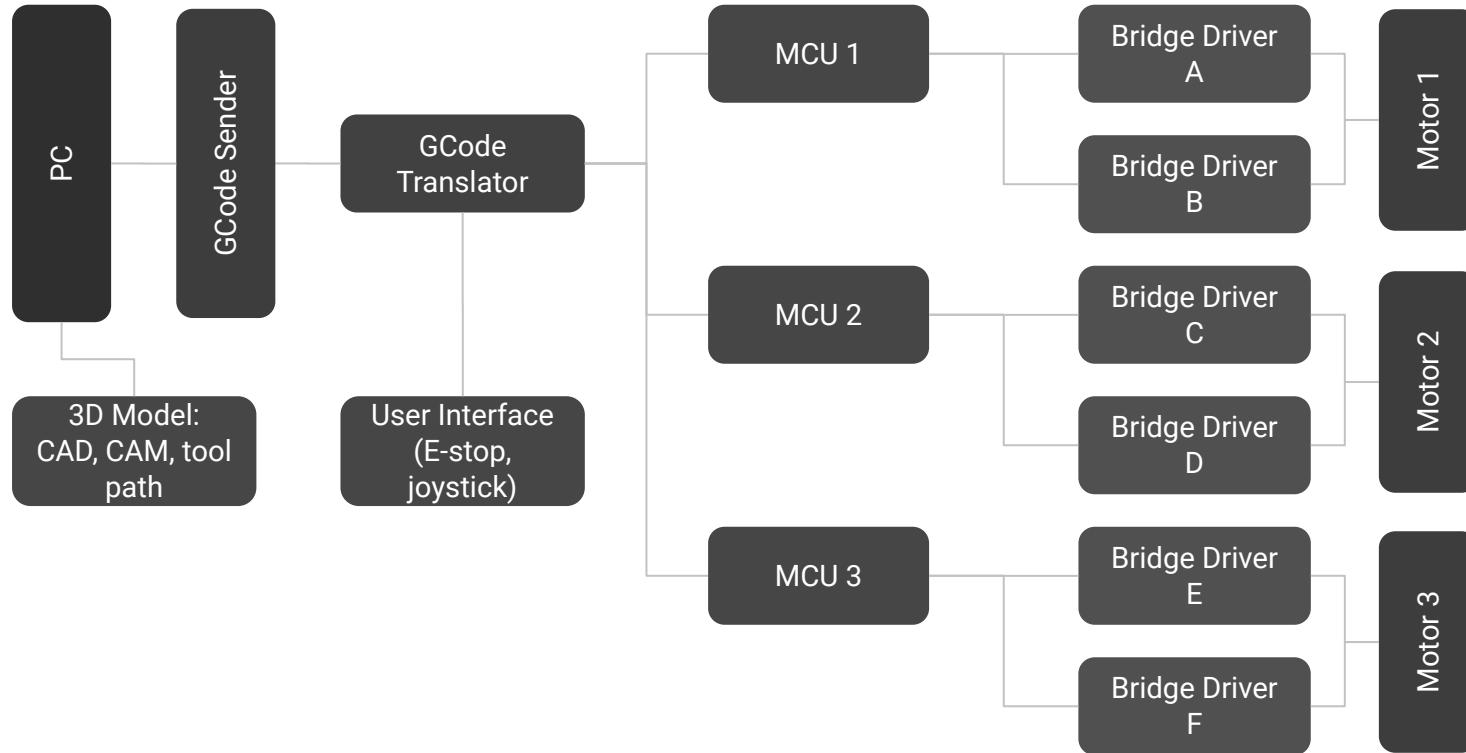
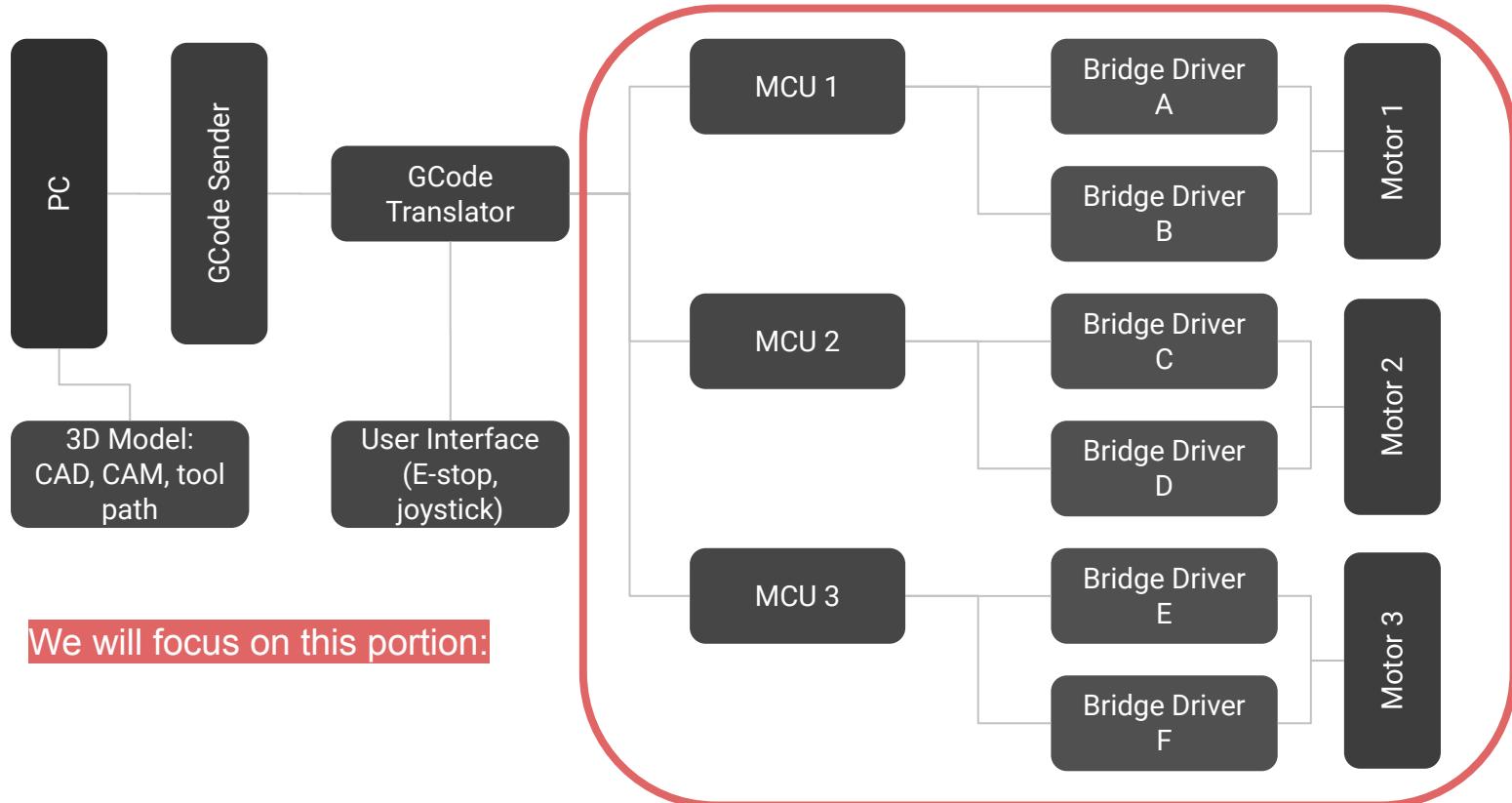


Cheap
motor!

$\frac{1}{4}$ "-20 lead
screw!

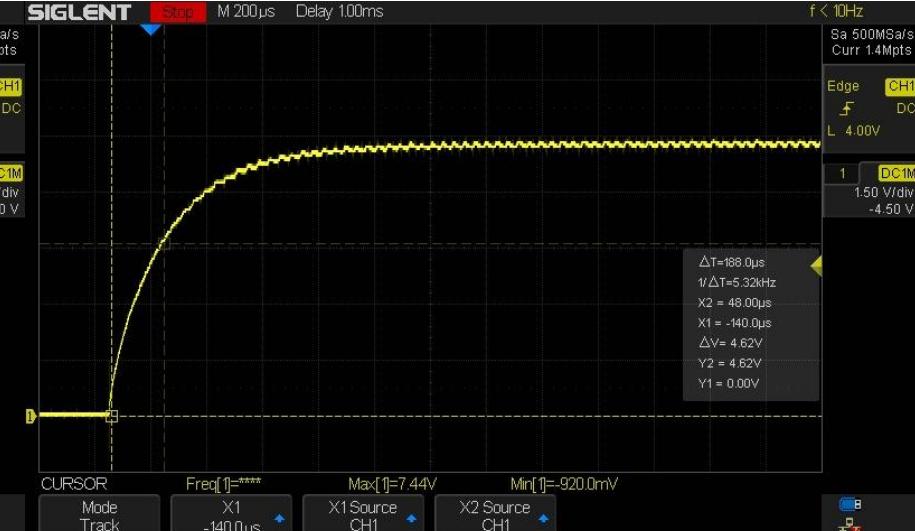
$\frac{1}{4}$ "-20 lead
screw!







