Updating KK7B, SHF,DEM or DEMI 900 and 1296 MHz. transverters

By Steve Kostro, N2CEI

PREFACE: Yes, It may be hard to believe, but the original 900 and 1296 "No-Tune" transverter concepts have been around for 25 years now[1]. Fundamentally, except for obsolesces of some passive and active components, these designs are sound examples of RF engineering even by today's standards. Throughout the years, these design concepts have been integrated, expanded, compressed, and developed into today's state of the art transverters. And, some of these same concepts are utilized in designs today[2].The development of DEMI 900 and 1296 MHz transverters was mainly to provide the best possible noise figure, with the maximum amount of output power coupled with receiver dynamic range and the ability to interface with just about any transceiver on the amateur radio market. Yes, some attention was given to frequency accuracy and stability and improvements have been made but, never have we had an opportunity develop as in the past 2-3 years in this field.

With the implementation of frequency synthesizers in higher frequency transverters providing a "New Life" to the hobby, it was only natural to address the issue with the lower and sometimes more popular frequency transverters. This paper will cover the upgrade of all KK7B, SHF, DEM and DEMI 900 and 1296 MHz transverters by first disabling the original Local Oscillators and integrating the A-32 synthesizer. The paper will describe the LO circuits, the levels required, and provide options to produce the final results. It will also discuss some of the A-32 fundamentals, quirks, and special frequency programming. So, let's begin with the A-32.

THE A-32 SYNTHESIZER: The pre-programmed A-32 synthesizer, designed and developed by Steve Hicks, N5AC of Hicks Consulting, with the prodding of DEMI, has become the basis of local oscillator generation in all transverters 2.3 GHz and higher[3]. After further development, the original 32-programmed frequencies have been expanded to 60+ covering many other transverter schemes, non-DEMI designs[4], and some future prototype development ideas. Some of these frequencies were intentionally unpublished to avoid consumer confusion and possible "misinterpretation".

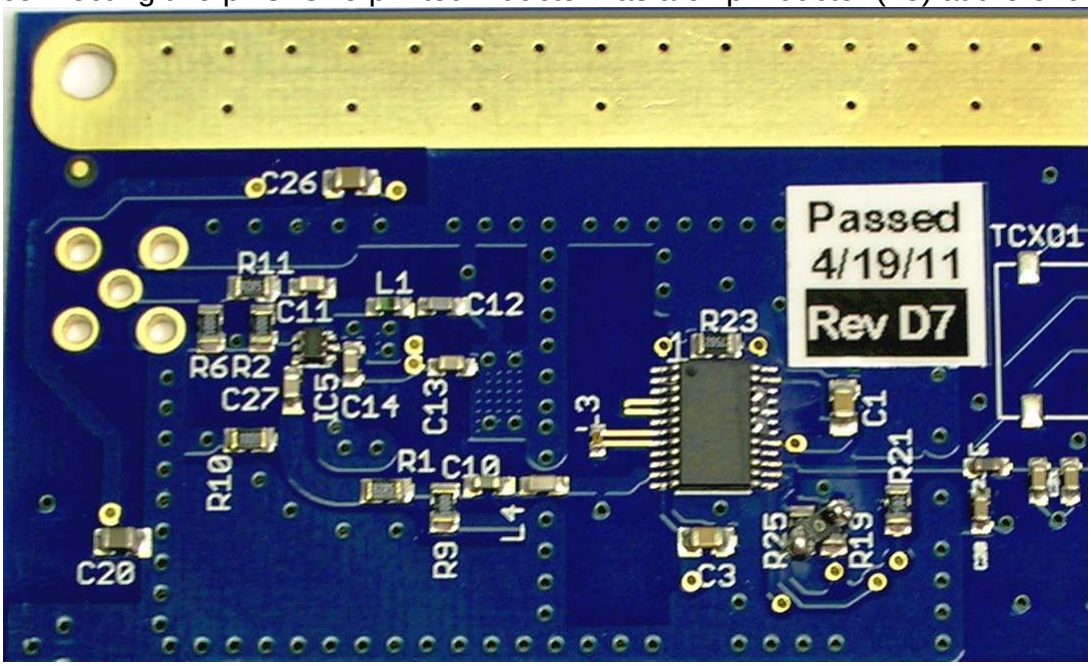
An example of this is the Local oscillator frequencies required for operation on 900 MHz are programmed but will not function without a circuit modification and component installation. This modification will enable the frequencies of interest for 900 MHz operation but will disable the synthesizer's ability to "Lock" on programmed frequencies above 900 MHz. After the synthesizer is modified, it will only function on the lower range of frequencies. To keep track of this in a production environment would require two separate models and added expense to the process. It was decided to work with it on an "As required" situation. The programming of the A-32 for the 900 and 1296

