Microvolt

May 2024

Antenna Time

Do you like antennas? Do you like to build antennas? Do you like to install antennas? Do you like how they look? If so, then let's talk antennas!

It's well-known in the amateur community, that if you have the worst radio on the market, but a good antenna, you can likely make your signal heard far and wide. By the same token, if you have the world's best radio and a lousy antenna, your signal is not likely to reach across the street any better than with a dummy load, if even that well.

So, if your antenna is really what matters, which antenna is the best? If not the *best*, just what does it mean to have a *good* antenna? We amateurs have a double-burden of designing and creating antennas that can not only receive well but can transmit well too.

Cover – The antenna

Norman Rockwell painted ***New Television Antenna*** for the 05 November 1949 issue of ***Saturday Evening Post*** in an effort to bridge generations. Today's modern reader could not imagine how happy new TV owners were, just to see a blurry, flickering black-and-white image for the first time.

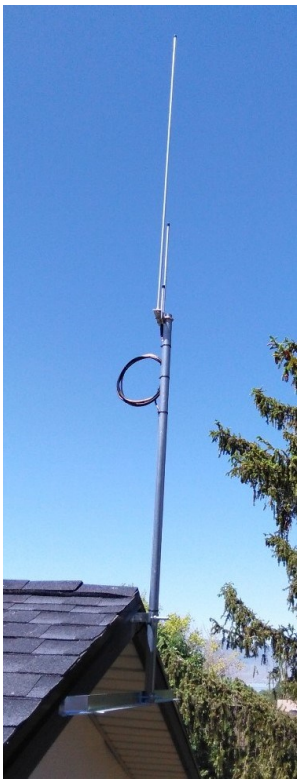
Ever since the first antenna by **Heinrich Hertz**, the challenge has been to design the ultimate antenna. The term ***antenna*** was coined by **Guglielmo Marconi**, when he raised some transmitting wires by a tent pole, called *l'antenna centrale* in Italian, a reference to a ship's mast. The shortened *antenna* soon caught on, and the word was born.

An antenna can be any electrically conductive object or material, can passively (doesn't require an additional power source) collect radio waves and convert them into electrical signals, and/or can passively convert electrical signals into radio waves. Most metallic objects (car body, house wiring, chain-link fence, tooth filling, aluminum siding, screwdriver, etc.) are not designed to work as antennas, but antennas they are. The objects that *are* designed to be antennas still appear in a variety of shapes, such as copper wire, aluminum tubing, and parabolic dishes.

Through the mysteries deep in the branch of physics known as ***electrodynamics***, an antenna performs its magic by interactions between moving electrical charges and the invisible fields that influence them. We mere mortals experience these interactions when we communicate with another station by means of these magical devices.

Perhaps the simplest of antennas is the ***dipole***, ideally a half-wavelength long of the target frequency. Indeed, it can be said that most amateur radio antennas are dipoles in one form or another. These include the center-fed dipole, off-center-fed dipole, fan or parallel dipole, Yagi beam, end-fed, J-pole, monopole, inverted-L, and the random or long wire.

Antenna properties



An antenna is said to have ***gain*** if more of its transmitted signal is directed (focused) in one direction than in others, like the effect of a flashlight reflector dish on its light. And the principle of ***reciprocity*** states that an antenna's receive properties are identical to its transmit qualities, so the same antenna will exhibit its strongest "receive gain" in the same direction. But an antenna can exhibit strongly transmitted and received signals in more than one direction, with weak spots between them. This three-dimensional combination is known as its ***antenna pattern***, and is often drawn to illustrate how much of its signal is aimed in multiple directions, to aid in antenna design or placement.

The antenna feed point impedance is an important quantity, for ***matching*** to its feed line, or coaxial cable in most cases. If not matched, some of the signal delivered to the antenna can be ***reflected*** back to the radio, often measured by ***SWR (standing wave ratio)***. And just as often, to reduce your antenna's SWR might require you to use a matching circuit or ***tuner***.

We can talk about antennas until we're blue-in-the-face, but you can read more in **this short but informative discussion on antennas** and how they work, without getting too bored or lost.

Microvolt editorial staff

Editorial – Why get a better antenna

A friend recently asked me for some advice on his radio setup, which consisted of a 2-meter mobile radio connected by 75 feet of RG-8X to a **Pockrus J-pole** on his roof. He said he felt his radio wasn't giving him the punch he needed, to communicate with his son on simplex two towns away, even at full power, which is 50 watts. He wondered if I knew of a VHF / UHF radio that can crank out, maybe, 100 watts.

I knew where he and his son live, so I simply, and almost flippantly, suggested that he upgrade to a higher-gain antenna, something like the Diamond X300A antenna. I told him, while he was at it, he should probably also upgrade his coax to LMR-400. Naturally, he wanted to know how changing two mere components would help more than a better radio, adding that, as he was increasing the power on his mobile radio, his son gave him increasingly improved reports.