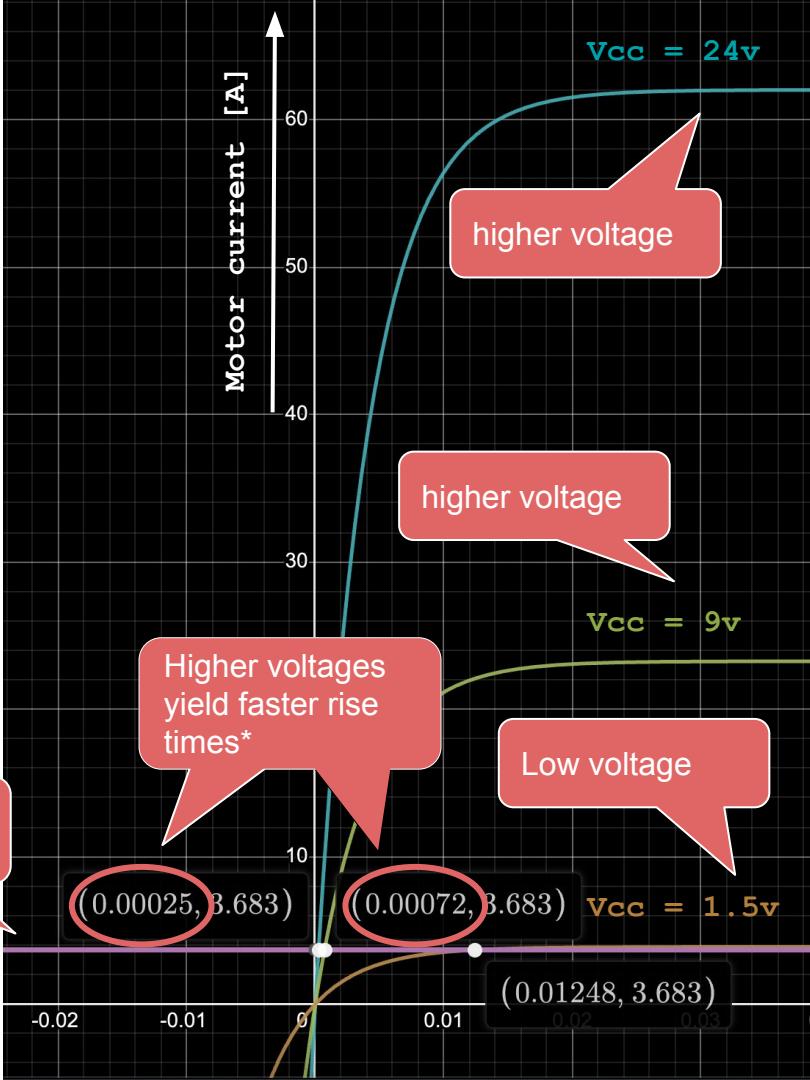
```
>> tau=368E-6s, R_ext=8.2ohm
```

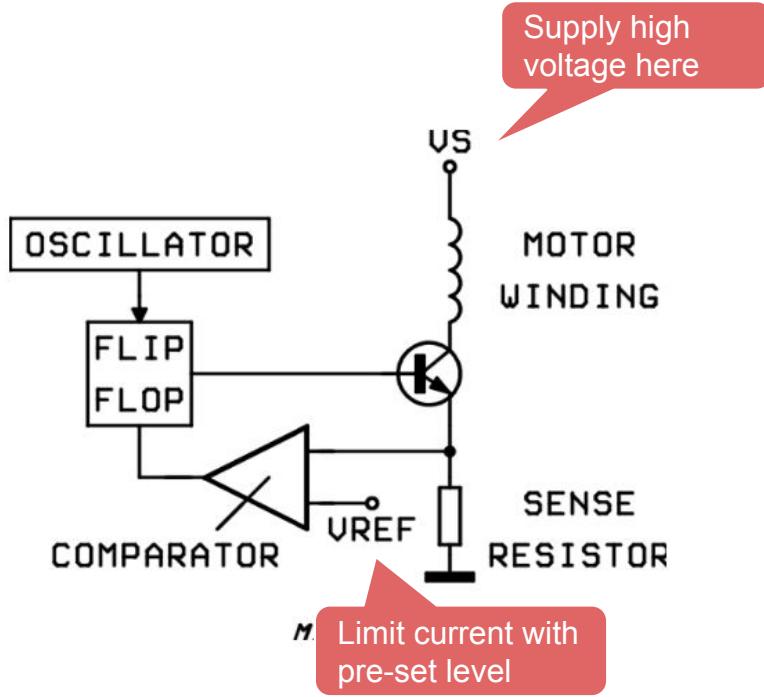


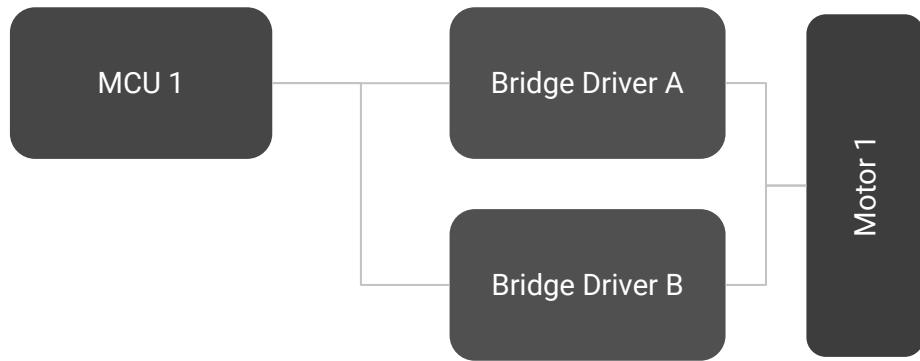
```
>> tau=168E-6s, R_ext=4ohm
```

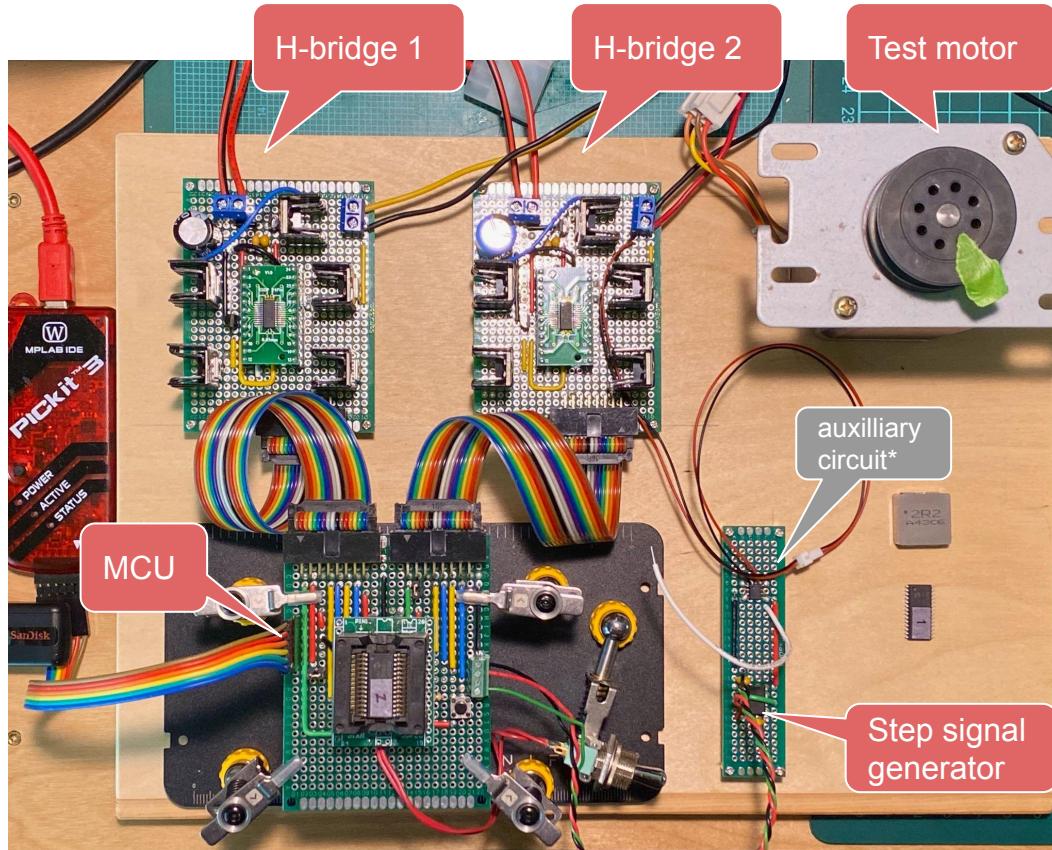
Assume first-order approx.
>>Motor: tau=L_0/(R_0+R_ext)
>> L_0=1.61E-3H, R_0=0.387ohm

