Design and Implementation of AC-AC ZVS Converter with High Efficiency for Induction Heating

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ABSTRACT
Induction heating is the best method of providing fast, consistent heat for vast selection of manufacturing applications which involve bonding or changing the properties of metals or other electrically-conductive materials. Our project explains the analysis and design of a new AC–AC resonant converter applied to domestic induction heating. The project is based on the half-bridge series resonant inverter topology.

The ordinary circuit of an AC-AC converter for induction heating typically includes a controlled rectifier and a frequency controlled current source or a voltage source inverter. It is a well known fact that the input rectifier does not ensure a sine wave input current, and is characterized by a low power. Recently many studies of high power factor rectifiers with a single switch have been made. The working is based on hard switching and only single output frequency is obtained. Output voltage is very low so that current flow through the inductor is very high. It affects the efficiency of the system.

The aim of this project is to propose a new topology to improve the efficiency while reducing the number of switching devices. The proposed topology is based on the series resonant half-bridge topology and requires only two rectifier diodes. It can operate with zero-voltage switching conditions during both turn-on and turn-off transitions. As a consequence, the efficiency can be increased and the number of switching device is reduced and also multiple output frequency can be obtained.

INTRODUCTION
Induction heating is used for an ever-widening range of industrial and scientific applications in modern world. Induction heating is the best method of providing fast, consistent heat for vast selection of manufacturing applications which involve bonding or changing the properties of metals or other electrically-conductive materials. This paper presents the analysis and design of a new AC–AC resonant converter applied to domestic induction heating. The project based on the half-bridge series resonant inverter topology.

INDUCTION HEATING
The advent and wide spread availability of reliable and efficient standard power modules has drastically changed the focus of the power system designer. In the days of centralized custom power supplies, the designer needed to understand the details of converter operation, and was often instrumental in making choices such as selection of converter topology, operating frequency and components. The need for this level of detailed knowledge about the internal workings of the converter is largely eliminated when using standard modules from reliable suppliers, and the designer can direct his time and energy to system related issues. Most of the converter topology choices will be transparent to the end user - that is, the specifications of the module and its performance in the end system will not be affected.

ZVS TOPOLOGY
Zero voltage switching can best be defined as conventional square wave power conversion during the switches on-time with “resonant “switching transitions. For the most part, it can be considered as square wave power utilizing a constant off-time control.
which varies the conversion frequency, or on-time to maintain regulation of the output voltage. For a given unit of time, this method is similar to fixed frequency conversion which uses an adjustable Duty cycle.

Regulation of the output voltage is accomplished by adjusting the effective duty cycle, performed by varying the conversion frequency. This changes the effective on-time in a ZVS design. The foundation of this conversion is simply the volt-second product equating of the input and output. Zero Voltage Switching has an advantage over the kind of switching that would normally be accomplished with a relay because there is a reduced chance for arcing. A relay could turn the power on when the voltage is, say, 120VAC, and an electrical arc (spark) could result.

**LITERATURE SURVEY**

This chapter deals with the development and implementation of ac-ac converter for induction heating. It contains five different groups explaining about the converter and its technique.

- Induction Heating
- Zero voltage switching
- AC-AC Converter
- Multiple inverter units
- Electronic Ballast

**INDUCTION HEATING**

Acero.J et.al [1] describes about domestic induction heating appliances, recent researches encompassing induction-heating appliances such as inverters, digital control, and inductors are presented. Today, induction hobs have become a sophisticated device and are progressively appreciated by a growing number of users.

Induction appliances get energy from the mains voltage, which is rectified by a bridge of diodes. A bus filter is designed to allow a high-voltage ripple, getting a resultant input power factor close to one. Then an inverter topology supplies the ac (between 20 and 100 kHz) to the induction coil. Formerly, the power electronics was located in a forced air-Cooled separate box placed on the floor, using thyristors as switching devices. However, in the later 1990s, the application of the resonant inverter topologies caused the integration of the electronics and the inductors in a compact hob, whose housing is compatible with the conventional resistive cookers.

Lichan Meng et.al [8] explains about induction cooker system. Nowadays, environmental deterioration and global warming effects have drawn pressing concerns around the world. Actions for reducing the carbon footprint in people’s daily life are highly advocated. The traditional way of cooking for mankind is to hang the pot over an open fire, which is burning some combustible substance such as wood, coal, or gas. Magnetic induction heating is a common technique producing high-frequency eddy currents losses on metallic objects.

