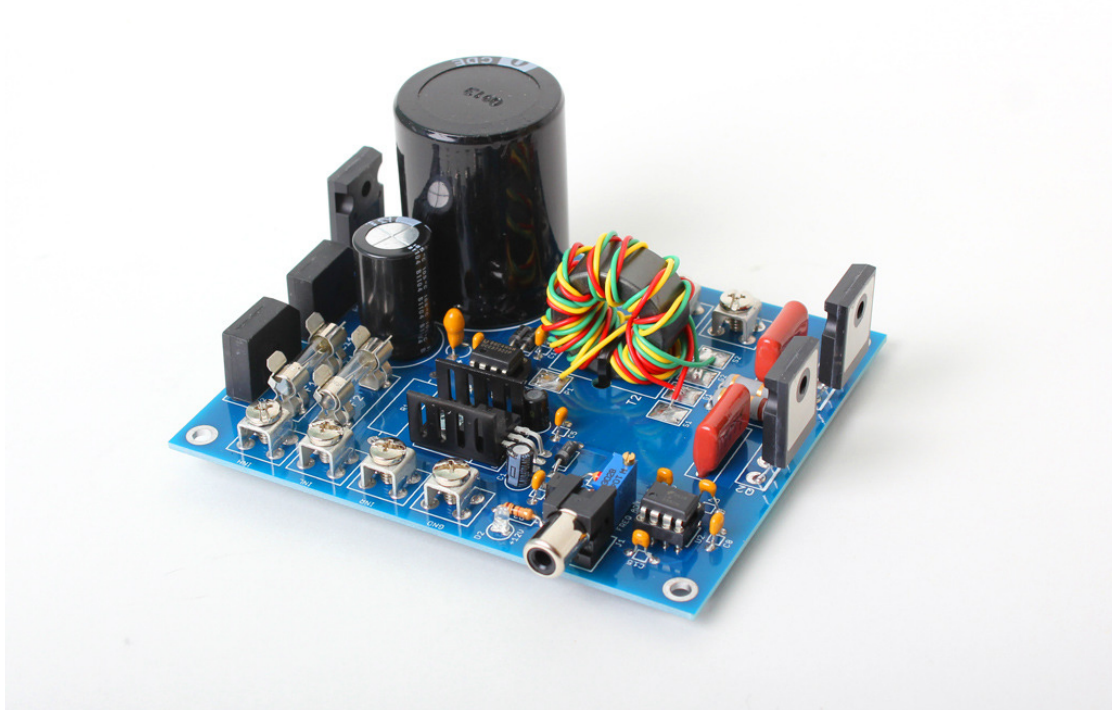


# ***Universal Flyback Driver 2.0***



## ***Instruction Manual***

**Eastern Voltage Research, LLC**



## **AGE DISCLAIMER**

**THIS KIT IS AN ADVANCED, HIGH POWER SOLID STATE POWER DEVICE. IT IS INTENDED FOR USE FOR INDIVIDUALS OVER 18 YEARS OF AGE WITH THE PROPER KNOWLEDGE AND EXPERIENCE, AS WELL AS FAMILIARITY WITH LINE VOLTAGE POWER CIRCUITS.**

**BY BUILDING, USING, OR OPERATING THIS KIT, YOU ACKNOWLEDGE THAT YOU ARE OVER 18 YEARS OF AGE, AND THAT YOU HAVE THOROUGHLY READ THROUGH THE SAFETY INFORMATION PRESENTED IN THIS MANUAL.**

**THIS KIT SHALL NOT BE USED AT ANY TIME BY INDIVIDUALS UNDER 18 YEARS OF AGE.**



## **SAFETY AND EQUIPMENT HAZARDS**

**PLEASE BE SURE TO READ AND UNDERSTAND ALL SAFETY AND EQUIPMENT RELATED HAZARDS AND WARNINGS BEFORE BUILDING AND OPERATING YOUR KIT.**

**THE PURPOSE OF THESE WARNINGS IS NOT TO SCARE YOU, BUT TO KEEP YOU WELL INFORMED TO WHAT HAZARDS MAY APPLY FOR YOUR PARTICULAR KIT.**



## VARIAC WARNING

**DO NOT USE A VARIAC WITH THIS PRODUCT. THIS PRODUCT REQUIRES POWER THROUGH AN ISOLATED TRANSFORMER (SUCH AS THE ONES PROVIDED IN THE KITS). A VARIAC IS NOT ISOLATED AND USING A VARIAC WITH THIS PRODUCT WILL CAUSE A SHORT CIRCUIT TO OCCUR WHICH WILL RESULT IN PERMANENT DAMAGE TO THE CIRCUITS.**



### **ELECTRICAL HAZARD**

**This circuit utilizes dangerous line voltages up to 115VAC. Failure to handle this circuit in a safe manner may result in serious injury or death!**



### **POWER SEMICONDUCTOR HAZARD**

**This is a solid state power device. Components may fail explosively at any time and eject high velocity projectiles.  
EYE PROTECTION IS REQUIRED AT ALL TIMES!**



### **ELECTROMAGNETIC FIELD HAZARD**

**This device when connected to a resonator will produce strong electric and magnetic fields. Exposure to this field should be limited.  
DO NOT USE THIS KIT IF YOU HAVE AN IMPLANTED BIOMEDICAL DEVICE!**



## **FIRE HAZARD**

**Due to high power dissipations of the the various semiconductors devices attached to the heatsink, the heatsink may become extremely hot, especially during periods of continuous operation. Please ensure the heatsink is not installed on or near any flammable material and that a cooling fan is ALWAYS used during operation.**

## **SAFETY GUIDELINES FOR LINE POWERED EQUIPMENT**

The electronic kit you purchased utilizes line voltages (115VAC) and also contains circuitry that produces output voltages in excess of 400VDC. Normally, consumer electronics equipment are safely enclosed to prevent accidental contact. However, the kit you have purchased does not come with an enclosure, and must be handled and operated with this in mind. Voltages exceeding 35V pose a safety hazard and depending on overall conditions and your general state of health, voltage and current levels have the ability to serious harm or even kill.

The following guidelines are to protect you from potentially lethal electrical shock hazards as well as the equipment from accidental damage.

It is also important to note that the danger isn't limited to only your body providing a conductive path, namely your heart. Any involuntary muscle contractions caused by an electrical shock, while perhaps harmless in themselves, may cause the person to be injured by falling, hitting a body part on something sharp, etc....

The purpose of these set of guidelines is not to frighten you, but rather make you aware of the appropriate precautions needed to safely build and operate this electronics kit.

- Perhaps, the number one rule – Don't work alone! If something does happen, it is extremely important to have someone nearby to render assistance or to call for help.
- When working on energized equipment (namely those that are line powered), always keep one hand in your pocket. This ensures there is not a complete

electrical path through your heart providing you accidentally make contact with live voltage.

