

# Medi DSP based Compact Domestic Sinewave UPS-cum-Inverter with Charger

Martin's Electronic Devices & Instruments

- Isolated sensing of Mains
- Cycle-Cycle current Limiting
- Low cost driver
- LED/7-segment/LCD display

# Medi Microcontroller based sinewave UPS/Inverter with charger

## Introduction

MEDI has developed a new micro-controller based digital sine wave inverter using DSP (Digital Signal Processor) with full bridge configuration topology MOSFET switches. This is a modified version of our 2008 Model with added features like:

- Isolated sensing of Mains: This will ensure that even if Phase-Neutral connection is reversed at the input side there will not be any electric shock on the PCB or battery.
- Cycle-Cycle current Limiting: This is an enhanced protection method for the short circuit / heavy load condition.
- Low cost driver: The costly driver with TLP250 is replaced with discrete components on the PCB
- LED/7-segment/LCD display: The PCB is designed with provision for LED, 7-segment display or LCD display.

This inverter is best suited for manufacturing for domestic applications as it is simple and easy. It consists of only a few components which are easily available, have only 3 smd components and with a single sided pcb. There are no windings which can possibly cause any error such as DC-CT or EE-16 transformers. Mounting of heatsink along with mosfets and soldering few components will complete this board. It consists of a LCD which will display all the parameters of the system and indicates any error during the functioning of the inverter. A low cost 16 character single line LCD will be of scrolling type, showing the status of the inverter such as batt voltage, mains voltage, inverter output voltage, inverter standby on/off, charger on/off, mains/ solar charging and many more. It is very simple to handle and very easy to set the values in the menu driven set-up mode.

This inverter is a very robust design which will not fail in any extreme conditions.

1. If 440V is applied to the AC input, it will not fail. It will indicate high voltage cut-off and restart when voltage is normal.
2. If AC mains is given to the inverter output, it will not fail. It will indicate phase input output reverse and continue to work after it is rectified.
3. It has fold-back current limiting for short circuit and heavy loads. At short circuit or heavy loads, current limiting action will take place instead of tripping which will lead to more reliability.

## Features

- LCD display for indicating various status of the system like inverter voltage, mains voltage, battery voltage, % of load, overload/short circuit status, battery low status, charger status etc.
- LCD based Menu driven setup of various parameters like battery full charge voltage, battery low voltage, load condition, Inverter output voltage, charging current etc.
- Protections against: Overload, short circuit, battery deep discharge, battery over charge, mains over voltage, reverse connection of phase in – phase out, reverse connection of phase and neutral of mains input. In all these error conditions will be shown in the LCD display.
- Priority solar charging facility: When solar charger is connected mains charger will be in stand-by and priority will be for solar charger.
- Delayed inverter cutoff for conditions like battery low, overload, short circuit etc. The system will automatically restart from cutoff after a few second buzzer beeps. The system will go to permanent cutoff if the error condition exists even after 4 restart.
- Bill of materials: Main PCB 850VA – Rs. 750/- or less, Transformer 850VA – Rs. 2000/-

1. LCD will display –

- Battery voltage
- Inverter output voltage
- Percentage of load
- Mains voltage
- Changer on/off
- Solar charging /mains charging
- Inverter standby on/off
- UPS mode / inverter mode
- Phase input output reverse : whether mains is connected to inverter output
- Neutral and phase reverse : whether neutral and phase is connected reverse
- Overload : if load is above 100% and below 300%
- Heavy : if load is above 300%
- Short circuit
- Overload trip
- Heavy load trip
- Short circuit trip

2. Menu driven set-up. There is no preset, the parameters such as battery low, charging current, inverter output voltage, load etc can be set by scrolling up and down keys and press enter.

3. Priority solar charging

4. Inverter/UPS selection switch, micro switch or ordinary switch selectable.

5. Inbuilt SMPS type constant current charging with full charge cut-off.

6. 20KHz operating frequency while inverter and charging, absolutely no sound.

