A MULTIFUNCTIONAL V2V SINGLE PHASE ON BOARD CHARGER FOR ELECTRIC VEHICLE

[U17EEP8701 – PROJECT PHASE II]

A REPORT

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CERTIFICATE

The project work embodied in the present Report entitled "**A MULTIFUNCTIONAL V2V SINGLE PHASE ON BOARD CHARGER FOR ELECTRIC VEHICLE**" has been carried out in the Department of Electrical and Electronics Engineering, Kumaraguru College of Technology, Coimbatore. The work reported herein is original and does not form part of any other project or thesis or paper published on the basis of which a degree or award was conferred on an earlier occasion or to any other scholar.

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ABSTRACT

This project presents the design and implementation of a single-phase multifunctional electric vehicle (EV) on-board charger with vehicle-to-vehicle (V2V) functionality for emergency roadside charging assistance situations. Using this function, an EV is able to charge from another EV in case of an emergency when the battery is drained and there is no access to a vehicle charging station. The designed EV charger can support the proposed V2V function with rated power and without the need for an additional portable charger. It can also provide multifunctions of vehicle-to-grid (V2G), grid-to-vehicle (G2V). All the functions are addressed in the control part through the sharing of existing converters in an all-in-one system. This EV charger is designed and controlled in ATMEGA 8.

ACKNOWLEDGEMENT

We wish to record my deep sense of gratitude and profound thanks to KCT Management, Principal, Head of the Department and Project Coordinator for the keen interest, inspiring guidance, constant encouragement with my work during all stages, to bring this work into fruition.

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LIST OF ABBREVIATIONS

EV - ELECTRIC VEHICLE

DC - DIRECT CURRENT

AC - ALTERNATING CURRENT

V2V - VEHICLE TO VEHICLE

G2V - GRID TO VEHICLE

V2G - VEHICLE TO GRID

PWM - PULSE WIDTH MODULATION

MOSFET – METAL OXIDE SEMICONDUCTOR FIELD EFFECT TRANSISTOR

IGBT - INSULATED GATE BIPOLAR TRANSISTOR

CHAPTER 1

INTRODUCTION

1.1 PROBLEM STATEMENT:

One of the largest sources of climate pollution in India is Transportation. To solve the climate crisis, we need to make the vehicles on our roads as clean as possible. We have only a decade left to change the way we use energy to avoid the worst impacts of climate change.

Emissions from cars and trucks are not only bad for our planet, they're bad for human health. Air pollutants from gasoline- and diesel-powered vehicles cause asthma, bronchitis, cancer, and premature death.

The long-term health impacts of localized air pollution last a lifetime, with the effects borne out in asthma attacks, lungs, and heart problems .

Government is planning to reduce pollution so we are moving from IC engine vehicles to electric vehicles and hybrid vehicles . Most of the customers are facing this type of challenges in EV applications

- Cost of the vehicle
- Battery import
- Minimum charging stations

For long travelling people they face a difficulty because of charging for that we implement a vehicle to vehicle charging mechanism

1.2 FIELD OF THE PROJECT:

This project mainly focussed on charging between two vehicles. If a person is using an electric vehicle for long distance traveling purpose.in vehicle after travel a certain distance the battery charge is very low. If there is no charging stations are available in particular distance so the vehicle is not accessing condition

The V2V charging techniques are used to avoid that kind of problem. A person easily gets the charge from another vehicle. The energy transfer between the vehicle using bidirectional converter set

So this electric vehicle converters is transfer the power in efficient manner

1.3 OBJECTIVES:

The main objective of the project is

- To develop effective charging circuit of one vehicle to another vehicle(V2V Charger)

- The energy transfer between EVs will be through a Bidirectional DC-DC charger in a conductive way which can take place at parking lots of workplaces, campuses, or residential premises and highways

- V2V uses smart homes and parking lots for power exchange.

1.4 LITERATURE REVIEW

LS1: K. T. Chau, Diyun Wu, Shuang Gao,"**Opportunities and Challenges of Vehicle-to-Home Vehicle-to-Vehicle and Vehicle-to-Grid Technologies**"

This paper mainly focused on individual components of the systems in EVs, such as electric machines, drive systems, batteries, fuel cells, onboard renewable energy, and so on . However, with the emerging concept of the smart grid, EVs will play a new role in energy exchange with the power grid. Nowadays they are capable of not only drawing the energy from the power grid with the plug-in function, but also delivering the energy back to the grid via the bidirectional charger.

Also this paper discuss about charging/discharging capability of GEVs and the energy-efficient requirement of power grid, the vehicle-to-home (V2H), vehicle-to-vehicle (V2V), and vehicle-to-grid (V2G) concepts have become more and more attractive in recent years and probably will turn into reality in the near future. This paper will really help to develop a converter selection.

LS2: S. Haghbin ,S .Lundmark,M.Alakula, and O.Carlson **"Grid connected integrated battery chargers in vehicle application",**FEB 2013

This paper mainly discusses vehicles using grid power to charge the battery, traction circuit components are not engaged during the charging time, so there is a possibility to use them in the charger circuit to have an onboard integrated charger. The battery charger can be galvanically isolated or nonisolated from the grid. Different examples of isolated or nonisolated integrated chargers are reviewed and explained. Moreover, a novel isolated-high-power three-phase battery charger based on a split-phase permanent magnet motor and its winding configuration is presented in this paper. The proposed charger is a bidirectional high-power charger with a unity power factor operation

capability that has high efficiency and different type of converter drives used in traction motoring and characterises of converter operations

1.5 ORGANIZATION OF THE REPORT:

CHAPTER 1 – Describes the problem identification and objectives of the project.

CHAPTER 2 – Deals with the proposed system configuration and overall structure of the project.

CHAPTER 3 – Focuses on the implementation of charging unit

. CHAPTER 4 – Presents the result

CHAPTER 5 – Points the conclusion of the project results and future scope of the project.

