P.B.M. Battery Regeneration

How to extend battery life with PBM tools

What practices are the best, depend on the type of battery.

For all battery types, degradation occurs faster at higher temperatures.

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Batteries:

Lithium-ion

When storing, lithium batteries degrade more while fully charged than if they are 70% charged. Optimal temperature for storing is about 15°C.

Degradation in lithium-ion batteries is caused by an increased internal battery resistance due to cell oxidation.

If Li-ION cells are discharged below a certain voltage a chemical reaction occurs that make them dangerous for recharging.

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Batteries:

NiCd

NiCd cells must be fully discharged, or else the battery loses capacity over time due to a phenomenon known as "memory effect".

Once a month (once every 30 charges) is recommended fully discharged NiCd battery.

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Batteries:

Lead-acid

These batteries employ a sulfuric acid electrolyte.

It can be generally be charged and discharged without exhibiting memory effect.

Degradation is caused by an increased internal battery resistance due to sulfation.

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Sulfation:

Sulfation is a chemical reaction in the battery which deposits a layer of sulfates on the lead. It will occur over time, specially when a battery stay unused for a long time.

Part of SO4 iones creates crystals on the plates and increase the internal resistance of the battery that avoid it to be properly charged.

In fact when the charging cycle start, the voltage very fast reach the gassing point value and normal charger immediately enter the “final charge” state.

Thanks to its cooperation with battery manufacturers, leaders in world wide market, PBM developed tools to recognize and treat the suplhated batteries.

P.B.M. Battery Regeneration

P.B.M. tools for Battery Regeneration:

BLT® - discharger

in dept - pbmbatterychargers.com

HF9® - universal charger

in dept - pbmbatterychargers.com

CYCLER - charger+discharger

in dept - pbmbatterychargers.com

P.B.M. Battery Regeneration

P.B.M. dedicated software:

PBM customers can use for free PC software which communicate with tools for DESULPHATION:

BLTVIEW®

HFVIEW®

P.B.M. Battery Regeneration

BLTò - the discharger

P.B.M. Battery Regeneration

BLT° - the discharger OWERVIEW

The BLT is a professional tool, which allow you to evaluate the efficiency of the battery, performing discharge, sending command to charger to charge and follow cyclic tests.

It is very useful tool for batteries maintenance and regeneration.

Not only, the BLT in conjunction with the charger HF9 can performe desulphation and recovery capacity of battery.

P.B.M. Battery Regeneration

BLT° - the discharger FEATURES

The presence of pre-programmed TESTs, TEST5h and TEST10h, makes BLT easy to use for testing Lead acid or GEL batteries.

Other available tests, like constant current or constant voltage, allow to use the BLT as an active load in order to perform functional and stress testing of Chargers or Power Supply.

The battery test is configured by:
nominal battery voltage, rated capacity, discharge time, minimum voltage, number of cycles, time for pause and the sampling time of the graph.

P.B.M. Battery Regeneration

BLT° - the discharger RANGE

The BLT range includes 4 models:

BLT160 (4V ÷ 96V / 2A ÷ 160A)
BLT125 (4V ÷ 120V / 2A ÷ 125A)
BLT300 (4V ÷ 96V / 2A ÷ 300A)
BLT250 (4V ÷ 120V / 2A ÷ 250A)
BLT3K (4V ÷ 120V / 2A ÷ 160A) limited power to 3 KW, the maximum discharger current is a function of the battery voltage

P.B.M. Battery Regeneration

BLT® - the discharger SOFTWARE BLTVIEW®

The BLT comes with the BLTVIEW®, free of charge dedicated software, useful for programming the work of BLT and download the data for the last 150 cycles, as well as graphs of voltages and currents of the last cycles (2400 samples of graphic memory) .

The BLTVIEW® allows you to manage and explore the database of cycles performed, evaluating the information, print out detailed reports with all information relating to charging and discharging of the battery, drawing up reports that show graphics with the resulting capacity after each of the test cycles.

