

## XX6SC2024 Circuit Description (Frequency band = 403-470MHz)

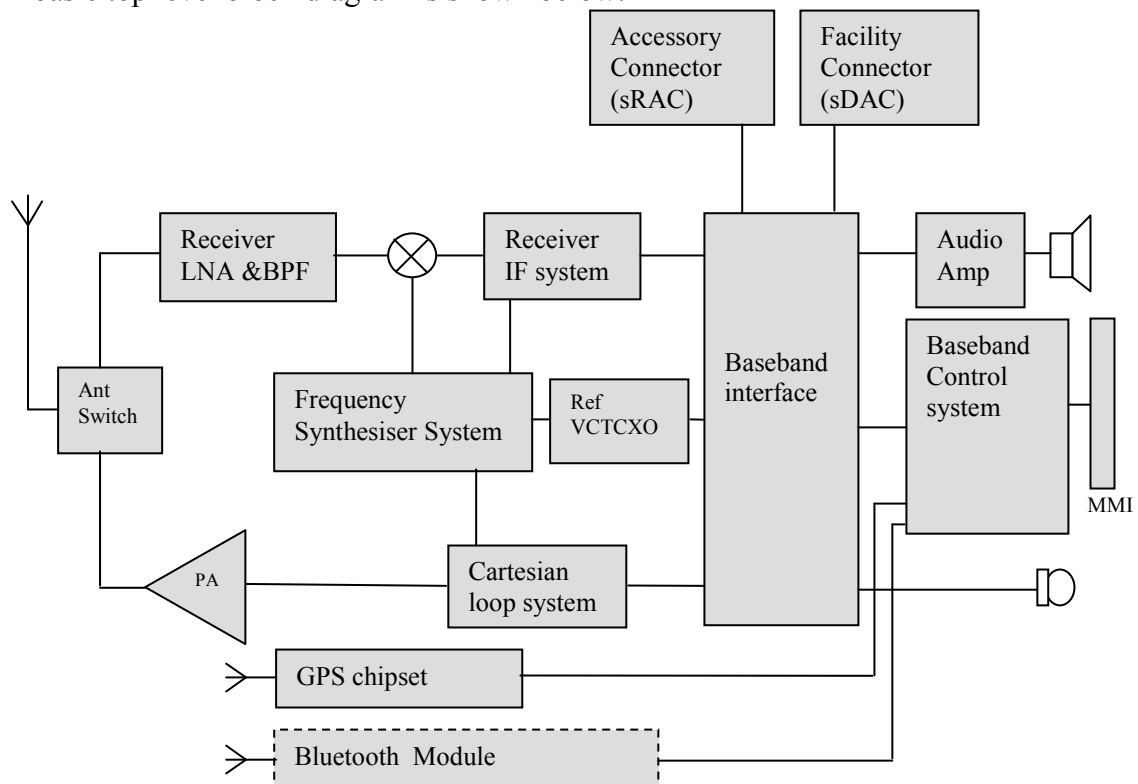
### 1. Introduction

The SC20xx series radio control system is built around a Texas Instruments baseband digital processor. This is supported by Sepura designed custom digital integrated circuits & CML designed chipset acting as analogue and digital-plus-encryption interfacing circuits, to provide both control and baseband digital signal processing functionality for the radio unit.

The radio hardware consists of a double conversion receiver and a Cartesian loop based transmitter. Local oscillator feeds (to both) are provided by a fractional-N frequency synthesiser system integrated in the CML chipset, locked to a high stability VCTCXO.

A high sensitivity GPS receiver with integral antenna is incorporated within the radio. An optional Bluetooth module may also be fitted within the radio.

