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PROTECTION STRATEGY FOR WIRELESS CHARGING ELECTRICAL VECHICLE.

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Abstract: Wireless charging has become increasingly popular for electric vehicles (EVs) in recent years. However, possible device damage may happen because of the sharp variations of inverter output current and the ZVS angle due to the alignment variation between resonant coils especially while charging. To design a protection strategy, the characters of the inverter output current and phase angle are analyzed when the wireless charging EV leaves.

The protection strategy is composed of the insufficient angle protection, overcurrent protection, and the excessive angle protection. A detection circuit is designed to measure the variation of inverter output current and phase angle. A wireless charging EV prototype is established to validate the proposed methods. The experimental results show that the designed detection circuit and protection strategy can catch the abnormal working state of the system when the wireless charged EV leaves and take measures immediately to protect the main circuit of the system from device damages.

Wireless power Transfer (WPT) is nowadays visible to us in many different areas of technology and in many different forms and types. The technological areas vary from the crucial biomedical technology to commercial products such as wireless electric vehicle, wireless charging units and many more. Wireless transmission is useful in cases where instantaneous or continuous energy transfer is needed but interconnecting wires are inconvenient, hazardous, or impossible. The wireless energy transfer gets unique in its area of technology because of its efficiency which is the most important parameter under consideration. This makes the wireless energy transfer different from other information transfer methods. Wireless power systems for near field energy transfer, are typically classified as either inductive or resonant. The wireless power transfer surpassing efficiency is the optimum technique to transfer the power wirelessly and power up the low power devices such as Mobile phones, small fans, and any microcontroller unit

Index Terms – Fundamental Structure of an ICPT System, Varating Requirement, System Description, Block Diagram, Matlab, Results.

Introduction

With the increase of population, the use of combustion engines (mainly in vehicles) is increasing rapidly. As a result, the use of fossil fuel is also increasing day by day, which is creating pressure on the fossil fuel resources as well as increasing environmental pollutions and global warming. An effective solution of this problem is the use of electric vehicles (EV). The charging of these EV can be made convenient by using wireless charging methodology. The use of inductive based wireless charging system (WCS) for EV is more convenient, flexible, reliable and safer than conductive charging and provides operator free charging facility.

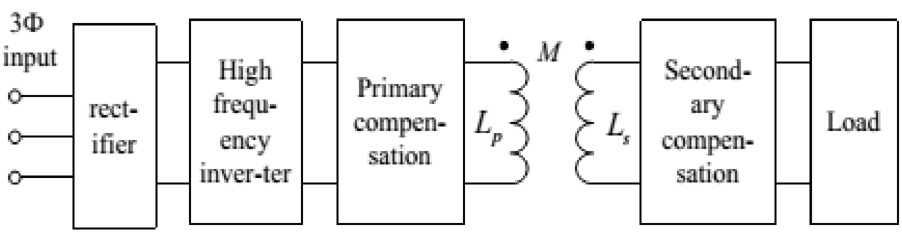
For the implementation of the charging system two coils are needed, one of which is installed in the parking garage (primary coil/transmitter coil) and another is installed inside the EV (secondary coil/receiver coil). The EV side coil should be small in size and light in weight in order to reduce additional load on the EV.

Another important aspect for designing an inductive base WCS is the compensation technique as it increases the power transfer ability and provide assistance for achieving soft switching of power electronics equipment's. There are four main compensation techniques and they are: SS (series-series), SP (series-parallel), PS (parallel-series) and PP

(Parallel parallel). Here, the alphabet "P" and "S" stand for the way how the capacitor (compensation/resonant capacitor) is connected to the coil, i.e., "P" means parallel connection of compensation capacitor with the coil and "S" means series connection of the compensation capacitor with the coil. In this paper, the SS (series-series) compensation topology is used to develop a WCS system for EV in MATLAB/Simulink

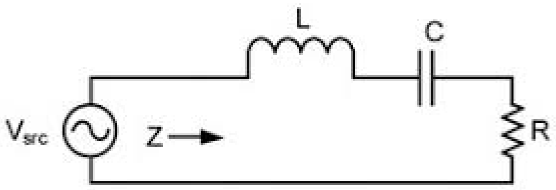
I. FUNDAMENTAL STRUCTURE OF AN ICPT SYSTEM

