SINCE 1948

ANODE

Official Newsletter of the West Rand Amateur Radio Club

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Upcoming Events / Meetings

10 JULY – Club General Meeting

15 JULY – WEST RAND AMATEUR RADIO CLUB AGM!!

27 JULY – HAMNET Monthly Meeting

14 AUGUST- Club General Meeting

31 AUGUST – HAMNET Monthly Meeting

HAMNET Net Every Thursday Night from 20h00 145.625 Repeater

All Welcome to Join in!!!

*** Keep up to date with all events using our RSS feed on the web site. Sync with your device, works with Android, and iOS. Visit www.zs6wr.co.za*

PTT

- **Clubs VHF Repeater 145.625**
- **UHF Repeater 439.000**
- **Echolink active on VHF**
- **DMR Repeater coming soon!!**

CLUB BULLETINS

Please Join us every Sunday from 11h15 CAT on the West Rand 145.625 Repeater for our club bulletins.

Relays on HF 7140 in the 40m band ! Echolink Available!

VISIT THE CLUB !!!!!

OPEN every Monday from 19h30

Wednesdays from 10h30 for POPS

Second Monday of every month is clubs General Meeting from 19h30

Editors Note:

Volume 4 is here, thanks again to everyone who has contributed. This month we have a great article by John ZS6YPJ, and Nic ZR6AEZ on PCB making and build an Icom CAT interface. This is definitely one to print and keep. Thanks for a great article and club tech talk on the same guys.

Please continue to send in articles and pictures, anything of interest, everything helps.

Apologies for a slightly later than normal edition, but personal life sometimes has to take priority.

Rory

ZS6RBJ

WE NEED YOUR INPUT !!!!

Please send any articles, pictures, information, anything you would like to see in the Anode to :

rorycrouch@mweb.co.za

All input and suggestions welcome!!!!

Visit the clubs Website

www.zs6wr.co.za

Chairman's Note:

Greetings to one and all. The SARL AGM, hosted by the West Rand Club, was a success and once again thanks to those who helped to make it so. Without the support of the members these activities would not be able to take place.
Club membership invoices have been sent to all members. A big thank you to those who have paid already. If you have not paid yet please do so as soon as possible

The Clubs AGM is being held on the 15th July. Registrations will start at 11:30 CAT for a 12:00 CAT start. Please make an effort to attend, but if you really cannot do not forget to fill in the proxy form and return it to the Club. Your vote is important for the Club.

The AGM is on the same day as the QRP contest, but we are hoping to juggle things around to enable ZS6WR to take part. Those members attending the AGM can make a contact from the Club. ZS6WR is leading the QRP contest at the moment.
The “Boot sale”held on the 3rd June was a huge success. There were lots of visitors and I think it might be one of the biggest ones we have had recently.

A lot of maintenance has taken place on and around the Clubhouse recently and I am sure you will agree with me that the Club is looking great. Thanks to those members who were involved.

The RAE started on Tuesday the 27th June. There will be about 11 candidates this time around. Good luck to the students.

73

Geoff Levey ZS6C

HAMNET Emergency Communications

A division of the South African Radio League

Gauteng South

West Rand Unit

MAY 2017 – JUNE 2017 ROUNDUP

Greetings and salutations to the West Rand and all the readers of this edition of the HAMNET Gauteng South - West Rand Unit Roundup.

What an amazing previous 2 months yet again and filled with all the disastrous events taking place around the country.

Great news this month is that our trusted Echolink Master and under cover HAMNET member has re-established the ZS6WR-R Echolink node and it is now operational once again. No more excuses for members who find themselves in areas not cannot access the West Rand Repeater.

On behalf of all the West Rand members, I would like to say thank you to HAMNET for the banners that have been distributed to all the regions. Glynn (ZS6GLN) thank you for allocating 2 banners to the unit, we will definitely put them to good use. Again, thank you all.

Weekly Nets and Monthly Meetings.

It was decided on 07 May 2017 to move the weekly West Rand Unit Net to a Thursday night and for the Monthly meeting to be moved to the last Thursday Night of each Month. The weekly novice net was also moved to the Tuesday Night.

As a result the weekly National Hamnet report was also moved to the Thursday Night net as the broadcast on a Sunday was interfering with Sunday lunches.

The purpose of the weekly net is intended to provide an "On Air" EmComm training platform and ALL HAMNET members are encouraged to attend the weekly nets. Non HAMNET members are more than welcome to call in and listen to the net as this will create an understanding amongst non HAMNET members of why it is crucial for EmComm Training and efficiency.

I need to also point out that no further event, disaster, emergency or exercise planning will be conducted via Whatsapp. All planning moving forward will ONLY be done "On Air" and notice of dates times etc. may still be disseminated via email, sms or Whatsapp.

Bike Awareness Run with Think Bike Marshals.

I wish to say thank you to all the members who participated in the bike run on 14 May 2017.

What an excellent training session in real time for all members. In summary the feedback has taught us that it is not easy keep up with bikes travelling at 100km + on a highway and that fast, accurate communications are required in events of this nature. The programming of radios is critical to any operation and we need to learn not to default our radios at the start of an operation either. We all need to ensure that we have programmed our radios to the correct deviation as well.

