

**OPERATION, INSTALLATION
AND MAINTENANCE MANUAL**

FOR THE

SCORPION

DIGITAL STEREO TRANSMITTER

DECEMBER 2002

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SCORPION TRANSMITTER OPERATING MANUAL

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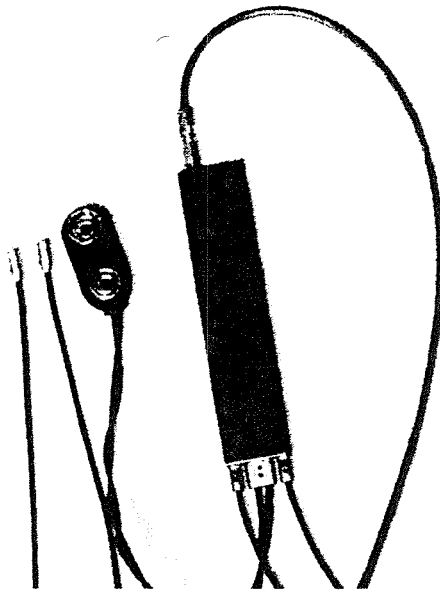
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1.0 INTRODUCTION



1.1 SCORPION DIGITAL STEREO TRANSMITTER

The Scorpion transmitter is a digital wireless stereo transmitter, which offers extremely high quality audio response. It provides inputs for two electret microphones, and uses a stereo analog-to-digital converter and a digital RF operating at selected UHF frequencies. Because the radio transmission is truly digital in nature, a companion Tektron digital receiver delivers audio signals, which are nearly indistinguishable from a hard-wire connection to the Scorpion transmitter microphones.

The unique characteristics of this transmitter also contribute to simple and user friendly operation. These include: dual channels of information transmitted from a single antenna, two microphones cables, and a power cable.

1.1.1 SCORPION TRANSMITTER SUMMARY OF FEATURES

- Two 16 bit channels, 50 Hz to 7900 Hz bandwidth
- 90 dB dynamic range with 0.01% distortion, exclusive of microphones
- Wide dynamic range obtained without AGC
- Forward Error Correction included
- External microphones on attached 18-inch cables
- Power cable
- Fully enclosed metal case
- 15.5 x 4 x 67 mm overall size
- SSMC antenna connector (6" long flexible antenna supplied)
- 10 mW output
- 1.0 ounces total weight

1.2 SCORPION TRANSMITTER PACKING LIST

1 each	Digital Stereo Transmitter
1 each	1/4 Wave Antenna
1 each	Operating Manual
2 each	Microphone Cable Assembly
1 each	Power/Control Cable

1.3 SCORPION TRANSMITTER CONNECTOR NOMENCLATURE

There is one jack on the Scorpion Digital Stereo Transmitter, which accepts an industry standard plug. An SSMC male connector is used for the antenna. The AEP mating antenna connector is part no. 7002-1541-010.

AEP connectors are available from:

Applied Engineering Products
104 John W. Murphy Drive
New Haven, CT 06513
Telephone: 1-800-444-5366

2.0 SCORPION TRANSMITTER SPECIFICATIONS

All performance specifications are typical at +25 degrees C, unless otherwise noted.

Audio Channels	2 (left/right stereo) or 1 (mono)
Microphones	External electret
Microphone Power	1.8 VDC @ 50 μ A
Analog S/N Ratio	86 dB (max. input to "A" weighted noise) *
Total Harmonic Distortion	0.01% (max input @ 1 kHz)*
Audio Frequency Response	50 Hz to 7900 Hz (-3dB)*
Stereo Separation	80 dB (40 Hz – 8 kHz)*
Audio Gain	30 dB (microphone input to receiver output)

* Exclusive of microphone, measured at Scorpion digital receiver analog output.

