UNIVERSAL CONVERTER

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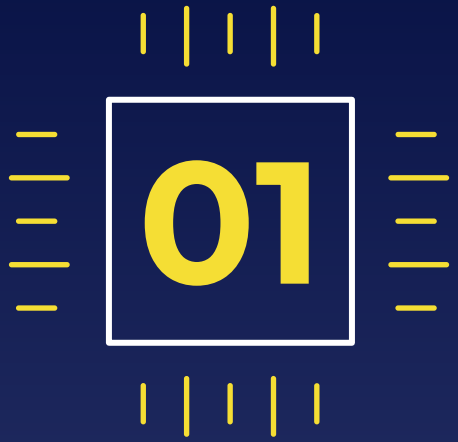
Prof. Bahram Shafai



PROBLEM FORMULATION

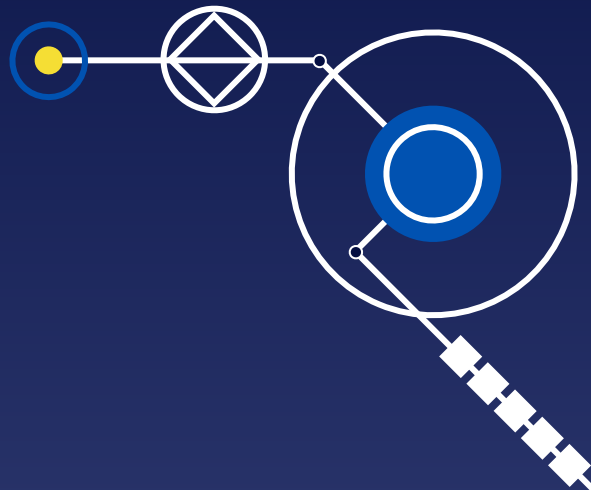
Configurable Power Conversion

Shortcomings of Existing Products

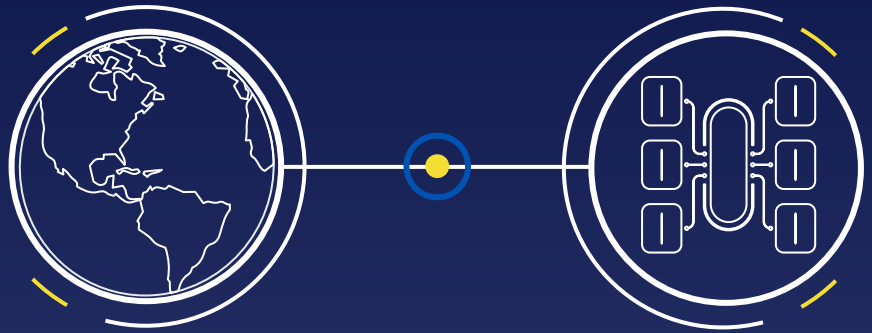
- Large in size and heavy
- Require internal batteries
- Relies on proprietary input connectors

Handheld Power Conversion

- DC inputs to variable DC output
- Simple & intuitive UI design
- Adaptable to any scenario



GOALS



Portability

- Small & lightweight
- Recreational & Professional

Compatibility

- Input from from any common power source
- Easy to configure output

02

SOLUTION APPROACH

PLAN OF ACTION

Part Selection

Determine components for best performance & function according to purpose

Simulation

Verify performance of core components and refine for efficiency

HW Design

Incorporate selected parts into schematic design and PCB layout

FW Dev

Design firmware architecture for system control & UI based on existing systems

Testing

Manufacture design & test performance, adjust parts per testing results

03

DESIGN IMPLEMENTATION

4-Switch Buck-Boost Converter

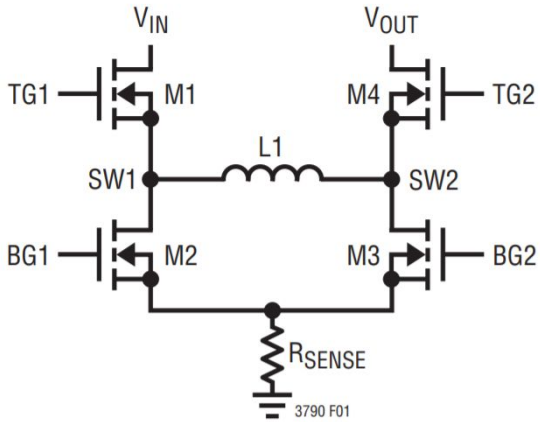


Figure 1. Simplified Diagram of the Output Switches

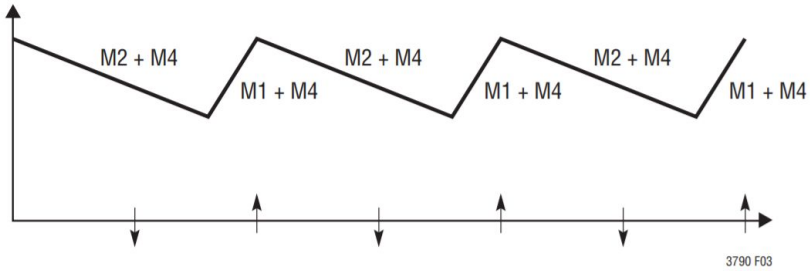


Figure 3. Buck Operation ($V_{IN} > V_{OUT}$)

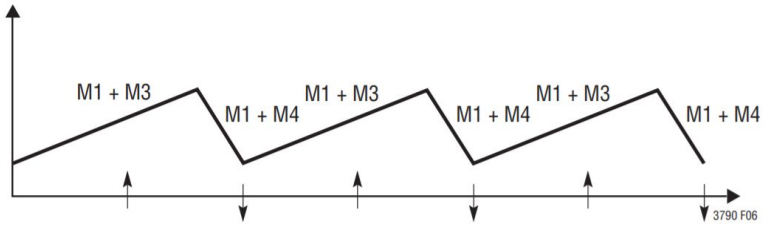
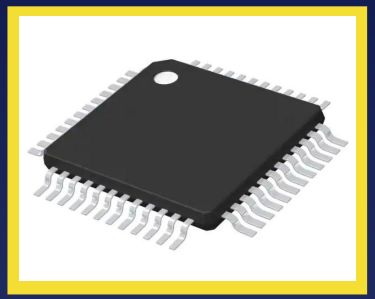


