Grid Connected Converter

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Client

Dr.Venkata Yaramasu
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Research Interests

Research interests include renewable energy, high power converters, variable-speed drives, electric vehicles, power quality, smart grid, and model predictive control.

Education

PhD, Electrical Engineering, Ryerson University, Toronto, Canada
ME, Electrical Engineering, S.G.S. Institute of Technology and Science, India
B.Tech, Electrical and Electronics Engineering, Jawaharlal Nehru Technological University, India

Introduction

- Our client Dr.Yaramasu research focuses on power electronic applications.
- He is working on different projects that focuses on the following power conversion applications :

  A- Wind Power Systems.

  B- Photovoltaic Systems.

  C- Motor Drives.

Problem

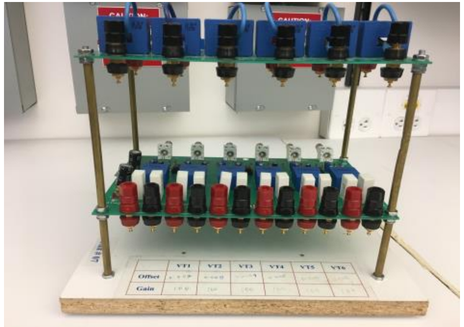
- There is no laboratory scale prototype converters available in the market that fits all of these applications.
- Needs plug and play converter to fit the three power conversion applications.
- Having such converter will help our client to develop new power converter topologies and test new controlling schemes such as model predictive control.

Goal

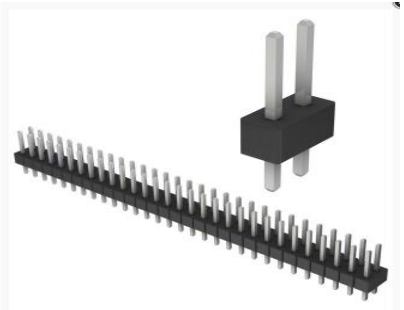
- Implement and build a prototype of multilevel converter for high power applications and test it using model predictive control.
- Practical power level is at 5 MW.
- Prototype power level is at 5 kW.

Overall Design

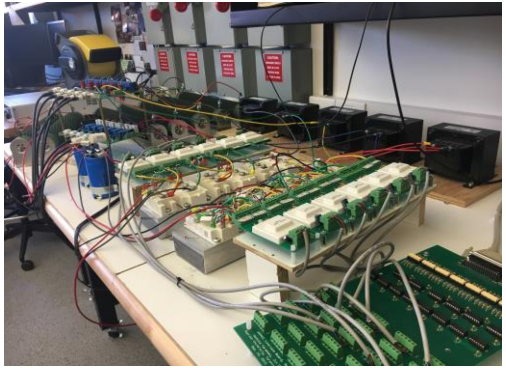
- Design consists of eight layers.
- A ground layer and seven PCB Layers.
- Layers parameters :
  Width : 132.30 mm
  Length: 228.60 mm
- Layers will be on top of each other.
- Stacked layers will reduce size, height, and weight of the converter.
- PCB layers will be connected using a built in 60 pins connector simplifying the design by reducing wiring.
- PCB's designed to run all input and output signals to the 60 Pins connector.
- Designing the grid converter using different layers enables our client to reuse each layer for different power applications.
- No hanging wires.



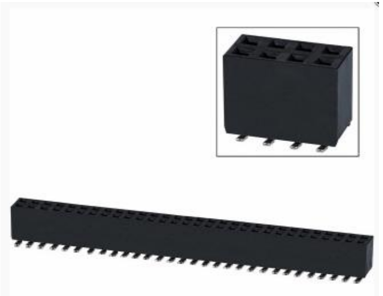
Voltage & Current Sensors



CONN HEADER 60POS



Old Design



CONN FEMALE 60POS

Subsystems

- Each PCB layer represents a subsystem that can be reused for other power conversion application as our client demand.