Large time constant!!
Tau = L0/R0 = 4.2ms

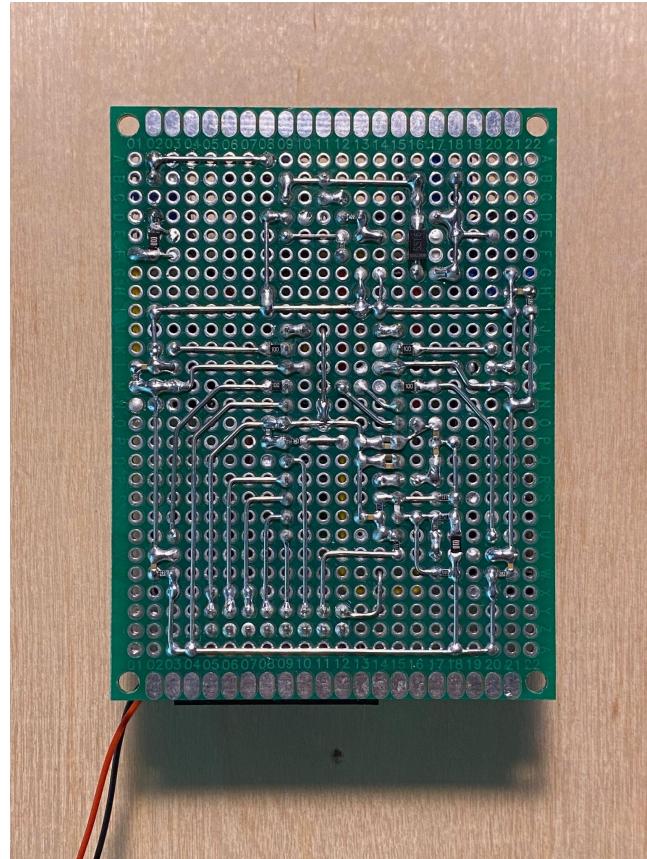
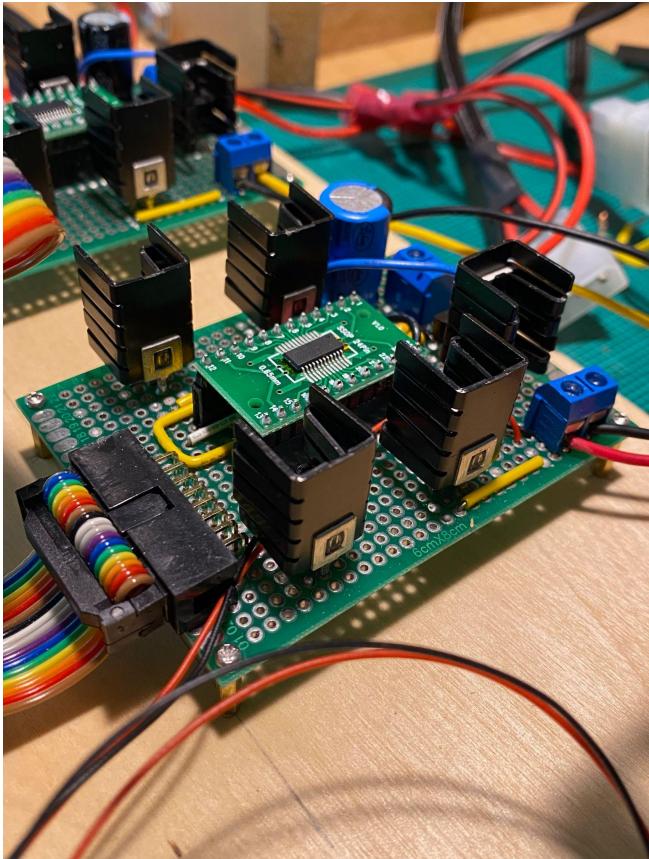


