AT

APPENDIX G:

USER'S MANUAL

AT

MODEL 1225 TRANSCEIVER
TECHNICAL MANUAL

produced by:

APPLIED TECHNOLOGY SOLUTIONS, INC.

4200-F Technology Court
Chantilly, VA 20151

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SECTION ONE
INTRODUCTION

1.0 GENERAL

This document is the Operating Manual for the Model 1225 Hand Held Transceiver produced by Applied Technology Solutions, Inc. The Model 1225 is one component of the Voice Privacy Low Probability of Detection (VPLPD) System 1200. Other System 1200 components include the Model 1245 Monitor System and the Series 1250 Transmitters.

The System 1200 uses spread spectrum modulation to provide secure, low probability of detection and interception communications to the user. The transmitted voice data is scrambled with a user selected key, to provide voice privacy and an additional level of security. The System 1200 employs an ATS proprietary self-synchronizing design. This design provides nearly instantaneous receiver synchronization and provides improved performance over other spread spectrum designs in a rapid fade, multi-path environment.

The Model 1225 Hand Held Transceivers can be used for direct communications with other System 1200 devices.

1.1 SPECIFICATIONS

The specifications for the Model 1225 Transceiver follow. Unless otherwise noted all specifications are at 25^{o} C with full capacity batteries.

RF CHARACTERISTICS

RF Channels:	2, Crystal Controlled
Normal Mode:	Transmit/Receive Channel A or B
Repeater Mode:	Transmit Channel A, Receive on Channel B

Transmit

Power Output:	900 mW
Emissions	
Spurious:	-55 dBc
Out Of Band:	-20 dBc
Freq. Stability:	+100 ppm -25° C to +68° C

Receive

Sensitivity:	-95 dBm
Selectivity	
Adjacent Channel:	-65 dB
Spurious & Image:	-85 dB

Antenna System

Antenna:	½ Wavelength, flexible
RF Output	
Compatibility:	50 Ω

AUDIO CHARACTERISTICS

Frequency Response:	± 6 dB, 300 - 5800 Hz
Microphone:	Internal or external
Mic Audio Processing:	Dual Time Constant AGC
Dynamic Range:	55 dB, Minimum
Speaker:	Internal or Remote
Rated Audio Output:	400mW into 16 Ω (less than 5% distortion)
Remote Speaker/Mic:	Model 1230-04

VOICE DATA SCRAMBLING

Type:	Synchronous Key Stream
Key Generation:	External, Hand Held, Model 1260 Key Loader
Key Storage:	Internal, non-volatile memory
Number of Keys:	Two sets, Private and Common

USER CONTROLS

On-Off/Volume
Channel (Mode) Select
Code Select
PTT

INDICATORS

Power/Battery Low
Transmit

POWER REQUIREMENTS

Battery Pack:	1200 mAh, Nickel Cadmium, rechargeable (1800 mAh available)

TEMPERATURE

Operating:	-25°C to +68°C
Storage:	-40°C to +85°C

PHYSICAL DIMENSIONS

Less Battery:	6.25" x 2.75" x 1.50" (HxWxD), 1lbs.
With 1200 mAh battery:	8.625" x 2.75" x 1.5" (HxWxD), 1lbs.

1.2 CONTROLS, INDICATORS, USER I/O

This section describes the user interfaces and indicators provided by the Model 1225 Hand Held Transceiver.

USER CONTROLS

VOLUME	Dual function rotary switch. It is the power on/off switch plus volume control
CHAN	The channels are A, B and R where R refers to repeater operation.
CODE	A two position switch allowing selection of either the common (C) or private (P) code.
PTT	A momentary push button switch that places the Model 1225 in the transmit mode.

STATUS INDICATORS

PWR	Green, multi-function LED. Steady illumination indicates that power is on and battery condition is normal. Blinking LED indicates that the battery voltage is low and approximately 180 minutes of receive or 15 minutes of transmit operation remain from the time the light starts blinking.
TX	Red LED, when illuminated, indicates that unit is in transmit mode.