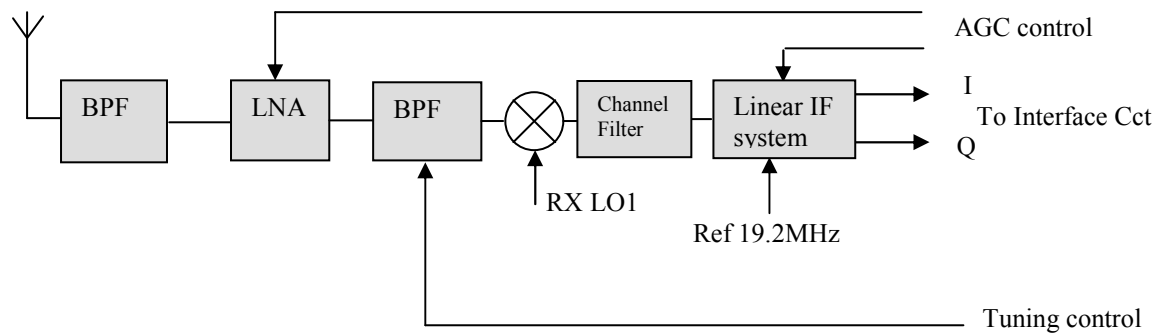
A basic top level block diagram is shown below:



### 2. Receiver Architecture

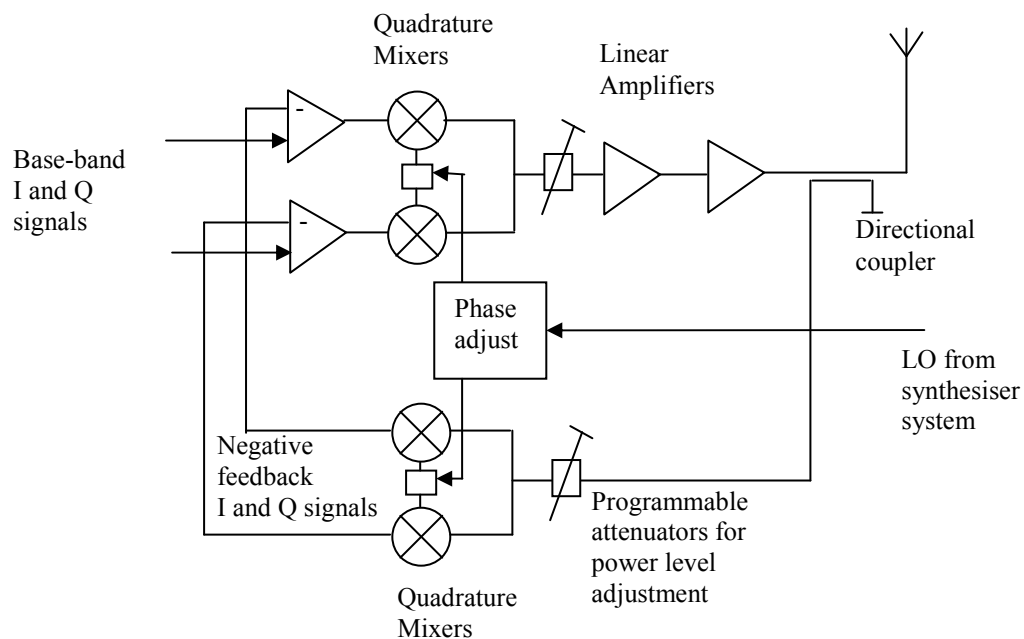
The receiver employs two discrete band pass filters to provide RF frequency selectivity. The LNA has switchable gain to provide coarse AGC adjustment. An active mixer is used to convert to the IF of circa 70MHz, followed by a crystal filter. The IF IC includes linear gain blocks, with integral AGC facilities and also provides

conversion from IF to base-band I and Q outputs. These are connected to the Base-band interface circuitry. AGC is controlled via the processor and base-band interface circuitry.

