BRUSHED DC-MOTOR DRIVER KIT. DATASHEET, ASSEMBLY INSTRUCTIONS, CIRCUIT BREAKDOWN & CODE.

Overview: This kit builds a versatile and powerful driver able to control nearly all Brushed DC-Motors. The circuit board itself is 50 by 75mm in size, with a height of just over 30mm once assembled. Brushed motors are widely considered the simplest form of DC motor as they require only two connections to achieve motion, one for power and one for ground. Their simplicity means they are widely used in small scale robotics, hobby projects and other low stress environments where longevity and power efficiency are not crucial. The kit takes controlling these motors one step further, giving the user precise digital control over the motors speed and direction, all while being beginner friendly and Arduino compatible.

General Power Rating & Usage:

PARAMETER	MIN	MAX	UNITS
Operating voltage	5	18	**V**
Continuous Current	-	25	**A**
Operating Temperature	-10	100	**℃**
Output BEC voltage	4.8	5.1	**V**
Output BEC current	-	200	**mA**

- For motors that require more than **4A** of current to run, the exposed power traces should be heavily tinned, with the motor terminals connecting to the PHASEA and PHASEB breakout points on the board's underside.
- To control the speed of the motor a **5V square wave** (PWM) with a duty cycle of 0-100% must be applied to the SPD input, its frequency must be between 100 Hz and 10 kHz, with 500Hz being recommended. The reverse function is triggered by applying a logical high signal (5V) to the REV input.
- The BEC (battery eliminator circuit) also supplies 5V power to the board meaning excess current draw will impact the driver's performance
- **DO NOT TOUCH THE CIRCUIT BOARD DURING OPERATION, ESPECIALLY THE POWER STAGE.**

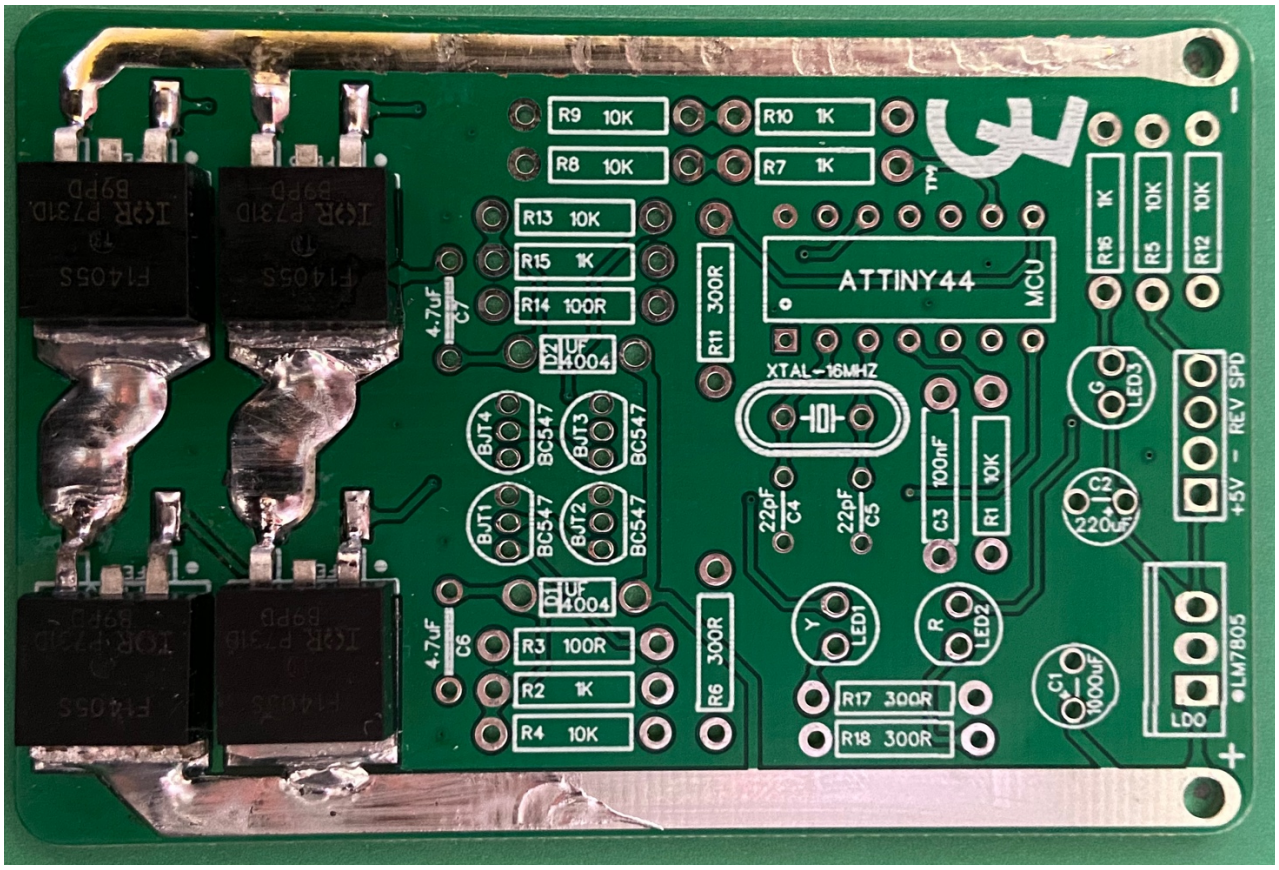
Component List/BOM:

QUANTITY	NAME	TYPE	PCB DESIGNATION
4x	IRF1405	N-Channel MOSFET	FET1, FET2, FET3, FET4
4x	BC547	NPN BJT (Transistor)	BJT1, BJT2, BJT3, BJT4
1x	Attiny44	Microcontroller	MCU
1x	XTAL	16Mhz crystal oscillator	XTAL-16MHZ
2x	UF4004	Ultrafast diode	D1, D2
2x	4.7uF	Monolithic bootstrap capacitor	C6, C7

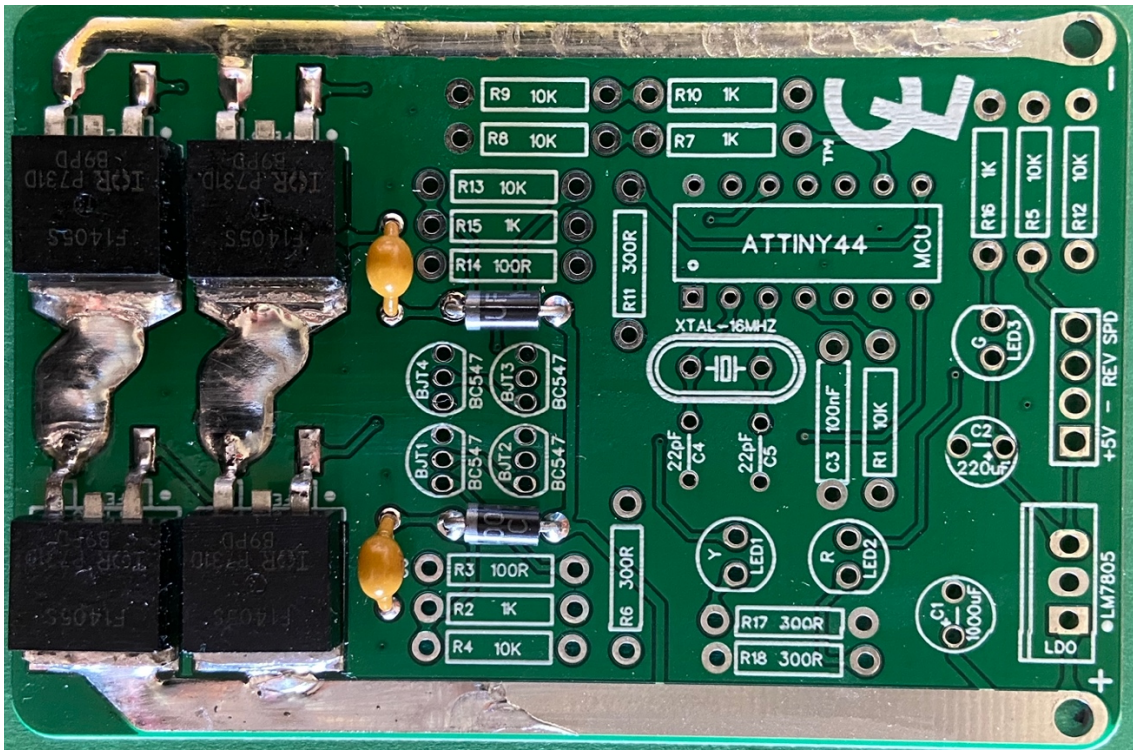
2x	22pF	Ceramic clock load capacitor	C4, C5
1x	1000uF	Electrolytic capacitor	C1
1x	220uF	Electrolytic capacitor	C2
1x	100nF	Film capacitor	C3
3x	R, G, Y	LEDs	LED1, LED2, LED3
1x	Header Pins	Row of 4 header pins	+5V, -GND, REV, SPD
1x	LM7805	5V linear voltage regulator	LDO
2x	100R (Ohm)	0.25W 1% metal film resistor	R3, R14
4x	300R (Ohm)	0.25W 1% metal film resistor	R6, R11, R17, R18
5x	1K	0.25W 1% metal film resistor	R2, R7, R10, R15, R16
7x	10K	0.25W 1% metal film resistor	R1, R4, R5, R8, R9, R12, R13

Assembly Instructions

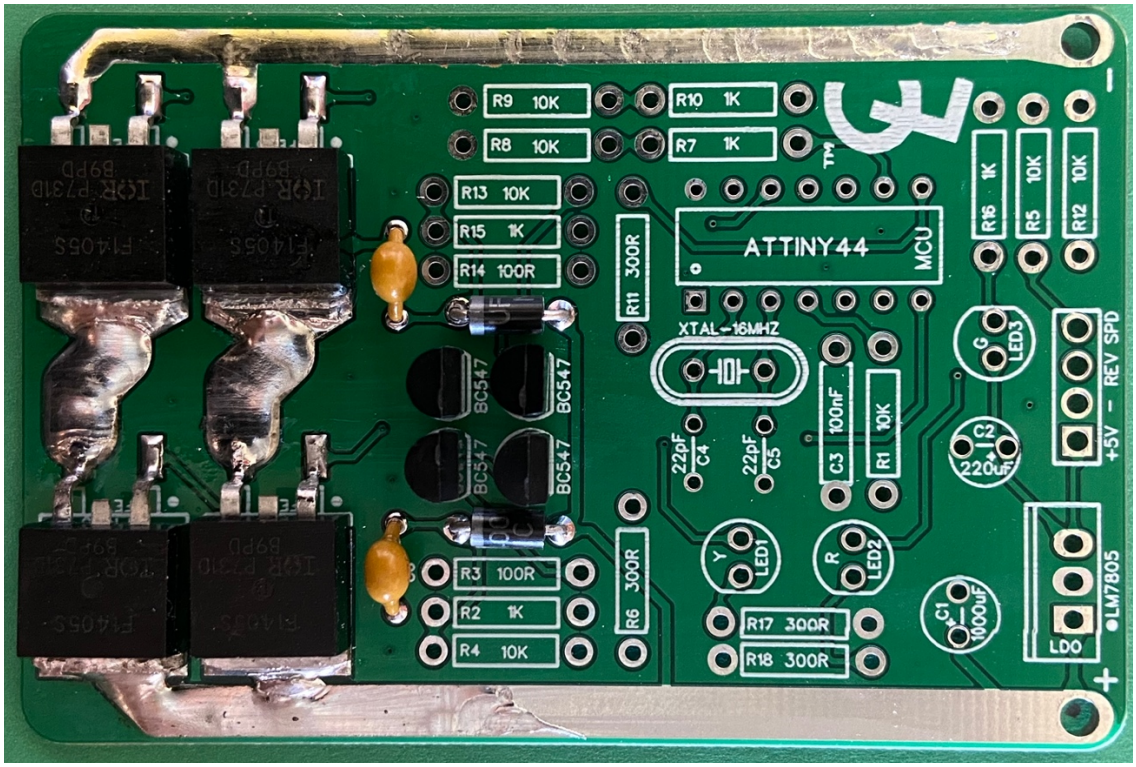
Step-1/Image-1: Solder the IRF1405 N-channel MOSFETs to the board at the spaces labelled FET1 – 4. When soldering lightly tin the large square pad before placing each component, once the MOSFET is positioned correctly use a flat head screwdriver or a thin piece of tape to hold it in place while the two small legs and the top tab are soldered down.



