Modifying a MA-Com / Ericsson LPE-200 for 900 MHz ham radio repeater use.

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Getting on to the 33cm band generally means getting your hands on some ex-commercial 900 MHz two way radio equipment, programming it for ham frequencies, and if necessary modifying the hardware to suit. One such radio is a 900 MHz version of the MA-Com or Ericsson LPE-200 handheld. If you have one of these radios, you'll know that reprogramming them for 900 MHz ham repeater operation is not as easy as just programming the frequencies and getting on air, and even if you can insert the correct frequencies, the LPE-200's synthesiser typically unlocks on receive below 928 MHz. Described here are the relatively simple modifications required to permit the VCO to successfully lock at frequencies useful for ham repeater operation within the 33cm band. Note that these modifications apply to the 900 MHz LPE-200 with a model number of KRD 103 104. 800 MHz models are not suitable for this modification. This mod will work for both the newer 25 MHz split repeater allocations without the need to replace front end filters, and the old ARRL 12 MHz split repeater allocations as well, but will need a change in front end filters for best sensitivity.

Standard disclaimers apply: All care but no responsibility taken for the accuracy of this information, or how you make use of it. If you damage your radio or render it inoperative, its entirely at your own risk.

Software modifications required:

The first step is to insert ham frequencies into the radio. The LPE-200 programmer software will not accept frequencies outside the TX range of 896 to 902 MHz and RX range of 935 to 941 MHz. However, with the use of some so-called SC4 files, the software can be tricked into loading out of band frequencies. SC4 files work by nominating a new frequency for the bottom end of the TX, RX and Talk Around bands. For example, lets say you nominate 902 MHz as the new lower end of the TX band with a SC4 file and instruct the programmer software to use this file. You then program in the lowest TX frequency the *software* accepts, being 896.0125 MHz, but with the SC4 file, the *radio* is actually told to actually TX on 902.0125 MHz, even though the software still says 896.0125 MHz. A similar process is used to alter RX frequencies, and for Talk Around frequencies, if needed. For those interested, the SC4 files nominate the new band bottom edge frequencies in Hertz, expressed as a hexadecimal figure broken into four bytes each, the first four being the TX bytes, the next four bytes for RX, and the last four bytes for Talk Around. In its normal implementation, talk around sets the TX frequency the same as the higher RX frequency, but with this you can specify at what frequency the TX for talk around starts off at. RX frequencies remain unaffected with talk around. However, as you'll later read, this modification renders the talk around feature inoperative.

For 25 MHz split repeater allocations: Create your SC4 file by opening notepad, and enter the following exactly as it appears here:

```
FREQTBL /f /b0 /=35
FREQTBL /f /b1 /=C3
FREQTBL /f /b2 /=6D
FREQTBL /f /b3 /=80
FREQTBL /f /b4 /=37
FREQTBL /f /b5 /=22
FREQTBL /f /b6 /=61
FREQTBL /f /b7 /=40
FREQTBL /f /b8 /=37
FREQTBL /f /b9 /=22
FREQTBL /f /bA /=61
FREQTBL /f /bB /=40
```

Save this file with a name like 900ham_TX+6_RX-10.SC4 or any name that you like, just make sure you save or rename the file to have a .SC4 extension. What you've just done is create a file that will begin the transmit band at 902.0125 MHz, even though the software shows frequencies starting at 896.0125 MHz (eg: actual TX frequency is +6 MHz above what is shown in software), and the RX band begins at 925.0125 MHz, even though the software shows frequencies starting at 935.0125 MHz (eg: actual RX frequency is -10 MHz, below what is shown in software). You will need to set the programmer software to make use of the SC4 file, this is done under the "General Options" screen. Now all that is required is a little mental arithmetic to program your desired frequencies. For example, if you wanted to insert 902.3125 MHz for TX into your local repeater, and 927.3125 MHz RX out from your local repeater, you'd program TX as 896.3125, and RX as 937.3125 MHz Program your frequencies into a 'conventional' system in programmer software, and write your frequencies to the radio.

