PARTS LIST AND TUNE UP PROCEDURES

(CONFIDENTIALITY REQUESTED)

This exhibit contains a list of the semiconductor devices used in the transceiver and the test equipment and tuning procedures for maintaining the transceiver.

EXHIBIT 10A	Function of RF Semiconductors and Other Active Devices
EXHIBIT 10B	List of Recommended Test Equipment for Servicing
EXHIBIT 10C	Tune Up Procedure

Exhibit 10A – Function of RF Semiconductors and Other Active Devices

Pursuant to 47 CFR 2.1033(c)(10)

Reference#	Part #	Circuit Application	Operating Frequency	Industry Equivalent
D101	4805218N57	Reverse Volt. Peak Detector	DC	RB715F
D102	4813833C02	DC Switch	DC	MMBD6100
D103	4802482J02	Antenna Switch	465-495MHz	MA4P959
D104	4802482J02	Antenna Switch	465-495MHz	MA4P959
D105	4805218N57	Reverse Volt. Peak Detector	DC	RB715F
D106	4805218N57	Reverse Volt. Peak Detector	DC	RB715F
D107	4805218N57	Forward Volt. Peak Detector	DC	RB715F
D108	4805218N57	Forward Volt. Peak Detector	DC	RB715F
D200	4802233J09	Voltage Multiplier	1.05MHz	IMN10
D201	4802233J09	Voltage Multiplier	1.05MHz	IMN10
D202	4862824C03	Crystal Warp	DC	1SV232
D203	4805649Q13	RX VCO Frequency Control	420-450MHz	1SV228
D204	4805649Q13	TX VCO Frequency Control	465-495MHz	1SV228
D205	4862824C01	TX VCO Modulator	Audio-495MHz	1SV229
D301	4802245J97	Switching Diode	DC	DAN235ETL
D302	4802245J97	Switching Diode	DC	DAN235ETL
D303	4802245J97	Switching Diode	DC	DAN235ETL
D304	4802245J97	Switching Diode	DC	DAN235ETL
D305	4880142L01	Switching Diode	DC	MMBV3401LT
D400	4813833C07	Steering Diode	DC	MMBD7000
D401	4813833C02	Steering Diode	DC	MMBD6100
D402	4809948D42	Steering Diode	DC	RB751V
D500	4813833C02	DC Switch	DC	MMBD6100
D502	4813825A23	Steering Diode	DC	MMSD301
D511	4813833C02	DC Switch	DC	MMBD6100
D513	4813833C02	DC Switch	DC	MMBD6100
Q100	4813828C32	TX RF Power Amplifier	465-495MHz	MRF1535
Q101	4813824A10	DC Switch	DC	MMBT3904
Q102	4813824A10	DC Switch	DC	MMBT3904
Q103	4813824A06	DC Switch	DC	MMBTA13
Q104	4813824A10	DC Switch	DC	MMBT3904
Q105	4886212B01	TX Driver Stage	465-495MHz	MRF1518
Q106	4805128M27	Current Source	DC	BSR33
Q107	4813824A10	DC Switch	DC	MMBT3904
Q108	4813824A10	DC Switch	DC	MMBT3904
Q200	4802245J95	RX Injection Amplifier	420-450MHz	BFS540
Q201	4809939C04	DC Switch	DC	UMC3 UM5
Q300	4809940E02	DC Switch	DC	DTC114YE
Q301	4813824A17	Current Source	DC	MMBT3906
Q302	4813824A10	DC Switch	DC	MMBT3904
Q303	4802245J95	RX Injection Amplifier	420-450MHz	BFS540
Q304	4809939C04	DC Switch	DC	UMC3 UM5
Q305	4802197J95	IF Amplifier	44.85MHz	PBR941
Q306	4813824A17	DC Switch	DC	MMBT3906

