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charger for electric cars based on the TMS320LF2407A

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Abstract

The research on digital chargers was hardly touched upon first. The digital charger's primary circuit, which includes a secondary rectifier and a shift-phase full bridge inverter, was designed with much theoretical consideration. The TMS320LF2407A served as the central component of our digital PID controller, software, and control system circuit. All of the technical details, including parameters and results, of the experiment were detailed. Dependable and able to handle the various charging processes required by current batteries is the charger's digital-control output, which employs soft-switching.

Introduction

A broad range of power batteries may be placed in electric cars, thus specialized charging infrastructure is needed to handle the increasing number of these vehicles on the road. As digital technology and digital signal processing (DSP) continue to grow in popularity, the control business is also seeing a significant technical shift. Consequently, there will be a considerable improvement in both the theoretical significance and the practical use of developing home electric vehicle charging equipment after research into digital control technology of special charger electric cars [1]. The digital charger's efficiency is highly related to the lord loop of the charging machine. With its compact size, excellent quality, and ease of implementation, inverter-type power offers a quick reaction time, a wide range of charging procedures it can manage, and a high working frequency. The full-bridge charging circuit with secondary rectification technique is the primary topic of this essay. Figure 1 shows the fundamental layout of the main circuit.Located on the secondary side of the transformer are rectifier diodes D1 and D2. In a single-phase or three-phase ac rectifier, the DC voltage is obtained by Vs, while Lf and Cf are the output filtering inductance and filter capacitance, respectively.

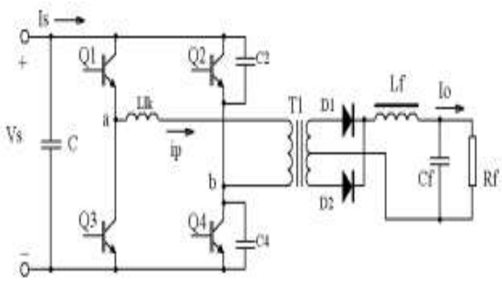

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Fig.1 The main circuit schematic

Viewed through the shaded area in Figure 2, the driving pulse timing diagram is almost indistinguishable from the traditional phase shifting control, with the exception that the dead time between Q2 and Q4 changes with duty cycle. If the bus voltage is abnormally high or low, there will be extra time between the second and fourth quarters. Each half cycle will see the simultaneous opening of Q4 and Q1, with the former being turned off first. As previously mentioned, the lagging bridge arms consist of Q1 and Q3, and the leading bridge arms are Q2 and Q4 [2].

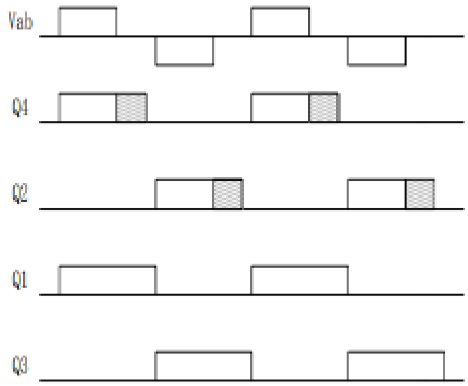

Fig.2 Driver pulse order of the main switch

Imagine for a second that Q1 and Q4 were both turned on from the outset, and that C2 and C4 buffered Q4's zero-voltage-switching (ZVS) at some time. Even though trailing current will still be present in Q4, ZVS turn-off losses will be significantly minimized. When the reverse voltage provided to Q2 exceeds 30V as a result of Llk (line equivalent inductance plus high-frequency transformer leakage inductance), a reverse avalanche occurs. Q2 acts as a zener diode when it is in this condition. The avalanche stops and ip weakens to zero because energy (1/2Llkip2) is transferred from the avalanche to Q2. A small amount of current will flow backwards via Q1, even if ip has just gone to zero, since the voltage difference between b and busbar is equal to the IGBT reverse avalanche voltage. As a result, Q1 trailing current will be eliminated and Q1 composite electric charge storage will be made easier.Q1 may also achieve zero voltage switching (ZVS) because of this. When applied to ground, a negative voltage opens Q2 without loss. Once Q1 is deactivated, Q3 will be engaged and go into a half cycle.

