

Exhibit 4. Circuit Description-----47 CFR. 2.1033(C) 10

This section provides the description of circuits required by subpart 2.1033 of the Commissions' rules.

The following are included:

- 4.1) Carrier Frequency Generation and Stabilization
- 4.2) Digital Modulation Techniques
- 4.3) Modulation Limiting and Post Limiter Filter
- 4.4) Means for Output Power Limiting
- 4.5) Spurious and Harmonic Emissions Suppression

4.1. Carrier Frequency Generation and Stabilization

As shown in Figure 4-1 the synthesizer IC (U301) reference oscillator employs a crystal controlled Colpitts oscillator running at a frequency of 16.8MHz. The oscillator transistor, start-up circuit, and temperature compensation circuit are located in the IC (U301) while the oscillator feedback capacitors, crystal, and tuning varactor are external. This oscillator is temperature compensated to an accuracy of $\pm 2.5\text{PPM}$ from -20°C to 60°C .

The method of temperature compensation is to apply an inverse Bechmann voltage curve, which matches the crystal's Bechmann curve to a varactor that constantly shifts the oscillator back on frequency.

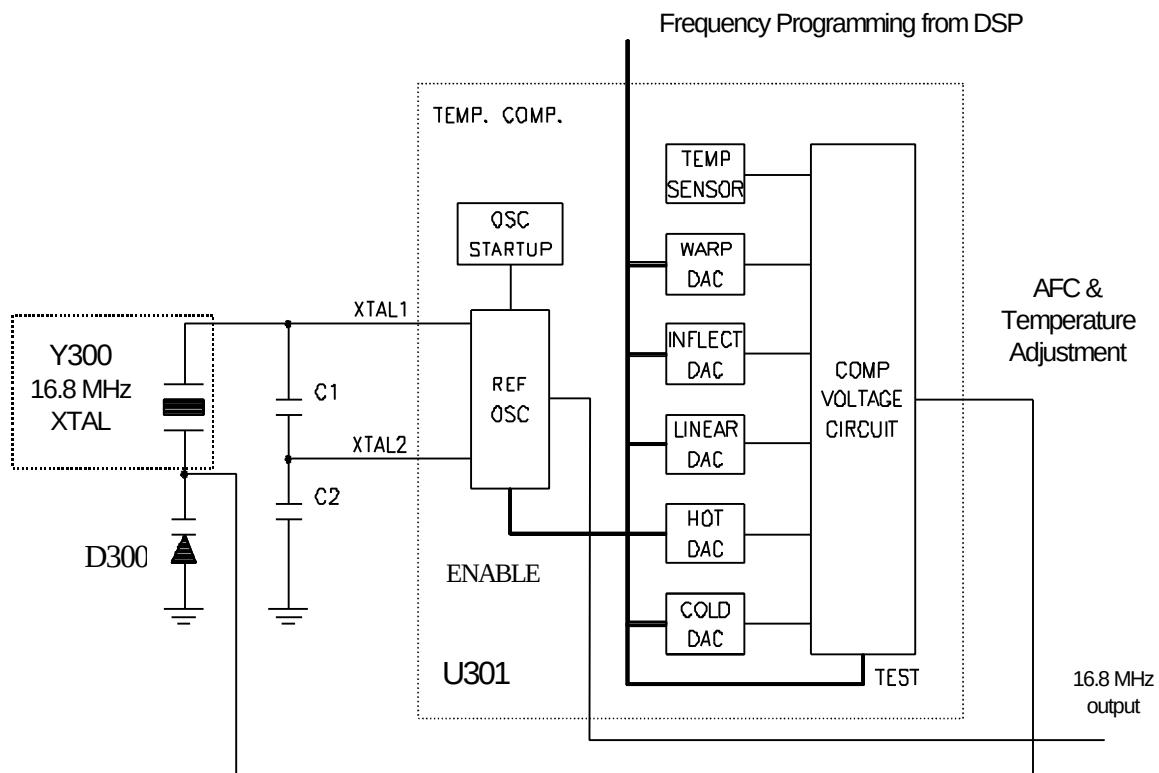


Figure 4-1: 16.8 MHz reference oscillator

The reference oscillator runs at 16.8 MHz. The signal from this reference oscillator is routed within the synthesizer IC (U301) which is used to control the stability of the main Voltage Controlled Oscillator (VCO) which oscillates at a frequency between 956.9 - 979.65 MHz (see figure 4-2). The synthesizer also buffers the 16.8 MHz signal and provides it to the U601, U602, U502, and U801 ICs (see figure 4-2 and 4-3). The PLL inside the U602 uses the 16.8MHz clock to be used as the reference for the TX offset. The frequency of the TX offset VCO (Q605) is 301.8 MHz which is divided by two in U502 and mixed with the main VCO to generate the transmit frequency. The frequency control for each VCO is accomplished by a PLL that compares the VCO frequency to the reference frequency thus locking each VCO to the reference oscillator.