Q400	4809940E02	DC Switch	DC	DTC114YE
Q401	4880141L03	DC Switch	DC	BCW68GLT1
Q403	4809940E02	DC Switch	DC	DTC114YE
Q404	4809940E02	DC Switch	DC	DTC114YE
Q405	4809940E02	DC Switch	DC	DTC114YE
Q407	4809940E02	DC Switch	DC	DTC114YE
Q408	4880048M01	DC Switch	DC	DTC144EKA
Q409	4880048M01	DC Switch	DC	DTC144EKA
Q410	4880048M01	DC Switch	DC	DTC144EKA
Q411	4880048M01	DC Switch	DC	DTC144EKA
Q412	4880048M01	DC Switch	DC	DTC144EKA
Q413	4809940E02	DC Switch	DC	DTC114YE
Q414	4809940E02	DC Switch	DC	DTC114YE
Q416	4809940E02	DC Switch	DC	DTC114YE
Q417	4813824A10	DC Switch	DC	MMBT3904
Q500	4813824A10	DC Switch	DC	MMBT3904
Q501	4809940E02	DC Switch	DC	DTC114YE
Q502	4809940E02	DC Switch	DC	DTC114YE
Q503	4813824A10	DC Switch	DC	MMBT3904
Q504	4880048M01	DC Switch	DC	DTC144EKA
Q505	4813824A10	DC Switch	DC	MMBT3904
Q506	4813824A10	DC Switch	DC	MMBT3904
U100	5113818A01	Power Control	DC	LM2904DR2
U101	5185130C65	TX Pre-Driver Stage	465-495MHz	30C65
U102	5113818A01	Power Control	DC	LM2904DR2
U103	5113819A04	Power Control	DC	MC3303
U200	5185963A27	Frequency Synthesizer	1-495MHz	FRACN_63A27
U201	5105750U54	VCO Buffer IC	420-495MHz	50U54
U300	5186144B01	RX Back-End IC	Audio-455KHz	SA616
U301	5109522E10	Inverter	DC	TC7W04F
U302	4808612Y05	Quad Mixer Diode	420-495MHz	SMS3928
U400	5102463J64	EEPROM	1MHz	X25128-2.7
U403	5102226J56	Microprocessor	7.56MHz	MC68HC11FL0
U404	5189233U02	FLASH	3.78MHz	AT49LV002N_70VI
U405	5113805A75	Shift Register	DC	MC74HC595ADR2
U503	5105469E65	Voltage Regulator	DC	LP2951C
U504	5185130C53	Audio and Signaling IC	DC	30C53
U505	5113818A01	Filter	Audio	LM2904DR2
U506	5113818A01	Filter	Audio	LM2904DR2
U507	5113818A01	Filter	Audio	LM2904DR2
U508	5113816A30	Voltage Regulator	DC	MC33269D
U509	5113806A20	Analog Switch	DC	MC14053BDR2
U510	5104187K94	Voltage Regulator	DC	LP2986ILDX
U514	4802393L66	DC Switch	DC	SI3455ADV
VR101	4813830A18	DC Switch	DC	MMBZ5235B
VR102	4813830A15	Current Source	DC	MMBZ5232B
VR402	4813830A09	DC Switch	DC	MMBZ5226B
VR500	4813832C77	Reverse Protection	DC	MR2835S
VR501	4813830A14	Reverse Protection	DC	MMBZ5231B

VR503	4813830G09	Reverse Protection	DC	MMSZ4684
VR504	4813830G09	Reverse Protection	DC	MMSZ4684
VR692	4813830A75	ESD Protection	DC	MMBZ20VAL
VR693	4813830A77	ESD Protection	DC	MMBZ33VAL
VR694	4813830A75	ESD Protection	DC	MMBZ20VAL
VR695	4813830A77	ESD Protection	DC	MMBZ33VAL
VR696	4813830A75	ESD Protection	DC	MMBZ20VAL
VR697	4813830A75	ESD Protection	DC	MMBZ20VAL
VR698	4813830A75	ESD Protection	DC	MMBZ20VAL
VR699	4813830A75	ESD Protection	DC	MMBZ20VAL
Y201	4880114R06	16.8MHz Crystal	16.8MHz	114R06
Y300	9186145B02	Ceramic Discriminator	455kHz	CDBCA455CX36

Exhibit 10B – List of Recommended Test Equipment for Servicing

Instrument	Recommended Type	Application
RF Signal Generator	HP 8656B or equivalent	Receiver Measurements
Modulation Analyzer	HP 8901B or equivalent	Frequency and Deviation Measurements
Audio Analyzer	HP 8903A or equivalent	Receiver Measurements
Power Meter	HP 438A or equivalent	Transmitter Power Measurements
Power Sensor	HP 8428A or equivalent	Transmitter Output Power
DC Power Supply	0-20 volts at 15 amps	
Attenuator Pad	75 Watts, 30 dB	Transmitter Measurements
DC Ammeter	30mA to 20 A	Current Drain Measurements
Computer	IBM PC, PC/XT, or PC/AT	Radio Alignment
Radio Interface Box	RLN4008E	Computer Interface to Radio
Cable	3080369B72	From RIB to Computer
Cable	AAPMKN4004	From RIB to Radio
Software	RVN4191	Radio Alignment

Exhibit 10C – Tune Up Information

Pursuant to 47 CFR 2.1033(c)(9)

All transmitter adjustments are performed by electronic means. The transmitter contains no electromechanical components for the purpose of transmitter tuning or adjustment.