CHAPTER 2

PROPOSED SYSTEM

2.1 Proposed Technologies :

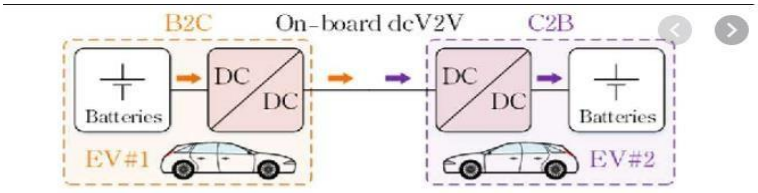
Now a days lot of technologies are used in V2X energy transformations in V2V condition two techniques are mainly used in our country

- Swapping technologies
- Using portable charging cables

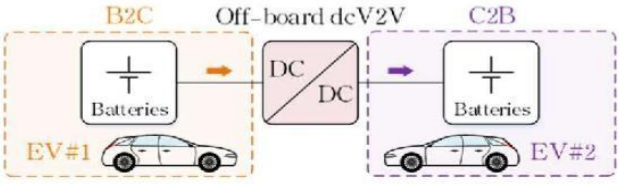
Swapping technology is one of the best solutions in vehicle charging. This technique is used to charge a battery within 5-10 minutes only. But lot of challenges in this techniques application

This technology needs a lot of battery swapping stations. In this manner lots of additional batteries are imported in other countries, so battery import cost is very high. Availability of battery and battery standards are main challenge in this system

Other technologies are available in V2V portable charger design .There are two types of chargers available one is on board charger and the other one is off board charger.



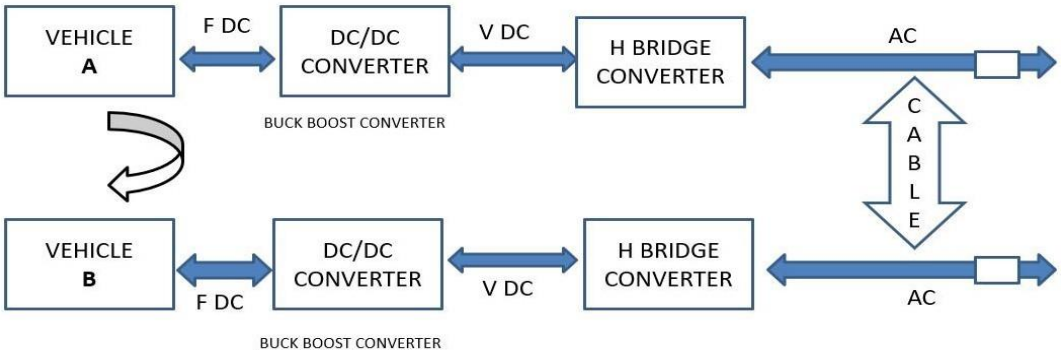
On-board dcV2V power transfer using only dc-dc converters.



Off-board dcV2V power transfer using an external dc-dc converter

The proposed system we are using on board the dc/dc charger. In this system two converters are only used so it's a cost effective technique. But this system is only applicable for DC bus energy transformations .

This technology is not supported by the AC grid and future implementation. So this circuit have a four converter electric vehicle charging unit



The overall block diagram of the system our project multifunctional V2V single phase on board charger

2.2 Configuration of Charging Unit:

There are two sets of similar properties used in the circuit . One set acts as a charging vehicle unit and another circuit acts as a discharging vehicle unit in the V2V system. Each unit there are one battery and two converter sets are used

Vehicle A acts as a source and vehicle B acts as a destination of the energy transfer function. Energy is transferred from one vehicle to another vehicle by using converters and cables. It's an ON board charging unit so each vehicle has a one set (Buck boost & H bridge converter) charger.

In V2V technology, vehicle-A battery acts as a source of the system in a buck boost converter which is connected to the battery in the source vehicle. A buck boost converter works as a buck converter. In buck boost converter, output is supplied to the H bridge converter which operates a dc/ac inverter so this inverter unit is converting a variable dc into ac supply.in future this system is supported by V2G functions also.

In vehicle B it operates a normal G2V charging state operation so the H bridge converter is converted to an ac to dc supply. The buck boost converter acts as a boost converter operation so the low voltage dc supply is converted to a high voltage dc . This dc is charged by the vehicle B battery .

The buck boost converter operation is decided by a converter switching device ON/OFF state and H bridge converter operation decided by a switching device firing angle . The converter switch firing angle is $\theta > 90^{o}$ the converter acts as a rectifier mode or converter firing angle is $90^{o} < \theta > 180^{o}$ the converter acts as an inverter mode. The converter is controlled by ATmega8 microcontroller

The converter switch system is decide a overall functional operation of charging unit

2.3 Circuit Diagram of charging circuit

The following circuit for over all project circuit diagram in our V2V charger design

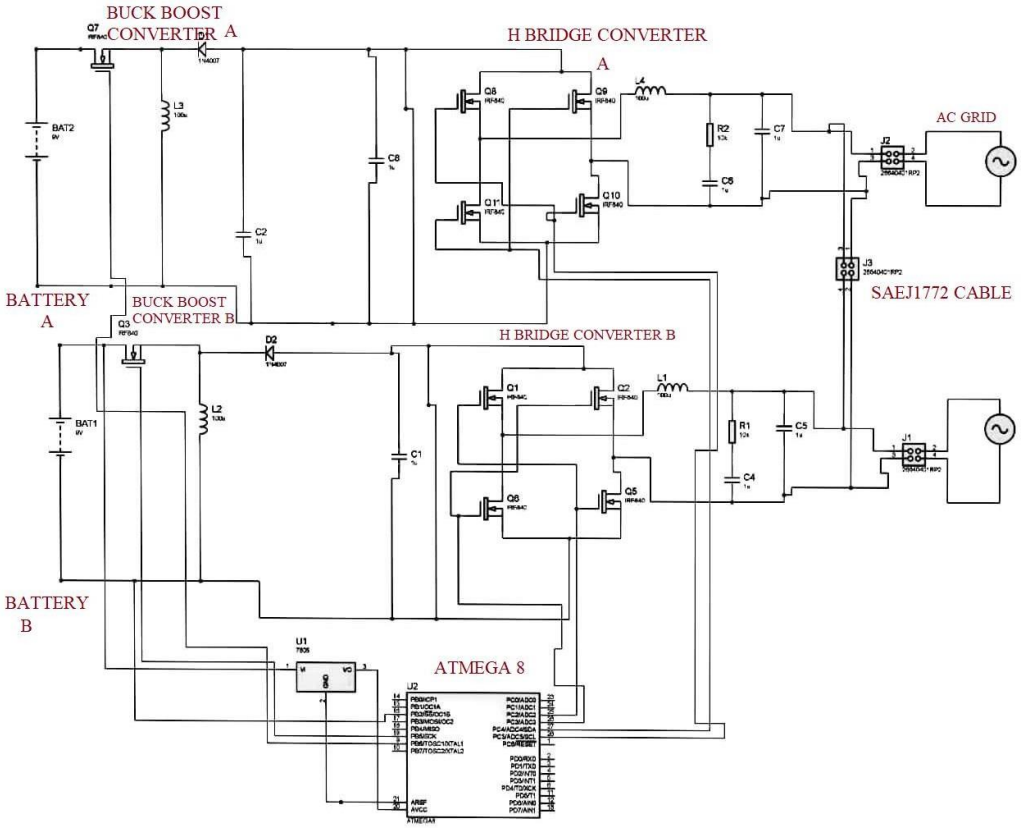


Fig 2.1 Circuit diagram of multifunction V2V single phase on board charger for electric vehicle