Figure 6. Boost Operation ($V_{IN} < V_{OUT}$)

PART SELECTION

LT3790

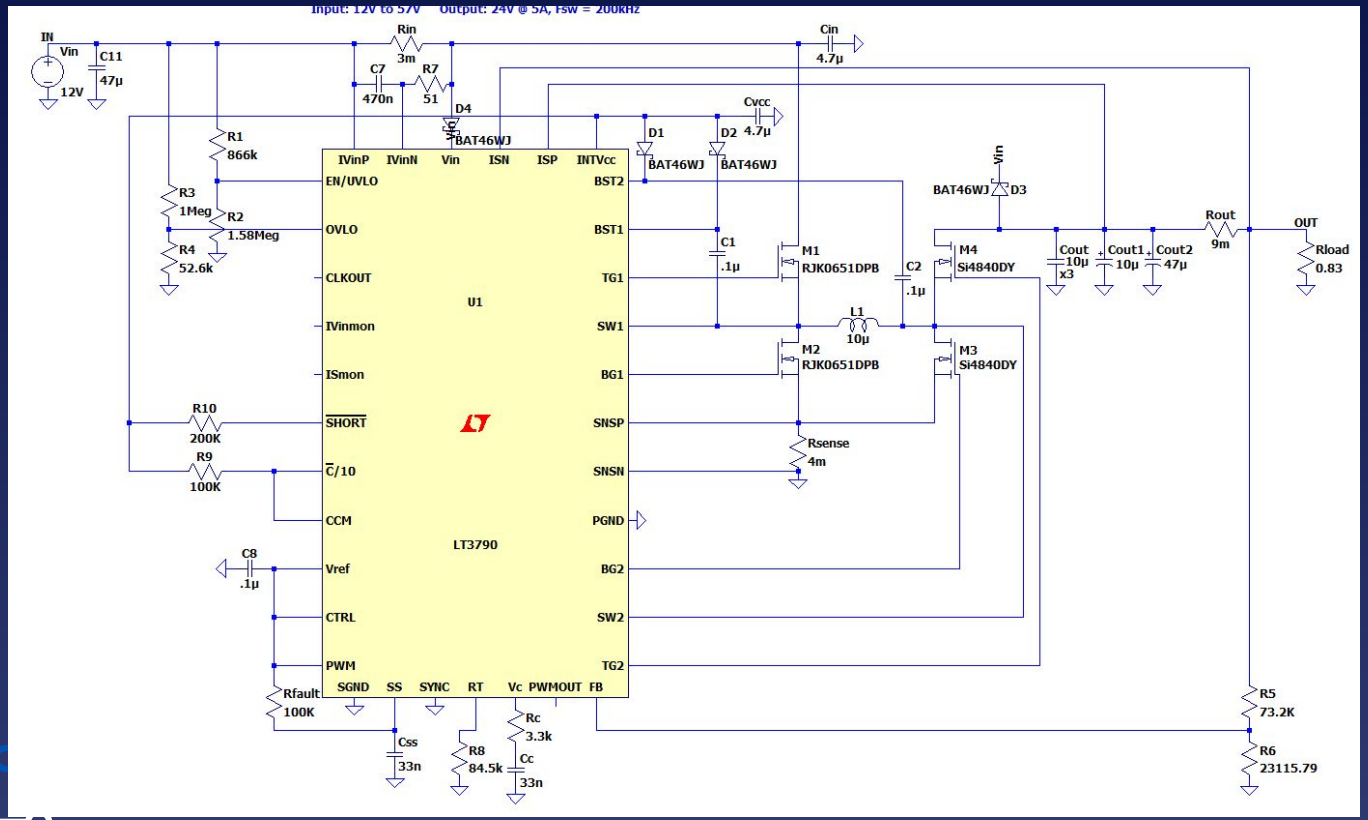
Powerful, small package switching buck-boost controller with voltage/current limiting



STM32 CPU

Reliable processor with all necessary peripherals to control LT3790 & OLED screen

SIMULATION


Input: 12V to 57V Output: 24V @ 5A, Fsw = 200kHz
IN
Vin
12V
C11
47µ
Rin
3m
C7
470n
R7
51
D4
BAT46WJ
Cin
4.7µ
Cvcc
4.7µ
D1
BAT46WJ
D2
BAT46WJ
R1
866k
R3
1Meg
R2
1.58Meg
R4
52.6k
IVinP
IVinN
Vin
ISN
ISP
INTVcc
EN/UVLO
OVLO
CLKOUT
IVinmon
ISmon
SHORT
C/10
CCM
Vref
CTRL
PWM
U1
LT3790
BST2
BST1
TG1
SW1
BG1
SNSP
SNSN
PGND
BG2
SW2
TG2
SGND
SS
SYNC
RT
Vc
PWMOUT
FB
C1
.1µ
M1
RJK0651DPB
M2
RJK0651DPB
C2
.1µ
L1
10µ
M3
Si4840DY
M4
Si4840DY
BAT46WJ
D3
Vin
Cout
10µ
x3
Cout1
10µ
Cout2
47µ
Rout
9m
OUT
Rload
0.83
Rsense
4m
R10
200K
R9
100K
C8
.1µ
Rfault
100K
Css
33n
R8
84.5k
Rc
3.3k
Cc
33n
R5
73.2K
R6
23115.79

