

**vtech** Vtech Communications Ltd. (Telecom / R&D)**TITLE : AT&T1430 2.4G HADLc MK1 Theory of Operation****MODEL NO : AT&T1430****DOCUMENT NO : 64-5125-00-00**

<b>Channel #</b>	<b>Transmit Frequency (GHz)</b>	<b>Receive Frequency (MHz)</b>	<b>Rx LO Frequency (GHz)</b>
27	2.41790	9.16800	9.2750
28	2.41815	9.16950	9.2765
29	2.41840	9.17100	9.2780

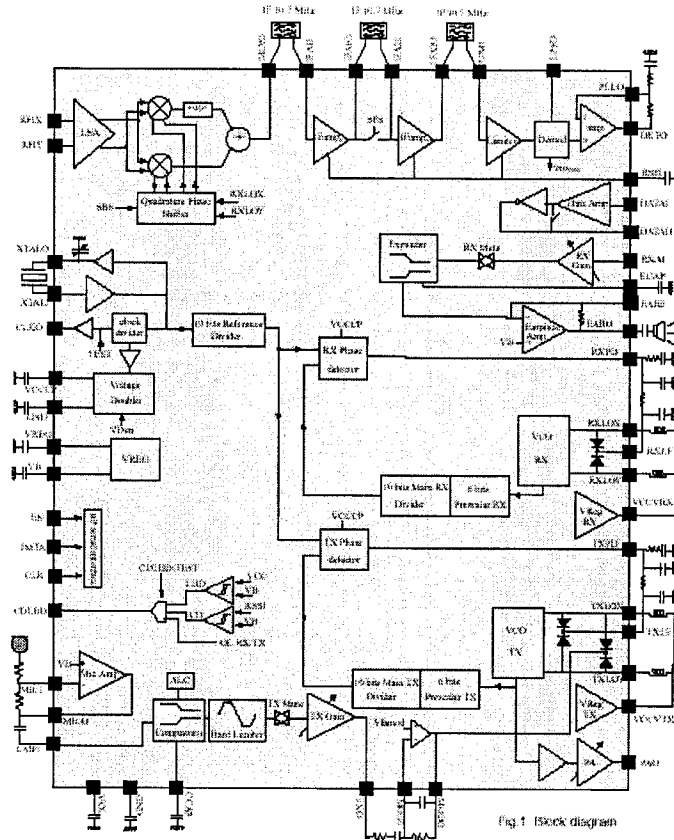
Table 3. Base Unit Frequencies

In case of 900MHz operation, both the handset and base RF modules follow the same block with only minor changes to incorporate the different transmit and receive frequencies. The block diagram of the RF chip is shown below:

**REV. NO. : 0****DATE: 06/22/01****Page: 21 of 27**

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TITLE : AT&T1430 2.4G HADLc MK1 Theory of Operation	
MODEL NO : AT&T1430	DOCUMENT NO : 64-5125-00-00



There are seven important input/output signals that are necessary for operation of the RF section (this does not include the separate supply lines for both Tx and Rx sections). A 8.0 MHz reference is present for use in the frequency synthesisers. The accuracy of this 8.0 MHz input will affect the accuracy of the transmit and receive frequencies. In order to ensure proper operation of the RF module, the 8.0 MHz reference signal must be at least 128mV<sub>p-p</sub> in amplitude. Also present is the three-line data (SPI) bus on which data is transferred to the synthesisers to set both the transmit and receive frequencies.

The modulation input allows analog voice and digital data (signalling) to be modulated directly onto the Tx carrier. There are three outputs from the RF module: Rx audio, Rx data and RSSI. The Rx data output is the demodulated signal which is subsequently filtered. The Rx audio output is the recovered analog voice that is sent to the audio circuits for additional processing.

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The RSSI output gives an indication of received signal strength. This is set to be high when the input signal is -90dBm or less at the antenna.

The RF module performs a single down-conversion of the incoming RF signal to 10.7 MHz where it is demodulated. The transmit section directly modulates the RF carrier.

