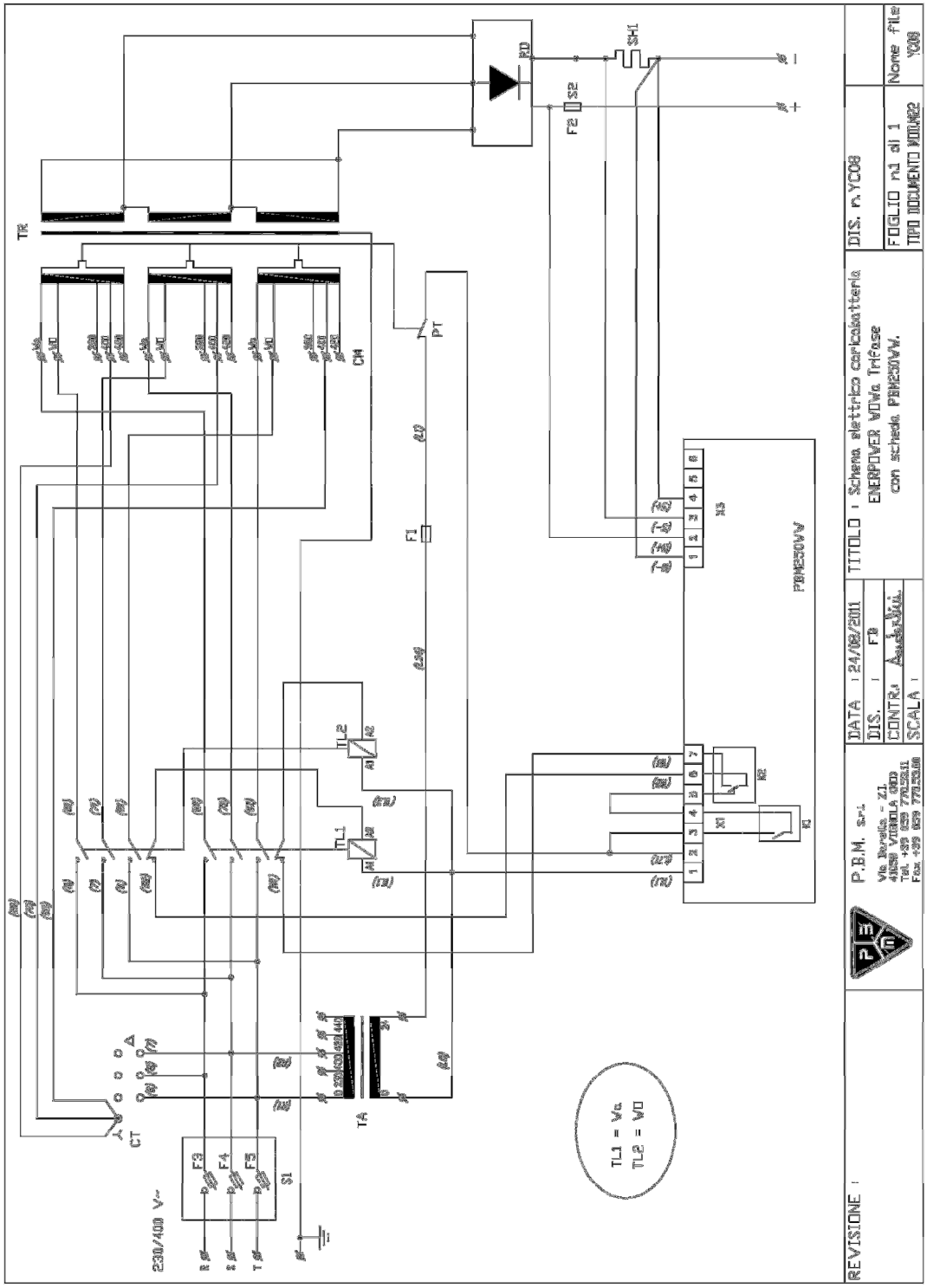
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Fax +39 059 770500