7. Pure sine wave output

8. DSP based very low component cost design

9. Single sided pcb, easy to assemble without any smd components

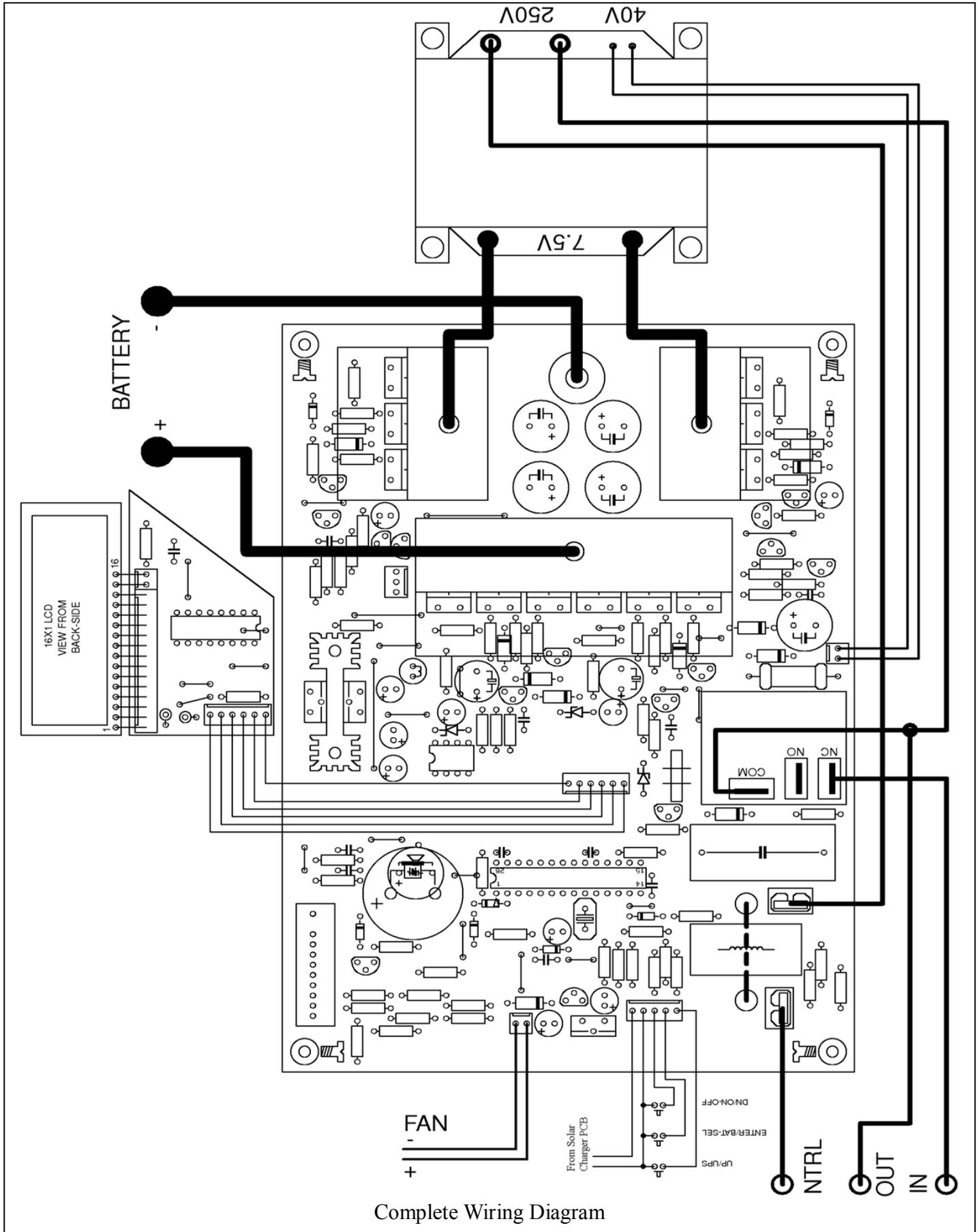
10. Ideal for Mixed load application

### Specification

- Battery Input voltage : 12V DC – 48V DC
- Mains Input voltage : 230V AC, 50Hz.
- Mains input range : 0V – 440V, 45Hz-65Hz
- AC Output (Inverter) : 230V +/- 3%, 50Hz
- Inverter topology : Bridge type center aligned switching. MOSFET based.
- Inverter output power : 300VA - 3000VA
- Battery charging : Constant current SMPS charging with full charge cutoff
- Charging current : Settable upto 15A
- Charger working range : 120V – 270V AC Mains input