In case of 2.4GHz operation, we will make use of the input port at 12.3MHz in the RF combo and implement the modulation. Then a new 2.4GHz down converter will be designed.

After studying the report from AT&T, the frequency beginning at 2.41GHz was chosen. Thanks to the attenuation of SAW filter (more than 30dB). The frequency range of 2.5GHz to 2.8GHz which the highest power of microwave oven is suppressed. This yields better selectivity at 2.4GHz.

The following sections explain the individual blocks in the RF module in detail.

## **3.1 Antenna Section**

### **3.1.1 Antenna**

The antenna is a device that allows effective conversion of energy from air to the RF module circuitry. The base has a  $\frac{1}{2}$  -wave antenna with approximately 0-dB gain relative to an isotropic radiator, while the handset has a  $\frac{1}{4}$  wave antenna with approximately -3 dB gain. The duplexer and filters that follow the antenna require a 50  $\Omega$  match to operate properly. The antenna is approximately matched to 50  $\Omega$  and requires a simple lump-component matching network to achieve this. If a network analyser is attached to the BFA connector after disconnecting the duplexer, the antenna match may be measured. In order to achieve a good 50  $\Omega$  match, one must be careful not to obstruct the antenna, as any object near the antenna will affect its impedance.

Since large frequency separation between RX and TX, a simple duplexer was used - two discrete band pass filters for TX and RX. In addition, there will be a quart wave transformer between the each path for additional rejection.

Since duplexer will be implemented, therefore a single antenna will be designed for both frequencies.

However, because of the space limitation and simple design, 2 antennas are placed in handset. The 2.4GHz antenna is placed in the case.

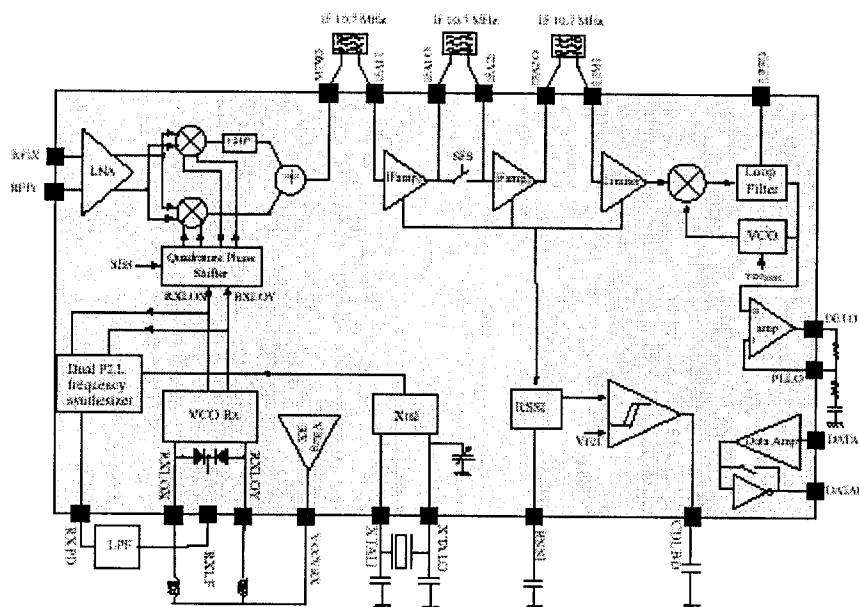
<b>REV. NO. : 0</b>	<b>DATE: 06/22/01</b>	<b>Page: 23 of 27</b>
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TITLE : AT&T1430 2.4G HADLc MK1 Theory of Operation	
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### 3.2 Receive Section

The block diagram of FM receiver is shown below:



#### 3.2.1 BALUN matching and differential low-noise amplifier

The purpose of the differential low-noise amplifier is to provide enough gain and the noise figure of the Rx section is fixed to a value as low as possible. It must provide a good 50 Ω match to both the SAW duplexer by the BALUN matching. This amplifier must also have good power handling capability due to the limited filtering which precedes it. The BALUN matching ensures the gain of this stage is not too wide-band, further improving its performance by allowing it to effectively reject signals that are far out of its passband.

