DIGITAL HOME-UPS (MK-1)

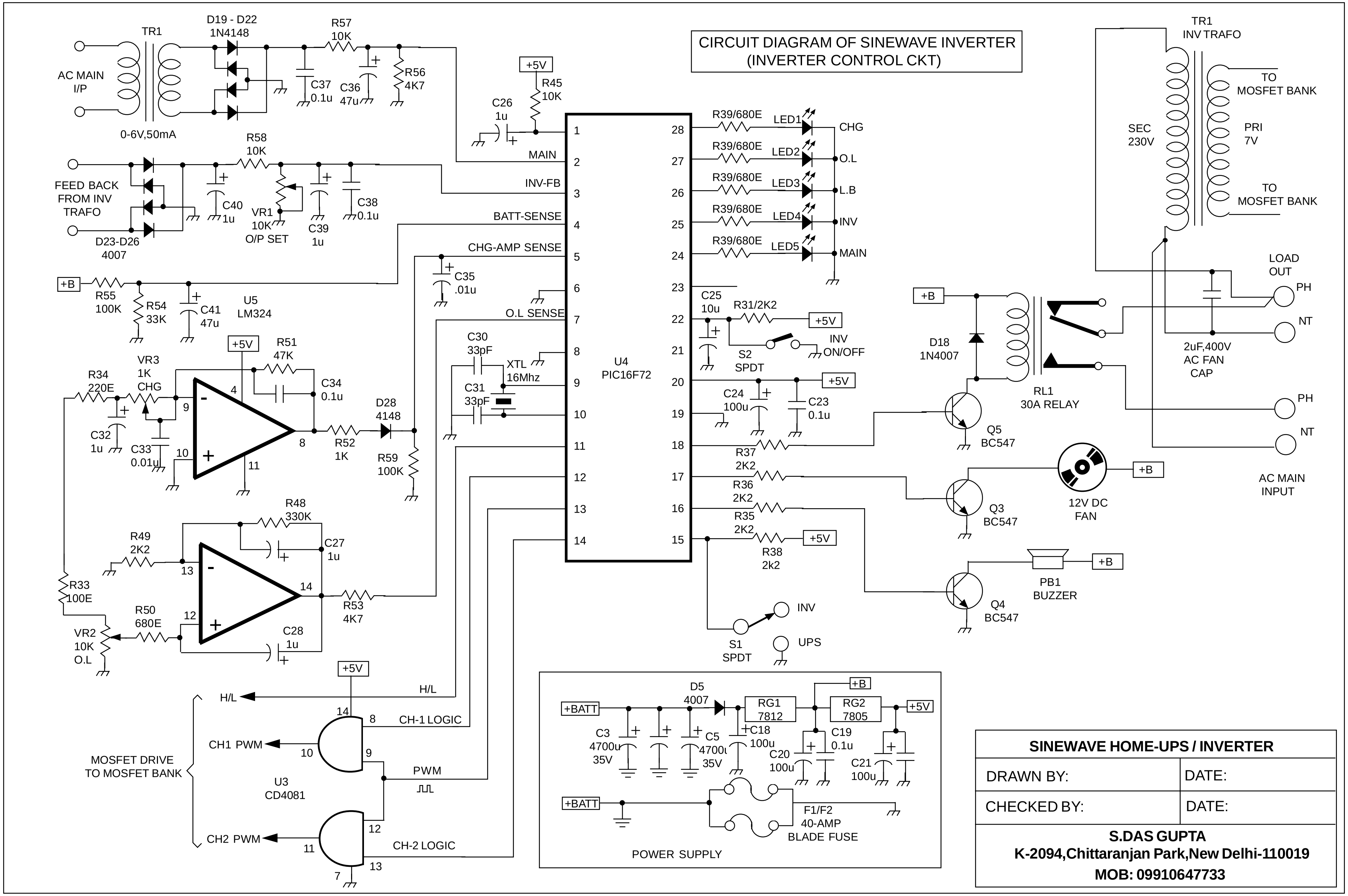
(SINEWAVE WAVE)

