A Novel Method for Vehicle Battery Charging System with Regeneration using Embedded System

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Abstract: *Industrial synchronous motors are used to increase the speed of a machine. It is more popular than other a.c. fixed-performance motor motors due to their longevity and great load capacity. Due to specific problems and difficulties, the speed regulation of the synchronous motor has not improved until recent improvements in the industrial sector. The goal of this project is to change the frequency of the automobile stator supply in order to manage the car's speed. The inverter for the three-phase MOSFET Bridge is used to acquire the voltage of the three-phase supply. MOSFET bridges are powered by a fixed dc power source acquired by using a diode bridge circuit to control the ac voltage found in ac mains. Filtering is done with a shunt capacitor filter. The process of a control circuit regulates the MOSFET Bridge. The control cycle contains the gating pulses required to unlock the MOSFET. The frequency output of the MOSFET Bridge is regulated by adjusting the frequency of the gating pulses. When the gating signal frequency changes, the MOSFET Bridge output frequency changes as well. As a result, we have the variable frequency's output. Because the hacking signal retrieved from the control hole is so weak, it cannot be used directly on the MOSFET Bridge. As a result, a driving circuit and an isolator are used. The opto Separator achieves the essential separation of the low-power control circuit from the high-power bridge.*

Keywords: Electric Vehicle, Battery charging System, Embedded System, Energy Regeneration, Microcontroller

I. INTRODUCTION

Hybrid Electric Vehicles (HEV) and Electric Vehicles (EV) are becoming more and more attractive due to the higher oil prices and the development of new battery technologies, such as Lithium-Ion, which have higher power and energy density. The battery charger converts the alternating current distributed by electric utilities into the direct current needed to recharge the battery. This mode of operation is known as Grid to Vehicle (G2V). However, a Vehicle to Grid (V2G) concept has arisen in the last years, allowing returning back to the grid the energy stored in the battery packs that has not been used by the vehicle. This operation mode will cause a great impact on the power grid. Specifications for V2G technology are still being developed by the Society of Automotive Engineers as part of the ZigBee Alliance [1]-[3].

At present, there are commercial EVs with single-phase unidirectional G2V chargers, which demand a highly distorted current form the grid. As an example, the measured current demanded by a commercial car (Reva-i) while charging the battery is shown in Fig. 1(a) and the harmonic spectrum is displayed in Fig. 1(b). The Total Harmonic Distortion (THD) of the demanded current is over 20%, far exceeding the value permitted by the standard IEEE-519. If a proliferation of EVs is expected in the next years, it is very important to investigate in the control strategies of chargers in order to reduce the harmonic distortion demanded by the batteries or the power grid will suffer a power quality degradation. Besides, the time required to recharge electric vehicle batteries depends on the total amount of energy that can be stored in the battery pack, and the power available from the battery charger. According to it, the design of three-phase chargers will allow, on the one hand, managing a higher power flow between the battery and the grid and, on the other hand, to provide or demanding power to help balance loads. Nowadays, a great study of charger models is being carried out [4]-[11]. In this paper a three-phase bidirectional (G2V and V2G operation modes) battery charger is presented. The novel control strategy proposed for the charger turns the car into a smart vehicle, demanding or injecting a sinusoidal and balanced source current, with unity displacement power factor, contributing to the improvement of the power quality. Simulation models of the battery pack, including the self-discharge effect, and the charger have been implemented to validate by simulation the proper operation of the charger under sinusoidal, distorted and unbalanced source voltages.

The electrical machine that converts electrical energy into mechanical energy and vice versa, is the workhorse in a drive system. Drive systems are widely used in applications such as fibers spinning mills, rolling mills, MAGLEV - linear synchronous motor propulsion, aircraft engines, paper and textile mills, electric vehicle and subway transportation, home appliances, wind generation systems, servos and robotics, computer Peripherals steer and cement mills, ship propulsion, etc. A synchronous machine, as the name indicates, must rotate at synchronous speed is uniquely related to supply frequency. Each machine has got its own advantages and disadvantages.

In a permanent magnet synchronous machine, the dc field winding of the rotor is replaced by a permanent magnet. The advantages are elimination of field copper loss, higher power density, lower rotor inertia and more robust construction of the rotor. The demerits are loss of flexibility of field flux control and possible demagnetization effect. The machine has higher efficiency than an induction motor, but generally its cost is higher, which makes the life cost of the drive some what lower. PM machines particularly at low power range are widely used in industry. Recently, the interest in their application is growing, particularly up to 100 kW. Three phase supply voltage are obtained with the help of three phase MOSFET bridge inverters.