I think 2 of the most important lessons discussed was the generalisation of messages transmitted and that the relay of same and responses can and do create confusion and secondly as pointed out by Lean (ZS6LMG) EmComm Operators need to master managing

multiple radios simultaneously. This could be as many as 3 or 4.

Regional and National Situation report back.

With regards to the various protests and events that are taking place, we as HAMNET need to be careful NOT to politicise any of these situations which arise. We do however need to consider OUR preparedness as HAMNET for these situations as and when they occur.

At the end of May meeting Leon (ZS6LMG) discussed that we need to be self-sufficient for at least 48 hours if and when we are deployed. This we will have to discuss in more detail moving forward and for those who closely monitored the various road closures and especially the Western Cape storm will know that without any advanced warning Knysna was all but destroyed by fire.

There are many lessons to be learnt from these situations and ALL members need to be "on the same page" which means we still have a lot of work to do team.

Even though the Western Cape HAMNET teams were activated and deployed and some were directly affected by the evacuations that were ordered, it was really great to hear that members of the West Rand did actually make an effort to tune up on the HAMNET HF frequencies as a "Standby" exercise. Thank you all.

With all these happenings we cannot ignore the fact that technology (lol) did fail in Knysna and even though we think radio towers are indestructible, this past month has shown us something different. I again ask you all to consider the following statement made in the previous Anode.

*Technology is great, as long as it works LOL. As can be seen now with no Echolink, we should never rely on any form of communication that relies on technologies such as Cell Phones or Internet, especially for HAMNET purposes, as they really become an issue when members have no alternate means of communicating. "**When all else Fails, Amateur Radio will not.**"*

I therefore encourage all HAMNET members to make a concerted effort to get both your base stations and mobiles operational as a matter of urgency. If you need help, ask, I know there are members who will be more than willing to assist you. Also come and spend more time on air with us.

HOW PREPARED ARE YOU

Marketing HAMNET.

During the May meeting, Glynn (ZS6GLN) and Leon (ZS6LMG) raised the need to engage the City of Johannesburg Disaster Management and highlighted the need for a full blown MARKETING campaign to draw in new members and grow the teams throughout Gauteng South. The East Rand have an existing MOU with the City of Ekhuruleni and now need to expand into COJ as well. The central and south areas also needs to be developed and grown.

All members are therefore asked to talk with other hams and potential hams and bring them on board.

TRAINING

For those who have not been able to attend any training sessions over the past 5 months or if you would like to attend either way, I am setting aside 08 July, 22 July and if needed 09 August 2017 for EmComm Training to be held at my home QTH. Please let me know who will be attending.

73 and 88 to one and all
Chad Mileham - ZS6OPS
HAMNET Gauteng South - West Rand Unit Coordinator

"Be Safe, Be Prepared and be Happy"







"HAMNET, the Emergency Communications division of the South African Radio League (SARL), provides communications for emergencies and can mobilise experienced communicators who with their own radio equipment will back up official channels or take over when all else fails."

All Amateur Radio Operators in good standing with SARL are welcome to join HAMNET. Please sign up on the National HAMNET Members Portal website. www.hamnet.co.za

West Rand Amateur Radio Club Established 1948

Kroton Street South
Weltevreden Park
P.O. Box 5344
Weltevreden Park, 1715

eMail/ePos: zs6wr.club@gmail.com
Website: http://www.zs6wr.co.za
Repeater frequencies: 145.625 MHz
Herhaler Frekwensies: 439.000 MHz

ZS6WR Banking details:

West Rand Amateur Radio Club
Standard Bank
Acc# 003892166
Northcliff Branch,

WEST RAND AMATEUR RADIO CLUB AGM 2017

Dear Member

The West Rand Amateur Radio Club will be holding its AGM on 15 July 2017 from 12h00. Please join us at our club house on Kroton Street South, Weltevreden Park for the event.

Members wishing to put forward nominations for committee may do so using the attached nomination form, to be received by a committee member via email or at the club house no later than 30th June 2017. Please note nominated person/s should be paid up members in good standing.

Members wishing to put forward motions for the AGM may also do so. Motions are to be received by the committee on or before 30th June 2017.

Registration for AGM as well as submissions of proxy/nomination forms will take place from 11h30 so that the AGM can commence at 12h00.

Should you be unable to attend, please complete and email/deliver the attached proxy form to be received by a member of the committee no later than the 14th July 2017

New members and current members who would like to pay the 2017/2018 membership fees may do so prior to the AGM or on the day. Please include your call sign as a reference number when paying by EFT. Please send all EFT/ bank deposit slips to zs6wr.club@gmail.com

We look forward to seeing you.

