EV Power Lithium Battery Management. BCU-MICRO-08-smd Instruction Manual.

Introduction

The EV Power Battery Management System (BMS) is designed for Lithium Iron Phosphate (LiFePO4, LFP) batteries of capacity 40-400Ah. These cells are generally used in applications where light weight and high power are required.

The BCU-micro-08x is a simple bare PCB microprocessor based battery control unit (BCU). It is designed to operate in unison with EV Power cell modules using the EV Power one-wire NC interface. The system is designed to prevent over-discharge and overcharge of LFP batteries.

It can directly control a charger and/or load via connected relays. The BCU-micro-08 comes in two versions each with different programming. Version A is for use with a three wire “latching” charge/discharge relay. Version B is for use with normal relays/contactors and solid state relays for separately controlling charge and discharge sources.

Unlike regular relays, three wire latching relays offer the advantage of drawing no power when active. Large charge/discharge currents can be directly controlled in this way without significant parasitic power being drained by the BMS itself. This is an EV Power industry first for managing LFP batteries.

While the BCU-micro-08 comes with standard programming it is also user programmable. It utilizes the PICAXE 08M chip and BASIC programming language. Open source software is available for it from EV Power on request.

Features

- Simple to install and use, microprocessor control.
- 12V power input
- Prevents overcharge and over-discharge of LFP batteries.
- Version A for three wire latching relays, Version B for normal and Solid State relays (SSRs)
- Uses the unique EV Power developed one-wire NC loop interface.
- User programmable using a standard three wire interface and PICAXE BASIC
- Can directly control relays with 12V coils requiring up to 2A hold current.

Objective

This manual will help with installation and operation of the bcu-micro-08.

An understanding of electrical principles and competence with electrical tools is required. Ability to use the volts, amps and Ohms setting of a multimeter is a prerequisite.

Disclaimer

This is a guide only. Potentially dangerous voltages and currents are involved when working with batteries. **It is the responsibility of the installer to have the appropriate qualifications and skills for working with high voltages and currents**. No liability whatsoever will be assumed by EV Power Pty Ltd for injury, accidents or damage resulting from the use of these instructions.

While every effort is made to make the system failsafe, no warranty is implied for any components other than the BCU-MICRO-08 unit itself.

Do not try to charge or discharge Lithium (LFP) batteries without the BMS installed. One over-charge or over-discharge WILL cause permanent damage.

How it works - Usage

The BCU has two attached LEDs. The green LED indicates that power is applied and the enable switch is ON. The Red LED indicates an electrical break in the NC loop. That is, a problem with a cell.

The BCU performs a number of functions:

1) It activates the relay(s) when the switch is ON and the cell module loop is indicating OK.
2) It monitors the BMS cell module loop. If any cell goes below 2.5V or above 4.0V (flashing red LED) for more than 10 seconds the relay(s) will open. A solid red LED indicates a permanent error.

If the relay is open and there is a solid red LED the system may be reset by turning the switch off and then on again. This will engage the relay for a short period and allow recharge if the cells are low.

