# Design and Implementation of MAX712 Programmable Charger

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**Abstract.** The Nickel-metal hydride (NiMH) batteries, a mean of power supply for portable equipment, have less pollution to the environment. They need to be set the technical parameters of them for prolonging their service life. So that they should be converted between Fast-charge and Trickle-charge to prevent overcharging. The Fast-Charge management chip, Max712/713, is designed by MAXIM company. And it can meet the Charge needs of 1-16 series NiMH batteries and has programmable functions. The two NiMH batteries with a capacity of 1300mAh and a voltage of 1.2v are designed programmatically. The number of rechargeable batteries and the time of quick charging are controlled by the pin allocation. Within two hours, the battery charging test is used to record the changes of the voltage at the two ends of the battery pack, the programmable charger automatically changes the state during the charging process. Therefore, it can protect the battery from overcharging.

## Introduction to Design

### MAX712/713 Internal Structure.

The internal structure of MAX712/ MAX713 is shown in Fig.1 It mainly consists of clock circuit, voltage gradient detection circuit, control logic circuit, output control circuit, comparator and so on. According to the test of voltage gradient and charging time, the voltage gradient detector can automatically translate the charging state[1]. The internal structure of MAX712、MAX713 is consistent, but when the charging rate <C/2, MAX712 is only suitable for NiMH battery and MAX713 is only suitable for NiCd battery. Therefore, this scheme is a design of NIMH programmable charger based on MAXIM712.

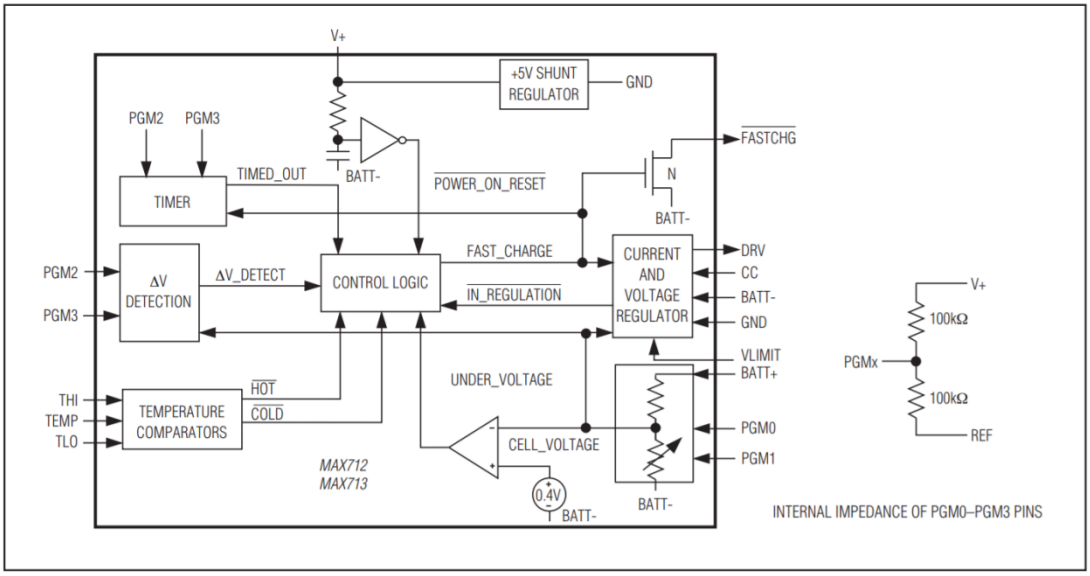


Figure. 1 Internal Structure Diagram of MAXIM712

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**Introduction of MAXIM712/713 Pin**.

The MAX712 chip has 16 pins, as shown in Fig. 2. The functions of each pin are shown inTab.1[2].

