<u>INET Spider II CDPD/CS Modem Technical Summary</u>

The INET Spider II product is a CDPD and Circuit Switched cellular modem designed to be compliant with Cellular Digital Packet Data System Specification - Release 1.1 and the Mobile Station - Land Station Compatibility Specification - EIAITIA-553. The modem is a completely self contained unit consisting of a processor and memory for data packetizeing, encryption, encoding, decryption, and decoding. It contains all of the RF transmit and receive circuitry required for AMPS call processing as well as creating and receiving a CDPD data stream on any standard cellular channel. The technology used in the construction of the modem mimics that of an AMPS cellular phone with its wideband data and voice capabilities. In addition, the modem has provisions for performing GMSK data bursts.

The product is packaged in a PCMCIA Type II housing and is solely powered and controlled through a PCMCIA PC Card version 2.1 interface. This interface specifies the DC voltage to be provided to the PCMCIA peripheral as a regulated 5 volts *+A5%*. The interface protocol is design to emulated a standard *16550* UART interface and can be configured on the PC side as a standard Communication Port connection.

The data flow into and out of the modem is metered by the modem processor. The data rate of transmission at the antenna terminal is fixed at 19.2 KHz in CDPD mode and 14.4 KHz in circuit switched/AMPS modem mode and is independent of any user application running on the PC side. The modem processor takes care of implementing all protocol controls on the CDPD channel and the aspects of the CDPD channel are not apparent to the users application. The protocol controls in AMPS mode are handled by the processor in conjunction with a TCM8O3O Baseband Processor for Analog Cellular Telephones.

Transmitter frequency and emissions type.
The transmitter covers the band of 824.010 MHz to 848.970 MHz and is tuned in 30 KHz steps. In CDPD mode, the modulation type is a Gaussian Minimum Shift Keying (GMSK) with BT= .5. The data rate is fixed at 19.2 Kbps. In the AMPS Circuit Switched mode, the modulation type is FSK with a data rate of 14.4 Kbps. Modulation of a carrier is done at the Transmit LO (181.2 MHz) with an I and Q modulator in CDPD mode and a standard FM modulator in AMPS mode. The baseband I and Q waveforms and the FM waveforms, with all of the filter characteristics required to meet the emissions mask, have been described digitally and stored permanently in non-volatile memory. A microcontroller is used to translate the data stream to be transmitted into the appropriate baseband signals. The digital signals are generated at 16 times over sampling, and the analog signals are recreated with an 8-bit digital-to-analog conversion process. This modulation technique requires no tuning or adjustments to meet the emissions mask. Also, because the data is encoded with a pseudo random sequence, the modulation mask is constant and independent of the data being sent. The output spectrum is constant and independent of user controls except for on/off commands.

The emissions mask as detailed in the CDPD version 1.1 system specification is: the emission power in either adjacent channel centered +1-30 KHz from the center frequency shall not exceed a level of 26 dB below the mean output power. The emission power in either alternate channel, centered +1-60 KHz from the center frequency shall not exceed a power level of 45 dB below the mean output power. The emission power in either second alternate channel centered +1-90 KHz from the center frequency shall not exceed a power level of 60 dB below the mean output power or -23 dBm, whichever is lower.

In AMPS voice mode, the emissions mask is controlled via a modulation limiter in the baseband processor. The modulation deviation is limited to +1-12 KHz maximum.

Transmitter power.
The transmit output power is classified via the CDPD specification and TIA-553 as class III. Maximum output power is set at 0.6 watts ERP, and is controllable in 4 dB steps from -2 dBW to -22 dBW. The actual level to be used for transmission is determined by a broadcast message sent by the service provider. The user has no provision for setting or adjusting the transmit power.

The output power is controlled by a analog voltage generated by a digital-to-analog converter. The actual RF transmit level is sampled by an RF detector and compared to the level requested by the processor and an error voltage is generated which is used to control the gain of the final power amplifier. The output of the RF detector is also provided to the modem processor where a caparison between expected levels of performance and measured levels can be compared to detect failure conditions. Control voltage levels for the various power levels the modem is expected to transmit at are loaded in the modem's nonvolatile memory at time of manufacture.

Required Bandwidth.
The transmission bandwidth is determined by Carson's Rule: BW = 2(Δf + ~ where, Δf = frequency deviation and **fmod** = modulation rate.