The general structure of an ICPT system is shown in Fig.2.2. AC source is commutated by a rectifier and then feed to a high frequency inverter, high frequency alternating current generated by the inverter is injected into the primary coil after primary compensation. The primary coil is tuned with compensation elements to minimize the VA rating of the power supply, and the secondary coil is tuned to enhance power transfer capability. The primary side and the secondary side are isolated by an air gap and there is no physical contact between them, therefore, the secondary side(load) may slide or rotating with the first coil with no mechanical attrition. Figure 2.2. General structure of ICPT system

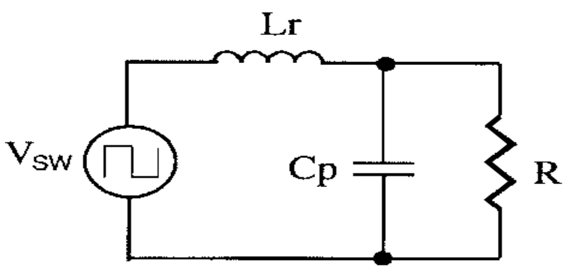


II. VARATING REQUIREMENT

In ICPT system, VA rating requirement for power supply is a major system cost, thereby the primary coil is compensated to reduce the VA rating and hence the size and cost of the power supply. As is shown in Fig.2.6, the basic primary compensation topologies include series compensation and parallel compensation. At the rated condition, the primary compensation capacitor is design to satisfy zero phase angle between the current and the voltage of power source. Thereby primary compensation capacitor values can be derived out with diriment compensation topologies. Where ‘SS’ represents series-series compensation for the primary coil and the secondary coil respectively, and the same goes for ‘SP’, ‘PS’ and ‘PP’. Because the compensation capacitors are designed at rated load value and rating coupling coefficient, for some ICPT



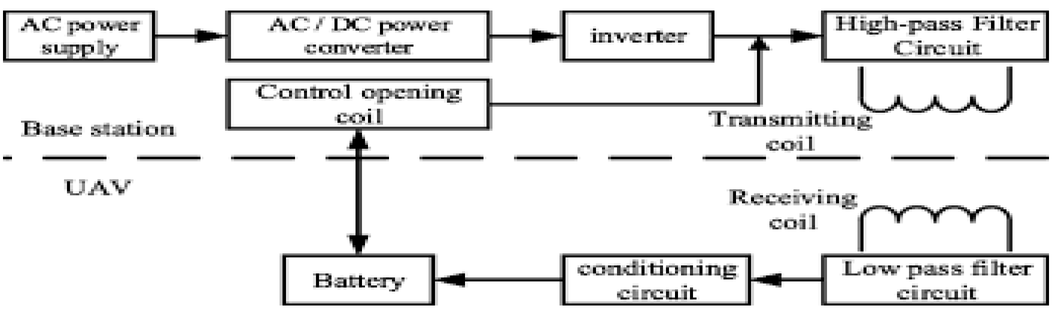
a. Series resonant converter



b. Parallel resonant converter

III. SYSTEM DESCRIPTION

The configuration of the proposed ICPT which consists of a presented VC-PFC, an inverter with a PLL, a CCT, a var compensation and a rectifier. The leakage inductance LP, the magnetizing inductance m L of the CCT and a resonant capacitor CP are consummated the LLC resonant tank, as show in. The system operation is briefly described as following: First, the VC-PFC is to convert the input AC power source in v into a controllable DC voltage d V for sourcing the inverter. By controlling the DC voltage d V, the output load power voltage regulation can be achieved. Next, the inverter provides a high frequency square wave supply to the LLC resonant tank in order to obtain a sinusoidal wave. Notably, the operation frequency of the inverter is at the resonant.