So, we looked up the specs on the two antennas, and started making comparisons. According to **published test data**, the Pockrus J-pole has 2.6 dBi (or 2.6 dBi - 2.15 dBi/dBd = 0.45 dBd) of gain on 2 meters. According to **Diamond's website**, the X300A has 6.5 dBi (or 6.5 dBi - 2.15 dBi/dBd = 4.35 dBd) of gain on 2 meters. At the same time, we looked up the loss figures for the coaxial cable. According to the **coax chart**, the loss on 2 meters per 100 feet of RG-8X is 4.5 dB, and the loss on 2 meters per 100 feet of LMR-400 is 1.5 dB.

Gains and losses measured in dB are nothing more than unit-less multipliers, calculated by

number of dB = $10\log_{10}$(output watts/input watts)

Their respective multipliers are therefore

RG-8X : 4.5 dB per 100 feet x 0.75 = 3.375 dB (about 54% loss, or 46% to the antenna)

LMR-400 : 1.5 dB per 100 feet x 0.75 = 1.125 dB (about 23% loss, or 77% to the antenna)

The 0.45 dBd gain of the Pockrus J-pole translates to x 1.109

The 4.35 dBd gain of the Diamond X300A translates to x 2.723

So, if he's transmitting with 50 watts on 2 meters, the actual ERP (effective radiated power) is

RG-8X and J-pole = 50 watts x 0.46 x 1.109 = **25.5 watts (roughly half the maximum)**

RG-8X and X300A = 50 watts x 0.46 x 2.723 = **62.63 watts**

LMR-400 and J-pole = 50 watts x 0.77 x 1.109 = **42.7 watts**

LMR-400 and X300A = 50 watts x 0.77 x 2.723 = **104.8 watts (roughly twice the maximum)**

This means that if my friend upgrades his antenna to a Diamond X300A and his coax to LMR400, his son can receive potentially twice as much signal power, instead of a fraction of the power, his radio can put out. The words "his son can receive" are important here, because my friend won't be magically generating that extra 54.8 watts from nothing. He's simply *focusing more of the power he's sending out, to a narrower audience*, similar to how a parabolic flashlight reflector focuses more of the light in a particular direction. This is the definition of *antenna gain*.

And now you know why I've installed a tall antenna (**Diamond X510HDM**, in my case) connected by LMR-400 to my indoor mobile radio. Let's see whether my friend does a similar thing.

Noji Ratzlaff KNØJI

Anything to add? Email **editor@utaharc.org**

Letters to the editor

Dear Editor:

I'm not sure I understand PL tones. It sounds like if several people are on my frequency, they can all hear me, but if I put on a PL tone, I can only hear the ones using that code. Is that right?

Paul in Provo

Dear Paul:

A CTCSS tone (also called FRS "code" and formerly "PL" tone) is simply a low-frequency hum sent or received along with your audio signal, but filtered out at the receiver, thus also called a "sub-audible" tone. Your receiver squelch circuitry reacts to its presence, compared with the noise level, depending on your radio settings. Your radio can be set to transmit a tone ("transmit" tone) and it can be set to receive one ("receive" tone). If your radio is set to receive a tone on a particular frequency or channel, you won't be able to hear anybody that's not also sending that same tone. If your radio transmits a tone, it doesn't prevent anybody listening on your transmit frequency from hearing you, but allows those on the same frequency using that same receive tone setting to hear *only* you.

Dear Editor:

I just recently got my license, and I've called out my call sign on the 146.620 repeater a dozen times and said, "listening," hoping somebody would answer, but I've never gotten a response. I know my radio works, because I've talked with a friend on the same repeater a few times. Why are people ignoring me? Am I saying something wrong?

Casey in Salt Lake City

Dear Casey:

First, welcome to the world of amateur radio! Second, we're glad you're trying to reach out and make contacts. As you've experienced, publicly attempting to attract the attention of somebody who's never met you, in a hobby of introverts can be a challenge. One thing you can try doing is changing what you say when you call out. Some hams might not know how to respond to a "KI7ABC, listening" announcement. Instead, try saying, "KI7ABC, anybody out there want to make a contact with a new ham?" Finally, it might help to make yourself known, by attending some club meetings or Field Day, after which you might no longer be a stranger to them.

Dear Editor:

Is it legal to use ham radio while you're drunk or under the influence? Not that I want to get on the air drunk (I don't drink), but when I encouraged my wife to get licensed, she reminded me that she's not able to get a driver's license because of the prescription medication she's on, so that got me thinking.

Sam in Eagle Mountain

Dear Sam:

It's not illegal to transmit on amateur radio while under the influence of alcohol, Marijuana, or medication, legal or otherwise. Then again, I can't say the same if you're mobile.