The tuning elements that are used for transmitter adjustment are:

Location	Type of Element	Function
U403	Microprocessor	Supplies data to Audio Filter IC, Fractional-N Synthesizer, Temperature Compensated Crystal Oscillator, and Power Control For Transmitter Modulation, Frequency and Power Adjustment
U200	Programmable Attenuator	Reference Modulation Balance
U504	Programmable Attenuator	Deviation Adjustment
U200	Digital to Analog Converter	Transmitter Frequency Adjustment
U200	Temperature Compensated Crystal Oscillator	Transmitter Frequency Adjustment
U504	Digital to Analog Converter	Transmitter Power Adjustment

The value of a particular tuning element is determined by data sent to that tuning element by microprocessor U403. This data is generated by the microprocessor based on tuning information that is stored in the microprocessor's EEPROM (Electrically Erasable Programmable Read Only Memory).

Tuning information is stored in the EEPROM during factory adjustment or by qualified field service facilities, using the attached procedure and recommended test equipment.

<u>Tuning Procedure</u>

Tuning Parameters

Supply Voltage

13.6+/-0.1Vdc @ DC Connector under operating condition
10A Current limit

Temperature

25+/-2°C

Table 1 Test Frequencies

Test Frequency	UHF R3 Portable & Mobile	
	TX (MHz)	RX (MHz)
F1	465.125	465.025
F2	470.125	470.025
F3	475.125	475.025
F4	480.125	480.025
F5	485.125	485.025
F6	490.125	489.975
F7	494.975	494.875

1. PA Bias Tuning

This procedure must be done before the transmitter is keyed the first time. To avoid FET device damage care must be taken not to exceed the drain current and dissipation limits of the devices by setting a too high bias voltage during tuning. The use of a power supply with an appropriate current limitation setting is recommended. The tune procedure should be done as fast as possible to keep the device temperature low and to achieve the required quiescent current accuracy.

General Tuning Procedure

Set the power supply to the voltage and current specified above and power up the radio.

Define:
For VHF Radios: PA_BIAS = 0xD9, **PA_BIAS_MAX** = 0xE9, **PA_BIAS_MIN** = 0xC9 **, High_limit** = 130 **,**
Low_limit = 100
For UHF Radios: PA_BIAS = 0x91, **PA_BIAS_MAX** = 0xB4, **PA_BIAS_MIN** = 0x82 , **High_limit** = 400 ,
Low_limit = 500

Key the radio with the following values:
ASFIC BYTE 04 (DAC U) = 0x00
ASFIC BYTE 05 (DAC R) = 0x00 (Driver Bias)
ASFIC BYTE 06 (DAC G) = 0xFF
Set the TX freq to 200 MHz for VHF Radios and to 500 MHz for UHF Radios in order to eliminate the VCO influence.
Measure the power supply current and put it in I_REF.
Set the ASFIC BYTE 04 (DAC U) to **PA_BIAS**.
Measure the power supply current and put it in I_BIAS.
Calculate: Delta = I_BIAS – I_REF.
IF Low_limit [mA] < Delta < High_limit [mA] *** PA bias current ok ***

Program CP with ASFIC BYTE 04 (DAC U) = **PA_BIAS** and go to END
ELSE
IF Delta > High_limit [mA] *** PA bias current too high ***
IF PA_BIAS < **PA_BIAS_MIN**
Terminate the procedure and report FAIL – Hardware failure
ELSE
PA_BIAS = PA_BIAS – 1
Go to stage (7)
ELSE *** PA bias current too low ***
IF PA_BIAS > PA_BIAS_MAX
Terminate the procedure and report FAIL – Hardware failure
ELSE
PA_BIAS = PA_BIAS + 1
Go to stage (7)

END: PA_BIAS tune completed

2. Driver Bias Tuning

General Tuning Procedure
(1) Set the power supply to the voltage and current specified above and power up the radio.
(2) Define:

Driver:
For UHF R2 40W: Hi Limit= 150 Low Limit=100
DRIVER_BIAS = 0xA5; DRIVER_BIAS_MAX = 0xBE, DRIVER_BIAS_MIN = 0x8C ,

(3) For VHF and UHF radios, key the radio with the following values:
ASFIC BYTE 04 (DAC U) = 0x00 (PA Bias)
ASFIC BYTE 05 (DAC R) = 0x00 (Driver Bias)
ASFIC BYTE 06 (DAC G) = 0xFF (Predriver Power Control)