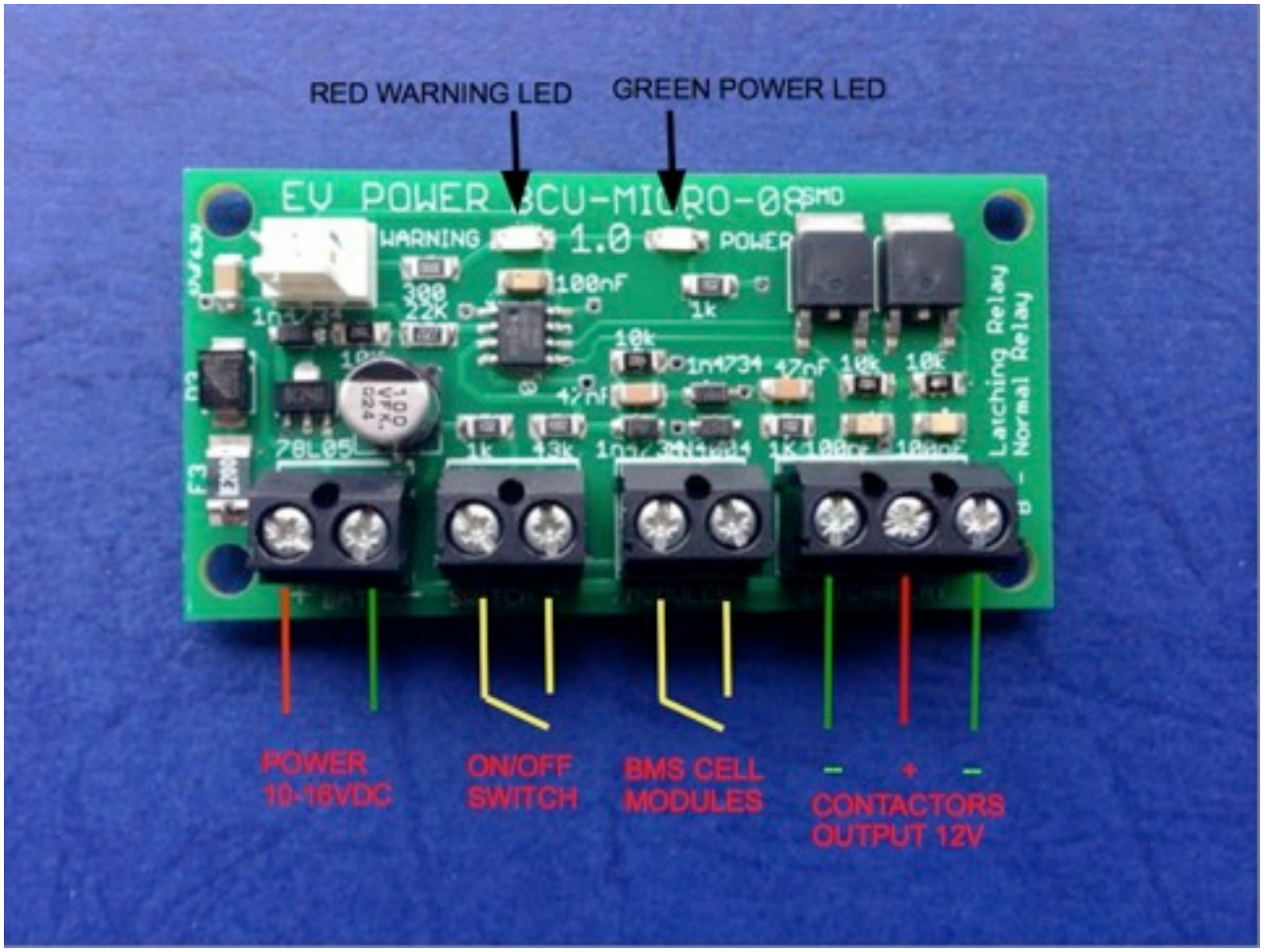
On the “A” version the relay is a special “latching” variety. It consumes no power when switched on. The downside of this is that it can remain ON if power to the BCU is removed or if the BCU itself fails. Check that the BCU is operating correctly occasionally by switching off and on again.

 VERSION “A” - DO NOT DISCONNECT POWER TO THE BCU WHILE THE LATCHING RELAY IS IN THE ON STATE or battery protection will be removed.

If the BCU cuts off the battery during discharge the battery is most likely nearly empty. DO NOT RESET AND CONTINUE DISCHARGE! Reset and charge the battery immediately.

Note that when switched off the BCU consumes about 5 mA. It will take some months to drain a full battery at this rate but it is best to either leave the battery on continuous float charge or to disconnect the BCU if the battery is to be stored for long periods.

If the relay opens during charging it means either the charge voltage has gone to high or the battery is unbalanced. Try reseting and charging a few times. If one red LED on the BMS cell modules on the battery comes on long before the others then that cell is running too high. Contact EV Power for advice in this instance.