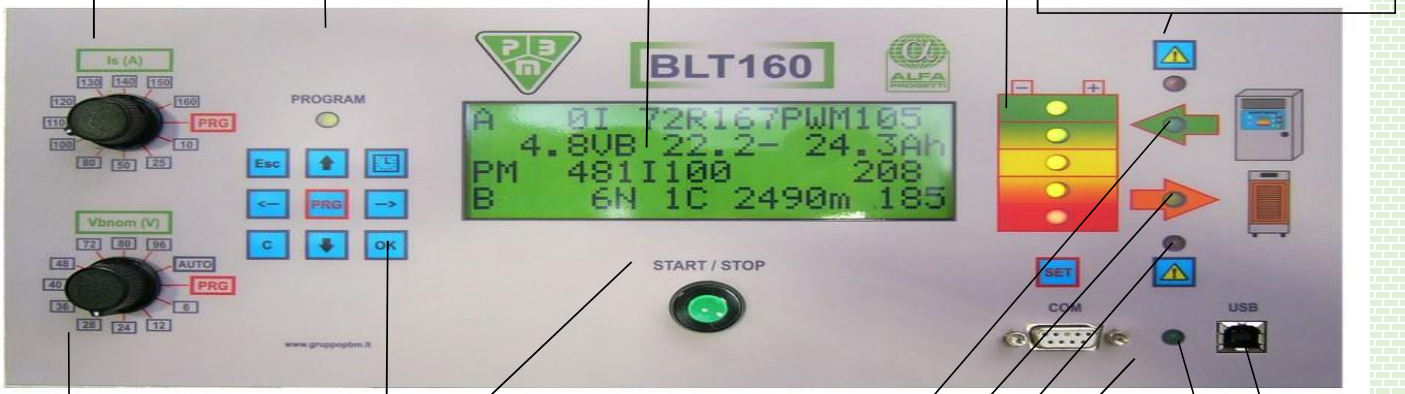
P.B.M. Battery Regeneration

BLT° - the discharger - FUNCTIONS

- Programming rated voltage and discharge current of the battery;
- Automatic management the stages of charging and discharging by connecting a charger;
- Complete control functions from operator interface;
- Select test mode:
  - Ø Test efficiency 5h (TEST5h)
  - Ø Test efficiency in 10h (TES10h)
  - Ø Free Cycles (CYCLES)
  - Ø Free Cycles with a final test 5/10h (C + T5 / C + T10)
  - Ø Test at constant current / constant voltage (ICOST / VCOST)

P.B.M. Battery Regeneration

BLT° - the discharger - FUNCTIONS



SW3 Discharge current selector switches

DL14 Yellow LED Ongoing programming

DY1 Multifunctional LCD display 4 lines x 20 chars

DL13 Green LED – 95% Battery

DL15 Green LED – 80% Battery

DL16 Yellow LED – 60% Battery

DL18 Yellow LED – 40% Battery

DL19 red LED – 20% Battery

DL11 red LED – Failure

Programming keyboard

P1 START – STOP Button

SW4: Rated battery voltage selector switches

DL12 Green LED Charging / End of charge

DL17 Yellow LED Discharging / End of dis.