(4) Set the TX freq to 500 MHz for UHF Radios in order to eliminate the VCO influence.
(5) Measure the power supply current and put it in I_REF.
(6) Set the ASFIC BYTE 05 (DAC R) to DRIVER_BIAS.
(7) Measure the power supply current and put it in I_BIAS.
(8) Calculate: Delta = I_BIAS – I_REF.
(9) IF Low_limit [mA] < Delta < High_limit [mA] *** Driver bias current ok ***
Program CP with ASFIC BYTE 05 (DAC R) = DRIVER_BIAS and go to END
ELSE
IF Delta > High_limit [mA] *** Driver bias current too high ***
IF DRIVER_BIAS < DRIVER_BIAS_MIN
Terminate the procedure and report FAIL – Hardware failure
ELSE
DRIVER_BIAS = DRIVER_BIAS – 1
Go to stage (7)
ELSE *** Driver bias current too low ***
IF DRIVER _BIAS > DRIVER _BIAS_MAX
Terminate the procedure and report FAIL – Hardware failure
ELSE
DRIVER _BIAS = DRIVER _BIAS + 1
Go to stage (7)

END: Driver_BIAS tune completed

3. Barcode Reading And DAC Sensitivity Measurement (For Xtal Only)

-Scan the crystal code:
A = Digit 1, B = Digit 2, C = Digit 3, D = Digit 4, E = Digit 5, F = Digit 6, G = Digit 7, H = Digit 8
temps(t): Array of temperature in steps of 5 deg C from –35 deg C to 90 deg C
Calc xtal_infl_temp = 22+A+(B/10)
Calc a1 = (C+D/10+E/100)*(-0.1)
Calc a3 = (8.20+(C+D/10+E/10)*(0.2)+(F+G/10+H/100)*(0.02)*(0.00001))
-Calc xtal_curve_ppm[26] From I=0 to 25:
-delta_temp = temps[i]-25
-xtal_curve_ppm[i] = a1*delta_temp+a3*delta_temp*delta_temp*delta_temp
- xtal_max_ppm = max value from the array xtal_curve_ppm

Oscillator Sensitivity
-UUT: Set Freq=438.025M , Mode Tx , DAC: hot:127, cold:127, lin:63, infl:63
-Adjust warp so ppm < 0.2 . Mark as table->warp_dac_center (=158). If Not in range 122 –390 then error.
-Check if warp_dac_center-64 < 0 OR warp_dac_center+64 > 511 Then "Min/Max warp DAC value is out of range".
-UUT set warp = warp_dac_center+64 , Meas and record : high_warp_freq[Hz] , meas_var_high[V] .
-UUT set warp = warp_dac_center-64 , Meas and record : low_warp_freq[Hz] , meas_var_low[V] .
-Calc OscSens:
1) comp_range_v = meas_var_low-meas_var_high;
2) ppm_range = (low_warp_freq-high_warp_freq)/high_warp_freq * 1e6;
3) table->osc_sensitivity = fabs(ppm_range/comp_range_v); " If < 10 OR > 40 then error "

Inflection
waris_match_curve.
-Read ic_temp1 till it < 35. Then report as TEMP1.
-Setup radio: set freq, mode=tx.
-ppm =1
-Set DAC: infl=64, linear=63, hot=127, cold=127
-Set table->warp_dac_center.
-Measure frequency @ warp_dac_center @ TC off. Mark as ic_infl_ref .
- ?table->lin_dac > 50 ; lin_dac = 50 ; lin_dac= table->lin_dac
- Find inflection.

Waris Match Curve
Set max_hot_error & max_cold_error arrays.
- SortErr for hot & cold.
- Find_best_match .
- table->hot_dac = best_match_hot % 128;
- table->lin_dac = best_match_hot / 128;
- table->cold_dac = best_match_cold % 128;
-Calc table->match_error_curve[26] and table->best_comp_curve[26]:
COLD:
match_error_curve[i] = abs(tc_curves[best_match_cold][i]-comp_curve_v[i])
best_comp_curve[i] = tc_curves[best_match_cold][i]
HOT:
same as cold just replace best_match_cold with best_match_hot.