#### 3.2.2 Rx VCO and PLL

The crystal local oscillator and reference divider provide the reference frequency for the Rx PLL. The programmed divider value for the reference divider is selected based on the crystal frequency. VCOs and varicaps are integrated. Resonance inductors is shared between bonding

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wires, leadframe of the package and external inductors. Here, 8MHz X' tal is select ed as a reference.

The Tx PLL is combined together with Rx PLL in the block "Dual PLL frequency synthesizer" . The synthesiser receives channel information from the audio module through the SPI bus. It also requires a stable clock reference which is supplied from the 8M Xtal.

A passive loop filter is employed connecting to the VCO to improve the phase noise and to allow relatively fast lock time.

In case of 2.4GHz operation, as UAA3517A has not been available yet, external devices including PLL(MB15E07SL-Fujitsu), VCO, LNA and mixer(BGD2022-Philips) have to be used in co-operated with UAA3515A. The VCO is oscillating at 1.2GHz and the second harmonic 2.4GHz is then selected as LO. The 1.2GHz is then fed back to the PLL for comparison. The IF frequency feeding in the UAA3515A is 12.3MHz instead of 10.7MHz.

### **3.2.3 Rx Mixer, IF Filter & IF Amplifier**

The function of the mixer is to combine the incoming signal with a LO signal in order to convert the desired signal to the 12.3/10.7 MHz intermediate frequency (IF). The mixer output is coupled off of the combo chip to a 12.3/10.7 MHz ceramic IF filter before it is injected into IF amplifier 1 integrated within the combo chip. The output of IF amplifier 1 is connected to input of IF amplifier 2 by shorting the SFS switch (software controlled). The output of IF amplifier 2 is connected to another 12.3/10.7MHz IF filter.

The 3dB bandwidth of 12.3MHz IF filter is 110kHz/230kHz. By using this in series configuration, the resultant 3 dB bandwidth is 80kHz (as shown in figure 3.1). It can provide the +/-150kHz adjacent channel rejection >30dB.

The limiter provide a 6dB gain for the 10.7MHz Rx signal path. It is used to limit the signal amplitude entering the demodulator.

<b>REV. NO. : 0</b>	<b>DATE: 06/22/01</b>	<b>Page: 25 of 27</b>
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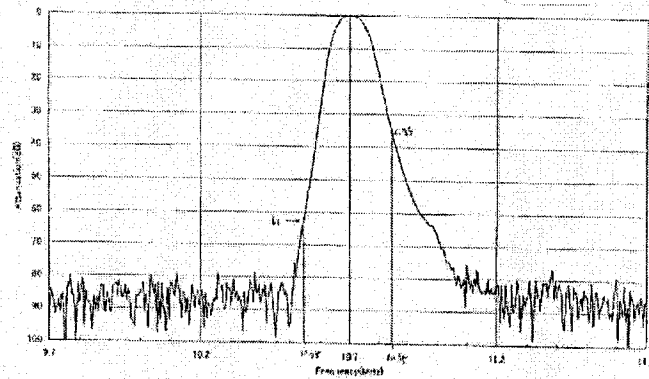


Figure 3.1 : Frequency response of 2x 10.7MHz IF filters (in series)

### 3.2.4 FM-PLL Demodulator

The FM-PLL demodulator is a wideband FM demodulator with programmable ability allowing to calibrate the center frequency of the VCO within the FM PLL to align the frequency as close as the nominal value (i.e.: 10.7MHz/12.3MHz(2.4G)). The quadrature voltage may be observed at the ATE test point connector through DETO pin. This voltage should nominally be 1.2 V for both the base and handset when a signal is centre tuned.