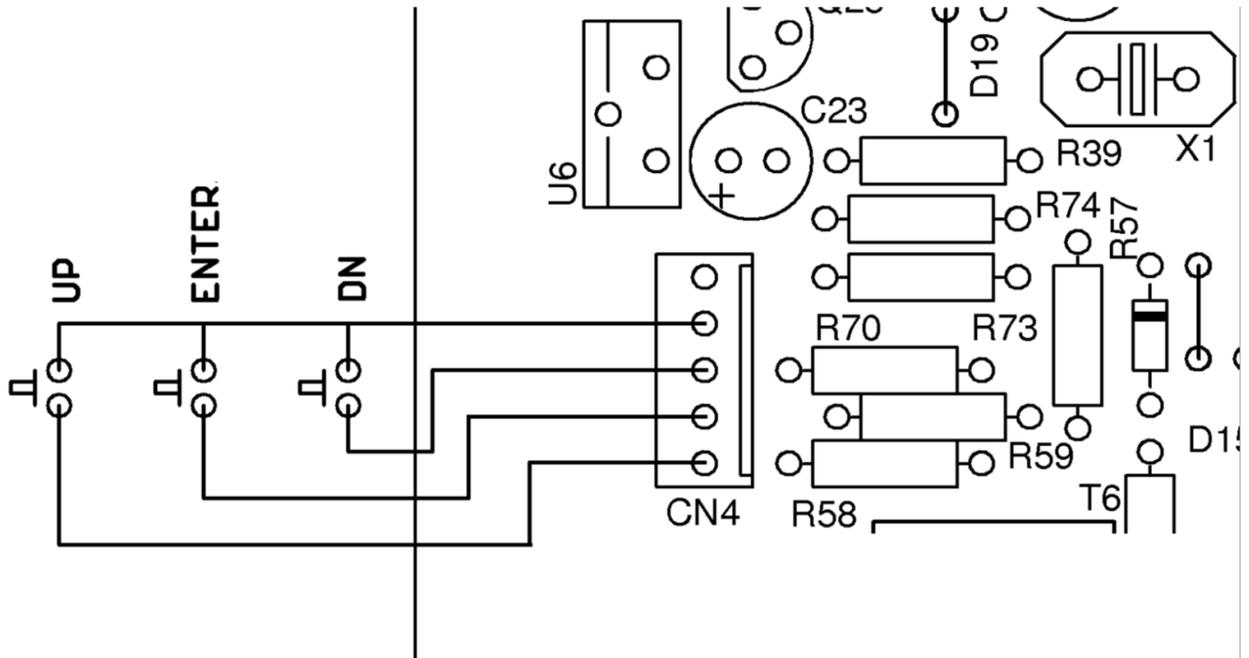
### Highlights

1. Full bridge configuration based on power MOSFETs
2. DSP based intelligent control
3. LCD based display for user-friendly display of parameters and status
4. Protection against 440V mains input
5. Protection against reverse polarity
6. Dynamic short circuit protection with fold-back current limiting.
7. Protections against all possible errors like battery low, over load, heavy load, short circuit etc.
8. Early warning for battery low and overload conditions. System continue normally if the error is corrected.
9. Cutoff and auto restart with permanent cut after 5 consecutive cutoff.
10. SMPS type constant current charger with full charge cutoff.
11. Pure sinewave output resulting in silent operation of motor and fans. Safe to all kind of loads.
12. Ideal for Mixed load application
13. Indigenous design with proven technology.
14. Auto detect of LCD and LED. Can change between LED / LCD while the system is powered.
15. Protection against accidental output feedback disconnection.



## How to do Setup

To do the setup no special type connection is required. The setup switched are to be connected to connector CN4 to which normally the ON/OFF, Battery Type selection and UPS/INV selection switches will be connected. During setup there will be 3 switched: UP, DOWN and ENTER. The connections of these switches are as shown below.



There will be a default value already set for parameters such as battery low, battery full charge etc. So, there is no need to change these values. Only the calibration of the meter is required by entering the calibrate mode. Also after the wiring and finishing of the inverter in the cabinet, the no-load set should be done.