Basically, all PIC microcontrollers offer the following features:

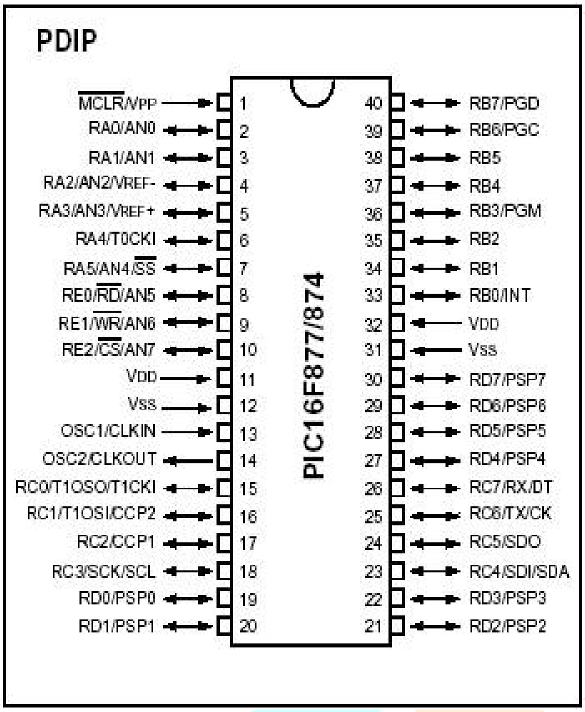
- RISC instruction set with around 35 instructions _9 Digital I/O ports
- On-chip timer with 8-bit pre scaler.
- Power-on reset
- Watchdog timer
- Power saving SLEEP mode
- Direct, indirect, and relative addressing modes
- External clock interface
- RAM data memory
- EPROM (or OTP) program memory

Peripheral features:

- High sink/source current 25mA
- Timer0: 8-bit timer/counter with 8-bit pre scaler can be incremented during sleep via external crystal/clock
- Timer2:8-bit timer/counter with 8-bit period register pre scaler and post scalar.
- Capture, Compare, PWM (CCP) module
- Capture is 16-bit, max resolution is 12.5ns, Compare is 16-bit, max resolution is 200 ns, PWM max, resolution is 10-bit
- 8-bit 5 channel analog-to-digital converter, Synchronous serial port (SSP) with SPI (Master/Slave) and (Slave)

Some device offers the following additional features:

- Analogue input channels
- Analogue comparators
- Additional timer circuits
- EEPROM data memory
- Flash EEPROM program memory
- External and timer interrupts
- In-circuit programming
- Internal oscillator
- USART serial interface



PIC 16F877A Specification:

