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DSP BASED FUZZY LOGIC CONTROLLER FOR BATTERY CHARGER

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ABSTRACT:-Human beings in 21 century mainly depends on machines that need energy to give required output & rechargeable batteries are main source of energy in many cases as it is used widely, but is required to adapt new technology for recharging batteries so that overcharging of battery don't occur which leads to battery damage. Research centre for computational intelligence made progress in making battery charger compatible with future need by developing partially DSP based fuzzy logic controller for a battery charger so that overcharging problem is solved. This project is an approach towards the development of a device which can control the charging of battery to specific level efficiently without damaging it in any way. We will be discussing over the various tools of **MATLAB** like **FUZZY LOGIC** and **DSP PROCESSOR** which are available to device this instrument. We will go for in-depth discussion regarding theory and working of each tool in detail. We will have a brief description on the scope of these controllers. We will be evaluating the scope and impact of these tools to control the overcharging automatically. Beside all these we will throw some light on how we can evaluate the safety speed of charging for different battery. After this we will show the various salient features of our system and discuss its compatibility. An analysis of the various challenges which this device may face with its suggested solutions will be discussed. At last before coming to the conclusion we will have an insight to the future remarks and development of this device as per future needs. The conclusions will reveal the impact of this device globally and will show its real merit. The aim of our project is to develop a DSP based fuzzy logic controller which will charge the battery to its optimum level and also preventing it from overcharging, by continuously monitoring its current and voltage. Experimental results have shown that **DSP+FUZZY** was to correctly adapt its charging according to the maximum level of charging. The learning process of charging battery using DSP based fuzzy logic controller is still on, encouraging for the computation of project.

KEYWORDS:- Fuzzy Inference System, Multiplexer, Pulse width modulation, Digital signal processing, Dual-access, random-access-memory, single-access, random-access-memory

I. INTRODUCTION

A. BACKGROUND

With the rise in portable devices such as laptops, cell phones, MP3 players and cordless power tools, the need for rechargeable batteries has grown substantially in recent years. The concept of the rechargeable battery has been around since 1859, when French physicist Gaston Plante invented the lead acid battery, which would later become the world's first rechargeable battery. That same chemistry is still used in today's car battery. The basic idea behind the rechargeable battery is simple: when electrical energy is applied to the battery, the electron flow from negative to positive that occurs during discharge is reversed and power is restored. This requires a charger in the case of devices with built-in batteries or for standard nickel-ca or nickel-metal hydride batteries, the most common multi-use rechargeable batteries used today in your remote control, flashlight or digital camera. Car batteries are one of the oldest kinds of rechargeable batteries and in fact, the electric car predates its gas-powered cousin. In a standard car, there is a single lead-acid SLI battery that supplies power to the starter, lights and ignition system. The battery charger in this case is the alternator, a clever device that converts gasoline power to electrical energy and distributes it where needed. In electric and hybrid cars, traction batteries are used to power the vehicle down the road. Traction batteries come in many varieties, from lead acid, to nickel-cadmium, nickel



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metal hydride and lithium ion. The recharging rate has improved substantially over the years and is broken down into three categories:

Slow: 14-16 hours, Quick: 3-6 hours, Fast: Less than one hour

The rate of charge is determined by how much electrical current is allowed into the battery by the charger. Some batteries can handle higher voltage in a shorter amount of time without overheating, while others need a lesser voltage applied over a longer period of time. The quicker the rate of charge, the more chance there is of overcharging, which can ruin a battery's chance of holding its charge. The key in avoiding an over charge is the ability to dissipate the charging current once maximum power has been reached. Most chargers have built-in voltage regulators do this, allowing you to safely leave your cell phone or computer plugged in overnight. The speed and effectiveness of the charge depends largely on the quality of the charger itself. This quality can be maintained with the help of DSP based fuzzy logic controller.

B. OBJECTIVE

- The aim of our project is to build battery charger of excellent quality, from above discussion we come to know that effective battery charging is very much important for improving battery life and its performance.
- So main objective of our project is to develop a DSP based fuzzy logic controller which charge the battery to its optimum level and also prevent it from getting overcharged.
- This can be done by continuously monitoring current and voltage of a battery by using DSP based fuzzy logic.