Variable speed drives with AC motors are superior to DC drive systems in many ways, important amongst them are as follows:

1. Very high speed of operation.
2. Rugged design
3. Less maintenance.
4. Most suitable for explosive, hazardous and dusty areas or where maintenance is both difficult and dangerous.
5. Possibility of gearless drive system.
6. Possible to operate the motor directly from the main by using bypass switch as a standard arrangement.
7. Reduction in starting current (Large torque per ampere burning stating)
8. Low electrical noise (No brushes).
9. Low cost of machine installation.
10. Energy saving: An average plant can save as much as 20% of its total energy.

In this we first consider the design of the control circuit. The heart of the project is three phase inverter section and control of inverter section. Let us start with the Clock generator using microcontroller. Microcontroller interface with keypad, LCD and ADC is as shown in fig. Using potentiometer ref signal to ADC is varied to change the output frequency of inverter.

II. PROPOSED SYSTEM

It is clear that speed of the synchronous motor can be controlled if the stator supply frequency can be controlled. Permanent magnet synchronous motor is used here with three stator windings for the motor operation. Three phase supply voltage are obtained with the help of three phase MOSFET bridge inverters. MOSFET bridges are mains with the help of diode bridge circuit. Shunt capacitor filter is used for filtering purpose. Operation of the MOSFET Bridge is controlled by the control circuit. Gating pulses required to turn the MOSFET on are obtained from the control circuit. By controlling the frequency of the gating pulses frequency of the output from MOSFET Bridge is controlled.

If frequency of the gating signal is varied, then the MOSFET bridge output frequency is also varied. Thus we obtain variable frequency output. Gating signal outputted by controller port, cannot be directly applied to MOSFET Bridge, as they are very weak. So isolator and driver circuit is used. Necessary isolation of low power control circuit from high power bridge is obtained by using opto-isolator.

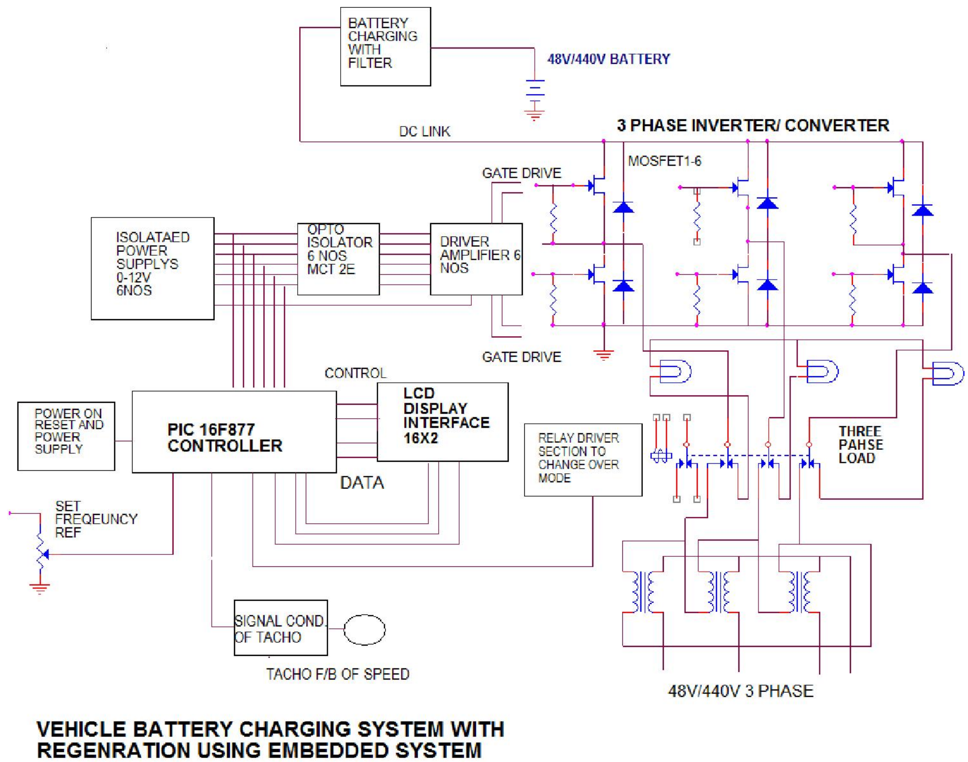

Fig. 1. Block Diagram

2.1 PIC 16f877 Microcontroller

This powerful (200 nanosecond instruction execution) yet easy-to-program (only 35 single word instructions) CMOS FLASH-based 8-bit microcontroller packs Microchip's powerful PIC® architecture into a 40 package and is upwards compatible with the PIC16C5X, PIC12CXXX, and PIC16C7X devices. The PIC16F877A features 256 bytes of EEPROM data memory, self-programming, an ICD, 2 Comparators, 8 channels of 10-bit Analog-to-Digital (A/D) converter, 2 capture/compare/PWM functions, the synchronous serial port can be configured as either 3-wire Serial Peripheral Interface (SPI™) or the 2-wire Inter-Integrated Circuit (I²C™) bus and a Universal Asynchronous Receiver Transmitter (USART).