[1] Engineering Notes on the 23 CM Transverter, Rick Campbell, KK7B, page 53, 1989 CSVHFS proceedings
[2] http://www.w1ghz.org/
[3] http://www.n5ac.com/apolLO-32Operation.pdf
[4] Visiting and Old Friend, 2009 Southeastern VHF Conference proceedings, page 58

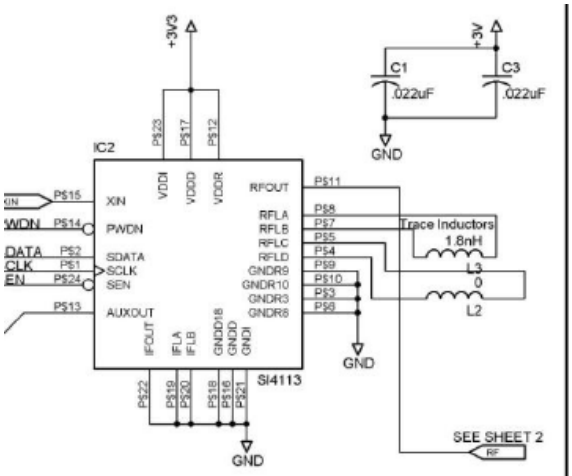
bands are listed below and may be utilized with all transverters, KK7B through present day DEMI transverters. The ***** in front of the band indicates that the circuit modification is required to produce the desired frequency.

Band	IF	Frequenc y	REV	7	6	5	4	3	2	1	0	Predicted PN, dBc/Hz @ 1 kHz
1296.1	WSS	1296.1							X			-74
1275	WSS	1275	C2		X							-81
903.1	WSS	903.1	C2								X	-79
902.1	WSS	902.1	C2			X						-74
1296	144	1152	C2			X					X	-81
1296	28	1268	C2			X		X				-81
1296	145	1151	C3			X				X	X	-81
1296	147	1149	C3			X		X		X	X	-81
1296	29	1267	C3			X		X	X			-81
1296	50	1246	D7			X	X	X		X	X	-81
*902	144	758	C3	X							X	-81
*902	146	756	C3	X						X		-81
*902	145	757	C3	X						X	X	-81
*903	144	759	C3	X					X			-81
*902	29	873	C3	X					X	X	X	-81
*902	28	874	C3	X				X				-81
*903	28	875	C3	X				X			X	-81
*902	50	852	D7	X				X		X	X	-81
*902	52	850	C3	X					X	X		-81
*903	50	853	D7	X				X	X			-81

As shown in the picture below, the synthesizer chip has two printed inductors each connecting two pins. One printed inductor has a chip inductor (L3) at the end of it.



The other, a bit shorter and is just above the L3 on the board. It is shown on the schematic as L2. This is where a 0402 3.9nH chip inductor is installed after cutting open the trace at the end. This will enable the A-32 to lock on the 900 MHz. frequencies. The L3 chip inductor shown is a 0402 component. If someone desires an A-32 operating on the 900 MHz frequencies but does not wish to do the 0402 work, simply ask for it to be done at DEMI when ordering.

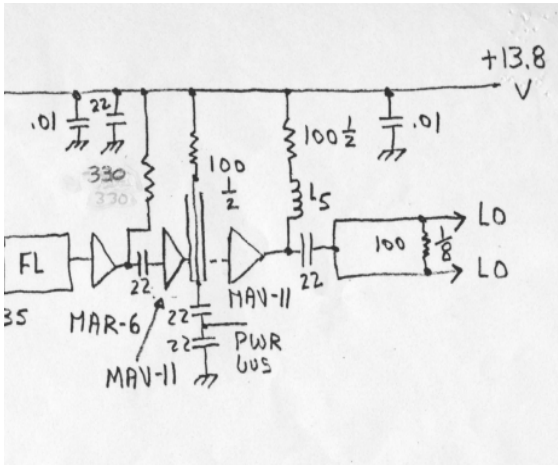


One other modification to the A-32 that may need optimization is the Pi attenuator pad (R6, R2, and R11) on the output of IC 5. Depending on the circumstance and the levels desired for the transverter upgrade, the attenuator's value might need adjustment. The standard output level of the A-32 is +3dBm. It is +13dBm with the attenuator removed.