For 12 MHz split repeater allocations: Create your SC4 file by opening notepad, and enter the following exactly as it appears here:

```
FREQTBL /f /b0 /=36
FREQTBL /f /b1 /=00
FREQTBL /f /b2 /=76
FREQTBL /f /b3 /=80
FREQTBL /f /b4 /=36
FREQTBL /f /b5 /=B7
FREQTBL /f /b6 /=91
FREQTBL /f /b7 /=80
FREQTBL /f /b8 /=36
FREQTBL /f /b9 /=B7
FREQTBL /f /bA /=91
FREQTBL /f /bB /=80
```

Save this file with a name like 900ham_TX+10_RX-17.SC4 or any name that you like, just make sure you save or rename the file to have a .SC4 extension. What you've just done is create a file that will begin the transmit band at 906.0125 MHz,

even though the software shows frequencies starting at 896.0125 MHz (eg: actual TX frequency is +10 MHz above what is shown in software), and the RX band begins at 918.0125 MHz, even though the software shows frequencies starting at 935.0125 MHz (eg: actual RX frequency is -17 MHz, below what is shown in software). You will need to set the programmer software to make use of the SC4 file, this is done under the "General Options" screen. Now all that is required is a little mental arithmetic to program your desired frequencies. For example, if you wanted to insert 908.1000 MHz for TX into your local repeater, and 920.1000 MHz RX out from your local repeater, you'd program TX as 898.1000, and RX as 937.1000 MHz   Program your frequencies into a 'conventional' system in programmer software, and write your frequencies to the radio

The software part of the modification is now done. If you were to turn on the radio now, you'll probably find that any RX frequency under about 928 MHz is unlocked, and the LPE-200 will beep incessantly at you. Lets fix that.

Disassembly:

To begin, disassemble the LPE-200 to gain access to the PCB. Unscrew the antenna, remove the battery, and pull of the talk-group selector and volume knobs. Turn the radio over so the back of the radio is facing you, and using a Torx T8 driver, undo the two Torx screws at the bottom corners. Using a small flat blade screwdriver, insert the blade in between the metal backplate (chassis) and polycarbonate case at the positions shown in the photo below. If you look carefully at the photo, you can see the gap or bulge in the polycarbonate case where some plastic catches are located:

This will release the plastic catches, and you can then tilt out (bottom first) and then pull down & away the chassis and PCB from the front housing. Be careful of the interconnecting ribbon cable as you do this. Remove this ribbon cable to the front panel by gently levering it out of its connector.

The next step is to undo the PA heatsink screws. Take a look at the below picture, the two screw sleeves indicated can be removed with a standard small flat blade screwdriver:

After this, remove the front shield off the chassis by undoing the four catches at the sides, again by using a small thin blade of a screwdriver. You can see one pair of these catches in the photo below, one is released, one still secured.


Once the catches are all undone, you can lever the front shield which will be holding the PCB out of the chassis. Be careful of the tiny ribbon cable connecting the PCB to

the volume & group selector controls, its not all that long. That ribbon cable can be removed from its header socket on the PCB… note which way it went in for when you reassemble the radio later. Then, finally, you can remove the PCB from the shield; it just clips in, and you can flex the short walls of the shield to release the clips that hold the PCB in place, and pull the PCB free.

Modification:

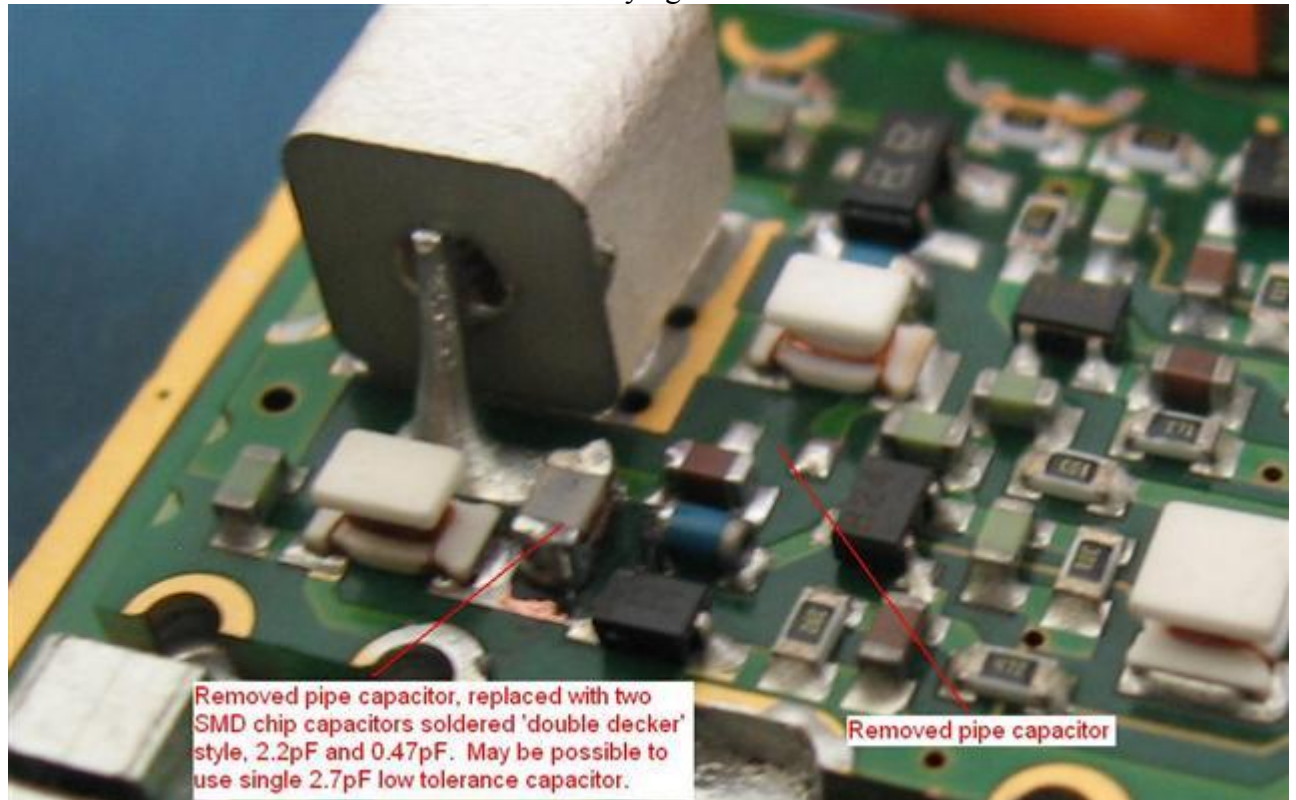Next, identify the VCO unit, as shown in the below photo:
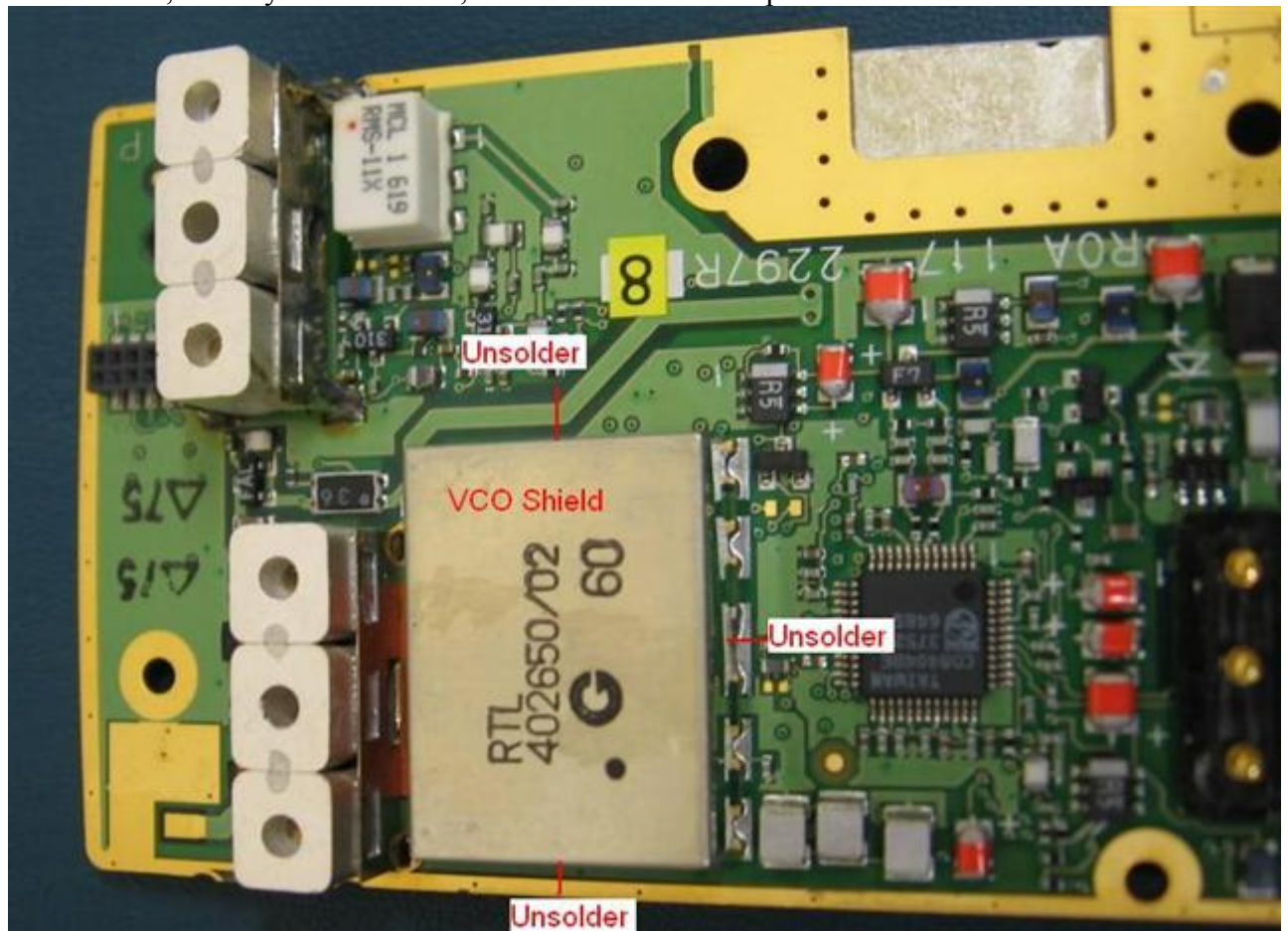
Notice how the VCO shield is attached at four points, in the middle of each edge. Unsolder the three attachment points that you can get access to, levering the VCO shield up or outwards as you go using a small flat blade screw driver. The attachment point that is inaccessible behind the front end filter cores you can leave alone for the time being. Once you've got the three accessible attachment points completely unsoldered, you can tilt the shield up enough to wiggle it back and forth to break off the last attachment point, and the VCO shield will come completely free.

