

***MODULAR TRI-PORT CONVERTER FOR SWITCHED
RELUCTANCE MOTOR BASED ON
HYBRID ELECTRICAL VEHICLES***

Submitted in partial fulfillment of the requirements for the award of

Bachelor of Engineering Degree in

Electrical and Electronics Engineering by

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**DEPARTMENT OF Electrical and ELECTRONICS ENGINEERING
SCHOOL OF ELECTRICAL AND ELECTRONICS ENGINEERING**

SATHYABAMA

INSTITUTE OF SCIENCE AND TECHNOLOGY

Accredited with Grade "A" by NAAC

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BONAFIDE CERTIFICATE

This is to certify that this Project Report is the bonafide work of **Anurag Srivastva** (Reg. No. 37140009) and **Bibhu Anand** (Reg. No. 37140017) who carried out the project entitled "**Modular Tri-Port Converter for Switched Reluctance Motor based Hybrid Electrical Vehicles**" under our supervision from December 2020 to April 2021.

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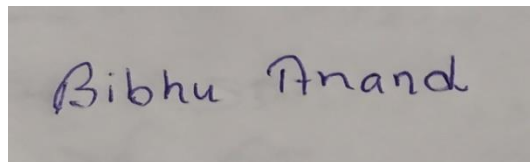
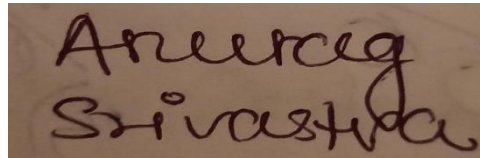
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DECLARATION

We **Anurag Srivastva**(Reg. No. 37140009) and **Bibhu Anand** (Reg. No. 37140017) hereby declare that the Project Report entitled “**Modular TriPort Converter for Switched Reluctance Motor based Hybrid Electric Vehicles**” done by us under the guidance of **Mrs. D. Ramya** is submitted in partial fulfillment of the requirements for the award of Bachelor of Engineering degree in Electrical and Electronics Engineering.



DATE: 24.03.2021

PLACE:Chennai

SIGNATURE OF THE CANDIDATES

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ABSTRACT

Hybrid electrical vehicle (HEV) is a popular transport solution to reducing carbon dioxide emissions. Switched reluctance motors (SRMs) are one among the foremost promising motors for such applications. In SRM-based series-type HEV, there are three energy components, i.e., generator, battery bank, and SRM. A tri-port converter is required to mix the three energy components in one power converter. The tri-port converter features a modular and concise structure, which meets the wants for HEV applications. The proposed tri-port converter supports five working modes, including generator to SRM, battery bank to SRM, generator and battery bank to SRM, generator to SRM and battery bank, and battery bank to SRM and generator under driving conditions; under standstill conditions, generator to battery bank and battery bank to generator energy flow also can be realized without requiring extra converters. The corresponding control strategies also are developed to cooperate with different working modes. Moreover, the fault tolerance characteristics of the tri-port converter are investigated to expand its feasibility under harsh HEV application conditions

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CHAPTER 1

INTRODUCTION

1.1 GENERAL

Hybrid electrical vehicle (HEV) could also be a preferred transport answer to reducing carbonic acid gas emissions. Switched reluctance motors (SRMs) are one of the foremost promising motors for such applications. In SRM-based series-type HEV, there are three energy elements, i.e., generator, battery bank, and SRM. A tri-port device is needed to combine the three energy elements in one power device. The tri-port device offers a standard and brief structure, that meets the needs for HEV applications. The planned tri-port device supports five operating modes. The corresponding management ways are also developed to collaborate with totally different operating modes. Moreover, the fault tolerance characteristics of the tri-port device are investigated to expand its feasibility underneath harsh HEV. For HEV, there are three main energy elements, namely, a battery, a motor, and a generator. So as to support versatile energy flows, many power electronic converters are required, within which B stands for battery bank, M stands for SRM, and G stands for generator. Specifically, B-M implies that the battery bank provides energy to the drive motor alone; M-B means that the motor recycles energy to the battery bank; G-M means that the generator provides energy to the drive motor alone; presently, some HEV integrates the generator and starter in one motor. Therefore, the battery must provide energy to the generator to begin the inner combustion engine (ICE), that is B-G. G-B means that the generator charges the

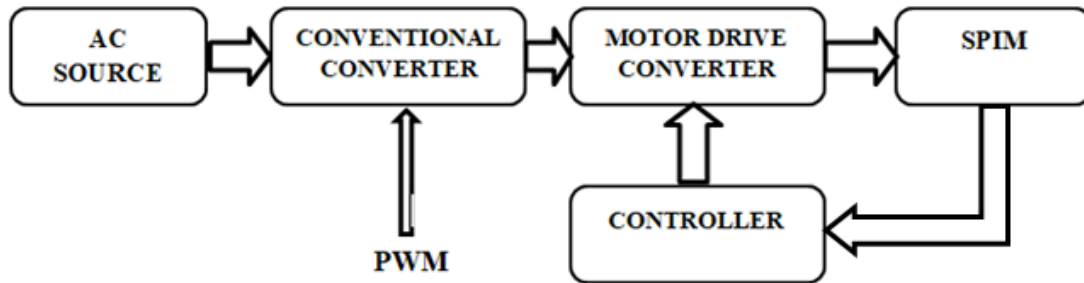
battery bank underneath HEV standstill conditions. G-M-B stands for the case that the generator provides energy to the motor and charges the battery at constant time. B-G refers to matters that the battery bank provides energy to the generator to begin ICE. For M-G-B, the motor releases energy to the generator and battery bank at intervals the braking condition. so as to modify the system structure, a tri-port device is needed to combine the generator, battery, and motor in one device, through that versatile energy flow states area unit completed. Additionally to the perform needs for versatile energy flow, the standard structure and simple power natural philosophy topology are also the thought for electrical powertrains of HEV to appreciate huge production. Therefore, it's associate pressing task to develop associate influence natural philosophy device with the aforesaid characteristics. application conditions.

1.2 SCOPE OF THE PROJECT

Another low-price battery supercharged SRM drive with driving and charging functions was additionally planned. Charging of battery is achieved through the motor windings while not external transformers or different charging units. because of the non-modular structure, the device cannot be utilized in HEV. so as to urge the characteristics of quick current build up and appropriate natural process, associate influence device with the functions of raised excitation and natural process voltages was designed by mistreatment a further electrical condenser for high-speed operations. notwithstanding, it's solely used for the driving mode. Similarly, paper planned a four-level device for SRM driving system to appreciate quick natural process. though the on top of mentioned progressive analysis has developed heaps of driving topologies for SRM driving or driving and charging integration topology.

1.3 EXISTING SYSTEM

In existing system, the SPIM motor pass by solely one supply. this kind methodology not reliable for continue running and additionally general standard electrical converter mistreatment for drive a motor. Hybrid electrical vehicle (HEV) application based mostly developments a tri-port device is required to mix the 3 energy elements in one power device for drive a motor.



1.4 EXISTING SYSTEMS TECHNIQUE:

- SPIM.
- CONVENTIONAL CONVERTER(RECTIFICATION)

1.5 LITERATURE SURVEY

AUTHOR: C. Feng, P. Yulong, L. Xinmei, G. Bin, and C. Shukang.

TITLE: The performance research of starter-generator supported reluctance torque utilized in HEV.

PUBLICATION: IEEE Trans. Magn., vol. 45, no. 1, pp. 635–638, Jan. 2009.

- The objective of this paper is to explain the role that reluctance plays in interior static magnet (IPM) starter- generator (SG) analytically. 4 or 6 pole models of SG including the radial and tangential flux are analyzed. For increasing the worth of q-axis reactance X_q , several possible factors are considered.

- The stationary torque versus control angle was predicted by Finite Element Analysis (FEA). The PM and therefore the reluctance components of the torque were analyzed and computed. The results show that the rotor shape, magnet length, magnet thickness and therefore the amount of poles etc. will observably affect the component of the reluctance. One working prototype of the SG was built and fully tested.

AUTHOR: H.-C. Chang and C.-M.

TITLE: An integrated driving/charging switched reluctance motor drive using three-phase power module.

PUBLICATION: Liaw IEEE Trans. Ind. Electron., vol. 58, no. 5, pp. 1763–1775, May 2011.

- This paper develops an integrated driving/charging switched reluctance motor (SRM) drive for electric vehicles using off-the-shelf three-phase intelligent power modules (IPMs). Five legs of two IPMs are employed to construct the four-phase SRM modified Miller converter. Moreover, its front-end dc/dc boost converter is made by the remaining one leg to spice up the dc-link voltage from a battery.
- Proper current and speed control schemes are designed to yield satisfactory driving performance. Especially, the performance under higher speed is enhanced by the boosted dc-link voltage and therefore the advanced shift of commutation instant. In idle case, some imbedded IPM power devices and SRM windings are arranged to make a buck-boost type or a buck-type switch-mode rectifier (SMR) for charging the battery from a utility with good charging control characteristics and a line drawn power quality.

- The rating derivations, performance analyses, and controller designs for these two SMRs are performed in detail. All constituted circuit components of the charger are naturally placed onboard; only the insertion of a power cable to the ac source socket is required.

AUTHOR: M. Barnes and C.

TITLE: Forward converters for dual voltage switched reluctance motor drives.

PUBLICATION: Pollock IEEE Trans. Power Electron., vol. 16, no. 1, pp. 83–91, Jan. 2001.

- A new circuit is presented which allows a switched reluctance motor to work from AC mains or a low voltage battery supply. Additionally the AC mains are often wont to charge the battery.
- The switched reluctance motor is employed because the voltage-changing transformer, potentially reducing the value of the system. The operation of the drive is explained, and results of an experimental prototype are presented.

AUTHOR: D. H. Lee and J. W. Ahn.

TITLE: A novel four-level converter and instantaneous switching angle detector for high speed SRM drive.

PUBLICATION: IEEE Trans. Power Electron., vol. 24, no. 3, pp. 862 -868, Mar. 2009.

- A novel four-level converter and instantaneous switching angle detector for a high speed switched reluctance motor are proposed. Since the excitation time is extremely short compared to the overall speed range of a high speed drive, the excitation current can not be built-up sufficiently. Also, the demagnetization current are often easily extended to the negative torque region.

- To obtain a quick current build-up and suitable demagnetization, a completely unique four-level converter is proposed. The proposed converter has a further charge capacitor and an active power switch compared to a standard asymmetric converter. The high voltage of the extra capacitor is applied to the phase winding within the fast excitation mode and therefore the phase current is rapidly decreased during the recharging of capacitor in demagnetization mode.
- In addition, an instant switching angle detector separated by main digital controller is meant for precise switching angle control. During high speed operation, rotor position error increases thanks to the constant sampling period of digital controller.

1.6 PROPOSED SYSTEM

- In proposed system, SRM motor drive by generator and dc source(battery) for relevant operation.
- Combination of diode and MOSFET converter used for drive a SRM motor through control system, also using SRM motor at hybrid electric vehicle.
- First of all, the generator/starter generate the energy for drive the SRM motor, in the second mode, battery and generator drive the SRM motor, after that third mode the battery to SRM motor energy transfer.

1.7 PROPOSED SYSTEM TECHNIQUE

- Fault tolerance
- SRM motor drive
- Tri port converter

1.8 *ADVANTAGES OF PROPOSED TECHNIQUE*

- Wide torque-speed range, robust structure and low cost.
- Tri port converter increase reliability
- Lower output-voltage ripple.
- Energy efficient (SRM motor)

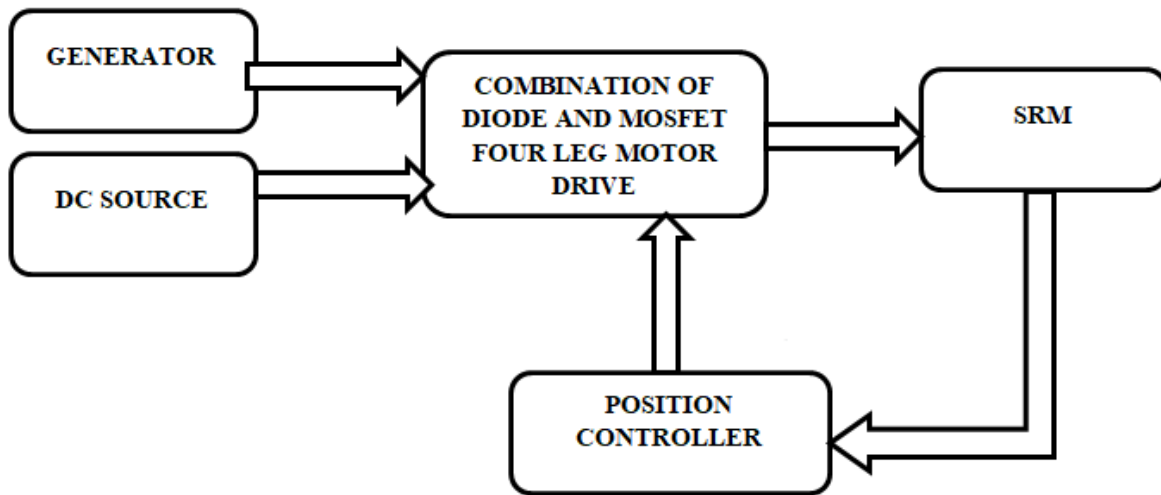
CHAPTER 2

PROJECT DESCRIPTION

2.1 *GENERAL*

Another low-cost battery powered SRM drive with driving and charging functions was also proposed. Its charging is achieved through the motor windings without external

transformers or other charging units. thanks to the non-modular structure, the converter can't be utilized in HEV. so as to get the characteristics of fast current build up and suitable demagnetization, an influence converter with the functions of increased excitation and demagnetization voltages was designed by using a further capacitor for high-speed operations. Nevertheless, it's only used for the driving mode. Similarly, proposed a four-level converter for SRM driving system to realize fast demagnetization. Although the above given state-of-the-art research has developed tons of driving topologies for SR driving or driving and charging integration topology, none of them can stratify the function presented. Required energy flow modes, during this paper, a completely unique converter with the characteristics of tri-port and modular structure is proposed. The proposed topology can support all the six working modes in Fig.1 almost without changing the normal driving topology of SRM. Moreover, the proposed converter has the fault tolerance function, which may block the fault point to realize fault tolerance operation. during this paper, the proposed tri-port converter and therefore the corresponding working modes



2.2 MODULES NAME

- SRM (SWITCHED RELUCTANCE MOTOR)
- FAULT TOLERANCE
- BATTERY

2.3 MODULE DESCRIPTION

SRM (SWITCHED RELUCTANCE MOTOR)

The switched reluctance motor (SRM) is a type of motor which is doubly salient with phase coils mounted around diametrically opposite stator poles. The SRM has no windings and having permanent magnets on the rotor. The rotor is basically a made of laminated steel and its shape forming salient poles. The stator consists of concentrated coils. SRMs having an easy and robust structure, which are suitable for high-speed

applications. High-speed motors having high power density, which is a crucial issue of traction motors in electric vehicles (EV). Therefore, high speed of SRM seems to be suitable for this type of application.

Construction of Switched Reluctance Motor

Variable Reluctance Motor or Switched Reluctance Motor has two types of constructions: Singly Salient Construction and Doubly Salient Construction. Stator and rotor magnetic circuits are laminated to scale back the core losses in both sort of SRM.

Singly Salient Construction:

A singly salient construction SRM consists of a salient two pole rotor and a non-salient stator. The rotor having no winding wound over it but the stator having two phase winding as shown in figure below.