- Wear footwear with non-conductive (rubber) soles. Do NOT work on line powered or high voltage equipment in barefeet.
- Always wear eye protection. Power semiconductor devices, and capacitors do have the potential to explode unexpectedly and project sharp fragments across the room.
- Always work in a clean, open area. Avoid working in cluttered spaces, especially if there are grounded objects nearby that could complete a circuit path in the event you make accidental contact with live voltage.
- Avoid wearing any kind of jewelry or other articles that could accidentally contact circuitry.
- Never operate your PC boards on top of conductive tables, or other conductive objects. PC boards should ALWAYS be supported by the provided stand-offs or placed on top of a non-conductive tabletop or other material.
- ALWAYS allow proper time for any large electrolytic or other high voltage capacitors to discharge after removing power prior to working or touching any circuit. ALWAYS use a multimeter to measure the voltage across large capacitors after power is disconnect to ensure the voltage has properly bled off.
- Use an isolation transformer if there is any chance of contacting line powered circuitry. A Variac is NOT an isolation transformer!
- Finally, if your kit involves a Tesla Coil – NEVER touch or attempt to draw an arc with an object from the output of a Tesla Coil. The output of a Tesla Coil poses not only an electrical hazard, but also a burn hazard. The output from even the smallest solid state Tesla Coil can cause serious burns. Always operate the Tesla Coil at a safe distance.

## **SAFETY GUIDELINES - SEMICONDUCTOR POWER DEVICES**

- Always wear eye protection. Power semiconductor devices, and capacitors do have the potential to explode unexpectedly and project sharp fragments across the room.
- Power semiconductors may be extremely hot. NEVER touch any semiconductors during operation or after use. Always allow proper time for components to cool down prior to handling them.

## **SAFETY GUIDELINES – HIGH TEMPERATURE COMPONENTS**

- Power semiconductors may be extremely hot. NEVER touch any semiconductors during operation or after use. Always allow proper time for components to cool down prior to handling them.
- The extruded aluminum heatsink will be extremely hot during and after use until it cools down to ambient temperature. NEVER place the heatsink on any material that is flammable such as wood, plastic, or paper. It is preferable to place the extruded aluminum heatsink onto a metal plate.
- NEVER operate the device without the use of a cooling fan. If you are using an extruded aluminum heatsink, be sure to blow fan parallel to the cooling fins of the heatsink to maximize the cooling effects of the fan. Always allow the cooling fan to continue running, even after power is removed, until the heatsink and board components are properly “cooled” down.

## **SAFETY GUIDELINES – ELECTROMAGNETIC FIELD OUTPUT**



**DO NOT USE THIS KIT if you have an implanted biomedical device such as a pacemaker!**

- Electromagnetic fields are produced when the Tesla coil is operating. Ensure that you and others are always at least five feet away from the devices during operation (small kits), and farther away with some of the larger kits such as the miniBrute Tesla Coil kit.
- Avoid contact with metallic objects. This is mostly important for the smaller CW based Tesla coils such as the SSTC 1.0 or Class-E Audio Modulated Tesla Coil. What happens is that the electromagnetic fields cause charge to build up on your person and any contact with something metallic will initiate a potential RF burn to occur. The burns are on the magnitude of an electrostatic shock – they are rarely harmful, but they can surprise you and give you a small instant of localized pain – again similar in receiving a electrostatic shock. Maintaining at least five feet away from the Tesla coil will prevent this from occurring.
- DO NOT use this kit if you have an implanted biomedical device.

## **Introduction to the Universal Flyback Driver 2.0**

Thank you for purchasing the Universal Flyback Driver 2.0. The Universal Flyback Driver 2.0 is a high power drive circuit which can be used with virtually all open-core type flyback transformers to generate high voltage arcs. With onboard controls to vary both output frequency and voltage, it's an extremely flexible design which can be used to drive almost any open-core flyback transformer.

Notice to Beginners: If you are a first time kit builder, you may find this instruction manual easier to understand than expected. Each component in this kit has an individual check box, while a detailed description of each component is provided as well. If you follow each step in the instruction manual in order, and practice good soldering and kit building skills, the kit is next to fail-safe.



**Please read this manual in its entirety before building, testing, or operating your kit!**

## **Circuit Description**

The Universal Flyback Driver 2.0 is an open-loop half-bridge switching power supply. It is called “open loop” as the output voltage is not regulated. Both control and half-bridge power are first rectified and filtered through BR2/C14 and BR1/C3 respectively to produce approximately 25-35VDC from a 24V transformer. Separate power supply circuits are provided for both control power and output power so that separate transformers can be used to power both control and output power. Linear regulator, U1 (LM7815) provides the +15VDC control voltage. Transistor, Q1 (N-Channel MOSFET) is utilized as the voltage control device, and with potentiometer R4, the user can vary the output voltage of the flyback driver. The oscillator of the flyback driver utilizes a 555 Timer IC running in astable mode (continuous operation) and has a variable frequency between approximately 5kHz and 120kHz which is controlled via potentiometer, R7. The unique configuration of this 555 Timer circuit provides a nearly 50% duty cycle regardless of the frequency setting. Finally, the 555 Timer output is fed into a high current gate driver, U3, which drives the half-bridge switching transistors (200V N-Channel MOSFETs), Q2 and Q3, whose output is connected directly to the flyback transformer's primary winding. Gate transformer, T2, provided electrical isolation between the control circuit and the half-bridge switching circuit.

This circuit can also be used to drive a solid state Tesla Coil (SSTC) resonator in open-loop mode. Open loop means that the user sets the output frequency, so it wouldn't be a self-tuning SSTC – it would have to be manually tuned via R7 so that the 555 Timer output frequency matches the resonant frequency of the resonator.

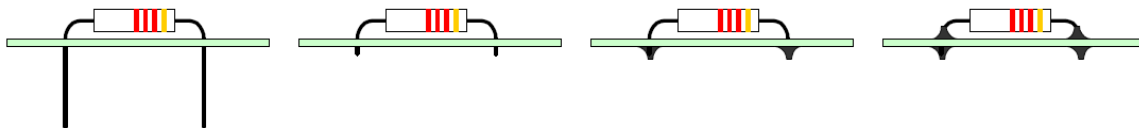
Finally, a basic audio modulation is possible by PWM modulation of U2 which is a 555 Timer IC. Audio modulation is possible by pulse width modulating (PWM) the output square wave of the 555 Timer IC. This allows one to convert the output of their flyback transformer into a very basic plasma speaker.

## Kit Building Tips

A good soldering technique is key! Let your soldering iron tip gently heat both the wires and pads simultaneously. Apply solder to the wire and the pad when the pad is hot enough to melt the solder. The finished joint should appear like a small shiny drop of water on paper, somewhat soaked in. If the pads have not heated up sufficiently, melted solder (heated only by the soldering iron itself) will form a cold solder joint and will not conduct properly. These cold joints appear as dull beads of solder, and can be easily fixed by applying additional heat to the pad and wire. All components, unless otherwise noted, should be mounted on the top side of the board. This is the side with the silkscreen printing.