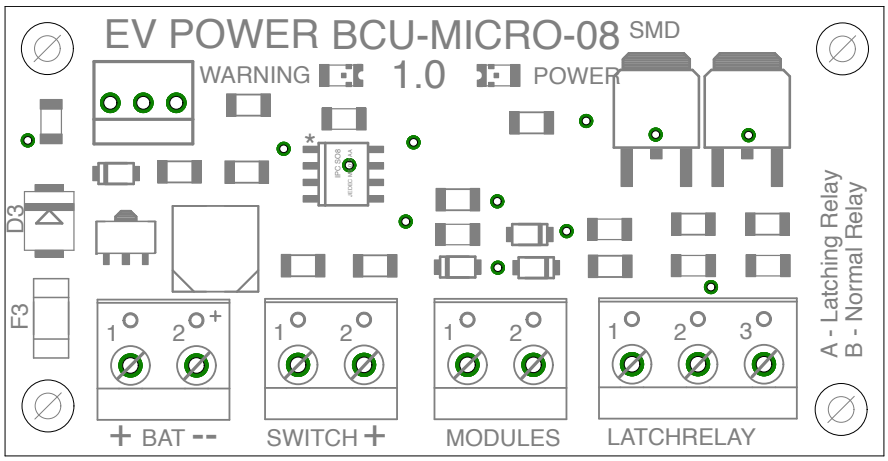
Above figure is for Version A or version B connections.

Connections for version 2.2. Note the connector for the Elcon TCCH charger enable. On version B this voltage free connector (NO relay) is enabled when the battery is OK. **On version A the charge connector will pulse only when the battery is switched off.**

The BMS is designed as the last line of defence for the battery pack to prevent damage. It should not be employed to disconnect the battery every time it is used. No battery warranty can be assumed if it is used contrary to these instructions.

An appropriate pre-charge system should be employed on any load devices which contain large capacitors. Relays/Contactors can jam in the ON state due to large switch-on surge currents with these devices.

Interrupting the wires to the charge and/or discharge relays can result in erratic operation of the BCU. Check its operation carefully if switches/relays are installed in series with the control outputs to the relays.



Suitable Relay Types - Version A - 3 wire latching relays

These relays consume no power when in the ON state.
The centre wire of these relays goes to the centre terminal (+12V) on the RELAYS block. The position of the other two wires is relay specific and can be determined by trial and error.

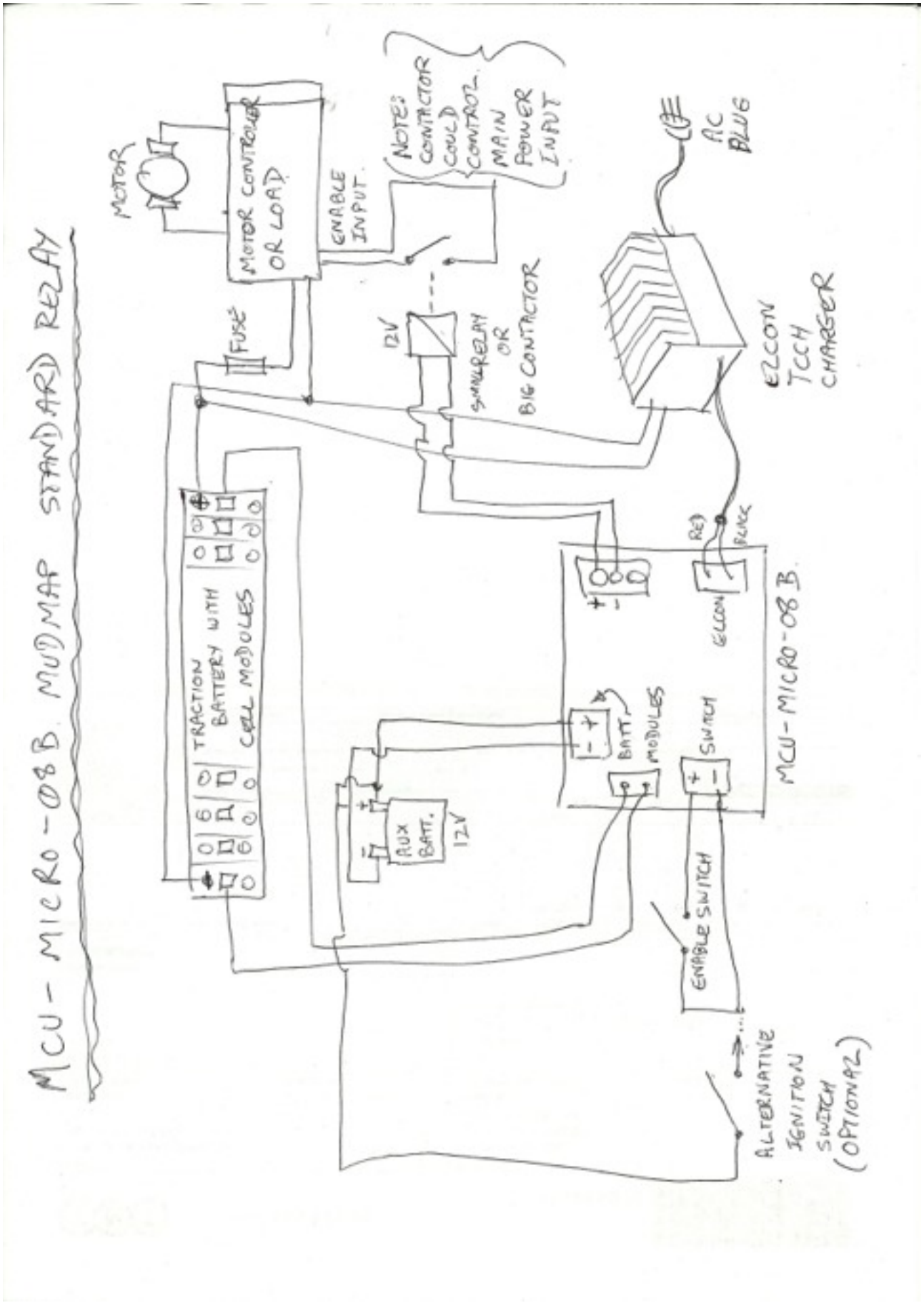
The above relay is suitable for charge/discharge control of up to three batteries of up to 30VDC 80A continuous each. It can alternatively control three phase charger inputs up to 240VAC 80A.

