CIRCUIT & DEVICE DESCRIPTIONS

PARA. 2.1033 (b)(4), (c)(10)

(10) FREQUENCY STABILIZATION

A temperature compensated crystal oscillator (U4) provides a 19.44 MHz reference frequency signal for the transmitter and receiver frequency synthesizers. This reference frequency is internally compensated to be within ±2.5 ppm over the temperature range of -30°C to +75° C. Upon power-up, the receiver searches and acquires a base station signal, and it adjusts the reference oscillator frequency to align itself to the high accuracy time base of the base station. The transmitter does not engage until after the receiver synchronizes to the base station.

(11a) ATTENUATION OF SPURIOUS EMISSIONS

The 800 MHz band transmitter frequency is obtained from mixing a phase locked VCO operating from 979.53 MHz to 1004.49 MHz with a 155.52 MHz signal. The 155.52 MHz signal is obtained by phase locking an oscillator to the VCTCXO output.

The 800 MHz band receiver frequency is obtained by dual conversion. The first conversion is obtained by mixing the incoming signal with the 979.53 MHz to 1004.49 MHz VCO to a first IF frequency of 110.52 MHz. The second conversion mixes the IF frequency with a phase locked VCO at 110.4 MHz to obtain the second IF frequency of 120 kHz. All VCO's are phase locked to the reference VCTCXO U4.

As a result of the above circuitry, the spurious signals are transmitter harmonics, reference oscillator 19.44 MHz harmonics, the local oscillators and the microprocessor clock.

The use of multi-layer printed circuit boards, with signal tracks between ground planes, for the radio as well as for the logic areas reduces the radiation to a minimum. Ceramic resonator bandpass filters for the duplexer attenuate conducted transmitter harmonics, reference oscillator and local oscillator signals. A bandpass filter in the receiver front end attenuates the local oscillator signal further. Additional suppression of radiation is achieved by shielding and key isolation between circuits.

(11b) LIMITING MODULATION

The modulation for the transmitter is produced inside a Digital Signal Processing integrated circuit. The modulation limiting is therefore controlled by an algorithm inside this chip. The limit is preset at the factory and cannot be changed thereafter.

ATTENUATING HIGHER AUDIO FREQUENCIES

The DSP chip provides an audio filter with a 120 log (f/3000) response, f=3K to 20KHz. Manchester encoded data signals are filtered prior to transmission by a four-pole lowpass filter providing an attenuation of 24 dB/Octave above 20 kHz.

The signal produced by the DSP chip is a differentially shifted PI/4 QPSK signal for the digital system and a FM signal for the analog cellular system. These signals are fed through a three-pole lowpass filter with a 3 dB down cut-off frequency of 25 kHz to limit the adjacent channel energy in the digital mode.

PARA. 2.1033 (b)(4)

(11c) OUTPUT POWER CONTROL

A loop circuit under supervision of the logic sets the output to any of the eleven power levels.

A digital word is transmitted to the gain control amplifier for output power adjustment.

A detector at the output of the power amplifier module senses the RF energy present and sends a corresponding DC voltage to the digital logic circuitry.

Upon receiving a command to set power level from the handset or from a base station the microprocessor sends a predetermined word to the ALC amplifier. The output detector voltage is then read by the microprocessor and compared to a preset value. If the detector voltage is outside the allowed tolerance an adjustment is made to the gain-controlled amplifier to bring the detector voltage into the proper range.

(12) DIGITAL MODULATION TECHNIQUES

The NRZ data stream is transformed to 10kbps Manchester encoded data in such a way that each NRZ binary one is transformed to a zero-to-one transition, and each NRZ binary zero is transformed to a one-to-zero transition.

The Manchester encoded data stream is filtered before being applied to the modulator. Direct binary frequency shift keying is used. A binary one into the modulator corresponds to a normal peak frequency deviation of 8kHz above the carrier frequency and a zero corresponds to a nominal peak frequency deviation 8 kHz below the carrier frequency.

(12a) DESCRIPTION OF PI/4 DQPSK

The modulation method used for the digital mode is known as PI/4 shifted differentially encoded Quadrature Phase Shift Keying. Eight distinct phase states are possible. The signal information is differentially encoded; symbols are transmitted as changes in phase rather than absolute phases. Transition of phase which would result in a zero amplitude momentarily are not allowed.

CIRCUIT & DEVICE DESCRIPTIONS

PARA. 2.1033 (b)(4)

1.0 LOGIC BOARD OPERATION

The logic board is the central controller system for the radio. It is made up of a microprocessor, DSP, codec, memory, and control logic.