2.4 Description of Circuit :

Battery Pack

The typical battery pack of a Battery Electric Vehicle consists of a large number of lead-acid batteries arranged in series and parallel combination. These batteries are selected such that they have relatively high power-to-weight ratio, and these are designed with high ampere-hour capacity such that they are very useful for traction systems. The size and capacity of the battery determines the range of the electric vehicle. The type of batteries are determined by the chemical names like lithium ion, NiCad, nickel metal hydride, lithium-ion, lithium polymer, zinc air, lithium air. The significant cost of the BEVs is because of the Battery pack in it. The cost is also proportional to the size of the battery pack. Unlike, combustion engine vehicles, the EVs have high energy efficiency

CONVERTERS

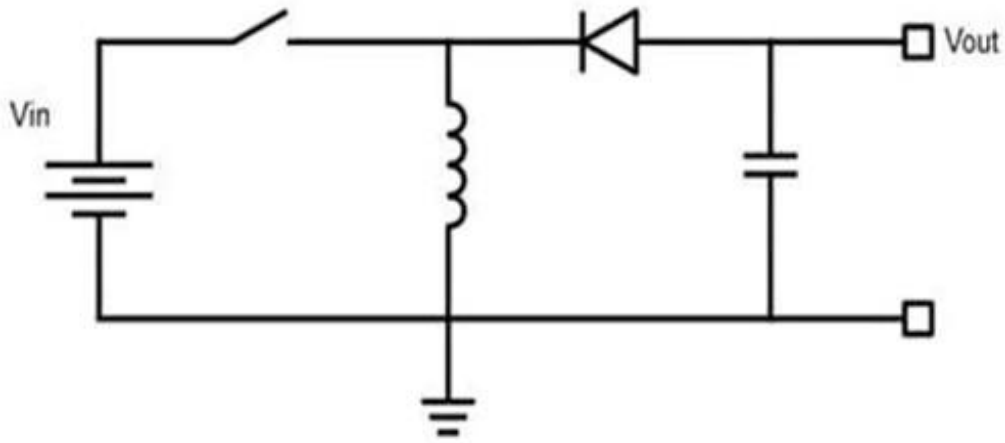
Selection of Converter

After benchmarking with various EV manufacturers, the battery pack of almost all the EVs are above 40kWh and their voltage levels range from 300 to 450V. The V2X converters are deployed for vehicles, houses, grids, buildings and have a voltage of 230V DC/AC, hence a DC-DC buck boost converter and H bridge converter can be deployed to supply the particular voltage level to the X.

BUCK BOOST CONVERTER

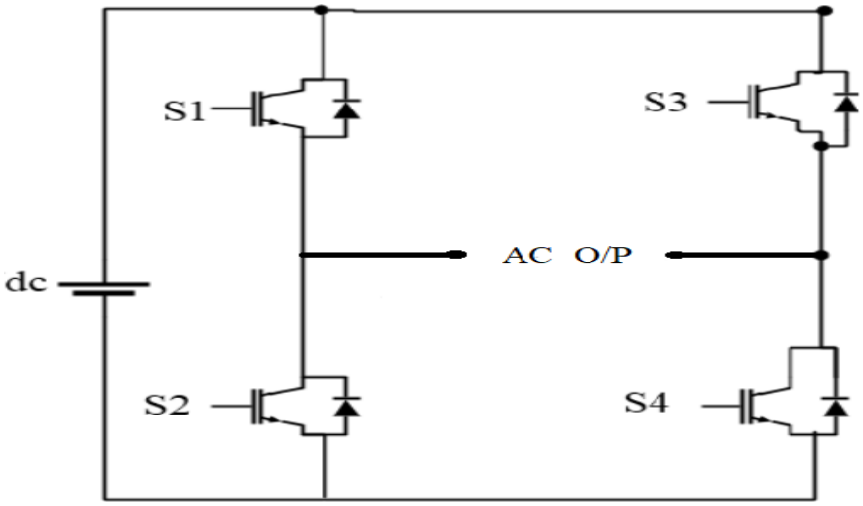
The buck–boost converter is a type of DC-to-DC converter that has an output voltage magnitude that is either greater than or less than the input voltage magnitude. It is equivalent to a flyback converter using a single inductor instead of a transformer. The output voltage is given as:VOUT = -VIN *D/(1-D)As seen from the equation above, the output voltage is always

reversed in polarity with respect to the input. Hence, a buck-boost converter is also known as a voltage inverter.



H BRIDGE CONVERTER

An H-bridge is an electronic circuit that switches the polarity of a voltage applied to a load. In this case we are using the full bridge bidirectional converter in our project.



An H bridge is built with four switches (solid-state or mechanical). When the switches S1 and S4 (according to the first figure) are closed (and S2 and S3 are open) a positive voltage will get the output terminal . By opening S1 and S4 switches and closing S2 and S3 switches, this voltage is reversed,

the negative voltage will get the output terminal . in this manner the DC supply is convert to the AC supply ,so its working as a inverter circuit

This converter is a bidirectional converter so we change the firing angle of the switches. The converter is working as a rectifier. In this manner the AC supply is converted to the DC supply.

In this type of converter applicable for upto 75 KW power rating system

2.5 Description of Components:

BATTERY

The lead acid battery is a type of rechargeable battery .Its ability to supply the cells have a relatively large power-to-weight ratio. These features, along with their low cost, make them attractive for use in electric vehicles to provide the high current required

Discharge

In the discharged state both the positive and negative plates become lead(II) sulfate (PbSO4), and the electrolyte loses much of its dissolved sulfuric acid and becomes primarily water. The discharge process is driven by the pronounced reduction in energy when 2 H+(aq) (hydrated protons) of the acid react with O2− ions

of PbO_2 to form the strong O–H bonds in H_2O (ca. −880 kJ per 18 g of water).This highly exergonic process also compensates for the energetically unfavorable formation of $Pb^{2+}(aq)$ ions or lead sulfate ($PbSO_4(s)$).