Dear Editor:

Will rain and snow affect the signal from my antenna if I install it outside on the roof?

Blair in Ogden

Dear Blair:

Yes, weather moisture can indeed affect both reception and transmission of the radio signal through your rooftop antenna, a little more noticeably on VHF and UHF, but not often noticeably on HF. On the other hand, if water gets into your connectors or your transformer ("balun") enclosure, it can affect your signals drastically, and not often for the better.

Send your thoughts to ***editor@utaharc.org***

Club news

Our most recent indictee into the Elmer Hall of Fame is Scott Rosenbush K7HSR, who presented a humorous and yet gracious discussion on **the importance of elmers and elmering** in our April 2024 club meeting.

Scott Rosenbush
K7HSR

An ***elmer*** is a person who mentors another ham radio operator by sharing, teaching, helping, and encouraging him or her, especially during those early years after being licensed. Scott gave instances from his own journey into amateur radio to highlight times and situations in which he was the beneficiary of elmering. He said that an elmer actually gave him some second-hand radio gear to help get him started, for which he was very grateful.

He strongly encouraged those who have been helped by an elmer to become one themselves. Scott emphasized that a person does not need to know everything about any facet of amateur radio to become an elmer.

And to those reaching out for help from an elmer, Scott said that he tends to have a better experience by talking with an elmer face-to-face than by asking questions on social media.

Scott has been a licensed ham for less than two years, and currently serves as the Public Information Officer for the ARRL Utah Section.

You can see the video presentation here: ***https://www.youtube.com/watch?v=WMajy7W0JLQ***. You can also view past club meeting presentations on our YouTube channel: *https://www/youtube.com/@UtahAmateurRadioClub*

(Photos courtesy James Bennett KK7AVS)

Letters to the editor

Starting with the March 2024 issue of *Microvolt*, we've been printing selected letters to the editor (see page 4). Please email submissions to **editor@utaharc.org**. We invite thoughtful, humorous, technical, and even controversial comments and questions, but please include your name and town. Entries will be accepted and edited for content at the discretion of the editorial staff. Speaking of which, if you're interested in joining said staff or would simply like to help proofread issues prior to publication, please also contact us.

For your information

Microvolt has expanded!

Your club newsletter *Microvolt* is now longer than the 8 pages you're used to. See the rest of the story in the online version, located at

user.xmission.com/~uarc/Microvolt/2024/May2024.pdf

Field Day 2024

Saturday noon 22 June through Sunday noon 23 June **near Payson Lakes**. We plan to start setting up Thursday night about 6:00 pm.

Annual UARC Steak Fry

Saturday 20 July 2024 at the **Spruces Campground**, **site GRP7** starting around 3:00 pm.

License classes

Salt Lake:

General : Tuesdays 7:00 pm to 9:00 pm
147.160+ MHz (127.3 Hz tone)

Orem:

Extra : 5 Tuesdays, 6:30 to 9:30 pm
Jul 16, Jul 23, Jul 30, Aug 6, Aug 13
Visit **psclass.orem.org** to register ($10)
Orem Traffic Training Room, 95 E Center St
HamStudy.org account required
Email **nojiratz@hotmail.com** for info

Eagle Mountain:

Technician : 5 Thursdays, 7 to 9 pm
May 23, May 30, Jun 06, Jun 13, Jun 20
Technician : 5 Thursdays, 7 to 9 pm
Aug 29, Sep 05, Sep 12, Sep 19, Sep 26
Email **ki6oss6365@gmail.com** to register (free)
Eagle Mountain City Hall, 1650 Stagecoach Run

Exam sessions

Salt Lake County:

- Email Garth Wiscombe W7PS **w7ps@arrl.net**
  May 20, Jun 24, Jul 29, Aug 25, Sep 30, Oct 28, Nov 25
- Email Rick Morrison W7RIK **w7rik@arrl.net**

Utah County:

- Sat 27 Apr 2:30 pm : **Provo** : **signup**
- Wed 15 May 7:00 pm : **Provo** : **signup**
- Sat 04 May 10:00 am : **Eagle Mtn** : **signup**

Club repeaters

Farnsworth Peak : 146.620– MHz (no tone)
Scott Hill : 146.620– MHz (no tone)
Lake Mountain : 146.760– MHz (no tone)

SDRs and Beacons

Northern Utah WebSDR : **sdrutah.org**
KK7AVS SDR : **k7xrd.club**
K7JL beacon 28.2493 MHz

HF remote and club transceiver stations

If you'd like to learn how to get started using the remote stations, visit the **HF remotes link** on **the club website**:
https://user.xmission.com/~uarc/HFRemote.html

How can I help?

