Optimal Design of Power Management System for Real Time Information Terminal of Construction Machinery Car

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Keywords: Construction machinery, Power management system, Condition information collection terminal; Optimize design.

Abstract. In order to solve the problem of throwing load when starting the vehicle and the need of entering the low power consumption mode during the non-construction period, a theoretical analysis and experimental verification method is adopted to design a construction machinery information collecting terminal for power distribution and management among multiple modules Power Management System. Test results show that: The optimized solution meets the power supply requirements of each module of the terminal, can adapt to the complicated application environment in the vehicle, can effectively protect the lithium battery, and achieve the purpose of optimizing the design.

Introduction

Engineering machinery as a kind of construction equipment, the vehicle information terminal for remote monitoring and fault early warning of operating conditions has become a necessary device for safety production. To ensure the stability of information terminals, a high performance of power management systems is critical. For 24V on-board application system, Even with high-performance linear voltage-stabilized power supply chip or switching power supply chip. There is still a high rate of damage [1].In this respect, Xu Yonghai [3] presents the configuration of high-power low ripple power supply system based on LM5005, but it occupies big area, the integration is difficult. Li Yanming etc [4] based on path charging management strategy, selecting bq24195 as the main control chip of power management chip, the flexible configuration parameters and working mode are realized through PC serial port, but need to occupy the single chip computer serial port resources, which is easy to use and makes the design more complex. In view of the above problems, this paper presents a stable, reliable and manageable new power supply system design scheme.

Option of Terminal Power Management System

Design Needs

It is required that the power management system should not throw load when the vehicle starts, and the information terminal will automatically enter the low power mode. Prevent the electromagnetic interference of vehicle electric equipment, and suppress surge, anti-connection and power filter treatment of system output. Also need to consider the construction machinery is often at high and low temperature, dust, vibration and other adverse work environment problems.

System Principle Configuration and Scheme Selection

Based on the device to enable the control to achieve the information terminal Low-power, the overall framework of the power management system is designed as shown in Figure 1, which contains two process subsystems including power and power off.
Power-on process: Single-chip computer ad acquisition to read onboard battery voltage, terminal stops conversion mode when below set threshold, whereas terminal exits low power mode, turn on GPRS module, GPS/BD positioning module, CAN communication module, Then send information to the server after obtaining location information and can bus data.

Power-down process: When the ad value is less than the set threshold, the microcontroller will enter the low power consumption mode. The microcontroller turns off can communication module in turn, GPS / BD positioning module, GPRS module, and enter standby mode.

Optimization Design and Realization of High Efficiency Power Supply

Power Interface Circuit

Due to the existence of inductive load such as ignition and motor, there are many kinds of interference such as transient surge, pulse group and voltage drop in vehicle power supply. Information gathering terminal Power Interface circuit needs to design the corresponding anti-interference circuit [4]. Fig. 2 is a power supply interface circuit, which includes a parabolic load circuit, a surge protection circuit, a reverse connection circuit, a filter circuit and an ad acquisition circuit to ensure the normal output of the Power interface.

As shown in Fig. 2. When the voltage falls, C1 and C5 can provide energy for the back-end load. AD acquisition circuit consists of voltage divider resistors and first-order filter circuit, used to collect the car battery voltage value. When the battery voltage is too low, enter the Low-power mode or close the terminal.

The surge suppression circuit consists of a parabolic load circuit composed of resistors, sm8s36a transient suppression diodes and a two surge suppression circuit with Q1 and Q2 as its core components. When the input voltage is higher than 32V D6 is penetrated, Q2 makes the Q1 in the cut-off state, cut off the power supply, thus protecting the back circuit. When the input voltage is below 32V, the circuit is normally powered. D4 limits Q1 gate-to-source voltage.

Anti-connection circuit is composed of two high-power diode gs1m, forward current can reach 2 A, anti-reverse electromotive force is 1000V, only when the wiring connection is normal, the power supply will be entered into the terminal.

Power Conversion Scheme Selection

Anti-jamming power supply cannot be directly used for each module of the terminal, but also need to be converted by step-down. The step-down conversion can take two kinds of conversion schemes, such as DC and LDO. DC-DC has high efficiency. However, the characteristics of EMI vary significantly with the load, and the high ripple voltage will appear. LDO is a linear conversion, suitable for buck, light load, high efficiency, and no EMI problems, the advantage is that there is a higher power rejection ratio, good transient characteristics, simple circuit cost, and disadvantage is low efficiency in high load [5]. According to the design of the power supply requirements, the use
of the 5V conversion converter, 4.2V, 3.3V conversion using LDO conversion scheme, as shown in Figure 3.