When installing components, the component is placed flat to the board and the leads are bent on the backside of the board to prevent the part from falling out before soldering. The part is then soldered securely to the board, and the remaining lead length is clipped off. It is also extremely important to place the components as close to the board as possible. This is necessary for proper operation over the wide frequency range of the various kits we provide. Also be sure that component lead lengths are always as short as possible. This will avoid adding any stray capacitances or inductances that can be detrimental to circuit operation.

An alternative approach (which is actually the one I use) is to install the component into the board and then apply a piece of masking tape on the topside to hold the component in place temporarily. The leads on the backside of the board are then trimmed leaving about 0.10" lead protruding through the backside of the board, and then soldered from the backside. You can then remove the masking tape, and finally apply a small amount of solder on the top to complete the joint on both sides. This is shown in the figure below.



**Universal Flyback Driver 2.0 Parts List****RESISTORS**

- ☐ 1 33 ohm Resistor, 2W, R1
- ☐ 1 3.3k Resistor, 1/2W (orange-orange-red), R2
- ☐ 1 10 ohm Resistor (brown-black-black), R5
- ☐ 2 5.1 ohm Resistor, 2W (green-brown-gold), R8, R9
- ☐ 1 1k ohm Resistor (brown-black-red), R3
- ☐ 1 2.2k Resistor (red-red-red), R6
- ☐ 2 100k Potentiometer, R4, R7

**CAPACITORS**

- ☐ 5 0.1uF Ceramic Capacitor, C2, C5, C6, C10, C15
- ☐ 2 10uF Electrolytic Capacitor, C1, C4
- ☐ 1 10uF Tantalum Capacitor, C9
- ☐ 1 15000uF 50V Electrolytic Capacitor, C3 (standard version)
- ☐ 1 6800uF 100V Electrolytic Capacitor, C3 (high power version)
- ☐ 1 2200pF Ceramic Capacitor, C7
- ☐ 1 0.01uF Ceramic Capacitor (marked M39014/01-1455 or BC103), C8
- ☐ 1 1uF Ceramic Capacitor (marked M39014/02-1407 or BC105), C13
- ☐ 2 0.68uF 250V Polypropylene Capacitor, C11, C12
- ☐ 1 2200uF (alternate 4700uF) 35V Electrolytic Capacitor, C14

**DIODES**

- ☐ 1 Bridge Rectifier (marked KBL04, KBL06, KBL08, or KBL10), BR1
- ☐ 1 Bridge Rectifier (marked KBL01, KBL02, KBL04, KBL06, KBL08, or KBL10), BR2
- ☐ 2 LED, Blue, D1, D2
- ☐ 1 1N4002 Diode (marked 1N4002), CR1
- ☐ 1 1N4148 Diode (marked 1N4148), CR2
- ☐ 2 1N5819 Diode (marked 1N5819), CR3, CR4

**SEMICONDUCTORS**

- ☐ 3 IRFP260 MOSFET, Q1, Q2, Q3
- ☐ 1 2N3904 Transistor, Q4

**INTEGRATED CIRCUITS (ICs)**

- ☐ 1 15V Regulator (marked LM7815), U1
- ☐ 1 555 Timer (marked 555), U2
- ☐ 1 Non-Inverting Gate Driver (marked UCC37322), U3

### **MISCELLANEOUS**

- ☐ 1 8DIP IC Socket
- ☐ 6 Screw Terminals
- ☐ 1 Power Transformer, 24V
- ☐ 1 Ferrite Toroid with 26 AWG wire, 3 strands
- ☐ 1 Extruded U-Channel Heatsink with Drill Template
- ☐ 1 TO-220 Heatsink
- ☐ 1 Misc. Hardware
- ☐ 1 AC Power Cord
- ☐ 4 Fuse Clips for 5x20mm fuses
- ☐ 1 Fuse, 3A
- ☐ 1 Fuse, 5A
- ☐ 1 Connector, RCA
- ☐ 1 PCB Board, Flyback Driver 2.0
- ☐ 1 Schematic, Flyback Driver 2.0

### **RECOMMENDED, NOT SUPPLIED**

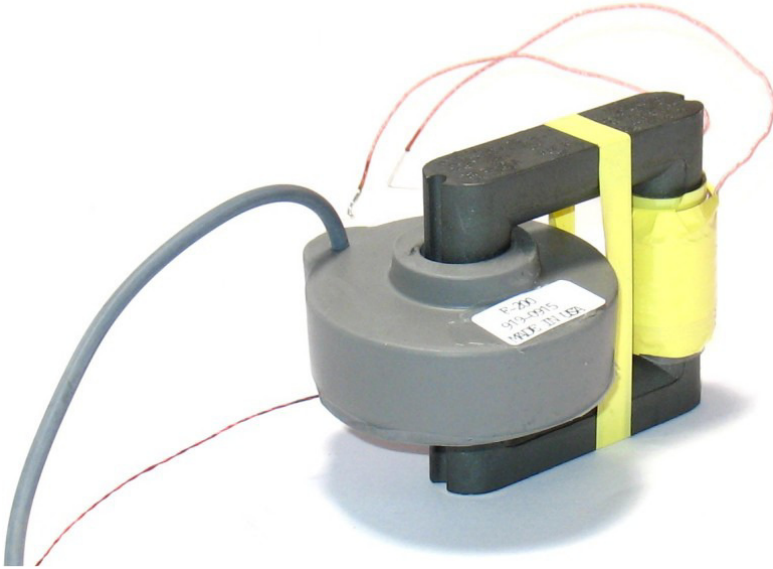
- ☐ 1 Enclosure for Universal Flyback Transformer board
- ☐ 1 Power Transformer, High Power, for higher voltages (OPTIONAL)

### **REQUIRED, NOT SUPPLIED**

- ☐ 1 Flyback Transformer (open core, old style preferred)
- ☐ 1 Power Transformer, 18V, 1A for Control Power
- ☐ A/R Electrical Tape or Wire Nuts

