

**TUNING PROCEDURE**

Table for tuning frequencies.

	UHF Band2
<u>Test/Tune Freq</u>	<u>450-512</u>
F1	450.025
F2	463.025
F3	475.025
F4	487.025
F5	499.025
F6	511.025
F7	519.975

TABLE 1

**1.0 CRYSTAL CODE EXTRACTION**

- a) Scan the 2D barcode of the Reference xtal
- b) Decode the crystal code to get crystal maximum ppm, crystal inflection temperature (xtal\_infl\_temp) and crystal curve ppm(t)(crystal ppm at given temperature) and store them in xtal\_max\_ppm, xtal\_infl\_temp and xtal\_curve\_ppm(t).

The following equations are used to calculate the above parameters

$$\begin{aligned}
 q1 &= (\text{dig1} * 10) + \text{dig2} \\
 q2 &= (\text{dig3} * 100) + (\text{dig4} * 10) + \text{dig5} \\
 q3 &= (\text{dig6} * 10) + \text{dig7} \\
 \text{xtal\_infl\_temp} &= q1 / 10 + 22 \\
 a1 &= -q2 / 1000 \\
 a2 &= (q3 + 0.1 * q2 + 410) / (5 * 10^6) \\
 \text{delta\_temp} &= \text{temps}(t) - \text{ref\_temp} \\
 \text{xtal\_curve\_ppm}(t) &= a1 * \text{delta\_temp} + a3 * \text{delta\_temp}^3
 \end{aligned}$$

where

q1: Digits 1 and 2 from xtal code  
 q2: Digits 3,4,5 from xtal code  
 q3: Digits 6 and 7 from xtal code ref\_temp:  
 temps(t): Array of temperature in steps of 5 deg c from -35deg C to 90deg C

**1.1 Oscillator sensitivity measurement**

- a) Use SBEP command to program synthesizer to receive frequency F7 of table 1 and also set the INFLECTION, COLD HOT AND LINEAR dacs to maximum to turn them off (INFLECTION dac=127, COLD dac=127, HOT dac=127, LINEAR dac=127)
- b) Use SBEP command to adjust warp dac to get frequency F7 within limits of table. Store warp dac value in warp\_dac\_center
- c) Indicate the PASS/FAIL status of the warp dac value. If FAIL: "Failed set warp dac value" warp\_dac\_center must fall within range of 122 to 390
- d) Obtain warp\_dac\_high and warp\_dac\_low using the equations below:
 
$$\begin{aligned}
 \text{xtal\_max\_v} &= (\text{xtal\_max\_ppm} * 2) / \text{approx\_sens} \\
 \text{warp\_dac\_range} &= \text{ABS}(\text{xtal\_max\_v} / \text{warp\_dac\_step\_v}) \\
 \text{warp\_dac\_high} &= \text{INT}(\text{warp\_dac\_center} + (\text{warp\_dac\_range} / 2)) \\
 \text{warp\_dac\_low} &= \text{INT}(\text{warp\_dac\_center} - (\text{warp\_dac\_range} / 2))
 \end{aligned}$$

where

$xtal\_max\_v$ =maximum required compensation voltage

$xtal\_max\_ppm$ =calculated in 1.0 (a).

constants:  $warp\_dac\_step\_v$ =0.0065 v/step

$approx\_sens$ =20 ppm/v

e) Use SBEP command to program the radio to  $warp\_dac\_high$

f) Use DMM to get voltage reading. Store it in  $V_H$

g) Use frequency counter to get frequency reading. Store it in  $F_H$

h) Use SBEP command to program the radio to  $warp\_dac\_low$

i) Use DMM to get voltage reading. Store it in  $V_L$

j) Use frequency counter to get frequency reading. Store it in  $F_L$

k) Calculate the oscillator sensitivity using the equation below;

$comp\_range\_v$ = $V_L - V_H$

$ppm\_range$ =[ $(F_L - F_H)/F_H$ ]\* $10^6$

$osc\_sens$ =ABS( $ppm\_range / ppm\_range\_v$ )+ $osc\_sens\_offset$

where

$osc\_sens$ =The sensitivity of the oscillator's frequency to the voltage applied to the varactor

constants:  $osc\_sens\_offset$ = 0

## 1.2 Translate crystal's ppm curve into voltage curve

a) Convert the crystal ppm curve vs temperature to voltage vs temperature curve as follows;

$V(t)$ =[ $(xtal\_curve\_ppm(t) + osc\_contrib(t)) / osc\_sens$ ]

where

$V(t)$ =voltage at given temperature

$osc\_contrib(t)$ =determined by hardware team

$osc\_sens$ =determined in 1.1 (m)

b) Invert the voltage vs temperature curve for compensation procedure as follows;

$comp\_curve\_v(t)$ = $comp\_curve\_vref + req\_contrib(t) - V(t)$

where

$comp\_curve\_v(t)$ =inverted voltage at given temperature

$comp\_curve\_vref$ =1/2 of  $V_{RO}$

$req\_contrib(t)$ =determined by hardware team

$V(t)$ =voltage at given temperature calculated in 1.2(a)

## 1.3 Search the IC's T.C. table for best compensation curve

a) Compare the converted crystal curve to the table of compensation of voltage curves located in the file given to the factory to find the curve which gives the minimum error over the entire temperature range. The curve fitting would give cold, hot and linear dacs values.