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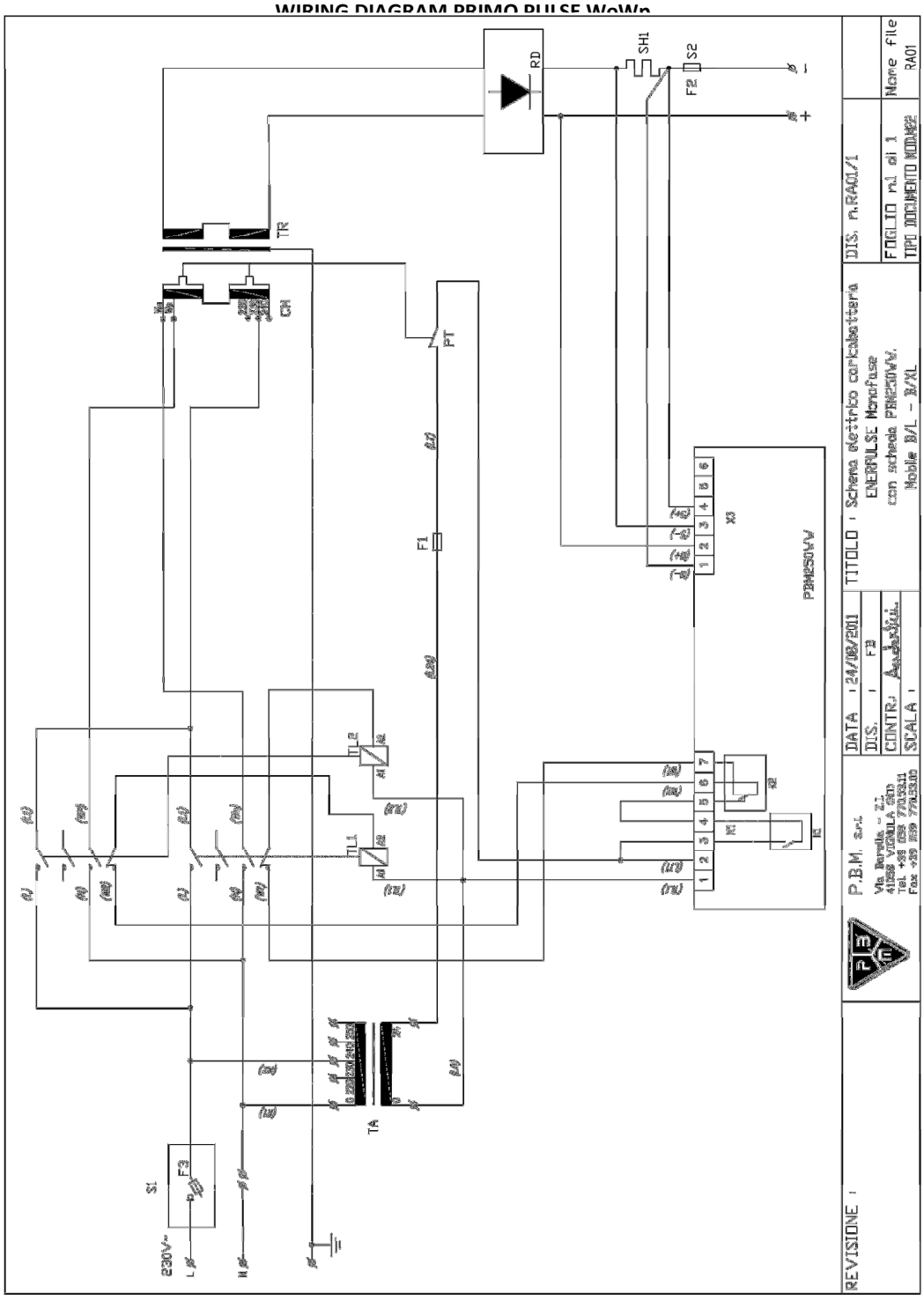
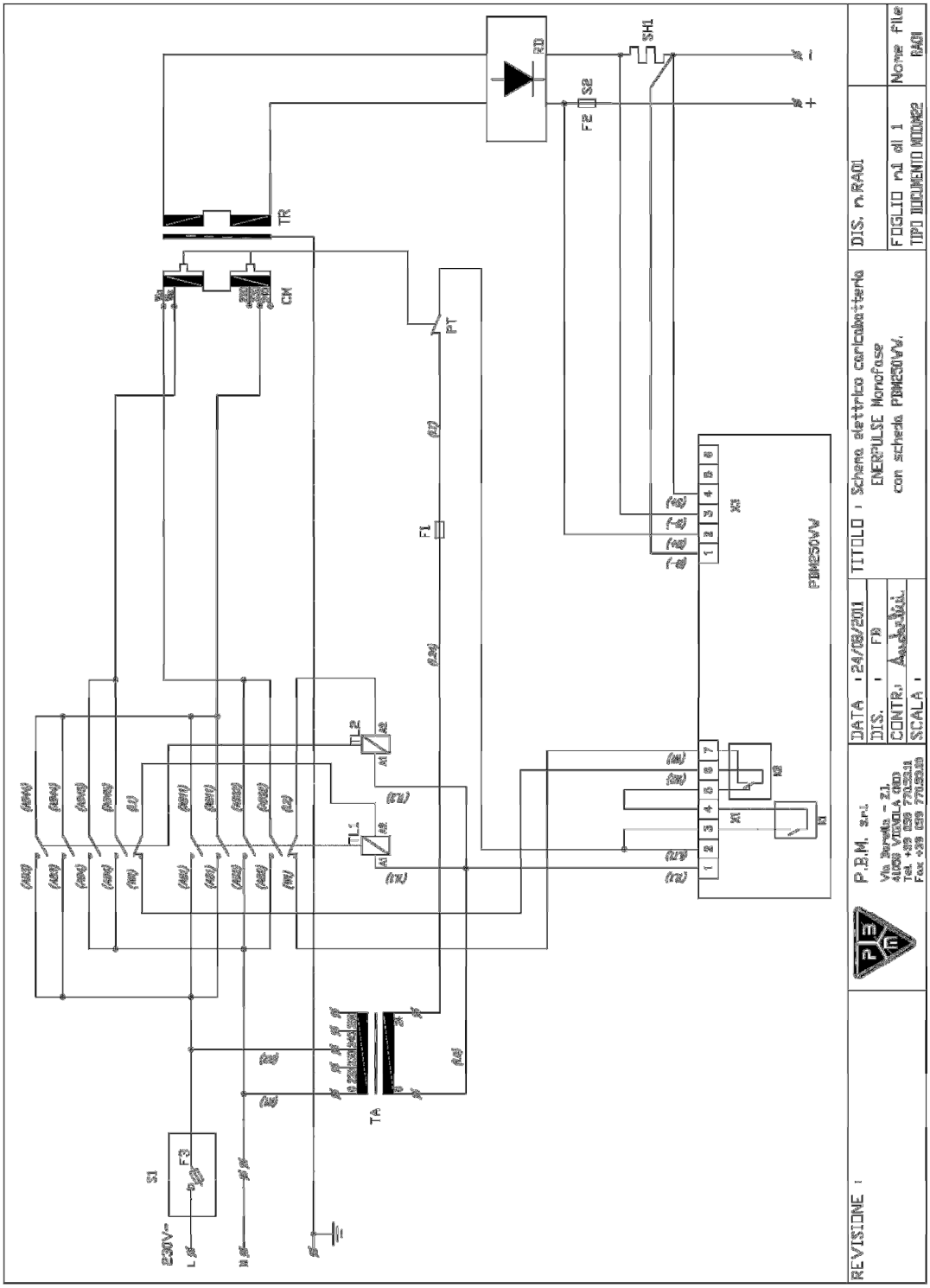
## WIRING DIAGRAM PRIMO PULSE