Mt. AIRY V.H.F. RADIO CLUB, INC.

CHEESE BITS

W3CCX
CLUB MEMORIAL CALL

ARRL Affiliated Club

Volume XLIX **October 2008** **Number 10**

PREZ SEZ:

Fall is upon us and I've seen a great start to many of the antenna projects for club members. Our VP, K3TUF is populating his new 180' tower with antennas and rotors and control boxes, transverters and power supplies, and lots of lightning protection. K3EGE is giving up his prior QTH, and in the process has made some of his VHF and microwave antennas available to others. A nice antenna party of 7 Pack Rats and one Philmont RC member helped Michael, KB1JEY, remove and transport an HD54 tower and many antennas to his QTH from the Shillingford estate. Paul, WA3QPX is also getting a similar tower to improve his EME ops. Joe, K1JT and Russ, K2TXB, teamed up with Al, K2UYH to add additional feeds to his 28' dish for contacts on 2.3 and 10.3GHz for the first weekend of the EME contest. Yours truly is almost finished with the trailer modifications and tower mount for EME yagis and dish. Joe, AA3GN, promises that he is going to do some tower and antenna work ASAP. In the process, we hope to raise to new heights the club's 222 repeater antenna. Marc, N2UO is making progress with his new 20' dish and mount, and the first part has been completed. Griff, NE3I has been able to add some elevation to his log periodic for improved performance. Ron, W3OR is still seeking assistance for tower and antenna maintenance. See if you can lend him a hand. Bill, AA2UK was heard from briefly during the September ARRL VHF QSO Party, and says that he will try to get his super-station back on the air this year. Let's make sure that we're all in the best shape for the VHF SS in January.

I was remarkably impressed with the topic and clarity of presentation made by Paul, W2PED at our September meeting. His diagrams and explanations of the 24GHz sub-harmonic mixer cut new territory for me and many others who attended. As one of the few club members with 24GHz narrow-band gear, it would be great to have others to communicate with on this band. We have a great line-up of meeting speakers and topics, including a tune-it-up night in December. Make sure you take the time to get to these meetings as it will add so much to the club cohesiveness and knowledge base.

The September contest participation appeared excellent, and I trust that all of you will submit logs. The N3NGE multi-op led the way with several hundred thousand points and QSOs through 10GHz. K3TUF as a single op, and the XYL KA3TUF lit up the airways also. Claire is liking the operational characteristics of the family station, and provided plenty of QSOs to me in the rover. I saw nice scores submitted by many, with contacts up to 3GHz. My 5 and 10GHz gear didn't play well since the June contest. I need to check out all the cabling to make sure we're getting IF to the transverters properly. N1XKT is also doing a bit of rovering and helping others fill their logs with additional QSOs on the bottom 4. I did not hear that anyone from the club participated in the 10GHz and up weekends. Admittedly, many of us had alternate obligations, but many of you are capable on that band. Perhaps we can plan some mountain-topping and coastal operation for this event next year, using 10 and 24GHz and LASER.

I hope by now that the distribution and mailing lists for Cheese Bits have been adjusted and that everyone is getting theirs properly and on-time. The board is considering a change to the distribution, and possibly going to posting the copies on the Pack Rat website. We still have a few dozen mailed copies to those who live in computer-free zones! Let your preferences be heard. Thanks, Lenny, W2BVH, for doing a great job since picking up this editorship and production over the summer.

73, Rick K1DS

Pack Rats **CHEESE BITS** is a monthly publication of the
Mt. AIRY VHF RADIO CLUB, INC. -Southampton, PA.
SUBSCRIPTION RATE: $16.00 PER YEAR (USA)
$20.00 PER YEAR (CANADA)
$10 PDF only
$24.00 PER YEAR ELSEWHERE
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PACKRAT BEACONS - W3CCX/B
FM29jw Philadelphia, PA
50.080 144.284 222.064 432.286 903.072 1296.245 MHz
2304.043 3456.207 5763.196 10,368.062 MHz (as of 1/08)
MONDAY NIGHT NETS

TIME	FREQUENCY	NET CONTROL
7:30 PM	50.145 MHz	K3EOD FM29ll
8:00 PM	144.150 MHz	N3ITT FN20kl
8:30 PM	222.125 MHz	K3TUF FN10we
8:30 PM	224.58R MHz	W3GXB FN20jm
9:00 PM	432.110 MHz	WA3EHD FN20kd
9:30 PM	1296.100 MHz	K3TUF FN10we
10:00 PM	903.125 MHz	W2SJ FM29LW

Visit the Mt Airy VHF Radio Club at: www.packratvhf.com or www.w3ccx.com

Editor's Column

Next Meeting: October 16, 2008 At our usual site: the Ben Wilson Senior Center, 580 Delmont Av, Warminster PA. Scotty Moyer, W3URR, will be giving a practical talk on all the electronics and mechanics behind taking a throw-away PC power supply and turning it into a beefy switching supply capable of powering 20 amp plus transceivers. If you need a few hundred more (cheap / free) watts of dc power you won't want to miss this!