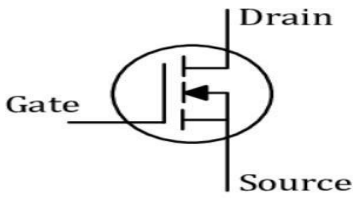
Charging

In the fully charged state, the negative plate consists of lead, and the positive plate is lead dioxide. The electrolyte solution has a higher concentration of aqueous sulfuric acid, which stores most of the chemical energy. Overcharging with high charging voltages generates oxygen and hydrogen gas by electrolysis of water, which bubbles out and is lost. The design of some types of lead–acid battery allows the electrolyte level to be inspected and topped up with pure water to replace any that has been lost this way.

MOSFET

MOSFET (Metal-Oxide-Semiconductor Field-Effect Transistor) is to be able to control the voltage and current flow between the source and drain terminals. its low gate drive power, fast switching speed, easy advanced paralleling capability, wide bandwidth, ruggedness, easy drive, simple biasing, ease of application, and ease of repair. In particular, it is the most widely used low-voltage (less than 200 V) switch. It can be found in a wide range of applications, such as most power supplies, DC-to-DC converters. there are three terminals

- Drain
- Source
- Gate



The IRF840 N-Channel type MOSFET is used. The MOSFET switches load upto 500volt and consume up to 8A,it can be turned on by providing a gate threshold voltage of 10V in between the Gate and Source pin.

Features:

N-Channel Power MOSFET

Continuous Drain Current (ID): 8A

Gate threshold voltage (VGS-th) is 10V (limit = ±20V)

Drain to Source Breakdown Voltage: 500V

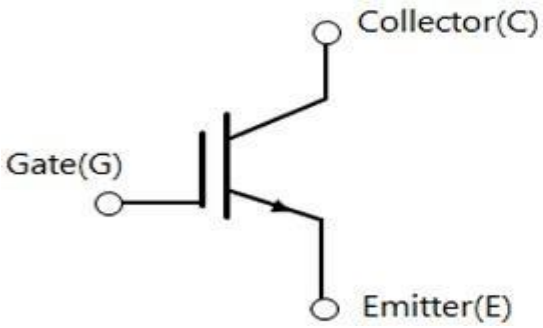
Drain-Source Resistance (RDS) is 0.85 Ohms

Rise time and the fall time is 23nS and 20nS

Available in To-220 package

IGBT

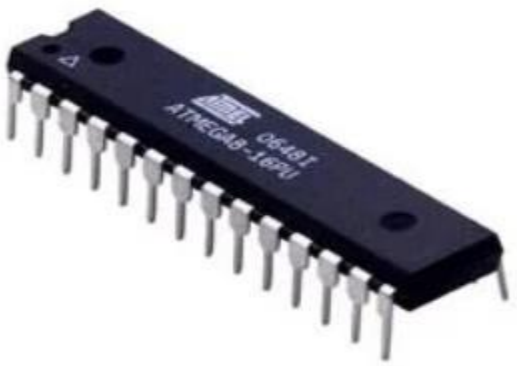
IGBT is the short form of Insulated Gate Bipolar Transistor. It is a three-terminal semiconductor switching device that can be used for fast switching with high efficiency in many types of electronic devices. These devices are mostly used in amplifiers for switching/processing complex wave patterns with pulse width modulation (PWM). The typical symbol of IGBT along with its image is shown below.



As mentioned earlier an IGBT is a fusion between a BJT and MOSFET. The symbol of the IGBT also represents the same, as you can see the input side represents a MOSFET with a Gate terminal and the output side represents a BJT with Collector and Emitter. The Collector and the Emitter are the conduction terminals and the gate is the control terminal with which the switching operation is controlled.

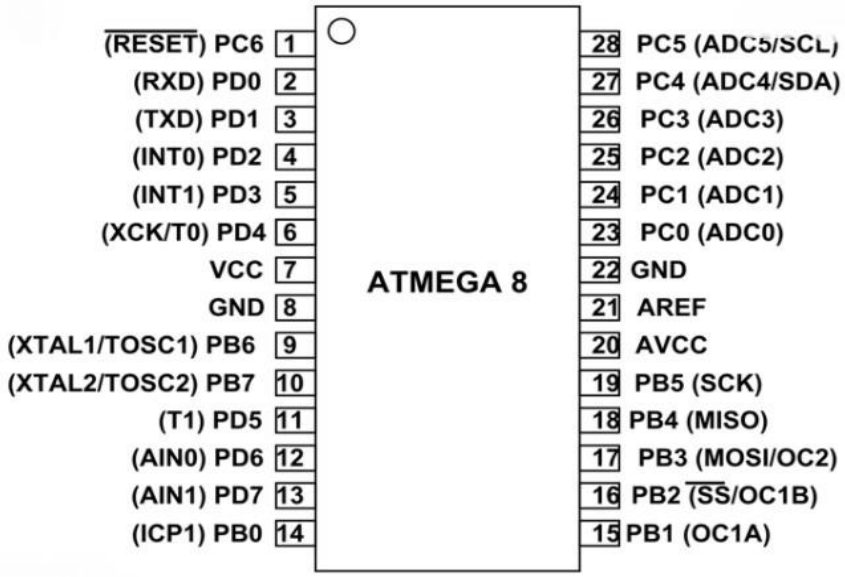
ATMEGA8

ATmega8. It is an 8-bit AVR microcontroller that is based on RISC CMOS technology and comes with a 28-pin interface for the PDIP package. The Program memory is 8K Flash while RAM and EEPROM are 1K and 512 bytes respectively. three ports available in ATmega8, namely port-B, port-C, and port-D and 23 I/O line can be obtained from these ports.



There are 3-Internal Timer/Counter are accessible, 8 bit-2, 16 bit-1, presenting numerous operating modes & supporting internal/external clocking.

ATmega8 microcontroller holds three integrated communication devices. One of them is an SPI, 4-pins are allocated to the Microcontroller to implement this system of communication.



ATmega8 USART supports both synchronous & asynchronous data transmission schemes. It has three pins allocated for that. In many communication projects, the USART module is mostly used for communication with PC-Microcontrollers.

Two-Wire Interface (TWI) is another communication device that is present in the ATmega8 microcontroller. It permits designers to set up a communication between two devices using two wires along with a mutual GND connection, As the output of the TWI is made using open collector outputs, therefore external pull-up resistors are compulsory to make the circuit. Inbuilt ADC (analog to digital converter) can alter an analog input signal into digital data of the 10-bit resolution.