PIC16F72 MICROCONTROLLER BASED DESIGN

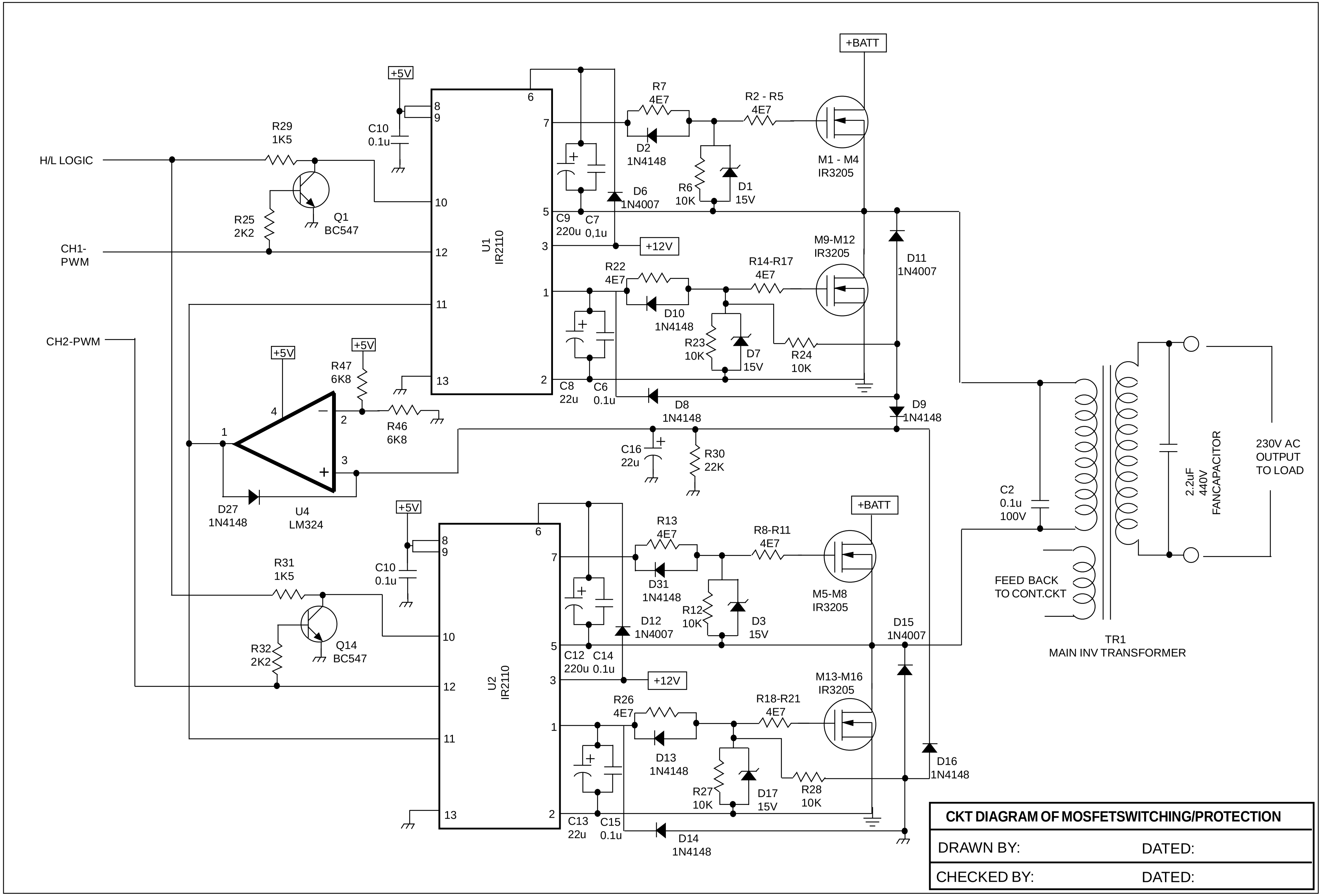
SINEWAVE HOME UPS / INVERTER

FEATURES & SPECIFICATION:

DC BATT.	: 12V,180AH (625/800VA)
INVERTER O/P VOLT	: 230V (+2%)
INV. O/P FREQ	: 50Hz
INV. O/P WAVEFORM	: SINE WAVE
HARMONIC DISTORTION	: <3%
CREST FACTOR	: >4:1
INV.EFFICIENCY	: 90% for 24V system
	: >85% for 12V system
AUDIBLE NOISE	: <60dB at 1-meter
INV. PROTECTION	: LO-BATTERY SHUT
	: OVER LOAD SHUT
	: O/P SHORT CKT SHUT
LO-BATTERY	: BEEP START AT 10.5V (BEEP AT EVERY 3-SEC)
	: INV SHUT DOWN AT 10V (5XBEEP at every 2-SEC)
OVER LOAD	: BEEP START AT 120% LOAD (BEEP at every 2-sec)
	: INV. SHUT DOWN AT 130% LOAD (5XBEEP at every 2-SEC)
LED INDICATION	: INVERTER ON
	: LOW-BATT - FLASH DUURING L.B ALARM
	- PERMANENT GLOW DURING CUT
	: OVER LOD - FLASH DUURING O.L ALARM
	- PERMANENT GLOW DURING CUT
	: CHARGING - FLASH DURING CHARGING
	- PERMANENT GLOW DURING ABSORPTION
	: MAIN - MAIN ON
CIRCUIT	: 8-BIT MICROCONTROLLER BASED CONTROL CIRCUIT
	: H-BRIDGE INVERTER OPERATION
	: MOSFET SWITCHING FAULT DETECTION
CHARGING ALGORITHM	: MOSFET based PWM SMPS CHARGE CONTROLLER 5-amp - 15-amp
	: 2-STEP CHARGING STEP-1: BOOST MODE (LED FLASH)
	STEP-2: ABSORPTION MODE (LED ON)
DC FAN	: FOR INTERNAL COOLING DURING CHARGING/INV OPERA TION



CIRCUIT DIAGRAM OF SINEWAVE INVERTER
(INVERTER CONTROL CKT)
AC MAIN I/P
TR1
0-6V,50mA
D19 - D22 1N4148
R57 10K
C37 0.1u
C36 47u
R56 4K7
+5V
R45 10K
C26 1u
FEED BACK FROM INV TRAFO
D23-D26 4007
R58 10K
C40 1u
VR1 10K O/P SET
C39 1u
C38 0.1u
+B
R55 100K
R54 33K
C41 47u
C35 .01u
U5 LM324
R51 47K
C34 0.1u
R34 220E
VR3 1K CHG
C32 1u
C33 0.01u
D28 4148
R52 1K
R59 100K
R48 330K
C27 1u
R49 2K2
R33 100E
R50 680E
VR2 10K O.L
C28 1u
R53 4K7
MAIN
INV-FB
BATT-SENSE
CHG-AMP SENSE
O.L SENSE
C30 33pF
C31 33pF
XTL 16Mhz
U4 PIC16F72
R39/680E
LED1 CHG
LED2 O.L
LED3 L.B
LED4 INV
LED5 MAIN
C25 10u
R31/2K2
S2 SPDT
INV ON/OFF
C24 100u
C23 0.1u
R37 2K2
R36 2K2
R35 2K2
R38 2k2
S1 SPDT
INV
UPS
H/L
CH-1 LOGIC
PWM
CH1 PWM
CH2 PWM
U3 CD4081
CH-2 LOGIC
MOSFET DRIVE TO MOSFET BANK
TR1 INV TRAFO
SEC 230V
PRI 7V
TO MOSFET BANK
LOAD OUT
PH
NT
2uF,400V AC FAN CAP
AC MAIN INPUT
D18 1N4007
RL1 30A RELAY
Q5 BC547
Q3 BC547
Q4 BC547
12V DC FAN
PB1 BUZZER
+BATT
D5 4007
RG1 7812
RG2 7805
C3 4700u 35V
C5 4700u 35V
C18 100u
C20 100u
C19 0.1u
C21 100u
F1/F2 40-AMP BLADE FUSE
POWER SUPPLY
SINEWAVE HOME-UPS / INVERTER
DRAWN BY:
DATE:
CHECKED BY:
DATE:
S.DAS GUPTA
K-2094,Chittaranjan Park,New Delhi-110019
MOB: 09910647733