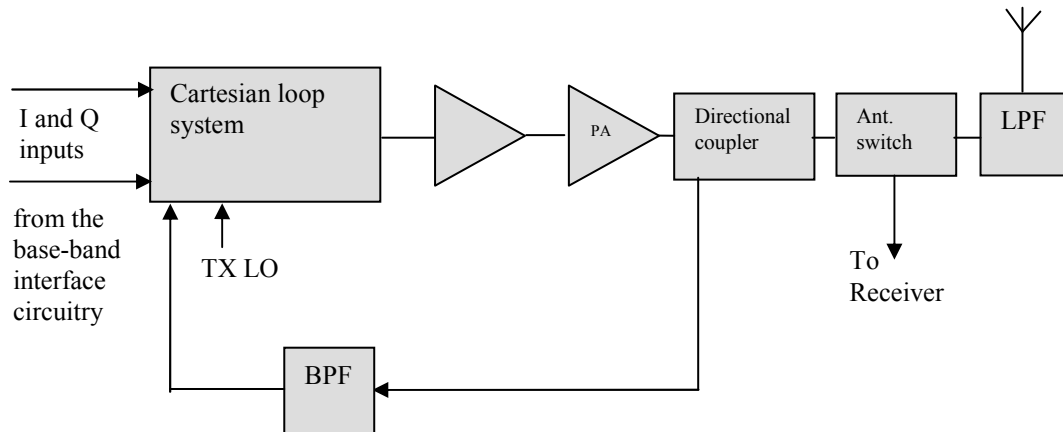


### 3. Transmitter Architecture

The transmitter uses a Cartesian feedback loop to achieve the power amplifier linearity necessary to meet the requirements of the TETRA specifications. The diagram below illustrates the Cartesian feedback loop concept in its simplest form: Negative feedback is applied in phase quadrature to dramatically enhance the overall transmitter linearity. The phase adjust control ensures that the feedback is always negative.



The implementation of the Cartesian loop, involves the use of an integrated Cartesian loop IC operating at the final carrier frequency. The injection signal from the frequency synthesiser is at 4 times the carrier frequency. This is illustrated in the diagram below.

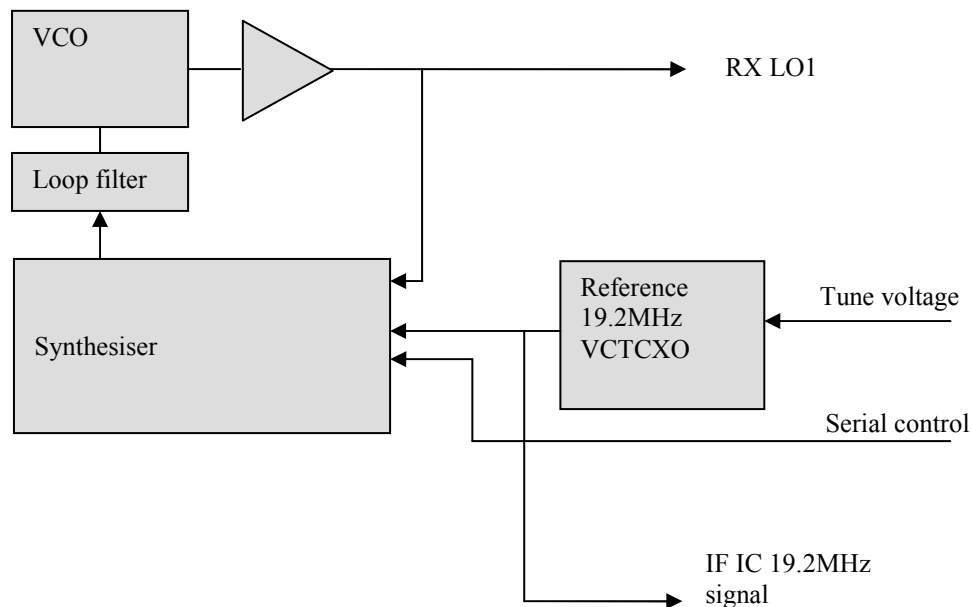


Quadrature I and Q base-band signals are applied to the integrated Cartesian loop system. The Cartesian loop IC provides a forward path signal which is then amplified in a discrete linear amplifier chain. The amplified signal is then routed through the directional coupler, antenna switch and a low pass harmonic filter, to the antenna. The output taken from the directional coupler is a reduced power level replica of the actual transmitted signal. This is attenuated, filtered and then applied as the feedback to the Cartesian loop IC. Injection signals to the Cartesian loop are provided via a divide by 2 circuit (within the Cartesian loop IC) by the frequency synthesiser system. Power level changes are achieved by changes in the programmable attenuators incorporated within the Cartesian loop IC, programmed via the control system.