Digitization	16 bit Linear Sigma-Delta A/D Conversion
Anti-Alias Filter	Linear Phase Digital Filter
	0.01 dB Passband Ripple, 80 dB Stopband Atten.
Sampling Rate	16 KHz
Sampling Accuracy	+/- 50 ppm, -10 to +50 degrees C
Information Rate	512 KBit/second
Coding	Rate 1/2 Forward Error Correction
Signaling Rate	1.024 MBit/second

2.0 SCORPION TRANSMITTER SPECIFICATIONS (Continued)

Transmission Frequency	Single Channel, selected UHF Frequencies 360 – 400 MHz
Frequency Stability	+/- 0.05%, -10 to +50 degrees C
Harmonic Output	More than 30 dB below fundamental
Modulation	Minimum Shift Keying
RF Spectrum	Evenly distributed about channel center
RF Bandwidth	1 MHz @ 10 dB below peak density
Power Output	10 mW minimum into 50 ohm load @ 6 VDC
Antenna Impedance	50 ohms (less than 5:1 VSWR)
Antenna	Whip monopole
Antenna Connector	SSMC Jack (male)
External Power	3 to ¹⁴ 10 VDC negative ground
Input Power	23 mA @ 3 VDC (typical 70 mW throughout input voltage range)
Operating Temperature Range	-20 to +60 degrees C
Storage Temperature Range	-40 to +80 degrees C
Size	15.5 x 4 x 67 mm
Weight	Less than 1 ounce

3.0 SCORPION TRANSMITTER OPERATION

3.1 POWER

Power is supplied externally through the POWER cable as shown in Figure 1.

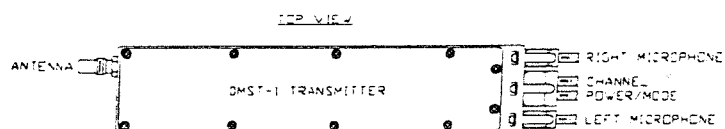
IMPORTANT: The Scorpion transmitter uses latching power and microphone cables, which can be removed. **DO NOT PULL ON THE CABLES.** To remove cables firmly depress connector latch before withdrawing connector. When connecting the cables do not use excessive force prior to full engagement. Do not attempt to force the microphone connector into power receptacle since the sockets may damage.

3.2 EXTERNAL POWER INPUT

A negative ground DC supply between 3 and 14 volts. Two AA size alkaline batteries will operate the Scorpion transmitter for approximately 16 hours. Even though the transmitter is provided with reverse voltage protection, exceeding the maximum voltage limits or failure to observe voltage polarity can cause damage to the transmitter.

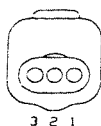
Figure 1 DST-1 Wiring and Function Diagram

DST-1 WIRING AND FUNCTION DIAGRAMS

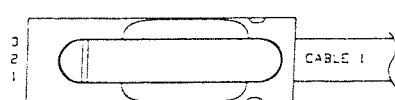


MICROPHONE CABLES

MATING END VIEW



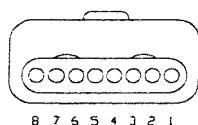
TOP VIEW



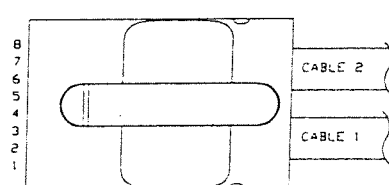
MIC CABLE WIRING				
CONN	PIN	CABLE	WIRE	FUNCTION
SHELL	1	SHIELD	SHIELD	SHIELD
1	1	RED	MIC POWER OUT	
2	1	WHITE	MIC AUDIO IN	
3	1	BLACK	MIC GND	

POWER/CONTROL CABLE

MATING END VIEW



TOP VIEW



POWER/CONTROL CABLE WIRING				
CONN	PIN	CABLE	WIRE	FUNCTION
SHELL	1	SHIELD	SHIELD	SHIELD
1	1	BLACK	POWER GROUND	
2	1	RED	+3-14 VDC IN	
3	1	WHITE	MODE SEL L	
4	1	YELLOW	MODE SEL R	
SHELL	2	SHIELD	SHIELD	
5	2	BLACK	CH SEL 1	
6	2	RED	CH SEL 2	
7	2	WHITE	CH SEL 4	
8	2	YELLOW	N/C	

MONO/STEREO SETTINGS		
MODE	MODE SEL L WHITE CABLE 1	MODE SEL R YELLOW CABLE 1
STEREO	GND	GND
MONO LEFT MIC	GND	CC
MONO RIGHT MIC	CC	GND
STEREO	CC	CC