![Figure 3. DC 5V Conversion circuit.](image)

DC-DC chip MP4570, the input voltage range of 4.5 to 55V, the load current of 3A, with soft-start, over-temperature shutdown. Pin 4 is the chip enable pin.

The configuration of the output voltage is determined by formula (1).

\[
V_{out} = V_{FB} \times \left( \frac{R_1 + R_2}{R_3} \right) \left( V \right)
\]

(1)

**Battery Management Circuit**

The cycle life of lithium-ion battery is not only influenced by manufacturing process and electrode parameters [6], but also with the battery charging method and the use of the environment. Therefore, the use of reasonable charging methods and excellent performance of the charging chip is particularly important [7]. Figure 4 is the charge management circuit

![Figure 4. Charge Management Circuit.](image)

The chip input voltage setting is determined by formula (2):

\[
V_{I_{in}} = V_{Lin} \times \left( \frac{R_{19} + R_{20} + R_{25}}{R_{25}} \right) \left( V \right)
\]

(2)

The charging current setting is determined by formula (3):

\[
I_{CHG} = 1.15 \times 1.8 / R_{16} \left( A \right)
\]

(3)

Charge management output voltage setting is determined by formula (4):

\[
V_{SYS} = V_{SYS_{-}REF} \times \left( \frac{R_{34} + R_{S5} + R_{S6}}{R_{S6}} \right) \left( V \right)
\]

(4)
where \( V_{\text{sys_ref}} \) is the reference voltage of output and the output voltage is set to 4.20V. After charging, CHGOK pin turns to high level with VCC. ACOK pin is low when the external power supply exists.

**Microcontroller and Bus Power Supply Circuit**

The MP20043DGT is used for power supply, two outputs can be provided. Channel 1 bus communication power supply, the output can be controlled by the microcontroller. Channel two power supply for the microcontroller, pulled up to the input voltage through the 10K resistor, to remain enabled.

![Microcontroller and bus power supply circuit](image)

**GPS / BD Dual-Mode Positioning Module Power Supply**

GPS / BD positioning module circuit is using RT9193-33 to power supply. Output enabled by the microcontroller control.

**Anti-disassembly Circuit**

When the terminal shell is disassembled, the internal program of the microcontroller judges that the terminal will not work normally, so as to prevent unauthorized disassembly.

**Experimental Results and Analysis**

The circuit board is drawn according to the schematic diagram, and the voltage of each node on the board is measured as shown in table 1. There is a small error in the measured value and the theoretical value, and the absolute error maximum is 0.08V, which satisfies the power supply requirement of each module.

<table>
<thead>
<tr>
<th>Theoretical/V</th>
<th>5</th>
<th>4.2</th>
<th>3.3^1</th>
<th>3.3^2</th>
<th>3.3^3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Measured 1/V</td>
<td>4.95</td>
<td>4.25</td>
<td>3.29</td>
<td>3.25</td>
<td>3.28</td>
</tr>
<tr>
<td>Measured 2/V</td>
<td>5.03</td>
<td>4.28</td>
<td>3.32</td>
<td>3.29</td>
<td>3.30</td>
</tr>
<tr>
<td>Measured 3/V</td>
<td>5.01</td>
<td>4.21</td>
<td>3.30</td>
<td>3.28</td>
<td>3.31</td>
</tr>
</tbody>
</table>

PS:1.3V3-BUS,2.3V3-CPU,3.3V3-GPS/BD

System charging performance test results shown in Figure 8. The initial stage of constant current charging, when the battery voltage reaches 4.06V, the charging current becomes smaller, when the battery voltage reaches 4.17V, the charging current becomes 0mA, the system stops charging the battery. By testing the system discharge, when the battery voltage is lower than 3.4V, the system can effectively avoid the over-discharge of the lithium battery so as to prolong the service life of the lithium battery.
Conclusion

Based on the analysis of functional modules of information terminal of construction machinery, this paper proposes the design scheme of system power supply. The power of the filter and anti-jamming treatment, reducing the vehicle load caused by the probability of device damage. The lithium battery charge and discharge management, improve battery life. By planning the terminal power-up and power-down process, effectively prevent the battery from damage due to over-discharge. After testing the design to meet the technical requirements of the vehicle environment for the relevant application has some reference.

References