For applications which require more than 120A continuous per battery a high power relay option is available. It can interrupt up to 500A at voltages of up to 750VDC.

Suitable Relay Types - Version B- Normal and Solid State relays

An example of a DC Solid State Relay. Switches up to 30VDC 100A max.

Solid State Relay for switching AC charger input, single phase 240VDC, 40A max


MCU - MICRO - 08B. MUDMAP STANDARD RELAY
MOTOR
MOTOR CONTROLLER OR LOAD
ENABLE INPUT.
NOTE: CONTACTOR COIL CONTROL MAIN POWER INPUT
FUSE
12V
SMALL RELAY OR BIG CONTACTOR
AC PLUG
ELCON TCCH CHARGER
TRACTION BATTERY WITH CELL MODULES
AUX BATT. 12V
BATT MODULES
SWITCH
ELCON
RED
BLACK
MCU - MICRO - 08B
ENABLE SWITCH
ALTERNATIVE IGNITION SWITCH (OPTIONAL)

General Battery Guidelines

LFP cells should be housed in a battery box away from dust, excessive heat and moisture. Appropriate restraints should be used that are capable supporting at least 5 times the battery weight in any direction. All restraints should be well insulated so as not to short out battery terminals.

Ensure that a dry powder type fire extinguisher is accessible close by. Lithium Iron Phosphate batteries do not generally catch fire even under extreme abuse. However they will burn if heat is applied from another source such as a short circuit. They contain organic solvent electrolyte which is flammable when released.

Be careful when working on batteries with metal tools, short circuits can occur very easily with catastrophic consequences. The handles of metal tools should be insulated with heat shrink or plastic duct tape.

DO NOT ALLOW YOUR BATTERY TO RUN FLAT. IT WILL BE PERMANENTLY DAMAGED AND EV-POWER CAN TAKE NO RESPONSIBILITY FOR THIS.
THE BATTERY SHOULD BE CHARGED AT LEAST ONCE A MONTH IF BEING STORED.

Cell Module Installation

This is covered in another manual. Install the cell modules first. It is not required for the prefabricated EV Power Pak batteries.

Charger Control

Quite often lead acid type chargers can also be used for charging LFP batteries.