Sort hot and cold Err array
<u>Meaning:</u>
Sort the max_hot_err & max_cold_err arrays.
From the lowest to biggest.
Just the first 512 lowest errors of all 8192 errors.
<u>Implementation:</u>
Scan 512 times the 8192 array.
Each scan find the element that have the lowest error and at the end of scan,

```
 just swap this record (error, index) with the first place element.
 (put the lowest in the first place, and next scan start from the next place.)

Find index of array max_hot_err  & and index of array max_cold_err where:
   1 - There linear is same(linear=curve_idx /128)
   2 - The max err between them, is the minimum of all cases.
lin_dac_array[64]  ; init all elements to 0
Scan 8192 times. Till
            - cur_lin_dac1 = max_cold_curve[rank1].curve_idx / 128;
            - If cur_lin_dac1 is in lin_dac_array then skip.
            - If not skip:
                        lin_dac_array[num_lin_dac] = cur_lin_dac1;
                        num_lin_dac++;
                        Scan 8192 times: Each curve:
                                    cur_lin_dac2=max_hot_curve[rank2].curve_idx /128;
                                    if (cur_lin_dac2 == cur_lin_dac1)
                                          cur_min_max_err = max(max_cold_curve[rank1].error,
max_hot_curve[rank2].error)
                                    if(cur_min_max_err < min_max_err)
                                          min_max_err = cur_min_max_err
                                          best_hot = max_hot_curve[rank2].curve_idx;
                                          best_cold = max_cold_curve[rank1].curve_idx;
              -if num_lin_dac > 64 then stop

Find Inflection
-Read ic_temp1 till it < 35.  Then report as TEMP1.
-Setup radio:  set freq, mode=tx.
-Set DAC: infl=64, linear=63, hot=127, cold=127
-Set table-> warp_dac_center
-Measure frequency @ warp_dac_center @ TC off. Mark as ic_infl_ref .
- ?table->lin_dac > 50 :     lin_dac = 50        ;         lin_dac= table->lin_dac
ppm =1
-Till ppm <= 0.15:
    - Set DAC :infl: 64 , hot:table->hot_dac, cold:table->cold_dac, lin:lin_dac
    - delay 0.2 Sec
    - Read freq. Calc  ppm = (freq-ic_infl_ref)*1000000/(ic_infl_ref);
    -if ( fabs(ppm) > min_ppm_error)
          - if (counter == 0)
                - old_infl_dac = infl_dac;
                 - old_ppm = ppm;
                 - ? (ppm > 0) :       infl_dac -= 10      ;      infl_dac += 10;
          -  if(counter !=0)
                   - if ( (old_ppm != ppm) && (old_infl_dac != infl_dac) )
                              - num_steps = old_infl_dac - infl_dac
                             - ? ((old_ppm < -0.5 ) && ( ppm > 0.5 ))  || ((old_ppm > 0.5 ) && ( ppm < -0.5 )) :
                                       num_steps = (int) (num_steps/2) ; ;
                            - pull_sens = fabs ( num_steps / (old_ppm - ppm) );
                  - old_infl_dac = infl_dac;
                  - old_ppm = ppm;
                  - infl_dac -= (int) (ppm * pull_sens);
    -counter ++
   }/* END: "if ( fabs(ppm) > Min_ppm_error)" */
 - ? infl_dac < 0  :  infl_dac =0  ;;
 - ? infl_dac >127  :  infl_dac =127  ;;
 - ? (old_infl_dac + infl_dac)= 0  Or = 254    Or  counter > 15  )                 // (254=127*2)
        - stop !
        -? Counter >10 :    “Failed inflection, too many times”      ;  “Infl dac is out of range” ;
-If Pass
- Report infl_dac As “INFL_SET_AMB”.
```

-Read temperature .Report as IC_TEMP. Mark as ic_temp , ? ((ic_temp < 20)||(ic_temp > 35)) :" TEMP SENSOR OFF/NOT CONNECTED" ;;
-table->infl_dac = (int) (infl_dac+ (1/infl_dac_step) * (ic_temp-table->xtal_infl_temp+infl_tmp_offset));

Final Warp
-UUT setup: freq=438.025 MHz , mode tx
-Set warp_center
-Set DAC values
-Find the table->warp_dac for ppm < 0.15:
ppm = (freq - LO_freq)/LO_freq * 1000000;

Main Data Base

```
typedef struct tc_table
{
  double tc_curves[NUMBER_COMP_CURVES][MAX_NUMBER_OF_TEMPS];     /* Voltage Vs Temperature Curve array.*/
  double temps[MAX_NUMBER_OF_TEMPS];                    /* Temperature Array.*/
  double osc_contrib[MAX_NUMBER_OF_TEMPS];  /*oscillator offset contrib to tc */
  double reg_contrib[MAX_NUMBER_OF_TEMPS];  /*regulator offset contrib to tc */
  double xtal_infl_temp; /* crystal's inflection temperature. The point between the upper and lower turning points in xtal_curve_ppm */
  double xtal_curve_ppm[MAX_NUMBER_OF_TEMPS]; /* Crystal polynomial equation in ppm */
  double xtal_max_ppm;  /* crystal maximum ppm in the polynomial equation */
  int warp_dac_center;  /* The warp DAC value needed to set the oscillator to the desired reference frequency */
  double osc_sensitivity; /* The sensitivity of the oscillator's frequency to the voltage applied to the varactor. */
  double comp_curve_v[MAX_NUMBER_OF_TEMPS]; /* the translated crystal curve in voltage including the osc_contrib[] and reg_contrib[] */
  double best_comp_curve[MAX_NUMBER_OF_TEMPS]; /* best IC compensation curve */
  double match_error_curve[MAX_NUMBER_OF_TEMPS]; /* the difference between best_comp_curve[] and comp_curve_v[] */
  int lin_dac;
  int hot_dac;
  int cold_dac;
  int infl_dac;
  int warp_dac;
}COMPENSATION_TABLE;
```