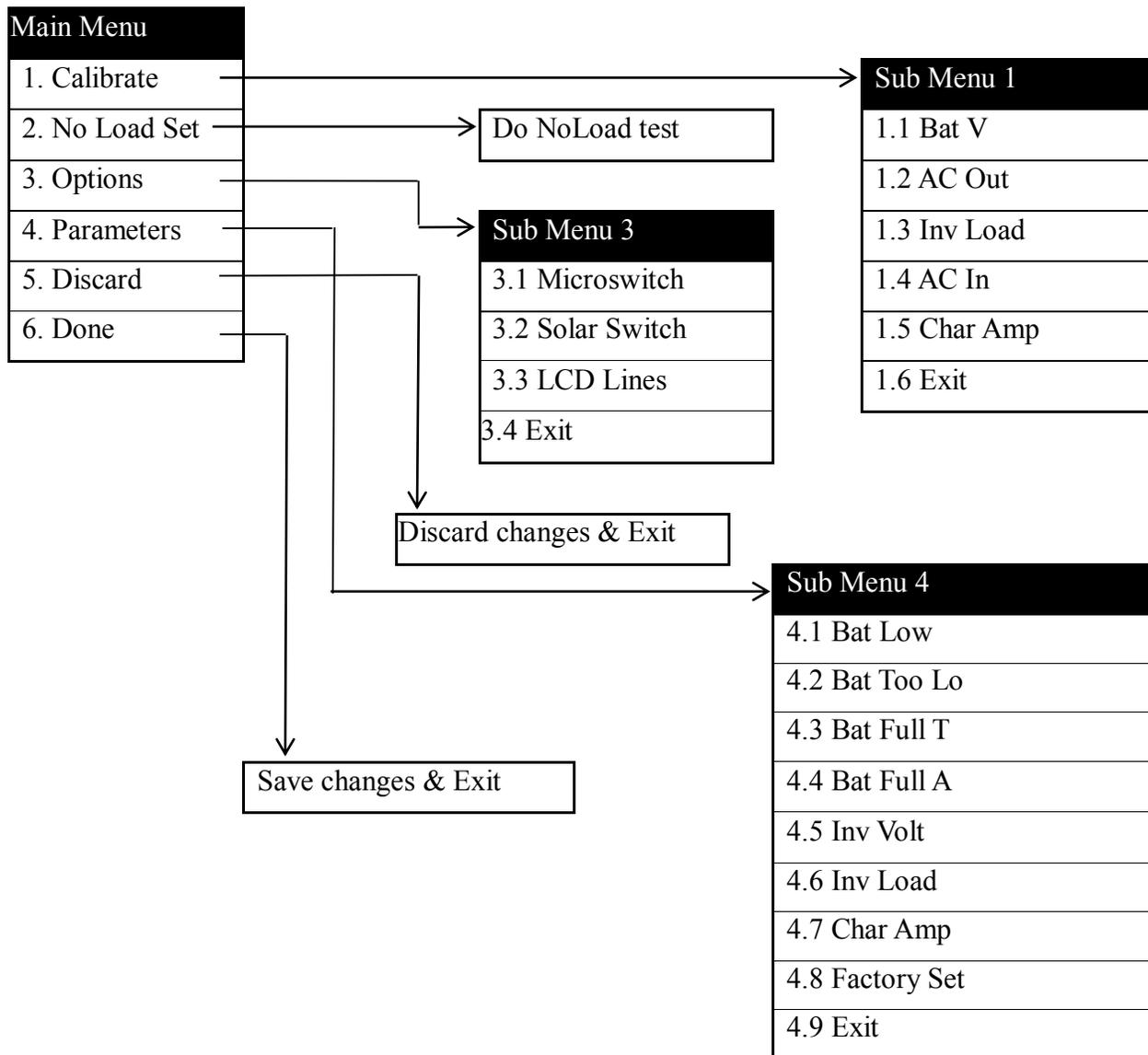
To enter setup simply press Enter switch and then power on the system.

The display will show 'Enter Setup? N'. Note that the default choice is 'No' which prevents accidental entry to setup mode. To change the choice to *Yes*, press the Up or Down switch. Pressing Up switch again and again will toggle the choice between Yes and No. While the choice is Yes (display is showing: 'Enter Setup? Y') press Enter switch. Now the system is in setup mode. While the system is asking 'Enter Setup?' question, if the user do not press any key for around 15 seconds the system will come back to normal working without entering setup mode even if the selected choice is Y (yes).