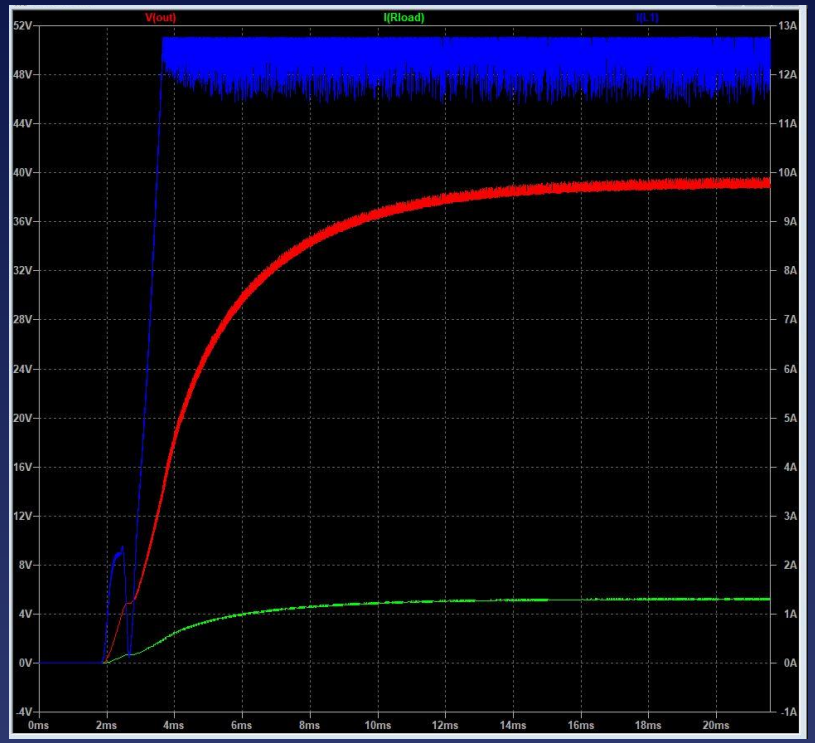
SIMULATION - INITIAL TESTING

Identify Performance Metrics

- Input/Output voltage ripple
- Output voltage stability
- Power efficiency
- Input current draw in stress cases

Converter Operating Parameters

- Input UVLO/OVLO hysteresis
- Switching Frequency
- Passive component values

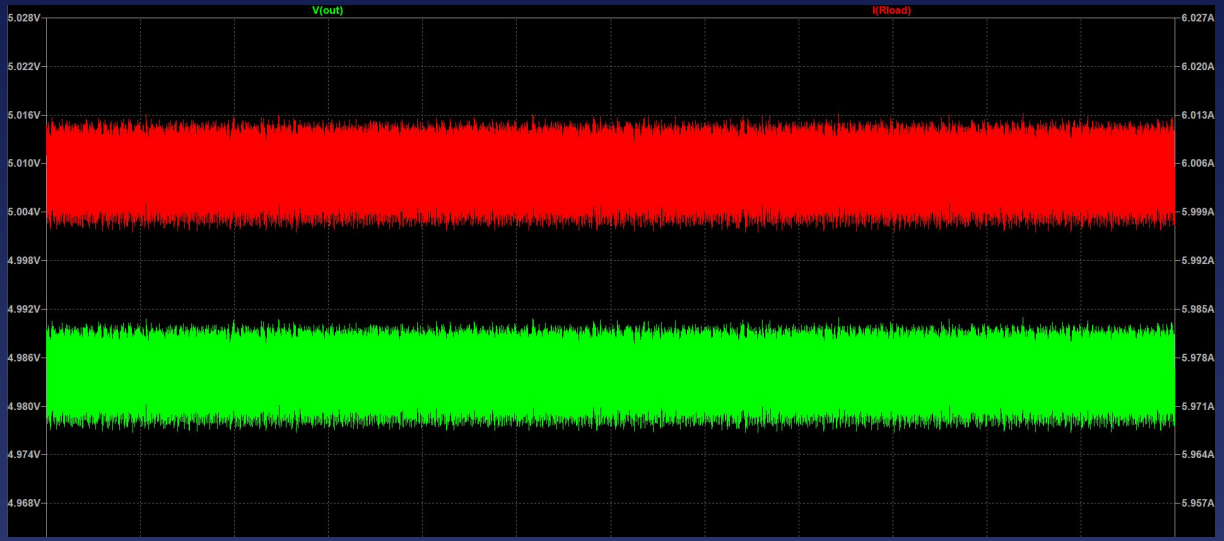


SIMULATION - TYPICAL BUCK CASE

12V to 5V @ 6A (30W)