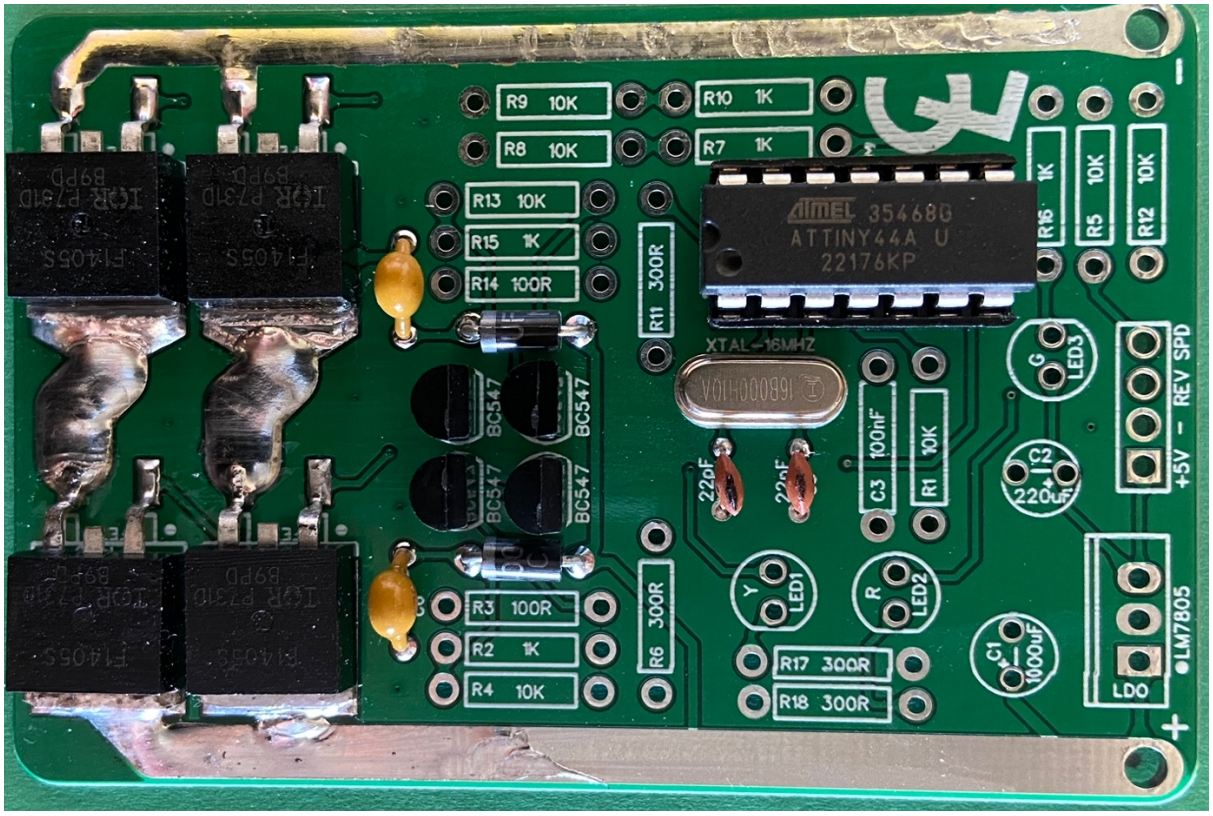
Step-2/Image-2: Solder the UF4004 ultrafast bootstrap diodes to the board at labels D1 and D2, *lining up the grey stripe with the silkscreens outline as diodes are polarised*. Then solder the 4.7uF monolithic ceramic bootstrap capacitors to the board at labels C6 and C7. These connections can be made on either side of the board, but the underside is recommended, *trim the excess legs when done.*