4. Reference Oscillator Warping

Adjustment of the reference oscillator is critical for proper radio operation. Improper adjustment will not only result in poor operation, but also a misaligned radio that will interfere with other users operating on adjacent channels. For this reason, the reference oscillator should be checked every time the radio is serviced. The frequency counter used for this procedure must have a stability of 0.1 PPM (or better).

General Tuning Procedure

Set the power supply to the voltage specified above and power up the radio.
Remove any audio input signals to minimize frequency inaccuracy
Set the radio to the Carrier Squelch Environment, to 25kHz Channel Spacing and to the lowest transmit power level to reduce current drain during tuning.
If the radio's frequency range is NOT Low Band (29.7-50MHz) perform the following procedure
    Disable modulation (Environment Override) to minimize frequency inaccuracy.
If the radio's frequency range is Low Band (29.7-50MHz) perform the following procedure
    Enable the microphone path (Environment Override).
Set the radio to the transmit frequency indicated in table 2.
Key up the radio.
If the radio's frequency range is Low Band (29.7-50MHz) perform the following procedure
    Set the IC value of the Transmit Power to $32.
If the radio's frequency range is NOT Low Band (29.7-50MHz) perform the following procedure
    Disable the digital modulation in the FRAC-N to minimize frequency inaccuracy.
Measure the transmit frequency and compare it with the specification limits +/- 0.2 ppm.
If the measured frequency is within the specification limits.
    Dekey the radio.
    Reference Oscillator Tuning done.
If the measured frequency is outside the specification limits.
    Read the codeplug value for the Oscillator Warp.
    While the transmit frequency is outside the specification limits.
Update the IC value of the Oscillator Warp without codeplug update.
Re-measure the transmit frequency and compare it with the specification limits.
Repeat steps (I) (ii) until the transmit frequency is within the specification limits.
    Write the value of the tuned Oscillator Warp to the codeplug.
    Dekey the radio.
    Reference Oscillator Tuning done.

Table 2 **Tuning Profile**

These tables list for each band at which softpot frequency each parameter must be tuned or calculated.

	UHF (25-44W)							
	None	**F1**	**F2**	**F3**	**F4**	**F5**	**F6**	**F7**
XTAL Temperature Comp.	•	•	•	•	•	•	•	Tune
Ref Osc Warp	•	•	•	•	•	•	•	Tune
Supply Voltage Threshold	Tune	•	•	•	•	•	•	•
PA Bias Voltage	Tune	•	•	•	•	•	•	•
TX Power	•	Tune	Calc.	Calc.	Tune	Calc.	Calc.	Tune
PA Control Voltage Limit	•	Tune	Tune	Tune	Tune	Tune	Tune	Tune
Modulation Balance	•	Tune	Tune	Tune	Tune	Tune	Tune	Tune
Deviation Limit (Voice)	•	Tune	Calc.	Calc.	Tune	Calc.	Calc.	Tune
Signaling Deviation	•	•	•	•	Tune	•	•	•
Front End Tuning	•	OF4	OF4	OF4	Tune	OF4	OF4	OF4
Rated Audio	•	•	•	•	Tune	•	•	•
RX Squelch	•	Tune	Calc.	Calc.	Tune	Calc.	Calc.	Tune
RSSI (MPT)	•	•	•	•	Tune	•	•	•

NOTES: • = No tuning required
Calc. = Linear interpolation using adjacent tune values
CFx = Use value obtained for Fx
OFx = Use offset calculated for Fx
25kHz = Use the values obtained for 25kHz channel spacing
Fixed = Use a fixed value (see appropriate table)

5. Transmitter Power Tuning

Overview: The softpots used for PA power setting do not contain the DAC values directly like they do in the portable radio. Instead they store the parameters (Mcp, Kcp) for approximation of the dependency between power and DAC setting. This procedure allows to set any power within the range of the PA without re-tuning. The PA output power (Pcp) levels are stored in the softpots for HIGH and LOW POWER. The following equations are used to calculate the DAC value for the desired power.

$$DAC\ PWR\ SET = 100 * \frac{4 * Kcp - Pcp}{Mcp}$$ **Equ. 1**

$$Pcp = 25 * \sqrt{desired\ power}$$ **Equ. 2**

The power is not stored directly in the softpots to avoid square root calculation by the radio software.