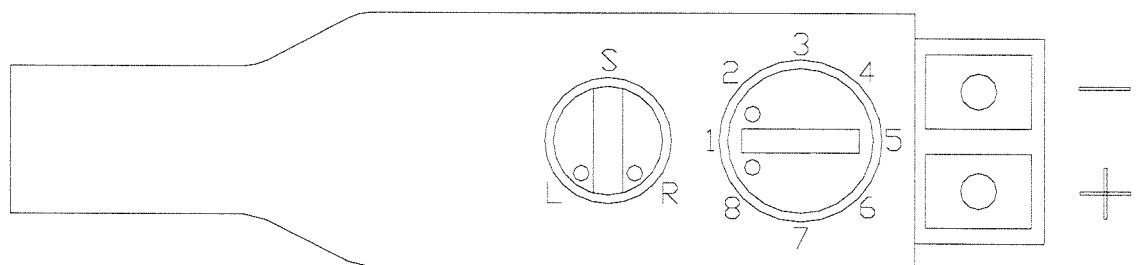
CHANNEL SETTINGS				
CHANNEL	FREQUENCY	CH SEL 1 BLACK CABLE 2	CH SEL 2 RED CABLE 2	CH SEL 4 WHITE CABLE 2
1	368.5	CC	CC	CC
2	366.6	GND	CC	CC
3	372.7	CC	GND	CC
4	374.8	GND	GND	CC
5	379.9	CC	CC	GND
6	382.0	GND	CC	GND
7	387.1	CC	GND	GND
8	391.2	GND	GND	GND

3.2.1 EXTERNAL CHANNEL CONTROL, MODE CONTROL AND POWER CONNECTION

An optional means to select the operating frequency and the stereo/mono mode is by external rotary switches mounted on a printed circuit board a small distance away from the center (8 pin) transmitter connector. This printed circuit board also provides the means to easily attach power supply wires to the Scorpion transmitter.

Connecting Power

Each wire cable exiting the center eight pin connector contains 4 very small individual wires. Normally, the power feed to the transmitter is via a power source (usually batteries) with a positive wire and a negative wire. These wires will probably be a much larger gauge than the #34 wires inside the Scorpion cable. Splicing large diameter wires to very small wires can be difficult, therefore, an attachment mechanism has been provided. A printed circuit board has been affixed to the end of the wires exiting the eight pin connector. At the end of the board are two solder pads that can be used to attach power supply wires.



Available on the same board are two rotary switches, one three position and one eight position switch. These switches control stereo/mono selection (3 position) and operating frequency (8 position).

Stereo/Mono Selection

Stereo or Mono operation is selected by rotating the three (3) position switch according to the selections shown below in the figure titled "Mode Switch Settings".

'L MONO' selects the left microphone. 'R MONO' selects the right microphone. Be sure to position the connector wires to the left when making adjustments.

MODE SWITCH SETTINGS	
MODE	SWITCH POSITION
STEREO	
L MONO	
R MONO	

(WIRES TO LEFT)

Channel (Frequency) Selection

The transmitter operating frequency is selected by rotating the eight (8) position switch according to the selections shown below in the figure entitled "CHANNEL SWITCH SETTINGS". The channel numbers correspond to the individual frequencies preset into the transmitter. Check the frequency sheet supplied with each Scorpion transmitter. Be sure to position the connector wires to the left when making adjustments.

CHANNEL SWITCH SETTINGS	
CHANNEL	SWITCH POSITION
1	
2	
3	
4	
5	
6	
7	
8	

(WIRES TO LEFT)

3.3 ANTENNA

A properly designed antenna is important to realizing maximum power output and range for the transmitter. The transmitter antenna connection is at the opposite end of the transmitter housing from the power and MIC connections. The antenna connection is completed by screwing on the antenna or cable connector to the matching transmitter connector. Connections should be finger tight, do not use wrenches or pliers to on the connector nut.

Custom antennas may be used with the Scorpion transmitter. The antenna connector is a standard SSMC female jack. The Scorpion is designed for a 50-ohm antenna load with VSWR less than 5:1. No damage will result from short or open circuits on the antenna jack, but it should be realized that rated power will only be delivered into a 50-ohm load.

Antenna orientation is not critical, however, several general principles should be taken into account. When using the supplied whip antenna, standing the Scorpion transmitter vertically gives an omni-directional radiation pattern. Orienting the Scorpion transmitter horizontally will result in a "Figure-8" pattern. One situation to avoid, if possible, is pointing the antenna directly toward the intended receiver site. This results in a theoretical minimum amount of signal radiated toward the receiver. In practical situations however, there will likely be enough reflections in the environment to ensure communication with even this orientation.