#### **4. Frequency Synthesiser Architecture**

The frequency synthesiser system uses a pair of synthesiser functions one for the transmitter and one for the receiver. The synthesisers use fractional-N divider techniques to provide a short locking time in combination with low adjacent channel phase noise levels. A reference voltage controlled temperature compensated crystal oscillator (VCTCXO) operating at 19.2MHz acts as the master reference for both synthesisers and the radio control system. Inherent frequency stability of the VCTCXO is better than 1 part per million. During trunked network operation, this reference is frequency locked to the received base station frequency.

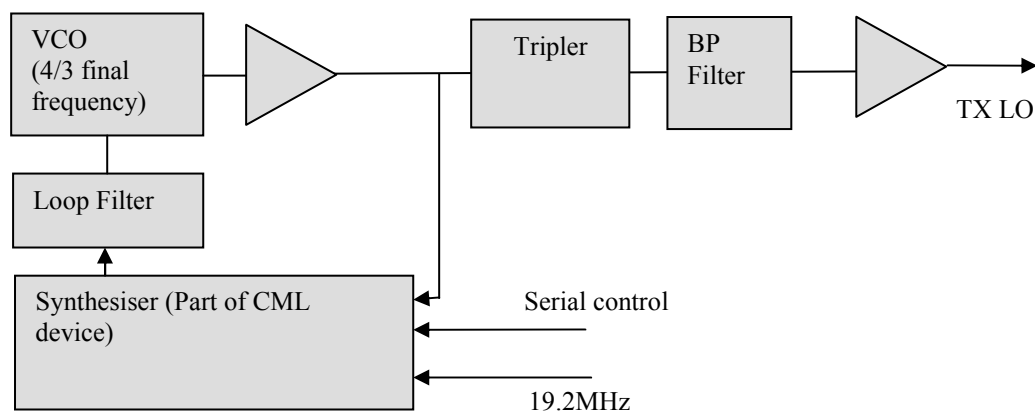
#### 4.1 Receiver Frequency Synthesiser



The local oscillator signal (RX LO)1 is at carrier frequency plus IF frequency A 19.2MHz reference signal (fed to a synthesiser on-board the receiver IF IC) enables conversion of the IF signal to base-band I and Q quadrature components.

#### 4.2 Transmitter Frequency Synthesiser

The transmitter VCO and synthesiser operate at 2/3 of final frequency. The VCO output is buffered then fed both to the synthesiser IC and to a frequency tripler circuit. The following filter passes the tripled frequency and suppresses unwanted harmonics of the VCO frequency. The local oscillator signal (TX LO) at 4 times carrier frequency is then amplified and injected into the transmitter Cartesian loop IC.



## **5. Baseband and Control hardware**

The core of the control and base-band circuitry is a highly integrated base-band digital processor. This is supported by analogue and digital base-band port custom integrated circuits.

Functionality in this section includes:

- CPU
- DSP
- Error correction and digital baseband filtering
- High performance A/D and D/A functions for both RF and audio interfaces
- Support for TEA encryption
- Support for Smart Card interface
- Support for Micro SD card interface
- Support for end-to-end encryption
- Real time clock
- Interfaces to other radio sub-systems

Memory is provided by 256MB of NAND Flash and 128MB of LPDDR RAM.

## **6. GPS**

The GPS incorporates RF and signal processing circuitry which is resident on the main PCB and in turn connected to the base band processor. The GPS antenna is an inverted F type made of metal and connects to the main radio PCB near the bottom surface of the radio case.

## **7. Optional Bluetooth Module**

The Bluetooth module consists of a highly integrated 2.4GHz Bluetooth compliant radio transceiver with audio, control data & high speed data interfaces.

## **8. MMI - Display and Controls**

The display is a TFT colour LCD with enhanced performance in difficult light conditions. The driver circuitry forms an integral part of the display module, which is connected to the main PCB via a flexible PCB.