Switched Reluctance Motor or variable Reluctance Motor-Singly Salient Construction

It should be noted that, in actual SRM the amount of phase winding on stator could also be quite two. As the rotor is of salient construction, the inductance of stator phase winding changes according to the rotor position. The inductance is minimum when the rotor axis and stator phase winding axis coincides whereas it's maximum when both the axis are in quadrature.

Doubly Salient Construction

The stator of doubly salient Switched Reluctance Motor is of salient construction and having 4-poles as shown in figure below. The rotor don't have any winding and is of salient construction but have 2-poles. Thus, this sort of SRM may be a hetro polar motor where the numbers of stator and rotor poles are not same.

Motor-doubly Salient Construction

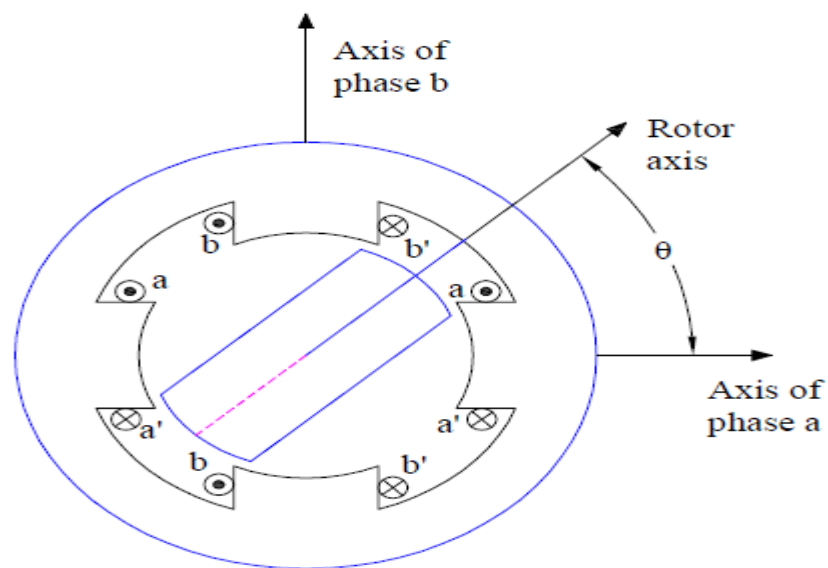
The stator phase windings are concentrated winding which are on opposite poles are either connected in series or in parallel to result into two phase winding on stator.

A doubly salient type Switched Reluctance Motor produces more torque than a singly salient type for a same size. Therefore, a doubly SRM is commonly and widely used as compared to singly salient type.

Working principle of Switched Reluctance Motor (SRM)

As we all know that magnetic flux have a bent to flow through lowest reluctance path, therefore rotor always tends to align along the minimum reluctance path. This is the basic working principle of Switched Reluctance Motor(SRM).

Therefore, when stator phase winding A is energized, the rotor align along this phase as shown in figure below.



When stator phase winding B is energized and winding A is de-energized, the rotor align itself along phase B as shown in figure below. Similarly, the rotor occupies an edge along phase winding C when this phase C is energized and B is de-energized. Thus, the rotor rotation in clockwise direction can be achieved by energizing the phase winding during a ABC sequence. Stator phase winding must be energized in ACB sequence to achieve rotor rotation in anti-clockwise direction.

It is much needed as , a particular phase winding must be energized and de-energized in synchronism with the position of rotor. This means as soon because the rotor align along the phase A, phase B must be energized and phase A must be de-energized if clockwise rotor rotation is required.

BATTERY

Battery parameters

Voltage: The voltage is supposed to be operated at that the battery nominal voltage . The actual voltage of PV systems may different from the nominal voltage. This is mainly counting on the State of Charge and therefore the temperature of the battery.

Capacity: The capacity is measured in ampere-hours (Ah). The quantity of charge that the battery can deliver at the rated voltage is termed as capacity. The capacity of battery of is directly proportional to the amount of electrode material present in the battery.

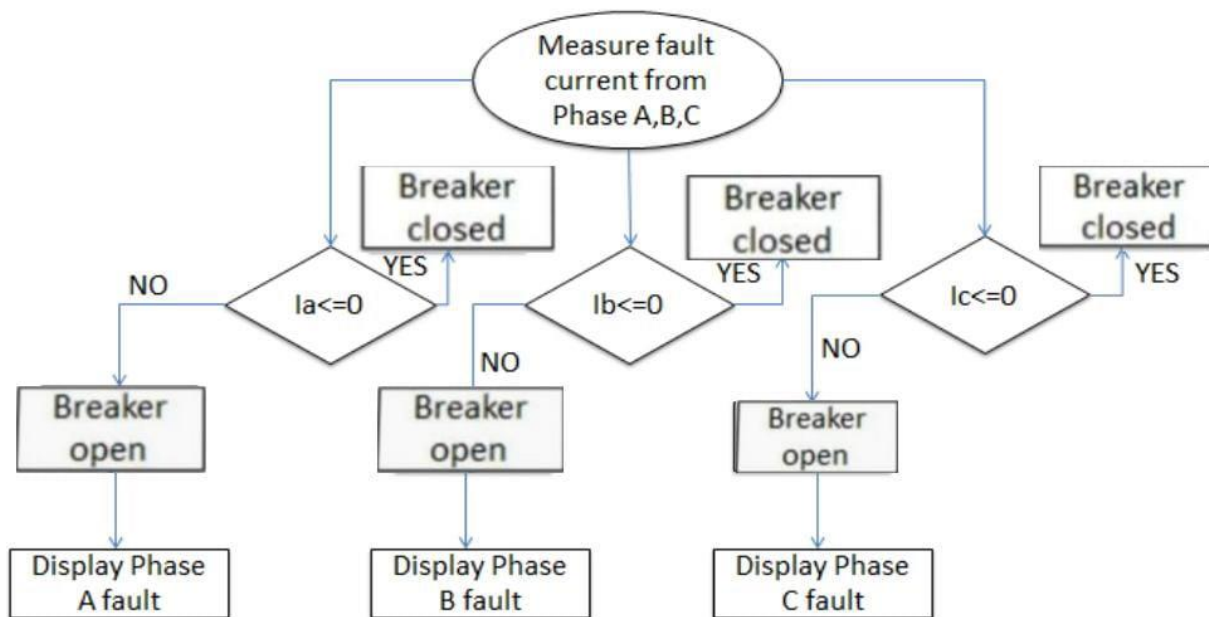
Battery efficiency: For designing PV systems it's vital to understand the efficiency of the storage system. For storage systems, usually the round-trip efficiency is employed , which is given because the ratio of the entire storage output to the entire storage input.

State of charge: The percentage of the battery capacity available for discharge is defined as the State of Charge (SoC), which is battery parameter.

Depth of discharge: Depth of Discharge (DoD) is an important parameter. The percentage of the battery capacity that has been discharged is defined as Depth of discharge.

Cycle lifetime: The number of charging and discharging cycles after that the battery capacity drops below 80% of the nominal value is defined as cycle life-time.

FAULT TOLERANCE



2.4. CIRCUIT DESCRIPTION

The proposed converter and its deduction progress, S1 ~ S8 are MOSFETs; D1 ~ D8 are diodes; J1, J2 and J3 are the relays that are used for fault tolerance operation. There are three ports for the proposed converter: the first port is connected with the generator, and the second port is connected with the battery tank. The first and second ports are combined by a front-end three-level DCDC converter. V1 and V2 are the voltages of generator (G) and battery bank (B), respectively. The third port is SRM, and therefore the corresponding drive topology may be a traditional asymmetrical half bridge, during which Na, Nb and Nc are the central tapped nodes which will be achieved without any change in the SRM body structure. La12 and La34 are the windings of phase A of SRM similarly, Lb12 and Lb34 are the windings of phase B of SRM; Lc12 and Lc34 are the windings of phase C of SRM. The phase winding nodes are linked with the front-end three level converter by a relay.

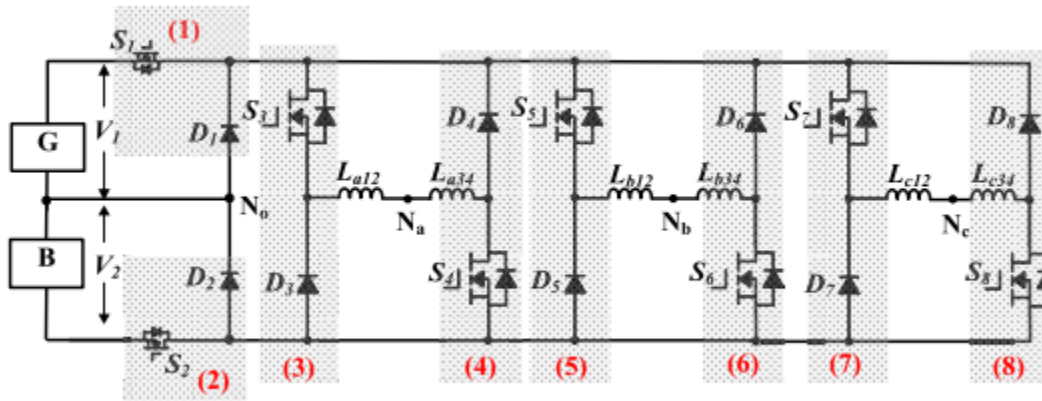


FIG. PROPOSED CIRCUIT DIAGRAM

The proposed topology features a modular structure that's convenient for enormous production. As shown in Fig., the proposed topology is composed of eight

modules, in which one diode and one switching device forms a module. Compared with a traditional asymmetrical half bridge driving topology for SRM, only two extra modules are added.

2.5 MODE OF OPERATION

Mode 1

In the proposed topology, there are different working states for different energy flow modes. Three excitation mode can be achieved when both the generator and battery bank are working together, by closing the switching devices S_1 and S_2 , S_1 is conducted, and only the generator supplies energy to the motor; conducting S_2 , only the battery bank supplies energy to the motor. The generator and battery bank supply energy to the motor at the same time, when both S_1 and S_2 are conducting. By controlling S_1 and S_2 , three voltage levels can be achieved, which are V_1 , V_2 and $V_1 + V_2$, respectively.

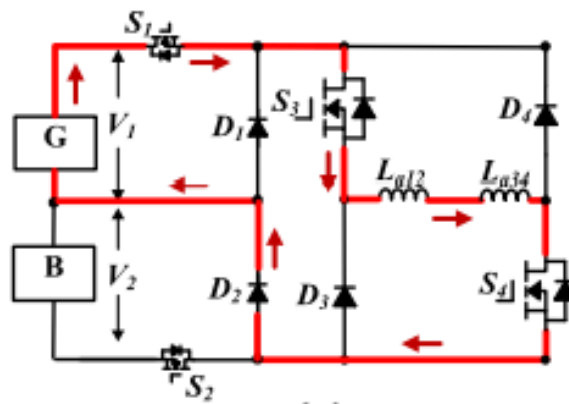


FIG. MODE 1

MODE 2

When an HEV operated in the standstill mode, energy is supplied from the generator to the battery bank. The proposed converter is operated as a DC-DC converter, when J1, J2 and J3 are turned ON; for phase-A, S1 and S3 are turned on, and therefore the generator charges SRM phase inductor, as illustrated in Fig. (a); and then, turn off S1 and S3, and turn on S2 to discharge the energy in SRM phase inductance to the battery bank, Demagnetization working states. (a) Freewheeling (b) Energy recycling. FIG. Working states under standstill condition. (a) G-B state 1 (b) G-B state 2. When the HEV is within the standstill mode, the battery bank supplies energy to the generator/ starter to start out the ICE. There are two working states in this progress. When J1, J2 and J3 is turned ON; for phase-A, by turning on S2 and S4, the battery bank charges SRM phase inductor, as illustrated in Fig. 7; and then S2 and S4 is turned OFF, turning S1 ON to make the SRM phase inductance discharge energy to the generator, whose working state

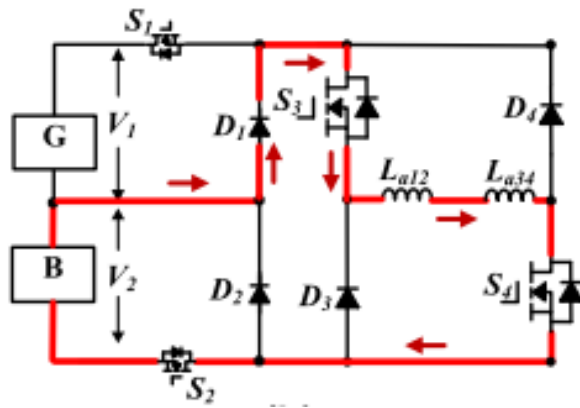


FIG.3.5. MODE 2

MODE 3

According to the given speed ω , under low speed condition the controller works in CCC mode, and under high speed condition, it works in voltage-PWM control mode. The whole control block diagram is presented in Fig.8. The classical proportional integral (PI) is used in the speed controller, which is used to regulate the SRM speed. The encoder gives the SRM rotor position information, and the corresponding motor speed can be calculated by using a micro-controller. In the CCC strategy, the phase current is that the control variable. The phase currents are measured by current sensors, and the current reference is derived from the speed controller. The hysteresis controller is employed to generate the driving signals for the switching devices. In the voltage-PWM control system, the phase voltage is the control variable. According to the speed error, the effective phase voltage is controlled by the duty ratios of switching devices. SRM control strategy under driving mode.

B-G and G-M are included within the standstill energy exchange mode. When HEV is within the standstill battery charging mode (G-B) or standstill generator starting mode (B-G), the proposed tri-port converter must work as a DC-DC converter. HEV standstill energy exchange control. (a) Control diagram for HEV standstill generator starting. (b) Control diagram for HEV standstill battery charging for transferring the energy from one to another components. In order to achieve a high-power level, the three phases work in the parallel mode. indicates the control block scheme. illustrates the control block diagram of battery bank supplying energy to generator; illustrates the standstill battery charging control block diagram.

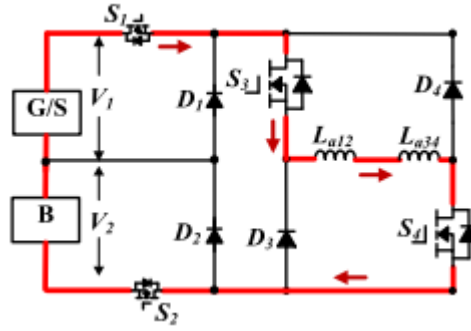


FIG.3.6. MODE 3

FAULT TOLERANCE ALGORITHM

Due to the harsh operation condition, the solid-state devices suffer from short-circuit and open-circuit faults, as well as the phase windings. Fault tolerance operation. (a) Left part open-circuit fault. (b) Left part fault tolerance working state 1. (c) Left part fault tolerance working state 2. (d) Right part open-circuit fault. (e) Right part fault tolerance working state 1. (f) Right part fault tolerance working state 2. Fig. shows a typical example of single switch open circuit fault. By switching on J1, the battery bank and the right part of the faulty phase converter form a new converter to achieve fault tolerance operation when the left part of the converter fails. The corresponding operation switching on S2 and S4, in this state, the phase winding L_{a34} is excited. The energy recycling loop is presented, in which S4 is turned off, and the energy in L_{a34} is recycled to the generator. By forming the fault tolerance topology, the faulty part can be blocked. Similarly, when the faulty phase converter is with open-circuit fault in the right part, as shown in Fig.11 (d), by switching on relay J1, the fault tolerance topology can be formed. The corresponding fault tolerance working states are presented, switching on S3, in this state, the phase winding L_{a12} is excited and produces a torque.

$$T_e = \sum_{k=1}^m T_k = \sum_{k=1}^m \frac{1}{2} i_k^2 \frac{dL_k(\theta)}{d\theta}$$

The energy recycling loop is, in which S3 is turned off, S2 is turned on, and the energy in La12 is recycled to the generator. In the fault tolerance topology, the switching devices S1 and S2 can be turned on all the time, which will not influence the power supply to healthy phases. Because the proposed fault tolerance can block the faulty part, the fault tolerance topology under short-circuit fault is the same as that under open-circuit fault. Therefore, for the fault diagnosis strategy, only the fault location information is needed. The fault diagnosis flowchart for one phase is, As illustrated in Fig., when current in phase A is always equal to or over zero ($i_a \geq 0$), by switching J1 ON and switching S3 OFF, if there is a current in phase A, or the phase A current can decrease to zero, the left part is faulty, otherwise the right part fault is encountered. Since each phase converter operates independently, the fault diagnosis strategy and fault tolerance operation also can be applied in other phases. For switching devices S1 and S2, the press pack switching devices can be employed. When press pack switching devices under fault condition are equivalent to a short circuit, the power supply will not be influenced.

