Down East Microwave Inc.

Design Note

DEMI

From: DEMI R & D Dept.

DN#: 039

Date: March 20, 2021

Re: DEMI 3456 to 3400 Transverter operating frequency change.

PREFACE: With the change in our 9 cm band plan, operation at 3456 MHz will cease to exist early summer of 2022. The tentative band plan proposal recommends our Weak Signal Terrestrial operation will move to 3400.300 MHz. This will require changing the LO frequency of our transverters from 3312 to 3256 MHz. when utilizing a standard 144 MHz IF frequency. This design note will describe a generic way of accomplishing this and address the possible issues that may occur centered on a 3256 MHz LO frequency requiring a 144.300 MHz IF.

EXPLANITION: The original "No-Tune" 3456 transverter (SHF and early DEMI) had a 552 MHz local oscillator circuit. This signal was delivered to the transverter board where it was then multiplied up to 3312 MHz and injected into the TX and RX mixers. Then with further refinement of the oscillator design, the base oscillator was increased to 1104 MHz and delivered to the now 3x multiplier to produce 3312 MHz. During this development, further modifications of the RF filters and Mixers were accomplished to eliminate or reduce the harmonic content of the transmitted signal and excessive receiver pass band noise. But even after the basic design was set, there were many small changes to the design with every production run, large or small. Some of these changes made little to no difference and some were so bad that it required us to scrap the circuit boards. The design objective of this "Tweaking" was to lower the operating frequency of the LO band pass filters and raise the frequency of the RF filters by skewing both types away from each other while keep 3400 MHz in play since it was always an option. It was desired to place a deep "NULL" of operating frequency (and noise) between 3312 and 3400 MHz. Sometimes this "Null" resulted into perfect examples of being the most difficult transverters to operate on 3400 MHz. Luckily, there are not many circuit boards out there with the "NULL" at 3400 out of the 500+ boards produced.

EXPECTED RESULTS: The bad news is, we have no idea or a way to identify which of these transverters will comply to our spec while operating at 3400 MHz. Yes, they will easily accept the frequency change but some will pass harmonics that will make their use undesirable. We predict that 300 will easily change comply to the frequency change. Another 100-150 will change with slight modifications and 50 -100 can be made useful but will be difficult to those without serious test equipment and skill. This design note will describe the basic changes required to achieve 3400 MHz with the best possible performance and highlight possible modifications to improve performance.

Depending on the actual vintage of circuit board, simply changing the LO frequency to 3256 MHz and operating may produce a transmitted signal with all harmonics at or better then -40dBc (-40 dB below the carrier). This should be the minimum results expected of the Lower power transverter. The high power (1-2 watt transverter) had a better rejection to transmitted harmonics because of the more narrow bandwidth of the built in 1 watt power amplifier. But this may in turn hinder the 56 MHz lower in frequency operation without modification. Some transverters may have reduced gain on both Transmit and Receive and still should be considered acceptable because of the -40dBc harmonic level. Very few transverters will have very low gain on both sides, but may be remedied with circuit modification but never make the -40dBc specification. So, if you are using this design note as an aid to a successful frequency change, expect the worst and be happy with the results obtained if it requires the minimal amount of work.

RECOMENDATIONS: The first recommendation is to not even consider purchasing a new Crystal for your SHF-LO or MICRO-LO oscillator. It would be difficult to find a manufacturer of a 5th or 7th over tone crystal in the frequency range required for under $100 anymore, and it would be nothing but a headache trying to settle down all of the extra harmonics that the filters will be passing with the frequency operation change. If you have a un-utilized A-32, this would be the easiest LO to implement and use. We have some old A-32 stock ready to go if you desire. If not, we recommend the purchase of a DIGILO Synthesizer, which requires a different mechanical install, and additional circuit modification. Then deal with the modifications listed in this document. A separate document will be provided covering the installation of a DIGILO in Design Note 40.

