TUNEUP PROCEDURE

8.0   TUNING PROCEDURES

This procedure was written in the sequence the radio is to be tuned. The following points
   should be noted:

1) Radio controller refers to the microprocessor in the radio.
2) Tester/test controller refers to external test system (hardware as well as software).
3) Values in tables may change to improve yield.

8.1.1   PROGRAMMING I.C.S WITH DEFAULT DATA
a) Power up radio.
b) Program DAC for receive per table 9.2
c) Program the Fractional N for receive per table 9.6
 - using the appropriate Band Select setting per table 9.9
 - using the appropriate Rx. Frequency information.

8.1.2   Synthesizer Reference freq setting:
Set the internal synthesizer reference frequency selection to:

TX   RX   Note: $01 selects 2.1Mhz, $10: 2.225MHz, $11:2.4MHz, $00
selects internal algorithm
UHF $00 $00
VHF $00 $00
LB
800 $00 $00

8.1.3   REFERENCE OSCILLATOR AND TEMPERATURE COMPENSATION

Reference oscillator frequency is 16.8Mhz unless stated otherwise in the table below:

a) Read crystal data from the crystal body and enter into computer.
   (A complete procedure on temperature compensation will be described later .)

EXHIBIT 7

8.1.4 RATED AUDIO:

a) Set radio to Carrier Squelch Test Environment and frequencies,
LB
VHF= F4 (154.925MHz)
UHF = 438.05Mhz
800 = 860.525 MHz

b) Inject a -47dBm RF signal modulated with a 1kHz tone at the 60% of rated deviation.
c) Adjust the ASFIC Volume Attenuator (VOL7 - VOL0) to obtain 500mW of audio power into a speaker or equivalent resistive load, V=3.16V.
d) Store the tuned Rated Volume Attenuator setting in the codeplug.

NOTE 1: Maximum Volume = Rated Volume + Max Audio Overdrive (in normal operation mode)

Max Audio Overdrive = 12.0dB

8.1.5 RECEIVER SQUELCH TUNING:

(Note that squelch adjustment can only be done after front end tuning is completed)

The squelch softpots must be tuned for every channel spacing until production data shows otherwise

a) Determine the frequency band of operation of the radio (Low band, VHF, UHF, 800MHz etc...)
b) Determine the radio channel spacing. That is 12.5KHz, 20KHz or 25KHz.
c) Set radio channel spacing to 25KHz
d) Set the radio to operate at frequency F1 (F5 for 800 MHz).
e) Modulate the signal generator with 1KHz tone @ 60% of rated system deviation. See table 1
f) Set the RF level to -47dbm and then adjust the audio output for 50% rated audio.
g) Set the ASFICcmp squelch attenuator (SQPOT5-0) to $0, to fully unsquelch the radio.
h) Adjust the signal gen. RF level until 10db sinad is obtained (CCITT filter set to OFF).
i) Increase the squelch attenuator settings (SQPOT5-0) until the speaker audio output is muted.
j) Wait 500msec, monitoring for squelch chatter. If chatter is present, repeat step h.
k) Repeat steps e to j for frequencies F2 to F7 (F6 to F7 for 800 MHz) that require tuning. Values for the untuned frequencies are to be interpolated by the test controller.
l).Repeat step d to step k for the rest of the channel spacing.
m) Program the squelch attenuator settings into the radio codeplug

(Note: the radio application software adds a negative offset values to the squelch attenuators when the radio unsquelch. This effectively adds a hysteresis to the squelch performance thus improving squelch chattering.)

Squelch tuning frequency recommended for PAT tuning

	UHF Band1	UHF Band2	UHF 300Mhz	VHF	800 MHz	
Test/Tune Freq	**403-470**					
F1	402.975			136.225		
F2	413.025			142.225		
F3	425.025			148.225		
F4	437.025			154.625		
F5	449.025			161.225	850.975	

| F6 | 460.025 | | | 167.225 | 860.525 | |
| F7 | 470.025 | | | 173.625 | 870.025 | |

8.1.6 FRONT END BANDPASS FILTER TUNING:

The FE for LB and 800 MHz need not be tuned. Note that the Dac for VHF/UHF is the DAC from the ASFIC

    a) Set radio to Carrier Squelch Test Environment.
    b) Program ASFIC to route the RSSI output to Universal connector
    c) The radio has 7 test points for Front End Bandpass filter, program the synthesizer to receive at the following test/tune frequencies

Frequency Bands (MHz) Used in PAT

	UHF Band1	UHF Band2	UHF 300MHz	VHF
Test/Tune Freq	**403-470**			
F1	**402.975**			136.225
F2	**413.025**			142.225
F3	**425.025**			148.225
F4	**437.025**			154.625
F5	**449.025**			161.225
F6	**460.025**			167.225
F7	**470.025**			173.625

DAC Start values for front end tuning.

