2.4.2.5 LED Indicators

The handset features a single LED indicator that is used to show that the handset is in-use or low battery.

3 *RF Module*

The basic function of the radio frequency (RF) circuits on both handset and base is to provide a full duplex wireless link between the handset and base units of the telephone. This is accomplished by setting up two simultaneous communications links between the handset and base RF modules. The RF receiver and transmitter circuitries essentially provide a link between the microphone and speaker in the handset to the telephone line in the base. In this way, the phone performs exactly as a corded phone, except without the cord.

The frequency at which the handset (operating at 3.6V) transmits to the base is centred around 925.65 MHz, and the frequency at which the base (operating at 5V) transmits to the handset is centred around 903.5 MHz. The SPP-A941 ADLI(MK4)uses a wideband FM scheme to directly modulate audio signals onto the RF carriers.

The following tables outline the frequencies and corresponding channel numbers used by the RF. The handset uses a high-side local oscillator (LO) while the base uses a low-side LO to down-convert the incoming signal.

Channel #	Transmit Frequency (MHz)	Receive Frequency (MHz)	Rx LO Frequency (MHz)
1	925.05	902.3	891.6
2	926.1	903.35	892.65
3	927.15	904.4	893.7
4	923.4	905.45	894.75
5	924.45	906.5	895.8
6	925.8	903.05	892.35
7	926.85	904.1	893.4
8	923.1	905.15	894.45
9	924.15	906.2	895.5
10	925.5	902.75	892.05
11	926.55	903.8	893.1
12	927.6	904.85	894.15
13	923.85	905.9	895.2
14	925.2	902.45	891.75
15	926.25	903.5	892.8
16	927.3	904.55	893.85
17	923.55	905.6	894.9
18	924.6	906.65	895.95

Channel #	Transmit Frequency (MHz)	Receive Frequency (MHz)	Rx LO Frequency (MHz)
19	925.95	903.2	892.5
20	927	904.25	893.55
21	923.25	905.3	894.6
22	924.3	906.35	895.65
23	925.65	902.9	892.2
24	926.7	903.95	893.25
25	927.75	905	894.3
26	924	906.05	895.35
27	925.35	902.6	891.9
28	926.4	903.65	892.95
29	927.45	904.7	894
30	923.7	905.75	895.05

Table 2. Handset Frequencies

Channel #	Transmit Frequency (MHz)	Receive Frequency (MHz)	Rx LO Frequency (MHz)
1	902.3	925.05	935.75
2	903.35	926.1	936.8
3	904.4	927.15	937.85
4	905.45	923.4	934.1
5	906.5	924.45	935.15
6	903.05	925.8	936.5
7	904.1	926.85	937.55
8	905.15	923.1	933.8
9	906.2	924.15	934.85
10	902.75	925.5	936.2

Channel #	Transmit Frequency (MHz)	Receive Frequency (MHz)	Rx LO Frequency (MHz)
11	903.8	926.55	937.25
12	904.85	927.6	938.3
13	905.9	923.85	934.55
14	902.45	925.2	935.9
15	903.5	926.25	936.95
16	904.55	927.3	938
17	905.6	923.55	934.25
18	906.65	924.6	935.3
19	903.2	925.95	936.65
20	904.25	927	937.7
21	905.3	923.25	933.95
22	906.35	924.3	935
23	902.9	925.65	936.35
24	903.95	926.7	937.4
25	905	927.75	938.45
26	906.05	924	934.7
27	902.6	925.35	936.05
28	903.65	926.4	937.1
29	904.7	927.45	938.15
30	905.75	923.7	934.4

Table 3. Base Unit Frequencies

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:

There are seven important input/output signals that are necessary for operation of the RF section (this