This document will address the A-32 synthesizer version of which we think is the majority of transverters "out there" from our production notes and with the rash of upgrades that occurred when the A-32 was first introduced. Also, you should know that we had the foresight to include the LO frequency for the EME band of 3400 MHz. The A-32 can generate the frequency of 3256 (1085.333 MHz x 3) by simply adding one more jumper (additional foresight!). This makes it convenient in that after the changes are done and tested, a simple toggle switch may be added to the front panel and both portions of the band may be utilized by a flip of a switch. If your transverter already has one of the A-32 synthesizers installed, reselect the correct frequency and begin to test. You will be able to verify if further modifications are required by placing a power meter on the transmit port and first verify that the specified output power is achieved (or close!) and then key the PTT without RF drive. If you see any output power higher than -40dBc (40 dB below the 10 mw or 1 watt desired frequency carrier), or you are not able to achieve the desired output power, then further modification should be necessary. BUT, it should not be attempted without a spectrum analyzer.

The latest assembled 3456 transverters and kits have the DIGILO installed in them and produce a direct 3312 MHz frequency with the closest harmonic up at x2. Select the direct frequency of 3256 and test and follow the same precautions as stated above. Then of course, if you have developed your own custom LO chain for your transverter, it will function after you adjust it and retest the unit.

For those seeking instant gratification and the best possible results, you may send your MICRO-LO version transverter to us to upgrade to a A-32 or DIGILO synthesizer or to change frequency and test your A-32 version transverter. There is an established fee on our website for all synthesizer upgrades. A retest and retune fee would be covered under our standard transverter repair fee. But, if you wish to do the change in frequency yourself, the rest of this design note will be helpful.

TESTING THE NEW CHANGE IN FREQUENCY: On the last pages is the current version of the DEMI 3456 Transverter schematic and board layout. It is expected that if you have the transverter you also maintain its documentation. If not, the kit version with the A-32 can be found on line in the manuals section of the website at: http://01895fa.netsolhost.com/PDF/Manuals/3456-144CK.PDF

The MICRO-LO version of this document is also found on the website but is essentially the same document with the A-32 being the only change. So, if you have a MICRO-LO version and have access to the older A-32, it is a drop-in replacement after setting the frequency. Just swap the boards, solder the coax, DC power and connect the 10 MHz source input through the extra BNC connector hole on the back panel. You can then make the decision if you desire the LOC light and the frequency select switch on the front panel. These details for modifying the front panel are found in Design Note 040. The LOC LED may be installed as shown in DN040 but the Frequency Switch is simply connecting # 2 of the A-32 to ground though the switch for 2320 MHz and # 3 to ground for 3400 MHz. Then test by following the basic procedure stated previously. If not-- continue the next part of this design note in modifying the transverter board for better overall performance in gain and harmonic level.

LO TEST: The MICRO -LO and A-32 multiplier scheme will produce harmonics every 1085 MHz for 3400 and 1104 MHz for 3456. It will not place any harmonics directly in the RF pass band of the RF (both TX and RX) filters. There is a test point of the output of the LO chain. It is indicated on the component placement diagram shown later in this document. It should be verified to allow correct operation. The C7 capacitor should be moved to the other pad and a 50 ohm coax should be attached to the pad and ground. The level should be between +7 and +13 dBm. Beyond the +10dBm level, the excess drive into the mixer will cause a non linear effect and "Push" the LO frequency through to the RF filters. Dropping the drive level of the LO injected into the power divider from +13 to +10 dBm may eliminate 9 to 18 dB of excessive LO bleed through power out of the Mixer. Yes, it can be eliminated in the RF sections but it is easier to do this with a 50 ohm resistor from the C7 pad (after it is installed coupling to the power divider) to the test pad and short or place a large larger than 10 pF capacitor to ground. This will lower the LO drive power by almost 3 dB if required. If the power is low, verify the coax connections and the output power of the A-32. Also recheck the frequency selection. It should be +3dBm or greater entering the transverter board. If that is OK, then suspect the LO chain MMICs and components or verify that there is not a spurious oscillation with a spectrum analyzer. Utilize the test points in the transverter assembly document to verify. If testing is complete, connect C7 to the Power divider and continue with the RF testing of the transverter.

