CHAPTER 7

POWER CIRCUIT DESIGN

This chapter describes design of hybrid multilevel inverter. Single phase hybrid multilevel inverter is designed and is repeated for three phase. Regulated power supply is designed for 40 V and 80 V DC output. As discussed in previous chapter gating signals are applied through digital signal processor, buffer, isolation and driver.

7.1 DESIGN OF HYBRID MULTILEVEL INVERTER

HMLI is designed for 110V, 5A rating. Gate pulse is obtained from circuit shown in previous chapter. MOSFET is chosen for high frequency switching, high voltage and high current operation. As shown in Fig. 7.1 separate DC voltages are connected.

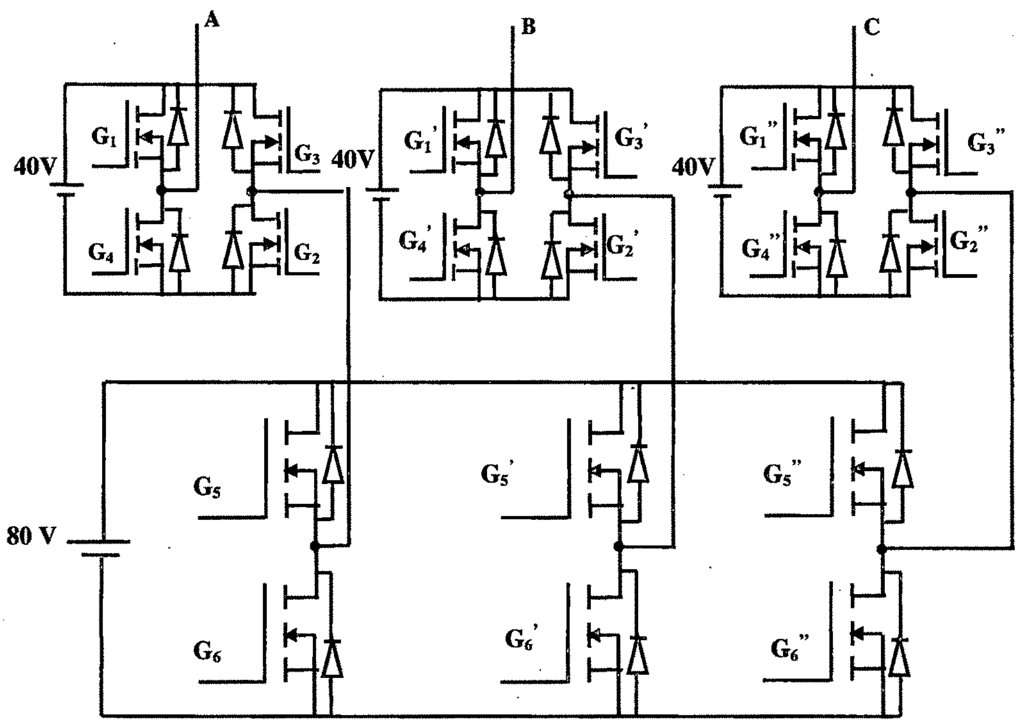

Fig. 7.1 Three phase hybrid multilevel inverter circuit diagram

7.1.1 DESIGN OF SINGLE AND THREE PHASE HYBRID MULTI LEVEL INVERTER

As shown in Fig 7.2 half bridge inverter is connected with H bridge inverter to form single leg of HMLI. As discussed switching is done at approximately 2.1 kHz frequency. Care is taken that switch has low saturation voltage and breakdown voltage is two to three times the supply voltage. Similarly for 3 phase such design is repeated.

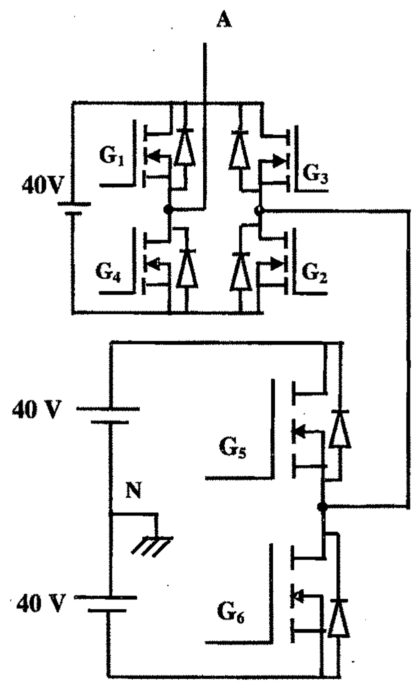

Fig. 7.2 Single leg of hybrid multilevel inverter circuit diagram

7.1.2 MOSFET SELECTION

As circuit operates at 110V rms and 5A current MOSFET is chosen accordingly.