1.1 ASIC CONTROL CHIP – D855

The ASIC control chip is made up of a ARM microprocessor and application specific logic circuits. The chip is the main control center for the radio and provides interfaces to the DSP's, codec, memories, keypad, display, alarms, and system interfaces.

1.2 MEMORY CHIP'S

D151 is the 2M x 8 flash memory used to store the radio's operating algorithm. This part may be field programmed to allow new revisions of the operating algorithm to be installed without opening the radio case.

D152 is the 256k x 8 static RAM used for stack, and microprocessor operation.

D153 is the 16k x 8 electrically erasable programmable read only memory. The part stores all of the users phone numbers, any system parameters that change, and the power down status of the radio.

1.3 USER INTERFACE

There is a 30 pin system connector that provides input power, control signals, and the receive and transmit audio interfaces.

1.4 AUDIO INTERFACE

D251 codec will provide the necessary audio conversions from analog to digital and digital to analog for all user interfaces. The codec will provide all necessary filters, A to D and D to A control functions for the radio.

1.5 DIGITAL SIGNAL PROCESSING

D201 is the DSP and provides all signal conversion and error correction for the incoming audio receive path and all signal conversions for the transmitted digital signal.

PARA. 2.1033 (c)(9)

Due to the high accuracy of the I/O, the modulation, transmit voice, DTMF, SAT and data deviations are all preset in the DSP software and are not adjustable in production or the field. These procedures give the test method to verify the phone has proper deviations.

RADIO TUNE/TEST INSTRUCTIONS

FILTERING
SAW, ceramic, and crystal filter technologies are used, and no tuning is required.

REFERENCE FREQUENCY ADJUSTMENT

TEST SETUP
Testing of the VCTCXO circuit is temperature dependent and should be carried out at an ambient room temperature of +23°C to +27°C. Any frequency adjustments should be made 1.0 hour after re-flow soldering to allow for relaxation of thermal stress.

Terminate ANT (X301) into a frequency counter with a 50Ω input impedance.

Enter the following test commands:
**** *The same channel should be used for all parts of this test* ****

@2705	*(read thermistor A/D from Patti)*
check result 1	
@80	*(initialize the transceiver- carrier off and audio muted)*
@6502	*(AFC off)*
@E11401FF	*(center DAC3)*
@3Czzxxxx	*(select a MID-CHANNEL)*
@8407	*(set the transmitter power level 7)*
@81	*(turn the transmitter on)*
check result 2	

TEST RESULTS

1. Verify that the returned value is in the range 41 to 54 hex. (A higher temperature corresponds to a lower reading).
2. Wait until output is stable (<±42Hz variation in frequency). Log output frequency and calculate error in Hz.

Verify that the transmitter frequency is <±100Hz of the channel frequency.

If necessary, adjust DAC3 with the commands *@E1140xxx* where xxx is 000 to 3FF (each step is approx. 48Hz) to achieve a transmitter frequency that is <±100Hz of the channel frequency plus 0.35ppm. DAC3 calibration limits are 110h and 300h.

END OF TEST
@80 *(carrier off and audio muted)*

SET TRANSMIT RF POWER
TEST SETUP

Before testing, provide the antenna (X301) with a 50Ω load capable of dissipating 5W (average power). Use 6.0 VDC at VCC_6V input on system connector.

Enter the following test commands:
@6502 *(set VCTCXO control voltage)*

@3C000334 *(tune to MID-CHANNEL CELLULAR BAND, CHAN 334)*
@81 *(turn on carrier output)*

For power levels 2 through 10, repeat the following setup and adjust the power level to comply with the Calibration Goal Mid-Channel column of the table in test results below:

@840x *(x is power level to be set, 2 = PL2, 3 = PL3, … A = PL10)*
@3900yy *(yy is hex setting corresponding to power level as follows:)*
Each hex setting is approx. 0.15dB.
@222D *(store power level value)*

For Power Levels 2 - 10 with Low and High Channel, verify that output power meets Low and High Channel Power Limits column of the table in test results below. NOTE: Before changing channels the carrier is to be turned off using the @82 command. After tuning to the desired channel using the @3C00xxxx command, turn on the carrier output using @81.

TEST RESULTS

Verify that the power levels for each of the setup settings is within the tolerance shown below. Use Calibration Goal Mid-Channel for calibration of levels 2 through 10.