Greetings Packrats! I just returned from the club sponsored 2008 Mid-Atlantic States VHF Conference in Bluebell and it was great! There were exciting presentations that covered many aspects of VHF/UHF radio. Literally something for everyone. Here are just a few examples of how wide ranging the presentations were: Brian Skutt, ND3F showed many examples of high sites with clear views to the horizon which are ideal for UHF/microwave ops but are **not accessible** by car. He then he showed and demo'd his under 80 pound (batteries included) 10 band portable station that will get you into those prime locations by backpack alone! Paul, W2PED gave a brilliant presentation of his recently developed subharmonic mixer for 24 GHz. This could help get you onto 24GHz using an inexpensive 6GHz surplus brick LO that's often available at many hamfests. If you find your TS-2000 is lacking a little sensitivity, Woody AK2F showed us how he opened his and squeezed out another 10 db of receive gain using a fairly painless process. In all there were 9 great presentations. If you couldn't make it this year you might consider attending a future conference.
A couple of weeks ago, several club members helped KB1JEY dismantle and transport the tower/antennas to his QTH from the estate of KB3IB. Look for an article on this operation in a future issue.
The 432 MHz, 6 Meter and Microwave portions of the fall VHF / UHF sprint events are scheduled for this month. See the September issue of Cheese Bits for additional details, or try http://www.svhfs.org/fall_sprint_rules.htm
This issue has part 2 of Paul Drexler's presentation of a subharmonic mixer for 24 GHz. Last month we covered the motivation and background for the design. This month Paul presents the "meat" of the design along with simulations and predicted performance. A future article will present actual results from a real prototype and a comparison with the predictions. Thanks Paul!!

Hope to see everyone at the next meeting.

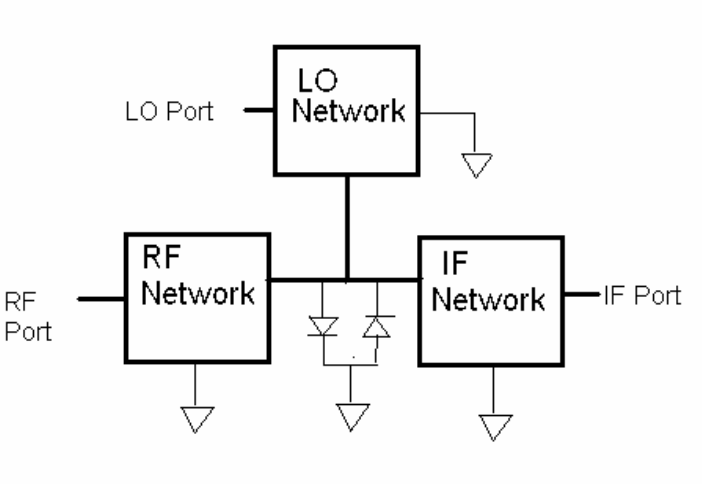
73, Lenny W2BVH

A x4 Subharmonic Mixer for 24 GHz Part II

Paul Drexler, W2PED

The first installment of this article gave some background on subharmonic mixers and gave a brief discussion on the mixer theory of operation. This installment will continue by presenting the design of the various circuit networks used in the mixer design.

For clarity, the mixer block diagram is again shown here for reference.



RF FILTER SECTION

The RF bandpass filter is a simple arrangement of two short-circuited λ/4 lines forming resonators at 24 GHz. The resonators are directly coupled through another transmission line, which is approximately λ/4 in length. All lines are nominally 70 ohms as a 70 ohm transmission line tends to give the best Q for filters. The resulting filter response is a broad bandwidth bandpass response centered at 24 GHz.