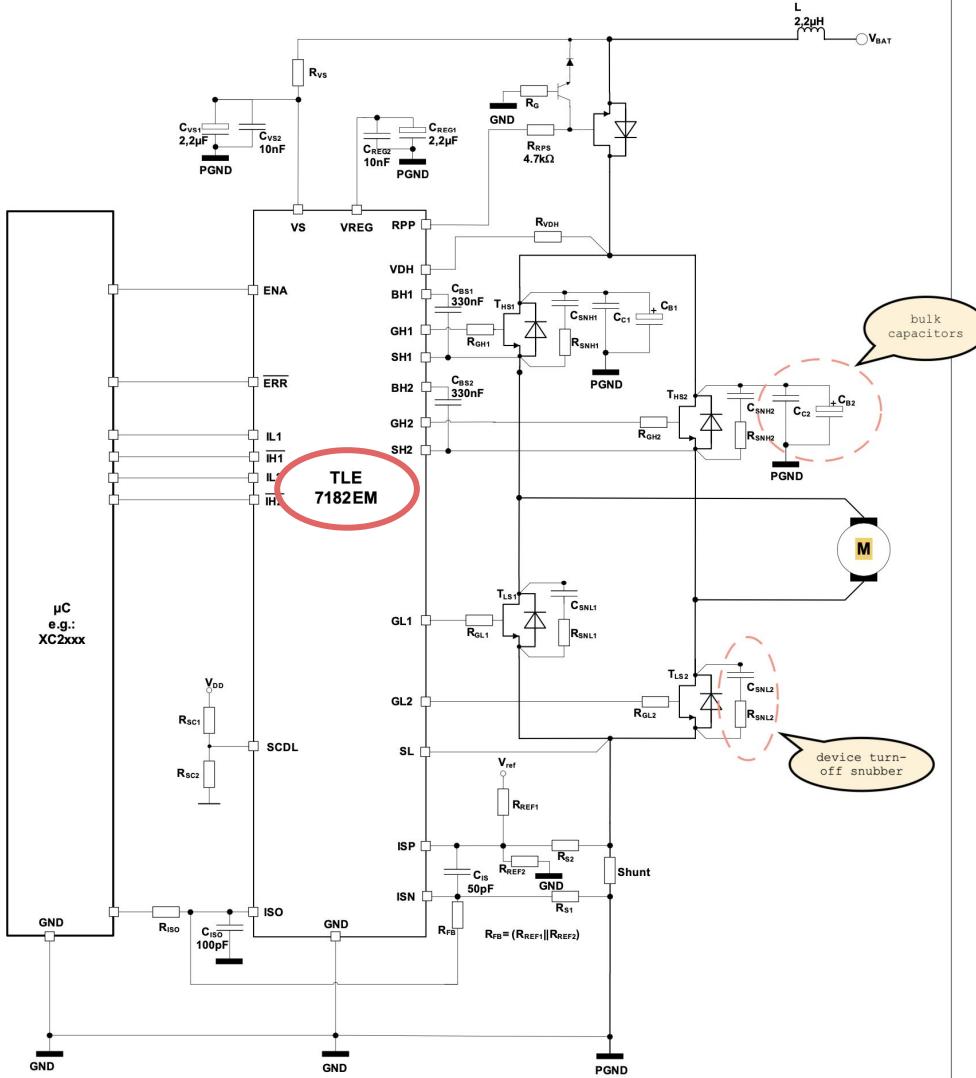


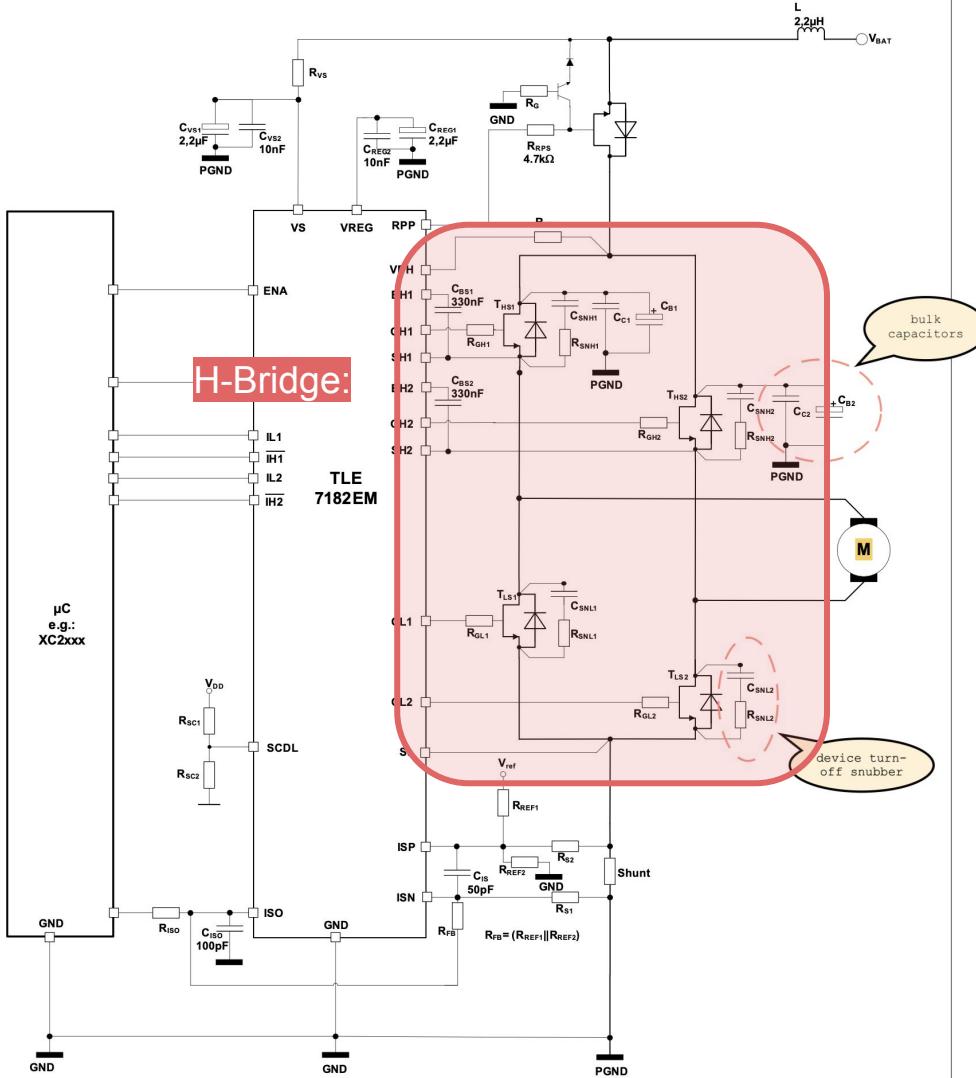




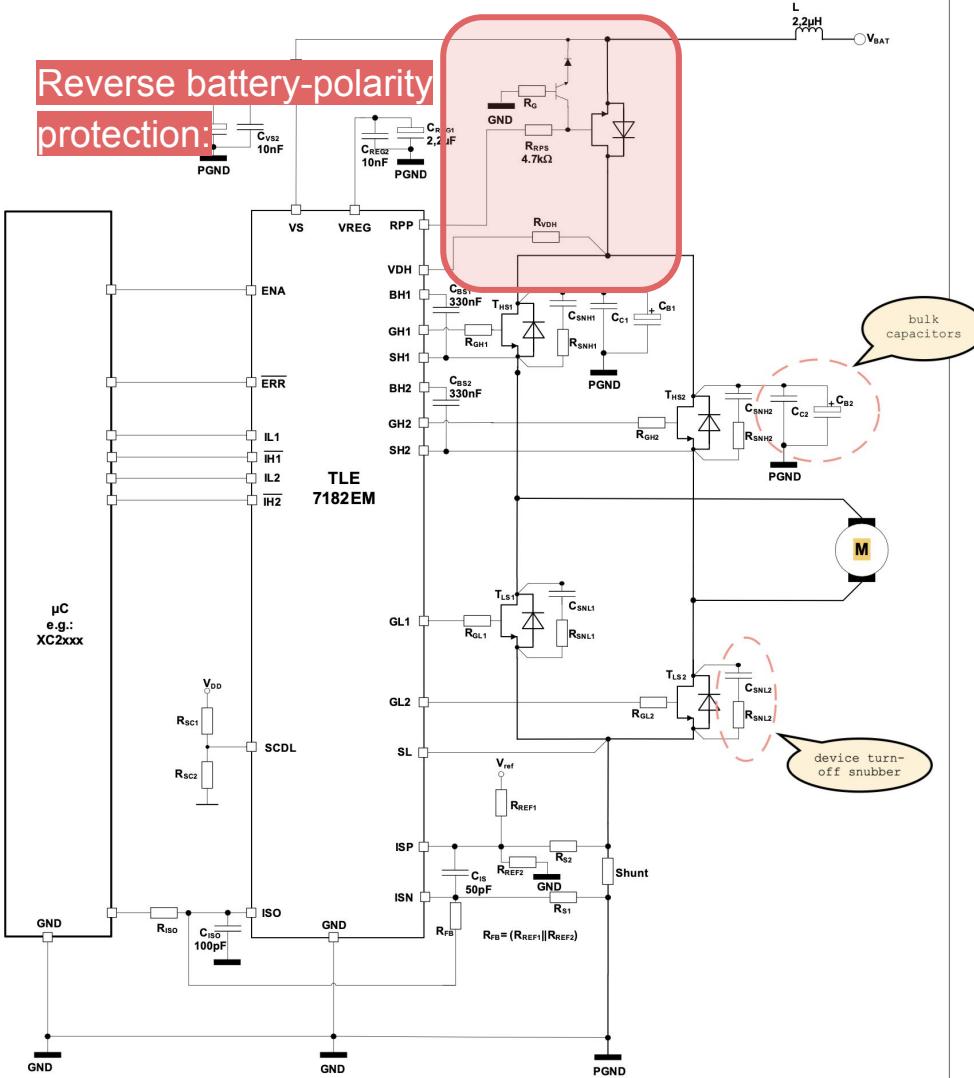
***Discussed later**

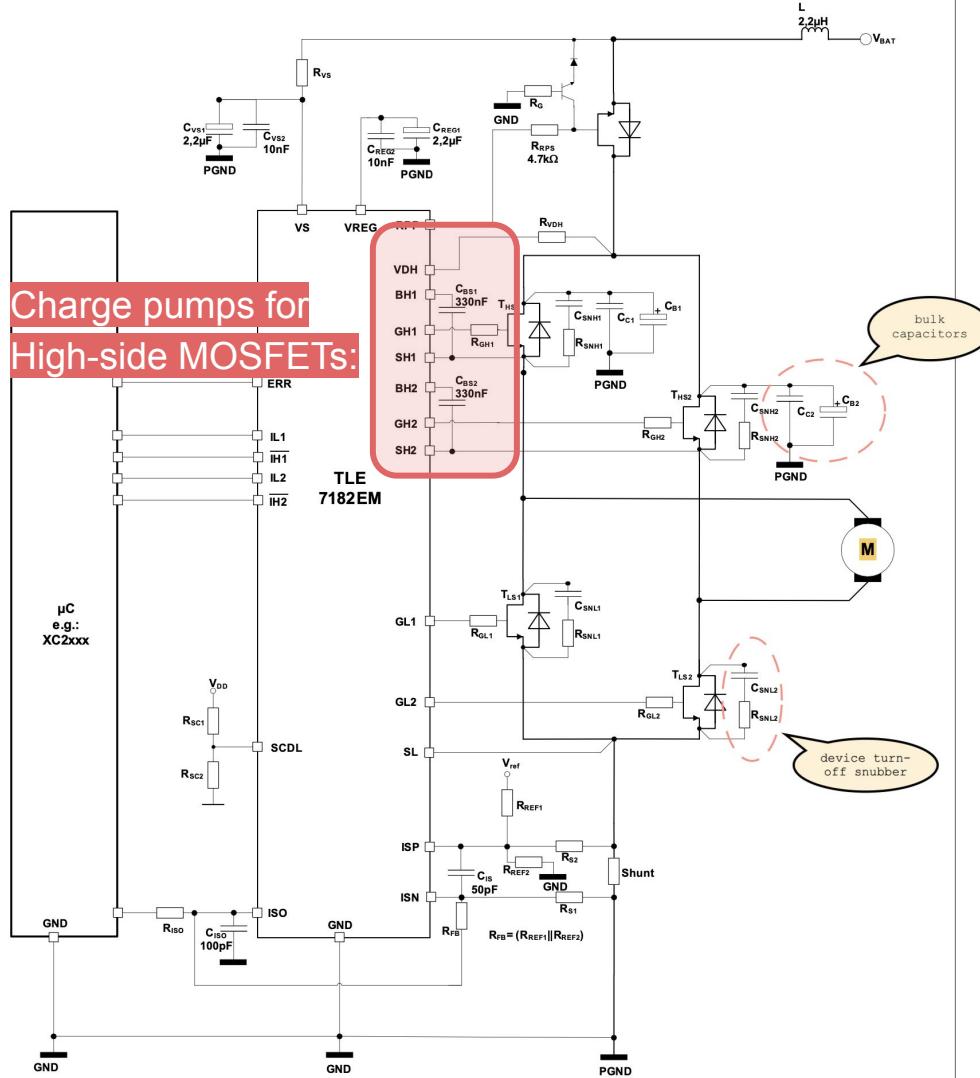


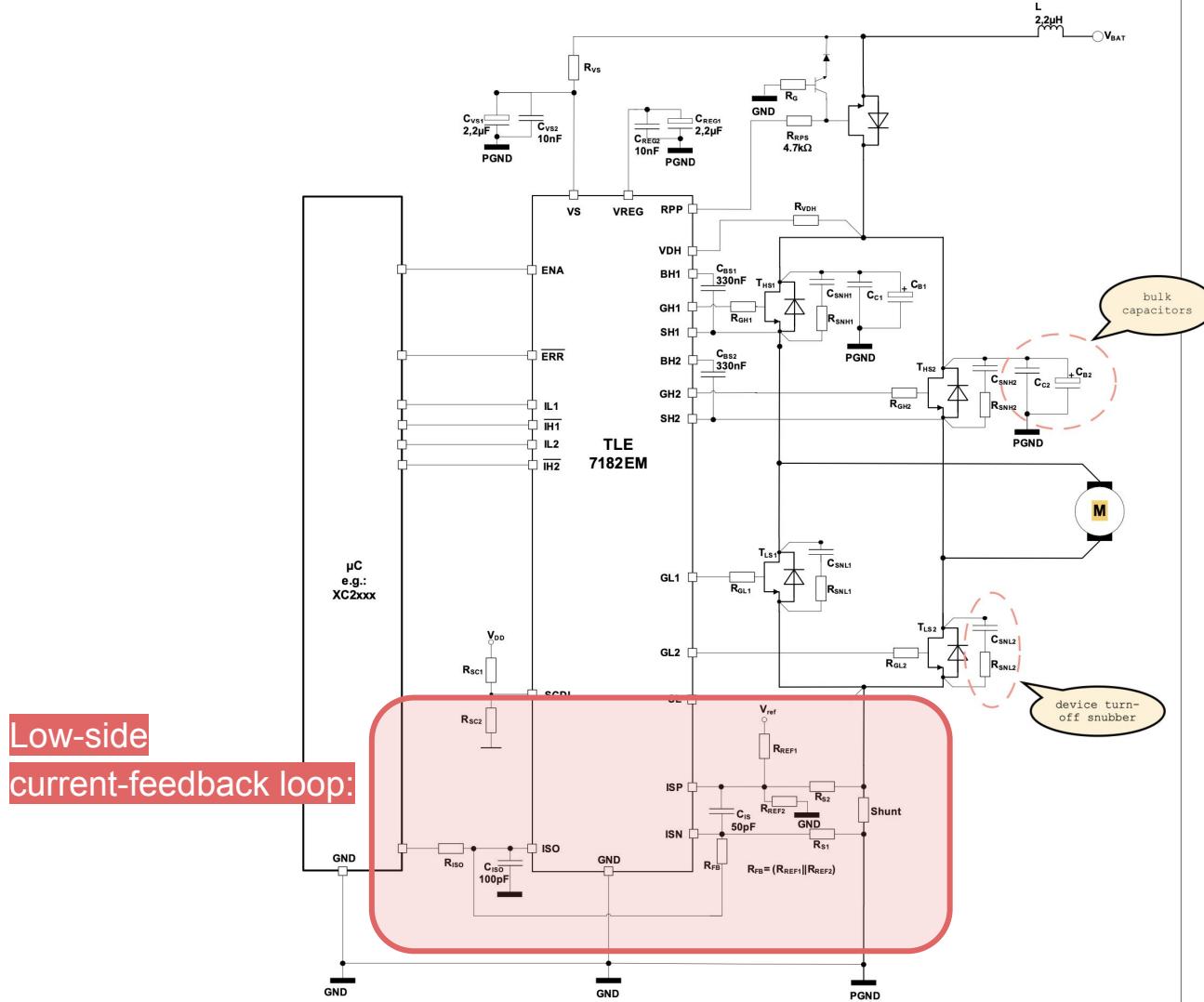