General Measurements

- 0.86 Ohm Load
- Output Ripple: 10-15 mV
- Efficiency: Pout/Pin = 93.03%

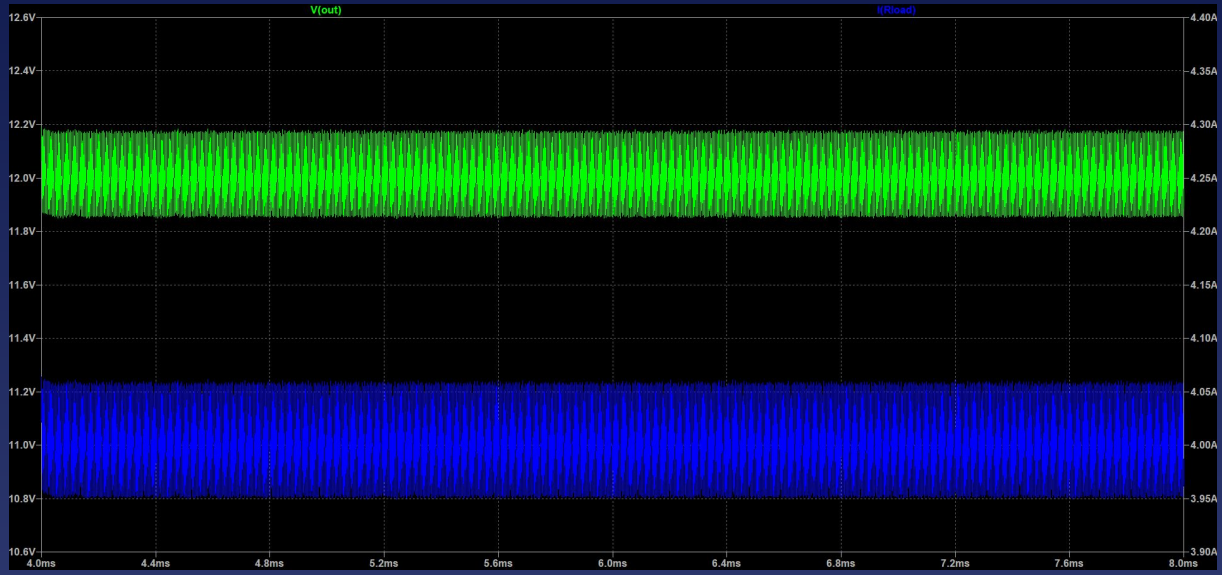


SIMULATION - TYPICAL BOOST CASE

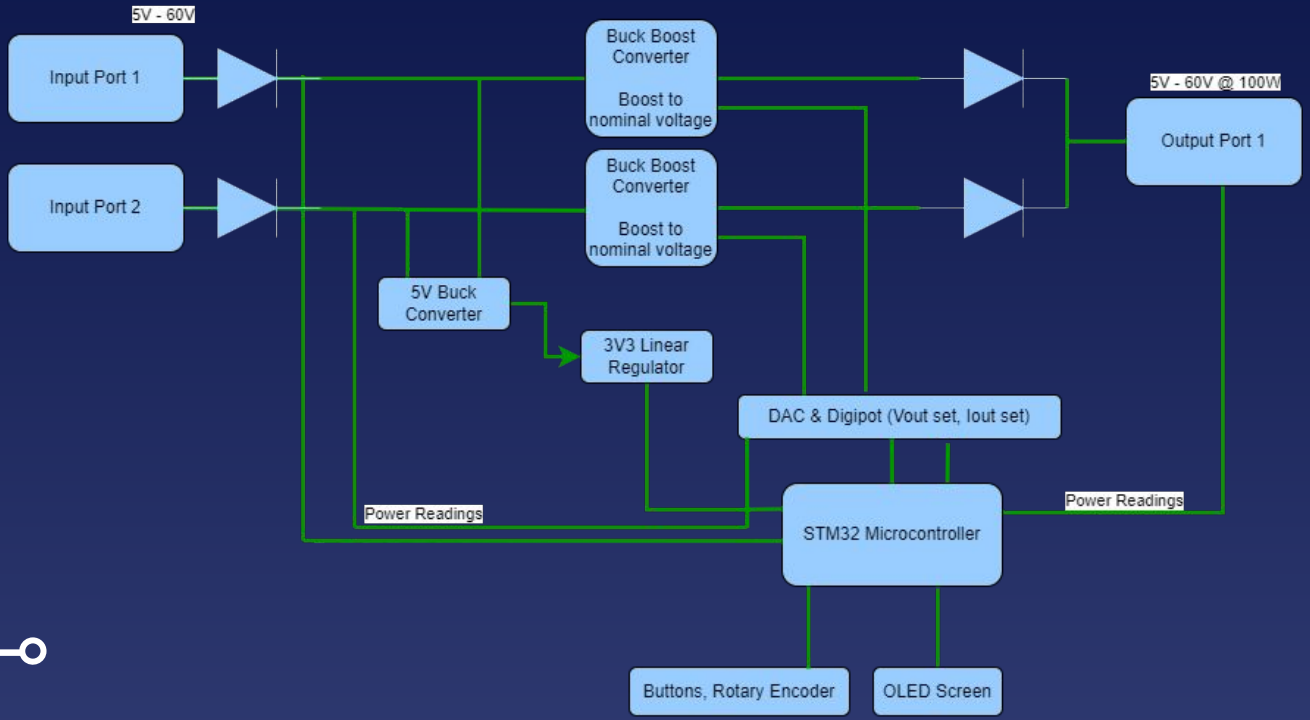
5V to 12V @ 4A (48W)

General Measurements

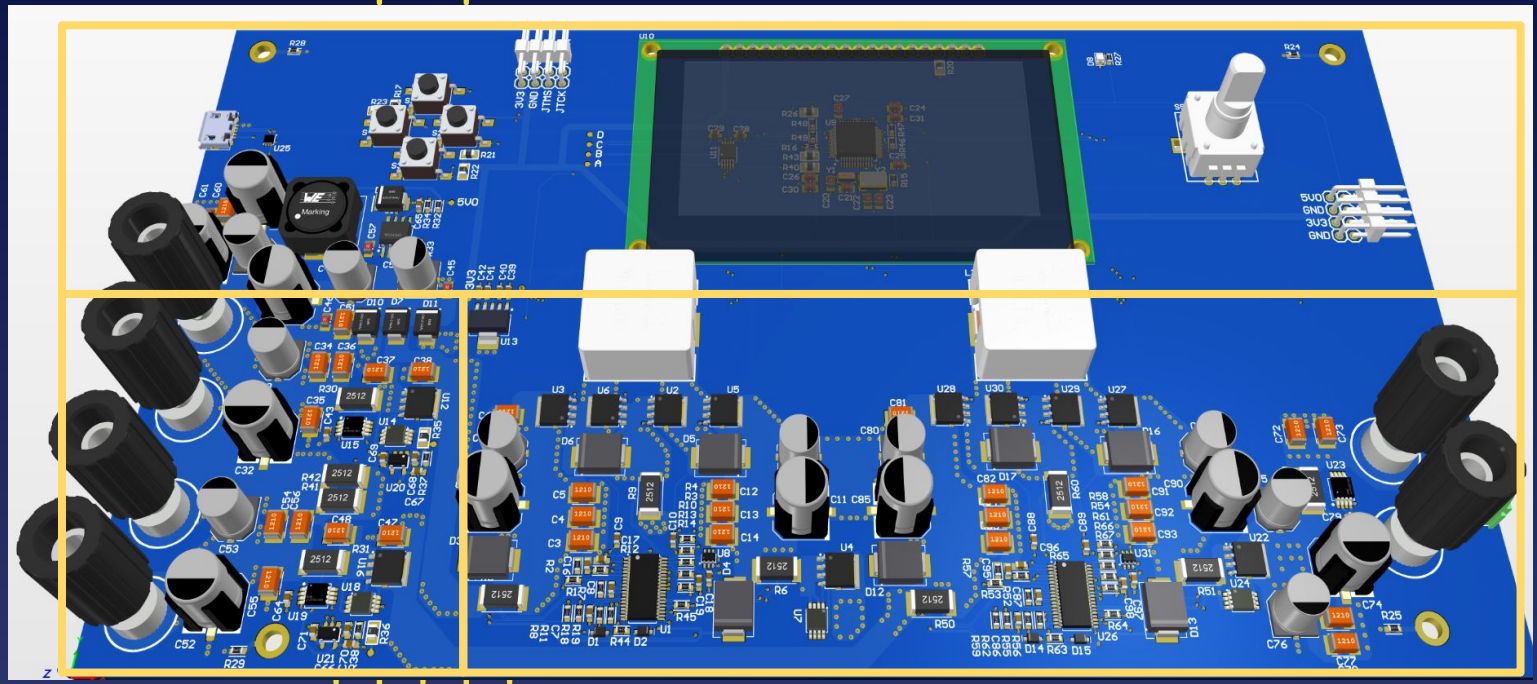
- 3 Ohm Load
- Output Ripple: 0.4V P-P
- Efficiency: Pout/Pin = 88.67%