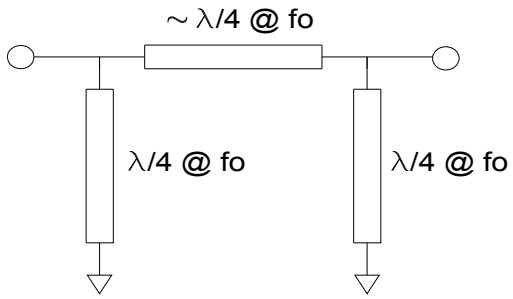


Figure 5 – Basic RF Filter

Next, resonant stubs were added to the filter at the input and output to provide a short circuit response at the LO and 2xLO frequencies. Each of the open circuited microstrip stubs are ~λ/4 in length at their respective frequencies, so these essentially look like trap filters at the LO and 2xLO frequencies.

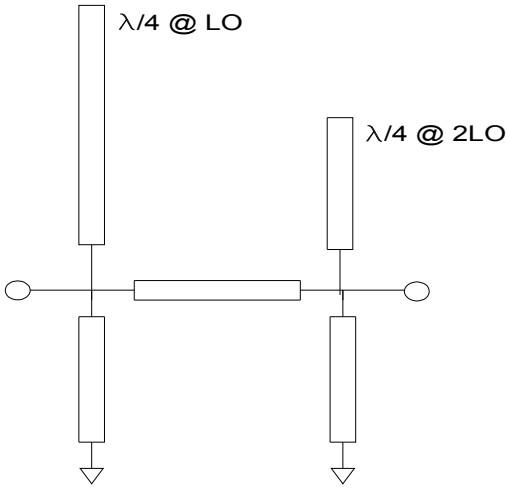


Figure 6 –RF Filter with Stubs Added

The filter section was designed using rough hand calculations and then the first iteration of the design was optimized using the student version of the Ansoft Designer circuit design software. Line lengths were adjusted for best match and insertion loss at 24 Ghz, and best resonance of each trap. The predicted RF filter response is shown in Figure 7. Low insertion loss is predicted at 24 GHz (blue trace), with the LO and 2LO frequencies being highly attenuated (reflected). The second trace (red) shows the return loss at each frequency. The RF filter is designed to have a very good return loss at 24 GHz, and a reflective impedance at the LO and 2LO frequencies.

Note that three discrete attenuation nulls are seen on the plot (next page), with an unaccounted-for transmission zero at the 3LO frequency (roughly 18 GHz). There is no stub present for this frequency, so where did this come from? The answer is that the longer stub at the LO frequency is an odd multiple of a quarter wavelength at the 3LO frequency as well!