Regards (on behalf of the WRARC)

- Phillip van Tonder (Secretary)
  ZS6PVT

(Please note, while it is not compulsory, any person wishing to RSVP before 30th June 2017 may do so, and this will also help with gathering numbers for catering purposes)

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PROXY FORM
WEST RAND AMATEUR RADIO CLUB AGM 15th July 2017

(Please complete in block letters)

I_____ (name)_____(call sign) a paid up/life member of the West Rand Amateur Radio Club hereby nominate _____ (proxy name) _____(proxy call sign), also a paid up//life member to vote/take part on my behalf at the AGM of the WRARC to be held at 12h00 on the 15th July 2017

Signed at _____ on this _____day of _____2017

Name: _____

Signature: _____

COMMITTEE NOMINATION FORM
WEST RAND AMATEUR RADIO CLUB AGM 15th July 2017

The following form to be completed by a paid up/life member of the West Rand Amateur Radio club. Please ensure that person/s nominated are also paid up members in good standing and that they will be able to carry out the duties required as a committee member.

Person/s nominated must also be in agreement and should be made aware of nomination beforehand.

I_____(name) _____(call sign) hereby nominate the following member/s to act on the committee of the West Rand Amateur Radio Club from 15th July 2017, for a period of 1(one) year until next AGM to be held in 2018

Name	Call Sign	Committee Role	Nominees Signature

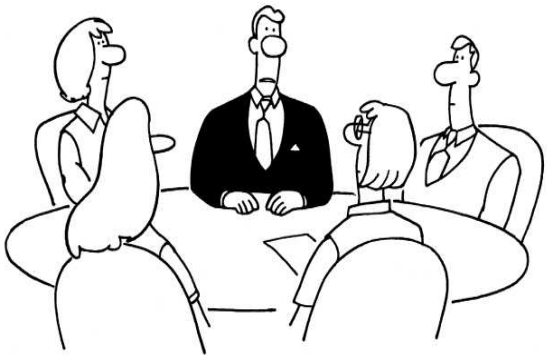
Nominators Signature: _____
Date: ___

Motion:

The motion 8.1.2 was tabled and open for debate.

Old motion reads:
8.1.2 For all club meetings, AGM or Special General Meeting a quorum will be 20% (twenty percent) of Members in good standing, including all written proxies.

New motion:
8.1.2 For all club meetings, AGM or Special General Meeting a quorum will be 10% (ten percent) of Members in good standing, including all written proxies.



"Whew! That was close!
We almost decided something!"

ICOM USB CAT & sound card interface with PCB by toner-transfer method

John Stiekema ZS6YPJ[1] Nic van Duffelen ZR6AEZ[1] June 25, 2017

[1]West Rand Amateur Radio Club, Kroton Street, Roodepoort

This is not the first and will not be the last article dealing with do-it-yourself manufacture of printed-circuit boards, using the toner transfer method. While this toner transfer method has been around since laser printers became popular, good results are often elusive. The particular variant of the method described here, has been used very successfully for many years, for both once-off prototyping and production runs of small single-sided PCBs. The method is easily learned and applied with average hobbyist skills, readily-available tools and materials, some bits from the scrapbox or metal merchant, an etching solution, common household chemicals and materials, and of course due care to prevent failure, injuries and harm to the environment. The authors are confident that with due attention to some highlighted points, the reader will be able to duplicate the method to reliably produce PCBs of excellent quality in their home workshop (or on the kitchen table). The application described, is a very useful USB interface to allow PC applications (HRD, WSJTX, etc.) to operate the radio. The variant described is suitable for ICOM radios with DIN auxiliary socket and data bus jack.

1 Introduction

What is a printed circuit board? Wikipedia[2] is our friend: "A printed circuit board (PCB) mechanically supports and electrically connects electronic components using conductive tracks, pads and other features etched from copper sheets laminated onto a non-conductive substrate. Components (e.g. capacitors, resistors or active devices) are generally soldered on the PCB"

We describe a method of making printed-circuit boards at home, using a variant of the toner transfer method that has surely been used by hobbyists to produce PCBs since the ready availability of laser printers. In contrast to other methods of PCB production, the particular variant of the toner transfer method described here has been used with 100% success to produce at least 20 prototypes and hundreds of production PCBs made for both academic and hobby purposes for more than a decade.

A successful project involving a printed circuit board, requires a useful circuit to be designed. As a second (and often integrated) step, the PCB layout and artwork is designed, using PCB CAD software. There are potentially many complex activities to be carried out in this process. For example, if the circuit deals with high power or high voltage the current-carrying capacity of tracks and their separation must be looked after. High power circuits may involve heat dissipation and the component layout and artwork must consider component temperature and any intended means of heat dissipation.

If RF frequencies and particularly VHF and higher frequencies are dealt with, the mechanical placement of components becomes critical; and progressively more so as frequency increases. At the higher frequencies the PCB design and component layout invariably gives rise to (unwanted or wanted) circuit characteristics. If unwanted, these are termed *parasitics* and their influence needs to be designed out—but if they are wanted they need to be designed in. An example of circuit characteristics implemented by PCB design, is the antenna for a short-range WiFi card implemented as copper tracks around the edge of its PCB.

What kinds of PCBs can be produced? The method for DIY manufacture of PCBs described here, has some characteristics and limitations as described in the paragraphs below.

