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DC to AC inverter card with IGBTs

Construction and performance

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Abstract

DC to AC inverter card with IGBTs

Johannes Eriksson

This paper presents the construction and evaluation of a DC to AC inverter with IGBT:s and the basic PCD-layout for the single IGBT drivers. The main work consisted of constructing a PCB-card for controlling a number of IGBT:s, simulate its properties and test driving it. The schematic of the card is an extension of the recommended use of the optocoupler HCPL316J with a few modulations made for the special demands on the Division of Electricity at Uppsala University. Even though, some basic changes were made in the schematic in this work, the main changes concerned choice of components due to economy and space and did not change the electrical properties of the card notably.

Except several electrical properties that will be the main focus in this paper, size and price are two things that also have been taken under consideration during the work. In the paper, many parts and components will be described to fully explain the function of the cards properties. This is for future reference and documentation and was one of the goals of the project.

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Abbreviations

AC	Alternating Current
DC	Direct Current
DESAT	Desaturation
EMP	Electro Magnetic Pulse
ESD	Electrostatic Discharge
IGBT	Insulated Gate Bipolar Transistor
MOSFET	Metal Oxide Semiconductor Field Effect Transistor
PCB	Printed Circuit Board
PWM	Pulse Width Modulation
SMD	Surface Mount Device
UVLO	Under Voltage Lock-Out
VDR	Voltage Dependent Resistor

1. Introduction

1.1 Background

The Department of Electricity at Uppsala University is engaged in a number of projects where power electronics play a central part. Though conversion of mechanical energy to electrical energy may take place in a wind turbine or wave power plant there are usually several more steps required to connect the energy source to the grid.

A common method is to convert the electrical energy into DC (Direct Current) from which AC (Alternating Current) is inverted. This is also the case in any electric device where the voltage source is a DC-battery, supplying energy to a device that requires AC (i.e. an electric engine in a car or a fan in a computer). Due to high effects, power electronics is used in several steps in the process of conversion. The DC to AC inversion is often done with a pulse width controlled IGBT (Insulated Gate Bipolar Transistor). The frequent use and demand of quite similar inverters in the division of electricity resulted in the conclusion that a specific standard inverter should be made. A number of people in the division agreed to a specific design that would fulfill different demands and a circuit diagram was drawn.

1.2 Aim and hypothesis

The main purpose of this project is:

To physically construct an IGBT-driver by first creating a layout for the PCB (Printed Circuit Board) card that is optimized for the application.

To gather, for comprehension, as much data as possible about the function of the driver to ease future development and implementation of the driver.

2. Theory and method

In this section, basic theory of how this inverter, some components works will be brought to light. Thoughts considering different electrical phenomena and safety will be discussed as well as the components used in relation to these.

2.1 Basic function of an AC-inverter and the six IGBT-drivers

The purpose of the AC-inverter is to transform the power from a DC-supply into 3-phase alternating current. This is done with six IGBT-drivers connected to a DC source. The IGBT-drivers are controlled through pulse width modulation (chapter 2.3) by a microcontroller or

computer. Every IGBTs collector and emitter is connected to either the positive or the negative side of the DC-supply on one side and the load on the other side. When an IGBT is switched on, it is conducting and current is flowing from the high power side via the IGBT through the load. By controlling which IGBTs are conducting through the 3-phase load, an alternating current is produced. This is done in impulses with a switching frequency of several kilohertz and follows a pattern that repeats depending on what kind of current and frequency is desired. It is this pulse width modulated signal that, in the load, becomes the three phase sinusoidal current that we know as AC.

2.2 IGBT

An IGBT is a high power transistor used in various situations where high switching frequencies and large currents are required. The basic gate drive layout is the same as the one with a MOSFET transistor, this explains the resemblance of the electrical symbol (Figure 1) of an IGBT to that of a regular transistor. Due to its abilities, IGBTs can be used in several areas like electric cars, induction heating and plasma physics replacing relays, thyristors and thyratrons.

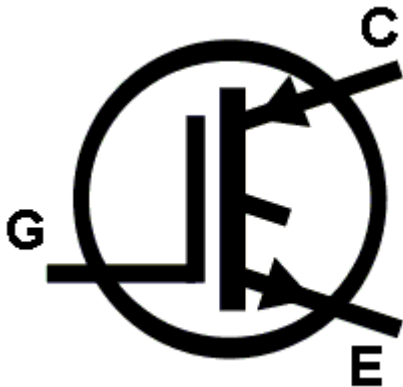


Figure 1 The electrical symbol for an IGBT.

2.3 PWM

When constant power is not required but the power source is DC, one can vary the average power output by turning it on and off as a rectangular pulse wave. If the device is an oven, one can turn it on for a minute and then when the required temperature is achieved, turn it off again just to turn it on when the temperature goes down. This is a very slow version of PWM (Pulse Width Modulation). When controlling the intensity of light from diodes one can use the same method. By turning the diode on and off at higher frequencies, 100-1000 Hz, and varying the duration of the pulses, one can make it appear as if the light from diode varies in intensity even though it in fact is only either on or off. It is the average intensity over time that varies, not the actual intensity when the diode is switched on. The same principle is used in

the motor control system in electric cars. An AC current is simulated through PWM and a varying magnetic field makes the motor rotate. The duration of the voltage pulses (see figure 2) is controlled by a controlling unit, such as a computer or microcontroller, and makes it possible to vary the frequency of the changing magnetic field.

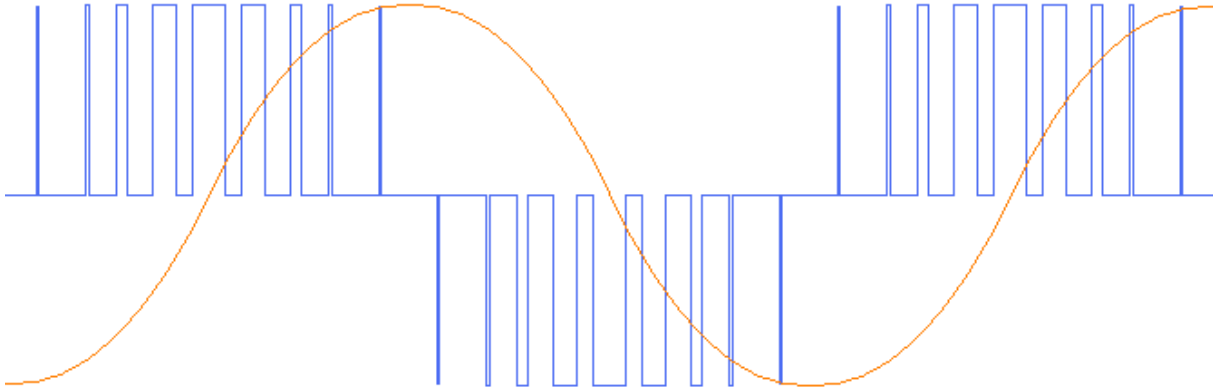


Figure 2 Pulse Width Modulation. A varying magnetic field (red) in the engine is induced by the voltage (and current) pulses (blue).