For any given transmitter antenna placement, there will be some receiver antenna orientations which will be more effective than others. When using the transmitter in an operational setting it will be helpful to try a variety of different receiving antenna placement and positions.

3.4 MICROPHONES

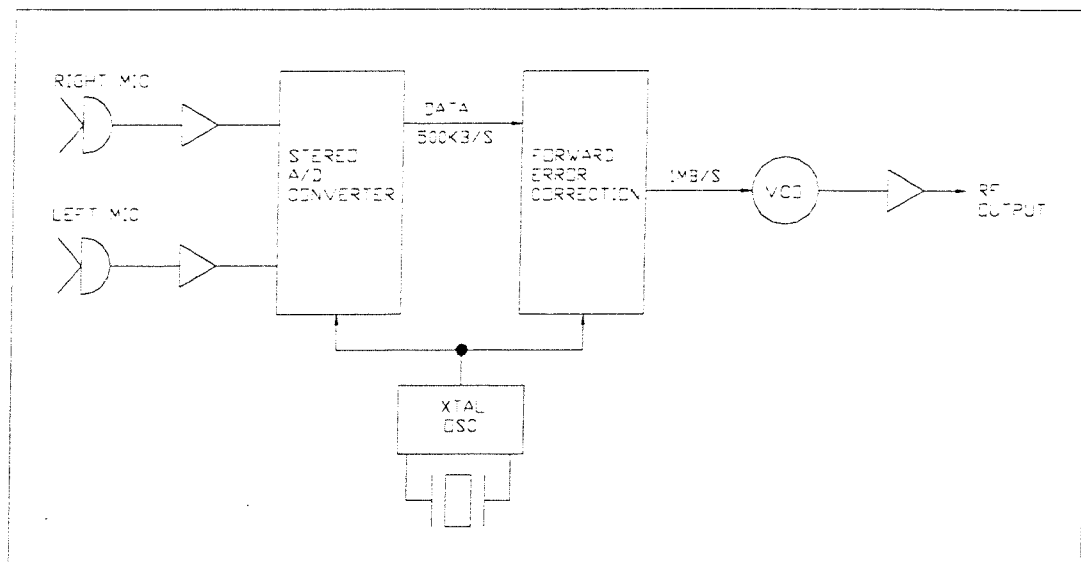
Two microphones, one for each stereo channel, or one microphone for single channel must be externally connected to the transmitter cables. The transmitter is designed to work with electret microphones and has been tested using the Knowles electret microphones, FG Series.

4.0 THEORY OF OPERATION

Converting analog audio waveforms to digital data, that is, a sequence of rapid on-off decisions has become almost commonplace in modern telephony, high fidelity, and audio recording equipment. Recent advances in analog-to-digital (A/D) and digital-to-analog (D/A) converters have made available inexpensive integrated circuits, which allow miniaturization of all the essential functions. The primary benefit of a digital format is that extremely accurate transmission, recording, and reproduction becomes a reality. A secondary benefit is that the digital format lends itself to coding and encryption in systems designed for private communications.

This section describes some details of the Tektron Digital Transmitter and the nature of its wideband, "low probability of intercept" signal.

4.1 TRANSMITTER BLOCK DIAGRAM



The figure shown above is a simplified block diagram of a typical Tektron Digital Stereo Transmitter. It shows the three essential functions; an analog-to-digital (A/D) converter; a forward-error-correction (FEC) and synchronization generator; and lastly, an RF module consisting of the oscillator, modulator and power amplifier.

In stereo mode the left and right microphone signals are amplified and input to a stereo analog-to-digital (A/D) converter. The A/D converter samples each of the inputs at 16 kHz and generates two 16-bit binary "words" which represent the instantaneous input voltages at the moment of sampling. Because the 16 kHz sampling rate is very high the analog input signals do not change appreciably from one sampling instant to the next. Thus, the stream of digital output words accurately represents the input audio signals.

4.1 TRANSMITTER BLOCK DIAGRAM (Continued)

Engineering textbooks give a rigorous mathematical description of this process and show that audio frequencies as high as $1/2$ the sampling rate may be conveyed by the sampling process without ambiguity. With 16 kHz sampling rate we may, therefore, design for an audio frequency response of 8 kHz. In fact, the A/D converter is a large-scale integrated circuit used in high-quality Compact Disk and digital audio applications. It employs an over-sampled "1-bit" conversion technique and includes a sophisticated digital filter for each channel resulting in a 7.6 kHz response at the 3 dB roll-off points.