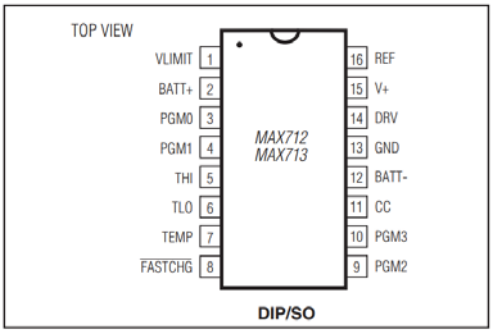


Figure. 2 pin configuration

Table 1. Pin function

| Pin | Pin Name | Features |
|---|---|---|
| 1 | VLIMIT | Set the maximum voltage of the battery pack to not exceed VLIMIT × the number of NiMH batteries. |
| 2 | BATT＋ | Battery pack positive electrode. |
| 3、4 | PGM0, PGM1 | Set the number of sections (1-16) of the battery pack being charged in series, and connect V+, Open, REF, BATT- with PGM1 and PGM0. |
| 5 | THI | The upper limit voltage of the temperature comparator, when the TEMP voltage is greater than THI, the fast-charge ends. |
| 6 | TLO | The lower limit voltage of the temperature comparator, when the TEMP voltage is less than TLO, the fast-charge ends. |
| 7 | TEMP | Temperature signal input. |
| 8 | FASTCHG | Fast charge status output, this terminal is low level during Fast-Charge, and becomes high level when fast-charge ends or turns into Trickle-Charge. |
| 9、10 | PGM2, PGM3 | Programmable pin, by setting the PGM2 and PGM3 pin voltages, you can set the maximum allowable time for Fast-Charge (33min~264min) and the rate of Trickle-Charge (C/4-4C). |
| 11 | CC | Intermittent compensation capacitor between CC and BATT- |
| 12 | BATT－ | Battery pack negative |
| 13 | GND | Power grounding, determine the IFAST size by accessing RSENCE with BATT-. |
| 14 | DRV | Drive the output of the peripheral PNP tube |
| 15 | V＋ | The terminal of the internal +5V shunt regulator, which is equivalent to the BATT- terminal voltage of +5V, providing the shunt current of 5mA~20mA for the chip. |
| 16 | REF | Internal 2.0V reference output. |

**Design of Circuit Parameter.**

The DC source must be greater than 5V and at least 1.5v higher than the maximum voltage at both ends of the battery pack (switch mode 2V)[3]. Therefore, the minimum DC should be 1.2v *2+1.5= 3.9v, and the DC voltage is designed at 12V.

The MAX712 / MAX713 is always in the state of Fast-charging or Trickle-Charge[4]. The Fast-Charge rate range is C/ 4-4c, while the Trickle-Charge rate is C/16. The maximum static current is 5 when it is not charged. The relationship between the Trickle-Charge current ITRICKLET and

the Fast-charge current IFAST is shown in Tab.2. The Fast-Charge current is calculated by the formula:

IFAST=Rechargeable battery capacity(mAh) ÷ Charging time(h) = 1300(mAh) ÷1.5(h) = 0.87(A)

Table 2 Relationship between ITRICKLET and IFAST

| PGM3 | FAST-CHARGE RATE | TRICKLE-CHARGE CURRENT | PGM3 | FAST-CHARGE RATE | TRICKLE-CHARGE CURRENT |
|---|---|---|---|---|---|
| V＋ | 4C | IFAST/64 | REF | C | IFAST/16 |
| Open | 2C | IFAST/32 | BATT— | C/2 | IFAST/8 |

The charging efficiency of NiMH batteries is about 80%[5]. It means, when charging at C/2 rate, the theoretical charging time is 2 h, but the actual time is about 2.5 h. According to the design scheme with a charging time of 2 h, R SENCSE = 0.5 V is obtained using the formula R SENSE =0.25 V / I FAST.

The MAX712/MAX713 can be configured with simple pins (Fig. 3) to control the number of charged battery cells and maximum charge time[6]. The MAX712/MAX713 allow a maximum Fast-Charge time of 264min and a minimum charge rate of no less than C/4. Pin PGM1 is left floating, PGM0 is connected to pin V+, and the rechargeable battery is determined to be 2 knots.