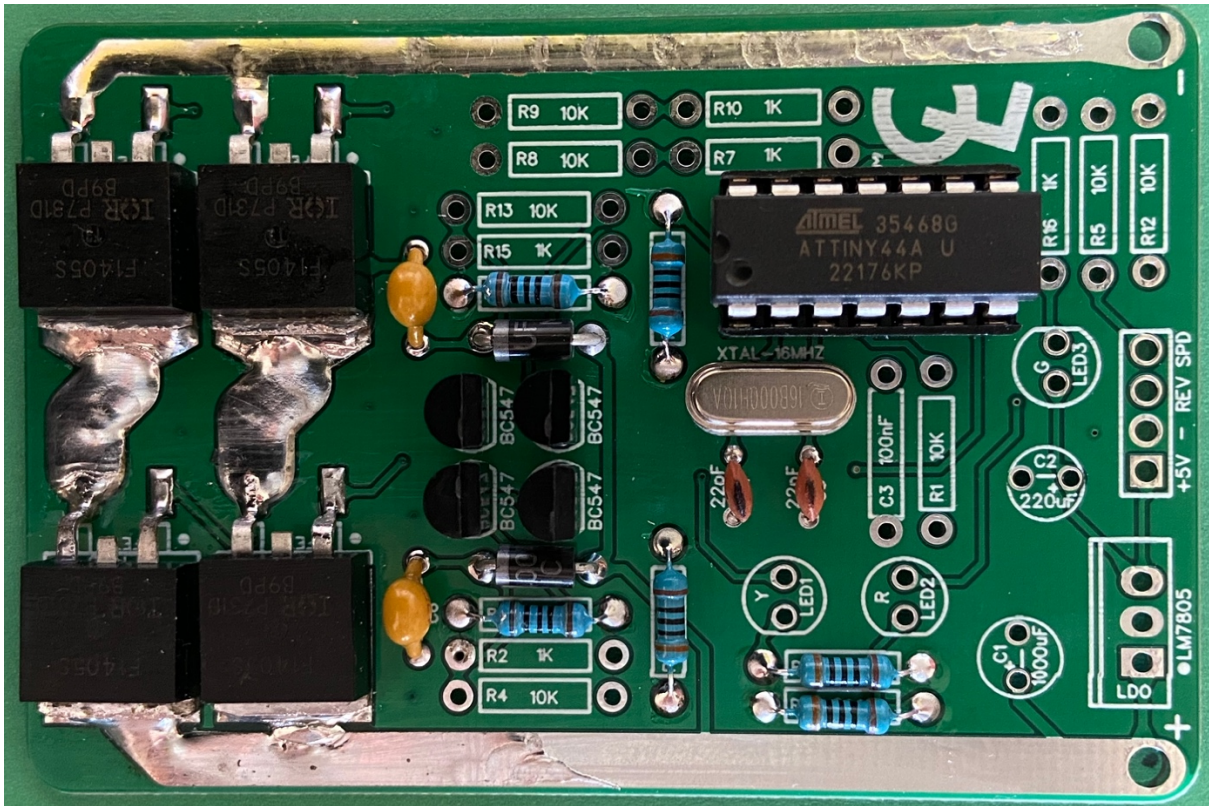
Step-3/Image-3: Solder the BC547 NPN, Bipolar Junction Transistors to the board at spaces BJT1 – 4. Spread the legs out slightly and place the components into each space with roughly a 3mm gap between them and the boards surface. *Make sure the BJTs flat edge aligns with the flat edge on the board's silkscreen as these devices must not be placed backward*. Bend the legs to stop the BJTs from falling out and solder on the underside, trimming excess legs when finished.



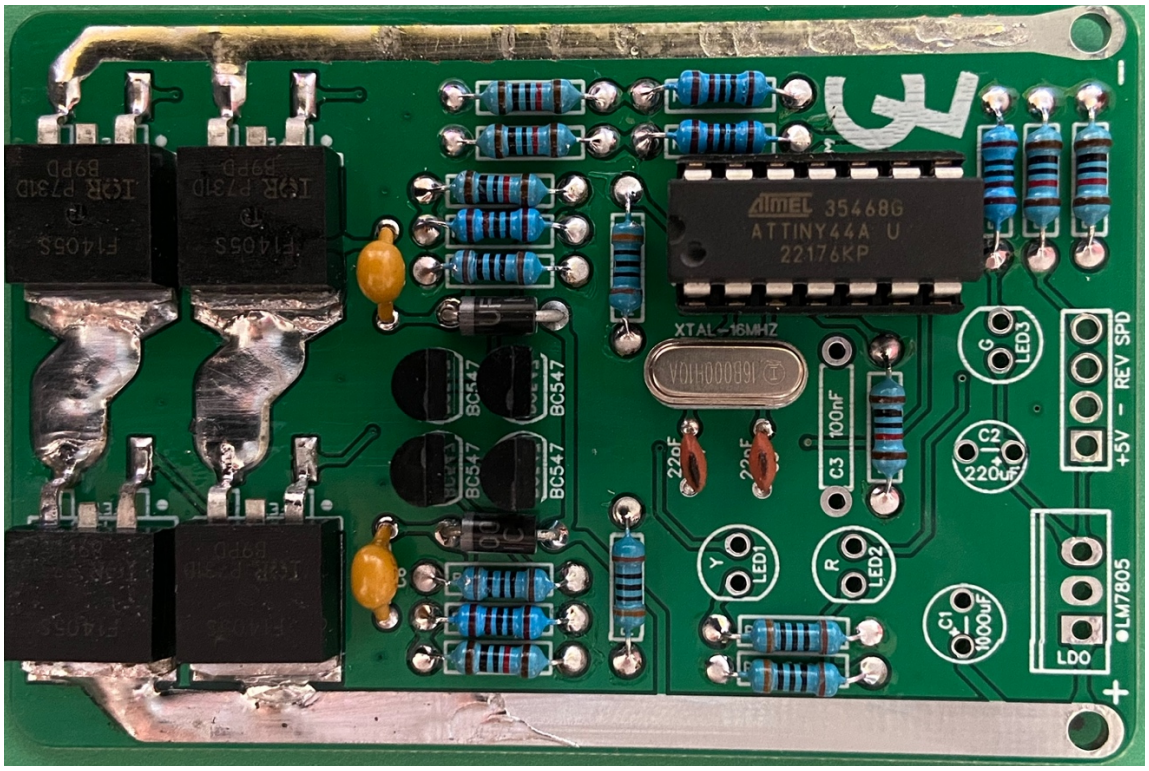
Step-4/Image-4: Solder the Attiny44 *or a dip14 socket* to the space labelled MCU, followed by the 16Mhz oscillator to label XTAL-16MHZ and the 22pF capacitors to spaces C4 and C5. These connections must all be made on the underside of the board so hold the components in place with tape while soldering.