Once you have the RX VCO exposed, identify the components as shown in the below diagram:
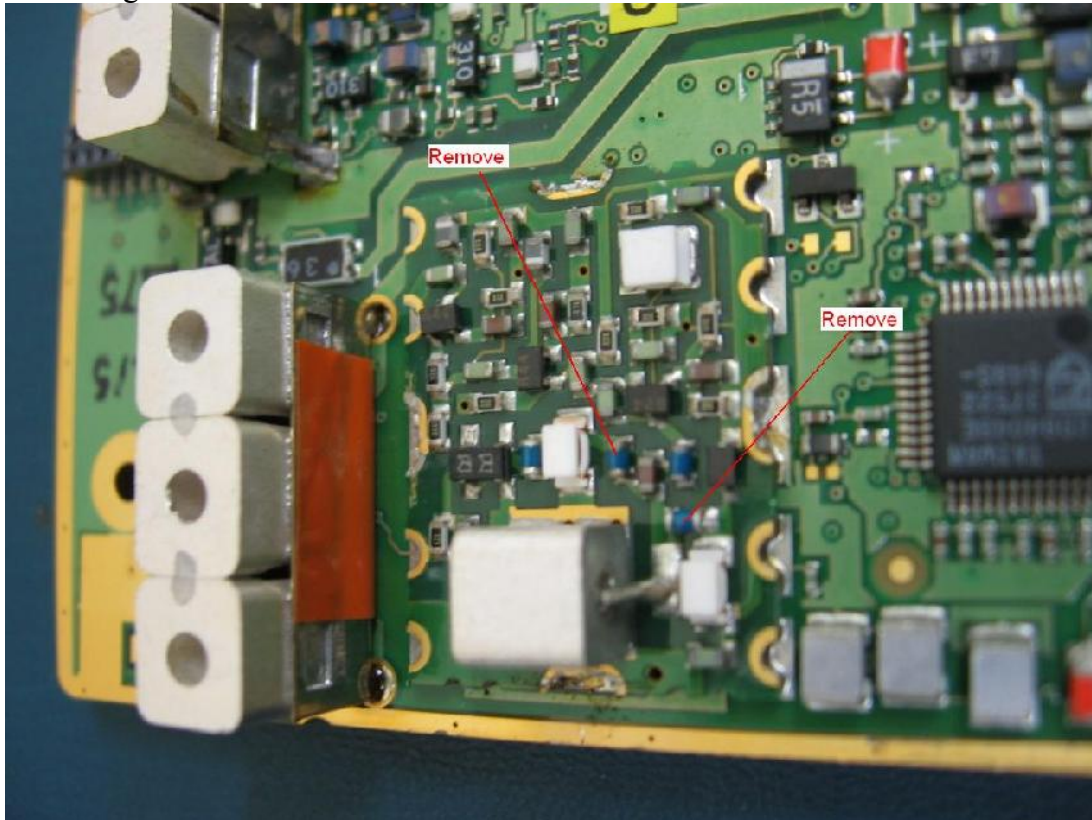
You'll need to remove two blue 'pipe' capacitors as shown above. The left hand capacitor is for the talk around facility, and its removal is necessary to increase the overall bandwidth of a single 'chunk' of spectrum that the VCO can cover, but will disable the talk around facility. The other capacitor, the one closest the edge of the VCO board, will be replaced with a size 0603 SMD chip capacitor. Use a low tolerance / high Q capacitor here, with a value of 2.7pF. I actually used a 2.2pF and 0.47pF pair of capacitors, soldered double-decker style. The value here is quite critical, and you should use high quality capacitors. Some low cost types have a tolerance of anything up to 0.5pF, which is enough to cause the VCO to become unlocked outside of our intended frequency bands.