WoWp

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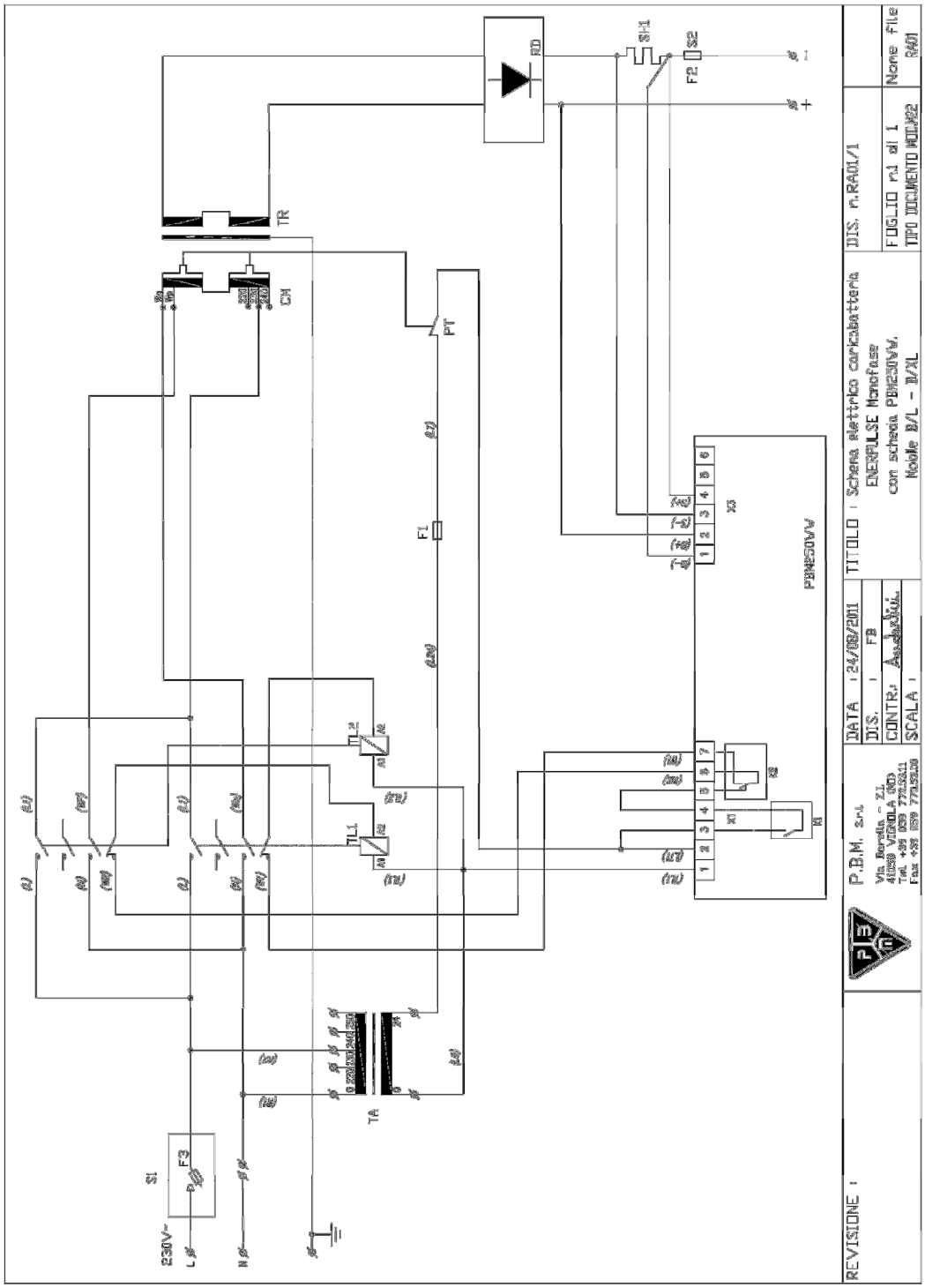
P.B.M. srl
REVISIONE :


RD
SH1
F2
S2
TR
CH
PT
F1
X3
PBM250V/W
TA
S1
F3
230V~
L
N
DIS. n.RA01/1
TITOLO : Schema elettrico carica batteria
ENERPULSE Monofase
con scheda PBM250V/W.
