# 1. OPERATIONAL DESCRIPTION

## 1.1 GENERAL DESCRIPTION OF CIRCUITRY

The VHF-4100/E consists of 3 sub-assemblies; VHF RF Assembly, Digital/Power Supply Assembly, and Rear Interconnect Assembly.

The VHF-4100/E power amplifier linearly amplifies the transmitter synthesizer output to a 20 watt (minimum) carrier power level for AM voice or analog data operation. The power output in VDL Mode 2 is a minimum of 18 Watts. Voice, analog data, or digital data is impressed on the input RF from the synthesizer in a closed feedback loop vector (I-Q) modulator system, used as a variable RF attenuator and phase modulator. A synchronous detector sampling the RF power output provides amplitude and phase (I-Q) feedback information to the vector modulator to linearize the amplitude and phase characteristics of the power amplifier. A low pass filter at the output attenuates the transmitter harmonics further. The worst case harmonic found during testing was 76 dB below the carrier level.

The VHF-4100/E receiver utilizes a single conversion design. The receiver synthesizer injection is applied to the first mixer, generating a 28.900 MHz first IF frequency (high side injection) which is amplified and then detected by use of Digital Signal Processing technology. For voice operation, a noise quieting squelch and carrier squelch, both implemented in DSP, are provided. In data modes, no audio is presented to the operators.

For receive operation, the VHF-4100/E frequency synthesizer is a single loop, TXCO reference controlled design and provides the receive LO for any 25 kHz or 8.33 kHz channel selected in the 118.000 to 150.8 MHz frequency range.

A second, dedicated frequency synthesizer is used for transmit operation. It is a single loop, TXCO reference controlled design and provides the direct transmit frequency RF drive for any 25 kHz or 8.33 kHz channel selected in the 118.000 to 150.8 MHz frequency range to the vector modulator and RF power amplifier.

Both receive and transmit frequency synthesizers use a common 23.1 MHz +/- 5 PPM temperature compensated crystal oscillator (TCXO) as the reference. Both synthesizers use advanced DSP technology, sigma-delta modulated fractional-N synthesis, to improve spurious performance and reduce phase noise while providing small channel spacing.

## 1.2 CIRCUITRY FOR SUPPRESSION OF SPURIOUS RADIATION

The low-pass filter suppresses transmitter spurious radiator. This is located on the RF Assembly and shown on schematic 828-1436-002. An additional low pass filter, common to both transmit and receive functions is in the common antenna cable from the unit. This filter provides additional filtering for transmitter harmonics in the 1.5 GHz GPS band. Non-harmonic spurious radiation is reduced by the advanced design of the phase locked loop frequency synthesizers and careful circuit board design.

## 1.3 CIRCUITRY FOR LIMITING MODULATION

Modulation limiting is achieved in the audio compressor that is implemented in software on the Signal Processor. As the compressor characteristic curves in this report show, this compressor circuit operates as a linear amplifier until the input signal reaches such level that the software begins to reduce the gain by mathematically scaling the internal digitally processed signal. The large dynamic range above the compression knee minimizes the possibility of over-modulation. This guarantees that the RF output cannot go to zero, even during severe overdrive of the audio input to the compressor.

## 1.4 CIRCUITRY FOR LIMITING POWER

The carrier power output is controlled by adjusting the DC component of the audio signal applied to the modulator controller on the RF assembly. This DC level is a service adjustment, not accessible to the operator.

A software controlled reduction of peak power occurs during times of low power supply voltage (less than 22.0 VDC) to prevent distortion of the positive modulation peaks. This is also a service adjustment and not accessible to the operator.

Separate modulation adjustments are provided for 25 KHz channel and 8.33 KHz channel operation. The 25 KHz channel and 8.33 channel modulation levels are set in software by values written into non-volatile memory. This is a service adjustment and not accessible to the operator.

## 1.5 DIGITAL MODULATION TECHNIQUES

These are digital

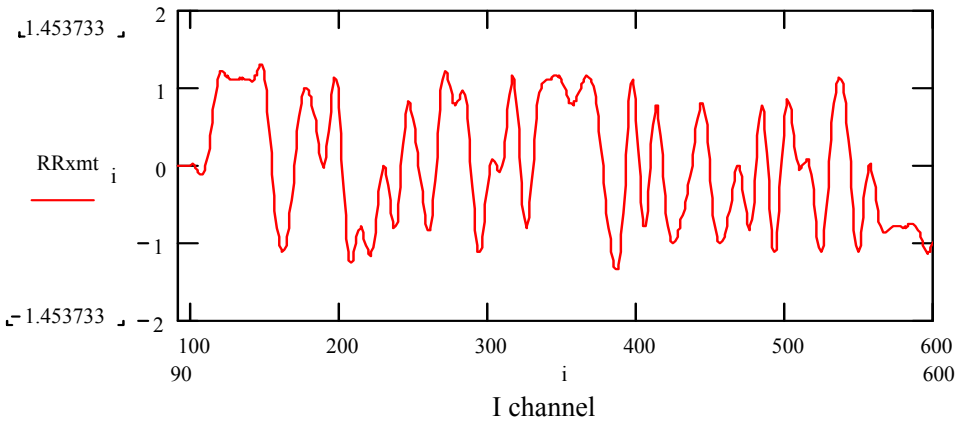
The modulation waveform, 31.5 kB/sec (10.5 kSym/sec) D8PSK using raised cosine shaping with excess bandwidth factor of 0.6, is generated in software by a Digital Signal Processor in complex form (I,Q) with 12 bit precision. 12 bit resolution D/A converter outputs at an 84 k/sample rate is filtered by a 2 section linear phase type low pass filter with –3 dB cutoff frequency of 8.5 kHz. The amplitude and phase response of the low pass filters is shown in Table 1.