Any charger used should charge to 3.65V x the number of cells in the battery. This peak voltage applies to ALL LFP type cells.

Note: 3.60-3.65V per cell is the standard peak charge voltage for LiFePO4 (LFP) chemistry.

Charging LFP batteries should have at least three main stages.

1) Bulk Charge at constant current until the peak charge voltage is reached.

2) Balancing charge at constant voltage until the charge current diminishes to about 2% of the Ah capacity of the battery.

3) Switch off charging - OR - Switch to a lower indefinite float voltage of 3.45V per cell.

An optional stage can be added before stage 1) to allow for gentle recharge of of deeply discharged cells. It should charge at a constant current about 2% of the Ah capacity of the battery.

Generally speaking the bulk charge current should be limited to no more than 0.5 x Ah capacity of the battery. This can vary according to the size type and brand of battery. Charge at constant current during the bulk charging phase until the peak charge voltage is reached.

It is important that once the peak voltage is reached the charger should begin to taper the charge current and switch off or fall to a lower voltage when the current falls to 1% of the Ah capacity.

Most modern chargers have a “Gel” or “AGM” charge program which is almost ideal for LFP batteries. Charge to 14.6-14.7V then float indefinitely at 13.6-13.8V. The charger may be left on when the battery is not in use if it has this characteristic.

Do not use chargers which have an “equalization” phase (unless it can be disabled). This will try to charge the battery to a high voltage and damage it.

Commissioning the system

First double check all the connections.

Switch on the BCU.

After double checking all high voltage connections connect the AC power to the charger input. The charger should commence charging. If not then check that all the green cell module LEDs are illuminated and all the cell module and signal wires are correctly connected.

Do this for a few seconds and switch off the charger at the wall.

Disconnect one of the signal wires between the cell modules. The red LED on the BCU will flash After a delay of about 10 seconds the contactor will switch off. Switching on the charger at this time should have no effect, that is, it will not switch on. Switch the charger off at the wall and reconnect the signal wire.

Reset the BCU by switching OFF/ON again.

Switch on the charger, it should now work. Charge until the battery is full and the charger switches off. If the BCU switches off then an overcharge has been attempted. Reset and recharge while watching the battery closely.

The battery should now be ready for use.

General Charging Tips

Once the battery pack is balanced it can be used and charged as required. Occasional partial recharges are acceptable but top up charges should be regular.

If there is a battery error the BMS will terminate charging. This may not be serious if the battery is slightly out of balance after a few partial charges or deep discharges. However if it persists it may be necessary to check the battery.

If the battery has been discharged to a point where one or more of the cells is below 2.5V the BCU will disconnect the battery. In this case reset the BCU by switching OFF/ON and recharge immediately. There is a short delay period during which the BCU will allow charging to take place.

If it does not not do not persist or worse battery damage may result. Check the battery and charge individual cells if required using a small current.

About Lithium Iron Phosphate Batteries

A “battery” is made up of “cells”. Each cell is an individual unit that cannot be split into a lower voltage component.

LFP cells have a nominal voltage of 3.2-3.4V. This is the voltage that the cells drop back to when at rest. They will stay around 3.2V until about 90% discharged when the voltage will begin to decrease until fully discharged at 2.5V. It is highly recommended to discharge less than 80% of the cells total Amp Hour capacity. This will help to maximize the cell life.

LFP cells may be connected in “series” (+ to – to + etc) to obtain a higher nominal voltage. This creates a “battery”. They may also be connected in “parallel” (+ to +, - to -) to increase the Ah capacity. Under no circumstances should cells or a battery be short circuited, that is the + connected directly to the – to create a loop. This will damage the cells and most likely the operator also.

Under no circumstances should the cell voltage be allowed to fall below 2.5V for a sustained period. Permanent damage will result. It is possible that this situation may occur if the battery is allowed to stand for a long time (ie. months). In this situation the BMS will not allow recharge because a cell is outside the safe range. To try and rectify the problem a small 4.5V 300mAh DC plug pack type power supply can be applied to individual cells one at a time until the cell voltages rise above 2.5V and the BMS will allow normal charging to commence. Care must be taken with the first few charges as the battery may be severely unbalanced.