The operation principle was introduced together with the power regulation, auto frequency tracking, and ZVS realization. On the basis of the study on the PFM control and PDM control, the resonant inverter was designed considering the power specification and the power regulation of the induction cooker system. The switches losses under different control schemes are determined and compared against each other. The optimized power control strategy is then designed by combining the benefits of and PDM. The control scheme was illuminated and the overall designed system including both the electrical and control parts was provided. Simulation evaluations were conducted to verify the system performance and the hybrid power regulation strategy.
ZERO VOLTAGE SWITCHING

Jung-Goo Cho et.al [6] describes about ZVS technology. ZVS full-bridge (FB) pulse width modulation (PWM) converters have received considerable attention in recent years. This converter is controlled by a phase-shifted PWM technique which enables the use of all parasitic elements in the bridge to provide ZVS conditions for the switches. Distinctive advantages including ZVS with no additional components and low-device voltage/current stresses make it very attractive for high-frequency high-power applications, where MOSFET’s are predominantly used as the power switches. The IGBT’s, however, are not suited for the ZVS FB PWM converter because the ZVS range is quite limited unless the leakage inductance is very large. In addition, several demerits such as duty-cycle loss and parasitic ringing in the secondary limit the maximum power rating of the converter.

Per Karlsson et.al [9] describes about the soft switching technique in which zero voltage switching converters are investigated. Quasi resonant link converters are used. The main problems are the semiconductor losses due to the finite duration of the switching transients and the electromagnetic compatibility (EMC) problems associated with the high voltage derivative with respect to time, occurring especially at the turn-off transients. In this paper, different means to achieve zero voltage switching (ZVS) are discussed. The aim is to perform the switching transients at, or close to, zero voltage across the semiconductor devices. ZVS can be retained on the active power switches to effectively reduce the switching losses. In addition, the conduction losses can also be reduced with fewer power switches.

MULTIPLE INVERTER UNITS

Fujita.H et.al [3] explains about the new zone control induction heating system using multiple inverter unit applicable under mutual magnetic coupling conditions. The next generation of semiconductor–wafer processing requires a heating method capable of a maximal temperature higher than 1350 °C and a quick heating-up performance as fast as 100 °C/s. Such a high-temperature and quick-heating method may enable us to improve the productivity of semiconductor devices. The required heating performance would be difficult to be achieved for conventional electric heating methods, such as resistive heaters made of nichrome/ceramic and halogen lamps.

The “zone-control induction heating” (ZCIH) system consisting of two or more sets of a high frequency inverter unit and a work coil. The inverters independently control the amplitude of each coil current to adjust the power provided to the work coil and/or the heat generated in each zone of the susceptor. As a result, the ZCIH system enables temperature uniformity not only in a heating-up period but also in a temperature-maintaining period. The phase-angle control of the coil current is required to adjust the current amplitude in a wide range.

Ha pham ngoc et.al [4 ] describes about the phase angle control of high-frequency resonant currents in a multiple inverter system. High frequency induction heating is one of the most attractive methods having the capabilities of high temperature and quick heating. However, a conventional induction heating with only one working coil has a problem in non uniform temperature and/or heat distribution on its work piece.

The phase angle control method of high-frequency resonant currents in a zone-control induction heating (ZCIH) system, which consists of split working coils and multiple inverters. The ZCIH system controls the amplitude of each coil current to make the temperature distribution on the work piece uniform. The amplitude of the coil current can be controlled in a wide range when its phase angle is adjusted to be the same with other coil currents. This paper theoretically derives the phase-angle change of the coil
current in transient states, and reveals that the phase-angle change can be considered as a first-order response. Phase-angle controller was designed and examined in experiments using a two-zone ZCIH system. It is clarified that the phase angle control makes it possible to adjust the current phase angle not only in steady states but also in transient states.

**ELECTRONIC BALLAST**

Chien-Ming Wang et.al [2] describes about the single stage high power factor electronic ballast with symmetrical half bridge topology. Most electronic ballasts are realized with load resonant inverters because they can provide an appropriate ignition voltage and a stable arc current with a low crest factor for fluorescence. The peak detection rectifier is traditionally used by the resonant inverter to get the input dc voltage source. Nevertheless, this circuit will cause a large and sharp input current when the input ac source voltage reaches its peak. The harmonics included in the input current is harmful for the other electrical must be attached to the electronic ballast to reduce the input line current harmonics.