CHAPTER 3

SIMULATION THEORY

3.1 GENERAL

MATLAB (Matrix Laboratory) is a fourth-generation programming language which provide numerical computing environment and it was developed by Math Works, MATLAB allows matrix manipulations, implementation of algorithms, creation of user interfaces, interfacing with programs written in other languages and plotting of functions and data, including C, C++, Java, and Fortran. As MATLAB is meant primarily for numerical computing, but an optional toolbox uses the MuPAD symbolic engine, which allow access to symbolic computing capabilities. An additional package which helps for graphical multi-domain simulation and Model-Based Design for dynamic and embedded systems is SIMULINK.

In 2004, MATLAB had around a million users across industry and academia. The users of MATLAB belong to different backgrounds such as engineering, science, and economics. MATLAB is widely utilized in academic and research institutions also as industrial enterprises.

3.2 MATLAB HISTORY

Cleve Moler, the chairman of the computer-science department at the University of latest United Mexican States, started developing MATLAB within the late Nineteen Seventies. He designed it to offer his students access to LINPACK and EISPACK while not them having to find out algebraic language. It presently unfold to alternative universities and located a robust audience at intervals the mathematics community. Jack very little, Associate in Nursing engineer, was exposed thereto throughout a visit Moler created to Stanford in 1983. Recognizing its industrial potential, he joined with Moler and Steve Bangert. They rewrote MATLAB in C and supported MathWorks in 1984 to continue its development. These rewritten libraries were called JACKPAC. In 2000, MATLAB was rewritten to use a more recent set of libraries for matrix manipulation, LAPACK. MATLAB was initial adopted by researchers and practitioners au fait engineering, Little's specialty, however quickly unfold to several alternative domains. it's currently conjointly utilized in education, particularly the teaching of algebra and numerical analysis, and is standard amongst scientists concerned in image process.

3.3 *SIMULINK*

Simulink, developed by MathWorks, could even be a business tool for modeling, simulating and analyzing multi-domain dynamic systems. Its primary interface could even be a graphical block schematization tool and a customizable set of block libraries. It offers tight integration with the remainder of the MATLAB setting and might either drive MATLAB or be written from it. Simulink is wide employed in management theory and digital signal process for multi-domain simulation and Model-Based style

Simulink could even be a diagram setting for multi-domain simulation and Model-Based style. It supports system-level style, simulation, automatic code generation, and

continuous check and verification of embedded systems. Simulink provides user a graphical editor, solvers for modeling and simulating dynamic systems and customizable block libraries. it's integrated with MATLAB, enabling you to include MATLAB algorithms into models and export simulation results to MATLAB for more analysis.

3.4 *Building the Model*

Simulink provides a collection of predefined blocks that you just will mix to form a close diagram of your system. Tools for class-conscious modeling, information management, and scheme customization change you to represent even the foremost complicated system in brief and accurately.

3.4.1 *Selecting Blocks*

The Simulink Library Browser contains a library of blocks usually accustomed model a system. As shown in Fig.3.2, these embody:

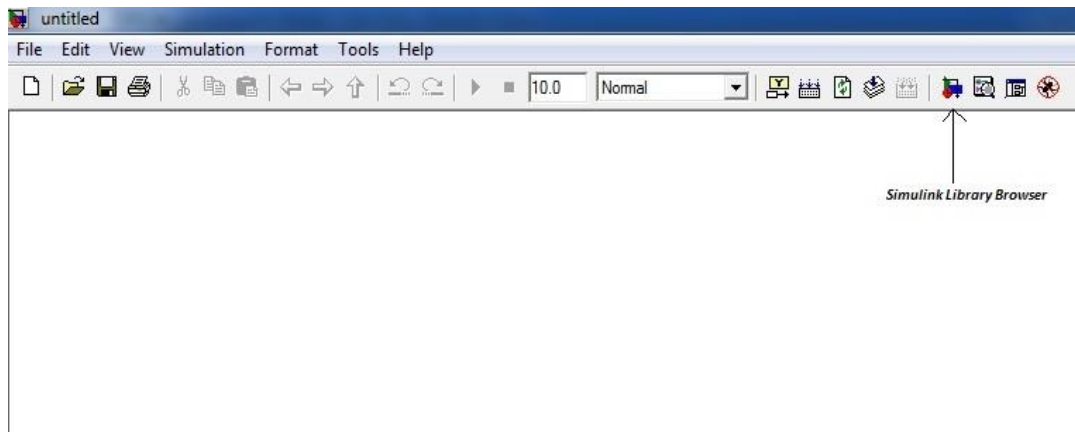


Fig.3.1. Building a new model

- Continuous and separate dynamics blocks, like Integration and Unit Delay
- Algorithmic blocks, like total, Product, and operation Table
- Structural blocks, like Mux, Switch, and Bus Selector

We can build custom functions by mistreatment these blocks or by incorporating hand-written MATLAB, C, Fortran, or adenosine deaminase code into the model. The custom blocks may be hold on in their own libraries at intervals the Simulink Library Browser.

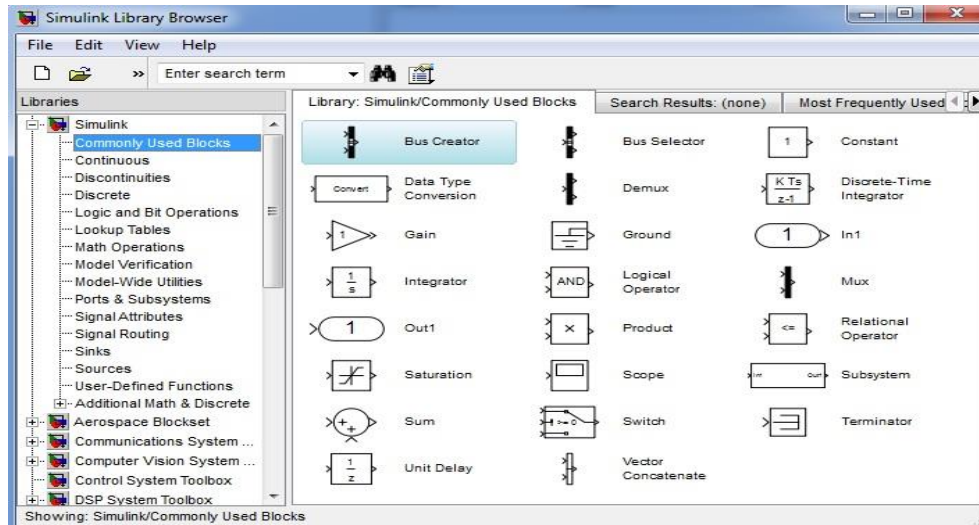


Fig.3.2. Commonly used blocks

Simulink add-on product allow you to incorporate specialised elements for region, communications, inflammatory disease management, management logic, signal process, video and image process, and different applications. Add-on product are on the market for modeling physical systems with mechanical, electrical, and hydraulic elements. To build a model as shown in **Fig.3.1** by dragging blocks from the Simulink Library Browser into the Simulink Editor, we tend to then connect these blocks with signal lines to ascertain mathematical relationships between system elements. Graphical info tools, like sensible guides and sensible signal routing, facilitate we tend to management the looks of the model as we tend to build it. we are able to add hierarchy by encapsulating a gaggle of blocks and signals as a scheme during a single block. The Simulink Editor provides a whole management over what we tend to see and use inside the model. as an example, we are able to add commands and submenus to

the editor and context menus. we are able to conjointly add a custom interface to a scheme or model by employing a mask that hides the scheme's contents and provides the subsystem with its own icon and parameter panel.

3.4.2 Navigating Through the Model Hierarchy

The somebody bar and Model Browser in Simulink helps to navigate the model. The somebody bar indicates the amount of hierarchy that we have a tendency to ar presently viewing and lets we will move up and down the hierarchy. The Model Browser provides an entire stratified tree read of your model, and just like the somebody bar, is wont to move through the amount of hierarchy.

3.4.3 Managing Signals and Parameters

Simulink models contain each signals and parameters. Signals ar time-varying knowledge described by the lines connecting blocks. Parameters ar coefficients that outline system dynamics and behavior. Simulink helps to see the subsequent signal and parameter attributes as shown in Fig.3.3:

- Data type—single, double, signed, or unsigned 8-, 16- or 32-bit integers; Boolean; enumeration; or mounted purpose
- Dimensions—scalar, vector, matrix, N-D, or variable-sized arrays
- Complexity—real or complicated values
- Minimum and most vary, initial price, and engineering units

If we decide to not specify knowledge attributes, Simulink determines them mechanically via propagation algorithms, and conducts consistency checking to make sure knowledge integrity. These signal and parameter attributes will be fixed either inside the model or in a very separate knowledge wordbook. we will then use the Model someone to prepare, view, modify, and add knowledge while not navigating through the whole model as shown in Fig.3.4.

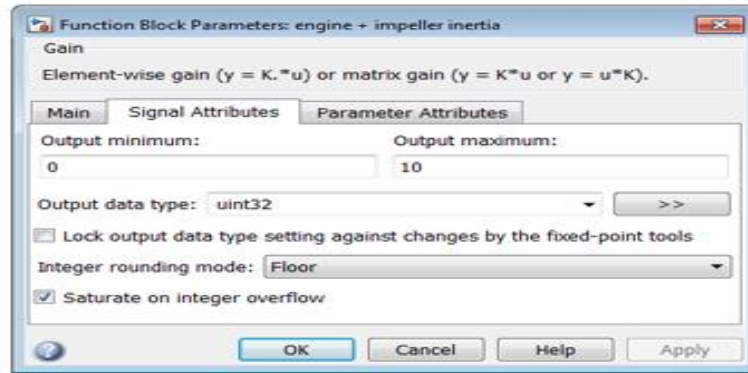


Fig.3.3 Signal Attributes tab

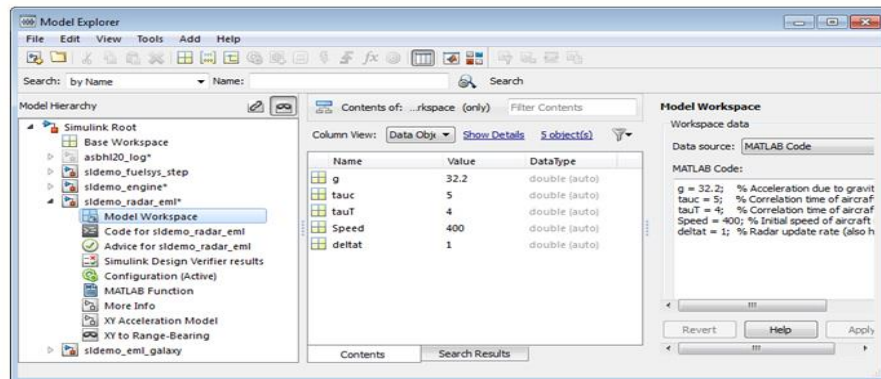


Fig.3.4 Model Explorer Window

3.4.4 Simulating the Model

We can simulate the dynamic behavior of the system and examine the results because the simulation runs. To make sure simulation speed and accuracy, Simulink provides fixed-step and variable-step lyric solvers, a graphical computer program, and a model profiler.

3.4.5 Choosing a Solver

Solvers as shown in Fig.3.5 square measure numerical integration algorithms that reckon the system dynamics over time mistreatment info contained within the model. Simulink provides solvers to support the simulation of a broad vary of systems, as well as continuous-time (analog), discrete-time (digital), hybrid (mixed-signal), and multirate systems of any size.

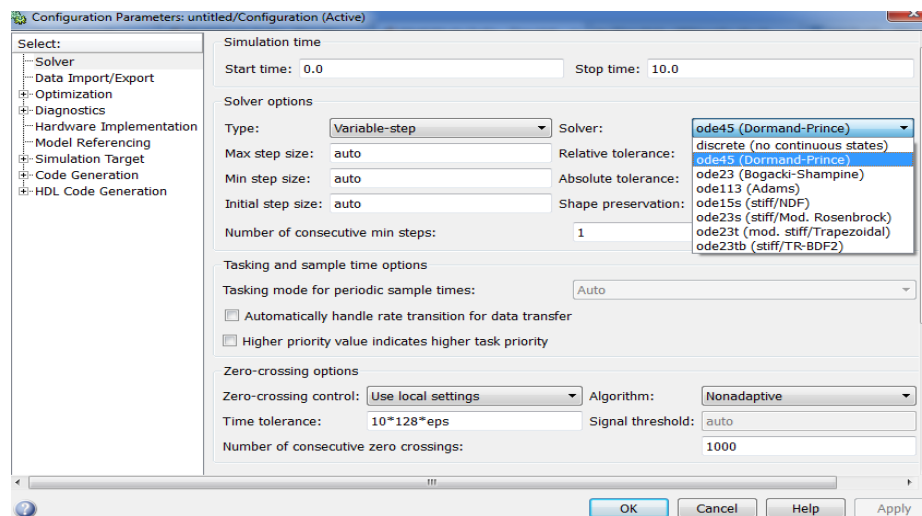


Fig.3.5. Configuration Parameters dialog box showing the Solver pane.

These solvers will simulate stiff systems and systems with discontinuities. we are ready to specify simulation choices, alongside the type and properties of the problem solver, simulation begin and stop times, and whether or to not load or save simulation information. We are ready to conjointly set improvement and diagnostic data. Totally different combos of choices are often saved with the model.

3.4.6 Running the Simulation

We can run your simulation interactively from the Simulink Editor or consistently from the MATLAB instruction. the next simulation modes are available:

- Normal (the default), that interpretively simulates the model
- Accelerator, which will increase simulation performance by making and execution compiled target code however still provides the flexibleness to vary model parameters throughout simulation
- Rapid Accelerator, which can simulate models quicker than Accelerator mode by making associate possible which will run outside Simulink on a second process core

To reduce the time needed to run multiple simulations, we are ready to run those simulations in parallel on a multi-core pc or pc cluster.

3.4.7 Analyzing Simulation Results

After running a simulation, we are ready to analyze the simulation results in MATLAB and Simulink. The simulation behavior can be understand by the debugging tools provided in Simulink.

3.4.8 Viewing Simulation Results

By viewing signals on the displays and scopes provided in Simulink the simulation behavior can be visualised. we are ready to conjointly read simulation information among the Simulation information Inspector, wherever we are ready to compare multiple signals from totally different simulation runs. Scope is that the block in Simulink by that we are ready to live and appearance at the voltage, current, and power in electrical domain. Fig.3.6 shows the output of a construction device through scope.

Alternatively, we are ready to build custom HMI displays victimization MATLAB, or log signals to the MATLAB space to seem at and analyze the knowledge victimization MATLAB algorithms and image tools.