The A-32 may be installed in the same enclosure as the transverter using whatever means (replace the position of the SHF LO coaxed to the circuit boards or supported from other means in the 900 MHz transverter) or installed in a separate enclosure complete with coaxial connections. The only extra connection that needs to be made to the A-32 is the 10 MHz input (if desired) and a provision for the "LOC" indicator.

KK7B/ SHF Design Transverters: The original 1296 KK7B design transverter required a 576 MHz signal from the SHF LO. The 900 MHz transverter had its own LO built on the transverter board. There was never a provision other than using a 144 MHz. "IF" because of the bandwidth of the RF filters on transmit but more on this later. A simple modification is done to both transverters providing excellent results. SHF Systems of Nashua, NH and Down East Microwave of Troy, ME provided different versions of these transverters as kits and complete assemblies with various enclosures, with or without 3-10 watt power amplifiers. Every unit has the potential to be upgraded.

THE SHF900: This transverter design was released in 1989. An original copy of the kit document is on the DEMI website[5]. Local oscillator levels are not specified but doing some back calculating and understanding that is a dual mixer system requiring +7dBm to each mixer, you can figure on a level of +10dBm to the input of the Wilkinson power divider. This document does not have any component designators so, the power divider is after the last MMIC (MAV 11 or MSA1104) in the LO chain.



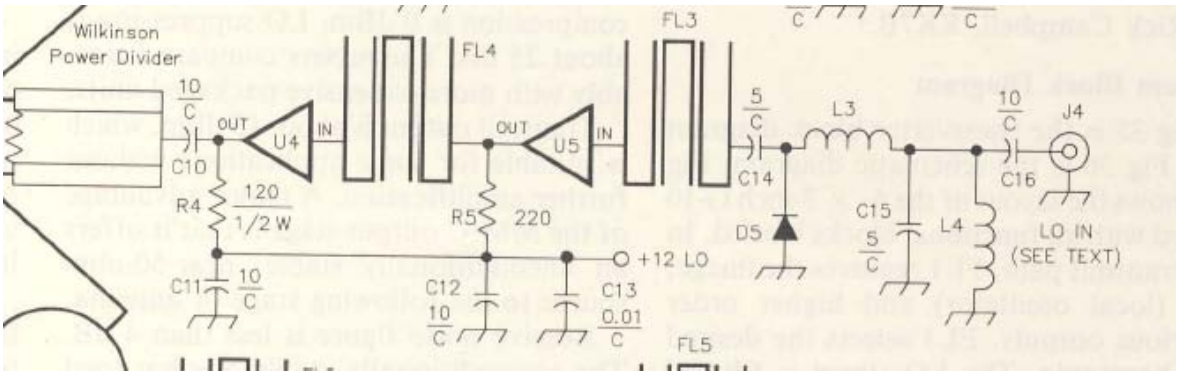
[5] http://www.downeastmicrowave.com/PDF/Manuals/SHF902.PDF

This leaves you with two options to complete the modification. First option, and only option if you desire to use a different IF frequency other than 2M, is to remove the MAV-11 attached to L5. The A-32 may be injected into the 22 pF capacitor found in the same position near L5. The L5 inductor must be removed to eliminate the DC voltage going back into the A-32. Then, the attenuator pad on the A-32 should be replaced with a 3 dB version. An 18-ohm series (R11) and two 300-ohm shunts(R6 and R2) will work.

The second option, which is the easiest but, can only be utilized with a 2M IF frequency is to remove the MAV-11 between the MAR-6 and the filter. (The MAV-11 with the arrow pointing to it on the schematic) The A-32 output is then injected directly into the last filter in the LO chain. The filter has about 3 dB loss so, the final MAV-11 would be driven with +0dBm producing a perfect level to the mixers without modifying the A-32. The 100 or 120-ohm bias resistor for that MMIC needs to be removed so that voltage does not travel back into the A-32 and burn out the attenuator pad.

Since there is not any IF frequency filtering in the SHF900, it may be used with other IF frequencies by selecting the appropriate LO frequency if and only if you chose the first modification option. The only further requirement is to add additional filtering to the output of the TX chain before further amplification. If the transverter is used at its designed output power, the non-filtered spurious may not be an issue, BUT, Introducing a high gain power amplifier without a filter would just be a headache!