To simplify the circuit of the electronic ballast and reduce its cost, some single-stage electronic ballasts have been proposed by integrating the PFC circuit into the inverter stage to perform both functions of the PFC and resonant inverter. The PFC power flow path of the proposed circuit has the conduction losses can also be reduced. Therefore, it can provide lower conduction loss than the conventional one.

Hung L. Cheng, et.al [5] proposes a novel single-stage high-power factor high-efficiency electronic ballast with symmetrical topology for fluorescent lamps. In order to improve the power factor of the electronic ballast, an additional power conversion stage of power-factor-correction (PFC) is usually introduced. Conventional methods face high switching and conduction losses. To solve these problems, novel single-stage electronic ballast with symmetrical topology is proposed. With symmetrical circuit configuration, ZVS for the power switches can be preserved. With buck–boost conversion, a high power factor can be achieved by operating the converter at discontinuous conduction mode (DCM) at a fixed frequency with a constant duty cycle. Electronic ballast with two series-connected fluorescent lamps is used for illustrating the circuit operation and the design procedure.

The circuit topology originates from the integration of two half-wave rectifiers with buck–boost power-factor correction converters and a half-bridge series-resonant parallel loaded inverter. A high power factor at the input line is assured by operating the buck–boost converters in discontinuous conduction mode. With symmetrical operation and carefully designed circuit parameters, zero-voltage switching on the active power switches of the inverter can be retained to achieve high circuit efficiency. The design equations are derived from the analyzed results based on fundamental approximation, and then an easy-to-use design tool is provided accordingly under considerations of filament heating and ignition.

**AC-AC CONVERTER TOPOLOGIES**

**INTRODUCTION**

Converting AC power to AC power allows control of the voltage, frequency, and phase of the waveform applied to a load from a supplied AC system. The two main categories that can be used to separate the types of converters are whether the frequency of the waveform is changed. AC/AC converters that don’t allow the user to modify the frequencies are known as AC Voltage Controllers, or AC Regulators. AC converters that allow the user to change the frequency are simply referred to as frequency converters for AC to AC conversion. Under frequency converters there are three different types of converters that are typically used: cyclo
converter, matrix converter, DC link converter (AC/DC/AC converter).

AC VOLTAGE CONTROLLER

The purpose of an AC Voltage Controller is to vary the RMS voltage across the load while at a constant frequency. Three control methods that are generally accepted are ON/OFF Control, Phase-Angle Control, and Pulse Width Modulation AC Chopper Control (PWM AC Chopper Control). All three of these methods can be implemented not only in single-phase circuits, but three-phase circuits as well.

- ON/OFF Control: Typically used for heating loads or speed control of motors, this control method involves turning the switch on for n integral cycles and turning the switch off for m integral cycles. Because turning the switches on and off causes undesirable harmonics to be created, the switches are turned on and off during zero-voltage and zero-current conditions (zero-crossing), effectively reducing the distortion.

- Phase-Angle Control: Various circuits exist to implement a phase-angle control on different waveforms, such as half-wave or full-wave voltage control. The power electronic components that are typically used are diodes, SCRs, and Triacs. With the use of these components, the user can delay the firing angle in a wave which will only cause part of the wave to be outputted.

- PWM AC Chopper Control: The other two control methods often have poor harmonics, output current quality, and input power factor. In order to improve these values PWM can be used instead of the other methods. What PWM AC Chopper does is have switches that turn on and off several times within alternate half-cycles of input voltage.

MATRIX CONVERTERS AND CYCLOCONVERTERS

Cycloconverters are widely used in industry for ac to ac conversion, because they are able to be used in high-power applications. They are commutated direct frequency converters that are synchronized by a supply line. The cycloconverters output voltage waveforms have complex harmonics with the higher order harmonics being filtered by the machine inductance. Causing the machine current to have fewer harmonics, while the remaining harmonics causes losses and torque pulsations. Note that in a cyclo converter, unlike other converters, there are no inductors or capacitors, i.e. no storage devices. For this reason, the instantaneous input power and the output power are equal.

- Single-Phase to Single-Phase Cycloconverters: Single-Phase to Single-Phase Cycloconverters started drawing more interest recently because of the decrease in both size and price of the power electronics switches. The single-phase high frequency ac voltage can be either sinusoidal or trapezoidal.