- *Single-sided vs double-sided* PCBs may implement conductive tracks on one or two surfaces, and even on intermediate layers between the surfaces. The present project is implemented with a single-sided PCB. Although double-sided boards may be produced with a process based on this method, the

additional complexities are beyond the method described in this article[1].

- *PCB size supported.* The PCB required for this project is small. While very suitable for small PCBs, there is essentially no limit to the size of the PCB that may be produced using this method; the size of single-sided PCB that may be produced depends on the size of your transfer tools and materials. Of course, if there is a size limit applicable to your PCB CAD software, this needs to be taken into account.
- *Precision supported.* Copper track widths and clearances beween these down to at least as small as 0.008" (0.2mm) are easily produced. Finer tracks require more precise temperature control and care with the transfer process to prevent smudging. The authors would recommend printing tracks and clearances no smaller than 0.012" to begin with.
- *PCB material supported.* Any heat-proof PCB material (i.e. resistant to temperatures at which laser printer toner melts) such as FR4 or even the older paxolin material, may be used. Any thickness may be used, up to 2.5mm thick and down to 0.5mm thick has proven successful. Single sided copper-clad PCB stock material is required, with copper layer in a bright and clean state.

2 The project

To demonstrate the PCB making process, and serving a useful function in its own right, we present a circuit designed by Nic ZR6AEZ with its PCB designed by John ZS6YPJ.

The application is a USB interface module, to deal with interfacing your radio to PC applications (for various purposes, including radio control for digital modes such as RTTY, PSK31 and WSPR). The present variant suits any ICOM radio with auxiliary DIN socket and data bus jack, i.e. with auxiliary connection facilities as identified in Figure 1.

The interface module described, uses a USB serial port (the BOB) to deal with connections to the CI-V data bus (TXD/RXD), SEND/PTT (RTS) and FSKK (DTR). It also includes convenient connections for interfacing with the PC sound card: MIC input from radio AF output, and SPKR out to radio MOD (modulation) input. The sound card could the PC sound card or a stand-alone USB sound card plugged into another USB port on the PC)—so the interface between the PC and radio could be two USB ports only, or via a single USB hub.

The interface module looks after the following functions:

Control bus interface (freq., mode, etc.):
rig CI-V bus ↔ RXD/TXD (serial port) ↔ USB ↔ PC ↔ PC radio control software[2]

PTT TX control:
PC radio control software → radio PTT (SEND) input

FSK/RTTY input:
PC radio control software → radio FSKK input

Audio interface for TX modulation:
PC sound card speaker output → radio MOD input

Audio interface for RX audio:
rig AF output → PC sound card mic input

See Figure 1 for circuit details of the interface module. The list of components for the project is presented in Table 1.

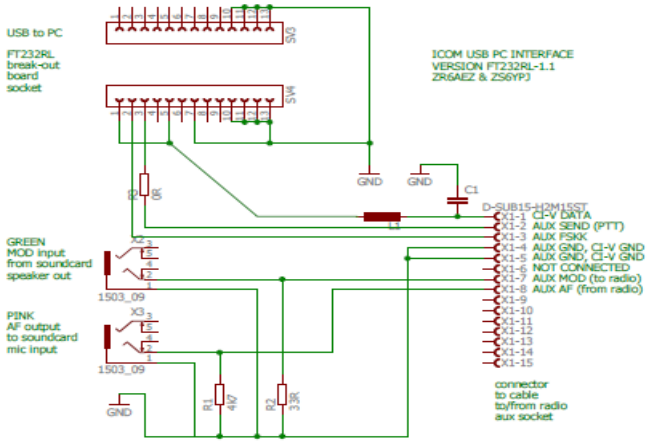


Figure 1: *ICOM USB interface - circuit schematic*

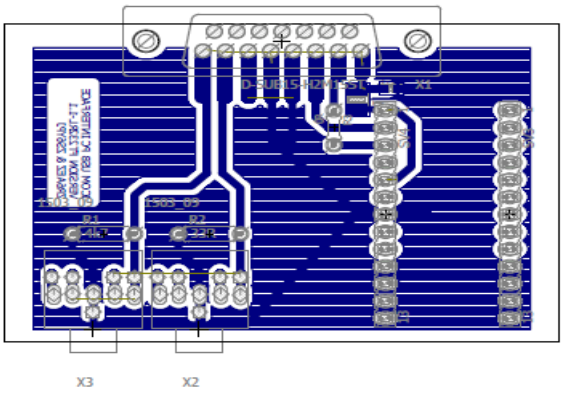


Figure 2: *ICOM USB interface - PCB layout & artwork*

[1] Production of double-sided boards can be dealt with in future, if required.

[2] See the manual for the radio and the control software for details on what functions are accessible via the CI-V interface.