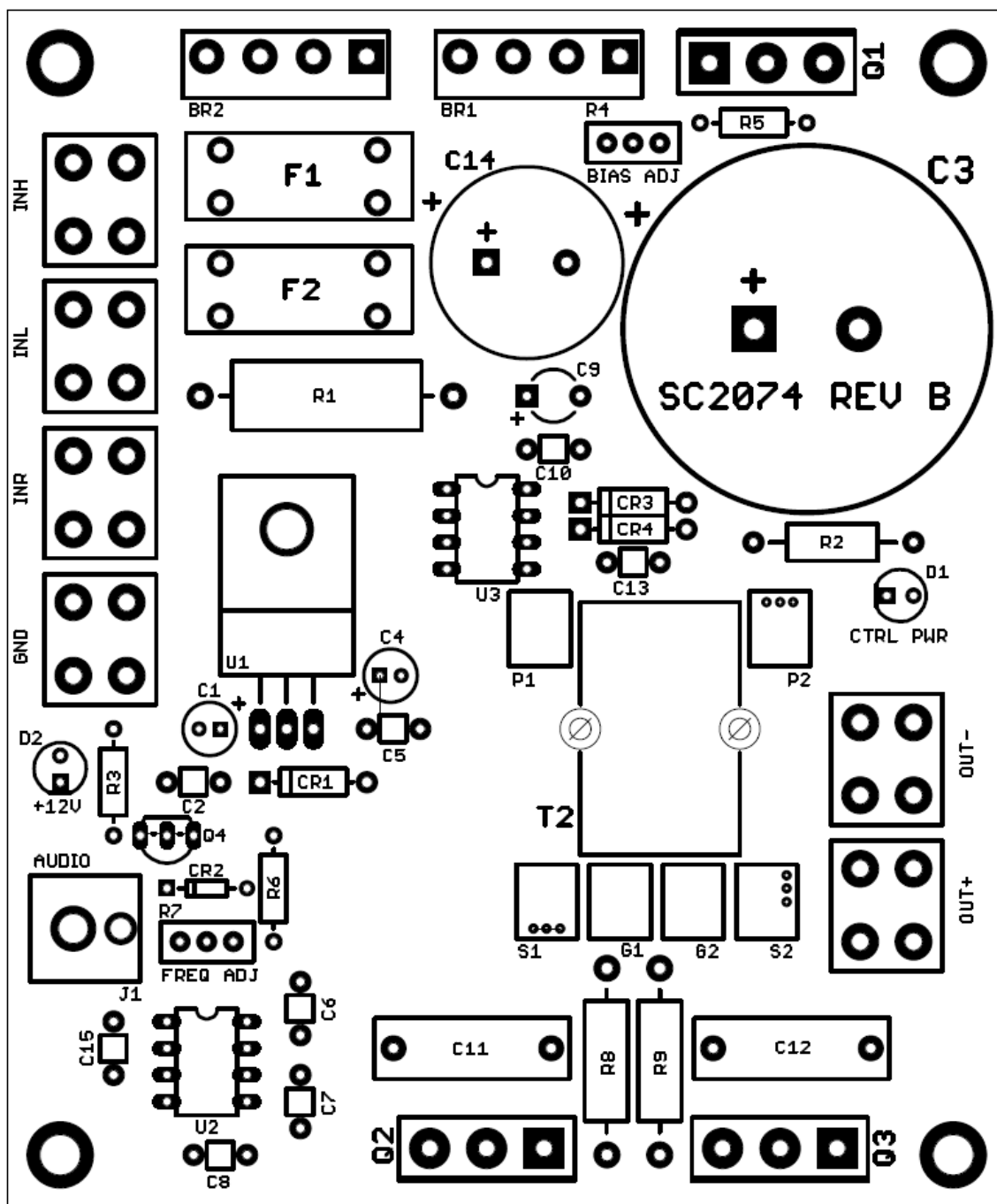
### **Sources for 18V, 1A Transformer**

Jameco – Surplus Transformers  
Digikey  
Mouser  
Newark Electronics



**Typical HV Flyback Transformer**

Universal Flyback Driver 2.0 Component Layout Diagram



## KIT Building Instructions

Now we will begin building the kit. There are just a few more important things to know before we install the first components.

For each component, the word “install” always means the following:

1. Pick the correct value to start with.
2. Insert the component into the correct printed circuit board (PCB) location.
3. Orient the component correctly – especially when there is a right and a wrong way to solder it in. (i.e. Electrolytic capacitors, diodes, ICs, transistors, etc...)
4. Solder all connections unless directed otherwise. Ensure enough heat is used to allow solder to flow for clean, shiny, and completed connections.

Also, please be sure to take us seriously when we say that good soldering is the key to the proper operation of your circuit!

- Use a 25W soldering pencil with a clean, sharp tip. DO NOT USE a high power soldering gun such as those trigger activated units.
- Use only rosin core solder intended for electronics use
- Ensure your work area is clean, and has plenty of bright lighting
- Build your kit in stages, taking breaks to check your work. Be sure to clean the board periodically with a brush or compressed air to remove any excess wire cuttings, etc...

Okay, so lets begin!

- ☐ 1. Install R1, 33 ohm, 2W resistors. This resistor will get hot so be sure to space it slightly above the board.
- ☐ 2. Install R2, 3.3k, 1/2W ohm resistor (orange-orange-red)
- ☐ 3. Install R3, 1k resistor (brown-black-red)
- ☐ 4. Install R5, 10 ohm resistor (brown-black-black)
- ☐ 5. Install R6, 2.2k resistor (red-red-red)
- ☐ 6. Install R8, 5.1 ohm, 2W resistor (green-brown-gold)
- ☐ 7. Install R9, 5.1 ohm, 2W resistor (green-brown-gold)

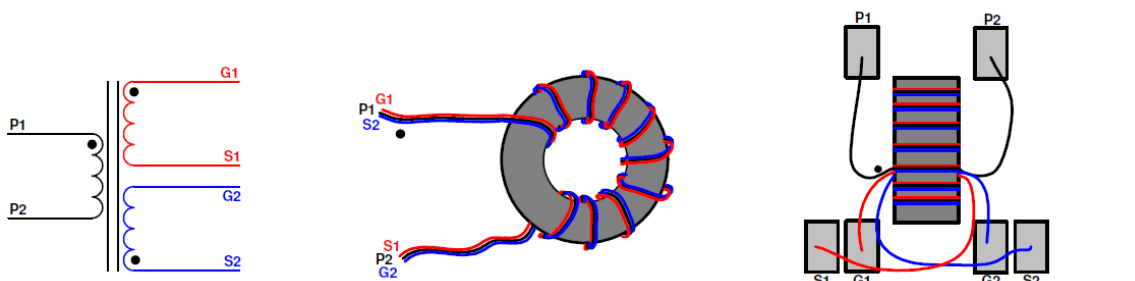
- ☐ 8. Install CR1, 1N4002 diode. The cathode band on the diode must match that shown on the silkscreen.
- ☐ 9. Install CR2, 1N4148 diode. The cathode band on the diode must match that shown on the silkscreen.
- ☐ 10. Install CR3, 1N5819 diode. The cathode band on the diode must match that shown on the silkscreen.
- ☐ 11. Install CR4, 1N5819 diode. The cathode band on the diode must match that shown on the silkscreen.
- ☐ 12. Install C2, 0.1uF capacitor (marking BC104)
- ☐ 13. Install C5, 0.1uF capacitor (marking BC104)
- ☐ 14. Install C6, 0.1uF capacitor (marking BC104)
- ☐ 15. Install C10, 0.1uF capacitor (marking BC104)
- ☐ 16. Install C15, 0.1uF capacitor (marking BC104)
- ☐ 17. Install C7, 2200pF capacitor (marking BC222)
- ☐ 18. Install C8, 0.01uF capacitor (marking BC103 or M39014/01-1455)
- ☐ 19. Install C13, 1uF capacitor (marking M39014/02/1407 or BC105)
- ☐ 20. Install C1, 10uF, 50V electrolytic capacitor. C3 has “polarity.” Polarity means the capacitor must be inserted a certain way. You may notice that one side of the capacitor, there is a black stripe with minus signs. This is the negative end. Looking at the PCB silkscreen, you will notice the positive side marked. Install this capacitor into the board ensuring the positive side of the capacitor installs in the hole that is marked positive on the PCB layout.
- ☐ 21. Install C4, 10uF, 50V electrolytic capacitor. Install this capacitor into the board ensuring the positive side of the capacitor installs in the hole that is marked positive on the PCB layout.
- ☐ 22. Install C9, 10uF, 35V tantalum capacitor (marking 10635). Install this capacitor into the board ensuring the positive side of the capacitor installs in the hole that is marked positive on the PCB layout.
- ☐ 23. Install C11, 0.68uF, 250V polypropylene capacitor.