- Three-Phase to Single-Phase Cycloconverters: There are two kinds of three-phase to single-phase cycloconverters: 3φ to 1φ half wave cycloconverters and 3φ to 1φ bridge cycloconverters. Both positive and negative converters can generate voltage at either polarity, resulting in the positive converter only supplying positive current, and the negative converter only supplying negative current.

With recent device advances, newer forms of cycloconverters are being developed, such as matrix converters. The first change that is first noticed is that matrix converters utilize bi-directional, bipolar switches. A single phase to a single phase matrix converter consists of a matrix of nine switches connecting the three input phases to the tree output phase. Any input phase and output phase can be
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connected together at any time without connecting any two switches from the same phase at the same time; otherwise this will cause a short circuit of the input phases. Matrix converters are lighter, more compact and versatile than other converter solutions. As a result, they are able to achieve higher levels of integration, higher temperature operation, broad output frequency and natural bi-directional power flow suitable to regenerate energy back to the utility.

The matrix converters are subdivided into two types: direct and indirect converters. A direct matrix converter with three-phase input and three-phase output, the switches in a matrix converter must be bi-directional, that is, they must be able to block voltages of either polarity and to conduct current in either direction. This switching strategy permits the highest possible output voltage and reduces the reactive line-side current.

**Z -SOURCE PWM AC-AC CONVERTER**

Single-phase PWM ac-ac converters with a minimal number of switches: voltage-fed Z-source converter and current-fed Z-source converter. By PWM duty-ratio control, they become “solid-state transformers” with a continuously variable turn’s ratio. All the proposed ac-ac converters in this paper employ only two switches. Compared to the existing PWM ac-ac converter circuits, they have unique features: providing a larger range of output ac buck-boost, reversing or maintaining phase angle, reducing in-rush and harmonic current, and improving reliability. The operating principle and control method of the proposed topologies are presented. Analysis, simulation, and experimental results are given using the voltage-fed Z-source ac-ac converter as an example. The analysis can be easily extended to other converters of the proposed family. The proposed converters could be used in Voltage regulation, power regulation, and so on.

The converter can buck and boost with step-changed frequency, and both the frequency and the voltage can be stepped up or stepped down . In addition, the converter employs a safe-commutation strategy to conduct along a continuous current path,
which results in the elimination of voltage spikes on switches without the need for a snubber circuit. The operating principles of the proposed single-phase Z-source buck boost matrix converter are described, and a circuit analysis is provided.

**INDUCTION HEATING**

**INTRODUCTION**

Induction heating is a non-contact heating process. It uses high frequency electricity to heat materials that are electrically conductive. Since it is non-contact, the heating process does not contaminate the material being heated. It is also very efficient since the heat is actually generated inside the work piece. This can be contrasted with other heating methods where heat is generated in a flame or heating element, which is then applied to the work piece. For these reasons Induction Heating lends itself to some unique applications in industry.

**INDUCTION HEATING APPLICATIONS**

Another common application is "getter firing" to remove contamination from evacuated tubes such as TV picture tubes, vacuum tubes, and various gas discharge lamps. A ring of conductive material called a "getter" is placed inside the evacuated glass vessel. Since induction heating is a non-contact process it can be used to heat the getter that is already sealed inside a vessel. An induction work coil is located close to the getter on the outside of the vacuum tube and the AC source is turned on. Within seconds of starting the induction heater, the getter is heated white hot, and chemicals in its coating react with any gasses in the vacuum. The result is that the getter absorbs any last remaining traces of gas inside the vacuum tube and increases the purity of the vacuum.

Induction heating can be used for any application where we want to heat an electrically conductive material in a clean, efficient and controlled manner. One of the most common applications is for sealing the anti-tamper seals that are stuck to the top of medicine and drinks bottles. A foil seal coated with "hot-melt glue" is inserted into the plastic cap and screwed onto the top of each bottle during manufacture. These foil seals are then rapidly heated as the bottles pass under an induction heater on the production line. The heat generated melts the glue and seals the foil onto the top of the bottle. When the cap is removed, the foil remains providing an airtight seal and preventing any tampering or contamination of the bottle's contents until the customer pierces the foil.

Yet another common application for induction heating is a process called Zone purification used in the semiconductor manufacturing industry. This is a process in which silicon is purified by means of a moving zone of molten material. An Internet Search is sure to turn up more details on this process that I know little about.