USER CONNECTIONS

Key Loader	A rear panel connector accessed by sliding the door. Connecting the Model 1260 Key Loader to this port, privacy codes can be downloaded from the loading device to the Model 1225 where they are stored in non-volatile memory. Operating power for the Model 1260 is supplied from this connector.
Mic	Side panel, 4 pin microphone connector. Accepts the standard Model 1230-04 Surveillance Micphone/Earpiece Assembly.

CONNECTOR SPECIFICATIONS

Microphone:	Hirose HR10A-7P-4P
Antenna:	SMA Female
Key Loader:	ATS Model 1230-03 Adapter Cable

SECTION TWO
OPERATION

2.0 GENERAL

The ATS Model 1225 Hand Held Transceiver is one of the System 1200 devices. The System 1200 devices were designed to provide secure communications to law enforcement agencies. This section describes the operation of the Model 1225 with the other units in the System 1200 family.

2.1 ATS 1200 SYSTEM COMPONENTS

The ATS System 1200 components include the Model 1245 monitor Station and the Series 1250 Transmitters.

2.2 MODEL 1225 OPERATION

Before operating the Model 1225, the user should read Section 1.2 of this manual, where the user controls and interfaces are described.

The ATS System 1200 was designed to support two primary operating scenarios. The first scenario is direct transceiver-to-transceiver communications. In this scenario, communications occur between individual transceivers, using either Channel A or Channel B. The second scenario requires the use of a repeater to extend the operating range. In the Repeater Mode, system components transmit on Channel A (or Channel C) and receive on Channel B. The Model 1240 Portable Repeater was designed primarily to support the second scenario but it also provides for direct communications capability.

To communicate with other units in the direct transceiver-to-transceiver mode, all units must be set to the same channel, either Channel A or B, set to the same code, either C or P and have the same keys loaded. In the repeater (R) mode, the Model 1240 Portable Repeater receives transmissions on Channel A and re-transmits them on Channel B. To use the repeater, the Model 1225 CHAN select must be set to R.

A fully charged battery pack should be installed onto the Model 1225 Hand Held Transceiver prior to each deployment. To operate the Model 1225, place the CHAN switch to the desired position, A, B, or R (repeater), select either the common (C) or private (P) code with the CODE switch and turn the unit on by rotating the VOLUME control from the OFF position.

NOTE

For non-repeater applications, all system transceivers MUST be set to the same channel and code. Cross channel or cross code operation is not possible.

During idle periods, the Model 1225 will power down most of the receive circuits.

The Model 1225 Hand Held unit only transmits when the PTT switch is depressed. The integral, side panel mounted PTT is a momentary switch and must be held down for the duration of the transmit interval. Optionally, the Model 1230-04 Surveillance Microphone/Earpiece Assembly can be used with the Model 1225 Hand Held Transceiver.

2.3 BATTERY

The Model 1225 Hand Held transceiver operates from a 1200 mAh or an 1800 mAh Nickel Cadmium, rechargeable battery. The battery slides onto the Model 1225 battery clip assembly located on the bottom of the unit. To remove the battery, push the retaining clip upwards towards the top of the unit and slide the battery in the direction opposite the clip. When installing a battery, insure the grooves on the top of the battery are properly aligned with the baseplate. The battery should slide on easily.

A blinking PWR LED on the Model 1225 indicates low battery conditions. The battery should be replaced immediately with a fully charged battery. The Model 1225 Hand-Held transceiver will operate for approximately 180 minutes in receive mode or 15 minutes in transmit mode after a battery low condition is indicated. Only critical transmissions should be made after the battery low condition is indicated.

2.4 PRIVACY CODES

Privacy keys are stored in non-volatile memory. The keys are loaded into memory using the Model 1260 Key Loader. If a keyed unit is lost or stolen, the keys in the remaining units can be changed quickly to maintain the overall security. Code selection is made using the top panel switch. Two codes selections are available, common (C) and private (P). The C code is factory set on all units and provides a common scrambler code for use during inter-agency operations. The P code is intended to be agency or group specific. The P code can be changed by the user. In operation, the Model 1225 uses different codes for Channel A and Channel B operation.

