WCFCountry
West Central Florida Section

THE WCF EXPERIMENTER

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FROM THE EDITOR:

My prayers have been answered. Some excellent articles have been submitted by amateur operators in the West Central Florida Section and we feature them in this quarter's edition. Many thanks to the authors for stepping up and I sincerely hope they and others will continue to do so in the future. On a different note, someone sent me a very good article on a light box that makes it easier to trace circuits on a circuit board. Unfortunately, all I have is the pictures. Somehow I lost the text. If this is your article, please resend me the text and your article will wind up in The Summer Edition of The Experimenter.

Etch Your Own Circuit Boards

By Bill Johnson KI4ZMV

Does this look familiar? This was an earlier project. It consists of a +/- 5-volt power supply driving an op-amp, which in turn turns on and off a clock, whenever the attached HT senses a signal on our repeater. Nightmare wiring jobs like this make you wonder if there might be a better way. There is. Etch your own circuit board.

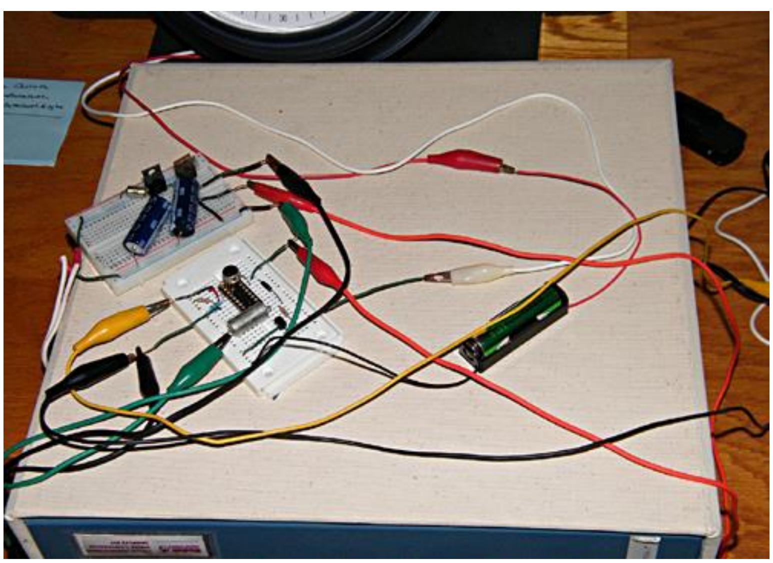


Figure 1. This is hardly a model of neatness. A custom circuit board would have made this both neater and more reliable. Page 1

If the complexity of etching your own frightens you, have heart. It is not as difficult as you might think. You may be pleasantly surprised to learn that the necessary software is available free, and that the etching chemicals can be found at any Wal-Mart. Just follow these simple nine steps.

Step 1. Prototype The Circuit

Before we get to the chemistry, you will first need a working circuit. This in turn has to be turned into a piece of artwork, which will later be transferred onto a copper clad board.
Figure 2 is a hand sketch of my prototype. This circuit converts RS232 to TTL using a Max232 chip. The board also contains a 5-volt voltage regulator. I built a breadboard version to verify that the circuit performed as expected from the sketch below.

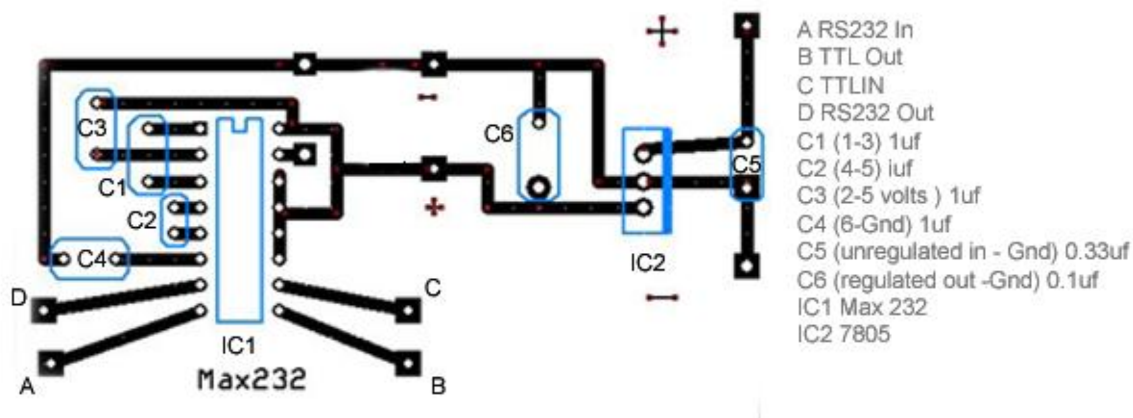


Figure 2. This is the circuit from which the prototype breadboard was wired, with the exception of the regulator that was added later. Figures 17 and 18 below show the transition from breadboard to circuit board.

Step 2. Create The Artwork

Guided by the circuit sketch, in figure 2, the next step is to create the artwork needed to etch your board.