HARDWARE OVERVIEW



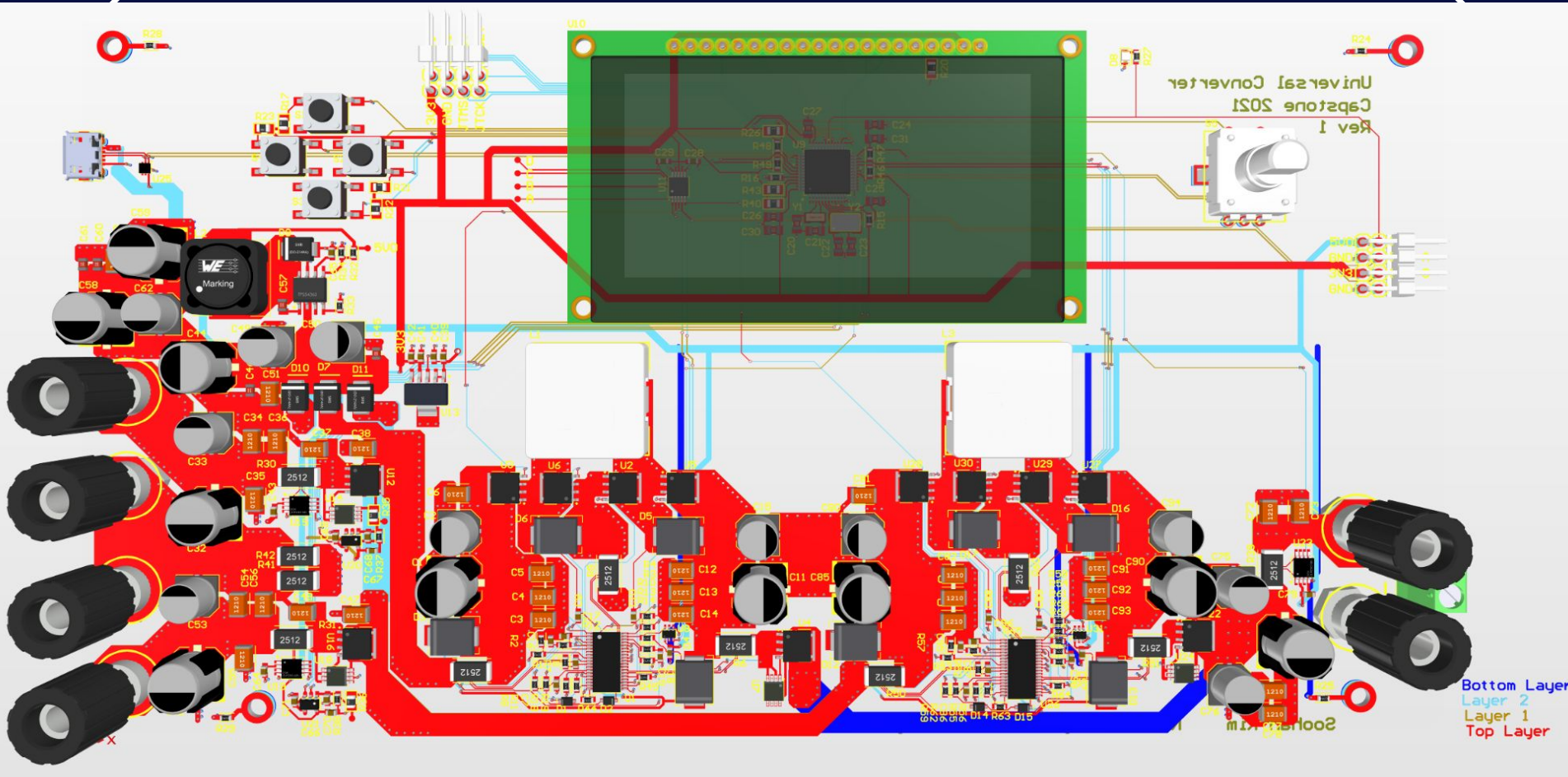
HARDWARE DESIGN



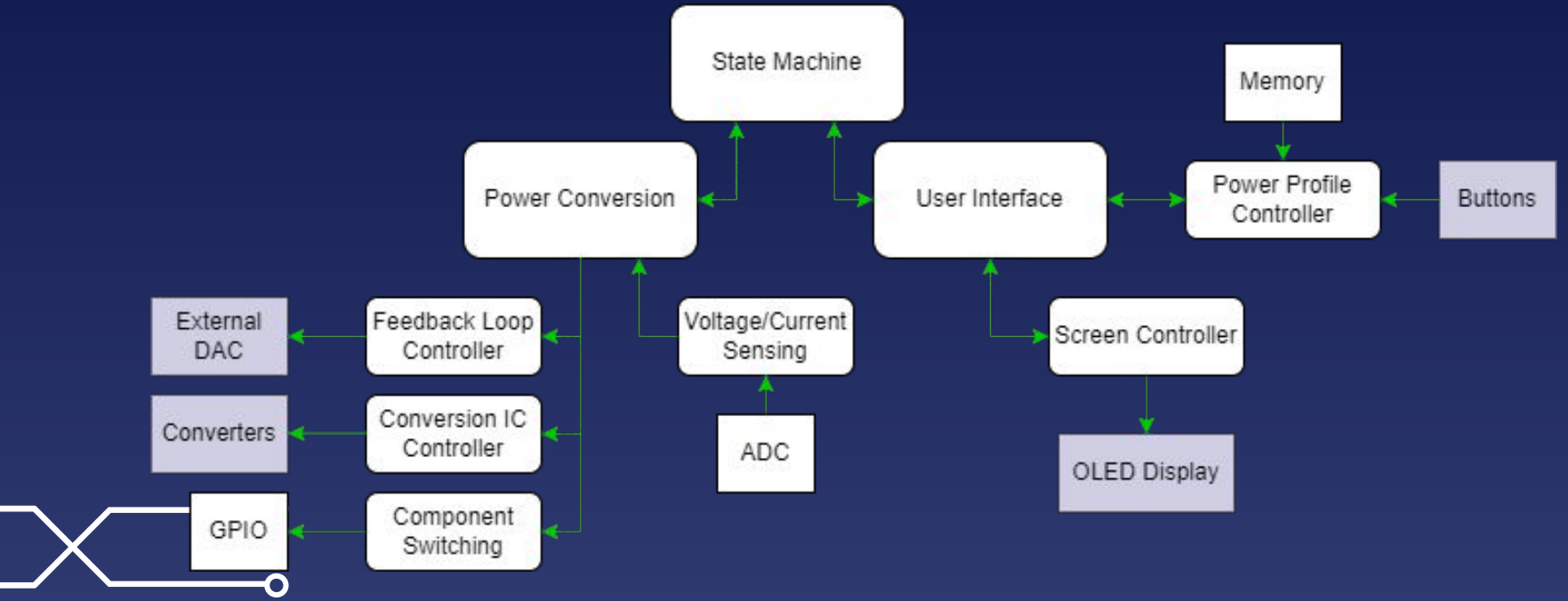
CPU

Powerpath

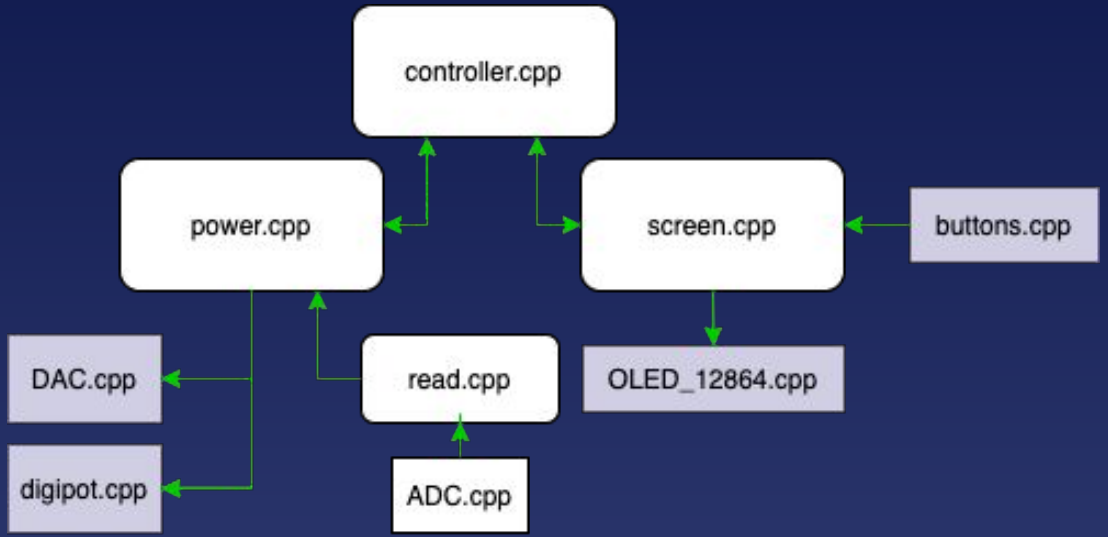
Converters


Universal Converter
Capstone 2021
Rev 1
Bottom Layer
Layer 2
Layer 1