**Table 1**

| Frequency (Hz) | Amplitude (dBr) | Phase (Degrees) |
|---|---|---|
| 100 | 0 | -32 |
| 1000 | 0 | -35 |
| 2000 | -0.2 | -40 |
| 3000 | -0.3 | -43 |
| 4000 | -0.5 | -46 |
| 5000 | -1.5 | -48 |
| 8500 | -3 | -50 |
| 10000 | -4 | -55 |
| 20000 | -10 | -70 |
| 100000 | -30 | -80 |

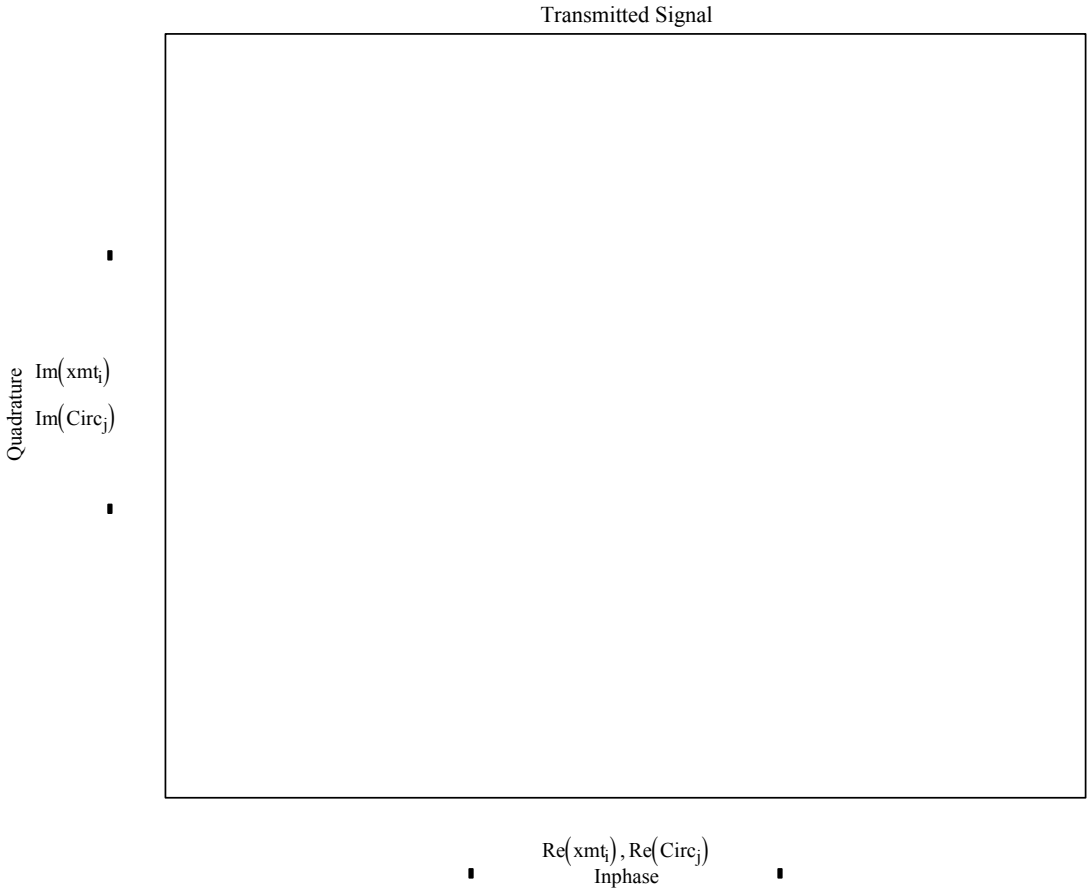
The filtered I, Q outputs are applied to a Vector (I,Q) modulator which creates the composite D8PSK waveform directly at the desired transmit frequency. Figure 1 shows a typical I channel baseband modulation signal during transmission of a VDL Mode 2 or Mode 3 message. The Q channel will be similar. Figure 2 shows the transmitted I and Q constellation showing the composite phase and amplitude characteristics produced by the I and Q signals. The constellation data points are shown in contrasting color.

**Figure 1**




I channel

**Figure 2**


Transmitted Signal
Quadrature
$\mathrm{Im}(\mathrm{xmt}_i)$
$\mathrm{Im}(\mathrm{Circ}_j)$
$\mathrm{Re}(\mathrm{xmt}_i), \mathrm{Re}(\mathrm{Circ}_j)$
Inphase