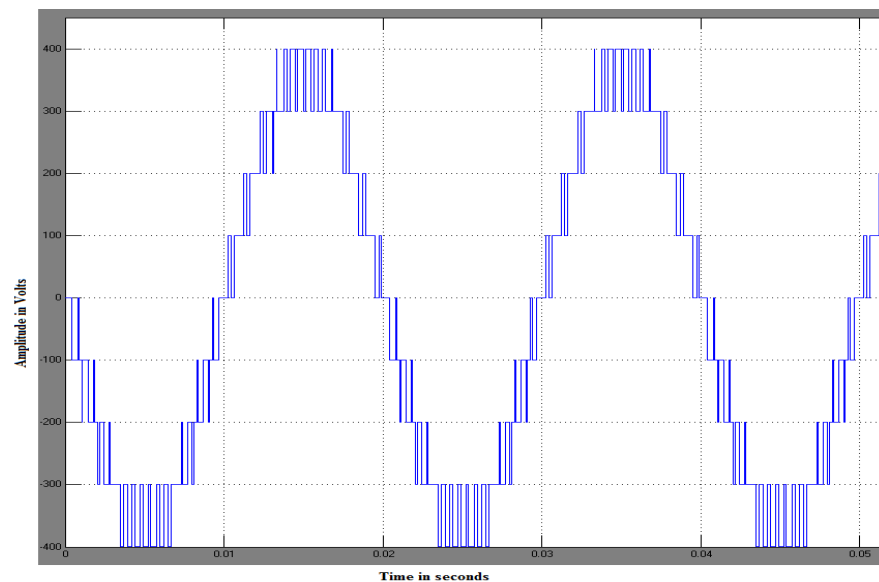


Fig.3.6. Multi-step waveform

3.4.9 Debugging the Simulation

Simulink supports debugging with the Simulation Stepper, that lets we tend to step back and forth through your simulation viewing knowledge on scopes or inspecting however and once the system changes states. With the Simulink programm we are able to step through a simulation one methodology at a time and examine the results of capital punishment that methodology. because the model simulates, you'll show data on block states, block inputs and outputs, and block methodology execution among the Simulink Editor.

3.5 SIM POWER SYSTEMS

SimPower Systems™ provides element libraries and analysis tools for modeling and simulating electric power systems. The libraries embrace models of electric power elements, together with three-phase machines, electrical drives, and elements for applications like versatile AC transmission systems (FACTS) and renewable energy systems. Fourier analysis, calculation of total harmonic distortion (THD), load flow, and other key electric power system analyses area unit automatic. Sim Power Systems was developed by Hydro-Québec of metropolis. SimPower Systems models as shown in Fig.3.7 is wont to develop management systems and check system-level performance. we will parameterize the model victimisation MATLAB® variables and expressions, and style management systems for the electric power system in Simulink®. we will add mechanical, hydraulic, pneumatic, and alternative elements to the model victimisation Simscape™ and check all in an exceedingly single simulation setting. To deploy models to alternative simulation environments, together with hardware-in-the-loop (HIL) systems, SimPowerSystems supports C-code generation. Starting with MathWorks unharness thirteen, SimPowerSystems and SimMechanics of the Physical Modeling product family work in conjunction with Simulink® to model electrical, mechanical, and

management systems. electric power systems area unit mixtures of electrical circuits and mechanical device devices like motors and generators. Engineers operating during this discipline area unit perpetually up the performance of the systems. necessities for drastically raised potency have forced installation designers to use power electronic devices and complicated system ideas that tax ancient analysis tools and techniques. additional complicating the analyst's role is that the undeniable fact that the system is commonly thus nonlinear that the sole thanks to are aware of it is thru simulation. Land-based power generation from electricity, steam, or alternative devices isn't the sole use of power systems. a typical attribute of those systems is their use of power physical science and management systems to attain their performance objectives. SimPowerSystems was styled to produce a contemporary design tool that enables scientists and engineers to apace and simply build models that simulate powersystems. SimPowerSystems uses the Simulink setting, permitting you to make a model victimisation straightforward click and drag procedures. Not solely are you able to draw the circuit topology apace, however your analysis of the circuit will embrace its interactions with mechanical, thermal, control, and alternative disciplines. this is often potential as a result of all the electrical elements of the simulation move with the intensive Simulink modeling library. Since Simulink uses MATLAB® as its process engine, designers also can use MATLAB toolboxes and Simulink blocksets. Sim Power Systems and Sim Mechanics share a special Physical Modeling block and association line interface. Users will apace place Sim Power Systems to figure. The libraries contain models of typical power instrumentation like transformers, lines, machines, and power physical science. These models area unit tried ones coming back from textbooks, and their validity is predicated on the expertise of the ability Systems Testing and Simulation Laboratory of Hydro-Québec, an outsized North yankee utility situated in North

American nation. The capabilities of Sim Power Systems for modeling a typical electrical grid area unit illustrated in demonstration files. And for users United Nations agency wish to refresh their information of installation theory, there are self-learning case studies.

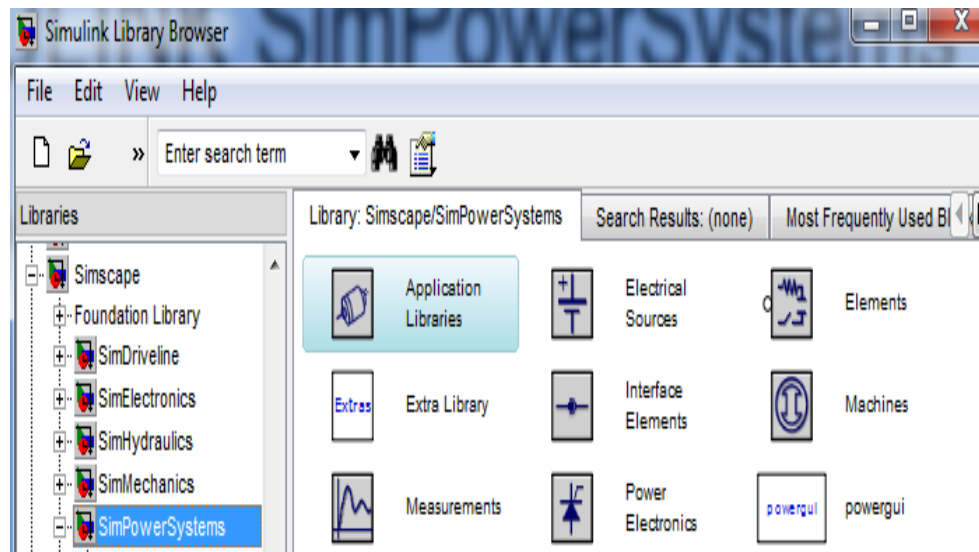


Fig.3.7. SimPowerSystems pane

3.6 Modeling Electrical Power Systems

With Sim Power Systems, we have a tendency to build a model of a system even as we'd assemble a physical system. The elements within the model area unit connected by physical connections that represent ideal conductivity ways. This approach describes the body of the system instead of etymologizing and implementing the equations for the system. From the model, that closely resembles a schematic, Sim PowerSystems mechanically constructs the differential pure mathematics equations (DAEs) that

characterize the behavior of the system. These equations are unit integrated with the remainder of the Simulink model. We can use the device blocks in Sim Power Systems to live current and voltage in your power network, and so pass these signals into customary Simulink blocks. supply blocks change Simulink signals to assign values to the electrical variables current and voltage. device and supply blocks connect an impact algorithmic program developed in Simulink to a SimPower Systems network.

3.7 Modeling Custom Components

Sim Power Systems enables to model custom components by using the fundamental elements included in its libraries and by combining these elements with Simulink blocks.

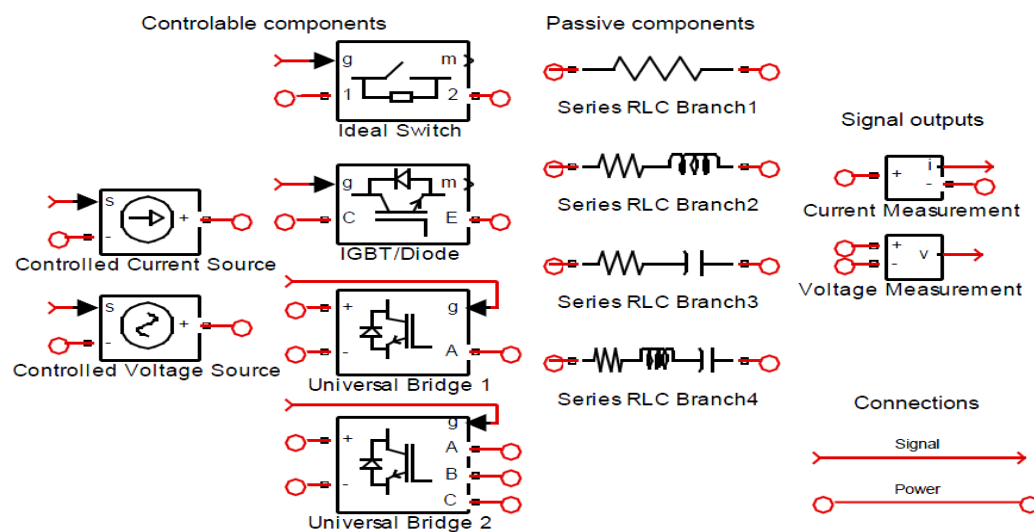


Fig.3.8. Simpower system Libraries

Sim Power Systems parts as shown in Fig.3.8 include:

Electrical elements: Linear and saturable transformers; arrestors and breakers; and line models.

Electric machinery: Models of synchronous, magnet synchronous, and DC machines; excitation systems; and models of hydraulic and steam turbine-governor systems

Power electronics: Diodes, simplified and complicated thyristors, GTOs, switches, IGBT models, and universal bridges that enable choice of normal bridge topologies

Control and measurement: Voltage, current, and ohmic resistance measurements; RMS measurements; active and reactive power calculations; timers, multimeters, and Fourier analysis; HVDC control; total harmonic distortion; and abc-to-dq0 and dq0-to-abc transformations

Electrical supplies: To implement curving current source, curving voltage supply, generic battery model, Controlled AC Current and Voltage sources, DC Voltage supply. To implement three-phase voltage supply with programmable time variation of amplitude, phase, frequency, and harmonics, and to implement three-phase supply with internal R-L ohmic resistance. the complete blocksets is shown in **Fig.3.9**.

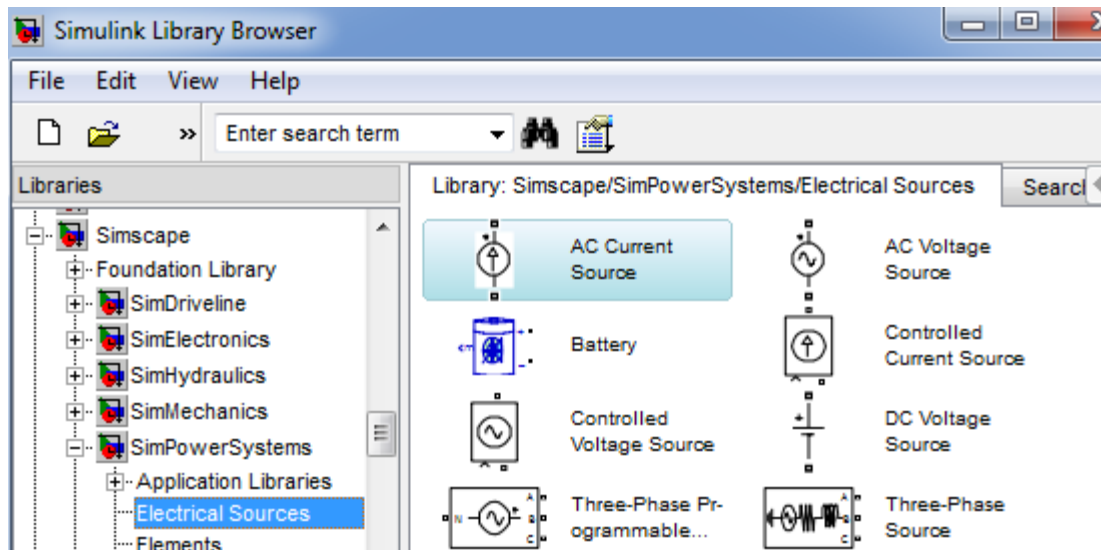


Fig.3.9. Blocksets of electrical sources used in SimPower Systems

Three-phase components: RLC masses and branches; breakers and faults; pi-section lines; voltage sources; transformers; synchronous and asynchronous generators; and motors, analyzers, and measurements

Electric Drives and different Application Libraries

SimPowerSystems provides the subsequent specialised application libraries:

Flexible AC Transmission Systems (FACTS): Phasor models of versatile AC transmission systems

Distributed Resources: Phasor models of wind turbines

Electric Drives: Editable models of electrical drives that embrace careful descriptions of the motor, converter, and controller for every drive. the electrical Drives library includes magnet, synchronous, and asynchronous (induction) motors. The converters and controllers implement the foremost common ways for

dominant the speed and torsion for these motors, like direct-torque management and field-oriented management.

SimPowerSystems supports the event of complicated, self-contained power systems, like those in cars, aircraft, producing plants, and power utility applications. you'll be able to mix SimPowerSystems with different MathWorks physical modeling merchandise to model complicated interactions in multi-domain physical systems. The block libraries and simulation strategies in SimPowerSystems were developed by Hydro-Québec of city.

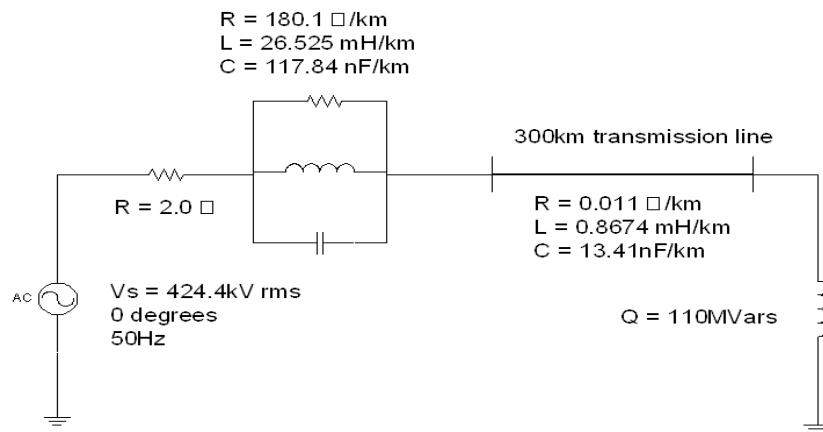


Fig.3.10. Circuit of a transmission line

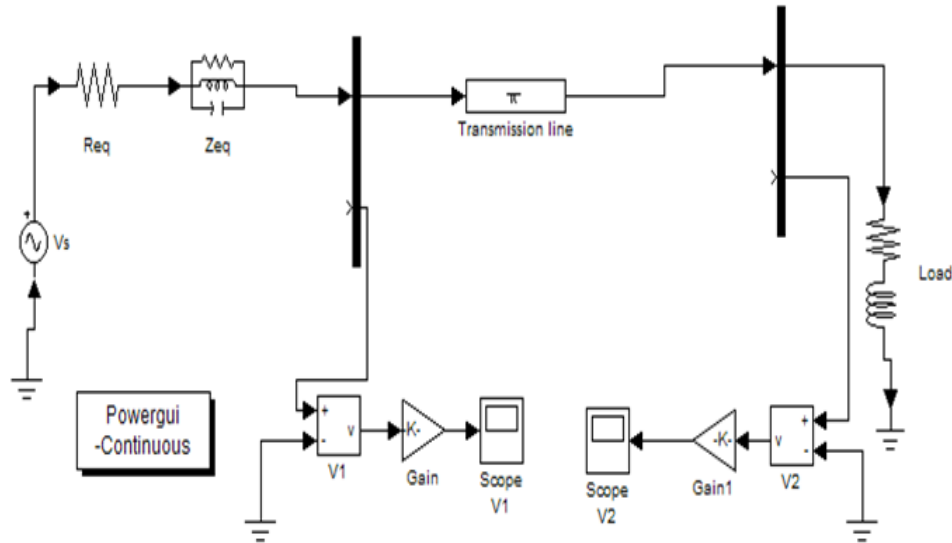


Fig.3.11. Same circuit designed in Simulink window

Thus users will quickly place SimPowerSystems to figure. The libraries that containing models of typical power instrumentation like transformers, lines, machines, and power physical science square measure wont to construct a electric circuit shown in **Fig.3.10** and also the utterly designed circuit of identical in Simulink window as shown in **Fig.3.11**

3.8 Connecting to Hardware

We can connect the Simulink model to hardware for fast prototyping, hardware-in the-loop (HIL) simulation, Associate in Nursing readying on an embedded system.