Top Layer

SOFTWARE OVERVIEW



SOFTWARE OVERVIEW



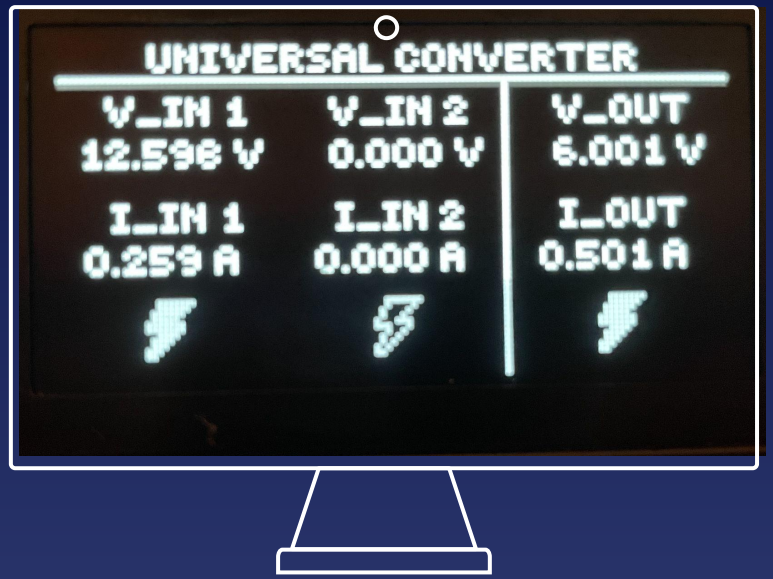
SOFTWARE DEVELOPMENT

Useful UI

- OLED code displays text and other graphics.
- Screen and buttons offer valuable information, navigation, and device control.