POWER LEVEL	POWER OUTPUT	Calibration Goal Mid-Channel	Low and High Channel Power Limits
2	+25.5 dBm	±0.25dB	+1.0dB/-1.5dB
3	+22.5 dBm	±0.5dB	+2.0dB/-2.0dB
4	+19.0dBm	±0.5dB	±2.5dB
5	+15.0dBm	±0.5dB	±2.5dB
6	+11.0dBm	±0.5dB	±2.5dB
7	+ 7.0dBm	±0.5dB	±2.5dB
8	+ 3.0dBm	±0.5dB	±3.0dB
9	-1.0dBm	±0.5dB	±5.5dB
10	-5.0dBm	±2.0dB	±8.5dB

END OF TEST

@82 *(turn carrier off)*

SET BURST MODE TRANSMIT RF POWER

TEST SETUP

Before testing, provide the antenna (X301) with a 50Ω load capable of dissipating 5W (average power). Use 6.0 V at VCC_6V and 12.0 V at VCC_12V input on system connector. **NOTE: This test must be completed within 10 seconds or transmitter will be automatically shut off to prevent component overheating.

Enter the following test commands:

@6502 *(set VCTCXO control voltage)*
@3C000384 *(tune to MID-CHANNEL CELLULAR BAND, CHAN 384)*
@81 *(turn on carrier output)*
@D1 (switch transmitter path and enable burst mode transistor)

For each power level, 0 through 1, repeat the following setup and adjust the power level to comply with the Calibration Goal Mid-Channel column of the table in test results below:

@840x *(x is power level to be set, 0=pl 0, 1=pl 1)*
@3900yy *(yy is hex setting corresponding to power level as follows:)*

Each hex setting is approx. 0.15dB.

Record the VGA hex setting for power levels 0 - 1.

@222D *(store power level value)*
NOTE: you MUST store a value here, EVEN if it's the same as the initial guess.

For Power Levels 0 and 1 with Low and High Channel, verify that output power meets Low and High Channel Power Limits column of the table in test results below.
NOTE: Before changing channels the carrier is to be turned off using the @82 command. After tuning to the desired channel using the @3C00xxxx command, turn on the carrier output using @81.

TEST RESULTS
Verify that the power levels for each of the setup settings is within the tolerance shown below. Use Calibration Goal Mid-Channel for calibration of levels 0 and 1.

POWER LEVEL	POWER OUTPUT	Calibration Goal Mid-Channel	Low and High Channel Power Limits
0	+35.0dBm	±0.25dB	+1.0dB/-1.5dB
1	+31.0dBm	±0.25dB	+1.0dB/-1.5dB

END OF TEST
@D0 *(turn burst mode off)*
@82 *(turn carrier off)*

TRANSMIT DEVIATION

TEST SETUP
Set the modulation test equipment to have 50 Hz high-pass and 15kHz low-pass filtering, and use Average detector.

Inject a 1004 Hz signal into the system connector input (X1200-2 ATMS and X1200-4 AGND). Adjust the level of the input signal to 45mV RMS.

Enter the following test commands:
@6502 *(AFC off)*
@3Czzxxxx *(tune to MID-CHANNEL CELLULAR BAND)*
@8400 *(set attenuation to power level 0)*
@81 *(turn the carrier on)*
@88 *(un-mute the transmit path)*
@AC *(turn on the compander)*
@2C0001 *(disable auto-writes to PATTI addr. 40, 48, & 88)*
@2C482C *(Tx PGA = -2.5dB, Rx PGA = +2.5dB)*
@2C4005 *(audio to system connector)*
Record the average deviation level. Multiply by 1.414 to get peak deviation.

TEST RESULTS
The transmit peak deviation should be 2.9kHz±500Hz

NOTE: Use of an Average detector (not peak) and multiplying the number measured by 1.414 to get peak removes the incidental FM from the measurement.

END OF TEST
@80 *(reset transceiver*

DTMF DEVIATION AND HIGH FREQUENCY

TEST SETUP
Set modulation analyzer for 50Hz HP and 15kHz LP, and use Average detector.

Enter the following test commands:

@3Czzxxxx *(tune to MID-CHANNEL CELLULAR BAND)*
@88 *(open transmit audio)*
@8400 *(set attenuation to power level 0)*
@81 *(turn the carrier on)*
@AA0D *(turn on DTMF high tone)*

Turn off injected audio signal to TU.

TEST RESULTS
Verify that the mobile transmitted tone is 1143Hz ±1.5% and the Average deviation 3.64kHz ± 10%. This corresponds to a peak radian deviation of (3.64kHz ±10% X 1.414) / 1.143kHz = 4.5 ±10%.

NOTE: Use of an Average detector (not peak) and multiplying the number measured by 1.414 to get peak removes the incidental FM from the measurement.