To load a P code into the Model 1225, use the Model 1230-03 Adapter Cable to connect the Model 1260 Key Loader to the key loader connector located on the rear side of the Model 1225. The POWER indicator on the Model 1260 should light (providing the Model 1225 is powered on). The Model 1260 is powered from the Model 1225. Select a code by rotating the KEY NUMBER thumb wheel switches on the Model 1260. (Selecting a code number above 300 will result in an error indication on the Model 1260.) Depress the LOAD KEY button on the Model 1260 to download the selected key. The KEY LOADED indicator on the Model 1260 should light, indicating that the new keys were successfully loaded into the Model 1225. If the LOAD FAIL indicator lights, the key load sequence did not succeed. If this occurs, check the setting of the KEY NUMBER switches to ensure that it is not set above 300. Verify that the interface plug on the Model 1260 cable is fully seated into the KEY LOADER connector on the Model 1225. Continuing LOAD FAIL indications mean that either the Model 1260 or the Model 1225 is defective and should be returned for repair. If a Model 1260 is suspected of failure, it should be tried with another Model 1225. If failures still occur, the Model 1260 is defective.

SECTION THREE

THEORY OF OPERATION

3.0 GENERAL

The Model 1225 Hand Held Transceiver is a push-to-talk, spread spectrum transceiver. It uses digitized audio. The digital data stream is scrambled before modulation for security. The combination of spread spectrum modulation and scrambled, digitized audio give the Model 1225 its low probability of detection and interception characteristics.

3.1 FUNCTIONAL DESCRIPTION

The Model 1225 block diagram can be divided into two sections. The upper half contains the digital and audio signal processing functions. The lower half contains the IF and RF signal processing functions.

3.1.1 Audio/Digital Section

In the transmit direction, audio can come either from the internal microphone in the Model 1225, or from an external speaker/microphone. Microphone audio is amplified by the microphone pre-amplifier stage. This stage also has an audio AGC (Automatic Gain Control) function that produces a constant audio signal level for the CVSD (Continuously Variable Slope Delta-modulation) encoder. The AGC has an attack time of less than 1ms and a decay time of 150 ms. A lowpass filter between the pre-amplifier and the encoder limits the audio signal bandwidth to prevent aliasing.

CVSD encoding converts the analog audio into a serial data stream. The bit rate of this data stream is equal to the CVSD clock signal frequency. Processing of the serial data stream is performed by the FPGA (Field Programmable Gate Array).

Serial data from the encoder is processed by the scrambler/ de-scrambler in the FPGA. The scrambler/de-scrambler is a dual purpose block that is switched between transmit and receive modes. In transmit mode, the encoder data stream is combined with a pseudo-random key stream. The key stream is generated from the scrambler key that is stored in the key memory. The scrambler key manager monitors the status of the CODE signal. It then reads the appropriate key from the key memory, and sends it to the scrambler/de-scrambler. The same key is used for both transmitting and receiving.

Key memory programming access for the Model 1260 Key loader is provided through the key loader input jack.

Once the data stream from the CVSD encoder is scrambled, it is ready to be spread spectrum modulated. The PN (Pseudo-Noise) sequence generator produces a long digital sequence, at a clock rate that is much greater than the signal from the data scrambler. The PN sequence is combined with data scrambler signal by the spread spectrum modulator. This produces the spread data signal, which, along with the PN sequence, is bi-phase modulated by the clock signal from the modulator clock generator. Further processing of these signals occurs outside the FPGA.

Two clock generator circuits are included in the FPGA, both being driven from the same crystal oscillator stage. The data clock generator has three outputs: the PN clock, the scrambler clock and the CVSD clock. The modulator clock generator has two outputs, one being twice the frequency of the other, driving the bi-phase modulators.

In the receive direction, the FPGA demodulates the BPSK (binary phase shift keyed) signal from the 2nd IF to recover the scrambled digital data. At the same time, the lock detector determines when a valid system signal is present, and controls the lock functions. .

The demodulator produces the baseband data signal, which is a scrambled CVSD data stream. The descrambler removes the scrambler key stream from the baseband data signal to recover the CVSD RX data signal. This signal is output from the FPGA to the CVSD decoder. The decoder converts this data stream to an analog audio signal.