RAM 368 bytes

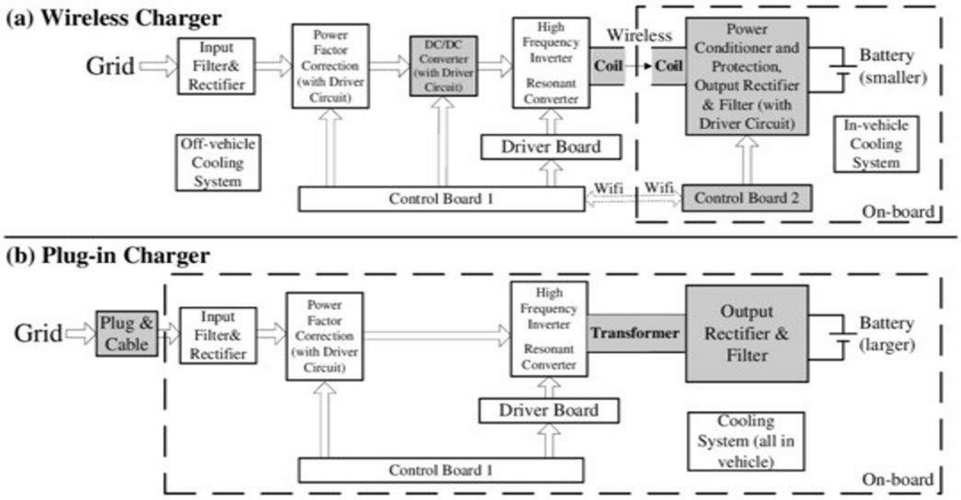
EEPROM 256 bytes

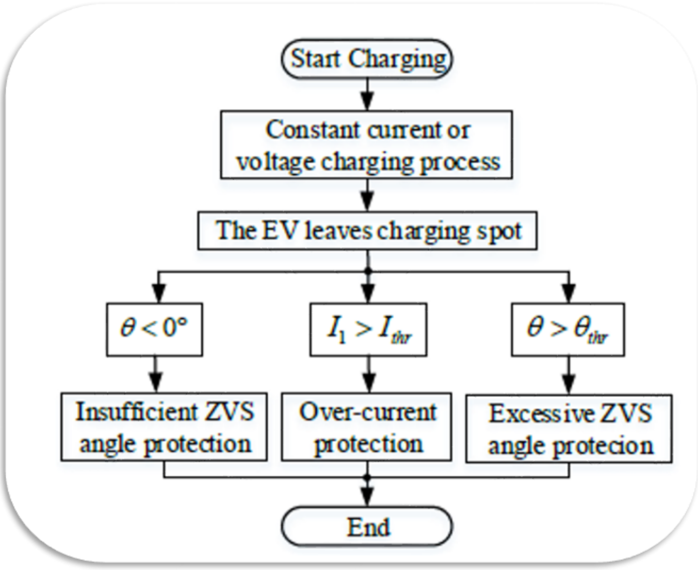
Flash Program Memory 8k words

Operating Frequency DC to 20MHz

I/O port Ports A, B, C, D, E

IV. BLOK DIAGRAM:



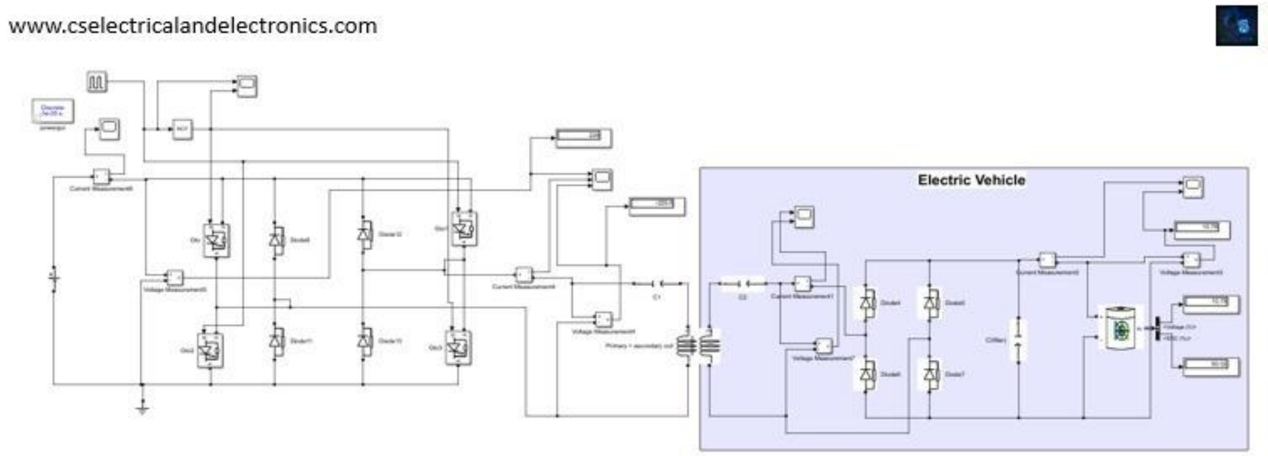


V. MATLAB:

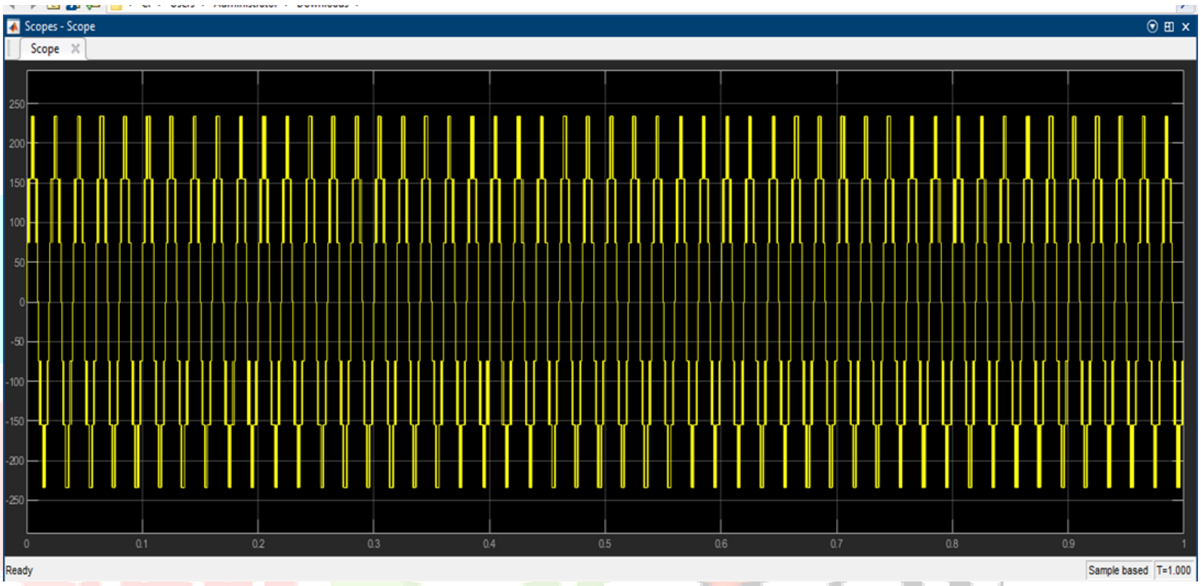
MATLAB is a high-performance language for technical computing. It integrates computation, visualization, and programming in an easy-to-use environment where problems and solutions are expressed in familiar mathematical notation. Typical uses include-