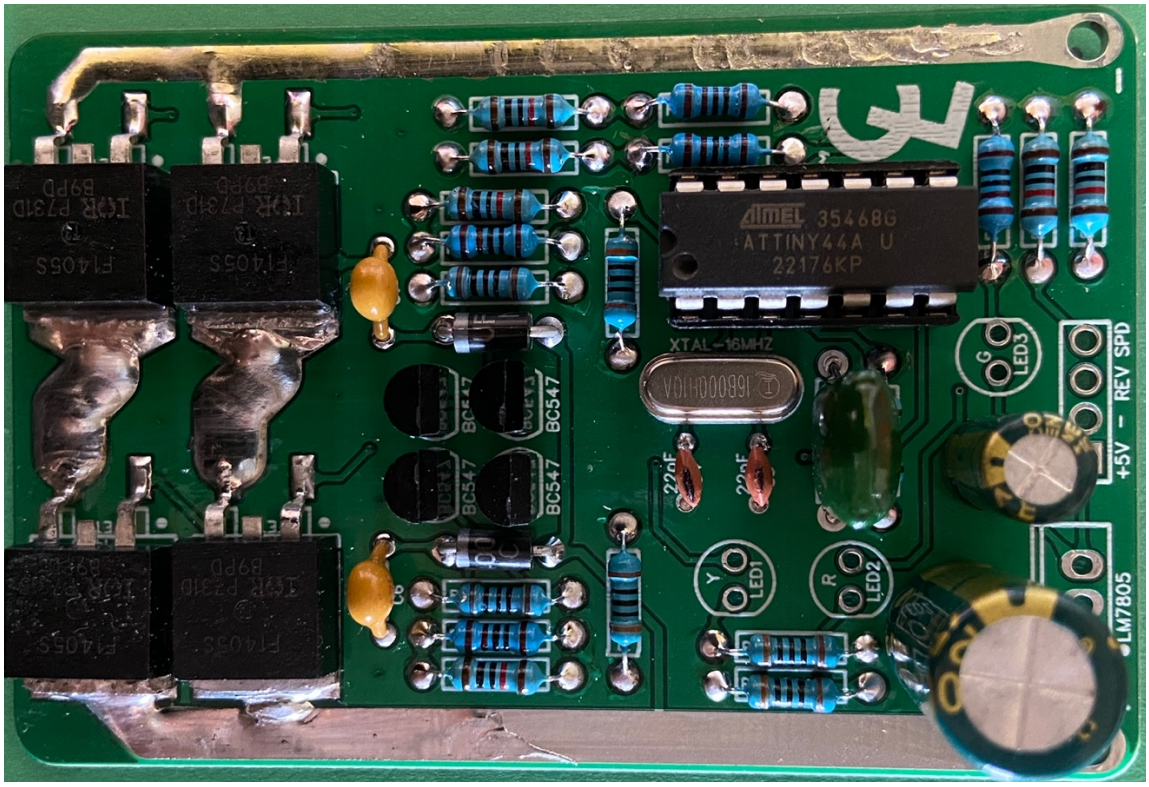
Step-5/Image-5: Solder the 100R (R = Ohm) resistors to the board at labels R3 and R14. Then solder the 300R resistors to the board at labels R6, R11, R17 and R18. Place the resistors as shown below, solder one end and then check that the resistor is still well positioned, if it is, solder the other end and then repeat. When all the solder connections are made, carefully cut off the extra resistor legs from the board's underside.