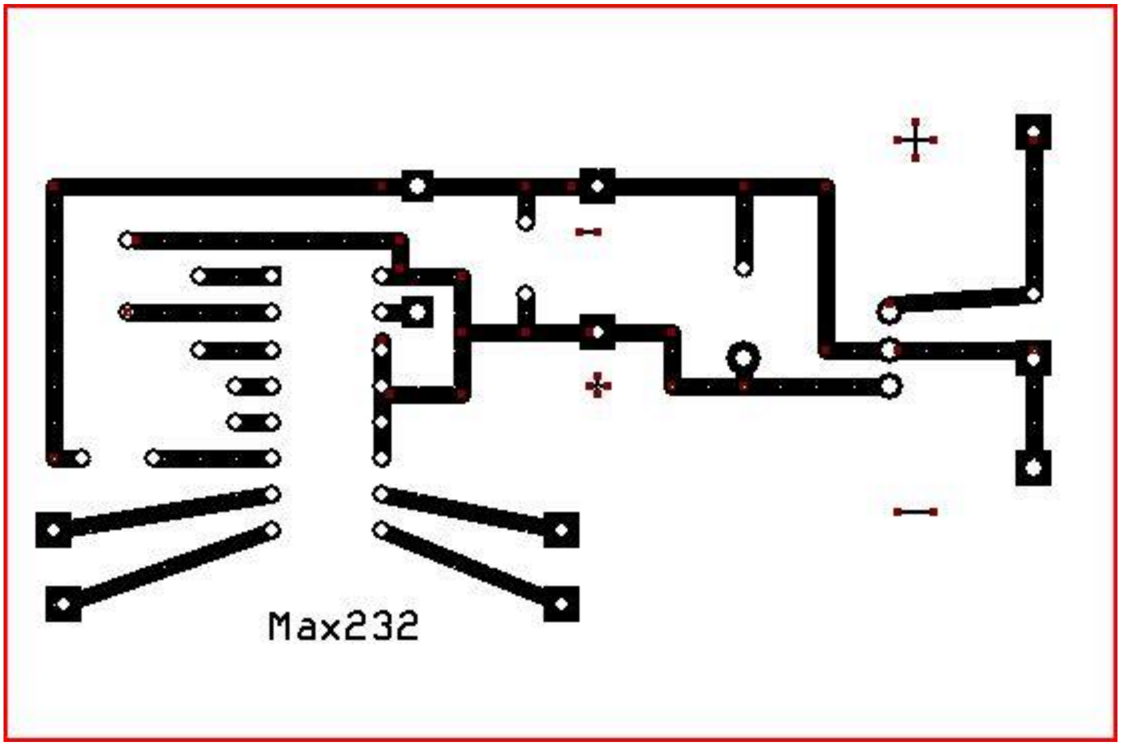


Figure 3. Artwork created using Express PCB

There are many options for turning your circuit into artwork, but the one I prefer is the software provided by Express PCB. You will find their free software at: http://www.expresspcb.com/expresspcb/. After you've made a few boards yourself, you may want to have the pros make your next one. That's up to you. The good news is that what you learn using their software will help you either way.

I will not go into using the software. The site above has excellent tutorials for that. I will assume you can get to the print stage. Figure 3 is an example of the printed output.
Here is something to keep in mind. For this procedure, you will lay your board out as if the traces were on the top, even though when you are finished, they will end up on the bottom side of the board, with your components on top. In the transfer process, the image will be reversed if viewed from the rear, but correct if viewed through the board, from the top.

Step 3. Print The Artwork

To transfer your artwork to a copper clad board you will need to first print it using a laser printer, the kind that uses toner. Inkjet will not work! Set your printer for high quality, heavy lay down.

The paper you use is critical. You want a paper that has a clay coating. You can find this in any stationary store. It has a glossy, magazine page look. I got excellent results with HP Presentation Paper 120g. A 250-sheet pack will last you a lifetime.

Of course, you will need some copper clad board. You can purchase new, or look for a supplier that sells scraps.

Step 4. Prepare The Board

The surface of the board must be cleaned. Any grease on the board will interfere the etching process, and possibly prevent a good transfer from your paper image to the surface of the copper. I have used S.O.S Pads, and sometimes cleanser and a sponge. The important thing is to end up with clean, shinny copper. The two boards in the back are finished. The one in the front is being cleaned.

Figure 4. Cleanser is a good choice for cleaning the copper on the board.

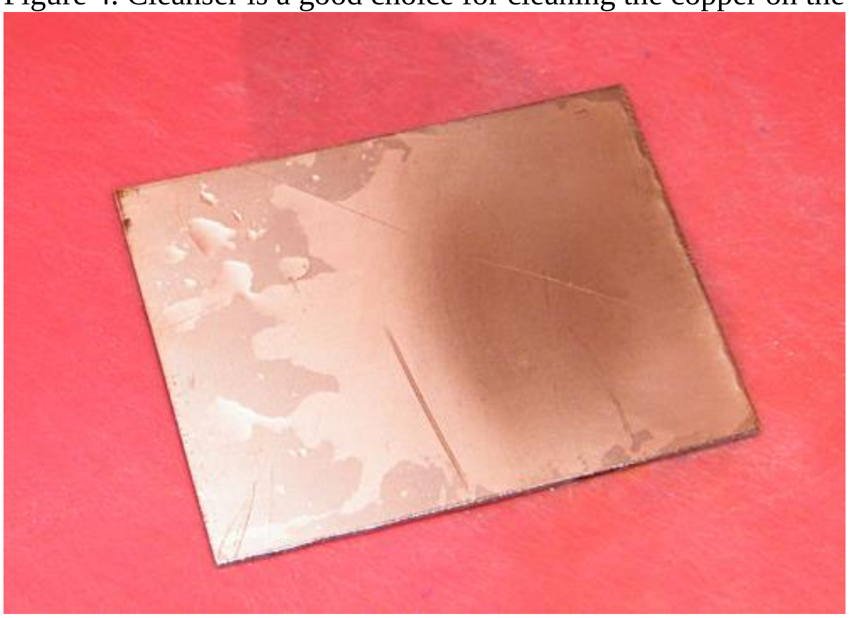


Figure 5. You can tell the surface is clean when water does not bead, and the surface is bright and shinny. Notice how the water beads on the left side of this board, but sheets on the right.