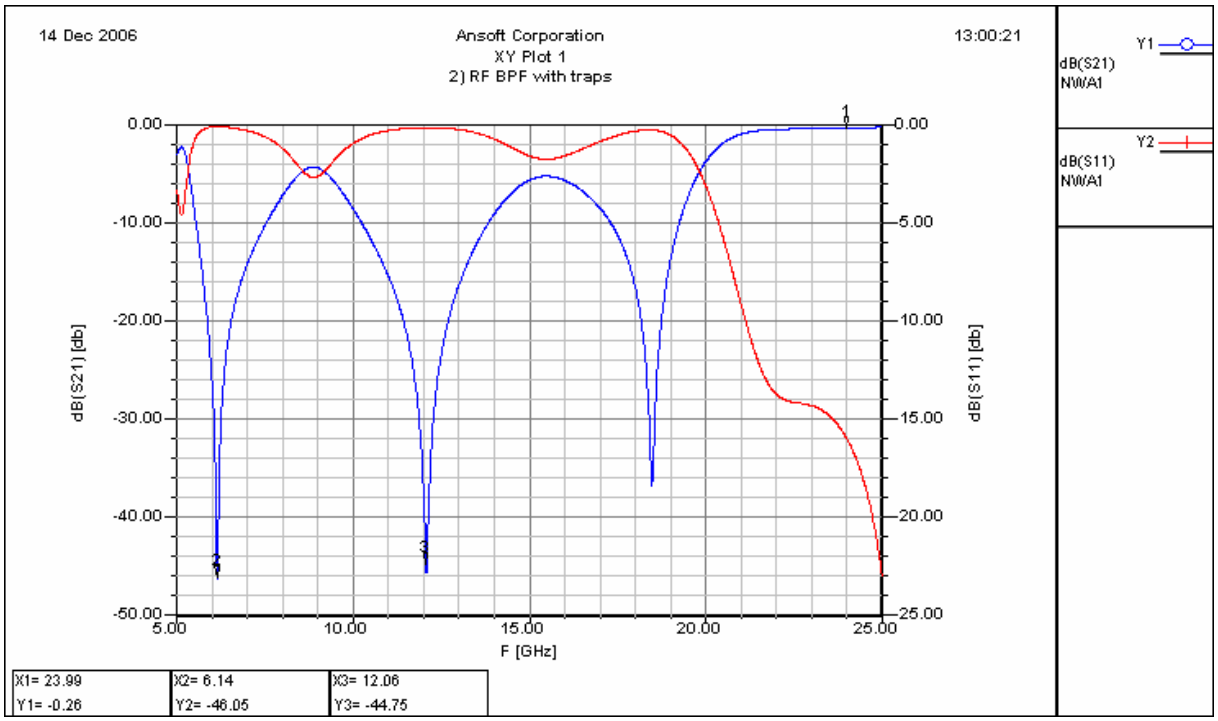


Figure 7 – Predicted Response of RF Filter with Stubs

LO FILTER SECTION

The LO bandpass filter is a simple edge-coupled design made from two $\lambda/4$ lines at the LO frequency. A more complex filter is unnecessary as the LO filter simply has to pass the LO and look reflective at the RF, 2LO, 3LO, and 4LO frequencies. The center frequency was designed for 6 GHz and the bandwidth was made wide enough to cover other possible desirable LO frequencies; in fact the bandwidth is considerably wider than necessary but this helps to ensure that reasonable etching process variations don't spoil the performance. In order to present a 50-ohm impedance match at the filter input/output, the coupled transmission lines need to be higher in impedance and consequently end up being *very* narrow lines. The lines are ideally around 4 mils in width with 4 mil spacing, when made on 10 mil Rogers 5880 material. For illustrative purposes, 4 mils is about the thickness of a sheet of standard copy paper! These line widths and spacing get to be a bit tricky to reliably etch by the board vendor. The author chose to compromise the design somewhat and make the coupled section lines just a little wider and slightly farther apart in order to come up with a more manufacturable design. Of course, this degrades the impedance match, so in order to improve the match; the final filter has two low impedance stubs added at the input/output. As a point of reference, the coupled line section of the filter is approximately 0.4 inches in length

Figure 8 – Layout of Edge Coupled LO Filter

The design of edge coupled filters can be especially troublesome unless the design includes all of the coupling effects, and the best way to do this is to make use of an electromagnetic (EM) simulator. An EM simulation showed that the basic design was shifted in frequency and would have given about a 3 dB insertion loss. With the aid of the EM simulation, the design was adjusted in length to give the desired center frequency.

The predicted LO filter response is shown in Figure 9 below. Insertion loss is under 0.5 dB and the return loss is better than 20 dB according to the simulation. The out of band response is not shown, but the filter is reflective at all the required frequencies.