Reach out to the club leadership by sending an email to **uarc@xmission.com**. Also, add to this page by emailing **editor@utaharc.org**

Spotlight – Chuck Johnson WA7JOS

Chuck Johnson WA7JOS got in to amateur radio in 1968 while attending Skyview High School in Smithfield, Utah. His electronics teacher was a ham radio operator, and there was an amateur radio club station at the school. Eventually, Chuck had upgraded to an Advanced amateur radio class license, and today holds an Extra-class license.

After graduating high school, Chuck attended Utah State College in Logan, where he received an Electrical Engineering degree. While there, he met his wife Arlene. Chuck and Arlene have 7 grown children, 3 girls and 4 boys.

Chuck's wife Arlene is KD7IZC, and also has her Extra-class license. Three of their sons also have their amateur radio licenses. In all, there are 16 licensed amateurs in Chuck's extended family.

Chuck's first job after college was repairing two-way radios, and he held that job for 5 years. Later, he became a design engineer for Broadcast Television Systems, and held that job for 24 years. The company, which has changed names many times, started as Telemation, an offshoot of KUTV channel 2. They manufacture products for television studios including routing switches.

Around 1976, Chuck became a member of UARC. Years later when Lon Stuart WM7E was the editor of *Microvolt*, Chuck was the Braille editor. Chuck copied a Braille version of *Microvolt* onto a floppy disk and sent it to the Utah State Library for the Blind. That was so cool, because it allowed us to get *Microvolt* in Braille.

In 1995 Chuck was elected UARC Treasurer, and he's been the UARC treasurer for 28 years, only retiring from that position last fall. Chuck has been a fantastic bookkeeper, and as a result, we've never been in the hole. He has always made sure that we had enough money when we wanted to start on a project.

Field Day is Chuck's favorite activity in amateur radio; in fact, he has never missed a Field Day since he became a licensed amateur. It all started when their children were small. Arlene and Chuck would take their children and spend the week at Payson Lakes to make sure that UARC had its spot. Even though the club has a permit, it might not get its desired spot because it's essentially first-come, first served.

Now that their children are grown, Chuck and Arlene still go up the Tuesday before Field Day to secure our spot. From his first Field Day, Chuck has always been there to set up beforehand and take down afterwards.

There are several ways UARC can make points during Field Day, and hosting an educational activity earns 100 points for the club. For that, Chuck has taught classes such as soldering, antennas, and CW during Field Day throughout the years. He also enjoys attending the Annual Steak Fry, which he has never missed since becoming a member. Chuck wants to encourage more members to participate in activities such as the Steak Fry, Field Day, and other activities throughout the year. Chuck is a true elmer who likes to help others whenever he can.

Chuck, we appreciate all of the contributions you have made over the years to UARC and amateur radio!

Linda Reeder N7HVF

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We encourage you to submit original pictures (highest resolution), articles, book reviews, software and hardware descriptions, nuggets of humor, and responses to editorials. Email the content, pictures attached, to the editor at **editor@utaharc.org** by the 24th just prior to the target month.

The **Utah Amateur Radio Club** was organized under its present name in 1927, although its beginnings may date back as early as 1909. In 1928, it became affiliated with the American Radio Relay League (club #1602) and is ***NOT*** a 501(c)(3) non-profit organization. It holds a club station license with the call sign W7SP, a memorial to Leonard "Zim" Zimmerman, amateur radio pioneer in the Salt Lake City area.

The club meets each month except July and August. The meetings are usually held on the second Thursday of the month at 7:30 PM in the University of Utah's Warnock Engineering Building, room 2230.

Club membership is open to anybody interested in amateur radio; a current license is not required. Dues are $20 per year, including a *Microvolt* subscription, which cannot be separated from membership. Those at the same address as a member who has paid the $20 can obtain a membership without a *Microvolt* subscription for $12. Send dues to club secretary James Bennett, 4960 W 5400 S, Kearns, Utah 84118. Send address changes to **kk7avs@gmail.com**

Tax-deductible monetary contributions are gladly accepted. Send directly to the treasurer Shawn Evans, 1338 S Foothill Dr, #265, Salt Lake City, Utah 84108-2321. For in-kind contributions, please contact **uarc@xmission.com** to make arrangements.

UARC maintains the 146.620– and 146.760– repeaters, which are administered by the UARC Repeater Committee. Direct comments and questions to any committee member. The 146.760– repeater is on IRLP node 3352.

The **UARC Ham Hotline** at **801-583-3002** is for information regarding amateur radio, including club, testing, meeting, and membership information. Leave your name, number, and a short message, and we'll make a good-faith effort to return your call.

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POSTMASTER: Send address changes to *Microvolt*, c/o James Bennett, 4960 W 5400 S, Kearns, Utah 84118.

UARC 2024 Board

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Immediate Past President: Morris Farmer, AD7SR

For late breaking news listen to the UARC Information Net Sundays at 9:00 pm on 146.620– or visit the announcement page.

