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Low-power electronic dice

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Abstract

This thesis aims to create low-power electronic dice with physical dimensions comparable to the commonly used ones. To achieve this goal, it was necessary to develop an optimized firmware, custom circuit boards, a companion mobile application, and 3D models. The solution uses Bluetooth Low Energy in both peripheral and broadcaster mode for communication between the mobile application and the dice. The physical orientation of the dice is determined using a MEMS accelerometer with low-power features and a hybrid super capacitor as the primary energy source. The implementation provides excellent flexibility in customizing the hardware and software, including support for multi-sided custom dice.

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1. Introduction

The biggest issue of this topic is to address how to power the electronic dice, considering the limited space and insufficient power density of common batteries, and how to charge the dice. My solution uses a hybrid super-capacitor with large capacitance, which is the perfect middle ground between traditional battery and large capacitor-powered solutions. Apart from the unique power source, this solution provides better hardware and software customizability than commercially available products.

In addition, it was necessary to design and build a compact electronic board that fits the given space and find out how to connect the board with the charger and programmer.

2. Implementation

The proposed solution consists of these components: dice, mobile app, charging dock, programming adapter, and multi-sided sleeves.

2.1 Playing dice

The firmware for the dice is made with Zephyr, and it had to be written to be as power-efficient as possible, not only to provide long play-time but also to preserve energy between playing sessions. Because of this, the dice sends side numbers and status messages in broadcast advertisements. However, it also features a peripheral mode that enables the mobile application to easily configure the dice parameters, such as the number of sides, blinking modes, etc, through custom GATT service and characteristics.

The hardware of the playing dice Figure 5 consists of a custom PCB Figure 1, which has to remain small to keep the dice size comparable to standard playing dice sizes, as well as the super capacitor, the main body shell, and the top cover. The top face is designed to be removable, allowing direct access to pogo pins pads for easy wire soldering during assembly. The main body shell also has these pads glued onto it to make the dice look the same from all sides. Optionally, a sleeve can be fitted around the dice, changing its appearance or number of sides.

2.2 Mobile application

The companion application is written in Flutter. It consists of two main sections: the playing screen Figure 4 that displays interpreted messages from playing dice in real-time, and a device and settings section Figure 3 for managing and configuring devices. This configuration includes: recording a new dice profile with custom numbers and side positions, and changing the blinking mode of individual sides.

One dice can have up to ten profiles that can, for example, be used for different games or different types of dice. Each profile can then have up to sixty sides that tell the dice where every number is located on the dice.

2.3 Charging dock and programmer

The charging dock Figure 2 is designed with the goal of minimizing costs. It features a status LED and a button connected to the dice through a pogo-pin connector. The dice is pressed down with the hinged lid, with press-fitted magnets at the end. The dock is held by just one screw that is hidden below the bay insert, which makes it easy to repair and replace parts.

The programming adapter Figure 6 can be used to connect the dice to J-Link programmer via pogo-pins, while the top clamp holds the PCB down, allowing testing even when the board is not fully assembled yet.

Both the dock and programming adapter assembly consists of a custom PCB and body parts designed for easy 3D printing, allowing users to customize it effortlessly.

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