DL20 Red LED Failure Warning

RS232 Serial connection

DL21 Green LED Communicating

USB connection

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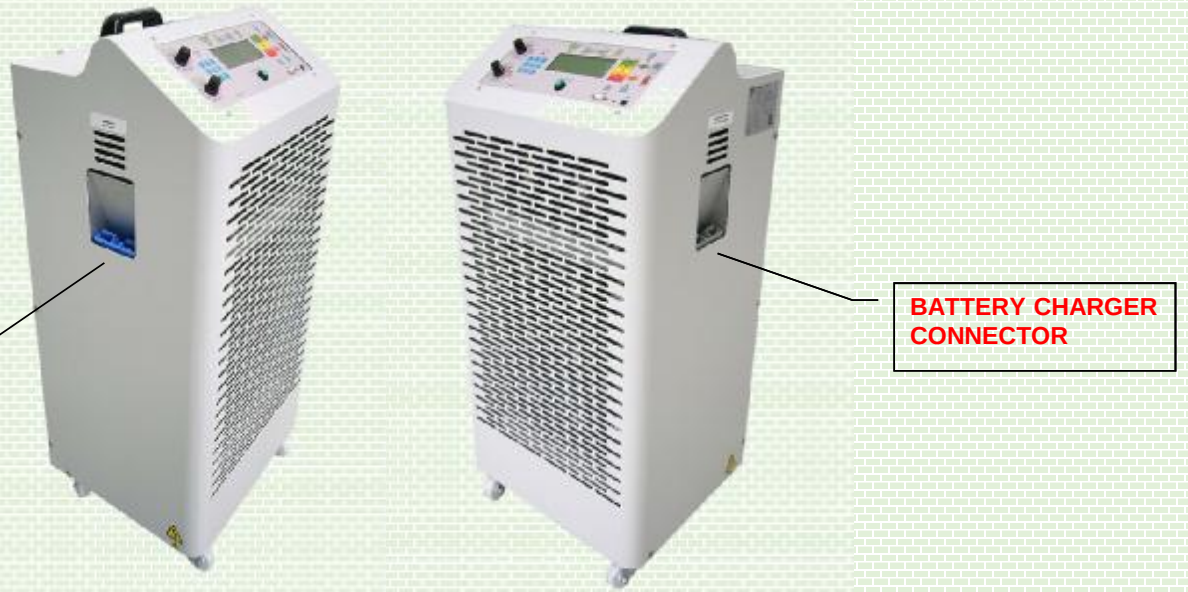
BLT° - the discharger - FUNCTIONS



P.B.M. Battery Regeneration

BLT° - the discharger - FUNCTIONS

When turn on BLT and press PRG key on the keyboard, is possible set next parameters:

RatV	= Battery voltage
RatAh	= Battery capacity
DiscI	= Discharge current
DT	= Discharge time
N.modoc=nn	= Test type (modoc) and cycles number (nn)
STV	= STopVoltage, voltage for STOP discharging

gg/mm/aa hh:mm PROG1
RatV=**xxx**V RatAh=**bbbb**
DiscI=**aaa**A DT=**ss**h**tt**m
N.**modoc**=**nn** STV=**v.vv**

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BLT° - the discharger - FUNCTIONS

When pressing PRG, the system enters the PROG 2 window:

MaxCT=**aa**h**bb**m PROG2
MinCT=**cc**h**dd**m Mag=**ee**%
PTaC =**ff**h**gg**m
PTaD=**ii**h**ll**m StD**rr**m

MaxCT = Maximum charge time (if this time is exceeded, a charge fault is reported)
MinCT = Minimum charge time
Mag = Charge increase
PTaC = Time pause after charge
PTaD = Time pause after discharge
StD = Time of diagrams sampling

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BLT° - the discharger - FUNCTIONS

When pressing PRG, the system enters the PROG 3 window:

gg/mm/aa hh:mm PROG3
IDB=bbbbbbbbbbbbbbbb
Notes:nnnnnnnnnnnnnnn
nnnnnnnnnnnnnnnn

gg/mm/aa = current date
hh:mm = current time
b.....b = Battery Identification Code (16 characters)
n.....n = Generic Notes field (32 characters)

P.B.M. Battery Regeneration

BLT° - the discharger - FUNCTIONS

Setting of modes of operation:

MODOC	DESCRIZIONE	ISCAR (A)	TS (h:m)	VST (V/el)	TCmin (h:m)	TCmax (h:m)	TPCar (h:m)	TPScar (h:m)
TEST	Test liberi	Ahnom/5	5:00	1.70	3:00	24:00	1:00	0:30
CICLI	Cicli liberi	Ahnom/5		1.85	0:01		0:05	0:02
TEST5	Test 5h fissi	Ahnom/5		1.70	3:00	24:00	1:00	0:30
TES10	Test 10h fissi	Ahnom/10	10:00	1.70	3:00	24:00	1:00	0:30
C+T5	N-1 cicli liberi +	Ahnom/5		1.85	0:01		0:05	0:02
	1 Test 5h fisso (car + scar + car)	Ahnom/5	5:00	1.70	10:00	16:00	1:00	0:30
C+T10	N-1 cicli liberi +	Ahnom/10		1.85	0:01		0:05	0:02
	1 Test 10h fisso (car + scar + car)	Ahnom/10	10:00	1.70	10:00	16:00	1:00	0:30
CONSTI	Only CONST. CURRENT DISCHARGE	RatAh/5		1.85	0:01		0:05	0:02
CONSTV	Only CONST. VOLTAGE DISCHARGE	RatAh/5	**:**	RatV	0:01		0:05	0:02

P.B.M. Battery Regeneration

BLT° - the discharger - FUNCTIONS

StV	BAh	Notes
<=1.70	0	100% discharged battery
1.71÷1.79	1÷19 %	99% to 81% discharged battery
=1.80	20%	80% discharged battery
>1.80	ratAh	No variation

General operation features:
When connecting a new battery, its current capacity is made equal to the set rated value.
Before starting a test cycle (i.e. while still in the START mode), and provided that a battery is connected, the current battery capacity can be set by pressing SET. Every time a button is pressed, the battery capacity increases by 10% up to the limit RatAh value. On exceeding the limit value, the system returns to 0%. If the No. modoc cycle number is set to 0, only is a single discharge performed, irrespective of the current battery capacity. During the charging process, the Mag% parameter allows to take into account the not-unitary performance of the battery recharge (programming page PROG2, see page 6). The Ahs actually delivered to the battery are calculated as follows: AhCar = Ah / (1+Mag%)
For example: with Ah=600 and Mag%=5, the AhChar value is 571. In order to reinstate 600 Ahs into the battery, it is necessary to charge AhCar * (1+Mag%), that is 630 Ah. The discharge stage ends either 1 minute after the stop voltage (STV) is reached or immediately, in case the voltage value drops below STV –0.01 V/cell.
For example: in case STV= 1.70, the discharging process stops immediately at 1.69 V/cell.
When reaching the stop voltage, depending on the voltage value, the current battery capacity is automatically reset.

P.B.M. Battery Regeneration

BLT° - the discharger - FUNCTIONS

TEST, TEST5 and TEST10 MODES

All of these modes are suitable to fully evaluate the efficiency of batteries in good state.

The TEST5 and TEST10 modes automatically set all parameters for a 5 or 10 hours discharge testing respectively.

Discharge stage: discharged capacity (DIS.Ah) is checked throughout every cycle.

The EFFICIENCY parameter is then calculated as follows:

EFFICIENCY = DIS.Ah*100/RatAh.

Charge stage: charged capacity (CH.Ah) is checked throughout every cycle.

When the minimum charge time (i.e. MinCT) is reached, if CH.Ah=RatAh, the system switches to the following time pause stage. Afterwards, it proceeds to the discharge stage.

If the CH.Ah>=RatAh condition is not reached within MaxCT, a failure indication is given.

The test proceeds anyway. However, the battery might not provide the required discharge Ahs any longer, thus causing the calculated EFFICIENCY parameter not to be relevant.

If the charge stage is completed within the following test cycles, the fault is automatically reset and proper calculation of the EFFICIENCY parameter is restored.

In the TEST5 and TEST10 modes, parameters are set as shown in Table G.1.

P.B.M. Battery Regeneration

HF9ò - the universal charger

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HF9° - the universal charger OWERVIEW

230VAC, 400VAC, 440VAC and 480VAC High Frequency Multitension Battery Charger. It allows to work on 2V to 120V batteries. Equipped with 8 selectable charge profiles and a dedicated software that allows an in-depth analysis of the charging data. Available in different versions with powers of 9, 12 and 16KW.

