Technical Reference Manual

VS-1200 Series

Frequency Domain Scrambler with Multi-Format ANI

VS-110 Series

Rolling Double Inversion Scrambler

VS-115

Rolling Double Inversion Scrambler with Multi-Format ANI

VS-1100 Series

Double Inversion Scrambler

VS-1150

Double Inversion Scrambler with Multi-Format ANI

VS-1000 Series

Voice Inversion Scrambler

VS-1050 Series

Voice Inversion Scrambler with Multi-Format ANI

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REGULATORY INFORMATION

The VS-1000, VS-1050, VS-1100, VS-115, VS-110 and the VS-1200 can be readily exported without a license. However, please note the following restrictions on the VS-1200.

Midian's VS-1200 Series of voice encryption products are subject to control by the United States Department of Commerce (US DOC). Diversion of the products different from the purpose for which they were sold is contrary to US DOC regulations and is strictly prohibited.

The VS-1200 may be exported to any country in the world without an export license unless the following applies:

1. Exports to Cuba, Sudan, Syria, Iran, and North Korea require a license from the US DOC.

2. Exports to nuclear end users or for nuclear end uses may require a license depending on the country of use.

3. Users listed on the US DOC Entity List, Denied Party List, Commerce Control List (subject to AT1 controls), etc. cannot be sold to without a license.

The Export Classification Control Number (ECCN) for the VS-1200 is 5A992. The VS-1200 is No License Required (NLR), except in cases listed above.

VS-1200:
The VS-1200 is a Digital Signal Processor (DSP) based Frequency Domain voice scrambler offering a high level of voice privacy. The DSP converts the analog signal into quantized digital data. It then converts the "Time Domain" signal into the "Frequency Domain". This results in an audio "frequency spectrum", which is then partitioned into bins that are encrypted by the non-linear key generator. The digitized data is converted back to the analog realm using a digital to analog converter.

The above technique and the lack of synchronization result in excellent audio quality, high security and enable the VS-1200 to be used in virtually any type of radio system. These systems include HF SSB, Conventional Two-Way, Trunking, Voting and Simulcast.

In addition to the radio encryption functions the VS-1200, VS-1150 and VS-115 offers ANI and Emergency ANI encode in the following formats;

- Motorola's MDC-1200
- Kenwood's FleetSync
- Harris' G-Star (aka GE-Star)
- DTMF
- 5-Tone (all formats)
- Midian's FMP (encode and decode) with auto descramble.

VS-110:
Midian's VS-110 is a rolling double inversion scrambler that offers 1020 possible codes (4 groups with 255 codes per group). Of these codes the scrambler may be programmed with up to 4 of these codes. The VS-110 series is compatible with Icom's UT-110. The VS-110 series' codes and groups are an exact match of those programmed in the Icom UT-110.

VS-115:
The VS-115 has the same scrambling features as the VS-110, but adds ANI and Emergency ANI encode in the above formats.

VS-1100:
Midian's VS-1100 is a double inversion scrambler (aka split-band scrambler) that offers 32 possible codes. Of these 32 codes the scrambler may be programmed with up to 4 of these codes. The VS-1100-MPM1 and VS-1100-MPP1 can be programmed with up to 16 codes. The VS-1100 series is compatible with Midian's VPU-6, Icom's UT-109 or Inysa's XPTO (Señalizacion y Telecontrol). A table showing the code relationships between manufacturers is in the on line help in the VS-1100 MPS software.

VS-1150:
The VS-1150 has the same scrambling features as the VS-1100, but adds ANI and Emergency ANI encode the above formats.

VS-1000:
Midian's VS-1000 voice inversion scrambler provides an entry level of voice security for two-way radio communications. The VS-1000 provides up to 4 different inversion frequencies that are button selectable and up to 16 different inversion frequencies using the binary select input lines. These inversion frequencies are programmable using the MPS software. The VS-1000 is compatible with Midian's VPU series voice inversion scramblers.

VS-1050:
The VS-1050 has the same scrambling features as the VS-1000, but adds ANI and Emergency ANI encode the above formats.

FMP Signaling

Midian's FMP signaling format is a 1200 baud mobile data FFSK signaling format used by Midian for ANI, status, auto descramble, and GPS location reporting. FMP adds decode functionality to the VS platform. The new functions supported by FMP are as follows:

- Status query (a.k.a. radio check)
- Position query (when unit is equipped with GPS)
- Selective call
- Spy
- Unit disable (a.k.a. stun, kill)
- Unit enable (a.k.a. un-stun, un-kill)
- Emergency acknowledge (terminate emergency sequence)
- Auto descramble*

These functions are invoked when a unit receives an 'FMP packet' from a CAD-800 with the exception of auto descramble (auto descramble is from scrambler to scrambler). Please reference the CAD-800 manual for greater details regarding the CAD software and hardware.