The TMS320LF2407A-Based Digital Control System Circuit

When a digital signal processor (DSP) is used as the controller for a switching power supply, not only are the problems caused by an excessive number of dividing elements, poor circuit dependability, and a complicated control circuit eliminated, but the inflexibility of a single, centralized controller is also mitigated. Higher frequencies, shorter instruction cycles, and an enhanced bus layout provide DSP potent data-processing capabilities. TMS320LF2407A, a newly added chip to TI's 24X family DSPs, is commonly used for digital control of motors and, with a little bit of programming and other circuitry, can charge electric vehicles digitally [3]. The logical structure of the control system is shown in Fig. 3.All of the control operations of the TMS320LF2407A-based control system are accomplished by means of an external circuit.

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TMS320LF2407A generates limited dual polarity PWM control signal,and the control signal drives IGBT(on/off) after amplifying by an isolated drive circuit;

• ADC sampling circuit samples input signal, which has been processed by filter circuit,and input to CPU;

• After testing by bias magnetic detection circuit,TMS320LF2407A would catch the bias magnetic signal and process, if bias phenomenon appeared in power transformers;

• Display and adjust settings through serial connection using SCI; Exchange data with external devices using a CAN2.0 controller.

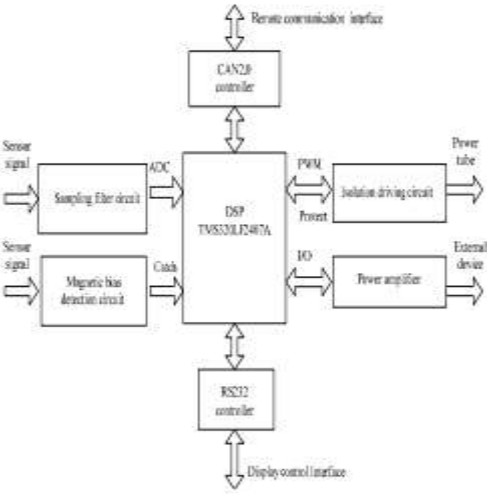

Fig.3 Frame chart of control system

While power is on, a number of possible abnormalities can occur, such as devices not working as expected, magnetic biassing, which can cause saturation on the primary side of the transformer, a full-bridge circuit straight-through, which can make the primary side busbar appear to have a short circuit, overcurrent on the vice side of the load, and radiator overheating. So, if the hardware circuit is well-built and the right safeguards are in place, the strange scenario may be fixed.

The Control System Software Design Process

In addition to monitoring and controlling the charging process overall, the control system also acts as an actuator for digital control at various points in the charging process. Our charging power control software is compatible with both C and assembly. so is essential to accomplish the control function, but do so in a logical and uncomplicated way. For the control system to work, a steady and dependable source of high power is required.

The Software's Overarching Design

The following are examples of the roles played by control software: sampling procedure; computer code uses the sample value to determine the output pulse width and then adjusts the PWM pulse width for the final product; It contains a CAN communication program, which allows it to receive control instructions and deliver the output current or voltage value, as well as a troubleshooting and protective function program. Figure 4 depicts the primary program flow chart and the first program of the control system software.

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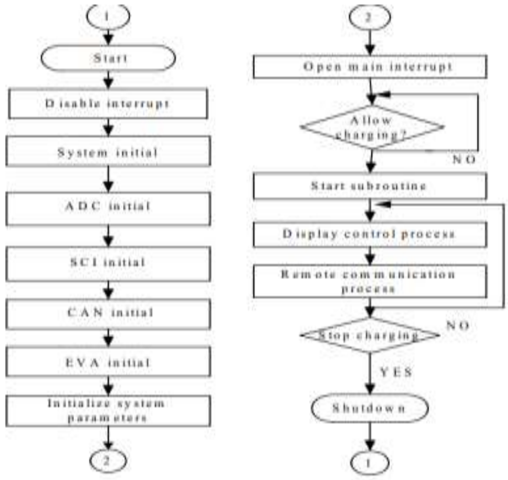

Fig.4 Main programme flow chart of control system

The software's operability may be enhanced by arranging processes like displaying content and controlling devices in the main program, rather than having those tasks performed in separate threads or via interrupts. Work that has to be processed often or urgently, on the other hand, is better suited to the interrupt method. The CAN communication software, in addition, makes use of the interrupt service routine for its own purposes. Methods and processes for charging may be determined and modified in light of the data obtained.