We are grateful to the management of our internet service provider XMission, for the donation of our web service. For account information go to http://www.xmission.com/ or call 801-539-0852

EIN : **99-0407768**

Utah Business Registration : **575790-0140**

Tech corner – Your own PCBs, Part 2

In the previous article, I discussed setting up ***ExpressPCB Plus*** and the schematic capture of a two-channel electret microphone mixer with an adjustable band-pass filter.

To minimize cost, ***ExpressPCB Plus*** limits you to one board size, 3.8" x 2.5" with two layers. You can waste space, you can put multiple copies of your circuit on the board, but if you want something bigger with more layers. you'll have to pay extra. If you're really tight on money and the circuit is simple, you can order boards without a solder mask and silk screen.

Abbreviations

We're going to work with modern components (no vacuum tubes), and minimal through-hole parts. These abbreviations might be useful when ordering online, so it helps to speak the lingo:

DIP (dual-inline package) : a type of integrated circuit package with pins for connections; can be placed in a socket if needed

EOL (end-of-life) : an obsolete part or one that didn't sell well; order a bunch if you can, but look for a replacement

footprint : appearance of an electronic part layout on the PCB, including vias, pads, silkscreen, copper

haywire : wire, typically insulated #30 used to fix mistakes

QFN (quad flat, no-lead) : QFP but without leads; almost impossible to solder without heat gun or reflow machine; avoid if possible

QFP (quad flat pack) : integrated circuit, like an SOP/SSOP/MSSOP, but with leads on all four sides

silkscreen : white paint used for part numbers, outlines, and other notes

SMD (surface-mount device) : wire lead-less component that's soldered directly to the PCB

solder mask : (historically) green paint on top of the PCB to keep solder from bridging between adjacent traces or pads

SOIC / **SOP** / **SSOP** (small outline package) : surface-mount integrated circuit with varying spaces between thin leads

trace : copper connection between two locations

via : hole lined with copper plating through the PCB

ExpressPCB Plus

ExpressPCB Schematic is loosely coupled to the board layout program. Unless you have two large monitors, I suggest you print the schematic for reference, to avoid clicking back and forth between screens.

1. Follow the help; there are tutorials and sample boards from simple to complex, to help you learn. If you already know a layout program such as ***KiCad*** or ***Altium***, just make sure you have a "handy list of expletives and know how to use them" (™*Calvin and Hobbes*).
2. Determine which parts and part types you're going to use, which you might already have included during circuit capture
3. Make sure your parts are available. Some parts become obsolete quickly, others have six to twelve months of lead time if they're out of stock, particularly integrated circuits. Don't order boards and find that your parts are EOL or won't be available for many months.
4. The ***ExpressPCB Plus*** has a small library of built-in footprints, but these are seldom enough. Learn how to make your own library; you'll accumulate quite a few over time.

Parts and cost

Your funds are most likely limited. The bottom line is that SMDs are cheaper than through-hole. For example, ten 1-kΩ, 5% 1/8 watt through-hole resistors will set you back 43¢, while the 0805 SMD equivalent costs 38¢ for ten. Once you get the hang of it, SMDs

are quicker to solder than through hole: you don't have to flip the board over, applying flux with a pen is easier, and you don't have bits of wire leads flying about the place.

A downside to SMDs, especially for small ones, is a lack of marking. You can usually tell the difference between a capacitor and a resistor but you'll probably need a **multi-meter** to figure out what value it is.

The final problem is sneezing and too much coffee. Once an SMD resistor falls on the carpet, it's gone. SMD parts come on reels for the automated "pick-and-place" machines used to assemble most consumer electronics. Small parts will be packaged in stamped, thin cardboard with an adhesive plastic cover. When they arrive, label them with their values and sizes. You may wish to cut them every 20 or so for storage. Make sure all are labeled, or you'll end up throwing them away. Instead of cardboard, larger parts will have a plastic backing or come in a tray.

Figure 1: 0603 ceramic capacitors, 1411 tantalum capacitors, FT232 SOP ICs, penny for size

Connectors

PCB connectors can easily become the most expensive part of any project. The easiest to work with are 0.1" headers, male and female. These will be found on Raspberry Pi and Arduino boards; you can design your PCB as a "hat" that connects to the underlying board. You can even stack these to build up some significant circuitry. Other common connectors are 3.5 mm DC power, USB type B and USB-C (useful for power), old school DE-9s, and RJ-11/RJ-45 jacks. For antennas you can get SMA and BNC jacks upright and 90 degree for PCBs. As I said, it's easy to spend more on the connectors than on the rest of your project.