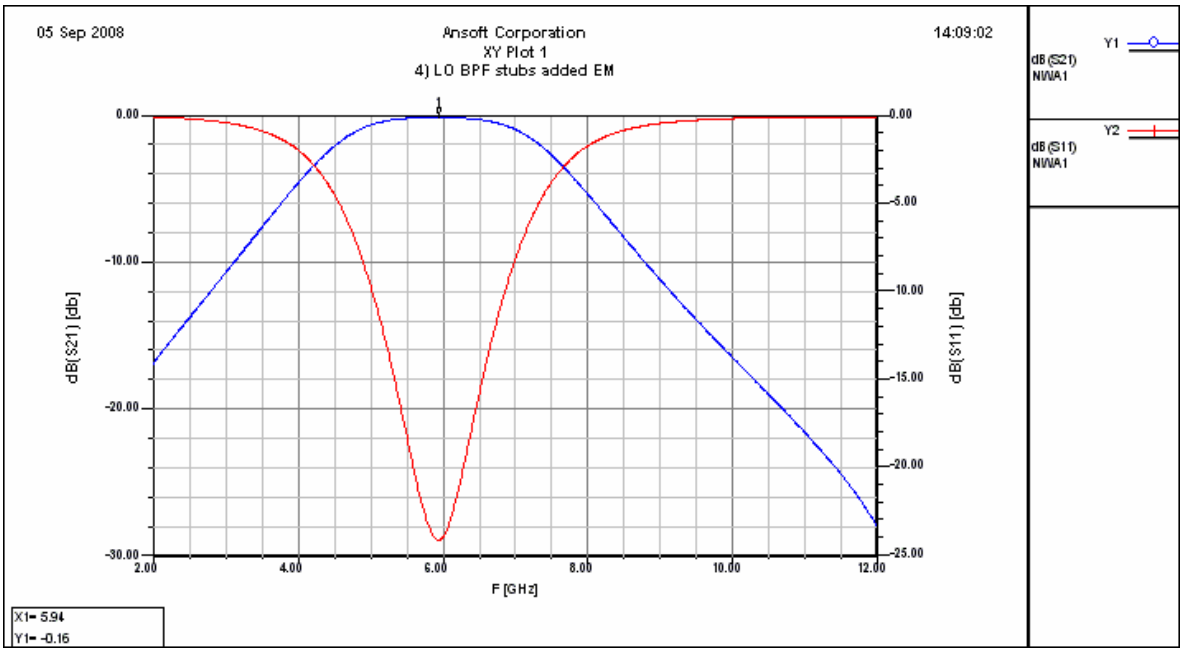


Figure 9 – Predicted Response of LO BPF

IF NETWORK

As mentioned earlier, the IF portion of the mixer is just as complex as the other portions of the design. This network is responsible for injecting the LO energy into the mixer diodes, passing the mixer's desired IF energy, and reflecting the RF, LO, and 3LO energy back toward the diodes. The IF section reflects the RF energy and all LO products back toward the diodes for two reasons:

- To prevent undesired energy appearing at the IF output (i.e. to attenuate the RF, LO, and LO harmonics)
- To reflect all energy other than the desired IF back toward the diodes in order to achieve low conversion loss.

Each of the open circuited microstrip stubs are ~1/4 wavelength at their respective frequencies and can also be thought of as high-Q *idler circuits.* This is not unlike the resonant stubs used in the 432 to 1296 tripler circuits of the past. All of the stub lengths are very sensitive in order to attain best mixer performance. Should a given stub be off by more than a couple of mils in length, the mixer performance will quickly degrade.

It should also be noted that it is no mistake that the high frequency stubs (i.e the RF and 3 LO stubs) are closest to the diodes. This keeps the reflected transmission path of the RF and 3 LO energy to be as short as possible for lowest loss. All of the interconnecting line lengths were optimized for best performance. Perhaps the most sensitive line length is the short line at the left side of the network - the line between the diodes and the RF stub. This line serves as an impedance match between the diodes and the rest of the circuit.

