Why design a High Efficiency Power Supply System for Micromouse with Vacuum

Present by:
Green Ye
Introduction

Classic 4 Wheeler

Tetra, 2009
Kato Yusuke
2010 2012 2013 All-Japan 1st place
History

Brabham BT46
1978, F1
Vacuum Design Robotracer

Banned in All-Japan after 2011 for safety reason
No restriction at any other places

Source of pictures: Online
Recent

Saiden, 2012
Utsunomiya Masakazu
Latest Trends

2014 All-Japan
2015 All Japan
2015 APEC
2016 APEC
2015 Taiwan
Why Vacuum???

Pros

\[ f = \mu N \]
Cons

- Power
- Weight
- Complexity
Why do we need to design a more efficient power system?
Why?

Need more power
  • Fan Power
  • More wheel motor power

Limited Space
  • Limited Battery Size
  • Limited PCB Space

Thermo
  • LDO Heats
  • IR Heats
Past Design

- 2 cell Lipo battery
- 5V LDO Regulator
- Encoder, Display, IR Emitter
- Motor Driver
- Motors
- 3.3V LDO Regulator
- MCU, Buzzer
- LC Filter
- IR Receiver
- Gyro
Past Design

5V LDO

• Simple
• Bulky
• Inefficient
How much power has been wasted?

- Average Battery Power 8V
- 5V LDO output: 5V
- Percent wastage: \((8-5)/8 = 37.5\%\)!
- Max current usage: 50-700mah
- Power wastage: 700mah \(\times 3V = 2.1W\) (peak)
IR Emitter (IR LED)

- Switching pulsing
- Simple
- Current limiting resistor
IR Emitter Problem

- Pulsing high current
- Voltage Divider
- Power waste

- Voltage Drop: 1.8V at 0.5A
- Resistor: 5 - 1.8 = 3.2V
- Power waste: 3.2V * 0.5A = 1.6W
- Efficiency: 1.8V / 5V = 36%
That is A LOT of power waste!

How do we fix this?
There is only one viable solution

That’s DC-DC technology!!
Efficient 5V system

LMZ21701
3x3mm package
Only 8 pins

Efficiency for $V_{IN} = 12$ V

![Efficiency Graph](image)

![LMZ21701 Schematic](image)
Efficient IR Driving Circuit

• Lower voltage
• Lower resistance
• Lower current
LMZ10501 (2V)
LMZ10501 Configure

Figure 12. Typical Application Circuit

Figure 20. Efficiency $V_{OUT} = 1.8$ V
New efficiency

- 333mah current
- 1.75V Voltage drop
- 0.25V on resistor
- IR Efficiency:
  now:  
  \[
  \frac{1.75V}{2V} = 87.5\%
  \]
  before:  
  36%
Efficient Fan Power Supply

- Vin: 12V (3 cell lipo)
- Vout: 3-4V
- Current: 3A Max

Fan Driver
Efficient?
Overall Looking for New Power System

- Boost Converter 98%+ efficiency
- H-bridge
- 3 cell lipo 12V average
- 2V Buck converter 90%+ efficiency
- 5V Buck converter 90%+ efficiency
- 3.1V 3A Max Buck Converter 90%+ efficiency
- Fan
- 3.3V 150 mah LDO Regulator
- IR Receiver
- Gyro
- 3.3V Buck converter 90%+ efficiency
- MCU
- Buzzer
- Encoder Display
- IR Emitter
Challenges

• Noise
  - Low-Pass Filter
  - More Caps
  - Isolate paths

• Space limit
  - More power IC
  - radiation
  - make more space
Demo Video
Q & A