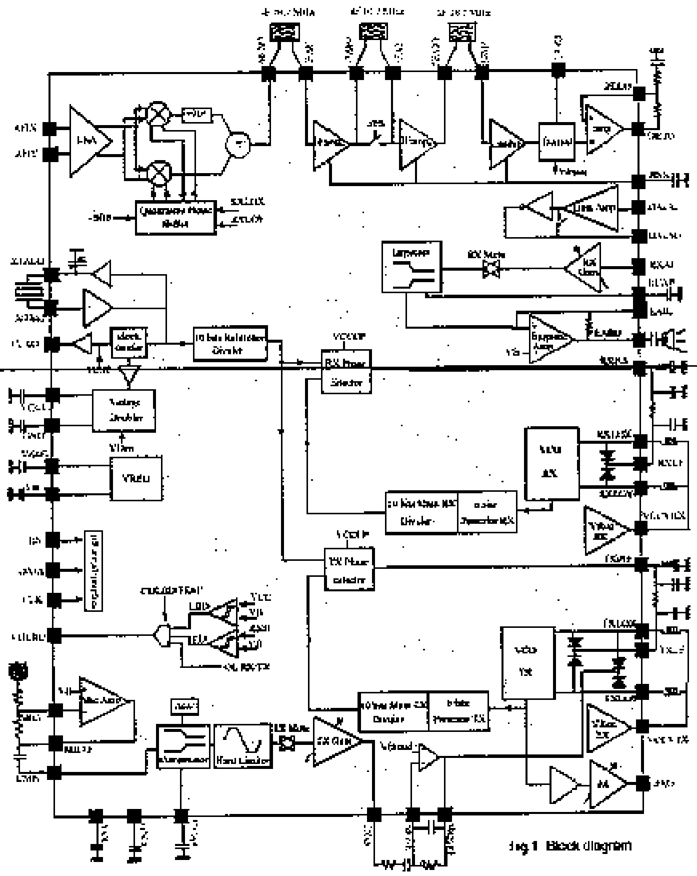


fig 1 Block diagram

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$_{p-p}$ 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. 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.

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 ½-wave antenna with approximately 0-dB gain relative to an isotropic radiator, while the handset has a ¼ wave antenna with approximately –3 dB gain. The duplexer and filters that follow the antenna require a 50 Ω match to operate properly. The antenna is approximately matched to 50 Ω 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 Ω match, one must be careful not to obstruct the antenna, as any object near the antenna will affect its impedance.

3.1.2 SAW Duplexer

The duplexer itself is simply composed of two microstrip lines and discrete capacitors that shift each filter's out-of-band match to high impedance. To ensure that the duplexer is operating correctly, the match looking into the filters from the BFA connector may be measured. To do this, it is necessary to remove the 0 Ω resistor that connects the antenna to the duplexer. A return loss of approximately 15 dB should be measured for both the Tx and Rx bands.

The duplexer provide two functions: The first one is to effectively pass the correct frequencies to the Rx and Tx sections of the RF module. It is important that these it has a low insertion loss in order to ensure a low front-end noise figure. It is also designed to provide > 30 dB rejection for the opposite band. This means that the transmit carrier will be attenuated by at least 30 dB before entering the receive section of the phone. A plot of H/S duplexer (Tx -> ANT) is shown below:

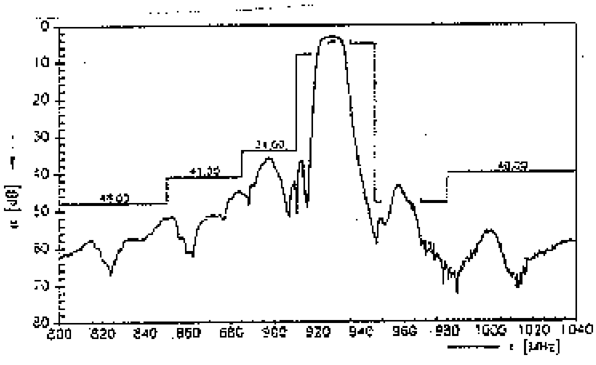


Figure 2.1 : Frequency response of H/S duplexer (Tx -> ANT)

In figure 2.1 the insertion loss is less than 4dB at 902 - 905 MHz while the 925 - 928 MHz band has >30dB attenuation. This duplexer is used for the Rx filtering and Tx filtering in the handset. In addition, the frequency response of H/S duplexer (ANT -> Rx) is shown below:

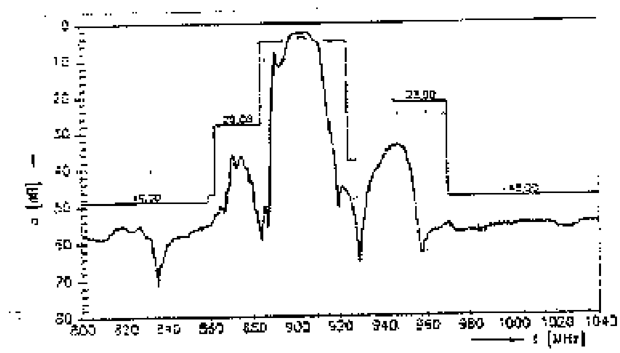
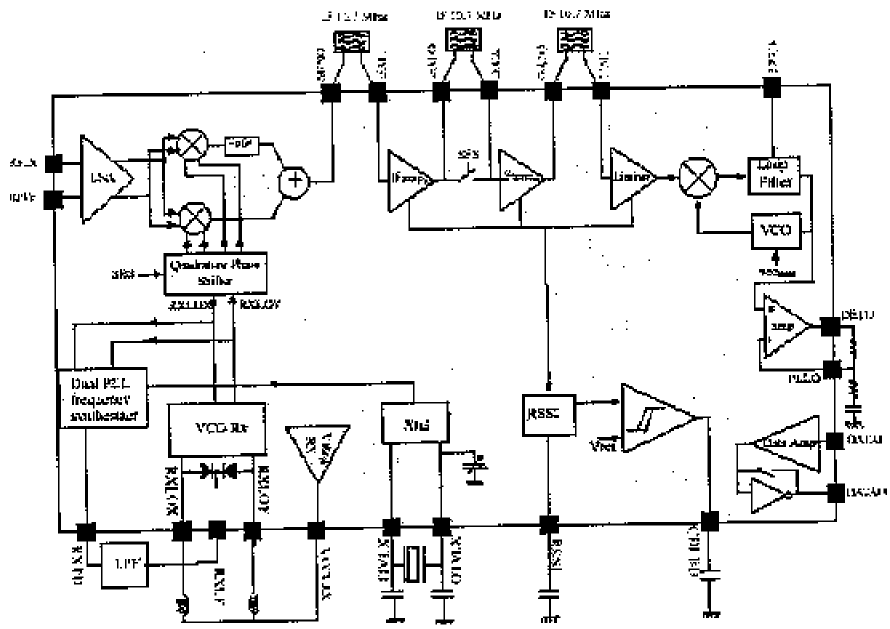


Figure 2.2: Frequency response of H/S duplexer (ANT -> Rx)

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 wires, leadframe of the package and external inductors. For MK4, 8MHz X'tal is selected 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.

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 10.7 MHz intermediate frequency (IF). The mixer output is coupled off of the combo chip to a 10.7 MHz ceramic IF filter before it is injected into IF ampilifer 1 integrated within the combo chip. The output of IF ampilifer 1 is connected to input of IF ampilifer 2 by shorting the SFS switch (software controlled). The second 10.7MHz IF filter is not used in this design. The output of IF amplifier 2 is connected to another 10.7MHz IF filter.

The 3dB bandwidth of 10.7MHz IF filter is 110kHz. 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.

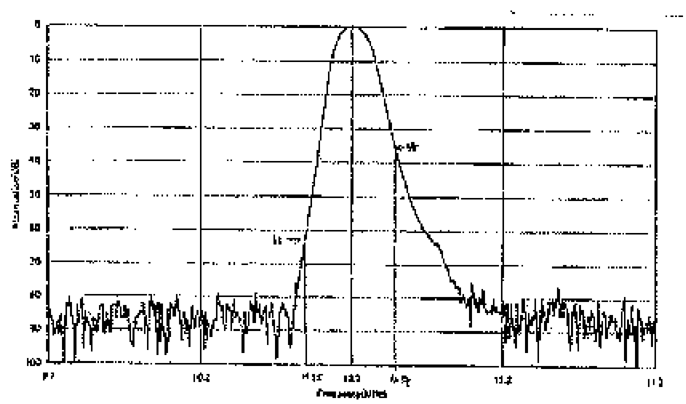


Figure 3.1 : Frequency response of 2x 10.7MHz IF filters (in series)

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 norminal value (i.e.: 10.7MHz). The quadrature voltage may be observed at the ATE test point connector through DETO pin. This voltage should nominally be 1.4 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 UAA3515 provides an RSSI detect (i.e.: CDLBD pin) that is proportional to the input signal level, sending to the MCU in the baseband section.