Power Electronics

DC-AC Inverter Project

Model Sample Report

Tutorial

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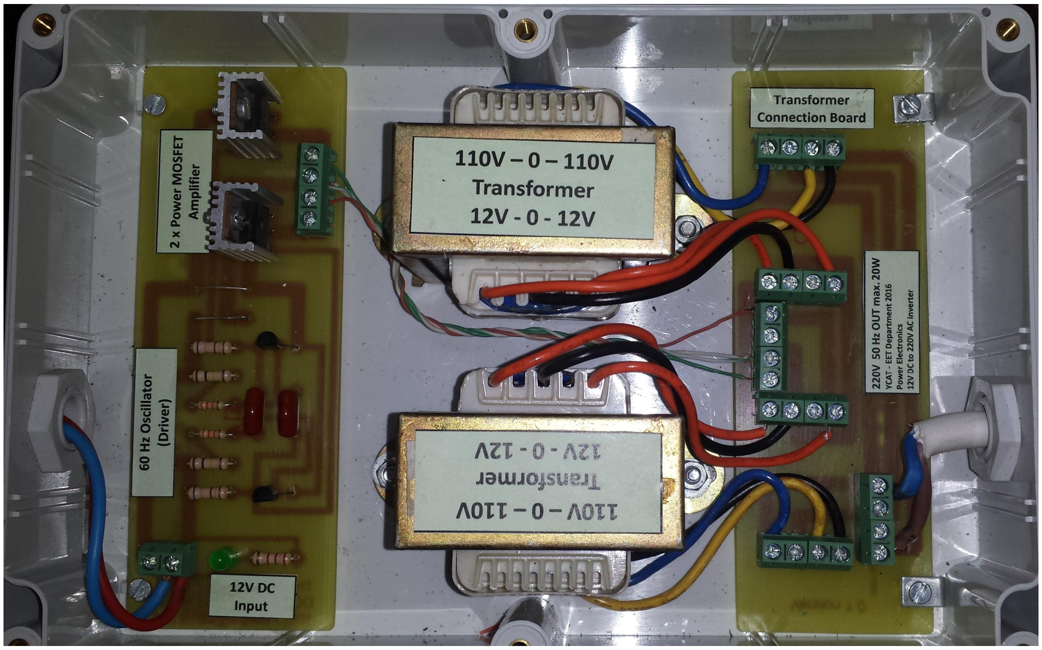

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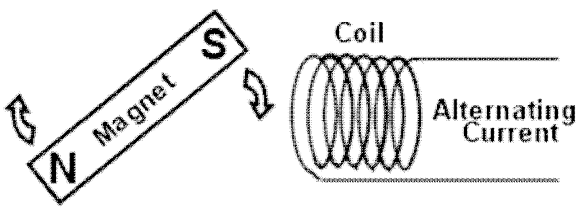
Introduction

Everyone uses some kind of electronic gadget while in their motor home, SUV or car. You might listen to your MP3 player, check for directions on your global positioning system or play a portable video game. These types of electronic devices can be recharged or powered by plugging them into the cigarette lighter in your vehicle.

But what if you want to use something a little more elaborate while you're on the open road? Maybe you want to make toast, watch an LCD TV, or perhaps even write an article on your laptop computer. These devices plug into regular wall outlets, not cigarette lighters. Making sure your electronic gear gets the juice it needs while on the road isn't a simple matter of finding the right adapter. You need a power inverter.

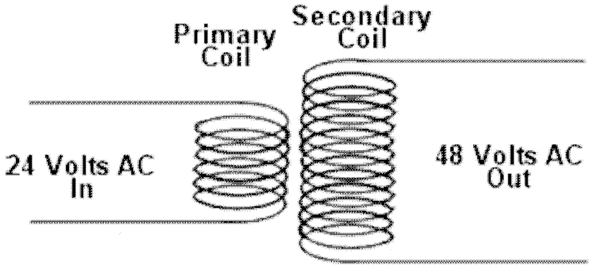
How a DC to AC Power Inverter works.

Power inverters convert direct current (DC), the power that comes from a car battery, into alternating current (AC), the kind of power supplied to your home and the power larger electronics need to function.