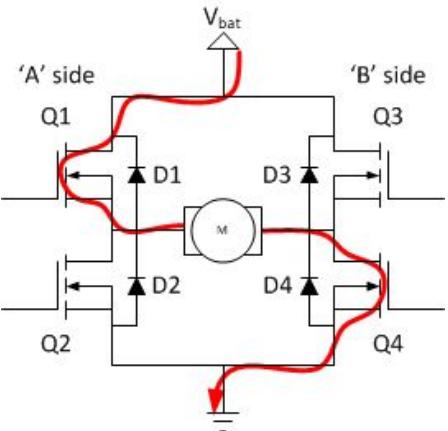


Reverse battery-polarity protection:

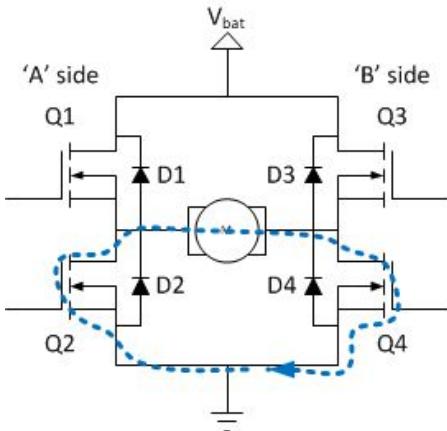






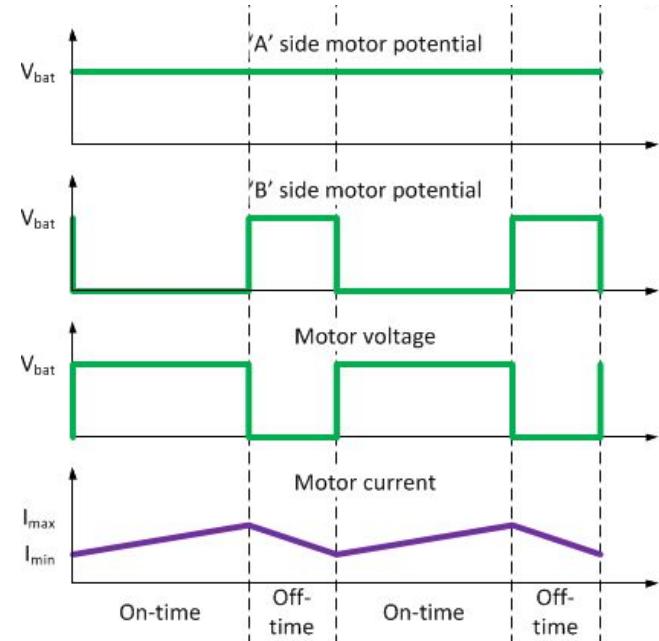


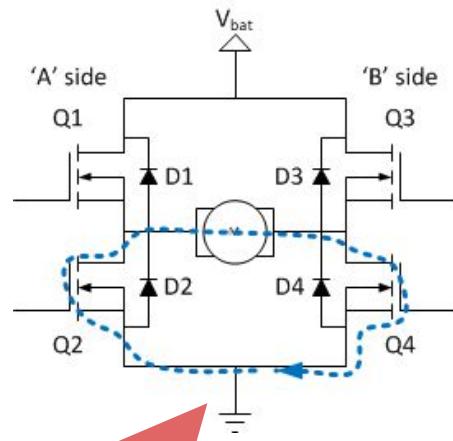
Above: "ON"/forward



Above: "slow-decay"