Test/Tune Freq	UHF BAND 2	UHF BAND 1	UHF 300MHz	VHF
F1				not tuned offset used
F2				not tuned offset used
F3				57 decimal
F4				not tuned offset used
F5				not tuned offset used
F6				not tuned offset used
F7				not tuned offset used

d) Inject a -70 dBm RF signal with Frequency F1 (F3 for vhf)with no modulation.
e) Measure the RSSI voltage with a high impedance DC voltmeter capable of 1mV resolution.. It is recommended that a RC (1.5K-47uF) be added at the input of the voltmeter to reduce RSSI noise.
f) PreSet the DAC value in the Front End Filter Softport with the DAC start values.
g) Measure the RSSI voltage. Increment (vhf, decrement for uhf) the DAC value twice (VHF) and compare to the previous value
h) Repeat until the change between the two latest RSSI reading is lower than the target value.
UHF : 0.42%   VHF : 0.5%
i) Store the Front End Filter Softport in the codeplug For F1. (not for vhf)
j) Repeat for other test point frequencies (F2-F7) that require tuning (not for VHF) For

VHF calculate the offset from DAC value to the default value of F3 and add the offset to all softpot values. Note: if any calculation exceeds the minimum or maximum softpot value set the softpot to the minimum or maximum value. Band owners should define the minimum value to prevent varicap problems.

8.1.7   RSSI slope selection bit settings:
These settings sets the RSSI slope selection in the ZIF at power up:

20-25KHz Channel spacings

LB			VHF			UHF			800		

Bit 24	Bit 25	Bit 26	Bit 24	Bit 25	Bit 26	Bit 24	Bit 25	Bit 26	Bit 24	Bit 25	Bit 26
			1	1	1	1	1	1	0	0	0

12.5KHz Channel spacings:

LB			VHF			UHF			800		

Bit 24	Bit 25	Bit 26	Bit 24	Bit 25	Bit 26	Bit 24	Bit 25	Bit 26	Bit 24	Bit 25	Bit 26
			1	1	1	1	1	1	0	0	0

8.1.8   RSSI display tuning for RSSI level1 to RSSI level 6
There are 6 RSSI display bars for models that have RSSI display. The threshold value for each display bar is to be determined by sending in a specific RF signal strength and getting the radio Microprocessor to measure the RSSI voltage using its own A/D converter. These A/D values so obtained are to be stored into the code plugs as RSSI level 1 to RSSI level 6, with the Antenna display icon corresponding to RSSI level 1. The RSSI slope selection settings are preset per 8.1.7.
The following RF levels are to be used to measure the A/D converter values for RSSI LEVEL1 to RSS LEVEL 6 for 20-25KHz radios using the test/tune frequency indicated. Note a RSSI offset will be used to derive 12.5KHz levels from 25KHz levels.
Test/tune frequency

UHF BAND 1	UHF BAND 2	300MHZ	VHF	LB	800
F4			F3		F6

RSSI LEVEL (20-25KHZ)	RF level
1	12BS SINAD
2	Interpolated between levels 1 & 6
3	Interpolated between levels 1 & 6
4	Interpolated between levels 1 & 6
5	Interpolated between levels 1 & 6
6	-90dBM at Radio Jack

Repeat measurement for 12.5KHz for another 6 levels and corresponding values into code plug.

8.2.1   TRANSMITTER POWER ADJUSTMENT

8.2.1.1 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.

1. 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.
2. If the VCO IC can't be set to battery saver mode, set the following receive frequencies:

Frequency Band	Test Frequency
LB	F7
VHF	F7
403-470MHz	F1
800	F7

This should be done automatically by the radio when entering the bias tuning environment. Previous radios required frequency setting by the tuning system.