IRF840N Power MOSFET is used. Features of IRF840 [1] are as follows:

-V_{DS} 500V

-I_D 8A(continuous)

-R_{DS} (on) Low i.e 0.85 Ω

-Exceptional dv/dt

-Low Gate Charge

-Application Oriented Characterization

- Low gate drive requirements

100KΩ resistance is connected as high impedance gate of MOSFET

K-1 type heat sink is used for MOSFET

7.1.3 DESIGN OF MOSFET SNUBBER

An RC snubber, placed across each switch can be used to reduce the peak voltage at turn-off and to damp the ringing. Design for snubber is given below.

f_s = 2 kHz

Edc = 40 V, i_L=2A

Let $L = 25\ \mu H$

$t_f = 66x10^{-9}$ s

where t_f is fall time

fs switching frequency

$C = i_L * t_f / E_{dc}$

$= 6 * t_f / 40$

$C = 0.01 \mu F$

$L = E_{dc} * t_r / i_L$

$t_r = 1.26\ \mu s$

where t_r is rise time

$d_i/d_t = i_L/t_r$

$= 1.58$ A/μs

Switch ON

$d_i/d_t = 0.395$ A/μs

$R = \sqrt{(4*L/C)}$

$R = 100\ \Omega$

Hence values for snubber are chosen as 100 Ω,1W and 0.01μF/400V.

7.2 DESIGN OF REGULATED POWER SUPPLY

Step down transformers of rating 230V/45V and 230V/70V are used to obtain 40V and 80V DC respectively from voltage regulator. Current rating is 5A as design is for 110V rms from output with 5A current.

Controlled transistor series regulator circuit is designed and implemented as shown in Fig. 7.3 Components are chosen as per requirement. Selection of transistors T_1, T_2, T_3 is done on basis of V_{CEO}, gain and power rating from datasheet [2-5]. Due to high power dissipation heat sink is included in circuit.

Working principle can be explained as follows: Unregulated DC voltage is passed through filter capacitor C and bleeder resistances R_B and as per change in output load current regulation is obtained from regulator circuit. If current through load increases drop across R_6 increases which increases base current of T_3 thus increasing collector current of T_3, which increases base current of T_1 through T_2 thus finally reducing emitter current of T_1 and regulating output current and voltage. R_2, R_3 and C_2 form filter and current limiting path for T_3. Zener diode gives minimum emitter voltage of T_3 with C_1 as filter for zener diode. Component choice is done as per requirement. Darlington pair of transistor T_1 and T_2 is control element and is called pass transistor as all load current flows through it. Zener diode and resistor R_1 act as reference element. The voltage divider R_5, R_6, and R_7 samples output voltage and delivers a negative feedback voltage to the base of transistor T_3 [6]. Design and practical readings for regulated power supply are given in Appendix A. While hardware setup is given in appendix B.

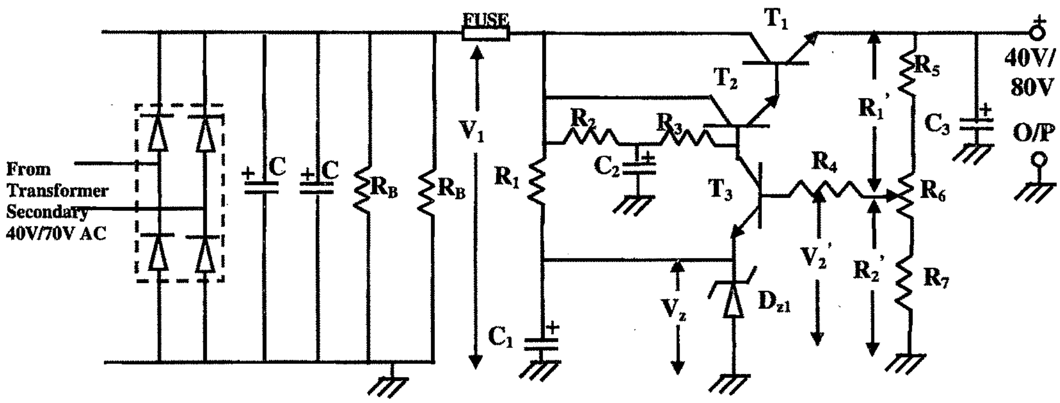

Fig. 7.3 Regulated power supply

Table 7.1 Component list

Component	Value
R_1	10 kΩ/1W-----22 kΩ/2W(for 80V)
R_2	470 Ω/0.5W
R_3	1 kΩ/0.5W
R_4	100 Ω/0.25W
R_5	6.2 kΩ------10 KΩ(for 80V)
R_6	500 Ω preset
R_7	1 kΩ
C_1	100 μF/16V
C_2	47μF/63V-----47μF/160V
C_3	100μF/63V
D_{z1}	6.2V/1W
T_1	2N3773----2N3773(for 80V)
T_2	2N3501----2N3773(for 80V)
T_3	BD139-----TIP122
Bridge rectifier 3510	35 A, 1000V
Bleeder resistance R_B	1 kΩ/10W ----2.2 kΩ/10W(for 80V)
Filter capacitor C	4700 μF/100V-----1800μF/160V(for 80V)

7.3 SUMMARY

In this chapter power circuit design is explained. Linear regulated power supply is also designed and its design is discussed. Hybrid multilevel inverter is designed. MOSFET switches were selected on design basis. Heat sink is selected as per dissipation. R-C snubber is also designed.