The audio output from the CVSD decoder is lowpass filtered to remove high frequency switching components. The Model 1225 has two audio amplifiers. One drives the internal speaker, while the other is used with the external speaker/microphone. A common volume control sets the gain of both amplifiers. The power on/off switch is integrated with the volume control.

All other controls, PTT, CODE, and CHANNEL, interface directly with the FPGA. The voltage monitor and activity detector also provide inputs to the FPGA. The FPGA generates the channel, code and T/R control signals based on the status of the front panel controls, and it drives the PWR LED.

The voltage monitor checks the battery voltage and sends a signal to the FPGA if the voltage gets too low. The FPGA contains logic that will blink the PWR LED indicating low battery voltage.

The activity detector measures the amplitude of the 2nd IF signal. Once a minimum threshold is passed, it sends a signal to the FPGA. The FPGA responds by taking the data demodulator out of power-down mode. The demodulator is powered-down during idle periods to conserve battery capacity.

Drive for the TX LED is taken from the switched DC power output from the power control. The power control switches based on the status of the T/R signal from the FPGA.

3.1.2 RF/IF Section

During transmit, the two biphase modulated signals from the FPGA are individually bandpass filtered, and then added together, to produce the baseband composite spread spectrum signal. This signal is up-converted at the first TX mixer. The output from the first TX mixer is bandpass filtered by the IF band split filters. The outputs from these filters are summed together by the IF combiner to produce the composite IF signal. The IF bandpass filter section is used for both transmitting and receiving. The signal source for the filters is switched by the IF T/R switch.

The composite IF signal is up-converted to the final transmit frequency by the TX up-converter mixer. The output of the TX up-converter mixer is bandpass filtered and amplified to drive the RF power amplifier. For economy, the bandpass filter used here is shared between the transmit and receive signal paths using RF switches controlled by the T/R signal. The RF switches isolate the transmit and receive signal paths to prevent interference.

The power amplifier is connected to the antenna through the antenna T/R switch. The status of this switch is controlled by the T/R signal from the FPGA.

Received signals from the antenna go through the antenna T/R switch to the LNA (Low Noise Amplifier). The output of the LNA is bandpass filtered by the shared channel filter. An RF amplifier stage follows the filter and drives the RX down-converter mixer. The down-converter mixer output signal frequency is the same as transmit signal frequency. Additional signal gain is provided by the IF amplifier.

In receive mode, the IF T/R switch connects the output of the IF amp to the IF band split section. Here, the received spread spectrum signal is separated into its composite parts, the spread data and PN signals.

These signals drive the despreader mixer which produces a BPSK at the 2nd IF frequency. This signal is further amplified and filtered, prior to going to the FPGA for demodulation.

Receive AGC control for the RF and first IF amplifiers is generated from the composite IF signal by the AGC generator. The AGC loop maintains a fixed signal level at the despreader output.

Channel switching is accomplished by changing the frequency of the local oscillator that drives the TX up-converter mixer and the RX down-converter mixer. The output from the local oscillator is shared between the two mixers. The state of the CHANNEL logic signal from the FPGA causes the local oscillator to output the appropriate frequency for either Channel A or Channel B operation.

3.2 RF CHARACTERISTICS

In rural areas, the Model 1225 provides line-of-site communication range with a practical limit of approximately 3 miles over normal terrain. Suburban communication range is affected by reflections and fading with a 0.5 mile radius being typical. In metropolitan areas, communication ranges are dependent on the site characteristics such as building density and RF environment. Operating ranges of approximately 1 block radius are practical.

SECTION FOUR
MAINTENANCE

4.0 TROUBLESHOOTING

When supplied with power, the top panel PWR LED should light. If the PWR LED blinks, the battery is low and must be replaced or recharged. If the PWR LED does not illuminate at all, verify LED operation by keying the transmitter and verifying the TX indicator lights. If the TX LED does not illuminate, attach different battery pack and retry. If the LED still does not illuminate return the unit for repair.

If the unit will not descramble the signal from another unit :

a. Insure that both units are set to the same channel operation.

b. Insure that both units are set to the same code setting.

NOTE:

Both units must be operating with the same code to achieve communications. Field personnel will not be able to verify the actual codes associated with common or private operation. If necessary, the issuing office should re-load the codes or return the units to ATS.

c. Verify that the antenna is properly connected to the antenna jack.