Table 1: *List of components (from EAGLE®)*

Part	Value	Description / Package
C1	10n	C0603
L1	27u	L3225M
R1	4k7	0207/7
R2	33R	0207/7
R3	wire link	0204/5
SV3	SIL socket	13p (9p used for BOB)
SV4	SIL socket	13p (9p used for BOB)
X1	D-sub 15p	solder-type socket
X2	Stereo Jack	3.5mm
X3	Stereo Jack	3.5mm
BOB	FT232RL	DIL18 (into SV3, SV4)

*http://www.giga.co.za/ocart/index.php?route=product/product&product_id=208&search=ft232

3 PCB production

3.1 Tools and Hardware

The tools are "common-or-garden" or at least if not in your's then in your neighbour's or children's or father's garden...

Computer with image manipulation software such as photoshop, inkscape or gimp. Beyond the CAD software that produces the image of the PCB you would like to manufacture, you are going to need copy, paste and move the image, to prepare it for printing. Ideally, you'd want to use the entire width of your paper, so depending on the size of the PCB, you'd want to rotate the image if necessary and copy rotated or non-rotated images, arranging these in a sequence of closely-spaced PCB images from left to right from one printing margin to the other. You would use as many lines of PCB images as you need—the limit being the height of the paper.

Laser printer. Several monochromatic laser printers have successfully been used for this process, including a few HP LaserJet 4 variants, HP LaserJet 1020, and more recently the Samsung M2020 with best results obtained using high-quality 1200dpi mode. Colour laser printers have not been used at all.

Temperature-controlled heat source. An old steam clothes iron that no longer steams, but still controls temperature at the "cotton" setting, is perfect.

Heat reservoir and PCB heat transfer device. An offcut of aluminium at least 25mm thick, and with length and breadth as large as the largest PCB you may want to make (but smaller than the largest paper size you can print in your printer). You can get this at Metals Center in Selby, or other places that sell aluminium plate.

Heat-proof roller. A roller from an old photocopy machine or laser printer is required. The roller should be at least as long as the width of the largest PCB you intend to make.

Plastic trays for holding chemicals for the processes. Photographic trays are good, though 2-litre ice cream tubs do just as well, provided your circuit board fits into it with lots of room to spare. You will need one for the etching solution, one for paper digesting solution (caustic soda) and one for clean water for rinsing.

Toothbrushes at least two would be useful, one for assistance with paper removal and the other with the etching process if required.

Thick building nylon line or weadeater replacement line, 2×20cm lengths will be useful. Box of matches or lighter to melt the line ends, and a drill bit large enough to feed the nylon line through a convenient location on the PCB, to be able to support the board and agitate it in the etching solution.

3.2 Materials

The materials will be found around your house (or your neighbour's, your son or daughter's, your father's) and at the electronics shop.

Copper-clad PCB stock material. You can buy this from Mantech or Communica, and other places besides. The most economical way to buy is by full stock sheet, 1.2m×1m of copper-clad FR4 board, if this amount can be used.

Get the thinnest material that will do the job. Too thin is no good, since boards that flex too much will become unreliable. Too thick eats your drills.

Inkjet glossy (coated) photopaper will act as the laser printer toner transfer medium. Epson photo quality glossy inkjet paper 140g/m^2 weight, works well.

Note that high-quality *inkjet* photo paper is used in your *laser* printer, and this is done at your own risk—the authors will not accept any responsibility for damage to your equipment.

A4 photo paper, when cut in half gives two A5 pages that can be landscape-fed into the printer. For even better utilisation of your photo paper, for smaller circuit boards, the A5 paper can be cut in two length-wise and stuck onto the full width of the top of a sheet of normal A4 paper with double-sided tape.

Normal printer paper for print testing using "economy" mode

3.3 Chemicals

PCB cleaning and degreasing materials. I have found Chemico cleaning powder and Zims scouring pads to be very useful. I have found Vim to be less useful, since it contains large scratching particles, unlike Chemico. Some people use acetone for degreasing, personally I prefer soap and fine scouring elbow grease action. Use plenty of water to rinse. If the water is too hard, final rinse with distilled/demineralised water may be wise.

Transfer "developer" solution for digesting the paper onto which the toner is printed. This is not absolutely required (plain water can be used also) but it does shorten the process of removal of the paper from the transferred toner. Caustic Soda (Sodium Hydroxide, NaOH) is used for this purpose. Make the solution by dissolving two teaspoons of caustic soda crystals in water in one of your ice cream tubs (be careful of splashing in eyes or on hands).

The etching solution recommended (amongst others which are suitable) is ferric chloride. It is highly corrosive and stains everything, and is non-poisonous in before it has reacted with copper (it is in fact used in water treatment processes).

Accoring to [3] which in turn cites a standard chemistry text, Iron(III) chloride (ferric chloride) etches copper in a two-step redox reaction to copper(I) chloride and then to copper(II) chloride, in the etching of printed circuit boards.

$FeCl_3 + Cu \longrightarrow FeCl_2 + CuCl$

$FeCl_3 + CuCl \longrightarrow FeCl_2 + CuCl_2$

In practice, we have noted some precipitation of iron from the solution also, this converting quickly to a crusty, rusty layer on the bottom of the tub, which can be rinsed out after decanting the remainder of the etchant when storing for re-use.