P.B.M. Battery Regeneration

HF9® - the universal charger FEATURES

- Ø Three Phase 400VAC +/-10% 9KW power
- Ø Available on request 230/440/480VAC 3phase
- Ø Suitable for battery from 2-96V max 80A
- Ø Available on 12Kw and 16KW power.
- Ø Microprocessor-controlled Charging process
- Ø Different types of curves:
- Ø CYCLIC P, CYCLIC Pb GEL,CYCLIC NiCd
- Ø CYCLIC LiPO, CYCLIC AGM, DESULPHATION
- Ø Multifunctional LCD Display
- Ø Failure diagnostic by means of LED's and LCD
- Ø Protection against battery polarity inversion
- Ø Stored charges

P.B.M. Battery Regeneration

HF9° - the universal charger RANGE

Model			
9KW	2-48V max 150A	2-80V max 90A	2-120V max 60A
16KW	2-48V max 250A	2-80V max 160A	2-120V max 100A

Other specials models availables on request

P.B.M. Battery Regeneration

HF9° - the universal charger FUNCTIONS

ID	Abbreviation	Name	Type of curve	Description
1	1 Pb ST 9UN	Pb Std cyclic	IUIUaE	Cyclic charging curve for Pb acid battery with a capacity between 6xInom and 8xInom
2	2Pb ST+ 9UN	Pb Std Plus	IUIUaE	Cyclic charging curve for Pb acid battery with a capacity between 8xInom and 10xInom
3	3 Pb GEL 9UN	Pb GEL	IUIUaE	Cyclic charging curve for Pb GEL battery with a capacity between 6xInom and 8xInom
4	4 Gel HAZE 9UN	GEL HAZE	IUUO	Cyclic charging curve for Gel HAZE battery
5	5 IU Des 9UN	Pb Desulphation	IUa	Charging curve for desulphation of Pb acid battery
6	6 AG DIS 9UN	AGM DISCOVERY	IUIO	Cyclic charging curve for AGM DISCOVERY battery
7	7 Ni Cd 9UN	NiCd	IUIUa	Cyclic charging curve for NiCd battery
8	8 Li Po 9UN	LiPO	IUa	Cyclic charging curve for Lithium-polymer battery