A visual check of the battery pack during charging should be made every 3 months. Switch off the BCU and on again to check that the contactor is operating correctly. Check the cells for corrosion or other damage.

Important Notes

- **Take care with the routing of power cables**
  Electric motors such as those used in electric winches are electrically “noisy” and can cause large inductive voltage spikes when switched on and off. Inverters can do the same. This may cause the BCU to reset and disconnect the load in some instances. Make sure the BCU and its attached cables are away from any large power cables and motors. If you are having trouble try rerouting cables. Keep the BCU input cables close together. If necessary use ferrite chokes on the BCU power inputs.
- **Recharge fully at regular intervals**
  LFP batteries do not have a memory, however continuous partial recharges may cause the battery to become unbalanced and lead to dropouts during charging. During daily usage it is important to occasionally charge the battery pack completely until the charger switches off. Continual partial

recharges will prevent the BMS balancing the pack and so may result in premature charger disconnects when the battery is next fully charged.

- **Never tap a portion of the battery for powering lower voltage peripheral devices.**
  This will unbalance the battery and result in continual charging errors and/or battery damage. Use a suitable DC-DC converter to power low voltage devices.
- **Do not bypass the BMS during charging.**
  It is designed to protect your battery but cannot do so if it is disconnected. The BMS should be configured to interrupt either the AC input or DC output of the charger. If there is a problem with the BMS do not charge the battery until it is corrected.
- **Do not allow the battery to go flat.** **If it goes flat this is a very serious situation. The battery should be periodically charged when it is being stored to prevent self discharge. The BMS uses a small amount of power whether the battery is used or not so regular charging is important.**

Fault Finding Q and A

QUESTION:

I took the car for it's first run yesterday. After about 40 kms the red low battery warning light came on. Luckily I was about 100 metre from home. I limped home and put it on charge.

The BMS management unit first indicated a cell problem with a red light, but when I reset it to put on the charger this turned off. Also the warning light on the dash for low voltage turned off. The unit currently has the green 'enable' light on.

ANSWER:

Always fully charge and balance the battery first!

A long drive for the first run is not advisable. You need to proceed with a little more caution or risk damaging cells.

Reset the BCU by switching off/on the enable switch to see if the charger will take up.
If not, check that all the cells are above 2.5V and fool the BCU by shorting the cell module connections together, only to get the charging started though!
Disconnect the short after about 5 minutes.

Then give it a full charge and watch the cells very closely esp. near the end of charge.

NOTES:
1) Don't "limp home", push or tow it home! Not even 100m!
2) Above 2.5V the cells are still ok to charge normally, the BCU may not allow the charger to take up if any cell is below 2.6V. Below 2.5V (but above 0.5V) charge cells individually using a small mobile phone charger until 2.7V is reached. Any cells at zero volts must be discarded, don't recharge.

Glossary

Amps (A) - A measure of the current flow through a wire.

Amp hours (Ah) - a measure of the capacity of a cell or battery. This is the number of amps x number of hours the cell can supply. For lithium cells the rate is usually calculated over a one hour period. A batteries Ah capacity can be increased by connecting cells in PARALLEL.

Battery - a number of cells connected in series and/or parallel.

BMS - Battery Management System, an electronic system to balance and protect lithium batteries.

Cell - one individual unit of a battery. Lithium (LFP) cells have a nominal voltage of 3.2-3.3V

Cell Module - an electronic device that connects between the positive and negative terminal of a LFP cell. It balances the cell voltage during charging and reports back to the master unit if a cell falls outside its safe operating voltage of 2.5-4.0V.

Contactor - A coil activated switch. Relay.

LFP (LiFePO4) - Lithium Iron Phosphate, a Lithium compound commonly used in Lithium Ion cells. Other common Lithium Ion chemistries include Lithium Cobalt, Lithium Manganese and Lithium Nickel.

BCU - Master Control Unit, the “brain” of the BMS that controls charge and discharge functions.

NC Loop - Normally Closed Loop. Used by the EV Power BMS cell modules when daisy chained together this loop has a low resistance when all the cells in the chain are within the voltage range 2.5 - 4.0V. Open circuit otherwise.