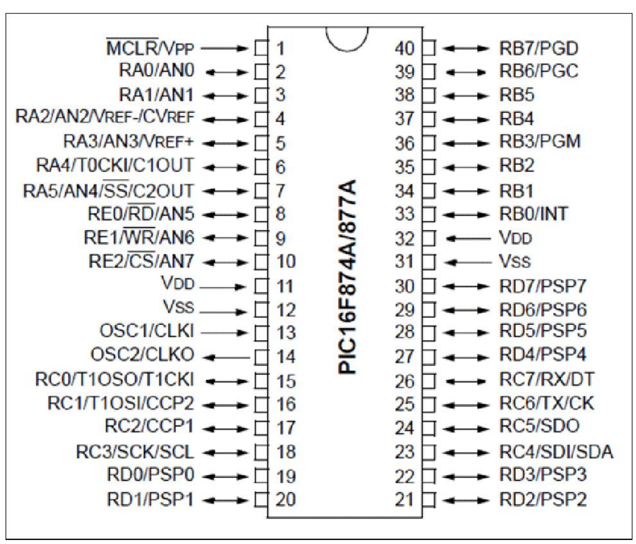

Fig 2. PIC16f877

IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
Impact Factor: 6.252
Volume 2, Issue 6, June 2022

A. Transformer

A transformer makes use of Faraday's law and the ferromagnetic properties of an iron core to efficiently raise or lower AC voltages. It of course cannot increase power so that if the voltage is raised, the current is proportionally lowered and vice versa.

- When it comes to the operation voltage, the step-up transformer application can be roughly divided into two groups: LV (voltages up to 1 kV) and HV application (voltages above 1 kV).
- Just as transformers can step down the voltage – going from a higher primary side voltage to a lower secondary side voltage – they can also step up the voltage, going from a lower primary side voltage to a higher secondary side voltage. These are known as step-up transformers.
- The transformer turns ratio (n) for a step down transformer is approximately proportional to the voltage ratio

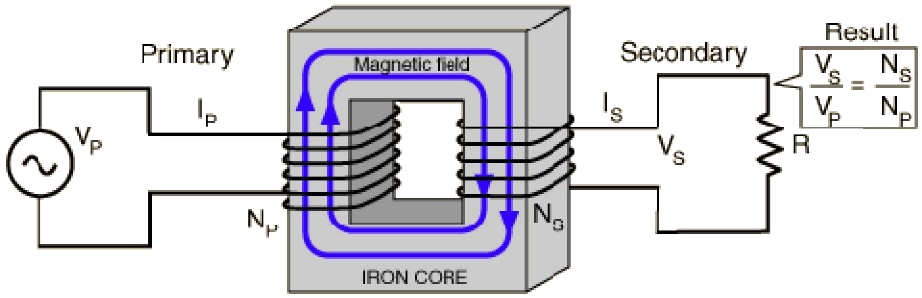

Fig. 3. Transformer

B. LCD Display

LCD (Liquid Crystal Display) screen is an electronic display module and find a wide range of applications. A 16x2 LCD display is very basic module and is very commonly used in various devices and circuits. These modules are preferred over seven segments and other multi segment LEDs. The reasons being: LCDs are economical; easily programmable; have no limitation of displaying special & even custom characters (unlike in seven segments), animations and so on.

A 16x2 LCD means it can display 16 characters per line and there are 2 such lines. In this LCD each character is displayed in 5x7 pixel matrix. This LCD has two registers, namely, Command and Data. The command register stores the command instructions given to the LCD. A command is an instruction given to LCD to do a predefined task like initializing it, clearing its screen, setting the cursor position, controlling display etc. The data register stores the data to be displayed on the LCD.