Step 5. Transfer The Image

The clean dry board is placed on a flat work surface. I use a piece of scrap plywood to protect the kitchen counters. It is a good idea to use some double-sided tape on the back of the board to keep it from moving around during the transfer process.

With the board in place you are ready to transfer your printed image. Carefully lay the printed circuit image face down on the copper side of the board, and then tape it to your work surface. You don't want it to move while you are applying heat and pressure.

Figure 6. The board is affixed to the work surface and under the sheet of paper containing the circuit. The image is face down.

The laser image consists of a heat sensitive resin. Our goal here is to re-melt this resin, and transfer it to the copper foil. Set the iron on high heat, and apply pressure. You will also want to move the iron around. Be careful not to move the paper. If you are concerned about the iron sticking you can place a sheet of standard copier paper over the one containing the image.

Step 6. Removing The Paper

Warning, the board will be hot after the transfer. Let it cool to the touch before you place it into a dish of warm tap water. Once in there, let it soak for a minute or so, gently rocking the dish back and forth.

After a time, the paper will become wet, and at that point you can gently peel it from the board. It will not all come off at once. Be patient.

Figure 7. After a minute or so the paper will come away from the board.

Figure 8. Most of the paper has been removed. Scrubbing with your fingers under running water will remove the rest.

At this stage you will have to gently scrub with your fingers to remove the last of the paper fibers. Don’t worry about damaging the transferred image. If everything went well up to this point, the toner has become one with the copper board.

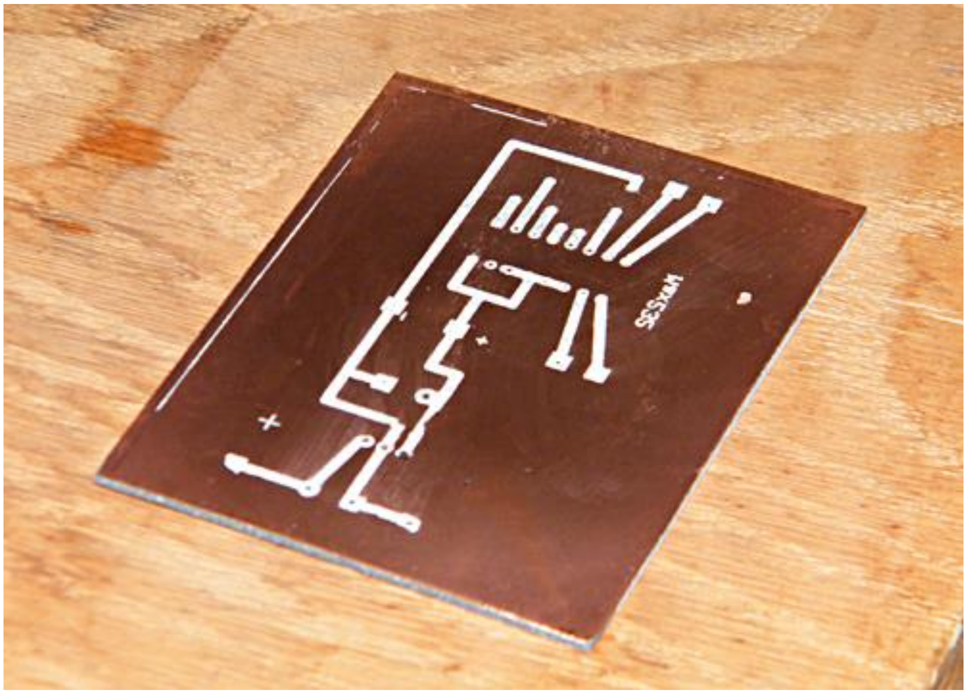


Figure 9. This board is clean enough and ready for etching. Note, there are some imperfections, but nothing major.

Step 7. Etch The Board

We are ready to etch away all the unprotected copper. You will need a mixture of two chemicals for this. Both can be found at Wal-Mart. The first chemical is hydrogen peroxide, the second is Muriatic acid. Hydrogen peroxide can be found in the drug department. You will find Muriatic in the paint department. It is used for cleaning bricks. It is also used to adjust the ph of swimming pools.

A word of caution! Muriatic acid can be dangerous if mishandled. Follow these simple precautions. Always add water, or in this case peroxide, to acid, never the other way round. And most important of all, wear some kind of eye protection. I also like to be near a source of running water just in case. I know all this may sound a bit scary, but if you use some common sense and are careful, you will be fine.

Figure 10. Notice I have a plastic measuring cup, and a glass tray for processing. *Do not use aluminum, or other metal pan for etching. Use only glass or plastic.*

The ratio of peroxide to acid is 2 to 1. For my board I measured out 4 ounces of acid, to which I added 8 ounces of peroxide making a total of 12 ounces. This was transferred to the glass baking-dish. Next I slid the board into the solution face up.