3.8.1 Running Simulations on Hardware

Simulink provides intrinsical support for prototyping, testing, and running models on cheap target hardware, as well as Arduino®, LEGO® MINDSTORMS® NXT,

PandaBoard, and BeagleBoard. we will style algorithms in Simulink for management systems, robotics, audio process, and pc vision applications and see them perform in real time.

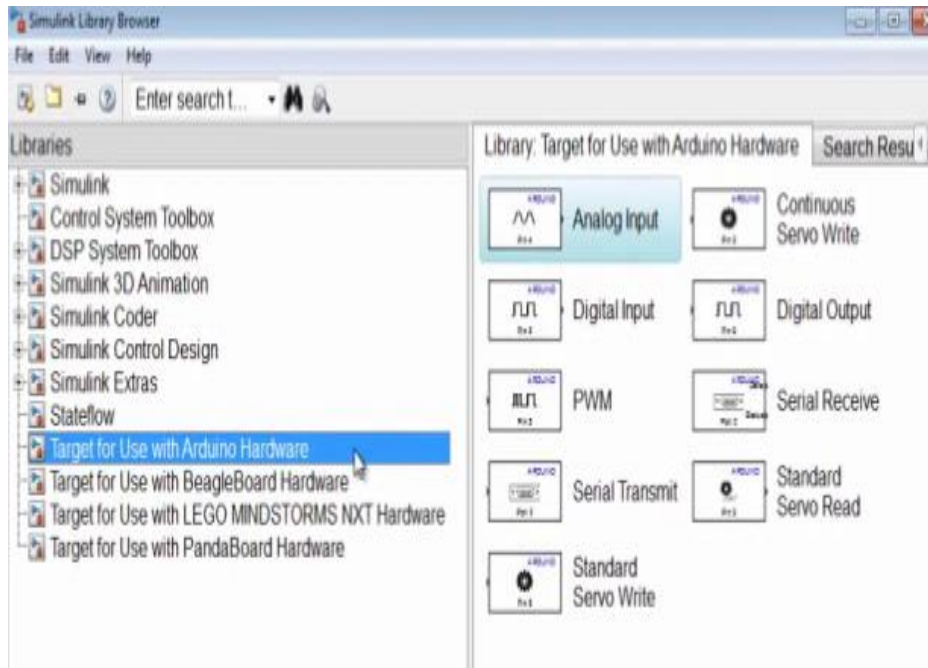


Fig.3.12. Hardware Interface to simulink

Simulink provides inherent support for prototyping, testing, and running models on affordable target hardware, as well as Arduino®, LEGO® MINDSTORMS® NXT, and BeagleBoard as shown in **Fig.3.13**



Fig.3.13. low-cost target hardware

With period Windows Target™, we will run Simulink models in real time on Microsoft® Windows® PCs and connect with a spread of I/O boards to form and management a period system as shown in Fig.3.12. To run the model in real time on a target pc, we will use xPC Target™ for HIL simulation, speedy management prototyping, and alternative period testing applications. See xPC Target peace officer for offered target element. Simulink models will be organized and prepared for code generation. By exploitation Simulink with add-on code generation product, you'll generate C and C++, HDL, or PLC code directly from your model.

3.9 APPLICATIONS

A number of MathWorks and third-party hardware and software package product ar available to be used with Simulink. as an example, Stateflow extends Simulink with a method surroundings for developing state machines and flow charts. together with Simulink soul, another product from MathWorks, Simulink can automatically generate C American Standard Code for Information Interchange document for amount

implementation of systems. as a result of the efficiency and suppleness of the code improves, usually this can be often turning into extra wide adopted for production systems, to boot to being a most popular tool for embedded system vogue work because of its flexibility and capability for quick iteration. Embedded soul creates code economical enough to be utilized in embedded systems. xPC Target in conjunction with x86-based amount systems provides associate surroundings to simulate and check Simulink and Stateflow models in amount on the physical system. Embedded soul to boot supports specific embedded targets, yet as Infineon C166, Motorola68HC12, Motorola MPC 555, TI C2000, TI C6000, RenesasV850 and Renesas SuperH. With HDL soul, to boot from MathWorks, Simulink and Stateflow can automatically generate synthesizable VHDL and Verilog. Simulink Verification and Validation permits systematic verification and validation of models through modeling vogue checking, desires traceability and model coverage analysis. Simulink vogue friend uses formal ways that to identify vogue errors like range overflow, division by zero and dead logic, and generates test case things for model checking among the Simulink surroundings. The systematic testing tool TPT offers technique|a way|a technique} to perform formal test- verification and validation method to stimulate Simulink models but to boot throughout the event section where the developer generates inputs to visualize the system. By the substitution of the Constant and Signal generator blocks of Simulink the stimulation becomes consistent.

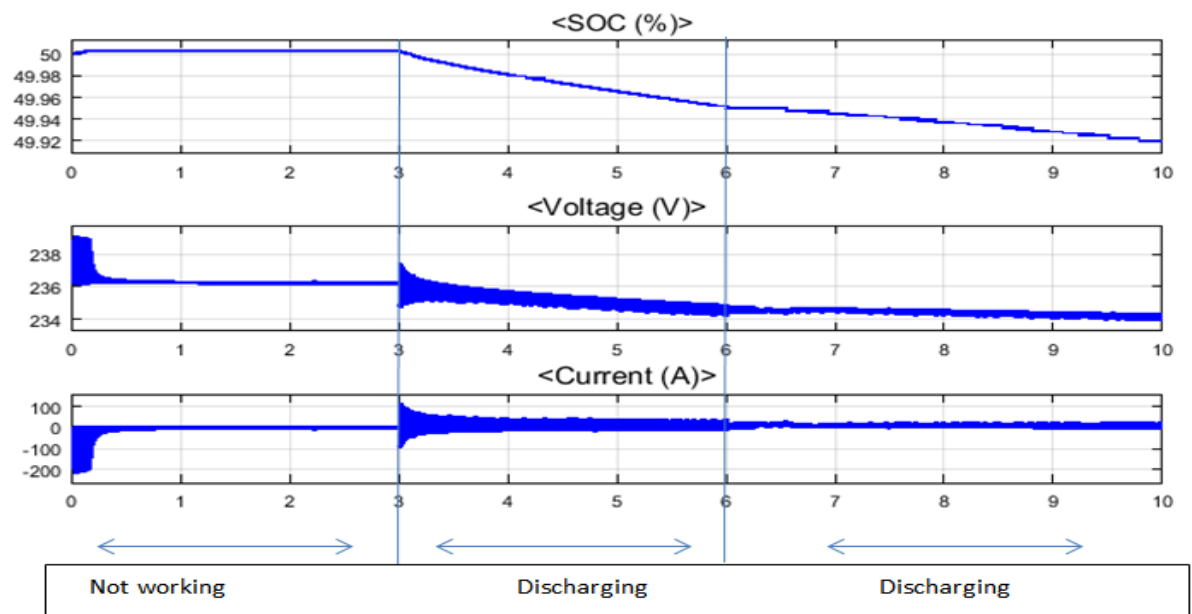
A library of graphical building blocks for modeling queuing systems to the Simulink surroundings is added by SimEvents. It to boot adds associate event-based simulation engine to the time-based simulation engine in Simulink.

CHAPTER 4

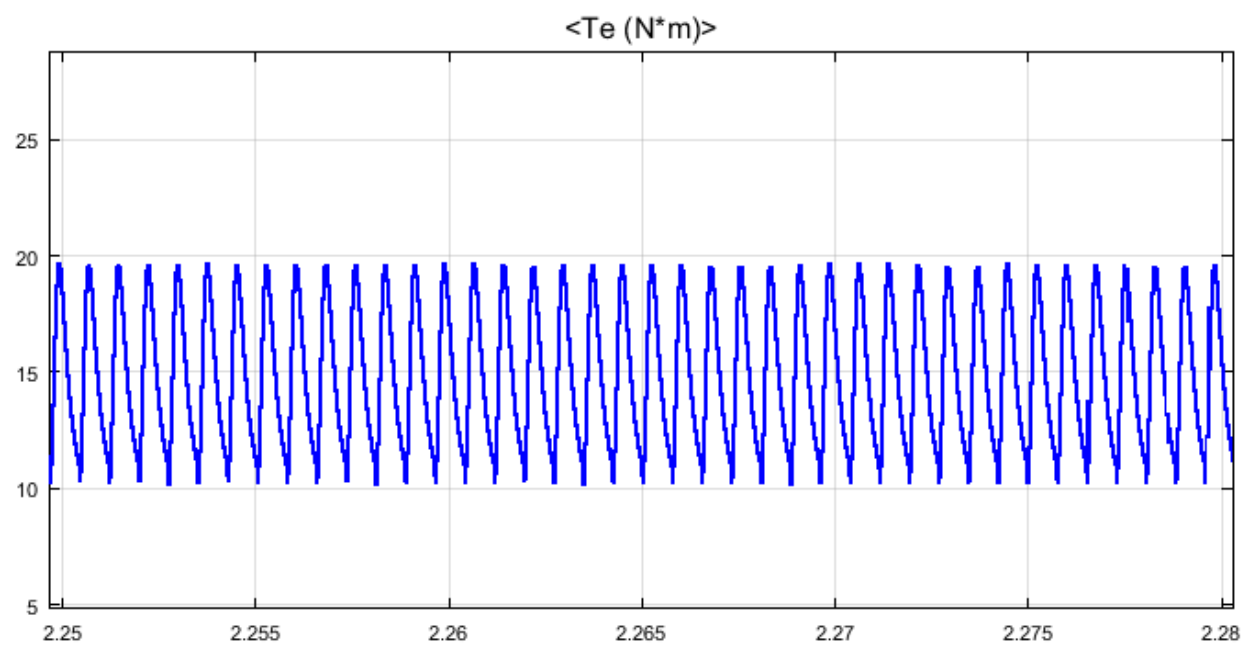
SIMULATION RESULTS

4.1 SIMULATIONS

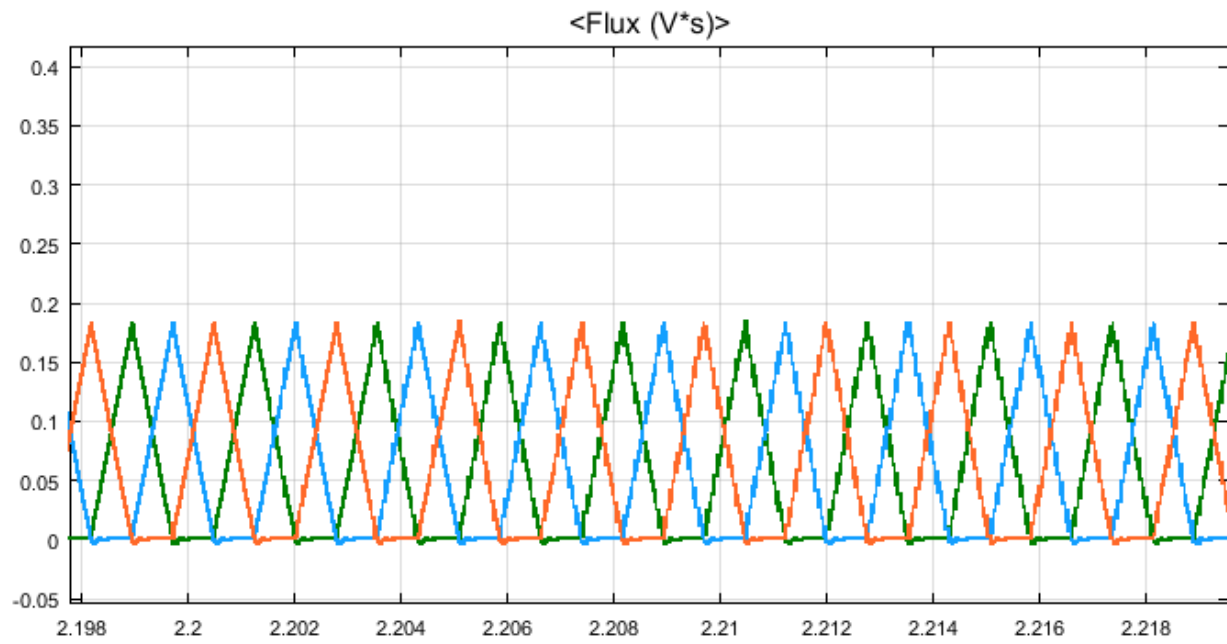
SIMULATION MODEL (different modes):