H/L LOGIC
CH1-
PWM
CH2-PWM
R29
1K5
R25
2K2
Q1
BC547
+5V
C10
0.1u
U1
IR2110
8
9
6
7
10
5
3
12
11
1
13
2
R7
4E7
D2
1N4148
R2 - R5
4E7
M1 - M4
IR3205
+BATT
R6
10K
D1
15V
D6
1N4007
C9
220u
C7
0,1u
+12V
R22
4E7
D10
1N4148
R14-R17
4E7
M9-M12
IR3205
D11
1N4007
R23
10K
D7
15V
R24
10K
C8
22u
C6
0.1u
D8
1N4148
D9
1N4148
R47
6K8
R46
6K8
U4
LM324
4
2
1
3
D27
1N4148
C16
22u
R30
22K
C2
0.1u
100V
2.2uF
440V
FANCAPACITOR
230V AC
OUTPUT
TO LOAD
FEED BACK
TO CONT.CKT
TR1
MAIN INV TRANSFORMER
U2
IR2110
R31
1K5
R32
2K2
Q14
BC547
R13
4E7
D31
1N4148
R8-R11
4E7
M5-M8
IR3205
R12
10K
D3
15V
D12
1N4007
C12
220u
C14
0.1u
D15
1N4007
R26
4E7
D13
1N4148
R18-R21
4E7
M13-M16
IR3205
R27
10K
D17
15V
R28
10K
D16
1N4148
C13
22u
C15
0.1u
D14
1N4148
CKT DIAGRAM OF MOSFETSWITCHING/PROTECTION
DRAWN BY:
DATED:
CHECKED BY:
DATED:

SINEWAVE HOME UPS / INVERTER

PARTS LIST (PCB)

CAPACITORS:

C1 : 0.1u,250V AC
C2 : NOT USED
C3 : 4700u,35V
C4 : 4700u,35V
C5 : 4700u,35V
C6 : 0.1u,ceramic
C7 : 0.1u,ceramic
C8 : 22u,40V
C9 : 220uF,40V
C10 : 0.1u,ceramic
C11 : 0.1u,ceramic
C12 : 220uF,40V
C13 : 22uF,40V
C14 : 0.1u,ceramic
C15 : 0.1u,ceramic
C16 : 22uF,40V
C17 : 220uF,40V
C18 : 100uF,40V
C19 : 0.1u,ceramic
C20 : 100uF,40V
C21 : 47uF,40V
C22 : 0.1u,ceramic
C23 : 10uF,40V
C24 : 100uF,25V
C25 : 10uF,40V
C26 : 1uF,40V
C27 : 1uF,40V
C28 : 1uF,40V
C29 : 0.1u,ceramic
C30 : 33pF, ceramic
C31 : 33pF,ceramic
C32 : 1uF,40V
C33 : 0.01u,ceramic
C34 : 0.1u,ceramic
C35 : 0.01u,ceramic
C36 : 47uF,40V
C37 : 0.1u,ceramic
C38 : 0.1u,ceramic
C39 : 1uF,40V
C40 : 1uF,40V
C41 : 47uF,40V

RESISTORS:

R1 : NOT USED
R2 : 4.7-ohm
R3 : 4.7-ohm
R4 : 4.7-ohm
R5 : 4.7-ohm
R6 : 10K
R7 : 4.7-ohm
R8 : 4.7-ohm
R9 : 4.7-ohm
R10 : 4.7-ohm
R11 : 4.7-ohm
R12 : 10K
R13 : 4.7-ohm
R14 : 4.7-ohm
R15 : 4.7-ohm
R16 : 4.7-ohm
R16 : 4.7-ohm
R17 : 4.7-ohm
R18 : 4.7-ohm
R19 : 4.7-ohm
R20 : 4.7-ohm
R21 : 4.7-ohm
R22 : 4.7-ohm
R23 : 10K
R24 : 10K
R25 : 2K2
R26 : 4.7-ohm
R27 : 10K
R28 : 10K
R29 : 1K5
R30 : 22K
R31 : 1K5
R32 : 2K2
R33 : 100-ohm
R34 : 220E
R35 : 2K2
R36 : 2K2
R37 : 2K2
R38 : 2K2
R39 : 680-ohm
R40 : 680-ohm
R41 : 680-ohm
R42 : 680-ohm
R43 : 680-ohm
R44 :2K2
R45 : 10K
R46 : 6K8
R47 : 6K8
R48 : 330K
R49 : 2K2
R50 : 680-ohm
R51 : 47K
R52 : 1K
R53 : 4K7
R54 : 33K
R55 : 100K/220K
R56 : 4K7 (for 6V trafo)
R57 : 10K
R58 : 10K
R59 : 100K