The transmitter frequency is programmed to a single frequency between 806-825 MHz composed by subtracting half of the TX offset VCO (Q605) frequency (301.8 MHz) from the main VCO (Q306) frequency 956.9- 979.65 MHz. The subtraction is done by a mixer in the U502 followed by a band pass filter FL501 (see figure 4-3) which selects the transmitter frequency of 806 - 825 MHz from the other mixing products and rejects spurious signals.

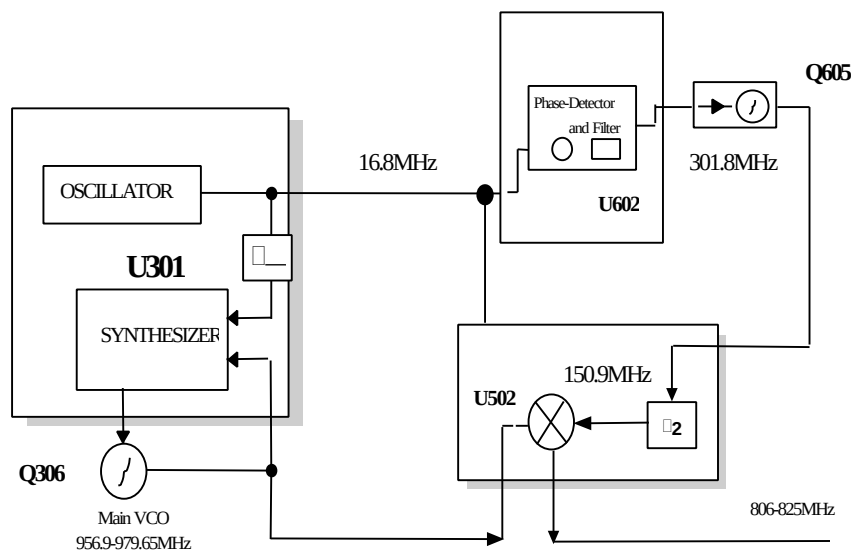


Figure 4-2 : Transmitter frequency generation subsystem

4.2. Digital Modulation Techniques

The subject radio makes use of 3 different modulation techniques termed Quad-16QAM, Quad-64QAM, and Quad-QPSK. In voice mode, the radio will function in Quad-16QAM mode only. In data mode, the radio will use any one of the three different modulation techniques (Quad-16QAM, Quad-64QAM, and Quad-QPSK) in a given time division multiplexed slot. The following describes each of the modulation techniques.

The modulation technique termed Quad-QPSK is a linear digital modulation of a multi-channel variant of a 4-state Quadrature Amplitude Modulation. Data bits to be transmitted are split into four parallel lower rate streams, each of which is QPSK modulated to its own sub carrier frequency at a rate of 4k symbols per second. The four resulting sub channel signals are then combined in frequency division multiplex fashion to produce the composite M-QPSK signal. This spectrally efficient linear modulation can achieve transmission at 32 kilobits per second in a 25 kHz channel. The transmitter is configured using TDMA time slotting so that up to 6 radio users can simultaneously share the 25 kHz channel.