RECEIVE SECTION TESTING: It is assumed that your assembled transverter version has your specified RF gain stage line up and/ or the use of an external LNA. The Kit document (web site link listed on previous page) explains the different combinations in the "Receive Assembly Options" section. It is then assumed again that if your RXRF filters have extra attenuation at 3400 MHz, if your are utilizing an external LNA, it will not matter. It also assumes that if you have both gain stages (as in some units) installed it will not matter. The standard is your transverter has only one stage installed and the total system gain should be checked and verified. It should be 15 dB or more, though most transverters shipped were in the low 20's. If you find that the RXRF filters have extra attenuation at 3400, you could install the IF gain stage but that will not improve your system noise figure. Yes, you could attempt to modify the RF filters but it would be simpler to add a low noise gain stage to the front end of the transverter with an external high quality LNA or low noise MMIC as the first stage of the RX chain. THEN-- understand that if the RXRF filter is offering extra attenuation, the same filter design is utilized in the TX filter side. But verify that all RX gain stages are operating correctly or review your initial set up. There could be a low gain stage in the front expecting a external LNA so recheck on 3456 MHz. But again, take what you can get on receive and add stages if needed where required to get what you want. Filter adjustment should not be required unless you want to "Tinker".

TRANSMIT SECTION TESTING: This is the most critical section. If excessive LO power is passed at either 3256 or 3312 MHz, it will be amplified by an external power amplifier. We have a general spec of -40dBc but it is up to you what level is OK. Now as an example, if you utilizes a 50 watt amplifier driven by a 10 mw transverter, -40dBc is 5 mw output out of the amplifier (not the transverter!). This is an insignificant amount of power at either 3256, 3312, 3544 or 3600 MHz which are the standard mixes that will be there. These signals will be attenuated further using any type of gain antenna but if not verified, you could just key your system up without IF drive and experience watts of output power being reflected back into the power amplifier producing additional spurious. Also-- if a TX gain stage is defective or oscillating for various reasons, it will be amplified. Therefore, the output spectrum should be checked before use to verify functionality and problems.

Checking with a power meter is a good test to verify if there is a problem or not with excessive LO bleed through. As mentioned above, if keying the PTT line generates output power without IF drive, there is a problem. And this test should be done with the enclosure closed up. The level of this problem is up to you. If you see a watt or more out of your 50 watt amplifier, some circuit adjustment should be done. To explain what is happening is simple. The level of excessive energy is being passed through the RF filters and being amplified. The question then becomes at what frequency and at what level. You can take a guess what the level may be by back calculating. If you have a 50 watt desired signal but the LO feed through power at Key down without IF drive is 1 watt, the leakage level is around -27 dBc. If you want to decrease that level, it can be done but it will be difficult without the aid of a spectrum analyzer. And even then it is trial and error and verify the results with the enclosure box closed. And of course, you don't want to spend the time doing this with the 50 watt power amp. It's easier to test at the mW level.

Next you need to understand that if the LO leakage is in spec. according to your power meter, it is possible that the RF + IF frequency (3400 +144 or 3456 +144) is bleeding through and shows up as normal power. For this test you need a spectrum analyzer. So, as mentioned above, if this signal is -27dBc the RF+IF frequency will be 1 watt output with a 50 watt amplifier and will cause the problem stated above. ALSO-- if there is any spurious signals generated in the TX chain, they will also be amplified and cause problems. Therefore, before actual use, we suggest a spectrum analyzer test.
With a spectrum analyzer, all testing can be done on the low power transverter easily. If you have a 1 watt version transverter, most likely you will need additional attenuation so not to damage your test equipment.

Let's assume we are testing a low power transverter and begin. The specified level of the 3456-144LP is 10 mw. Some units will reach 40 mw but this could cause some of the issues we are trying to eliminate. With the analyzer set to at least a 300 MHz bandwidth and adjusted to a safe input level to measure 10 mw, set the TXRF output port level to 10 mw without compressing the input of the instrument! You may see the LO signal (3256 or 3312) 40-50 dB down or less from the top of the screen. The LO bleed through level and all other harmonics and spurious should be measured in reference to the transverter output level on the desired RF frequency set to10 mw by adjusting the IF level control, signal generator control or IF transceiver output level. Of course, the 1 watt transverter should be set to the 1 watt level and the analyzer should be adjusted to that level to measure from there. Just be sure you do not compress the analyzer and produce harmonics within the test instrument confusing the desired results. Now, you may have also seen the RF + IF when setting the output level which is generated in the mixer diode. It is actually the 2nd harmonic of the IF mixing with the LO signal. If you were to increase the IF level, you would see the RF+IF signal increase in a non-linear function. One extra dB input may produce and extra 3-6 dB of harmonic output. So-- it is important to be sure you can obtain 10 mw of output power with the lowest amount of IF drive power possible and why we specify it at this level. Bottom line is at the output power of 10 mw, if all spurious are less than -40dBc, you are done! Be sure the enclosure is closed and tight when you make the last measurement. Now, if the levels are close, you make the choice. If they are out of spec, continue reading.