## 1.4 Align the crystal curve to the IC's compensation curve

a) Send SBEP command to program the LVFRACN with a warp value of  $warp\_dac\_center$  found in 1.1 (a) with inflection, cold hot and linear dacs off.

b) Use frequency counter to get frequency of the oscillator. Store it in  $ic\_infl\_ref$

c) Send SBEP command to program the LVFRACN with inflection, cold, hot and linear dacs to settings in 1.3(a).

d) Use SBEP command to adjust inflection dac setting to get as close as possible to frequency of  $ic\_infl\_ref$  in 1.4(b). Store it in  $ic\_infl\_set\_amb$

e) Use thermo-hunter to get the temperature at crystal. Store it in  $ic\_temp$

f) Calculation of inflection dac setting using the equation below;  

$$\text{infl\_dac} = \text{INT}(\text{ic\_infl\_set\_amb} + (1/\text{infl\_dac\_step}) * (\text{ic\_temp} \text{ xtal\_infl\_temp} + \text{infl\_tmp\_offset}))$$

where

infl\_dac=inflection dac value  
 ic\_infl\_set\_amb=inflection dac value in 1.4 (d)  
 ic\_temp=temperature measured in 1.4 (e)  
 xtal\_infl\_temp=temperature read from 2D code in 1.0 (a)  
 constants: infl\_dac\_step=0.33 deg/step  
 infl\_tmp\_offset=0 deg

g) Use SBEP command to save inflection, cold, hot and linear dac settings in the codeplug

### 1.5 Reference oscillator warping (Final warp)

- a) Use SBEP command to adjust warp dac setting to get frequency F7 of table 1.
- b) Use SBEP command to save warp dac setting in codeplug

### 1.6 Dac sensitivity measurement

- a) Program radio to rx/tx mode, freq=MHz, DAC setting=127
- b) Measure if radio lock, Vctrl
- c) Measure frequency and DAC voltage
- d) Program DAC=97, measure freq and DAC voltage
- e) Program DAC=157, measure freq and DAC voltage

## 2.0 TRANSMITTER POWER ADJUSTMENT

### 2.1 General description of PA bias adjustment.

Tuning of the PA Bias is required to compensate for FET device tolerances due to lot to lot variation during the FET die fabrication process. To obtain optimum power and efficiency, the bias should be tuned in the factory after it is built or after a repair.

- a) Program the FRACN to switch off the RF signal by setting VCO IC to battery saver mode. If this is not possible for hardware reasons, set the VCO to RX mode. This step should be performed by setting the bias tuning environment.
- b) If the VCO IC can't be set to battery saver mode, set the receive frequency to F1. This should be done automatically by the radio when entering the bias tuning environment. Previous radios required frequency setting by the tuning system.
- c) Initialize the PCIC for bias tuning by setting the following parameters TX mode switch on the PIN diodes (RX to low, ANO on)
  - set power D2A (D2A#1) to maximum
  - set voltage limit D2A (D2A#2) to minimum
  - set PA bias D2A (D2A#3) to minimum

This allows controlling the power control voltage by the voltage limit D2A. The PIN diodes should be on to avoid instabilities. For the same reason the antenna output must be terminated with 50 ohm termination. In case of PA oscillation an RF induced additional current would lead to tuning inaccuracies.

- d) Measure the dc current the radio draws from the voltage supply. Note the measured value as VL0 B0 CURRENT.
- e) Increase the voltage limit D2A (D2A#2) until the dc current exceeds the "VL0 B0 CURRENT" as specified in table 2 "VL CURRENT". Note the measured value as "VL B0 CURRENT". The additional current is drawn by the driver.

- f) Increase the PA bias D2A (D2A#3) until the dc current exceeds the “VL B0 CURRENT“ as specified in table 2 “ B CURRENT “. The additional current is drawn by the FET. After this step a balance between the FET current (gain) and the driver current (gain) has been achieved. The balance is maintained when the RF output power is altered.
- g) Store the PA bias D2A value in the PA bias softpot.

**2.2 Transmitter PA bias adjustment procedure**

- a) Set radio environment for PA bias tuning. This relates to steps a)-c) of section 2.1.
- b) Measure the radio dc current and note the value as “ VL0 B0 CURRENT“. This relates to step d) of section of 2.1.
- c) Increase the voltage limit D2A (D2A#2) until the dc current exceeds the „VL0 B0 CURRENT“ as specified in table 2 “VL CURRENT“. Note the measured current as “ VL B0 CURRENT“. This relates to steps e) of section 2.1.
- d) Increase the PA bias D2A (D2A#3) until the dc current exceeds the „VL B0 CURRENT“ as specified in table 2 “ B CURRENT“. This relates to steps f) of section 2.1.
- e) Store the PA bias D2A value in the PA bias softpot.