It is during the switching times, during the time when the signal changes and there is a voltage drop and a current flowing through the IGBT, that most of the energy is lost. Faster switching times is therefore desired to minimize losses. However, high currents and high switching frequencies is not easy to combine but IGBTs are constantly improved and research in power electronics makes new IGBTs that can handle more power and smaller losses available every year.

2.4 Switching losses

The switching losses in the IGBTs are inevitably where the largest energy losses are. The controlling unit itself cannot handle more than possibly a few tens of watts at max while every single IGBT will consume at least the same amount of energy in switching losses. This of course depends on the application and power output but since most applications will require tens of kilowatts continuously, switching losses on a few percent will be in the order of hundreds of watts. Since it is the type of IGBTs that determines the switching losses and since the inverter card is supposed to be able to handle several kinds of IGBTs it is no use to make an estimation of how great the losses will be. The information about the switching losses for an IGBT is available in the datasheet of the IGBT and the following equations will show how it can be calculated for different frequencies.

The losses during switching,

$$P_{switching} = \frac{V_{s(off)} \times f_s}{2} \times [t_{on} + t_{off}] \times I_{on},$$

where $P_{switching}$ = Losses during turn on and turn off (W), $V_{s(off)}$ = Blocking voltage when switch is off (V), t_{on} = Time taken for the switch to turn on (s), t_{off} = Time taken for the switch to turn off (s), f_s = Switching frequency (Hz) and I_{on} = Conduction current (A)

and the losses when the IGBT is switched on,

$$P_{on} = D \times I_{on}^2 \times R_{ds},$$

where P_{on} = Conduction losses when the switch is on (W), D = Duty Cycle, R_{ds} = "On" resistance of the device (Ω)

together makes up for most of the losses in the IGBT switching cycle since there are no losses when the IGBT is switched off. The total power loss,

$$P_{total} = P_{switching} + P_{on},$$

where P_{total} = Total losses (W)

in relation to the total power distributed through the IGBT (in per cent)

$$\eta = \frac{P_{in} - P_{total}}{P_{in}} \times 100$$

where P_{in} = Input Power (W) and η = Efficiency (%)

gives an expression for the efficiency of the driver. Losses in the magnitude of a few percent is to be expected.

2.5 Ohm's law

Ohm's law, named after the German physicist Georg Ohm, states that the current through a conductor is directly proportional to the voltage between two points of different potential. The proportionality constant, R , describes the resistance and gives the equation

$$U = R \times I$$

where U is the potential difference (Voltage, V) and I is the current (Ampere, A). The resistance is measured in Ohm's (Ω). Depending on the application the requested resistance in a material is very diverse. In an isolating material the resistance should be as high as possible, several $G\Omega$ if possible. In conductors, on the other hand, the voltage should be as low as possible and a resistance in the order of a few $m\Omega$ per meter is quite common.

2.6 Joules first law

Depending on the conductivity of a material and the current flowing through it, there will be energy losses through heating. Joules law

$$Q = I^2 \times R \times t$$

Where Q is heat generated by the current, I is the magnitude of the current, R is the resistance and t is the time, we can derive that the larger the current, the more energy will be lost. This is the reason why high voltage is used for electric energy transportation over longer distances. When higher currents are used the demand for less resistance is increased if the energy losses are to be kept at a low level. If the currents become too high the conducting material will become so warm it will melt or burn and this is why some of the conductors must be larger than others in different applications.

2.7 Miller Capacitance

The Miller capacitance is one of the main obstacles when it comes to frequency limitations of the IGBT.

When a voltage amplifier (figure 3) is used to invert the DC power signal, the equivalent input capacitance increases with the amplification. This is called the Miller effect⁽¹⁾. The increased impedance due to the Miller effect is given by

$$C_M = C(1 + A_v)$$

Where $-A_v$ is the gain of the amplifier and C is the feedback capacitance or inductance. Since an IGBT can be viewed as an amplifier where the base current is the signal that is being amplified, the Miller effect will cause the IGBT to show capacitive properties.

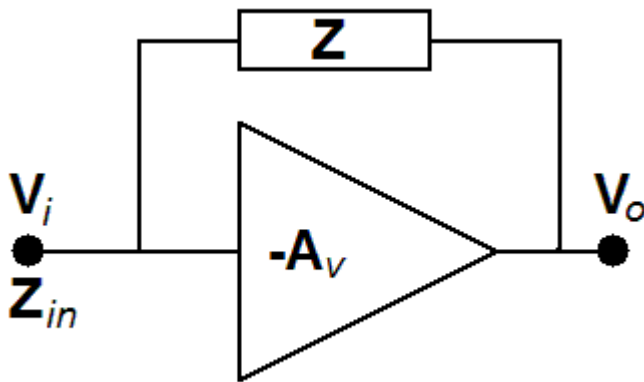


Figure 3 An amplifier with an impedance in parallel. A transistor can be viewed as an amplifier used to amplify currents.

In an ideal inverting voltage amplifier of gain, $-A_v$, and with an impedance, Z , connected between its input and output nodes the output voltage is given by

$$V_o = -A_v V_i$$

and

$$-A_v = \frac{V_i}{V_o}$$

Since all of the current flows through Z and no current (approximation) flows through the amplifier, the current is given by

$$I_i = \frac{V_i - V_o}{Z} = \frac{V_i \left(1 - \frac{V_o}{V_i}\right)}{Z} = \frac{V_i(1 + A_v)}{Z}$$

Since the input impedance of the circuit is

$$Z_{in} = \frac{V_i}{I_i} = V_i \frac{Z}{V_i(1 + A_v)} = \frac{Z}{(1 + A_v)}$$

, and Z usually is a capacitance,

$$z = \frac{1}{sC}$$

The input capacitance is calculated by

$$z_{in} = \frac{1}{sC_M}$$

where

$$C_M = C(1 + A_v).$$

When the IGBT is not in use the voltage across the collector and emitter is the same as system voltage. If an IGBT connected in parallel is switched on there will be a sudden voltage drop and this is where we will see the effects of the Miller capacitance.

2.8 Transients

A transient event is a short lived signal or burst of energy in a system. Voltage peaks induced by EMP (Electro Magnetic Pulse) is one source of transients. Switching, connecting and disconnecting, is also a source of sudden change of state which causes transients. Some components have limited resilience and caution is to be made when handling different electrical components since it is very easy to damage them irreparably by just touching them with your bare hands. An electrostatic discharge, even too small to feel with you finger, may ruin a component.

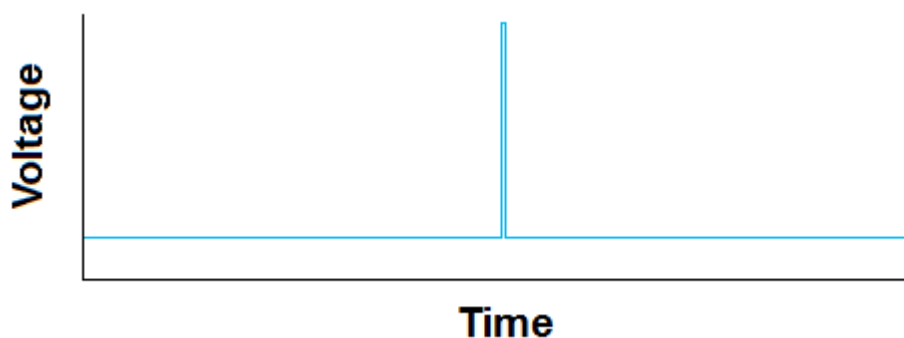


Figure 4 Illustration symbolizing a transient event.