When you enter setup (by pressing Enter switch while display is showing: 'Enter Setup? Y') the display will show the software version number for a while. Then the menu will be shown. Navigating through the menu driven setup is exactly same as our earlier microcontroller based sinewave designs. Details are given from the next page onwards.

## Menu driven setup

We have provided a very user friendly menu driven setup procedure. The menu style is as below:



When you enter setup you are starting at Menu1: **Calibrate**. If you press up switch you will see menu 2: **No Load Set**. Up switch is for going to the next item while Down switch is for going to the previous item. Menu is having auto-wrap facility, means: While displaying the last item in a menu if up switch is pressed then the first item is displayed. Similarly while displaying the first item in a menu if down switch is pressed then the last item is displayed.

To enter a menu just press the enter switch while the menu is displayed. For example if you want to enter the calibration menu: While you are in the main menu, press up or down switches until the display show 1. *Calibrate* and then press enter. From the sub menu if you want to go back to the main menu: press up or down switches until the display show 'Exit' and press Enter.

## 1. Calibrate Menu

The first menu is for calibrating various parameters that the microcontroller reads. For example the battery voltage is given to the microcontroller through a resistance divider network which scale down the voltage to 0.2034. Due to the variation of resistance value this scale down may not be correct. So the system may show slightly different reading. To make the reading correct we have to do the calibration. Calibration is required for Battery voltage, AC input volt, AC output volt, Inverter load and charging current.

## 2. No Load Set menu

This is for a kind of self test of the system. After doing the wiring you need to run the No-Load test at least once. This is required for correct functioning of the system.

## 3. Options Menu

This menu is for setting various Options. At present two options are given : Microswitch/Rocker switch selection and Solar switch or Battery switch selection. This is explained below in detail.

## 4. Parameters menu

This menu is for setting various parameters like battery full charge voltage, battery low voltage etc. Normally these voltages will be automatically set by the microcontroller at power on time. Normally there is no need to change any parameters.

## 5. Discard Menu

Execute this menu if you have somehow done some unwanted changes in the setup values so do not want to write this to the non-volatile memory. The changes you have made will be discarded and the old values will be restored.

## 6. Done Menu

Execute this menu if you have done the necessary changes in the setup and want to write this to the non-volatile memory.

## Sub Menus

### Sub-Menus of Calibration Menu

Calibration menu has five sub menus (plus one exit menu to go back to main menu). They are:

► 1.1 Bat V, ► 1.2 AC Out, ► 1.3 Inv Load, ► 1.4 AC In and ► 1.5 Char Amp. The two numbers separated by dot in the display indicate the menu number and sub menu number. For example 1.3 *Inv Load* means Sub menu 3 of main menu 1.

The calibration menu is given for correcting the reading shown by the system. That is, if the battery voltage is 12.3V but the system shows 12.8V then we can use the calibration menu to correct the display. You have to use a good multimeter while doing the calibration. After assembling the PCB it is recommended to do the calibration because there is a good chance for slight variations in the display of various parameters due to the tolerance of resistors.



While doing the calibration of different parameters the display may seem not increasing / decreasing. For example when doing the battery calibration suppose the display shows 10V and you need to make it 12V. If you press UP switch the display may not increase as expected. But do not give up!. Just press and hold the switch. The display will change slowly. This is because the range of the calibration is too wide.

### 1.1 Bat V

This menu is for calibrating the battery voltage reading. To enter this menu press Enter while the display shows this menu. Inside this menu the display will show the present battery voltage. Suppose the display shows 13.0V but with a good multimeter you measure the actual battery voltage as 12.5V. Now press Down switch to correct the reading. When the reading is OK press Enter switch.

### 1.2 AC Out

This menu is for calibrating the AC output reading. To enter this menu press Enter while the display shows this menu. The inverter will start with an output around 200V. During this working of inverter there will not be any AVR correction and output will vary as per battery voltage and load. It is expected to run this in no-load condition. Inside this menu the display will show the present inverter output voltage. Suppose the display shows 180V but with a good multimeter you measure the actual inverter output voltage as 202V. Now press Up/Down switch to correct the reading. When the reading is OK press Enter switch.