*Auto descramble is available on the VS-1200, 1150 and 1050 only. The Packet Based Auto Descramble uses our FMP signaling and the Tone Based Auto Descramble uses a pilot tone to cause the receiving scrambler to automatically decode scrambled audio, independent of the mode switch setting. The VS-110 and 115 already have auto-descramble built into it, for this reason Midian does not recommend using the FMP for auto-descramble in the VS-110 and 115.

Packet Based (FMP) Automatic Descramble:

If this is enabled in the MPS software, the receive mode of the scrambler is automatically switched between scramble and clear. If the unit receives a leading FMP packet indicating that the transmitter is in scramble mode, then it will automatically descramble the transmission. The receive mode will go back to clear when the transmission ends which is when COR (or VOX) goes inactive. The state of the Mode In signal will have no bearing on the receive mode of the scrambler.

IMPORTANT: For this feature to work, units must have ANI enabled and be configured to transmit a Leading FMP packet. Also, the Enable CAD Decode box must be checked and the system I.D. must be the same.

Important Note: When using a *unique system I.D.* do not attempt to 'clone' the VS-1xxx board by reading one and then programming another. When the VS-1xxx board is read, the system I.D. will **not** be read out, but will be displayed as the default I.D. "4D6964" in the MPS. If another VS-1xxx board is then cloned with this information, it will be programed with the default system I.D. and be incompatible with the CAD-800. To ensure the VS-1xxx board stays compatible with the CAD-800 always program them from a saved *file.*

For all diode protected inputs (i.e. PTT Input, Mode Input, COR Input) the voltage level to be required for a logic low is less than 0.5 V and a logic high requires at least 2.1 V. All inputs and outputs can be programed for a positive or negative active polarity.

PTT Input:
This input to the scrambler signals that the PTT button is pressed. The scrambler uses this to determine which audio path is active, RX or TX. In addition, this signals the scrambler when to send the initial the ANI (VS-1200, VS-1050 and VS-115 only).

PTT Output:
This output is asserted when the scrambler has a reason to key-up the radio. If connected to the same point as PTT IN, PTT OUT must be configured as common under Signaling\Settings in the MPS software. When configured as common, the output is asserted from the time PTT IN goes active until the time the ANI (VS-1200, VS-115, VS-1150 and VS-1050 only) has been sent. After that PTT OUT will release PTT so the unit will not remain keyed forever.
If the PTT path of the radio is broken, PTT IN and OUT are connected to different points and are not common. The PTT OUT connection allows the scrambler to assert PTT and send an emergency ANI.
If ENI is not used, and if it is acceptable for ANI's to be incompletely transmitted on a momentary PTT, then connecting PTT OUT is not necessary.

COR:
The COR Input is used to indicate to the unit that the channel is active to take the scrambler out of power save mode.

Mode Input:
This input can be connected to a momentary or latched switch for the selection of secure or clear mode. With a momentary switch pressing and releasing will switch modes. Pressing and holding the switch will toggle between security keys if the scrambler is programmed with multiple keys. When using a latched switch only mode select is available. Audio tones will only be heard when using a momentary switch.

Mode Output:
This output can be connected to the cathode of an LED with a 1 K limiting resistor in series connected to a voltage source up to 15 V. Failure to include a current limiting resistor in series with the LED will cause damage. Another application of this output is to provide a logic level (high or low (0-3.3 V) to indicate mode to the radio's mode indication icon (if applicable).

Emergency Input (VS-1200, VS-1050, VS1150 and VS-115 Only):
Activating this input will cause the scrambler to key up the radio and transmit the Emergency ANI if it is programmed for this feature.

Trunking Delay Input:
Connect this input to a point in the radio that gives an output upon acquisition of a channel. When used, the scrambler will wait up to 5 seconds for a channel to be acquired and send voice audio with ANI (if applicable). After 5 seconds, if the trunking delay has not been activated the PTT will be released with no audio or ANI being sent.

Audio Enable Output:
Connect this to a point in the radio that will cause the audio amplifier of the radio to turn on. The unit will assert this output when it wants to produce beeps through the radio speaker. The beep tones themselves come from RX OUT.

Binary Code Select Inputs:
The binary select inputs on connector P-2 pins 3,5,6 and 7 are provided for code selection. The VS-1200 can only use 1-line or 2-line binary as it is only capable of 3 codes. The VS-110, VS-1100, VS-1000 and VS-1050 can support up to 4-line binary for 16 codes.