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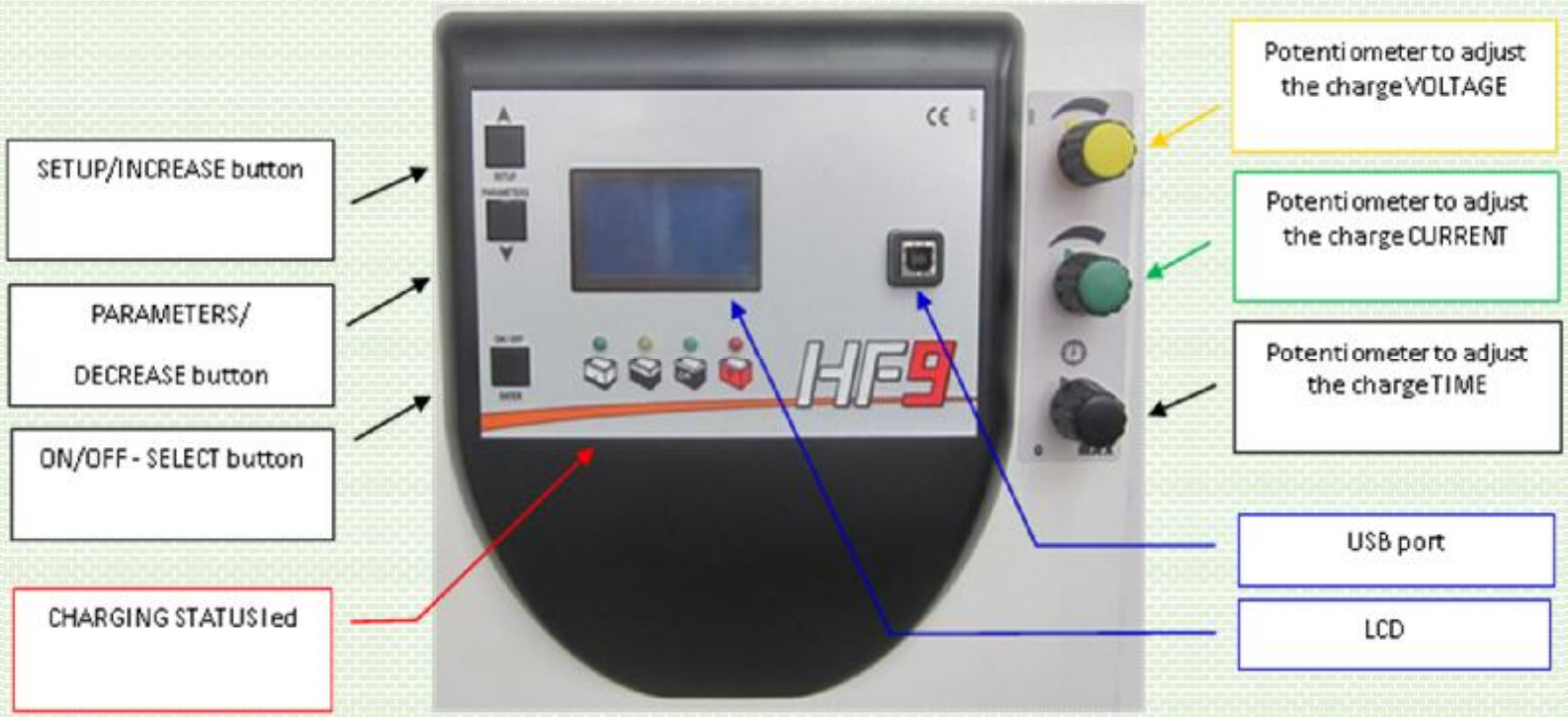
HF9® - the universal charger FUNCTIONS



P.B.M. Battery Regeneration

HF9° - the universal charger FUNCTIONS

a) DEFINING THE CURVE

1Go to row 1-
2Press button P3 (select)
3Select the desired charging curve using the P1 and P2 buttons (up, down)
4Exit using P3

b) DEFINING THE BATTERY VOLTAGE

1Go to row 2-
2Press button P3 (select)
3Select the rated voltage the battery using the P1 and P2 buttons (up, down)
4Exit using P3

c) DEFINING THE BATTERY CURRENT

1Go to row 3-
2Press button P3 (select)
3Select the rated charging *current* using the P1 and P2 buttons (up, down)
4Exit using P3

c) DEFINING THE CHARGING TIMEOUT

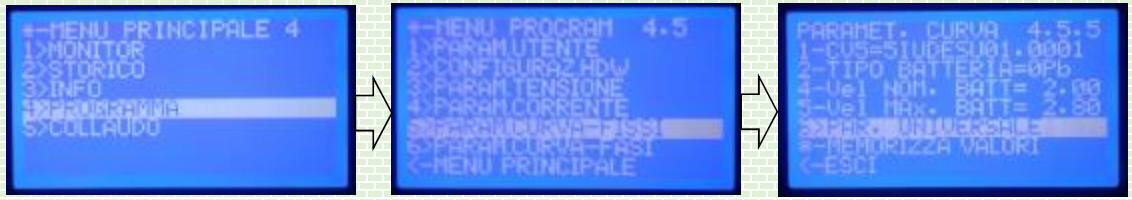
1Go to row 4-
2Press button P3 (select)
3Select the maximum charging time (safety timeout) using the P1 and P2 buttons (up, down)
4Exit using P3

c) SAVING THE CHARGING PARAMETERS

1Go to row *-
2Press button P3 (select)
3When the control board saves the data the MEMO lettering flashes

P.B.M. Battery Regeneration

HF9° - the universal charger FUNCTIONS



Monitor Menu → P2 → MAIN MENU → Menu 4>PROGRAMME → Menu 5> CURVE PARAM-FIXED → Menu 6> UNIVERSAL PAR.