Multiplying 16 kHz by 16 bits/sample by 2 channels yields the output digital data rate of 512 Kbits per second (KB/s). This is applied to the digital coding and synchronization section of the transmitter, which generates a 1.024 MB/s, coded data output.

The 512 KB/s digital audio signal is converted to a 1.024 MB/s output via a rate $1/2$ forward-error-correction (FEC) code. A rate $1/2$ FEC means that the output data stream has twice as many bits as the input data stream. FEC coding is a standard technique used in digital systems to reduce the signal-to-noise (S/N) ratio required at the receiver. Of course, more than a few errors per sample will overwhelm the decoding algorithm but even so the final result is that the receiver requires a lower S/N ratio with FEC coding than without.

4.1 TRANSMITTER BLOCK DIAGRAM (Continued)

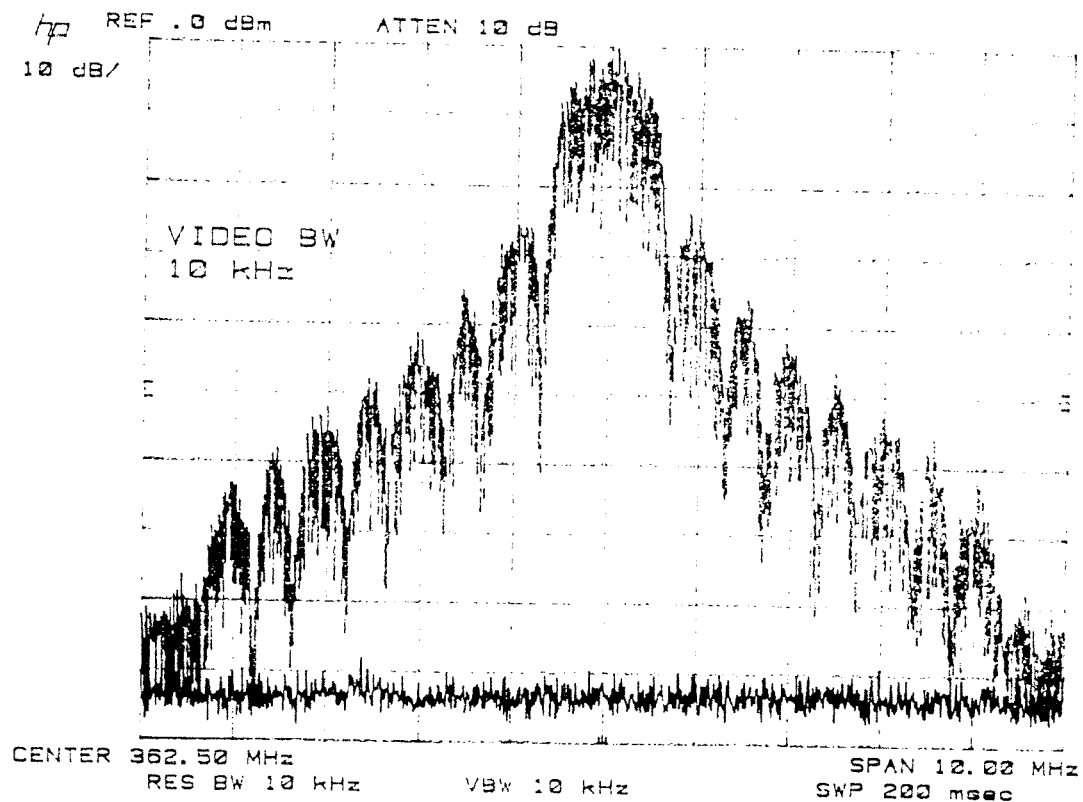
NOTE: It should be emphasized that FEC coding is not the same as data encryption used for classified message traffic. There is no message "key" which can be changed to prevent unauthorized reception. However, FEC coding does lend a measure of privacy in the Digital Stereo Transmitter, in that an unauthorized receiver will have to discover the particular algorithm used before recovery of good data is possible. Furthermore, as described in more detail below, using both A/D conversion and FEC coding makes it impossible for a narrow band analog receiver to break-out the audio signal.

The final connection in the transmitter block diagram consists of the FEC coder output link to the RF module, which generates the carrier frequency and amplifies it to 10mW output power.