In fig 4 a transient event is pictured. It's the sudden change, the discontinuity in the current, voltage or magnetic field that ruins the component.

3. Construing the inverter

3.1 Scheme

The IGBT driver can break for several reasons. Short circuit or misconnection of either signals or power will undoubtedly lead to failure. Noise induced to the signals or computational errors can damage the power electronics and overload conditions induced by the load of component failures in the gate drive circuitry can also damage the IGBTs. Whatever the error may be, cautions can be made to prevent the damage from being too devastating.

The central part of the inverter card is the optocoupler HCPL 316J. The purpose of the optocoupler is to transfer electrical signals with light waves, thus making the connection from one side to the other completely electrically isolated. The optocoupler is a standard component in electronics and is used in many applications where electrical isolation is of essence. The HCPL316J is an extra adequate model since it is specially made for this kind of application. Except sending the signal forward it also has several other feedback gates that control the function of the PCB-card and communicates with the controlling unit. Fig 7 shows the internal circuitry of the HCPL316J and shows that the input and output side is completely galvanically isolated from each other, both in the IN signal and in the FAULT output signal.

Fig 5 shows the suggested use of the HCPL316J by the manufacturer from the datasheet⁽²⁾.

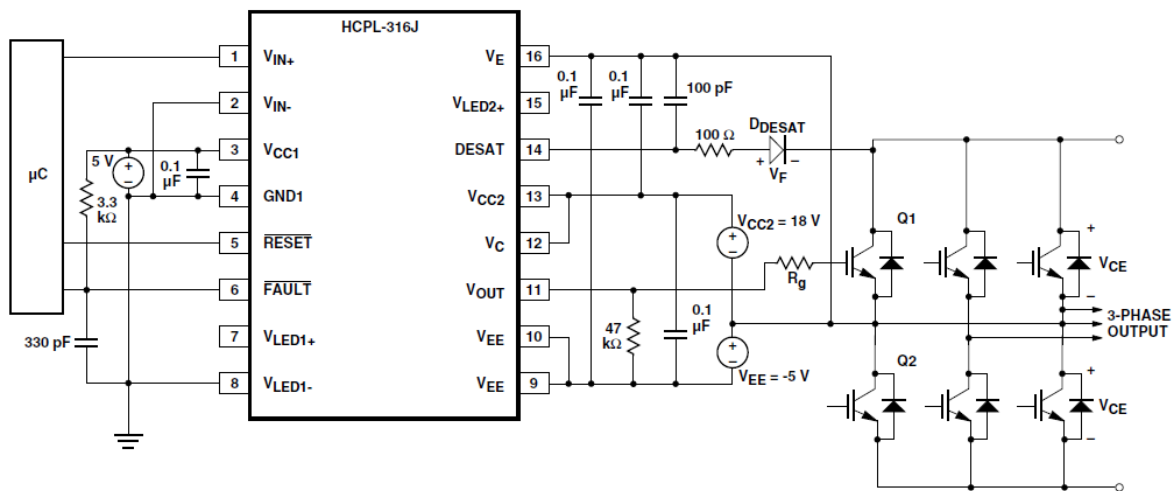


Figure 5 Suggested schematic for use of HCPL 316J, from the datasheet of HCPL 316J.

Some text from the datasheet⁽²⁾, page 21, explaining the function of the different components used in the driver.

As a further explanation of the limitations and abilities of the HCPL 316J and to why the extra transistor step is used, the internal circuitry⁽²⁾ of the HCPL316J is shown in figure 7.

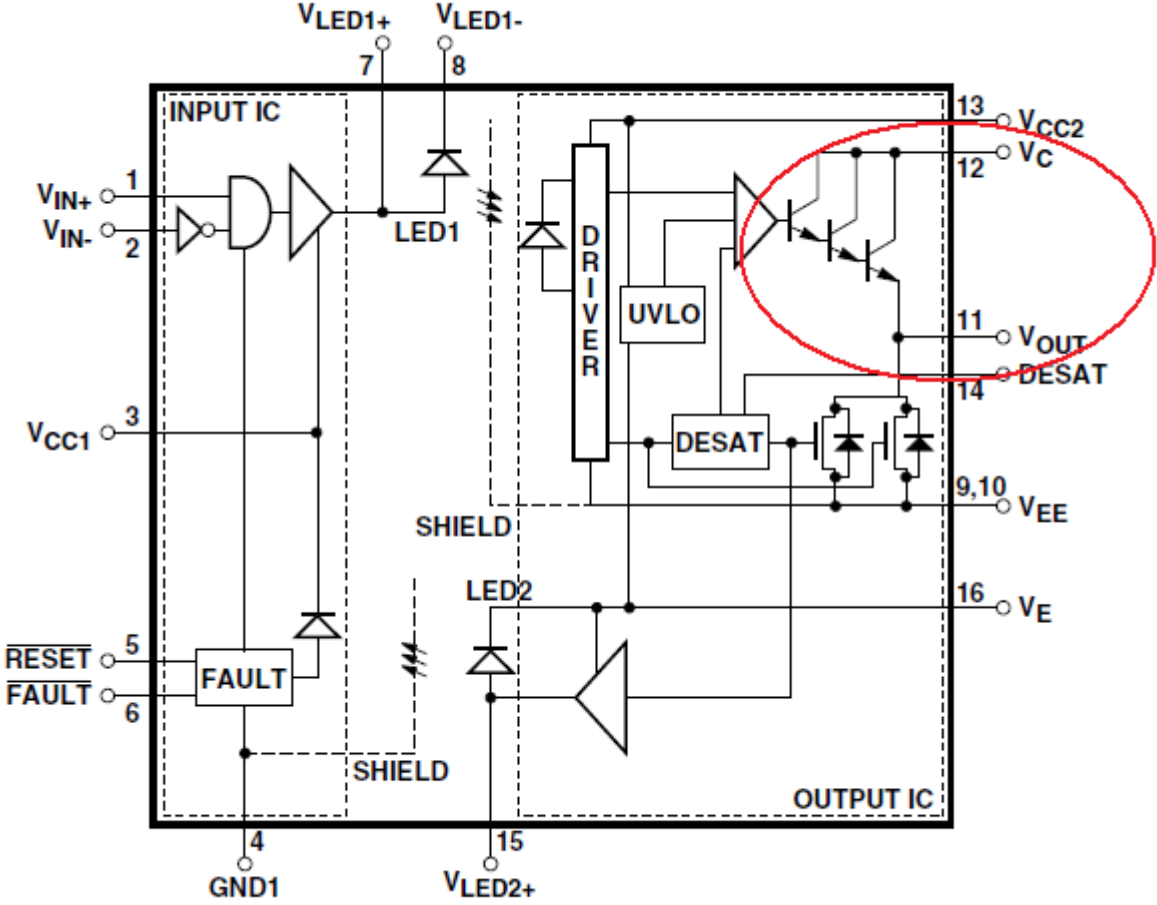


Figure 7 The internal circuitry of HCPL 316J. Illustration from the datasheet to HCPL 316J.

