Topics

• Keil hint: timing using *os_time*
• Motor Electrical Model
• Back EMF
• Motor electromechanical behavior
• MOSFETs and motor drive
• H bridge
• PWM
• Back EMF measurement
Timing from Keil Tools

```c
// systime is not needed since internal ostime runs at same 100 us rate.
void RealTime1(void const *args)
{
    long timeval;
    systime1++;
    timeval = (long) os_time; // assume atomic?
    if((systime1 % 1000) == 0)
        { printfNB("\r\n RealTime1: ostime=%ld systime1 %ld\n", 
                      timeval, systime1);
            // every 1000 ms- lets see if delays
```
Timing from Keil Tools

~50 us (check depends on clock rate?)
DC Motor Physical Model-review

\[ \vec{F} = il \times \vec{B} \]
\[ \tau = \vec{r}_1 \times \vec{F}_1 + \vec{r}_2 \times \vec{F}_2 \]
Motor Electrical Model

Motor Electrical Model
Back EMF
Motor electromechanical behavior

Continued on board
Also - see motor worksheet……

Note: missing e-stop!
Given: $R_m = 0.1 \text{ ohms}, V_{\text{batt}} = 7.2 \text{ V}, R_{\text{bat}} = 0$.

$V_{ds} = ? \Rightarrow I_{ds} = ? \text{ amps}$

MOSFETs and motor drive

$V_{GS} = 20 \text{ V}$

$V_{gs} = 20 \text{ V}$

$P_{\text{trans}} \sim 35 \text{ W}$

$V_{gs} = 6 \text{ V}$

$P_{\text{trans}} \sim 72 \text{ W}$
R_m = 0.1 \text{ ohms}, V_{\text{batt}} = 7.2 \text{ V}, R_{\text{bat}} = 0.
V_{\text{ds}} = 3.6 \text{ V} \Rightarrow I_{\text{ds}} = \frac{(7.2 - 3.6 \text{ V})}{(0.1 \text{ ohm})} = 36 \text{ amps}

V_{\text{gs}} = 20 \text{ V} \\
P_{\text{trans}} \sim 35 \text{ W}

V_{\text{gs}} = 6 \text{ V} \\
P_{\text{trans}} \sim 72 \text{ W}
H bridge gate driver devices

3-Phase Brushless DC Motor Pre-Driver

Features and Benefits
- Drives 6 N-channel MOSFETs
- Synchronous rectification for low power dissipation
- Internal UVLO and thermal shutdown circuitry
- Hall element inputs
- PWM current limiting
- Deadtime protection
- FG outputs
- Standby mode
- Lock detect protection
- Overvoltage protection

Package: 28-contact QFN (ET package)

Description
The A4931 is a complete 3-phase brushless DC motor pre-driver. The device is capable of driving a wide range of N-channel power MOSFETs and can support motor supply voltages up to 30 V. Communication logic is determined by three Hall element inputs spaced at 120°.

Other features include fixed off-time pulse width modulation (PWM) current control for limiting inrush current, locked-rotor protection with adjustable delay, thermal shutdown, overvoltage monitor, and synchronous rectification. Internal synchronous rectification reduces power dissipation by turning on the appropriate MOSFETs during current decay, thus shorting the body diode with the low RDS(ON) MOSFET. Overvoltage protection disables synchronous rectification when the motor pumps the supply voltage beyond the overvoltage threshold during current recirculation.

The A4931 offers enable, direction, and brake inputs that can control current using either phase or enable chopping. Logic outputs FG1 and FG2 can be used to accurately measure motor rotation. Output signals toggle state during Hall transitions, providing an accurate speed output to a microcontroller or speed control circuit.

Operating temperature range is -20°C to 105°C. The A4931 is supplied in a 5 mm × 5 mm, 28-terminal QFN package with exposed thermal pad. This small footprint package is lead (Pb) free with 100% matte tin leadframe plating.

Figure 1. 33883 Simplified Application Diagram
MC3383 protection

Figure 12. Gate Protection and Flyback Voltage Clamp

Figure 2. 3383 Simplified Internal Block Diagram
MC3383 H bridge

!!CAUTION!!
Software fries hardware....
**PWM**

https://developer.mbed.org/handbook/PwmOut

<table>
<thead>
<tr>
<th>Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>PwmOut (PinName pin)</code></td>
<td>Create a <strong>PwmOut</strong> connected to the specified pin.</td>
</tr>
<tr>
<td><code>write (float value)</code></td>
<td>Set the output duty-cycle, specified as a percentage (float)</td>
</tr>
<tr>
<td><code>read ()</code></td>
<td>Return the current output duty-cycle setting, measured as a percentage (float)</td>
</tr>
<tr>
<td><code>period (float seconds)</code></td>
<td>Set the PWM period, specified in seconds (float), keeping the duty cycle the same.</td>
</tr>
<tr>
<td><code>period_ms (int ms)</code></td>
<td>Set the PWM period, specified in milli-seconds (int), keeping the duty cycle the same.</td>
</tr>
<tr>
<td><code>period_us (int us)</code></td>
<td>Set the PWM period, specified in micro-seconds (int), keeping the duty cycle the same.</td>
</tr>
<tr>
<td><code>pulsewidth (float seconds)</code></td>
<td>Set the PWM pulsewidth, specified in seconds (float), keeping the period the same.</td>
</tr>
<tr>
<td><code>pulsewidth_ms (int ms)</code></td>
<td>Set the PWM pulsewidth, specified in milli-seconds (int), keeping the period the same.</td>
</tr>
<tr>
<td><code>pulsewidth_us (int us)</code></td>
<td>Set the PWM pulsewidth, specified in micro-seconds (int), keeping the period the same.</td>
</tr>
<tr>
<td><code>operator= (float value)</code></td>
<td>A operator shorthand for <code>write()</code></td>
</tr>
<tr>
<td><code>operator float ()</code></td>
<td>An operator shorthand for <code>read()</code></td>
</tr>
</tbody>
</table>