END OF TEST
@AB *(turn DTMF off)*
@80 *(initialize transceiver)*

SAT DEVIATION

TEST SETUP
Set modulation analyzer for 50Hz HP and 15kHz LP *NOTE: Use of an Average detector (not peak) and multiplying the number measured by 1.414 to get peak removes the incidental FM from the measurement.* Apply an on-channel RF signal to the antenna connector at –50dBm, 6030.0Hz tone at ±2kHz deviation *(this is required for the phone to transpond the tone)*.

Enter the following test commands:

@3Czzxxxx *(tune to MID-CHANNEL CELLULAR BAND)*
@6502 *(lock the VCTCXO)*
@8400 *(power level 0)*
@81 *(turn on transmitter)*
@A002 *(turn SAT on (6030 Hz))*
@85 *(mute receive audio)*
@87 *(mute transmit audio)*

TEST RESULTS
Verify that the mobile transmitted frequency is 6030Hz ±1Hz and the Average frequency deviation is:
1.414 KHz ±10%. This corresponds to a peak deviation of (1.414kHz ±10%) X 1.414 = 2.0kHz ±10%.

NOTE: Use of an Average detector (not peak) and multiplying the number measured by 1.414 to get peak removes the incidental FM from the measurement.

END OF TEST
@80 *(initialize transceiver)*

DATA (SIGNALING TONE) DEVIATION

TEST SETUP
Set modulation analyzer for 50Hz HP and 15kHz LP, and use Average detector.

Enter the following test command:

@3Czzxxxx	*(tune to MID-CHANNEL CELLULAR BAND)*
@6502	*(lock the VCTCXO)*
@8400	*(set attenuation to power level 0)*
@81	*(turn the carrier on)*
@8F	*(turn on 10kHz data tone)*

TEST RESULTS
Verify that the Average transmit deviation level is 5.66kHz ±10%. This corresponds to a peak deviation of (5.66kHz ±10%) X 1.414 = 8.0kHz ±10%.

NOTE: Use of an Average detector (not peak) and multiplying the number measured by 1.414 to get peak removes the incidental FM from the measurement.

END OF TEST
@80 *(initialize transceiver)*

RECEIVER ALIGNMENT

The receiver requires no alignment.

DESCRIPTION

Para. 2.1033 (c) (4 – 8)

This transmitter is only for use in the Domestic Public Cellular Radio telephone Communication service, Subpart H of Part 22. When operating in the 800 MHz range, AMPS and DAMPS technology will be employed. The frequencies are generated using a phase locked loop frequency synthesizer; the transmit audio contains a 2:1 ratio compandor, 6db/Octave pre-emphasis, ±12 kHz deviation limiting and a post limiter filter per para. 22.915 (d)(1). This cellular transceiver OEM module is being prepared for quantity production.

(4) Type of Emissions: AMPS 40K0FID, 40K0F8W
DAMPS 30K0DXW

(5) Frequency Range: 824-849 MHz

(6) Range of Operating Power: This transmitter is designed for cellular mobile telephone operation. The transmitter is adjusted to achieve 3 watts in CLASS 1 mode, and 0.355 watts in CLASS 4 mode, measured at the antenna connector. The transmitter output is controlled by a binary data message emitted by the base station. The power level can be controlled in eight levels in CLASS 1 mode, eleven levels in CLASS 4 mode, as defined in EIA/TIA IS-137A. Each power level will be maintained to +2, -4 dB (with additional tolerances at power levels 8,9, and 10 per EIA/TIA IS-137A) over a temperature range of -40 to +70 °C and a supply voltage, measured at the radio, between 5.2 to 6.8 VDC and 10.9 to 16.3 VDC.

(7) Maximum Power Rating: An antenna system with 2.5 dBd antenna gain and 1.5 dB cable loss, resulting in an antenna system gain of 1.0 dB is utilized in the assessment of output power and maximum power rating. The maximum power rating for CLASS 1 and CLASS 4 operation under environmental and supply voltage variations, measured at the antenna connector, is equal to 3 watts and 0.5 watts, respectively, plus the power level tolerance of +2, -4 dB. Therefore the maximum output power measured at the antenna connector is 5 watts and 0.8 watts, respectively, per EIA/TIA IS-137A less the 1 dB antenna system gain. The maximum effective radiated power, which includes the 1 dB antenna system gain, is 6.3 watts and 1 watt, respectively, for CLASS 1 and CLASS 4 operation.

(8) DC Voltage and Current: The DC voltage and total input current of the entire final power amplifier module is as follows:

CLASS	PL	Po	6.0 VDC Current	13.6 VDC Current
1	0	3W	400 mA	800 mA
1	7	.005W	100 mA	0 mA
4	0/2	.355W	400 mA	0 mA
4	10	.0003W	100 mA	0 mA