Figure 11. Board first immersed into the etching solution

Shortly after immersion, you will notice a dark discoloration form on the surface of the board. The chemicals are doing their job, but you have to help by gently rocking the tray back and forth. Alternately you can move the board around with an old toothbrush. Gently scrubbing the surface with the brush also helps. Be patient. The etching process takes about 30 minutes at room temperature. Rocking and scrubbing brings fresh chemical in contact with the copper, and at the same time moves the exhausted chemical out of the way.

Eventually all the copper will be eaten away leaving only the circuit traces.

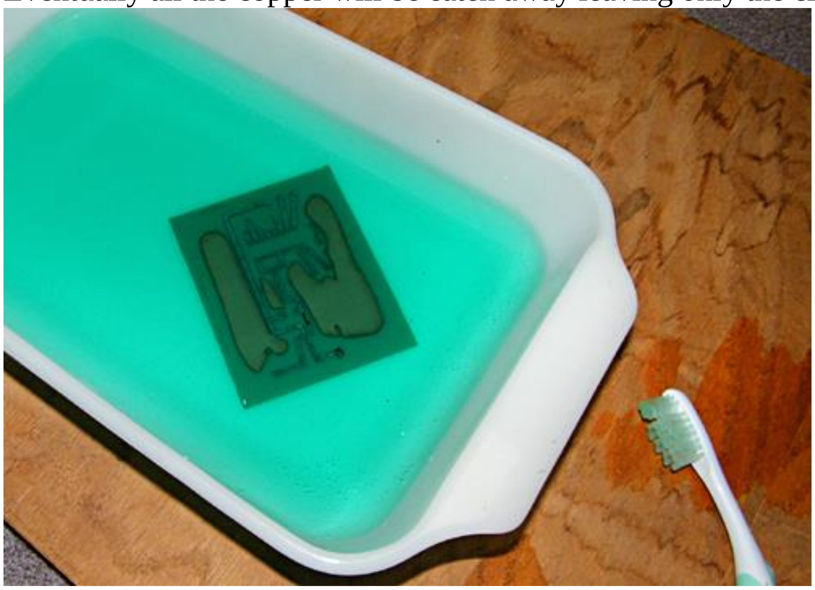


Figure 12. Almost there. Only a couple islands of excess copper remain.

Step 8. Clean Resin From The Board

After all the exposed copper has been etched away, you will have to remove the toner from the board. This is done with some steel wool, or an SOS soap pad. You will be amazed at how well the resin stuck to your copper board at this stage. A good deal of scrubbing is required to remove it.

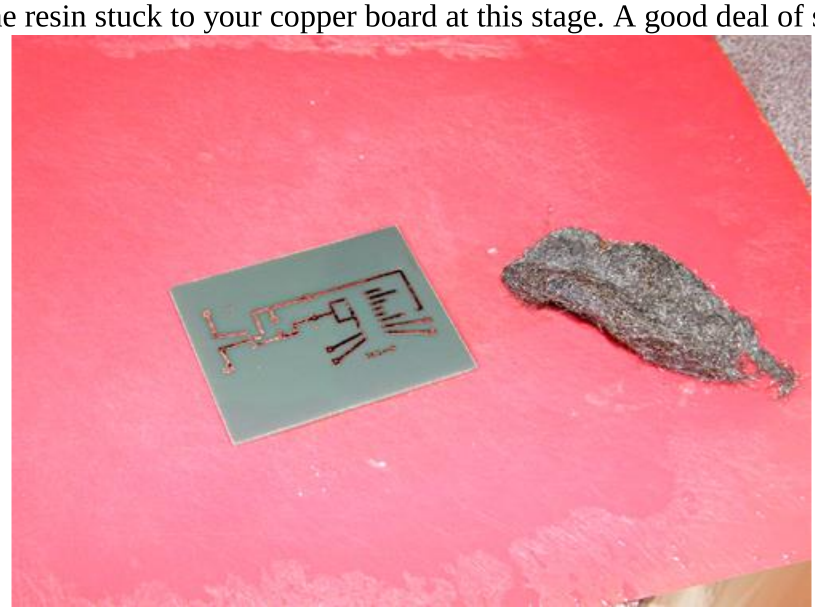


Figure 13. Steel wool is used to remove the resin from the image the remaining copper.

Figure 14 is what you are aiming for at this stage. All the unprotected copper has been removed, along with the resist. The foil is bright, shiny and ready for drilling.

