OPERATIONAL DESCRIPTION – EXHIBIT L

1.1 GENERAL DESCRIPTION OF CIRCUITRY

The VHF-4000 consists of 3 sub-assemblies; A1 VHF RF Assembly, A2 Signal Processor/Power Supply Assembly, and A3 Rear Interconnect Assembly.

The VHF-4000 power amplifier linearly amplifies the transmitter synthesizer output to a 16 watt (minimum) carrier power level for AM voice or analog data operation. The power output in VDL Mode 2 is a minimum of 15 watts. Voice, analog data, or digital data is impressed on the input RF from the synthesizer in a vector (I-Q) modulator, 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, and to maintain power output in varying environmental conditions. A low pass filter at the output attenuates the transmitter harmonics to a level at least 60 dB below the carrier level.

The VHF-4000 receiver utilizes a single conversion design. The receiver synthesizer LO (high side injection) is applied to the first mixer, generating a 28.875 MHz first IF frequency which is amplified and then detected by use of DSP technology. For voice operation, a noise quieting squelch and carrier squelch is provided.

For receive operation, the VHF-4000 frequency synthesizer is a single loop, TCXO reference-controlled design and provides the receive LO for any 25 kHz or 8.33 kHz channel selected in the 118.000 to 136.992 MHz frequency range. (Note that by definition, 8.33 kHz = 25 kHz/3, and all references to these frequencies can be written to one Hz).

A second, dedicated frequency synthesizer is used for transmit operation. It is a single loop, TCXO 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 136.992 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. The +/- 5 PPM tolerance includes the effects of aging for up to 10 years of operation.

There are no operator adjustments for power level, microphone gain, audio compression, or other transmitter parameters. The operator controls (provided by a separate assembly) are for frequency selection and receiver audio gain (volume).

1.2 TYPES OF EMISSIONS

When 25 kHz AM operation is selected, voice or analog data modes are enabled. The types of emissions on 25 kHz analog channels are:

5K00A3E and 10K00A3D

When 8.33 kHz AM operation is selected, only voice is enabled. The type of emission on 8.33 kHz analog channels is:

5K00A3E

When 25 kHz channel VDL Mode 2 operation is selected, the digital data mode is enabled. The transmit waveform is a 31.5 Kb/sec D8PSK signal using raised cosine filtering with excess bandwidth of 0.6. The type of emission on 25 kHz digital data channels is:

14K0G1DE

1.3 FREQUENCY RANGE

Frequency range: 118.000 through 136.975 MHz (including two 8.33 kHz channels at 136.983333 and 136.991666 KHz)

1.4 OPERATING POWER

AM voice and analog data modes - 18 watts carrier power (not adjustable by operator)
Minimum carrier power is 16 watts under any single aircraft normal environmental condition, to satisfy the requirements of airworthiness authorities.
VDL Mode 2 – 18 watts average power (not adjustable by operator)
Minimum average power is 15 watts under any single aircraft normal environmental condition, to satisfy the requirements of airworthiness authorities.

1.5 MAXIMUM POWER RATING

Part 87 of the FCC Rules and Regulations, Section 87.131, defines a maximum power rating of 55 watts for an Aircraft (Communication) Class of station. The VHF-4000 does not exceed this limitation.

1.6 DC VOLTAGES AND CURRENTS

The DC voltage applied to the drains of the final transistors is 27.5 VDC (nominal). With an un-modulated carrier, the DC current into the final amplifier stage typically total 4 amperes in voice and analog data modes. In VDL Mode 2, the modulated DC current into the final amplifier stages typically totals 3.7 amperes.
The sources of A1Q906 and A1Q903 (the power output stages) are grounded.

1.7 CIRCUITRY FOR SUPPRESSION OF SPURIOUS RADIATION

The low-pass filter suppresses transmitter spurious radiator. This is located on the A1 RF Assembly and shown on schematic 828-3186-002. 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 through the 1.5 GHz GPS band.

1.8 CIRCUITRY FOR LIMITING MODULATION

Modulation limiting is achieved in the audio compressor that is implemented in software on the A2 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.

1.9 CIRCUITRY FOR LIMITING POWER

The carrier power output is controlled by adjusting the DC component of the audio signal applied to the modulator controller, A1U800 on the RF assembly, 828-3186-002. This DC level is a service adjustment, not accessible to the operator. The VHF-4000 contains circuitry on the RF assembly that prevents excessive power output with changes in operating conditions, with the use of an automatic feedback control system. No user accessible controls are employed.
A software controlled reduction of peak power occurs during times of low power supply voltage (less than 22.0 VDC) so 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.