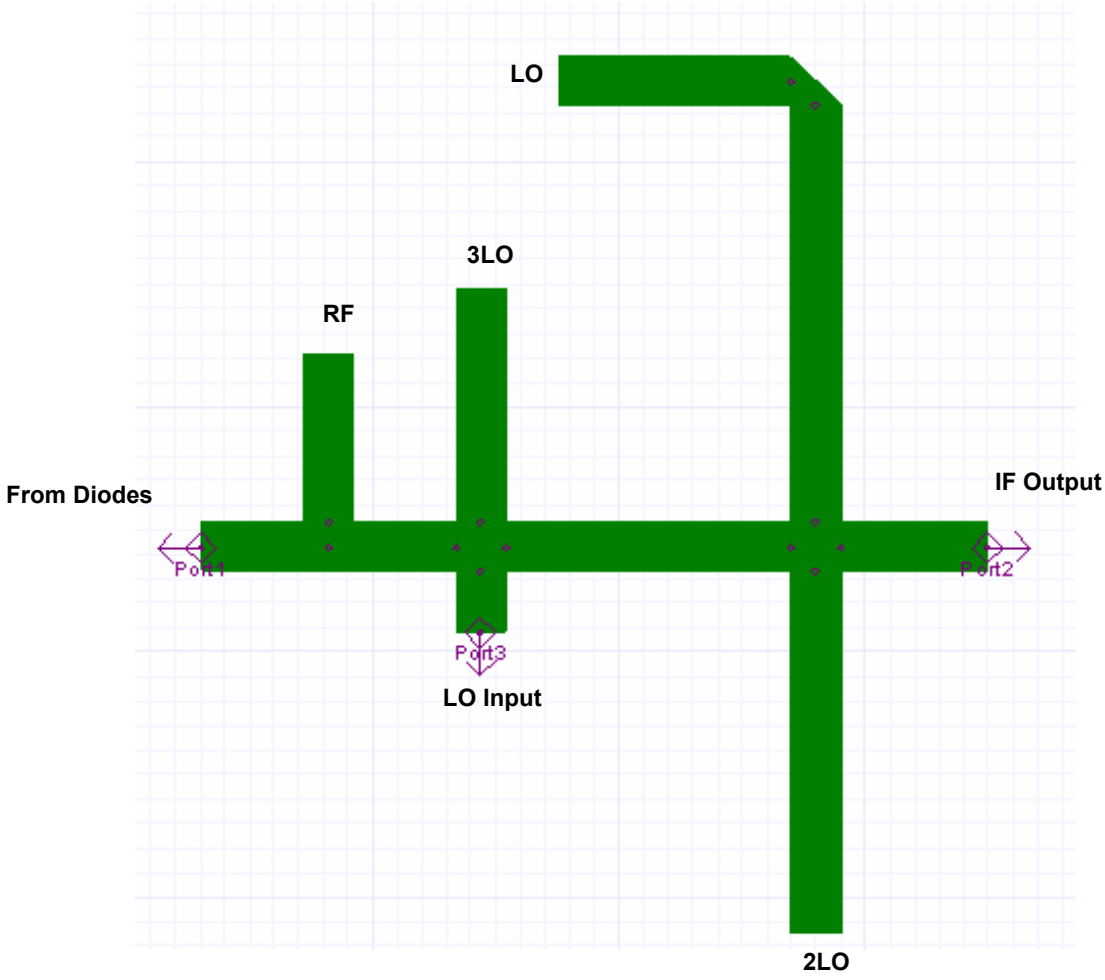


Figure 10 – IF / LO Injection Network

CONNECTING IT ALL TOGETHER

The initial mixer was designed for 10 mil thick Rogers 5880 high frequency circuit board material. The Rogers material was chosen as it has very good high frequency circuit properties including low dielectric losses (loss tangent ~0.0009 at 10 GHz). A 10 mil thick material was chosen in order to keep the transmission line widths a reasonable width considering the frequency of operation. At one point I considered using a 5 mil thick material, but I found that the thinner material would result in *extremely* narrow line widths in the LO bandpass filter, making it un-manufacturable on the thinner 5 mil material.

With the basic design of each of the mixer sections in hand, the next step was to connect it all together and analyze the circuit with the aid of Ansoft Designer, a nonlinear circuit simulator. An LO level of +10 dBm was assumed to start. The initial results were not all that encouraging… the first pass at the mixer design showed an insertion loss of over 20 dB! This isn't all that surprising for several reasons: 1) when connected together, there are interactions between the various networks 2) each of the filter networks were designed to work into a perfect 50 ohm load, and the diodes do not present an ideal 50-ohm impedance and 3) since each of the reflective stubs are high-Q, it was assumed that some optimization would be required.

The next step in the design process was to go back and painstakingly optimize each stub and transmission line length in order to obtain the best performance. This included minimizing the mixer conversion loss and suppressing the output level of each of the undesired signals. Fortunately, the two are more or less related; as each of the undesired outputs is minimized, the mixer efficiency tends to improve. Several key changes gave a much improved mixer conversion loss, and suppression of the undesired signals, while further optimization yielded smaller improvements.

Once I was satisfied with the overall mixer performance as described above, a more accurate EM analysis approach could be implemented. As mentioned earlier, the use of electromagnetic analysis (EM analysis) gives much more accurate analysis results as it takes electromagnetic effects into account including mutual coupling between transmission lines. The downside is that this is a 'computationally demanding' exercise for the PC and it tends to be time consuming. Another issue is that during EM analysis, it is not possible to easily change the design to evaluate the effects of a change, so this makes it an iterative, somewhat labor intensive process. This author had decided that it would be worth the effort to go the extra step and to 'fine tune' the design using the more accurate EM analysis; this would give the best chance of a first-pass success. Additionally, two mixers were designed – one for a 144 IF, and another for a 432 IF.

Figure 11 (illustrates the artwork layout of the mixer. The RF input is on the left, LO input at the bottom trace, and the IF is in the right. The mixer length is just over 0.75 inches. The LO filter appears as one solid line unless the view is greatly magnified.