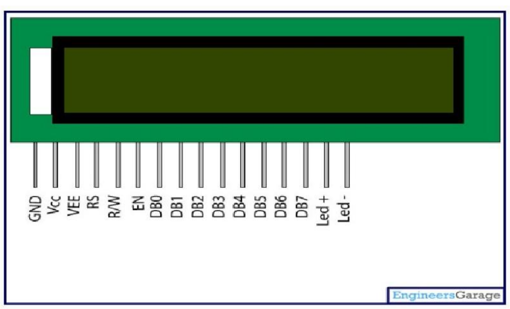

Fig. 4 LCD Display

C. Convertor/ Power Bridge Rectifier

The stabilization of d.c. output is achieved by using the three terminal voltage regulators IC. This regulator IC comes in two flavours: 78xx for positive voltage output and 79xx for negative voltage output. For example, 7805 gives +5 V and 7905 gives -5 V stabilized output. These regulator ICs have in-built short circuit protection and auto-thermal cut-out provision. If the load is very high the IC needs 'heat sink' to dissipate the internally generated power.

IJARSCT

ISSN (Online) 2581-9429

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Impact Factor: 6.252

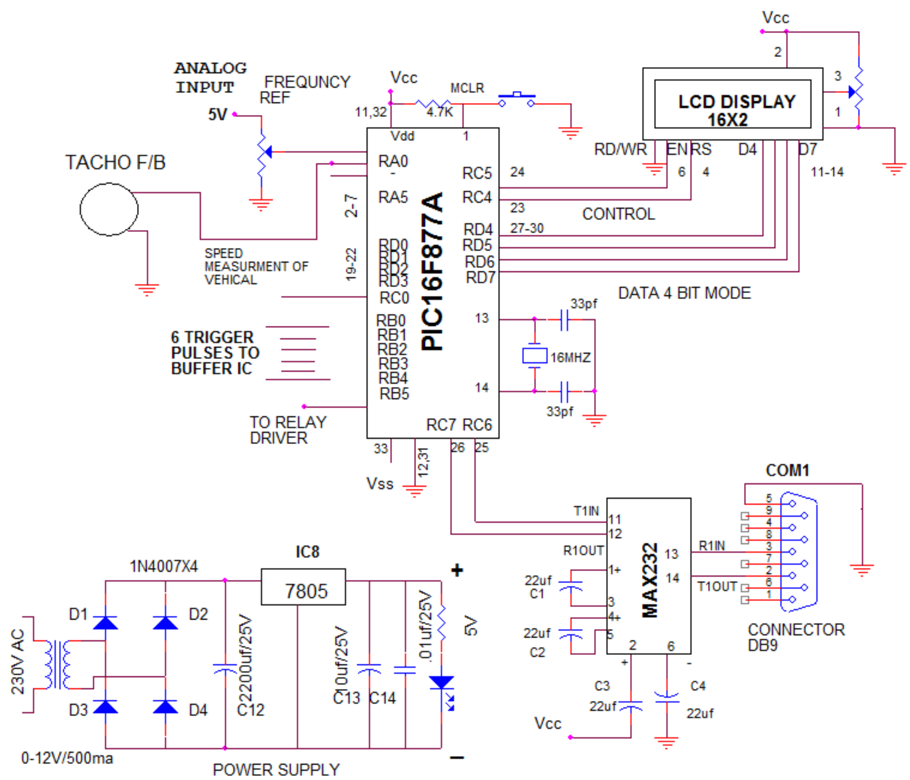
D. Design of Isolator and Driver Circuit

The above fig. shows the isolater and driver circuit. Square wave pulses are available at the output of the control circuit. Which have phase relation as per the requirement. The power circuit is operating at very high voltage while control circuit is operating at the various voltages as compare to power circuit. so the control circuit ground and power circuit ground must be isolated from each other to protect control circuit from any damage due to malfunctioning in power circuit. If isolation is not used then it may be dangerous to operator. Also without isolation when gate pulses are applied the device becomes on and the live terminal of supply is connected to ground of control circuit and power circuit. Any operation trying to control the circuit is likely to touch control ground (which is usually supposed to be the safest potential) and in fact is directly in contact with the live terminal of supply. Thus it is dangerous for the operation. This isolation is very much essential.

One more requirement of isolation for gate drives in the system used here is as follows for operating power MOSFET's as switches on appropriate gate voltage must be applied to drive the MOSFET's into the saturation mode for low on state voltage. The control voltage should be applied between the gate and source terminals. The logic circuit generates four control pulses; these pulses are shifted in time to perform the required logic sequence for power conversion from dc to ac. However, all six logic pulses have a common ground. But for all MOSFET's gate voltage must be applied with respect to its sources.

The isolation can be provided by either pulse transformer optocoupler. Here optocouplers are used. An optocoupler used here is an IC chip MCT2E which is containing an IR LED and photo transistor as transmitter\ receiver pair. The output of MICROCONTRLLER is given to output of respective MCT2E to buffers. The signal available from optocoupler alone is not having enough strength to drive the power device. So BC547 is used as a driver transistor. Now the signal available at the emitter of driver transistor is suitable to drive the power switching device.