- ☐ 24. Install C12, 0.68uF, 250V polypropylene capacitor.
- ☐ 25. Install D1, LED. The short lead of the diode is the cathode and will install into the square pad on the PCB board.
- ☐ 26. Install D2, LED. The short lead of the diode is the cathode and will install into the square pad on the PCB board.
- ☐ 27. Install an 8-pin DIP socket into the U3 location. Note that one end of the DIP socket is marked by a notch; this end **MUST** be oriented as shown on the PCB layout.
- ☐ 28. Install U3, UCC37322 Gate Driver IC into the 8-pin DIP socket that was installed in the previous step. Note that one end of the IC is marked by a dot, notch, or band; this end **MUST** be oriented as shown on the PCB layout.
- ☐ 29. Install U2, 555 Timer. The 555 Timer IC may be soldered directly to the PCB without worry, but you may use an 8-pin DIP socket (your own) if you prefer. Use the same care in soldering such a socket and inserting the IC as you would in direct soldering of the chip. Note that one end of the IC is marked by a dot, notch, or band; this end **MUST** be oriented as shown on the PCB layout.
- ☐ 30. Install Q4, 2N3904 transistor. This transistor needs to be orientated properly. Please insert Q4 into the board with the flat edge of the transistor orientated according to the silkscreen layout drawing.
- ☐ 31. Install the six (6) screw terminals.
- ☐ 32. Install R4, 100k potentiometer
- ☐ 33. Install R7, 100k potentiometer
- ☐ 34. Build and install T2, gate transformer, as shown in the instructions below. Visibly check to ensure the windings of the transformer connect to the board as shown below. Failure to connect the windings properly will result in failure of the MOSFET switching devices, Q2 and Q3.

1. Begin by grouping all three (3) windings together.



2. Tie a knot in one end and secure to a bench / vise, etc... and then twist all windings together. This can be done by hand, or by using a cordless drill. If using a cordless drill, simply insert the ends of the three (3) windings into the drill chuck and then operate the drill to twist the windings.



3. Winding the transformer with 12 Turns. Ensure the windings are tight against the core and evenly spaced around the entire core.
4. Attach the transformer to the board as shown in the schematic and illustration above. Note the dots showing the proper phasing of the windings and should match that to the schematic. It is important to keep the lengths of the windings as short as possible when connecting to the board lands.

- ☐ 35. Install the four (4) fuse clips in the board location designated F1 and F2 on the PCB board. Note, that there are end-stops on each of these clips which must be facing the outside when installed, or the fuse will not install properly.
- ☐ 36. Install the 3A fuse into the F2 fuse clips.
- ☐ 37. Install the 5A fuse into the F1 fuse clips.
- ☐ 38. Install U1, LM7815 Linear Regulator. This component must be installed with the included heatsink and hardware. The easiest way to solder this to the board is to first attach the component and heatsink / hardware to the board, ensuring the leads on U1 are properly bent (formed) to align with the solder holes and heatsink mounting hole. Once the heatsink assembly is attached, the three (3) leads of the LM7815 can be soldered to the PCB. Be sure not to bend the leads more than once as they will break!
- ☐ 39. Install RCA connector, J1. There are two black plastic tabs underneath this connector that should be cut off to ensure the connector sits flat on the board.
- ☐ 40. Install BR1, bridge rectifier. The notched end of BR1 is the positive pin and must be installed in the square pad in the PCB board. (marking KBL04, KBL06, KBL08, or KBL10)

- ☐ 41. Install BR2, bridge rectifier. The notched end of BR2 is the positive pin and must be installed in the square pad in the PCB board. (marking KBL01, KBL02, KBL04, KBL06, KBL08, or KBL10)
- ☐ 42. Install C14, 2200uF, 35V electrolytic capacitor. C14 has “polarity.” Polarity means the capacitor must be inserted a certain way. You may notice that one side of the capacitor, there is a black stripe with minus signs. This is the negative end. Looking at the PCB silkscreen, you will notice the positive side marked. Install this capacitor into the board ensuring the positive side of the capacitor installs in the hole that is marked positive on the PCB layout.
- ☐ 43. Attach the four (4) threaded stand-offs to the base of the heatsink. The PCB board will sit on top of these stand-offs.
- ☐ 44. Using the included 6-32 hardware, attach the PCB board to the four (4) threaded stand-offs. The board should be oriented so that the three (3) component mounting holes in the heatsink align with the component locations Q1, Q2, and Q3 on the PCB.
- ☐ 45. Install Q1, IRFP260 MOSFET. With the PCB board mounted to the heatsink, first insert Q1 into the board. Do NOT solder Q1 at this time. The metallized back of Q1 will be the side that attaches to the heatsink. Using the included hardware and thermal insulator, attach Q1 to the heatsink. **Ensure that the thermal insulator is centered and in place between the transistor and the heatsink.** Once Q1 is attached to the heatsink, solder it to the board. This ensures that the fit and alignment of Q1 will match the heatsink mounting hole.
- ☐ 46. Install Q2, IRFP260 MOSFET. With the PCB board mounted to the heatsink, first insert Q2 into the board. Do NOT solder Q2 at this time. The metallized back of Q2 will be the side that attaches to the heatsink. Using the included hardware and thermal insulator, attach Q2 to the heatsink. **Ensure that the thermal insulator is centered and in place between the transistor and the heatsink.** Once Q2 is attached to the heatsink, solder it to the board. This ensures that the fit and alignment of Q2 will match the heatsink mounting hole.
- ☐ 47. Install Q3, IRFP260 MOSFET. With the PCB board mounted to the heatsink, first insert Q3 into the board. Do NOT solder Q3 at this time. The metallized back of Q3 will be the side that attaches to the heatsink. Using the included hardware and thermal insulator, attach Q3 to the heatsink. **Ensure that the thermal insulator is centered and in place between the transistor and the heatsink.** Once Q3 is attached to the heatsink, solder it to the board. This ensures that the fit and alignment of Q3 will match the heatsink mounting hole.
- ☐ 48. Remove hardware from Q1, Q2, and Q3, and remove PCB board from the heatsink.