To improve the reactivity of used ferric chloride, the temperature can be raised prior to etching, up to close to boiling point if required (since this is still below the temperature required to re-melt the toner). Putting the solution in an ice cream tub in the microwave is a good way to heat it up.

Note that while the authors will not accept any responsible for destroyed, corroded or discoloured microwave ovens and corresponding lack of friendliness in the kitchen, we have not encountered any problems while heating ferric chloride using this method, provided that nothing is spilled. Since accidents can always happen, we strongly advise putting the tub containing the ferric chloride into another container that will hold the contents it if the first springs a leak. In any case, the lot should be placed onto a bed of newspaper or in a cardboard box in the microwave oven.

Note particularly, that the iron sludge at the bottom and sides of the container, may cause holes to be burned in the plastic tub, causing leaks. Hence the importance of filtering out any iron precipitate sludge at the bottom of the etching tub after a few etching sessions. Prior to shelf storage, the partially-used ferric chloride may be filtered with a coffee filter and stored in a convenient non-metallic container for later re-use.

When the reactivity of the ferric chloride is slow even if the solution is heated close to boiling, it is exhausted must be disposed of.

Etchant neutraliser. For disposal of ferric chloride etchant, mix with your digester solution (use extra NaOH if required—excess is not harmful) then wait for the floc to form (which is a safer/less soluble form of the iron and copper metal salts) then dilute and dispose of down the drain.

See the appendix of this document, for further details on disposal of spent etchant (as well as filters and iron oxide sludge that collects at the bottom of the etching tub).

3.4 PPE

Since we will be working with potentially hazardous chemicals and power tools, appropriate precautions are required to prevent damage to our eyes, hands or clothing.

Rubber gloves to prevent skin damage from exposure to caustic soda, ferric chloride and caustic soda (and all product species besides).

Light leather gloves to prevent burns during the hot transfer process.

Goggles or protective glasses are essential for preventing of eye damage due to splashes of the liquid chemicals.

Chemical-resistant overalls (or old ones) are advised, for protection of your clothes from the corrosive and staining effects of the chemicals.

Nearby sink with clean cold running water is essential, and if not available a portable eye bath is required.

3.5 The PCB Production Method

The PCB production method is described in sequence.

1. Prepare the transfer
   (a) Prepare the transfer image: Using your image manipulation software, copy/rotate the PCB underside image (use Figure 3). Note that the image of the underside copper is viewed as if from the top through a transparent board.

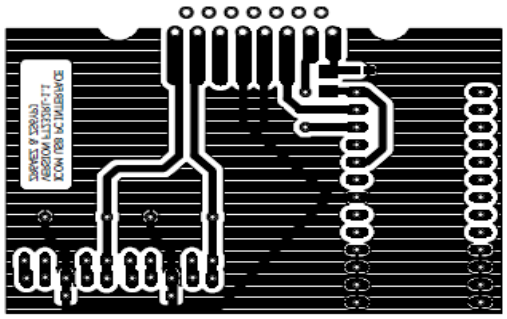


Figure 3: *ICOM USB interface PCB copper side (actual size)*

(b) Duplicate the image as many times as required to fill the entire A4 page width between your printer's printing margins. This is the *transfer image*.
(c) Verify print: Print the transfer image on plain paper using economy (toner saver) printing mode, and verify that the scale is 100% by checking that your *largest multi-pin component fits onto its intended location*.
(d) Print the transfer: Place clean dust-free, fat-free sheet of A4 paper in the printer output tray for the transfer to nestle on. Insert the photo paper into the paper tray, glossy side to be printed on and avoid fingering the glossy side. Set the printing mode to *black* and *highest quality*. *Never* touch the printed side, unless you would like to learn the value of a fat-free transfer surface. Remove both the paper and photopaper (the transfer safely between) and place in a plastic sheath for storage.
(e) Cut transfer to size: Just before transferring, carefully and without touching the toner surface, cut to the size of the PCB blank. At least the two alignment edges must be very straight.