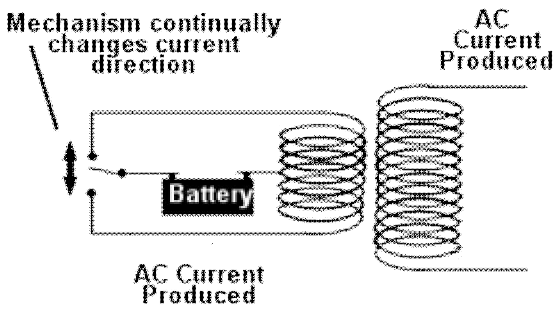
So how can an inverter give us a high voltage alternating current from a low voltage direct current? Let's first consider how an alternator produces an alternating current. In its simplest form, an alternator would have a coil of wire with a rotating magnet close to it. As one pole of the magnet approaches the coil, a current will be produced in the coil. This current will grow to a maximum as the magnet passes close to the coil, dying down as the magnetic pole moves further away. However, when the opposite pole of the magnet approaches the coil, the current induced in the coil will flow in the opposite direction. As this process is repeated by the continual rotation of the magnet, an alternating current is produced.

Now let's consider what a transformer does. A transformer also causes an electric current to be induced in a coil, but this time, the changing magnetic field is produced by another coil having an alternating current flowing through it. Any coil with an electric current flowing through it will act like a magnet and produce a magnetic field.



The voltage produced in the secondary coil is not necessarily the same as that applied to the primary coil. If the secondary coil is twice the size of the primary coil, the secondary voltage will be twice that of the voltage applied to the primary coil. We can effectively produce whatever voltage we want by varying the size of the coils.

If we connect a direct current from a battery to the primary coil, it would not induce a current in the secondary as the magnetic field would not be changing. If we can make that



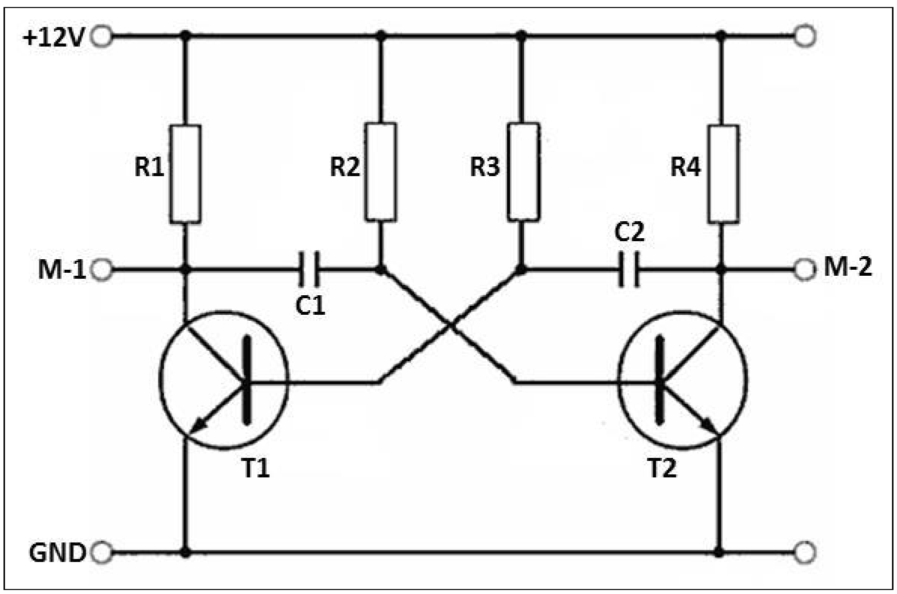
direct current effectively change direction repeatedly, then we have a very basic inverter.

Suppose you had lightning-fast hands and were deft enough to keep reversing the battery 50–60 times a second. You'd then be a kind of mechanical inverter, turning the battery's DC power into AC at a frequency of 50–60 hertz.

Project Goal

The team (group of the selected trainees) produces one 12V DC to 230V AC inverter for a minimum output power of 15W. The device is usable, when it works a minimum of 30 minutes with a load of 10W. The device must be ready 2 weeks before the trimester ends. Together with the device, the team has to provide documentation including project goal, circuit diagram, circuit description, material list, risk analysis, PCB layout, assembling steps and test report.