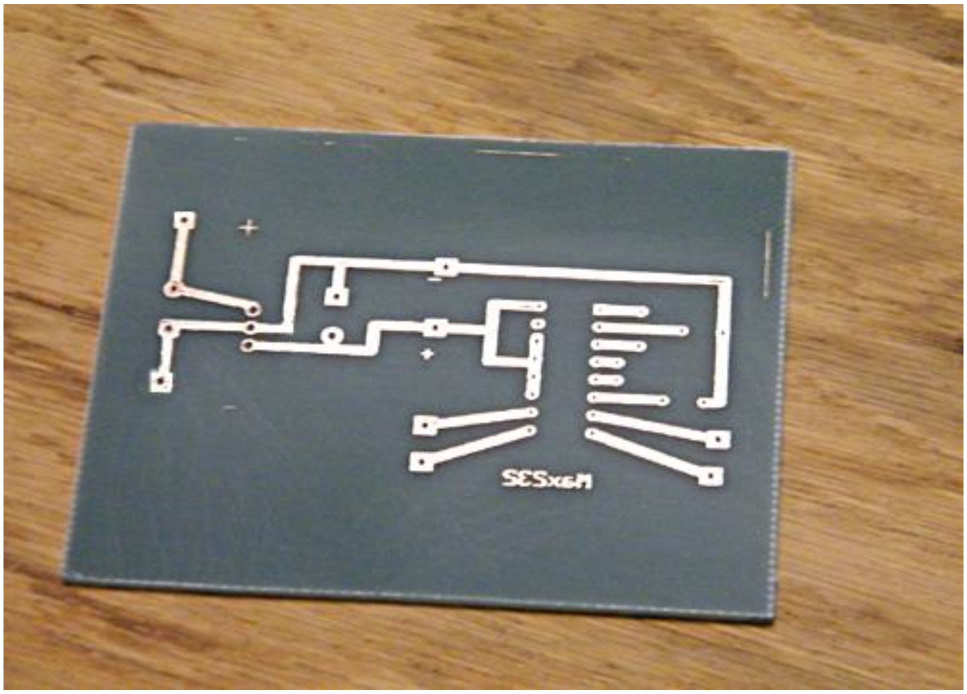


Figure 14. The cleaned board, ready for drilling. Not perfect, but serviceable.

Step 9. Drilling

We are going to need some very small drills for this step. I bought a couple sets of these at Harbor Freight. They were inexpensive, and work quite well. You do have to be careful not to snap them. They are quite small. We will be using one with a diameter of 0.025 inches.

Figure 15. Drill sets purchased at Harbor Freight.

I've been told that you can do this by hand, but I think a drill press is the way to go, along with a lot of light and a set of powerful magnifiers.

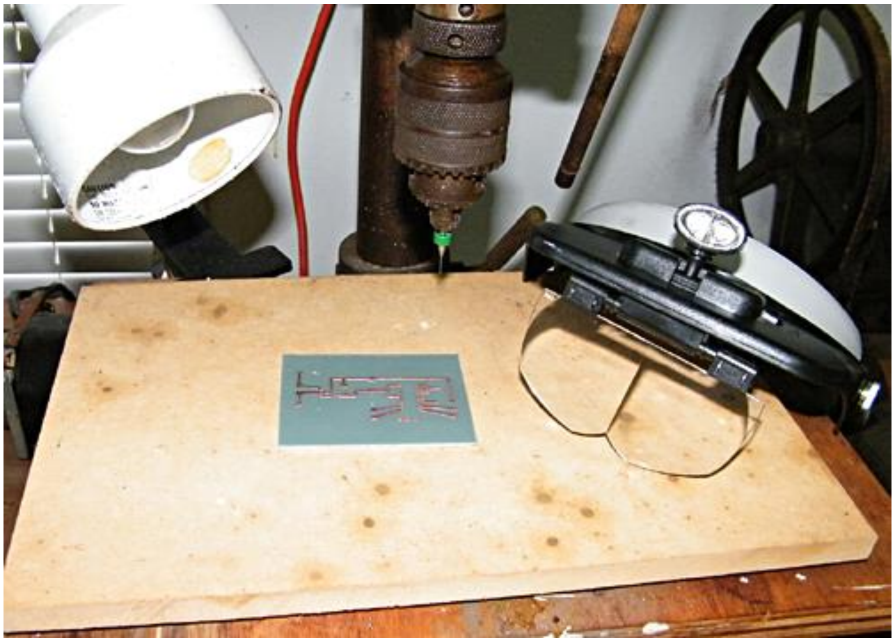


Figure 16. Board drilling setup

Figure 17 shows is the finished board etched, drilled, and ready for components. You are viewing the traces through the translucent board lit from behind. The sixteen-pin socket dropped in nicely. The 0.025 holes gave just enough wiggle room to accommodate the 0.020 pins.