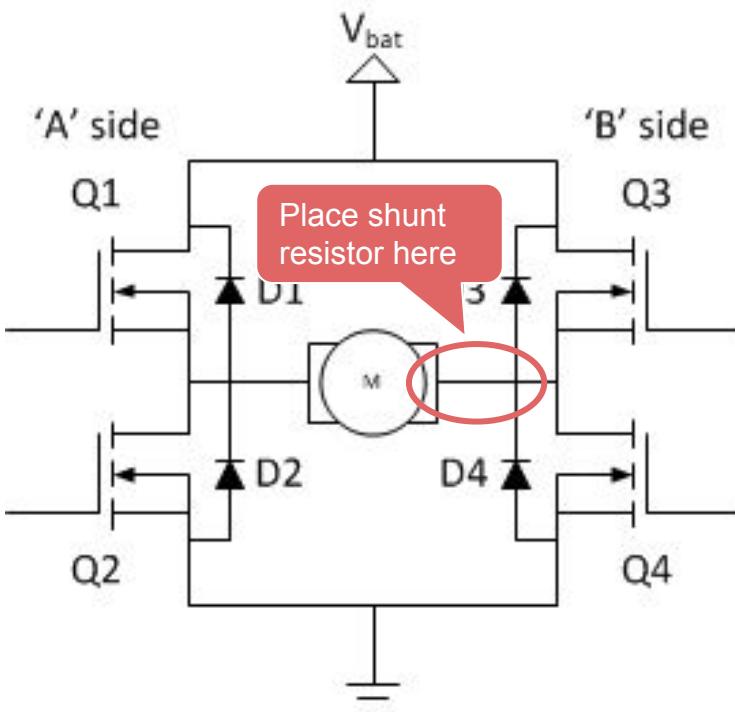
- "ON" period
- "OFF" period

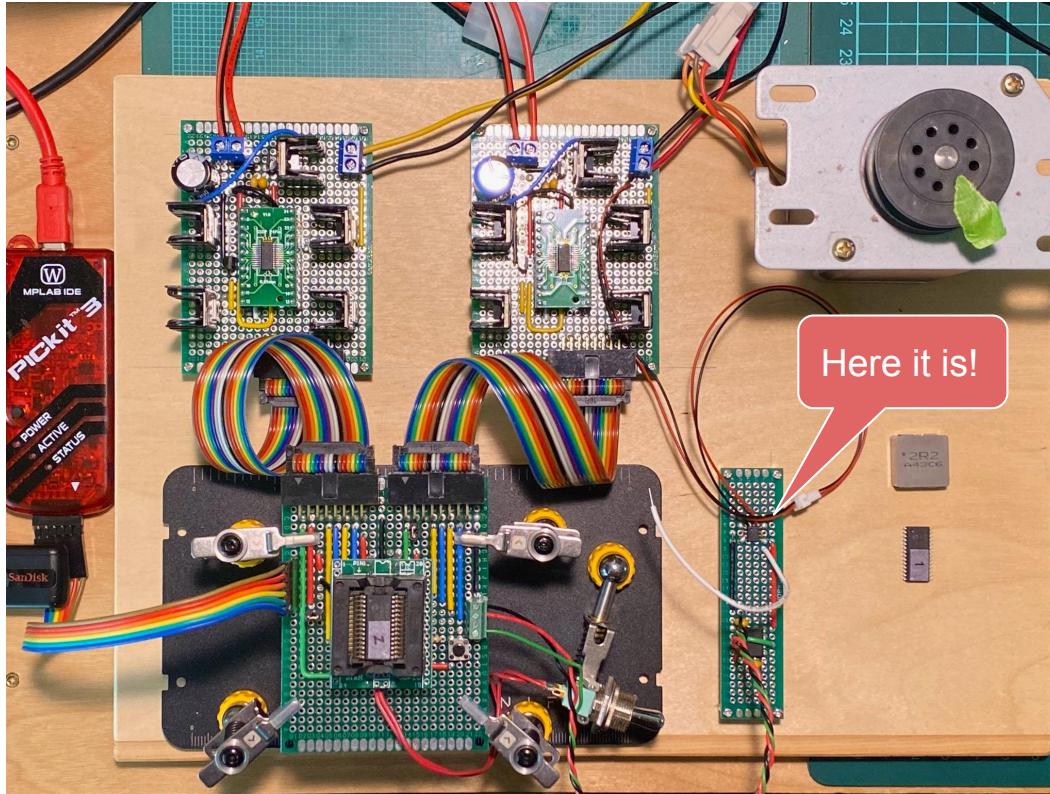




Current does not flow through
low-side shunt during off cycle

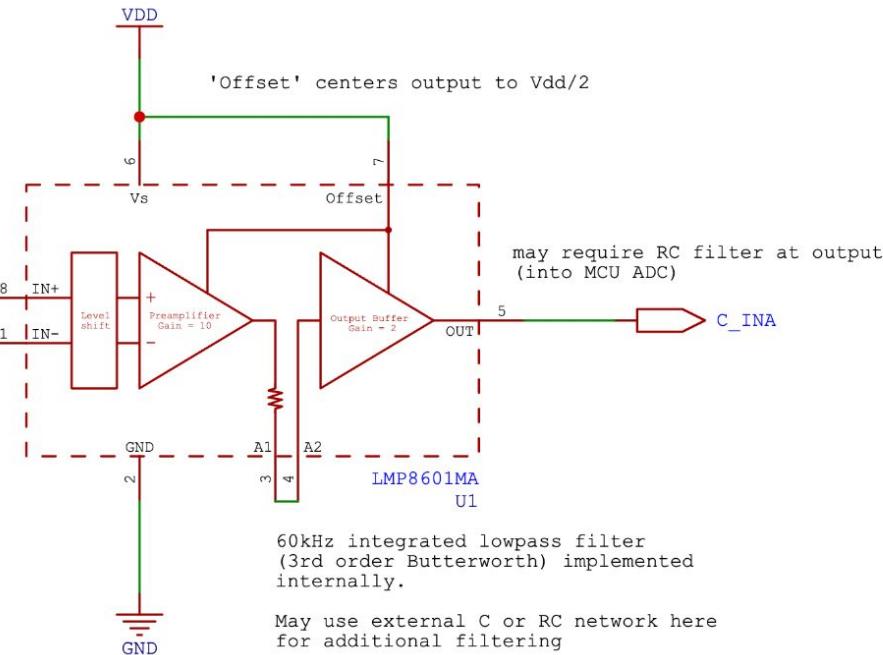
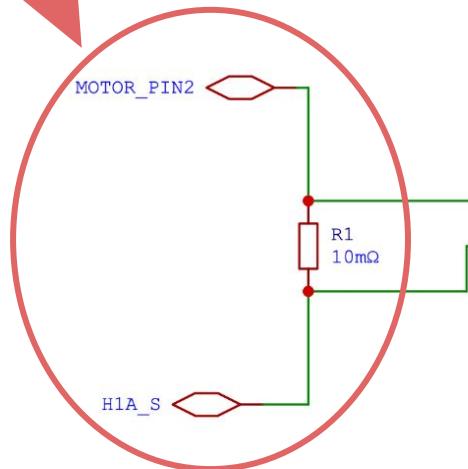


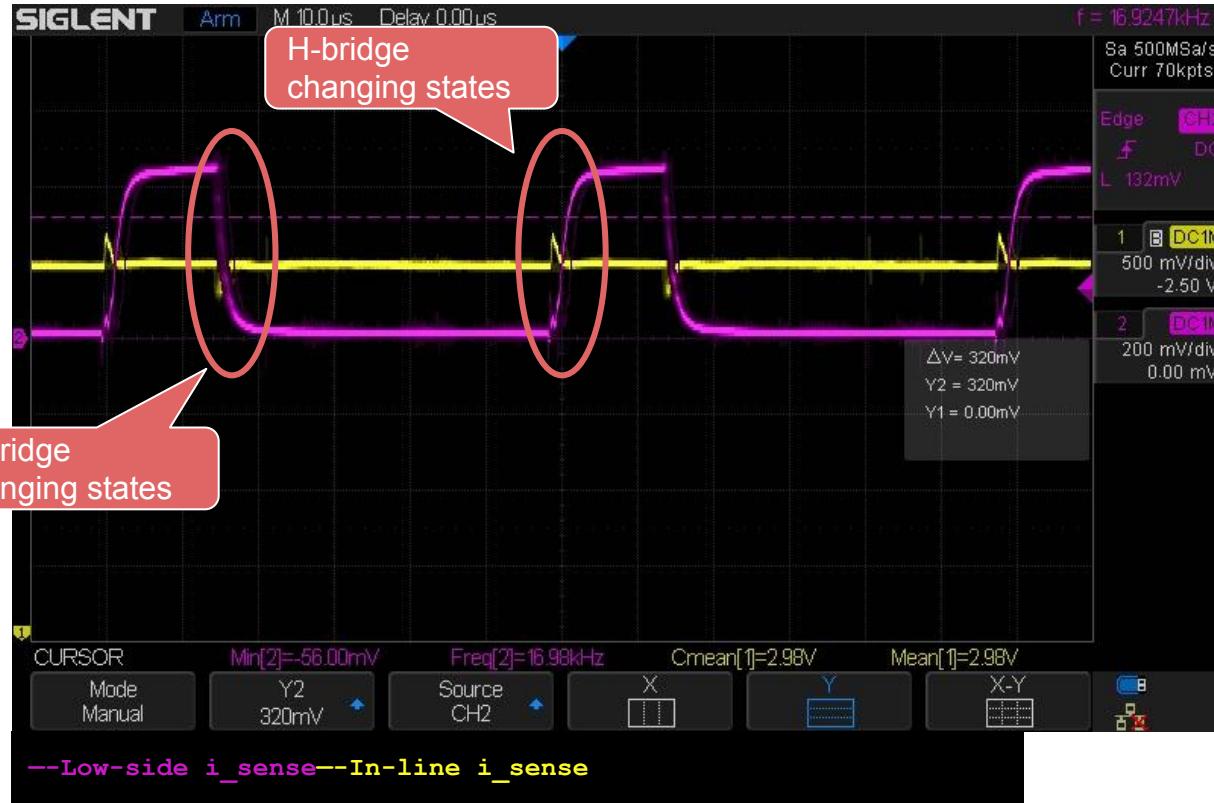


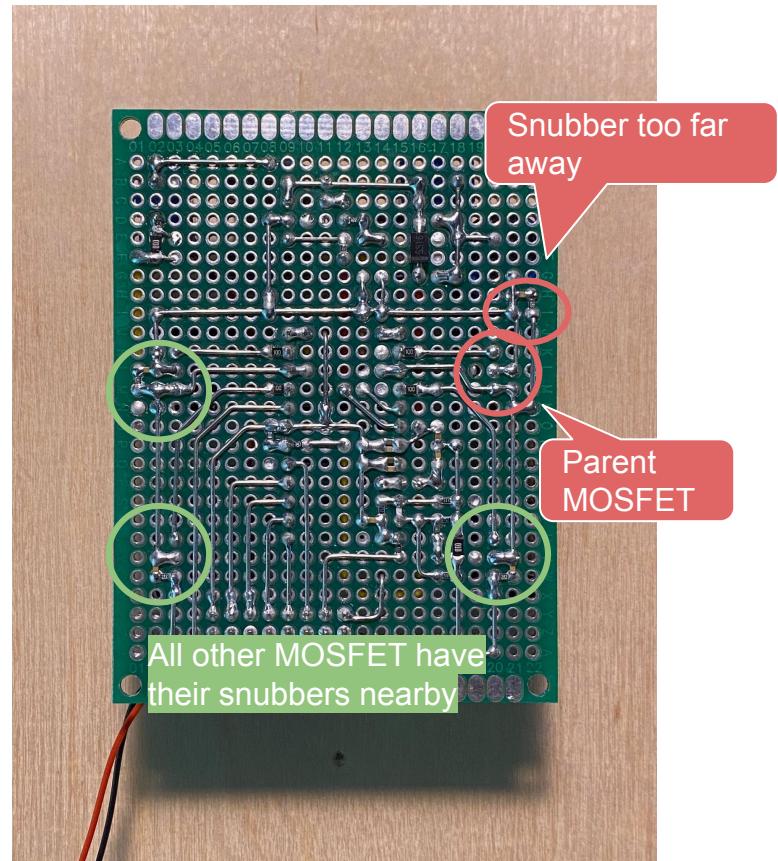
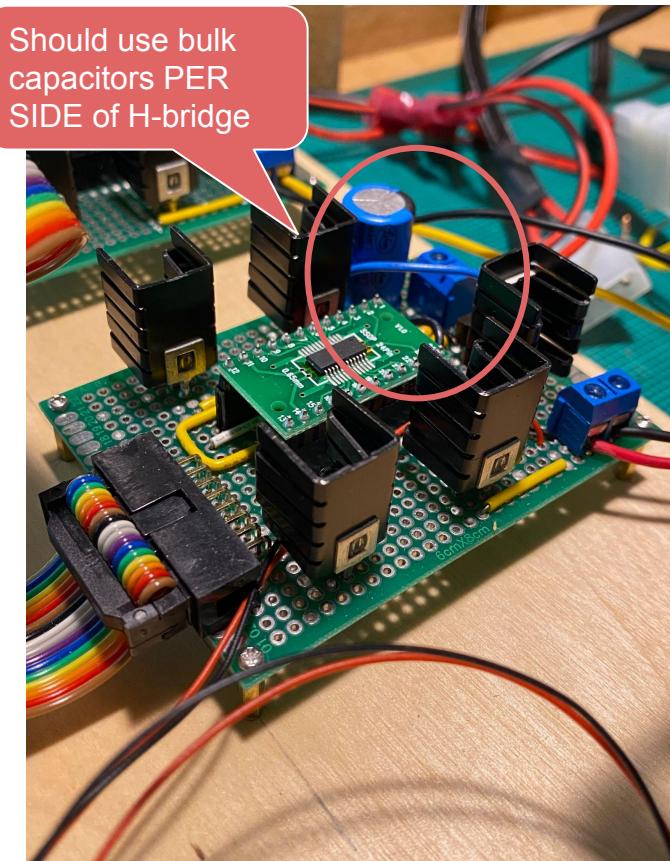