2. Prepare transfer tools
   (a) Clean and scrub the transfer plate before heating it.
   (b) Place the heating iron on top of transfer plate, set the temperature setpoint correctly ("cotton" may work for you too). Wait for the transfer plate to get hot. Too hot produces smudgy effects, too cold does not properly remelt the toner.
   (c) Set the transfer roller ready for action.
   (d) Get a dry, fat and dust free wooden clothes peg (remove the spring) to assist with alignment of transfer.
3. Prepare PCB blank
   (a) Cut PCB blank exactly the right size, or a few mm oversize. De-burr the edges well. Make sure you have at least two straight sides to align with the transfer.
   (b) Clean PCB blank. Use Chemico paste on a fine scouring pad to clean copper to bright pink. Rinse well. There must be zero greasiness on the PCB blank copper surface. Clean the edges and top also. Prevent contamination from any source. Rinse well and drip-dry on fat free surface, copper side not touching anything. For hard water areas, last rinse to be demin/distilled water.
4. Prepare etchant
   (a) Decant your ferric chloride solution into 2l ice cream tub. Be careful, the solution is corrosive and poisonous.
   (b) If the etchant has been used a few times before and is becomming slow, heat it: Place it on some newspaper or in a pizza box into the microwave oven, for not longer than 6 minutes for 1l of solution at 900W microwave power, to bring room-temperature solution from 25°C to close to boiling (scale heating time up or down depending on volume, microwave power and starting temperature). Be careful, the solution is hot, corrosive and poisonous.
5. Prepare "transfer developer" solution (paper dissolver solution)
   (a) Make a 7% solution of caustic soda in water (strength not too critical—chuck two teaspoons of the stuff into 1l of room-temperature water in an ice cream tub). Be careful, caustic soda is corrosive and poisonous.
   (b) Stir with a toothbrush, which is now also ready for action if required.
6. Transfer (re-melt the toner to the copper)
   (a) Place the clean PCB copper side up on the heated transfer plate. Don't worry if it buckles, it will flatten again.
   (b) Remove the transfer from its protective sleeve and quickly cut to size (or it is cut already).
   (c) Holding the edges only, carefully place one edge of the transfer on the edge of the PCB blank. Use the clothes peg to align. Be very careful not to commit the transfer until it is aligned—any misaligned touch will cause the process to need to be repeated.
   (d) One the transfer position is committed, place the roller on the committed edge and roll initially with light pressure, then with moderate pressure. Using heavy pressure will cause the toner to flow on the copper, giving a smudgy effect.
   (e) Remove the PCB with transfer paper stuck to the top from the transfer plate. Natural air cool slowly to room temperature (chuck it on a newspaper sheet on the table and leave it to cool)
7. Develop the transfer (remove paper layer from toner layer and from PCB copper)

(a) Place the transfer in plain water or caustic soda (paper digester solution).
(b) Wait 10 minutes or so, for the paper to disintegrate. If using plain warm (not hot) water to soften, wait as long as it takes for paper to soften and start lifting (can be 30 minutes or longer, depending on the paper used). Remove any residual paper layers by scrubbing the transfer with the toothbrush.
(c) Rinse and dry the board—drying on the still-hot transfer plate is most convenient.
(d) If any whiteness appears on the transfer, the paper materials have not been properly removed. We are most concerned with removing anything stuck to the copper areas, since the etchant must get access to all areas not masked by the toner. Re-soak in water/digester solution and scrub away all traces of the paper with the toothbrush.
(e) Rinse, dry, inspect and if clear of all whiteness from the paper (only black toner and copper should be visible) then the PCB with its toner mask, is ready for etching.

8. Etch the PCB
   (a) Drill 4 holes somewhere non-critical (or corresponding to mounting holes) to take the weedeater nylon. Melt the underside ends, making etching handles.
   (b) Dunk the board in the etchant, agitating continuously with the handles.
   (c) From time-to-time inspect the etching progress. If too slow, stop the etch, rinse the board and first heat or re-heat the etchant.
   (d) If certain areas are too slow, help along with the toothbrush.
   (e) Holding to the light from time to time to check etch progress—once all copper is removed between all tracks (and not 10 seconds longer) dunk the etched board into another 2l tub with clean water.
9. Drill and final preparation
   (a) Either hand or machine drilling may be used. Start with large drills and move to smaller.
   (b) Lightly sandpaper surface to deburr drill holes. Some of the toner will start coming away.
   (c) Completely wet a cloth/toilet paper with acetone, and quickly wipe over the board to remove the remaining toner. Don't spend time doing this, or the board surface will dissolve in the acetone and combine with the toner, causing at least blackness but at worst reduction in quality of insulation of gaps between tracks (toner is part carbon which is conductive)
   (d) Cut to size if required.
10. Clean up
    (a) Decant etching solution into glass bottle using funnel with filter paper. Seal and store for future use (prepare to heat it next time it is used).
    (b) Take the filter paper and iron oxide sludge at the bottom of the etching tub, and add the left-over "developer" solution and add extra caustic soda if required. You need to convert the brown/green liquid into a clear liquid with a light-coloured floc that will settle at the bottom of the ice cream tub.
    (c) The clear liquid and floc can now be agitated and diluted, and disposed of in your sewer drain. The floc will be a precipitate of iron hydroxide and copper hydroxide, both of which is are not very soluble in water and therefore safer to throw away in your drain. The clear liquid will be normal table salt mixed with the extra caustic soda, and this is safe enough to dilute and flush away down the sewer drain.

4 Assembly and testing

Discrete components. Solder the SMD components first, first tin one pad on the PCB, then re-flow the tinned pad with the corresponding device pin, while holding the device in place. Solder the other pin (or pins, for multi-pin devices). Insert and solder the through-hole resistors, jumpers and stereo jacks.

USB to TTL serial Break-Out Board. Solder two 9-way SIL pin headers onto the BOB. This may be directly inserted into your PCB and soldered—or else solder a 18p DIL wide socket (flat blade type socket required, not turned-pin socket) to plug your BOB into. You may have to cut down the pin header pins a bit, to get the BOB to sit on top of the socket properly.