THE SHF 1240: The transverter was provided and optimized with the SHF LO, which operated at 576 MHz. The A-32 is not capable or programmed that low in frequency. Rick Campbell, KK7B designed the LO multiplier circuit[6] on the transverter so that it could be utilized with various frequencies harmonically related to a final output frequency of 1152 MHz. This means, one can easily inject an 1152 signal directly from the A-32 into the transverter board. The options are very similar to the SHF900 transverter. Using one of the various publications of this popular transverter[7], (yes, complete with component designators!) the modification is simple.

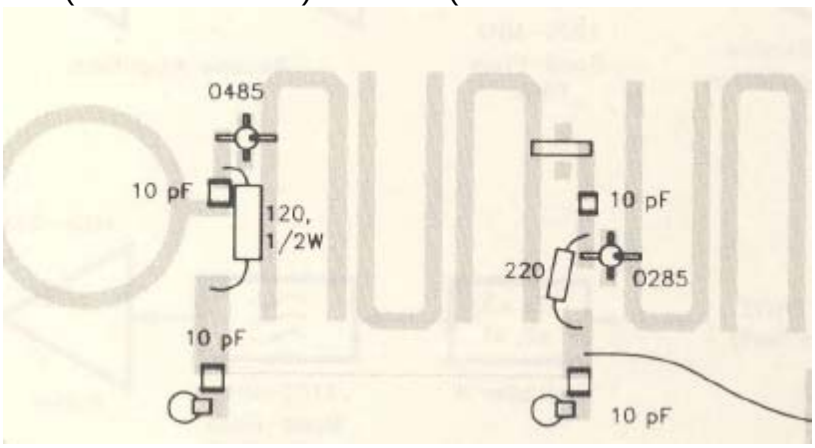


It is a two-mixer design with a Wilkinson power divider. The mixers requires +7dBm, therefore, the divider requires +10dBm. This can be accomplished by modifying the attenuator pad value on the A-32 and directly injecting the signal into the power

[6] A Single Board No-Tuning 23 CM Transverter, Rick Campbell, KK7B, page 44, 1989 CSVHFS proceedings
[7] Complete Schematics and board layouts published in ARRL UHF/Microwave Projects Manual and ARRL Handbooks from 1991- 1997 and at the DEMI website in the manuals section

divider after removing U4 (the 0485 MMIC) and R4 (the bias resistor). Any desired LO /IF combination may be used because the limited filtering in the IF section (Low pass at 150 MHz.) will allow any signal to pass. The only caution is to add additional TX filtering if using a power amplifier after the original transverter board. This may be difficult if the unit is a complete 3-watt assembly.

The second option is and may only be utilized with a 2 M IF frequency is to inject the A-32 LO signal in between U5 (the 0285 MMIC) and FL4 (the last 1152 band Pass filter). Rick designed the board with extra amplification in case you started with a lower frequency LO frequency than 576 MHz. During assembly, one gain stage is not assembled and a strap is used in its place. This strap is now removed and the input to the filter is utilized for the input from the A-32 at any frequency around 1152 MHz. No attenuation changes are required on the A-32. The 220 ohm bias resistor to U5 is removed of course along with the original SHF LO and then replaced with the A-32 circuit.



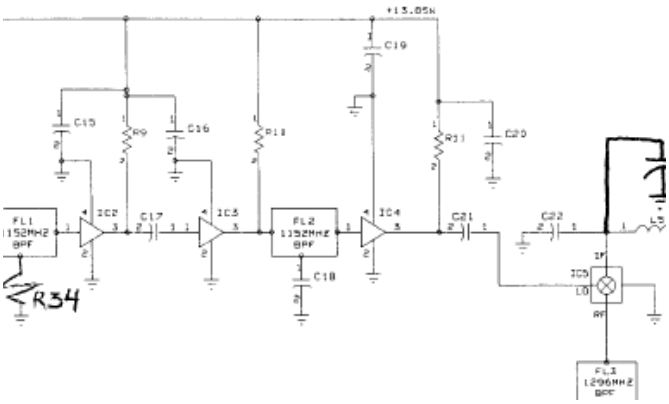
Both transverter designs are “sound” and only lack RX selectivity. The upgrade of frequency accuracy and stability is a great plus for this design and with an extra filter or two, a low noise LNA and power amplifier; they would be part of a top-notch system. And of course, the transverters utilized at their stock levels with the frequency upgrade will allow the QRP operation to me much more enjoyable!