By adding some logical gates to the input gate, a buffer is created that protects the HCPL 316J from transients that may be induced in the cable carrying the signal. Instead of removing the 0.1 μ F capacitors are kept in the scheme to absorb transients from the switching of the IGBTs. A 100 Ω resistor is put in series to the diode on gate 14. This is to limit the current flowing through the HCPL 316J. Two zener diodes are added between the gate and the emitter of the IGBT to avoid any fault voltages higher than 17 V. If the voltage between the base and emitter of the IGBT will occur then the zener diodes will short circuit and therefore protect the HCPL 317J. With these changes made, the final circuitry of the application can be viewed in figure 8.

THREE PHASE SIX PULSE IGBT INVERTER

SINGLE CHANNEL IGBT GATE DRIVE (DRVx)

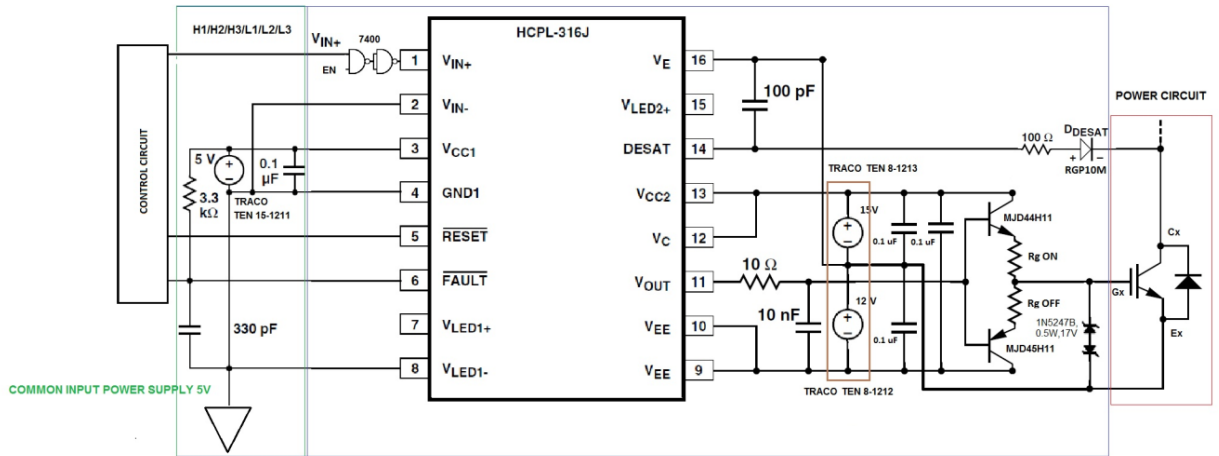


Figure 8 The schematic used in the project of the division of Electricity.

Figure 9 shows the six drivers connected together as they are used for 3-phase inversion. By adding varistors, fuses and overcurrent protection, the complete layout of the new inverter is demonstrated.

POWER CIRCUIT (3 PH. BRIDGE INVERTER)

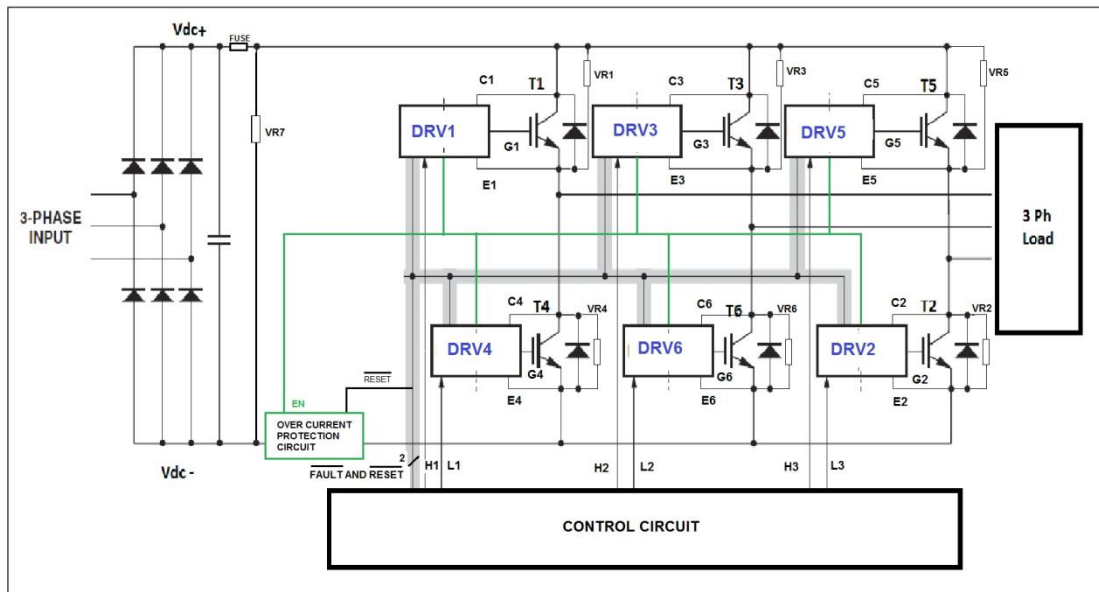


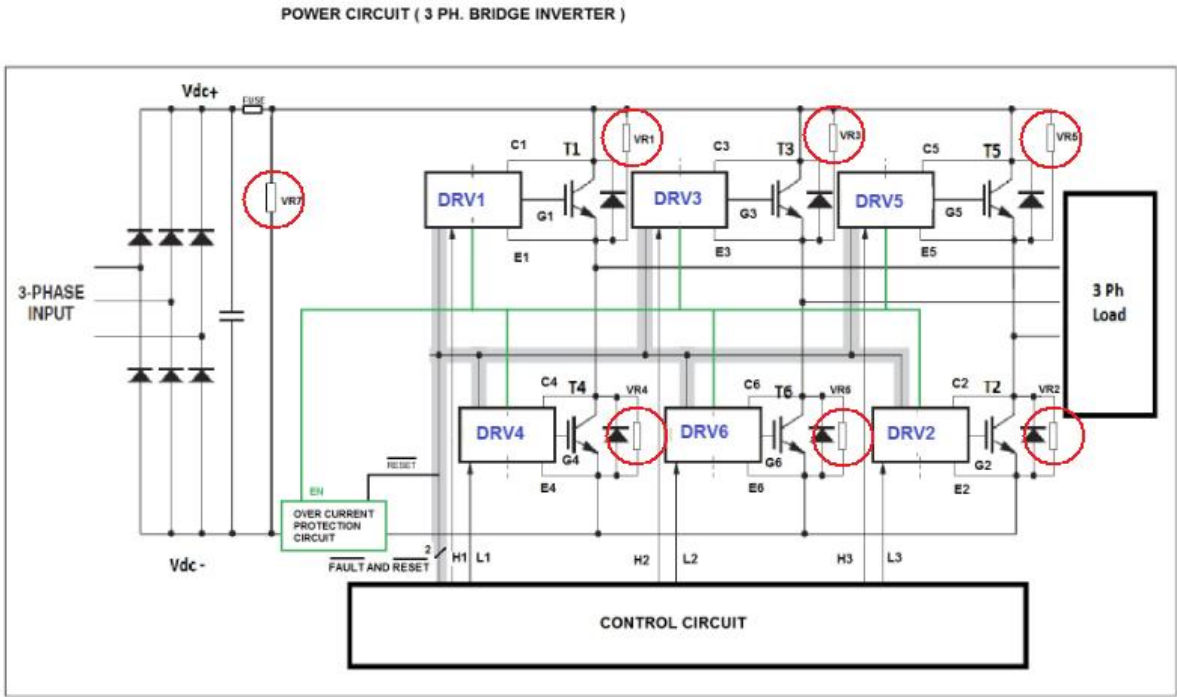
Figure 9 Six drive, three phase, AC inverter. The six drivers creates a 3-phase current through the load.