SAE J1772 STANDARD CABLE

It's a standard cable for energy transfer function in electric vehicles. It is also known as a J plug, is a North American standard for electrical connectors for electric vehicles maintained by the SAE International and has the formal title "SAE Surface Vehicle Recommended Practice J1772, SAE Electric Vehicle Conductive Charge Coupler". This cable operate a general physical, electrical, communication protocol, and performance requirements for the electric vehicle conductive charge system and coupler

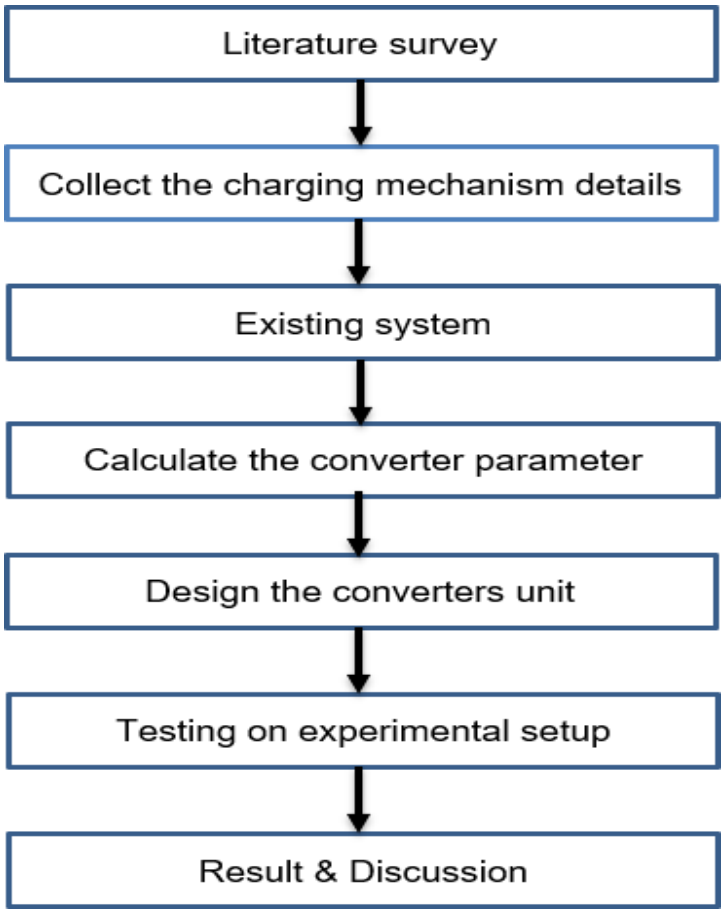
SAE J1772

SAE J1772-2009 electric vehicle connector.

CHAPTER 3

IMPLEMENTATION

3.1 Flow Chart



3.2 IMPLEMENTATION SYSTEM:

ON board charging unit hardware setup there are four converters. two converters are placed in source vehicle A (Buck Boost converter,H Bridge converter).another two converters are placed in destination vehicle B.

First implementation step is select the components based on parameters .At the time collect all the components and connect as per the circuit diagram.

Converter operations depend on PWM input . PWM input signal is generated by ATmega8. Initially code the ATmega8 microcontroller .First step is to declare the global variables & ADC function command. ADC runs at 125KHz at the sample rate @16MHz,which runs at free running mode.

Next, initialize all input/output ports (Port B Port C Port D) and Timers/Counters. System clock provides the source clock signal, timer/counter 0,2 is disable mode .Timer 1 is running condition ,its a 16bit register.8 MHz clock value which operates Fast PWM mode 0×00FF. At the same initialize the time interrupt flags,USART,Analog comparator,ADC,SPI ,TWI registers.

A buck -boost converter to buck the voltage for the battery which is connected to the H-Bridge converter circuit to convert the voltage and connected to the other vehicle input by its operated mode of charging means which vehicle is going to be charged.

The circuit added a bidirectional converter. It will act as an inverter and also a rectifier because the battery has charge by AC input and also another vehicle battery that the main thing has been implemented .

While using a buck - boost converter can change the desire voltage to work in both AC and DC voltage to reliable the for conversation

CHAPTER 4

RESULT AND DISCUSSION

4.1 System Specifications:

BATTERY

Lead acid	-	-12v/5A
Charging /discharging efficiency	-	50-95%
self-Discharge rate	-	3-20%/month
Cycle durability	-	<350 cycle

BUCK BOOST CONVERTER

COMPONENTS	**TYPE**	**RANGE**
MOSFET	IRF840	440V/5A
DIODE	IN4007	40V/5A
Inductor	330mH	110V/1A
Capacitor	1000uF	1A/63V

- Source vehicle -BUCK mode

  duty cycle-0.294s

  output voltage-5.7v

- Destination vehicle- BOOST mode

  duty cycle-0.705s

  output voltage-12.6 v

H BRIDGE CONVERTER

COMPONENTS	**TYPE**	**RANGE**

IGBT	G40N60	600V/20A
RESISTER	10K ohm	12V/1A
Inductor	20mH	110V/1A
Capacitor	1000uF	1A/63V

CONTROLLER

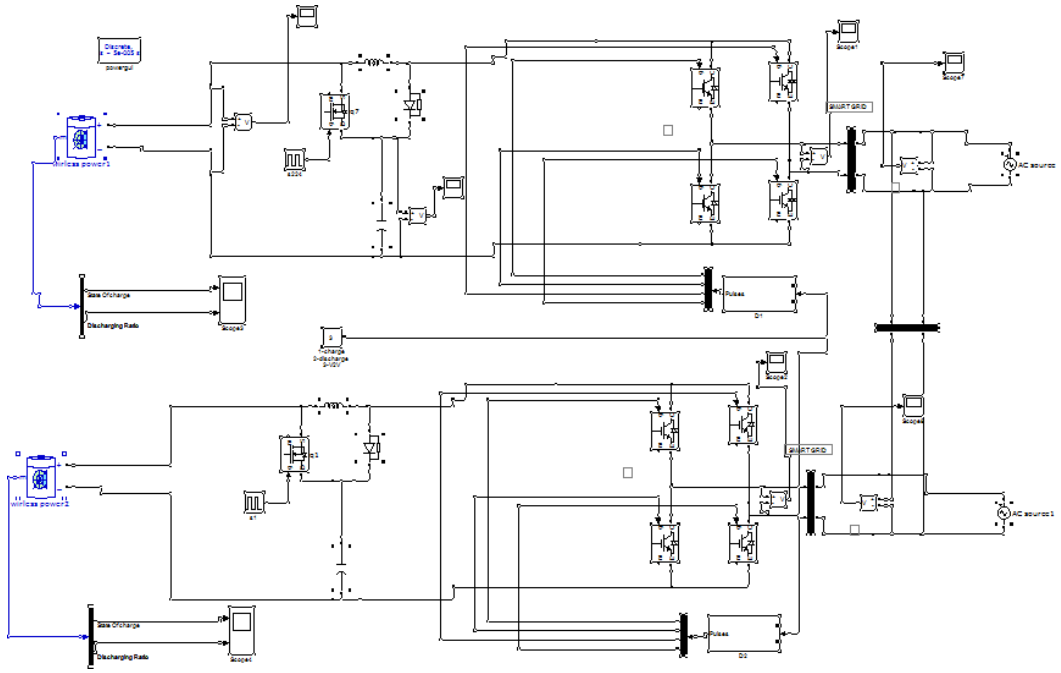
- ATmega8 Microcontroller

Operating mode		Fast PWM mode
clock source		system clock
clock value		8MHz
output		Non Inverting
Timer selection		Timer (16 Bit)
Input capture		Falling edge