- ❑ 49. Install C3, 15000uF, 50V electrolytic capacitor (or 6800uF, 100V if you have the high power version). C3 has “polarity.” Polarity means the capacitor must be inserted a certain way. You may notice that one side of the capacitor, there is a black stripe with minus signs. This is the negative end. Looking at the PCB silkscreen, you will notice the positive side marked. Install this capacitor into the board ensuring the positive side of the capacitor installs in the hole that is marked positive on the PCB layout.
- ❑ 50. Trim leads of Q1, Q2, Q3 on bottom side of board if you have not already done so.
- ❑ 51. Re-attach PCB board to the heatsink. **Again, ensure that thermal insulators are properly placed between Q1, Q2, and Q3.** If thermal insulators are not in place when the board is powered up, the components will fail.
- ❑ 52. Attach rubber feet (4) to bottom of heatsink. Each rubber foot should be placed over each of the four (4) flathead screw heads on the bottom of the heatsink.
- ❑ 53. Review Figures 1 and 2 below and decide which configuration you plan on using with your Flyback Driver 2.0 kit. Because both flyback and control power have separate inputs for AC power, there is an infinite number of transformer configurations which can be used for operation.

#### **FIGURE 1 Description**

Figure 1 shows the use of a single center tapped transformer to provide power to both the control and power circuits of the flyback driver. For this configuration, transformer output voltages should not exceed the voltages provided in Table 1 below. Only half of the output voltage of the transformer is used to provide power for the control circuitry while the entire output voltage of the transformer is used to provide power for the flyback half-bridge power circuit.

#### **FIGURE 2 Description**

Figure 2 shows the use of two separate transformers to provide power to the flyback driver. The 18V transformer (**not supplied with the kit, but must be purchased by customer**) is used to provide control power to the flyback, while a separate higher voltage transformer is used to provide power for the flyback half-bridge power circuit. Again, voltages shall not exceed the voltage ranges as specified in Table 1 below.

Please note that there are other transformer configurations possibly which are not shown in this document. It is up to the user to properly design and specify transformers for use in other configuration.

Configuration	Transformer	Allowable Voltage Range
FIGURE 1	T101	25VAC - 36VAC CT
FIGURE 2 (Standard Kit)	T101	18VAC CT, 1A
	T102	18VAC – 36VAC
FIGURE 2 (High Power Kit)	T101	18VAC CT, 1A
	T102	18VAC – 70VAC

TABLE 1

This table is only a guideline. It is the users responsibility to ensure that the correct voltages are present on the Flyback Driver 2.0 when selecting transformers – in particular that the voltage across C3 is never exceeded, even in a no load condition.



**The most important thing when specifying the output voltage of the transformer used in your Flyback Driver 2.0 kit is the capacitor voltage rating of C3. For the standard kit, this capacitor is a 15000uF, 50V capacitor. The high power kit uses a 6800uF, 100V capacitor. Ensure that the output voltage (unloaded) of the transformer does not exceed the voltage rating of C3, otherwise C3 may fail.**

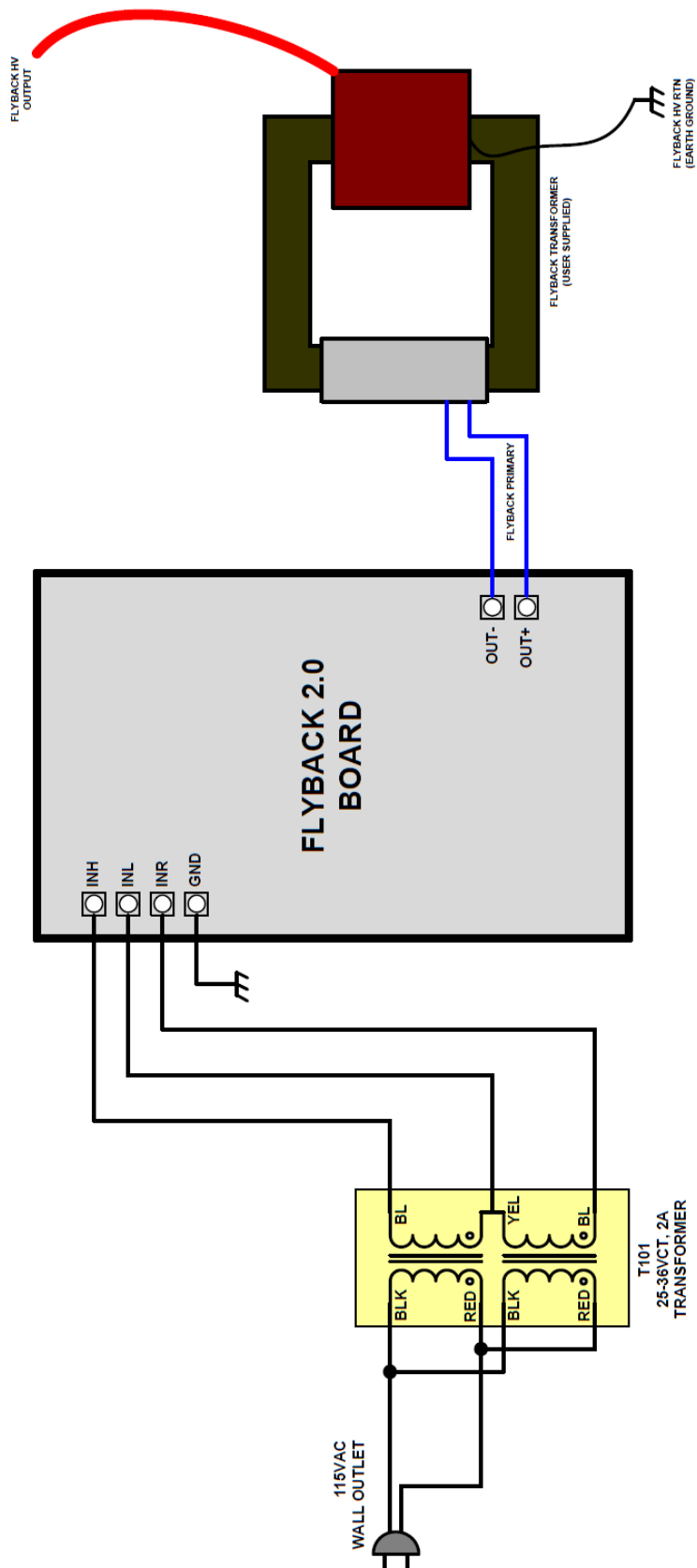
**Voltage at C3 is approx. = (AC Voltage applied across INH / INR) \* 1.414**

**Note that the unloaded (no load) voltage of the transformer will exceed this so be sure not to use a transformer which will exceed this even under no load.**