ORGINAL DEMI TRANSVERTERS: In 1995, DEMI introduced the first single board 900 and 1296 transverter that included a Low Noise amplifier and power amplifier fit for a standard die cast box. This original design had a +7dBm LO level mixer. Three years later, the design was changed to a +17dBm mixer to improve out of band signal handling. A retrofit kit was released at that time for the older designs. The key is to identify the mixer part number in the Mini Circuits database[8] If the mixer is a +17dBm level, proceed to the next section of this manual titled “+17dBm Level Transverter”. If you desire to upgrade the +7dBm level, the only changed required is to replace the mixer with a model that will fit the board pattern and proceed to the +17dBm section of this document. Documents for both designs are on the website.[9] [10] Both 900 and 1296 of the same mixer injection level have the same component designators (or close enough in this case) so that the designs may be interchanged if you only can find one document. The simplest A-32 modification is to keep the 2M IF. As with the KK7B designs, changing the IF frequency ranges will require additional filtering on the TXRF

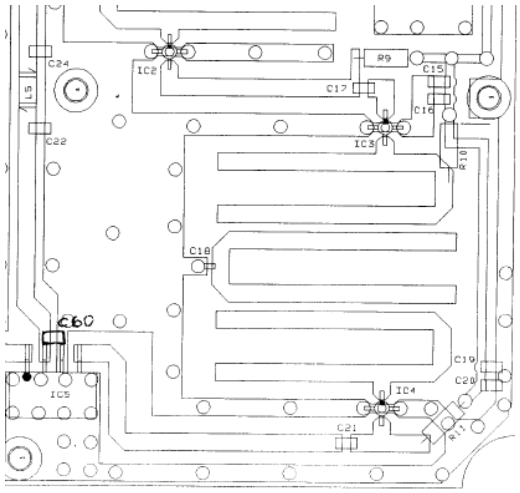
[8] http://www.minicircuits.com/homepage/homepage.html
[9] http://www.downeastmicrowave.com/PDF/Manuals/1296-144CKrA.PDF
[10] http://www.downeastmicrowave.com/PDF/Manuals/903_144rC.pdf

side. It would be difficult to install the additional filtering within the same enclosure if you have the 3 or 10-watt models. However, nothing is impossible.

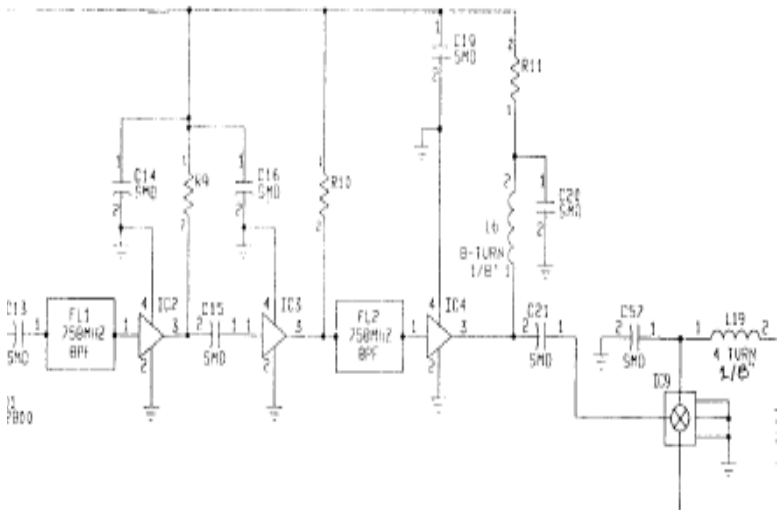
+7dBm LO MIXER: The simplest way to do this modification is to remove IC3 and inject the output of the A-32 directly into FL2. Then remove R10. Then the best way to disable the rest of the LO is to remove R9,R8,R7 and VR1. Also remove the PTC if installed. No modifications to the A-32 are required. This is for both 900 and 1296 designs.