Programmed Reliability

- Reliability of control and information is integral for proper consumer use.
- Development in C++ optimized for embedded system.



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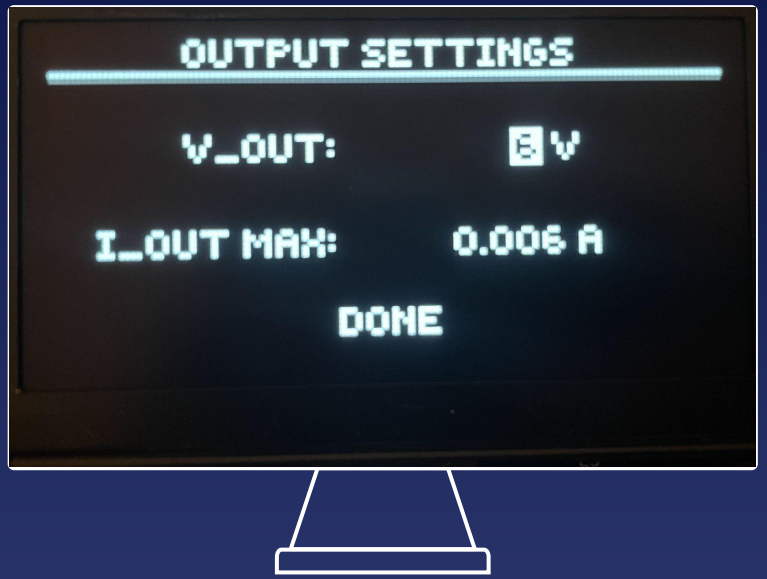
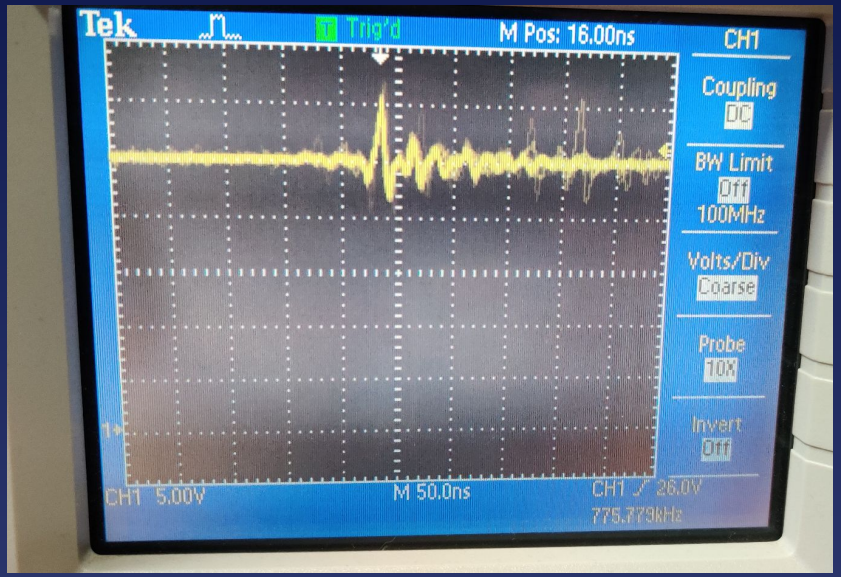


04

FUNCTIONAL ANALYSIS

FUNCTIONAL TESTING



Vout

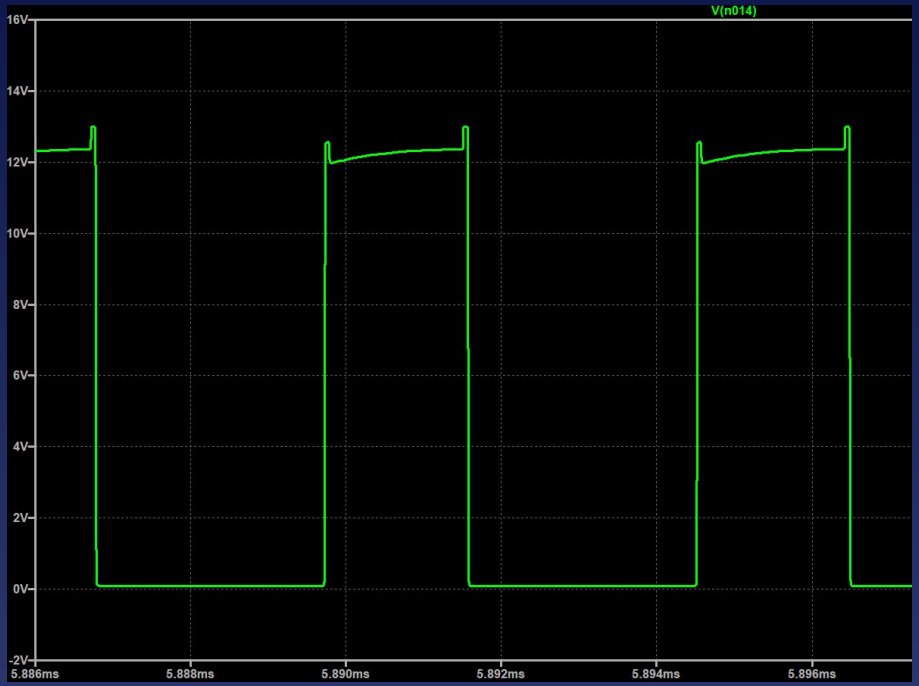
Initial Trials

- 12V Input boosted to 24V Output
- Vctrl monitoring for CC or CV state
- Ensuring consistent DC waveforms internal to system
- Comparing input/output range to simulation