DIODES:

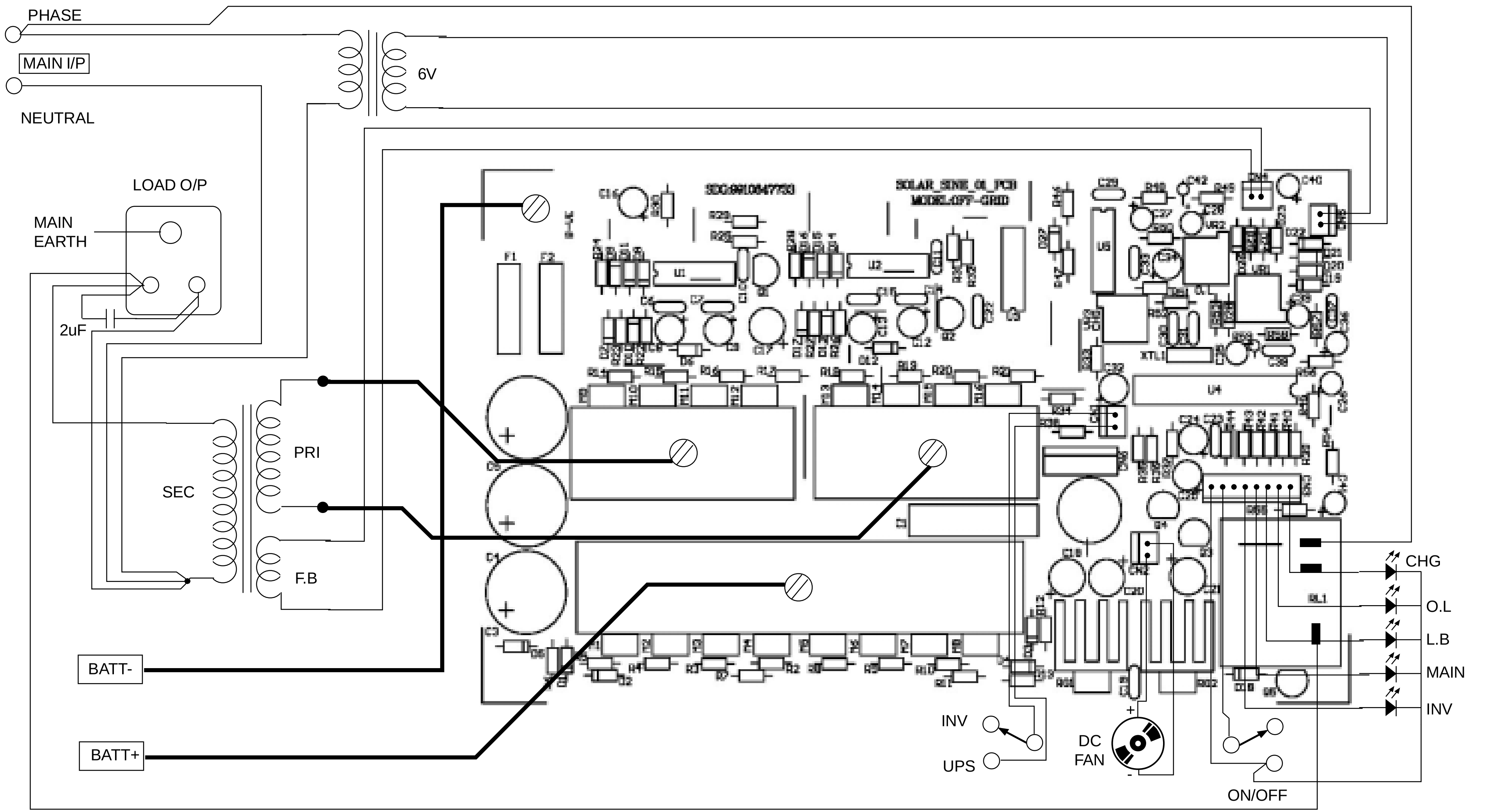
D1 : 15V,zener
D2 : 1N4148
D3 : 15V,zener
D4 : 1N4148
D5 : 1N4007
D6 : 1N4007
D7 : 15V,zener
D8 : 1N4148
D9 : 1N4148
D10 : 1N4148
D11 : 1N4007
D12 : 1N4007
D13 : 1N4148
D14 : 1N4148
D15 : 1N4007
D16 : 1N4007
D17 : 15V,zener
D18 : 1N4007
D19 : 1N4148
D20 : 1N4148
D21 : 1N4148
D22 : 1N4148
D23 : 1N4007
D24 : 1N4007
D25 : 1N4007
D26 : 1N4007
D27 : 1N4148 (put reverse)
D28 : 1N4148

SEMICONDUCTORS:

U1 : IR2110
U2 : IR2110
U3 : CD4081
U4 : PIC16F72
U5 : LM324
XTL1 16Mhz,crystal
RG1 : 7812 (for 12V only)
RG2 : 7805
Q1 - Q5 : BC547
M1 - M16 :IRF3205, MOSFET

MISC:

VR1 : 10K
VR2 : 10K
VR3 : 10K
PB1 :10mm Goli buzzer
RL1 : 30A,Thimble Relay
F1 - F2 : 40A, Blade fuse
LED1 - LED5 : 3mm/5mm LEDs



PCB WIRING LAYOUT

PCB TESTING:

1.Connect the battery to PCB, connect LEDs, ON/OFF switch on to the PCB. Keep the ON/OFF switch OFF and check the voltages at VCC and VDD pins of IC. [U4] - Pin20:5V,pin1:5V,pin8 and 19:0V. [U5] - Pin4:12V,pin11:0V, [U3] - pin14:12V,pin7:0V, [U1 / U2] - Pin3:12V, pin6:12V, pin8 & 9:5V,pin13:0V

2.Switch ON the inverter switch check voltages at pin13 of [U4]:3.2V, pin12 and 14 of [U4]:2.5V, [U3] pin10 & 11:7.8V gate of MOSFET M9 - M12 & M13 - M16:3.8V, gate of M1 - M4 & M5 - M8:14V

3. Now connect the primary of inverter transformer and switch ON the inverter. Adjust preset VR1 to set the output voltage at 230V.