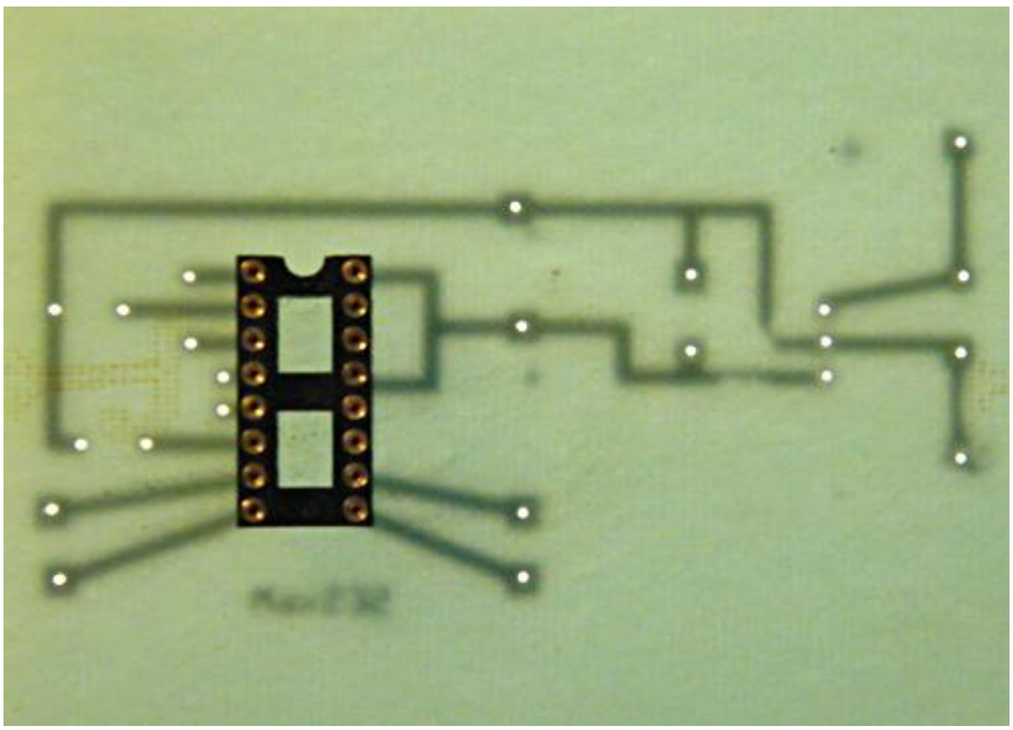


Figure 17. Image of the finished board viewed with transmitted light. The foil pattern is on the bottom side.

Here is the comparison of the finished circuit next to the breadboard version.

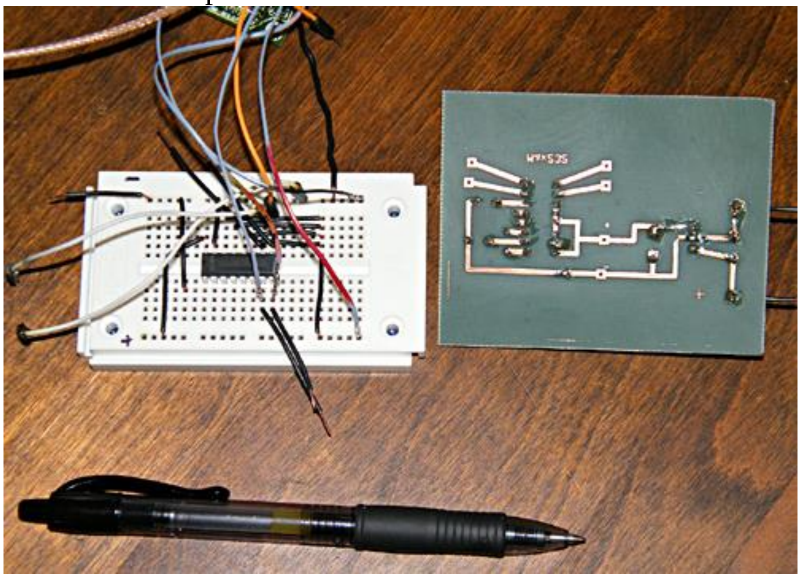


Figure 18. Breadboard next to final circuit board's foil side.

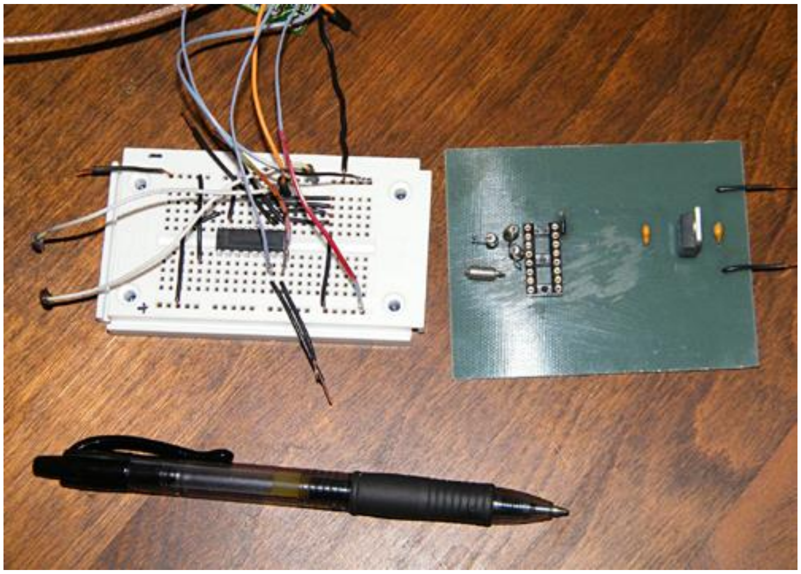


Figure 19. Breadboard next to final circuit board's topside. All components are in place with the exception of the Max 232 chip.

So here is a summary of the entire process:

1. Prototype the circuit
2. Create the artwork
3. Print the artwork on a laser printer using clay stock paper
4. Clean a copper clad board cut to size
5. Transfer the artwork to the board by applying heat
6. Remove the paper backing
7. Etch the unprotected Copper
8. Drill the holes
9. Populate the board

Not every project justifies your making a circuit board. They are a lot of work for something that will be used once or twice, and then placed on a shelf to collect dust. However, if your project will get some use, and more importantly, some day to day abuse, the circuit board is the way to go. The decision is yours. You now have the tools to fabricate your own circuit boards.

BITS AND BYTES – All About Microcontrollers

By Darrell Davis KT4WX

ARRL WCF Section Manager and ARRL Technical Specialist

Welcome back to our next installment of *Bits and Bytes*. I have been busy with my college studies and Section business so I have not had as much time to write and experiment as I would like but that is how it goes from time to time. Let us get to it.

MICROCONTROLLER TERMS: This month's new terms have to do with input and output ports that we defined last time. Certain ports on a microcontroller are designed to interface either to other microcontrollers or peripheral IC's. Now let us list and briefly list some of the most popular serial port standards in use today and we will introduce the concept of Pulse Width Modulation, a very common microcontroller technique and what it is used for in modern microcontroller design.