Cut and drill the box. Measure carefully then drill holes for stereo jacks to poke out of your box. Drill holes and fret-saw in between for mini-USB socket on the BOB. Make the cut-out to sink the D-sub 15 socket into position (note that it is not soldered yet)

Solder D-sub 15 socket. Adjust position on the PCB of this socket, so that the mounting tabs of the socket push flush against the side of the box, then solder the D-sub 15 socket in position.

Finalise. Drill two ϕ3 mounting holes in board (somewhere in ground plane) and corresponding holes in box. Mount the PCB, spaced off the box lid with M3 countersunk bolts, each with three nuts and include washers behind nuts you will tighten to secure the bolts onto box lid and PCB.

Dsub15 plug ↔ 13pDIN plug, and Dsub15 plug ↔ 3.5mm mono plug. A short (300mm) piece of 3-pair

or 4-pair cable (e.g. scrap CAT5 UTP cable) is needed to join appropriate pins of D-sub 15 plug to the 13p DIN plug, which goes into the radio AUX socket. A similar length of RG174U or audio coax is required to join the D-sub 15 to the 3.5mm mono plug, which goes into the radio CI-V jack.

The D-sub 15 plug will have two cables from it, one to the DIN 13p radio AUX plug and the other to the 3.5mm mono plug to radio CI-V socket. See the circuit diagram Figure 1 and your radio user manual, for details.

Testing. Plug in USB cable, and make sure software (e.g. WSJTX) talks to BOB. Check 5V power, RXD and TXD indicator LEDs work. Plug in sound card patch cables between sound card and PCB stereo jacks. Adjust levels to make sure input to PC and ALC of radio are not excessive. All systems go—this is where the fun starts!

References

[1] AUTODESK® **EAGLE**, Version 8.2.2, © 2017 Autodesk, Inc. All rights reserved.

[2] wikipedia, https://en.wikipedia.org/wiki/Printed_circuit_board#Chemical_etching

[3] wikipedia, https://en.wikipedia.org/wiki/Iron(III)_chloride, 2017-06-18

[4] wikipedia, https://en.wikipedia.org/wiki/Sodium_hydroxide, 2017-06-24

Glossary of terms

artwork	the copper pattern on the PCB
BOB	break-out board (USB to TTL-serial interface)
CAD	computer-aided design (software)
CI-V	ICOM data bus
EAGLE	PCB design software
$FeCl_3$(aq)	50%mol ferric chloride etching solution
IC	integrated circuit
NaOH(aq)	7%mol caustic soda (sodium hydroxide)
PC	personal computer (djou kompoeta, djou leptop)
PCB	printed circuit board
PCB stock	single-sided copper-clad fibreglass sheet that will become a PCB
PPE	personal protective equipment
RXD	serial port received data
SOIC	small outline integrated circuit
SMD	surface-mound device
TTL	0-5V "transistor-transistor logic"
TMD	through-hole device
TXD	serial port transmitted data

APPENDIX

A Disposal of used ferric chloride etching solution

From Yahoo answers we find what appears to be trustworthy guidance, since it agrees with experience and is based on plausible chemistry:

"When you pour the Iron(III) Chloride on to a Copper-clad computer board with your circuit traced out on it, the enchant will eat away the undesired Copper by Oxidizing it to the very soluble $CuCl_2$ and reducing the $FeCl_3$ to $FeCl_2$.

After you use your enchant, you will have a solution of $FeCl_2$, $CuCl_2$, and probably some remaining $FeCl_3$. All of these can be removed from solution by precipitating the metal ions out using a Hydroxide.

All of the Iron/Copper Chloride salts in your used etchant solution are quite soluble, but their Hydroxides are barely soluble. if you add some Sodium Hydroxide ('lye', commonly found in drain cleaner), you can form the metal Hydroxide precipitates which can be filtered or decanted off, leaving a much milder solution behind.

$FeCl_3\,(aq) + 3\,NaOH\,(aq) \longrightarrow Fe(OH)_3\,(s) + 3\,NaCl\,(aq)$
$FeCl_2\,(aq) + 2\,NaOH\,(aq) \longrightarrow Fe(OH)_2\,(s) + 2\,NaCl\,(aq)$
$CuCl_2\,(aq) + 2\,NaOH\,(aq) \longrightarrow Cu(OH)_2\,(s) + 2\,NaCl\,(aq)$

Make sure and dilute the solution before you add the NaOH (preferably a NaOH solution). Dissolving NaOH in water is a very exothermic process, so the solution's temperature will rapidly rise if you are not careful. It is also a very bad idea to get any NaOH in your eyes or on your skin, so be careful but when used responsibly NaOH is fine.

When the Hydroxide precipitates are heated, they will form the metal Oxide salts. So for example, by heating $Cu(OH)_2$, you will form CuO. The heat generated by the above reactions might also be enough to convert the Hydroxides into Oxides, so that is certainly a possibility but disposing of Fe_2O_3, FeO (or the combination of the two, Fe_3O_4), and CuO should be no problem.

The remaining NaCl solution will be no problem disposing of down the drain, as would any excess NaOH which happens to remain."

◇

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