Life Board Documentation v1.00

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1. INTRODUCTION

The Dropout Design Life Board plays Conway's Game of Life on a 4×4 grid of LEDs. Moreover, multiple boards may be connected together to produce larger grids of nearly any size and shape. The provided firmware implements a four-way simultaneous communication and distributes a decentralized clock using a minimum number of pins.

The Life Board was originally designed to teach basic through-hole soldering to college freshmen. It proved so effective that we have decided to offer up the board to the general public. Its simple hardware is easy for a novice to understand and its low component count makes soldering relatively rapid. The firmware may also be an instructive introduction to AVR programming. Ultimately, a large number of assembled LIFE boards is an eye-catching demonstration of Conway's powerful ideas.

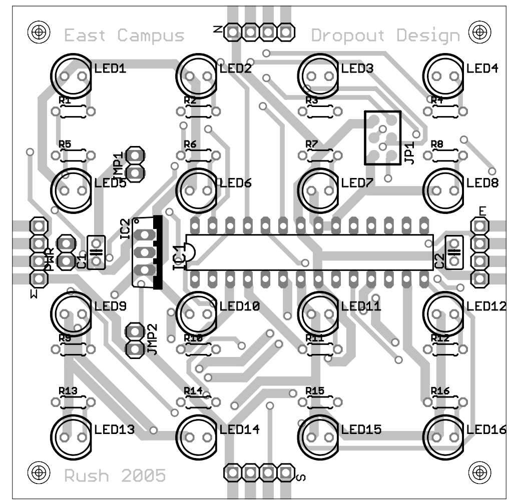

FIG. 1: The top of the Life Board showing component placement

2. THEORY

Conway's Game of Life is, ideally, played on an infinite rectangular grid with some initial pattern of living and dead cells. A global clock ticks off generations and with each new tick cells die and are born, depending only on the state of their neighbors. A living cell with exactly two or three living neighbors survives to the next generation. A dead cell with exactly three living neighbors comes to life. These simple rules not only produce pleasing patterns, but may also be used to perform computation. It turns out that Conway's Game of Life is Turing complete—any calculation that can be done on any real or theoretical computer could be done, in theory, within this simple rule system.

Since the updated state of a cell is dependent only on its neighbors, it is possible to update one cell's status without global knowledge of the entire grid. This distributed computing is the premise for the Life Board implemetnation. On each clock tick, every board in the grid sends the status of its edges to its neighbors. Corner data is routed and retransmitted to pass through the diagonal. In this way, each board can obtain the state of all immediately neighboring LEDs and use them to calculate its next state.

3. HARDWARE

Logic is controlled by a single AtMega48 microcontroller, powered by a 7805 voltage regulator. 16 pins (ports B and D) are used to control the LEDs. A single pin is responsible for broadcasting data in all directions while four pins receive indepedently from each.

3.1. Assembly

First, the firmware should be loaded onto the AtMega48 using an AVR programmer such as an SDK-500 or ISP (Kits come with flashed AVRs, so this step may be skipped). If the chip is soldered directly to the board, changing firmware becomes very difficult. If you expect to be changing firmware, it is highly recommended that you use an optional 28-pin DIP socket so that the AtMega48 may be removed at a later date.

To keep costs as low as possible, the Life Board does not have a soldermask or silkscreen. Instead, refer to Figure 1 for component placement. We recommend populating the board in order of height. First solder the resistors R1 through R16 and decoupling capacitors C1 and C2, followed by the AtMega48 and LEDs L1-L16. Solder the voltage regulator last. The AtMega48, LEDs, and voltage regulator are polarized components; take care that they are placed in the proper orientation.

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3.2. Use

The board may be tested running in isolation. Provide an input voltage of between 6V and 12V (We recommend 12V simply because it is readily available.) to the power connection point. If the board is held so that the "Dropout Design" text is visible and correctly oriented, the power connection will be directly to the right of the west terminal with ground on top and power on bottom. Alternatively, power may be applied directly through one of the terminals. Ground will be the leftmost and power the rightmost connection of the north and south (top and bottom) terminals. Similarly, ground will be the bottommost and power the topmost connection of the east and west (right and left) terminals. Once power is applied, the board should play Life on a 4x4 grid.

Once several boards are known to function properly, they may be connected (with the power disconnected) simply by placing them side by side and bridging the terminal pads between the two boards with solder. If a large number of boards are to be connected, you may wish to build a baseboard with mounting holes. The boards measure $2.8'' \times 2.8''$ and mouting holes are located at the corners, $0.15''$ from the edges. Once the boards are connected, simply turn on the power. The boards will automatically detect each other's presence and begin playing life on the larger grid.

Note that communication takes place over edges. Transmitting the status of a corner LED across a diagonal actually requires two separate transmissions which may take place using either of the adjacent boards as a relay. This does produce one small limit to layout of large numbers of boards. For diagonal communication to function, a board must be present which shares an edge with both of the corner-sharing boards. In the vast majority of cases, this detail is irrelevant; it generally only limits layouts with holes in the middle.

4. THANK YOU

We hope you enjoy the Life Board. We also hope you will find our documentation to be of the highest quality. This document will be updated periodically as we receive feedback. If you have comments or suggestions, feel free to contact us at life@dropoutdesign.com.

APPENDIX A: BILL OF MATERIALS

Ref	Description	Mfg	Mfg Part	Supplier	Supplier Part	Q
Board	Life Board	Dropout Design	LIFE	Dropout Design	LIFE	1
MCU	Atmega48	Atmel	ATMEGA48-20PI	Digikey	ATMEGA48-20PI-ND	1
VREG	5V Linear Regulator	Fairchild	LM7805CT	Digikey	LM7805CT-ND	1
L1-L16	Indicator LEDs (T1)	Everlight	EL-333HT	Mouser	638-333HT	16
R1-R16	220Ω 16 Watt Res.	Yageo	CFR-12JB-220R	Digikey	220EBK-ND	16
C1-C2	.1μF Cap.	Kemet	C315C104M5U5CA	Digikey	399-2127-ND	2

APPENDIX B: SCHEMATICS