	VL Current	B Current
450-512	100mA +/- 10%	280mA +/- 10%

Table 2.

**2.3 Transmitter Power Adjustment**

(Important: Section 2.2 must be completed before power adjustment can be carried out)

The Waris radio power-level tuning is across the band at 7 discrete test frequencies, each at 2 discrete power levels. In addition, there are 2 nominal power setting.

- a) Program radio to Test Mode Carrier Squelch Environment to appropriate power level
- b) Set radio to the correct transmitter frequency
- c) Key up the radio
- d) Set PA control Voltage Limit softport to \$3F without codeplug update
- e) Set Transmit Power Softpot to DAC1 value and measure output power P1
- f) Set Transmit Power Softpot to DAC2 value and measure the output power P2
- g) Dekey the radio and calculate the Mcp & Kcp

$$M = (\text{SQRT}(P1) - \text{SQRT}(P2)) / (DAC1 - DAC2)$$

$$Mcp = -1000 * M$$

$$Kcp = 20 * (\text{SQRT}(P1) - (M * DAC1))$$

- h) Repeat for other test point frequencies that require tuning, value for untuned frequencies are to be interpolated by the test controller and programmed into codeplug

$$DAC\_PWR\_SET = 50 * (Kcp - Pcp) / Mcp$$

$$Pcp = 20 * \text{SQRT}(\text{desired power})$$

Power is tuned to the window specified below:

UHF: (450-512)

Hi Power	4.4-4.6W
Lo Power	1.1-1.3W

**3.0 BALANCING/LIMITING LOW AND HIGH PORT Modulation of the Synthesizer**

**3.1 Modulation Balancing (MOD ATTN)**

- a) Program the radio for low power using the settings obtained in procedure 2.3 above.
- b) Program the ASFICcmp to mute the microphone .Set ASFICcmp for FLAT\_TX\_RTN mode (Flat audio response) and default attenuator settings (Note 1).
- c) Program the synthesizer to the lowest transmit tune frequency as in table 1 and set the ADC bits 12-11 = "10" . These bits set the fractional-N low port sensitivity to a max of 5.0 kHz. Set the Mod Attenuator enable bit to "1" to enable the high port modulation.
- d) Apply an 80 Hz tone, 100 mVrms (140mV for 800MPT)at the external test box "Audio In " input.
- e) Measure deviation (D1)
- f) Change the input tone to 3kHz, 100mVrms (7mV for 800MPT)and measure deviation (D2)
- g) Find the ratio in dB using  $20\log[D1/D2]$
- h) Remove the audio signal by disabling the external Tx audio path
- i) Program the Mod attenuator setting of the fractional-N using the equation below:  
 Modulation attenuator setting = (current setting at step i) +  $-(5 \times (\text{dB value of step i}))$
- j) Re-enable the External Tx audio path .
- k) Repeat steps (f) - (i) until the ratio in dB of step (i) is  $\leq \pm 0.20\text{dB}$ , store modulation attenuator setting to EEPROM.

NOTE : The attenuator settings of the ASFICcmp are defaulted for minimum attenuation (MOD6 - MOD0 = \$FF) before start of balancing. The fractional-N modulation attenuator should be set to 6.4dB, ie \$20 (32 decimal).

**3.2 Modulation Limiting**

- a)Disable the FLAT\_TX\_RTN mode. Select the Ext Mic and unmute it.
- b)Inject at the Ext Mix Input a 1khz tone,80mVrms with the preemphasis enabled and adjust the Mod attenuator of the ASFICcmp to obtain the deviation in Table 3
- c)Dekey the radio
- d) Store the attenuator setting in the codeplug.
- e)Repeat the steps (f ) to (p) for other frequencies as per the tuning matrix.

Reference Voice Deviation

<u>Channel Spacing</u>	<u>Deviation (kHz)</u>	Table 3
25	4.30 - 4.60	
20	3.40 - 3.60	
12.5 kHz	2.20 - 2.30	

NOTE 2 :For 20khz channel spacing, increase the Mod attenuator of ASFICcmp by 1.95db. Verify the deviation reduces to the range of 3.4 to 3.6khz. If tuning is required, adjust only the Mod attenuator of ASFICcmp to ensure the deviation is reduced within this range. This should be carried out at the highest frequency

**3.3 For 12.5 KHz Channel spacing.**

Program the synthesizer's ADC bit 12..11 to 11( Reduce deviation sensitivity of the synthesizer). Verify the deviation reduces to the range of 2.2 to 2.3 khz. If tuning is required, adjust only the Mod attenuator of ASFICcmp to ensure the deviation is reduced within this range. This should be carried out at the highest frequency.