4.2 Simulation Results:

Circuit has done in MATLAB SIMULINK

SIMULINK CIRCUIT DIAGRAM:

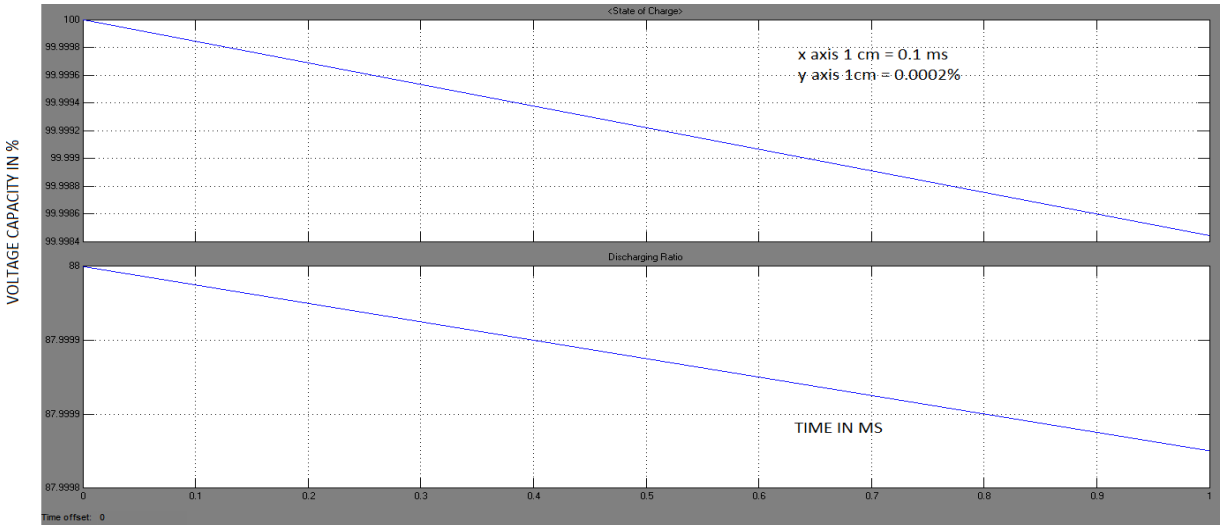


overall project Simulation diagram using MATLAB SIMULINK

V2V Technology simulink diagram outputs are dragged below in simulink output.In circuit two batteries are provided one is for source and another one is for destination then the batteries are connected with converter in simulink diagram . In V2V operation is the combination of V2G & G2V technology. the source circuit is working on V2G principles and the destination circuit is working on G2V principles. In future this charging circuit is used for V2X function

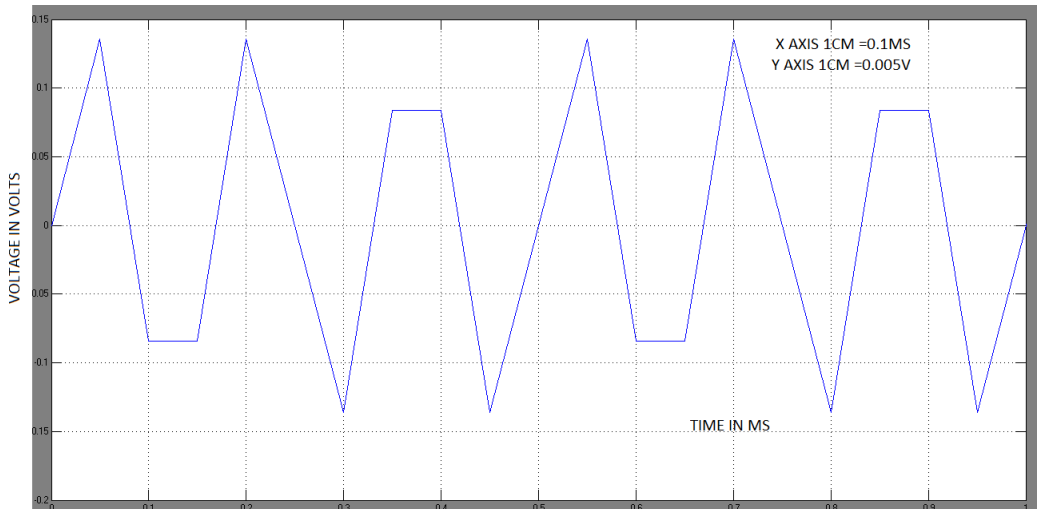
SIMULINK OUTPUT:

BATTERY "A" OUTPUT: Discharging mode



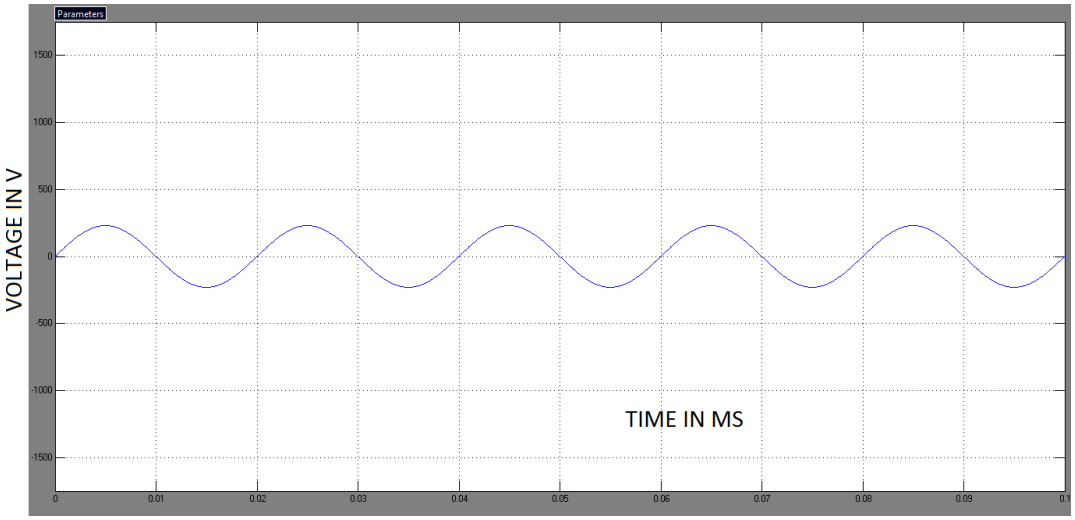
When the battery A is discharging, the exponential voltage decreases immediately so the voltage has fall down from 100 - 0 %