Now what do we do with these levels. First, if there is a damaged diode, the mixer will be un balanced and produce a large RF + IF signal and LO bleed through. Levels of -20 dBc would be expected. If it is closer to spec, it is important to verify the drive level from the multiplier circuit. If you passed up the LO output power test and are not sure of the level being injected, now is the time to check it before additional major work is started. The LO bleed through power is easier to eliminate by reducing the LO drive than to make adjustments in the mixer or TXRF chain. This adjustment may yield the best results and will reduce the RF+IF harmonic content but not by the same amount as the LO bleed. If the LO level is readjusted it will require you to set the output level back to 10 mw. Now, this also works in the other direction. If the LO drive power is too low, it will require more IF drive to get the desired 10 mw output level. This causes the RF+IF harmonic level to be excessive. You will know where you are at, when the level is correct.

After that is completed, you are left with the result of the Mixer and RF filter's pass bands. Be sure to measure the levels with the enclosure closed up and tight. Now again, if you find all levels close to -40dBc, it's a judgment call. It can be improved but-- it takes time and some patience.

In an example, we completed the modification of a low power transverter with an A-32 installed. We installed a toggle switch to have the ability to change the LO frequencies for easy testing. We then set the IF drive level to 10 mw and these were the initial measurements with the enclosure closed.

	Frequency	LO Level	RF+ IF Level	RX Gain	RX Noise	Spurious
Before Mod	3456	-40 dBc	-45 dBc	23.81dB	1.66 dB	NO
Before Mod	3400	-46 dBc	***-29 dBc***	24.56dB	1.61 dB	NO
After Mod	3456	-48 dBc	-45 dBc	23.81 dB	1.66 dB	NO
After Mod	3400	-46 dBc	-50 dBc	24.56 dB	1.61 dB	NO

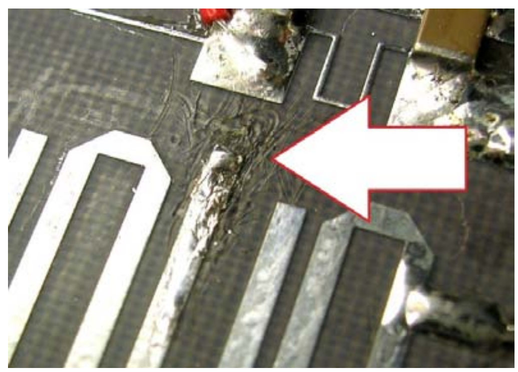
As you can see, in this version of transverter, the only problem was the 2nd harmonic of the 144 MHz IF mixing with the LO producing 3544 MHz. Now, one would think that a signal that is almost 100 MHz away from the design frequency of the filters would not exist. BUT, because these are near 150 MHz band width filters we were skewing higher in frequency away from 3312 MHz as the first goal, but to allow 3400 MHz to pass, it would attenuate 3544 and much as 3600. But, in this transverter, it does not. Now, is it completely the filters fault? Not exactly. We have also done some mods on the mixer with tuning stubs. But for now, let's discuss "Snow Flaking"

Snow Flaking is the art of adjusting Microwave Circuits by adding or subtracting circuitry in the active circuits on the Printed Circuit board. Since the circuit board metal is either Gold, Copper, or Tined Copper, you can only add metal that will solder. This leaves Copper, Brass or Tin plate steel. Tin plate steel is a bit rough to work with and Gold is expensive, we either use Copper or Brass. Some use silver paint but the drying time slows the process. Copper foil is the house favorite here. So-- we have many assorted small wooden dowels or Q-tips without the tips and we attach various sizes of Copper foil to the ends with some sort of adhesive. Some of these Copper attachments are very small. Some are 50mil square. Some are specialized to mimic specific parts of the microwave circuitry we work on. But in this case any non conductive stick that had some small amount of metal on it would work. Another method is to cut assorted small sized pieces of copper foil and trial fit were required. The trick is not to lose them on the board somewhere and have them get stuck where they don't belong. But basically, you drop one on the part of the circuit you want to adjust and slide it around with a insulated tool or wooden dowel until the desired results are achieved.