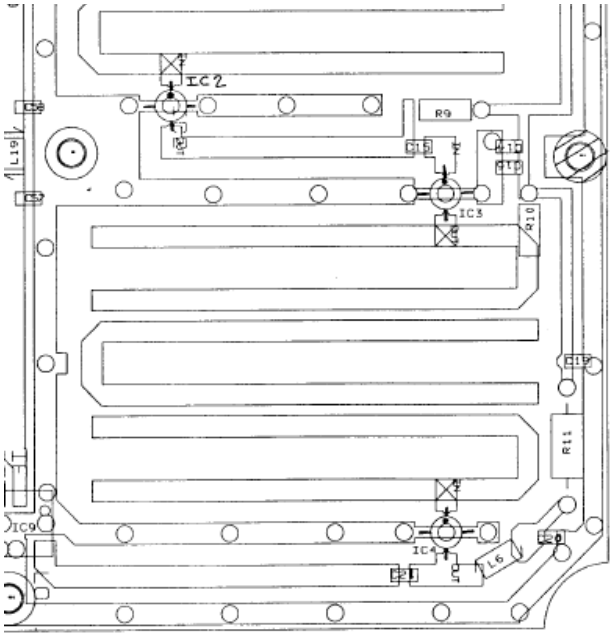


If you desire to use a different IF than 2M, remove IC4 and R11. Then replace the attenuator pad on the A-32 as stated before (R6, R2, and R11) with 18 and 300-ohm resistors. This will provide the mixer directly with +7dBm input. Now, the entire LO section of the transverter may have its +DC disabled by removing R7-R10 and VR1. There is a low pass filter on the IF side of the mixer but it will pass anything under 150 MHz. The only other precaution is FL3 and FL4 will not provide enough filtering of a 1268 signal if any at all so extreme filter changes or additions will be required using a 28 MHz IF. A 50 MHz IF may work with little or no extra filtering added. The issue is the LO bleed through. Again, the 3 or 10 watt high gain amplifiers will only make matters worse without the extra filters.



+17dBm LO INPUT: To utilize the +17dBm LO input level mixer transverters, and keep the 2M IF frequency range, you need to use the extra gain stages in the LO chain. First, remove IC2 and R9. The A-32's signal is injected into C15 to drive IC3. Disable the bias in the rest of the LO and LO chain and job done. To change IF frequency range is not difficult but it's a lot of effort to make it work well. The attenuator on the A-32 would need to be removed or adjusted down in attenuation (+13dBm max output) and a outboard gain stage installed

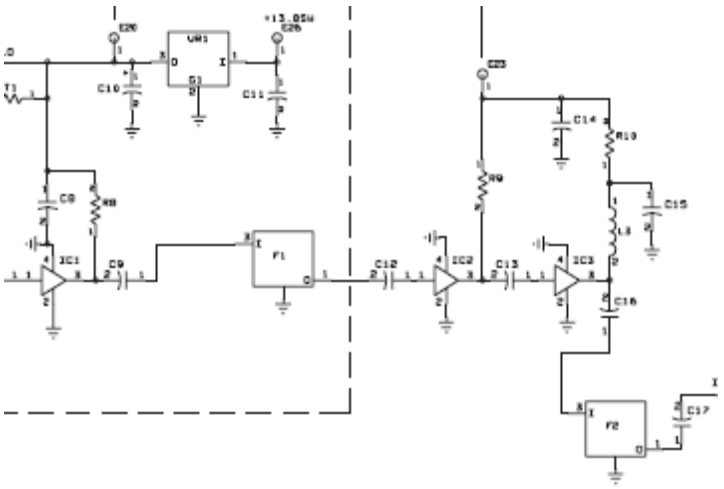




between the A-32 and the mixer to make up the difference to obtain the correct injection level. IC4, as is, could be utilized if the traces were cut on the filter and made into 50-ohm traces with a DC blocking capacitor. The A-32 output could be injected there. The final level would need to be tested and measured going into the mixer. The level could be adjusted by changing the attenuator pad on the A-32 to compensate. And as stated before, a 28 MHz IF can be utilized but additional filtering would be required on the RF TX stages.

Finally, the A32 may be mounted onto the lid of the die cast enclosure. A connector for the 10 MHz in may be installed anywhere in the enclosure along with the LOC indication LED. The A-32 may also be installed in its own enclosure and the assemblies simply coaxed together.

DEMI CLAMSHELL TRANSVERTERS: The DEMI Clamshell transverter designs were released in 2000. The related documents may be found on the DEMI website. The 3 and 10 watt transverters[11],[12], and the ½ and 1 watt transverters [13],[14] have changed a bit over the last 10 years or so years but the LO level has remained the same at +17dBm. This is the same main transverter board utilized in all HP transverters (25, 30, 50,60Watts) for both bands. Two separate IF models (2M and 10M) were designed using helical filters. Because of the helical filters in the LO section, it is best to replace the Xtal LO with the same frequency A-32. The helical filters are near impossible to replace and actual cost of replacement is a very un-economical choice. If you do desire to change the IF frequency, the simplest way would be to bypass all of the gain stages and filters in the LO chain and have an off board gain stage to amplify the A-32 signal,