Please see the manual for the specific VS product or help files in the MPS software for programming. For any programming instructions for a particular radio, please consult Midian's application notes for the VS series, if available.

This section describes how to determine and set the audio levels.

Audio Levels Overview:

To ensure the best audio quality, the scrambler must be configured to match the audio levels used by the radio. The scrambler uses programmable gain amplifiers to accomplish this. Determining the gain settings for these amplifiers is an involved process, so Midian simplified this process by developing an algorithm that requires the technician to make only four voltage measurements. From these four measurements, all of the many internal settings are determined.

Still, getting the best audio quality will likely require a bit of trial and error. The scrambler only has control of audio voltage levels, not input and output impedances. These impedances can dramatically influence the levels.

The Four Voltage Measurements:

An oscilloscope and a communications test set/service monitor are required for the measurements. It is recommended that the measurements be recorded in units of mV peak-to-peak. Each measurement must be taken with system modulation at either 60% or 100%, but Midian recommends using 60%

These measurements must be taken within 15 seconds of powering the scrambler on. This is because the scrambler may enter power saving mode after that time. Measurements made while the scrambler is in power saving mode will not be valid. The unit ships with the power save feature enabled by default. The power save feature can be disabled via the MPS software so that it will not interfere with taking measurements, if desired. To do this program the VS-1xxx with a high COR polarity and make sure the violet wire is not attached to anything. Please note that the levels provided to the option board may be different between narrow band and wide band.

TX Alignment Set-Up: A method for controlling transmit modulation is required for accurate measurements in the TX mode. A small speaker held in place near the microphone by a rubber band can serve this purpose in most cases. Use a sine-wave generator to inject a 1000 Hz tone into the speaker. Adjust the output of the sine wave generator so that the transmitter produces 60% of rated modulation while PTT is pressed. Note that if the audio source (such as a speaker) is moved even slightly, the TX modulation may change significantly. Care must be taken to avoid changing the TX modulation while taking the measurements.

RX Alignment Set-Up: Using a service monitor send a fully quieting signal (-50 dBm) to the receiver with a 1000 Hz tone at 60% modulation, adjust the volume of the receiver to a comfortable listening level and measure the audio level at the speaker using an AC coupled oscilloscope. Once the volume is adjusted and the measurement taken do not adjust the volume control during the remainder of the alignment.

1. **TX Input:** This procedure is to determine the audio level that the scrambler will see at the TX audio pickup point after it is installed. The scrambler must be installed and powered-on while making this measurement. Use the TX Alignment Set-Up procedure and measure the audio level at TP1 on the scrambler.

2. **RX Input:** This procedure is to determine the audio level that the scrambler will see at the RX audio pickup point after it is installed. The scrambler must be installed and powered-on while making this measurement. Use the TX Alignment Set-Up procedure and measure the audio level at TP2 on the scrambler.

3. In the programming software under audio levels set the TX In to the same level as measured in step 1 and for a preliminary adjustment set the TX Out for the same level. Set the RX In to the same level as measured in step 2 and for a preliminary adjustment set the RX Out for the same level. Program the unit.

4. **RX Output:** This procedure is to determine the audio level that would normally appear at the RX audio insertion point in an unmodified radio. Using the same RX Alignment Set-Up procedure verify the audio level at the speaker is still at the same level measured initially in the RX Alignment Set-Up procedure. If not adjust the RX Out level accordingly.

5. **TX Output:** The goal of this procedure is to determine the audio level that would normally appear at the TX audio insertion point in an unmodified radio. Using the same TX Alignment Set-Up procedure verify the modulation is still at 60%, if not adjust the TX Out level accordingly.

Programming the Audio Levels: After determining the audio levels at the audio hookup points, it is necessary to program the scrambler for these levels. In the programming software, there is a slider control on the Audio Levels Screen for each of the of four audio hookup points. Locate the column that corresponds to the modulation and units of measurement for each of the audio hookup points. Adjust the slider bar such that the value appearing in the appropriate column matches what was measured as closely as possible.

SCRAMBLER OPERATION

Mode Select:

Momentary Switch:
When using a momentary switch, pressing and then releasing the switch will cause the scrambler to switch modes.

Latched Switch:
When using a latched switch, pressing the switch will toggle the mode. Depending on the programmed polarity will determine the mode. For example if the polarity is programmed as low, then the scrambler will be in scrambled mode when taken to ground.