3.2 Protection

3.2.1 Varistors

The nonlinear current-voltage characteristics of varistors make them ideal for protecting sensitive components. The varistor is also known as Voltage Dependent Resistor or VDR and as the name implies its conducting properties varies with the voltage. The placing of the varistors, parallel to the component they are protecting, ensures that if a transient voltage flow is suddenly induced or somehow created in the circuit, the varistor becomes conducting and absorbs most of the excessive energy. Even though the varistor can't handle to high levels of energy, it absorbs most of the smaller transients associated with connecting and disconnecting a device etc. These transients could otherwise damage other components leading to critical errors.

The varistor to the left in figure 10 handles voltage peaks between V+ and V- and therefore protects the whole inverter from being exposed to transients. The other six varistors each is associated with a single driver and IGBT to handle transients between the power line and the load.



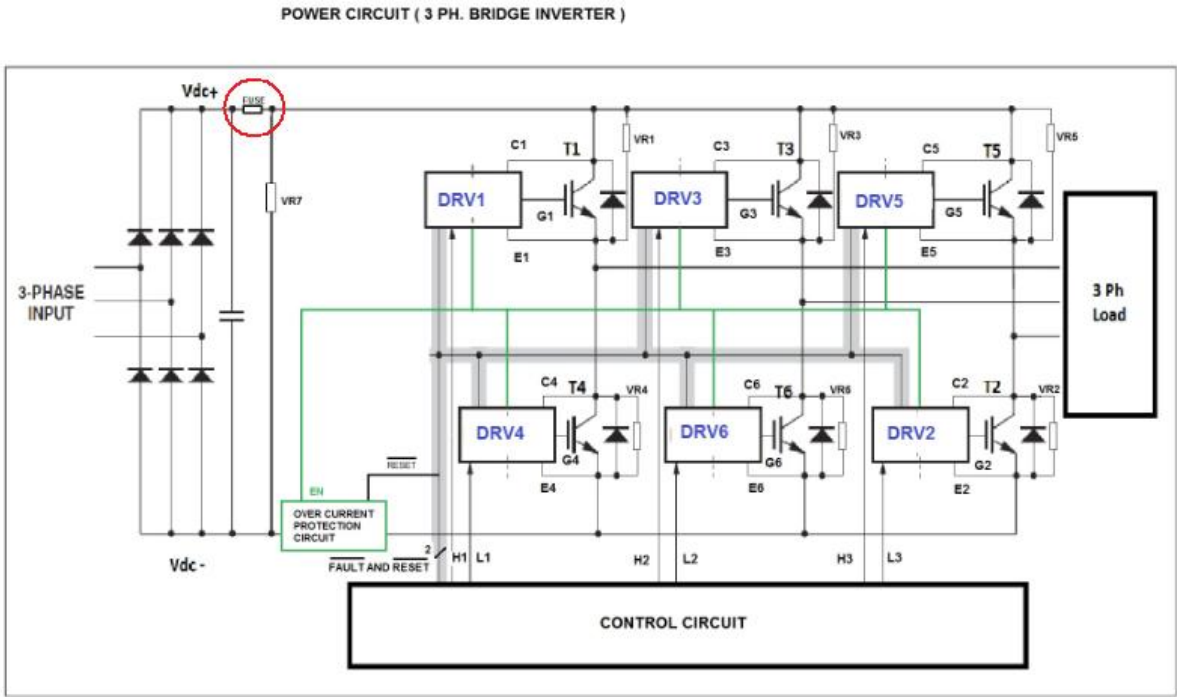
Notes: 1. Input is a 5V DC supply common for all the DRVs
2. Varistor (vr1,vr2...vr6) ratings are selected according to the switch ratings
vr7 rating depends on the dc link voltage

Figure 10 The basic schematic of the inverter showing the varistors are in the red circles.

3.2.2 Fuses

Due to the use of varistors, the property of the fuse can be adapted. The placing of the fuse in the circuit can be viewed in figure 11. The fuse doesn't have to break every sudden current peak immediately but can wait to break until the varistors have done their part. This of course depends on where the error current occurs. A slower fuse won't change the properties of the safety but makes the inverter more reliable.

It should be mentioned that this fuse doesn't break until the current level reaches several hundreds of Amperes. Even though some kind of transient may create a current of higher magnitude, the short duration of the transient will not trigger the slow fuse but instead short-circuits through the varistor.



Notes: 1. Input is a 5V DC supply common for all the DRV's
 2. Varistor (vr1,vr2...vr6) ratings are selected according to the switch ratings
 vr7 rating depends on the dc link voltage

Figure 11 The basic schematic of the inverter showing the fuse in the red circle.

3.2.3 Freewheel diode

When the IGBT switches off the current but the magnetic field in the engine still forces a current to flow whereon the freewheeling (figure 12) diodes starts conducting. This is to avoid voltage peaks over the IGBTs not conducting. If there was no diode the IGBT would be damaged by the sudden voltage peak. Therefore the diode must be able to handle the same amount of current as the IGBT.