General Tuning Procedure

Set the power supply to the voltage specified above and power up the radio.
Read the tuning parameters from the radio and determine the values for DAC1 and DAC2.
Set the radio to the Carrier Squelch Environment and highest Transmit Power Level.
Disable modulation (Environment Override) and remove any audio input signals to minimize frequency inaccuracy.
This procedure is to be performed for all Power Tuning Channels indicated in table 1.

Set the radio to the appropriate transmit frequency.
Key up the radio.
Set the IC value of the Transmit Power to the value DAC1.
Measure the transmit power and note the value as P1.
Set the IC value of the Transmit Power to the value DAC2.
Measure the transmit power and note the value as P2.
Dekey the radio.
Calculate Mcp and Kcp with the following equations:

$$M = -\frac{\sqrt{P2} - \sqrt{P1}}{DAC2 - DAC1}$$ **Equ. 3**

$$Mcp = 2500 * M$$ **Equ. 4**

$$Kcp = 6.25 * \left(\sqrt{P1} + M * DAC1\right)$$ **Equ. 5**

Write the values Kcp and Mcp the codeplug.
Repeat steps (A) to (J) for all the channels that require actual tuning. Values for the untuned channels are to be interpolated by the test controller and programmed into the codeplug.

Transmit Power Tuning done.

6. Modulation Balance Tuning:

Modulation balance balances the modulation sensitivity of the VCO and reference modulation (synthesizer low frequency port) lines. Balance algorithm is critical to the operation of signaling schemes that have very low frequency components (e.g. PL) and could result in distorted waveforms if improperly adjusted. The radio stores only one set of tuning data for all supported channel spacings (12.5, 20 and 25 kHz). Therefore, tuning should only be performed for 12.5 kHz channel spacing.
In the radio the deviation for 12.5 kHz is set by reducing the modulation sensitivity within the synthesizer IC. The reduction of the low audio frequency components is done by a division by 2 in the digital modulator and very accurate. The high audio frequency components are attenuated by a resistive network that has typically 6.3 dB. This inaccuracy will bring the modulation out of balance in the not tuned channel spacing. Tuning at 12.5 kHz will reduce the low frequency components at 25 kHz channel spacing, while tuning at 25 kHz will increase the low frequency components at 12.5 kHz channel spacing. Due to the fact that the upper spec limit is only 1dB, but the lower spec limit is -3 dB, tuning at 12.5 kHz improves the margin.

<u>General Tuning Procedure</u>

Set the power supply to the voltage specified above and power up the radio.
Set the radio to the External Signal Modulation Balance Environment, to 12.5kHz Channel Spacing and to the lowest transmit power level to reduce current drain during tuning.
This procedure is to be performed for all Modulation Balance Attenuator Tuning Channels indicated in table 2.

Set the radio to the appropriate Modulation Balance Attenuator Tuning Channel.
Remove any audio signals applied to any audio inputs to avoid a transmit frequency offset.
Key up the radio.
If the radio's frequency range is Low Band (29.7-50MHz) perform the following procedure
Set the IC value of the Transmit Power to $32.
Update the IC value of the VCO Attenuator to its maximum setting ($255) without codeplug update.
Apply an 80Hz tone @ 100mV RMS to the Auxiliary Transmit Audio Path.
Measure the transmit deviation, note the value as D1.
Apply a 3kHz tone @ 100mV RMS to the Auxiliary Transmit Audio Path.
Measure the transmit deviation, note the value as D2.
Find the ratio of the measured transmit deviation values in dB using equation 20*log(D1/D2).
If the ratio of the measured transmit deviations is within ±0.15 dB

Dekey the radio.
Modulation Balance Tuning for the set Tuning Channel done. Continue with step (A) for the next Modulation Balance Attenuator Tuning Channel

If the ratio of the measured transmit deviations is NOT within ±0.15 dB

Read the codeplug value for the Modulation Balance Attenuator.
While the ratio of the measured transmit deviations is outside the specification limits.
Disable modulation (Environment Override) to minimize frequency offset.
Update the IC value of the Modulation Balance Attenuator without codeplug update.
Enable modulation (Environment Override).
Repeat steps (E) to (I).
Repeat steps (a) to (d) until the ratio of the measured transmit deviations is inside the specification limits