BUCK BOOST CONVERTER -A OUTPUT: Buck operation



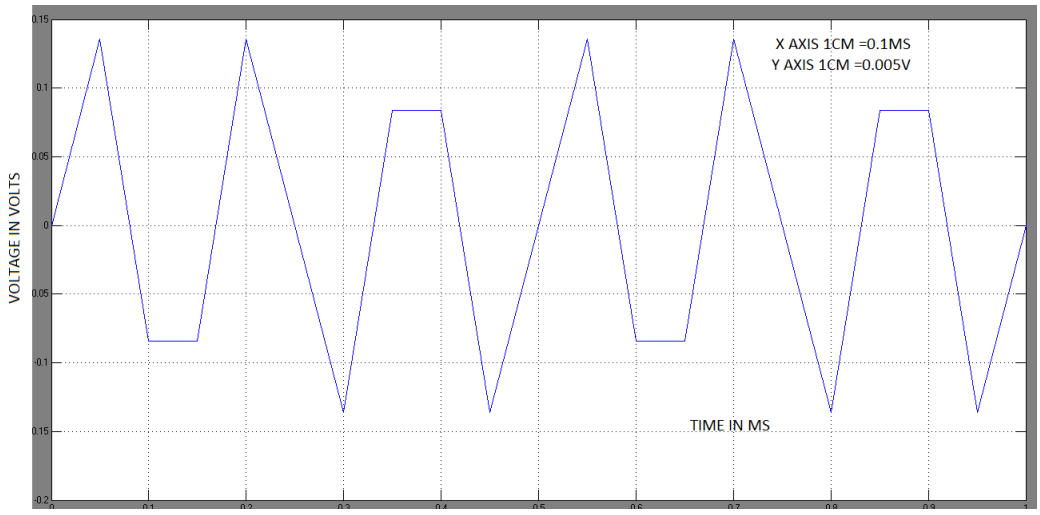
Buck - Boost converter (buck operation) which steps down voltage from its input (source) to its output (load).Run the simulation and observe waveforms on Scope input voltage > output voltage.

H BRIDGE CONVERTER-A OUTPUT : Inverting mode



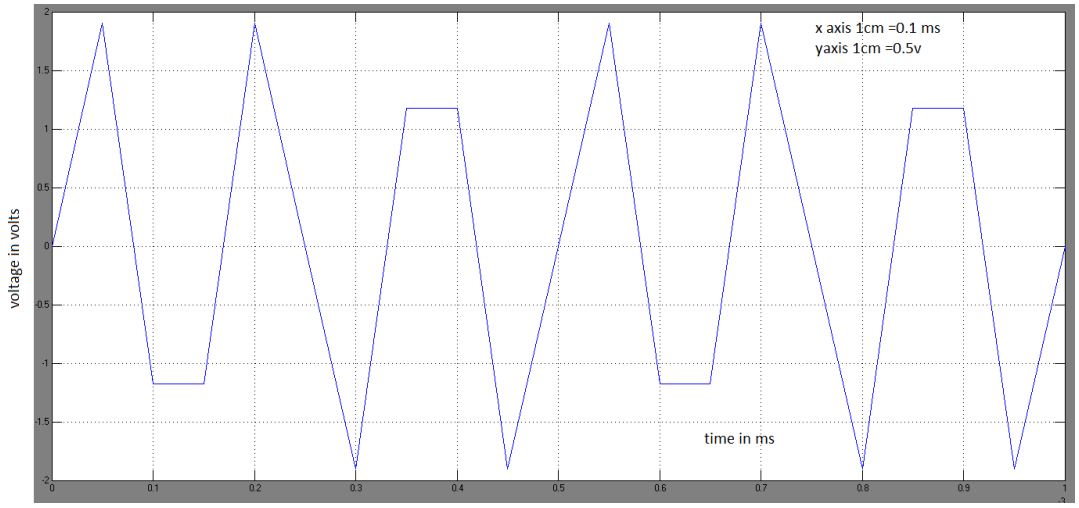
Converter “A” works as an inverter that inverts the dc voltage into sine wave ac voltages. This ac voltage output is input of the vehicle B H bridge inverter . This voltage output is directly connected to the AC grid (V2G) to the future purpose.

H BRIDGE CONVERTER-B OUTPUT: Rectifier mode



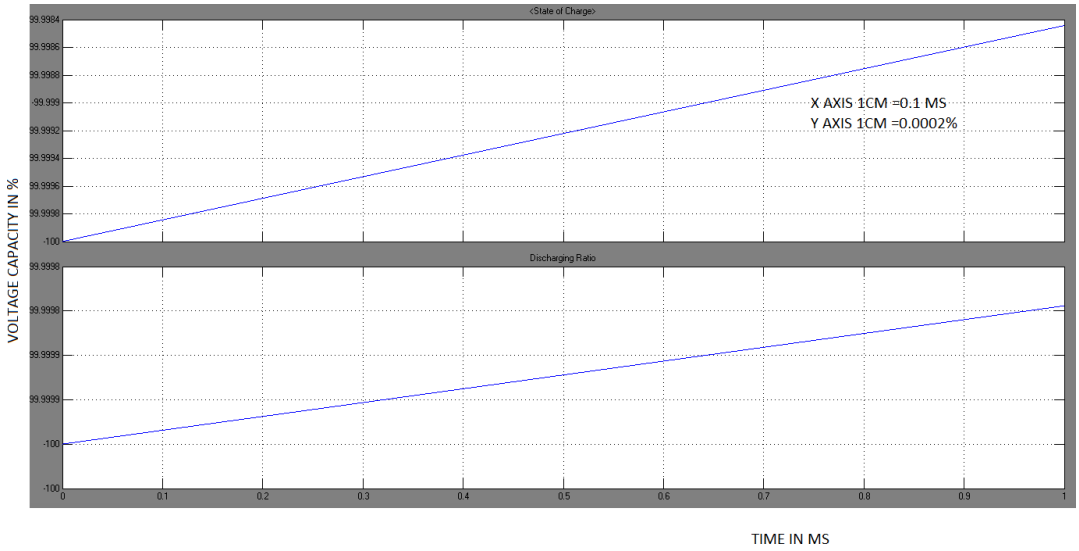
The V2V operation of this system Vehicle B side H bridge Converter B works as a rectifier that convert ac voltage into dc voltage

