Abstract

This application note describes the High Voltage GreenPAK IC design configuration as an integrated smart lock motor driver with dynamic overcurrent detection that accommodates varying supply voltages and loads. The application note comes complete with a design file which can be found in the Reference section.
Smart Lock Motor Driver with Battery Discharge
Compensation

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1 Terms and Definitions

DC Direct current
PWM Pulse width modulation
CMP Comparator
CCMP Current comparator
MCU Microcontroller unit
HV High voltage
GPO General purpose output

2 References

For related documents and software, please visit:
https://www.dialog-semiconductor.com/products/greenpak

Download our free GreenPAK Designer software [1] to open the .gp files [2] and view the proposed circuit design. Use the GreenPAK development tools [3] to freeze the design into your own customized IC in a matter of minutes. Find out more in complete library of application notes [4] featuring design examples as well as explanations of features and blocks within the GreenPAK IC.

[2] AN-CM-298 Smart Lock Motor Driver with Battery Discharge Compensation.gp, GreenPAK Design File

Author: Petro Zhuk
3 Introduction

Most smart locks use batteries for their power supply, and the battery life is typically 6 months to 1 year. This time depends on the wireless technology used (Wi-Fi, Bluetooth, ZigBee), and how often the door is locked and unlocked. In many cases the motor is powered by four AA batteries, and that is also used in this design example.

Smart lock manufacturers use varying mechanisms for detecting the completion of the deadbolt opening/closing: limit switches, accelerometer fixed on the shaft, hall sensor and magnets fixed on the gear, etc. All these require the associated external components along with the motor driver IC.

One of the deadbolt position detecting schemes is measuring the motor current, and turning off the motor when the deadbolt locks while the motor current increases to a defined threshold, see Figure 1. This method doesn’t require special extra components. However, the threshold must be set relative to a specific supply voltage, usually fully charged batteries.

![Figure 1: Motor Current Waveform](image1)

An improvement to the design is to measure the RMS current per motor and set different current levels to compensate for different battery voltages, see Figure 2. This application note describes how to configure the High Voltage GreenPAK IC for this design approach.

![Figure 2: Motor Current Waveform with Compensation](image2)
4  Construction and Operation Principle

4.1  Operation Principle

The behavior of the design can be divided into three sections, see Figure 3:

Motor stall checking: if the motor current is too high after 100 ms of starting the motor, the driver turns off the motor. Also, the motor current is measured at this time.

Current level setting: current CMP Vref is set depending on the motor current (set higher than measured value).

Overcurrent waiting: if the motor current becomes higher than the selected value during this time, then the motor will be turned off.

![Figure 3: Design Operations](image)
4.2 HV GreenPAK Design

Figure 4: HV GreenPAK Design

RegFile for current CMP is used to measure motor current. There are 16 values, which are switched from higher to lower, see Figure 5.

Figure 5: RegFile Data
After 250 ms the Register File is switched by two values to set a new current level, as shown in Figure 6. When the motor current increases to this new current level, the motor will be turned off, see Figure 7.

For different power supply voltages and loads the motor current will be different. For higher motor current “motor off level” will become higher.
4.3 Application Circuit

Figure 8: Typical Application Circuit

PIN#2 Motor ON – rising edge turns on the motor.
VDD range: 2.3 V – 5.5 V.
VDD2 range: 3.6 V – 6.0 V.
4.4 Motor Test

Table 1: Motor Parameters

<table>
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<tr>
<th>Winding Resistance</th>
<th>Winding Inductance</th>
<th>No-Load RMS Current</th>
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<tr>
<td>Ohm</td>
<td>uH</td>
<td>Power Supply 6.0 V</td>
</tr>
<tr>
<td>1.6</td>
<td>730</td>
<td>170</td>
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</table>

Motor starting current is about 2 A at power supply 6.0 V, and after 200 ms decreases to the nominal value, which depends on the power supply voltage. See Figure 9 through Figure 12.
Smart Lock Motor Driver with Battery Discharge Compensation

Figure 11: Motor Starting Current Waveform, Power Supply 6.0 V

Figure 12: Motor No-Load Current, Power Supply 6.0 V
5 Design Operation Waveforms

5.1 Normal Operation

Power supply: 6.0 V.
Motor RMS current: 170 mA.
Motor Off current: 620 mA.

![Figure 13: No-Load Motor, Power Supply 6.0 V](image1)

Power supply: 3.6 V.
Motor RMS current: 127 mA.
Motor Off current: 460 mA.

![Figure 14: No-Load Motor, Power Supply 3.6 V](image2)
Power supply: 3.0 V.
Motor RMS current: 310 mA.
Motor Off current: 670 mA.

5.2 Stalled Motor at the Start
Motor Stall Detection time is 100 ms. If the motor current is high during 100 ms after the start, the motor will be automatically turned off.
6 Conclusion

This application note describes one specific example for High Voltage GreenPAK, and how it can be customized for a particular motor and battery set. It is a very flexible and simple solution for motor control using configurable internal logic that supports designer preferences. Integration of the motor driver within GreenPAK means the entire circuit fits within a very small physical space.

The designer can tailor the circuitry for when the motor current or the power supply voltage is changing. GreenPAK also allows design of a constant current and constant voltage motor driver with embedded protection features like Overcurrent, Undervoltage, Overtemperature, etc.
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Revision History

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<th>Description</th>
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