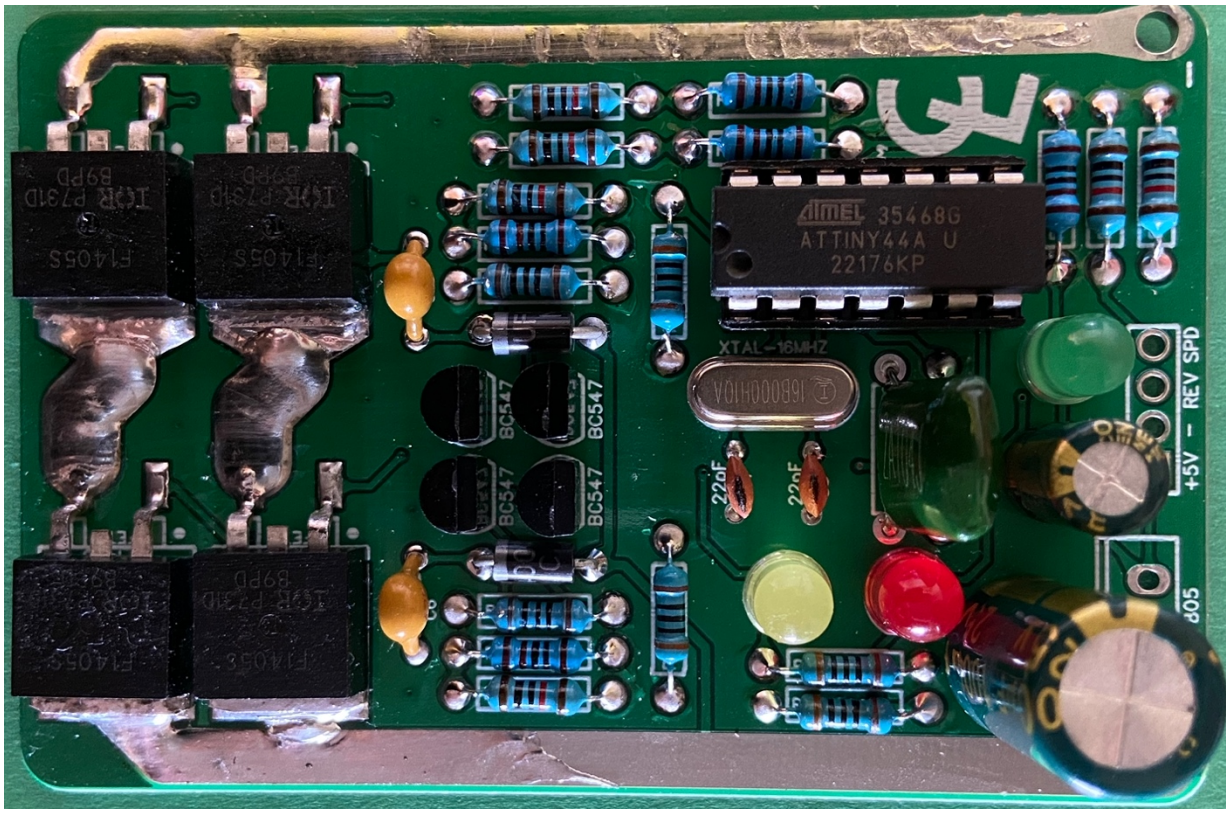
Step-6/Image-6: Solder the 1K Ohm resistors to the board at labels R2, R7, R10, R15 and R16. Then solder the 10K Ohm resistors to the board at labels R1, R4, R5, R8, R9, R12 and R13. Place the resistors as shown below, solder one end and then check that the resistor is still well positioned, if it is, solder the other end and then repeat. When all the solder connections are made, carefully cut off the extra resistor legs from the board's underside.



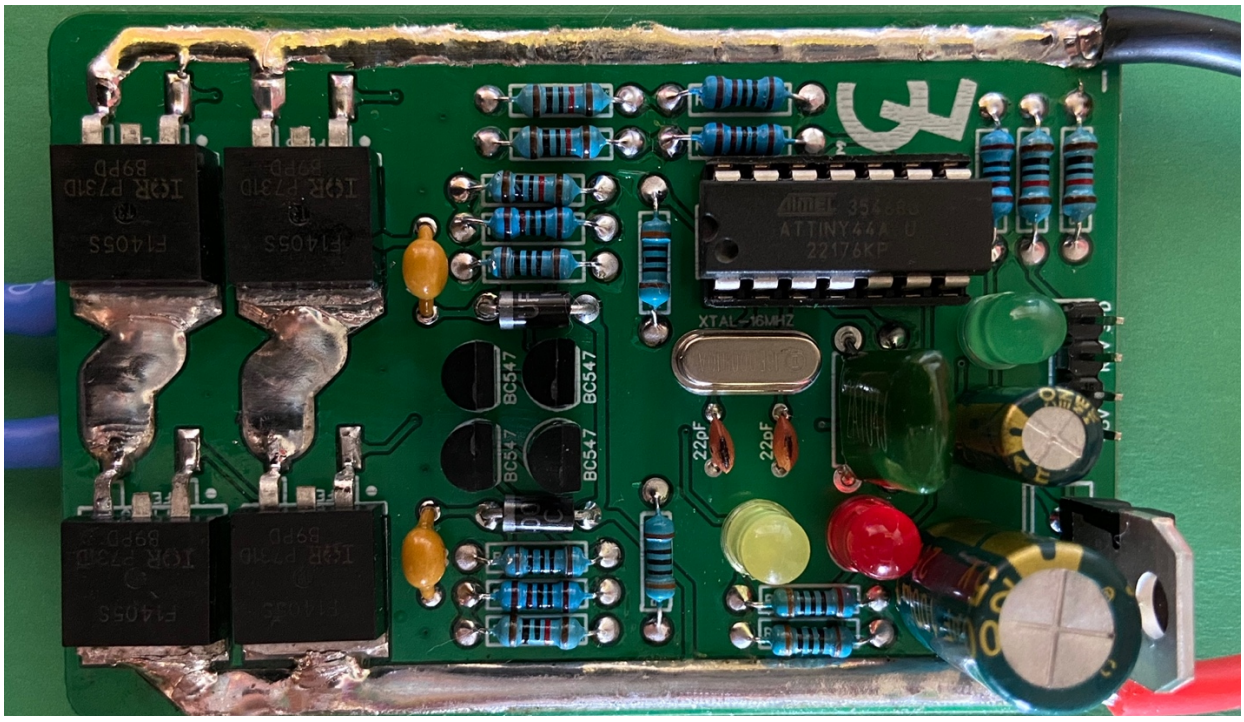
Step-7/Image-7: Solder the power supply and decoupling capacitors to the board. First place the large green 100nF film capacitor into the spot labelled C3. Then place the 1000uF electrolytic capacitor into C1 and the 220uF electrolytic capacitor into C2. *Make sure the longer lead goes through the hole marked with a + as electrolytic capacitors are polarised*, then make the solder connections on the board's underside.