Nominal Voltage - the resting voltage of a charged cell. For LFP cells this is normally in the range 3.2-3.4V.

Parallel connection - electrical connection of cells positive to positive, negative to negative. This increases the amp hour capacity but maintains the same cell voltage. Battery capacity (Ah) = cell capacity x number of cells in parallel.

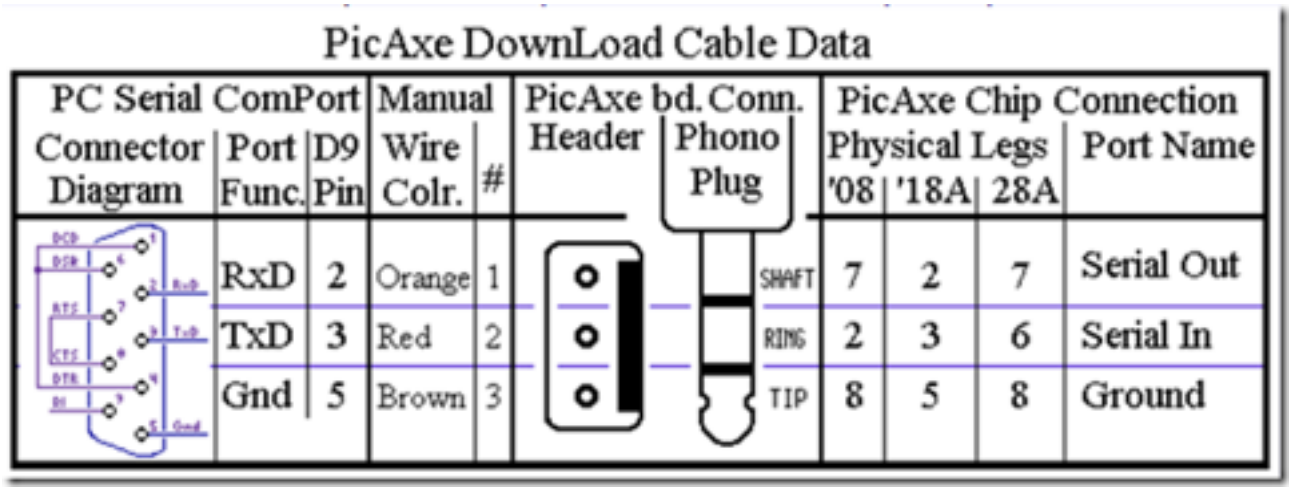
Series connection - electrical connection of cells connected positive to negative to increase the battery voltage. Battery voltage = cell voltage x number of cells in series.

Volts (V) - A measure of the electrical pressure or potential. A batteries voltage can be increased by connecting cells in SERIES.

Watts (W) - A standard measure of electrical power. For DC potentials, Watts = Amps x Volts (P = I . V). kW or Kilowatts = Watts x 1000

Watthour (Wh, kWh) - A measurement of battery capacity or actual energy storage. This measurement is a better indicator than Amphours because it also allows comparison of battery capacities of different voltages. Watthours = Volts x Amphours. eg. 12V 100Ah battery = 1200 Wh, 24V 50Ah battery = 1200 Wh ==> different voltages but same capacity for actual work.