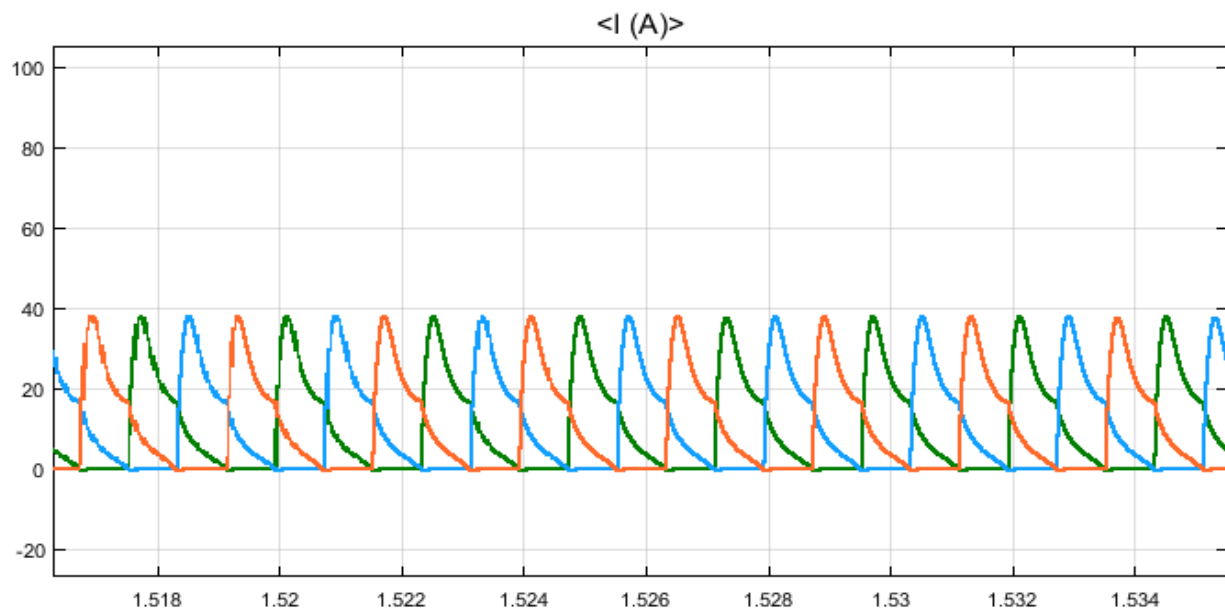
Electromagnetic torque



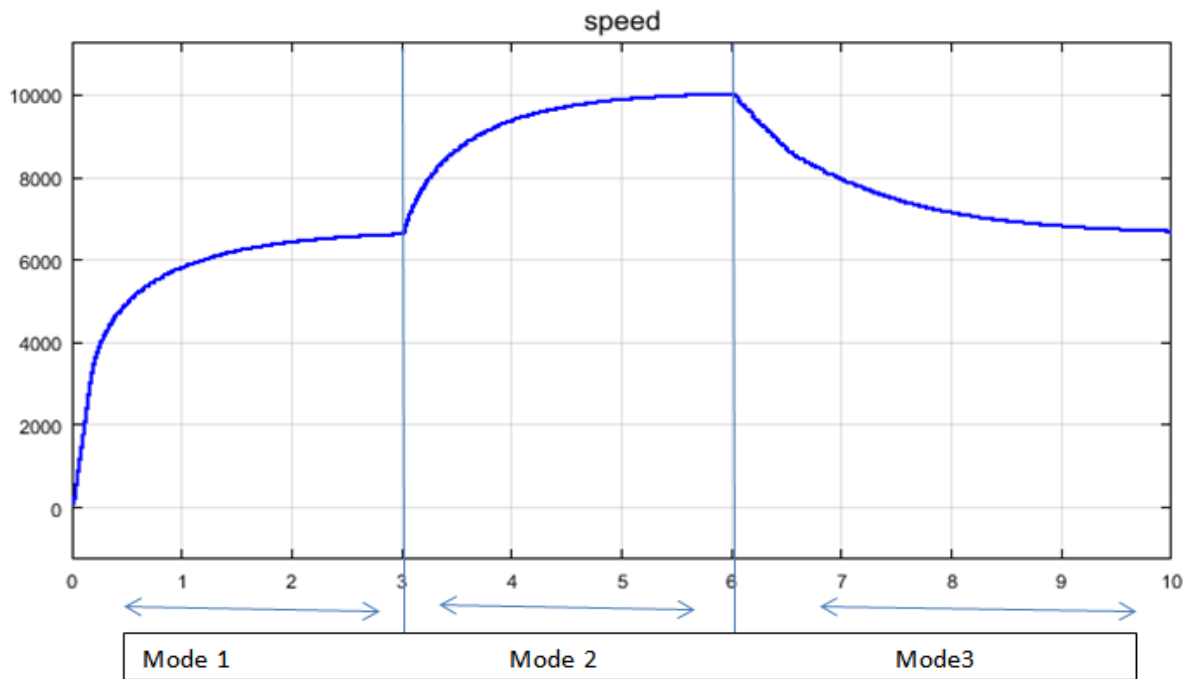
Flux



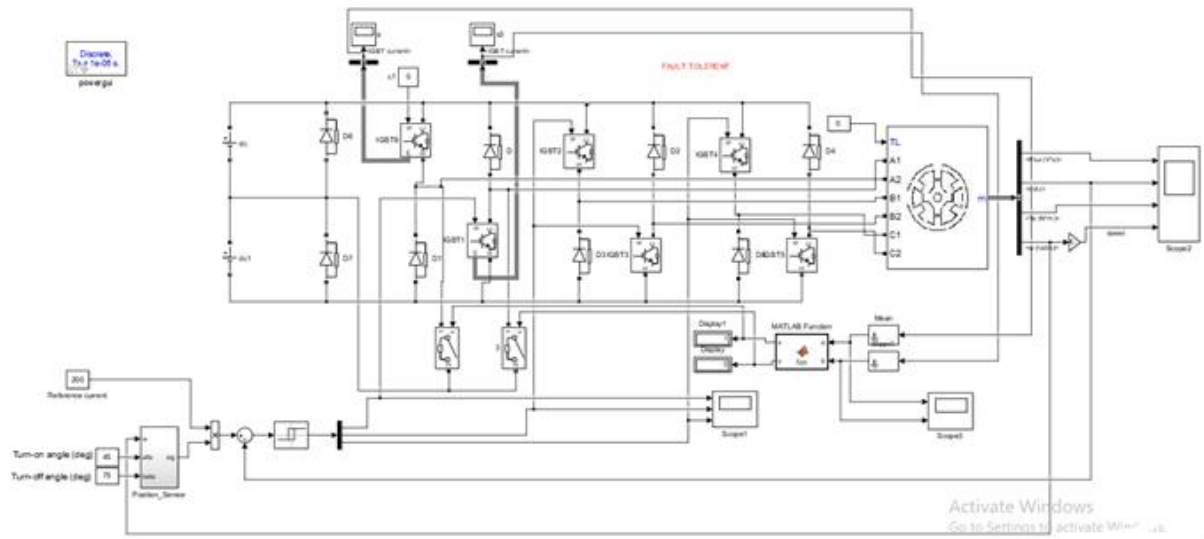
Motor current



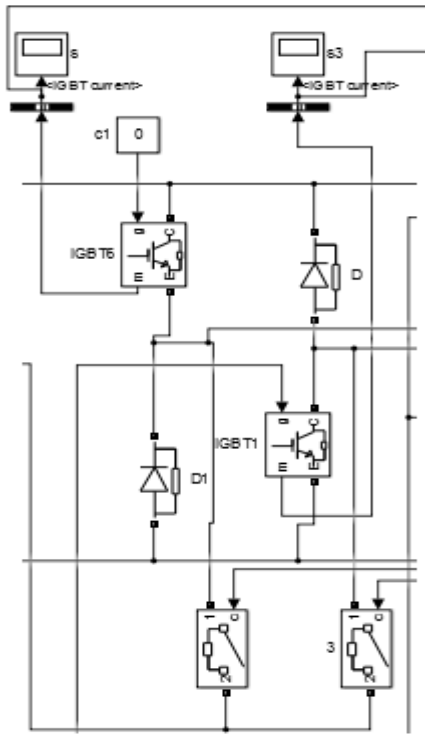
Motor speed



SIMULATION MODEL (Fault analysis):



PHASE A (LEG A (Fault) , LEG B)



Command window display faulted phase A (Leg A)

```
leg A get fault
leg A get fault
leg A get fault
leg A get fault
leg A get fault
leg A get fault
leg A get fault
leg A get fault
leg A get fault
leg A get fault
```

Appendix 1: (Phase A fault)

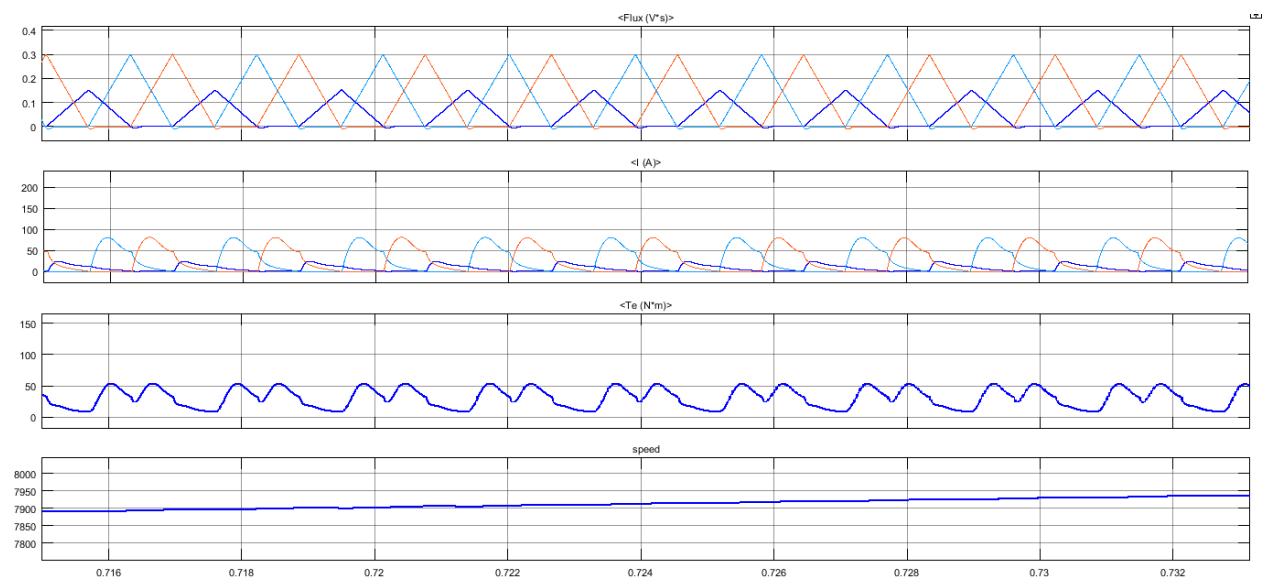
```
function [x , y] = fcn(a,b)
x=0;
y=0;
%#codegen
if a<=0
    disp('leg A get fault');
    x=1;
    y=0;
end
```

```

if b<=0
    disp('leg B get fault');
    y=1;
    x=0;
end

```

Flux, Motor speed, current, motor speed (after the Phase A fault):



CHAPTER 5

HARDWARE DESCRIPTION

5.1 INTRODUCTION

The hardware system of the projected convertor is enforced employing a PIC micro-controller. The code like Proteus, Mplab, and Micropro is employed for the system style for committal to writing the pulses in to the PIC controller. the facility provide circuit is intended which will management the PIC and driver circuit to drive the pulses to the MOSFET.

5.2 SOFTWARE UNIT

- **MICROPRO**

Introduction & options This Versatile applied scientist could be a dedicated PIC small controller applied scientist. All the PIC series of IC's except the seventeen series may be programmed with this Hardware through RS232 Port of computer. This applied

scientist additionally supports ICSP programming for on board programming of supported flash PIC devices. MPLAB IDE, PIC CCS C compiler Demo code with MPLAB Plug-in, and programming directions are provided in fixed storage. The applied scientist code is compatible to Windows ninety-eight, Windows 2000, and Windows XP platforms. A Soft copy of the user manual is additionally enclosed within the CD, additionally to the textual matter supplied with the Kit. This Dedicated applied scientist is for programming a good vary of PIC small controllers as well as EEPROMS, PIC12 series, PIC16 series & PIC18 series of IC's.

SPECIFICATIONS

- Auto detection of applied scientist by code
- Regulated Power provide five,13.5V
- Auto Flash upgrades through port
- 16 rate oscillator
- Built in RS232 instrumentality
- ZIF socket for simple programming
- External ICSP Interface for on board programming
- Programmable configuration and ID
- Selective Erase and programming for supported PIC Devices
- Manual / car Reset
- Configurable COM Port.
- Program, Read, Verify and Blank check Modes
- Hex Code Editor
- Program & Verify fly Window
- Switchable to MPLAB code

- Extensive Integrated facilitate
- Debug vector scan & write
- Oscal price scan & program (for chosen chips)

- **MPLAB**

MPLAB Integrated Development surroundings (IDE) could be a free, integrated toolset for the event of embedded applications on Microchip's PIC and dsPIC microcontrollers. HI-TECH code is Associate in Nursing Australian-based company that has ANSI C compilers and development tools. supported in 1984, the corporate is best identified for its advanced C professional compilers with whole-program compilation technology, or all-knowing Code Generation (OCG). advanced code was bought by semiconductor device on twenty Gregorian calendar month 2009, whereat it refocused its development effort solely on supporting semiconductor device merchandise. The advanced C compiler for PIC10/12/16 MCUs (Lite mode) could be a software package compiler. All PIC10, PIC12 and PIC16 series devices are supported by MPLAB. The options of advanced C compiler are listed as followings:

- Fully compatible with Microchip's MPLAB IDE
- Fully ANSI-compliant
- Includes Library supply - for traditional libraries and sample code for I/O drivers
- Includes macro program, linker, preprocessor, and ballroom dance driver
- Runs on 32/64-bit Windows, Linux and mack OS X

5.2.1 CONTROLLER UNIT

A Microcontroller (can be abbreviated as μ C or MCU) is a type of small sized computer on a single metal-oxide-semiconductor (MOS) integrated circuit (IC) chip containing a processor core, memory, and programmable input/output peripherals. Program memory within the sort of NOR flash or OTP ROM is additionally typically enclosed on chip, additionally as a generally touch of RAM. It is designed for performing embedded applications, in distinction to the microprocessors employed in personal computers or alternative general-purpose applications.

PICs are fashionable each industrial developers and hobbyists alike thanks to their low value, wide availableness, massive user base, in depth assortment of application notes, availableness of affordable value or development tools is free, and serial programming (and re-programming can be done with flash memory) capability. semiconductor unit proclaimed on September 2011 the cargo of its 10 billionth PIC processor.

The PIC design is characterized by its different attributes:

1. Separate code and information areas (Harvard architecture) for devices apart from PIC32, that includes a John von Neumann design.
2. A tiny low range of mounted length directions. Most directions are single cycle execution (2 clock cycles, or four clock cycles in 8-bit models), with one delay cycle branches and skips.
3. One accumulator (W0), the employment of that (as supply operand) is inexplicit. (i.e. isn't encoded within the opcode)

4. All RAM locations operate as registers as each supply and/or destination of math and alternative functions.
5. A hardware stack is available which store come back addresses and fairly touch of available information area (typically 256 bytes), can be extended through banking.
6. information area mapped CPU, port, and peripheral registers.
7. The program counter is additionally mapped into the info area and writable. (this is employed to implement indirect jumps)

The Universal Synchronous Asynchronous Receiver Transmitter (USART) module is one among the two serial Input and output modules. (USART is additionally called a Serial Communications Interface or SCI.) The USART is organized as a full-duplex asynchronous system that may communicate with peripheral devices, like cathode-ray tube terminals and private computers, or it is organized as a half-duplex synchronous system that may communicate with peripheral devices, like A/D or D/A integrated circuits, serial EEPROMs, etc.

Microcontrollers unit of measure utilized in mechanically controlled merchandise and devices, like engine management systems, implantable medical devices, remote controls, work machines, appliances, power tools, toys and different embedded systems. By reducing the scale and value compared to a style that uses a separate silicon chip, memory, and input/output devices, microcontrollers build it economical to digitally management even a lot of devices and processes. Mixed signal microcontrollers square measure common, group action analog parts required to regulate non-digital electronic systems.

Microcontrollers which operating at clock rate frequencies as low as 4kHz uses 4-bit words, for low power consumption (milliwatts or microwatts). they'll typically have the power to retain practicality whereas looking ahead to an incident like a button press or alternative interrupt; power consumption whereas sleeping (CPU clock and most peripherals off) could also be simply nanowatts, creating several of them compatible for long lasting battery applications. alternative microcontrollers might serve performance-critical roles, wherever they will got to act a lot of sort of a digital signal processor (DSP), with higher clock speeds and power consumption.

The first single-chip silicon chip was the 4-bit Intel 4004 free in 1971, with the Intel 8008 and alternative a lot of capable microprocessors turning into on the market over ensuing many years. However, each processors needed external chips to implement a operating system, raising total system price, and creating it not possible to economically computerize appliances.

The Smithsonian establishment says TI engineers urban center frontiersman and Michael airman succeeded in making the primary microcontroller in 1971. The results of their work that went business in 1974 was the TMS a thousand. It combined storage, read/write memory, processor and record one chip and was targeted at embedded systems.

Partly in response to the existence of the single-chip TMS a thousand, Intel developed a ADP system on a chip optimized for management applications, the Intel 8048, with business elements initial shipping in 1977. It combined RAM and read-only storage on identical chip. This chip would notice its approach into over one billion computer keyboards, and alternative various applications. At that point Intel's President, Luke J.

Valenter, explicit that the microcontroller was one among the foremost palmy within the company's history, and dilated the division's budget over twenty-fifth.