Modello B/L - B/XL
FOGLIO n.1 di 1
TIPO DOCUMENTO MOD/M02
Nome File
RA01
DATA : 24/08/2011
DIS. : FB
CONTR.:
SCALA :
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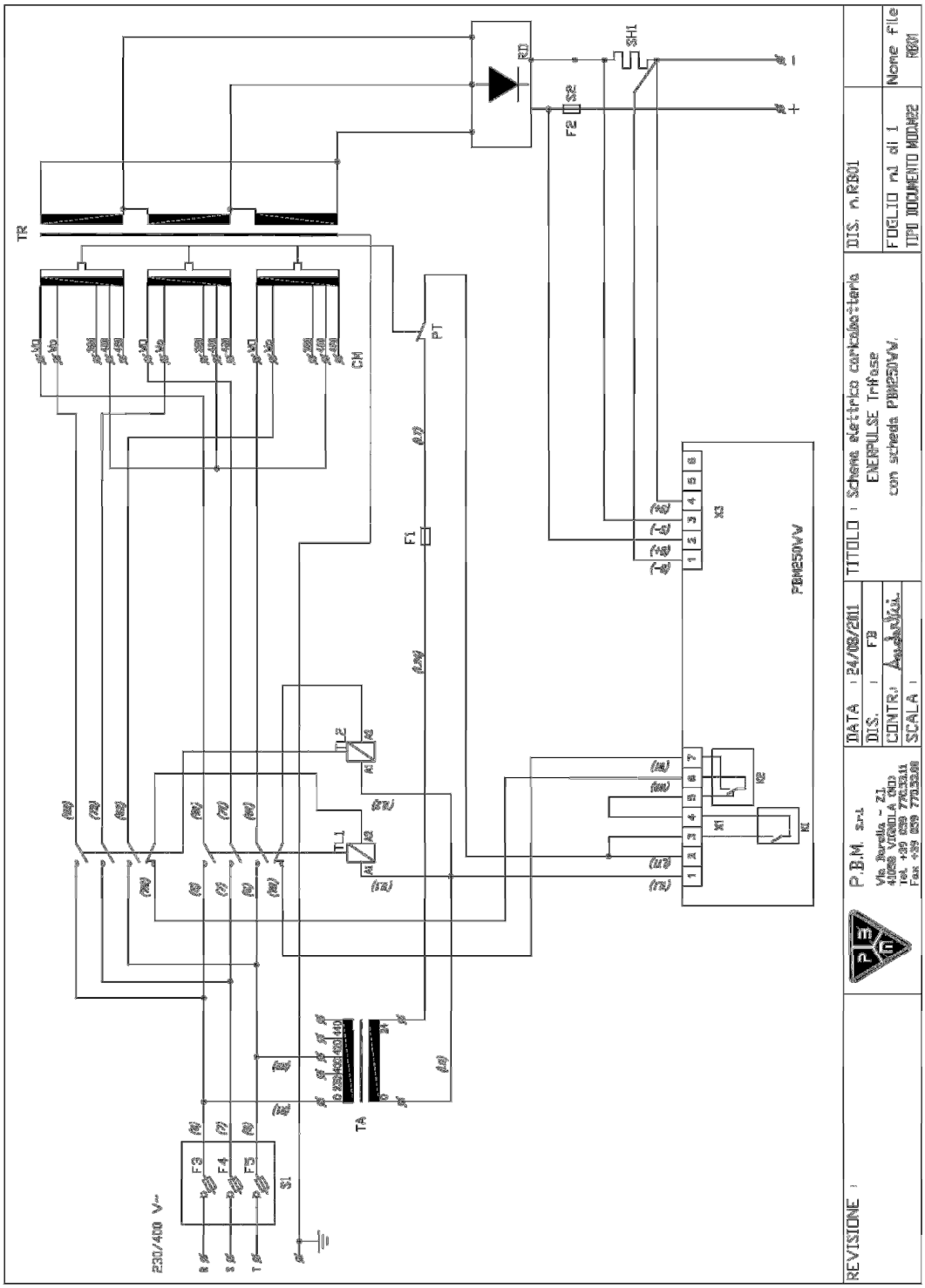
REVISIONE :


TR
RD
SH1
SS2
FS2
PT
F1
CH
X3
PBM250W/V
K2
K1
K2
TL2
TL1
TA
F3
F4
F5
S1
230/400 V~
DATA 24/08/2011
DIS. FB
CONTR.:
SCALA
TITOLO : Schema elettrico cablaggio
ENERPULSE Trifase
con scheda PBM250W/V
DIS. n.R1901
FOGLIO n.1 di 1
TIPO DOCUMENTO MOD.A2
Nome file
R001
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