Here's what the VCO should look like after carrying out the modifications:

Removed pipe capacitor, replaced with two SMD chip capacitors soldered 'double decker' style, 2.2pF and 0.47pF. May be possible to use single 2.7pF low tolerance capacitor.

Removed pipe capacitor

To solder in this tiny SMD chip capacitor will require a low wattage and very fine tipped soldering iron, and some very fine solder. Don't fool yourself, a standard size soldering iron tip simply will not do. A magnifying lens to assist in seeing the area you're soldering will be a great help… I use a loupe or magnifying eye monocle myself.

If you have it, clean up the area with some solder flux removing spray and electronic grade cleaning fluid. Now it is time to seal up the VCO shield. If you've been testing the radio without the shield in place and are worried that the modification has not worked with the VCO appearing to attempt lock too low in frequency, fear not: adding the shield actually raises the frequency of operation of the VCO by some 6 to 8 MHz. Solder on the shield in the three accessible places, no need to worry about the last reattachment point next to the front end filters.

This is what my finished product looked like:

Resolder VCO shield
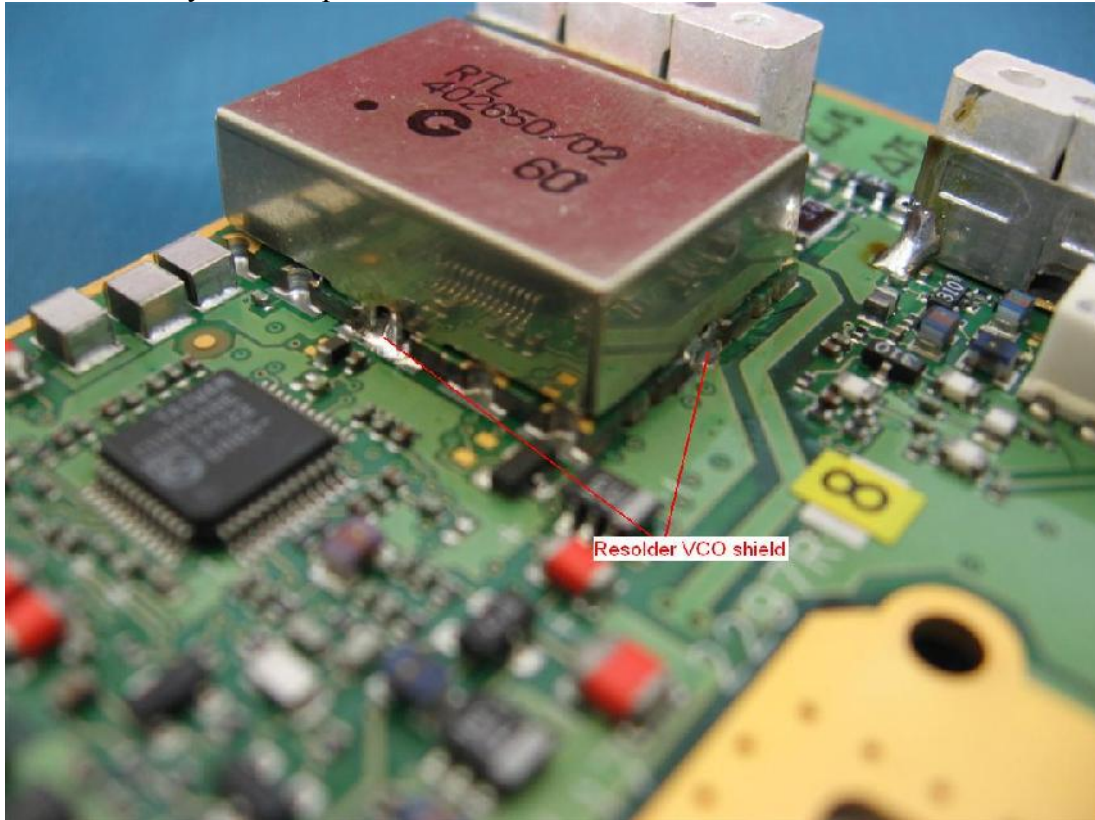
Now reassemble the radio, being careful to align the pins of the volume & talk group selector ribbon cable accurately onto the header connector on the PCB and in the correct orientation that you noted when taking it off (you did do this didn't you?). Check it by looking at it from several different angles to confirm all pins are in the header connector properly.

After reassembly, confirm that the VCO & synthesiser locks at the lowest & highest programmed frequencies on receive, and then do the same for the lowest & highest transmit frequencies too. If the highest TX frequency is unlocked, then you'll need to very slightly lower the value of SMD chip capacitor(s) installed. If the lowest RX frequency is unlocked, you'll need to very slightly increase the value of SMD chip capacitance installed. By very slightly, I mean perhaps 0.1 or 0.2pF. This is where double-decker style of soldering is useful; adding a very small value SMD chip capacitor is easy, replacing the top soldered one with a slightly lesser value is also quite easy.

The end results:
Before the mod, the LPE-200 was retuned for better RF mute sensitivity in 'Radiomaint' and managed to open the mute at -127dBm or 0.10uV across 935 to 941 MHz. After the mod, the mute continues to open at 0.10uV from 925 to 928 MHz, so replacement of the front end filters is not needed for best receive performance with repeater operations using a 25 MHz split. For 12 MHz split repeater allocations however, the receive performance is hurt badly by the front end filters: RX at 922 MHz has the mute opening at 2.5uV, and down at 918 MHz the mute opens at a massive 8uV, so replacing the front end filters would definitely be an advantage here. For both 25 & 12 MHz split programming, receive & transmit remain stable across

temperature ranges of 30 degrees F to 110 degrees F, across all battery voltage ranges down to the point where the LPE-200 issues a "low batt" warning, and is stable at both low & high power selections.

At last all those quite cheap 900 MHz LPE-200s that you've been seeing can be put to good use for 33cm ham operations. Enjoy!