CDPD WIRELESS MODEM

TPRM RF Transceiver Description

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1 Introduction

This document describes the RF transceiver design of the cost reduction revision for the Tellus CDPD Wireless Modem. Tellus CDPD Wireless Modem is designed to operate over AMPS frequency band using cellular digital packet data (CDPD) technology.

2 Overview

The RF transceiver is designed for the Tellus CDPD Wireless Modem based on the CDPD Specification Release 1.1. The RF transceiver interfaces between a mobile antenna and a baseband unit. The Receiver of RF transceiver converts RF signals from the air into baseband signals, and the Transmitter of RF transceiver converts the baseband I/Q signals out the ASIC unit into RF and transmits the RF signals into air through the mobile antenna. The RF transceiver will discuss in detail in following sections:

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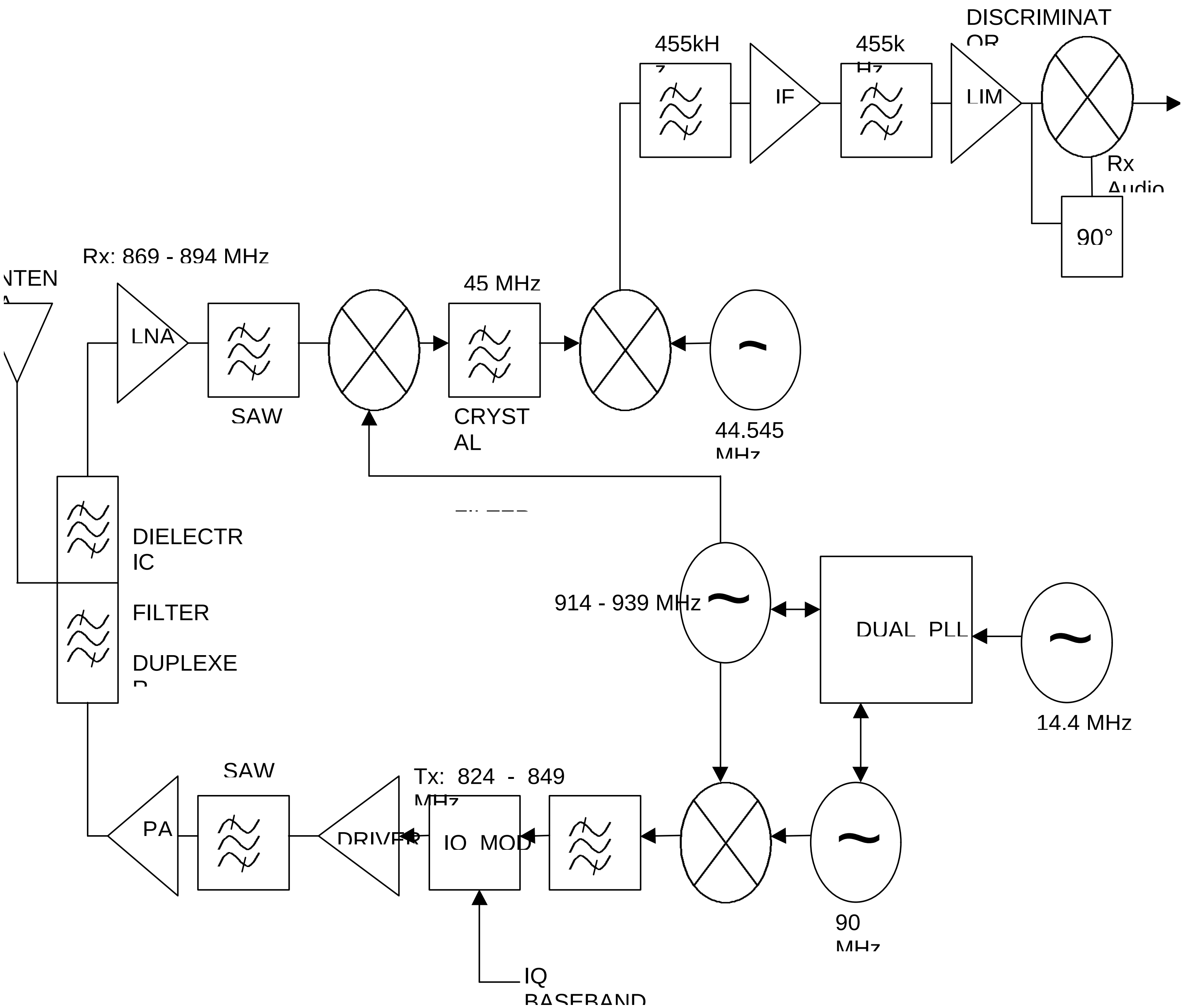
3 Frequency Plan

The RF transceiver operates over the AMPS frequency band. The reception covers the frequency range of 869-894 MHz, and the transmission covers the frequency range of 824-849 MHz. The RF channel bandwidth is 30 KHz. The current frequency plan has been adopted by Tellus Design Engineer, a double conversion VCO frequency range of 914-938 MHz for the main LO, a 90 MHz offset IF VCO for transmitter, a 44.454 MHz for the second Receiver LO, and 14.4 MHz TXCO for reference. After the first Receiver Mixer, a 45 MHz IF signal generated, and a 455 KHz signal generated after the second Receiver Mixer.