That is to say :
From the Monitor menu, you can access the MAIN MENU by pressing P2
Select menu 4>PROGRAMME
Select menu 5> CURVE PARAM-FIXED
Select menu 6>UNIVERSAL PAR.

P.B.M. Battery Regeneration

BATTERY DESULPHATION

ü Step 1: SULPHATION DETECTION

ü Step 2: DESULPHATION CYCLES

ü Step 3: CAPACITY RECOVERY

P.B.M. Battery Regeneration

1. SULPHATION DETECTION

1. SULPHATION DETECTION

To recognize a Sulphated Battery the first STEP is to perform a single cycle of Discharge and Charge using the Standard Lead acid profile and verifying how fast the discharger reach the Vstp and later the charger reach the Final Charge.

RULE :

A Sulphated Battery is recognized when:

- The discharge reach in few seconds the STOP Voltage;
- During the charge the charger in few seconds reaches the gassing point and immediately enter the Second stage (YELLOW Led ON).

P.B.M. Battery Regeneration

1. SULPHATION DETECTION

We program the BLT for a TEST5 with 1 cycle, with the battery status to be plenty (all 5 leds inside the battery simbol are ON and the AhB is equal to the nominal C5 capacity: in this way the BLT will start with a Discharge.

MODOC	DESCRIZIONE	ISCAR (A)	TS (h:m)	VST (V/el)	TCmin (h:m)	TCmax (h:m)	TPCar (h:m)	TPScar (h:m)
TEST5	Test 5h fissi	Ahnom/5	5h	1.70	3:00	24:00	1:00	0:30

P.B.M. Battery Regeneration

1. SULPHATION DETECTION

For Example : for a 48V 600 Ah
PROG1 : TEST5 = 5, 1,70V, 5h00, 120 A
PROG2 : MaxCT = 13h, MinCT = 10h
A typical charging time can be calculated as:
- C5 / Ch.Current * 1,1 + 4h
We can than calculate the MinCT for this value and the MaxCT with 3h more.

gg/mm/aa hh:mm PROG1
RatV= **48**V RatAh= **600**
DiscI=**120**A DT= **5h00**m
N.**TEST5= 1** STV=**1.70**

P.B.M. Battery Regeneration

1. SULPHATION DETECTION

We program the HF9 for profile STD (curve 1) or ST+ (curve 2) depending on the ratio beween Battery Capacity and Charger Current:
Profile 1 STD : when the Capacity is between 6 and 8 time the Charger current
Profile 2 ST+ : when the Capacity is between 8 and 10 time the Charger current
When possible we set the charger current to a current = C5 /6
For example 48V 600 Ah
- Voltage = 48V
- Current = 100 A
- Time = this parameter is not used in Cyclic charge

ID	Abbreviation	Name	Type of curve	Description
1	1 Pb STD U01	**Pb Std cyclic**	IUIUaE	Cyclic charging curve for Pb acid battery with a capacity **between 6xInom and 8xInom**
2	2Pb ST+ U01	**Pb Std Plus**	IUIUaE	Cyclic charging curve for Pb acid battery with a capacity **between 8xInom and 10xInom**

P.B.M. Battery Regeneration

2. DESULPHATION CYCLES

2. DESULPHATION CYCLES

To desulphate the battery it is important to perform 1-2 cycle of discharge followed by a very slow recharge.