Figure 2 : Common PCB connectors

Ordering the Parts

There are three main parts suppliers for hobbyists: **Mouser Electronics** (https://www.mouser.com/), and **Digikey** (http://www.digikey.com/), and **Jameco Electronics** (https://www.jameco.com/). Their online cata-

Tech corner – Your own PCBs, cont'd

logs are great places to check on parts availability, and all three provide excellent service. When the parts arrive, put them in a box labeled for your project especially if you have several projects running at once. But if you can't wait for a part, your local electronics store may have what you want: connectors, battery holders, wire, through-hole parts, NTE ICs, and a myriad of other things you won't need until you do.

Creating a new board

If you've followed these instructions and captured the circuit, you're ready to create the PCB.

1. Fire up ***ExpressPCB Plus***
2. From the ***Gallery***, select ***New*** and fill in the required board information
3. You should get a blank 3.8" x 2.5" area sized to fit the screen. ***Red*** front side copper, ***Green*** back side copper, ***Yellow*** front side silkscreen.
4. Place your most important components. Life is easier if these loosely follow your schematic diagram. Lay out all the components before you begin adding traces.
5. Place the smaller passive components nearest to where they connect to things, the shorter your traces, the happier you and your circuit will be.
6. Place mounting holes on the corners with sizes suitable for the screws you'll use. #4 screws work nicely with a 0.125" hole, plated or not.

Wiring it up

Start with the ground connections. Typically, the back of your PCB will be nearly completely covered with copper that's connected to signal ground. For some simple parts, you merely need to place a plated via to the back side. You still need to tell the system what to do on the other side. For complex parts, follow these steps:

1. Select the part, right click on it.
2. Click ***Ungroup*** on the menu that pops up.
3. Select the pin/via to ground, right click on it.
4. Click either ***Bottom Copper Thermal Isolation*** if the via is part of a pad, or ***Bottom Copper Solid*** if it's just at the end of a trace.
5. Click the ***X*** to kill the menu, the change has occurred.
6. Select the area of the part by left click and drag.
7. Right-click the area and select ***Group*** from the popup menu.

To run a trace, click the ***Trace*** button and start left clicking along the path. Right click to finish. There's no auto-router.

Ground plane pour

Once you're happy, and everything's labeled, it's time to pour the ground plane:

1. Select ***Rectangle***
2. Click the ***Pour*** symbol (looks sort of like a paint bucket on top)
3. Select ***Bottom Copper***
4. Make the rectangle cover the area to pour
5. Final check: are there isolated ground areas? That is, an area with copper that's not connected to the rest of the plane? You might need to move some vias or traces around so they're all connected, particularly if there's a ground via from the top.

Final checklist

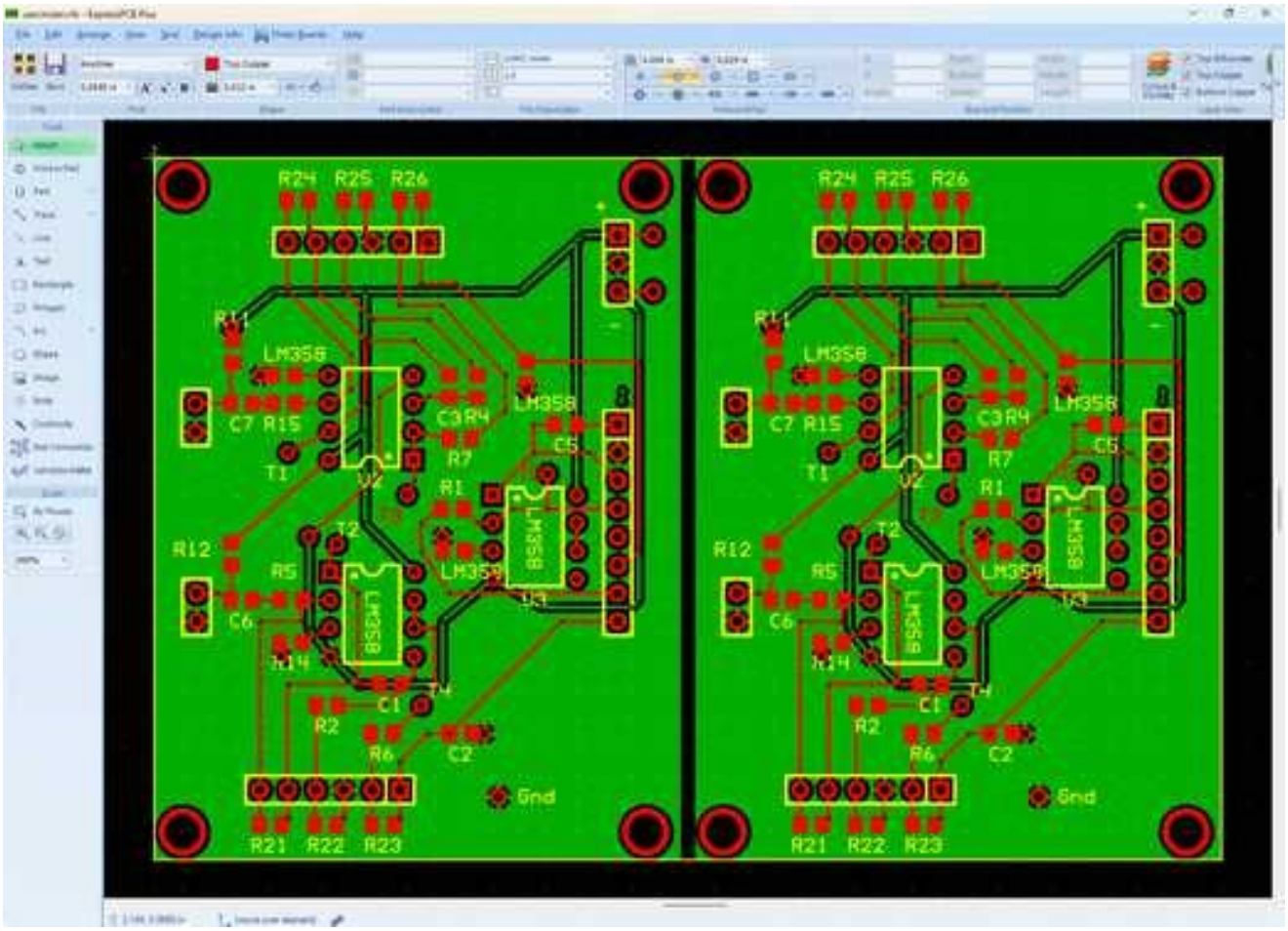
- Are all your ground vias actually connected to the ground plane?
- Are all your silkscreen annotations actually silkscreen and not copper?
- Is your ground plane totally connected? If there are areas not connected to the rest of the ground plane you may have to move traces so the fill algorithm can connect other areas to this one. If