- Grid converter contains the following layers :

❖ **First layer:**
  - ➢ Heatsink

❖ **Second layer:**
  - ➢ NPC Power Board (SK 50 MLI 066)

❖ **Third, fourth, and fifth layer:**
  - ➢ Gate Drivers (SKHI 22B R)

❖ **Sixth layer:**
  - ➢ dSpace Interface Board (DS 1103)

❖ **Seventh layer:**
  - ➢ Voltage sensor

❖ **Eighth layer:**
  - ➢ Current sensor

Subsystems

- **Layer 1 : Heatsink**
  Transform heat from IGPT's to the heatsink and cool down power board.

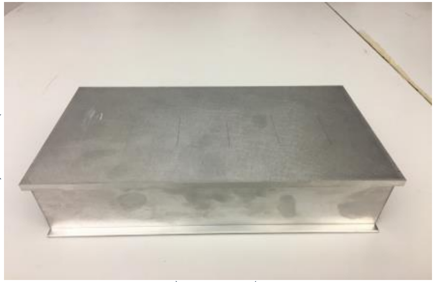
- **Layer 2: NPC Power Board**

  A- Motor Drives.
  AC (fixed v,f) => DC => AC (variable v,f)

  B-Wind Power Systems.
  AC (variable v,f) => DC => AC (fixed v,f)

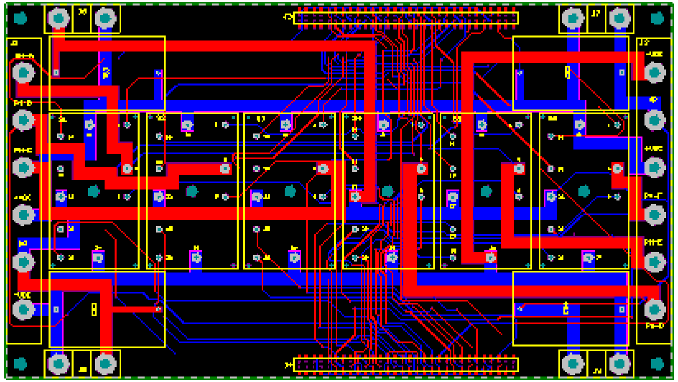
  C- Photovoltaic Systems.
  DC => AC (fixed v,f)