Serial Port Standards: Unlike in the desktop PC world, the serial port is still alive and well in the embedded (microcontroller) world and could not get by without them very well. The following are a list of the common serial port standards in use in the microcontroller world. I have not listed all serial standards, just the most popular ones:

❿ **SPI (Serial Peripheral Interface)** - Pronounced “spy”, SPI is a standard developed by Motorola, now Freescale Semiconductor, that uses four wires with the following signals: MOSI (Master Out Slave In), MISO (Master In Slave Out), CLK, and SS (Slave Select). A good reference article on SPI is on Wikipedia at https://en.wikipedia.org/wiki/Serial_Peripheral_Interface_Bus. This is a very common serial interface that is one of the most popular in use today.

❿ **I^{2}C** (**Inter-Integrated Circuit**) - Pronounced “I-squared-C”, is a standard developed by Phillips, now NXP Semiconductor, that uses just two wires with the following signals: Serial Data Line (SDA) and Serial Clock Line (SCL). A good reference article on I2C is on Wikipedia at https://en.wikipedia.org/wiki/I%C2%B2C.

❿ **UART (Universal Asynchronous Reciever and Transmitter)** - Pronounced “you art”. UART most often implements the RS232 data standard. The RS232 was formerly used in desktop PC's but is still in use in microcontrollers. The RS422 and RS485 are variations of RS232 but use the same data standard as RS232.

❿ **USB (Universal Serial Bus)** – yes even microcontrollers come equipped with USB serial ports either in USB Host or USB On The Go configurations depending upon the microcontroller.

❿ **CAN (Controller Area Network)** - Pronounced “can”, is a data standard first developed by Bosch for use in automobiles between the main ECM and auxiliary controllers. More and more microcontrollers are coming with CAN controllers on them.

There is an excellent tutorial for beginners on serial communication at https://learn.sparkfun.com/tutorials/serial-communication/all.

***FEATURED MICROCONTROLLER – RASPBERRY PI*:** Last time we introduced the Arduino. Now we introduce the Raspberry PI. The Raspberry PI is a 32 Bit ARM Microcontroller based full fledged microcontroller based computer that is designed to run a full operating system. The ARM is a microcontroller architecture designed and patented by ARM Holdings Plc., a British company, which does not manufacture the chips. Rather, they license out the architecture to the several different microcontroller manufacturers, such at Texas Instruments, ST Microelectronics, Freescale Semiconductor, AMD, Huawei, and Samsung. The ARM microcontroller architecture is what is used the modern smart phone or tablet.

Raspberry PI 1 – The Original:

First introduced in early 2012, the Raspberry PI was available in two models: Model A (without extra USB and Ethernet controller) and Model B (with extra USB and Ethernet controller). It had a Broadcom 2835 microcontroller. The Broadcom 2835 comes with: an ARM 11 microcontroller, with a single core processor, 700 Mhz clock speed, 256 MB of RAM, and onboard video controller. The later versions (called the Model B+) had 512 MB of RAM. The original Raspberry PI had two USB 2.0 ports, a 26 Pin header for input and output interface, an HDMI and composite (NTSB compatible) video outputs, and a sound card, output only. The Raspberry PI uses an SD Card slot for the user to plug in an SD Card which contains the Operating System. The main operating system choices is Raspian Linux but there are a few others that have ported to the Raspberry PI that are less well known. The Raspberry PI is powered from either a micro USB power connector, or one can supply +5VDC to the interface header. It takes approximately 700 mA of current at +5VDC to power the Raspberry PI for an approximate power consumption of 3.5 Watts of power. The street price of the Model A is approximately \$20-\$25 and the Model B is approximately \$30-\$35.

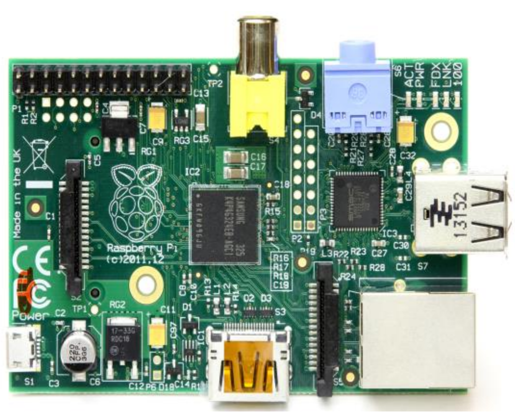


Figure 1: The Original Raspberry PI – Model B

Raspberry PI 2 – Second Generation:

A second generation Raspberry PI was introduced in 2014, called the Raspberry PI 2. The Raspberry PI 2 comes with a Broadcom 2836 microcontroller which replaced the previous Broadcom 2835 microcontroller. The Broadcom 2835 microcontroller comes with: an ARM Cortex A7 quad core microcontroller with a 900 MHz clock speed, 1 GB of RAM, and onboard video controller. The Raspberry PI 2 increased the number of USB ports from two to four, and changing the SD Card slot from a full card to a micro SD Card slot (saving board space), and increased the interface header from 26 pins to 40 pins. The power consumption is approximately the same as the original Raspberry PI, which is really neat considering the increased capability.