Tech corner – Your own PCBs, cont'd

not, you might need to add an "above ground" trace to hop over the congested area.

- Are some of the traces too close to vias or other traces?
- Have you correctly established which is pin #1 on your integrated circuits?
- Are all pins hooked up that need to be hooked up?
- Have you annotated the version of your board in some way?
- Do you have the right foot prints for all parts? A 603 resistor can be soldered onto an 805 pad set but vice versa not so good.
- Do ground vias that will have solder on top have thermal isolation on the bottom copper?
- Do you have mounting holes for screws?
- Is there sufficient space around ICs for you to use a socket? Most parts don't have an outline and IC sockets are space hogs.

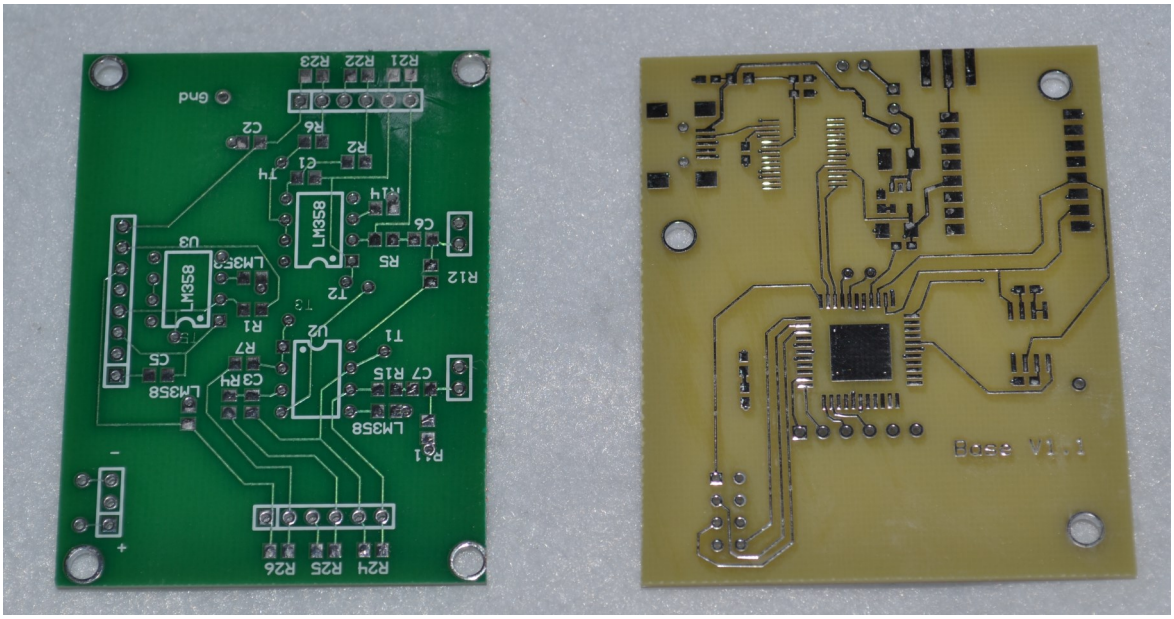
After completing the circuit on the left hand side, I grouped and copied it to the right hand side. The results looked like this:



Tech corner – Your own PCBs, cont'd

Ordering the boards

Click on ***Order boards*** and decide what services you want. I opted for the *solder mask* and *top silkscreen* which costs extra but makes your life much easier. Give 'em your credit card, and let them do the work. Less than 2 weeks later, here they are.