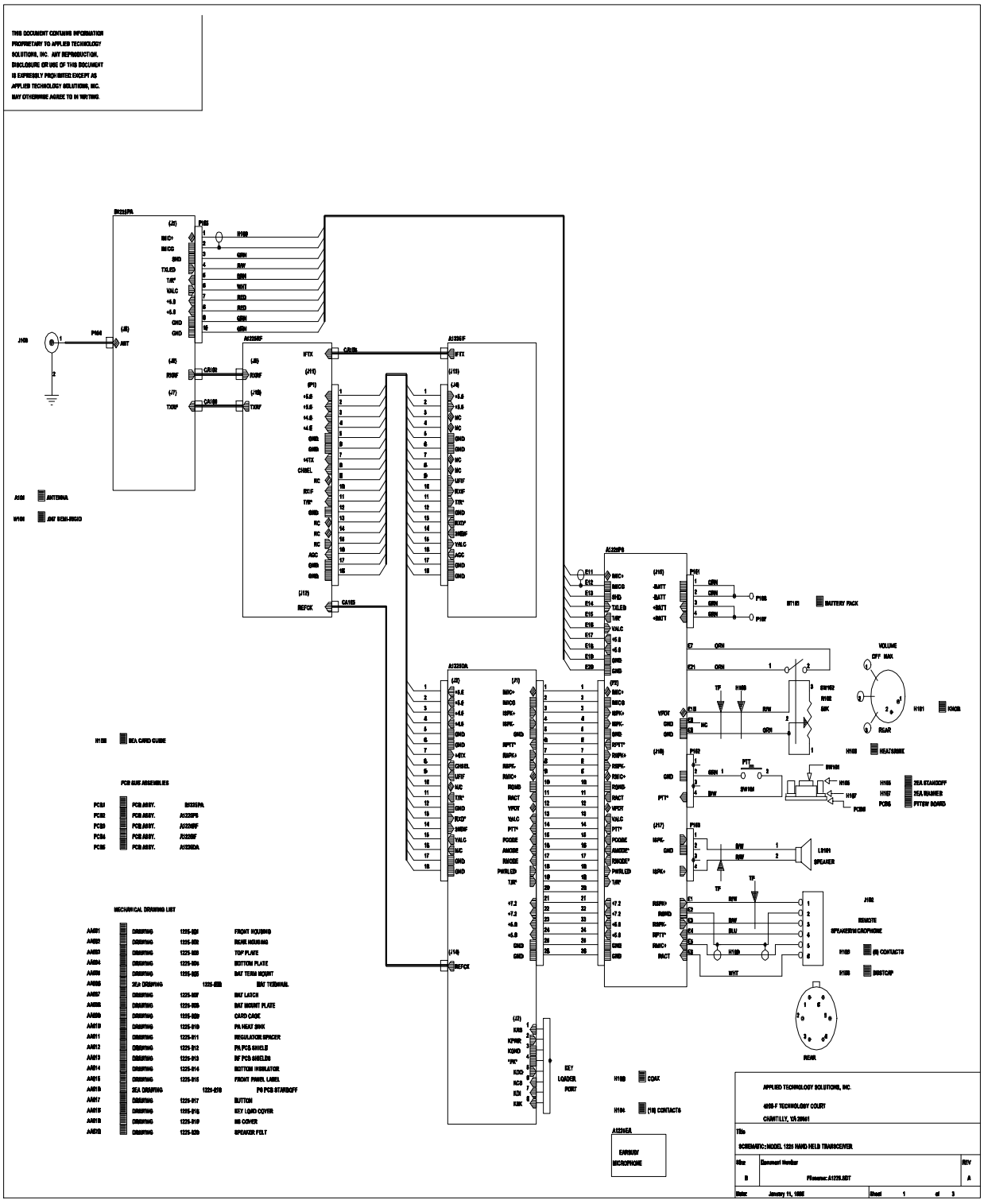
d. Return the unit to the factory for repair.

4.1 MAINTENANCE

The Model 1225 is designed for simple installation and use. There are no user maintenance requirements.