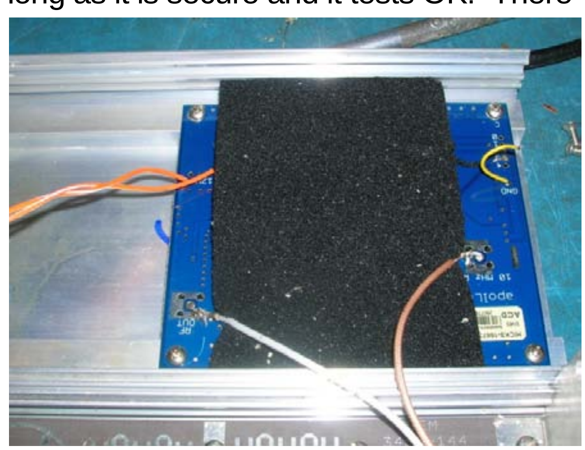
Now with that simple knowledge, you could start to test and take hours to find the spots that help or hurt the performance. Yes, if you add metal and the performance gets worse, it may mean that the circuit needs to be trimmed but it takes experience to determine this. So, in this case, we have found the "Hot Spots" through experimentation and design knowledge. Since we have been making certain changes to the board over many years, we know where they are. We will give you suggestions of where to check and when the improvement is observed; solder the snow flake in place.

If you look on the component placement diagram provided, we have some indications marked. Start with the stubs in the TX RF mixer. Understand that because of tolerance of the mixer diode pair, the stubs used are design to be in the general range. They are there to reduce the RF+ IF (or 2nd harmonic of the IF signal) level being delivered to the TX Gain chain. Start there and if you desire to operate both 3456 and 3400, you may need to compromise. Now there is no voltage on the Mixer so you can leave the transverter in transmit and slide the snowflakes around to find the compromise that works. It may appear that a stub may want to be shortened but you can find what you need by addition. When you think you have a good spot, solder the flake down being sure that it is flat to the circuit and there isn't any excess solder and test. You may see that it should be longer, shorter, smaller or larger so adjust! Multiple flakes are OK! It's whatever it takes to get the job done. Then check with the case closed first verifying that the output is still at 10 mw. That's important because it will change! If it does, readjust the drive level and if required re-position of the Flake and retest. If you get to the point of getting nowhere, make it the best it can be and if still out of spec, continue on to the next hotspot. Try sliding a snow flake along the circuitry that connects the diode legs to the mixer. If you find what you need, solder it in and test as before. Now you may get curious and start to slide a snow flake around the ring of the mixer and find deep nulls. You can try adding a snow flake to see if it helps and again, with the lid closed up. It's rare to find a spot that you can actually attach a snow flake to that will help but you may try!