Other applications include melting, welding and brazing or metals. Induction cooking hobs and rice cookers. Metal hardening of ammunition, gear teeth, saw blades and drive shafts, etc are also common applications because the induction process heats the surface of the metal very rapidly. Therefore it can be used for surface hardening and hardening of localised areas of metallic
parts by "outrunning" the thermal conduction of heat deeper into the part or to surrounding areas. The non contact nature of induction heating also means that it can be used to heat materials in analytical applications without risk of contaminating the specimen. Similarly, metal medical instruments may be sterilised by heating them to high temperatures whilst they are still sealed inside a known sterile environment, in order to kill germs.

**REQUIREMENT FOR INDUCTION HEATING**

In theory only three things are essential to implement induction heating:

- A source of High Frequency electrical power,
- A work coil to generate the alternating magnetic field,
- An electrically conductive work piece to be heated.

Having said this, practical induction heating systems are usually a little more complex. For example, an impedance matching network is often required between the High Frequency source and the work coil in order to ensure good power transfer. Water cooling systems are also common in high power induction heaters to remove waste heat from the work coil, its matching network and the power electronics. Finally some control electronics is usually employed to control the intensity of the heating action, and time the heating cycle to ensure consistent results. The control electronics also protects the system from being damaged by a number of adverse operating conditions. However, the basic principle of operation of any induction heater remains the same as described earlier.

**ZERO VOLTAGE SWITCHING TECHNIQUE**

**INTRODUCTION**

Zero voltage switching can best be defined as conventional square wave power conversion during the switches on-time with "resonant" switching transitions. For the most part, it can be considered as square wave power utilizing a constant off-time control which varies the conversion frequency, or on-time to maintain regulation of the output voltage. For a given unit of time, this method is similar to fixed frequency conversion which uses an adjustable duty cycle.

**DETAILED OVERVIEW**

The technique of zero voltage switching is applicable to all switching topologies; the buck regulator and its derivatives (forward, half and full bridge), the fly back, and boost converters, to name a few. This will focus on the continuous output current, buck derived topologies.

Zero Voltage Switching has an advantage over the kind of switching that would normally be accomplished with a relay because there is a reduced chance for arcing. A relay could turn the power on when the voltage is, say, 120VAC, and an electrical arc (spark) could result.
Insulated gate bipolar transistors (IGBT’s) are widely used in switching power conversion applications because of their distinctive advantages such as easiness in drive and high frequency switching capability. The performance of IGBT’s has been continuously improved, and the latest IGBTs can operate at 10–20 kHz without including any snubber circuit. Moreover, IGBT’s are replacing MOSFET’s for the several or several tens of kilowatt power range applications since IGBT’s can handle higher voltage and power with higher power density and lower cost compared to MOSFET’s.

The maximum operating frequency of IGBT’s, however, is limited to 20–30 kHz because of their tail-current characteristic. To operate IGBT’s at high switching frequencies, it is required to reduce the turn-off switching loss. Zero-voltage switching (ZVS) with a substantial external snubber capacitor zero current switching can be a solution.

The aim is to perform the switching transients at, or close to, zero voltage across the semiconductor devices. At a first glance, this would give zero, or low, switching losses. However, this is not entirely true in the case of IGBTs and this is also discussed. The discussion treats the IGBT switching behaviour at hard-switched conditions, and with RCD charge-discharge snubbers, intended to provide zero voltage transistor turn-off. The resonant DC link (RDCL) converter investigated suffers from two severe drawbacks, both of which are highlighted. These drawbacks also put focus on quasi-resonant DC link (QRDCL) converters. A QRDCL converter is implemented and waveform and loss measurements are presented.

The technique of zero voltage switching in modern power conversion is explored. Several ZVS topologies and applications, limitations of the ZVS technique, and a generalized design procedure are featured. Two design examples are presented: a 50 Watt DC/DC converter, and an off-line 300 Watt multiple output power supply. This topic
concludes with a performance comparison of ZVS converters to their square wave counterparts, and a summary of typical applications.

Advances in resonant and quasi-resonant power conversion technology propose alternative solutions to a conflicting set of square wave conversion design goals; obtaining high efficiency operation at a high switching frequency room a high voltage source. Currently, the conventional approaches are by far, still in the production mainstream. However, an increasing challenge can be witnessed by the emerging resonant technologies, primarily due to their lossless switching merits. The intent of this presentation is to unravel the details of zero voltage switching via a comprehensive analysis of the timing intervals and relevant voltage and current waveforms. The concept of quasi-resonant, “lossless” switching is not new, most noticeably patented by one individual and publicized by another at various power conferences.