When the switch controls the rechargeable battery, the connection method of the pin PGM3 and PGM2 is determined according to the charging time of the design scheme, as shown in Tab. 3.

Table 3. Connection method of PGM3 and PGM2

| Section number | TIMEOUT(min) | Voltage gradient selection | PGM3 access | PGM2 access |
|---|---|---|---|---|
| 1 | 90 | Enabled | REF | REF |
| 2 | 180 | Enabled | BATT- | REF |

## Application Implementation

### Circuit Diagram.

Using the Altium designer software[7]. he circuit diagram is shown in Fig. 3. Switch S1 manages 1-2 cells: When S1 is closed, PGM1 and PGM0 in switch S2 are connected to V+, that is, 1 and 3 are closed, charging one battery; when S2 is disconnected, PGM1 is suspended in S2, and PGM0 is connected to V+. Closes 1, 4 and charges two batteries. The battery charge status can be identified by the output LED or with the master interface.

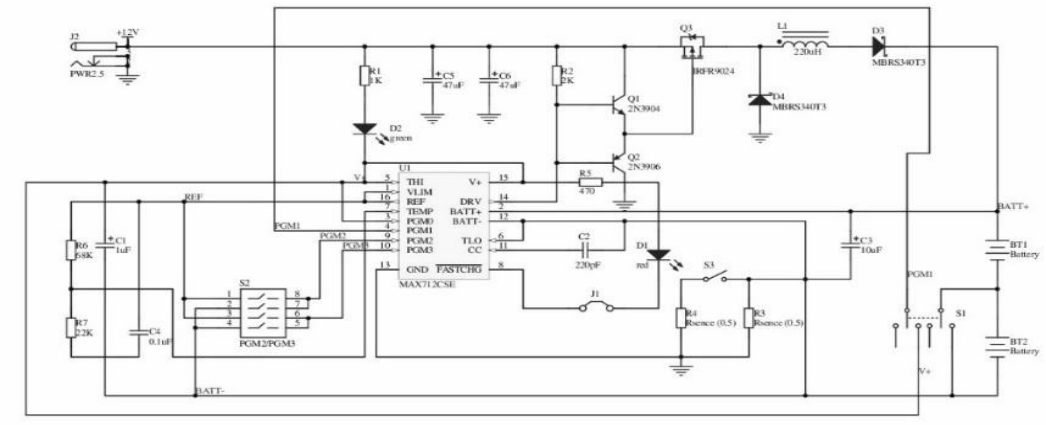


Figure. 3 Programmable Charger Circuit Design

**PCB Board.**

Using the Altium designer software, a PCB (Printed Circuit Board) board is shown in Fig.4. According to the circuit diagram of Fig.3, the layout design is made to determine the placement position of the components in the circuit diagram[8]; then the wiring design is performed to meet the electrical performance, the wiring is neat, and there is no crossover; the final processing is completed after the final determination is made[9].