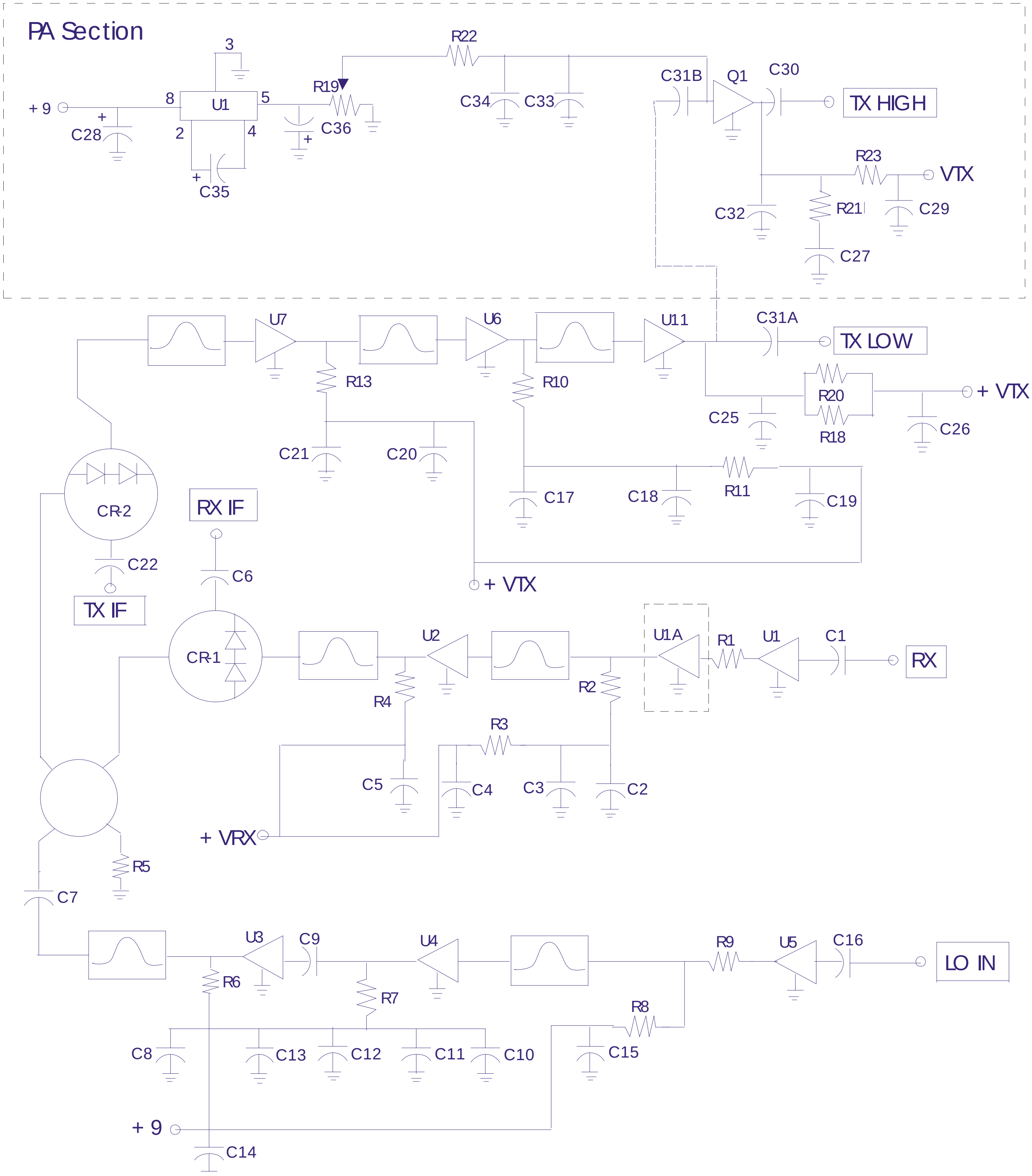
If the results you have been looking for are still not achieved, it's time to test the filters. You may have seen designs of hairpin filters with chip capacitors on the ends. Well, they were much lower in frequency. At this frequency, fractions of a Pico-Farad make a large difference, so-- we need to utilize very small snowflakes and make minor adjustments. The slight adjustments occur in the inner hairpins of the filter stubs. You can poke at every one of them within the 3 RF filters and see change. Only a couple of them will work for what you need. Take your time, and always check to verify with the enclosure closed. Below is a transverter we have modified that produced the previous data.