C. SCOPE

Adaptive battery chargers can be employed in future instead of existing battery charger which is costly, bulky, and large sized with the help of this technology. This adaptive battery charger will be more integrated instead of using various circuits like buck-boost, DSP kit etc it will use only one circuit for e.g. instead of using 2 circuits of buck-boost it will use only one circuit that take care of charging the battery and also preventing it from over charging.

II. METHODOLOGY FOR THE BATTERY CHARGER

Why to build such a Battery Charger?

Many Battery Chargers are available in the Market with Different algorithms but the Battery charger with fuzzy Control provides a better Charging rate as well as we can save our battery from Over Charging and also from Getting Damaged due to Overcharging. Thus due to efficient Decision control battery charger with Fuzzy Control provides with safe Environment for the charging of battery.

- Methodology for the Battery Charger

Battery charging with DSP based Fuzzy Controller includes the following steps:

- Initially build a FIS so as to provide our System with Efficient Decision making ability.
- In Simulink Environment attach the Same FIS file with the fuzzy controller.
- Construct the complete model with the various inputs and observe the output of the system i.e. observe the plot of the input parameters with the output of the fuzzy controller.
- Implementing the same model in DSP based Kit for the practical implementation of the same.
- Using the concept of the PWM generation Control the Boost and BUCK circuit for the charging of the Battery.

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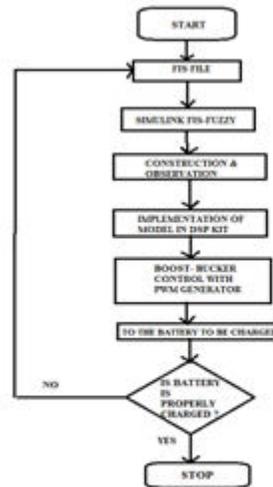


Fig.1 The block diagram for the methodology

The Explanation for the various blocks is as follows:

A. FIS file

The FIS stands for the fuzzy inference system which basically helps to determine the relationship between the input and the output of the system. It helps to control the parameter variation and is efficient in decision making process. In our case the input of the FIS file is the battery voltage and the battery current. These two quantities will act as a input to the inference engine and the decision will be made according to the rules made and also with the help of the Membership function type and also its range. This is a very effective tool in MATLAB and thus acts as a decision box of the processor.

B. Simulink

This block helps us to find out whether the FIS system is giving us the Correct results or not. In this we have used a fuzzy toolbox in the simulink environment. The output of the fuzzy system which has been made can be easily viewed from the simulink output.

C. DSP Processor

The Same FIS file which was used under Simulink Environment is to be loaded in the DSP processor. The same processor is to be connected with the PWM generator which will generate the PWM signals which will further operate the Boost circuit which will help in charging the battery and Buck circuit which will help to protect the battery from getting over charged.

D. Feedback path

Once the charger starts working it will continuously feedback the voltage level and current level. And according to the received feedback system will monitor the working of the Boost and Buck Circuit.



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III. TOOLS

A. MATLAB

Matlab is an interactive system for doing numerical Computations. A numerical analyst called Cleve Moler wrote. The First version of Matlab in the 1970s. Matlab makes use of highly respected algorithms and hence you can be condensing about your results. Powerful operations can be performed using just one or two commands. You can build up your own set of functions for a particular application. The MATLAB high-performance language for technical computing integrates computation, visualization, and programming in an easy-to-use environment where problems and solutions are expressed in familiar mathematical notation.

B. The toolbox provides three categories of tools:

What makes the Fuzzy Logic Toolbox so powerful is the fact that most of human reasoning and concept formation is linked to the use of fuzzy rules. By providing a systematic framework for computing with fuzzy rules, the Fuzzy Logic Toolbox greatly amplifies the power of human reasoning. Further amplification results from the use of MATLAB and graphical user interfaces, areas in which The Math Works has unparalleled expertise.

C. What Can the Fuzzy Logic Toolbox Do?

The Fuzzy Logic Toolbox allows you to do several things, but the most important thing it lets you do is create and edit fuzzy inference systems. You can create these systems using graphical tools or command-line functions, or you can generate them automatically using either clustering or adaptive neuro-fuzzy techniques. If you have access to Simulink, you can easily test your fuzzy system in a block diagram.