In addition to the operating systems that are already ported, mostly of the Linux variety, Microsoft Windows 10 ARM has been ported to the Raspberry PI as well. Now with full introduction of the Raspberry PI 2, the original Raspberry PI Model B and Model B+ have been discontinued but the original Model A+ is still being produced. The average street price of the Raspberry PI 2 is from $35-$40.

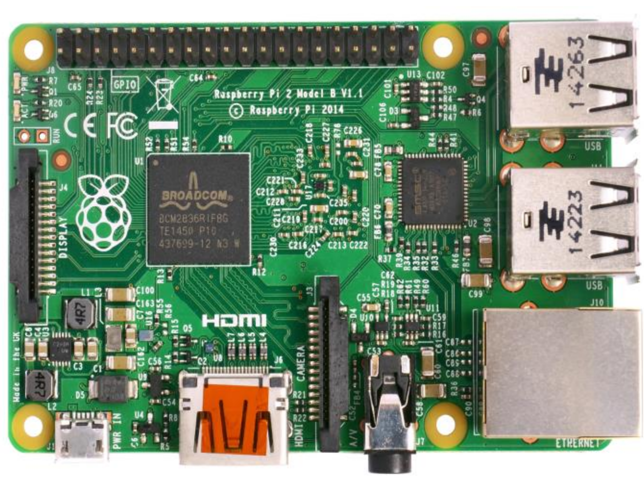
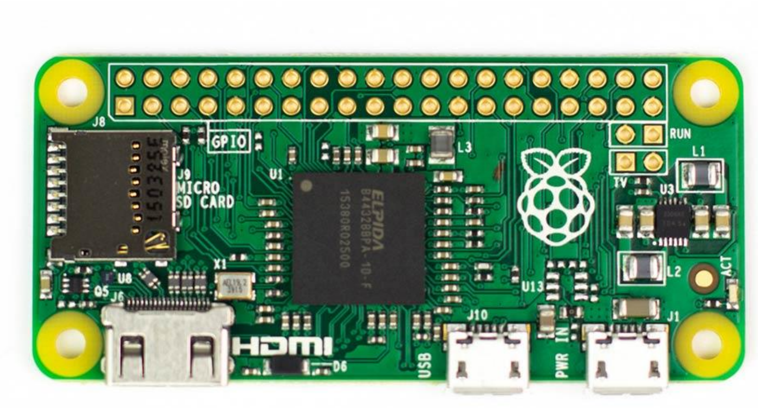


Figure 2 – The Raspberry PI 2 – Model B

Raspberry PI Zero – Later Comer:

Introduced in late 2015, the Raspberry PI Zero is smaller than the original Raspberry PI or Raspberry PI 2. The Raspberry PI Zero comes with the original Broadcom 2835 microcontroller, but with one micro USB connector, mini HDMI video connector. Also this version does not come with the 40 pin header or a composite video connector. However one can solder the appropriate headers onto the Raspberry PI Zero board as needed.

In addition to the small size, the Raspberry PI Zero only consumes around approximately 160 mA of current at +5VDC, for a total power consumption of just approximately 800 mW. The makes the Raspberry PI Zero ideal for integration into another project or device or where you need the power of the PI but with very low power drain. Also it is being advertised as going for the selling price of $5. That is right, $5, the price of a fast food meal on a budget meal. However as of this writing, the Raspberry PI Zero is not in stock with most dealers but that should change as time goes along.



For more information on the Raspberry PI you can read some introductory information on Wikipedia at https://en.wikipedia.org/wiki/Raspberry_Pi. You can also read quite extensively at the main Raspberry PI page at http://www.raspberrypi.org. There are many video tutorials on YouTube as well as PDF documents on the Raspberry PI that can be found a good Google search. It sure beats the old days when finding info was difficult if the device did not come with any print or documentation on a CD. How have times changed.

That is all for this installment of *Bits and Bytes.* Until next time, keep your soldering iron hot and your microcontroller code coming.

The ARRL West Central Florida Section Presents:

SECOND ANNUAL ARRL WEST CENTRAL FLORIDA SECTION TECHNICAL CONFERNCE

DATE: **Saturday February 27, 2016**

TIME: **ARRIVAL AND WELCOME - 8:15 TO 8:45 A.M.**
CONFERFENCE OPENING - 9:00 A.M.
CONFERENCE CONCLUSION - 5:00 P.M.

PLACE: **Hillsborough County Emergency Operations Center**
2711 E. Hanna Av., Tampa, FL 33610

COST: **No Admission Charge. Bring or buy your lunch**
Coffee provided courtesy of The Glorious Society Of The Wormhole
Dougnuts and Iced Tea courtesy of the ARRL West Central Fl. Section.

ARRL TECHNICAL PUBLICATIONS TO BE GIVEN AWAY THROUGHOUT THE DAY.

SPECIAL GUEST SPEAKER FROM THE ARRL LABORATORY: ED HARE W1RFI - LAB MANAGER

CONFERENCE REGISTRATION
May be made by several methods

Website: http://arrlwcf.org/wcf-special-events/wcftechconference/

Email: kt4wx@arrl.net

U.S. Mail: 6350 Mills Road
Fort Meade, FL 33841-9584

This conference is a conference on all technical topics in amateur radio. It is not just limited to digital technology but will no doubt include that. We are planning to have a variety of speakers in a variety of topics: Topics that are included but are not limited to include: Antenna Design, Mobile Radio Installations, HF Digital Communications, Digital Voice Modes,Microcontrollers, Digital Signal Processing, APRS, WinLink2000, and more.