4.2 REPAIRS

Repairs to the Model 1225 should be performed by an authorized factory representative.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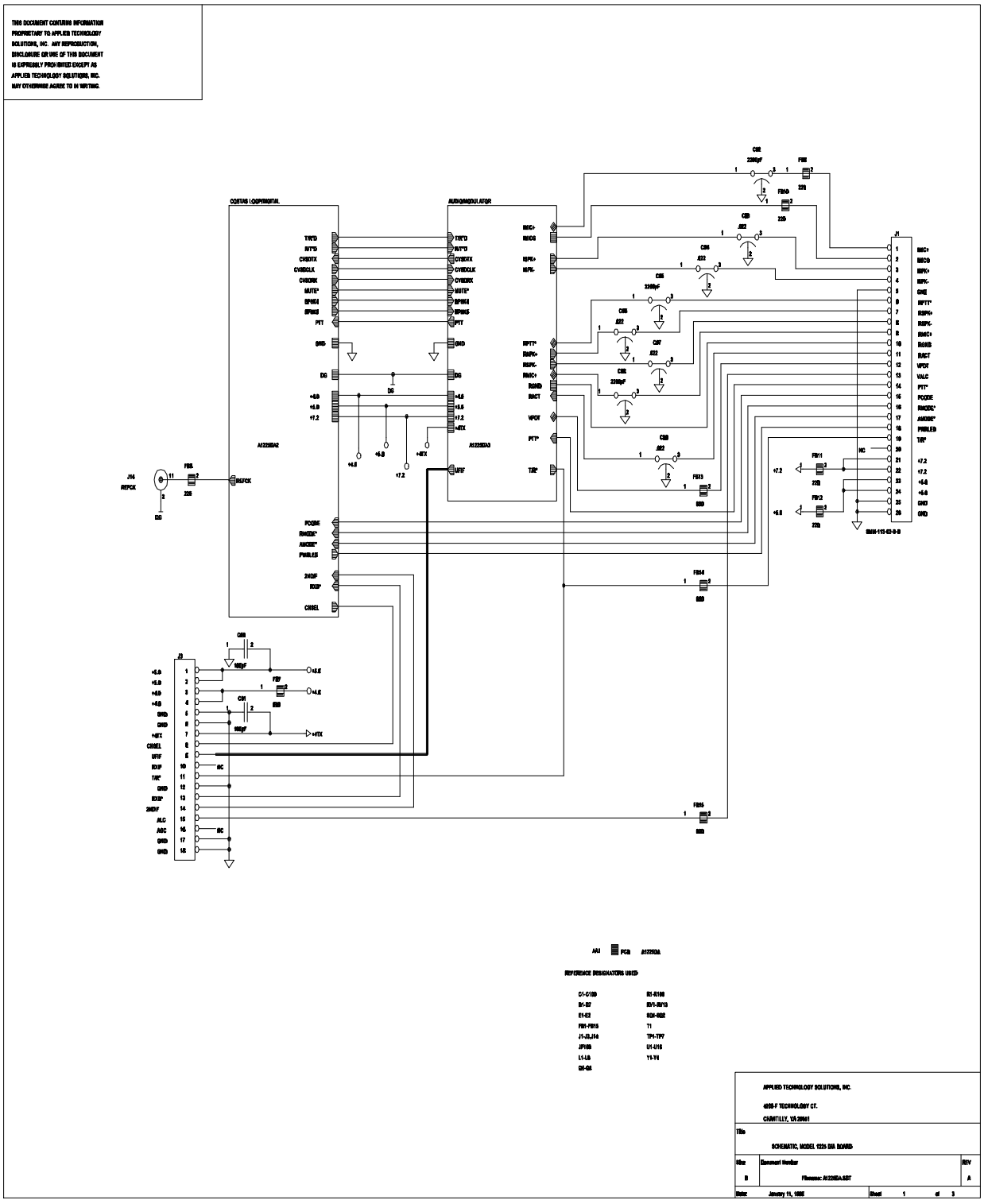
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AUDIO/MODULATOR
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J1