1. Initialise 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 Ω. In case of PA oscillation an RF induced additional current would lead to tuning inaccuracies.
2. Measure the dc current the radio draws from the voltage supply. Note the measured value as VL0 B0 CURRENT.
3. Increase the voltage limit D2A (D2A#2) until the dc current is within the limits of the "VL0 B0 CURRENT" as specified in table 8.2.1.3 "VL CURRENT". Note the measured value as "VL B0 CURRENT". The additional current is drawn by the driver.
4. Increase the PA bias D2A (D2A#3) until the dc current exceeds the "VL B0 CURRENT" as specified in table 8.2.1.3 " 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.
5. Store the PA bias D2A value in the PA bias softpot.

8.2.1.2 Transmitter PA bias adjustment procedure

I. Set radio environment for PA bias tuning. This relates to steps 1-3 of section 8.2.1.1.
II.
III. Measure the radio dc current and note the value as " VL0 B0 CURRENT". This relates to steps 4 of section of 8.2.1.1
IV. Increase the voltage limit D2A (D2A#2) until the dc current is within the limits of the „VL0 B0 CURRENT" as specified in table 8.2.1.3 "VL CURRENT" . Note the measured current as " VL B0 CURRENT". This relates to steps 5 of section 8.2.1.1
V. Increase the PA bias D2A (D2A#3) until the dc current exceeds the „VL0 B0 CURRENT" as specified in table 8.2.1.3 " B CURRENT". This relates to steps 6 of section 8.2.1.1
VI. Store the PA bias D2A value in the PA bias softpot.

Table 8.2.1.3

	VL Current	B Current		
LB	0 mA			
136-174	100mA +/- 10%	1000mA +/- 10%		
403-470	100mA +/- 10%	280mA +/- 10%		
800				

8.2.2 Transmitter Power Adjustment

(Important: Section 8.2.1.2 must be completed before power adjustment can be carried out)

The 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

$$M = (SQRT(P1)-SQRT(P2))/(DAC1-DAC2)$$
$$Mcp = -1000*M$$
$$Kcp = 20*(SQRT(P1)-(M*DAC1))$$

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

$$DAC\_PWR\_SET = 50*(Kcp-Pcp)/Mcp$$
$$Pcp = 20*SQRT(desired power)$$

8.2.2.1   Power Tuning Frequency Table:

Transmit frequency   recommended for PAT tuning

	UHF Band1	UHF Band2	UHF 300MHz	VHF	800
Test/Tune Freq					
F1	402.975				136.025	805.975
F2	413.025				142.025	815.525
F3	425.025				148.025	820.025
F4	437.025				154.825	838.025
F5	449.025				161.025	850.975
F6	460.025				167.025	860.525
F7	470.025				173.825	870.025

8.2.2.2   Power Tuning Level Specification at each test point Table:

	UHF:	VHF:		LB:	**800:**
800:	(403-470)	136-174			(806-825)
					(826-870)
Hi Power 2.1-2.3 W	4.4-4.6W	5.1-5.4W			3.2-3.4 W
Lo Power 1.1-1.3 W	1.1-1.3W	1.1-1.3W			1.1-1.3 W

8.2.4   BALANCING/LIMITING LOW AND HIGH PORT Modulation of the Synthesizer

Modulation Balancing (MOD ATTN):

a) Program the radio for low power using the settings obtained in procedure 8.7 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 8.6.1 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 at the external test box "Audio In " input.

e) Measure deviation (**D1**)

f) Change the input tone to 3kHz, 100mVrms and measure deviation (**D2**)

g) Find the ratio in dB using **20log[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 x (dB value of step   i**))

j) Re-enable the External Tx audio path .

k) Repeat steps f) - l) until the ratio in dB of step i) is <±0.20dB, store modulation attenuator setting to EEPROM.

NOTE 1: 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).

Modulation Limiting

l) Disable the FLAT_TX_RTN mode. Select the Ext Mic and unmute it.

m) 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 section 9.8

o) Dekey the radio

p) Store the attenuator setting in the codeplug.

q) Repeat the steps (f) to (p) for other frequencies as per the tuning matrix.

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

8.2.5 12.5KHz Channel spacing.
 Program the synthesizer 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.

EXHIBIT 7