Code Select:
Momentary Switch:
When using a momentary switch, pressing and holding the switch will toggle the scrambler through the programmed codes. The scrambler will emit a number of tones corresponding to the code that is being switched to. When the desired code is reached simply release the switch.

Latched Switch:
Multi-code operation is not available when using a latched switch, unless the binary inputs are used for code selection.

Per-Channel:

Some versions of the scramblers can do code selection on a per-channel basis, based on a binary selection or serial communication with the radio.

ANI:
VS-1200, VS-1050, VS-1150 and VS-115 only: When the PTT Input is activated, the scrambler will transmit the unit's ANI as programmed into the ANI Unit ID field in the MPS software.

ENI:
VS-1200, VS-1050, VS-1150 and VS-115 only: When the Emergency Input is activated, the scrambler will transmit the unit's Emergency ANI as programmed into the ENI Unit ID field in the MPS software.

Lone Worker:
VS-1200, VS-1050, VS-1150 and VS-115 only: If a button is assigned for the Lone Worker function, pressing the assigned button within the Transmit Delay Time will prevent the transmission of the ENI. If the optional accelerometer is installed, then motion can be used to reset the timer.

TROUBLESHOOTING

De-scrambling Problems:
The following are potential causes and solutions for the problem of a receiving scrambler not decoding the scrambled audio:

Mismatched Security Keys:

A common problem resulting in a failure to de-scramble is that the transmitting and receiving scrambler are not using the same security key. The scrambler can be configured to have multiple security keys, selectable by the operator. Each operator must have the same key selected for the units to communicate. The receiving scrambler does not automatically switch to the key selected in the transmitting scrambler.

Another way that security keys often become mismatched is that users attempt to 'clone' scramblers. When the configuration of a scrambler is read, the security keys will read as Not Defined. This prevents someone who has stolen a scrambler from learning the security keys. Let's say an attempt is made to clone a working scrambler with a key of 12345678. First, the unit with key 12345678 is read. Then, a new unit is programmed immediately thereafter. The new unit will end up programmed with a security key of Not Defined. The result is that the new unit does not communicate with the older one.

It is strongly advised that the scrambler configuration be stored in a file. Later, if new units are added, they should be programmed using the saved file, not another scrambler.

MIDIAN WARRANTY

Midian warrants its products to be free from defects in material and workmanship for 3 years from the date of shipment. Specially configured or customized products carry a 1 year warranty on parts and labor. If such malfunction occurs, it will be repaired or replaced at Midian's discretion without charge for materials or labor if returned to the factory. This warranty does not apply to any parts damaged due to improper use - including accident, neglect, unreasonable use, physical abuse, and improper installation - or to unauthorized alterations or modifications to the equipment. It does not extend to damage incurred by natural causes such as flood, lightning, fire, etc. or to damage caused by environmental extremes such as power surges, transients, etc. Keypads on Midian products and keypad options are warranted for 1 year. Midian's warranty does not extend to batteries, fuses, lights and mic cables nor does it cover products not originally manufactured by Midian such as printers, computers, radios, etc.

Equipment for repair may be returned to the factory without an RMA. Instead Midian's repair form should be requested, completed and included with the product(s) for repair. Repair by other than Midian will void this guarantee. In-warranty product must be shipped, freight prepaid, to Midian. Midian will return (US only), freight prepaid via FedEx Ground, the repaired or replaced product to the purchaser. Freight for international repairs is to be paid for by the purchaser. Out-of-warranty repairs are billed at a rate of $65.00 per hour, plus replacement parts and return shipping.

This warranty applies to the original purchaser of the product only. Midian is not liable under this warranty, or any implied warranty, for loss of use, loss of profits or revenues, loss of time, damages to equipment as a result of using Midian's products, or for indirect, special, incidental or consequential damages of any kind sustained from any cause experienced by the purchaser/user. Some states do not permit the exclusion or limitation of implied warranties or consequential damages. This warranty provides special legal rights and the purchaser may have other rights which may vary from state to state. Midian will not be liable for any breach of warranty or other claim in an amount exceeding the purchase price of the specific Midian product purchased by customer.

Midian makes no warranty other than the one set forth above. THIS LIMITED WARRANTY IS EXCLUSIVE AND IN LIEU OF ANY OTHER WARRANTY, EXPRESS OR IMPLIED, INCLUDING BUT NOT LIMITED TO ANY IMPLIED WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE AND CONSTITUTES THE ONLY WARRANTY MADE WITH RESPECT TO THE PRODUCTS. No guarantee is made with respect to the products as to system performance unless such a guarantee has been set forth in a separate contract document signed by Midian.

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