Most microcontrollers at this point had 2 variants. One had AN eradicable erasable programmable read-only memory program memory, that was considerably costlier than the promenade variant that was solely programmable once. Erasing the erasable programmable read-only memory needed exposure to ultraviolet through a transparent quartz lid. One-time components could be created in lower-cost opaque plastic packages. In 1993, the introduction of EEPROM memory allowed microcontrollers (beginning with the semiconductor unit PIC16x84) to be electrically erased quickly while not a chic package as required for erasable programmable read-only memory, permitting each speedy prototyping, and In System Programming. constant year, Atmel introduced the first microcontroller exploitation memory board . different firms chop-chop followed suit, with each memory varieties. Cost has plummeted over time, with the foremost price effective 8-bit microcontrollers being obtainable for beneath \$0.25 in amount (thousands) in 2009, and a number of 32-bit microcontrollers around \$1 for similar quantities. today microcontrollers square measure low-cost and pronto obtainable for hobbyists, with massive on-line communities around bound processors. within the future, MRAM might probably be used in microcontrollers as a result of it's infinite endurance and its progressive semiconductor wafer method price is relatively low. concerning fifty fifth of all CPUs sold among the planet square measure 8-bit microcontrollers and microprocessors. consistent with Semico, over four billion 8-bit microcontrollers were sold in 2006. A typical home in a developed country is perhaps about to possess solely four all-purpose microprocessors however around 3 dozen microcontrollers. A typical mid-range automobile has as several as thirty or additional

microcontrollers. they will even be found in several electrical devices like laundry machines, microwave ovens, and telephones. Microcontrollers should offer real time (predictable, tho' not essentially fast) response to events among the embedded system they are dominant. once bound events occur, AN interrupt system will signal the processor to suspend process the current instruction sequence ANd to begin an interrupt procedure (ISR, or "interrupt handler"). The ISR can perform any process needed supported the supply of the interrupt before returning to the primary instruction sequence. attainable interrupt sources square measure device dependent, and typically embody events like an interior timer overflow, finishing AN analog to digital conversion, a logic level amendment on AN input like from a button being ironed, and information received on a communication link. wherever power consumption is significant as in battery operated devices, interrupts may wake a microcontroller from a occasional power sleep state wherever the processor is halted till needed to try to to one thing by a peripheral event. Microcontrollers sometimes contain from many to dozens of general purpose input/output pins (GPIO). GPIO pins square measure software system configurable to either AN input or AN output state. once GPIO pins square measure designed to AN input state, they are typically used to browse sensors or external signals. designed to the output state, GPIO pins will drive external devices like LEDs or motors. Many embedded systems have to be compelled to browse sensors that manufacture analog signals. this is often the aim of the data converter (ADC). Since methodors square measure engineered to interpret and process digital information, i.e. 1s and 0s, they are unable to do to to something with the analog signals which can be sent to that by a tool . that the analog to digital device is utilized to convert the incoming information into a type that the processor will acknowledge. A less common feature on some microcontrollers could also be a data converter (DAC)

that allows the processor to output analog signals or voltage levels. In addition to the converters, several embedded microprocessors embody a variety of timers additionally . one among the foremost common kinds of timers is that the Programmable Interval Timer (PIT). A PIT might either count from some worth to zero, or up to the capability of the count register, overflowing to zero. Once it reaches zero, it sends AN interrupt to the processor indicating that it's finished enumeration. this is often helpful for devices like thermostats, that sporadically check the temperature around them to determine if they need to indicate the air con on, the heater on, etc. an avid Pulse breadth Modulation (PWM) block makes it attainable for the hardware to control power converters, resistive masses, motors, etc., while not exploitation several hardware resources in tight timer loops. Universal Asynchronous Receiver/Transmitter (UART) block makes it attainable to receive and transmit information over a serial line with very little or no load on the hardware. Dedicated on-chip hardware additionally typically includes capabilities to talk with different devices (chips) in digital formats like I²C and Serial Peripheral Interface (SPI).

FEATURES

- Floating channel designed for bootstrap operation
- Fully operational to +600V
- Tolerant to negative transient voltage dv/dt immune
- Gate drive offer vary from ten to 20V
- Under-voltage opposition for each channels

- 3.3V logic compatible
- Separate logic offer vary from 3V to 20V
- Logic and power ground $\pm 5V$ offset
- CMOS Schmitt-triggered inputs with pull-down
- Cycle by cycle edge-triggered conclusion logic
- Matched propagation delay for each channel
- Outputs in part with input

A micro-controller is a single integrated circuit, commonly with the following features:

- Central process Unit - starting from tiny and easy 4-bit processors to advanced 32- or 64-bit processors
- Volatile Memory (RAM) for knowledge storage
- ROM, EPROM, EEPROM or non-volatile storage for program and operative parameter storage
- Discrete Input and Output bits, permitting management or detection of the logic state of a personal package pin
- Serial Input/Output like serial ports (UARTs)

- Other Serial Communications Interfaces like I²C, Serial Peripheral Interface and Controller space Network for system interconnect
- Peripherals like timers, event counters, PWM generators, and watchdog
- Clock generator - usually associate generator for a quartz temporal arrangement crystal, resonator or RC circuit
- Many embody analog-to-digital converters, some embody digital-to-analog converters
- In-circuit programming and debugging support

Analog Applications:

10-bit, up to 8-channel digitizer (A/D), Brown-out Reset (BOR), Analog Comparator module with, 2 analog comparators Programmable on-chip voltage reference (VREF) module, Programmable input multiplexing from device inputs and internal voltage reference, Comparator outputs area unit outwardly accessible.

High-Performance RISC CPU:

Only thirty-five single-word directions to be told, All single-cycle directions other than program branches, that are two-cycle, operative speed: DC –20 rate clock input DC – 200 ns instruction cycle, Around 8K * fourteen words of Flash Program Memory, Up to 368 x eight bytes of knowledge Memory (RAM), Up to 256 x eight bytes of EEPROM information Memory, Pinout compatible to various 28-pin or 40/44-pin PIC16CXXX and PIC16FXXX microcontrollers.

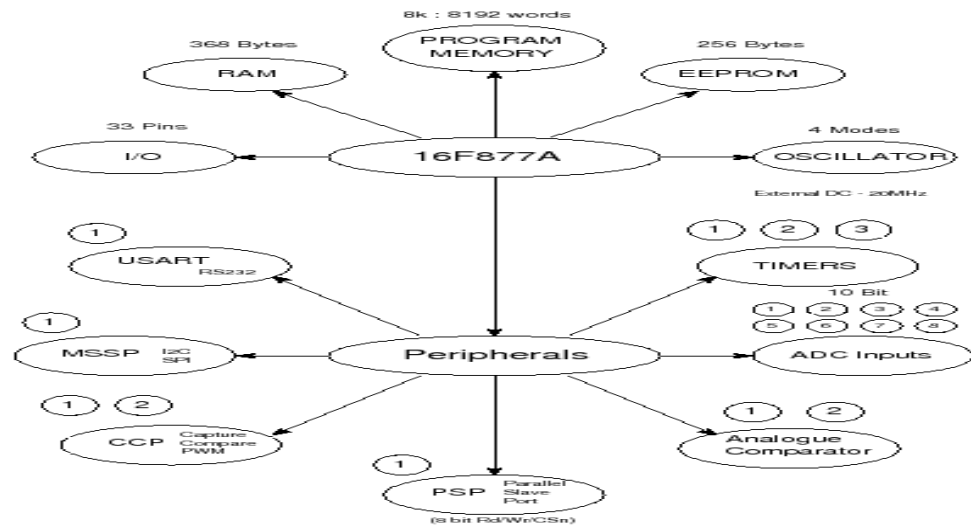


Fig.5.1. Micro-controller Peripherals

Peripheral Details:

Timer0: 8-bit timer/counter with 8-bit pre-scaler, Timer1: 16-bit timer/counter with pre-scaler, area unit typically incremented throughout Sleep via external crystal/clock, Timer2: 8-bit timer/counter with 8-bit amount register, pre-scaler and post-scaler, 2 Capture, Compare, PWM modules, Capture is 16-bit grievous bodily harm, resolution is twelve.5 ns Compare is 16-bit grievous bodily harm, resolution is two hundred ns, PWM max, resolution is 10-bit Synchronous port (SSP) with SPI (Master mode) and I2C (Master/Slave), Universal Synchronous Asynchronous Receiver Transmitter (USART/SCI) with 9-bit address detection, Parallel Slave Port (PSP) – eight bits wide with external RD, WR and Caesium controls (40/44-pin only), Brown-out detection electronic equipment for Brown-out Reset (BOR).

CMOS Technology:

Low-power, high-speed Flash/EEPROM technology, totally static style, Wide operational voltage vary (2.0V to 5.5V), industrial and Industrial temperature ranges, Low-power consumption.

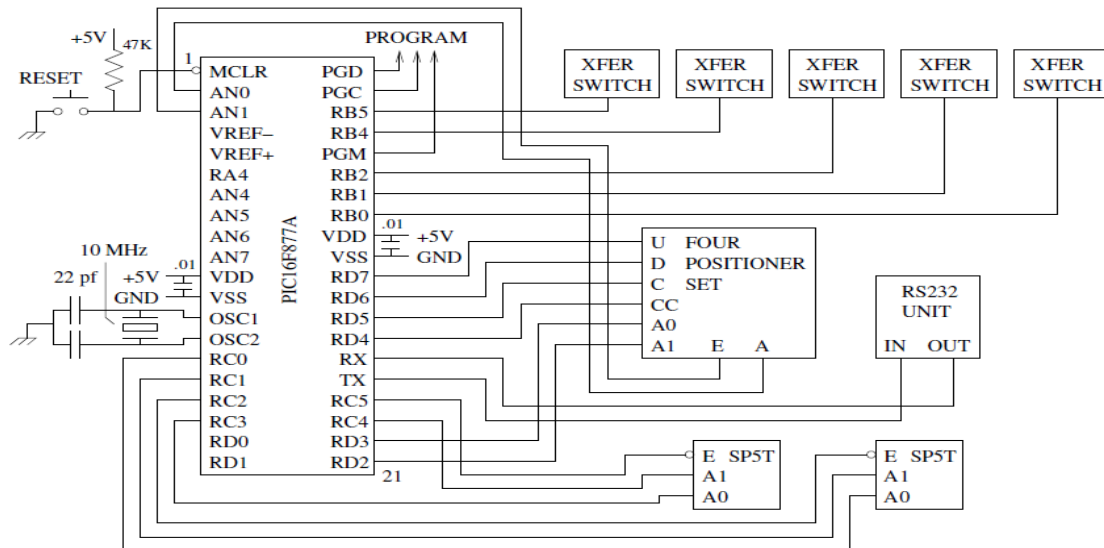


Fig.5.2. Microcontroller PIC16F877A

5.3.1 MOSFET GATE DRIVER

The High and Low facet Driver (IR2112) may be a high voltage, high speed power MOSFET and IGBT driver with freelance high and low facet documented output channels. latch immune CMOS technologies and Proprietary HVIC modification ruggedized monolithic construction. Logic inputs area unit compatible with normal CMOS or LSTTL outputs, down to 3.3V logic. The output drivers feature a high pulse

current buffer stage designed for minimum driver cross physical phenomenon. Propagation delays area unit matched to change use in high frequency applications. The floating channel are often wont to drive Associate in Nursing N-channel power MOSFET or IGBT within the high facet configuration that operates up to 600 volts. The driver circuit is employed to drive the bi-directional convertor switches wherever during this project the convertor acts as a shunt active filter (2-quadrant) for unity power issue operation and also the dc voltage regulation. Here 2 BJT's (n-type and p-type) area unit used for amplification.

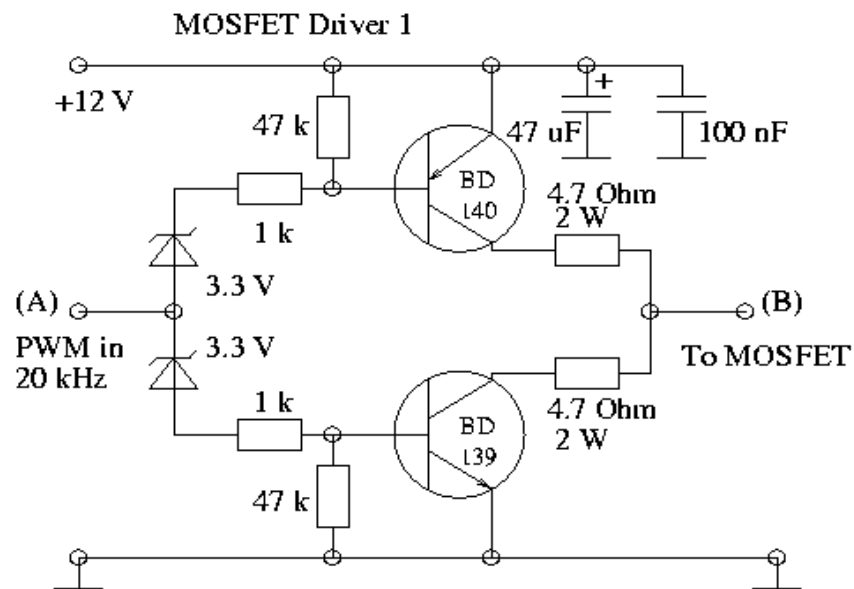


Fig.5.3. DRIVER CKT IR2110



Fig.5.6. IR2110 Driver

FEATURES

- Floating channel designed for bootstrap operation
- Fully operational to +500V or +600V
- Negative transient voltage & dV/dt immune can be tolerated
- Gate drive offer vary from ten to 20V
- Under-voltage resistance for each channel
- 3.3V logic compatible
- Separate logic offer vary from three.3V to 20V
- Logic and power ground $\pm 5V$ offset
- CMOS Schmitt-triggered inputs with pull-down
- Cycle by cycle edge-triggered conclusion logic
- Matched propagation delay for each channel
- Outputs in part with inputs

Proprietary HVIC and latch immune CMOS technologies alter ruggedized monolithic construction. Logic inputs are compatible with commonplace CMOS or LSTTL output, down to 3.3V logic. Propagation delays are matched to change use in

high frequency applications. The floating channel may be accustomed drive Associate in Nursing N-channel power MOSFET or IGBT within the high facet configuration that operates up to five hundred or 600 volts.

5.3.3 MOSFET

A cross section through an n-MOSFET when the gate voltage V_{GS} is below the edge for creating a conductive channel; there's little or no conduction between the terminals source and drain; the switch is off. MOSFET attracts electrons, when it is highly positive ,as it induces an n-type conductive channel within the substrate below the oxide, which allows electrons to flow between the n-doped terminals; the switch is ON.