### 1.3 Inv Load

This menu is for calibrating the inverter load reading. To enter this menu press Enter while the display shows this menu. The inverter will start and the output will be at the set inverter voltage. Inside this menu the display will show the present inverter load. You have to connect some considerable load to get good calibration. A load near the full load is recommended. Suppose you have connected 400W but the display shows 380W. Now press Up/Down switch to correct the reading. When the reading is OK press Enter switch.

### 1.4 AC In

This menu is for calibrating the AC input reading. To enter this menu press Enter while the display shows this menu. User should connect the mains while running this setup. To get good calibration, it is recommended to input an AC voltage above 200V. Inside this menu the display will show the present mains voltage. Suppose the display shows 230V but with a good multimeter you measure the actual AC input voltage as 238V. Now press Up/Down switch to correct the reading. When the reading is OK press Enter switch.

### 1.5 Char Amp

This menu is for calibrating the charging current. To enter this menu press Enter while the display shows this menu. The charger mode will start. Note that you have to connect a good ammeter in series with the battery and input the mains supply. Charger will function irrespective of the battery voltage. There will not be any full charge cutoff. You have to connect an ammeter in series with the battery. The battery and ammeter connection should be very firm. Any battery side loose contact will cause excess voltage across the MOSFET since the charger is functioning without any full charge cutoff. This can cause MOSFET damage.

Inside this menu the display will show the charging current you have set in the parameter menu. For example if you have set 8A in the parameter menu then the display will show Char Amp = 8A. The display will be steady and will not change. Initially the ammeter connected in series with the battery will show 0A. Press up key for a long time and the ammeter will start showing the current. Using UP and DN switches bring the current to the desired value. Press Enter when done. **The mains should be disconnected only after pressing the Enter switch.**

### 1.6 Exit

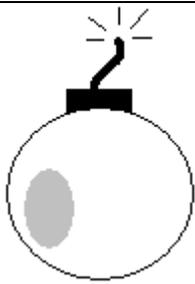
This menu is to exit the submenu and go back to the main menu *Calibration*.

## Menu 2: No Load Set

Inside this menu the system takes some readings that are important for the correct working of the inverter. It is very important to run this menu at least once. During no load set the system also take some readings which are important for proper sensing of ac input, ac output and load feedback. For proper working of inverter and charger these parameters are important.



While doing no load set the mains should not be connected. If mains is present the system will not complete no load set. It is supposed that voltage at pin 2, 3 and 4 should be around 2.5V. If the voltage is not within +/- 2% the system will not complete no-load set.



Very Important: If you replace the transformer or change the primary or secondary connection of the transformer you should run the No Load Set at least once. This is important because inside this menu the system sense the polarity of the transformer. It is needed for correct line interactive changeover. Incorrect polarity can cause the re-boot of the computer and sometimes damage the MOSFETs.

## Sub-Menus of Options Menu

Options menu has only two sub menus (plus one exit menu to go back to main menu). They are:

► 3.1 Microswitch ► 3.2 Solar Switch ► 3.3 LCD Lines

### 3.1 Microswitch

This menu is used to select whether the user needs microswitch or simple switch for inverter ON/OFF. To enter this menu press Enter while the display shows this menu. Inside this menu the display will show 'Microswitch Y' or 'Microswitch N'. If Y is selected it means microswitch type ON/OFF switch. If N is selected it means ordinary ON/OFF switch. User can change between Y ◀▶ N with up or down switches. When the correct option is selected press enter switch.

### 3.2 SolarSwitch(not applicable for this design)

This menu is used to select whether switch 2 should function as solar / mains charger selector or Tubular / automotive battery selector. To enter this menu press Enter while the display shows this menu. Inside this menu the display will show 'SolarSwitch Y' or 'SolarSwitch N'. If Y is selected it means switch 2 will function as solar charger / mains charger selection switch. If N is selected it means switch 2 will function as tubular battery / automotive battery selection switch User can change between Y ◀▶ N with up or down switches. When the correct option is selected press enter switch.

### **Tubular battery / Automotive battery selection**

If user has selected switch 2 to function as Tubular battery / Automotive battery selection switch then Tubular battery will be selected if switch is closed. Automotive battery will be selected if switch is open. When tubular battery is selected *Bat Full T* voltage (selected in menu 4.3) will be considered as battery full charge voltage. *Bat Full T-1.0V* will be considered as battery reconnect voltage. When automotive battery is selected *Bat Full A* voltage (selected in menu 4.4) will be considered as battery full charge voltage. *Bat Full A-0.6V* will be considered as battery reconnect voltage.