132.30 mm



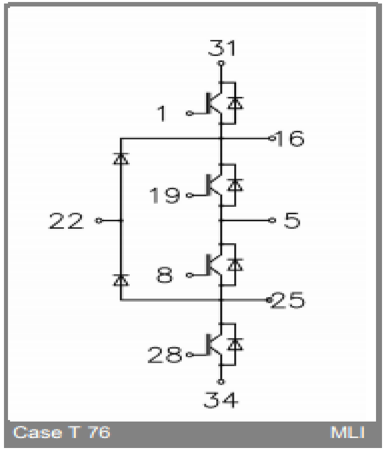
228.60 mm

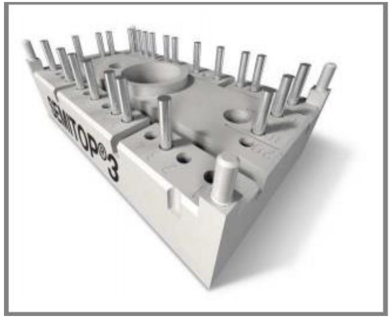
132.30 mm

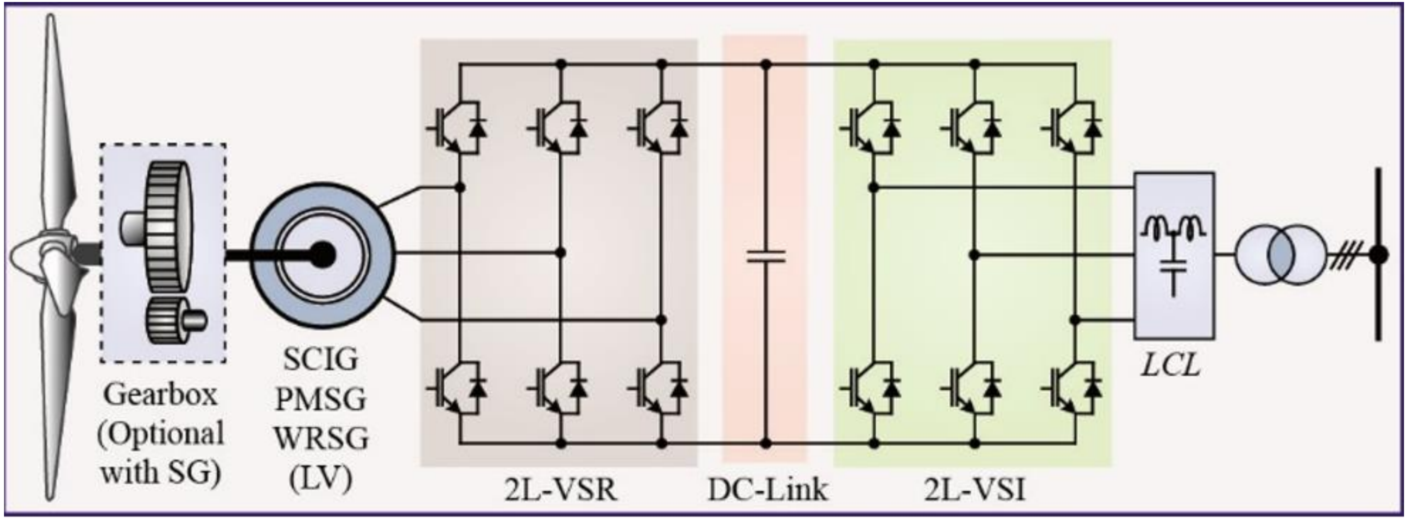


228.60 mm

NPC Power Board Schematic







NPC Power converter

Layers 3 ,4 and 5

Gate Drivers Layers

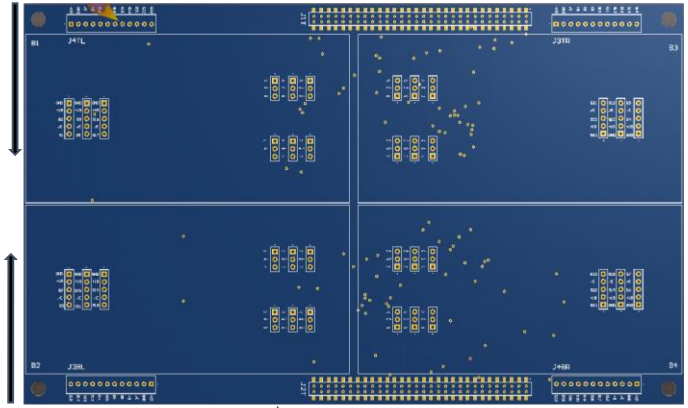
- Each phase contains four IGPT’s.
- One gate driver fits two IGPT’s.
- Two IGBTs required per phase.
- Total 12 gate drivers for 6 Phases.
- Each layer will have 4 gate drivers.
- Three layers of gate drivers are needed.

56.00mm

100.00 mm

Function

- Provides electrical isolation between signals side from dSpace device (5V) and power side (400V).
- dSpace equipment is used to provide gating signals. The cost of dSpace is around $15,000. Therefore, gate drivers help in protecting a $15,000 device by providing electrical isolation.



