

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 Freq. | Industry Equivalent |
|-------------|----------------|-----------------------------|-----------------|---------------------|
| D102 | 4813833C02 | DC Switch | DC | MMBD6100 |
| D103 | 4802482J02 | Antenna Switch | 403-440MHz | MA4P959 |
| D104 | 4802482J02 | Antenna Switch | 403-440MHz | MA4P959 |
| D105 | 4805218N57 | Reverse Volt. Peak Detector | DC | RB715F |
| D106 | 4805218N57 | Reverse 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 | 358-395MHz | 1SV228 |
| D204 | 4805649Q13 | TX VCO Frequency Control | 403-440MHz | 1SV228 |
| D205 | 4862824C01 | TX VCO Modulator | Audio-440MHz | 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 | 4886163B01 | TX RF Power Amplifier | 403-440MHz | MRF1535 |
| Q101 | 4813824A10 | DC Switch | DC | MMBT3904 |
| Q102 | 4813824A10 | DC Switch | DC | MMBT3904 |
| Q103 | 4813824A06 | DC Switch | DC | MMBTA13 |
| Q105 | 4886212B01 | TX Driver Stage | 403-440MHz | MRF1518 |
| Q106 | 4805128M2 7 | Current Source | DC | BSR33 |
| Q200 | 4802245J95 | RX Injection Amplifier | 358-395MHz | 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 | 358-495MHz | 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 | 4880048M0 1 | DC Switch | DC | DTC144EKA |
| Q409 | 4880048M0 | DC Switch | DC | DTC144EKA |

| | | | | |
|-------|------------|------------------------|--------------|---------------------|
| | 1 | | | |
| 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 | 403-440MHz | 30C65 |
| U102 | 5113818A01 | Power Control | DC | LM2904DR2 |
| U103 | 5113819A04 | Power Control | DC | MC3303 |
| U200 | 5185963A27 | Frequency Synthesizer | 1-440MHz | FRACN_63A27 |
| U201 | 5105750U54 | VCO Buffer IC | 358-440MHz | 50U54 |
| U300 | 5186144B01 | RX Back-End IC | Audio-455KHz | SA616 |
| U301 | 5109522E10 | Inverter | DC | TC7W04F |
| U302 | 4808612Y05 | Quad Mixer Diode | 358-440MHz | SMS3928 |
| U400 | 5102463J64 | EEPROM | 1MHz | X25128-2.7 |
| U403 | 5102226J56 | Microprocessor | 7.56MHz | MC68HC11FL0 |
| U404 | 5189233U02 | FLASH | 3.78MHz | AT49LV002N_70V I |
| U405 | 5113805A75 | Shift Register | DC | MC74HC595ADR2 |
| U501 | 5102190C33 | Voltage Regulator | DC | LM2941T |
| 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:

| <u>Location</u> | <u>Type of Element</u> | <u>Function</u> |
|-----------------|--|--|
| 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.

Tuning Procedure

Tuning Parameters

Supply Voltage

13.8+/-0.1Vdc @ DC Connector under operating condition
5.5A Current limit

Temperature

25+/-2°C

Table 1 Test Frequencies

| Test Frequency | UHF R1 | |
|----------------|----------|----------|
| | Mobile | |
| | TX (MHz) | RX (MHz) |
| F1 | 403.000 | 403.025 |
| F2 | 409.175 | 409.200 |
| F3 | 415.325 | 415.350 |
| F4 | 421.500 | 421.525 |
| F5 | 427.675 | 427.700 |
| F6 | 433.825 | 433.850 |
| F7 | 440.000 | 439.975 |

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** = 0xA4, **PA_BIAS_MAX** = 0xB4, **PA_BIAS_MIN** = 0x94, **High_limit** = 330, **Low_limit** = 300

Key the radio with the following values:

ASFIC BYTE 04 (DAC U) = 0x00

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

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 l=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

Meaning:

Sort the max_hot_err & max_cold_err arrays.

From the lowest to biggest.

Just the first 512 lowest errors of all 8192 errors.

Implementation:

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" ;;


```

Final Warp

- UUT setup: freq , mode tx
- Set warp_center
- Set DAC values
- Find the table->warp_dac for ppm < 0.15:

$$\text{ppm} = (\text{freq} - \text{LO_freq})/\text{LO_freq} * 1000000;$$

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;

```

2. 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 +/-30Hz.

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 (1-28W) | | | | | | | |
|---------------------------------|-------------|------|-------|-------|------|-------|-------|------|
| | 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)

3. 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.

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

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

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:

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

$$Mcp = 2500 * M \quad \text{Equ. 4}$$

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

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.

4. 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.

General Tuning Procedure

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

5. 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.

General Tuning Procedure

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