Step-8/Image-8: Connect the indicator LEDs to the board at the spaces labelled LED1, LED2 and LED3, each space is also marked with a letter to show the correct colour. *Ensure the flat edge of each LED is aligned with the flat edge on the boards silkscreen as LEDs are polarised and will not work backwards*. The solder connections must be made on the underside of the board, so secure the LEDs with tape and trim the excess legs when done.



Step-9/Image-9: Solder the LM7805 linear voltage regulator to the space labelled LDO, *make sure the back (ground) tab aligns with the double line on the component's silkscreen*. Then solder the row of 4 header pins to the spaces labelled +5V – REV and SPD. Both these parts will need to be soldered on the board's underside, so use tape to hold them in place. Finally solder power wires to the +, -, PHASEA and PHASEB pads with between 8 and 18 AWG wire being recommended.

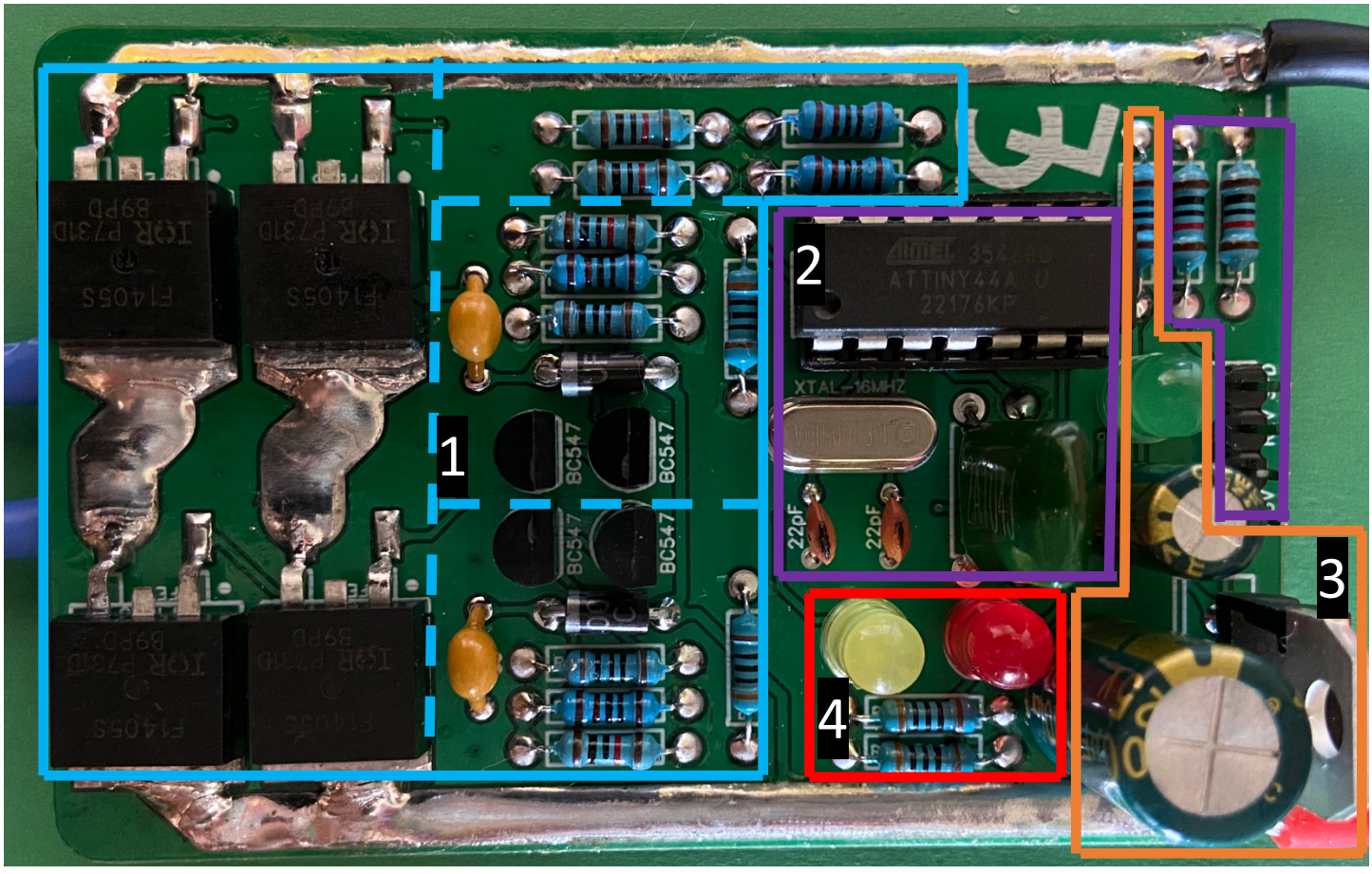


Final Step: Clean any excess flux and any other grime that may have been left behind during the soldering process from the board, using a cotton swab or a cloth dipped in isopropyl alcohol is recommended. Ensure all solder connections look good via visual inspection, using a powerful torch helps noticeably with this and then that's it, you have just built your own Brushed DC-Motor Driver, congratulations!