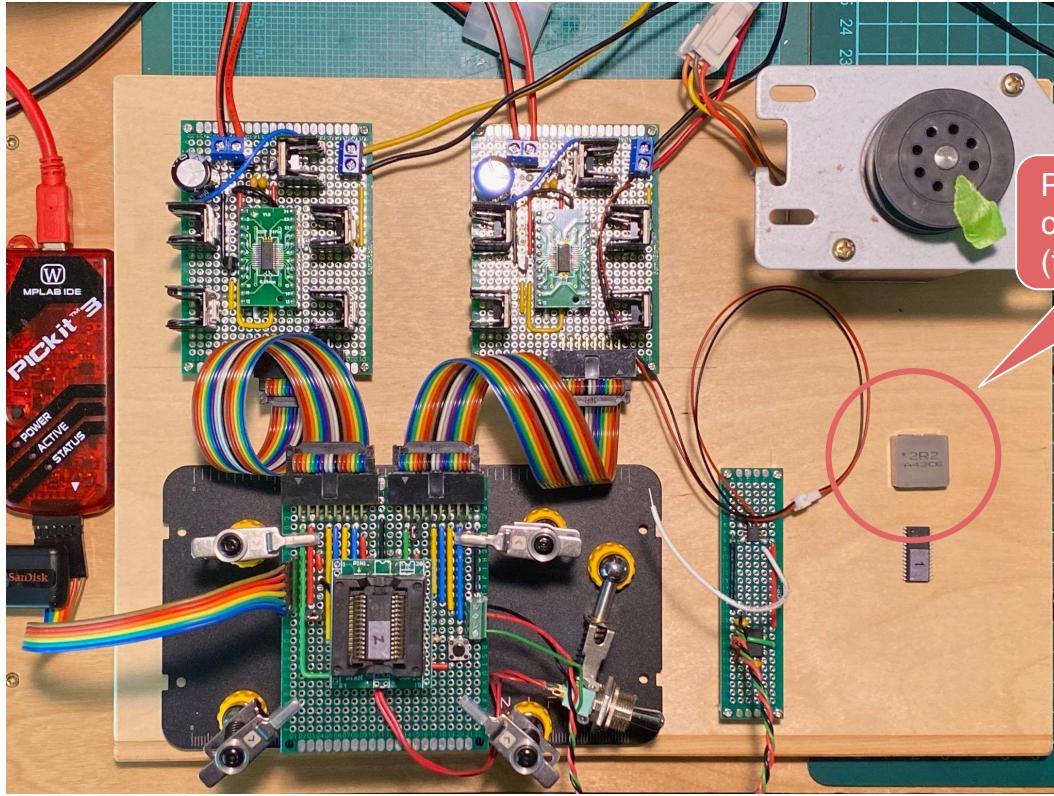
Here it is!

In-line shunt placement





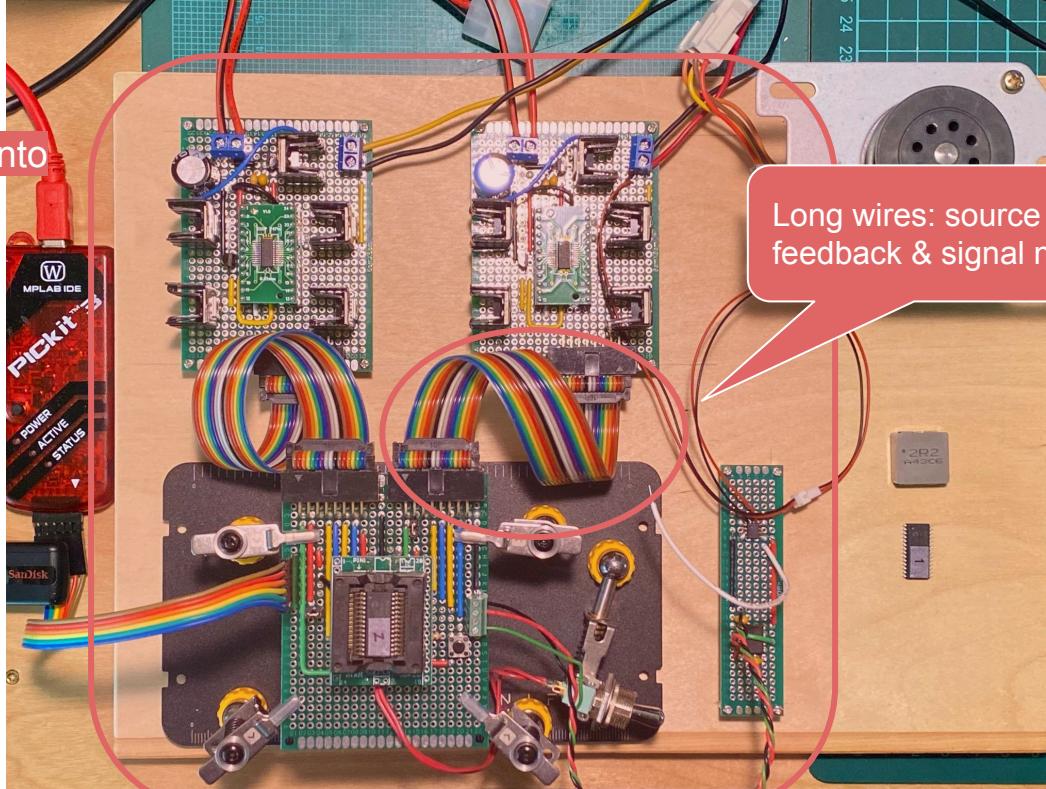


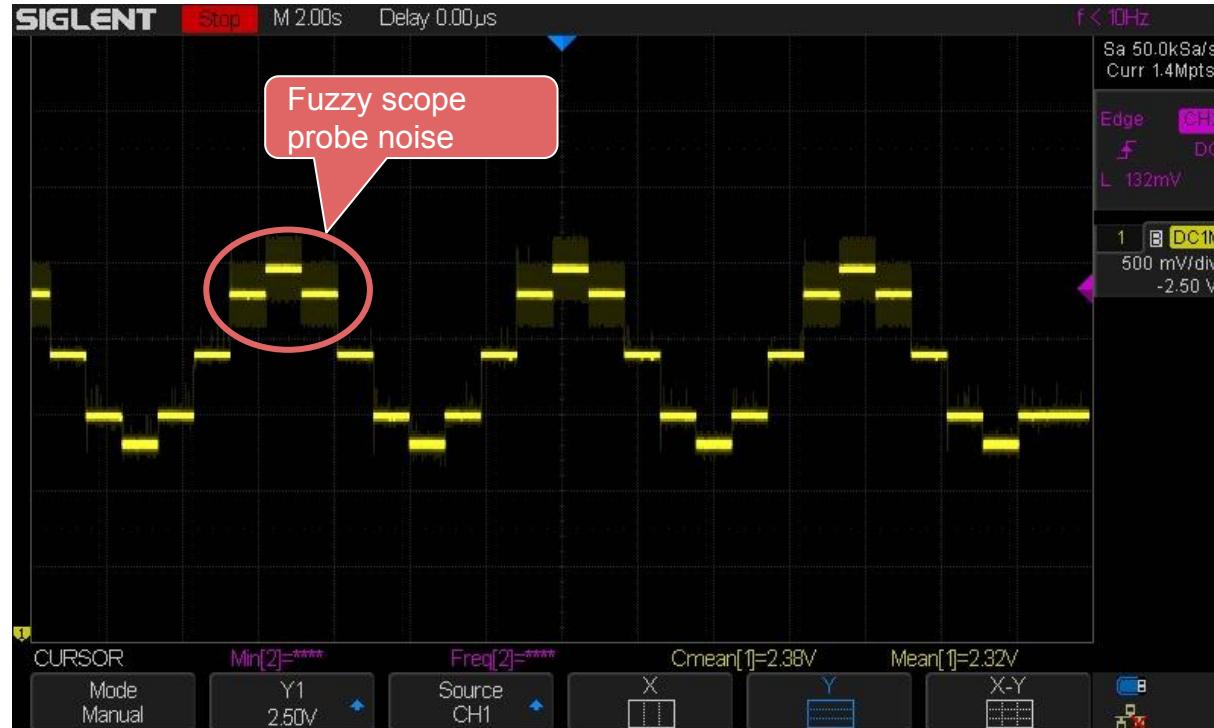


Power inductor not
currently in-use
(too large)

Consolidate into
one board!