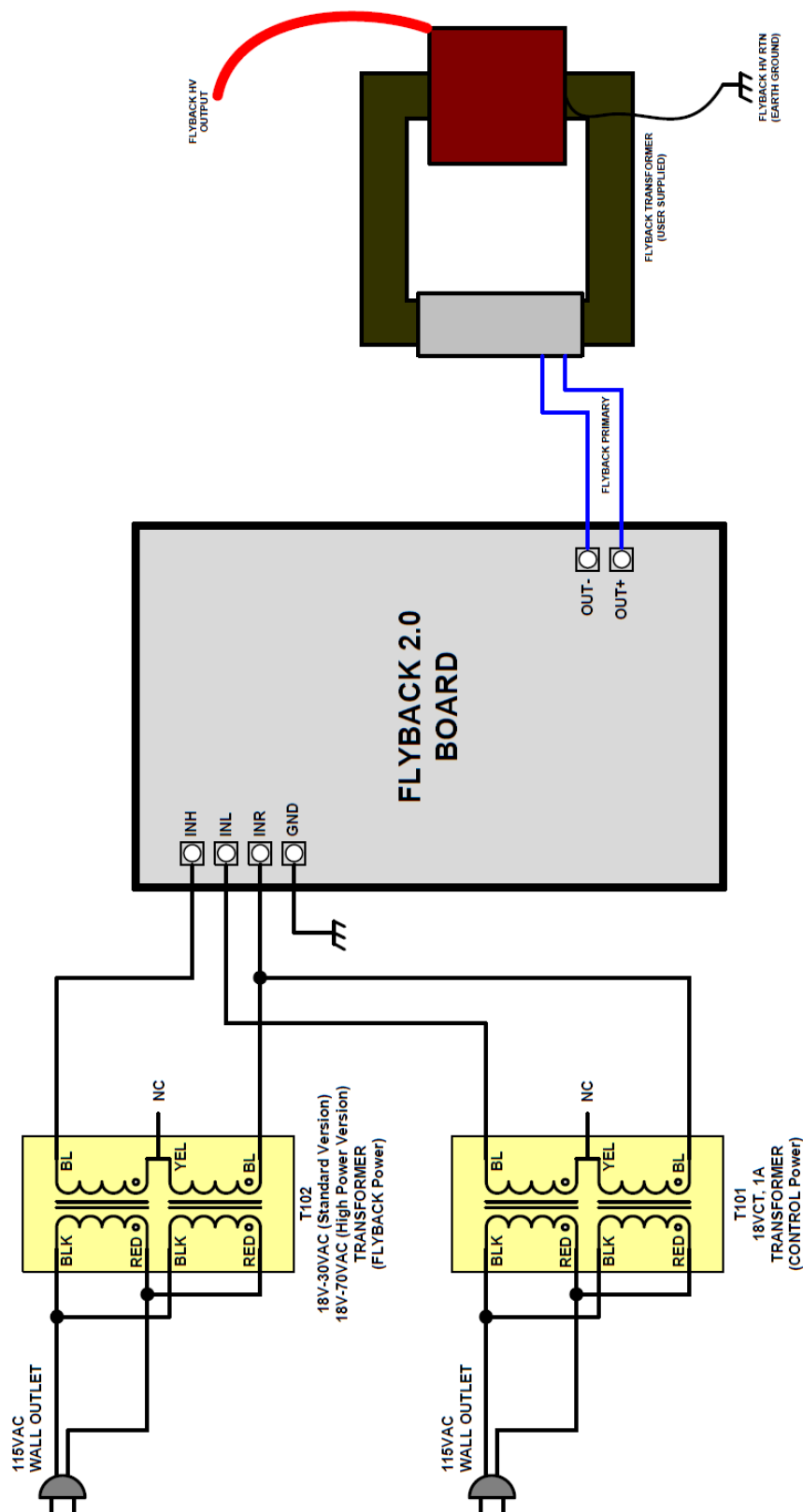
- ☐ 54. Install T101 (and T102 if using Figure 2 configuration) as shown in Figure 1 and Figure 2 below.

**DO NOT connect the flyback transformer to the PCB board at this time.**

Congratulations! You have just completed your Universal Flyback Driver 2.0 kit. Please take a few moments to look over the board and ensure that all the components are installed properly with the correct orientation. Since some of the parts may be unfamiliar to you, you may want to be extra sure that they have been inserted correctly. After you are sure that everything seems to be properly installed, move on to the set-up and testing section.



**FIGURE 1**



**FIGURE 2**

## Set-up and Testing

Okay, so lets begin!

### RECOMMENDED TEST EQUIPMENT, NOT SUPPLIED

- ☐ 1 Analog or Digital Multimeter



**Please be sure to wear safety glasses when testing and operating the Flyback Driver 2.0 Kit!**

- ☐ 1. Install fuse, F2 (3A), at this time. Remove fuse, F1 (5A) for these initial tests.
- ☐ 2. After putting on your safety glasses, plug in the 120VAC power cord providing power to T101. Note that the flyback transformer should NOT be installed at this time. Using a multimeter, verify that the following voltages are correct. If they are not, then there is a problem with your circuit that needs to be diagnosed and corrected.

Check	Component	Measuring Point	Voltage
<input type="checkbox"/>	R1	Right-hand side lead	24V $\pm$ 2V (See note 1)
<input type="checkbox"/>	U1	Pin 1 (Input)	18V to 24V
<input type="checkbox"/>	U1	Pin 3 (Output)	15V $\pm$ 0.5V
<input type="checkbox"/>	U3	Pin 1 (Vcc)	15V $\pm$ 0.5V
<input type="checkbox"/>	U3	Pin 8 (Vcc)	15V $\pm$ 0.5V
<input type="checkbox"/>	U2	Pin 4 (Reset)	15V $\pm$ 0.5V
<input type="checkbox"/>	U2	Pin 8 (Vcc)	15V $\pm$ 0.5V

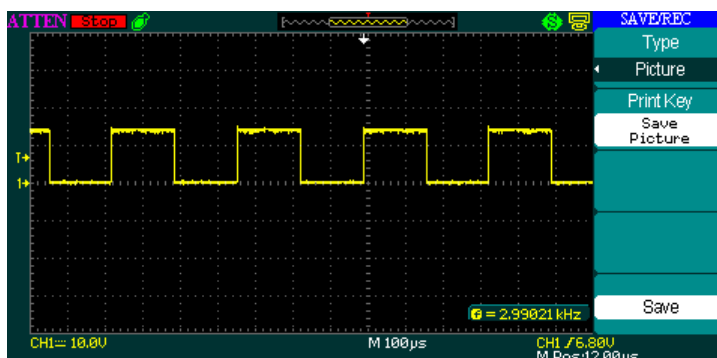
Note: All voltages should be measured with respect to the GND screw terminal.

Note 1: This is when an 18VAC, 1A transformer is used for T101.

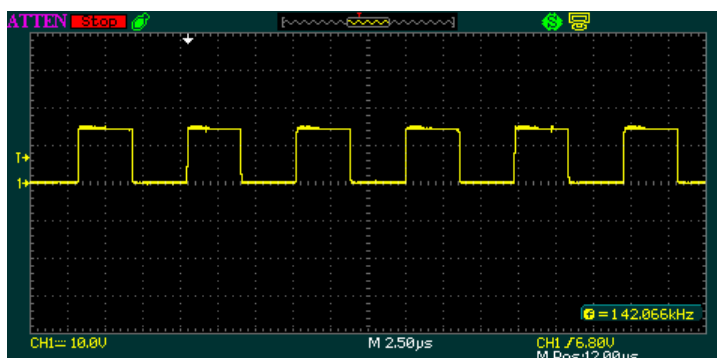
- ☐ 3. Verify that both LEDs, D1 and D2, are illuminated. If they are not, and the voltages above are correct, they may be installed backwards.
- ☐ 4. (OPTIONAL) If you have access to an oscilloscope, or other instrument that is capable of measuring frequency, you can check the operational frequency range of your Flyback Driver 2.0 kit. Connect your oscilloscope probe or frequency counter to Pin 3 of U2 (555 Timer). While adjusting potentiometer, R7, verify that the frequency range is adjustable as shown in the table below.