1.10 DIGITAL MODULATION TECHNIQUES

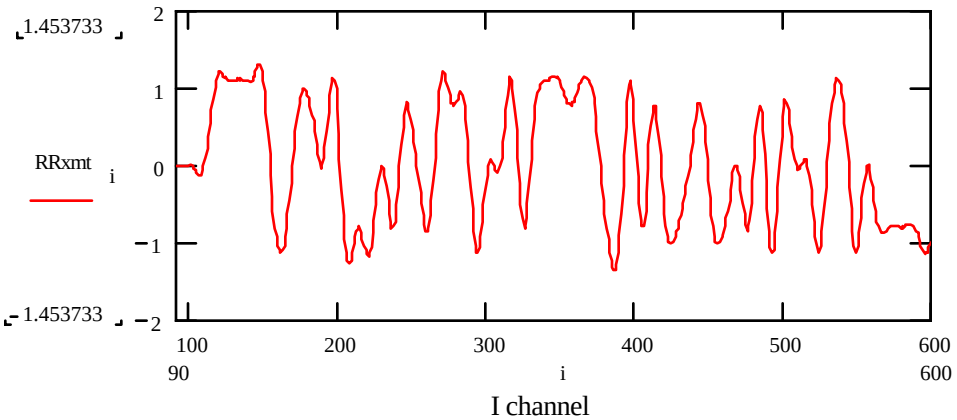
One of the Modulation formats of the VHF-4000 is emission designator 14K0G1DE. This is a digital 31.5 kB/sec (10.5 Ksym/sec) D8PSK waveform using raised cosine shaping with excess bandwidth factor of 0.6. The data transmitted is convolved with a psuedo-random pattern. The modulation waveform is generated 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 are filtered by two section linear phase-type low pass filters 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

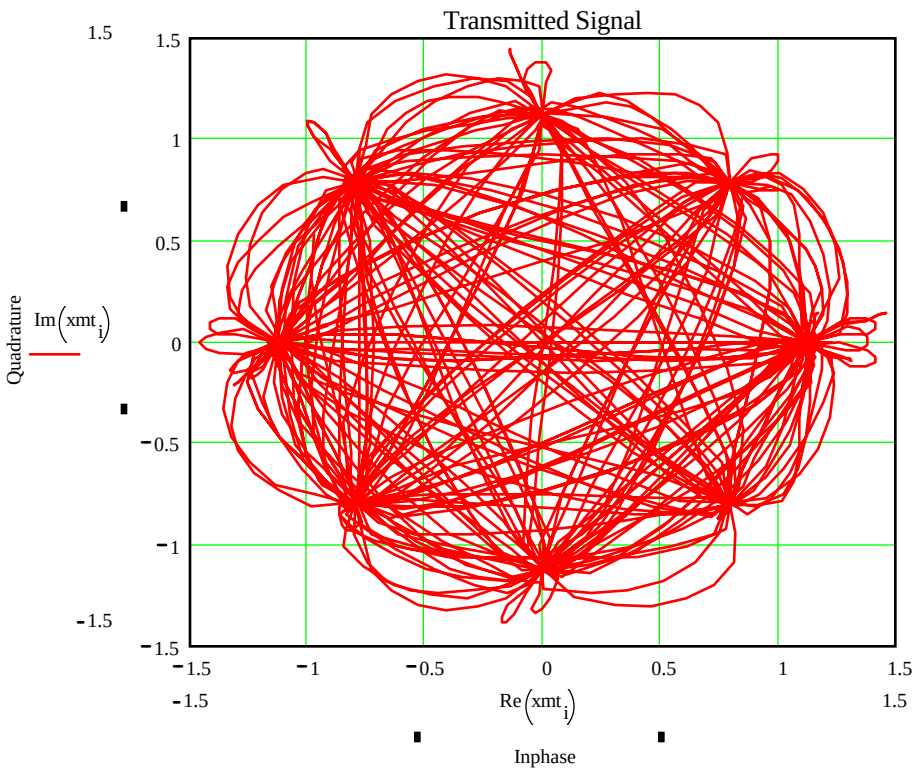
The filtered I, Q outputs are applied to a Vector (I,Q) modulator which creates the composite D8PSK waveform directly at the desired transmit frequency. Figure 1 show a typical I channel baseband modulation signal during transmission of a VDL Mode 2 message. The Q channel will be similar. Figure 2 shows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

Figure 1



I channel

Figure 2


Transmitted Signal
1.5
1
0.5
0
-0.5
-1
-1.5
Quadrature
Im(xmt_i)
-1.5
-1
-0.5
0
0.5
1
1.5
Re(xmt_i)
Inphase