E. Main Power Circuit



VEHICLE BATTERY CHARGING SYSTEM WITH REGENRATION USING EMBEDDED SYSTEM

- The three phase inverters are normally used for the high power applications. In order to get a three phase output, three single phase inverters can be connected in parallel as shown in above fig.
- The gating signals of the three single phase inverters should be advanced or delayed by 120° with respect to each other in order in order to obtain three phase balanced voltages.
- The transformer primary winding must be isolated from each other, while the secondary winding may be connected in wye or delta.
- A three phase output can be obtained from a configuration of six power devices and six diodes as shown in fig. the configuration is known as the three phase bridge configuration.
- The diodes D1 to D6 connected across the transistors are called as the “Feedback Diodes”. These diodes will return back the stored energy from the inductive load to the DC supply.
- They also protect the power transistors against a negative V_{CE}. The negative V_{CE} may appear across the transistors if the load is inductive.

III. Result and Conclusion

Production This paper describes work that has been developed in order to provide a conceptual system to assist and manage

Electrical Vehicles (EV) charging process.

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Following photograph shown actual model of our project:

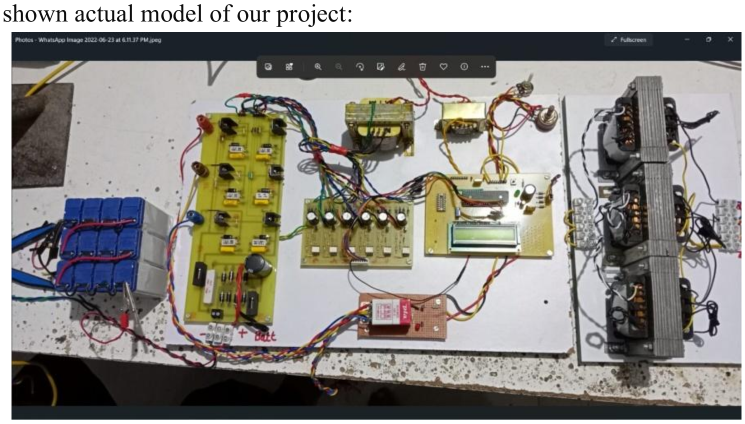

Figure 5: Photograph of hardware.

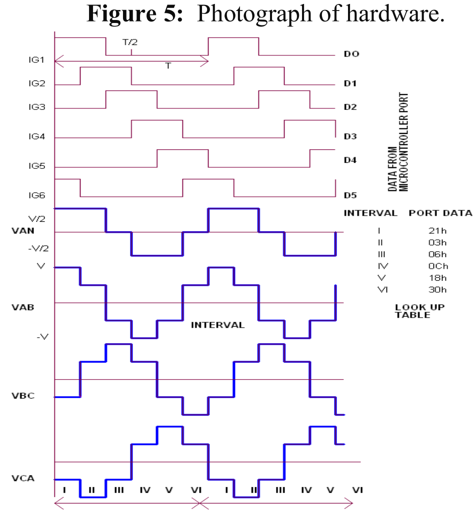

Fig. 6. 3 phase inverter waveforms

Here we successfully implemented a Novel Method for Vehicle Battery Charging System with Regeneration using Embedded System. Gets outcomes are given below:

- Regeneration braking can minimize the wear of the brake pads, extend the driving range of EVs and reduce the maintenance cost significantly.
- Operation principle and equivalent power circuit of EVs under regenerative braking control are described in this paper.
- To overcome the influence due to the uneven system parameters, temperature change, and disturbance, a robust sliding mode current controller is designed.
- Reachability, sliding mode plane, and stability of the system using the proposed controller are put forward and demonstrated.The performance of the suggested controller is validated by experiments; Experimental results demonstrate that the proposed scheme could achieve good dynamic performance and robust stability.
- The driving range could be improved by the proposed controller, which validates the correctness and feasibility of regenerative braking for battery-powered EVs.

ACKNOWLEDGMENT

It gives us great pleasure in presenting the paper on “A Novel Method for Vehicle Battery Charging System with Regeneration using Embedded System”. We would like to take this opportunity to thank our guide, Dr.Sridhar Khule, Dr. Rakesh Sriwastawa, Prof.Somnath Hadpe Professor, Matoshri Collage of Engg. Research Center, Nshik for giving us all the help and guidance we needed. We are grateful to him for his kind support, and valuable suggestions were very helpful.

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