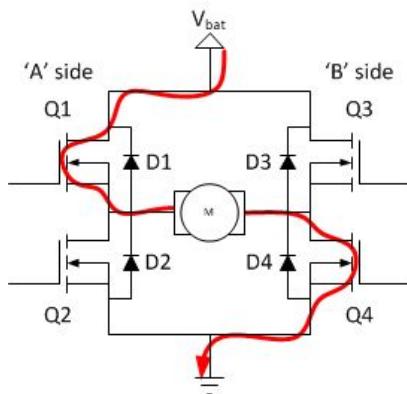
Long wires: source of
feedback & signal noise!



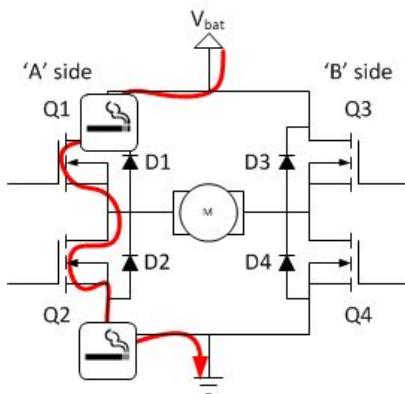


--Imotor



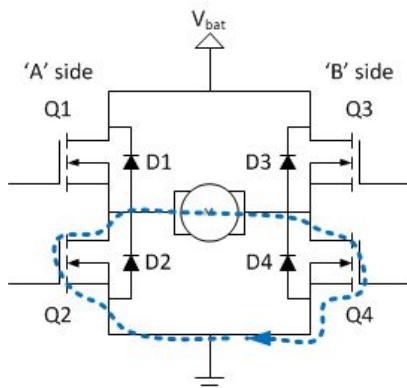


Above: "ON"/forward

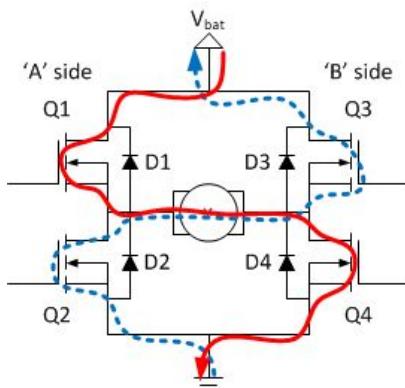


→ "ON" period
→ "OFF" period

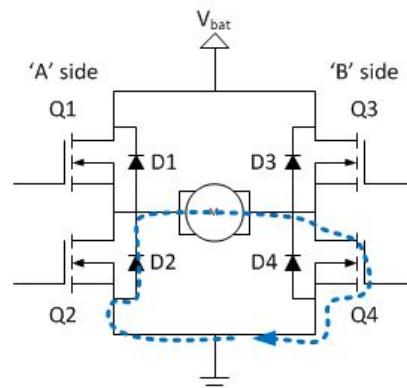
Above: "shoot-through"
-PROHIBITED



Above: "slow-decay"



Above: "fast-decay"



Above: discontinuous
current*

H-bridge: MOSFET selection

- ⑤ Calculated continuous current based on maximum allowable junction temperature. Package limitation current is 75A.

t_{gd}	Gate-to-Drain (Miller) Charge	—	—	ns	$V_{GS} = 10V, S_6$
$t_{d(on)}$	Turn-On Delay Time	—	14	—	$V_{DD} = 28V$
t_r	Rise Time	—	101	—	$I_D = 62A$
$t_{d(off)}$	Turn-Off Delay Time	—	50	—	$R_G = 4.5\Omega$
t_f	Fall Time	—	65	—	$V_{GS} = 10V, S_6$

Source: IRF3205 datasheet

Note: switching time << motor tau

MOSFET driver output

5.1.11	Output source resistance	R_{Sou}	2	—	13.5	Ω	$I_{Load} = -20mA$
5.1.12	Output sink resistance	R_{Sink}	2	—	9.0	Ω	$I_{Load} = 20mA$

Source: TLE7182EM datasheet

Remark: MOSFET switch time dominated by driver limitations

Design Deep Dive: MOSFET selection

- Given $V_{DD} = 24V$, $Motor_R = 0.387\Omega$
 - I_{max} (steady state) = **62A**
- Operating at such high voltages reduces rise time T_{rise} from **12.4ms** → **0.2ms**
 - However, faulty operation could lead to very high currents!

⑤ Calculated continuous current based on maximum allowable junction temperature. Package limitation current is 75A.

t_{gd}	Gate-to-Drain (Miller) Charge	ns	$V_{GS} = 10V$, St
$t_{d(on)}$	Turn-On Delay Time	14	
t_r	Rise Time	101	
$t_{d(off)}$	Turn-Off Delay Time	50	
t_f	Fall Time	65	

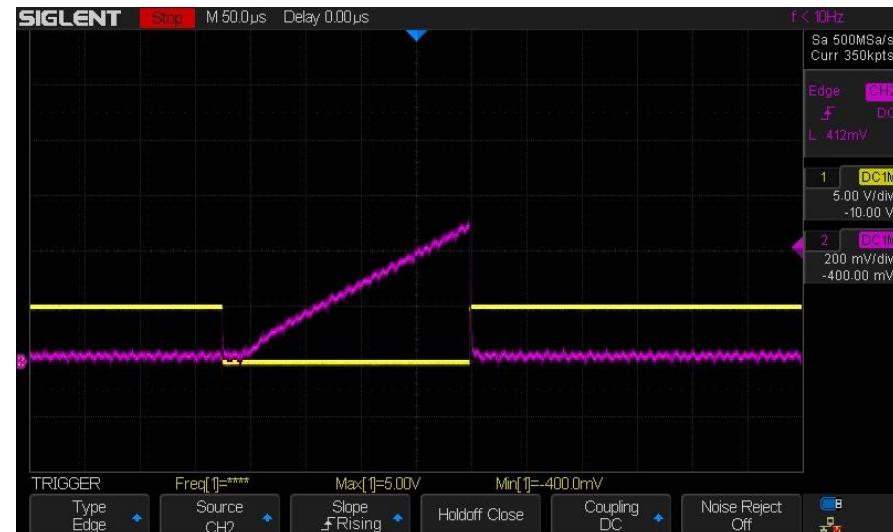
$V_{DD} = 28V$
 $I_D = 62A$
 $R_G = 4.5\Omega$
 $V_{GS} = 10V$, St

Above: from IRF3205 datasheet

Note: switching time << motor tau

MOSFET driver output

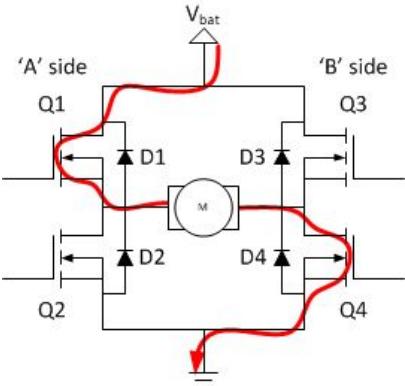
5.1.11	Output source resistance	R_{Sou}	2	-	13.5	Ω	$I_{Load} = -20mA$
5.1.12	Output sink resistance	R_{Sink}	2	-	9.0	Ω	$I_{Load} = 20mA$



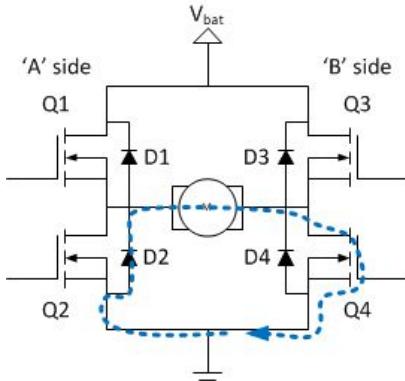
--Motor current, $V_{DD} = 24V$

Left: from TLE7182EM datasheet

Remark: MOSFET switch time dominated by driver limitations

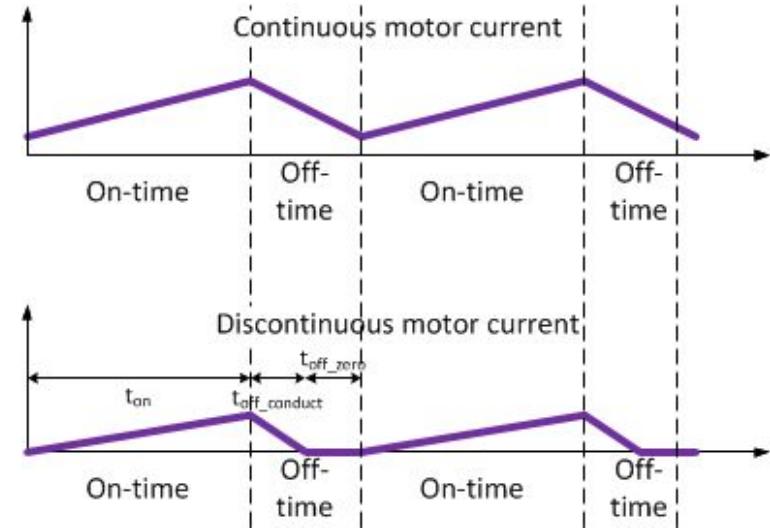


Above: "ON"/forward



Above: discontinuous current flow

- "ON" period
- "OFF" period



Above: because of the body diode, motor current is prevented from reversing