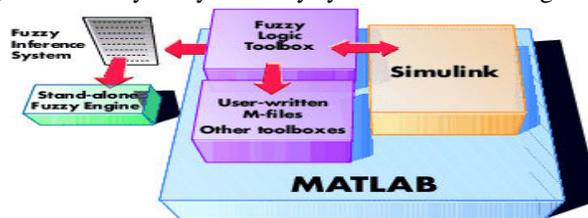


Fig.2 Fuzzy Interfacing

D. SIMULINK

This is You can customize the stand-alone engine to build fuzzy inference into your own code. All provided code is ANSI compliant. Because of the integrated nature of the MATLAB environment, you can create your own tools to customize the Fuzzy Logic Toolbox or harness it with another toolbox, such as the Control System Toolbox, Neural Network Toolbox, or Optimization Toolbox, to mention only a few of the possibilities. made possible by a stand-alone Fuzzy Inference Engine that reads the fuzzy systems saved from a MATLAB session.

E. DSP PROCESSOR (SAMPLE PROCESSOR + ADVANTAGES OVER PENTIUM PROCESSOR)

The 'C5x DSK is one of the simplest 'C5x DSP application boards. Even though no external memory is available on the board, the 10K on-chip RAM of the 'C50 provides enough memory for most DSP application programs. The kernel program is contained in the 32K, 8-bit PROM. The PROM is only for DSK boot loading and cannot be accessed after boot



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loading, as this portion of the on-chip memory is reserved for the kernel program. Figure 1–2 shows the memory map of the 'C5x DSK. The on-chip, dual-access, random-access-memory (DARAM) B2 is reserved as a buffer for the status registers. The single-access, random-access-memory (SARAM) is configured as program and data memory. The kernel program is stored in this area from 0x840h–0x980h. If the kernel program performs an overwrite, a reset signal is required to let the DSK reload the kernel program. Since the kernel program is stored in the SARAM, this on-chip memory cannot be configured as data memory only (RAM = 0). The interrupt vectors are allocated, starting from 0x800h. The IPTR in the PMST register should not be modified (refer to subsection 3.6.3, Status and Control Registers of the TMS320C5x User's Guide).

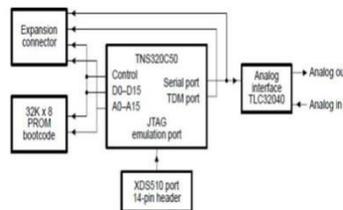


Fig.3 Block diagram of C5x DSP kit

1. The TLC32040 AIC on the board provides a single-channel, input/output, voice quality analog interface with the following features:
2. Single-chip digital-to-analog (D/A) and analog-to-digital (A/D) conversion with 14 bits of dynamic range.
3. Variable D/A and A/D sampling rate and filtering
4. The AIC interfaces directly to the 'C50 serial port. The master input clock to the AIC is provided by a 10-MHz timer output from the 'C50.
5. The AIC is hard-wired for 16-bit word mode operation. The reset pin of the AIC is connected to the BR pin of the 'C50.

DSK analog capabilities are suited to many applications, including audio data processing. You can directly connect most pre-amplified microphones and speakers to the DSK analog input and output. For more information concerning the AIC, refer to the AIC data sheet, literature number SLAS014E. The DSK provides six headers, including the XDS510, to help you to design your own external hardware. The majority of the 'C50 and other integrated circuit (IC) signals to the board are connected to these headers. The XDS510 header allows the DSK to become a portable XDS510 target system.

The 'C5x DSK has its own windows-oriented debugger that makes it easy to develop and debug software code. The DSK communicates with the PC using the XF and BIO pins through the RS-232 serial port. Figure 1–3 shows the module connections between the RS-232 serial port of the PC and the DSK.

F. MATLAB REFERENCE

There is reference documentation for all MATLAB functions:

- Function Reference — Lists all MATLAB functions, grouped into categories
- Handle Graphics Property Browser — Provides easy access to descriptions of graphics object properties.
- C and Fortran API Reference — Covers those functions used by the external interfaces, providing information on syntax in the calling language, description, arguments, return values, and examples.