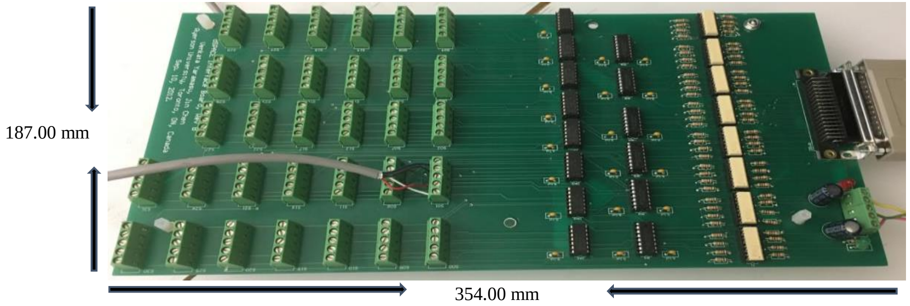
132.30 mm

228.60 mm

Layer 6: dSpace Interface Board

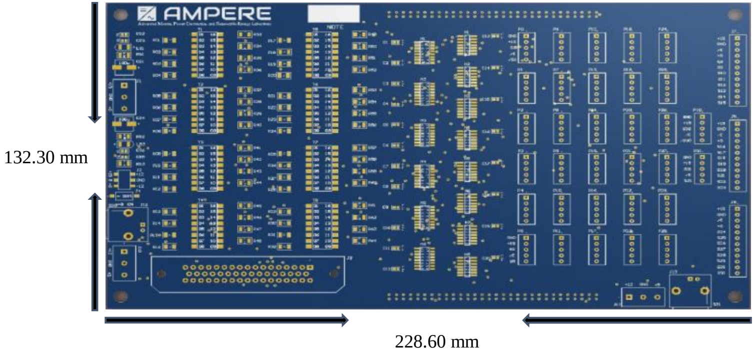
dSpace Layer

- dSpace device is required for real time implementation of model predictive control.
- In order to use the dSpace, we needed to design the second generation of the dSpace interface board.
- The second generation has smaller size.



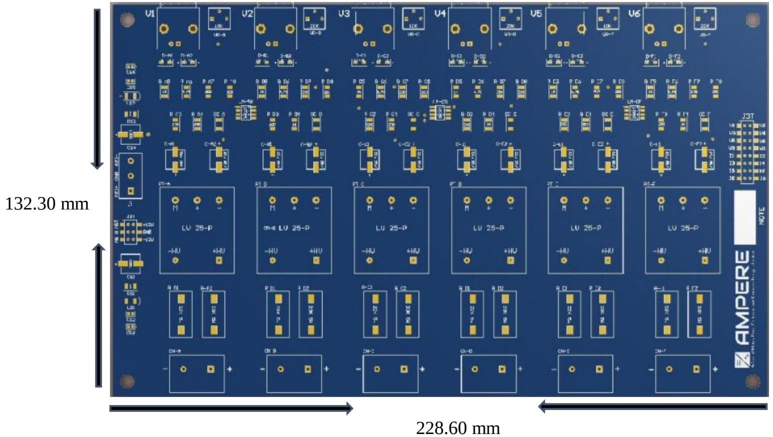
Function

- Convert TTL logic signals from the dSPACE DS1103-based to CMOS logic.
- This logic conversion is required since the IGBTs are CMOS logic.



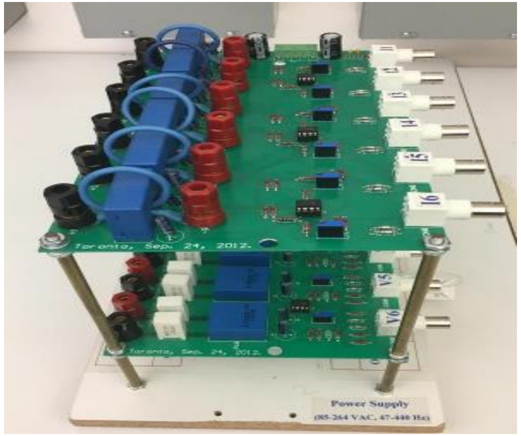
Layers 7 and 8: Current and Voltage Sensors

Voltage Sensor Layer



- It has six voltage sensors.
- Three phase voltages are measured by three sensors.
- Two DC link voltages are measured.
- The sixth is a back up sensor.
- The controlling method is a feedback control. Hence, voltages are measured.

Current Sensor Layer



- It has six current sensors.
- Current is measured when flowing through the wire from the red pin input to the black pin output.
- Current measurements is needed for the model predictive technique.

Budget

- Our budget is around $3000.
- The budget covers manufacturing PCB’s.
- More than 400 electrical components.
- Pictures shows a list of components we bought.