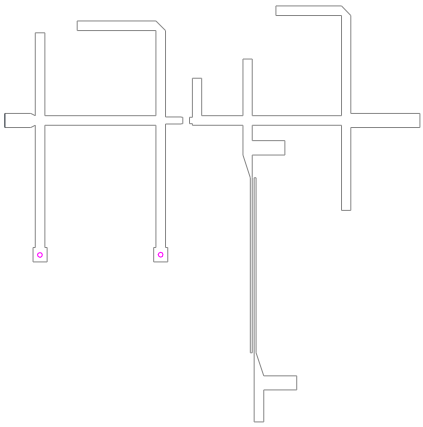


Figure 11 – Prototype Mixer Layout

The analysis plot in Figure 12 shows a predicted spectral plot of the mixer (432 IF version) when analyzed as a downconverter

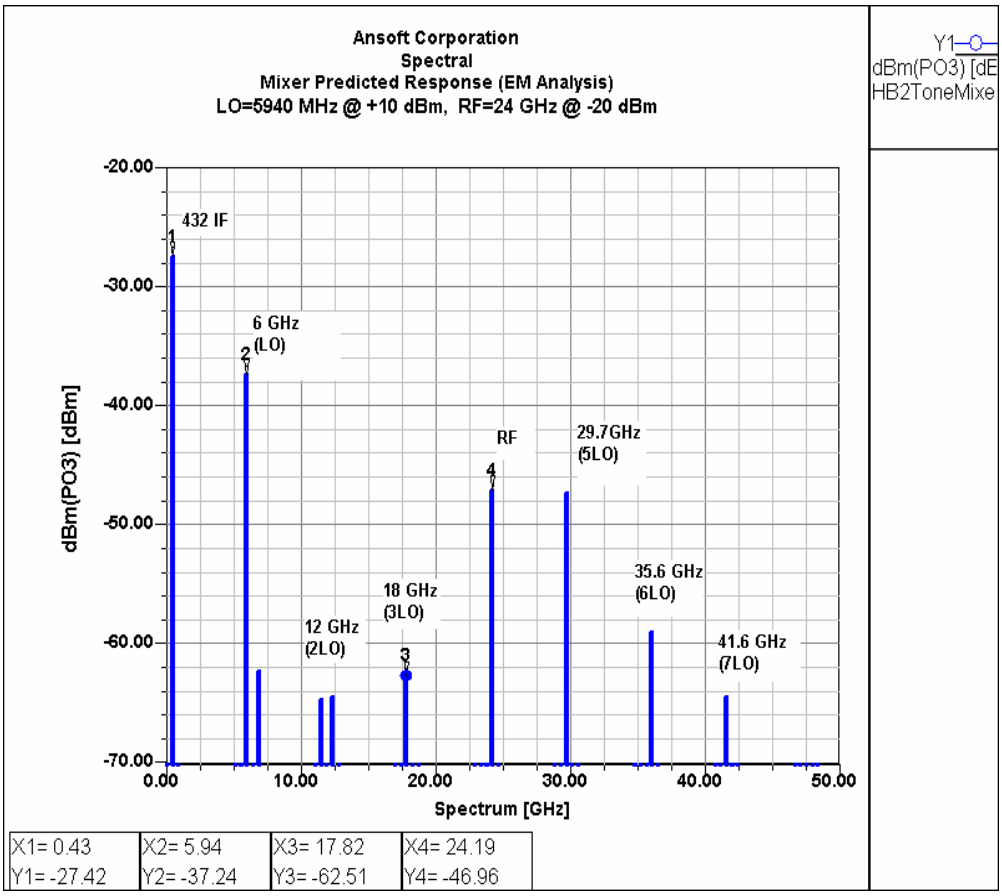


Figure 12 – Predicted Spectral Plot of 432 IF Mixer

For the mixer analysis the 24 GHz input level is at -20 dBm, and the 5940 MHz LO is at +10 dBm. The conversion loss is predicted at ~8 dB and the 6 GHz LO feed through is 10 dB below the desired IF signal level. Since the 6 GHz input is at +10 dBm and a level of –37 dBm is predicted at the mixer's IF connector, this represents some 47 dB of rejection of the LO as measured at the mixer IF. Note that the 2LO, 3LO, and RF signals are also very well attenuated. The 5LO, 6LO, and 7LO responses can also be seen but are not of much concern as they are well attenuated from the desired IF signal.

Although not shown here, the simulated results of the 144 MHz IF version of the mixer is practically identical to that shown above.

In Part III we will present the results of measurements on an actual mixer built to the above design and compare them to the predictions in this article. **Stay Tuned!** 73, Paul W2PED

KB3NRL Appointed Recording Secretary

Rich, KB3NRL has accepted the job of recording secretary for our club. Welcome to your new position, Rich and thanks for volunteering!