The MATLAB online documentation also includes

- Examples — An index of examples included in the documentation.
- Release Notes — New features, compatibility considerations, and bug reports for current and recent previous releases.
- Printable Documentation — PDF versions of the documentation suitable

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for printing.

In addition to the documentation, you can access demos from the Help browser by clicking the Demos tab. Run demos to learn about key functionality of MathWorks™ products and tools.

IV. DESIGN AND IMPLEMENTATION

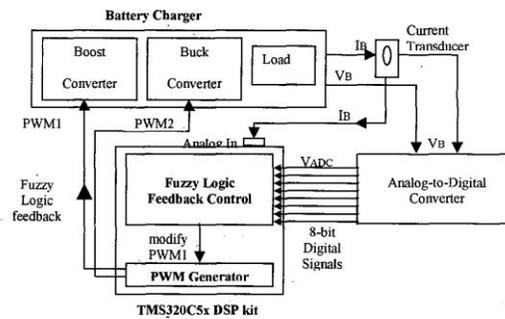


Fig.4 Basic Block Diagram

1. The Above block diagram represents the basic design of the DSP based fuzzy controller. The Controller basically takes the continuous feedback from the battery and takes it as an input to the system.
2. The processor process the inputs and generates the basic signals which basically controls the duty cycle of the BOOST –BUCK circuit by the means of PWM generator.
3. Thus continuous feedback and the efficient decision making properly take care of the proper charging of the battery.

The various important parameter of DSP processor which helps in proper charging are:-

The TMS320C5x Digital signal processor is a powerful tool, competent of fast arithmetic to provide control over PWM waveform details. The DSP generates two pwm waveform of different pulse width, to supply gating signals for the boost and buck converters in the battery charger. The DSP kit generates pwm waveform by replacing a sawtooth wave with a dc source. The duty cycle of PWM waveform is carefully designed to avoid overlapping, thus leaving a small interval between the two. During the battery charging process, the power switch for boost converter is switched on while the buck converter is off and vice versa. The kit also provides fuzzy control algorithm for the battery charger. A reliable fuzzy control feedback control system is essential to ensure the battery would not be overcharged. The fuzzy control is also essential to supply the appropriate gain for the battery charger to function in a steady state and to obtain optimum charging rate. Battery charger with DSP based fuzzy feedback system is shown above. The fuzzy controller is designed to detect the charging current from the analog in and battery voltage variation from the i/o port of TMS3205x DSP. The duty cycle (modulation index) of PWM1 of boost converter will be determined according to i/p battery voltage and charging current level, define by the fuzzy interference. However, the PWM2 of buck converter is maintained to provide protection for the battery. For instance, if the battery voltage continues to increase gradually while current is low during the charging process, the fuzzy controller will maintain increase current A drop in the charging current level triggers the fuzzy controller to increase o/p voltage of the charger, by modifying the duty cycle of the boost converter. The fuzzy controller for the battery charger system is constructed based on i/p membership function corresponding to battery voltage and charging current, while the o/p membership function is related to duty cycle of boost PWM1, after which new duty cycle of PWM1 is defined.

V. DESIGN STEPS FOR THE BATTERY CHARGER

Open Matlab.

Type Fuzzy

- Go to File.....New.....Sugeno model
- Add Variable to the inputs and also to the output of the system from edit menu....