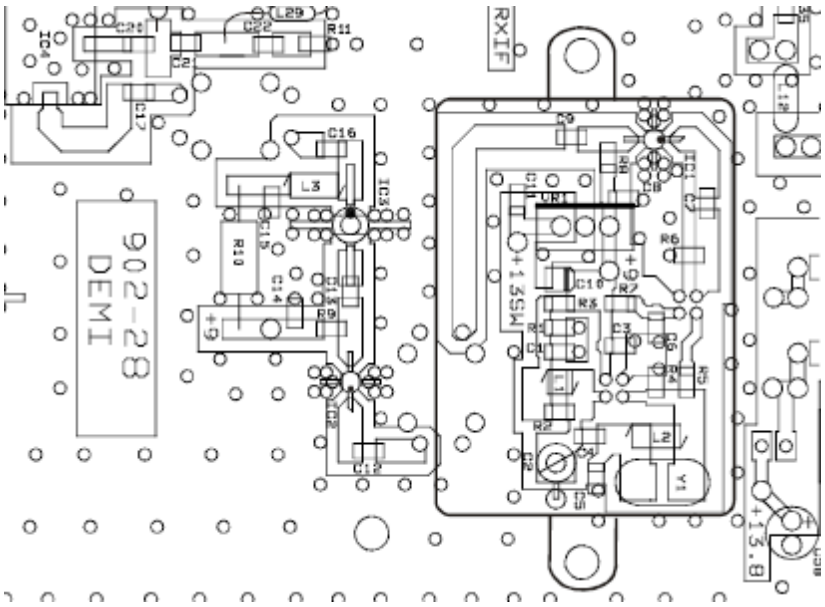


[11] http://www.downeastmicrowave.com/PDF/Manuals/1296-144CKrD.PDF
[12] http://www.downeastmicrowave.com/PDF/Manuals/90X-144CK_RevD.pdf
[13] http://www.downeastmicrowave.com/PDF/Manuals/90X-144CK_RevE.pdf
[14] http://www.downeastmicrowave.com/PDF/Manuals/1296-144.PDF

and then inject the +17dBm level directly into the mixer. Then, the IF section would need modification because of the discrete band pass filters. Simply copy the other transverter's IF diplexer.

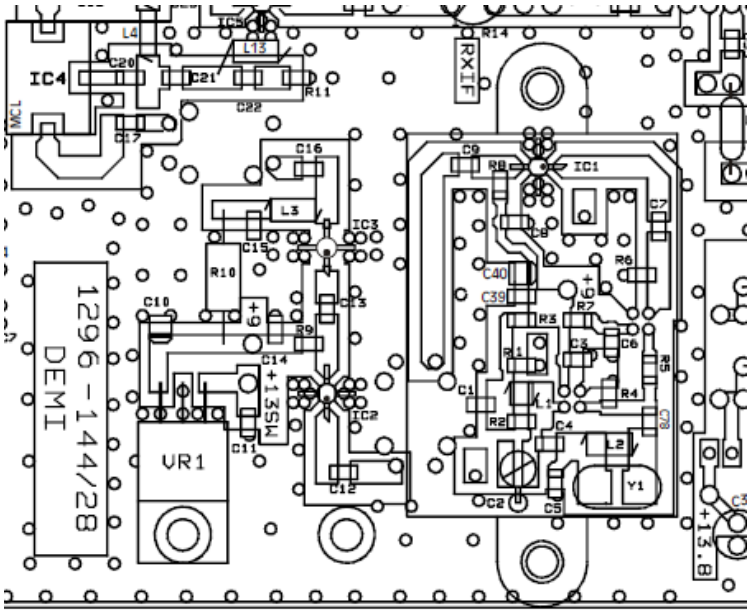
The simplest modification without changing the IF frequency is to inject the A-32 output into C9. To do this, remove the LO shield, IC 1 and R8. A +3dBm input from the A-32 will yield the correct level at the input of the mixer.

Schematically, the 900 and the 1206 LO's are identical. The only differences you would encounter is the model change for the 3 and 10 watt transverters using Hybrid power modules to the newest model utilizing 1 watt MMIC's. During this design transition, the 9-volt regulator was moved from the oscillator shield area to outside on the board bolted to the enclosure. The two different component placements are shown for clarification. The regulator is required to supply DC power to the MMIC's in the LO chain. To disable the rest of the oscillator circuit, the DC needs to be removed from Q1 and Q2 by removing R3 and R7. Remember, the deigns difference have nothing to do with frequency, only revision.