J2
J3
J4
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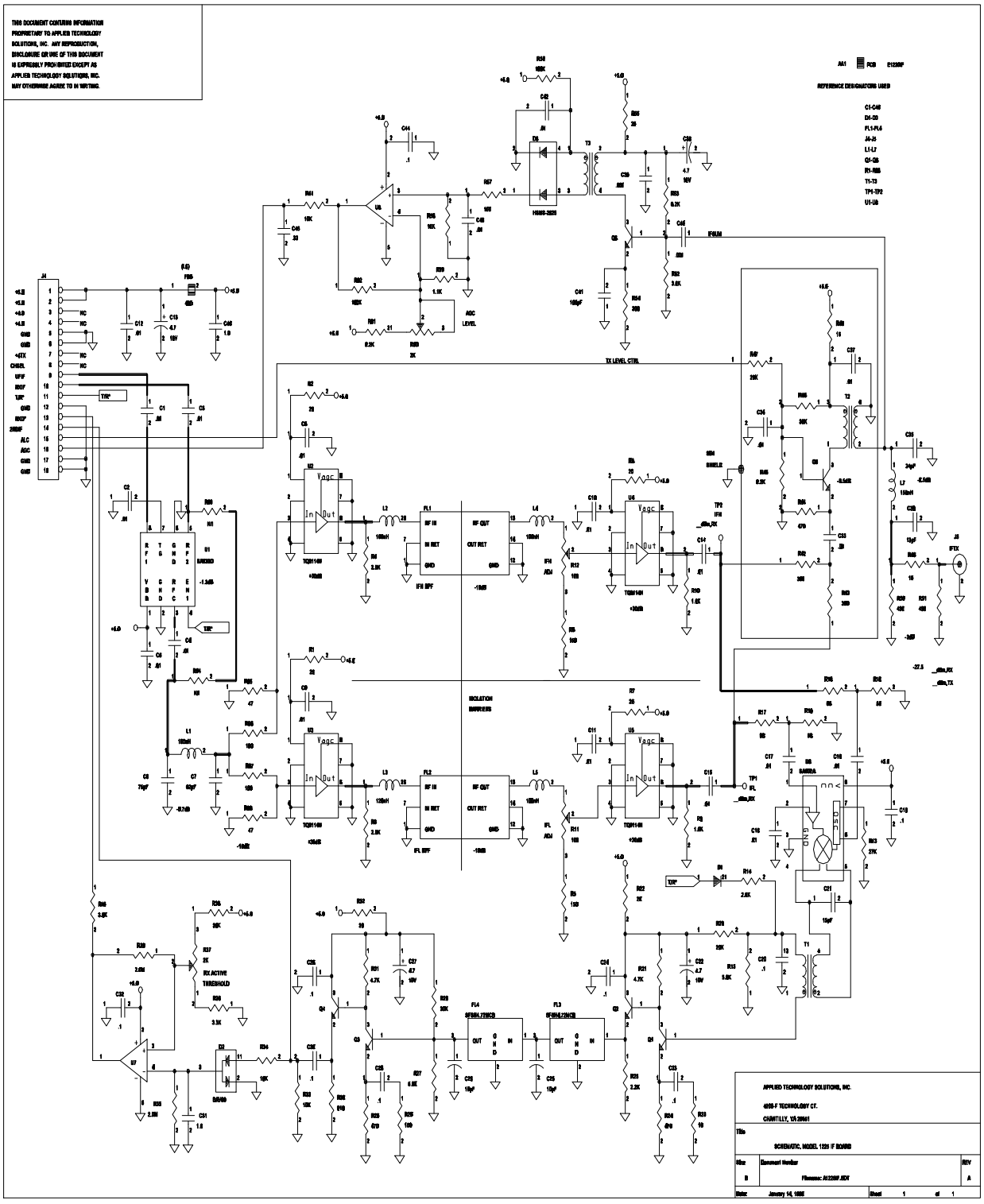
January 11, 1999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ADC LEVEL
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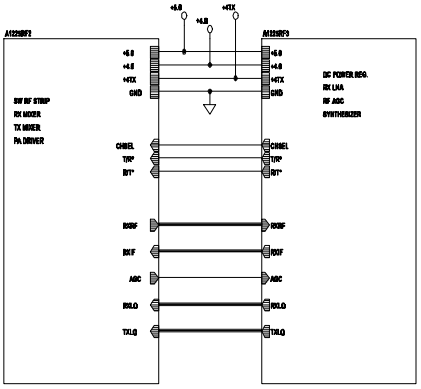