Rich replaces Bill, K3EGE. Quoting our president K1DS: "He [Bill] has done a super job, jumping in on the heels of Walt, WA3AQA, when Walt was no longer able to manage the function. Our thanks to you Bill for a job well done."

Contest Loaners

The January test will be on us before we know it. **Requesters**: please let your needs for loaner equipment be known on the reflector, at a board of directors or general meeting. **Contributors**: Your spare stuff is needed on the air at a fellow 'Rats QTH gathering points !

Ham Radio URL of the Month

For those who missed the presentation on improving the receive gain of a TS-2000 at the Mid-Atlantic VHF Conference, a simplified version is available at mysite.verizon.net/ak2f/ . The complete article is available on the conference CD

Member needs assistance in moving a tower

Rich KB3RNL recently posted this on the Packrats reflector:

Horst Zodrow, W3/DJ7LC, is giving me his 45 foot TRI-EX crank-up tower including rotor, TH3-Jr 10-15-20m Beam, and a 10-el 2m cross Yagi. It is standing in Churchville less than a quarter mile from my house. But there is some rust at the base. The tower will crank down but tilting it over on it's original base isn't going to work. I will make a substitute base to tilt it over on but it will require some extra hands to get it down safely (being that the work is at a German station there will have to be some German suds available). So I am looking for four or five people to help. I would like to take it down Saturday October 11. Please let me know if you could help.
Rich's email is: renwright1@verizon.net

SWAP /SHOP

Kenwood TS 811- 70cm multimode transciever $275. Yaesu FT980 multimode HF transceiver. Will display 6m, 2m, and 432 frequency when used with transverters having 28-30 MHz output. $475. Control boxes for Hy-Gain rotators-- Ham M (1) Series 5 $25, (1) Series 2 $25, AR22 2 boxes $15 All these boxes are brown Bakelite.
HAM M rotator with new type control box $225 . All prices plus shipping

R. Alfred Whiting K3BRS 301-622-2302

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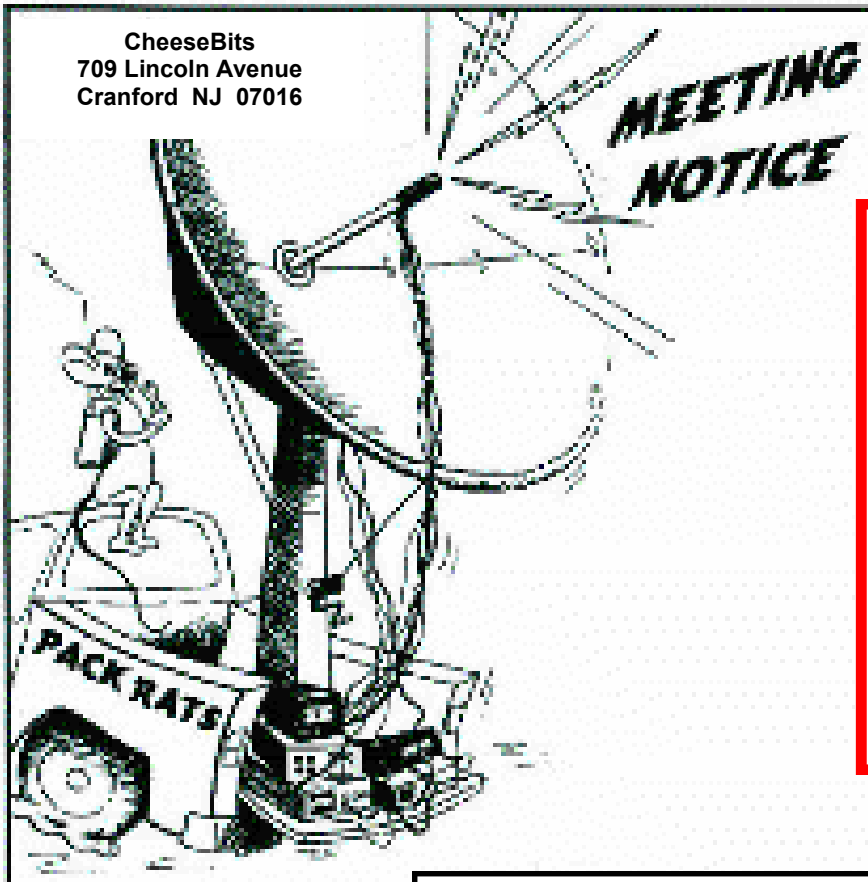

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