4 Block Diagram



5 Duplexer

For the operation of the full duplexer, the duplexer is connected to one antenna and functions to distinguish a received signal from the transmitted signal.

It composed of an RX band pass filter and an RX band rejection filter. The RX band rejection filter removes harmonic signals in the transmitted signal and noises in the received band. So it prevents unwanted radiation and depreciation of the characteristics of received sensitivity. The RX band pass filter prohibits so the transmitting signal comes into the received input that the characteristics of suppressing sensitivity are improved. And it suppresses the image signal of the first IF for satisfying the receiver characteristics. The duplexer is designed that have flat characteristics and small insertion loss for satisfying the same electrical characteristics in the transmitting and the receiving band.

The characteristics of the transmitting band are as follows. The insertion loss is max 2.4 dB, the flatness is max 1.6 dB, and has min 36dB suppressing characteristic within the receiving band. The characteristics of receiving band are as follows. The insertion loss is max 4.0dB, the flatness is max 1.3dB, the suppressing characteristic of the transmitting band is min 45dB, and has a min 65dB suppressing characteristic in the IF band.

6 Receiver Description

The receiver consists a Low Noise Amplifier (LNA), RF SAW filter, down conversion mixers, IF crystal filter, IF amplifier, FMIF circuit and data slicer.

The receiver circuit is double conversion super-heterodyne. The first IF is 45 MHz, and the second IF is 455 KHz. The received signal from the antenna goes to the LNA (Low Noise Amplifier) through duplexer. The LNA boosts the weakly received signal and applied it to the first mixer. The first mixer mixes the applied signal and the first local oscillator signal (914~938 MHz) provided from the frequency synthesizer module (PLL and VCO), and generates the first IF signal (45 MHz). The first IF signals then mixes with the crystal oscillator (44.545 MHz) to generate the second IF signal (455KHz). The second mixer is built in the FMIF IC. The FMIF IC then demodulated the second IF signal to baseband signal, this signal goes through the audio filter and the data slicer to generate the digital signal for baseband ASIC.

6.1 LNA

The LNA amplifier features low noise and high gain with proper LC input and output matching networks. It amplifies the signal received from the antenna through the duplexer. The LNA is built in with first mixer.

The typical gain of the LNA is about 13dB, and the noise figure is 1.8dB.

6.2 RF Filter

The amplified RF signal then pass through a RF band pass filter (BPF). This filter suppressed the unwanted signals and noises in the receiving band.

The insertion loss of the BPF is typically 4dB max, the flatness is max 2.0dB, the suppressing characteristic of the transmitting band is typically 30dB, and out of operating band is more than 35dB. The output and input impedance of the BPF is typically 50 Ohms.

6.3 The First Mixer

The first mixer is an active double balance mixer performs the conversion of the RF signal (869-894 MHz) from the RF SAW filter output with the local frequency synthesizer signal (914-939 MHz) to produce the first IF signal at 45 MHz. Also, produced other mixed elements (nFlo±mFrx) of two input signals caused by the nonlinear characteristics of mixer.

The conversion gain of mixer is about 6 dB.

6.4 IF Crystal Filter

The function of the IF crystal filter is filtering the unwanted mixed elements produced by mixer. Also, to improve sensitivity by decreasing sideband noises in the IF and suppresses the image signal of the second IF.

The IF crystal filter is 2 poles design with 3 dB BW at ±15 KHz and 15 dB at ±60KHz. The insertion loss of this filter is 2dB.

6.5 IF Amplifier

IF amplifier is a single stage with 10 dB gain at 45 MHz.

6.6 FMIF IC

The FMIF IC contains a second mixer, the second IF filter, the second IF amplifier, the limiter, and the FM detector.

The second mixer performed the conversion of the first IF signal (45MHz) with the crystal oscillator's third overtone frequency (44.545 MHz) to generate the second IF signal (455 KHz). The mixer has a conversion gain about 18dB.

The second IF signal generated at the second mixer is supplied to the second IF amplifier through two ceramic filters, one before and one after the second IF amplifier. The second IF amplifier has a gain of 25dB. The second IF signal goes into the limiter to reduce the FM noises. The limiter has a gain of 59dB. Two ceramic filters are used for reducing the sideband noises and select the desired mixing product between the second IF amplifier blocks. Each has about 6dB loss.

The second IF signal applied to FM demodulation circuit into the quadrature detector with 90^{o} phase shifted from the tank circuit with high Q. The demodulated signal generated at the detection circuit is supplied to the audio filter and the data slicer to produce the digital signal for the baseband ASIC.