### **Solar Charger Mains charger selection**

If user has selected switch 2 to function as Solar Charger / Mains charger selection switch then solar charging will be selected if switch is closed. Mains charging will be selected if switch is open. This is exactly as our old sinewave models. When the system is in solar charging mode, mains charger will be forcefully disabled irrespective of battery voltage. When mains charger is selected the charger will function as usual. The zero drop solar charger circuit we have provided can automatically switch to solar charging when sunlight is present.



Note: When switch 2 is selected as Solar Charger / Mains charger selection switch, the system will assume the battery as Tubular battery. So the *Bat Full T* voltage (selected in menu 4.3) will be considered as battery full charge voltage. *Bat Full T-1.0V* will be considered as battery reconnect voltage.

### **3.3 LCD Lines**

This is a new menu item added from version 4.0 onwards. When entering this menu the display will show the number of lines in LCD. You can use 1 line, 2 line or 4 line LCD. With up/down switches the number of lines can be selected. There is no meaning to select more than 4 number of lines. If selection is more than 4 then the system will take lines = 4.

### **Sub-Menus of Parameter Menu**

Parameter menu has eight sub menus (plus one exit menu to go back to main menu). They are:

▶ 4.1 Bat Low, ▶ 4.2 Bat Too Lo, ▶ 4.3 Bat Full T, ▶ 4.4 Bat Full A, ▶ 4.5 Inv Volt, ▶ 4.6 Inv Load, ▶ 4.7 Char Amp and ▶ 4.8 Factory Set. The two numbers separated by dot in the display indicate the menu number and sub menu number. For example 4.3 Bat Full T means Sub menu 3 of main menu 4.

#### **4.1 Bat Low**

This menu is for setting the battery low voltage (that is, the battery voltage level at which the battery low warning should start). To change this simply press enter while this menu is displayed. The display will show the present setting. Press Up or Down switches to change to the desired value and press enter. The default value for this parameter is 10.0V. Normally you need not change this.

#### **4.2 Bat Too Lo**

This menu is for setting the battery low too voltage (that is, the battery voltage level at which the system go to immediate cut). To change this simply press enter while this menu is displayed. The display will show the present setting. Press Up or Down switches to change to the desired value and press enter. The default value for this parameter is 9.0V. Normally you need not change this.

### 4.3 Bat Full T

This menu is for setting the battery full charge voltage for Tubular battery (that is, the battery voltage level at which charger turns off). Note that we have an option to use switch 2 for battery selection (see option menu). To change this simply press enter while this menu is displayed. The display will show the present setting. Press Up or Down switches to change to the desired value and press enter. The default value for this parameter is 14.0V. Normally you need not change this.

For tubular battery, system automatically select the battery charge reconnect voltage as Bat Full Voltage – 1.0V

### 4.4 Bat Full A

This menu is for setting the battery full charge voltage for Automotive battery (that is, the battery voltage level at which charger turns off). Note that we have an option to use switch 2 for battery selection (see option menu). To change this simply press enter while this menu is displayed. The display will show the present setting. Press Up or Down switches to change to the desired value and press enter. The default value for this parameter is 13.8V. Normally you need not change this.

For Automotive battery, system automatically selects the battery charge reconnect voltage as Bat Full Voltage – 0.6V

### 4.5 Inv Volt

This menu is for setting the output voltage of inverter. To change this simply press enter while this menu is displayed. The display will show the present setting. Press Up or Down switches to change to the desired value and press enter. The default value for this parameter is 220V. Normally you need not change this.

### 4.6 Inv Load

This menu is for setting the inverter load. To change this simply press enter while this menu is displayed. The display will show the present load setting. Press Up or Down switches to change to the desired value and press enter. The default value for this parameter is 500W.

### 4.7 Char Amp

This menu is for setting the charging current. To change this simply press enter while this menu is displayed. The display will show the present load setting. Press Up or Down switches to change to the desired value and press enter. The default value for this parameter is 8A.

### 4.8 Factory Set

Pressing Enter in this menu will load the default factory settings for the parameters.

### 4.9 Exit

This menu is for exiting from the sub menu and go back to the main menu *Parameters*.