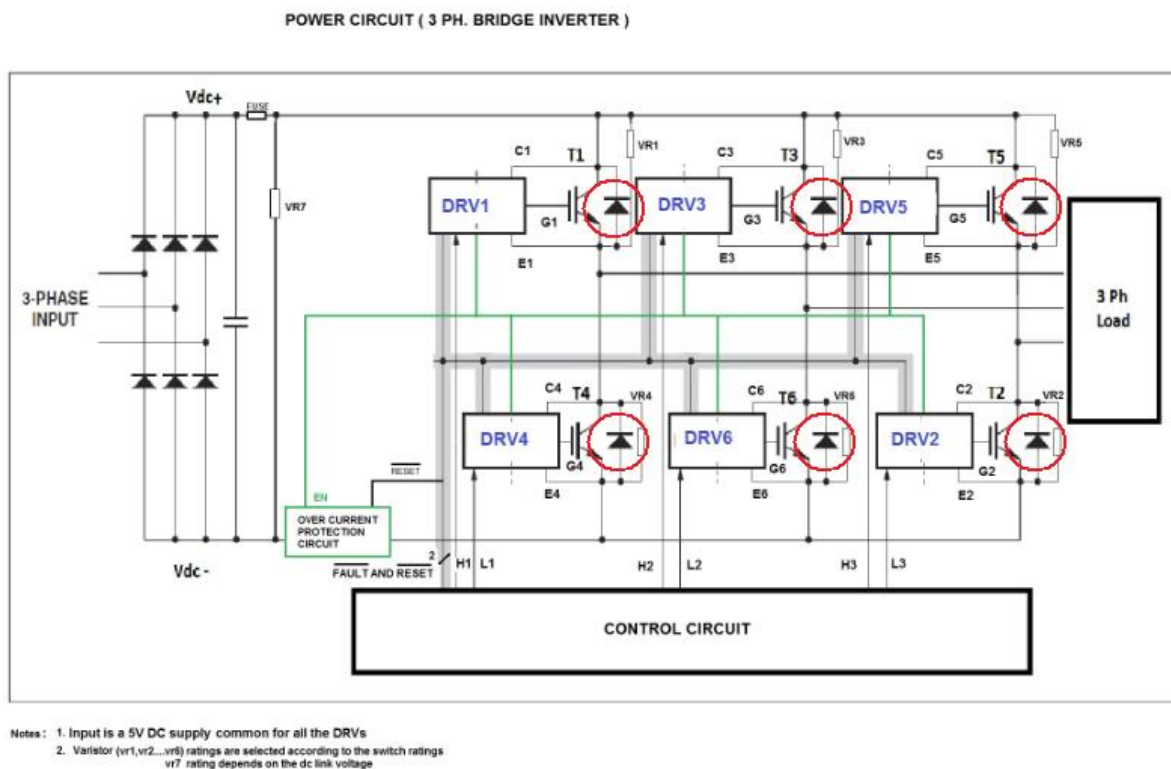


Figure 12 The basic schematic of the inverter showing the freewheeling diodes in the red circles.

3.2.4 The HCPL 316J Desat, Reset and Fault

When the IGBT is switched on but the voltage drop from the collector to the emitter of the IGBT exceeds 7 volts, the HCPL 316J slowly, but within $5\mu\text{s}$, lowers the output voltage to the gate and sends a signal to the microcontroller by making the $\overline{\text{FAULT}}$ go low. The microcontroller can now take appropriate action and the $\overline{\text{FAULT}}$ state of the HCPL 316J can be reset by a signal via the $\overline{\text{RESET}}$ gate. The internal circuitry of the HCPL 316J is shown in figure 13, highlighting the UVLO (Under Voltage Lock Out) and DESAT (Desaturation) circuits.

Signals of too low (less than 10 volts) voltage on the output may damage the IGBT since it can make it switch on but it's not supposed to work with that kind of voltage. This is where the

UVLO detects the insufficient voltage drop between DESAT and V_{CC2} and the HCPL 316J reacts the same as with the Desat protection.

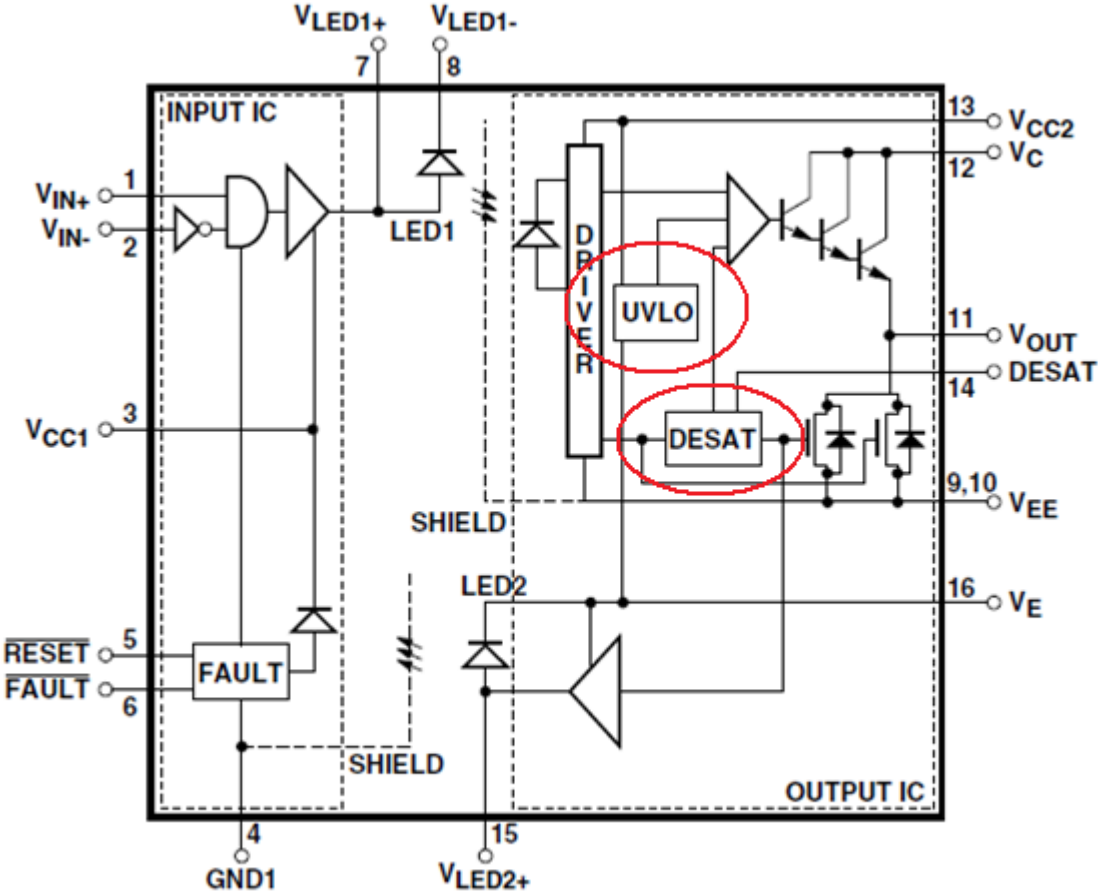
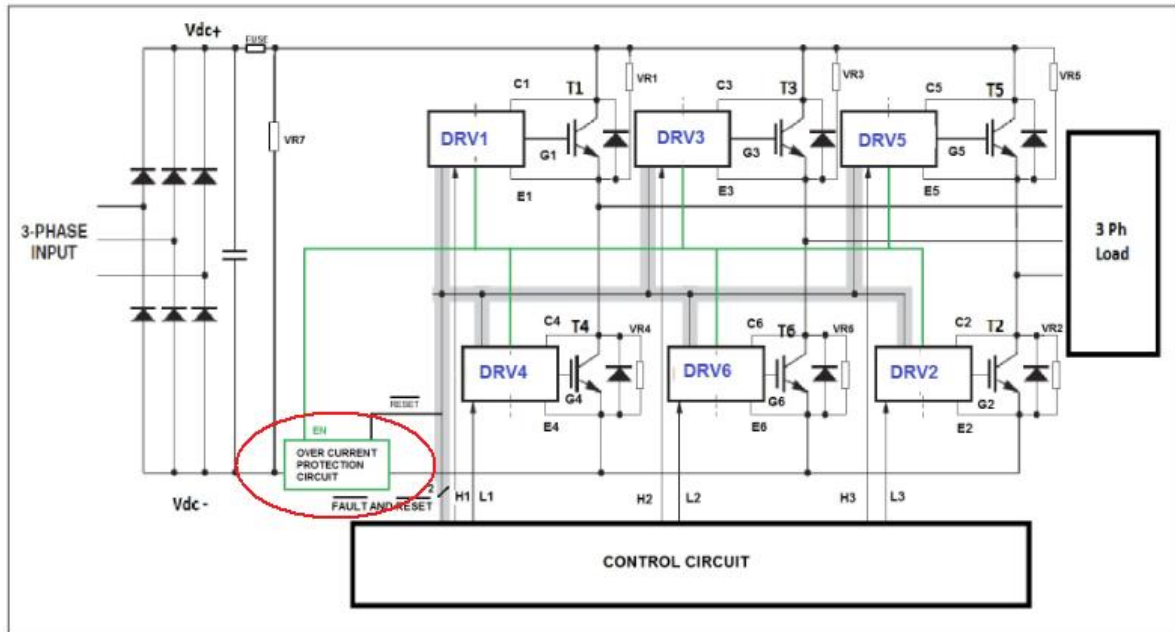


Figure 13 The internal circuitry of the HCPL316J showing the UVLO and DESAT function in the red circles.