7 Frequency Synthesizer

The frequency synthesizer consists of main LO (914-938 MHz), IF VCO (90 MHz), dual PLL, reference frequency TCXO 14.4MHz and loop filters. Its purpose is to generate the channel spacing and offset the transmitter IF VCO.

7.1 TCXO

The TCXO 14.4 MHz is a reference frequency source of the RF and IF VCO has the frequency stability of $\pm$2ppm over the temperature range –20^{o}C to +70^{o}C. The reference divider in PLL IC divides this 14.4 MHz by 480 and makes reference frequency 30KHz. This reference frequency is supplied to one of the input phase detector in the PLL IC.

7.2 Main LO

The main LO frequency (914-938 MHz) is 90 MHz higher than the desired transmit carrier frequency and 45 MHz higher than the desired receive frequency. It is a common base design with the resonant circuit in the collector. The resonant circuit consists of a coaxial resonator in parallel with a varactor and other LC components. The tuning sensitivity of the RF VCO is 10 MHz/V and control by the PLL. The main LO signal goes into input stage of the phase detector of the PLL through a RF prescaler and the main divider. This signal then compares with the reference frequency signal; the phase difference between two signals generated the error signal. This error signal is used to control the varactor through the loop filter to fine-tune the main LO frequency.

7.3 IF VCO

The IF VCO frequency (90MHz) is designed to offset the main LO frequency to provide desired carrier frequency for the transmission band. The IF VCO is a LC bipolar oscillator using a shunt C coupled resonator. The tuning sensitivity of this VCO is 4MHz/V. A buffer stage follows the IF VCO to boost the signal level and reduces load pulling. The IF VCO signal goes into input stage of the phase detector of the PLL through an IF prescaler and the divider. This signal then compares with the reference frequency signal; the phase difference between two signals generated the error signal. This error signal is used to control the varactor through the loop filter to fine-tune the IF VCO frequency.

7.4 Loop Filter

Loop filter is RCL low pass filter design with 2 or 3 poles. Its purposes to reduce the load pulling.

7.5 Dual PLL (Phase-Lock Loop)

Dual PLL designed for frequency synthesis. Each PLL consists a prescaler, phase detector, charge pump, and lock detector.

8 Transmitter Description

The transmitter consists of IQ modulator and upconverter, RF filters, driver amplifier, and power amplifier.

The transmitter takes the IQ signals provided by the baseband, modulated with desired carrier after the upconverter. The signal then amplified by the driver amplifier and passes through a SAW filter to select the desired signal, and suppressed the image signals and noises. The power amplifier takes this signal boosted up to the nominal level +8 dBm to +28 dBm. The output of the power amplifier routed to the TX filter of the duplexer and goes out to the antenna.

8.1 IQ Modulator and Upconverter

The Upconverter is a double balance mixer mixing the main LO signal (914-938MHz) and 90MHz offset VCO to produce the desired carrier. Then the IQ modulator takes the IQ signal from the ASIC combined with the desired carrier in quadrature modulator circuit to create the transmit signal.

8.2 RF Filters

RF filters are basically SAW filters design to filter the out of band signals and noises.

The insertion loss of the SAW is typically 4dB max, the flatness is max 2.0dB, and the insertion loss of the receiving band is typically 20dB and out of operating band is more than 35dB. The output and input impedance of the SAW is typically 50 Ohms.

8.3 Driver Amplifier

Driver amplifier is a single stage with 10dB gain at transmission band.

8.4 Power Amplifier

The power amplifier is dual supply voltage and high efficiency is selected for this design. It is three stages MESFET operates from 3V to 5V. The negative voltage generator is external and concerted positive supply to negative and feed into PA Vgate terminals. The power control for the transmitter is from the baseband and with other control line to toggle the PA on/off. The maximum output power is +31.1dBm.

9 Power Management

Power supplied to the transceiver by the external supply either from AC adaptor or by power supply. The low drop out regulator is used to stabilize the source. Three control lines together with dual load switch used to control the transceiver on/off. The receiver is always turn on during the operation, and the transmitter is toggling depend on the transmitting burst.

10 Shielding and Grounding

The transceiver is partition in number of blocks. Each block contains a circuit with ground cover around. The purpose of block partition is to have a good isolation between each circuit. A shielding block is covers each circuit to prevent the interference and EMI radiation. The transceiver design with solid ground around both sides of the board nears the edge. The purpose of the ground ring is serves as ESD protection, prevent EMI radiated back from the antenna, and making good contact between top and bottom cover.

11 Antenna

Antenna is omni-directional in horizontal plan with 2dBi gain, and VSWR max 2.0:1.

Antenna is an interface block between the air and the transceiver module. It transmits the modulated signal from the transmitter in bursts through air and receives data from the base-station through air. The matching network between the antenna and the duplexer is to match the antenna impedance to 50-ohms. Good matching network would bring the insertion loss lower and better proximity.