The recovered audio signal from the demodulator has a peak-to-peak amplitude of approximately 0.43 V (for 25 kHz peak-to-peak modulation). One path from the recovered audio port is filtered through a low-pass data filter and passed back into the baseband module.

### 3.2.5 Data Comparator & Data Phase Shifter

The data comparator is an inverting hysteresis comparator. The open collector output is current limited to control the output signal slew rate. An external bandpass filter is connected between DETO and DATAI (AC coupled). An external capacitor can be added to further reduce the slew rate.

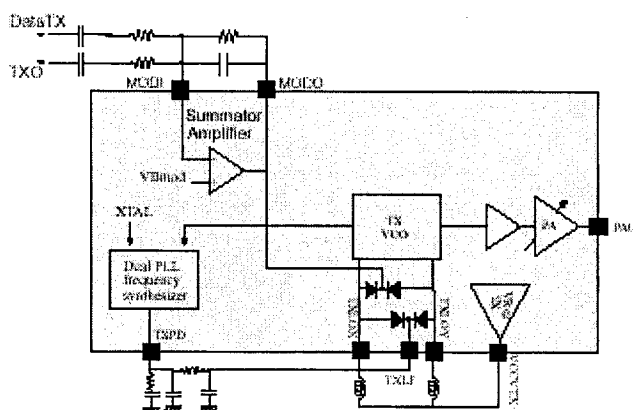
The data phase shifter allows 180 degree phase change of the received data for programming convenience.

### 3.2.6 RSSI Comparator

The UAA3515A provides an RSSI detect (i.e.: CDLBD pin) that is proportional to the input signal level, sending to the MCU in the baseband section.

### 3.3 Transmit Section

The block diagram of transmit section is shown below:



#### 3.3.1 Tx Amplifiers

A programmable power amplifier is used to provide the necessary gain for the transmit section. It amplifies the signal from the Tx VCO to apply the correct output power into the antenna (-3 dBm for both handset and base).

There is a Chebyshev low-pass filter between duplexer Tx\_in port and PAO pin. The cutoff frequency of the filter = 915MHz, 3 poles and ripple <.1dB. The source and load impedance = 50 ohms. It is used to reduce the 900 MHz harmonics power level.

In case of 2.4GHz operation, the internal modulation of UAA3515A is used and it will be oscillated at around 800MHz or 1.2GHz. Then an extra multiplier (x2) and a 2.4GHz power amplifier are used.

Since frequency multiplier will employ in the design. Filter is needed to suppress the fundamental frequency. (800MHz or 1.2GHz)



File : AT&T1430_IPS_1	Date : 06/22/01	TITLE : Internal Product Specification
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**8.7.2 Handset Frequencies**

Channel #	Transmit Frequency (GHz)	Receive Frequency (MHz)	Rx LO Frequency (GHz)
0	912.75	2.41115	2.39885
1	912.90	2.41140	2.39910
2	913.05	2.41165	2.39935
3	913.20	2.41190	2.39960
4	913.35	2.41215	2.39985
5	913.50	2.41240	2.40010
6	913.65	2.41265	2.40035
7	913.80	2.41290	2.40060
8	913.95	2.41315	2.40085
9	914.10	2.41340	2.40110
10	914.25	2.41365	2.40135
11	914.40	2.41390	2.40160
12	914.55	2.41415	2.40185
13	914.70	2.41440	2.40210
14	914.85	2.41465	2.40235
15	915.00	2.41490	2.40260
16	915.15	2.41515	2.40285
17	915.30	2.41540	2.40310
18	915.45	2.41565	2.40335
19	915.60	2.41590	2.40360
20	915.75	2.41615	2.40385
21	915.90	2.41640	2.40410
22	916.05	2.41665	2.40435
23	916.20	2.41690	2.40460
24	916.35	2.41715	2.40485
25	916.50	2.41740	2.40510
26	916.65	2.41765	2.40535
27	916.80	2.41790	2.40560
28	916.95	2.41815	2.40585
29	917.10	2.41840	2.40610