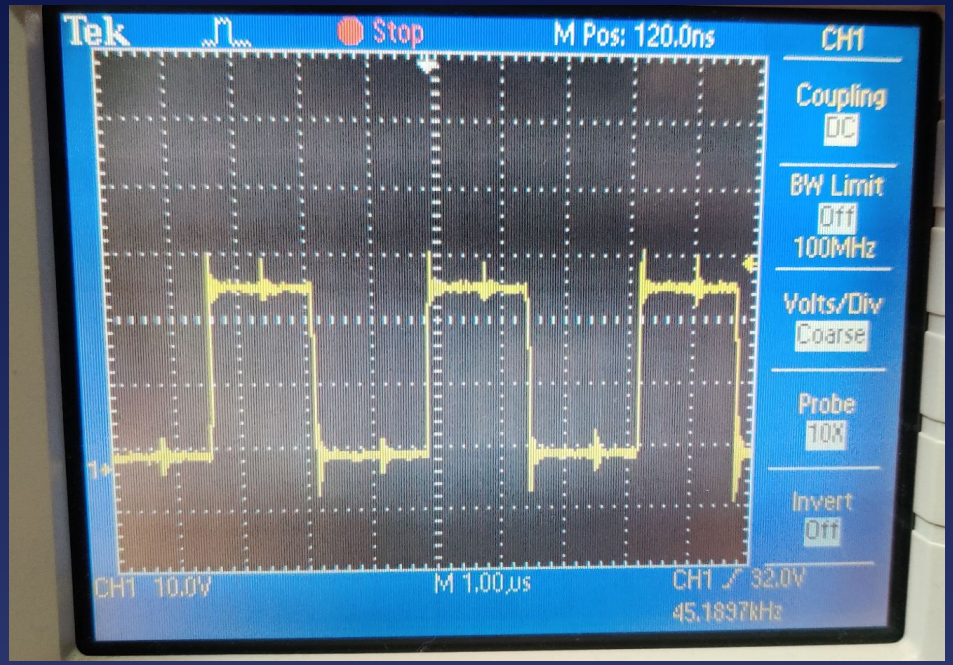
Peripheral Bringup

- SPI for OLED screen
- I2C for DAC and Digipot
- ADC for Sensing

FUNCTIONAL TESTING

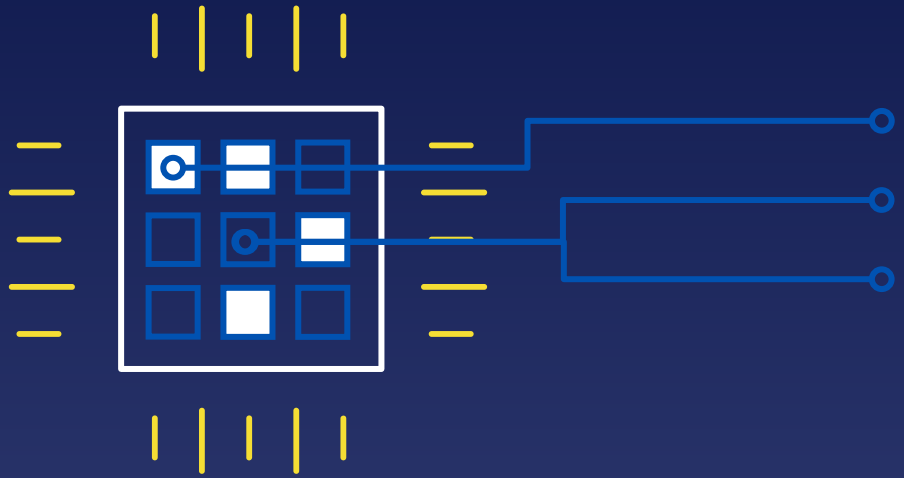


Simulated Inductor Voltage



Actual Inductor Voltage

COST ANALYSIS

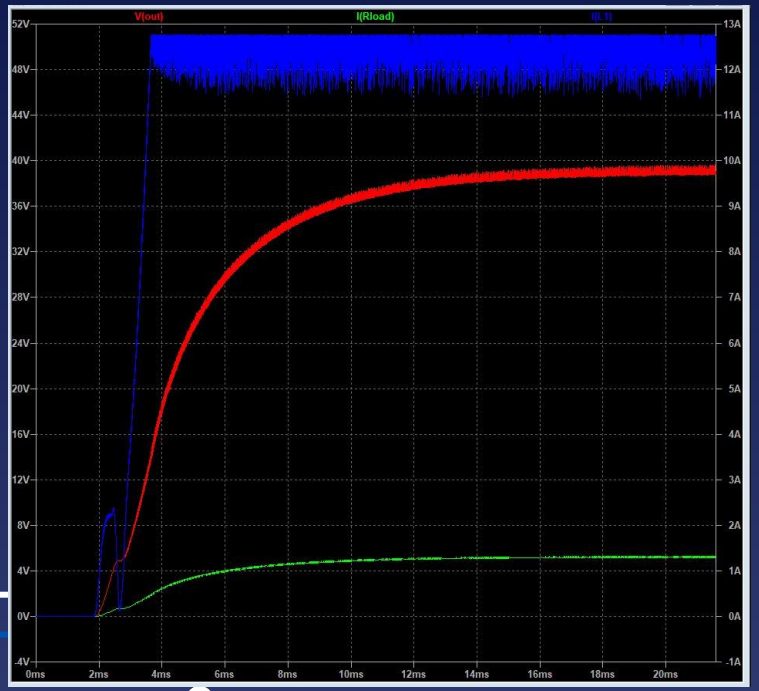


Manufactured PCBs	$290
PCB Components	$657
TOTAL	**$947**

Questions?

APPENDIX A:
SIMULATION - STRESS CASES

5V to 60V @ 2A



60V to 5V @ 6A