Index	Quantity	Description	Unit Price
1	100	CONN RECEPT 5POS 24AWG MTA100	0.2699
2	100	CONN HEADER VERT 5POS .100 TIN	0.1835
3	12	TERM BLOCK 3POS SIDE ENT 9.52MM	3.942
4	1	CBL SHIELDED 22AWG UL2464 4C 50'	36.55
5	50	CONN HEADER FEMALE 3POS .1" TIN	0.4
6	50	CONN HEADER FEM 5POS .1" SGL TIN	0.47
7	1	AC/DC CONVERTER 5V +/-12V 40W	42.23
8	1	AC/DC CONVERTER 5V +/-15V 40W	47.76
9	1	DIN RAIL 35MMX7.5MM SLOTTED 1M	2.78
10	4	SWITCH SLIDE DIP SPST 25MA 24V	1.61
11	10	CONN FEMALE 60POS DL .1" TIN SMD	4.983
12	5	MOSFET N-CH 60V 115MA SOT-323	0.397
13	5	CONN FEMALE 16POS DL .1" TIN SMD	1.711
14	5	CONN FEMALE 6POS DL .1" TIN SMD	0.842
15	6	ICL 30 OHM 20% 5A 22MM	1.482
16	10	HEX STANDOFF M5 STEEL 8MM	0.8
17	10	80 MODII HDR DRST UNSHRD STKG	18.863
18	10	HEX STANDOFF M5 STEEL 40MM	0.7623
19	1	SOLDER PASTE SN63/PB37 250G	41.95
20	6	RELAY GEN PURPOSE SPST 20A 12V	3.28
21	6	DIODE ARRAY GP 100V 175MA SOT323	0.204
22	2	CONN HEADER VA VERT 2 POS 7.92MM	0.208
23	4	CONN HEADER VERT 12POS .100 TIN	0.574
24	20	CONN HEADER .100 SINGL STR 5POS	0.423
25	50	CONN HEADER .100 SINGL STR 3POS	0.2902
26	12	HEX NUT 0.275" NYLON M4	0.083
27	6	VARISTOR 390V 6.5KA DISC 20MM	0.5272
28	2	CONN BARRIER STRIP 3CIRC 0.438"	1.851
29	6	IC LEVEL SHIFTER HEX 16-SOIC	0.957
30	20	CAP ALUM 100UF 20% 500V SNAP	4.276
31	1	HEATSINK FOR PWR MOD/IGBT/RELAY	74.42
32	1	CONN D-SUB RCPT 50POS R/A SOLDER	31.17
33	1	CONN BNC JACK R/A 50 OHM PCB	1.485
34	6	RES SMD 33K OHM 5% 5W 5329	0.834
35	6	RES SMD 22K OHM 5% 5W 5329	0.834
36	20	CONN QC TAB 0.250 SOLDER	0.0611
37	50	CONN TERM BLOCK 3POS 5.08MM PCB	1.25
38	6	TRANSDUCR VOLTAG CLOSE LOOP 10MA	59.5
39	6	SENSOR CURRENT HALL 50A AC/DC	21.47
40	8	OPTOISO 5.3KV 4CH TRANS 16SMD	1.1024
41	6	IC GATE NOR 4CH 2-INP 14-SO	0.296
42	6	IC OPAMP GP 1.1MHZ 8SO	0.295
43	6	CONN BARRIER STRIP 2CIRC 0.438"	1.84
44	12	SWITCH SLIDE DIP SPST 100MA 20V	0.8004
45	20	CAP CER 0.1UF 50V X7R 0603	0.0124
46	20	CAP CER 1UF 50V X5R 0603	0.0526
47	20	CAP CER 330PF 50V C0G/NP0 0603	0.1898
48	20	CAP ALUM 22UF 20% 35V SMD	0.1384
49	20	CAP ALUM 100UF 20% 35V SMD	0.1601
50	6	TRIMMER 20K OHM 0.5W PC PIN	3.192
51	6	TRIMMER 10K OHM 0.5W PC PIN	2.679
52	50	DIODE ZENER 10V 500MW SOD123F	0.0881
53	10	CONN ADAPT PLUG TO JACK BNC	2.254
54	5	CONN ADAPT PLUG TO JACK BNC	4.88
55	25	LED ORANGE CLEAR 0603 SMD	0.1448

Conclusion

- The GCC team is implementing a prototype converter of high power applications.
- A plug and play converter will be delivered to our client Dr.Yaramasu.
- The converter should fit three major power applications.
- Our team is on schedule, and we are half the way.
- Team completed designing PCB’s.
- Team is approaching the second stage which is simulating and testing.
- Therefore, we believe our team is capable of delivering a well designed product that satisfies our client.

Thank You

Questions