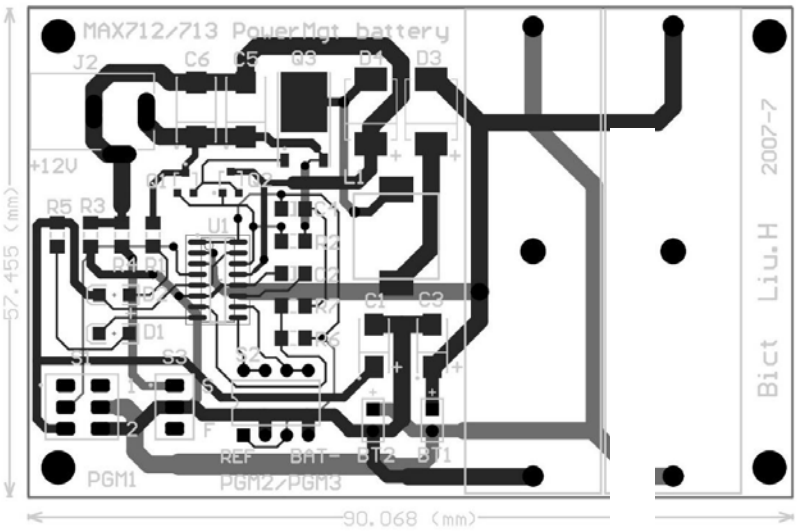


Figure. 4 Programmable Charger PCB Board Diagram

**Charging Test.**

After the patch and soldering, the programmable charger is completed, and finally two finished products are produced for charging test[10]. Conduct a comparison test during the charging test, select one of them to charge one battery and the other to charge two batteries. Before the data was recorded, it was found through pre-experiment that the charging effect was well, and data recording and effect observation were possible. As shown in Fig.5. The data and analysis are shown as Tab.4 and Fig.6.

Figure. 5 Picture of Real Products

Table 4 Programmable Charger charging Test

| TIME（MIN） | STAGE | CELL VOLTAGE（V） | STAGE | CELL VOLTAGE（V） |
|---|---|---|---|---|
| 0 | 2 | 0.23 | 2 | 0.51 |
| 15 | | 0.68 | | 1.37 |
| 30 | 3 | 0.82 | | 1.43 |
| 45 | | 0.91 | 3 | 2.13 |
| 55 | | 1.23 | | 2.45 |
| 60 | | 1.35 | | 3.15 |
| 70 | | 1.68 | | 3.31 |
| 75 | | 1.71 | | 3.39 |
| 85 | | 1.72 | 4 | 2.92 |
| 90 | 4 | 1.42 | | 2.92 |
| 95 | | 1.42 | | 2.72 |
| 100 | | 1.41 | 5 | 2.72 |
| 120 | 5 | 1.41 | | 2.72 |

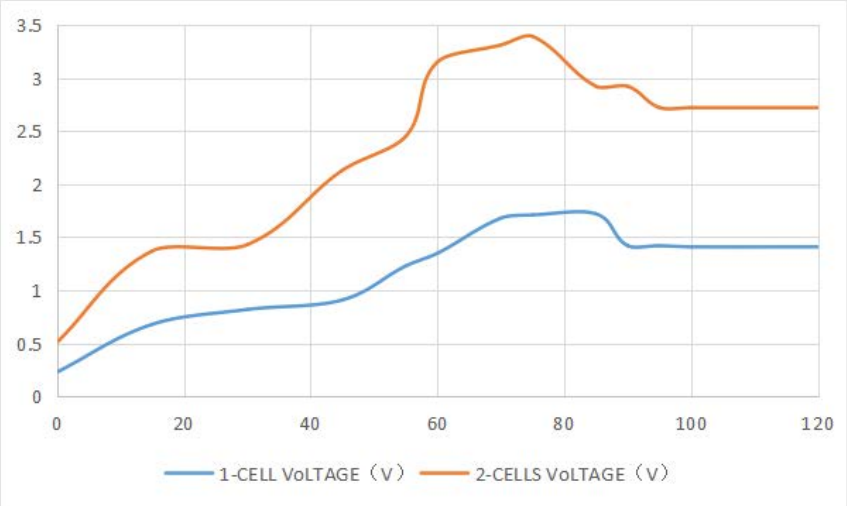


Figure. 6 Voltage curves of NiMH Battery for Programmable charger

At stage1, chip draws negligible power from battery, but the battery already has some power inside, and enters the fast-charge state in a short period of time (stage 2), and power-on reset circuit holds chip in trickle charge. At stage3, device enters the fast-charge state, and the voltage at both ends of the battery is up to the maximum value. At stage 4, cell voltage slop became negative, fast-charge switched to trickle charge. At stage 5, remove the power, chip draw negligible current from the battery, voltage basically unchanged.

## Conclusion

The experimental results show that the NiMH battery charger designed with MAX712 has the advantages of short charging time, high charging efficiency and programmability. As a green battery, it is suitable for small household appliances, computers, mobile communications and other fields.


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