A Quick Overview of Digital PID Controller Design

The various advantages of PID control are due to its adjustable parameters and simple architecture. Consequently, it became the de facto norm in continuous system control. A linear combination of proportional, integrative, and differential approaches is used to determine the controlled variable's deviation. The values of the control variables are determined by sample time deviation in digital PID control, which is an example of sampling control. Hence, for type (1), it is not feasible to do exact direct computations of the integral and differential item. We apply the incremental proportional integral derivative (PID) approach and arrive at the following control law formula for this system. Due to the high frequency required by the charger, the controller's response time has to be swift. At time i, the PWM pulse width—the controllable variable—is represented by ui, which stands for the increments. To show that incremental algorithms are space and effect efficient, we may look at tape (2). These methods just save the deviation from the first three iterations. The cumulative error is small when mistakes in computations or inaccuracies are first noticed. Also, since it remembers its state from the prior restart, the system's response time might be significantly reduced. The approach also reduces the impact of random factors on the output value, making the system more reliable overall. Results were satisfactory after some trial and error was used to determine the optimal values for the PID controller in this configuration. It is possible to calculate the output pulse-width of the next cycle from the sampling period, which is the main circuit's switching cycle, and each sampling interrupt necessitates a calculation. There was an inbuilt PID algorithm in the ADC's interrupt management strategy.

Outcomes of Analyses and Technical Specifications

Charger, electric vehicle (EV) power battery (Ni-H), pure resistance load, personal computer (PC), and test equipment (digital oscilloscopes) make up the whole of the experiment system. The principal side voltage (Up) and current (IP) waveform test results are shown in Fig. 5.Up and IP are the ideal principal voltage and current in the waveform. Because power switches operate at ZVS (Zero Voltage Switch) and ZCS (Zero Current Switch), the primary voltage and current do not show as current peak and voltage peak like conventional hard switching. Fig. 6 displays the output response curve of the system. From the graph, we can deduce that the system only needs half a second to double the output voltage from 200 to 500 volts. This demonstrates the system's benefits, which include a fast reaction time, little overshoot, and excellent, consistently precise results. The following are examples of Charger's technological parameters:

- Input voltage: AC 380V three-phase AC;
- Output voltage: DC 300V-720V adjustable;
- Output current: 0-30A adjustable;
- Charging efficiency:≥90%;
- Output ripple:≤1%;
- Work temperature: −20℃-+60℃.

Fig.5 Waveform of power transformer prior current and voltage

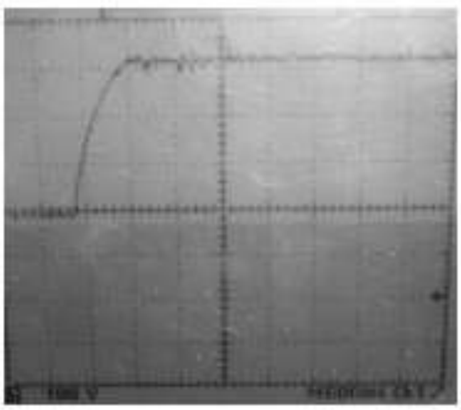

fig.6 Response curve of system set value

Conclusion

Digital electric car chargers employ soft switching to improve efficiency and reliability. The control system is able to handle the complex charging requirements of different kinds and powers of batteries thanks to its use of digital control technology and a digital processing chip, which also allows for remarkable real-time performance. Thanks to its modular construction, the device is compatible with both people and EVs.

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