The modulation technique termed Quad-16QAM is a linear digital modulation of a multi-channel variant of a 16-state Quadrature Amplitude Modulation. Data bits to be transmitted are split into four parallel lower rate streams, each of which is 16QAM modulated to its own sub carrier frequency at a rate of 4k symbols per second. The four resulting sub channel signals are then combined in frequency division multiplex fashion to produce the composite M-16QAM signal. This spectrally efficient linear modulation can achieve transmission at 64 kilobits per second in a 25 kHz channel. The transmitter is configured using TDMA time slotting so that up to 6 radio users can simultaneously share the 25 kHz channel.

The modulation technique termed Quad-64QAM is a linear digital modulation of a multi-channel variant of a 64-state Quadrature Amplitude Modulation. Data bits to be transmitted are split into four parallel lower rate streams, each of which is 64QAM modulated to its own sub carrier frequency at a rate of 4k symbols per second. The four resulting sub channel signals are then combined in frequency division multiplex fashion to produce the composite M-64QAM signal. This spectrally efficient linear modulation can achieve transmission at 96 kilobits per second in a 25 kHz channel. The transmitter is configured using TDMA time slotting so that up to 6 radio users can simultaneously share the 25 kHz channel.

4.3. Modulation Limiting and Post Limiter Filter

The transmitted data or audio is processed using three software algorithms in a Digital signal Processor (DSP), which automatically prevents modulation in excess of 100 percent. The software algorithms consist of a speech coder, a Quadruple-QPSK digital modulator, Quadruple-16QAM digital modulator, Quadruple-64QAM digital modulator, and a baseband filter as shown in the following Figure (4-3).

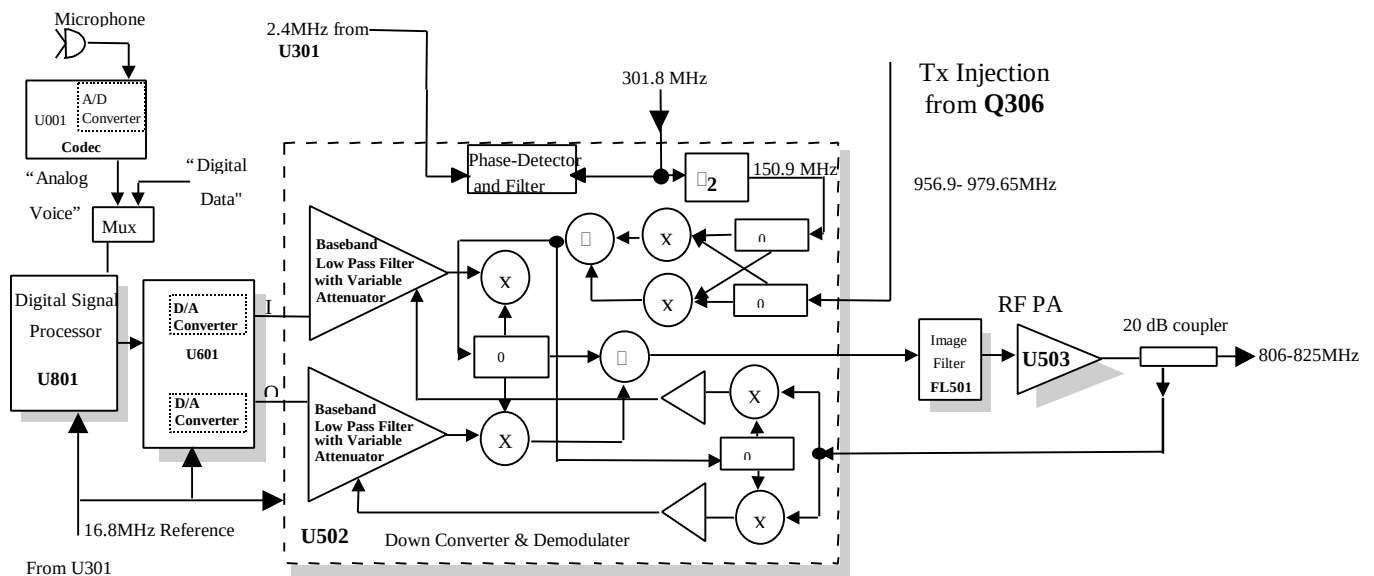


Figure 4-3: Transmitter modulation system

4.4. Means for Output Power Limiting

Transmitter internal power calibration is done setting the gain of the baseband attenuator that controls the level of baseband input into IC U502.