- Math and computation
- Algorithm development
- Data acquisition
- Modeling, simulation, and prototyping
- Data analysis, exploration, and visualization
- Scientific and engineering graphics

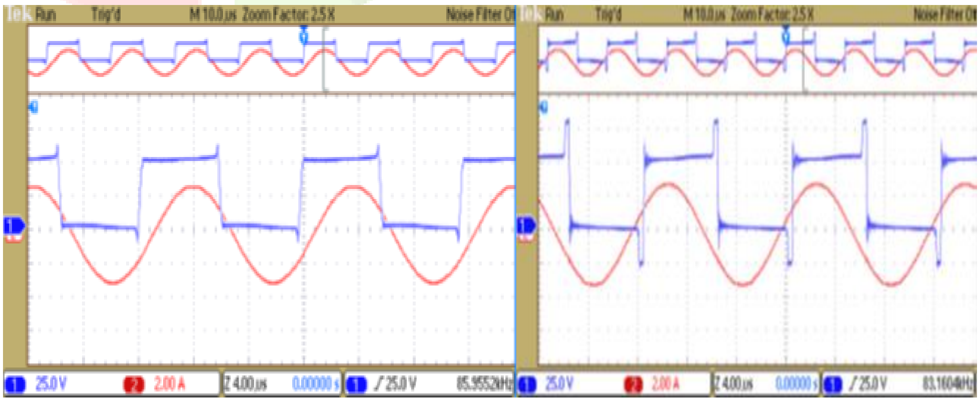
MATLAB is an interactive system whose basic data element is an array that does not require dimensioning. This allows solving many technical computing problems, especially those with matrix and vector formulations, in a fraction of the time it would take to write a program in a scalar non-interactive language such as C or FORTRAN.