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- Select first input Variable.....Name it from the GUI....and then double clicking the block adjust the range and the membership functions as per the requirement of the system. Repeat the same steps for the second input along and also for the outputs...
- Name first variable as Input voltage from the battery and second as the current level. Name the 1st output as the Duty Cycle for the Boost circuit and other as the duty cycle of Buck Circuit.....
- Adjust the range of the membership functions of input as well as for the output of the system.....
- Double Click the Central Block of the system and the make rules using Rule Editor in the Fuzzy logic Toolbox. Go To view Surface.....so as to view the Surface.....
- Go To View Rule to view the rules
- Save the file.
- Export the file to the Workspace.
- File..... Export toWorkspace.
- Type Simulink in the command Window.
- Simulink Browser will get open and goto File.....Select new...
- From Simulink Browser Click on Source and Select the signal generator and then drag it in the simulink Environment for the Voltage signal....
- Double Click on it and the adjust the parameters such as Type of Signal and Its Frequency and sample time....
- Same step to be repeated for the input Current.....
- Search the MUX from the commonly used block and drag it to the simulink Environment.
- Connect the input of both the signal generator to the MUX .
- Click on the Fuzzy Logic Toolbox and Drag the fuzzy controller to the simulink Environment. Double Click and the type the name of the FIS file which was exported to the Workspace. Drag another Signal generator from the same Simulink Browser. Double Click on it and the select the Option of the signal from External Source and theconnect the output of the fuzzy controller to the input of the signal generator.....
- Drag another MUX in the same Environment and then connect the O/P of the signal generator whose input has been given from fuzzy controller to the one of the inputs of the MUX and connect the input voltage block to the other input of the MUX.....
- Search **Scope** from the browser and then drag it in the simulink Environment and connect the input of the scope. Double Click on the Scope Block A black coloured window will appear. Right Click on it and adjust the Axis parameter along with other parameters.
- Go to Main window of the simulink Environment and goto
- SimulationStart Simulation.
- Observe the O/P in the Scope window of the Model Constructed.....
- Adjust the Various Parameters so as to Obtain better results and to check out the performance of the system.....

VI. SIMULATION RESULTS

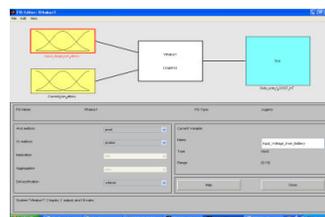


Fig.5 FIS File For the Boost Circuit

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The above file shows the Fuzzy inference system which was made for the BOOST circuit battery charger.

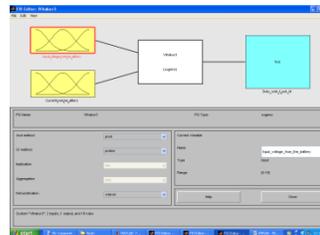


Fig.6 Fis File For Buck Circuit

The above file shows the Fuzzy inference system which was made for the BUCK circuit battery charger.

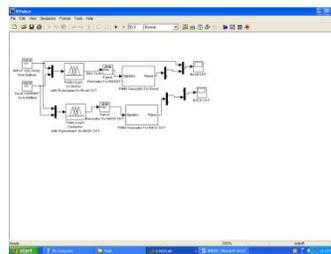


Fig.7 Simulink Model with Controllers For Boost and Buck Circuit

The above figure represents the basic block diagram of the fuzzy controller which was made for the efficient battery charging.

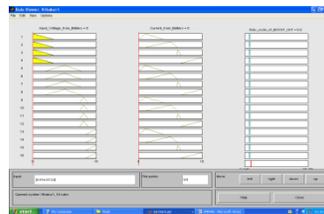


Fig.8 Rule Execution Of Boost Circuit

The above figure shows the rule firing which takes place as the various inputs are provided by the source to the system.

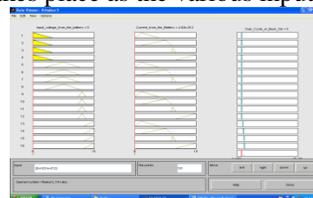


Fig.9 Rule Execution of the Buck Circuit

The above figure shows the rule firing which takes place as the various inputs are provided by the source to the system.



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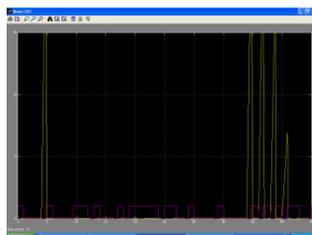


Fig.10 Simulink Result for the Boost Circuit with Width Modulation

The above figure shows the continuous variation in the width of the duty cycle of the BOOST and BUCK circuit which is used for the charging and the protection of the battery during charging.

VII. CONCLUSION

- Fuzzy feedback controller for the application of battery charger is proposed in the above discussion. The DSP kit successfully provided near optimal PWM waveform generator and fuzzy feedback control in the battery charger. Hence, reducing the need for extra components.
- The DSP based fuzzy logic controller provides excellent alternative method of controlling the battery charges by using the advanced fuzzy logic techniques for battery system feedback control.
- The battery charger system is able to achieve desired o/p at a better dynamic performance and easy implementation.

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