Appendix A

Details of practical components employed

A.1 Design of gate driver Isolation circuit

For n-channel MOSFET switches, when gate to source voltage is more than threshold voltage for turn-on, the switch turns on and when it is less than threshold voltage the switch turns off. The threshold voltage is generally of the order of +5 volts but for quicker switching the turn-on gate voltage magnitude is kept around +15 volts where as turn-off gate voltage is zero or little negative. It is to be remembered that the two switches of an inverter-leg are controlled in a complementary manner. When the upper switch of any leg is on, the corresponding lower switch remains off and vice-versa. When a switch is on its drain and source terminals are virtually shorted. Thus with upper switch on, the source of the upper switch is at positive dc bus potential. Similarly with lower switch on, the source of upper switch of that leg is virtually at the negative dc bus potential. Sources of all the lower switches are solidly connected to the negative line of the dc bus. Since gate control signals are applied with respect to the source terminals of the switches, the gate voltages of all the upper switches must be floating with respect to the dc bus line potentials. This calls for isolation between the gate control signals of upper switches and between upper and lower switches. Only the sources of lower switches of all the legs are at the same potential and hence the gate control signals of lower switches need not be isolated among themselves. The isolation provided between upper and lower switches must withstand a peak voltage stress equal to dc bus voltage. Gate-signal isolation for inverter switches is generally achieved by means of optical-isolator employed is
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Figure A.1: Isolation circuit schematic

1.C. TLP-250* circuits. The gate isolation schematic is shown in Fig. A.1

A.2 Design of gate driver dead time circuit

The dead time circuit is used to provide the delay for the pulses generated from the Arduino.

The dead time consists as shown in Fig. A.1 of the RC circuit which is used to provide the delay for the circuit.

Design Calculations:

Desired delay \( t_d = 1 \mu \text{sec} \)

Pulse Amplitude (V) = 5 Volts

Voltage across capacitor \( C_d, V_c = V(1 - e^{-\frac{t}{RC}}) \)

To get \( V_c = 2.5V \) at \( t = t_d \)

Chosen \( R = 70\Omega, C_d = 22\mu\text{F} \)

For switch ON and OFF of MOSFET we are giving +15 Volts and -9 Volts with the help of two zeners (15 Volts, 9 Volts)

\[
I_{z_{\text{max}}} = \frac{P}{V_z} = \frac{1}{15}
\]

\[
R_z = \frac{(V_i - V_z)}{I_{z_{\text{max}}}} = 390
\]

A.3 PCB design for gate driver circuit

The PCB design for gate driver circuit is done using eagle cad software the greaber file was generated. Using Ferric Chloride (FeCl3) solution etching was done and 12 gate driver circuits were designed on 3 PCB boards with 4 drivers on each board
APPENDIX A. DETAILS OF PRACTICAL COMPONENTS EMPLOYED

Figure A.2: Dead time circuit schematic

the PCB layout picture is as shown Fig. A.3 and PCB printed boards are shown in Fig. A.3b

A.4 practical set-up initially developed

The practical set-up was initially developed in the laboratory with the available resource to test the performance of the proposed techniques on 3L-NPC converter the pictures of which are shown in Fig. A.4

A.5 Voltage Sensor card

Voltage sensor LV 25-P [104] have been used to measure desired voltages in the present work. These sensors can be used to measure DC, AC, Pulsed signal voltages with galvanic isolation between primary circuit (high voltage) and the secondary circuit (electronic circuit).

Features:

- Designed for 160 V DC and 100 V AC
- Linear operation over entire range
- Offset voltage of output: 5 mV
Figure A.3: (a) PCB layout (b) Practical PCB circuits

- Maximum AC Frequency: 8 kHz

**Design notes:**

- Closed loop (compensated) voltage transducer using the Hall effect.
- Op-amp TLE2084 used for scaling and filtering.

## A.6 Current Sensor card

Current sensor LA25-P \[^{105}\] have been used to measure desired currents in the present work.

These sensors can measure DC, AC and pulsating currents with galvanic insulation between primary and secondary circuits **Features:**

- Primary Current: 25 A (RMS)
- Loop Type: Closed
- Band width: 200 kHz
- Delay time: <.1 $\mu$s
Figure A.4: (a) Initial experimental set-up (b) output pole voltage of 3L-NPC converter
• Offset voltage of output: 8 mV

**Design notes:**

• card receives current inputs and gives output as analog output signals.

• Hall-effect type closed loop current sensors are used to avoid saturation problems.

• Op-amp TLE2084 used for scaling and filtering.

• Secondary to Primary turns ratio 1000:1.

• Linear operation over entire range.

### A.7 FPGA experimental kit

The FPGA controller board employed is an Advanced SPARTAN 6 based controller with following on board peripherals and features

**Features:**

• Single Precision floating point unit

• Operating frequency upto 150 MHz

• 8 channel 12 bit bipolar ADC at 1 msp

• 100 programmable GPIOs

• 84 PWM lines

• Input Range: 10V, 5V, 0-10V

• 4 channel 12 bit bipolar DAC

• Output range :10V, 5V

• External ADC via SDA Bus.