Left: mixer board with solder mask. Right: bare LoRa board

Next month

Assembly, box printing, testing, hay-wiring.

Jed Marti KI7NNP

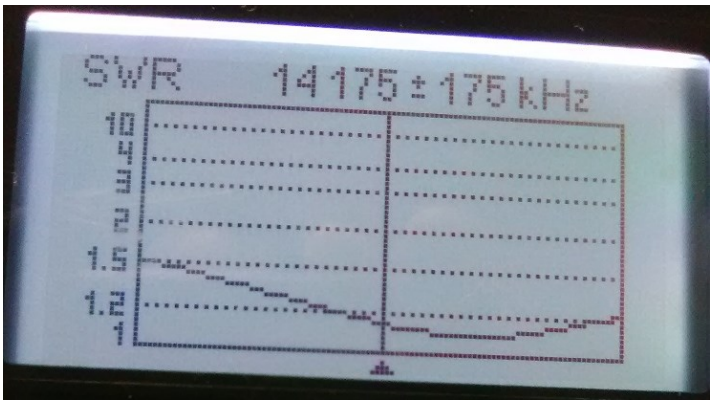
ARRL Rocky Mountain Division Convention

Strays – An HF antenna needs a tuner

A fair number of amateurs say that one should cut a wire HF antenna to the proper dimensions for resonance, instead of purchasing an unnecessary tuner. After all, they say, that's the *purpose* of a tuner, right?

Let's confine this discussion to antennas intended for transmission on 1.8 MHz through 30.0 MHz, which encompasses all of the HF bands, plus 160 meters. The reasons for not applying this to VHF or UHF are that 1) store-bought VHF / UHF antennas *tend* to exhibit very low SWR across the bands and 2) many are difficult to tune, while you can easily fashion a hardware match for the rest. Besides, you're not likely to find many VHF tuners on the market today, primarily due to lack of demand.

Let's say that I create a dipole for 20 meters, using all the math necessary to cut the elements to the right lengths. Then, once I construct it and examine it with an antenna analyzer, I'm very happy to see that the SWR bandwidth across the entire 20-meter band resembles a smile, like this:



It shows about 1.5 SWR at 14.000 and 1.2 SWR at 14.350, dipping to about 1.1 SWR at the lowest point in between, about 14.245 MHz. I'm not sure how it could look better! So, because the antenna appears so good on the analyzer, I'm never going to need a tuner with it. Or will I?

There are two good reasons for me to use a tuner with this antenna, in spite of its stellar-looking SWR: to reduce signal loss and to make better use of the signal that does arrive at the antenna.

One of the biggest reasons I want low SWR is to reduce the amount of signal lost in my coax with each trip through it. So, if I kept my transceiver right at 14.245 MHz, I'll minimizing the signal power lost in the coax. But, that's just not reasonable, since I want to make use of the *entire* 20-meter band.

A tuner can help me do just that, and once I select a frequency, I can direct the tuner to match the antenna system at the new frequency. Then, my antenna system has achieved an optimal SWR once again, minimizing my signal loss through my coax.

Next, the point at which the SWR shows the lowest across the band is called the ***resonant frequency***, so-called because at that point the antenna system impedance is ***resistive***. If I tune away from resonance, my antenna system impedance becomes ***reactive*** instead of resistive, capacitively reactive below, and inductively reactive above.

Power fed into a reactive load is neither consumed nor dissipated, and so is not transmitted, and is reflected back to the transceiver, and again some of it will be lost in the coax as heat. Adding my tuner to the antenna system will once again allow me to operate on a section of the 20-meter band that's above or below the original resonant frequency, making good use of the signal by providing it with a resistive, instead of reactive, load.

One more (important) reason to use a tuner is to increase your antenna's bandwidth. While the example I gave shows complete band coverage by my 20-meter antenna, if my antenna for some reason does not provide that coverage, a tuner can help compensate.

Back to the VHF / UHF case, don't those antennas need tuners, and for the same reasons? Yes, especially for the greater coax losses at those higher frequencies. For those antennas, it's often quite easy to design and build a matching unit, such as a beta match, gamma match, stub match, or others.

Noji Ratzlaff KNØJI