4.2 OUTPUT RF SPECTRUM

The Tektron Digital Stereo Transmitters emit a unique RF spectrum, which is fundamentally different from that of conventional audio transmitters. It has wideband, low-probability-of-detection characteristics which are identical to those in costly spread-spectrum systems. This is a consequence of the inherently high data transmission rate needed for CD quality audio combined with MSK (minimum-shift-keying) modulation, which gives a uniform spectral density within the radio channel.

The figure shown is a Spectrum Analyzer plot of the Scorpion transmitter RF output which illustrates this point nicely with the analyzer set to 10KHz resolution bandwidth.



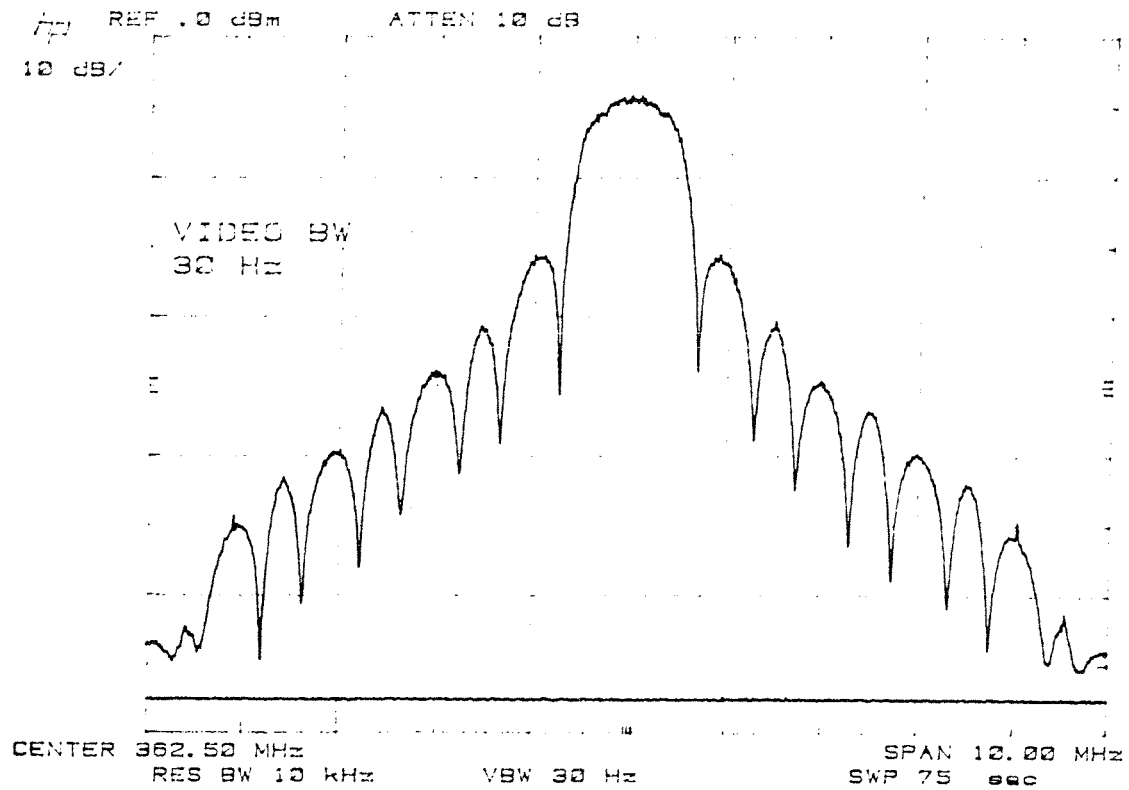
4.2 OUTPUT RF SPECTRUM (Continued)

(This bandwidth is typical of commercial audio receivers and scanners, which are intended for narrowband AM and FM reception.) Two characteristics of the Scorpion transmitter spectrum are immediately evident. First, it is a wideband signal spread out over 1.12 MHz. Second, the spectral density is about 0.25 milliwatts in a 10 kHz bandwidth.

This occurs even though the total transmitted power has not changed! It is still 10 mW. But now, due to the wideband modulation, the total power is spread over 100 "channels" of 10 kHz bandwidth each. The significance of this latter point is that a 20 dB reduction in the power measured at a scanner's detector has been achieved, and the likelihood of detection is correspondingly reduced. As compared with a conventional analog audio transmitter, the Scorpion transmitter appears to be a weak, noisy signal - albeit one occupying 100 adjacent 10 kHz channels!