4.No voltage regulation: Check the connection of feed back winding of transformer, check voltage across C40, if there is no voltage check D23-D26, check voltage across C38 (pin3 of U4) it should be 1.6V or above,if there is no voltages check R58,VR1,C38,C39. If the pin3 is showing 1,.6V or above then replace U4.

5.Now connect 700VA load and adjust VR3 for overload trip. If there is no over load trip then check voltage at pin7 of U4, it should be 2V or above, if the voltage at pin7 is <2v then check the components connected to pins 8 & 9 of LM324.

6.Reduce load momentarily short the resistor R54 physically from outside and check the lo-batt occurs or not. pin4 of U4 is meant for lo-batt sense, when the voltage at this pin is >2.25V then inverter works normal, if the voltage at this pin is <2.25V then lo-batt occurs.

7.Now connect AC MAINS and keep the system in inverter mode and check the main changeover takes place at 150V AC (inverter off), and reduce the main voltage to 100V the inverter starts. If it does not happens then check the follwing voltages at Pin2 of U4. when AC volt is 100V, pin2 of U4 is 0.5V, when AC volt is 150V the pin2 volt is 0.9V.

8.Now keep the system in UPS mode and check the inverter start when Ac main volt age is below 170V and mainchangeover takes place when AC main voltage is above 190V. If it does not happen then check the follwing voltages at Pin2 of U4. when AC volt is 170V, pin2 of U4 is 1.04V, when AC volt is 190V the pin2 volt is 1.21V.

9.Now adjust the charging current with VR3, charging current can be adjust from 5-amp to 15-amp. if the circuit not controlling the current then check the voltage at pin 5 of U4 it should be 2.5V. If the the pin5 voltage is below 2.5V then check the components connected to pins13,12,14 of LM324, if the voltage is above 2.5V then replace U4.

SINEWAVE INVERTER / HOME-UPS VOLTAGE CHART

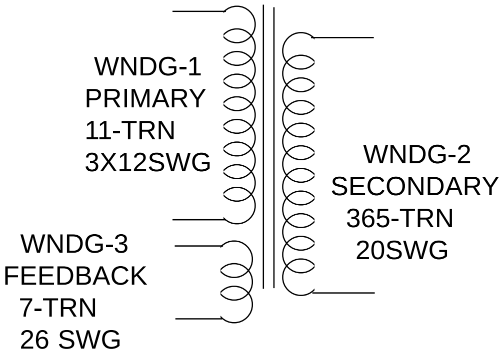
U4 - 16F72 PIN NO	INV-ON	MAIN-ON
1	5V	5V
2	0V	1.5V
3	2.5V	2.5V
4	2.8V	2.89V
5	0.5V	1.4V
6	0V	0V
7	0.9V	0V
8	0V	0V
9	0.91V	0.91V
10	1.46V	1.46V
11	5V	0V
12	2.5V	5V
13	3.8V	2.4V
14	2.5V	5V
15	5V(INV /	0V (UPS)
16	0V	0V
17	0V	5V
18	5V	0V
19	0V	0V
20	5V	5V
21	0V	0V
22	5V (INV ON	/ 0V INV OFF)
23	0V	
24	0V	5V
25	5V	0V
26	0V	0V
27	0V	0V
28	0V	PULSE
U3-LM324 PIN NO		
7	0V	0V
8	2.5V	5V
9	3.8V	2.4V
10	1.68V	2.15V
11	1.68V	2.15V
12	3.8V	2.4V
13	2.5V	5V
14	5V	5V

U1 - IR2110 PIN NO	INV-ON	MAIN-ON
1	3.72V	4.88V
2	0V	0V
3	12V	12V
5	7V	10V
6	15V	18V
7	13V	9V
8	5V	5V
9	5V	5V
10	3V	0V
11	0V	0V
12	1.68	2.4V
13	0V	0V

U1 - IR2110 PIN NO	INV-ON	MAIN-ON
1	3.72V	4.88V
2	0V	0V
3	12V	12V
5	7V	10V
6	15V	18V
7	13V	9V
8	5V	5V
9	5V	5V
10	3V	0V
11	0V	0V
12	1.68	2.4V
13	0V	0V

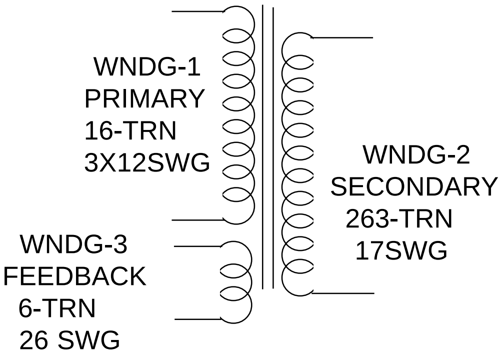
[redacted]