BUCK BOOST CONVERTER - B OUTPUT : Boost operation



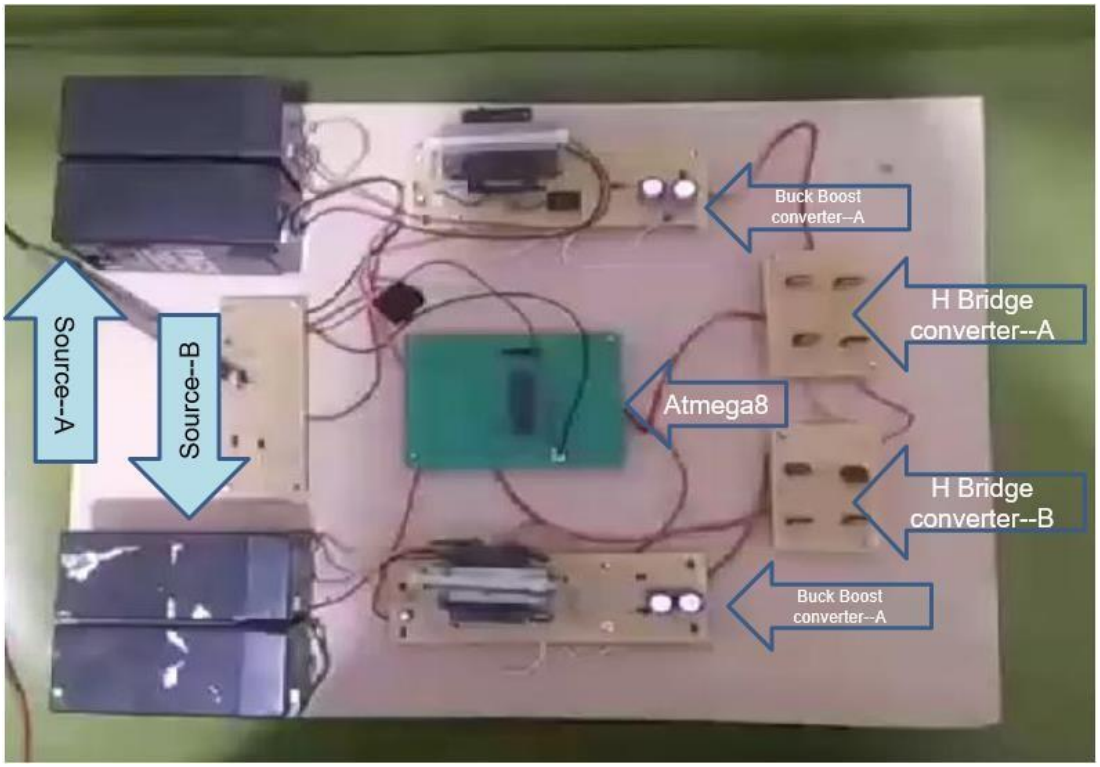
Buck - Boost converter (boost operation) which steps up voltage from its input (source) to its output (load).Run the simulation and observe waveforms on Scope input voltage < output voltage

BATTERY B CHARGING OUTPUT:



When the battery B is charging, the exponential voltage increases immediately so the voltage is rises from 0 - 88.8%

4.3 HARDWARE CIRCUIT



CHAPTER 5

5.1 CONCLUSION:

This project multifunctional EV charger with a novel V2V function that enables the charger to provide roadside charging assistance. The proposed system portable charging cables are used but our system only used a charging converter and e standard SAE J1772 cable of V2V energy transformation function. This function will become vital when the number of EVs grows and the demand for roadside charging assistance subsequently increases. Also this converter set is very useful for V2X functionality in future purposes. The design procedure of V2X(V2G,G2V) function is analytically verified through hardware circuits.

5.2 FUTURE SCOPE:

In future, the vehicle battery drawn down at Rural area, then there's no charging stations by using another vehicle can charge the battery and can charge though the AC source also

APPENDIX

CODING:

```
#include <mega8.h>
#include <delay.h>
#include <alcd.h>
void adc_init(void)
{
  ADCSRA |= (1 << ADPS2) | (1 << ADPS1) | (1 << ADPS0);
  ADMUX |= (1 << REFS0);
  ADMUX |= (1 << ADLAR);
  ADCSRA |= (1 << ADFR);
  ADCSRA |= (1 << ADEN);
  ADCSRA |= (1 << ADSC);
}
unsigned int read_adc(unsigned char ch)
{
        ADMUX &= 0xF8;
        ADMUX |= ch;
        ADCSRA |= (1 << ADSC);
        while ((ADCSRA & 0x10)==0);
        return(ADCW);
}
```

```
void main(void)
{
// Input/Output ports Initialization
PORTB=0x00;
DDRB=0x02;
PORTC=0x00;
DDRC=0x00;
PORTD=0x00;
DDRD=0x00;
 // Timer/Counter 0 Initialization
TCCR0=0x00;
TCNT0=0x00;
  // Timer/Counter 1 Initialization
TCCR1A=0x81;
TCCR1B=0x09;
TCNT1H=0x00;
TCNT1L=0x00;
ICR1H=0x00;
ICR1L=0x00;
OCR1AH=0x00;
OCR1AL=0x00;
OCR1BH=0x00;
OCR1BL=0x00;
```

```
 // Timer/Counter 2 Initialization
ASSR=0x00;
TCCR2=0x00;
TCNT2=0x00;
OCR2=0x00;
 //External Interrupt Initialization
MCUCR=0x00;
 // Timer/Counter interrupt Initialization
TIMSK=0x00;
 //USART Initialization
UCSRB=0x00;
 //Analog Comparator Initialization
ACSR=0x80;
SFIOR=0x00;
 //ADC Initialization
ADCSRA=0x00;
 //SPI Initialization
SPCR=0x00;
//TWI Initialization
TWCR=0x00;
// Alphanumeric LCD Initialization
lcd_init(16);
adc_init();
lcd_clear();
```

```
while (1)
        {

        V=adc_read(5);
        i=adc_read(4);
        p[d]=v*i;
        z=exor(v,i);
        PORTB=0x03;
        delay_ms(z*10);
         PORTB=0xAC;
        delay_ms(z*10);
        PORTB=0x07;
        delay_ms(z*10);
        }
}
```

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