In CDPD mode, the data rate equals 19.2 Kbps and for equal number of "l's" and "0's", the modulation rate **(fmod) =** Data rate/2 =e fmod = 19.2Kbps/2 = 9.6 KHz. Further, Δf = fmod x ~ where, the modulation index (~) equals *0.5* for CDPD. Therefore, Af = 9.6 KHz x 0.5 = 4.8 KHz. **BW** = 2(4.8 **KHz + 9.6 KHz) =** 28.8 **KHz.**

In AMPS mode, there are two bandwidth requirements; one for wideband data transmission and one for voice/modem transmission. For signaling tone and wideband data, the frequency deviation is set to 8 KHz and the modulation rate is 10 KHz. **BW** = 2(8 **KHz + 10 KHz) = 36 KHz.** For AMPS voice or modem mode, the maximum frequency deviation allowed is 12 KHz at a modulation rate of 3 KHz. BW 2(12 **KHz + 3 KHz) =30 KHz.**

Power requirements.
The modem requires 5 volts dc *+l-.75* volts for proper operation. The only circuitry that runs off the filtered 5 volts provided by the host is the last two gain stages of the transmitter, a 3.8 volt regulator for some receiver amplifiers and a dc-to-dc converter, all other circuitry either runs off of the 3.3 volts generated by the dc-dc converter or off of a regulated voltage derived from the converter. The modem processor continuously monitors the supplied voltage and detection of under voltage or over voltage conditions will cause the modem to inhibit any transmissions to prevent erroneous operation.

Tune up procedure.
There are no manually tunable devices in the modem design. The 15.36 MHz temperature compensated crystal oscillator used for all frequency generating circuits contains a voltage tuning element for setting the final reference frequency. This voltage is generated by a DAC and the calibration value is stored in nonvolatile RAM at the time of manufacture. The baseband processor used for AMPS call processing also has some factory set parameters used to control audio gain, modulation deviation limiting and signaling tone and SAT deviation characteristics. These values are also stored in non-volatile RAM at the time of manufacture.

Frequency determination.
All local oscillators, clocks and timing signals are derived from one crystal source. This source is a 15.36 MHz temperature compensated crystal oscillator which is designed for cellular applications and purchased to a specification indicating compliance to frequency tolerance requirements for this class of equipment. There are no other free running oscillators, clock sources, or timing generating devices in the modem. This one reference is used for all frequency generating circuits.

The final transmitted signal is generated from the mixing of a transmit LO and the main LO. The transmit LO is a 181.2 MHz VCO phase locked to the 15.36 MHz reference oscillator with a reference frequency of 60 KHz when in CDPD mode and 5 KHz when in AMPS mode. The main LO is also phase locked to the reference oscillator with a 30 KHz phase reference clock. It will be tuned from 914.91 MHz to 939.57 MHz with a step size of 30 KHz. The receiver uses the main LO and a receive LO. The receive LO is at 91.2 MHz and is also locked to the reference oscillator and uses a 24 KHz phase reference clock. All three phase lock loop circuits have lock indicator signals that verifies proper operation of the circuitry. This signal is provided to the modem processor and is monitored during normal operation. The transmitter will not be enabled unless all phase lock loops are indicating that they all properly locked to their assigned frequency.

The frequency stability of the reference oscillator is specified to a temperature of -30 to + 70 degrees C. The modem is specified with an operational temperature range of 0 to +45 degrees C. An internal temperature sensor is included in the modem to detect temperature conditions outside 0 to + 70 degrees C. When detecting a temperature range outside this range the modem processor will not allow transmissions to occur.

Spurious Radiation suppression.
A metal shield is required around the entire modem to suppress spurious emissions. The modem housing provides this function. In order to ensure the top and bottom cover are connected electrically, the grounding tabs on the 15-pin connector must be bent at roughly 45 degree angles at the time of assembly. All test data was taken with the grounding tabs utilized.

Electronic Serial Numbers.
Each modem has a unique 32-bit Electronic Serial Number (ESN) assigned to it at the time of manufacture which identifies the modem to the cellular system when in AMPS mode. The CDPD network uses a combination of an IP number and authentication exchange to uniquely identify the modem to the CDPD network even though each modem is assigned a 48-bit electronic identification (EID) per the CDPD requirements.

The ESN host component is a 4 Mbit ELASH memory chip which is permanently attached to the circuit board of the modem.

The integrity of the modem's operating software is not alterable. A 32-bit cyclic redundancy check (CRC) of the operating software is performed after system reset. If the CRC fails, the system remains in boot mode and will not execute the operating software.

In addition to the ESN, the host component contains the operating software. The ESN is encoded using cyclic coding (32-bit CRC). The ESN is factory set and is not alterable, transferable, removable, or otherwise able to be manipulated in the field.