Numerous efforts focusing on zero current switching ensued, first perceived as the likely candidate for tomorrow’s generation of high frequency power converters. In theory, the on off transitions occur at a time in the resonant cycle where the switch current is zero, facilitating zero current, hence zero power switching.

During the ZVS switch off-time, the L-C Tank circuit resonates. This traverses the voltage across the switch from zero to its peak, and back down again to zero. At this point the switch can be reactivated, and lossless zero voltage switching facilitated.

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The advantages of zero voltage switching technique are as follows:-

- Reduced EMI / RFI at transitions
- No power loss due to discharging Goss
- No higher peak currents, (i.e. ZCS) same as
- Square wave systems
- High efficiency with high voltage inputs at
- Any frequency
- Can incorporate parasitic circuit and component L & C

POWER SEMICONDUCTOR DEVICES

INTRODUCTION

A power semiconductor device is a semiconductor device used as a switch or rectifier in power electronics. A switch mode power supply is an example. Such a device is called a power device. A power semiconductor device is usually in commutation mode and therefore has a design optimized for such usage. Among these various power devices, IGBT and MOSFET shows the gate control applications.

MOSFET

The MOSFET transistor family consists of two main types, these being "depletion-mode" and "enhancement-mode" types. Although MOSFETs can be made in either polarity, N-channel MOSFETs are available in all four types while P-channel depletion-mode devices are not available. In the advantages include increased circuit density, lower power, and the ability to create analog and digital circuitry side-by-side on the same chip.
The Power MOSFET technology has mostly reached maturity and is the most popular device for SMPS/lighting ballast type of application where high-switching frequencies are desired but operating voltages are low. Being a voltage fed, majority carrier device (resistive behaviour) with a typically rectangular Safe Operating Area, it can be conveniently utilized. Utilising shared manufacturing processes, comparative costs of MOSFETs are attractive.

For low frequency applications, where the currents drawn by the equivalent capacitances across its terminals are small, it can also be driven directly by integrated circuits. These capacitances are the main hindrance to operating the MOSFETS at speeds of several high voltages. The resistive characteristics of its main terminals permit easy paralleling externally also. At high current low voltage applications the MOSFET offers best conduction voltage specifications as the RDS (ON) specification is current rating dependent. However, the inferior features of the inherent anti-parallel diode and its higher conduction losses at power frequencies and voltage levels restrict its wider application.

IGBT

IGBT is a three terminal power semiconductor device primarily used as an electronic switch. It is a voltage controlled four-layer device with the advantages of the MOSFET driver and the Bipolar Main terminal. IGBTs can be classified as punch-through (PT) and non-punch-through (NPT) structures. In the punch-through IGBT, a better trade-off between the forward voltage drop and turn-off time can be achieved. Punch-through IGBTs are available up to about 1200 V. NPT IGBTs of up to about 4 KV have been reported in literature and they are more robust than PT IGBTs particularly under short circuit conditions. However they have a higher forward voltage drop than the PT IGBTs.

Its switching times can be controlled by suitably shaping the drive signal. This gives the IGBT a number of advantages: it does not require protective circuits, it can be connected
in parallel without difficulty, and series connection is possible without dv/dt snubbers.

The IGBT is presently one of the most popular devices in view of its wide ratings, switching speed of about 100 KHz an easy voltage drive and a square Safe Operating Area devoid of a Second Breakdown region. It can be connected in parallel without any difficulty and thus fast response as to all other thyristor devices. IGBT switches electric power in many modern appliances. This device has high current carrying capability. Also it having low forward voltage drop.

Table shows the specifications of various semiconductor power devices such as SCR, GTO, TRIAC, power MOSFET and IGBT. Compared to MOSFET, IGBT having more advantages and applications. Among these various power devices IGBT and MOSFET shows the gate control applications. In this IGBT shows the high speed applications and appropriate switching frequency than the MOSFET. Table 7.1 shows the various parameters and specifications are comparison.

SIMULATION RESULTS

INTRODUCTION TO 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 includes,

- Algorithm development
- Modelling, simulation, and prototyping
- Data analysis, exploration, and visualization
- Scientific and engineering graphics.

This is a huge niche one way to tell is to look at the number of MATLAB-related books on mathworks.com. Even for supercomputer users, MATLAB can be a valuable environment in which to explore and fine-tune algorithms before more laborious coding in another language.