The lower front facing keys use an elastomer key mat acting upon contact domes on a flexible PCB assembly which also contains backlighting LEDs and the duplex microphone.

The upper front facing keys, indicators LEDs, duplex earpiece and half duplex microphone are mounted on a separate PCB above the LCD.

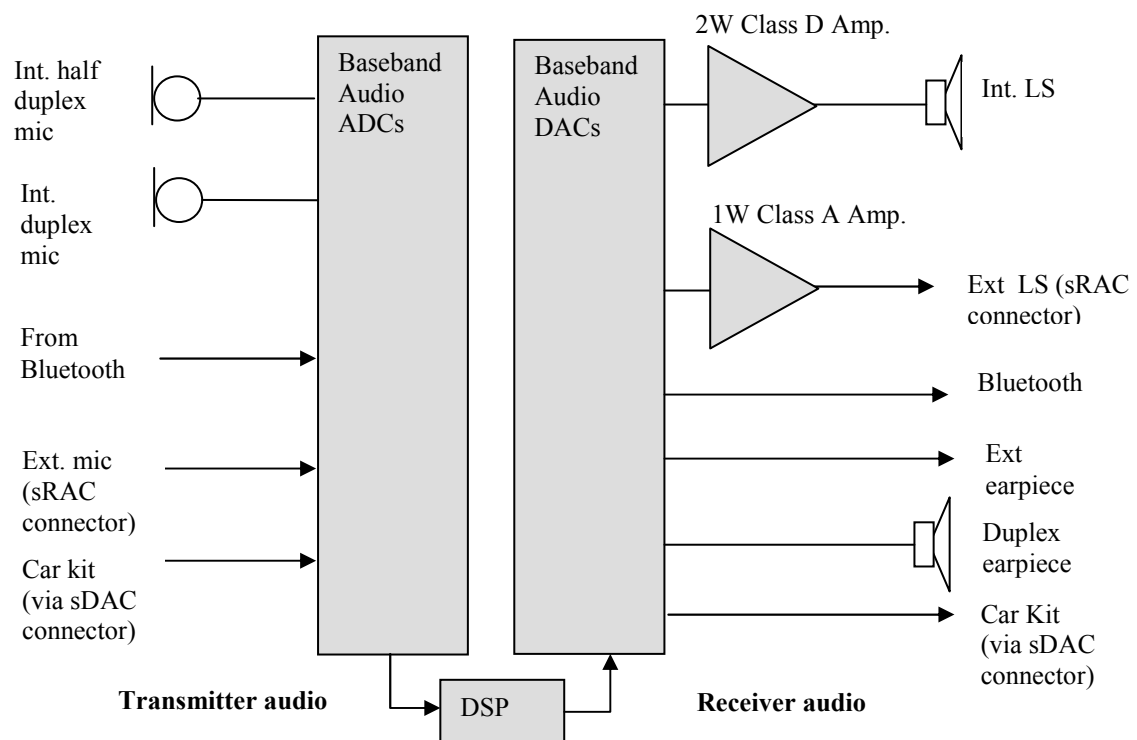
Discrete switches are used for the side and alarm keys and a shaft encoder is used for the rotary control on the top of the product.

## 9. Audio

The transmitter audio functionality is all included in a Texas instruments audio codec integrated circuit. The device provides multiple audio inputs with independently controllable audio paths and gains.

The receiver audio path is also supported by the same analogue custom integrated circuit. This device included the volume control attenuator. To provide the correct power levels to loudspeakers separate audio amplifiers are provided.

All digital processing of the audio is handled by a DSP. This provides additional gain management, noise reduction and alert tone generation and includes the TETRA speech codec.



## 10. Battery and Radio Power Supplies

The battery uses Lithium Polymer technology. Two cells are used to provide nominal 7.4V. The battery includes internal functions to provide accurate battery monitoring capabilities and cell protection circuits.

Circuitry is included within the radio to support battery charging which is managed by the baseband processor.

Within the radio itself a combination of switched mode and linear regulators is used to provide additional 5V, 3.3V, 1.8V & 1.2V supply lines to the remaining radio circuitry.