ADVANTAGES

- Silicon gate for fast switching speeds.
- Low $R_{ds(on)}$ to attenuate On-losses, specified at elevated temperature.
- Rugged---SOA is power dissipation limited.
- Source to empty diode characterized to be used with inductive loads.
- Dynamic dv/dt rating
- Repetitive avalanche rated

- Fast switching
- Ease of paralleling
- Simple drive requirements

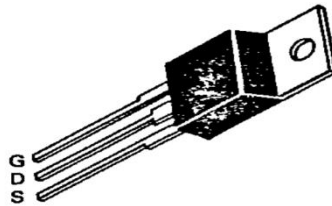


Fig.5.8. IRF840

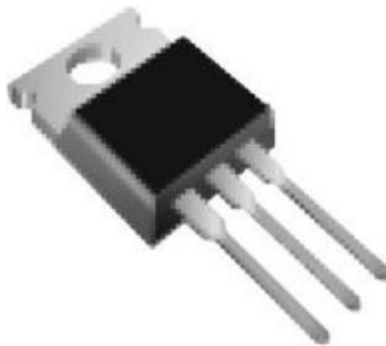


Fig.5.9. IRF840

PRODUCT SUMMARY		
V_{DS} (V)	500	
$R_{DS(on)}$ (Ω)	$V_{GS} = 10\text{ V}$	0.85
Q_g (Max.) (nC)	63	
Q_{gs} (nC)	9.3	
Q_{gd} (nC)	32	
Configuration	Single	

Table 2: MOSFET Specification

FEATURES

- $I_{ds} = 8\text{A}$; $V_{ds} = 500\text{V}$; $R_{ds(on)} = 0.850\Omega$
- Single Pulse Avalanche Energy Rated
- SOA is Power Dissipation Limited
- Nanosecond Switching Speeds
- Linear Transfer Characteristics
- High Input Impedance

5.3.4 DIODE

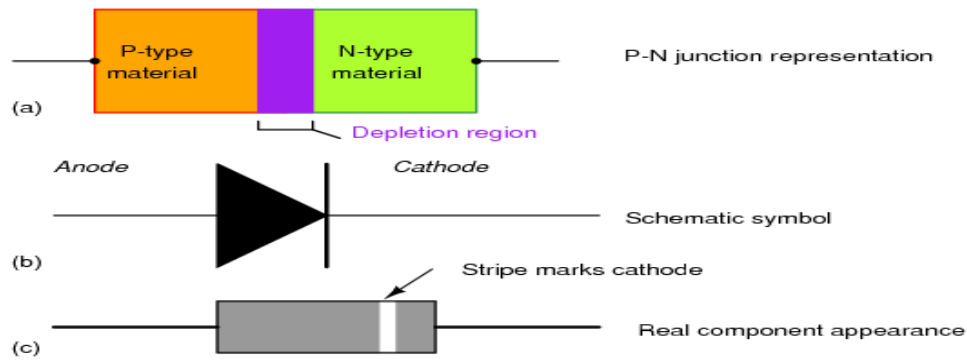


Fig.5.10. Diode

In electronics, a diode may be a sort of two-terminal electronic component with nonlinear resistance and conductance (i.e., a nonlinear current–voltage characteristic), distinguishing it from components like two-terminal linear resistors which obey Ohm's law. A diode, the foremost common type today, may be a crystalline piece of semiconductor material connected to two electrical terminals. A tube (thermionic tube, electron tube, thermionic valve, electronic device" tube diode (now rarely used except in some high-power technologies) may be a vacuum tube with two electrodes: a plate and a cathode. the foremost common function of a diode is to permit an electrical current to pass in one direction (called the diode's forward direction), while blocking current within the other way (the reverse direction). Thus, the diode are often thought of as an electronic version of a check valve. This unidirectional behavior is named rectification, and is employed to convert AC to DC, and to extract modulation from radio signals in radio receivers—these diodes are sorts of rectifiers.

Diode have more complicated behavior than this easy on-off action. Until a particular threshold voltage is present within the forward direction (a state during which the diode

is claimed to be forward-biased) Semiconductor diodes don't begin conducting electricity. The drop across a forward-biased diode varies only a touch with the present, and may be a function of temperature; this effect are often used as a temperature sensor or voltage reference.

By varying the semiconductor materials and introducing impurities into (doping) the materials semiconductor diodes nonlinear current–voltage characteristic are often tailored. These are exploited in special purpose diodes that perform many various functions. for instance, diodes are wont to regulate voltage (Zener diodes), to guard circuits from high voltage surges (avalanche diodes), to electronically tune radio and television receivers (varactor diodes), to get frequency oscillations (tunnel diodes, Gunn diodes, IMPATT diodes), and to supply light (light emitting diodes). Tunnel diodes exhibit negative resistance, which makes them useful in some sorts of circuits.

5.3.5 INDUCTOR

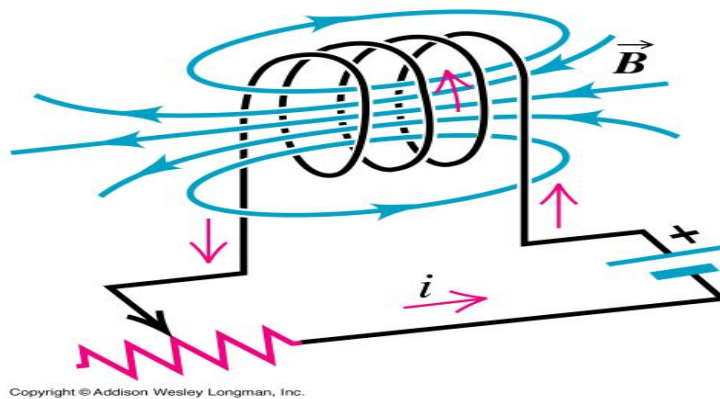


Fig.5.11 Inductor

An inductor (or reactor or coil) may be a passive two-terminal electrical component wont to stored energy during a magnetic flux. Any conductor has inductance although the conductor is usually wound in loops to strengthen the magnetic flux. Due to the time-varying magnetic flux inside the coil, a voltage is induced, consistent with Faraday's law of electromagnetic induction, which by Lenz's law opposes the change in current that created it. Where current and voltage change with time inductors are used in that electronics, thanks to the power of inductors to delay and reshape alternating currents. Inductors called chokes are used as parts of filters in power supplies or are often wont to block AC signals from passing through a circuit.

An inductor is employed because the energy memory device in some switched-mode power supplies. The inductor is energized for a selected fraction of the regulator's switching frequency, and de-energized for the rest of the cycle. The input-voltage to output-voltage ratio is determined using energy transfer ratio. This XL is employed in complement with a lively semiconductor unit to take care of very accurate voltage control.

5.3.6 CAPACITOR



Fig.5.12. Capacitor

A electrical condenser (formerly referred to as condenser) may be a passive two-terminal electrical element accustomed store energy in an electrical field. The styles of sensible capacitors vary wide, however all contain a minimum of 2 electrical conductors separated by an insulator (insulator); for instance, one common construction consists of metal foils separated by a skinny layer of insulating film. once there's a possible distinction (voltage) across the conductors, a static field of force develops across the insulator, inflicting charge to gather on one plate and electric charge on the opposite plate. Energy is keep within the electric field. a perfect electrical condenser is characterized by one constant price, capacitance, measured in farads. this is often the quantitative relation of the electrical charge on every conductor to the voltage between them. The capacitance is greatest once there's a slim separation between massive areas of conductor, thence electrical condenser conductors area unit usually referred to as "plates," touching on associate early suggests that of construction. In observe, the insulator between the plates passes a tiny low quantity of

outpouring current and conjointly has an electrical intensity level limit, leading to a breakdown voltage, whereas the conductors associated leads introduce an unwanted inductance and resistance. Capacitors area unit wide employed in electronic circuits for block electrical energy whereas permitting AC to pass, in filter networks, for smoothing the output of power provides, within the resonant circuits that tune radios to specific frequencies and for several different functions.

5.3.7 POWER SUPPLY UNIT

PIC 16F877A Microcontroller power supply

Generation method +5V DC power supply and +12V DC power supply is described in this section.

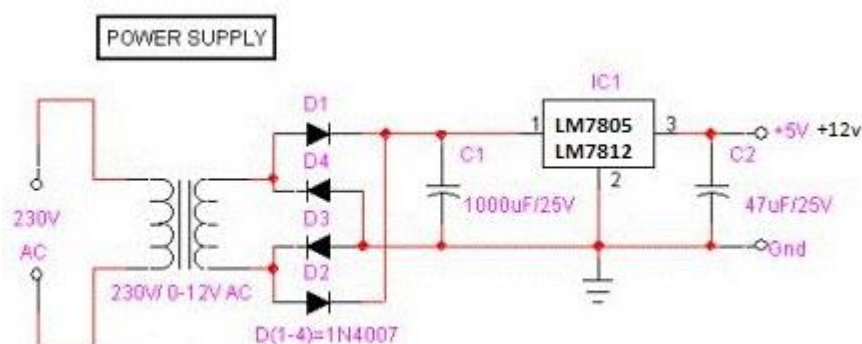


Fig.5.13. Power Supply Unit

The power offer section is that the vital one. It ought to deliver constant output regulated power offer for productive operating of the project. A 0-12V/1mA electrical device is employed for this purpose. the first of this electrical device is connected in to

main offer through on/off switch& fuse for shielding from overload and tangency protection. For converting 12V AC to 12V DC voltage the secondary is connected to the diodes. And filtered by the capacitors, that is more regulated to +5v, by victimization IC 7805 and +12v by victimization IC7812.

5.11 Regulator IC's

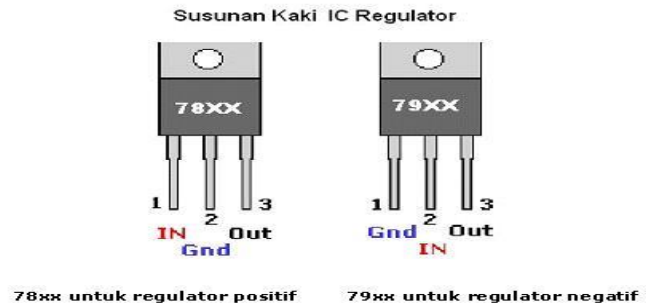
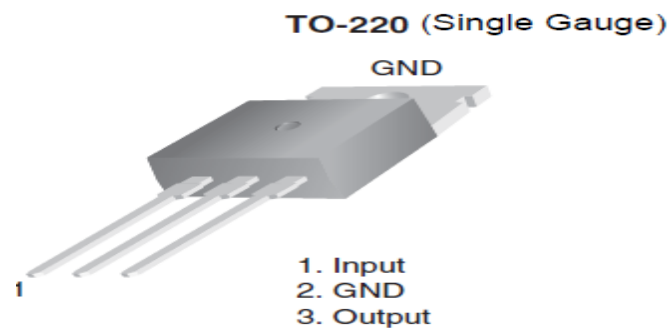
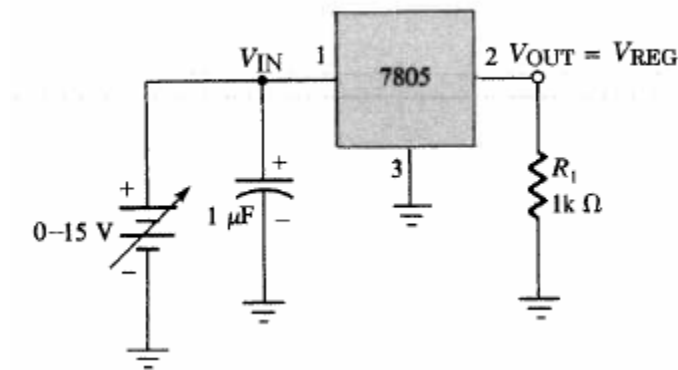


Fig.5.14. Regulators Unit





In physical science, a linear regulator could be a element accustomed maintain a gentle voltage. The resistance of the regulator varies in accordance with the load leading to a relentless output voltage. In distinction, the change regulator is nothing over simply an easy switch. This switch goes on and off at a set rate sometimes between fifty rate to one hundred rate as set by the circuit. The control device is created to act sort of a resistance, ceaselessly adjusting a potential divider network to take care of a relentless output voltage. the first advantage of a change regulator over linear regulator is extremely high potency, heaps less heat and smaller size. The electronic transistor (or alternative device) is employed in concert half a possible divider to determine the regulated output voltage. The output voltage is compared to a reference voltage to provide a bearing signal to the electronic transistor which is able to drive its gate or base. With feedback and sensible choice of compensation, the output voltage is unbroken moderately constant. Linear regulators square measure usually inefficient: since the electronic transistor is acting sort of a electrical device, it'll waste power by changing it to heat. In fact, the ability loss because of heating within the {transistor junction, electronic transistor ,semiconductor device, semiconductor unit,

semiconductor} is that the current times the voltage born across the transistor. a similar operate will usually be performed far more expeditiously by a switched-mode power provide, however a linear regulator could also be most popular for lightweight hundreds or wherever the specified output voltage approaches the supply voltage. In these cases, the linear regulator could dissipate less power than a whipper. The linear regulator conjointly has the advantage of not requiring magnetic devices (inductors or transformers) which may be comparatively dearly-won or large, being usually of easier style, and being quieter. Linear regulators exist in 2 basic forms: series regulators and shunt regulators. Series regulators square measure the additional common kind. The series regulator works by providing a path from the provision voltage to the load through a variable resistance (the main electronic transistor is within the "top half" of the voltage divider). the ability dissipated by the control device is capable the ability provide output current times the dip within the control device. The shunt regulator works by providing a path from the provision voltage to ground through a variable resistance (the main electronic transistor is within the "bottom half" of the voltage divider). the present through the shunt regulator is amused aloof from the load and flows uselessly to ground, creating this type even less economical than the series regulator. It is, however, simpler, generally consisting of simply a voltage-reference diode, and is employed in terribly powerless circuits wherever the wasted current is simply too tiny to be of concern. this type is extremely common for voltage reference circuits. All linear regulators need Associate in Nursing input voltage a minimum of some minimum quantity above the specified output voltage. That minimum quantity is termed the dropout voltage. as an example, a standard regulator like the 7805 has Associate in Nursing output voltage of 5V, however will solely maintain this if the input voltage remains higher than regarding 7V, before the output voltage begins droopy below the

rated output. Its dropout voltage is thus $7V - 5V = 2V$. once the provision voltage is a smaller amount than regarding 2V higher than the specified output voltage, as is that the case in low-tension micro-chip power provides, supposed low dropout regulators (LDOs) should be used. once one needs Associate in Nursing output voltage above the accessible input voltage, no linear regulator can work (not even Associate in Nursing LDO). during this state of affairs, a change regulator.

5.3.8 Load

If an electrical circuit contains a well-defined output terminal, the circuit connected to the current terminal (or its input impedance) is that the load. (The term 'load' may additionally visit the ability consumed by a circuit; that topic isn't mentioned here). Load affects the performance of circuits that output voltages or currents, like sensors, voltage sources, and amplifiers. Mains power shops give a simple example: they provide power at constant voltage, with electrical appliances connected to the ability circuit conjointly creating up the load. once a dynamical appliance switches on, it dramatically reduces the load electric resistance. If the load electric resistance isn't much above the ability provide electric resistance, the voltage can drop. during a domestic atmosphere, change on a heating appliance could cause incandescent lights to dim perceptibly.

CHAPTER 6

CONCLUSION & APPLICATIONS

6.1. CONCLUSION

SRM has been used because the motor for HEV application in this paper. so as to attain versatile energy management for HEV, this paper projected a tri-port convertor with standard and cryptic structure to mix a generator, A battery bank associate degreed an SRM in one converter; and therefore the corresponding operating modes, management strategy and fault tolerance operation area unit investigated. the most contributions of this paper are:

(i) a unique tri-port convertor for HEV is projected that supports versatile energy flow management. beneath the driving condition, the projected topology supports 5 energy flow modes together with generator to SRM, battery bank to SRM, generator and battery bank to SRM, generator to SRM and battery bank, and battery bank to SRM and generator. Under the standstill condition, the projected topology supports 2 energy flow modes, particularly generator to battery bank, and battery bank to generator modes.

(ii) so as to work with the six operating modes, the corresponding management methods area unit projected to attain flexible energy management.

(iii) The fault tolerance operation and techniques of the pro- posed topology area unit studied to expand the projected topology function.

By deploying the projected tri-port convertor for SRM based HEV system, the topology with a standard structure can be massively created and supports all six operating modes in one convertor. moreover, the projected system also can support fault identification and fault-tolerant operation. In more-electric ships and airplanes, the projected tri-port converter can also be applied to attain high power density, high responsibleness and versatile energy flow.

6.2. APPLICATION

- Motor drive
- Energy storage application
- E-vehicle application

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