3.2.5 The over current protection circuit

The over current protection circuit used in the application is another step to ensure the safety of the user and protecting the components. The current is measured with a transducer and the information about the current is transmitted to the control unit which breaks the current if any anomalies are detected. Figure 14 shows the circuit in its context.

POWER CIRCUIT (3 PH. BRIDGE INVERTER)



- Notes: 1. Input is a 5V DC supply common for all the DRVs
 2. Varistor (vr1,vr2...vr6) ratings are selected according to the switch ratings
 vr7 rating depends on the dc link voltage

Figure 14 The over current protection circuit in the red circle sends a signal to the control unit when a problem is detected.

Figure 15 shows the basic function of the circuit. A transducer⁽³⁾ is used to measure the current. The signal is sent through a logical cat and to the control unit which responds by turning of the IGBT-drivers or takes appropriate actions to minimize the damage of the component.

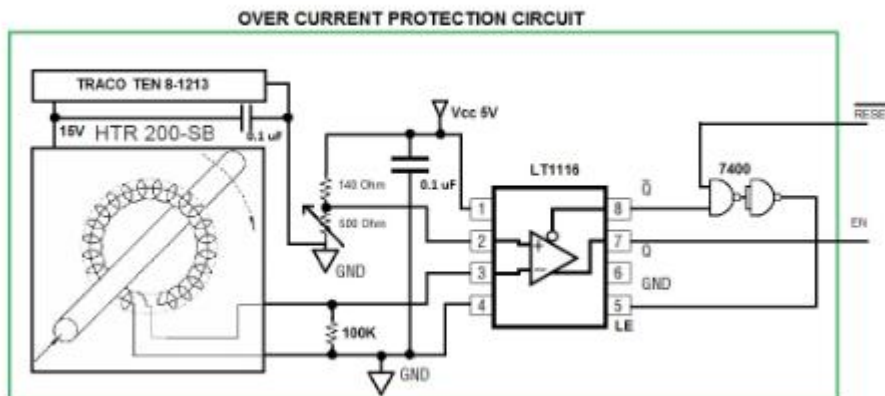


Figure 15 Picture showing the current protection circuit. The transducer. HTR 200-SB uses the Hall effect to measure the current.

3.2.6 Other

It is reasonable to assume that several applications, for example the engine in an electric car is fused or has some kind of over current protection. The voltage supply may have an equivalent too. Also the controlling unit itself can work as a kind of protection. If some irregularities are detected the controlling unit could serve as a protection.

3.4 List of components

The components, model names, number of components used for each driver and the price (all prices from either Elfa⁽⁴⁾ or Farnell⁽⁵⁾) is shown in the following list. Originally an extra Traco (Ten 15-1211) was used but by replacing it with a similar Traco providing power to the low power side of all the six drivers, the price and size was reduced.

Type of component	Model	Numbers of components	Price/component (SEK)
Optocoupler	HCPL-316J	1	57,5
Traco	Ten 8-1213	1	230
Traco	Ten 8-1212	1	230
Capacitor 10 nF	B37931-K5103-K60	1	0,112
Capacitor 100 pF	B37871-K5101-J60	1	0,468
Capacitor 100 nF	C1206C104K5RAC	3	0,28
Capacitor 330 pF	B37930-K5331-J60	1	0,188
Terminal	MKDSN 1.5/2	3	5,49
Terminal	MKDSN 1.5/8	1	
Resistance 4.7 ohm	ACS5S 4R7 J TR	2	8,37
SMD-resistance 10 ohm	RN73C2A10RBTG	1	19,5
SMD-resistance 3.3 kohm	RM0207SFCN3321T52	1	2,22
Capacitor 100 nF	SF1H104Z-L515B	1	0,676
Transistor	MJD45H11	1	11,48
Transistor	MJD44H11	1	11,15
Diode	RGP10M	1	1,75
Zenerdiode	1N5247B	2	0,23
Total price for the components of each driver			1163,244

3.4 PCB-layout

The layout of the PCB card is one of the central results of this work. The layout presented is the 17th version made since the project started. A previous version (the 6th) was printed and tested but due to some short-circuits it never worked and since that it was never properly tested. During the work of making the card more cost efficient, safe and smaller, the cost of a single card has been reduced to 33 % of the size of the 6th (10 by 10 cm) version to the 17th (4.4 by 7.5 cm) version. The total cost of the components has been reduced from 1593 to 1163 SEK and since the price of the card depends of the size of the card, it the cost of the PCB itself was reduced.

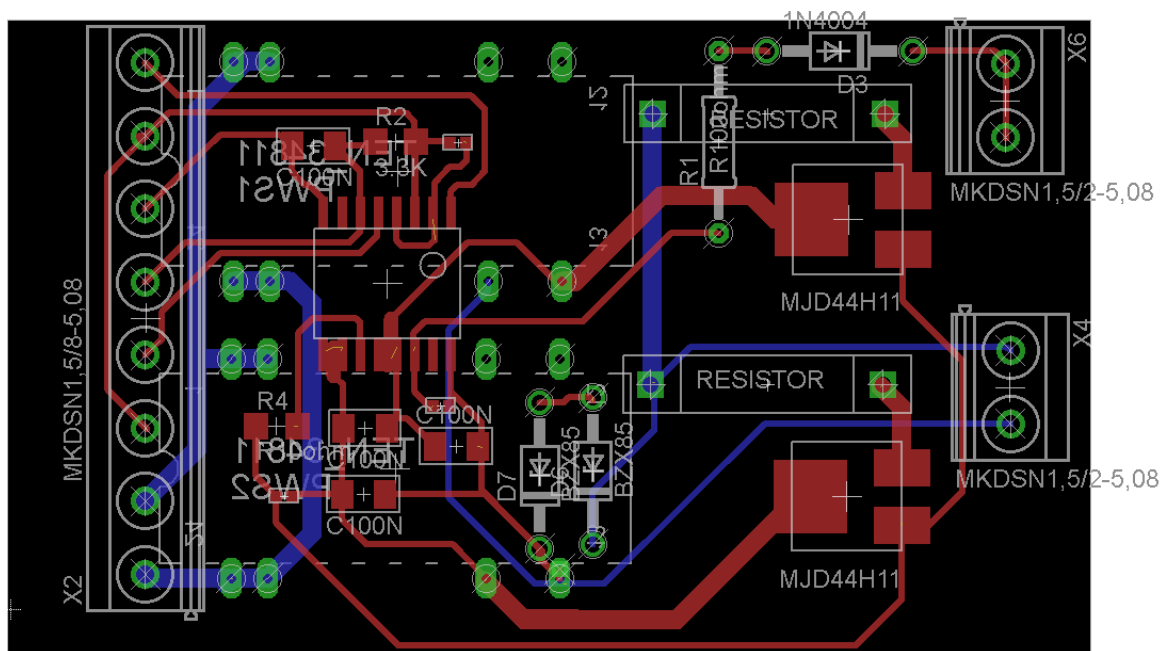


Figure 16 Suggested layout of the PCB-card. Red conductors are placed on the top side of the card and blue conductors are placed on the bottom side.

