EECS192 Lecture 4
Feb. 6, 2018

Notes:
Check off-
- 2/9: Motor drive/stall, steering servo
- Quiz 2: power MOSFET/motor drive Tues 2/13

Topics
- Quiz 1
- Polarized capacitor
- Project proposal feedback
- Driving MOSFETs and motor (conclusion)
  - MC33883 MOSFET driver
  - H bridge
- PWM and motor drive (conclusion)
- RC servo notes
- Power supplies and Wiring
- Linear Regulator
- Buck Converter

47uF, 16V electrolytic, polarized
Not all same- ESR…
Project proposal feedback
Motor Driver

Schematic
- Estop: what to switch?
- G_EN = 5V not 3.3V.
- Snubbing capacitors and diode
- Drive.brake.enable.dir- shoot through protection
- Need accel/coast/brake to avoid burning out motor/transistors
- Conventions: L->R, top to bottom
- Connectors- battery, motor, IO connections+ground

Circuit Layout
- Mounting holes
- Big wires, short distances
- QFN vs SOIC package, SMD vs through hole
- Heat sinks- horizontal transistor is more robust
- Estop switch
- Signal connectors- include ground
- Power connectors

Software
- Tasks vs interrupts vs main() vs RtosTimer
H-Bridge Gate Driver IC

The 33883 is an H-bridge gate driver (also known as a full-bridge pre-driver) IC with integrated charge pump and independent high and low side gate driver channels. The gate driver channels are independently controlled by four separate input pins, thus allowing the device to be optionally configured as two independent high side gate drivers and two independent low side gate drivers. The low side channels are referenced to ground. The high side channels are floating.

The gate driver outputs can source and sink up to 1.0 A peak current pulses, permitting large gate-charge MOSFETs to be driven and/or high pulse-width modulation (PWM) frequencies to be utilized. A linear regulator is incorporated, providing a 15 V typical gate supply to the low side gate drivers.

This device powered by SMARTMOS technology.

Features

- $V_{CC}$ operating voltage range from 5.5 V up to 55 V
- $V_{CC2}$ operating voltage range from 5.5 V up to 28 V
- CMOS/LSTTL compatible I/O
- 1.0 A peak gate driver current
- Built-in high side charge pump
- Under-voltage lockout (UVLO)
- Over-voltage lockout (OVLO)
- Global enable with <10 μA Sleep mode
- Supports PWM up to 100 kHz

ORDERING INFORMATION

<table>
<thead>
<tr>
<th>Device (Add R2 Suffix for Tape and Reel)</th>
<th>Temperature Range ($T_A$)</th>
<th>Package</th>
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<tbody>
<tr>
<td>MC33883HEG</td>
<td>-40 °C to 125 °C</td>
<td>20 SOICW</td>
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</table>

Figure 1. 33883 Simplified Application Diagram


**MC33883 + H bridge**

![Diagram of MC33883 and H bridge](image)

- **G_EN = 5V**

**Figure 14. Application Schematic with External Protection Circuit**

**CAUTION!!!!**
Software fries hardware....
Need protection logic- 74HCxxx
Estop?
PWM and Motor Drive

https://github.com/ucb-ee192/SkeletonMCUX/tree/master/frdmk64f_pwm

FTM_UpdatePwmDutycycle
(BOARD_FTM_BASEADDR, BOARD_FTM_CHANNEL,
    kFTM_CenterAlignedPwm, updated_duty_cycle);

Figure 40-21. CPWM period and pulse width with ELSnB:ELSnA = 1:0
PWM for Main Motor control

\[ i_m = \frac{T}{T_o} i_{\text{max}} \]

Is \( i_{\text{max}} \) constant?
Motor Electrical Model

Back EMF
Motor electromechanical behavior

Also- see motor worksheet……

Motor Electrical Model

\[ i_m = \frac{V_{\text{BAT}} - k_e \dot{\theta}_m}{R_m} \]

Conclusion:
\[ <i_m> = ? \]

Motor Resistance?
Peak current?
PWM for Steering Servo

Gotchas:
• 4.8 or 6V, (Not 7.2V!)
• max current 2A
• May be sensitive to noise on supply line
• Performance depends on voltage
Power supplies and Wiring

Power supply wiring - BAD!

+11.1V

Voltage regulator

Voltage regulator

On board: what does this look like electrically (as a schematic)?
On board: what does this look like electrically (as a schematic)?
Power supplies and Wiring

Ohms/square

For some given depth, resistance is directly in proportion to length and inversely proportional to width.

Therefore, we can rate the resistive material of constant depth in terms of ohms per square.

<table>
<thead>
<tr>
<th>Cu Weight oz.</th>
<th>Thickness mm(mils)</th>
<th>mΩ/Square 25°C</th>
<th>mΩ/Square 100°C</th>
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<tbody>
<tr>
<td>1/2</td>
<td>.02 (0.7)</td>
<td>1.0</td>
<td>1.3</td>
</tr>
<tr>
<td>1</td>
<td>.04 (1.4)</td>
<td>0.5</td>
<td>0.65</td>
</tr>
<tr>
<td>2</td>
<td>.07 (2.8)</td>
<td>0.25</td>
<td>0.36</td>
</tr>
<tr>
<td>4</td>
<td>.13 (5.3)</td>
<td>0.13</td>
<td>0.18</td>
</tr>
</tbody>
</table>

Driving MOSFETs and motor

MC33883 protection

Caution: don’t run motor current through here

Figure 12. Gate Protection and Flyback Voltage Clamp

Figure 2. 33883 Simplified Internal Block Diagram
Power supplies and Wiring
Linear Voltage Regulator

V_{IN} \rightarrow \text{regulator} \rightarrow V_{REG} = 5.0V

0.5 ohm (equiv. for 1 amp load)

V_{REG} = 5.0V
Linear Regulator for RC servo power

• Power limit? Heat....

Caution: caps required for stability for some voltage regulators

V_{IN} \rightarrow \text{regulator} \rightarrow V_{REG} = 5.0V

0.5 \text{ ohm}
(equiv. for 1 amp load)

P_{diss} = ?

V_{REG} \uparrow \quad I_{IN} \uparrow \quad P_{diss} \uparrow

V_{IN} \rightarrow \quad V_{IN} \rightarrow \quad V_{IN} \rightarrow
Buck Converter- DC-DC

Why? Efficiency ~90%

Waveforms on board (also see buck converter notes.)
Buck: high to low. Boost: low-to-high)
Buck Converter
LM2678
Buck Converter

https://en.wikipedia.org/wiki/Buck_converter