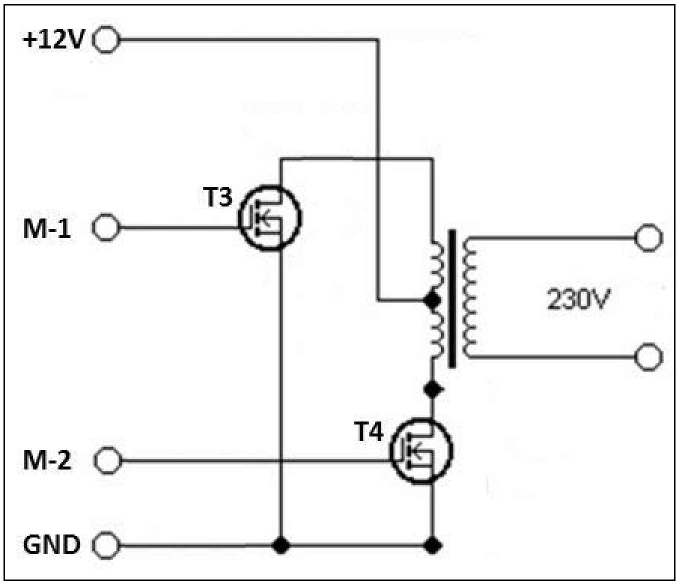
Circuit Diagram



Circuit diagram of oscillator

Components:

R1, R4	820 OHM
R2, R3	133 KOHM
C1, C2	100 nF
T1, T2	BC 548
CON	Connection to power unit M-1 and M-2 (MOSFETS)
	Connection to input 12V DC (battery)



Circuit diagram of power unit

Components:

TX	2x TR1A1212, 12-0-12 to 110-0-110 Transformer, 2x12W
T3, T4	IRF720 with heatsinks
CON	Connection to oscillator M-1 and M-2
	Connection to output (230V)
	Connection to 12V input (Battery)

Circuit Description

Our main aim is to develop an AC signal of 220V. This requires use of high power MOSFETS to allow the flow of maximum amount of current to the load. For this reason, we use a power MOSFET IRF720 with a maximum collector current of 4A.

This simple low power inverter circuit converts 12V DC to 230V AC. By doing a simple modification, it is also possible to convert 6V DC to 230V AC or 110V AC. It can be used as inverters for home needs to enable light loads at the time of an electricity failure. It’s just a square-wave inverter so it is possible to power only light bulbs, and small power tools that do not require a frequency with a sinusoidal wave form.

The oscillator is built with two transistors, wired as an astable multivibrator. The operating frequency of astable multivibrator is set to about 50Hz. The power MOSFETs are directly driven by the collector output of the transistors. The MOSFETs will switch according to the pulse from the astable multivibrator. Each of the MOSFET switches allows the DC source voltage to appear across the 12V input of the transformer in alternate intervals, causing an alternating voltage to be developed across the 220V output. The transformer used in this project is an ordinary 220 to 12V step down transformer which is connected in inverted manner.

Material List

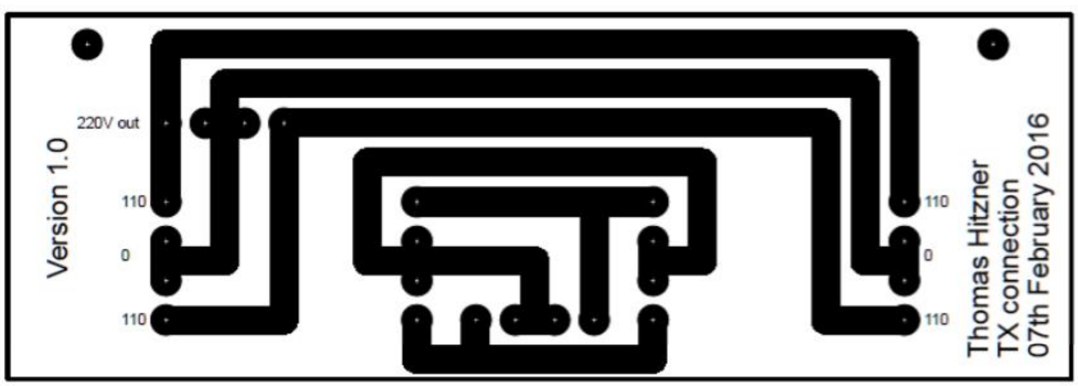
Component	Description	Cost
1 Plastic box	plastic box- big enough for all components, (22cmx15cmx6cm in this example, also other housings possible, depending on design)	20 SAR
2 Transformers	12V-0-12V/1A to 110V-0-110V (circuit is designed for 2x12W in this example. Other transformers possible, depending on output power)	48 SAR
2 Power Mosfets	IRF 720, 350V, 4A (also other MOSFETS possible, depending on output power)	20 SAR
2 Resistors	820 OHM (astable multivibrator)	2 SAR
2 Resistors	133 KOHM (part of the 60 Hz, RC circuit of astable multivibrator)	2 SAR
2 Capacitors	1 nF (part of the 60 Hz, RC circuit of astable multivibrator)	2 SAR
2 Transistors	BC 548 (astable multivibrator)	2 SAR
1 LED	Green, 1.8V, 10 mA, (to show status of 12V DC input)	1 SAR
1 Resistor	2.2 KOHM, as series resistor for the LED	1 SAR
15 connectors	2 pin connectors for connection between the boards and external	15 SAR

	connections, green with screws	
2 Heatsinks	2cmx1cm for the MOSFETS (also other heatsinks possible, depending on output power)	2 SAR
2 housing bushings	PG16, for external connections	16 SAR
PCB material	Copper, one side lamination, about 10cm x 15cm	5 SAR
	Total cost	116 SAR