The name MATLAB stands for matrix laboratory. MATLAB was originally written to provide easy access to matrix. MATLAB features a family of application-specific solutions called toolboxes. Very important to most users of MATLAB, toolboxes allow you to learn and apply specialized technology. Areas in which toolboxes are available include signal processing, control systems, neural networks, fuzzy logic, wavelets, simulation, and many others.

It is a software package for modelling, simulating and analyzing dynamic systems. It supports linear and non linear systems, modelled in continuous time, samples time, or a three stage of the two systems can also be multirate, i.e., have different parts that are sampled or updated at different rates. As MATLAB and SIMULINK are integrated.

SOFTWARE REQUIREMENTS

Simulation Software required for the conduction of work is provided on MATLAB 7.10.

SIMULINK

Simulink (Simulation and Link) is an extension of MATLAB by Math works Inc. It works with MATLAB to offer modelling, simulating, and analyzing of dynamical systems under a graphical user interface (GUI) environment. The construction of a model is simplified with click-and-drag mouse operations.

Simulink includes a comprehensive block library of toolboxes for both linear and nonlinear analyses. Models are hierarchical, which allow using both top-down and bottom-up approaches. As Simulink is an integral part of MATLAB, it is easy to switch back and forth during the analysis process and thus, the user may take full advantage of features.
This tutorial presents the basic features of Simulink and is focused on control systems as it has been written for students in my control systems. We can simulate, analyze and revise our models in either environment at any point.

MATLAB was originally entirely a command-line environment, and it retains that orientation. But it is now possible to access a great deal of the functionality from graphical interfaces menus, buttons, and so on. These interfaces are especially useful to beginners, because they lay out the available choices clearly.

**SIMPOWER SYSTEM**

SimPowerSystems is a modern design tool that allows scientists and engineers to rapidly and easily build models that simulate power systems. SimPowerSystems uses the Simulink environment, allowing to build a model using simple click and drag procedures. Not only can draw the circuit topology rapidly, but analysis of the circuit can include its interactions with mechanical, thermal, control, and other disciplines.

This is possible because all the electrical parts of the simulation interact with the extensive Simulink modeling library. Since Simulink uses MATLAB as its computational engine, designers can also use MATLAB toolboxes and Simulink block sets. SimPowerSystems and Sim Mechanics share a special Physical Modeling block and connection line interface.

MATLAB is a software package for computation in engineering, science, and applied mathematics. It offers a powerful programming language, excellent graphics, and a wide range of expert knowledge. MATLAB is published by and a trademark of The Math Works, Inc.

The focus in MATLAB is on computation, not mathematics: Symbolic expressions and manipulations are not possible (except through the optional Symbolic Toolbox, a clever interface to maple). All results are not only numerical but inexact, thanks to the rounding errors inherent in computer arithmetic. The limitation to numerical computation can be seen as a drawback.

**SIMULATION OF AC-AC CONVERTER FOR INDUCTION HEATING**
In this fig 15v input is applied to the circuit. Half bridge rectifier and inverter circuitry is used for the conversion process. Two mosfets are used as the power devices. Here RL load is used and the simulation output is taken across the load. Scope is given to view the simulation results. Each mosfet have pulse generators. Voltage and current is measured across the whole circuit.

**SIMULATION RESULTS**

Here fig shows the output voltage wave form of an ac-ac converter circuitry. Input voltage of 15v is applied. Output of the simulation is taken across the load. Output voltage is doubled when it is compared with the input voltage.

![Fig output voltage wave form](image1)

Here fig shows the output current wave form across the load. Current wave form is also in continuous mode operation.

![Fig output current wave form](image2)

**CONCLUSION AND FUTURE WORK**

The proposed AC-AC converter is to improve the efficiency while reducing the power device count for induction heating applications. This topology is based on the series resonant half-bridge topology and requires only two rectifier diodes. The effective output voltage is doubled, allowing a significant current reduction in the switching
devices. Moreover, the proposed topology can operate with zero-voltage switching conditions during turn-on for both switching devices, and also during turn-off transitions for one of them. As a consequence, the efficiency is improved while the device count is reduced.

In the first phase of the project we implement ZVS technique and obtained the simulation output. In future we implement and design the converter and use for multiple frequency outputs. Thus efficiency can be increased. Also the switching losses can be reduced.

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