The output power is set by varying the level of baseband input into U502 which in effect changes the RF input to the PA U503. This procedure begins by setting the baseband attenuation to zero and configure the transmitter to transmit in full power and automatic level train mode. During automatic level training, U502 will set the lowest allowable baseband attenuation that results in a maximum power out of the radio without clipping the PA. This power is typically higher than the targeted power setting. To lower the output power, the level of baseband attenuation is increased until it is within the target window. This is accomplished by reading the level train result from U502 and use it as the starting point and iteratively increasing it until the output power is within the target window. Then the digital word that corresponds to that particular attenuator setting is then stored in the Flash Memory U802. If automatic level training resulted in a power lower

than the target power, the baseband attenuator will not be decreased since doing so will clip the RF PA U503 and increase potential adjacent channel power. This calibration is performed at five frequencies across the band and is maintained over various conditions as follows:

1. Five frequencies across the band. An interpolation algorithm is used to calculate the setting in-between the calibration frequencies.
2. Two temperature points: one for 3dB cutback (at 80°C) and the other total thermal shutdown (at 100°C). The temperature is monitored by the microprocessor via an on board thermistor located next to the RF PA's hottest section.

In operation, output power is also attenuated from the maximum rated level in response to digitally coded commands received from a companion base station which measures the quality of the transmitted signal.

4.5. Spurious and Harmonic Emissions Suppression

Refer to Figure 4-4 below for the following description. A SAW filter, FL501, is placed before the Power Amplifier U503 to ensure that a clean drive signal is delivered to the Power Amplifier input. The power amplifier output is isolated from mismatched loads in the antenna connector by coupler and an isolator. The coupler provides 20dB harmonic rejection, and the isolator ensures that the power amplifier will see a stable load for any load variations applied to the antenna connector.

The band pass SAW filter, coupler, and the isolator attenuate spurious and harmonic signals that are generated in the transmitter section. Proper shielding within the transceiver also attenuates radiated spurious emissions and harmonics.

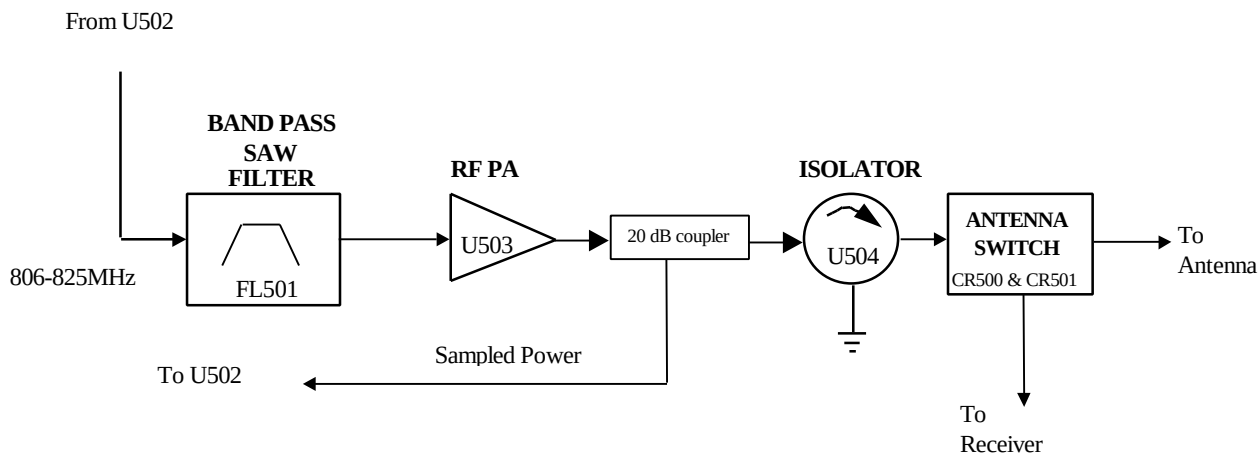


Figure 4-4: Transmitter chain