4.2 OUTPUT RF SPECTRUM (Continued)

The following figure has the analyzer video bandwidth set to average the display and give a more accurate reading.



4.3 OPERATIONAL SECURITY - LOW PROBABILITY OF DETECTION

Operational security has become an ever increasing problem to law enforcement investigations as commercial scanners and walkie-talkies grow more and more common. As a wideband, smooth-spectrum transmitter, the Tektron Digital Stereo Transmitter provides a significant contribution to two important security requirements, freedom to operate without detection, and privacy of message content.

This section addresses the relationship between radio wave propagation, low spectral density and their effect on operational security.

4.3.1 RADIO WAVE PROPAGATION

Any radio transmission creates an electromagnetic (E/M) field emanating from the antenna. This field can be likened to a series of expanding circles of energy, growing in diameter as they leave the point of origin.

As the distance between a radio transmitter and receiver increases, the received field strength decreases geometrically in proportion to the distance covered. In free space the field diminishes as the square of the distance. Thus, when the distance between transmitter and receiver is doubled the field strength will reduce to $\frac{1}{4}$ (2 squared) of its previous value.

Signal propagation over ground is even more severely attenuated. At the VHF and UHF frequencies (30 - 1500 MHz), a common estimate is that attenuation varies as the fourth power of distance. In that case, doubling the distance between transmitter and receiver will reduce the signal to $\frac{1}{16}$ ($2 \times 2 \times 2 \times 2$) of what it had been.

4.3.1 RADIO WAVE PROPAGATION (Continued)

The significance of these calculations is that there is a very large difference in field strength between the near vicinity of the transmitter and a point at the farthest distance at which a signal can be received. Low probability of detection comes into play, for any transmitter, when the detection device is a sufficient distance away from the transmitter to be affected by this drastic drop in signal strength. It is also true that it is very difficult to make a signal "absolutely undetectable" when close to a transmitter. In fact, if a sensitive laboratory grade spectrum analyzer is used, ANY practical signal can be detected within 50 feet of the transmitter.

4.3.2 LOW SPECTRAL DENSITY EMISSION - HIDING A SIGNAL IN NOISE

When any radio receiver attempts to pick up signals, it must do so in competition with the random background noise, which is present in its environment, as well as the random noise generated within the receiving apparatus itself. Since the 1940s it has been recognized that spreading a signal's bandwidth beyond the required minimum will reduce its probability of detection by unauthorized receivers. The reason lies in the property of random noise energy being smoothly distributed across the spectrum. The amount of noise power a receiver picks up is directly proportional to the bandwidth employed. If the desired signal is made noise-like and spread to the point where its spectral density - its received Watts per Hertz of bandwidth- is below the random noise background, it literally will be undetectable! Of course, all this assumes the intended receiver can "de-spread" the signal and restore the proper signal/noise ratio before demodulating it in the normal fashion.

4.3.2 LOW SPECTRAL DENSITY EMISSION - HIDING A SIGNAL IN NOISE (Cont.)

Contemporary spread-spectrum transmitters generally achieve a 10 to 20 spreading factor (called "processing gain" in the engineering literature) which means that the signal received in a scanner or narrow-band receiver is reduced by the same factor.

For example, a spread-spectrum signal will register only 1/10 or 1/20 the energy of a comparable AM or narrowband FM transmission. This is an important improvement but must be evaluated in light of the 10 billion to one ratio of signal strengths experienced between the immediate vicinity of the transmitter and the furthest practical receiving range.

A scanner will typically stop on a signal if there is enough energy centered around the frequency it is inspecting. If the signal is spread out across a wide range in the spectrum, the detection device will 'see' less energy than it needs to cross its alarm threshold and it will not register the presence of an RF transmitter.

An important fact when considering bandwidth is that it is the size of the band that is critical, not how the band was created. A transmitter of any design that produces a wideband signal was created. A transmitter of any design that produces a wideband signal will effectively hide from a scanner or narrow band receiver. Thus, a spread spectrum transmitter with a bandwidth of 1.5 MHz is no more effective at avoiding detection than any other design (of equal power) with a 1.5 MHz bandwidth.

Thus, if two transmitters of the same radio frequency output power are located the same distance from a scanner or narrow band receiver, the transmitter with the widest bandwidth will be the least likely to be detected, whether it is a "spread spectrum" transmitter or not.