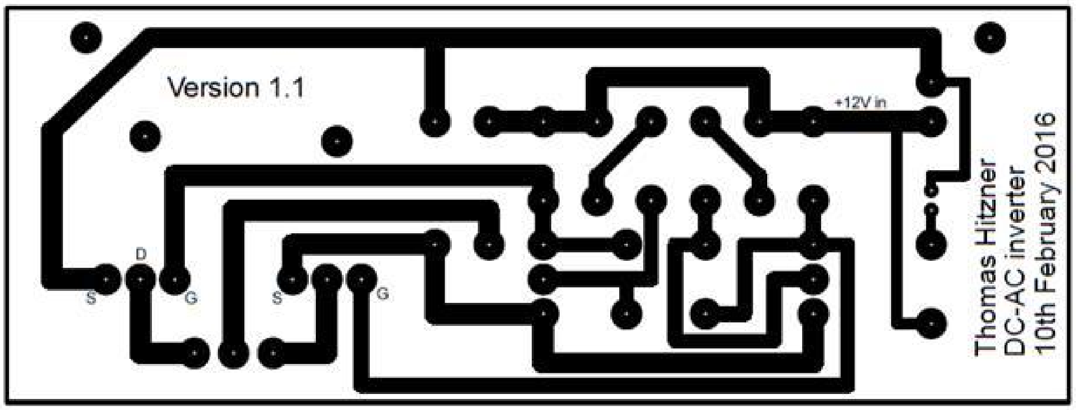
PCB Layout

To make the product flexible, the design is divided into 2 boards.

1. The first board is for the transformers and the 220V output. Depending on power output and type of transformer, it can be modified. For this example, 2 transformers in parallel are used to double the output power. The used type of transformer is TR1A1212.



2. The second board is for the oscillator and the power MOSFET unit. Depending on frequency and integrated circuits, the oscillator can be modified. Depending on output power, the MOSFET unit can be modified too.



Assembling Steps:

It is best to start with the smallest and flattest components and then work up to the larger components after the small parts is done. Bend the leads as necessary and insert the component through the proper holes on the board. To hold the part in place while you are soldering, you may want to bend the leads on the bottom of the board at a 45 degree angle.

Test Report

The device was tested under different conditions.

Input V	Input A	Load OHM	Output V	Output P	Efficiency %
14.4 V	0.25 A no load current 3.6W loss	No load	220V	0W	-
14.4 V	3.79A	330 OHM	82.4 V	20.57 W	37 %
14.4 V	2.79 A	660 OHM	117.2 V	20.81 W	51 %
14.4 V	2.27 A	990 OHM	138.6 V	19.40 W	59 %
14.4 V	1.93 A	1320 OHM	152.8 V	17.68 W	63 %
14.4 V	1.68 A	1650 OHM	163.1 V	16.12 W	67 %
14.4 V	1.50 A	1980 OHM	170.7 V	14.71 W	68 %
14.4 V	1.36 A	2310 OHM	176.6 V	13.50 W	69 %

18.8 V	1.74 A	2310 OHM	230.0 V voltage at no load 287 V	22.90 W	70%

Reviewing the project goal: "…..The team produces one DC-AC inverter for a minimum output power of 15W. The device is usable, when it works a minimum of 30 minutes with a load of 10W….."

- Measured maximum output power: 22.9 W. – Goal reached.
- 30 minutes running test with 13.5 W output power was successful. – Goal reached.

Summary of possible improvements:

The 30 minutes running test with 13.5 W output power was successful. The temperature of the MOSFETs was below 40 degrees Celsius during the complete test. Regarding the datasheet the temperature can be 90 degrees Celsius. The NO LOAD power consumption is 3.6 W. This power is used for the status LED, the 60 Hz oscillator and the no load current of the transformer (iron losses.) The overall efficiency of the test device is about 70%. Most of the loss is because of the used transformer (very weak short circuit voltage (copper losses), and high no load current (iron losses.) Professional produced inverters working with 99 % efficiency. Further projects should use better transformers.