SINEWAVE INVERTER / HOME-UPS TRANSFORMER WINDING DATA



TRANSFORMER:600VA/800VA
BATT-VOLT:12-VOLT
CORE NO: 16-NO
STACK HIGHT:3” OR3.5”
LAMINATION:C-6 CRNO

SINEWAVE INVERTER / HOME-UPS TRANSFORMER WINDING DATA



TRANSFORMER:1200VA/1500VA
BATT VOLT: 24-VOLT
CORE NO: 7-NO
STACK HIGHT:3”
LAMINATION:C-6 CRNO

COMPONENT	600VA	800VA	1200VA	1500VA
RG1	JUMPER AT PIN1-3	JUMPER AT PIN1-3	7812	7812
R55	100K	100K	220K	220K
R54	33K	33K	39K	39K
M1 - M4	2XIRF3205	4XIRF3205	3XIRF3205	4XIRF3205
M5 - M8	2XIRF3205	4XIRF3205	3XIRF3205	4XIRF3205
M9 - M12	2XIRF3205	4XIRF3205	3XIRF3205	4XIRF3205
M13 - M16	2XIRF3205	4XIRF3205	3XIRF3205	4XIRF3205
TR1 (INVERTER TRANSFORMER)	SEE WINDING DATA			

SINEWAVE INVERTER / H-UPS TESING AND FAULT FINDING

Assemble the card and make all the wiring including LED connections, ON/OFF switch, feedback from inverter transformer, 6-volt main sense to CN5, -VE of battery to card, +VE of battery to large heatsink.
Don’t connect the transformer primary to two small heat sinks.
Connect battery +ve wire to card through MCB and 50-amp ammeter.

Before proceding for final testings be check the +VCC voltage at the pins of U1 - U5 as follows.
U1:pin8 and 9:+5V,pin3:+12V, pin6:+12V, U2:pin8 and 9:+5V,pin3:+12V, pin6:+12V, U3:pin14:+5VV, U4:pin20:+5V,pin1:+5V, U5:pin4:+5V.

1) Switch ON the battery MCB and note that ampere meter should not jump beyond 1-amp. If theam pere shoot then remove U1 and U2 temporily and switch ON the MCB again.

2) Switch ON the ON/OFF switch of inverter and note that Relay becomes ON and INV LED should glow. If the relay is off check the voltage at pin18 of microcontroller.It should be 5V if there is no voltage check uC, if the 5V ias available then check R37 and Q5.
If INV LED is not glowing check voltage at pin25 of uC (5V). If INV LED is glowing and relay is ON then goto the next step.

3) Connect CRO at pin13 of uC, switch OFF and switch ON the inv switch and check the modulated PWM waveform at this pin. If there is no modulated PWM waveform replace uC.
Once you get the modulated PWM check 50Hz HI/LO logic at pin12 and pin14 of uC, If the logic pulse waveform @50% duty cycle is not available then replce the uC.If the pulse are available the goto next step.

4) Now check PWM output at pin10 and pin12 of U3(CD4081) which are finally fed to the H-Bridge MOSFET drivers U1 and U2.(also check the voltages at pin9 and 12 - 3.4V, pin8 and 13 - 2.5V, pin10 and 11 - 1.68V). If the pwm pulse or voltages are not available are not available at this pins then check the IC U3 and/or the track from microcontroller to this IC. If every thing is O.K thenswitch OFF the inverter switch and goto next step.

5) Now Insert U1 at its base an and switch ON the inv ON/OFF switch, check pwm waveform at the gates of MOSFET M1 - M4 and at the gates of M9 - M12 (please note that the PWM pulse at M9 - M12 is out of phase compare to the PWM at gates of M1 -M4. If the PWM pulse are not available at the gates of M1 -M4 / M9 - M12 then check the pin11 of U1 should LOW, if this pin is High then it means the U1 is in shut down mode. To check this check voltage at pin2 of U5 - 2.5V and pin3 of U5 - 0V or <1V, if pin2 voltage is < 1V then check R47 and R48, if pin3 voltage is >2.5V then checkD11,D9, MOSFET M9 - M12 and its associated components (for this refer to ckt diagram).
If pin11 of U1 is low and still the PWM pulse are not coming out from pin1 and pin7 of U1 then re place the IC U1. After rectifying the fault switch OFF the inverter ON/OFF switch and goto next step.

6) Now Insert U2 at its base an and switch ON the inv ON/OFF switch, check pwm waveform at the gates of MOSFET M5 - M8 and at the gates of M13 - M16 (please note that the PWM pulse at M13 - M16 is out of phase compare to the PWM at gates of M5 -M8. If the PWM pulse are not available at the gates of M5 -M8 / M13 - M16 then check the pin11 of U2 should LOW, if this pin is High then it means the U2 is in shut down mode. To check this check voltage at pin2 of U5 - 2.5V and pin3 of U5 - 0V or <1V, if pin2 voltage is < 1V then check R47 and R48, if pin3 voltage is >2.5V then checkD15,D6, MOSFET M13 - M16 and its associated components (for this refer to ckt diagram).
If pin11 of U1 is low and still the PWM pulse are not coming out from pin1 and pin7 of U2 then re-place the IC U2. After rectifying the fault switch OFF the inverter ON/OFF switch and goto next step.

7) Connect the transformer primary to the heatsinks as per the wiring diagram and switch ON the in-verter, adjust preset VR1 to get 230V AC at voltmeter. If the output voltage is not regulating please see the follwing conditions. Output voltage is high, Check voltage at pin3 of microcontroller, it should be 2.5V, if there is no voltage at this pin check the feedback connection from inv trans-former to CN4, check voltage across C40, and check componentsR58, VR1 etc.

[redacted] - 3% according to transformer quality.If there is no regulation then check the diodes D23 - D26, any one of them are defective or also replace C39 and C40, if still the problem is there then replcae the microcontroller.