4.3.3 MESSAGE SECURITY

Tektron's digital modulation also preserves message security since the transmitted signal is a binary code representation of the audio received at the microphone. The Tektron system also adds parity bits to the binary code according to an error correction algorithm. This combination eliminates transmission intelligibility for any receiver not designed to match the Tektron transmission parameters.

The combination of these characteristics mean there is no observable correlation between audio events, such as sudden loud noise or loud single frequency tones when a spectrum analyzer is used as a detection device. Neither is there any form of recognizable audio available to a detection receiver employed as an intercept device.

5.0 MAINTENANCE

The Scorpion transmitter is designed to afford maximum user adaptation to operational requirements. User maintenance is limited to proper installation of power and attachment of the microphones. Because of special tools and processes required, there are no user repairable items inside the transmitter.

The Scorpion transmitter does, however, employ modular design and construction and it is possible that a damaged unit may be repaired economically at the factory. If a unit is damaged, it may be sent for an estimate of repair costs to:

Tektron Micro Electronics, Inc.
7483B Candlewood Road
Hanover, MD USA 21076-3102
Telephone: 410-850-4200
FAX: 410-850-4209

Please call for an RMA (Returned Merchandise Authorization) before sending. Tektron will provide specific shipping instructions at the time an RMA is issued.

6.0 WARRANTY INFORMATION

6.1 WARRANTY

Tektron Micro Electronics ("the Manufacturer") warrants to the first purchaser that this equipment will be free of defects in materials and workmanship for a period of one (1) year from the date of shipment to a purchaser.

6.2 LIMITATION OF WARRANTY

This warranty does not cover repairs or replacements required as a result of misuse, mishandling, improper storage, extreme weather or other Acts of God, failure to perform maintenance, alterations or repairs made other than in accordance with the Manufacturer's directions or other use inconsistent with the Manufacturer's instructions. Use in accordance with the Manufacturer's instructions is the responsibility of the user. This warranty is available only to the first purchaser of the equipment, but the exclusions and limitations herein apply to all persons and entities.

This warranty does not apply to consumable items included in the equipment, such as batteries.

6.3 EXCLUSIONS FROM WARRANTY

Manufacturer MAKES NO OTHER WARRANTY, EXPRESS OR IMPLIED, AND SPECIFICALLY MAKES NO WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR USE.

6.4 EXCLUSIVE REMEDY

The Manufacturer will, at its option, repair or replace any equipment or parts not conforming to this warranty at its facility or other location approved by it at no charge to the user. The Manufacturer will not charge the customer for any parts or equipment furnished or services provided by or at the direction of the Manufacturer, except that customers will be responsible for all costs of shipping to the Manufacturer any item required to be returned to the Manufacturer. The equipment or part repaired or replaced by the Manufacturer's agent will be returned at the Manufacturer's cost.

To obtain warranty service, contact the Manufacturer at the address or phone number listed below to determine if return of any item is required.

Tektron Micro Electronics, Inc.
7483A Candlewood Road
Hanover, MD 21076 USA

(410) 850-4200 FAX (410) 850-4209

At the time authorization is requested, the Purchaser will be asked to identify the product serial number, a description of the problem(s) and associated symptoms, their designated point of contact and telephone number, and the shipping address for return of the repaired product. To minimize delays, please be sure to provide adequate information.

Do not return the defective parts or equipment to the Manufacturer without prior authorization from the Manufacturer.

6.5 LIMITATION OF LIABILITY

Except for the remedy above described, the Manufacturer will have no (a) other obligation with regard to any breach of warranty or other claim with respect to the equipment; (b) liability for any direct, indirect, consequential or incidental loss or damage caused by or occurring in connection with any of the equipment; (c) liability for any injury, loss of life or property caused by or occurring in connection with the use of any of the equipment.

Any warranty or other claim with respect to the equipment must be made in writing delivered to the Manufacturer within one year and 30 days after date of receipt of the equipment by the first purchaser and include evidence of the date of receipt and source of purchase. Any claim not received by the Manufacturer within such shall be deemed waived.

WARRANTY CARD

Please complete (print) the following information.

Name of Buyer_____

Address_____

City_____ State_____ Zip Code_____

Country_____ Telephone Number_____

Model No._____ Serial No._____

Model Description_____

Date Purchased_____

Tektron Distributor or Agent from which purchased_____

After completing, please detach and send to the following address:

Tektron Micro Electronics, Inc.
7483A Candlewood Road
Hanover, MD 21076 USA