P.B.M. Battery Regeneration

2. DESULPHATION CYCLES

We program the BLT for a TEST5 with 1 cycle, with the battery status to be plenty (all 5 leds inside the battery symbol are ON) and the AhB is equal to the nominal C5 capacity: in this way the BLT will start with a Discharge.
Since the charging current is 1/30 C5, it is important to Set on the BLT.
MaxCT to 40h and MinCT to 36h so that the charger have enough time to fill the battery.
For Example : for a 48V 600 Ah
PROG1 : TEST5 = 1, 1,70V, 5h00, 120A
PROG2 : MaxCT = 40h, MinCT = 30h

gg/mm/aa hh:mm PROG1	MaxCT=**40h00m** PROG2
RatV= **48**V RatAh= **600**	MinCT=**30h00m** Mag=**10**%
DiscI=**120**A DT= **5h00m**	PTaC =**01h00m**
N.**TEST5= 1** STV=**1.70**	PTaD=**00h30m** StD **1m**

P.B.M. Battery Regeneration

2. DESULPHATION CYCLES

We program the HF9 for profile 5 DES (curve 5)
Charging Voltage = Battery Nominal Voltage
Charging Current = C5 / 30
Charging Time = 36h
The time is greater than 30h since we need to perform the overcharging factor. In addition it can happen that, even with a low current, at the beginning the battery reach 2,7Vc so that the charger goes in Voltage limitation, reducing the output current. This fact would prolong the charging time of 2-3h.

ID	Abbreviation	Name	Type of curve	Description
5	5 IU Des U01	Pb **Desulphation**	IUa	Charging **curve for desulfation of Pb acid battery**

P.B.M. Battery Regeneration

3. CAPACITY RECOVERY

After the desulphation charges, 3-5 cycles of standard charge are used to complete the capacity recovery

P.B.M. Battery Regeneration

3. CAPACITY RECOVERY

We program the BLT for a TEST5 with 5 cycle, with the battery status to be plenty (all 5 leds inside the battery symbol are ON) and the AhB is equal to the nominal C5 capacity: in this way the BLT will start with a Discharge and repeat cycles made of DISCHARGE and CHARGE.

At each cycle we will see the discharged capacity growing, and we will stop the test when between a cycle and the following we see that the battery is not improving anymore.

MODOC	DESCRIZIONE	ISCAR (A)	TS (h:m)	VST (V/el)	TCmin (h:m)	TCmax (h:m)	TPCar (h:m)	TPScar (h:m)
TEST5	Test 5h fissi	Ahnom/5	5h	1.70	10:00	13:00	1:00	0:30

P.B.M. Battery Regeneration

3. CAPACITY RECOVERY

For Example : for a 48V 600 Ah
PROG1 : TEST5 = 5, 1,70V, 5h00, 120 A
PROG2 : MaxCT = 13h, MinCT = 10h

A typical charging time can be calculated as:
C5 / Ch.Current * 1,1 + 4h
We can than calculate the MinCT for this value and the MaxCT with 3h more

gg/mm/aa hh:mm PROG1
RatV= 48V RatAh= 600
DiscI=120A DT= 5h00m
N.TEST5= 5 STV=1.70

MaxCT=13h00m PROG2
MinCT=10h00m Mag=10%
PTaC =01h00m
PTaD=00h30m StD 1m

P.B.M. Battery Regeneration

3. CAPACITY RECOVERY

We program the HF9 for profile STD (curve 1) or ST+ (curve 2) depending on the ratio beween Battery Capacity and Charger Current:
Profile 1 STD : when the Capacity is between 6 and 8 time the Charger current or
Profile 2 ST+ : when the Capacity is between 8 and 10 time the Charger current
Charging Voltage = Battery Nominal Voltage
Charging Current = C5 / N (where N is 6 to 8 (7 typical) for Profile 1 and 8 to 10 (9 typical) for profile 2)
Charging Time = not used in cyclic charge.

ID	Abbreviation	Name	Type of curve	Description
1	1 Pb STD U01	**Pb Std cyclic**	IUIUaE	Cyclic charging curve for Pb acid battery with a capacity **between 6xInom and 8xInom**
2	2Pb ST+ U01	**Pb Std Plus**	IUIUaE	Cyclic charging curve for Pb acid battery with a capacity **between 8xInom and 10xInom**

P.B.M. Battery Regeneration