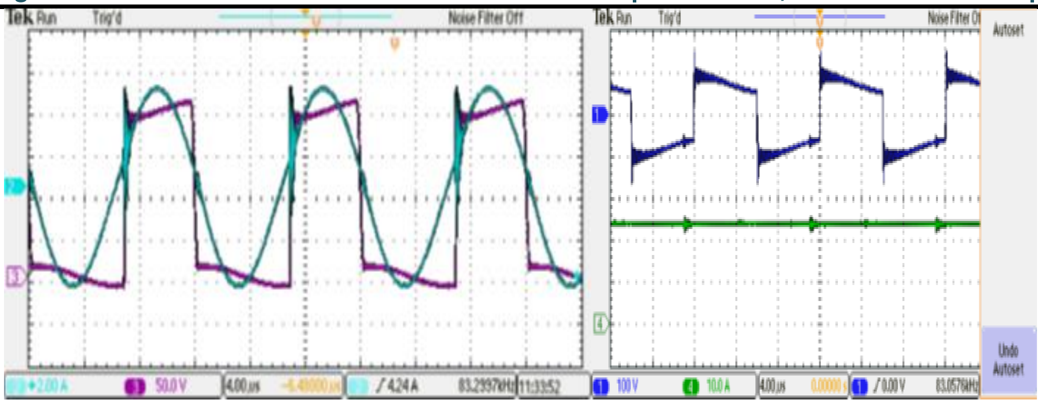


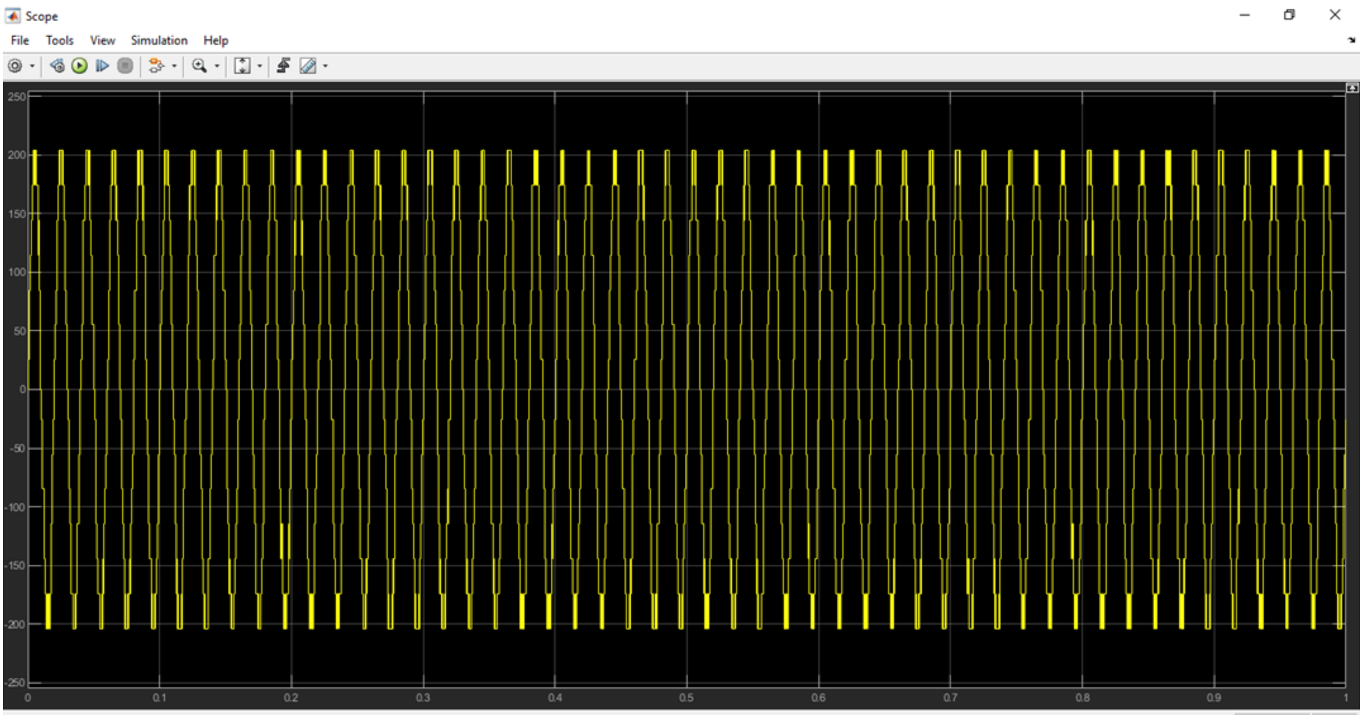
VI. RESULTS AND DISCUSSION



Output Voltage for symmetric 9 level inverter







Output Voltage for Asymmetric 15 level Inverter

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