Coil Driver Kit

Version 2.0

For batch 2011-09

Read at least this paragraph!
The signal side of this kit is common-anode!
If you feed this board 12V, you’ll find that the signal components are all between +12V and +7V, ground has nothing to do with it.

Parts List

Qty	Part Description	Package	Distinguishing Features / Marking				
1	600v N-Channel IGBT	TO220					
2	Signal Transistor BC327	TO92	Bent leads, Marked 'BC 7-25' (Printing Error?)				
1	12R Resistor		Brown	Red	Black	Gold	Brown
5	620R Resistor		Blue	Red	Black	Black	Brown
4	10K Resistor						
1	100K Resistor						
2	2R2 Power Resistor	Large Ceramic	Large white resistor printed with '10W 2R2J'				
1	0.22uF Capacitor	MKT					
1	63v 1uF Capacitor	Electrolytic					
1	16v 4700uF Capacitor	Electrolytic					
1	15v Zener Diode	DO-35	Little red signal diode.				
5	75v Zener Diode	017AA	The biggest diodes in the box!				
1	1N5819 Schottky Diode						
2	50K Cermet Trimpot						
1	MCP6542 Dual Comparator	DIP-8					
1	4N35 Opto-Isolator	DIP-6					
1	79L05 -5v Linear Regulator	TO-92					
2	Fuse Clips						
1	10A Fuse						
1	2.54mm Shunt						
1	40x1 2.54mm Breakaway Pin Header						
2	2 Contact PCB Mount Screw Terminal						
1	TO-220 Heatsink						
1	M3 Bolt						
1	M3 Nut						
1	Red LED	3mm	Diffused Red Lens				
1	Blue LED	3mm	Waterclear Lens				

Assembly Instructions

Install the components starting with the lowest-profile parts first to aid in keeping things flush when soldering.
Important Notes

- **You must** install the 15v gate protection Zener diode before installing the IGBT to prevent damage from ESD.
- Install the heat-sink flush with the board and before the IGBT, otherwise your bolt holes may not line up.

How it works

Yes, how it works is before the operating instructions.

The coil driver kit basically has three modules to it; The oscillator, the gate driver and the high power stuff.
In version 1.2, we used a 555 timer - we got rid of that. The problem was that while you could control both the frequency and the pulse width, the controls weren't truly orthogonal.
Instead, we went for a dual comparator based oscillator broken into two stages. The first stage is your basic square-wave oscillator, the second stage compares the voltage at the timing capacitor to an arbitrary threshold, giving you PWM control. The control isn't quite linear (exponential charge curve) but it doesn't affect the frequency.

The chip we chose is the MCP6542 from microchip, two push-pull comparators in a DIP8 (no, it's not a PIC, no the 6 pin jumper is not an ISP header. besides, PIC uses "ICSP" and it's six in line.)

The PWM signal is fed into the the gate-drive system.
The gate drive system is a push-pull pair of NPN transistors, one in common collector, the other in common emitter.

The power components were added more out of a fear of magic blue smoke than anything else, so I'll go into a bit of detail as to why we installed them, and how they help.

Zener Diodes:
Most FETs have what's called an avalanche breakdown mode (some IGBTs do not). The avalanche breakdown mode acts as a high valued zener diode and can soak-up the energy from an inductive spike.
Data-sheets for FETs usually have a "one shot avalanche breakdown energy" and this value isn't big, especially if the FET is already under load.

The dirty great bank of zener diodes can chew up 25W of inductive spikes and still be in-spec. This allows the transistor to get on with shunting current regardless of the size of the inductive spikes. (if you can get more than 25W of repeated inductive kickback, I want to hear about it, it sounds cool)

Ceramic Resistors:
The resistors limit the current passing through the system and can burn heaps of power for a short period of time.
The advantage here is that when something goes wrong with your hackery, instead of just exploding, it takes a few seconds for something to catch fire.
The resistors are rated to 10W each (20W 1.1ohm combined). Being wire-wound ceramic resistors, the failure point is up around the point where the solder-mask burns away and the FR4 circuit board catches fire. There's also a lot of thermal mass in these components so they don't break quickly.

Fuse:
Why not?
The fuse is on the positive supply input. It says "10A Slow", but you know better.
The 10A fuse shouldn't blow under normal circumstances (normal isn't what it's there for)
If you want it to snuff sooner, use a smaller fuse.

We designed this thing initially to drive ignition coils. It soon became a power component playground.
All of the power components beyond the transistor are safety nets and are not required.
In some cases, you may want to bypass the resistors, increase the inductive spike voltage by disconnecting the zeners, replace the fuse with a nail, whatever you do with the board is up to you, just make sure you analyse the circuit and understand the signs of impending failure.

Operating Instructions

The Basics:
To use the internal oscillator, jumper the pins A and C and that’s it.
Pin C is connected to the timing capacitor, Pin A is connected to the threshold comparator.

The opto-coupler lets you connect a signal from another system without making an electrical connection. The opto-coupler is quite slow so don’t expect accurate timing past about 20KHz. To use the opto-coupler, place the jumper over pins A and D, and connect your signal at the opto-coupler.
Pin D is connected to the opto-coupled signal.

Fiddly Bits:
Changing the frequency range:
After fiddling around with this kit for a while, you’ll notice that the lowest frequency is about 100Hz, and the resolution up the top-end is pretty poor.
The frequency is determined by the RC delay between the frequency pot and the timing capacitor (and some other constants with logs and stuff). If you increase the capacitance, the frequency goes down. If you reduce the capacitance, the frequency goes up.
We’ve found that 22nF makes for a range appropriate to an ignition coil (This is what is supplied in the kit), 1nF can push past human hearing.

Using an analogue waveform to modulate the pulse width:
The pulse width pot has three pins broken out to headers, +5V and signal-ground (+12V and +7V)
Setting the pot to some mid point gives you roughly 25K ohms to either rail, connecting an analogue signal here is completely valid. This gives you control over the threshold the PWM is generated with.
Keep your ground conflicts in mind here!

Using the threshold comparator alone:
injecting a signal across pin A and and pin B, using pin B as negative reference uses the second stage comparator bypassing the internal oscillator. This still uses the PWM trimpot as the threshold.
Again, watch out for ground conflicts!
If you want to control the state of the gate directly, use this method. The worst the comparator can do is introduce a propagation delay.

Other break-in points:
We put a header over the frequency pot letting you control the frequency from off-board, even modulate it. (you’ll need a DAC or a signal MOSFET or something)

Odd Projects:
Plasma speaker:
Using a flyback coil, a bunch of cat5, two capacitors and a coil-driver board, we made a crude plasma speaker.
We wound 15 turns of a strand of solid-core cat5 cable around the core of a flyback coil and connected it to the output of the coil-driver, changed the timing cap to 1nF, put capacitors in series with BOTH lines from a mono headphone jack and ran that across the PWM trimpot. (the capacitive or transformer coupling makes ground conflicts and DC offsets go away.)
Pushing the frequency past human hearing makes for a stable ribbon of plasma about 1cm long (and quiet), modulating the pulse width using the audio modulates the diameter of the flaming hot plasma like a speaker diaphragm.
It’s not loud, it’s horribly inefficient even for a plasma speaker, it pushes the IGBT into territory that better suits a MOSFET, but it works.