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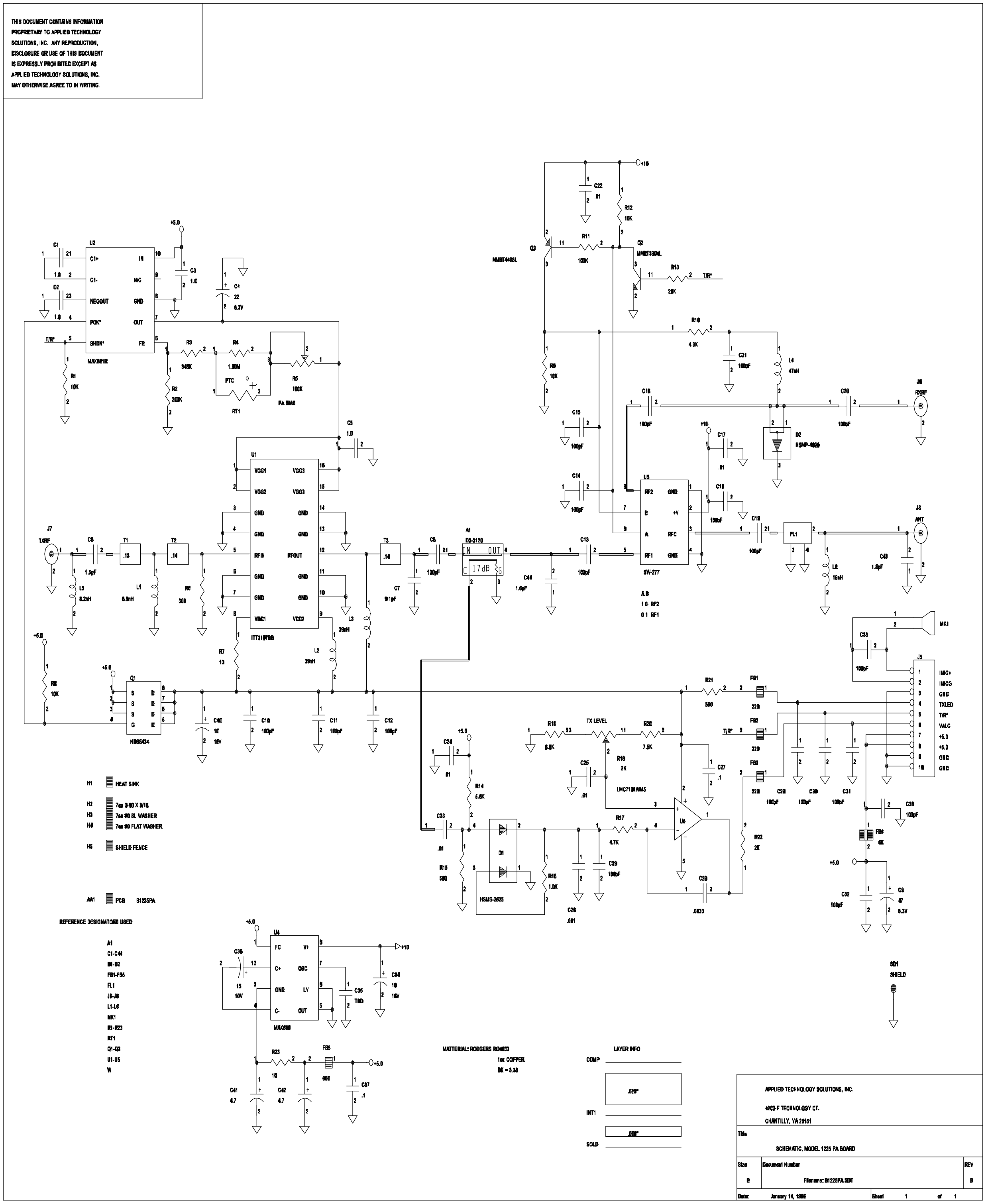
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