Check	Component	Measuring Point	Voltage
<input type="checkbox"/>	U2, 555 Timer	Pin 3 (Output)	~ 3kHz to 120kHz

Once this test is completed, set the frequency to the midpoint using R7. This will be the starting point for the remainder of the test.



U2, 555 Timer Pin 3 Output (Low Frequency) - 3kHz



U2, 555 Timer Pin 3 Output (High Frequency) - 142kHz

- ☐ 5. Unplug the 120VAC. Due to the capacitor storage on the board, it may take about 10 seconds for the power to bleed off. Wait until the LEDs completely turn off before proceeding to the next step.
- ☐ 6. Install fuse, F1 (5A) at this time.
- ☐ 7. After putting on your safety glasses again, plug in the 120VAC power cords for T101 (or T101 and T102 if you are using the Figure 2 configuration.)
- ☐ 8. Potentiometer R4 controls the output voltage of Q1 which is the DC bus voltage used to provide power to the half-bridge. Using a multimeter, measure the voltage across Q1-Source to GND and verify that you can adjust this voltage by adjusting R4. The adjustment voltage range will depend upon the particular transformer being used.



**Ensure this voltage does not exceed the voltage rating of C3. If it does, disconnect power immediately and choose a new transformer with a lower output voltage.**

For typical operation, the voltage will be set to its maximum (Q1 saturated and acting as a short). At this time, set the voltage for maximum output voltage.

- ❑ 9. (OPTIONAL) If you have access to an oscilloscope, you can monitor the output voltage of the Flyback Driver 2.0. Since the output of the flyback driver is not referenced to ground, it must be measured differentially using two (2) oscilloscope probes.

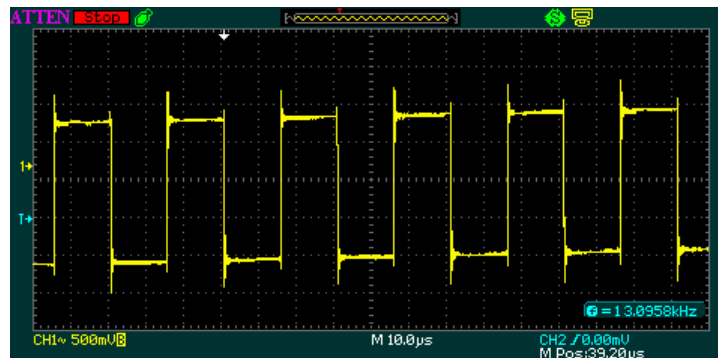


**NEVER CONNECT THE GND CLIP OF AN OSCILLOSCOPE TO THE OUT+ OR OUT- TERMINALS OF THE FLYBACK DRIVER. DOING SO WILL SHORT OUT THE HALF-BRIDGE CIRCUIT AND CAUSE YOUR CIRCUIT TO FAIL!!!!**

To measure differentially, two oscilloscope probes must be used.

- A. Disconnect power to the flyback driver
- B. Connect oscilloscope probe channel 1 to OUT+
- C. Connect oscilloscope probe channel 2 to OUT-
- D. Connect the GNDs of the two oscilloscope probes together. **DO NOT CONNECT THESE TO ANYTHING ELSE!!!!**
- E. Set oscilloscope to ADD Channel 1 and 2
- F. Set oscilloscope channel 2 to INVERT. When channel 2 is inverted and channel 1 and 2 are added, this is the same as Channel 1 – Channel 2, or a differential measurement.
- G. Verify the oscilloscope GND clips are connected only to each other and not anywhere else.
- H. Apply power to the flyback driver

- I. Adjust oscilloscope so you can see and measure the output square wave. (Note: Both channels must have same V/div settings) Sample plots are shown below of the output waveforms.
- J. You can also adjust R7 at this time and check how the output voltage varies.
- K. Disconnect power.



Output Voltage of Flyback Driver (Differential Measurement of OUT+ / OUT-)

- ☐ 10. Unplug the 120VAC power cord. Due to the capacitor storage on the board, it may take about 10 seconds for the power to bleed off. Wait until the LEDs completely turn off before proceeding to the next step.
- ☐ 11. Install the primary wires of the flyback transformer to the screw terminals labeled OUT+ and OUT- on the board.



**Be sure your flyback transformer is capable of operating at the output voltage that the Flyback Driver 2.0 is outputting. Output voltage is approximately +/- the maximum voltage you measured in Step 7. For example, if you measured 44V as the maximum voltage in Step 7, the output voltage to the flyback transformer primary will be +/-44V square wave or a total 88V peak-to-peak. If the primary voltage on the flyback is too high, it may destroy your flyback.**

- ☐ 12. Verify that the ground (RTN) connection from the HV winding of the flyback transformer is properly connected to EARTH GND as shown in Figures 1 and 2.



**The output of the flyback transformer is High Voltage. DO NOT touch or allow yourself to come into contact with the output HV wire at any time!**

- ☐ 13. Plug in the 120VAC power cord.
- ☐ 14. If everything was installed properly, your flyback transformer should be operating and producing high voltage. With the power off, you can position the HV output wire close to a GND discharge point to create a high voltage arc.
- ☐ 15. Once everything has been verified to be working correctly, you can now try adjusting the output frequency of your driver. Flyback transformers typically have a resonant frequency between 10kHz and 100kHz depending on their type, size, and configuration. To get maximum output voltage, the output frequency of the driver needs to be set to the resonant frequency of the flyback transformer. To do this, simply adjust potentiometer R7 until the longest output arc is achieved.

Congratulations! Your Flyback Driver 2.0 is now completed and operational.

## **Troubleshooting**

**PROBLEM:** No output arc. (Blue LEDs are not working)

**SOLUTION:** In this case, either Q1, Q2, Q3 or U3 has probably failed. Your unit will require diagnose and repair.

**PROBLEM:** Output arc is very small

**SOLUTION:** The output frequency of the driver may not be set correctly. Try adjusting potentiometer R7 to try to match the output frequency of the driver to the resonant frequency of the flyback driver. Also, ensure that the voltage output of Q1 is set at its maximum voltage. Potentiometer R4 is used to adjust this output voltage.

## **Conclusion**

We sincerely hope that you have enjoyed the construction of this Eastern Voltage Research Kit. As always, we have tried to write this instruction manual in the easiest, most “user friendly” format that is possible. As our customers, we value your opinions,

comments, and additions that you would like to see in future publications. Please submit comments or ideas to:

Eastern Voltage Research, LLC

Technical Support  
support@easternvoltage.com

Thanks again from the people here at Eastern Voltage Research.

### **Terms and Conditions of Sale**

Before opening or assembling your kit, please read and review the latest Terms and Conditions of Sale on our website at the following link:

<http://www.easternvoltage.com/terms.html>