Appendix 1. Program Source code



PicAxe DownLoad Cable Data

PC Serial ComPort			Manual		PicAxe bd. Conn.		PicAxe Chip Connection			
Connector Diagram	Port Func.	D9 Pin	Wire Colr.	#	Header	Phono Plug	Physical Legs '08	'18A	28A	Port Name
	RxD	2	Orange	1		SHAFT	7	2	7	Serial Out
	TxD	3	Red	2		RING	2	3	6	Serial In
	Gnd	5	Brown	3		TIP	8	5	8	Ground

```
'*****************************************************************************************************************
*****

#PICAXE 08M2
'
'           BMS-BCU-MICRO-08 - BATTERY CONTROL UNIT FOR  EV POWER BMS CELL MODULES
'
'           This simple unit monitors cell module input.  If error for 10 seconds
'            disconnection occurs.
'
'            FOR USE WITH THREE WIRE LATCHING RELAYS
'
'           2.1 - added latching variable, same code for MICRO-A and B
'                   added code to switch off relay when powered ON with enable ON
'                           2.2 - 20-11-12  - added code for 11V - 16V switch range     11V = 104, 16V = 151
'                           2.3 - 11-1-13 - removed 11-16V switching range, needs more thought
'
'

'*****************************************************************************************************************
*****


'
symbol latchingvalue = 1                        ' set latching = 1 for MICRO-A and latching = 0 for MICRO-B
'symbol hysterisis       = 5                     ' hysterisis value for offvoltage


' PICAXE pin assignments
symbol alarmpin      = 0
symbol contactoroff = 1
```

```
symbol contactoron = 2
symbol cellmodules = pin3
symbol switchinput = 4

' Define constants
'symbol offvoltage = 104            '<20 = switchoff
symbol offvoltage = 20             '<20 = switchoff
symbol overvoltage = 255

' Define variables
symbol voltage      = b0
symbol acount       = b1
symbol latching     = b2
symbol errorflag    = b3
symbol lastsecond = w2
'symbol offplushysterisis             = b6

'*****************************************************************************************************************
***
' MAIN PROGRAM
start0:

latching = latchingvalue                ' set latching = 1 for MICRO-A and latching = 0 for MICRO-B
'offplushysterisis = offvoltage + hysterisis

suspend 1

gosub relayoff
errorflag = 0

'low contactoroff           ' set output so not in indeterminate state
'low contactoron

initialise:

readadc switchinput, voltage        ' stay switched off if unit is powered up with switch on
'debug voltage
pause 100
if voltage => offvoltage then : goto initialise endif
```

```
gosub sleepsomemore

main:

if cellmodules = 0 then
  for acount = 1 to 15                    ' 15 seconds from warning to shutdown
      pause 500
      gosub flasher
      errorflag = 1
      readadc switchinput, voltage
      if voltage < offvoltage then : gosub sleepsomemore : endif
          if cellmodules <> 0 then
                  errorflag = 0
                  goto modulesok
          endif
  next acount
  gosub closedown
endif

modulesok:

readadc switchinput, voltage
pause 100
'debug voltage
if voltage < offvoltage then : gosub sleepsomemore : endif

goto main
end

'subroutines
'*****************************************************************************************************************
*******
'  CLOSE DOWN if voltage or cell modules are out of range, only re-enable if switch is off/on again

closedown:
if voltage< offvoltage or voltage > overvoltage then
  low alarmpin
else
  high alarmpin
endif
```

```
gosub relayoff
errorflag = 2

stayclosed:
readadc switchinput, voltage
pause 100
if voltage => offvoltage then : goto stayclosed : endif

gosub sleepsomemore

goto main
return

'*************************************************************************************************************
******
'   SLEEP if switch is off

sleepsomemore:
gosub relayoff
low alarmpin
errorflag = 0

stayoff:

readadc switchinput, voltage
pause 100
if voltage < offvoltage then : goto stayoff : endif

gosub relayon

goto main
return

'*************************************************************************************************************
******
' FLASH the alarmpin

flasher:
high alarmpin
pause 500
low alarmpin
```

```
return

'*****************************************************************************************************************
******

'  RELAY ON pulse for latching relay


relayon:

if latching = 0 then

        low contactoroff

        high contactoron

else

        low contactoroff

        high contactoron

        pause 100

        low contactoron

endif

pause 1000


return

'*****************************************************************************************************************
******

' RELAY OFF pulse for latching relay


relayoff:

if latching = 0 then

        low contactoroff

        low contactoron

else

        low contactoron

        high contactoroff

        pause 100

        low contactoroff

endif

pause 1000


return


'*****************************************************************************************************************
*******

'  PARALLEL PROGRAM TO OUTPUT TERMINAL INFORMATION


start1:
```

```
pause 200

main1:

waitasecond:
if time = lastsecond then
        goto waitasecond
else
        lastsecond = time
endif

if voltage < offvoltage then
        sertxd ("STA=OFF")
else
        sertxd ("STA=ON")
endif

sertxd (" ERR=",#errorflag,cr,lf)



if time = 60 then : time = 0 : endif

goto main1
end

interrupt:return
```