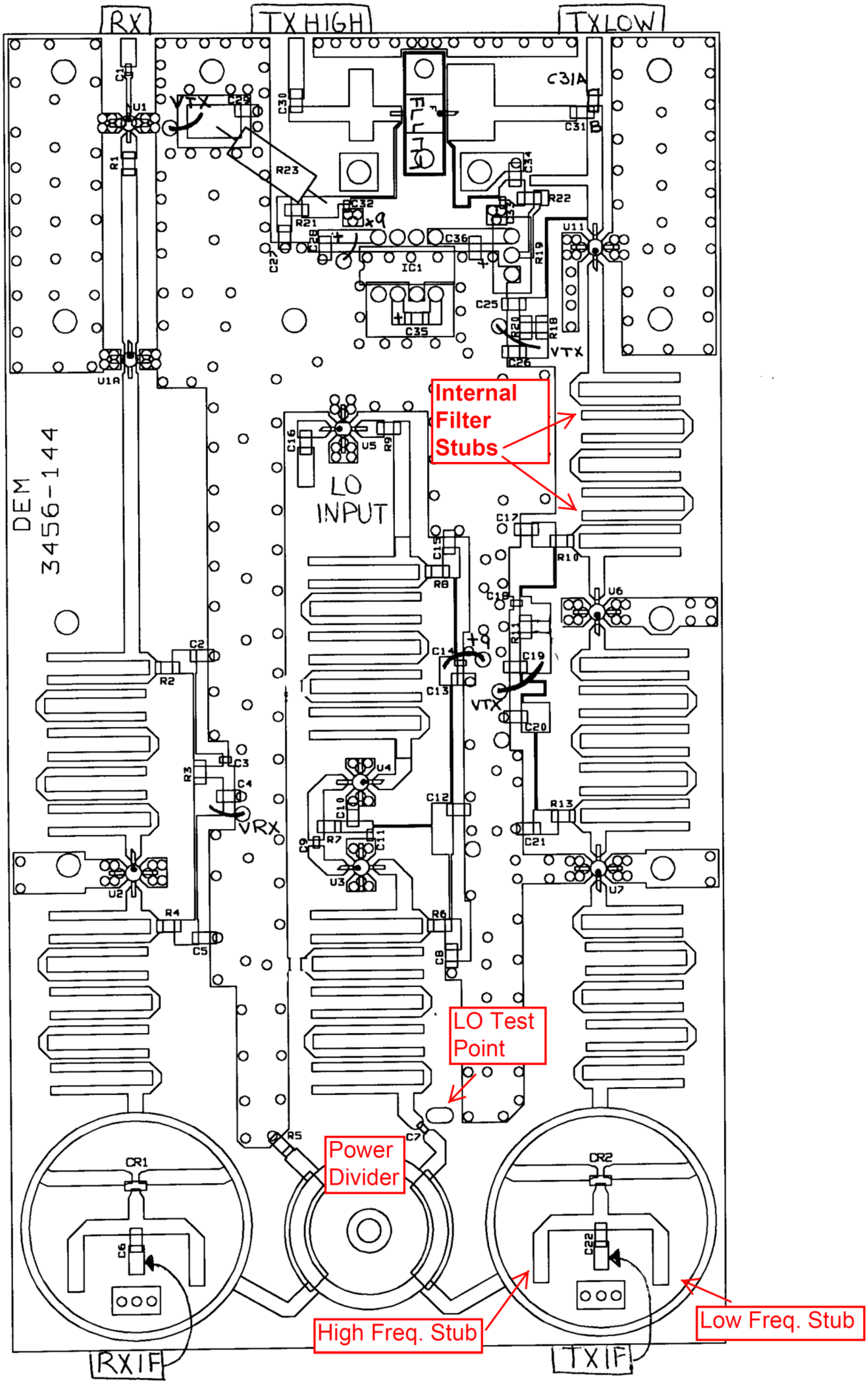
Its difficult to hold a snow flake down with a tweezer or something pointed and solder in place without leaveing a large indentation,so don't wory about it as long as it is secure and it tests OK! There is also no need to solder a snow flake on both ends of the hairpin filter as long as one end works. ALSO-- sometimes you will find excess solder on some connections to the filters or Mixers that are causing the problems. It is rare but it can be checked and removed easily to find out. And again, just because these were the only changes to the circuit on this board doesn't mean it is all you require. If you still need improvement, get in there and poke around. The worst you can do (and it is doubt ful) is to break a $2 MMIC. And then worst case, if you can not acheive the desired results, it can be sent to us for a final check and test. ALSO-- if you find large changes in performance



when the enclosure is fit together, try placing some conductive static foam or Echo-sorb material on the lid and synthesizer as shown.



3456-144 TRANSVERTER SCHEMATIC


RX
TX HIGH
TX LOW
VTX
DEM
3456-144
LO
INPUT
Internal
Filter
Stubs
VRX
LO Test
Point
Power
Divider
High Freq. Stub
Low Freq. Stub
RXIF
TXIF

Hope this document has been helpful in understanding the potential issues in changing the 3456 transverter to 3400. We will continue to review all transverters sent to us to modify and report any other issues found with the conversion process and report it at the end of this document. As of now, we have not converted a SHF version of the transverter with the 552 MHz LO but have a good idea of what should work. We will cover this in Design Note 40 along with the DIGILO install.

There is no reason that any 3456 transverter that was released by DEMI cannot be put on 3400 MHz without excellent results. It is easy to do with the correct equipment and time. If you have any further questions, please contact us through any channel. Thanks for reading, from the Gang at DEMI.