9) Now check the LO-BATT trip is working or not, for that short the resistor R54 externally with a twezer from above the PCB and check inverter should trip and lo-batt LED glows and buzzer beeps for 9-sec @1-beep per sec approx.If the low batttery is not working then check the voltage at pin4 of microcontroller, in normal condition it is >2.5V, when the voltage drops to <2.5V at this pin lo-battery occurs.In case of abnormal voltage at this pin check R55 and R54.

10) Now check the overload, for testing initially apply 400W load to the output and adjust preset VR2, and check overload occurs or not.Please note that in normal condition the voltage at pin7 of microcontroller is <2V, when the voltage at this pin is >2V overload occur. @ 400W load, and after varying the preset If the over load does not occur then check the voltage at pin14 of U5 (LM324), it should be >2.2V. If the voltage at this pin is <2.2V then check R48,R49,R50 and R33 or may be the comparator is deffective, or also may be the negative track on the PCB becomes more thicker. If still the voltage at pin14 of LM324 is low then increase the value of resistor R48 to 470K /560k / 680k to solve the problem.

(BASICALLY THE COMPARATOR SENSE THE VOLTAGE DROP ACROSS THE FUSE 2X40-amp AND LENTH OF THE NEGATIVE TRACK)

11) Once the testing of inverter operation is over, now test the main changeover.Keep the mode switch in **inverter mode** (keep CN1 open) switch on the inverter, connect the main lead to the variac, increase the variac voltage to 140V AC and see the inv to main changeover occurs or not. If there is no changeover then check the voltage at pin2 of microcontroller, it should be >1.24V, if the voltage is less than 1.24V then check the sense transformer voltage (6V AC at its secondary) or check the components R57,R56.
Once the changeover occurs then reduce the variac voltage to <90V and check the main to inverter changeover occurs or not. The changeover should occur when the voltage at pin2 of microcontroller is <1V.

12) Once the above testing is over, now test the main changeover in UPS mode.Keep the mode switch in **UPS mode** (keep CN1 short) switch on the inverter, connect the main lead to the variac, increase the variac voltage to 190V AC and see the UPS to main changeover occurs or not. If there is no changeover then check the voltage at pin2 of microcontroller, it should be >1.66V, if the voltage is less than 1.66V then check the sense transformer voltage (6V AC at its secondary) or check the components R57,R56.
Once the changeover occurs then reduce the variac voltage to 180V and check the main to UPS changeover occurs or not. The changeover should occur when the voltage at pin2 of microcontroller is <1.5V.

13) At last check the charging of battery. Keep the mode switch in inverter mode, apply main and increase the variac voltage to 230V AC, and see the charging current should increase gradually in ampere meter. Adjust the charging current with VR3, the current variation should be in between 5-amp to 12/15-amp. If the charging current is too high and not able to reduce at required value then increase the value of R51 to 100k and/or if you are not increase the charging current to required value then decrease the value of R51 to 22K, please note that when the sensed current voltage at pin5 of microcntroller reaches to 2.5V the mocrocontroller regulates the PWM and hence the charging current.
During charging mode please note that only the lower branch of MOSFETs (M6 -M12 / M13 - M16) are switching @8kHZ and the upper branch of MOSFETs are OFF.

14) Also check the operation of FAN, FAN is ON when the inverter is ON, and FAN become OFF when inverter is OFF. Similarly FAN is ON when Charging is ON and FAN is OFF when charging is OFF.

SINEWAVE INVERTER / HOME-UPS(MK-1)

CIRCUIT WORKING

Here the circuit is designed around PIC16F72 microcontroller with some other analog components, but the heart of the circuit is the microcontroller. Refer to circuit diagram to understand the working details.

INVERTER MODE:
As soon as the controller got the power from battery the controller scan the voltage logicat its pin22 which is used for INV ON/OFF, this pin by default kept high (5V), when the inverter switch is ON this pin becomes low and the controller jump to inverter ON mode.

when the inverter is ON the controller start producing PWM pulse at its pin13 (ccp out), before producing PWM pulse the controller also check the voltage logic at its pin16 (INV/UPS switch) if this pin is high (INV mode) then controller giving the full 70% modulated duty cycle (50 Hz modulated with 7.8kHz) at one shot, if the pin16 is low (UPS mode) then the controller producing the duty cycle from 1% - 70% @.250mS delay. This is for soft delay output in UPS mode.

Along with the PWM the controller producing chanel select logic from pin12 and pin13 of the microcontroller which is fed to pin8 and pin12 of IC CD4081. During first phase of pulse (i.e 10ms) the pin12 of the controller is high and PWM is available from pin10 of CD4081 only and after 10mS, pin14 of controller is high and the PWM is available from pin11 of CD4081, hence this way two out of phase PWM is available to switch on the MOSFETs.

Besides that a high logic (5V) is available from pin11 of the controller, this pin becomes high when inverter is ON and becomes low when inverter is OFF. This high logic is fed to pin10 of both the MOSFET drivers U1 and U2, (HI pin) to switch ON the high side MOSFETs of both the bank.

MOSFET Switching:
Refer to MOSFET switching circuit diagram.

Here U1 (IR2110) and U2 (IR2110) high side / low side mosfet driver are used, refer to data sheet of this IC to understasnd more. Here the two MOSFET bank with high side and low side MOSFETs are used for transformer’s primary switching. Here we are describing the operation of bank (using IC U1) only as the other bank driving is similar to each other.