NOTE 1: Modulation must be removed from the Fractional –N Synthesizer while it is being programmed.
Dekey the radio.
Write the value of the tuned Modulation Balance Attenuator to the codeplug.
Modulation Balance Tuning done

7. Modulation Limit Tuning

Modulation limit tuning sets the maximum deviation of the carrier. The radio stores only one set (7 values across the frequency band) of tuning data for 25kHz channel spacing. Therefore, tuning across the frequency band must only be performed for 25 kHz channel spacing. For 12.5 and 20kHz channel spacings an offset value in the codeplug is used to reduce the deviation. The offset value should be tuned at one frequency only.
MDC/LTR Low Band radios which use 5 kHz rated system deviation for 20kHz channel spacing do not have to be tuned at 20kHz channel spacing.

<u>General Tuning Procedure</u>

The Modulation Balance Tuning must already be done for this procedure to be valid.

Set the power supply to the voltage specified above and power up the radio.
Set the radio to the Carrier Squelch Environment, to 25kHz Channel Spacing and to the lowest transmit power level to reduce current drain during tuning.
Enable the microphone path (Environment Override).
This procedure is to be performed for all Modulation Limit Tuning Channels indicated in table 2

Set the radio to the appropriate Modulation Limit Tuning Channel.
Remove any audio signals applied to any audio inputs to avoid a transmit frequency offset.
Key up the radio.
If the radio's frequency range is Low Band (29.7-50MHz) perform the following procedure
Set the IC value of the Transmit Power to $32.
Apply a 1kHz tone @ 800mV RMS to the External Microphone Audio Path.
Measure the transmit deviation and compare it with the specification limits in the table 3.

Table 3 **Reference Voice Deviation Tuning Limits**

This table lists the tuning window for the reference voice deviation. All signaling deviations are based on this voice deviation. For 25/30 kHz channel spacing the deviation is tuned at multiple softpot frequencies. For all other channel spacings only an offset value is determined at one softpot frequency

Channel Spacing	Rated System Deviation	Deviation Tuning Window
25/30 kHz	5 kHz	4.40 – 4.60 kHz (Except Low Band R3 @ F6&F7) 4.20 – 4.40 kHz (Low Band R3 @ F6&F7)
20 kHz (Low Band 20 kHz systems in North America only)	5 kHz	4.40 – 4.60 kHz (Except Low Band R3 @ F6&F7) 4.20 – 4.40 kHz (Low Band R3 @ F6&F7)
20 kHz	4 kHz	3.40 – 3.60 kHz
12.5 kHz	2.5 kHz	2.20 – 2.30 kHz

If the measured transmit deviation is within the specification limits
Dekey the radio.
Modulation Limit Tuning for the set Tuning Channel done. Continue with step (A) for the next Modulation Limit Tuning Channel

If the measured transmit deviation is outside the specification limits

Read the codeplug value for the VCO Attenuator.
While the measured transmit deviation is outside the specification limits.
Update the IC value of the VCO Attenuator without codeplug update.
Re-measure the transmit deviation and compare it with the specification limits.
Repeat steps (a) (b) until the measured transmit deviation is inside the specification limits
Dekey the radio.
Write the value of the tuned VCO Attenuator to the codeplug.
VCO Attenuator Tuning for the set Tuning Channel done. Continue with step (A) for the next Modulation Limit Tuning Channel
This procedure is to be performed for all remaining Modulation Limit Tuning Channel Spacings (12.5 and 20kHz) and the Modulation Limit Tuning Channel indicated in table 2

Enable the microphone path (Environment Override) and set the appropriate Modulation Limit Tuning Channel Spacing.

Set the radio to the appropriate VCO Attenuator Tuning Channel for the set channel spacing.

Remove any audio signals applied to any audio inputs to avoid a transmit frequency offset.

Key up the radio.

Apply a 1kHz tone @ 800mV RMS to the External Microphone Audio Path.

Measure the transmit deviation and compare it with the specification limits in Table 3.

If the measured transmit deviation is within the specification limits

Dekey the radio.
VCO Attenuator Tuning for the set Channel Spacing done. Continue with step (A) for the next Modulation Limit Tuning Channel Spacing

If the measured transmit deviation is outside the specification limits

Read the codeplug value for the VCO Attenuator.
While the measured transmit deviation is outside the specification limits.
Update the IC value of the VCO Attenuator without codeplug update.
Re-measure the transmit deviation and compare it with the specification limits.
Repeat steps (a) (b) until the measured transmit deviation is inside the specification limits
Dekey the radio.
Write the value of the tuned VCO Attenuator to the codeplug.
Modulation Limit Tuning for the set Tuning Channel done. Continue with step (A) for the next Modulation Limit Tuning Channel