Driving Brushed DC-Motors

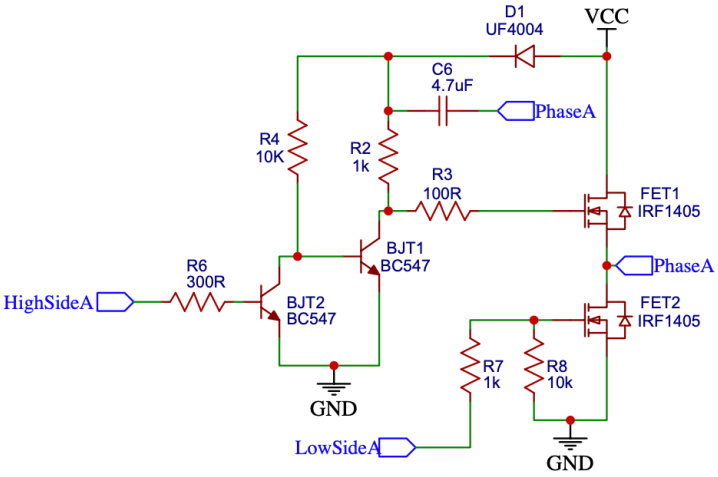
Summary: Driving a Brushed DC-Motor in one direction at full power can be achieved with just a battery and switch, however, to achieve these motors full potential a specialised drive circuit such as this kit should be used. This driver is essentially a full-bridge run by an AVR microcontroller alongside a 5V power regulator, some digital signal inputs and indicator LEDs. Combined they create a circuit able to control the direction of current flow through and using a PWM method the voltage applied to a Brushed DC-Motor, effectively controlling said motors spin direction and speed. The bulk of this work is done by two, dual N-channel half-bridges, utilising two NPN transistors an ultrafast diode, a monolithic ceramic capacitor and a few resistors to achieve the "bootstrapping" necessary to turn the high-side MOSFET fully on. A Benefit of this "bootstrapping" is that it relies on square wave PWM to function, making said PWM signals duty cycle a reliable and easy way to control the speed of the motor. In short, the duty cycles on-time as a percentage directly equates to the percentage of the supply voltage applied on the output and subsequently the speed of the motor.

Circuit Board Breakdown:

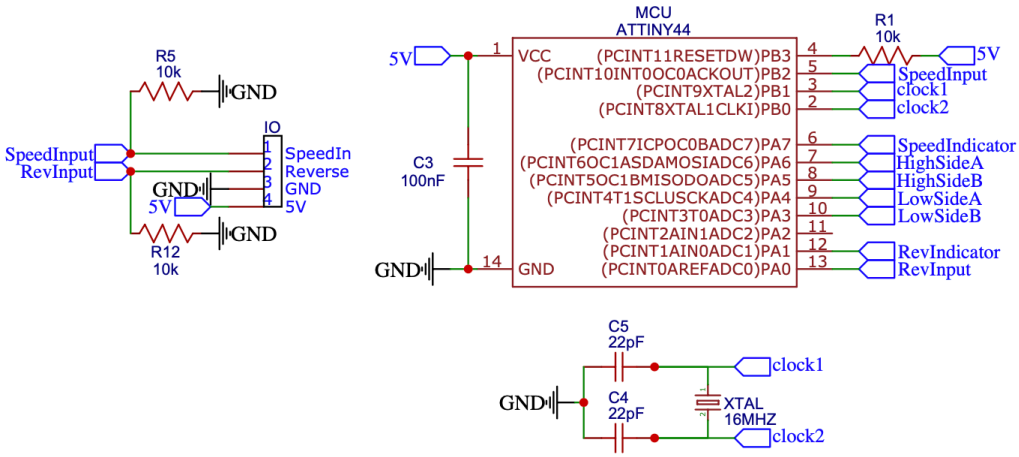


Circuit Stage Schematics.

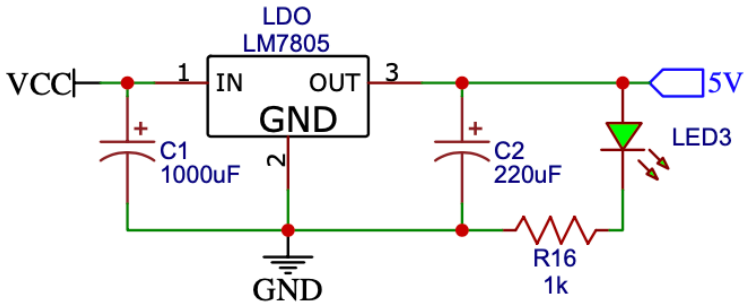
1) Blue: Power Stage.



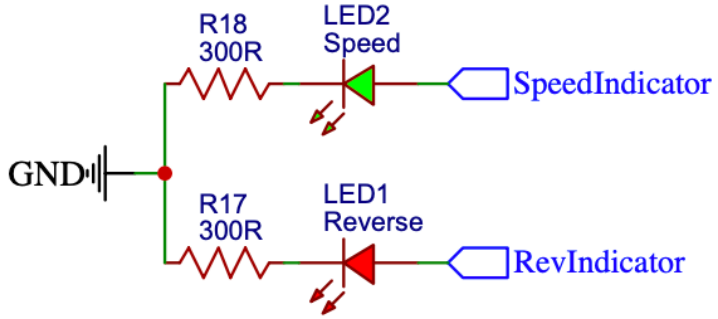
2) PURPLE: Microcontroller & Signal Inputs.



3) ORANGE: 5V Power Supply.



4) RED: Indicator LEDs.



Source Code: The drivers source code has been preprogramed into the Attiny44 microcontroller. But for those who are looking to customise this driver for their own application the annotated and Arduino IDE friendly program is made available via the product page at www.casuallyloaded.com as a .ino file. The code does assume the user has a basic understanding of C++, bitwise operators, interrupt vectors, using timers, direct AVR port manipulation and Arduino variables namely the millis() function.