Once the inverter is ON the controller make the pin10 of U1 is high which in turn switch ON the high side MOSFETs (M1 - M4) ON, PWM for channel-1 from pin10 of CD4081 is fed to pin12 of the drver IC (U1) as well as it is fed to the base of Q1 through R25. When the PWM is high the pin12 of U1 is high and switch ON the low side MOSFETs of bank 1(M9 - M12), alternately it switch ON the transistor Q1 which in turn make the pin10 voltage of U1 low, hence switching OFF the high side MOSFETs (M1 - M4).
So it stands that by default the high logic from pin11 of the microcontroller switched ON high side MOSFETs of both the bank, when the corresponding PWM is high the low side MOSFETs are ON and high side MOSFETs are OFF, this way the switching cycle repeats.

Pin11 of U1 is used for hardware lock of both the driver. By default this pin kept low, when in any condition the low side MOFET switching not occurs (say during o/p short circuit or false pulse occurs at the output), the VDS voltage of low side MOSFETs shoots up which in turn makes the output pin1 of comparator (U4) high and latched through D27, and makes pin11 of U1 and U2 high, and in turn switched OFF both the MOSFET driver completely, help the MOSFETs from burn out.

Pin6 and pin9 is of +VCC of the IC (+5V), pin3 is of +12V for MOSFET gate drive supply, pin7 is the high side MOSFET gate drive, pin5 is the high side MOSFET return path, pin1 is the low side MOSFET drive, and pin2 is the low side MOSFET return. pin13 is the ground of the IC (U1).

LOW BATTERY PROTECTION:
When the controller run the inverter routine it repeteadly sense the voltage at its pin4 (BATT SENSE), pin7 (OVER LOAD sense) and pin2 (AC MAIN sense).

If the vltage at pin4 is >2.6V the controller ignore it and jump to other sense routine, once the voltage comes down to 2.5V the controller halt its routine here, swiched OFF the inverter routine and low battery LED becomes ON and buzzer beeps.

OVER LOAD:
Over load is a common features applied in every inverter systems. Here to trip the inverter when the load exceeds the rated load capacity the battery current sensed across the negative line (i.e the voltage drop across the fuse and negative track of the low side MOSFET bank) and this very low voltage drop @mV is further amplified by the comparator U5 (comprising pins12,13 1nd 14) - refer to circuit diagram.

The amplified voltage output from pin14 of comparator (U5) is wired as inverting amplifiier fed to pin7 of the microcontroller. The software set voltage value for this pin is 2V. As discussed earlier the controller sensing the voltages at this pin also while running the inverter routine, when the load current increase the voltage at this pin also increases, when the voltage at this pin7 of the controller is >2V the routine shuts off the inverter and jump to overload routine, shuts off the inverter, switch ON the overload LED and buzzer beeps, after 9-beeps the controller switched ON the inverter and scan the voltage at pin7 again, if the controller found pin7 voltage <2V then it run the inverter on routine normally other wise it shut down the inverter again, This is called the auto reset mode.

INVERTER TO MAIN CHANGEOVER:
As we have stated earlier the when is inverter, the controller check the voltage at its pin4 (for Low-batt), pin7 (for overload) and pin2 for AC main voltage status. We know that the system is running in two mode (a)UPS mode,(b) inverter mode.So before checking the pin2 voltage of controller the routine first check in which mode the system is operating by sensing the high/lo logic at pin16 of the microcontroller.

Inverter to main changeover (INV-MODE): In this mode when the AC main voltage is 140V AC the changeover occurs, this voltage is software setteble, it means when the pin2 volage is >0.9V the controller shuts off the inverter and jump to main on routine where the routine scan the pin2 voltage to check the AC main faliure and run the charging routine which we have discussed later.

Inverter to main changeover (UPS-MODE): In this mode when the AC main voltage is 190V AC the changeover occurs, this voltage is software setteble, it means when the pin2 volage is >1.22V the controller shuts off the inverter and jump to main on routine where the routine scan the pin2 voltage to check the AC main faliure and run the charging routine which we have discussed later.

MAIN TO INVERTER CHANGEOVER:
During main ON the controller first check in which mode the system is operating by sensing the high/lo logic at pin16 of the microcontroller and then scan the pin2 voltage of the controller for changeover in this mode.

main to inverter changeove (INV-MODE): In this mode when the AC main voltage is 90V AC the changeover occurs, this voltage is software setteble, it means when the pin2 volage is >0.53V the controller jump to inverter on routine as decribed earlier.

main to inverter changeove (UPS-MODE): In this mode when the AC main voltage is 175V AC the changeover occurs, this voltage is software setteble, it means when the pin2 volage is >1.03V the controller jump to inverter on routine as decribed earlier.

BATTERY CHARGING:

During MAIN ON Battery charging occurs. As we know during battery charging the system working in SMPS topology,let us discussed how it works.

To charge the battery the output circuit (MOSFET and Inverter transformer) works as a boost converter. Here the all the low side MOSFETs of both the bank working together as a switch and the primary of the inverter transformer act as an inductor, when all the low side MOSFETs are ON the energy stored at the primary coil of transformer and when the MOSFETs are OFF the stored energy rectified by the in-build diode inside the MOSFETs and transfered the DC voltage to battery,the amount of stored energy depends on the ON time of the low side MOSFETs hence the percentage of duty cycle of the charging PWM.

When the system running in main on mode the charging PWM (from pin13 of micro) is gradually increase from 1% to maximum limit, when the PWM increases the DC voltage to battery also increases resulting increase in battery current, the battery current are sensed across the DC fuse and negative track of the PCB and the voltage is further amplified by the amplifier U5 (pin8, ppin9 and pin10 of the comparator) this
amplified voltage or sensed current are fed to the pin5 of microcontroller. This pin voltage is set in software as 1V, when the voltage at this pin is >1V the controller decreasing the PWM duty cycle till it down to <1V, if the voltage at this pin comes down to <1V the controller increasing the PWM, in this way the controller maintaining the voltage at this pin at 1V and hence the charging current.