Mounting the A-32 can be done on the opposite side of the clamshell enclosure. All wiring can be routed back to the main assembly. The AUX connection in the rear panel may be utilized for the 10 MHz. input if desired or another hole may be placed in either panel to accommodate.

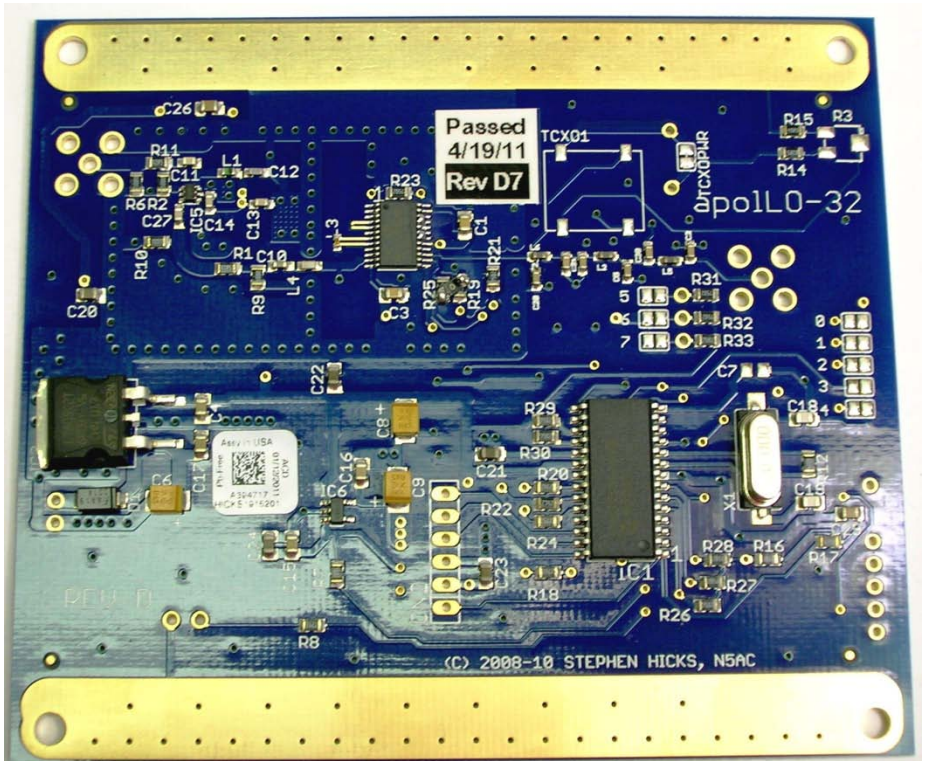
If modifying a High Power version of either transverter, we have found the mounting the A-32 on or near the transverter board or Heat Sink is difficult to do. Yes, in production, DEMI does mount the A-32 to the actual transverter board but it is assembled for the bottom up. To do this as a retro fit would



require disassembling the entire unit (well almost!), custom drilling of mounting holes and boards, then provide standoffs. The best retro fit would be to mount the A-32 to the inside of the bottom cover. Bundle all cables and wires when complete.

FINAL NOTES: All upgrades are simple but anyone can make it as complicated as one wants! In all instances, the most complicated part of the modification is the mechanical attachment of the A-32 inside of the transverter enclosure. Be sure to route the 10 MHz source input signal away from RF circuit traces on the transverter board. Also, mixing with the IF signal could occur if signal wires get to close. The A-32 may be kept external from the transverters and the LO signal can be coaxed to the correct placement on the transverter board. Levels are important as the actual 10 MHz levels into the A-32. Please follow the A-32 guide as referenced previously in this document.

IN CONCLUSION: The intention of this document is to possibly get an underutilized or "shelf bound" transverters back on the air and operating close to today's standards. Of course, if I have stimulated thoughts of re-working other types of transverters of different manufactures for better performance or using the A-32 as a basis for your own design, that's a plus ! No matter what, there is plenty of info in this document to help anyone upgrade one of the original transverters, the newer versions, and today's models. All info may be utilized to convert or modify transverters of different frequencies. It's an experimenters hobby and if using something that had little value in its present state, then you have nothing to lose but a little operating time. Maybe it would be the operating time you would have lost anyway trying to make that contact with that "drifty" transverter. Give it a try!



Have fun and catch you on the bands!

73,
Steve, N2CEI