The layout of the PCB-card as made in Eagle is shown in figure 16. This card is made to be equivalent to the electrical scheme shown in previous figures.

3.4.1 Thickness of conductors

Some are thicker since they are supposed to handle more current. Through the conductors supplying power to the Tracos the current will be high. The Collector-Emitter current will be of the same magnitude as the power supply since it is the transistors that consume the greatest part of the energy. This is the reason why they are wider, the larger conductor area gets, the smaller resistance becomes.

3.4.2 SMDs

Surface mounted components, also known as SMDs (Surface Mounted Device), are equivalent to other “not” surface mounted components electrically but usually much smaller and sometimes cheaper. In everyday electronics where PCB-cards are used like remote controls and cell phones, SMDs and ICs (Integrated Circuits) are used instead of the components used when soldering by hand. This is to reduce size, price and to make the manufacturing process more efficient. Even though there’s no plans to mass produce this IGBT-driver the characteristics of SMDs are desirable for the application. Also the small size and mounting close to the board reduces vibrations which otherwise could be a problem if the card was used in an electric car.

3.4.3 In and Out and potential differences

On one side of the card there are inputs and on the other side there are outputs. Since the output side is connected to high voltages and currents it’s good to keep the input side as far away from the output side as possible. This is because the input side is connected to the controlling unit and a distance between them minimizes the noise from the switching of the transistors and IGBTs to be induced to the signals. By placing these on different sides the distance is optimized. The distance to the Desat input connected to the output side is isolated by some extra distance since this point is usually on a higher potential than the rest of the card.

3.4.4 Isolation of In and Out by ground separation

The point of using an optocoupler is to avoid electrical fault to propagate and harm other parts. Therefore it is critical that no other parts are electrically coupled in parallel to the optocoupler. Therefore there is no connection on the PCB card between the IN and OUT side. Ground planes can be added to provide a more stable electromagnetic environment and shielding from electromagnetic bursts as well as keeping the potential on the card stable. If this is made it’s important to keep the ground planes separated as well.

3.4.5 Heat dispersion

The components producing heat are spread out on the card to prevent hotspots. The components from which most excessive heat is produced are the two transistors and the two Tracos. The transistors and the Tracos are therefore placed on separated sides of the PCB card. This makes the area of the card smaller as well.

4. Conclusion and discussion

4.1 Results

By compressing the design in Eagle the area of the card went from 10 by 10 cm to 4.4 by 7.5 cm. The total area therefore decreased to 33% of the initial area. The main reason to why the area could be reduced was that one component, a power supplying Traco was removed from the card and the remaining components were placed on both sides of the PCB card. This made the PCB card itself much cheaper price of the cards are determined by the size of the cards.

4.2 Implications of results

The card is smaller and cheaper than the original layout. If the card is to be implemented in an electric car, size is one of the main obstacles. Since the size of an inverter now has been reduced significantly, it is easier to implement the design in an electric car. The PCB layout is stable and the SMD components can handle vibrations and the mechanical stresses they will be exposed too. The layout as a whole is easy to overhaul and understand. Outputs and inputs are separated with distance and a surface for labeling of the inputs is reserved in front of the terminals to ease for future users.

4.3 Limitations of results

Since the aim spreads through a wide area of computer simulation, PCB construction and reporting the theoretical work, and these different areas chronologically depended on each other it was hard to predict the outcome of the physical testing. Due to the time limitation, no physical testing was therefore done.

However progress in the development where made and conditions, and hopefully outcomes, for future testing where improved.

5. Future work

The inverter card will be used in a variety of contexts. Some will be used constantly in a power station, turned on for most part of the year. Some will be in electric cars where temperatures may vary during the year and they will be frequently exposed to vibrations and g-forces. A combination of stresses will expose the components for unexpected challenges and the effects are hard to predict. Therefore an all-round long time testing period would be recommended. The choice to use SMD components in this project was to minimize the size and distance to the card and therefore minimizing the effects of vibrations. However cables in and out haven't been considered in that manner.

More fuses and varistors can be implemented in the design and the breakage time of the fuses must be calculated properly.

The controlling unit that is used can also be implemented as a safety precaution. The HCPL 316J alerts the unit when a fault condition is detected but the controlling unit as a system can also detect faults. Maybe voltage and current measurements in the engine can provide data for more accurate and appropriate controlling if the IGBT-driver. Programming for safety is a necessity to fulfill the safety demands in an electric car.

6. Svensk sammanfattning

En IGBT-styrd växelriktare gör om likspänning till växelspanning. IGBTer är en form av transistor som kan hantera betydligt högre strömmar och spänningar än vanliga elektronikkomponenter. Arbetet har till stor del handlat om att vidareutveckla och utvärdera egenskaperna hos det omriktarkort som man planerar att använda på institutionen för elektricitetslära. Omriktarkortet är utvecklat för att inneha olika egenskaper som önskas då växelspanning produceras utifrån likspänning i de sammanhang som berör de som finns på institutionen för Elektricitetslära på Uppsala Universitet. De främsta områdena är växelriktning för att koppla upp sig på elnätet vid en kraftstation samt växelriktning av en DC spänning till motorn i en elbil.

Själva kretsschemat är i huvudsak en vidareutveckling av en redan befintlig design men kortets praktiska egenskaper har ej blivit testade, simuleringar på kortets egenskaper hade ej gjorts och en genomtänkt kretskortlayout hade ej blivit framtagen. Mitt arbete har till stor del gått ut på att konstruera kretskortet rent fysiskt och därmed se till att de egenskaper som krävs av kortet tas till vara på i slutprodukten. En del praktiska lösningar och säkerhetstänk som kan förbigåtts har implementerats på den slutgiltiga kretskortlayouten.

Som en sidoeffekt av arbetet med kretskorslayouten har även kortets storlek reducerats och antalet komponenter minskats vilket gjort att priset och storleken på en 3-fas växelriktare har sjunkit betydligt.

Målet var även att simulera kortets egenskaper i PSpice. PSpice är ett mycket kraftigt och väldigt arbetskrävande simuleringsprogram men de slutgiltiga simuleringarna ger ofta resultat som kan jämföras med de faktiska. Dessvärre så kunde dessa ej genomföras i tid till redovisningen men arbetet är påbörjat och kommer att fullföljas senare.

7. References

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